COAXIAL CABLE EFFECTS ON THE HIGHER BANDS

I am sure you all remember hearing somewhere, that you should always measure your antenna with your SWR meter as close to the antenna as possible. The ARRL Handbook has been touting that fact since for as long as I can remember. One modification to this mantra was to insert a half wavelength between measuring device and antenna. As we all know, an impedance will repeat itself every half wavelength , so the antenna impedance will be reproduced a half wavelength away, no matter what shape the coax is in. This can be handy if you are aware of that fact.

On the UHF and microwave frequencies, measuring antennas becomes a problem for several reasons: First and foremost, the measuring devices are fewer and more expensive than their low frequency brethren. Secondly, the results can be skewed by deficiencies on coaxial cable, and improperly applied connectors among other things! Going back to the first point: You cannot buy an MFJ SWR bridge for 2.3 GHz. (yet). Most hams measure SWR by using surplus directional couplers and power meters. Another hot setup requires the directional coupler, crystal detectors HP-415 meters, and signal generators. A few lucky hams have found good return loss bridges that work on all the low microwave bands. The return loss bridge eliminates the directional coupler and power meter, and typically has a wider and more accurate bandwidth than a typical directional coupler has. You can make a cheap and very accurate return loss bridge yourself. Ordinary resistors with leads will work very well to 450 MHz. Careful construction will extend that to the 900 MHz band. Paul Wade, W1GHZ, took that design and "chipified" it to raise the operating frequency to at least 2304 MHz. This is nothing to sneeze at, boys and girls. All you need with the return loss bridge is a modulated signal source (signal generator) and an indicator such as the HP-415 series. You can even homebrew the 415, but with so many of those things around at fleamarkets, I wonder why anyone would bother, unless they had a special application, such as small size !

OK, now that we know ways to measure SWR at your favorite microwave band, we can look at typical SWR responses that we will encounter in the real world. The second impediment to getting good numbers shows up here. The first band we will look at is the 23 cm band. Below is a nice graph of a recently assembled 2314LYRM 36" long loop yagi. This is a nice little loop yagi that makes a great simple rover antenna. Note how smooth the response curve is. It has great return loss from about 1260 to well over 1300 MHz. "Gosh", you are saying to yourself, "that is such a nice response, I should just go out and buy one of those huh?"

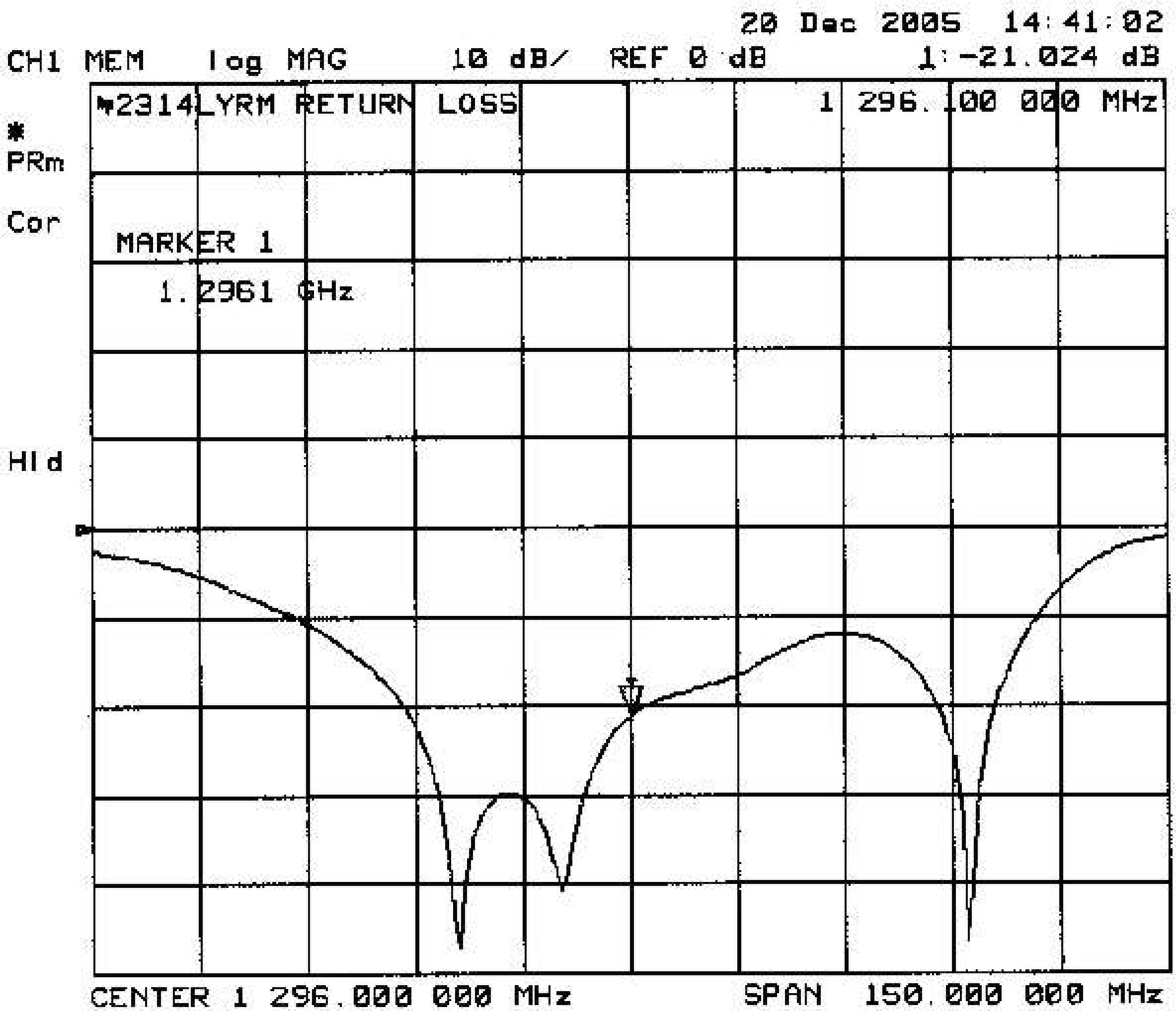

FIGURE 1

Now we start to insert coax in between the return loss bridge and the antenna. Here is that same antenna and about 40 ft of LMR-400 coaxial cable. The first thing you notice is that the nice smooth response now has some ripple on it. The match is still pretty good, and under 1.2:1, but you can see that the response has been changed for the worse. The original response is superimposed on the graph as a comparison.

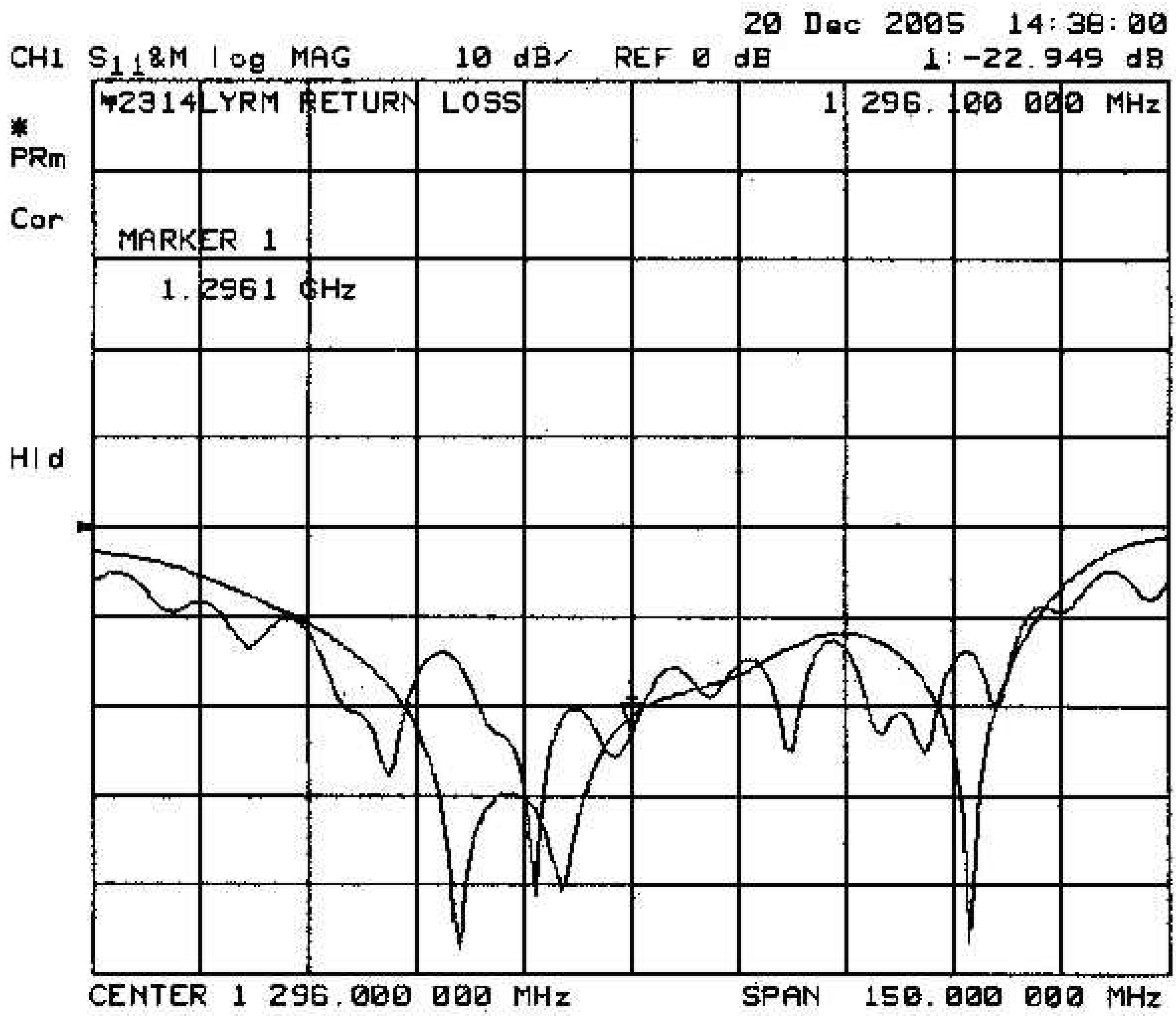

FIGURE 2

The bumps are quite noticeable. Note that there is a spacing between nulls on the rippled curve. The spacing is less with longer runs of cable. What is going on here? The fact is that you are now measuring the imperfections in the coaxial cable as well as those in the antenna. They both interact!

OK, now I am going to insert about 15 ft of old RG-8 cable that has had the markings rubbed off it from many years in the hot sun and the driving rain. (See below) This is cable that should be thrown out. Look what it has done to your beautiful antenna response!!! This is just awful. What it is telling you is that any piece of coaxial cable is "suspect", and unless you have means to test it, you should treat any piece of coaxial cable in your test setup as a source of significant error. Said another way, it is pointless to adjust your 1296 loop yagi while looking through 10 or 15 ft of cable that is of unknown return loss quality. (Been there....Done that!) . If the cable will provide a match with inherent ripple of about 20 dB return loss (1.2:1), then you can only adjust your antenna to about a 1.2:1 VSWR. If you do better, it is not real, and you are just conjugately matching your new antenna to an imperfect piece of coax in your test setup. When you connect to another feedline later on, and try to work your buddy Wally across town, the match will be much worse!

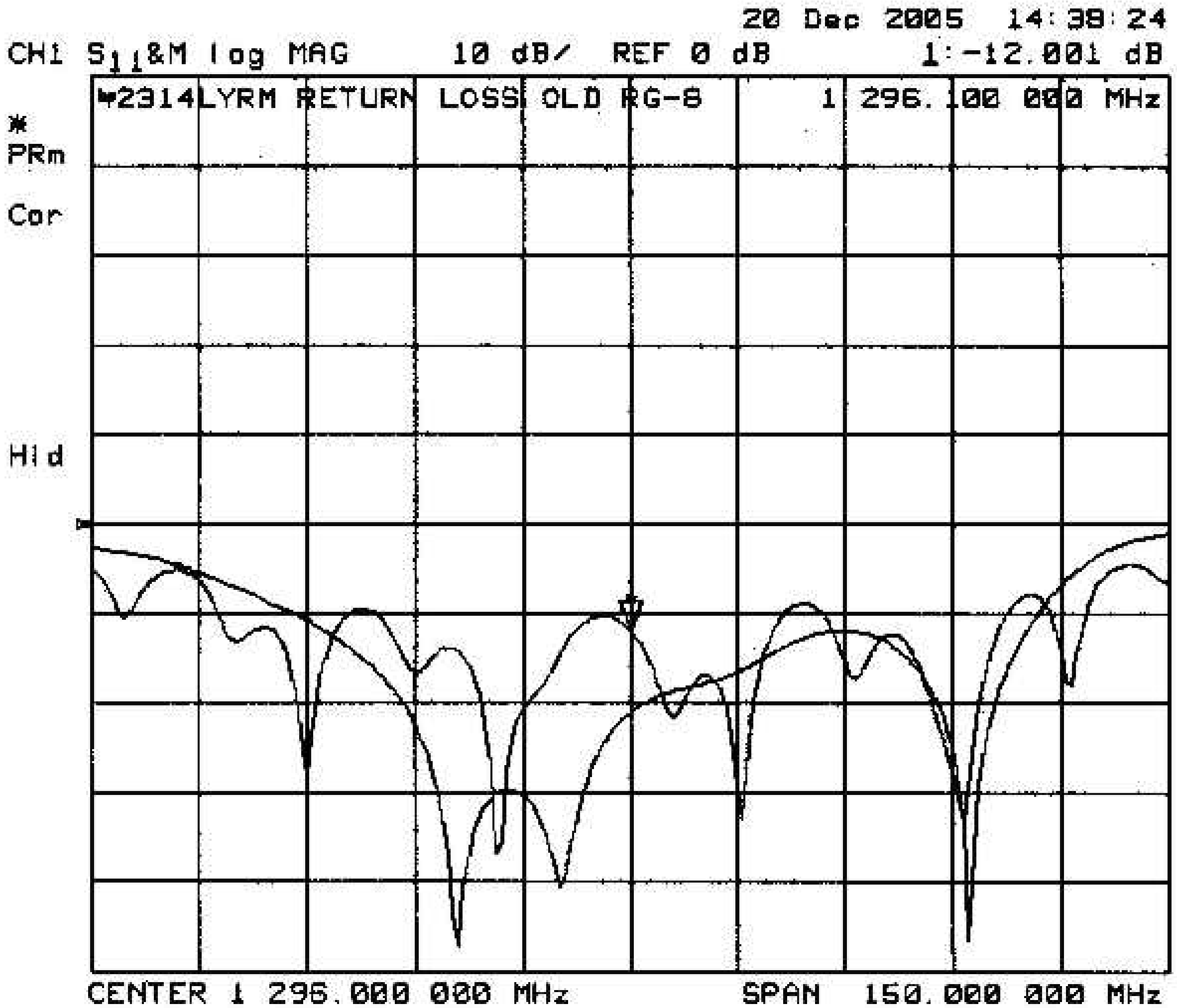

FIGURE 4

The last 1296 charts shows a run of 140 ft of Belden 9913F coax connected to the same antenna. This is a flexible version of the quasi air dielectric 9913 cable. Note what has happened. First off, the ripple is very much in evidence with many more bumps due to the increased length. Note also that the VSWR seems pretty good everywhere! The ripple is down quite aways, as this is pretty good cable at 1296. Next I will disconnect the antenna entirely. Note that the return loss has remained at about 15 dB or about 1.5:1. The transmitter will like the match, but you will not work anyone with no antenna attached. This exercise shows that, as you increase the length of coaxial cable, it gets harder and harder to determine how well your antenna is working. It is truly like trying to look out a window that someone has thrown mud at!

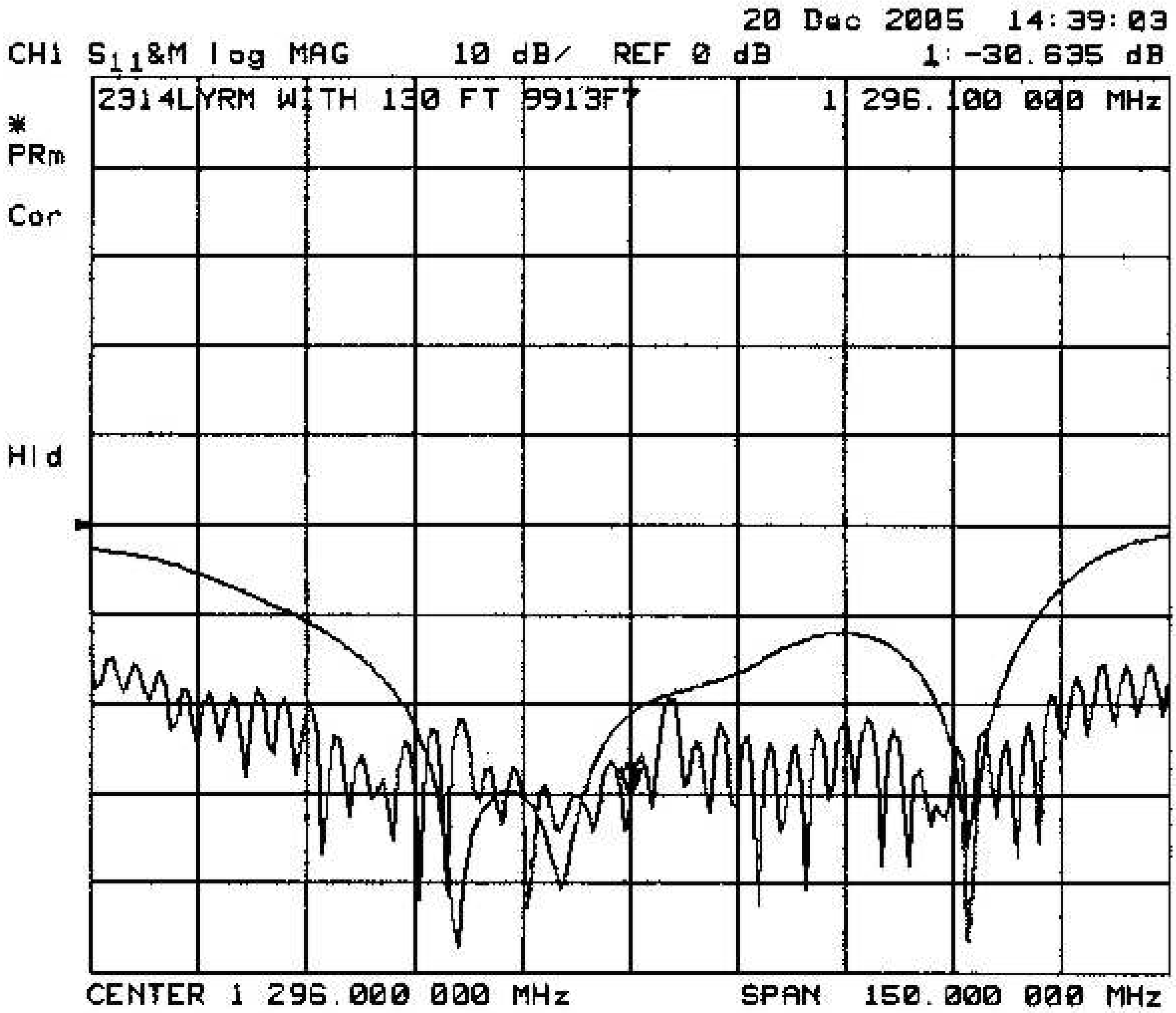

FIGURE 5

140 ft of Belden 9913F coaxial cable feeding a 2314LYRM antenna.

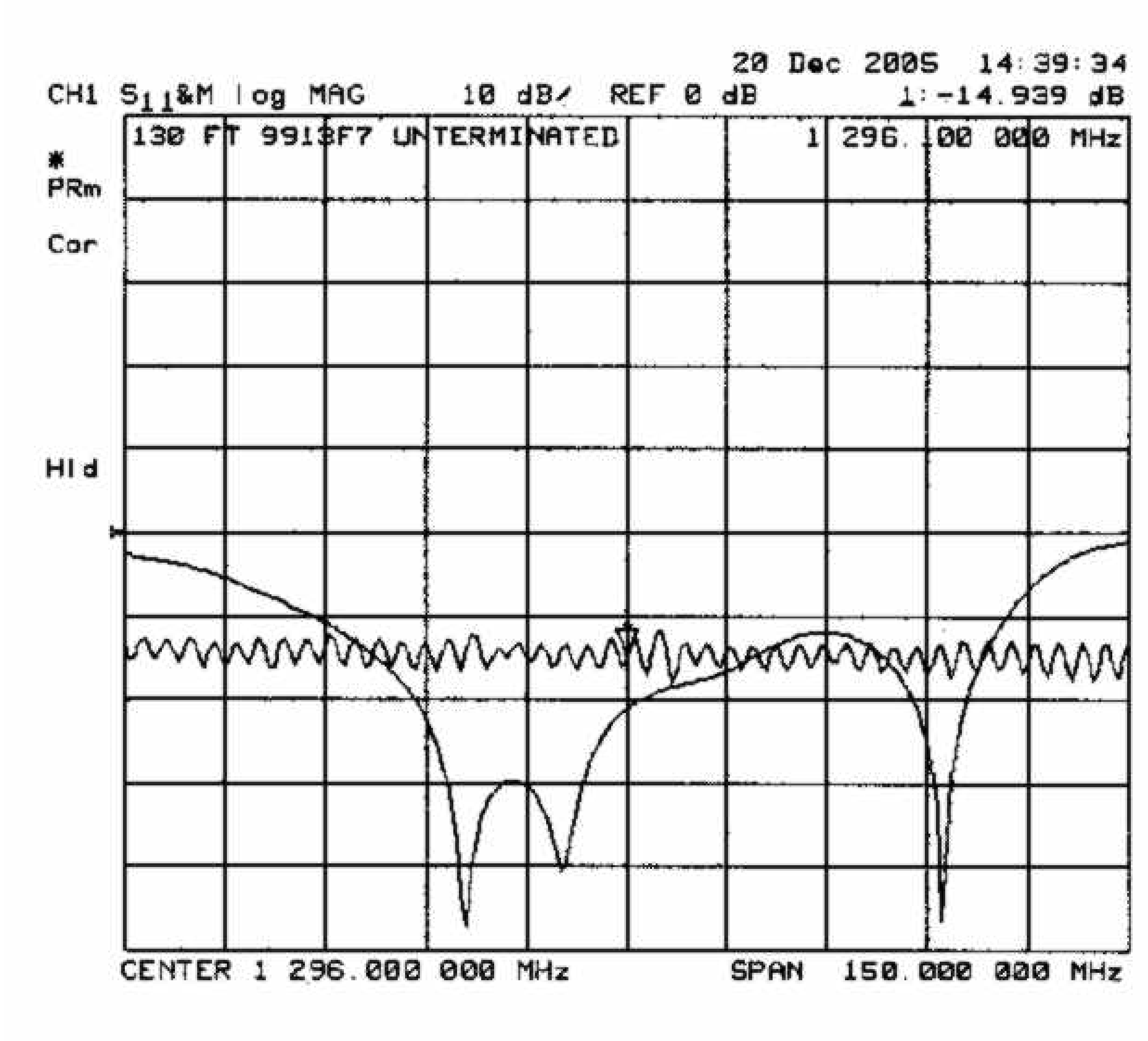

FIGURE 6.

The same run of coaxial cable with nothing connected at the far end! Note that even with no antenna attached, the VSWR is about 1.5:1 at 1296! The return loss is hovering at about 14 dB. The actual loss in the cable is 1/2 of that number. From this curve we can guess that the cable loss is about 7 dB for the 140 ft run at 1296.

Lets now look at 2304. If 1296 MHz looked daunting, 2304 is outright scary. (At least as far as getting a good VSWR is concerned.) Don't get me wrong, 2304 is a great band. It just takes a tad more understanding to wring the most performance out of that band when compared to 432 or 144 MHz. We will now look at the very impressive return loss curves of the 1321LYRM 36" 21 element loop yagi. Gads that is a swell looking antenna!

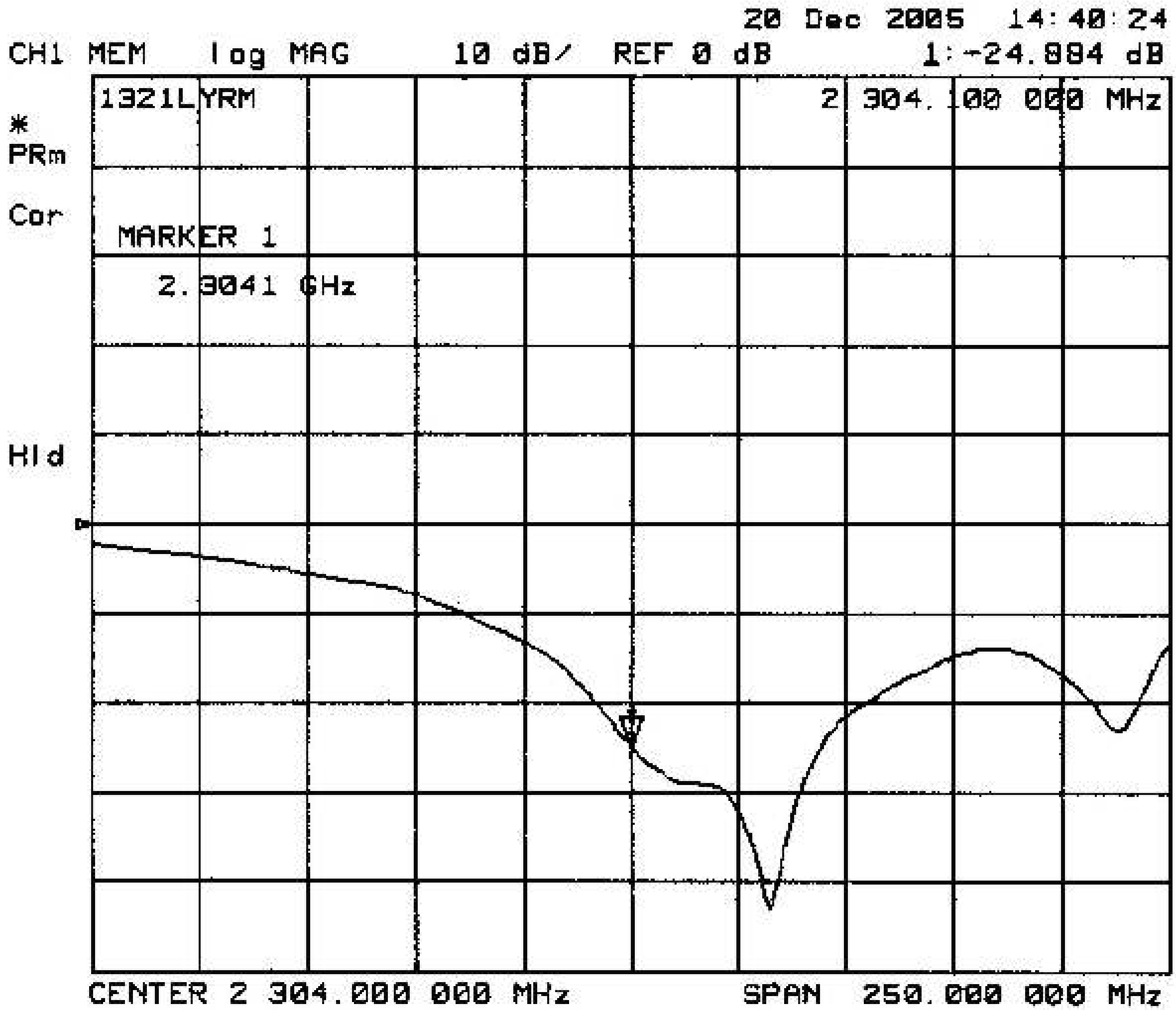

FIGURE 7.

The 1321LYRM antenna return loss curve

Now we put 20 ft of LMR-400 coax in between the antenna and the measuring device. Note that the ripple appears again.

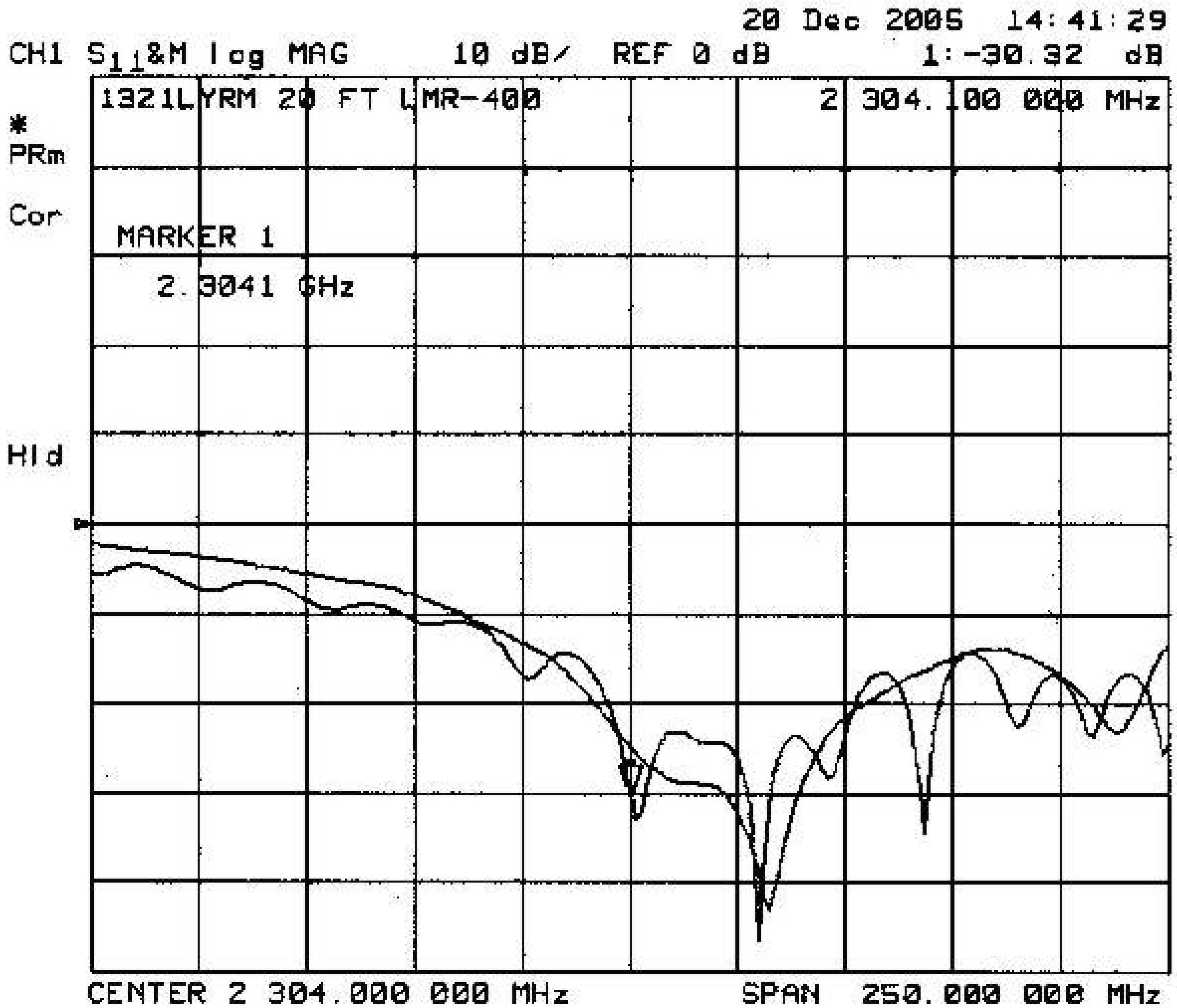

FIGURE 8

Add another 20 ft of coaxial cable for a total of 40 ft and the 2304 response is not looking all that great. At 2304, the difference is not noticed, but at other spots it may be better or worse Note that some of the ripple is at about 18 dB where it had been better than 30 dB before!

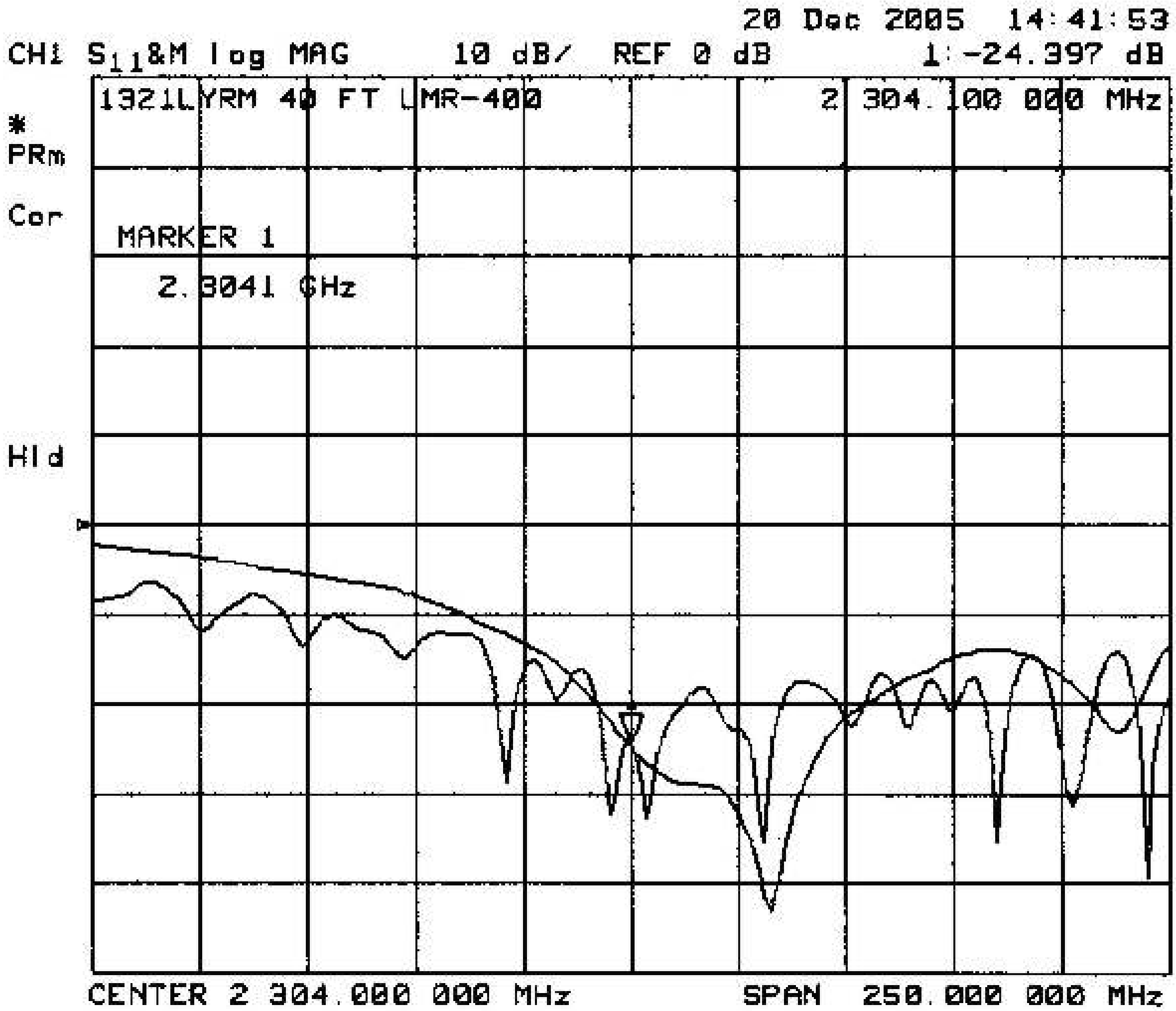

FIGURE 9

Compare this to FIGURE 2 (40 ft at 1296 MHz) to see any increase in ripple with frequency. If you take the same 40 ft run of LMR-400 and terminate it with a good 50 ohm load, here is what you will see.

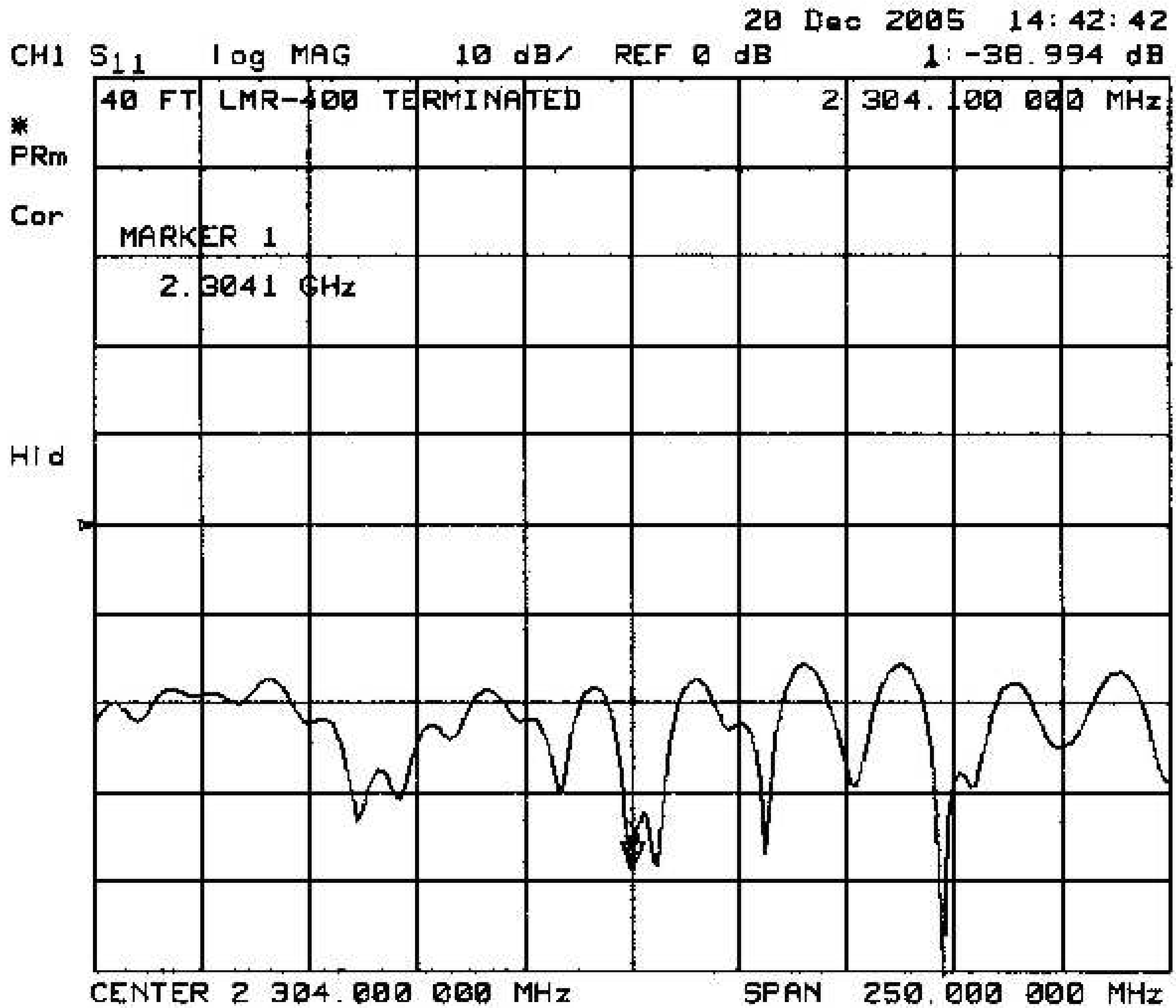

FIGURE 10

Note that the cable is typically exhibiting about a 20 dB return loss, or 1.2:1 VSWR, although, at some spot frequencies it is only 16 dB. This particular piece of cable was almost perfect at 2304.1,but at 2385 MHz it was 1.3:1 or about 18 dB return loss.

Now we insert some bad coax cable. Unfortunately, the old RG-8 used on 1296 was so bad it made the response almost disapopear, so I chose a 20 ft piece of really nice European cable similar to LMR-400, but one that had type N connectors that were improperly applied, and loose on each end. The braid had not been combed out properly, so the braid had loosened over time, and a slight impedance bump appeared.

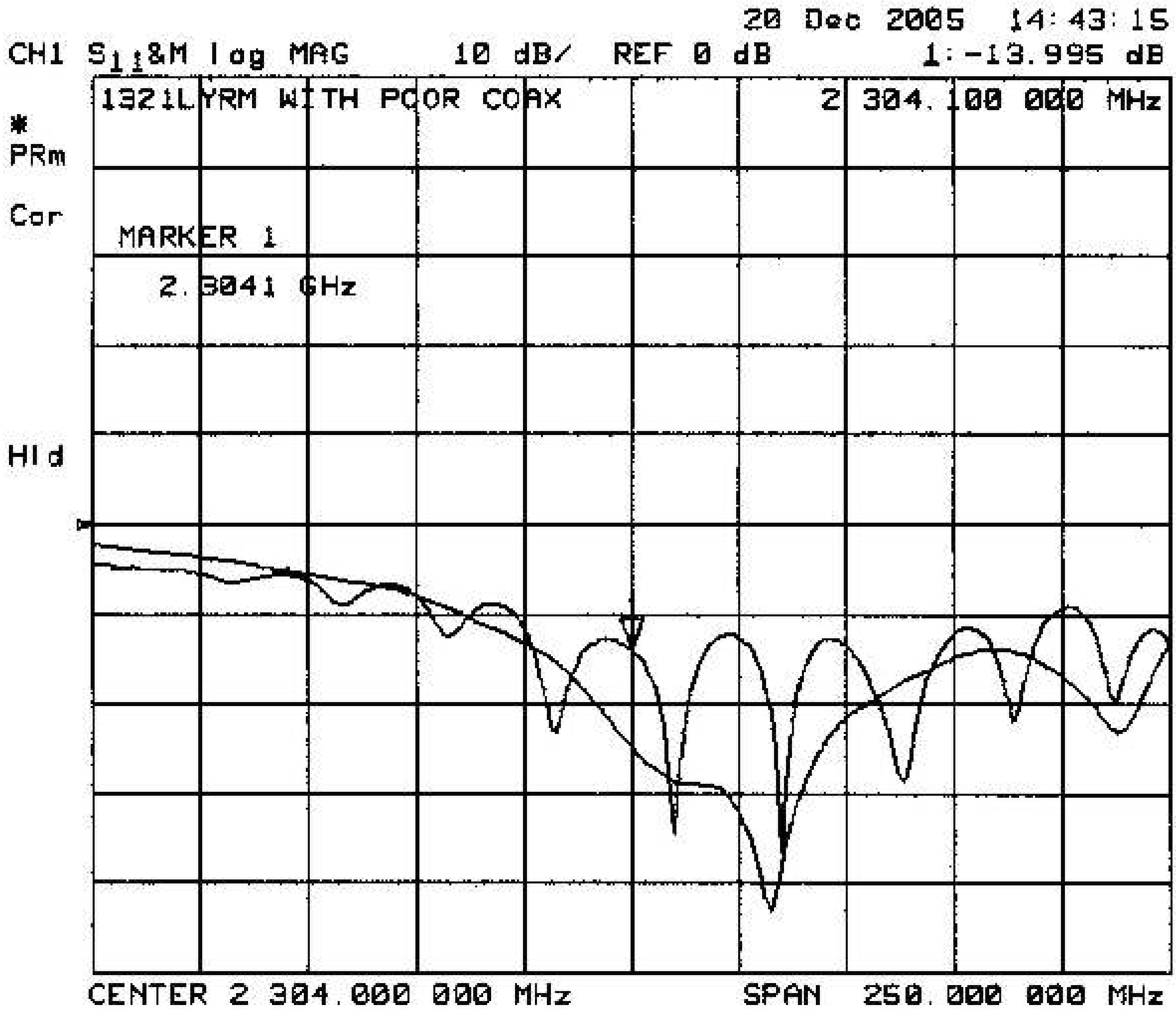

FIGURE 11

This last chart is literally the picture that is worth a thousand words. Look at the two superimposed curves. The only difference being a relatively short piece of nice looking coax has been inserted in the line! The connectors were nice and new looking. The cable seemed new and fresh. In conclusion, on the higher bands every component may be suspect. A poorly assembled or loose connector, a piece of coax, an antenna relay, or power divider, all may be capable of messing up your system. It is true that, by themselves, any fault may not break the system. What they will do is rob you of performance. Your recourse is to be able to measure each component, or, if you cannot measure, then realize that every item can have an effect on the system, and that nothing can be checked with a simple visual inspection in most cases. These VSWR curves were presented with that in mind. I hope you can get a feel for how to analyze your system performance. Be aware that, as you go higher in frequency, good VSWR becomes a more fleeting target. My motto for 2304 is "CHECK EVERYTHING! NOTHING WORKS AS IT SHOULD!" If you can get better than a 1.5:1 SWR in your shack at 2304, you are doing well. The trick is to be able to divide the system up to check individual components. Then put them all together. This is the route to getting the most performance (and enjoyment) out of your system. By gaining some insight into how coaxial cable behaves at these frequencies, you can develop the skills needed to keep your system in good operating condition.