Sherwood Lab Setup for Dynamic Range Measurements

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My lab has been upgraded over time from 1975 when I started testing receivers. Initially I had an HP 606A, an HP 608C, and a hybrid combiner. All measurements were done on 20 meters since the 608C only went down to 10 MHz. Since neither generator was leveled, isolation between generators was not an issue. Of course, drift was an issue, and the generators were generally turned on hours ahead of time, if not the evening before. Microphonics and line-related sidebands were a minor issue. Leakage from the 606A was more of a problem when trying to measure Noise Floor below -130 dBm. The waveguide-beyond-cutoff performance of the 608C was likely better than the 606A leakage from the cabinet.

The tube-type generators were later replaced with HP 8640A generators, similar to the popular 8640B model, but with no digital readout and no drift stabilizer. Functionally, the A and the B models worked the same. Being leveled generators, isolation between the generators was of concern, particularly with the small number of high dynamic range transceivers on the market.

About 15 years ago I replaced my HP 8640As with an HP 8662A and an 8663A. A few years ago, I added HP 8642A synthesizers, four at the Denver lab and two at my rural QTH. The 8642As have better phase noise on HF than the 8662A/8663A, though at much higher frequencies the 8662A/8663A have better numbers.

When one measures phase noise in the -150 dBc/Hz range, it would be desirable to also have a crystal oscillator for comparison, but it would be very expensive to have those on each amateur band. Once generator phase noise gets down to this level, most transceivers are much worse than that. I don’t believe users could ever differentiate between -145 dBc/Hz vs. 155 dBc/Hz when on the air.

To match levels for a two-tone DR3 test I use an HP 3586C level meter. My pair of level meters agree within 0.2 dB of each other after warm-up, so absolute level is acceptably accurate. For spectral analysis I have several HP units. Three 3585As, two 8568Bs, and a 3561A FFT analyzer I have used for special measurements when I needed to capture single-shot events such as AGC attack distortion, or to look at the third-order products buried in 20 dB of noise (FTdx-3000), for example.

With leveled signal generators, one needs lots of isolation between the generators, or IMD can be generated in the test setup on the same frequency as the desired measurement.

Note: Higher-frequency buffer amps and combiners than listed below are used for VHF/UHF measurements.

Here is my typical HF setup.

Two 8642As feed individual Mini-Circuits buffer amps (ZHL-32A) running on 24 V DC. from separate HP power supplies. These have 25 dB gain, a noise figure of 10 dB, and can put out +29 dBm. The synthesizers are set to about -9 dBm, and the amps are normally run about 10 dB below the 1 dB compression point.

The output of the buffer amps feed 15 MHz Mini-Circuits low pass filters, (assuming I am testing on 20 meters), which is my normal standard. Then there are Mini-Circuits 20 dB in-line pads that feed the Mini-Circuits 4-way hybrid combiner. Any unused ports of the combiner are terminated with 50 ohm loads.

The reason for using a 4-way combiner instead of a 2-way, is to be able to duplicate what the League at times does with a third signal set at the noise floor of the radio. I think this method of measuring the third-order product buried in noise is meaningless when a radio is used on the air, but occasionally I like to see if I get the same numbers. Additionally, two of the four ports on a 4-way combiner provide additional isolation of the signal generators.

The output of the combiner feeds a pair of HP 355 step attenuators, one with 10 dB steps and one with 1 dB steps. A cable then runs to the back of the radio where there is a 10-dB in-line pad. The 10-dB pad assures a reasonable termination to the hybrid combiner. (Not perfect, but one can tolerate only so much additional loss.)

Normally I produce -20 dBm at the output of the 10 dB pad that feeds the radio. This usually has been adequate to measure any radio up to about 105 dB dynamic range, assuming a normal noise floor. In the case of the TS-990S at 20 kHz, I needed a few more dB output, so I had to drive the buffer amps a few dB harder. Since I am well below 1 dB compression point, that was not a problem.

Since Peter Hart with RadCom is getting similar wide spaced TS-990S measurements (50 kHz in his case and 20 kHz in mine), we clearly have adequate isolation. His best measurement with the preamp ON is 111 dB and my best measurement with the preamp OFF is 111 dB, both on 20 meters. His measurements were in 2400Hz bandwidth, and mine in 500 Hz, so that may explain the need for the preamp in his lab.

When testing a Flex 6600 or 6600M transceiver with the preamp OFF, the noise floor is -111 dBm due to the high insertion loss of the 7-pole front-end bandpass filter. Thus, the receiver requires injection of two test signals modestly higher than -20 dBm. It is necessary to push the buffer amps a few dB harder, and to use a 6-dB in-line attenuator at the receiver input rather than a 10-dB pad. Since the 6600 has a 33 dB noise figure without a preamp, many people in a quiet location will normally run the 16 dB preamp to push the noise figure down to 18 dB. With both preamps and 32 dB of gain, the 6600 has a noise figure of about 12 dB. Testing a 6600 with the 16-dB preamp is very easy, and doesn't require any special measures.