

PicoConnect[®] 900 Series

Gigabit, RF, microwave and pulse passive test probes



Low cost

From only \$699

Gigabit probe heads

For Ethernet, USB 3, HDMI, SATA, PCI, LVDS
Up to 9 GHz bandwidth (18 Gb/s serial data rate)
Down to 40 ps transition time

RF, microwave and pulse probe heads

Up to 5 GHz bandwidth
Down to 70 ps transition time

Low input capacitance

0.3 pF typical, 0.4 pF maximum

Standard instrumentation interface

Fits all SMA, K and PC3.5 50 Ω input ports

Convenient

Available individually or as sets of six
Supplied with precision low-loss cable and solder-in kit
12 models for different applications

The shape of probes to come

The PicoConnect 900 Series low-invasive, high-frequency passive probes are designed for microwave and gigabit applications up to 9 GHz and 18 Gb/s. They deliver unprecedented performance and flexibility at a low price.

The probes employ a unique (patent pending) in-PCB construction to realize extremely low capacitance, coplanar microwave integrity, robust reliability and very low cost. The result is a family of miniature interchangeable passive probe heads that cover a range of division ratios, bandwidths and coupling types.

Gigabit digital probes

- High-speed logic voltage applications
- Up to 9 GHz
- Up to 18 Gb/s
- Less than 40 ps transition time
- Suited to Ethernet, USB3, HDMI, SATA, PCI, LVD and other high-speed cabled, chip-to-chip and backplane interfaces

RF and microwave probes

- High crest-factor pulse capability
- Up to 5 GHz
- Less than 70 ps transition time



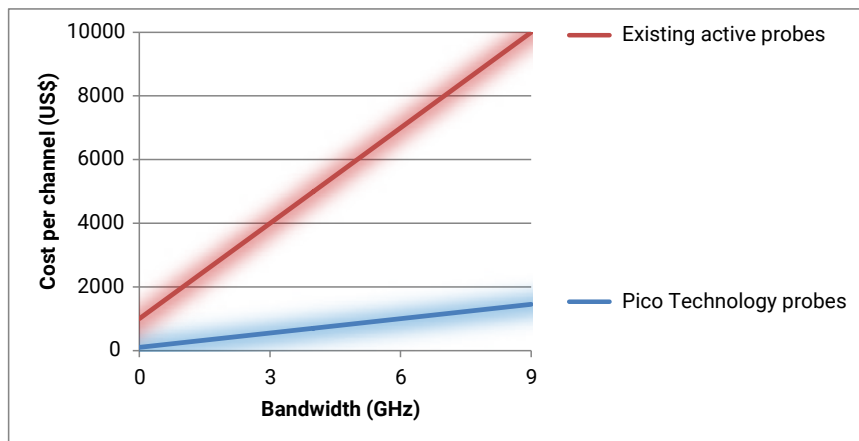
Features of the 900 Series probes

- Interchangeable probe heads at division ratios of 5:1, 10:1 and 20:1, AC or DC-coupled
- Extremely low loading capacitance of < 0.3 pF typ., 0.4 pF upper test limit
- Accurate probing of high speed transmission lines for $Z_0 = 0 \Omega$ to 100Ω
- Stated probe ratio compensated to correct for loading of low-impedance probe input
- Class-leading uncorrected pulse/eye response and pulse/eye disturbance.
- Slim, fingertip design for accurate and steady probing or solder-in at fine scale.
- Passive design gives high dynamic range, low noise, linearity and long-term flatness
- Tolerant of very high input slew rate, hardened to EM discharge and no saturation and recovery characteristic. Can address high-amplitude pulse and burst applications
- Screened to minimize noise or response change from finger proximity and EMI
- Supplied with robust, high-performance, highly flexible low-loss microwave coaxial cable.

Price breakthrough

At 1 GHz and above and supplied by just a few manufacturers, the majority of available test probes have been of familiar oscilloscope probe shape but with an active buffer amplifier within the probe body. They are mechanically complex, quite bulky, often heavy and always costly. In a survey of all available active probe models between 3 GHz and 30 GHz, we found that list prices lay on or above the \$1000 + \$1000/GHz line. Of course you need to multiply this by the number of signal channels to be probed.

The 900 Series passive probes all lie close to the \$100 + \$150/GHz line, less when purchased as a kit. Compared to the competition, that is less than one sixth of the cost per channel!



The most flexible high-frequency probes

Interchangeable division ratio

Because of the ever-present limitations upon slew rate, high-speed digital signals have moved to lower and lower amplitudes, with some operating at only 100 mV swing. Inevitably, to raise probing impedance when using a low-cost probe, we have to divide this voltage to an even lower amplitude. The PicoConnect 900 Series interchangeable probe heads optimize this process by providing three division ratios to bring you the right probe ratio for each application. The 5:1 ratio is a particularly attractive and slightly faster option when probing low-swing logic.

AC or DC coupled probe head

Pico also brings the flexibility of AC or DC coupling, again through selection of interchangeable probe heads. Low-impedance probes load the probed signal, slightly reducing the amplitude, and if the signal has a DC bias they will source or sink current to or from the signal source, potentially changing the device operating bias. The AC-coupled probe avoids the DC bias problem. Low-frequency 3 dB cut-off is less than 160 kHz and droop of pulse top or base is < 0.1%/ns on all AC-coupled models. Applications for AC-coupled probing include DC-biased data streams such as HDMI, USB, SATA, ECL and PECL; and the probing of small signals on supply and control lines, as when looking for current noise or decoupling problems.

Load-compensated divide ratio for multiple typical line impedances

The PicoConnect 900 Series low-impedance probes are suited only to the probing of relatively low-impedance test nodes, typically in the range 0 Ω to 100 Ω. Many applications involve probing terminated transmission lines, generally 50 Ω, 45 Ω or 75 Ω single-ended. It is also common to use two probes on 100 Ω or 90 Ω differential lines (50 Ω or 45 Ω single-ended). On the assumption of a test node impedance in this range, the 900 Series probes are ratio-compensated and give a maximum ratio error as follows:

| Transmission line impedance | Error with probes of ≤ 250 Ω | Error with probes of > 250 Ω |
|---|------------------------------|------------------------------|
| 0 Ω node | +11% (+0.9 dB) | +6% (+0.5 dB) |
| 45 Ω -20% line, 90 Ω differential (22.5 Ω node) | +3.5% (+0.3 dB) | +2.4% (+0.2 dB) |
| 50 Ω +20% line, 100 Ω differential (25 Ω node) | -3.5% (-0.3 dB) | -2.4% (-0.2 dB) |
| 75 Ω line (37.5 Ω node) | -6% (-0.54 dB) | -3% (< -0.26 dB) |
| 100 Ω line (50 Ω node) | -11% (-1.0 dB) | -6% (-0.5 dB) |

High-energy pulse and burst applications

Passive probes, neglecting relatively small self-heating contributions, are inherently linear and suffer from permanent damage or ratio shift only under overload conditions. The PicoConnect 910 family of RF, microwave and pulse probe heads uses MELF resistor technology and can be used for high-amplitude narrow pulse or burst applications such as high-energy physics, radar or RF imaging. The 910 family can withstand amplitudes in excess of the probe voltage rating under the following conditions:

- Peak pulse or burst voltage within ±150 V peak [notes 1,3]
- Peak pulse or burst width less than 500 ns [note 2]
- Pulse or burst power not greater than (probe voltage rating)²/probe input resistance

Notes

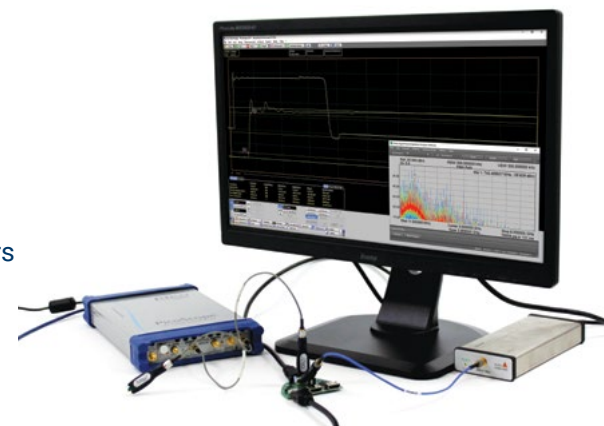
1. The 900 Series probes do not offer a user-protective barrier against touching of the test node. This application is only for suitably qualified personnel with full awareness of high-energy pulse and RF handling and precautions. Pico Technology recommends only solder-in usage of the probe in these applications.
2. To ensure that touch current lies within acceptable limits of EN 61010-031:2015 for voltages greater than 42.4 V peak, pulse or burst width must not exceed 500 ns and pulse mark:space must be below 2%.
3. Standard SMA 50 Ω attenuators can be used to further reduce probe output signal amplitude if required.

Probes for use with a wide range of instrumentation

The PicoConnect 900 Series passive probes are suitable for use with any measurement instrument with 50 Ω input impedance, including:

- Oscilloscopes
- Sampling oscilloscopes
- Receivers
- Spectrum and modulation analyzers
- Power meters
- Millivoltmeters
- Network analyzers

Standard connectorized SMA, PC3.5 and K accessories such as attenuators, signal dividers, multiplexers, filters and cables of varying length and performance can also be placed in series with the probe output to further condition or route the signal.



Probing was a compromise ... until now

There is a rapidly proliferating need to probe, measure and view very high speed and broadband signals. Gigahertz signal frequencies were once the domain of radio and microwave engineering and were typically localized and narrowband within any given system. Today, a multiplicity of broadband signals are routinely found within digital and computing systems, personal communication, media and gaming devices, and position, sensing and control systems. Engineers now demand that these measurements, once the domain of relatively few highly skilled microwave engineers using high-cost instrumentation, be simpler and much cheaper to perform.

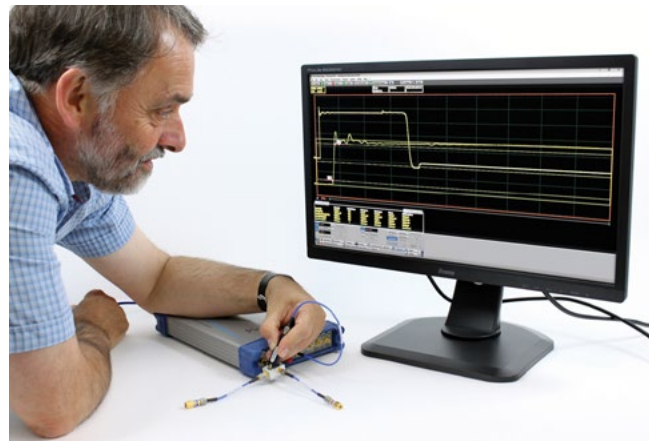
The problem with invasive measurements

High-frequency and broadband signals typically propagate in transmission lines, whose transmitted efficiency and signal integrity rely on consistent characteristic impedance along their length. In turn, characteristic impedance is determined by conductor and insulator materials and their geometries relative to each other and adjacent grounds. These too must remain consistent if signal losses and reflections are to be minimized.

The challenge is to make contact with and measure these high-frequency or broadband signals without significant disturbance of the signal or, by inference, the transmission lines that carry them. This would be a non-invasive or, more realistically, a low-invasive measurement.

Until now, microwave probing solutions have tended to be bulky, too invasive, too expensive, with poor measurement repeatability and in some cases mechanically or electrically fragile. As a result, transmission lines under test have often been physically interrupted and either rerouted to, or power-divided to, a terminating measurement instrument. While this method produces very accurate measurements, it can also be inconvenient or impractical in cases such as these:

- Signal interruption, delay or attenuation may disturb the system function while under test.



- The interruption and subsequent repair of fine pitch or buried PCB tracking.
- Multiple system signal paths may need to be interrupted and fitted with matching pick-off networks and propagation delays, even if only one needs to be measured.

The 900 Series passive probes are a cost-effective and long overdue solution in all of these cases.

The principle behind the PicoConnect 900 Series passive probes

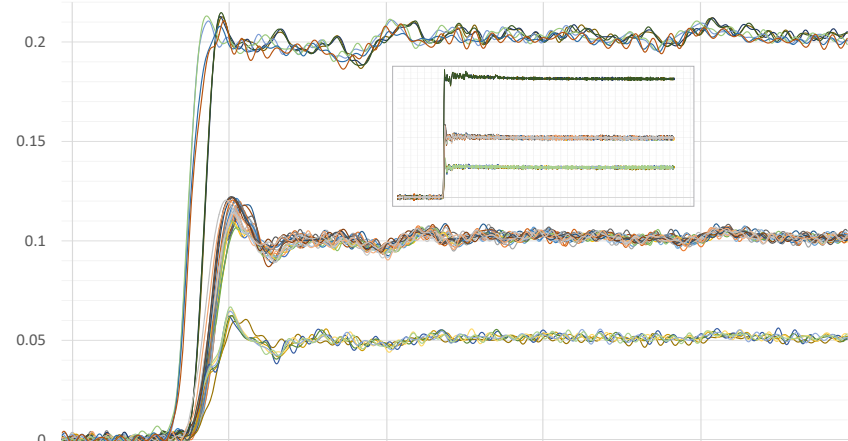
Low-invasive contact probing of a microwave transmission line is challenging because any addition of conductor material (let alone circuitry) will add capacitance and disturb the line geometry and line impedance at the point of contact. However, if the additional loading of the probe is firstly minimized and then made consistent at all frequencies of interest, the overall impact of probing will be a small reduction of signal amplitude at the probe tip. Critically, this is not a change of wave or pulse shape or its relative spectral content and phases. A subsequent adjustment of probe or instrument gain, or scaling of a measurement result, can then compensate for the small amplitude reduction at the point of measurement. The result is excellent pulse fidelity and consistency as shown in the graphs below.

The 900 Series low-impedance, single-ended passive probes are suited to applications up to 9 GHz and transition times down to around 40 ps. Probe tip impedance lies between 1 k Ω and 200 Ω and all have a very low parallel input capacitance of typically 0.3 pF (0.4 pF max.)

Designed for reliability

Low-cost, highly repeatable, very robust and high-integrity coplanar microwave design and screening are all simultaneously achieved through within-substrate assembly of components and edge-of-substrate assembly of test pins and connectors (patent applied for).

Note: PicoConnect 900 Series probes are not designed to be used as launcher probes. These probes are intended as low-invasive measurement devices for browsing of already terminated transmission lines. This purpose is distinct from launcher probes, which are intended to terminate an unterminated transmission line in a measurement or signal injection.



PicoConnect passive probe family pulse shapes – first 2 ns (inset 17 ns)
(Corrected TDT using PicoScope 9311 20 GHz TDT/TDR sampling oscilloscope relative to reference through-path)

Specifications – RF, microwave and pulse probes

| Model | 911 | 912 | 913 | 914 | 915 | 916 |
|--|---|-------------|--------------------|-------------|---------------------|-------------|
| Nominal division ratio | 20:1 | | 10:1 | | 5:1 | |
| Bandwidth (-3 dB) ^[Note 8] | > 4 GHz | | > 4 GHz | | > 5 GHz | |
| Max. usable data rate (fundamental) | 8 Gb/s | | 8 Gb/s | | 10 Gb/s | |
| Max. usable data rate (3rd harmonic) | 2.6 Gb/s | | 2.6 Gb/s | | 3.3 Gb/s | |
| Max. usable data rate (5th harmonic) | 1.6 Gb/s | | 1.6 Gb/s | | 2 Gb/s | |
| Transition time | < 87.5 ps | | < 87.5 ps | | < 70 ps | |
| Probe tip impedance (nominal) | 960 Ω | | 440 Ω | | 230 Ω | |
| Probe tip capacitance (typical) | 0.3 pF | | 0.3 pF | | 0.3 pF | |
| Probe tip capacitance (maximum) | 0.4 pF | | 0.4 pF | | 0.4 pF | |
| Return loss for probed line | < -10 dB typ. | | < -12 dB typ. | | < -14 dB typ. | |
| | All probes < -18 dB typ. for frequency < 1.0 GHz. | | | | | |
| Accuracy for line $Z_0 = 40 \Omega$ to 60Ω ^[Note 1] | < ±0.13 dB (±1.6%) | | < ±0.18 dB (±2.1%) | | < ±0.30 dB (±3.4%) | |
| Accuracy for line $Z_0 = 0 \Omega$ to 100Ω ^[Note 2] | < ±0.25 dB (±2.9%) | | < ±0.50 dB (±6.0%) | | < ±0.93 dB (±10.2%) | |
| Nominal error for line $Z_0 = 75 \Omega$ ^[Note 4] | < -0.17 dB (-1.9%) | | < -0.26 dB (-2.9%) | | < -0.54 dB (-6.0%) | |
| Continuous voltage | 14 V AC RMS | 14 V RMS | 10 V AC RMS | 10 V RMS | 8 V AC RMS | 8 V RMS |
| DC blocking voltage (max.) ^[Note 3] | 50 V DC | – | 50 V DC | – | 50 V DC | – |
| Peak voltage ^{[Note 5],[Note 6]} | < 150 V | | | | | |
| Pulse width at peak voltage | < 500 ns | | | | | |
| Mark:space at peak voltage | < 1:120 (0.8%) | | < 1:230 (0.4%) | | < 1:360 (0.3%) | |
| Coupling ^[Note 3] | AC | DC | AC | DC | AC | DC |
| Low-frequency cut-off (-3 dB) | 40 kHz | – | 80 kHz | – | 150 kHz | – |
| Pulse /eye droop | > 50 ns/% | – | > 20 ns/% | – | > 10 ns/% | – |
| Flatness (±0.5 dB) | 120 kHz to 2 GHz | DC to 2 GHz | 240 kHz to 2 GHz | DC to 2 GHz | 450 kHz to 2 GHz | DC to 2 GHz |
| Output impedance ^[Note 7] (for test node impedance 50 Ω) | 717 Ω | | 245 Ω | | 203 Ω | |
| Additive voltage noise @ 23 °C | 3.4 nV/√Hz | | 2.0 nV/√Hz | | 1.7 nV/√Hz | |

Specifications – gigabit digital probes

| Model | 921 | 922 | 923 | 924 | 925 | 926 |
|--|---|-------------|---------------------|-------------|---------------------|-------------|
| Nominal division ratio | 20:1 | | 10:1 | | 5:1 | |
| Bandwidth (-3 dB) ^[Note 8] | > 6 GHz | | > 7 GHz | | > 9 GHz | |
| Max. usable data rate (fundamental) | 12 Gb/s | | 14 Gb/s | | 18 Gb/s | |
| Max. usable data rate (3rd harmonic) | 4 Gb/s | | 4.6 Gb/s | | 6 Gb/s | |
| Max. usable data rate (5th harmonic) | 2.4 Gb/s | | 2.8 Gb/s | | 3.6 Gb/s | |
| Transition time | < 58.3 ps | | < 50 ps | | < 38.8 ps | |
| Probe tip impedance (nominal) | 515 Ω | | 250 Ω | | 220 Ω | |
| Probe tip capacitance (typical) | 0.3 pF | | 0.3 pF | | 0.3 pF | |
| Probe tip capacitance (maximum) | 0.4 pF | | 0.4 pF | | 0.4 pF | |
| Return loss for probed line | < -13 dB typ. | | < -15 dB typ. | | < -15 dB typ. | |
| | All probes < -18 dB typ. for frequency < 1.0 GHz. | | | | | |
| Accuracy for line $Z_0 = 36 \Omega$ to 60Ω ^[Note 1] | < ±0.20 dB (±2.4%) | | < ±0.27 dB (±3.1%) | | < ±0.25 dB (±2.9%) | |
| Accuracy for line $Z_0 = 0 \Omega$ to 100Ω ^[Note 2] | < ±0.48 dB (±5.6%) | | < ±0.86 dB (±10.4%) | | < ±0.90 dB (±10.9%) | |
| Nominal error for line $Z_0 = 75 \Omega$ ^[Note 4] | < -0.19 dB (-2.2%) | | < -0.40 dB (-4.5%) | | < -0.48 dB (-5.3%) | |
| Continuous voltage | 7 V AC RMS | 7 V RMS | 5 V AC RMS | 5 V RMS | 5 V AC RMS | 5 V RMS |
| DC blocking voltage (max.) ^[Note 3] | 50 V DC | – | 50 V DC | – | 50 V DC | – |
| Peak voltage ^[Note 6] | < 25 V | | | | | |
| Mark:space at peak voltage | < 1:20 (5%) | | < 1:30 (3.3%) | | < 1:30 (3.3%) | |
| Coupling ^[Note 3] | AC | DC | AC | DC | AC | DC |
| Low-frequency cut-off (-3 dB) | 70 kHz | – | 140 kHz | – | 160 kHz | – |
| Pulse /eye droop | > 20 ns/% | – | > 10 ns/% | – | > 10 ns/% | – |
| Flatness (±0.5 dB) | 210 kHz to 2 GHz | DC to 2 GHz | 420 kHz to 2 GHz | DC to 2 GHz | 480 kHz to 2 GHz | DC to 2 GHz |
| Output impedance ^[Note 7] (for test node impedance 50 Ω) | 54 Ω matched | | 48 Ω matched | | 187 Ω unmatched | |
| Additive voltage noise @ 23 °C | 0.9 nV/√Hz | | 0.9 nV/√Hz | | 1.6 nV/√Hz | |

Specifications – all models

| Environment | |
|---|--|
| Operating temperature range | 0 to 50°C |
| Storage temperature range | -20 to +70°C |
| Temperature range for stated specifications | 15 to 30°C |
| Operating humidity range | 5% to 80% RH non-condensing |
| Storage humidity range | 5% to 95% RH non-condensing |
| Altitude range | up to 2000 m |
| Pollution degree | 2 |
| Safety approvals | EN 61010-031 ^[Note 9] |
| EMC approvals | Not applicable |
| Environmental approvals ^[Note 9] | WEEE, RoHS |
| General | |
| Output connector (probe head) | SMA(f) |
| Supplied cable | 60 cm SMA(m-m) precision unsleeved high-flex 085 microwave coaxial cable (unsleeved and 30 cm options also available) |
| Supplied accessories | Pack of replacement probe tips; two coils of solder-in gold-plated wire; SMA-to-BNC adaptor (with RF, microwave and pulse models only) |
| Dimensions (probe head) | 68 x 19 x 11 mm |
| Nominal probe tip pitch | 5 mm |
| Weight | 5 g |

All specifications are subject to change without notice.

Note 1: Line impedance range representative of most common 50 Ω (100 Ω differential) and 45 Ω (90 Ω differential) lines ± 20% mismatch.

Note 2: Line impedance range covers all typical transmission line or test node impedances in the range 0 Ω to 100 Ω (200 Ω differential).

Note 3: CAUTION: When using AC coupled probes, to avoid damage to the connected instrument ensure that it can withstand transient voltage equal to the DC bias of the test node divided by the nominal probe ratio.

Note 4: Typically it will be possible to scale results at the connected instrument to correct for this small nominal error.

Note 5: WARNING: For peak voltage above 42.4 V, to ensure that touch current lies within acceptable limits of EN 61010-031:2015, pulse or burst width must not exceed 500 ns and pulse mark:space must remain below 2%.

Note 6: CAUTION: To avoid damage to the probe, RMS voltage over the pulse period must remain within specified probe rating.

Note 7: Probes having unmatched output impedance will not absorb pulse aberrations that reflect off mismatch at the connected instrument input. Pulse fidelity and flatness are therefore more dependent on good instrument match.

Note 8: Bandwidth (BW) is calculated from measured transition time (t_r) as $BW \text{ (GHz)} = 350 / t_r \text{ (ps)}$.

Note 9: See *PicoConnect 900 EU Declaration of Conformity* for details.