

# **RIGOL**

## **Performance Verification Guide**

### **MSO7000/DS7000 Series Digital Oscilloscope**

**Aug. 2019**

**RIGOL (SUZHOU) TECHNOLOGIES INC.**



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## General Safety Summary

Please review the following safety precautions carefully before putting the instrument into operation so as to avoid any personal injury or damage to the instrument and any product connected to it. To prevent potential hazards, please follow the instructions specified in this manual to use the instrument properly.

### **Use Proper Power Cord.**

Only the exclusive power cord designed for the instrument and authorized for use within the local country could be used.

### **Ground the Instrument.**

The instrument is grounded through the Protective Earth lead of the power cord. To avoid electric shock, connect the earth terminal of the power cord to the Protective Earth terminal before connecting any input or output terminals.

### **Connect the Probe Correctly.**

If a probe is used, the probe ground lead must be connected to earth ground. Do not connect the ground lead to high voltage. Improper way of connection could result in dangerous voltages being present on the connectors, controls or other surfaces of the oscilloscope and probes, which will cause potential hazards for operators.

### **Observe All Terminal Ratings.**

To avoid fire or shock hazard, observe all ratings and markers on the instrument and check your manual for more information about ratings before connecting the instrument.

### **Use Proper Overvoltage Protection.**

Ensure that no overvoltage (such as that caused by a bolt of lightning) can reach the product. Otherwise, the operator might be exposed to the danger of an electric shock.

### **Do Not Operate Without Covers.**

Do not operate the instrument with covers or panels removed.

### **Do Not Insert Objects Into the Air Outlet.**

Do not insert anything into the holes of the fan to avoid damaging the instrument.

### **Use Proper Fuse.**

Please use the specified fuses.

### **Avoid Circuit or Wire Exposure.**

Do not touch exposed junctions and components when the unit is powered on.

### **Do Not Operate With Suspected Failures.**

If you suspect that any damage may occur to the instrument, have it inspected by **RIGOL** authorized personnel before further operations. Any maintenance, adjustment or replacement especially to circuits or accessories must be performed by **RIGOL** authorized personnel.

### **Provide Adequate Ventilation.**

Inadequate ventilation may cause an increase of temperature in the instrument, which would cause damage to the instrument. So please keep the instrument well ventilated and inspect the air outlet and the fan regularly.

### **Do Not Operate in Wet Conditions.**

To avoid short circuit inside the instrument or electric shock, never operate the instrument in a humid environment.

**Do Not Operate in an Explosive Atmosphere.**

To avoid personal injuries or damage to the instrument, never operate the instrument in an explosive atmosphere.

**Keep Product Surfaces Clean and Dry.**

To avoid dust or moisture from affecting the performance of the instrument, keep the surfaces of the instrument clean and dry.

**Prevent Electrostatic Impact.**

Operate the instrument in an electrostatic discharge protective environment to avoid damage induced by static discharges. Always ground both the internal and external conductors of cables to release static before making connections.

**Use the Battery Properly.**

Do not expose the battery (if available) to high temperature or fire. Keep it out of the reach of children. Improper change of a battery (lithium battery) may cause an explosion. Use the **RIGOL** specified battery only.

**Handle with Caution.**

Please handle with care during transportation to avoid damage to keys, knobs, interfaces, and other parts on the panels.

## Safety Notices and Symbols

### Safety Notices in this Manual:

**WARNING**

Indicates a potentially hazardous situation or practice which, if not avoided, will result in serious injury or death.

**CAUTION**

Indicates a potentially hazardous situation or practice which, if not avoided, could result in damage to the product or loss of important data.

### Safety Terms on the Product:

**DANGER**

It calls attention to an operation, if not correctly performed, could result in injury or hazard immediately.

**WARNING**

It calls attention to an operation, if not correctly performed, could result in potential injury or hazard.

**CAUTION**

It calls attention to an operation, if not correctly performed, could result in damage to the product or other devices connected to the product.

### Safety Symbols on the Product:



Hazardous Voltage



Safety Warning



Protective Earth Terminal



Chassis Ground



Test Ground

# Document Overview

This manual is designed to guide you to properly test the performance specifications of **RIGOL** MSO7000/DS7000 series digital oscilloscope. For the operation methods mentioned in the test procedures, refer to User Guide of this product.

## Main Topics in this Manual:

### Chapter 1 Overview

This chapter introduces the preparations before performing the performance verification tests and the notices.

### Chapter 2 Performance Verification Test

This chapter introduces the limit, test devices required as well as the test method and procedures of each performance specification.

### Appendix Test Record Form

The appendix provides a test record form for users to record the test results and judge whether each performance specification can meet the requirement.

## Format Conventions in this Manual:

### 1. Key

The key on the front panel is denoted by the format of "Key Name (Bold) + Text Box" in the manual. For example, **Utility** denotes the "Utility" key.

### 2. Menu

The menu items are denoted by the format of "Menu Word (Bold) + Character Shading". For example, **System** denotes the "System" menu item under **Utility**.

### 3. Operation Procedures:

→ denotes the next step of operation. For example, **Utility** → **System** denotes that first press **Utility**, and then press the **System** softkey.

## Content Conventions in this Manual:

MSO7000/DS7000 series includes the following models. Unless otherwise specified, this manual takes MSO7054 as an example to illustrate the test methods for the performance verification of the MSO7000/DS7000 series.

Model	Analog Bandwidth	No. of Analog Channels	No. of Channels of Function/AWG	No. of Digital Channels
DS7054	500 MHz	4	--	--
DS7034	350 MHz	4	--	--
DS7024	200 MHz	4	--	--
DS7014	100 MHz	4	--	--
MSO7054	500 MHz	4	2 (option)	16 (required to purchase the probe)
MSO7034	350 MHz	4	2 (option)	16 (required to purchase the probe)
MSO7024	200 MHz	4	2 (option)	16 (required to purchase the probe)
MSO7014	100 MHz	4	2 (option)	16 (required to purchase the probe)

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# Chapter 1 Overview

## Test Preparations

Before performing the test, make the following preparations.

1. Self-test
2. Warm-up (make sure that the instrument has been running for at least 30 minutes)
3. Self-calibration

### Self-test

When the oscilloscope is connected to power, press the Power key at the lower-left corner of the front panel to start the oscilloscope. (You can also press **Utility** → **System** → **Power status**, and select "Switch On". After the instrument is connected to power source, it will start directly.) During the start-up process, the oscilloscope performs a series of self-tests. After the self-test, the welcome screen is displayed.

If the oscilloscope cannot start normally, refer to "Troubleshooting" section in MSO7000/DS7000 User Guide to locate the problem and resolve it. Do not perform self-calibration or performance tests until the instrument passes the self-test.

### Self-calibration

Make sure that the oscilloscope has been warmed up or operating for more than 30 minutes before performing self-calibration.

1. Disconnect all the input channels.
2. Press **Utility** → **System** → **SelfCal**, and the press **Start** to execute self-calibration. The self-calibration lasts for about 65 minutes.
3. Restart the oscilloscope, and then press **Acquire** → **Acquisition** to select "Average", and then press **Averages** to set it to 16.
4. Set the vertical scale of each channel to 2 mV/div and view the offset of the waveform of each channel. If the offset is greater than 0.5 div, check whether there are interference signals around you and whether the power source is well grounded. If yes, perform self-calibration again.

## Test Result Record

Record and keep the test result of each test. In the Appendix of this manual, a test result record form which lists all the test items and their corresponding performance limits as well as spaces for users to record the test results, is provided.

**Tip:**

It is recommended that users photocopy the test record form before each test and record the test results in the copy so that the form can be used repeatedly.

## Specifications

The specification of each test item is provided in Chapter 2. For other technical parameters, refer to *MSO7000/DS7000 DataSheet* (available to download them from **RIGOL** website: <http://www.rigol.com>)

**Tip:**

All the specifications are only valid when the oscilloscope has been warmed up for more than 30 minutes.



## Chapter 2 Performance Verification Test

This chapter takes MSO7054 as an example to illustrate the performance verification test methods and procedures of MSO7000/DS7000 series digital oscilloscope. Fluke 9500B is used in this manual for the tests. You can also use other devices that fulfill the "Specification" in Table 2-1.

Table 2-1 Test Devices Required

Device	Specification	Recommended Model
Oscilloscope Calibrator	DC output voltage range: 1 M $\Omega$ : 1 mV to 200 V 50 $\Omega$ : 1 mV to 5 V Fast edge signal rise time: $\leq 150$ ps	Fluke 9500B

**Note:**

1. Make sure that the oscilloscope passes the self-test and self-calibration before executing the performance verification tests.
2. Make sure that the oscilloscope has been warmed up for at least 30 minutes before executing any of the following tests.
3. Please reset the instrument to the factory setting before or after executing any of the following tests.

# Impedance Test

## Specification

Input Impedance	
Analog Channel	1 MΩ: 0.99 MΩ to 1.01 MΩ
	50 Ω: 49.5 Ω to 50.5 Ω

## Test Connection Diagram



Figure 2-1 Impedance Test Connection Diagram

## Test Procedures

### 1. Impedance test when the input impedance is 1 MΩ

- 1) Connect the active head of Fluke 9500B to CH1 of the oscilloscope, as shown in the figure above.
- 2) Configure the oscilloscope:
  - a) Press **1** in the vertical control area (Vertical) on the front panel to enable CH1.
  - b) Press **1** → **Impedance** to set the input impedance of CH1 to 1 MΩ.
  - c) Set the vertical scale of CH1 to 100 mV/div.
- 3) Turn on Fluke 9500B; set its impedance to 1 MΩ and select the resistance measurement function. Read and record the resistance measured.
- 4) Adjust the vertical scale of CH1 of the oscilloscope to 500 mV/div; read and record the resistance measured.
- 5) Turn off CH1. Measure the resistances of CH2, CH3, and CH4 respectively using the method above and record the measurement results.

### 2. Impedance test when the input impedance is 50 Ω

- 1) Connect the active head of Fluke 9500B to CH1 of the oscilloscope, as shown in the figure above.
- 2) Configure the oscilloscope:
  - a) Turn on CH1.
  - b) Set the input impedance of CH1 to 50 Ω.
  - c) Set the vertical scale of CH1 to 100 mV/div.
- 3) Turn on Fluke 9500B; set its impedance to 50 Ω and select the resistance measurement function. Read and record the resistance measured.
- 4) Adjust the vertical scale of CH1 of the oscilloscope to 500 mV/div; read and record the resistance measured.
- 5) Turn off CH1. Measure the resistances of CH2, CH3, and CH4 respectively using the method above and record the measurement results.

## Test Record Form

### 1 M $\Omega$ Input Impedance

Channel	Vertical Scale	Test Result	Limit	Pass/Fail
CH1	100 mV/div		0.99 M $\Omega$ to 1.01 M $\Omega$	
	500 mV/div			
CH2	100 mV/div			
	500 mV/div			
CH3	100 mV/div			
	500 mV/div			
CH4	100 mV/div			
	500 mV/div			

### 50 $\Omega$ Input Impedance

Channel	Vertical Scale	Test Result	Limit	Pass/Fail
CH1	100 mV/div		49.5 $\Omega$ to 50.5 $\Omega$	
	500 mV/div			
CH2	100 mV/div			
	500 mV/div			
CH3	100 mV/div			
	500 mV/div			
CH4	100 mV/div			
	500 mV/div			

## DC Gain Accuracy Test

### Specification

DC Gain Accuracy	
Specification	$\pm 2\%$ of Full Scale <sup>[1]</sup>

**Note**<sup>[1]</sup>: Full scale =  $8 \times$  Current Vertical Scale. 500  $\mu\text{V}/\text{div}$ , 1  $\text{mV}/\text{div}$ , and 2  $\text{mV}/\text{div}$  are a magnification of 4  $\text{mV}/\text{div}$  setting. For vertical accuracy calculations, use full scale of 32  $\text{mV}$  for 500  $\mu\text{V}/\text{div}$ , 1  $\text{mV}/\text{div}$ , and 2  $\text{mV}/\text{div}$  vertical sensitivity setting.

### Test Connection Diagram



Figure 2-2 DC Gain Accuracy Test Connection Diagram

### Test Procedures

#### 1. DC gain accuracy test when the input impedance is 1 $\text{M}\Omega$

- 1) Connect the active head of Fluke 9500B to CH1 of the oscilloscope, as shown in the figure above.
- 2) Set the impedance of Fluke 9500B to 1  $\text{M}\Omega$ .
- 3) Output a DC signal with +3  $\text{mV}_{\text{DC}}$  voltage ( $V_{\text{out1}}$ ) via Fluke 9500B.
- 4) Configure the oscilloscope:
  - a) Press **1** in the vertical control area (Vertical) on the front panel to enable CH1.
  - b) Press **1** → **Attenuation** to set the probe attenuation ratio to "1X".
  - c) Press **1** → **Impedance** to set the input impedance of CH1 to 1  $\text{M}\Omega$ .
  - d) Set the vertical scale to 1  $\text{mV}/\text{div}$ .
  - e) Set the horizontal timebase to 1  $\mu\text{s}/\text{div}$ .
  - f) Set the vertical offset to 0.
  - g) Press **Acquire** → **Acquisition** to select "Average", and then press **Averages** to set it to 32.
  - h) Adjust the trigger level to avoid that the signals are being triggered by mistake.
- 5) Press **Measure** → **Add** → **Category** to select "Vertical". Then, select "Vavg" measurement parameter to enable the average measurement function. Read and record  $V_{\text{avg1}}$ .
- 6) Adjust Fluke 9500B to make it output a DC signal with -3  $\text{mV}_{\text{DC}}$  voltage ( $V_{\text{out2}}$ ).
- 7) Enable the average measurement function. Read and record  $V_{\text{avg2}}$ .
- 8) Calculate the relative error of this vertical scale:  $|(V_{\text{avg1}} - V_{\text{avg2}}) - (V_{\text{out1}} - V_{\text{out2}})| / \text{Full Scale} \times 100\%$ .
- 9) Keep the other settings of the oscilloscope unchanged.
  - a) Set the vertical scale to 500  $\mu\text{V}/\text{div}$ , 2  $\text{mV}/\text{div}$ , 5  $\text{mV}/\text{div}$ , 10  $\text{mV}/\text{div}$ , 20  $\text{mV}/\text{div}$ , 50  $\text{mV}/\text{div}$ , 100  $\text{mV}/\text{div}$ , 200  $\text{mV}/\text{div}$ , 500  $\text{mV}/\text{div}$ , 1  $\text{V}/\text{div}$ , 2  $\text{V}/\text{div}$ , 5  $\text{V}/\text{div}$ , and 10  $\text{V}/\text{div}$  respectively.
  - b) Adjust the output voltage of Fluke 9500B to  $3 \times$  the current vertical scale and  $-3 \times$  the current vertical scale respectively.
  - c) Repeat Step 3) to 7) and record the test results.
  - d) Calculate the relative error of each vertical scale:  $|(V_{\text{avg1}} - V_{\text{avg2}}) - (V_{\text{out1}} - V_{\text{out2}})| / \text{Full Scale} \times 100\%$ .
- 10) Turn off CH1. Test the relative error of each scale of CH2, CH3, and CH4 respectively using

the method above and record the test results.

## 2. DC gain accuracy test when the input impedance is 50 $\Omega$

- 1) Connect the active head of Fluke 9500B to CH1 of the oscilloscope, as shown in the figure above.
- 2) Turn on Fluke 9500B; set its impedance to 50  $\Omega$ .
- 3) Output a DC signal with +3 mV<sub>DC</sub> voltage (Vout1) via Fluke 9500B.
- 4) Configure the oscilloscope:
  - a) Turn on CH1.
  - b) Set the probe attenuation ratio to "1X".
  - c) Set the input impedance of CH1 to 50  $\Omega$ .
  - d) Set the vertical scale to 1 mV/div.
  - e) Set the horizontal timebase to 1  $\mu$ s/div.
  - f) Set the vertical offset to 0.
  - g) Press **Acquire** → **Acquisition** to select "Average", and then press **Averages** to set it to 32.
  - h) Adjust the trigger level to avoid that the signals are being triggered by mistake.
- 5) Test the relative error of each scale of CH1 (except the tests of 2 V/div, 5 V/div, and 10 V/div) according to Step 5-9 in **DC gain accuracy test when the input impedance is 1 M $\Omega$**  and record the test results.
- 6) Turn off CH1. Test the relative error of each scale of CH2, CH3, and CH4 respectively using the method above and record the test results.

## Test Record Form

### 1 M $\Omega$ Input Impedance

Channel	Vertical Scale	Test Result			Limit	Pass/Fail
		Vavg1	Vavg2	Calculation Result <sup>[1]</sup>		
CH1	500 $\mu$ V/div				$\leq 2\%$	
	1 mV/div					
	2 mV/div					
	5 mV/div					
	10 mV/div					
	20 mV/div					
	50 mV/div					
	100 mV/div					
	200 mV/div					
	500 mV/div					
	1 V/div					
	2 V/div					
	5 V/div					
	10 V/div					
CH2	500 $\mu$ V/div					
	1 mV/div					
	2 mV/div					
	5 mV/div					
	10 mV/div					
	20 mV/div					
	50 mV/div					
	100 mV/div					
	200 mV/div					
	500 mV/div					
	1 V/div					
	2 V/div					

	5 V/div					
	10 V/div					
CH3	500 uV/div					
	1 mV/div					
	2 mV/div					
	5 mV/div					
	10 mV/div					
	20 mV/div					
	50 mV/div					
	100 mV/div					
	200 mV/div					
	500 mV/div					
	1 V/div					
	2 V/div					
	5 V/div					
	10 V/div					
CH4	500 uV/div					
	1 mV/div					
	2 mV/div					
	5 mV/div					
	10 mV/div					
	20 mV/div					
	50 mV/div					
	100 mV/div					
	200 mV/div					
	500 mV/div					
	1 V/div					
	2 V/div					
	5 V/div					
	10 V/div					

**Note**<sup>[1]</sup>: The calculation formula is  $|(V_{avg1} - V_{avg2}) - (V_{out1} - V_{out2})| / \text{Full Scale} \times 100\%$ ; wherein,  $V_{out1}$  and  $V_{out2}$  are  $3 \times$  the current vertical scale and  $-3 \times$  the current vertical scale respectively.

**50 Ω Input Impedance**

Channel	Vertical Scale	Test Result			Limit	Pass/Fail
		Vavg1	Vavg2	Calculation Result <sup>[1]</sup>		
CH1	500 uV/div				≤2%	
	1 mV/div					
	2 mV/div					
	5 mV/div					
	10 mV/div					
	20 mV/div					
	50 mV/div					
	100 mV/div					
	200 mV/div					
	500 mV/div					
	1 V/div					
CH2	500 uV/div					
	1 mV/div					
	2 mV/div					
	5 mV/div					
	10 mV/div					



	20 mV/div				≤2%	
	50 mV/div					
	100 mV/div					
	200 mV/div					
	500 mV/div					
	1 V/div					
CH3	500 uV/div					
	1 mV/div					
	2 mV/div					
	5 mV/div					
	10 mV/div					
	20 mV/div					
	50 mV/div					
	100 mV/div					
	200 mV/div					
	500 mV/div					
1 V/div						
CH4	500 uV/div					
	1 mV/div					
	2 mV/div					
	5 mV/div					
	10 mV/div					
	20 mV/div					
	50 mV/div					
	100 mV/div					
	200 mV/div					
	500 mV/div					
1 V/div						

**Note<sup>[1]</sup>:** The calculation formula is  $|(V_{avg1} - V_{avg2}) - (V_{out1} - V_{out2})| / \text{Full Scale} \times 100\%$ ; wherein,  $V_{out1}$  and  $V_{out2}$  are  $3 \times$  the current vertical scale and  $-3 \times$  the current vertical scale respectively.

# Bandwidth Test

The bandwidth test verifies the bandwidth performance of the oscilloscope by testing the amplitude loss of the oscilloscope under test at full bandwidth.

## Specification

Bandwidth		
Amplitude Loss <sup>[1]</sup>	500 MHz	-3 dB, all-channel mode
	350 MHz	-3 dB, all-channel mode
	200 MHz	-3 dB, all-channel mode
	100 MHz	-3 dB, all-channel mode

**Note<sup>[1]</sup>:** Amplitude Loss (dB) =  $20 \times \lg(V_{rms2}/V_{rms1})$ ; wherein,  $V_{rms1}$  is the measurement result of amplitude effective value at 1 MHz and  $V_{rms2}$  is the measurement result of amplitude effective value at full bandwidth.

## Test Connection Diagram



Figure 2-3 Bandwidth Test Connection Diagram

## Test Procedures

1. Connect the active head of Fluke 9500B to CH1 of the oscilloscope, as shown in the figure above.
2. Turn on Fluke 9500B; set its impedance to 50 Ω.
3. Configure the oscilloscope:
  - 1) Press **1** in the vertical control area (Vertical) on the front panel to enable CH1.
  - 2) Press **1** → **Attenuation** to set the probe attenuation ratio to "1X".
  - 3) Press **1** → **Impedance** to set the input impedance of CH1 to 50 Ω.
  - 4) Set the horizontal timebase to 500 ns/div.
  - 5) Set the vertical scale to 100 mV/div.
  - 6) Set the horizontal position and vertical offset to 0.
  - 7) Set the trigger level to 0 V.
4. Output a Sine with 1 MHz frequency and 600 mVpp amplitude via Fluke 9500B.
5. Press **Measure** → **Add** → **Category** to select "Vertical". Then, select "VRMS" measurement parameter to enable the effective value measurement function. Read and record  $V_{rms1}$ .
6. Output a Sine with 500 MHz frequency (the setting value is different for different models of the oscilloscope under test; 1 GHz please refer to Table 2-2) and 600 mVpp amplitude via Fluke 9500B.

Table 2-2 Setting Value of the Oscilloscope under Test

Model	Full Bandwidth	Horizontal Time Base
MSO7054/DS7054	500 MHz	1 ns/div
MSO7034/DS7034	350 MHz	2 ns/div
MSO7024/DS7024	200 MHz	2 ns/div
MSO7014/DS7014	100 MHz	5 ns/div

7. Set the horizontal timebase to 1 ns/div (the setting value is different for different models of the oscilloscope under test; please refer to Table 2-2).
8. Enable the effective value measurement function. Read and record Vrms2.
9. Calculate the amplitude loss: **Amplitude Loss (dB) = 20 × lg (Vrms2/Vrms1)**.
10. Keep the other settings of the oscilloscope in Step 3 unchanged and set the vertical scale to 500 mV/div.
11. Output a Sine with 1 MHz frequency and 3 Vpp amplitude via Fluke 9500B.
12. Repeat Step 5.
13. Output a Sine with 500 MHz frequency (the setting value is different for different models of the oscilloscope under test; please refer to Table 2-2) and 3 Vpp amplitude via Fluke 9500B.
14. Repeat Step 7-9.
15. Turn off CH1. Test CH2, CH3, and CH4 using the method above respectively and record the test results.

## Test Record Form

Channel	Vertical Scale	Test Result			Limit	Pass/Fail
		Vrms1	Vrms2	Amplitude Loss <sup>[1]</sup>		
CH1	100 mV/div				-3 dB to 3 dB	
	500 mV/div					
CH2	100 mV/div					
	500 mV/div					
CH3	100 mV/div					
	500 mV/div					
CH4	100 mV/div					
	500 mV/div					

**Note** <sup>[1]</sup>: Amplitude Loss (dB) = 20 × lg (Vrms2/Vrms1).

## Bandwidth Limit Test

The bandwidth limit test verifies the 20 MHz bandwidth limit function and 250 MHz bandwidth limit function of the oscilloscope respectively by testing the amplitude losses of the oscilloscope under test at the bandwidth limits.

For different input impedances of the oscilloscope under test, the bandwidth limits are different, as shown in Table 2-3.

Table 2-3 Bandwidth Limit

Input Impedance of the Oscilloscope	Available Bandwidth Limit
50 Ω	20 MHz and 250 MHz
1 MΩ	20 MHz and 250 MHz

## Specification

Bandwidth Limit	
Amplitude Loss <sup>[1]</sup>	-3 dB, all-channel mode

**Note<sup>[1]</sup>:** Amplitude Loss (dB) =  $20 \times \lg(V_{rms2}/V_{rms1})$ ; wherein,  $V_{rms1}$  is the measurement result of amplitude effective value at 1 MHz and  $V_{rms2}$  is the measurement result of amplitude effective value at the bandwidth limit.

## Test Connection Diagram



Figure 2-4 Bandwidth Limit Test Connection Diagram

## Test Procedures

### 1. 20 MHz bandwidth limit test

- 1) Connect the active head of Fluke 9500B to CH1 of the oscilloscope, as shown in the figure above.
- 2) Turn on Fluke 9500B; set its impedance to 50 Ω (or 1 MΩ).
- 3) Configure the oscilloscope:
  - a) Press **1** in the vertical control area (Vertical) on the front panel to enable CH1.
  - b) Press **1** → **Attenuation** to set the probe attenuation ratio to "1X".
  - c) Press **1** → **Impedance** to set the input impedance to 50 Ω. (Note: when the impedance of Fluke 9500B in Step 2 is set to 1 MΩ, the input impedance of the oscilloscope should be set to 1 MΩ).
  - d) Set the vertical scale to 100 mV/div.
  - e) Set the horizontal timebase to 500 ns/div.
  - f) Set the horizontal position and vertical offset to 0.
  - g) Set the trigger level to 0 V.
- 4) Output a Sine with 1 MHz frequency and 600 mVpp amplitude via Fluke 9500B.
- 5) Press **Measure** → **Add** → **Category** to select "Vertical". Then, select "VRMS" measurement parameter to enable the effective value measurement function. Read and record  $V_{rms1}$ .
- 6) Press **1** → **BW Limit** to set the bandwidth limit to "20 M".

- 7) Output a Sine with 20 MHz frequency and 600 mVpp amplitude via Fluke 9500B.
- 8) Set the horizontal timebase to 20 ns/div.
- 9) Enable the effective value measurement function. Read and record Vrms2.
- 10) Calculate the amplitude loss: **Amplitude Loss (dB) = 20 × lg (Vrms2/Vrms1)**, and compare the result with the specification. At this point, the amplitude loss should be within the specification range.
- 11) Keep the other settings of the oscilloscope in Step 3 unchanged and set the vertical scale to 500 mV/div.
- 12) Output a Sine with 1 MHz frequency and 3 Vpp amplitude via Fluke 9500B.
- 13) Repeat Step 5.
- 14) Output a Sine with 20 MHz frequency and 3 Vpp amplitude via Fluke 9500B.
- 15) Repeat Step 8-10.
- 16) Turn off CH1. Test CH2, CH3, and CH4 using the method above respectively.

## 2. 250 MHz bandwidth limit test

- 1) Connect the active head of Fluke 9500B to CH1 of the oscilloscope, as shown in Figure 2-4.
- 2) Turn on Fluke 9500B; set its impedance to 1 MΩ.
- 3) Configure the oscilloscope:
  - a) Press **1** in the vertical control area (Vertical) on the front panel to enable CH1.
  - b) Press **1** → **Attenuation** to set the probe attenuation ratio to "1X".
  - c) Press **1** → **Impedance** to set the input impedance to 1 MΩ.
  - d) Set the vertical scale to 100 mV/div.
  - e) Set the horizontal timebase to 500 ns/div.
  - f) Set the horizontal position and vertical offset to 0.
  - g) Set the trigger level to 0 V.
- 4) Output a Sine with 1 MHz frequency and 600 mVpp amplitude via Fluke 9500B.
- 5) Press **Measure** → **Add** → **Category** to select "Vertical". Then, select "VRMS" measurement parameter to enable the effective value measurement function. Read and record Vrms1.
- 6) Press **1** → **BW Limit** to set the bandwidth limit to "250 M".
- 7) Output a Sine with 250 MHz frequency and 600 mVpp amplitude via Fluke 9500B.
- 8) Set the horizontal timebase to 2 ns/div.
- 9) Enable the effective value measurement function. Read and record Vrms2.
- 10) Calculate the amplitude loss: **Amplitude Loss (dB) = 20 × lg (Vrms2/Vrms1)**, and compare the result with the specification. At this point, the amplitude loss should be within the specification range.
- 11) Keep the other settings of the oscilloscope in Step 3 unchanged and set the vertical scale to 500 mV/div.
- 12) Output a Sine with 1 MHz frequency and 3 Vpp amplitude via Fluke 9500B.
- 13) Repeat Step 5.
- 14) Output a Sine with 250 MHz frequency and 3 Vpp amplitude via Fluke 9500B.
- 15) Repeat Step 8-10.
- 16) Turn off CH1. Test CH2, CH3, and CH4 using the method above respectively.

## Test Record Form

### 20 MHz bandwidth limit test

Channel	Vertical Scale	Test Result			Limit	Pass/Fail
		Vrms1	Vrms2	Amplitude Loss <sup>[1]</sup>		
CH1	100 mV/div				-3 dB to 3 dB	
	500 mV/div					
CH2	100 mV/div					
	500 mV/div					
CH3	100 mV/div					
	500 mV/div					
CH4	100 mV/div					
	500 mV/div					

Note <sup>[1]</sup>: Amplitude Loss (dB) =  $20 \times \lg (\text{Vrms2}/\text{Vrms1})$ .

### 250 MHz bandwidth limit test

Channel	Vertical Scale	Test Result			Limit	Pass/Fail
		Vrms1	Vrms2	Amplitude Loss <sup>[1]</sup>		
CH1	100 mV/div				-3 dB to 3 dB	
	500 mV/div					
CH2	100 mV/div					
	500 mV/div					
CH3	100 mV/div					
	500 mV/div					
CH4	100 mV/div					
	500 mV/div					

Note <sup>[1]</sup>: Amplitude Loss (dB) =  $20 \times \lg (\text{Vrms2}/\text{Vrms1})$ .

# Timebase Accuracy Test

## Specification

Timebase Accuracy <sup>[1]</sup>	
Specification	$\leq \pm(2 \text{ ppm} + \text{Clock Drift}^{[2]} \times \text{Number of years that the instrument has been used}^{[3]})$

**Note**<sup>[1]</sup>: Typical.

**Note**<sup>[2]</sup>: Clock drift  $\leq \pm 2$  ppm/year.

**Note**<sup>[3]</sup>: For the number of years that the instrument has been used, please calculate according to the date in the verification certificate provided when the instrument leaves factory.

## Test Connection Diagram



Figure 2-5 Timebase Accuracy Test Connection Diagram

## Test Procedures

1. Connect the active head of Fluke 9500B to CH1 of the oscilloscope, as shown in the figure above.
2. Turn on Fluke 9500B; set its impedance to 50  $\Omega$ .
3. Output a Sine with 10 MHz frequency and 1 Vpp amplitude via Fluke 9500B.
4. Configure the oscilloscope:
  - 1) Press **1** in the vertical control area (Vertical) on the front panel to enable CH1.
  - 2) Press **1**  $\rightarrow$  **Attenuation** to set the probe attenuation ratio to "1X".
  - 3) Press **1**  $\rightarrow$  **Impedance** to set the input impedance to 50  $\Omega$ .
  - 4) Set the vertical scale to 50 mV/div.
  - 5) Set the vertical offset to 0.
  - 6) Set the horizontal timebase to 1 ns/div.
  - 7) Set the horizontal position to 1 ms.
5. Observe the screen of the oscilloscope. Press **Cursor**  $\rightarrow$  **Mode**, then select "Manual" to enable the manual mode of cursor measurement. Measure the offset ( $\Delta T$ ) of the middle point of the signal (namely the crossing point of the rising edge of the current signal and the trigger level line) relative to the screen center using manual cursor measurement and record the measurement result.
6. Calculate the timebase accuracy; namely the ratio of  $\Delta T$  to the horizontal position of the oscilloscope. For example, if the offset measured is 1 ns, then the timebase accuracy is 1 ns/1 ms=1 ppm.
7. Calculate the timebase accuracy limit by using the formula  $\pm(2 \text{ ppm} + 2 \text{ ppm/year} \times \text{Number of years that the instrument has been used})$ .

## Test Record Form

Channel	Test Result $\Delta T$	Calculation Result <sup>[1]</sup>	Limit	Pass/Fail
CH1			$\pm(2 \text{ ppm} + 2 \text{ ppm/year} \times \text{Number of years that the instrument has been used}^{[2]})$	

**Note<sup>[1]</sup>:** Calculation Result = Test Result  $\Delta T/1$  ms.

**Note<sup>[2]</sup>:** For the number of years that the instrument has been used, please calculate according to the date in the verification certificate provided when the instrument leaves factory.



# Appendix Test Record Form

**RIGOL** MSO7000/DS7000 Series Digital Oscilloscope Performance Verification Test Record Form

Model: \_\_\_\_\_ Tested by: \_\_\_\_\_ Test Date: \_\_\_\_\_

## Impedance Test

### 1 M $\Omega$ Input Impedance

Channel	Vertical Scale	Test Result	Limit	Pass/Fail
CH1	100 mV/div		0.99 M $\Omega$ to 1.01 M $\Omega$	
	500 mV/div			
CH2	100 mV/div			
	500 mV/div			
CH3	100 mV/div			
	500 mV/div			
CH4	100 mV/div			
	500 mV/div			

### 50 $\Omega$ Input Impedance

Channel	Vertical Scale	Test Result	Limit	Pass/Fail
CH1	100 mV/div		49.5 $\Omega$ to 50.5 $\Omega$	
	500 mV/div			
CH2	100 mV/div			
	500 mV/div			
CH3	100 mV/div			
	500 mV/div			
CH4	100 mV/div			
	500 mV/div			

DC Gain Accuracy Test

1 MΩ Input Impedance

Channel	Vertical Scale	Test Result			Limit	Pass/Fail
		Vavg1	Vavg2	Calculation Result <sup>[1]</sup>		
CH1	500 uV/div				≤2%	
	1 mV/div					
	2 mV/div					
	5 mV/div					
	10 mV/div					
	20 mV/div					
	50 mV/div					
	100 mV/div					
	200 mV/div					
	500 mV/div					
	1 V/div					
	2 V/div					
	5 V/div					
10 V/div						
CH2	500 uV/div					
	1 mV/div					
	2 mV/div					
	5 mV/div					
	10 mV/div					
	20 mV/div					
	50 mV/div					
	100 mV/div					
	200 mV/div					
	500 mV/div					
	1 V/div					
	2 V/div					
	5 V/div					
10 V/div						
CH3	500 uV/div					
	1 mV/div					
	2 mV/div					
	5 mV/div					
	10 mV/div					
	20 mV/div					
	50 mV/div					
	100 mV/div					
	200 mV/div					
	500 mV/div					
	1 V/div					
	2 V/div					
	5 V/div					
10 V/div						
CH4	500 uV/div					
	1 mV/div					
	2 mV/div					
	5 mV/div					
	10 mV/div					
	20 mV/div					
	50 mV/div					
	100 mV/div					
	200 mV/div					
	500 mV/div					
	1 V/div					
	2 V/div					
	5 V/div					
10 V/div						

**Note<sup>[1]</sup>:** The calculation formula is  $|(V_{avg1} - V_{avg2}) - (V_{out1} - V_{out2})| / \text{Full Scale} \times 100\%$ ; wherein,  $V_{out1}$  and  $V_{out2}$  are  $3 \times$  the current vertical scale and  $-3 \times$  the current vertical scale respectively.

### 50 $\Omega$ Input Impedance

Channel	Vertical Scale	Test Result			Limit	Pass/Fail
		Vavg1	Vavg2	Calculation Result <sup>[1]</sup>		
CH1	500 uV/div				≤2%	
	1 mV/div					
	2 mV/div					
	5 mV/div					
	10 mV/div					
	20 mV/div					
	50 mV/div					
	100 mV/div					
	200 mV/div					
	500 mV/div					
CH2	1 V/div					
	500 uV/div					
	1 mV/div					
	2 mV/div					
	5 mV/div					
	10 mV/div					
	20 mV/div					
	50 mV/div					
	100 mV/div					
	200 mV/div					
CH3	500 mV/div				≤2%	
	1 V/div					
	500 uV/div					
	1 mV/div					
	2 mV/div					
	5 mV/div					
	10 mV/div					
	20 mV/div					
	50 mV/div					
	100 mV/div					
CH4	200 mV/div				≤2%	
	500 mV/div					
	1 V/div					
	500 uV/div					
	1 mV/div					
	2 mV/div					
	5 mV/div					
	10 mV/div					
	20 mV/div					
	50 mV/div					

**Note<sup>[1]</sup>:** The calculation formula is  $|(V_{avg1} - V_{avg2}) - (V_{out1} - V_{out2})| / \text{Full Scale} \times 100\%$ ; wherein,  $V_{out1}$  and  $V_{out2}$  are  $3 \times$  the current vertical scale and  $-3 \times$  the current vertical scale respectively.

### Bandwidth Test

Channel	Vertical Scale	Test Result			Limit	Pass/Fail
		Vrms1	Vrms2	Amplitude Loss <sup>[1]</sup>		
CH1	100 mV/div				-3 dB to 3 dB	
	500 mV/div					
CH2	100 mV/div					
	500 mV/div					
CH3	100 mV/div					
	500 mV/div					
CH4	100 mV/div					
	500 mV/div					

Note <sup>[1]</sup>: Amplitude Loss (dB) =  $20 \times \lg (V_{rms2}/V_{rms1})$ .

### Bandwidth Limit Test

#### 20 MHz bandwidth limit test

Channel	Vertical Scale	Test Result			Limit	Pass/Fail
		Vrms1	Vrms2	Amplitude Loss <sup>[1]</sup>		
CH1	100 mV/div				-3 dB to 3 dB	
	500 mV/div					
CH2	100 mV/div					
	500 mV/div					
CH3	100 mV/div					
	500 mV/div					
CH4	100 mV/div					
	500 mV/div					

Note <sup>[1]</sup>: Amplitude Loss (dB) =  $20 \times \lg (V_{rms2}/V_{rms1})$ .

#### 250 MHz bandwidth limit test

Channel	Vertical Scale	Test Result			Limit	Pass/Fail
		Vrms1	Vrms2	Amplitude Loss <sup>[1]</sup>		
CH1	100 mV/div				-3 dB to 3 dB	
	500 mV/div					
CH2	100 mV/div					
	500 mV/div					
CH3	100 mV/div					
	500 mV/div					
CH4	100 mV/div					
	500 mV/div					

Note <sup>[1]</sup>: Amplitude Loss (dB) =  $20 \times \lg (V_{rms2}/V_{rms1})$ .

### Timebase Accuracy Test

Channel	Test Result $\Delta T$	Calculation Result <sup>[1]</sup>	Limit	Pass/Fail
CH1			$\pm(2 \text{ ppm} + 2 \text{ ppm/year} \times \text{Number of years that the instrument has been used}^{[2]})$	

Note <sup>[1]</sup>: Calculation Result = Test Result  $\Delta T/1$  ms.

Note <sup>[2]</sup>: For the number of years that the instrument has been used, please calculate according to the date in the verification certificate provided when the instrument leaves factory.