RADIO FREQUENCY SYSTEMS
The Clear Choice®

Field Insertion Loss (Attenuation) Measurement

Written by Vinny Benevento, Electrical Engineer, RFS

July 2009

Field Insertion Loss (Attenuation) Measurement

Written by Vinny Benevento, Electrical Engineer, RFS

July 2009

Executive Summary

The purpose of the white paper is to review the different methods of measuring insertion loss in coaxial cable and discuss the uncertainty associated with the measurements.

In this paper, attenuation and insertion loss are considered the same. The terms may be used interchangeably.

Field Insertion Loss (Attenuation) Measurement

Contents

Field Insertion Loss (Attenuation) Measurement

Through measurement technique

The most accurate way to measure attenuation in coaxial cable and the one used by most RF cable manufacturers is to use the "through measurement" technique. The one drawback with this technique is that you need to have access to both ends of the cable. This is not always possible in the field with long lengths of cable running up towers. Typically there is only access to one end of the cable at the bottom of the tower.

To allow for measuring attenuation when the cable is already installed, the reflected measurement Technique is used.

Reflected measurement

This technique is the "S11 reflected attenuation" measurement, utilizing a short on the top end connector. This test method results in a response that is double (2 times) the actual attenuation and the VSWR effect adds to the uncertainty. This method gives an approximate attenuation measurement, or footprint, of a cable run. Some test equipment can be set to a mode that will divide the attenuation signal by 2 and display this. Due to the VSWR uncertainty errors the plot displayed will have a rippled response curve and estimation must be used to approximate the attenuation. The problem with this method is in choosing the position(s) on the trace to determine attenuation, either at the minimum, maximum or average of the trace.

Selecting Average (Mean) Attenuation

Most operators select the average attenuation. This involves creating a new response line through the center of the peak to peak or using the averaging function on newer analyzers. This is chosen to approximate the attenuation response as the rippled response **[figure 1]** is not an actual cable attenuation response due to the measurement set-up. Generally speaking, this method has become the accepted industry standard field test measurement technique.

The following example explains why using minimum or maximum values should be avoided.

In the field, when reading a S11 combination plot of insertion loss and return loss, you may see an attenuation change of 1dB (peak to peak) at some frequency **[figure 2]**. In order to get this magnitude of change, a VSWR change of 2.5:1 (7dB Return loss) would be needed.

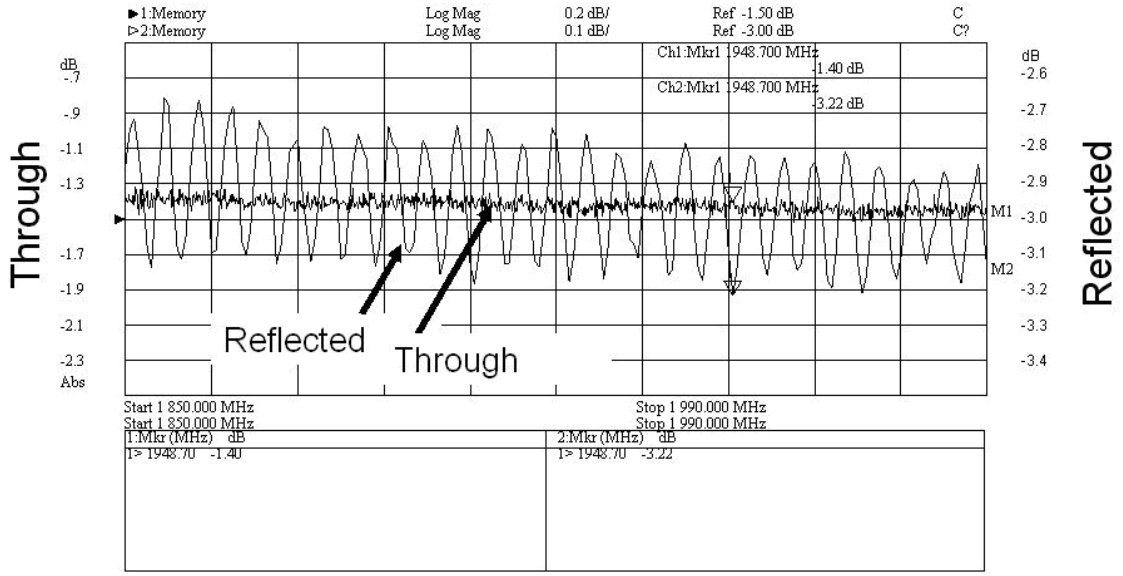

Figure 1 "Through" versus "Reflected" attenuation measurements on the same cable. The attenuation response was done using the cable mode setting (divide by 2).

But in reality the VSWR/Return loss of the cable is no worse than 1.135 (-24dB) so the change in attenuation would be less that 0.1dB.

The field analyzer has inaccuracies measuring a length of cable with a short and a magnitude of around 5dB. The coupler inside the analyzer has a high error rate when measuring a high return loss. The error rate magnifies the attenuation/return loss change significantly. For these reasons the average of the trace would be the correct location.

Risk of Selecting Minimum or Maximum Attenuation

Selecting either the minimum or maximum value can add an increased level of inaccuracy to the field measurement, as noted above. The following may skew the pass/fail results:

1. Attenuation actual versus nominal – due to manufacturing processes, the actual attenuation may vary from one manufacturing production lot to another, in some cases by as much as 5%.
2. Return Loss actual versus nominal – due to the manufacturing processes, the actual return loss

performance may vary from one manufacturing production lot to another, in some cases by as much as 6dB. So some cable may be -30dB in operating bands while another batch/lot may be at -25dB, both meeting the nominal -24dB.

Any one or all of the variables above could introduce inaccuracy into the calculated attenuation value. For example, the difference in return loss may be compounded by selecting the worst case reflected attenuation, generating a fail result, where measuring the same batch/lot of cable using the average (or mean) values would generate a pass result.

Although the common and practical practice is to use the reflection method to measure insertion loss, the translation from return loss to reflected insertion loss is magnified due to the inaccuracy of the field test equipment.

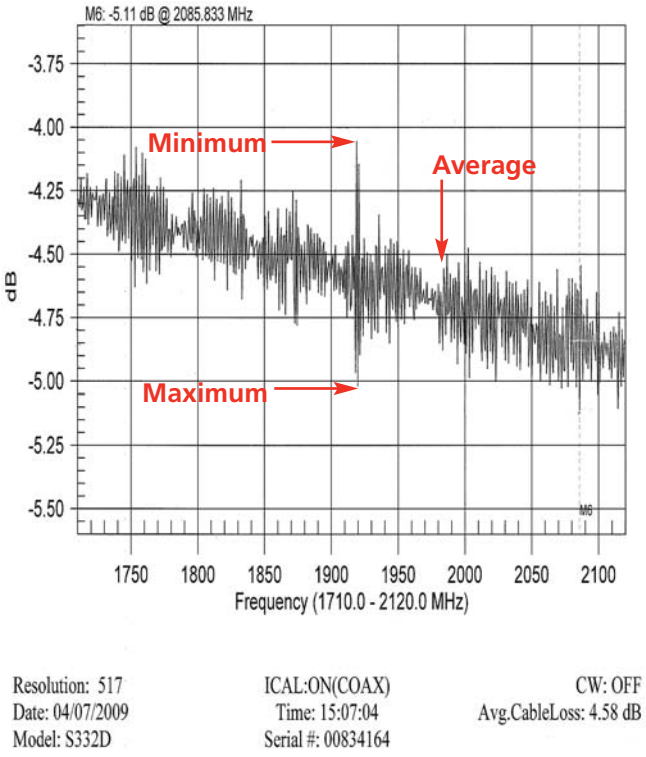

Figure 2 Insertion and return loss plot showing peak to peak attenuation change.

Field Insertion Loss (Attenuation) Measurement

Conclusion

Due to these measurement uncertainties it is recommended to use the best test equipment available with precision loads and shorts and to use the average attenuation method. This is still less precise than a through measurement and margin should be allowed from manufacturer specification.

Company profile

RFS serves OEM, distributors, system integrators, operators and installers in the broadcast, wireless communications, land-mobile and microwave market sectors.

As an ISO 9001 & 14001 compliant organization with manufacturing and customer service facilities that span the globe, RFS offers cutting-edge engineering capabilities, superior field support and innovative product design.

RFS is committed to globally fulfilling the most demanding worldwide environmental protection directives and integrating green-initiatives in all aspects of its business.