



High-Performance 75 Ohm BNC HDTV Interface: Measuring VSWR and Return Loss Up to 6 GHz

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Introduction

With the introduction of high-definition video signals operating at data rates up to 1.485 Gb/s for 1080i and 2.97 Gb/s for 1080p, a new generation of BNC connectors need to perform at significantly higher frequency than standard BNC. To meet the broadcast industry's stringent HDTV standards Radiall's new 75 ohm HDTV BNC connectors offer a true 75 ohm interface designed to offer low VSWR and return loss over a frequency range from 0 to 6 GHz.

The increase frequency range—from 3 GHz to 6 GHz—presents concerns over testing the connectors. This paper shows that a 75 ohm calibration kit specified up to 3 GHz can be used to measure VSWR up to 6 GHz.

Commercially available 75 ohm calibration kits are specified up to the 3 GHz that was the maximum frequency used for broadcast applications. Even so, these calibration kits are often still functional at higher frequencies. Thus we propose to show that the Radiall 75 ohm calibration kit yields reliable results to 6 GHz.

Our method compared two low VSWR and low Insertion Loss standards (air lines) at 50 ohm impedance and 75 ohm impedance.

- A 50 ohm calibration kit (specified up to 18 GHz) measured VSWR of the 50 ohm standard between 0 to 6 GHz.
- A 75 ohm calibration kit (specified up to 3 GHz) measured VSWR of the 75 ohm standard between 0 to 6 GHz.

By comparing the VSWR of two standards, we will show the validity of 75 ohm calibration kit for measurements up to 6 GHz.

Finally the 75 ohm calibration kit will be used to characterize the true 75 ohm BNC HDTV interface up to 6 GHz. Figure 1 gives the BNC HDTV VSWR interface performance.

Connector Configuration	VSWR		
	DC- 1.5 GHz	1.5 – 3 GHz	3 – 6 GHz
Straight plug and jack cable connectors	1.05	1.12	1.25

Figure 1 : VSWR performance of Radiall's BNC HDTV interface and connectors

50 Ohm and 75 Ohm Calibration Dynamic Measurements

First two calibrations were performed in the 0 to 6 GHz frequency range by using two commercial calibration kits to measure the RF dynamic:

- 50 Ω specified up to 18 GHz
- 75 Ω specified up to 3 GHz

A dynamic lower than -50 dB between 0 to 3 GHz and -40 dB between 3 to 6 GHz are acceptable for electrical characterization in our case (depend on specifications). The results are shown in Figure 2.

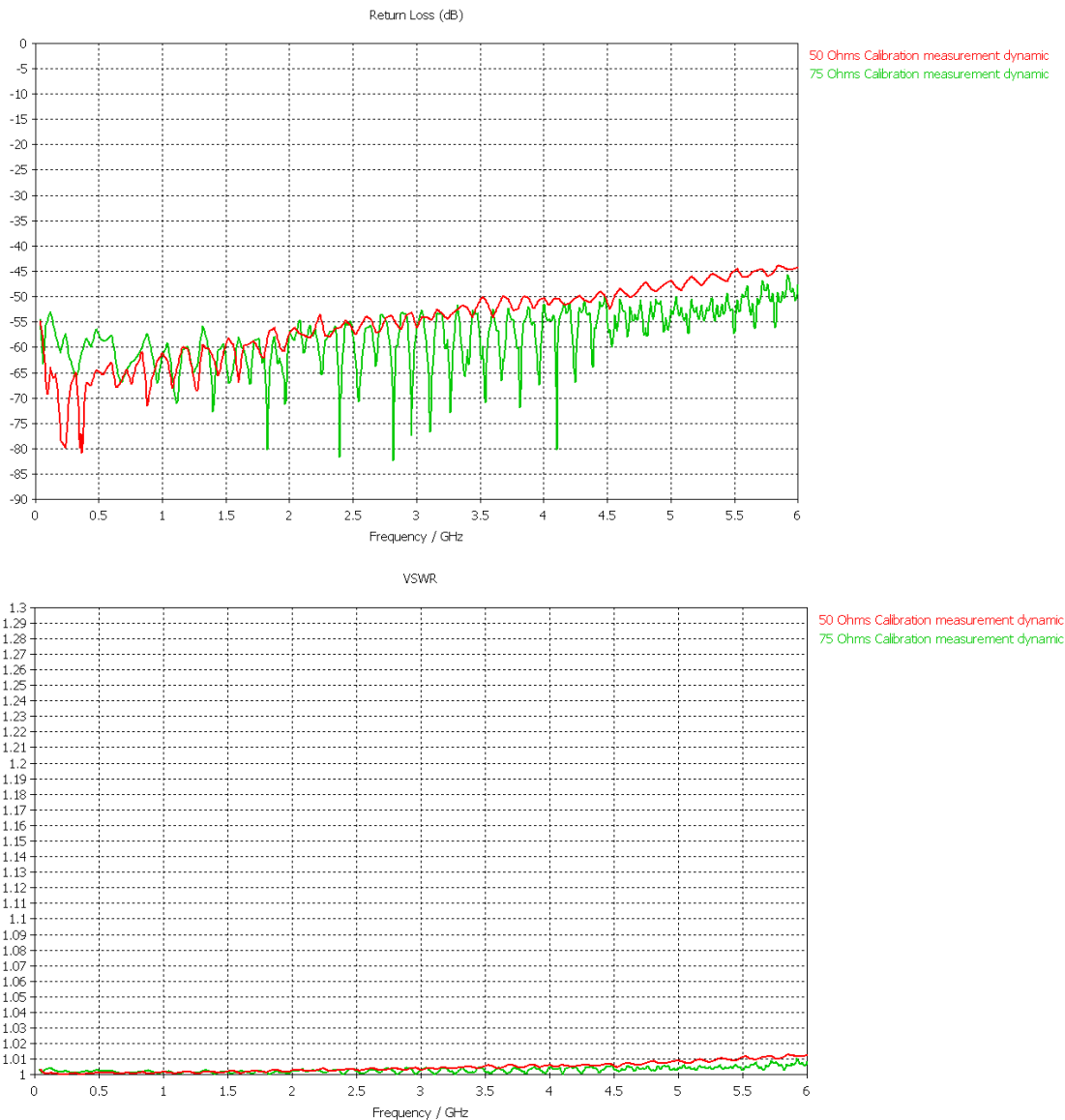


Figure 2. Calibration measurement dynamic

The dynamic of the 50 ohm and 75 ohm calibration are quite close and are both lower than -45 dB for return loss and 1.01 for VSWR over the entire 0 to 6 GHz frequency band. We have a high-level correction in terms of reflection due to the connection component between the VNA port and calibration plane.

75 Ohm Matched Load Measurement with 75 Ohm Calibration Kit

To ensure that the calibration done with 75 ohm calibration kit is suitable for measurements up to 6 GHz, a 75 ohms load is measured by using the 75 ohm calibration. Figure 3 shows the return loss and VSWR for the matched load.

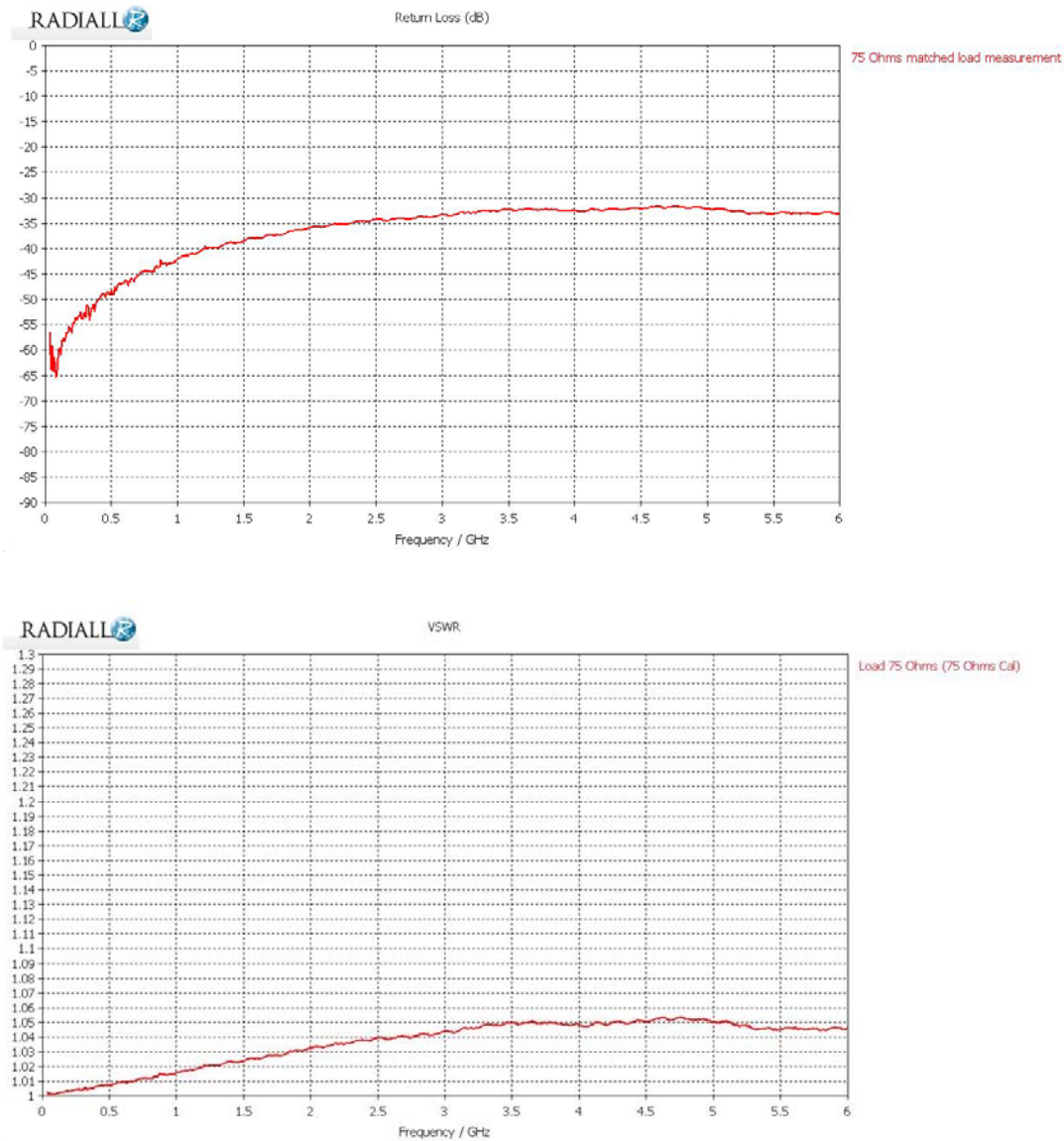


Figure 3. Measurement of 75 ohm matched load with 75 ohm calibration kit

The VSWR of the matched load is lower than 1.1 in the frequency band 0 to 6 GHz. The measured value is in accordance with the specification of the measured matched load in this bandwidth.

50 Ohm and 75 Ohm Air Line Measurements



Figure 4. 50 ohm and 75 ohm air lines

By using the 50 and 75 ohm calibration kits, we were able to compare the electrical properties between the two standard 50 and 75 air lines up to 6 GHz. As a result, it was confirmed that the functionality of the 75 ohm calibration kit did perform up to 6 GHz.

The two air lines are measured by using 50 ohm and 75 ohm calibration. Taking into account geometrical dispersion between 50 ohm and 75 ohm air lines and measurement dispersions, the VSWR of the air lines are lower than 1.1 as shown in Figure 5, we can conclude that the measured VSWRs are comparable. The two lines have a VSWR lower than 1.1 up to 6 GHz.

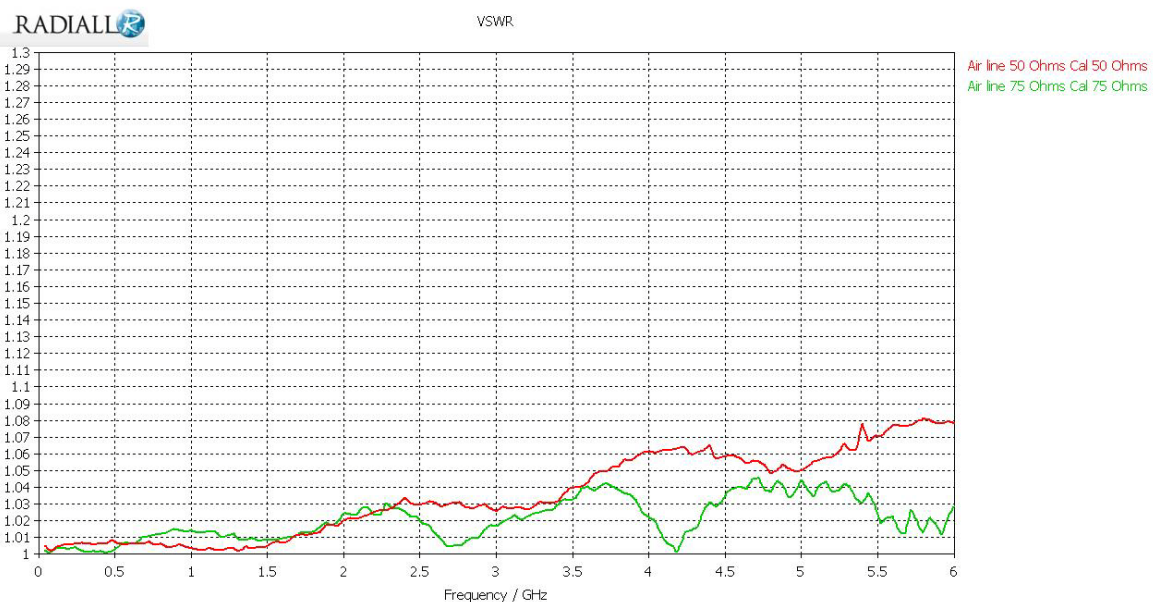


Figure 5. 50 ohm and 75 ohm air line VSWR measurements by using 50 ohm and 75 ohm calibration kit

Note that the VSWR of the two lines are very close in the frequency band under consideration. Equally important, more than 99.8% of the energy passes through the connector—with only a low 0.2% reflected.

To validate that the 75 ohm calibration presents the same reference (calibration plane) that 50ohm calibration, Figure 6 shows the phase measurements at 50 and 75 ohms. The phase of measurements show that the maximum phase difference between the two air lines is less than 2 degrees at 6 GHz. Both calibration kits measured with the same phase.

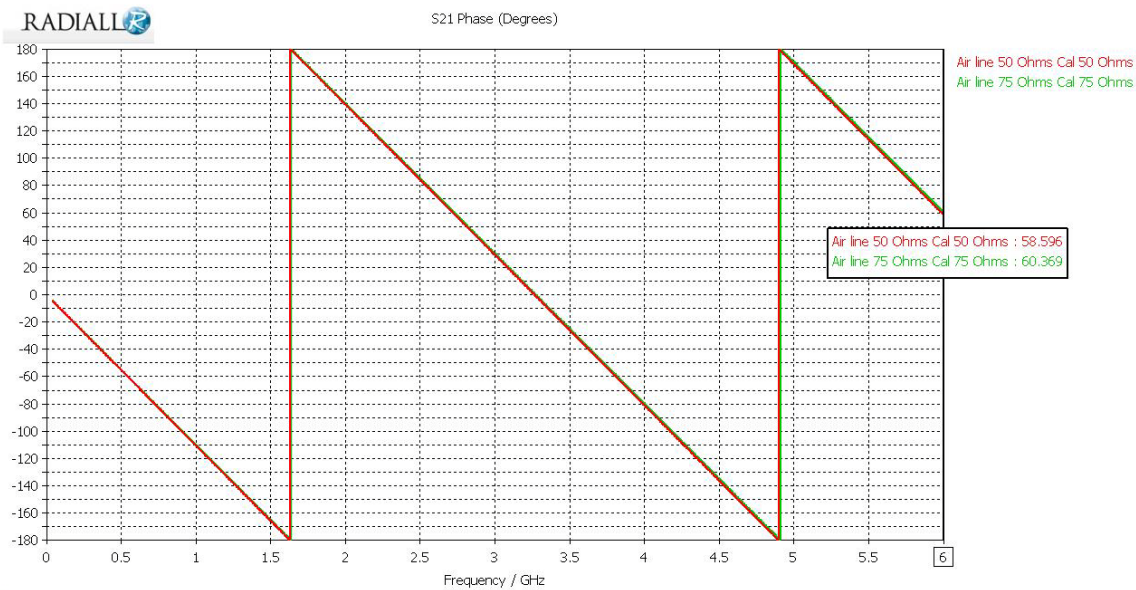


Figure 6. 50 ohm and 75 ohm air line phase measurements by using 50 Ω and 75 Ω calibration kit

Given our comparison between the VSWR and the phase of our two air lines, it is clear that the 75 ohm calibration kit is as suitable as the 50 ohm calibration kit.

Measurement of Straight Plug and Straight Jack Connectors

With TDR measurements we cannot isolate the pair of BNC HDTV connectors shown in figure 7.

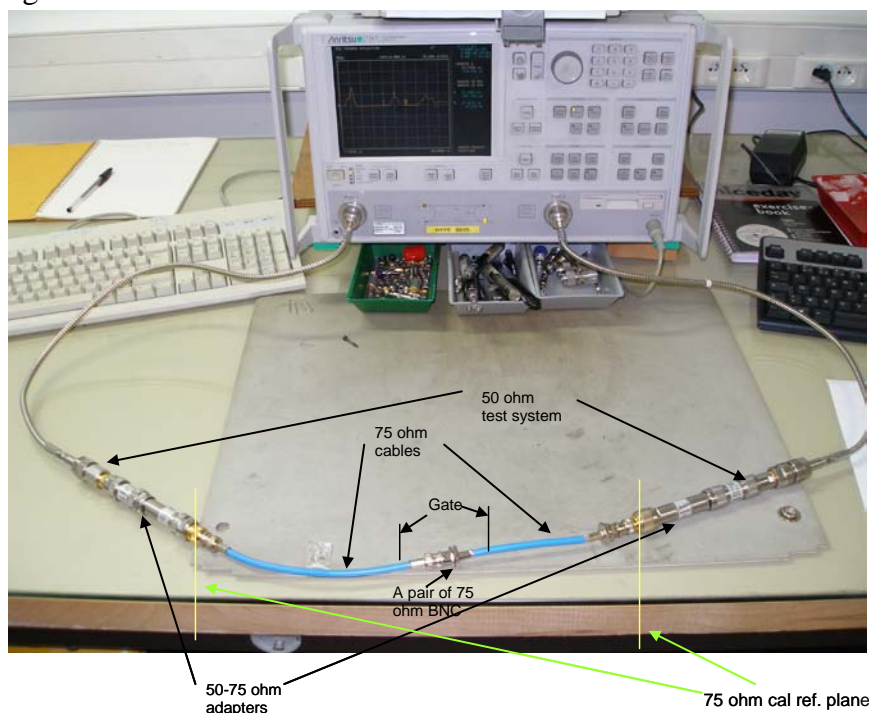


Figure 7. TDR measurement of BNC HDTV connector

Figure 8 shows that the VSWR is lower than 1.06 across the entire frequency range which allows for significant headroom in HDTV transmission.

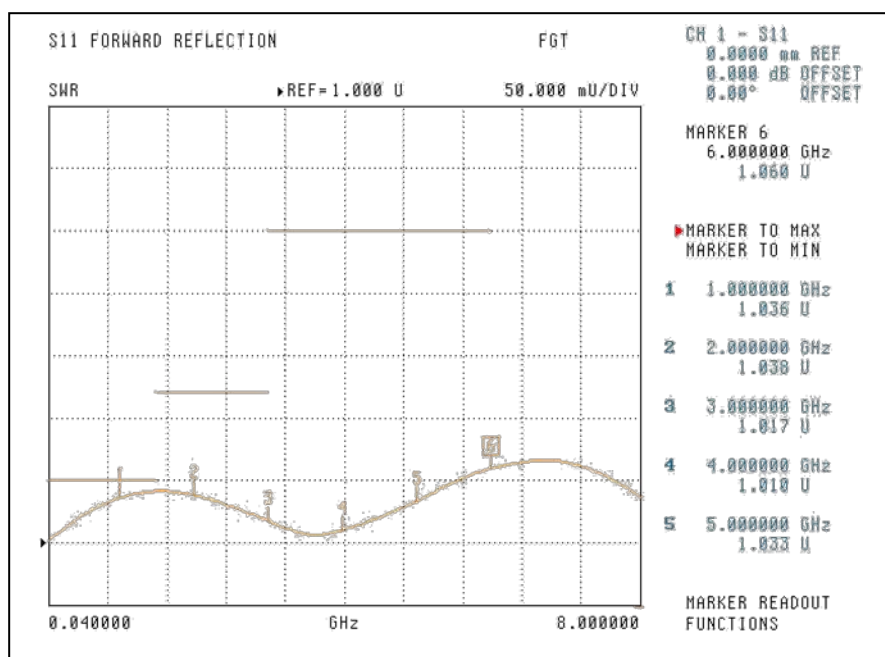


Figure 8. VSWR measurement BNC HDTV connector

Conclusion

In this paper, we show how to validate the use of a calibration kit over a frequency range beyond that for which it is specified. The main idea was to validate for ourselves the specifications of a given calibration kit by evaluating the electrical characteristics of known standards when they are measured with the calibration kit.

Measurements confirm our commercial 75 ohm calibration kit is suitable to characterize microwave components up to 6 GHz. Even while the kit can be used for testing, the results will be for the worst case—the product tested will perform better than the measured values.