MSO7000X Series

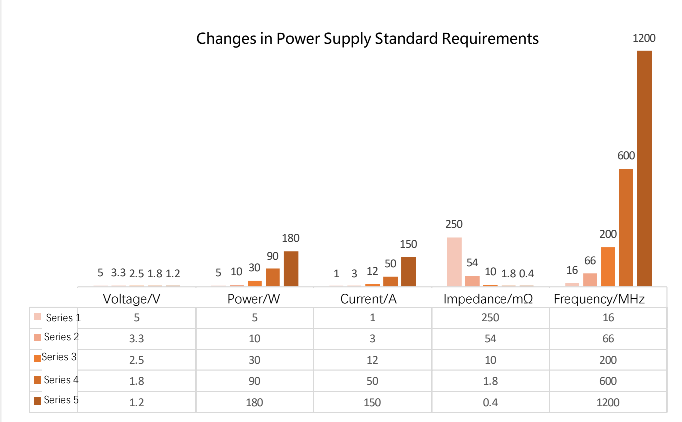
Advanced Power Analysis with MSO7000X

Introduction to the Background

With the advancement of semiconductor processes, large-scale digital circuits have been widely applied, and the integration of high-speed digital circuits continues to increase. Tens of millions of digital gates are now integrated into a single chip. When such a large number of gates switch, issues such as switching noise, crosstalk, and power supply variations arise.

With the development of chip manufacturing processes, domestic chips with a 5-nm process have emerged, while internationally, the process has reached as low as 2 nm or even lower. Chips with such high integration require increasingly lower supply voltages, while the current will correspondingly increase. The noise margin for power engineers is becoming smaller and smaller. Moreover, with the development of high-speed signals, power quality has also become an important factor affecting signal quality. Therefore, testing power integrity in power systems is particularly important.

Power Network Requirements:



	Voltage/V	Power/W	Current/A	Impedance/mΩ	Frequency/MHz
Series 1	5	5	1	250	16
Series 2	3.3	10	3	54	66
Series 3	2.5	30	12	10	200
Series 4	1.8	90	50	1.8	600
Series 5	1.2	180	150	0.4	1200

Power Engineer Workflow

Common evaluation metrics

Maximum power and operating temperature, efficiency and performance, temperature effects and stability, switching speed and response time

Voltage and electromagnetic interference resistance...

Stage II

Power supply prototyping board design and testing

Power topology, power planes, power rails, PDNs, filter circuits...

Common Test Items

Harmonic test, EMI pre-scan, standby standard test

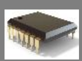
Aging test

Stage I

Power device selection (IGBT/MOSFET/BJT)

Power IC (AC-DC/DC-DC/DC-AC)

Power management chip, driver IC

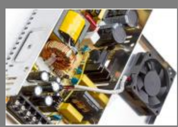




Common Test Items

Power Quality, Switching Losses, Harmonic Analysis, Ripple Testing, Safe Operating Area, Inrush Current, Startup/Shutdown Time, Loop Response Analysis

Stage III

Certification of product conformity



MSO7000X Series Mixed Signal Oscilloscope Power Analysis Option (MSO7000X-PWR)

Using the power analysis functions of the MSO7000X series mixed signal oscilloscope, you can gain a deeper understanding of power quality and reliability. The MSO7000X features a bandwidth of up to 2 GHz, a sampling rate of up to 10 GSa/s, and a standard memory depth of 1 Gpts. The smooth user interface, combined with a 15.6-inch capacitive touch screen, provides strong hardware support for your analysis work. Additionally, the combination of high-bandwidth oscilloscopes, analysis software, voltage and current probes, and graphical tools makes it easy to identify issues, even without deep power expertise.

MSO7000X-PWR Analysis Functions

Power Quality

For input-stage power analysis, the quality of the input AC line is assessed by testing the voltage, current, and power at the input terminal. The measurement situation can be intuitively viewed through power graphs and test charts.

Harmonic Analysis

Analyzes the harmonic content of the input voltage and current of the power supply. The input signal is subjected to FFT to obtain individual harmonic components, replacing the harmonic measurement function of a spectrum analyzer. The harmonic analysis can reach up to the 100th harmonic, and the power of each harmonic component can be intuitively viewed through harmonic histograms and result tables.

Switching Loss

The internal losses of a power supply can be broadly categorized into switching loss, conduction loss, additional loss, and resistive loss. These losses occur simultaneously in lossy components, and power switch loss is one of the two main sources of loss in a switching power supply. The switching loss analysis primarily measures the power and energy losses of power devices during the switching and conduction phases. These losses can be intuitively viewed through power graphs and result tables.

Ripple Analysis

Ripple analysis is one of the essential tests for power supplies, reflecting the regulation capability and filtering quality of the DC power supply voltage. The sources of ripple mainly include power-frequency ripple (AC signal components related to the power frequency), switching ripple (AC signals related to the switching frequency), interference from surrounding signals, or sudden load changes, all of which can be addressed using the MSO7000X-PWR software.

Safe Operating Area

The SOA refers to the working current and voltage conditions under which tens of thousands of power devices (including IGBT, MOSFET, SiCFET, GaN high-electron-mobility transistors) can operate without self-damage or performance degradation. For power or failure analysis engineers, it's crucial to monitor SOA test results closely and ensure that devices do not exceed the defined limits. Operating outside these limits compromises design reliability.

Loop Analysis

Loop analysis reflects the stability of the switching power supply's control loop. Leveraging the optional built-in function/arbitrary waveform generator, the MSO7000X-PWR can directly perform loop response analysis on the oscilloscope. Through Bode plots and gain/phase margin measurements, developers can assess the stability of the power control loop, achieving negative feedback under any conditions. This method also eliminates the need for costly network analyzers or loop analyzers.

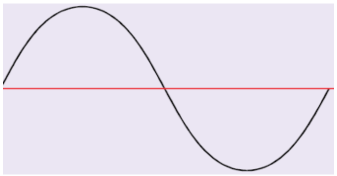
Power Quality Analysis

By analyzing the power quality of the input power, the input power and distortion levels can be effectively evaluated. This test is designed for optimizing power frequency and serves as the first checkpoint for power input quality.

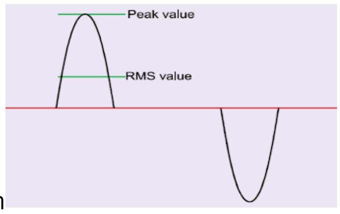
Test Items

- Input Voltage: RMS voltage, voltage crest factor, and voltage frequency
- Input Current: RMS current, current crest factor
- Input Power: Active power, apparent power, reactive power, power factor, and phase angle.

Voltage RMS/ Current RMS:

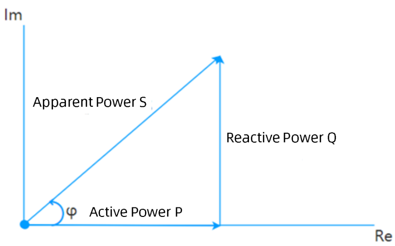


Voltage Waveform



Current Waveform

Crest factor = Peak-to-peak value / RMS value



Active Power: The power consumed by the resistive element in an AC circuit.
Reactive Power: In an AC circuit, the capacitive or inductive elements only exchange energy without consuming it. This part of the power is referred to as reactive power.
Apparent Power: The product of voltage and current in an AC circuit, representing the capacity of devices such as transformers.
Power Factor: The ratio of active power to apparent power in a circuit, typically used to describe the load effect in a circuit. When the power factor equals 1, the circuit behaves as a pure resistive load, with active power equal to apparent power, achieving the highest efficiency.
Phase Angle: Power factor angle

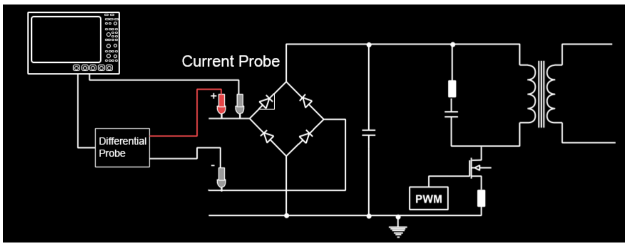
$$\text{Power Factor } (\cos\varphi) = \frac{\text{Active Power (P)}}{\text{Apparent Power (S)}} = \frac{\text{Active Power (P)}}{\sqrt{(\text{Active Power (P)})^2 + (\text{Reactive Power (Q)})^2}}$$

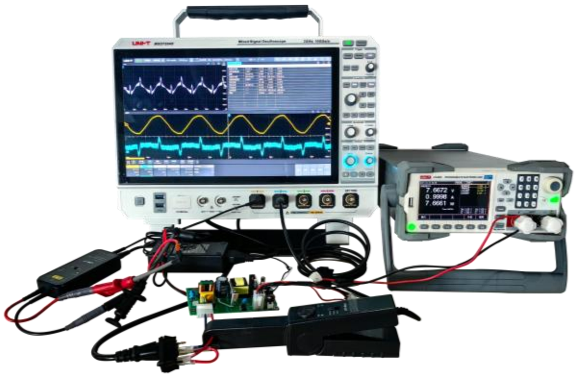
Test Environment Preparation

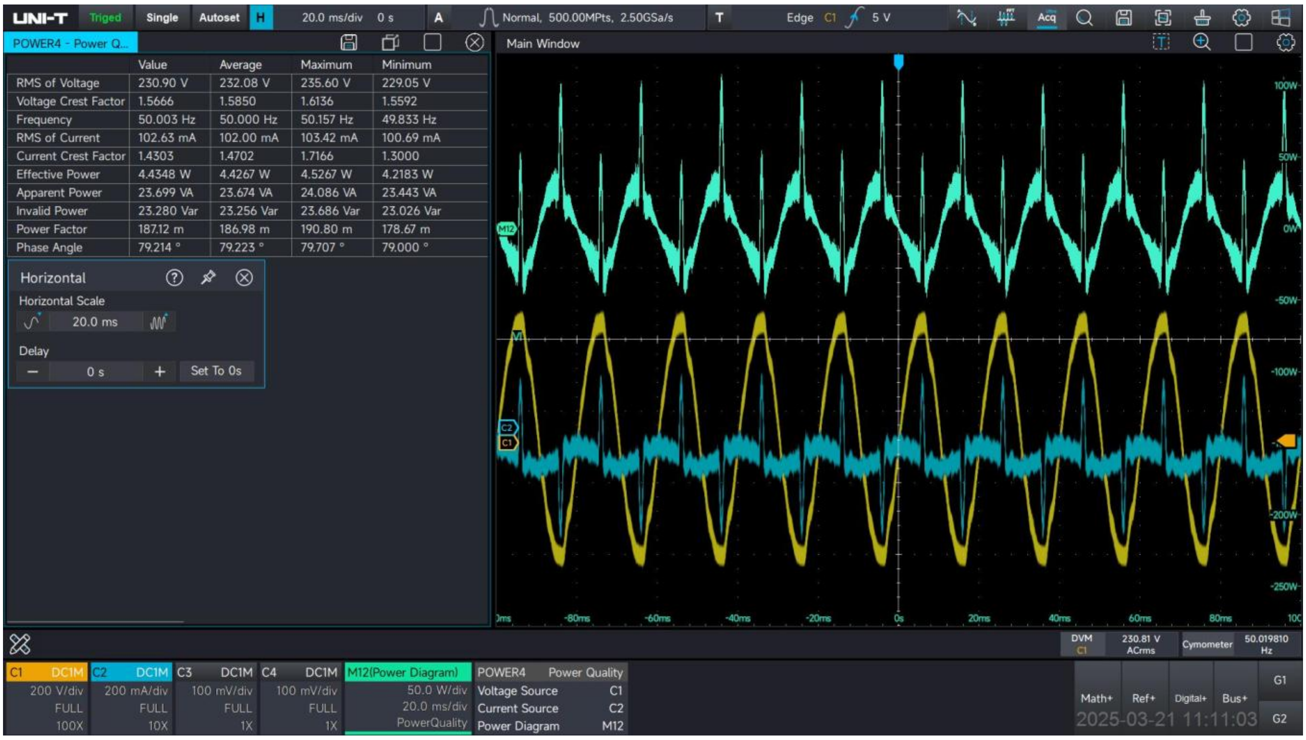
1. Oscilloscope: Any model from the MSO7000X series (1 GHz/2 GHz).
2. Differential Probe: Recommended UT-P3X series high-voltage differential probes (input differential voltage ±800Vpp to 14kVpp), selectable based on requirements.
3. Current Probe: Recommended UT-P4X series current probes, with maximum measurement current ranging from 20 A to 500 A, selectable based on requirements.
4. Electronic Load: Recommended UTL8500 series, with maximum load power up to 600 W, selectable based on requirements.

Test Environment Configuration

Connect the differential and current probes to the positive and negative terminals of the input power supply according to the signal connection diagram for power quality analysis. Before use, the current probe must be zeroed and demagnetized to ensure the reliability of the test results.







Input power supply indicators analyzed by MSO7000X-PWR software.

Harmonic Analysis

When a sinusoidal voltage is applied to a nonlinear load (such as UPS, switching power supplies, rectifiers, frequency converters, inverters), the current flowing through the load does not have a linear relationship with the applied voltage. The distortion of the fundamental current results in non-sinusoidal current, generating harmonics in the circuit.

Hazards of Harmonics

1. Reduces the efficiency of electricity production, transmission, and utilization, causing electrical equipment to overheat, produce vibrations and noise, age insulation, shorten lifespan, fail, or burn out.
2. Causes local parallel and series resonance in power systems, potentially destroying equipment.
3. Triggers erroneous operation of relay protection and automatic devices, leading to confusion in electricity metering.
4. Interference with communication and electronic equipment.

Harmonic analysis primarily involves measuring the harmonic conditions of the input current/voltage of the power supply. By applying the Fourier transform, the discrete signal is expanded into a Fourier series to obtain the discrete spectrum. Then, the spectrum lines corresponding to each harmonic are selected from the discrete spectrum to calculate the harmonic parameters.

Significance of Harmonic Testing

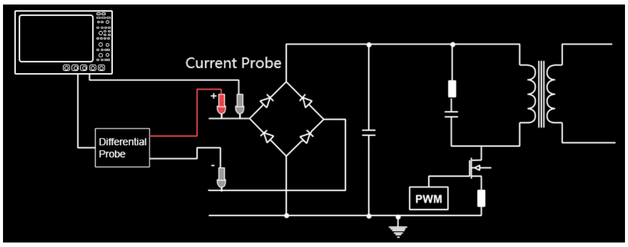
To suppress conducted interference, ensure that the input sinusoidal voltage and its harmonic power levels do not interfere with the power board, causing abnormal power supply quality. The various harmonic parameters must meet different harmonic standards.

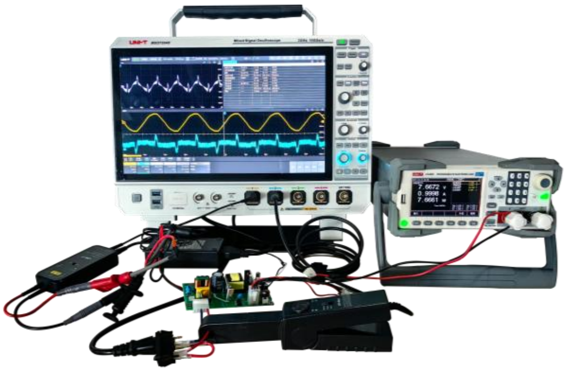
Test Environment Preparation

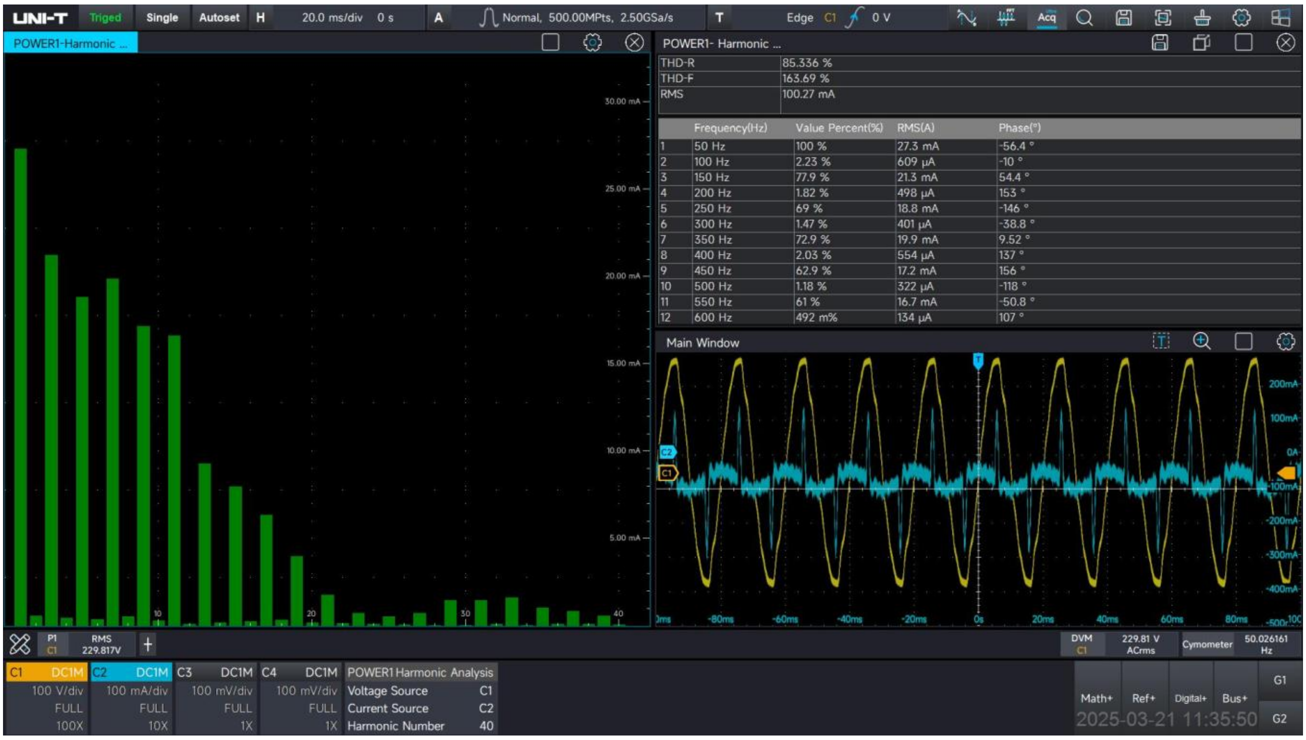
1. Oscilloscope: Any model from the MSO7000X series.
2. Voltage Probe: It is recommended to use the UT-P3X series high-voltage differential probes (input differential voltage ±800 Vpp to 14 kVpp), which can be selected according to needs.
3. Current Probe: It is recommended to use the UT-P4X series current probes with a maximum measurement current of 20 A to 500 A, selectable based on requirements.
4. MSO7000X-PWR Power Analysis Option.

Test Environment Configuration

Connect the differential probe and the current probe to the positive and negative terminals of the input power supply according to the signal connection diagram. Before use, it is necessary to zero and demagnetize the current probe to ensure the reliability of the test results.







Switching Loss

Losses are inevitable in energy conversion systems. Although it is impossible to achieve 100% conversion efficiency in practical applications, a high-quality power supply can reach a very high level of efficiency, approaching 95%.

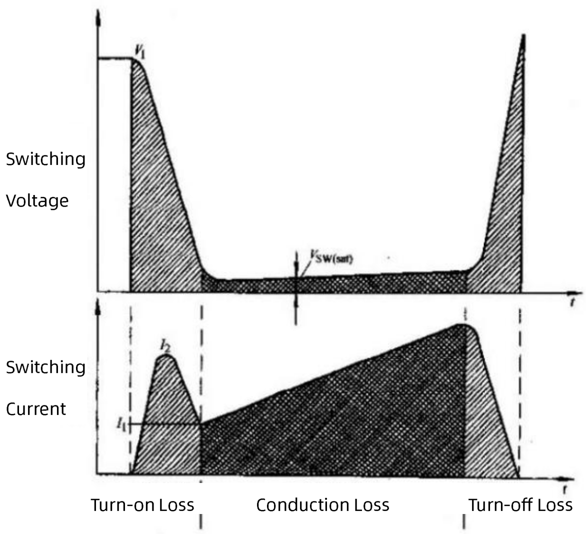
Most of the losses in Switched-Mode Power Supplies (SMPS) come from switching devices (MOSFETs and diodes), with a smaller portion from inductors and capacitors. Devices with higher resistance can also increase losses. Therefore, when selecting an IC, it is necessary to clearly understand its internal components to achieve high efficiency, such as the losses of switching devices (conduction losses during the turn-on process from the off state to the on state, conduction losses in the on state, turn-off process losses from the on state to the off state, and losses in the off state which are almost zero and can be neglected).

Switching devices have tens of thousands of switching cycles within one working cycle, and each switching cycle is in the millisecond range. It is difficult for ordinary oscilloscopes to analyze the loss situation of multiple cycles. The MSO7000X comes standard with a 1 Gpts memory depth, which allows for the analysis of multiple cycle waveforms at the millisecond time base setting, and together with the MSO7000X-PWR power analysis software, it can complete the measurement of multi-cycle switching losses.

Test Items

Turn-on power loss, conduction power loss, turn-off power loss, non-conduction power loss, total power loss, turn-on energy loss, conduction energy loss, turn-off energy loss, non-conduction energy loss, total energy loss, number of switching cycles, etc.

Losses are obtained by multiplying the voltage and current waveforms across the switch, which are approximately linear.



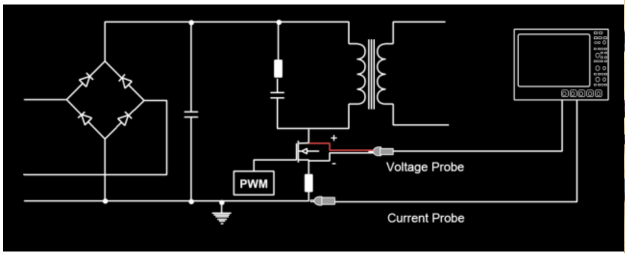
Switching losses during power switching transitions are more complex, both in themselves and in the components involved. To observe loss-related waveforms, an oscilloscope with a voltage probe connected to the drain-source (or collector) is required, while an AC current probe can measure the drain or collector current. When measuring the loss at each switching instant, it is important to use a short lead probe with a shield, as any unshielded lead of any length may introduce noise from other power sources and thus not accurately display the true waveform. Once a good waveform has been obtained, the area enclosed by the two curves can be calculated by the simple method of summing triangular and rectangular segments.

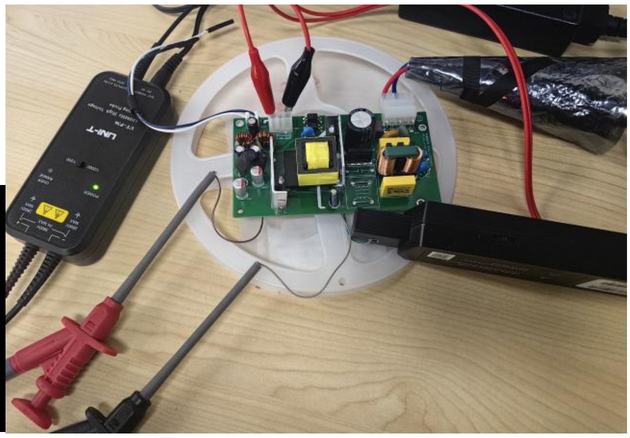
Test Environment Preparation

1. Oscilloscope: Any model from the MSO7000X series.
2. Voltage Probe: It is recommended to use the UT-P3X series high-voltage differential probes (input differential voltage ±800 Vpp to 14 kVpp), which can be selected as needed.
3. Current Probe: It is recommended to use the UT-P4X series current probes with a maximum measurement current of 20A to 500A, selectable based on requirements.
4. MSO7000X-PWR Power Analysis Option.

Test Environment Configuration

Connect the differential probe and the current probe to the positive and negative terminals of the input power supply according to the signal connection diagram. Before use, it is necessary to zero and demagnetize the current probe to ensure the reliability of the test results. A small-time lag can cause significant measurement errors in switching losses. Time lag calibration should be performed to correct any time lag of the oscilloscope or probes. Time lag calibration should be carried out initially and rerun whenever there are changes in any part of the hardware setup (such as replacing probes, changing oscilloscope channels, etc.) or when there are changes in the temperature environment.



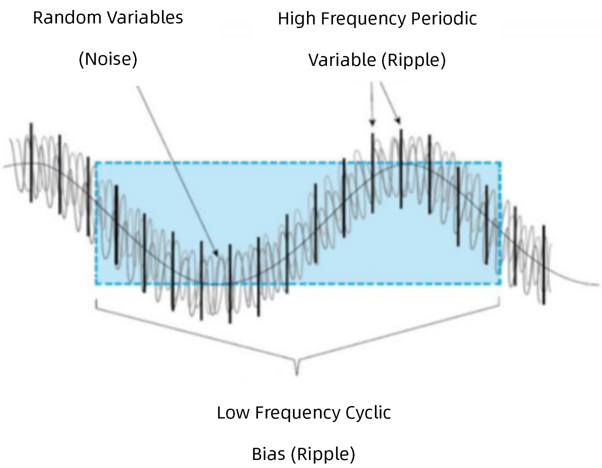


The loss values within the switching cycles are analyzed using the MSO7000X-PWR software.

Ripple Analysis

Ripple Analysis

The power supply ripple metric is an important parameter for switch-mode power supply modules or DC/DC converters. The output of a switch-mode power supply is not truly constant; it experiences periodic disturbances. These disturbances resemble the patterns of water ripples, referred to as "ripple." Ripple can manifest as either voltage ripple or current ripple.



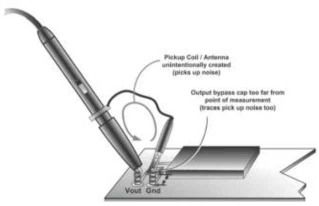
Low-Frequency Ripple

This type of ripple originates from the AC input cycle. Since the power supply's suppression of input variations is not perfect, any changes in the input will cause corresponding variations in the output.

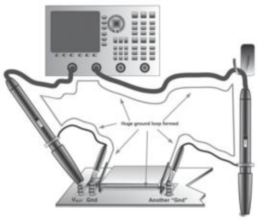
High-Frequency Ripple

This type of ripple comes from the switching cycle. Switch-mode power supplies do not output energy in a linear, continuous manner. Instead, they package energy into discrete units for transmission, resulting in ripples that correspond to the switching cycles.

Wrong Probe Measurement Methods:



Long grounding loops



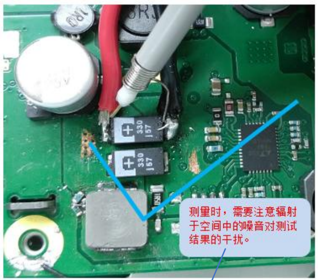
Extraneous probes introducing

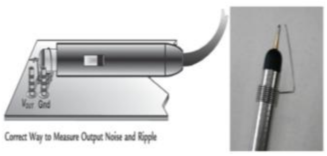
The inductor is a source of radiation, and the probe will pick up the spatial radiation from the inductor and superimpose it on the signal obtained from the measurement.

Noise measurement posture: Probe tilted to touch inductance.

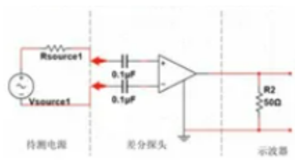
Correct Probe Measurement Methods:

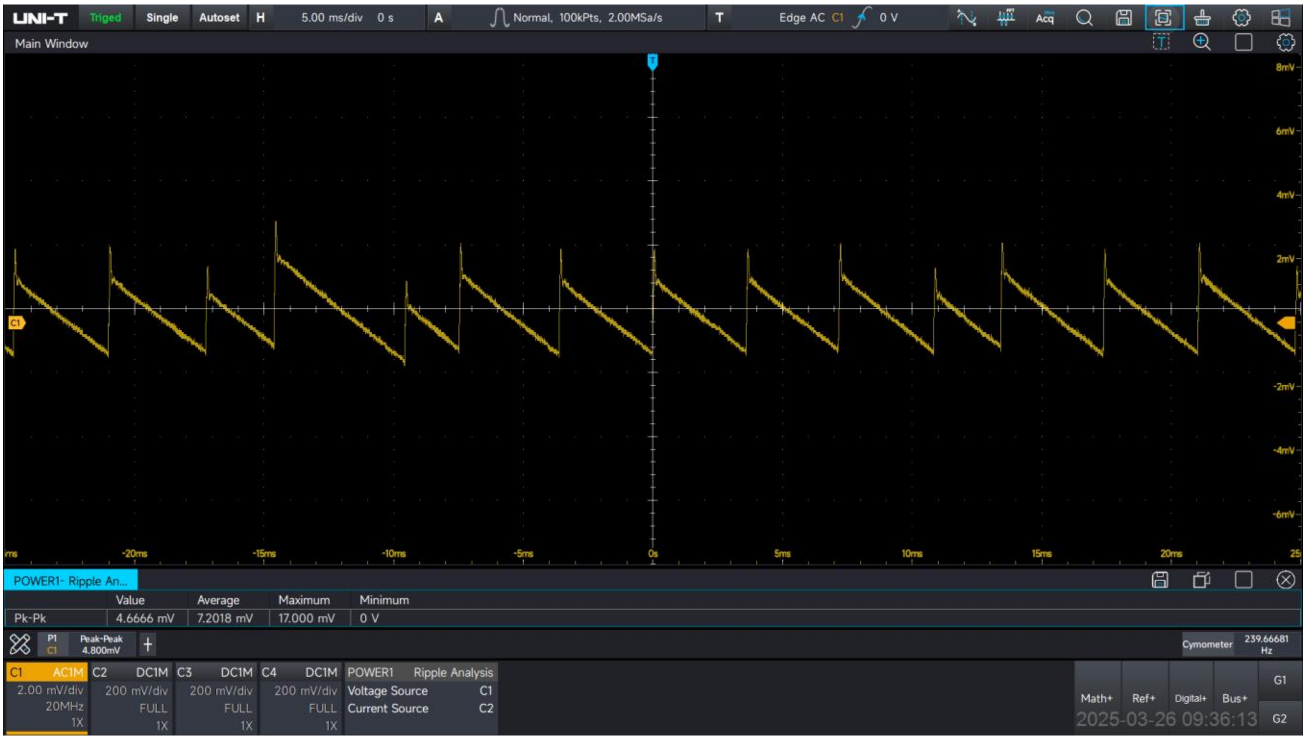
The probe should be spotted vertically, with as little as possible touching the radiation source, removing the excess probe, and using a grounding spring or ripple cap.



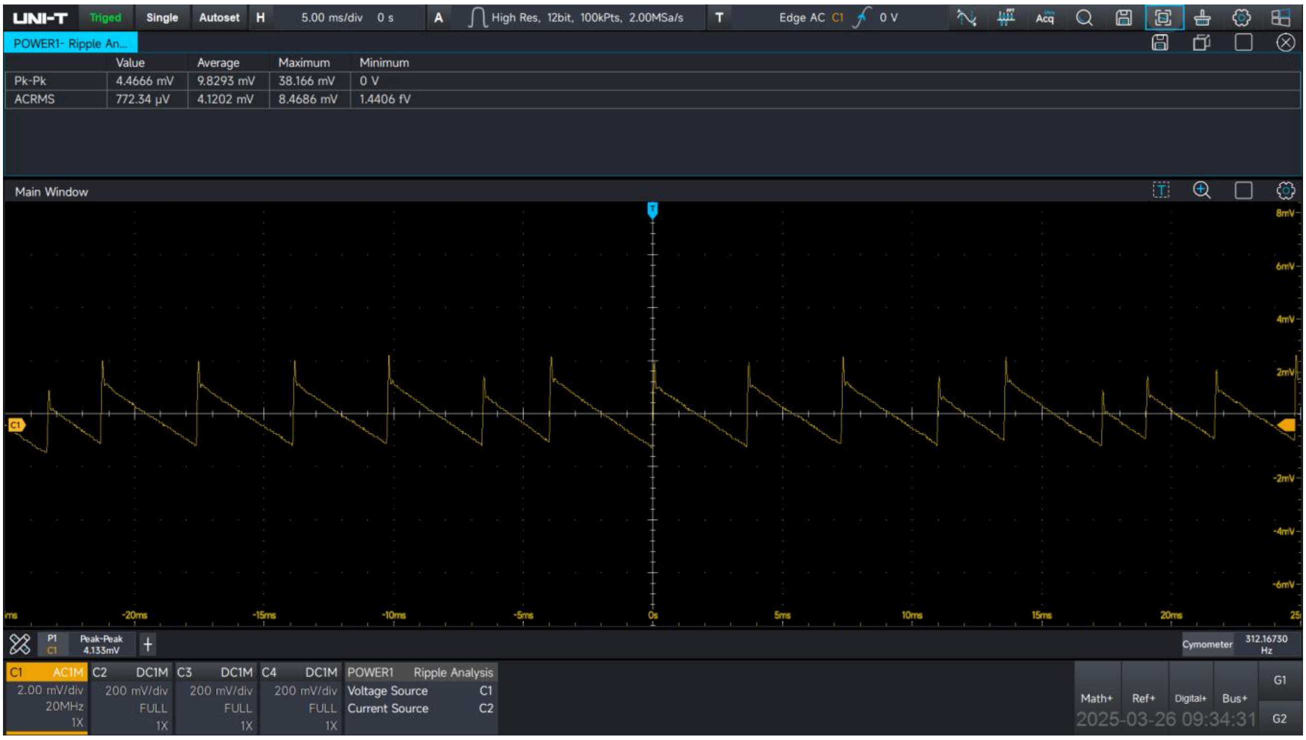


When measuring, it is necessary to pay attention to the interference of noise radiating in the space with the test results.

	Passive Probe	**Active Differential Probe**	**Coaxial Cable**
Test Schematic			
Oscilloscope Setup	Termination: 1 MΩ Bandwidth limit: 20 MHz Coupling: AC Probe attenuation ratio: 1:1	The power supply to be measured is connected in differential mode, , with the oscilloscope terminated at 50 Ω.	Set the oscilloscope to 50-ohm termination to match the coaxial cable impedance.Oscilloscope set to 50-ohm termination to match coax impedance
Advantages	Low cost allows the same test sample to be quickly tested at different points of ripple.	The ground of the oscilloscope is isolated from the ground of the part to be measured, which can solve the interference introduced by the power supply ground.	Coaxial cable test results are more accurate and less affected by human factors.



Ripple measured with intersecting long ground loop, introducing interfering noise, measured ripple 4.8 mV.



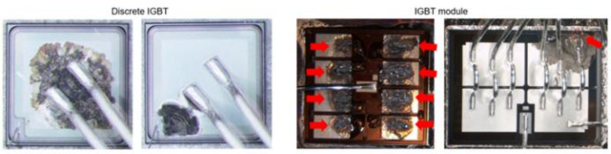
Ripple measured in MSO7000X in high-resolution 12-bit mode using a grounded spring with a measured ripple of 4.1 mV.

Safe Operating Area

Failed components are often sent to the original manufacturer for Failure Analysis, and terms commonly encountered include over voltage, over current, short circuit, and EOS. However, the underlying causes of failure are closely related to the overall application environment and system design of the equipment.

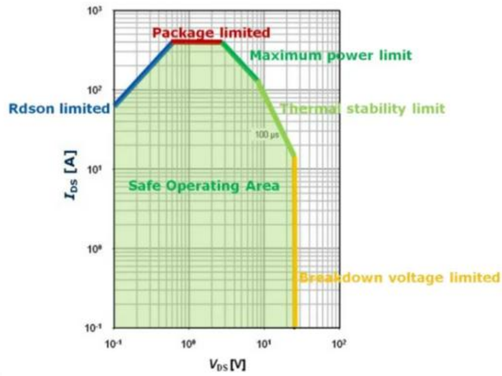
The number of components inside a complete machine can range from dozens to tens of thousands or more. Component failure is inevitable, and what can be done is to fully assess and test the key parameters of the components according to the performance requirements of the entire machine. In the event of a failure, review the design, reproduce the failure, identify the root cause, and avoid falling into the same pitfalls.

The Safe Operating Area (SOA) is a graphical technique used to evaluate switching devices and ensure that the stress does not exceed the maximum specifications. As the name implies, it means that as long as the operating conditions (voltage, current, load changes, junction temperature, etc.) do not exceed the boundaries of the SOA stress template, the switching devices can still operate stably according to the design requirements. Otherwise, as shown in the figure below, the situation of component burnout may occur.



MOS Tube Safe Work Area

The SOA is crucial for determining whether a MOSFET can handle the power level you require, especially for MOSFETs operating in the saturation region. In short, to ensure the safe operation of a MOSFET, it must be within the SOA area (the green area in the above diagram).

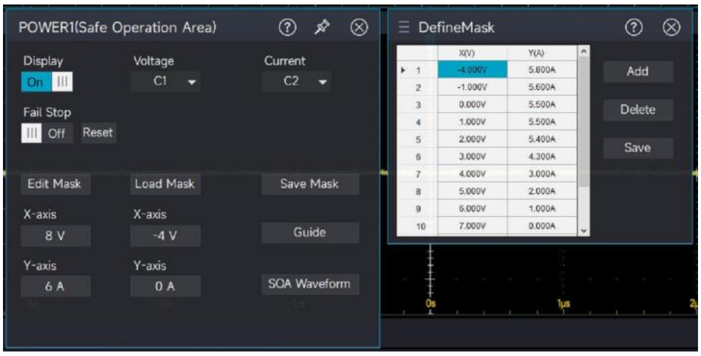


- **RdSon Limit (Blue)**: This is limited by the device's on-resistance (usually the maximum on-resistance at the maximum allowable junction temperature). Has a constant slope because each point on the line represents the same resistance value.
- **Current Limit (Red)**: This indicates the current limit, which generally depends on the package's limitations.
- **Maximum Power Limit (Dark Green)**: This has a constant negative slope (slope of -1), with each point on the line representing the same constant power.
- **Thermal Instability Limit (Light Green)**: Beyond this limit, the MOSFET may become thermally unstable and be destroyed.

· **Breakdown Voltage Limit (Yellow)**: This is generally the VBR(DSS). Exceeding this limit may cause the MOSFET to fail due to breakdown.

MSO7000X-PWR software provides SOA stress template testing to test power chips including IGBTs, MOSFETs, and new wide bandgap semiconductor process devices. You can set up SOA templates, save, and import these templates for stress testing , ensuring a thorough understanding of device performance before design, leading to optimal product designs.

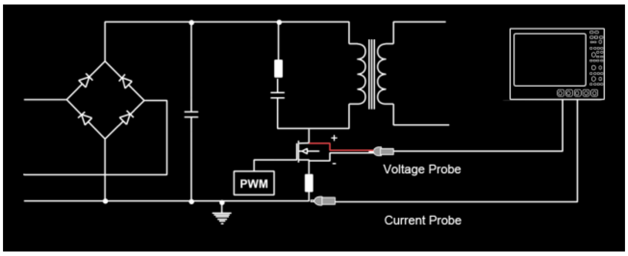
Test Environment Configuration

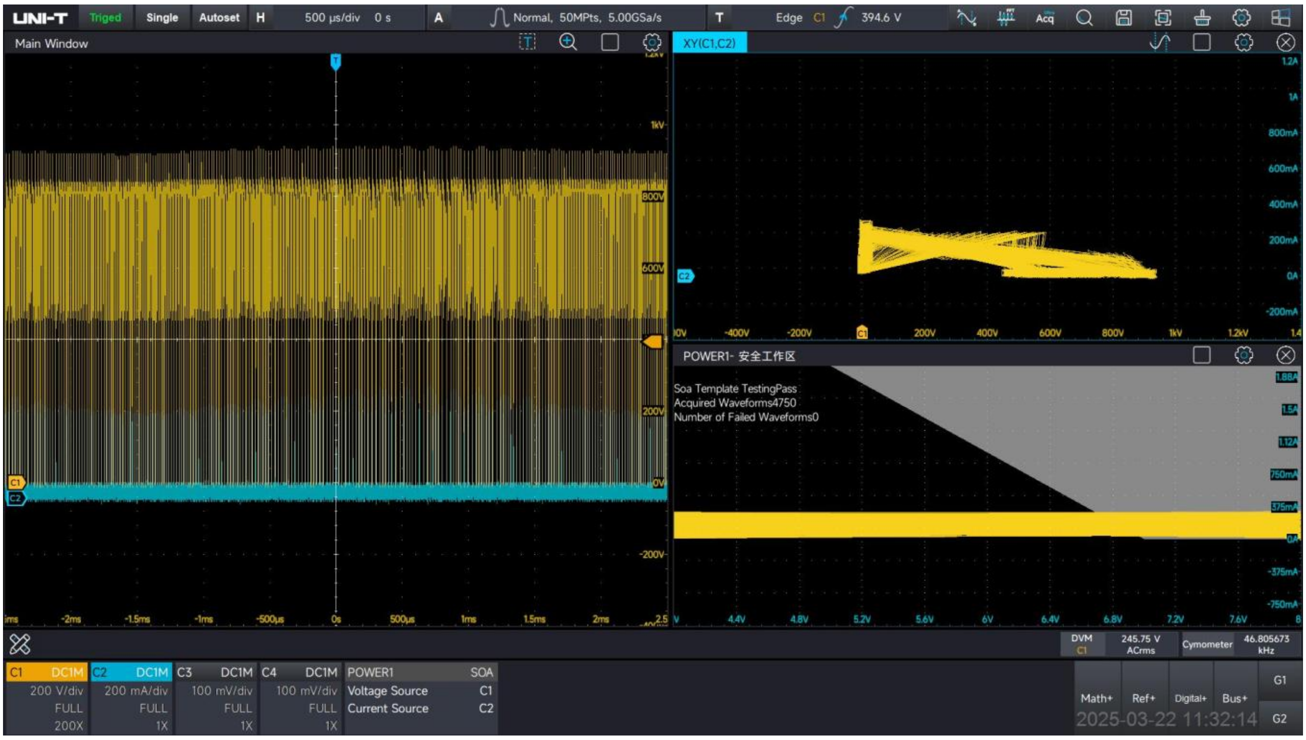


1. Oscilloscope: Any model from MSO7000X series.
2. Voltage Probe: It is recommended to use UT-P3X series high-voltage differential probes (capable of handling differential input voltages of ±800 Vpp to 14 kVpp), which can be selected based on specific needs.
3. Current Probe: It is recommended to use the UT-P4X series current probes, with a maximum measurable current ranging from 20 A to 500 A, selectable according to requirements.
4. MSO7000X-PWR Power Analysis Option.

Test Environment Preparation

Connect the differential probe and the current probe to the positive and negative terminals of the input power supply according to the signal connection diagram. Before use, it is necessary to zero and demagnetize the current probe to ensure the reliability of the test results.





Perform SOA stress template testing with the MSO7000X-PWR, automatically collect waveform data, and determine Pass/Fail.

Loop Analysis

Loop analysis is used to verify the stability of control system loops. In switch-mode power supplies and operational amplifier feedback networks, loop testing can accurately measure the stability and response speed of the power supply, providing engineers with a reference for designing stable control circuits.

By injecting a disturbance signal of varying frequency into the switch-mode power supply, the dynamic modulation capability of the circuit system at various frequency points in response to different disturbance signals can be judged based on its output. Utilizing Bode plots and gain/phase margin measurements, designers can determine the stability of the power supply control loop.

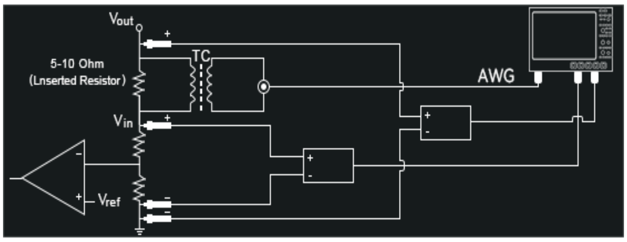
Control loop analysis uses a built-in AWG (Arbitrary Waveform Generator) as the input excitation source. A signal injector/isolation transformer is used to inject the signal into the control loop. The oscilloscope scans a specified frequency range to obtain the corresponding gain and phase curves, automatically calculating the gain and phase margins to confirm the stability of the control loop. The higher the margin, the better the loop stability.

Test Environment Preparation

1. Oscilloscope: Any model from the MSO7000X series.
2. Two 1:1 Passive High Impedance Probes.
3. One Isolation Transformer/Signal Injector.
4. MSO7000X-AWG Function/Arbitrary Waveform Generator Option.
5. MSO7000X-PWR Power Analysis Option.

Test Environment Configuration

Inject the AWG signal into the control loop through the signal injector, connecting it across the ends of the series injection resistor. Use two 1:1 voltage probes to connect to the input and output of the loop respectively, and connect the input and output to the oscilloscope channels. Execute the power analysis software, and the oscilloscope will automatically perform the test until completion.

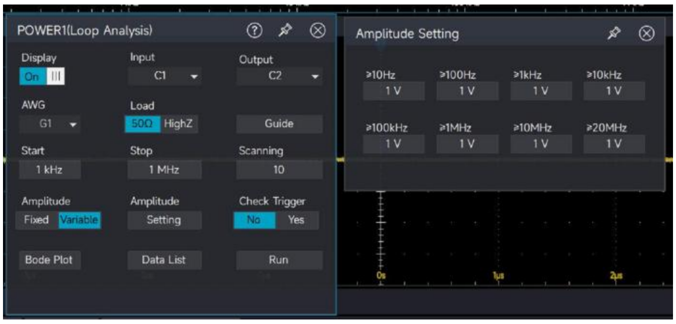


Precautions for Loop Analysis

1. The probe must introduce the signal into the oscilloscope with 1X attenuation; otherwise, it will affect the measurement results.
2. Since the injected disturbance signal is a sine wave, to ensure that the injected signal is not affected by the DC offset of the power supply itself, the oscilloscope should use AC coupling.
3. Injection resistor size: The injection resistor should not significantly affect the steady-state value of the loop. For common voltage divider feedback networks, resistors are typically in the kiloohm (kΩ) range, in which case an injection resistor of 5-10 ohms is recommended. If the feedback resistors reach the megaohm (MΩ) range, a larger injection resistor may also be acceptable.The size of the injection resistor. In principle, the injection resistor should not affect the steady-state value of the loop. Common voltage divider feedback network resistors are at least in the kiloohm (KΩ) range, in which case an injection resistor of 5-10 ohms should be used. If this resistance value is larger, reaching the megaohm (MΩ) level, then using a larger injection resistor is also acceptable.
4. Injection amplitude:The relationship between the injection amplitude and the output amplitude of the AWG is given by:

$$V_{inf}=V_{out}-V_{in}=\left(R_{inf}/R_{AWG}+R_{inf}\right)*V_{in}$$

A too low injection amplitude may result in inaccurate measurements at low frequencies. A high injection amplitude may cause distortion during high-frequency measurements. It is recommended to set an appropriate injection amplitude within different frequency ranges.



Conduct loop analysis testing automatically with the MSO7000X-PWR software, which automatically evaluates the phase margin and gain margin.

Technical Specifications

Power Quality	Measurement Parameters: RMS voltage, voltage crest factor, frequency, RMS current, current crest factor, active power, apparent power, reactive power, power factor, and phase angle. Source Selection: Voltage source, current source. Frequency Reference: Voltage source, current source. Required Device: High-voltage differential probes and current probes.
Harmonic Analysis	Harmonic Distortion THD: THD-R, THD-F, RMS, frequency, magnitude, magnitude RMS, and phase. Types of Harmonics: Odd harmonics, even harmonics, and total harmonics. Number of Harmonics: 100. Frequency Reference: Harmonic source, voltage source, and current source. Required Device: High-voltage differential probes and current probes.
Switching Loss	Power Parameters: Turn-on power loss, conduction power loss, turn-off power loss, non-conduction power loss, and total power loss. Energy Parameters: Turn-on energy loss, conduction energy loss, turn-off energy loss, non-conduction energy loss, total energy loss, number of cycles. Measurement Statistics: Maximum value, minimum value, and average value.
Safe Operating Area	SOA Coordinate System: Linear/logarithmic. Stop when a violation is detected.
Ripple Analysis	Ripple Source: Voltage source, current source. Ripple Statistics: Current value, maximum value, minimum value, and average value.
Loop Analysis	Measurement Parameters: Frequency, amplitude, gain, and phase. Scan Mode: Continuous, single. Impedance: 50 Ω, high impedance. Frequency: Up to 60 MHz (requires optional AWG). Amplitude: Up to 6V (requires optional AWG). Bode plot for gain and phase curves. Required Device: Two UT-PO8A 1:1 probe, UT-ISOT signal injector, or other 1:1 isolation transformer.
Plotting	Power graph, harmonic histogram, switching loss power graph, SOA waveform graph, and Bode plot.

Ordering Information

Product Models	
MSO7204X	2 GHz bandwidth, up to 10 GSa/s (single-channel 10 GSa/s, dual-channel 5 GSa/s, 4-channel 2.5 GSa/s) 4-Channel Oscilloscope
MSO7104X	1 GHz bandwidth, up to 10 GSa/s (single channel 10 GSa/s, dual channel 5 GSa/s, 4-channel 2.5 GSa/s) 4-Channel Oscilloscope
Options	
MSO7000X-AWG	Dual 60 MHz Function/Arbitrary Wave Generator
MSO7000X-PWR	Advanced Power Analysis
Recommended Probes and Accessories	
Attachment Type	**Recommended**
Passive High Resistance Probes	UT-P05(1:1/10:1) 200 MHz
	UT-P06 (1:1/10:1) 300 MHz
	UT-P08 (1:1/10:1) 350 MHz
	UT-P07A (10:1) 500 MHz
High Voltage Differential Probes	UT-P30 (100 MHz; ±800 Vpp)
	UT-P31 (100 MHz; ±1.5 kVpp)
	UT-P32 (50 MHz; ±3k Vpp)
	UT-P33 (120 MHz; ±14 kVpp)
	UT-P35 (50 MHz; 1.3 kV)
	UT-P36 (50 MHz; 5.6 kV)
Current Probes	UT-P40 Current Probe (100 kHz; 0.4A to 60 A)
	UT-P41 Current Probe (100 kHz; 0.4A to 100 A)
	UT-P42 Current Probe (150 kHz; 0.4A to 200 A)
	UT-P43 Current probe (25 MHz; maximum measurement current 20 A)

	UT-P44 Current probe (50 MHz; max. measurement current 40 A)
	UT-P4030D Current probe (100 MHz; max. measurement current 30 A)
	UT-P4150 Current probe (12 MHz; max. measurement current 150 A)
	UT-P4500 Current probe (5 MHz; max. measuring current 500 A)
	UT-4100A Current Probe (600 kHz; 100A max.)
	UT-4100B Current Probe (2 MHz; 100A max.)
Signal Injection Transformer	UT-ISOT (2 Hz-2 MHz)

UNI-T Oscilloscope New Products

Picture	Series	Channel	Bandwidth	Sampling Rate	Memory Depth
	MSO7000X Series	4+16	1G/2G/2.5 GHz	10 GSa/s	1 Gpts
	UPO7000L Series	4	1G/2 GHz	10 GSa/s	1 Gpts
	MSO3000X Series	4+16	250M/350M/500 MHz	5 GSa/s	500 Mpts
	MSO3000HD Series 12-bit	4+16	200M/350M/500 MHz	2.5 GSa/s	500 Mpts
	MSO2000X Series	4+16	100M/200M/300 MHz	5 GSa/s	100 Mpts