SolderSmoke II

Local Adventures in Wireless Electronics

By Bill Meara

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William R. Meara

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CHAPTER 1

Introduction, People and Community, The Lexicon, On Understanding (and Math), Traditions

So where did SolderSmoke come from? The SolderSmoke books have their roots in a podcast of the same name. This is the second book – it picks up where the first one left off: our 2010 return to the United States after ten years in Europe. When we launched the podcast in 2007, Mike Caughan and I had discussed several possible names. "Bilateral Junction" fit well with the transistor focus of the podcast, but sounded a bit too psychiatric. "Dawn Patrol" seemed too military. Finally there was a quote from a fellow who talked about the joy that comes from listening to a homebrew radio that has emerged amidst a cloud of… SolderSmoke. That was it.

Regarding the style of the podcast, many listeners have noted the influence of Jean Shepherd, the radio personality that my father and I listened to when I was growing up. Shep was a ham. He got me interested in ham radio, and I am sure that he has had an influence on the podcast. But there were other influences: The Car Talk program was a big influence. And recently, while listening to old recordings of pre-TV radio shows, I started to think that perhaps the name SolderSmoke may have been influenced by Gun Smoke…

Much of the material in this book is taken from the SolderSmoke Daily News, a blog that I launched in 2008 as an adjunct to the podcast. There are now thousands of posts on the blog. They are all indexed but I think it is still often difficult to follow a project or an idea through the postings of a blog. So in this book I will try to group the postings together and tie them together in a more digestible way. This is a book about the rigs I have built and the circuits that I have tried to understand in the years following our return from Europe.

Having been born in the International Geophysical Year (1958), with any luck I may be able to operate through two or three more solar cycles. I retired from the Foreign Service in 2019, but we are setting up a winter refuge in the Dominican Republic so there is the possibility of more foreign adventure. There are still a lot of things I haven't tried yet in ham radio: there's still moon-bounce, meteor scatter, amateur television, and many other things. And of course—as readers will have certainly noticed—there are many things about radio that I still don't understand: I'm really shaky on the Smith Chart and the design of narrow-band amplifiers… I think I understand the waves that are emitted by my antenna, but I have a lot of trouble thinking about 20 meter photons… Maybe we can explore these and other mysteries in future editions of this book… Please stay tuned!

Personalities and Community

Pete Juliano N6QW : After the first co-host of Soldersmoke (Mike Caughan KL7R) was killed in a 2007 car crash, the podcast limped along for about seven years as a mostly solo effort. I would occasionally have guests on the show, and they were all great, but the podcast was clearly in need of a new permanent co-host. In 2014, Pete Juliano N6QW made his first appearance on the program. Originally intended to be for just one appearance, the podcast was so good and so much fun that we quickly set up Part II, then Part III… Peter became the SolderSmoke co-host and has been with us for every episode since that first appearance.

Pete is a true master of the homebrew craft and more than made up for my own shortcomings and lack of experience. He was on the air in Solar Cycle 19 when I was an infant. He was an officer in Vietnam in the Navy Seabees when I was still in First Grade. Pete has owned and worked on just about every important post-war piece of ham radio gear, and I think he has built more homebrew SSB transceivers than anyone in history. He is a very talented and prolific writer who is always ready to share his knowledge with those who are willing to learn. He is a true Elmer to all of us. And he is a good person who has carried a heavy load of family responsibilities with grace and good humor. We are very lucky to have him on the podcast.

Farhan VU2ESE: Ashhar Farhan goes by his last name. I have always called him just Farhan. Based in his home city of Hyderabad, India, Farhan has had an enormous influence on ham radio homebrewing over the last several decades. I think I first became aware of his work around 2004 – he was deeply involved in the response by Indian ham radio operators to the horrific Tsunami of that year – I saw him on CNN. Later I learned that he was the designer of the BITX 20 transceiver, a truly ingenious, simple and low-cost rig that could put people on the air with single sideband phone for an expenditure of around 5 dollars U.S. Farhan's rig saved money by using nylon washers from the kitchen sink in place of more expensive toroidal coil cores. Farhan designed the BITX 20 in 2000 during an overnight flight from Europe back to India. All he had with him was a notebook, a pencil, and the calculator in his phone. Many thousands of the BITX rigs have been built around the world. I caught the BITX wave rather late, and only got going around 2010; I have since homebrewed at least five versions of this rig, more if we include BITXs using boards designed and manufactured by Farhan in India.

Many other designs came from Farhan's fertile mind. Like many others around the world, I found myself building most of them.

Farhan is a true Renaissance Man: He was in a rock band and knows the lyrics to classic rock songs a lot better than I do. He developed the software that allowed the Urdu language to be written into computers. He has been a passionate advocate for poor Indian farmers. Early in the pandemic he worked with others to develop ventilators that could be built cheaply in developing countries. He runs a social/cultural center in Hyderabad called Lammakaan that is home to a very active ham radio club. And throughout he has been a devoted son, husband, and father. It was my privilege to host Farhan during two visits to Washington. I hope he comes back soon.

Farhan Visits Northern Virginia and SolderSmoke HQ

Our good friend Farhan came to Northern Virginia last week for the 50th Anniversary Symposium of AMSAT. We were really delighted that he also came to SolderSmoke HQ. Elisa and I gave him a lightning tour of Washington DC (including a quick visit to The Air and Space museum) and then we headed back to the shack from some radio work.

In the picture above you can see my BITX-20 (that Farhan designed) off his right shoulder. Off his left shoulder sits my ET-2 rig. I really wanted to show Farhan how well the N0WVA regen performs -- he was impressed, especially when we started listening to SSB contacts. It was really amazing that we were doing this with just one J-310 FET. This was great fun. Farhan tells me that he will soon take up the "two transistor challenge."

When he was here in 2017, I tried to demonstrate my version of Rick Campbell's R2 Direct Conversion receiver. Unfortunately, when I tried to show off the "single signal" capability that is the whole purpose for this receiver, it was NOT producing a single signal output -- you could hear the signal on both sides of zero beat. One of the small AF chokes I had used had gone open, knocking our one of the two DC receivers. This time I had the problem fixed and single signal reception was successfully demonstrated.

Farhan brought me two pieces of test gear that I have needed for a long time: A step attenuator and a two tone generator. Paired with his Antuino, these devices will bring about a big increase in capability on my bench.

It was really great to have Farhan in the shack. We had a great time talking about ham radio and homebrewing. Elisa and I both really enjoyed hearing from Farhan about his travels and about his life in India. We are all really lucky to be in the same hobby as Ashhar Farhan. Thanks for the visit Farhan.

Dean Souleles KK4DAS: I first came into contact with Dean in December 2019 when he asked me to send him a crystal for a Michigan Mighty Mite transmitter that he wanted to build. Dean lives very close to me in Farifax county Virginia, but it was December and it was cold, so I decided to use the U.S. mail to send the crystal to Dean. Well, don't you know that the USPS frowns mightily on sending a radio crystal in an envelope designed to carry only a letter. So Dean's household got a message from the post office indicating they were holding a package with "postage due." Dean's wife Sandy thought it was knitting supplies. She soon found our little crystal (with a small bill from the USPS.

Dean has made great and rapid progress as a homebrewer. He is obviously aided in this by the troubleshooting skills that he picked up in the software world, including during a stint at the Jet Propulsion Laboratory in Pasadena.

After his Michigan Mighty Mite success Dean let the Vienna Wireless Makers Group in the construction of a direct conversion receiver and a single sideband transceiver. He is probably the only ham in the world to have homebrewed Farhan's sBITX (hybrid SDR and HDR) transceiver.

On the Importance of Really Understanding Radio and Radio Circuitry

In the first version of this book I included (in bold letters) sections in which I described my efforts to deeply understand how the circuits I was using really worked. I mentioned that this yearning for understanding probably had its roots in the influence of Jean Shepherd: Shep seemed to expect true radio hams to really understand the gear that they worked on. As a child, James Clerk Maxwell would often ask about how things worked: "What's the go of it? What's the particular go of it?" That is the kind of understanding that I wanted. But as I progressed, I would often come across hams who had other notions about what constituted "understanding." These people were often Electrical Engineers, deeply schooled in mathematics. For them, knowing the math was synonymous with understanding how circuits worked. Asked, for example, how a mixer mixed, they would spit out trigonometry formulae. I found this kind of understanding insufficient and unsatisfying.

I was not alone:

In 1990, after seven years of teaching at Harvard, Eric Mazur, now Balkanski professor of physics and applied physics, was delivering clear, polished lectures and demonstrations and getting high student evaluations for his introductory Physics 11 course, populated mainly by premed and engineering students who were successfully solving complicated problems. Then he discovered that his success as a teacher "was a complete illusion, a house of cards."

The epiphany came via an article in the American Journal of Physics by Arizona State professor David Hestenes. He had devised a very simple test, couched in everyday language, to check students' understanding of one of the most fundamental concepts of physics—force—and had administered it to *thousands of undergraduates in the southwestern United States. Astonishingly, the test showed that their introductory courses had taught them "next to nothing," says Mazur: "After a semester of physics, they still held the same misconceptions as they had at the beginning of the term."*

The students had improved at handling equations and formulas, he explains, but when it came to understanding "what the real meanings of these things are, they basically reverted to Aristotelian logic—thousands of years back."

To Mazur's consternation, the simple test of conceptual understanding showed that his students had not grasped the basic ideas of his physics course: two-thirds of them were modern Aristotelians. "The students did well on textbook-style problems," he explains. "They had a bag of tricks, formulas to apply. But that was solving problems by rote. They floundered on the simple word problems, which demanded a real understanding of the concepts behind the formulas."

From: http://harvardmagazine.com/2012/03/twilight-of-the-lectureFrom the blog February 2010:

In "SolderSmoke -- The Book" I describe the quest for deep understanding of the circuits that we build and use. There is some discussion in the book of the role of mathematics in this quest. A while back a reader e-mailed me on this subject. In the hope of stimulating a discussion, I'll present the key paragraph from that e-mail here (the author will, for now, remain anonymous):

I appreciate your quotes from Feynman, Asimov, etc. about not really being able to fully understand everything. As a math teacher I can say that one of the biggest misunderstandings about math is that it "explains" the phenomena of physics and engineering. (Science and math teachers are notorious for saying to a student who has just asked a "why" question things like, "well the math is a little bit more complicated than what you can handle right now. Wait until you have had a year or so of calculus.") In reality it's the exact opposite! The math equations actually hide the answers. They are very good at accurately describing phenomena, or at predicting what will happen next, but they can never answer the question of why one equation works and another does not. We get very comfortable with allowing the familiar math equations to hide our inability to really answer the "whys."

This really resonated with me. Of course, I don't mean to be anti-math here, but I thought this e-mail on the limits of mathematics was very interesting. In "Empire of the Air" Tom Lewis wrote, "At Columbia, Edwin Howard Armstrong developed another trait that displeased some of the staff and would annoy others later in life: his distrust of mathematical explanations for phenomena of the physical world. All too often he found his professors taking refuge in such abstractions when faced with a difficult and seemingly intractable conundrum. Time and again as an undergraduate at Columbia, Armstrong had refused to seek in mathematics a refuge from physical realities."

So in this book I will continue the effort to come up with explanations of circuitry that do not seek mathematical refuge from physical reality.

The SolderSmoke Lexicon:

Steve Silverman KB3SII is our official Lexicographer:

Over the years we have taken up many words and phrases. For some of them the meaning is obvious. For others, not so much. Here goes:

The Knack: Dilbert's disease.
https://soldersmoke.blogspot.com/2023/01/dilbert-knack-video-who-was-doctor.html

Knackification: Taking an older piece of gear and converting it into a useful piece of ham radio equipment. Example: Converting a JC Penny CB radio into a real ham 10 meter AM rig.

Noodling: Pete brought this musical term into ham radio. It means thinking about circuitry and sketching out ideas for possible solutions.

TRGHS: The Radio Gods Have Spoken. When a plan, or a circuit, or a rig, or a contact comes together so easily or naturally as to suggest that the radio gods are pleased and are willing to help.

JoO: Joy of Oscillation. What you experience when your oscillator (especially a Michigan Mighty Mite) actually works.

JoVo: Joy of Variable Oscillation. As with a VFO or PTO.

Fat Finger Syndrome: When a person struggles with controls or buttons or even parts that are too small for their fat fingers.

Al Fresco: A rig -- sometimes under test -- operated with all of the circuitry exposed on the workbench, often on a pine board.

DiFX: An SSB transceiver that does NOT use the BITX architecture.

OTD: Obsessive Tinkering Disorder. Like OCD but more fun. Closely related to Dilbert's Disease (The Knack).

Haywire: How many of our rigs look before we have a chance to clean up the wiring.

Tombstone: When you heat up a surface mount part, flip it vertical. and leave one end soldered in, usually for testing.

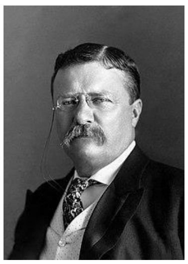
Kluge or Kludge. A slap-dash, jerry-rigged, Rube-Goldberg, Heath-Robinson, temporary, less-than-perfect solution to a problem. There is much controversy about how to pronounce it. Kludge as in Stooge or Kludge as in Fudge? (The author believes the correct pronunciation is Kludge, as in Fudge.)

https://soldersmoke.blogspot.com/search?q=Kludge

Bike Shedding: The **law of triviality** is C. Northcote Parkinson's 1957 argument that people within an organization commonly or typically give disproportionate weight to trivial issues. Hams will often pay more attention to cabinetry than to circuitry.

Waterfall Police: Hams, often on 40 meters, who find themselves (through credit card purchases) equipped with SDR transceivers that have waterfall displays. Some of these hams then spend their time patrolling the band, on the lookout for any signals that look in any way "different." When they find such a signal, they pounce! They complain loudly and pompously that the signal is "distorted." Or "too wide." Or "off frequency." They usually don't know what any of these terms mean. But they believe their waterfall display empowers them to police the ham bands, and to criticize those whose signals do not appear (to them!) to be normal.

Teddy Roosevelt on the Waterfall Police:



"It is not the critic who counts; not the sharp-tongued appliance operator who points out how the homebrewer stumbles, or where the builder of rigs could have built them better. The credit belongs to the ham who is actually melting solder, whose fingers are marked by burns and glue and blood; who strives valiantly; who errs, who splatters and distorts again and again, because there is no homebrewing without error and shortcoming; but who does actually strive to build and improve his rigs; who knows great enthusiasms, the great devotions; who spends himself in a worthy project; who at the best knows in the end the triumph of saying "rig here is homebrew," and who at the worst, if he fails, at least fails while daring to try, so that his place shall never be with those cold and timid amateurs who never try to build anything, but who only stare at their waterfalls, ready to pounce on those who do homebrew."

HDR (vice SDR) Hardware Defined Radio. (I take credit for that one.)

Presence, Brightness – Two of the more popular terms used by the "Enhanced SSB" folks to describe "signal quality." Pseudoscience (more pseudo than science.) Use of these terms usually leads to many hours of on-the-air discussion of how best to set menu items in the software of commercial (appliance) "radios."

Radical Homebrew Fundamentalism – The belief that hams should — to the greatest extent possible – build their own gear, using – to the greatest extent possible – discrete components. And, of course, hams should understand the circuitry.

Smoke (magic): What is released from components when you make a mistake.

Smoke test: When you first power-up a new device. Smoke emitted = FAIL! No smoke = PASS

Murphy's Whiskers: The tiny, almost invisible wires that inevitably fall off when you are stripping small coax like RG-174. One of these little monsters will position itself in such a way as to cause your creation to not work. Closely related to the remnants of steel wool (which should be banished from all ham shacks).

The Pope's Pee: Possibly an Irish accolade. John EI7BA was trying to extol the virtues of WD-40: "It's the Pope's pee!" This is apparently considered high praise. (Other Irishmen claim ignorance of this term.)

Mojo: Merriam-Webster: : a seemingly supernatural power, influence, or ability

Juju: Google: In modern-day slang, "juju" has taken on a broader, more secular meaning. It typically refers to a sort of positive, ineffable, magnetic power — an energy, feeling, or vibe that any of us can create, give off, or experience (in some cases without even realizing it).

BASTA! Enough! Enough already! That's enough! From the comic Mafalda. This word exists in both Spanish and Italian, but it is used more frequently (and with more fervor!) in Italian. Pete N6QW uses it a lot.

Exorcism: Much like in the movie. When we have to work to rid our amplifiers of evil oscillations.

Papa Legba: C.F. Rockey W9SCH wrote about Papa Legba in his article "Prologmena for QRP Transmitters." The Rock acknowledged that at times nothing seems to work. At that point, in desperation, you would have to "sacrifice chickens to Papa Legba." We knew that Papa Legba was an important VooDoo spirit, but I never knew of his connection to communication: *From Wikipedia: **Papa Legba** serves as the intermediary between the lwa and humanity. Legba facilitates communication, speech, and understanding.* So, Papa Legba is a phone guy.

Killing Chickens: See "Papa Legba" See also:

https://soldersmoke.blogspot.com/2016/01/dead-chickens-and-fake-transistors.html

Ghost in the Machine: From the title of the album by The Police. Spurious oscillations, parasitic oscillations, unwanted images.

Soul in the New Machine: From the 1981 book by Tracy Kidder about early computer development. Homebrew rigs have soul. Commercial appliances do not. Soul is added when the builder employs noodled innovative circuitry, or parts provided by friends.

Ludite (one d) A person who opposes technological advances. Usually pejorative, but it can be an accolade when used to describe the preferences of a Radical Fundamentalist Homebrewer (see above).

The Speed of Dark: My son Billy asked me about this when I was telling him about c.

First Light: Derived from astronomy, but here used with receivers: When the first signals are received by a newly built receiver.

Ooh that's Awesome: Billy says this as we open the SolderSmoke Mailbag.

Ciao Bravi Raggazzi! My daughter Maria says this at the close of each podcast: So long, you clever fellows!

Excelsior: Jean Shepherd's slogan. Latin. Translates as "Ever Upward." There was a large billboard in Rome with this word in very large letters. It seemed to be aimed at me.

Brass Figlagee with Bronze Oak Leaf Palm: An award given by Jean Shepherd. SolderSmoke has continued issuing this award.

Tales of Woe: Any sad story about a difficult build, or a difficult repair. Usually refers to problems that remain unresolved.

Not for the Faint of Heart: The recognition that homebrewing is not easy, and is not for those who are easily frustrated or deterred.

Not Plug and Play: The recognition that the devices that we build often DO NOT work the first time we power them up. If you want plug and play, buy a commercial product. But it will not have soul.

Rig (vice radio): An important but subtle distinction: "Rig" harkens back to the days of early radio, when a station was a conglomeration of parts and circuits. "Radio" often implies a commercial appliance box. So it is correct to say, for example, that, "Rig here is a homebrew plate modulated transmitter, going to a homebrew tuner. Receiver is a heavily modified Mate for the Mighty Midget." You could not describe this set up as a "radio." Similarly, it is kind of incorrect to describe a modern commercial device as a "rig." These things are, sadly, more aptly described as "radios." An Icom 7300 is a radio, not a rig.

Thermatron: A vacuum tube, or, as the Brits say "a valve." This term was invented by our good friend Grayson Evans KJ7UM, author of Hollow-State Design for the Radio Amateur. It should be used whenever referring to these devices.

Tribal Knowledge: The vast set of skills, and bits of knowledge that allow hams to build their own gear. How to solder, how to troubleshoot, how to tap aluminum, how to read a schematic, how to wind coils, how to strip insulation from wire, etc. Homebrewers learn these skills from other hams and develop these skills by actually building their own gear. Pete Juliano N6QW has a vast collection of Tribal Knowledge that he shares via his publications and on-line activities, including the SolderSmoke podcast.

WYKSYCDS: Closely related to Tribal Knowledge. Acronym: "When you know stuff, you can do stuff." Indeed you can! This was on our first sticker.

"Bob's your uncle": British term meaning "your problem is solved." Wikipedia: "**Bob's your uncle**" is a phrase commonly used in the United Kingdom and Commonwealth countries that means "and there it is" or "and there you have it" or "it's done". Typically, someone says it to conclude a set of simple instructions or when a result is reached. The meaning is similar to that of the French expression "*et voilà!*". The origins are uncertain, but a common theory is that the expression arose after Conservative Prime Minister Robert Gascoyne-Cecil, 3rd Marquess of Salisbury ("Bob") appointed his nephew Arthur Balfour as Chief Secretary for Ireland in 1887, an act of nepotism, which was apparently both surprising and unpopular. Whatever other qualifications Balfour might have had, "Bob's your uncle" was seen as the conclusive one.[1][2]

Socketry: A very useful term coined by G-QRP founder George Dobbs G3RJV. It refers to all the connectors and sockets that you have to put into a new rig. Socketry is often an annoying but necessary final step in the construction process. The excitement comes in the building of the actual circuitry. Socketry, like cabinetry, is a bit boring.

Grand Pooh-Bah: That would be me. In the early days of the podcast, someone (was it Brent, KD0GLS?) named me as Grand Pooh Bah of SolderSmoke. This honor (?) apparently was derived from a character in The Flintsones: GPB was the leader of their lodge. However, Ron Sparks AG5RS notes: Grand Pooh-Bah is, as you say, a Flintstones character, but it is not the origin of the term. It actually goes back bit more than a century. The original character was named Pooh-Bah and was Lord High of nearly everything. He appeared in *The Mikado* by Gilbert and Sullivan in 1885.

IBEW: The International Brotherhood of Electronic Wizards. That would be us. Sort of. I coined this term in an effort to describe the global commonality of our interest in radio. But there are problems with this term: "Brotherhood" seems to cut off half the human race, and IBEW reminds most Americans of a labor union. IBEW found its way onto the SolderSmoke stickers, but we really need something better, something more inclusive and less confusing.

A Thing of Beauty: An Irish term, usually " tis a thing of beauty." Sometimes used ironically by hams: "I don't care what the HOA says, I think your 5 element quad is a thing of beauty!"

Grief Box: Any homebrew device that is generating an inordinate number of "tales of woe."

The Laboratory at Newbury Park: Pete N6QW's shack.

The Wizard of Newbury Park: Pete Juliano, N6QW

The Wilds of Northern Virginia: Where the SolderSmoke podcast has been produced since 2010.

Shame Shelf: Where homebrewers put projects that they were unable (thus far) to get working.

Hamsplaining: A term invented by Dean KK4DAS: An amateur radio enthusiast giving demonstrably incorrect advice with unjustified confidence in their own abilities and knowledge; often this advice is given to someone who is a real expert on the subject. Example: Bill trying to tell Dean how to write computer code. Similar to Mansplaining.

Radio Infatuation: When you become so enamored of a newly built rig that you move it directly to the operating bench. But then, gradually, you learn of flaws and imperfections. This causes you to move the rig back to the workbench (where you should have left it for at least two weeks) Coined by Jerry KI4IO.

Seagulling. As in seagulling a project. This is when you swoop in on someone else's project, screech about it a lot, poop on it, then fly away without doing anything.

TRADITION!

It is also important for us to carry on with important ham radio traditions. One of the most important is April Fool's Day. We started observing this very early. Here is a list of our contributions.

2007 NJ State Assembly banned soldering in the home. Write to your Assemblyman! And apparently many did! we can only wonder about the confusion this must have caused in Trenton.

2008 AA1TJ's microwatt signal copied in Rome with my Drake 2-B. Played a clip of the CW signal. It kept repeating A P R I L F O O L in Morse. Some guys still didn't get it. One guy wrote: "I think it is saying APRIL FOOL– what does that mean?"

2009 A new fragrance for men. Cologne that smells like solder. Chicks dig it.

2010 My new book about Homebrewing will be featured on the Oprah book club. Ask your wife to keep an eye peeled for announcements of this segment. Many did. The wives were incredulous.

2011 Homebrew your own microphone using Tartar Sauce.

2012 We did not really do one this year, but we did Post Google's excellent video explaining how they had brought Morse Code into the G-mail system FB!

2013 SolderSmoke will be advertising on WWV and WWVH. Listen up!

2014 Use of an Altoid mint (not the tin) as a crystal radio detector.

2015 A New Company in China: Homebrew 4 U! They will make homebrew radios that you can call your own!

2016 Changing SolderSmoke's technology and name: We are now WireWrapRap! Hey, we were supposedly just trying to be hip and modern.

2017 Pete Juliano's QRP Hall of Fame REVOKED for excessive use of RF amplifiers.

2018 SolderSmoke being sued by the California Marijuana and Vaping industry for trademark violations. They objected to our use of the word "smoke." Pete's computer taken by court order!

2019 Malicious code in Si5351 – Pete quitting the podcast in response!

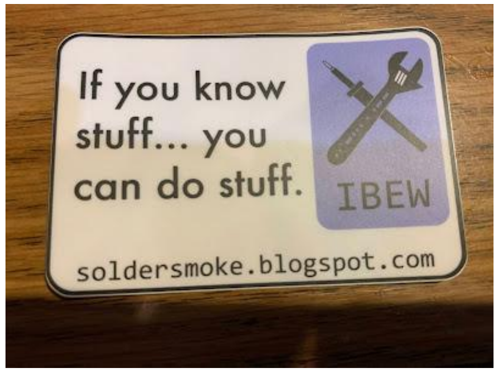
2020 S38E Cease and Desist order. FT-8? FT-FAKE!

2021 Legacy equipment BANNED by the FCC. This one got passed around quite a lot, with many (still!) believing it to be true.

2022 Techie Tattoos and SolderSmoke TV. No, sorry, Pete and I are not breaking into the world of HGTV-style shows. But the tattoo idea seems to have grabbed a few people.

2023: PeteGPT: An Artificial Intelligence program was used to fill a gap caused by a Skype failure in a recent podcast. Bill is happy – this will enable him in future episodes to have Pete decry the Si5351 and fully embrace homebrew analog discrete VFOs.

2024: The City of San Francisco was taking legal action against Bill because he had placed a SolderSmoke sticker on a lamp post at the corner of Haight and Ashbury. Outrageous! Unbelievable! But several people did believe this, including one guy who wrote (quite sincerely) that we were getting what we deserved for vandalizing the City by the Bay.



Our sticker – the one that supposedly got me in trouble in San Francisco.

2025: The FCC bans the use of Direct Conversion Receivers

CHAPTER 2

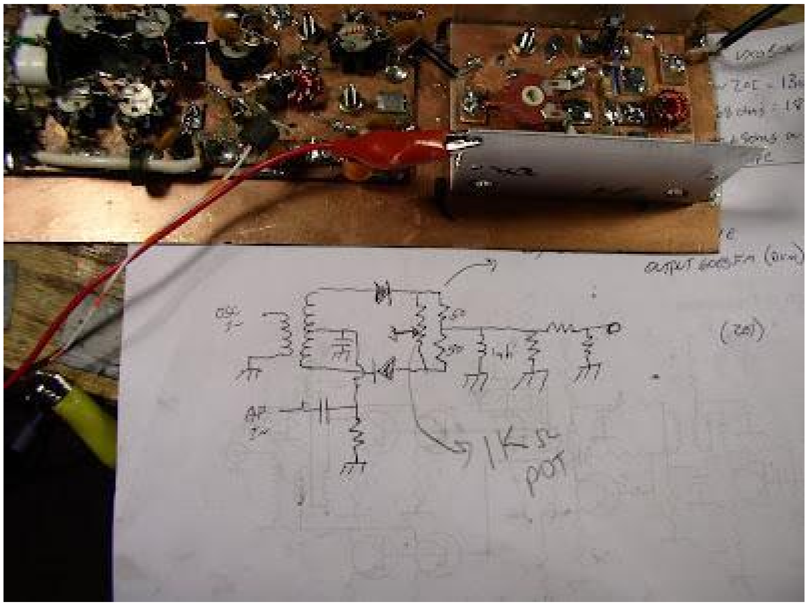
Double Sideband Rigs

That first DSB rig that I built out in the Azores was, for me, like a magic carpet. It carried my voice and my thoughts out across the oceans, and brought back to my ears the voices and thoughts and laughter of friends far away. As I explained in my previous SolderSmoke book, I've always been a "phone guy," more interested in voice communications than in the use of Morse code or keyboard modes. Double sideband provided me with a relatively easy way to homebrew my own phone gear – first a transmitter, then a receiver to go with it, later a full DSB transceiver. But all this stuff was pretty crude, with much room for improvement. When I found myself back in the USA in 2010, my early projects were focused on improving the double sideband gear that I had built while abroad. Here are some of those improvement projects.

RE-BALANCING A BALANCED MODULATOR

November 2011

My effort to bring my Azorean 17 meter DSB rig back to life continues. This is proving to be harder than I thought. I'm still taming my version the JBOT amp. It still seems to break into oscillation -- I think the oscillation freq is around 1 MHz. But I am making progress. I had to go back and work on the balance modulator circuit. I really like the simple two diode singly balanced mixer circuit. But my original Azorean board had, like the oscillator board, been through a few too many rounds of modification and repair. I decided to start over. See above. I even came up with my own little innovation on this circuit. Doug DeMaw's original design called for a 100 ohm pot at the junction of the two diodes, with the signal coming off the tap. You adjust the pot to balance the circuit and null out the carrier. But I didn't have a 100 ohm pot. Lots of 1K controls were available, so I put in two 50 ohm resistors in place of the pot, then put the 1k pot between the diodes, with the tap to ground. This balances things out nicely. See below.



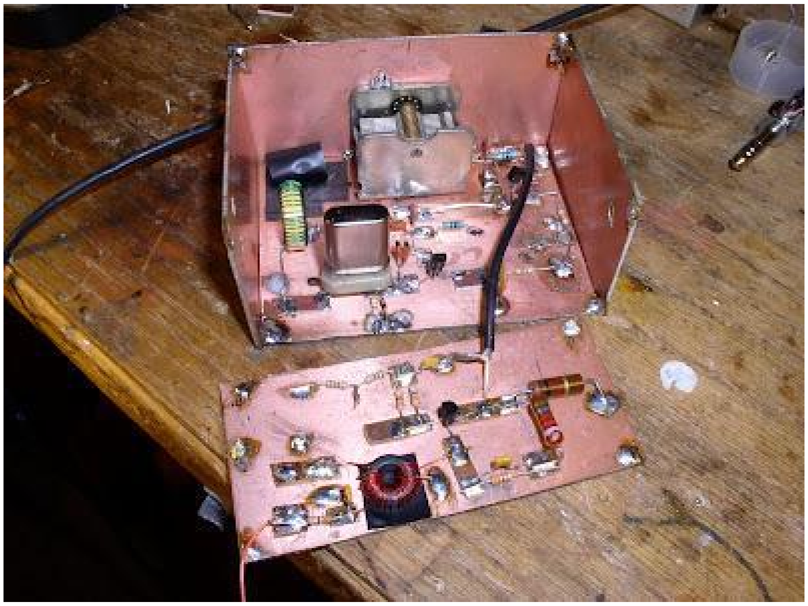
PUTTING FARHAN'S JBOT AMPLIFIER IN MY AZORES DSB TRANSMITTER

November 2011

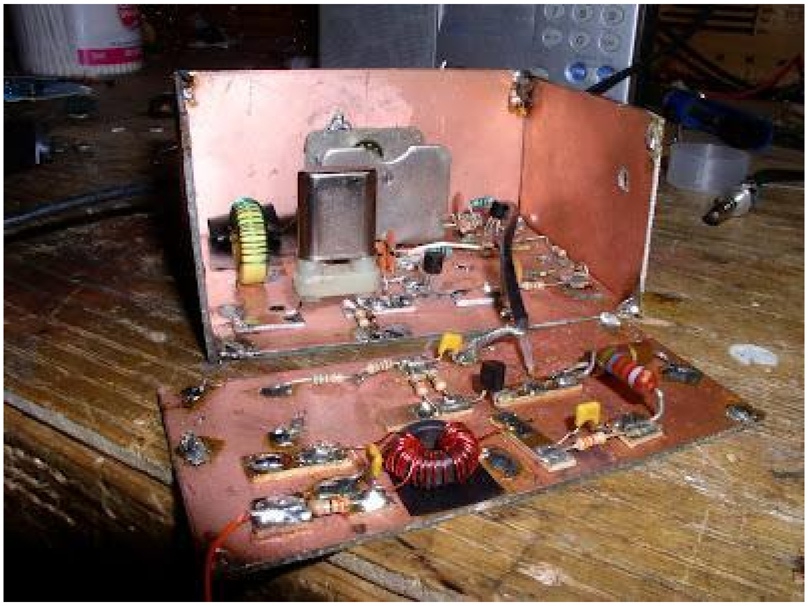
I've been remiss in posting to the blog, but I have a good excuse: I've been melting solder. I have been working on the installation of my new Farhan-designed JBOT amplifier in my old Azorean DSB transceiver. I'm really enjoying this project, and I now see it as the first in a series. My shack has a number of creations that were built during the peak years of the last solar cycle, but have since fallen into disuse. Many of them were partially cannibalized -- usually it was the RF amplifier that was taken out. The JBOT was just what I needed. I plan to refurbish all of these rigs, adding a bit of India to each one of them. This is very much in keeping with our "International Brotherhood of Electronic Wizards" ethos. The installation went fairly well, but with all of the ups and downs that accompany this kind of project. The amp worked fine on the bench, fed with a signal generator and into a dummy load. But of course, life got more complicated when I installed it in the rig. Yes, it took off on me. This was no fault of the amplifier -- I just needed to add some additional shielding. It is working fine now. See above. I moved it out of center stage and put it off in the corner to avoid feedback problems.

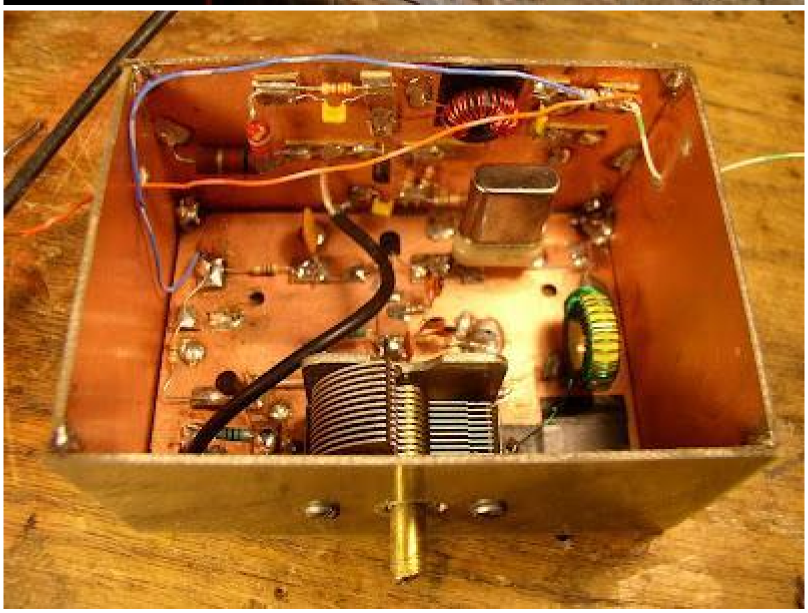
REBUILDING THE VXO OSCILLATOR IN MY AZOREAN DSB TRANSMITTER

OCTOBER 2011



With my JBOT amp ready for installation, it was time to go back and check out the rest of the circuitry on my old Azorean DSB/Direct Conversion 17 meter "Magic Carpet" transceiver. I was surprised to find that the oscillator, well, wouldn't oscillate. The MPF102 that I had in the main oscillator circuit was blown. I suspect voltage spikes from the T/R relay. I installed the required diode across the relay coil. (I seem to blow up a lot of MPF102s. Is it just me, or are these devices really fragile? They are junction FETs, not MOSFETS, so I thought of them as being more robust. But I seem to go through a lot of them.) After messing around with the oscillator and buffer circuits, the nice clean Manhattan isolation pads that had been there at the start were all messed up, with big piles of solder with the ends of multiple axial leads stuck in there. I decided to start afresh. Out came the little PCB box that housed the oscillator, buffer and amp stages. Off came the walls of the box. (When I built this thing the first time, I didn't realize that I would need an amp to get to the 7 dbm needed to drive the diode ring. I ran out of room on the main board and ended up building the needed amplifier on the back wall of the box!) So I got to build this little circuit again, ten years and three countries after the original build. It was fun. I like building oscillators. There is that satisfying sense of closure and completion when, at the end of the effort, you turn on your receiver and hear the tone from your creation. There was also a fun little bit of troubleshooting. After rebuilding the oscillator circuit I noticed that applying power to the "on the wall" amplifier caused the oscillator to shut down. At the buffer, I was seeing RF in and RF out, but the whole thing would shut down when I powered up the next stage. Obviously there wasn't a lot of BUFFERING going on! Sure enough, the MPF102 was bad. I replaced it from my dwindling supply, and all was right with the universe. Now the amp goes in. But first I will build the low pass filter. I promise.





Why DSB Signals Sound BAD in Direct Conversion Receivers

In July 2015 my friend Peter Parker from Melbourne Australia produced a short YouTube video that raised a question about DSB that had long been troubling me: Why can't a direct conversion receiver be used to listen to the transmission of a double sideband transmitter? We had been given some very authoritative warnings about this: In "W1FB's Design Notebook" (page 171) Doug DeMaw wrote: "It is important to be aware that two DSSC (DSB) transmitters and two DC receivers in a single communication channel are unsatisfactory. Either one is suitable, however, when used with a station that is equipped for SSB transmissions or reception. The lack of compatibility between two DSSC (DSB) transmitters and two DC receivers results from the transmitter producing both USB and LSB energy while the DC receiver responds to or copies both sidebands at the same time."

In his video Peter was reviewing a new commercial DSB transceiver and happened to come across another station transmitting DSB (that's very rare!). This allowed us to hear just what happens when we try to listen to a DSB signal with a DC receiver: It sounds, as DeMaw warned, "unsatisfactory." There is a lot of distortion.

There is quite a bit of technical irony here: You can easily make a very simple phone transceiver using a direct conversion receiver and a double sideband transmitter. I built and used several of these DC/DSB rigs. The irony is that two of these rigs would have difficulty talking to each other. That is what DeMaw was telling us. In essence, we've been warned that the simple DSB/DC rigs we've put on the air cannot communicate satisfactorily with similar simple rigs. They are, it seems, doomed to only speak with SSB/Superhet rigs.

This is one of those technical issues that raises illuminating questions. Faced with DeMaw's warning and Peter Parker's video, the radio amateur faces two choices: 1) Simply accept the information and move on, or 2) Try to understand WHY this is so.

Here's why:

It helps to start with a review of the relationship between the sideband signals and the carrier in an AM transmission. Here is the diagram that I used in the first book:

In the transmitter, the carrier mixes with the audio signal to produce an output consisting of the carrier and two sidebands. In most AM transmitters, the mixer is actually the transmitter's final RF amplifier. The upper sideband is the sum product, the lower sideband is the difference product. These three signals are all of slightly different frequencies. The sidebands emerge from the mixing process with specific phase and frequency relationships to the carrier (that is important). In the output, the two sidebands and the carrier all move in and out of phase with each other in the electronic equivalent of a well-choreographed dance of phase and amplitude. (You could also picture the action of an old Spirograph.) At a certain point in this dance both sidebands and the carrier will briefly be in phase, all happily hitting their positive peaks together. This corresponds to the envelope peak shown in the diagram. But this in-phase condition won't last because - remember - the three signals are of slightly different frequencies and therefore cannot stay in phase. After a time, the carrier will be hitting its positive peak just when both the sidebands are hitting their negative peaks. If the amplitudes are right, the combined negative voltage of the sidebands will counteract the positive voltage of the carrier. At this point the envelope is at minimum. The three signals continue with this "phase dance," tracing as they go a modulation envelope that varies precisely with the frequency of the modulating audio signal.

By looking at the above diagram, you can easily get a sense of how a phase difference in the carrier would distort a double sideband signal. Imagine the signal pictured above, but with the carrier removed. We can easily remove it with a balanced modulator - this is exactly what we do in our simple DSB transmitters. On the receiver side, we can try to replace the carrier with a signal at the carrier frequency from our local oscillator. But consider what will happen to that beautiful modulation envelope if our local oscillator does not EXACTLY match the phase of the original carrier. The resulting modulation envelope will NOT look like the modulating signal. It will be distorted.

Fourier taught us that all complex repeating waveforms have within them multiple sine waves. The complex wave form that is an AM signal is composed of the lower and upper sidebands and the carrier. In that complex wave form, the original modulating signal shows up in the form of the "envelope." We can remove the carrier at the transmitter and then replace it with an identical signal at the receiver, but that is not easy to do. In order for that same envelope to reappear in the receiver, that local oscillator signal has to be exactly of the same frequency and exactly at the same phase as the original carrier. This is not easy to achieve.

In his wonderful book "The Science of Radio" Paul Nahin discusses the practicalities of carrier reproduction: He notes that if the phase mismatch is less than 90 degrees, it will merely result in an amplitude attenuation of the signal. But when the mismatch hits 90 degrees the signal completely vanishes. He notes that even a difference of 90 degrees represents an astonishingly small difference: If the radio signal is at 1 MHz (in the AM broadcast band), a difference of 90 degrees would occur if the local oscillator signal were to be only 250 nanoseconds out of alignment with the original carrier. You might think that this is something that could easily be adjusted for, but Nahin points out that this phase alignment mismatch will be changing "because the received signal has made its way through space via a time-varying path (e.g. consider the case of a receiver on an airplane that isn't flying in a circle around an airplane, or radio signals scattered back down to earth from an altitude fluctuating ionosphere.)"

And of course, if the receiver's local oscillator is not EXACTLY on the frequency of the carrier, it cannot remain in phase with the original carrier, so the above problems will arise. But it also useful to leave aside the phase problem and look at the direct results of even a small frequency difference:

Imagine a distant transmitter sending us a double sideband suppressed carrier signal centered on 7200 kHz modulated by a 1 kHz tone. The upper sideband will be at 7201 kHz, the lower sideband at 7199 kHz.

Leaving aside possible phase problems, if our local oscillator is exactly at the same frequency as the suppressed carrier at the transmitter (7200 kHz) we can take the two incoming sidebands, mix them with our local oscillator in our receiver's product detector, and take the difference frequencies: both sidebands are exactly 1 kHz away from the Local oscillator, so both will produce 1 Khz signals at the output of our product detector. Great!

But look what happens if there is even a very tiny error in the frequency of our receiver's local oscillator. Let's say it is off by only 1 Hz. This is an error of less than one part in 7 million. That's tiny. But look what happens:

The incoming upper sideband on 7201 kHz mixes with the local oscillator signal of 7200.001 kHz and produces an output of: .999 kHz.

The incoming lower sideband on 7199 kHz mixes with the local oscillator signal of 7200.001 kHx and produces an output of 1.001 kHz.

There are now TWO audio output frequencies from the product detector. You would probably not be able to discern a difference between frequencies this close together, but realize that these two frequencies will be moving in an out of phase. They will be beating against each other. You will hear the beat! It will sound like a thumping, twice per second. That is, as DeMaw put it, unsatisfactory. You can actually hear this thumping in the video that Peter Parker made: https://www.youtube.com/watch?v=rDd4cjkOAi8
At the 6 minute 27 second point Peter uses his Direct Conversion receiver to listen to VK7HKN who is transmitting Double Sideband. You can hear the thumping described above as Peter attempts to tune in VK7HKN. At some points it sounds like a flutter on the signal. Note that later in the video, Peter goes to his SSB transceiver and listens to VK7HKN. No thumping or flutter is heard there. And that leads us to the simplest solution to this problem: Just use a SINGLE sideband receiver that receives only one of your two sidebands. This is what happens in the vast majority of contacts involving a DSB transmitter.

Let's simplify things by assuming we are transmitting only a single audio tone of 1000 Hz through our DSB transmitter. The rig's VFO is at 7100 kHz. The 1 kHz tone results in signals at 7101 and 7099 kHz (the sum and difference products from the mixer). Along comes somebody with a direct conversion receiver. He puts his receiver oscillator on 7100 kHz. From the mixer (product detector) in his receiver he would get a 1 kHz tone from the signal at 7101 kHz (7101 kHz - 7100 kHz = 1 kHz) and ANOTHER 1 kHz tone from the 7099 kHz signal 7100 kHz - 7099 kHz).

You might think that this is perfect: The two signals would add and you'd get the 1 kHz tone you wanted. This would happen only if the two 1 kHz signals were in phase. But they are not in phase. They can't be. Here's why: Remember that they originate from two RF signals (7099 and 7101) at two different frequencies. Think about it: There is no way that two signals of different frequencies can remain in phase.

There would be phase differences between these two signals, so you would end up with a less than pure 1 kHz tone. And if -- as is likely -- your local oscillator is a bit off frequency you'd get a real mess. If for example the local oscillator was at 7100.1 kHz, you'd have tones at   900 Hz (7100.1 - 7101) and 1.1 kHz (7100.1 - 7099).   Yuck. Unsatisfactory.

You might think you could just use the local oscillator in your DC receiver to replace the carrier in the DC receiver, turning it into an AM signal, then use an envelope detector as you would with any AM signal. But not so fast! For this to work your local oscillator would have to be not only at the same frequency as the original carrier, but also in the same phase. That is hard to do. (Hard, but possible -- that is what they do with synchronous detectors using phase locked loops.)

I could hear many of the DC-DSB problems as Peter tuned in the DSB signal of VK7HKN using the DC receiver in the MDT transceiver. It was indeed unsatisfactory.   But don't worry. It is highly unlikely that when using a DSB rig you will encounter another DSB rig. I speak from experience on this. Pity.

CHAPTER 3

The Single Sideband Rigs

Double sideband was great fun but it was clear that I should take the leap into the 1950s and get rid of one of the sidebands. As my building skills improved, this became possible. I built my first single sideband transmitter during the later portion of my time in the Azores. Friends had grown accustomed to the novelty of my Double Sideband signal. They could switch from upper sideband to lower sideband and hear me just the same. And because I was using a direct conversion receiver, I would hear them just the same as well. But on that morning when I first fired up a single sideband transmitter, I was rewarded on April 3, 2002 by a report from Ed, WB6KOK . "Bill, there is something wrong with your rig! You've lost your lower sideband!" Music to my ears! Success! Back in Virginia, I continued to peak and tweak this homebrew SSB rig. And I belatedly joined the BITX revolution by homebrewing single sideband transceivers modeled on a design by my good friend Ashhar Farhan, VU2ESE.

FIXING UP MY AZOREAN SSB TRANSMITTER

TUESDAY, DECEMBER 28, 2021

How to Fix the Spur Problem in my 17 Meter SSB Transmitter?

I built the transmitter almost 20 years ago. It is in the larger box, which originally housed a Heathkit DX-40. There is a lot of soul in that old machine. Details on this construction project are here: https://soldersmoke.blogspot.com/2021/12/junk-box-sideband-from-azores-2004-qst.html (The smaller box is a Barebones Superhet receiver set up for 17 meters.)

In a 2004 QST article I discuss a problem I had with "spotting" or "netting." This is something of a lost art, something that you had to do back in the pre-transceiver days, when running a separate transmitter and receiver. This was how you got the transmitter on the receiver's frequency. Essentially you would turn on the carrier oscillator and the VFO and let a little signal get out, enough to allow you to tune the VFO until you heard zero beat on the receiver. My problem was that around one particular frequency, I would hear several zero-beats. This made netting the receiver and the transmitter hard to do.

Important note: This is really just a problem with the "netting" or "spotting" procedure -- the problematic spur does <u>not</u> show up in any significant way in the output of the transmitter. I can't see it on my TinySA. But it is strong enough to be heard in the unmuted receiver sitting right next to the transmitter. And that creates the netting problem.

In the QST article, I said that I noticed that the problem seemed to be centered around 18.116 MHz. As I approached this frequency, the tones -- desired and unwanted -- seemed to converge. That was an important clue. In the article I said I thought that I could eliminate the problem with just one trimmer cap to ground in the carrier oscillator, but looking back I don't think that this really fixed the problem.

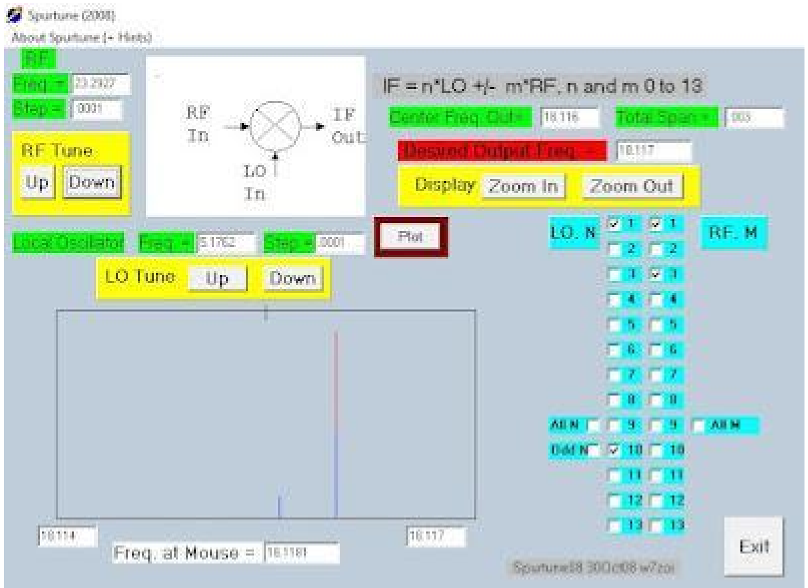
I recently took a fresh look at it. Exactly which frequencies were causing the unwanted signals that appeared in my receiver?

I used an Excel Spread sheet to find the culprits.

1	5.17602		23.2927
2	10.35204		46.5854
3	15.52806		69.8781
4	20.70408		93.1708
5	25.8801		116.4635
6	31.05612		139.7562
7	36.23214		163.0489
8	41.40816		186.3416
9	46.58418		209.6343
10	51.7602		232.927
11	[illegible]		

The first column shows the carrier oscillator and its harmonics. The second column shows the VFO when tuned for a signal at 18.11668 MHz (23.2927-5.17602), along with its harmonics. Check out the 10th harmonic of the carrier oscillator and the third harmonic of the VFO: 69.8781-51.7602 = 18.1179. Those two harmonics would produce the problem I had been experiencing.

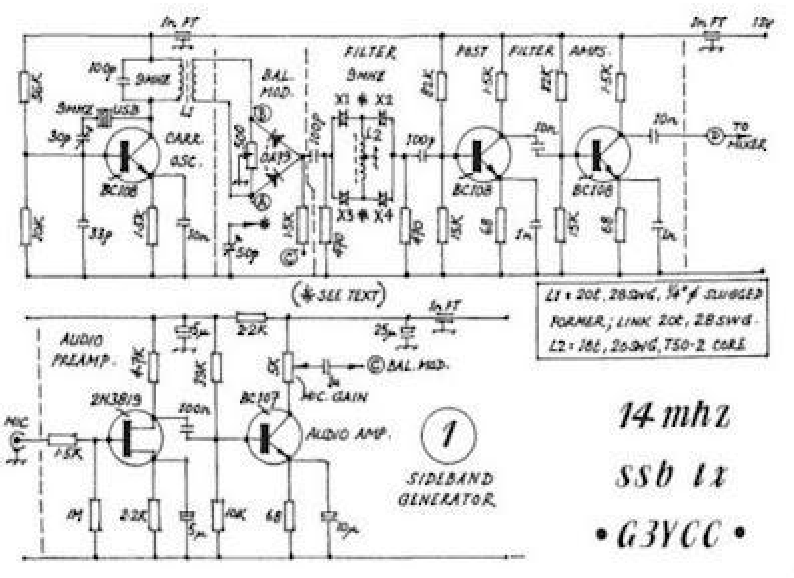
I turned to one of Wes Hayward's programs for confirmation. Spurtune08 came in the EMRFD LADPAC software package. Here is what I saw when I plugged in the above frequencies:



You can see the little spur off to the left of the main signal. In the program, as I tune the 23 MHz VFO frequency, the spur moves closer to the main frequency as I approach 18.116 MHz, just as it does in the real rig.   Note that I have only turned on the 10th harmonic of the carrier oscillator and the 3rd harmonic of the VFO. Spurtune08 is very useful. Thanks Wes!

So, what is to be done?   For a time,   I am just restricted my operations on 17 meters to above 18.120 MHz. (I worked several DX stations with it on December 27.) But obviously I need to fix this. This rig needs an exorcism. I think I only need to get rid of one of the harmonics, and the 10th harmonic of the carrier oscillator seems easier to kill. I'm thinking of putting the carrier oscillator in an Altoids box, and then adding some filters to knock down the 10th harmonic.

Here is the G3YCC schematic that inspired this rig. I used G3YCC's carrier oscillator and balanced modulator circuits, just using a 5.176 MHz crystal and changing the tank circuit in the collector:



How would you folks knock down that 10th harmonic?

THURSDAY, FEBRUARY 3, 2022

Exorcism Lite -- Spur Suppressed on 17 meter Transmitter -- Split TX/RX Station On The Air

I spent most of January in the tropics, away from my workbench. This seems to have had a good effect on my 17 meter split TX/RX project. As I was leaving, heading south, I was thinking about several difficult options to deal with my spur problem (see previous blog posts). I thought about turning the transmitter into a transceiver by building a receiver board. I thought about putting San Jian frequency counters on both the transmitter and the receiver, then doing a visual numerical "netting" by just putting the two devices on the same frequency (I actually ordered 3 San Jian counters). The counter option was even more complicated than it at first seemed -- I would have to build a converter to shift the RX VFO frequency up. VK2EMU suggested a tube type "Magic Eye" (interesting idea, but also complicated). This was getting out of hand.

When I got back home, I took a new look at the problem. I decided to take one more shot at suppressing the 8th harmonic of the carrier oscillator. I had already built a new oscillator and buffer using the circuit from Farhan's BITX20. And I had put it in a metal box. Now I decided to do three things:

1) Tighten up the low pass filter at the output of the buffer by moving the cutoff frequency lower (to around 7 MHz) thereby getting a bit more suppression at 41 MHz
2) Try putting a series LC shunt circuit tuned to 41 MHz at the output of the carrier oscillator (between the oscillator and the buffer).

3) Reduce the voltage to the oscillator/buffer. I have this on a pot, so I can adjust it down to the point where the remnant of the harmonic is no longer audible, while keeping the main carrier osc signal sufficiently strong.

It seemed to work. I could now hear the desired frequency for spotting, without the confusing tone from the spur.

Why had I been able to do this back in 2002 in the Azores using a simple trimmer cap to ground? My guess is that I was using my Drake 2-B as the receiver. The trimmer cap to ground may have reduced harmonic output. And I was probably cranking back the RF gain on the 2-B to the point where I could hear the desired signal but not the remnants of the spur. I have no RF gain control on the Barebones Barbados receiver that I am using in this project.

So, what's the lesson from all this? Well, if you are faced with a serious technical problem, and you find yourself considering complicated and difficult solutions, go to the Dominican Republic for about a month (especially if it is January or February), and then take another look at the problem when you return. If you are unable to travel this far or for this long, taking a walk or taking a weekend break from a troublesome problem will likely have a similar mind-clearing effect.

THE BITX REVOLUTION

As the airplane took off from Stockholm and headed southeast over Russia, Ashhar Farhan went to work on the design. He had only a notepad, a pencil, the calculator in his cell phone, and six hours before landing in Hyderabad, India. But he had a good idea: Farhan (he goes by his last name) wanted to design a single sideband transceiver that could be built – homebrewed -- by Indian hams of very modest means. There could be no unobtainium, no exotic ferrite cores, no fancy lattice filters, no exotic variable capacitors. Transformer and coil winding would be kept to a minimum. Mouser and Digi-key were out of reach and out of the question; everything drawn on that notepad had to be easily obtained in the electronic parts markets of Indian cities. And because the target audience included thousands of people who were struggling hard to just put food on the table, it had to all be inexpensive. Very inexpensive.
It also had to be reliable, and relatively easy to get going. So none of the amplifier stages would be running at the bleeding edge, teetering on the verge of oscillation. Simplicity is a virtue, so it would be for one band: with sunspots abundant, 20 meters was chosen. The switchover from transmit to receive can make transceiver building very complicated, but Farhan had the idea of bidirectional amplifiers in mind as he put pencil to paper. Bidirectional amplifiers had been described in the 2003 ARRL book "Experimental Methods in RF Design" by Hayward, Campbell and Larkin. The signal flow through these circuits can easily be reversed: apply power to one terminal, and it is a receive amplifier, sending your signal from left to right, en route to the speaker. Apply power to the terminal marked "T" and it is a transmit amp, ending your signal from right to left, en route to the antenna. Simplicity also mandated a single conversion design, with a crystal filter.
With the architecture established, Farhan began to focus on the parts. Instead of an expensive crystal filter, builders would "roll their own" using cheap crystals surplus from the computer industry. Some of the toroidal

cores would be wound not on ferrite, but instead – in an echo of the ham tradition of raiding the kitchen for breadboards – on ordinary nylon washers, perhaps from a kitchen sink. The tuning capacitors would be very cheap polyvaricons – the kind you see in old portable AM/FM radios. With these and other design decisions, the cost was kept extremely low: 300 rupees. This would be a five dollar SSB transceiver.

Farhan headed home from the airport with the schematic on the notepad. The first BITX 20 was soldered together in three sessions over a three day period. It worked as promised. Farhan's design was posted to the internet in 2003. Thus was launched the BITX revolution.

HOW TO BUILD A BITX-20

(by Farhan VU2ESE)

October 2012

I spotted this in the BITX-20 mailing list this morning. The response is from Farhan:

blake,

i would suggest a different route. a long and winding one, that will finally lead to a bitx.

the idea is to learn. you do this by understanding what you build and building what you understand. by 'understand', i specifically mean, being able to measure. here is what i suggest, buy yourself a bunch of 2N3904s from the local radio shack and some resistors and caps. then build this :

http://www.phonestack.com/farhan/testosc.gif

this is an oscillator. if you plug a coil between the open ends, it will
become a vfo, if u plug a crystal, it becomes a crystal oscillator. you can
use your frequency oscillator to check the frequency it is oscillating at,
etc.

with this, you would have mastered the first of the three blocks that make
up almost every radio circuit. but next, you must make another test
instrument. a power meter. most of us ham start out with a simple RF probe.
while that was fine and dandy for its day, now we can do much much better.
we can make a very accurate power meter that enable you to measure things
as finely as anybody in this business. W7ZOI has designed a super simple
power meter. it is available as a kit.
read about the power meter here :
http://www.kangaus.com/Documentation%20files/Power%20Meter%20Documentation%20May%202011.pdf
you can purchase the kit at www.kangaus.com
(I have no business interest with kanga or any other kit manufacturer)

with the power meter in place, you can now measure the power levels coming
out of any circuit with great accuracy.

now, you can build a single stage feedback amplifier (there are six of them
used in the bitx) on a copper clad board. using the test oscillator as an
input, you can measure how much gain the amplifier has (measure the
oscillator output, then connect the oscillator to the amp and ,measure the
amp output. the, amp output - oscillator output = amp gain).

of course, while building both these blocks, you will discover what
voltages to expect at which junction of components in both these
blocks.

next, you can build a step attenuator. which is a really simple thing and
of immense value in the home lab. here is a design
http://www.arrl.org/files/file/Technology/tis/info/pdf/9506033.pdf
or you can now buy it in a kit form from
http://www.qrpkits.com/attenuator.html

finally, you can build a simple signal generator like this :
http://www.phonestack.com/farhan/siggen.html . this will allow you
change
frequencies and measure what a circuit does at different frequencies.
you
can use this to test how the filters are doing and get them to 'spot'
where
you want them to.

so, there it is, a signal generator, a power meter, step attenuator,
test
oscillator. four, very simple test instruments that you can build
yourself. they will give you one helluva education in radio. and within
weeks, you will understand and start building on your own!!

- farhan

> Quoting bfabman :
>
> Hello Everyone, I have been watching the group for a few months now
> with interest. I have no electronic experience to speak of, but I
have
> a burning desire to make one of these, and I am wondering what all of
> you think of someone like myself building one as my first real radio
> project, to be used for qrp mountain topping. I don't have any
> electronic test equipment for the final alignment, other than a
> standard DIG vom meter. (I am willing to buy some equipment if
> necessary) I think that this would be an awesome winter project just
> don't know if it would be over my head. If I got it all built, could
I
> actually get it aligned and working properly. I did make a Norcal
> frequency counter project last year and it turned out very well.
Thanks
> for your opinions before I spend the money. Blake
>
> Paul Daulton K5WMS
> beacon WMS 185.302 khz qrss30/slow 24/7
> Jacksonville,Ar 72076
> em34wu

And from Farhan in February 2012:

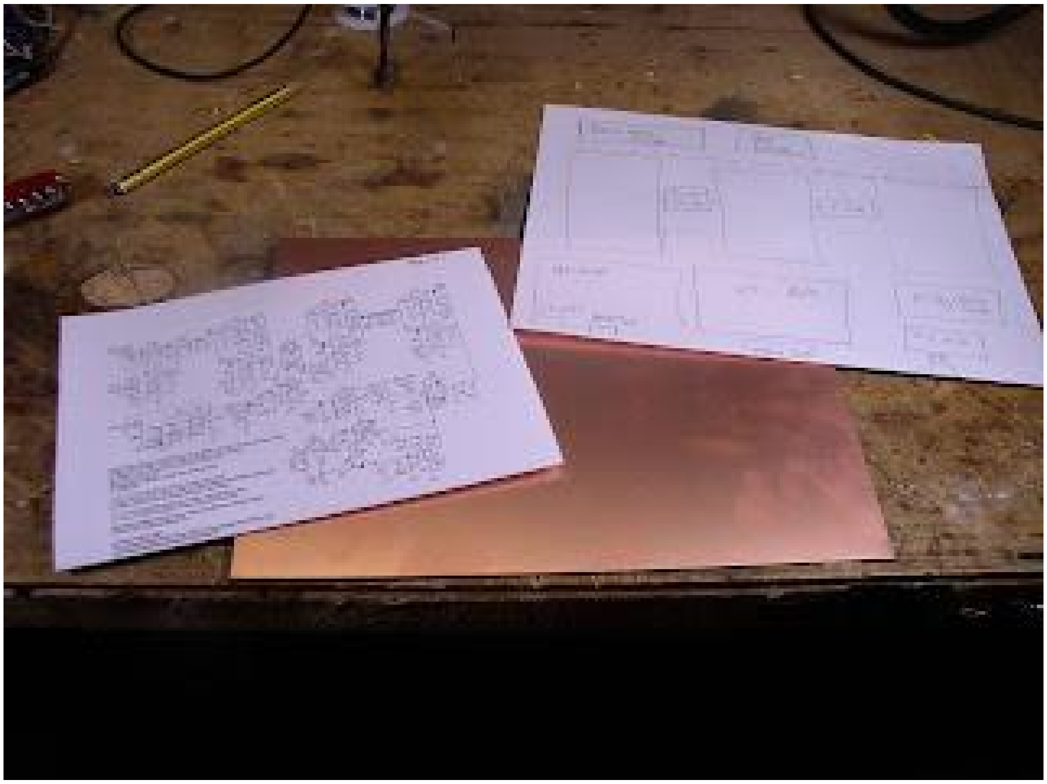
I have often seen builders finishing an entire build, then powering it up to face the frustration of a dead circuit. I suspect that the trouble is with our kit building mind set. As a kit builder, we assume that if it has worked well for a few hundred others, there is no reason for it to not work for us. But the truth is more sobering ... Of the hundred odd components, any of them could get swapped by another, or a bad solder, wrong polarity, etc. can all conspire to thwart your attempts. The bitx manuals are really some of the best produced in recent years and yet, even with leonard's videos, troubleshooting kits is a challenge. I am proposing a more elaborate, slower but surer approach to

building the bitx. It is as follows: build it one stage at a time, use one stage to test the next. For instance, one could start with the bfo first. Just a single transistor with the crystal. Then use an RF probe to check the rf output. If there is no output, then sort that out before proceeding to the next stage. With the addition of the buffer amp, the output should go up. Then one could proceed to the audio amp. Injecting audio from your mp3 player or computer could check that it works. Next, replace the audio source with the mic amp, this tests the mic amp. Now, if you add the two diode modulator, you should be able to receive the dsb at 10 MHz on your HF transceiver. This approach tests each stage individually and in isolation before proceeding to the next. It also provides wholesome education to the builder. In software industry, it is called a 'test driven development' method of developing software. In the end, this approach is no slower than the current approach, except that surprises are not kept for the last. I am sure that some of us can come out with a sequence of stages to build where each stage is tested using the previous stage. As much as bitx is about building it cheap, it is also about learning your radio from inside. Bitx is also education on the cheap, don't give up that opportunity. - farhan VU2ESE

I came late to BITX. I built my first – a 17 meter version – in 2013.

TUESDAY, AUGUST 20, 2013

Building the BITX! Update #1



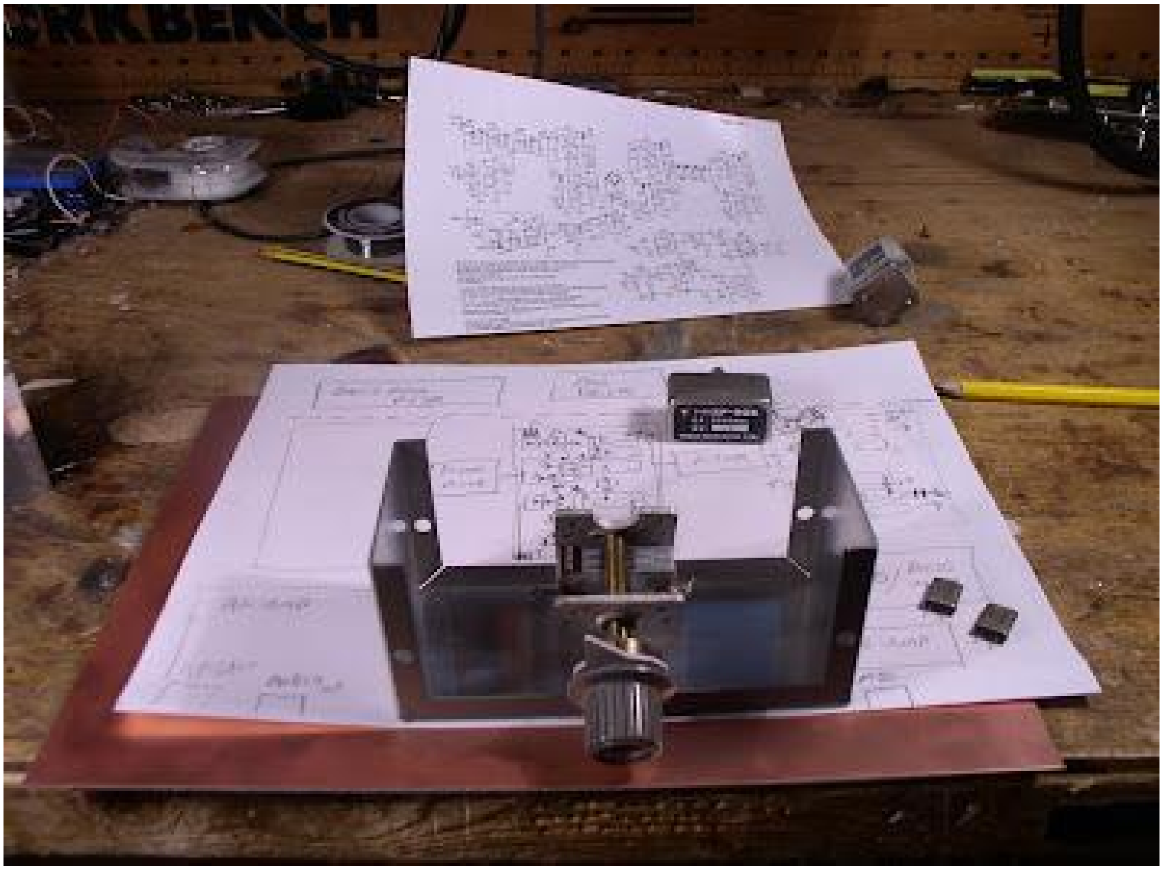
There it is guys: A blank canvas of copper-clad board. A clean slate ready to be filled with the components for a BITX transceiver. As you can see, I am fighting my "build first, design/plan later" tendencies. No real design work for me on this one (thanks Farhan!) but I am trying to plan where everything will go on the board. (Thanks to Jim, W8NSA for the board.)   I'm going to build it Manhattan style (perhaps with an ugly dead bug or two). I'm starting with a big board because I always seemed to end up with a shortage of space. It looks like I can easily get all of the circuit (minus the PA) on this board. I'll build the PA on a separate piece of copper-clad.

I'd like to build it for 17 meters, but if I stick with the 10 MHz filter that means I have to build a VFO at around 8.1 MHz. That's not impossible, but in my experience it is easier to build simple, stable VFOs at lower frequencies.

I notice that there are a lot of cheap crystals available at higher frequencies. So, instead of keeping the filter at 10 MHz and trying to get the VFO stable at 8.1, what do you guys think about keeping the VFO in the 4 MHz range and building the filter with crystals in the 14 MHz range?

SATURDAY, AUGUST 24, 2013

BITX Build: Update #2



Not much progress to report. But I have been thinking about the filter frequency. Here is my latest idea:

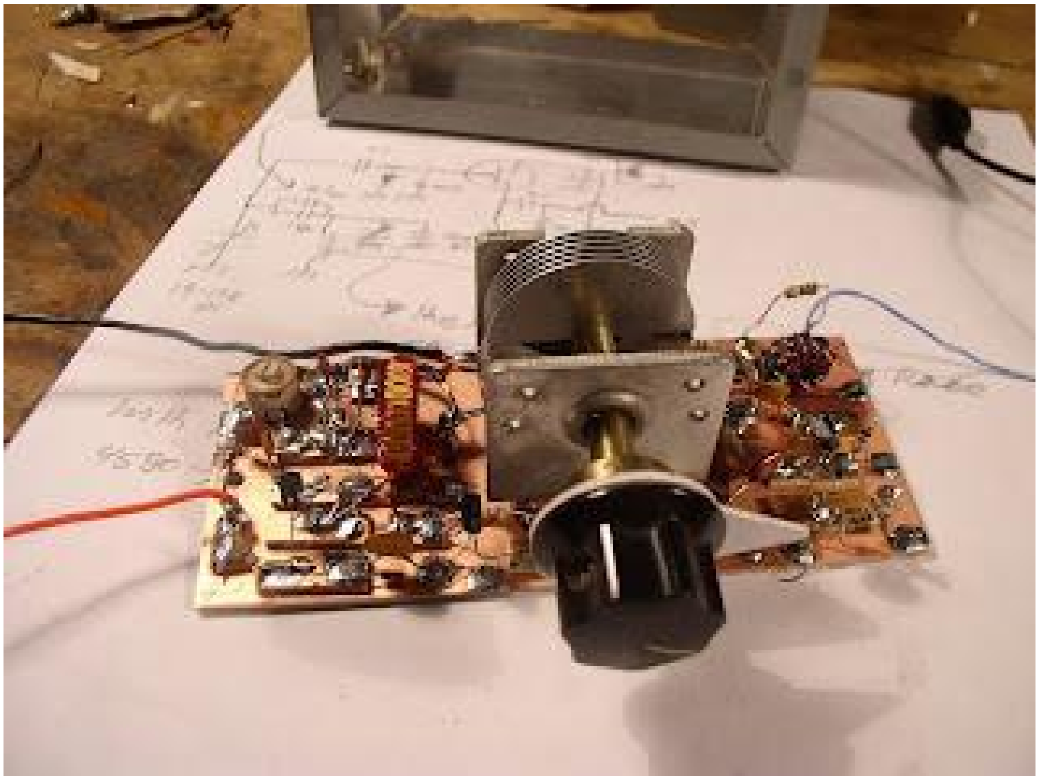
Maybe I'll build the VFO in the 5 MHz range. This would allow me to use the 9 MHz Yaesu filter (and associated crystals) that Steve Smith sent to me (see above). With this I could be on 75 and 20 meters.

I could build another filter at 13 MHz and, using the same VFO in the 5 Mhz range, get on our beloved 17 meter band. I kind of like the idea of plug-in filters.

You can see my ideas for the board layout. I'm thinking of a Doug DeMaw Universal Hartley VFO inside the box shown above.   The tuning cap you see is out of an old Heath QF-1 Q Multiplier. It has a very nice reduction drive built into the tuning shaft. It measures 19 to 148 pf.

MONDAY, AUGUST 26, 2013

BITX Build Update #3



This weekend I built the VFO. I used Doug DeMaw's FET Hartley, from his "QRP Notebook," page 50.

Getting a VFO into the desired frequency range always seems to involve a bit of "cut and try." Not only do you have to get in the correct freq range, but you also have to try to get the tuning range of your variable cap (or coil) to match the band you want to cover. In my case, thinking of 20 meter SSB, I need about 200 kHz of tuning range. And sticking with my 9 MHz (for 20) and 13 MHz (for 17) plug-in filter plan, I need the VFO to be in the 5 MHz range.

That main tuning cap you see above has more capacitance than necessary (19-148 pf). One option would be to pluck out some of the rotor plates (been there, done that). But that seems a bit barbaric, so instead I just reduced the overall capacitance by putting a smaller fixed capacitor (about 20 pf) in series.

Yesterday I had it percolating nicely. Waveform looks beautiful on the Tek 465. But it was drifting too much. I had a cheap plastic trimmer cap in there. This morning I replaced it with a more substantial ceramic trimmer. This seems to have improved stability quite a bit.

I need to put some stabilizing substance on that toroid. DeMaw prescribes Q-dope. I'm all out. What is the field expedient substitute? Was it clear nail polish?

WEDNESDAY, AUGUST 28, 2013

BITX Build Update #4 VFO Stability

I wasn't quite satisfied with the long-term stability of my VFO. It seemed like it was drifting about 70 Hz per hour, even after the initial warm-up period. So, all out of Q-Dope, I went to the local pharmacy in search of clear nail-polish. (My family was making fun of me.) I got home and applied several coats of "Sally Hansen No Chip Top Coat Vernis de Protection." I let it dry a bit, then started watching the frequency counter. At first results were disappointing. Drift continued. Now it seemed to be drifting up! I cracked the books. EMRFD has a good chapter on temperature compensation of VFOs, but the process seemed painful. I wasn't looking forward to it.

I left the VFO on when I went to work, noting the freq as I departed. Ten hours later I returned, and was delighted to find the frequency almost exactly where I left it! It may have taken a while for the nail polish to completely dry. I'll leave it running again today to see how it does.

WEDNESDAY, SEPTEMBER 4, 2013

BITX Build UPDATE # 5: ADRIFT!

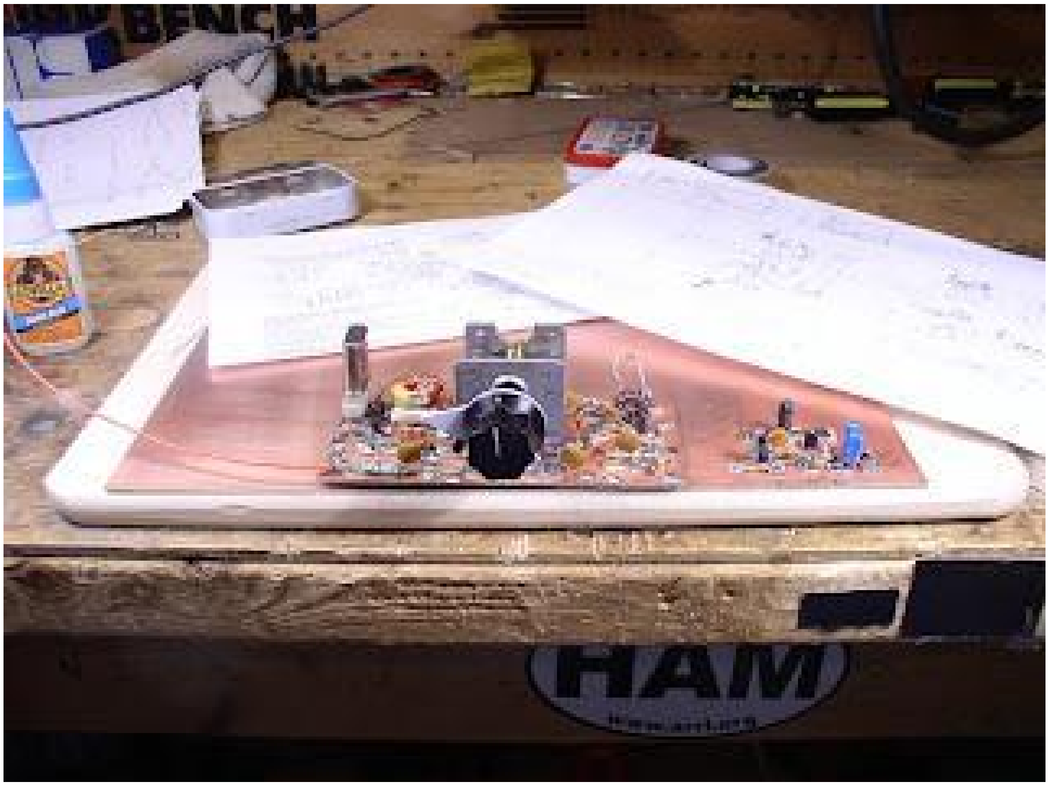
Sometimes it is better to have LESS test gear. Watching my 5 MHz VFO on the frequency counter was driving me nuts. If I hadn't had the counter, I might have been satisfied with the VFO. Ignorance is bliss! It did settle down a bit. But then it would wander off. I hated watching it drift around. I have been spoiled by Doug DeMaw's VXOs. So, I went for the VXO. It will run around 23 MHz. I'll build the filter at 5 MHz. That's definitely the plan. For now.

I intend to go back and build a real VFO someday. There seems to be a lot of magic and lore involved. Bees Wax! Hot Glue! Nail Polish! Q-Dope! Air-wound coils!

TEK 465 is still broke. I think it is the high voltage supply or (less likely) the CRT.

SATURDAY, SEPTEMBER 7, 2013

BITX Build Update #6: Rock Steady



So, having given up on the VFO, this week I built a VXO. The IF in my W4OP-built Barbones Superhet is at 5 MHz. That receiver has a VXO running at 23.133-23.168 MHz with two crystals switchable from the front panel. My plan is to build a 5 MHz filter for the BITX 17. So I just plucked one of the crystals in the Barebones RX and used it to test and tweak the VXO. Trying different values for the series inductor, I got wide variations in freq swing. With .7uH I could only pull the rock 9 kHz (too little). With 5.6 uH, it was pulling 434 KHz (way too much -- it was acting like a VFO). 3.213 uH was just right: With my 19-148 pF variable cap (with 53pF in series) I got a swing of 22 kHz, with crystal-oscillator stability.

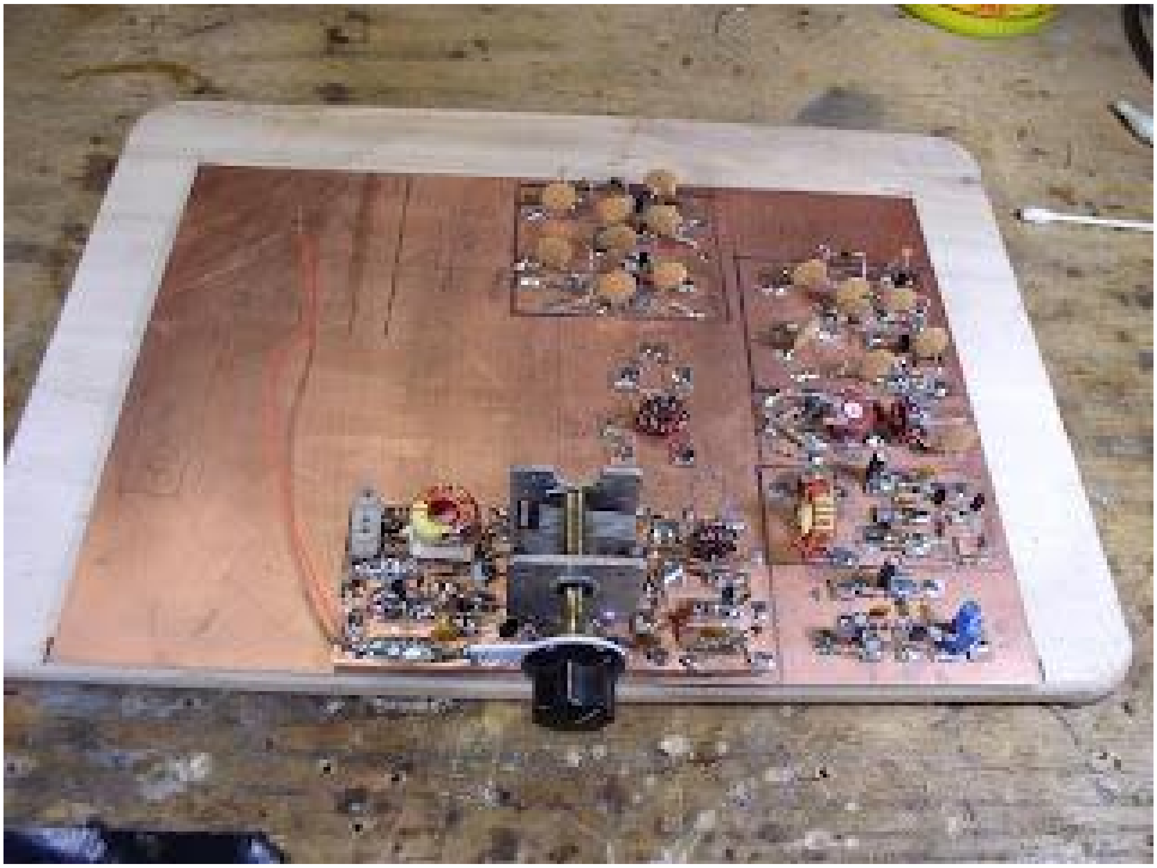
I know, I know: I could have done this with a DDS chip, or with an SI570. But simplicity is a virtue, and the BITX is all about simplicity, right? Having recently built a DDS RF generator, and now this simple three transistor device, I must say that I like the simple analog circuit better. But hey, that's just me. I'll talk about this in the next podcast.

Today I built the mic amp circuit. You can see it off to the right of the VXO.

One of these days I'm going to have to actually troubleshoot and fix my Tek 465. But I'm afraid of that thing! The voltages in there are HIGH, and so is the circuit complexity.

SUNDAY, SEPTEMBER 15, 2013

BITX Build Update # 7



As you can see (above) I've made lots of progress on the BITX-17. Going counter-clockwise from the lower right, you can see the mic amp, the BFO/carrier oscillator, the first mixer, the first and second bi-directional amplifiers, the diode ring VXO mixer and the VXO.

I plan on building the whole rig (including the power amplifier stages) on this wonderful piece of PC board (thanks to Jim, W8NSA).

I had what I thought was the brilliant idea of using LEDs for all the T/R switching diodes. I thought I'd use red for receive and blue for transmit. I consulted with the BITX yahoo group and cooler heads prevailed.

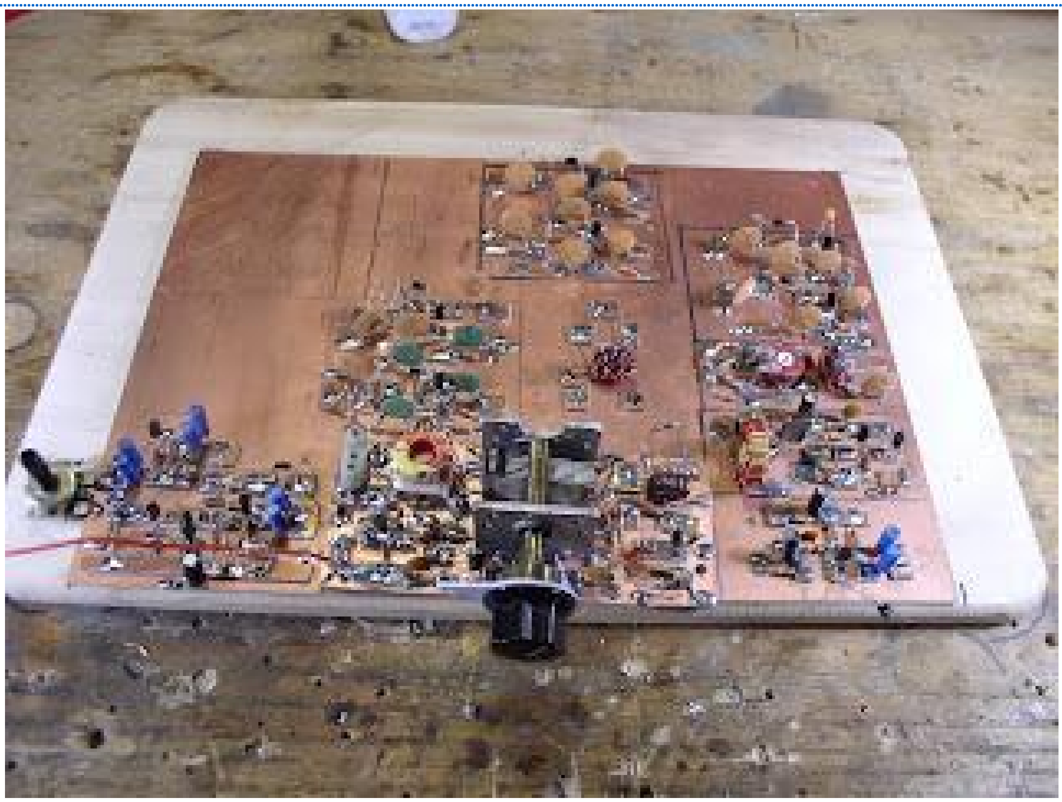
The design has an LM-386 as the speaker amp. I'm kind of bothered by this -- I'd prefer an all-discrete component rig, so I am thinking of building an AF amp with discrete transistors instead, perhaps the circuit from Roger Hayward's RX for the Ugly Weekender. What do you all think about this?

I'm having a lot of fun building this rig. If anyone out there is looking for a fall/winter project, build one of these.

I have to order some 5 MHz crystals for the filter and oscillator. Mouser has them at about 70 cents each.

WEDNESDAY, SEPTEMBER 18, 2013

BITX Build Update #8



Big progress on the BITX: All the bidirectional amp stages are done. A bag of 20 5 MHz crystals arrived from Mouser today. I put one in the BFO/Carrier oscillator and it fired right up. I'll soon be checking frequencies on these crystals, looking for four that are closest in frequency for use in the filter.

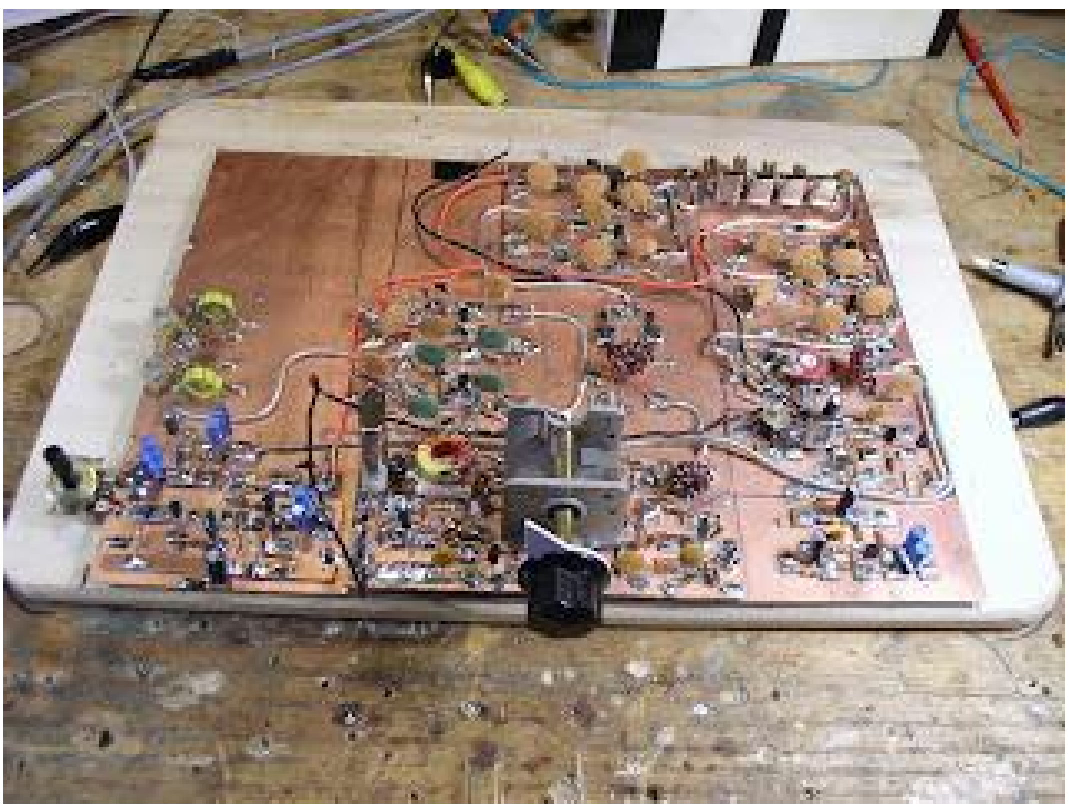
While waiting for the mail I built the audio amplifier for the receiver (lower left corner in the picture above). Here I need some advice/encouragement: In an effort to keep this rig "all discrete" I decided to dispense with the LM386, and replace it with an AF amp using individual transistors. I found a circuit in the 1980 ARRL Handbook that I liked. It has two direct coupled transistors, one NPN, the other PNP. I went with a 2N3904 and a 2N3906. The Handbook said it would yield 40 db gain. I figured this was a close enough replacement for the 46 db gain of the LM386.

As usual, I'm not sure of the impedance matching. I built the first AF stage from the BITX schematic (the stage that precedes the LM386). It goes to a 10K pot. The wiper of the pot would normally go into pin 3 of the LM386. I have the wiper going through a 4.7 uF electrolytic into base of the first transistor. The Handbook says the circuit has an input impedance of 1000 ohms. Does my arrangement sound OK?

Output impedance from this Handbook circuit is also 1000 ohms. I tried it with some HI-Z headphones that I have, putting AF in from my Maplin AF sig generator. It sounds OK. Not a LOT of audio available. But OK. I may need one more stage to drive a speaker.

MONDAY, SEPTEMBER 23, 2013

BITX Build Update #9 -- Discretion



With the exception of the PA, all of the stages of my BITX 17 are built. Over the weekend

I put in the DC wiring for the receiver and the inter-stage connections (using the Belden coax with the exposed shield and Teflon di-electric). It looks nice.

In my experience, almost all new superhet receivers require a certain amount of debugging and coaxing before they will work. This one is no exception. The VFO and the BFO work fine, and all three RF and IF amp stages are also good. The bandpass filter that I built passes the desired band and tunes up nicely on the right frequency. The product detector was acting weird and wasn't balancing out properly, but I got that all sorted.

I can put an 18.110 MHz signal at the antenna connection and see the signal go through the bandpass filter (with loss), on to the RF amp stage, to the first mixer where it meets the 23 MHz energy from the VFO. A very messy mixture goes from the mixer to the first IF amp which sends it to the 5 MHz Cohn filter. The filter works, but it has a lot of ripple, so I need to work on the termination impedances. Second IF works fine, then the signal goes to the product detector. AF comes out.

Here's where the discretion comes in. Instead of the LM386 chip, I built a 40db two transistor direct coupled AF amplifier.

So it all works, but the receiver is quite deaf. I think I just don't have enough gain in the whole system. I looked at the schematic for the BITX-17 kit. It very helpfully has total (net) gain figures for the RX. I can see that my current configuration comes up short.

Here is what I'm thinking of doing: I might replace the 40db direct-coupled AF amp with a 100 db Darlington pair. I really like the discrete Darlington AF amp that KD1JV has in his "all discrete" transceiver:
http://kd1jv.qrpradio.com/ADC/ADC-40.htm Nice. 3 2N3904's driving a speaker. I may use that.

THURSDAY, SEPTEMBER 26, 2013

BITX Build Update #10 -- Darling(ton)

Having concluded that I was significantly short on overall receiver gain, I went in yesterday and changed my AF amp from a 40db direct-coupled circuit to a 100db Darlington pair. I immediately noticed a big increase in audio output.

I did a quick receiver alignment using my Arduino/AD9860 sig generator. First I determined the actual bandpass of the crystal filter: 4.998170 MHz -- 5.000960 MHz. Using a freq counter, I set the BFO at 5.00126. I immediately started hearing 17 meter SSB signals from the West Coast. That's always a nice moment: first signals through a new receiver. Kind of like "first light" in a new telescope. Even with the filter ripple, it sounds great.

I think I'm still significantly short of gain. Audio is still faint. I notice that in the BITX17A they have added a second transistor (Q17) in the second RX receive amp. Maybe I should try something similar. Or should I add some gain in the audio chain?

I'm really enjoying this BITX project.

SUNDAY, SEPTEMBER 29, 2013

BITX Build Update #11 -- Peakin' and Tweakin'

Oh how I love the sound of a newly built receiver! I'm sitting here listening to G0MJS on 17 meters. Lots of other stations from across the pond coming in very nicely.

Earlier in the week I had some sensitivity problems. I could hear the noise floor, but just barely. And the receiver just seemed to have trouble inhaling. So I started poking around. It seemed that each poke improved things a bit. I had used Farhan's original schematic (mostly).   Later versions put an additional transistor in the IF amp. So I went ahead and added that mod. That helped a bit. Then I noticed that BFO energy was getting into the AF amp.   So I put a .1uF cap to ground at the input to the AF preamp. That took care of the RF and did no damage to the AF.

But the rig still seemed a bit hard of hearing. This morning Farhan advised me to take a look at the mixers. I used some junk-box diodes that I didn't know too much about...
I measured the forward resistance and found it to be quite a bit higher than the usual 1N914s. So I switched all 6 mixer diodes. That helped noticeably.

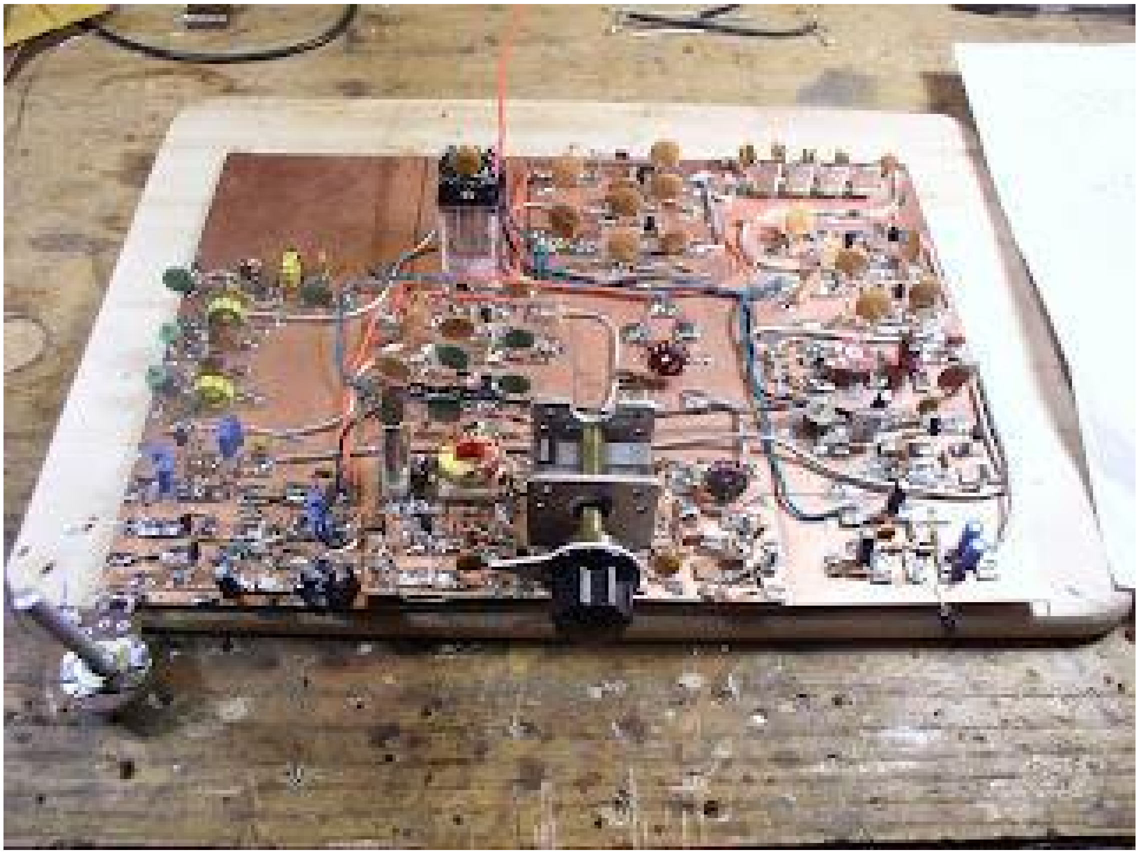
I also checked the input bandpass filter.   It seems OK.   In the process I learned to use the EMRFD filter programs (thanks Wes) and the ELSIE filter program (also very nice).

Anyway, the rig sounds great now.   On to the transmitter.

Farhan advises building the power amplifier on a separate copper clad board. But I have room for it on my main board. Should I live dangerously?

SATURDAY, OCTOBER 5, 2013

BITX BUILD UPDATE #12 -- Relay and PA, BITX 17/10?



As you can see, the board is starting to fill up. I really like it. It seems (to me) like the canvas of a painting approaching completion. This morning I put in the T/R relay. That space in the upper left is reserved for the driver and the IRF510 Power Amplifier.

I got some help from the Chief Designer this week. As noted in an earlier post, Farhan advised me to check the mixers. I knew that I had them wired correctly and that they were in fact mixing, but when Farhan advises you to check something, YOU CHECK IT. Farhan was right (see earlier post).

It really sounds great. I know that the filter still has significant ripple in it, but the receiver sounds so good I'm reluctant to mess with it. Should I de-ripple it?

On the train yesterday I was thinking about this rig, and it occurred to me that my 23.1 MHz VXO/ 5 MHz IF arrangement means that this 17 meter transceiver could also generate signals on the 10 meter band. Of course, I'd have to build a second bandpass filter, but the radio gods guided my hand and caused me to leave space on the board for just such a filter (see above). I realize the IRF510 PA wouldn't be too good up at those frequencies, but when the radio gods speak, you have to listen.

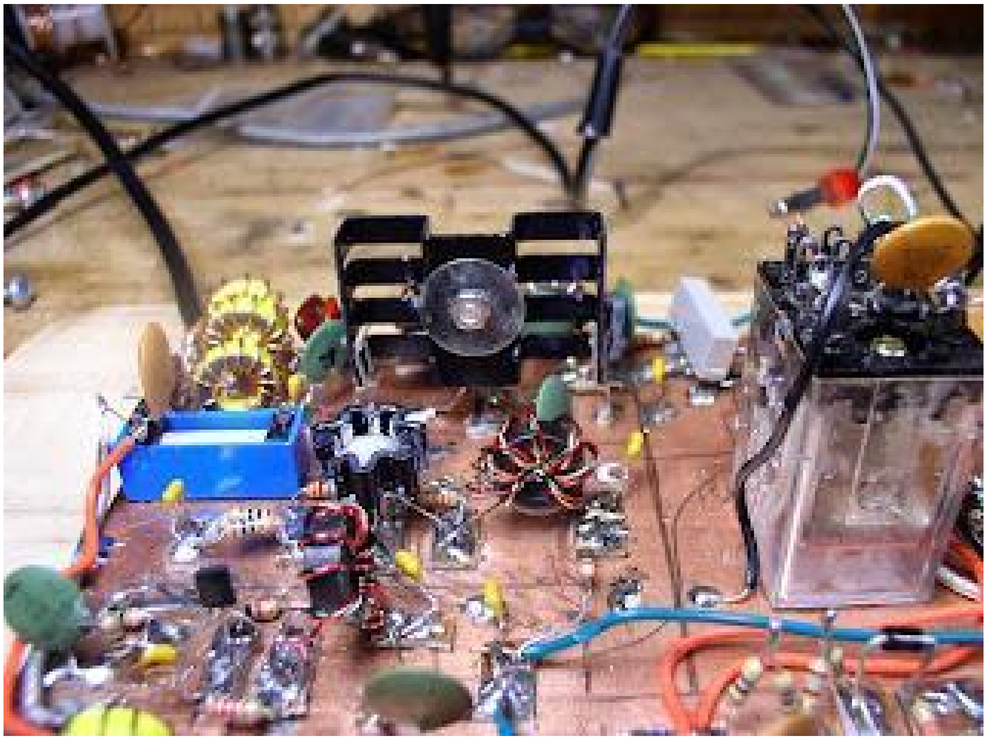
SUNDAY, OCTOBER 6, 2013

BITX BUILD UPDATE #13 -- VIDEO TOUR

I hope to get the next podcast out within a week or so. The BITX has been keeping me busy!

SATURDAY, OCTOBER 19, 2013

BITX Build Update #14 -- STABILITY!



Good news on the BITX. I think I have solved the low frequency oscillation problem in the power amplifier. I tried running the PA off a separate power supply -- the oscillations disappeared, leading me to conclude that the feedback was taking place via the power supply lines. I put a 22 uF cap to ground from the top of the PA's RF choke. With this cap in place I can dispense with the separate supply kludge. The amp is stable.

This morning I also resolved a different stability problem. I'm using a relay for T/R switching. One set of contacts controls the DC power, the other set was supposed to disconnect the receiver input from the antenna/lowpass filter when on receive. But I had positioned the relay too far from the LP filter and RX input, so I ended up with this long piece of coax that was hanging off the PA output terminal and carrying lots of RF on transmit. Yes, this led to oscillations. I thought about repositioning the relay, but I think part of the problem is that even if optimally positioned, the long unshielded contact levers inside this relay would be radiating a lot of RF and causing stability problems. So instead I put a small reed relay very close to the PA out and RX in connections. It carries the signal to the receiver when in R mode, and disconnects the RX when in T mode, without any long coax lines or unshielded relay levers. It works.

I still have a few things to do:

-- I need to build a proper speaker amplifier so that I can dispense with the amplified computer speakers KLUDGE.

-- I need to get a 3 pole double throw switch and some crystal sockets so that I can switch crystals from the front panel. Three rocks will cover all of 17 meter phone.

-- I have to build a case for this rig. I'm thinking wood, with tin or aluminum sheeting glued to the inside (for shielding).

SUNDAY, OCTOBER 20, 2013

BITX Build Update #15 -- Necessary Mic Amp Mod

I was having trouble with the mic amp on my new Manhattan Discrete BITX 17. I had it wired as per the schematic, but it just wasn't working right -- I was getting very little DSB out of the balanced modulator, but everything worked fine if I 1) unbalanced the bal mod or 2) injected audio (from a sig generator) directly into the audio in port of the balanced modulator. Clearly something was wrong in the mic amp circuit. I noticed the collector voltage seemed quite low.

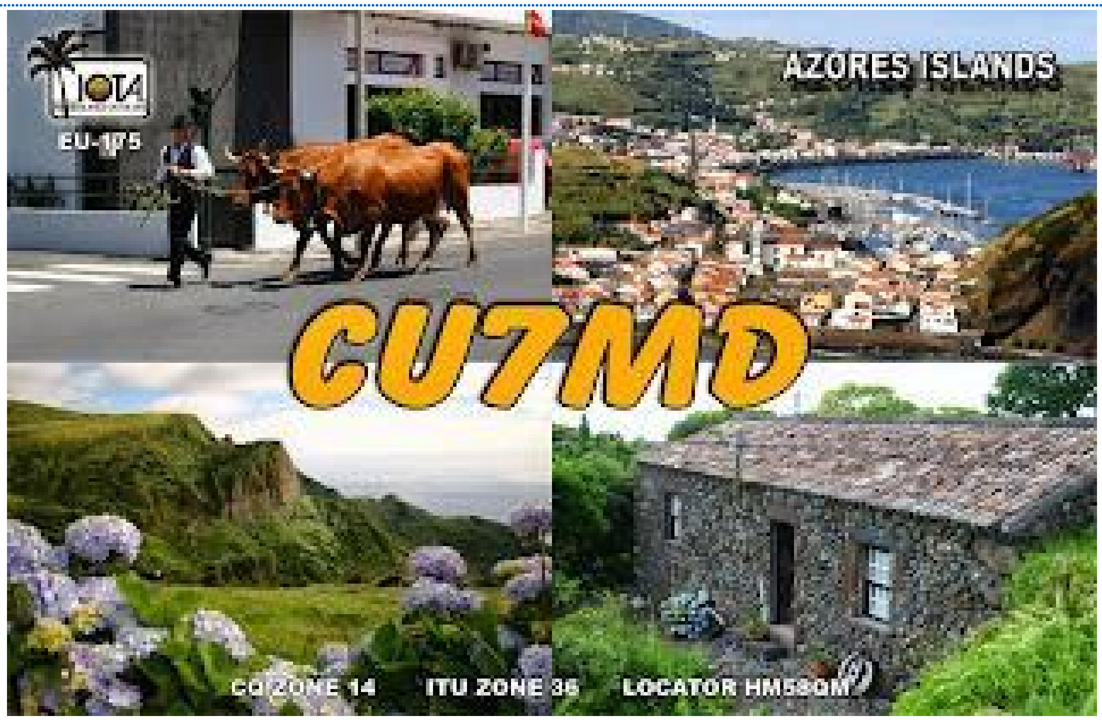
Some quick Googling revealed that others had struggled a bit with this problem also.

As one builder noted, the 10K resistor value may have worked with lower gain transistors. We must remember that BITX was (very admirably) designed for minimal cost and maximum use of scrounged parts.

I swapped the 10K resistor for a 39K and all is right with the world. The band is not yet open here, but I bravely called a European aeronautical mobile station, hoping that he would be my first QSO on this rig. I think he heard me, but no QSO (yet!).

SUNDAY, OCTOBER 20, 2013

BITX BUILD UPDATE #16 -- FIRST QSO!!!!!!!!!!!



Wow, it is very clear that the radio gods are pleased with my BITX efforts! I had my first QSO on the new rig today. And it was with a station in my old home, the place where I got my start in 17 meter homebrew phone: THE AZORES! CU7MD. Very cool.

SATURDAY, OCTOBER 26, 2013

BITX BUILD UPDATE #17 Arv's Discrete AF AMP

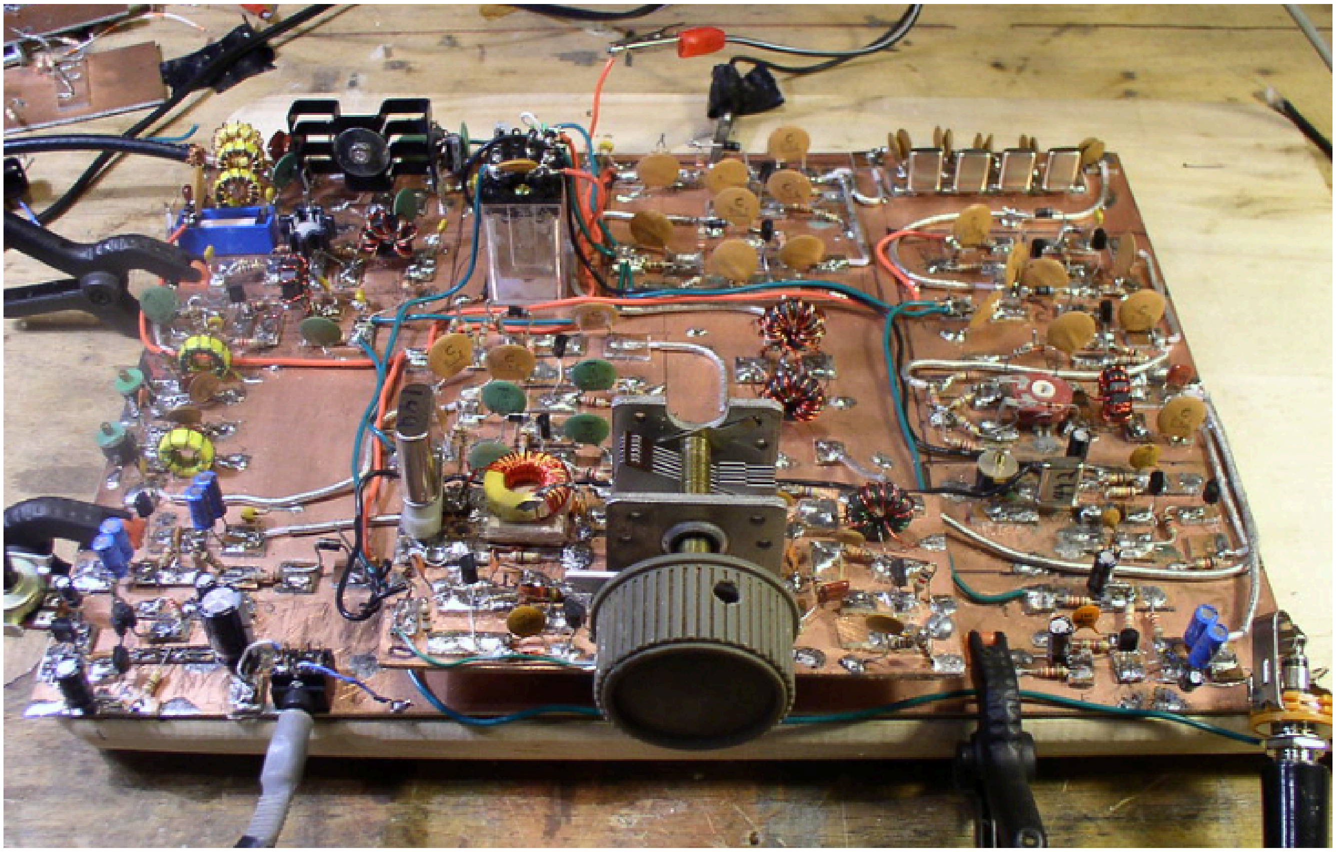
I've been kind of cheating with the audio output from my BITX17: I've been using one of those little battery-powered computer speakers. It sounded fine, but hey, this is supposed to be a homebrew project right? I've already noted my ideological objections to the use of the LM386 IC chip. The files of the BITX20 yahoo group provided a very promising and completely discrete AF amp circuit by Arv Evans, K7HKL (Arv recently passed away). I used a 2N3906 and a 2N3904, with a 2N2222 driving them. It works like a charm. Not a bit of feedback or motor-boating. It sounds great. I've already had a contact with it: Jack, W7YUM is a builder of big amplifiers out in Salt Lake City. He seemed very impressed with the BITX concept so we may have a Utah BITX in the works.

MONDAY, OCTOBER 28, 2013

Slide Show of BITX 17 Build

As I was building this rig, I periodically stopped and took a picture of the board. I think the resulting slide show is kind of fun. Check it out: There is a button to launch the slide show.

http://www.flickr.com/photos/106886073@N04/sets/72157637045750216/



SUNDAY, NOVEMBER 3, 2013

BITX Build Update #18 -- BITX in a Box?

I've really been enjoying using my BITX17 without an enclosure. Having all the electronics exposed on the workbench really accentuated the homebrew nature of this rig. But obviously it was time to box this thing up. At a local craft store, I found a wooden box that is exactly the right size for my BITX copper clad board. I put the BITX in the box yesterday. I kind of miss the exposed electronics.

The far left control is AF gain. The need for a few inches of wire to the pot has introduced a bit of AC hum. I'll try to knock this down with better shielding on the lead to the pot.

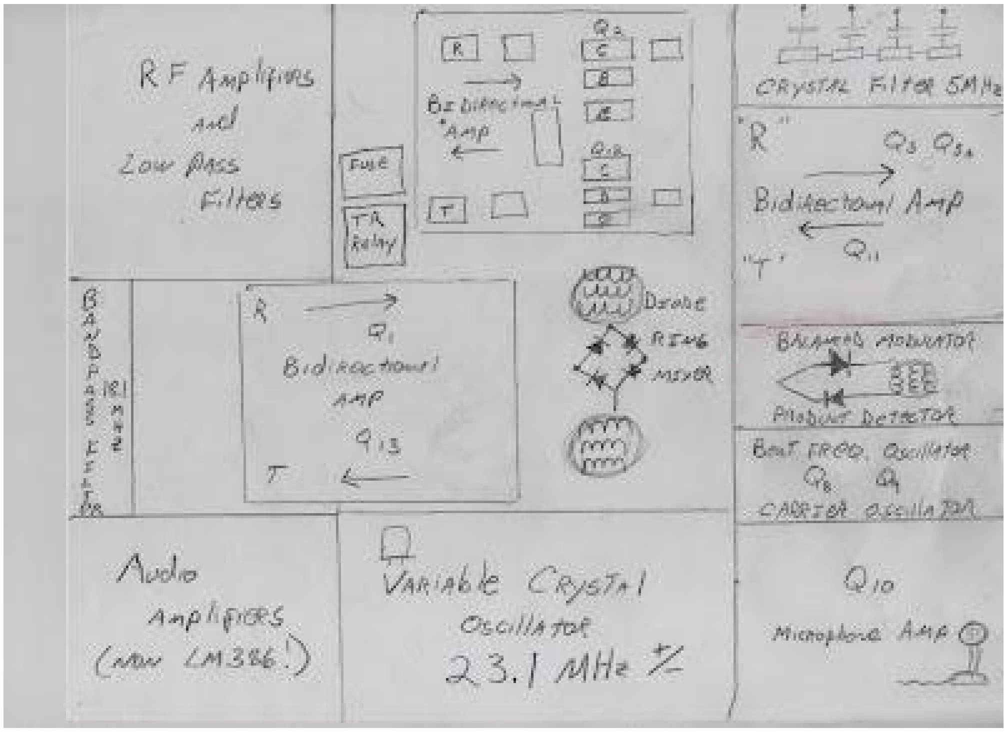
But this gets brings us too a bigger question: the need for a cabinet that shields. Obviously the wood shields it only from dust. I know there are some benefits to putting this thing in a proper metal box. The AC hum would be less of a problem. Also -- listen to this -- in the morning, before 17 opens, I can hear -- faintly -- the WWV transmission on 5 MHz (recall that the IF in this rig is 5 MHz). And if I ever build an external linear amp for this rig (I might), I guess a proper metal box would help prevent the kind of oscillation that often drives me crazy on these kinds of projects.

So, what do you guys think?   Stick with the wood, or put it in a metal box?   Any thoughts on putting metal shielding material around the inside of the box (thick aluminum of tin foil)?

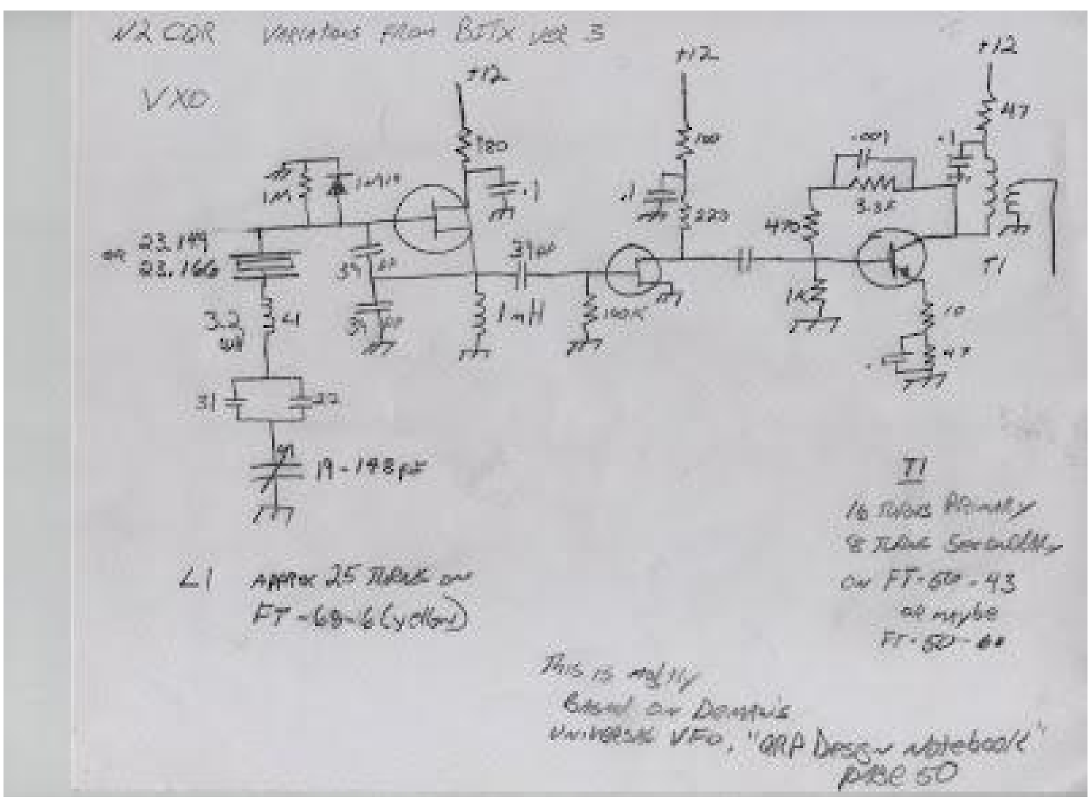
(The other black control knob is for a rotary switch that will allow me to select among two or three crystals for the VXO.)

WEDNESDAY, NOVEMBER 13, 2013

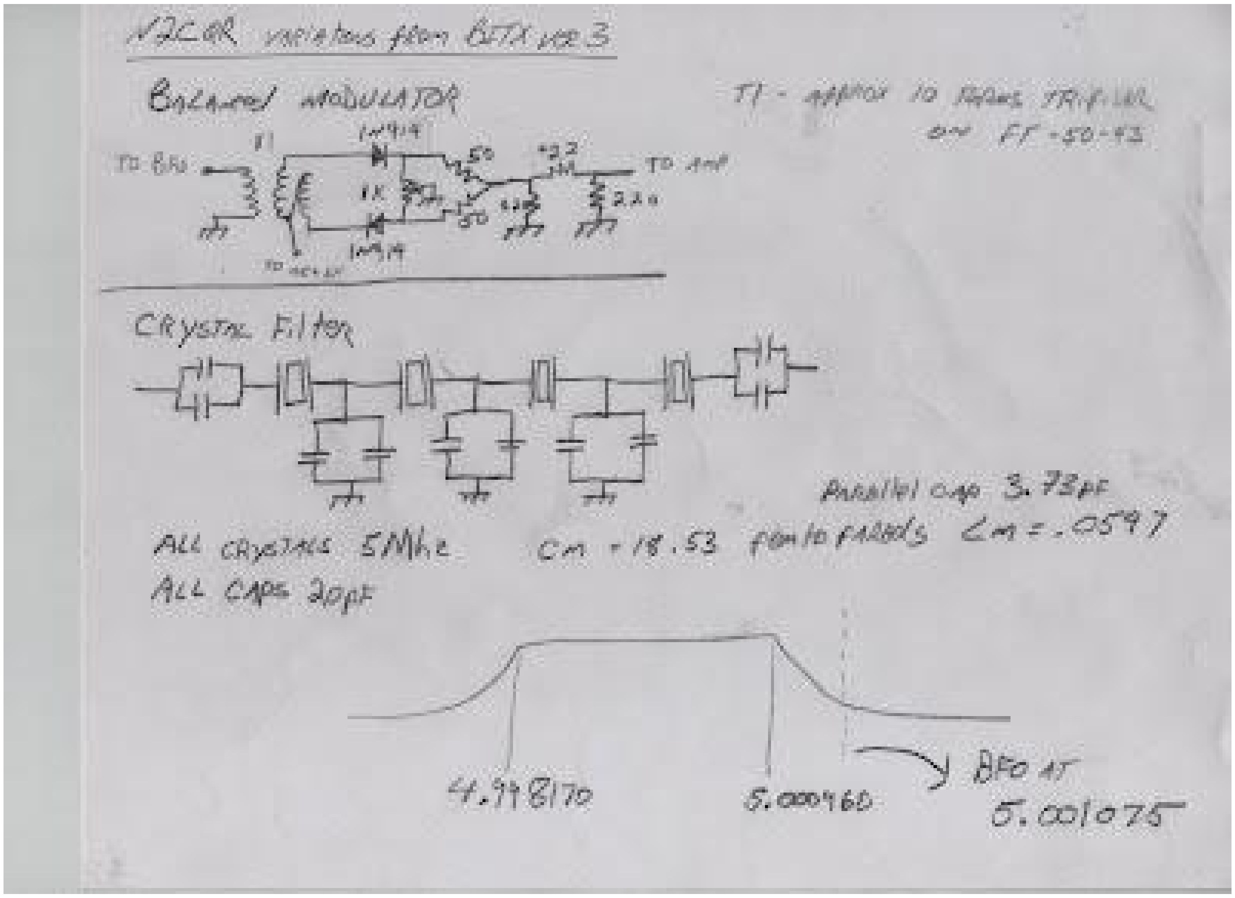
BITX Build Update #19 Layout, VXO, Bal Mod, Filter, PA



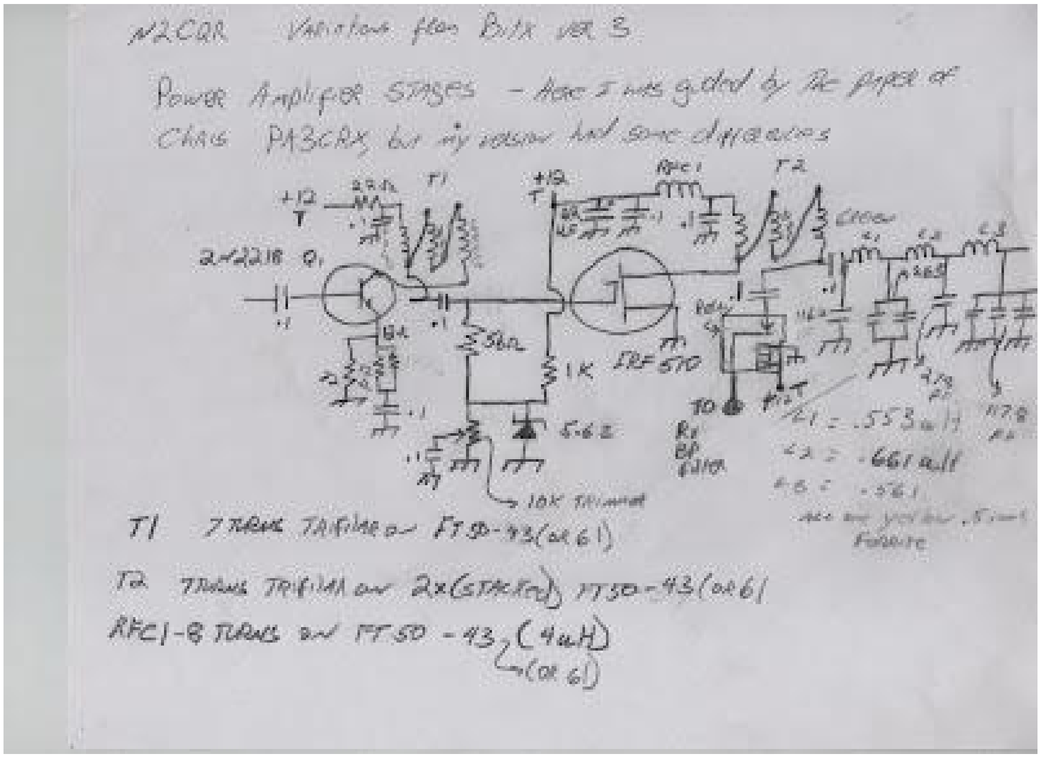
The files of the BITX20 Yahoo group were very useful to me during my BITX build. So I have decided to make a contribution myself. I uploaded a few drawings today. Here is how I laid out the circuitry on my 8 inch by 11 inch copper clad board. I included the isolation (Manhattan) pads for one of the bidirectional amps.



Here is the VXO.   I built it on a separate board, but I could have put it on the main board.



Here is the balanced modulator and crystal filter.



Here is the power amplifier circuitry. Amazingly easy to stabilize.

THURSDAY, NOVEMBER 21, 2013

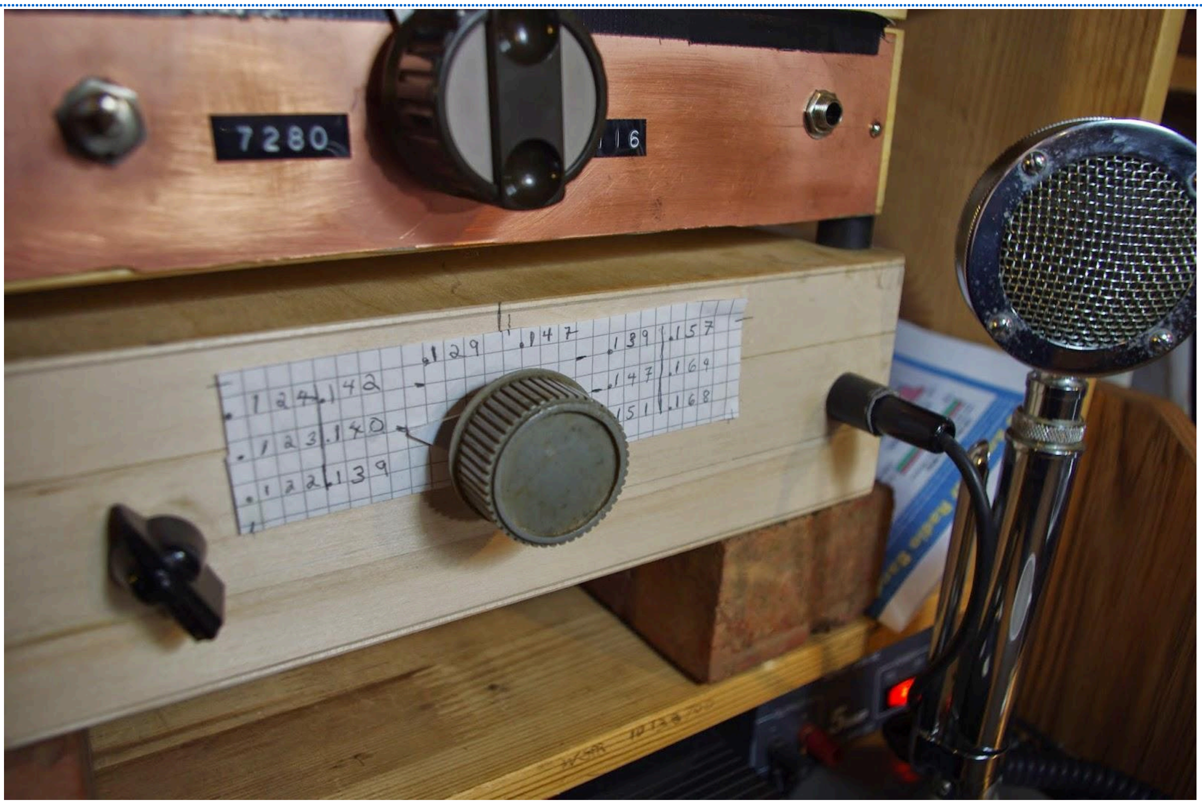
BITX Build Update #20 -- Switchable Crystals, South Africa QSO

I got tired of popping the hood and manually changing my VXO crystals. First I tried to switch the rocks using a rotary switch on the front panel, but I think the leads were too long and the output was kind of squirrely. So I dug around in the junk box and found a 12 volt double pole double throw relay. I put the crystal sockets across the two poles and ran leads from the armature terminals to the crystal terminals. I use the rotary switch to activate the relay. I cover about 41 kHz of the 17 meter band with the two crystals.

17 meters has been in great shape. On November 16 I had a very nice contact with Syd, ZS1TMJ in Glenwilliam, South Africa. That's about 8000 miles on 5 watts SSB.

MONDAY, JANUARY 26, 2015

New Analog Frequency Readout for BITX17 VXO



I've been getting tired of being in the dark about the frequency on which my BITX17 was operating. So I pulled out some graph paper, my frequency counter, and a pencil. You will see two frequencies at each point -- that's because I use two crystals, switched by the black knob on the left. I realize this paper and pencil approach is hopelessly out of date, but I see it as "appropriate technology" for a discrete component all-analog transceiver.

Pete set me straight on how to come up with the numbers: VXO frequency minus ACTUAL carrier oscillator/BFO freq. After doing this I took great delight in going on the air and asking guys with fancy "glowing numerals" rigs to compare their freq readout with my pencil and graph paper readouts: they were painfully close.

But I am not slipping completely into stubborn Luddite-ism; this weekend I worked on a DDS-based AD9850/Arduino VFO with I-Q output based on Paul M0XPD's Kanga-UK Arduino Shield. STAY TUNED!

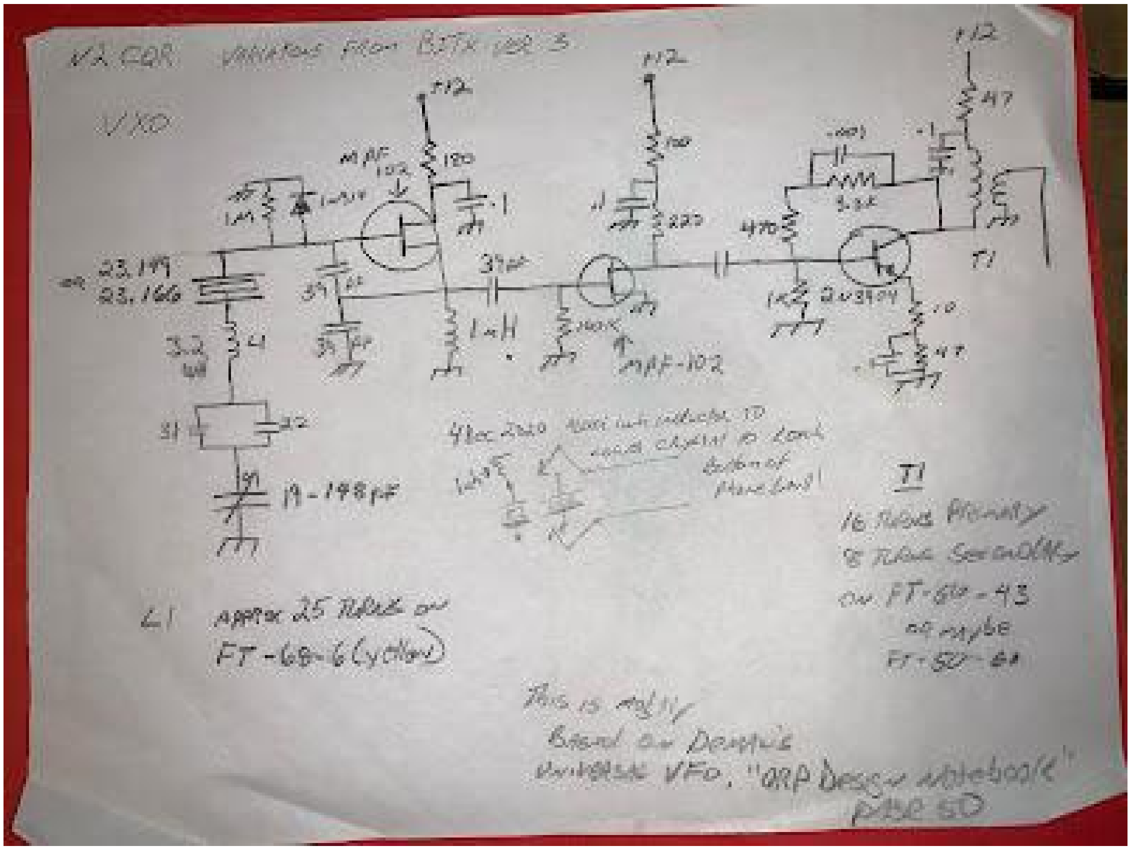
SATURDAY, DECEMBER 5, 2020

Adding 10 kHz of Coverage to My BITX 17

Solar Cycle 25 is underway. The Solar Flux Index and Sunspot numbers are up considerably. I have dusted off my old BITX17 transceiver. This time around I am using it in conjunction with a waterfall display provided online by NA5B's KiwiSDR receiver, which is located about 9 miles east of me. This SDR receiver allows me to see the entire 17 meter band.   It was this panoramic display that made me pay more attention to the fact that the Variable Crystal Oscillator (VXO) that I am using in this rig prevented me from tuning the lower 10 kHz of the 17 meter phone band (18.110 -- 18.120 MHz).

I use two crystals switched by a relay to cover the band. One is at 23.149 MHz, the other at 23.166 MHz. The crystal filter is at 5MHz. With a coil and some caps I could move the frequencies of the oscillator enough to cover 18.120 to 18.168 MHz (top of the band).

When I first built this thing, I kind of wrote off the lower 10 kHz of the phone band. I couldn't get the oscillator to work that low, and I was already satisfied with the top 48 kHz. But the NA5B waterfall often showed SSB stations in that lower part of the band. I wanted to talk to them. So I started thinking about how to do this.



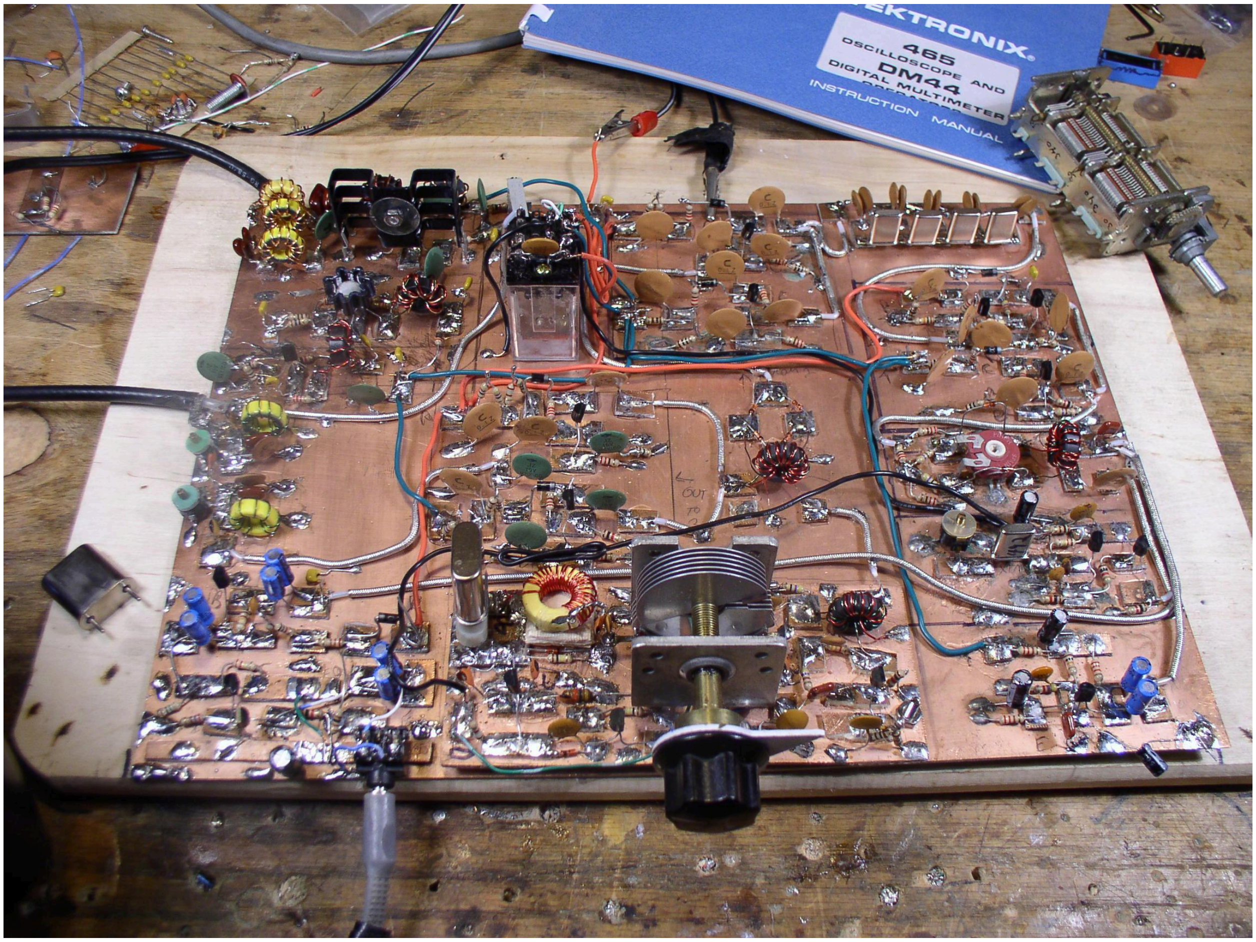
Looking at my schematic (above) I remembered that most of the frequency lowering was done by L1, a 3.2uH toroid. I figured that to go a bit lower, I would just have to add inductance. But I didn't want to lower the frequency provided by BOTH crystals -- I just wanted to bring the frequency with the lower crystal down a bit.

In my junkbox I found a 1 uH coil. I disconnected the lower lead of the 23.149 MHz crystal from its connection to the relay. I soldered the 1 uH coil between the crystal and the relay (see picture above). This moved the lower limit down to 18.087 MHz.

Now crystal one provides 18.087 - 18.144 MHz
crystal two provides 18.137 - 18.167 MHz

So now I have the whole phone band. Bob is my uncle. TRGHS.

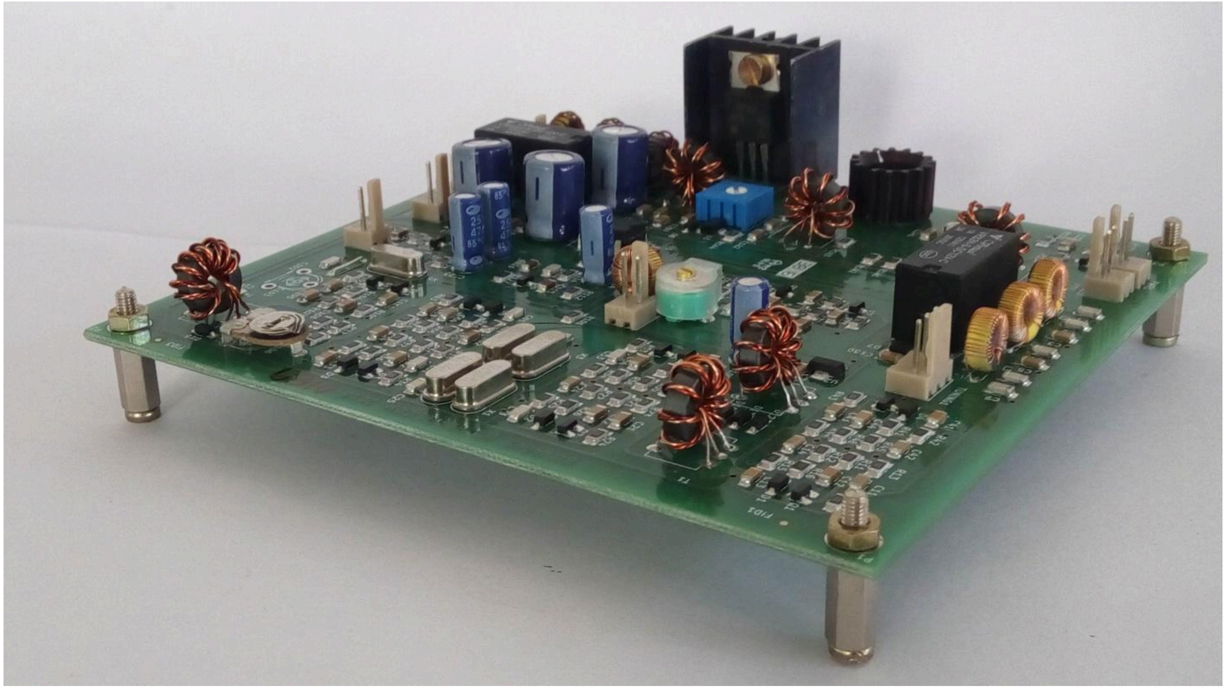
This was a very quick and satisfying little fix. As Pete says WYKSYCDS: when you know stuff you can do stuff. Indeed. And as I rebuild and repair gear that I built years ago, I am often reminded that as time goes by, we learn more. We end up knowing more and being able to do more.



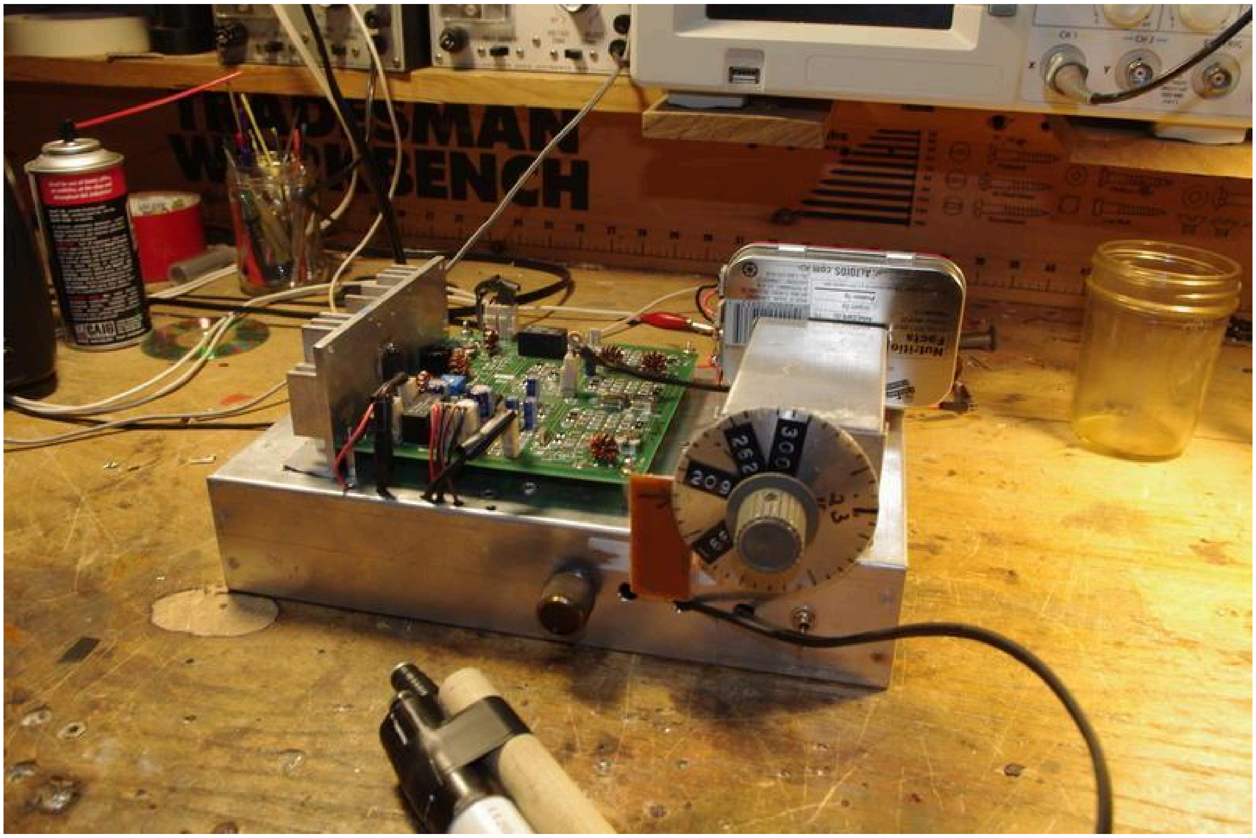
Then I built another one for 20 in 2013. Then a third for 40 in 2015. All were built from scratch. I stopped at three for fear that people would think I was obsessed. But I guess I was because when Farhan launched a new BITX project in 2016, I wanted in.

THE BITX 40 MODULE

This new one was different. Sunspots were disappearing, so this one was for 40 meters. But the really big difference had to do with the construction: you didn't really have to build this one. Ninety five percent of the build would take place in small factories in India. Instead of scrounging parts for a hard-core scratch-build, Farhan and his team would put almost all of the circuity on one small (5"X5") PC board. All the buyer would have to do would be to connect the peripherals – microphone, speaker, antenna and power connectors, etc. and find a suitable enclosure.



It might seem kind of ironic that the fellow who launched a homebrew revolution would suddenly turn to the production of what can be seen as a factory-made rig, but there is solid logic behind Farhan's decision to launch what he called the BITX 40 Module. That little board would be an invitation to hack, to modify, to innovate. The layout of the parts on the board is almost identical to the layout seen in the schematic, and all the parts are clearly labeled.   For hams who would never dare to even open the cabinet on their expensive and mysterious commercial transceivers, the $45 BITX 40 Module would serve as sort of a homebrew gateway rig. Want to put it on another band? Want to increase the power level? Want to add CW capability? How about some AGC or a digital frequency readout? Well get out the soldering irons and give it a go.
The e-mail traffic on the BITX20 yahoo group confirm that Farhan's plan is working brilliantly. More than 1000 BITX Modules have been sent to hams around the world, and many long-dormant or never-used soldering irons have been heated up.



What I really like about the BITX 40 Module is its purity, its discrete analog nature. Sure, the parts are surface mount, but Farhan deliberately selected the largest available surface mount parts. Each stage is easy to identify and understand. There are no mysterious digital chips containing incomprehensible arrays of millions of transistors, no lines of code in which a misplaced semicolon could do you in. So, when it came time to bring more stability to the BITX VFO, I naturally resisted Pete's inevitable suggestion that I simply throw a digital synthesizer at it. I'd had some recent success building an analog VFO. I'd gone back and carefully read the books of Doug DeMaw and Wes Hayward, and I'd carefully followed their advice: An air core coil and a quality variable capacitor. NP0 fixed capacitors, using many in parallel to avoid having too much current through any single capacitor (this tends to spread out the heating and improve stability). Sturdy physical construction with attention paid to keeping heat away from the coils and the capacitors. Operating the oscillator at low voltage. For the BITX 40 VFO mod, I went with a simple oscillator from the classic homebrew guidebook "Solid State Design for the Radio Amateur" by Hayward and DeMaw (my copy has a dedication from Wes himself). It has a simple Hartley oscillator with less than a dozen parts.

Years ago, Farhan had described a signal generator in which he had wound the oscillator coil on a straw from a fast-food restaurant. Applying this principle, I use a piece of the cardboard tubes from coat hangers. A search of my junk box yielded a suitable variable capacitor. The coil and the capacitor went into a small aluminum box. The FET and any of the parts that might be generating heat went into an Altoids tin attached to the back of the aluminum box (one observer described it as an Altoid backpack). Paranoid about heat, I even put the Zener diode regulator and its current limiting resistor on the outside of the Altoids backpack – in the analog VFO game, heat is your enemy.

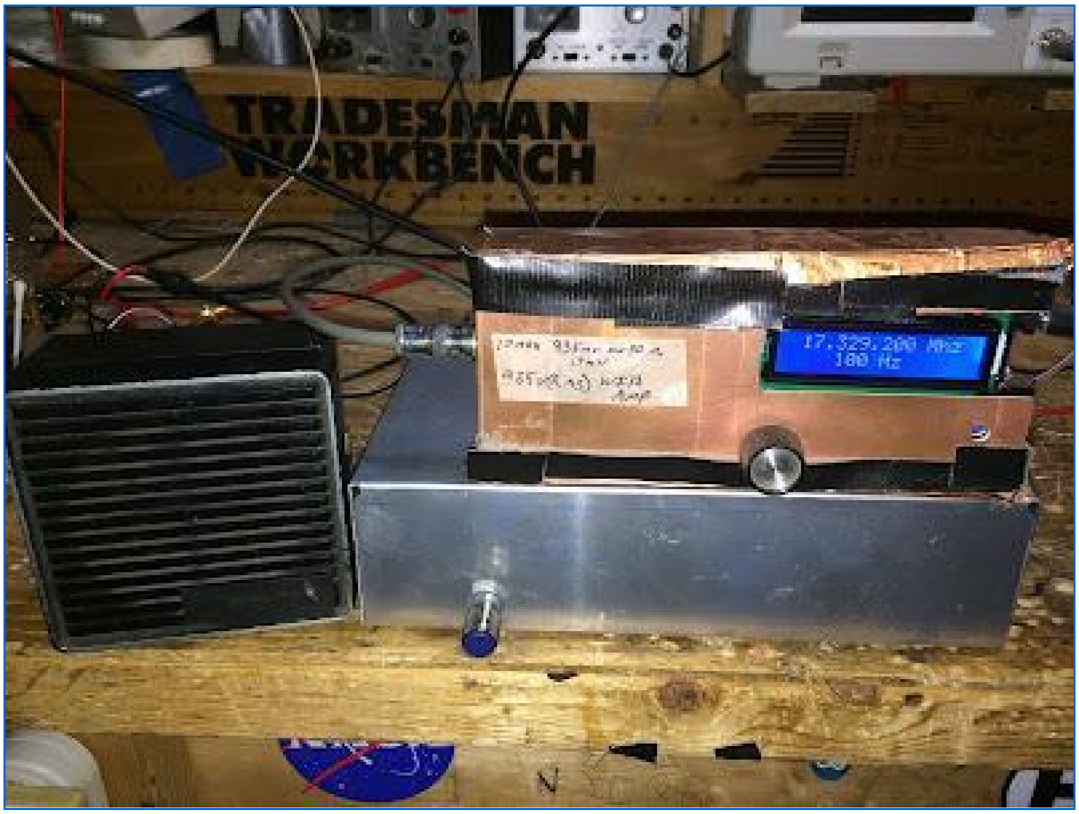
After some testing and tweaking (I had to remove a few turns on the coat hanger coil), I knew my VFO would be providing the RF signal needed to replace that of the original drifty VFO. It was time to wrap this thing up and make some contacts.

I had a suitable box, but I just couldn't get myself to do it. I couldn't hide Farhan's beautiful board inside a metal case. I liked looking at it. I wanted to keep it visible. (Pete calls this "al fresco style.") So, in an example of how, as a homebrewer, you CAN have it your way, I put the board on top of the box instead of inside the box. I was thinking outside the box!

Farhan's board went in the center, and my Altoids backpack VFO went to the right. I think it looks pretty cool.

THURSDAY, MARCH 16, 2017

A BITX 60



Inspired by Don ND6T, I decided to put a BITX40 Module on the 60 Meter band. All you really have to do is modify the bandpass filter. Don showed us how to do this by simply adding three 100pf caps. I was going to order SMD caps, but this just didn't seem right -- I found three of the old "with wires" kind and easily soldered them into position. The bandpass shifted as Don had promised.

You also have to change the VFO freq. You need it to be in the 17.3 MHz range. Don has a nifty program for the Raduino that also works with the Si5351/Ardunio Uno combo that I use. It keeps you on the five channels currently authorized on 60. Unfortunately I managed to let the smoke out of yet another innocent Si5351 breakout board. Amazon and Lady Ada are sending me another one, but in the meantime I pressed into service an old AD9850 DDS. I had a little trouble getting the 17MHz signal through the BITX's VFO 4 MHz VFO system, but I eventually figured it out. The receiver is working nicely. I like the relaxed 60 meter conversations.

SATURDAY, MARCH 18, 2017

Channelized! BITX 60 with the Five Channels (with video)

Here's an update on my BITX 60 project. The modified module is in the lower box. An Arduino Uno and an Si5351 (this one with unreleased smoke) is in the Heath QF-1 box on the top. I am using an Arduino sketch written by Don ND6T. It spits out the needed 17 MHz LO freq needed for each of the five 60 meter channels. You can scroll through the channels by just holding down the rotary switch interrupt button.

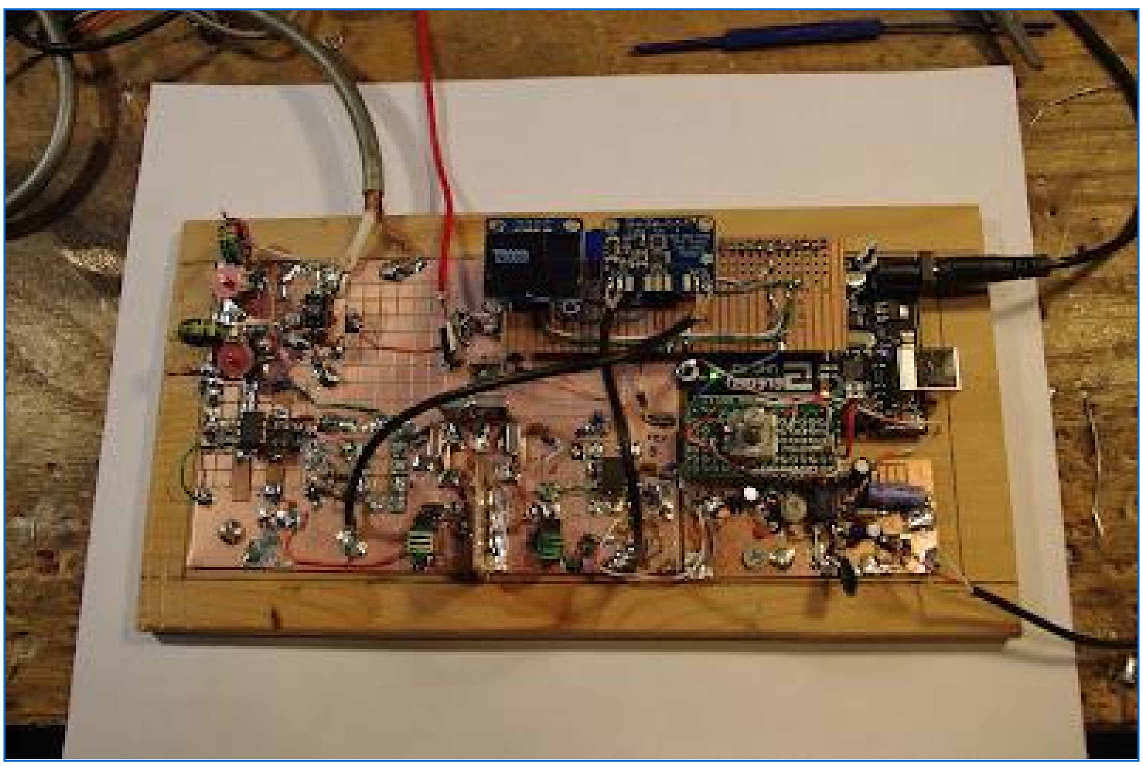
There is a move afoot to liberate from channelization about 15 kHz of the 60 meter band. When that happens, I'm ready to go -- I'll just reconnect the rotary encoder for the Si5351 and load some new code. I suspect that by the time that happens, Don will have modified his code so that the 15kHz "tunable" segment will be integrated into the current program and will appear as one of the options as you scroll through the choices.

For reasons that most readers will understand, I have resisted channelization for many years. But here I am, channelized on 60. It is not so bad. I'm having fun listening to a new band, using a modified BITX, an Arduino, a bit of Heathkit and code from a fellow ham.

DIFX - DiFFERENT TRANSCEIVERS

FRIDAY, JANUARY 6, 2017

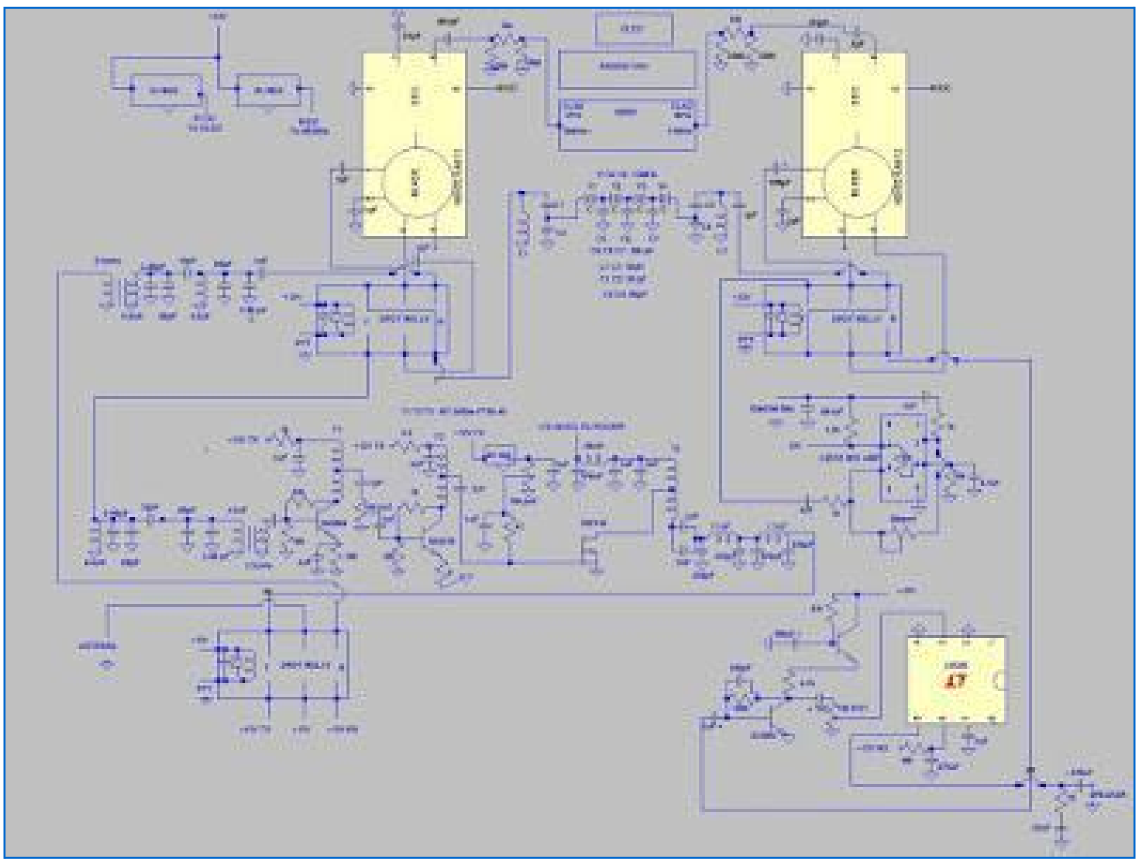
NE602 Si5351 OLED "Whole Foods" Receiver



This is one of those projects that sort of just happened. First I built an Si5351/Arduino synthesizer with a small OLED I2C display (program by Thomas LA3PNA -- thanks Thomas). Tom Hall AK2B up in New York helped me get the Si5351 VFO and BFO going -- thanks Tom. Then, over the holidays I decided to build a rig of some sort around the Si5351. I started with a superhet receiver using an NE602 as the mixer and another as the product detector. I power the NE602 with an 8 volt regulator from W8NSA -- thanks Jim. I made a 4 crystal 11 MHz Cohn filter using crystals left over from a BITX project. The software from AADE helped me design the matching networks to match the filter to the 1500 ohm impedances of the NE602s.   I built the circuits on a milled board sent to me by Pete Juliano N6QW -- thanks Pete!   I put a dual tuned circuit at the front end, going into a MOSFET RF amplifier.   For audio amp I have an LM386. The whole thing is screwed down to a barbeque grilling plank from Whole Foods -- thanks Whole Foods! (This seems appropriate -- the "O" in OLED is for "Organic"!) It sounds nice. I may eventually try to put some relays in to switch the NE602s and the filter around to make this a transceiver.

SATURDAY, JUNE 3, 2017

My Organic Chip Rig with an LTSpice Schematic



CLICK ON IMAGE TO ENLARGE

This is a rig that came together through a process of Spontaneous Construction. It started out with an innocent effort to get an Organic Light Emitting Diode display to work with an Si5351/Arduino combination.   Then I figured I'd make a superhet receiver with it. Then Pete said I should make it a transceiver.

Most of my earlier transceivers so closely followed the schematics of Farhan or others that it didn't really make sense for me to prepare a new schematic. This one was different. So I decided to prepare a proper schematic. I tried a few of the free-ware CAD or drawing programs, but each of them had a learning curve at the entrance. So I turned to LTSPICE. I have already climbed that learning curve.

The results appear above. Click on the image to make it bigger. I'm sure there are errors in there. And I think some of my parts choices might be less than optimal. But it works well.

The filter was designed with the help of AADE software.

The idea of using two NE602s with a filter between them came (I think) from the Epiphyte.

The band pass filters were designed with ELSIE software.

The RF power chain is mostly from Farhan's BITX40 module, with the pre-driver and driver modified for a bit more gain. Farhan's amp is the most stable power amplifier I have ever used. It hasn't given me any trouble, even at 20 Watts. Strongly recommended.

The microphone amp is derived from the 741 op amp circuit used in the (in)famous Wee-Willy DSB rig.

The receiver AF amp also comes from Farhan's BITX40 Module.

Please let me know if you spot errors or have suggestions for circuit improvement.

A link to the .asc LTSpice file appears below. Perhaps some brave soul more skilled in LTSpice than I am might want to turn this drawing into an actual simulation. Some of the parts (like the NE602s) have actual simulated components behind the drawings. Others (like the relays and the LM741 and LM386) are just drawings. But go ahead and flesh this thing out. Who knows, it might come to life in the PC and start making QSOs on 40!

Here is the .asc file: http://soldersmoke.com/NE602 Rig.asc

SUNDAY, APRIL 23, 2017

DiFX! My New NE602 Rig is On the Air

Pete would call this a DiFX: a transceiver that is Different from a BITX. This started with my effort to get an Si5351 working with a little 1 inch square OLED screen. Tom Hall AK2B helped me with the software (thanks Tom). Once I got that done, I figured I could build a simple receiver with a homebrew 11 MHz crystal filter, two NE602 chips, and an LM386 AF amplifier. That was working great, then Pete told me to turn it into a transceiver. I used some of Pete's boards (thanks Pete).

The Epiphyte transceivers also use two NE602's, but they ingeniously switch the BFO and VFO between the two chips. I didn't switch the oscillators -- instead I switched the inputs and outputs of the two chips using two DPDT relays (thanks Jim). A third DPDT relay switches the antenna between T and R, and turns on and off the PA stage and the AF amplifier.

This is a DIFX, but there is some BITX circuitry in there. The power amplifier stages are right out of the BITX Module, as is the AF amplifier (thank again Farhan).

The only real problem I ran into had to do with the very low power out of the NE602 VFO mixer on transmit and the impedance matching between the NE602 and the PA chain. I had to increase the gain on the first RF amp (pre-driver) using ideas from Steve Weber's 40 meter SSB CW QST contest rig (thanks Steve). I experimented with various connections between the NE602 and the BP filter. Finally I got it going.

The heat sink on this one is different too: it is just the chassis.   The IRF 510 is bolted (insulated) to the aluminum box.

I fired it up this afternoon and in spite of horrible conditions on 40, quickly had a nice rag chew with KJ4ZMV in Indiana. I haven't even built a mic amp yet! I am running the D-104 right into the NE602 balanced modulator. There are no signs of unwanted modulation or spurs.

FB!   TRGHS!   VIVE LA DIFFERENCE!

TUESDAY, FEBRUARY 16, 2021

The Quarantine Hodgepodge

As I continue to Stay In The Shack, last week I was looking for something to do. This is what I came up with.

Left to right:
-- Speaker
-- Ramsey-kit QAMP20 modified for 40. I now have two MTP3055V MOSFETS in there.
-- BITX40 Module with a *solidified* VFO from a Galaxy V (note the knob from a Drake 2B!)
-- Power supply
It puts out about 15 watts SSB. I was bracing for attacks from the 40 meter waterfall police, but no, everyone said it sounds great. I had four very nice contacts yesterday. It was fun.

Still to do: Possibly a San Jian frequency counter to give some Juliano Blue glowing numerals for the frequency readout. This would be a step up from the Juliano Blue sticky note and corresponding piece of black electrical tape that currently serves as the frequency indicator.

FRIDAY, MARCH 5, 2021

Over the Waterfall into the Dark Side: Hodgepodge SDR

This one's for Pete. My effort to add features and modes to my Hodgepodge transceiver took a dramatic turn when I connected the rig to my computer via an RTL-SDR dongle. Woohoo! A Hodgepodge waterfall! Check it out. https://www.youtube.com/watch?v=Fyow06oSRYs&t=66s

The dongle was modified for direct sampling at HF. In the box with the dongle I have one amplifier stage, consisting of a 40673 dual gate MOSFET and one parallel tuned circuit, now tuned to the Hodgepodge IF of 11.998 MHz. I tap the the Hodgepodge's BITX40Module at the output of the first mixer, just before the crystal filter. This was a lot of fun. I can even check my own signal on transmit! This is like having the best of both worlds.

SUNDAY, FEBRUARY 28, 2021

Putting the Quarantine Hodgepodge Rig on CW (Video)

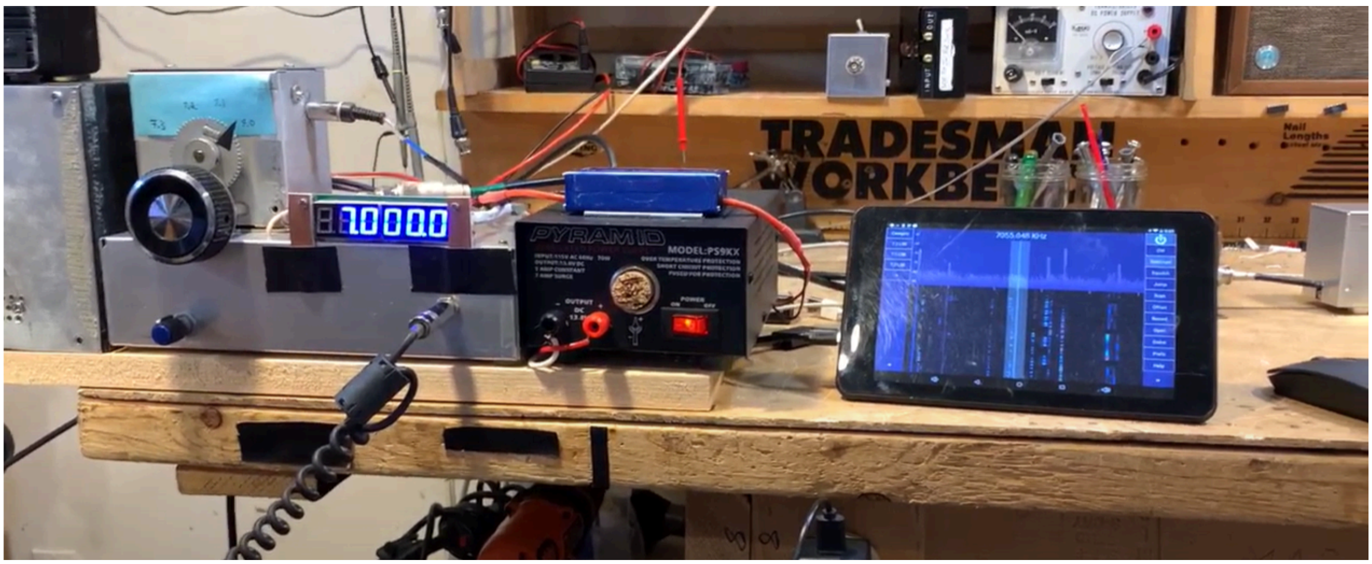
Putting this rig on CW posed a real Hodgepodge challenge: What did I have laying around that would let me do this? Then I remembered: Years ago I built a little 750 Hz audio tone generator. So I pressed that into service. I also needed a sidetone so I built a little RF-actuated circuit that turns on a piezo buzzer when I go key down. And I put a little DC monitoring device (recommended early in 2020 by the Ham Radio Workbench podcast) between the power supply and the rig. There is more to do! Stay tuned.

FRIDAY, MARCH 19, 2021

Hodgepodge: Tablet SDR with a Bluetooth Mouse (video)

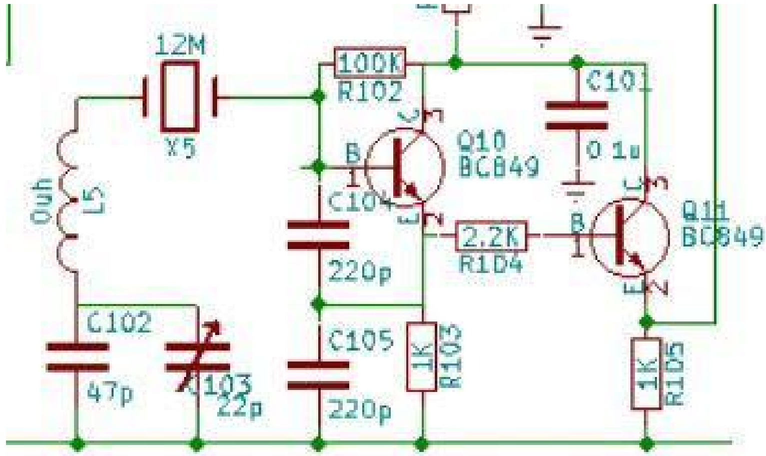
I continue to find things in the shack that I can connect to the Hodgepodge. Here it's an old Android tablet with a Bluetooth mouse.
https://www.youtube.com/watch?v=aeTtEqgZHcQ&t=143s

The waterfall is pretty, but this addition just shows why SDR is really TOO easy. The modified RTL-SDR dongle is doing direct sampling, so there is not even any phasing circuitry to tinker with. All the filtering and sideband selection is happening in software inside the 40 buck Android tablet. The results look nice, but I don't find it very satisfying -- all I did was connect some cables. So it's back to HDR for me.



Hodgepodge: Moving the Carrier Oscillator Frequency (and a Flashback to 2002) (Video)

As explained in the video, in the course of using my RTL-SDR dongle I noticed that the signal being put out by my Hodgepodge rig had some problems. There was poor opposite sideband rejection, and in terms of audio quality I has putting out too many lows and too few highs. I figured the problem was the result of the carrier oscillator frequency being a bit too low, a bit too close to the flat portion of the crystal filter passband. I needed to move that carrier oscillator frequency up a bit.



BITX40 Module BFO

In the actual BITX40 Modules, L5 was replaced by just a jumper wire, and the C103 trimmer was not on the board. Farhan and his team instead selected X5 crystals to match the passband of the 12 MHz crystal filter. Mine was originally at 11.998653 MHz. But I wanted to tweak mine a bit -- I wanted to move it up about 500 Hz. Reducing the capacitance would move the frequency up. Putting capacitance in series with C102 would have the effect of reducing the capacitance in the circuit. I just removed the jumper wire and used the holes for L5. First I put in a single 30pf capacitor. This dropped the capacitance between X5 and ground to 18 pf. That resulted in too large a shift. So I added another 30 pf cap in parallel with the first one. This resulted in a total capacitance from X5 to ground of 26 pf. This was about right -- the carrier oscillator/BFO frequency was now 11.9991 Mhz. I had moved the carrier oscillator frequency up by 447 Hz -- just about what I was hoping for.

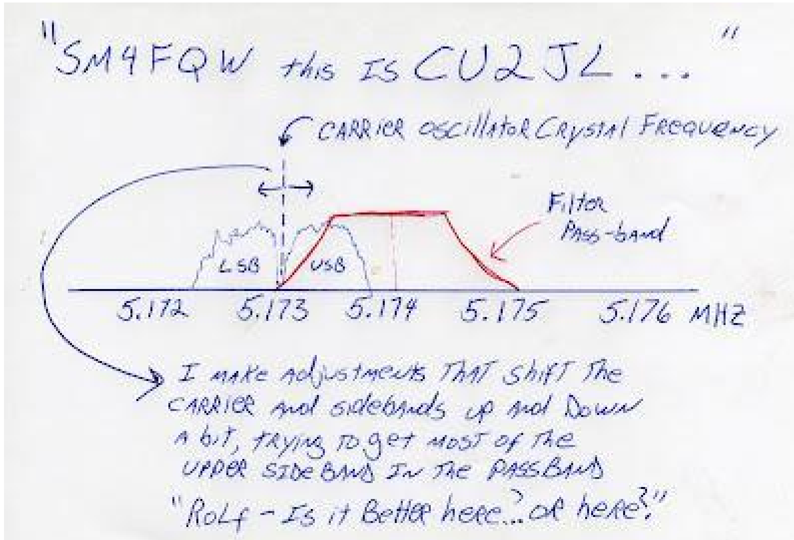
This was a very satisfying fix. it was a chance to put to use experience with other SSB rigs, to make use of the RTL-SDR dongle as a diagnostic tool, and to tinker with the BITX40 Module in the way that Farhan had intended for it to be tinkered with.

I'd done this kind of adjustment before, but without the benefit of an SDR display. Below is the story of one such adjustment.

A Flashback to 2001-2002

(From my book "SolderSmoke -- Global Adventures in Wireless Electronics")

Now it was time for some debugging and fine tuning. I needed to make sure that the frequency of the carrier oscillator was in the right spot relative to the passband of the crystal filter. If it was set too high, the filter would be chopping off high notes in my voice that were needed for communications clarity, and it would allow too much of what remained of the carrier (residuals from the balance modulator) through. If it was set too low, the voice signal transmitted would be lacking needed base notes. I didn't have the test gear needed to perform this adjustment properly, but my friend Rolf, SM4FQW, up in Sweden came to my aid.

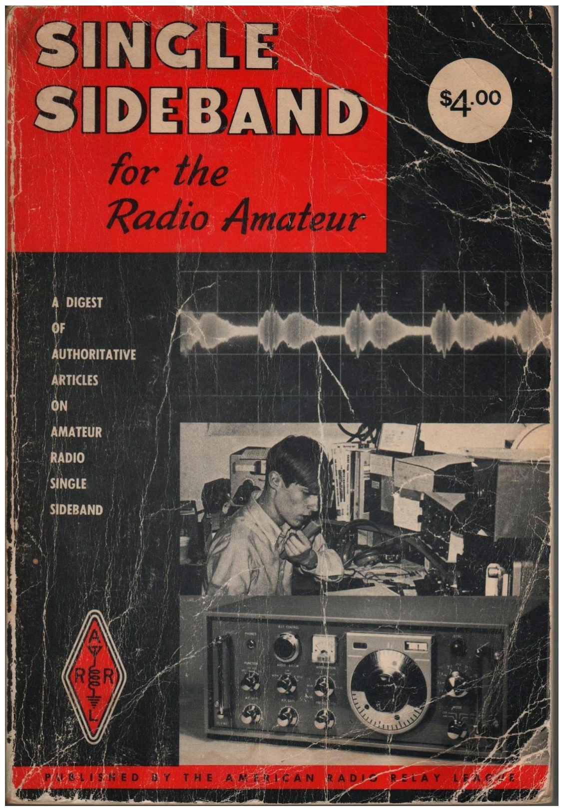


One night, during a conversation with Rolf, I explained my problem and he offered to help me make the adjustments… by ear. Performing an electronic version of open-heart surgery, with power on and Rolf on frequency, I opened the case of the new transmitter. The carrier oscillator has a small capacitor that allows the frequency of the crystal to be moved slightly. With Rolf listening carefully, I would take my screwdriver and give that little capacitor a quarter turn to the right. "Better or worse?" I would ask.

I think this little adjustment session captures much of the allure of ham radio. There I was, out in the North Atlantic, late at night hunched over a transmitter that had been forged from old Swans and Heathkits, from cell phone chips, and from bits of design from distant members of the fraternity of solder smoke. Pericles, the source of many of the key parts, was gone. So was Frank Lee, the amateur whose *SPRAT* article had inspired the project. But Rolf and I carried on with the core tradition of the radio fraternity: hams help their fellow hams overcome technical difficulties.

SSB PRINCIPLES

SIDEBAND INVERSION AND THE HALLAS RULE
WORDS TO LIVE BY
May 2015



Joel Hallas, W1ZR, (aka "The Doctor") has an especially good column in QST this month. He takes on a topic that has confused (and re-confused!) many of us: sideband inversion. Simply put, if you have a single sideband signal, and you put it through a mixer, depending on the frequencies involved and on whether you take the sum or the difference product of the mixer, the sideband may or may not get INVERTED! You could start out with an UPPER sideband signal coming out of your sideband generator, then, after you mix it with your VFO (or Si5351!) you end up with a LOWER sideband signal. This can be quite an unpleasant surprise.

Joel gives us a good rule for remembering when this will happen:

"Sideband reversal occurs in mixing only if the signal with the modulation is subtracted from the signal that isn't modulated."

Words to live by my friends. Words to live by.

The confusion on this topic often arises in discussions of the old scheme of using a 5 MHz, 9 MHz filter/VFO combination to generate LSB on 75 meters and USB on 20 meters. This is very convenient, but you need to remember Joel's rule to get this scheme right.

It is easy to get confused on this. I got confused when Steve Smith sent me a 9 MHz filter out of an old Yaesu. I had visions of using the old 9 MHz 5 MHz scheme. But no.... With a 9 MHz sideband generator, you can get on both 75 and 20 with a VFO running at 5 to 5.5 MHz, but you won't get the nice sideband inversion situation described above because with neither band will you be subtracting the signal with modulation (9 MHz) FROM the signal without modulation (5-5.5 MHz).

But this scheme does work if you start out with a sideband generator on 5 MHz and the VFO running around 9 MHz (the reverse of ham radio lore). You start out with Upper Sideband at 5 MHz. and mix it with a VFO running at 8.5 -- 9.5 MHz, for 20 meters you will take the SUM of the two frequencies. So no sideband inversion. You will be happily on 20 meter USB (the mode used on that band). For 75 meters you will be SUBTRACTING the SIGNAL WITH THE MODULATION (5 MHz) <u>from</u> the SIGNAL WITHOUT THE MODULATION (8.5-9.5 MHz). So, following Joel's rule you WILL get sideband inversion. Here you will be on 75 meter LOWER sideband (the mode used on that band).

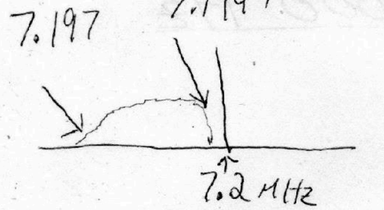
It was very nice that Joel admitted to falling victim to this kind of confusion himself in a column he wrote years ago.

N2CQR

How Sideband Inversion Happens

N2CQR
23 Dec '16

- Received Signal -



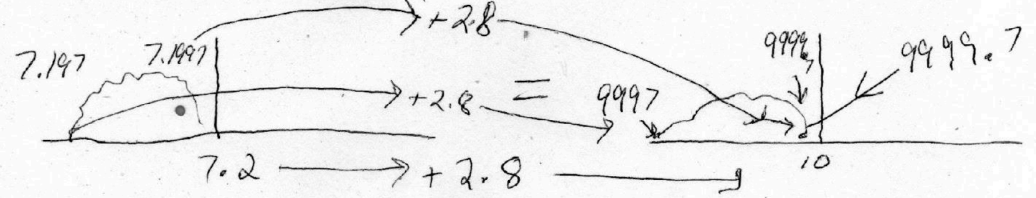
Here is an LSB Signal at 7.2 MHz. The frequencies below it correspond to the audio frequencies: 300 Hz = 7.1997, 3000 Hz = 7.197 MHz.

Suppose our IF (and Crystal Filter) is at 10 MHz

We have two options for our Local Oscillator (VFO): 17.2 MHz or 2.8 MHz

---

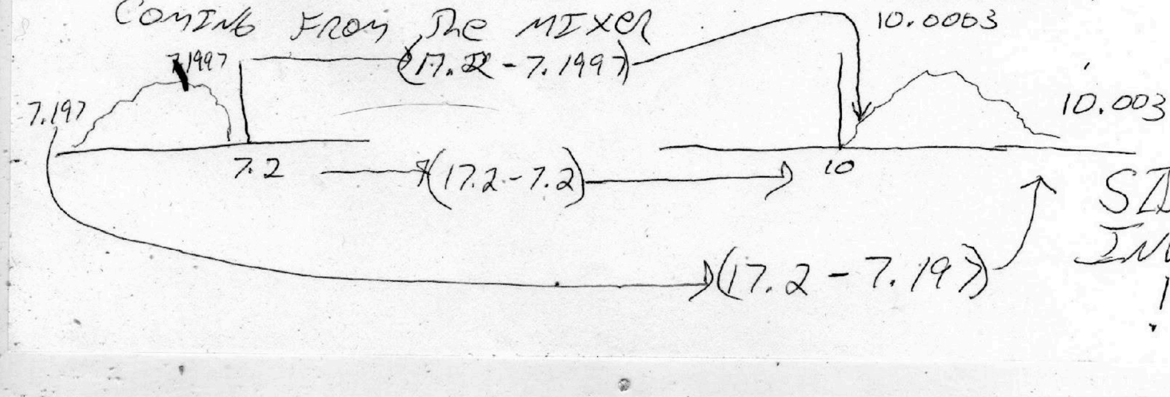
At 2.8 MHz we will take the SUM product coming from the mixer



We add 2.8 MHz to all of the received frequencies and end up with a Lower Sideband signal at 10 MHz

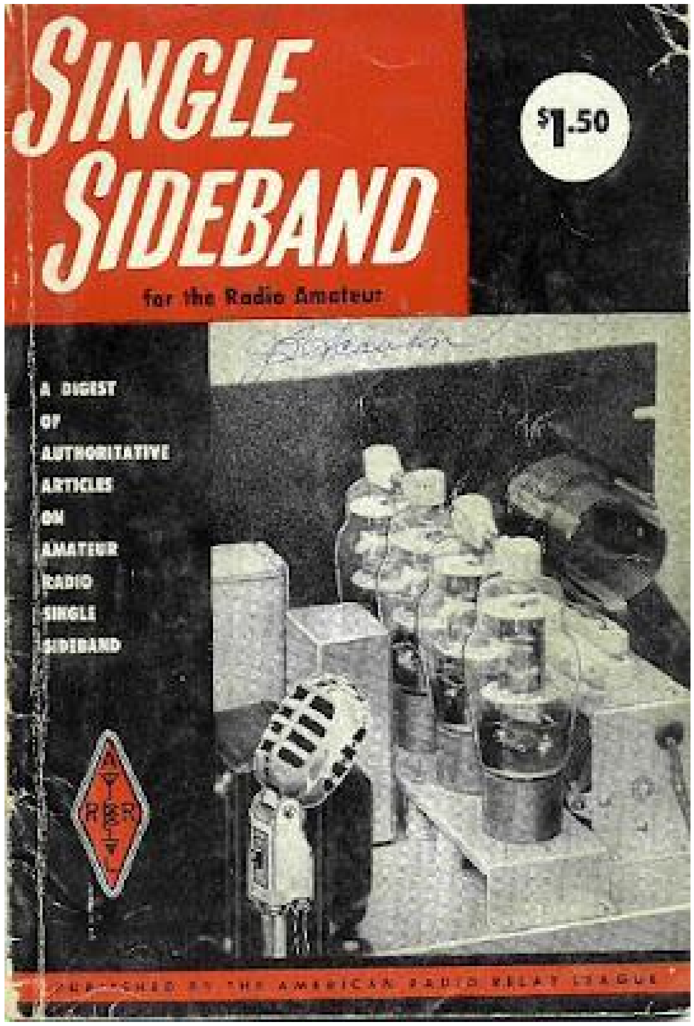
NO INVERSION

At ~~IF~~ 17.2 MHz we will take the Difference product coming from the mixer



THURSDAY, JUNE 17, 2021

The Stubborn Myth about USB and LSB



It has been repeated so often and for so long that many of us have come to believe it. I myself believed it for a while.   Like many myths, it has a ring of truth to it. And it is a simple, convenient explanation for a complex question:

Why do ham single sideband operators use LSB below 10 MHz, but USB above 10 MHz?

Here is the standard (but WRONG) answer:

In the early days of SSB, hams discovered that with a 9 MHz SSB generator and a VFO running around 5.2 MHz, they could easily reach both 75 meters and 20 meters (True). And because of sideband inversion, a 9 MHz LSB signal would emerge from the mixer as an LSB signal (True), while the 20 meter signal would emerge -- because of sideband inversion -- as a USB signal (FALSE!) That sideband inversion for the 20 meter signal explains, they claim, the LSB/USB convention we use to this day.

Why this explanation is wrong:

There is a very simple rule to determine if sideband inversion is taking place: If you are subtracting the signal with the modulation FROM the signal without the modulation (the LO or VFO) you will have sideband inversion. If not, you will NOT have sideband inversion.

So, you just have to ask yourself: For either 20 or 75 are we SUBTRACTNG the Modulated signal (9 MHz) from the unmodulated signal (5.2 MHz)?

For 75 meters we have: 9 MHz - 5.2 MHz = 3.8 MHz NO. We are not subtracting the modulated signal from the unmodulated signal. There will NOT be sideband inversion.

For 20 meters we have 9 MHz + 5.2 MHz = 14.2 MHz. NO. No subtraction here. No sideband inversion.

So it is just arithmetically impossible for there to be the kind of happy, easy, and convenient USB/LSB situation described so persistently by the myth.

We discussed this several times on the podcast and in the blog:

https://soldersmoke.blogspot.com/2015/05/sideband-inversion.html

https://soldersmoke.blogspot.com/2012/05/usblsb-urban-legend-debunked.html

This myth shows up all over the place:

We see the myth here:

http://n4trb.com/AmateurRadio/Why%20The%20Sideband%20Convention%20-%20formatted.pdf

Here the web site owner warns that this is "highly controversial." Really? Arithmetic?

http://9m2ar.com/lsb7.htm

The myth is very old. Here is a clip from a 1966 issue of "73" magazine:

> Phasing rigs generating their sideband at 9 mc usually use a 5 mc VFO, so that the VFO output may be *added* to a 9 mc upper sideband to get USB output on 20 meters, or *subtracted* from the same 9 mc signal to get LSB on 75.

https://worldradiohistory.com/Archive-DX/73-magazine/73-magazine-1966/73-magazine-01-january-1966.pdf

Finally, to my disappointment, I found the myth being circulated by the ARRL, in the 2002 ARRL Handbook page 12.3:

> quency be above the fixed SSB frequency on some bands and below it on others. To reduce circuit complexity, early amateur filter-method SSB transmitters used a 9-MHz IF and did not include a sideband switch. The result was that the output was LSB on 160, 75 and 40 m, and USB on the higher bands. This convention persists today, despite the flexibility of most modern amateur SSB equipment. Appropriate filtering methods and filters for SSB generation are discussed in the **Filters** chapter.

The fact that the Handbook attributed this to a desire to "reduce circuit complexity" by not including a sideband switch should have set off alarms. We are talking about hams who built their own SSB rigs, usually phasing rigs. A sideband switch would not have added significant circuit complexity. I think they could have handled it.

It is interesting that earlier ARRL Handbooks do not repeat this myth. I found no sign of it in Handbooks from 1947, 1959, 1963, 1973, and 1980. And I found no sign of it in several editions of that great ARRL book "Single Sideband for the Radio Amateur."

For my next homebrew rig, I will build a rig that DOES do what the myth promises. I will have the SSB generator running on 5.2 MHz USB. The VFO (out of an old FT-101) will be running around 9 MHz. So for 75 meters we WILL be subtracting the signal with the modulation from the signal without the modulation: 9 MHz - 5.2 MHz = 3.8 MHz.   There will be inversion. This 75 meter signal will be LSB.   For 20 we will just add the 5.2 MHz USB signal to the 9 MHz VFO. There will be no inversion. We will have a USB signal on 20.   I'm thinking of calling this new rig "The Legend." Or perhaps, "The Mythbuster."

CHAPTER 4

Morse Code CW RIGS

...   - - -   .-. .-. -.--

This is probably going to make people mad at me, but over the years I have developed something of an aversion to Morse Code (or CW as we call it). . Don't get me wrong – I'm pretty good at it. I passed the 20 word per minute code test for the Advanced Class license, and I can still move along at this speed with a problem. But I just don't like it very much. It seems slow, tedious, and old fashioned. It is like talking to someone one letter at a time. And it often seems like a waste of technology – we build modern rigs with lots of fancy circuitry, but when we use CW, we don't use much of this circuitry. We are just turning the transmitter on and off! It seems a bit barbaric to me. We have built machines and software to decode digital bits coming in through the airwaves, displaying the message on our screens. Yet somehow we insist on spending a lot of time memorizing the Morse alphabet and then "copying" the incoming messages in our heads. The kicker is that when Morse Code was first developed, the inventors never imagined that people would "learn" to decode the Morse Code by ear – they figured that the dots and dashes would appear on a paper tape, which could then be carefully decoded. It was only when the operators found that they could do it faster by ear that the Morse madness really kicked in.

But still, it has its uses.   If you are building very simple gear, or very low power gear, Morse and CW might be the way to go.

When we got back to Virginia, I worked on some of the early Morse Code ear that I had built decades before while in the Dominican Republic. Later, I took up the challenge of truly minimalist, simple gear.

FRIDAY, SEPTEMBER 16, 2022

Fixing Up An Old Homebrew Rig -- Barebones Superhet and VXO 6 Watter

I'm not exactly sure why I pulled this old rig off the shelf, but I'll write up what I did -- I often use this blog as a kind of notebook. I can look back and easily see what I did on my last encounter with the rig.

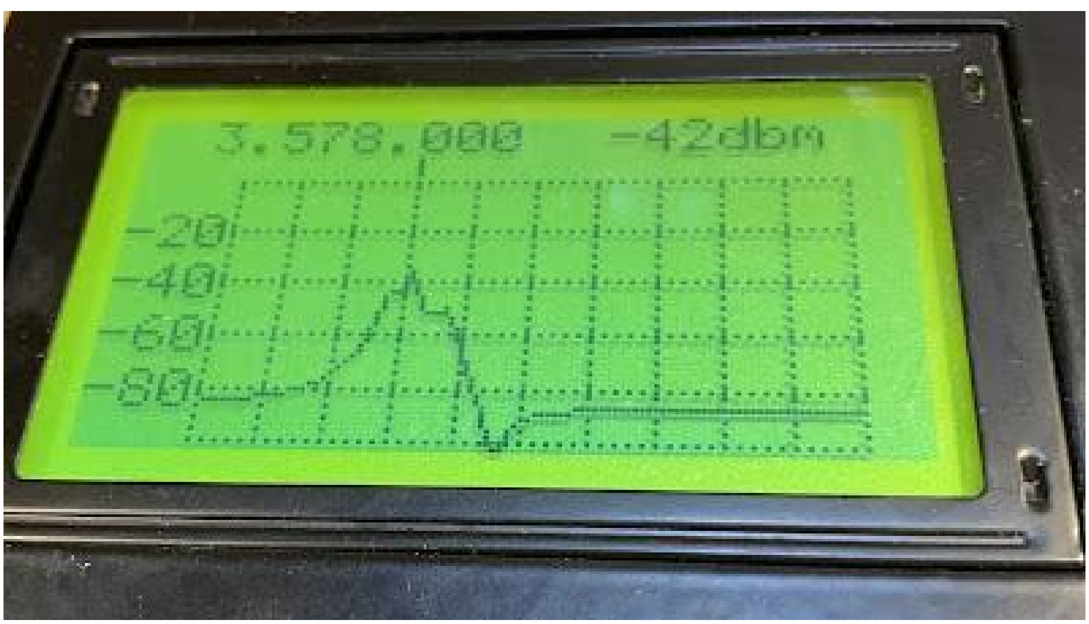
The receiver is Doug DeMaw's Barebones (aka Barbados) Superhet. This was my first superhet receiver. I built in in 1997. The transmitter was my first real homebrew project -- it is the VXO 6 watter from QRP classics. I built it in the Dominican Republic, probably in 1993 or 1994. I built the power supply so that I could say that the entire rig is homebrew.

This rig is getting a bit long in the tooth: The receiver is built with 40673 Dual-Gate MOSFETs, an some of the transistor cans have gotten rusty. The frequency readout on the receiver is the top of a coffee can fitted onto the reduction drive behind the tuning knob from a Drake 2-B (not MY 2B!).

Here are two 2013 videos that I did on this receiver:
https://soldersmoke.blogspot.com/2013/03/video-of-my-barebones-superhet.html

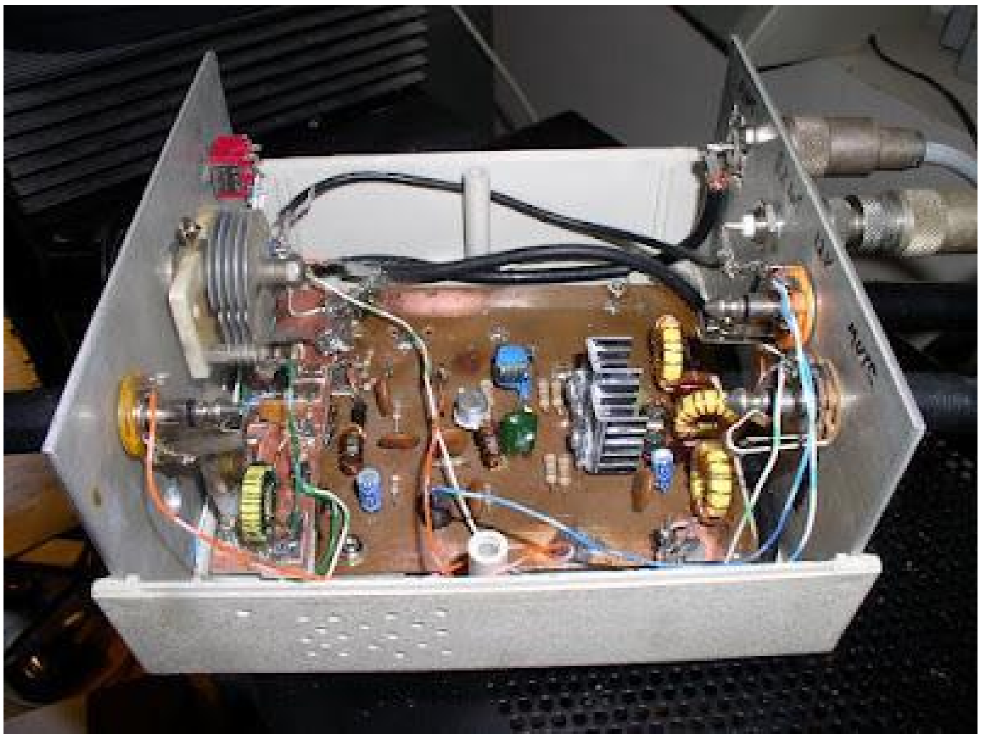
-- I put the crystal filter back in CW mode. I had widened it so that I could listen to 20 meter SSB, but I decided to go back to its original configuration. When I built the receiver in 1987, I didn't characterize the crystals -- I just used the capacitor values that Doug DeMaw had in his article. I pretty much did that again this time, just putting caps that are close in value to what Doug had. DeMaw used color burst crystals at 3.579 MHz. So I guess this would be a GREAT receiver for the Color Burst Liberation Army!

-- I used My Antuino (thanks Farhan!) to check the passband. Here is what it looks like. I just put the Antuino across the 10k resistors on either side of the input and output transformers. The coil cores had become very loose -- I just tried put them in the right place. I may need to put some wax in there to allow them to better stay in place. I think they could have used toroids instead -- that would have been easier. One of the transformer connections was open -- they don't work well that way, once I fixed that, the passband looks like this:



-- Each of the horizontal divisions is 500 Hz. The passband is not pretty, but it is OK, and I didn't feel like doing too much work on this to get it in better shape.

-- The filter peak was a bit lower in frequency than expected. I found that trimmer cap C3 in series with the BFO crystal would not allow me to lower its frequency sufficiently. So I moved C3 to a position in parallel with the crystal. With this mod, I could get the BFO frequency to 3578.69. This produces a 690 Hz tone when the received signal is at the peak of the IF passband. Opposite sideband rejection is quite good.



March 2013 Rebuild of the VXO 6 watter

-- I didn't have to do any real work on the transmitter. The RF amplifier in the transmitter had served for a time as the RF amp in by 17 meter DSB rig (I had added a bias circuit, which I removed when I put the amplifier back in Class C). Some time ago I rebuilt the oscillator circuit (which had been literally cut off the board when I used the amplifier in the DSB rig).

-- I did have to reconfigure the muting circuit -- the T/R switch in the transmitter switches the antenna and also -- through a two wire circuit -- cuts off 12 V DC to the transmitter when in receive mode.

-- For sidetone I just put a small piezo buzzer through a 1k resistor between 12 V DC and the key line.

It all worked fine -- I talked to three stations on the high end of the 20 meter CW band.

SUNDAY, OCTOBER 13, 2019

More on the ET-2 : Better Pictures and More Circuit Description. Some Thoughts on Simplicity

So yesterday I made my first contact using my ET-2 rig.   Last night I got an e-mail from Gary, the fellow at the other end of that contact:

Evening Bill, N2CQR....Yes I did learn about you from the spot on the DX Summit cluster. I tuned to the freq to see if I could even hear your 80 mW and you were a good real 569 when calling CQ. You built up to a real 589 on the later transmissions. I did not have either of the two pre-amp positions on in the ICOM 756 Pro II. There was not any QRM on the freq either. Your spot indicating the 80 mW is what really got my attention.

My antenna is a 2 element yagi at about 115 ft and it really works great for me.

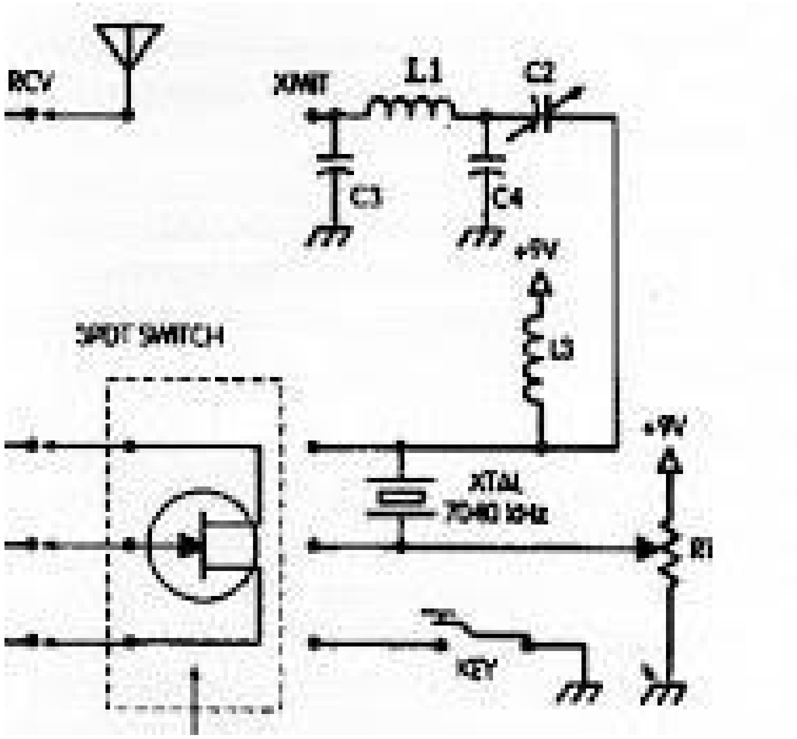
Thanks for the picture of the great little transmitter. Glad to be your first DX QSO with it. Hi Hi Maybe again soon. My pleasure to work you.
73, Gary, K4MQG
Fort Mill, SC

Farhan commented on yesterday's post, saying that it was hard to tell (from my pictures) where the rig started and ended. He was right. So this morning I have tried to clean up my bench a bit -- I hope these pictures are better.

Above you see the whole rig. The transmitter board is right next to the key that Farhan gave me. You can see the 7040 crystal. A C-Clamp holds to the bench the piece of scrap plywood that serves as the base for this rig. Next to the C-Clamp you see the TR switch --

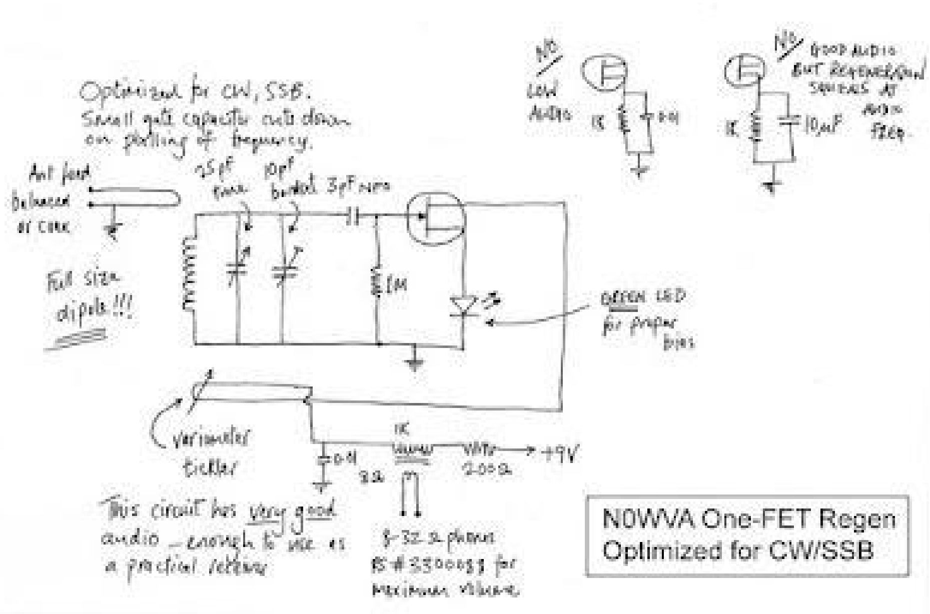
the just switches the antenna -- both transmitter and receiver are powered at all times. I can hear the transmit signal in the headphones and this serves as my sidetone.

Here is a close-up of the transmitter with the schematic below:



The transmitter is VERY simple. Nine parts, including the low-pass filter. You can barely see the J310 FET to the right of the crystal.

Here is the receiver:



I really like N0WVA's regen. The green diode in the source circuit is the key. This one does not squeal when you go into excessive regeneration (when you think about it, regens should NOT squeal at audio frequencies -- but most do). Also, the green diode dims a bit when you are at the right amount of regeneration. In the picture you can look down the tube of the variometer that Pericles HI8P gave me many years ago. The big variable cap is from the junk box -- I think it may be from a Johnson Viking transmitter. Note the long shaft with the insulating connector -- this is to reduce the hand capacity effect. On the right you see a smaller cap with just one vane -- this is my fine tuning control --- with the smaller cap at mid range, I would just set the big capacitor to put the receiver at 7040 -- with the smaller cap I could tune +/- 12 kc. I also used an insulating shaft on the smaller cap -- the connector for this one is from an old 1930s era regen that I picked up at the Kempton Park rally in London.

Instead of the audio transformer and Radio Shack headphones, I just used some old DLR-1 WWII Headphones. They are very sensitive and work well.

Lots of soul in this new machine: The variometer from Pericles. The WWII headphones. The 1930s era shaft connector. The circuit idea from the Autumn 2001 SPRAT. Farhan's key.

I recently read on Hack-a-Day of a new FPGA chip that has on it 35 BILLION transistors. I'm sure that thing can produce some fascinating results, but can anyone really understand it, or feel that they really BUILT something that has that kind of chip at its center? On the other hand, I did rely on a lot of modern digi technology in this project: The Reverse Beacon Network reported back that my unanswered CQs were in fact getting out (one as far as Kansas to K9PA). And in the end I had to ask -- via the DX Summit Spotting cluster -- for someone to listen for me. So I can't go full Luddite here. And I wouldn't want to have to use a rig this simple every day. No way. It is just too hard to use. But there is a beauty and a challenge in simplicity. There is some virtue in using just two transistors instead of 35 billion.

Thanks to N0WVA, W2UW, VU2ESE, HI8P, K4MQG, The G-QRP club and their inspirational journal SPRAT, the RBN and the DX Summit.

Minimalist Masochism at Solar Minima -- But More Contacts with the ET-2

Dylan Thoams

"Rage, rage against the dying of the light"

I thought of that line from Dylan Thomas's poem when I read on G3XBM's web site that we are kind of at the very bottom of the solar cycle. Roger wrote on 22 October: "Solar flux is 64 and the SSN 0. A=5 and K=0. As far as I am aware this is the lowest solar flux this solar minimum."

I also thought of this as I pounded brass (Indian brass!) in an effort to make a few more contacts with my ET-2 two transistor rig. Obviously venturing forth on 40 meters with just TWO transistors (one for transmit and one for receive) and crystal control AT SOLAR MINIMA is not for the faint of heart. It is almost a Dylan-esque act of defiance.

I have had to resort to please for help on the DX Summit, the SolderSmoke blog and the SKCC Schedule page. Fortunately for me, the brotherhood has sprung to my support.

W1PID (who gave me contact #3) also gave me contact #4 on 21 October.

W4KAC in Hickory NC was contact #5. This was on 22 October. This was the only marginal contact so far. He was running 5 W into an end fed half wave.

Yesterday was a big day for the ET-2. I had two solid contacts:

#6 was N2VGA in New York UPDATE: Larry N2VGA confirmed by e-mail that this was a "random" contact -- not the result of my on-line pleas for assistance. He just heard my CQ and responded. FB.

#7 was K4CML in Newport News, Va. He switched to QRP himself at 2.5 watts for a nice 2X QRP contact.

Looking at my Rigol 'scope, I now think I'm putting out about 150 milliwatts. Not bad for a single J310. I may have to invest in a heat sink.

40 seems most cooperative in the morning (around 0930 local) and again in the afternoon (around 1630 local).

Thanks to all who have helped. I will try to make a few more.

The ET-2 with Callsign Tattoos

This rig will probably soon turn into wall art here at SolderSmoke HQ. With this in mind I have started writing on the wooden base of the rig the callsigns of all stations worked. So far we have 10.   There is space for more.

Frequency is 7038.6 kHz.   I usually try for contacts around 1430 UTC (0930 Eastern) and again at around 2130 UTC (1630 Eastern). I post messages asking (pleading!) for assistance on the DX Summit site and on the SKCC Sked board.

If you are within reasonable range for a signal in the 100 milliwatt range (antenna is either 40 meter NVIS dipole or a doublet) please keep an eye on the DX Summit and/or SKCC sites and maybe try to have a contact.

Background on the rig here:

https://soldersmoke.blogspot.com/2019/10/more-on-et-2-better-pictures-and-more.html

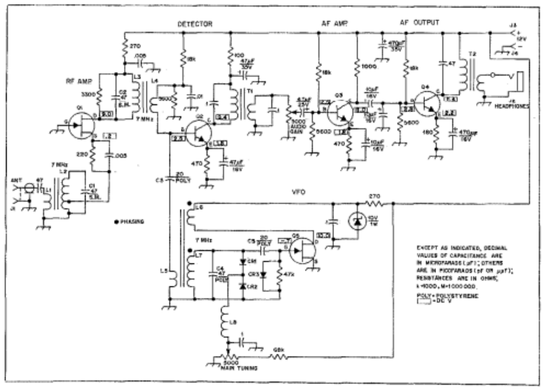
CHAPTER 5

Receivers

I believe the receiver is the heart of any ham radio station. This belief is rooted in very early ham radio experiences. I started out with a Lafayette HA-600A general coverage shortwave receiver. I was able to make many contacts with it, using a Heathkit DX-40 as the transmitter. But it was my acquisition of the Drake 2-B receiver (pictured above) that made me a receiver believer. It was as if I had been deaf, but with the 2-B, suddenly I could hear. Specifically I could hear incoming signals from the other side of the planet on the 15 meter band, signals that I had never heard with that poor old Lafayette. One night, I made contact with ZL2ACP, in Wai Pawa, New Zealand. I bounded up the stairs and woke my parents up to tell them this this astonishing news. That Drake 2-B was a big deal.

But there was another thing that made me believe in the centrality of the receiver: the conventional wisdom was that building a receiver was just too hard for radio amateurs. The ARRL and others encouraged us to perhaps try our hands at transmitter construction, but for the receiver, well, we should go commercial. Just buy one. Because, they said, building a receiver was hard to do. This made me think that to be a true radio amateur, I should accept this challenge and build my own receiver. So I tried… It took a while for me to get it working.

ANOTHER ATTEMPT AT THE HERRING AID 5 DIRECT CONVERSION RECEIVER



During the summer of 1976, at the age of 17, I made an audacious attempt to join the ranks of the true homebrewers. I tried to build a receiver. It was the Herring Aid 5 from the July 1976 issue of QST, a 40 meter Direct Conversion receiver intended for use with the famed Tuna Tin 2. As I have recounted on the podcast (perhaps ad nauseum), I never got it to work. My recent encounter with the ORIGINAL Tuna Tin 2 (Mojo was transferred to my BITX17, and it definitely works better now) got me thinking about this painful experience. I decided to try again.

There is an updated NORCAL schematic for this rig. I found it (and some good articles) on the NJQRP club page. In the original, designer Jay Rusgrove, WA1LNQ, used only parts that could be found at Radio Shack stores. In the days before the internet and Mouser, this was a good idea. Instead of toroidal ferrite and iron powder coils, Jay built his coils around Radio Shack solenoidal 10 uH chokes.

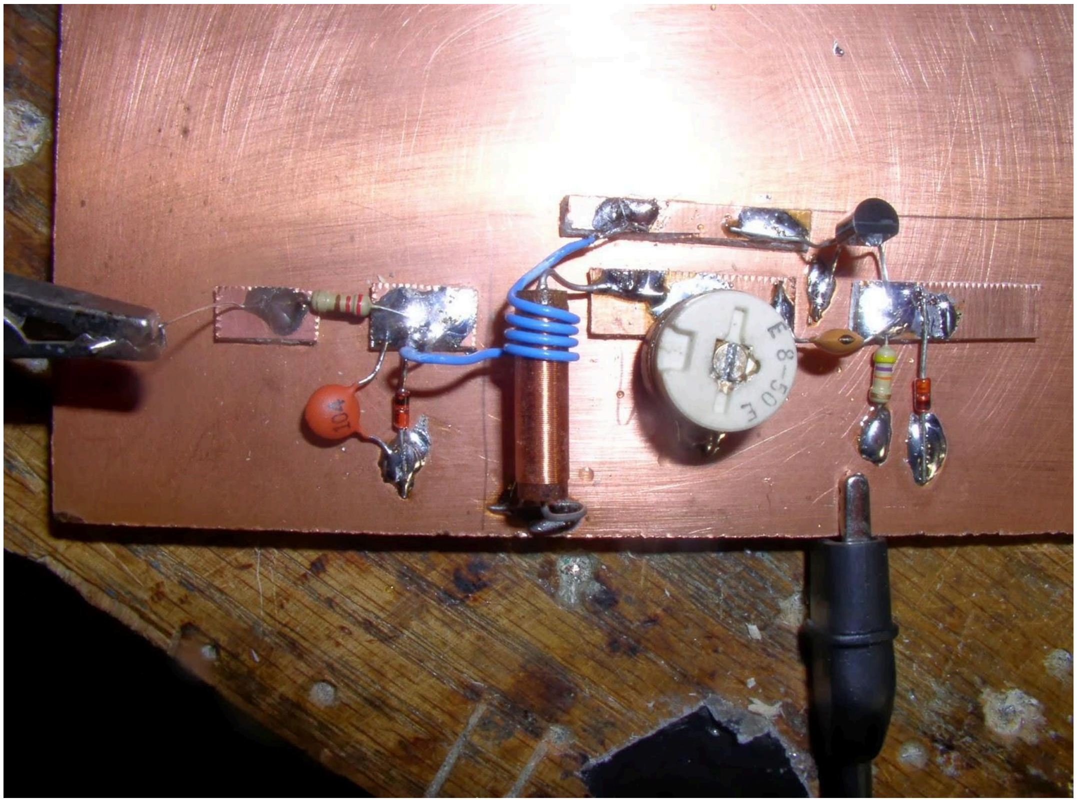
I now know that my problem was that I never got the oscillator working. I remember being able to hear signals with my "almost" receiver when I put my HT-37 in "CAL" mode and tuned through 40. I was so close! The Herring Aid was picking up RF from the HT-37 and using that in lieu of the LO energy that obviously wasn't coming from my Herring Aid VFO. But WHY didn't that oscillator work?

Today I started with the VFO. Again, it didn't work! But now I have decades of troubleshooting experience under my belt. So I poked around a bit. Then I decided to look closely at the phasing.

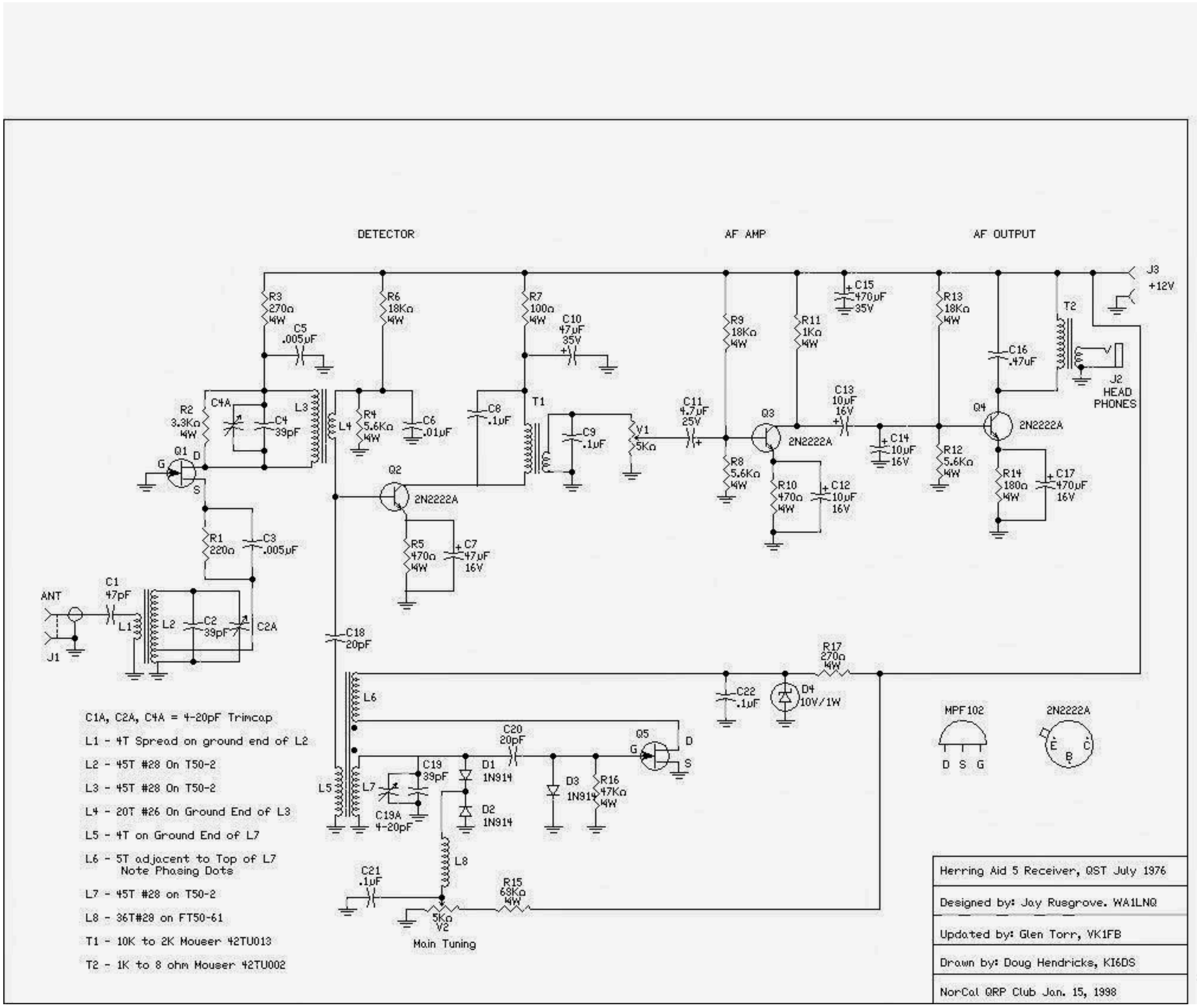
Take a look at the schematic(above) and the picture (below). L7 is the 10uH choke. L6 is 4 turns wound over it (or adjacent to it). Now, here is the key question: Look at the phasing dots. How would you guys connect those coils? For me, the schematic indicates that the TOP of L6 should go to the Zener and the BOTTOM of L6 should go to the drain of the JFET. The TOP of the choke should go over to C5, and BOTTOM of L6 should go to ground. Right? Or am I reading the phasing dots wrong?

Well, the oscillator was not oscillating in this configuration. Then I did something that I might not have known to try back in 1976: I reversed the phase of L6: I put the top of the coil to the Drain of the JFET and the bottom of the coil to the Zener. Bingo. The joy of oscillation. Now it works. (The picture below shows it as it is when the oscillator is working well.)

So, is there an error in that diagram? Was this not all my fault?



Aha! I just looked at the schematic of the NORCAL version. Check out the dots! I think that was the problem!


DETECTOR
AF AMP
AF OUTPUT
J3
+12V
J2
HEAD
PHONES
ANT
J1
C1A, C2A, C4A = 4-20pF Trimcap
L1 - 4T Spread on ground end of L2
L2 - 45T #28 On T50-2
L3 - 45T #28 On T50-2
L4 - 20T #26 On Ground End of L3
L5 - 4T on Ground End of L7
L6 - 5T adjacent to Top of L7
Note Phasing Dots
L7 - 45T #28 on T50-2
L8 - 36T#28 on FT50-61
T1 - 10K to 2K Mouser 42TU013
T2 - 1K to 8 ohm Mouser 42TU002
Main Tuning
MPF102
D S G
2N2222A
E B C
Herring Aid 5 Receiver, QST July 1976
Designed by: Jay Rusgrove. WA1LNQ
Updated by: Glen Torr, VK1FB
Drawn by: Doug Hendricks, KI6DS
NorCal QRP Club Jan. 15, 1998

Sure, this receiver is not "state of the art." But that's the whole point. I wanted to finish the receiver project that I couldn't finish back in 1976.

I tried to stick as close as possible to the original design and parts. NORCAL came up with an updated schematic in 1998 with parts that are more readily available. But Designer Jay Rusgrove was shooting for something that could be built with all the parts coming from Radio Shack. I think that is probably one of the factors that attracted me to the project way back when. That's why Jay went with varactor tuning (no hard-to-get variable caps!). And that's why he used coils that were wound on Radio Shack 10uH RF chokes (no need for hard-to-find toroidal cores). In this sense there is some common ground between the BITX rigs and the Herring Aid 5.

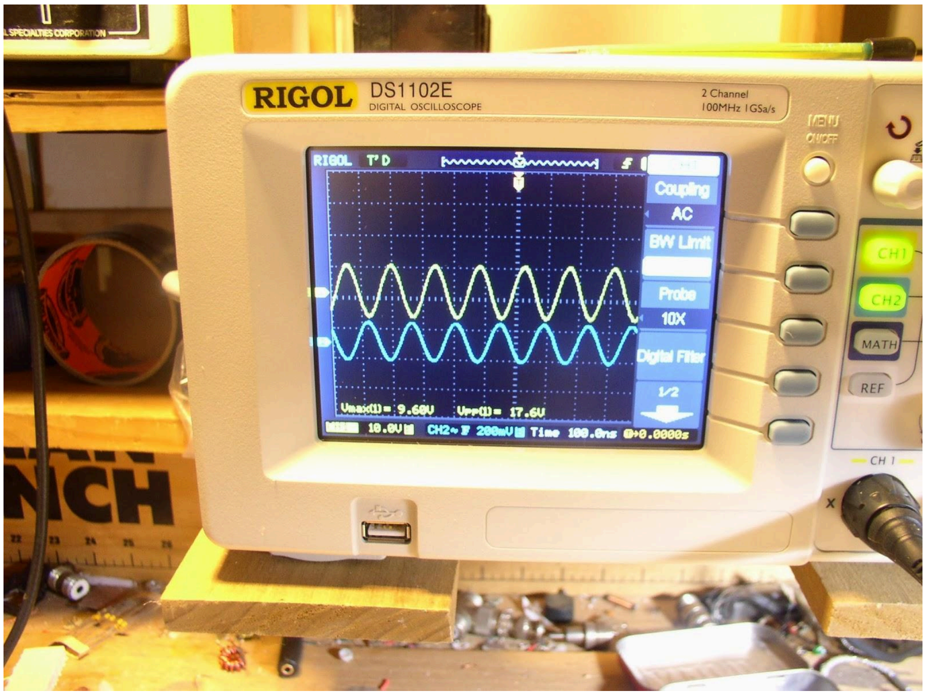
I stuck with the RF-choke as a coil idea for the VFO, but went with the NORCAL-prescribed toroids for the front end and mixer coils. (I may go back and try to use chokes in these circuits, but I'm not sure my junk-box will yield the kind of RF chokes that Jay used).

I wish I had known a few things when I was building this back in 1976: More knowledge about how to wind the coils would have been a big help. I wish I had realized that I could use a SW receiver to get the oscillator on the right frequency. I guess this was in the days before Ugly and Manhattan building techniques, but it would have been nice to know that there was no need to actually etch a board for this project (I did!).

The coils really are a bit tricky. Jay didn't use any trimmer caps, so I guess you had to just hope that the front end coil and cap resonated somewhere near 40 meters. As for tuning the oscillator, Jay recommended scrunching and un-scrunching the turns on the RF choke. Yikes! Give me some trimmer caps!

I also found that you have to watch the level of the RF going from the oscillator to the mixer. Too much, and the receiver is deaf. Too little, same result. You need to experiment a bit with the number of turns on the pick-up coil from the oscillator.

The warnings about the pitfalls of that single BJT mixer were right on the mark: Lots of AM SW breakthrough. But I kind of like the background music. Strong RFI from local FM broadcast stations was another story (WMZQ is a country music station!). I reached into my junkbox and found a low-pass filter from a Heathkit DX-60. I just put that between the antenna and the receiver and the country music was GONE!



Opposite "sense" winding and resulting phase shift

I thought I had discovered an error in the schematic that (I hoped) explained my failure to get this simple receiver running (scroll down for details). But Dex, ZL2DEX, in New Zealand spotted something that got QST off the hook and put all the blame back on me:

I had failed to check the rotational sense of the windings. The schematic called for 4 turns over the Radio Shack choke. So I just went ahead and wound them. I didn't pay any attention to the direction of the winding. I then hooked it up in accordance with the phasing dots in the diagram. And it didn't work. So I switched the coil connections around. And it worked. Aha! I thought! QST messed up! It wasn't my fault.

Dex brought me back to reality. He noted that I probably wound the coils with the wrong rotational sense. I confirmed this. I rewound the coil following the rotational sense of the choke. I hooked it up following the phasing dots of the schematic. This time the oscillator started right up. So the problem wasn't an incorrect drawing of the phasing dots. Instead it was my failure to remember that phasing is more than just the top or the bottom of a transformer's winding. Rotational sense is also important. That's why "phasing dots"are sometimes referred to as "sense dots."

This doesn't come up very often, because most of the toroidal transformers we make are bifilar or trifilar -- the windings are always in the correct sense because we twist the wires together before putting them on the coil. When we look at those phasing dots, we are focused on getting the proper tops of coils connected to the appropriate bottoms of other windings. We don't pay any attention to the sense of the windings. Thanks to Dex for bringing me back to my senses :-o

Grob's Basic Electronics has this definition for those phasing dots:

"Used on transformer windings to identify those leads having the same instantaneous polarity."

This morning I did a little experiment to confirm all this: I took a toroidal core and wound a little transformer. Using a dual trace scope, I looked at the input and output wave forms. Sure enough, when the windings are in the same rotational sense, there is no phase shift. But when that secondary is wound in the opposite sense, you get a 180 degree phase shift. I know this is very basic, but it was fun to re-learn it and to confirm it.

I really love this little receiver. I have it playing 40 meter CW as I type. It sounds great. I feel the urge to build a Tuna Tin 2 and put both of them on 40.

In the original Tuna Tin 2 article, Doug DeMaw notes that Jay Rusgrove was thinking of doing a companion receiver and says that he was thinking of calling it the "Clam Can 5" ! There were jokes about receivers for hams with "tin ears" and about there being "something fishy" about these rigs.

Thanks to Doug DeMaw and Jay Rusgrove and QST for bringing us these little circuits.

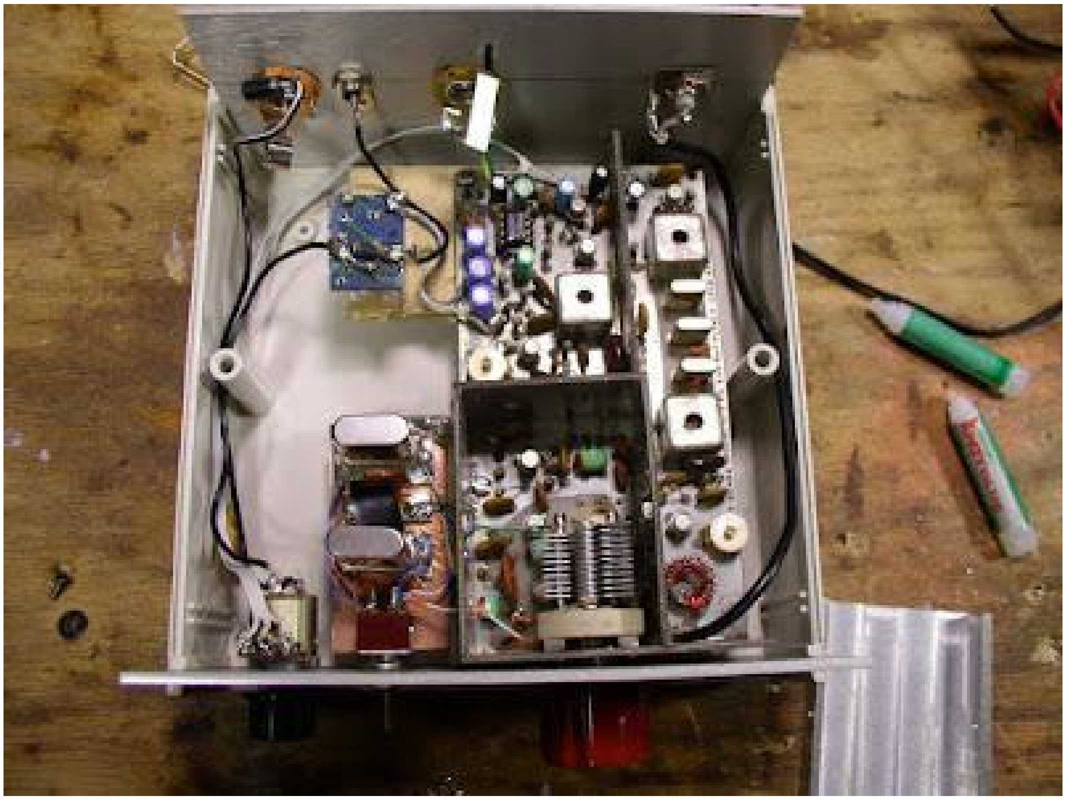
BACK TO THE BAREBONES

December 2011

My rehabilitation of homebrew 17 meter gear from the last solar cycle continues. Following the same path that I followed in 2001-2002, I will now move from DSB to SSB. I pulled out the little receiver that I put together way back when. It is a version of Doug DeMaw's "Barebones Superhet" (aka "Barbados Superhet"). I bought it on the net. It had been put together by a skilled builder on a FAR Circuits board. The fellow who built it had changed the IF from Doug's original color burst freq (3.579 MHz) to 5 MHz. He had also put in a varactor controlled VFO using a DC voltage multiplier to get more voltage variation across the varactor. I also think he had it built for 20 meters. I converted it to a 17 meter receiver. I put in a VXO, using two crystals controlled by a panel switch. I also changed the caps in the filter so as to broaden the response for SSB. As I was going through all these modifications, I turned to the USENET for help and advice. Dale, W4OP, came to my assistance. Little did we know how DETAILED his familiarity with my RX was:

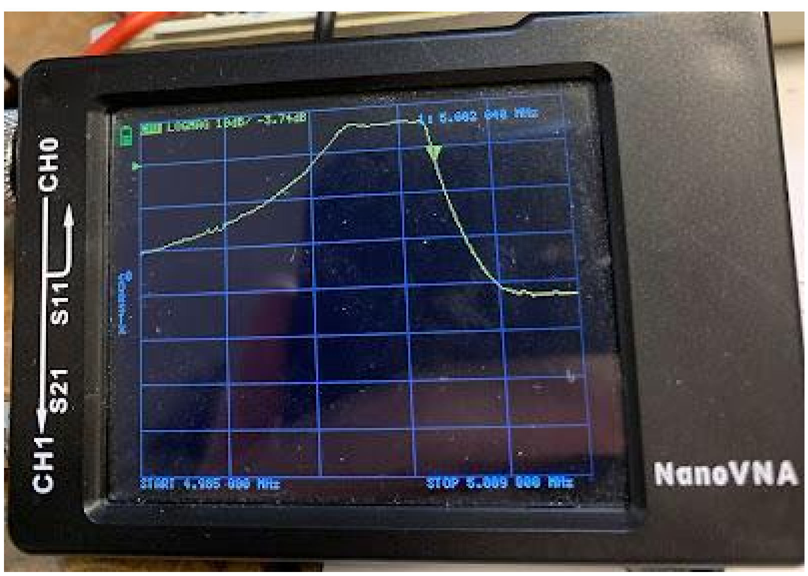
"Bill N2CQR MOHBR" ...@virgin.net> wrote in message news:22f6e3ee.0503292244.1b9a1481@posting.google.com...
> Dale: Wow, another Barbados RX builder. That was my first successful > superhet project. I now have the one I built (still on 20), and this > morning > I got another one (the one built by someone else on a factory-made > board)going on 17 with a VXO. I have a THIRD partially built Barbados > RX board. If this > keeps up, I'll soon have a BBRX museum. >Hi Bill,
Did I sell you mine years ago? I seem to recall using a temp stabilized varicap in a shielded enclosure for main tuning. It was done on a factory board. Or was that a 6M xverter I sold?
Dale

Newsgroups: rec.radio.amateur.homebrew
From: meara.lon...@virgin.net (Bill N2CQR MOHBR)
Date: 30 Mar 2005 22:33:57 -0800
Local: Thurs, Mar 31 2005 1:33 am
Subject: Re: Homebrew projects
Dale: Wow, small world! Yea I think that is the one I'm working on. I think you also had a DC-DC converter to bring the voltage to the varicaps up. Very nice enclosure for the oscillator. I now have it percolating nicely as a VXO around 23 Mhz (for the 17 meter band). Bill



[Putting a Barebones Superhet on 17 Meters with an NE602 Converter (Video)]

Armed now with a NanoVNA, I took a look at the passband of the 5 MHz filter in my Barebones Superhet (BBRX) W4OP built it on a Circuit Board Specialist Board. He put a 5 MHz CW filter in there; I broadened the passband for phone by changing the values of the capacitors. Here is what the passband now looks like in the NanoVNA:



This is what DeMaw would call an "LSB filter." You would get much better opposite sideband rejection by using it with an LSB signal, placing the BFO/Carrier Oscillator slightly above the passband, in this case near 5.002 MHz.

When I first built the down converter to get the 18.150 MHz signal down to the 7 MHz range (where I had the receiver running) I used an 11 MHz crystal for the NE602's local oscillator. But this created a big problem: 18.150 - 11 = 7.150 MHz. That is in the 40 meter band, but note: NO SIDEBAND INVERSION. Then in the BBRX 7.150 MHz - 2.150 MHz = 5 MHz (the filter frequency) but again: NO SIDEBAND INVERSION. The signal started as a USB signal and remained a USB signal.

I briefly tried shifting the BFO frequency to the other side of the filter passband. If I could get it to around 4.985 MHz, it might work, but because the filter passband was so large, and because the crystal frequency was so low, I was unable to shift the crystal frequency that far. In any case the results would have been less than ideal because of the "LSB" shape of the filter. Back to the drawing board.

I decided to <u>cause</u> one sideband inversion.

At first I put a 25.175 MHz crystal module in my down converter. This shifted the 17 meter phone band down to the 40 meter CW band. It worked, but I cold hear strong 40 meter CW signals being picked up by the wiring of the receiver (the box is plastic!). I went back to the module jar in search of frequency that would move 17 meter phone to the 40 meter area (so I would not have to re-build the BBRX front end) but outside the actual 40 meter band.

I ended up using a 25 MHz crystal in the down converter. 25 MHz - 18.150 MHz = 6.85 MHz WITH SIDEBAND INVERSION. After checking on the NA5B Web SDR to see that there are no strong signals in the 6.835 to 6.89 MHz range, I retuned the output circuit on the converter and tweaked the input capacitor on the Barebones. I shifted the VFO frequency down to 1.835 to 1.89 MHz and put the BFO at 5.002 MHz. The receiver was inhaling on 17 meter SSB.

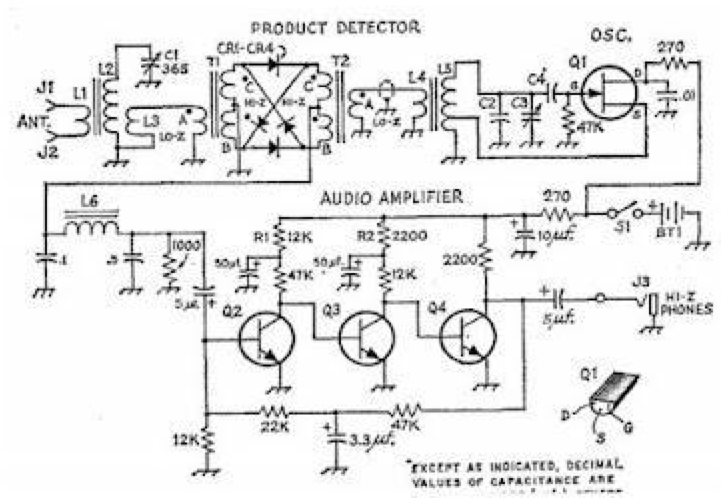
One more change to the BBRX: in his June 1982 QST article, DeMaw warned that trying to get speaker level audio out of the 741 op amp that he used would result in audio distortion. And it did. So I put one of those little LM386 boards I have been using into the BBRX box. I just ran audio in from the wiper of the AF gain pot. It sounds good.

In effect this is my first double-conversion receiver. I usually prefer single conversion, but this project has highlighted for me one of the advantages of double conversion for someone like me who eschews digital VFOs: Starting with a crystal filter at 5 MHz, with double conversion I could keep the frequency of the LC VFO low enough to ensure frequency stability. That would have been impossible with a 5 MHz IF in a single conversion 17 meter rig. But if I were starting from scratch for a 17 meter rig, I could stick with single conversion by building the filter at 20 MHz, keeping the VFO in the manageable 2 MHz range.

Now, on to the SSB transmitter. The Swan 240 dual crystal lattice filter from the early 1960s needs some impedance matching.

SUNDAY, AUGUST 9, 2020

Presence (Absence?) and Direct Conversion Receivers (with wise comments from Farhan)



DC RECEIVER FROM 1968 PAPER.

Hello Bill,

I was reading an online article by Wes Hayward, W7ZO from 1968 about the history of direct conversion receivers (http://w7zoi.net/dcrx68a.pdf) . It was linked in an email in qrptech. It recounts how he had first build a dc receiver with a single diode for the detector, and how microphonic it was, and dissatisfying an experience. This was in the early days of solid state devices, and so they were hard to come by. He describes meeting another ham engineer at work Dick Bingham, W7WKR who immediately recognized that what he needed was a diode ring mixer. The story goes on to describe their experiments, and success at this design.

They decided to write up the design for QST. I won't bore you with the details...the article is well worth reading about how Wes mailed the radio and the design to ARRL, and how it ended up in the hands of a new person on their staff there, Doug DeMaw, W1CER (later W1FB.). Here is an excerpt from the article describing Doug's reaction to the receiver:

"This was the epiphany, the moment when Doug realized that solid-state technology had produce a new way to build a simple receiver. Doug tuned the receiver higher in the band and found some SSB. Again it was like nothing he had ever heard. It was as if the voice came from the same room. Doug used the term *presence* in his description."

Here I present the earliest use, that I know of, of presence being used to describe a receiver.   I have to say when I read it, I immediately thought of you guys, and decided to share.

Thanks for all you guys do.
dave   /nt1u

Bill replied:

Thanks Dave.   Yea, that's the 1968 article that launched the use of DC receivers. I had forgotten about DeMaw's early use of "presence."

Just to cause trouble, perhaps we should start commenting on "absence" i.e. "I dunno OM, I think your rig lacks a bit of absence in the mid-range... turn menu item 63b to ELEVEN!"
:-)
73 Bill

Farhan wrote:

Mon, Aug 3 at 3:22 PM

When I got my license, my friend Anil SM0MFC was living in Hyderabad. He lent me his HW-8. I stringed up a 40 meter dipole with a lamp cord and worked with it. Somehow, the combination of the lamp cord length and the 40 meter inverted V made it resonate on 20 m as well. The HW-8 had a nominal antenna tuner and I worked pretty good DX.

Till date, it remains the best receiver that I have used for regular contacts. The only trouble it had was the the MC1496 was a nominal detector, it overloaded heavily with shortwave broadcast stations. There was an unnecessary RF amplifier in the front-end that they could have done without.

I made several direct conversion receivers, but never managed to hang on to any. This makes me want to build one, one of these evenings. I even have a KK7B R1 kit. but real men solder on without any PCBs or even circuit diagram!

A 7/14/21 direct conversion radio that puts out 3 watts of power is what my ideal setup would be. I am not too bothered with the images on CW. I just tune them out in my head. Real soon now, at the moment, i am trying to finish a radio that has been in the works for years. Finally, I am making some headway.
-f
--
Farhan of course is no slouch in the DC receiver area. Years ago he wrote a wonderful post about building a DC receiver with his cousin for her class project:
https://web.archive.org/web/20171109081542/http://www.phonestack.com/farhan/dc40.html

Included in this post was a passage that I included in my book SolderSmoke -- Global Adventures in Wireless Electonics:

Why build a receiver?

Why do you want to build it? These are available at the Dubai Duty Free **asked Harish, an old friend, when he spotted us struggling over the DC40 one evening. I didn't have an answer to this question and considering the amount of work piled this quarter, it appeared to be a sensible thing to ask.**

I think this question is answered by us all in different ways. My personal answer would be because we human beings are fundamentally tool builders. We have an opposable thumb that allows us to grip the soldering iron.

For an engineer (by the word 'engineer', I don't just mean those who have a degree, but anyone who applies technical knowledge to build things) the act of building a receiver is a fundamental proof of her competence and capability. It is much easier to put out 1 watt signal than it is to receive a 1 watt signal.

A simple definition of a good receiver is that a good receiver consistently, clearly receives only the intended signal, such a definition hides a wide range of requirements. The receiver has to be sensitive enough to pick up the weakest signal imaginable (note: clearly), it has to

be selective enough to eliminate other signals (only), it has to be stable enough (consistently).

For a ham or an engineer, building a usable receiver is a personal landmark. It establishes a personal competency to be able to understand the very fundamental operation of the radio and mastery over it.

Bill: OM Ryan Flowers did a 5 part series on building the DC40. If you are want to build one, I suggest you use the schematics on Ryan's site. There was an error in Farhan's original schematic -- Farhan corrected it but some of the incorrect schematics are still floating around the internet. Here is part one of Ryan's series:
https://miscdotgeek.com/building-direct-conversion-receiver-part-1/

Farhan's DC40

PHASING RECEIVER

For years, the letters I and Q had been popping up in articles about ham radio receivers. This was usually in connection with new-fangled "software defined radio" or SDR. These receivers take much of the work done by the amplifiers, mixers and filters in our receivers, and hand this work to the computer. Essentially, there is an analog-to-digital converter that takes a stretch of the electromagnetic spectrum, digitizes it, and makes it available for display and manipulation on a computer. Obviously this opened fantastic possibilities: in our old hardware defined radios, for example, the bandwidth of a filter was determined by the physical characteristics of the coils, crystals and capacitors that we soldered in. But in SDR, that bandwidth could be varied with a few keystrokes – it could be broadened to allow an AM shortwave broadcast station to be heard in its full 10 kHz of glory, or narrowed down to a tiny 1 Hz to let a the tiny, weak and slow signal from a distant WSPR station become detectable.

The possibilities were enticing, but my ludite curmudgeon tendencies kicked in and I tried my best to ignore all this. These SDRs seemed to take all the circuitry away from us, turn it into lines of code, and stuff it into little black mystery box integrated circuits. Heck, they were even stuffing SDRs into USB sticks and calling them "dongles." Yuck.

But still, the talk of I and Q was alluring. It reminded me of something, something very old in radio, something that had tormented me as a young ham: phasing.

In —---------- I described my struggle to understand the phasing method of single sideband generation. This was the technique used in my beloved Hallicrafters HT-37 transmitter. I noticed that the SDR receivers seemed to be using a similar technique. I found it intriguing that these ultra modern devices would be using the same techniques used in my 1959 tube-type transmitter.

There were other things that lured me in. For years I'd been reading about "binaural" receivers. Somehow these receivers sent to the two headphones two slightly different versions of the same incoming radio signal. One was the I channel, the other the Q channel. This reportedly created a strange stereo-like effect. The Morse Code, it was said, seemed to move around in your head as you tuned the receiver. There was a whiff of the psychedelic 60's in the discussions of the binaural receivers. It's groovy man, the CW floats around IN YOUR HEAD." Our friend Farhan in India wrote that there are two kinds of hams – "those who have listened to I and Q, and those who have not."

As described earlier, I'd been building digitally synthesized oscillators. Paul Darlington M0XPD and the Kanga UK company had sent me an Arduino Shield that carried the AD9850 synthesizer. Paul and Kanga had wisely included on the shield a few additional chips that took the output of the AD9850 and converted it to two streams of square waves, one 90 degrees behind the other. One morning, I realized that on that little Kanga shield, I had a good portion of the circuitry needed to move into the world of groovy binaural receivers and Software Defined Radios. And in the back of my mind was another, closely related project: Rick Campbell's R2. But first I had some understanding to do. Why would those additional chips on the Kanga board be useful in a receiver? Why would it help to split that VFO signal into two streams, identical but 90 degrees apart?

Understanding: I and Q and Phasing Receivers

I'd been through this battle before, but then it was on the transmit side. See Chapter 4 for a description of my teenage tech-agony and my eventual breakthrough. Now I was struggling with essentially the same questions, but now on the receive side.

Consider a direct conversion (DC) receiver. They are very simple, just an oscillator running at the operating frequency, a mixer, and some audio amplification. For some reason they sound especially good. Some think this has to do with their simplicity – they seem to put your ears close to the actual signal, close to the ether. They are very "frequency agile" -- just by changing the frequency of that oscillator you can move across wide swaths of the electromagnetic spectrum, practically from DC to daylight. That is quite useful.

But that simplicity and agility comes with a price: Suppose you are trying to receive a signal on 7010 kHz CW (Morse Code). You tune your oscillator to 7009 kHz. Your mixer produces sum and difference frequencies. The sum will be far beyond the audio range and is easily filtered out. The difference frequency is what you want. That difference frequency will be a nice 1 kHz audio tone, which is what you send to your audio amplifiers and, eventually, your headphones. All is well.

But wait! Right in the middle of your conversation you are disturbed by another station in your headphones. Right on your frequency. You think, "How rude. What a lid!" But not so fast! Remember you are on a direct conversion receiver. That other station could be quite far away, say on 7008 kHz. With your VFO set at 7009, that signal will also produce a 1 kHz tone in your headphones. Welcome to the world of DC receivers. You are listening to "both sides of zero beat." We use the term "zero beat" because a signal coming in on exactly the same frequency as the VFO would not "beat" with the VFO energy and would not produce any audio. The beat frequency would be zero. The signal coming in on 7010 would "beat" with your oscillator to produce 1 kHz tone. But so would that signal on 7008 kHz. This is also sometimes referred to as hearing "the image." In describing this interference problem we sometimes talk of "listening to both sidebands" but this terminology can be confusing. Here it is better to think in terms of "listening to both sides of zero beat" or "both sides of the VFO frequency."

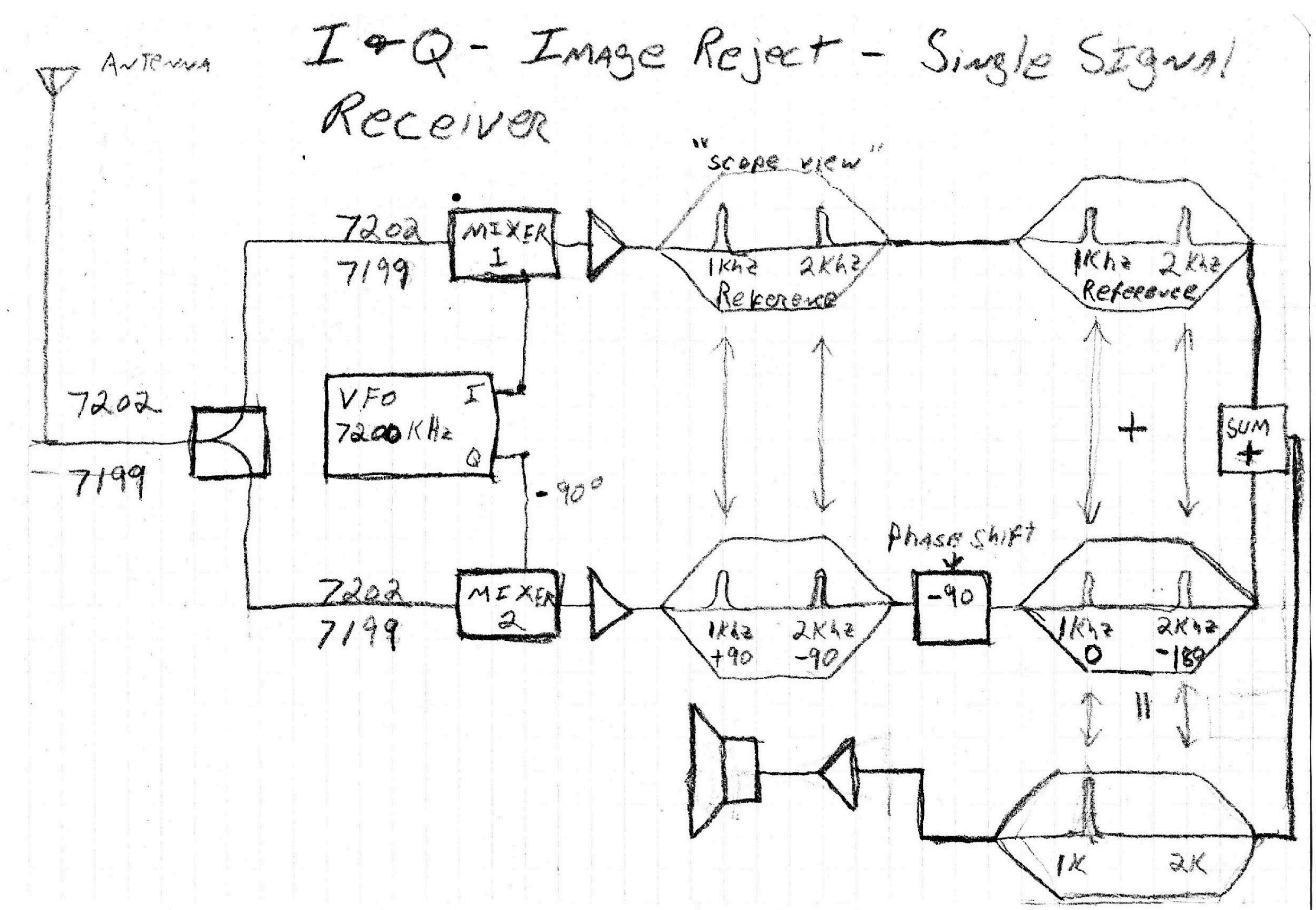
Obviously this situation is far from ideal. Our little direct conversion receiver is charming, simple and frequency agile, but it is pulling in twice the needed frequency spectrum and exposing us to a lot of interference. We could solve this problem by going to a superheterodyne design that involves the conversion of all incoming signals to a single intermediate frequency at which sharp filters are used. But if we do this we lose the advantages that come with direct conversion. The phasing method allows us to keep the advantages of direct conversion while eliminating the "both sides of zero beat" problem.

As I know from bitter teenage experience, phasing methods can be hard to understand. In fact, I think very few hams actually understand how phasing transmitters and receivers really work. Many can recite the trigonometric formulae that provide a mathematical explanation, but if asked, I think very few hams could accurately describe in words how these circuits actually manage to produce a single sideband signal or receive on only one side of zero beat. This is a shame, because I think there is real beauty and cleverness in these phasing designs. Let me take a shot at explaining how they work.

There are a couple of important things to keep in mind as we get started: The first has to do with phase is relative. If I say that something is 90 degrees behind, you have to ask, "Behind what?" In

my description, I will be talking about "reference signals." These are arbitrarily designated references that answer the "behind what?" question. Behind what? Behind the reference signal.

The second has to do with mixers. Remember that mixers produce complex repeating waveforms. Complex repeating waveforms are composed of multiple sine waves. Among those sine waves we will find a signal that is the sum of the two inputs and one that is the difference of the two inputs. These outputs will also have specific phase relationships determined by their frequency relationships to the local oscillator or VFO. Remember that last sentence.



The first thing we do is we build an oscillator that has two outputs, one 90 degrees behind the other. We say they are in quadrature. One is called "I" for "In phase" the other is called "Q" for "Quadrature." I did this with the AD9850 board from Kanga UK.

We then build TWO simple direct conversion receivers. I used simple SBL-1 mixers followed by audio amplifiers.

To the mixers we connect outputs from the quadrature VFO. So the mixers are getting the same frequency from the VFO, but one is getting it 90 degrees behind the other.

To the mixers we also send the RF signal coming in from the antenna. Here both mixers get completely identical signals. The RF signal just goes through a "splitter." This splitter does not introduce any phase shift.

Now, using the more complex receiver described above, let's tune into another signal, and deal with a slightly different interference problem. This time the desired signal is on 7199 kHz. We will start out just listening to the output from Mixer 1. We tune our oscillator to 7200 kHz and hear a nice 1 kHz tone. All is well. But again, an interfering signal appears. This one produces an annoying 2 kHz tone in our headphones. It is obviously not exactly on our frequency, but we can hear it. We suspect that some "lid" has rudely plopped down very close to us, perhaps on 7198 kHz, but, as with the case described earlier, he is in fact innocent of lid-ness. He is far away in frequency, on 7202 kHz. But because we are using a direct conversion receiver that signal mixes with our VFO and produces the annoying 2 kHz tone. We are again hearing "the other side of zero beat" or the "image" in our direct conversion receiver. But now we are close to having the circuitry needed to prevent that 7202 kHz signal from bothering us. We are getting close to the promised land of "image rejection" and "single signal reception."

Let's take a look at the signals coming out of the two mixers. First let's look at the top one. This is important: The output from Mixer 1 will be our REFERENCE SIGNALS. From here on, whenever we discuss phase we will be doing so in reference to the output of the output from Mixer 1. You will get lost if you don't keep that in mind.

In Mixer 1 the desired signal on 7199 kHz mixes with the VFO signal of 7200 kHz and produces a difference frequency of 1 kHz. Also in Mixer 1 the undesired signal on 7202 kHz produces a difference frequency of 2 kHz. We hear them both. They are shown in the little spectrum scope in the diagram.

Something very similar is happening in Mixer 2 on the bottom. But remember: Mixer 2 is being fed with a VFO signal 90 degrees behind that going into Mixer 1. As you might expect, the 2 kHz signal coming out of Mixer 2 is 90 degrees behind the 2 kHz coming out of Mixer 1. After all, the VFO signal going into the mixer on the bottom is 90 degrees behind the VFO signal going into the mixer on the top. The result here is quite intuitive.

But something significantly different happens when that desired 7199 kHz signal moves through the two mixers. This signal is producing a 1 kHz tone in both outputs. Again, remember that the output from Mixer 1 (on top) are our references. When we look closely at the 1 kHz output from the bottom amplifier (Mixer 2), we discover something that is centrally important to the phasing technique: The 1 kHz output from Mixer 2 is NOT – as you might expect – also 90 degrees behind the 1 kHz signal coming out of Mixer 1. Instead this one is 90 degrees AHEAD of the 1 KHz signal from Mixer 1. That is very important.

Take a look at the diagram. The 1 kHz signal coming out of Mixer 2 is 90 degrees ahead (+90 degrees) of the 1 kHz signal from Mixer 1. The 2 kHz signal from Mixer 2 is 90 degrees behind (-90 degrees) the 2 kHz signal from Mixer 1. It is that difference in phase that allows phasing transmitters and receivers to work.

Remember what we want to do: We want to get rid of that interfering signal coming in on 7202 kHz. That is causing the 2 kHz tone. We want that 2 kHz tone to disappear. We want to "reject the image."

For signals to "null each other out" they have to be of identical frequency and amplitude, and 180 degrees out of phase. For example, when one it hitting +2 volts, the other is -2 volts. Combine the two signals and they disappear. If they are "in phase" they reinforce each other.

Take a look at the phase relationships coming out of the two mixers. Neither the 1 kHz signals nor the 2 kHz signals are, at this point, 180 degrees out of phase with their counterparts from the other mixer. But we can easily make that 180 degree phase shift happen, and happen only to the offending, interfering image signal.

Watch what happens when we add some circuitry that adds an additional 90 degrees of delay to the output from Mixer 2. (There are many ways to do this.) Adding an additional 90 degrees of delay to the Mixer 2 output makes the bottom 1 kHz signal IN PHASE with the 1 kHz signal from the top (Mixer 1) circuitry – it has a phase difference of 0 degrees. But the 2 kHz signal from Mixer 2 is also getting an additional 90 degree delay. That leaves the 2 kHz signal from Mixer 2 180 degrees out of phase with the 2 kHz signal from Mixer 1. BINGO! Now, if we combine the signals from the top (Mixer 1) with those from the bottom (Mixer 2) , we will reinforce the desired 1 kHz signal, and null out the undesired 2 kHz signal. Pretty cool, eh?

And this nulling out phenomenon will apply to ALL signals coming in above the VFO frequency. This means, in essence, that instead of producing audio output for any signals above and below the frequency of the oscillator, this receiver will now produce output only for signals below "zero beat." It will "reject the image." Through a rearrangement of the I and Q oscillator outputs and/or the placement of the 90 degree phase shift network, we can set the receiver up to respond to signals either above or below zero beat. This is allows us to set up the receiver for Upper or Lower Sideband reception. The advantages of the direct conversion receiver are maintained, while the principal disadvantage is, in a very clever way, eliminated.

If we really want to understand how this kind of circuit works, we need to go back a bit and explore the phase relationships that exist in the outputs of the mixers. Why is it that in that bottom mixer the 1 kHz signal is 90 degrees ahead of the reference signal while the 2 kHz signal is 90 degrees behind?

At this point you might want to go back to review the mixer theory discussed in Chapter XX. Here is a summary:

1). When two signals are fed into a non-linear device, they mix to produce a complex repeating wave.

2). We know from Fourier that any complex repeating wave is composed of a number of sine waves.

3). The output of the mixer will include waves that are the sum of the two inputs and the difference of the two inputs.

These are just the physical facts of life for mixers. This is how signals interact and combine when they go into non-linear systems. This can all be describes very well with trigonometry.

But there is an additional fact of life for mixers that is at the heart of the phasing technique: The phase relationships between mixer outputs differ depending on whether the input signal is above or below the local oscillator or VFO. That is the physics fact that allows us to create transmitters that send out SINGLE sideband signals, and direct conversion receivers that respond to only one side of zero beat.

Look at it this way: If in the example above in the bottom circuit both the 1 kHz signal and the 2 kHz signal came out of Mixer 2 90 degrees behind the signals coming from Mixer 1, there would be no way for us to distinguish between the two, no way for us to null out the undesired one. Fortunately for us, there is an inherent difference in phase between a signal that comes in higher in frequency than the local oscillator and one that comes in lower in frequency than the local oscillator. This is not about whether we are selecting sum or difference frequencies –in our receiver we are always working with difference frequencies. Instead we are dealing with frequency relationships between incoming signals and the local oscillator, and the phase differences that result. It is the phase differences that allow phasing rigs to work.

Back in Chapter 4 I wondered about the origins of the phasing technique: Was this something conceived of by a study of the mathematics and later put into practice? Or did some stumble upon this at the workbench, with the mathematical explanation coming later? I looked into this and learned that the math came first. In 1914 it was established mathematically that an AM signal is composed of the carrier and two separate sidebands. (Many hams resisted this notion, claiming that sidebands were just math tricks that didn't exist in the real world.) In 1915 John R. Carson applied for a patent for the idea of suppressing the carrier and one of the sidebands. Early single sideband systems were essentially filter rigs, generating SSB at low frequencies using LC filters and then up-converting to the desired frequency range. Ralph V.I. Hartley (of Hartley oscillator fame) patented a phasing SSB system in 1928 but the technology was not available to actually build one. In 1946 R.B. Dome designed a wideband audio phase shift network that would make the critical 90 degree phase shift described above possible. One year later, Oswald "Mike" Villard W6QYT put the Stanford University Amateur Radio Club station W6YX on the air (75 meters) with a phasing transmitter using Dome's circuit.

BUILDING A RECEIVER WITH AN HRO DIAL

As I've mentioned, I am building a superhet receiver around the beautiful National Radio gearbox/dial that Armand WA1UQO gave me. First step was to build the VFO. Before I started, I went back to Doug DeMaw's books and read his words of wisdom on how to build stable VFOs. I followed his advice:

-- Air core coils.
-- Tuning capacitors with bearings at both ends.
-- NPO fixed capacitors.
-- All frequency determining parts in a separate box
-- Run the oscillator stage at lower voltage (6 volts)
-- Stable solid physical construction.
-- One-sided PC boards.

I went a bit further. I wound the main coil on a cardboard tube from a coat hanger. I coated it with several layers of clear nail polish. I glued it down with a generous dose of gorilla glue.

There are some fixed caps in the circuit. I didn't want them physically hanging off other parts, so I used bits of balsa wood to support them.

I put the actual oscillator stage in its own Altoids tin and attached this tin to the bot that held the main coil and capacitor. I put the 6 volt Zener diode and its dropping resistor on the outside of the box to minimize heating. The buffer and amplifier went into another Altoids tin. I used a wooden grilling plank from Whole Foods as my base.

At first, Armand's gear box and reduction drive didn't seem wo work very well. There seemed to be a lot of "play" in the mechanism. Some words of wisdom from Pete N6QW and the blog Dave AA7EE provided the solution. There is a spring in the gearbox that hold the teeth of the gears together and prevents the kind of play that I encountered. With guidance from Dave, I was able to put some

ACTIVE DECOUPLING

TO David VK5DGR

Wow David, I was really pleased to find out that there is someone else out there interested in how this active decoupling circuit really works.

When I looked at your write up -- especially the LTSPICE simulations -- it was quite eerie. I have the same simulations here.

I think we might have slightly different takes on this.

I think you can see the circuit as TWO different circuits. The 47K resistor and the 10uF cap form a standard RC low pass filter with a very low Fc. That obviously will make a big contribution to knocking the noise down, but the voltage drop across that resistor could be problematic, right?

The second element is the transistor. I think that it too -- by itself -- would contribute to the filtering. This is because the emitter current is FAR MORE of a function of base current than it is of the collector voltage (where the noise is).

With the LTSPICE model, disconnect the 47K resistor and the 10uF cap. Cut the line from the collector to the base circuit. Set up a separate 11 volt source and feed that through another 47k resistor to the base. Watch the noise output. It disappears.

So the RC circuit in the base can be seen as a way of getting the needed 11 volts DC without the noise. The transistor itself contributes to the noise reduction and -- of course -- also makes a big contribution by carrying the current to the load. This avoids the voltage drop you'd get by trying to pull that current through just the RC filter.

I'm not quite sure of my analysis. What do you think?

Hi Bill,

Yes I was riding my bike yesterday here (on a 38C Adelaide day!) listening to SolderSmoke and heard you talking about this circuit and it rang a few bells! Fine Business - really getting our head around these circuits is one joy of the hobby.
I like your analysis - the step of holding the base at a fixed voltage is a very useful thought experiment (or simulation).
Yes I agree the the resistor selection is a trade off between DC voltage drop and filtering. The gain of the transistor makes it possible to decouple the two circuit elements, at the expense of a little voltage drop to keep the transistor away from saturation.
I also went a little nuts analysing an oscillator that wouldn't start and again trying to find the source of a notch in a double tuned filter. I fear I have "the Knack" !!
73, David VK5DGR

To
BITX20@groups.io
Jul 29 2017 at 4:22 AM I've finished the Bitx40 experimental project today. I added the AF-AGC and LM386 POP limitter with raduino v1.20.1 (Thanks Allard). And I also added the DuinoVOX for Digital Mode operation. It's a great radio but the problem is only the "LCD noise" when increasing the AF volume. hi... Can I reduce this noise? Or I have to use the analog VFO? Any suggestions welcome.
ja9mat Hidehiko

To Hidehiko JA9MAT:
Very simple. Just three parts. NPN transistor (like a 2N3904) and a 47k resistor (collector to base) 100 uF cap (base to ground). Vcc the collector. Emitter goes to the DC power input of the AF amplifier.
You can see my use of this circuit in the schematic in this blog post:
Look in the lower right, near the LM386 AF amplifier. Click on the schematic to enlarge. 73 Bill N2CQR
My Organic Chip Rig with an LTSpice Schematic

Thanks Bill,
Well I added "3-parts"(2N3904+47kohm+100uF) between the D18(1N4148) and the junction of R111(100ohm) and R1113(220ohm). The noise has absolutely gone!
ja9mat Hidehiko.

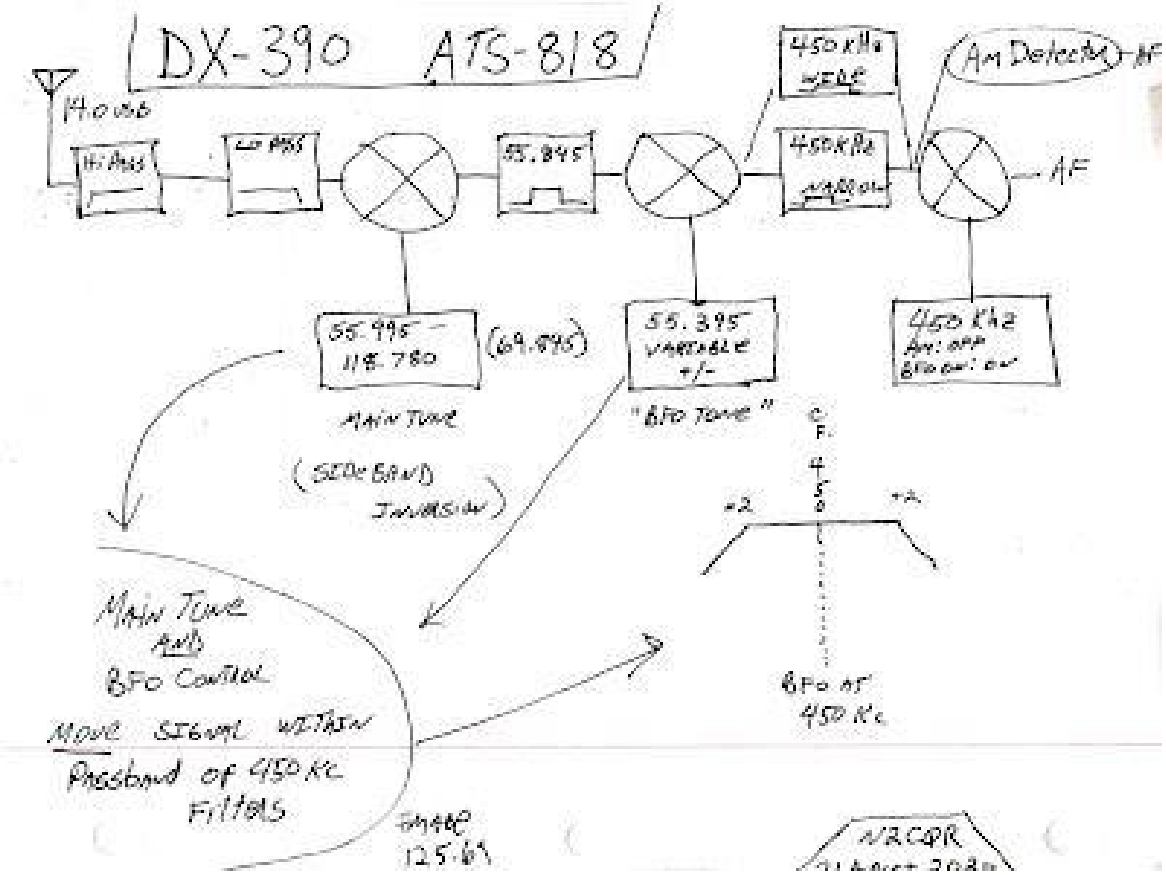
Video on the Strange Tuning of the Radio Shack DX-390 Receiver

I'm more of a single conversion guy myself, but in working with the DX-390 I came to appreciate the benefits (especially regarding image rejection) of the double conversion technique.

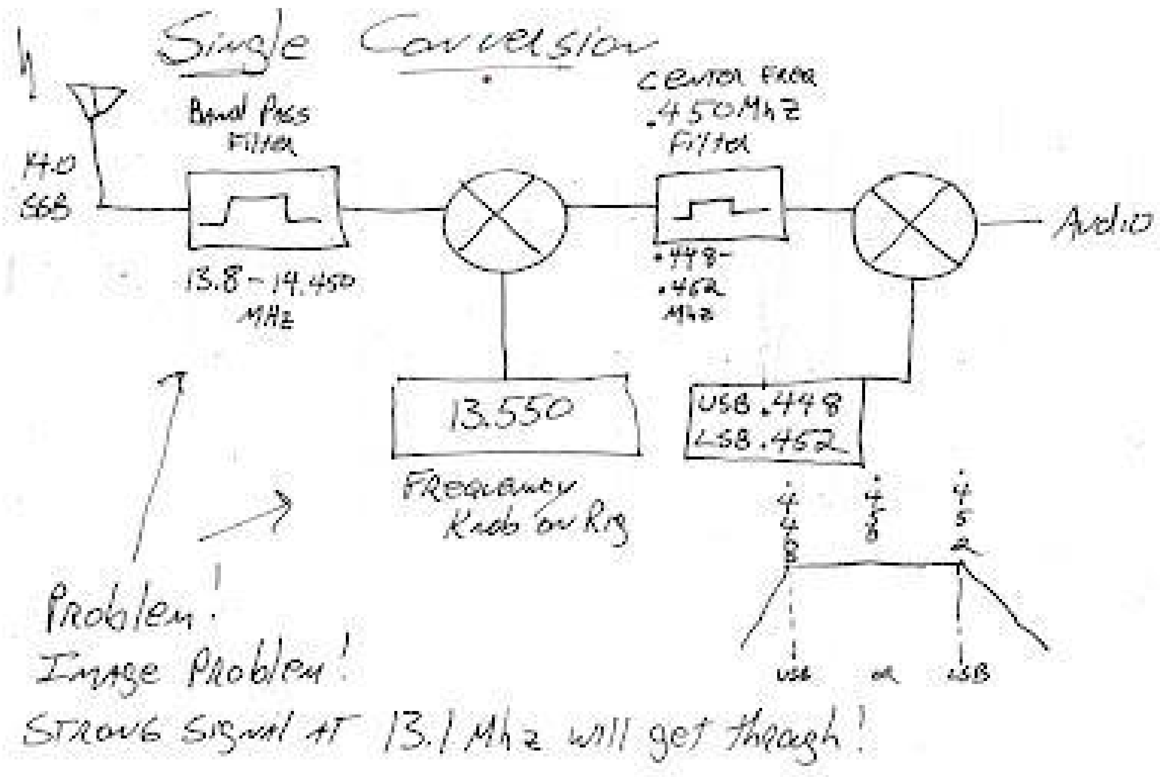
While working on the DX-390, I discovered that the BFO control on the front panel DOES NOT change the BFO frequency. It was fun to try to figure out why the designers did it this way. It does make sense once you consider the limitation imposed by that PLL main tuning oscillator that only moves in 1 kHz steps. I hope the video explains things.

https://www.youtube.com/watch?v=vAjbI3zryHk&t=4s

Here is the drawing I used in the video:



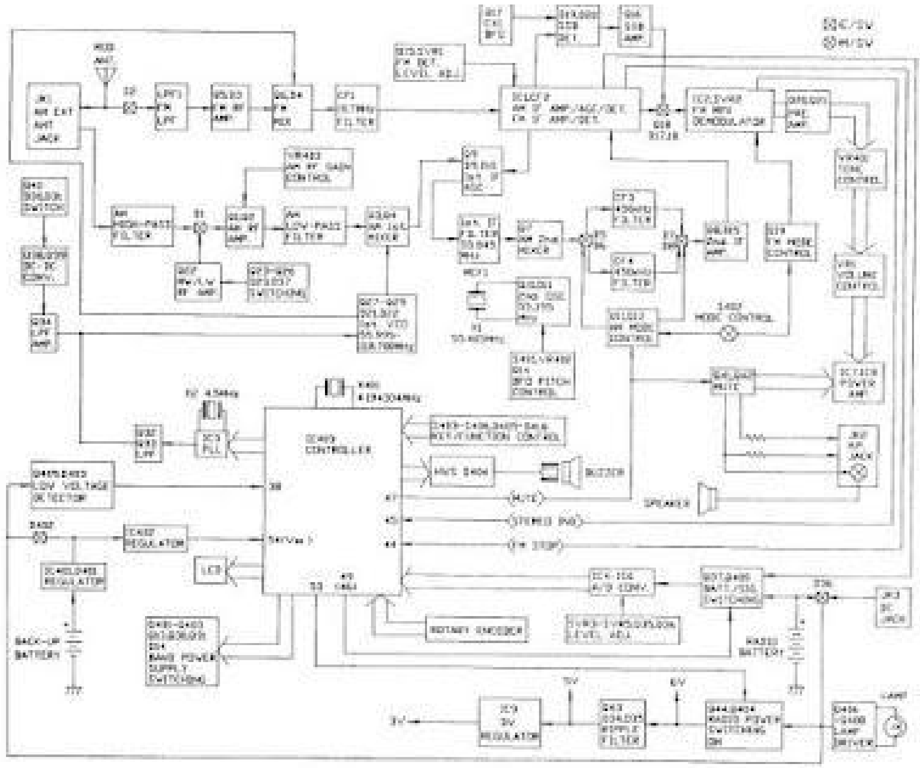
And here is a drawing that shows how a single conversion superhet with a fixed or switchable (usually crystal-controlled) BFO works:



SUNDAY, AUGUST 16, 2020

Fixing up a Radio Shack DX-390 (AKA Sangean ATS-818) While Suffering from Fat Finger Syndrome

I've had this Radio Shack DX-390 portable receiver since the early 1990s. I bought it when I was in the Dominican Republic. It accompanied me on some interesting trips to the Haitian border, and on one very memorable 1994 trip to the Haitian capital. I have made some CW contacts with it serving at the inhaler.



Click on the diagram for a better view. It is a dual conversion superhet. First IF is at 55.845 MHz. There is a big 90's era IC-based PLL oscillator that runs from 55.995 to 118.7 MHz -- The main tuning dial moves this oscillator. Second IF is at 450 kHz. There is an oscillator at 55.395 that takes the signal down to 450 kHz. Selectivity (not a lot) is provided by ceramic filters. Finally there is a product detector and a 450 kHz oscillator that produces the audio. While there are many mystery chips in this receiver, there is also a lot of discrete-component analog circuitry in there -- it is kind of a pleasing mix.

DX-390 Main Board. Note kludged toroidal replacment for L10 (just above ferrite antenna)

The old DX-390 suffered a lot of wear and tear. The case is very beat up. The most serious problem was that at some point, probably on a cold, dry, winter day in Virginia, static electricity took out the FET in the receiver's front end. I made a half-hearted effort to fix it, but it never really worked properly.

I occasionally found myself thinking of this receiver.   I spotted one on e-bay not long ago, and bought it. This newer one was in very nice shape.

But that old one was kind of staring at me from the corner of the shack. "C'mon radio man," it seemed to say, "can't you fix a shortwave receiver?" So this week I took up the challenge.

First the FET. I had kludged an MPF102 in there, but that didn't seem to work well. Internet fora seemed to think that a J310 would do better, so I installed one of them -- it did seem to work better. (Note: Pete Juliano likes J310s -- TRGHS.)

Kludged in J310. And two sets of back to back diodes

During my earlier repair effort I had apparently destroyed the front end output transformer (L10) but I discovered that I had replaced this with a toroidal transformer. It still worked, so I left well-enough alone.

I was pleased that the old receiver was receiving OK, but there was a problem: The "BFO" control wasn't working. The BFO would come on, but turning the BFO control did not vary its frequency.

At this point I discovered that while there are many copies of the DX-390 service manual and schematic on the internet, all of them have seriously degraded copy quality right around the parts of the circuitry that I needed to study. Sometimes Murphy overpowers the Radio Gods. It took me a while to get a useful schematic of the BFO control mechanism.

BFO is a bit of a misnomer here: the control actually shifts the frequency of the 55.395 MHz oscillator that drives the second mixer. See Block diagram above).   There is a varactor diode in the base circuit of a BLT oscillator circuit. Turning the BFO control varies the voltage going to the varactor thus causing the oscillator frequency to slide up and down. But mine wasn't moving. And that was a problem.

So I dove right in, trying to figure out why it was oscillating, but not shifting in frequency. At this point I discovered that I too am afflicted with the disease that Pete Juliano suffers from: Fat Finger Syndrome. That BFO control circuit has a nice big 100k pot, but all the fixed resistors and caps were surface mount and SMALL. As I poked around trying to troubleshoot, I managed to make things worse. It turned out that the lead carrying 6 volts to the BFO control circuitry had broken. But before I discovered this, I managed to do all kinds of damage to the board. I lifted two PC board pads (I should have turned down the temperature on my soldering iron). Then, when I tried to fix this, I managed to put a solder bridge across two parts of the circuit that definitely should not have been connected.

This resulted in a bizarre BFO situation. From the center position, turning the BFO to the left OR TO THE RIGHT would move the BFO in the same direction. So I could tune in an SSB station by turning to the right, or by turning to the left. That was just not right.

Lifted solder pads. And small wires that now bridge the gaps

Uffff. It took me a while to find that fault. While trying to figure this out, I built the circuit in LTSpice just to see what it was SUPPOSED to be doing. This helped. Eventually, through careful inspection with magnifying goggles, I found a solder blob, and removed it. Now all was right with the universe. Even though I had caused most of the trouble, it was still quite satisfying to fix it.

Some additional observations on the DX-390.

-- It really is a Sangean ATS-818 in disguise. Just look at the marking on the PLL board. If you can't find a decent DX-390 schematic, just use an ATS-818 schematic.

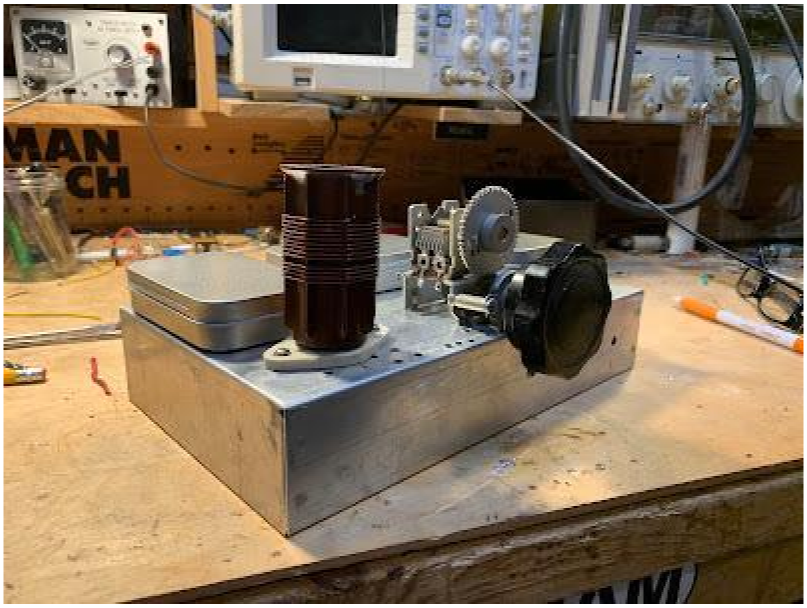
ATS 818 marking along the bottom (green) part
of the PLL board

-- The service manuals on these receivers are quite good: the include bloc diagrams, detailed alignment instructions, and even voltage charts for all the chips and transistors. Impressive and useful.

-- The static discharge vulnerability is hard to understand. There is so much cool circuitry in these receivers, why not add four simple diodes? Not wanting to repeat this saga, I went in and put two sets of back-to-back small signal diodes in each receiver: one set on the telescoping antenna, and other at the input for the external antenna. Curiously, on the newer receiver, it looks like a previous owner had gone in and tried to address this vulnerability -- but he did a very incomplete job. He just put ONE diode between the external antenna input and ground. I had always thought that two diodes back to back would give you good protection from static discharge. And I don't think that single diode protects the front end in any way from discharge coming in from the telescoping antenna.

This was a good project. I got more familiar with general coverage dual-conversion receivers. And I got reacquainted with an old receiver that I liked a lot. Both receivers could probably use some alignment. I'll take that up next.

Quarantine Project: An AM Receiver for the 31 Meter Band. The Q-31.



During this StayInTheShack (SITS) emergency, it is good to have something to work on. I decided it would be best to try to build something using only items currently in my parts collection. I've been getting into shortwave listening again, and I've discovered that the 31 meter band (9.4 - 9.9 MHz) is my favorite. Thus the "Quarantine

On-Hand 31 Meter AM Receiver." A big part of the inspiration for this project comes from the AM receiver of Paul VK3HN.

I propose that we all designate rigs built during quarantine as "Q" rigs. This will be the Q-31.

I had an old chassis on the shelf. It held my WSPR DSB rig in Rome, and various other projects over the years. It has so many holes in it that it looks like it has been used for target practice.

A while back Pete N6QW sent me this really magnificent variable capacitor with at least two reduction dries and an anti-backlash gear. I've been looking for a project that will allow me to use AND display this beautiful part. It will be the main tuning cap for the Q-39. It will stay -- like the tubes in the rigs of days-gone-by -- above the chassis.

While in London many years ago I picked up an old regen receiver at the Kempton Park rally. The parts are still in my junk box. A very nice 1.7 uH plug in coil (with socket) was there. That will be the main coil in the Hartley Oscillator that will be the VFO. I will add a few turns for the feedback coil (see circuit diagram below). I wonder of that Eddystone coil was around for the Blitz?

On the recommendation of our old friend Rogier (originally PA1ZZ), a few years ago Elisa got me a set of grey Altoids-sized metal boxes. I will have three of these atop the target-practice chassis (they will provide shielding and will cover up the holes):

-- One will hold the bandpass filter (designed with the Elsie program) and the mixer (probably diode ring, with transformers from Farhan).

-- One will hold two IF amps with a 10 kHz 455 kHz IF filter between them (thanks to Bruce KK0S for the filters).

-- One will hold the AM detector and the AF amplifiers.

-- A fourth box will be under the chassis and will hold all the powered parts of the VFO circuitry.   I base my VFOs on this simple circuit from page 34 of Solid State Design for the Radio Amateur:

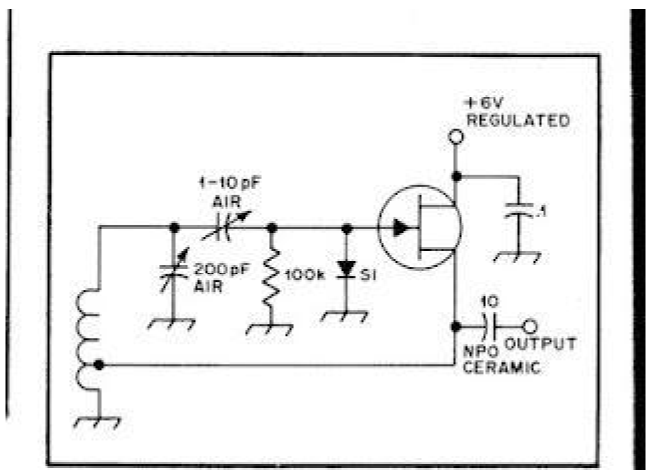


Fig. 7 — W7ZOI high-stability Hartley VFO circuit.

This quarantine looks like it is going to last a long time, so it is best to take your time on projects like this. I might work on the VFO today. No need to rush...

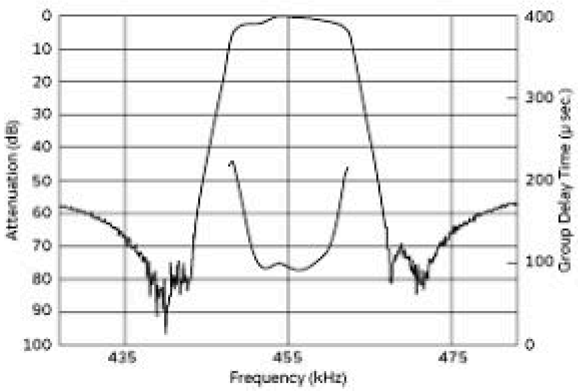
I am shooting videos as I go along and will at some point start putting them up on my YouTube channel.

So, I suggest that any of you who are feeling bored and confined (that would be almost all of us) fight back by launching a Quarantine "Q-Rig" project.   Send reports to me -- I will try to put them on the SolderSmoke blog.

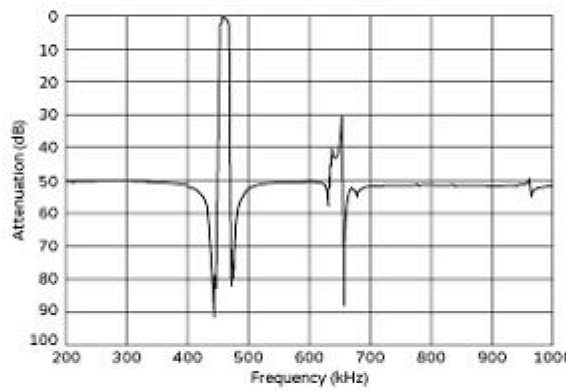
Remember: StayInThe Shack!   #SITS! #flattenthecurve.

73 Bill

The Ceramic Spurs July 5, 2020



Frequency Characteristics



Spurious Response

Paul Taylor VK3HN's magnificent AM receiver was the inspiration for my Quarantine-31 Shortwave Broadcast receiver. Like Paul I decided to make use of ceramic filters at 455 kHz for selectivity. I started with the +/- 3 kHz filters that Paul used, but I found them kind of narrow for SW listening. So I went with some wider ceramic filters that Bruce KK0S had sent me. But I misread the specs that Bruce sent. I thought they were 10 kHz wide filters. I realized later that they were +/- 10 kHz -- really twice as wide as I needed. So I went back to Mini-Kits in Australia and got some +/- 6 kHz filters. 12 kc wide should be just about right, I thought.

The bandwidth was right, but I started noticing a problem: I could hear strong SW broadcast stations at two places on my dial. This brought to mind an admonition from R.A Penfold, author of "Short Wave Superhet Receiver Construction" (1991 Babani Publications). He advised keeping a few standard 455 kc IF cans in the circuit because, he warned, the ceramic filters have spurious responses, spurs that the IF cans can help knock down.

Penfold was right. Look at the filter response curve on the right (above). There is a nasty spur at around 640 kHz. This was the cause of my problem. Here is why:

Suppose I was tuning Radio Marti's big signal on 9805 kc. My VFO would be running at 9350 kc.

9805-9350=455. Great, but...

With that spur at 640 kc, I could tune down to 9620 kc on my dial. My VFO would be running at 9165 kc.

9805-9165=640. Bad. That 640 kc difference product would make it through to my detector and AF amp. I'd have Radio Marti showing up in two places. I didn't like this.

I thought about putting a series LC circuit tuned to 640 kc at the output of the ceramic filter. This looked like a possible solution, but on the bench it looked like I would have trouble getting a circuit of sufficiently high Q.

So rummaging around in my junk box I found an old Murata CFM455B filter. This filter is quite broad, but it does <u>not</u> have the spur at 640 kc. I could use it as a kind of roofing filter just ahead of the +/- 6 kHz filter. Putting it there would allow me to avoid having to build additional matching circuits for the 455B filter.

+/-6kc filter upper left, 455B wide filter to the lower right.

I'm happy to report that this fix works.   The 6 kc filter provides the needed selectivity, and the broader 455B filter knocks down the 640 kc spur.

Beware the Ceramic Spurs!

Q-31 with the can for the ceramic filters open

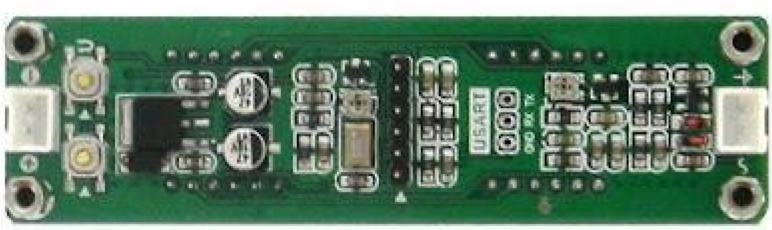
FRIDAY, JANUARY 1, 2021

Glowing Numerals for the Lafayette HA-600A (With Jeweled Movements)

I really like this receiver. I have strong sentimental ties: it was my first SW receiver. But the frequency readout situation was kind of rough -- depending on where you put the Main Tuning cap, your Band Spread dial could be WAY off.

China to the rescue! Specifically the very nice San Jian PLJ-6 frequency counter boards. I have used these in several projects. I like them a lot. I get mine on e-bay. They are very cheap. Here is the manual with specs:

https://www.mpja.com/download/35057tebasic%20manual.pdf



As I did with my BITX20, I put mine in an Altoids-sized box. I got to use my Goxawee rotary tool with circular metal blade to cut the rectangular hole. Hopefully future efforts will yield neater results, but the flying sparks were fun; they made me feel like one of those car-part "fabricators" on cable TV.

To tap the VFO frequency, I just put a bit of small coax at the point where the 10 pf cap from the VFO circuit enters the first mixer. I ran this cable to the unused "Tape Recorder" jack on the back of the Lafayette -- this connects to the input of the counter. I attached

11 volts from the power supply to an unused terminal on the accessory jack of the Lafayette -- this powers the counter.

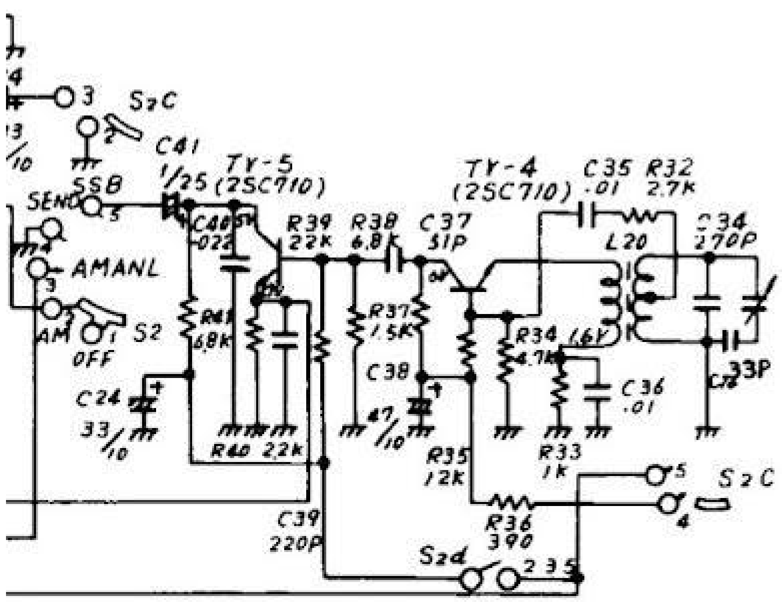
Having a counter on the VFO proved very illuminating -- in more ways than one. I measured the Center Frequency (CF) of my IF to be at 456 kHz. I set the PLJ-6 to display the VFO frequency MINUS 465 kHz. For AM broadcast signals, this worked fine: I'd tune the signal for peak S-meter reading. This meant that the carrier was right at the CF.

For SSB, things were a bit different. I set the BFO knob to be RIGHT AT 465 kHz when the dot is in the center position. With the BFO there, I *could* tune in SSB signals. The suppressed carrier would be right at the center of the IF passband, with the audio information above or below the suppressed carrier frequency. But it didn't sound good this way -- it sounded better if I would tune an LSB signal 2 kHz down from the center, then adjust the BFO down about 2 kHz. This put most of the audio in the peak portion of the IF filter's curve. Doing it this way means that I have to remember that the number displayed on the PLJ-6 is 2 kHz down from the actual suppressed carrier frequency of the transmitting station. I can live with that.

I am going to leave the Lafayette on the corner of my workbench so that I can easily tune in hams and SW broadcast stations. Having modified the product detector and added the digital frequency readout makes listening to this receiver even more pleasing. The jeweled movements are as smooth as ever.

THURSDAY, OCTOBER 15, 2020

Too Simple? Deficiency of the Lafayette HA-600A Product Detector?



I've been having a lot of fun with the Lafayette HA-600A receiver that I picked up earlier this month. Adding to the mirth, I noticed that on SSB, the signals sound a bit scratchy, a bit distorted, not-quite-right. (I'm not being facetious; this is an interesting problem and it might give me a chance to actually improve a piece of gear that I -- as a teenager -- had been afraid to work on.)

Before digging into the circuitry, I engaged in some front panel troubleshooting: I switched to AM and tuned in a strong local AM broadcast signal. It sounded great -- it had no sign of the distortion I was hearing on SSB. This was an important hint -- the only difference between the circuitry used on AM and the circuitry used on SSB is the detector and the BFO. In the AM mode a simple diode detector is used. In SSB a product detector and BFO is used. The BFO sounded fine and looked good on the scope. This caused me to focus on the product detector as the culprit.

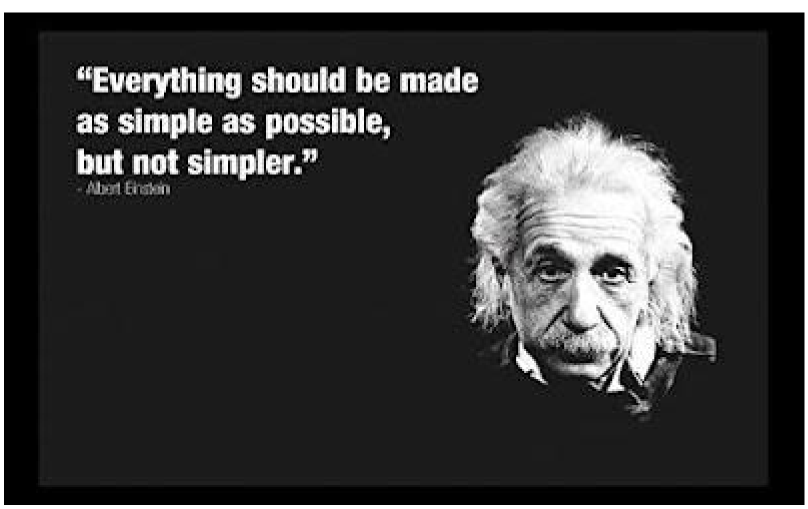
Check out the schematic above. Tr-5 is the product detector. It is really, really simple. (See Einstein quote below.) It is a single-transistor mixer with BFO energy going into the base and IF energy going into the emitter. Output is taken from the collector and sent to the audio amplifiers. (A complete schematic for the receiver can be seen here: https://nvhrbiblio.nl/schema/Lafayette_HA600A.pdf)

I had never before seen a product detector like this. One such detector is described in Experimental Methods for RF Design (page 5.3) but the authors devoted just one paragraph to the circuity, noting that, "We have not performed careful measurement on this mixer." The lack of enthusiasm is palpable, and probably justified.

A Google search shows there is not a lot of literature on single BJT product detectors. There is a good 1968 article in Ham Radio Magazine: http://marc.retronik.fr/AmateurRadio/SSB/Single-Sideband_Detectors_%5BHAM-Radio_1968_8p%5D.pdf It describes a somewhat different circuit used in the Gonset Sidewinder. The author notes that this circuit has "not been popular."

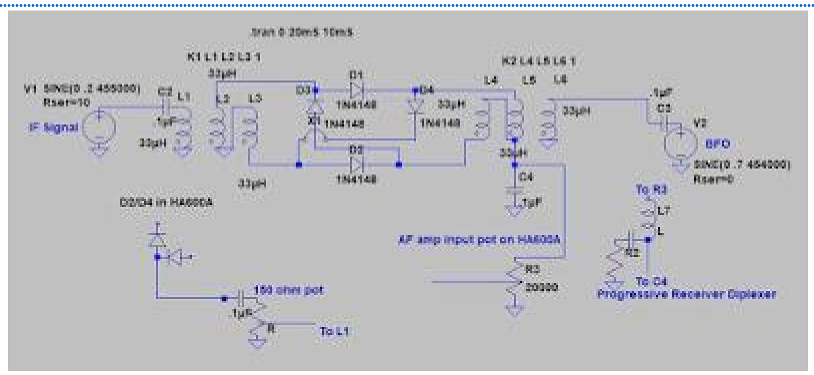
To test my suspicion that the product detector is the problem, I set up a little experiment. I loosely coupled the output of a signal generator to the IF circuitry of the HA-600A. I put the sign gen exactly on the frequency of the BFO. Then, I switched the receiver to AM, turning off the BFO and putting the AM diode detector to work. I was able to tune in the SSB signals without the kind of distortion I had heard when using the product detector.

So what do you folks think? Is the product detector the culprit? Or could the problem be in the AGC? Should I start plotting a change in the detector circuitry? Might a diode ring work better?



SUNDAY, NOVEMBER 22, 2020

Wrapping up the HA-600A Product Detector Project -- Let's Call Them "Crossed Diode Mixers" NOT "Diode Rings"



This has been a lot of fun and very educational.   The problem I discovered in the Lafayette HA-600A product detector caused me to take a new look at how diode detectors really work. It also spurred me to make more use of LTSpice.

In the end, I went with a diode ring mixer. Part of this decision was just my amazement at how four diodes and a couple of transformers can manage to multiply an incoming signal by 1 and -1, and how this multiplication allows us to pull audio out of the mess.

But another part of the decision was port isolation: the diode ring mixer with four diodes and two transformers does keep the BFO signal from making its way back to into the IF chain. This helps prevent the BFO signal from activating the AGC circuitry, and from messing up the S-meter readings. LTSpice helped me confirm that this improvement was happening: in LTSpice I could look at how much BFO energy was making its way back to the IF input port on the diode ring mixer. LTSpice predicted very little, and this was confirmed in the real world circuit. (I will do another post on port isolation in simpler, singly balanced diode mixers.)

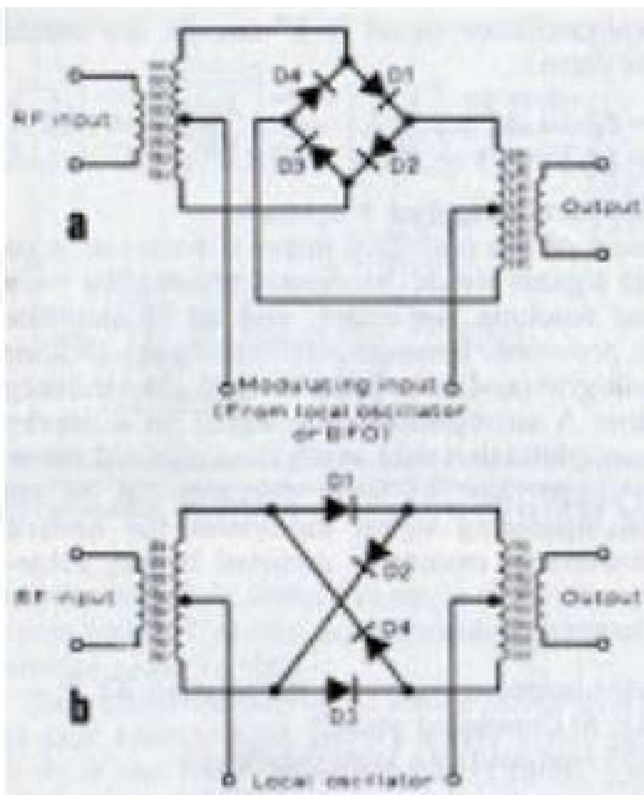
At first I did have to overcome some problems with the diode ring circuit. Mine seemed to perform poorly with strong signals: I'd hear some of the "simultaneous envelope and product detection" that started me down this path. I also noticed that with the diode ring, in the AM mode the receiver seemed to be less sensitive -- it was as if the product detector circuit was loading down the AM detector.

One of the commenters -- Christian -- suggested putting some resistance into the input of the diode ring circuit. I put a 150 ohm pot across the input, after the blocking capacitor. The top of the pot goes to the capacitor, the bottom to ground and the wiper to the input of L1 in the diode ring circuit (you can see the circuit in the diagram above). With this pot I could set the input level such that even the strongest input signals did not cause the envelope detection that I'd heard earlier. Watching these input signals on the 'scope, I think these problems arose when the IF signals rose above .7 volts and started turning on the diodes. Only the BFO signal should have been doing that. The pot eliminated this problem.   The pot also seemed to solve the problem of the loading down of the AM detector.

With the pot, signals sounded much better, but I thought there was still room for improvement. I thought I could hear a bit of RF in the audio output. Perhaps some of the 455 kHz signal was making it into the AF amplifiers.   I looked at the circuit that Wes Hayward had used after the SBL-1 that he used as product detector in his Progressive Receiver. It was very simple: a .01 uF cap and 50 ohm resistor to ground followed by an RF choke. I can't be sure, but this seemed to help, and the SSB now sounds great.

A BETTER NAME?

One suggestion: We should stop calling the diode ring a diode ring. I think "crossed diode mixer" or something like that is more descriptive. This circuit works not because the diodes are in a ring, but because two of them are "crossed."   From now on I intend to BUILD this circuit with this crossed parts placement -- this makes it easier to see how the circuit works, how it manages to multiply by -1, and to avoid putting any of the diodes in backwards.

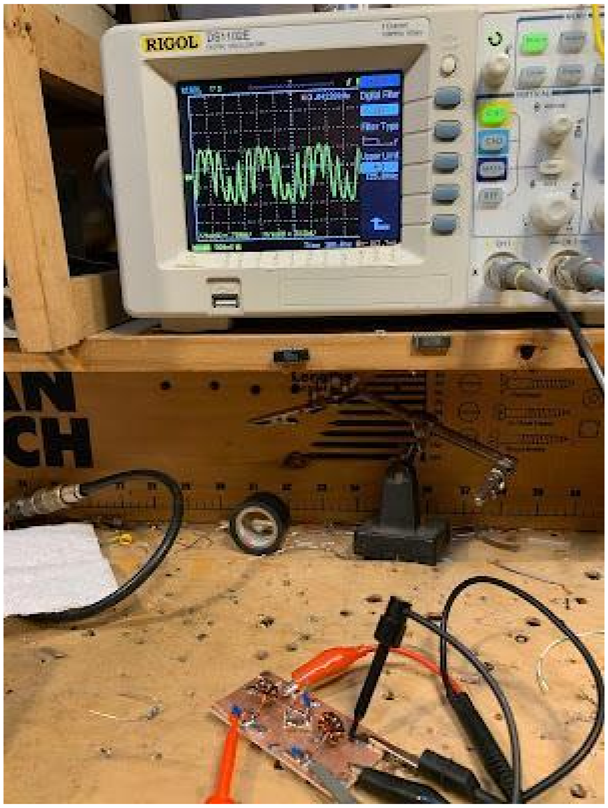


I prefer the bottom diagram

A KNOWN PROBLEM?

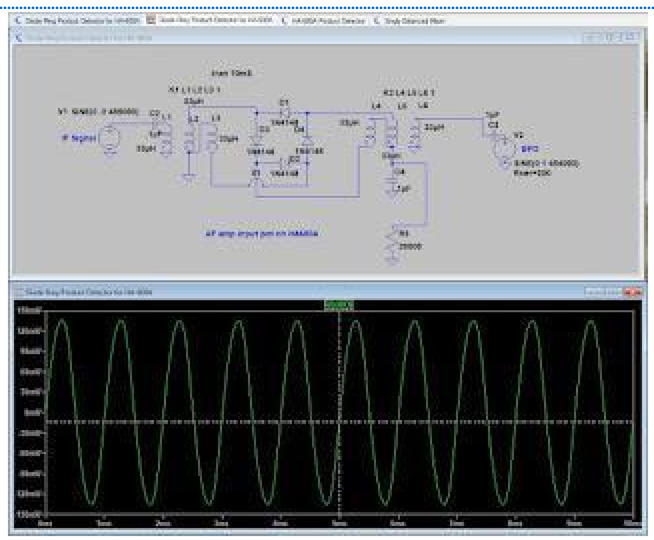
I'm left wondering if the engineers who designed the HA-600A were aware of the shortcomings of the product detector. It is really strange that my receivers lacks a 12V line from the function switch to the product detector. And it is weirder still that the detector works (poorly) even with no power to the transistor. What happened there?

When you look at the HA-600A manual, you can see a hint that maybe they knew there was a problem. For CW and SSB, the manual recommends leaving the AF control at the quarter or halfway point, then controlling loudness with the RF gain control. This would have the effect of throttling back the RF gain (and the potential for product detector overload) when strong signals appear. MGC in addition to the AGC. Any memories or insights on this would be appreciated.



TUESDAY, NOVEMBER 17, 2020

A Diode Ring Product Detector for the HA-600A? Problems.



Pete advised me to try this a week or so ago, but it took me a while to follow through and try it out.

I got the two diode, one transformer product detector working well, but with it a new problem arose: 455 kHz energy from the BFO was leaking past the product detector back into the S-meter/AGC circuitry. This showed up in the form of a constant S-3 reading when I switched to SSB/CW. This was annoying.

I figured the problem was that the only signal really being balanced out was the IF signal going into L1 of the product detector. I took another shot at putting the BFO signal into this port, with the IF signal going into the unbalanced potentiometer port. This did indeed take care of the BFO leakage S-meter problem, but once again the SSB did not sound great -- I think the old problem of simultaneous envelope and product detection returned.

This was obviously a port isolation problem. I remembered that the diode ring "doubly balanced" configuration has much better port isolation. So on Sunday morning I built one, first in LTSpice and then on the bench.

For the bench model I used some PC board pads out of Pete Juliano's $250,000 CNC machine. For the toroids I used two trifilar coils wound by Farhan's dedicated staff in Hyderabad. The diodes were sent to me by Jim W8NSA. So there was lots of soul in this new machine.

The circuit worked in LT Spice and at worked well when tested on my bench with my FeelTech (for the BFO) and HP8640B (for the IF signal) sig gens with my Rigol 'scope watching for the audio out.

But I ran into some problems when I popped the new board in there in place of the old product detector: The 455 kc BFO leakage problem is gone and the S-meter is where it should be, but...

-- I'm seeing a return of the old simultaneous envelope and product detection problem. SSB was sounding scratchy again and indeed, when I removed the BFO signal from the diode ring circuit I could hear SSB signals making it into the audio amplifiers. These signals sounded just like AM signals as heard through an envelope detector without a BFO.

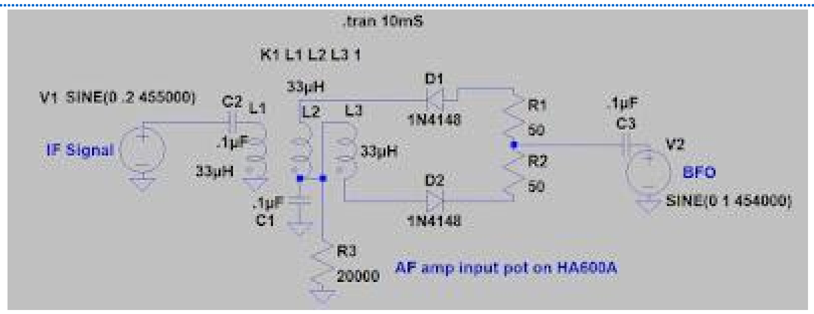
-- The diode ring circuit also had a very bad effect on how the HA-600A worked in AM mode. It seemed like the new circuit was loading down the diode AM demodulator. SW broadcast signals sounded awful in the AM mode until I disconnected the IF input to the diode ring circuit (this input is NOT switched -- it is always connected, even in the AM mode).

So, for now, am back to using the two-diode, single transformer, singly balanced product detector with IF signal going to the balanced (L1) port and the BFO going in through the wiper of the 100 ohm pot.

Any suggestions on how to overcome the problems with the diode ring circuit?

FRIDAY, NOVEMBER 13, 2020

How Does My Singly Balanced, Two-Diode, Single Transformer Product Detector Really Work?



As young James Clerk Maxwell used to say, "What's the go of it?" and "What's the *particular* go of it?"

I studied this circuit carefully when I was using it as a balanced modulator in my DSB rigs. I wrote up my conclusions in my book "SolderSmoke -- Global Adventures in Wireless Electronics."

BALANCED MODULATOR CONFIGURATION:

When I was using it as a balanced modulator, I had the RF "carrier" signal going into L1. This RF signal was 7 dbm, enough to switch the diodes on at voltage peaks. With the "center tap" of L2/L3 grounded for RF, this meant that when the "top" of L2 is negative, the "bottom" of L3 is positive. In this situation BOTH D1 and D2 will turn on and conduct.

When the top of L2 is positive, the bottom of L3 is negative and neither of the diodes is on. Neither conducts.

So we have the RF signal turning the diodes on and off at the frequency of the RF signal.

Audio from the microphone and mic amplifier is sent into the center tap connecting L2 and L3. The level of this audio is kept low, below the point where is could turn on the diodes. The center tap IS grounded for RF by the .1uF capacitor, but it is NOT grounded for AF. That is key to understanding this circuit.

In essence by turning the two diodes on and off at the rate of the RF signal, the audio signal is facing severe non-linearity through the diodes. We could say it is alternately being multiplied by 1 and 0. This non-linearity is what is required for mixing. We therefore get sum and difference products: Sidebands. At this point, Double Sideband.

The way the transformer is set up means the RF carrier signal is balanced out: Even when the two diodes conduct, the top of R1 and the bottom of R2 are of equal and opposite polarity, so there is no carrier signal at the junction of R1 and R2 (they are actually a 100 ohm variable resistor that can be adjusted to make SURE they balance out). So the carrier is suppressed and all that remains are the sidebands: Suppressed Carrier Double Sideband.

PRODUCT DETECTOR CONFIGURATION:

What happens when we use this circuit as a product detector in a receiver? Let's assume we are working with a 455 kc IF. If you run a 454 kc 7 dbm BFO signal into L1, it will turn the diodes on and off as described above. But you will NOT be able to put the 455 kc IF signal into the center tap of L2/L3 -- that center tap is GROUNDED for 455 kc. So you will have to run your IF signal into the resistors, and take the audio output from the center tap of L2/L3. This works. I tried it in my HA-600A. But there is a problem: Envelope detection.

In this arrangement, we are balancing out NOT the 455 kc IF signal, but instead we are balancing out the BFO. We don't really NEED to balance out the BFO -- it can easily be knocked down in the audio amplifiers, and IT is not responsible for the problematic envelope detection. We DO need to balance out the IF signal, because if that gets through we can get simultaneous "envelope detection" and product detection. And believe me, that does not sound good.

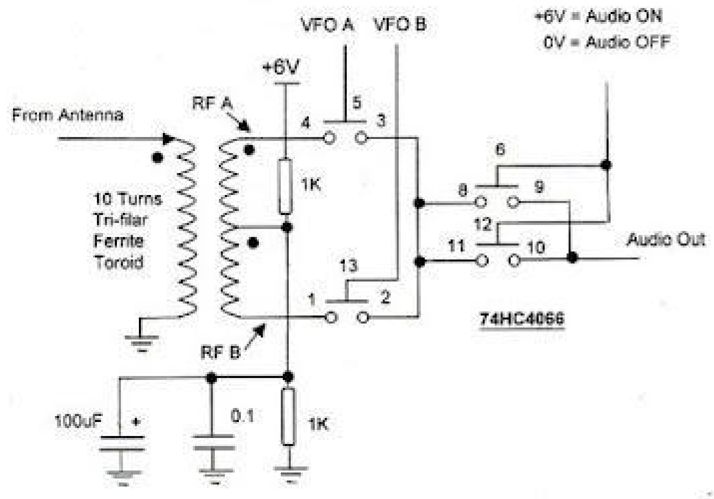
So I tried putting the IF signal into L1, and the BFO signal into the resistors (as shown above). I took the audio from the junction of L2/L3. This seemed to work better, with envelope detection greatly reduced.

BUT WHAT'S THE GO OF IT?

But how is this circuit mixing in this configuration? The strong BFO signal is still controlling the diodes, BUT, with the BFO signal coming in through the resistors, when the top of R1 is positive the bottom of R2 is ALSO positive. In this situation D1 will conduct but D2 will not. The IF signal is facing a big non-linearity. This will result in sum and difference frequencies. The difference frequency will be audio. But with D1 and D2 turning on and off in a very different way than we saw in the balanced modulator, how does the mixing happen?

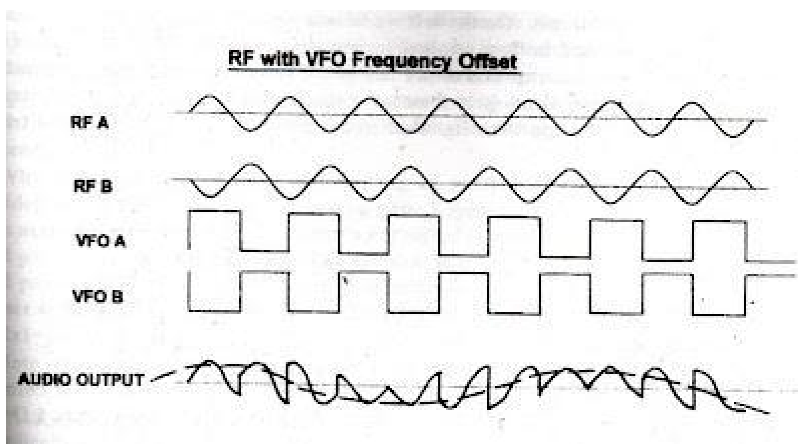
I think the answer comes from the summer 1999 issue of SPRAT, the amazing journal of the G-QRP club. Leon Williams, VK2DOB wrote an article entitled "CMOS Mixer Experiments."

Here is Leon's 74HC4066 circuit:



I think those two gates (3,4,5 and 1,2, 13) are the functional equivalent of the two diodes in our product detector. In Leon's scheme the VFO is supplying signals of opposite polarity. Ours is providing only one signal, but the fact that the diodes are reversed means that they act just like the gates in Leon's circuit. The transformer is almost identical to the one we use in the product detector.

Let's look at the output from Leon's circuit:



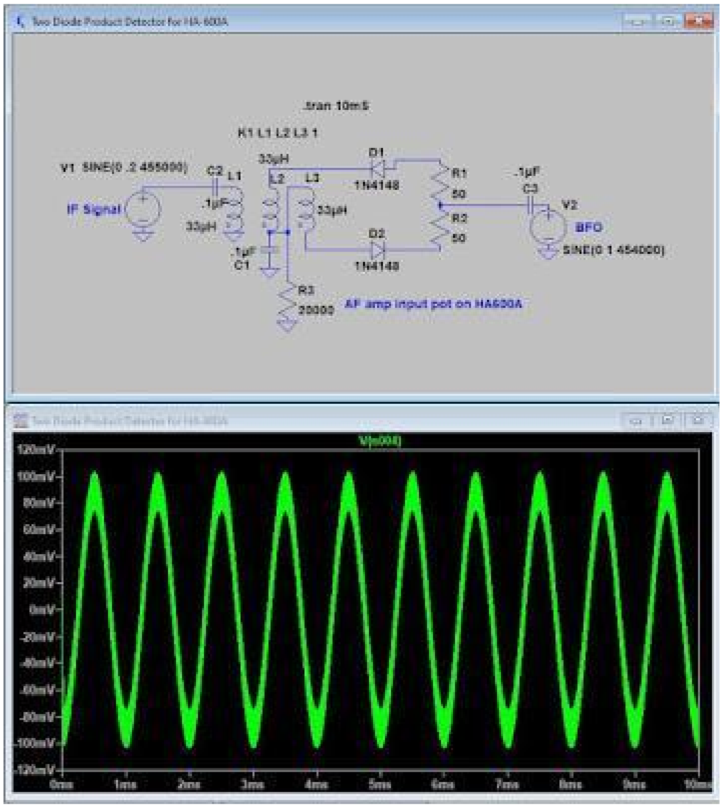
"VFO A" going high is the equivalent of the BFO going to its positive peak and D1 conducting.
"VFO B" going high is the equivalent of the BFO signal to its negative peak and D2 conducting.

Take a ruler, place it vertically across the waveforms and follow the progress at the output as the two signals (RF A and RF B) are alternately let through the gates (or the diodes). You can see the complex waveform that results. The dashed line marked Audio Output shows the difference frequency -- the audio. That is what we sent to the AF amplifiers.

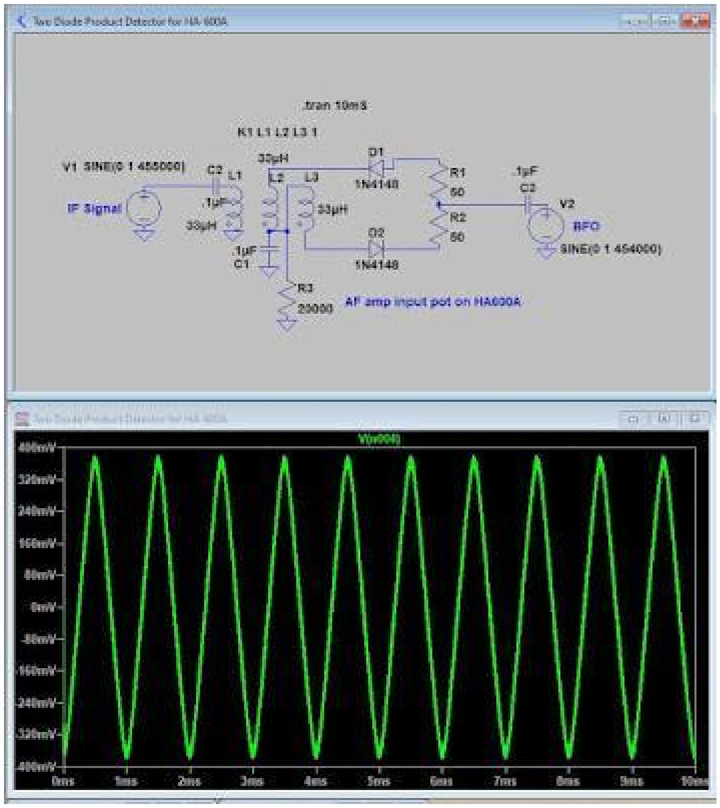
One concern remains:

What happens when the 455 kc IF signal getting to L1 get so strong that IT also starts to turn the diodes on and off? I think this will result in distortion, and we can see this in LT Spice.

Here is the output waveform when the If signal at L1 is kept below the level that would turn on the diodes:



Here you can see it with a much stronger IF signal:



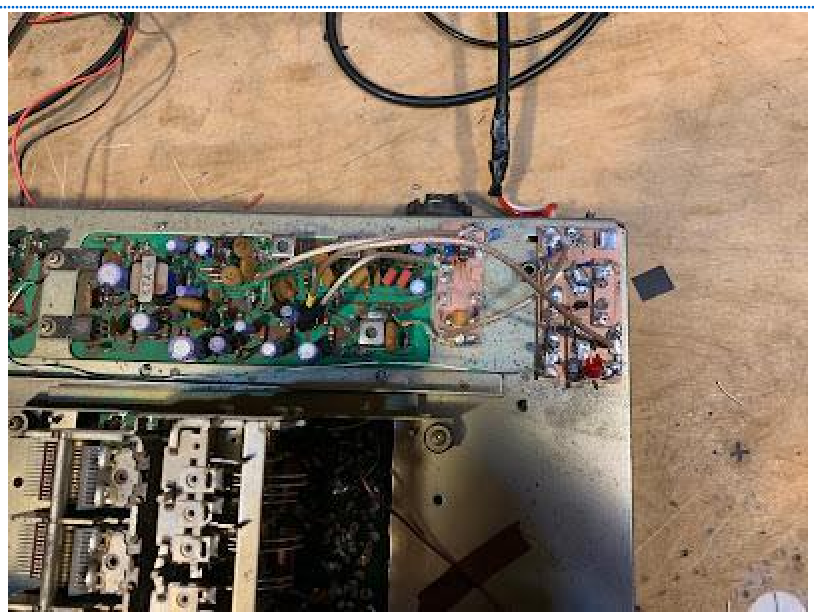
The output waveform becomes more of a sawtooth.

How can I prevent this from happening?   I know AGC should help, but the AGC in this receiver doesn't seem to sufficiently knock down very strong incoming signals.

Does my analysis of these circuits sound right?

MONDAY, NOVEMBER 9, 2020

Improving the Product Detector in the Lafayette HA-600A



Diode product detector on the left, BFO amp in the right

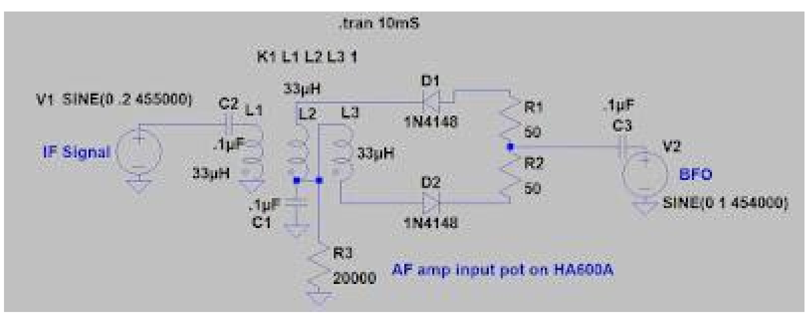
As noted [in an earlier blog post,](#) I didn't like the sound of SSB and CW when using the product detector in my Lafayette HA-600A. It just did not sound right. The receiver sounded fine on AM with the diode detector. But when I switched in the product detector, it sounded bad. The BFO was fine. The problem was there even when I used an external BFO. And SSB sounded great when I just coupled some BFO energy into the IF chain and used the diode detector to listen to SSB. My suspicions were focusing on the very simple BJT product detector.
Steve N8NM built the HA-600A product detector both in LTSpice and in the real world. It worked fine in both versions. Steve even put the product detector into his S-38 receiver -- he reported it worked well there.

I too built the thing in LTSpice. Then I went and rebuilt the circuit on a piece of PC board. I connected the new circuit to the HA-600A, using my external FeelTech sig generator as the BFO. IT STILL SOUNDED BAD ON SSB.

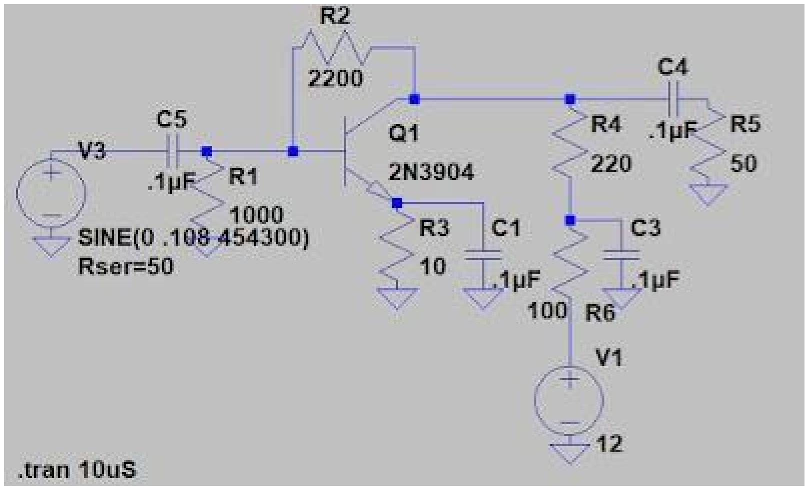
At this point I started Googling through the literature. I found a promising article by Robert Sherwood in December 1977 issue of Ham Radio magazine entitled "Present Day Receivers -- Problems and Cures." Sherwood wrote:

"Another area that could use additional work is the product detector. As the name implies, its output should be the product of the two input signals. If BFO injection is removed, output should go to zero. If this is not the case, as in the Heath HW series, envelope detection is also occurring, which causes audio distortion."

I checked my circuit. When I removed the BFO signal from the product detector, envelope detection continued. In fact, with the receiver in SSB mode, and with the BFO disconnected, I could listen to the music of WRMI shortwave. It seemed that Sherwood was explaining well the problem I was having: Simultaneous envelope and product detection was making SSB sound very bad in my receiver. What I was hearing just seemed to SOUND like what you'd get with a mixture of product and envelope detection: "scratchy" sounding SSB. This also seemed to explain why SSB would sound fine when using the diode detector with loosely coupled BFO energy -- in that case it would be envelope detection only, with no ugly mixture of both kinds of detection.



So I built a better detector. I had had great luck with the two diode one trifilar transformer singly balanced design used by both Doug DeMaw and Ashhar Farhan. I built the circuit using one of the trifilar toroids given to me by Farhan, and connected it in place of the original BJT product detector. With the FeelTech Sig Gen as BFO, I got good results -- most of the signal disappeared with I disconnected the BFO. Looking at the circuit, I realized that I was balancing out not the IF signal but instead the BFO signal. To minimize envelope detection I needed to put the IF signal on the balanced input of the product detector (to L1 in the diagram above). When I did this, envelope detection seemed to disappear completely and the receiver went silent when I disconnected the BFO.



Finally, I needed to find a way to use the BFO in the HA-600A with the new product detector. Obviously I needed more BFO signal -- I needed about 7 dbm, enough to turn on the diodes. I converted the outboard product detector board into a simple amplifier and put it between the HA-600A BFO and the BFO input port of the new product detector. This works fine.

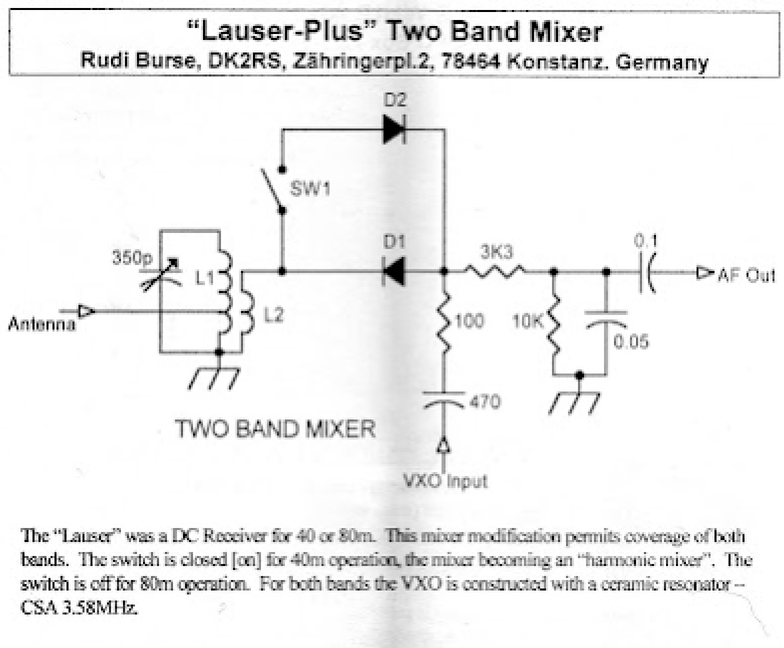
A few issues remain:

1) The output from the HA-600A BFO through the above BFO amp (and across the 50 ohm resistor) is NOT a pretty 455 kc sine wave. But the peaks of the distorted wave appear to be enough to turn on the diodes, and when I look at the voltages across each diode (on my two channel 'scope) I see mirror images -- one is on when the other is off. Is this good enough?

2) Moving the BFO input from L1 to the junction of the two 50 ohm resistors (that is actually a 100 ohm pot) has big implications for how this mixer works. With the BFO energy going through the toroid, BOTH diodes are being alternately turned on and turned off. But both are on, and then BOTH are off. With the BFO energy going in through the other side, one diode turns on when the other is off. I think the mixing result is the same, with AF coming out of the output port, but the way the mixer works in this configuration is very different. Does this sound right?

THURSDAY, AUGUST 11, 2022

What Coil for the Polyakov Input Circuit? How to calculate a coil value for resonance.



So, what is the value for L1 and L2? What coil should I use?
Michael AG5VG had that question. And so did I when I built this receiver. See below for the process I used in answering this question.

On Tuesday, August 9, 2022 at 10:53:32 PM EDT, Michael S wrote:

Good Evening Bill,

My name is Michael and I really enjoy your podcast with Pete. I have also spoken with him in regards to the design of a 20M bandpass filter I made for a homebrew rig. I am currently in the process of making a 20 meter DSB - SC type. Thank you for all the information that you speak and teach about during your podcast. I also enjoy the humor. It's great.

The Polyakov is a simple DC receiver and it amazes me and how the sound quality is. My question is, what is the turns on the toroid for the antenna primary side and the radio secondary and how did you figure out the turns because looking at the schematic it doesn't give that information that I can see. Also how you resonated it with the variable capacitor that looks like a 365pf air variable.

Thank you for your time and keep up the great work on the podcast and the content on YouTube.

73s,
Michael

AG5VG

My response:

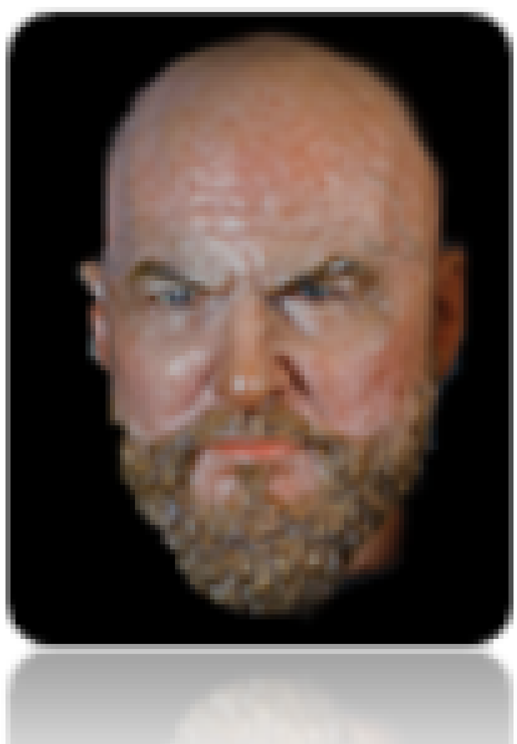
Good questions Michael. When I saw the SPRAT article I too was struck by the fact that it didn't give a value for the coil. But DK2RS did have a large value variable capacitor... And he was billing this as a dual-band (80-40) rig. So I figured he wanted that LC circuit to resonate as low as 3.5 MHZ and as high as 7.3 MHZ. So, with a variable cap that goes up to 350 pf, what value L should I use? I started by calculating the resonant frequency of the frequency mid-way point: 5.1 MHz. I figured the variable cap should be around 162 pf at the mid-way point. At this point I went to the on-line resonant frequency calculator: https://www.1728.org/resfreq.htm (a REALLY useful site!). This site revealed I needed a coil of about 6 uH. This put me in the ballpark. But then -- with the site -- I tested it with the values of the variable cap I had on hand. Mine was 23pf to 372 pf. (you really need an LC meter to do this kind of thing).
Again at the resonant freq calculation site: 23 pf and 6uH = 13.5 MHz 372 pf and 6 uH = 3.3688 MHz
This would have been OK, but I wanted to move the frequency range down a bit, so I tried. 6.5 uH
23 pf and 6.5 uH = 13 MHz 372 and 6.5uH = 3.23 MHz
Now, how many turns? First look at the overall coil -- don't worry about taps at this point. I use the Toroid Turns Calculator: http://toroids.info/
Start by asking yourself "What core do I have on-hand? Let's say you have a T-50-2 (red/clear). The calculator shows you need about 36 turns. Do-able, but physically kind of tight.
I found a big core in my junk box. A T-106-2. The calculator showed I'd need about 22 turns on this core. It was much easier to get these turns on the larger core.
You have to measure the core after you wind it to make sure you are at the desired inductance. One side of the main coil went to ground, the other side to the top of the variable cap.
Now for the taps and secondaries: The schematic shows a tap. This is usually about 1/4 of the number of turns up from ground. I picked about 5 turns, and wound a little tap in there at that point -- that tap went to the antenna. You also have a secondary coil --no value is given, but based on experience I guessed around 5 turns -- I wound these turns on top of the primary one lead went to ground, the other went to the diodes and the switch.
The last thing to do is to see if the circuit resonates on both bands that you want to receive. You can do this with a signal generator, or with the band noise: Hook up an 80 meter antenna. Put the cap closer to its max value and tune the cap -- can you hear band noise? Or can you hear (or see on a 'scope) a signal at 3.5 MHz? You should be able to peak it with the main cap. Try to do the same thing on 40 meters -- here the variable cap should be closer to minimum capacity.
That's it. That's how I did it. You can do it too! Good luck with the Polyakov.
One hint: Building the VFO is the hard part. You can get started by using a signal generator in place of the VFO. Just make sure you have the level right -- around 620 mV input.

Good luck -- Let us know if you have trouble. And please let us know how the project goes.
73 Bill N2CQR

20 meter rig built by AG5VG

WEDNESDAY, AUGUST 10, 2022

[Vasily Ivanenko on Vladimir Polyakov's Subharmonic Detector]



Our old friend "Vasily" sent in a very insightful comment about the Polyakov receiver. It was so good that it merits a blog post of its own. Here it is. Thanks Vasily!

Vasily Ivanenko August 9, 2022 at 12:49 AM

Thanks Bill. My own experiments at HF with subharmonically pumped Schottky diode mixers show clearly that almost every mixer parameter we measure is worse than our classic balanced mixer topologies. Definitely 2LO-RF isolation was better than other unbalanced mixers without the need for a transformer.

I guess it's appealing for low-complexity receiver builders. For zero IF receivers, I like and run my LO at 1/2 RF frequency and then use a doubler -- that's a great advantage for
a DC/ Zero-IF receiver and a built-in feature for the subharmonic mixer.

The SH mixer becomes quite appealing at SHF to mm-wave lengths where making a quiet, temp stable LO gets rather expensive and tricky.

Subharmonically pumped mixers can also work at odd integers if the mixer LO/RF drive is balanced and designed to produce distortion that for example, triples the LO frequency. Rohde & Schwarz had a 40.1 GHz spectrum analyzer with one --- and if the LO was 13 GHz while the RF was 39.5 GHz, this gave an IF output of 500 MHz in 1 particular circuit. Really amazing design work. Here's an interesting URL:

https://www.eravant.com/products/mixers/subharmonically-pumped-mixers

The SH mixer has been around for > 4 decades. The oldest SH mixer paper I've got in my library is from Schneider and Snell from 1975. I don't think they invented the SH, but this pair helped popularize it for the world and design work continues today.I've seen optical SH mixers with I/Q outputs in research papers.

Here's the abstract and citation:

Harmonically Pumped Stripline Down-Converter

M. V. Schneider, W. W. Snell
Published 1 March 1975
Physics, Engineering
IEEE Transactions on Microwave Theory and Techniques

A novel thin-film down-converter which is pumped at a submultiple of the local-oscillator frequency has given a conversion loss which is comparable to the performance of conventional balanced mixers. The converter consists of two stripline filters and two Schottky-barrier diodes which are shunt mounted in a strip transmission line. The conversion loss measured at a signal frequency of 3.5 GHz is 3.2 dB for a pump frequency of 1.7 GHz and 4.9 dB for a pump frequency of 0.85 GHz. The circuit looks attractive for use at millimeter-wave frequencies where stable pump sources with low FM noise are not readily available.

Best to you!

TUESDAY, AUGUST 9, 2022

Polyakov Direct Conversion Receiver on 80 Meters (video)

In today's episode I put the switch in the open position turning the receiver into an ordinary Direct Conversion receiver with a single diode as the detector. I find that it works pretty well on 80, but probably not as well as it does on 40 (where it is in full Polyakov mode). (Yesterday I demonstrated

the receiver in action on 40 and provided details on the circuit. See: https://soldersmoke.blogspot.com/2022/08/polyakov-ra3aae-direct-conversion.html)

You will notice that when I throw the switch, but before I retune the input LC network, you can still hear the signal from the previous band. So when I have it in 40 and I throw the switch to open, you can still hear the 40 meter signal. Apparently one diode will (poorly) demodulate a signal with the VFO running at HALF the operating frequency. I saw this in the real world receiver and also saw it in an LTSpice simulation. In LTSpice the signal level drops significantly when I go to just one diode: From 50 mv peak to 15 mv peak, but it can still be heard. Something similar happens when I go from 80 to 40. When I close the switch and suddenly have two diodes and a 3.5 MHz VFO trying to demodulate the 80 meter signal, I can still hear the 80 meter signal, but it is much weaker and a lot more noise is getting through. Again, I saw this in the real world and in LTSpice. It looks as if with the two diodes, the 3.5 MHz signal is being sampled twice each VFO cycle. This may result in some output in the audio range. But again, it is much weaker.

MONDAY, JANUARY 11, 2021

KLH Model Twenty-One II -- Is My Speaker Dried Out?

A few years back Rogier PA1ZZ very kindly sent me a box of electronics parts. Included was an FM table-top radio with a nice walnut case. Thanks Rogier!

I hadn't looked at the receiver in years, but this week I dusted it off and looked it up on the internet. Turns out that it is kind of famous. It was produced by the KLH company. The K stood for Henry Kloss, one of the giants of Hi-Fi audio gear. Henry appears in the picture below.

I got the receiver working, but it sounds awful. It sounds much better with an external speaker, which is disappointing because the internal speaker was the main attraction of this receiver. It even has a little badge on the front panel trumpeting(!) its "Acoustic Suspension Loudspeaker."

I'm wondering if the problem is in fact the speaker. The cone looks intact, but it seems very dried out. It *has* been more than 50 years... What do you guys think? Picture above. Any other suggestions on what to do with this thing, or how to make it sound better?

Some KLH history:

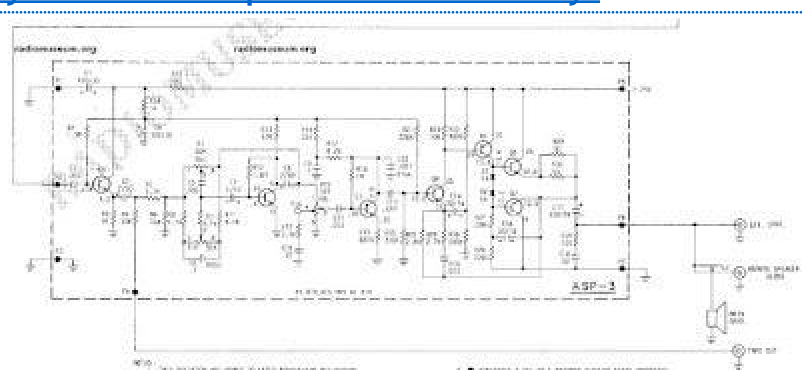
https://klhaudio.com/history

https://antiqueradio.org/KLHModelTwentyOne21FMRadio.htm

KLH receiver with pillow

SATURDAY, JANUARY 23, 2021

KLH Model Twenty-One II AF Amplifiers Too Hot. Why?



I've been working on this nice old FM receiver that Rogier PA1ZZ sent me. When I first tried it, it sounded terrible. I thought it might have been the speaker, but the speaker is fine. There was clearly something wrong in the AF amplifier. Schematic above. Click on it for a better view.

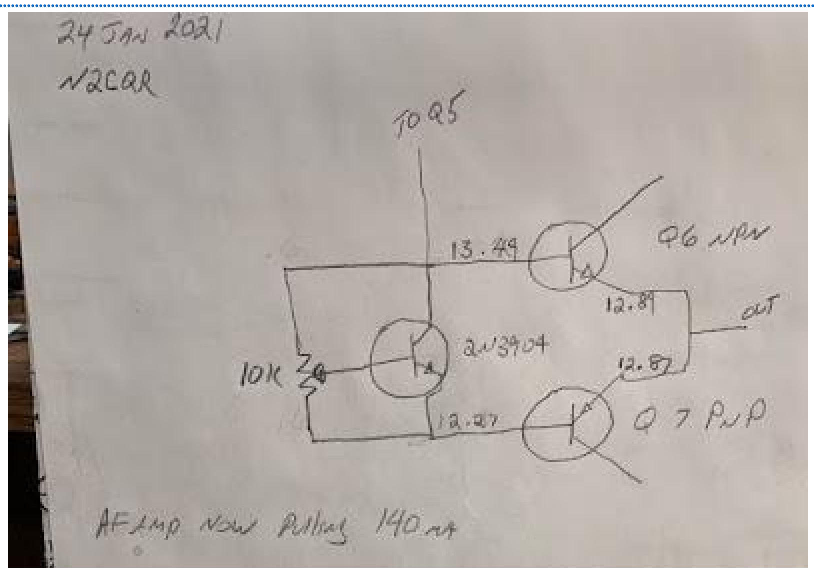
I ended up replacing the complementary pair of output transistors (Q6 and Q7) . The original had house brand designations -- I wasn't sure what to replace them with, so I just used a TIP29C and a TIP30C. With these transistors in there, the receiver sounds good. But the heat sink on the transistors is getting way too hot. I think the AF amplifier is now pulling about 1.4 amps, which is too much.

Another thing I did: I thought Q4 and Q5 might have been bad, so I replaced them with a 2n3904 and a 2n3906.

Why do you guys think the heat sink is getting so hot? What should I do? The supply on this receiver is 25V DC.

SUNDAY, JANUARY 24, 2021

VBE Multiplier Makes KLH Receiver "Cool Running"



Yesterday I turned to the SolderSmoke wizards for advice on how to fix my KLH Model Twenty-one II FM receiver. I had finally gotten the thing working -- it wasn't the speaker, it was the AF amp, probably one of the final transistors was blown. I replaced the finals and the driver. For the finals I used a TIP29C and a TIP30C. For the driver a 2N3906. With this fix the receiver was sounding good, but the heat sink on the AF amplifiers was way too hot.

If you look at the comments in yesterday's post, you will see some great suggestions on how to fix this problem. The comments and Google led me to Alan W2AEW's YouTube channel and his video on a circuit called the VBE multiplier. Voltage Base-Emitter multiplier. I'd never used this circuit before. It allows you to adjust the bias on the bases of the two transistors in a push-pull amplifier.

This morning I built the circuit on a small piece of PC board. There were just two components: a 10k trimmer pot and a 2N3904 transistor.

With the little board installed, I adjusted the pot for a 1.2 volt difference between the bases of Q6 and Q7. I ended up with base voltage values almost identical to those called for in the KLH schematic.

The receiver sounds very nice now, and is no longer on the verge of bursting into flames. I even made up my own version of the pillow that KLH claimed was necessary for proper acoustic suspension.

Sometimes it is nice to be able to listen to something other than the chatter on the ham bands. And it is fun to do so with a receiver that you have worked on.

I even used some Desitin as a substitute for heat sink compound.

Thanks to Rogier for the receiver, to ZL2DEX, K0EET, W2AEW and David McNeill for the good advice. And to Dale K9NN who sent me a box of parts from which emerged the 10k pot I used in this project. Thanks guys. 73

CHAPTER 6

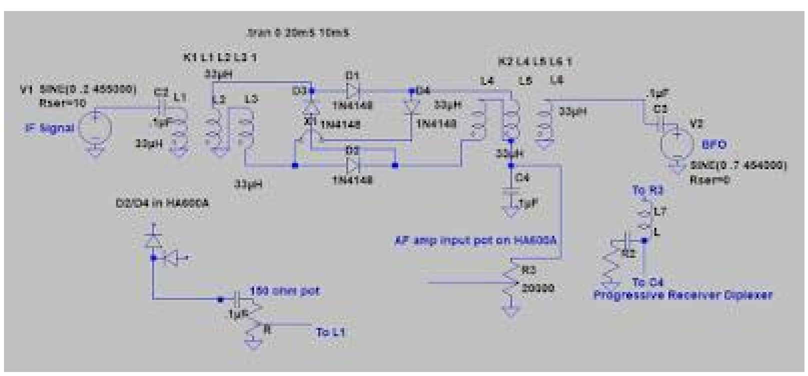
Mixers

I think receivers are at the heart of the ham radio station. And at the heart of the receiver is a mixer. The real problem that radio receivers have to solve is taking electromagnetic waves of high frequency (in our case 3 - 30 million cycles per second) and converting them to acoustical waves of audible frequency, say 300 to 3000 cycles per second. Sure, there are also amplifiers and oscillators and filters in the receiver, but in a real sense they are all just supporting the stage or stages that do this conversion. That stage is the mixer.

I really wanted an intuitive understanding of the mixer. As James Clerk Maxwell would have asked (as a boy), “What’s the go of it? What’s the particular go of it? When you ask these kinds of questions about mixers, people will often respond with trigonometry, with sine and cosine math. This was not really what I was looking for. I had a sneaking suspicion that even with all the math, you might not have the kind of intuitive understanding I was looking for – you wouldn’t know the particular go of it.

Mixers seem strange. We say they are multiplying (and does a simple diode do that?) and that they produce sum and difference frequencies (which seems inconsistent with multiplying!). It took me a while, but I did figure it out. Here I will present some of the projects that got me to this understanding.

LET’S CALL THEM “CROSSED DIODE MIXERS” NOT “DIODE RING MIXERS” NOVEMBER 2020



This has been a lot of fun and very educational. The problem I discovered in the Lafayette HA-600A product detector caused me to take a new look at how diode detectors really work. It also spurred me to make more use of LTSpice.

In the end, I went with a diode ring mixer. Part of this decision was just my amazement at how four diodes and a couple of transformers can manage to multiply an incoming signal by 1 and -1, and how this multiplication allows us to pull audio out of the mess.

But another part of the decision was port isolation: the diode ring mixer with four diodes and two transformers does keep the BFO signal from making its way back into the IF chain. This helps

prevent the BFO signal from activating the AGC circuitry, and from messing up the S-meter readings. LTSpice helped me confirm that this improvement was happening: in LTSpice I could look at how much BFO energy was making its way back to the IF input port on the diode ring mixer. LTSpice predicted very little, and this was confirmed in the real world circuit. (I will do another post on port isolation in simpler, singly balanced diode mixers.)

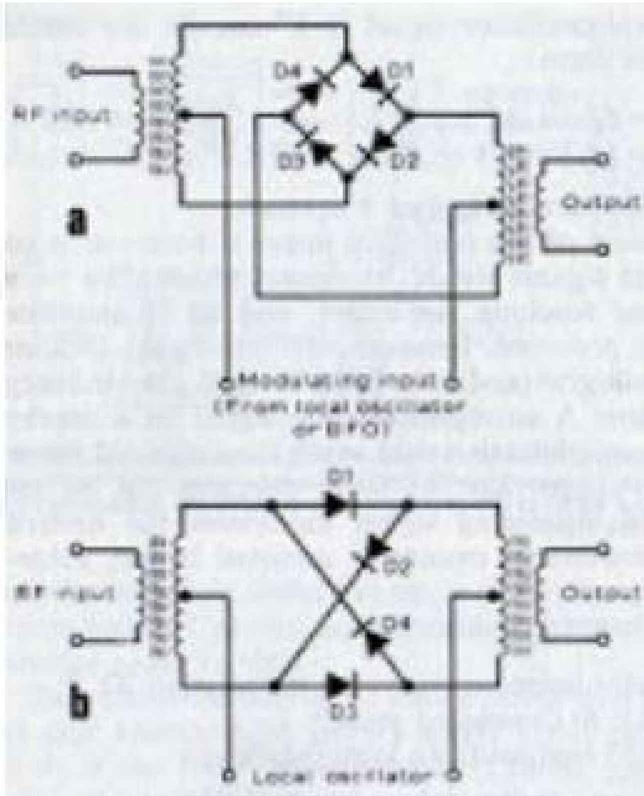
At first I did have to overcome some problems with the diode ring circuit. Mine seemed to perform poorly with strong signals: I'd hear some of the "simultaneous envelope and product detection" that started me down this path. I also noticed that with the diode ring, in the AM mode the receiver seemed to be less sensitive -- it was as if the product detector circuit was loading down the AM detector.

One of the commenters -- Christian -- suggested putting some resistance into the input of the diode ring circuit. I put a 150 ohm pot across the input, after the blocking capacitor. The top of the pot goes to the capacitor, the bottom to ground and the wiper to the input of L1 in the diode ring circuit (you can see the circuit in the diagram above). With this pot I could set the input level such that even the strongest input signals did not cause the envelope detection that I'd heard earlier. Watching these input signals on the 'scope, I think these problems arose when the IF signals rose above .7 volts and started turning on the diodes. Only the BFO signal should have been doing that. The pot eliminated this problem. The pot also seemed to solve the problem of the loading down of the AM detector.

With the pot, signals sounded much better, but I thought there was still room for improvement. I thought I could hear a bit of RF in the audio output. Perhaps some of the 455 kHz signal was making it into the AF amplifiers. I looked at the circuit that Wes Hayward had used after the SBL-1 that he used as product detector in his Progressive Receiver. It was very simple: a .01 uF cap and 50 ohm resistor to ground followed by an RF choke. I can't be sure, but this seemed to help, and the SSB now sounds great.

A BETTER NAME?

One suggestion: We should stop calling the diode ring a diode ring. I think "crossed diode mixer" or something like that is more descriptive. This circuit works not because the diodes are in a ring, but because two of them are "crossed." From now on I intend to BUILD this circuit with this crossed parts placement -- this makes it easier to see how the circuit works, how it manages to multiply by -1, and to avoid putting any of the diodes in backwards.



I prefer the bottom diagram

DIODE RING MIXERS ARE FUNDAMENTALLY DIFFERENT (FROM SIMPLE DIODE MIXERS)

APRIL 2009

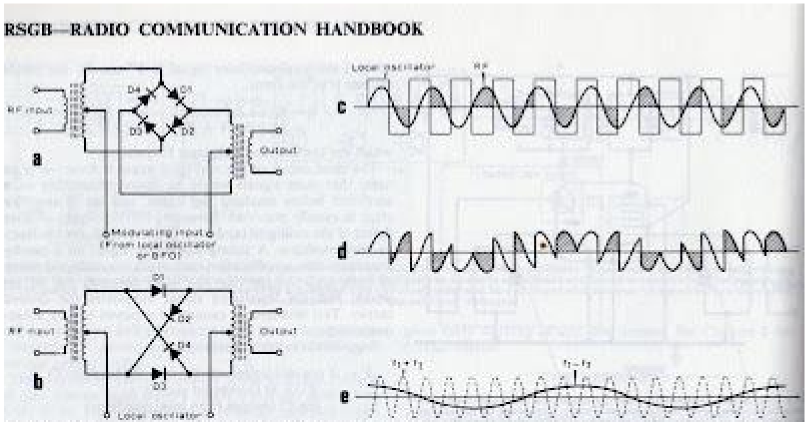
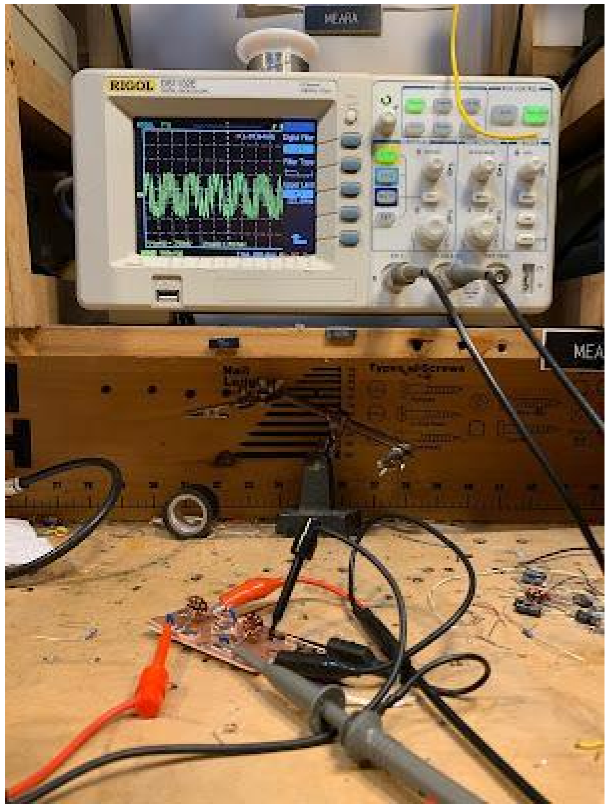


Fig 1.97. The ring-diode circuit (a) is a double-balanced modulator, both input signals cancelling at the output to leave only heterodyne products. In (b) the same circuit is redrawn to show the switching action of the diodes. When the local oscillator applies a positive half-cycle (ideally a square wave), diodes D1 and D3 conduct (c). On negative half-cycles these diodes are cut off, and signal passes through D2 and D4, arriving at the output transformer with reversed polarity. The resulting waveform (d) consists entirely of sum and difference frequencies (e) and harmonics.

Joop, PE1CQP, and I have been discussing mixer circuits, especially the ever-popular diode ring. Here is my latest e-mail to Joop. The RSGB diagram for the ring diode mixer appears above.

Joop: I think the way the diode ring mixer works is very different from the way a two diode singly balanced mixer functions. The effect, of course, is the same. But the polarity reversing element introduced by the ring configuration -- it seems to me -- makes this a very different circuit. Attached is the RSGB Handbook diagram I mentioned. I like it, because you can really SEE how the actions of the diode ring produce the sum and difference freqs (you have to keep Fourier in mind, and imagine the results of filtering). The two diode circuit simply "chops" the input signal at the rate of the LO. And it would even work in a non-switching mode -- you could, for example, use FETs instead of the diodes and bias them to operate in the non-linear portion of their curves, right? This makes me think that the diode ring mixer circuits (aka "polarity switching mixers" or "commutating mixers") are very different. 73 Bill

DIODE RING MAGIC
November 2020



I continue to work on the product detector of my Lafayette HA-600A. This work has caused me to brush up on my understanding of how mixers really work.

I think one of the most interesting mixer circuits is the diode ring. With just four diodes and one or two transformers, this device manages to take an incoming signal and multiply it by either 1 or -1 depending on the polarity of the local oscillator signal. That is pretty amazing.

Alan Wolke W2AEW did an excellent video on this: https://www.youtube.com/watch?v=junuEwmQVQ8

Inspired by Alan, I took my most recent homebrew diode ring mixer (with transformers from Farhan, diodes from Jim W8NSA, and a PC board base from the CNC mill of Pete N6QW) and hooked it up to two signal generators and an oscilloscope. I had the local oscillator at 10 MHz and the signal oscillator at 7 MHz. You can see my results in the pictures (above and at the end). You can see the resulting difference frequency (3 MHz) in the broad up and down pattern. And you can see the sum frequency (17 MHz) signal in the faster oscillations. All you would need is some filtering to separate them out.

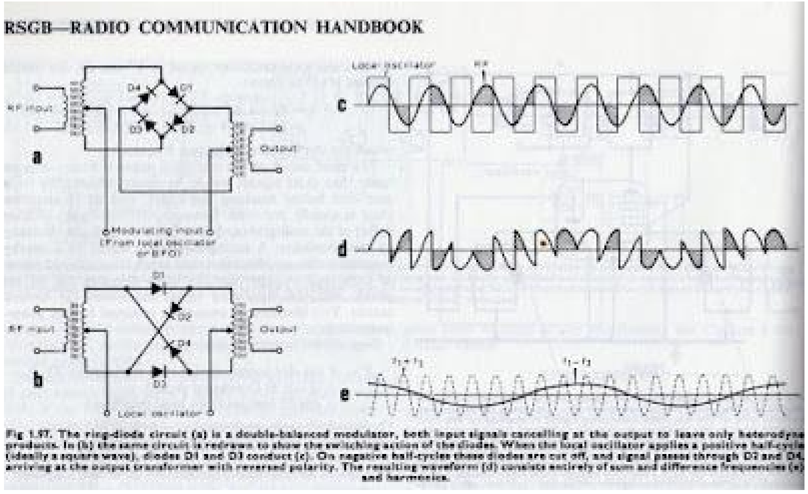
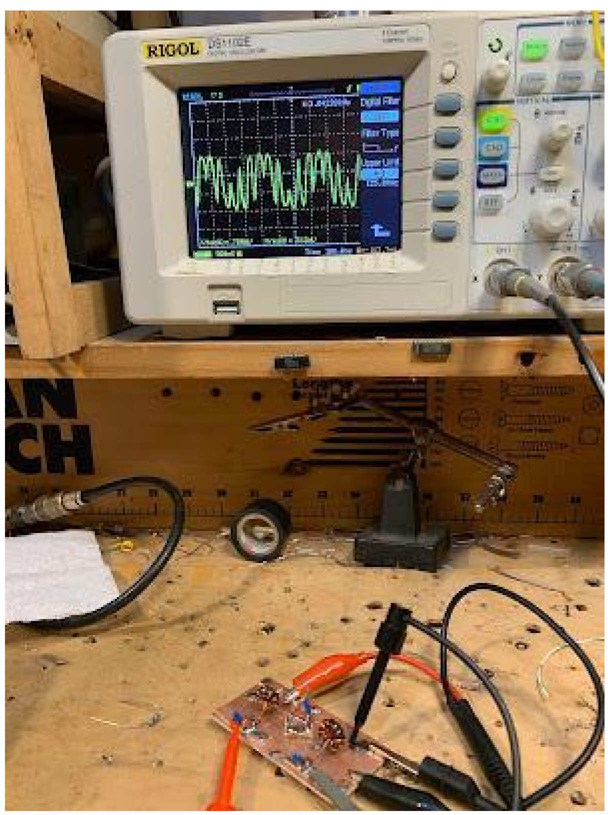


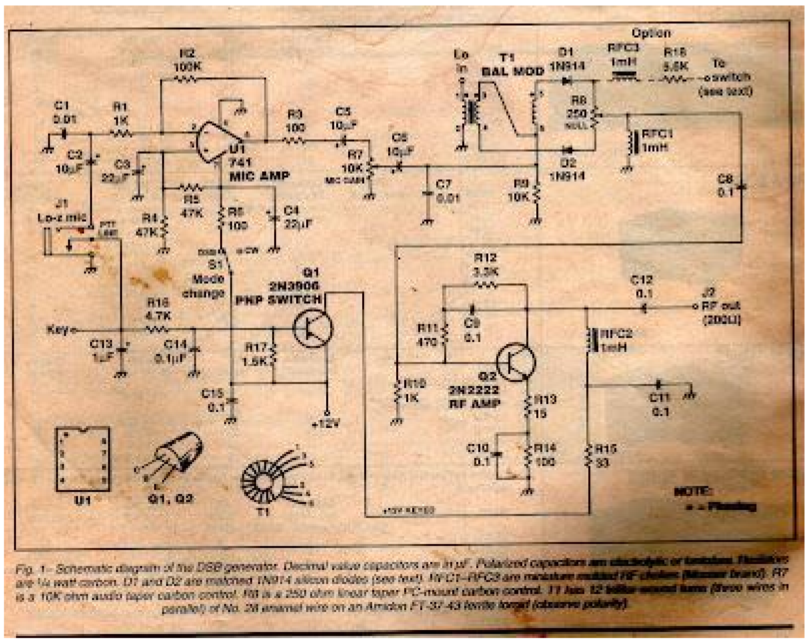
Fig 1.97. The ring-diode circuit (a) is a double-balanced modulator, both input signals cancelling at the output to leave only heterodyne products. In (b) the same circuit is redrawn to show the switching action of the diodes. When the local oscillator applies a positive half-cycle (ideally a square wave), diodes D1 and D3 conduct (c). On negative half-cycles these diodes are cut off, and signal passes through D2 and D4, arriving at the output transformer with reversed polarity. The resulting waveform (d) consists entirely of sum and difference frequencies (e) and harmonics.

I really like the RSGB Handbook diagram (above). I think the bottom schematic with its crossed diodes really explains how the phase reversal takes place: when the LO turns on D1 and D3 (the horizontal ones), multiplication by 1 takes place. But when the LO turns on D2 and D4 (the crossed diodes), up goes to down and down to up, creating phase reversal, or, in math terms, multiplication by -1.

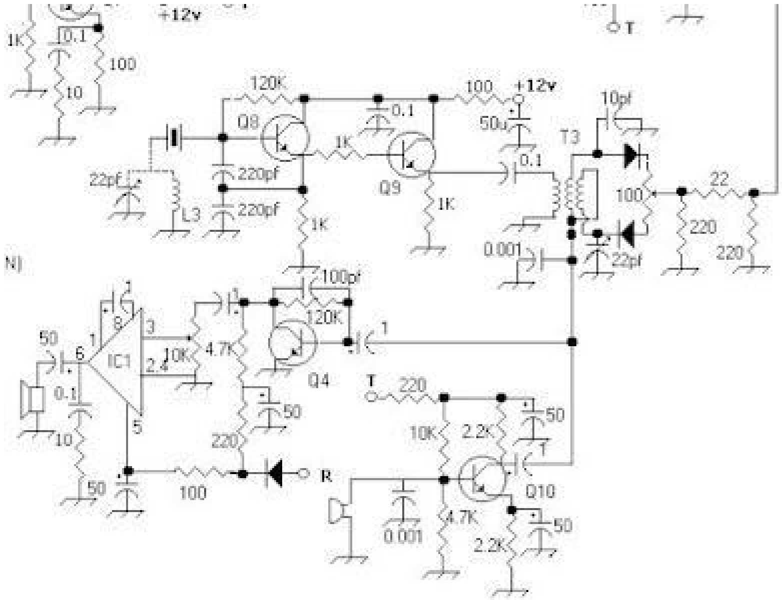
At a more basic level, mixing takes place whenever -- in a non-linear circuit -- one signal is controlling the gain or attenuation experienced by the other signal. A complex waveform results, a waveform that contains sum and difference products. A circuit like the diode ring, that alternately multiplies by 1 and -1, is non-linear in the extreme, and the multiplication is controlled by the LO. The results can be seen in the diagram's complex waveforms, on Alan's Tek 'scope, and on my Rigol. And in those complex waveforms you can SEE the sum and difference frequencies. That is really cool.



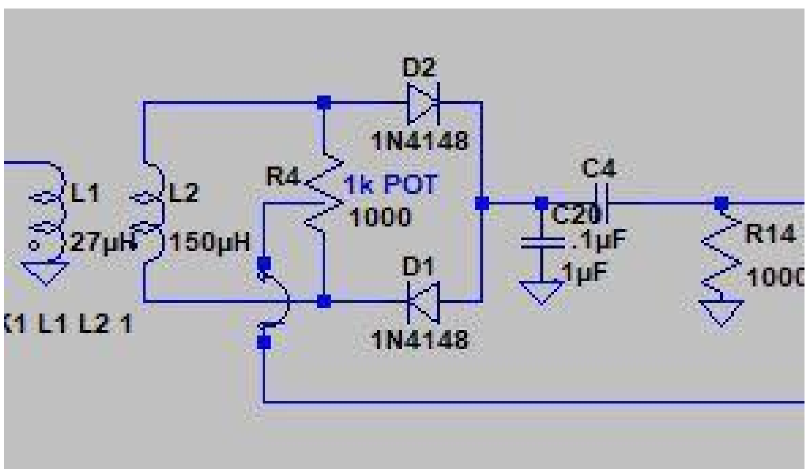
UNDERSTANDING TWO DIODE SINGLY BALANCED MIXER CIRCUITS
February 2021



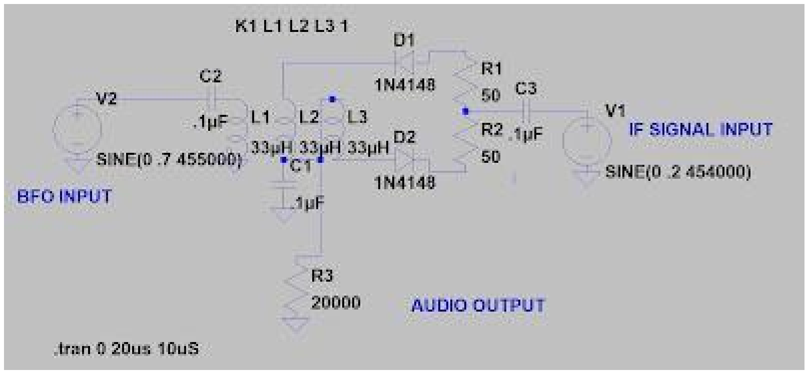
In 2001, out it in the Azores, I built a 17 meter version of Doug DeMaw's Double Sideband transmitter ("Go QRP with Double Sideband" CQ Magazine, February 1997). I struggled to understand the balanced modulator -- how it mixed, balanced, and how it produced DSB. I later presented my understanding of the circuit in my book "SolderSmoke -- Global Adventures in Wireless Electronics" pages 132-137. In essence, I figured out that you had to think of the balancing and the mixing as two separate operations: The transformer provided the balance that eliminated the carrier (the LO signal) while the diodes presented the two signals (audio from the mic amp and LO from the VFO) with a highly non-linear path. The LO was successively turning on both diodes then turning off both diodes. The audio signal was being "chopped" at the rate of the LO. This produced a complex waveform that contained sum and difference frequencies -- the upper and lower sidebands. The carrier was balanced out by the transformer because the two outputs of the transformer were always of opposite polarity, and they were joined together at the output of the mixer.



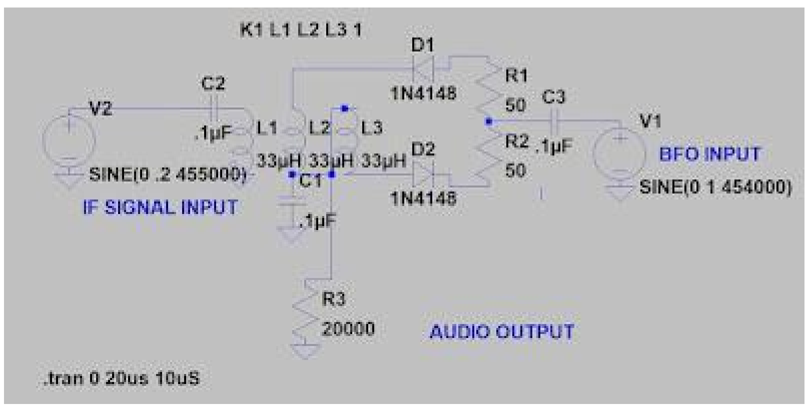
Fast forward to 2013. I built a 17 meter version of Farhan's famous BITX 20 rig. Above you can see the balanced modulator stage, which also serves as the product detector. As you can see, it is essentially the same circuit as the one used by Doug DeMaw in his DSB rig.



In 2018 I built a simple direct conversion receiver for my nephew. [For the mixer I] used what I considered to be just a cut-down version of the circuit used by DeMaw and Farhan. I got the idea for this from [Olivier F5LVG and his RX-20 receiver] from SPRAT. It had the RF signal coming in on L1 and the VFO signal coming in to the wiper of the 1 k pot. But with this arrangement, the diodes were NOT both being turned off on half the VFO cycle, then both being turned on during the other half. Instead, as the VFO signal swung positive, D2 would conduct and D1 would shut down. When the VFO signal swung negative, D1 would conduct and D2 would shut down. It worked, but the diodes were being switched in a very different way than they had been in the DeMaw and Farhan circuits. If you have the strong LO signal going in on L1, BOTH diodes conduct, then BOTH don't conduct. But if you have the LO going in through the pot, one diode conducts while the other does not conduct.



After I concluded that the BJT product detector circuit in the HA-600A was causing distorted SSB and CW reception, I tried the old DeMaw/Farhan circuit, this time in product detector mode. See above. This worked better, but I realized that this configuration was balancing out the BFO signal, and not the IF signal. My problem with the original product detector had been that IF signal was getting simultaneous envelope detection AND product detection. So I decided to just switch the inputs and put the IF signal into L1 (where it would be balanced) and the BFO into R1/R2 (the 100 ohm pot).



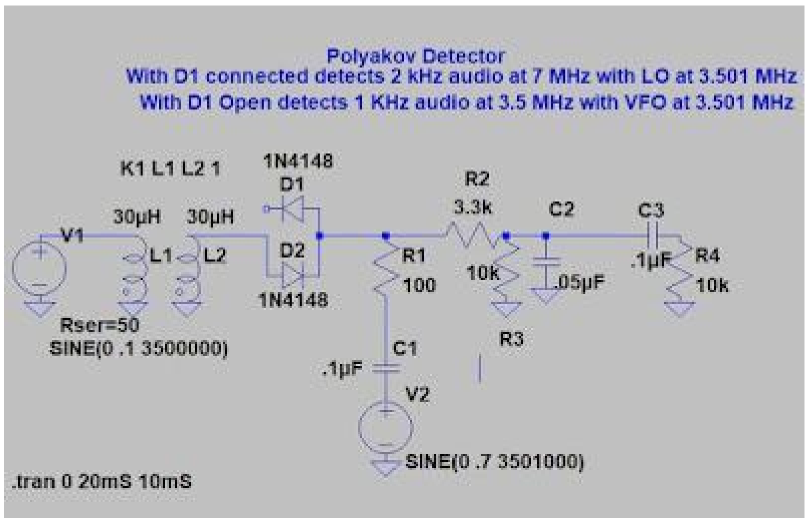
This seemed like it would reduce the envelope detection problem, right? I mean, L1 is the balanced input, right? But I wonder if we need to consider how the diodes were being switched in this arrangement. Instead of having both conducting and then both not conducting, in this arrangement one would be conducting during half the BFO's cycle, while the other was not. That means that at any given moment, the two output sides of the transformer would be looking into very different loads -- hardly a condition conducive to balance. But I used LTSpice to look at the audio output under the two different port arrangements. Sherwood advised looking at the output of the product detector with the BFO turned off --there should be no output with the BFO off. And indeed, putting the IF signal into L1 and the BFO into the R1/R2 pot resulted in less of the distortion causing envelope detection. The way the diodes were being switched didn't seem to adversely affect the balancing out of the IF signal. I am not sure why this doesn't seem to cause trouble.

There was, however, another problem with the use of this circuit in the Lafayette HA-600A: port isolation. The BFO signal was getting back into the IF signal input on L1. I could see it on the S-meter. This was worrisome not only because of the S-meter, but also because the same circuit was driving the receiver's AGC -- in effect, the BFO was turning the gain down. Theoretically, this should not have been happening. Look at the transformer. the BFO currents going through L2 and L3 should be of opposite polarities and should be cancelling each other out in L1. But obviously this was not happening. Perhaps this was the result of the sequential way the diode are switching in this arrangement. On the bench, if I put the BFO into L1, I saw very little BFO signal at the R1/R2

junction. If I put the BFO signal into the R1/R2 junction, I was a lot of BFO signal at the top of L1. And that is what I saw on my S-meter when this circuit was used in the HA-600A.

On the bench, if I turned off the BFO and put an AM modulated signal into the junction of R1/R2, I can see audio getting through once the input signal reaches 1 volt peak. I do NOT see that kind of "breakthrough" envelope detection when (with the BFO off) I put a modulated signal into L1. So the singly balanced circuit is doing that it is supposed to do -- it is balancing out the signal going into L1.

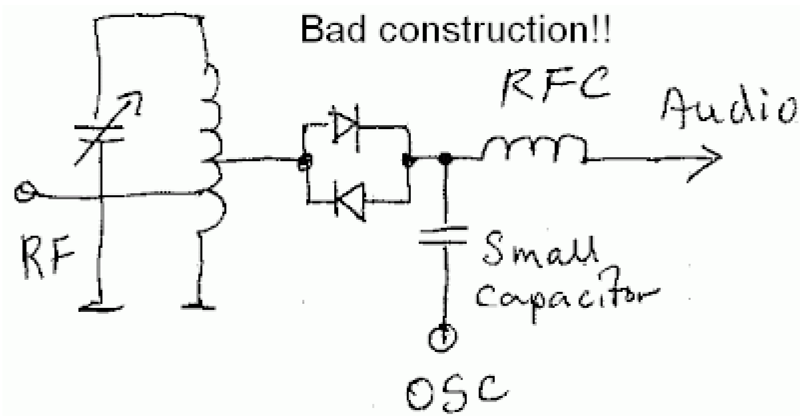
So it seemed that with the singly balanced circuit I would have to choose: suffer from the poor port isolation or AM breakthrough. Clearly it was time to go for a doubly balanced circuit. And that is what I did.



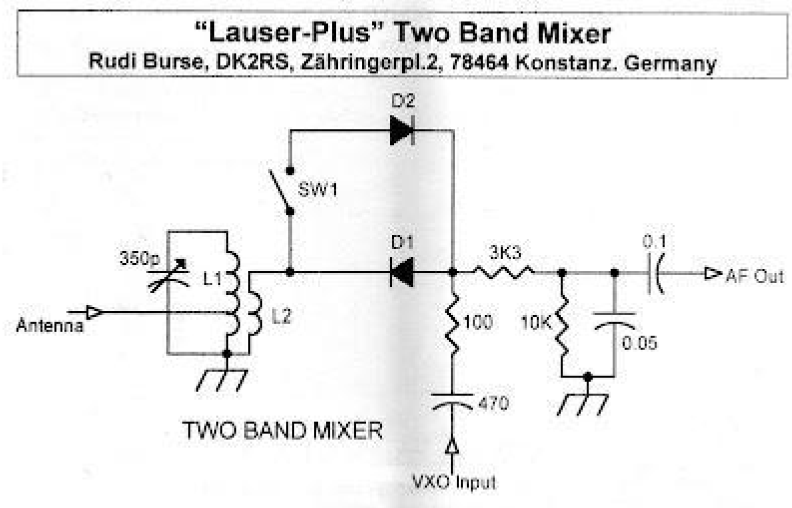
Finally, I took a look at another two diode detector, the Polyakov or "subharmonic" detector. This is a really interesting circuit that can teach us a lot about how mixers work. Here you can run the local oscillator at 1/2 the signal frequency. With two diodes back to back, the incoming signal is being sampled TWICE during each cycle of the local oscillator. That is equivalent to having the signal sampled at twice the local oscillator frequency. This circuit allows you to run the oscillator at a much lower frequency -- this could allow much greater oscillator stability. In the circuit above, with both diodes connected, a 7 MHz incoming signal would produce a 2 kHz tone.

Another big plus of this circuit comes if you take D1 out of the circuit (as shown). In this configuration the circuit becomes a normal diode detector. Here it will receive a signal at 3.5 MHz, converting that signal into a 1 kHz audio tone. So you can get a direct conversion receiver for 40 and 80 meters fairly easily.

POLYAKOV'S RUSSIAN MIXER
March 2010



I'm planning on building a DC receiver for use with the WSPR system. I will probably follow W3PM's lead and put a crystal filter between the antenna and the mixer. This will be a fixed frequency receiver aimed at one 200 hz slice of the 30 meter band. Of course, the big question is what mixer circuit I should use. I'll probably go with an SBL diode ring, but while perusing the literature, I again came across "The Russian Mixer" of Vladimir Polyakov, RA3AAE. Michael, AA1TJ, is a big fan of this circuit, and has been talking about it on Radio Havana Cuba. What a cool circuit it is! Just two diodes in parallel, cathode to anode. RF from the antenna goes in one side, and the local oscillator signal is placed at the other end. The LO signal causes the diodes to turn on and off on voltage peaks, effectively chopping up the incoming signal, producing sum and difference frequencies. LA8AK's drawing of one version of this circuit appears above. (Obviously OM AK didn't like this configuration, but it gives you the idea.) The really cool part is that because you have two diodes, the "chopping" takes place at TWICE the LO frequency. This happens because on a positive LO peak one of the diodes conducts, and then, on the negative peak, the other conducts. So it is as if the mixer gate is opening twice each LO cycle. This allows you to run the oscillator at half the operating frequency, with advantages for stability and for the effort to eliminate common mode hum. A while back I saw (somewhere!) a clever use of this circuit. LO was running at around 3.5 Mhz. With the two diodes in the circuit, it was a 40 meter receiver. They had a switch that could remove the second diode from the circuit. By throwing this switch, the RX went to 80 meters. Does anyone remember this circuit? Where did it appear? SPRAT? QQ? Tech Topics? I can't find it. I had the impression that OM Polyakov was active in the early days of radio. But some Googling shows that he is of much more recent vintage, still active and listed on QRZ.com. Here he is: 



The "Lauser" was a DC Receiver for 40 or 80m. This mixer modification permits coverage of both bands. The switch is closed [on] for 40m operation, the mixer becoming an "harmonic mixer". The switch is off for 80m operation. For both bands the VXO is constructed with a ceramic resonator – CSA 3.58MHz.

I found it! SPRAT 110, Spring 2002, page 5. A short article by OM Rudi Burse, DK2RS. This is the variation on the Polyakov Russian Mixer that I mentioned a couple of days ago. I'd been digging through piles of books and old magazines looking for this. My wife thought I'd gone nuts. (Well, nuttier than usual, actually.) It didn't help that I responded "The Polyakov Russian sub-harmonic mixer circuit with two band application!" when she asked what I was looking for. Of course, I should have known that it was in SPRAT. It just happened that the issue with this article was piled under a lot of junk on the workbench. I really like this circuit. Ingenious. And now that I have come to understand mixers a bit better, I can appreciate this one more. Here's how I'd explain it: With the switch closed, the signal from the LO "opens" one of the diodes on the positive peak, and it opens the other diode on the negative peak. So that RF signal from the antenna is getting sampled and mixed twice each cycle of the LO. The resulting complex waveform has sum and difference frequencies of RF+2LO and RF-2LO. With the switch open, you only have one diode sampling the RF, and it opens only ONCE each LO cycle. So the complex waveform that comes out of this single diode had frequencies of RF+LO and RF-LO. This opens the possiblity of DC receivers for 80/40, 40/20, 20/10 meters, etc. I guess a key adjustment in this circuit would be getting the LO level just right. Thanks SPRAT! Thanks Rudi! Thanks Vladimir Polyakov!

You'll see in the comments attached to my last blog post that our man on the left coast, Steve Smith, gave that cute little Doug DeMaw/Vlad Polyakov receiver a name that might set American-Russian hamrelations back a bit: He called it "Vlad The Inhaler." Good one Steve! (But you might want to stay out of the diplo game!)

MONDAY, AUGUST 8, 2022

Polyakov (RA3AAE) Direct Conversion Receiver: 40 meter DC RX with VFO at 3.5 - 3.6 MHz (with video)

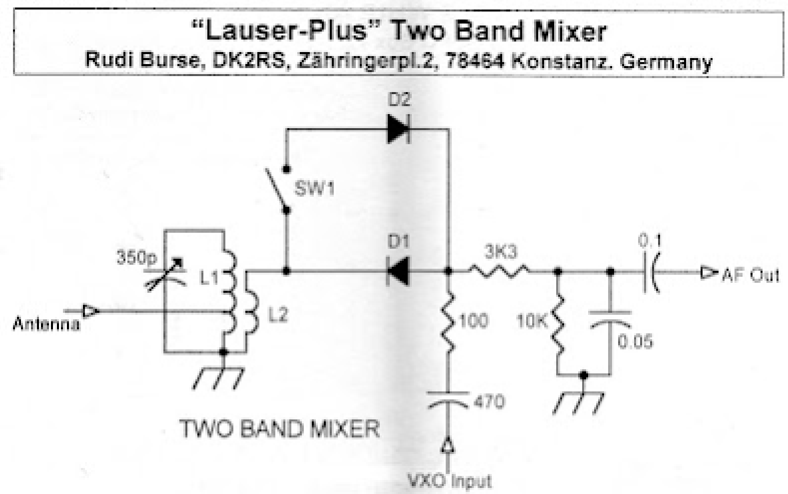
I've been reading about Polyakov (or "sub-harmonic") Detectors for a long time:

https://soldersmoke.blogspot.com/search/label/Polyakov--Vladimir

But until now, I never built one. Recently, Dean KK4DAS and the Vienna Wireless Makers group have been building a Direct Conversion receiver. Their receiver uses an Si5351 as the VFO, but of course Dean and I have decided to try to do things the hard way by building non-digital VFOs. At first we just came to the conclusion that my earlier Ceramic Resonator VFO wasn't much good (it drifted too much). This led us into standard Colpitts and Armstrong VFOs, and the fascinating

world of temperature compensation. Then I remembered the Polyakov circuit -- this would allow us to use a 3.5 MHz VFO on the 7 MHz band. Lower frequency VFOs are easier to stabilize, so I started building my first Polyakov receiver. You can see the results (on 40 meters) in the video above.

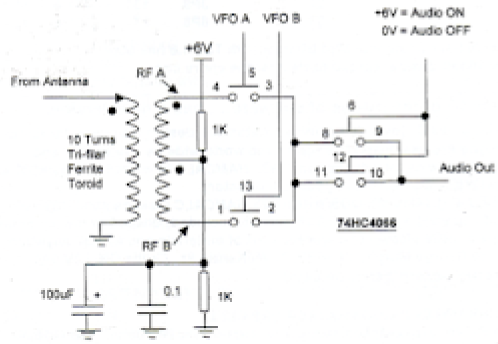
I started working with a circuit from SPRAT 110 (Spring 2002). Rudi Burse DK2RS built a Polyakov receiver for 80 and 40 that he called the Lauser Plus. (Lauser means "young rascal" or "imp" in German.) For the AF amplifier, I just attached one of those cheap LM386 boards that you can get on the internet. With it, I sometimes use some old Iphone headphones, or an amplified computer speaker.



The "Lauser" was a DC Receiver for 40 or 80m. This mixer modification permits coverage of both bands. The switch is closed [on] for 40m operation, the mixer becoming an "harmonic mixer". The switch is off for 80m operation. For both bands the VXO is constructed with a ceramic resonator -- CSA 3.58MHz.

The Polyakov mixer is a "switching mixer." The book excerpt below shows how I understand these circuits. The enlightenment came from the Summer 1999 issue of SPRAT (click on the excerpt for an easier read):

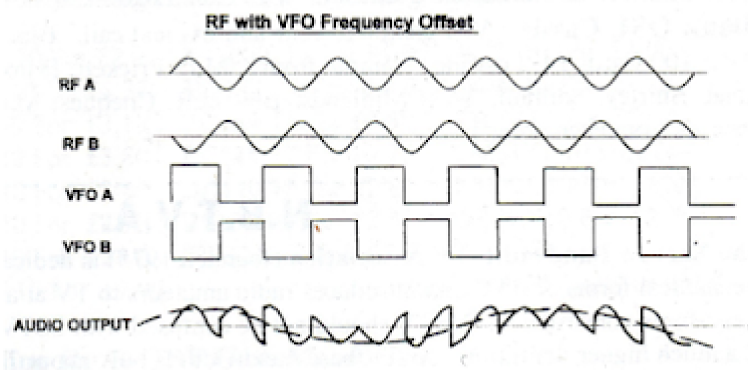
Let's take a look at Leon's circuit. On the left we have a signal coming in from the antenna. It goes through a transformer and is then applied to two gate devices. Pins 5 and 13 of these gates determine whether the signals at pins 4 and 1 will be passed on to pins 3 and 2 respectively. Whenever there is a positive signal on gate 5 or on gate 13, signals on those gaps can pass through the device. If there is no positive signal on these gates, no signals pass. Don't worry about pins 6-12.



RF A is the signal going to pin 4, RF B is the "flip side" of the same signal going to pin 1. VFO A is a square wave Variable Frequency Oscillator signal at Pin 5. It is going from zero to some positive voltage. VFO B is the flip side. It too goes from zero to some positive voltage.

Look at the schematic. Imagine pins 5 and 13 descending to bridge the gaps whenever they are given a positive voltage. That square wave signal from the VFO is going to chop up that signal coming in from the antenna. It is the result of this chopping that gives us the sum and difference frequencies. Take a ruler, place it vertically across the waveforms, and follow the progress of the VFO and RF signals as they mix in the gates. You will see that whenever pin 5 is positive, the RF signal that is on pin 4 at that moment will be passed to the output. The same process takes place on the lower gate. The results show up on the bottom "AUDIO OUTPUT" curve.

Now, count up the number of cycles in the RF, and the number of cycles in the VFO. Take a look at the output. You will find that that long lazy curve traces the overall rise and fall of the output signal. You will notice that its frequency equals RF frequency minus VFO frequency. Count up the number of peaks in the choppy wave form contained within that lazy curve. You will find that that equals RF frequency plus VFO frequency.



Leon's circuit shows us how a simple switching circuit in which the switches are controlled by the VFO can result in an output that has the sum and difference components. That is the hallmark (and most useful part) of real mixing. Remember -- we say that mixing happens in non-linear circuits when the passage of one signal depends on what is happening with the other signal. A switch is as non-linear as you can get! And that switch is being controlled by the VFO.

In a Direct Conversion receiver we usually run the VFO at the operating frequency. This results in audio just above and just below the operating frequency.

The Polyakov Direct Conversion circuit is a bit different. It has the switches (the diodes) turned on twice each cycle: When the VFO voltage goes to a positive peak, this turns on one of the diodes. When the VFO goes to a negative peak, this turns on the other diode. So in effect the switch is being turned on TWICE each cycle. So with the Polyakov you run the VFO at HALF the operating frequency. For a DC receiver designed to run around 7.060 MHz, you build a VFO at around 3.53 MHz. This has some immediate advantages. My favorite is that it is easier to get a VFO stable at a lower frequency. It is easier to stabilize a VFO at 3.53 MHz than it is at 7.060 MHz.

When you open that SW 1 switch in the Lauser Plus, you no longer have a Polyakov mixer. Now you just have a diode mixer. It will be opening and closing once each cycle at the VFO frequency. DK2RS used this to cover not only the 40 meter band (in Polyakov mode) but also the 80 meter band (in single diode detector mode). That is why DK2RS has that big variable capacitor in the input circuit -- that LC circuit needs to tune all the way down to 3.5 MHz and all the way up to around 7.3 MHz. (I used a coil of about 6.5 uH to do this.)

With just one diode and operating at 80 meters, it works, but not as well as it does in the Polyakov mode on 40. I can pick up 80 meter signals, but in this mode there seems to be more of an "AM breakthrough" problem. "Experimental Methods in RF Design" on page 8.11 describes what is going on (the last sentence is most relevant here):

AM Demodulation

A common problem with direct conversion receivers is demodulation of AM signals anywhere in the RF passband of the receiver. This is most often observed on 40 m when foreign broadcast signals are very strong. **Fig 8.19** illustrates the problem. Any mechanism in the mixer that produces a dc output at the mixer IF port from a signal at the RF port will result in the envelope of an AM signal appearing as weak audio, right at the input to a 100-dB gain audio amplifier. DC outputs occur when a mixer has second order distortion. Second order distortion is common when balanced mixers become unbalanced. Since the usual way that balanced mixers unbalance is the presence of LO signal at the mixer RF port, it is evident that AM demodulation is a symptom of both poor LO to RF isolation and high audio gain. Improving the shielding around the VFO, and LO to RF isolation often improve a receiver's immunity to AM demodulation. Receivers that use VFOs operating at half (or twice) the signal frequency usually have better AM rejection than receivers with fundamental VFOs, due to improved LO to RF isolation.

Direct Conversion Receivers 8.11

Here are some very good links with information on the Polyakov receiver:

LA8AK on Polyakov: http://noding.com/la8ak/c21.htm

LA8AK's Home Page: http://www.agder.net/la8ak/index1.htm

LA8AK SK: http://www.agder.net/la8ak/ Almost seventeen years after his death he continues to help his fellow radio amateurs through his web sites. TNX OM! FB!

BH1RBG: https://sites.google.com/site/linuxdigitallab/rf-ham-radio/dc-polyakov-based-first-dc-receiver

Hack-A-Day on Polyakov: https://hackaday.com/2015/11/15/polyakov-direct-digital-synthesis-receiver/

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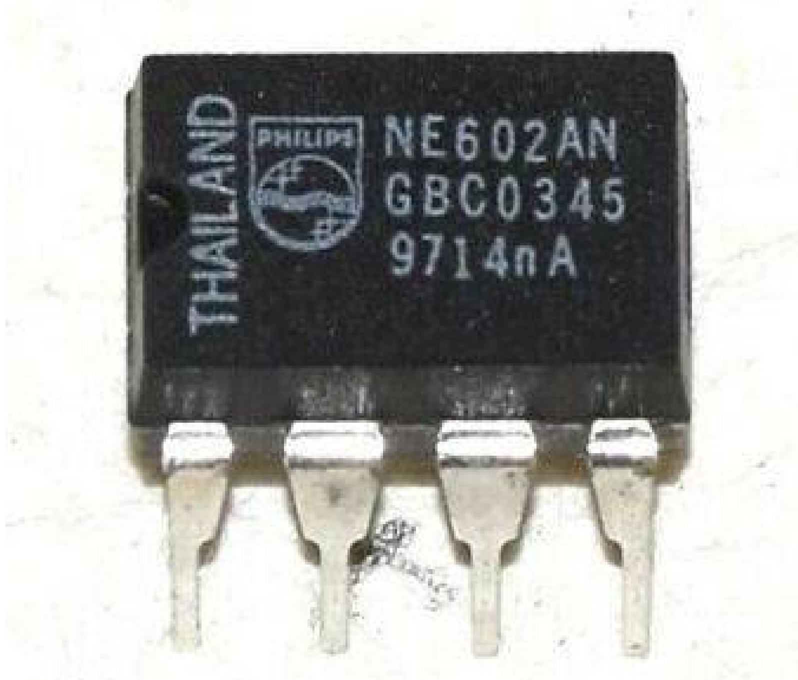
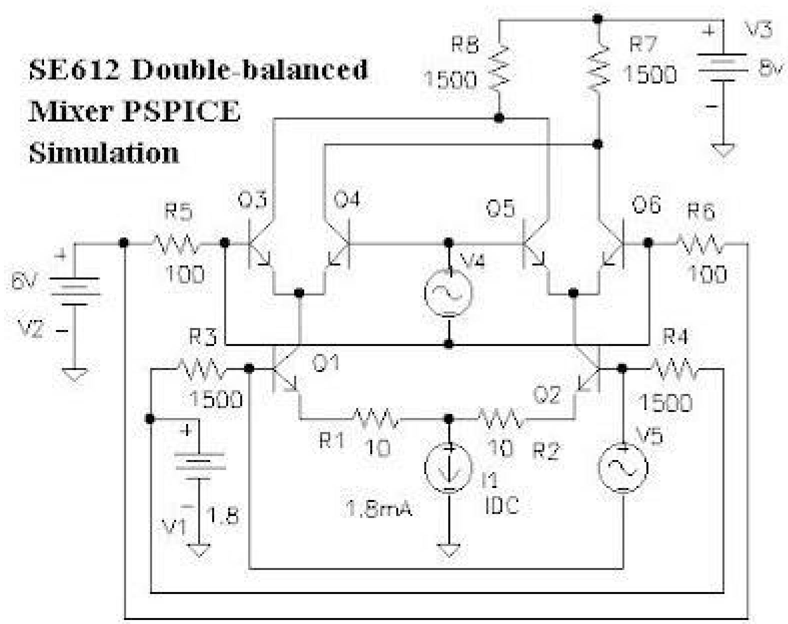
UNDERSTANDING THE GILBERT CELL MIXER

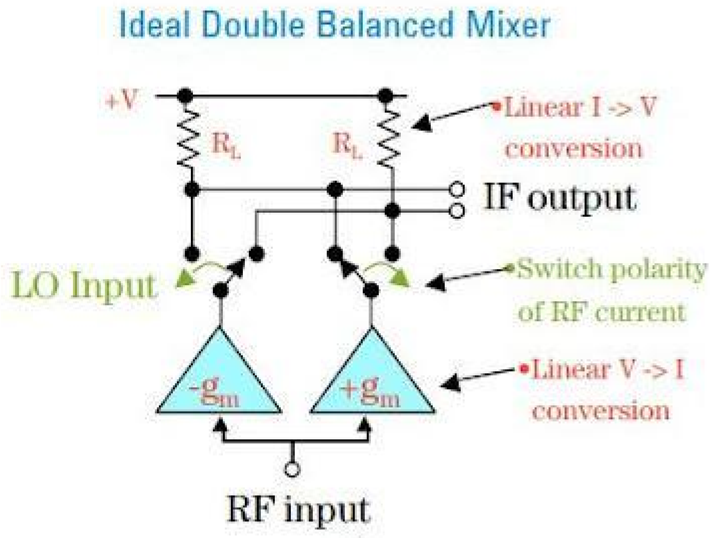




I think the key to understanding the Gilbert Cell Double Balanced mixer is to separate out the three tasks that this device completes, and consider them one at a time, using different diagrams:

1) It mixes two signals to produce sum and difference outputs.
2) It balances out the RF input.
3) It balances out the LO input.

Task 1 -- Mixing

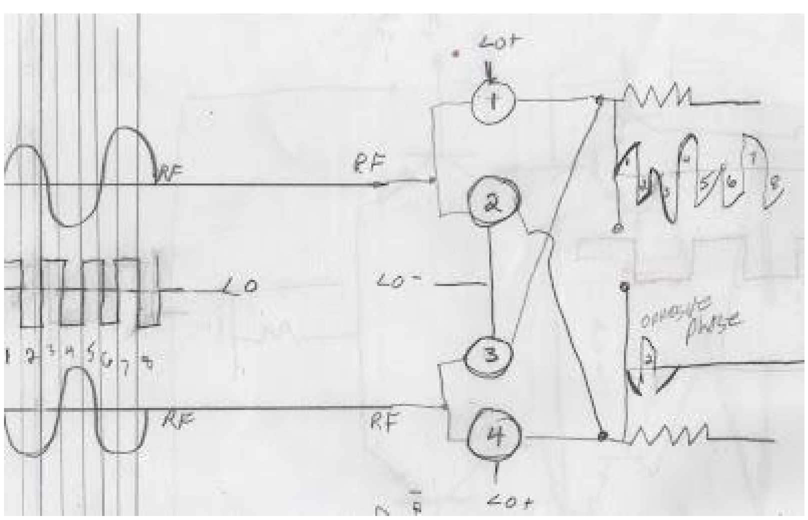


The Gilbert cell is like the diode ring mixer in that it switches the polarity of the input signal at a rate set by the Local Oscillator. Another way of saying this is that the mixer multiplies the input signal by 1 and by -1.

Steve Long of the University of California described the essence of this mixing this way (using the diagram above):

An ideal double balanced mixer simply consists of a switch driven by the local oscillator that reverses the polarity of the RF input at the LO frequency. [***http://literature.cdn.keysight.com/litweb/pdf/5989-9103EN.pdf***](http://literature.cdn.keysight.com/litweb/pdf/5989-9103EN.pdf)

In an effort to see this for myself, I drew (noodled!) this diagram:



There are four transistors -- two differential pairs with RF coming into the bases of the pairs. The LO is a square wave. The LO alternately turns on transistors 1 and 4, then 2 and 3. When 1 and 4 are on, we are in period 1 -- here there is no switching of polarity. Portions of the RF waveform are

passed to the outputs. But when the LO turns on transistors 2 and 3, portions of the RF waveform are "crossed over" to the opposite output. Polarity is reversed. We see this in period number 2.

Take a look at the resulting output waveforms. This is the same waveform we see coming out of a diode ring mixer. I really like this drawing because in that complex waveform you can actually see the sum and difference frequencies:

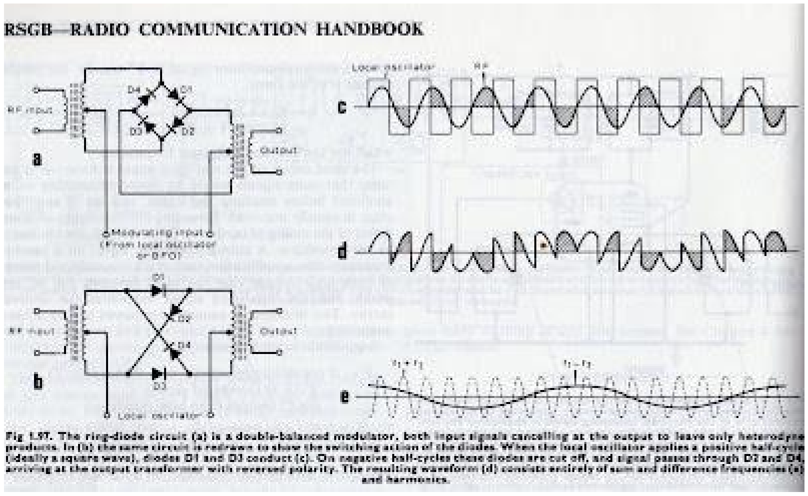
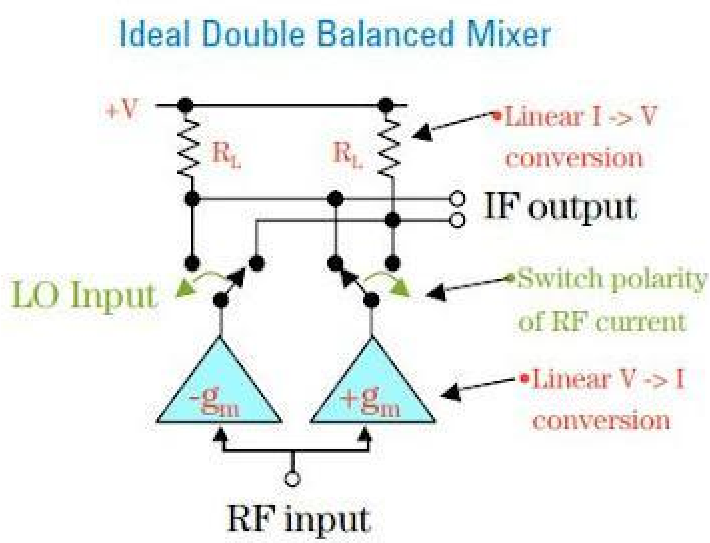


Fig 1.97. The ring-diode circuit (a) is a double-balanced modulator, both input signals cancelling at the output to leave only heterodyne products. In (b) the same circuit is redrawn to show the switching action of the diodes. When the local oscillator applies a positive half-cycle (ideally a square wave), diodes D1 and D3 conduct (c). On negative half-cycles these diodes are cut off, and signal passes through D2 and D4, arriving at the output transformer with reversed polarity. The resulting waveform (d) consists entirely of sum and difference frequencies (e) and harmonics.

I could see this diode ring waveform myself on my oscilloscope:
https://soldersmoke.blogspot.com/2020/11/diode-ring-magic.html

TASK 2 -- Balancing Out the RF Input

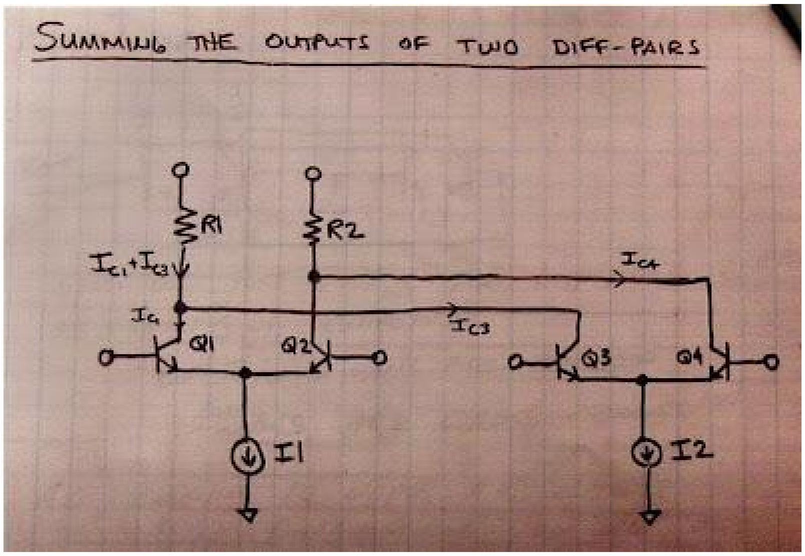
In a diode ring, and in other diode mixers, the balancing out of the input signals really takes place in the trifilar toroidal coils that are part of the circuit. Barrie Gilbert needed an integrated circuit mixer that <u>did not</u> use coils.



Again referring to the above diagram, Steve Long of the University of California put it this way:

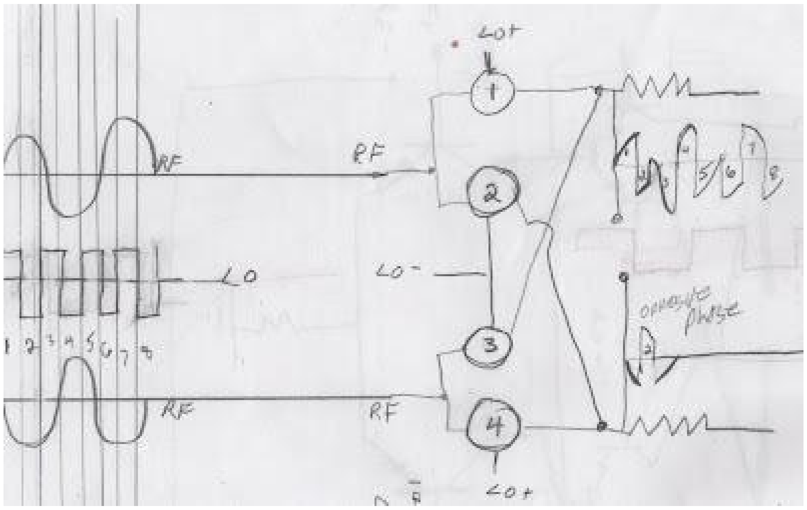
The ideal balanced structure above cancels any output at the RF input frequency since it will average to zero.

To fully understand this I find it helps to look at the Gilbert cell circuit drawn in a different way. Here is a drawing from Alan Wolke W2AEW that I found very helpful. It comes from his excellent YouTube video: https://www.youtube.com/watch?v=7nmmb0pqTU0



Suppose the RF waveform at I1 is causing the current through R1 and R2 to increase. At the same time, the opposite phase current through I2 will be causing the current through R1 and R2 to DECREASE. So there is no net effect of the RF signal at the output. The RF is balanced out.

TASK 3 - Balancing Out the Local Oscillator Signal



Here too I used my own drawing, and was guided by the words of Steve Long:

It also cancels out any LO frequency component since we are taking the IF output as a differential signal and the LO shows up as common mode.

The important thing to realize here is which transistors are being turned on and off by the local oscillator signal. On one half cycle of the LO, transistors 1 and 4 are on. So the LO signal at the LO frequency are both pulling the same amount of LO frequency current through the resistors. So you have the same change in voltage at the output terminals. And the output terminals are differential. The LO signal results in no voltage difference between the terminals. So the LO frequency is balanced out.

The same thing happens on the following half of the LO cycle. Here, transistors 2 and 3 are turned on. Again, both transistors pull the same amount of LO frequency current through the resistors. There is no differential voltage. So no LO frequency energy passes to the output. LO frequency is balanced out.

I am surrounded by Gilbert Cell Mixers and I have been using them in my homebrew rigs for many years. I use them in up-converters for my RTL-SDR receivers. I have one in the downconverter for my 17 meter receiver and had one as the mixer in my first SSB transmitter. I built a 40 meter SSB transceiver with NE602s on either end of the crystal filter. Years ago, I built a DSB transceiver with several NE602s. My SST QRP CW transceiver is made with NE602s. I have on my bookshelf Rutledge's book "The Electronics of Radio" that is all about the NORCAL 40 transceiver, built using NE602 chips. But until now I really didn't know how these chips worked. Truth be told, for me they were mysterious little black boxes, and that bothered me. Now I feel a lot better about using these clever devices. I plan on stocking up on the old style (non-SMD) NE602s.

Apparently Barrie Gilbert rejected the idea that he invented the circuit that bears his name. It seems that Howard Jones first used this circuit in 1963, with Gilbert developing it independently (in an improved form) in 1967.

Barrie Gilbert was quite a guy, with electronic roots in the world of tinkering:

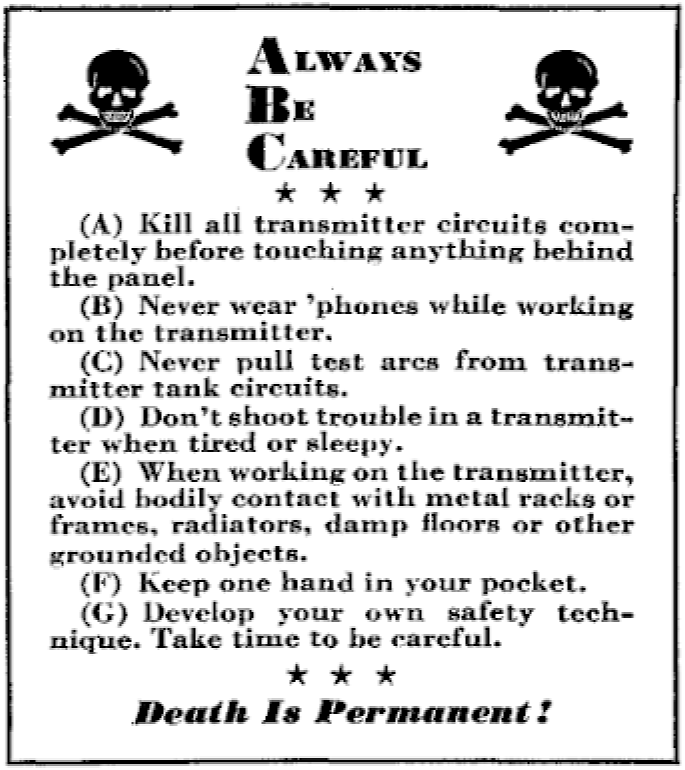
https://www.microwavejournal.com/articles/33425-living-and-learning-with-barrie-gilbert

https://vintagetek.org/barrie-gilbert/

Gilbert, Barrie

CHAPTER 7

Boatanchors



This is an old story, about old gear. If you are interested in circuitry, and electronics, and building, there are certain types of equipment that will attract you, especially when you are just starting out. You will find yourself interested in simple gear, gear that you can work on and understand. Enter the boatanchors. These are old tube-type pieces of gear. They are usually big and heavy. That is where the nickname comes from. Legend has it that they can be used as boatanchors. I think the Heathkit DX-100 transmitter (I have owned two of these beasts) is the rig that led to the nickname. At one of my early diplomatic posts we were transitioning from old teletype gear to laptop computers. Our teletype may have become an actual boat anchor.

I like this old gear. I still have the old Drake 2-B receiver and Hallicrafters HT-37 transmitter that I used as a teenager. But when my kids were born I realized that my continued drawing of breath was now more important. And as the kids became ambulatory I became wary of high voltage in the shack. So around this time I transitioned away from boatanchors. I now occasionally find myself working on this gear, but I have to be especially careful – I have grown accustomed to low voltage equipment and am no longer as wary as I need to be to safely work on equipment with voltages in the lethal range. As the QST ad (above) says, Death Is Permanent! Always be careful!

SATURDAY, APRIL 4, 2020

WEDNESDAY, MARCH 18, 2020

Double Trouble: Notes on TWO Hallicrafters S-38E Restorations and Alignments (with videos)

Winterfest S-38E on the left, junker on the right

I have been talking bad about the Hallicrafters S-38E receiver for several years now. For a long time I agreed with my friend Pete Juliano in his colorful description of the receiver: "a pig with lipstick."

But as I've gotten to know the receiver better, I have come to like it. It is very simple. There is a certain minimalist thing that explains the attraction; it is a challenge to make the most of this very low-budget 1950's receiver. It uses tubes, but the voltage is not really in the very lethal range. It covers a wide range of frequencies. Its frequency stability is fairly good. And it sounds great on AM (scroll to the bottom to listen). It seems to be technologically related to the Echophone EC-1 -- we have been posting about

the WWII advertisements featuring Hogarth and his (unbelievable) efforts to attract women with this receiver.

The S-38E has a big "picture window" frequency dial, marked with exotic foreign locations (Java!). I share with it a similar vintage with the S-38E: IGY. The S-38E was produced from 1957-1961. Duck and cover my friends; the CONELRAD frequencies are marked on the dial. Working on these two receivers has kept me busy during the first few days of the COVID-19 emergency.

I now own two of these things. I might get a third. I thought it would be worthwhile to write up my experiences with the S-38E. I hope this information will be of use to others who might work on this piece of gear.

Winterfest RX on the left, junker on the right

SHOCKINGLY BAD?

I had an S-38E as a kid. Around 1980, I gave it to my cousin Mary's husband Mike so he could listen to shortwave broadcasts. Recently I asked him about that S-38E -- he said it had given him a nasty shock. That was because of the "transformer-less" AC/DC power supply -- if you plugged the AC line cord in "the wrong way" you would be putting 115 V AC on the chassis. Ouch.

AC/DC DESTROYS AN ANTENNA COIL

I picked up an S-38E at a Vienna Wireless Winterfest a few years ago. I think I paid ten bucks. I didn't pay attention to the polarity of the AC plug and managed to plug it in the wrong way. Then I managed to short the antenna terminal to what turned out to be a very AC hot (115V) chassis. This destroyed a significant portion of the antenna coil. Smoke was released.

ISOLATION TRANSFORMER

Not wanting to repeat the hot chassis disaster, I installed an isolation transformer. On the junker, I used the Triad N-49X, available from Digikey. In retrospect I probably should have gone with the larger, 35 watt N-51X, but Fred KC5RT provided a great suggestion that would make the smaller N-49X adequate: Run the filaments in series DIRECTLY from the AC line, with neither side of the AC line to the chassis. Then run the rest of the circuitry through the isolation transformer. This would take a lot of current out of that little transformer and would likely make replacement with a larger unit unnecessary. I will try this later. Update: 2 April 2020: I tried to run the S-38E with the filaments in series fed with AC directly from the line cord and the rest of the circuit running through the isolation transformer. I got it working this way. Sort of. But AC hum was a lot louder and I found myself back in the AC/DC transformerless situation with the chassis going hot if the set is plugged in "the wrong way." So I retreated, going back to having the whole receiver running off the isolation transformer. The hum went back to the earlier (normal) level

and the chassis would not go hot no matter how I plugged it in.

On the Winterfest S-38E it looks like I had used a larger isolation transformer.

I put a 500 ma fuse in the primary circuit. On the N-48X the black lines are primary, the red are secondary. One black line goes to the fuse, then on to the front panel on/off switch. The other side of the switch goes to the AC line. The other side of the AC line goes to the other black line. Neither of the AC lines goes to chassis. On the secondary side, one of the red lines goes to Pin 4 of V5 (rectifier); the other goes to the B- line which is Pin 3 of V3 the 12AV6 which is also connected to the volume control. I put the isolation transformer on the top side of the chassis. It ends up close to the speaker, and fairly close to the AF output transformer. This raises hum concerns.

Where I placed the isolation transformer on both my S-38Es

HUM?

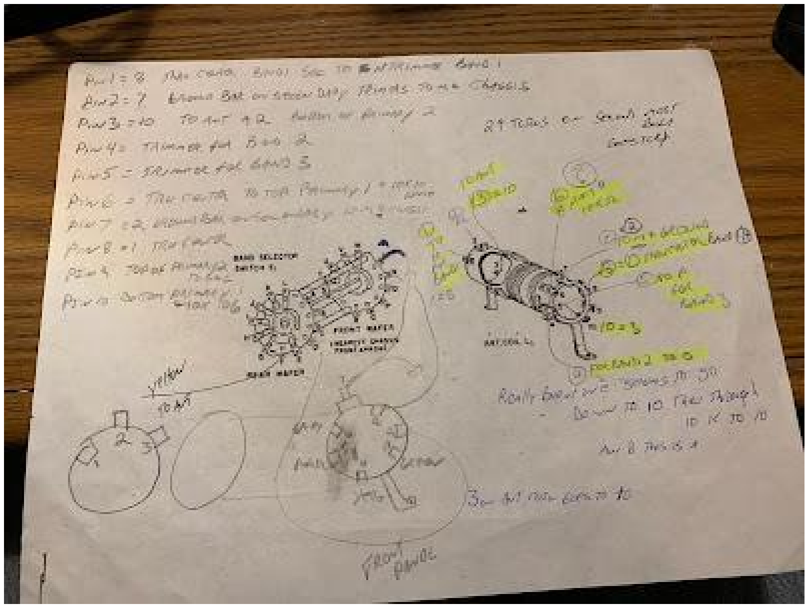
I did a test to see if my placement of the isolation transformer was adding to the hum. I simply took the S-38E back to its original transformer-less configuration and then listened to the hum. I noticed no difference and concluded that the isolation transformer is NOT adding to the hum. If there is a difference, I'd say that there is less hum with the isolation transformer. (And yes, I did make sure the AC line plug was in the correct way with the old power supply configuration.)

See what you think:

The hum is not really a problem. You can only hear it when the volume control is turned all the way down. As soon as you turn the volume control to the right, band noise overwhelms the hum and you can't hear it any more. I think this was the normal condition of this very economical receiver.

The two receivers have different speakers. The Winterfest speaker measures 7.6 ohms (DC) and the junker has a 3 ohm speaker (closer to that called for in the schematic). I think the 3 ohm speaker results in somewhat less hum.

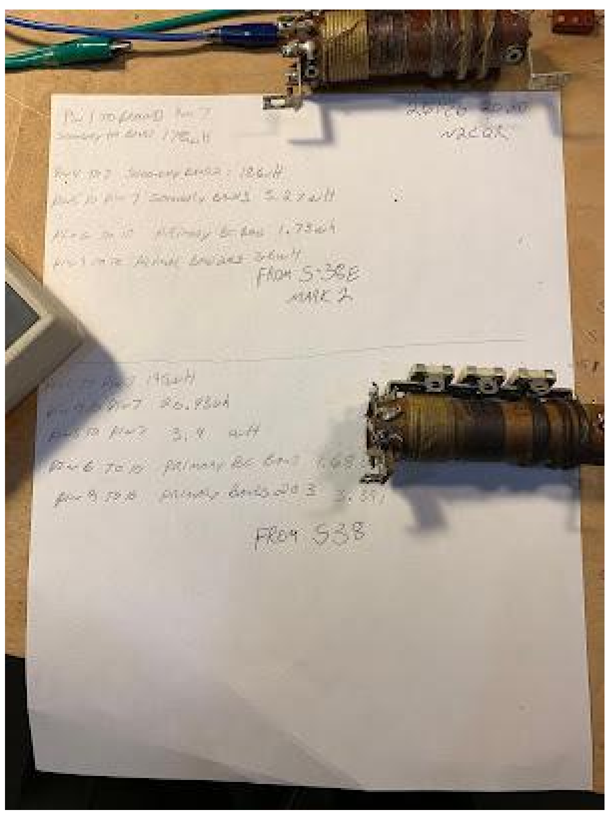
REPAIRING/REPLACING THE ANTENNA COIL



After the smoke release, I tried to re-wind the burned out portions of the antenna coil on the Winterfest S-38E, but I got tired of the project, cursed all S-38s, and sent mine to the basement/crawl space. I would have given it away, but I was afraid that the recipient would electrocute himself. So it sat in the basement for a couple of years. Recently I got interested in shortwave listening again, so I pulled out the S-38E.

On e-bay, I found and bought an S-38 antenna coil. I put it in my S-38E, hoping that it would bring the receiver back to life. But I had a lot of trouble with the front end alignment. I theorized that the coil I had bought was from the original model of the S-38, and perhaps the S-38E coil had different inductances. So I went back to e-bay. There I found a junker S-38E being sold by Mark W1MEM. It had been owned by KA1WFY.

At the suggestion of Scott W1NB on the AntiqueRadio forum, before installing the coil from the junker, I measured the inductances of the S-38E coil and the previously obtained S38 coil. I was surprised to find that the values were almost identical. That meant that my theory about coil inductance differences was incorrect. But I took the S-38E coil from the junker and put it in my S-38E. I took note of the fact that the junker did not in fact look like junk, but there it was, sitting on the floor of the workshop, having had its antenna coil extracted. And I had in hand the old S-38 coil that I knew from testing was very close in value to the S-38E coil.



I was kind of getting tired of S-38s at this point, and I thought about leaving work on the junker S-38 for another day (or another year, or decade), but familiarity with the innards of the rig and alignment procedures is perishable, so I decided to try to get the junker

going while it as all still fresh in my mind. I installed the isolation transformer mod on the junker and put the S-38 antenna coil in. That is how I came to own a second S-38E.

RF ALIGNMENT PROBLEMS

One of the problems I had was that the alignment instructions for the S-38E are very sparse. For the front end alignment, they just tell you to put signal generator signal into the antenna terminal, put a meter or scope on the audio output then tweak the antenna and oscillator coils for max output. I had no trouble getting the oscillator on the right frequency -- for bands 2 and 3 that would be the signal frequency PLUS .455 MHz. For Band 4 it would be signal frequency minus .455 MHz. But I could not get the LC circuit in the front end to peak on the input frequency. Now, if you have the peak for the input LC circuit in the wrong place, your receiver will still work (sort of) but image rejection will be even more horrible than it is designed to be.

For example, assume you want to tune a strong signal at 7.0 MHz. Your VFO is at 7.455 MHz. The difference frequency is .455 MHz. This signal goes through the IF transformers and you hear the signal.

But now tune down .910 MHz to 6.09 MHz. Your VFO will be at 6.545 MHz. 7.0 - 6.455 = .455 Unless the front end LC filter blocks the strong signal at 7.0 MHz, it will also show up at 6.09 MHz on your dial. If the S-38E is aligned properly, that front end LC circuit will track the tuned frequency. In this case it will be peaked at 6.09 MHz and the strong signal from 7.0 MHz will not get through. Oh happy day! That 7.0 MHz signal shows up only on one place on the dial. All is right with the universe.

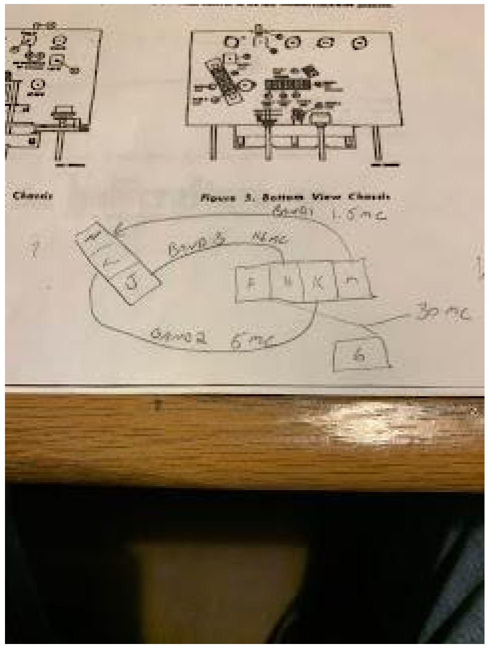
Of course there is another image problem. If you are tuned to 3.9 MHz, your VFO is at 4.355 MHz. If a shortwave broadcaster fires up on 4.81 MHz, well 4.81 - 4.355 = .455 That is why I can hear "Brother Stair" raging away, seemingly at 3.9 MHz. Even if a simple receiver like this is properly aligned, a powerful shortwave broadcast signal will often get past the puny single LC circuit in the front end.

But what happens if the S-38E is misaligned? What happens if that LC circuit is peaking above the desired frequency?

Now when you tune to 6.09 MHz, the front end tuned circuit may be peaked at say 6.5 MHz. There is only one tuned circuit in this receiver front end, so the "skirts" are quite wide. Wide enough to let that 7.0 MHz signal through to the mixer where it mixes with the 6.545 MHz VFO output to produce a very audible output. This is what was happening when my S-38E was misaligned. The 40 meter ham band and the 75 meter hambands were both showing up at two places on the dial. After alignment, this problem disappeared.

I realized later what my problem was: I was putting far too much faith in the accuracy of the frequency readout needle on the front panel of the S-38E. Many of these receivers had had their dials restrung over the years, so in many cases the placement of the needle was significantly off.

MY RF ALIGNMENT METHOD



What you really need to do is this: At first, don't pay much attention to where the red or yellow frequency indicators are pointing. View them as rough measures. Put a signal generator across on the A1 antenna terminal, with ground from the sig gen going to both A2 and GND. Then put a scope probe across the same A1 -A2/GND terminals. On Band 2 set your sig generator to, say, 4.0 MHz. Tune the main tuning dial UNTIL YOU SEE A BIG DIP ON THE SCOPE. At that point your front end is tuned to 4.0 MHz. Now, you need to set the oscillator coil to 4.455 MHz. I used a separate general coverage receiver (Radio Shack DX-390) tuned to this frequency. I slowly tuned the trimmer on the oscillator coil until I could hear the oscillator on 4.455 MHz on the DX-390. At this point the front end is in alignment.

It might not be that easy at first. You may need to use the LC trimmer and the oscillator trimmer to kind of "walk" the two desired frequencies close to each other. But by doing this, I was able to get the LC circuit to peak at the frequency at which the VFO was .455 MHz above the freq at which the LC signal peaked (the desired signal frequency). Now, you may notice that the red frequency indicator is not at 4.0 MHz exactly.

Later I decided to tackle this problem of front panel calibration. I decided to only worry about Band 2 (1.6 -5.0 MHz) and Band 3 (4.8-14.5 MHz).

I picked two frequencies on these two bands that would use the same position of the red tuning pointer. (I put they yellow bandspread pointer at 0.) I chose 9 MHz and 3.1 MHz.

For Band 3, at 9 MHz I set up my sig gen and scope as described above. With the sig gen on 9 MHz, I tuned the main tuning dial for a dip at 9 MHz. Then, keeping the tuning cap at the same spot, I moved the red pointer to exactly 9 MHz. (I just pinched the cord to the front panel with my finger and slid the red pointer down along the cord a bit. I then turned on my general coverage receiver, set it to 9.455 MHz and turned oscillator trimmer H (see above) until I heard the VFO at that frequency.

I then moved the S-38E to Band 2. I set the sig gen to 3.1 MHz. Leaving the main tuning cap and the red pointer exactly where they were, I tuned the antenna coil trimmer L until I saw the dip on my scope. I then turned the general coverage receiver on to 3.555 MHz and tuned oscillator trimmer K until I heard the oscillator signal at that frequency.

The S-38E was then aligned for RF on Bands 2 and 3 with fairly good front dial calibration.

Here is how to tell if you've got it lined up right. Tune to the 75 meter band on Band 2 or to the 40 meter band on band 3. Then tune 910 kHz BELOW where you found the ham band. Do you hear the ham chatter in that second location on the dial? If you do, the signal strength should be significantly lower than the signal strength 910 KHz up. If you don't hear it at all, great. If you hear it at significantly reduced strength, that's OK too. the S-38E has only ONE tuned circuit between the mixer and the antenna, so you can't expect really great image attenuation. But if you hear the image at the same strength (or stronger!) than the desired signal, you have placed the peak of the antenna input tuned circuit in the wrong place. See above. Try it again.

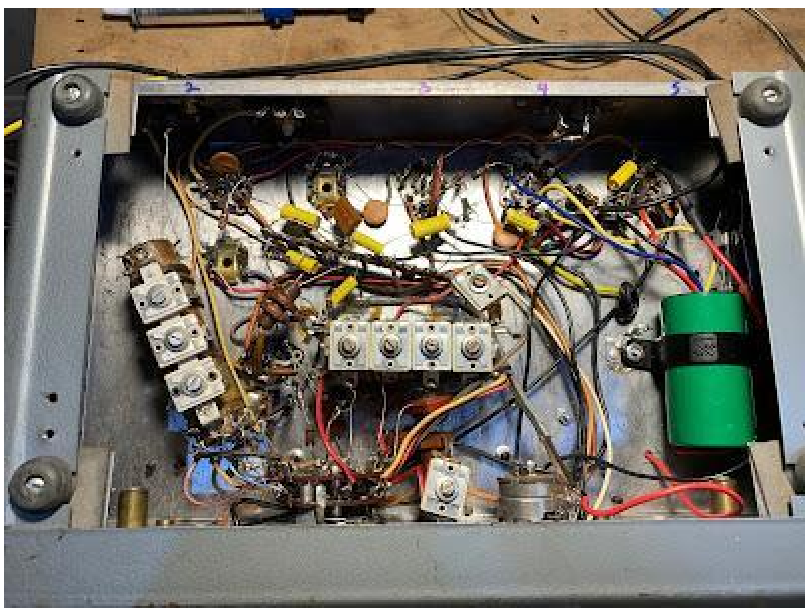
IF ALIGNMENT

IF alignment was relatively easy: I put a 455 kHz signal onto the grid of V1 and my scope on pins 5 & 6 of V3. I then peaked the four IF transformer coils. The IF cans in he Winterfest receiver were close to .455 kHz. The coils in the junker were quite a bit out of tune.

RECAP

On the first S-38E I assumed that I would have to change out all the electrolytics and the older tubular capacitors. So I did. But with the second ("junker") S-38E my replacement capacitors from Hayseed Hamfest had not yet arrived. So I pulled out my Variac and made a somewhat hasty effort to re-form the original caps. It seemed to work. No smoke was released. Nothing exploded. There is no horrible hum. But I could tell that all was not quite right. The BFO really wasn't oscillating properly. When the capacitor kit from Hayseed Hamfest arrived, I replaced all the caps. The receiver works great -- including the BFO.

Recapping in process. Hayseed electrolytic in green can.. Old tubular caps being replaced by new yellow caps.



Recapping completed

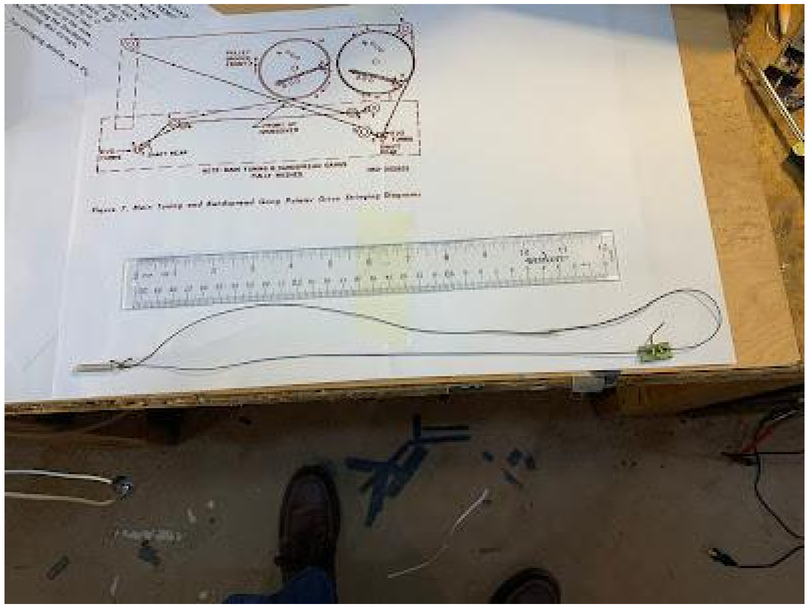
ALIGNMENT OF THE JUNKER

Armed with my newfound knowledge of how to align an S-38E, I applied this skill to the junker and was able to get it aligned without difficulty.

RE-STRINGING OF DIAL CORDS

On both of these S-38-Es there were dial string problems. Interestingly, both problems were with the BANDSPREAD dial cord, NOT with the MAIN TUNING dial strings. I see this as evidence that these receivers were used by ham radio operators. You don't really need the bandspread to tune AM shortwave station, or AM broadcast band stations. But novice ham radio ops would be frantically tuning that bandspread control up and down, wearing those dial springs out. The Bandspread dial string on my Winterfest S-38E broke while I

was turning it -- I replaced it but it is not really smooth, so I may try again. The Bandspread dial on the junker broke also.



Broken Bandspread string from Winterfest S-38E

Approximating the size for the replacement string

My re-stringing skills were better the second time around. Tips: use a small file to "roughen up" the spindle on the tuning knob (just the center of the spindle, so it will grab the cord better). Before installing, rub the new dial cord with an isopropyl alcohol pad, then run the string (still a a bit wet) several times over a piece of violin rosin. This seemed to prep the dial cord well.

Sometimes you need a bit more tension on the string to get the tuning spindle to grip properly. Unlike the Drake 2-B, the S-38E does not have several hooks on which to attach the spring. Not wanting to have to start all over just to add a bit more tension on the string, I came up with an easier solution: Just put a few twists in the string near the spring by twisting the spring (with strings attached) around a few times. Like this:

You also need something that allows the indicator needle to grip the dial cord. I cut open a short piec of heat-shrink tubing, put it over the cord at the desired spot, hit it with hot air, then put a small dab of super glue at each end of the tubing. (See above.) This allowed the dial pointed to grip the cord very firmly. Because you may need to move the red pointer during dial calibration (see above) I'd recommend NOT putting the drops of glue on the cord for the red pointer -- you may need to slide the red one up or down a bit.

TUBES

On the Winterfest S-38E, the BFO had a very rough tone, making it impossible to copy SSB or even CW. I thought it might be a bad set of filter caps, but after I replaced them, the problem was still there. So I then replaced the tubes (warning -- that 50CS audio amplifier is expensive). This fixed the problem

The junker had original Hallicrafters tubes.

SATURDAY, JUNE 11, 2022

Putting the "Mate for the Mighty Midget" Back to Work -- With a DX-100 on 40 Meter AM

After working on it for a while I got so fond of my old Hammarlund HQ-100 that I moved it from the AM/Boatanchors operating position over to a more convenient spot right next to my computer. This left a big gap on the receive side of the AM station.

I briefly put my HRO-ish solid state receiver above the DX-100, but I'm afraid that receiver needs some work. More on that in due course.

I thought about putting my SOLID STATE Lafayette HA-600A atop the thermatronic DX-100, but this just didn't seem right. The Radio Gods would NOT approve.

So I turned my attention to the Mate for the Mighty Midget that I built in 1998 and have been poking at and "improving" ever since.

This receiver worked, but not quite right. It received SSB stations well enough, but when I turned off the BFO I could no longer hear the band noise. I wasn't sure how well the RF amp's grid and plate tuned circuits tracked. And I had serious doubts about the detector circuit that Lew McCoy put in there when he designed this thing back in 1966.

As I started this latest round of MMMRX poking, I realized that I now have test gear that I didn't have in 1998: I now have a decent oscilloscope. I have an HP-8640B signal generator (thanks Steve Silverman and Dave Bamford). I have an AADE LC meter. And I've learned a lot about building rigs.

FRONT END TRACKING

The MMRX has a tuned circuit in the grid of the RF amplifier, and another in the plate circuit of the RF amplifier. There is a ganged capacitor that tunes them both. They need to cover both 80/75 and 40 meters. And they need to "track" fairly well: over the fairly broad range of 3.5 to 7.3 MHz they both need to be resonant at the same frequency.

McCoy's article just called for "ten turns on a pill bottle" for the coils in these parallel LC circuits. The link coils were 5 turns. No data on inductance was given. Armed now with an LC meter, I pulled these coils off the chassis and measured the inductances of the coils. I just needed to make sure they were close in value. They were:

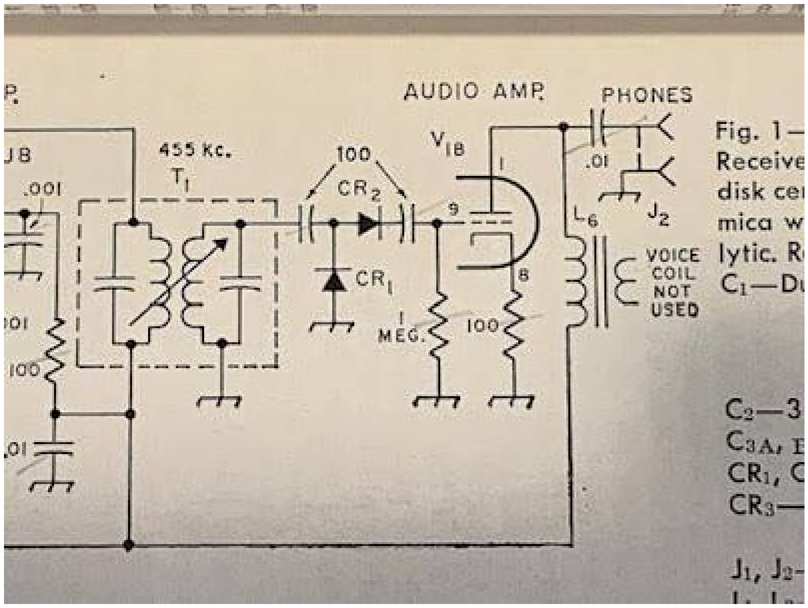
L1 was .858uH L2 was 2.709 L3 was .930uH L4 was 2.672

Next I checked the ganged variable capacitors. At first I found that one cap had a lot more capacitance than they other. How could that be? Then I remembered that I had installed trimmer caps across each of the ganged capacitors. Adjusting these trimmers (and leaving the caps connected to the grid of V1a and V2A, I adjusted the trimmers to get the caps close in value. I think I ended up with them fairly close:

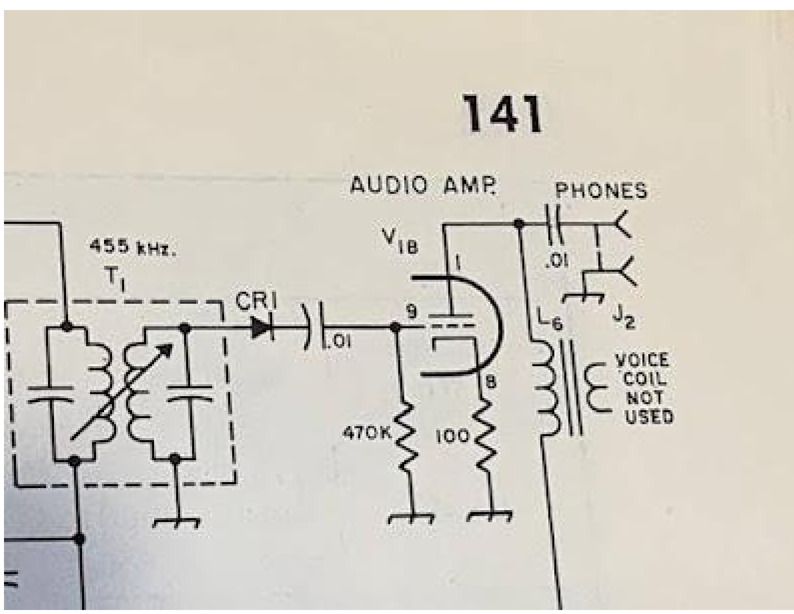
C1: 63.77-532 pF C2 64.81 -- 525.1 pF

I put the coils back in and checked the tracking on 40 and on 80/75. While not perfect, it was close enough to stop messing with it.

DETECTOR CIRCUIT



I've had my doubts about the detector circuit that Lew McCoy had in the MMMRX. In his 1966 QST article he claimed that the circuit he used was a voltage doubler, and that this would boost signal strength. But I built the thing in LT Spice and didn't notice any doubling. And consider the capacitors he had at the input and output of the detector: 100 pF. At 455 kHz 100 pF is about 3500 ohms. At audio (1 kHz) it is 1.5 MILLION ohms. Ouch. No wonder years ago I put a .1 uF cap across that output cap just to get the receiver working.



Scott WA9WFA told me that by the time the MMMRX appeared in the 1969 ARRL handbook, the second "voltage doubling" diode was gone, as were the 100 pF caps. Now it was just a diode, a .01 uF cap and a 470,000 ohm resistor. I switched to the 1969 Handbook circuit (but I have not yet changed the 1 meg grid resister to 470k -- I don't think this will make much difference). Foiled again by a faulty QST article, again by one of the League's luminaries.

6U8s out, 6EA8s in

We learned that the 6U8 tubes originally called for by Lew McCoy are getting old and not aging well. So I switched all three to more youthful 6EA8s. This seemed to perk the receiver up a bit.

MUTING from the DX-100

My K2ZA DX-100 has a T/R relay mounted in a box on the back of the transmitter. When the Plate switch goes up, it switches the antenna from receiver to transmitter. The box also has a one pole double throw switch available for receiver muting. I put the common connection to ground, the normally connected (receive position) connect the ground terminal of the AF output transformer to ground -- it is disconnected from ground on transmit. The other connection (normally open) is connected to the antenna jack -- on transmit this connection ground the receiver RF input connection. These two steps mutes the receiver very nicely.

Replacing Reduction Drive

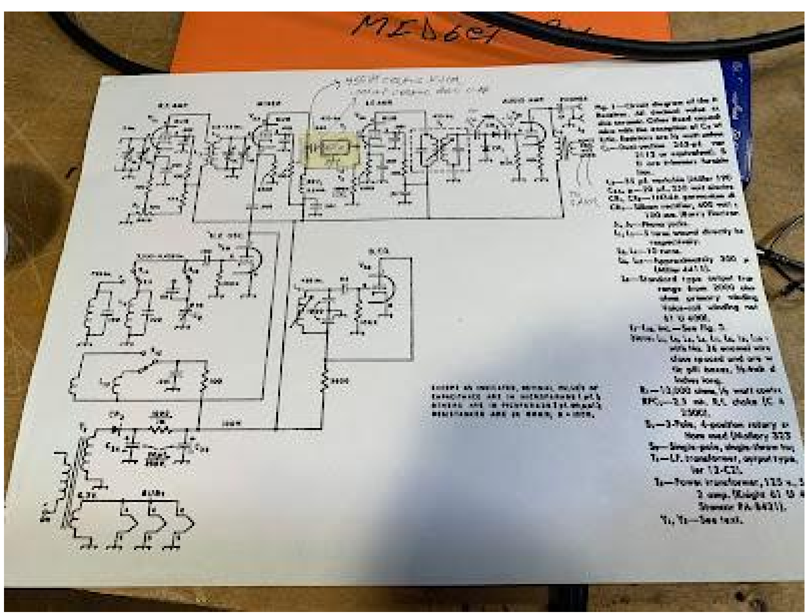
Over the years I have had several different reduction drives on the main tuning cap. I had a kind of wonky Jackson brothers drive on there that needed to be replaced. I put in a new one -- this smoothed out he tuning considerably.

Ceramic Resonator

I never could get McCoy's 455 kc two crystal filter to work right. So at first I made due with the two 455 kc IF cans. This made for a very broad passband. Then I put a CM filter in there. This was more narrow, but with a lot of loss. There may have been others. But the filter spot is currently held by a 6 kHz wide ceramic filter. This one is my favorite so far.

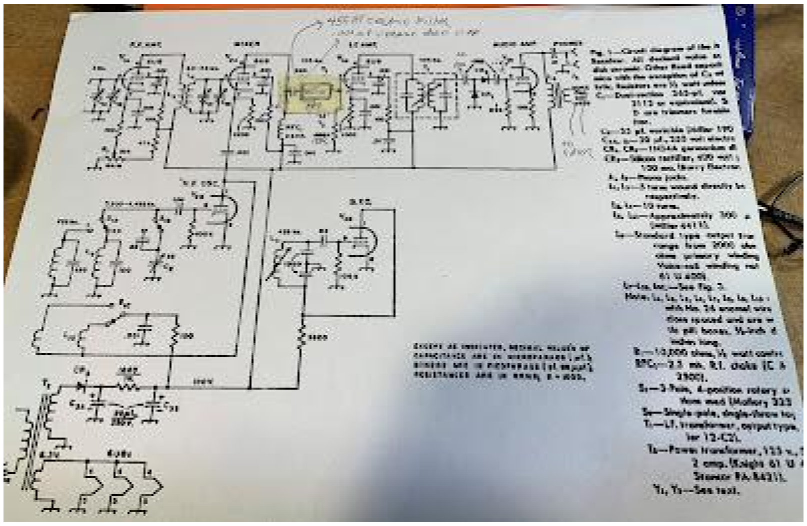
Digital Readout

When I was running the DX-100 with the Hammarlund HQ-100 I built a little frequency readout box. The box was from a Heath QF-1 Q multiplier (I am sorry about this). The readouts are in Juliano Blue and come via e-bay from San Jian. I now have it hooked up to the DX-100's oscillator. I haven't tapped into the MMMRX's oscillator yet.



MONDAY, OCTOBER 25, 2021

Putting a Ceramic Filter in the "Mate for the Mighty Midget" Receiver



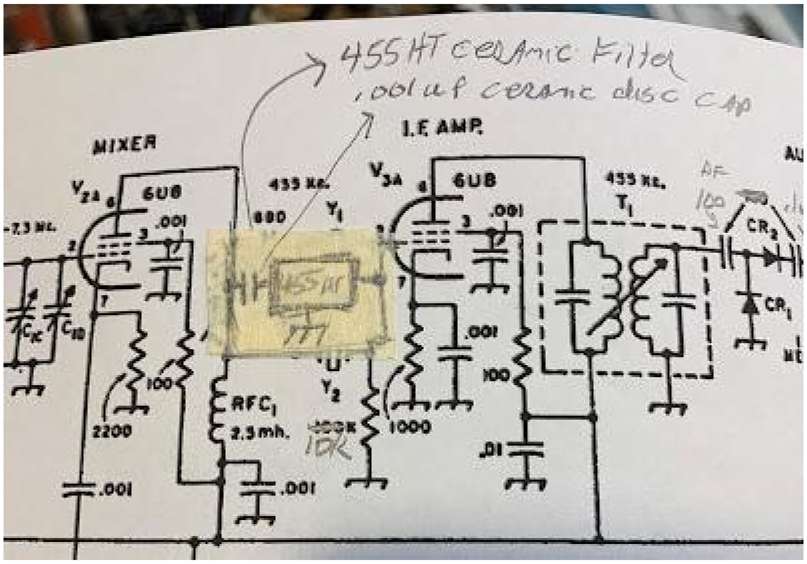
It is really simple. I had one of the +/- 3kHz (6 kHz wide) 455HT filters on hand. The spec sheets call for 2000 ohms at both ends, but looking at the schematic it appeared that I already had high impedance on both sides of the filter. I put a .001 uF cap on the input side to keep the DC voltage off the filter (see above and below). This capacitor allows us to avoid the dreaded problem of electro-migration that is so nicely described by SV8YM here:

http://sv8ym.blogspot.com/2010/07/mysterious-case-of-withering-filters.html.

Tasos also provides a good description of the innards of those little black boxes that contain ceramic filters.

Once you get the filter in your receiver, you have to carefully place the BFO signal in relation to the filter passband. I have trouble properly sweeping 455 kHz filters -- my HP8640B will not go that low. Nor will my Antuino (I need to modify the code -- someone help me please). I know the NanoVNA will do the job, but I just couldn't seem to get it to work. So I went "old-school" and manually swept the filter using my FeelTech sig gen and my Rigol scope. This gave me a rough idea of where the passband was. I put the BFO on the low end of the filter passband, at 451 kHz.

With this filter the MMM RX has become a real asset. The 6 kHz bandwidth allows for nice reception of both SSB signals and AM sigs. I may try to use one of the +/- 2 kHz filters (4 KHz wide), but so far I have not been able to find a source for this part.



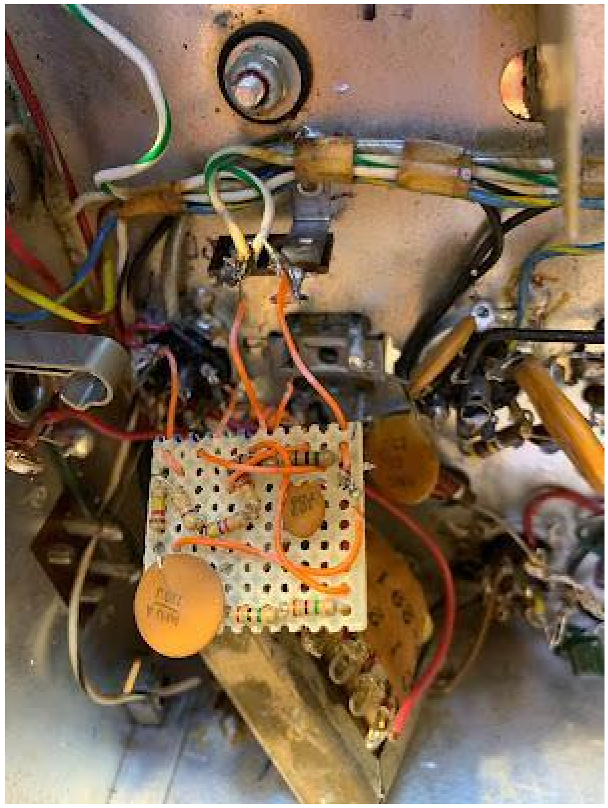
TUESDAY, MAY 17, 2022

Troubleshooting and Fixing Old Faults in my Long-Suffering Hammarlund HQ-100

Work continues on my old Hammarlund HQ-100. I give background on the rig and explain the electrical trauma it likely suffered. Following Dave K8WPE's dictum that we can still learn a lot from old receivers, I dug into this one. I wanted to fix a long-standing S-Meter/AVC problem. This led me to an interesting troubleshoot, with at least one "waste of time" detour. Eventually I found the fault in one of the coils in the grid circuit of the RF amplifier. The coils had been smoked years ago, perhaps by a lightning strike. I came perilously close to permanently losing 10-30 MHz. But I figured out how to fix the smoked coil. So my S-Meter/AVC problem was fixed. I really like listening to this thing. There is still a lot of nice material on the SW bands. There are some very nice broadcasts in Spanish. Please subscribe to my YouTube channel.

You can see where the coil burned. Wire remained intact, but the insulation burned creating a Primary to Secondary connection.

I just very carefully lifted one of the coils way from the other, eliminating the unwanted connection.



Here's my homebrew "RC Printed Network" Z2 module. This was unnecessary -- the original was good. I put the original back in.

Electric Radio magazine recently ran a two part series on the HQ-100.

SATURDAY, OCTOBER 2, 2021

Selenium RECTIFIED

Selenium rectifiers. The name kind of sounds like Dilithium crystals, possibly related to flux capacitors.

Anyway, there were two of them in the Globe Electronics V-10 VFO Deluxe that I recently bought. Obviously they had to go, so I took them out yesterday, replacing them with a 1N5408 silicon rectifier.

The new diode had a significantly lower voltage drop than the selenium rectifiers -- this pushed the output voltage from the power supply up to around 200V. It is supposed to be around 185 V. So I put a 470 ohm, 5 watt resistor (found in the junkbox) in series.   This brought the output voltage to 167 V. Close enough. VFO seems to be working fine.

I'm glad I did the extraction before these aging components released their nasty toxic smoke.

W3HWJ has a good article on replacing these nasty old parts, with some interesting info on their history: http://www.w3hwj.com/index_files/RBSelenium2.pdf

Backgound on the element Selenium: https://en.wikipedia.org/wiki/Selenium

CHAPTER 8

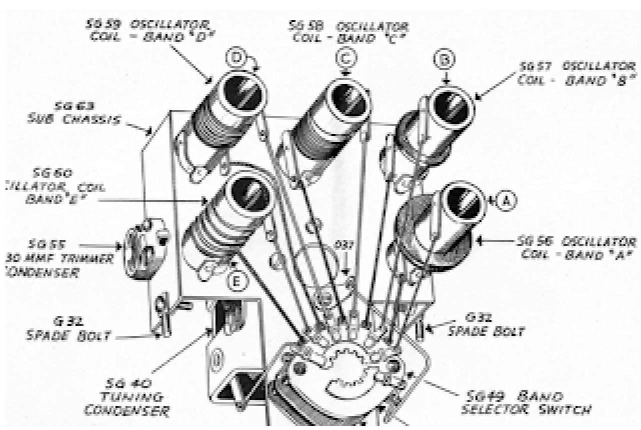
Test Gear

I often find myself pledging NOT to work on test gear. I like working on rigs, and I like to use test gear to build or fix the rigs, but try to draw the line on building the test gear myself. I reason that this could lead to an almost endless vortex of building: First the gear. Then you have to build the test gear to work on the gear. Then some test gear to work on the test gear… You can see the problem. Indeed when I was building my first supehet receiver, a piece of homebrew test gear was recommended. They said it was needed to measure the motional parameters of the crystals for the filter. But the test device was more complicated and difficult than the receiver itself. So I passed on that test gear project and built the receiver without it.

But of course, I often violated the no-working-on-test gear rule.

SOLID STATING A HEATHKIT SG-6

November 2012

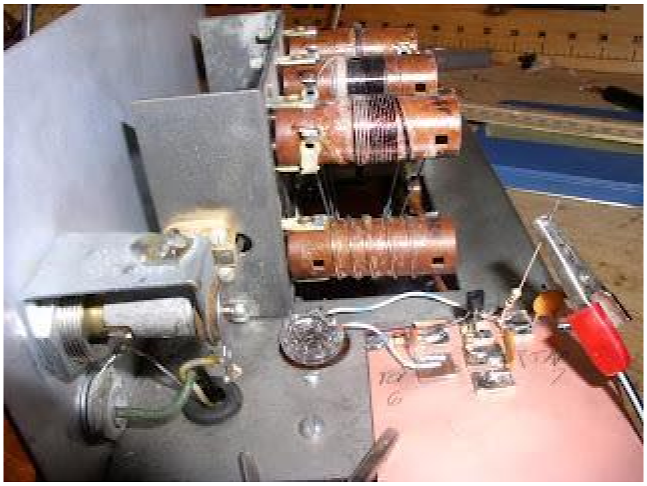


I've recently become acutely aware of the shortcomings of my signal generator. It is a Heathkit SG-6. It is *really* old. It has a selenium rectifier in it. It has one of those old mic connectors on it for the output. The output is very low. But I like the cabinet and there is a nice switchable coil/variable capacitor LC circuit in there (see above).

In 2008 in Hyderabad, India Farhan went to McDonalds with his kids and went home with some straws. Soon the straws are chopped up and turned into coil forms for a signal source: http://www.phonestack.com/farhan/siggen.html

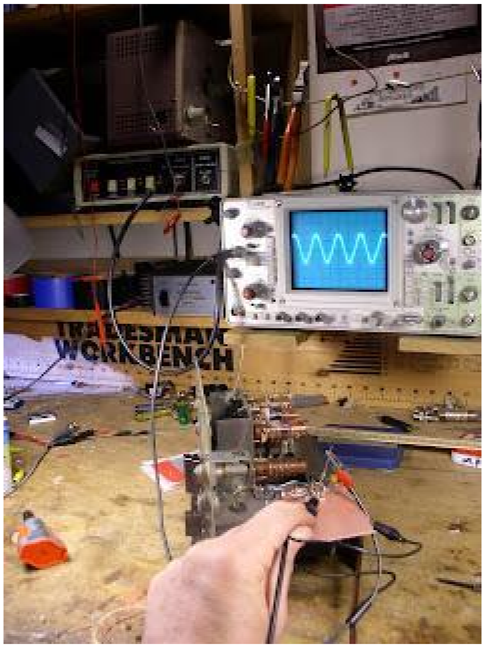
So here is my idea: de-tube the SG-6. Turn the selenium over to the HAZMAT authorities. Save the coils and the cap and most of what George Dobbs would call "the socketry." Use an MPF-102 for the oscillator, then make use of the buffer and feedback amp from Farhan's soda straw circuit.

What do you guys think?



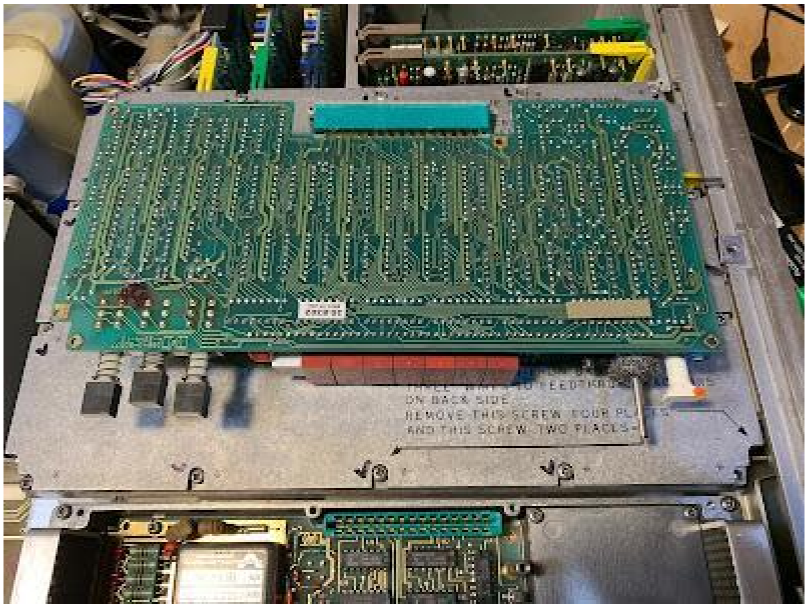
We have kind of half a holiday today -- I have the day off, but the kids went to school. I made use of the additional shack time to test the feasibility Farhan-izing my old, not-so-beloved Heathkit SG-6 signal generator. I did a quick Manhattan build of the oscillator section from Farhan's sig generator (link in yesterday's post). Using an idea from an old 73 Magazine article on a similar project (thanks Clint!), I smashed the tube (appropriate, don't you think?) and connected (using the glass stump!) Farhan's oscillator directly to the pins that lead to the switchable coils and the variable cap of the SG-6. I just wanted to see if it would oscillate, and see if there was a big change in SG-6 dial calibration.

Wow, it worked great! It oscillates very nicely on all but the upper frequency band setting (20-50 MHz). I feel confident that I'll get it to oscillate at least up to 30 MHz. Next I'll build Farhan's buffer and amplifier stages. The SG-6 had a switchable attenuator -- I want to include that feature in the solid state version. I'll have to give some thought to the audio modulation feature (nice for aligning AM receivers).



FRIDAY, SEPTEMBER 11, 2020

HP8640B Counter Repair --- Discretion? Or Valor?



Inspired by BH1RBG, I cracked open the HP8640B to have a look at the counter circuitry. Above is the view that greeted me. That is the main counter board after I pulled it out of its socket. You can see the seven little red LED display modules.

It is not as bad as it looks. In fact, I found the construction and accessibility of the HP8640B to be quite impressive (much better than the Tek 465 with all its flaky plug-in transistors). The manual has good, detailed info on how to get into the various compartments, and even as you work, instructions on which screws to remove or loosen appear on the tops of each RF-tight compartment. Nice. This thing was obviously built with the needs of a future repairman in mind.

Above is that same board flipped over. Again, not as bad as it looks.

Above is board A8A3, the board that I suspect is causing me trouble. When I go through the troubleshooting routines in the manual, I get to the point where they check decimal point position. Everything is fine UNTIL I GET TO 16 MHZ. Then the decimal point is not where it should be and the frequency displayed is very wrong. (This is in the internal mode -- the counter works fine with an external signal source). The manual then sends me to Service Sheet 15 which points to possible problems on this A8A3 board, U3, U7 or U6D.

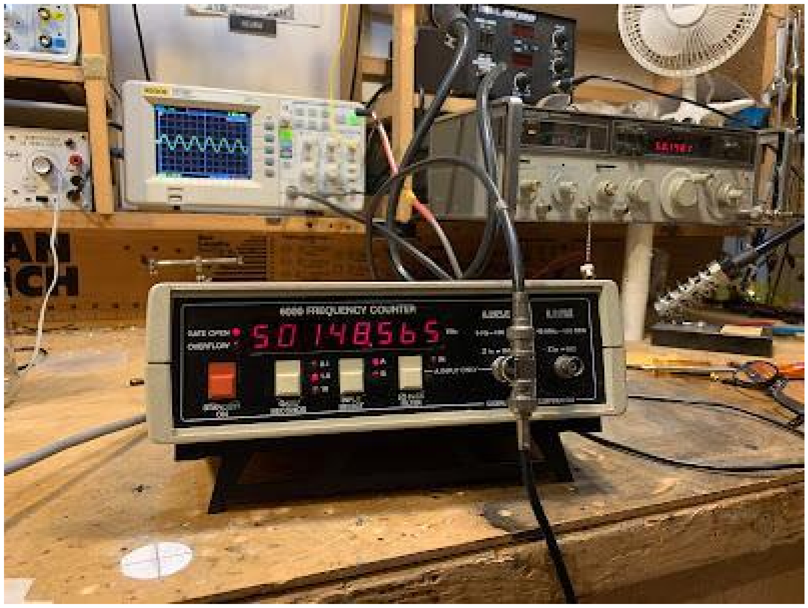
Troubleshooting this will be tough. I do not have the extender board that would allow me to test this A8A3 board with the other counter board raised up above it and operating. BH1RBG noted that getting the extender boards is almost as tough as getting the HP8640B itself.

While it really bugs me (!) to have a part of this device not working properly, I could just leave it as is. The signal generator is working fine, and I could use the external counter input to check the frequency. But this is a real kludge.

What do you folks think?   Fix it or leave well enough alone? Discretion or valor? Anyone have an extender board? Any ideas on where the fault might be?

THURSDAY, SEPTEMBER 24, 2020

Global Specialties Corporation 6000 Frequency Counter -- Anyone have a Plessey SP8630B Chip?



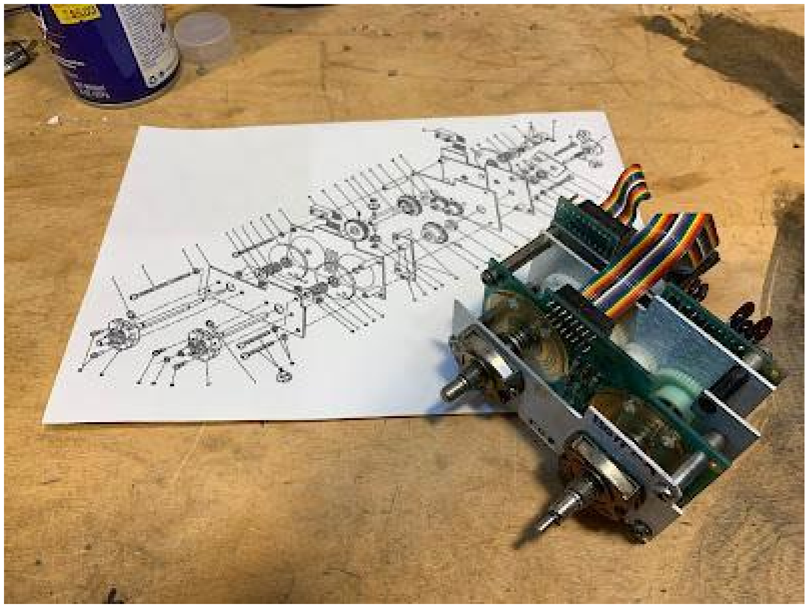
Continuing my effort to improve my workbench and its test gear, this week I turned to an old frequency counter that I picked up at the Kempton Park Radio Rally in London many years ago. It was not working when I got it, but long-time SolderSmoke listeners will recall the tale of woe that resulted from my having soldered a replacement IC (that Tony Fishpool G4WIF had sent me) UPSIDE down. Tough times my friends, tough times.
Well, I'm working on it again. First I converted it from 220 to 110 power. I had a transformer in the junk box that fit nicely, both electrically and mechanically. In the course of doing this, I learned something about this counter that I did not know: As long as it is plugged in, even if you turn it off, the time-base oscillator keeps running. And get this Color Burst Liberation Army members: The oscillator runs at 3.579545 MHz. TRGHS.

With sunspots scarce and with Pete pessimistic about the solar cycle, VHF and UHF now seem more interesting. I need to have more test gear for the higher frequencies. This counter works up to 650 MHz. Yea!

When I first fixed this thing, I was quite pleased to get it going with "Input A -- 5 Hz to 100 MHz." But now I want to get "Input B -- 40 MHz to 650 MHz" working also. I used a 50 MHz signal from my newly repaired HP-8640B to trouble shoot Input B. I think one of the divider chips is bad. It is a Plessey SP 8630B. Does anyone have one of these chips in their junk box?

MONDAY, SEPTEMBER 21, 2020

HP8640B Internal Frequency Counter Fixed (More Repairs Pending)



The HP8640B is a complicated machine. Above you see just one sub-assembly, and the page from the manual that describes it. This is what I've been working on. The little spring "tine" fell out of one of those discs behind the two control knobs. So I had to open this thing up, find the spot from which the tine had fallen, and glue it back in.

I used Gorilla Super Glue, followed 24 hours later by a dab of JB Weld "minute weld" dual epoxy. One of the other tines was about to fall out, so I went ahead and gave all the tines in this assembly the glue treatment. (I bought some "Weld On" acrylic cement but the warnings on the label were quite sobering. So I left that can sealed up.)

This morning I put the thing back together. This is not easy. At one point a spring popped and a tiny metal part that is probably irreplaceable seemed to fly away into the black hole that is the shack's carpet.   I had just about given up hope when I found the thing sitting right in front of me on the bench. TRGHS.

The HP8640B fired up right away without trouble and the internal frequency counter is working fine.

As I noted in the last SolderSmoke podcast, a very nice community devoted to the HP8640B has developed around the world. Here are some of the notable participants:

Bill at Electronics Revisited is a very nice fellow with lots of experience on the HP8640B. He offered to sell me a replacement unit for the assembly pictured above. If you have an ailing HP8640B and are looking for someone to work on it for you, Bill is the guy you should talk to: http://www.electronicsrevisited.com/ He also very kindly offers to answer any questions you may have about the HP8640B.

Here is the e-bay page of the fellow in Bangalore who makes the brass gears. Mine are on the way!
https://www.ebay.com/usr/engineeringideas?_trksid=p2047675.l2559

Marcus VE7CA has a great site devoted to the HP8640B: https://www.ve7ca.net/TstH86.htm

BH1RBG in China has a nice site describing his adventures with the HP8640B: https://sites.google.com/site/linuxdigitallab/home/hp8640b-20v-power-supply-down

K6JCA has a good blog post about fixing the tines and the gears: http://k6jca.blogspot.com/2018/09/repair-log-hp-8640b-rotary-switches-and.html

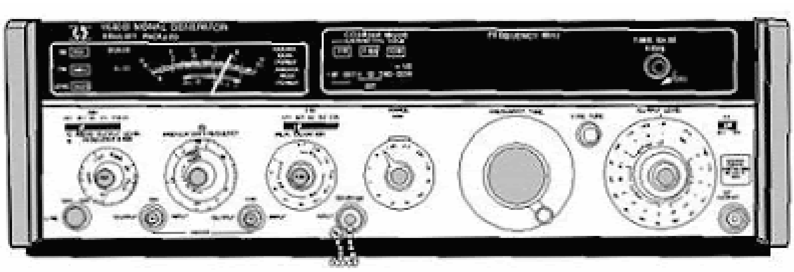
Steve Silverman (who gave me this HP8640B) found a really useful history of the device: http://hpmemoryproject.org/timeline/bob_devries/some_memories_05.htm#part_05_chapt_09

And of course special thanks to Dave VE3EAC who alerted me to the falling tine problem and put me on the path to a successful repair.

The gears should be here in a few weeks, so that will be another opportunity to work on this HP8640B. Also there are some tines in the attenuator assemby that might reinforce with the glue treatment.

SUNDAY, SEPTEMBER 13, 2020

HP8640B -- Fault Found! A very TINY and Hard-to-Fix Fault



Every dark cloud has a silver lining. Here, the silver for me came from opening up the HP8640B. What an impressive looking piece of gear. It looks like something from the Apollo command module, or perhaps from a nuclear weapon. "The RF source is a 256 to 512 MHz cavity-tuned oscillator that is mechanically tuned..." There is phase lock circuitry. The are AM and FM modulators and a really useful array of attenuators. There is a frequency counter with an external port and an internal frequency counter that measures the original 256-512 MHz signal, then divides down to give a very accurate readout of the output frequency. This is the kind of device that would generate a cult following. Count me in!

Also, I've sometimes lamented the lack of VHF test gear on my work bench -- the HP8640B could really help me move me into the VHF range.

I started the troubleshooting with some observations and noodling. At what frequency did the internal counter stop working? What did the readout look like when it stopped working? What device failure could lead to these symptoms? I was aided in this by suggestions sent in by readers of my previous blog posts. Thanks guys.

I was just getting ready to start some intrusive testing on the logic devices in the internal counter when Dave VE3EAC sent me this:

I think you might be overthinking the failure mode here. I had a similar problem with my unit and it was one of my early Covid-fix-it projects. There is an assembly that controls the bands on the front. It has the famous gears that crack. On the back side are two sets of rotary switches that control a lot of stuff. The switches are of a very unique HP design and offer a lot of advantages over traditional switches EXCEPT they fail in an unusual manner. A PC board has all of the interesting wiring and very tiny double leaf springs short tracks together as needed. The springs tend to break away from the plastic posts on the rotating plate and not make the needed contact. Very carefully examine the insides of the 8640 and your bench top to see if any have fallen out. These are difficult to buy or fabricate. The disk is designed to be rotated 180 and use a new set of posts to locate the springs. Use a small dab of epoxy to set in place. The totally mechanical repair fixed my unit that also would not read above 16 MHz. There are a number of web pages that give great detail of this repair. Also it is worth while to replace the Delrin gears if they are cracked. Replacement brass ones are available on eBay and they will permanently fix the gear problem.

I had thought about the problem being in the frequency range switch, but I had sort of tested for this by slowly rocking the switch through various positions as I watched the display. A dirty rotary switch will usually allow the circuit to intermittently work as you rock the switch. But this didn't happen. And the HP switch felt quite sturdy, so I focused on the circuitry.

When I got VE3EAC's message, I carefully flipped the HP8640B over and for the first time opened the bottom of the compartment. The bottom view is much more impressive than the top view:

The switches that VE3EAC wrote about are just below the ribbon cable near the center front. I could see the little springs that he was discussing on the switches. They appear MUCH more delicate than the rotator on a standard rotary switch. And I didn't see any of them lying around below the switch. But when I tried to flip the HP8640B over, something in there moved and caught my eye. I pulled out some tweezers and pulled this out:

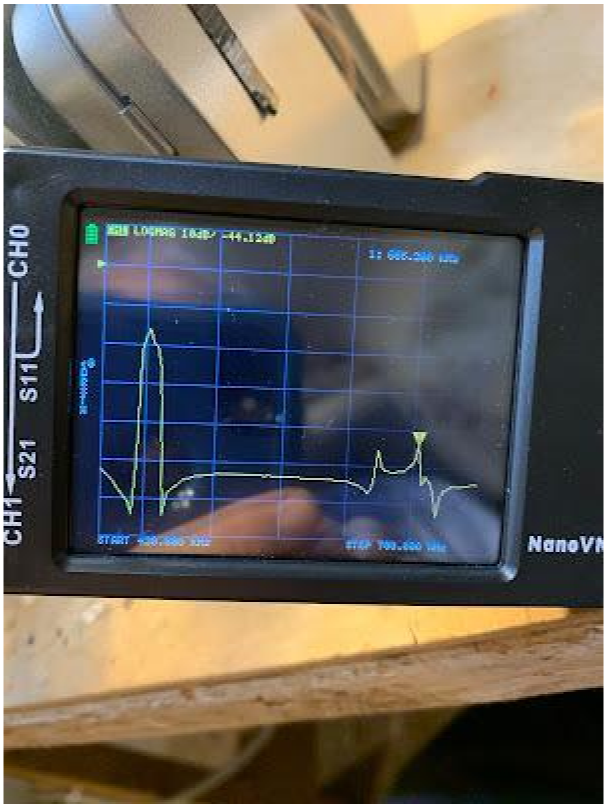
Wow. That little spring contact fell off the switch. That was preventing the HP8640B internal counter's time base from changing as I went above 16 MHz.   It is ironic that such a big and solidly built device such as the HP8640B should be laid low by such a TINY part.

This gets me back to my original question: Discretion or valor? Getting that spring back onto that switch will not be easy. VE3EAC sent me this K6JCA link describing how to do this. Yikes, it even requires the purchase of a special tool!
http://k6jca.blogspot.com/2018/09/repair-log-hp-8640b-rotary-switches-and.html

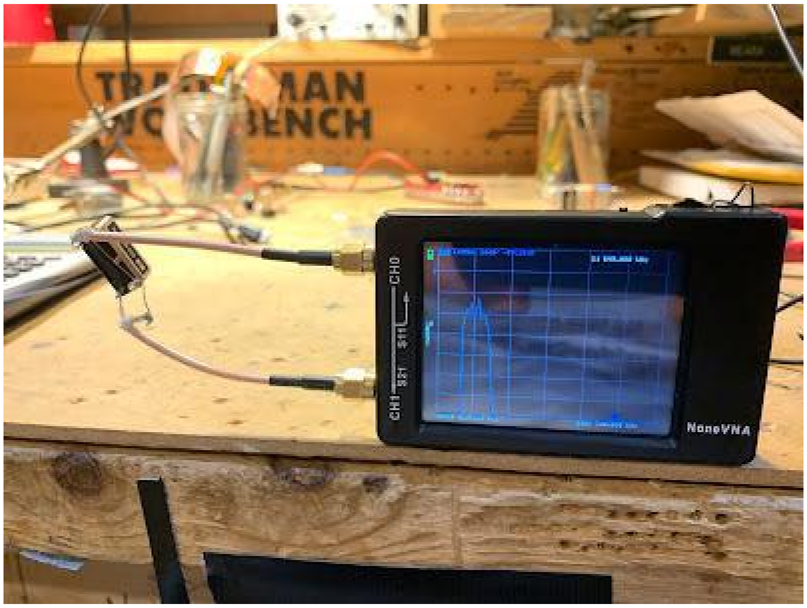
I'm going to let the HP8640B sit there with the cover off for a while. It will be taunting me, challenging me to fix it, to make it work the way Hewlett and Packard intended. It may take a while, but I think I'm going to have to accept this challenge. I've become real fan of the HP8640B and it would be a shame to leave it wounded like this.

SATURDAY, JULY 11, 2020

Receiver Filter Fix with the NanoVNA

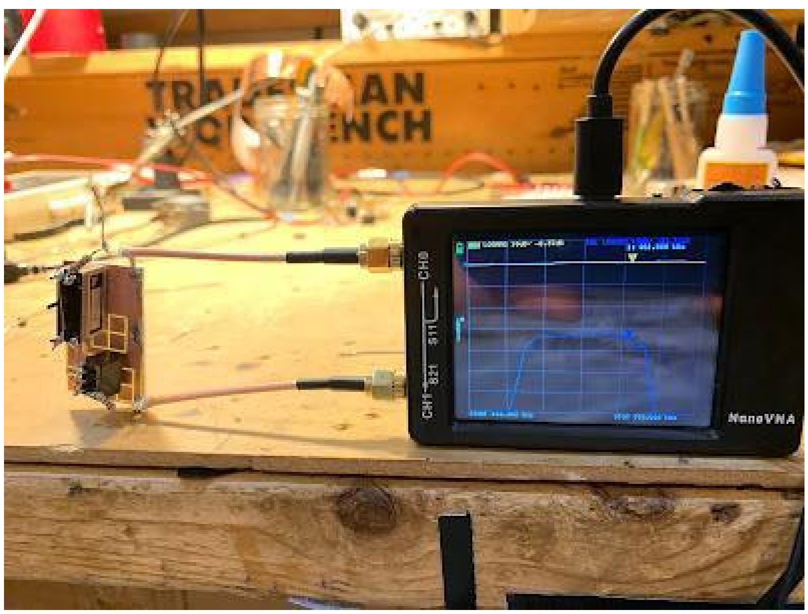


The picture above shows my problem. As predicted by the Murata data sheet and as warned by R.A. Penfold, that nice 455 kc ceramic filter has a significant response at around 640 kc.   This caused me to hear Brother Stair twice as often as I should have. Clearly a spur exorcism was called for.



Click on the picture for a better image. As noted last time, my first idea was to build a series 640 kc trap LC circuit and put it ahead of the ceramic filter. But I had trouble getting the desired high Q. So I then thought about putting a wider 455 kc filter ahead of my 12 kc filter. I would, of course, need one that did NOT have the 640 kc spur. I found a 455B filter in my junk box. I used the NanoVNA to look at its response. No spur at 640 kc! Yea!

Next I put the two filters together, 455B first, then the 12 kc filter. Success! You can see on the NanoVNA that there is no spur at 640 kc.



With close to the desired termination impedances, the passband at 455 kc looked pretty good. I just put 1500 ohm resistors in series at the input and output of the dual filter combo.

It worked. Spur exorcised! I no longer hear each SW broadcast stations at two spots on my dial.

Repairing My Maplin Audio Waveform Generator

I picked this generator at the Kempton Park rally in London many years ago. I use it quite a bit, not only for circuit testing but also as an easy way to get my homebrew BITX rigs to send a signal so that I can adjust my antenna. I just plug this thing into the mic jack, crank in a small amount of 1 kHz audio, and I am ready to minimize SWR.

It never gave me any real problems until last week. I opened it up and examined the circuitry for the first time. Lots of mystery chips in there. Fortunately they are all socketed. Thank you Maplin.

Even without really knowing how each of the ICs work, it was easy to troubleshoot. See the schematic in the article that begins on page 21 in this .pdf:

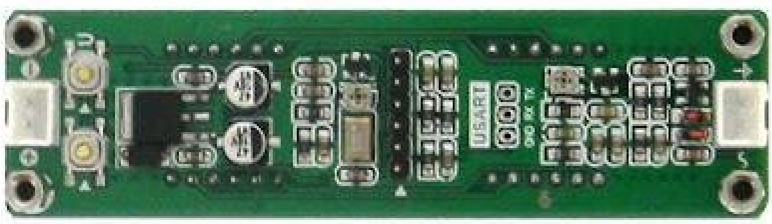
https://worldradiohistory.com/UK/Mapelin/Maplin-Projects-Book-48.pdf
My Rigol scope showed a good signal going into and coming out of IC8, the LF351 op-amp. From there the signal goes to IC5 a 4066BE. But nothing was coming out of IC5. Thus IC5 was my lead suspect. I put in a quick order to Digikey. A couple of days and a few bucks later the chips (as always, I ordered several) were on my doorstep. Within a few minutes IC5 was replaced and the generator was as good as new.

One annoying problem with this generator is that it has no automatic shut-off circuitry. So if I forget to turn it off, I soon have to buy two 9V batteries. Tony G4WIF suggested a simple timer circuit. I may do that soon. Or, given that we are already on the IC dark side with this project, there is this: https://www.youtube.com/watch?v=C4C2H_3BU3o&feature=youtu.be

I recently find myself replacing a lot of chips in various rigs and devices in my shack. It seems that chips go bad more frequently than discrete transistors or even tubes. But maybe I'm just using older gear with older, more fragile chips. What do you folks think?

FRIDAY, FEBRUARY 19, 2021

A Problem with the San Jian PLJ6-LED Counter



I had hoped to use this handy and cheap little frequency counter to add some glowing Juliano Blue to the frequency readout on my Quarantine Hodgepodge rig. I've used these boards with my BITX20, my HA-600A, and with my DX-100/HQ-100 rigs. But guess what -- these boards do not work with the BITX40 module board that is the heart of the Quarantine Hodgepodge. And the reason why is interesting.

Here is what happens: First, you plug in the IF frequency of your rig. In my case 12 MHz. You connect your VFO output to the signal input on the PLJ6. You power up the PLJ6. You then have to select one of two IF frequency options. One of these options ADDS your IF frequency to whatever it detects at the signal input. In my case, for a 7.2 MHz signal it would detect a VFO signal at 4.8 MHz. If it were to ADD this signal to the IF freq, it would readout 16.8 MHz. And it does. But obviously that is wrong. So you go to the other option -- this one SUBTRACTS the designated IF frequency FROM whatever it finds at the signal input. So here we get 4.8 - 12 = -7.2 Almost perfect right? But here is the problem: The PLJ6 can't handle negative numbers! So it displays 000000. Not helpful.

Here is the manual:
https://www.mpja.com/download/35057tebasic%20manual.pdf

I didn't have this trouble with any of the other rigs because none of them required the use of negative numbers. My BITX 20 for example had an IF of 11 MHz and has the VFO running a bit above 3 MHz -- so the PLJ6 just adds the IF to the VFO signal and Bob is my uncle. Similar problem-free addition takes place with the other rigs.

I found some discussion on this problem on the internet. Here is one:
https://groups.io/g/BITX20/topic/bitx40_and_plj_6led_frequency/4330098?p=,,,20,0,0,0::recentpostdate%2Fsticky,,,20,2,0,4330098

Some of the respondents didn't seem to understand the problem. Others hint that the ability to handle negative numbers was as some point in the code for the PLJ6 device, and may somehow be accessible, but no further info is provided.

I have already worked up a possible solution, but I'm interested in how you folks would approach this problem.   Any thoughts or suggestions? I will reveal my solution in the days ahead.

SATURDAY, OCTOBER 10, 2020

Chip Replaced, GSC 6000 Counter Fixed

This thing has been half-broken for a long time. I needed to get the input for 40 MHz - 650 MHz working   I got the a replacement SP8630B Plessey divide-by-ten counter chip on e-bay, and yesterday I extracted the old chip and put in the replacement. I took great care NOT to solder this one in upside down (as I had done with another chip replacement in this counter). I used solder flux and solder wick to gradually get the pins free of the board. (You can see the old chip in the picture above.)
As to what happened to the original SP8630B chip, John over on the Vintage Test Gear Facebook page wrote:

The Plessey SP8630A/B is an ECL divide by 10 prescaler, with a upper working frequency of 600MHz. That generation went out of production in the late 1980s. Plessey was bought by a Canadian company now called Micrel. You may be able to find one from one of the specialist obsolete component companies, but it may be dead on arrival. Those ECL ICs had a fairly high mortality rate if they are very old.

It is the old story of "metal migration". In early semiconductors very small impurities in the silicon structure cause minute bits of the metallisation to leach out into the essentially non-conducting silicon insulation. Many old devices, although they have never been used, were found to be very leaky and this degrades the gain of the active devices. The worst types are the very old Germanium transistors.

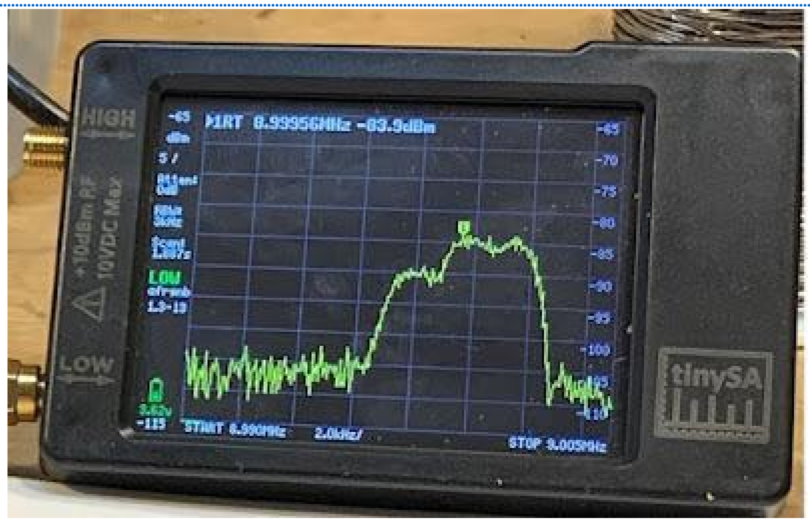
As the semiconductor scientist learnt more about the super cleanliness required and the better purification of the metals the problem tended to improve. The Marconi company I worked for back in the 1980s had a real problem with comms satellites failing after a few years of service. Of course you can't go up there and swap out the faulty devices.

Accelerated ageing of a backup satellite showed that some devices just stopped working after being subjected to high and low temperature cycling, which is a common problem with satellites in orbit!

I am liking this little machine more and more. It is very simple -- no microcontroller, just a collection of gates.   I discovered that the main main crystal oscillator is actually built inside a little oven to keep the temperature stable -- oscillator and the oven stay on as long as the counter is plugged in, even when the device is switched off. I calibrated the counter with WWV and with my HP8640B and with my little Feeltech sig gen counter.   I wish I knew how to calibrate the counter in the Rigol DS1102E oscilloscope.

FRIDAY, NOVEMBER 5, 2021

The Importance of Keeping the Noise FLAT



A few days ago I put up a blog post about using a noise generator (in my case my cheap FeelTech sig generator) and my TinySA spectrum analyzer to look at the passband of a crystal filter. I was using the 9 MHz filter used by Dean KK4DAS and the Vienna Wireless Makers Group. The idea is simple: insert broadband noise into the input. The filter should pass more of the noise that falls within its passband. The TinySA should let you see this. At first, I was pleased that I could clearly see the passband.   I thought I had succeeded. See above.

But I was bothered by something. Look at that bump in the passband. It should be close to flat across the top.

I decided to take a look at the same filter with my NanoVNA. Here I was not using a noise generator. The NanoVNA sweeps the filter using and looks at output in the Log-Mag mode. Here is what it looked like (below):

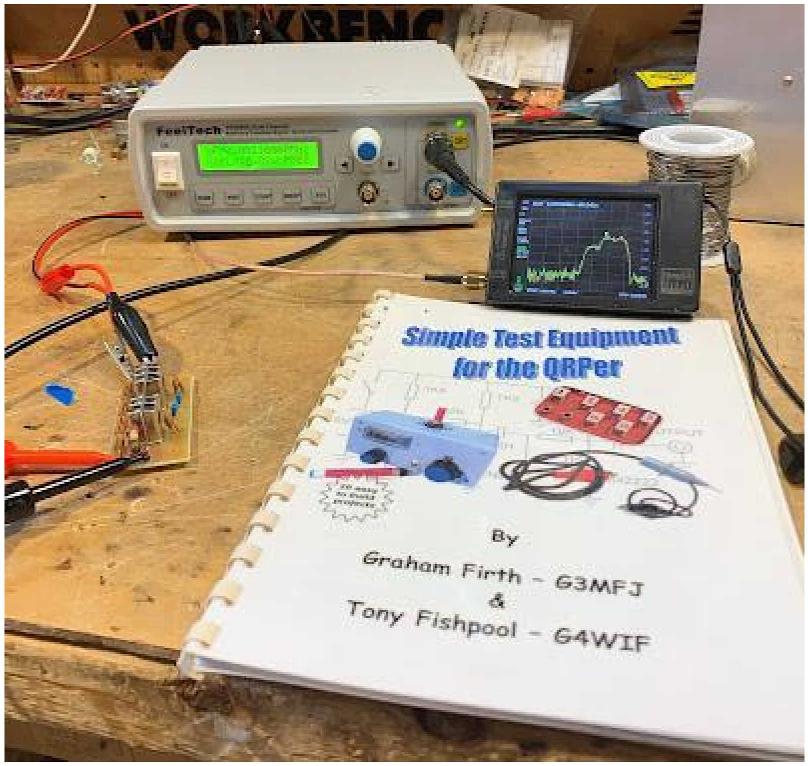
That was much better. But why the difference?   Tony Fishpool G4WIF suggested that my noise source might not be putting out noise at the same level on all frequencies. I took at look at the noise output of the FeelTech sig gen in the range of the filter passband (with some above and below frequencies for reference) and I found that the flatness of this noise depended a lot on what frequency I had the sig gen set to. I tuned it around a bit until I found a setting that produced a flat noise output in the desired frequency range. Then I went back and swept the filter with the noise and the TinySA again. Here is what it looked like with the "flat" noise:

Better, I think. Closer to the passband displayed by the NanoVNA.

Tony points out that these Chinese sig gens don't really put out random noise -- they give us predictable noise. Dean said "Predictable Noise" would be a good name for a rock group.   I said they could open for my favorite: "The Ceramic Spurs."

SATURDAY, OCTOBER 30, 2021

Using Noise to Sweep a Filter with the TinySA



I've been meaning to try this for a long time. Years ago Tony Fishpool and Graham Firth wrote about using a noise generator and a spectrum analyzer to sweep the bandpass of a filter. The idea here is to send very broadband noise into a filter, and then use a spectrum analyzer to see which frequencies make it through.

I thought about building a noise generator like the one in Tony and Graham's book, but then it occurred to me that probably had one sitting on my bench. Sure enough, a look at the manual for my cheap FeelTech function generator revealed that PRESETS 3 and 8 are noise generators.   I quickly pulled out a 9 MHz filter that Dean KK4DAS had given me, put the noise into one end and the TinySA on the other end. Bob was quickly my uncle. See above.

More recently Tony G4WIF built a comb generator as a noise source:
http://www.fishpool.org.uk/combgenerator.htm

Thanks to Tony, Graham, and Dean. And to the folks who developed the TinySA.


I DON'T OFTEN
LISTEN TO FM RADIO
BUT WHEN I DO,
I ALWAYS USE A TINYSA
imgflip.com

CHAPTER 9

Radio Physics

MAGNETISM, RELATIVITY, AND UNDERSTANDING

February 2014

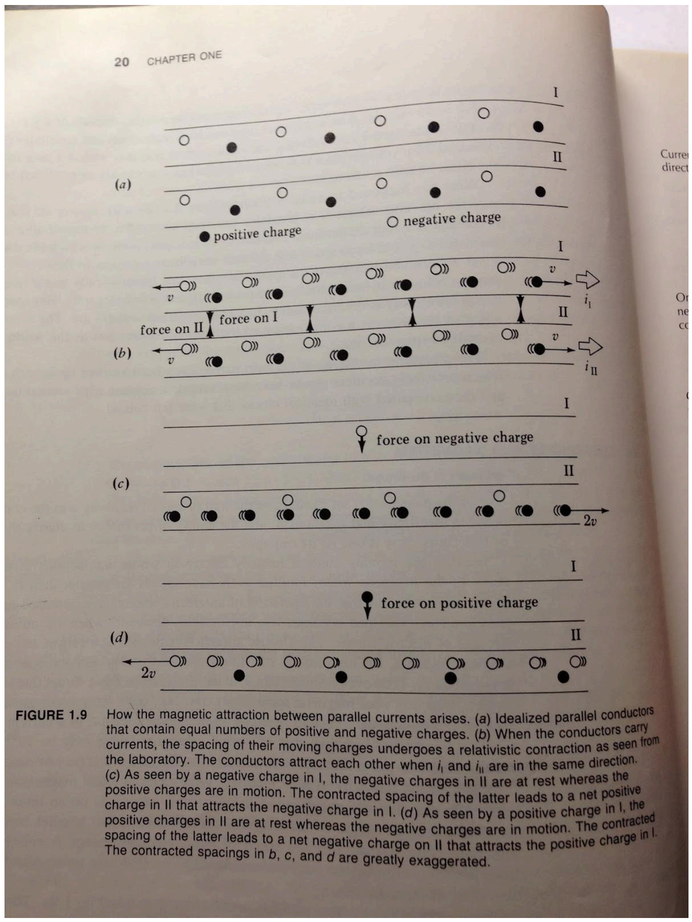

20 CHAPTER ONE

FIGURE 1.9 How the magnetic attraction between parallel currents arises. (*a*) Idealized parallel conductors that contain equal numbers of positive and negative charges. (*b*) When the conductors carry currents, the spacing of their moving charges undergoes a relativistic contraction as seen from the laboratory. The conductors attract each other when i_I and i_{II} are in the same direction. (*c*) As seen by a negative charge in I, the negative charges in II are at rest whereas the positive charges are in motion. The contracted spacing of the latter leads to a net positive charge in II that attracts the negative charge in I. (*d*) As seen by a positive charge in I, the positive charges in II are at rest whereas the negative charges are in motion. The contracted spacing of the latter leads to a net negative charge on II that attracts the positive charge in I. The contracted spacings in *b*, *c*, and *d* are greatly exaggerated.

Bill,

I'd been meaning to share these stories with you after I read your book a couple years ago but I never got to it. I thought you might enjoy them, from an "engineering perspective", I guess.

One of the courses I had to take for my undergrad was an engineering physics type class. I loved it. I think a lot of hams seem to have more curiosity about the physics of electronics than regular non-ham engineers, at least that's how it's always seemed to me. Anyway, I'm sending you a snapshot of the relativistic length contraction figure in the book "Concepts of Modern Physics", 4th Ed by Arthur Beiser. I thought you'd enjoy it as it is almost identical to what you mentioned in Soldersmoke (from your "Atoms to Amperes" book I think).

Hopefully there's enough resolution there to make it out. Basically, when you flow current in the same direction in both wires, they attract. That's because the electrons see effectively many more positively charged nuclei from the other wire than they do other electrons due to the nuclei distances being compressed by the Lorentz-Fitzgerald contraction (later refined by Einstein).

When I first saw this, in my early 20s, I was completely floored! Nowhere had I ever learned anything like this from the ham license manuals or even my basic physics course. The implications were also very profound -- magnetism was nothing more than electrostatic attraction, the attraction between charges. The "electromagnetic" force was really just an electric force. Relative motion between charges gives the illusion of "magnetism".

Much later, I listened to some of the old Feynmann lectures. In them at one point he adamantly proclaimed that there's only the electric force between charges, and there is no magnetic force! I still find this confusing. Recently I brought this up to a university RF engineering professor. I wondered why we dealt with Maxwell's equations when in reality the magnetic field is an illusion. The "real" formulas come from Feynmann's theory of quantum electrodynamics! His reply was something along the lines of Maxwell's equations being a solution of quantum theory that worked well for our purposes. To be honest, I didn't really understand his reply and I'm still skeptical! I think his point was that the QED calculations are overly complicated and unnecessary for most problems we deal with, things like patterns from an antenna. I don't think Maxwell's equations appropriately describe things like lasers though, which are more quantum in nature with the coherent beam.

FYI, most engineering students I ran across had only passing curiosity for these things. Only in graduate school did I start to find people curious enough to really try to understand "what lies beneath" some of this stuff, mainly this physics. Honestly not even everyone in grad school was all that captivated. As you've said before, there's a lot of "turn the crank" mentality in engineering where you wade through mathematics to get answers, not always thinking about the physics. It's even worse in the digital world, where everything gets boiled down to computer code!

One more quick thing. I talked to a physics prof once, asking him if there was any research happening in his department focused on electromagnetics and radio waves, etc. His reply: "radio waves are nothing more than the result of accelerating electrons". Period! Discussion over. In other words, that's ancient history. Engineers are still very much involved with new technologies involving antennas and amplifiers, etc. But as far as the physicists are concerned, I get the impression that our whole field is pretty ho-hum. But he was right about accelerating electrons, I also found out later. And it doesn't have to be electrons. Anything carrying charge undergoing acceleration will emit photons. That's another crazy situation that I only more recently learned.

Hope that was entertaining!

CHAPTER 10

Antennas and Accessories

I'm not very good at building antennas. I just don't have the kind of mechanical building skills that this kind of construction calls for. I'm more of a rig builder – I'm more comfortable at a workbench than up on the roof. In fact, as I approach age 65, I no longer even go up there. Freddy – the fellow who cleans our gutters – also takes care of any antenna work that needs to be done. I will construct the Hex beam kit, for example, but Freddy will take it up top and put it on the rotor and tripod.

Although I'm just not very good at building them, there is no doubt that antennas and associated devices are really very important. So I don't ignore them.

REFLECTIONS ON REFLECTOMETERS

In November 2013, I got an e-mail from a kindred spirit:

Bill,

I just finished reading SolderSmoke and I must say your story resonated with me. One of the mysteries that caught my attention that you didn't mention was the SWR meter or more precisely, the reflectometer used in many SWR meters. Like the one I used as a novice back in 1966 in Michigan.

I struggled to understand how such a really simple device like that could measure power going in both directions at the same time, especially when each signal was alternating current to begin with.

Anyway, I think I finally figured it out and wrote it up. I thought you might like to see it. It isn't as short and concise as many of your explanations but I hope you like it.

By the way, I will be using some of your explanations with the kids in our new high school amateur radio club we just started.

Best Regards,

Dennis Klipa, N8ERF

I was very pleased to get Dennis's e-mail. In fact, I had mentioned the mystery of the SWR meter in the first edition of this book. At the very end I had listed this simple little device as being among the many things in ham radio that I had not been able to understand. Dennis's e-mail promised enlightenment. His article was entitled: "Relectometers – A Simple Explanation of How They Work – It is Not Magic!!"

It has long been recognized that most hams do not know how their SWR meters work. Take a look at this sidebar from an April 1959 QST article by Warren B. Bruene W0TKK:

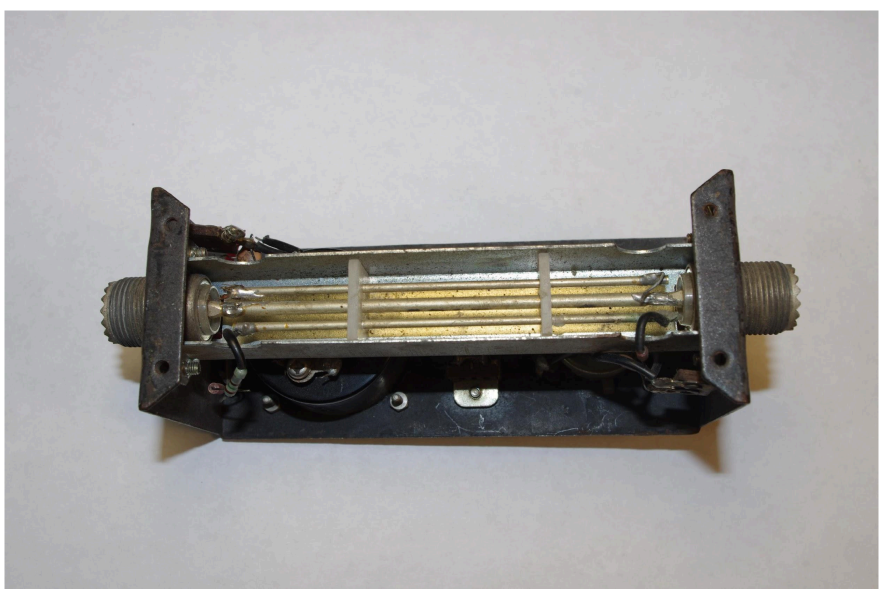
We wouldn't attempt to guess the numerical value of the ratio

$$\frac{\text{Hams who use s.w.r. bridges and don't know how they work}}{\text{Hams who use s.w.r. bridges and do know why they work}}$$

but it must be pretty high. If you want to move from the numerator to the denominator of the expression above, here's the article to help you do it.

As soon as I read the first paragraph in Dennis Klipa's article, I knew that gold had fallen into my hands, and that I would soon be moving from numerator to the denominator in the Bruene ratio. It was really great to be in contact with a fellow ham who obviously shared in my desire to really understand the circuitry, but Dennis had obviously succeeded in understanding one of the circuits that I had had the most difficulty in figuring out. Like me he was trying to understand it at the level of flowing electrons. And like me, he was not satisfied with equations – he wanted to *really* understand.

I still have the first SWR meter I ever owned. Well, I have most of it. I've had it since 1973 but the forces of entropy and perhaps some cannibalization efforts have carried parts of it away from me. But the most important – and mysterious – parts are still there. As you can see, there is not much to it – just a center conductor, two similar conductors parallel to it and a few resistors, diodes and capacitors. is Now I know how it works.



UNDERSTANDING: HOW DOES MY SWR METER REALLY WORK?

When a radio wave moves down a transmission line, that line will offer its own inherent impedance to the flow of the wave. This is called the characteristic impedance of the line. If, at the end of that line the wave encounters a pure resistance equal to the characteristic impedance, all of the energy in

that wave will be absorbed in that pure resistance. However, if that resistance at the end of the line is NOT the same as the characteristic impedance of the line, some of the energy will "bounce back" down the line. It will be reflected back. It will then interact with the outgoing wave, at some points along the line reinforcing the outgoing wave, at other times partially nulling it out. This pattern of reinforcement and nulling out is what we call a "standing wave." The ratio between the peak value (where the waves are reinforcing) and the minimum value (where they are nulling each other out) is the Standing Wave Ratio or SWR.

The SWR provides us with useful information about our antenna systems. One way to measure SWR would be to go along the transmission line with a meter and measure the recurring peaks and troughs. If you found no variation in RF voltage or current along the line, congratulations – you have no standing waves! Your SWR is 1:1. If you find a peak that is twice the voltage (or current) of a trough, you have an SWR of 2:1, indicating a mismatch of that proportion at the point where your antenna meets the transmission line. If your transmission line has a characteristic impedance of 50 ohms, you would see an SWR of 2:1 if the antenna had an impedance of 100 ohms or 25 ohms.

Obviously taking measurements along the line is quite inconvenient. A better method began to take shape when, in September 1949, O. Norgoden of the Naval Research Lab published an article entitled "A Reflectometer for H-F Band. " In late 1956, the great Lew McCoy W1ICP modified Norgoden's design, making it easy for radio amateurs to use. Thus was born the mysterious Monimatch that decades later Dennis Klipa would so completely and clearly explain.

Sitting in the comfort of our shacks, our beloved SWR Monimatch meters tell us how well our antenna's impedance is matched to that of the transmission line. This is important because we know from basic physics that maximum energy transfer takes place when the impedances of devices are matched. And we can learn if our antennas are resonant at our operating frequency. This is important because a resonant antenna will carry maximum RF current, and that is what sends out our radio waves.

The Monimatch SWR meter is also called a "reflectometer." A reflect-o-meter. It allows us to measure the amount of energy being reflected back down the transmission line from the antenna. This may sound like a simple task, but it is not. Think about it: on that transmission line, on that piece of coax going from your rig you will often have not only the signal going out from your transmitter, but also, at exactly the same frequency, a weaker version of that signal bouncing back. The outgoing and reflected signals will be interacting all along the line. The reflectometer's job is to distinguish between the two and measure them, providing you with a lot of valuable information about your antenna system. But how, exactly, does the reflectometer do this? How does it work?

I think this is an example of how sometimes the simplest devices can be the most difficult to understand. The Monimatch is deceptively simple. In the March 1998 issue of Electric Radio magazine, Lew McCoy gave a wonderful description of the genesis of the Monimatch:

"One morning, George Grammer, our Technical Director (at ARRL) called me into his office and handed me a paper, in a publication from the United States Naval Observatory. The paper talked about the possibility of the practicality of designing an RF measuring device -- but the paper was only theoretical. George told me he wanted me to use the information in the paper to see if we could come up with a practical device…. He told me to build a 50 ohm trough, a section of coaxial line that had 50 ohm impedance. He then dismissed me from his office and I went out scratching my head."

Dennis Klipa and I also did a lot of head scratching about this device. Not about how to invent it, but to understand how it works. Most of the ham radio literature on this device seems to rush through the theory behind it. In article after article, in handbook after handbook, we found the same kind of sweeping, breezy statements that were supposed to impart understanding, but only left us more confused. For example, in the October 1956 QST article in which McCoy presented his invention, he describes the new device very quickly:

"It is simply a section of transmission line to which a linear inductor is loosely coupled. The combination of inductive and capacitive coupling is such that the incident component of r.f. voltage on the line is balanced out when the constants are properly chosen, leaving only the reflected component to actuate an r.f. voltmeter used as an indicator." **Wow, I thought, if they understood that, hams must have been MUCH smarter in 1956.**

The April 1959 issue of QST carried an article by one of the ham pioneers in this field, Warren Bruene (a close friend of Lew McCoy). The title was "An Inside Picture of Directional Wattmeters – What They Do – How They Do It." Promising, right? Alas, for Dennis and me it didn't shed much light. Bruene lost me with this important sentence:

"An important thing to note is that at any point along the line the reflected components of voltage and current are 180 degrees out of phase." **To me this seemed to imply that something happened to the electricity at the reflection point that made it distinguishable from the forward signal. This didn't make any sense to me. I continued to scratch my head.**

The August 1964 issue of QST had an article by S.C. Shallon entitled "The Monimatch and SWR." The third paragraph reads: *"How does the Monimatch work? What do its readings mean."* Again very promising. But look at what follows:

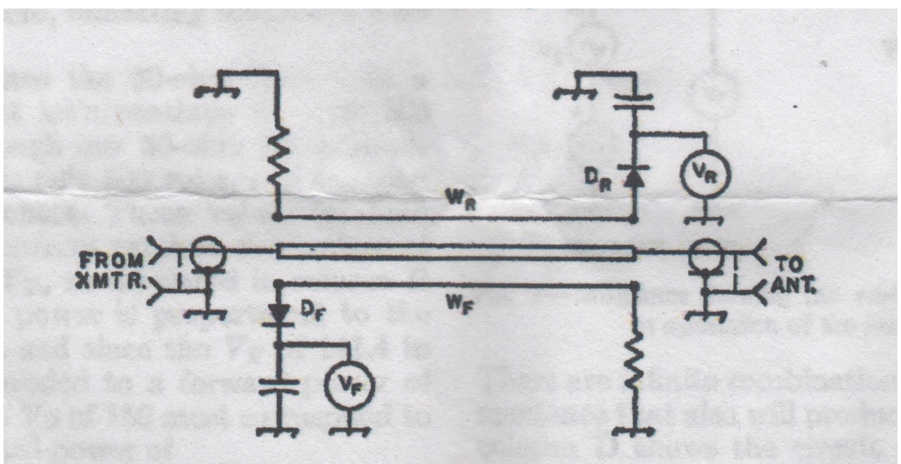


Fig. 1—Basic circuit of the Monimatch.

"One version of the Monimatch is shown in Fig. 1. R.f power from your transmitter feeds in through the coax connector on the left, and the coax connector to your antenna connects to the coax connecter on the right. The two pickup wires Wr and Wf are equal in length and are spaced equally from the center conductor. The r.f. voltage from one end of the pickup wire Wf is rectified by diode Df and read

on meter Vf. Similarly the r.f. voltage at the opposite end of pickup wire Wr is rectified by diode Dr and read on meter Vr.

The r.f. voltages Vf and Vr are a resultant produced by both capacitive and inductive coupling from the center conductor. When the Monimatch is properly adjusted and terminated in its design impedance (e.g. 50 ohms), the two capacitively-coupled voltages, Vc, and the two inductively-coupled voltages, Vi, are all equal to each other.

Table I

Monimatch Voltages and Currents with 100 Watts in Load

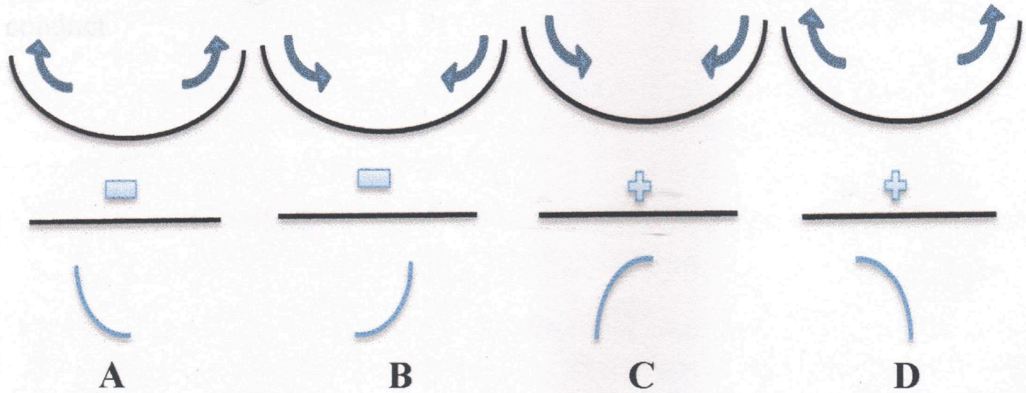
	A	B	C	D
Load (ohms)	50	100	25	40 + j30
Load Voltage (volts)	70.7	100	50	63.2 + j47.4
Load Current (amperes)	1.41	1	2	1.58
V_C (proportional to load voltage)	70.7	100	50	63.2 + j47.4
V_I (proportional to load current)	70.7	50	100	79.0
$V_F = V_C + V_I$	141.4	150	150	$142.2 + j47.4 = 150 \angle 18.4°$
$V_R = V_C - V_I$ (or $V_I - V_C$)	0	50	50	$-15.8 + j47.4 = 50 \angle 108.4°$
Indicated Forward Power (watts)	100	112.5	112.5	112.5
Indicated Reverse Power (watts)	0	12.5	12.5	12.5

Table 1 shows the way these voltages are combined to produce the measured voltages Vf and Vr. Notice on pickup wire Wf, the equal voltages Vc and Vi add in phase to give Vf ; voltage Vf is an indication of so-called "forward" power. On pickup wire Wr the equal voltages Vc and Vi are opposite in phase because the voltage is measured at the end of the wire opposite from that at which the measurement is made on pickup wire Wf. In this case Vr is the difference between Vc and Vi and the resultant produces a zero reading at Vr: voltage Vr is an indication of the so-called "reverse" power, and the reverse-power reading is zero when the Monimatch is properly balanced and terminated."

These paragraphs seemed to be taking us closer to true enlightenment, but there were a few head scratchers in there too. Like: ***"On pickup wire Wr the equal voltages Vc and Vi are opposite in phase because the voltage is measured at the end of the wire opposite from that at which the measurement is made on pickup wire Wf."*** **The article seemed to cry out for more explanation and more illustrations, but during this period, QST often seemed to treat clarity as a sign of weakness and technical ineptitude.**

Fifty years later, Dennis Klipa stepped in to fill the clarity gap. First here are his illustrations of how the capacitive coupling between the center wire and the pickup wires creates electromotive force in the pickup wires at various portions of the sine wave on the center conductor:

Figure 6. Capacitive or Electrostatic Effect

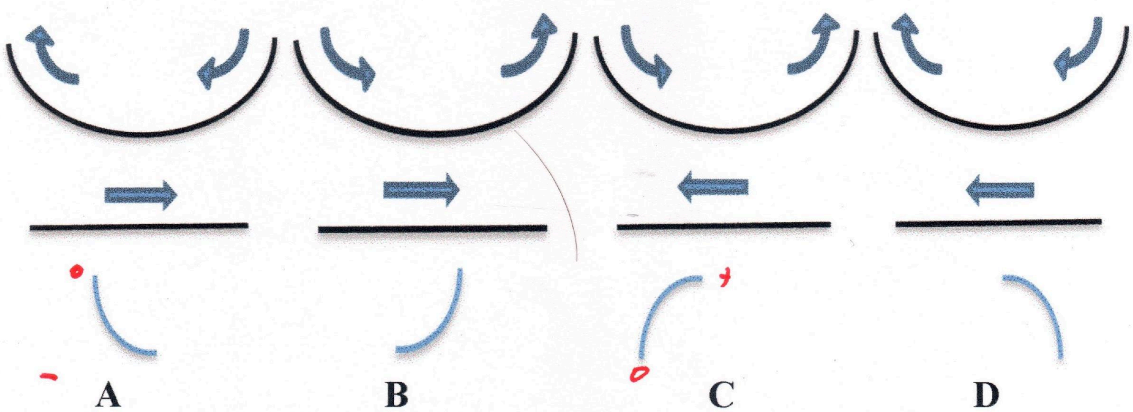


Dennis's chart merits some close examination. The four dark straight lines in the center represent the center conductor. The curved line above represents one of the pickup loops.

At the bottom you see four phases of an AC signal: In A, the signal is going from zero to its maximum negative point. In B it is going from maximum negative back to zero, and so forth. The arrows about the curved pickup loop show how the capacitive coupling between the center conductor and the pickup loop creates an electromotive force in the pickup loop. When that center conductor is getting more negative (as in A) that growing negative charge is pushing free electrons in the pickup loop away from the center out into BOTH ends. That is a point that eluded me until I saw Dennis's chart. Remember: the pickup loop and the center conductor form a capacitor, and when that center conductor grows more or less positive or negative, it alternates between pulling electrons into the center of the loop and pushing them out toward the ends.

But the center conductor and the loop ALSO form a transformer in which the two wires are inductively linked. Here, the way in which current in the center conductor creates EMF in the second conductor in a fundamentally different way.

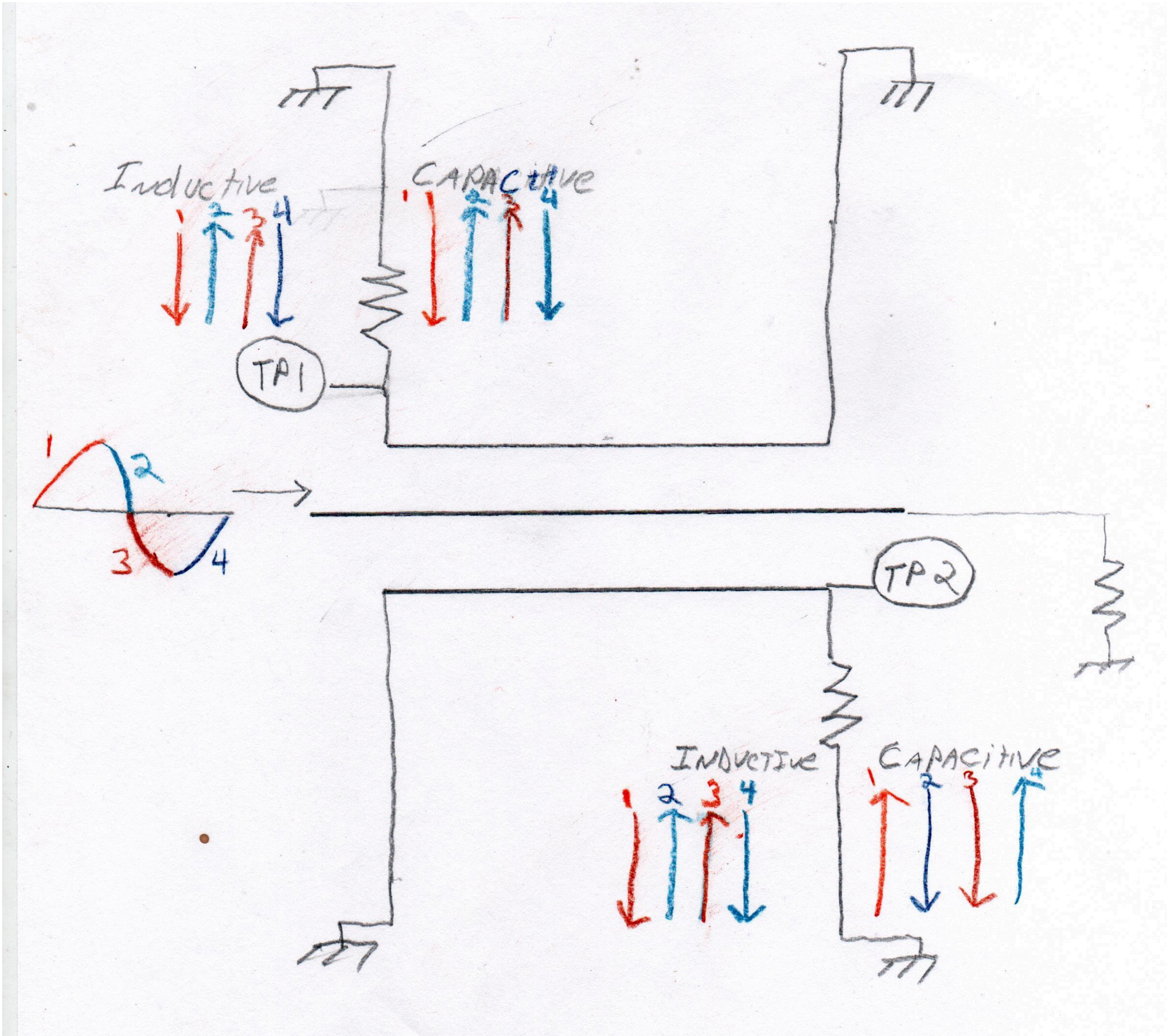
Figure 5. Inductive or Magnetic Effect



To understand this you have to think back to transformer and inductor theory: Remember that an increasing current in the primary coil will induce in the secondary a “back EMF” in the direction opposite to the original current flow. This is what we see in A. When in B that current starts to decrease, the collapsing magnetic field will induce in the secondary an EMF force in the same direction as the primary current flow. The same thing happens in the second half of cycles C and D. You can see in this chart that the inductive effect creates an EMF in the secondary in one direction or the other. Compare the pickup loop arrows in the two diagrams above. One describes a capacitor, the other a transformer. McCoy’s reflectometer was both at the same time.

Armed with this information, we can begin to understand how McCoy’s simple little machine sorts out the forward power from the reflected power.

First, let’s look at what happens with only forward power – we’ll set it up so the transmission line is properly terminated and nothing is reflected back. Remember, we have set up the center conductor and the pickup loop so that the capacitive power and the inductive power are at the same level.



The picture shows a wave going into the meter from the left. Here the meter is terminated in a 50 ohm resistor, so no energy is reflecting back from the load. The signal is broken up into four parts, each representing 90 degrees of the signal. Referring back to Dennis Klipa's explanations of how the inductive and capacitive coupling sends energy to the parallel pick-up loops I drew a diagram showing the currents that would flow through resistors placed at opposite ends of these pick-up loops. You can see how for a wave traveling from left to right, in the resistor on the left, in each of the 90 degree segments of the signal, the inductively coupled energy is in phase with the capacitively coupled energy. A measuring device placed at TP1 will record a signal.

But look what happens in the resistor on the right: there, in each 90 degree phase of the signal the inductively coupled energy will be 180 degrees out of phase with the capacitively coupled energy. They will cancel out. A measuring device placed at TP2 will show no signal.

Obviously any wave traveling in the opposite direction will be detected at TP2 and NOT at TP1. We have created a DIRECTIONAL meter and this is very useful.

Here is how it becomes an SWR meter: Suppose that the 50 ohm resistor were to be replaced by one with another value, let's say 25 ohms. Some of the energy coming down the transmission line

would not be absorbed by the load. Some of it would be reflected back, and would enter our SWR meter from left to right. We would see a voltage at TP2. We could easily calibrate our meter by replacing the 50 ohm resistor with various resistances and recording the ratio between the reading at TP1 and that found at TP2. Most SWR meters have a variable resistor that allows us to place the TP1 reading at full scale on a voltmeter – this makes it easier to read the ratio and see the SWR.

In a sense you can see the SWR meter as being similar to a Wheatstone bridge: When 50 ohms is the load, no voltage develops at TP2. But when anything other than 50 ohms is the load, then a voltage will appear at TP2 and the ratio of this voltage and that at TP1 will – after calibration -- tell us the SWR.

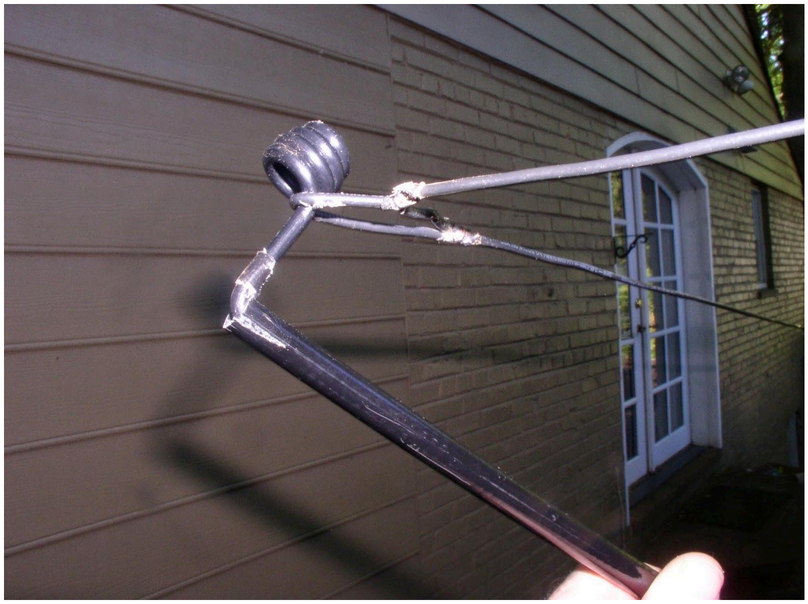
Diodes are almost always a part of the SWR meter circuit, but they aren't really important here – they simply rectify the RF signals at the test points and allow the meters to operate.

When I first struggled to understand how these little meters worked, I had a tough time accepting that in that center conductor we had one wave moving left to right and another moving – in the same wire – right to left. But of course we do. That is precisely what CREATES the standing waves along the line: At certain points on the line the incoming and outgoing waves will be in phase and will produce a signal peak. At other points they will be out of phase and will produce a signal minimum. The ratio of this signal peak to minimum is the Standing Wave Ratio. It is proportional to the mismatch between the characteristic impedance of the transmission line and the load. And that is what we are measuring with our little SWR reflectometer.

MONDAY, JULY 14, 2014

Scrap wood, some wire, four fishing poles and an old tripod: Moxon Update

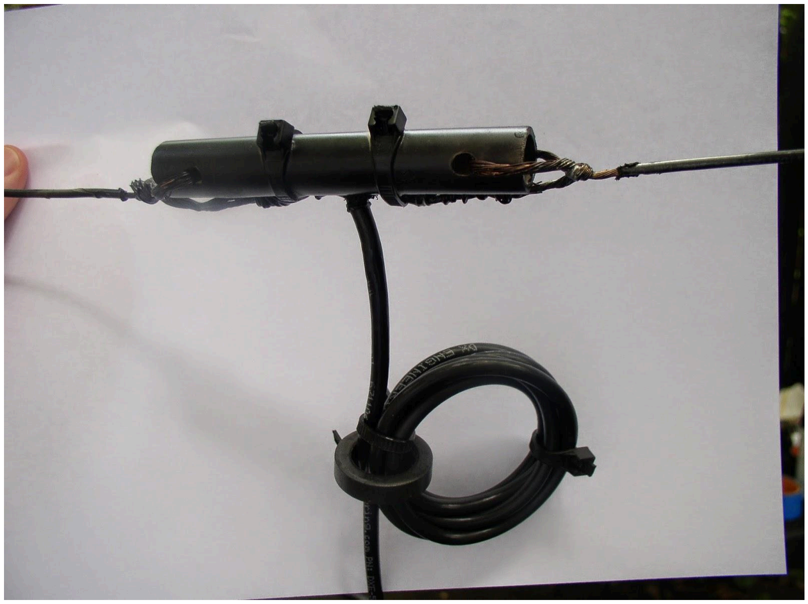
It is not up on the roof yet, but we are getting close. Above you can see the center "hub" -- just some scrap plywood and 8 u bolts.



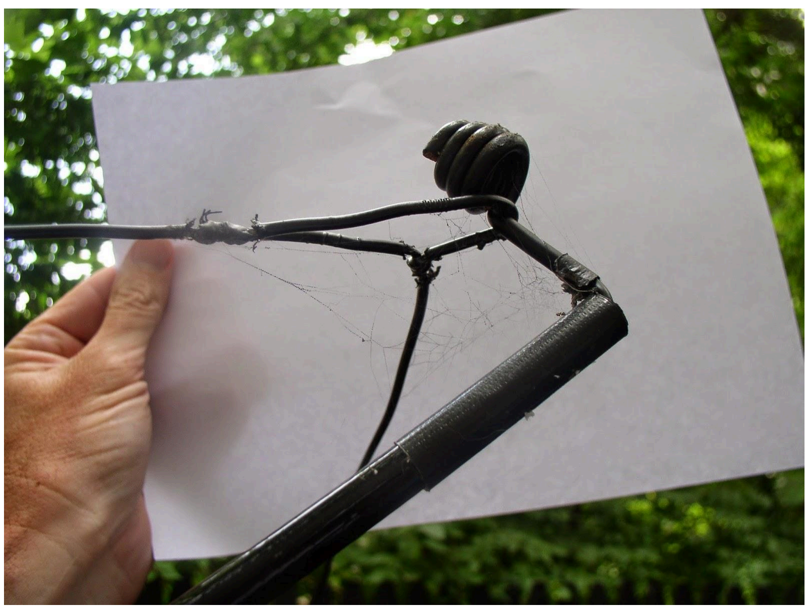
Here is how I handled the corners. The coil thing is from the end of a bungee cord. It makes for easy disassembly.

Here is how the mast connects to the hub. I had some 1x1 scrap wood. The 1x1 will be U-bolted into the rotator.

Made of wire and fishing poles, Moxons are not very photogenic. But I think mine looks great. The 17 meter version is quite small.



A bit of a balun. Just to keep RF currents off the outside of the braid.



That tripod was last aloft in the Dominican Republic (1992-1996!). Two spray cans of flat black paint have been applied. Stealth!

Four 16 foot "crappie" telescoping fiberglass poles purchased from Amazon.

The only thing holding me up at this point is a safety concern. The roof has a somewhat steep pitch, and I am not at agile as I used to be. So before I install this magnificent sky hook I'm getting one of those roof safety harness systems that roof workers are supposed to use (but rarely do). This sill also benefit the poor fellow who comes to clean our gutters.

FRIDAY, MARCH 2, 2018

Moxon Destroyed

The north-east region of the U.S. is experiencing a very strong winter storm. These storms are called "Nor-Easters"- that describes their track up the coast. Here, we had wind gusts at 71 mph -- that was around what we had with Hurricane Sandy. But no rain or snow down here -- it is a different story in New England.

I was on the air, having a nice chat with Ivo OP2A on 17 when suddenly my SWR went way up. I knew immediately what had happened. I stepped outside and saw what you see above.

Oh well, we had a good run. It went up there on July 20, 2014. Not bad for some fiberglass poles from Amazon, some scrap lumber and some wire from Steve Silverman (thanks Steve).

To tell you the truth I was kind of hoping this would happen. I'll replace it with a Moxon or a Hex that covers at least 20 and 17.

Monday, January 2, 2012

2012 Off to a Good Start: Balanced ATU Success!

2012 is off to a good start here at SolderSmoke HQ. I'm planning on putting up an 80-10 dipole fed with open wire (window) line. So I need a balanced ATU. A very simple link coupled design appears in lots of the antenna books and handbooks (1980 ARRL Handbook page 19-8, RSGB's "Practical Wire Antennas" by John Heys, page 86): Just a series LC circuit in the primary and another tuned circuit with a split stator variable cap in the secondary. The junk box was VERY cooperative: I found a big tuning coil (or might it have been two coils?) probably from an old Heathkit DX-40 or DX-60) -- that would work for the secondary coil. Then for the primary I found a smaller coil that would fit perfectly (with one layer of Gorilla tape) inside the secondary. I also found two really pristine 1000 pF air variables (I know, they can't handle much voltage, but, hey, that's one of the benefits of being a QRP guy, right?) I used the HW-7 as a signal generator and this morning did some experiments with different loads. You have to play around a bit with the taps on the secondary, but the ATU seems quite capable of matching loads from about 50 ohms up to at least 10K, and it works from at least 40 meters to 15 meters.

I found it very pleasing to see that SWR meter go down to 1:1. I'll now -- in the finest traditions of ham radio -- wait until the snow starts falling and the wind starts howling before I try to put an antenna in the trees.

SATURDAY, JULY 14, 2018

Homebrew Tuner for Doublet Antenna

For now, I've put the Moxon project on the back burner. I will take it up again once Old Sol starts showing some spots. In its place a 135 foot doublet is going up. I got at a hamfest a while back. (It is the only HF antenna that I ever bought!) It is the SPI-RO Manufacturing Company's Model A-10. It came with 100 feet of 450 ohm window line. It will be up on the roof soon.

Today I put the tuner on the wall in the car port right outside the shack. I even built a little shelf for the SWR meter (used one of those Whole Food grilling planks!). I put a 25 ohm resistor where the feed line will connect. I was able to tune it up on the two bands I tried: 40 and 17.

There is a smaller coil inside the big one -- the smaller coil resonates with the lower variable cap.

You can see all the homebrew rigs in the background -- waiting patiently for the antenna.

I actually built the tuner back in 2012, but never used it. Description here:

https://soldersmoke.blogspot.com/2012/01/2012-off-to-good-start-balanced-atu.html

I will try to provide a schematic and more details soon.

TUESDAY, JULY 12, 2022

Hex Beam at N2CQR

I got my K4KIO Hex Beam up on the roof yesterday. I think it looks pretty good! It is in the same spot that I had my beloved Moxon. Curse you Nor'Easter!

Putting this thing in the air made me appreciate the relative simplicity of the Moxon. It had just four poles, not six. It weighed just nine pounds, not 25. It was significantly smaller. On the other hand, that antenna just gave me one band -- I have 20, 17 and 12 on this one, and I could add three more. Also, this one is a lot more rugged, and is likely to survive the next Nor'Easter.

It was fun spinning it around. First QSO was DX on 20 SSB: EA1HDZ. This morning I spoke to KP3CQ in Puerto Rico. Later, I was listening to ZS3Y -- he was faint until I tried him on long-path. He was transmitting on the long path and was much stronger when I pointed in that direction.

I kept the 75 meter doublet -- I just put it on another tripod. So I will be able to continue to use that antenna for 40 meter AM contacts (I've been having a lot of those lately).

SATURDAY, JANUARY 18, 2020

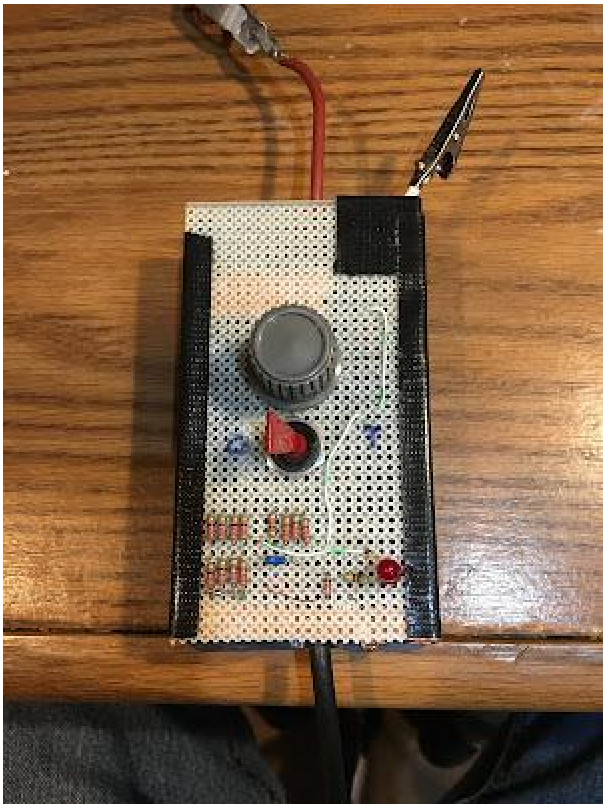
The End Fed Half Wave Antenna and EFHW Tuners

In the SPRAT 179 (Summer 2019) article describing their Peregrino (Pilgrim) transceiver, Joan EA3FXF and Eduardo EA3GHS recommend the use of an End Fed Half Wave (EFHW) antenna. Their circuit incorporates an EFHW tuner and an SWR indicator. As I planned my trip to the Dominican Republic with a uBITX, I had this antenna system idea in mind. I was attracted by the possibility of avoiding having to carry coax with me. And it seemed that an EFHW antenna would be easier to get up in the air than a coax-fed dipole.

When searching for schematics for EFHW tuners I came across the QRPguys tuner kits.

https://qrpguys.com/end-fed-half-wave-sota-antenna-tuner

This looked like just what I needed, so I ordered one. But I placed my order kind of late, and I started to worry that I might not get the tuner kit in time. So I decided to homebrew my own (just in case!)



As it turned out, QRPguys got the kit to me in plenty of time. It went together very quickly and is a really useful piece of gear. My homebrew version works fine, but I prefer the QRPguys device.

You can check out the manual here:

https://qrpguys.com/wp-content/uploads/2019/09/efhw_40m_tuner_assy_090119.pdf

The circuits are interesting. The EFHW antennas present an impedance not of 50-70 ohms, but of 3000-5000 ohms. The Peregrino and the the QRPguys circuits use a matching transformer to change the high impedance to 50 ohms. In both circuits polivaricon capacitors are used to tune for resonance. The QRPguys circuit uses an N7VE LED absorption bridge -- I found it very satisfying to put the circuit into "tune" mode and then just adjust the capacitor until the LED went out. That means the antenna system is presenting 50 ohms to the transmitter.

SOTA beams has a good explanation of the EFHW antenna here: http://sotabeams.co.uk/efhw/

I did use a counterpoise. 

CHAPTER 11

DOMINICAN REPUBLIC

My wife Elisa is from the Dominican Republic. I lived there from 1992 to 1997, and have been going back regularly of the last thirty years. For a number of good reasons we decided to get a place in the DR. We wanted to be able to get out of the cold winters of the United States. Elisa wanted a place in her home country. And as her mom grew old we knew that Elisa (her mother's only child) would have to spend more and more time with her. So we bought an apartment in Cap Cana, on the eastern tip of the Island of Hispaniola. Elisa arranged for me to have a shack on the top (seventh) floor. There I am, in my Dominican shack. We plan to spend about half the year there, and about half the year back in Virginia.

WEDNESDAY, JANUARY 15, 2020

Notes From the Dominican Republic on possible uBITX mods

It was really great to have the multiband and CW/SSB capabilities of the uBITX with me in the Dominican Republic. And even with my large wooden box, the rig and all its accouterments fit into my carry on baggage (and there were no problems with airport security). (In the picture above you can see the cloth case that held the whole station, including the antenna.)

As I used the rig, I thought about possible mods for future operations. Here are some ideas:

-- Filter for CW? Definitely. Farhan suggested switching in a more narrow 12 MHz IF filter for CW operations, but that seems like a bit too much work. I am going to try to use an audio frequency filter. I've ordered the active CW filter from QRPguys. I've long been intrigued by these kinds of filters, but they didn't seem very wirthwhile with a DC receiver. With a superhet like the uBITX they make a whole lot more sense.

-- Sidetone volume control. Need it, especially with fellow vacationers trying to sleep nearby. Should be easy -- just a pot on the side-tone line.

-- Low impedance mono headphones. Need them.

-- An LED light for logging. Would help.

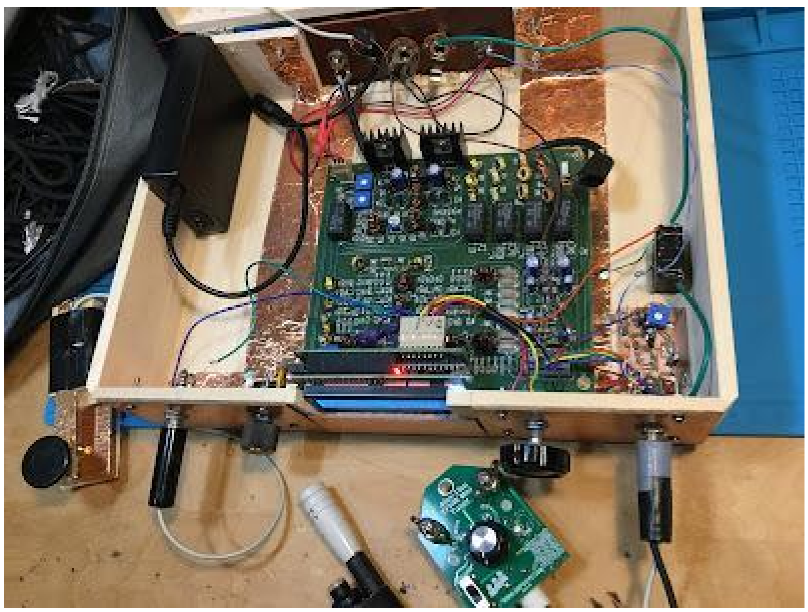
-- Switch to turn off the 16X2 display to save power? I thought about this but I checked after we got back and the whole display pulls only about 20 ma. So it probably isn't worth it to put in a switch.

-- Internal protective cover for the uBITX board.   I used the extra space in my big wooden box to store the key, the mic, the battery, the tuner, etc.   They all bounce around a bit and could damage the uBITX board. So I will try to build in some internal physical shielding, perhaps from a BITX plastic box.

-- Brass contacts for my homebrew CW key.   I think brass is better than the copper foil I am currently using. I already did this with some brass bolts from the local hardware store. Mush improved. Pounding brass is better than pounding copper tape.

-- I installed an additional stage of microphone amplification but I have this stage running even on receive. But I checked and the amount of current pulled by this stag is so small that it is not even worth changing the power supply line.

-- Reduce output to below 5 watts on CW.   To make the rig "QRP Compliant."



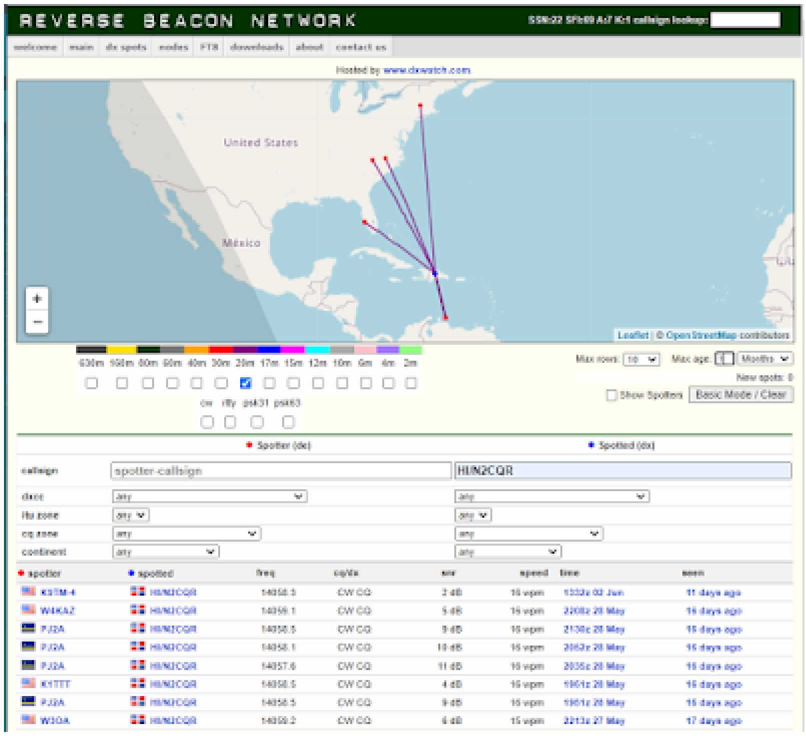
In the pictures you can also see my homebrew straight key, the QRPguys EFHW tuner, my mic (the original SolderSmoke podcast mic!), the 3 amp-hour LiPo battery, the additional stage of mic amplification.   The little relay that you see just above the mic amp allows for the keying of an external amplifier.

June 14, 2021

Santo Domingo Shack on 12th Floor Balcony -- SST QRP CW

June 2021. We were in Santo Domingo, Dominican Republic. At this point we were in a 12th floor apartment in the center of the city. I would take my SST 20 meter CW transceiver and EFHW antenna out on the balcony. I made no contacts from this location, but one of my CQs was picked up by K9TM on the Reverse Beacon Network (see below).

All the other RBN spots were the result of calls from the eastern tip of the island. (Click on the RBN image for a clearer view.)



SUNDAY, MAY 30, 2021

QRP - QRP Contact from Dominican Republic

It took some brass pounding on my homebrew key, but on May 28, 2021 I made a real QSO from the eastern tip of the island of Hispaniola. KJ4R came back to my CQ near 14.060 MHz. I was running just 1-2 watts from my SST transceiver to an end-fed half wave antenna. Ed KJ4R was in South Carolina running 5 watts, also to an EFHW antenna. TRGHS. Thanks Ed. And thanks to Bob Scott KD4EBM and Wayne Burdick N6KR.

SATURDAY, DECEMBER 18, 2021

On 17 meter CW from Santo Domingo with a uBITX

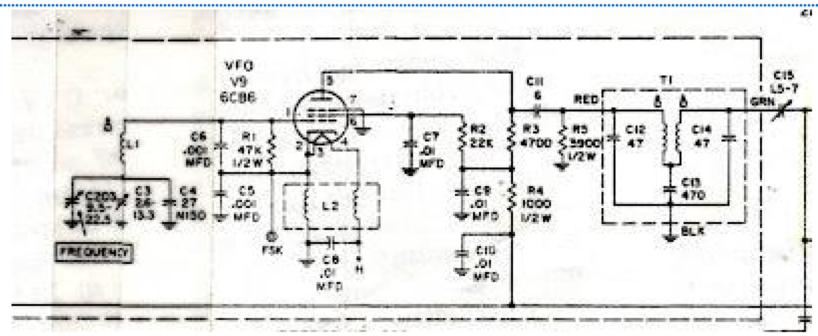
We are up on the 12th floor of a building in Santo Domingo. I brought my uBITX and managed to check in as baggage a 16-foot crappie fishing pole. I figured I needed to get the 1/2 wave antenna away from the building -- last time I was here I was unable to make any contacts from this location with the antenna stretched along the balcony. Last time I was QRP with an SST transceiver.
The fishing pole worked well, but I operated with fear that it would fall or that the neighbors would complain). Today I got on 17 CW with the uBITX (more power than the SST), put it on 17 CW and promptly worked W4A, a special events station commemorating E. Howard Armstrong. Turns out that today is Armstrong's birthday. TRGHS.

On the Reverse Beacon Network my CQs were heard by KO7SS in Arizona (very cool skimmer station at 8100 feet!) and by W2NAF (interesting operations in Antarctica, Svalbard and Virginia Tech).

CHAPTER 12

VARIABLE FREQUENCY OSCILLATORS

Solid-Stating an HT-37 VFO -- Advice Needed



Original HT-37 VFO Circuit

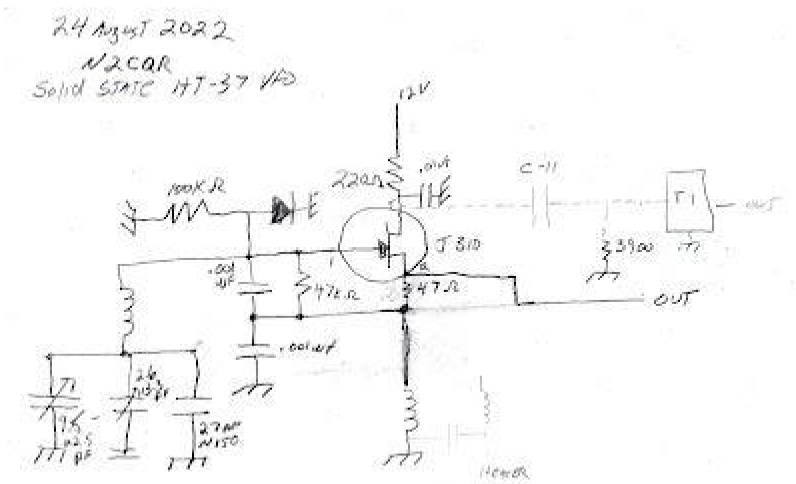
A couple of things before I start:

First, this is not my fault. The Radio Gods are to blame. I innocently tried to by an HT-37 tuning capacitor on e-bay, but the seller sent me the entire VFO unit. The only thing missing was THE TUBE. Clearly, that was a sign, right?
Second, this is a work in progress. That is why my diagram (below) is a bit ugly. I am looking for your input and advice on how I might do this better. I will understand if religious principles prevent some of you from participating in this endeavor.

I am trying to solid-state this device WITHOUT major surgery, and without adding any reactive components that would change the resonance or tuning range of the original. The original circuit tunes from 5 to 5.5 MHz and that is fine with me.

I started out by just sticking a J-310 FET into pins 1, 2, and 5 of the tube socket. I put 12 V on the drain and the thing oscillated right where it is supposed to. That was a good sign.

Here is what I have done so far:



Bill's initial solid state conversion of HT-37 VFO

Mechanically, my effort has been very simple. At first I tried to fashion a more serious male socket for the FET using two broken 7 pin tubes. This didn't work well.

So then I just ran three short wires up through the center hold of the tube socket to the connections for pins 1,2, and 5. I superglued the J-301 to the chassis and made some non-reactive connections: I put a 47 ohm resistor on the source, and a 220 ohm resistor on the drain. I grounded the drain for RF with a .01 uF cap to ground. I added a 100k resistor and a diode on the gate. Oh yea, I put a couple of ferrite bead on the FET gate lead. (See pictures below.)


Three lead up through the center hole


A rare look inside an HT-37 VFO

The original thermatron circuit has an output bandpass transformer, a 3900 ohm resistor and a coupling cap. I left them in the circuit, but they are not doing anything.

The output from the source of the FET looks pretty good. I can see some VHF on the trace, but I suspect this is from my FM broadcast nemesis at 100.3 FM (one mile away). On a receiver, I can hear some AF noise on the signal, but this may be the result of the RFI from THE BIG 100 -- WASHINGTON'S CLASSIC ROCK.

So what do you folks think? What else could I do, or should I do?

SUNDAY, JULY 31, 2022

Another HT-37 VFO -- No Temperature Compensation Trimmer Capacitor?

Is that thing beautiful or what? That is the VFO assembly from an HT-37. This one includes the fly-wheel mechanism. It tunes 5 - 5.5 MHz. I'll probably replace the tube with an FET, but mostly keep it as is for use in a future transceiver. It is built like a battleship. Hallicrafters did not mess around with the solidity of VFO construction.

I was a bit disappointed when I did not see the split stator temperature compensation trimmer cap that was present on the Hallicrafters variable cap that I bought back in February 2021:
https://soldersmoke.blogspot.com/2022/02/differential-temperature-compensation.html

I took a look inside my own (beloved) HT-37 and saw that it too lacks the temp compensation trimmer that came with the February 2021 variable cap. Could it be that the February 2021 seller had the source wrong? Could he have in fact been selling me the variable cap from an HT-32? Or could it be that Hallicrafters added this split stator temp compensation capacitor to later versions of the HT-37?

Hallicrafters patented the split stator temp compensation circuit (U.S. patent #2718617). Chuck Dachis says in his book about Hallicrafters that the company had perfected this circuit by 1957.

An HT-32B transmitter was selling for $725 in 1963. That's $7020 in today's money. Wow, and that is just for the transmitter!

TUESDAY, FEBRUARY 15, 2022

Differential Temperature Compensation Capacitors in the Hallicrafters HT-37 Main VFO Tuning Circuit

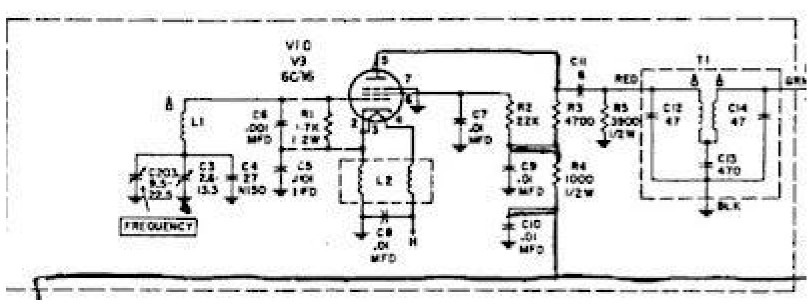
I've been watching with great interest Mike WU2D's excellent series on VFO construction. His second video is especially interesting because he talks about how we can use a split stator differential capacitor to build a temperature compensation circuit that will allow us to "dial in" the proper amount of temperature compensation.

The heart of this circuit is the split stator differential capacitor. The stator is split; but there is a common rotator. As the rotator moves, the capacity across one part of the capacitor increases while the other part decreases -- thus the total capacity remains unchanged. If we connect two capacitors of the same capacitance BUT OF OPPOSITE TEMPERATURE CHARACTERISTICS -- we can use this split stator cap to select just the right amount of temperature compensation.   Very cool. Even cooler: Mike actually built a split stator differential capacitor. That, my friends, is dedication.

I was sitting here this morning thinking about all this when it occurred to me that right in front of me was a capacitor that might be relevant to all this (see above). I bought it on e-bay one year ago after Pete N6QW had alerted me to it. It is the main tuning capacitor from an HT-37 transmitter. What attracted us was the big anti-backlash mechanism. But now I realized that it had another charming feature.

Looking at it a bit more closely I saw a split stator differential cap just like the one that Mike had made. Attached to the two rotors were two tubular capacitors. The three caps are in parallel with the main tuning cap. Bingo -- this is a temp compensation circuit.

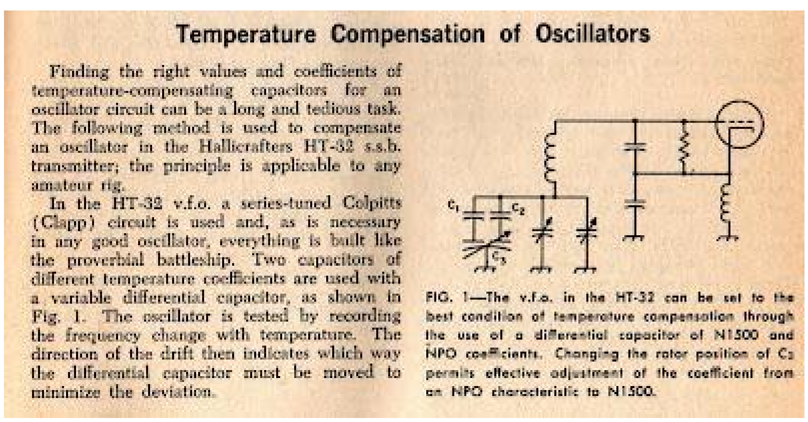
I checked the HT-37 manual. The manual says that temp compensation is set at the factory. OK. But the schematic does not show the split stator caps and the two tubular caps (see below). Could it have been that this circuit was added later perhaps to address drift? (We do see it in the HT-32B schematic -- see below.)



HT-37 VFO SCHEMATIC

Anyway, it was very cool to find this example of the circuit Mike was discussing. In the photo at the beginning of this post you can see the three caps. Below you can see the split stator cap in the background.

In the comments a reader points out correctly that this circuit was discussed in the ARRL book "Single Sideband for the Radio Amateur." Indeed, it is on page 51 of the 1970 edition, ARRL gave credit for the circuit to Hallicrafters:

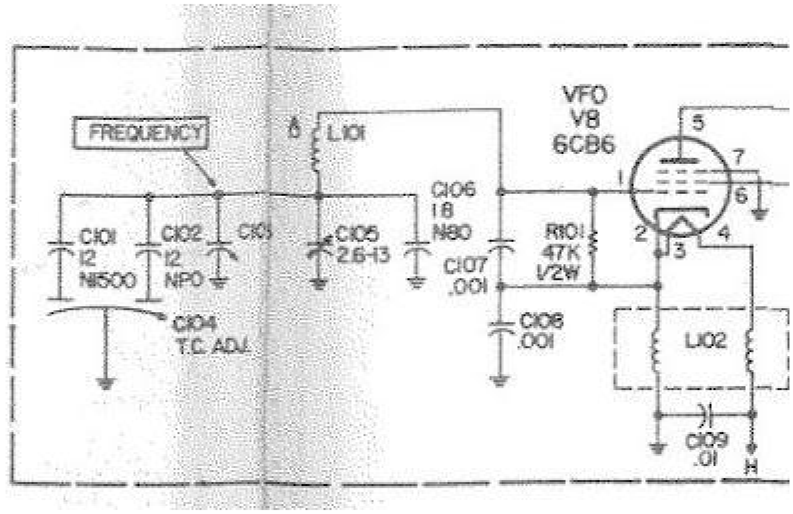


Temperature Compensation of Oscillators

Finding the right values and coefficients of temperature-compensating capacitors for an oscillator circuit can be a long and tedious task. The following method is used to compensate an oscillator in the Hallicrafters HT-32 s.s.b. transmitter; the principle is applicable to any amateur rig.

In the HT-32 v.f.o. a series-tuned Colpitts (Clapp) circuit is used and, as is necessary in any good oscillator, everything is built like the proverbial battleship. Two capacitors of different temperature coefficients are used with a variable differential capacitor, as shown in Fig. 1. The oscillator is tested by recording the frequency change with temperature. The direction of the drift then indicates which way the differential capacitor must be moved to minimize the deviation.

FIG. 1—The v.f.o. in the HT-32 can be set to the best condition of temperature compensation through the use of a differential capacitor of N1500 and NPO coefficients. Changing the rotor position of C_3 permits effective adjustment of the coefficient from an NPO characteristic to N1500.



HT-32B VFO Circuit

Joe Carr K4IPV (SK) also discussed this circuit. In his article in Popular Electronics in August 1993, he too gave credit to Hallicrafters. Carr also gave some detailed instructions on how to use the circuit to stabilize a VFO. See pages 78 and 79 of the August 1993 Poptronics:

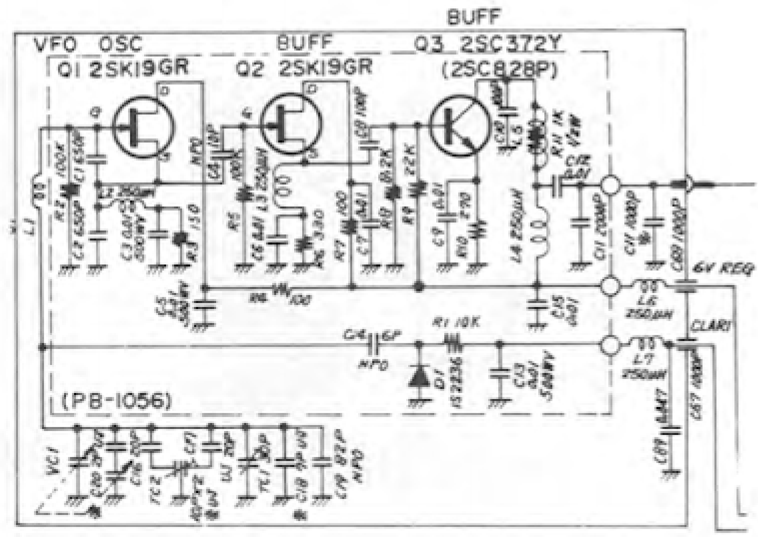
https://worldradiohistory.com/Archive-Poptronics/90s/93/PE-1993-08.pdf

FRIDAY, FEBRUARY 25, 2022

Split Stator Temperature Compensation Also Used in Yaesu FT-101

The eagle eye of VE3EAC spotted this (he also correctly pointed to a tiny broken "tine" as the cause of my HP8640B woes).   I had missed the temp comp circuit. Inside the Yaesu FT-101 VFO box that I used in my Mythbuster rig, there is a split stator capacitor and two temperature compensation caps similar to that recently described by Mike WU2D. Very

cool. You can see the temp compensation cap in the picture (above). The red arrow points to the split stator cap, the blue arrow points to to the two temperature compensation caps attached to it. You can see them all in the schematic below(in the lower left of the schematic).



CHAPTER 13

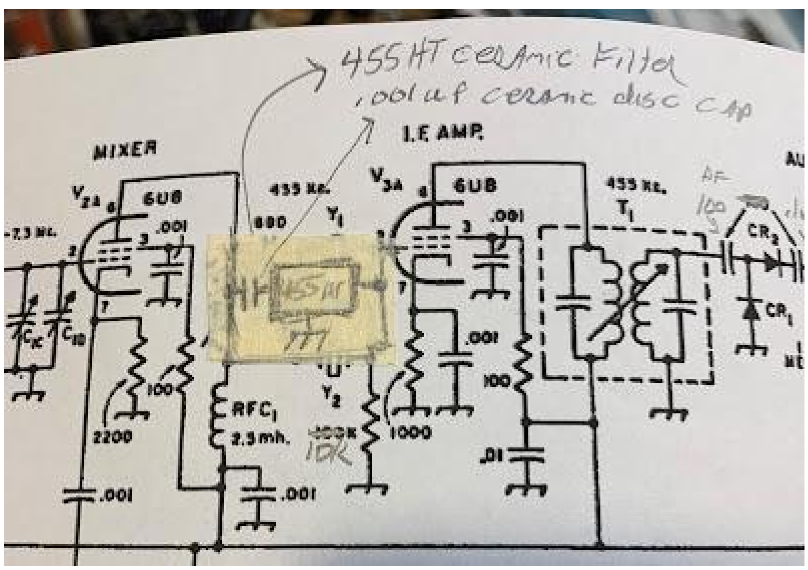
FILTERS

FRIDAY, NOVEMBER 12, 2021

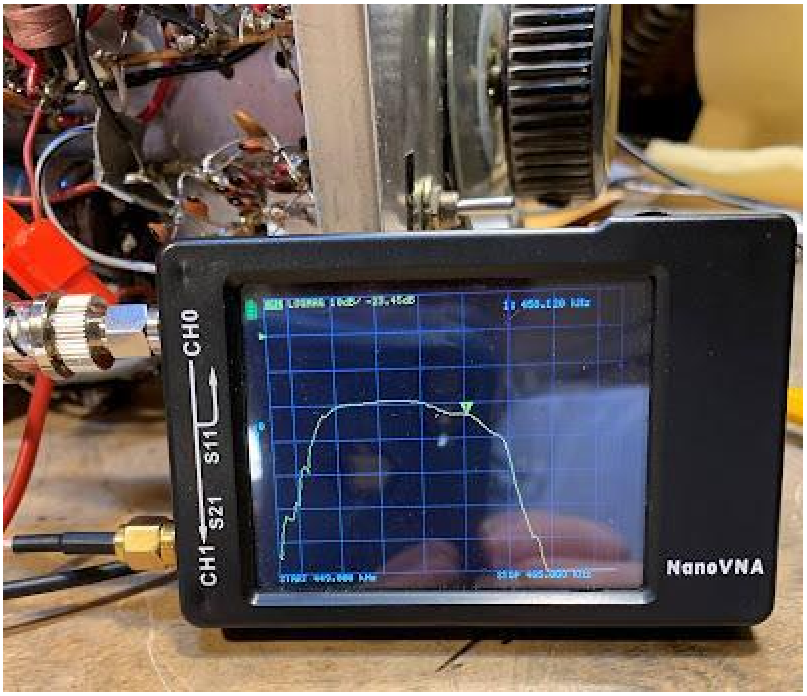
Mate for the Mighty Midget with 6 kHz Ceramic Filter

I built this receiver back in 1998, but I continue to have fun tinkering with it. I wrote an article about it for "Electric Radio" magazine (Number 115). One of the major shortcomings was the crystal filter that Lew McCoy prescribed. It was very difficult to get 455 kHz crystals to work well as filters. At various times I've had all kinds of replacements in there in place of Lew's filter: a 455 kHz IF can, a Toyo CM-5 hybrid ceramic filter, a fancy Millen high Q IF transformer. None of them really worked well.

Recently I put a little +/- 3 kHz ceramic filter in there. This is a 6 kHz wide filter at around 455 kHz. I think it works really well. Above you can see the receiver in action. I use it with a little powered computer AF amplified speaker -- I just don't like headphones.



The latest filter mod with the 6 kHz ceramic filter is shown above.



Above you can see what the whole 455 kHz filter and transformer passband looks like. The input was through a 2k resistor placed between the .001 uF cap and the filter. The output was also through a 2k resistor placed at the top of the secondary of T1. (So don't pay any attention to the insertion loss.)

The NanoVNA is displaying 2 kHz per division. I put the BFO at 451 kHz. This results is excellent opposite sideband rejection. The filter is really too wide for SSB, but it is about perfect for AM, which I listen to quite often on both 75 and 40. SSB and AM both sound quite good. Check out the video above.

It is kind of amazing what can be done with just three 6U8 tubes.

There are many previous SolderSmoke blog posts about the Mate for the Mighty Midget Receiver here:
https://soldersmoke.blogspot.com/search?q=Mighty+Midget   Be sure to keep selecting "earlier posts" so see more.

ATURDAY, NOVEMBER 20, 2021

The Double Crystal Lattice Filter in the Swan 240 -- Smoothing it out with a NanoVNA

In SolderSmoke Podcast #234, I said that I was scrutinizing the filter from the Swan 240 that I had picked up around 1994 in the Dominican Republic. I cannibalized it out in the Azores in the early 2000s and used the parts to build -- among other things -- my first SSB transmitter. I never really focused much attention on the filter that I pulled out of that old rig -- I was just happy that it seemed to work. But I am now older and wiser, and I have some test gear that lets me look at the passband of that filter.

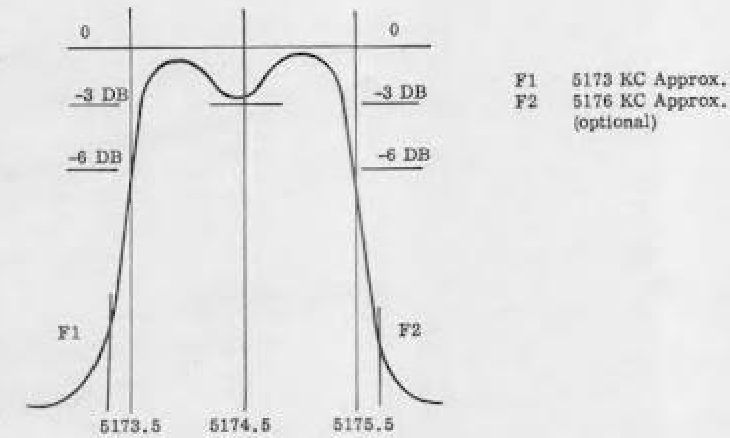
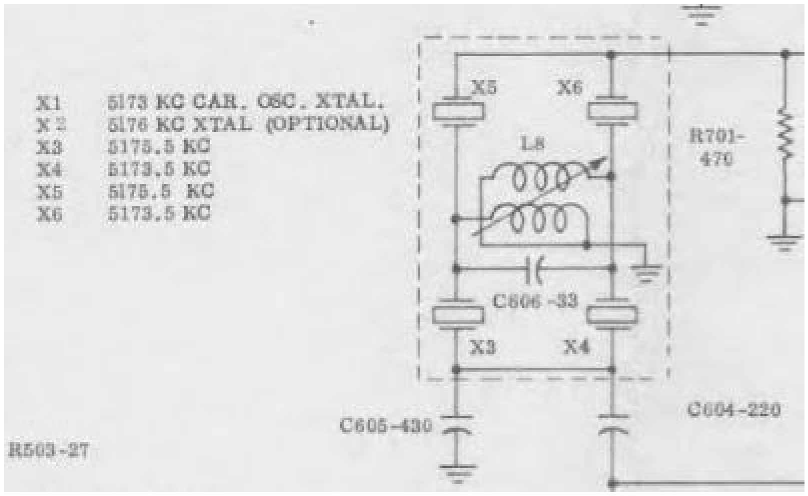


FIGURE 7. CRYSTAL FILTER RESPONSE CHARACTERISTICS (TYPICAL)

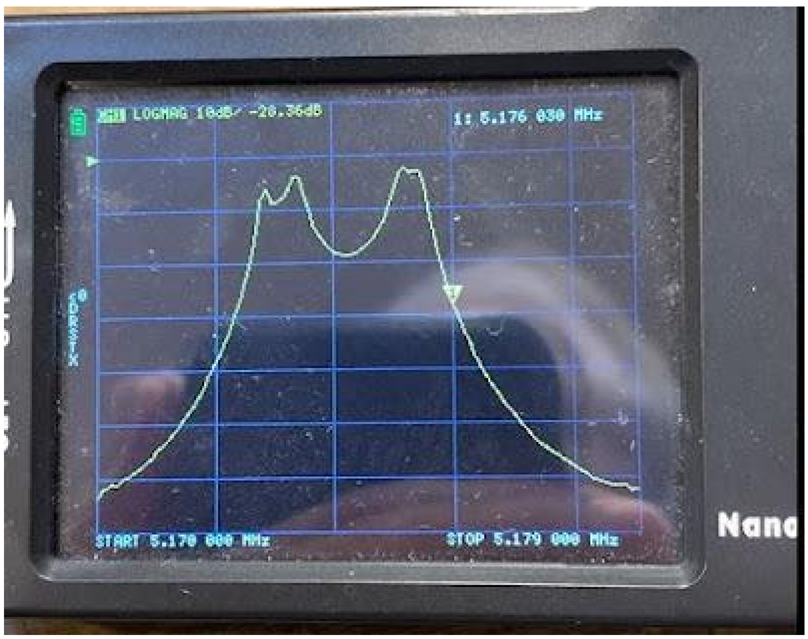
First, take a look at what it is supposed to look like. This is from the manual. Yikes! That passband looks far from flat. I can almost hear homebrewers around the world shrieking in horror and disgust.

CRYSTAL FILTER

Sideband suppression is accomplished with a high frequency crystal filter consisting of two half lattices operating back-to-back. The crystal frequencies are 5173.5 and 5175.5 kc. The passband of the filter, centered at 5174.5 kc, is approximately 3 kc, and the shape of the response is such that the lower sideband, (5173.5 minus audio) is suppressed 40 db below the upper sideband, (5173.5 plus audio). This filter is suitable for operation on the other sideband, provided a crystal oscillator frequency of approximately 5176.5 kc is used. This crystal must be suitably matched to the oscillator circuit, and should be calibrated for a load of 20 picafarads. Commonly available crystals, made to work with 32 picafarads, will not function satisfactorily in this circuit.

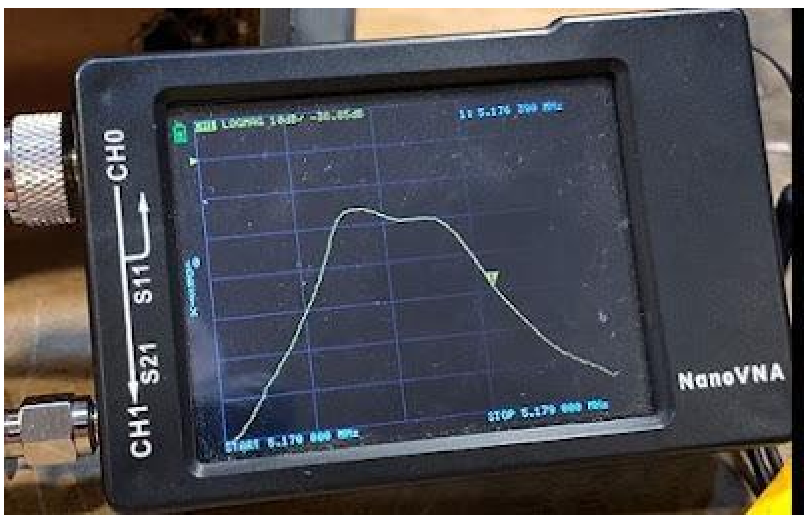


Above is a description of the filter, and the schematic, again from the manual.



Here is what my extracted and somewhat re-built filter looked like in my NanoVNA (more shrieking!). The dip in the passband is a lot worse here -- it looks like 10 db vs. 3 db in the manual. This is probably because I'm not even attempting any impedance matching on the filter -- it is just seeing the 50 ohms in and out of the NanoVNA.

Here is my 2002 attempt to rebuild the filter and put it in my SSB transmitter, along with my more recent attempt to flatten the passband. I no longer had the adjustable coil L8, so I made my own coil based on guidance from Ben Vester W3TLN's January 1959 QST article on "Surplus-Crystal High-Frequency Filters." (Ben had an early influence on Pete Juliano's tube-rig designs.) In the picture above I have 1k pots between the filter and the input and the output of the NanoVNA, as described by Nick M0NTV.



Adjusting the 1 k pots, I could smooth out the passband quite a bit. Measuring the pots and adding the 50 ohms of the NanoVNA, it looks to me like this filter is smoother with about 280 ohms at the input and output. I may build two matching networks or some transformers. Some TIAs may also be needed.

WEDNESDAY, JUNE 30, 2021

10 Pole Crystal Filter Passband as Seen in Antuino and NanoVNA

I continue to work on the "Mythbuster" rig, but I am taking it slow, trying to learn something from each stage. I'm especially trying to master the used of the great test gear that has arrived in my shack in recent years: The Antuino, the NanoVNA, and the TinySA.

Above you can see the passband of the 10 pole crystal filter as measured across the 50 ohm terminations on the filter. I use simple FT37-43 transformers to match the filter impedance down to 50 ohms. I used the Antuino first -- it scanned the passband and held the image on its screen. I then disconnected the Antuino and connected the NanoVNA. So in this shot you can see the passband on both devices.

You will notice that the Antuino says there is a 20db insertion loss. That's only because in the Antuino 20db is really 0 db loss. I think the NanoVNA gives a more accurate insertion loss reading -- about 3-5 db. The cool thing is how similar the shapes of the passband are.

CHAPTER 14

Poetry, Cartoons, and Additional Reading

THURSDAY, JANUARY 14, 2021

A Poem about Shacks and Rigs and Ham Radio

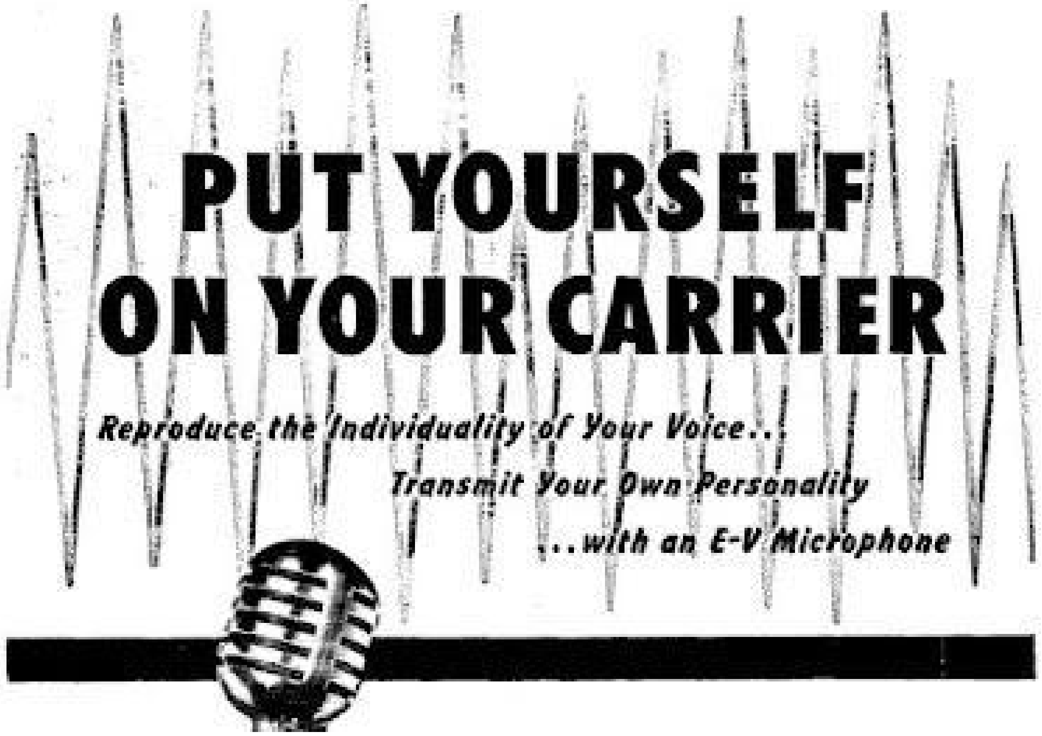
The Little Black Box of jewels and rocks
with lanterns that flicker and glow,
make lighter the gloom in my little back-room
where often I hasten to go.
An anthem it peals of whistles and squeals
and voices so ghostly and dear
that you'd never decry, should you chance to pass by-
what a brotherhood foregathers here!

Each separate tone has a soul of its own;
each voice is the voice of a friend.
United through space in this gathering-place
at the radiant signal's end.
Reverberant sounds ride the wave that rebounds,
like the waves of the sea from afar,
reporting the doings, the comings and goings
of brothers... wherever they are.

A curious band, spread over the land,
yet joined from equator to poles
disperses the gloom in the little back-rooms
by this magic communion of souls.
I could part with a lot of the things that I've got,
but I'll carry my love to the tomb,
of that little black box and the joys it unlocks
... when I enter that little back room.

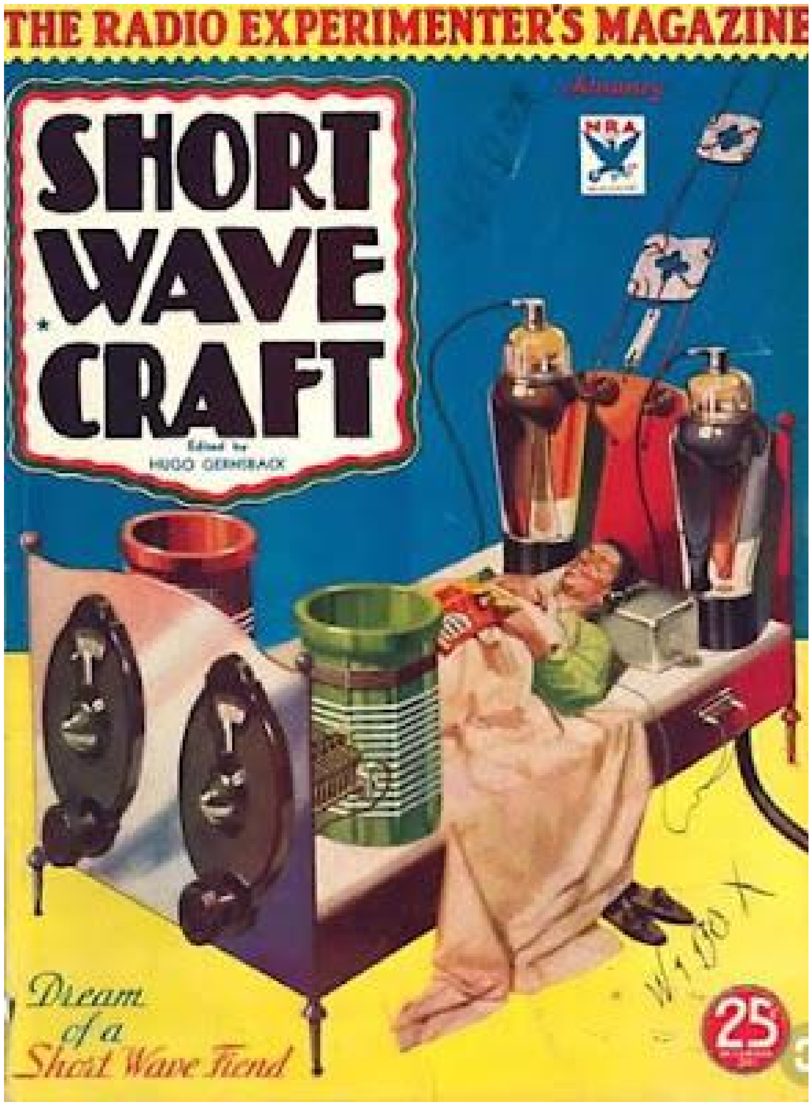
(published in QST magazine sometime 1965.)

Thanks to Jeff Murray for alerting us to this. I had not seen it before. It really got me -- I am working in my little back room on a box with jewels (jeweled movements!) and rocks.



Traumatic troubleshooting

om the front cover of the July 14, 1934 issue of Amateur Wireless.
his UK weekly magazine was the predecessor of Practical Wireless.


THE RADIO EXPERIMENTER'S MAGAZINE
SHORT WAVE CRAFT
Edited by
HUGO GERNSBACK
Dream of a Short Wave Fiend
25¢


MEET YOUR
NEW NEIGHBOR
Everyone knows that the world is growing smaller through the development of Science and Industry—the War is a grim reminder of this fact . . . but when the job of war is done and the Peace is won the world will become a Neighborhood of Nations—working and living together for their mutual betterment.
Radio will serve the world in a measure far greater than ever before—for pleasure, education, safety and convenience of all mankind!
Look to Hallicrafters—they are planning ahead today for your radio tomorrow—plans born of wartime manufacturing experience and engineering developments.
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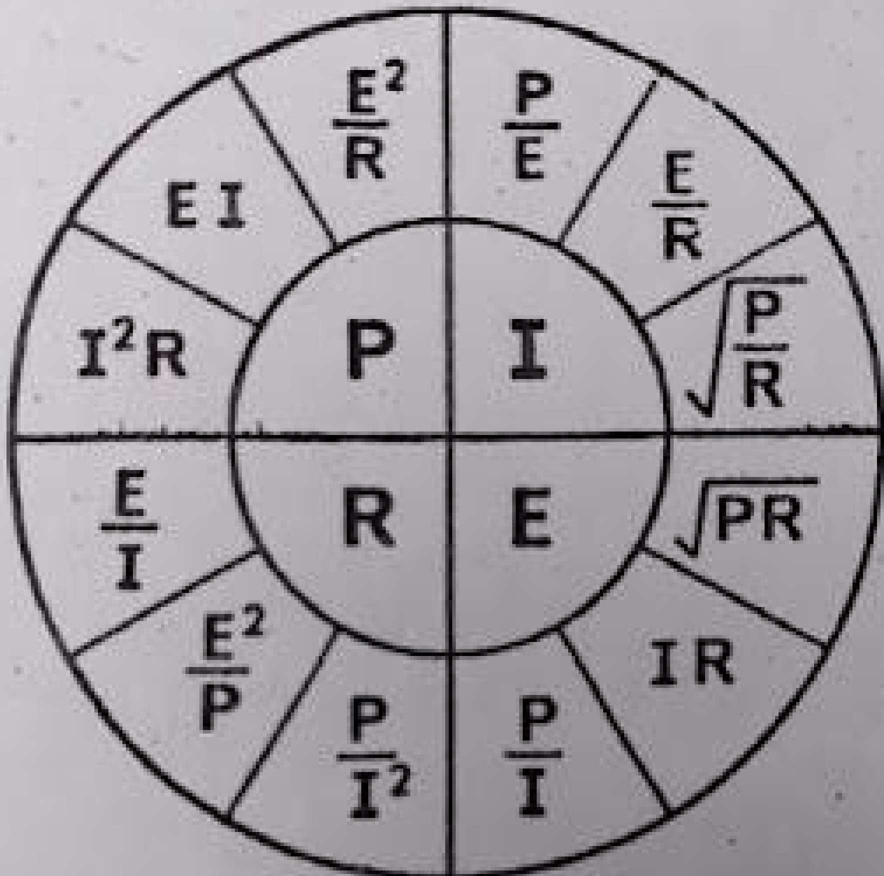
THE HALLICRAFTERS CO., MANUFACTURERS OF RADIO
AND ELECTRONIC EQUIPMENT, CHICAGO 16, U. S. A.



P = POWER IN WATTS

I = INTENSITY OF CURRENT IN AMPERES

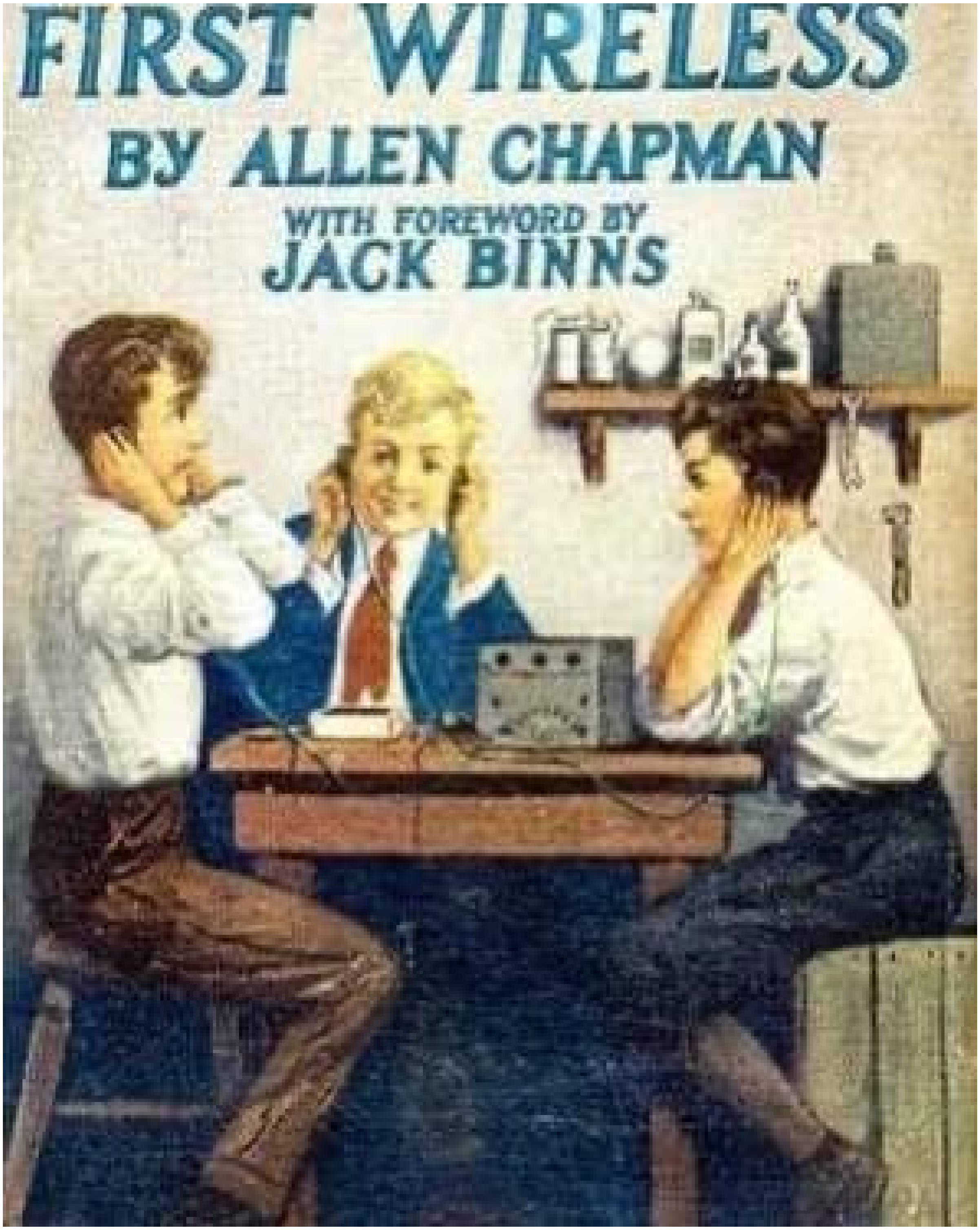
R = RESISTANCE IN OHMS

E = VOLTAGE POTENTIAL IN VOLTS

Homer Price, Homebrewer
https://en.wikipedia.org/wiki/Homer_Price?fbclid=IwAR2cRUCurQBXaP-m4LdPFBOnBU4nvgZwtOZqrAzF8MaGvS4Xb_eTWHSWE2E

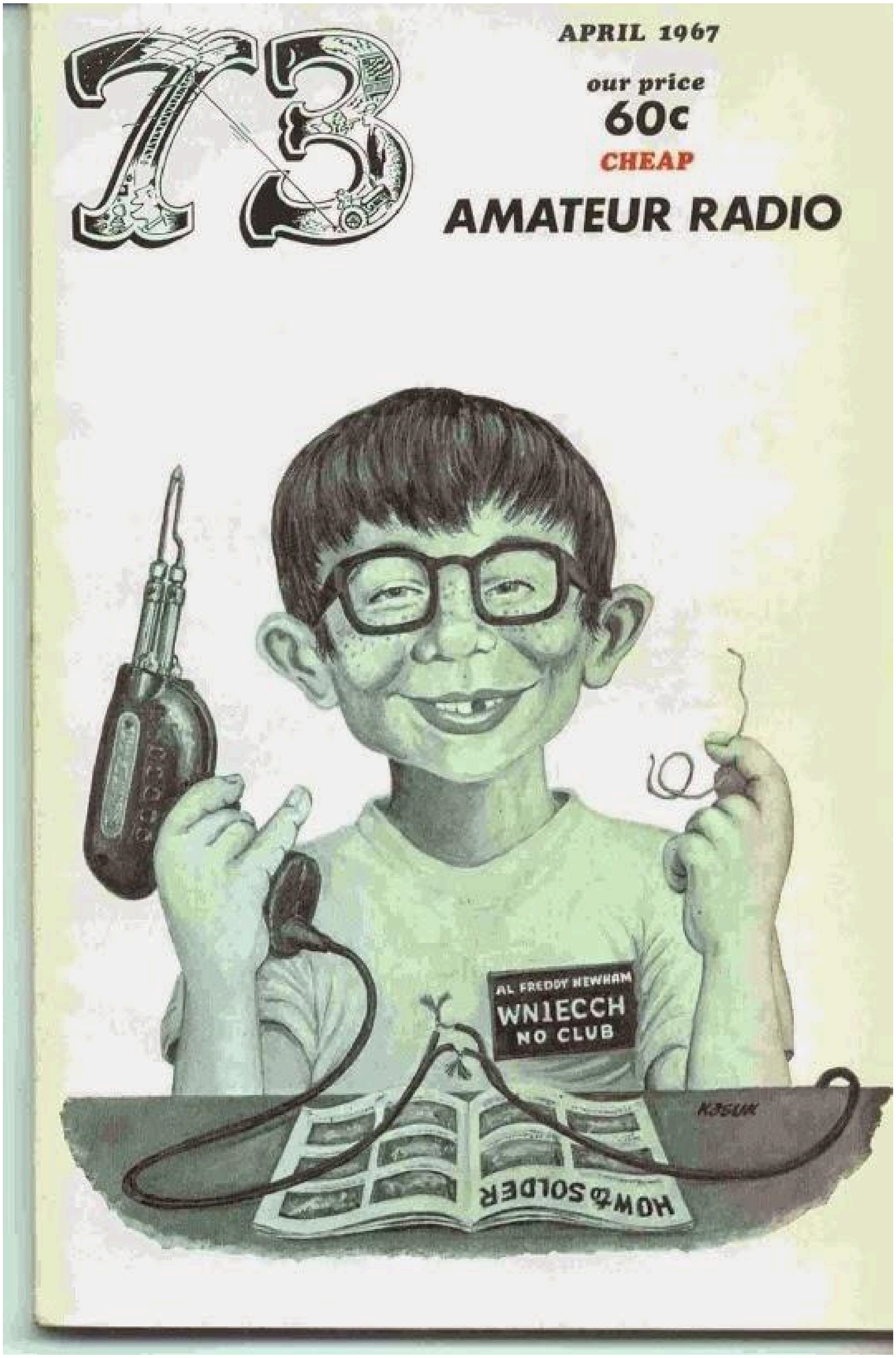

REPAIR MANIFESTO
WE HOLD THESE TRUTHS TO BE SELF-EVIDENT
IF YOU CAN'T FIX IT, YOU DON'T OWN IT.
REPAIR IS BETTER THAN RECYCLING
Making our things last longer is both more efficient and more cost-effective than mining them for raw materials.
REPAIR SAVES YOU MONEY
Fixing things is often free, and usually cheaper than replacing them. Doing the repair yourself saves you money.
REPAIR TEACHES ENGINEERING
The best way to find out how something works is to take it apart.
REPAIR SAVES THE PLANET
Earth has limited resources. Eventually we will run out. The best way to be efficient is to reuse what we already have.
REPAIR CONNECTS PEOPLE AND THINGS
REPAIR IS WAR ON ENTROPY
REPAIR IS SUSTAINABLE
WE HAVE THE RIGHT:
TO DEVICES THAT CAN BE OPENED
TO REPAIR DOCUMENTATION FOR EVERYTHING
TO REPAIR THINGS IN THE PRIVACY OF OUR OWN HOMES
TO ERROR CODES & WIRING DIAGRAMS
TO CHOOSE OUR OWN REPAIR TECHNICIAN
TO NON-PROPRIETARY FASTENERS
TO REMOVE 'DO NOT REMOVE' STICKERS
TO REPLACE ANY & ALL CONSUMABLES OURSELVES
TO TROUBLESHOOTING INSTRUCTIONS & FLOWCHARTS
TO AVAILABLE, REASONABLY-PRICED SERVICE PARTS
REPAIR
IS INDEPENDENCE SAVES MONEY & RESOURCES
REQUIRES CREATIVITY
MAKES CONSUMERS INTO CONTRIBUTORS
INSPIRES PRIDE IN OWNERSHIP
IFIXIT
JOIN THE REVOLUTION WITH IFIXIT.COM

Rogier, PA1ZZ


FIRST WIRELESS
BY ALLEN CHAPMAN
WITH FOREWORD BY
JACK BINNS

Radio Record magazine, 03 August 1928.
Photo: Macmillan Brown Library

Radio Corporation of America


73
APRIL 1967
our price
60¢
CHEAP
AMATEUR RADIO
AL FREDDY NEWHAM
WN1ECCH
NO CLUB
HOW to SOLDER


OCTOBER, 1916
15 CENTS
The Electrical Experimenter
POPULAR ELECTRICAL NEWS ILLUSTRATED
THE WIRELESS GIRL
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RADIO AMATEUR NEWS
H. GERNSBACK — EDITOR

Vol. 1. APRIL, 1920 No. 10

An Amazing Art

F a future chronicler, let us say one hundred years hence, were to write up the progress of the various scientific arts, he would become very much bewildered in his endeavor to write an accurate history of the radio art as it blossomed in the good year Anno Domini 1920.

If he took recourse to the scientific literature and magazines of the prevailing period, his bewilderment would grow. Seemingly he would not find the slightest indication of just what instruments and apparatus were the best ones or the ones most commonly used in the dark ages of 1920. If he were to go back for a similar period, and were to try to chronicle the history of the electric telegraph and telephone, he would find no such difficulty. He would immediately find that even in the early stages, the telegraph and the telephone had been standardized at least for each prevailing country, and it would not be difficult for him to find out which telegraph and telephone instruments were the best ones or the standard type of the prevailing periods.

In radio telegraphy and telephony, he would find a very amazing state of affairs. Not only for the year 1920 but for any period since the beginning of the art. If he were to study the subject at all, he would for instance, find out that in the year 1920, the radio enthusiasts of that day were using many different forms of aerials. He would find aerials strung on top of the roofs, he would find aerials buried in the ground, and he would find aerials under water, as well as concentrated or loop aerials operated indoors. Our historian would have considerable trouble to find out just what aerial was the standard for the period of 1920 as well as which type was the most efficient. Most probably he could never solve the mystery.

Next, he would turn his attention toward detectors. Here he would find no doubt, that the vacuum tube led all the others, but that crystal detectors, electrolytic detectors and many others still were being used by the thousands. Surely, there should be one type as a standard or one type that was the best! But, our historian would not be able to find it.

The same would be the case with tuning coils, loose couplers, honeycomb coils and kindred instruments. Turning to sending instruments, he would find that we were using spark coils, transformer coils, arcs, transformers, vacuum tubes, and high power buzzers, all of these being used for transmitting purposes.

In looking back a few years before 1920, he would find all the amateur instruments scattered over the table, while two years later would find the same amateur with all his instruments enclosed in cases or mounted on panels.

In perusing the literature of this glorious period, our historian will no doubt come to the conclusion that the entire radio tribe of the time was either addle-brained or did not know its business, otherwise why have so many styles, so many different sorts of instrumuents, when one should be theoretically the best, and naturally should be adopted by the entire radio fraternity.

To our way of thinking today, such reasoning seems preposterous, but to the expert a hundred years hence, *our* reasoning will appear not only preposterous, but infantile.

And the moral of this editorial? It is simply this: the radio art of today is similar to the millinery business. Every season brings forth a new and very interesting crop of womans' hats in all sorts of different shapes, sizes, colors, etc., no attempt being made to standardize the woman's hat as for instance the man's hat. The result is that the average woman's hat costs three or four times as much as the man's hat, for the simple reason that no attempt has been made toward standardization.

We are certain that the next few years will see a great change of heart on the side of the manufacturers building radio instruments. They will find out that it does not pay to change styles and types overnight because, they themselves are the losers. Five out of ten radio manufacturers in the past have become insolvent for the simple reason that they had too many styles of the same instrument, when one or two would have sufficed. No manufacturer can put out a new instrument without expending several hundred or thousand dollars in tools, dies, parts, raw materials, etc. The minute he attempts to bring out too many styles he competes with himself, and invariably a great many thousand dollars expended in such tools, raw materials, etc., are left on his hands because the particular instrument will sell no longer and the tools and parts become worthless junk. If the manufacturer were getting a large price for his radio goods he could afford to stand the loss. In the millinery business for instance, a high price is charged and assessed on the hats that sell, and at the end of the season the few "stickers" that are left on the shelves can be sold at ridiculous prices because they already had been paid for in the good sellers.

In the radio business, this is not the case, and that is the main reason why the business is not healthy, why amateurs cannot get goods when they want them, and why so many radio concerns go out of business. If the average amateur could see the grave-yards of dis-continued radio apparatus parts in the average manufacturer's shop, he would appreciate the fact that a standardization of all radio apparatus is in order. As long as manufacturers persist in turning out too many styles and types, prices on radio instruments will be very high and will go much higher than they are now, and in the end the amateur must foot the bill. Besides the radio business in general will not be healthy. The blame, of course, does not lie with the amateur, but rather with the manufacturers. The amateur simply buys what is offered and shapes his idea from the various instruments that he sees offered for sale. In connection with this, it should be noted that the few manufacturers who prospered are almost exclusively those that do not make a wide and variegated line of radio apparatus, but are suppliers of a few well selected items on which they are constantly making improvements.

H. GERNSBACK.

THURSDAY, JULY 1, 2021

Summer Reading for Homebrewers: Frank Jones and the FMLA by Michael Hopkins AB5L (SK)

Frank Jones W6AJF (SK)

I read these stories when they were first coming out and I really liked them. Here are all the FMLA episodes. Don't try to read them all in one sitting. Spread them out. Savor them. Think about the message that Frank was sending us.

All of the FMLA episodes: https://tomfhome.files.wordpress.com/2019/12/frank_and_the_fmla.pdf

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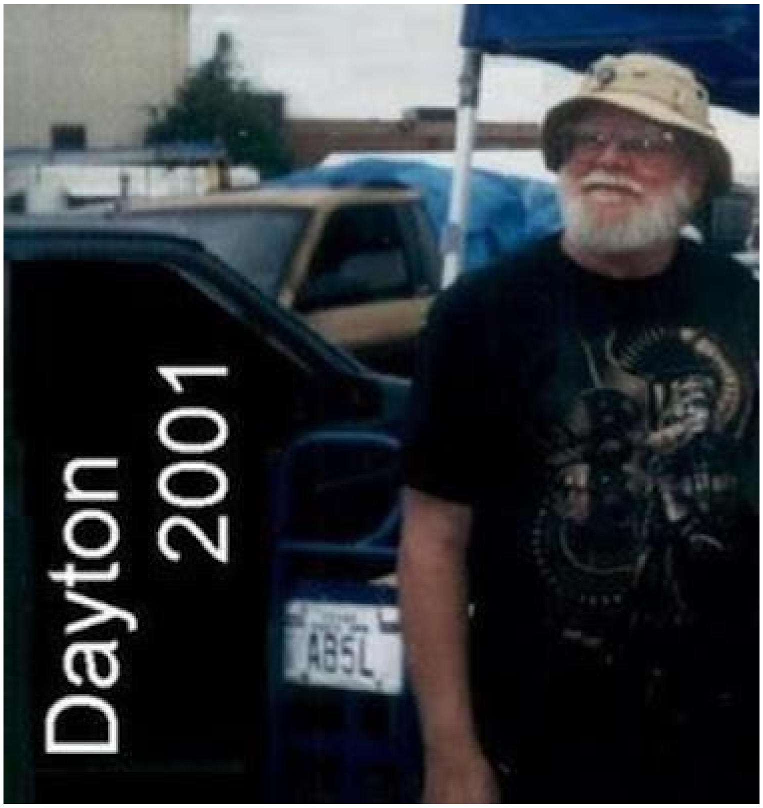
Related articles, books and links:

Frank's obit: https://www.pressdemocrat.com/article/news/frank-jones/

Frank's book "5 Meter Telephony": https://w5jgv.com/downloads/5-Meter%20Radiotelephony%20by%20Frank%20Jones.pdf

Frank's 1937 Antenna Handbook: http://rfcec.com/RFCEC/Section-3%20-%20Fundamentals%20of%20RF%20Communication-Electronics/23%20-%20RADIO%20ENGINEERING%20DATA/1937%20-%20Jones%20Antenna%20Handbook%20(By%20Frank%20C.%20Jones).pdf

About the author, Michael Hopkins
AB5L: https://www.rantechnology.com/index.cfm?key=view_resource&TransKey=615604E8-9DAA-40A3-9E48-4160806D893D&CategoryID=8E884CE4-9CED-4957-872B-5EBDB058D540&Small=1

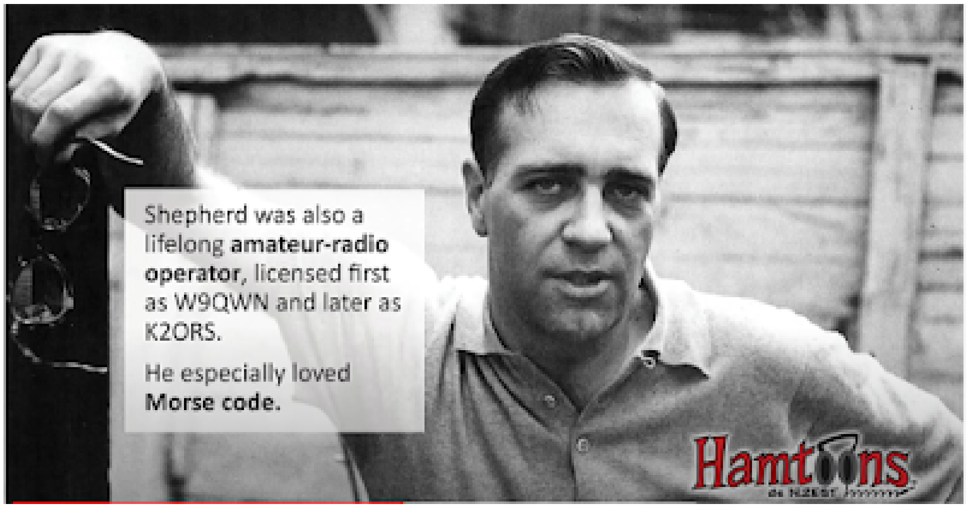


SU

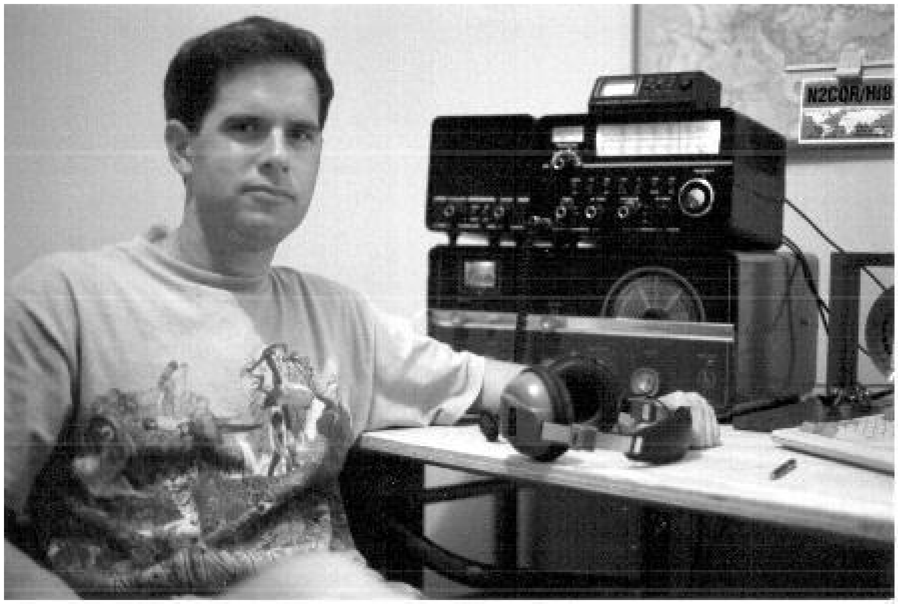

Pete Juliano N6QW


E. Howard Armstrong

George Dobbs G3RJV



ABOUT THE AUTHOR



The author in 1994 in the Dominican Republic

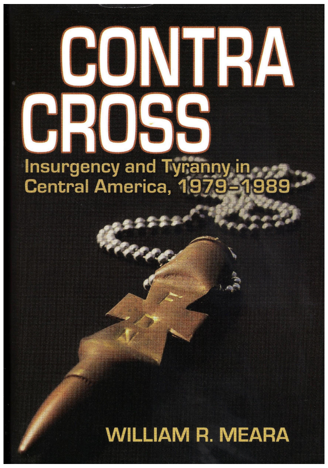
The author in 2024 in the Dominican Republic

Bill Meara has been melting solder and throwing antenna wires up into trees since he was twelve years-old. Because of his day job (before retirement he was a U.S. diplomat), he lived and worked in Central America, the Dominican Republic, Spain, Portugal (The Azores), the United Kingdom, and Italy.

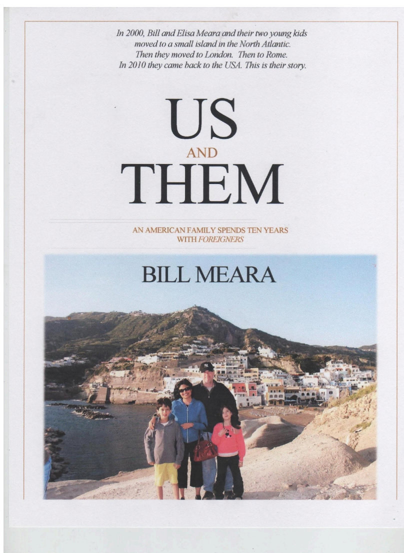
He is the host of the SolderSmoke podcast (www.soldersmoke.com), and he blogs at SolderSmoke Daily News (soldersmoke.blogspot.com). He has published numerous articles in amateur radio magazines, and is the author of the non-fiction book "*Contra Cross*" which was published in 2006 by Naval Institute Press.

He lives in Virginia and in the Dominican Republic with his wife Elisa. His e-mail address is bill.meara@gmail.com

Also by Bill Meara…



http://contracross.com



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