PICOTEST

Injectors

Documentation

Version 2.2, March 2025

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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.

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

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Chapter 1 - Overview

Welcome

Thank you for purchasing one or more of Picotest's Injectors. The term injector is used to describe a test setup accessory that supports the interconnection between the test instrument and the device under test (DUT). In some cases, the injector might be essential to the test and in other cases, help to improve the measurement fidelity.

Power integrity and power supply applications today are much more demanding than ever. Today's designs require increases in switching frequency and bandwidth, higher efficiency, lower standby currents and ultra-low impedance levels. A high-resolution, high-fidelity test setup is more critical than ever to getting the accurate test data needed.

Picotest Injectors are designed to greatly improve the accuracy of test results.

Summary of Benefits:

- Accurate power integrity and PDN impedance measurements
- More accurate voltage regulator and power supply measurements
- Ability to measure test systems' impedance, stability, and step load non-invasively
- Ability to make high fidelity PSRR, PSNR, and PSMR measurements
- Ability to test VRM output impedance
- Ability to mount, calibrate, and bias components under test
- Greatly reduce distortion in Bode plot and impedance measurements
- Improve RSA, SA and MDO measurements related to noise and EMI

Documentation and Support

This documentation details the use of various Picotest Injectors. Specifications for the individual injectors are also included.

The support section of Picotest's web site, https://www.picotest.com/support/injectors/ contains additional documentation and various publications on testing power integrity, power supplies, and other linear and power circuit design using the Picotest Injectors.

Warranty

Every Picotest product purchased from Picotest.com is backed by a 1-year manufacturer's warranty.

For warranty service or repair, product must be returned to a service facility designated by Picotest. Please contact the local service representative for further assistance.

Calibration

Picotest Injectors do not require calibration or recalibration.

Safety Information

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.

Please note that the absolute maximum voltages ratings are below 50VAC and 75VDC for the following Signal Injectors: J2110A, J2111B, J2180A, J2102B, J2140A, J2115A, and J2150A.

Please note that the absolute maximum voltages ratings are below 40VDC+VAC for the following Signal Injectors: J2111B and J2112A.

Please note that the absolute maximum voltages ratings are below 50V (DC+AC) for the following Signal Injectors: J2120A.

Please note that the absolute maximum voltages ratings are below -50V (DC+AC) for the following Signal Injectors: J2123A.

Please note that the absolute maximum voltages ratings are below 400V (DC) for the following Signal Injectors: J2121A. Also, please follow this warning:

> **Warning: Without providing VSS ±12V,**
> **please do not connect any DUT at the OUT terminal,**
> **or this injector will be damaged.**

Please note that the absolute maximum (common mode + differential) voltage rating is below 9.5V (DC+AC) for the J2114A.

Please note that the absolute maximum (differential) voltage ratings are below 50V (DC+AC) for the following DC blockers: J2130A.

Please note that the absolute maximum voltage ratings are below 75VDC for the following DC blockers: Port Saver™ (P213xA)

Chapter 2 – Introduction to Signal Injectors

Introduction

Injectors, also known as test adapters or interface adapters, are used to inject or transmit signals into and from various circuits so that the circuit's characteristics can be tested. Tests include PDN impedance, transient step loading, Bode plot control loop analysis, circuit and component impedance measurements, and conducted susceptibility measurements, to name just a few.

The network analyzer, sometimes referred to as a Frequency Response Analyzer ("FRA") or Vector Network Analyzer ("VNA"), is a common piece of equipment in most electronics labs. Analyzers are used for a variety of tasks including stability analysis, component characterization, and of course frequency response measurements. They can vary in features, but regardless of the analyzer being used, the analyzer oscillator signal must be injected into the circuit being tested for a measurement to be made.

The quality of the injector, or test adapter, and the injection method can have a direct impact on the test results. For example, it is often the case that we see hobby store transformers used to inject signals into the loops of power supplies. In this case, the results are likely to be distorted due to the poor frequency response and impedance matching of the transformer.

It is critical to understand the bandwidth limitations and the impedance of the test interface adapter, as well as the impact of the injection signal magnitude on the measurement to get accurate and repeatable test results.

Different injectors are used for different tests. In some cases, more than one injector will support various aspects of the test. The details can be found in the following sections.

The Picotest Injectors may be used with just about any network analyzer including those from OMICRON Lab, Keysight, Copper Mountain, Rohde & Schwarz, Venable, Ridley, and others. Please refer to the connection diagrams, shown with each injector, to see how each is interconnected with the test equipment.

Injection Transformers – J2100A & J2101A

The injection transformer is by far the prevalent method for connecting the network analyzer to a circuit being tested for loop stability (Figure 1). The goal of the transformer is to inject a signal into the control loop being measured, without impacting the performance of the loop. To accomplish this to a reasonable degree, it is important to pick an injection point that is unaffected by the terminating impedance of the transformer, which is often in the range of 5 to 50 Ohms.

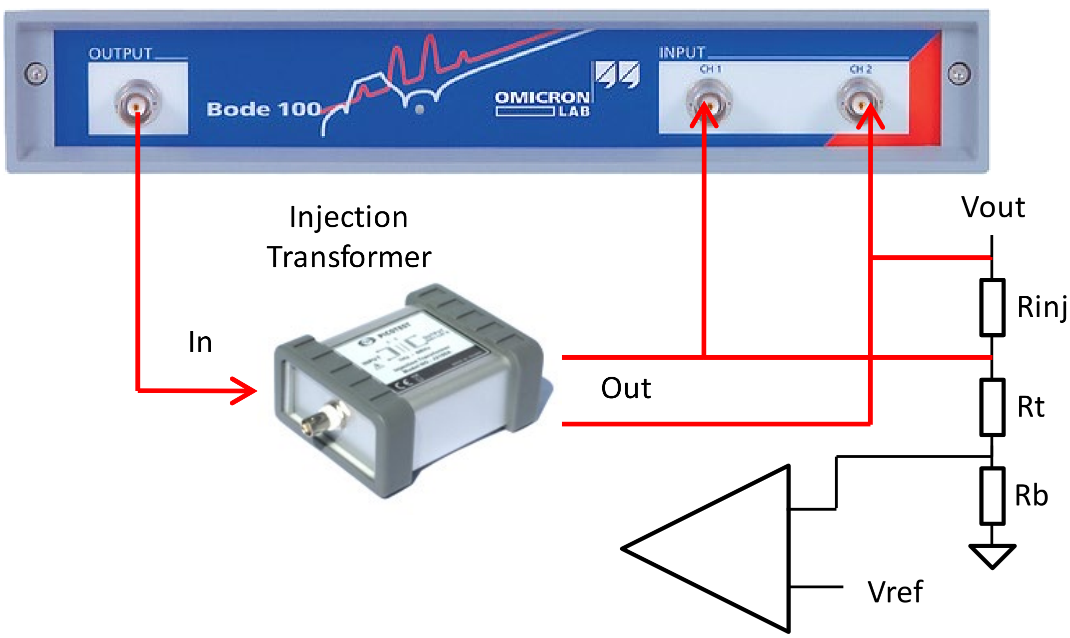


Figure 1: Sample setup for the injection transformer (J2100A or J2101A) used to perform stability measurements.

The transformer itself is outside of the measurement, leading many to incorrectly believe that the transformer is a non-critical element. The frequency range of the injection signal is dependent on the circuit being measured. The measurement of a typical Power Factor Corrector (PFC) control loop generally requires a measurement frequency of 1Hz or lower, as it is common for a PFC to have a control loop bandwidth of less than several Hz. The bandwidth of a high-performance linear regulator can be as high as several MHz. While several different transformers can be used to address this range, it is beneficial to use a single transformer or two transformers covering different frequency bands at most, due to the high cost of the transformers.

The design of a transformer that has significant permeability at 1Hz and minimal attenuation at 10MHz or more is difficult to achieve. The core materials are quite expensive, and the transformers generally must be hand wound. These issues combined with the relatively small market volume size dictate the cost. Engineers often use audio transformers or hum eliminators as signal injection transformers. The result is that the incorrect results are invariably produced from the use of these poor injection transformers.

Solid-State Voltage Injector – J2110A

While it is possible to obtain high quality injection transformers with bandwidths as wide as 1Hz to 5MHz or more, in some cases this is still insufficient for the testing of some circuits. For example, a typical heater control loop might have a bandwidth of less than 1Hz while some linear regulators and opamp circuits can have bandwidths of up to 100MHz or greater. For these applications, a solid-state injector can provide the necessary bandwidth. The solid-state injector is often called a "Bode Box." A solid-state injector can perform at DC, while the upper frequency limit is dictated by the components selected and the printed circuit board material and layout. It is possible to obtain a solid-state injector with a working range of DC – 100MHz, though above 50MHz the interconnection between the injector and the circuit being tested can become quite critical. It is essential that ripple from the injector's power supply does not dramatically degrade the dynamic range or the signal to noise ratio of the measurement. Bode and other plots are often much cleaner when using a solid-state injector than compared with those made with an injection transformer.

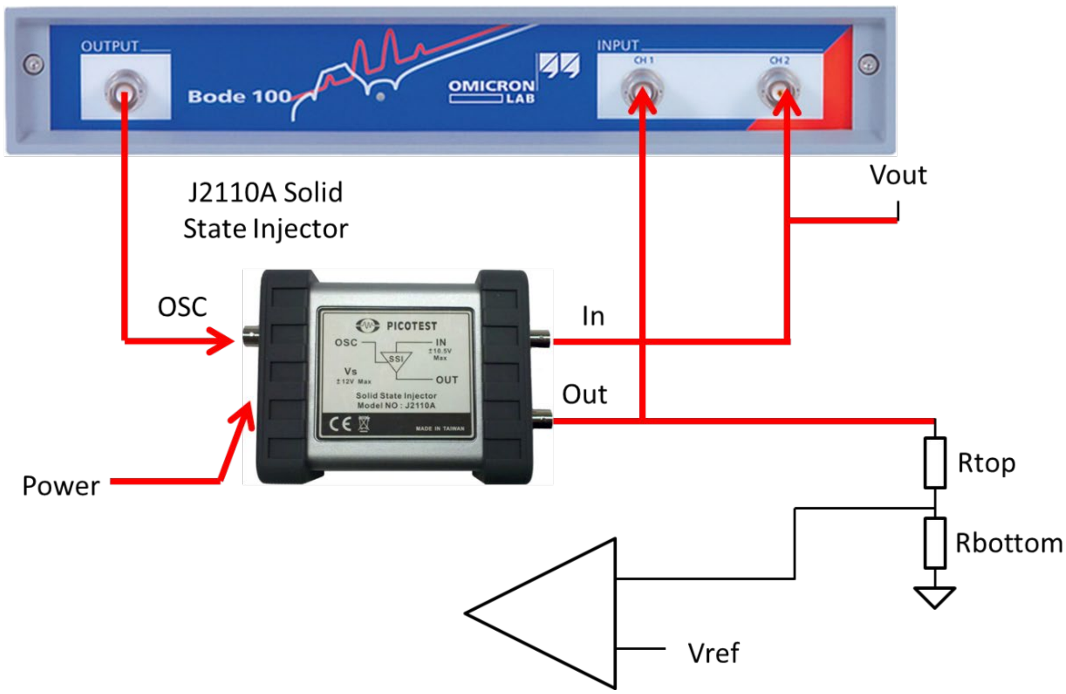


Figure 2: Sample setup for the solid-state injector "Bode Box" (J2110A) used to perform stability measurements.

The selection of a valid injection point in the circuit is more critical when using a solid-state injector than with the injection transformer. The solid-state injector presents an infinite impedance between the points of injection. In order to provide correct results one side of the measurement must present a much higher impedance than the other side. In a typical power supply control loop, the voltage sense divider is generally a good injection point, since the output impedance of the power supply is very low compared with the impedance of the voltage sense divider.

The solid-state injector is sometimes limited by its operating voltage, in this case +/- 12V. This is not the amplitude of the injection signal, but the DC operating voltage of the output that the injector is connected to. However, most applications requiring a solid-state injector fall within these operational limits.

Solid-State Current Injectors – J2111B & J2112A

The current injector is possibly the most versatile of the signal injectors. While it is not designed to replace an electronic load, the current injector is capable of performing a transient small-signal step loading at switching speeds and bandwidths that electronic loads cannot match. Also, the capacitance of an electronic load is generally too high and impacts the measurement where the J2111B and J2112A are minimally invasive.

Incorporating a 40MHz current monitor, the current injector can also be used to measure output impedance, as well as, the stability of a filter, combined with the negative resistance of a switching converter or power supply. An added benefit is that using a current injector, these measurements can all be made using the full system loading since the injector is connected in parallel with the actual load.

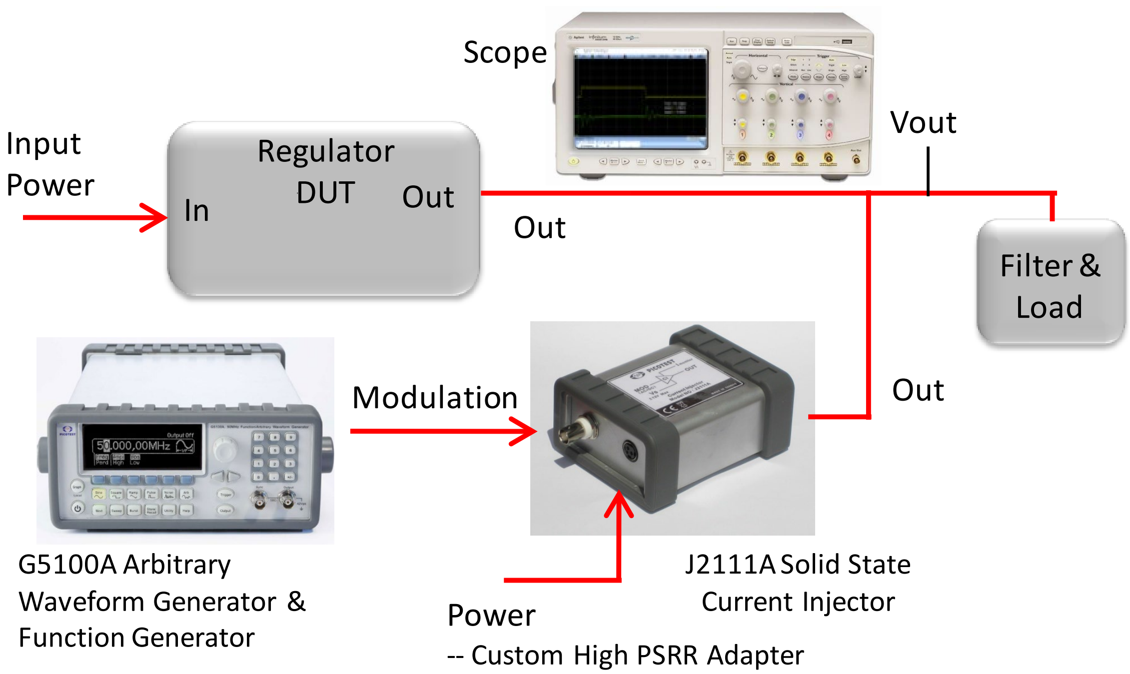


Figure 3: Sample setup for the Solid-State Current Injector (J2111B) used to perform a non-invasive load transient measurement.

The J2111B current injector is a bilateral device, which works with positive or negative voltages and includes an internal bias for use with a network analyzer. The bias can be disconnected for use with an external waveform or arbitrary waveform generator such as the Picotest G5100A.

The current injector is basically a voltage to current converter with a gain of 10mA/V for the J2111B and 200mA/V for the J2112A. For example, with the J2111B, put in a 1V signal into the modulation port and get 10mA out of the output port and 10mV out of the current monitor port. The current injector can be controlled by the output of the network analyzer (for frequency domain sweeps) or a function generator or arbitrary waveform generator (for time domain control and load profiling).

The J2111B current injector is capable of sinking 100mA while the J2112A can sink up to 1A. The J2112A is not bilateral and can only operate from positive voltages while the J2111B can sink current from either positive or negative voltages. There is no bias switch for the J2112A as the bias is always positive 24mA.

Line Injectors – J2120A, J2121A, and J2123A

While the injection transformer is a very wideband adapter, it is not useful for measuring ripple rejection (PSRR) of a power supply or even an opamp. This is because the attributes that make the injection transformer perform so well also result in a transformer that is intolerant of DC current. Even very small DC currents (5mA or less) can greatly reduce the signal capacity or even totally saturate the transformer. For this reason, the line injector is another essential test adapter.

It allows a test signal to modulate the line or bus voltage. Like the current injector, the line injector can be controlled by a network analyzer's oscillator output or a time domain signal.

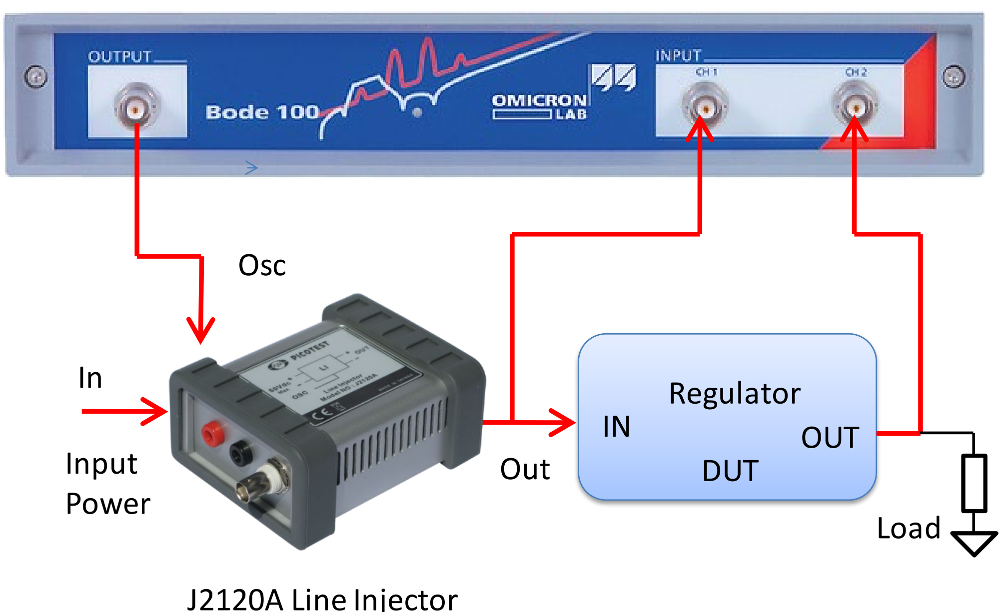


Figure 4: Sample setup for the Line Injector (J2120A) used to perform a PSRR measurement.

The J2121A is also used to perform PSRR testing. But it can also be used to measure the converter input impedance and inductors under DC bias

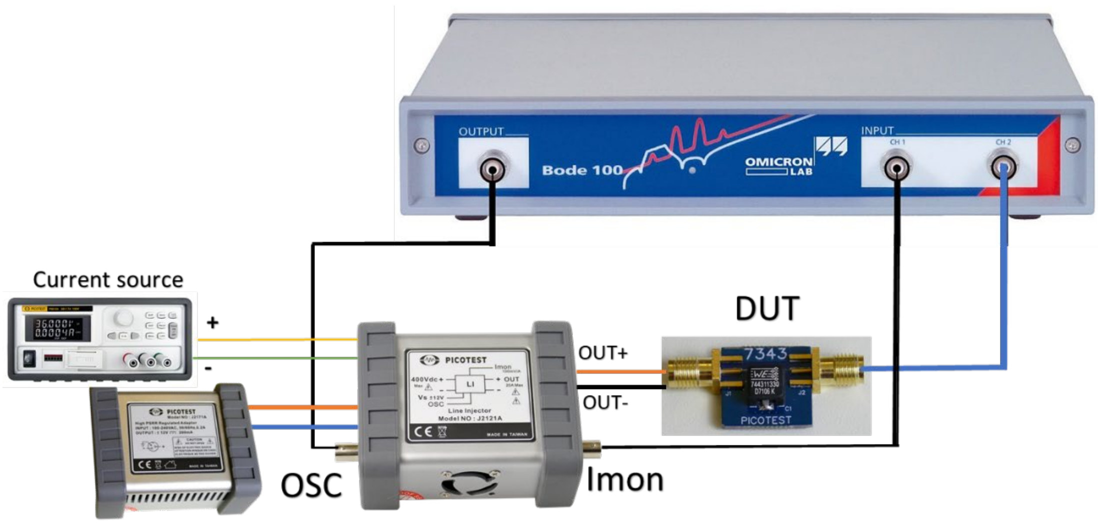


Figure 5: Sample setup for the Line Injector (J2121A) used to measure an inductor under DC bias conditions.

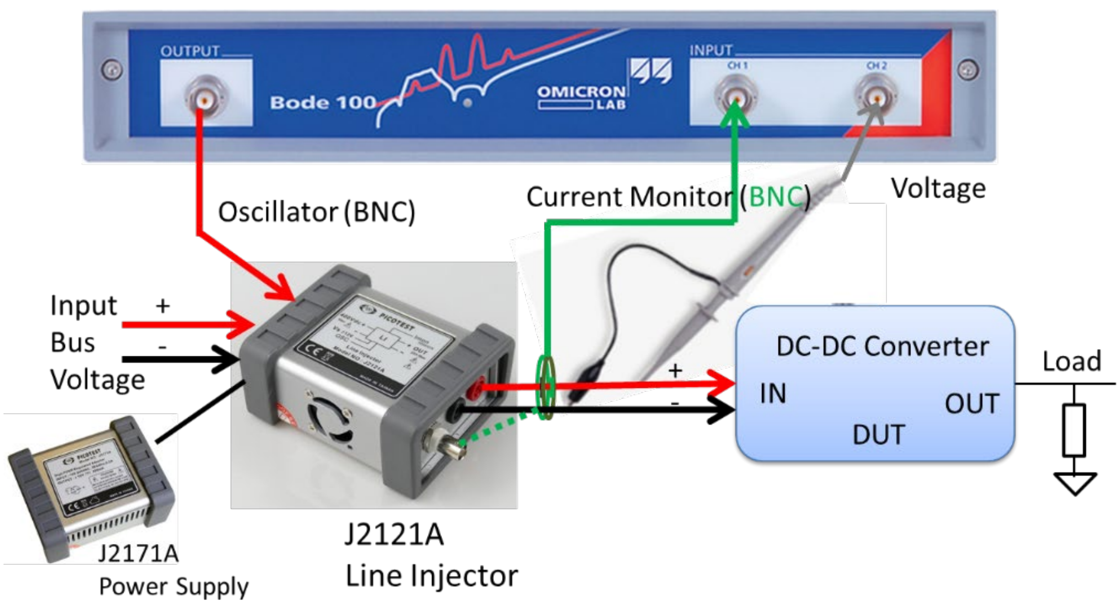


Figure 6: Sample setup for the Line Injector (J2121A) used to measure the input impedance of a DC-DC converter.

⚠ Warning: Without providing VSS ±12V,
please do not connect any DUT at the OUT terminal,
or this injector will be damaged.

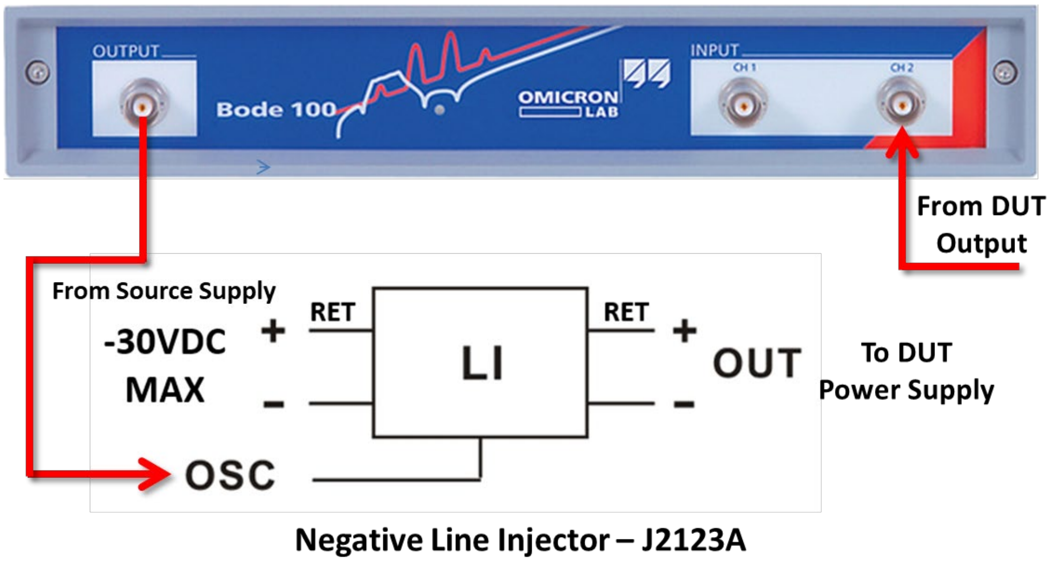


Figure 7: Sample setup for the Negative Voltage Line Injector (J2123A) used to measure PSRR (ripple rejection, conducted susceptibility, etc.).

Bias Injector – J2130A

When using the network analyzer to measure impedance, such as the capacitance and ESR or a capacitor, or the DCR of an inductor, etc., it is often necessary to provide a voltage bias to the device being tested. This is true of semiconductor junction capacitances, varactors, and some ceramic capacitors (especially X5R). In these cases, the impedance is a function of the DC bias on the device. The Picotest DC bias injector (J2130A) is used for this purpose during impedance measurements.

Attenuators – J2140A

There are two common uses for attenuators when used in conjunction with the network analyzer. One is to attenuate the oscillator source signal. While this may seem odd, one of the most common errors in analyzer measurements is using a source signal that is too large. Even though the analyzer allows setting of the signal output amplitude, the lowest setting is often too high to allow an accurate small-signal measurement to be made. The correct amplitude is the smallest amplitude that exceeds the noise floor.

Attenuators are also useful for improving the dynamic range of the measurement. In some cases, as in measuring the open loop gain of an opamp as one example, the low frequency loop gain will be extremely large (100dB or more is not uncommon). Attenuating the output signal increases the effective range of the measurement.

Preamplifiers – J2180A, J2180A-20, and the J2181A

The J2180A (20dB gain), J2180A-20 (20dB gain), and J2181A (60dB gain) are low noise preamplifiers provide a fixed, AC coupled gain stages while converting a 1 MOhm input impedance to a 50 Ohm output impedance. With a 3dB bandwidth of 0.1Hz to 100MHz (J2180A), 20Hz to 100MHz (J2180A-20) and 10Hz to 1MHz (J2181A), the preamplifiers improve the sensitivity of oscilloscopes, network analyzers and spectrum analyzers while reducing the effective noise floor and spurious response. The J2180A-20 is lower noise (about 1/3rd) than the J2180A at the cost of some low frequency bandwidth. The J2181A has high gain at the cost of a reduced high end bandwidth. The preamplifiers can also serve as a low frequency DC blocker for a spectrum analyzer or you can use them to connect a high input impedance oscilloscope probe to 50 Ohm equipment. The preamplifiers offers very low noise, fast 100V/uS slew rate for pulse applications and very low distortion for audio applications.

Note of Caution: The J2171A power supply is a switching supply and, therefore, radiates noise. The preamplifiers can pick up this noise and amplify it and the result can be seen as spurs in the output spectrum if it is close to the J2171A, or any other switching power supply for that matter. Please make sure to separate the J2171A power supply from the preamplifiers as far as possible, stretching the connecting cable to avoid this issue.

Active Filter – J2190A

The J2190A active filter presents a high impedance (approximately 150 kOhms) minimizing the loading of the circuit being tested. The output impedance is 50 Ohms allowing low noise coaxial connections to all typical test equipment. The 0.1Hz-10Hz noise band is common for opamp measurements, voltage regulators and voltage references.

The J2190A is a 4th order high pass and 4th order low pass filter with an optimally flat response and 0dB gain. Additional filters can be cascaded for even sharper cutoff.

The J2190A is not a programmable filter, though it is easily customizable to a particular noise bandwidth and/or circuit gain.

Picotest Family of Ground Loop Isolators

Picotest makes a unique family of ground isolators covering a variety of applications, test setups, and instruments. If there is a ground loop to suppress or eliminate from impacting a measurement, Picotest has the appropriate isolator.

Ground Isolator	Frequency Response	Main Application	Optimized for Impedance Level	Typical CMRR (10kHz)	Recommended Maximum Voltage *	Power	Notes
J2102B	DC - 6 GHz	2-port shunt-through	100s of micro ohm, milli-ohms, ohms	80dB	3.3V	Passive	Best general solution
J2113A	DC-800 MHz	2-port shunt-through	> 1mOhm	57dB	1.9V	Active	Better choice if you need to measure below 3kHz and below a maximum frequency of 500MHz, but with voltage limits
J2114A	DC - 10 MHz	2-port shunt-through	Micro-ohms	100dB	2.5V	Active	Ideal for ultra-low impedance, passive and PDN measurement, but low bandwidth
J2115A	DC - 2.2 GHz	Scopes - Power Rail Probe	100s of micro ohm, milli-ohms, ohms	60dB	2.5V	Passive	Optimized for Scope usage. Very small and can be used for impedance but higher minimum frequency than J2102B and lower CMRR. Good for scope measurements and impedance

*** NOTES**

The impedance level and the CMRR are tied together and also to the minimum measurement frequency and cable length, so it gets complicated

J2102B and J2115A can both tolerate hundreds of Volts, which would destroy the instruments they are connected to.

Recommended max voltage is to prevent damage to the instrument. This can be increased using attenuating probes or DC Blocks

Figure 8: General comparison of the Picotest family of ground loop isolators.

Common Mode Transformer – J2102B

The J2102B is a passive common mode transformer used to attenuate the effects of low frequency ground loops for impedance measurements. It is used for the Bode 100/500, Keysight E5061B (port 1-2 measurements), Rohde & Schwarz ZNL, Copper Mountain, and most other VNAs. This is generally the best isolator for most applications including impedance testing using the 2-port shunt-through configuration.

Semi-Floating Differential Amplifier – J2113A

The J2113A is a solid-state Semi-Floating Amplifier (SFA), or ground loop isolator, that provides the BEST isolation for low impedance measurements. The J2113A removes the groups loops associated with VNAs and Oscilloscopes which occur in many different types of test setups. The ground loops are often subtle or hidden and can impact the measurement results dramatically if not accounted for. The J2113As frequency response, as shown below, is flat from DC to over 800MHz, all while maintaining 50 Ohm impedance at both the input and the output for accurate, low-noise measurements. It allows measurement both lower and higher in frequency than achievable with a Common Mode Transformer. The J2113A supports power distribution network (PDN) measurement, component measurement, PSRR testing and many other applications.

High CMRR Isolation Amplifier – J2114A

Measuring micro-Ohm PDN bus impedances requires an isolator with high CMRR (see reference). The J2114A is a solid-state USB powered high CMRR (> 100dB) amplifier or ground loop isolator, that provides the BEST isolation for ultra-low impedance measurements (less than 100µ Ohms). The J2114A removes the groups loops associated with VNAs and oscilloscopes which occur in many different types of test setups. This level of CMRR (highest of all Picotest ground isolators) is necessary to impact the ground loop errors for these impedance levels. If measuring ultra-low impedances is needed, this isolator is essential to the removal of ground loop errors.

Reference: https://www.picotest.com/product/j2114a-high-cmrr-isolation-amplifier-ground-loop-breaker/#

Coaxial Isolator – J2115A

Ground loops exist in many oscilloscope test setups. In particular, the P2104A, P2105A and commonly available 'power rail' probes, which measure small signals, are susceptible to errors caused by ground loops. The J2115A was designed to fit easily into test setups, in-line with a power rail probe, and to virtually eliminate the ground loop connection's induced errors. A compact footprint, SMA connections, high CMRR, and high bandwidth enable this probe coaxial isolator to significantly reduce ground loop errors in power rail noise measurements.

Power Amplifier & High CMRR Isolation Amplifier – J2116A

The J2116A is a combined unit with source power amplifier and ground isolator with up to +22.5dBm gain and 100dB CMRR. It is used to improve signal-noise in crosstalk and ultra-low impedance measurements while also eliminating the ground loop that is present. The unit is small and fits in line with most 1-port 'micro' probes.

Active Splitter – J2161A

Perform the "Gold Standard" PDN measurement on oscilloscopes: the 2-port shunt-through impedance measurement is enabled by the Picotest J2161A 2-way active splitter, along with any ground Isolators (J2102B, J2113A, J2114A, or J2115A for ground loop breaking). The combination allows measurement of low impedances over frequency down to

1 mOhm covering a bandwidth of 100Hz to over 500MHz (scope dependent).

2-Port Probe Adapter for the Keysight E5061B – J2160A

The Picotest J2160A Probe Adapter provides a low noise, compact solution when using the E5061B T/R ports in a 2-port shunt-through measurement. The T/R ports are desirable for low frequency 2-port measurements, since these ports are semi-floating, allowing low impedance measurements without the use of a coaxial common mode transformer such as the J2102B. The floating ports allow milli-Ohm measurements even at very low frequency and up to the 30MHz range of the T/R ports.

The current solution uses a resistive 6dB port splitter combined with coaxial cables to support this measurement. The J2160A is a slim profile adapter, converting the three E5061B BNC ports to two BNC ports for the 2-port measurement. The 6 dB resistive port splitter is included internal to the adapter, so no external splitter or cables are required. The short connections are neater, consume less bench space, and can result in a lower noise measurement.

The adapter can also be combined with ultra-wide bandwidth DC blockers, such as the Picotest Port Saver. This enables 2-port measurements of sensitive devices without the 50 Ohm DC port loading, which could overload the device being measured and/or severely distort the measurement results.

The Picotest adapter also supports the extended 2-port shunt-through measurement, allowing higher impedance 2-port measurements by adding a series resistor to each port.

Chapter 3 - Signal Injectors: Measurements and Specifications

J2100A/J2101A Injection Transformers

One of the most common tests performed by a network analyzer is the control loop stability measurement or Bode plot. The injection transformer is the most prevalent method for connecting a network analyzer to the circuit in order to perform the stability measurements.

There are two different injection transformers, each with different overall bandwidths to support various types of applications.

Main Features

J2100A 1Hz-5MHz Transformer

- 1Hz supports PFC regulators
- 5MHz high enough for most power supplies and regulators
- 23 Octave range
- Low distortion for superior precision
- 5 Ohm termination for minimum impact to loop
- Includes attenuation to assure small signal measurement

J2101A 10Hz-45MHz Transformer

- 10Hz supports off-line power supplies
- 45MHz high enough for even state of the art regulators
- 23 Octave range
- Low distortion for superior precision
- 5 Ohm termination for minimum impact to loop
- Includes attenuation to assure small signal measurement

Description

The goal of the transformer is to inject a signal into the control loop being measured, *without impacting the performance of the loop*. The test is performed by inserting an oscillator signal into the control loop, allowing an OPEN LOOP measurement in a CLOSED LOOP system. The analyzer sweeps the frequency while measuring the voltage at each side of the transformer. One side of the transformer is the input signal while the other side is the output signal. The division of the two results in the loop gain and loop phase or bode response. The transformer is isolated and, therefore, capable of floating on a high voltage, such as in a Power Factor Corrector (PFC) circuit, which is often close to 400VDC.

The usable bandwidth of an injection transformer is generally significantly greater than its 3dB frequency limits. This is because the transformer itself is outside of the measurement, leading many to incorrectly believe that the transformer is a non-critical element.

The bandwidth of the transformer is strongly related to the terminating impedance (i.e. the impedance of the instrument). The source impedance of the oscillator in the Omicron Bode-100, and most other network analyzers, is 50 Ohms. Assuming this impedance, the recommended termination resistor is 5 Ohms. This significantly attenuates the injection signal, which is generally beneficial, as a common error in Bode measurements is using a signal which is too large, and therefore, resulting in a measurement that is not a "small signal" measurement. This low value termination resistance also improves the low frequency bandwidth of the transformer.

An added benefit of this low value is that it can generally be left in the circuit at all times, simplifying the connection to the network analyzer without appreciably impacting the output voltage of the circuit being tested.

Today's power systems demand better measurements at both higher and lower frequencies. Engineers often use audio transformers or video transformers for signal injection purposes. This is unwise, as the low frequency performance of a video transformer is generally quite poor while both the low and high frequency performance of the audio transformer are quite poor. Many of the transformers sold as injection transformers use ferrite core materials, which are good for high frequency but relatively poor for high frequency.

The design of a transformer that has sufficient permeability at 1Hz and minimal attenuation at 10MHz or more is difficult to achieve. The core materials are specially processed, and the transformers generally must be hand wound.

Most other injection transformer manufacturers use an inexpensive ferrite transformer; the price is not indicative of the cost of the transformer. The Picotest injection transformers are made of a specially annealed amorphous material in order to obtain nearly infinite permeability (>100,000). The difference in the measurement results between a Picotest transformer and another variety of transformer depends on the circuit. A switch-mode power supply is less demanding, while an opamp or a 3 terminal regulator is more demanding. In particular, the LM317 style regulator requires the measurement to be

referenced to Vout and not ground. In this case the transformer parasitics are much more evident.
The Picotest injection transformers are capable of an impressive 23 Octave bandwidth. This bandwidth is still not sufficient to support all requirements, and so two transformers have been designed. One is optimized for performance from 1Hz to 10MHz while the other is optimized for 10Hz to 40MHz.

Either transformer is usable for most applications. The lower frequency transformer is usable for PFC measurements, where the bandwidth is generally below 10Hz while the higher frequency transformer is usable for the newest switch-mode converters and LDOs which have bandwidths up to several MHz.

While the injection transformer is a very wideband adapter, it is not useful for measuring ripple rejection (PSRR) of a power supply or even an opamp. This is because the attributes that make the injection transformer perform so well also result in a transformer that is intolerant of DC current. Even very small DC currents (5mA or less) can greatly reduce the signal capacity or even totally saturate the transformer.

Connecting the Injection Transformer: Stability

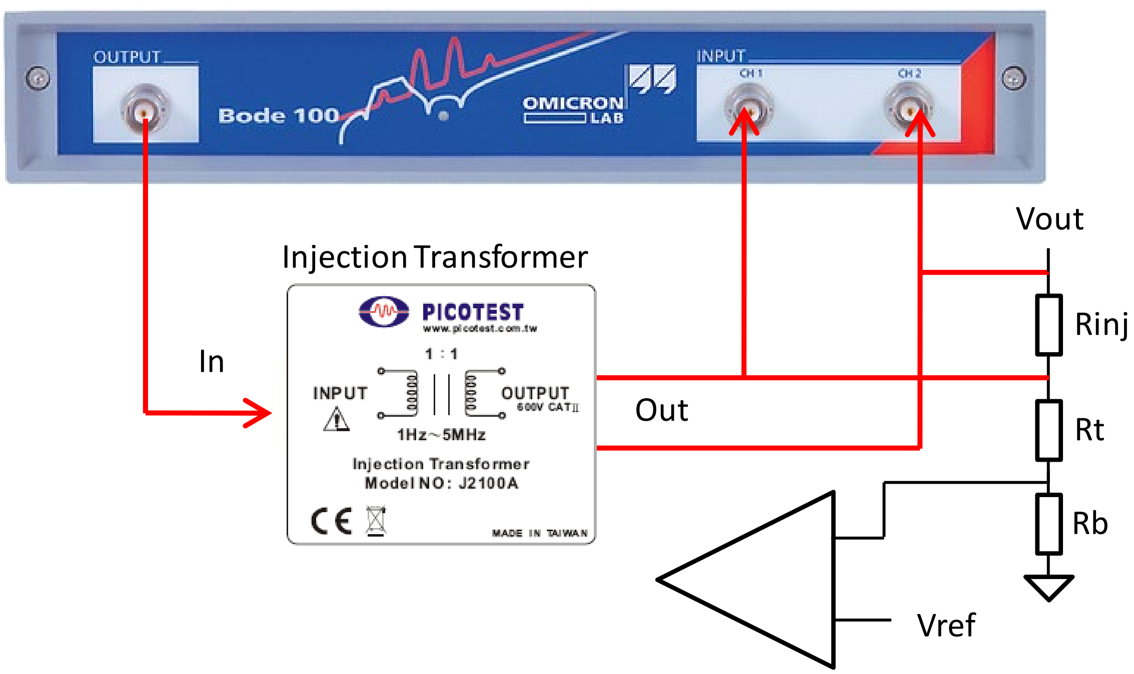
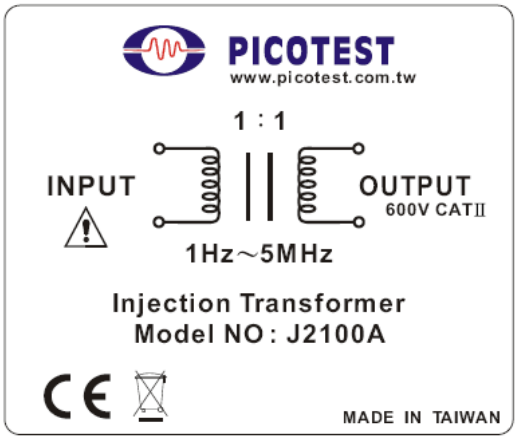


Figure 9: Injection Transformer Connections for stability measurements.

The injection transformer is connected as shown above. The output oscillator of the Bode analyzer is connected via a BNC connector to the input of the transformer. The output of the transformer is connected across the "in-circuit" injection resistor (Rinj). This allows the analyzer oscillator to stimulate the loop while the loop response is recorded.

Technical Specifications: J2100A



Characteristic	Rating	Conditions
DCR		25 degC
Ratio	1:1	
Termination Impedance	5 Ohms	
Nominal 3dB Bandwidth	10Hz - 5MHz	
Isolation Voltage	600V CATII	3kVrms/1min
Isolation Capacitance	150pF	1kHz
DC current	10mA	DC current at which inductance(@1kHz) drops 10% (typical) from its value without current
Temperature range	0-50°C	
Maximum Altitude	6000 Ft	

* Performance at -10dBm input level

Caution: To avoid equipment damage and/or severe injuries or death ensure that the absolute maximum ratings are never exceeded.

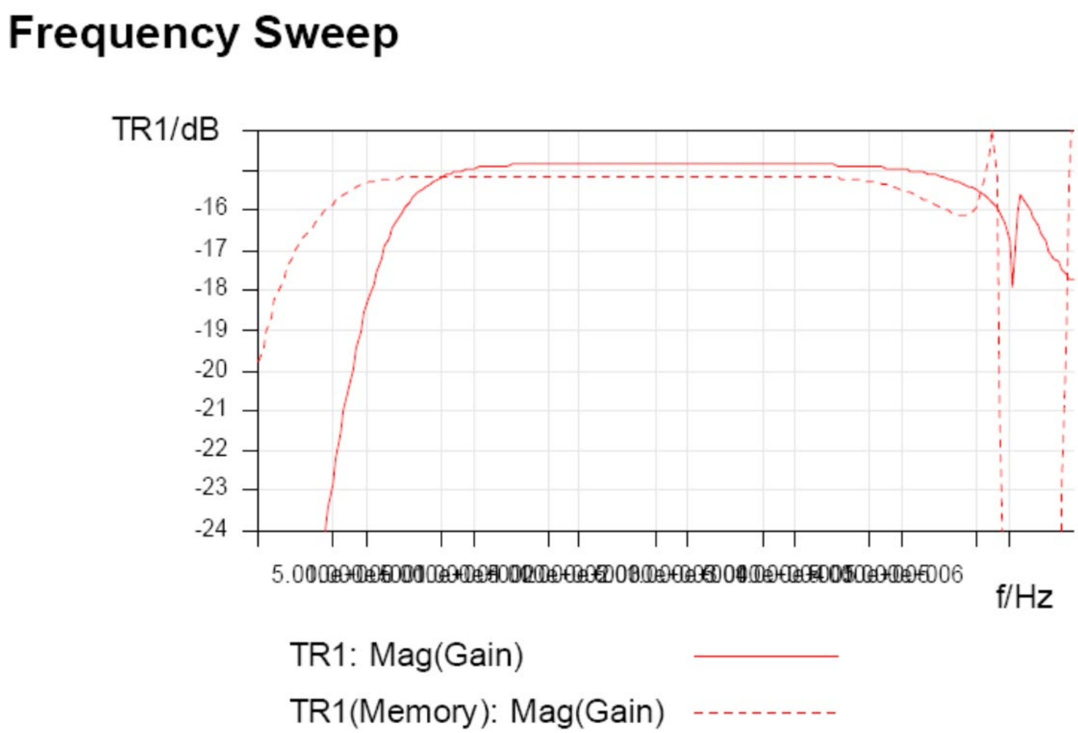
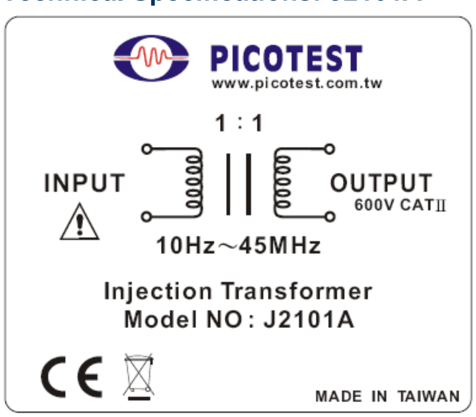


Figure 10: Frequency Response for the J2100A and J2101A injection transformer.

Technical Specifications: J2101A



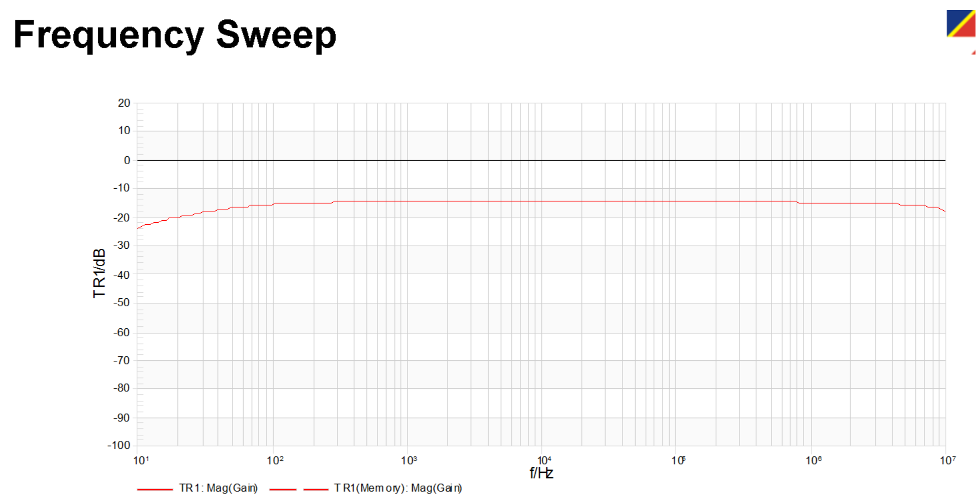


Figure 11: Frequency Response for J2101A injection transformer.

Characteristic	Rating	Conditions
DCR		25 degC
Ratio	1:1	
Termination Impedance	5 Ohms	
Nominal 3dB Bandwidth	10Hz - 5MHz	
Isolation Voltage	600V CATII	3kVrms/1min
Isolation Capacitance	150pF	1kHz
DC current	10mA	DC current at which inductance(@1kHz) drops 10% (typical) from its value without current
Temperature range	0-50°C	
Maximum Altitude	6000 Ft	

⚠ Caution: To avoid equipment damage and/or severe injuries or death ensure that the absolute maximum ratings are never exceeded.

J2110A Solid-State Voltage Injector

Main Features

J2110A Solid-State Bode Box Voltage Injector

- DC-100MHz; supports thermal and mechanical controls and highest performance regulators
- Low distortion for superior precision
- 25 Ohm insertion resistance
- 50 Ohm oscillator input
- < 3uA typical bias current
- >2 MΩ typical Input Resistance
- Includes J2171A High PSRR Regulated Adapter

Description

The solid-state voltage injector, or "Bode box", is employed in the same way as the injection transformer. As noted in the introduction section, the J2110A injector has a wider bandwidth. However, the selection of a point in the circuit to insert the injection connection can be more challenging. In order to provide correct results one side of the measurement must present much higher impedance than the other side. A rule of thumb is that one side should have an impedance that is at least 50 to 100 times greater than the other. In a typical power supply control loop, the voltage sense divider is generally a good injection point, since the output impedance of the power supply is very low compared with the impedance of the voltage sense divider.

Connecting the Solid-State Injector: Stability

The solid-state injector is connected in much the same way as the injection transformer. The exception, as noted above, is that the impedance on the Vout side must be different from the Rtop side.

No injection resistor is used.

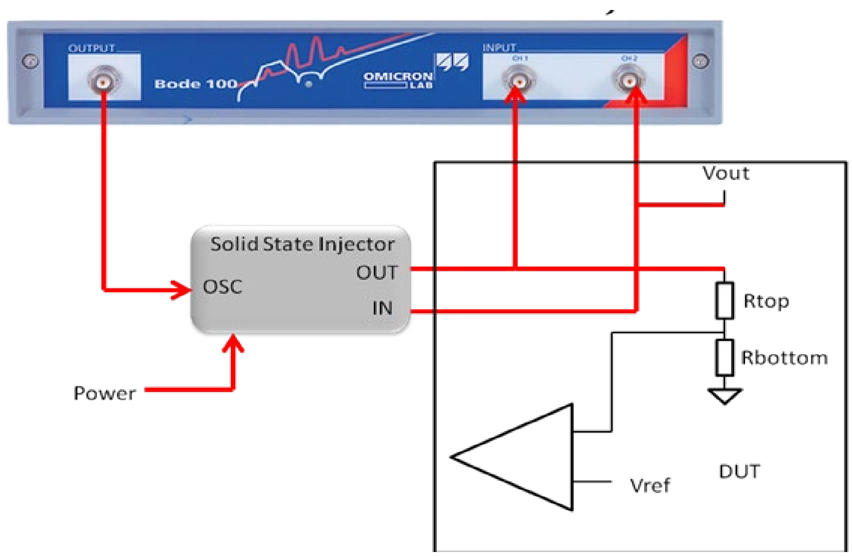
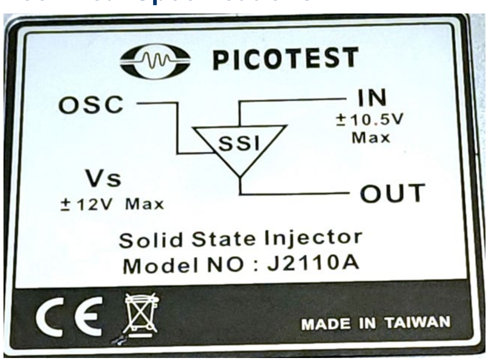


Figure 12: Solid-State Injector Connections for stability measurements.

Technical Specifications



Characteristic	Rating	Conditions
Max Vs	+/-12V	25 degC
Max Icc	20mA	
Max input voltage DC+AC	+/-10.5V	
Output Voltage	+/-10.5V	
Offset Voltage	3mV	
-3dB Bandwidth (-10dBm)	DC-100MHz	
Temperature range	0-50°C	
Maximum Altitude	6000 Ft	
Absolute Maximum Voltage	<50 VAC and 75VDC	

J2120A Line Injector

Main Features

J2120A Line Injector

- 10Hz-10MHz usable bandwidth
- Low loss design
- 5 Amps maximum current
- 50VDC maximum input
- Easily measure input filters and PSRR

Description

The line injector allows the input DC supply voltage to be modulated by the network analyzer source signal, as in the case of a PSRR measurement. The line injector must be capable of a frequency range well below the AC line frequency and at least above the control loop bandwidth of the circuit being tested.

Connecting the Line Injector: PSRR

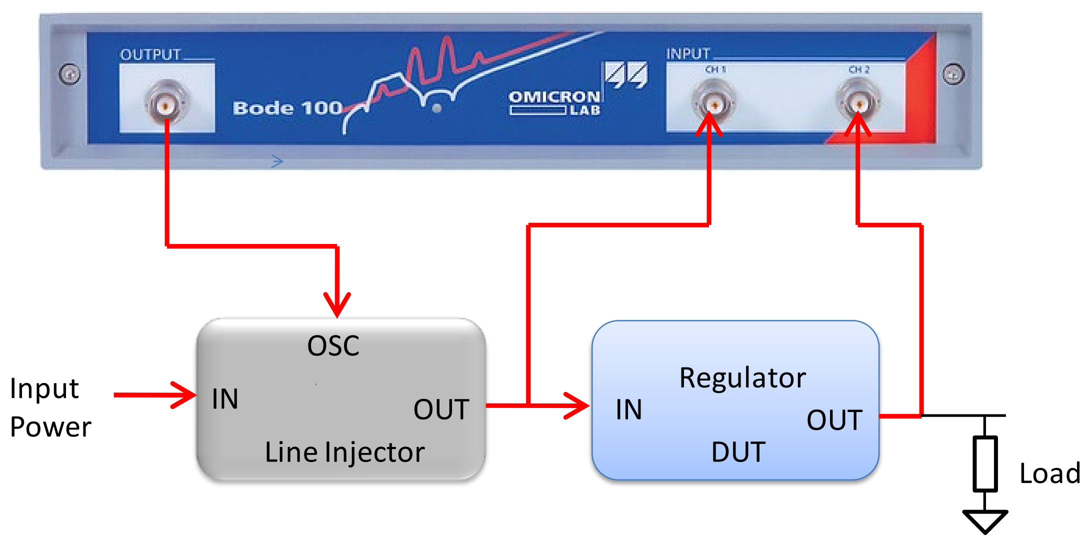


Figure 13: Line Injector Connections for PSRR measurements.

The line injector is only capable of sourcing current, so that the output amplitude can be significantly impacted by the operating current and the total storage capacitance at the load. The Bode-100 network analyzer has a very high selectivity so distortion at the output of the line injector generally does not influence the measurement. Again, this is a small signal injector, so the oscillator signals should be kept as small as possible above the noise floor. As a guide, try to keep the input signal amplitude below 50mVpp (-20dBm). In some cases, we want to attenuate the source signal even further, and so we have included the attenuators in the injector kits. Some analyzers, such as the Omicron-Lab Bode-100 allow shaping the injection amplitude as a function of frequency, which helps optimize the signal level.

Measuring Input Impedance

The line injector can also be used in conjunction with a current probe to measure the input impedance of a power supply. The input impedance of a switching power supply or regulator is negative, which is a stability concern when combined with an EMI filter, making the measurement an important part of the design, analysis and verification process. The current probe must be set for 1A/V or the results need to be scaled accordingly for different settings.

Connecting the Line Injector: Input Impedance

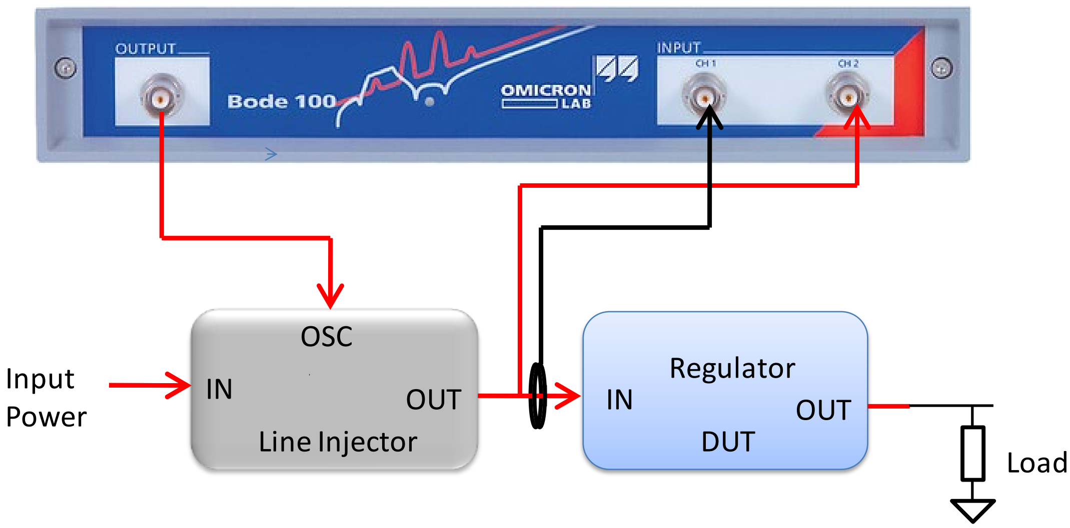
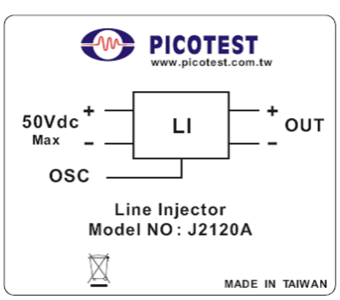
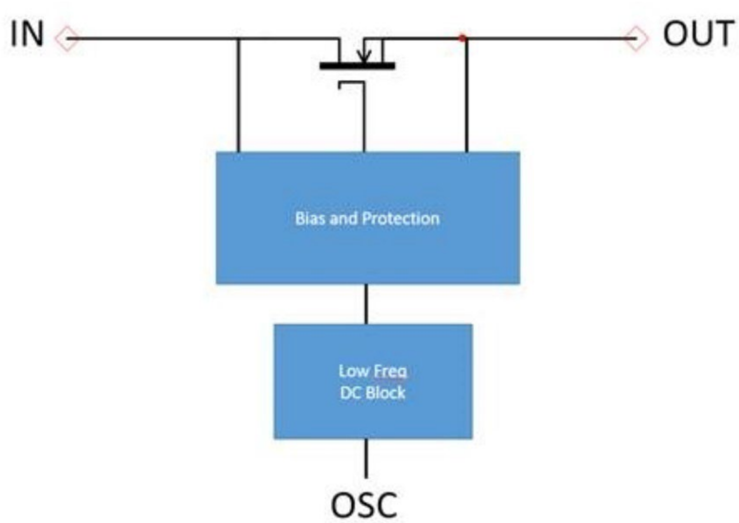


Figure 14: Line Injector Connections for input impedance measurements.

Technical Specifications and Block Diagram





Connection Note: the black connection is always the return; the red connection is Vin and can be negative (voltage).

Note: The J2120A line injector includes an internally biased N-Channel MOSFET. This means that there is a voltage drop between the J2120A input and output. To get an input voltage of 1.2V at the regulator could require 2.5-3.5V depending on the operating current.

The MOSFET operates open loop so as not to become unstable when connected to the external regulator

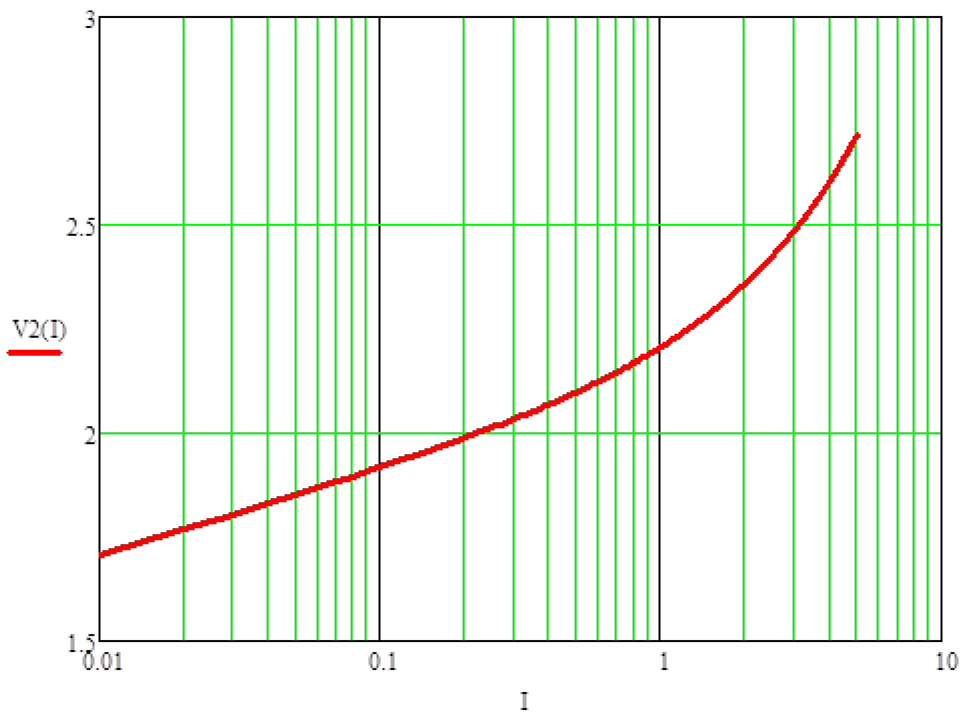


Figure 15: Line Injector voltage drop.

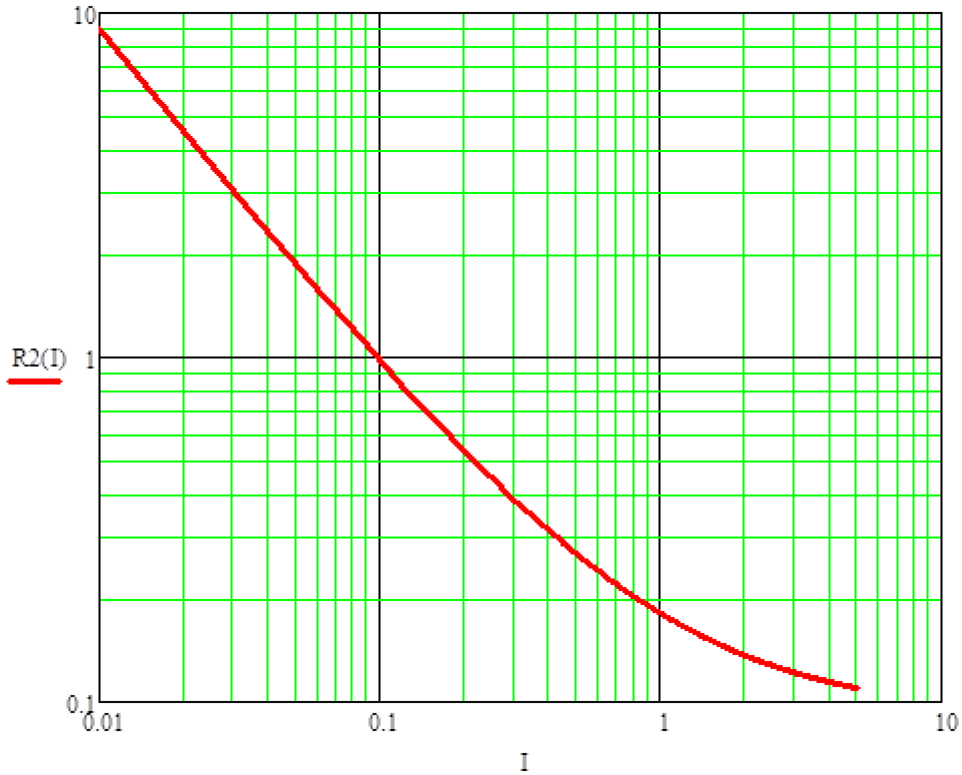


Figure 16: Line Injector output resistance.

Characteristic	Rating	Conditions
Maximum DC Input Voltage	50V	
Maximum Continuous Current	5A	
Maximum Voltage Drop	3.25V	At 5A
3dB Frequency Response	15Hz-5MHz	Vin=5V RL=50 Ohms
Useable frequency response	10Hz-10MHz	
Recommended injection signal	-20dBm - 0dBm	
Temperature range	0-50°C	
Maximum Altitude	6000 Ft	
Absolute Maximum Voltage	<50V (DC+AC)	

EMI Note: Exceeding 0dBm may cause the J2120A unit to exceed CE EMI limits.

J2121A High Power Line Injector

Main Features

J2121A Line Injector

- 400V/20A max – Supports High Power 270V Military and Satellite Buss Applications
- 100Hz - 1MHz Bandwidth
- Regulated Input-Output Voltage Drop, 750mV
- Isolated Current Sense Monitor Output (for VNAs only, does not work with oscilloscopes
- Fan cooled, includes low-noise power supply, J2171A
- 1 Ohm Calibration Fixture
- J2171A 200mA Low Noise Power Supply
- Inputs: Bus Voltage: Plus and minus, standard banana jacks female, Signal Modulation: BNC
- Power: J2171A proprietary connector, cable and power supply included
- Outputs: Voltage Output: Plus and minus, standard banana jacks female
- Isolated Current Sense Monitor: BNC

Description

The J2121A is especially suited to high power applications such as those associated with military and satellite busses. It can be used with input bus voltages up to 400V and supply up to 20A at 1MHz. The line injector allows the input DC supply voltage to be modulated by the network analyzer source signal (oscillator). The J2121A line injector output is DC regulated and provides a fixed voltage drop of 750mV from the input bus voltage fed into the injector in addition to the AC modulation signal. The J2121A can be connected to the power supply input under test and, depending on the test probe connection points, can be used to measure either PSRR or the power supply's input impedance The line injector can also be used to measure the impedance/inductance of an inductor under bias.

While a current probe can be used as part of a test setup, the J2121A includes a current sense monitor output that can be connected to the VNA.

The J2121A comes with the J2171A power supply and connecting cable, used to power it, and a 1 Ohm calibration fixture.

J2120A – J2121A Injector Comparison

- The J2121A supports much higher voltage and current applications. It has a fixed voltage drop, 750mV
- The J2120A has ultra-low noise output, 50V/5A max 10MHz bandwidth, passive, variable voltage drop (1.5V-3.5V) based on the load impedance

- The J2120A favors PSMR and low current, low voltage, PSRR measurement applications
- The J2121A has a much higher voltage range, much higher current rating and integrated Hall current monitor, saving the need for an external current probe
- The J2121A favors high voltage, high current PSRR testing and DC/DC and Inductor impedance measurements

Connecting the Line Injector: PSRR

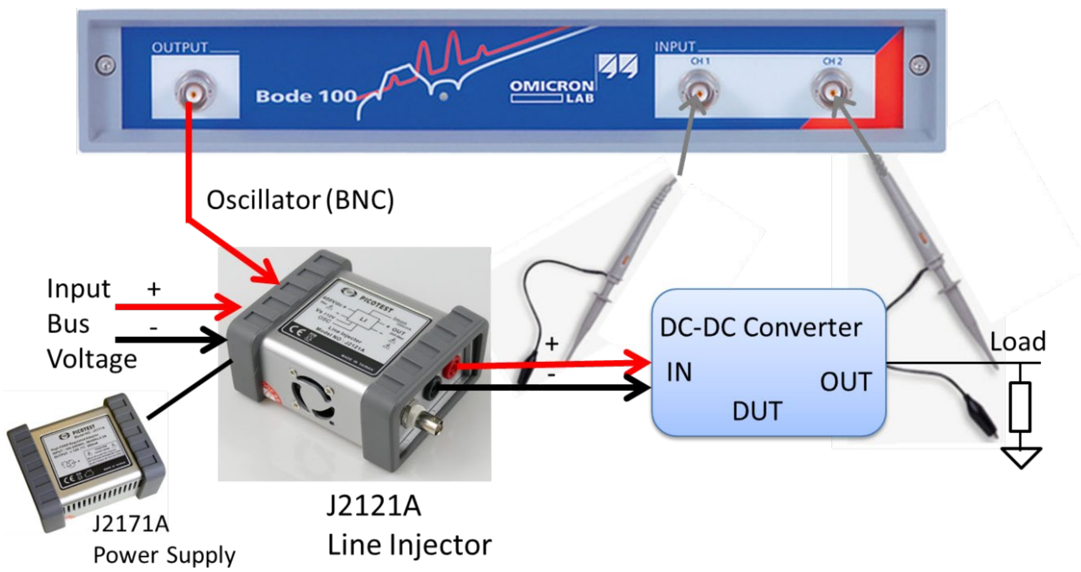
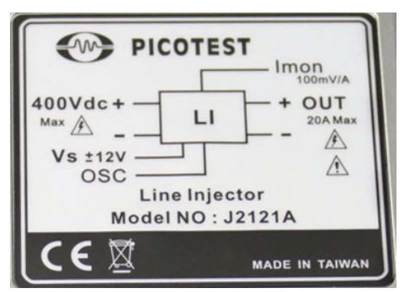


Figure 17: J2121A Line Injector Connections for PSRR measurements.

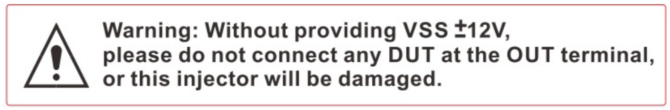
Technical Specifications

Characteristic	Rating	Units
Maximum DC Input Voltage	400	VDC
Maximum Continuous Current	20	A
Typical Input-Output Voltage Drop	0.75	VDC
Modulation Input Impedance	50	Ohms
3dB Frequency Response	DC-1M	Hz
Useable Frequency Response	10-1M	Hz
Current Monitor Scale (AC)	100	1mV/A
Current Monitor Termination Impedance	>10K Ohms	Ohms
Max Current Monitor DC Offset	100	mV



EMI Note: Exceeding 0dBm may cause the J2120A unit to exceed CE EMI limits.

VSS Note:



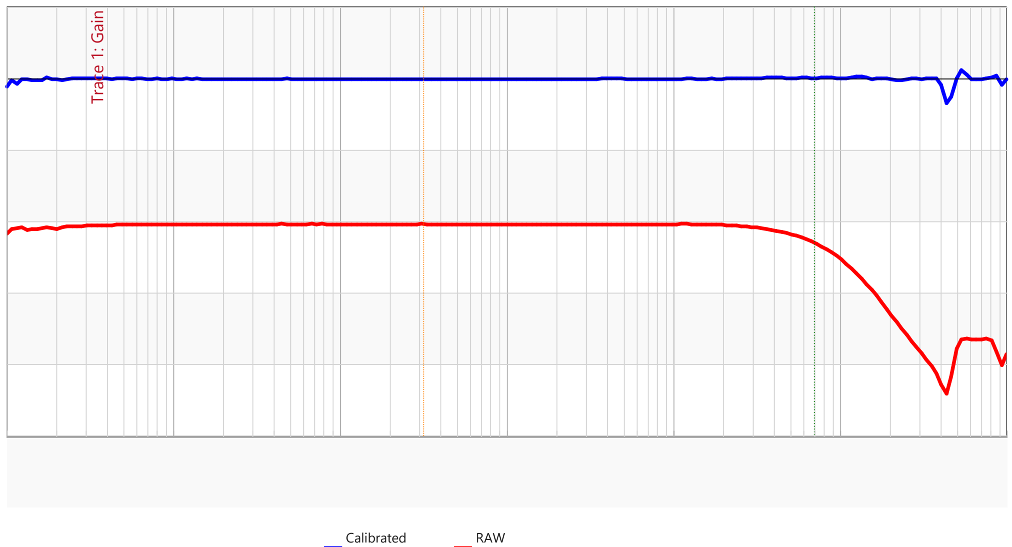


Figure 18: The current monitor transfer ratio measurement shows the 100mV/A (-20dB) transfer function from the modulation current to the current monitor output. Uncalibrated, the -3dB frequency is 700kHz. Calibrated the response is 10Hz-1MHz.

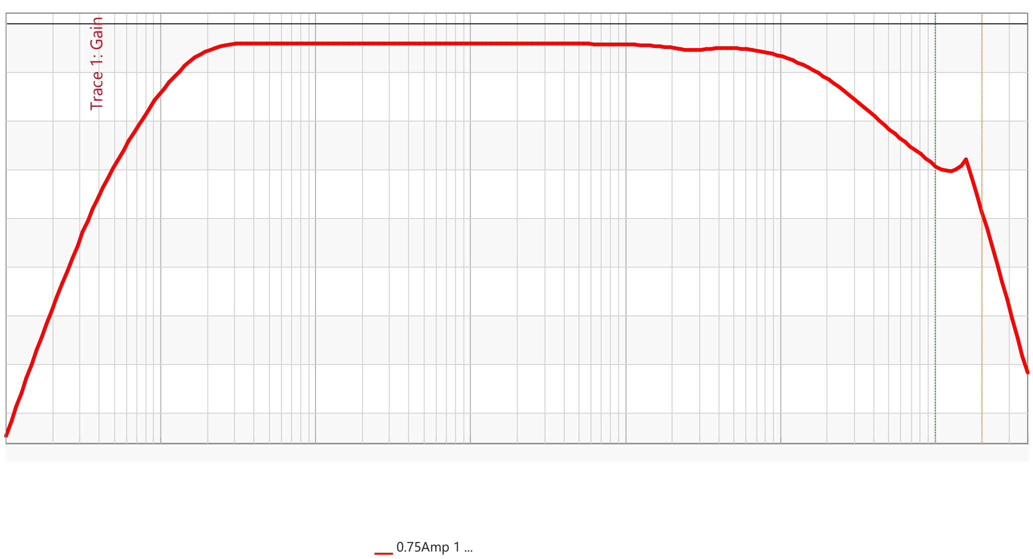


Figure 19: Current Monitor Transfer Function - transfer function from the modulator input to the output, measured with a 1 Ohm load. The Current Monitor Termination Impedance is >10 kOhms.

J2123A Negative Voltage Line Injector

Main Features

J2123A Line Injector

- Negative voltage line injector
- Modulate a DC Power Source Voltage
- Combines modulation signal with bus voltage
- 10Hz-50MHz usable bandwidth
- Low Impedance, Low Noise, and Low Voltage-Compliance
- 3 Amps maximum current
- -30VDC max input
- Easily measure input filters and PSRR

Description

The line injector allows the input DC supply voltage to be modulated by the network analyzer source signal, as in the case of a PSRR measurement. The line injector must be capable of a frequency range well below the AC line frequency and at least above the control loop bandwidth of the circuit being tested.

The voltage drop and output resistance, as a function of output DC current should be very close to this formula:

$$V(I) := 2.312 \cdot I^{0.055} + I \cdot 0.09$$

$$R(I) := 0.127 \cdot I^{-0.945} + 0.09$$

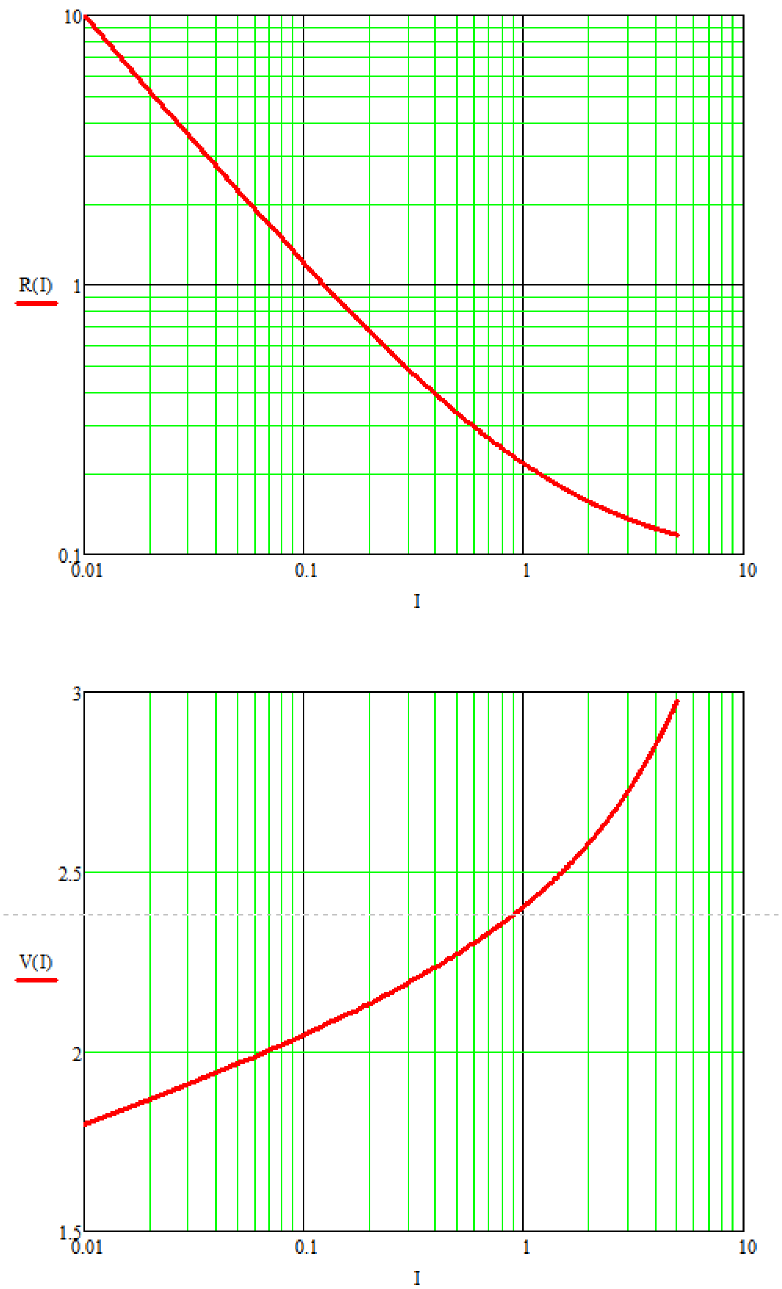


Figure 20: the voltage drop of the J2123A is graphically represented above.

Connecting the Negative Voltage Line Injector: PSRR

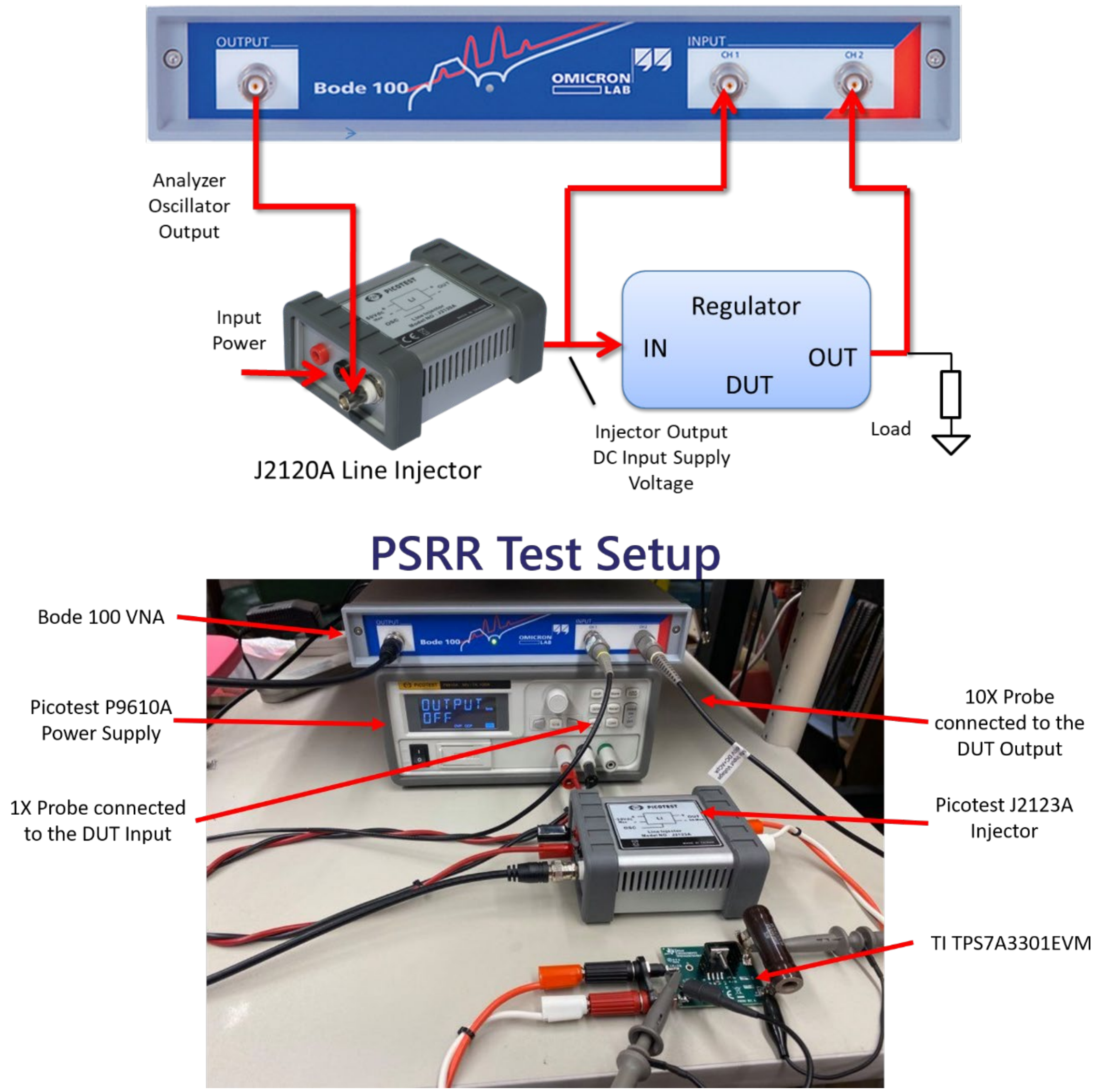


Figure 21: Line Injector Connections for PSRR measurements.

Important Usage Note: The J2123A will be damaged if the input voltage is reversed. In a negative voltage system, the return jack (ground or 0 volts) should be more positive than the MINUS SUPPLY connection. To clarify, there is a polarized internal capacitor connected per Figure 1. Do not apply a reverse voltage across this capacitor.

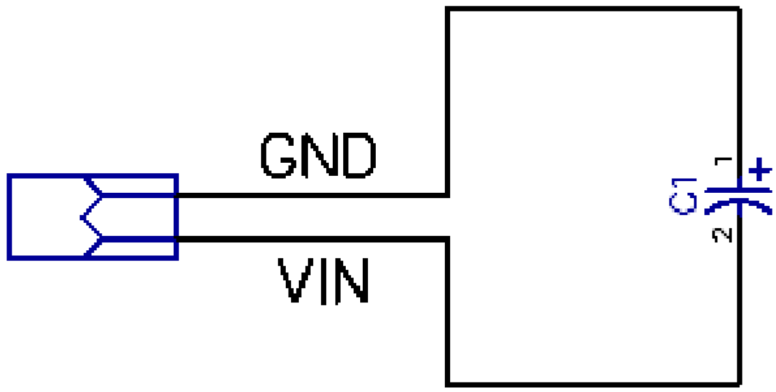
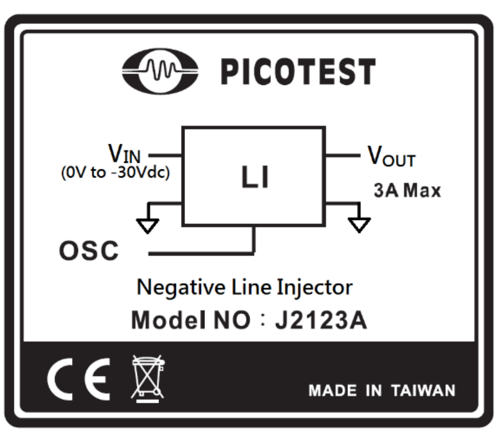


Figure 22: Internal input capacitor polarity.

The line injector is only capable of sourcing current, so that the output amplitude can be significantly impacted by the operating current and the total storage capacitance at the load. The Bode-100 network analyzer has a very high selectivity so distortion at the output of the line injector generally does not influence the measurement. This is a small signal injector, so the oscillator signals should be kept as small as possible above the noise floor. As a guide, try to keep the input signal amplitude below 50mVpp (-20dBm). In some cases, we want to attenuate the source signal even further, and so attenuators are available. Some analyzers, such as the OMICRON-Lab Bode-100 allow shaping the injection amplitude as a function of frequency, which helps optimize the signal level.

The line injector allows the input DC supply voltage to be modulated by the network analyzer source signal, as in the case of a PSRR measurement. The line injector must be capable of a frequency range well below the AC line frequency and at least above the control loop bandwidth of the circuit being tested.

Technical Specifications



Technical Specifications

Characteristic	Rating	Units
Maximum DC Input Voltage	30	VDC
Maximum Continuous Current	3	A
Maximum Input-Output Voltage Drop	3	VDC
Modulation Input Impedance	50	Ohms
3dB Frequency Response	20-20M	Hz
Useable Frequency Response	10-50M	Hz
Temperature Range	0 - 50	°C
Maximum Altitude	6000	Ft
Absolute Maximum Voltage	< -50V (DC + AC)	

Caution: To avoid equipment damage and/or severe injuries or death ensure that the absolute maximum ratings are observed and not exceeded at all times.

EMI Note: Exceeding 0dBm may cause the J2120A unit to exceed CE EMI limits.

J2130A DC Blocker/DC Bias Injector

J2130A Main Features

J2130A Bias Injector

- 10Hz-10MHz usable bandwidth Low loss design
- Easily measure varactors, junction capacitance
- Measure X5R capacitor voltage sensitivity
- Bias low power transistor amplifiers and diodes for parameter extraction

Description

The Picotest DC bias injector (J2130A) is used for applying a DC voltage bias on components during impedance measurements. The J2130A is a Resistor Capacitor Bias Tee which is useful for measuring components, such as capacitors, diodes, small signal BJTs, opto-couplers and more.

Connecting the DC Bias Injector: Component Bias

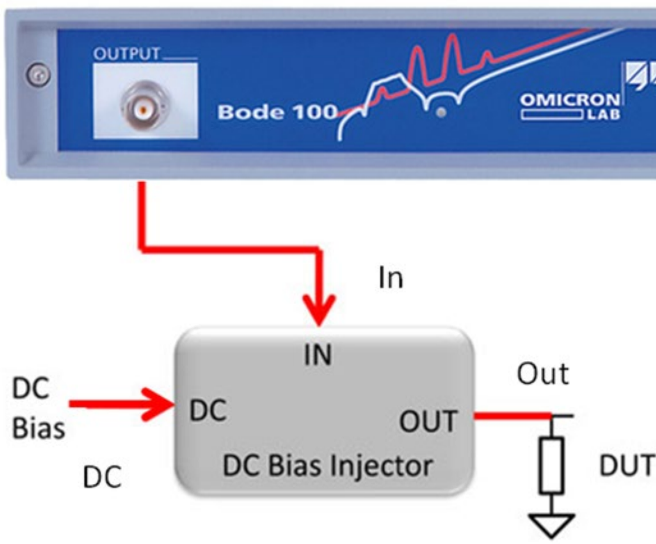
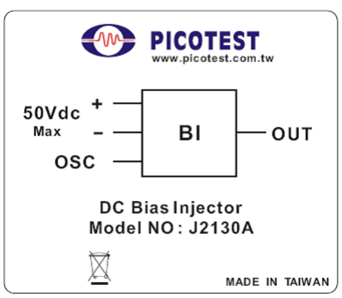
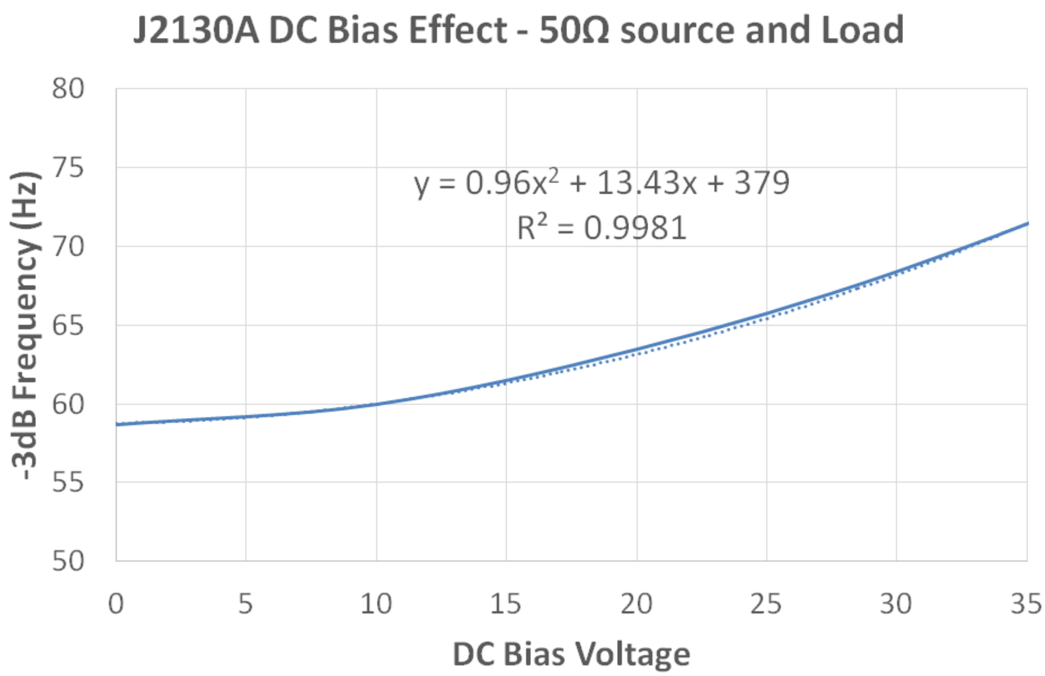


Figure 23: Connections for DC Bias Impedance measurements.

Technical Specifications



Characteristic	Rating	Conditions
Maximum DC Bias	50VDC	
Bias Resistance	10 kOhms	
Maximum Bias Current	5mA	At 50V
Frequency Response	100Hz-1GHz+	Frequency Sweep 10Hz~500MHz, Power=-10dBm
Temperature range	0-50°C	
Maximum Altitude	6000 Ft	
Absolute Maximum Differential Voltage	<50V DC	Input-Output
Absolute Maximum Voltage	<50 VAC and 75VDC	



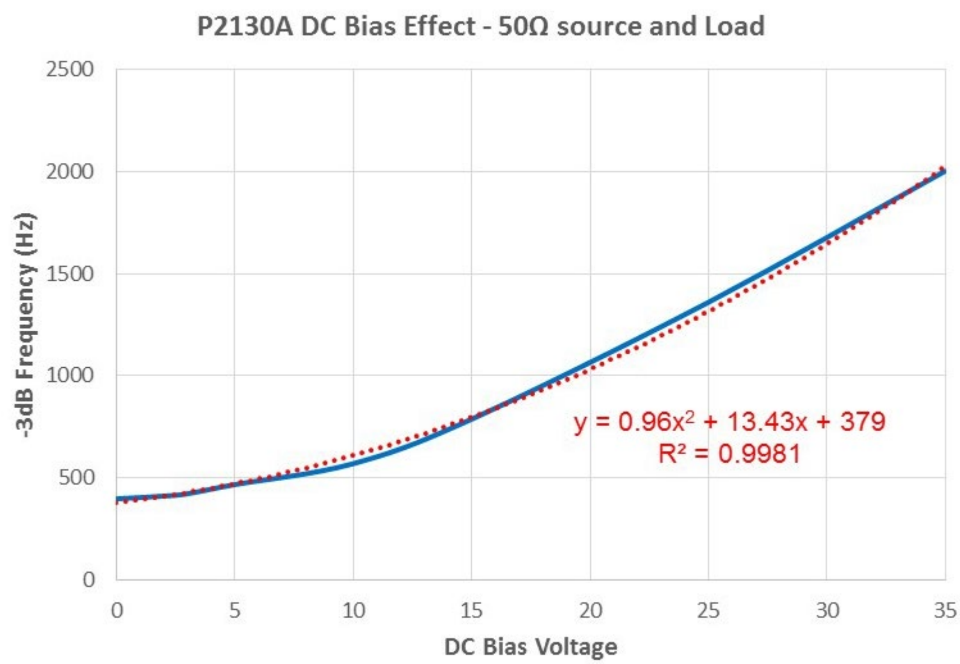


Figure 24: The effect of DC bias on the J2130A frequency performance which shifts the - 3dB frequency.

J2111B/J2112A Solid-State Current Injector

Main Features

J2111B & J2112A Solid-State Current Injector

- High PSRR Low Noise Regulator with Universal input
- 20nSec typical rise and fall time
- DC-40MHz usable range (interconnection dependent)
- Two Quadrant Bipolar operation works with positive or negative source
- Built in offset for use with Network Analyzer
- Precision current monitor
- Works with AWG, Function generator and network analyzer
- Measures Non-invasive phase margin, Output impedance, reverse transfer, crosstalk, input filter stability
- Fast transient load stepping (up to 100mA with the J2111B and 1A with the J2112A)

Description

The current injector is one of the most versatile injector products. Coupled with the G5100A, or other equivalent function generator, it can perform small signal load steps up to 40MHz, with very fast rising and falling edges. Using the G5100A or other AWG, also allows the rise and fall times to be controlled, various waveforms or even arbitrary waveforms. This can be used to simulate the effects of many different types of loads, including high speed digital circuit loading, which is often largely dynamic.

The current injector can also be used to measure output impedance of power supplies, voltage regulators, power buses and even batteries. It can be used to non-invasively measure the stability of a combined input filter and the negative resistance of a switching power supply. It also has application in the measurement and extraction of transistor data, including small signal current gain, Ft, and many other dynamic performance parameters.

In RF and instrumentation circuits it can be used to provide constant current biasing for class A amplifiers and buffers.

The current injector has two connections for the output, Output and GND. The input is DC+AC and can be connected to either a signal generator or a network analyzer. A built-in bias current enables Class A operation for use with a network analyzer. The Current Injector and DC Bias injector can also be used for this purpose.

The current injector is basically a voltage to current converter with a gain of 10mA/V for the J2111B and 200mA/V for the J2112A. For example, with the J2111B, put in a 1V signal into the modulation port and get 10mA out of the output port and 10mV out of the current monitor port. The current injector can be controlled by the output of the network analyzer (for frequency domain sweeps) or a function generator or arbitrary waveform generator (for time domain control and load profiling).

The J2111B is not the same as an electronic load. In many cases, the use of an electronic load will interfere with the measurement results, either due to limited bandwidth or due to high capacitance of the load and internal dampers, necessary to stabilize the load.

The J2111B is designed to provide only small signal currents, with very low capacitance and with high speed. In most cases, we prefer that the system be the load and that the J2111B be used to make measurements in an operating system as this provides the most accurate results.

The J2111B includes bias positions of -25mA, 0 and +25mA. This bias is provided as a convenience for the user (negative bias for testing negative voltages, positive bias for testing positive voltages). Since the J2111B can only sink current it is necessary to provide a bias in order to put the device into class A operation. If this is not done, only one half of the analyzer signal would be provided, resulting in a severely distorted signal and poor accuracy. To be clear the J2111B only sinks current, not sources, and, therefore, cannot generate voltages much higher than the power supply being tested. So, for example, it cannot be used to measure a resistor as it requires a voltage source to sink current.

In cases where the 25mA is too large, it is possible to provide an external bias. The modulation input is 50 Ohms and the transconductance of the J2111B is 10mS. Use the J2130A bias injector along with the J2111B for measuring references. This combination results in 50uA/V and at the 50V limit of the bias injector the J2111B can produce up to 2.5mA. The typical offset in the J2111B is 150uA, and it can be as high as 400uA. It is also possible to use the J2110A in conjunction with the J2111B.

The J2111B current injector is capable of SINKING 100mA while the J2112A can SINK up to 1A. The J2112A is not bilateral and can only operate from positive voltages while the J2111B can sink current from either positive or negative voltages. There is no bias switch for the J2112A as the bias is always positive 24mA.

J2111B vs. the J2112A

The J2111B is a bit more versatile than the J2112A since it is bidirectional and operates to zero current. Most engineers want to take advantage of the larger current injection capability of the J2112A. However, what they don't understand is that it is VERY difficult to drive long cable interconnect inductances at that level of current. Therefore, such large currents are usually better created by load stepper circuits directly on the PCB.

In fact, what customers should be more interested in is not large signal testing, but small signal testing for stability measurement purposes.

J2111B – J2112A Injector Similarities

- Both injectors can be used to perform Non-Invasive Stability Measurement (getting the phase margin from an output impedance measurement)

- Both injectors can be used in the time domain for step load or load profile testing or in the frequency domain for impedance testing
- The output signals of both injectors are driven the same; from either the Bode 100/500 or a voltage source/AWG

J2111B – J2112A Injector Differences

The differences are:

- The J2111B is bidirectional. It can sink or source current. The J2111B can work with positive or negative voltages
- The J2112A can only source current so it can only work with positive voltages
- The J2111B has a maximum current output of 75mA (Bias DC current of +/-25mA and 0mA, and Voltage controlled current portion of 50mA)
- The J2111B has a voltage to current scaling 1V/10mA (10mA/V scaling)
- The J2112A has a maximum current output of 1A (minimum output current of 24mA)
- The J2112A has a voltage to current scaling 1V/200mA (200mA/V scaling)
- The J2111B goes to 40MHz (about 20ns edges, but this will be dependent upon the interconnect inductance)
- The J2112A goes to 50MHz (about 10ns edges possible, but this will be dependent upon the interconnect inductance)

Note: J2111A vs J2111B: The J2111B increases the allowable voltage to -60V to -1.5V and +1.5V to +60V and improves thermal design.

Basic Operation of the Current Injector and Other FAQs

If measuring negative regulators, the negative voltage goes to the red jack and ground goes to the black jack, just as if it were positive. For negative regulators a modulation voltage of zero is Zero amps and -5V is -50mA. For positive regulators a modulation of zero volts is zero amps and +5V is 50mA. The transconductance is 10ms, so 10mA/Volt.

The bias switch can bias the positive regulator 25mA (+bias position) and the negative regulator -25mA (-bias position).

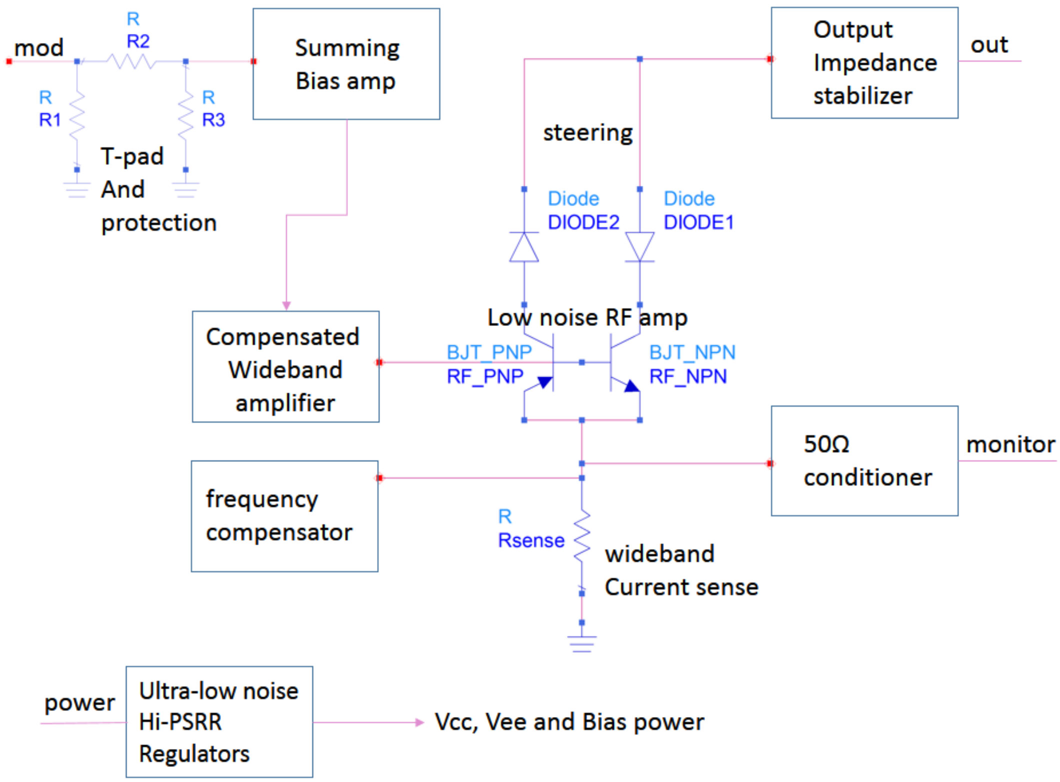


Figure 25: Current Injector internal block diagram.

3-port V/I Impedance Testing

Connecting the Current Injector Example: Output Impedance VNA measurement

The accurate measurement of impedance in electronic systems is crucial for ensuring stability, reliability, and performance. Among various techniques, 3-port impedance testing stands out as a robust method for assessing the characteristics of complex networks and components especially those at elevated voltages (>12V). This article explores how Picotest products, specifically the J2111B Current Injector and Non-Invasive Stability Measurement (NISM) software, combine with a Vector Network Analyzer to provide a comprehensive solution for electronic engineers engaged in 3-port impedance testing.

3-port impedance testing involves measuring the impedance of a control loop using Voltage and Current measurements (V/I). This method is particularly valuable for analyzing the stability of feedback loops for output voltage equal to or greater than 12V. By test output impedance, we can use NISM to compute the phase margin, which is essential for optimizing performance and ensuring stability. The Output is the VNA's oscillator going to the J2111B, Channel 2 is the voltage monitor and Channel 1 is connected to the J2112B's current monitor. If the leads are kept really short using low inductance coax this measurement will work, though a ground isolator might be required on the voltage probe to minimize the ground loop error. This can be achieved using PDN cable and a J2102B or J2113A.

For an output impedance measurement, connect the output of the current injector using a scope probe (preferably 1X for best sensitivity) from the VNA to the output of the regulator.

Connect the scope probe to the "T" input (terminated into 1 MOhm) and the current monitor from the current injector to the "R" input (terminated into 50 Ohms). The LF Output connects to the modulator input of the current injector. This is all shown below in the connection diagram.

There is also a bias switch on the current injector that needs to be switched to the "+" position for positive (voltage) regulator measurements.

The sweep frequency should be from 100Hz to 10MHz and a signal injection level of 0dBm is a good place to start for signal level. We would also recommend using a low receiver bandwidth or IF Frequency (at most 100Hz).

For the number of points per decade in the sweep, we typically use 401. Going higher than that is not a problem, but potentially unnecessary. Should the peak in impedance at the bandwidth of the regulator be so steep that it appears to be aliased or truncated, increasing the number of points per decade and/or narrowing the frequency sweep span around that peak will help improve the accuracy.

Plot the magnitude (|Z|) and group delay (Tg) on 2 grids since when using 2 traces on the same grid only one axis is displayed at a time (corresponding to whichever trace is selected).

To do a small signal load step, change the modulator from the network analyzer to an AWG and change the bias switch on the current injector from the "+" position to the middle position (no bias current). The scope probe and current monitor would then go to an oscilloscope. Now generate a square voltage pulse with the AWG and this will present itself as a square load pulse at the output of the regulator. The scaling for the AWG voltage to load current transformation is 100:1, meaning a 0 to 1V pulse would represent a 0 to 10mA load step.

Make sure the current monitor is terminated into 50 Ohms and that the voltage waveform is AC coupled so as to best see the voltage response at the output of the device. I find it easiest to trigger off of the "Sync" output of the AWG, however, syncing off of the load current pulse will also work.

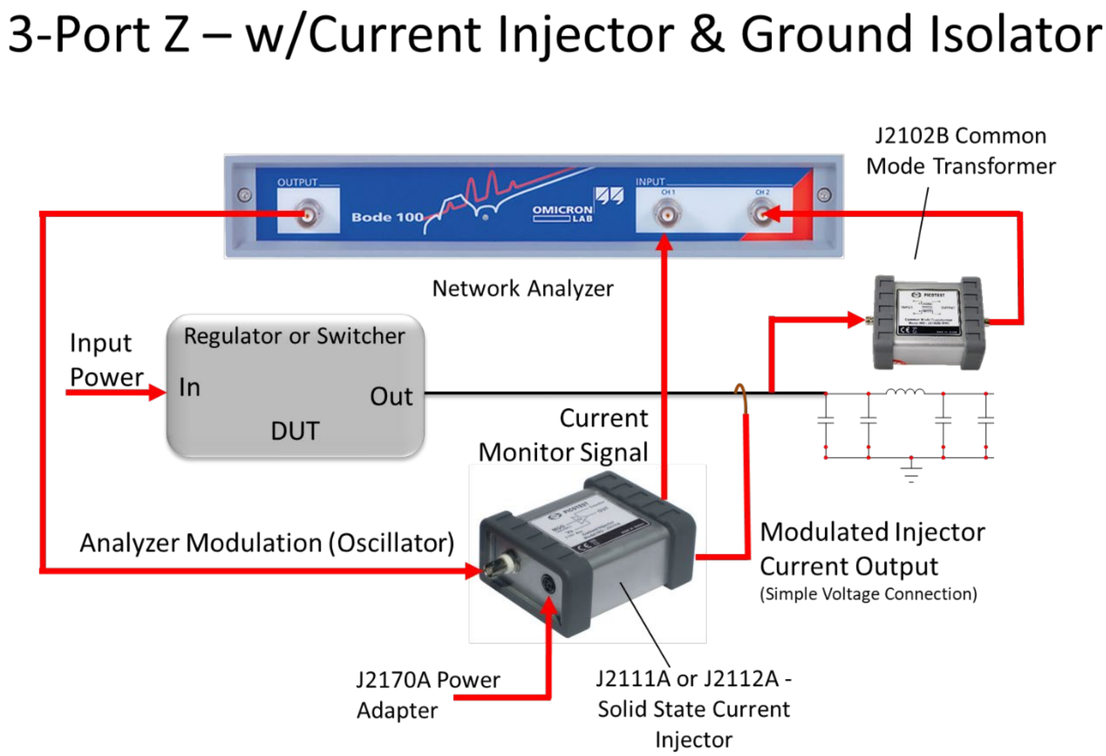
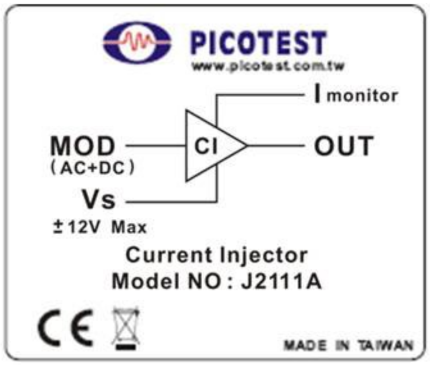


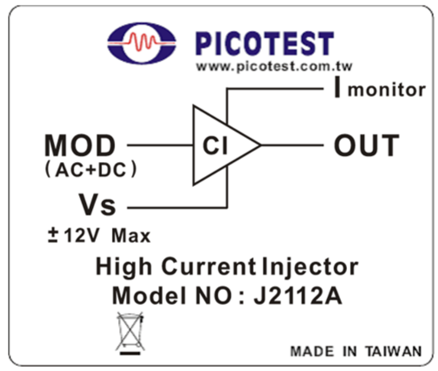
Figure 26: Current Injector Connections for output impedance measurements including ground loop isolator.

There are some drawbacks to the 3-port test setup. The J2111B current injector (3-port) method works in a pinch, and for higher power supply output voltages, but with lack of calibration support, inability to measure the OFF-state impedance, and lower maximum frequency the 2-port shunt-through is superior in almost every way.

If this method is needed, Picotest's suite of products, including the J2111B Current Injector and NISM software, provides electronic engineers with a powerful and integrated solution for 3-port impedance testing. By combining precision current injection, high-fidelity signal amplification, and comprehensive stability analysis, these tools enable accurate and reliable impedance measurements. This integrated approach not only enhances the accuracy of the testing process but also provides valuable insights into the stability and performance of electronic systems, ultimately leading to better design and optimized performance.

Technical Specifications





Characteristic	J2111B Rating	J2112A Rating
Max input voltage DC+AC	+/-5V	+5V
Maximum Output Current	+/-74mA	+1A
Minimum Output Current	0A	24mA
Minimum Output Voltage	+/- 1.5V	+1.5V
Absolute Output Voltage Requirements	-60V to -1.5V and +1.5V to +60V	10V
Current Monitor	1V/A	0.1V/A
Modulator Gain	10mA/V	200mA/V
Offset Current (typical)	+/-24mA	+240mA
Usable Bandwidth	DC-40MHz	DC-40MHz
Temperature range	0-50°C	0-50°C
Maximum Altitude	6000 Ft	6000 Ft
Absolute Maximum Voltage	<40V (DC + AC)	<50V (DC + AC)

Note: The J2111B increases the allowable voltage to -60V to -1.5V and +1.5V to +60V and improves thermal design over the J2111A. The J2112A should be kept to lower duty cycles as the voltage rises in order to reduce power dissipation within the unit.

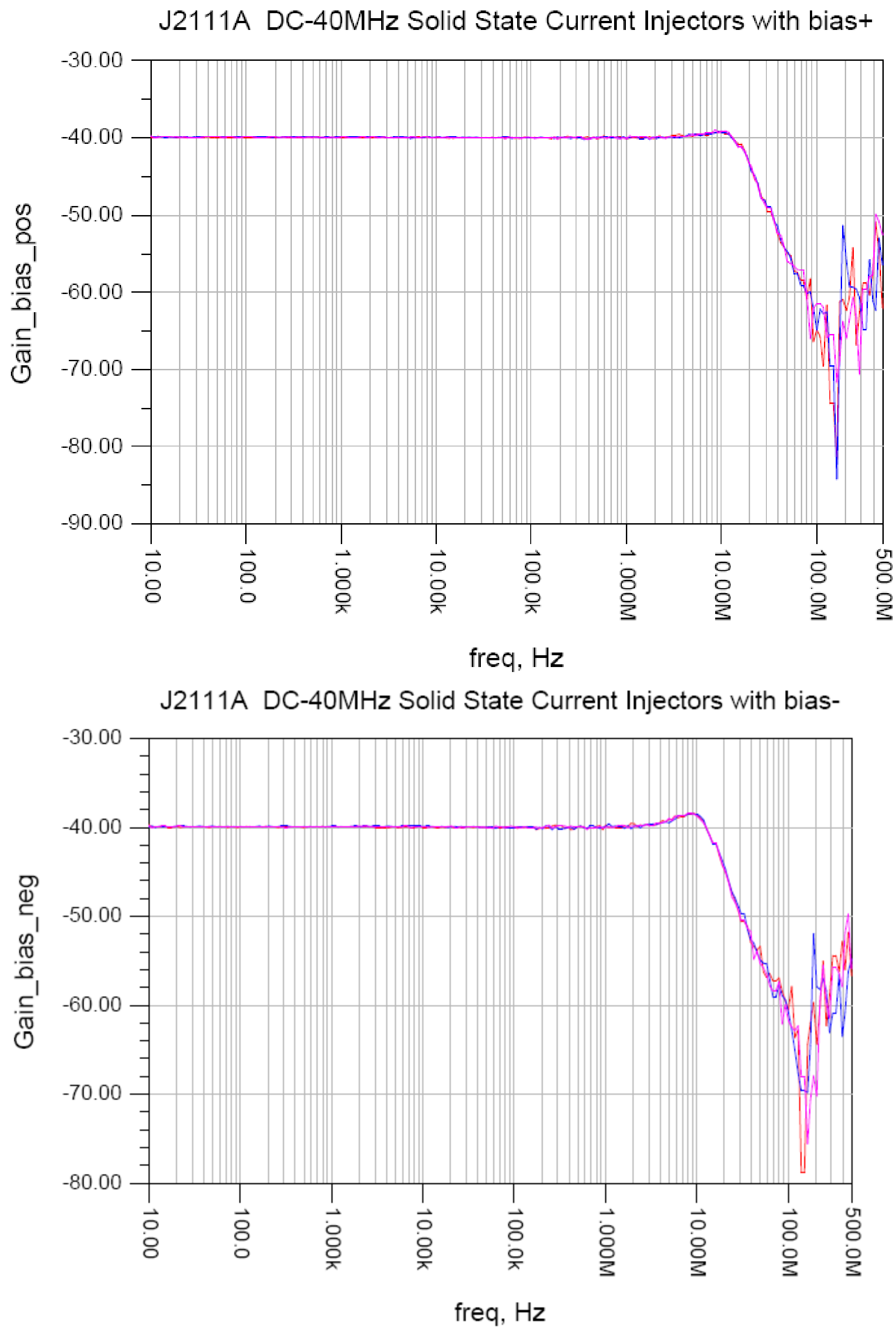


Figure 27: J2111A/J2111B frequency response. The J2111A and B have similar responses.

J2171A High PSRR Regulated Adapter (Power Supply)

Main Features

J2171A Power Supply for Picotest powered injectors

- Universal input voltage 100V-240V
- +/-12V 200mA output
- Very low output impedance
- Very low noise
- Ultra-high PSRR

Description

The J2171A power adapter is specially designed for use with the Picotest J2110A, J2111B and other signal injector products. The supply combines a universal worldwide input (100 to 240 VAC) with two high performance linear regulators.

While there are many off-the-shelf power supplies available that can provide a universal input voltage and 12V output voltage, they do not provide the same performance as the J2171A. Most switching regulators produce significant ripple at and above 100kHz. This ripple passes through the PSRR of the internal opamps, reducing the noise floor. While this may work in many applications, it is less than ideal. Typical switching power supplies and even typical linear regulators have a high output impedance at 40MHz, due to the ESL of the output capacitors and the nature of the control loop.

The J2171A uses a discrete design approach, offering very low output impedance, stable performance with large ceramic decoupling capacitors and ultra-high PSRR compared with typical off-the-shelf devices. To maintain a good noise floor for various measurements, the power supply must have very low noise.

Characteristic	Rating	Conditions
Absolute Maximum Input Voltage	240V	60Hz
Output Voltage	+/-12V	
Maximum Icc	200mA	
Temperature range	0-50°C	

Note: The J2171A is a special version of the J2170B with 200mA output current capability to support the J2121A line injector and now the standard in the Picotest product line.

J2140A Attenuators

Main Features

J2140A Attenuator

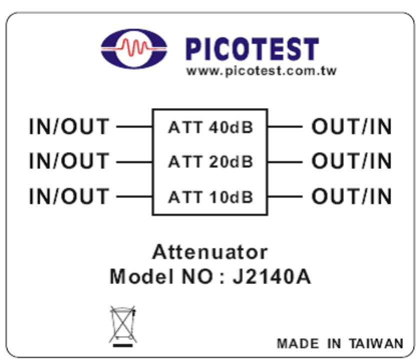
- Integrated unit includes 20dB, 40dB and 60dB
- Cascade for greater attenuation
- Improve noise floor or assure small signal measurement

Description

There are two common uses for attenuators when used in conjunction with the network analyzer. One is to attenuate the oscillator source signal. While this may seem odd, one of the most common errors in analyzer measurements is using a source signal that is too large. Even though the analyzer allows setting of the signal output amplitude, the lowest setting is often too high to allow an accurate small-signal measurement to be made. The correct amplitude is the smallest amplitude that exceeds the noise floor.

Attenuators are also useful for improving the dynamic range of the measurement. In some cases, as in measuring the open loop gain of an opamp as one example, the low frequency loop gain will be extremely large (100dB or more is not uncommon). Attenuating the output signal increases the effective range of the measurement.

Technical Specifications



Characteristic	Rating
Maximum input level	+20dBm
3dB Frequency Range	DC-100MHz
Maximum VSWR	1.3
Attenuation accuracy	0.2 dB
Absolute Maximum Voltage	<50 VAC and 75VDC

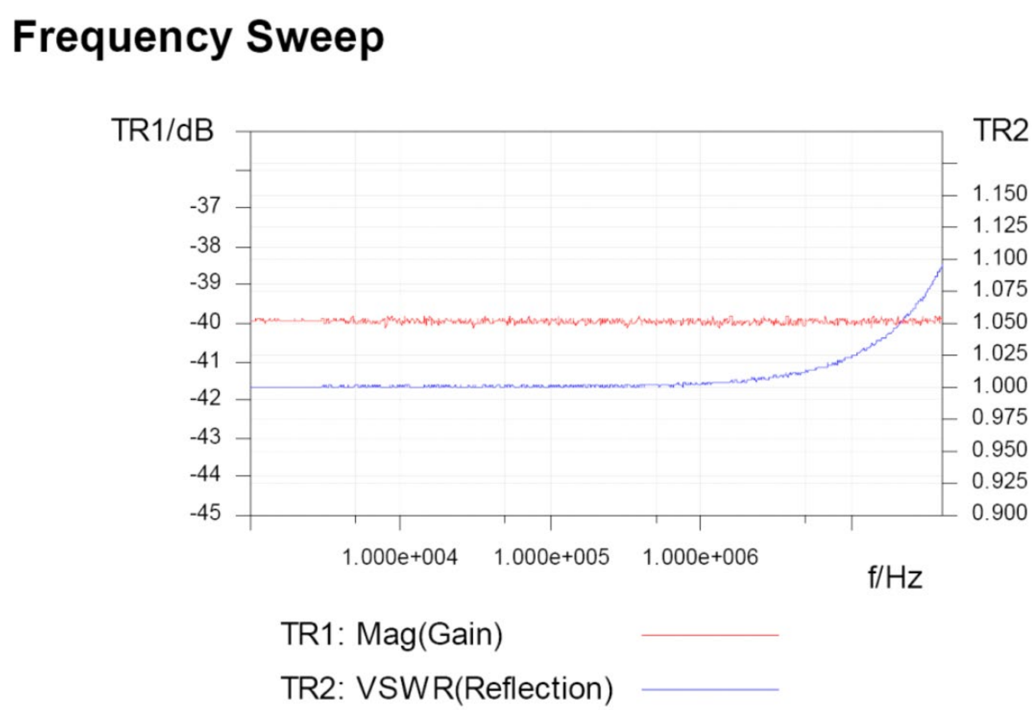


Figure 28: 40dB attenuator frequency response.

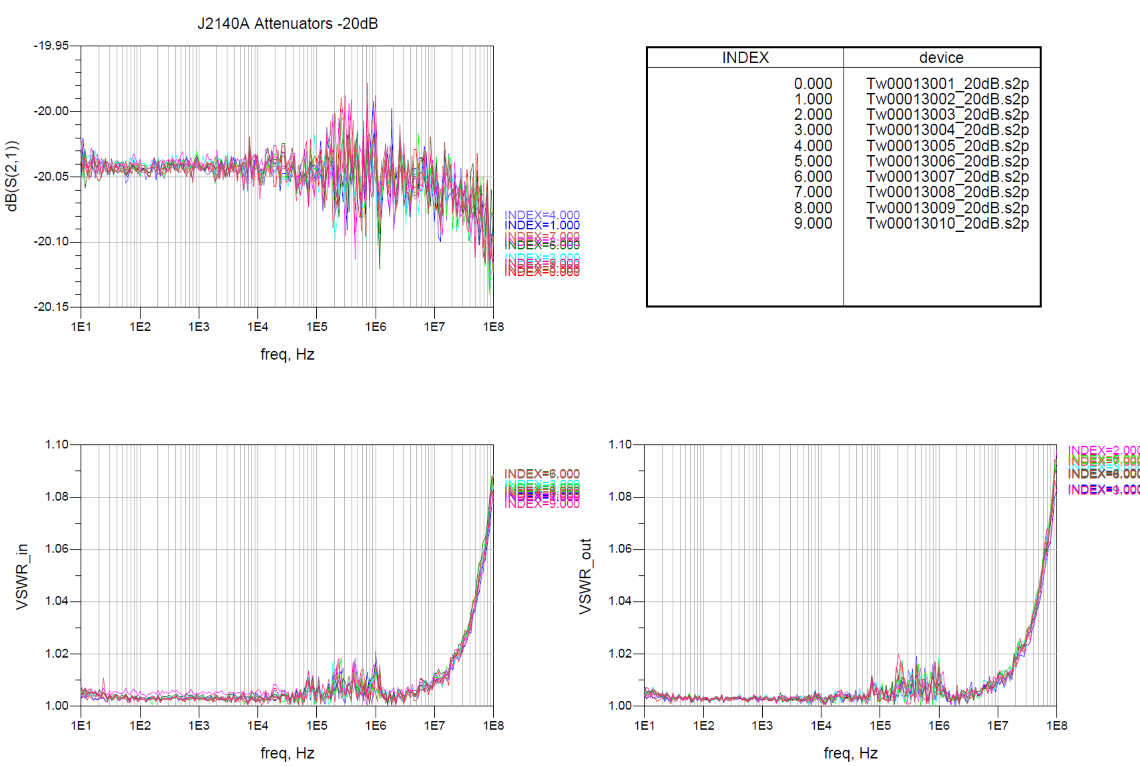


Figure 29: J2140A S21 and VSWR frequency response.

J2180A, J2180A-20, and J2181A Ultra Low Noise Preamps

Main Features

J2180A and J2180A-20 Ultra Low Noise Preamps

- Works with all oscilloscopes, spectrum analyzers and network analyzers
- Active DC bias loop maintains low DC output voltage
- High input impedance compatible with typical probes minimizes circuit loading
- Ultra-low noise
- Works with near field probes for EMI troubleshooting
- Improves effective noise floor and spurious response
- Very wide bandwidth (0.1Hz – 100MHz, J2180A), (20Hz – 100MHz, J2180A-20
- Compatible with J2171A power supply

J2181A 10Hz to 1MHz 60dB Ultra Low Noise Preamp

- Increased Gain
- Works with all oscilloscopes, spectrum analyzers and network analyzers
- Active DC bias loop maintains low DC output voltage
- High input impedance compatible with typical probes minimizes circuit loading
- Ultra-low noise. 1.5nV/rt_Hz
- Works with near field probes for EMI troubleshooting
- Improves effective noise floor and spurious response
- Wide bandwidth (10Hz – 1MHz)
- Compatible with J2171A power supply

Description

The J2180A low noise preamplifier provides a fixed, AC coupled 20dB gain while converting a 1 MOhm input impedance to a 50 Ohm output impedance. With a 3dB bandwidth of 0.1Hz to 100MHz, the preamplifier improves the sensitivity of oscilloscopes, network analyzers and spectrum analyzers while reducing the effective noise floor and spurious response. The preamplifier can also serve as a low frequency DC blocker for a spectrum analyzer or use it to connect a high input impedance oscilloscope probe to 50 Ohm equipment. The J2180A preamplifier offers very low noise, fast 100V/uS slew rate for pulse applications and very low distortion for audio applications. A typical noise plot shows the noise is 2.4nV/rt_Hz. The J2180A-20 is about 1/3rd the noise of the J2180A (as measured over a 10s timeframe, 8mVrms/J2180A vs. 2.3mVrms/J2180A-20 output referred).

The J2181A is a low noise preamplifier that provides a fixed, AC-coupled 60dB gain while converting a 1 MOhm input impedance to a 50 Ohm output impedance. With a 3dB bandwidth of 10Hz to 1MHz, the preamplifier improves the sensitivity of oscilloscopes, network analyzers, and spectrum analyzers, while reducing the effective noise floor and spurious response. The J2181A includes wrap-around high-permeability shielding to reduce susceptibility to ambient noise. The preamplifier also serves as a low-frequency DC blocker (6.3V) for a spectrum analyzer or you can use it to connect a high-input impedance oscilloscope probe to 50 Ohm equipment. The J2181A preamplifier offers very low noise, fast 100V/uS slew rate for ultra-low noise measurement for PLL, LNA, ADC power rails, and ultra-low noise voltage references and regulators, using an oscilloscope or spectrum analyzer. A typical noise plot shows the noise is 1.5nV/rt_Hz.

Connecting the Preamp: EMI and Noise Measurements

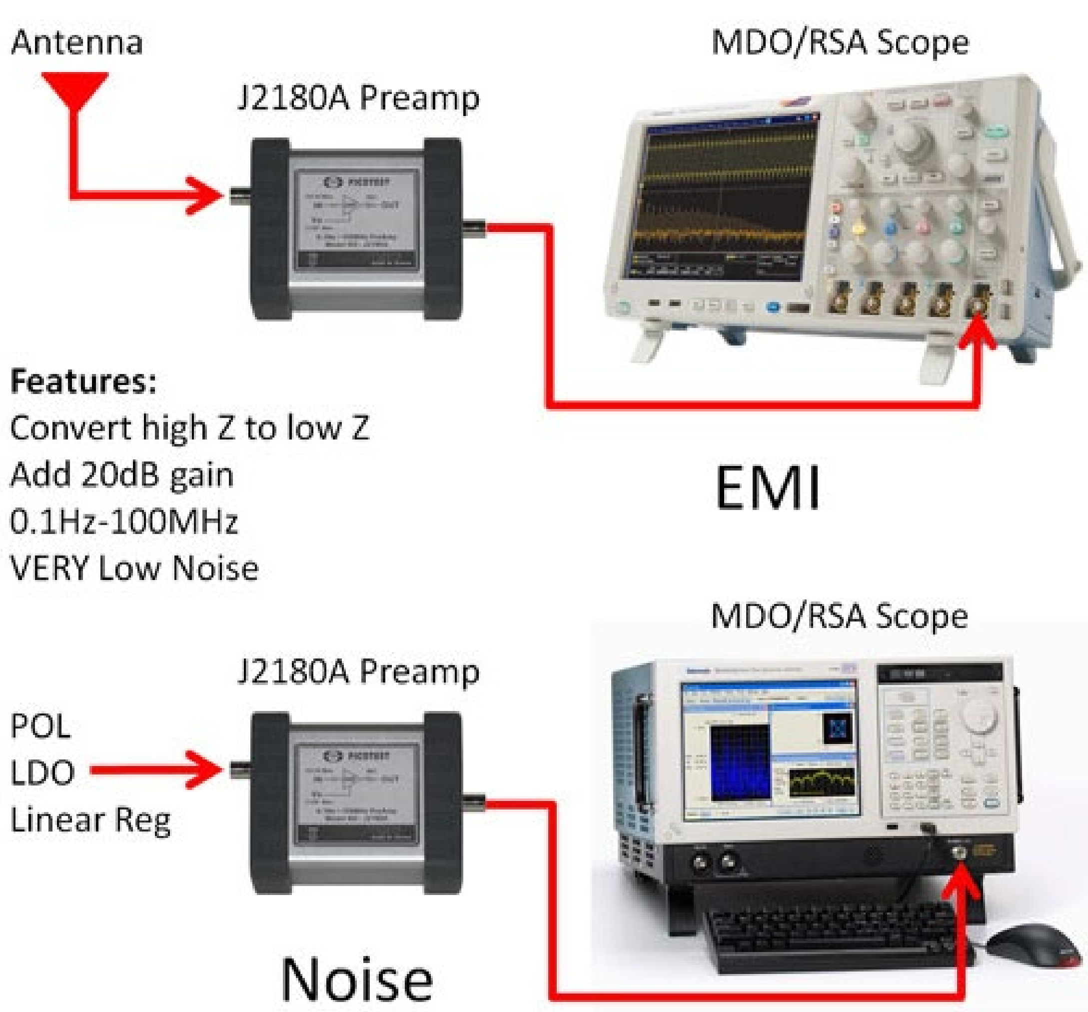
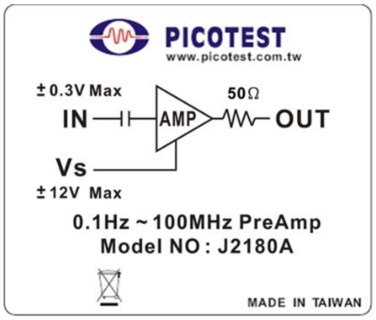


Figure 30: Sample setups for the J2180A Preamp used for noise and EMI measurements.

Technical Specifications



J2180A

Characteristic	Rating	Rating
Maximum Vcc	+/-12	V
Maximum Icc	20	mA
Max Operating DC Input Voltage	50	VDC
Max DC Input Surge	60	Vpk
Ac Input Voltage Range	+/-0.38	V
Output Voltage	3.0	Vpp
Input Impedance	1MegOhm ||10pF	ohms
Output Impedance	50	ohms
Vs Power Supply Range	+/-12	V
-3dB Bandwidth	0.1 – 100M	Hz
Gain	20 (26 without termination)	dB
Gain Accuracy/Flatness	within +/- 0.5	dB
Temperature Range	0-50	C
Maximum Altitude	6000	Ft
Absolute Maximum Voltage	< 50VAC and 75VDC	
Maximum Vcc	+/-12	V

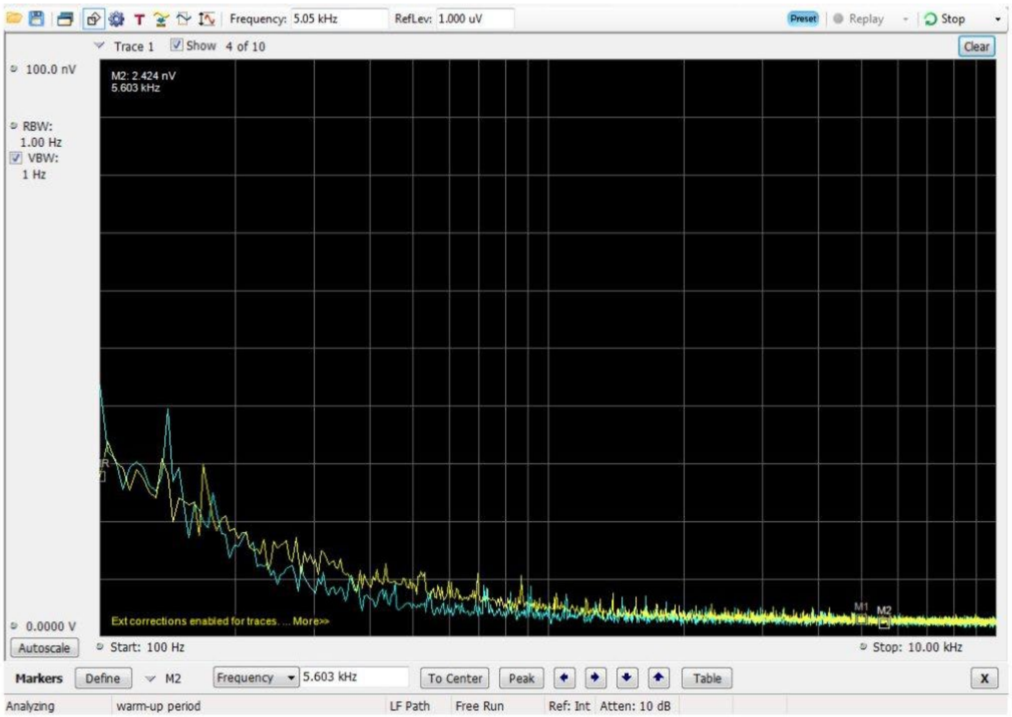


Figure 31: Input referred Noise Density 100nV full scale, mid-range noise density is 2nV/Root-Hz.

J2180A-20

Characteristic	Rating	Rating
Maximum Vcc	+/-12	V
Maximum Icc	20	mA
Max Operating DC Input Voltage	50	VDC
Max DC Input Surge	60	Vpk
Ac Input Voltage Range	+/-0.38	V
Output Voltage	3.0	Vpp
Input Impedance	1MegOhm ||10pF	ohms
Output Impedance	50	ohms
Vs Power Supply Range	+/-12	V
-3dB Bandwidth	**20 – 100M**	Hz
Gain	20 (26 without termination)	dB
Gain Accuracy/Flatness	within +/- 0.5	dB
Temperature Range	0-50	C
Maximum Altitude	6000	Ft
Absolute Maximum Voltage	< 50VAC and 75VDC	
Maximum Vcc	+/-12	V

J2181A

Characteristic	Rating	Rating
AC Input Voltage Range	6mV	Vpp
Output Voltage	3.0	Vpp
Noise	1.5n	V/rt-Hz
DC Block	Bi-directional 20V	V
Input Impedance	AC=100Ohms+ 195uF DC=200kOhms	Ohms
Output Impedance	50	Ohms
-3dB Bandwidth	10-1M	Hz
Gain	60	dB
Gain Accuracy/Flatness	within +/- 0.5	dB
Temperature Range	0-50	C
Maximum Altitude	6000	Ft
Absolute Maximum Voltage	< 50VAC and 75VDC	

J2190A 0.1Hz to 10Hz Active Filter

Main Features

J2190A 0.1Hz to 10Hz Active Filter

- 0.1Hz to 10Hz 4th Order Filter
- Ultra-low noise
- Cascadable with additional filters
- Compatible with J2171A power supply

Description

The J2190A active filter presents a high impedance (approximately 150 kOhms) minimizing the loading of the circuit being tested. The output impedance is 50 Ohms allowing low noise coaxial connections to all typical test equipment. The 0.1Hz-10Hz noise band is common for opamp measurements, voltage regulators and voltage references. Many application notes offer schematics of such a filter for test purposes. An engineer's time is much too valuable to be spent building test equipment. We have created a 4th order high pass and 4th order low pass filter with an optimally flat response and 0dB gain. Additional filters can be cascaded for even sharper cutoff.

The J2190A is not a programmable filter, though it is easily customizable to a particular noise bandwidth and/or circuit gain.

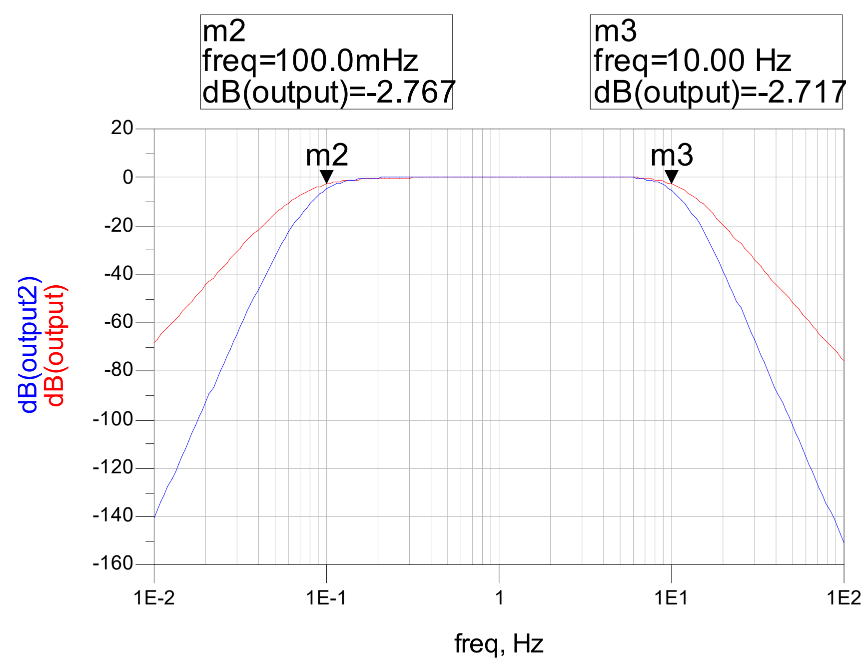
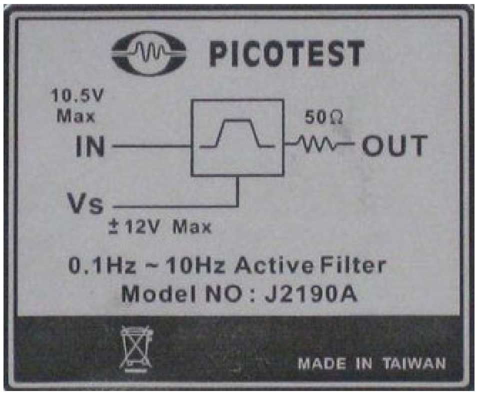


Figure 32: Frequency response of a single filter (red trace) and 2 cascaded filters (blue trace).



Characteristic	Rating
Gain	0 dB
Noise	
Input Impedance	1 MOhm
Output Impedance	50 Ohms
3dB Bandwidth	0.1Hz – 10Hz
Temperature Range	0 – 50C
Maximum Altitude	6000
Absolute Maximum Voltage	<50 VAC and 75VDC

J2102B Common Mode Transformer

Main Features

- Greatly attenuates the effects of low frequency ground loops
- Supports the 2 Port shunt-through impedance measurement required for Power Distribution Networks (PDNs)
- Maintains 50 Ohm transmission line integrity from 1Hz to beyond 6GHz
- Works with all types of test equipment to eliminate ground loops, such as Network Analyzers, Oscilloscopes and Spectrum Analyzers

Description

It is difficult for conventional low frequency network analyzers with grounded receivers to measure a mΩ shunt impedance in the low-frequency range, because the measurement error is caused by the test cable ground loop between the source and receiver. Generally, this problem occurs in the low-frequency range below 100 kHz, which is an essential frequency range for evaluating the impedance of DC-DC converters and bulk bypass capacitors. The simplest and most effective solution for eliminating a ground loop is to add a wideband common mode transformer to the measurement, such as the Picotest J2102B Common Mode Transformer. The transformer for a low impedance PDN measurement must have very wide bandwidth, low loss and tight coupling; otherwise, the results will not be accurate over the measured frequency range. It is also important to maintain the 50 Ohm transmission line impedance through this transformer. The J2102B accomplishes this.

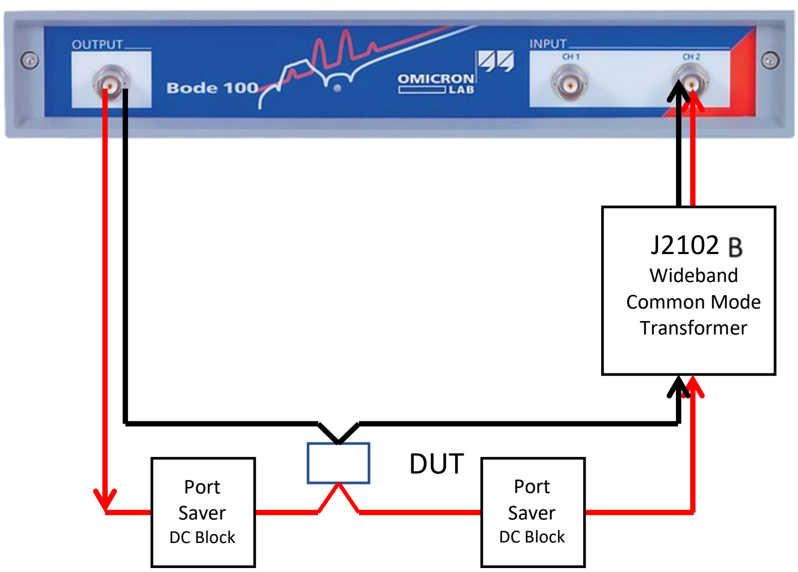


Figure 33: Connection diagram showing the placement of the J2102B common mode transformer. Inclusion of the transformer eliminates the low frequency distortion caused by instrumentation ground loops. The Port Saver DC blocks are only necessary when voltages greater than the Bode 100/500 VNA input voltage derated limits are exceeded.

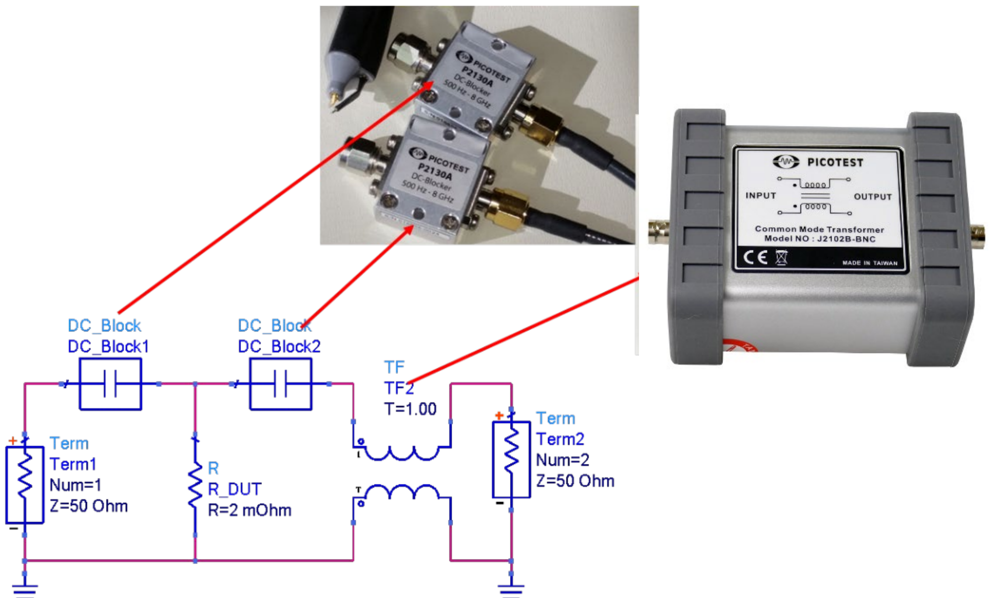


Figure 34: Electrical connection diagram showing the placement of the J2102B and Port Saver DC blockers for a 2-port shunt impedance measurement.

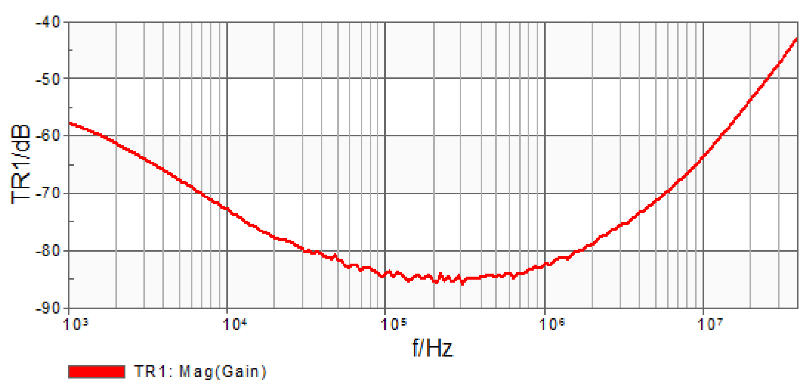


Figure 35: Common Mode Frequency response of the J2102B.

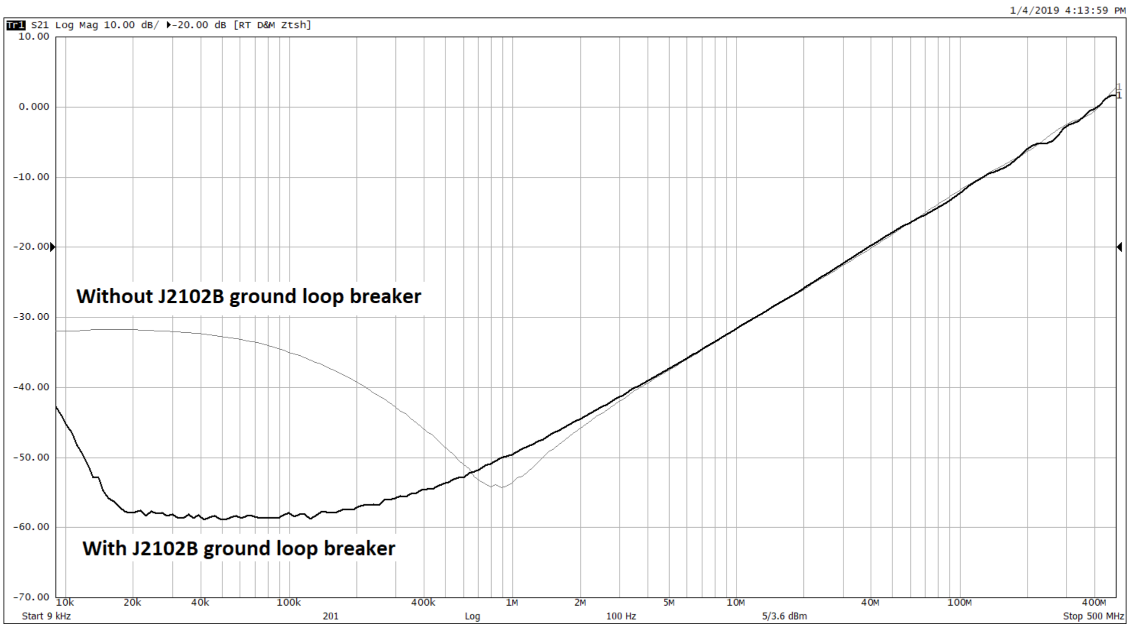


Figure 36: Impedance measurement of a 1mΩ resistor with and without the J2102B common mode transformer using the Copper Mountain S5065 VNA.

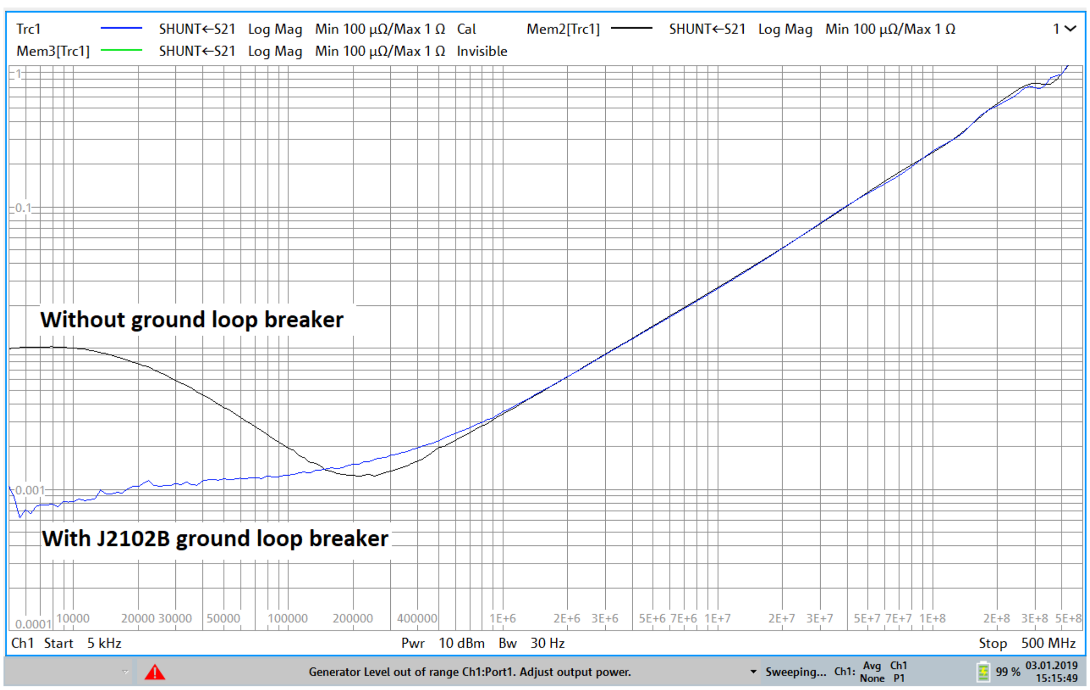


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Figure 37: Impedance measurement of a 1mΩ resistor with and without the J2102B common mode transformer using the Rohde & Schwarz ZNL VNA.

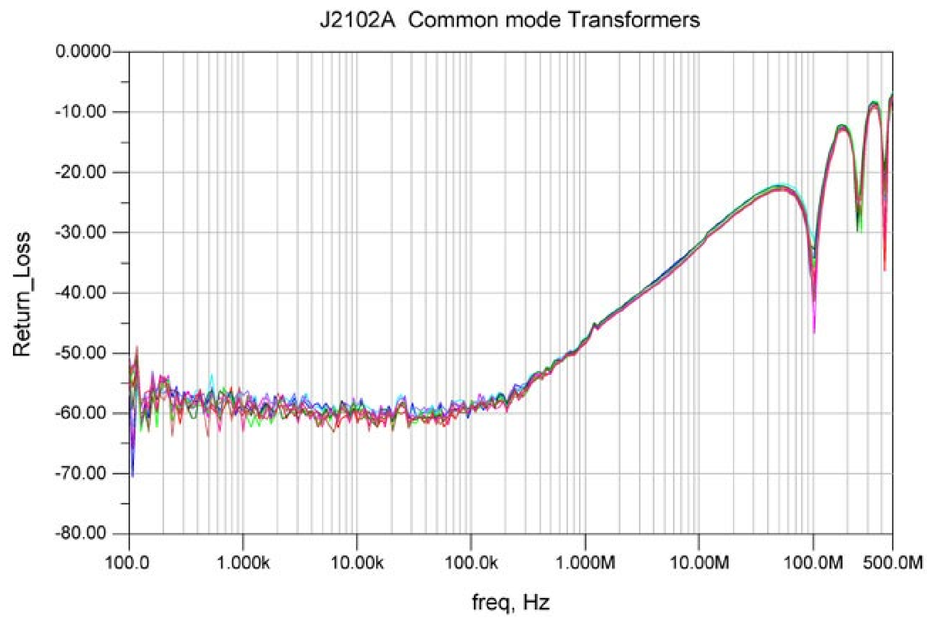
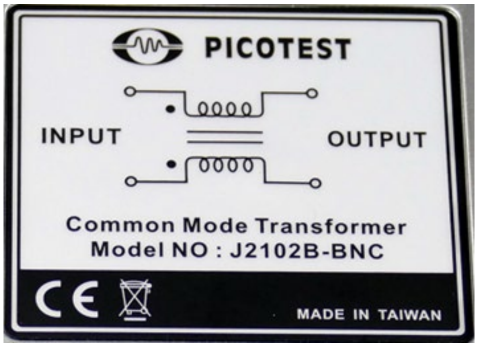
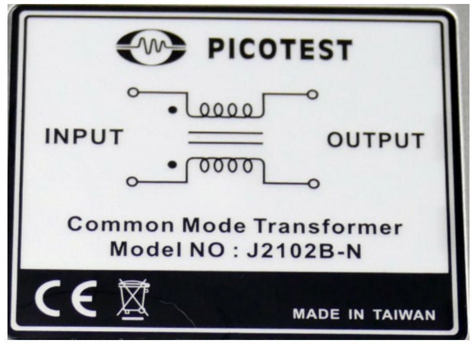


Figure 38: J2102B Return Loss Graph.

Figure 39: J2102B Insertion Loss Graph.

Technical Specifications





Characteristic	Rating
3dB Bandwidth	1Hz-6GHz
Insertion Loss	TBD
Return Loss	TBD
Maximum Voltage	50V
Temperature Range	0-50C
Maximum Altitude	6000 Ft
Absolute Maximum Voltage	< 50VAC and 75VDC

J2113A Semi-Floating Differential Amplifier

Main Features

- Eliminates DC ground loop down to DC
- Works up to ~800MHz (-3dB)
- Supports the 2-port shunt-through impedance measurement required for Power Distribution Networks (PDNs)
- Works with all types of test equipment to eliminate ground loops, such as Network Analyzers, Oscilloscopes and Spectrum Analyzers
- Popular for oscilloscopes - isolate probe grounds - J2113A is optimized for pulse response
- Perfect for component measurements
- Excellent CMRR performance
- Works in applications where the input voltage is < 1.9V

Description

The 2-Port Shunt-Through impedance measurement is the Gold Standard for PDN testing and Power Integrity assurance. Power Integrity assessment and optimization is an essential element in today's designs. It is critical that power supplies, printed circuit boards, and decoupling be properly designed to achieve flat impedance goals. Commonly applied "Rules-of-thumb" generally don't work well in high-speed circuits or other sensitive applications. Design assurance, optimization and troubleshooting all require accurate low impedance measurements. Whether modeling components, testing power supply output impedance, assessing target impedance, or looking to manage PDN resonances, Picotest has a 2-port testing solution available. And the J2113A is essential to removing the ground loops associated with VNAs and Oscilloscopes which occur in many different types of test setups.

For the 2-port shunt-through impedance measurement, either J2102B, J2114A, or the J2113A is essential to maintaining the accuracy of this measurement.

The 2-port measurement requires a Thru calibration. Setup ALL the cabling to the DUT and use a shorting barrel where the component or circuit connections will be made. Note, DC Blocks may be necessary to connect in-line for some powered circuit tests, so the 50 Ohm VNA ports do not load the measurement. If Port Saver DC Blocks are necessary, they, and all other cabling, should be included in the calibration. Place the ground isolator (J2102B) on the Channel 2 side of the measurement. Perform a Thru Calibration. Remove the shorting barrel. Now connect to the DUT and perform the measurement.

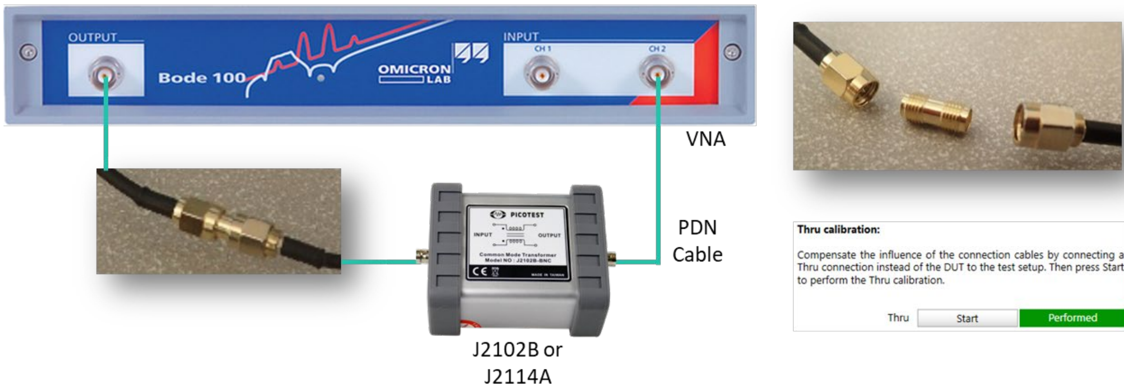


Figure 40: Calibrating the 2-Port Shunt-Through Measurement.

The measurement of low impedances can be difficult due to the limitations of various measurement techniques. The two-port shunt-through method allows the measurement of ultra-low (uOhms to Ohms) impedance values. Limitations introduced due to the resistances of the ground braids of the two cables being in parallel with each other and in series with the DUT can be remedied by using a J2102B common mode transformer, J2114A ground isolator, or the J2113A differential amplifier. This is the test setup for the measurement of most types of passive components.

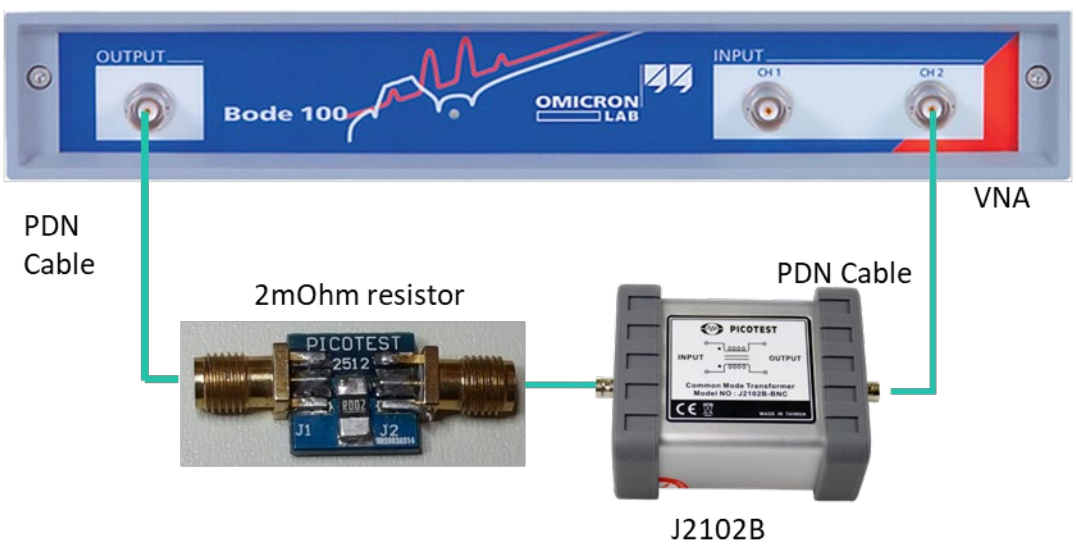


Figure 41: Measuring a low value resistor using Picotest Decoupling Boards in a 2-port configuration. PDN Cable helps minimize measurement errors.

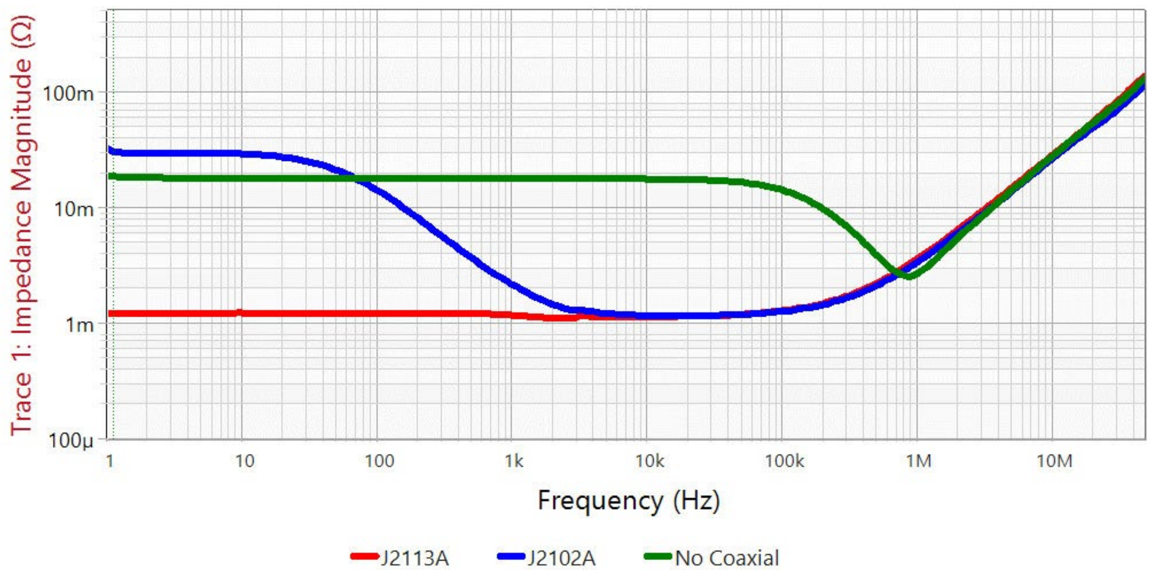


Figure 42: J2113A - J2102B - Comparison Plot. Measurement is of a 1 mOhm resistor with the J2102B (same as J2102A) passive coaxial transformer, the J2113A Semi-Floating Differential Amplifier and with no ground loop breaker at all. The reduction in the error of the measurement is clearly seen.

Shown below is the Picotest P2102A 2-Port Probe. With its multiple head options, browsing multiple board connections to make the 2-port measurement is easy.

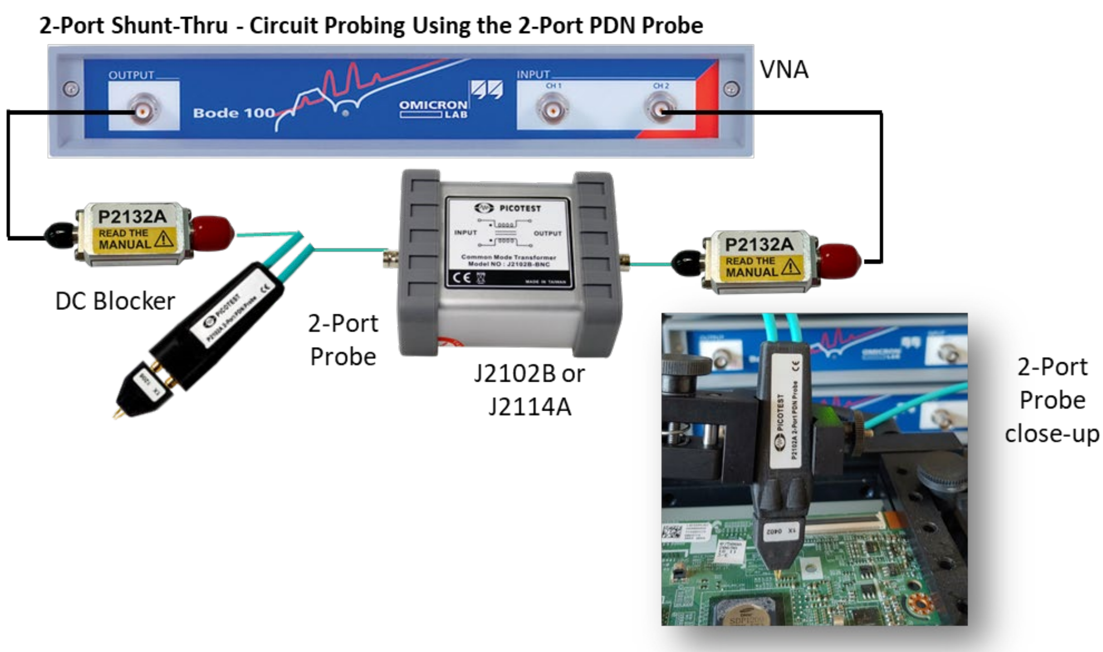


Figure 43: Measuring the in-circuit output impedance using the Picotest P2102A 2-Port Transmission Line Probe.

Two Picotest P2105A 1-Port probes can also be used. This will provide more flexibility with connection pitch and the ability to probe both sides of a PCB.

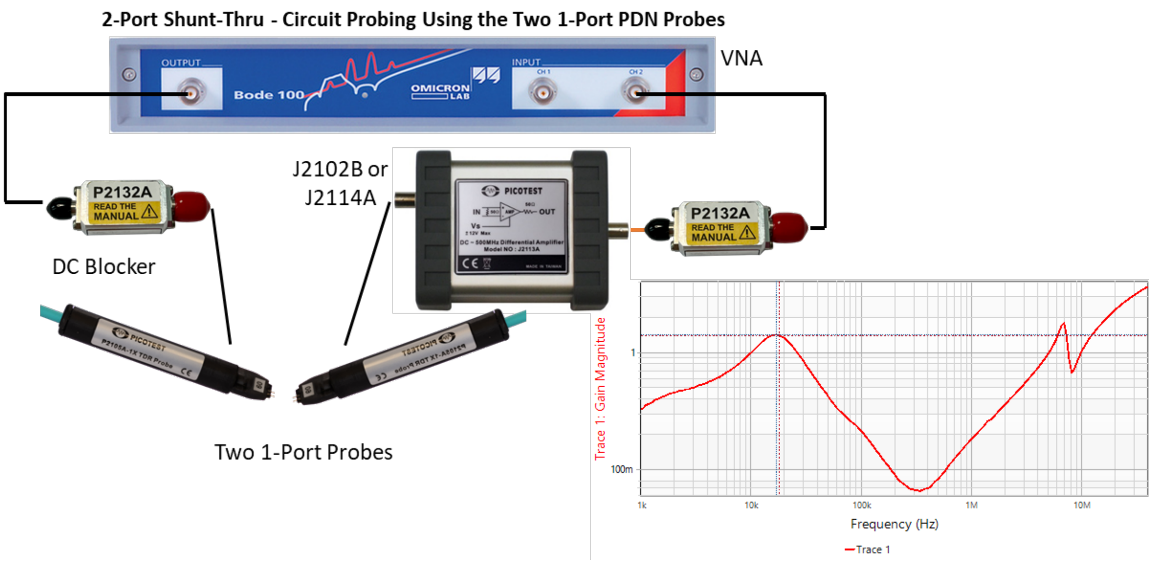


Figure 44: Test setup for measuring the in-circuit output impedance using two 1-Port PDN Probes (P2105A). The J2102B has been replaced by the J2113A.

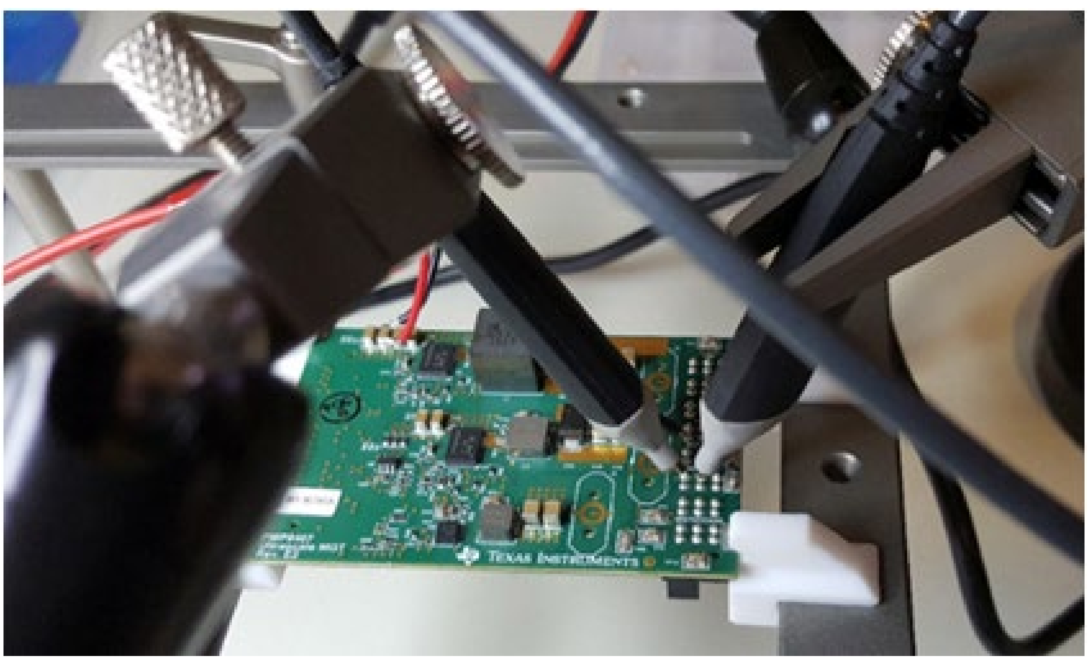


Figure 45: Setup image of the in-circuit 2-port impedance measurement using two 1-Port PDN Probes.

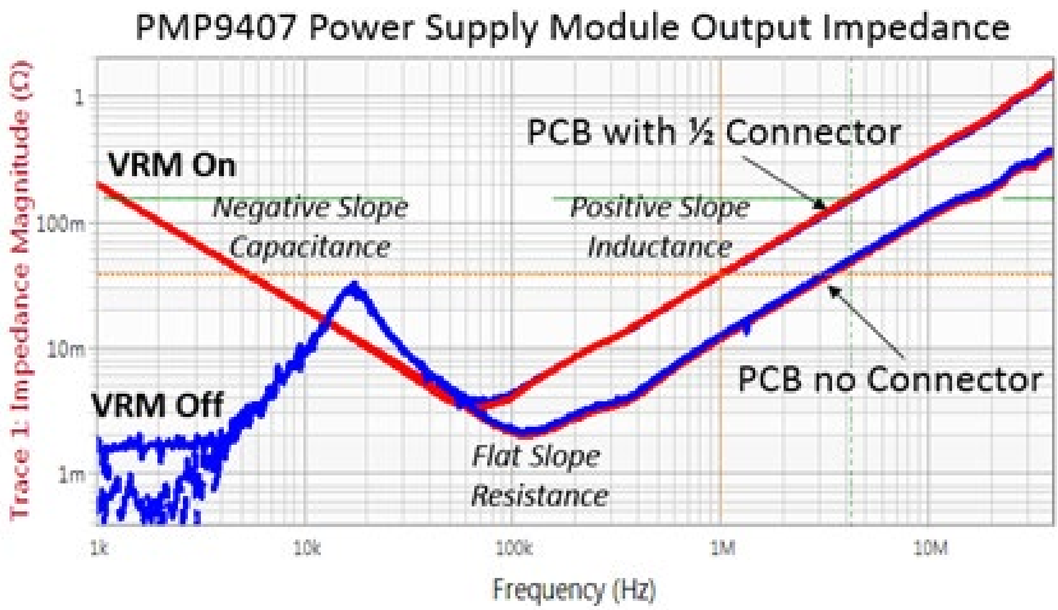
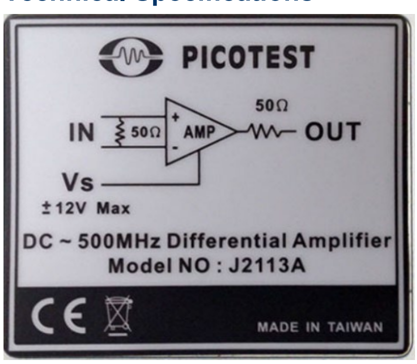


Figure 46: **2-Port shunt-through impedance measurement results using two 1-Port PDN Probes.**

Technical Specifications



Characteristic	Rating
Typical Bandwidth	DC-800 MHz (-3dB), DC-700MHz (-1dB)
Maximum Voltage	1.9V
CMRR (Typical)	57dB
Temperature range	0-50C
Maximum Altitude	6000 Ft
Absolute Maximum Input Voltage	is +/- 2V

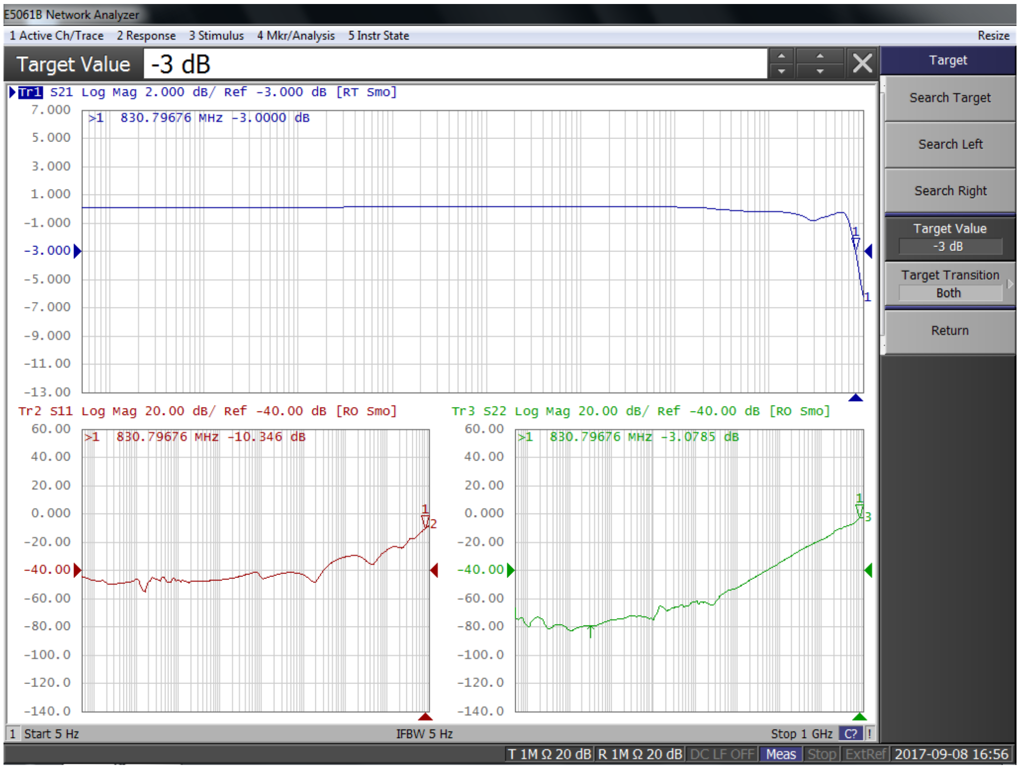


Figure 47: S21, S11, and S22 plots show 3dB S21 -3dB bandwidth @ 830MHz and S22 -6dB bandwidth @ 635 MHz.

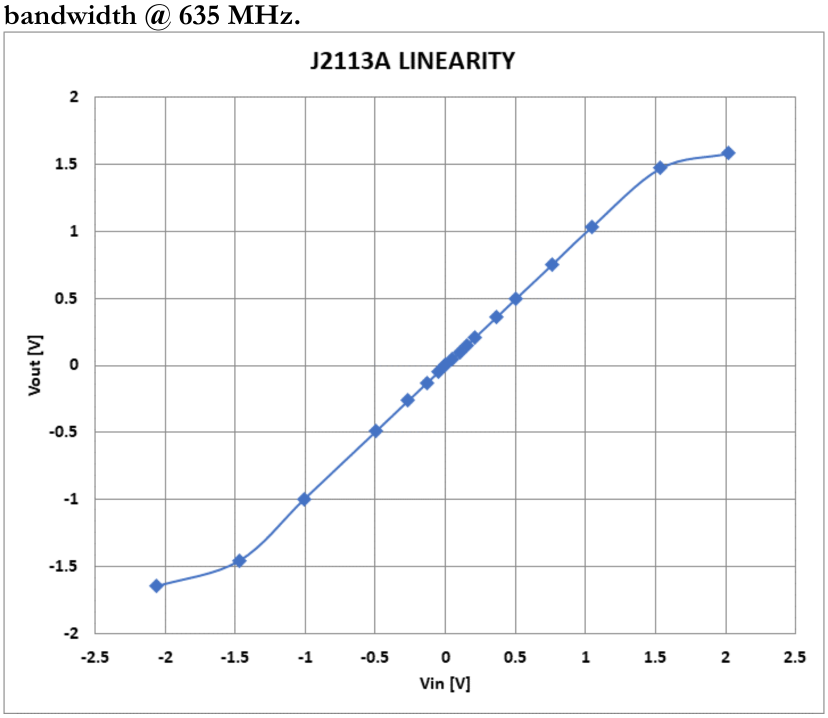


Figure 48: J2113A Linearity Graph.

J2114A High CMRR Isolation Amplifier

Main Features

- Eliminates DC ground loop down to DC
- Supports the 2-port shunt-through impedance measurement required for Power Distribution Networks (PDNs)
- Enables measurement of ultra-low (micro-Ohm) impedances
- Greater than 100dB isolation
- Works up to 10MHz
- Works with all types of test equipment to eliminate ground loops, such as Network Analyzers, Oscilloscopes and Spectrum Analyzers
- Popular for oscilloscopes – isolate probe grounds – J2114A is optimized for pulse response
- Excellent CMRR performance

Description

The J2114A is a solid-state high CMRR (> 100dB) Amplifier or ground loop isolator, that provides the BEST isolation for low impedance measurements. The J2114A removes the groups loops associated with VNAs and Oscilloscopes which occur in many different types of test setups. The J2114A's frequency response, as shown below, is flat from DC to over 10MHz, all while maintaining 50 Ohm impedance at both the input and the output for accurate, low-noise measurements. It allows measurements both lower and higher in frequency than what is achievable with a Common Mode Transformer. The J2114A supports ultra-low power distribution network (PDN) impedance measurement, component measurement, PSRR testing, and many other applications. The J2114A is USB-powered and internally has a +/-12V isolated DC/DC converter. The input voltage range is approximately +/-10V without attenuating probes or DC blocks.

Figure 49: The J2114A is connected like the J2102B in the 2-port shunt-through setup (as close to Port 2 as possible). Inclusion of the transformer eliminates the low frequency distortion caused by instrumentation ground loops.

Figure 50: The J2114A is powered by a USB connection and comes with PDN Cable.

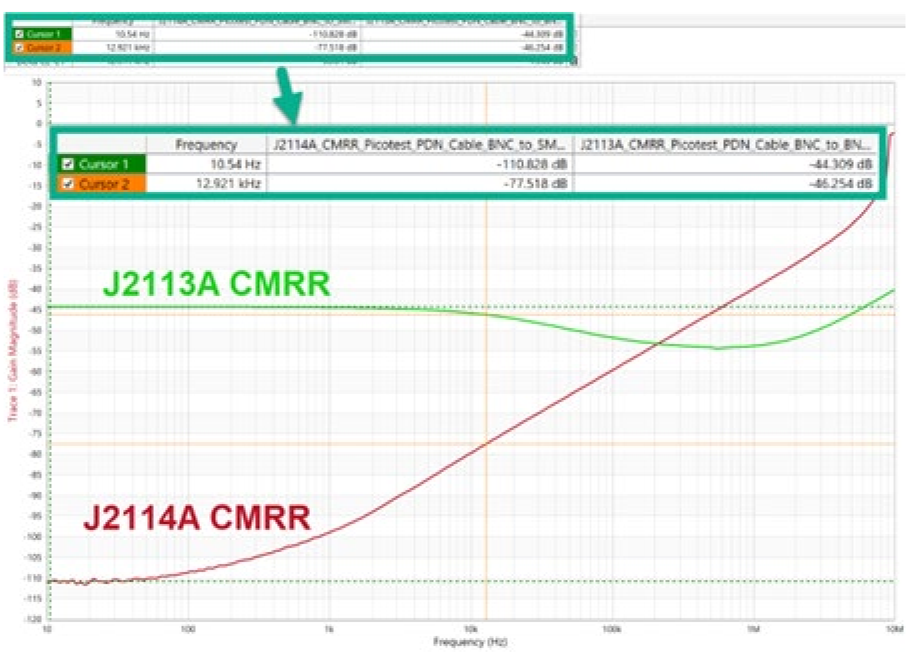


Figure 51: Frequency response of the Common Mode Rejection for the J2113A and J2114A shows how much more CMRR the J2114A possesses, necessary for ultra-low impedance testing.

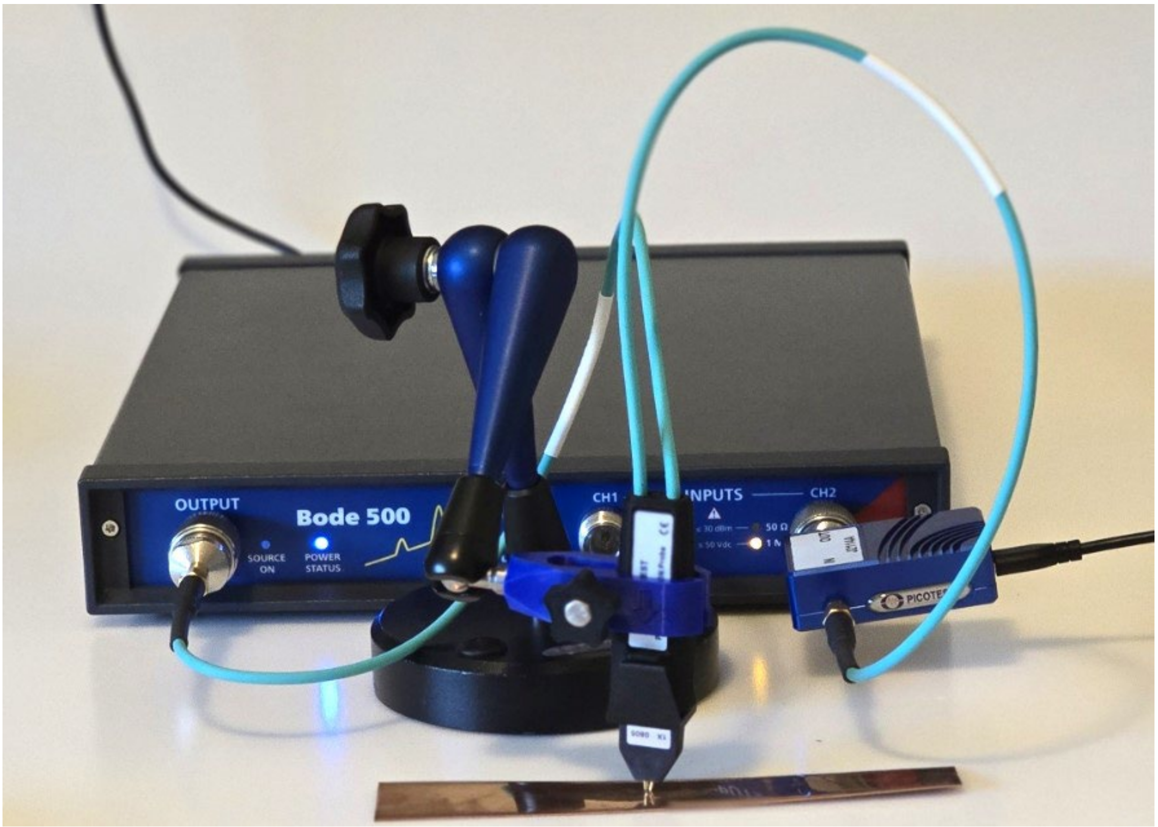


Figure 52: 2-port impedance measurement with the P2102A probe, J2114A, and the Bode 500 VNA.

Technical Specifications

Characteristic	Rating
Recommended Bandwidth	DC-10 MHz
Maximum Voltage	Common mode + differential is 9.5V max
Maximum Voltage Differential	Differential mode is 7.07 Vrms max 9.5Vpk
CMRR	> > 100dB
Temperature Range	0-50C
Maximum Altitude	6000 Ft

J2115A Probe Coaxial Isolator

Benefits

- Greatly attenuates errors associated with the ground loop in oscilloscope measurements
- Improves the accuracy of power rail probes
- Reduces cable shield induced ground loop errors regardless of the test setup
- Easy to add multiple J2115A for as many channels as are needed in a test setup

Main Features

- Works with all power rail probes
- Small form factor fits easily into the test setup
- No adjustments necessary
- Maintains 50 Ohm transmission line integrity and signal bandwidth to > 2GHz
- Works with all types of test equipment to eliminate ground loops, such as Network Analyzers, Oscilloscopes and Spectrum Analyzers

Description

The Picotest Probe Coaxial Isolator is a common mode transformer that minimizes the ground loop in power rail and other forms of voltage probe measurements that exist in all oscilloscopes, and other instrument setups.

There is a ground loop created due to the front panel of the instrument and the cable connections at the device under test (DUT). This front panel ground appears across the various scope input channels. Offsets in this ground voltage at the DUT translate to voltage inaccuracies in oscilloscope measurements. The common mode ground signal at the DUT is additive with the desired test signal, and it needs to be diminished and/or effectively eliminated. It can result in mV to tens or even hundreds of mV of measurement offset.

The J2115A Probe Coaxial Isolator is a simple fix for the impacts of the ground loop. The J2115A is essential to achieving the most accurate oscilloscope measurements, especially power rail probe measurements and other voltage probe measurements.

Ground loop errors mostly impact sensitive circuits, such as PLLs or LNAs, but also create VDD droop and ground bounce errors in high power ASIC cores. These ground loops occur when two or more cable shields are connected to "ground" at both ends, with voltage differences between the ground shields at the DUT. There are several papers on the subject (see Application Notes section), but there are a few ways to manage the ground loops:

There are several papers on the subject shown below, but there are a few ways to manage the ground loops:

1. Reduce the ground connection impedance using low shield resistance cable such as PDN cable
2. Make at least the most sensitive channel connection as short as possible
3. Add common mode isolators. This is the most effective solution.

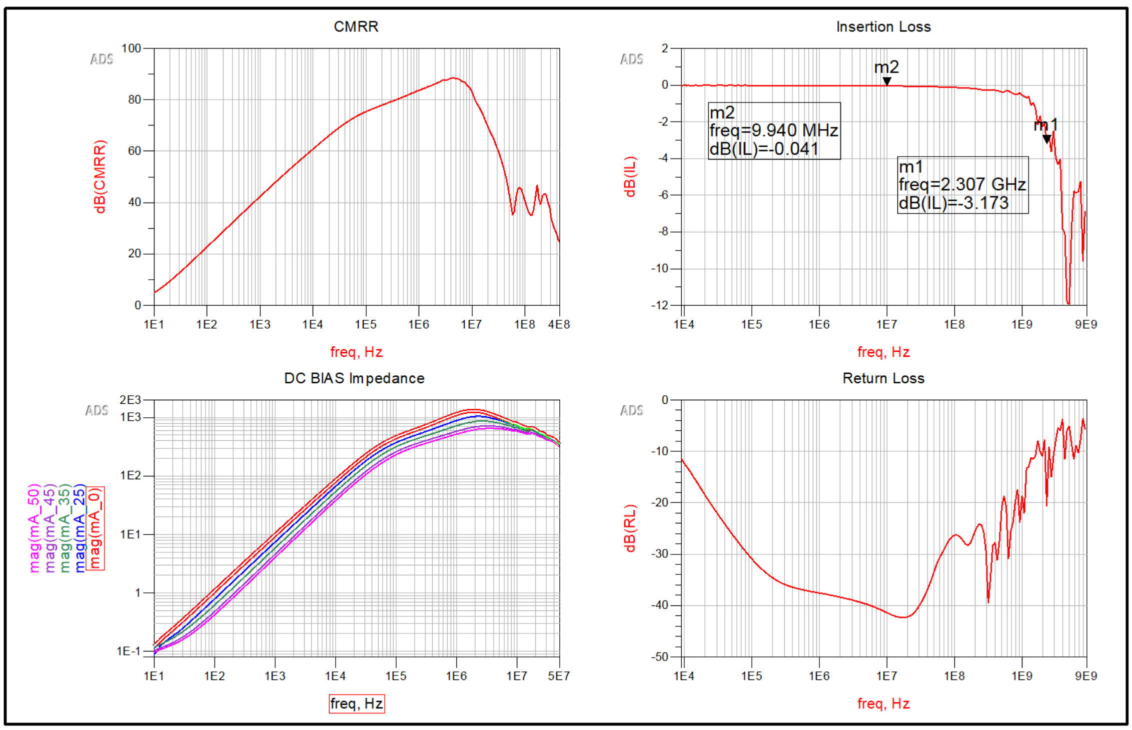


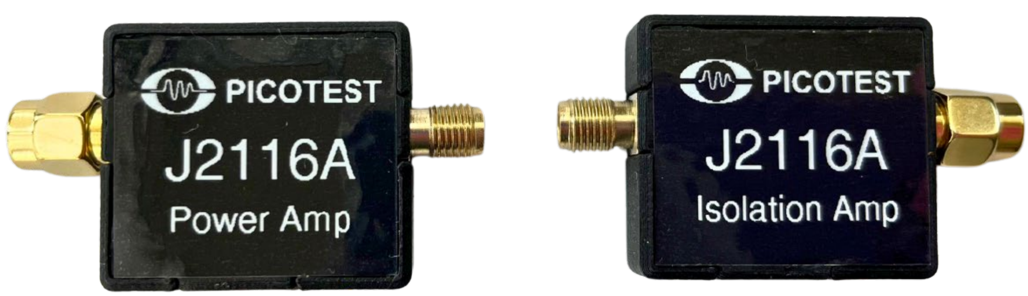
Figure 53: J2115A performance for CMRR, insertion loss, DC bias, and return loss.

Technical Specifications

Characteristic	Rating
3dB Bandwidth	2.2GHz
Insertion Loss 10MHz	0.1dB
CMRR 10kHz	60dB

CMRR 1MHz	80dB
CMRR 10MHz	80dB
GND Saturation Current (50% inductance)	45mA
Ground Resistance	68 mOhm
Signal Resistance	85 mOhm
Insulation Voltage	> 600V
Temperature Range	0-50°C
Maximum Altitude	6000 Ft
Absolute Maximum Voltage	< 50VAC and 75VDC

J2116A Power Amplifier & High CMRR Isolation Amplifier



Benefits

- Combined signal amplifier with high CMRR ground isolator
- +20dBm output / 100dB CMRR
- Supports 2-port shunt through impedance measurement as low as 1uOhm
- Sub-uOhm impedance floor
- Measure crosstalk as low as -150dB

Main Features

- Very flat response for simple de-embedding
- Compact design mounts directly on microprobe heads
- Isolator can run for 100hours on a pair of 9V batteries
- Works with PDN probes
- Small form factor fits easily into the test setup
- No adjustments necessary
- Maintains 50 Ohm transmission line integrity and signal bandwidth to > 2GHz

Description

The J2116A is a combined unit with source power amplifier and ground isolator with up to 22.5dB gain and 100dB CMRR. It is used to improve signal-noise in crosstalk and ultra-low impedance measurements. It achieves +20dBm output with +/-9V power and +22.5dBm with +/-12V power. It works with all popular VNAs including the Keysight E5061B and the OMICRON Lab Bode 500.

The J2116A can be powered from +/-9V - +/-12V using an external power supply or batteries. Power is applied to the unit using connections from a supplied 4-pin Molex connector VEE-GND-GND-VCC (left to right). This is so that an external power supply can be used to power the isolator. SMA connectors are provided to input and output connections.

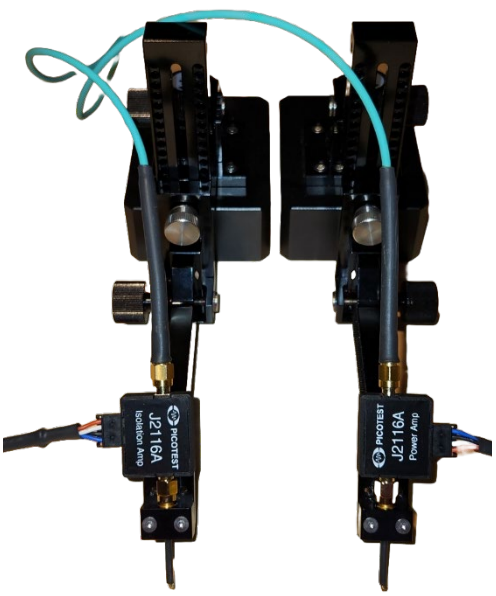


Figure 54: J2116A Isolation Amp and Power Amp shown here connected to a PacketMicro 1-port GHz left and right 1-port probes.

Technical Specifications Source Power Amplifier

General Characteristics	Rating
Frequency Range	DC-140MHz
Gain	20dB
Input signal connector	SMA(F)
Output signal connector	SMA(M)
Input Characteristics	**Rating**
Maximum input signal ±9V	225mVrms
Maximum input signal ±12V	300mVrms

Input Impedance	50Ω
Input Return Loss 140MHz	18dB
Damage level	10Vpk
Output Characteristics	**Rating**
Maximum output amplitude ±9V	2.25Vrms 20dBm
Maximum output amplitude ±12V	3Vrms 22.5dBm
Output impedance	50Ω
Output return loss 140MHz	18dB
DC offset	±20mV
Damage Reverse power	1W
Rise/Fall time	2.5ns
Overshoot	3%
Characteristics	**Rating**
Supply Voltage Range	±9V - ±12V
Operating Current ±9V	±28mA
Operating Current ±12V	±38mA
Power connector	4 pin Molex nano-fit cable included
Characteristics	**Rating**
Size	Approx. 27mm x 48mm
Weight	Approx. 15g

Technical Specifications Ground Isolator

General Characteristics	Rating
Frequency Range	DC-10MHz
Gain	20dB
Input signal connector	SMA(M)
Output signal connector	SMA(F)
Input Characteristics	**Rating**
Maximum input signal ±9V	225mVrms
Maximum input signal ±12V	300mVrms
Input Impedance	50Ω
Input Return Loss 10MHz	>40dB
Input referred noise 100Hz-10MHz	1nV/rt-Hz
Input referred noise 0.1Hz-10Hz	60nVpp
Damage level	10Vpk
Output Characteristics	**Rating**
Maximum output Amplitude ±9V	2.25Vrms 20dBm

Maximum output Amplitude ±12V	3Vrms 22.5dBm
Output Impedance	50Ω
Output Return loss 10MHz	>10dB
DC Offset*	±350uV
Damage Reverse power	400mW
Rise/Fall time	110ns
Overshoot	3%
CMRR	105dB@10Hz 20dB@1MHz
Characteristics	**Rating**
Supply Voltage Range	±9V - ±12V
Quiescent Current typical	±6.5mA
Quiescent Current max	±10mA
Power connector	4 pin Molex nano-fit cable included
Characteristics	**Rating**
Size	Approx. 27mm x 48mm
Weight	Approx. 15g

* input and output returns tied together and measured at -30dBm input

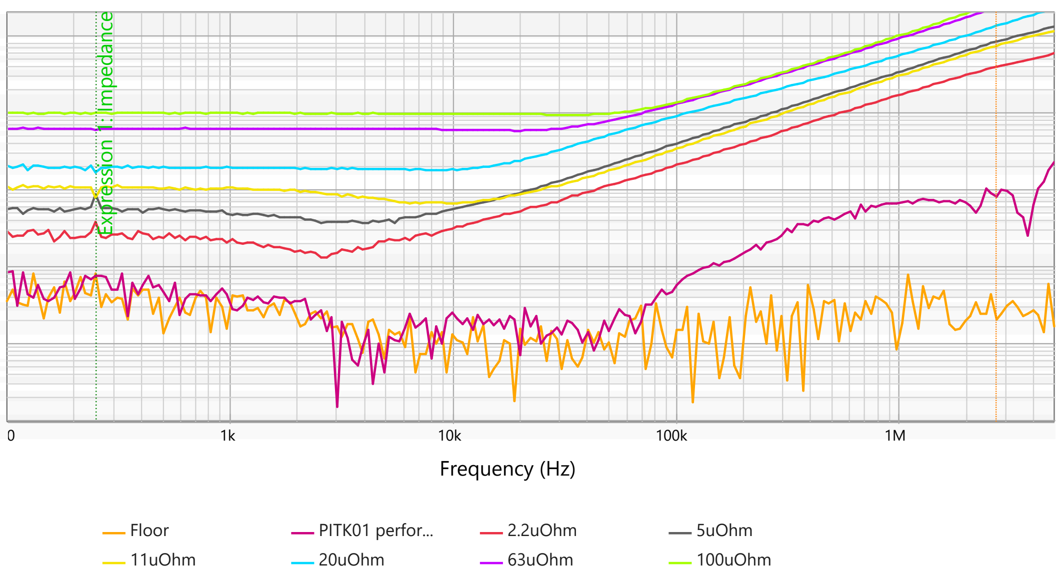


Figure 55: Sample measurements from 2.4uohms to 100uohms (without calibration, only gain corrected.).

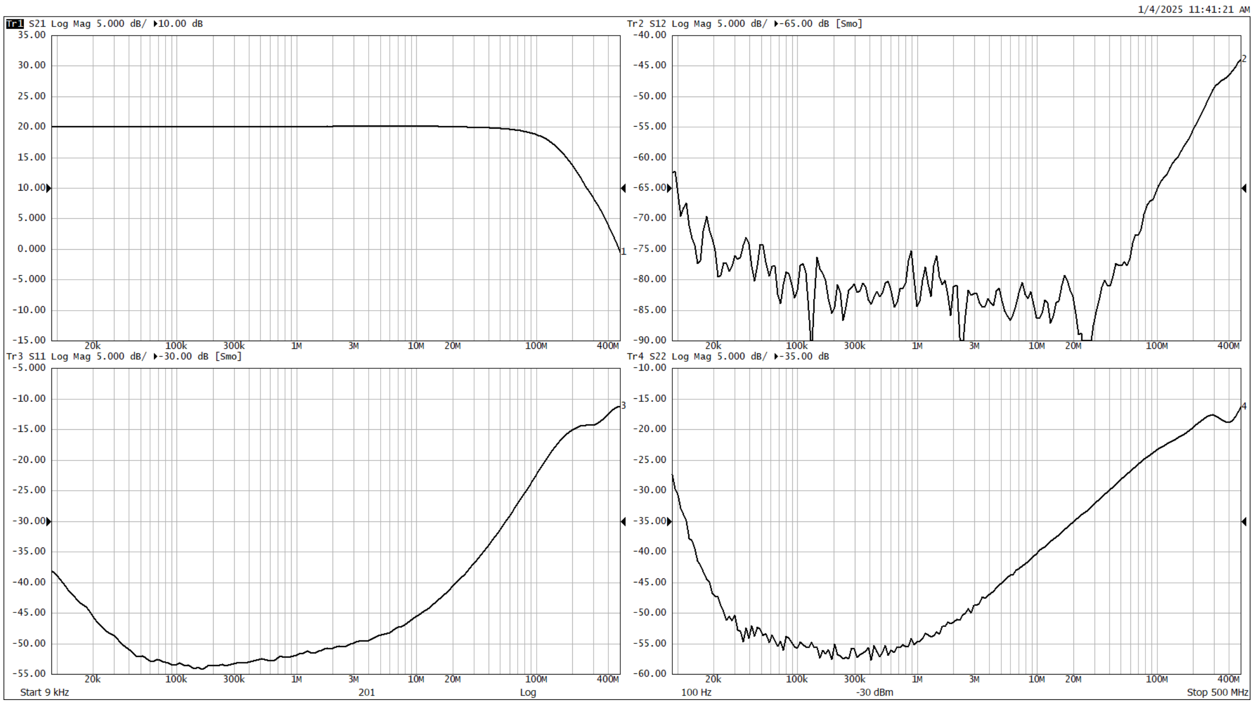


Figure 56: Source Power Amplifier S-parameter performance.

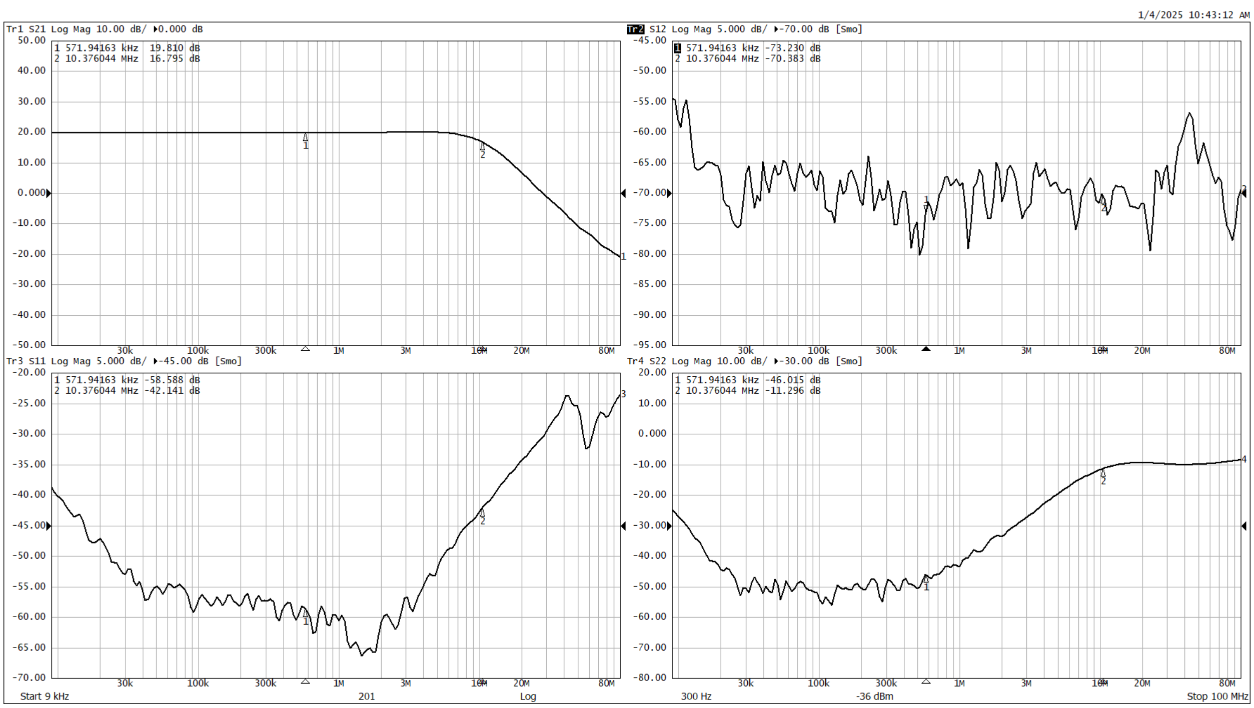


Figure 57: Isolator S-parameter performance.

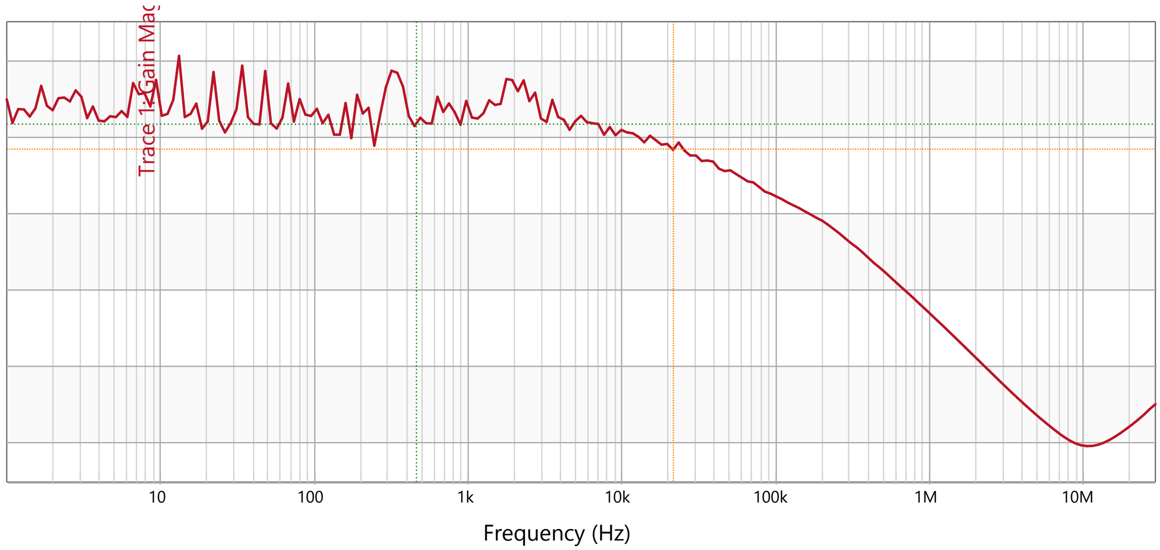


Figure 58: CMRR Performance.

J2161A Active 2-Way Splitter

Main Features

- Enables PDN low impedance measurement down to 1 mOhm
- Two-way splitter with Single Ended Input and Outputs
- Low, flat frequency response enables 2-port shunt-through impedance measurement
- Works with the Tektronix Series 6 Oscilloscope
- Works with the J2102B Common Mode Transformer to improve low end frequency response
- Combination maintains 50 Ohm transmission line integrity to ~500MHz (scope dependent)
- RoHS and CE compliant
- J2171A power supply included

Description

Perform the "Gold Standard" PDN measurement on the Tektronix Series 6 oscilloscope: the 2-port shunt-through impedance measurement is enabled by the Picotest J2161A active splitter, along with either a J2102B or a J2113A differential amplifier (for ground loop breaking). The combination allows measurement of low impedances over frequency down to 1 mOhm covering a bandwidth of 100Hz to over 500MHz (scope dependent).

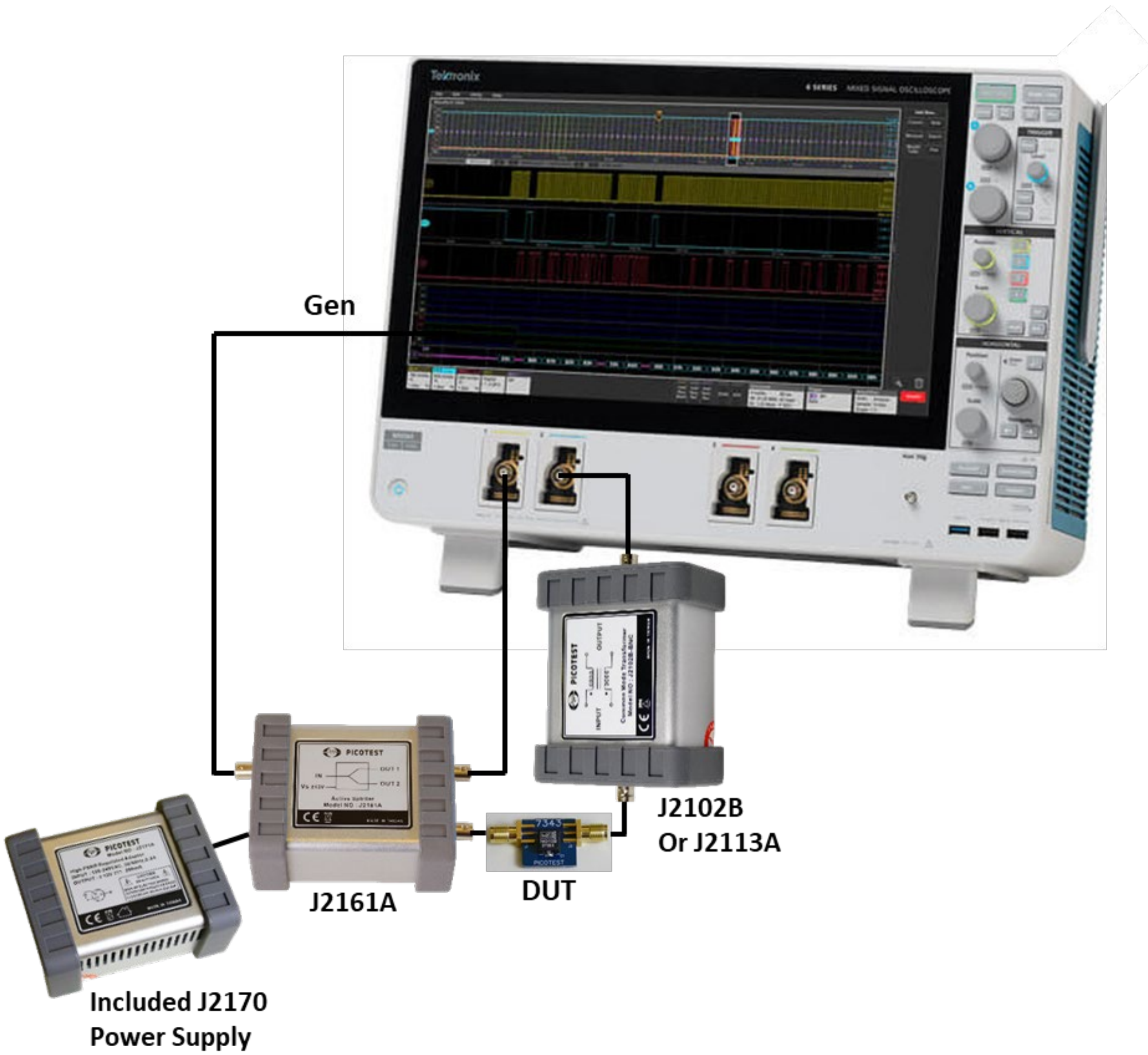


Figure 59: – 2-port shunt-through impedance test setup using the Tektronix Series 6 scope, J2161A, and the J2102B.

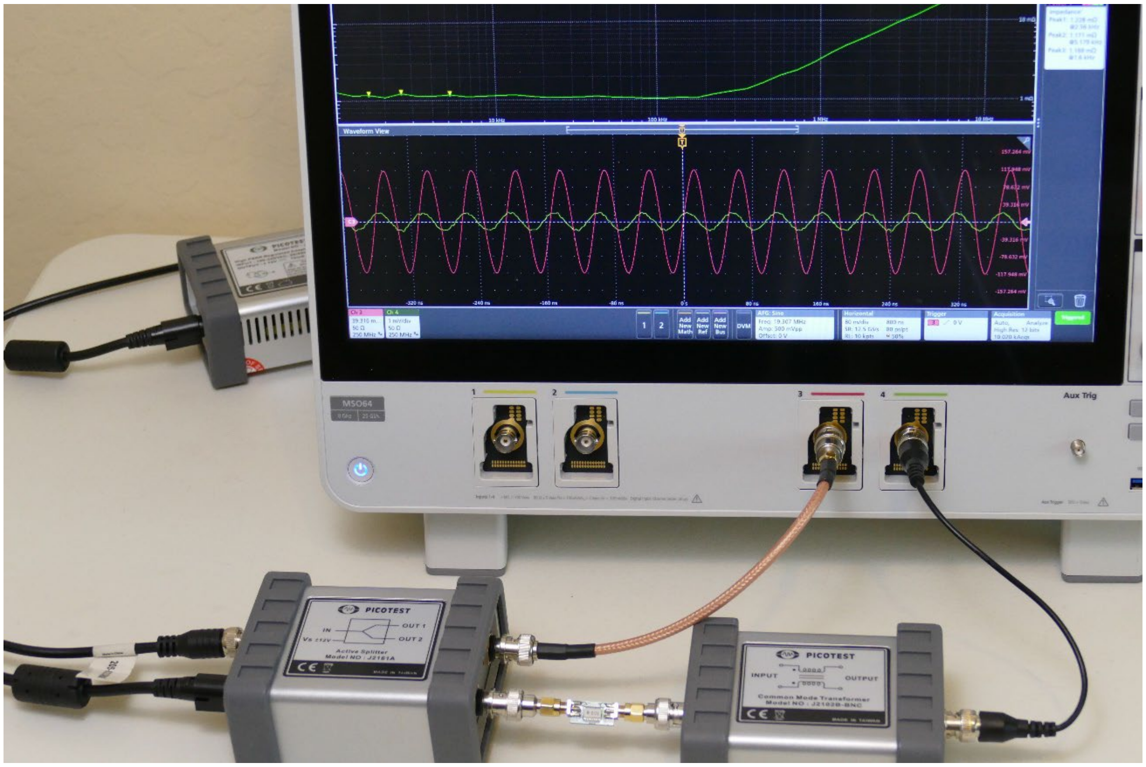


Figure 60: – Tektronix Series 6 test setup to perform the 2-port shunt-through impedance measurement using the Picotest J2161A active splitter (left) and the J2102B common mode transformer (right).

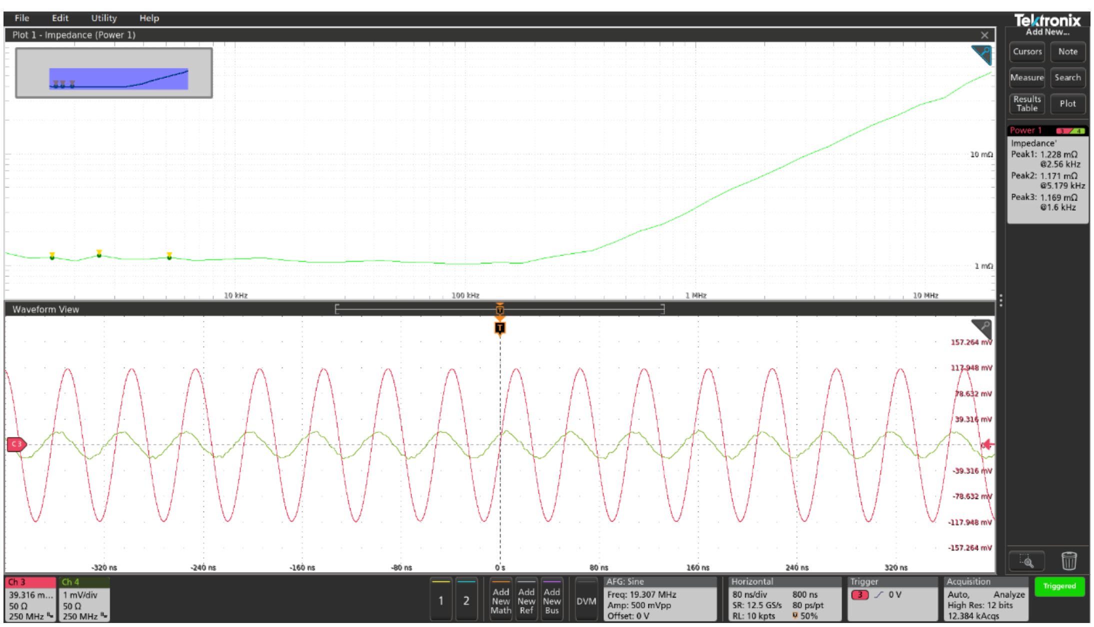


Figure 61: 2-Port Shunt-Through Impedance measurement of a 1 mOhm (1.17m) resistor.

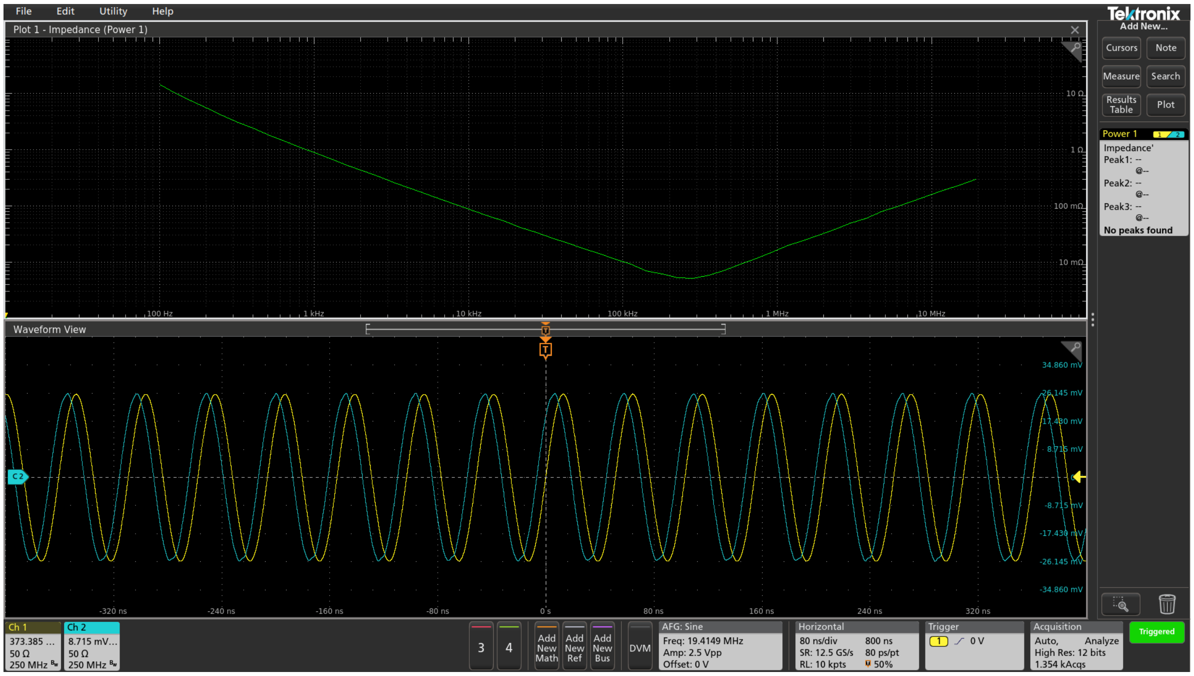


Figure 62: 2-Port Shunt-Through Impedance measurement of a 100uF polymer capacitor.

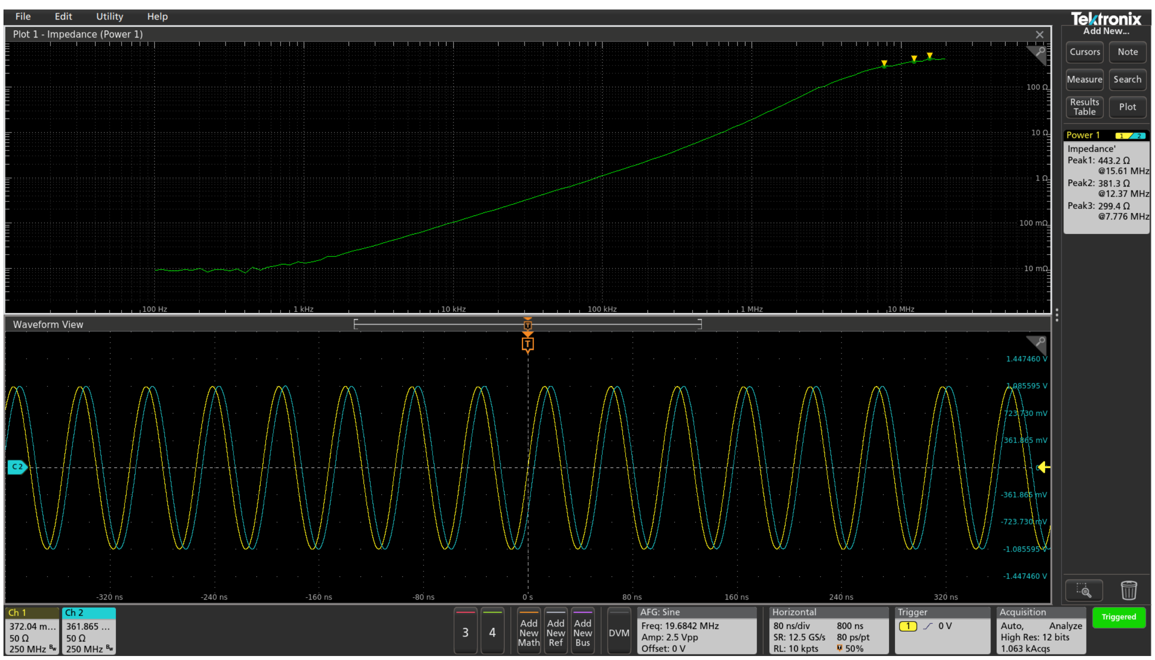


Figure 63: 2-Port Shunt-Through Impedance measurement of a 3.3uH inductor.

Technical Specifications

Specifications	
Characteristic	**Rating**
Uncalibrated Insertion Loss	≤ 100MHz 1dB >100MHz - 500MHz 3dB
Input Return Loss (typical)	≤ 100MHz < -20dB >100MHz - 500MHz 12dB
Output Return Loss (typical)	≤ 100MHz < -20dB >100MHz - 500MHz 12dB
Gain	1
Out to Out Isolation	>75 dB (up to 100MHz)
Maximum Input Voltage	2Vpk DC+AC
Temperature Range	0-50C
Maximum Altitude	6000 Ft
Absolute Maximum Voltage (input or output)	2.5V pk DC+AC into 50 Ohms

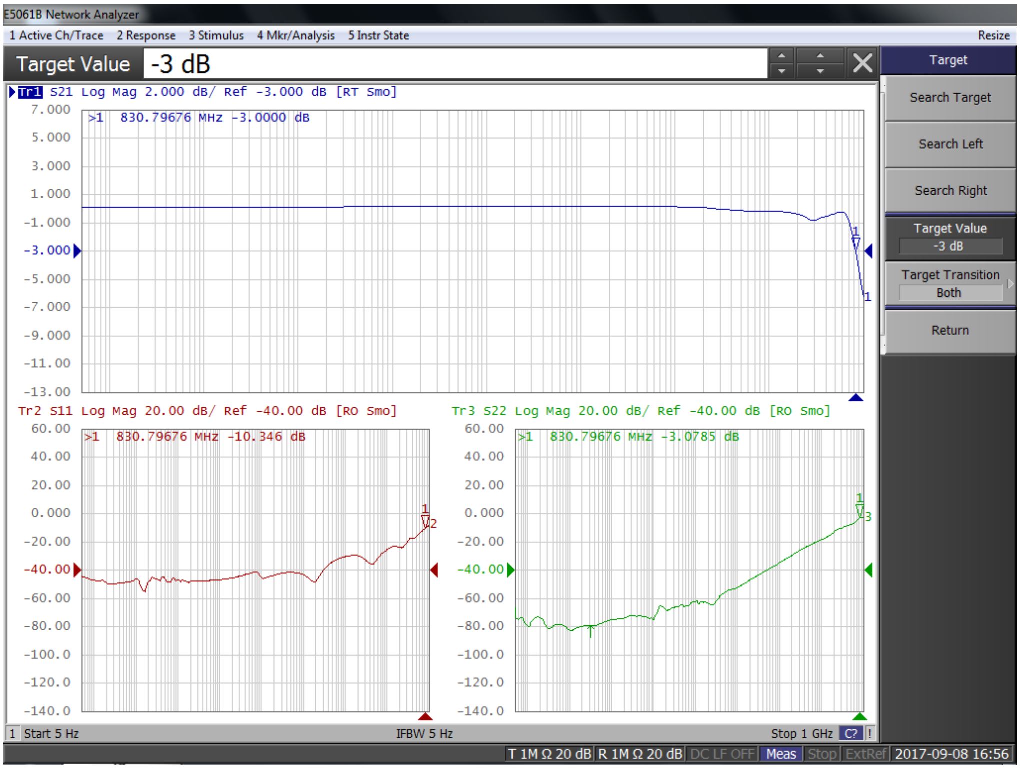


Figure 64: S21, S11, and S22 plots show 3dB S21 -3dB bandwidth @ 830MHz and S22 -6dB bandwidth @ 635 MHz.

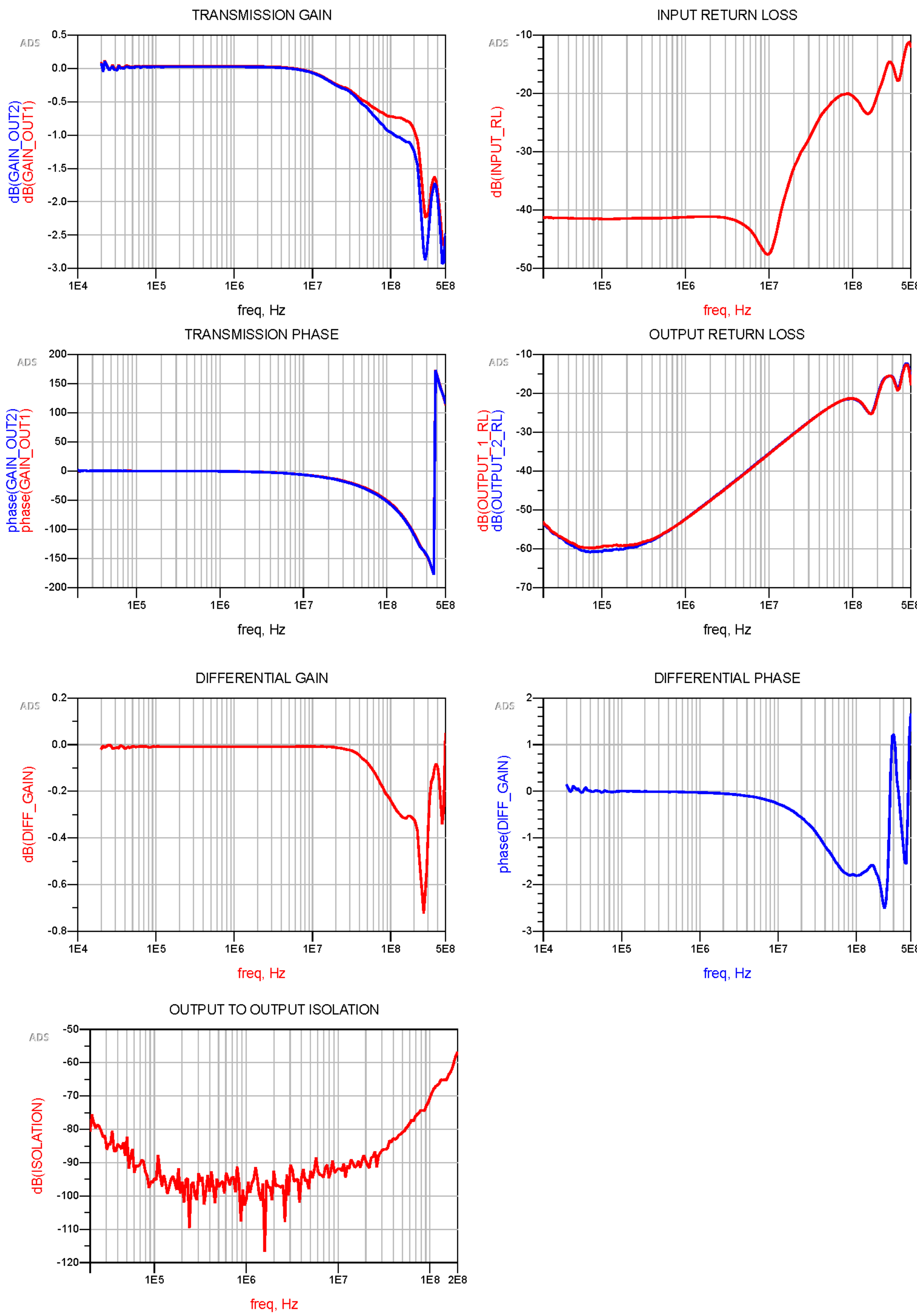


Figure 65: J2161A Typical measured frequency response data.

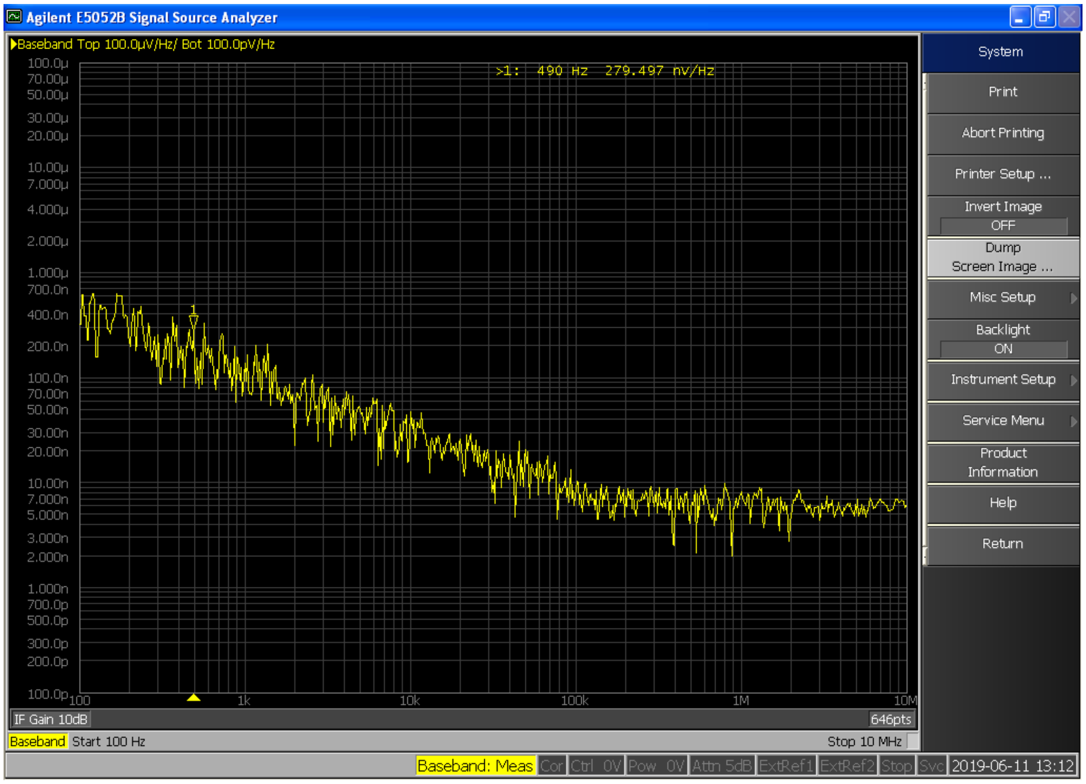


Figure 66: J2161A Typical Noise Density plot.

J2160A 2-Port Probe Adapter Panel for the Keysight E5061B

Main Features

J2160A Adapter Panel

- Low noise, compact adapter with internal 6dB port splitter
- Supports 2-port shunt-through and ultra-low impedance measurement
- Rugged, comfortable, ergonomic design; slim form factor
- Semi-floating port allows low frequency, low impedance measurement
- Easy to attach and detach
- Neater connections consume less bench space
- Works with the J2130A DC Bias Source

Description

The Picotest J2160A Probe Adapter provides a low noise, easy to connect and compact solution when using the E5061B T/R ports in a 2-port shunt-through measurement; the main measurement used in component and Power Integrity/PDN impedance measurements.

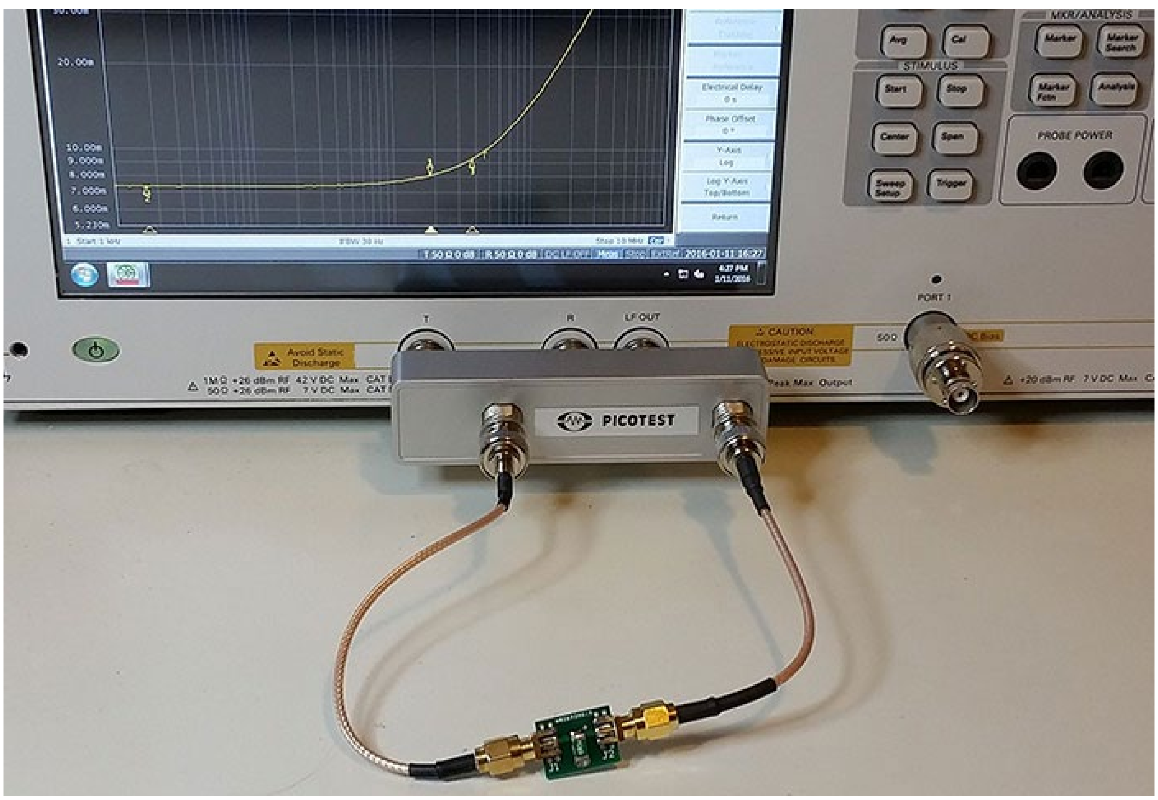


Figure 67: 2 Port Probe Adapter Panel for the Keysight E5061B VNA.

Using the Picotest J2160A shown below, connect the three GP Ports on the Keysight E5061B. This configures the ports for the 2-Port Shunt-Through measurement at low frequencies.

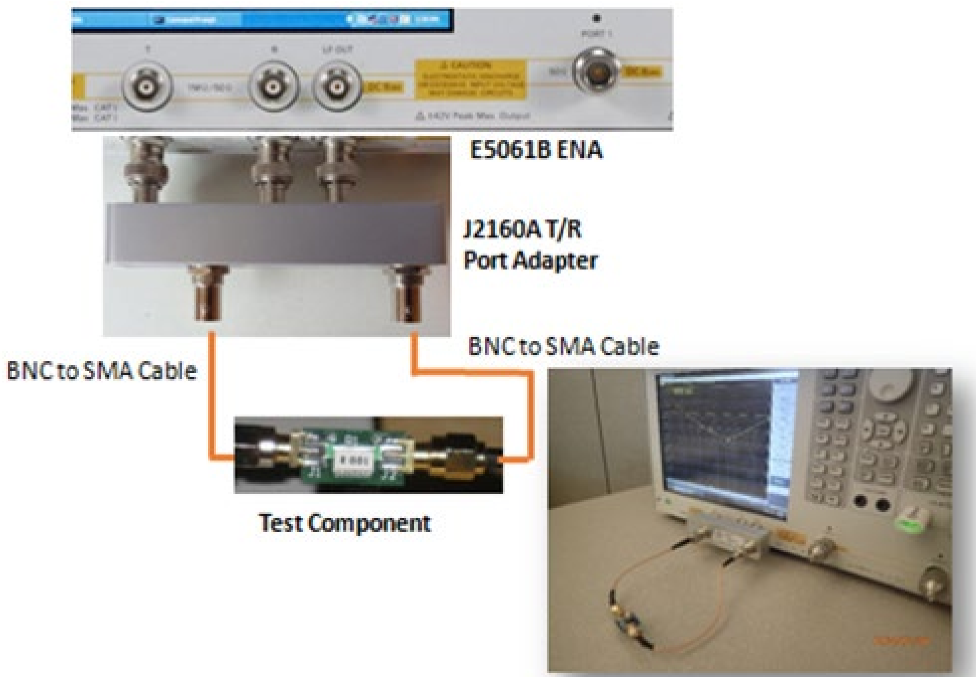


Figure 68: Measuring Components Using the Keysight E5061B GP Ports (Low Frequency).

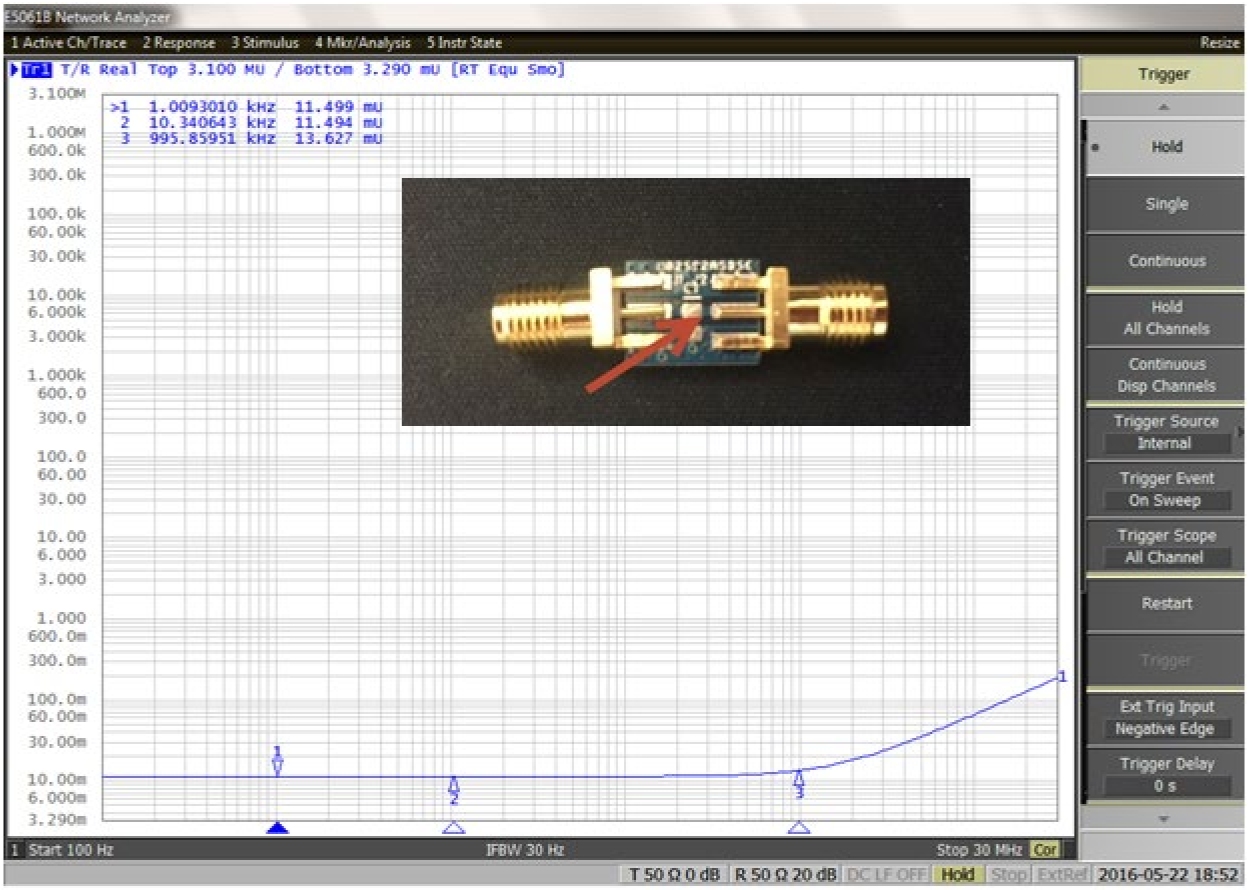


Figure 69: 10 milli-Ohm Resistor measurement using the Keysight E5061B VNA GP Ports and the Picotest J2160 adapter.

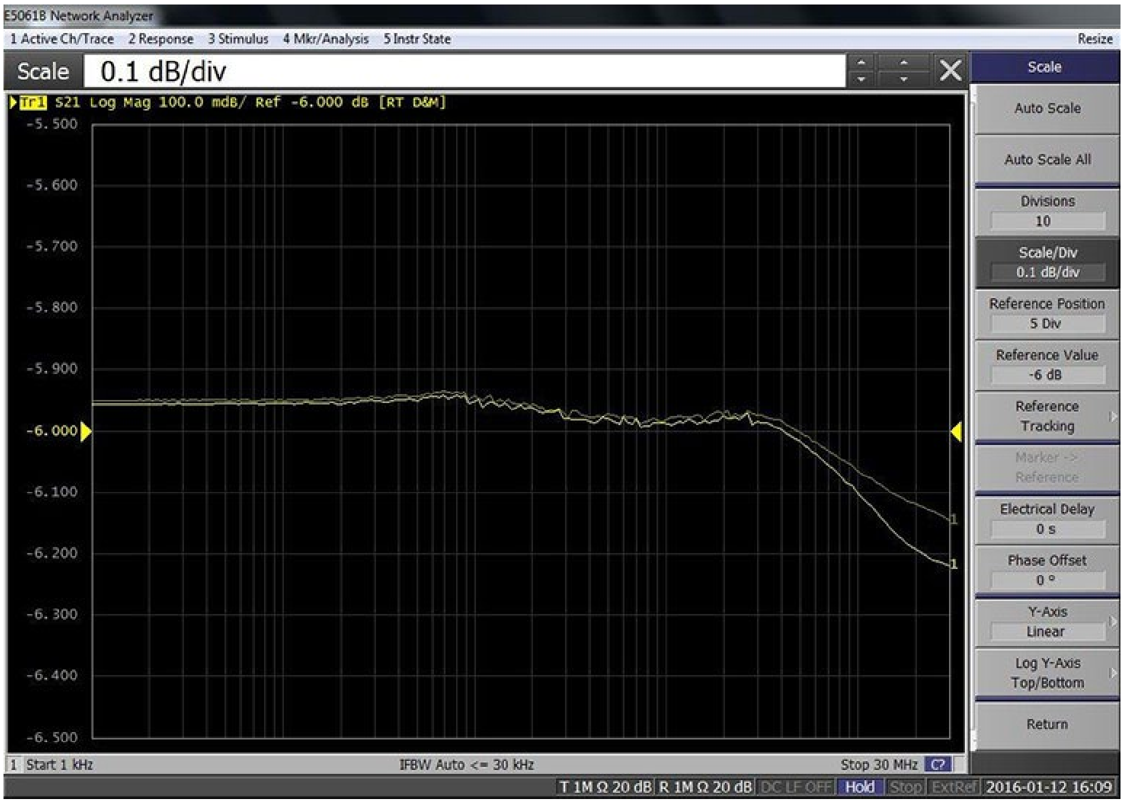


Figure 70: The 6dB splitter is accurate to within 0.25dB across the full frequency range of the instrument.

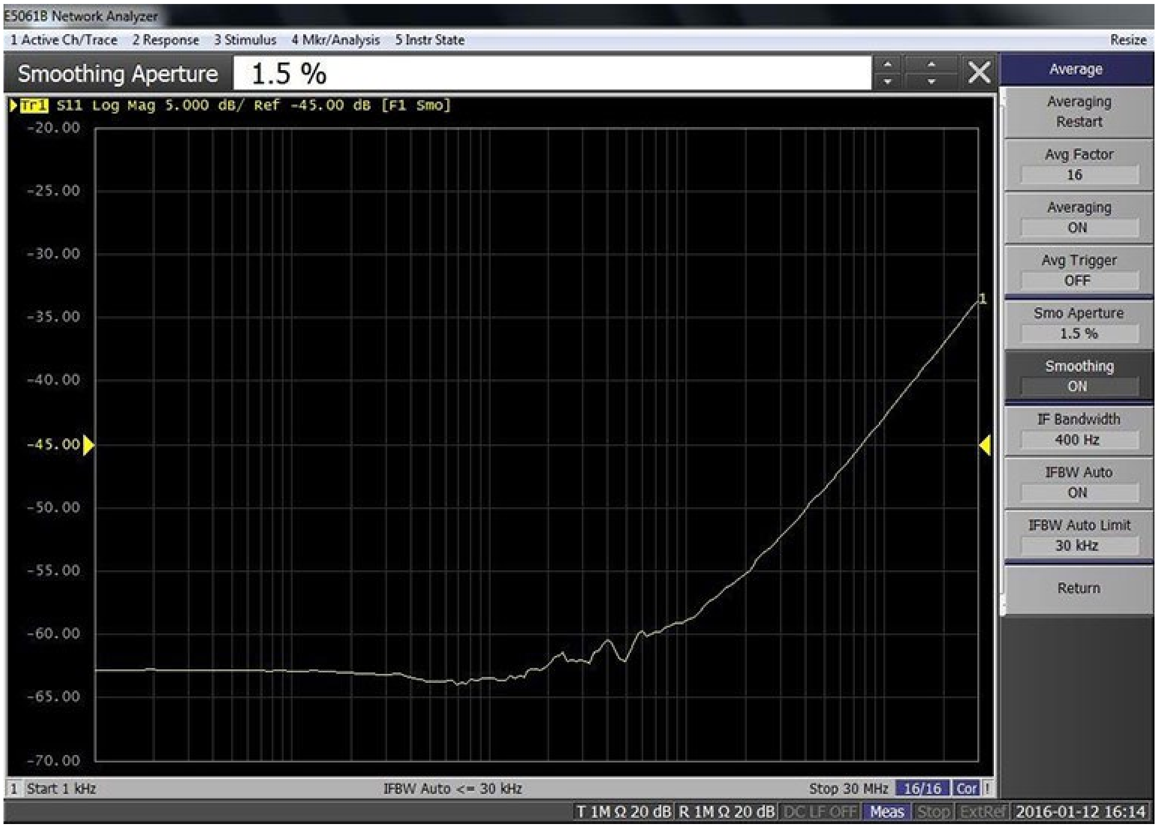


Figure 71: The T port return loss is better than 30dB over the full frequency range of the instrument.

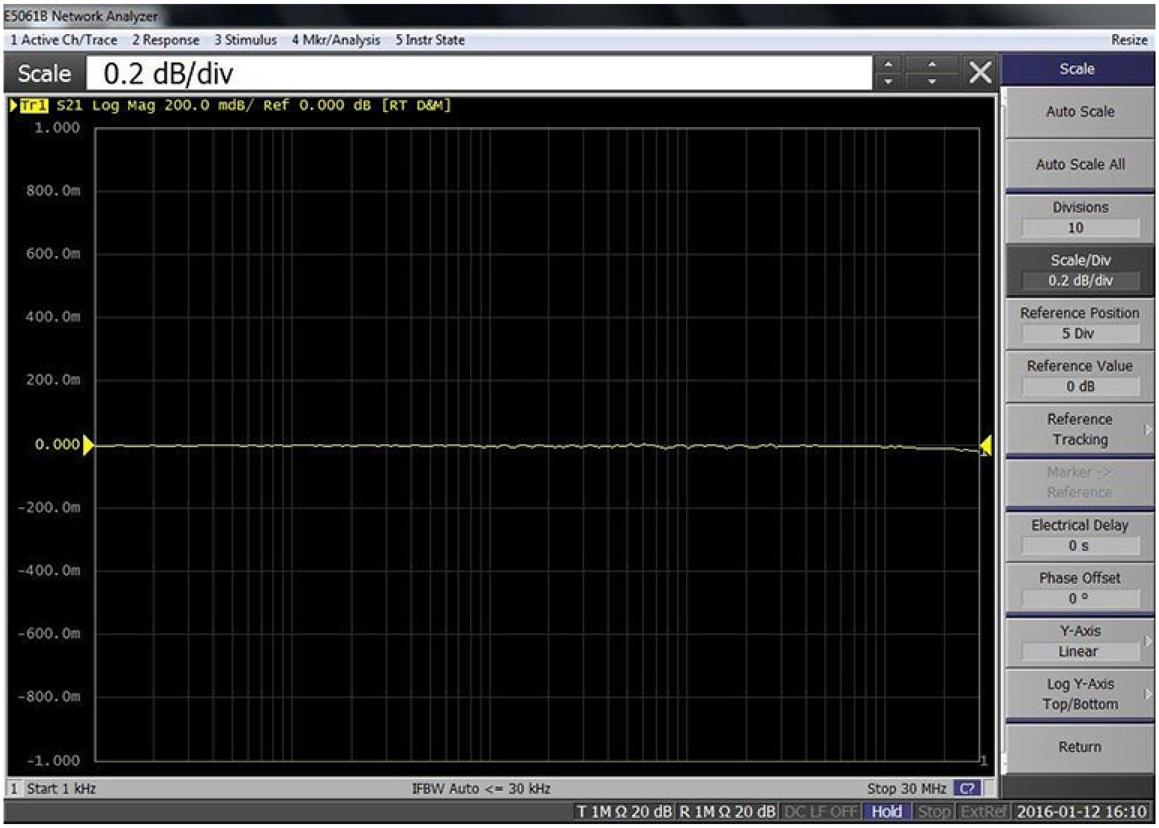


Figure 72: The T port insertion loss is less than a few hundredths of a dB over the full instrument range.

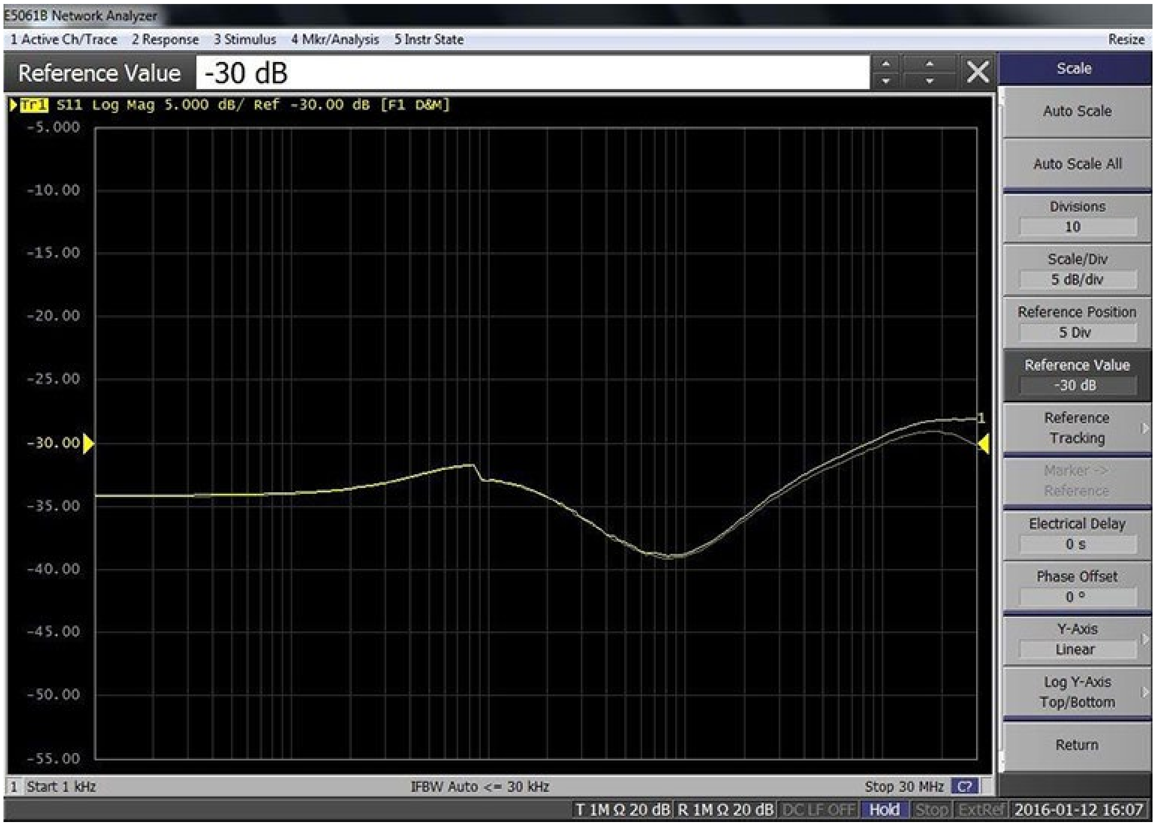


Figure 73: The return loss of the 6dB splitter legs is better than 25dB over the full measurement range of the instrument.

Injector Input/Output Impedances

J2110A	Impedance
Modulation Input	50 Ohms
Output	25 Ohms
Input	High Z
J2111B	
Modulation Input	50 Ohms
Current Monitor Output	50 Ohms
J2120A	
Modulation Input	10K Ohms
J2121A	
Modulation Input	50 Ohms
J2123A	
Modulation Input	50 Ohms
J2140A	
Input	50 Ohms
Output	50 Ohms
J2180A	
Input	High Z
Output	50 Ohms
J2190A	
Input	High Z
Output	50 Ohms
J2112A	
Modulation Input	50 Ohms
Current Monitor Output	50 Ohms
J2113A	
Input	50 Ohms
Output	50 Ohms
J2102B	
Input	50 Ohms
Output	50 Ohms
J2114A	
Input	50 Ohms
Output	50 Ohms
J2115A	
Input	High Z
Output	High Z
J2161A	
Input	50 Ohms
Output 1	50 Ohms
Output 2	50 Ohms