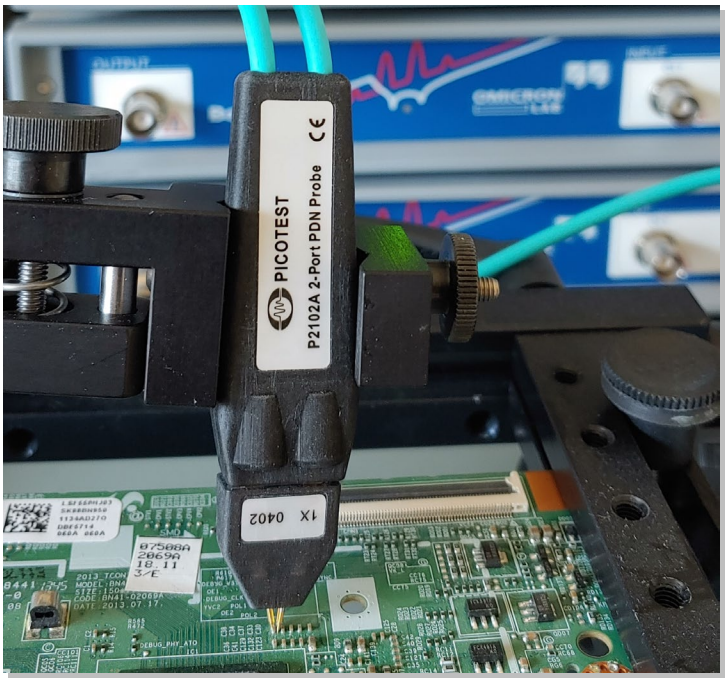
PICOTEST

Probes and Protection Devices



Documentation

Version 1.73, February 2025

Trademarks

Copyright notice

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Declaration of Conformity (EU)

The equipment adheres to the guidelines of the council of the European Community for meeting the requirements of the member states regarding the electromagnetic compatibility (EMC) directive and the RoHS directive.

Declaration of Conformity (UK)

The equipment adheres to the regulations of the UK government for meeting the requirements regarding the Electromagnetic Compatibility (EMC) Regulation and the Regulation for Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment.

The PDN Cables are compliant with REACH EC 1907/2006.

Information for disposal and recycling

The Picotest Probes and Cables and all its accessories are not intended for household use. At the end of its service life, do not dispose of the test set with household waste!

For customers in EU countries (incl. European Economic Area) Picotest test sets are subject to the EU Waste Electrical and Electronic Equipment Directive (WEEE directive). As part of our legal obligations under this legislation, Picotest offers to take back the test set and to ensure that it is disposed of by an authorized recycling facility.

For customers outside the European Economic Area

Please contact the authorities in charge of the relevant environmental regulations in your country and dispose of Picotest products and all its accessories only in accordance with your local legal requirements.

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Chapter 1 - Overview

Welcome

Thank you for purchasing Picotest's PDN 'Browser' probes.

The Picotest PDN probes are precision passive transmission line 'Browser' probes that support a variety of measurements including impedance (1-Port Reflection and 2-Port Series and Shunt-Through), 3-Port Voltage/Current, Step Load, Ripple, Noise, TDT/TDR, PCB Resonances, Clock Jitter, and the Non-Invasive Stability Measurement ('NISM')[1] [2] [3]. The probes have some significant advantages compared to active probes and other types of passive probes.

The high-bandwidth, fixed-pitch probe tip design enables accurate measurements for a wide variety of component and connector sizes. It eliminates the need for soldering SMA or coax cables to your board and the risk of damaging fine copper pads or pulling up small components. You can get connectivity to circuit boards and devices without connectors.

The probes can be used for 'browser' style measurement. For instance, if you have multiple power rails across your board, the small form factor and easy probe tip placement enables you to quickly browse the regulator outputs, allowing you to decide which rails need further investigation. When coupled with NISM, you have a powerful tool for assessing the stability of multiple power sources no matter the physical configuration.

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[1] https://www.picotest.com/non-invasive-stability-measurement.html
[2] https://www.picotest.com/product/power-integrity-measuring-optimizing-and-troubleshooting-power-related-parameters-in-electronics-systems/
[3] https://www.picotest.com/product/j2102b-common-mode-transformer/

Impedance Measurement Demands New Probe Capabilities
High-speed applications put pressure on the measurement of power supply busses to unprecedented frequencies. As an example, the measurement of PDN impedance for FPGAs, ASICs, and high-speed digital devices generally requires the measurement of impedance levels in the milliOhm scale at frequencies exceeding 1GHz. Measuring the high-speed step load response in power systems using 2-port impedance is difficult because of the need to connect two 50Ω transmission lines to the output capacitor. To further compound this difficult task, these measurements often need to be made in very small circuits such as cell phones, solid state disk drives, and computer tablets, to name a few examples.

These revolutionary probes alleviate many of these challenges while maintaining the precision 50Ω characteristics required for these types of measurements.

A Variety or Pitches and Swappable Probe Heads Adds Versatility
Picotest probes are available in a variety of pitches. In most cases you can also swap probe heads that have different pitches or different capabilities. This versatility allows you to get the most out of your investment.

What is a Transmission Line Probe?
Transmission line probes are special types of passive probes that replace the high impedance probe cable found in a traditional passive probe with a precision transmission line, that has a characteristic impedance that matches the oscilloscope's input (50Ω). This greatly reduces the input capacitance to a fraction of a picofarad, minimizing the loading of high frequency signals. The probes are referred to as 'PDN' probes, because of their effective use in measuring the low and ultra-low impedances found in power distribution networks.

The input impedance of the Picotest probes remains nearly constant over their entire frequency range. The probes are useful in applications that produce fast rising, narrow pulses with amplitudes which exceed the dynamic range of active probes. They also tend to have less parasitic effects on frequency response, so they are ideal for measuring impedance. By providing a simple yet elegant and flexible solution to probing high-frequency signals, Picotest's transmission line probes preserve signal fidelity and allow high-bandwidth test equipment to accurately measure circuit characteristics.

P2104A 1-Port Browser PDN Probe

The P2104A probe is the ideal probe for testing ripple and impedance in PDN applications. It is available with probe heads that have various probe tip spacings (50mil, 60mil, 70mil, or 100mil) allowing good connectivity to various component sizes. It also comes in one of four attenuations (1X, 2X, 5X, or 10X). The probes are compatible with all equipment including VNAs, oscilloscopes, and spectrum analyzers. Measurements of greater than 100mOhms, approximately, are possible. The range is not dependent on the probe, but inherent in the 1-port reflection methodology. The probe heads are INTERCHANGEABLE.

Figure 1: P2104A 1-port probe head and cable.

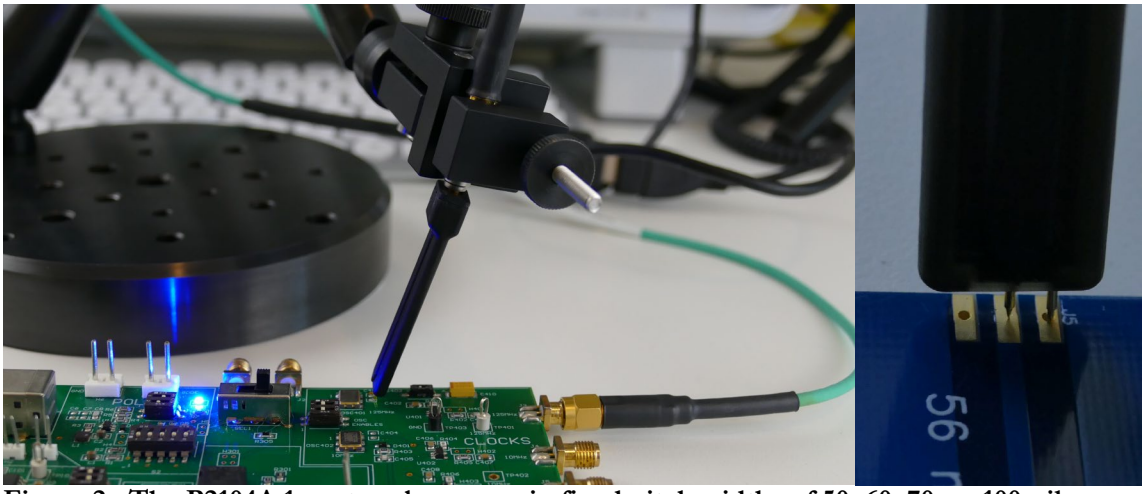


Figure 2: The P2104A 1-port probe comes in fixed pitch widths of 50, 60, 70, or 100mils. Various attenuations are also available. A probe holder is a useful accessory.

P2104A 1-Port Probe Feature and Benefit Summary

- High bandwidth - > 6 GHz (uncorrected) Note: USABLE BANDWIDTH FOR VNA WITH CALIBRATION IS HIGHER
- Impedance, Ripple, Noise TDT/TDR, 2 port impedance (using two P2104A probes), PCB resonances, Clock Jitter and Non-invasive Stability
- Virtually no capacitive loading (< 1pf, 420fF typical)
- Very flat frequency response (Impedance floor ~ 100mOhms for 1-port reflection impedance)
- Interchangeable probe heads (snap on/off feature)

- Supports Browsing Measurement on Multiple Rails
- Applications: Power Integrity, Power Electronics, Signal Integrity
- Available in various attenuations and pin pitches: Optimized for sensitivity and SNR
- Integrated series resistor option available for extended measurement range
- Use two (2) P2104A 1-Port Probes for High Bandwidth 2-Port Measurements
- Bi-directional – send signals to the DUT for signal injection or receive signals from the DUT
- Use as a Browser accessory with Power Rail probes
- 50 Ohm impedance compatible with all 50 Ohm instruments
- Rugged, ergonomic design, and small form factor gets into tight places
- Slim body with spring tips provides good visibility of the target and reliable connectivity
- Uses PDN Cable ® for optimum performance
- Includes P2100A CAL Calibration Board for SOLT and ISOLATION calibration
- Supports NISM - Non-Invasive Stability Measurement for Phase Margin Testing

P2102A 2-Port Browser PDN Probe

The P2102A 2-port probe comes with four (4) interchangeable, snap on, probe heads sizes (1206, 0805, 0603, and 0402) allowing good connectivity to various component sizes. It also comes in one of four attenuations (1X, 2X, 5X, or 10X).

Figure 3: P2102A 2-port probe.

The probes are compatible with all equipment including VNAs, oscilloscopes, and spectrum analyzers.

The P2102A probe is designed to work with the J2102B common mode transformer, or the J2113A ground loop isolator, which eliminates instrument DC ground loops in low impedance measurements.

P2102A 2-Port Probe Feature and Benefit Summary

- Supports Measuring:
  Impedance, Transient Step Load, Ripple, Noise, 2-port impedance, PCB resonances, Clock Jitter, and Non-invasive Stability
- Wide Bandwidth – 300MHz *
- Measures < 1mOhm *, Up to kOhms **
- Four (4) Interchangeable Probe Heads –- Sizes 1206, 0805, 0603, and 0402
- Various Attenuations – 1X for optimum sensitivity and SNR, 2X, 5X, and 10X. Higher attenuation is for higher voltages, impedance, or reduced loading
- True 4-Point Kelvin Measurement
- Browsing capability greatly eases testing of multiple rails and repeat measurements
- Virtually no capacitive loading
- Includes PDN Cables® for ultra-high shield attenuation and ultra-low shield resistance
- Rugged, ergonomic design; small form factor gets into tight places
- Supports Non-Invasive Stability Measurement (NISM)
- Supports the Extended Range 2-Port Shunt-Through measurement

* Calibration dependent
** Using the EXTENDED 2-port setup.

Figure 4: P2102A 2-port probe comes with multiple interchangeable probe heads and the P2100A-CAL board (not shown here).

P2103A Differential Browser Probe TDR Applications

The Picotest P2103A probe is a 100 Ohm input impedance differential transmission line 'browser' probe for TDR/TDT applications. This precision probe supports a variety of measurements.

To characterize a differential pair, the TDR must drive a differential signal and measure the response as the reflected differential signal. This requires two channels to be connected to the same end of the differential pair, and have the equivalent of two, simultaneous stimulus – either launching a differential signal or launching a common signal into the device under test (DUT). This is done with a differential TDR.

Figure 5: P2103A TDR probe. The P2103A differential probe comes in fixed pitch widths of 50 and 100mils. Custom pitches are also available.

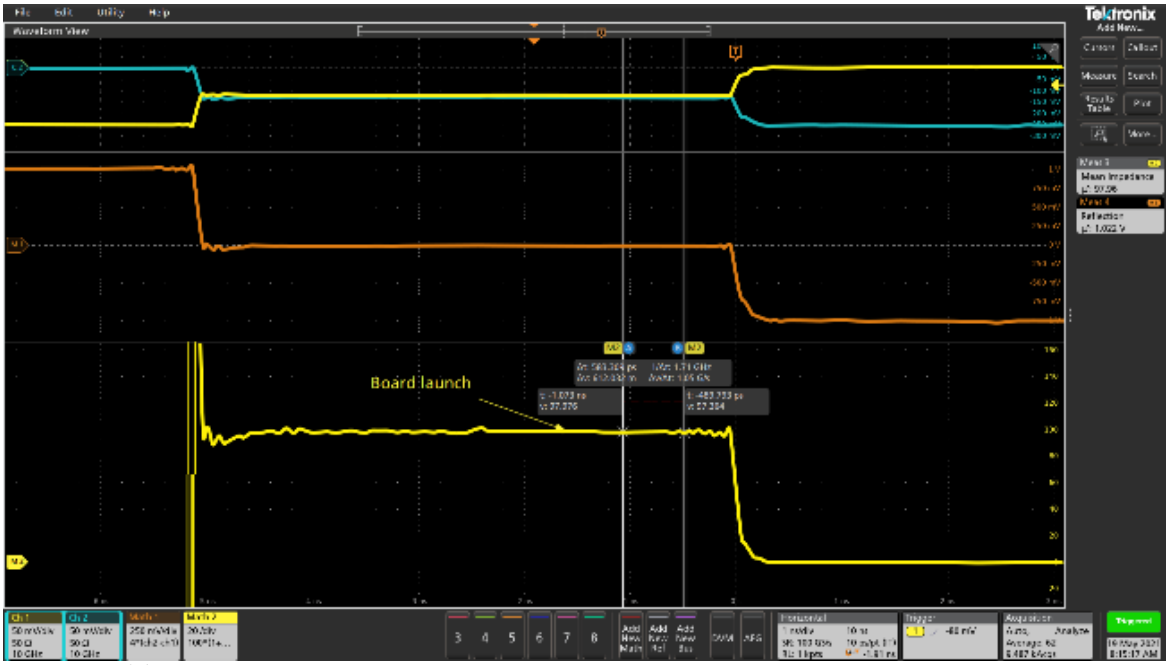


Figure 6: The P2103A recorded differential signal, gamma function and 100 Ohm measurement.

P2103A Differential Probe Feature and Benefit Summary

- 6GHz Bandwidth (uncorrected)
- Works for all Time Domain Reflectometry (TDR/TDT) applications
- Compatible with the Picotest J2154A PerfectPulse® Differential TDR (Differential mode only)
- Compatible with all 50 Ohm Instruments; 100 Ohm nominal differential impedance
- Fixed pitches available: 50 and 100 mils
- Spring pins for easy landing
- Short pins and integrated PDN Cable® for low coupling and optimum shielding
- Handheld browser style for repeatable and easy probing; Handle design fits most probe holders
- Slim low-profile housing for comfort and visibility

Applications *

- Differential transmission lines measurement
- PCB coupon tester including characteristic impedance including Even/Odd mode impedance
- Calculation of cable and PCB trace length, dielectric constant, and loss tangent
- Locate and detect impedance mismatches
- Failure analysis of PCB with or without components mounted
- Package impedance testing

- Measuring each of the five impedances associated with a differential pair
- Measuring the degree of coupling between lines in a differential pair
- Measuring the differential impedance of a twisted pair cable
- Measuring the reflected noise of a differential signal crossing a gap
- Measuring the mode conversion in a differential pair
- Identifying specific physical features that contribute to mode conversion in a differential pair

* When coupled with the J2154A TDR.

P2105A – The Versatile Multi-Function Probe

The Picotest P2105A probe is a 50 Ohm 1-port transmission line 'Browser' probe. With superior user ergonomics, the probe is simple to hold and probe with using integrated spring pins (pogo pins). However, what sets the P2105A apart from other probes is its unmatched versatility. Users can swap (snap on and off) various heads on the common handle making this probe extremely versatile. It can be used for TDR, voltage ripple (as with other power rail probes), transient load current stepping, and near-field testing applications. In other words, it supports a variety of measurements including impedance. TDT/TDR, ripple, noise, PCB power rail, VRM (Voltage Regulator Module) and PDN impedance, and clock jitter. It has significant advantages in comparison to active probes and other types of passive probes as can be seen by a review of the specifications.

The P2105A is referred to as a 'browser' probe for its ability to quickly and easily be moved from point-to-point/rail-to-rail simply by reseating the probe points. The probe achieves a very low inductance at the tip to mitigate space constraints on a dense PCB, while eliminating the need to add additional SMA connections or other test points necessary for impedance measurements. It is especially useful when there are multiple rails to assess and there is no time or PCB iterations available to provide test point implementations for each. Repeated measurements are simplified because connection is by simply touching the tip to existing trace.

Figure 7: The P2105A 5 in 1 probe uses interchangeable heads to change functionality. Probe heads are available for TDR/Ripple/Impedance, transient load current stepping, and near-field measurements. Different probe pitches are also color-coded.

P2105A for TDR, Ripple, and Impedance Testing

The P2105A is one of the lowest noise probes on the market, much lower than most active power rail probes. This makes it the perfect probe for TDR, voltage ripple, and impedance testing. It can measure TDR quantities when coupled with a TDR, voltage ripple in the time domain, and impedance in the frequency domain.

P2105A TDR/Voltage Ripple/Impedance Probe Feature and Benefit Summary

- 15GHz Single-Ended Precise High Bandwidth Probe for all Time Domain Reflectometry (TDR) Applications
- 1x Attenuation
- Compatible with the Picotest J2154A PerfectPulse TDR
- Fixed pitches available: 20, 31, 40, 50, 60, 70, 80, 100, 150 mils, or GSG SMA
- Compatible with all 50 Ohm Instruments
- Spring pins for easy landing
- Short pins and integrated, but removable, PDN cable for low coupling and optimum shielding
- Handheld browser style for repeatable and easy probing; Handle design fits most probe holders
- Slim low-profile housing for comfort and visibility
- Compatible with the Picotest Probe Holder

Applications *

- Power rail measurements of voltage ripple
- 1-port reflection impedance measurements (> 100mohm)
- Low-cost PCB coupon tester - Characteristic Impedance PCB traces
- Measure PCB trace length, characteristic impedance, and dielectric constant
- Locate and detect impedance mismatches
- Measure parasitic values of inductance and capacitance such as bond wires, vias, and ESL
- Measure PCB trace path rise/fall time and overshoot/undershoot
- Supports cable and trace loss modeling

Custom pitches are available.

The probe is compatible with all 50 Ohm instruments, including the J2154A PerfectPulse TDR, vector network analyzers (VNAs), oscilloscopes, and spectrum analyzers. The probe is designed to work with the traditional single ended TDR setup. When used with a TDR, getting it backwards won't normally result in any damage. The P2104A and P2105A can do damage if connected backwards to an active power rail.

Figure 8: P2105A TDR probe. The P2105A probe comes in a variety of fixed pitch widths. Custom pitches are also available.

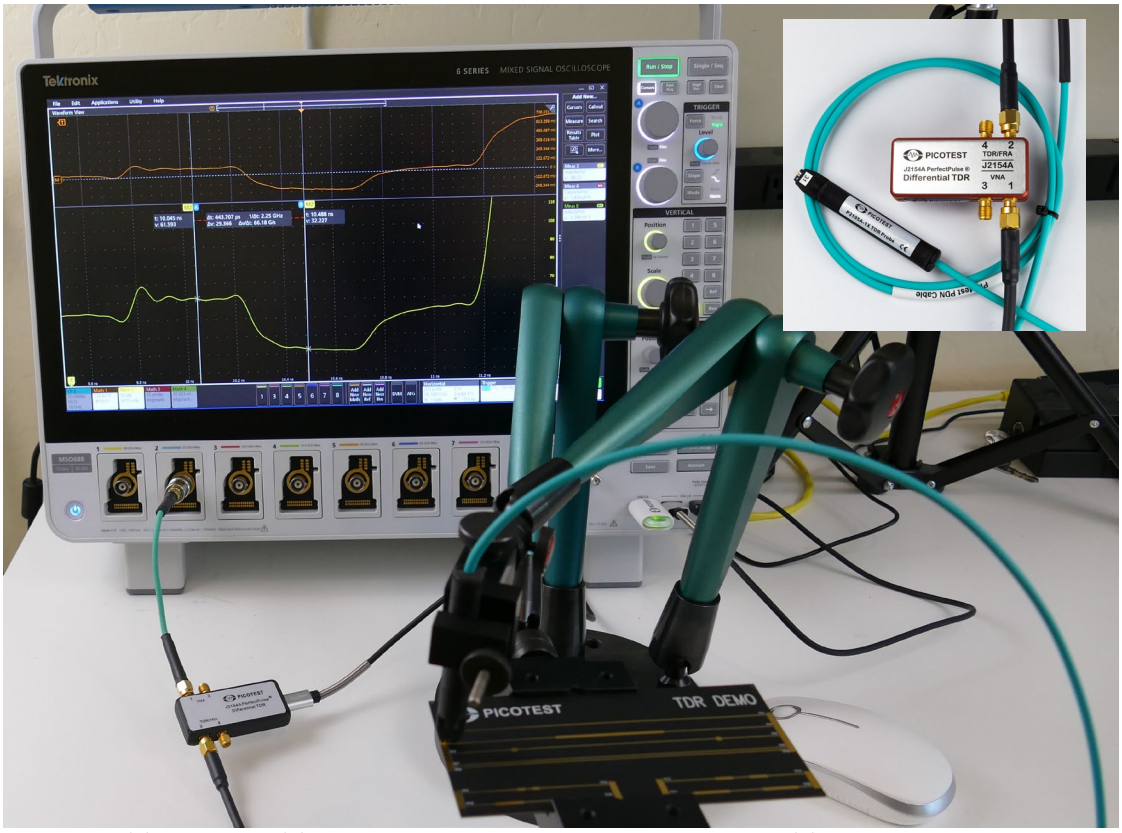


Figure 9: The P2105A TDR probe with the J2154A PerfectPulse TDR. A probe holder is a useful accessory.

P2105A Probe – Embedded Filter Option

The P2105A can be fitted with a bandpass filter (customizable at purchase) to remove spikes and other noise elements from measurements. The filter sits between the standard P2105A probe head and the probe handle. The insert can be designed at purchase with a variety of RC filter combinations.

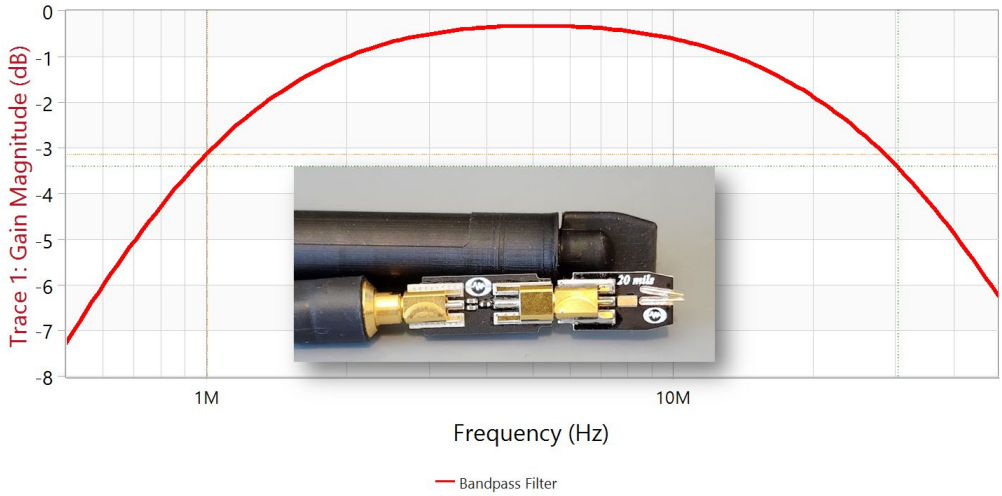


Figure 10: P2105A 20 mil tip with added bandpass filter (internal image). Probe is housed in final form.

P2105A (S10 Version) for Transient Load Step Testing

Picotest's line of transient steppers enables testing of very fast load current transitions, high peak and average power, via multiple form factors that previously were unavailable or impractical to accomplish. In particular, demanding low-voltage, high-current applications including those found in data centers, AI, graphics, EV, servers, and high dynamic current capable power supplies can now be tested, including crosstalk, thermal performance and EMI, long before the final circuit loads (e.g. ASICs, FPGAs, etc.) are even available.

The product line provides load step testing orders of magnitude faster and higher than previously available. Three product levels are available based on load current and delivery form factor: less than 10A using the P2105A (S10) probe head, 10A-50A using the S50 probe head, and up to 2047A in a custom solution (S2000). The S10 is discussed here and the S50 below.

The S10 under 10A low duty cycle (1%) solution is a hand-held browser-style probe format using the P2105A handle with a specialized probe head using a form factor that fits into tight places (70mil pin pitch). The open-loop current step is a single pre-defined current step,

determined by the custom resistor selection and the power rail voltage being stepped. The step is performed by opening and closing a GaN switch inside the probe. Therefore, the probe must be connected to a voltage source to be used.

The baseline load current value is set at the time of purchase for a specified voltage-current combination, resulting in fixed resistor value inside the probe (appropriately selected for derating purposes by Picotest technical support). The probe can be used at other output voltages and the current (pulse) will scale accordingly.

The S10 probe is triggered by a CMOS/TTL compatible signal (5V 50 Ohm signal, SMA or BNC connector) that essentially shorts or open the resistive connector to cause the load current step. The 2 output pins (+/-) are placed across the power rail. The current step (current sinking into the positive pin) mimics the control signal. The rise/fall time will be near instantaneous due to the speed of the GaN switch. The actual current rise/fall time will be a function of the interconnecting parasitics and will normally in the nS region.

P2105A Load Step Probe Feature and Benefit Summary

- High speed load current pulse
- Up to 10A load current steps (peak) – P2105A with S10 Head
- < 500ps Switching, DC – 50MHz, 100us dwell time
- Wattage < 200W peak, <1W avg., Voltage 0.6V – 72V, < 10A
- GaN-enabled – Orders of magnitude faster edge speeds than other solutions, nS load steps possible
- On and off control, user defined (at time of purchase) load current step, scales with power rail voltage
- High-speed excitation for tight spaces
- Custom-designed single resistor solution
- Average power dissipation determines supported maximum duty cycle
- Load steps at VRM bandwidth – Very low loading capacitance, Superior to electronic loads
- Spring pins for easy landing (70mil) - Short pins and integrated, but removable, PDN cable for low coupling and optimum shielding
- Handheld browser style for repeatable and easy probing; Handle design fits most probe holders
- Slim low-profile housing for comfort and visibility

Applications

- Load step current pulse testing
- Control loop stability testing

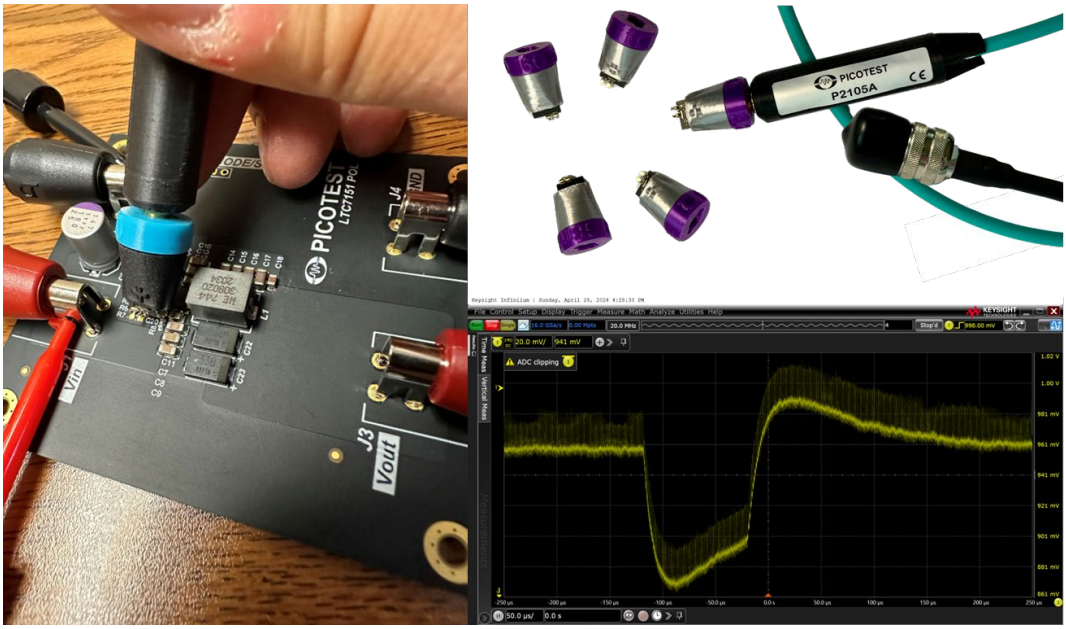


Figure 11: P2105A based S10 fast load stepper. The probe is placed on the output capacitor or blank pads and load step triggered via a user applied control signal. The head has a 70mil pitch. The step (I for a specific V) is user definable at the time of purchase, though the performance can be scaled for different voltages.

P2105A for Near-Field Testing

One of the optional snap-on probe heads for the P2105A probe is a near field probe head. Two H-field loop style heads are offered, 31 mils and 100 mils, each with different sensitivity to magnetic fields.

P2105A EMI/Near Field Probe Feature and Benefit Summary

- Fixed pitches available: 31 and 100 mils
- Custom loops patterns are available
- Handheld browser style for repeatable and easy probing; Handle design fits most probe holders
- Slim low-profile housing for comfort and visibility

Applications

- Identifying and fixing EMI problems
- Finding sources of EMC emissions problems.
- Non-invasive probing of RF and power circuits.
- Measure the characteristics of switching power supplies, clock signals, and high-current carrying traces due to their strong magnetic field emissions including inductor/transformer current transients and MOSFET switching

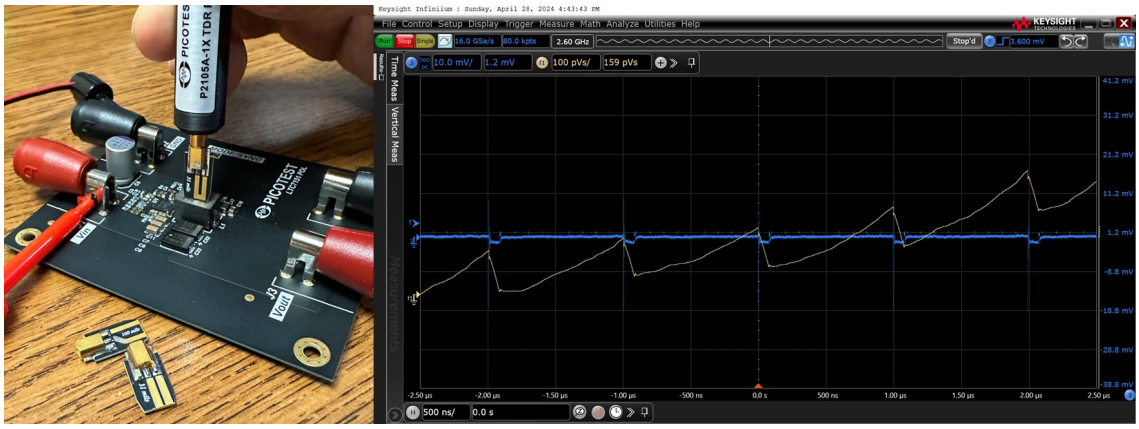


Figure 12: One of the optional P2105A heads is near field loop. Above shown measuring the switching current in an inductor. The probe head is sealed/packaged in the production unit.

Figure 13: P2105A probe with near-field head.

S50 Version Browser Probe for Transient Load Step Testing

The S50 10A-50A probe is used to perform transient load current step testing. It uses a water-cooled browser-style probe format with 6 user pre-defined current steps (6-bit logic level control). The current step (current sinking into the positive pin) is controlled by a control wire pair. This is a 6-bit control bus with 3.3V or 5V logic level. Each current switch in the head can be turned on or off and each can have a level set at the time of manufacturing. So, there are 6 discrete levels that can be switched individually or combined to achieve up to 50Amps. Like the P2105A S10 solution, the current levels are dependent on the voltage of the power rail and sized based on six resistors predefined at the time of purchase.

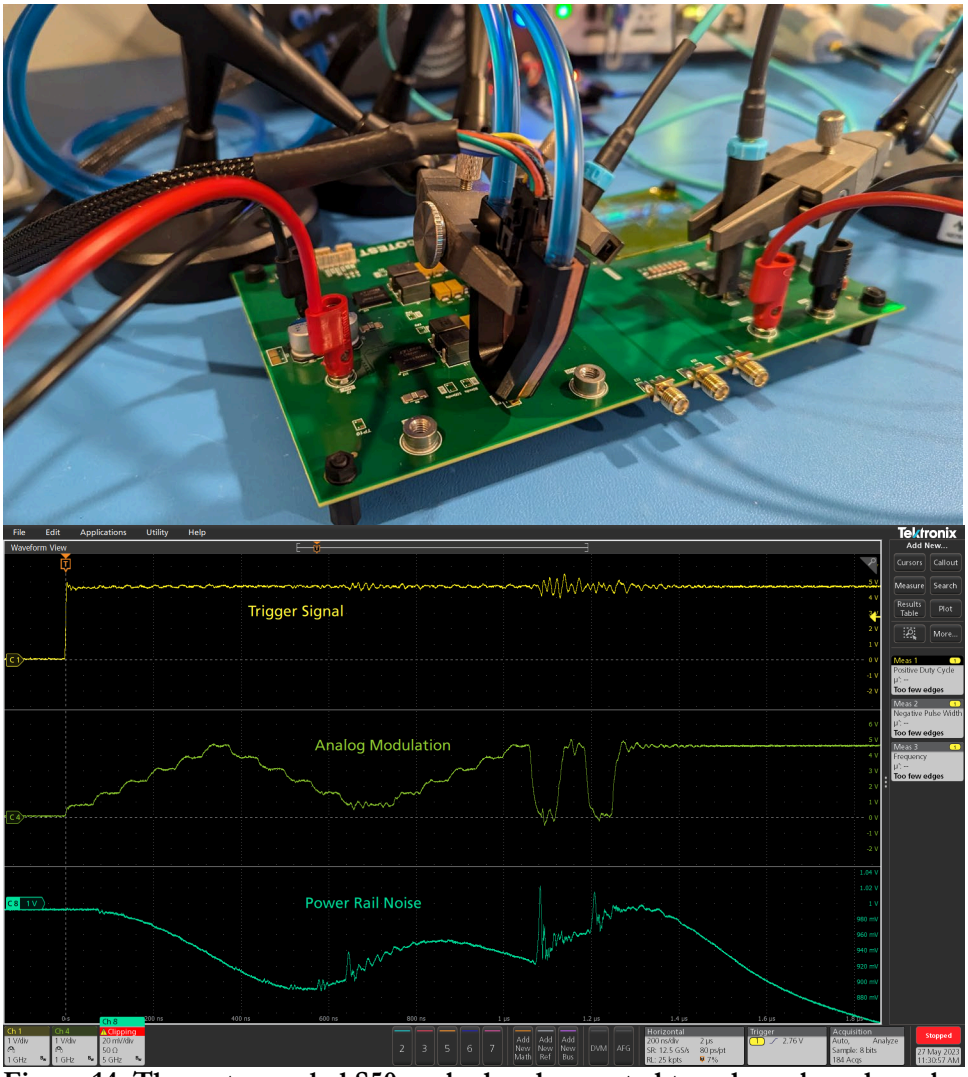


Figure 14: The water cooled S50 probe head mounted to a demo board can be modulated by a user defined analog source to create all sorts of load patterns.

The probe head is connected to a water pump for cooling. A molex connector with an eight (8) wire breakout cable is also plugged into the back of the head as illustrated below. The probe head itself comes with spring tips (or solder tabs optional) to facilitate connection to pads on the PCB.

S50 HEADER	BREAKOUT HEADER	MOLEX	Resistance (User-Defined)	Switch	Resistor	Power	Current
1	1	4				+5V	50mA
5	2	8				GND	
2	3	3	220mΩ	Q3	R5		4.35A
3	4	2	82mΩ	Q6	R8		10.87A
4	5	1	430mΩ	Q2	R4		2.27A
6	6	7	82mΩ	Q5	R7		10.87A
7	6	6	82mΩ	Q4	R6		10.87A
8	8	5	931mΩ	Q1	R1		1.06A

Figure 15: The pinout for the breakout cable that controls the load step levels. Sample resistor values and resulting load currents for a 1V power rail are shown. If the voltage of the power rail changes, the resulting load currents will move commensurately. The probe can be placed on any voltage power rail, but the load currents will vary accordingly.

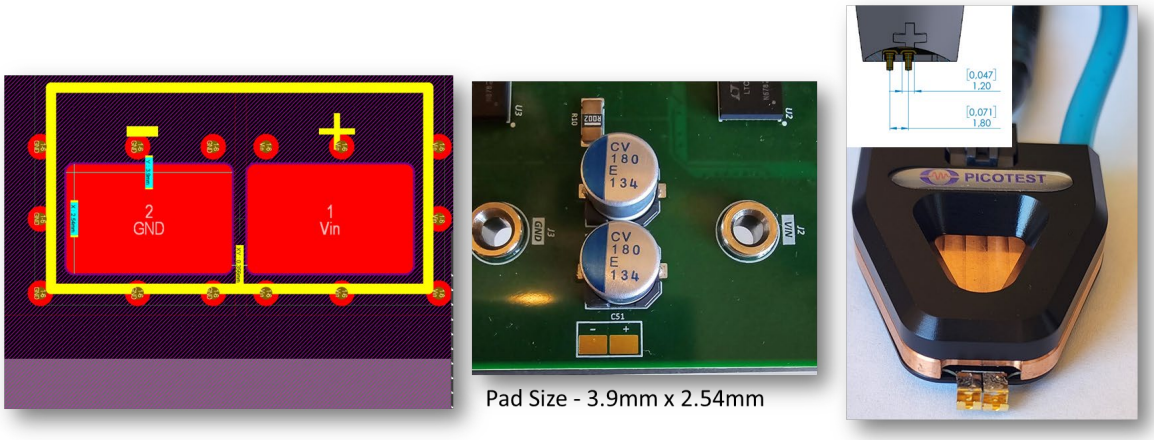


Figure 16: Suggested solder pad size.

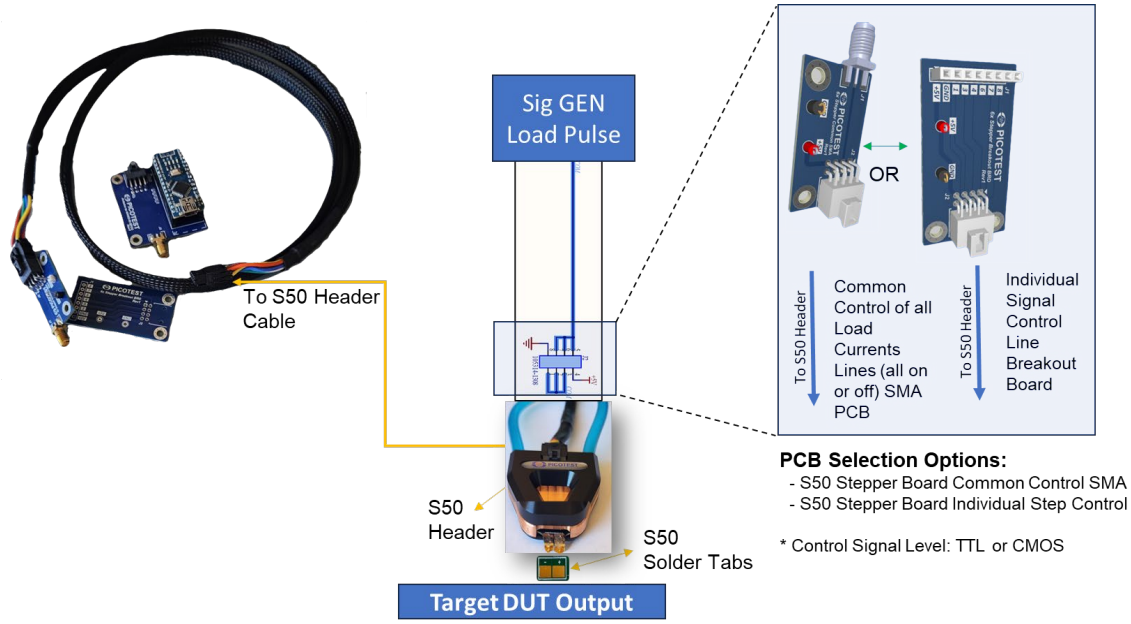


Figure 17: The S50 probe comes with a water cooling pump, a control cable (black) and two breakout boards for simplified load step control.

The S50 probe comes with two break-out boards. One board turns on and off all load current levels together. The second board allows control of each level individually.

Individual Signal Breakout Board

- Apply 5V and Ground (either to the breakout connector or the clip points)
- Drive any pin high or low with 5V to toggle the current for the pin

S50 HEADER	BREAKOUT HEADER	MOLEX	Resistance User-Defined	Switch	Resistor	Power	Current
1	1	4				+5V	50mA
5	2	8				GND	
2	3	3	220mΩ	Q3	R5		4.35
3	4	2	82mΩ	Q6	R8		10.87
4	5	1	430mΩ	Q2	R4		2.27
6	6	7	82mΩ	Q5	R7		10.87
7	6	6	82mΩ	Q4	R6		10.87
8	8	5	931mΩ	Q1	R1		1.06

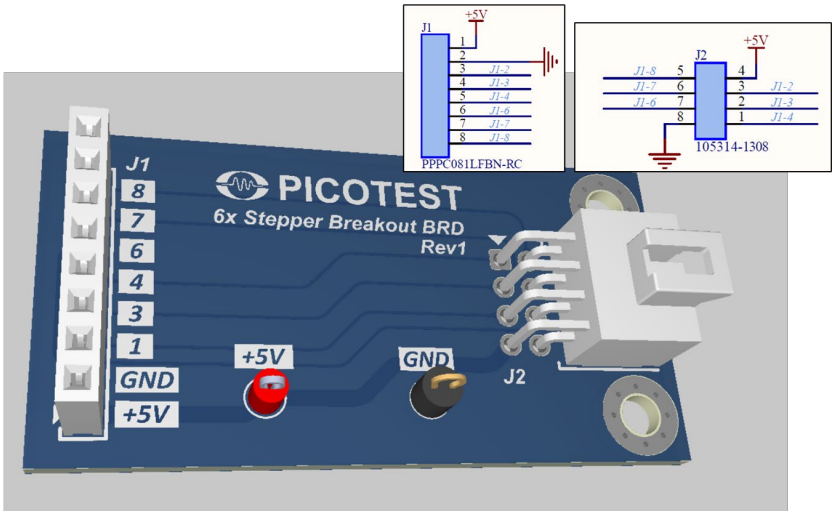


Figure 18: The S50Breakout board allow you to turn on and off each of the 6 switches to control different current steps.

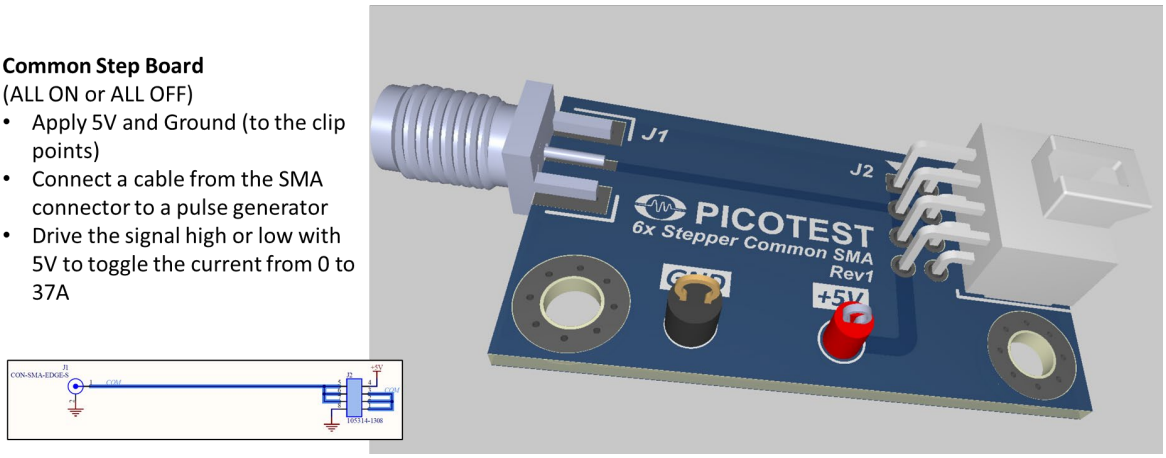


Figure 19: The S50COMMON common breakout board allow you to turn on and off all 6 switches to control a 'full load' current step.

Picotest offers both open and closed loop load current control options for the S50 and S2000. The open loop stepper is essentially a signal level voltage-controlled switch that opens or closes a path from the power rail through a GaN FET and custom resistor. So, while the probe can be moved to rails of different voltages and the step current will vary based on the power rail voltage (V/R, with R user-definable at the time of purchase). Closed loop current control uses OPAMP feedback and custom, three-terminal sense resistors, allowing up to 100MHz analog bandwidth. The power density is much lower for closed-loop control than for open-loop control while the cost for closed-loop control is higher than for open-loop control.

P2106A 1-Port Resistive Divider Probe

The Picotest P2106A probe is a high impedance voltage divider 'Browser' probe, specifically designed to be low bandwidth and resonance free. When paired with the Picotest J2180A low noise amplifier and PDN cable, the low noise measurement can be connected directly to any 50 Ohm instrument, including signal source analyzers, spectrum analyzers, and low-noise oscilloscopes. The P2106A provides one of the lowest noise floor testing solutions allowing measurement of sensitive power supplies for power amplifiers and telecommunications equipment up to 65V.

The bottom resistor is typically 1K and the tip resistor sets the attenuation. The P2106A-20K-20X has approximately a 19K tip resistor and 1K bottom resistor. This ~1kOhm Thevenin impedance forms a low pass filter with the coaxial cable (30pF/ft) and the J2180A low noise preamplifier input capacitance (~36pF) (Fbw=1/(2*PI*1k*125pF)=1.2MHz. There is essentially zero capacitance at the probe tip. The general application is to connect a relatively High Z, uncompensated probe to the J2180A amplifier for the purpose of getting a low noise, low bandwidth signal to a 50 Ohm instrument.

The P2106A is available in fixed pin pitches of 50, 60, or 100mils. The P2106A probe can be purchased in almost any desired attenuation (1:1, 20:1 and User-Defined Attenuations Variable Resistance including 20kOhm). Using an uncompensated voltage divider results in near zero capacitance and is assured to be resonance free for accurate measurement with minimal loading. The uncompensated divider results in a low bandwidth measurement, set primarily by the coaxial cable and J2180A preamplifier capacitance.

P2106A 1-Port Probe Feature and Benefit Summary

- Available in custom attenuations and resistance levels
- Bandwidth – Typically 1-2 MHz
- Low loading, uncompensated assures no peaking
- Supports low noise measurement
- Couples to J2180A preamplifier to reduce noise, convert to 50 Ohm instrument compatibility
- Available in various attenuations and pin pitches: Optimized for SNR
- Virtually no capacitive loading (< 1pf, 420fF typical)
- Rugged, ergonomic design, small form factor gets into tight places
- Slim body with spring tips provides good visibility of the target and reliable connectivity
- Uses PDN Cable ® for optimum performance

What's Included with Picotest Probes

Your Picotest P2102A Probe kit includes the following:

- 2-Port Probe with PDN Cables
- 4 Heads 0402, 0603, 0805, 1206
- P2100A-CAL probe calibrator board
- Probe Case

Your Picotest P2103A Probe kit includes the following:

- Differential Probe with PDN Cables
- Differential Demo board
- Probe Case

Your Picotest P2104A Probe kit includes the following:

- 1-Port Probe with PDN Cable
- P2100A-CAL probe calibrator board
- Probe Case
- Optional: Additional probe heads

Your Picotest P2105A Probe kit includes the following:

- Probe with PDN Cable
- TDR Demo Board
- Probe Case
- Optional depending on purchase: Additional probe heads (TDR/ripple, load stepper, bandpass filter, or near field

Your Picotest S50 Probe kit includes the following:

- S50 Water cooled probe head
- PCOOLV1 Water cooling pump and tubing
- 8 Signal Control Cable with Molex connector
- S50BREAKOUT 6-Pos-Stepper-Breakout Board
- S50COMMON Common-SMA- Breakout Board
- Probe Case

Your Picotest P2106A Probe kit includes the following:

- 1-Port Probe with PDN Cable
- Probe Case

Documentation and Support

This documentation details the use of various probes. Specifications for the individual probes are also included. The support section of Picotest's web site, https://www.picotest.com/support.html, contains additional documentation and various publications on testing power supplies, regulators, and other equipment using the Picotest probes.

Warranty

Every Picotest product purchased from Picotest.com is backed by a 1-year manufacturer's warranty. For warranty service or repair this product must be returned to a service facility designated by PICOTEST. Please contact the local service representative for further assistance.

Chapter 2 –Probe Usage

Probe Usage

The PDN probes have a wide dynamic range and can measure up to various voltage levels without distortion (see specifications table for the voltage ranges for different attenuations). The low inherent noise enables the measurement of small input signals. The P2104A and the P2102A may be used with any 50 Ohm instrument. Both are bi-directional and can be used like a traditional probe to record signals, as well as to inject stimulus (load step currents or EMI). The probes are especially useful for VRM/stability measurements.

Usage notes:

- Variable pin compression means variable inductance and coupling. It is recommended that the same pressure/pin depression be used for calibration and actual testing. There may be an uncertainty of 100-200 pH.

- The resistors on the calibrator board are all 49.9 Ohms. Very small resistors are used to stay out of the way of the pins and to present minimum parasitic inductance.

- The 2-port SOLT fixture removal calibration works well for low impedance testing. Consult the VNA's or oscilloscope's user manual for details on performing probe calibration.

- Full 2-port calibration with isolation is important to measure inductance values below a few nH.

- Typical cable markers are placed on the cables/probe head for identifying the ports and the probe head has an indent in the housing for the tip side while the ground side is flat and smooth.

- It is recommended that the pads used for testing be oversized by 20% if possible, to make it easier to land the probe. For instance, the calibrator pads are about 20% oversized.

- Two 1-port P2104A probes are generally better than one 2-port P2102A probe for coupling and pin length, but harder to use and generally require probe holders to fix the relative angle. One of the issues with using two 1-port probes is they should be calibrated at a particular angle and separation distance. Once they are calibrated, the same exact distance and angle need to be used for the measurement. A second issue is that if they get too far apart, it causes transimpedance and not self-impedance. Two upsides are that they can be used to measure from both sides of the board (ideal plane impedance from a pair of vias) or perpendicular for less coupling. A big upside to the 2-port probe is that while there is coupling, it is fixed and so doesn't require the same precision for placement / measurement.

- Excessive pressure on the pins can damage the pin springs leaving the pin stuck in a depressed state. The pins can be replaced at the factory, but it is recommended to avoid excessive pressure on the probe tips.

Connecting a Browser Probe to the Instrument and Making a Measurement

To connect the PDN Browser probe, connect the SMA connector of the probe to the SMA connector on the instrument. If the instrument has a BNC or N connector, then a SMA to BNC or N adapter is required.

For measurements on most instruments, configure the settings as follows:

- Input impedance of the channel = 50 Ω
- Unit = V
- Attenuation = 1:1 (for the 1x probe)

Note: Not all instruments will handle this the same way. Instruments that accept the extended range [4]just want to know the tip resistor. Other instruments might want the attenuation.

[4] "The Simple Truth about Complex Impedance Probes", Apr 19, 2022, https://www.youtube.com/watch?v=HFTd7pH06s4

Place the signal and ground pins on the target measurement points in the circuit. It is critical to get the orientation correct.

The probe consists of the probe head for connection to the DUT, the probe cable, and SMA connector(s). The 2-port probe has two SMA connectors, one for each port with a common ground.

The probes have standard SMA connectors on each port.

For the P2102A, the positive pins/signals are on the side with the label.

Figure 20: A 2-port measurement using the P2102A probe. Pressure is needed to seat the four pins firmly in place. The probe head should match or be larger than the capacitor being measured across. Two pins go on each side of the capacitor.

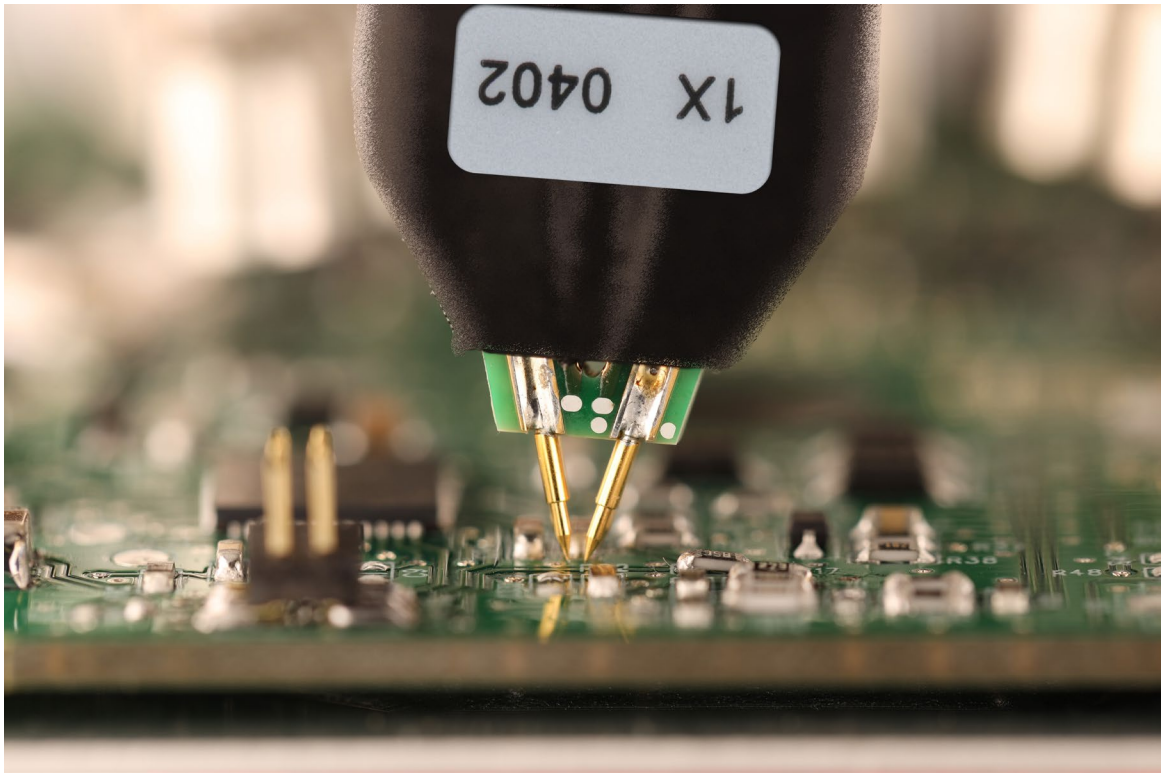


Figure 21: Two signal lines go on the positive side of the capacitor and two ground lines go on the ground side of the capacitor. The positive probe side is the side with the label.

Figure 22: A 2-port measurement using a probe holder which can help supply even pressure for the four pins.

For the P2104A, the signal pin is the pin in the center. The ground pin is offset from center.

Figure 23: The center pin is the positive pin on the P2104A 1-port probe.

For the P2105A, the positive pin/signal is marked. The other pin is ground.

Figure 24: The signal pin is marked on one side of the P2105A probe head. Rings are color coded for head style (ripple/TDR, step load, near-field) and pitch size.

P2104A 1-Port Probe Applications

The P2104A is a versatile 1-port probe that can be used to support many different tests. Here are few examples.

Signal Injection – Jitter Testing using the J2150B (VRTS3 Board)

The P2104A probe is bi-directional. It can both receive (traditional usage) a signal and transmit a signal.

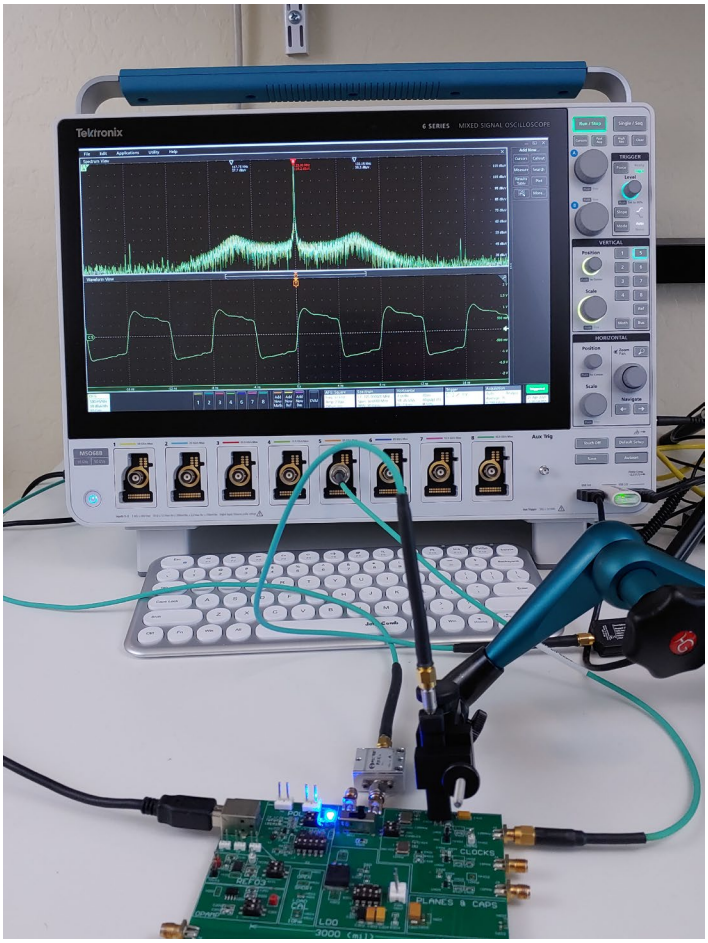


Figure 25: The spectrum domain response is obtained by connecting the output of the J2150B harmonic comb to the P2104A probe and injecting the signal into the circuit to see the impact of noise on the signal jitter.

Testing PCB Traces and Small values of Capacitance and Inductance

The P2104A probe can be paired with the J2154 Differential TDR to measure PCB traces and parasitic inductance and capacitance.

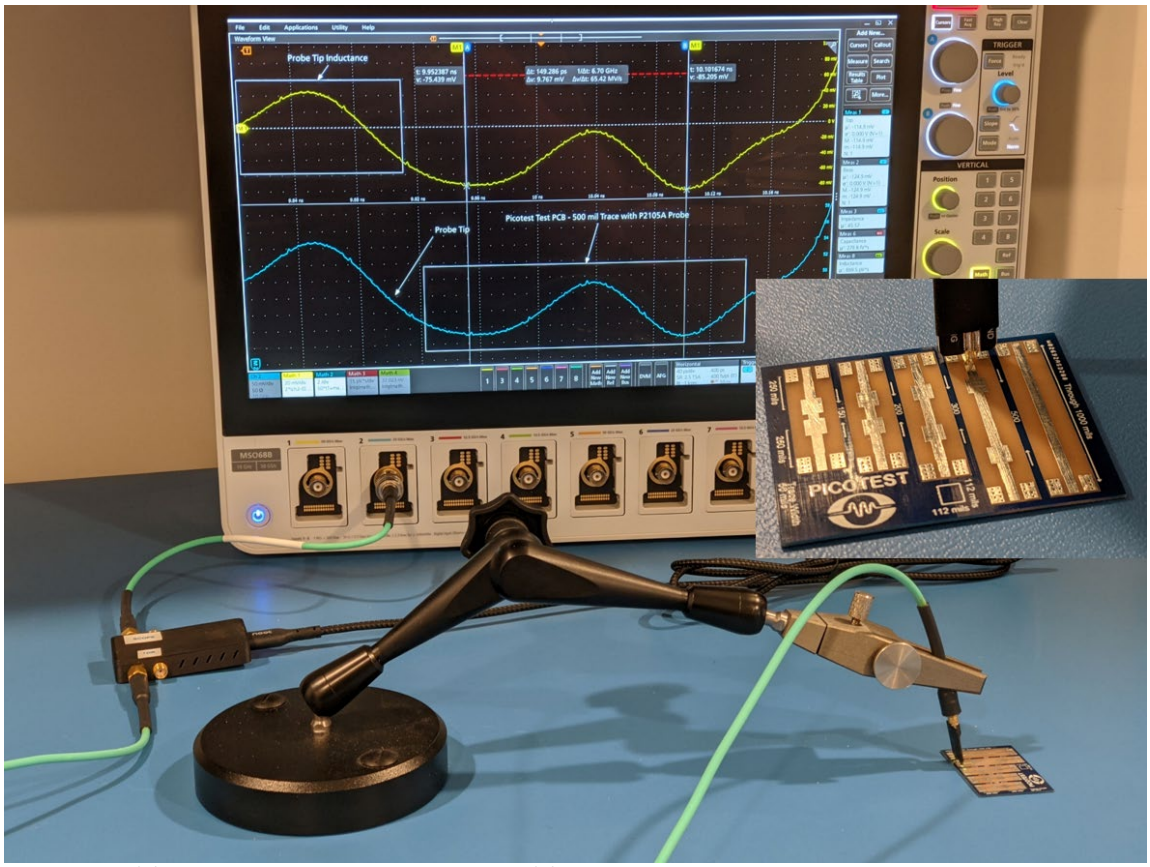


Figure 26: The Picotest J2154A differential TDR (left) can be used with the 1-port probe to test PCB traces for impedance and continuity and for capacitance and inductance elements.

Testing Ripple

The P2104A probe can be used to measure power supply output ripple voltages.

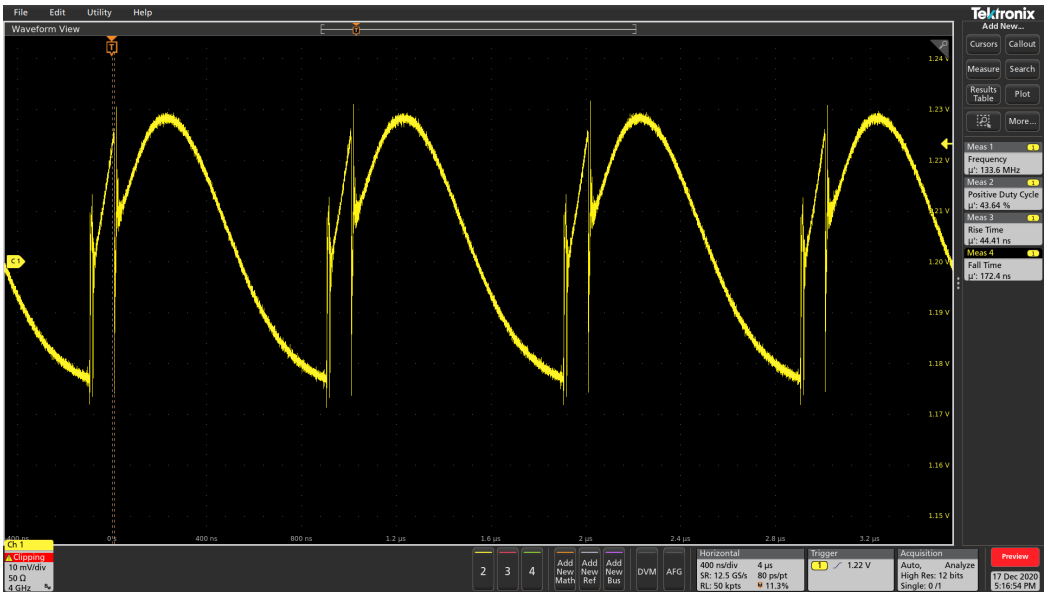


Figure 27: The output ripple of a power supply can be tested simply by connecting the P2104A to the output and ground (across an output capacitor) of a switching power supply.

P2102A 2-Port Probe Applications

See the instrument's user guide for calibration instructions. The calibration process can be measurement (setup) dependent.

Calibration

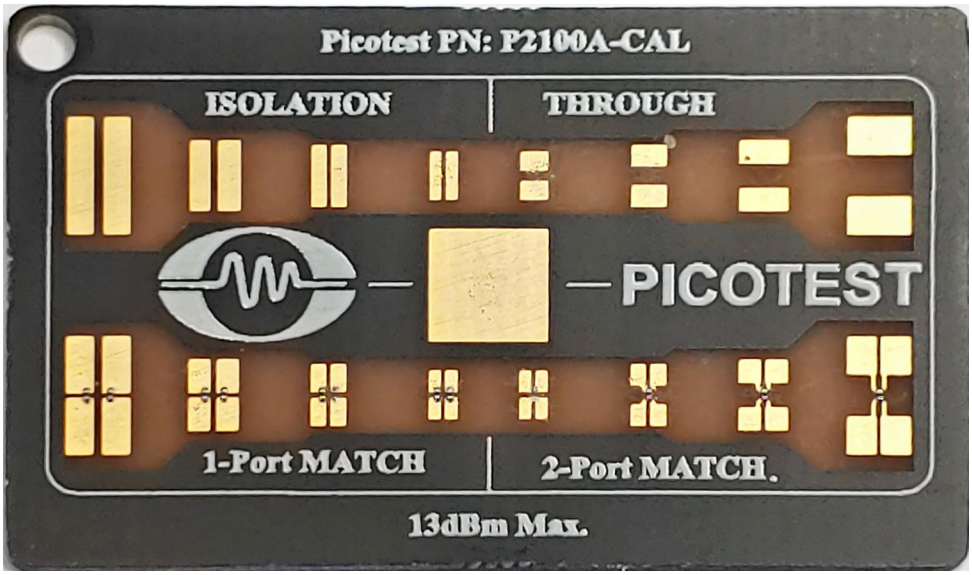


Figure 28: P2100A -CAL probe calibrator board showing the open short and load (50 Ohm) pads for different sized probe heads.

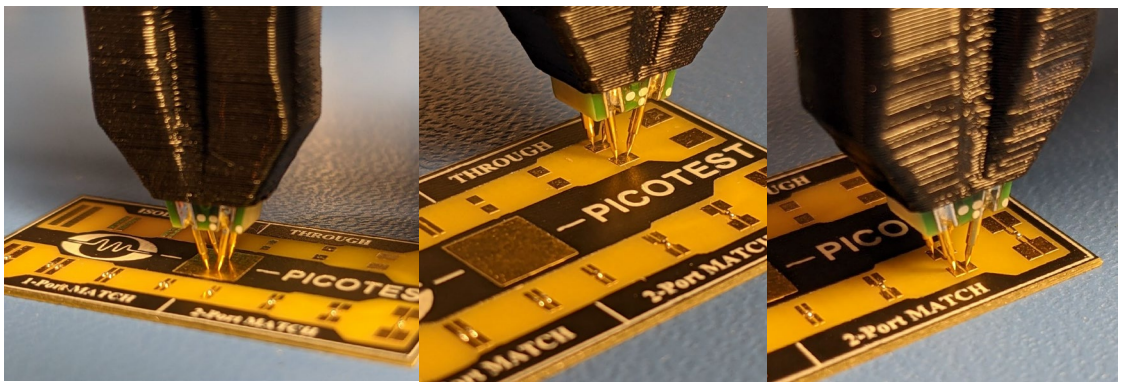


Figure 29: Performing an SOL calibration: Short (left), Open (center), and load (50 Ohm, right) calibration.

Low Impedance PDN Power Integrity Testing (VRTS3 Board)

This sample test measures the output impedance and stability of an LDO using a 2-port probe and a common mode transformer.

The J2102B common mode transformer is essential here, as there is an instrument ground loop which would otherwise distort the low frequency data. Therefore, it is generally required for VNA 2-port measurements.

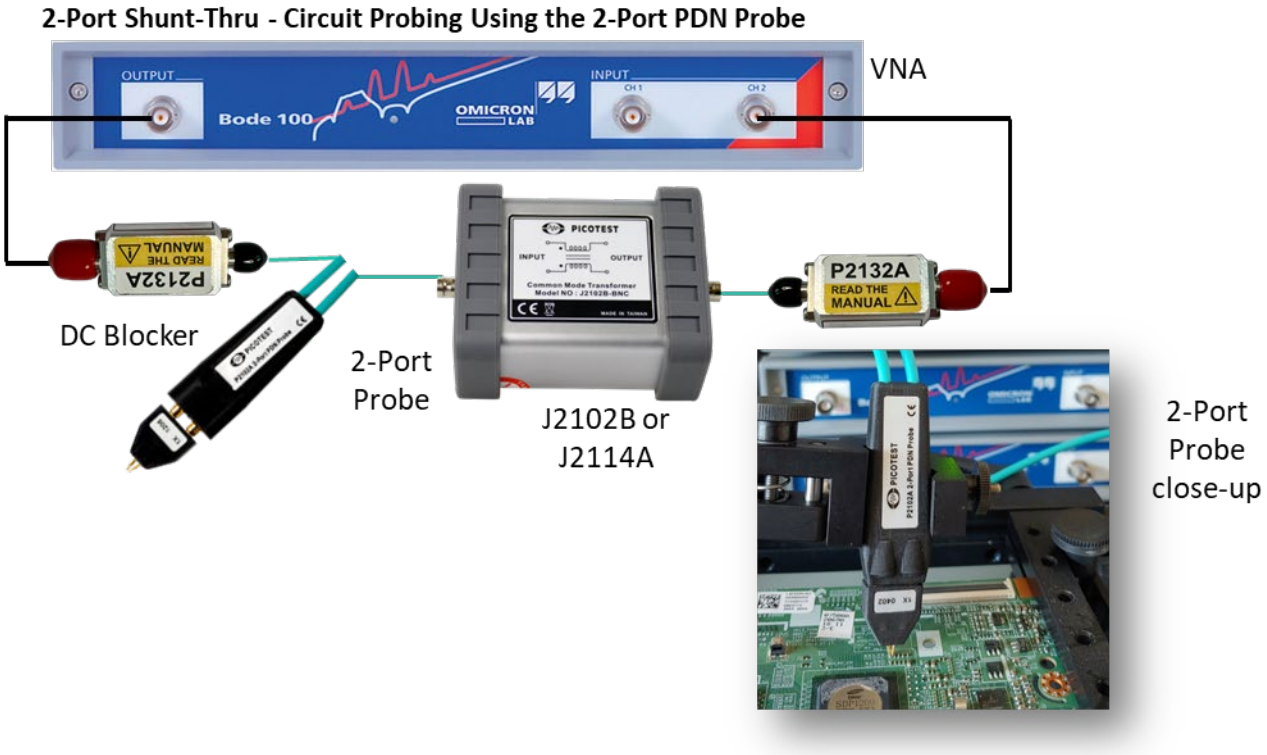


Figure 30: The 2-port probe setup for a 2-port impedance/stability measurement of an LDO. In this case, NISM software is also used to convert the impedance measurement to phase margin (stability). The J2102B common mode transformer is used to break the instrument ground loop that impacts low frequency data.

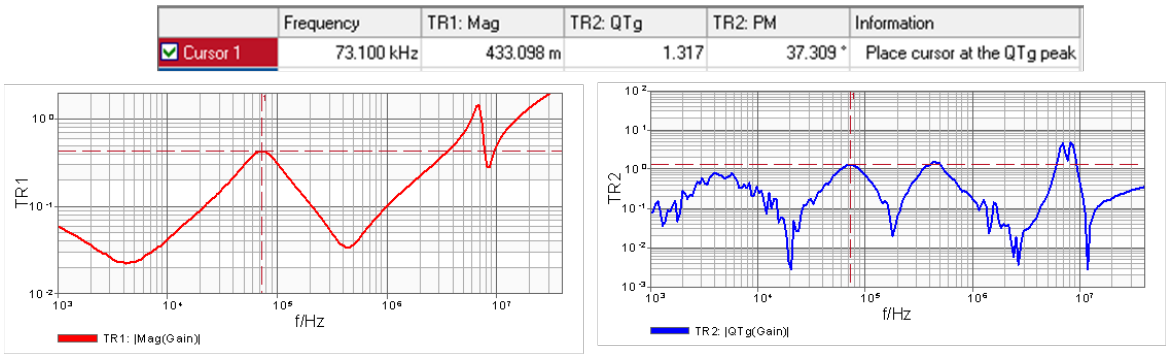


Figure 31: The impedance data is shown to the left. The group delay is shown on the right and is converted to phase margin (stability) via a simple cursor measurement and the built-in NISM software.

NISM Stability Measurement (VRTS3 Board)

NISM is a powerful technique for measuring the stability of control loops. The NISM software, embedded in commonly used VNAs, converts output impedance to phase margin. This is extremely useful considering that many of today's power ICs do not have their control loops exposed, and in fact, in those cases, NISM is the only way to make an accurate stability measurement.

In this case, the output impedance of a Voltage Reference is measured. The VNA, in this case the Bode 100, is used to measure the impedance at the output of the reference. The impedance is then converted to Phase margin using a simple cursor measurement, as shown below.

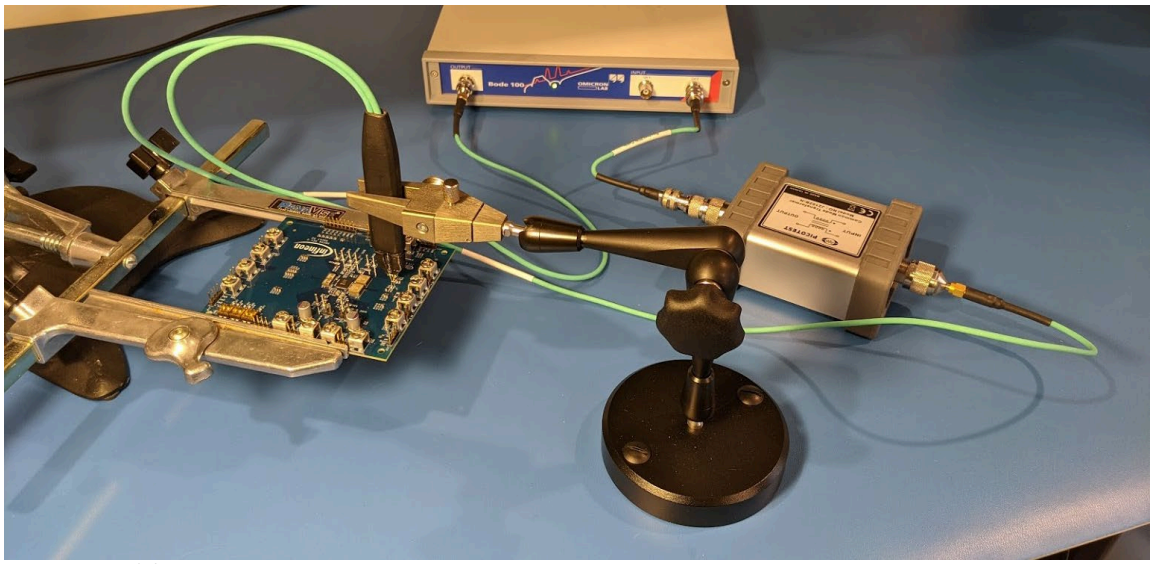
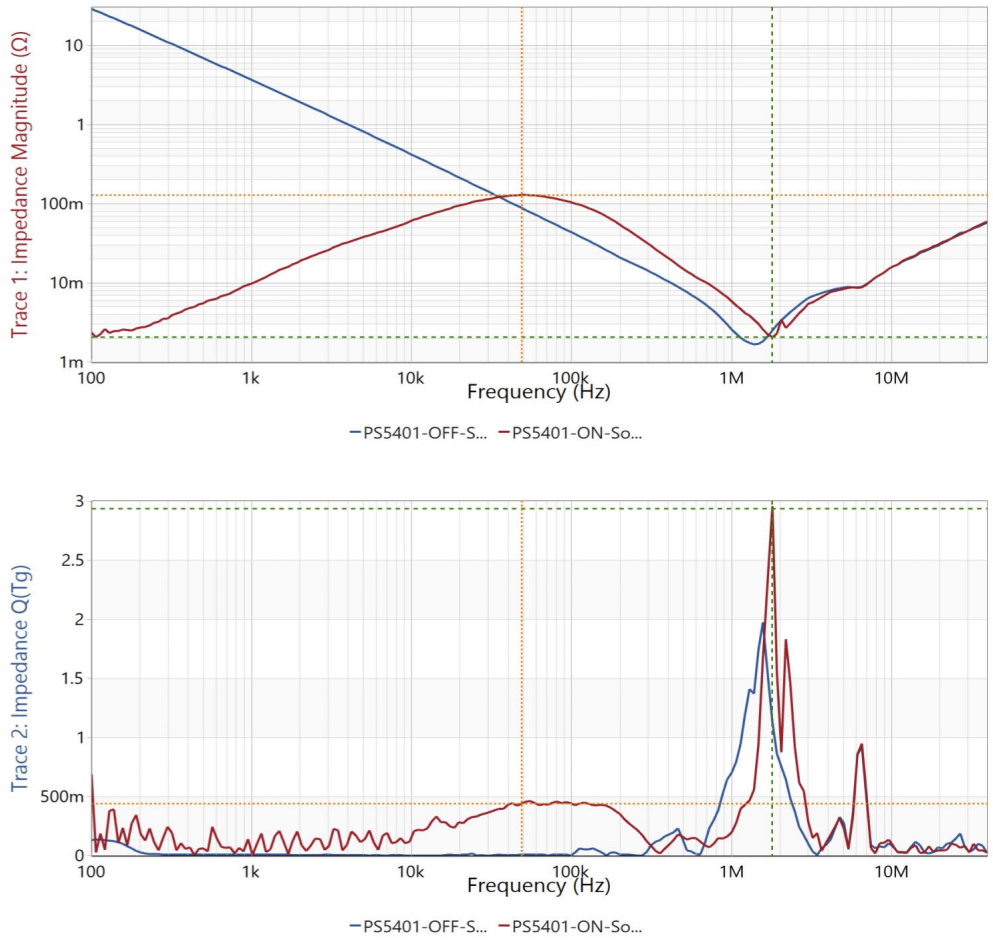


Figure 32: The P2102A 2-port probe in the 2-port shunt-through test setup is used to measure the output impedance at the output capacitor of a power supply. This same test can be performed on any power supply control loop including POLs, switchers, and linear regulators. The software converts the output impedance to phase margin.



	Cursor 1	Cursor 2	
Frequency	1.805 MHz	48.874 kHz	
Trace 1	**Magnitude**	**Magnitude**	
PS5401-ON-So...	2.058 mΩ	127.677 mΩ	
Trace 2	**Q(Tg)**	**Q(Tg)**	
PS5401-ON-So...	2.935	438.715 m	

Phase margin Cursor 1-Cursor 2: >71° of PS5401-ON-So...

Figure 33: Stability of the Infineon PS5401 at C42 is measured using NISM. Top graph is the on and off state impedance. The bottom graph is the QTg waveform. The measurement reveals the phase margin of the voltage reference to better than 71 degrees.

Chapter 3 – Accessories and Specifications

Port Saver® Description

The Port Saver family of DC blocks incorporates new features designed to protect the most valuable instruments while also greatly improving performance. Port Saver includes inrush currently limiting, which together with the transient protection, limits the voltage that appears at the instrument when a DC voltage is applied. Pre-charge allows the block to charge even without a connection to the instrument, eliminating the inrush. Self-discharge allows the DC block to discharge even if it is removed from both the source and the instrument, eliminating potential damage from energy stored in the block.

Typical RF blocks are based on ceramic capacitors, which exhibit AC and DC bias effects, making it very difficult to calibrate, as well as ferro-resonant noise. Port Saver blocks do not exhibit DC or AC bias effects, resulting in greatly improved calibration and measurement accuracy and do not exhibit ferro-resonant noise, making them quieter.

Port Saver Usage

Connecting a Port Saver – Direction
The Port Saver is not bi-directional. It requires you to connect it properly. The male connector connects to the instrument while the female end connects to the probe (see Figure 30).

Connecting a Port Saver - Precharge
Port Saver may be connected to an instrument in the off or on state. Once the instrument is on, wait 60 seconds for the Port Saver to charge before connecting to the Port Saver port. This is to allow the tantalum caps to charge when not connected to an instrument, completely avoiding the inrush. This will reduce or eliminate port related inrush currents.

Disconnecting a Port Saver = Discharge
Wait 60 seconds for the Port Saver to discharge before removing it from the instrument. This is to discharge the internal capacitors when power is removed.

P213xA Port Saver Feature and Benefit Summary

- Transient protection - Limits inrush surge - Surge transient tested
- No DC Bias or AC bias effects
- Self-charging and discharging
- Low Noise – works with 1-port probes

- Wide frequency range
- Various Frequency Ranges/Clamp Voltages Available
- Customizable: Input Voltage, Clamp Voltage, Frequency Range
- Vast improvements over other protection devices and past DC blocks

Port Saver® DC Blockers: When and Why to Use Them

A coaxial DC Block (or Blocker) is used when DC isolation is required to protect sensitive test equipment or RF circuitry. Since the probe impedance of 50 Ohms would load low impedance sources, it is often necessary to block any DC current. Either the J2130A DC bias Injector or the P2131A Port Saver DC Blocker can be used for this purpose. The P2131A has male and female SMA connectors that allow it to be easily connected to the 1-Port and 2-Port probes. An SMA to SMA cable, or an SMA to BNC cable can then be used to connect the probe to the instrument if necessary.

Figure 34: The P2131A and P2132A Port Saver DC blockers, available separately.

The P2131A DC Blocker lets through frequencies while simultaneously providing low insertion loss and excellent VSWR with a bandwidth of 500Hz – 800MHz and a 3dB bandwidth of 200Hz – 1.3GHz. Its maximum differential (input – output) voltage is 75V.

The P2132A DC Blocker lets through frequencies while simultaneously providing low insertion loss and excellent VSWR with a bandwidth of 2Hz – 50MHz and a 3dB bandwidth of 1.3Hz – 450MHz. Its maximum differential (input – output) voltage is 6V.

Blocks can still damage RF equipment if voltages are exceeded at the instrument. The blocking cap is VERY large to get to low frequency so it can transfer a lot of energy. That is one reason for the attenuating probes rather than the blocks.

Note: The male connector connects to the instrument. The female end connects to the probe. You may need an SMA (f)-BNC (m) adapter to connect to an oscilloscope.

Port Saver P2131A - Standard Specifications

Characteristic	Rating
Absolute Maximum Input Voltage	+/-75VDC
Typical 3dB Frequency Range	200Hz – 1GHz
Pre-charge, Dis-charge Time Constant	10s
Insertion Loss (Typical)	0.8 dB
Probe Factor	1.1
Return Loss	< 1.3
Impedance	50 Ohms
Instantaneous Peak Inrush Current	15A
Inrush Clamp Voltage	7.5V < 1us
Connector Type	SMA (Male) – SMA (Female)
Working Temperature	-40 – 75°C

Port Saver P2132A Specifications

Characteristic	Rating
Absolute Maximum Input Voltage	+/-6VDC
Typical 3dB Frequency Range	1.3Hz – 450MHz
Pre-charge, Dis-charge Time Constant	60s
Insertion Loss (Typical)	12.1dB
Probe Factor	4.1
Return Loss	< 1.3
Impedance	50 Ohms
Instantaneous Peak Inrush Current	1A
Inrush Clamp Voltage	250mV < 1us
Connector Type	SMA (Male) – SMA (Female)
Working Temperature	-40 – +75°C

Note: The specifications are subject to change without notice. **Note: Blue bold text indicates a characteristic that can be customized. Please inquire.**

Consult the instrument's manual to verify the input voltage and any inrush current requirements.

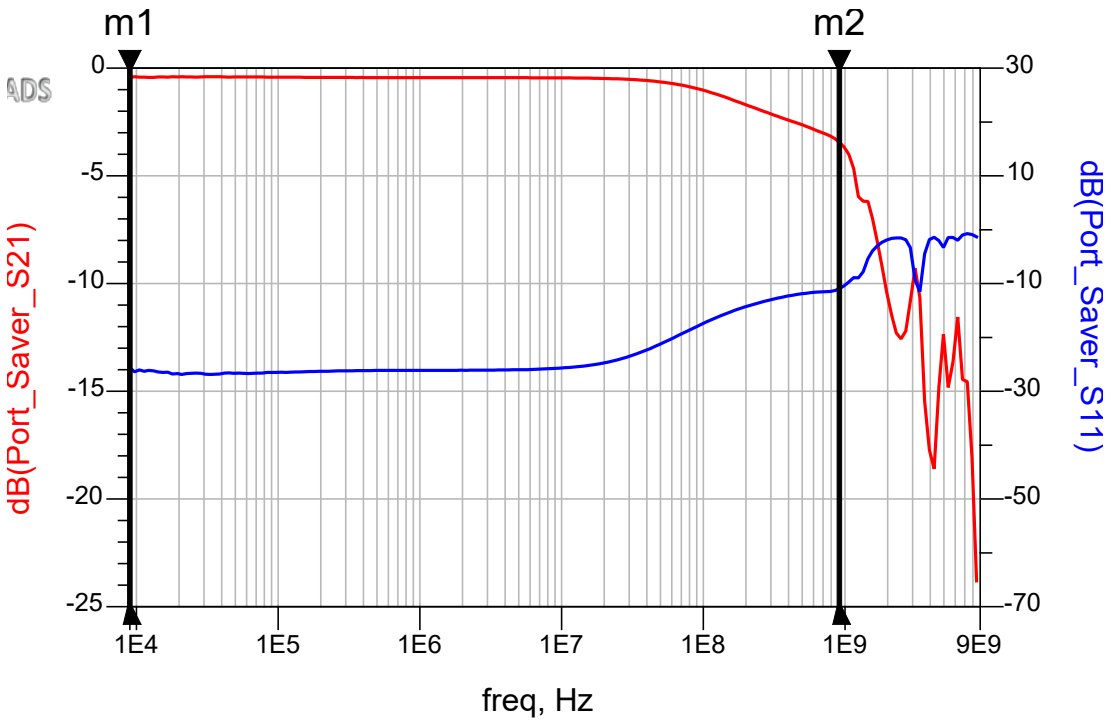


Figure 35: S parameter data.

Probe Specifications

P2102A Specifications

Probe Voltage and Impedance for Different Attenuations	**Impedance: Maximum Tip voltage** 50 Ohms: 5 Vrms (1X Attenuation) 100 Ohms: 8.9 Vrms (2X Attenuation) 250 Ohms: 11 Vrms (5X Attenuation) 500 Ohms: 14Vrms (10X Attenuation)	**VNA Port Voltage *** 5Vrms 4.45Vrms 2.2Vrms 1.4Vrms

Characteristic	Rating
Bandwidth	DC-300MHz **
Maximum thru Current any Port	1Amp
Probe Connectors	SMA-Mini SMP - 1 meter length, BNC available as an option
Interchangeable Probe Tip Size	Four (4) Included: 0402, 0603, 0805, and 1206
Insulation Resistance	20MOhms
Port to Port Isolation	TBD
Rise Time	350 ps
Operating Temperature	0 to 45° C (32° F to 104° F) at 80% Relative Humidity
Nominal Length with Cable	1 meter
Attenuation	1X, 2X, 5X, or 10X – Selected when purchased, NOT Changeable
Probe Pitch	Fixed
Calibrator Board Resistor Rating	30mW (Supports 13dBm)
Maximum Relative Humidity	80% at 31° C max
Usage	Indoor
Altitude	3000 m (9850 feet)
Absolute Maximum Voltage	< 50VAC and 75VDC

Note: The specifications are subject to change without notice.

* The Maximum Port Voltage shown based on the specified maximum tip voltage. Consult the VNA's manual to verify the VNA port voltage is below the ratings of the instrument.
** The actual bandwidth and minimum measurable impedance obtained are dependent on calibration and test setup.

P2103A Specifications

Characteristic	Rating
Bandwidth	DC-6GHz (uncorrected)
Attenuation	1x
Probe Connectors	SMA-Mini SMP - 1 meter length, BNC available as an option
Probe Pitch	Fixed - 50 (1.27mm) and 100 mil (2.54mm) pitches
Operating Temperature	0 to 45° C (32° F to 104° F) at 80% Relative Humidity
Maximum Relative Humidity	80% at 31° C max
Altitude	3000 m (9850 feet)
Absolute Maximum Voltage	< 50VAC and 75VDC

Note: The specifications are subject to change without notice.

P2104A Specifications

Probe Voltage and Impedance for Different Attenuations	Impedance: Maximum Tip voltage 50 Ohms: 5 Vrms (1X Attenuation) 100 Ohms: 8.9 Vrms (2X Attenuation) 250 Ohms: 11 Vrms (5X Attenuation) 500 Ohms: 14Vrms (10X Attenuation)	VNA Port Voltage * 5Vrms 4.45Vrms 2.2Vrms 1.4Vrms

Characteristic	Rating
Bandwidth	DC-6GHz-8GHz ** 50, 60, 70, and 100 mil pitches 1X Attenuation
Impedance Range	Typical 1-port impedance reflection floor -ceiling limits (~100mOhms – ~k Ohms). Not probe dependent. See instrument's manual
Input C:	<1pF
Maximum thru Current any Port	1Amp
Probe Connections	MINI_SMP
Probe Tip Size/ Probe Pitch	Available in various pitches 50 mil 60 mil and 100mil Probe Pitch is Fixed
Insulation Resistance	20MOhms
Rise Time (1X)	58ps (100 mil), 50ps (70/60 mil), and 44ps (50 mil)
Operating Temperature	0 to 45° C (32° F to 104° F) at 80% Relative Humidity
Nominal Cable Length	1 meter
Attenuation	Available in various attenuations 1X, 2X, 5X, 10X. Selected when purchased, NOT changeable by user
Maximum Relative Humidity	80% at 31° C max
Usage	Indoor
Pin Resistance	Typical: 15m Ohms, Maximum 30m Ohms **
Altitude	3000 m (9850 feet)
Absolute Maximum Voltage	< 50VAC and 75VDC

Note: The specifications are subject to change without notice.

* The Maximum Port Voltage shown based on the specified maximum tip voltage. Consult the VNA's manual to verify the VNA port voltage is below the ratings of the instrument.
** The actual bandwidth and minimum measurable impedance obtained are dependent on calibration and test setup.

P2105A TDR/Ripple/Impedance/EMI/Load Step Probe Specifications

Probe Voltage and Impedance	Impedance: Maximum Tip voltage 50 Ohms: 5 Vrms (1X Attenuation)	VNA Port Voltage * 5Vrms

Characteristic	Rating
Bandwidth	DC-15GHz **
Probe Tip Size/ Probe Pitch	20mil - 0.508mm 31mil - 0.7874mm 40mil - 1.016mm 50mil - 1.27mm 60 mils - 1.54mm 70 mils – 1.78mm 80 mils – 2.03mm 100 mils – 2.54mm 150 mils – 3.81mm GSG SMA Custom pitches available
Impedance Range	Typical 1-port impedance reflection floor -ceiling limits (~100mOhms – ~k Ohms). Not probe dependent. See the instrument's manual
Input C:	<1pF TBD
Attenuation	1:1
Maximum thru Current any Port	1Amp
Probe Connections	SMA
Probe Loading Input	50 Ohms
Rise Time (1X)	58ps (100 mil), 50ps (60 mil), and 44ps (50 mil)
Operating Temperature	0 to 45° C (32° F to 104° F) at 80% Relative Humidity
Nominal Cable Length	1 meter
Maximum Relative Humidity	80% at 31° C max
Usage	Indoor
Pin Resistance	Typical: 15m Ohms, Maximum 30m Ohms
Altitude	3000 m (9850 feet)
Absolute Maximum Voltage	< 50VAC and 75VDC

P2105A - S10 Transient Load Step Option

Pin Pitch	70 Mils
Edge Rate (R/F time)	<500ps switching *
Repetition Rate	DC-50MHz (Limited by average power and dwell time)
Control Signal - switched (open loop)	User Supplied – 5V pulse generator 0-5V CMOS and TTL compatible logic level
Maximum Dwell Time	100us dwell

Input voltage rating	**Based on custom resistor ***
Output current rating	**Based on resistor up to 10A**
Wattage	**<1W avg.**
Voltage	**0.6V – 72V**
Connector Type	**SMPM pulse, spring tip**
Rise/Fall Time	**~3ns but this characteristic is largely determined by the interconnect profile – board impedance**
Leakage Current	**@ 48V - <250 uA**
Overshoot/understood	**None - Resistive Step**
Capacitive Loading	**< 120pf @0V**

P2105A - Embedded Filter Option

Bandpass Filter Bandwidth	**1MHz – 30MHz – 3dB Can be customized/user-defined**
Filter Order	**Single LC Filter**

P2105A Near-Field (H-Field) Head Option

Types	**31 Mils, 100 Mils – H-Field Loop**
Bandwidth	**1GHz**

Note: The specifications are subject to change without notice.

* The Maximum Port Voltage shown based on the specified maximum tip voltage. Consult the VNA's manual to verify the VNA port voltage is below the ratings of the instrument.

** The actual bandwidth and minimum measurable impedance obtained are dependent on pin pitch and calibration of the test setup.

P2106A Specifications

P2106A-20X-20K **P2106A-1X-__ (User defined resistance)** **P2106A-__X-__ (User defined attenuation and resistance)**	1-Port Transmission Line PDN Probe Sizes 50, 60, and 100 mil Pitches Available in 1:1, 20:1 and User-Defined Attenuations Variable Resistance including 20kOhm Includes Calibration board and PDN Cable® (1m, SMA-Mini SMP) Delivery time is 4-5 weeks ARO for custom attenuation and connectors.	**P2106A-20X-20K** **P2106A-1X-__ (User defined resistance)** **P2106A-__X-__ (User defined attenuation and resistance)**

Probe Voltage and Impedance	**Impedance: Maximum Tip Voltage** 20 kOhms: 65 Vrms (20X Attenuation)	**SMPM Voltage** 3.25V

Characteristic	Rating
Bandwidth	**DC-1MHz *** **Attenuation can be customized**
Attenuation	**Available in almost any user defined attenuation** **Selected when purchased, NOT changeable by user**
Probe Tip Size/ Probe Pitch	**Available in 50 mil 60 mil and 100mil Fixed Pitches**
Input C:	**<1pF**
Probe Connection	**MINI_SMP**
Rise Time (1X)	**175ns - 350ns**
Pin Resistance	**Typical: 15m Ohms, Maximum 30m Ohms**
Nominal Cable Length	**1m**
Operating Temperature	**0 to 45° C (32° F to 104° F) at 80% Relative Humidity**
Maximum Relative Humidity	**80% at 31° C max**
Usage	**Indoor**
Altitude	**3000 m (9850 feet)**
Absolute Maximum Voltage	**< 50VAC and 75VDC**

Note: The specifications are subject to change without notice.

* The Maximum Port Voltage shown based on the specified maximum tip voltage. Consult the VNA's manual to verify the VNA port voltage is below the ratings of the instrument.

** The actual bandwidth and minimum measurable impedance obtained are dependent on pin pitch and calibration of test setup.

S50 Load Stepper Specifications

Characteristic	Rating
Edge Rate (R/F time)	<500ps switching *
Repetition Rate	DC-50MHz (Limited by average power and dwell time)
Control Signal - switched (open loop)	User Supplied – 0-5V CMOS and TTL compatible logic level
Maximum Dwell Time	Up to 100%
Input Voltage Rating	Based on custom resistor *
Output Current Rating	Based on resistor up to 50A
Wattage	<50W avg.
Voltage	0.6V – 72VDC
Output Connector Type	Spring Tips
Control Connector	8-pin Breakout Cable Provided
Water Cooling	Supplied
Rise/Fall Time	~3ns but this characteristic is largely determined by the interconnect profile – board impedance
Operating Temperature	0 to 45° C (32° F to 104° F) at 80% Relative Humidity
Nominal Cable Length	1 meter
Spring Tip Resistance	Typical: TBD Ohms
Altitude	3000 m (9850 feet)
Overshoot/Undershoot	None - Resistive Step
Capacitive Loading	< 1800pf @0V

*** Final signal edge speed is dependent on the load board design, voltage, and current. A 6-position water-cooled sub-ns browser step load probe. Resistance is set at the time of manufacturing. Any of the 6 resistors can be any value, they don't need to be the same.**

P2124A Specifications

Absolute Maximum DC Input Voltage	**50V (Probe), 7.5V (Transceiver Application)**
Peak Current	**10A**
Maximum Continuous Current	**6A**
Maximum Voltage Drop at 6A	**3.5V**
Output Voltage	**Output range is 0V to approximately 3.5V below Vin**
Modulation Signal Level	**0 to approximately the Voltage Drop**
Modulation Input Impedance	**50 Ohms**
3dB Frequency Response (typical) (0.6Ohm resistive load)	**30 – 40MHz**
Modulation Frequency Range	**10-250MHz**
Temperature Range	**35 C**
Maximum Altitude	**6000 Ft**
Output Impedance at 6 Amps	**200mOhms**

Safety Information

To avoid personal injury and to prevent fire or damage to this product or products connected to it, review and comply with the following safety precautions. Be aware that if this probe assembly is used in a manner not specified, the protection this product provides may be impaired. Only qualified personnel should use this probe assembly. Do not connect the probe to any voltage that exceeds the maximum permissible input voltage specified in the data sheet. Non-compliance with this instruction carries the risk of an electric shock. Make sure not to cause any short circuits when performing measurements on sources with high output currents. Short circuits may cause injuries or burns.

Risk of injury caused by pointed object

The pins of the probe are extremely pointed and can easily penetrate clothes and skin. Therefore, handle the probe pins with great care. When transporting the probe, e.g. when carrying it in a pocket or tool bag, always use the supplied case. To exchange a probe pin, use tweezers or pliers to avoid injuries.

Use only grounded instruments

Do not connect the probe ground lead to a potential other than earth ground. Always make sure the probe and the measurement instrument are grounded properly.

Observe probe ratings

Do not apply any electrical potential to the probe input which exceeds the maximum ratings of the probe, or the accessories connected to it. In a combination always the lower rating / measurement category applies to both probe and accessories connected to it.

Do not operate with suspected failures
Refer to qualified service personnel.

Indoor use only
Do not operate in wet/damp environment. Keep product surfaces dry and clean. Do not operate the product in an explosive atmosphere.

Handling Information

Handle with care especially when fitted with the extra thin and sharp spring contact tip to avoid any injury. Note that the probe cable is a sensitive part of the probe. Do not damage through excessive bending or pulling. Avoid mechanical shock to this product in general to guarantee accurate performance and protection.

Caution: To avoid equipment damage and/or severe injuries or death ensure that the absolute maximum ratings defined in this manual are observed at all times and never exceeded.

Cleaning

To clean the exterior of the probe, use a soft cloth moistened with either distillated water or isopropyl alcohol. Before use allow the probe to dry completely.