VVM measurement with E5061B for replacing 8508A vector voltmeter

Oct 2014
Keysight Technologies

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Overview of VVM measurement with E5061B

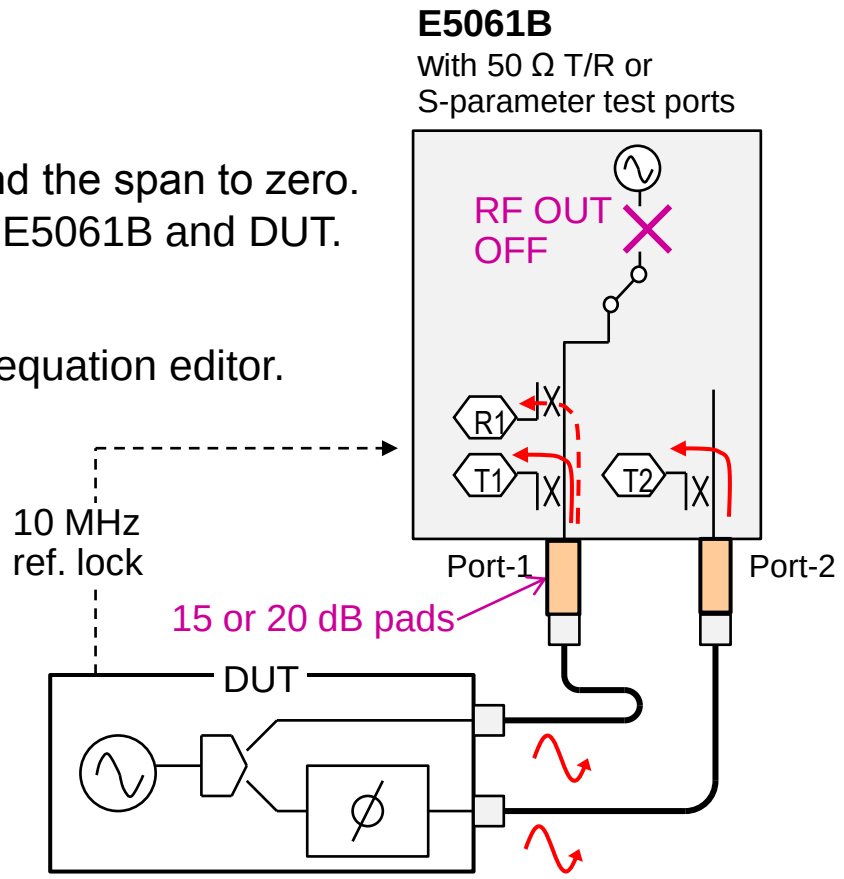
Application discussed here

Measuring the phase difference (& magnitude ratio) of external CW signals with 50 Ω inputs in the freq range around 100 to 200 MHz.

Measurement method with E5061B

- Turn the source output OFF (RF OUT OFF).
- Set the center to exactly the same as DUT's CW, and the span to zero. If possible, lock the 10 MHz reference between the E5061B and DUT.
- Attach 15 or 20 dB attenuator pads to Port-1 & 2.
- Measure the ratio Port-2/Port-1=S21/S11 using the equation editor.

  → S21/S11 = (T2/R1)/(T1/R1) = T2/T1



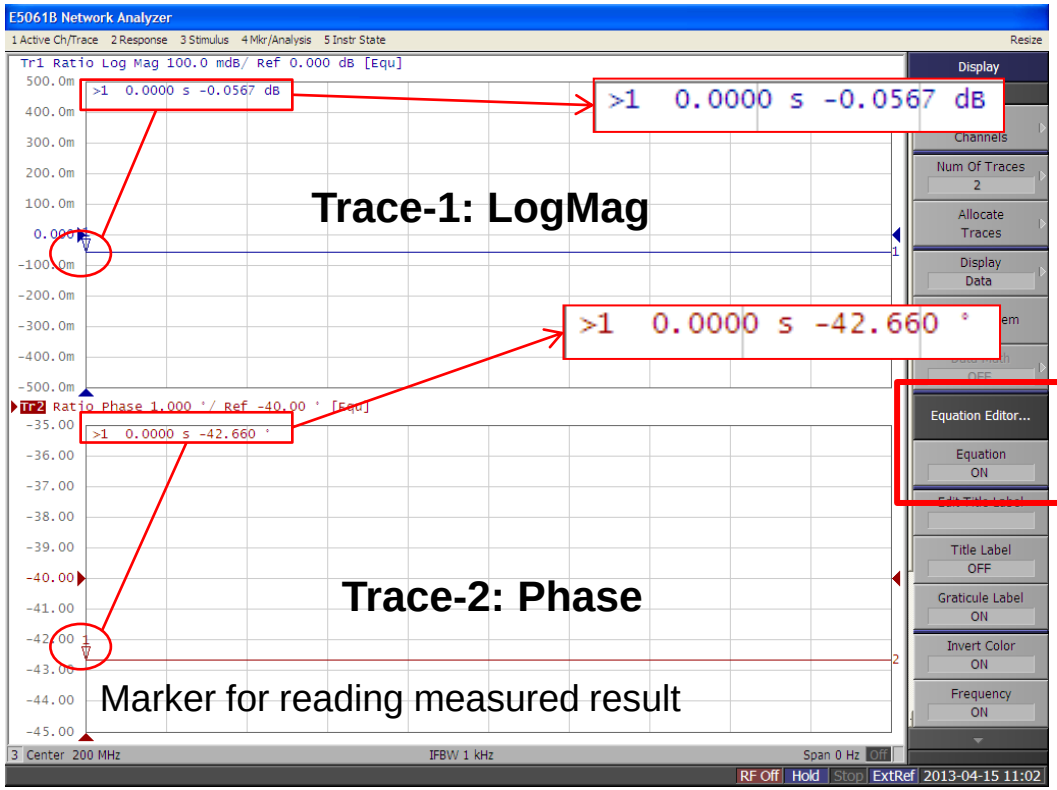
Measurement example

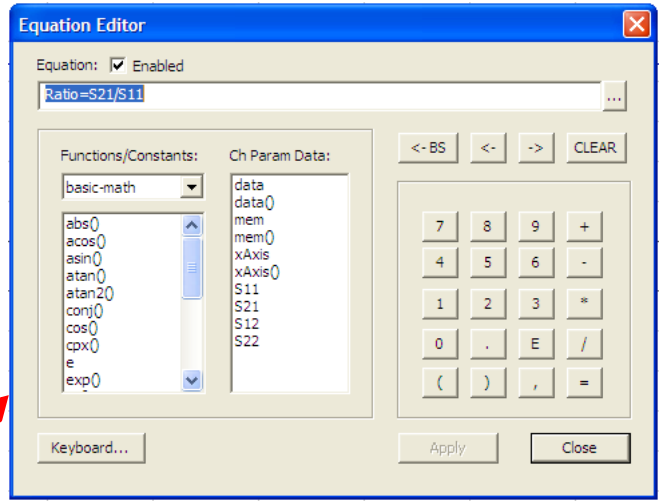
Ratio measurement of external 200 MHz CW signals

E5061B setting:

Center=200 MHz, span=0, NOP=2, IFBW=1 kHz, RF OUT: OFF

Trigger: Internal continuous





Equation: Ratio=S21/S11

Tips for VVM measurement with E5061B

Adding attenuator pads

• Impedance mismatches between the DUT and the analyzer's test ports are the most significant error sources, especially in case the isolation between the DUT's output ports is not high.

• To reduce these mismatch errors, it is necessary to improve the raw port matches by adding 15 or 20 dB attenuator pads.

• This is true even for the 8508A. To make a good measurement correlation between the E5061B and 8508A, the attenuator pads should be connected to both analyzers.

Port extension

• Setting a positive or negative port extension to the Port-2 compensates the difference of electrical lengths between two signal paths.

Measurement frequency

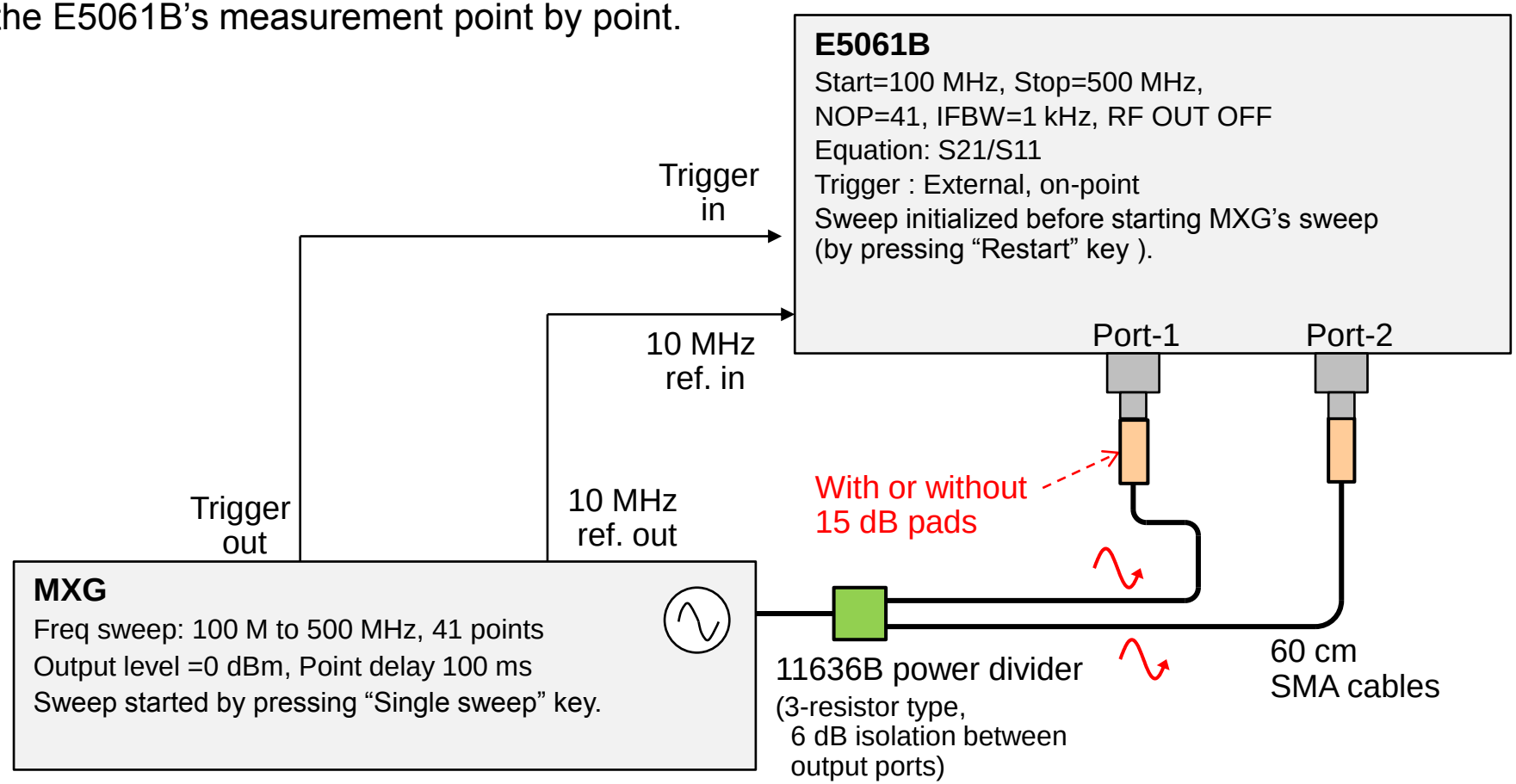
• The E5061B's center frequency must be set to exactly the same as the DUT's frequency. If possible, lock the 10 MHz reference between the DUT and the E5061B.

• If the 10 MHz locking is not possible and the DUT's frequency might be slightly differ from the E5061B's frequency, use a wider IFBW (e.g. 10 kHz) to capture the DUT's signal.

Effect of attenuator pads and port extension

Experimental measurement (1)

- Measured almost equally divided CW signals (100 MHz to 500 MHz, 10 MHz step).
- Swept the frequency of the DUT's CW signals, and measured its ratio by synchronizing the E5061B's measurement point by point.

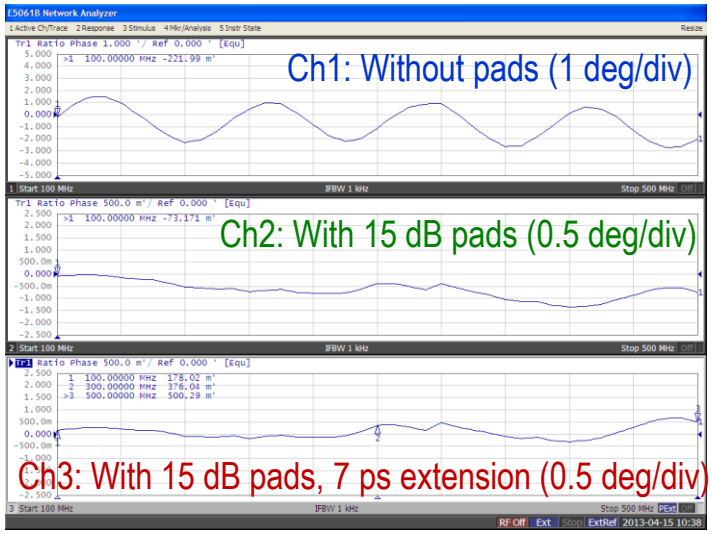


Effect of attenuator pads and port extension

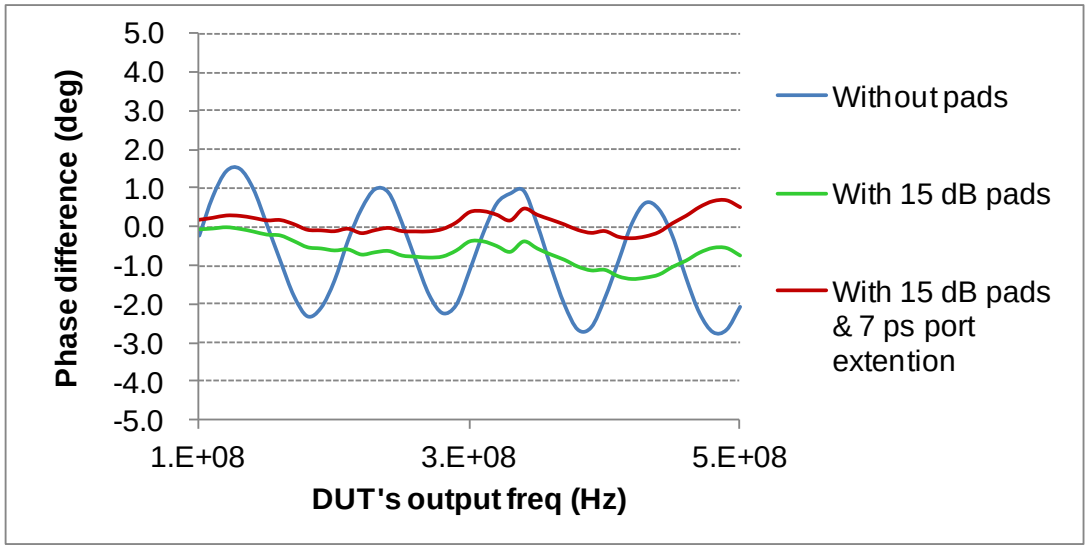
Experimental measurement (1), results

• The ripples caused by impedance mismatches are reduced by adding 15 dB pads to the Port-1 & 2.

• Setting +7 ps port extension to the Port-2 (applied to the S21 measurement) compensates the difference of electrical lengths between two cables, and the measured phase gets closer to 0 degree up to high frequencies.



100 MHz

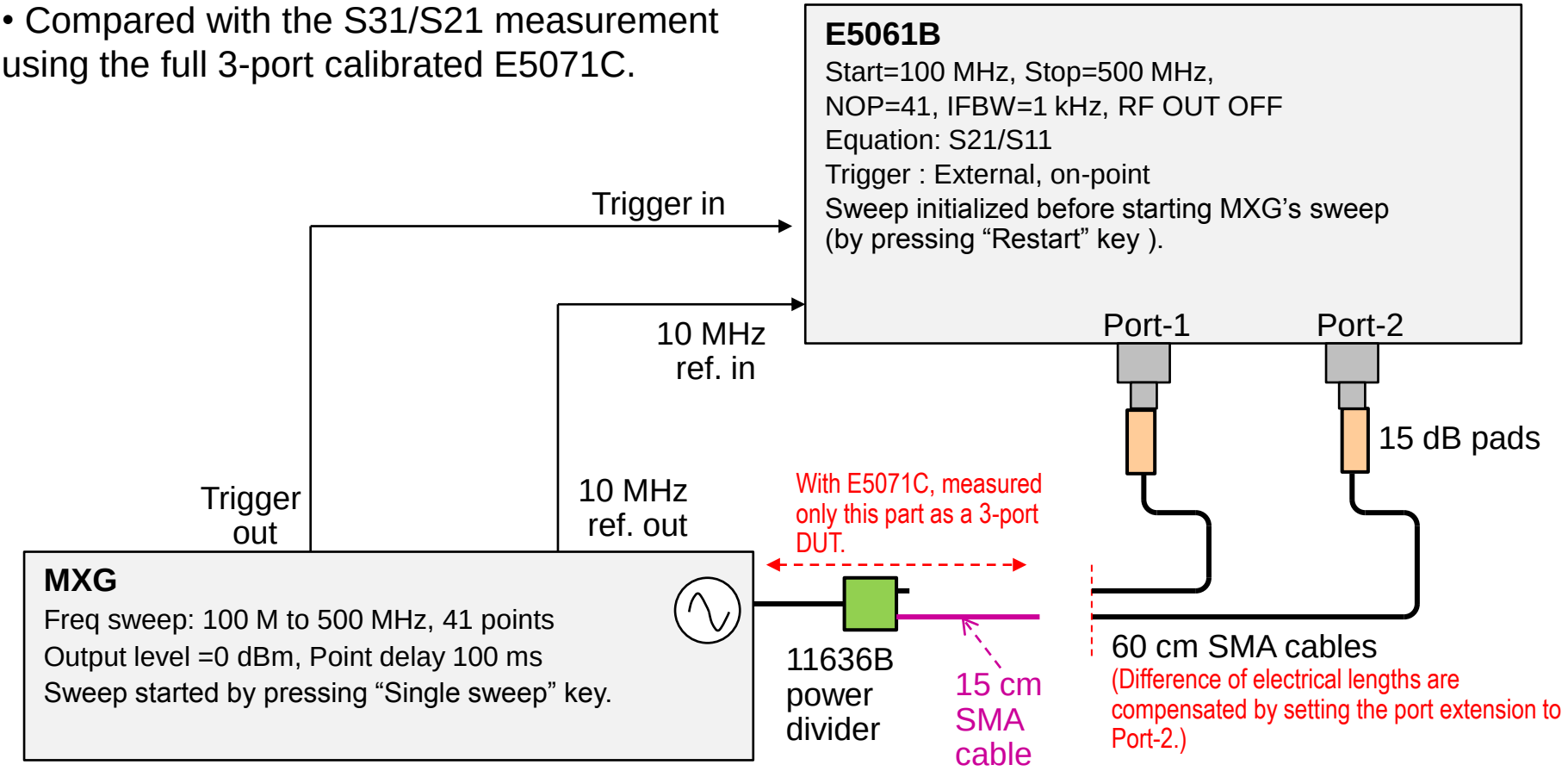


500 MHz

Measurement accuracy

Experimental measurement (2)

- Measured unequally divided CW signals by adding a 10 cm cable only to the Port-2 path.
- +7 ps port extension applied to the Port-2.
- Compared with the S31/S21 measurement using the full 3-port calibrated E5071C.

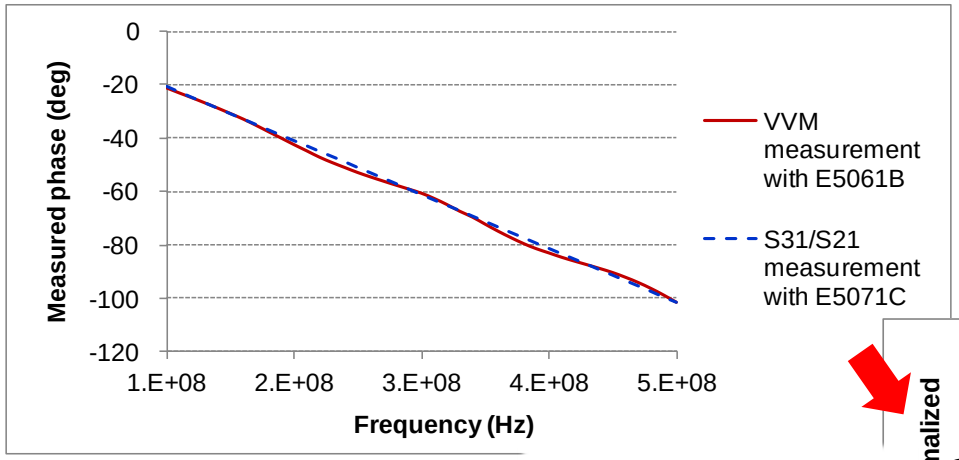


Measurement accuracy

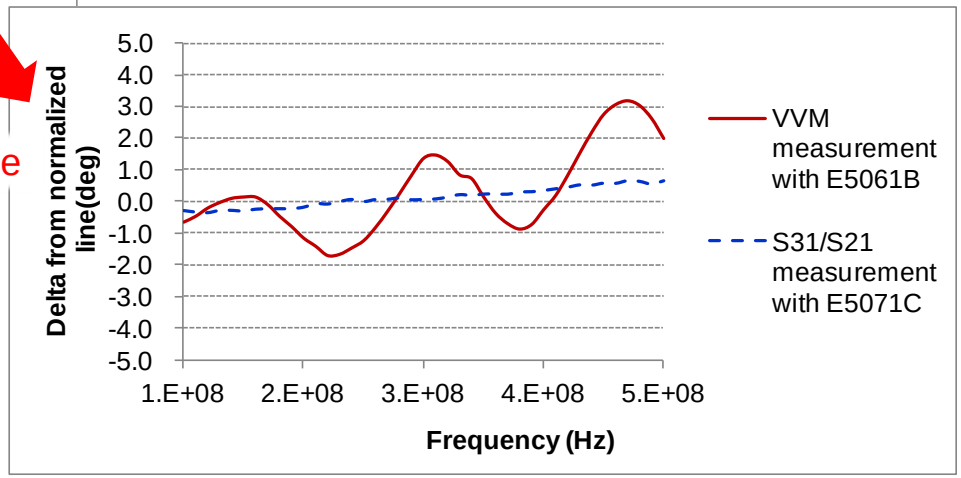
Experimental measurement (2), results

• The E5061B's VVM measurement exhibits ripples of 1 or 2 dB even using the 15 dB pads, due to significant mismatches and the divider's low isolation (=6 dB) between its output ports.

• But overall the E5061B's measurement has a good correlation with the E5071C's S31/S21 measurement.



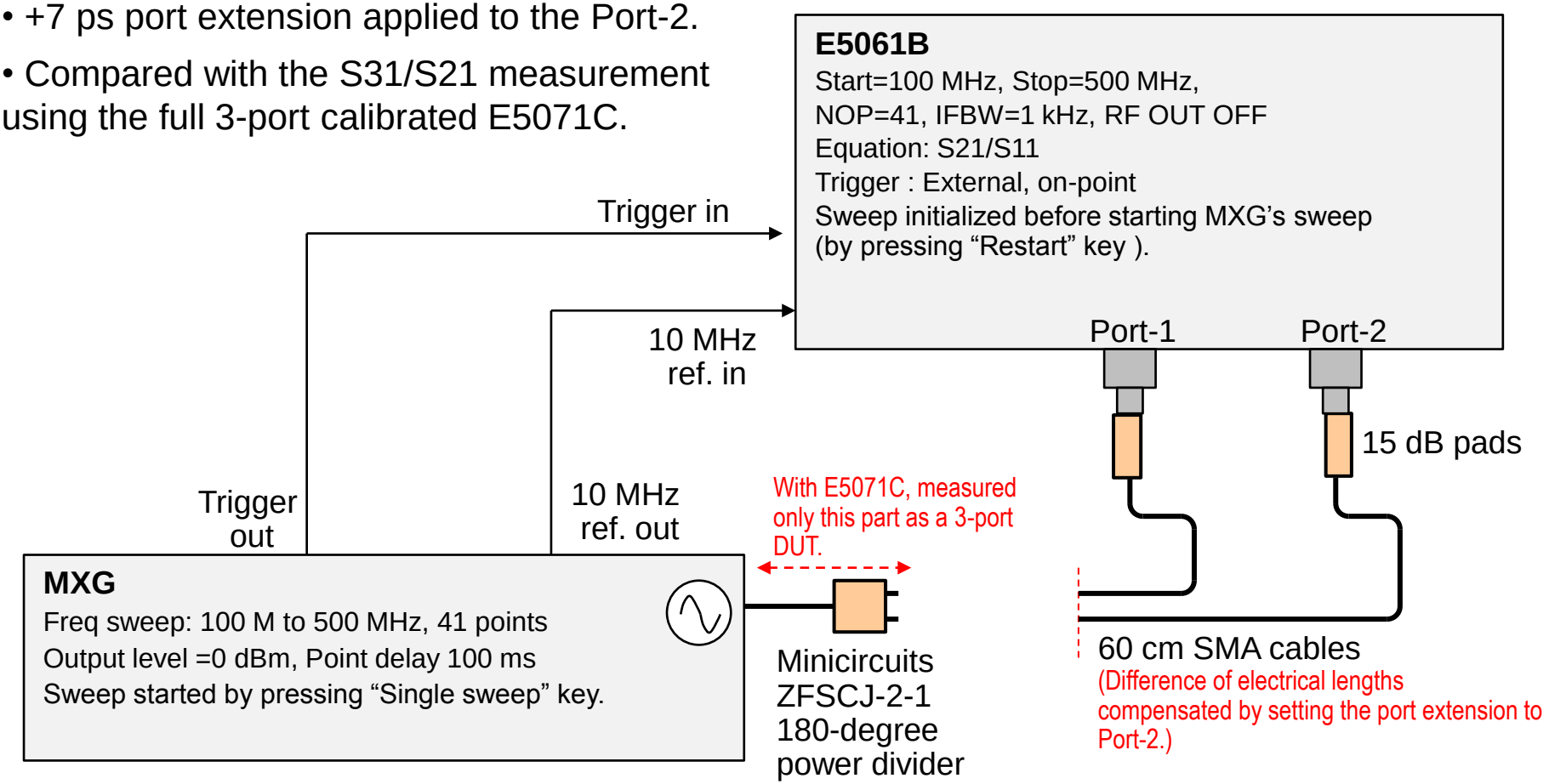
Normalized to flat line



Measurement accuracy

Experimental measurement (3)

- Measured 180-degree shifted CW signals with a 180-degree power divider (30 dB isolation between output ports).
- +7 ps port extension applied to the Port-2.
- Compared with the S31/S21 measurement using the full 3-port calibrated E5071C.



Measurement accuracy

Experimental measurement (3), results

- The E5061B's VVM measurement has a very good agreement with the E5071C's S31/S21 measurement.
- The ripples are small thanks to the divider's high isolation (=30 dB) between its output ports.