

AE6980T Optical Automotive Ethernet Tx Compliance Test Software

Accurately Qualify the nGBASE-AU Optical PHY with TDFOM-Assisted Measurements

nGBASE-AU Optical Automotive Ethernet

Optical Automotive Ethernet uses optical fiber to transmit data between systems within a vehicle. IEEE Std 802.3cz defines optical connectivity standards supporting single-lane data rates up to 50 Gbps, with up to four in-line connectors and a maximum reach of 40 meters over OM3 multimode glass optical fiber. The key advantages of Optical Automotive Ethernet include superior electromagnetic compatibility (EMI/EMC), low signal attenuation and interference, high data rates, and reduced cable harness weight.

Transmitter Distortion Figure of Merit (TDFOM)

In the IEEE 802.3cz standard, the Transmitter Distortion Figure of Merit (TDFOM) is the primary metric for evaluating the quality of an optical transmit signal to ensure transmitter–receiver interoperability. TDFOM represents the optical power penalty of a measured transmitter compared to an ideal transmitter. It is also used to calibrate reference transmitters for assessing the quality of receivers with compliant transmitters. To derive TDFOM, the optical signal is filtered, sampled, noise-added, and equalized according to a specified reference receiver. The maximum noise power supported for a given BER is then calculated, providing a measure of signal quality. Higher TDFOM values—indicating tolerance to less noise power—correspond to increased receiver sensitivity penalties and reduced signal integrity. Conversely, lower TDFOM values correspond to better receiver sensitivity and higher signal integrity.

The AE6980T software v1.2 expands the solution to provide full IEEE 802.3cz and OPEN Alliance TC7 v1.0 10GBASE-AU transmitter compliance testing, including a complete suite of Tx test cases, variable reflector support, and TP2-to-TP3 channel-loss compensation.

Test	Clause
TDFOM Average Optical Power (AOP)	IEEE 802.3cz -Section 166.6.4.3, Open Alliance TC7 Test House -Section 10.3.2
TDFOM Optical Modulation Amplitude (OMA)	IEEE 802.3cz -Section 166.6.4.4, Open Alliance TC7 Test House -Section 10.3.3
TDFOM Extinction Ratio (ER)	IEEE 802.3cz -Section 166.6.4.5, Open Alliance TC7 Test House -Section 10.3.3
Transmitter Distortion Figure of Merit (TDFOM)	IEEE 802.3cz -Section 166.6.4.8, Open Alliance TC7 Test House -Section 10.3.3
TDFOM OAR (OMA to AOP Ratio)	IEEE 802.3cz -Section 166.6.4.13.2
Optical Transmitter AOP (when Tx is set to OFF)	IEEE 802.3cz -Section 166.6.4.3, Open Alliance TC7 Test House -Section 10.3.2
Uncorrelated Random Jitter	IEEE 802.3cz -Section 166.6.4.7, Open Alliance TC7 Test House -Section 10.3.3
RIN12OMA	IEEE 802.3cz -Section 166.6.4.6, Open Alliance TC7 Test House -Section 10.3.3
Transmitter Clock Frequency	IEEE 802.3cz -Section 166.6.3.2, Open Alliance TC7 Test House -Section 10.3.2
Center Wavelength	IEEE 802.3cz -Section 166.6.4.2, Open Alliance TC7 Test House -Section 10.3.1
RMS Spectral Width	IEEE 802.3cz -Section 166.6.4.2, Open Alliance TC7 Test House -Section 10.3.1
Optical Return Loss	IEEE 802.3cz -Section 166.6.4.2, Open Alliance TC7 Test House -Section 10.3.5

Why TDFOM-Assisted Measurements?

The AE6980T provides TDFOM measurements along with a suite of TDFOM-assisted optical parameters calculated during the process of obtaining the TDFOM value. For example, the TDFOM-OMA measurement is computed using the equalized, averaged, and cleaned waveform, and then referenced to the input of the reference receiver.

Why use TDFOM-assisted measurements instead of plain measurements?

Plain measurements can be misleading in the presence of noise or transient effects. A distorted waveform could pass a measurement limit even though the receiver cannot decode it. Similarly, two transmitters with the same OMA could perform very differently in a real link. TDFOM-assisted measurements address this by applying a TDFOM reference equalizer model to the transmit waveform, then calculating OMA, ER, AOP, and OAR at the transmitter output.

TDFOM more accurately reflects real-world performance by capturing how well a signal will operate in an in-vehicle optical link with dispersion and equalization. It quantifies the penalty introduced by transmitter distortion due to unequalizable ISI and noise, expressed as a dB loss in link margin. This makes TDFOM a more predictive metric for interoperability, ensuring that compliant devices can reliably interoperate.

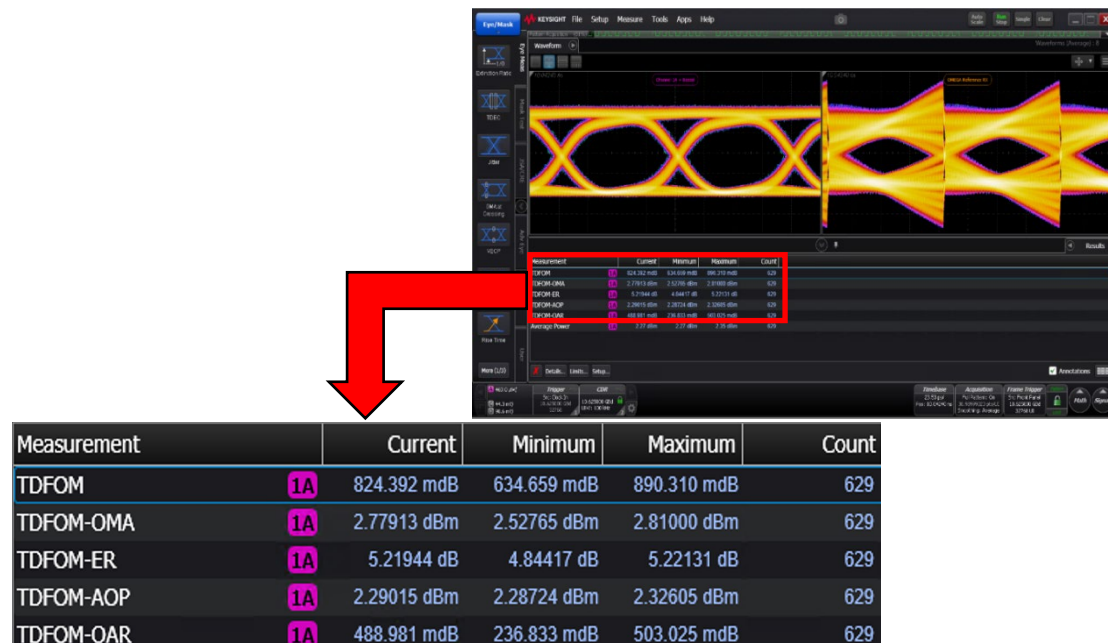


Figure 1. TDFOM measurement functions loaded on FlexDCA

How to Measure TDFOM

To measure TDFOM, the same test setup is used as for other transmitter test parameters such as OMA, ER, and jitter. For the TDFOM measurement, SSPR-NRZ or SSPR-PAM4 test patterns are utilized. The input low-pass filter of the TDFOM reference receiver is a 4th-order Bessel-Thomson filter with a –3 dB bandwidth of 16.4 GHz for all data rates. The TDFOM process also employs a reference receiver with specific timing recovery, additional signal filtering, and a decision feedback equalizer in the signal path.

The oscilloscope should be configured to capture samples from all symbols in the complete test pattern, with a sample rate of at least 15 samples per unit interval (UI), and by averaging several complete test pattern captures. The optical splitter and variable reflector are adjusted so the transmitter is tested with the maximum optical return loss specified in IEEE 802.3cz PMD transmitter characteristics—12 dB.

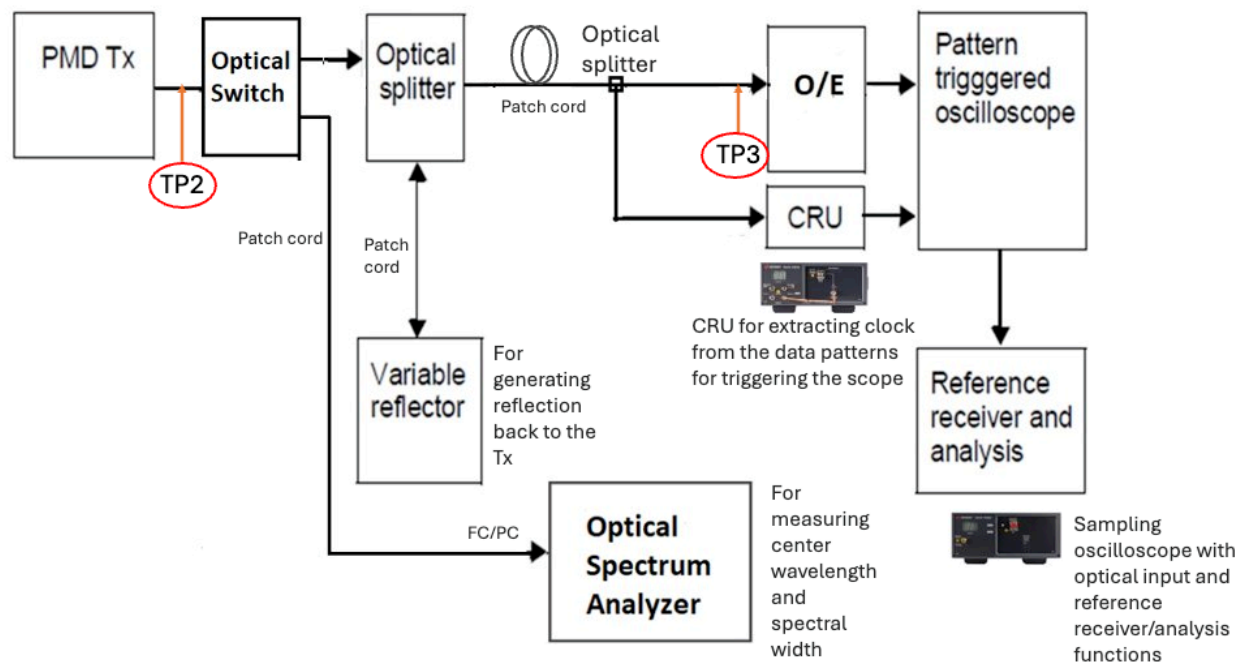


Figure 2. IEEE 802.3cz transmitter conformance test block diagram for TDFOM test

TDFOM Compliance Tests

The Keysight AE6980T Optical Automotive Ethernet Tx Compliance application is an easy-to-use optical transmitter test solution running in the Keysight FlexDCA software with option N1010100A (R&D package). It enables automatic execution of nGBASE-AU TDFOM measurements for transmitter compliance according to IEEE 802.3cz and Open Alliance TC7 Test House specifications. In addition to measurement data, the application generates a margin analysis report showing how closely your device passes or fails each test relative to the defined limits.

Key benefits of the application include:

- Saving time in understanding standard requirements — TDFOM is a complex measurement that is not trivial to understand or implement. This measurement is carefully implemented in partnership with an optical chipset vendor to ensure accuracy and industry compliance.
- Performing TDFOM-assisted optical transmitter measurements — including OMA, ER, AOP, and OAR, leveraging waveform processing needed to calculate TDFOM.
- Reducing test setup time — complex equipment configuration is simplified to a single button push.
- Facilitating device debugging — with custom configurations in FlexDCA, enabling quick generation of HTML reports that summarize device performance.

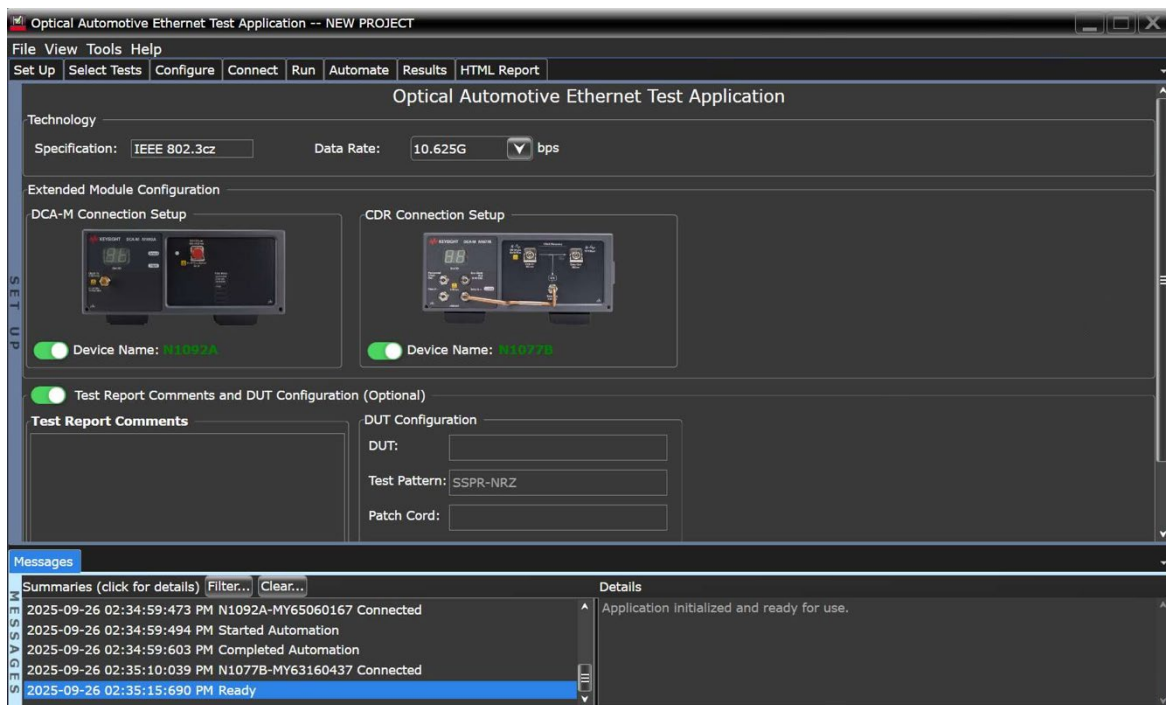


Figure 3. AE6980T compliance test setup screen

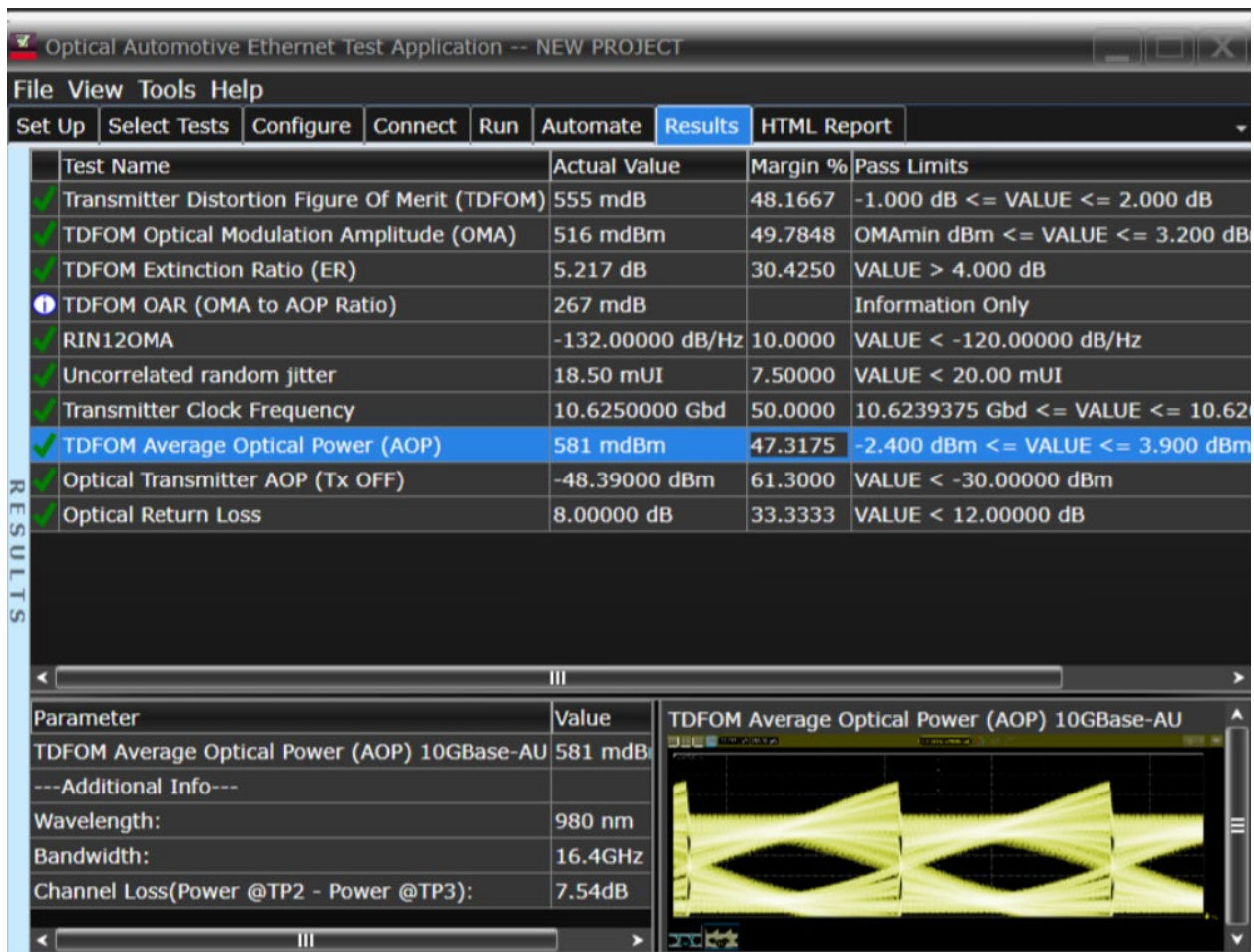


Figure 4. AE6980T test result screen

AE6980T Key Features

- Compliant test specs: IEEE 802.3cz:2023 (IEEE 802.3:2020 Amendment 7), and Open Alliance TC7 test house D1.0:2025
- Supported data rate: 10 Gbps (with 25 Gbps support in the future)
- Supported oscilloscope: Keysight N1092A and N1092C
- Supported clock recovery: Keysight N1077B
- Supported optical signal wavelengths: 850nm, 980 nm, 1310 nm, 1550 nm
 - Note: 980 nm wavelength selection requires user optical calibration on FlexDCA with a 980 nm CW optical source and a power meter.
- Supported channel loss compensation by manually applying channel loss of each channel component to move the measurement point from TP3 to TP2

Ordering Information

For Optical Transceiver 980nm PHY testing – PHY generating test patterns

Model	Description	Required Options and Features
N1092A or N1092C	DCA-M sampling oscilloscope - N1092A: single optical, no electrical channel - N1092C: single optical, dual electrical channels	280 (25-28 Gbaud filters) 30A (30GHz amplified) - FS1 (fast sampling rate) - IRC (Impulse response correction) - LOJ (Low jitter timebase) - PLK (Pattern lock capability)
N1077B	Optical clock data recovery	264 (125 Mbd to 64 Gbd input) - SXT (External splitter) - EVA (Integrated variable equalizer)
N/A from Keysight	Optical spectrum analyzer	To measure center wavelength and spectral width
AE6980T	nGBASE-AU Optical Automotive Ethernet Tx Test SW	IEEE 802.3cz transmitter test SW
N1010100A	FlexDCA sampling oscilloscope SW	Research and Development package option (L-RND)
N/A from Keysight	1:2 optical splitter with PLC type (A)	To connect the ferrule sleeve and DCA-M//CDR 10:90 split ratio, 980nm wavelength, 50/125 OM3 fiber type, FC/PC to FC/PC connectors, 0.5m – 1m
N/A from Keysight	FC/PC ferrule sleeve (B)	To connect fiber optic patch cord and optical splitter
N/A from Keysight	Fiber optic patch cord (C)	1m – 3m, automotive grade, for connecting DUT connector and FC ferrule sleeve
N/A from Keysight	Optical splitter with PLC type (D)	To connect the DUT optical connector and variable reflector//fiber patch cord
N/A from Keysight	Optical variable reflector (E)	To generate reflection back to the transmitter
N/A from Keysight	1:2 optical 90/10 splitter with PLC type (F) (optional)	To sense the optical power of the reflection. 90/10 split ratio, 980 nm wavelength, 50/125 OM3 fiber type, FC/PC to FC/PC connectors, 0.5m – 1m
N/A from Keysight	Fiber optic cord (G)	Automotive grade, for connecting DUT connector and FC ferrule sleeve

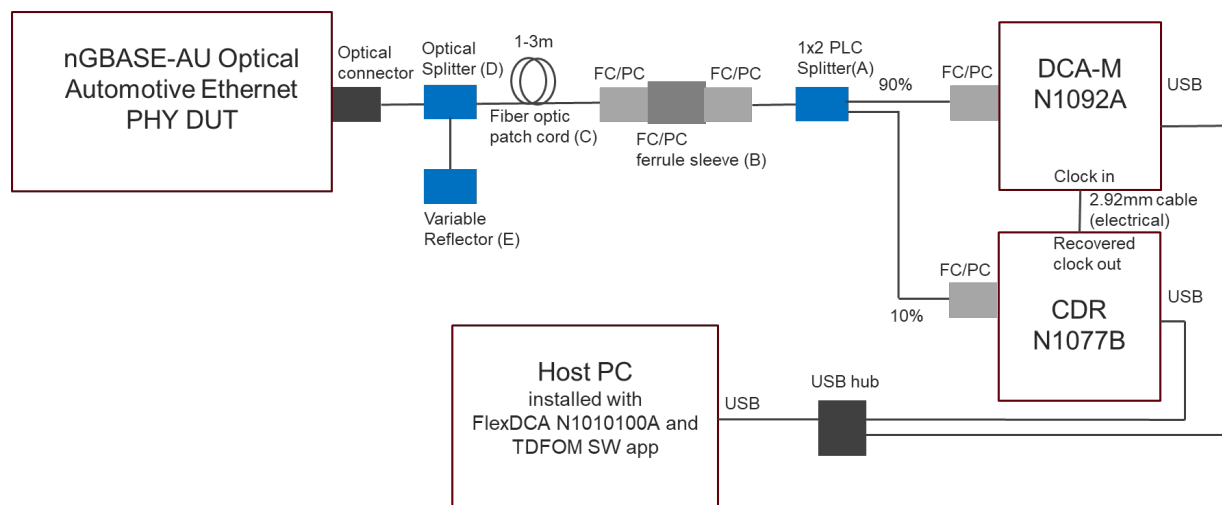


Figure 5. Transmitter PHY test block diagram example

For FOT (Fiber Optical Transceiver) testing – note that FOT doesn't generate test patterns

Model	Description	Required Options and Features
N1092C	DCA-M sampling oscilloscope N1092C: single optical, dual electrical channels	• 280 (25-28 Gbaud filters) • 30A (30 GHz amplified) • FS1 (fast sampling rate) • IRC (Impulse response correction) • LOJ (Low jitter timebase) • PLK (Pattern lock capability)
M8195A	65 GSa/s arbitrary waveform generator with an AXIe chassis	• 002 (2 channel) • M9502A-U20 (2 slot AXIe slot chassis) or M9505A-U20 (5 slot AXIe slot chassis)
B2900 Series (B2901C or B2902C)	Precision source measurement unit	To supply bias current to the FOT
N/A from Keysight	Optical spectrum analyzer	For measuring center wavelength and spectral width
AE6980T	nGBASE-AU Optical Automotive Ethernet Tx Test SW	IEEE 802.3cz transmitter test SW
N1010100A	FlexDCA sampling oscilloscope SW	Research and Development package option (L-RND)
N/A from Keysight	Fiber optic patch cord	1m – 3m, automotive grade, for connecting DUT connector and FC/PC connector of N1092C
N/A from Keysight	Optical variable reflector (E)	To generate reflection back to the transmitter
N/A from Keysight	1:2 optical 90/10 splitter with PLC type (F) (optional)	To sense the optical power of the reflection.

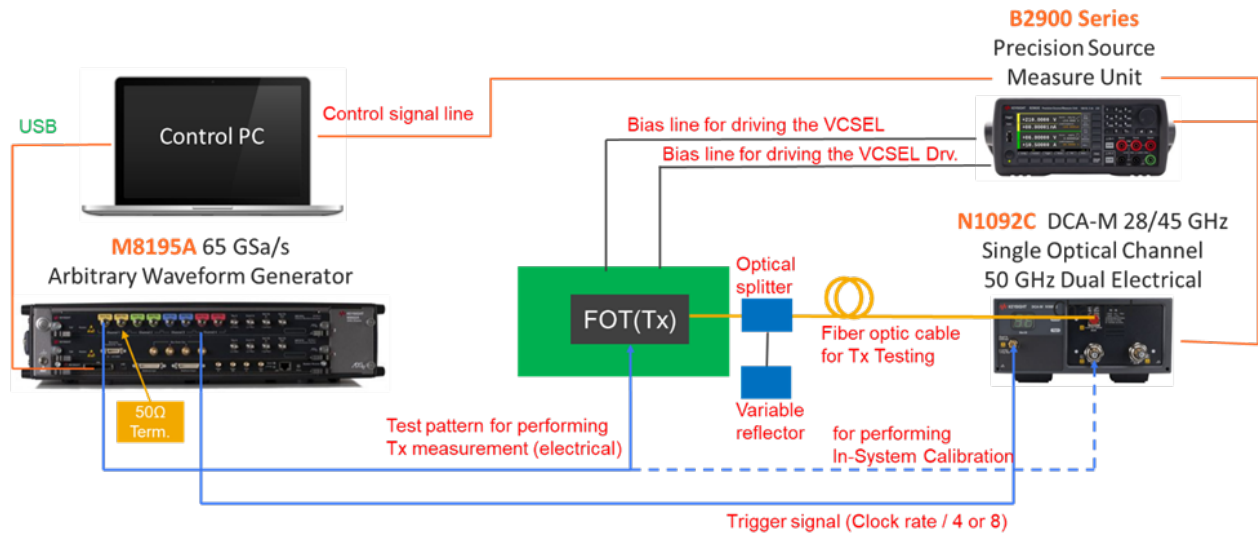


Figure 6. FOT transmitter test block diagram example

For 980 nm wavelength use calibration for the N1092x DCA-M optical channel

DCA optical calibration procedure can be found here. https://helpfiles.keysight.com/scopes/FlexDCA-PG/Content/Topics/Commands/CALibrate/aa_FlexDCA_optical.htm

Model	Description	Required options
N/A from Keysight	980 nm CW optical source	Source optical power level (for DCA-M with Option 30A) - Allowable: 500 uW to 2.5 mW - To meet specifications: 500 uW to 1mW
N/A from Keysight	Optical power meter	Supporting 980 nm wavelength and optical power range of the source

Software License Types for AE6980T

Keysight offers a variety of flexible licensing options to fit your needs and budget. Choose your license term, license type, and KeysightCare software support subscription. Licenses are available either as node-locked, transportable, USB portable or floating and can be purchased with 6, 12, 24, or 36 months of support.

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1. Americas (North, Central, and South America, Canada); Europe (European Continent, Middle Eastern Europe, Africa, India); Asia (North and South Asia Pacific Countries, China, Taiwan, Japan).

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Selecting Your License

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Step 3. Choose your license type: node-locked, transportable, USB portable, or floating.

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