

Circuits	Measurements					Notes	Picotest Equipment Used in the Test (Requires a VNA or FRA, all tests can be performed with the Bode 100)
	1-Port	2-Port	2_Port Extended	3-port	Scope		
LDOs, Linear Regulators, POLs, and DC-DC Converters		x	x	x	x	DC blocks can be used to eliminate DC loading if 50 ohms loads the circuit. The 2-port extended range can reduce the loading at the expense of the minimum measurable impedance magnitude (the size of the Extension resistors). DC blocks at high voltage can potentially damage 50Ohm instrument due to inrush. Check with VNA manufacturer.	2-port connections (50 ohm coax or 2-Port Probe P2101A), 2-DC Blocks P2130A (included with P2101A or can be purchased separately for direct 50 ohm coax connections), J2102B 2-port can also be performed with Tek Scope with FRA Software + J2161A + J2102B 2-port extended - 2-port equipment plus resistors or attenuating probe 3-port (V/I measurement) - J2111A + Current Probe * Oscilloscopes 2-Port Measurement: J2161A and J2102B Optional for all measurements: Picotest PDN Cables and Cable Kit
References and Opamps		x	x	x	x	Same Notes as in LDOs above. In general, the opamp and reference impedance is too low for 1-port measurement	2/3Port - Same as LDOs above
Voltage Levels							
Low Voltage ≤ 3.3V	x	x	x	x	x	Can use a 1x probe	1-Port Probe P2100A, (Probe includes 1-P2130A DC Block or can be purchased separately for direct 50 ohm coax connections) 2/3Port - Same as LDOs above
Med Voltage 3.3V-40V			x	x	x	See the 2-port extended note below. DC blocks can be applicable to all measurements, with a limitation on minimum measurable impedance magnitude. DC block at high voltage can potentially damage 50Ohm instrument due to inrush. Check with VNA manufacturer. Modulated e-load or current transformer injection can be used for 3-port measurement. But this might require a power amplifier.	See 2-port and 3-port above B-AMP 12 - https://www.picotest.com/products_OL000168.html
High Voltages > 50V			x	x	x	See the 2-port extended note below. DC blocks can be applicable to all measurements, with a limitation on minimum measurable impedance magnitude. DC block at high voltage can potentially damage 50Ohm instrument due to inrush. Check with VNA manufacturer. Modulated e-load or current transformer injection can be used for 3-port measurement. But this might require a power amplifier. 2-port extended range https://ieeexplore.ieee.org/document/7851286 usnig 20:1 (1K tip resistors) will get the 56V to a level the VNA can tolerate. This could go down to a few milliOhms The top diagram (a) works and so does (b), which is a beefier version of J2111A/J2112A (or a modulated electronic load if they have one) our J2111A could do it if we made it thermally beefier, which would be their (b) in the top diagram. The 3-port impedance measurement works independently of how it is modulate. It could be modulated using a current transformer, or their top (a) or (b) and measuring with a current probe rather than a resistor. This eliminates one ground loop	See 2-port and 3-port above B-AMP 12 - https://www.picotest.com/products_OL000168.html
Impedance Levels							
Ultra low impedance sub milliohm		x				Might require source power amplifier. Applicable to less than 3.3V.	See 2-port above B-AMP 12 - https://www.picotest.com/products_OL000168.html
impedance 500mOhm-5kOhm	x					A DC block needs to be included if the voltage is greater than 3.3V. DC block at high voltage can potentially damage 50Ohm instrument due to inrush. Check with VNA manufacturer.	See 1-port above

Note: 3-Port Test Limitations

The 3-port measurement is hard to calibrate given the nature of the setup and usage of the J2111A for current monitoring/sinking. The J2111A adds 25mA to load current which may be too large for some references.

It is generally a harder test to setup (often a current probe, which can be noisy is needed) and unlike the 1 or 2-port measurements you can't measure with power off (a useful data set in PDN design).

The J2111A Output Voltage limits are -40V to -1V and 1V to 50V. The J2112A Output Voltage limits are 0.7V - 50V (the range of the power supply output voltage that the injectors may be connected to)

Note: 2-Port Extended Test Notes

A 1x probe can measure up to 3.3V. A 10x probe can measure up to 33V but its lower impedance boundary is > 5mohm, as opposed to the regular 2-port measurement which can measure down to uohms

J2102B vs. J2113A

The J2102B paired with the Picotest PDN Cable is the best general solution. The J2113A is a better choice if you need to measure below 3kHz and below a maximum frequency of 500kHz. Due to the limited CMRR, the J2113A is not recommended below 1mOhm.

If other cables are used with either solution, there may be significant degradation in measurement accuracy below 1MHz due to poor cable shield resistance and isolation.

Measurement	Instrument								Picotest Website Solution Page	Picotest Equipment Used in the Test
	Bode 100	R&S ZNL/ZNLE	Keysight E5061B	CM S5048	Tek Scope Series 5/6	R&S RTA/B/M	Siglent SDS1000X-E-FG series scopes	Keysight InfiniiVision X-Series		
Stability via Bode Plot	x		x		x	x	x	x		FRA Bundle (include J2100A, J2120A) Optional: J2101A, J2110A, B-AMP12 Requires Scope's FRA Software add-on (see below) and in some cases an AWG Keysight: J2160A T/R Probe Adapter
Stability via NISM	x	x	x						x	See Measuring Impedance Sheet E5061B requires Picotest NISM software option R&S ZNL requires Picotest NISM software option
Impedance	x	x	x	x	x	x	x	x	x	See Measuring Impedance Sheet
PSRR (Low Power)	x	x	x	x	x	x	x	x	x	J2120A
PSRR (High Power)	x	x	x	x	x	x	x	x	x	J2121A
TDR: Cable, PCB, Dielectric					x	x	x	x	x	J2151A
DC-Biased Component Test	x		x							J2130A
Inductors Biased (low current up xx amps)	x	x	x	x	x	x	x	x	x	J2121A
Inductors Biased (high current up to 125A)	x	x	x	x	x	x	x	x		J21xxA, 1st Quarter 2020
DC-DC Converter Input Impedance	x	x	x	x	x	x	x	x	x	J2121A
EMI					x	x	x	x		EMI Probes
Load Step					x	x	x	x		J2111A, J2112A, LoadSlammer
Noise Measurements					x	x		x		J2180A
Harmonic Signal Injection					x	x		x		J2150A

Scope Software: e.g. R&S®RTx-K36 FRA option, Tek 5/6-PWR software