

Advanced CV-Measurements and Calibration at the Wafer-Level

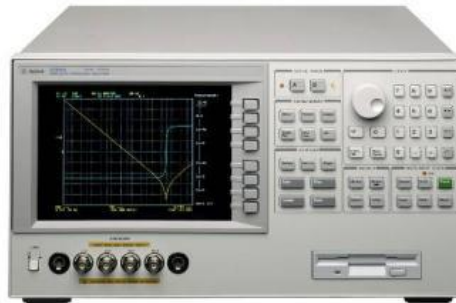
Quick How-To Reference

C-V Instrumentations

Agilent 4980A



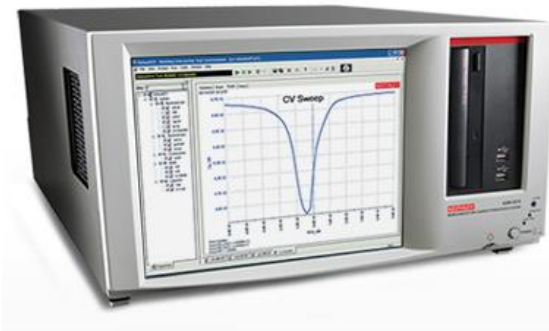
Agilent 4294A



Keysight E4990A



Keithley 4200-SCS



Keysight B1500A



C-V Instrumentations: Auto-Balancing Bridge Method

Agilent 4980A

- Keithley 4200+CVU : 1 kHz to 10 MHz | DC Bias : Up to 30V

Agilent 4294A

- Agilent B1500+MFCMU : 1 kHz to 5Mz | DC Bias : Up to 25V

Keysight E4990A

- Agilent 4980A : 20 Hz to 2 MHz | DC Bias : Up to 40V

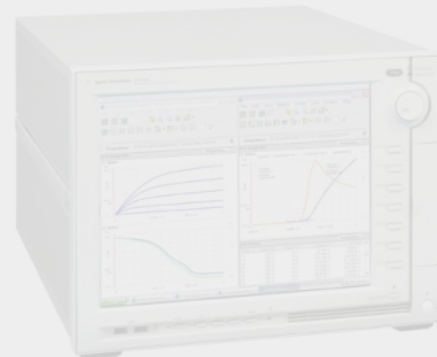
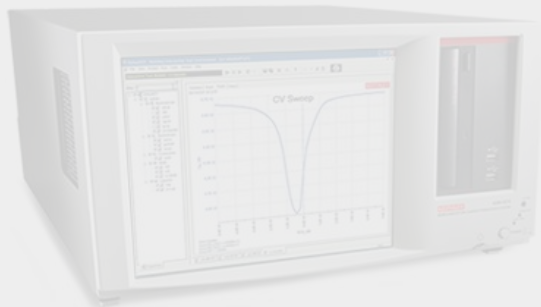
- Agilent 4294A : 40 Hz to 110MHz |DC Bias : Up to 40V

- Agilent 4981A : 120 Hz to 1 MHz | DC Bias : None

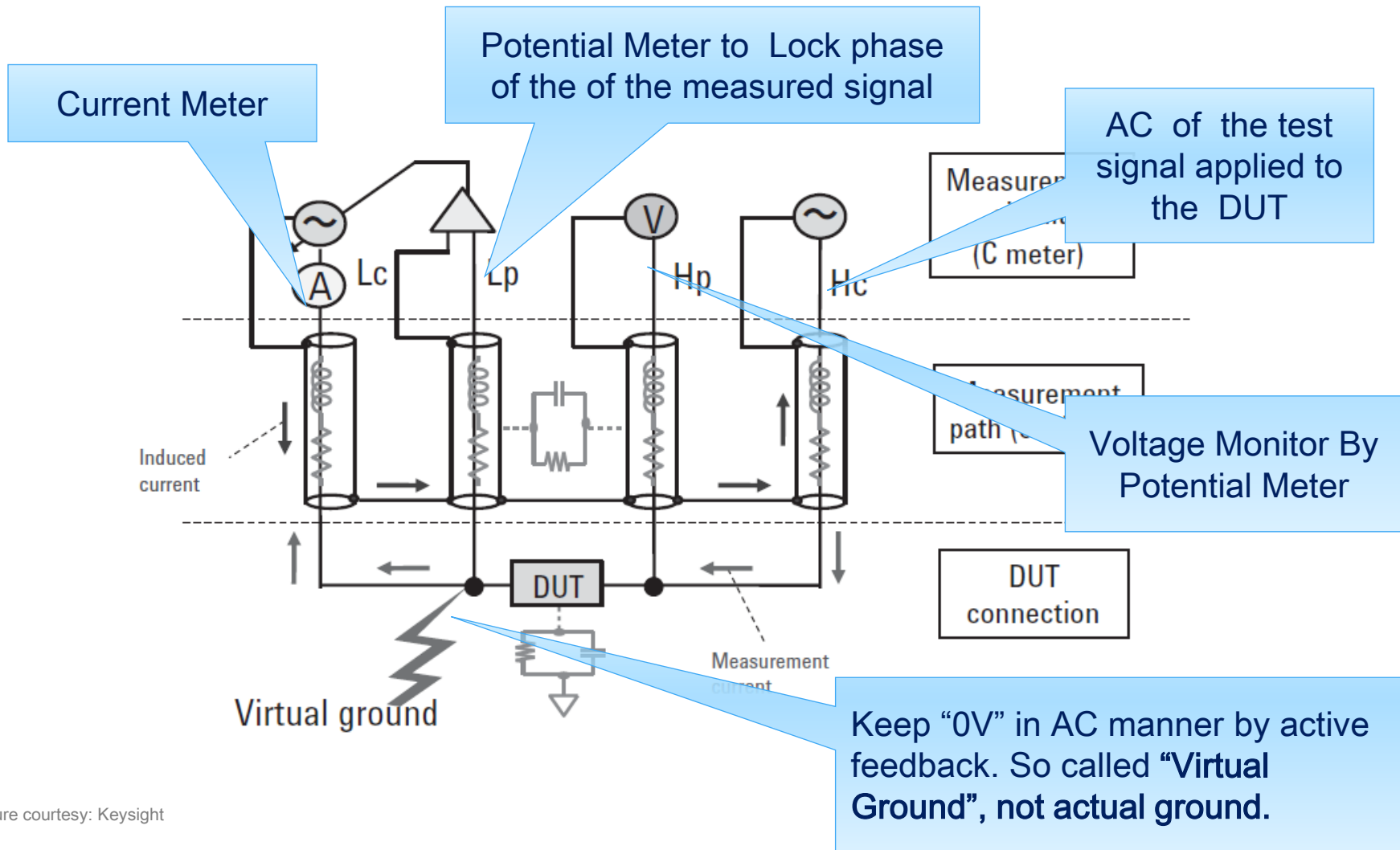
Keithley 4200-SCS

- Keysight E4990A : 20Hz to 120MHz | DC Bias : Up to 40V - NEW

Keysight B1500A

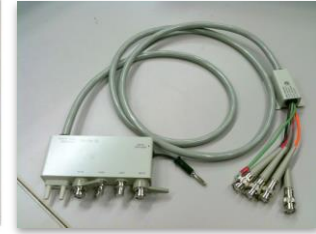
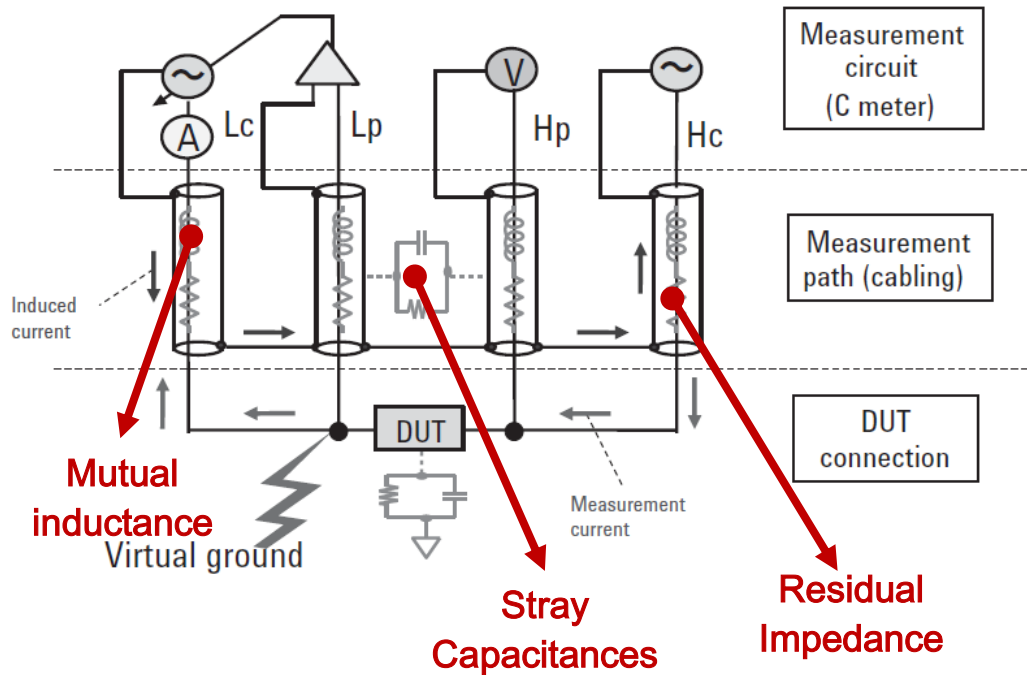


Auto-Balancing Bridge Method (ABB)

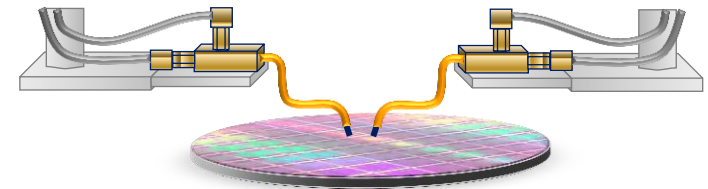


Picture courtesy: Keysight

ABB: Sources of Errors

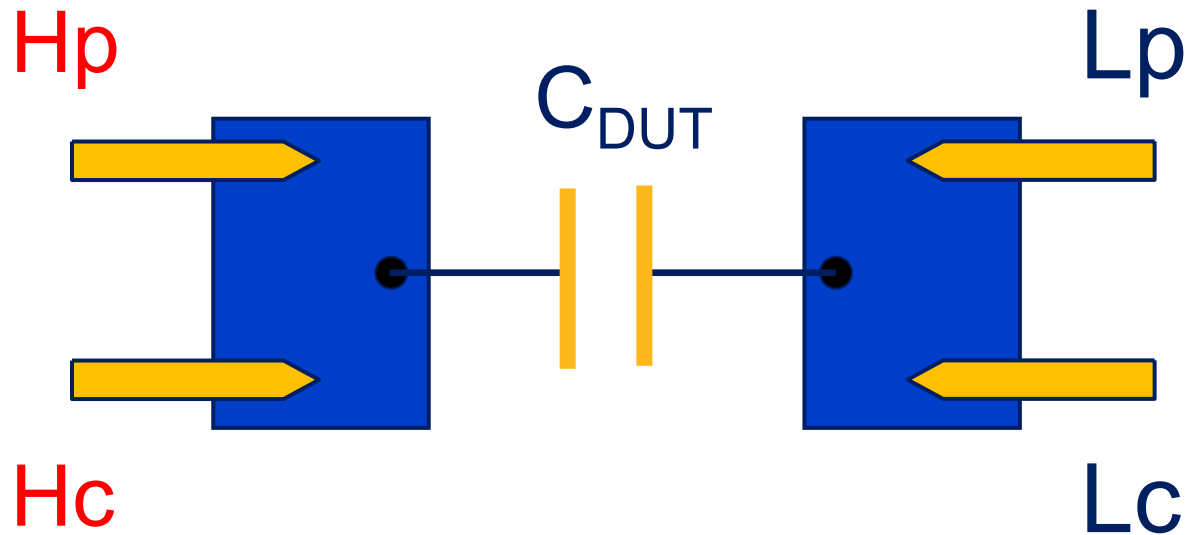


Picture courtesy: Keysight



- Residual impedance in the cables
- Stray capacitance between cables or to ground
- Mutual inductance caused by the current flow between adjacent cables

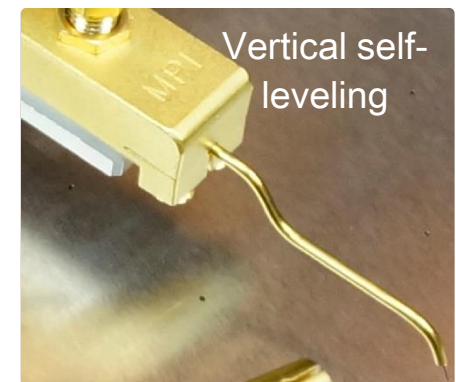
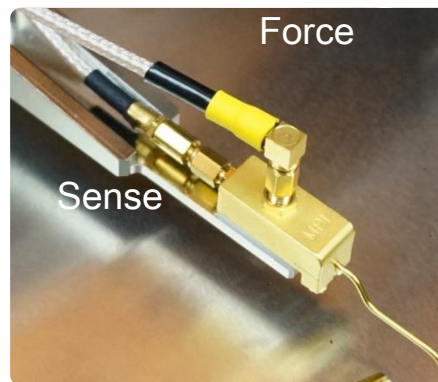
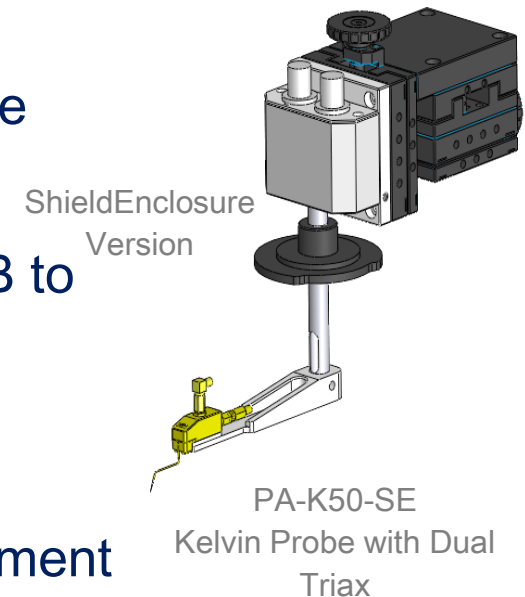
ABB: Sources of Errors



Eliminate cable resistance from the measurements

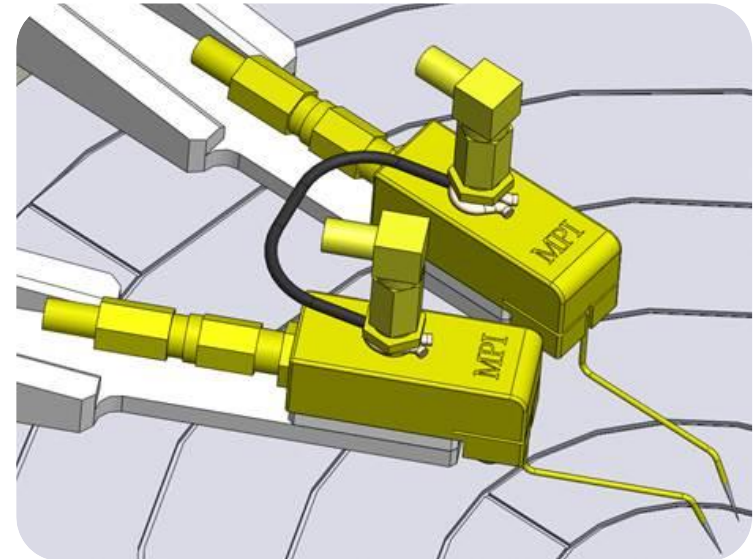
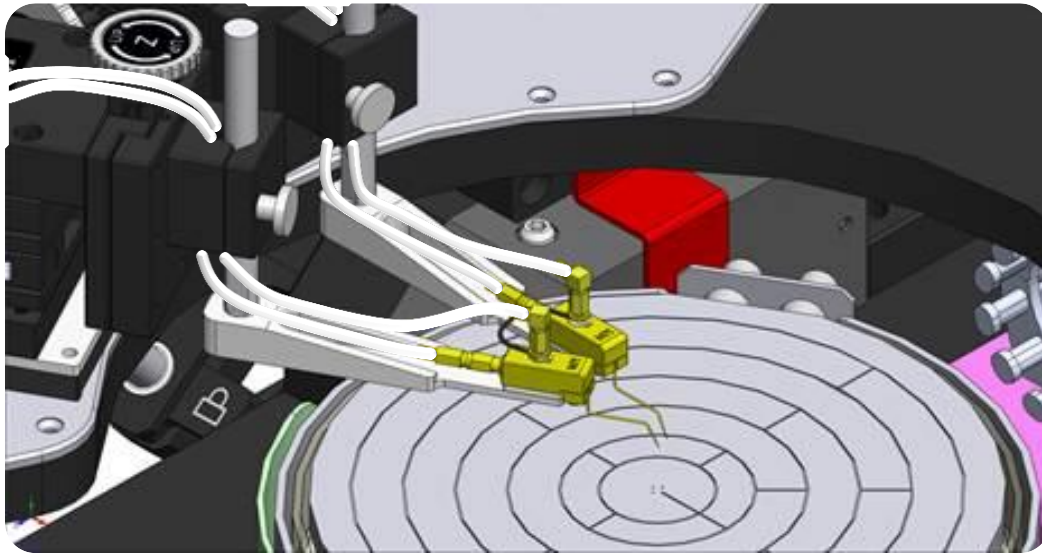
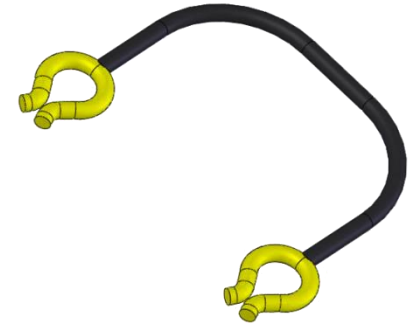
MPI Solutions: Kelvin Probe Arm

- Eliminate the effects of the residual impedance
- Shielding the cables to eliminate stray capacitance
- Vertical self-leveling for easy tip replacement
- 2M |1M Direct Impedance Analyzer BNC to SSMB to Probe with no disturbance
- Easy to reconnect for different IV/CV/PIV measurements
- For Ultra Low noise and accurate IV/CV Measurement in open and Shield Environment System



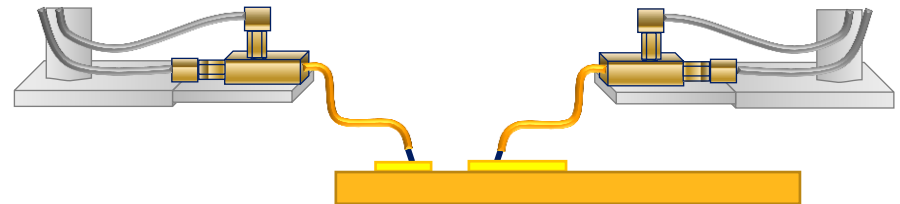
MPI Solutions: V-Ground Connector

- Provide 4-TP Connection for accurate CV at higher frequency >2MHz
- Eliminate the mutual inductance between cables
- Provides the shortest connection for virtual ground
- Included in the Kelvin Probe



On wafer verification on Calibration Substrate

- System needs to be calibrated with Open/Short or Open/Short/Load calibration method from the CV instruments prior to any measurement
- MPI calibration substrates include required standards and are qualified using the NIST methodology
 - loads are accurately trimmed to 50 Ohm with $< 0.3\%$ error
 - reference capacitance for CV calibration verification
- Recommended substrate models:
 - AC-3 for DUT pads $< 50\text{ }\mu\text{m} \times 50\text{ }\mu\text{m}$
 - AC-5 for larger pads



Calibration Substrates Qualified: AC-2 Example

Nominal capacitance per unit length, pF/cm	1.492
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Nominal characteristic impedance @20 GHz	50 Ω
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Effective dielectric constant @20 GHz, real part	4.94
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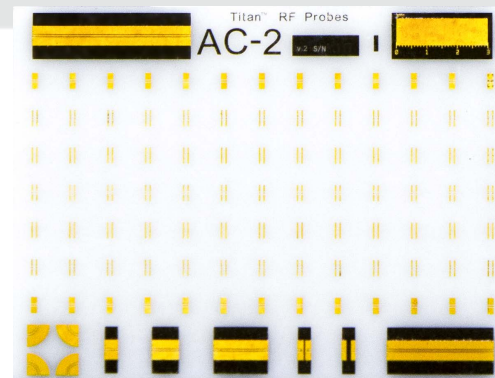
Effective velocity factor @20 GHz	0.45
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Parameters of the simplified model of line losses	
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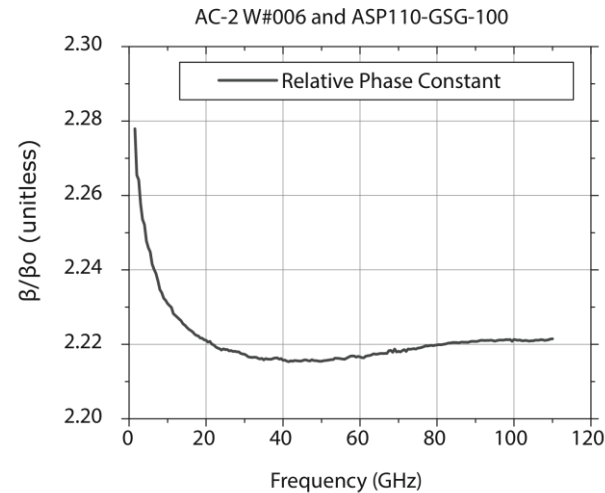
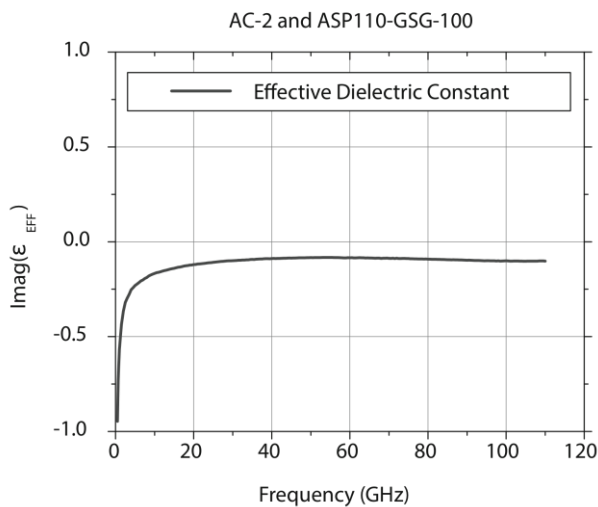
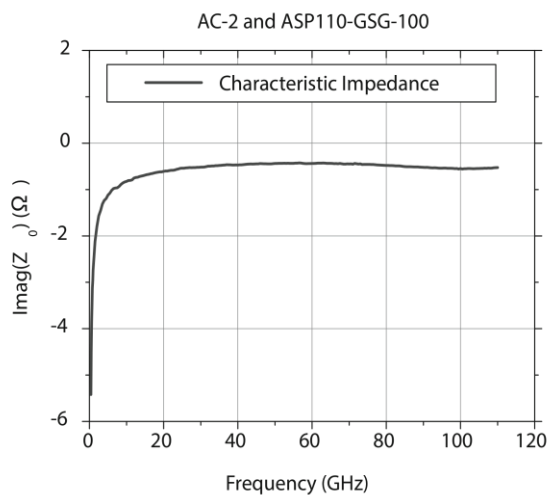
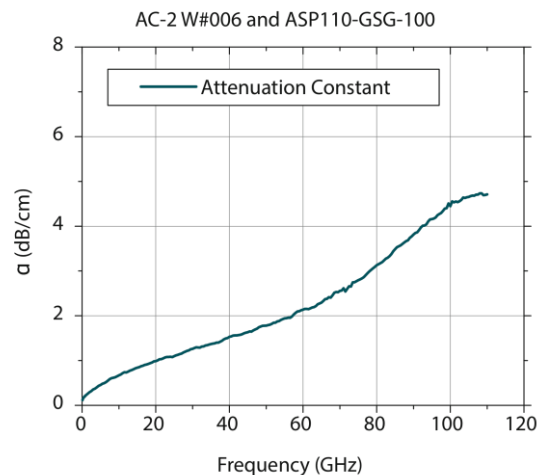
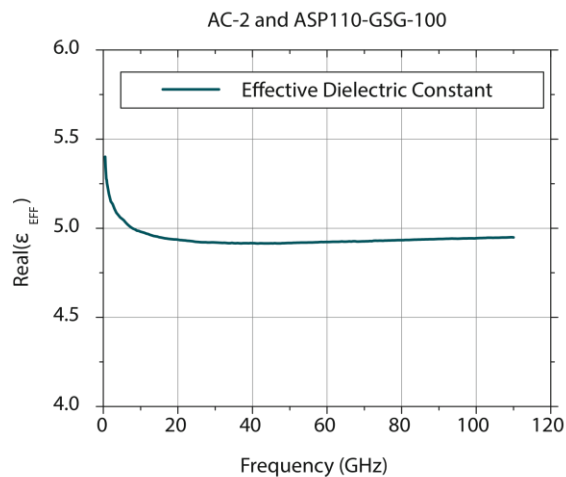
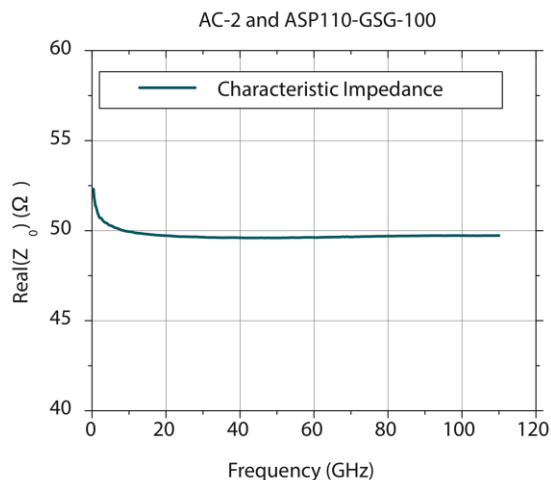
Reference loss, dB	0.34
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Reference delay, ps	25.5
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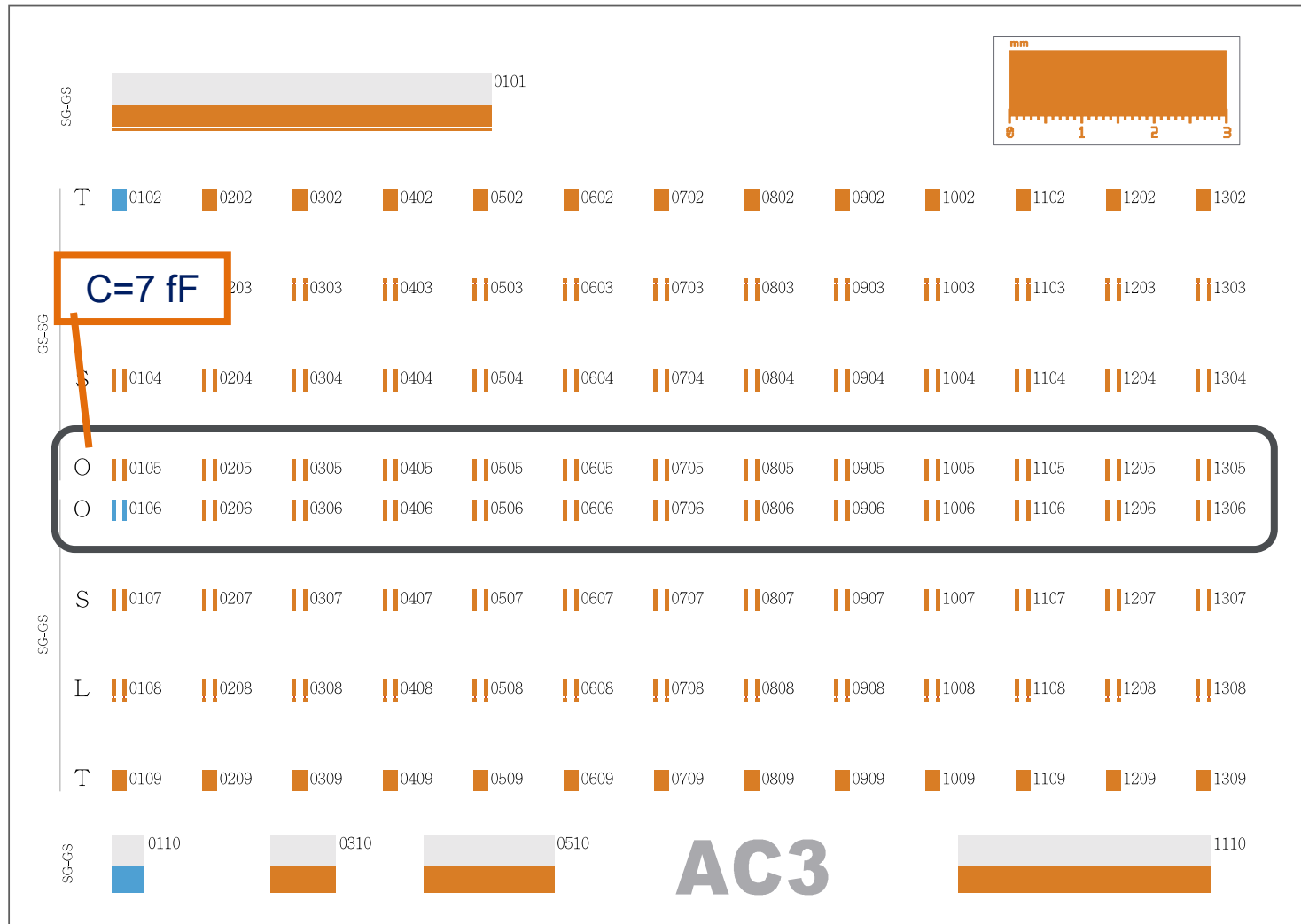
Reference frequency, GHz	20
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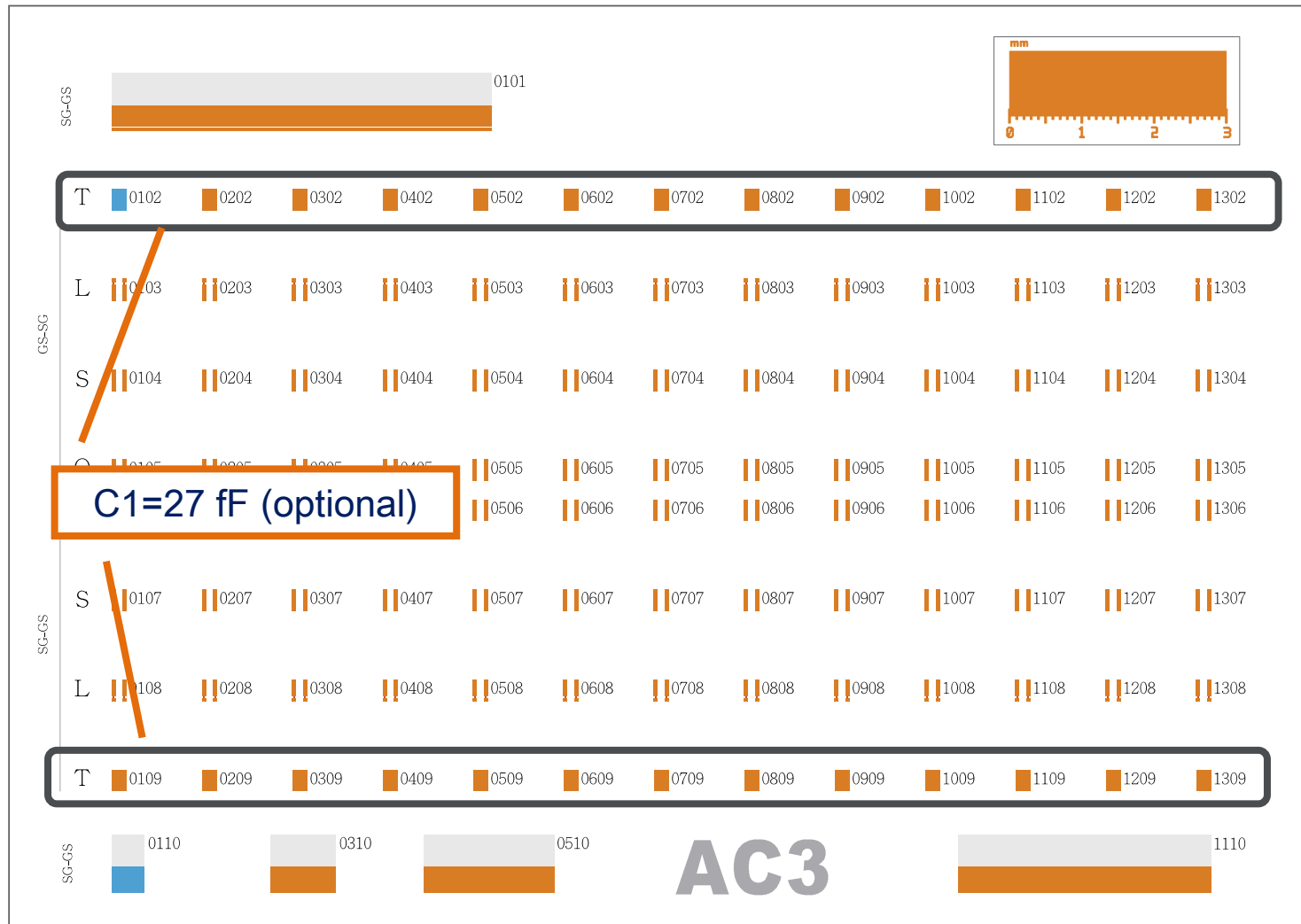
Calibration Substrates Qualified: NIST methodology



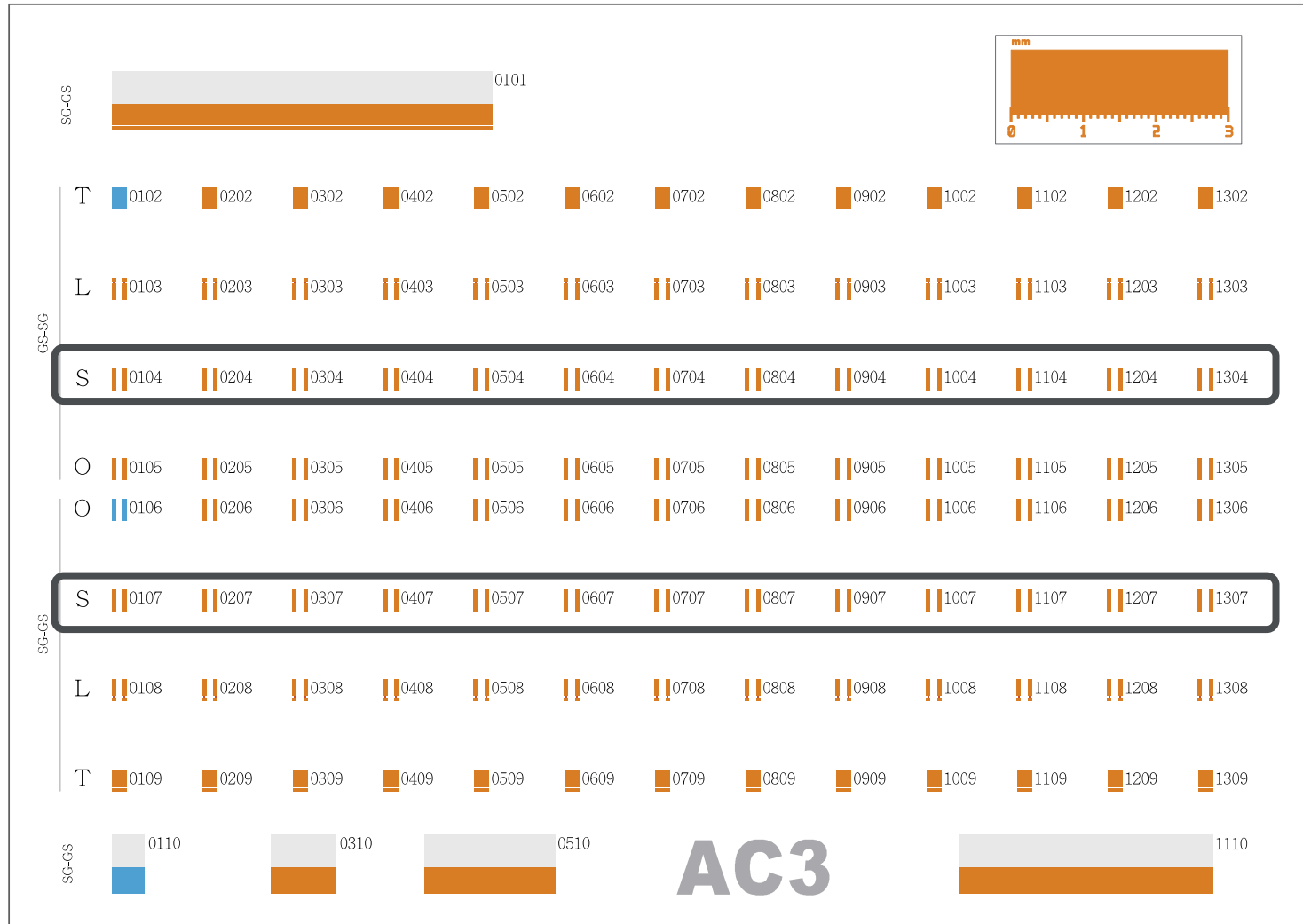
AC-3: Open Standards



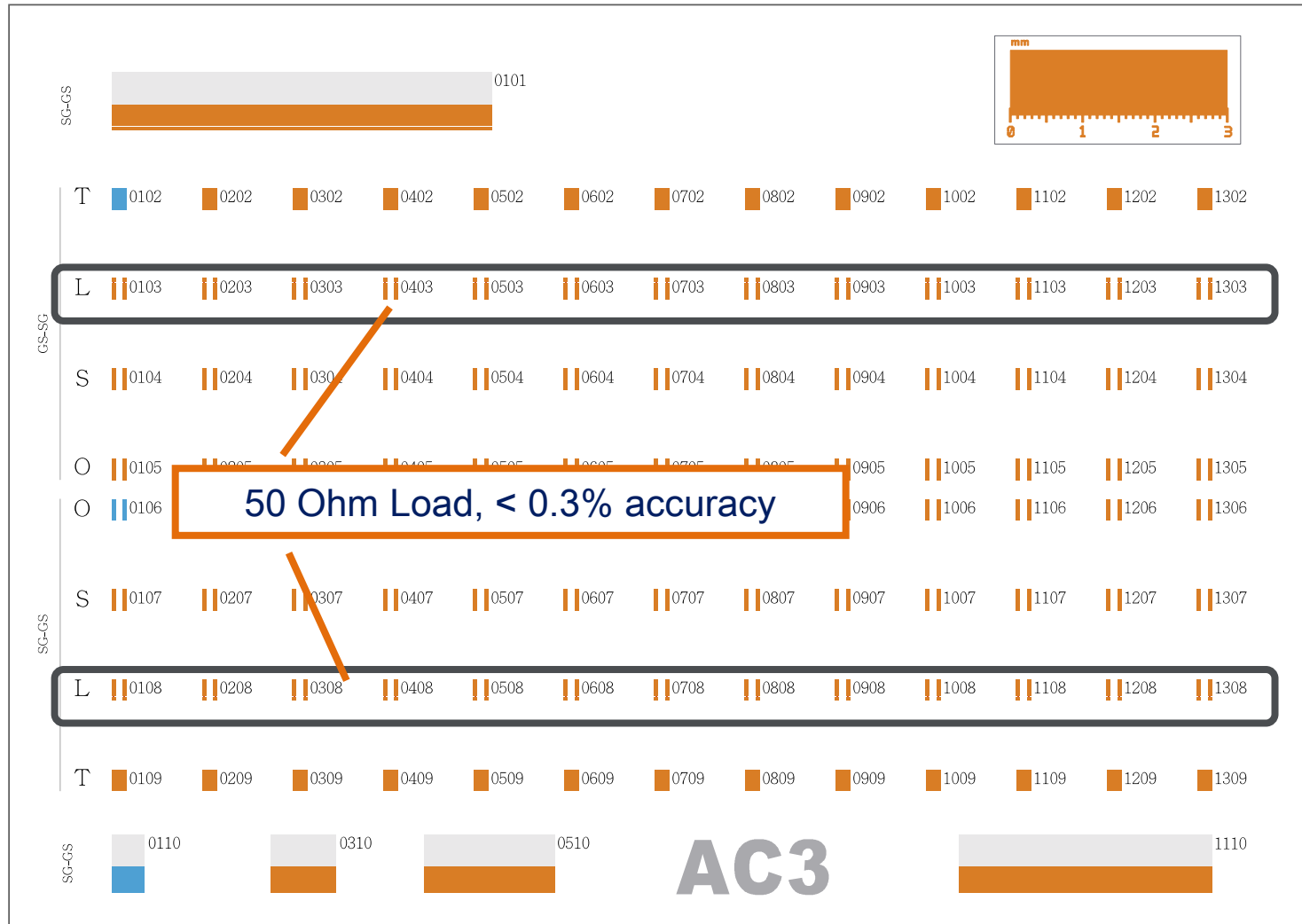
AC-3: Open Standards (Optional)



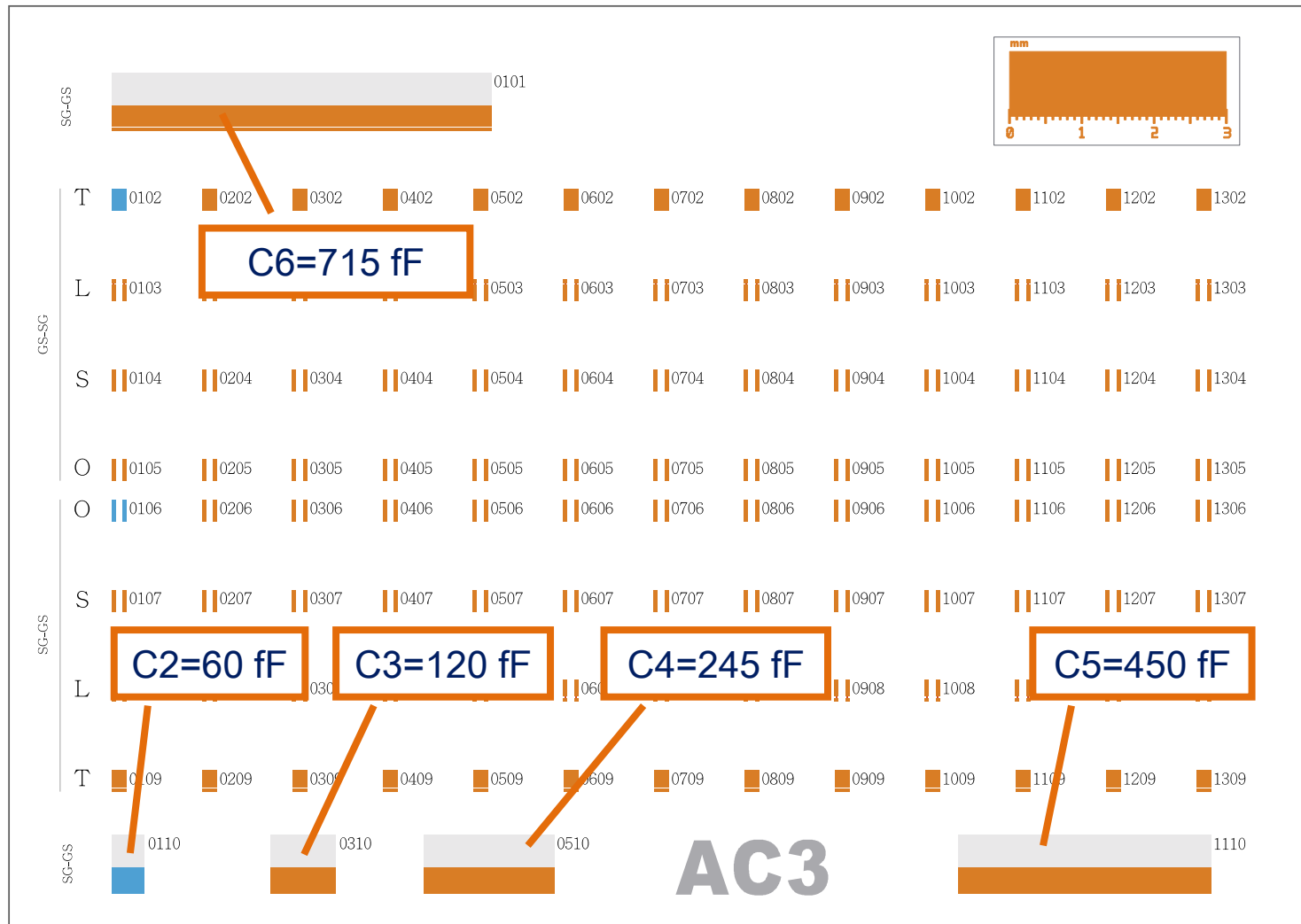
AC-3: Short Standards



AC-3: Calibration Loads



AC-3: Verification Capacitances



The background is a deep blue with a complex pattern of light rays or lens flares emanating from the center, creating a sense of depth and movement. The rays are lighter blue and white, contrasting with the darker blue background.

Thank you

MPICORPORATION