MegiQ

RF Development Tools

Balanced and UFL Calibration kit

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Contents

Connectors need special care.

Damage to connectors / wearing down do *not* fall under warranty!

So treat your connectors with care.

Introduction

The MegiQ UFL and Balanced Calkit was developed to make it possible to perform VNA measurements on small PCBs and antennas, where the traditional SMA and N-connectors fall short because they are too bulky. It is a set of adapters and calibration standards that allow you to get onto your PCB and measure close to the point of interest.

Calibration Standards

Unlike the traditional connectorized calibration kits, we don't provide calibration correction factors to be entered into the VNA settings. The calibration standard we provide are the (precision) resistors on the calibration PCBs. You will be matching and measuring against these calibration standards. Up to 6GHz for UFL and 3GHz for pinheaders this is close enough to an 'ideal' impedance to give reliable measurement results.

Cautions

Misuse might damage the connectors or VNA, or lead to nonsense results.

- Do not over tighten the SMA connectors. A little more than hand-tight is sufficient.
- Beware of cheap or poor quality SMA connectors. The slightest damage or misalignment to the center pin can easily ruin a female SMA. The warranty does not cover damaged connectors.
- If an SMA connector does not feel right when screwing then DO NOT CONTINUE. Find out what is wrong or replace the connector.
- SMA port connectors have a maximum of 500 mating cycles, after that the reliability and repeatability decreases. If you anticipate many cycles it is a good idea to use a SMA Female to Male adapter as a ‘port saver’.
- UFL connectors are easy to use but fragile. Do not force them on, and pull them off straight up and without too much force.
- Connectors easily get dirty and tend to spread the dirt all over the lab. Keep the connectors clean and regularly brush them with flux remover or other (non-aggressive) solvents.
- The female UFL connectors on the cables wear out fairly quickly. Throw them out when you don't trust them or when you get unstable results.

Performing a VNA measurement

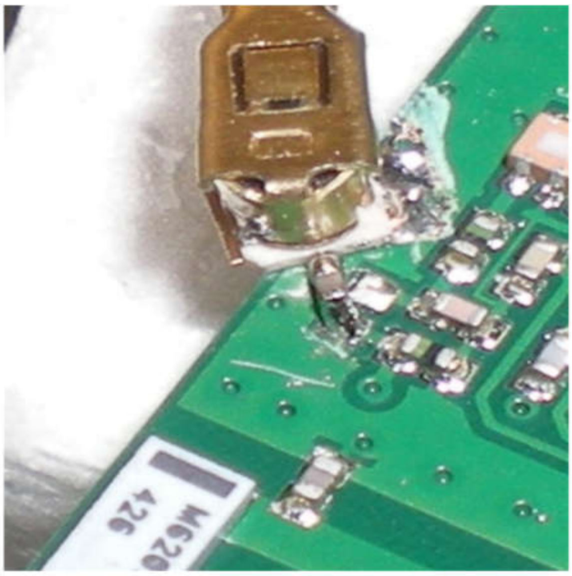
Performing a measurement with a Vector Network Analyser is not very difficult, as long as you do the right steps in the right order. These steps are independent of the kind of VNA measurement you want to do. It all just has to do with the use of the high frequencies, which makes it different from many other, lower frequency measurements.

- Think it all well over: what do you want to know, what do you want to do with the results, etc. ?
- Choose the point where you want to measure. It is RF, so every millimetre counts: run length transform impedances, so choose this point carefully.
- Make sure you use the right cables, connectors.
- Make the right measurement set-up (hardware) and the set-up of the instrument.
- Perform the calibration. (see “calibration”)
- Perform the measurements.
- Interpret and save the results.

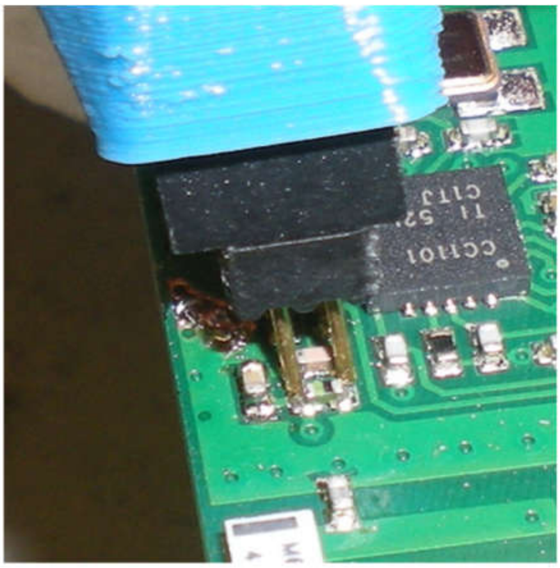
Preparing a PCB for measurement

It is very useful to prepare the design of a PCB with footprint(s) for UFL measurement. This footprint can be left open during production, but during development this is an invaluable advantage for accurate measurements.

If there is no predefined UFL footprint it is usually possible to temporarily add a UFL by cutting some copper and scratching open the ground pads and use de-embedding to correct for the connection. If that is not possible, the balanced probe can also be used to 'probe' the desired point. Make sure that the trace that feeds the measuring point is disconnected (cut).

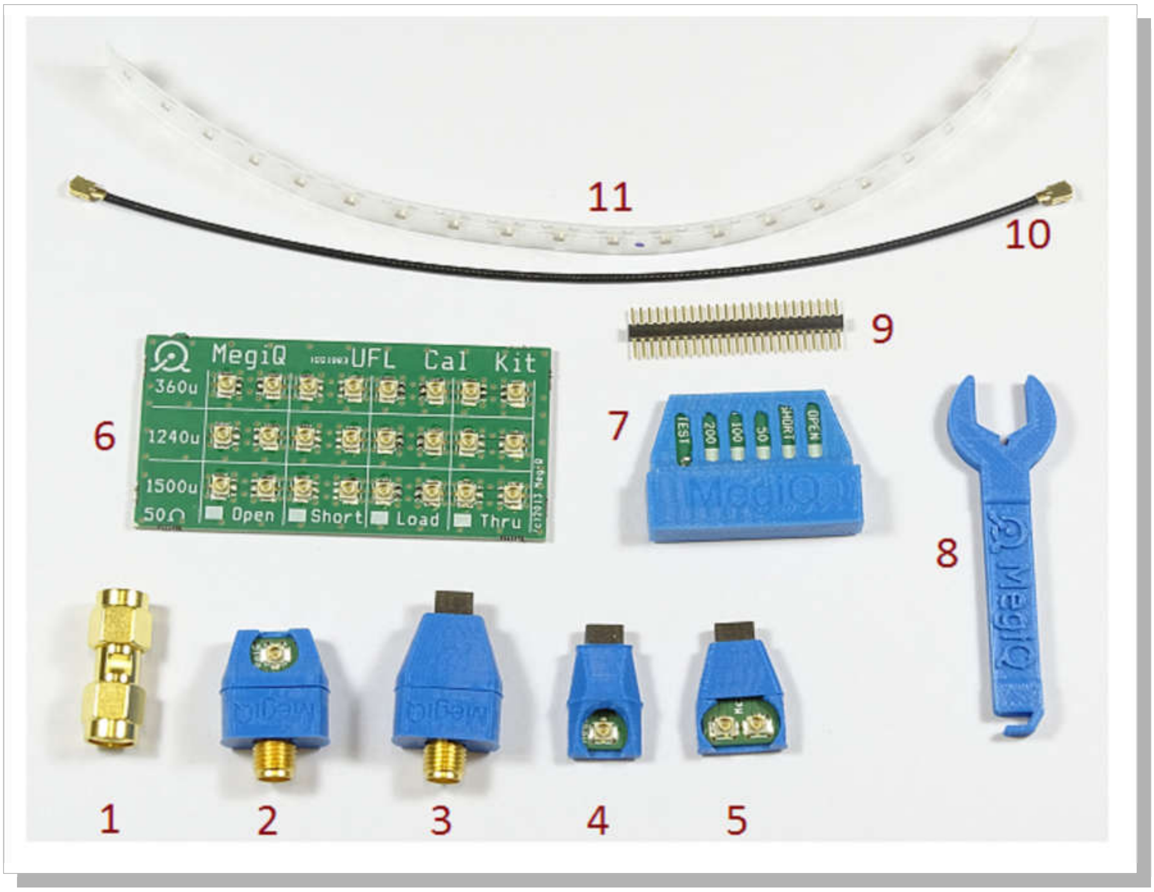


Adding a UFL for measurement



Measuring with the balanced probe

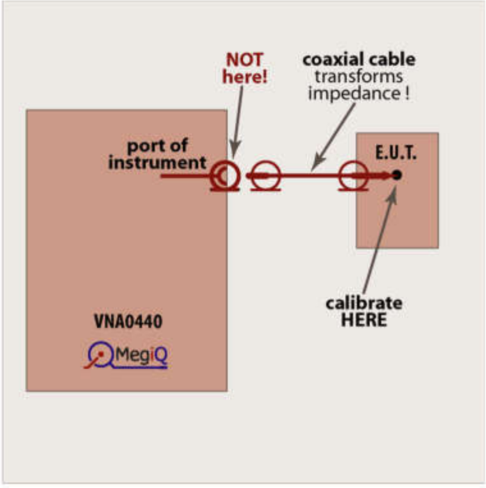
Contents of the UFL-BalCal kit



Nr	Desc	Pieces
1	SMA Male to Male adapter	3
2	SMA – UFL adapter	3
3	SMA – Balanced adapter	2
4	UFL – Balanced adapter	2
5	UFL – Differential adapter	1
6	UFL Calibration Kit	2
7	Balanced Calibration Kit	2
8	SMA Torque wrench	1
9	Blank pin headers for Balanced measurements	2
10	UFL to UFL cable	10
11	Blank UFL connectors for UFL measurements	20
	Ferrite Core	3

Calibration

In vector network analysis you are interested in impedances of components and circuits. At high frequencies almost any length of cable will act as an impedance transformer, thus altering the impedance you actually see. Furthermore at even higher frequencies many cables become lossy, which influences gain *and* impedance plots.

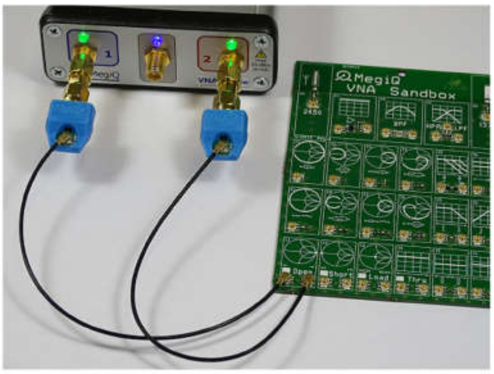


Point of calibration: at the E.U.T.

Luckily these cables act as linear elements and can be 'calibrated-out' by linear algebra. Do not be afraid, the instrument will do this for you, but it should be fed with some well known impedances for every frequency of interest before you start the actual measurement. Therefore before using the instrument you should perform a calibration on the whole set-up, including the cables, connectors, etc. for the frequency range you want to use in your measurement.

The instrument stores this set of calibration data.

But, changing cables, connectors or frequency range means that you must renew the calibration. Avoid bending cables to much after calibration. (depending on the quality of the cable of course)



Typical calibration setup on the MegiQ VNA Sandbox

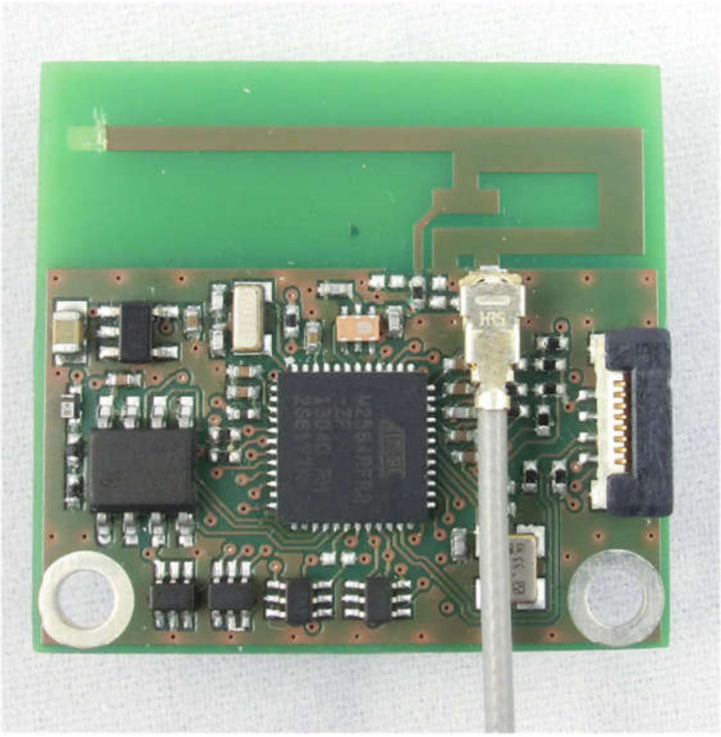
The well known impedances the MegiQ VNA uses for this are an **Open** Connection (O) a **Short** Circuit (S) a **Load** resistor of 50Ω (L) and a **Through** connection (T).

Again: during the calibration process, use the very same cables and connectors you are going to use in the actual measurement! Not calibrating the whole set-up will lead to very confusing results!

Ferrite cores

In some setups, especially on PCBs with small ground planes, the UFL cables leading to the measurement carry enough ground current to affect the results. To prevent this the UFL cable can be fed through one of the ferrite cores. One winding (thread the cable through the hole twice) near the measurement point usually works well, more windings are not necessary.

Using UFL connectors



Real Life UFL measurement

Choice for UFL connectors

Most connectors are far too bulky for miniature RF electronic circuits and influence the system you are measuring too much. UFL brings a solution.

Although the *basic accuracy* is less than that of a good SMA or N-type connector, the *system accuracy* in a real life situation is often far better. This makes UFL a good choice for coaxial common mode connections.

See the picture above and imagine the trouble you would encounter, both mechanically as well as electrically, when using SMA on this location and how it would influence antenna performance!

Advantages

When use with care UFL will give you a lot of advantage.

- the footprint is small, you can design in test points in your design
- it has less influence on the fields near to the connector
- they are inexpensive
- they are small
- the cables assemblies use thin cables
- when using the footprint in your design, you can dis-embed just up to the point of

interest, i.e. *on* your PCB!

Disadvantages

There are of course also disadvantages:

- the quality of the connector itself is lower that that of a good SMA
- they are not very sturdy when mating and unmating, use with care!
- there are good, but also some very bad UFL/UFL cables around.(check them when you buy them)
- you need special calibration OSLT tools (which you find in this kit)

Design-in

The footprint of the UFL jack is small, so in most cases you can design the footprint in on your target PCB. When you leave this footprint on the PCB of your final product, you can probe impedances even on the final product, without having to change the topology of the PCB. No “sudden bulky connectors” changing the complete RF behaviour!

This is one of the most important advantages of UFL making them a far better choice in many situation than the “better” SMA or N-types.

Real life use

The real life use is simple, it is a 50 ohm coaxial connector like an SMA is, so use is straight forward. But they are small, so perhaps you will have to wear glasses when inserting or un-mating the UFLs.

SMA to UFL

The kit contains three SMA-to-UFL converters. These are in most cases better then the standard ones in the sense that the UFL-cable come out of the VNA without a right angle. This is much more handy.

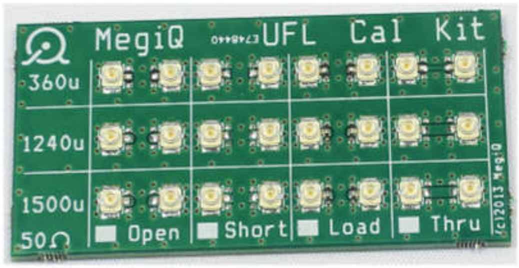
Use an SMA-male-to-male adapter (also in the kit) if you want to screw the SMA-UFL adapter directly on the VNA.

SMA to UFL Adapter

Calibration

Calibrate the whole set-up before using. Please refer to the section about calibration in the VNA manual.

The UFL calibration tool PCB contains two OSLT circuits each for three thickness of layers. This will allow you to calibrate for most of your PCB circuits.



UFL OSLT calibration tool

For every thickness and circuit (O,S,L or T) there are two identical circuits, which you will need in case of 2-port calibration.

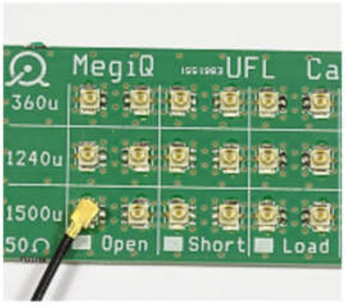
Note: when calibrating for “Isolation” you should terminate the port into 50 ohm.

UFL Calibration

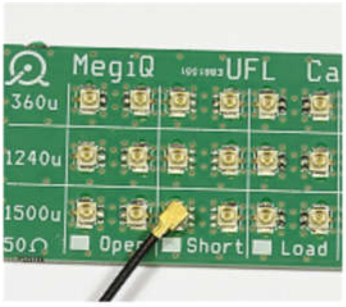
Your VNA provides a procedure or buttons to perform a user calibration of your setup. For a one-port calibration you need to perform an Open-Short-Load calibration of the test setup connected to the port in use. For a two-port calibration you need to perform an OSL on each of the ports and a Through calibration between the ports. An Isolation calibration between the ports may also be required.

One-port UFL calibration

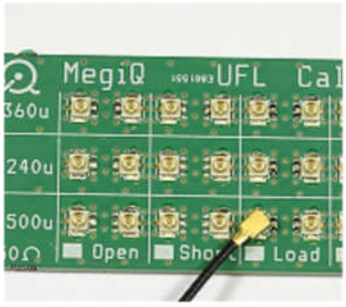
The pictures below show the connections for a 1-port calibration. The calibration will be valid for a UFL on the same footprint on a PCB with the ground 1.5 mm below the signal layer.



Open calibration



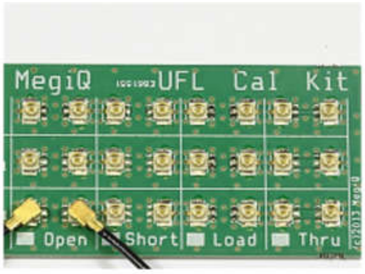
Short calibration



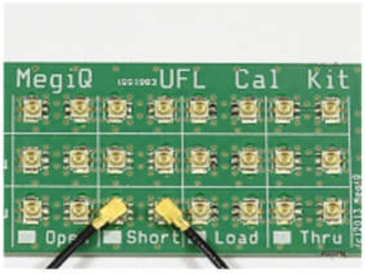
Load calibration

Two-port UFL calibration

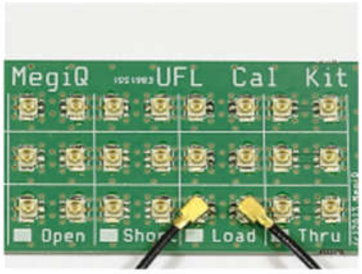
These pictures show the connections during the steps of a two-port calibration.



Open calibration

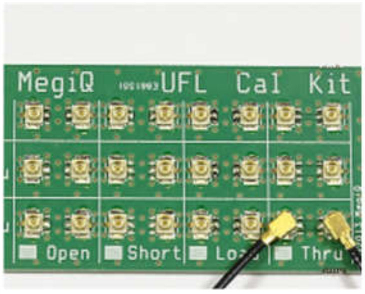


Short calibration



Load calibration

Isolation calibration

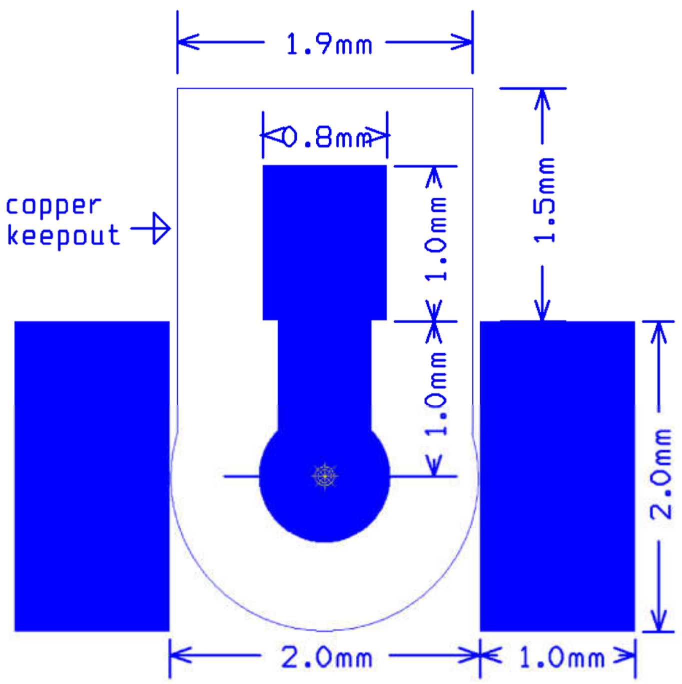


Through calibration

For a full two-port calibration you need to go through 7 or 8 steps (2xO-S-L, Through, Isolation). The MegiQ VNA software makes it possible to combine the calibration steps with a dual calkit such as the MegiQ UFL calkit. This reduces the procedure to 4 steps (O-S-L/I-T). The Isolation calibration is combined with the Load calibration when the two ports are connected to the loads.

UFL Footprint

The footprint that was used on the UFL calkit can be replicated on your design to get the most accurate measurements.

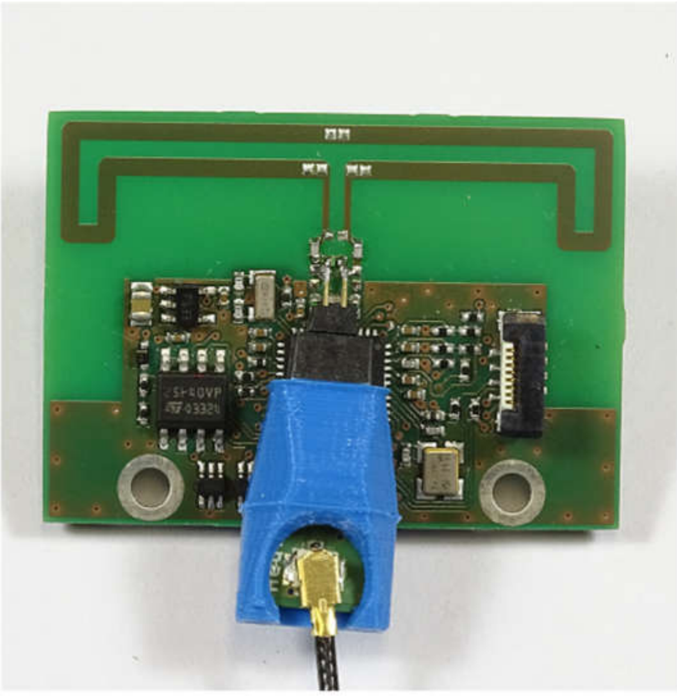


Actual UFL footprint on the Calkit

This footprint was designed for best robustness of the calkit, to minimize break off. It is not the optimum footprint for 50 Ohm impedance but it is quite near.

If your actual footprint deviates from this one you can de-embed it from the measurement. It depends on the VNA if de-embedding is supported. With some VNAs you have to search deep into the menus.

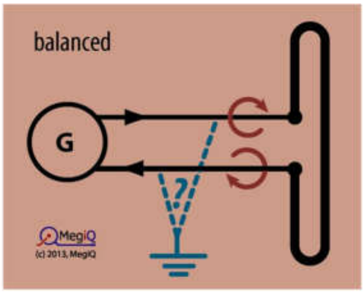
Using Balanced Lines



Real Life balanced measurement

Choice for symmetrical

In many circuits the RF-signal is not referenced "against earth" (or against a ground plane) but symmetrical. This does not always imply that there is no connection to earth. In this manual we discern "***Balanced***" and "***Differential***".



True "Balanced", no reference to earth

Often shielding is not needed: unwanted radiation from the transmission lines is cancelled by balancing the line. Such a line looks like two conductors in parallel, fed and loaded in a balanced way and are also called *Lecher Lines*.

There are a lot of antennae that are balanced by nature, like the open and folded dipole, many loops. (examples of *non-*balanced antennae: ground-plane antenna, inverted-F, ...)

Symmetrical antennae are less sensitive to grounding the system. So, with balanced antennae, portable systems are less sensitive to positioning and holding.

Furthermore there are a lot of chips out there that have differential inputs and outputs.

Choice differential / balanced

The Balanced kit contains probes for:

- **True Balanced**
  (both *SMA* and *UFL to balanced pin adapter, 3 ... 3000 MHz*)
- **Differential**
  (the *Dual UFL to differential pin adapter, DC ... 4000 MHz*)

The ***Differential probe*** is more broadband, since there is no balun involved, but it's use is more limited. It is a good choice when the system you are measuring has a low impedance to earth and is insensitive to pulling both sides with 50 ohm to earth. You will need at least two-ports on your VNA and will have to do the subtraction between the two channels by yourself. In case you want to do a 2-port differential measurement, you will need 4 ports on the VNA. So in practice these differential probes are limited to symmetrical 1-port measurements.

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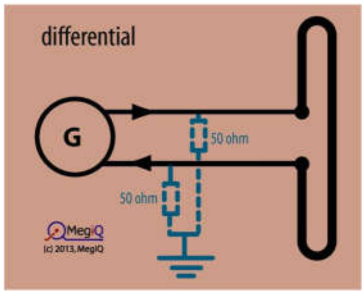


Differential" forces to earth through source impedances

In most cases the true ***Balanced probe*** will be the better choice. It is less broadband, they are suited for up to 3GHz.

Using this probe you will not pull any side of the system to earth and will only need one port on your VNA for each balanced port you want to measure.

The symmetrical probes

Grounding

The Differential measurement needs to be grounded to the EUT. The Balanced measurement normally does need to be grounded to the VNA but in some setups it may reduce noise or interference. The probes have four connections. The inner two are the signal pins and the outer two pins are connected to the VNA ground so that they can be used with a 4-pin header to connect the ground to the measurement.

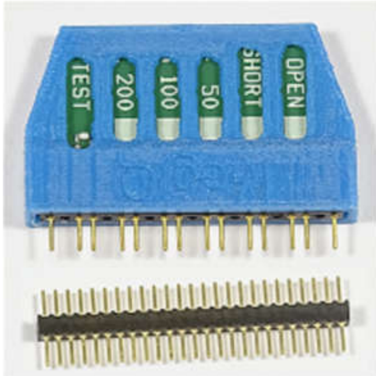
Balanced Calibration kit

As with single-ended, also the symmetrical probes need calibration. The MegiQ balanced calkit has the calibration impedances at the tip of the pin headers. You can calibrate the system up to "on the PCB" since the kit provides the same blank pin headers to be used for your measurements.

The calibration procedure for balanced is in principle the same as with single ended coaxial. Be careful with the pin headers, do not bend them.

You have the choice between three common load impedances, 50, 100 and 200 ohm. There is also a "test-circuit" which is actually a LCR-series connection.

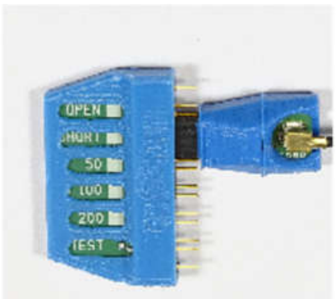
In the pictures below you see how to connect the probe(s) to the calibration tool during the calibration procedure.



Balanced calibration tool and blank header

The 'Test' connection can be used to verify the calibration. It is a series LCR circuit that shows a nice circle on a Smith chart.


Open calibration


Short calibration


Load calibration

You can use either the 50 Ohm, 100 Ohm or 200 Ohm load for your load calibration.

For a two-port measurement you also need to do a Through calibration and possibly an Isolation calibration.

For the Isolation calibration you can use the Loads on the two calkits. For a Through calibration you can use a setup as in the picture. But it would be more correct to solder two pinheaders back to back and use that between the two probes.

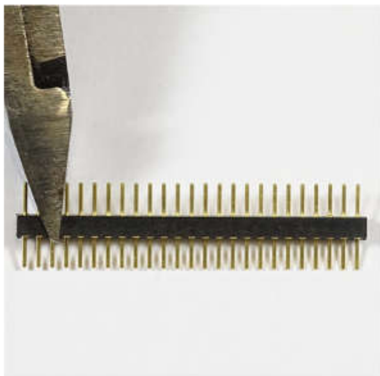

Through calibration

Measuring

The pin headers can be soldered on the pads of a 0402 component, or over the component itself. However, this tends to be very delicate and pads or components easily break off the PCB. It is recommended to support or fix the coax that feeds the balanced adapter.

It is even better to design in two through holes for the pins. The pins should NOT be soldered all the way through because they are calibrated at the tip. But sinking them a tiny bit into the holes and then solder them makes the setup much stronger.

The blank pin headers are provided for your measurements. A pair of pins can be cut off the strip. It is necessary to sacrifice a third pin because it is impossible to cut between them. Make the cut as if you want to cut the third pin in half but watch out for flying pins!



Cutting the pin header