

A Brief Test of the Sony XDR-F1HD Tuner

Tim McVey, 9/9/2008

The Sony XDR-F1HD has been receiving a lot of praise, and the price is low, so I bought one. Many vendors were selling it for about \$100, and iBiquity was even offering a \$50 rebate (which I received in about 3 weeks). I connected it to an APS13 antenna (which is in my attic) and was immediately impressed. After using it for a few weeks, I decided to run a few basic RF tests to see what this thing is actually doing.



First, I performed a crude sensitivity measurement. I did this by simply connecting a 50Ω signal generator directly to the antenna terminal and measuring the signal required for various conditions. The test signal was a mono FM signal, modulated by a clean ($<0.1\%$ THD) sine at 1kHz, with 75kHz peak deviation. The mismatch between 50Ω and 75Ω --assuming the input impedance actually is 75Ω -- amounts to less than 2dB of loss so I didn't worry about it.

The tuner required -110dBm ($0.71\mu\text{V}$, or **10.0dBf**) for 10dB SINAD. This is the input power required to produce the 1kHz sine on the audio output jack at 10dB above the noise; measured on oscilloscope.

The tuner required -99dBm ($2.5\mu\text{V}$, or **21.0dBf**) for minimum 40dB quieting; measured on oscilloscope. This is much higher than reported by others, but still remarkably sensitive.

I repeated the tests at 88.1, 90.1, 92.1, 94.1, 96.1, 98.1, 100.1, 102.1, 104.1, 106.1, and 108.1 to see if sensitivity varied across the FM band. Readings did not vary by more than $\pm 1\text{dB}$.

I did not measure AM performance. This is because I don't really care: I don't have an adequate AM broadcast antenna, and the one supplied with the Sony only picks up noise.

Like most everyone else, I was amazed by the selectivity of the FM tuner. This tuner resolves every channel on the FM dial here, and does so with very good sound (or at least as good as the broadcasters allow it to be). On my bench, I measured **73dB adjacent channel selectivity**. This is not a typo. I mean seventy-three, both on the upper and lower adjacents. I could not measure the alternate channel selectivity (implying $>100\text{dB}$). I repeated this test 3 times. This exceeds any FM tuner I have ever measured (a few dozen?).

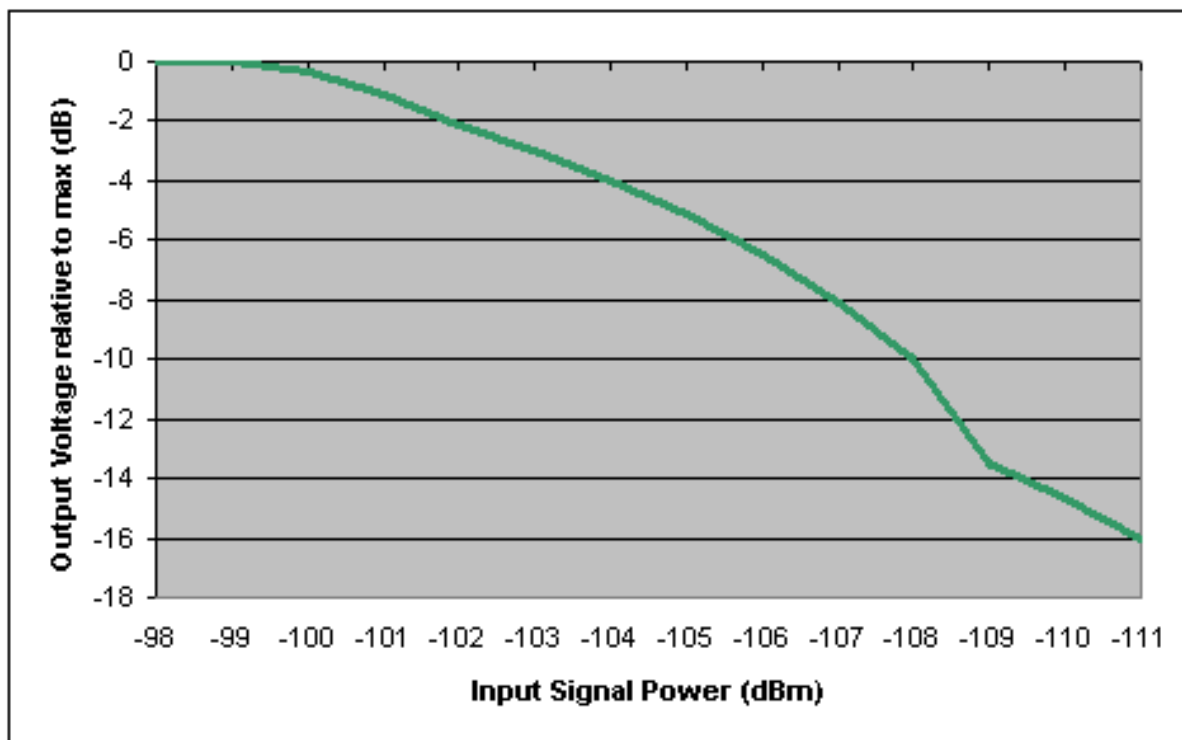
I checked image rejection, and found this to be **71dB** when tuned to 98.1 MHz. This is adequate for an FM tuner, especially since there is not likely to be a strong signal in the image range (108.9 to 129.4 MHz).

I noted two spurious responses at 98.1 MHz, both $>80\text{dB}$ down. No problem there.

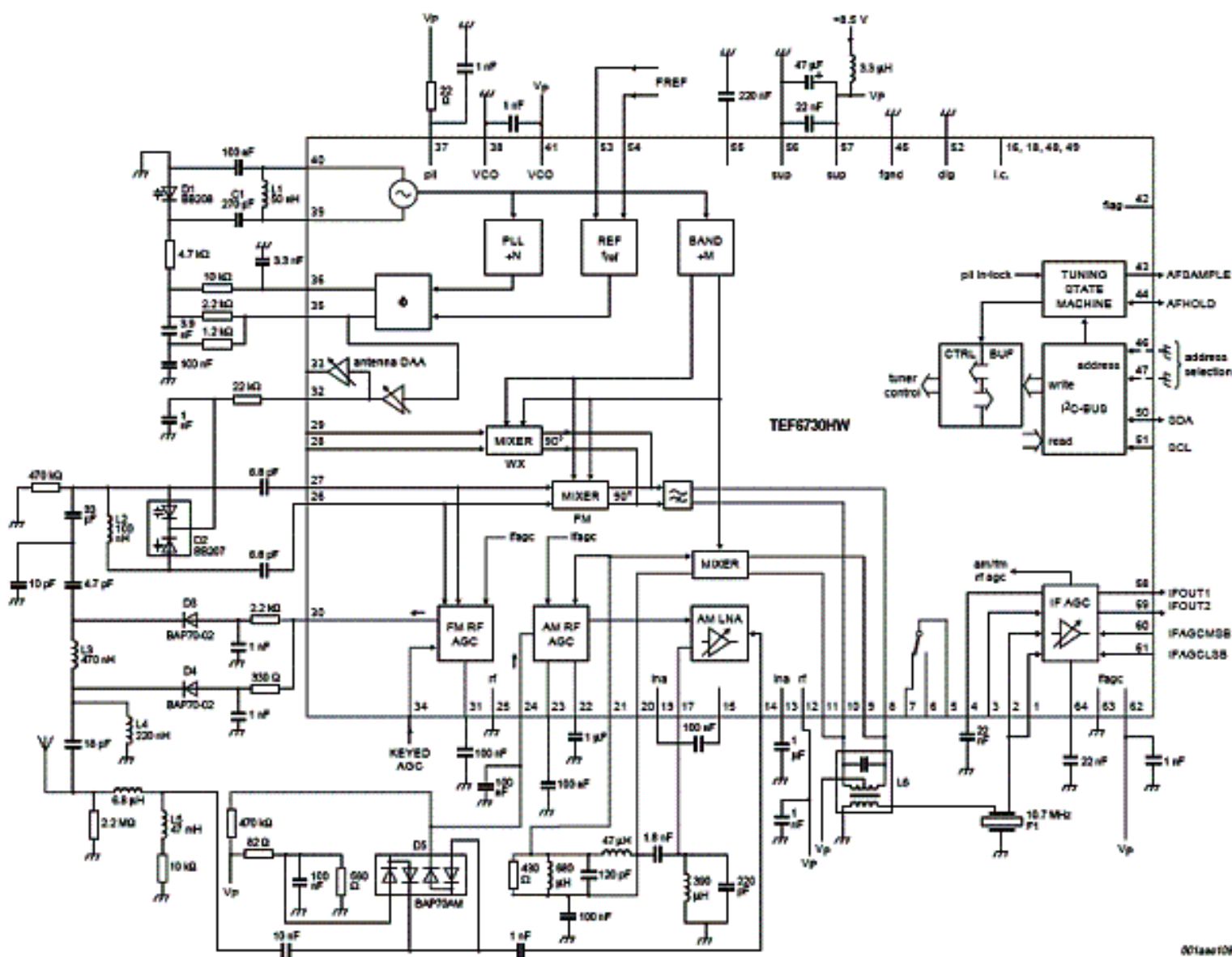
I did not bother to measure intermod performance. According to the datasheet for the chipset used in the tuner design (NXP TEF-6730), the 3IIP is $108\text{dB}\mu\text{V}$ (0dBm) minimum. This is very good for a FM-band-only tuner. Ahead of this is a single, varactor-tuned matching circuit and a PIN diode circuit (see details later in this article). I would not expect problems. (Details of the input circuit are covered in detail in Brian Beezley's article at <http://www.ham-radio.com/k6sti/xdr-f1hd.htm> --be sure to read this as it goes into more depth than this review.)

The XDR-F1HD has a 3-segment bargraph that indicates signal strength. It looks like a cellphone display. It's just about as useless. On mine, there are 3 bars. The first bar turns on for an input signal of -97dBm ($3.1\mu\text{V}$), which is about the 40dB quieting sensitivity, so I'd say that is a useful indicator. The second bar turns on at -89dBm ($7.9\mu\text{V}$). The third bar turns on at -81dBm ($20\mu\text{V}$).

This tuner behaves in an unusual way for weak signals. There is no muting in the traditional sense, where the audio is cut off below a certain RF input level. Instead, there is a gradual reduction in audio output (volume). The muting action starts at the 40dB quieting threshold (again, that is useful). The rolloff is shown here:



Whether or not you like this is probably a matter of personal taste. But it seems to have led to a discussion in the club about just how the antenna gets coupled to the tuner. Following is an application design from the TEF6730 datasheet. The tuner probably has a very similar circuit to this, though I couldn't get the shield off to verify it. If true, this explains much of the behavior of the tuner.



The antenna input appears to connect directly to the mixer on the TEF6730 via a tuned circuit controlled by the on-chip "Antenna Digital Auto Alignment." (The action of the tuner when connected to a network analyzer confirms this circuit is present.) There has been speculation about a noticeable loss of performance if the antenna is not exactly matched to the input of the XDR-F1HD, or, more specifically, the input of the mixer does not see a match into its characteristic impedance (75Ω on the data sheet). Some DX'ers are now talking about inserting a preamp and attenuator between the antenna and the tuner. It's said that by placing the "pad" right on the input jack, you guarantee the mixer sees a proper termination, and the preamp compensates for the loss in the pad. If the preamp gain is greater than the pad loss, then the soft mute threshold is raised by that difference, so you effectively defeat the mute.

The TEF6730 datasheet says the mixer has a noise figure of 5 dB max (3.5dB typical) under certain conditions which I assume are met by the tuner design. This ought to be in the ballpark of any decent preamp, except for perhaps the cheap "bullet" amps you buy at Radio Shack. But be careful because your preamp could limit the performance of the tuner if it creates intermod. It should not have so much gain that it presents an input signal stronger than the mixer can handle. Note the TEF6730 rates the maximum RF input voltage as 75mV (-11.2dBm) minimum at the chip input. Violate this at your own peril.

The pad and preamp suggestion makes sense, though it makes you wonder why Sony bothered with the DAA design if true. It is true that any mixer must see its characteristic impedance on all of its ports in order to perform correctly. However, who's to say the circuit components between the antenna jack and the chip don't present a reasonable match to the mixer? We'll just have to connect a network analyzer to the tuner and find out. I used an Agilent 8753ES.

Figure 1 shows the return loss from 80-120MHz, with the tuner set to 88.1 MHz. Figure 2 shows the same test displayed as VSWR for those who prefer that format. The marker shows the values at 88.1 (-2.2dB return loss, or 7.6:1 VSWR), which is not great. The other marker shows the best return loss happens at 102.4MHz. This explains why my unit doesn't have the sensitivity that others have reported. I hope the tuner that you purchase comes with better alignment than mine did.

Figure 3 depicts Return Loss, with the tuner set to 98.1 MHz. The return loss is only about 2.5dB (VSWR 7.1:1). The point of best match occurs at 113.5MHz, where the VSWR is only 1.3:1. Figure 4 is the same plot, displayed as VSWR. Figure 5 is a Smith Chart formatted display of impedance.

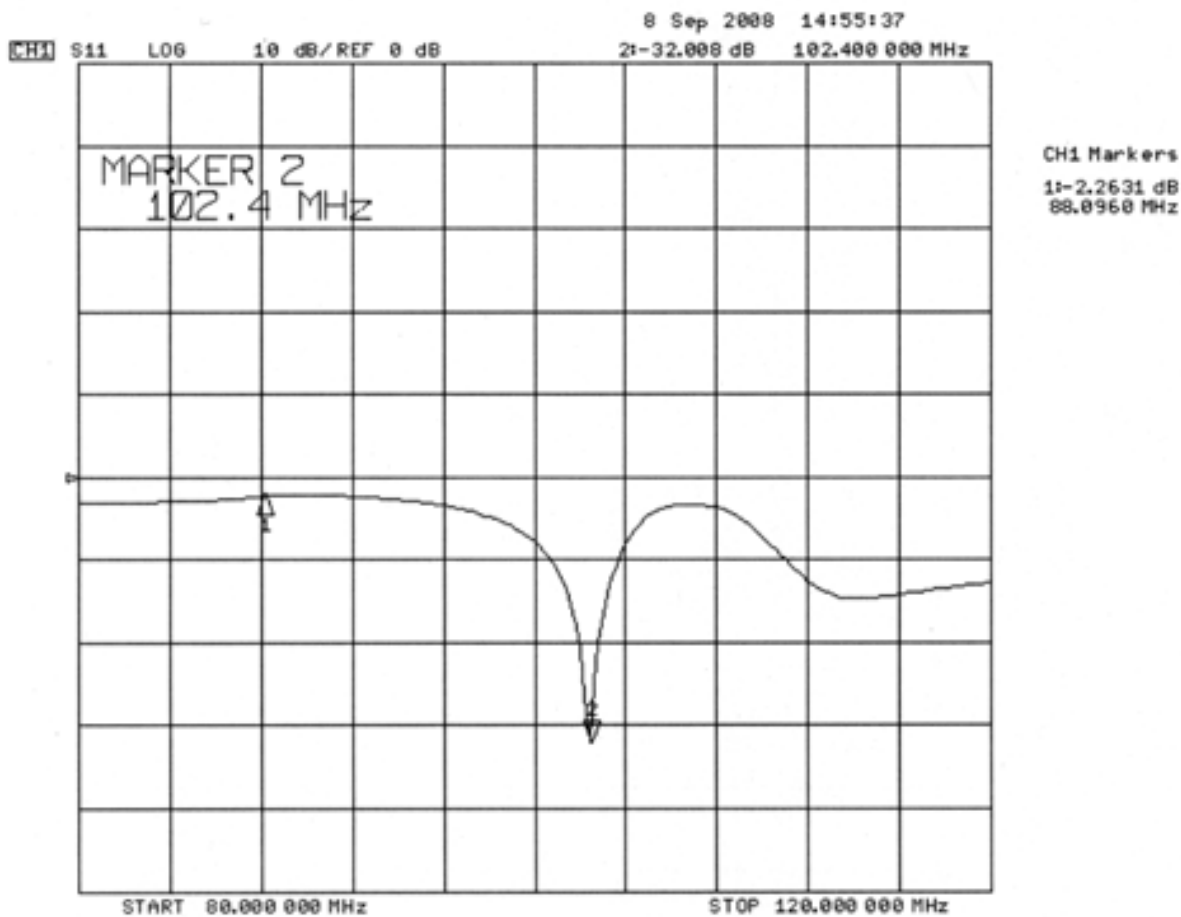


Figure 1 (S_{11} when tuned to 88.1MHz, Return Loss)

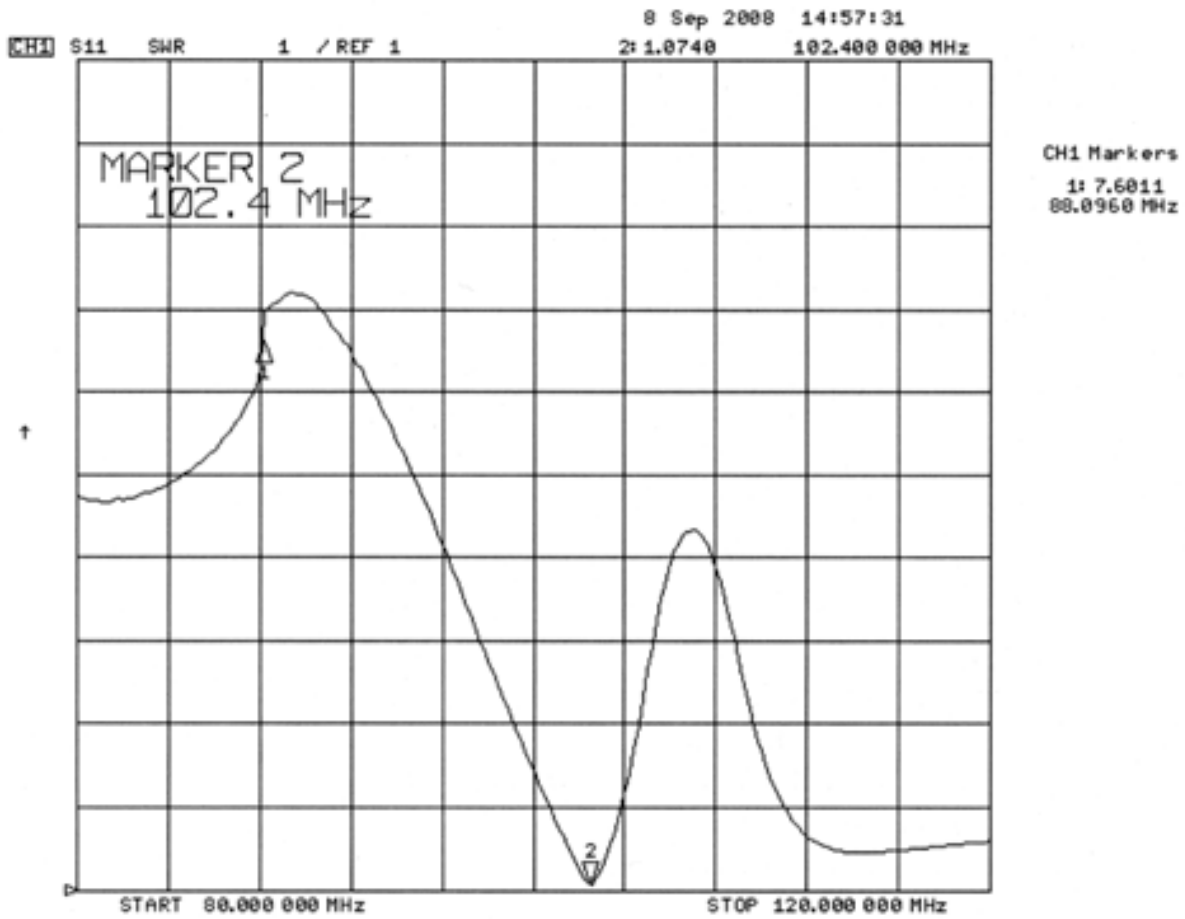


Figure 2 (S_{11} when tuned to 88.1 MHz, VSWR)

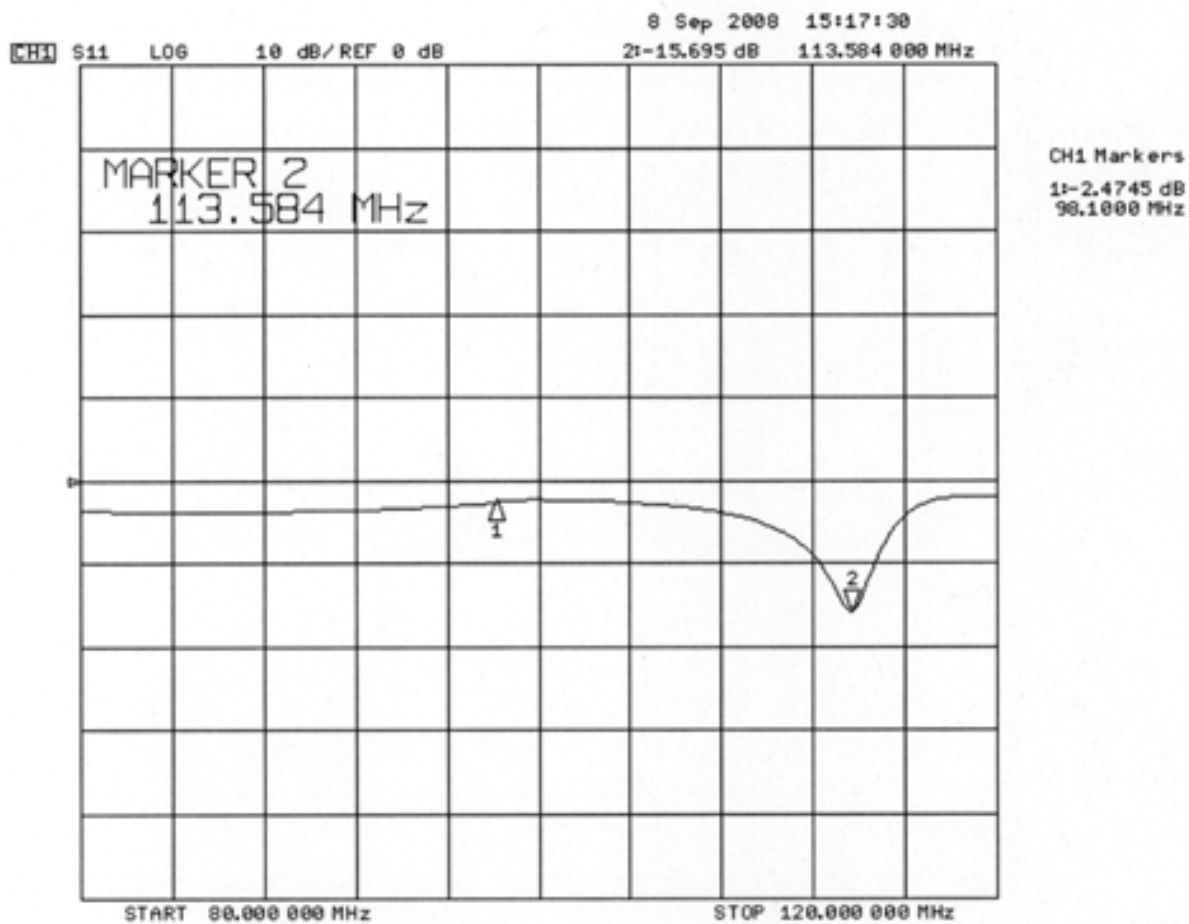


Figure 3 (S_{11} when tuned to 98.1MHz, Return Loss)

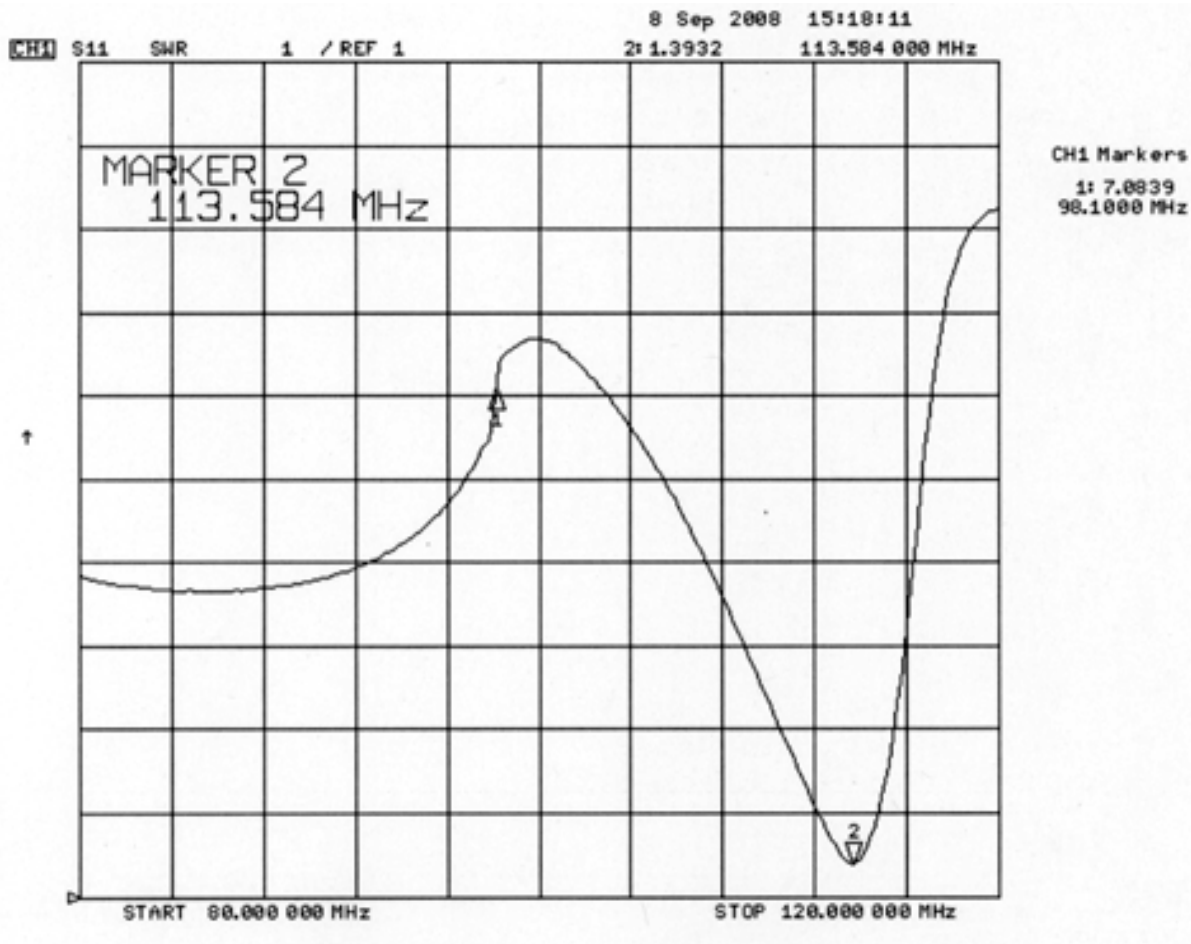


Figure 4 (S_{11} when tuned to 98.1 MHz, VSWR)

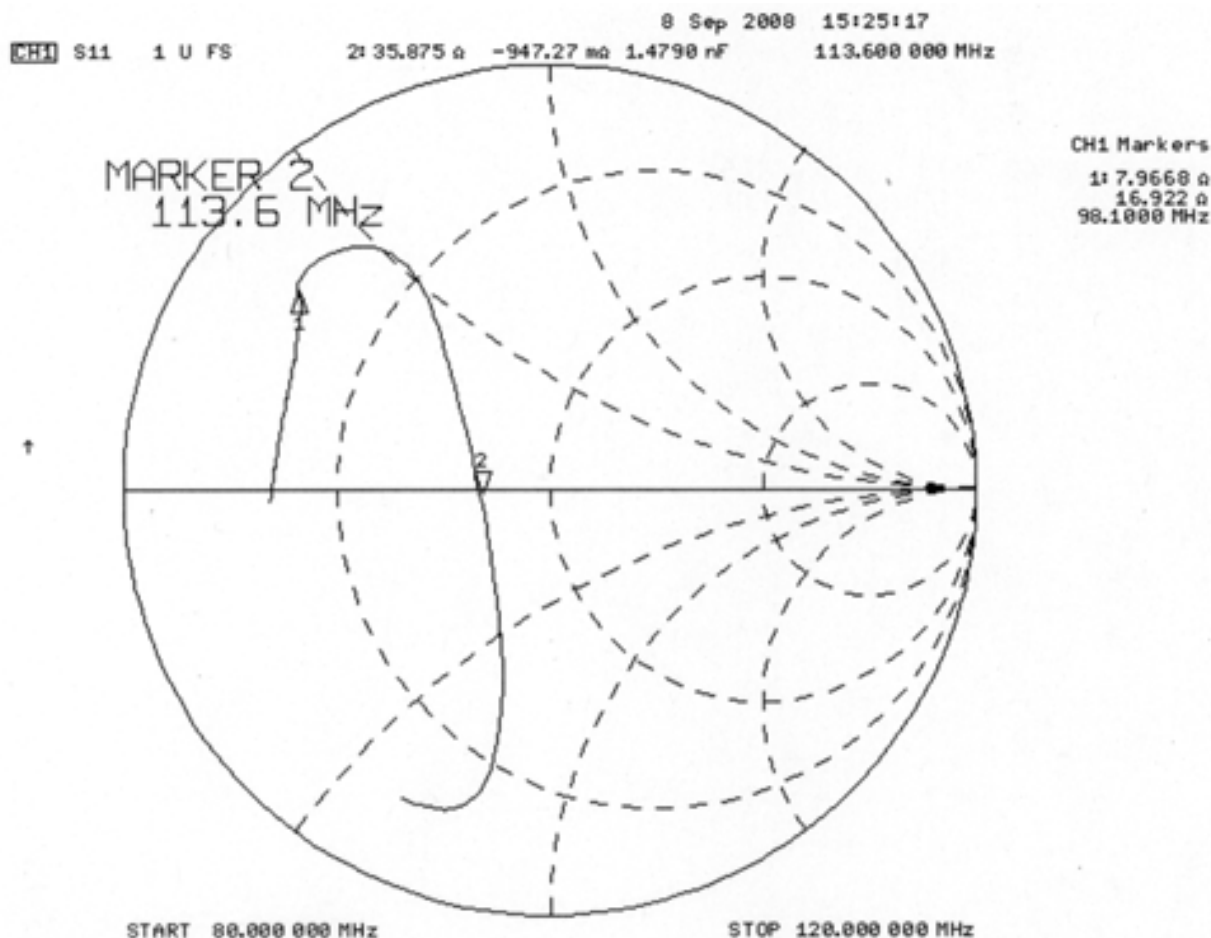


Figure 5 (S_{11} Complex Impedance, when tuned to 98.1 MHz)

Figure 6 depicts Return loss with a 6dB pad inserted. Figure 7 is the same, presented as VSWR. Figure 8 presents the input impedance on a Smith chart. Normally, adding a pad like this is a pointless thing to do. Typically, return loss would improve by the amount of the pad (6dB), but in this case it improved by 14dB (or lowered VSWR to 1.3:1), so the mixer input apparently isn't matched. This confirms the suspicions, and suggests that if the loss could be made up by a preamp with a better than 3.5dB noise figure (especially if it could be installed at the antenna), the misalignment becomes negligible and the overall FM DX system should become quite noticeably more sensitive.

Out of curiosity, I varied the attenuator to see how the VSWR varies. Using -15dBm test power, and with the tuner set at 98.1, the results are shown in the table.

Attenuation	Minimum VSWR across band	VSWR at tuned frequency	Maximum VSWR across band
none	1.08	3.7	4.1
3 dB	1.01	1.7	1.94
6 dB	1.01	1.27	1.39
10 dB	1.01	1.09	1.16

20 dB

1.01

1.02

1.03

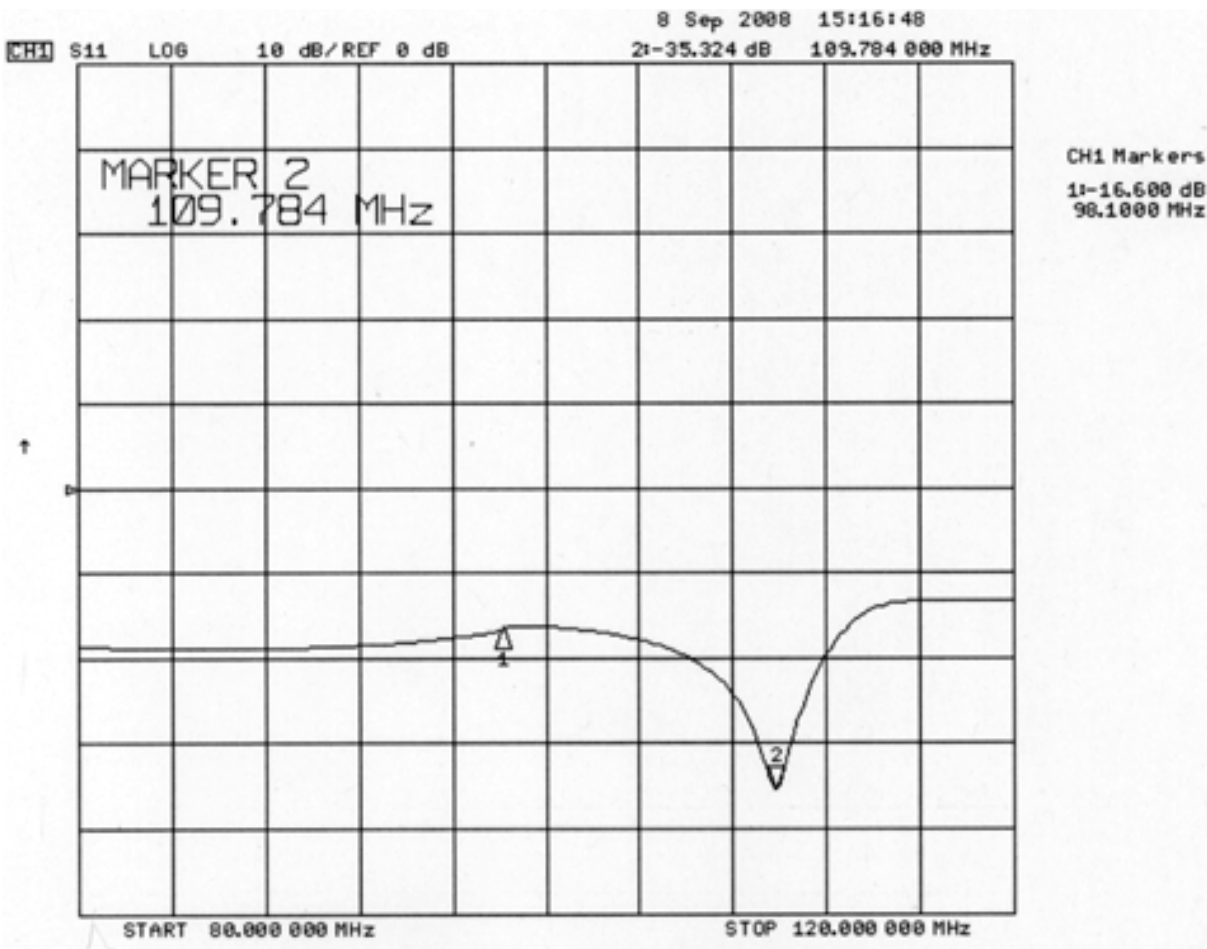


Figure 6 (Return Loss, tuned to 98.1 MHz, with 6dB pad)

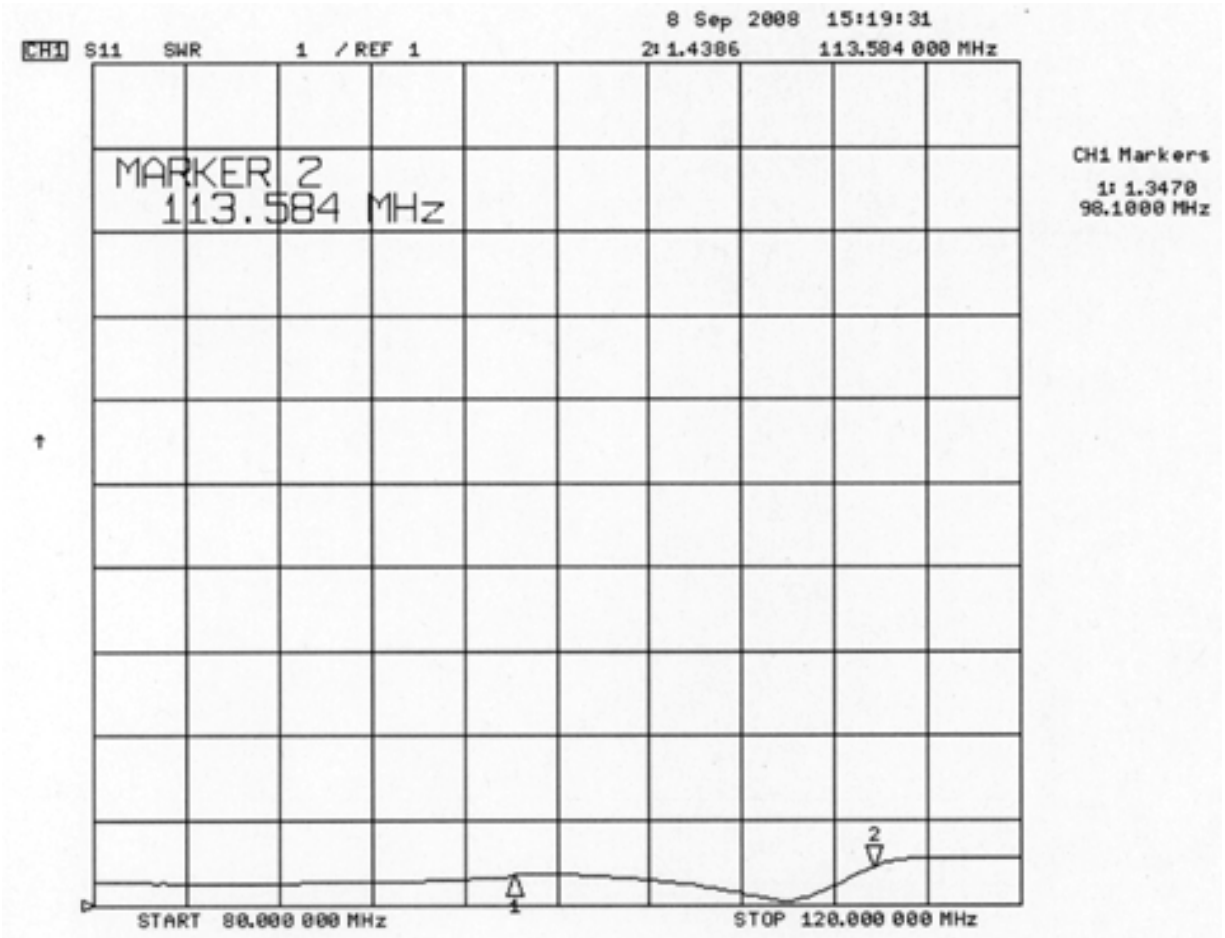


Figure 7 (VSWR, tuned to 98.1 MHz, with 6dB pad)

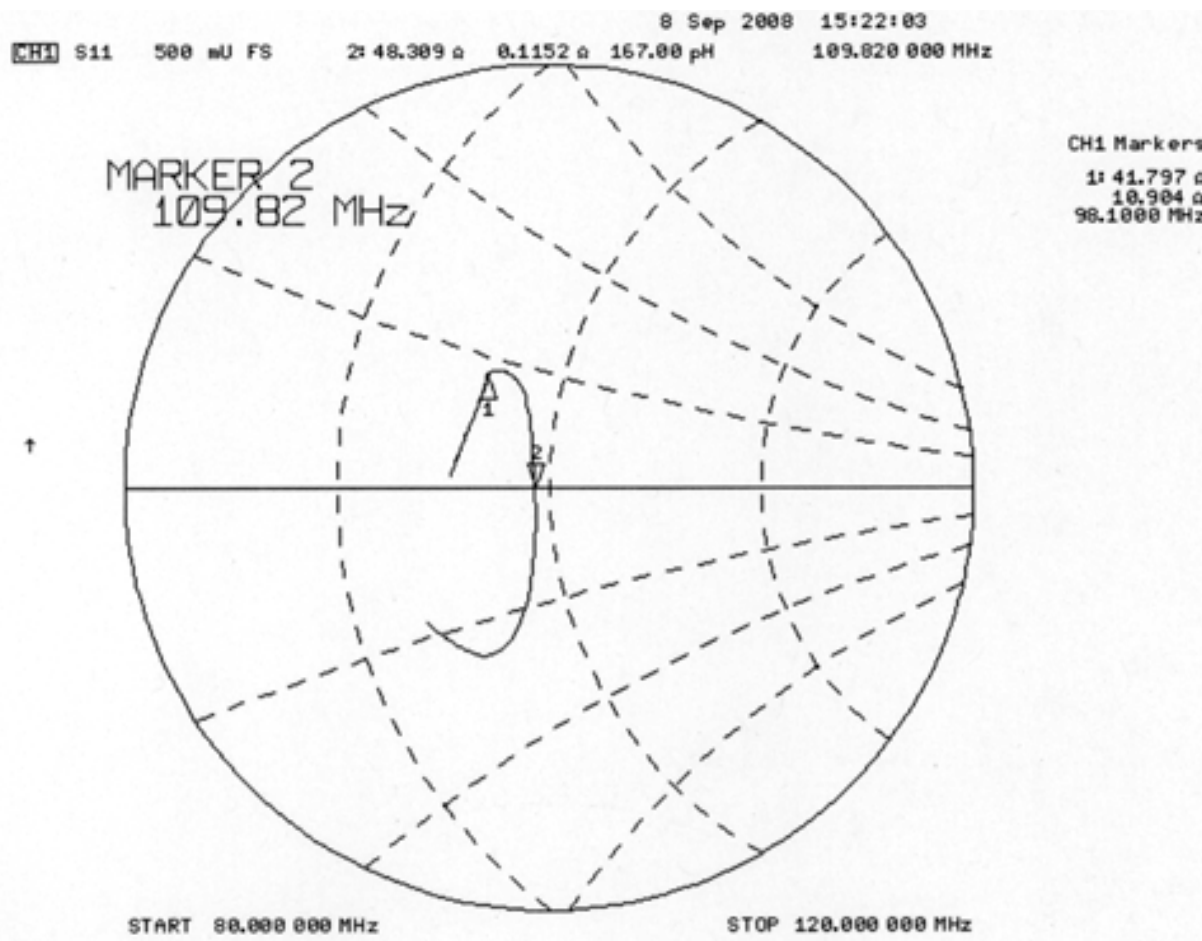


Figure 8 (Impedance, 98.1 MHz, 6dB pad)

The input characteristics of the tuner vary with the tuned frequency. Figures 9, 10, 11 show Smith Chart displays of the input, with the 6dB pad inserted, using a source power of -15dBm. (Note the sweep range in these plots is 88-108 MHz.) In each, marker #1 remains at 98.1MHz for a visual reference. As the tuner is tuned from 88 to 108, the VSWR at the tuned frequency didn't change appreciably. Instead the entire function simply moved in frequency, presumably because of the DAA circuit. This is why the min and max VSWR across the band varies with tuning. The plot for 92.7 was included because that was the frequency with the greatest deviation from 50 Ω .

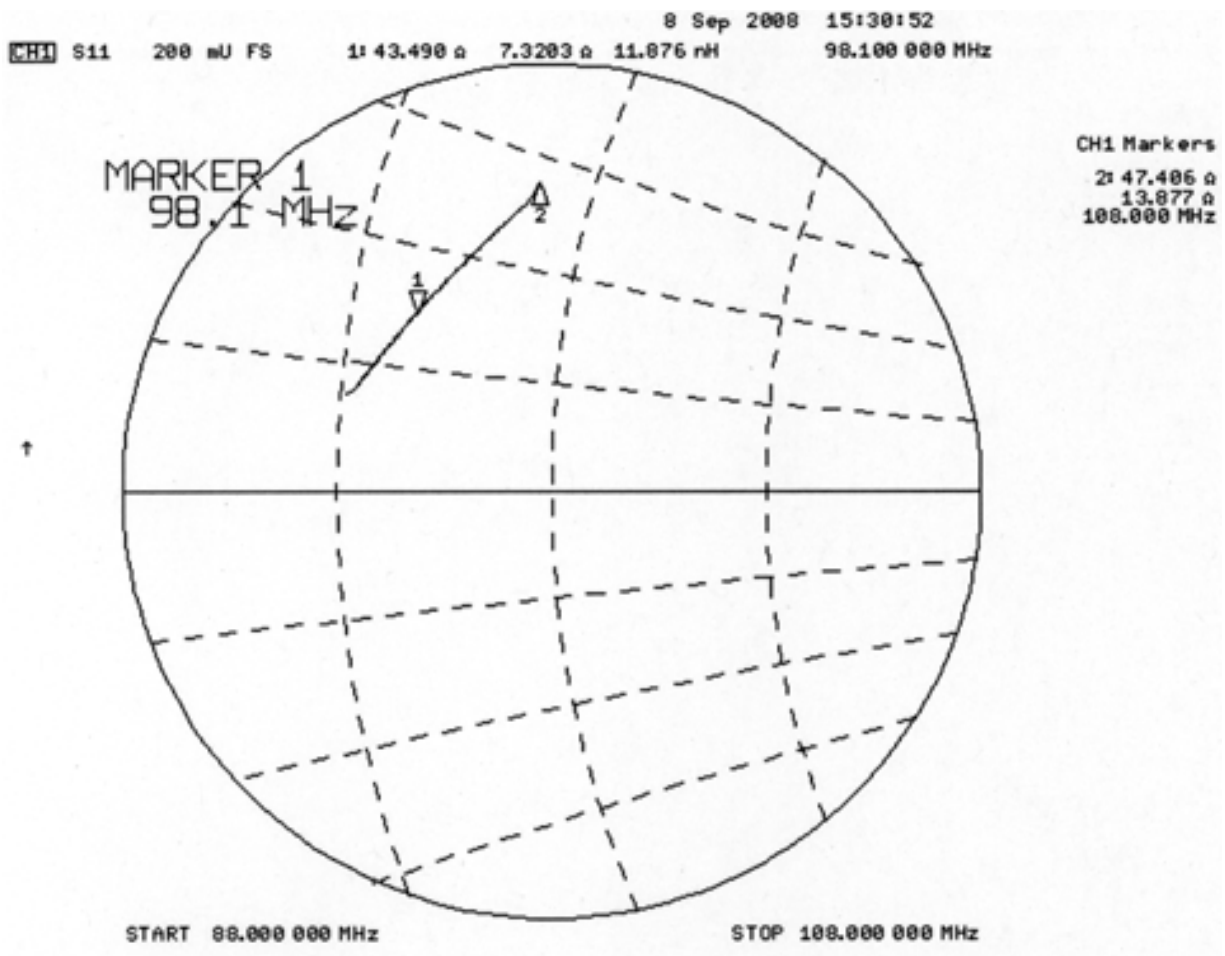


Figure 9 (Impedance, 107.9 MHz, 6dB pad)

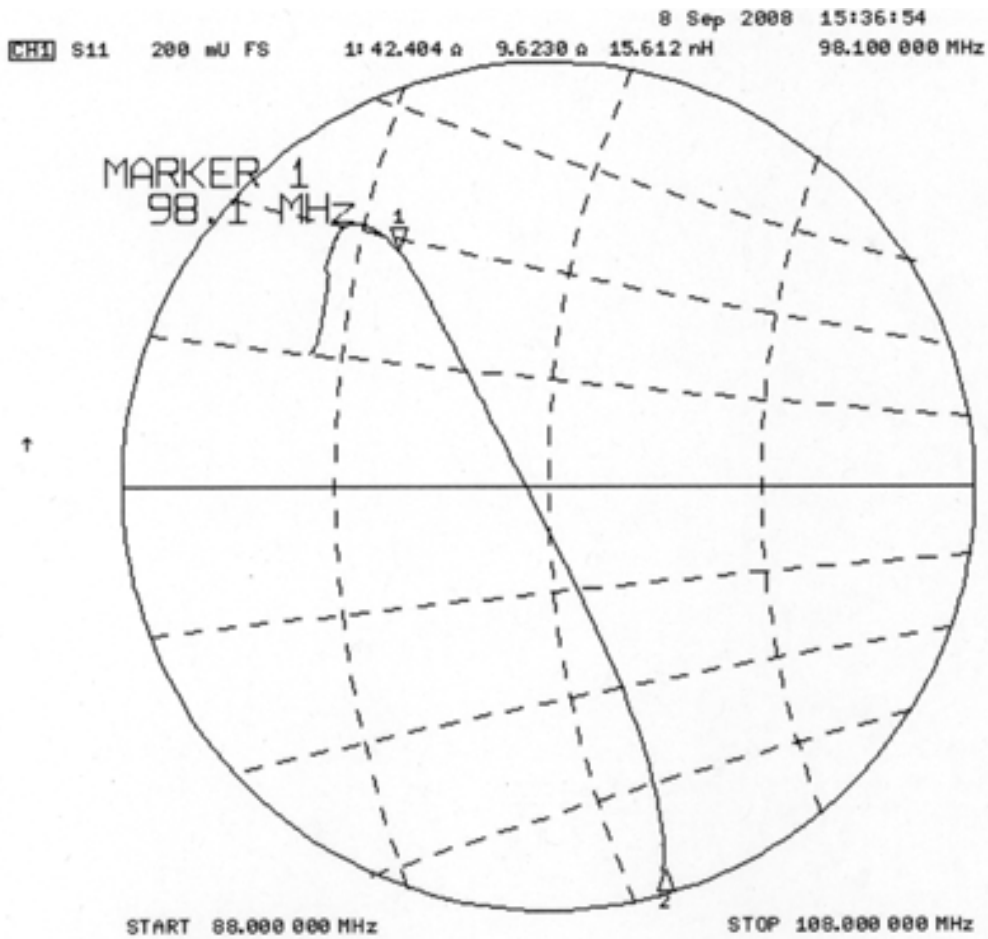


Figure 10 (Impedance, 92.7 MHz, 6dB pad)

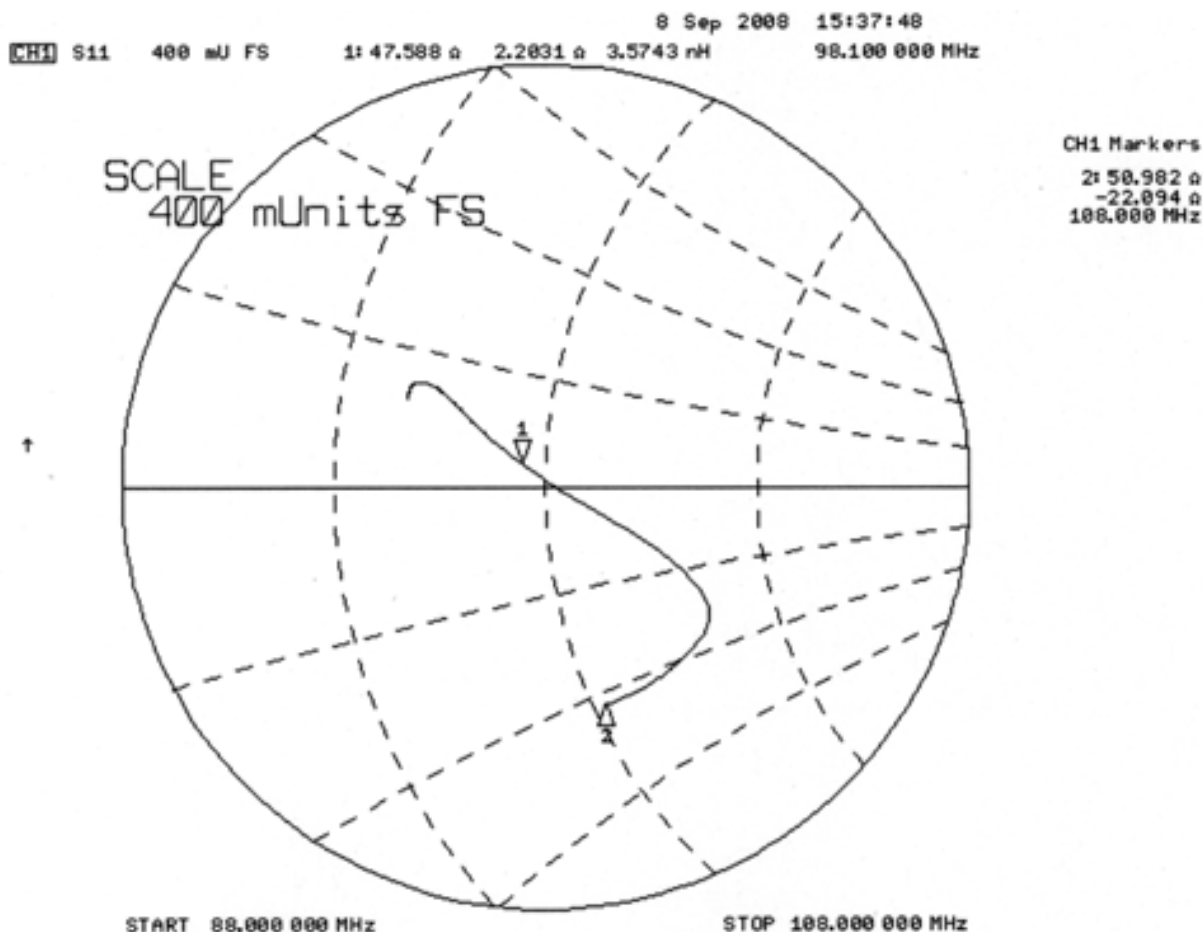


Figure 11 (Impedance, 87.9 MHz, 6dB pad)

There is an antenna peaking coil (according to Beezley, cited above) that I could have adjusted to align my unit. However, my front end shield was soldered together. I used a 250W soldering gun (!) and managed to remove one side, but not the side I needed to access the coils. This cover was on so securely that it would have destroyed the tuner to remove it. So, I decided to live with the misalignment. By the way, I tried connecting a pad and preamp at home and saw little noticeable difference. There was no frequency where I could hear a station that I couldn't hear without the pad/preamp. I recognize that others may have different results due to their antennas, signal environment, and degree of misalignment. My antenna is an APS13 which has better than 3.0:1 VSWR across the entire band, and better than 2.0:1 across 70% of the band.

I made a valiant attempt to find hacking points in the XDR-F1HD. There are two modifications (other than the alignment) that I would really like. One is to have an old-fashioned knob to spin. This would be fairly easy to do since one merely needs a couple of switches to wire in parallel with the up/down tune buttons on the case. Mount the reed switches on the back of a weighted knob, then mount the knob in something. However, the plastic case of the XDR-F1HD is too small to mount it anywhere! More important for DX'ing, however, is a place to connect an S-meter. I instantly judge band conditions with S-meters. I measured and probed everything I could on both modules, to no avail, looking for some voltage that varied with input power. A careful study of the TEF6730 data sheets convinced me that such a voltage is not available. There seems to be no way to add an S-meter to this

tuner.

The IF (10.7MHz) is readily available ahead of the DSP filter and demod, and could be brought out to drive an external RDS decoder or SCA decoder.

The tuner is a delight to use, though it has some foibles. It doesn't allow direct entry of frequency (which is kind of silly since the remote control has a keypad). The S-meter is useless. And the display doesn't display all the RDS info a DX'er might want to see (but it is perfectly adequate for any normal usage). That power transformer runs very hot...it seems almost dangerous. I like the 100kHz steps, and I set a preset for every 1 MHz to allow for quick movement up or down the dial. The angle over which the remote works is very limited. But these are trivial quibbles that pale in comparison to the marvelous technology inside the box.

This tuner represents state-of-the art; the technology inside is amazing. \$99 buys an FM tuner that is as good as any FM tuner ever made, for purposes of DX'ing. The unit is small enough to be made portable. You could power it off an inverter in your car, or hack it to run off batteries (the board requires only 5.0 and 10.0V unregulated DC power).

I recommend that every DX'er purchase one. Every other radio or tuner in existence you can buy for \$100 probably has lousy DX performance (especially in the areas of ACS and overload rejection). To keep up with the performance of the XDR-F1HD, you must find (and align) one of the very best of the 70's or early 80's era tuners. If you already have an excellent tuner, it might still be good to buy one of these XDR-F1HD's and keep it around as a backup in case your vintage equipment falls in need of repair. Our club should probably hoard a few of these for future loaners or auctions. Yes, it is that good. It is not perfect, but it comes close.

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