Kirby calibration SMA kit

The page gives you the information needed to use the SMA calibration and verification kit on the following **HP** or **Agilent** VNAs.

- 8510A, 8510B and 8510C
- 8752A, 8752B and 8752C
- 8753A, 8753B, 8753C, 8753D, 8753E, 8753ES, 8753ET
- 8719A, 8719B, 8719C, 8719D and 8719ES
- 8720A, 8720B, 8720C, 8720D and 8720ES
- 8722A, 8722B, 8722C, 8722D and 8720ES

Look at these pages if using the kit with other makes or models of VNA. If your VNA is not listed, please contact us

- Agilent/Keysight ENA series
- Agilent/Keysight PNA series
- Agilent/Keysight FieldFox series
- Anritsu
- Copper Mountain
- LA Techniques
- Rohde & Schwarz
- VNWA

Misinterpreting what HP mean by the sex of connectors during calibration

Irrespective of what test ports your VNA may have, if you wish to test SMA or 3.5 mm devices then you need an SMA or 3.5 mm calibration kit. The SMA or 3.5 mm is obviously sexed, unlike the APC7 which is sexless.

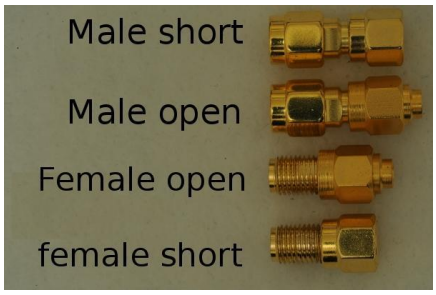
One should understand that the sex HP/Agilent/Keysight refer to the **test port**, and **not** that of the calibration standard on the 8510, 87xx and ENA series. So if one is going to connect a female short, one must select SHORT(M), since this standard is going to fit on a male test port. This seems somewhat illogical. Agilent realized this, and changed the convention for thePNA and FieldFox series. The also changed the parentheses for hyphens, so
SHORT(M) == SHORT-F-

Identifying parts

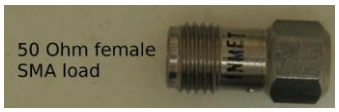
The following photographs should help one identify the main parts of your calibration and verification kit.

Parts used for calibration - these are the 6 most important parts

First there are the opens and shorts, which are designed such that the delays of the opens are a little less than the shorts, so the phase difference between the open and short remains close to the optimal 180 degrees at all frequencies.



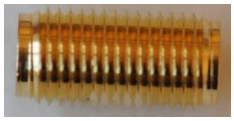
A number of different female loads have been used, but all look broadly similar to that below



A number of different male loads have been used, but all look broadly similar to that below. All loads meet the specification of >= 32 dB return loss from DC to 7 GHz.

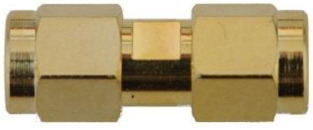
Female-Female thru

The female-female thru is not needed to calibrate the VNA, but can be used to measure devices with two male connectors each end. Although not shown on this photo, this has two flats around the middle, so it can be loosened with a 5.5 mm spanner. You are advised to purchase a 5.5 mm spanner.



Male-Male thru

The male-male thru does not need to be used to calibrate the VNA, but can be useful if measuring devices with two female connectors at each end, which is quite common for RF parts. Two types of male-male thru have been used, although they look almost identical. One has a black dot on the side, whereas the other does not. The significance of these differences will be discussed later when we describe how to measure non insertable devices with the kit.



Attenuator used for verification of the VNA calibration

A serial-numbered attenuator is supplied along with measured data which is put on the USB stick. The attenuation and phase of S21 and S12 (which should be the same) should be compared to that what you measure. The serial number on the attenuator should match that of the kit, and the contents of the USB stick.

Entering calibration kit coefficients

It is **absolutely essential** that a VNA has the correct calibration constants for a calibration kit. Just taking random opens and shorts, and picking the 3.5 mm calibration kit from your VNA will result in incorrect measurements. They might look fine, and show a nice flat S12 and S21 of close to 0 dB, and an S11 and S22 of -60 dB or more, but the results of any measurements will be incorrect.

Since no HP or Agilent vector network analyzer will have the correct constants for this calibration kit, these must be entered as a user-defined calibration kit. There are 3 ways to so this. One or more of these methods will work on any HP/Agilent 87xx or 8510 series VNA.

1. Using a floppy disk. (The easiest if your VNA has a floppy drive)

   Download one of the following files. The 8510C just has one file, which must start with the name CK_. The other instruments need more than one file, and these are in zip files. Note that kits with a serial number of 0001 to 0155 need a different file to the kits with serial numbers 0156 and later. The design of the open standard changed a little, so new coefficients are needed.

2. Using the keys on the front panel of the VNA.
3. Copying over GPIB using the VNA Cal Kit Manager 2.1 software, available from the Keysight web page.

The following table shows which methods work with which VNA.

VNA	Floppy disk	GPIB using Calkit Manager 2.1	Front panel
8752A, 8752B, 8752C	No floppy in VNA	Supported	Supported
8753A, 8753B, 8753C	No floppy in VNA	Supported	Supported
8753D, 8753E, 8753ES, 8753ET	Supported	Supported	Supported
8510A	No floppy in 8510A	Supported	Supported
8510B	No floppy in 8510B	Supported	Supported
8510C	Supported	Supported	Supported
8719D and 8719ES	Supported	Supported	Supported
8720D and 8720ES	Supported	Supported	Supported
8722D and 8722ES	Supported	Supported	Supported

If you have HP 8510C, late versions of the 8753, 8719, 8720, 8722 series which have floppy drives then can request a floppy disk like this.

from which it is very easy to load the coefficients.

Method #1 - Installing coefficients from floppy disk.

If your VNA has a floppy disk drive, then ordering the kit with a floppy disk is probably easiest. If you don't have a disk, then you can download the files and write them to your own floppy disk. Although you are unlikely to be able to purchase a new computer with a 3.5" floppy disk drive, there are plenty of USB floppy disk drives on the market. We use a Sony model PCGA-UFD5, which was designed for the Sony Vio, but seems to work fine in other XP and Windows 7 machines.

VNA	Kits with serial numbers 0001 to 0155	Kits with serial numbers 0156 and later
8510C	CK_SMA_E	CK_SMA_L
8753D, 8753ES and 8753ET	85033-SN-0001-to-0155.zip	85033-SN-0156-or-later.zip

Method #2 - Installing coefficients over GPIB in Windows with Cal Kit Manager 2.1

For this you need a Windows PC equiped with a National Instruments or Agilent GPIB board, and a GPIB cable to connect the PC to the VNA. You also need to install the VNA Cal Kit Manager 2.1 software from the Keysight web site. Once you have done this, you need to open the file with the coefficients in. There are two files for download. Which one depends on the serial number of your kit. Plese download:

- 85033-SN-0001-to-0155.ckm
- 85033-SN-0156-or-later.ckm

and follow the instructions in the help file for the VNA Cal Kit Manager 2.1 software.

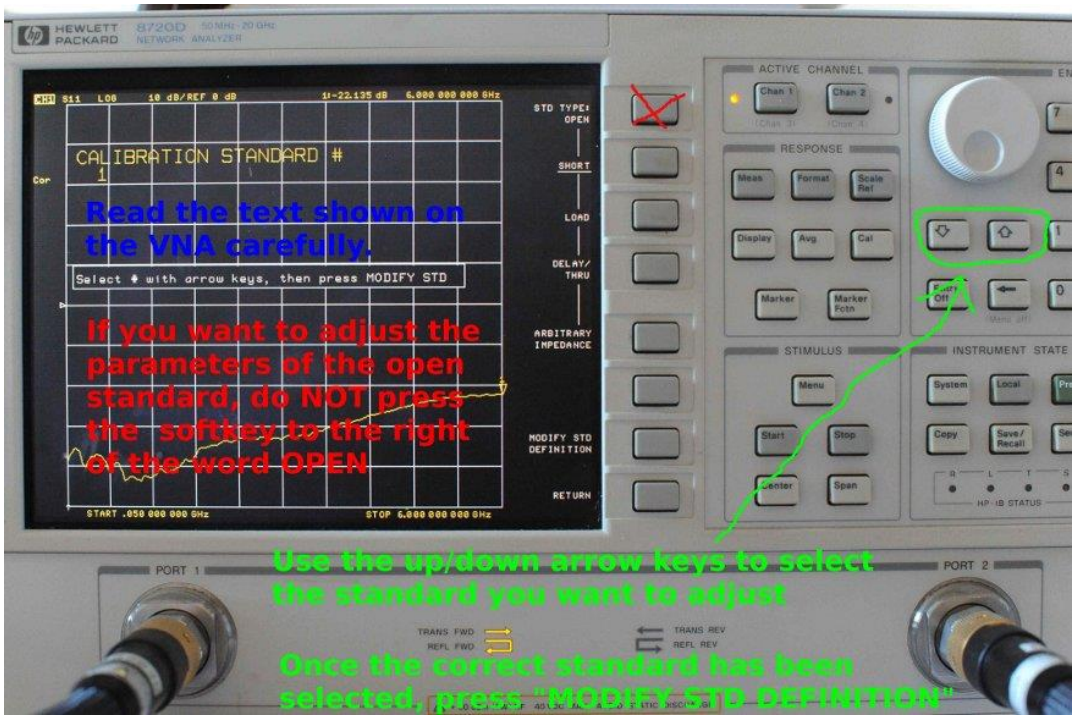
If you wish to send the coefficients via GPIB under Unix or Linux, then please contact us. We have some software we wrote for Solaris, that would probably work on Linux.

Method #3 - Installing coefficients with the instrument's keypad.

This is the most flexible, and works with all instruments. You can't actually overwrite any of the internal kits, but HP/Agilent have provided you with one or two USER kits, which the user has total control over. The method of doing this is given in the manuals, but in essence you need to:

1. Change the calibration kit to a 50 Ohm type N. The 85032B kit is in most of these VNAs, and is a good choice.
2. Change all the coefficients of the devices.
3. Change the name of the kit to "SMA" or similar
4. Save as a user kit. The 8510 series supports two user kits, but the 8753, 8719, 8720 and 8722 series only support one user kit. This is stored permanently - assuming your battery or supercap is working to retain the memory.
5. Load the user kit whenever you want to use the SMA kit. The kit name should then show SMA.

There is one step in this process where it is easy to go very wrong, which will probably means start the process from scratch. BE CAREFUL. The annotated photo below shows this.



Note in yellow the VNA indicates calibration standard 1. Note that SHORT is underlined. If one wishes to change the parameters of the open standard, it is tempting to press the soft key to the right of the

word OPEN. However, what that will do is redefine standard 1 to be an open, rather than a short. Instead one should use the up/down arrow keys until the standard underlined is OPEN, and not SHORT as in this example.

Standard Definitions

There are two sets of coefficients, depending on serial number. (For non-standard kits, which have been supplied to specific customer requirements, other coefficients will apply)

Serial numbers 0001 to 0155

System Zo = 50 Ω Calibration kit label: SMA

	Type	C0	C1	C2	C3	Fixed or sliding	Delay(ps)	Zo(Ω)	Loss(Ω/s)	Fmin (GHz)	Fmax (GHz)	Coax or waveguide	Standard
1	Female short						41.398	50	700 M	0	999	Coax	SHORT(M)
2	Female open	60.896	2808.1	-1440.3	104.33		39.6	50	700 M	0	999	Coax	OPEN(M)
3	Load					Fixed	0	50	700 M	0	999	Coax	Broadband
4	Delay/thru						0	50	700 M	0	999	Coax	Thru
5													
6													
7	Male short						57.834	50	700 M	0	999	Coax	SHORT(F)
8	Male open	50.389	761.36	-968.22	68.376		55.1	50	700 M	0	999	Coax	OPEN(F)

Serial numbers 0156 or greater

System Zo = 50 Ω Calibration kit label: SMA

	Type	C0	C1	C2	C3	Fixed or sliding	Delay(ps)	Zo(Ω)	Loss(Ω/s)	Fmin (GHz)	Fmax (GHz)	Coax or waveguide	Standard
1	Female short						41.398	50	700 M	0	999	Coax	SHORT(M)
2	Female open	71.252	-1189.96	-110.417	-0.964691		39.6	50	700 M	0	999	Coax	OPEN(M)
3	Load					Fixed	0	50	700 M	0	999	Coax	Broadband
4	Delay/thru						0	50	700 M	0	999	Coax	Thru
5													
6													
7	Male short						57.834	50	700 M	0	999	Coax	SHORT(F)
8	Male open	33.5662	4024.34	-541.72	-0.520207		55.1	50	700 M	0	999	Coax	OPEN(F)

The fringing capacitance of an open is assumed to be given by the 3rd order polynomial:

$$C_{fringing}=C0x10^{-15} + C1x10^{-27}f + C2x10^{-36}f^2+C3x10^{-45}f^3$$

where the capacitance is in Farads and the frequency in Hz.

1. Ensure the system impedance is set to 50 Ω
2. Standard labels that specify sex, (M) or (F), refer to the sex of the analyzer's test port connector, **not** the standard. This is very confusing, but is the way HP/Agilent specify this in the 8753, 8510, 8720 and ENA series of instruments. In the PNA and FieldFox series of instruments, the sex refers to the calibration standard.

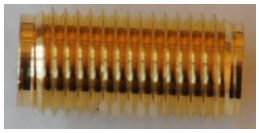
Standard Class Assignments

Calibration kit label: SMA								
Class	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**Standard Class Label**
$S_{11}A$	2	8						Opens
$S_{11}B$	1	7						Shorts
$S_{11}C$	3							Load
$S_{22}A$	2	8						Opens
$S_{22}B$	1	7						Shorts
$S_{22}C$	3							Load
Forward Transmission	4							Thru
Reverse Transmission	4							Thru
Forward Match	4							Thru
Reverse Match	4							Thru
Response	1	7	2	8	4			Response
Response and Isolation	1	7	2	8	4			Response & Isolation

The 50 Ω Female to female SMA barrel has a delay of 41.398 ps

After making a 2-port calibration using a SOLT technique, if the DUT is non-insertable (i.e. it has two male ports or two female ports), then it necessary to add an adapter. The kit is supplied with two barrels which allow you do make measurements on non-interstable devices. In order to get accurate phase results, you must compensate for the delay caused by the barrel. One does this by seting a port extension on the CAL menu of the VNA. If you add the female barrel to test port 1, then

set a port extension of +41.398 ps. Depending on the design of your VNA, it may be necessary to enter that as 0.041398 ns, but the display should show 41.398 ps.

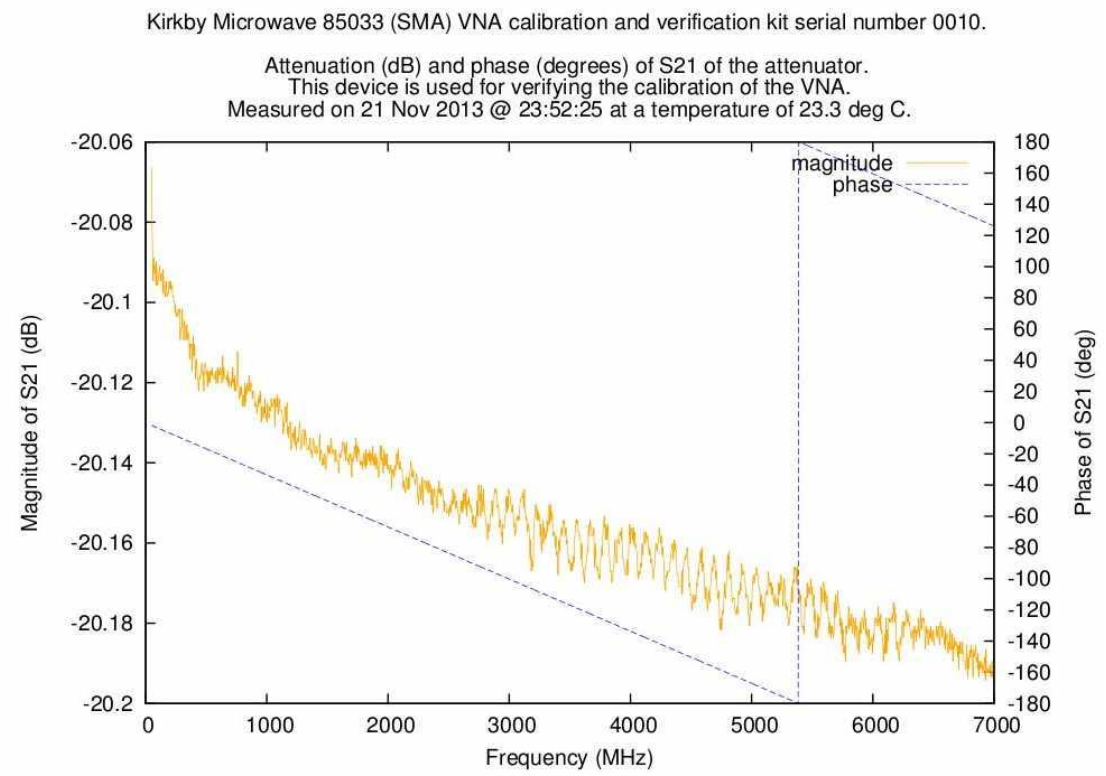


The 50 Ω Male to male SMA barrel with a black dot on the side has a delay of 78.362 ps

The 50 Ω Male to male SMA barrel without a black dot on the side has a delay of 75.992 ps

Verifying the performance after calibration

After using one of our kits to calibrate your VNA, it is sensible to check the VNA is giving good results. A failure to give good results indicates either a fault in the VNA or an error in uploading the coefficients properly. Unlike calibration kits from other manufacturers, **all** our kits include a fixed attenuator with measured data on the attenuation. The data will be found on a USB stick included with your kit in the directory "Measured_data_of_attenuator". If you get similar results, you can be confident there are no serious problems. Here is a typical plot given for one of our kits.



Note the aim of the verification attenuator is **not** to prove your VNA is within specification - if you need to know that, send it back to the **manufacturer**, and **not** a third party lab. But the attenuator will give you a good idea if there are any serious problems.