MPI CORPORATION

Advanced CV-Measurements and Calibration at the Wafer-Level

Quick How-To Reference

Company Confidential

C-V Instrumentations

Agilent 4980A

Agilent 4294A

Keysight E4990A

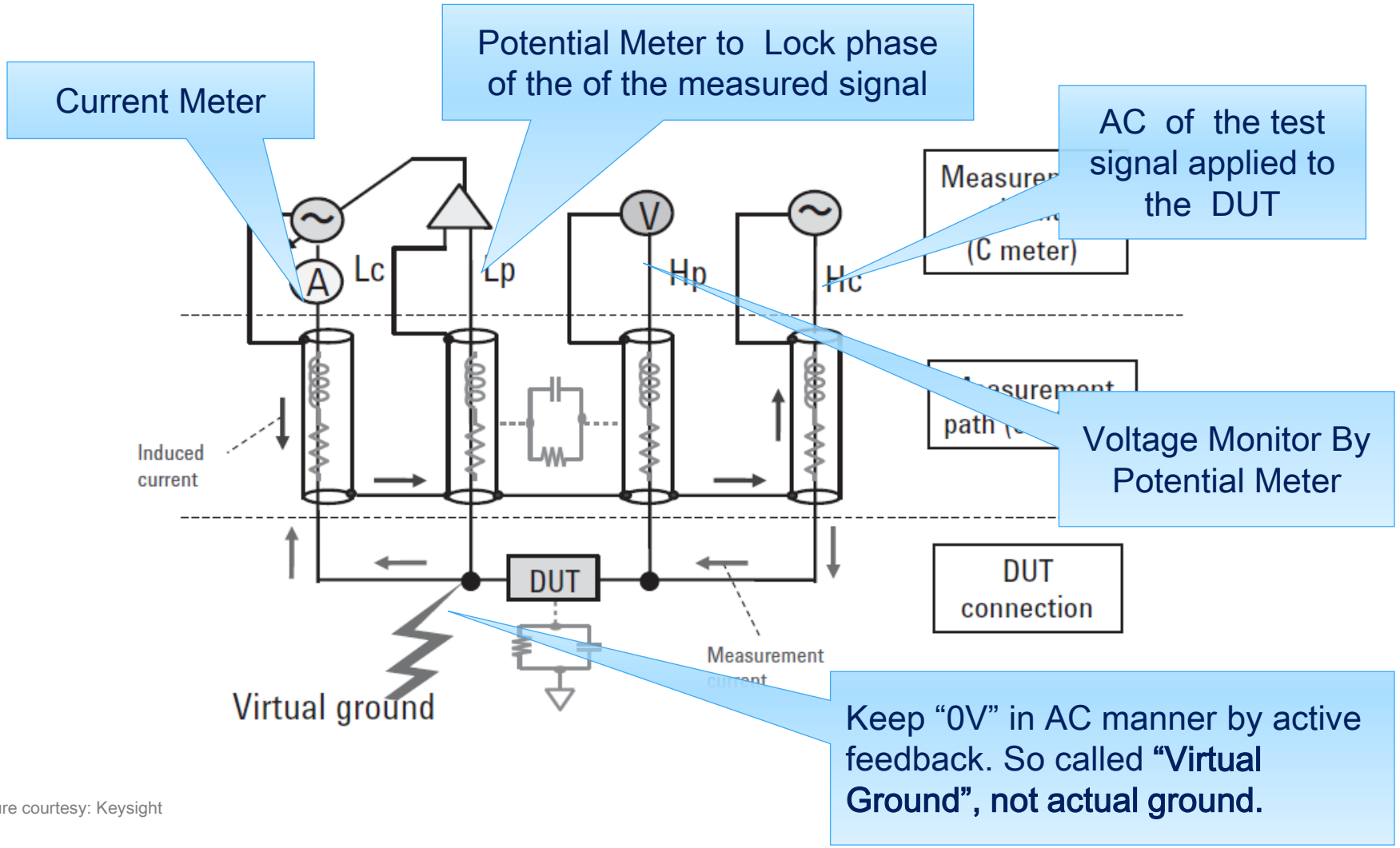
Keithley 4200-SCS

Keysight B1500A

C-V Instrumentations: Auto-Balancing Bridge Method

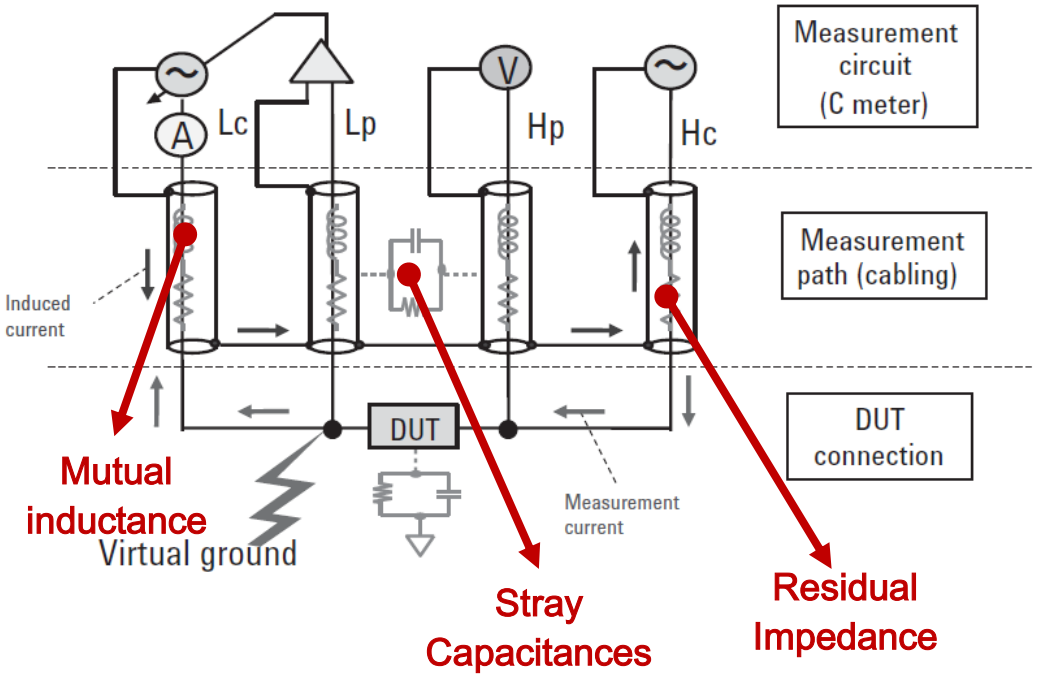
- Keithley 4200+CVU : 1 kHz to 10 MHz | DC Bias : Up to 30V
- Agilent B1500+MFCMU : 1 kHz to 5Mz | DC Bias : Up to 25V
- Agilent 4980A : 20 Hz to 2 MHz | DC Bias : Up to 40V
- Agilent 4294A : 40 Hz to 110MHz |DC Bias : Up to 40V
- Agilent 4981A : 120 Hz to 1 MHz | DC Bias : None
- Keysight E4990A : 20Hz to 120MHz | DC Bias : Up to 40V - NEW

Auto-Balancing Bridge Method (ABB)

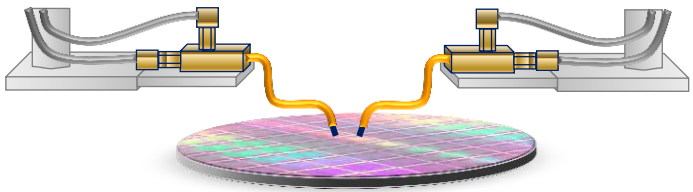


Picture courtesy: Keysight

ABB: Sources of Errors

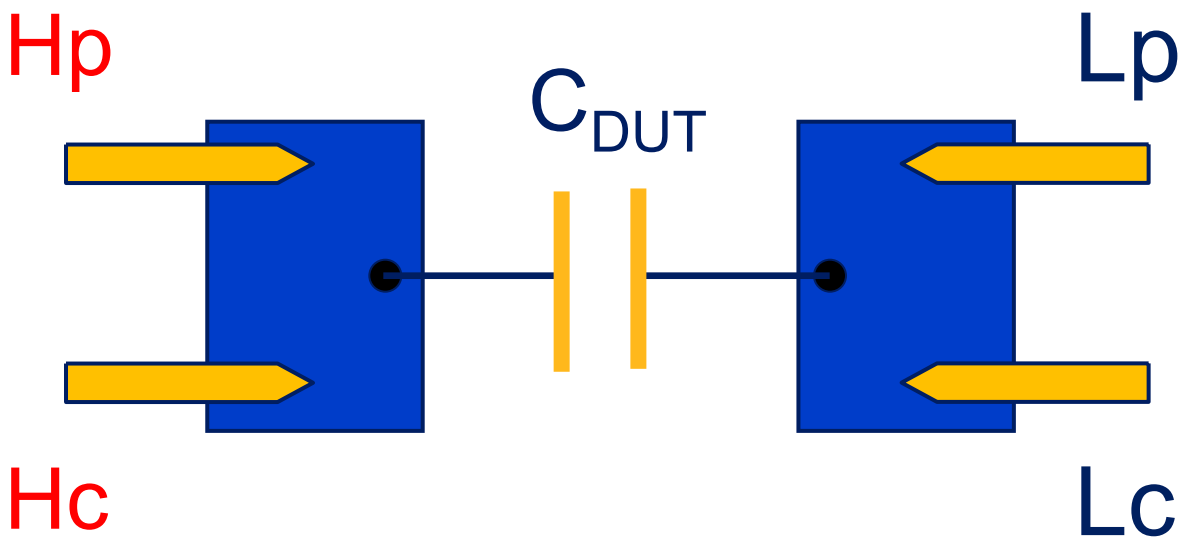


Picture courtesy: Keysight



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

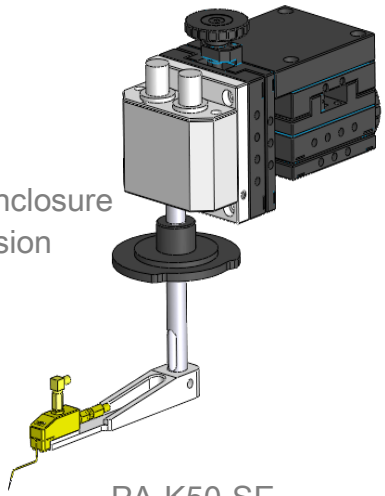
ABB: Sources of Errors



Eliminate cable resistance from the measurements

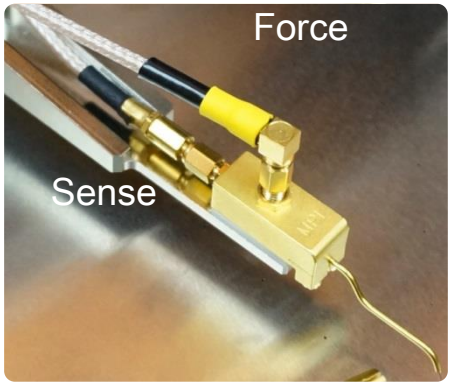
MPI Solutions: Kelvin Probe Arm

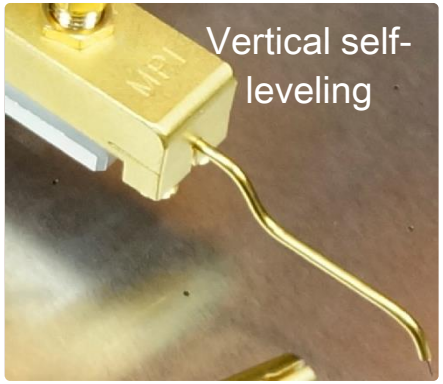
- Eliminate the effects of the residual impedance
- Shielding the cables to eliminate stray capacitance
- Vertical self-leveling for easy tip replacement
- 2M |1M Direct Impedance Analyzer BNC to SSMB to Probe with no disturbance
- Easy to reconnect for different IV/CV/PIV measurements
- For Ultra Low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



ShieldEnclosure Version

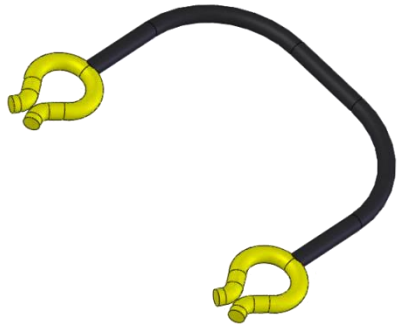
PA-K50-SE
Kelvin Probe with Dual Triax

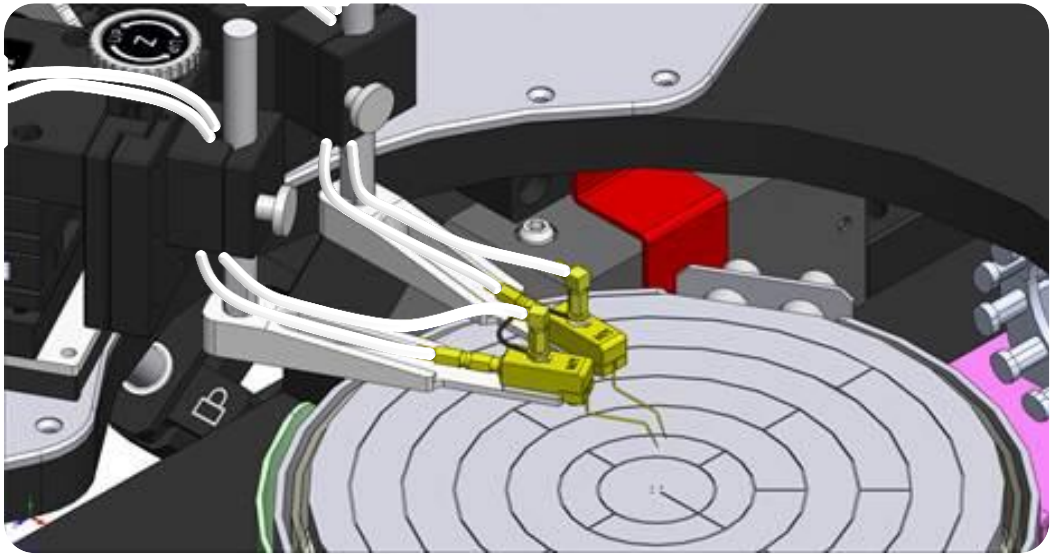


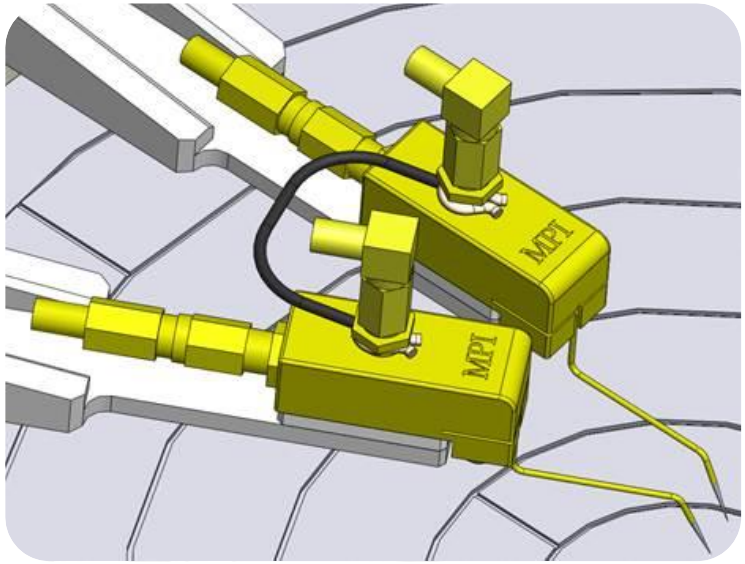


MPI Solutions: V-Ground Connector

- 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





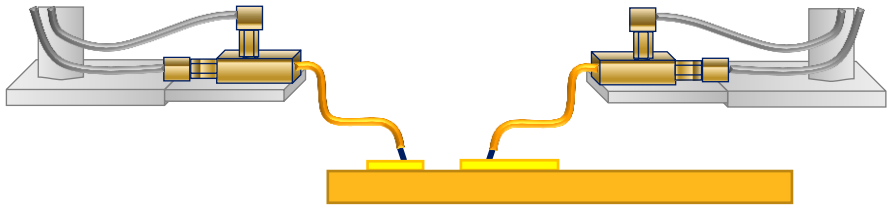


On wafer verification on Calibration Substrate

- System needs to be calibrated with Open/Short or Open/Short/Load calibration method from the CV instruments prior to any measurement

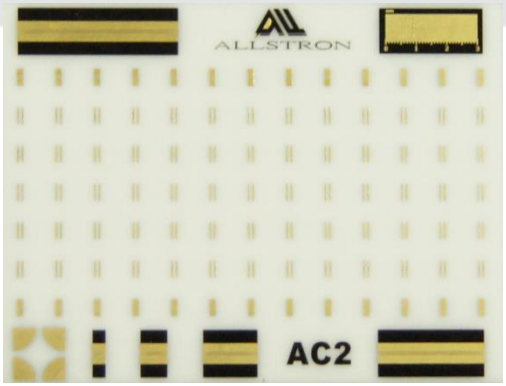
- MPI calibration substrates include required standards and are qualified using the NIST methodology
  - loads are accurately trimmed to 50 Ohm with < 0.3% error
  - reference capacitance for CV calibration verification

- Recommended substrate models:
  - AC-3 for DUT pads < 50 um x 50 um
  - AC-5 for lager pads

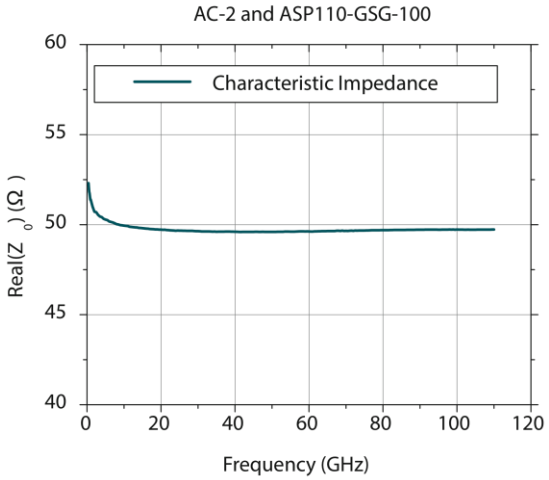


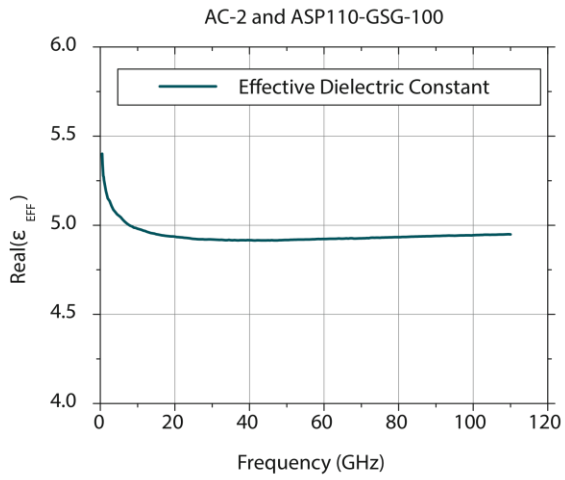
Calibration Substrates Qualified: AC-2 Example

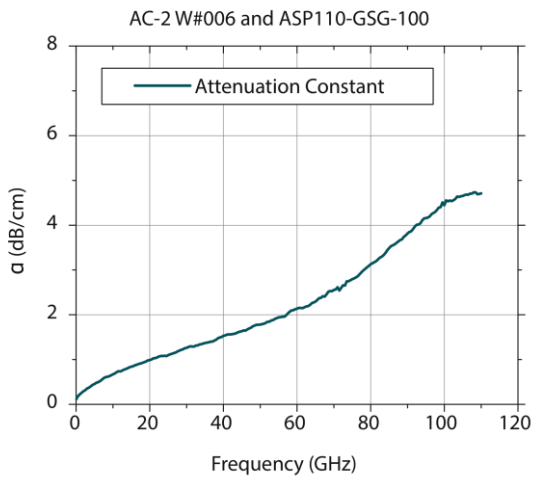
Nominal capacitance per unit length, pF/cm	1.492
Nominal characteristic impedance @20 GHz	50 Ω
Effective dielectric constant @20 GHz, real part	4.94
Effective velocity factor @20 GHz	0.45
Parameters of the simplified model of line losses	
Reference loss, dB	0.34
Reference delay, ps	25.5
Reference frequency,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

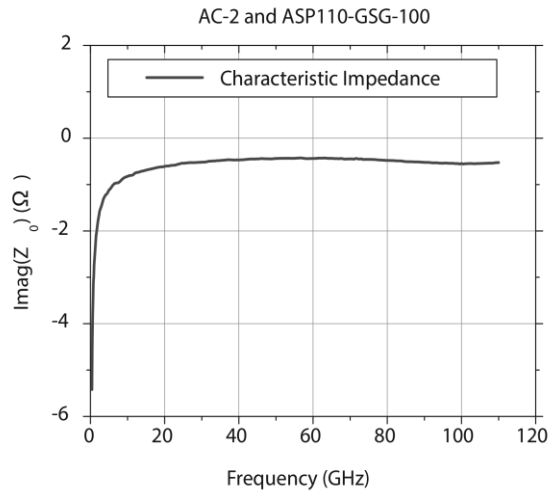


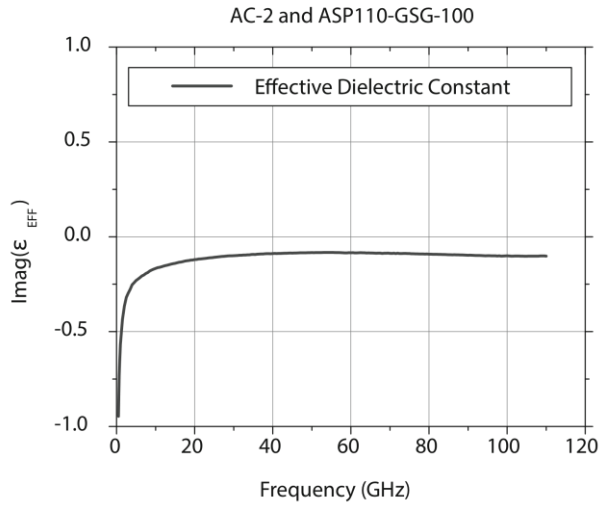
Calibration Substrates Qualified: NIST methodology

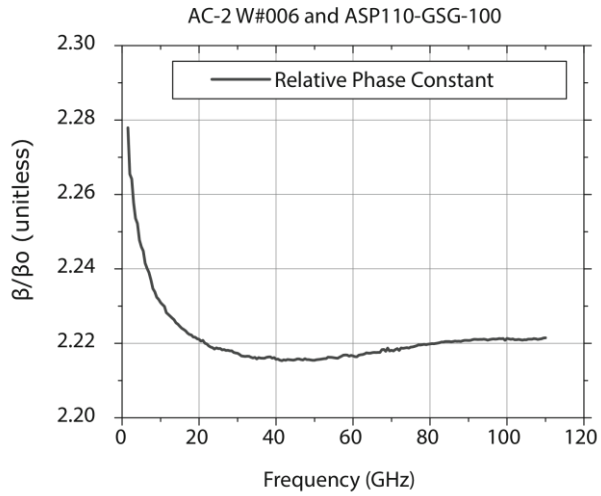




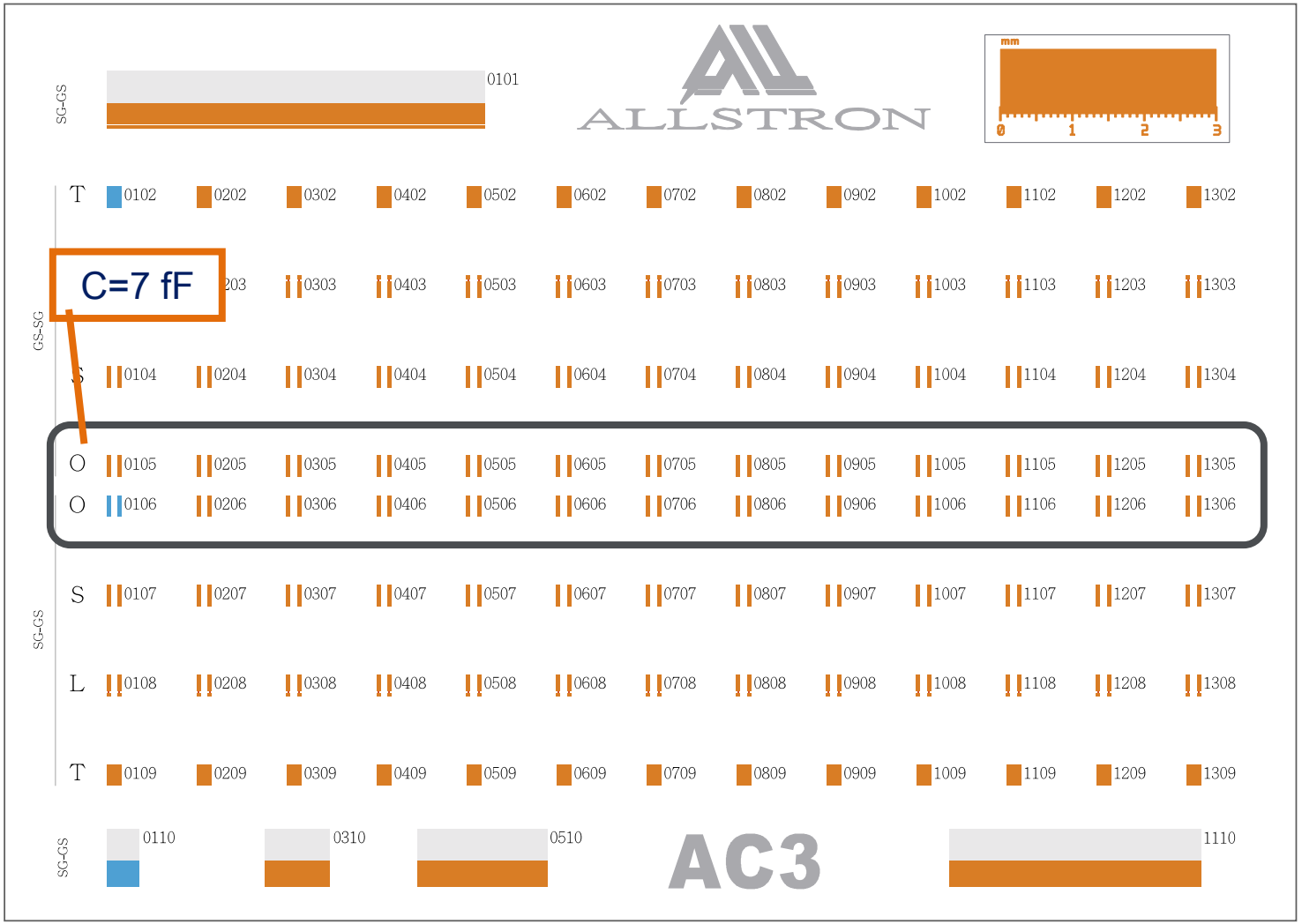




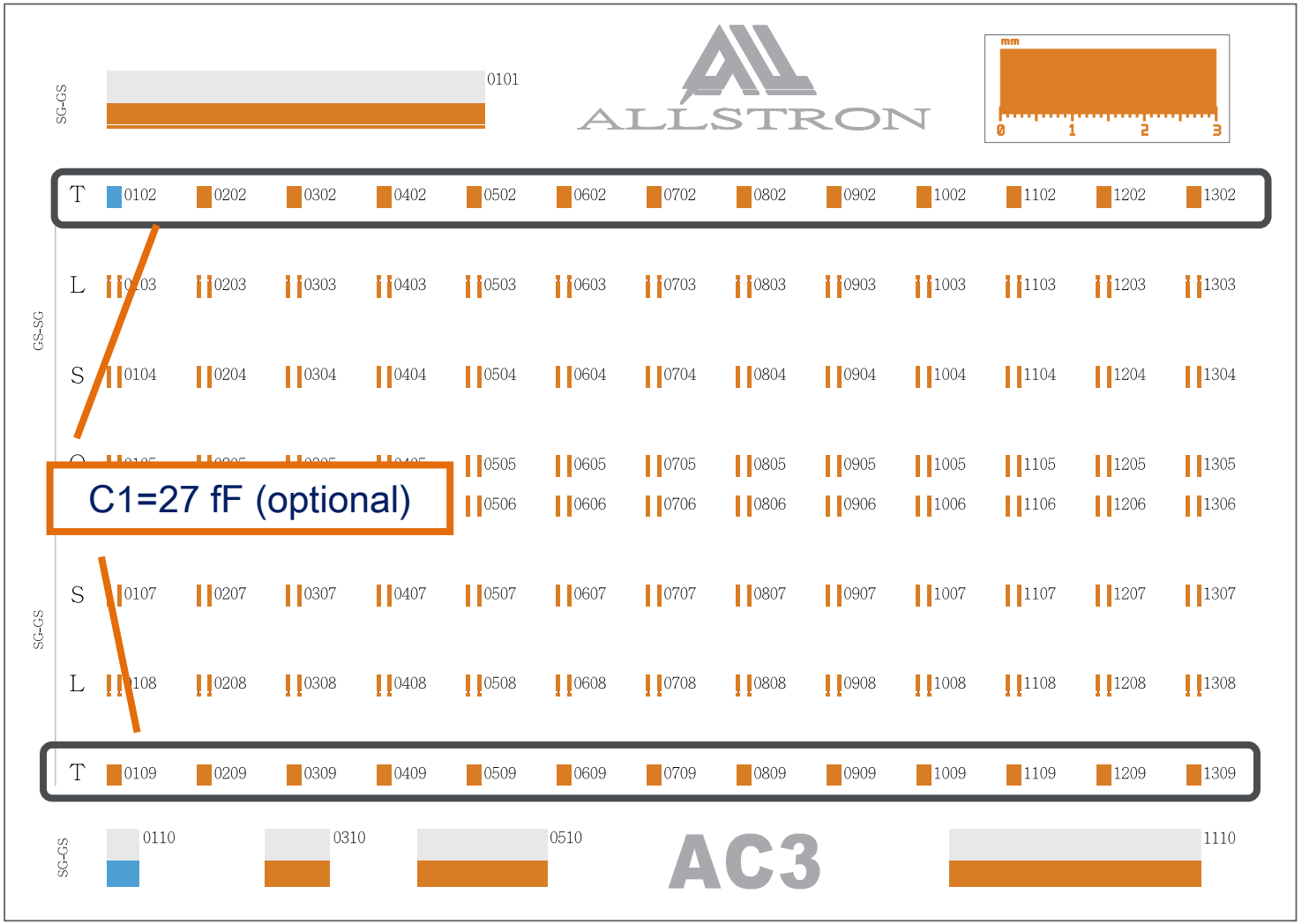




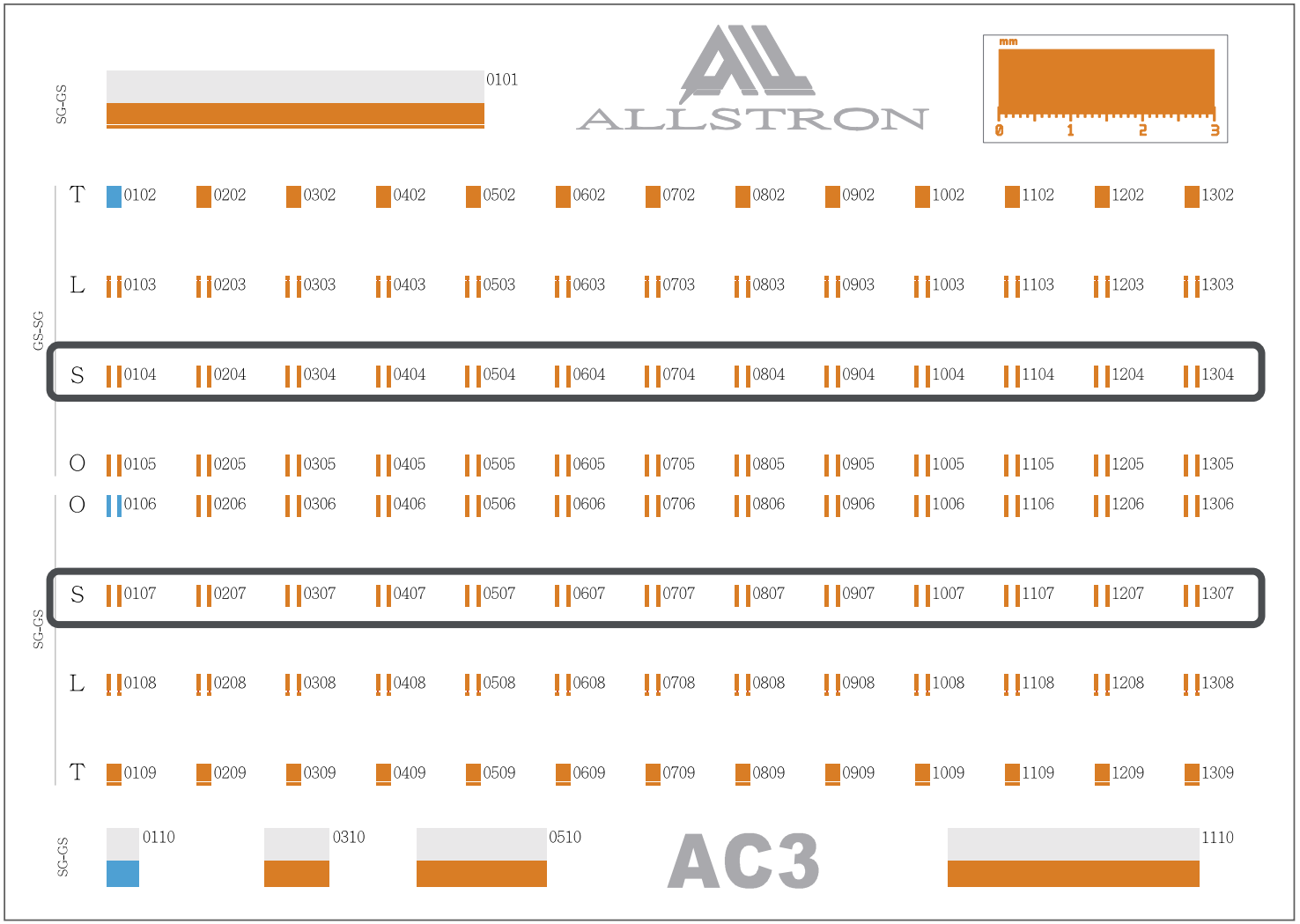
AC-3: Open Standards



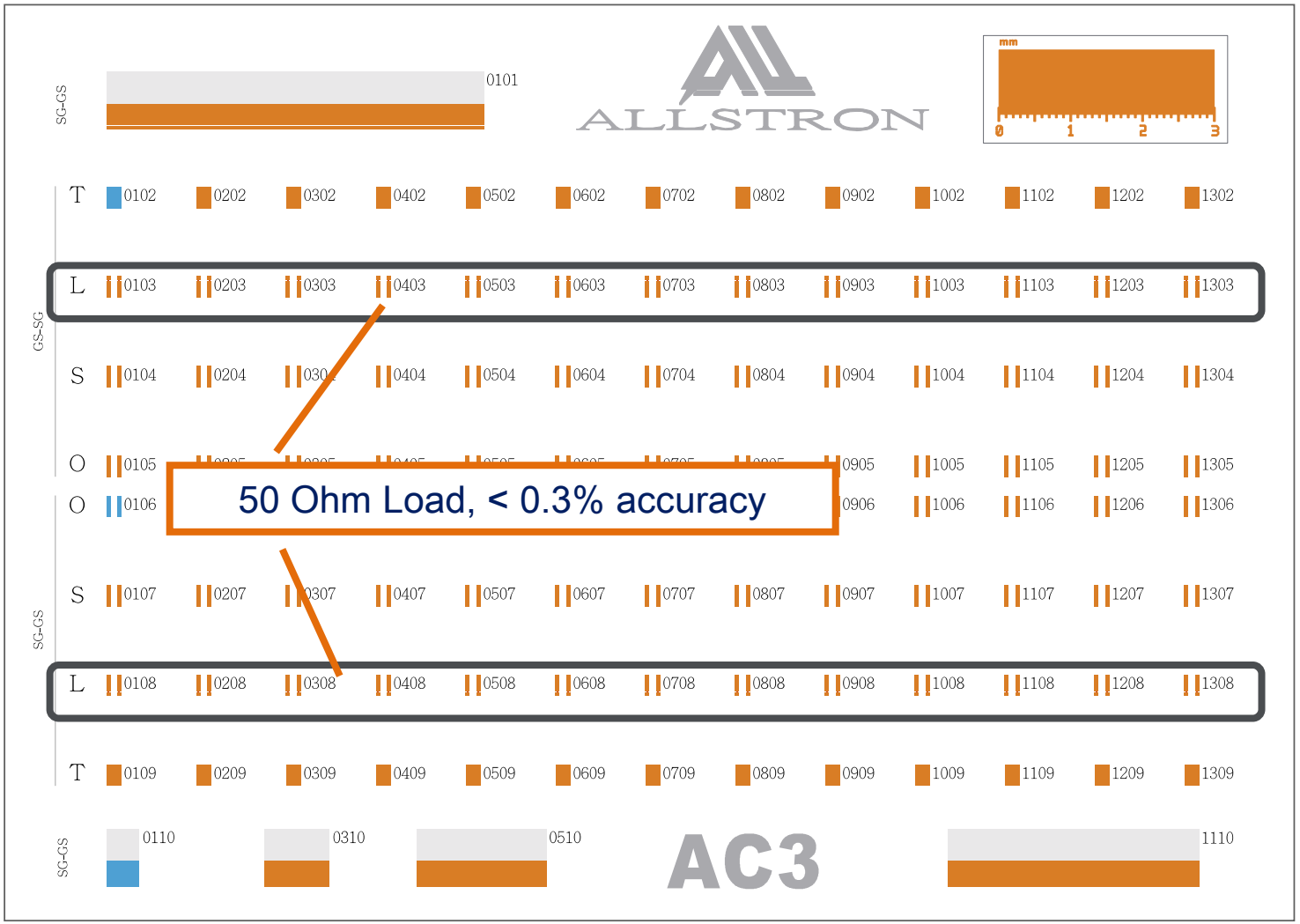
AC-3: Open Standards (Optional)



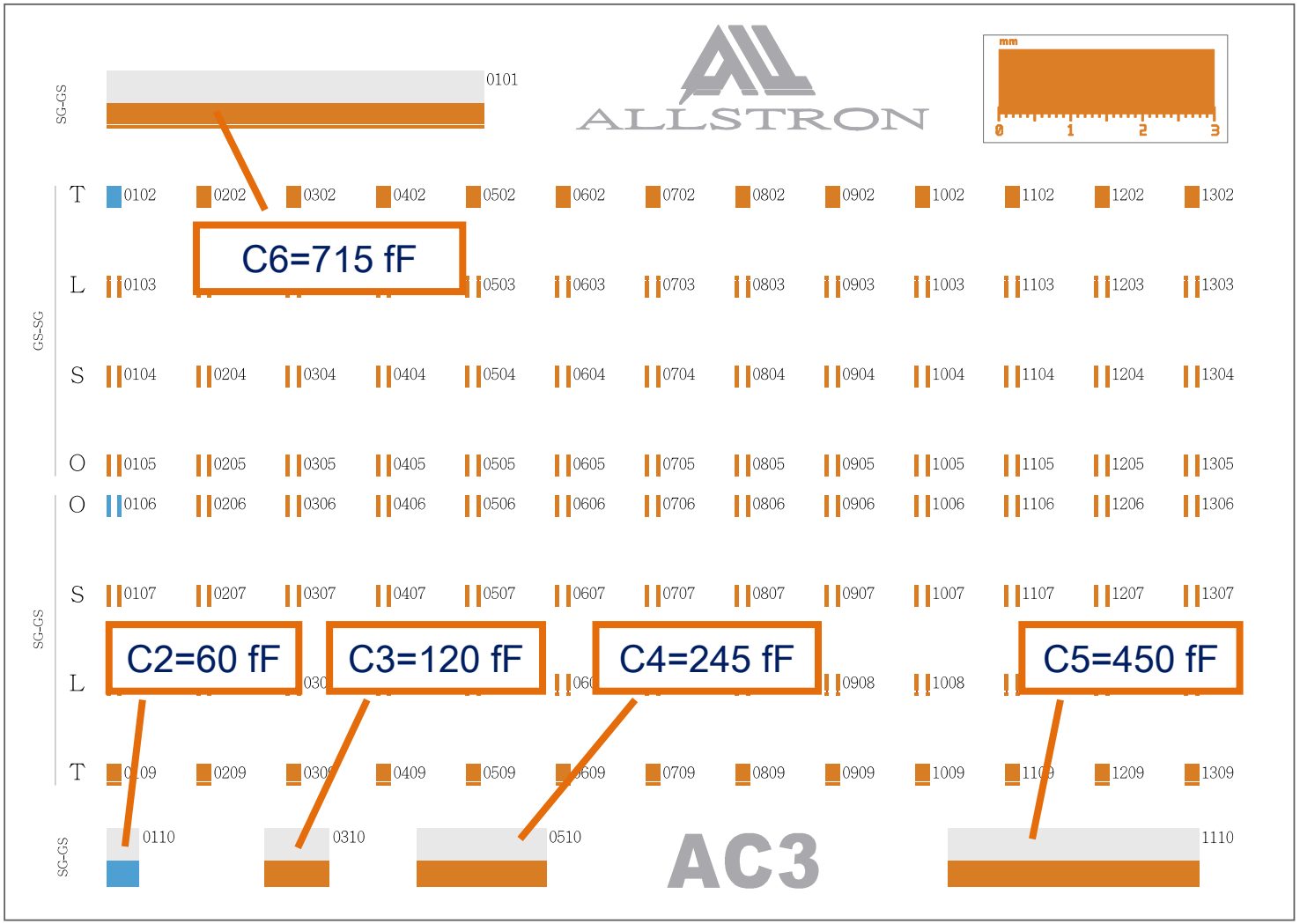
AC-3: Short Standards



AC-3: Calibration Loads



AC-3: Verification Capacitances



Thank you

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