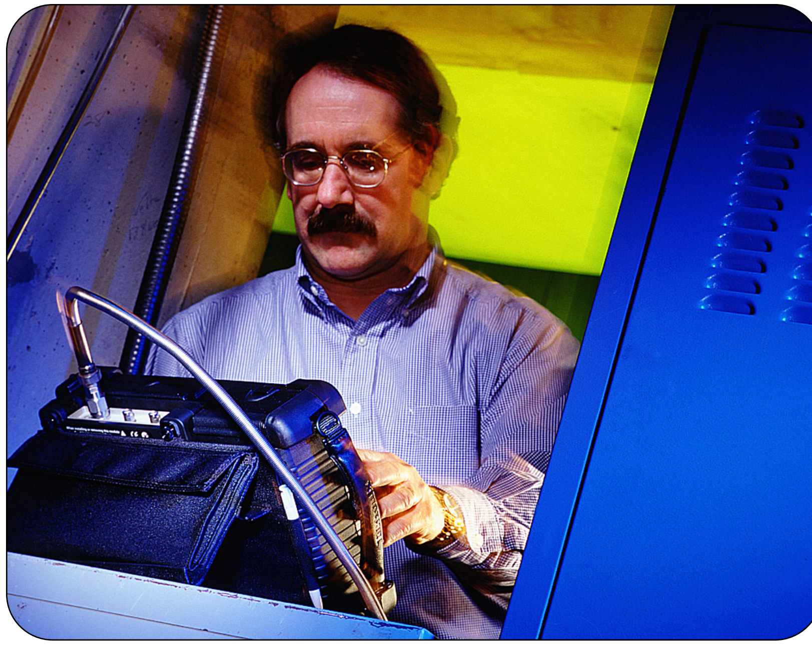
Accurate Reflection Measurements and the NetTek™ YBA250



Using Precision vs. Non-Precision Adapters and Their Effect on the Standards

Reflection measurements are usually made as a comparison of the unknown (device being measured) to a known standard. This standard is assumed to be perfect. The process of comparing is called "calibrating" the measurement equipment.

Any non-precision adapter that is placed in between the YBA250 (where the comparison was made) and the unknown can dramatically affect the reflection measurement. The higher the frequency of measurement, the worse the degradation will likely be. All measurements made here are done for a sweep of 100 MHz to 2000 MHz. The comparisons are made at the US PCS band at 1900 MHz.

An example of a precision adapter is shown in Figure 1. This is a double-female "barrel" connector, Tektronix Part Number 103-0429-00 (The double-male version is 103-0430-00).

Figure 2 is an ordinary "non-precision" adapter. This does not look radically different from the precision one. If you look closely, it does not have the same quality of machining as the precision unit, but does not appear significantly better.

Figure 1. Precision adapter, double female, Tektronix Part Number 103-0429-00.

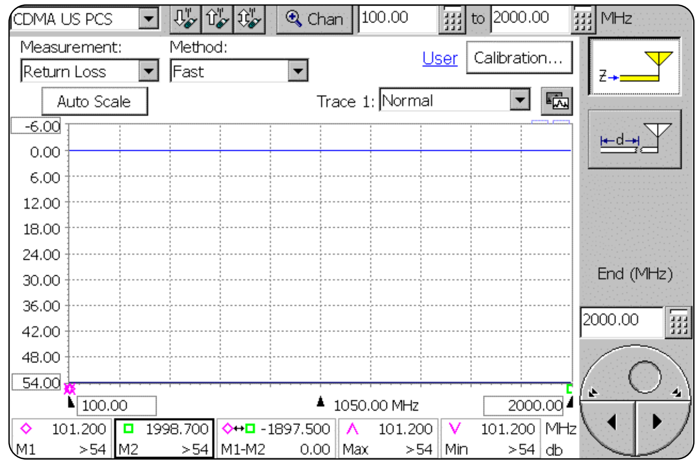
Figure 2. Non-Precision Adapter

The precision adapter has been made with precision machining of the connection surfaces and the diameters of the component parts. Precision female center connectors often have six fingers instead of the four fingers common on less expensive adapters. However, the only real way to tell if a connector is a precision one is to know the VSWR specifications over the frequency range to be measured.

To demonstrate the effect that ordinary connectors can have on return loss measurements, we calibrated the test instrument with the YBAC1 calibration kit. The load from this calibration kit is shown on the right in Figure 3 vs. a different precision load on the left.

▶ *Figure 3. Connectors*

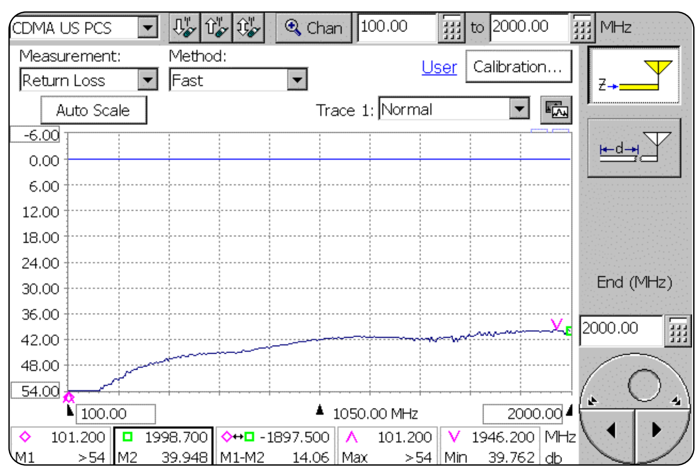
Figure 4 is a plot of the same load we used when we calibrated the YBA250. This shows that when comparing the calibration load to itself, we plot greater than 54 dB return loss.



▶ *Figure 4. Calibrated load*

We then used the calibrated YBA250 to measure a different precision load (on the left in Figure 3).

Both of the loads used are specified at 41 dB Return Loss (RL). Figure 5 indeed shows about 40 dB RL when "comparing" the second load to the first one (the calibrating load).



▶ *Figure 5. Comparison vs. calibrated load*

Now we connect the original load using two precision adapters – One double male and one double female. See Figure 6.

This setup will allow us to insert various quality adapters and compare them to the precision ones.

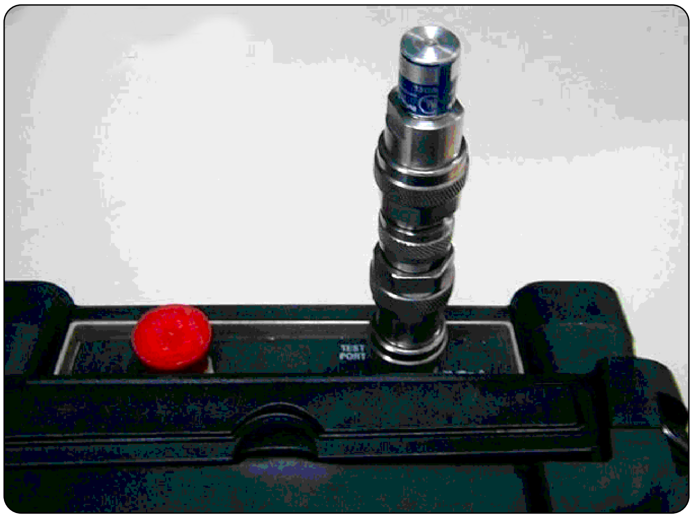


Figure 6. Adapter setup

As you can see in Figure 7, the precision adapters degrade the measurement very slightly. Our measurement capability is still about 40 dB.

The fact that the original calibration standard shows 40 instead of 54 dB means that if we try to measure a standard that is exactly equal to the original one, it will not show more than 40 dB.

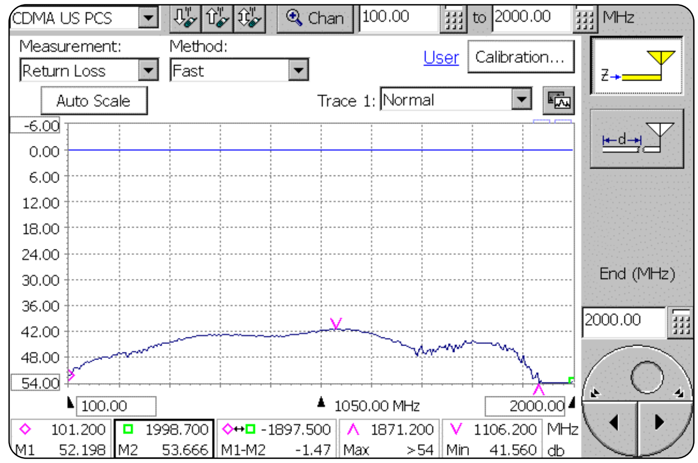


Figure 7. Comparison vs. adapter setup

In Figure 8, we have replaced the original load with the second one and it still shows about a 40 dB capability.

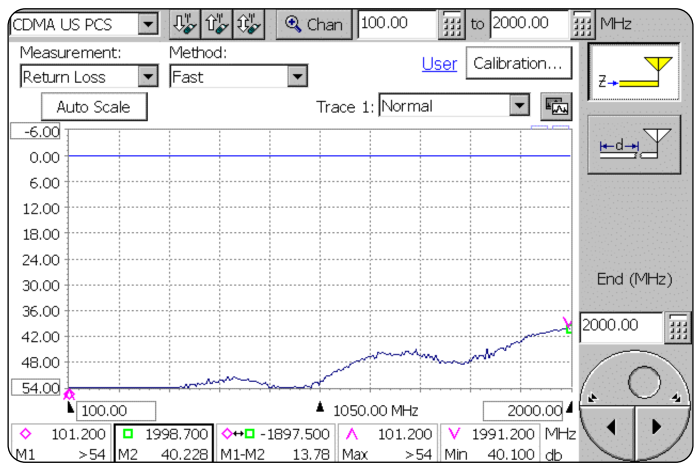
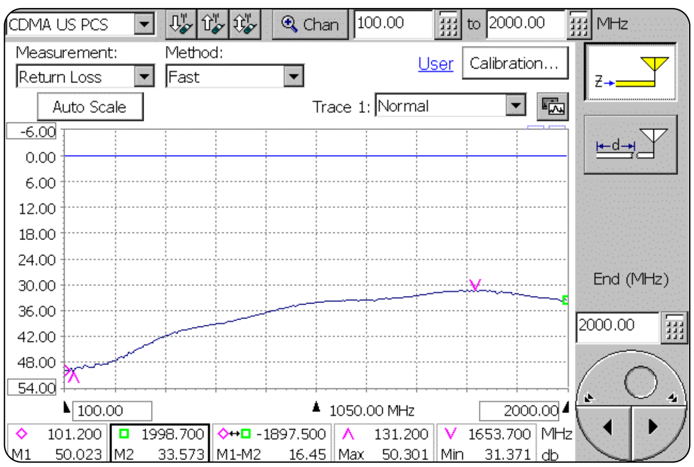


Figure 8. Comparison vs. second precision load

Now we replace the precision double-female with a non-precision one.

▶ *Figure 9. The non-precision adapter.*



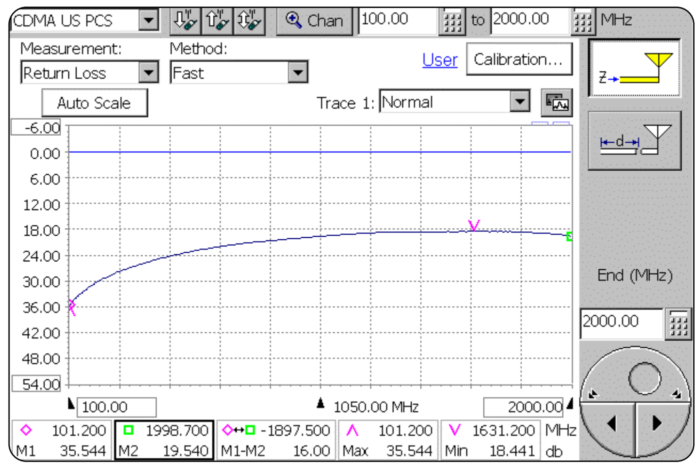
▶ *Figure 10. The non-precision adapter shows 30 dB return loss.*

Note that the best return loss we can measure has now degraded to 30 dB simply from the addition of this adapter.

This adapter looks just as good to the eye as a precision one. However, it will allow us no more than a 30 dB return loss measurement, as seen in Figure 10.

Not all such adapters work the same as the one in Figure 9, but you will never know until your measurements come out wrong.

▶ *Figure 11. Adapter from a "universal" adapter kit.*



▶ *Figure 12. Very poor at 18 dB return loss.*

There are many adapters available that can indeed pass enough signal that a receiver or transmitter can communicate through them, but reflection measurements simply can not be made through them. One example of an un-useable adapter is one made up from a kit that has many different adapters that can be put together to quickly provide connection between just about anything. Figure 11 shows a double-female type "N" made from one of these kits. It has been swept in Figure 12, which shows that it has very poor performance at the PCS band with 18 dB return loss for just this connector.

Figure 13. Type “UHF” adapters.

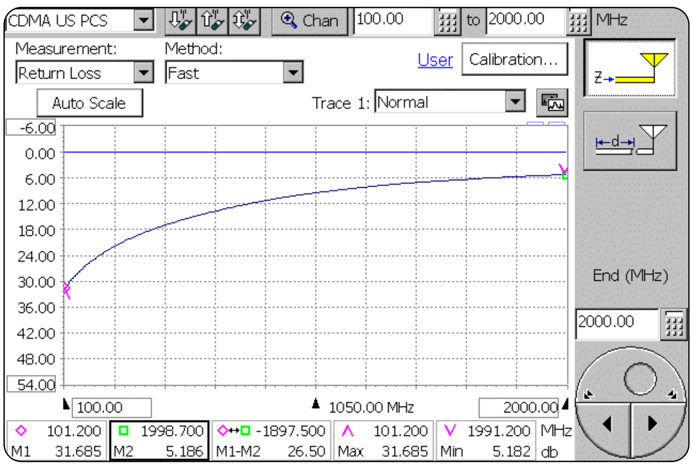


Figure 14. Essentially useless at 6 db Return Loss.

Some types of connectors are simply not any good to start with. We now examine an older type of connector that is still used for CB radios in the USA. It is the "UHF" connector (PL259 or Type M). Figure 13 shows a pair of these that we swept. The result is shown in Figure 14. This is actually much worse than you might imagine. A return loss of 6 dB at the PCS frequency is about the same as you might find if the antenna had been completely destroyed by a lightning stroke. This is just how bad these connectors are even when new.

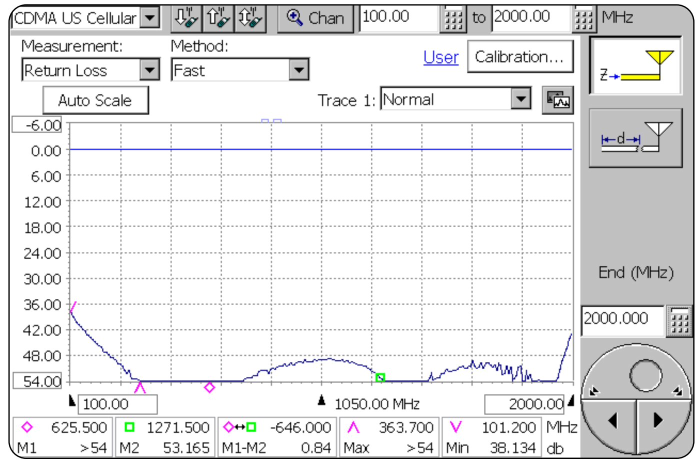


Figure 15. DC block provides adequate value

The final item is to measure through a precision DC block. This component is needed if you want to measure a coax or an antenna system that has a voltage present that exceeds the rating of the test instrument. This particular DC block also isolated the coax shield, which may be handy if the test instrument is operating from mains power and this causes a “ground loop”.

Figure 15 shows the trace of the return loss of the DC Block (with the original cal kit load on the end of the DC Block).

It has really excellent return loss above about 200 MHz.

Maintenance of the Calibration Kit

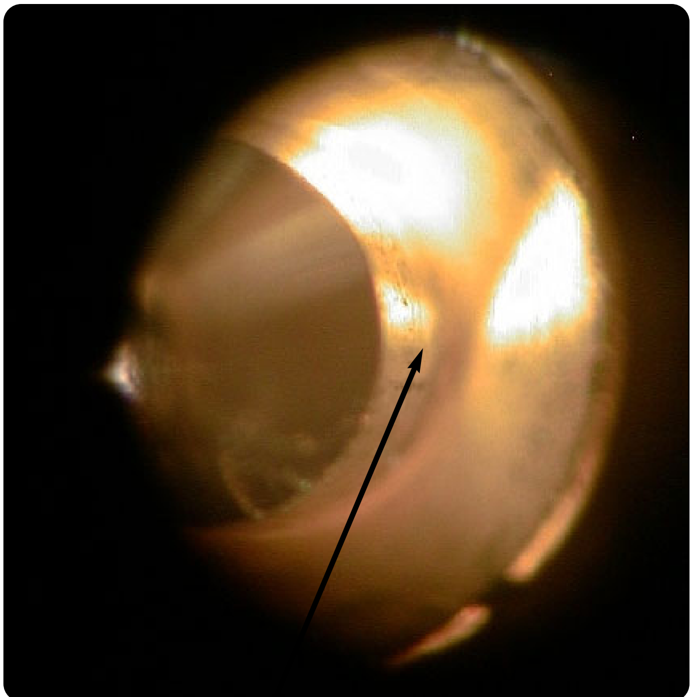
It is critical to maintain the quality of the standards used for the comparison measurements.

Keeping the standards clean is the first part of good care.

Keeping them in good mechanical condition is the next and perhaps the most important part. The technique used to attach the standards to the YBA250 is a large part of the care of these standards. When each standard is connected, it must be held from turning, while the outer nut is turned to tighten the standard. This pushes the center pins straight together, and prevents damage. If the entire standard is turned, the center pins are twisted against each other as they go together. This may cause damage to the center pins – both in the YBA250 and in the calibration standard. If this should occur, the accuracy of the calibration standard can be as bad as if a non-precision adapter is used. The damage will be permanent.

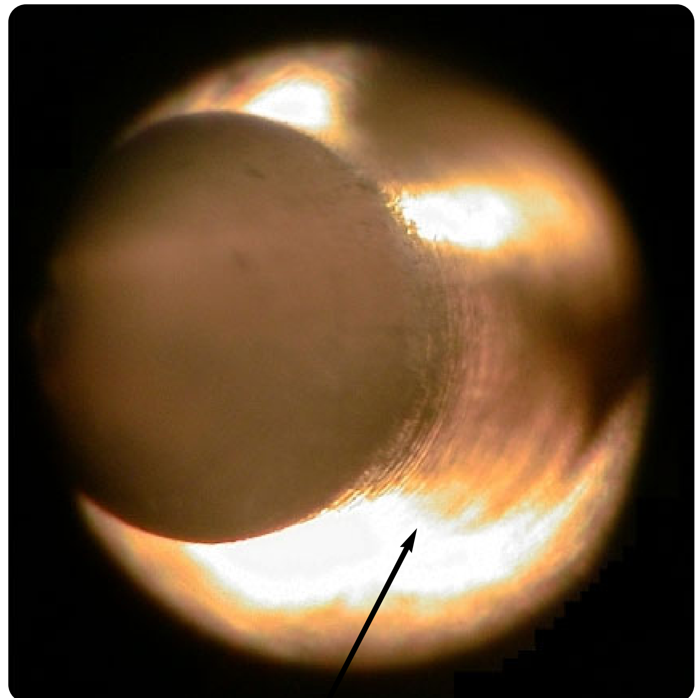
▶ *Figure 16. Avoid improper attachment of the standard.*

▶ *Figure 17. Proper attachment of the standard, as shown here, is critical.*



▶ *Figure 18. New connector*

Smooth



▶ *Figure 19. Damaged connector*

Scored

Figure 18 illustrates a microscope photo of two center pins from type "N" precision connectors magnified 60 times. The pins are pointing to the left, and the base of each pin is to the right. The photo on the left is a pin that has never had a connection improperly made. Notice how the tapered side is smooth.

Now look at Figure 19. Notice how the pin has significant scoring from the mating connector that was twisted on. Particularly near the point. This scoring is the result of *only one* improper connection having been made. Imagine the damage from just a few improper connections.

The final consideration is that any connector that is part of a system under test may or may not itself have been damaged. The worst damage is a center pin that is not in the center, or that is sticking out too far from the connector. Be sure to check for this kind of connector damage before connecting to the YBA250, or permanent damage to the test instrument may occur.

Precision Components Available

The following optional precision components can facilitate accurate measurements of Return Loss and VSWR:

Component Description	Part Number	Notes
Precision RF Cable, 10 feet (3 Meters) long	012-1619-00	Male Type N both ends
Double female type N adapter	103-0429-00	The "barrel" to use with cable
Double male type N adapter	103-0430-00	
DC Block – Type N	119-6598-00	
7-16 female to N female adapter	103-0431-00	
7-16 male to N female adapter	103-0432-00	

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