N.E.W.S. LETTER

The Publication of the North East Weak Signal Group

MAY 2002 VOLUME TEN ISSUE THREE

President: W1GHZ Paul Wade
V P: WA1MBA, Thomas Williams

CURRENT OFFICERS

Secretary: N1GJ George Jones
Treasurer: N1DPM Fred Stefanik

NEXT MEETING

OUR NEXT MEETING MAY 11TH
AT THE RADDISON HOTEL IN ENFIELD CONNECTICUT
DUCT TAPE AUCTION AND CONFERENCE PLANNING

IN THIS ISSUE

DON'T FORGET

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2 METER VHF AND ABOVE NET
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W1COT, K1UHF OR K1PXE NET CONTROL

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FROM THE PRESIDENT

May meeting
Our next meeting will be at the Radisson hotel in Enfield, CT on May 11th. I've heard a few new calls on the bands - invite these guys to the meeting if you talk to them.

Our program this month will be the one we didn't get to last month, accessories for the new Yaesu FT-817 portable transceiver. In addition to the one in last month's newsletter, I've put together a 222 MHz transverter for the FT-817, to cover the one band it was missing. I'll have the transverter to show, and possibly some PC boards to sell. You can get a preview at www.w1ghz.org/222xvtr/222.htm

If you've done anything interesting for the FT-817, bring it to the meeting.

Spring Sprints
Hope you didn't forget. There was some activity on 2 meters last week, and I'm looking forward to trying out the new transverter in the 222 Sprint. Don't forget to send in your scores.

VHF Conference and Microwave Update
The official announcement was in the NEWSletter, and at www.microwaveupdate.org . October will be here soon, and there is lots to be done. If we all pitch in and each do a small job, we can make this joint conference a success without overburdening anyone.

Matt, KB1VC, has volunteered as chairperson for Microwave Update, and Bruce, N2LIV, will again chair the Eastern VHF/UHF Conference.

At the meeting, we will try and pin down some of the volunteer opportunities.

Duct Tape Auction
Another duct tape auction, another opportunity to find a new home for some treasures, so tape two items together (one good, the other, uh, interesting) and bring them to the meeting. Someone will be unable to resist one of them!

N.E.W.S. webpage
The NEWS group now has its own domain, with a new URL for the club webpage: www.newsvhf.com Ron is doing a great job as webmaster, so check it out. I love the scrolling banner with the next meeting date.

Paul W1GHZ

SECRETARY'S REPORT OF THE NEWS BOARD MEETING OF 9 MARCH 2002.

The NEWS Board Meeting was called to order by President Paul Wade, W1GHZ, at 11:45 AM. The first item for discussion was the delivery of the NEWS Letter. Apparently there are still some problems with getting out the NEWS Letter on time to the appropriate members. The subject of commercial ads in ther NEWS Letter is also on the table. We need the NEWS Letter Editor, Del, K1UHF, in on any changes. More discussion will be held at the full membership meeting.

A request for volunteers to work on the joint Microwave Update/Eastern VHF Conference was put out by Matt, KB1VC. A sign-up sheet will be circulated at the main meeting.

Ron, WZ1V, will discuss the results of the ARRL January VHF Contest.

We need to contact the Hotel about our needs for the Conference in October. The Secretary, N1GJ, will send a letter to the Hotel, reminding them of our regular meetings in May and November and our needs for those meetings. The Secretary will contact Bruce, N2LIV, about who to contact at the Hotel.

The subject of speakers for the VHF portion of the New England ARRL Convention was brought up. Lew Collins, W1GXT, is coordinating this for the Convention Committee. We need to determine who will speak at the Convention and let Lew know.

We need publicity for Microwave Update. Matt, KB1VC, and Bruce, N2LIV, will contact the ARRL about getting out the word. NEWS will also arrange to hand out flyers on Microwave Update at the ARRL Convention in August.

K1KI of the ARRL, and a member of NEWS, requested a list of NEWS members and their info. We need a club policy on this- it will be brought up to the full membership. Phone numbers and e-mail addresses seem to generate the most concern.

The Board meeting was adjourned at 12:11 PM.

SECRETARY'S REPORT OF THE NEWS MEETING OF 9 MARCH 2002.

The March meeting of the NEWS Group was called to order by President Paul Wade, W1GHZ at 1:11 PM. A discussion of the delivery of the NEWS Letter followed. Several problems popped up during the past few weeks. Anyone can get current copies of the NEWS Letter from the Del, K1UHF, web site. Art, W1RZF, will contact another club in the area, the Yankee Clipper Contest Club, about how they handle getting out news letters to their members. For now, we will continue to mail out copies to those who request it. Send requests to Tom, WA1MBA. We will have a final solution presented at the May meeting. Commercial ads are not now a problem, as long as the NEWS Letter remains at 10 pages or less. We also need a new way of indicating who is paid up dues-wise.

After discussion of the subject, it was voted by the membership, to send out membership lists containing only name, call and local address. This is the new NEWS policy.

The July meeting of NEWS will again be held at the Knights of Columbus Picnic Ground in Enfield, CT. Tom, W1NWE, will contact the Knights about reserving their grounds for our meeting on 20 July.

The latest copy of the SETI League newsletter was passed around to any NEWS Group members who were interested.

The New England ARRL Convention coming up in August, at Boxboro, MA, was mentioned. We will have some sort of talk on VHF/UHF. We need to get with Lew, W1GXT, to determine time and place, etc. We will use this opportunity to publicize the Microwave Update/Eastern VHF Conference scheduled for late October.

In a follow-up to last time, Art, W1RZF, again asked for club support of his on-going effort to increase activity on the VHF, UHF and Microwave bands. We need more random CQing in the evenings. Next time you tune across the band and hear nothing, give out with a CQ.

The new 10 GHz repeater in Western Massachusetts is on the air. Look for it around 10368.220-10368.250 MHz. It is located in FN 32 lm.

The joint Microwave Update/Eastern VHF Conference planned for 24 to 27 October 2002, was discussed. Matt, KB1VC, passed around a sign-up sheet for volunteers to handle the many jobs associated with such an undertaking. When you read this, think about what you can do to help. See Matt. He can always use more help. There will be six paper sessions-2 on Friday and 4 on Saturday.

Ron, Wz1V, gave a report on and led a discussion of the 2002 ARRL January VHF Contest. It looks like we did not finish on top nationally. We need all NEWS member to get on as best they can and submit scores to the League in this annual event. Ron collected names and scores of those who worked the contest but were not yet on his list. NEWS is on record as NOT agreeing with recent changes in the rules put out by the League.

Just before the break, a Duct-Tape Auction was held. It was ably run be our President Paul Wade, W1GHZ, broken foot and all! The usual good-humored comments were made about the quality of the items put up for bid. A fair number of dollars changed hands.

After the break, the main speaker of the day, Al Greenwood, N1EUX, gave a talk on operating small privately owned power generating stations. Al showed a video tape of this three stations in operation. The talk was well received.

The meeting was adjourned at 3:45 PM.

JANUARY VHF SS CLUB COMPETITION WRAP-UP

With the receipt of the latest RVHFG Journal, the unofficial word is now out:

Rochester VHF Group: 35 logs totaling 2,369,441.
Highest scoring club, Medium Category winner.

Mount Airy VHF Radio Club (Pack Rats) 51 logs totaling 2,110,469. Unlimited Category winner.

North East Weak Signal Group: 20 logs totaling 1,412,613.

Obviously, the RVHFG has made a huge comeback. How did they accumulate such a big score? 2 Multi-multis, 400K and 660K. 1 SO over 200K. 4 Rovers 100K or over!

By comparison, the Packrats had 2 Multi-multis 320K and 165K. 4 SO's over 100K, and dozens of smaller scores.

We had no Multis, 7 SO's approximately 100K or over, and the smallest number of logs in our history! Enjoy last years' gavel, it may be our very last - it's entirely up to you, all of you! Now would be a good time to start planning how you will improve your station for next years' competition.
You say your station is already optimum? Then think of how you can assist a fellow club member to make improvements or just plain participate!

73 es GL, Ron WZ1V

A 222 MHZ TRANSVERTER FOR THE YAESU FT-817

Paul Wade W1GHZ ©2002

When the Yaesu FT-817 was introduced last year, it seemed like an ideal IF rig for portable microwave transverters. I couldn't resist! After playing with my new toy for a while, I said, "the only thing missing is 222 MHz." After the mountains closed for winter, I started thinking about fixing this deficiency.

An ideal accessory should have the same features that make the FT-817 so attractive: good performance in a small, light package requiring only modest power. An ideal location for a transverter would be inside the battery compartment, but the FT-817 uses AA-cells rather than the C-cells found in older generations of portable transceivers, so there just isn't enough space. However, I was able to pack the 222 MHz transverter shown in Figure 1 in a small case that sits on top of the transceiver. It provides performance similar to all the other bands, and even bandswitches automatically with the radio.

Description

One of my projects the previous winter was a "Miniverter" - a bare-bones printed-circuit transverter for 144 MHz. My intent was to install these inside small 10-meter transceivers to make microwave IF rigs. Then I was seduced by the FT-817 - but the Miniverter became the start of a 222 MHz transverter.

A minimal transverter like the Miniverter consists of a mixer, also called a "frequency changer," a local oscillator (LO) to mix with the RF and IF frequencies to produce the sum or difference frequencies, filters to select the desired output frequency, and amplifiers. The local oscillator is usually the hardest part: mixers, helical filters, and MMIC amplifiers are inexpensive and readily available.

The local oscillator must stable and have low phase noise, so a crystal oscillator is the most obvious solution. Good crystals have become more expensive and harder to find, except for frequencies used in computers - those are cheap and produced in high volumes. I looked through the Digi?Key catalog for DIP-packaged oscillators and found one usable for 222 MHz: 66 MHz, times three, is a perfect LO for a 12 meter (24 MHz) IF.

The next problem is multiplying the frequency times three. A frequency tripler is usually touchy and inefficient. After some thought, I realized it is also unnecessary; the packaged oscillators have a square-wave output, and a square wave has lots of third-harmonic content. Separating out the third harmonic and amplifying it with an MMIC will probably produce more output than using the same MMIC as a frequency tripler.

Since the frequencies are widely spaced, a simple diplexer is sufficient to separate out the third harmonic frequency, 198 MHz, from the fundamental crystal frequency, 66 MHz. I sketched out a simple circuit, built a dead-bug style breadboard, and fiddled with values for best results. The final circuit is shown in the schematic, Figure 2. The packaged oscillator is intended to drive logic, equivalent to a

load of several hundred ohms, while an MMIC amplifier input is closer to 50 ohms, so a series resistor, R20, provides a better load for the oscillator. A series resonant circuit, L5 and C3, is a short circuit at 66 MHz, so the fundamental output is dissipated in R20. At the same time, L5 and C3 form an inductive combination at 198 MHz: in combination with C4, the result is an impedance step-down transformer which also forms a high-pass filter. At the output of the MMIC amplifier, A5, an output of several milliwatts at 198 MHz is available, with other frequencies at least 10 dB down. After the helical filter, FL1, and another amplifier, A6, an LO level of perhaps +12 dBm is supplied to the mixer. All the other oscillator harmonics are at least 60 dB down, as shown in Figure 3.

The packaged oscillators don't have any provision for frequency adjustment, but they are cheap. I placed two orders for four pieces, and each group had two that came within 1 KHz of 198.000 MHz. They do seem to be quite stable, settling down after a short warmup and staying put, which is what really counts.

RF circuit

The 222 MHz output from the mixer passes through a three-resonator helical filter, FL2, to eliminate the other mixing products; the receive path passes through the same filter to eliminate out-of-band signals. A 3-dB pad made up of chip resistors between mixer and filter allows each to work into a reasonable impedance match, which makes the performance of each much more predictable.

Transmit circuit

In transmit, the clean signal coming out of the helical filter is amplified by two MMIC stages to get the power level high enough, +13 dBm, to drive a power amplifier module, A7. I chose a 5 watt module, the Mitsubishi M67723, as a good complement to the FT-817 - a higher power module requires much more current and heat-sinking, increasing size and weight.

Finally, the output passes through a low-pass filter to reduce harmonic content. The design is right out of the tables in the ARRL Handbook, and works just like the book - see the measured response in Figure 4. The Handbook suggests that some amplifiers are less stable with capacitor-input filter, so I took the hint and used the inductor-input topology.

Receive circuit

I chose to use an MMIC front end for simplicity rather than a GaAsfet for ultimate noise figure. The noise figure is still better than most transceivers. A tuned circuit at the front end provides reasonable rejection but not enough for an RF-polluted mountaintop - real filters are required for these locations.

The receive gain, with two MMIC stages, is just high enough to overcome losses in the mixer and IF switch. More important is the dynamic range; the second-stage MMIC and the high-level mixer were chosen so that the dynamic range is limited by the FT-817 and not the transverter.

IF interface

The IF interface is tailored to match the FT-817, which has two output jacks, selectable by band. I prefer to connect the transverter to the rear jack and use the front jack for other VHF and UHF bands. A band-selection voltage is available on the rear accessory jack of the FT-817; this voltage is used by connected to the transverter so that it will only transmit when tuned to the IF band, 12 meters.

On the web, I found a nice band-detect circuit by K6XX (www.k6xx.com) Since only one band, 12 meters, is needed, I reduced it to a simple comparator, an LM393 dual-comparator IC, U4. (Actually, all bands below 10 meters are detected - this is intended for VHF+ operation.) The other half of the comparator is used for the PTT line from the accessory jack, with diodes to provide the AND logic for band selection.

The comparator output drives a relay, which is the simplest way of switching voltages between transmit circuits and receive circuits. The voltages also activate PIN diode switching for the IF. The FT-817 is operated at the lowest standard power output level, 1/2 watt, but further power reduction is necessary before driving the mixer. At the 1/2 watt level, ordinary 1/4 watt resistors are adequate for an input attenuator: in this case, R1-5 make up a 13 dB attenuator for both transmit and receive. Further power reduction for transmit is provided by a variable attenuator consisting of R6, R7, and R8; R7 adjusts the maximum drive power. On receive, the variable attenuator is bypassed by the PIN diodes. A simple low-pass pi filter, C1, L2, and C2, keeps LO and RF frequencies out of the transceiver.

Voltage regulators

The FT-817 will operate with a rather low battery voltage, so the transverter has internal voltage regulation to allow operation over a wide range of voltage. Most of the circuit is supplied from an 8-volt three-terminal regulator IC, U2: the regulator needs 3 volts headroom, so operation is guaranteed down to 11 volts. At 11 volts, a "12 volt" battery is nearly dead.

The oscillator is powered from a 5-volt regulator, U1, running off the 8-volt regulator, so that the oscillator is doubly regulated for additional stability. A separate 5-volt regulator, U3, provides stable bias for the power amplifier: if it were not separately regulated, the change in current on transmit would change the oscillator frequency slightly. Three-terminal regulators are small and cheap enough to use duplicates and avoid problems.

Printed-circuit board

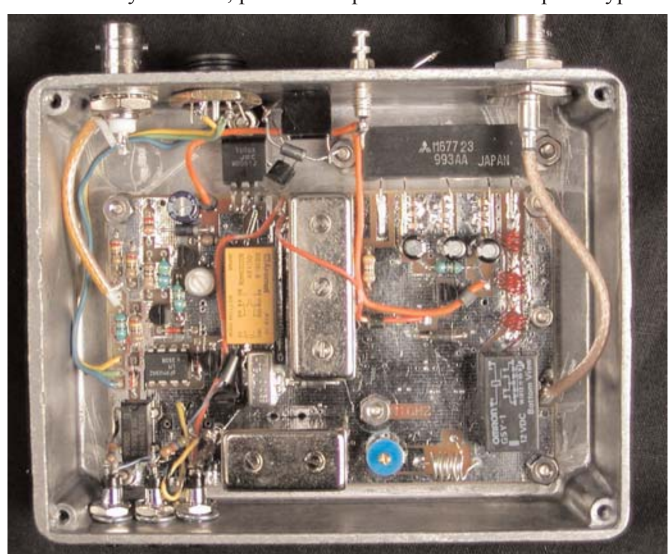
If you are only making one of something, a printed circuit board isn't necessary. A hand-cut board or dead-bug construction will do just fine -but making more than one gets awfully tedious. I'd prefer to spend the time doing a good printed-circuit layout to make assembly easy. Finally, if you are making something neat, others will want to copy it - every FT-817 owner I know wishes that Yaesu had included 222 MHz.

One of the things I experimented with in building the Miniverter was a printed-circuit service from ExpressPCB. They provide free PCB layout software (download from www.expresspcb.com) that is quite easy to learn and use. When the PCB layout is complete the layout, the data is uploaded to their website. For $59, four days later you receive three finished printed circuit boards - not a bad deal. The boards are high quality double-sided boards with plated-through holes and tinned finish for easy soldering; you can't make these in the basement.

One of the ExpressPCB limits is that the board size is exactly 3.8 x 2.5 inches - or the price is much higher. A board this size, in a metal box with room for a comfortable fit, seems appropriate for the FT-817. Clearly, I had to fit the transverter in this board area. I sketched a block diagram, marked the board outline on a sheet of paper and shuffled the large components around. There wasn't a whole lot of room left over. The small components would have to be chip components on the bottom side - an approach that worked well for the Miniverter, where I managed to fit two transverters in the same standard board outline.

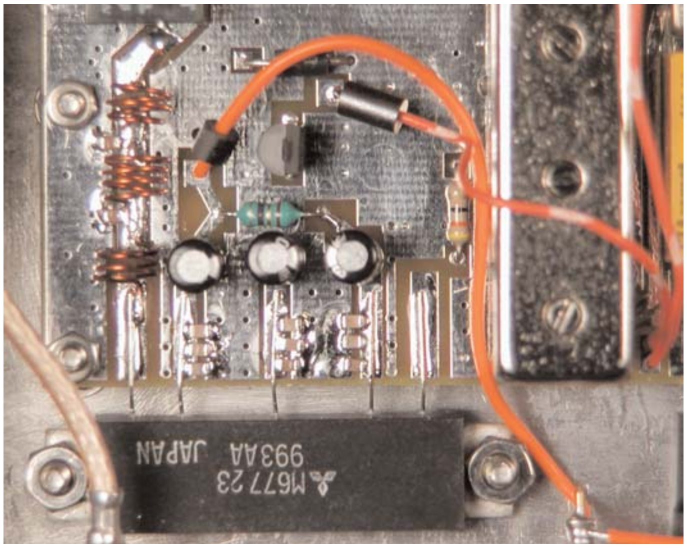
Looking at the top view of the board in Figure 5, the main helical filter, FL2, is placed as a barrier between the RF side of the board and the IF and LO sections. The isolation helps to reduce "birdies." The lower-frequency side is crammed fairly tight to preserve as much space as possible on the higher-frequency side, since most of the gain is at 222 MHz. High gain with tight spacing is a recipe for instability.

The other key to stable, predictable performance is adequate bypass-



ing. The schematic diagram includes not only plenty of capacitors, but also different values at different frequencies - the values are chosen for operation just below the self-resonant frequency of each capacitor. The power amplifier, A7, is bypassed for a wide frequency range, shown in the detail photo in Figure 6, since bipolar transistor amplifiers are prone to oscillate at low frequencies. Chip capacitors are small enough to use freely, and inexpensive enough, perhaps a nickel each in small quantities, to use by the dozen.

Construction



All of the essential components are mounted on the printed circuit board. The two that require heat sinking, A7 and U2, attach along one edge so that they may be bolted to the box (a dab of heat-sink compound doesn't hurt). Figure 5 is a photograph of the complete assembly. The die-cast aluminum box I used has some raised text and mold marks on the bottom, so the surface isn't flat enough. There are two ways to fit the board in - one of them avoids the raised text. However, the power amplifier module, A7, needs a flat mounting surface, and it lands on one of the mold marks. I flattened the area by scraping off the raised metal with a deburring tool, then wrapping some sandpaper around a small flat block and sanding the area flat. The die-cast metal is soft enough that it isn't a big job.

The top of the printed circuit board can be seen in Figure 5. Component placement diagrams from the ExpressPCB software are shown in Figure 7 for the topside and Figure 8 for the bottom side. Figure 9 is a photograph of the bottom side assembly with all the chip components.

Additional closeup photos of the assembly might help with construction: the LO section in Figure 10, the receive section in Figure 11, and the IF and switching area in Figure 12. A back view of the transverter with the cover open is shown in Figure 13. Digital cameras sure make this easy!

A parts list spreadsheet is shown in Figure 14, with Digi-Key part numbers where appropriate. This is a do-it-yourself kit.

The local oscillator should be assembled first and aligned, along with the voltage regulators U1 and U2 (heat sinking is not necessary for just the LO), but not the mixer. The key adjustment is to retune FL1 to 198 MHz, since standard Toko filters are only available for 187 or 192 MHz. A coax connector is temporarily attached near the mixer pins to measure the LO output, and the two tuning screws on top of FL1 are adjusted for maximum output. Turning the screws clockwise increases the frequency; at least two full revolutions of each screw will be required to reach 198 MHz.

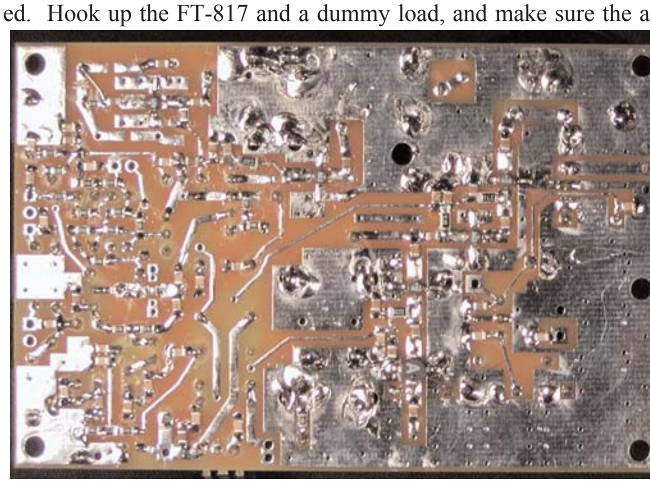
After the LO is aligned, the rest of the board may be assembled. I like to test the board before final assembly into the box, looking for transmit output (>+10 dBm) at the A7 input pin connection, and applying a signal generator to the antenna connection for receive testing to peak C5. A printed-circuit mount SMA connector will slip on both of the above test points without soldering. Also, see that R7 will vary the transmit output but not the receive.

Try to test everything possible before final assembly, while both sides of the board are still accessible. The band detect input should operate and turn on the yellow LED when the input voltage is below about 2.9 volts, and not at higher voltage. Grounding the PTT input should only activate the relay when the yellow LED is on. Finally, trim all the component leads on the bottom side and go over everything one last time checking for shorts.

The printed circuit board is mounted to the box with six 4-40 screws through the big holes in the board. The board must be spaced high enough to provide clearance for bottom-side components, but low enough so that the power amplifier leads are short. A flat washer and a hex nut seem to be the right combination; the washer is against the box. Then the board is held down with more hex nuts; at least two locations need small-pattern nuts to clear the components.

Adjustment

After assembly into the box, the transmit attenuator must be adjusted. Hook up the FT-817 and a dummy load, and make sure the all



the switching works right - using the mike button in CW mode will switch to transmit with no output power. Turn R7 fully counterclockwise, then adjust the FT-817 for low power at 24.9 MHz CW. Key the transverter and turn up R7 for maximum output; probably greater than 6 or 7 watts. Adjust R7 for 5 watts out and linearity will be good. Another adjustment is to peak FL2 at this frequency, so that the bandpass will cover the whole band. Then readjust R7 for 5 watts output again. Finally, C5 may be adjusted while receiving a weak signal, or adjusted for best noise figure if possible.

Performance

The transmitter output is set for 5 watts, to match the other bands on the FT?817. The output spectrum, shown in Figure 15, is pretty clean - the LO is 45 dB down, and other spurs are lower. The second harmonic is 50 dB down and higher harmonics are more than 70 dB down. At this power output, total current for the radio plus transverter is around 2 amps, which is reasonable for battery operation, and close to the current for the FT-817 alone at 5 watts output on other bands. On receive, the transverter draws about ¼ amp. While I haven't measured the noise figure, weak-signal sensitivity seems very close to a Down East Microwave transverter with GaAsFET front end.

Frequency stability is excellent after warmup. There is no frequency adjustment, it is where it is and stays there. Audio reports on sideband are good.

Of course, if you want this transverter to cover the whole 222 MHz band, the FT-817 must be modified to transmit on all frequencies. See www.mods.dk for details.

Comparison

I believe that there is only one transverter available today for 222 MHz with good performance, from Down East Microwave - a high-performance unit. I built a kit for my home station and am very pleased with it. I also borrowed some ideas to incorporate in this transverter, but elected to make some tradeoffs. Here is a quick comparison:

Power - the DEMI unit output power is 25 watts or more, and needs a hefty heat sink as a result. I chose to keep the power to 5 watts, and the metal box with no heat sink only warms up slightly. Current drain is also much lower.

Filtering - the DEMI unit has an additional helical filter before the power amplifier to further reduce spurs. Probably more important at the higher power level. It didn't fit on the smaller board. I also reduced the output low-pass filter from 4 sections to 3, losing a few dB of harmonic reduction.

Receiver - the DEMI unit has a GaAsFET front end, so the noise figure is a couple of dB lower. Making a stable GaAsFET amplifier with self-biasing can be tricky, so I went for a simple, reliable MAR-6. Good enough for a low-power station.

IF interface - the DEMI unit devotes a lot of board space to a universal IF interface so that it can be used with any radio ever made. This one is tailored to the FT-817. To use it with another rig (say, inside an Elenco K2), modify the board design.

Local oscillator - the DEMI unit uses a relatively expensive crystal, with a trimmer to set it right on frequency (until it ages). I used a cheap computer oscillator for simplicity and compactness. If this is the only transverter with a 12-meter IF, just put the frequency that hits 222.100 MHz in a memory and you'll always be right on.

Conclusion

This transverter adds the missing link to the FT-817, adding 222 MHz with performance comparable to other bands. Now a backpacker or rover can have all the VHF and UHF bands and still travel light.

Editor's Note: Due to space limitations all the pictures do not appear here in the NEWSletter. See http://www.w1ghz.org/222xvtr/222.htm for full details.

AN AUDIO TONE INDICATOR FOR TUNING OR ANTENNA MEASURING

Paul Wade W1GHZ ©2002

While measuring antennas years ago, we found that it is difficult to point a large antenna and watch a meter simultaneously. I eventually made a box which converted the meter output into an audio tone whose frequency was proportional to the meter reading. This allowed peaking by ear, listening for the highest pitch. It worked very well, for all except a few tone-deaf individuals.

Last year, I was "snowflake" tuning a surplus microwave amplifier, sliding tiny bits of metal around the circuit to retune it to 10 GHz. Here again, it was hard to watch the meter while looking through a microscope to move the flakes. It occurred to me that the audio tuning box might help - but I couldn't find it. Since I have passed on the antenna measuring fun and equipment on to others, the box probably went along. I continued trying to tune the amplifier, but finally slipped while I was looking at the meter and let the smoke out.

It was time to build a new audio tuning box. I found the schematic in an old notebook, dated 1977. The integrated circuits I used are still available 25 years later, but are better ones available now? Not really, unless we are trying to do something fancier, like a computer interface. For a simple circuit, the old stuff is fine.

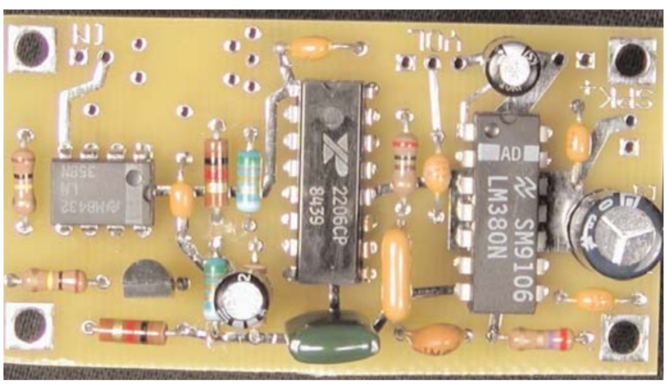
I found data sheets on the web for the parts and made a few improvements to the circuit - I have learned a few things in the intervening years. The major improvement is a heftier audio amplifier. The original amp was in an 8-pin DIP package and would fail after a few hours at full volume in the hot sun. A 16-pin DIP package version has several pins for heat-sinking to the PC board and a higher power rating. The schematic diagram is shown in Figure 1.

The heart of the circuit is the U2, the XR2206 waveform generator. The output is a nice sine wave, with frequency set by C2. The charging current for C2 is controlled through pin 7, which we vary to change the frequency. An op-amp, U1a, and a transistor, Q1, translate the input voltage to a current through R3 of one milliamp per volt. R4 provides a small leakage current to set the minimum frequency, since we can't hear zero. Resistor R7 sets the output AC from U2 to a voltage that won't overdrive U3, the audio amplifier, though it distorts a bit at max volume. R9 adjusts the volume, and C6 rolls off the highs - the best value depends on the speaker. R10 and C9 keep the audio amp from oscillating at dog-whistle frequencies, but the resistance isn't too critical if you can't find the exact value. The other half of U1 is available for experimenting; possible uses might be a peak indicator, or expanding part of a meter range for fine tuning.

Since I've promised this circuit to a number of hams over the years, but never had an extra PC board, it was time to do a new layout. I recently used the ExpressPCB free software and quick prototype service (www.expresspcb.com) to make PC boards for the "Miniverter1," a bare-bones transverter. The circuit in Figure 1 is pretty simple, so the layout on a double-sided board isn't hard. All the components are on the top and the signal wiring on the bottom, except for a couple of short crossovers. The common ground wiring is on top, allowing direct connection with no ground loops - a good idea for RF or audio. The board layout and assembly diagram is shown in Figure 2; only about a third of the standard size board is required. Since the minimum order is three standard-size boards, it makes sense to use the whole board area, either for multiple copies of this circuit or for some other circuit. See the "Free software" section for some hints.

Construction is simple, with no tiny parts or surface-mount assembly. Just stick the leads through the holes and solder them in. The completed board is shown in Figure 3, and a complete unit in a box is shown in Figure 4.

The final adjustment depends on the input. Many surplus test instruments have an output of 0 to 1 Volt for a chart recorder, while older tube instruments might have a 10-volt output. The 100K pot at the input is adjusted to provide a good pitch for a full-scale reading on the test meter, so that the output goes from a low growl at zero reading to that pitch at full scale, allowing peaking by ear.



Free Software

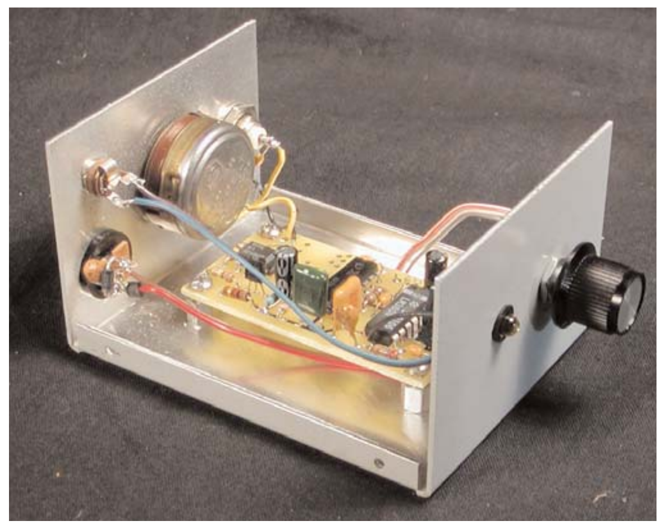
Design software used to be expensive and hard to use. This project was completed using only free software, downloaded from the Internet and run on a PC. All the files I generated are available at www.w1ghz.org/tonemeter.zip, and you may modify them as you please.

The schematic, tonemeter.asc, was generated using SwitcherCAD III software from www.linear?tech.com, a circuit simulation tool. I also used the software to simulate operation of the voltage-to-current converter. This file is v_to_i.asc; just load it and click the run button to see it go. Play with the software to modify the schematic, add parts, and move them around.

The PC layout used the ExpressPCB software mentioned above. The completed layout file is tonemeter.pcb; open it with the software and it pops up on the screen, with the bottom side in green, the top in red, and the parts in yellow. Play with it: select a part and slide it around - the wiring follows. Add parts, modify the wiring, cut-and-paste the whole circuit to make multiple copies. If you make a mistake, just Undo.

When the board is complete and triple-checked, pull down the "Layout" menu and click on "Order Boards Via the Internet." They will arrive in four days!

The tonemeter circuit only fills a small part of the area. To fill it up, I added other patterns - in this case, four small boards to mount Anderson Powerpole connectors inside my projects for DC power connections, to match the connectors on the "RIGrunner" (www.westmountainradio.com). The combo layout is in the tone_ppole.pcb file.



Summary

We have described a quick-and-easy project that is not only useful, but demonstrates what we can accomplish with free design software. Even if you don't build it one, play with the software and see what you could design.

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