Keysight N2806A Calibration Pulse Generator

User's Guide

KEYSIGHT TECHNOLOGIES

Notices

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CAUTION

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WARNING

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Introduction

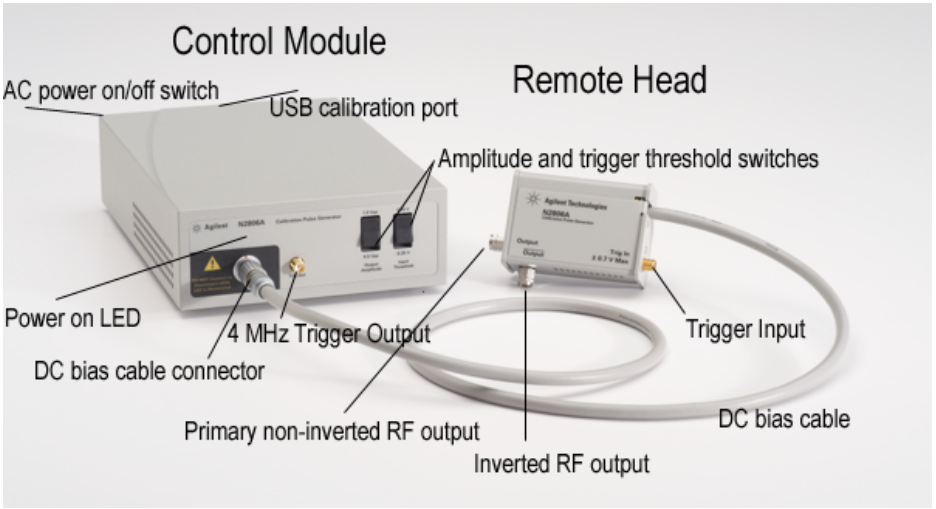
The N2806A Calibration Pulse Generator delivers a high-speed, time-domain output step or square-wave response over a wide range of clock data rates while also delivering significant frequency-domain spectral content for frequencies from DC to well over 60 GHz.

The N2806A can be used in a variety of applications, such as high-performance oscilloscope development. It also can be used as a step generator to calibrate scope input channel responses and to facilitate characterization of the actual DUT (device under test) response. It can act as an input stimulus signal for Keysight's PrecisionProbe and PrecisionCable software applications, and is included in the N2807A PrecisionProbe Advanced Kit.

The N2806A is also used for applications in high-frequency network analysis, as they benefit from the edge speed and pure spectral content produced. With the sub-7 ps falling edge of 90%-10% you can characterize components well beyond 60 GHz.

Description of the N2806A Parts

The N2806A consists of a remote head and a control module, shown below. Accessories included with the N2806A are a 2.4 mm female to 3.5 mm male adapter (11901-60004), a 2.4 mm 50 ohm terminator with a female connector (85138B), and a 1 m input cable with 2.92 mm connectors (N2812A).



Remote Head The fan-cooled remote head accepts input signals over a wide range of frequencies and produces a sub-7 ps falling-edge, output square-wave response.

Primary non-inverted RF output and Inverted RF output ($\overline{\text{Output}}$) The primary non-inverted RF output and inverted RF outputs provide a differential output signal through two independent 1.85 mm precision RF connectors. For example, if the primary output has a falling edge the inverted output will have the corresponding rising edge. The two edges are time correlated.

Trigger Input The Trig In port is used to input the signal that the remote head triggers on.

DC Bias cable A flexible, 14-wire bundled DC bias cable permanently connected to the remote head connects the remote head to the control module.

Control Module The control module provides power and sets the output amplitude (either 0.5 V or 1.0 V peak-to-peak) and input thresholds (either 0.00 V or -0.25 V) for the remote head. It also has a built-in 4 MHz square-wave generator that can be used as a generic trigger signal for the remote head trigger input.

Power On LED This LED illuminates green when power to the N2806A is on.

DC bias cable connector The DC bias cable from the remote head connects here.

CAUTION Do not plug in or unplug the DC Bias cable while the power is on. Doing so could damage the amplifier in the remote head.

4 MHz Trigger Output Trig Out is the square-wave signal generator output that can be used as a generic trigger signal for the remote head trigger input.

Amplitude and trigger threshold switches Use these selectors to switch between two RF output amplitudes, 0.5 V and 1.0 V peak-to-peak; and two trigger input threshold levels, 0.00 V and -0.25 V.

AC Power on/off switch Press the power switch to turn power on or off to the N2806A.

USB Calibration port The USB port connects to uninitialized flash memory that may be used for future products. If desired, you can initialize the 8 Gb drive and use it to store files.

Setting Up the N2806A and Measuring a Fast Edge

Follow these steps to set up your N2806A and use it to measure a fast edge. These steps assume the use of a Keysight 90000 Q-Series Infiniium oscilloscope.

1. Turn power on to the oscilloscope and open the Infiniium application.
2. Connect the RF output at the remote head to high bandwidth channel 1R on the oscilloscope using a 1.85 mm female-to-female connector.
3. Connect the included 2.4 mm 50 ohm termination to the Inverted RF output.
4. Connect the DC bias cable to the control module.
5. Use the N2812A 2.92 mm cable to connect Trig Out on the control module to Trig In on the remote head.
6. Select 0.5 V for the output amplitude and 0.00 V for the trig threshold on the front of the control module.
7. Plug in the power cord to the control module and turn on AC power at the back of the control module.
8. Press **[Default Setup]** on the oscilloscope.
9. Change the oscilloscope slope to trigger on a falling edge.
10. Press **[Auto Scale]** or manually set your desired volts per division, time per division, and offset.

Other Setup Options

For many applications, you will need to connect the edge to the device under test (DUT). In these cases, be sure to get the remote head as close as possible to the DUT, as any extra cabling will reduce edge speed.

You do not have to use Trig Out on the control module as the trigger input for the remote head. If you have an application-specific signal you want to use, the signal can be put directly into the remote head.

CAUTION

Output and $\overline{\text{Output}}$ must always be terminated with 50 ohms to avoid degradation of the edge due to signal reflections directly into the remote head, provided this signal satisfies the input requirements for the remote head. If you are using only one of the two outputs, terminate the other output with a 1.85 mm or 2.4 mm 50 ohm terminator such as the Keysight 85138B (included with the N2806A).

The following figure shows the N2806A buffering an 8.2 Gbps PRBS^7 signal. Orange is the original signal with a 95 ps rise time. Yellow is the signal after being buffered by the N2806A.

Requirements for Inputs into the Remote Head

There are three requirements for the remote head input signal. If these requirements are not met, the N2806A will not successfully trigger on the edges and accelerate them:

- The signal must cross either 0.00 V or -0.25 V. Too much DC bias will prevent triggering. To remedy, you can purchase a DC Block, either Keysight N9398C (50 kHz to 26.5 GHz) or Keysight N9399C (700 kHz to 26.5 GHz). You can also use Keysight 11742A (45 MHz to 26.5 GHz).
- The minimum slew rate on the input edge must be >2 V/ns to achieve the specified output rise/fall times.
- The input signal's maximum voltage is ±700 mV. If your Trig In signal is too large, you can purchase a 6 dB attenuator covering DC to 26.5 GHz (Keysight part number 8493B-006).

CAUTION Significantly exceeding the ±700 mV input voltage can damage the remote head.

Connector Compatibility

- A 1.85 mm connector (found on both RF outputs of the N2806A) is compatible with a 2.4 mm connector. However, performance will be degraded if a 2.4 mm adapter is connected to the RF output that is being used.
- A 2.92 mm connector is compatible with 3.5 mm and SMA connectors.

CAUTION Do not connect 1.85 mm or 2.4 mm connectors with 2.92 or larger connectors or else you will permanently damage the connectors.

Environmental Characteristics

For complete specifications and characteristics, direct your web browser to www.keysight.com/find/N2806A.

Temperature	Operating: 5 °C to 35 °C Non-operating: -40 °C to 65 °C
Humidity	Operating: up to 95% relative humidity (non-condensing) at 40 °C Non-operating: up to 90% relative humidity at 65 °C
Altitude	Operating: up to 3,000 meters (9,000 feet) Non-operating: up to 15,300 meters (50,000 feet)

Service and Replacement Parts

WARNING This product has no user-serviceable parts. To prevent electrical shock, do not disassemble the remote head or control module.

Repair of the N2806A Calibration Pulse Generator is done only by Keysight Service Centers. The N2806A has no user-serviceable parts.

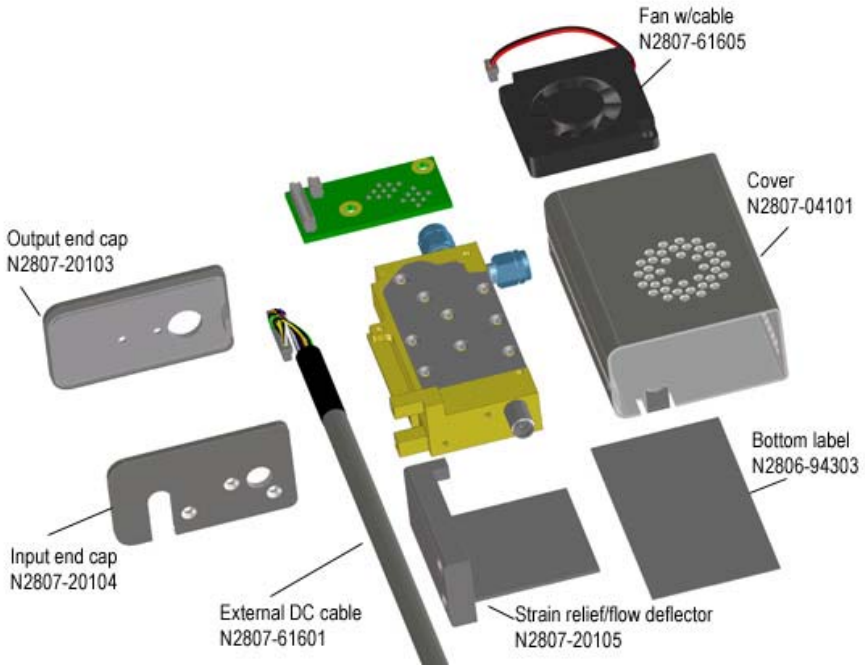
If your N2806A requires service, contact your local Keysight Service Center for shipping instructions. Send both the remote head and the control module if any repairs are needed.

The following table and figures show all parts that can be replaced.

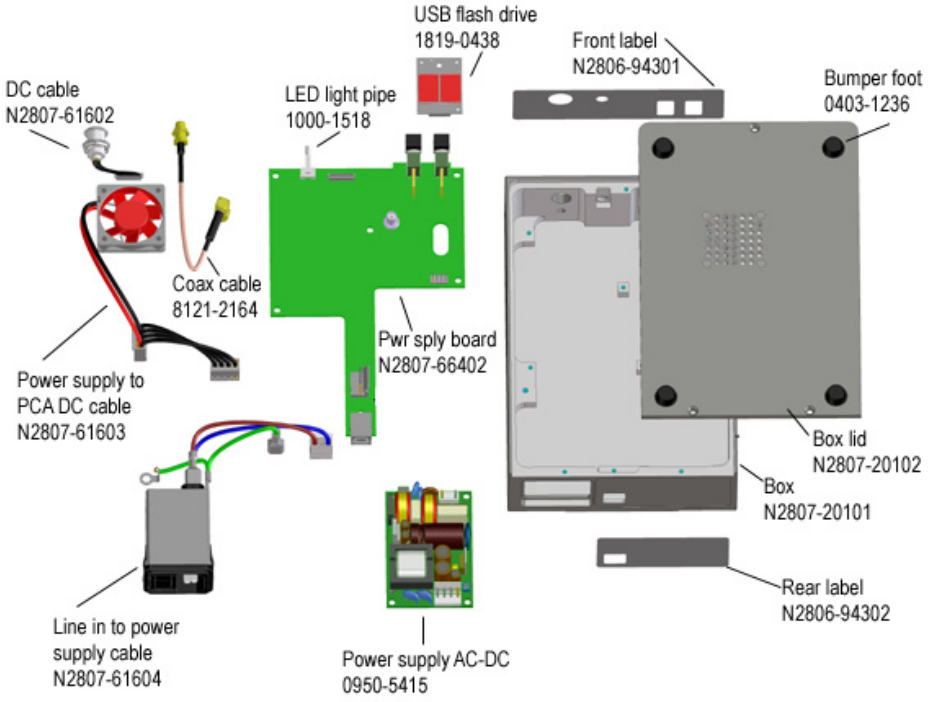
Description	Keysight Part Number
Input cable, 2.92 mm connectors	N2813-61601
Cover	N2807-04101
Output end cap	N2807-20103
Input end cap	N2807-20104
DC bias cable	N2807-61601
Fan with cable	N2807-61605
Strain relief and flow deflector	N2807-20105
Label - remote head	N2806-94303
Bumper foot	0403-1236
Power supply AC-DC 25W	0950-5415
LED light pipe	1000-1518
IC 2 GB USB flash drive	1819-0438
Cable assembly - coaxial	8121-2164
Label - front power case	N2806-94301
Label - Rear power case	N2806-94302

Description	Keysight Part Number
Machined power box	N2807-20101
Machined power box lid	N2807-20102
Internal DC cable	N2807-61602
Power supply to PCA DC cable	N2807-61603
Line In to power supply cable	N2807-61604
PCA - Power supply box	N2807-66402

Remote Head Replaceable Parts



Control Module Replaceable Parts



Testing Performance

This section describes the process for testing performance:

1. Measure the rise time at 0.5 V peak-to-peak.
2. Measure the rise time at 1.0 V peak-to-peak.
   a. Measure the rise time at 0.5 V with the attenuator.
   b. Calculate the attenuator rise time using the 0.5 V rise times with and without the attenuator.
   c. Measure the rise time at 1.0 V with the attenuator.
   d. Calculate the rise time at 1.0 V by removing the scope and attenuator rise times.

CAUTION

Let the N2806A warm up before testing.

The oscilloscope must be warmed up (with the oscilloscope application running) for at least 30 minutes prior to the start of any performance test.

Specifications

- Rise time 10%-90% (warranted): < 10 ps
- Fall time 90%-10% (warranted): < 8 ps

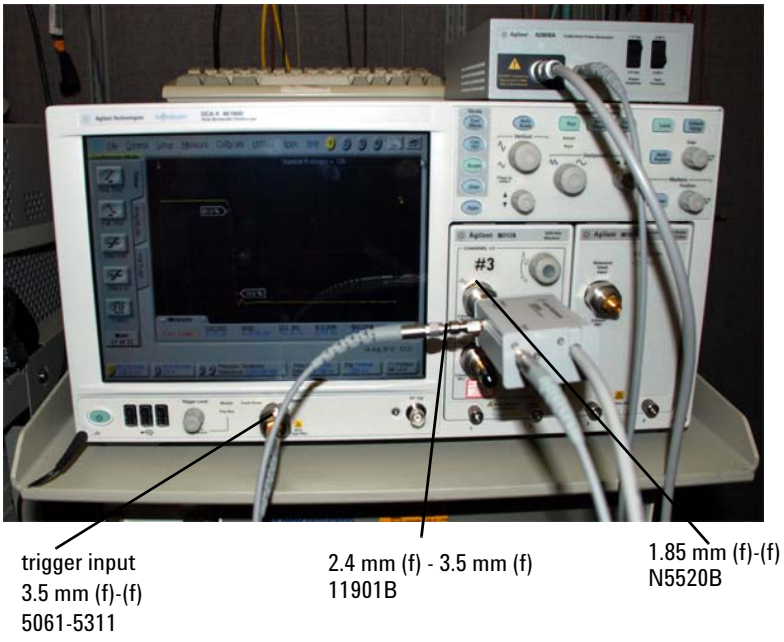
Equipment Required

Description	Recommended Model/Part Numbers
Sampling Scope Frame	Keysight 86100A/B/C/D
Sampling Scope Module	Keysight 86117A (50 GHz) or 86118A (70 GHz)
50 ohm cable	Keysight N2812A (in addition to supplied cable)
1.85 mm (f)-(f) connector	Keysight N5520B
3.5 mm (f)-(f) connector	Keysight 5061-5311
2.4 mm (f) - 3.5 mm (f) connector	Keysight 11901B
6 dB attenuator	Keysight 8490G

Measuring Rise and Fall Times at 0.5 V peak-to-peak

Connections

Connect the equipment as shown in the following illustration:



1. Turn on power to the sampling scope and to the N2806A and allow the instruments to warm up for 30 minutes.
2. Calibrate the Keysight 86117A module by selecting Calibrate > All Calibrations > Calibrate Left Module (if the module is in the left slot). Follow the prompts and allow the calibration to complete.
3. Use the N2812A 2.92 mm cable to connect Trig Out on the control module to Trig In on the remote head.
4. Connect the N2806A **OUTPUT** to the channel 1/3 input of the 86117A using the 1.85 mm connector.

5 Connect the 50 ohm cable to the N2806A $\overline{\text{OUTPUT}}$ using the 2.4 mm to 3.5 mm adapter, and to the front panel trigger input of the sampling scope using the 3.5 mm connector.

N2806A Setup

Set the switches on the control module to:

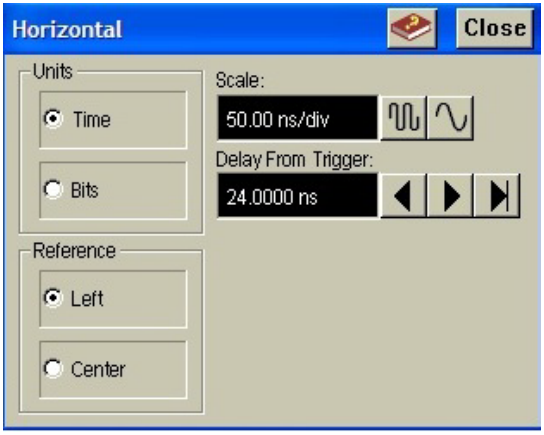
- Output Amplitude: 0.5 V peak-to-peak
- Input (Trigger) Threshold: 0.00 V

Scope Setup

1 Set the horizontal setting as follows:

   a Select **Setup > Horizontal**.

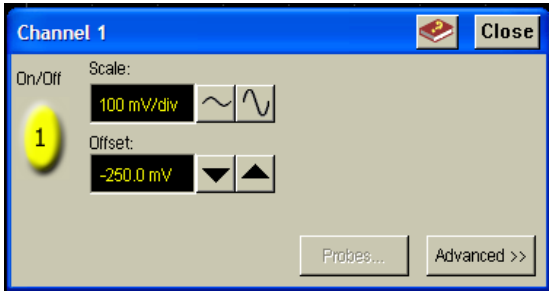
   b When the Horizontal window appears, set the scale to 50 ns/div, set the delay to 24 ns (minimum), and set the reference to the left.



2 Set the vertical setting as follows:

a Select **Setup > Channels > Channel 1**.

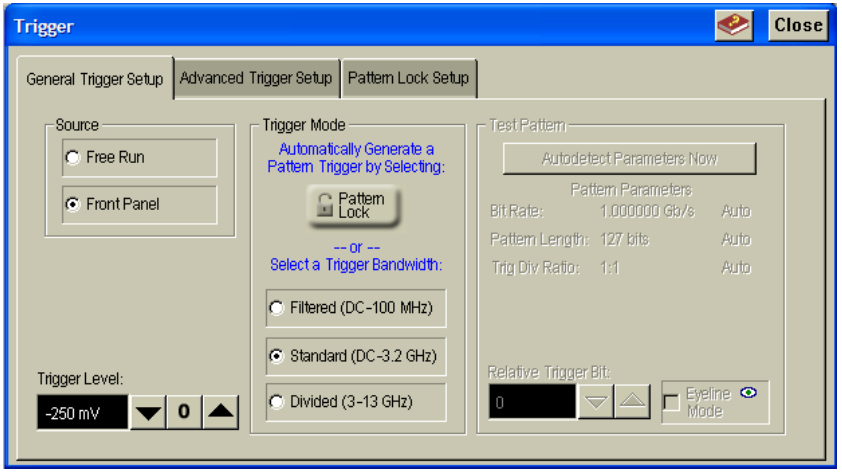
b When the Channel 1 window appears, set the scale to 100 mV/div and the offset to -250 mV.



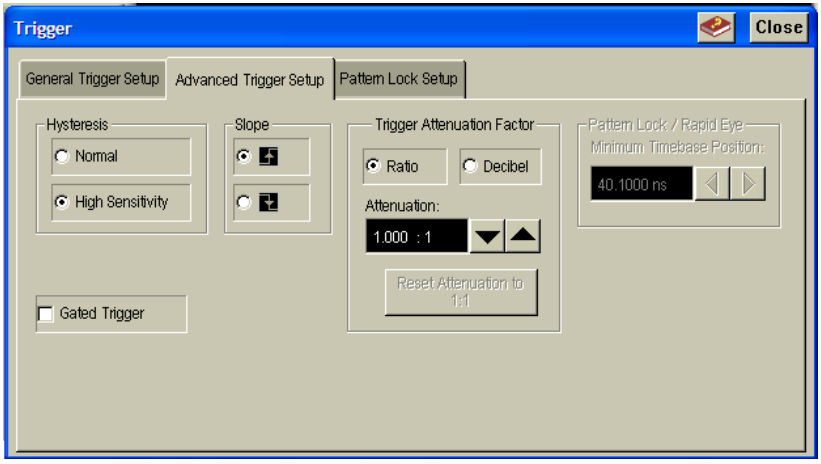
3 Set the Trigger settings as follows:

a Select **Setup > Trigger**.

b In the General Trigger Setup tab, set the source to be the front panel, and set the trigger level to -250 mV.



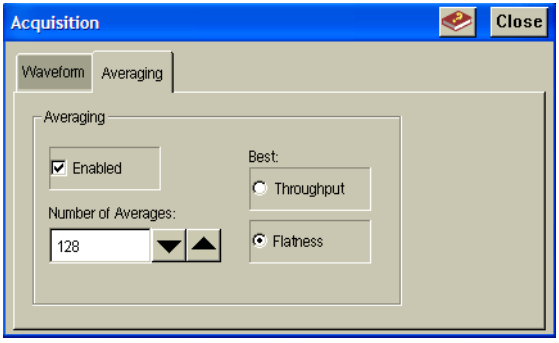
c In the Advanced Trigger Setup tab, set the hysteresis to high sensitivity, and set the slope to the rising edge.



4 Set the averaging as follows:

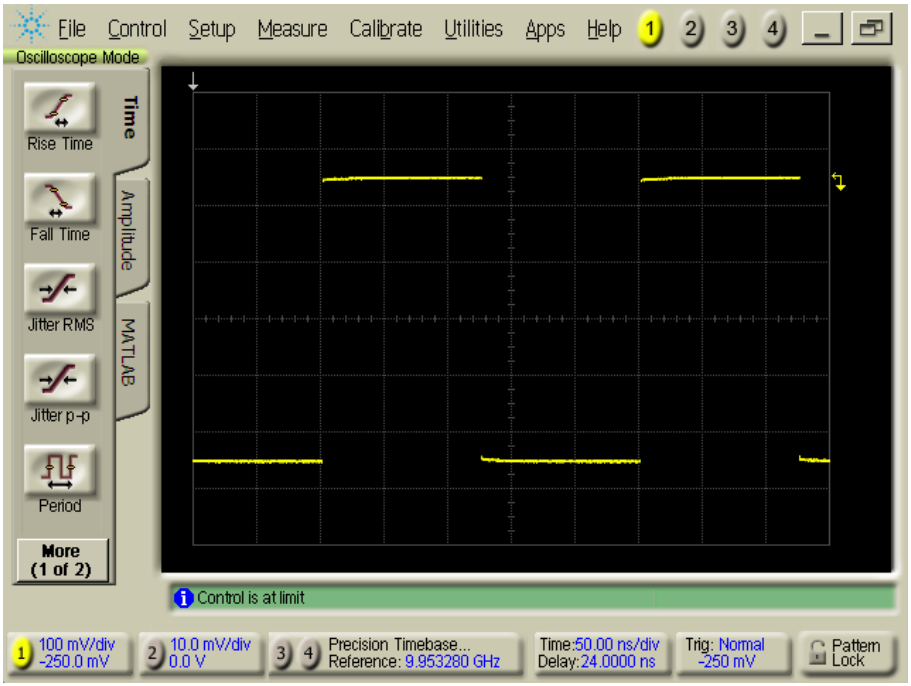
a Select **Setup > Averaging**.

b When the Acquisition window appears, go to the Averaging tab. Click the check box to enable averaging, then set the number of averages to 128 and set Best to flatness.



Rise Time Measurement Test without using the Attenuator

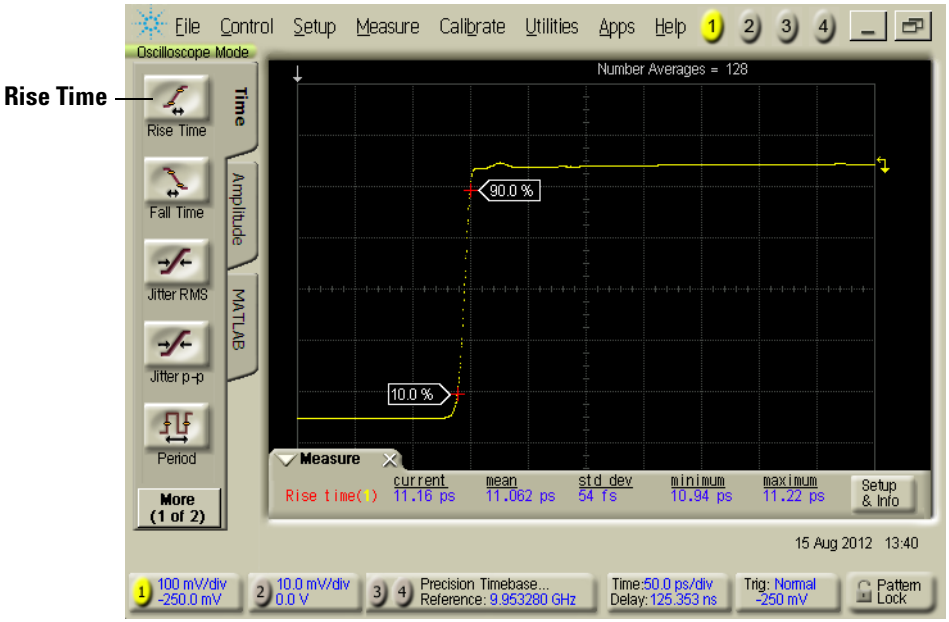
1 Adjust the waveform until the first visible rising edge is at the left-most edge of the screen.



2 Carefully adjust the horizontal scale to 50 ps/div, adjusting the horizontal position of the waveform to keep the rising edge on screen.

3 Move the rising edge to the third division to lengthen the top of the waveform and improve the rise time measurement.

4 Press **Rise Time** on the left side of the screen and press **[Clear Display]** on the scope.



5 When 128 averages have been made, copy the Mean rise time measurement to the Measured Value 0.5 V Rise Time cell of the Performance Test Record.

6 The contribution of the scope must be removed from the measurement. The formula for expressing the relationship is:

$$\text{Measured Tr} = \sqrt{(CorrectedTr)^2 + (N2806ATr)^2}$$

The Corrected Tr (Corrected Value Rise Time) is calculated by the equation:

$$CorrectedTr = ModuleTr - \left(\frac{(ModuleTr - MinTr)}{6}\right)$$

Where Module Tr is the module contribution:

$$ModuleTr = \frac{0.35}{\text{Max Module Bandwidth}}$$

For a 50 GHz module the equation would be:

$$ModuleTr = \frac{0.35}{50GHz} \cong 7ps$$

Calculate this value for your module, and place the result in the Module Value 0.5 V Rise Time cell of the Performance Test Record.

Min Tr is the connector technology contribution, representing the lower limit (fastest) of the module's transition time:

$$MinTr = \frac{0.35}{\text{Max Connector Bandwidth}}$$

For the 86117A module (2.4 mm connector), Max Connector Bandwidth is 56.5 GHz. For the 86118A module, Max Connector Bandwidth is 73.3 GHz. Therefore, for a 50 GHz module (86117A), the equation would be:

$$MinTr = \frac{0.35}{56.5GHz} \cong 6.1947ps$$

Calculate this value for your module, and place the result in the Connector Value 0.5 V Rise Time cell of the Performance Test Record. This same value will be used for all rows of the Connector Value column.

Finishing the Corrected Tr equation with the 86117A example:

$$CorrectedTr = 7ps - \left(\frac{(7ps - 6.1947ps)}{6}\right) = 6.8658ps$$

Calculate this value using your Module Tr and Min Tr values and place the result in the Corrected Measure 0.5 V Rise Time cell of the Performance Test Record.

Finally, calculate the N2806A Tr:

$$\text{N2806A} = \sqrt{MeasuredTr^2 - CorrectedTr^2}$$

For a 10.8 ps measured rise time using an 86117A:

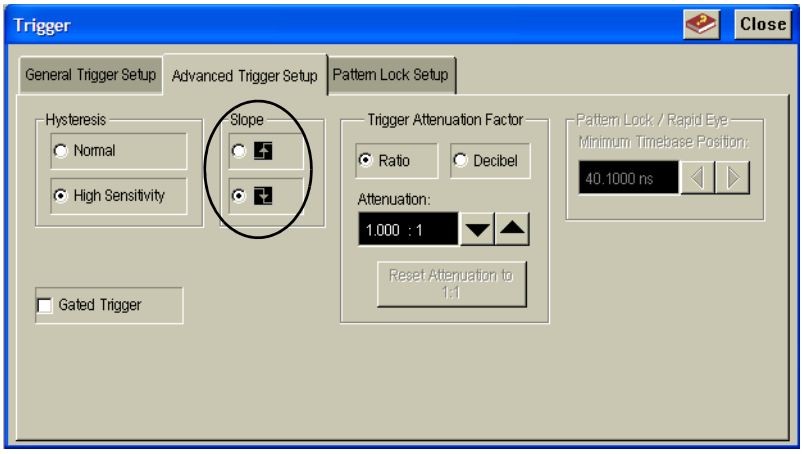
$$\text{N2806A Tr} = \sqrt{(10.8ps)^2 - (6.8658ps)^2} = 8.3474ps$$

Calculate this value using your Measured Tr and Corrected Tr values and place the result in the N2806A Measure 0.5 V Rise Time cell of the Performance Test Record. If this value is greater than 10 ps, the unit failed the rise time test.

If the unit passes, place the Measured Tr value in the Without Attenuator cell of the Attenuator Tr Record.

0.5 V Fall Time Measurement Test

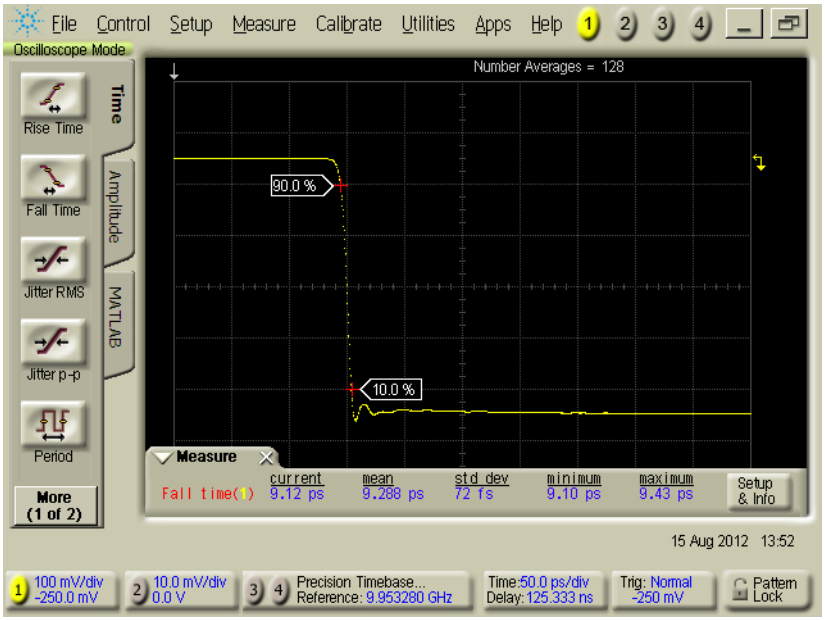
1 Repeat the steps described in the Scope Setup section, but change the Slope setting in the Advanced Trigger Setup tab from Rising Edge to Falling Edge.



2 Adjust the waveform until the first visible falling edge is at the left-most edge of the screen.

3 Carefully adjust the horizontal scale to 50 ps/div, adjusting the horizontal position of the waveform to keep the falling edge on the screen.

4 Press **Fall Time** on the left side of the screen and press **[Clear Display]** on the scope.



5 Repeat steps 5 and 6 from the 0.5 V Rise Time Measurement Test section, substituting fall time (Tf) for rise time (Tr).

6 If Corrected Measure Tf is greater than or equal to the limit shown in the performance test record, the unit failed the fall time test.

Measuring Rise and Fall Times at 1.0 V peak-to-peak

Now that you have results for measuring rise time at 0.5 V, follow the steps in this section to measure rise and fall times at 1.0 V. You will:

1 Measure the rise time at 0.5 V with the attenuator.

2 Calculate the attenuator rise time by using the 0.5 V rise times with and without the attenuator.

3 Measure the rise time at 1.0 V with the attenuator.

4 Calculate the rise time at 1.0 V by removing the scope and attenuator rise times.

Connections

Make the connections as described in "Measuring Rise and Fall Times at 0.5 V peak-to-peak", except add the 6 dB attenuator between the N2806A OUTPUT and channel 1/3 input of the 86117A.

N2806A Setup

Set the switches on the control module to:

- Output Amplitude: 0.5 V peak-to-peak
- Input (Trigger) Threshold: 0.00 V

Scope Setup

1. Set the horizontal and trigger settings as described in "Measuring Rise and Fall Times at 0.5 V peak-to-peak".
2. Set the vertical setting as follows:
   a. Select Setup > Channels > Channel 1.
   b. When the Channel 1 window appears, set the scale to 50 mV/div and the offset to -250 mV.

0.5 V Rise Time Measurement Test using the Attenuator

1. Take the rise time measurement as described earlier.
2. Enter the Measured Tr in the With Attenuator cell of the Attenuator Tr Record.

Calculate Attenuator Rise Time

1. Use sum-of-squares to calculate the contribution of the attenuator to the measured rise time:

$$AttenuatorTr = \sqrt{(WithAttenRT)^2 - (WithoutAttenRT)^2}$$

Example:

$$AttenuatorTr = \sqrt{(11.895ps)^2 - (10.894ps)^2}$$

$$AttenuatorTr = 4.78ps$$

2 Enter your Attenuator Tr value in the Attenuator Tr cell of the Attenuator Tr Record. This value will be used to calculate the corrected 1.0 V N2806A rise and fall times.

Connections -- 1.0 V using attenuator

Keep the connections as described on the previous page, keeping the 6 dB attenuator between the N2806A OUTPUT and channel 1/3 input of the 86117A.

N2806A Setup -- 1.0 V using attenuator

Set the switches on the control module to:

- Output Amplitude: 1.0 V peak-to-peak
- Input (Trigger) Threshold: 0.00 V

Scope Setup -- 1.0 V using attenuator

1 Set up the scope as described earlier.

2 Set the vertical settings as follows:

   a Select Setup > Channels > Channel 1.

   b When the Channel 1 window appears, set the scale to 100 mV/div and the offset to -250 mV.

1.0 V Rise Time Measurement Test using the Attenuator

1 Take the rise time measurement as described earlier.

2 Enter the measured rise time in the Measured Value cell of the 1.0 V Rise Time row of the Performance Test Record.

3 Remove the contributions of the scope and attenuator from the measurement. The formula for expressing this relationship is:

$$MeasuredTr = \sqrt{(CorrectedTr)^2 + (N2806ATr)^2 + (AttenuatorTr)^2}$$

Arranging this to solve for the N2806A rise time:

$$N2806ATr = \sqrt{(MeasuredTr)^2 - (CorrectedTr)^2 - (AttenuatorTr)^2}$$

4 Place the result in the 1.0 V Rise Time N2806A Measure cell of the Performance Test Record. If this value is greater than the limit, the unit has failed.

1.0 V Fall Time Measurement Test using the Attenuator

1. Repeat the steps for Scope Setup above, but change the Slope setting in Advanced Trigger Setup from Rising Edge to Falling Edge.
2. Repeat the steps for measuring a Falling Edge described earlier.
3. Place the Measure Tr value in the Measured Value cell of the 1.0 V Fall Time row of the Performance Test Record.
4. Use the previously calculated values and the sum-of-squares equation to determine the N2806A Fall Time for 1.0 V and enter it in the N2806A Measure column of the 1.0 V Fall Time row.
5. If the value is greater than the Limit, the unit has failed.

Attenuator Tr Record

	With Attenuator	Without Attenuator	Attenuator Tr
Rise Time			

Performance Test Record

	Measured Value	Module Value	Connector Value	Corrected Measure	N2806A Measure	Limit
0.5 V Rise Time						10 ps
0.5 V Fall Time						8 ps
1.0 V Rise Time						11 ps
1.0 V Fall Time						9 ps

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