Model 4700
Photodiode Characterizer

Complete PD Measurement system
The 4700 Photodiode Characterizer is a complete photodiode test system. It will characterize PDs or APDs (upcoming) without the need for additional power supplies. It is this simple: Connect your device and press “start.”

Sensitive Current Measurement
Like our optical power meters, the dBm Optics photodiode meters employ an electrometer-based design. This approach allows much lower currents to be measured (below 200 fA) at much higher speeds. Normal current meter approaches cannot operate this fast because the impedance and input capacitance combines with that of the photodiode to yield slow response time. This is not the case with the dBm Optics 4700.

High Speed
In addition to the speed advantages of the electrometer-based measurement approach, the 4700 has a high-speed parallel architecture that allows higher speed measurements. The 4700 will characterize a photodiode over a 100 nm span in less than 1 second.

Full Electrical Measurement
The photodiode measurement cards for the 4700 have built-in voltage bias, thus eliminating the need for separate supplies.

Integrated Polarization Dependency Characterization
The 4700 will simultaneously measure responsivity and polarization dependent responsivity (PDR) by using traditional all-states, swept all-states, or 4- or 6-state matrix methods. Full PDR over wavelength takes <8 seconds.

Integrated Return Loss
For fiber coupled devices, return loss is often an important specification. The ORL option for the 4700 provides return loss simultaneous with the responsivity measurement.

Fiber Coupled or Free Space
The 4700 will perform fiber-coupled characterization three different ways: using a tunable laser; free space using a TLS and collimator; or using a monochrometer.

Summary
- Simultaneous responsivity, PDR, and return loss measurement across wavelength
- Measure linearity to < 0.05 dB
- Cover telecom photodiode wavelengths
- Measure directly from the photodiode, or 0-10 V from a trans-impedance amplifier
- Test embedded PD in amplifiers simultaneous with optical parametric tests
- Great absolute accuracy, measurements down to < 200 fA
- > 100 dB total dynamic range
- Confirm Polarization Dependent Responsivity to < 0.005 dB
- Linearity measurement to ±0.05 dB
- High speed measurement: 0-100,000 rps
- Large color display makes data visualization and analysis simple
- Communicate over GPIB or Ethernet
- Exchange data using a USB flash drive
- 1-16 channels
- System can be upgraded with additional capabilities such as polarization control, attenuation, shutter
- 4-year warranty
Model 4700: Photodiode Characterizer Overview

- High resolution 4”x6” display
- Data entry and instrument setup are easy with the built-in knob
- USB flash drive allows simple data transfer
- Built-in Ethernet means accessibility over a network, from a desktop, from home or another remote location via a VPN
- Measurements at any rate from 0.01 to 100,000 rps
- High-speed GPIB makes the Model 4700 easy to integrate into an automated test rack
- Real-time power reference, wavelength reference and ORL

1 or 2 channels available (Contact dBm Optics if more than two channels are needed.)

Model 4700 Photodiode Characterizer Test System

- TLS or Fixed LDs
- Shutter
- Splitter
- Wave Ref
- Wavelength reference (optional)
- Atten
- 0-20 dB Attenuator (optional)
- Pol Cntrl
- 4- and 6-state polarization state controller (optional)
- Pol Scrmbl
- Optional High-speed polarization scrambler and/or sweeper (optional)
- 2x2 Lo PDSR Splitter
- DPL
- Back reflection measurement (optional)
- Pref
- Power reference (optional)

Up to 5 integrated independent wavelength source diodes
Model 4700: Photodiode Characterizer
System Configuration

Fiber-coupled solution

Free-space solution

All connections are electrical

Partial Reflectors

Monochrometer

GPIB Control

Dual Real-time references

PD Electrical Connection

PD Optical Connection

NIST/NBS Reference Detector

Device to be tested is moved into optical path

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### Model 4700: Photodiode Characterizer
#### Options and Ordering Information

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>4700</td>
<td>1-2 channel photodiode characterizer mainframe</td>
</tr>
<tr>
<td>201</td>
<td>Power meter module, 800-1700 nm</td>
</tr>
<tr>
<td>202</td>
<td>Precision power meter module, 800-1700 nm</td>
</tr>
<tr>
<td>210</td>
<td>Remote power meter module, 800-1700 nm</td>
</tr>
<tr>
<td>222</td>
<td>Precision power meter module, 800-1700 nm, analog output</td>
</tr>
<tr>
<td>280</td>
<td>Photodiode measurement module</td>
</tr>
<tr>
<td>288</td>
<td>Photodiode measurement module, 8 channels</td>
</tr>
<tr>
<td>301</td>
<td>Real-time power reference measurement module</td>
</tr>
<tr>
<td>310</td>
<td>Optical shutter/automatic dark calibration</td>
</tr>
<tr>
<td>402Q</td>
<td>Precision wavelength reference module (extended range); 5 pm accuracy; 5 pm repeatability</td>
</tr>
<tr>
<td>402T</td>
<td>Precision wavelength reference module; 5 pm accuracy; 5 pm repeatability</td>
</tr>
<tr>
<td>410Q</td>
<td>Precision wavelength reference module (extended range); 1 pm accuracy; 1 pm repeatability</td>
</tr>
<tr>
<td>410T</td>
<td>Precision wavelength reference module; 1 pm accuracy; 1 pm repeatability</td>
</tr>
<tr>
<td>501</td>
<td>Bare fiber adapter, low stress, easy alignment</td>
</tr>
<tr>
<td>502</td>
<td>Bare fiber to FC adapter</td>
</tr>
<tr>
<td>681HP</td>
<td>Internal tunable laser source, high power, 820-860 nm</td>
</tr>
<tr>
<td>684LN</td>
<td>Internal tunable laser source, low noise, 1260-1340 nm</td>
</tr>
<tr>
<td>684HP</td>
<td>Internal tunable laser source, high power, 1260-1340 nm</td>
</tr>
<tr>
<td>688LN</td>
<td>Internal tunable laser source, low noise, 1510-1620 nm</td>
</tr>
<tr>
<td>688HP</td>
<td>Internal tunable laser source, high power, 1520-1630 nm</td>
</tr>
<tr>
<td>692</td>
<td>Laser diode sources (1-5 sources). Specify 1-5 of the most common sources: 980 FBG; 1310 DFB; 1480 DFB; 1490 DFB; 1550 DFB; any wavelength from 1519-1630 nm DFB 980 FP; 1310 FP; 1490 FP; 1550 FP</td>
</tr>
<tr>
<td>705</td>
<td>Rack ears</td>
</tr>
<tr>
<td>740</td>
<td>Internal GPIB controller (required to automatically control external TLS or external polarization controller)</td>
</tr>
<tr>
<td>921</td>
<td>Internal variable attenuator, 0-20 dB, SM output</td>
</tr>
<tr>
<td>940</td>
<td>Internal optical return loss (ORL) module</td>
</tr>
<tr>
<td>953I-13</td>
<td>Internal automatic matrix method PDL/IL measurement (4- and 6-state polarization controller), 1310 nm version</td>
</tr>
<tr>
<td>953I-15</td>
<td>Internal automatic matrix method PDL/IL measurement (4- and 6-state polarization controller), 1550 nm version</td>
</tr>
<tr>
<td>962</td>
<td>Built-in source split with shutters for 2 DUTs</td>
</tr>
<tr>
<td>963</td>
<td>Built-in source split with shutters for 3 DUTs</td>
</tr>
<tr>
<td>972</td>
<td>Built-in source split with switches for 2 DUTs</td>
</tr>
<tr>
<td>973</td>
<td>Built-in source split with switches for 3 DUTs</td>
</tr>
<tr>
<td>982</td>
<td>Built-in source split for 2 DUTs</td>
</tr>
<tr>
<td>983</td>
<td>Built-in source split for 3 DUTs</td>
</tr>
</tbody>
</table>
Model 4700: Photodiode Characterizer
Mainframe Specifications

<table>
<thead>
<tr>
<th>Specification</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Channels per mainframe</td>
<td>1 or 2 channels</td>
</tr>
<tr>
<td>Input connections</td>
<td>Select from among the following at time of ordering:</td>
</tr>
<tr>
<td></td>
<td>1.5 UNIV Universal 1.5 mm ferrule interface</td>
</tr>
<tr>
<td></td>
<td>2.5 UNIV Universal 2.5 mm ferrule interface</td>
</tr>
<tr>
<td></td>
<td>BF Bare fiber interface</td>
</tr>
<tr>
<td></td>
<td>FC FC connector interface</td>
</tr>
<tr>
<td></td>
<td>LC LC connector interface</td>
</tr>
<tr>
<td></td>
<td>MU MU connector interface</td>
</tr>
<tr>
<td></td>
<td>SC SC connector interface</td>
</tr>
<tr>
<td></td>
<td>ST ST connector interface</td>
</tr>
<tr>
<td></td>
<td>SMA SMA connector interface</td>
</tr>
<tr>
<td>Speed per channel</td>
<td>Variable measurement speed from 100K rps to 0.1 rps</td>
</tr>
<tr>
<td>System transmit speed</td>
<td>Transmitting to host with Ethernet is 3 Mbytes/second (dedicated link). Transmitting to host with GPIB is 1.7 Mbytes/second into a PC.</td>
</tr>
<tr>
<td>Multiple channel speed</td>
<td>100K rps per channel regardless of number of channels</td>
</tr>
<tr>
<td>Trigger latency(^1)</td>
<td>&lt; 40 ns latency; &lt; 40 ns jitter</td>
</tr>
<tr>
<td>Display</td>
<td>4” x 6” graphical display; VGA (800 x 600); TFT LCD color</td>
</tr>
<tr>
<td>Data storage</td>
<td>Memory for &gt; 100K readings per channel on all channels real-time storage</td>
</tr>
<tr>
<td>Triggering</td>
<td>Software synchronous trigger or two selectable external trigger inputs</td>
</tr>
<tr>
<td>Interfaces</td>
<td>IEEE-488, 100-BaseT Ethernet standard</td>
</tr>
<tr>
<td>Command set</td>
<td>IEEE-488.2 compliant (SCPI-like)</td>
</tr>
<tr>
<td>Power</td>
<td>90-265 VAC; 175 VA max; 47-63 Hz. No switch or fuse change required.</td>
</tr>
<tr>
<td>Ambient temperature</td>
<td>10 ºC to 35 ºC (50 ºF to 95 ºF). Contact factory for 0 ºC to 40 ºC (32 ºF to 104 ºF).</td>
</tr>
<tr>
<td>Storage temperature</td>
<td>-40 ºC to +70 ºC (-40 ºF to 158 ºF).</td>
</tr>
<tr>
<td>Humidity</td>
<td>&lt; 95% non-condensing 0 ºC to 35 ºC</td>
</tr>
<tr>
<td>Warm-up time</td>
<td>60 minutes to full specifications; useable immediately after turn on</td>
</tr>
<tr>
<td>Recalibration period</td>
<td>1 year; certificate of calibration included</td>
</tr>
<tr>
<td>Warranty period</td>
<td>Standard warranty is 4 years (Options 402, 410, 953I, and all switch modules carry a one-year warranty)</td>
</tr>
<tr>
<td>Size</td>
<td>16.8” w x 16.4” d x 5.25” h (42.6 cm x 41 cm x 10.5 cm)</td>
</tr>
<tr>
<td>Weight</td>
<td>15 lbs (6.8 kg)</td>
</tr>
<tr>
<td>Mounting</td>
<td>Benchtop or rack mount</td>
</tr>
</tbody>
</table>

\(^1\)Trigger latency defined as total time from trigger edge to initiation of measurement
## Power Meter Modules

**Option 201, Option 202, Option 221, Option 222, Option 210, Option 301**

### Specifications

#### Sensitivity and Noise

<table>
<thead>
<tr>
<th>Range</th>
<th>Fixed Range</th>
<th>Measurement</th>
<th>Resolution</th>
<th>5 secs $\pm$W</th>
<th>100 ms $\pm$W</th>
<th>10 $\mu$s (full speed) $\pm$W</th>
<th>Power Meter Module</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>100 ms $\pm$dBm</td>
<td>10 $\mu$s (full speed) $\pm$dBm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fast 10 mW</td>
<td></td>
<td></td>
<td></td>
<td>$\pm$W dBm</td>
<td>$\pm$W dBm</td>
<td>$\pm$W dBm</td>
<td></td>
</tr>
<tr>
<td>Fast 100 µW</td>
<td></td>
<td></td>
<td></td>
<td>$\pm$W dBm</td>
<td>$\pm$W dBm</td>
<td>$\pm$W dBm</td>
<td></td>
</tr>
<tr>
<td>Fast 1 µW</td>
<td></td>
<td></td>
<td></td>
<td>$\pm$W dBm</td>
<td>$\pm$W dBm</td>
<td>$\pm$W dBm</td>
<td></td>
</tr>
<tr>
<td>Fast 10 nW</td>
<td></td>
<td></td>
<td></td>
<td>$\pm$W dBm</td>
<td>$\pm$W dBm</td>
<td>$\pm$W dBm</td>
<td></td>
</tr>
<tr>
<td>Fast 100 pW</td>
<td></td>
<td></td>
<td></td>
<td>$\pm$W dBm</td>
<td>$\pm$W dBm</td>
<td>$\pm$W dBm</td>
<td></td>
</tr>
</tbody>
</table>

**Accuracy**

- Absolute uncertainty at reference conditions: 2.5%
- Absolute operational uncertainty: 5%
- Relative uncertainty: <1% + noise (per table above)

#### Measurement Speed

<table>
<thead>
<tr>
<th>Auto-Range Mode</th>
<th>Full Measurement Range</th>
<th>1 Reading</th>
<th>2,000 Readings</th>
<th>500,000 Readings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fast 10 mW - 2 nW</td>
<td>10 dBm to -57 dBm</td>
<td>10 $\mu$s</td>
<td>20 ms</td>
<td>5.00 s</td>
</tr>
<tr>
<td>Fast 100 µW - 20 pW</td>
<td>-10 dBm to -77 dBm</td>
<td>10 $\mu$s</td>
<td>20 ms</td>
<td>5.00 s</td>
</tr>
<tr>
<td>Fast 1 µW - 200 fW</td>
<td>-30 dBm to -97 dBm</td>
<td>10 $\mu$s</td>
<td>20 ms</td>
<td>5.00 s</td>
</tr>
<tr>
<td>Fast 10 nW - 2 pW</td>
<td>-50 dBm to -107 dBm</td>
<td>10 $\mu$s</td>
<td>20 ms</td>
<td>5.00 s</td>
</tr>
<tr>
<td>Fast 1 mW - 0.5 fW</td>
<td>-60 dBm to -117 dBm</td>
<td>10 $\mu$s</td>
<td>20 ms</td>
<td>5.00 s</td>
</tr>
<tr>
<td>Med 10 mW - 20 pW</td>
<td>10 dBm to -77 dBm</td>
<td>1 ms</td>
<td>21 ms</td>
<td>5.00 s</td>
</tr>
<tr>
<td>Med 10 mW - 200 fW</td>
<td>10 dBm to -97 dBm</td>
<td>10 ms</td>
<td>30 ms</td>
<td>5.01 s</td>
</tr>
<tr>
<td>Slow 10 mW - 2 fW</td>
<td>10 dBm to -107 dBm</td>
<td>1.5 s</td>
<td>1.52 s</td>
<td>6.52 s</td>
</tr>
<tr>
<td>Slow 10 mW - 0.5 fW</td>
<td>10 dBm to -117 dBm</td>
<td>5 s</td>
<td>5.02 s</td>
<td>10.02 s</td>
</tr>
</tbody>
</table>

### Connections

- **Model**: Description
  - 1.5 UNIV: Universal 1.5 mm ferrule interface
  - 2.5 UNIV: Universal 2.5 mm ferrule interface
  - BF: Bare fiber interface
  - FC: FC connector interface
  - LC: LC connector interface
  - MU: MU connector interface
  - SC: SC connector interface
  - ST: ST connector interface
  - SMA: SMA connector interface

*Select when ordering. Additional connectors may be available. Input connection can be changed in the field.*

(Continued)
Power Meter Modules
Option 201, Option 202, Option 221, Option 222, Option 210, Option 301
Specifications (Continued)

Polarization Uncertainty of Measurement

| < ±0.0015 dB typical; 0.0035 dB guaranteed for precision power meter module (Option 202, Option 301) |
| < ±0.0050 dB for power meter module (Option 201, Option 210, Option 221, Option 222) |

Return Loss

| > 55 dB |

Remote Power Meter Module, 800-1700 nm (Option 210)

| Input configurations: 3 mm free space; 1 mm free space; FC, SC, ST, UC Universal connector or BF (bare fiber) |
| Input orientation: End (axial) entry or side entry |
| Cable length: 1 meter standard; call factory for additional lengths |

Precision Power Meter Module, 800-1700 nm (Option 221)

| Analog output: 0-2V (4V max) |
| Output impedance: 600 ohms typical |
| Maximum input voltage: ±10V |
| Bandwidth: DC up to 7.5 kHz depending on range |

Precision Power Meter Module, Analog Output*, 800-1700 nm (Option 222)

| Analog output: 0-2V (4V max) |
| Output impedance: 600 ohms typical |
| Maximum input voltage: ±10V |
| Bandwidth: DC up to 7.5 kHz depending on range |

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1. From 1500 to 1620 nm. For 1400-1635, add 3 dBm; for 800 nm-1650 nm, add 10 dB noise and resolution specs (or multiply to W by 10).
2. Assume automatic or manual dark calibration performed.
3. Peak noise is typically 3 to 3.5 times the RMS figure. Noise figures are typical performance.
4. Per “Guidelines for Evaluating and Expressing the Uncertainty of NIST Measurement Results;” NIST Technical Note #1297
5. Wavelength = 1310, 1520-1625 nm, T (ambient) = 23°C ± 2C, 1.1 mm diameter beam, 30 µW
6. Wavelength = 800-1650 nm, T (ambient) = 10 to 35°C, Fiber with N.A. <0.3, -70 dBm to +3 dBm (total wavelength range 800 nm-1700 nm)
7. Maximum variation ± for 4 measurements, filter on
8. Maximum variation ± for 50 measurements, filter on
9. Maximum variation ± for 10,000 measurements, filter on
10. Includes the time to change range and take readings. All readings equally spaced.
11. Measurement noise may be higher with analog output due to conducted noise from devices and cables connected to the analog output connection.
Photodiode Measurement Modules (Internal)
Option 280, Option 288
Specifications

(For use in measuring responsivity or current from external photodiode)

**General Specifications**

<table>
<thead>
<tr>
<th>Specification</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Measurement rate</td>
<td>100,000 readings per second (10 μs measurement time)</td>
</tr>
<tr>
<td>Measurement modes</td>
<td>Current measurement; voltage measurement</td>
</tr>
<tr>
<td>Photodiode bias supply voltage range</td>
<td>0 to 10V</td>
</tr>
<tr>
<td>Photodiode bias supply voltage resolution</td>
<td>5 mW resolution</td>
</tr>
<tr>
<td>Photodiode bias supply voltage noise</td>
<td>&lt; 50 μV DC to 20 KHz</td>
</tr>
</tbody>
</table>
| Display, absolute measurement          | Displays 1 mV per mA measured from photodiode with no user calibration applied. Display in linear (mW) or log (dBm).
| Display, relative measurement (Pref ON) | Displays the cal factor of mA per mW applied. Display in log (dB).      |
| Math                                   | Both dB and linear offset functions available standard                  |
| PD calibration factors                 | Selectable from front panel; GPIB, Ethernet, or RS-232                 |
| Triggering                             | Selectable through CSA mainframe. < 40 ns maximum trigger misalignment. |
| Maximum input                          | ±40 V peak (no damage)                                                  |
| Channels                               | 1 channel for Option 280; 8 channels for Option 288                     |
| Input connection                       | 12-pin circular connector                                               |

**Voltage Mode Specifications**

<table>
<thead>
<tr>
<th>Range</th>
<th>Resolution</th>
<th>Noise @ 10 μs¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 V</td>
<td>200 μV</td>
<td>&lt; 1 mV</td>
</tr>
<tr>
<td>1 V</td>
<td>200 μV</td>
<td>&lt; 200 μV</td>
</tr>
</tbody>
</table>

¹ Peak-to-peak noise

**PD Current Mode Specifications**

<table>
<thead>
<tr>
<th>Range</th>
<th>Resolution</th>
<th>Noise @ 100 ms¹</th>
<th>Noise @ 10 μs²</th>
<th>Equiv Optical Power (direct)</th>
<th>Equiv Optical Power (10% tap)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 A</td>
<td>20 μA</td>
<td>&lt; 20 μA</td>
<td>&lt; 80 μA</td>
<td>30 dBm</td>
<td>1 W</td>
</tr>
<tr>
<td>100 mA</td>
<td>2 μA</td>
<td>&lt; 2 μA</td>
<td>&lt; 8 μA</td>
<td>20 dBm</td>
<td>100 mW</td>
</tr>
<tr>
<td>10 mA</td>
<td>200 nA</td>
<td>&lt; 200 nA</td>
<td>&lt; 800 nA</td>
<td>10 dBm</td>
<td>100 mW</td>
</tr>
<tr>
<td>1 mA</td>
<td>20 nA</td>
<td>&lt; 20 nA</td>
<td>&lt; 8 nA</td>
<td>0 dBm</td>
<td>100 μW</td>
</tr>
<tr>
<td>100 μA</td>
<td>2 nA</td>
<td>&lt; 20 nA</td>
<td>&lt; 8 nA</td>
<td>-10 dBm</td>
<td>100 μW</td>
</tr>
<tr>
<td>10 μA</td>
<td>200 pA</td>
<td>&lt; 200 pA</td>
<td>&lt; 800 pA</td>
<td>-20 dBm</td>
<td>10 μW</td>
</tr>
<tr>
<td>1 μA</td>
<td>20 pA</td>
<td>&lt; 20 pA</td>
<td>&lt; 80 pA</td>
<td>-30 dBm</td>
<td>1 μW</td>
</tr>
<tr>
<td>100 nA</td>
<td>2 pA</td>
<td>&lt; 2 pA</td>
<td>&lt; 40 pA</td>
<td>-40 dBm</td>
<td>100 nW</td>
</tr>
<tr>
<td>10 nA</td>
<td>200 fA</td>
<td>&lt; 200 fA</td>
<td>&lt; 4 pA</td>
<td>-50 dBm</td>
<td>100 nW</td>
</tr>
</tbody>
</table>

¹ Peak-to-peak noise

**Response Time Specifications**

<table>
<thead>
<tr>
<th>Range</th>
<th>Response with 1 pF PD Capacitance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 A</td>
<td>~ 20 KHz</td>
</tr>
<tr>
<td>100 mA</td>
<td>~ 20 KHz</td>
</tr>
<tr>
<td>10 mA</td>
<td>~ 20 KHz</td>
</tr>
<tr>
<td>1 mA</td>
<td>~ 20 KHz</td>
</tr>
<tr>
<td>100 μA</td>
<td>~ 7.5 KHz</td>
</tr>
<tr>
<td>10 μA</td>
<td>~ 7.5 KHz</td>
</tr>
<tr>
<td>1 μA</td>
<td>~ 0.1 KHz</td>
</tr>
<tr>
<td>100 nA</td>
<td>~ 0.1 KHz</td>
</tr>
<tr>
<td>10 nA</td>
<td>~ 0.01 KHz</td>
</tr>
</tbody>
</table>
## Wavelength Reference Module Options (Internal)

### Options 410Q, 410T, 410THR, 402Q, 402T

### Specifications

<table>
<thead>
<tr>
<th>Description</th>
<th>410THR*</th>
<th>410Q</th>
<th>410T</th>
<th>402Q</th>
<th>402T</th>
</tr>
</thead>
<tbody>
<tr>
<td>Precision wavelength reference module (high resolution)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Precision wavelength reference module (extended range)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Absolute wavelength accuracy</td>
<td>&lt; 0.6 pm typical; &lt; 1 pm guaranteed under enhanced accuracy conditions*</td>
<td>&lt; ±1 pm</td>
<td>&lt; ±1 pm</td>
<td>&lt; ±5 pm</td>
<td>&lt; ±5 pm</td>
</tr>
<tr>
<td>Repeatable</td>
<td>&lt; 0.08 pm at one standard deviation typical under enhanced accuracy conditions*</td>
<td>&lt; ±1 pm</td>
<td>&lt; ±1 pm</td>
<td>&lt; ±5 pm</td>
<td>&lt; ±5 pm</td>
</tr>
<tr>
<td>Wavelength range</td>
<td>1510-1648 nm full accuracy; wider wavelength range at reduced accuracy</td>
<td>1260-1640 nm</td>
<td>1510-1648 nm full accuracy; wider wavelength range at reduced accuracy</td>
<td>1260-1640 nm</td>
<td>1510-1648 nm full accuracy; wider wavelength range at reduced accuracy</td>
</tr>
<tr>
<td>Minimum sweep range</td>
<td>1 nm from:</td>
<td>1 nm from:</td>
<td>1 nm from:</td>
<td>1 nm from:</td>
<td>1 nm from:</td>
</tr>
<tr>
<td></td>
<td>1520-1532; 1536-1550; 1561-1573; 1575-1594; 1595-1608; 1610-1638; 5 nm for other wavelengths</td>
<td>1520-1532; 1536-1550; 1561-1573; 1575-1594; 1595-1608; 1610-1638; 10 nm for other wavelengths</td>
<td>1520-1532; 1536-1550; 1561-1573; 1575-1594; 1595-1608; 1610-1638; 10 nm for other wavelengths</td>
<td>1520-1532; 1536-1550; 1561-1573; 1575-1594; 1595-1608; 1610-1638; 10 nm for other wavelengths</td>
<td>1520-1532; 1536-1550; 1561-1573; 1575-1594; 1595-1608; 1610-1638; 10 nm for other wavelengths</td>
</tr>
<tr>
<td>Maximum wavelength error that can be corrected</td>
<td>The &quot;Wavelength Offset Wizard&quot; corrects beginning-of-sweep wavelength errors up to 5 nm. The error in any 5 nm span of the sweep may not exceed 200 pm.</td>
<td>The &quot;Wavelength Offset Wizard&quot; corrects beginning-of-sweep wavelength errors up to 5 nm. The error in any 5 nm span of the sweep may not exceed 200 pm.</td>
<td>The &quot;Wavelength Offset Wizard&quot; corrects beginning-of-sweep wavelength errors up to 5 nm. The error in any 5 nm span of the sweep may not exceed 200 pm.</td>
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<td>The &quot;Wavelength Offset Wizard&quot; corrects beginning-of-sweep wavelength errors up to 5 nm. The error in any 5 nm span of the sweep may not exceed 200 pm.</td>
</tr>
<tr>
<td>Optical input power</td>
<td>+3 dB to -3 dB</td>
<td>&gt; -15 dBm into &quot;TLS IN&quot; PORT typical</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minimum sweep rate</td>
<td>20 nm/second for full specifications.</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Maximum sweep rate</td>
<td>100 nm/second guaranteed; 120 nm/second typical.</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Mode hop correction</td>
<td>Automatic: Finds, characterizes and corrects for single or up to 15 mode hops encountered during the sweep. Mode hops must be at least 1 nm apart and not be at the beginning 1 nm of the sweep.</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Wavelength resolution</td>
<td>0.01 pm</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Wavelength correction</td>
<td>Each power/IL/ORL/PDL measurement point wavelength is automatically connected to the actual wavelength</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Wavelength sweep rate</td>
<td>Full specifications generally apply to TLS at its maximum sweep rate. At slower rates, some TLS become unstable and can even sweep backwards for short periods of time. TLS must sweep forward monotonically.</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Data available</td>
<td>Wavelength axis automatically corrected when wavelength correction is enabled. Data trace showing wavelength correction applied (TLS wavelength error) may be displayed.</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

* The 410THR operates like the 410T in all respects except that accuracy and repeatability are enhanced with the 410THR. To obtain these enhanced results, the sweep should be configured as follows: 1) sweep rate 40 nm/second; 2) sweep start and sweep end in one of the following wavelength ranges: 1523 nm to 1530 nm, 1538 nm to 1550 nm, 1563 nm to 1571 nm, 1578 nm to 1588 nm, 1599 nm to 1605 nm, 1615 nm to 1623 nm; 3) analog filtering off 4) TLS models: Agilent model 81600B, New Focus model 6500, dBm Optics model 4200. Note: Accuracy is improved over the 410 outside these conditions, but performance may vary.
# Tunable Laser Sources (Internal)
## 680 Series*
### Specifications

<table>
<thead>
<tr>
<th></th>
<th>681</th>
<th>684</th>
<th>688</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Tuning range</strong></td>
<td>835-850 nm</td>
<td>1265-1345 nm</td>
<td>1520-1630 nm</td>
</tr>
<tr>
<td><strong>Tuning range, mode-hop free</strong></td>
<td>835-850 nm</td>
<td>1265-1345 nm</td>
<td>1510-1620 nm</td>
</tr>
<tr>
<td><strong>Output power</strong></td>
<td>+6 dBm</td>
<td>0 dBm</td>
<td>+6 dBm</td>
</tr>
<tr>
<td><strong>Signal to source spontaneous emission ratio (SSE) 5,7</strong></td>
<td>&gt; 40 dB</td>
<td>&gt; 70 dB</td>
<td>&gt; 40 dB</td>
</tr>
<tr>
<td><strong>Signal to total source spontaneous emission ratio (STSE) 5,7</strong></td>
<td>&gt; 15 dB</td>
<td>&gt; 55 dB</td>
<td>&gt; 15 dB</td>
</tr>
<tr>
<td><strong>Tuning speed</strong></td>
<td>2 to 1000 nm/s (±1%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Wavelength resolution 2</strong></td>
<td>0.08 pm (10 MHz)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Absolute wavelength accuracy 1</strong></td>
<td>&lt; ±1 pm with precision wavelength reference (Option 410)</td>
<td>&lt; ±5 pm with wavelength reference (Option 402)</td>
<td>&lt; ±30 pm in fixed wavelength mode</td>
</tr>
<tr>
<td><strong>Wavelength repeatability 2</strong></td>
<td>&lt; ±1 pm with precision wavelength reference (Option 410)</td>
<td>&lt; ±5 pm with wavelength reference (Option 402)</td>
<td>&lt; ±30 pm in fixed wavelength mode</td>
</tr>
<tr>
<td><strong>Wavelength resolution</strong></td>
<td>0.1 pm</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Wavelength stability 3</strong></td>
<td>&lt; ±2.5 pm</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Tuning linearity 4</strong></td>
<td>&lt; ±1 pm in swept mode with precision wavelength reference (Option 410)</td>
<td>&lt; ±5 pm in swept mode with wavelength reference (Option 402)</td>
<td>&lt; ±80 nm in swept mode without wavelength reference</td>
</tr>
<tr>
<td><strong>Linewidth</strong></td>
<td>&lt; 50 MHz</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Side mode suppression (SMSR)</strong></td>
<td>&gt; 50 dBc typical</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Optical shutter</strong></td>
<td>&gt; 80 dB extinction available with integrated optical shutter/automatic dark calibration (Option 310)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>RIN</strong></td>
<td>-140 dBc (0.1 GHz to 1.0 GHz); -150 dBc/Hz (1 GHz to 2.5 GHz) typical</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Connector</strong></td>
<td>FC/APC standard; FC/APC-PM available</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Trigger output</strong></td>
<td>+5 volt trigger at beginning of continuous sweep</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Remote interfaces</strong></td>
<td>GPIB (IEEE 488); Ethernet; USB Flash Drive</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Power</strong></td>
<td>90-240 VAC</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Environmental: Operating</strong></td>
<td>+10 ºC to +32 ºC (+55 ºF to +90 ºF); &lt; 80% RH non-condensing</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Environmental: Storage</strong></td>
<td>-20 ºC to +70 ºC (-4 ºF to +158 ºF); &lt; 80% RH non-condensing</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Size</strong></td>
<td>16.8” width x 16.4” depth x 5.25” height (42.6 cm x 41 cm x 10.5 cm)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Weight</strong></td>
<td>6 lbs (2.7 kg)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Shock/vibration</strong></td>
<td>ISTB Procedure 2B; 100G non-operating</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Laser safety</strong></td>
<td>Class 3B (FDA 21 CFR 1040.10); Class 3A (IEC 825-1; 1993)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Most common for optical component test applications.

**NOTE:** All specifications measured with one-hour warm up and constant temperature 23 ºC (±2 ºC).

**CAUTION:** Viewing the laser output with certain optical instruments (e.g., eye loupes, magnifiers, microscopes) within a distance of 100 mm may pose an eye hazard.

---

1 Using installed wavelength correction option if noted, see Option 402 for specifications or Option 410 for operating parameters
2 1 pm in step mode
3 In fixed wavelength mode
4 0.1 nm bandwidth; signal to max ASE; 1-3 nm from carrier
5 0.2 nm bandwidth; signal to max ASE; > 5 nm from carrier
6 Signal to total ASE > 0.5 nm from carrier
7 Measurement taken at maximum rated power
Variable Attenuator (Internal)
Option 921
Specifications

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attenuation range</td>
<td>&gt; 20 dB</td>
</tr>
<tr>
<td>Wavelength range</td>
<td>1525-1610 nm</td>
</tr>
<tr>
<td>Accuracy</td>
<td>0.3 dB</td>
</tr>
<tr>
<td>Excess loss</td>
<td>1.5 dB typical; 1.8 dB max</td>
</tr>
</tbody>
</table>

Polarization Controller (Internal)
Options 953I-13, 953I-15
Specifications

<table>
<thead>
<tr>
<th>Parameter</th>
<th>953I-13</th>
<th>953I-15</th>
</tr>
</thead>
<tbody>
<tr>
<td>Internal 4- and 6-state polarization controller; 1310 nm version</td>
<td>Internal 4- and 6-state polarization controller; 1550 nm version</td>
<td></td>
</tr>
<tr>
<td>Insertion loss</td>
<td>1.0 dB typical</td>
<td>1.0 dB typical</td>
</tr>
<tr>
<td>Insertion loss variation</td>
<td>0.1 dB max for all SOP states</td>
<td>0.1 dB max for all SOP states</td>
</tr>
<tr>
<td>Wavelength dependent loss</td>
<td>&lt; 0.6 dB 1260-1360 nm</td>
<td>&lt; 0.6 dB 1530-1565 nm</td>
</tr>
<tr>
<td>Return loss</td>
<td>55 dB min</td>
<td>55 dB min</td>
</tr>
<tr>
<td>SOP repeatability</td>
<td>±0.1 degrees on Poincaré sphere</td>
<td>±0.1 degrees on Poincaré sphere</td>
</tr>
<tr>
<td>Rotation angle wavelength dependence</td>
<td>-0.068 degrees/nm</td>
<td>-0.068 degrees/nm</td>
</tr>
<tr>
<td>SOP switching speed</td>
<td>250 µs max</td>
<td>250 µs max</td>
</tr>
<tr>
<td>States generated</td>
<td>-45, 0, 45, 90, RHC, LHC</td>
<td>-45, 0, 45, 90, RHC, LHC</td>
</tr>
<tr>
<td>Maximum optical power</td>
<td>300 mW min</td>
<td>300 mW min</td>
</tr>
<tr>
<td>Wavelength</td>
<td>1260-1360 nm</td>
<td>1480-1620 nm</td>
</tr>
</tbody>
</table>

Polarization Scrambler (Internal)
Option 957-I
Specifications

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Insertion loss</td>
<td>0.05 dB</td>
</tr>
<tr>
<td>Output degree of polarization</td>
<td>&lt; 5%</td>
</tr>
<tr>
<td>Insertion loss variation</td>
<td>&lt; 0.01 dB</td>
</tr>
<tr>
<td>Center wavelength</td>
<td>980, 1060, 1310, 1480, 1550, 1600</td>
</tr>
<tr>
<td>Wavelength range</td>
<td>100 nm centered on wavelength above</td>
</tr>
<tr>
<td>DOP</td>
<td>5%</td>
</tr>
<tr>
<td>ORL</td>
<td>65 dB</td>
</tr>
<tr>
<td>Scrambling bandwidth</td>
<td>DC to 700 kHz</td>
</tr>
</tbody>
</table>
### Miscellaneous Option Specifications and Descriptions

**Note:** Each model/unit has an Options and Ordering Information sheet. Refer to this sheet to determine option availability.

<table>
<thead>
<tr>
<th>Option</th>
<th>Description</th>
<th>Specifications</th>
</tr>
</thead>
</table>
| 310    | Optical shutter/automatic dark calibration | “Off” blocking: > 100 dB  
Wavelength range: 700-1700 nm |
| 501    | Bare fiber adapter, low stress, easy alignment | N/A |
| 502    | Bare fiber to FC adapter | N/A |
| 692    | Laser diode source module. Select one laser diode. (Up to 5 total laser diode sources; order additional sources using 692X-xxxx.) | N/A |
| 692X   | Additional laser diodes for 692-xxxx. Includes switch. Select up to 4. | N/A |
| 705    | Rack ears (4000 Series) | N/A |
| 740    | Internal GPIB controller (required to automatically control external TLS or external polarization controller) | Allows control of external TLS or external polarization controller |
| 940    | Internal optical return loss (ORL) module | ORL measurement range dependent on test system configuration: > 55 dB under most conditions; > 70 dB with optimal configurations. (See Application Note 2004-014A.) |
| 956    | Automated matrix method PDL/IL measurement | Works in conjunction with customer’s Agilent/HP 8169A polarization controller. Requires Option 740. |
| 972    | Built-in source split with switches for 2 DUTs | Additional PDL: +0.015 PDL |
| 973    | Built-in source split with switches for 3 DUTs | Additional PDL: +0.040 PDL |
| 974    | Built-in source switch for 2 external lasers | N/A |
| 974-PM | Built-in PM source switch for 2 external lasers | N/A |
| 975    | Built-in source switch for 3 external lasers | N/A |
| 976    | Built-in source switch for 4 external lasers | N/A |
| 982    | Built-in source split for 2 DUTs | Additional PDL: +0.015 PDL |
| 983    | Built-in source split for 3 DUTs | Additional PDL: +0.040 PDL |

* Contact the factory for extended specification, custom-designed, and OEM products or specials.  
* Technical data subject to change.