Power Ripple and Noise Measurement Solution

SOLUTIONS

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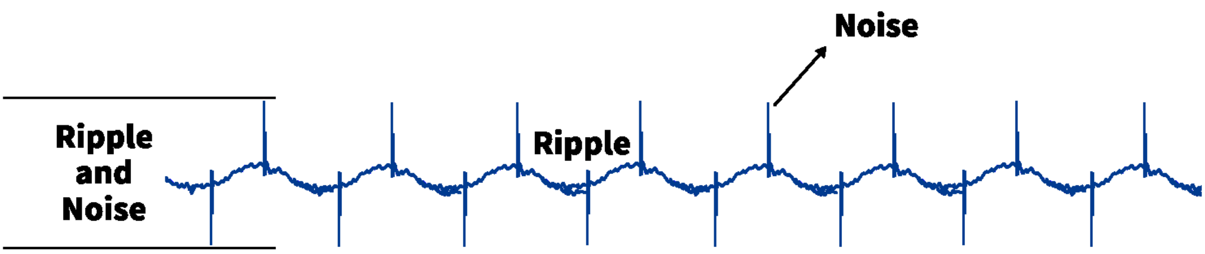
1 OVERVIEW

The power supply is the heart of electronic products, providing continuous energy to the system. Power supply ripple and noise are critical parameters for evaluating power supply quality, reflecting the instability and interference of the power output. Large ripple or noise can lead to low power efficiency, unstable system operation, accelerated device aging, and other issues. Therefore, correctly measuring and assessing ripple and noise levels is crucial when designing or selecting a power supply.

Power supply ripple refers to the periodic variation or fluctuation present in the power output. It is a component synchronized with the switching frequency, an AC interference signal superimposed on the stable DC signal, measured in millivolts (mV). Ripple waveforms differ between power supplies. They can be caused by power supply design, power filters, and other factors, or influenced by load changes or other external interference.

Power supply noise differs from ripple. It is another high-frequency component appearing between the output terminals, referring to non-periodic random interference present in the power output. It can be understood as discontinuous, irregular voltage or current spikes caused by "interference" (such as improper circuit design, unreasonable wiring, poor contact, etc.) from both inside and outside the system.



2 CHALLENGE

In recent years, with continuously decreasing power supply voltages, faster circuit switching speeds, smaller chip packages, and increasingly complex power delivery networks (PDN), power integrity requirements have risen significantly. Power ripple and noise measurement have become increasingly challenging. Probes are often used during testing, primarily because they are convenient, offer high input impedance, and are less likely to affect the circuit under test.

However, power supply noise is very low. During testing, both the oscilloscope and the probe will introduce noise. Using traditional oscilloscopes and probes might result in excessive inherent noise drowning out the noise and ripple, or insufficient offset range failing to meet test requirements. Therefore, using a high-resolution, ultra-low-noise oscilloscope along with a low-noise, high-offset-range power rail probe is essential for accurate power ripple and noise measurement.

Furthermore, the actual testing process involves multiple operations. Improper operation can introduce interference noise and external electromagnetic interference (EMI), reducing measurement accuracy.

Therefore, mastering the correct methods for ripple and noise measurement is critical.

3 SOLUTION

3.1 Oscilloscope Selection

12-bit High-Resolution Oscilloscope.

Oscilloscopes currently available on the market offer 8-bit, 10-bit, and 12-bit options. Among these, 12-bit oscilloscopes have the highest quantization level (4096 levels) and the smallest quantization error, resulting in more accurate waveform reproduction and measurement results. Furthermore, as a true 12-bit oscilloscope, its front-end amplifier and analog-to-digital converter (ADC) are specifically designed for high-resolution applications, offering lower noise, and advantages in effective number of bits (ENOB), DC gain accuracy, etc. When the high-resolution mode is enabled, the resolution can reach up to 16-bit, making it highly suitable for power ripple and noise measurement.

The fundamental switching frequency of power conversion devices might be relatively slow, but edge speeds and rise times are generally much faster, easily generating high-frequency noise and harmonics. Therefore, the selected oscilloscope must have sufficiently high bandwidth to quickly diagnose problems related to high-frequency interference. SIGLENT's current high-resolution oscilloscopes now cover bandwidths from 70 MHz to 8 GHz, providing users with multiple options.

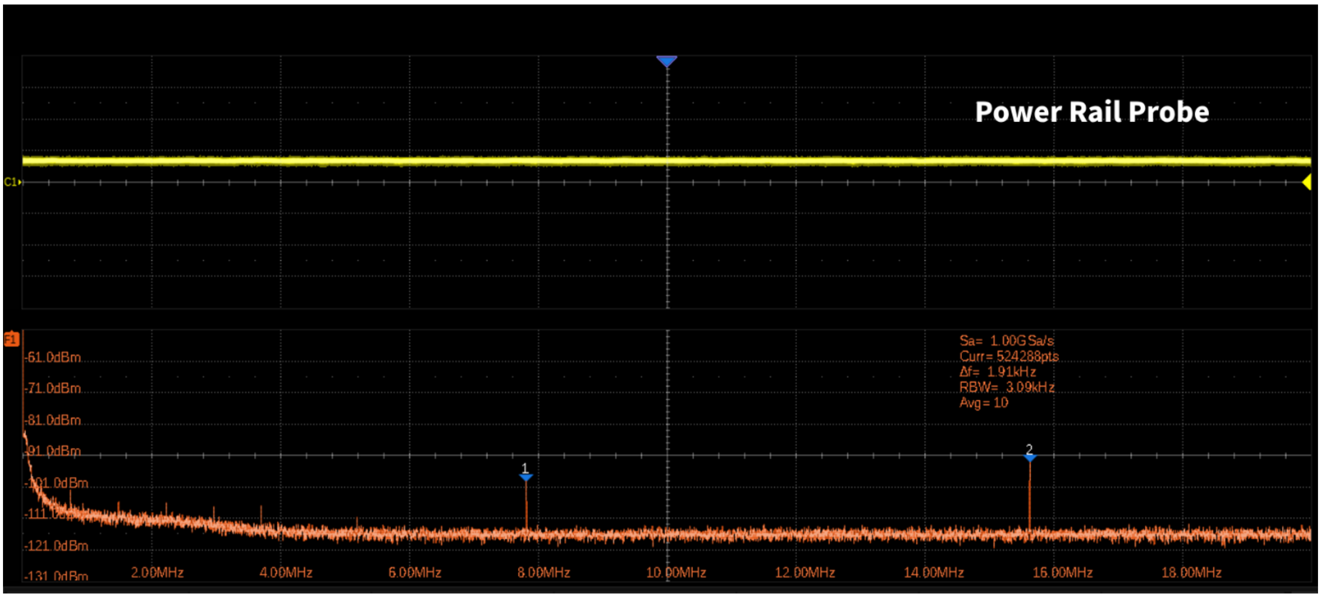
3.2 Probe Selection

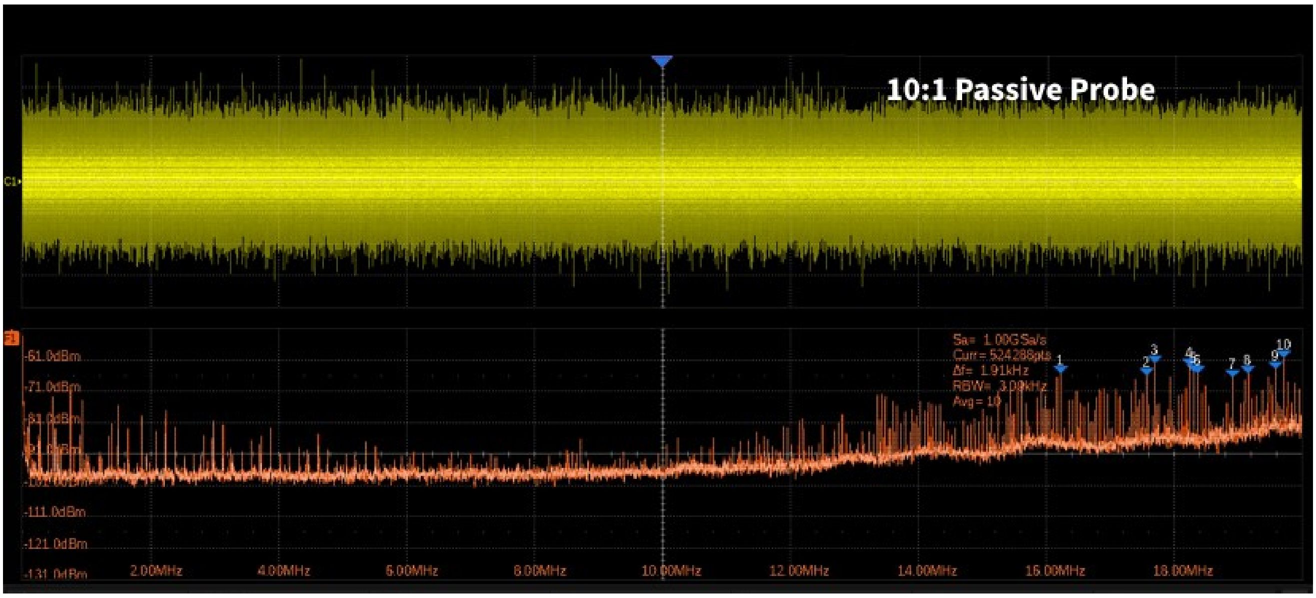
High Bandwidth, Low Noise, High Input Impedance, Large Voltage Offset Range Power Rail Probe.

In the past, when measuring power noise and ripple, engineers often used passive probes directly to probe the power and ground nets near the chip under test. However, conventional passive probes have a bandwidth of only 6 MHz at 1x attenuation, which is too low. At 10x attenuation, the inherent noise of the oscilloscope when connected becomes too large, compromising test accuracy. Additionally, to test the ripple or noise on the DC component, the oscilloscope was typically set to AC coupling mode. However, AC coupling filters out the DC component while also filtering low-frequency noise and drift. Therefore, a probe with a sufficiently large vertical offset range is needed for testing.

The SIGLENT power rail probe, SAP4000P, specifically designed for testing power ripple and noise, is recommended. Its mV-level sensitivity allows users to more accurately detect noise, ripple, and transient changes on DC power supplies, providing a low-noise, large-offset-range solution for measuring power rails.

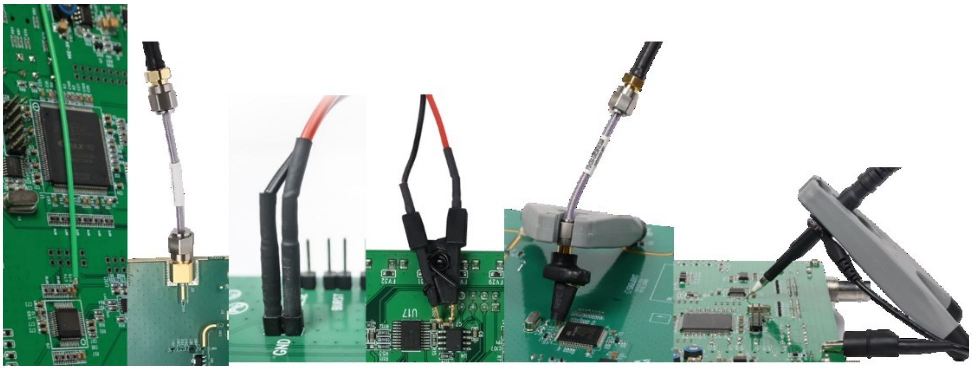
The comparison chart below shows the noise when connecting the power rail probe alone versus a 10:1 passive probe, with no device under test connected and all other conditions consistent. It is clear that the noise using the passive probe is significantly higher than with the power rail probe:





The SAP4000P offers up to 4 GHz bandwidth. Its low-noise characteristics help distinguish the noise from the oscilloscope and probe itself from the noise and ripple of the DC power supply under test. Its ±24V offset setting range easily centers dynamic signals with DC components near the oscilloscope screen's centerline. The input dynamic range reaches +/-600mV, allowing users to measure large voltage jumps on the power supply. Furthermore, a high impedance of 50 KΩ at low frequencies eliminates loading effects, minimizing interference with the power supply under test, while a low impedance of 50Ω at high frequencies matches coaxial cables, improving test bandwidth.

The SAP4000P also provides multiple accessories, such as SMA male-to-male cables, high-frequency point probes, and miniature SMD clips, enabling flexible connection setups like direct cable connection, soldering at the test point, passive probe probing, etc., to meet the needs of different application scenarios.



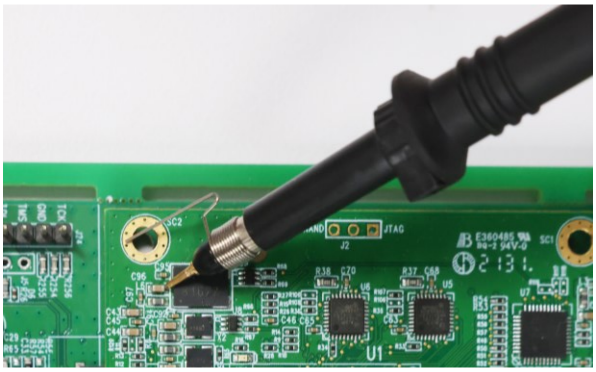
3.3 Precautions

Oscilloscope Bandwidth: Power ripple is low-frequency noise, identical to the switching frequency, typically tens to hundreds of kHz. Therefore, limiting the bandwidth to 20MHz for measurement avoids high-frequency noise affecting ripple measurement. Power noise is high-frequency interference, generally referring to the AC component superimposed on the output voltage over the full bandwidth. Full bandwidth must be enabled for noise measurement.

Oscilloscope Vertical Scale: The lower the vertical scale setting, the lower the inherent noise of the oscilloscope system. During measurement, use the oscilloscope's vertical scale knob coarse and fine adjustment functions to zoom the signal waveform to occupy 80%---90% of the screen. This provides greater resolution.

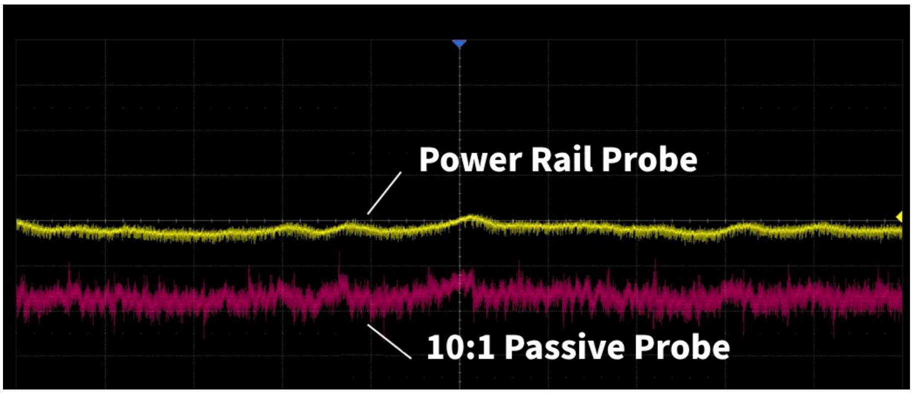
Sampling Rate: The principle is to sample the rising edge of the waveform detail of interest with 3-5 points, preferably more than 5 points. A high sampling rate reduces waveform distortion during testing.

Grounding Method: When using a standard passive probe, to avoid excessive noise coupling into the ripple test, the distance between the probe ground (GND) and the test point should be as short as possible. Avoid introducing EMI signals into the test results due to a large loop area of the signal under test. The correct method is to use the probe tip for point probing and a short ground spring to minimize EMI introduction. Other methods, such as using a two-lead adapter or a miniature SMD clip, can also increase testing convenience.



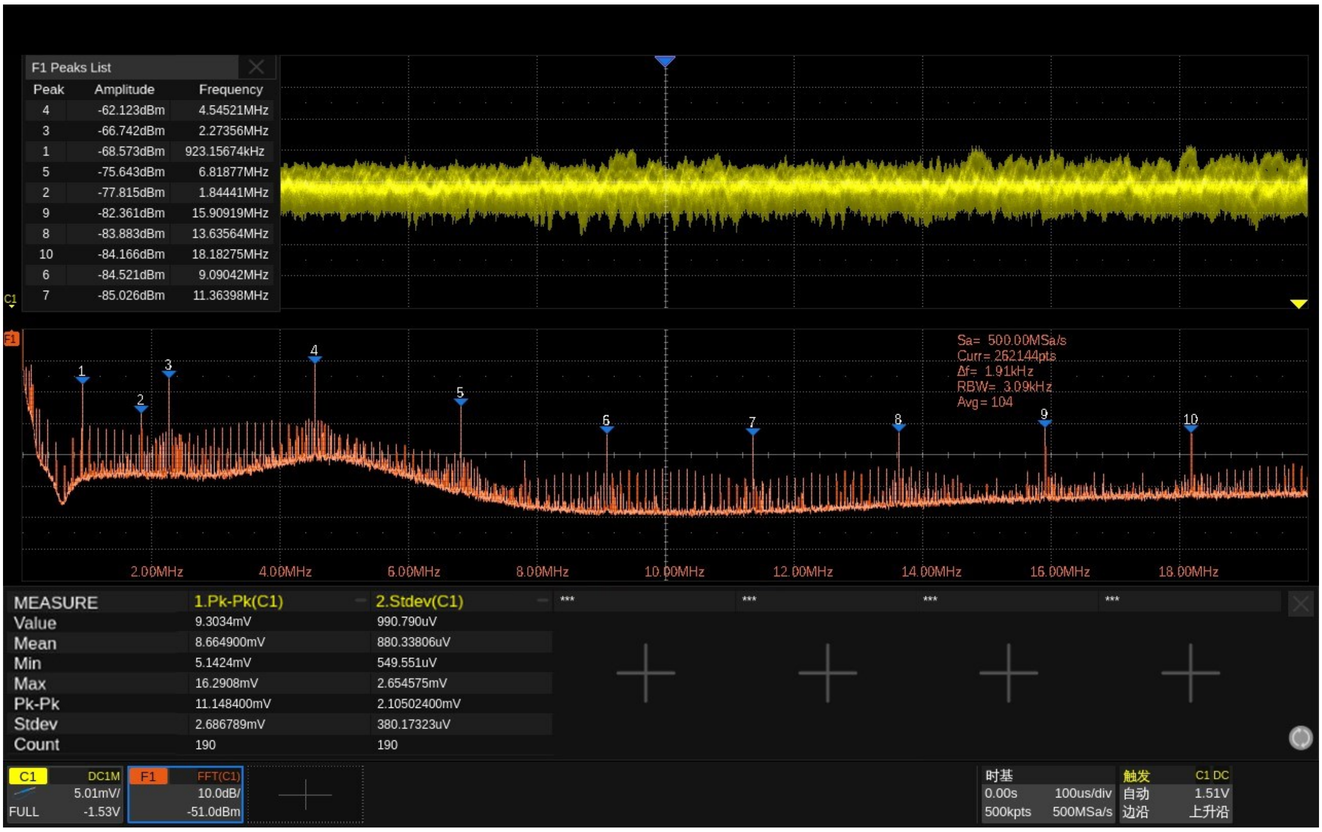
3.4 Test Results

The same test point (filter capacitor on the DDR3 power pin) of the same device under test was measured using both the power rail probe and a passive probe. Settings for horizontal timebase, vertical scale, impedance, etc., were identical (different vertical offsets were set for waveform clarity, and the vertical scale was not adjusted to fill the screen). Standard deviation and peak-to-peak value were selected for measurement. It is evident that when using the ordinary passive probe, the signal is buried in noise, while the power rail probe accurately captures the test result.



3.5 Result Analysis

During power noise analysis, the power ripple and noise can be directly observed and measured using an oscilloscope to infer the source of interference. However, as digital device voltages decrease, power supply design difficulty increases significantly. Observing the time-domain waveform alone may not locate the problem. At this point, FFT (Fast Fourier Transform) can be used to convert the time-domain power waveform to the frequency domain for analysis. From the FFT graph below, the main frequency components of the noise can be identified. During circuit debugging, viewing signal characteristics from both the time domain and frequency domain perspectives can effectively accelerate the debugging process. Of course, the spectrum effect after FFT varies between different oscilloscopes, mainly related to the number of points. The more points supported, the higher the frequency resolution, and the better the FFT effect. Currently, SIGLENT's SDS7000A series FFT supports up to 32 Mpts. Additionally, it supports peak lists, intuitively displaying the amplitude and frequency of the main frequency components.



4 SUMMARY

This article introduced the precautions and debugging techniques for power ripple and noise testing using SIGLENT high-resolution oscilloscopes paired with the low-noise, large-offset-range, high-impedance-input power rail probe SAP4000P. If the impact of these interferences on high-speed signal transmission needs to be investigated, further analysis can be performed using eye diagram and jitter analysis functions (supported by SDS6000Pro, SDS6000L, SDS7000A series).

About SIGLENT

SIGLENT is an international high-tech company, concentrating on R&D, sales, production and services of electronic test & measurement instruments.

SIGLENT first began developing digital oscilloscopes independently in 2002. After more than a decade of continuous development, SIGLENT has extended its product line to include digital oscilloscopes, isolated handheld oscilloscopes, function/arbitrary waveform generators, RF/MW signal generators, spectrum analyzers, vector network analyzers, digital multimeters, DC power supplies, electronic loads and other general purpose test instrumentation. Since its first oscilloscope was launched in 2005, SIGLENT has become the fastest growing manufacturer of digital oscilloscopes. We firmly believe that today SIGLENT is the best value in electronic test & measurement.

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