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APPLICATION NOTE 3962

Microcoaxial "Pigtails" for RF Measurements to and Beyond 5GHz

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Abstract: Microcoaxial "pigtails" are an invaluable tool for anyone trying to diagnose or repair RF signal path issues. If applied carefully, they can be used to characterize networks up to and beyond 5GHz. This note gives a general overview of their versatility and presents techniques for proper application.

Click here for an overview of the wireless components used in a typical radio transceiver.

One of the challenges faced by anyone involved in contemporary radio design and debug is being able to accurately measure portions of a signal path that are not connectorized. For instance, how does one measure the insertion loss (S21) of a filter if the input end is coupled to a diplexer and the output to an LNA? Or, perhaps the output power and linearity of a power amplifier (PA) is in question, but it happens to connect to a diplexer on one end and a Tx driver on the other? The answer to these scenarios (and many others) lies in the careful use of a semi-rigid micro-coaxial cable, commonly referred to as a "pigtail" (**Figure 1**).

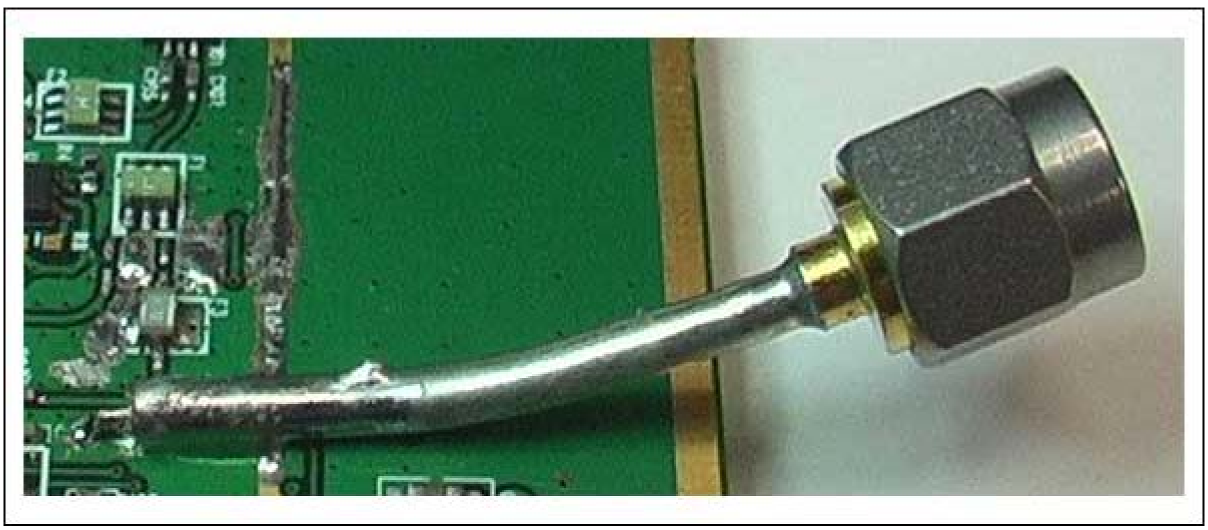

Figure 1. Sealed microcoaxial cable, good to 5GHz+.

Semirigid microcoaxial cable can be obtained in many characteristic impedances from many sources (www.micro-coax.com). For 50Ω applications, they can range from very small and flexible [8mil outer diameter (0.203mm)] to very stout and robust [250mil outer diameter (6.35mm)]. What makes these cables so versatile, however, is that they can be soldered directly into a signal path and used as a temporary means of measuring key parameters, even if the circuit was not designed to accommodate such measurements.

Returning to the aforementioned insertion loss scenario: If the insertion loss of a SAW filter was in question, one would first break the circuit on the input and output sides of the device. Then, two microcoaxial cables would be soldered to the board, allowing a simple two-port test of the device. This measurement is a true accounting of how the device is performing on this particular board. For example, it would be evident if the PCB layout was somehow incorrect and S21 was more than the device manufacturer intended. Applying the same technique to a PA allows testing and optimization of the circuit without outside contributors present. Transmitter spurious emissions can be eliminated from the measurement, mismatches at the input and output can be identified, layout issues become much more apparent, and a full range of tests can be applied to diagnose problems.

To get the most out of a pigtail, some guidelines should be followed. First, consider the frequency at which the measurement will be made. A handmade cable with coaxial cable connected to an SMA edge-mount connector may be acceptable at frequencies up to 2GHz. Above 2GHz, however, these become unpredictable in regards to return loss and impedance due to the SMA-to-coaxial transition (**Figure 2a**, **2b**). For higher frequencies, a 'sealed' cable assembly is probably more appropriate (Figures 1, **3**). Sealed cables can sometimes be found at local used parts and equipment dealers. These assemblies, when cut in half, yield two pigtails each.

Figure 2a. Handmade microcoaxial cable—good to approximately 2GHz to 3GHz.

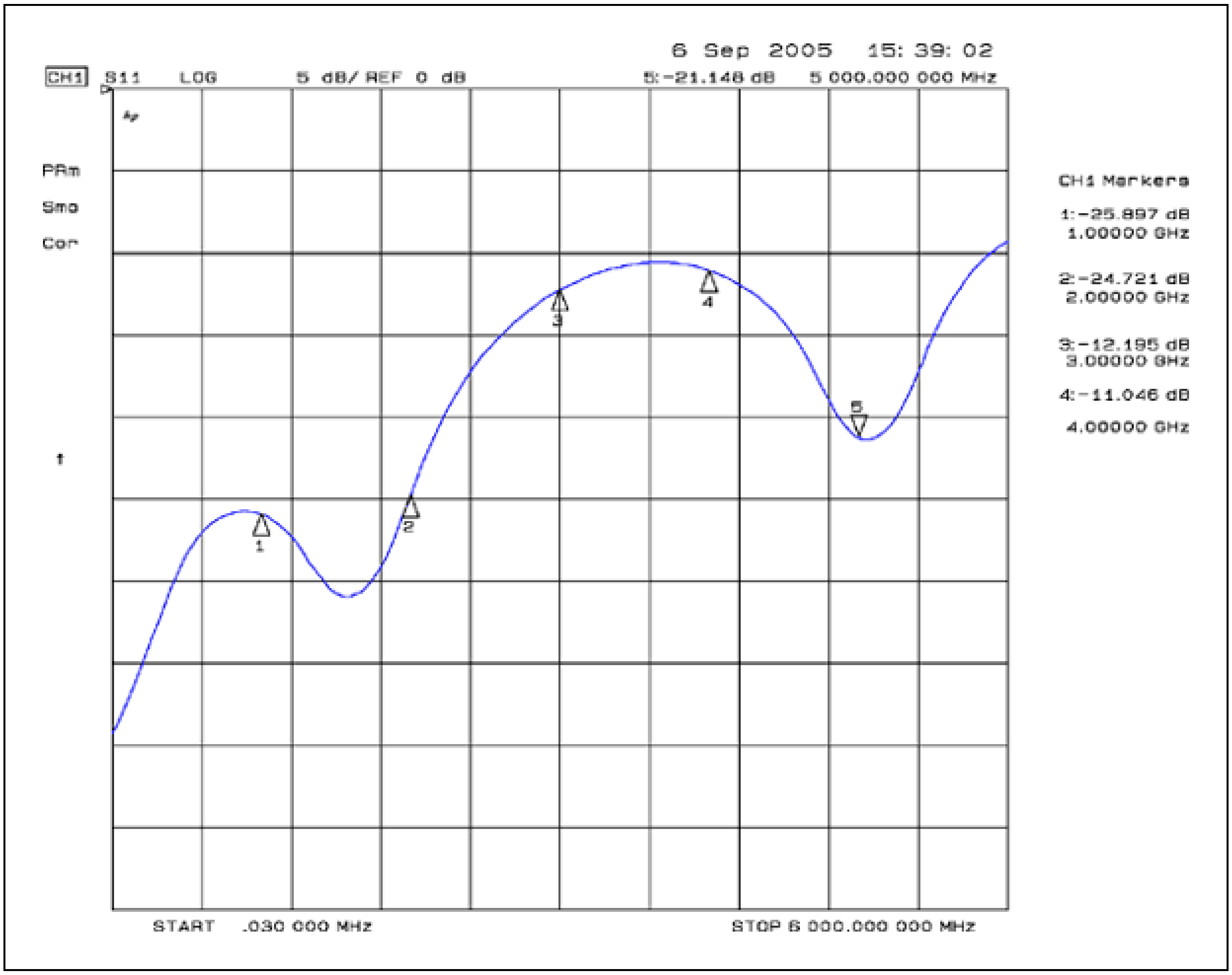

Figure 2b. Return loss (S11) of the handmade microcoaxial cable (terminated to 50Ω on a PCB).

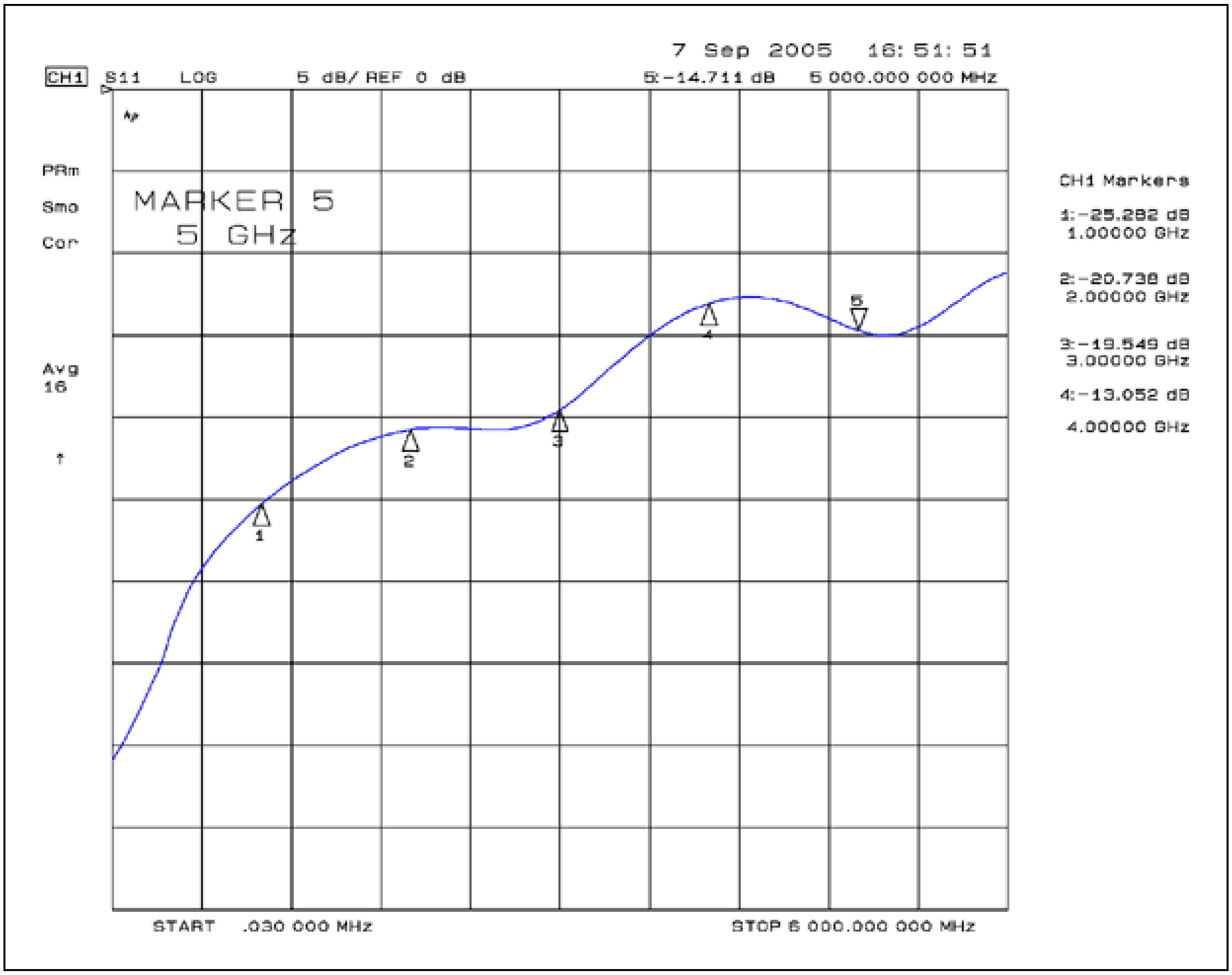

Figure 3. Return loss (S11) of the sealed microcoaxial cable.

While keeping overall cable length as short as possible minimizes insertion loss, it is also extremely important to minimize the amount of center conductor protruding from the cable end. Any excess here will degrade return loss of the pigtail significantly (**Figures 4a**, **4b**).

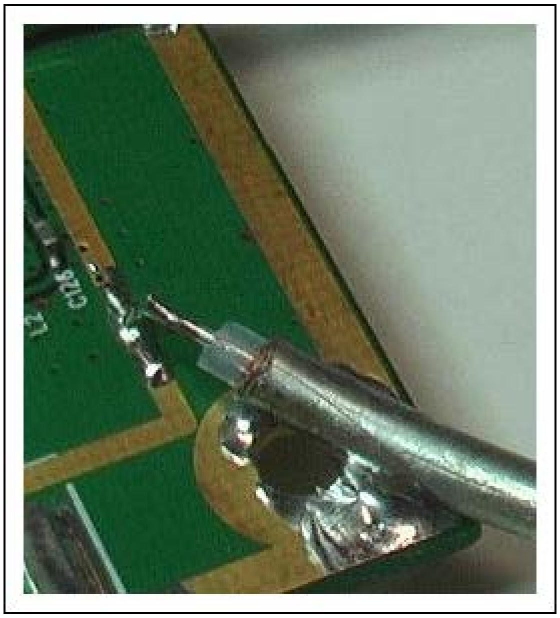

Figure 4a. Excess center conductor length can be detrimental.

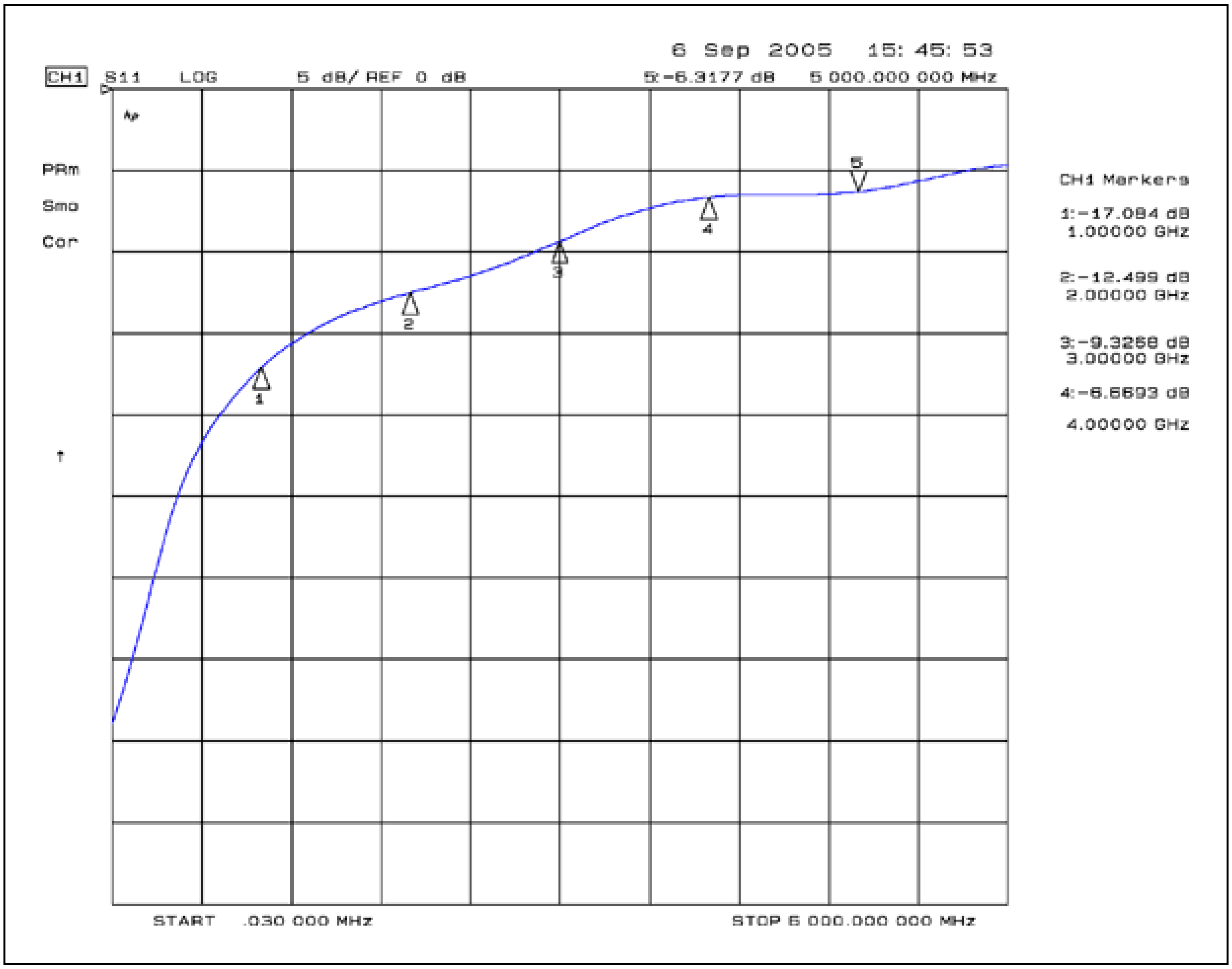

Figure 4b. Return loss with excess center conductor length.

Another item to consider when setting up for a measurement is the DC-voltage level where the pigtail will be connected. Keep in mind that many spectrum analyzers (and other equipment) can be damaged by DC voltage. Therefore, always try to break the transmission path so as to place a DC-blocking capacitor between the pigtail and the device under test.

Finally, do not be shy about grounding. If there is solder mask in the way, get out the X-Acto® knife and make room. The more shield to ground-plane contact the better, for both RF and mechanical reasons. To have the ground connection break loose during a measurement would be more than a nuisance; it could mean a pulled PCB trace or broken blocking cap.

With these guidelines, some microcoaxial cable, and a little creativity, the hidden parameters of your transmission path no longer have to be a mystery. These inexpensive tools allow us to optimize impedance matches, locate previously unsuspected insertion losses, isolate portions of a system, and genuinely 'know' a radio design better than ever before.

A similar article appeared in the February 2006 issue of *RF Design Magazine*.

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