RIGOL

用户手册

PHA 系列高压差分探头

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RIGOL TECHNOLOGIES CO., LTD.

保证和声明

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文档编号

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一般安全概要

⚠注意

本产品使用过程中涉及高压测量，为了您和设备的安全，使用本产品之前，请务必仔细阅读本手册！

安全术语和符号

使用本产品之前，请仔细阅读如下安全注意事项。

	产品上的⚠符号表示对人体或设备有损害，用户在使用相关功能之前须阅读手册中标有⚠符号的内容。 手册中的⚠符号表示重要信息，用户须阅读该内容后才可使用产品。
	产品上⚠的符号表示高电压。
	产品上⏚的符号表示测量接地端。

安全注意事项

⚠注意

- 请注意最高输入电压，小心触电。
- 请勿在潮湿的环境下或者易爆的风险下使用。
- 使用之前，请检查探头外皮是否有破损，若出现破损情况，请停止使用！
- 被测电路接入探头之前，确保被测电路已被关闭。
- 探头的 BNC 输出线连接示波器或者其它波形测量仪器时，确保 BNC 端子已经可靠接地。
- 测量结束后，先关闭电路，再取走探头。

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一般性检查

1. 检查运输包装

产品在出厂前均已经过了严格的检验，当您收到产品时，请先查看包装箱是否完好。如运输包装已损坏，请保留被损坏的包装或防震材料，直到货物经过完全检查且探头通过电性和机械测试。

因运输造成探头损坏，由发货方和承运方联系赔偿事宜。**RIGOL** 公司恕不进行免费维修或更换。

2. 检查探头

若存在机械损坏或缺失，或者探头未通过电性能和机械测试，请联系您的 **RIGOL** 经销商。

3. 检查附件

请根据本手册 **附录 2 装箱清单** 一节检查随机附件，如有损坏或缺失，请联系您的 **RIGOL** 经销商。

高压差分探头简介

PHA 系列高压差分探头（以下简称 PHA 系列探头），通过高压差分输入线连接被测电压，将输入的高差分电压转换为低电压。输出接口与波形测量仪器相连，将电压波形显示在测量仪器上。

主要特色

- 高带宽，满足大部分高频测试系统的需要
  PHA0150：70MHz
  PHA1150：100MHz
  PHA2150：200MHz
- 量程丰富，两档衰减档，满足大部分共模测试电路的要求
  50X：150V（DC + peak AC）
  500X：1500V（DC + peak AC）
- 5MHz 带宽限制功能[1]
  在测量低频信号时，能减少高频信号的噪声和干扰，满足大部分开关电源中 FETs 的开关频率的测量。
- 高压差分输入模式
- 输入端具有较高的输入阻抗和较低输入电容，测量准确、快速
- 良好的共模噪声抑制能力
- 标准 BNC 输出接口，可与大多数厂家的波形测量仪器配合使用
- 声光报警功能，并支持手动关闭
- 自动记忆功能，关机将自动保存关机前的工作设置状态

说明[1]：
当 5MHz 带宽限制功能打开时，PHA 系列探头的输出电路内部接入一个 5MHz 的低通网络。低通网络可以减少高频含量、噪音和谐波，有助于对低频信号进行测试和分析。

使用场景

PHA 系列探头可用于需要进行高压浮地测量的场景，例如：

- 浮地电压测量
- 开关电源设计
- 逆变、UPS 电源测量
- 变频器测量
- 电子镇流器设计
- CRT 显示器设计
- 低压电器试验
- 强电或高压隔离测量
- 电源转换等相关设计
- 焊接、电镀电源测量
- 变频家电测量：感应加热、电磁炉
- 电机驱动设计
- 电工实验
- 电力电子和电力传动实验

探头部件总览

PHA 系列探头包含 PHA0150、PHA1150 和 PHA2150，本手册以 PHA1150 为例进行说明。



图 1 PHA1150 高压差分探头

出厂设置默认选择高衰减倍数档位、选择 FULL 带宽、声音报警功能打开。

部件说明

- **高压差分输入线**
  连接绝缘活塞探夹，测量电压输入信号。
  也可以连接延长线（约 1 米）增加输入线长度。使用延长线时，要求被测信号频率在 5MHz 以下。

- **最大差模输入电压**
  1500V（DC + peak AC）

- **过载指示灯**
  当被测电压超过探头量程，过载指示灯变亮。

- **ATTENUATION**：档位切换按键
  用于切换量程档位。PHA 系列探头有两个量程：
  - ✧ 50X：最高测量电压为 150V
  - ✧ 500X：最高测量电压为 1500V

- **BANDWIDTH**：带宽切换按键
  用于切换带宽。PHA 系列探头支持两种带宽：
  - ✧ FULL：满带宽（PHA0150 满带宽为 70MHz，PHA1150 满带宽为 100MHz，PHA2150 满带宽为 200 MHz）
  - ✧ 5MHz：当测量低频信号时，为减少高频信号的干扰，可选择 5MHz

- **AUDIBLE OVERRANGE**：过载报警开关按键。
  - ✧ ON：打开声音报警功能
  - ✧ OFF：关闭声音报警功能

  过载报警开关打开时，当被测电压超过探头量程时，探头发出蜂鸣报警。

- **负载阻抗**
  探头的输出阻抗是 50Ω，当负载（例如示波器）的输入阻抗为 1MΩ 时，测得信号幅度等于输入幅度。当负载输入阻抗设置为 50Ω 时，高频幅频特性会更平坦，测得信号幅度为输入的一半。

- **USB 电源接口**

标准的 USB Type-C 型接口。PHA 系列探头可以通过 USB 适配器、示波器、USB 移动电源供电，供电设备满足 DC 5V 1A 即可。

- **输出接口**
  标准 BNC 输出接口，可连接大多数厂家的波形测量仪器。

探头使用方法

使用 PHA 系列探头进行测量之前，请仔细阅读**安全注意事项**一节。

测量准备

1. 预估被测电压幅值，看其是否在探头的电压量程内。如果超过电压量程，请更换合适探头，否则可能导致测量不准确或探头损坏，甚至可能会造成安全事故。

2. 准备规格为 DC 5V 1A 的电源适配器。

3. 将探头通电预热至少 20 分钟，同时准备一台测量仪器（如示波器）。

4. 确保被测设备在关闭状态或无输出。

测量步骤

检查并确保测量系统安全且上述准备工作已就绪。

1. 将探头的输出线连接至测量仪器的输入端口。
2. 将 USB Type-C 线一端连接至符合规格的电源适配器上，一端连接至探头的电源端口，接通电源。探头面板上的指示灯都亮起表示探头正常启动。
3. 根据所测电压，选择合适的探头电压量程。
4. 根据探头的量程选择匹配的测量仪器的衰减值，再根据被测电压的大小，调整测量仪器的量程档位。
5. 根据被测对象选择合适的探夹，将探夹的一端安装在探头输入线上，另一端与被测对象连接。
6. 打开被测设备，进行测试。
   测试时，探头主体应尽量远离高压脉冲电路以减小对探头的干扰。

   ⚠注意：当被测电压超过探头量程时，探头过载指示灯亮起。如果 AUDIBLE OVERRANGE 是打开状态，探头还会发出报警声，此时请立即关闭被测设备。

测试完毕后，先关闭被测电路电源，再关闭探头电源，将探头的两个输入端与被测点断开，输出 BNC 插头从测量仪器上退出。

测量过程中需要注意的事项

⚠注意

1. 测量前，尽量使高压差分输入线缠绕，这样可以更好的减小引线电感和外界噪声的影响，提高探头的抗干扰能力。缠绕方式如下图所示：

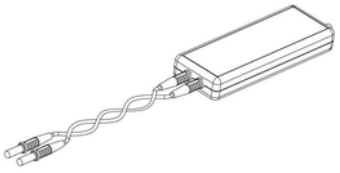


图 2 高压差分输入线的缠绕方式

2. 尽量不要延长输入线，否则会引入更多的噪声。如果必须要额外加长输入线，则应保证各延长线的长度相同，并且输入频率不超过 5MHz（如果超过 5MHz 输出会有一定的误差）。如下图举例所示：

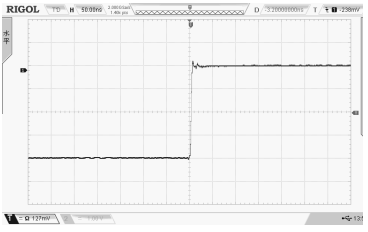


图 3 未添加输入延长线的波形

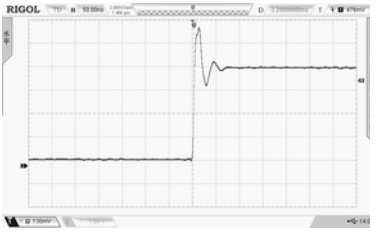


图 4 添加输入延长线（1m）的波形

常见故障及排查

	故障现象	故障排除方法
1.	面板指示灯不亮或闪烁	1. 检查电源适配器插头与电源插座的连接。 2. 检查电源适配器输出与探头电源接口之间的连接。 3. 检测电源适配器是否正常工作。
2.	测量波形不能稳定显示或误差明显	1. 检查探头输入端与探夹之间及探夹与被测点之间的连接。 2. 检查探头输出与测量仪器的连接。 3. 更换探头或测量仪器进行排查。

规格

技术参数

指标名称		PHA0150	PHA1150	PHA2150
带宽（-3dB）		70MHz	100MHz	50X：160MHz 500X：200MHz
上升时间		≤5ns	≤3.5ns	50X：≤2.4ns (典型值≤2.2ns) 500X：≤2ns (典型值≤1.8ns)
精度		±2%		
量程选择(衰减比)		50X/500X		
最大差分测量电压 (DC + peak AC)		衰减比为 50X 时：±150V 衰减比为 500X 时：±1500V		
共模电压 (DC + peak AC)		±1500V		
最大输入对地电压（Vrms）		600V CATIII 1000V CATII		
输入阻抗	单端对地	5MΩ±1%		
	差分输入	10MΩ±1%		
输入电容	单端对地	＜4pF		
	差分输入	＜2pF		
CMRR	DC	＞80dB		
	100 kHz	＞60dB		
	1 MHz	＞50dB		
	3.2 MHz	＞30dB		
	50 MHz	＞26dB		
噪声(Vrms)		衰减比为 50X：＜50mV 衰减比为 500X：＜300mV		
过载指示电压阈值		衰减比为 50X：153V±3V 衰减比为 500X：1530V±30V		
延时时间		21ns	16ns	
带宽限制(5MHz)		≥-3dB@5MHz		
过载指示灯(红灯)		有		
过载报警声		有(可选择关闭)		
自动保存功能		有		
输出阻抗		50Ω		
安全标准		EN61010-1: 2010		

EMC 标准	EN61326-1:2013　EN61000-3-3:2013 EN61000-3-2:2006+A1:2009+A2:2009

尺寸规格

指标名称	PHA0150	PHA1150	PHA2150
探头尺寸	176mm x 65mm x 25mm		
探头主体重量	216g		
绝缘活塞探夹	152mm x 50mm x 13mm		
鳄鱼夹	106mm x 43mm x 16mm		
高压差分输入线	28cm		17cm
探头输出线	1m		

操作环境

环境特性	参数
工作温度	0℃～50℃
存储温度	-30℃～70℃
工作湿度	≤85%RH
存储湿度	≤90%RH
工作海拔高度	3000m
存储海拔高度	12000m

附录

附录 1 最大差模电压与频率的关系

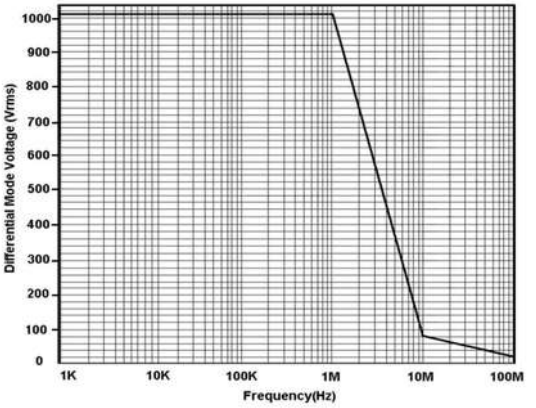


图 5 PHA0150/PHA1150/PHA2150 最大差模电压 VS 频率

附录 2 装箱清单

本节列出了 PHA 系列探头的标配附件。

表 1 PHA 系列探头标配附件

名称	规格	数量
电压探头本体	PHA0150/PHA1150/PHA2150	1 个
鳄鱼夹	CAT II 1000V CAT III 600V	1 对（红黑）
绝缘活塞探夹	-	1 对（红黑）
USB Type-C连接线	1 米	1 根
装箱清单	-	1 张
保修卡	-	1 张

附件说明



鳄鱼夹



绝缘活塞探夹



USB 线

附录 3 保修概要

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RIGOL

User Guide

PHA High-Voltage Differential Probe

Apr. 2022
RIGOL TECHNOLOGIES CO., LTD

Guaranty and Declaration

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Product Certification

RIGOL guarantees that this product conforms to the national and industrial standards in China as well as the ISO9001:2015 standard and the ISO14001:2015 standard. Other international standard conformance certifications are in progress.

Contact Us

If you have any problem or requirement when using our products or this manual, please contact **RIGOL**.

E-mail: service@rigol.com
Website: www.rigol.com

General Safety Summary

⚠CAUTION

This device involves the high-voltage measurement. To use the device safely and ensure your personal safety, please carefully read and observe the instructions specified in this manual before using the device.

Safety Terms and Symbols

Before using the device, read the following safety notices carefully.

	The ⚠ symbol printed on the device indicates that the user should refer to a corresponding topic in the manual (marked with the ⚠ symbol) before using the relevant function. In the manual, the ⚠ symbol indicates particularly important information that the user should read before using the device.
	The ⚠ symbol printed on the device indicates high voltage warning.
	The ⏚ symbol printed on the device indicates test ground.

Safety Precautions

⚠CAUTION

- Beware of high voltages to avoid electric shock. Understand the maximum input voltage for the probe.
- Do not operate in wet conditions or in an explosive atmosphere.
- Before use, please check whether the exterior of the probe is damaged. If damaged, stop using it.
- Turn off the circuit under test before connecting it to the probe.
- When connecting the BNC output cable of the probe to the oscilloscope or other devices, ensure that the BNC terminal is safely grounded.
- After measurement, turn off the circuit first and then remove the probe.

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General Inspection

1. Inspect the packaging

RIGOL has carried out strict inspections on each product before leaving the factory. When you receive the product, please check whether the packaging is intact. If the packaging has been damaged, do not dispose the damaged packaging or cushioning materials until the shipment has been checked for completeness and the probe has passed both electrical and mechanical tests.

The consigner or carrier shall be liable for the damage to the instrument resulting from shipment. **RIGOL** would not be responsible for free maintenance/rework or replacement of the instrument.

2. Check the probe

In case of any mechanical damage, missing parts, or failure in passing the electrical and mechanical tests, contact your **RIGOL** sales representative.

3. Check the accessories

Please check the accessories according to **Appendix 2 Package List** in this manual. If the accessories are damaged or incomplete, please contact your **RIGOL** sales representative.

PHA High-Voltage Differential Probe

The PHA series high-voltage differential probe (hereinafter referred to as PHA series probe) connects to the voltage under test through the high-voltage differential input cable to convert the input high voltage into the low voltage, and then display the waveforms on the waveform measuring instrument by connecting its output interface to the waveform measuring instrument.

Main Features

- High bandwidth to meet the requirements of most high-frequency test system
  PHA0150: 70 MHz;
  PHA1150: 100 MHz;
  PHA2150: 200MHz
- Diversified ranges and two attenuations to meet the requirements for most common-mode test circuit
  50X: 150 V (DC + peak AC);
  500X: 1500 V (DC + peak AC);
- 5 MHz bandwidth limit[1]
  For the low-frequency signal measurement, this function can reduce the noise and interference of high-frequency signals to meet the measurement requirement for the switching frequency of most switching transistors (FETs) in the switching power supply.
- High-voltage differential input mode
- Higher input impedance and lower input capacitive on the input terminal ensure accurate and fast measurement
- Sound common-mode noise rejection
- Standard BNC output terminal, compatible with the waveform measuring instruments of most manufacturers.
- Audible alarm beeper and visible indicator blinking for sounding the alarm;

the alarm can be disabled manually

- Auto memory function, capable of automatically saving the working status that was set before it is shutdown

Note[1]:

When the bandwidth is limited to 5 MHz, the internal output circuit of the PHA series probe is connected to a 5 MHz low-pass network. The low-pass network can reduce the high-frequency components, the noise, and the harmonics, which is conducive to the testing and analysis of the low-frequency signals.

Measurement Scenarios

The PHA series probe is mainly used in scenarios where high-voltage floating measurement is required, such as

- Floating voltage measurement
- Switching power supply design
- inverter/UPS power measurement
- Inverter measurement
- Electronic ballast design
- CRT display design
- Low-voltage apparatus test
- Strong current or high voltage isolation measurement
- Power conversion and other related designs
- welding/plating power measurement
- Frequency conversion home appliance measurement: induction heating; induction cooker
- Motor drive design
- Electrical engineering experiment
- Power electronics and power drives experiment

Probe Components

The PHA series probe consists of PHA0150, PHA1150 and PHA2150. This manual takes PHA1150 as an example to introduce the components of the PHA series probe.

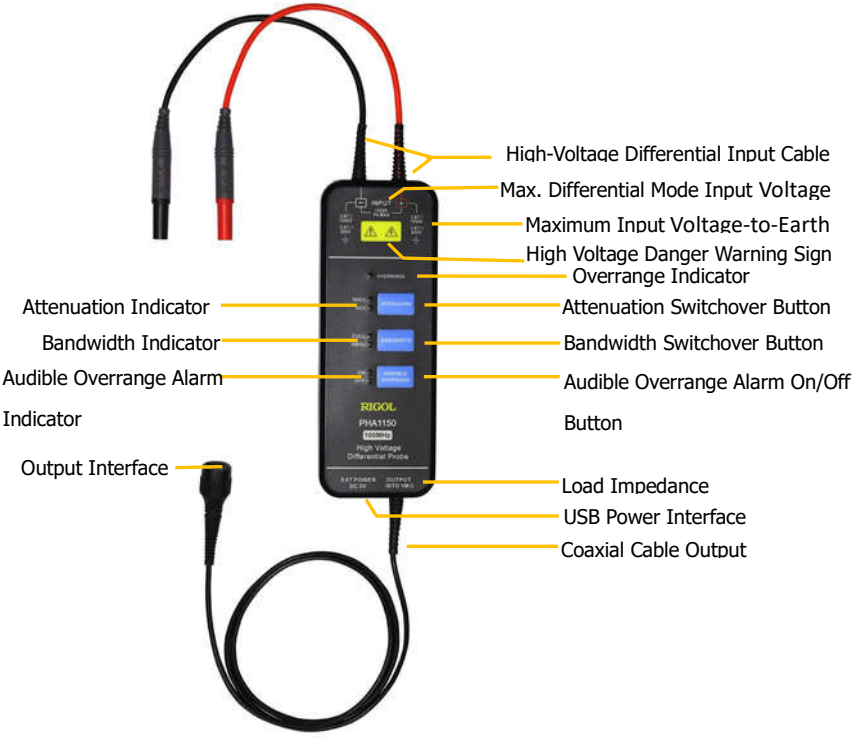


Figure 1 PHA1150 High-Voltage Differential Probe

By default, 500X is selected for OVERRANGE; FULL is selected for BANDWIDTH; and ON is selected for AUDIBLE OVERRANGE.

Probe Component Description

- **High-Voltage Differential Input Cable**

  Used to measure the input voltage signal after connecting it to the insulated plunger hook clip. It can be extended with the extender leads (approx. 1 m). When using the extender leads, the frequency of the signal under test should be below 5 MHz.

- **Max. Differential Mode Input Voltage**

  1500 V (DC + peak AC)

- **Overrange Indicator**

  When the voltage under test exceeds the probe range, the overrange indicator lights on.

- **Attenuation Switchover Button**

  Press this button to switch over between the voltage range (attenuation) settings of the probe. For the PHA series probe, two attenuation ratios are available: 500X and 50X.

  - ✧ 50X indicates that the max. measurement voltage is 150 V.
  - ✧ 500X indicates that the max. measurement voltage is 1500 V.

- **Bandwidth Switchover Button**

  Press this button to switch over between the bandwidth. The PHA series probe supports two bandwidths.

  - ✧ FULL: indicates the full specified bandwidth of the probe. For PHA0150, its full bandwidth is 70 MHz; for PHA1150, its full bandwidth is 100 MHz; for PHA2150, its full bandwidth is 200 MHz.
  - ✧ 5 MHz: When measuring the low-frequency signal, to reduce the interference of the high-frequency signal, you can select the 5 MHz bandwidth.

- **Audible Overrange Alarm On/Off Button**
  - ✧ ON: Turns on the alarm beeper.
  - ✧ OFF: Turns off the alarm beeper.

  When ON, an audible alarm will be sounded once the voltage under test exceeds the probe range.

- **Load Impedance**

  The output impedance of the probe is 50 Ω. When the input impedance of the load (e.g. oscilloscope) is 1 MΩ, the measured signal amplitude is input amplitude. When the input impedance of the load is set to 50 Ω, the high-frequency amplitude-frequency characteristics will be flatter, and the measured signal amplitude is half of the input amplitude.

- **USB Power Interface**

  A standard USB Type-C interface. It provides power with a standard USB adapter. You can connect it with the oscilloscope to provide power for the probe; or use the mobile power supply to charge for the probe. The power specification should be DC 5 V, 1 A.

- **Output Interface**

  indicates a standard BNC output terminal, which is compatible with the waveform measuring instruments of most manufacturers.

To Use the Probe

Before using the current probe, make sure to refer to **Safety Precautions**.

Preparation for Measurement

1. Evaluate the amplitude of the voltage under test and check whether it is within the voltage range of the probe. If it is beyond the max. range of the probe, please replace a proper probe. Otherwise, the measurement would be incorrect or the probe may be damaged. Even worse, this may lead to safety accidents.
2. Prepare one power adapter (DC 5 V, 1 A).
3. Connect the probe to power source and have a 20-minute warm-up at least. Meanwhile, prepare one measuring instrument (e.g. an oscilloscope).
4. Please ensure that the device under test is powered off or the output is disabled.

Measurement Steps

Check and ensure that the measurement system is safe. Make sure that the above preparation for measurement is ready.

1. Connect the output cable of the probe to the input terminal of the measuring instrument.
2. Use the USB Type-C cable to connect its one end to the specified power adapter and the other end to the power interface of the probe. Insert the power adapter into the socket to provide power to the probe. If the indicators on the panel light on normally, it indicates that the probe has been launched normally.
3. Select a proper range for the probe based on the measuring voltage.
4. Select the proper attenuation ratio of the measuring instrument based on

the probe range. Then adjust the range of the instrument based on the voltage under test.

5. Select a proper probe clip according to the object under test. Connect one end of the clip to the input cable of the probe and connect the other end to the object under test.
6. Turn on the device under test to start testing.
   During testing, keep the probe body far away from the high-voltage pulse circuit to reduce interference to the probe.

⚠CAUTION

When the voltage under test exceeds the probe range, the overrange indicator lights on. If ON is selected for AUDIBLE OVERRANGE, it will sound an alarm. At this time, please turn off the device under test immediately.

After the test is completed, disconnect power from the circuit under test first, and then turn off the power of the probe. Disconnect two input terminals of the probe from the test point, and disconnect the output BNC connector from the measuring instrument.

When the extender leads are used, the connection steps are as follows:

1. Connect one end of the double-ended BNC coaxial cable to the BNC terminal of the high-voltage differential probe, and connect the other end to the input terminal of the oscilloscope.
2. Connect the output cable and input cable to the probe.

Precautions During Measurement

⚠CAUTION

1. Before measurement, try to twist the high-voltage differential input cables as much as possible, which can better reduce the interference of the lead inductance and external noise to improve the anti-interference ability of the probe. The twisting method is shown in the figure below:

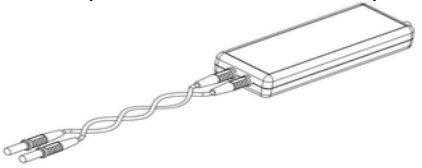


Figure 2 Twisting the High-Voltage Differential Input Cable

2. Try not to extend the input cable, as this will bring more noises. If you have to extend the cable, extend the cable with the same length. Besides, the input frequency should not be greater than 5 MHz. Otherwise, errors will occur for the output, as shown in the figure below.

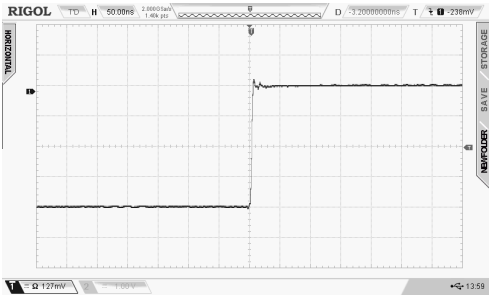


Figure 3 Waveforms Generated without Extending the Input Cable

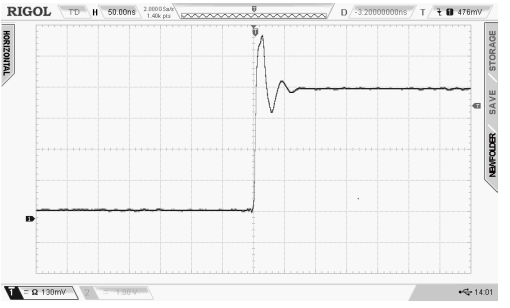


Figure 4 Waveforms Generated with the Input Cable Being Extended

Failures and Troubleshooting

	Failures Description	Troubleshooting
1.	The indicators on the panel blink or do not light.	1. Check whether the power adapter plug and the power socket are properly connected. 2. Check whether the power adapter output and the probe power interface are properly connected. 3. Check whether the power adapter is working properly.
2.	The measured waveforms cannot be stably displayed or obvious errors occur.	1. Check whether the probe input and the probe clip are properly connected; whether the probe clip is properly connected to the test point. 2. Check whether the probe output is properly connected with the oscilloscope. 3. Replace the probe or the measuring instrument to locate the problem.

Specifications

Technical Specifications

Characteristics		PHA0150	PHA1150	PHA2150
Bandwidth (-3 dB)		70 MHz	100 MHz	50X: 160 MHz 500X: 200 MHz
Rise Time		≤5 ns	≤3.5 ns	50X: ≤2.4 ns (Typical ≤2.2 ns) 500X: ≤2 ns (Typical ≤1.8 ns)
Accuracy		±2%		
Range (Attenuation)		50X/500X		
Maximum Measurable Differential Voltage (DC + peak AC)		50X: ±150 V 500X: ±1500 V		
Common Mode Voltage (DC + peak AC)		±1500 V		
Maximum Input Voltage-to-Earth (Vrms)		600 V CAT Ⅲ 1000 V CAT Ⅱ		
Input Impedance	Between each input and ground	5MΩ±1%		
	Between differential inputs	10MΩ±1%		
Input Capacitance	Between each input and ground	<4pF		
	Between differential	<2pF		

	inputs	
CMRR	DC	>80 dB
	100 kHz	>60 dB
	1 MHz	>50 dB
	3.2 MHz	>30 dB
	50 MHz	>26 dB
Input Referred Noise (Vrms)		50X: <50 mV 500X: <300 mV
Overrange Voltage Threshold Indicator		50X: 153V±3V 500X: 1530V±30V
Delay		21 ns | 16 ns
Bandwidth Limit (5 MHz)		≥-3 dB@5 MHz
Overrange Indicator (Red)		Yes
Audible Overrange Alarm		Yes (ON/Off is available)
Auto Save		Yes
Output Impedance		50 Ω
Safety Standards		EN61010-1:2010
EMC Standards		EN61326-1:2013; EN61000-3-3:2013 EN61000-3-2:2006+A1:2009+A2:2009

Mechanical Characteristics

	PHA0150	PHA1150	PHA2150
Probe Dimensions	176 mm x 65 mm x 25 mm		
Probe Body Weight	216 g		
Insulated Plunger Hook Clip	152 mm x 50 mm x 13 mm		
Alligator Clip	106 mm x 43 mm x 16 mm		
High-Voltage Differential Input Cable Length	28 cm		17cm
Probe Output Cable Length	1 m		

Working Environment

Environment Characteristics	Description
Operating Temperature	0℃ to 50℃
Storage Temperature	-30℃ to +70℃
Operating Humidity	≤85%RH
Storage Humidity	≤90%RH
Operating Altitude	3,000 m
Storage Altitude	12,000 m

Appendix

Appendix 1 Max. Differential Mode Voltage vs Freq.

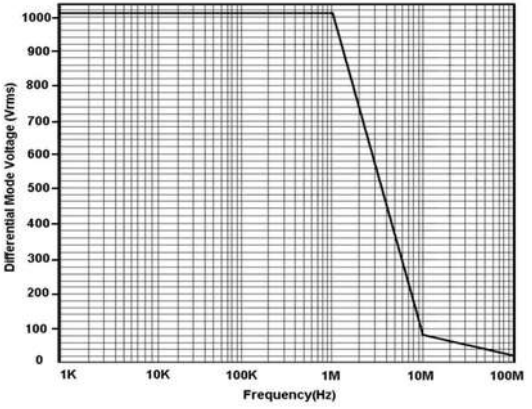


Figure 5 PHA0150/PHA1150/PHA2150 Max. Differential Mode Voltage vs Freq.

Appendix 2 Package List

This section lists the standard accessories of the PHA series probe.

Table 1 Standard Accessories of the PHA Series Probe

Name	Specification	Qty.
Probe Body	PHA0150/PHA1150/PHA2150	1
Alligator Clip	CAT II 1000 V CAT III 600 V	1 Pair (red/black)
Insulated Plunger Hook Clip	-	1 Pair (red/black)
USB Type-C Cable	1 m	1
User Guide	-	1
Warranty Card	-	1

Accessories



Alligator Clip



Insulated Plunger Hook Clip



USB Type-C Cable

Appendix 3 Warranty

RIGOL TECHNOLOGIES CO., LTD. (hereinafter referred to as **RIGOL**) warrants that the product will be free from defects in materials and workmanship within the warranty period. If a product proves defective within the warranty period, **RIGOL** guarantees free replacement or repair for the defective product.

To get repair service, please contact with your nearest **RIGOL** sales or service office.

There is no other warranty, expressed or implied, except such as is expressly set forth herein or other applicable warranty card. There is no implied warranty of merchantability or fitness for a particular purpose. Under no circumstances shall **RIGOL** be liable for any consequential, indirect, ensuing, or special damages for any breach of warranty in any case.