Letters to the Editor

VHF Frequency Multiplication Using the SA602 IC (Jul/Aug 2008)

Dear John and *QEX* Editor,

In the article "VHF Frequency Multiplication Using the SA602 IC," there are a few misunderstandings. Briefly, in my opinion:

1) This kind of multiplier must function in linear mode to produce the second harmonic effectively.

2) The SA602 is a low-level device, its RF input is linear only up to –30 dBm input and limits hard at –20 dBm. Therefore, its output here is a square wave that doesn't contain even harmonics. Also, its core is meant to be a switching mixer, so the oscillator input is out of linear mode, too.

3) AN1983 does not mention any gain figures. It states only that the second harmonic is 10 to 15 dB higher than the fundamental, in output.

The circuit should be tested with much smaller signals and attenuation between stages to keep the device in linear mode in both inputs. Lower frequencies and an oscilloscope will reveal the signal forms, needed for linear multiplication. After all, AN1983 is not so bad.

— Kindly, (Mr) E-P Mänd, Finland. (Member of ARRL and SRAL, Technical class from 1970; BsC); **e-p.mand@pp.inet.fi**.

Dear Mr. Mänd,

Thank you for your interest in my article and for the questions that you raise. (For those readers not familiar with all of the literature that concerns the NE/SA602, Application Note 198, published in 1987, states that the 1 dB compression point, which defines the upper limit of the effective mixer dynamic range, is about –25 dBm.) If I understand your letter correctly, you are concerned that the amplitude of the signal fed to the mixer is such that the mixer output waveform is a square wave, which contains no even harmonic energy, preventing the circuit from operating as a frequency doubler.

This concern is valid, but does the mixer run completely out of linearity for input signals larger than –25 dBm? In order to answer this question, I went back to the lab to measure the overtone oscillator/mixer circuit formed by U1, L1, R1, Y1, and C1–C5 only, in both the time and frequency domains.

The first test was to view the output waveforms at pins 4 and 5 of U1 with a Tektronix 2246A 100 MHz oscilloscope. The periodic waveforms were definitely not square waves (more generally, the waveforms were not half-wave symmetric — mathematically required if they contain no even harmonic energy). Next, I used an HP4195A Network/Spectrum Analyzer to view the frequency spectrum of the oscillator (U1 pin 7) and mixer output (U1 pins 4 and 5) at the fundamental (36.425 MHz) and second harmonic (72.85 MHz).

Table 1

	36.425 MHz	*72.85 MHz*
Osc. Output (U1 pin 7)	–1.7 dBm	–15.8 dBm
Mixer Output (U1 pin 4)	–4.0 dBm	–4.3 dBm
Mixer Output (U1 pin 5)	–5.7 dBm	–4.3 dBm

An advantage I had gained since my original work was due to an HP41800A Active Probe I had just obtained. The HP41800A probe has a bandwidth of 5 Hz to 500 MHz, with an equivalent input resistance of 100 kΩ in parallel with 3 pF. This essentially eliminates the loading effect of the spectrum analyzer when making measurements. Table 1 gives the results I obtained from the spectrum analyzer.

As the table shows, the oscillator output power of the second harmonic is about 14 dB below the fundamental, while at the output of the mixer the second harmonic is only about 3 dB below the fundamental — equivalent to a conversion loss of about 3 dB. The presence of such a large second harmonic indicates that the mixer still maintains enough linearity to perform frequency conversion sufficient for my design, albeit at a 3 dB conversion loss.

A second test that I ran on this circuit was to attenuate the oscillator signal prior to feeding it to the mixer, as you suggested. With C1 and C2 removed (equivalent to infinite attenuation) I measured –2.5 dBm at 72.85 MHz at pin 4 and pin 5, while with C1 and C2 in place (equivalent to zero attenuation) I measured –4.3 dBm at 72.85 MHz as shown in Table 1. Resistor values of 4 kΩ, 2 kΩ and 1 kΩ placed in series with C1 resulted in power levels in between the values for infinite attenuation (–2.5 dBm) and no attenuation (–4.3 dBm). This seems to be about a zero sum game. Any gain in conversion efficiency because of lower signal levels seems to be offset by the concomitant reduction in the amplitude of the input signal itself, resulting in approximately the same output power level.

— 73, John E. Post, KA5GSQ, 5635 Four O'Clock Ln, Prescott, AZ 86305; **john.post@erau.edu**

Receiver Performance Measurement and Front End Selectivity (Sep/Oct 2008)

Dear Larry,

I was very interested in Henry Rech's article on Receiver Performance Measurement and Front End Selectivity in the Sep/Oct issue of *QEX*, especially as Henry quotes some of my work. Some of his references took me back, too — I worked briefly with John Dingley and Roger Winn at Racal, for Sosin at Marconi and for a subcontractor to Redifon where Ron Barrs was Chief Engineer! It should be remembered that much of the work published in the 1970s was the result of the fashion in the late '60s and early '70s to use broadband circuitry to minimize tuning time in service, and production and test costs in manufacture. The resultant downturn in performance was an unwanted and unexpected side effect. Examples of this appeared in the marine field, where receivers meeting the mandatory Type Approval tests in the lab proved useless on board ship.

Pat Hawker, G3VA, in his Technical Topics column in the RSGB *RadCom*, advocated the advantages of front end selectivity over a good many years, and I cannot disagree. One point that Henry does not mention is reciprocal mixing: in its way, this is more insidious than intermodulation, since reducing signal levels reduces reciprocal mixing dB for dB, rather than for *n* dB, as in the case of intermodulation. Improved front end selectivity helps with reciprocal mixing as well.

The noise testing methods using a notch have been described in *Marconi Instrumentation* magazine back in the early 1960s: one occasionally sees the *MI* test equipments at flea markets. The method was also described in the same magazine in the 1970s as applied to transmitter testing The FT-102 used in my measurements does indeed have a relatively narrow front end. It is used only to establish the noise floor, however, with the actual signal measurements being carried out with a spectrum analyzer. The noise floor can be varied with a step attenuator to check the "dB for dB," indicating that intermodulation is not

Table 2

Number of signals at various noise levels in 2002 and in 2007 using a dipole at 7 MHz

	Number of signals Jan 2002			*Number of signals Oct 2007*		
Time (UTC)	*–10 to –20 dBm*	*–20 to –30 dBm*	*–30 to –40 dBm*	*–10 to –20 dBm*	*–20 to –30 dBm*	*–30 to –40 dBm*
00-01						
01-02						
02-03	1	12	12	2	3	6
03-04				2	1	8
04-05						
05-06					1	2
06-07		1	4		3	2
07-08				1	1	3
08-09						
09-10						2
10-11						
11-12						
12-13						
13-14						
14-15		1	1			2
15-16			2			2
16-17	1	3	18		1	9
17-18	5	5	20		5	9
18-19	2	8	23		5	10
19-20	1	4	18			8
20-21	2	6	27		3	13
21-22		6	25			13
22-23	1	3	23		3	11
23-24	2	5	7			

Table 3

Noise floor and signal levels measured during a 20-hour period in 2007

Time (UTC)	*Number of signals* *Noise floor (dBm)*	*–10 to –20 dBm*	*–20 to –30 dBm*	*–30 to –40 dBm*
0215	–96	2	3	4
0230	–100		3	6
0300	–99	1	2	8
0315	–98	2	1	6
0505	–102		1	2
0530	–102		1	2
0610	–99		3	2
0640	–103		2	2
0715	–102	1	1	2
0730	–100		1	3
0945	–100			2
1440	–101			2
1530	–95			2
1620	–99		1	8
1640	–100		1	9
1700	–96		5	7
1730	–95		3	9
1800	–95		5	10
1920	–95			8
1935	–102			5
2015	–102		3	11
2045	–95		1	13
2130	–100			13
2200	–98		3	9
2215	–97		2	11

affecting matters. The measured noise levels are consistent with those expected in a quiet rural location from on a dipole in accordance with Recommendation ITU-R P.372-8 "Radio noise."

The measurements in my original *QEX* article were made at what was about the peak of the sunspot cycle, and the question remained as to how different the results are at the bottom of the cycle. That may be found in my March/April 2008 *NCJ* article. Since there is no copyright problem between *NCJ* and *QEX*, those tables are shown here as Tables 2 and 3.

The measurements still suggest that about 100 dB of dynamic range is all that is required for most amateurs, but the major point is where that 100 dB begins. The use of an antenna attenuator with as much as 40 dB of available attenuation seems justified. Phase noise is a more subtle problem, in that multiple low level signals add in ways that does not happen with intermodulation. A good front end preselector helps in many ways, as the designers of such classic receivers as the HRO, AR88 , SX28 and SuperPro apparently appreciated.

— 73, Peter Chadwick G3RZP, Senior Radio Systems Consultant, Medical Products Group, Zarlink Semiconductor, Cheney manor, Swindon SN2 2QW, United Kingdom; **peter.chadwick@Zarlink.Com**

Dear Larry,

I read Peter Chadwick's letter to you and was fascinated to find that he had an involvement with some of the references cited in my article. This was a time when receiver design was in a state of rapid development.

Peter noted that I omitted a mention of reciprocal mixing. His point is valid.

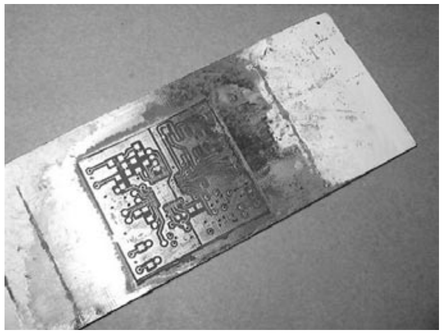
Receiver overall performance is largely dependent on front end linearity, first oscillator phase noise behavior, front end selectivity, roofing filter bandwidth and inherent sensitivity. All of these also affect the receiver dynamic sensitivity (that is, how a receiver noise floor varies as the signal environment in which it is embedded changes) in particular. I believe the notion of "dynamic sensitivity" has to be looked at in more detail.

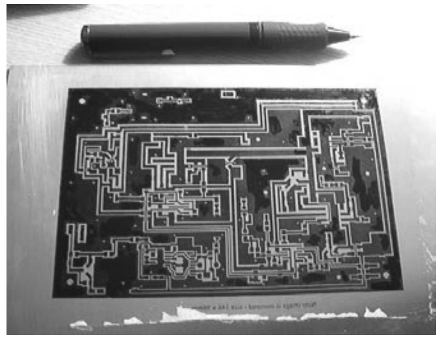
It would seem to me that the conventional battery of tests that are used do not adequately address the comparative performance of receivers. My article focuses on IMD performance and front end selectivity and how the Noise Power Ratio Figure of Merit (NPRFOM) might be a way out of this.

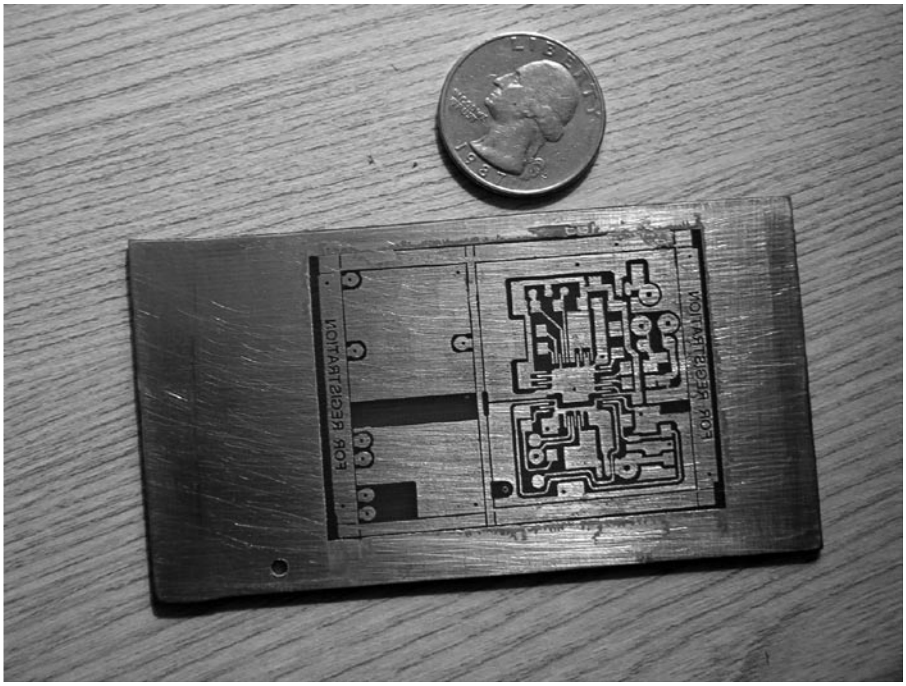
Given that the IMD characteristic of a receiver may not be only third order, as discussed in my article, point measurements may not describe the complex IMD behavior of a particular receiver, and hence receiver comparisons based on such measurements may not be valid. For instance, two receivers may have the same calculated IP3 but may vary in actual IMD performance. This is another point I could have emphasized in my article.

I would argue that the NPRFOM test fits the bill as a general figure of merit test very well and is a means by which the overall performance of a receiver can be characterized, taking account of all the determinants of receiver performance in one test.

— 73. Henry Rech, 55 King St, Dandenong, Victoria, Australia, 3175; **hjrech@optusnet.com.au**







Press-n-Peel Circuit Boards (Sep/Oct 2008)

Dear Larry:

If only WA9PYH's article on Press-n-Peel had appeared last year, before I embarked on building a G3XJP reference-design STAR (software transmitter and receiver), I would have saved time and effort. His notes are invaluable for any builder that homebrews circuit boards. There are some points I'd like to add to Jim's excellent article, however.

Two of the many boards for my STAR project housed surface-mount ICs with leads measuring 0.27-mm on 0.5-mm pitches. Once I perfected my technique through trial and error, I was able to readily make fine-line double-sided boards to accommodate tiny DDS and CODEC chips.

I found that 2-oz. Copper fiberglass FR4 material, obtained at low cost on eBay, was the best substrate. I etched my boards with a mixture of ferric chloride and hydrochloric acid. I used Chip Quik flux to ease attachment with an ordinary soldering iron.

Rather than using Press-n-Peel, which is somewhat expensive, I used ordinary glossy photo paper intended for inkjet printers. I bought 10-mil heavyweight paper called Special Moments, made by

Greenbrier International, Inc. It was available at my local Dollar Tree store, priced at eight sheets for a dollar.

Although some people have warned that running this glossy stock through a laser printer can ruin the printer's fuser, I have never experienced that problem, not even after making dozens of prints. To be on the safe side, however, it might be worthwhile purchasing a surplus printer, as Jim did for his projects. My printer is a Hewlett-Packard Laserjet 2300.

I print my layouts on the Special Moments paper, and then transfer them to the polished and cleaned copper, using an iron, as Jim explained. The clothes iron is dedicated to this purpose, as the process leaves a brown stain on the iron that is almost impossible to remove. (Ask me why I gave my wife a gift of a brand new iron!) The clothes iron deposits the plastic-based laser toner onto the copper boards in the same manner as Press-n-Peel. The deposited image is a great resist.

Depending on the size of the board and the thickness of the copper, and how much heat and pressure is applied, there can be places on the board where the laser toner resist doesn't adhere. These areas show up clearly when you peel off the paper, but they can be touched up manually with a Sharpie pen prior to etching. These pens are now available with ultra-fine points. I use a broad-point black Sharpie to touch-up large areas on the image, and a fine-point black Sharpie pen for the tiniest traces.

I found I could also partially peel off the Special Moments paper after heating, and if I observed any traces that didn't transfer, I could fold the paper back down, and hit the board with more heat. Partially peeling off the paper preserves the registration of the original artwork, as there is a portion of unpeeled paper that still adheres to the underlying copper.

Lastly, I always scratch my call sign and date onto my boards, prior to etching. It's nice to have your call sign etched forever on homebrew circuit boards.

I've attached a few photographs of some of my boards.

I hope these hints will help others to make fine-line boards. It's now easier than ever to homebrew advanced radio projects on your kitchen table!

— 73, Alex Mendelsohn, AI2Q, 164 Sea Road, Kennebunk, ME 04043; **ai2q@arrl.net**

Optimum Lossy Broadband Matching Networks for Resonant Antennas (Sep/Oct 2008)

Hi Larry,

When I received my copy of the Sept/Oct issue of *QEX* in the mail, I did a quick read of the article; it came out very well. Thanks for all your efforts. I detected a few minor errors that I did not pick up before.

On page 35, Figure 11, y-axis: The top number should be 120 instead of 3.

On page 36, in the second paragraph, line 11: Figure 12D should say Figure 12C.

On pages 36-40, Figures 12, 16, 17 and 18: The y-axis of each graph is dual-use and is intended to show SWR values from 1.0 to 3.0 and loss values from 0 to 2.0 with a label of "Loss (dB)." This can be accomplished by moving the "SWR" label upward to make some space for the loss label.

Thanks again. I enjoyed working on this project with you.

— 73, Frank, AI1H, 41 Glenwood Rd, Andover, MA 01810; **ai1h@comcast.net**

Hi Frank,

Thanks for pointing out those errors and incomplete labels on some of the graphs with your article. I also enjoyed working with you on this article, and look forward to doing it again soon.

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

Broadband Impedance Matching (Nov/Dec 2008)

Dear Larry,

The article "Broadband Impedance Matching" in the Nov/Dec 2008 issue of *QEX* contains an error. In Figure 17, page 29, the source impedance (RS) should be 50 Ω, not 750 Ω. The graphs of Figure 18 are based on RS = 50, as is the "With Inverter" graph of Figure 16. Sorry I didn't catch this when I reviewed the final layout PDF file.

— Sincerely, Frederick B. Huber, 9422 Deer Ridge Dr, Cedar Rapids, IA 52411; **fhubler@msn.com**

Hi Frederick,

Thank you for pointing out the mistake that we made when drawing Figure 17. We sincerely apologize to our readers for that error.

— 73, Larry, WR1B; **lwolfgang@arrl.org**