# Open-Short Deembedding

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## 1 Calibration and Deembedding

Device characterization almost always requires a test fixture to interface the device under test (DUT) with measurement equipment. A two-port DUT with a simple test fixture is shown in Fig. 1(a), where the ports IN, OUT and GND are the measurement access points. Physically, these ports can be direct probing pads (for example on-wafer) or simple PCB connectors (like SMA), but, in both cases, direct measurement at the interface defined by these ports means that, what we are measuring is, in fact, the DUT plus fixture, not just the DUT.

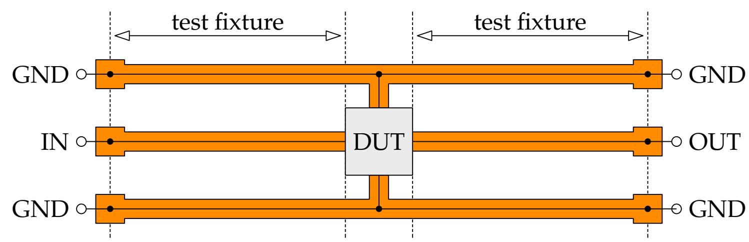
At low frequencies, where the wavelength of the signal is much larger than the test fixture dimensions, the fixture around the DUT can be well considered a short circuit as shown in Fig. 1(a), and straightforward measurement yields accurate description of device performance.

As we move to higher frequencies, the wavelengths of interest become comparable to, or much smaller than, the dimensions of the fixture. From an electrical point of view, the same test fixture now looks drastically different, as shown in Fig. 1(b). The traces leading to the DUT effectively become transmission lines, acting as a distributed shunt-series network. As a result, direct measurement at reference plane A becomes grossly inaccurate at high frequencies because the device performance is completely masked by the fixture.

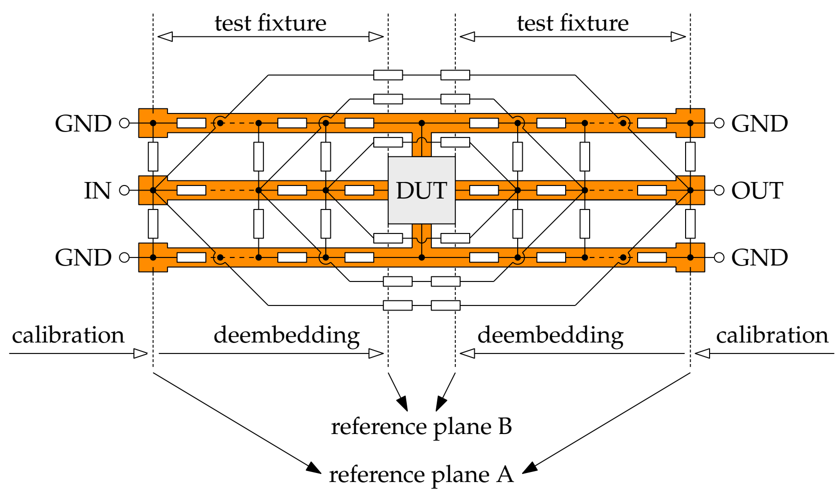
So, while calibration allows accurate high frequency measurements at reference plane A, it falls short of extracting the device performance simply because the physical constraints of the setup set a limit on how close to the DUT the measurement ports can be. Deembedding is the process that allows us to “subtract” the fixture from the measurement, effectively moving the reference plane from A to B.

## 2 Open-Short Deembedding

Open-short deembedding is a technique suitable for low gigahertz ($< 10$ GHz) on-wafer measurements. In this case, the transmission line model of the fixture




(a) Wavelength of interest ≫ test fixture dimensions.




(b) Wavelength of interest ≪ test fixture dimensions.

Figure 1: DUT plus test fixture.

in Fig. 1(b) can be simplified into a single shunt-series section which reduces the model to a pi-T parasitic network as shown in Fig. 2 top left corner (indicated as raw measurement). The fixture can then be deembedded from the raw measurement of the DUT by using two additional test structures on-wafer: an open and a short.

Fig. 2 shows a graphical representation of the open-short deembedding procedure, where $S$, $Y$ and $Z$ denote S-, Y- and Z-parameters, respectively. The two-port Z-parameters of the deembedded DUT, $Z_{\mathrm{DUT}}$, are

$$Z_{\mathrm{DUT}} = (Y_{raw} - Y_{open})^{-1} - (Y_{open} - Y_{short})^{-1} \tag{1}$$

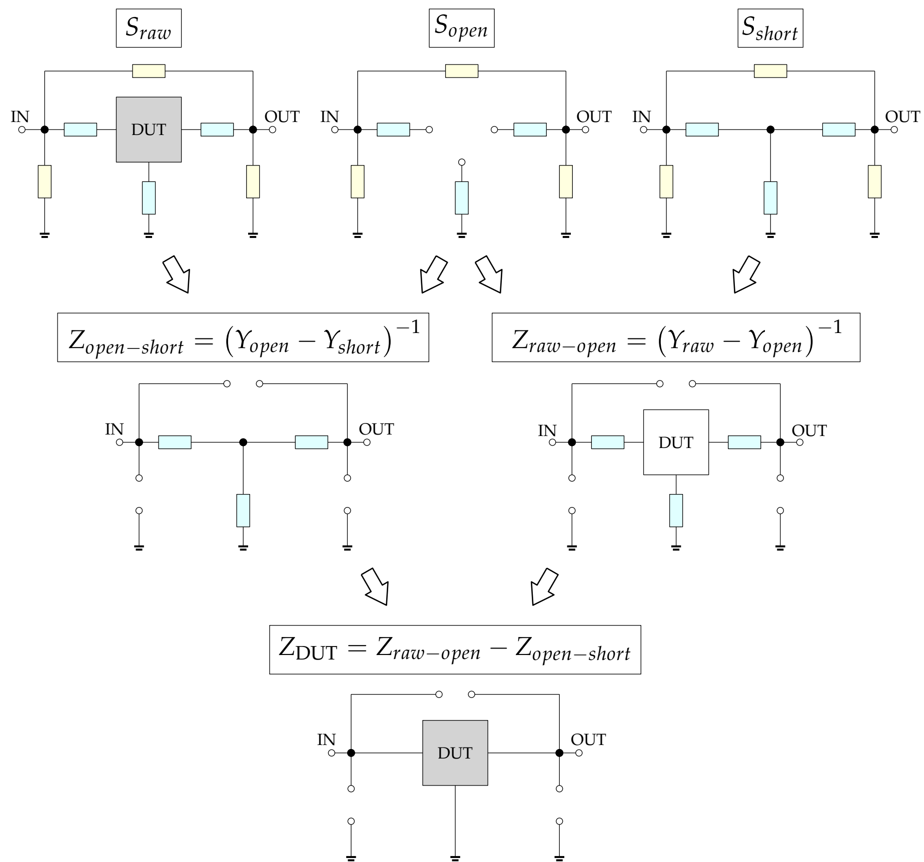



Figure 2: Open-short deembedding combines three sets of measurements to remove test fixture and arrive at DUT performance.