AOATest

AN-101
APPLICATION NOTE

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# De-Embedding And Calibration Of Patchpanel

**By Steve Smith**

In all RF measurements the level of difficulty is dependent on the degree of accuracy required, this isequally true when using the Patchpanel. For any form of measurement the most accurate calibration it is best to make the measurement points as close as feasible to the device or module being tested. There is usually a limit to how physically we can get to the device being tested where we can sensibly connect calibration standards, beyond this calls for de-embedding which if done correctly can give more accurate results.

## 1 or 2 port Calibration of Standard DIB Interface

Probably the easiest point to use for calibration is the final RF connection before the device being tested, this way at very least we can allow for the losses and frequency-dependent effects introduced mainly by the cables, and to a lesser extent by the high-quality precision RF connectors used on the Patchpanel.. Figure 1 shows a simplified RF device or module test setup using the Patchpanel, in in you see the base unit, the standard Device under test interface board (DIB), with the user's own Loadboard attached. To calibrate this the easiest place for accurate calibration would be to remove each RF connector from the DUT board and make this connector interface to be the reference point for calibration.

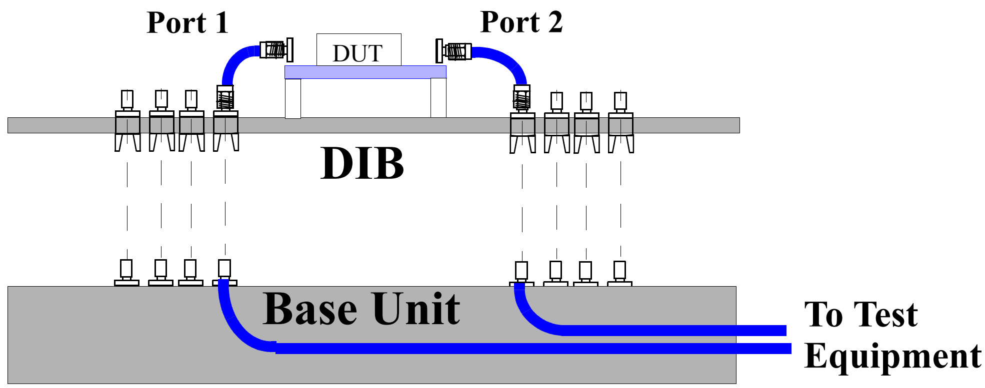
## De-Embedding of 1 or 2 port Calibration of Standard DIB Interface

A further technique that could be used for calibration is something known as de-embedding. How this works is that designed onto the DUT board are a number of additional RF connectors, each going to the appropriate RF calibration standard, open, short, load, through, the length and properties of each trace is matched to the length and properties of the physical trace that actually goes to the DUT. In this case during calibration each of these standards is connected in turn as necessary, then when the calibration is completed the cables are re-connected to the DUT ports. One note here is that for the through standard the trace length needs to match the TOTAL length from port 1 to the DUT plus from the DUT back to port 2. The advantage of this technique is that it is easier and cheaper to do compared to designing custom standards, however the disadvantages are that a) it doesn't include the parasitic effects of the DUT socket, and b) that because of fab variations it really requires to be included at the time of the DUT board design.

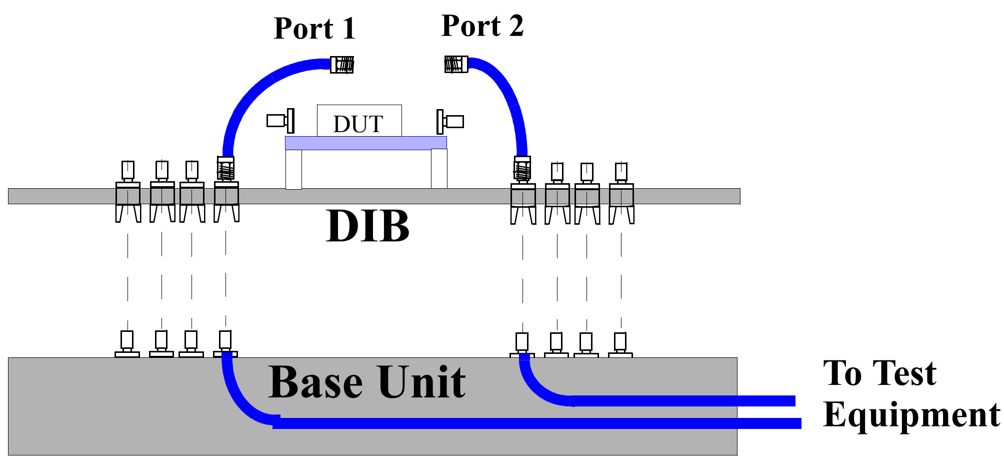
For an even a more accurate calibration then probably the best way to exclude the effects of the loadboard and test socket would be to build a selection of custom calibration standards that physically plugs into the DUT test socket. These would be 50Ohm, Open, Short or through depending on the type of measurement being made, however great care is required in the design of these standards because if done incorrectly they could become significant error. Also when using a through standard it would be wise to make sure that the RF paths used matched length cables which have similar propogation properties. This is also shown in Fig. 1.

**Figure 1 Basic Calibration Of Patchpanel with Standard DIB**

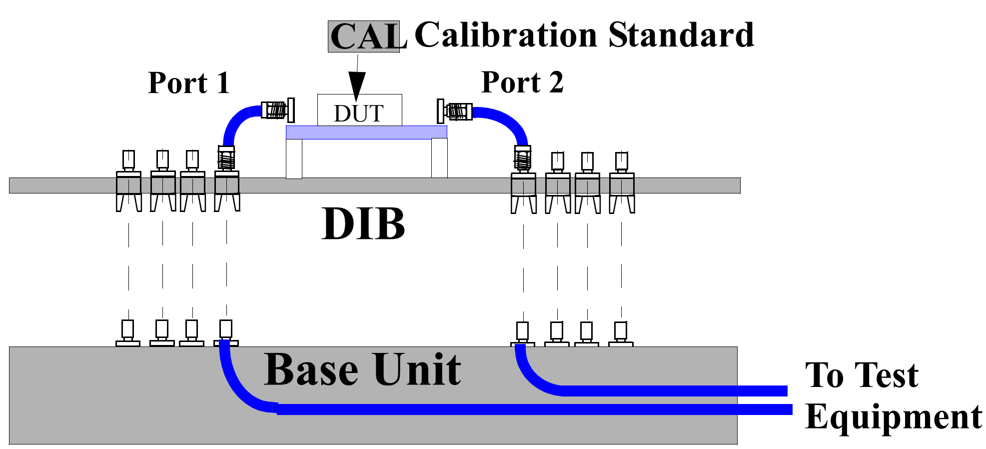
**Typical 2-Port Configuration**




**Calibrating 2-Port Configuration**




**De-Embedding with custom Calibration Standard**



**1 or 2 port Calibration of Custom DIB Interface**

As mentioned earlier the easiest point for calibration is the final RF connection before the device being tested, however with a custom DIB this becomes more difficult because ideally there are no cables between the DIB and the Device Under Test (DUT). So there are a number of different techniques for getting around this problem. One possibility is that you build a Calibration Load-board which has similar tracelengths, connectors, and properties as the DIB. This way first the calibration load board is connected to the Patchpanel, the calibration is performed and this board is then replaced by the DIB for actual testing. Because the Patchpanel is precision machined and uses top quality RF connectors this technique should be very repeatable. The advantage of this technique is that it is easy to use, the disadvantage is that there may be small manufacturing variations in board thickness and tracewidths, These shouldn't introduce significant errors, but as frequency increases above 6GHz these effects may become more noticeable. Figure 2 shows a simplified RF device or module test setup using the Patchpanel, in in you see the base unit, the custom Device under test Interface Board (DIB). Other possible calibration techniques would be to include a calibration tree of precision RF relays on the board which would switch in the reqired paths and standards via matched trace lengths for calibration. Finally custom calibration standards as discussed in the De-embedding section could be plugged into the DUT test socket.

**De-Embedding Custom DIB Interface**

For an even a more accurate calibration then as in the case of de-embedding the standard DIB loadboard and test socket would be to build a selection of custom calibration standards that physically plugs into the DUT test socket. These would be 50Ohm, Open, Short or through depending on the type of measurement being made, however great care is required in the design of these standards because if done incorrectly they could become significant error. Also when using a through standard it would be wise to make sure that the RF paths used matched length cables which have similar propogation properties.

**Calibration-Scalar**

Scalar calibration usually requires a stable RF signal generator, an RF power meter and possibly an RF frequency meter. First the signal generator is hooked up to the base unit of the Patchpanel via the RF cable to be used in the final fixture. If possible measuring the RF signal level at the DUT will yeild the greatest accuracy, If this isn't possible then a loopback technique is employed using two identical cables, the path loss at the DUT is then assumed to be half of the measured value at the loopback point. See Fig 3. Frequency measurement is more streightforward because this ought not change with cable length.

**Calibration Vector**

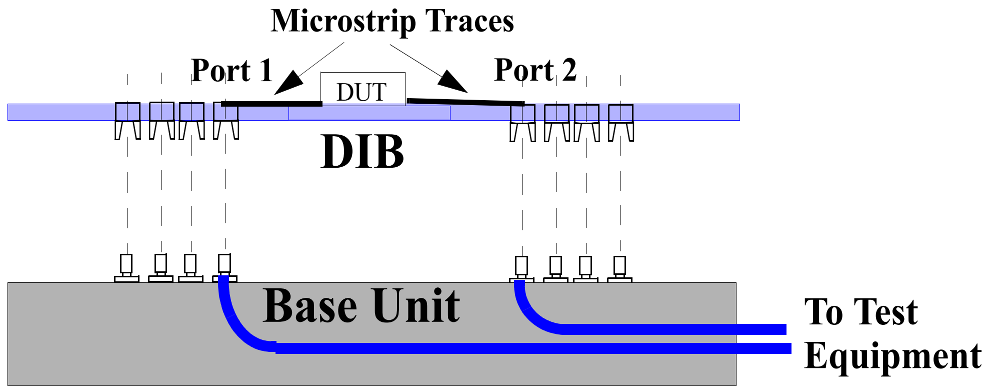
Vector calibration requires as a very minimum an open, short and 50 Ohm load standard, for accurate vector measurements it is essential that these standards be applied as close to the DUT as possible. Using the loopback technique would require custom computation and introduce too many possible errors to be useable - especially at microwave frequencies. The better the quality of these calibration standards the more accurate will be the measurements, we would recommend regular calibration of all standards and care to keep the contact surfaces free of contanination.

**Further Assistance**

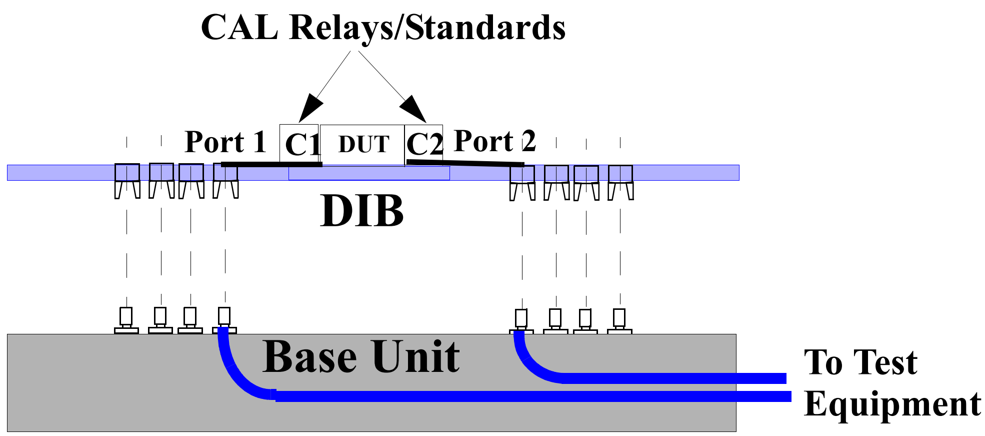
For our full-range of consulting and custom solutions, contact our sales office at 408-323-1164

**Figure 2 Calibration Of Patchpanel with Custom DIB**

**Typical 2-Port Configuration**




**Typical 2-Port with Integral Cal Relays/Standards**




**De-Embedding with custom Calibration Standard**