

Letters to the Editor

A Direct-Reading Reflection Coefficient and Power Meter (Nov/Dec 2007)

There are several errors in my article, and several items need clarification. I apologize for the number of errors, and thank Bob Kopski, K3NHI, for pointing out most of them.

In the subtitle, delete the words “piece of,” so it reads “This easy to construct test instrument combines power measurement and reflection coefficient measurement capabilities.”

Bob Kopski’s call is given incorrectly in paragraph 2 of the Introduction. It should be K3NHI.

In the second paragraph under Construction, the references should be to the AD8307AR and AD8307AN.

Figure 1 is from Zack Lau’s *QST* article, with the original component numbering, which is not the same as the numbering of the corresponding components in Figure 2. In particular, R4 of Figure 1 corresponds to R1 of Figure 2.

The connector in the lower left corner of Figure 2 should be J2.

There are a number of corrections for Figure 3: The plus and minus signs in the two sections of U4 are reversed. [See Figure 1 in this Letters column for a corrected Figure 3. — Ed.] The wire from the wiper of R18 to pin 5 of U4 should not be connected to the 9 V dc wire it crosses. I mentioned in the text that the TLV2462CP

op amp specified for U4 is a legacy of an earlier design, and could be replaced by a JFET input op amp such as the TL082 if the input to Pin 5 of U4(B) is shifted to Pin 6 of U3. Another reason to make this change is that the TLV2462 is rated for a maximum supply voltage of only 6 V dc, and it needs to operate from the 9 V dc supply. The recommended DVM module has a very high input impedance and an internal input bias of approximately 5.8 V dc, so it needs the instrumentation amplifier U3 and the buffer U4(A) as a driver. Some DVMs on the market can live with a low common-mode voltage, and could be connected directly between the R18 wiper and S1, eliminating the need for U3 and U4(A).

John B. Murphy, K6ILN, wrote with a question about the URL listed for the DVM module. Somehow the initials and URL got transposed. The module is from Marlin P. Jones & Associates, Inc, and the URL should be www.mpja.com.

— 73, Ralph Gaze, W1RHG, 35 Linda Terrace, Portsmouth, RI 02871; rgaze@arrl.net

The Star-10 Transceiver (Nov/Dec 2007)

Dear Readers,

In the Nov/Dec 2007 issue we published Part 1 of an article by Cornell Drentea, KW7CD, “The Star-10 Transceiver.” This article generated an avalanche of correspondence — far more than I have seen on any other *QEX* article! I could easily fill the

entire Letters section of several issues with correspondence about this one article. There was a significant amount of correspondence expressing praise for the design effort and the introduction to the design of the Star-10, with the outstanding list of specifications presented in Part 1.

While many readers expressed their pleasure at reading about this exhaustive design and construction effort, some readers took issue with statements in the article. Regrettably, this led to copies of correspondence to the *QEX* Editor being posted on various Web sites and e-mail reflectors long before we had an opportunity to review or respond to the comments, let alone publish any discussion in this issue. Tempers flared and any opportunity for a technical discussion quickly disintegrated.

QEX, as our subtitle declares, is “A Forum for Communications Experimenters.” As such, we invite reasoned disagreements presented as technical discussions on the merits of a circuit, theory or idea. We will not, however, participate in attacks on character or debates about the extent of an author or reader’s technical understanding.

One longtime *QEX* subscriber and professional radio engineer wrote to say:

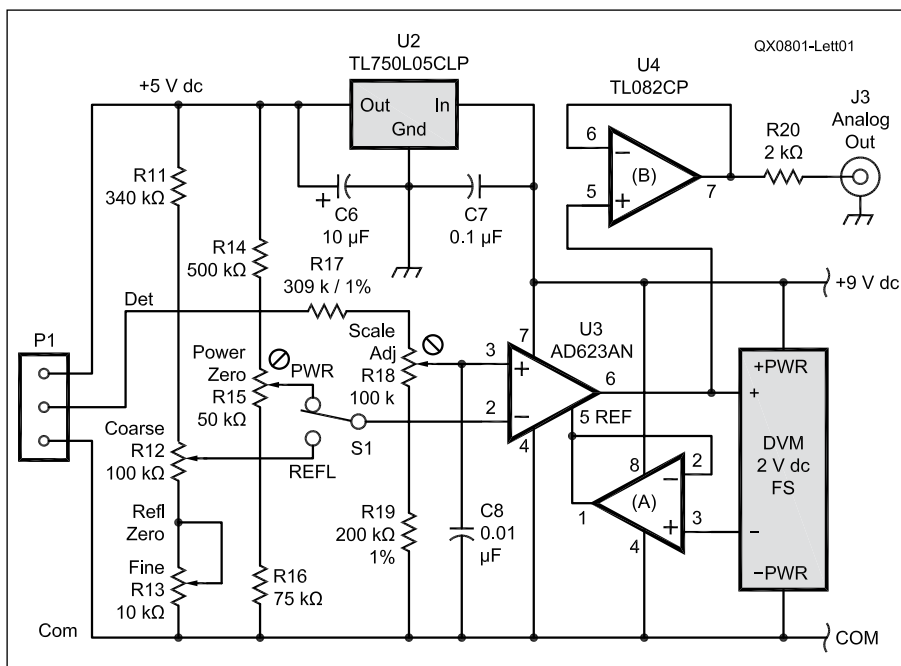
“There is nothing ‘so called’ about software defined radios, and nothing old-fashioned about the quadrature modulator and demodulator direct conversion designs used in many SDRs. ... (Even the most) anti-SDR person would be hard pressed to argue that the flexibility of SDRs is merely ‘perceived.’ Nor is there anything ‘controversial’ about their performance — performance can be measured.”

I will acknowledge that as Editor, I probably should have removed the paragraph that made those statements. I honestly don’t believe the author intended the comments as an attack on any person or group of radio enthusiasts, however, and no particular radio design or designer was mentioned in the original manuscript or the printed article.

Several points seemed to stand out as I reviewed the negative comments about this article. Some readers believe that:

- The article presented software defined radios in a negative light.
- The performance specifications made claims without any data to back them up.

There are several technical points here that may not be familiar to all *QEX* readers. Many articles could be written about the technical issues on both sides of these coins. We won’t take the space here to delve into detail, but would invite reasoned technical presentations on the topics.



There are a number of ways to describe software defined radios, or SDR. Some will argue that SDR really only describes a radio that converts an RF signal to baseband and then uses various digital signal processing techniques to manipulate the signal in software routines to demodulate the signal. Others would include a broader category of radio that uses traditional conversion to intermediate frequency stages, with DSP stages to filter or otherwise process the signals.

The article in the Nov/Dec 2007 issue was only Part 1 of a planned 3 Part article. Parts 2 and 3 go into quite a bit more detail about the circuitry as well as the performance measurements presented in Part 1. I believe many of the questions about performance claims will be answered when the remaining two parts are published in *QEX*. We had planned to publish Part 2 in this issue, but as I mentioned in Empirical Outlook, we were unable to complete the schematic diagrams in time for this issue, so you will have to wait until the Mar/Apr 2008 issue to read Part 2. Our intention is to follow that with Part 3 in the May/June 2008 issue.

— 73, Larry Wolfgang, WR1B, *QEX* Editor,
lwolfgang@arrl.org

Dear *QEX* Editor:

Congratulations on one of the finest transceiver designs I've ever seen; the *Star-10* transceiver. Cornell Drentea has created a classic, perhaps the most optimized application of existing state-of-the-art technology applied to superhet HF broadband design yet published. I only hope that commercial manufacturers of amateur HF transceivers take these specifications as a new performance standard.

I think this is a very well written, however abbreviated, article. I suspect that many (even advanced) readers will have difficulty with the spurious analysis. I understand Cornell's technique of spur analysis, but this might be news to many. Indeed, advanced spurious analysis, so critical in building broad-banded, multi-octave transceivers probably deserves a multi-part article unto itself!

To be fair, this is a very complex design, and the number of technologies converging at a very high level is a challenge for all but the most well-read radio designers. Indeed, I'm certain advanced radio designers worldwide will reference this article for decades to come. For my part, I needed clarification of several points from Cornell.

As far as dynamic range goes, it is clear that the *Star-10* is an outstanding radio. However, Cornell might have been a bit more particular with his specifications. Hopefully, this will become clearer in the subsequent parts. For instance, he specifies 500 Hz sensitivity at -136 dBm and quotes the NF at 15 dB. The noise power in

500 Hz at this NF would be -132 dBm, or 4 dB *higher* than the sensitivity specification. Cornell told me that the initial NF as calculated with his software and reported in Figure 3 was 15 dB for -132 dBm, but the NF with the preamp on is actually 11 dB, which should place the total noise at -136 dBm. That is the same as the sensitivity specification. Normally, sensitivity is taken to be at a 10 dB SINAD, or in this case, -126 dBm. Cornell also said that his IIP3 measurements were taken with the preamp on, so this -126 number can be taken as the basis of a crude DR (CP1/sensitivity), two-tone DR, and the composite DR. I hope Cornell clears this up in the subsequent installment, or at least in corrections and additions in *QEX*. Some simple classic calculations can be derived from Cornell's published specifications:

"Crude DR" — With a CP1 taken at about 10 dB below IIP3, we get $+35$ (-126), or a whopping 161 dB. Obviously this must include the action of the AGC, but it must be pointed out that his AGC does not affect the front end, so the DR of the preamp + mixer is indeed 161 dB! The preamp is outstanding to reflect only an 11 dB NF with that kind of IIP3. These numbers are not, in and of themselves unusual. The mixer alone, with a 15 dB NF and IIP3 of $+45$ dBm has a 500 Hz DR of 157 dB (assuming a CP1 of $+35$ dBm (IIP3 -10 dB)).

Two-tone DR is taken to be where the worst case third-order product equals 10 dB below the sensitivity. This is the point where the third-order product just begins to desensitize the receiver. IIP3 is $+45$ dBm, which implies a pair of input tones of at least -15 dBm. Therefore, the two-tone DR (defined for a 10 dB SNR) is -126 (-15) or about 111 dB. Again, this is outstanding.

Composite dynamic range as defined in part one of the article is stated as 150 dB, which must be measured directly since it involves the AGC action of the receiver. This number is quite reasonable, given the above specifications and proper AGC design.

Although the preamp specification is outstanding, it is quite believable. A mixer with $+45$ dBm IIP3 is also outstanding, but quite possible using $+27$ dBm LOs. Indeed these better IIP3/LO ratios are possible using FET-rings and resonant gate circuits. (I was part of the Siliconix team that designed the Si8901 in 1983. Ed Oxner, KB6QJ, then optimized the performance. (See "The Real Si8901 Story," *QST* Sep 1993, p 79.) Perhaps an interesting aside is the fact that our boss at Siliconix was Rudy Severns, N6LF, former editor of *QEX*! (It's a small world!) Another ham, Van Brolini, NS6N, was also directly involved with the Si8901 design. In retrospect, that was quite a group!

Cornell surprised me when he told me that his mixer used a Calogic High-Speed DMOS Quad FET Analog Switch Array, the SD5000. The Si8901 is simply the SD5000

quad analog DMOS switch reconfigured into a FET-ring mixer by using a new metal mask on the die. Our Si8901 design was as simple as that: a new metal mask on the quad SD5000 die. He also indicated that to insure the high dynamic range in the LNA, he used an adaptation of a Norton amplifier utilizing two high dynamic range CP-650 FETs in push-pull. The preamplifier, as well as other front end and first IF functions use class A devices and 24 V dc to facilitate the high dynamic range. Therefore, Cornell used the best combination of LNA and mixer technology to optimize front end NF and DR. There is nothing miraculous about these specifications. Indeed, high-end HF radios for decades have used the Si8901 to achieve >100 dB DR.

The dynamic range specifications are quite impressive. The LO synthesizer performance, however, is what catches the more discerning eye. Maintaining 25 dB SNR with a -110 dBm signal and a -20 dBm interference signal 5 kHz removed from the desired -110 dBm signal reflects world class synthesizer and filter design. Here, the interference signal is only 5 dB below the upper IIP3 DR. The fact that this is a general coverage radio (implying a far greater challenge in synthesizer design) makes these specifications all that more impressive. According to Cornell, laboratory details of the test configurations and conditions to support these outstanding specifications backed up by pictures of the phase noise as well as blocking dynamic range using world class equipment similar to that used in the ARRL labs will be presented in Parts 2 and 3.

I am looking forward to the second installment. Indeed, this may be the finest amateur HF radio ever built and I'm certain it will generate considerable attention.

— Sincerely, Robert J. Zavrel Jr, W7SX,
ARRL TA, Sr. RF Engineer; w7sx@aol.com

Dear *QEX* Editor:

Judging by some letters I received, there seems to be some misunderstanding about what composite linear dynamic range means.

As stated on page 9 in Part 1 of my article, composite linear dynamic range is defined as the ability to funnel a given large RF signal range into a final transducer without compressing the receiver and using multiple AGCs. This is a terminology used by some RF designers to characterize one particular kind of dynamic range.

Contrary to some beliefs, this kind of dynamic range is easy to measure. One simply measures the MDS, and with the AGCs on, finds the compression point of the entire system. AGCs keep the system out of compression to the highest point possible. This definition gives the 150 dB results as shown in Figure 3 of the article.

Of course, there are other kinds of dynamic range. They have been addressed separately in the specifications section of the article. Laboratory details of the test configurations, and conditions to support the specifications (which are actually the laboratory results), backed by pictures of the phase noise as well as blocking dynamic range results using equipment similar to that used in the ARRL laboratory, will be presented in Parts 2 and 3 of the article. All tests have been performed in the well equipped KG6NK laboratory.

Please note that phase noise plots (photographs) will show performance from 500 Hz to 20 kHz. This is because in CW work, we are interested in the very close in performance. A picture of all equipment used in the tests will be included in Part 3.

In addition, my MDS specification assumes a 0 dB SNR and not the more common 10 dB SINAD point. This is a matter of preference on my part, since with a good synthesizer, one can observe such signal well into the MDS, on a spectrum analyzer or an RMS voltmeter. As shown in Figure 3, the computer analysis gave an absolute MDS of -132 dBm or a 15 dB noise figure. In the final tests, however, the MDS was measured at -136 dBm after doing some tweaking. This resulted in an 11 dB noise figure (not 15 dB), which I forgot to change in reporting the specifications. I apologize for any inconvenience this might have caused.

The two tone dynamic range test was performed with 20 kHz tone spacing. A 2 kHz tone spacing test was not performed. A 5 kHz offset (or closer) blocking dynamic range (BDR) test was administered, however, and recorded using an HP-3561 dynamic signal analyzer. The results will be shown in Part 3 of the article.

I hope this answers the questions received. More detailed information will be included in the remainder of the article.

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Dear QEX Editor,

Cornell Drentea's article on his *Star 10* transceiver is a beast to assimilate, but after scanning it three times it is starting to make sense. I think his front-panel label, "Made in USA," is a nice touch.

I doubt Cornell "irradiated" his aluminum chassis parts (see the caption under the lead photo, on page 3), but I'll bet he did *irridite* them (a chemical process for aluminum that produces a fingerprint-resistant frosty surface often found in professional-quality electronic equipment).

I'm looking forward to seeing Part 2.

— 73, Keith Kunde, K8KK, 8355 Dalepoint
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att.net

A Low-Cost Atomic Frequency Standard (Nov/Dec 2007)

Dear Larry,

Here are two items that might be helpful to readers undertaking this project. One, the power supply specification for the rubidium oscillators is very tight on ripple (1 mV). The unit is particularly sensitive at 60 and 120 Hz. The lock circuit for the crystal oscillator frequency modulates the crystal oscillator very slightly, so that the applicable harmonic "straddles" the Rb absorption line. The FM frequency is about 60 Hz, making the locked signal 120 Hz/degree. The signal is weak and is therefore easily masked by power supply ripple. This shows up by the oscillator never finding lock. I discovered this the hard way.

The other item is that if the 10 MHz output is used to control microwave oscillators, the FM will become significant. The spec is "artful" in that it shows the spectral purity starting for frequencies above 120 Hz. One solution is to phase-lock the crystal oscillator with a narrow bandwidth to the Rb oscillator's output.

— 73, Donald Haselwood, W4DH, 18727
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Thanks Donald,

I heard from a number of readers who have successfully completed this project. Your tips should prove helpful to anyone thinking about building this project or looking for ways to improve the performance.

— 73, Larry, WR1B; lwolfgang@arrl.org

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