CONSIDERATIONS FOR CONSTRUCTION OF LNA / RELAY COMBINATIONS

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INTRODUCTION

Extremely weak signal reception and very high powered transmission from the same antenna presents many challenges. This paper will address various considerations for dealing with these extremes. The focus is primarily on the bands below 23cm, since the bands 23cm and up are usually circular polarized and a high power relay is usually not required due to high isolation between left and right CP ports.

RELAY – LNA CONFIGURATIONS

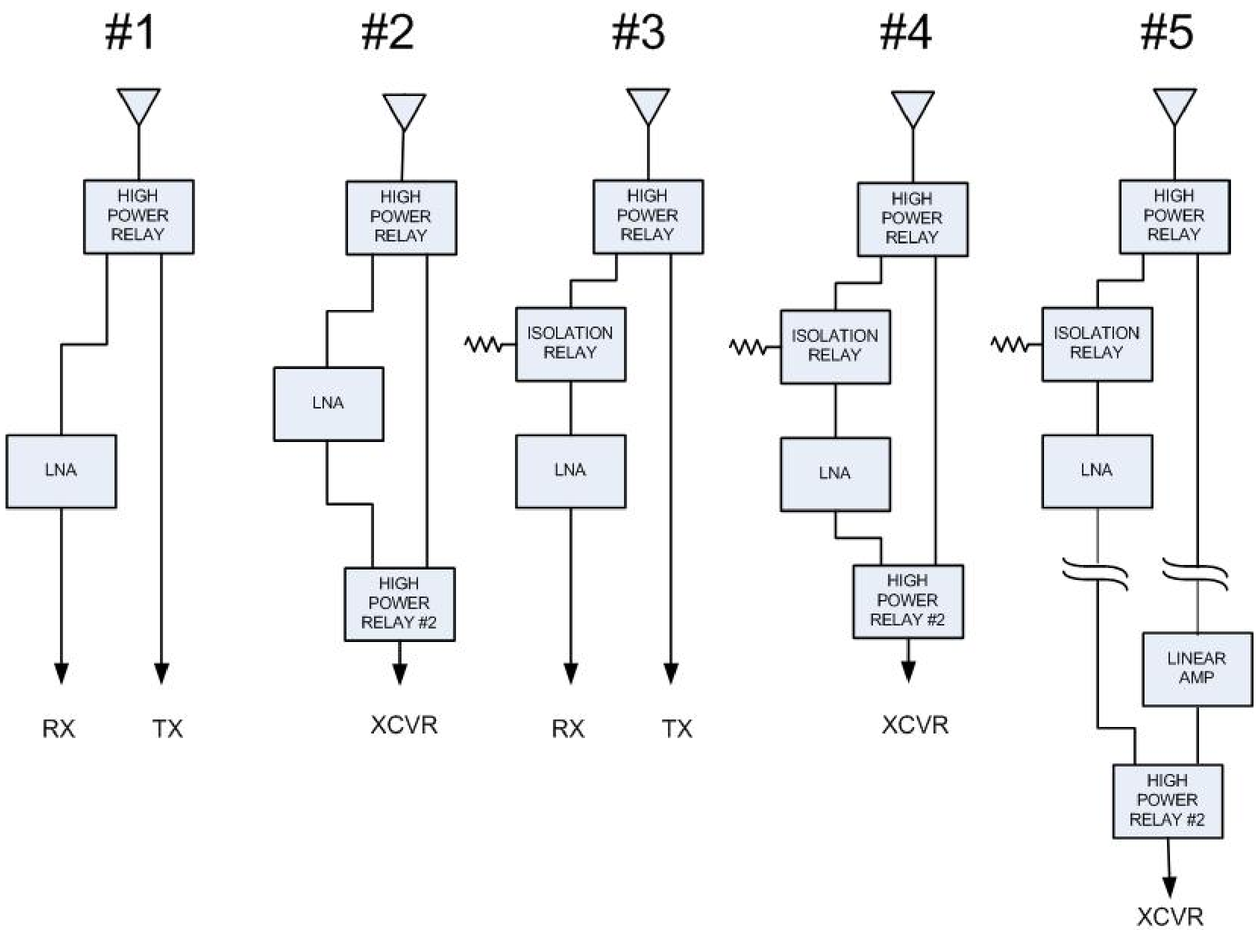


FIGURE 1. HIGH POWER RELAY / LOW NOISE AMPLIFIER CONFIGURATIONS

CONFIGURATION #1. This is probably the most basic usable configuration. The key to successful use of this scenario is the relay. It needs to have sufficient isolation to protect the LNA from the transmitter. What is the maximum power input of a typical LNA? This is a subject within itself, but for this effort, we will assume 0dBm. Assume a transmitter power of 1000 watts or 60 dBm. So the relay needs to have an isolation specification of 60dB. This is easily achieved by many types of relays. And this configuration has the best chance to achieve the lowest loss, and consequently best system noise figure. A drawback is the need for two separate feedlines. Another drawback is that this configuration has no means of terminating the LNA input for benchmark purposes. It also is not quite as failsafe as terminating the LNA input during transmission.

CONFIGURATION #2. This is a variation of scenario #1 that utilizes another high power relay at the antenna, to eliminate the need for two feedlines. An important requirement is that relay #2 needs to have sufficient isolation to protect the *output* of the LNA. A drawback is that use of a High Power Amplifier (HPA) will require another relay in the shack to switch between the receiver and HPA.

CONFIGURATION #3. This configuration provides the most fail safe situation. A drawback is the need for two feedlines. Another drawback is the additional loss of an isolation relay and associated cabling ahead of the LNA. For weak signal work and particularly EME, these additional losses can result in lost contacts. It is a tradeoff between having the ultimate fail safe situation or a few tenths of dBs on that extremely weak station you have been trying to work for weeks or months.

CONFIGURATION #4. This is a variation of #3 that places another high power relay at the antenna to eliminate one of the feedlines. Again the drawback is that another relay is required in the shack. Also the second high power relay at the antenna needs to have high isolation characteristics.

CONFIGURATION #5. This configuration has the same characteristics as #3 but needs an additional relay to combine RX and TX for transceiver operation in the shack. The main difference is that this relay can be somewhat smaller (less power requirement, and less isolation requirement).

RELAY TYPES

<u>ALL ABOUT THE TRANSCO-Y</u>. These relays were designed prior to 1960, but are still fairly common. They have very low loss and high isolation, and can handle 1500watts on 144 MHz. They are rated at 500 watts at 1 GHz, so their power rating at 432 MHz is probably 800 to 1000 watts.

Other specifications: typically 0.05dB insertion loss and greater than 60dB isolation at 432 MHz and below. Since most of the Transco-Y's in existence are used or new old stock, they need to be checked before using. One thing I have noticed is that the dc resistance of the contacts seems to be directly related to insertion loss, so initial checks can be done with an Ohm meter. DC resistance for a closed contact should be less than 0.2 Ohms. Some of my best relays measure 0.10 Ohms.

If you notice intermittent connectivity or resistance much greater than a 2 tenths of an ohm the relay needs servicing. If you are fortunate enough to have a relay whose connectors have flat surfaces accommodating a wrench, you can remove the connectors and clean the contacts. I recommend cleaning with solvent and very fine steel wool. For reassembly of units with normally closed contacts, you should energize the coil while assembling. This gets the contacts out of the way so they will not be damaged. With the connector removed, you may have to "help" the solenoid to get started.

If the connectors do not accommodate a wrench, you can take an old N or PL-259 connector and saw off the threaded shell (See Figure 2) and use it as a "grip" so the connector threads won't be damaged. The connector can then be removed with a vice grip.

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If you need to remove or replace the coils, they are NOT THREADED, but a close fit held by a set screw and glue. First you must back out the set screw, which is a .050 Allen screw. And if you try to back it out it will break your wrench unless you heat it first to break the lock-tite. I use a pencil tip torch to heat it first. Often you have to heat it up pretty good since the relay body is quite a heat sink.

Once the set screw is backed out, I have used my old boy scout knife and a small hammer and carefully tap around the edges of the coil to break it loose.

Do you have an open coil that you plan to replace? (otherwise, there is not much reason to disassemble).

Reassembly is pretty much straightforward. Make sure you have it aligned the same way it came out so the contact is aligned properly. Replacing the glue is possibly not necessary, just re-tighten the set screw. If used in damp environment you may want to seal the coil base with silicone.

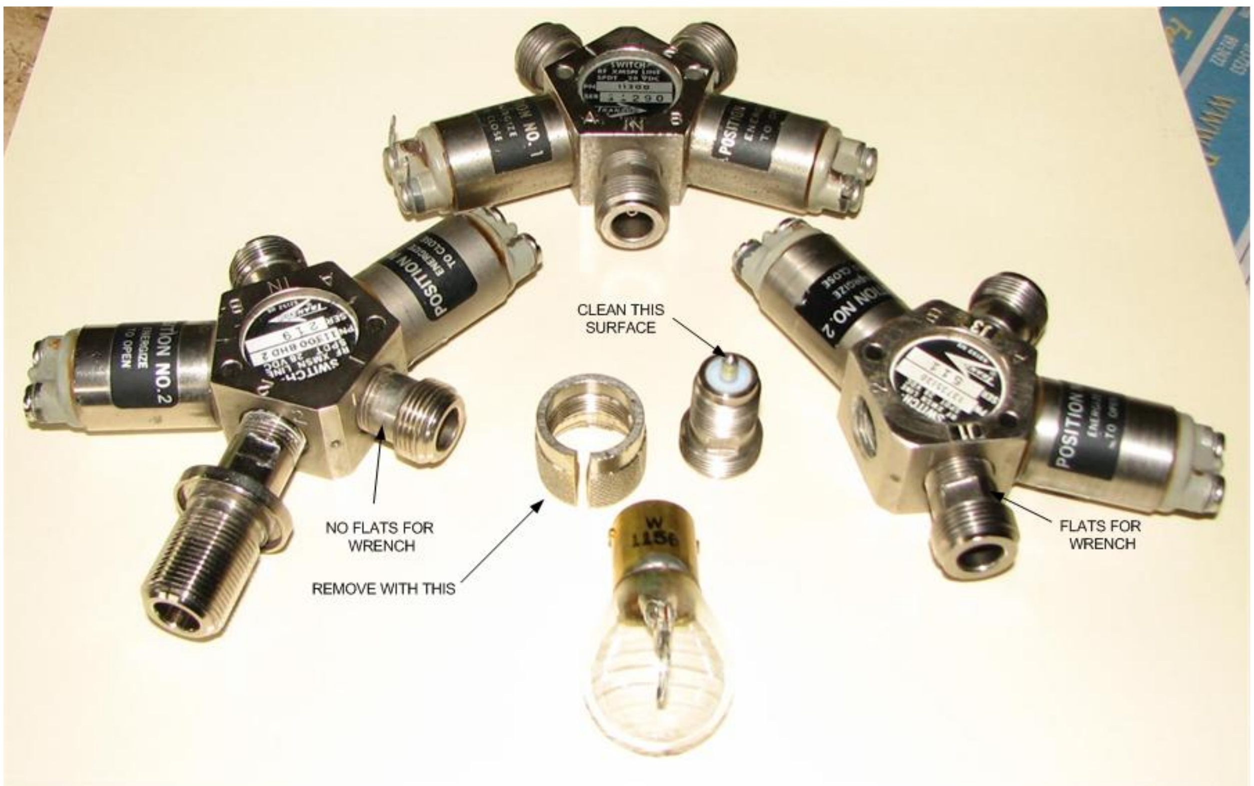


FIGURE 2. ASSORTED TRANSCO-Y AND OTHER ITEMS

Another means of servicing without removing the connectors is to “electrically burnish” the contacts. This can be done by using a 12vac transformer and an automotive light bulb as shown in Figure 3.

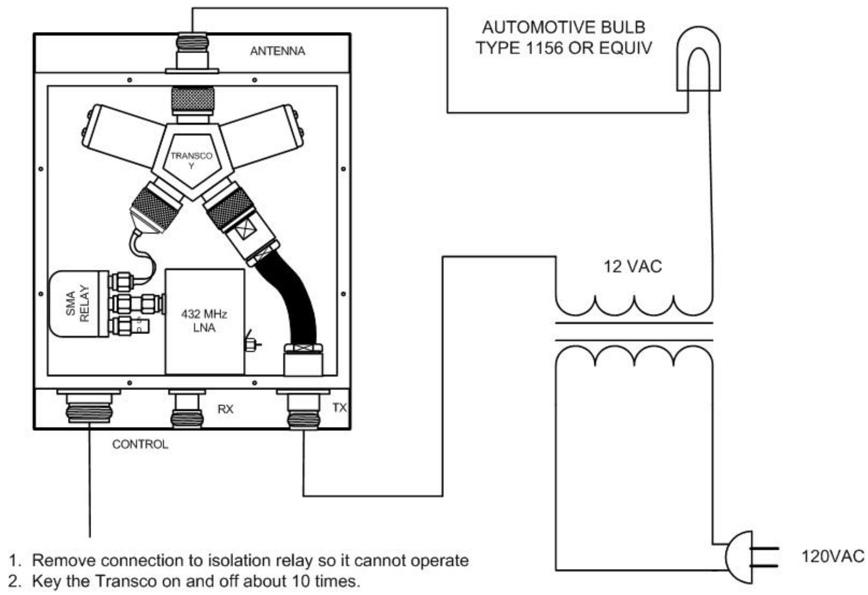


FIGURE 3. ELECTRIC BURNISHING TECHNIQUE

The Transco-Y is usually available for less than $50. Shop around, I have found them for much less. The bottom line is that the Transco is an economical and effective relay to get you on the moon while you continue to search for the perfect solution.

OTHER TYPES OF RELAYS

There are way too many relay types to cover them all here. But I will address a few more common types that I am familiar with and their characteristics.

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FIGURE 4. ASSORTED RELAYS

If you ever happen to see a Transco relay like the one at the top of Figure 4, part number 810C51100, or 810C51200, you should grab it. These are awesome relays. They are rated at well over 4000 watts on 144 MHz, over 3500 watts on 432 MHz. They have terrific insertion loss performance and isolation is 90 dB or more. Their drawback is that they have SC connectors which are extremely hard to come by, but which are excellent connectors if you happen to have some.

The RLC relay in the figure is the same format as the Transco, so I would tend to think that its performance is similar. Its power limitation is probably driven by the N connectors. N connectors should probably not exceed 1500 watts. They probably should not be used at greater than 1kw, but hundreds of us do. Either of these, the high power Transco or the RLC are very scarce.
Worthy of mention is the subject of latching relays. When it comes to protecting your LNA or receive chain, I highly recommend that you stick with fail safe relays. And your fail safe relays should be **energized to receive**. Use of toggle circuits with latching relays for this application is asking for trouble. EME aficionados have all met Murphy and Murphy loves anything complicated where there are potential failures.

The DK-84 at the bottom of Figure 4 is a very good isolation relay. It has excellent insertion loss performance, and it actually grounds the open contact so its isolation is very high. They are rated at around 200 watts, so not a good choice for high power.

The Relcomm RDL-SR012 is a very interesting relay. They are very available on Ebay for $50 or less. The Ebay ones are typically brand new. They are often erroneously rated at 1KW at 1 GHz. The Chart in Figure 5 is the actual manufacturer's rating. Their insertion loss performance is excellent and their isolation is exceptional at greater than 80 dB. I have not used these, for EME, but they look good.

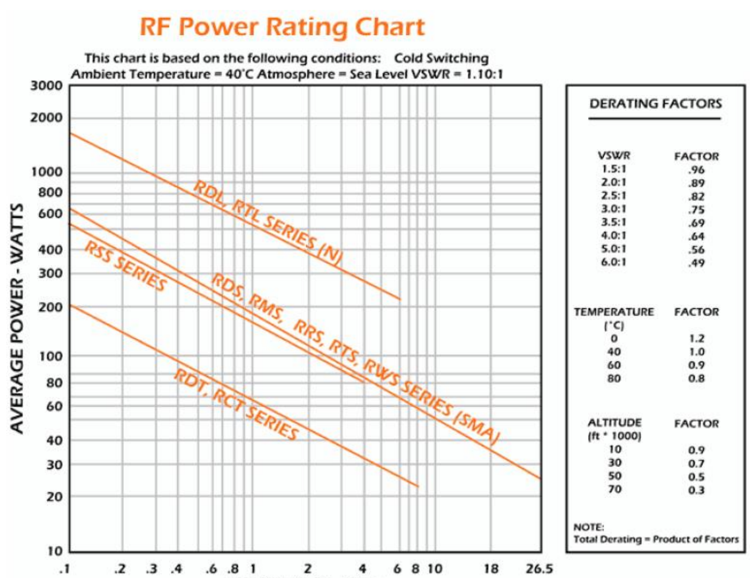



FIGURE 5. RELCOMM RELAY POWER VS FREQUNCY CHART

One more relay worthy of mention is the Tohtsu CX600NL. This relay is rated at greater than 1500 watts on 432 MHz and below. Its insertion loss performance is not outstanding and the isolation specification (35 dB on 432 MHz) requires the use of an isolation relay.

There are many other good relays out there, such at the HF-400, which I know are quite good, and quite expensive, but I have no experience with them.

After blowing many preamps in my early days of EME, I finally learned the importance of relay isolation specifications. There are basically two schools of thought on the subject of isolation. One approach is to use an isolation relay. The other is to *NOT* use one, as shown in configurations #1 and #2 in Figure 1. To not use one, you need to have one of these super relays with huge isolation numbers. The Tohtsu will not work. The main drawback in my opinion is the lack of a termination reference. I use the termination on my isolation relay to asses my overall system function when other references (such as the sun) are not available. Of course the drawback to using an isolation relay is the additional loss.

IMPACT OF LOSSES AHEAD OF THE LNA

What effect do additional losses in front of the LNA have on system performance? This can be demonstrated best with VK3UM's EME Calculator. Let's assume an LNA noise figure of 0.2 dB and a 0.1 dB loss ahead of the LNA. My echo S/N is 19.3 dB. If we increase the loss ahead of the LNA by 0.1 dB, it results in a decrease in S/N of 0.5 dB. A half a dB can easily make or break a QSO on EME. But a blown LNA can ruin your whole day. It's a decision you have to make. Below in Figure 6, is a photo of my current 70cm feed.

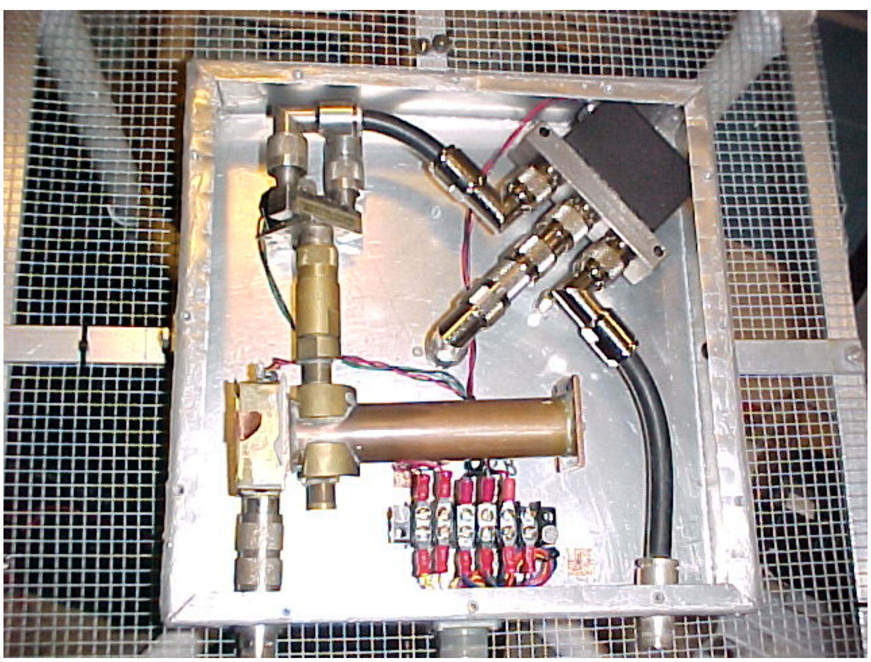


FIGURE 6. KL6M 70CM LNA RELAY ENCLOSURE

My cavity LNA measures 0.16 dB noise figure. My overall noise figure of this arrangement is 0.37 dB. As a result of this writing, I intend to remove the isolation relay and a few other things and give it a go.

ENCLOSURES

I have been refining my other LNA-Relay enclosures for 432 and 222 MHz since day one of my EME experience. My focus has been on the following areas:

1. Achieve the lowest losses ahead of the LNA as possible
2. I made the choice to keep an isolation relay, so I incorporate that into my enclosure design
3. Minimize the size and weight of the system
4. Maximize weather resistance

The following two photos in Figure 7 show two more varieties of my LNA-Relay enclosures.

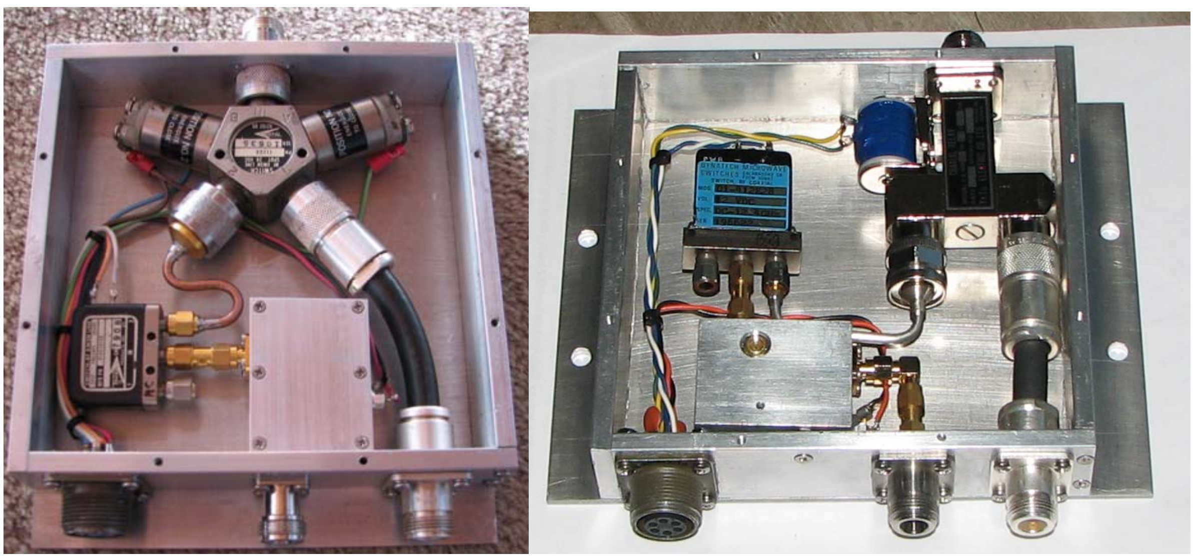


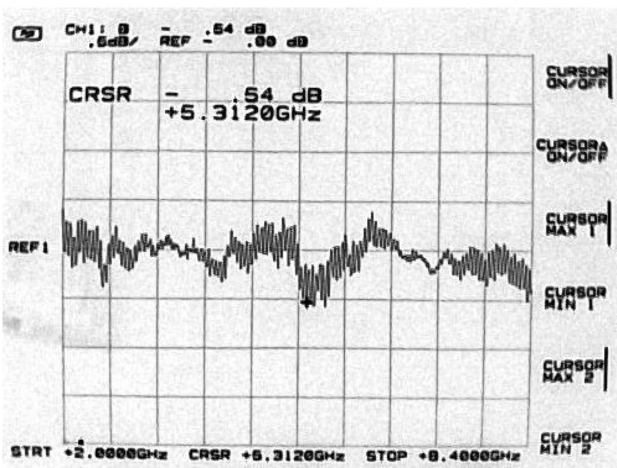
FIGURE 7. ENCLOSURES

On the subject of weep holes. Some folks believe you should always have them. I believe that my enclosures above do not need them because they are very nearly air tight. They can be completely sealed, or at least enough that there is no damage from moisture in any of them that I have experience with. Weep holes should possibly be used when your enclosure is not air tight. I just don't use them.

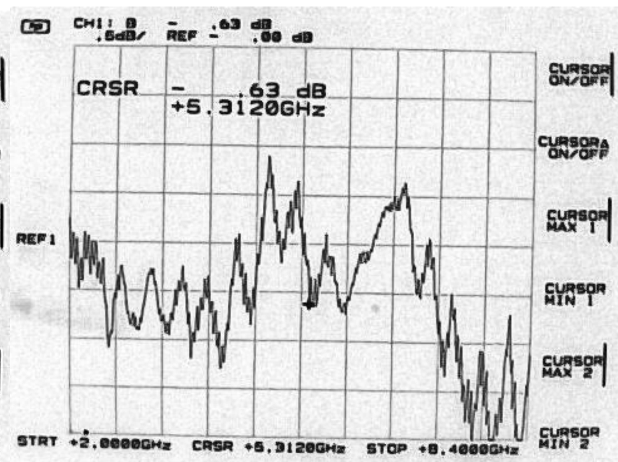
CONNECTORS

Quality of connectors can make significant differences in system performance. A picture is worth a 1000 words so I will show a comparison of physically similar adapters that are quite different electrically. The adapters are pictured in Figure 8. In Figure 9, I compared #3 to #4 and #5 to #6 by photographing their response on the network analyzer. #4 and #6 are substandard quality purchased (cheaply) on Ebay. My intent is simply to provide a reminder to be aware of inferior connector quality.

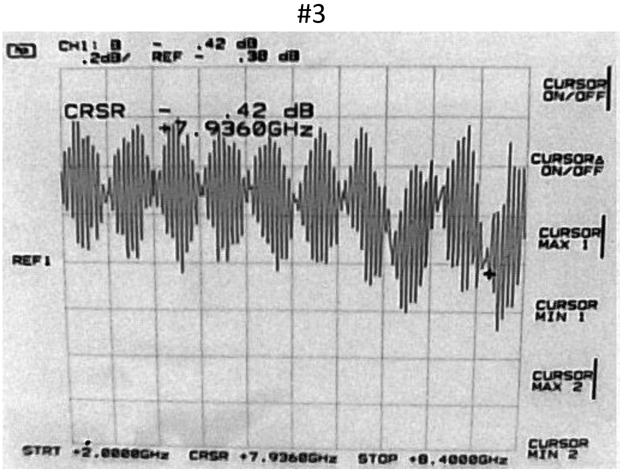

FIGURE 8. N TO SMA ADAPTERS




#3




#4

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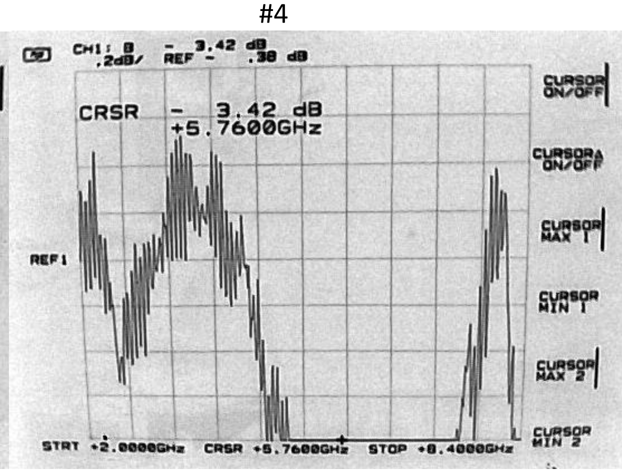


#6

FIGURE 9. COMPARISON OF CONNECTORS

SEQUENCERS

There are many types available.  My only suggestions are to certainly have one in your system, and to make it one that can be fail safe.  I.e., if you have an isolation relay and if the sequencer fails or the power to it fails, that the isolation relay still protects the LNA.  The main thing you protect from is "hot-switching" (with RF power applied).  That can do serious damage.

CONCLUSION

There are many decisions to be made on how to configure an EME station.  I hope that this material has helped you in that process.  If you have further questions, feel free to write me at kl6m@hotmail.com

I am QRV 222, 432, 1296 EME.  I have been active on 144 and 2304, and hope to get back on those.  Future band additions are 900, 3400, and 5760.

Hope to see you on the MOON !!

73,  Mike, KL6M