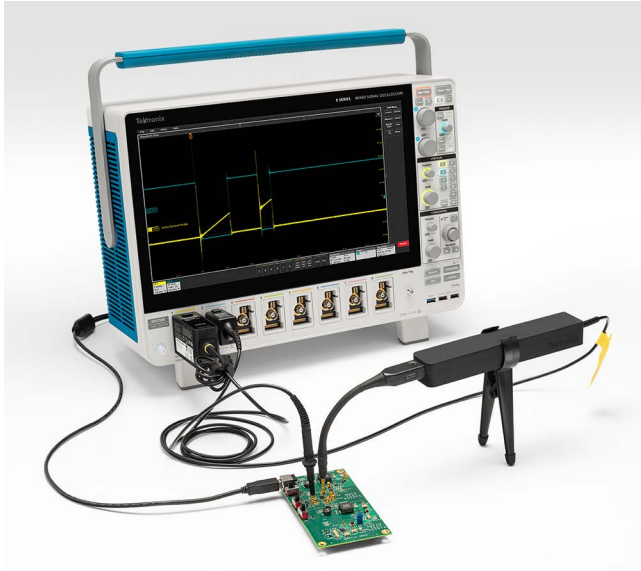


IsoVu Isolated Current Probes

TICP100, TICP050, TICP025 Datasheet



Overview

The IsoVu™ isolated current probes deliver exceptional bandwidth, noise rejection, accuracy, and ease of use for making current measurements.

Complete galvanic isolation eliminates ground loops and enables very high common mode rejection. In a 1X configuration, the probe's 50 Ω input offers extremely low noise of less than 4.7 nV/ $\sqrt{\text{Hz}}$, ideal for making accurate measurements on shunts. The probes offer a variety of attenuation tips to extend the differential voltage range. Depending upon the shunt used, the probes can perform current measurements from microamperes (μA) for low-power mobile designs to hundreds of amperes for industrial and mobility systems.

Key performance specifications and features

- Galvanic isolation between probe tip and the oscilloscope
- Available in three bandwidths: 1 GHz, 500 MHz, and 250 MHz
- Wide current measurement range determined by the shunt used with 1X, 10X or 100X probe tips
- Noise $4.70 \text{ nV} / \sqrt{\text{Hz}}$ ($21 \mu\text{V}_{\text{RMS}}$ at 20 MHz)
- Up to 90 dB CMRR at 1 MHz
- Maximum common mode voltage: 1800 V; For use in a Pollution Degree 1 environment; transient level not to exceed 5 kV_{pk}
- 1.5% DC gain accuracy

- Compatible with the 4, 5, and 6 Series MSO instruments, including the latest B models
- TekVPI™ interface enables control and probe configuration from the oscilloscope front panel or programming interface
- Optional tips to measure currents in environmental chambers from -40°C to +125°C

Key applications

- Current shunt measurements
- Half/full bridge designs using SiC or GaN, FETs, or IGBTs
- Double pulse testing (DPT)
- Floating gate measurements
- Power converter designs
- Switching power supply designs
- Steady state, sleep, and wake-up state current monitoring

Tips expand measurement ranges, minimize hassle, and reduce noise

The IsoVu isolated current probes are well-suited for both low current and high current measurements that are challenging or impossible with sensor-based clamp-on oscilloscope probes. With three different attenuation tips, you can easily measure a wide range of currents based on the shunt resistance and its power rating.

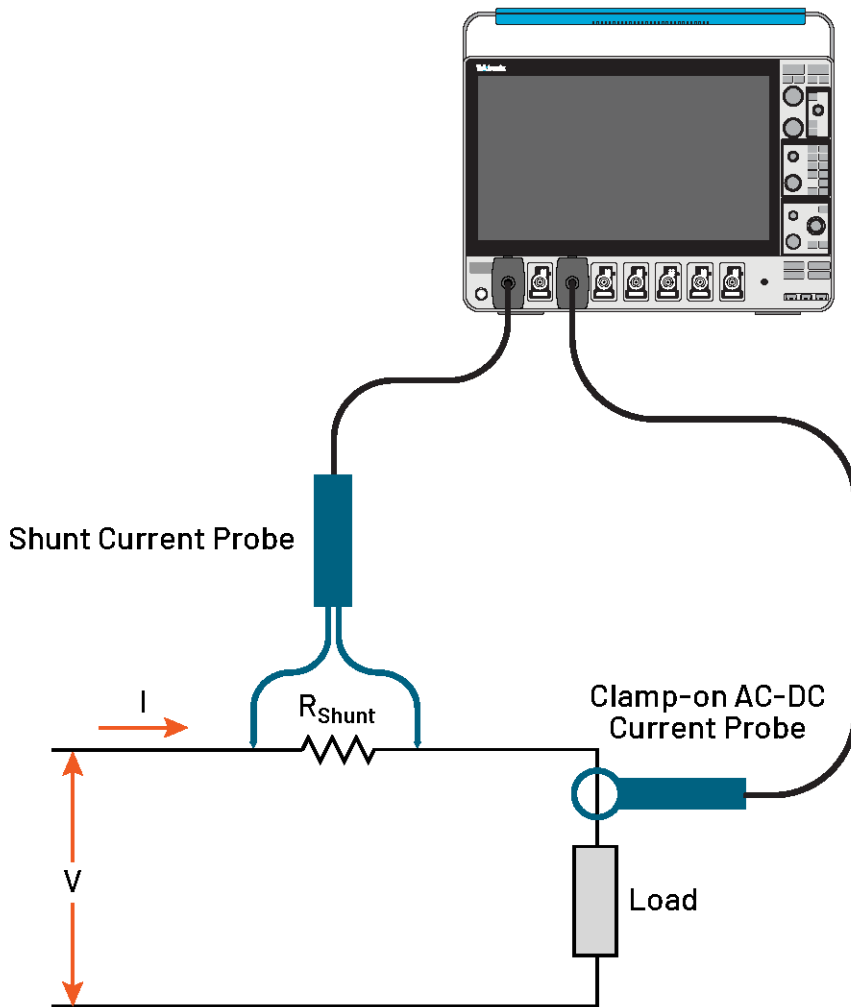
The probes are designed to provide high-performance current measurements while offering convenient connectivity. Tips are equipped with MMCX and SMA connectors to ensure proper grounding and shielding, which is crucial for minimizing noise, ground loops, and ensuring accurate current measurements. These tips enable direct connection to most commercially available shunts, but you can also use appropriate adapters to interface the tips with their shunts.

The probe tips connect to the probe body with a unique reversible IsoConnect™ interface, allowing you to snap-fit the tips without worrying about orientation. Designed for flexibility, the probe tips have a small bend radius, facilitating connection in tight spaces. The standard probe includes a tripod adapter and a bipod for convenient placement and positioning in the test setup.

Current shunt measurements

There are two methods to measure current in test systems. The first method involves sensing the fields around the electrical conductors and converting them into signals that represent the current. This method is used by most clamp-on style current probes, or Rogowski coils. The second method involves measuring currents using Ohm's law. One can measure current by measuring the voltage drop across a precision shunt resistor, which is the method used by the IsoVu isolated current probes.

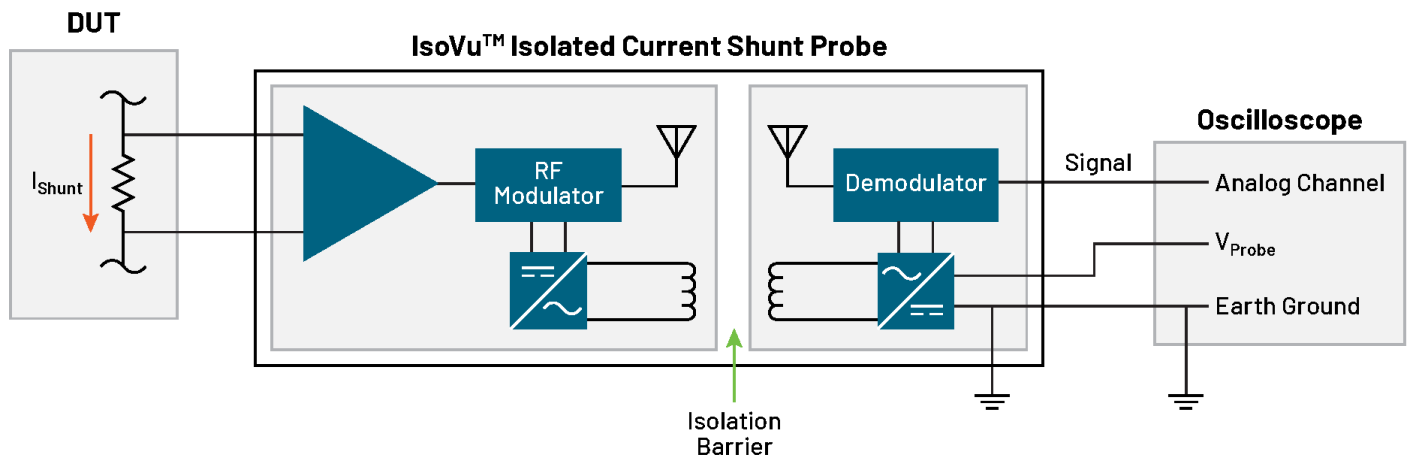
Current shunts, or current viewing resistors (CVRs), typically have a wide frequency response, accurately measuring both AC and DC currents across a broad spectrum of frequencies. Their compact size allows for easy integration into existing circuitry with minimal space requirements. Although shunt resistors must be designed into a PCB and result in voltage drop, they offer some key advantages compared to sensor-based current measurements, including high accuracy, minimal distortion, and low interference.



Isolation enables floating measurements and exceptionally low noise

The IsoVu isolated current probes enable you to make more accurate dynamic current measurements on your oscilloscope, outside traditional limits.

Unlike transformer, Rogowski, or Hall effect current probes, IsoVu isolated current probes enable measurements from DC to hundreds of MHz when paired with high-performance shunts or CVRs. Complete RF isolation between the probe tip and the oscilloscope eliminates ground loops and helps deliver extraordinary common mode rejection (CMRR) up to 90 dB at 1 MHz to dramatically reduce common mode noise. Low attenuation and low input impedance ($50\ \Omega$) limits noise contribution to less than $4.7\ \text{nV}/\sqrt{\text{Hz}}$ noise contribution ($<150\ \mu\text{V}$ at 1 GHz) when measuring low voltages ($\pm 0.5\ \text{V}$) across shunts.



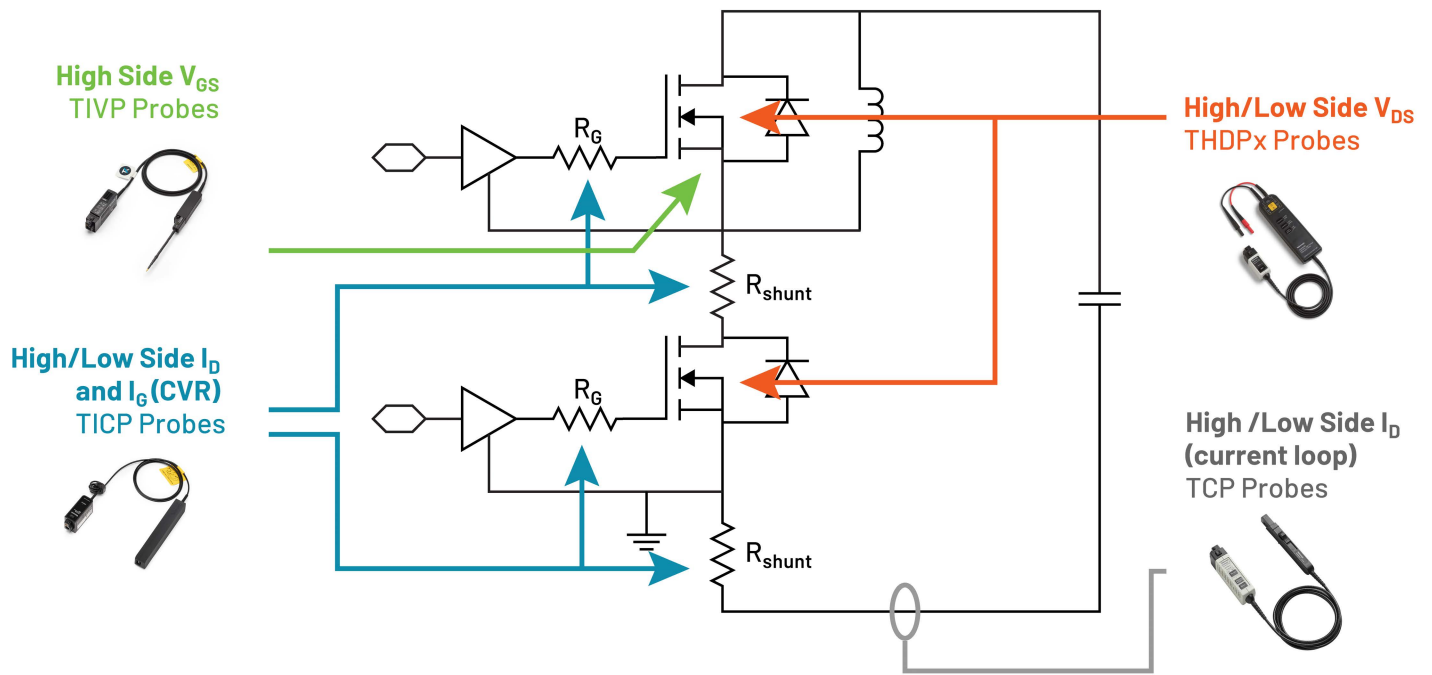
Test beyond ambient temperature with extreme temperature tips

The extreme temperature (ET) tips enable current measurements across a wide temperature range from -40°C to $+125^{\circ}\text{C}$. Optional six-foot tip cables provide convenient connectivity between a DUT positioned inside a temperature chamber and a Tektronix oscilloscope and isolated current probe located outside the chamber. Available in three attenuation configurations, they deliver exceptional bandwidth performance up to 700 MHz.



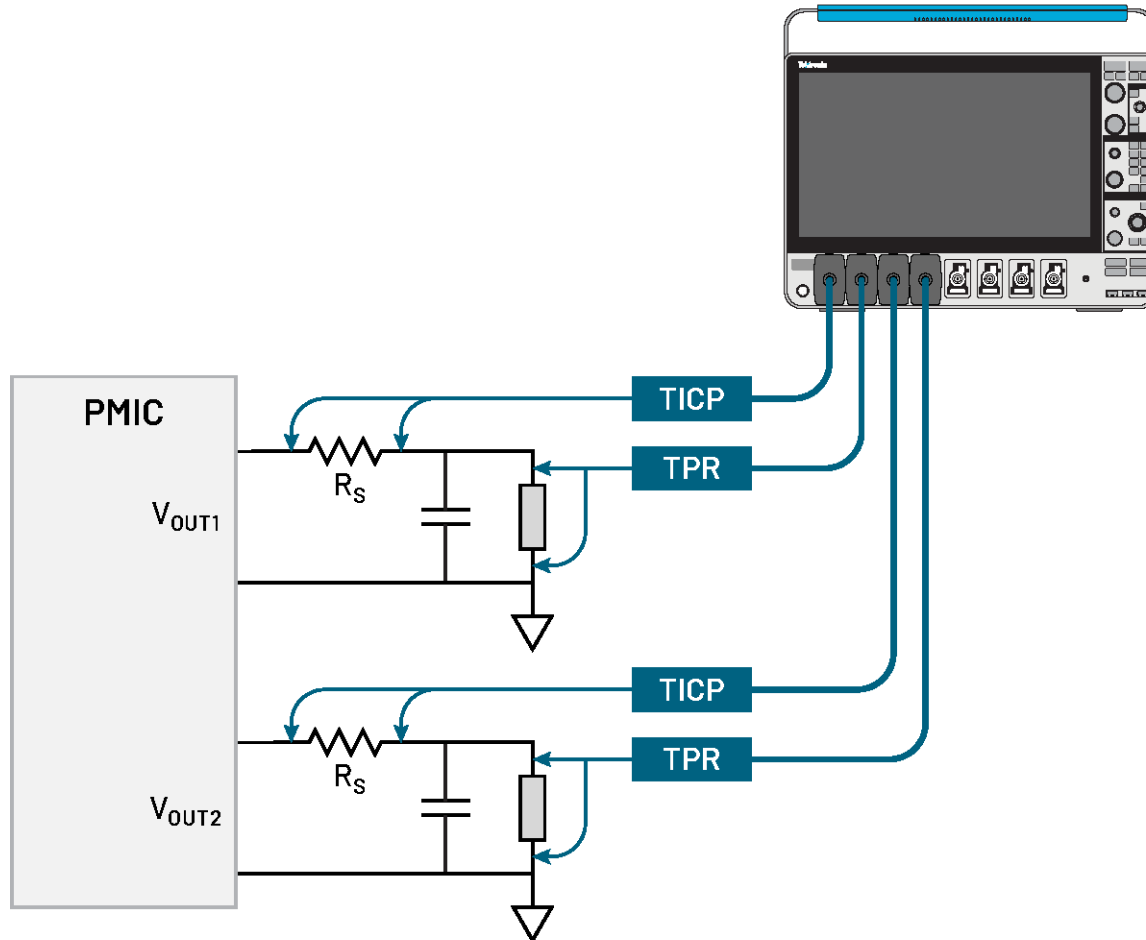
Measuring high-fidelity currents in high power systems

The IsoVu isolated current probes provide the bandwidth you need to accurately see the fast risetimes of wide bandgap (WBG) switching devices. This enables you to accurately measure dynamic currents in high-power SiC and GaN power converters. They complement the groundbreaking IsoVu isolated voltage probes and represent a similar isolation breakthrough for current measurements. The isolation eliminates ground loops and enables accurate measurements of high-side drain currents (I_D).



Measuring low currents in low power systems

The IsoVu isolated current probes have the bandwidth to measure current consumption during specific system activities and transitions from sleep to active states. The low-noise architecture is critical for accurately measuring low currents across the shunts. The common mode voltage rating of these probes is higher than most differential probes, enabling current shunt measurements on higher voltage power rails. When paired with the low-noise of the 6 Series MSO, the overall system offers low-noise performance to efficiently measure rail currents.



Measuring currents with the wideband shunts

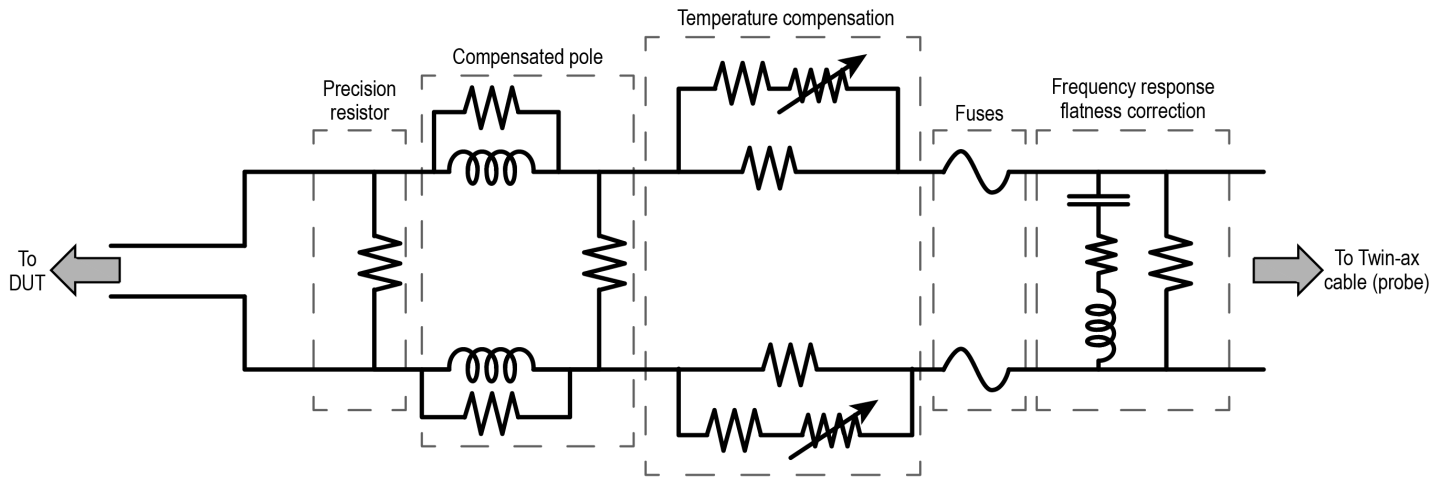
Most commercial current shunts operate at low-bandwidths in the range of a few tens of Megahertz at best. Beyond this bandwidth range, their parasitic inductance effects kicks in, effectively impacting the current measurements and rendering them less useful for accurate measurements.

Wideband shunts for IsoVu™ isolated current probes provide industry-leading current measurements with bandwidths up to 250 MHz, that's over five times the bandwidth of most commercially available shunts, along with a smooth roll-off behavior, high common-mode rejection, and low-noise.

In addition to the frequency compensation, there is also on-board temperature compensation that keeps the gain flat over the entire operating temperature range. The wideband shunts act as the first line of defense against voltage spikes and over-current. Integrated fuses, spark gaps, and isolation work together to safeguard the equipment in challenging test conditions.

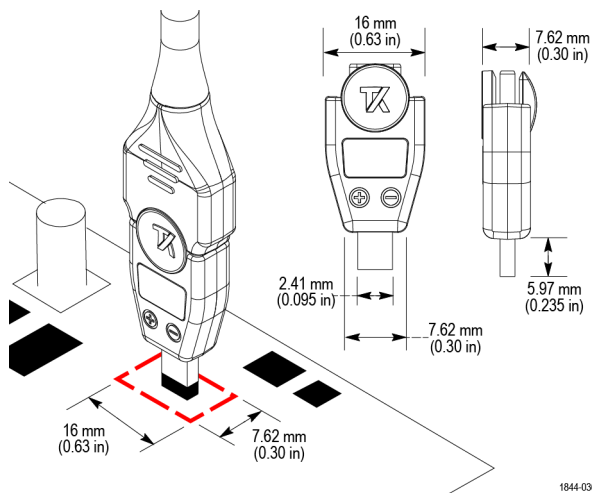
These plug-and-play smart shunts integrate with Tektronix oscilloscopes for current measurements—auto-configuring the units, and vertical scale, ensuring the measurements are performed at minimal noise levels. They connect to the DUT using industry standard square pins.

Combined with a Tektronix oscilloscope, software, and isolated current probes, these innovative wideband shunts enable precise characterization of standby and operating currents in embedded designs, high-performance computing systems, and any application that requires precision high-bandwidth current measurements.



1844-037

Wideband shunt block diagram



1844-036

Specifications

All specifications are typical and apply to all models unless noted otherwise.

Probe and tip overview

IsoVu isolated current probe overview

Characteristic	TICP100	TICP050	TICP025
Bandwidth	1 GHz	500 MHz	250 MHz
Rise time	400 ps	700 ps	1.4 ns
DC gain accuracy	±1.5%		
Maximum common mode voltage	1800 V; For use in a Pollution Degree 1 environment; Max with transient level not to exceed 5kV _{pk}		
	1300 V; Pollution degree 2; Max with transient level not to exceed 5kV _{pk}		
	600 V for CAT III; Pollution degree 2		
	1000 V for CAT II; Pollution degree 2		
RMS noise spectral density	4.70 nV / √Hz (<21 μV _{RMS} at 20 MHz)		
Probe cable length	2 meters		

TICS wideband shunts overview

Characteristic	TICS0005	TICS0050	TICS0500	TICS5000
Resistance	5 mΩ	50 mΩ	500 mΩ	5 Ω
Bandwidth	250 MHz	250 MHz	250 MHz	250 MHz
Rise time	1.6 ns	1.6 ns	1.6 ns	1.6 ns
Maximum pulse current (derates based on current pulse width. Refer to pulsed current curve graph)	200 A	20 A	2 A	200 mA
Maximum current (A DC)	12 A	4.5 A	1.4 A	200 mA
Minimum current (A) equals two times the noise floor at full bandwidth	30 mA	3 mA	300 μA	30 μA
Noise Floor (A RMS) at full bandwidth	15 mA	1.5 mA	150 μA	15 μA
Dynamic range	±100 A	±10 A	±1 A	±0.1 A
Power rating	0.69 W	1.0 W		
DC gain accuracy	<2%			

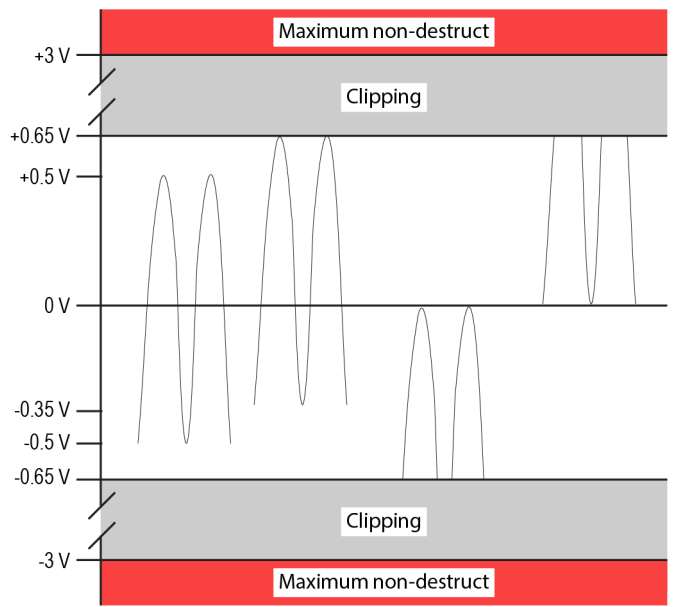
Characteristic	TICS0005	TICS0050	TICS0500	TICS5000
Insertion inductance	2 nH to 3 nH for square pins with jumper			
	4 nH to 5 nH for square pins with shunt			
	9 nH to 10 nH for twisted pair accessory with shunt			
Twin-ax cable length	229 mm (9 in.)			
The built-in fuses have a maximum interruptible voltage rating of 400 V; above this potential, arcing can occur across the open fuse element, allowing current to continue flowing.				

Input voltage range, input impedance

Differential input voltage range + offset range should not exceed maximum measurable input voltage. For example, offset is limited to ± 0.15 V in TICPSMA's ± 0.5 V range.

Probe tips	Differential input voltage range	Offset range	Maximum measurable input voltage (Vpk)	Maximum non-destructive differential voltage	Input impedance
TICPSMA	± 0.5 V	± 0.5 V	0.65 V	± 3 V; 3 V _{RMS}	50 Ω N.A.
TICPMM1/TICPMM1ET	± 0.5 V	± 0.5 V	0.65 V	± 3 V; 3 V _{RMS}	50 Ω N.A.
TICPMM10/ TICPMM10ET	± 5 V	± 5 V	6.5 V	± 15 V; 15 V _{RMS}	500 Ω <3 pF
TICPMM100/ TICPMM100ET	± 50 V	± 50 V	50 V	± 60 V; 60 V _{RMS}	5000 Ω <3 pF

Full ± 0.5 V offset is available in the IsoVu isolated current probe's ± 0.125 V range.



1844-019

Differential input voltage range

Noise floor (A RMS)

$$\text{Noise Floor (A RMS)} = \frac{4.70 \frac{nV}{\sqrt{Hz}} \times \sqrt{\text{Bandwidth}}}{R_{shunt}}$$

IsoVu isolated current probe noise floor (A RMS)

Shunt selection	20 MHz	250 MHz	1 GHz
50 Ω TICP as shunt	420 nA	1.5 μA	3.0 μA
5 Ω shunt	4.2 μA	14.9 μA	29.7 μA
1 Ω shunt	21 μA	74.3 μA	149 μA
500 mΩ shunt	42 μA	149 μA	297 μA
50 mΩ shunt	420 μA	1.5 mA	3.0 mA
5 mΩ shunt	4.2 mA	14.9 mA	29.7 mA
500 μΩ shunt	42 mA	149 mA	297 mA
50 μΩ shunt	420 mA	1.5 A	3.0 A
15 μΩ shunt	1.4 A	5.0 A	9.9 A

Wideband shunts noise floor (A RMS)

Shunt selection	20 MHz	120 MHz	250 MHz
5 Ω (TICS5000)	4.2 μA	10 μA	15 μA
500 mΩ (TICS0500)	42 μA	100 μA	150 μA
50 mΩ (TICS0050)	420 μA	1.0 mA	1.5 mA
5 mΩ (TICS0005)	4.2 mA	10 mA	15 mA

The wideband shunt noise floor is dependent on TICP input range, bandwidth, and shunt value. Numbers above calculated with TICP in the ±20 mV range.

Maximum measurable current

Maximum depends on shunt power rating.

$$\text{Maximum Measurable Current (A)} = \frac{\text{Maximum Measurable Input } V_{pk}}{R_{shunt}}$$

The IsoVu isolated current probe maximum measurable current

Shunt selection	TICPMM1	TICPSMA	TICPMM10	TICPMM100
50 Ω TICP as shunt	13 mA		-	-
5 Ω shunt	130 mA		1.3 A	10 A
1 Ω shunt	650 mA		6.5 A	50 A
500 mΩ shunt	1.3 A		13 A	100 A
50 mΩ shunt	13 A		130 A	1.0 kA
5 mΩ shunt	130 A		1.3 kA	10 kA
500 μΩ shunt	1.3 kA		13 kA	100 kA
50 μΩ shunt	13 kA		130 kA	1000 kA
15 μΩ shunt	43.3 kA		433.3 kA	3300 kA

Wideband shunts maximum measurable current

Shunt selection	10 μs	1 ms	100 ms	1 s	100 s
5 Ω (TICS5000)	0.2 A	0.2 A	0.2 A	0.2 A	0.2 A
500 mΩ (TICS0500)	2 A	2 A	2 A	1.8 A	1.5 A
50 mΩ (TICS0050)	20 A	20 A	7.6 A	5.7 A	4.6 A
5 mΩ (TICS0005)	195 A	63 A	23 A	16 A	12 A

Derates based on current pulse width. Pulse Width durations are based on a Square Wave input. For Triangle Wave input (as in Double Pulse Test), the Maximum Pulse Width can be multiplied by 3.5. For example, for a double-pulse test that peaks at 20 A, the 50 mΩ TICS can withstand a 3.5 ms ramp. A 20 A square wave impulse could only be held for 1 ms.

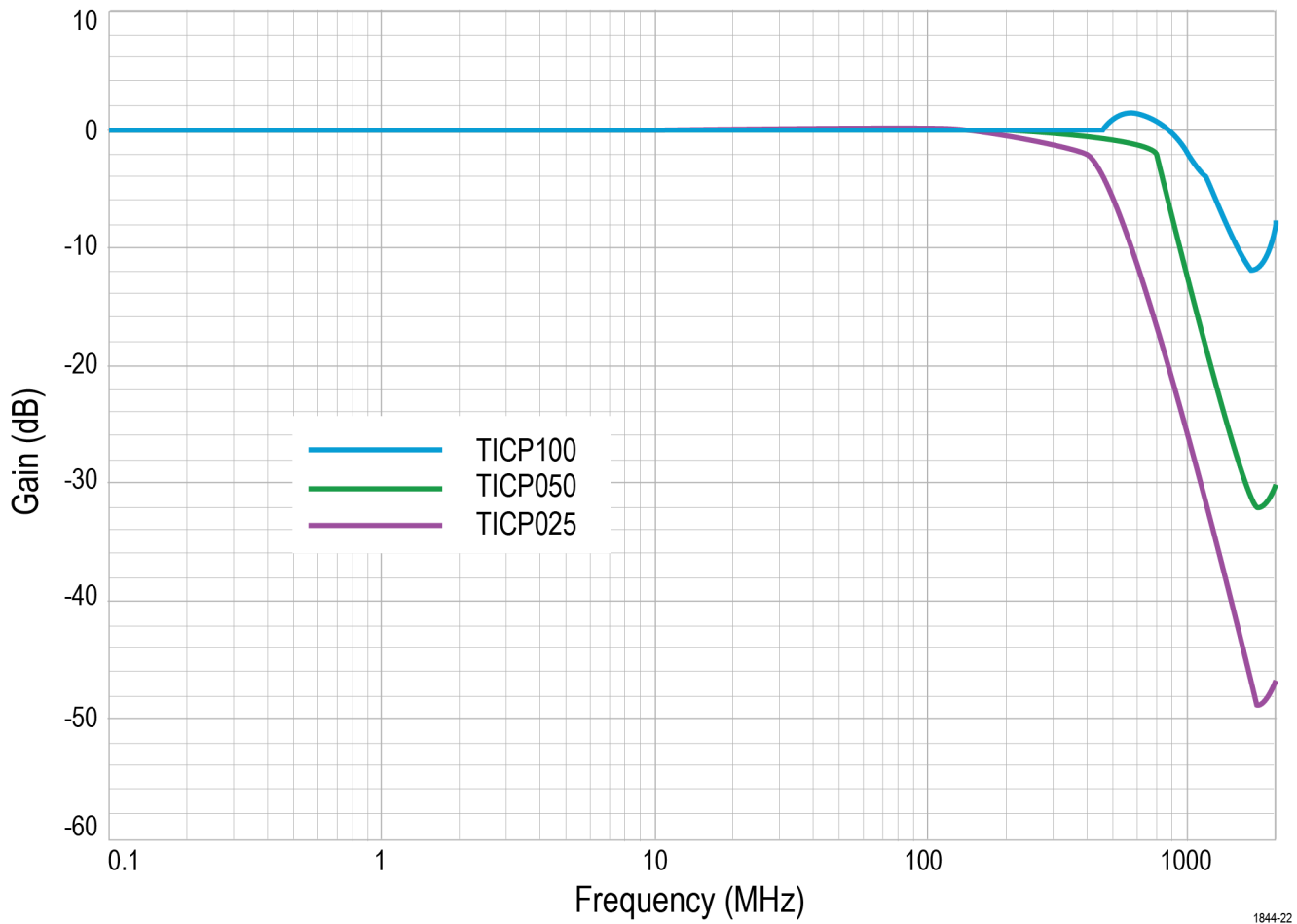
Probe Ranges

Numbers are published for TICPSMA and TICPMM1 tips. For 10X or 100X tips, multiply by 10 or 100 respectively.

Input range	Offset range	RMS noise spectral density (V_{RMS})	Noise floor at 20 MHz (V_{RMS})
±0.5 V	±0.15 V	22.9 nV / \sqrt{Hz}	102.5 μV_{RMS}
±0.35 V	±0.30 V	17.4 nV / \sqrt{Hz}	77.8 μV_{RMS}
±0.25 V	±0.40 V	15.0 nV / \sqrt{Hz}	67.2 μV_{RMS}
±0.175 V	±0.475 V	9.5 nV / \sqrt{Hz}	42.4 μV_{RMS}
±0.125 V	±0.5 V	8.7 nV / \sqrt{Hz}	38.9 μV_{RMS}
±0.09 V	±0.5 V	6.3 nV / \sqrt{Hz}	28.3 μV_{RMS}
±0.065 V	±0.5 V	5.5 nV / \sqrt{Hz}	24.7 μV_{RMS}
±0.045 V	±0.5 V	4.7 nV / \sqrt{Hz}	21.2 μV_{RMS}
±0.03 V	±0.5 V	4.7 nV / \sqrt{Hz}	21.2 μV_{RMS}
±0.02 V	±0.5 V	4.7 nV / \sqrt{Hz}	21.2 μV_{RMS}

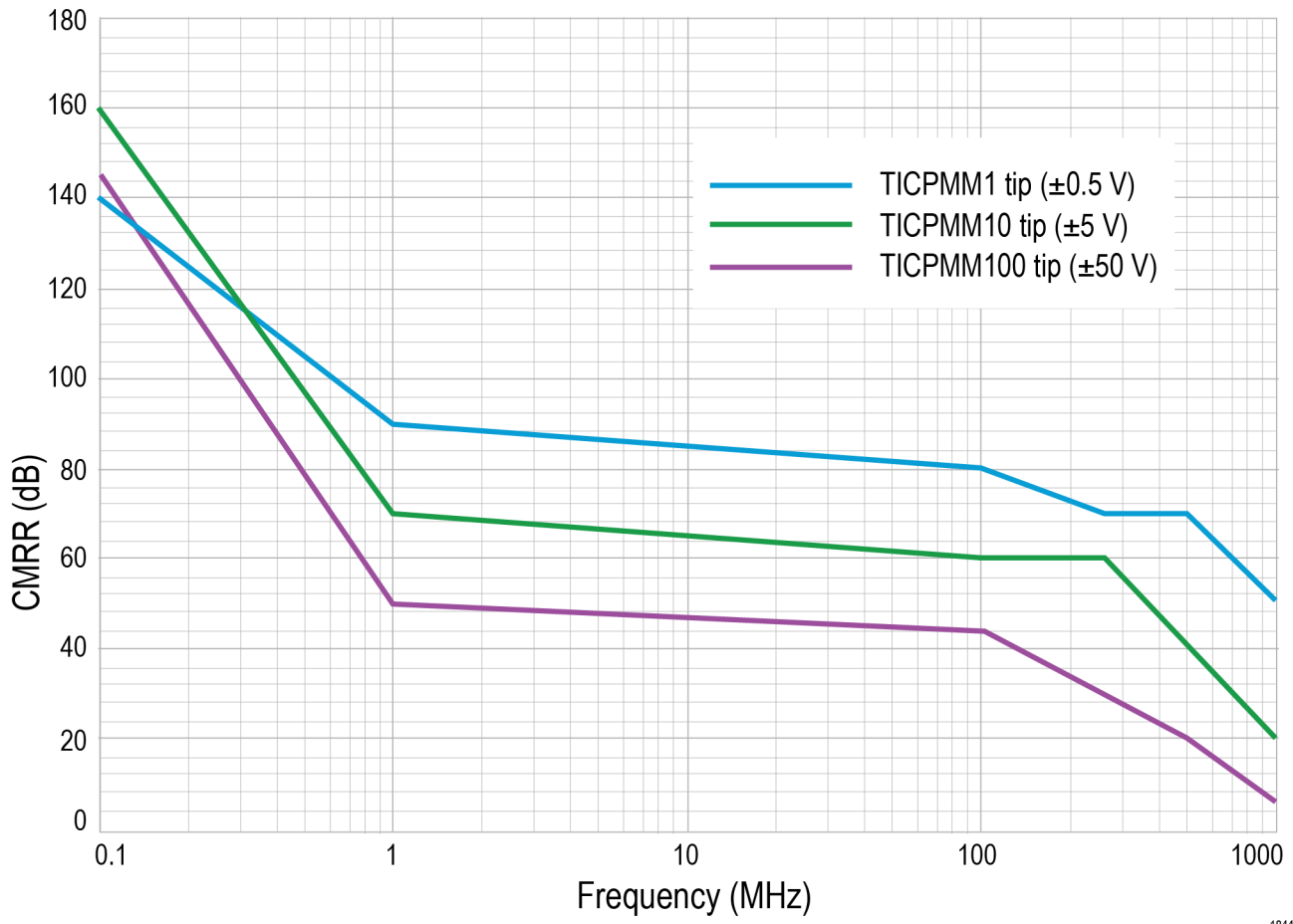
Wideband shunts CMRR

Sensor Tip Cable	DC	1 MHz	100 MHz	250 MHz
5 Ω (TICS5000)	120 dB	105 dB	52 dB	40 dB
500 m Ω (TICS0500)	120 dB	105 dB	67 dB	55 dB
50 m Ω (TICS0050)	120 dB	110 dB	80 dB	70 dB
5 m Ω (TICS0005)	120 dB	110 dB	90 dB	82 dB



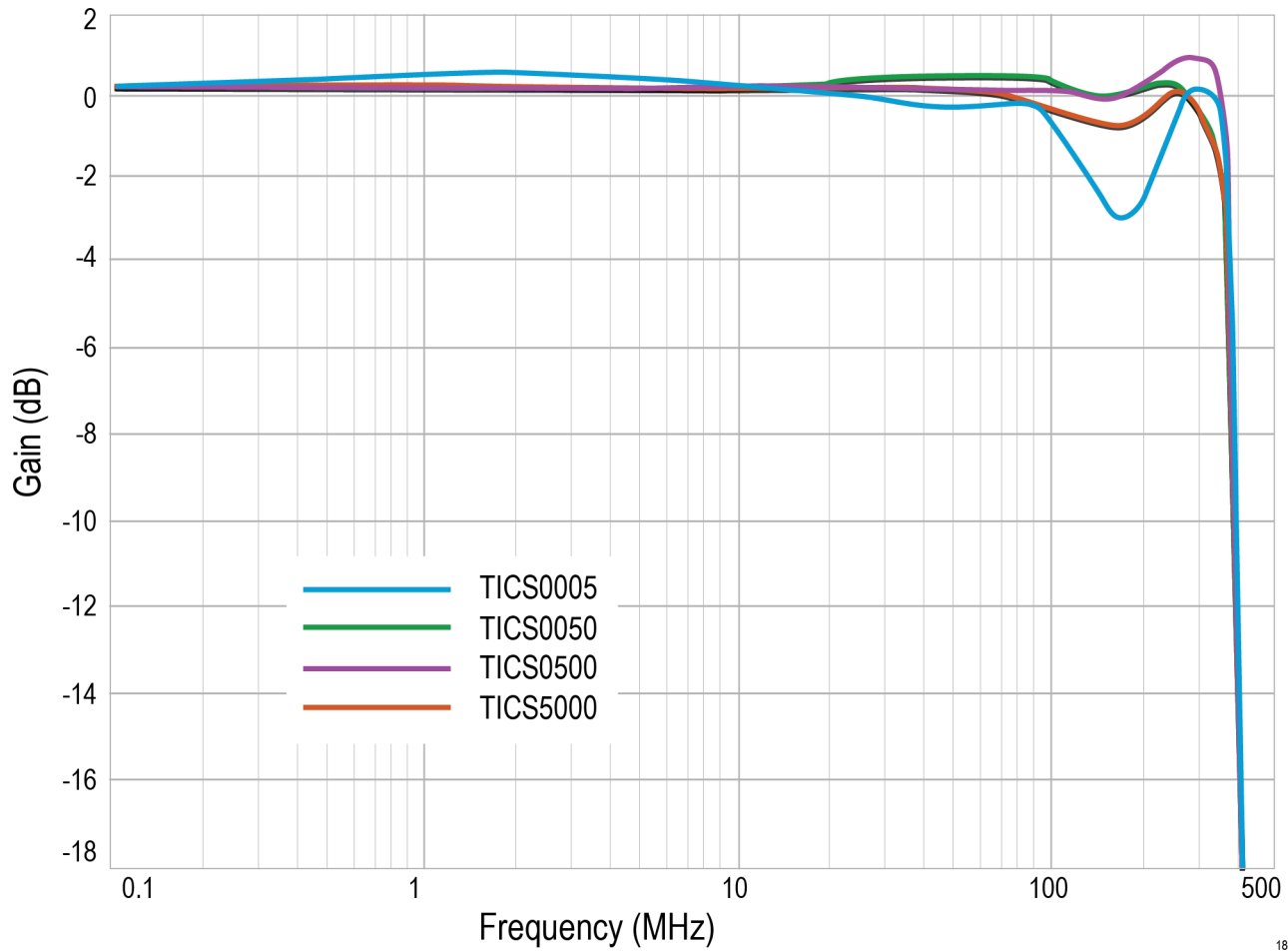
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IsoVu isolated current probes frequency response



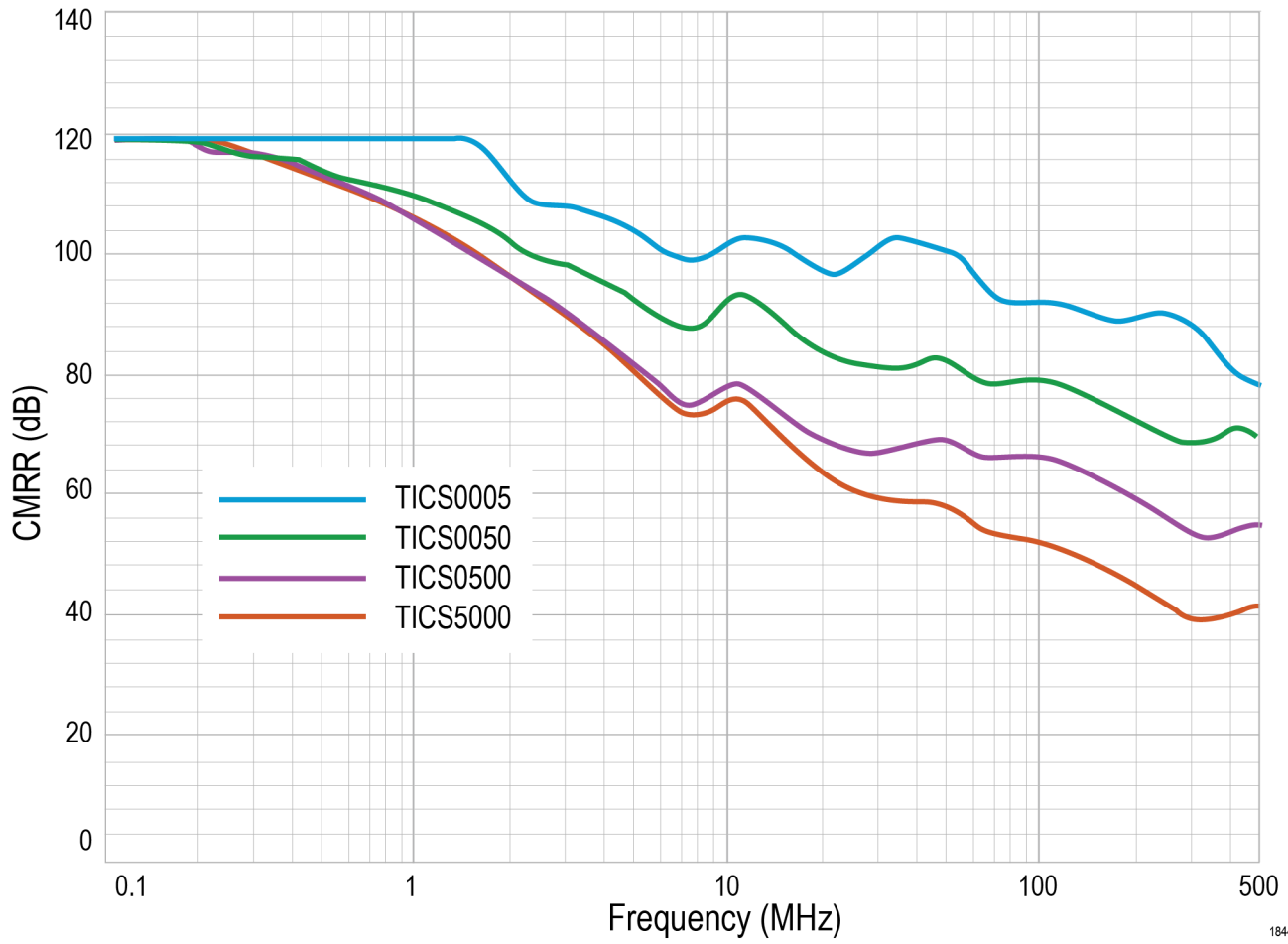
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IsoVu isolated current probes common mode rejection ratio (CMRR)



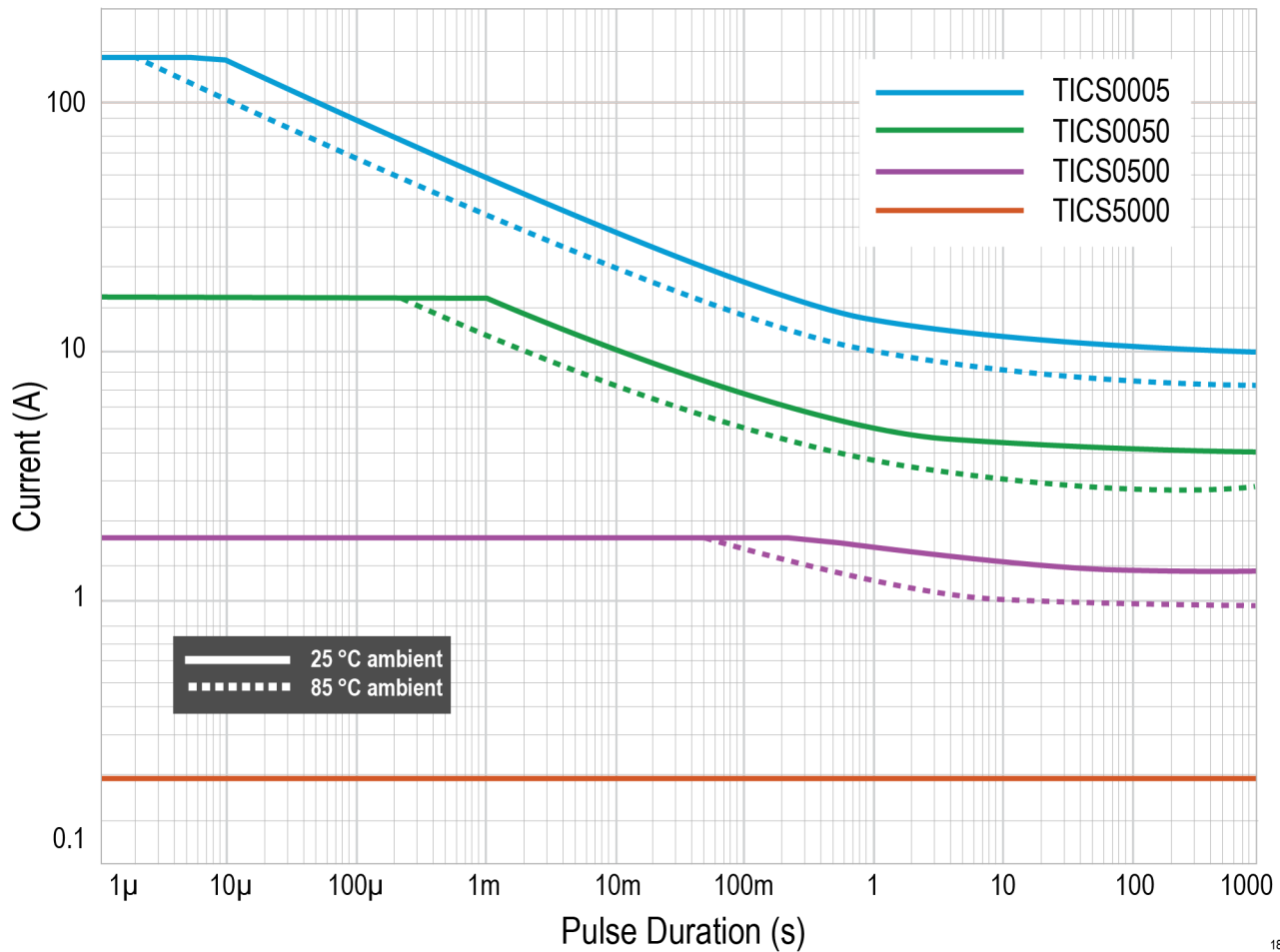
1844-030

Wideband shunts frequency response



1844-031

Wideband shunts CMRR



1844-032

Wideband shunts square-wave pulse current derating curve

Pulse Width durations are based on a Square Wave input. For Triangle Wave input (as in Double Pulse Test), the Maximum Pulse Width can be multiplied by 3.5. For example, for a double-pulse test that peaks at 20 A, the 50 mΩ TICS can withstand a 3.5 ms ramp. A 20 A square wave impulse could only be held for 1 ms.

Wideband shunts pulse current derating calculations

Calculate max current for a square current pulse of width *t* using the following equation:

$$I_{max} = \min \left(\sqrt{\frac{P_{max}}{R_{shunt}}}, \frac{1V}{R_{shunt}} \right)$$

For an isolated pulse or ramp (effectively zero duty cycle):

$$P_{max} = P_d + \frac{C}{\sqrt{t}}$$

For repetitive operation with duty cycle $0 < D \leq 1$, P_{max} is further reduced according to the duty-cycle derating expression below:

$$P_{max} = \frac{P_d}{P_d + D \cdot \frac{C}{\sqrt{t}}} \cdot \left(P_d + \frac{C}{\sqrt{t}} \right)$$

The coefficients P_d and C are tabulated by ambient temperature and shunt model; refer to the following table for values.

Shunt	25°C		85°C	
	C	P _d	C	P _d
5 mΩ	0.6	0.69	0.31	0.36
50 mΩ	0.6	1.0	0.31	0.52
500 mΩ	0.6	1.0	0.31	0.52
5 Ω	0.6	1.0	0.31	0.52

Example

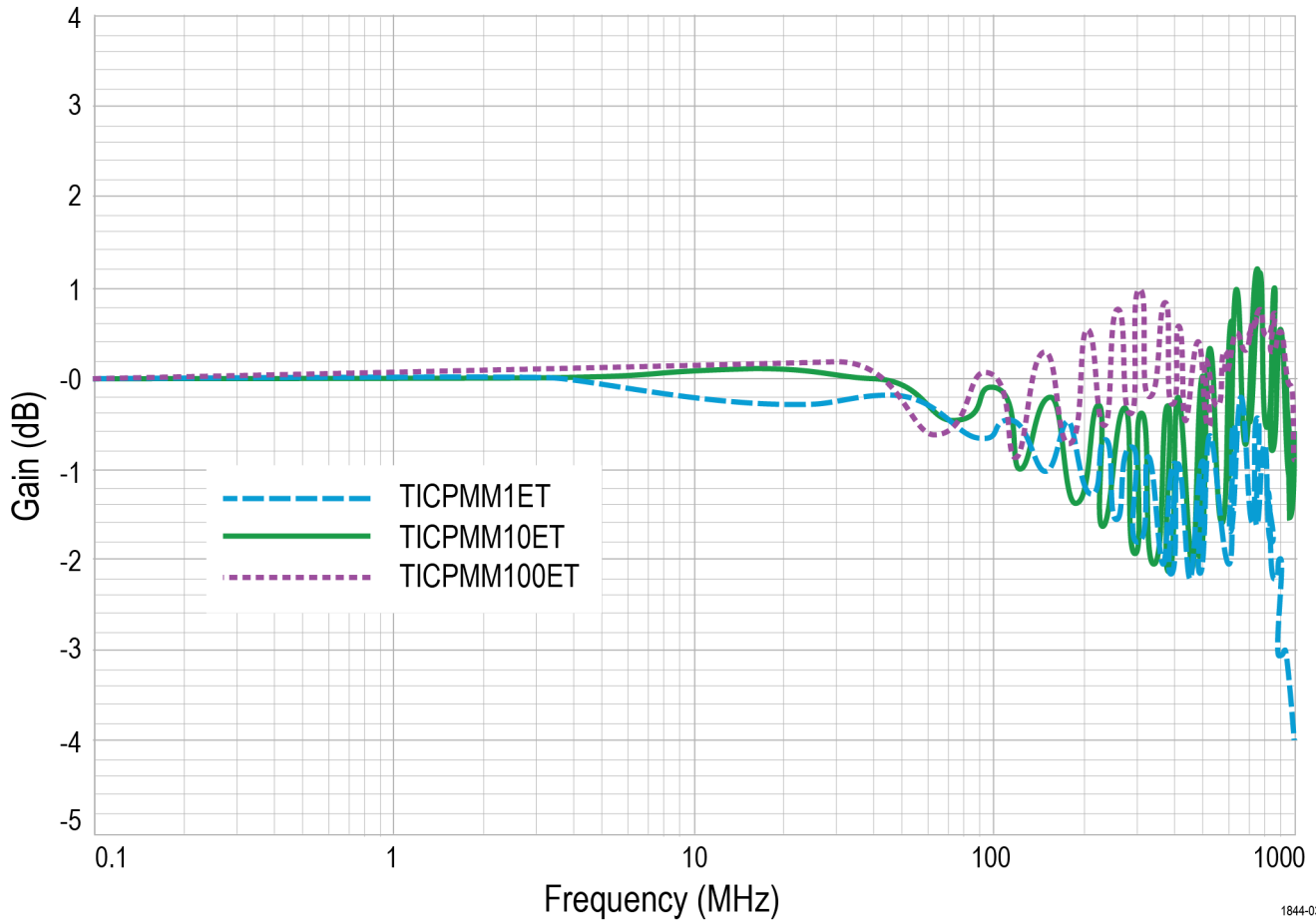
A pulse train double pulse test with 5 pulses starts at 0 A and ramps over a period of 100 μs. Though there are short OFF periods between the pulses, it is more conservative to calculate the pulse width assuming that those periods do not exist and model the ramp as a continuous signal. In addition, because the double pulse test is a ramp waveform, the 3.5X scaling factor is applied to t .

$$R_{shunt} = 5 \text{ m}\Omega, t = \frac{100 \mu s}{3.5} = 28.6 \mu s, P_d = 0.69, C = 0.6$$

$$P_{max} = P_d + \frac{C}{\sqrt{t}} = 0.69 + \frac{0.6}{\sqrt{28.6 \cdot 10^{-6}}} = 113 \text{ W}$$

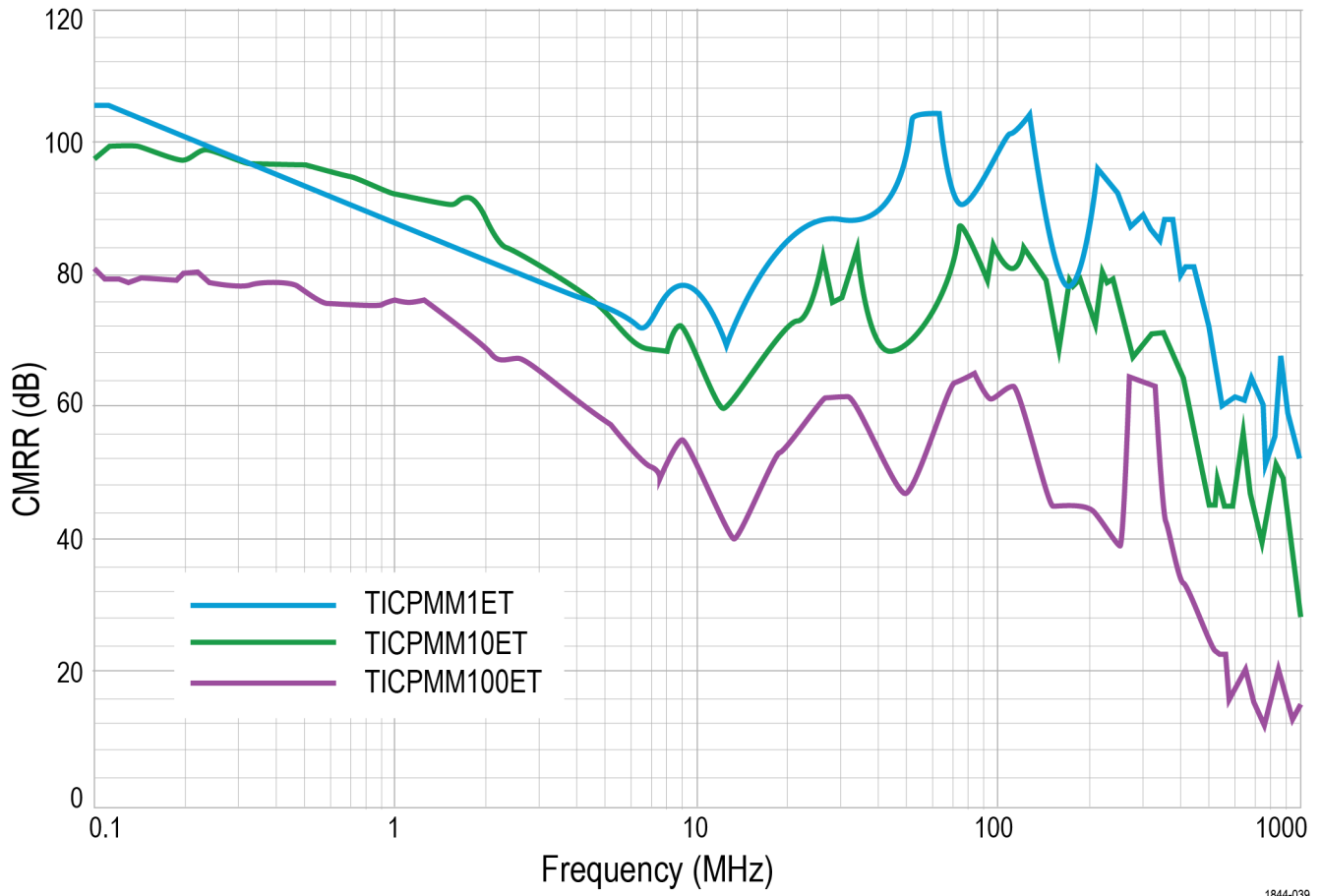
$$I_{max} = \sqrt{\frac{P_{max}}{R_{shunt}}} = \sqrt{\frac{113 \text{ W}}{5 \cdot 10^{-3} \Omega}} = 150 \text{ A}$$

The calculation above shows the 5 mΩ TICS0005 will survive a 150 A ramp that lasts less than 100 μs.



1844-038

Extreme temperature tip frequency response



1844-039

Extreme temperature tip CMRR

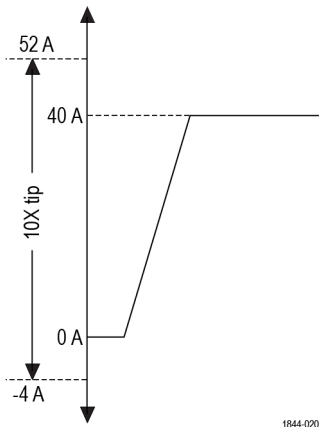
Application Examples

Application examples for Wide Bandgap (WBG) and PMIC power integrity.

WBG example (800V, 40 A typical; 0.125 Ω shunt)

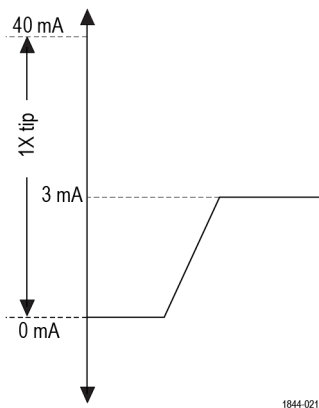
In a 800 V SiC circuit switching at 40 A, a 125 m Ω shunt will produce a 5 V signal. To measure this using the IsoVu isolated current probe the 10X tip must be used. In the ± 3.5 V range apply 24 A of offset.

The measurable current range goes from 52 A to -4 A. At these settings, the RMS noise floor at 250 MHz bandwidth is 2.2 mA RMS



PMIC power integrity (48 V, 3 mA typical; 1 Ω shunt)

On a 48 V PMIC bus, the standby current of 3 mA will produce a 3 mV signal on a 1 Ω shunt. Use the 1X tip in the most sensitive ± 20 mV range, apply offset to view the 3 mA current and capture transients from 0 A to 40 mA with a RMS noise floor of 21.2 μ A

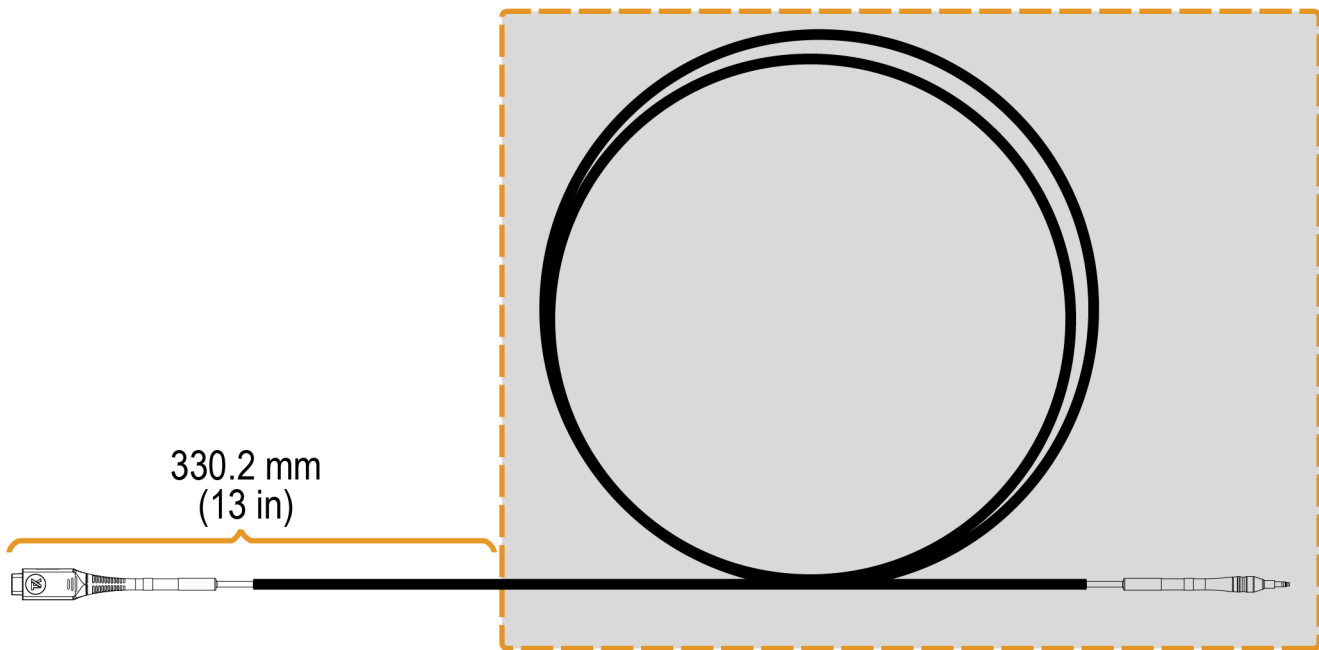


Environmental requirements

Characteristic	Component	Operating	Non-operating
Compensation box, probe head, and SMA tip adapter temperature		0°C to +50°C	-20°C to +70°C
Standard tips temperature	TICPMM1, TICPMM10, TICPMM100, TICS0005, TICS0050, TICS0500, TICS5000, TICPTWCBL	-40°C to +85°C	-40°C to +85°C
Extreme temperature tips (ET) temperature	TICPMM1ET, TICPMM10ET, TICPMM100ET	-40°C to +125°C	-40°C to +125°C; Storage temperature is -40°C to +85°C
Humidity	All components	5% to 85% relative humidity up to +40°C, 5% to 45% relative humidity up to +50°C, non-condensing	5% to 85% relative humidity up to +40°C, 5% to 45% relative humidity up to +70°C, non-condensing
Altitude	All components	Up to 3,000 meters	Up to 12,000 meters

Tektronix extreme temperature (ET) tips enable accurate current measurements in environmental testing applications across an extended operating range of -40°C to +125°C.

In the illustration below, the shaded region within the dashed boundary indicates the recommended working zone for extreme temperature operation. To prevent environmental chamber access-port leakage from impacting the probe head, this working zone should begin at least 13 inches (330.2 mm) from the probe head.



1844-033

Regulatory compliance

EMC

Conforms to European Union EMC Directive (CE-marked)

Safety

Conforms to European Union Low Voltage Directive (CE-marked)

Conforms to ANSI/UL61010-1 (CSA-marked)

Conforms to ANSI/UL61010-2-030 (CSA-marked)

Certified to CAN/CSA C22.2 No.61010-1 (CSA-marked)

Certified to CAN/CSA C22.2 No.61010-2-030 (CSA-marked)

RoHS

Conforms to European Union Restrictions on Hazardous Substances (CE-marked)

Ordering information








Select the appropriate instrument and options for your measurement needs.


Model overview

Model	Description
TICP025	250 MHz Tektronix Isolated Current Probe
TICP050	500 MHz Tektronix Isolated Current Probe
TICP100	1 GHz Tektronix Isolated Current Probe

Standard accessories






The following table lists the accessories that are shipped with the probe.

Accessory	Description	Part number
	1X probe tip cable with MMCX connector	TICPMM1
	10X probe tip cable with MMCX connector	TICPMM10
	SMA tip adapter	TICPSMA
	Clamp-on ferrite common mode choke	276-0905-XX
	Bipod is used to hold the probe.	020-3210-XX
	Tripod adapter for 1/4 in - 20 UNC thread accessories.	103-0508-XX
	Probe tip adapter. Adapts an MMCX IsoVu tip to standard 0.100" spaced, 0.025" square pins.	131-9717-XX





Accessory	Description	Part number
	Soft carrying case with foam insert.	016-2147-XX

Recommended accessories

The following table lists optional accessories.

Accessory	Description	Part number	
	100X probe tip with MMCX connector	TICPMM100	
	TICP 5 mΩ low-power shunt	TICS0005 (Qty. 1) TICS0005PK (Qty. 10)	
	TICP 50 mΩ low-power shunt	TICS0050 (Qty. 1) TICS0050PK (Qty. 10)	
	TICP 500 mΩ low-power shunt	TICS0500 (Qty. 1) TICS0500PK (Qty. 10)	
	TICP 5000 mΩ (5 Ω) low-power shunt	TICS5000 (Qty. 1) TICS5000PK (Qty. 10)	
		TICP cable for shunts	TICPTWCBL (Qty. 1) TICPTWCBLPK (Qty 5)
	1X extreme temperature tip with MMCX connector	TICPMM1ET	
	10X extreme temperature tip with MMCX connector	TICPMM10ET	
	100X extreme temperature tip with MMCX connector	TICPMM100ET	
	Twisted pair solder-in accessory	174-7492-XX	

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	Square pin to MMCX adapter, 0.062" spacing	131-9677-XX
	MMCX to IC grabber lead	196-3546-XX
	Square pin to IC grabber lead	196-3547-XX
	MicroCKT grabbers	206-0569-XX

Supported oscilloscopes

The measurement systems can be used with the following Tektronix oscilloscopes.

- 4 Series MSO, 4 Series B MSO
- 5 Series MSO, 5 Series B MSO, 5 Series MSO LP
- 6 Series MSO, 6 Series B MSO

Service options

Standard warranty

1 year

Opt. R3 - Repair Service 3 Years (including warranty)

Opt. R5 - Repair Service 5 Years (including warranty)

Opt. C3 - Calibration Service 3 Years

Opt. C5 - Calibration Service 5 Years

Opt. D1 - Calibration Data Report

Opt. D3 - Calibration Data Report 3 Years (with Opt. C3)

Opt. D5 - Calibration Data Report 5 Years (with Opt. C5)

Opt. T3

Three year total protection plan, includes repair or replacement coverage from wear and tear, accidental damage, ESD or EOS plus preventative maintenance. Including a 5 day turnaround time and priority access to customer support

Opt. T5

Five year total protection plan, includes repair or replacement coverage from wear and tear, accidental damage, ESD or EOS plus preventative maintenance. Including a 5 day turnaround time and priority access to customer support

Probes and accessories are not covered by the oscilloscope warranty and Service Offerings. Refer to the datasheet of each probe and accessory model for its unique warranty and calibration terms.

Certifications

Tektronix is registered to ISO 9001:2015 and ISO 14001:2015.

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