Probing High-speed Signals with the Agilent 86100 Series of Wide-bandwidth Sampling Oscilloscopes

Product Note 86100-6

The high bandwidth and low noise of equivalent-time sampling oscilloscopes provide precise displays of high-speed signals. Historically, if the signal could not be routed to the oscilloscope through a high-quality cable, thus requiring the use of a probe, accurate measurements became difficult to achieve. Three important measurement accessories help make probe based measurements both simple and accurate for the Agilent 86100 Wide Bandwidth Oscilloscope:

- Agilent 113X, 115X, and 116X series of high performance probes with up to 13 GHz of bandwidth
- Agilent N1022B probe adapter
- Agilent 83496A/B clock recovery module

Agilent Technologies

Probes

Agilent offers a wide variety of probes with the bandwidth and connectivity required for high-speed waveform analysis. These include differential and single-ended probes with solder in, socketed, SMA, and browsing probe heads offering variable spacing probe tips for today's high-density IC's and circuit boards. Typical bandwidths are available from 1.5 to 13 GHz (9/05). All probes have a flat frequency response over the entire probe bandwidth to eliminate distortion and frequency-dependent loading effects.

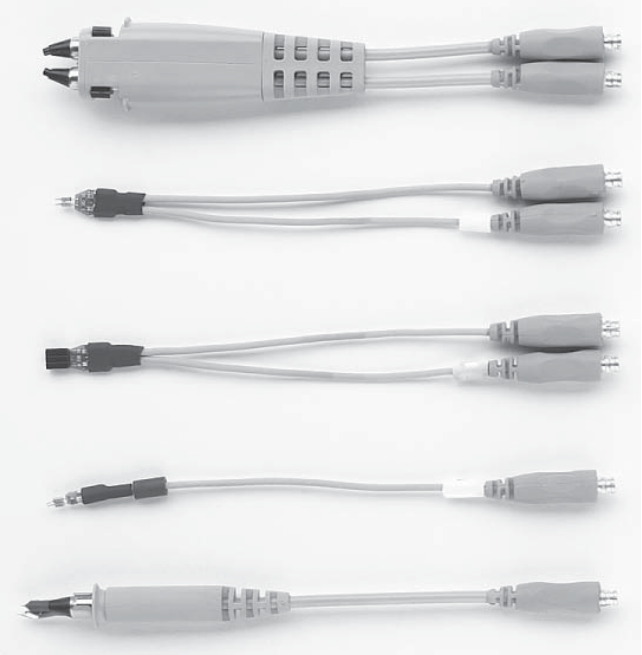


Figure 1: infiniimax probes

Connecting the probe to the oscilloscope

The precision 3.5 mm connector used for the electrical channels of several 86100 plug-in modules is not directly compatible with the standard probe interface of Agilent real-time sampling oscilloscopes. This problem is solved with the N1022B Probe Adapter. The N1022B Probe Adapter provides power, calibration, and a high-integrity signal path between the probe and the 861XX series plug-in module. The interface of the probe amplifier section attaches to one side of the adapter. The other side of the probe adapter is an instrumentation grade 3.5 mm connector that attaches to the bulkhead male 3.5 mm connector of the electrical channel of the oscilloscope plug-in module. For power and identification, an interface cable from the probe adapter attaches to the probe power port of the oscilloscope plug-in.

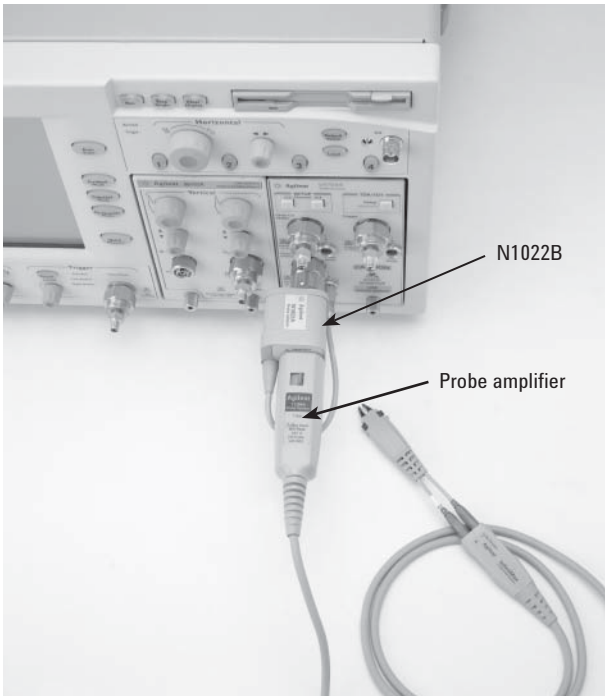


Figure 2: Connecting a probe through the N1022B adapter

The N1022B is directly compatible with the following modules:

86101A	86102A and U
86103A and B	86105A
86106A	86112A
83481A	83483A
83485A	83486A
83487A	54751A
54753A	54754A

The following plug-in modules have 2.4 mm compatible connectors. The 85130-60010 2.4 mm (f) to 3.5 mm bulkhead adapter is required in addition to the N1022B:

86106A	86106B
86109A	86109B
86116A	86116B
86117A	86118A
83484A	

(For non-oscilloscope applications, a type 'N' (m) to 3.5 mm bulkhead adapter (N1022-60014) is available. There is also a 3.5 mm (f) to 3.5 mm bulkhead adapter (85052-60034)).

The following plug-in modules do not have built-in probe power supplies. The Agilent 1143 power supply is used to provide probe power through the N1022B. (In this configuration an automatic gain and offset calibration is not available. A manual gain calibration can be performed to account for probe attenuation and signal splitting). The 01143-61602 probe power extension cable may be useful to allow the 1143 power supply to be located over 1 meter away from the oscilloscope or other instrument.

86105B
86105C
86116B
86117A
86118A

The 86100 oscilloscope mainframe has built-in calibration routines (except as noted above) to compensate for probe attenuation and offset to allow a direct display of the actual signal levels found at the probe tip. Very high frequency and small pitch probes such as the N5381A 12 GHz solder-in probe head are difficult to connect to the 86100 BNC calibration connector. The E2655B Deskew and Performance Verification fixture is recommended.

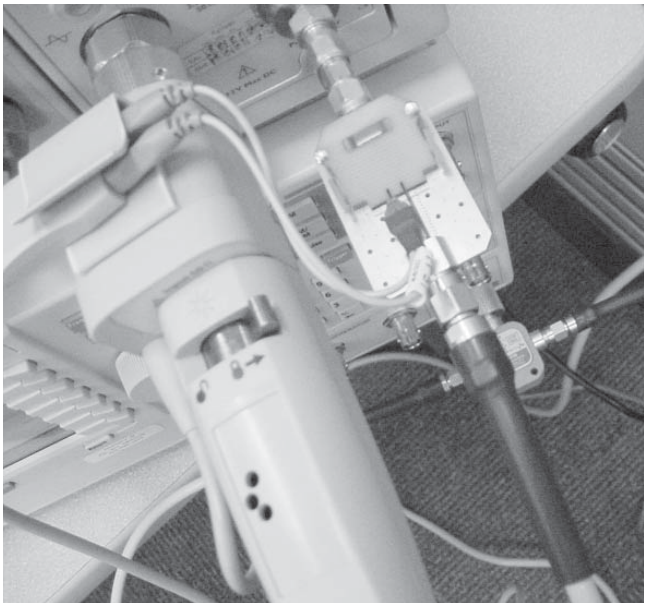


Figure 3: The E2655B Deskew and Performance Verification fixture allows for easy probe calibration with the 86100 DCA

Triggering the oscilloscope with a clock extracted from the probed signal

Sampling oscilloscopes are different from real-time oscilloscopes in that they require a triggering signal other than the test signal itself. The triggering signal is often a clock that is synchronous to the signal under test. In a probing scenario, a separate system clock for triggering may not be present. When the necessary synchronous 'trigger' is not available, one solution is to derive a clock from the data being measured. This process is performed with the 83496A/B clock recovery module.

The N1022B and appropriate probe are connected to the 83496A/B input port where the signal is evenly split within the module (see Figure 4). Half is used for clock extraction; the other half is routed to the 83496A/B front panel and then connected to the input channel of the adjacent plug-in module. The 83496A/B will derive a clock from the data. The recovered clock signal rate is divided by eight and routed internally in the 86100 mainframe. The full rate clock or user selected rate divided clock is available at the 83496A/B front panel and can be useful as a trigger for eye diagram analysis when data pattern lengths are multiples of two. (A divided trigger with an even divisor yields an incomplete eye, see Product Note 86100-5). Above 7.1 Gb/s, the front panel recovered clock has a minimum divide ratio of two. The 83496A/B option 100 requires at least 150 mVpp at its input port to accurately perform clock extraction. If a 10:1 probe is used (such as the 1134A), the signal level at the probe tip must be greater than 1.5 Vpp. If a 3.45:1 probe is used (such as the 1169A), the signal level at the probe tip must be greater than 500 mVpp. Note however, that a proper probe calibration will compensate for both the probe attenuation and signal splitting within the 83496A/B and provide an accurate display of signal levels on the oscilloscope screen. (83496A/B option 101, without internal splitters, requires half the input signal of 83496A/B option 100 for clock extraction. Any signal splitting outside the module must be considered when determining system limits.)

The 83496A/B clock recovery module can derive a clock from NRZ signals with rates as low as 50 MB/s, as high as 13.5 Gb/s, and any rate between, providing the ultimate in flexibility and value. (As of 12/06 the data rate must be entered into the 83496A/B to allow it to properly synchronize to the signal being probed). As low as 300 femtoseconds rms, the residual jitter of the output clock is virtually negligible, allowing accurate measurements of very low levels of signal jitter. The 83496A/B can be configured with a tunable loop bandwidth. This critical feature allows the module to be operated as a "golden PLL" with the optimal loop bandwidth for whatever standard/data rate is being tested. Loop bandwidth will control what spectrum of jitter is observed and what is tracked out from eye-mask and jitter tests. For example, low frequency jitter can be removed, which is usually of low importance since system receivers easily tolerate it. Testing with an optimal loop bandwidth assures that good parts do not appear to be bad, and bad parts do not appear to be good. For more information on the use of clock recovery loop bandwidth, refer to product note 86100-5 "Triggering Wide-bandwidth Sampling Oscilloscopes for Accurate Displays of High-speed Digital Communications Waveforms".

The following configurations for the 83496A/B are available:

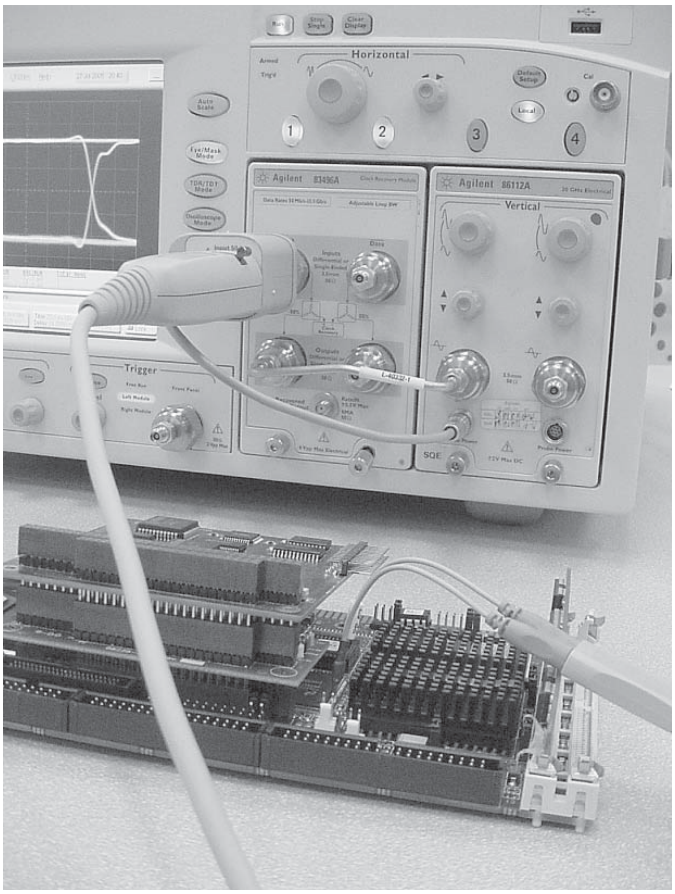
Option 100: Electrical differential or single-ended clock recovery 50 Mb/s to 7.1 Gb/s. The input signal is internally split and ~50% routed back out to the measurement channel of the adjacent plug-in module. When measuring differential signals, the most convenient technique is to use a differential probe tip, rather than provide two input signals to the 83496A/B. The probe provides a single-ended signal to the 83496/861XX channel representative of the difference between the signals at the two probe tips. The 83496A/B Option 101 electrical/optical clock recovery module is not recommended for probing as it does not have an internal signal divider. It can be used, but requires an external power divider that precludes the installation of the N1022B on the front of the clock recovery module. A complicated adapter scheme is required. See below.

Special Option 101-H05: This special option version of the electrical/optical clock recovery module integrates the signal splitting within the module. Use for electrical signals is similar to Option 100. No special adapters other than the N1022B are required.

Option 200: Increase operating range to 50 Mb/s to 13.5 Gb/s. Available for either Option 100 or Option 101 configurations. When measuring clocks, rates from 25 MHz to 7.75 GHz are allowed.

Option 300: Add golden PLL (tunable loop bandwidth capability). Loop bandwidth is tunable from 30 KHz to over 10 MHz. (Without Option 300, the loop bandwidth can be configured at two discrete settings, dependent upon data rate).

Option 200 and 300 can also be added at a later date. The module must be returned to an Agilent service center for the upgrade.



Probe calibration procedures

The 86100 DCA has a built-in calibration process to compensate for probe attenuation and offsets. The probe calibration is achieved by attaching the probe tip to a known DC signal that is available from the oscilloscope mainframe. The process is Calibration/All calibrations/CH 'X' Probe compensation (for the channel the 83496A/B output is routed to).

For probe compensation with plug-in modules that do not include a probe supply outlet (86105B, 86105C, 86117A, 86118A) the calibration procedure is similar. However, if there is a voltage offset, it must be compensated for manually (Setup/Channels/ Channel X/Advanced with the attenuation factor adjusted to account for signal loss in splitting and/or probe voltage division).

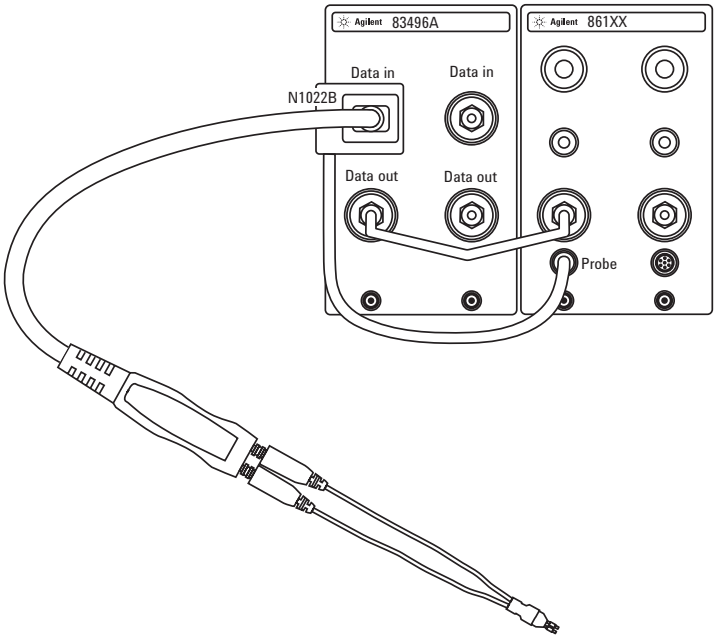


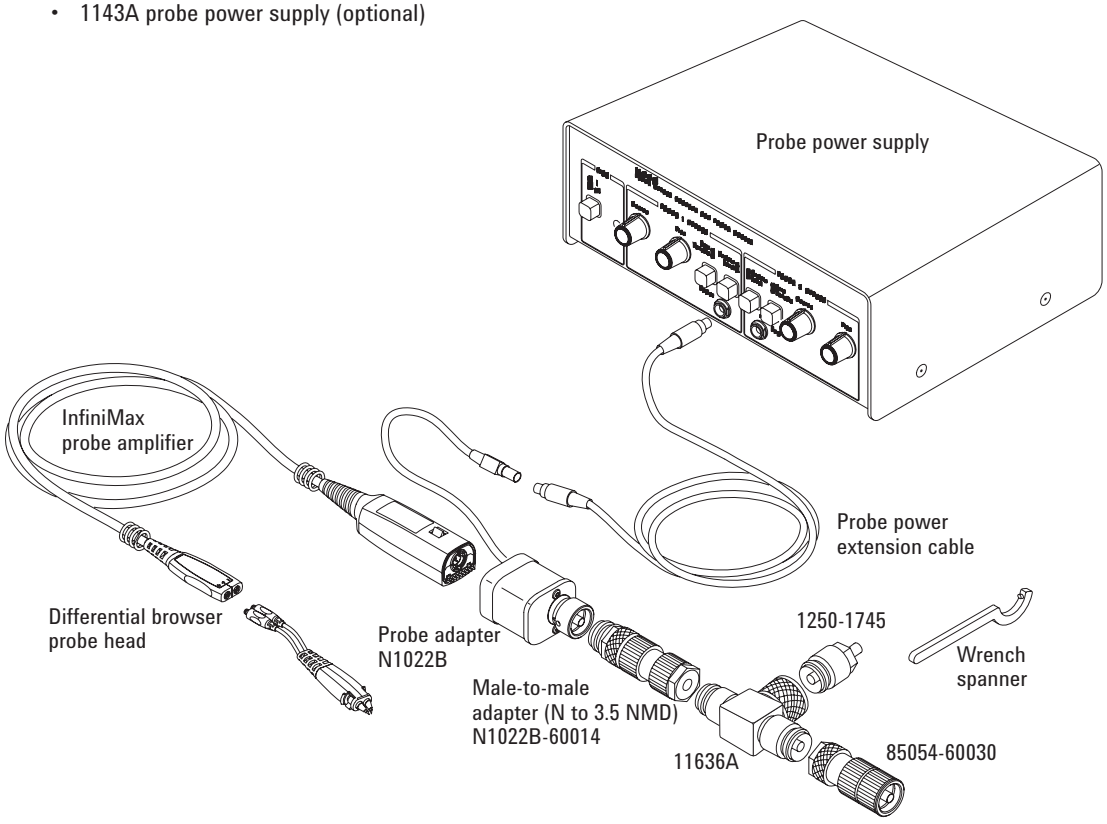
Figure 4: Connector scheme using the 83496A/B and N1022B

Probing configuration when using the optical/electrical configuration of the 83496A/B (Option 101)

The primary usage of the 83496A/B Option 101 is for extracting clocks from optical signals. However, electrical inputs are provided to derive a clock from an electrical signal. Unlike 83496A/B Option 100 or special Option 101-H05, there are no internal dividers to tap the electrical signal and pass it to a measurement channel. If an electrical signal is to provide a trigger and be simultaneously observed, it must be divided before entering the 83496A/B.

In a probing scenario, the chain of adapters required to connect a probe and probe adapter becomes complex as shown in the following sketch. Parts needed are:

- N1022B, probe adapter
- N1022-60014, adapter Type-N male to 3.5 NMD male
- 11636A, DC-18 GHz power divider, Type-N, 50 ohm
- 85054-60030, adapter: 3.5 mm female, Type-N male
- 1250-1745, adapter: 3.5 mm female, Type-N female
- 01143-61603, probe power extension cable
- 1143A probe power supply (optional)



Adapting and splitting signals for probing and clock extraction with the 83496A/B option 101

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