Measuring And De-Embeding Coupling Capacitors Using VNA's And Mwoffice

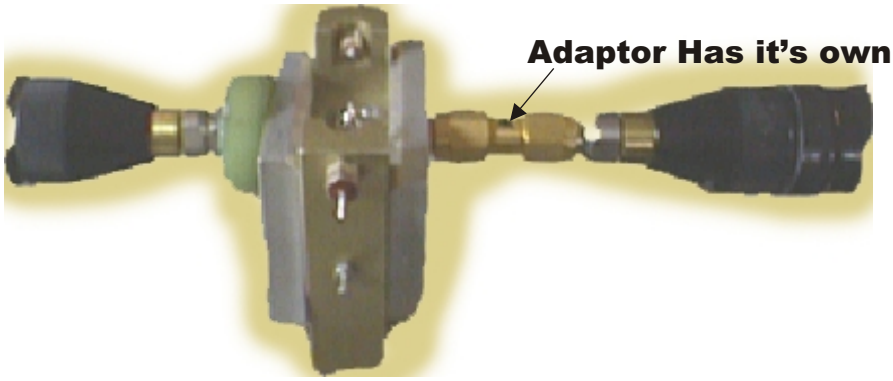
Diamond Engineering

0405 Capacitor Measurement

The development of smaller size compound interdigital capacitors leads to higher useful frequency response. This memo describes the measurement and technique used for low loss components. A VNA is necessary for accurately measuring low losses. There are two main problems. The first is due to the VNA cables. One is Female while the other is Male. The second is the test fixture imperfections. The test fixture used to make the measurements is mechanically symmetrical. This is because of the correction technique to be used. Therefore it is necessary to use a barrel adaptor at one of the test fixture ports as shown below.

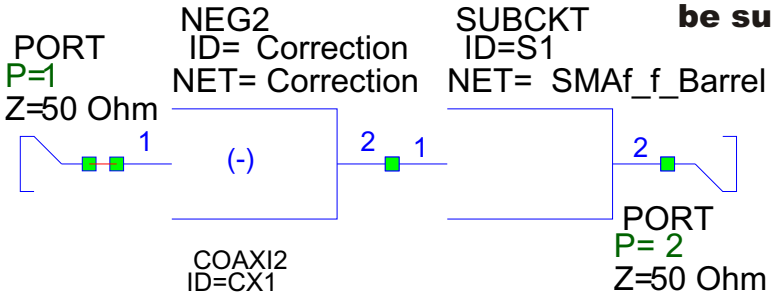
The 0405 XR7 hi K cap has C values to .1Uf. It is a multilayer structure

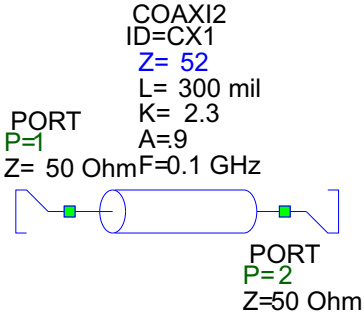
Test Fixture



The adaptor S-Parameters are measured using a Teflon SMA barrel whose length is known. This allows the S-Parameters of the two piece assembly to be measured. The Adaptor [S] matrix is extracted by subtracting the delay of the barrel based on length. The coaxial loss is reduced by the same ratio. This assumption relies on near perfect impedance and match. Both sections must have the same basic physical structure.

Adaptor [S] matrix must be measured with a Barrel Adaptor. The physical lengths and likeness allow the barrel delay and loss to be subtracted from the results.





The coaxial simulation of the SMA barrel is subtracted from the over all [S] matrix based on delay and loss. This results in the Adaptor [S] matrix which itself may be further refined as a simple coaxial element. In this manner the loss-frequency and group delay of the adaptor may be determined for use with De-Embedding the test fixture measurements. The vector negation and coaxial modeling form the basis of the measurement.

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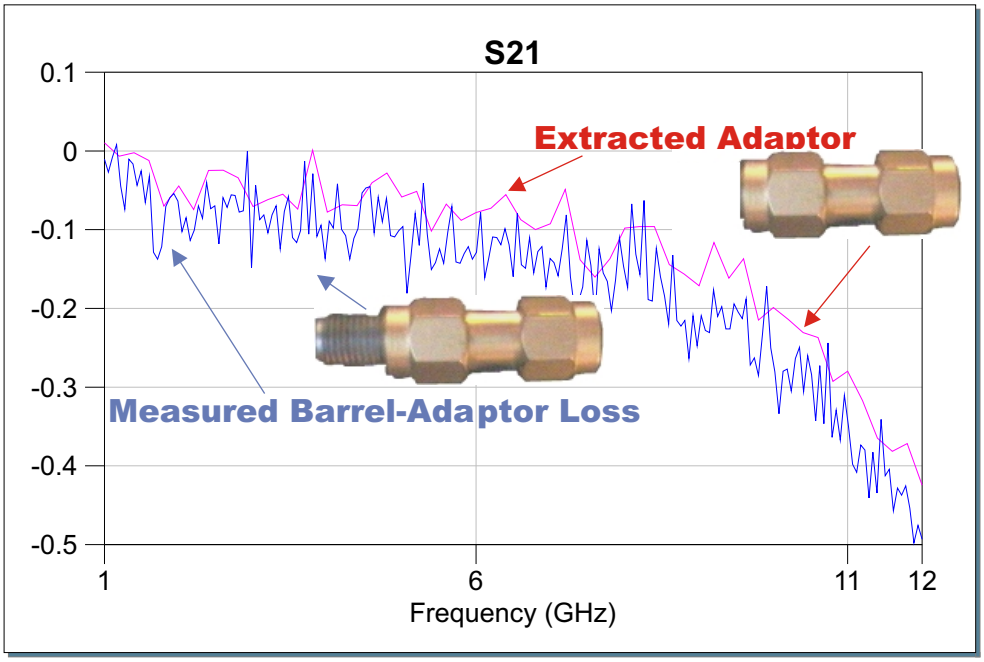
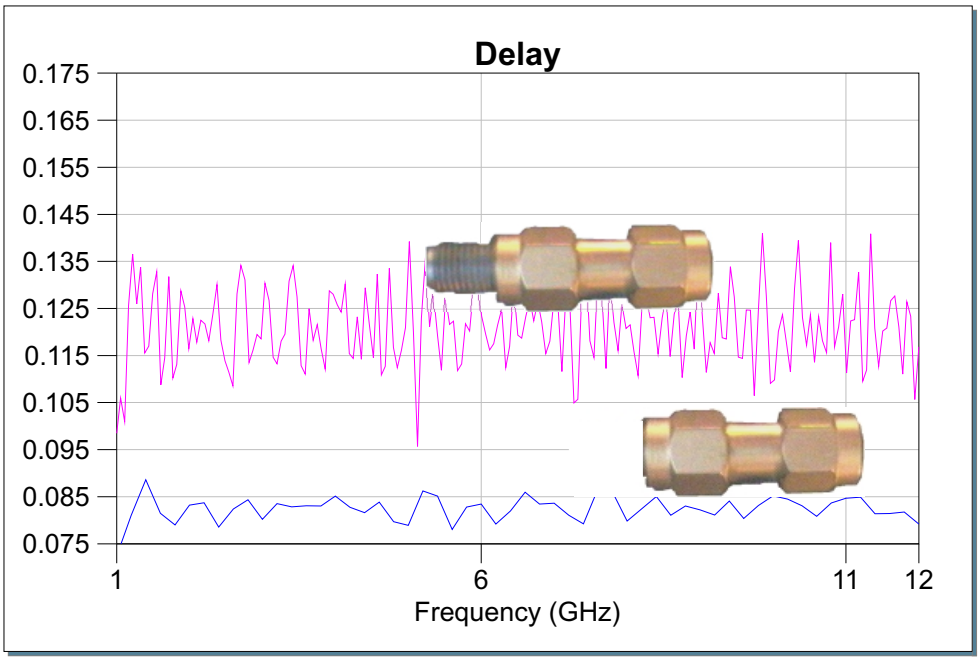
Adaptor Loss After Barrel Negation



Delay Extraction of The SMA Adaptor



The above extraction represent a combination of direct measurement and simulation correction based on physical knowledge. The same procedure may be applied to the test fixture. Text fixture symmetry can can also be applied to establish the Negation input and output [S] matrix. The test fixture is first measured with a through element. Ideally a through PCB is installed. The measurement gives the [S] matrix of the entire assembly including the SMA adaptor. The negation of the

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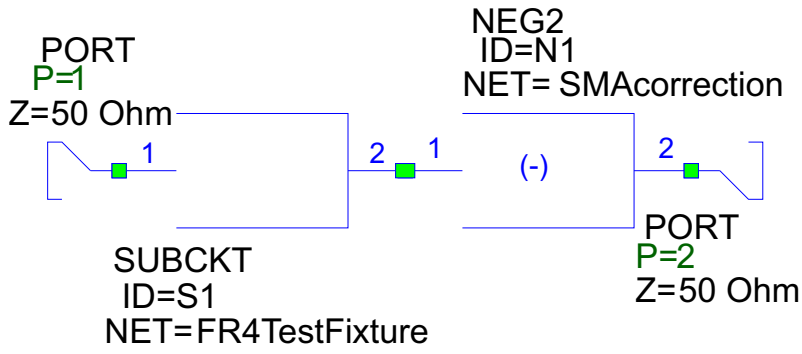
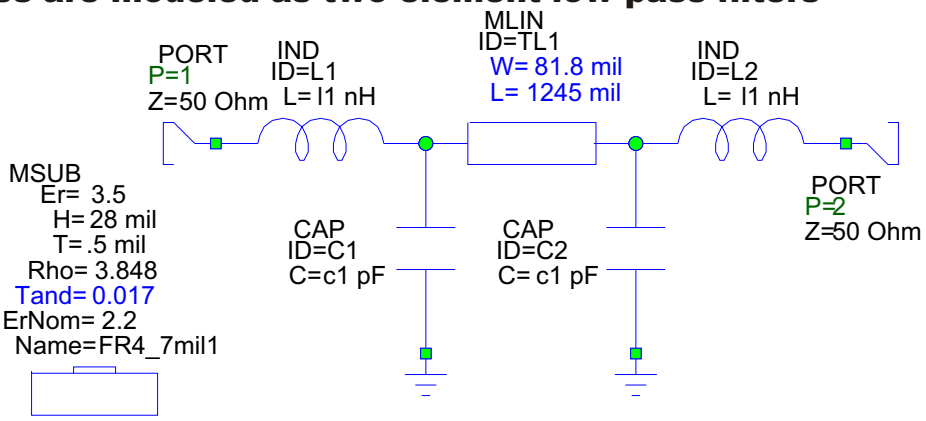
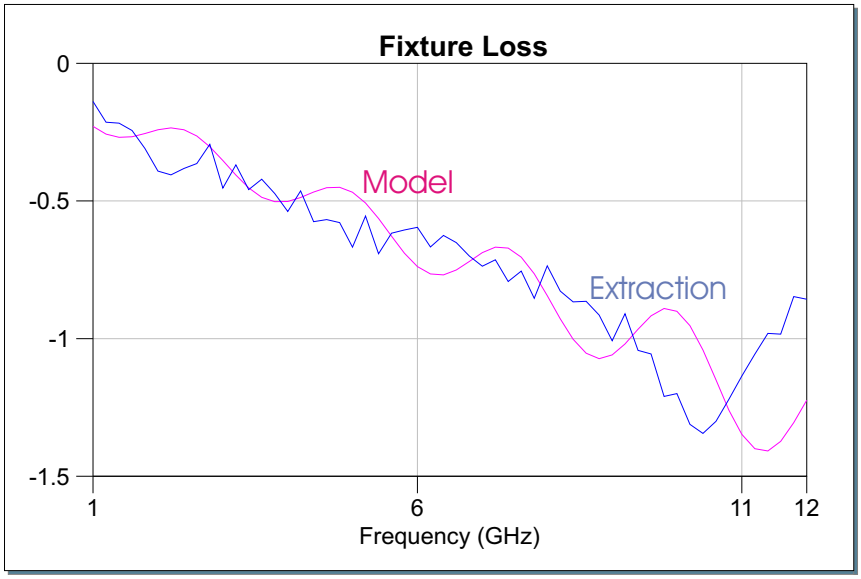
Fixture measurement is vector corrected to negate the sma adaptor. This results in improved loss accuracy



A physical model is established for the extracted test fixture. The connector discontinuities are modeled as two element low pass filters



The extracted fixture [S] matrix is modeled using measured physical parameters and optimized to match the measured [S] matrix



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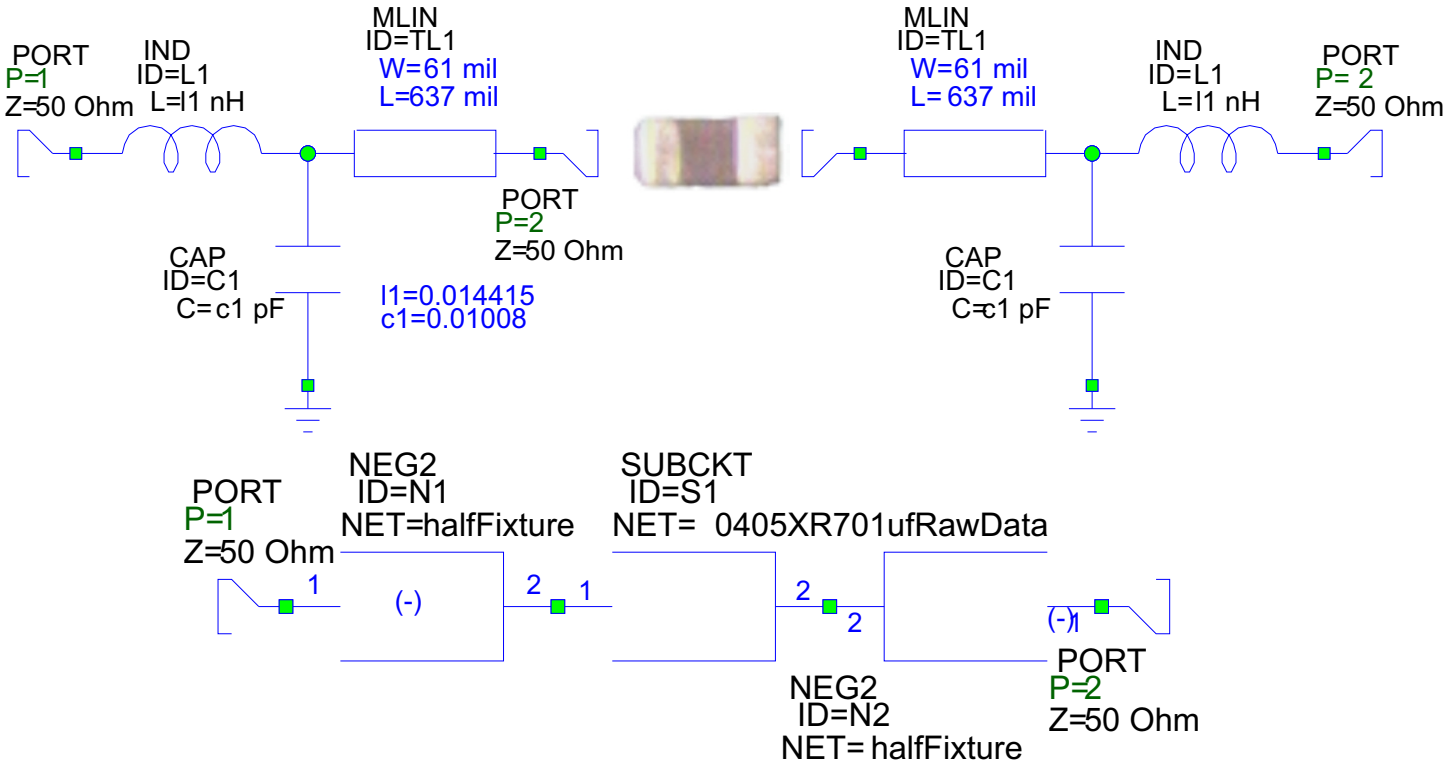
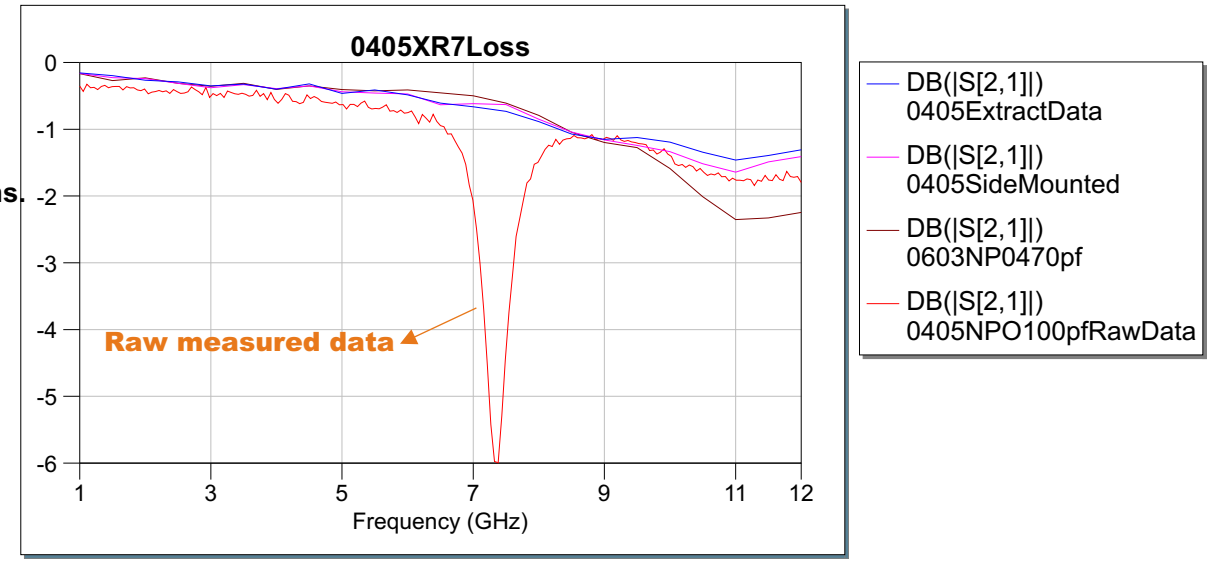
The symmetry of the equivalent test fixture is then used to break the fixture into two identical input and output networks. The [s] matrix of the DUT can then be extracted using the previous negation principal. It should be mentioned that the resulting device [S] matrix then includes the transmission line end effects or the mounting parasitics.



The measurements were made on an X7R 0405 .01Uf cap. The part was measured in it's normal mounting configuration and also on it's side. It can be seen that the side mounted measurement is nearly identical up to 8 or 9 GHz where differences begin to show up. Also shown is an 0603 version. Through frequencies up to 5GHz there is no significant insertion loss differences. It is amazing that such a high value X7R capacitor behaves so well. It is a broad band part.

Extracted Loss data for 0405 X7R in two mounting configurations. 0603npo as well.



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