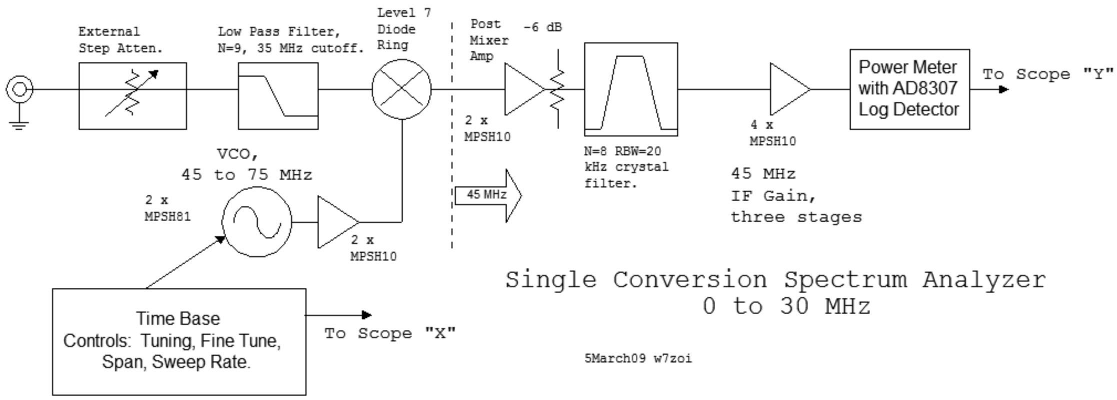
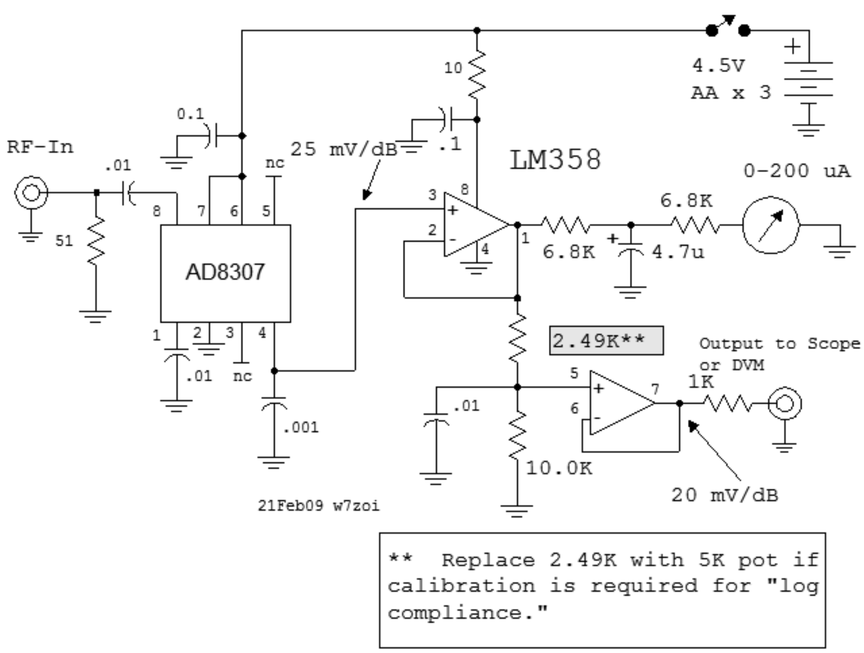
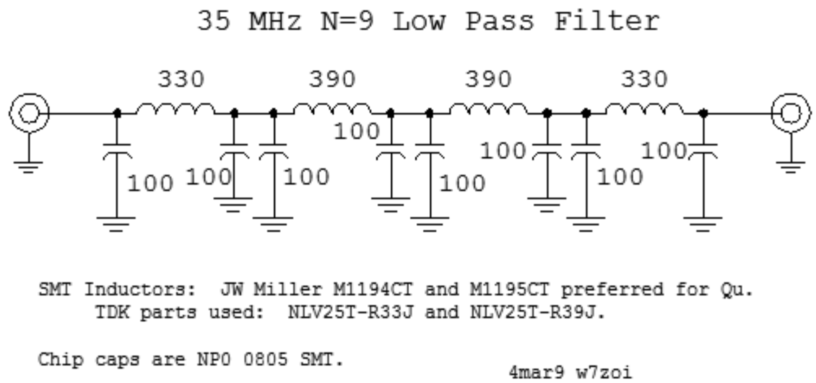
A Single Conversion Spectrum Analyzer, 5, 6, and 14March09 w7zoi

This analyzer was intended to be a very simple instrument. The block diagram is shown below. The thought is that a simplified AD8307 power meter would be built first, which would then be an instrument that can be used for measurements on the analyzer as it is built. The power meter later serves as the log amp part of the spectrum analyzer.

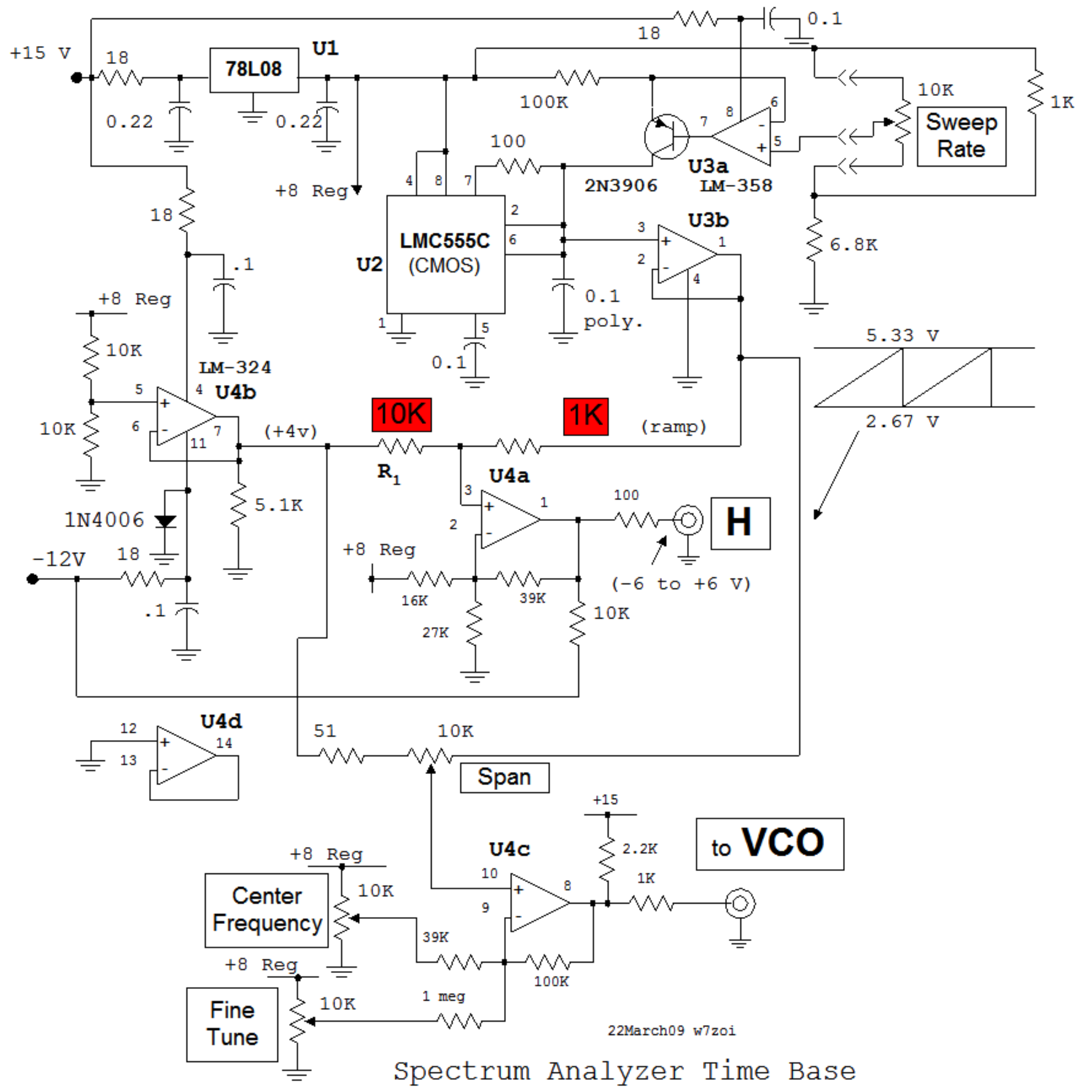


The power meter is shown below. I used a 200 uH meter movement, for there was a beauty in the junk box. The two 6.8K can be replaced with 1.2 and 1.5 K if a 1 mA meter is used. The 2.49K resistor set up the output for 10 dB per major division when used with a spectrum analyzer or with other sweep systems. Stick with battery operation for this power meter. The battery could eventually be replaced with a regulator running from the analyzer 15 volt supply.

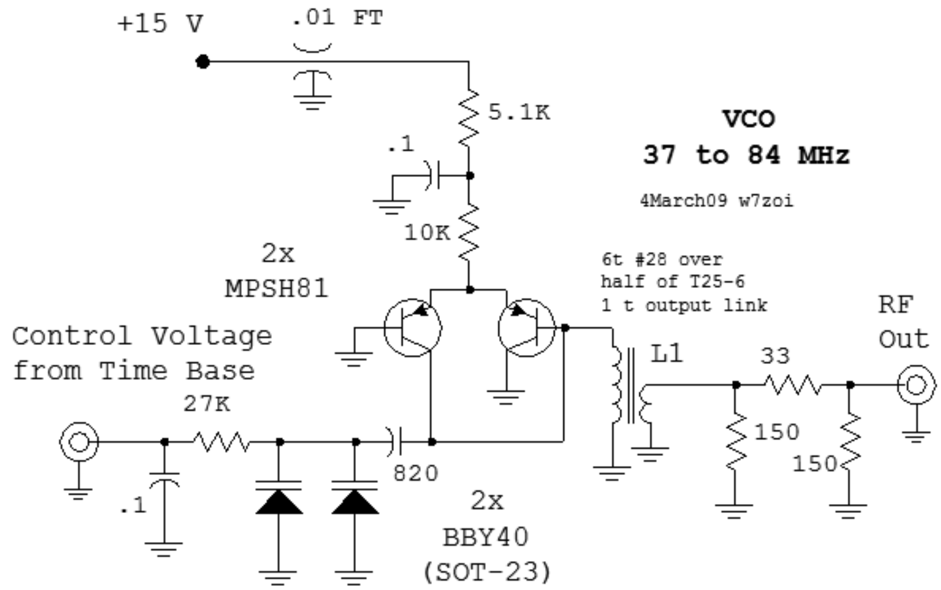




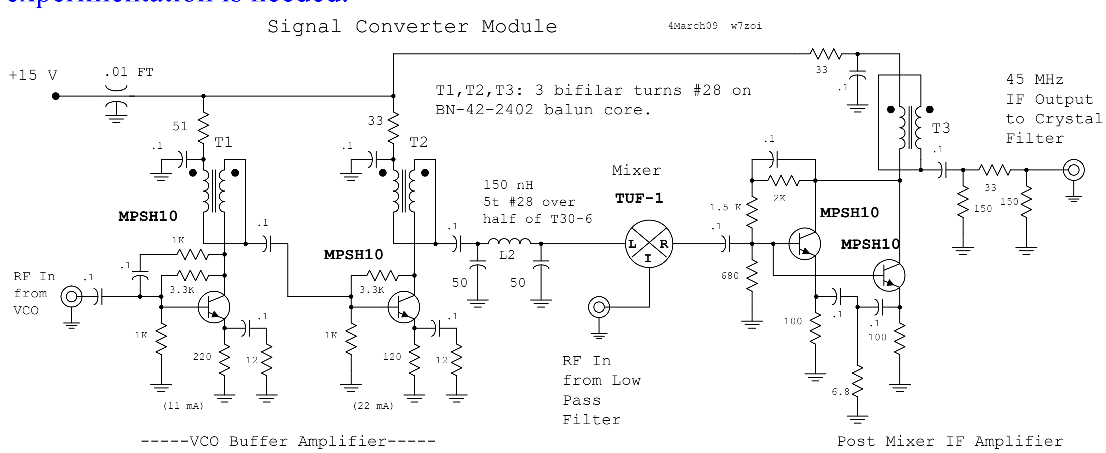
This is the input low pass. It is definitely worthwhile to use SMT here. This is a killer filter that is easy to build if built with care!



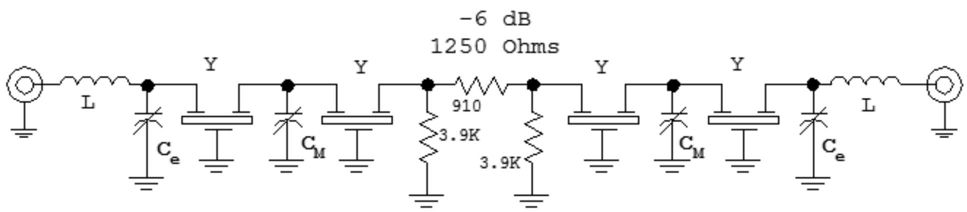
The time base, show above, is very similar to one by Bob Kopski, K3NHI. Thanks, Bob.



This is the VCO, which is built in a small box. I would recommend that other builders integrate it and related buffers in one box. Indeed, one board with the VCO, buffers, mixer, and post mixer amplifier would probably work, eliminating some coax and connectors. But experimentation is needed.



Crystal Filter Module
(BW=20 kHz, IL with pad = 8.5 dB)

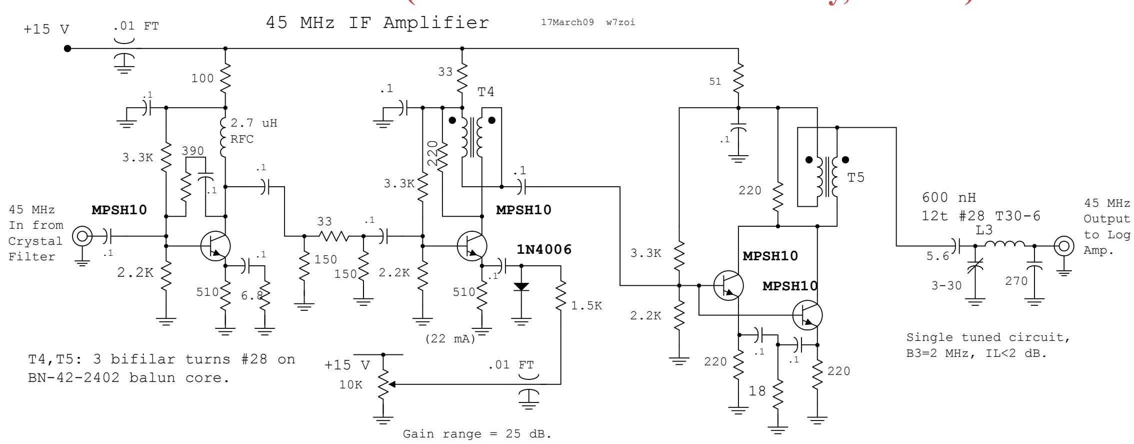


L = 1.1 uH, 16 t #28 on T30-6 toroid

C_M, C_e = 2-30 pF   7Feb09, w7zoi

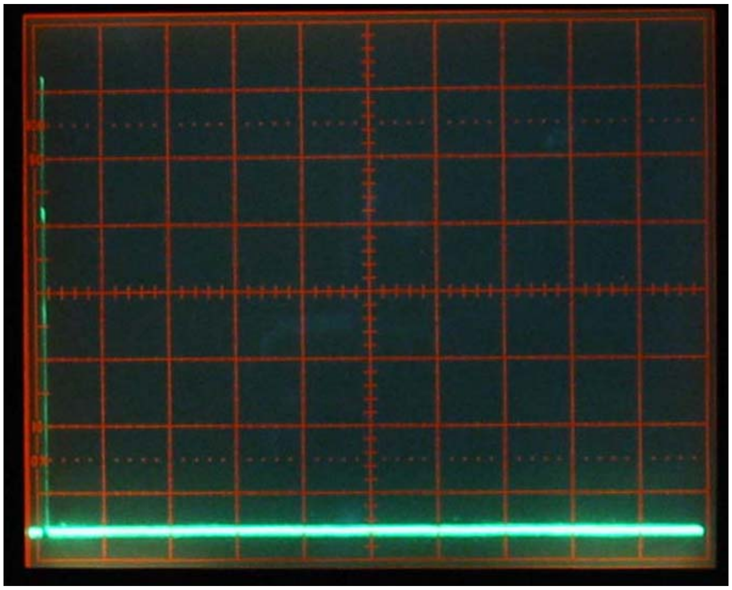
Y = 45 MHz monolithic crystal filter

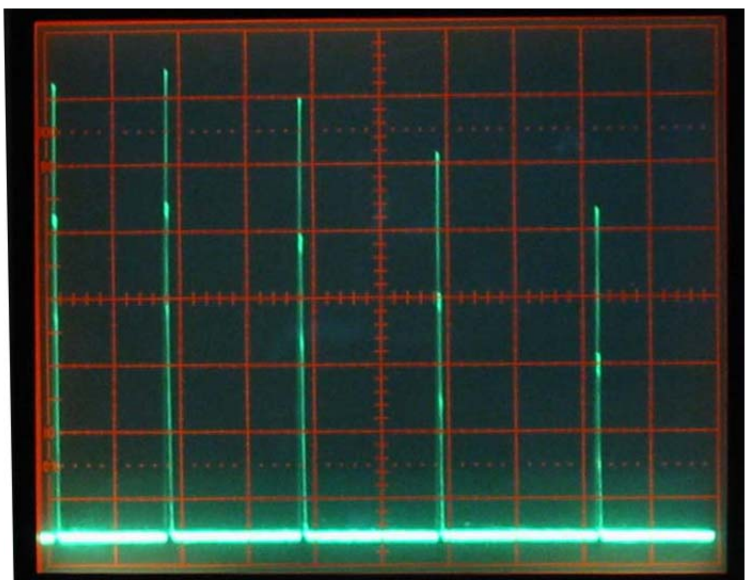
This is the crystal filter module, using surplus filters. I had to go to an 8th order filter to get rid of spurious responses 500 kHz above the 45 MHz one. See eBay item 270167960091, still available on 14March09. **(Who knows what is there today, in 2023.)**

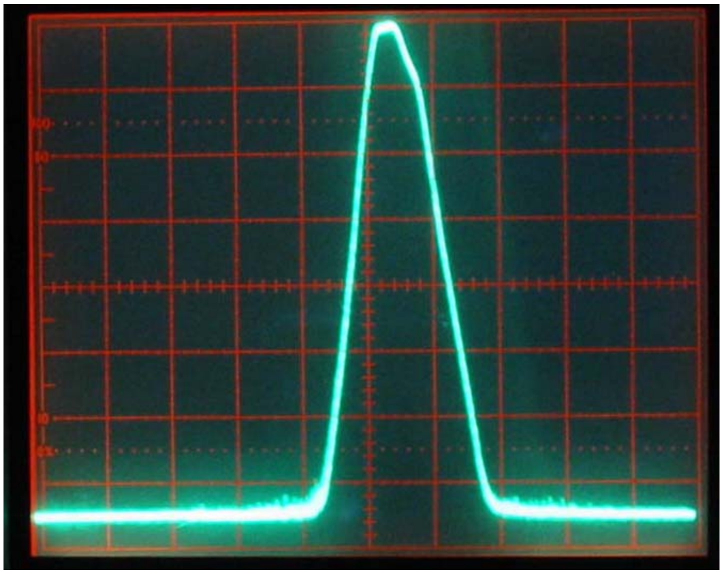


This IF amplifier follows the crystal filter. I ended up using parallel transistors in the output to avoid gain compression problems while getting up to around 0 dBm to drive the power meter/log amp.

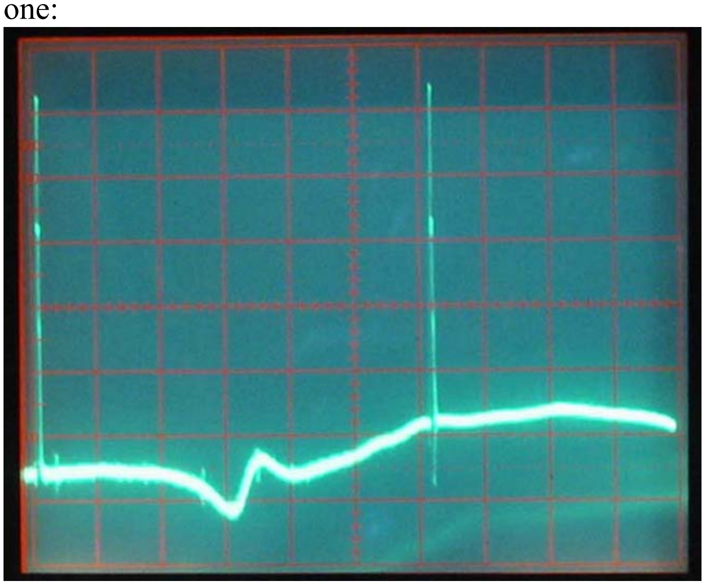
OK, now for some photographs.

 This is with the analyzer set for "max span." The zero spur is shown at the left.

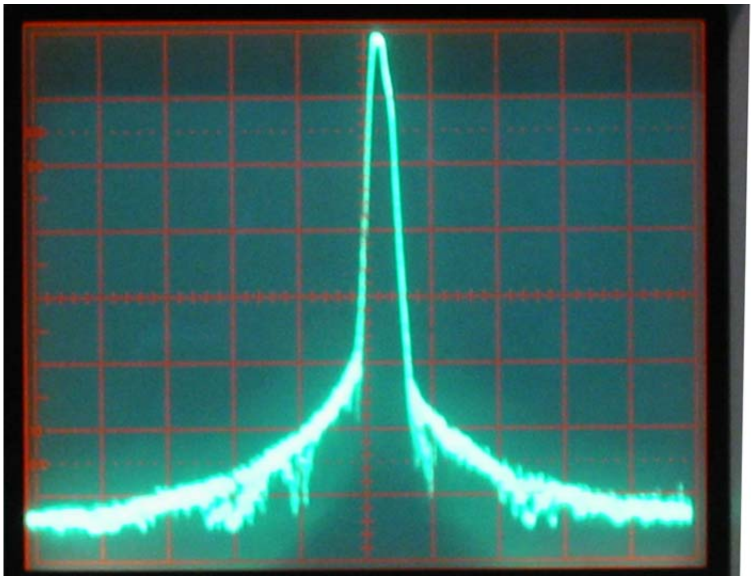
 This photo still shows a max span shot with the zero spur at the left. However, a 7 MHz comb generator is attached to the input. The 7 MHz line, about 2 div in from the left, will go up to the top of the screen if the span rate and/or span are decreased.

 This shot shows the 7 MHz line when we have spanned in all the way. Note that the filter can easily be aligned *in situ* in this system.

As I was tuning the signal generator around, I observed some unusual signals. Here's one:

 This is a max span shot, but with a -30 dBm signal applied at 22.5 MHz. This is half of the 45 MHz IF. Note that the whole baseline has come up with this input. We know that the 2nd harmonic of the HP8640B is suppressed by 60 dBc or so. Hence, this response suggests a mixer problem. Generally, this 2nd order distortion is not this bad, although it is common. The ideal system uses an IF that exceeds the highest input by a factor of 2.

A signal was injected at half of the 110 MHz IF of my 1998 QST analyzer and a slight response was detected, but it was not as severe as the response above.



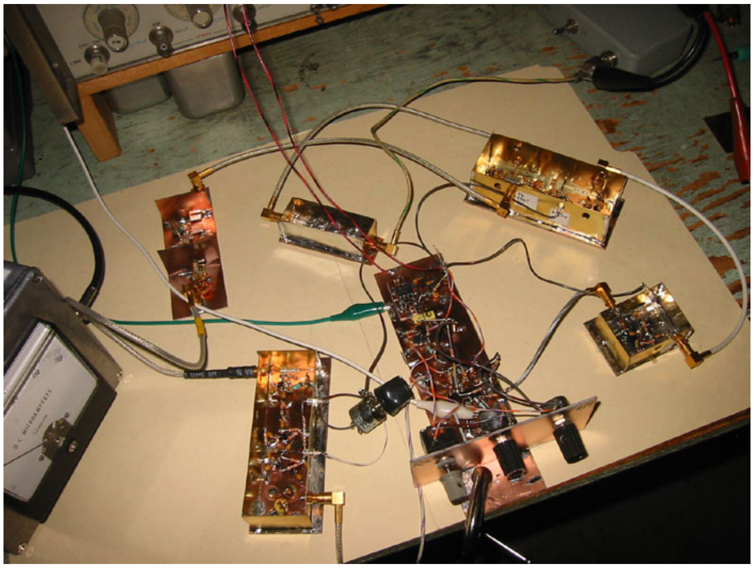
This was a very interesting and confusing display. As we reached 14.76 MHz on the input signal source, the display got funny with the above appearing. It was clear in looking at the display that it was modulated, suggesting an FM station. As it turns out, 103.3 MHz (our strongest local FM station) divided by 7 is 14.76 MHz. Careful tuning showed a few other similar responses, but none as bad as this one, or the half-IF one. (See March 6 comments.)

Some photos of the modules

The initial configuration used nothing but open boards except for the power meter/log amp, which was in a box with the meter movement. The thing worked. However it was plagued by loud spurs from the FM band. These spurs were simple 1:1 images, so they were wide and **really did** get in the way of other measurements. In contrast, the spurs that are present with the QST analyzer are usually the result of high order mixer products, so the lines are narrow when compared with normal signals. As such, they are much less distracting and often don't really get in the way of measurements.

The other problem noticed with the open boards was a baseline rise. That is, the output of the log amp was many dB above the value expected. There were peaks in explainable places on the scope display when the system was operated.

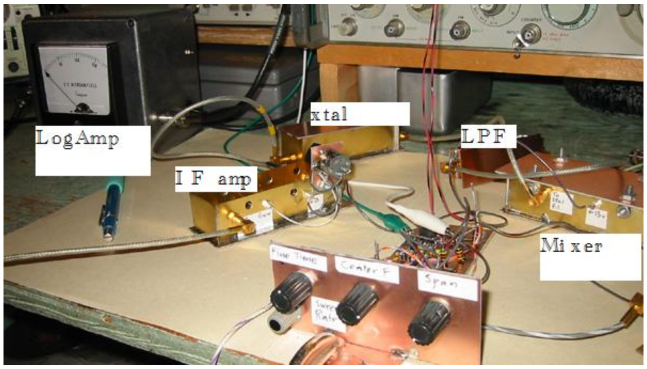
The next step was to get rid of the elevated baseline. It was relatively easy to get rid of most of it, merely by adding shield walls.

 This shot shows the system after the walls were added. Coax connectors were placed in the walls to carry the signals including the VCO control voltage from the time base board. There are no walls around the crystal filter at this time, although the board did have a couple of shields between filter sections. I used push-on type SMB coax connectors from the junk box.

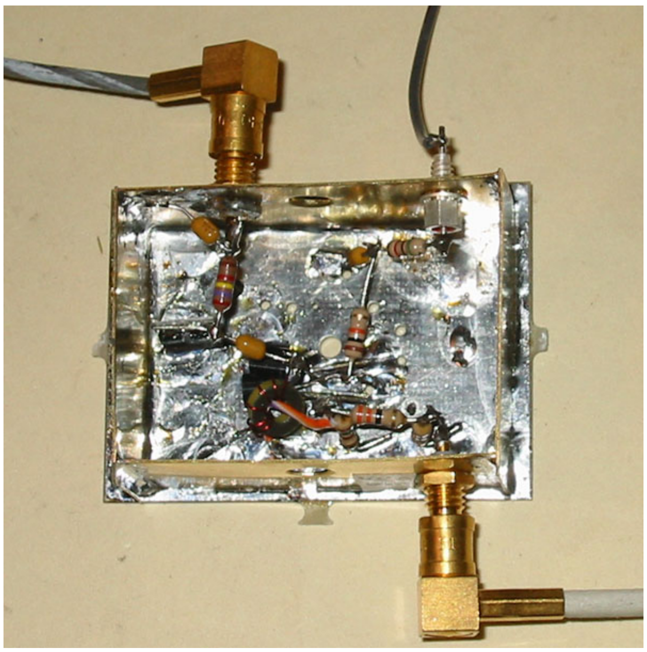
Quick and dirty experiments with scraps of PC board indicated that the most sensitive boards with regard to the baseline rise and the FM spurs were (1) the mixer and (2) the input low pass filter. Lids were put on these modules. The lid on the mixer module was fastened with nuts on spade bolts attached to the walls. The lid on the LPF was soldered in place. After the LPF lid was in place, the filter was again examined with a tracking generator; the performance is now exactly what the simulation says with no sign of any stopband problem of any kind. More detailed measurements with a signal generator would probably have revealed the performance limitations.

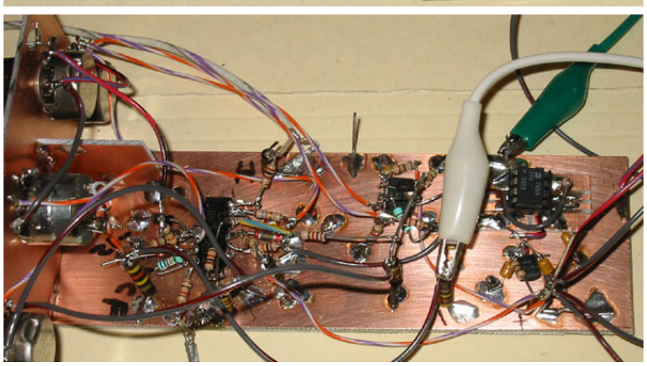
There was still an elevated baseline, but it had no coherence. That is, there were no bumps as the system was swept. At that juncture there was only a low pass filter on the output, confining the noise spectrum from the IF amplifier to a 50 MHz bandwidth. This low pass was replaced with a low Q single tuned circuit. This filter, although just one resonator, was carefully configured to have a symmetric shape versus frequency. This took care of the baseline problem, dropping it to a level that is hardly higher than the power meter level with no input source connected.

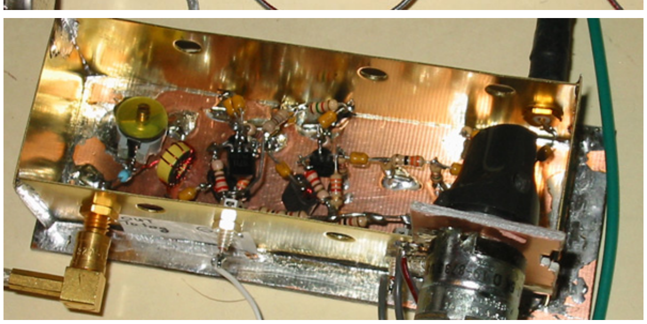
FM spurs remained, so I started wrapping more shields around boxes. Walls were installed around the crystal filter and a lid was then attached. That seemed to take care of most problems. The VCO is still open, although intuition tells me that it should be buttoned up.



This view shows the modules scattered across the bench.


A close-up view of the VCO.


The time base.


The IF amplifier, still with shield

Later Experiments on March 6, 2009:

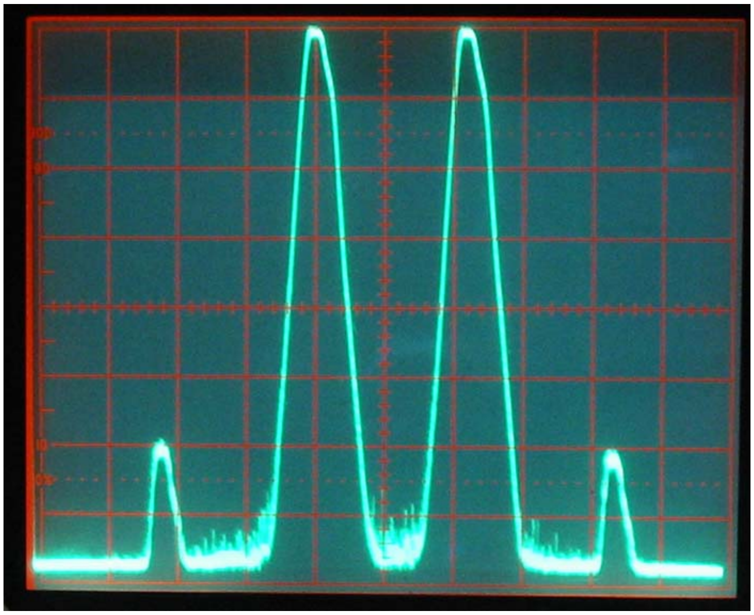
Following yesterday's experiments and photos, I put a lid on the VCO. That took care of that weird response I had when I applied a signal of 103.3 / 7 = 14.76 MHz to the input. There is now no sign of that response. Incidentally, I looked at other sub-harmonics and none that I tried generated the weird response. There was something special about n=7.

Next I put a shield on the 45 MHz IF amplifier. That didn't seem to have much impact on things.

There is still a severe problem when I presented the front end with half of the IF. Otherwise, it's pretty clean. I can see some FM signals when nothing is grounded, but they are way down. As Rick commented, the half IF problem is a classic and something that we often just live with. It is ***NOT*** a show stopper.

Next I applied a two tone signal to the box. The goal is to find out if the analyzer is suitable for IMD measurements, for that is vital to a great deal of design. I used my two HP generators through a 6 dB hybrid. I then looked at the IMD on screen. Three figures are attached showing inputs of two tones at -30, -25, and -20 dBm.

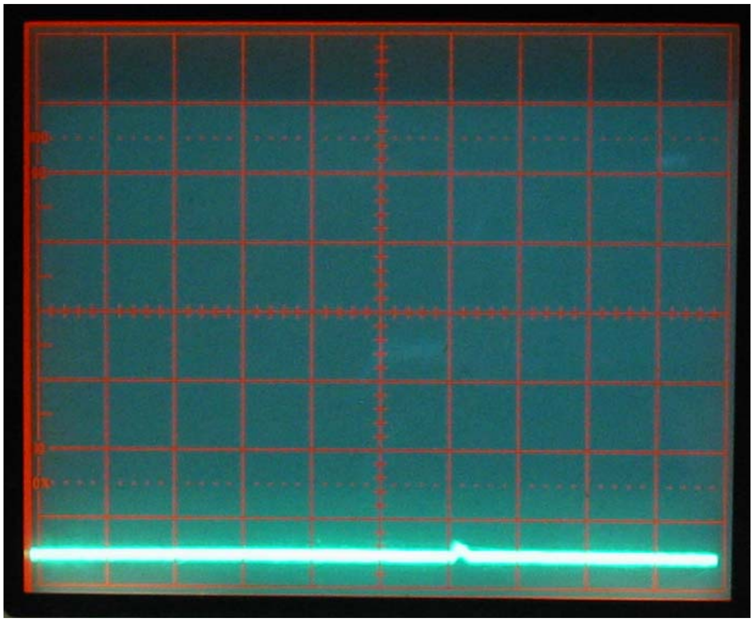
This is the -30 case with IMD tones down by about 67 dB. That puts the input intercept of the analyzer at IIP3=+3.5 dBm.


The IIP3 value predicted by this, the -25 dBm per tone case, is +5 dBm.


A similar value is predicted by this measurement, the -20 dBm/tone case.

The signals were beginning to compress with the -20 dBm input tones. This would probably not have been the case if I had reduced the IF gain to keep the signals on screen. Rather, I merely offset the signals with the vertical position control on the scope.

Having examined the strong signal character, the next thing to do is to look at weak signal behavior.


This plot shows a signal of -107 dBm applied to the analyzer. This is the mystical 1 microvolt that we talked about "in the day."

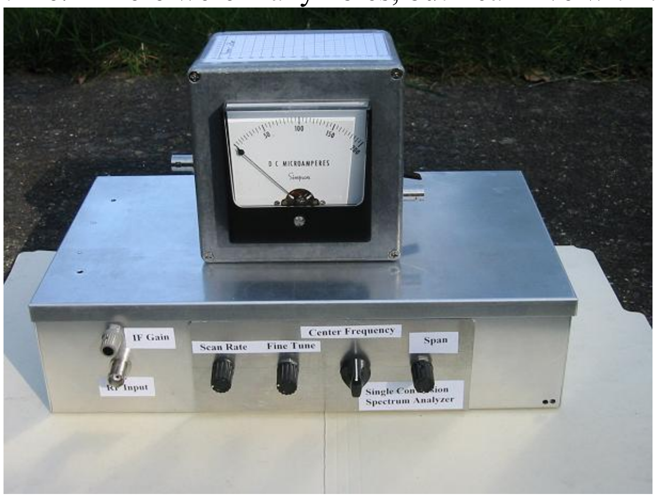
I continue to be both enthused and confused with this project. I've concluded that it is a good thing. That is, it is a very simple way to make an analyzer that really works. But it is not the brain dead, *anyone can build one* design that I had dreamed of when I was smoking some of that stuff that I found up in the woods behind the house. (Just kidding, Roger!) I don't know about you guys, but I can't seem to make an analyzer that does not require a lot of shielding. Perhaps *an analyzer without shielding* is an oxymoron.

The FM signals are strong at my house. I turned one of the analyzers on and attached a single wire (length 2 ft) to the input and let it sit on the bench in front of the instrument. The loudest signal was -27 dBm in my basement with about a dozen others within 10 dB of that level. The strongest was not the 103.3 mentioned yesterday, but 100.3 MHz. When I have attached the transmission line from a VHF ham antenna in the past, I've seen signals in the -10 dBm area. (M^2 144 MHz 9 element Yagi.)

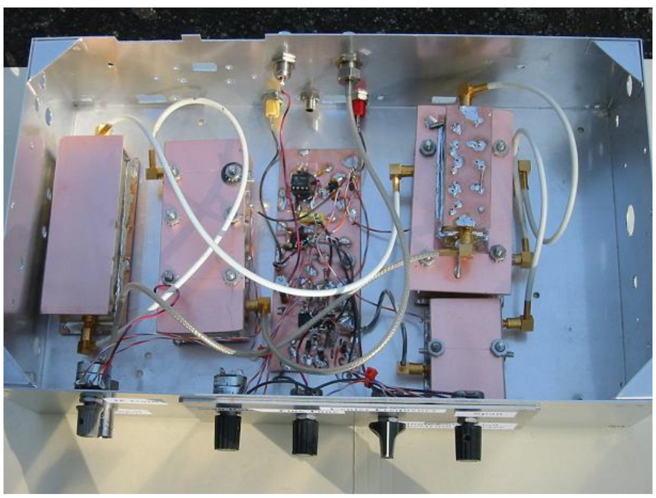
As I was walking around this afternoon (March 6th) and thinking about the project, I tried to envision the reaction of some poor unsuspecting sole who was building this box without sufficient warning about the need for extreme shielding. He or she might be quite frustrated by the experience. On the other hand, once he or she managed to get the instrument playing, a great deal of experimental experience would have been garnered. I'll invite you all to drop by and take a look at it. (That will more difficult for some than others.)

The box of boxes, March 14, 2009.

The next step in the project is to “finalize” things by putting things in a box. I managed to find an enclosure in the attic of the garage, a box that had a portable rig in it at one time. There were many holes, but I can live with that.



This is the front panel of the system.


And this is the inside of the box.

At this time I have decided not to generate any PC board layouts for this design. The shielding difficulties have made me think that the overall performance will not be suitable for the originally envisioned, general purpose applications for the less sophisticated builder/experimenters. I may change my mind on this issue. Many thanks to all of you who participated in these experiments.

The analyzer shown in these photos has been dismantled and stored in a cardboard box. Hence, that “demo” is no longer possible.