Certificate of Calibration

Kirkby Microwave Calibration

Calibration Certificate number 85033-1234-06102024

Model Number	85033
Manufacturer	Kirkby Microwave Ltd
Description	SMA calibration and verification kit
Serial number	1234
Maximum frequency	7 GHz
Date of Calibration	6th October 2024
Procedure	85033-4
Temperature	(21 ± 2)°C

Location of calibration	**Customer**
Kirkby Microwave Ltd	xxxxxxxxxxxx
Stokes Hall Lodge	xxxxxxxxxxx
Burnham Road	xxxxxxxxxxxxx
Althorne	xxxxxxxxxxx
Chelmsford	xxxxxxxxxxx
Essex	
CM3 6DT	xxxxxxxxxx
UNITED KINGDOM	xxxxxxxxx

As Received Conditions

Not applicable, as this was a new calibration kit.

As Completed Conditions

The measured values of the were observed in specification at the points tested.

Calibration data

Since there are measurements at at least 801 frequencies, on several devices, it is impractical to provided the measured results on the calibration certificate, although they are provided on a USB stick included with the calibration kit. However, the coefficients of the calibration standards derived from the measurements are listed below.

Notes on the format of the data

Almost all VNAs will take data in the format used by HP, Agilent and Keysight. The open calibration standards are modelled as a length of transmission line terminated in a capacitor,

which is the fringing capacitance. The fringing capacitance is frequency dependant. The capacitance C is given by the following 3^{rd} order polynomial

$$C(f) = C0 \times 10^{-15} + C1 \times 10^{-27} f + C2 \times 10^{-36} f^2 + C3 \times 10^{-45} f^3$$

where C is in farads and f in Hz. The transmission line has some length, and so delay. The values of $C0, C1, C2$ and $C3$ as well as the delay are given below.

The short calibration standards are modelled as a length of transmission line terminated in an inductor. This inductance is frequency dependant. The inductance L is given by the following 3^{rd} order polynomial

$$L(f) = L0 \times 10^{-12} + L1 \times 10^{-24} f + L2 \times 10^{-33} f^2 + L3 \times 10^{-42} f^3$$

where L is in henrys and f in Hz. The transmission line has some length, and so delay. However, the variation of inductance with frequency is small, and so some VNAs assume this variation to be zero. For VNAs supporting entry of $L0, L1, L2$ and $L3$, the data is given. For VNAs not supporting the entry of $L0, L1, L2$ and $L3$, the inductance is compensated for by assuming a slightly longer delay. For this reason data is provided in two formats for the shorts.

Note, if an instrument supports reading of Touchstone files for the calibration standards, then that is the most accurate way of using the data. However, not many instruments support this.

Important
Please read the user manual on the SMA calibration kit, which may be downloaded from
https://kirkbymicrowave.co.uk/Downloads/User-Manual-for-85033-SMA-calibration-kit.pdf
This is because HP/Agilent/Keysight have changed the way they refer to the gender of calibration standards. The female short used to be denoted as `SHORT (M)`, to indicate it connected to a male test port, but in later instruments the female short is denoted as `SHORT -F-`. Note the change of M to F and parentheses to hyphens. This is discussed more fully in the user manual.

1 Coefficients of calibration standards

This is given in two formats, for VNAs accepting inductance coefficients on the shorts, and those not accepting inductance coefficients. All VNAs should accept the capacitance coefficients $C0, C1, C2$ and $C3$

1.(a) Calibration coefficients for female calibration standards

1.(a).(i) Female short, for VNAs accepting inductance coefficients.

This will be `SHORT (M)` for some older HP/Agilent instruments, and `SHORT -F-` for newer HP/Agilent instruments, as well as instruments made by Advantest, Anritsu, Copper Mountain,

Deepace, LA Techniques, Keysight, National Instruments, Pico Technology, Rohde & Schwarz, SDR-kits, Siglent, and Tektronix.

```
Optimization results from file female-short-0887.s1p. Data fitted to 7.00 GHz:
Offset Z0 = 49.716510 ohm
Offset loss = 4326.028843 Mohm/s
Offset delay = 75.000000 ps
Offset length  = 22.484434 mm
Offset loss = 0.056363 dB/sqrt(GHz)
L0 = 142.871765 * 1e-12 H
L1 = 8769.964722 * 1e-24 H/Hz
L2 = -1269.560714 * 1e-33 H/Hz^2
L3 = 83.241151 * 1e-42 H/Hz^3
```

1.(a).(ii) Female short, for VNAs not accepting inductance coefficients.

This will be `SHORT (M)` for some older HP/Agilent instruments, and `SHORT -F-` for newer Agilent instruments, as well as instruments made by Advantest, Anritsu, Copper Mountain, Deepace, LA Techniques, Keysight, National Instruments, Pico Technology, Rohde & Schwarz, SDR-kits, Siglent, and Tektronix.

```
Optimization results from file female-short-0887.s1p. Data fitted to 7.00 GHz:
Offset Z0 = 49.661078 ohm
Offset loss = 3779.159018 Mohm/s
Offset delay = 78.326100 ps
Offset length  = 23.481574 mm
Offset loss = 0.051422 dB/sqrt(GHz)
L0 = 0.000000 * 1e-12 H
L1 = 0.000000 * 1e-24 H/Hz
L2 = 0.000000 * 1e-33 H/Hz^2
L3 = 0.000000 * 1e-42 H/Hz^3
```

1.(a).(iii) Female open

This will be `OPEN (M)` for some older HP/Agilent instruments, and `OPEN -F-` for newer Agilent instruments, as well as instruments made by Advantest, Anritsu, Copper Mountain, Deepace, LA Techniques, Keysight, National Instruments, Pico Technology, Rohde & Schwarz, SDR-kits, Siglent and Tektronix.

```
Optimization results from file female-open-0887.s1p. Data fitted to 7.00 GHz:
Offset Z0 = 49.674495 ohm
Offset loss = 2996.090367 Mohm/s
Offset delay = 75.000000 ps
Offset length  = 22.484434 mm
```

```
Offset loss = 0.039036 dB/sqrt(GHz)
C0 = 68.374654 * 1e-15 F
C1 = -2173.974029 * 1e-27 F/Hz
C2 = 601.336934 * 1e-36 F/Hz^2
C3 = -53.372512 * 1e-45 F/Hz^3
```

1.(a).(iv) Female-female thru

Delay = 78.695 ps

1.(b) Calibration coefficients for male calibration standards

1.(b).(i) Male short, for VNAs accepting inductance coefficients.

This will be `SHORT (F)` for older HP/Agilent instruments, and `SHORT -M-` for newer Agilent instruments, as well as instruments made by Advantest, Anritsu, Copper Mountain, Deepace, LA Techniques, Keysight, National Instruments, Pico Technology, Rohde & Schwarz, SDR-kits, Siglent, and Tektronix.

```
Optimization results from file male-short-0887.s1p. Data fitted to 7.00 GHz:
Offset Z0 = 51.000000 ohm
Offset loss = 2250.633565 Mohm/s
Offset delay = 56.000000 ps
Offset length  = 16.788378 mm
Offset loss = 0.021895 dB/sqrt(GHz)
L0 = 7.446788 * 1e-12 H
L1 = -601.247086 * 1e-24 H/Hz
L2 = 7535.584739 * 1e-33 H/Hz^2
L3 = -742.597650 * 1e-42 H/Hz^3
```

1.(b).(ii) Male short, for VNAs not accepting inductance coefficients.

```
Optimization results from file male-short-0887.s1p. Data fitted to 7.00 GHz:
Offset Z0 = 49.306660 ohm
Offset loss = 2064.281663 Mohm/s
Offset delay = 57.800646 ps
Offset length  = 17.328198 mm
Offset loss = 0.020727 dB/sqrt(GHz)
L0 = 0.000000 * 1e-12 H
L1 = 0.000000 * 1e-24 H/Hz
L2 = 0.000000 * 1e-33 H/Hz^2
L3 = 0.000000 * 1e-42 H/Hz^3
```

1.(b).(iii) Male open

This will be `OPEN (F)` for some older HP/Agilent instruments, and `OPEN -M-` for newer Agilent instruments, as well as instruments made by Advantest, Anritsu, Copper Mountain, Deepace, LA Techniques, Keysight, National Instruments, Pico Technology, Rohde & Schwarz, SDR-kits, Siglent, and Tektronix.

```
Optimization results from file male-open-0887.s1p. Data fitted to 7.00 GHz:
Offset Z0 = 49.721343 ohm
Offset loss = 6066.350041 Mohm/s
Offset delay = 55.100000 ps
Offset length  = 16.518564 mm
Offset loss = 0.058066 dB/sqrt(GHz)
C0 = 67.340834 * 1e-15 F
C1 = -5283.248747 * 1e-27 F/Hz
C2 = -1030.605515 * 1e-36 F/Hz^2
C3 = 152.400895 * 1e-45 F/Hz^3
```

1.(b).(iv) Male-male thru

Delay = 75.322 ps

2 Measurements of male-female attenuator for verification purposes

Measured data on the male-female attenuator may be found on the USB stick.