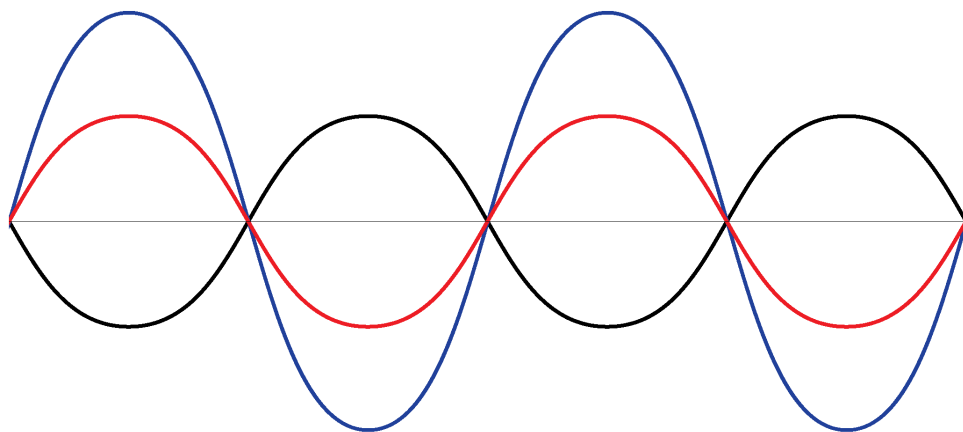


CT4028A

# 39 kV High-Voltage Oscilloscope Probe

User Manual



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# Notices

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Made in Taiwan

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## Warranty

### LIMITED TWO-YEAR WARRANTY

Cal Test Electronics, Inc warrants these products to be free from defective material or workmanship for a period of 2 year from the date of original purchase. Under this warranty, Cal Test Electronics, Inc is limited to repairing this product when returned to the factory, shipping charges prepaid, within the warranty period.

Units returned to Cal Test Electronics, Inc that have been subject to abuse, misuse, damage, or accident, or have been connected, installed, or adjusted contrary to the instructions furnished by Cal Test Electronics, Inc, or that have been repaired by unauthorized persons, will not be covered by this warranty.

Cal Test Electronics, Inc reserves the right to discontinue models, change specifications, price, or design of this device at any time without notice and without incurring any obligation whatsoever.

The purchaser agrees to assume all liabilities for any damages and/or bodily injury which may result from the use or misuse of this device by the purchaser, his employees, or agents.

THIS WARRANTY IS IN LIEU OF ALL OTHER REPRESENTATIONS OR WARRANTIES EXPRESSED OR IMPLIED AND NO AGENT OR REPRESENTATIVE OF CAL TEST ELECTRONICS, INC IS AUTHORIZED TO ASSUME ANY OTHER OBLIGATION IN CONNECTION WITH THE SALE AND PURCHASE OF THIS DEVICE.

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# Compliance Information

## Safety

### EC Declaration of Conformity - Low Voltage

Compliance was demonstrated to the following specification as listed in the Official Journal of the European Communities: Low Voltage Directive: 2014/35/EU.

EN 61010-031:2015 Ed 2.0. Safety requirements for electrical equipment for measurement, control and laboratory use - Part 031: Safety requirements for hand-held probe assemblies for electrical measurement and test.

## Environmental

### Restriction of Hazardous Substances (RoHS 2)

The product and its accessories conform to the Directive 2011/65/EU (RoHS 2) on the restriction of the use of certain hazardous substances in electrical and electronic equipment, inclusive of any modification and addendum to said Directive.

EN ISO 63000:2018 Technical documentation for the assessment of electrical and electronic products with respect to the restriction of hazardous substances.



China RoHS 2 refers to the Ministry of Industry and Information Technology Order No. 32, effective July 1, 2015. See "Hazardous Substances Disclosure Table" on page 19.

### Product End-of-Life Handling

The equipment may contain substances that could be harmful to the environment or human health if improperly handled at the product's end of life. To avoid release of such substances into the environment and to reduce the use of natural resources, we encourage you to recycle this product to an appropriate system that will ensure that most of the materials are reused or recycled appropriately.



This product is subject to Directive 2012/19/EU of the European Parliament and the Council of the European Union on waste electrical and electronic equipment (WEEE), and in jurisdictions adopting that Directive, is marked as being put on the market after August 13, 2005, and should not be disposed of as unsorted municipal waste. Please utilize your local WEEE collection facilities in the disposition of this product.

---

# Terms & Symbols

The following terms, symbols, and definitions, individually or combination may appear on the product or in this user manual.

## Terms

### CAUTION

A caution statement calls attention to an operating procedure, practice, or condition, which, if not followed correctly, could result in damage to or destruction of parts or the entire product.

### WARNING

A warning statement calls attention to an operating procedure, practice, or condition, which, if not followed correctly, could result in injury or death to personnel.

### NOTE

A note statement calls attention to an operating procedure, practice, or condition, which, should be noted before proceeding.

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## Symbols



CAUTION – Statements or instructions that must be consulted in order to find out the nature of the potential hazard and any actions which must be taken.

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WARNING - HIGH VOLTAGE - possibility of electric shock.

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The Conformité Européenne (CE) Mark is the European Union's (EU) mandatory conformity marking for regulating the goods sold within the European Economic Area (EEA).

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The UK Conformity Assessed (UKCA) marking is a conformity mark that indicates compliance with applicable requirements for products sold within Great Britain. Similar to the CE mark, products bearing the UKCA mark are acceptable in the UK market.

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# Safety Information

## Usage Precautions

**WARNING** The high-voltage probe is designed to prevent accidental shock to the operator when properly used. This operating note must be read and understood prior to using the probe. Improper procedure or incorrect analysis of the measurement situation can result in serious shock.

**WARNING** This high-voltage probe must only be used by personnel who are trained, experienced, or otherwise qualified to recognize hazardous situations and who are trained to the safety precautions that are necessary to avoid possible injury when using such a device.

**WARNING** When measuring higher frequency signals, be sure to comply with the Voltage vs Frequency Derating Curve. Do not apply to the input any potential that exceeds the maximum rating of the probe.

**WARNING** This high-voltage probe is designed for use with Measurement Category *other than* II, III and IV only (formerly CAT I). Do not use the probe for measurements performed on circuits defined by any other measurement category or transient overvoltages of more than 1500 V. Refer to IEC Measurement Category Definitions on page 7 for a definition of measurement categories.

**WARNING** The ground lead is critical to the safe operation of the probe. Failure to make this connection when making high-voltage measurements may result in personal injury or damage to the probe or oscilloscope. This connection must always be made **BEFORE** the probe tip comes in contact with the high voltage and must not be removed until the probe tip has been removed from the high-voltage source.

**WARNING** Do not exceed 30 minutes of contact between the probe and the circuit-under-test when measuring voltages  $\geq 30$  kV DC or  $\geq 20$  kV ACrms. It is recommended to wait 5 minutes between measurements.

**WARNING** Hands, shoes, floor, and work bench must be dry. Avoid making measurements under humidity, dampness, or other environmental conditions that might affect safety.

**WARNING** To avoid injury, remove jewelry such as rings, watches, and other metallic objects. Do not touch exposed connections and components when power is present.

**WARNING** Do not work alone when working with high-Voltage Circuits.

**WARNING** The probe is designed to be used in office-type indoor environments.

- Do not operate in the presence of noxious, corrosive, flammable fumes, gases, vapors, chemicals, or finely-divided particulates.
- Hands, shoes, floor, and workbench must be dry. Avoid making measurements under humid, damp, or other environmental conditions that might effect the safety of the measurement situation.
- The probe body should be kept clean and free of any conductive contamination. Refer to the section on cleaning.

---

**WARNING** To reduce the risk of shock or fire:

- Connect the probe to the oscilloscope before connecting probe to the circuit under test. Disconnect the probe input from the circuit before disconnecting the probe from the oscilloscope.
- Do not exceed the voltage rating category rating of the probe. Use only accessories provided with probe.
- Keep finger behind the finger guard of the probe body.
- For your own safety, inspect the probe for cracks and frayed or broken leads before each use. If defects are noted, DO NOT use the probe.
- Keep the probe's output cables away from the circuit under test, as they are not intended to be in contact with these circuits.

**WARNING** It is advisable to turn the high-voltage source off before connecting or disconnecting the probe.

**WARNING** Do not attempt to take measurements where the source and the test instrument chassis or return lead is not properly grounded.

---

## IEC Measurement Category & Pollution Degree Definitions

Measurement Category (CAT) - classification of testing and measuring circuits according to the types of mains circuits to which they are intended to be connected.

Measurement Category *other than* II, III, or IV: circuits that are not directly connected to the mains supply.

Measurement Category II (CAT II): test and measuring circuits connected directly to utilization points (socket outlets and similar prints) of the low-voltage mains installation..

Measurement Category III (CAT III): test and measuring circuits connected to the distribution part of a building's low-voltage mains installation.

Measurement Category IV (CAT IV): test and measuring circuits connected at the source of the building's low-voltage mains installation.

Pollution - addition of foreign matter, solid, liquid, or gaseous (ionized gases) that may produce a reduction of dielectric strength or surface resistivity.

Pollution Degree 2 (P2)- only non-conductive pollution occurs except that occasionally a temporary conductivity caused by condensation is expected.

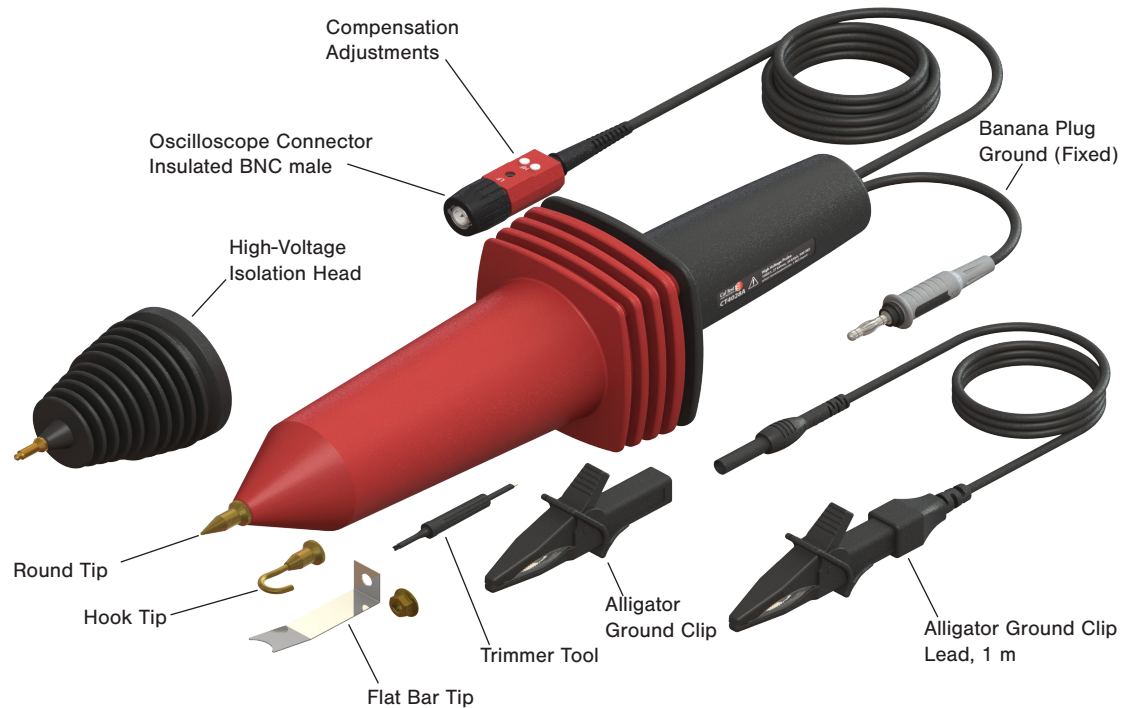
# Introduction

## Overview

The Cal Test CT4028A High-Voltage divider probe can be used with analog or digital oscilloscopes that have an input resistance of  $1\text{ M}\Omega$  ( $\pm 1\%$ ) and nominal input capacitance between 10 and 35 pF. The CT4028A is a 1000:1 divider which extends the voltage measurement capability to 27 kV ACrms.

Features of the probe:

- Up to 39 kV (DC + ACpeak) or 27 kV ACrms
- 50 MHz bandwidth (-3dB)
- $\pm 3\%$  accuracy
- IEC/EN 61010-031



**Figure 1** Probe and Supplied Accessories

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## Supplied Accessories

**Table 1**                    **CT4028A Accessory Replacements**

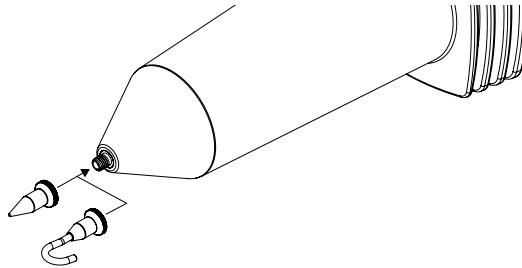
| Accessory                                        | Model No. | Quantity |
|--------------------------------------------------|-----------|----------|
| Round Tip                                        | CT2960A   | 1        |
| Hook Tip                                         | CT2961A   | 1        |
| Flat Bar Tip                                     | CT2962A   | 1        |
| Deluxe Trimmer Tool                              | CT3648    | 1        |
| Trimmer Tool                                     | CT4214    | 1        |
| Alligator Ground Clip, Black                     | CT4108-0  | 1        |
| Alligator Ground Clip Lead, 1 m                  | CT4494-85 | 1        |
| High-Voltage Isolation Head (for use > 25 kV DC) | CT4107    | 1        |

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## Using Accessories

### Round Tip & Hook Tip

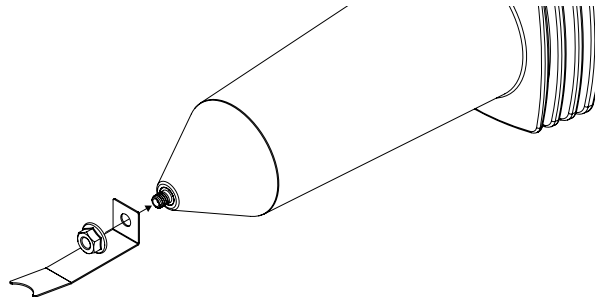
Thread either the Round Tip or the Hook Tip onto the probe's M5 tip stud and securely hand-tighten.



**Figure 2** Attaching the Round and Hook Tips

### Flat Bar Tip

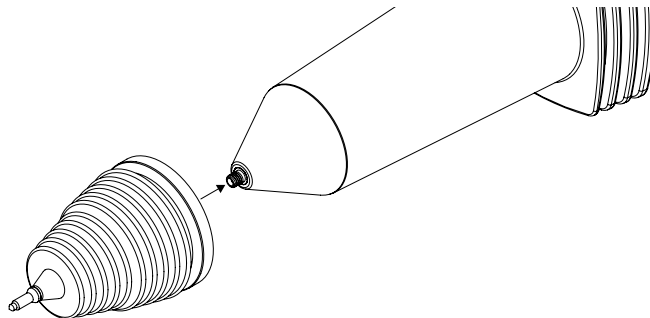
The end of the Flat Bar Tip can be clamped to the device-under-test (DUT). To secure the Flat Bar Tip to the probe, use the supplied M5 flange nut (8 mm wrench or nut driver) as show in Figure 3.



**Figure 3** Attaching the Flat Bar Tip

### High-Voltage Isolation Head

When measuring voltages at or above 25 kV DC, thread on the High-Voltage Isolation Head to increase the probe's voltage capability.

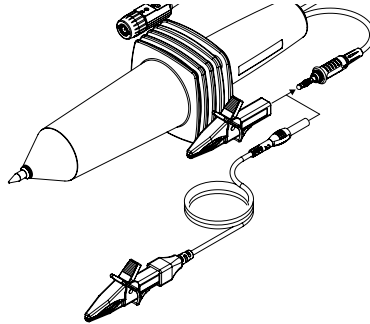


**Figure 4** Attaching the High-Voltage Isolation Head

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### Alligator Ground Clips

Plug on either the individual Alligator Ground Clip or the Alligator Ground Clip lead to provide the probe's required ground connection. See Figure 5.

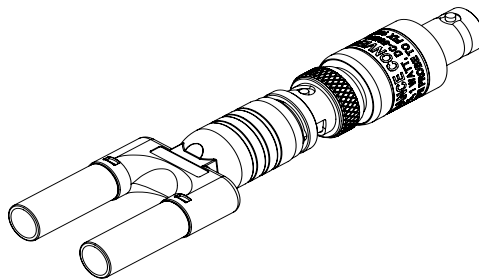


**Figure 5** Attaching Alligator Ground Clips

## Optional Accessories

### DMM Converter

For connecting the probe to a Digital Multimeter (DMM) you can use the CT3197B High-Voltage Probe BNC Converter. The high-voltage probe converter allows impedance matching of the probe's 1 M $\Omega$  output to a DMM's 10 M $\Omega$  input. Usable with most quality DMMs, you can order this converter separately.



**Figure 6** CT3197B High-Voltage Probe BNC Converter

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# Measurement Instructions



Before connecting the probe for your measurement, read all the warnings in this section and all of the warnings in the section “Safety Information” on page 6.

Frequency compensate the probe to your oscilloscope prior to usage. See “Frequency Compensation” on page 14.

## Steps

1. Turn the high-voltage source off before making any connections.
2. Connect the alligator ground clip lead or the individual alligator ground clip to the banana ground plug then connect the alligator clip to a good earth ground or reliable chassis ground.
3. Connect the probe's BNC male connector to the oscilloscope's BNC output.
4. On the oscilloscope, select the desired volts/division range. If the oscilloscope has probe attenuation setting, set it to 1000:1, if available.

### WARNING

Before turning on the high voltage source, make sure that no part of the person holding the probe is touching the device under test.

5. After confirming that the probe operator is not touching the device under test, turn on the high-voltage source.
6. Measure the voltage under test and observe the waveform on the oscilloscope.

### WARNING

Remember the actual voltage is 1000 times greater than the oscilloscope waveform if the probe attenuation has not been set to 1000:1.

7. Turn off the high voltage source.
8. Disconnect the probe tip from the high-voltage source.
9. Disconnect the probe's ground clip lead.

### WARNING

Disconnect the probe tip from the high voltage source BEFORE disconnecting the alligator ground clip lead.

### WARNING

Do not exceed 30 minutes of contact between the probe and the circuit-under-test when measuring voltages  $\geq 30$  kV DC or  $\geq 20$  kV ACrms. It is recommended to wait 5 minutes between measurements.

### WARNING

Do not attempt to take measurements from sources where the chassis or return lead is not grounded.

### WARNING



The ground lead is critical to the safe operation of the probe. Failure to make this connection when making high-voltage measurements may result in personal injury or damage to the probe or oscilloscope. This connection must always be made BEFORE the probe tip comes in contact with the high voltage and must not be removed until the probe tip has been removed from the high-voltage source.

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**WARNING** Do not connect the ground clip to the high voltage source or the probe tip to the ground for any reason.

**WARNING** Do not make any floating measurements with the probe.

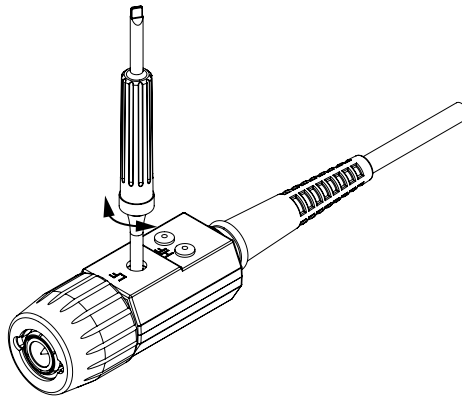
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# Frequency Compensation

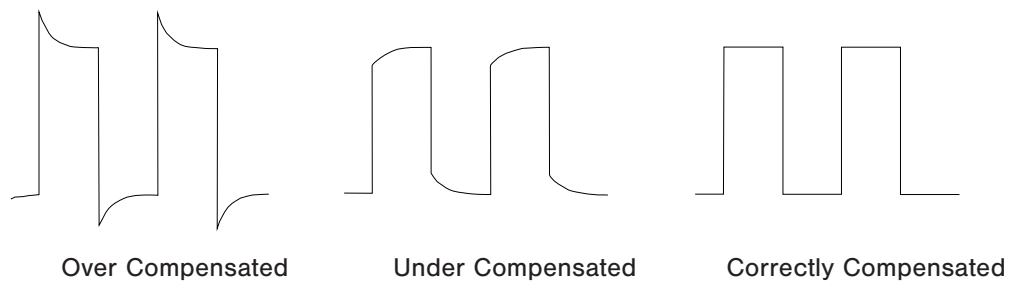
Use the following frequency compensation adjustments to compensate the probe to the oscilloscope's input capacitance. You should preform this adjustment whenever you connect the probe to a different oscilloscope input channel or to a different oscilloscope.

## Low Frequency Compensation Adjustment

1. Connect the probe to the oscilloscope.
2. Connect the probe tip to a square-wave function generator.
3. Adjust the function generator's output to square-wave, 200 Hz and 10 V amplitude.
4. Adjust the oscilloscope time base so that you can see several waveform cycles.
5. Using supplied trimmer tool, adjust the Low Frequency Adjustment Point (Figure 7) for the flattest square-wave top. Figure 8 shows the correctly compensated waveform.



**Figure 7** Low Frequency Adjustment Point



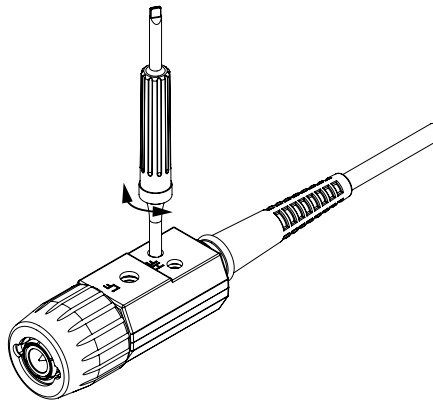
**Figure 8** Frequency Compensation Waveforms

## High Frequency Compensation Adjustment

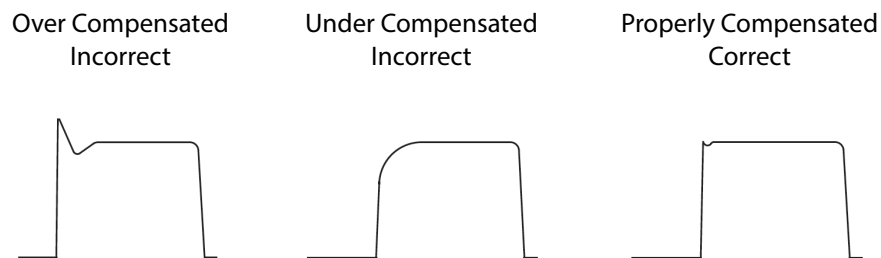
### NOTE

Should seldom be required, however, if the probe has HF adjustment capability and adjustment is necessary, continue with the steps below.

6. Remove the two plastic plugs from the housing HF compensation points.
7. Connect the probe to the oscilloscope.
8. Connect the probe tip to a square-wave function generator.
9. Adjust the function generator's output to square-wave, 200 kHz and 10 V amplitude.
10. Adjust the oscilloscope time base so that you can see several waveform cycles.
11. Using supplied trimmer tool, alternately adjust the two High-Frequency Adjustment points (Figure 9) for flat-topped square waves. Figure 10 shows the correctly compensated waveform.



**Figure 9** High-Frequency Adjustment Points



**Figure 10** High-Frequency Compensation Waveforms

# Specifications

The probe and oscilloscope should be warmed up for at least 20 minutes before any testing and the environmental conditions should not exceed the probe's specified limits.

**NOTE** All entries included in the following tables are characteristics unless otherwise stated.

**Table 2 Safety Specifications**

| Parameter             | Condition                                                              |
|-----------------------|------------------------------------------------------------------------|
| IEC/EN 61010-031:2015 | Measurement Category <i>other than</i> II, III, or IV (formerly CAT I) |

**Table 3 Electrical Specifications (Not Warranted)**

| Parameter               | Characteristic                         |
|-------------------------|----------------------------------------|
| Maximum Input Voltage   | 39 kV (DC + AC Peak)<br>27 kV ACrms    |
| Maximum Loading Current | 45 $\mu$ A                             |
| Attenuation             | 1000X                                  |
| Bandwidth               | DC to 50 MHz (-3 dB)                   |
| Rise Time               | $\leq 7$ ns                            |
| Input Resistance        | 900 M $\Omega \pm 5\%$                 |
| Input Capacitance       | 2.0 pF                                 |
| Signal/Noise            | > 60 dB @ 1 kHz<br>> 50 dB @ 1 MHz     |
| Accuracy                | < 3%, 0 to 35 kV DC<br>< 3% @ 1 kHz AC |
| Temperature Coefficient | $\leq 200$ ppm/ $^{\circ}$ C           |
| Compensation Range      | 10 pF to 35 pF                         |

**Table 4 Mechanical Specifications**

| Parameter             | Characteristic                                                            |
|-----------------------|---------------------------------------------------------------------------|
| BNC Cable Length      | 2 m (6.6 ft)                                                              |
| Operating Temperature | 0 $^{\circ}$ C to 50 $^{\circ}$ C (32 $^{\circ}$ F to 122 $^{\circ}$ F)   |
| Storage Temperature   | -20 $^{\circ}$ C to 70 $^{\circ}$ C (-4 $^{\circ}$ F to 158 $^{\circ}$ F) |
| Humidity              | $\leq 80\%$ RH @ 40 $^{\circ}$ C (104 $^{\circ}$ F)                       |
| Dimensions            | 340 mm length, 75 mm wide, 75 mm high                                     |
| Weight                | 460 g (1 lb)                                                              |

# Voltage Derating

The following graph shows the voltage versus frequency derating curve for the probe.

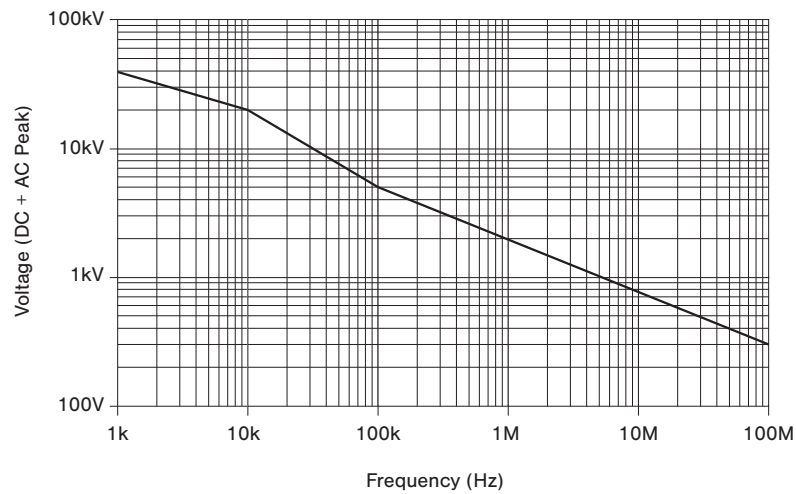
## **WARNING**



When measuring higher frequency signals, be sure to comply with the Voltage vs Frequency Derating Curve. Do not apply to the input any potential that exceeds the maximum rating of the probe.

Note that inflection points on the curve occur at the following locations:

39 kV @ 1 kHz / 20 kV @ 10 kHz / 5 kV @ 100 MHz / 300 V @ 100 MHz



**Figure 11** Voltage Derating Curve

---

## Cleaning

Clean only the exterior probe body and cables. Use a soft cotton cloth light moistened with a mild solution of detergent and water. Do not allow any portion of the probe to be submerged at any time.

**WARNING** Dry the probe thoroughly before attempting to make voltage measurements.

**CAUTION** Do not subject the probe to solvents or solvent fumes as these can cause deterioration of the probe body and cables.

# China RoHS 2

## Hazardous Substances Disclosure Table



China RoHS 2 refers to the Ministry of Industry and Information Technology Order No. 32, effective July 1, 2015, titled Management Methods for the Restriction of the Use of Hazardous Substances in Electrical and Electronic Products. To comply with China RoHS 2, we determined this product's Environmental Protection Use Period (EPUP) to be 25 years in accordance with the Marking for the Restricted Use of Hazardous Substances in Electronic and Electrical Products, SJ/T 11364.

中國 RoHS 2 指工業和信息化部令第 32 號，自 2015 年 7 月 1 日起生效，題為《電氣電子產品有害物質限制使用管理辦法》。為符合中國 RoHS 2，我們根據電子電氣產品有害物質限制使用標誌 SJ/T 11364 將本產品的環保使用期限 (EPUP) 確定為 25 年。

| Part Name<br>零件名稱                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Hazardous Substance 有害物質 |                      |                      |                                            |                                           |                                                      |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------|----------------------|----------------------|--------------------------------------------|-------------------------------------------|------------------------------------------------------|
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Lead<br>(Pb)<br>鉛        | Mercury<br>(Hg)<br>汞 | Cadmium<br>(Cd)<br>鎘 | Hexavalent<br>Chromium<br>(Cr (VI))<br>六價鉻 | Polybrominated<br>biphenyls (PBB)<br>多溴聯苯 | Polybrominated<br>diphenyl ethers<br>(PBDE)<br>多溴二苯醚 |
| Printed Circuit Board Assemblies<br>印刷電路板組件                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | X                        | O                    | O                    | O                                          | O                                         | O                                                    |
| Electrical Components<br>電氣元件                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | X                        | O                    | O                    | O                                          | O                                         | O                                                    |
| Metal Components<br>金屬部件                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | X                        | O                    | O                    | O                                          | O                                         | O                                                    |
| Plastic Components<br>塑料部件                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | O                        | O                    | O                    | O                                          | O                                         | O                                                    |
| <p>This table is made per guidance of SJ/T 11364.<br/>該表是根據 SJ/T 11364 的指南製作的。</p> <p>O: Indicates that this hazardous substance contained in all of the homogeneous materials for the part is below the limit requirement in GB/T 26572.<br/>O: 表示該有害物質在該部件的所有均質材料中的含量低於 GB/T 26572 中的限量要求。</p> <p>X: Indicates that this hazardous substance contained in at least one of the homogeneous materials used for this part is above the limit requirement in GB/T 26572.<br/>X: 表示該有害物質在用於該部件的至少一種均質材料中的含量高於 GB/T 26572 中的限量要求。</p> |                          |                      |                      |                                            |                                           |                                                      |



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Revision: A

