Agilent N4391A Optical Modulation Analyzer

Get insight into amplitude, phase and polarization modulated optical signals

Data Sheet

Agilent Technologies

Introduction

The N4391A optical modulation analyzer is a new type of optical test instrument for in-depth analysis of optical transmission signals operating with advanced modulation format.

The instrument is based on a 90000 Infiniium oscilloscope, a special version of the 89600 vector signal analysis software and an optical polarization-diverse coherent receiver. Depending on the test needs, the instrument can be configures to best fit the application. In addition it is possible to use a non-Agilent data acquisition system.

The Agilent 89600 vector signal analysis software is a very flexible tool for in-depth analysis, leveraging the know-how of the RF world into the optics world.

The optical coherent receiver is ready to support comprehensive characterization of data rates up to and beyond 100Gbit/s, depending on the data acquisition unit and modulation scheme.

New analysis tools for the optics world imported from the RF-world, offer comprehensive characterization of complex modulation, and offer new ways to characterize the new parameters needed to qualify transmission of 100Gbit/s over a 50 GHz-wide channel with advanced modulation formats.

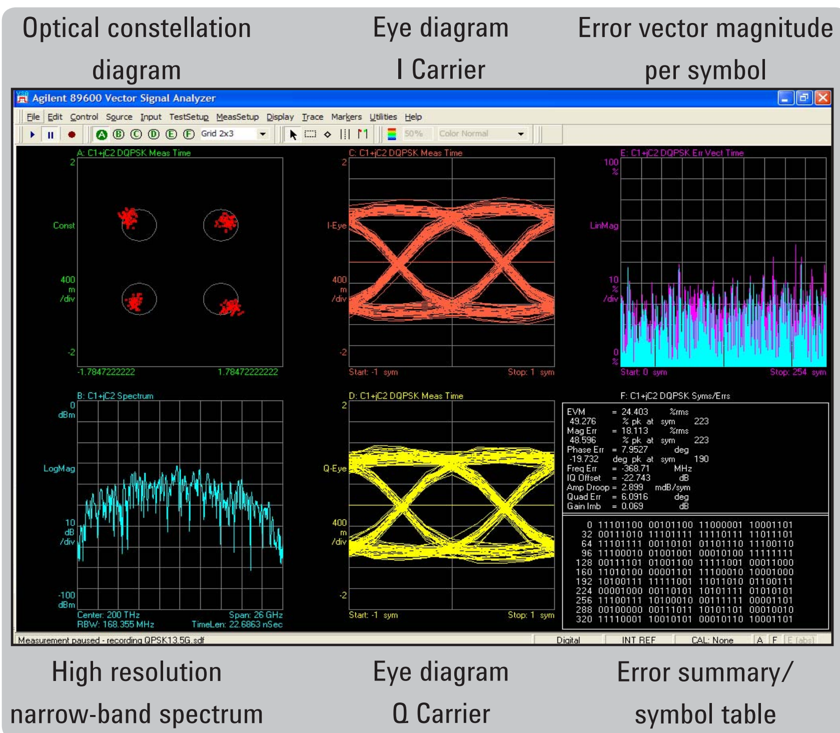


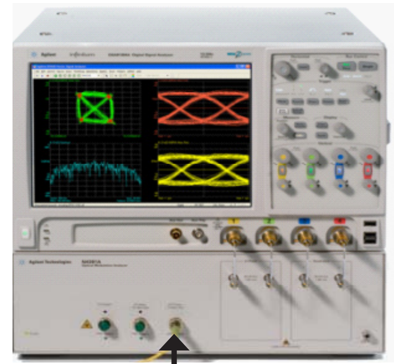
Figure 1.

Features and Benefits

- Wide-bandwidth time-domain polarization-diverse coherent optical receiver, for state-of-the-art   advanced modulation format analysis.
- Specifications for instrument performance.
- Real-time sampling for optimal phase tracking.
- Highest flexibility, with numerous modulation formats, analysis tools and instrument configurations.
- In-depth analysis of optical transmitters and links with new analysis tools, such as constellation diagram with masks and error vector analysis.
- Optical constellation diagram with quantitative description of constellation errors for precise description of the transmitter, making test results comparable.
- Full support of DQPSK/DPSK with polarization multiplexed signals.
- No clock input or hardware clock recovery necessary.
- Long pattern analysis available depending on selected data storage option.
- Real-time high resolution spectral analysis
- Laser linewidth measurement
- Bit Error Analysis, even with polarization multiplexed signals
- Flexible hardware and software concept for future adoption to new requirements and investment protection.

Applications

The N4391A's most common application is the test of optical transmitters and subcomponents like modulators and modulator drivers. In this application, the output of the transmitter is connected to the N4391A. Now the transmitter biasing can be aligned in real-time and the constellation diagram shows potential distortions and imbalances between the I (in-phase axis) and Q (quadrature axis) carriers of the x and y polarization planes (Option 210/211).



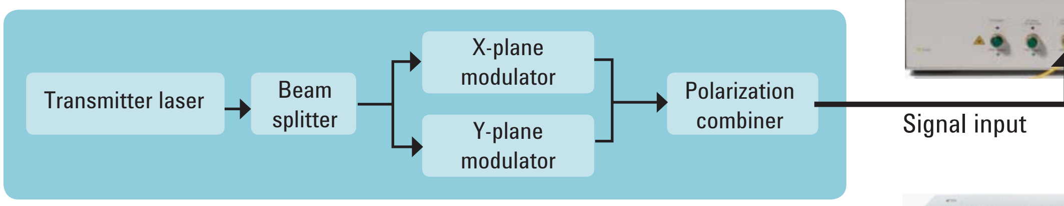


Figure 2.

An alternative application uses the transmitter laser as local oscillator for the coherent receiver of the modulation analyzer. In this applications any frequency offset between the carrier and local oscillator is avoided. This setup can be used to avoid any phase noise introduced by the local oscillator of the coherent receiver (Option 220).

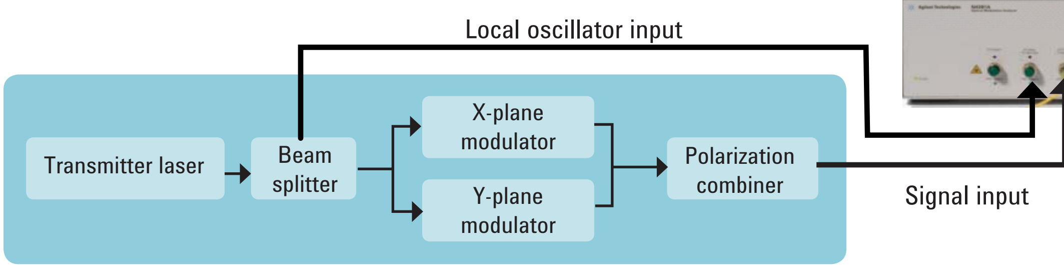


Figure 3.

Especially for modulator testing, it is useful to access the instrument's internal local oscillator. This signal, available at the output of the optical receiver, can be fed into the input of an optical modulator to provide the carrier. As in the setup above, no frequency offset occurs in the system, eliminating all uncertainties due to frequency offset or phase noise of the local oscillator (Option 211/ 220).

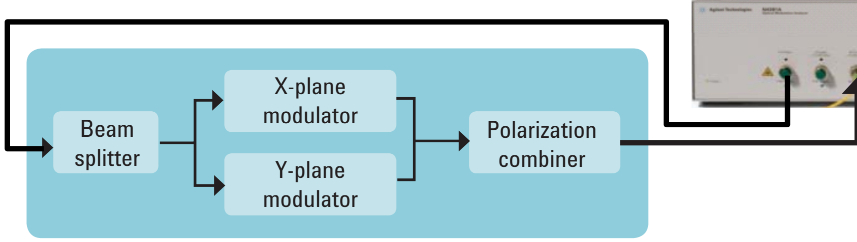


Figure 4.

These applications are closely related to transmitter characterization. In systems which use advanced modulation formats, tests at the receiver side of the transmission are also needed to compare the impairments of the transmission line to the quality of the constellation of the signal. For this kind of test, results provided by the optical modulation analyzer depend on the internal data processing. Different data processing in the user's receiver may result in a different bit error ratio than measured by the test instrument.

Constellation and Eye Diagram Analysis

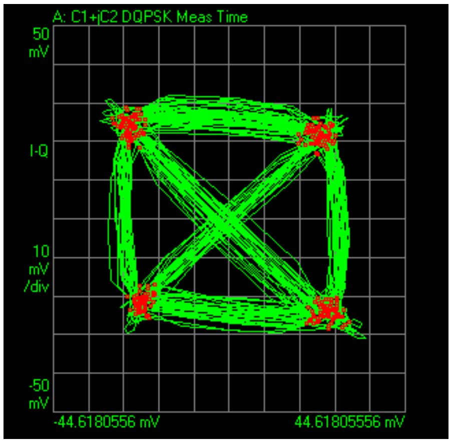


Figure 5.

Optical I-Q diagram

The I-Q diagram (also called a polar or vector diagram) displays demodulated data, traced as the in-phase signal (I) on the x-axis versus the quadrature-phase signal (Q) on the y-axis.

This tool gives deeper insight into the transition behavior of the signal, showing overshoot and an indication of whether the signal is bandwidth limited when a transition is not close to a straight line.

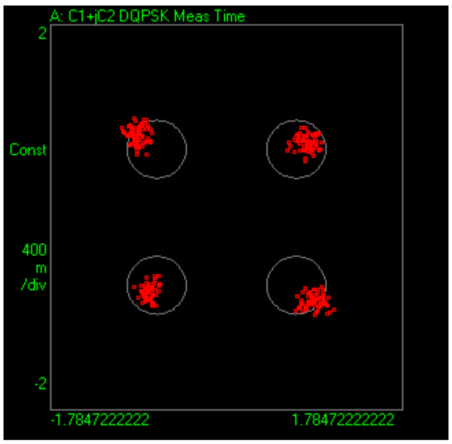


Figure 6

Optical constellation diagram

In a constellation diagram, information is shown only at specified time intervals. The constellation diagram shows the I-Q positions that correspond to the symbol clock times. These points are commonly referred to as detection decision-points, and are interpreted as the digital symbols. Constellation diagrams help identify such things as amplitude imbalance, quadrature error, or phase noise.

The constellation diagram gives fast insight into the quality of the transmitted signal as it is possible to see distortions or offsets in the constellation points. In addition, the offset and the distortion are quantified by value for easy comparison to other measurements.

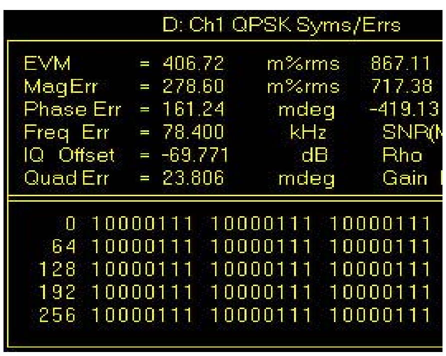
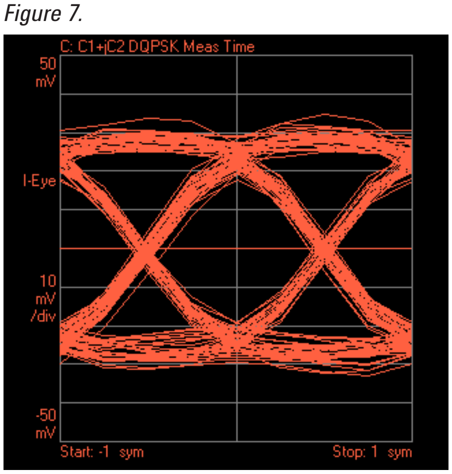


Figure 7.

Symbol table/error summary

This result is one of the most powerful of the digital demodulation tools. Here, demodulated bits can be seen along with error statistics for all of the demodulated symbols. Modulation accuracy can be quickly assessed by reviewing the rms EVM value. Other valuable parameters are also reported as seen in the image below.

- I-Q offset
- Quadrature error
- Gain imbalance



Eye diagram of I or Q signal

An eye diagram is simply the display of the I (real) or Q (imaginary) signal versus time, as triggered by the symbol clock. The display can be configured so that the eye diagram of the real (I) and imaginary (Q) part of the signal are visible at the same time.

Eye diagrams are well-known analysis tools for optical ON/OFF keying modulation analysis. Here, this analysis capability is extended to include the imaginary part of the signal.

Figure 8.

Signal Integrity and Bit Error Analysis Tools

Error vector magnitude

The error vector time trace shows computed error vector between corresponding symbol points in the I-Q measured and I-Q reference signals. The data can be displayed as error vector magnitude, error vector phase, only the I component or only the Q component.

This tool gives a quick visual indication of how the signal matches the ideal signal.

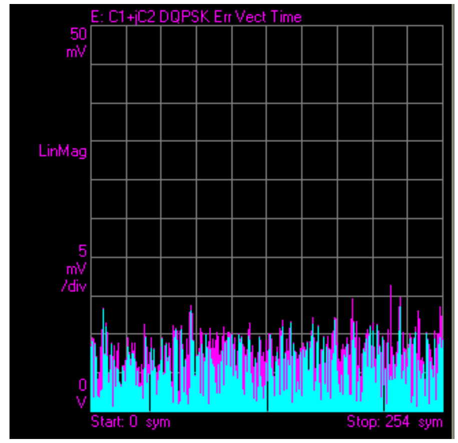


Figure 9.

$$\text{EVM}[n] = \sqrt{\text{I err}[n]^2 + \text{Q err}[n]^2}$$

Where [n] = measurement at the symbol time
I err = I reference – I measurement
Q err = Q reference – Q measurement

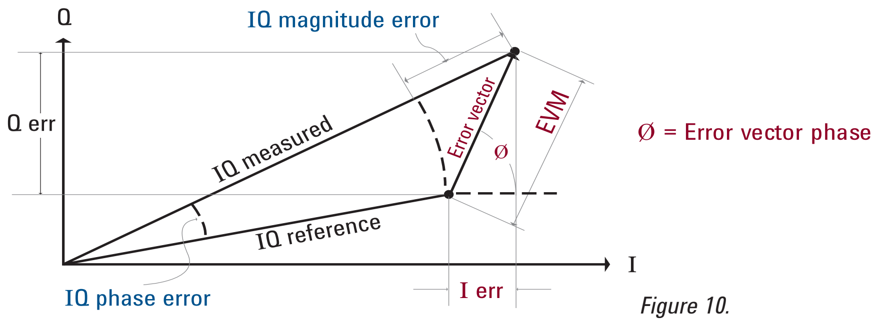


Figure 10.

Phase Error Analysis

The concept of error vector analysis is a very powerful tool, offering more than just EVM, it provides the magnitude and the phase error (Fig 13.) for each symbol or sample. The phase error is displayed for each sample point and each constellation point in the same diagram, showing what happens during the transition.

This information gives an indication about the shape of phase error. It can be a repetitive or a random-like shape, which can give a valuable indication about the source of the phase error, like in jitter analysis.

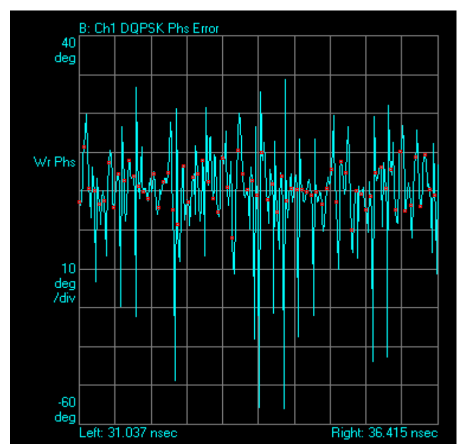


Figure 11.

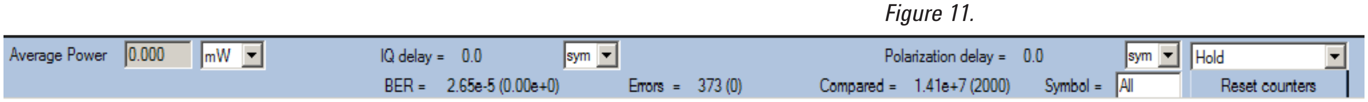


Figure 12.

Bit/Symbol/Error analysis

Beside the wide variety of physical parameters that can be analyzed, the optical modulation analyzer offers also an error analysis on bit and symbol level. Being able to detect the transmitted symbols and bits, enables comparison of the measured data against the real transmitted data. With PRBS of any polynomial up to 2^31 and the option for user defined patterns, the optical modulation analyzer is able to really count the symbol errors and to measure the bit error.

Having these analysis tools, it is now very easy to identify the error causing element either transmitter, link or receiver, if a classic electrical point to point BER test fails.

In addition this feature offers the option to perform a stress test to a receiver, by exactly knowing the quality of the receiver input signal and being able to compare to the overall BER of the system.

Spectral Analysis and Transmitter Laser Characterization

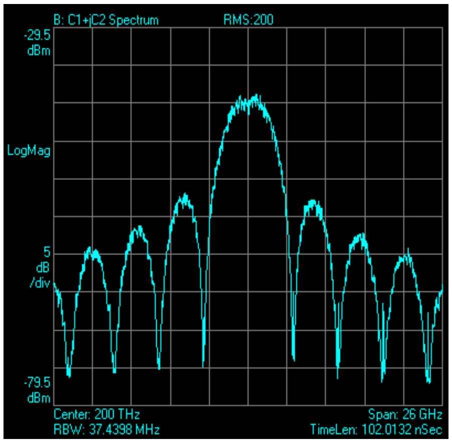


Figure 13.

Narrow-band, high-resolution spectrum

The narrow-band high resolution spectrum displays the Fourier-transformed spectrum of the time-domain signal. The center-frequency corresponds to the local oscillator frequency, as entered in the user interface.

This tool gives a quick overview of the spectrum of the analyzed signal and the resulting requirements on channel width in the transmission system. The spectrogram shows the evolution of the spectrum over time, offering the option to monitor drifts of the carrier laser (see Figure 14).

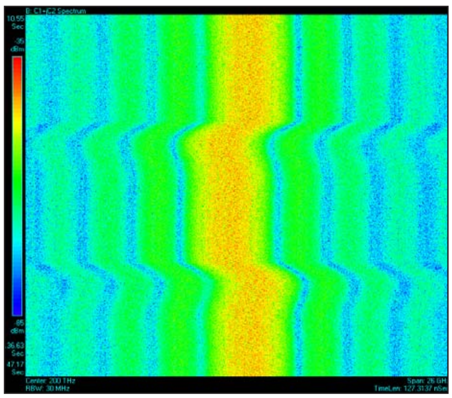


Figure 14.

Spectrogram

A spectrogram display provides another method of looking at trace data. In a spectrogram display, amplitude values are encoded into color. For the Spectrum Analyzer application, each horizontal line in the spectrogram represents a single acquisition record.
By observing the evolution of the spectrum over time ,it is possible to detect sporadic events that normally would not be visible as they occur only during one or two screen updates.
In addition, it is possible to so detect long-term drifts of a transmitter laser or even detect periodic structures in the spectrogram of a laser spectrum.

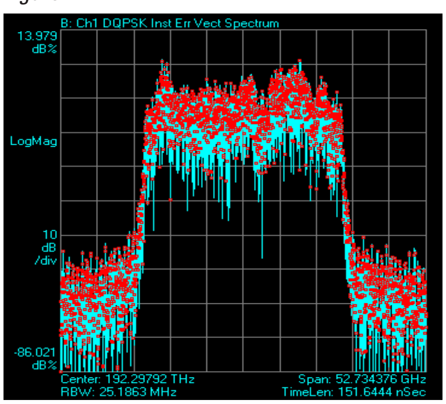


Figure 15.

Error vector spectrum

The EVM spectrum measurement is calculated by taking the FFT of the EVM versus time trace. Any periodic components in the error trace will show up as a single line in the error vector spectrum.
Using this tool to analyze the detected signal offers the posibility to detect spurs that are overlayed by the normal spectrum. Therefore spurs that are not visible in the normal signal spectrum can be detected. This helps to create best signal quality of a transmitter or to detect hard to find problems in a transmission system.

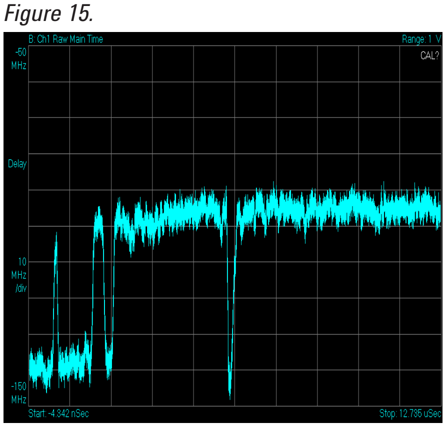


Figure 16.

Laser line-width measurement

In optical coherent transmission systems operating with advanced optical modulation formats, the performance of the transmitter signal and therefore the available system penalty depends strongly on the stability of the transmitter laser. The spectral analysis tools can display besides to the pure high resolution spectrum, the frequency deviation of the CW frequency of an unmodulated transmitter laser over a measured time period. In figure 16, the frequency deviation of a DFB laser is displayed on the Y-axis and the x-axis is scaled either in symbol number or time.
This gives an excellent insight into the time-resolved frequency stability of a laser and helps in detecting error causing mode-hopes.

Symbol Polarization Display

With real-time polarization-diverse detection, all information of the incoming electromagnetic field is available from the instrument. The polarization status of each detected symbol is displayed as a blue dot on the poincaré sphere. The example on the right side shows the typical distribution of a polarization multiplexed incoming signal with QPSK modulation.
This display shows the distribution of the symbols on the poincaré sphere and supports signal integrity test at each point in the optical link from transmitter to receiver.

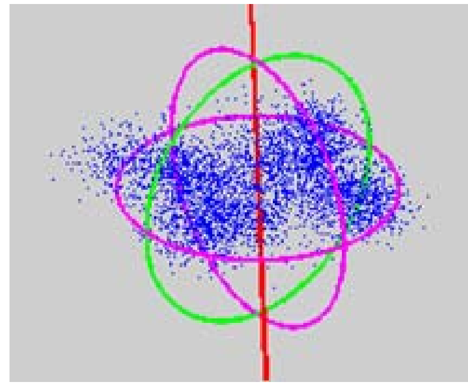


Figure 17.

36 Modulation Formats included

D8PSK

Differential 8-Phase Shift Keying (D8PSK) is a differential modulation format where the bits for a given symbol are determined by the phase change from the previous symbol. There are four possible phase state transitions (+/- (pi/6), +/- (pi/3), +/- (2pi/3), and +/- (5pi/6) radians) so each symbol represents $\log_2(8) = 3$ bits of data.

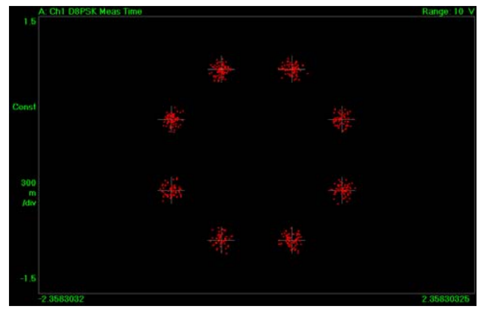


Figure 18.

16 QAM

Quadrature Amplitude Modulation is one hot candidate for next generation optical modulation after (D)QPSK. QAM 16 codes 4 bits in one symbol. Together with a polarization multiplexed transmission (dual polarization DP) a reduction of symbol rate from transmission data rate by a factor of 8 can be achieved.

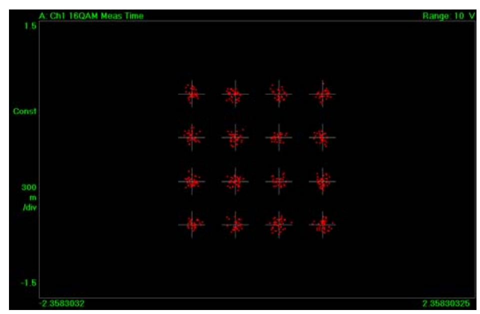


Figure 19.

32 QAM

32 QAM transmits 5 bits per symbol. In the N4391A, demodulation capabilities of up to QAM 1024 are already included.

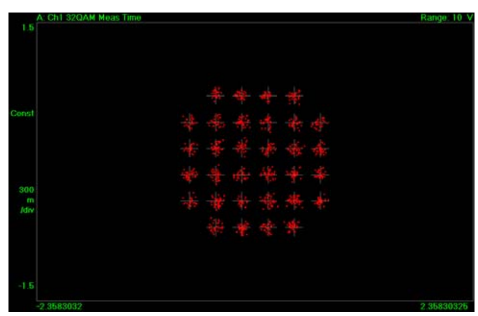


Figure 20.

The N4391A has 36 modulation formats already included. This makes the N4391A an ideal tool for advanced foreward looking research, as all the analysis tools are at hand and don't need time consuming algorithm implementing.

N4391A Theory of Operation Block Diagram

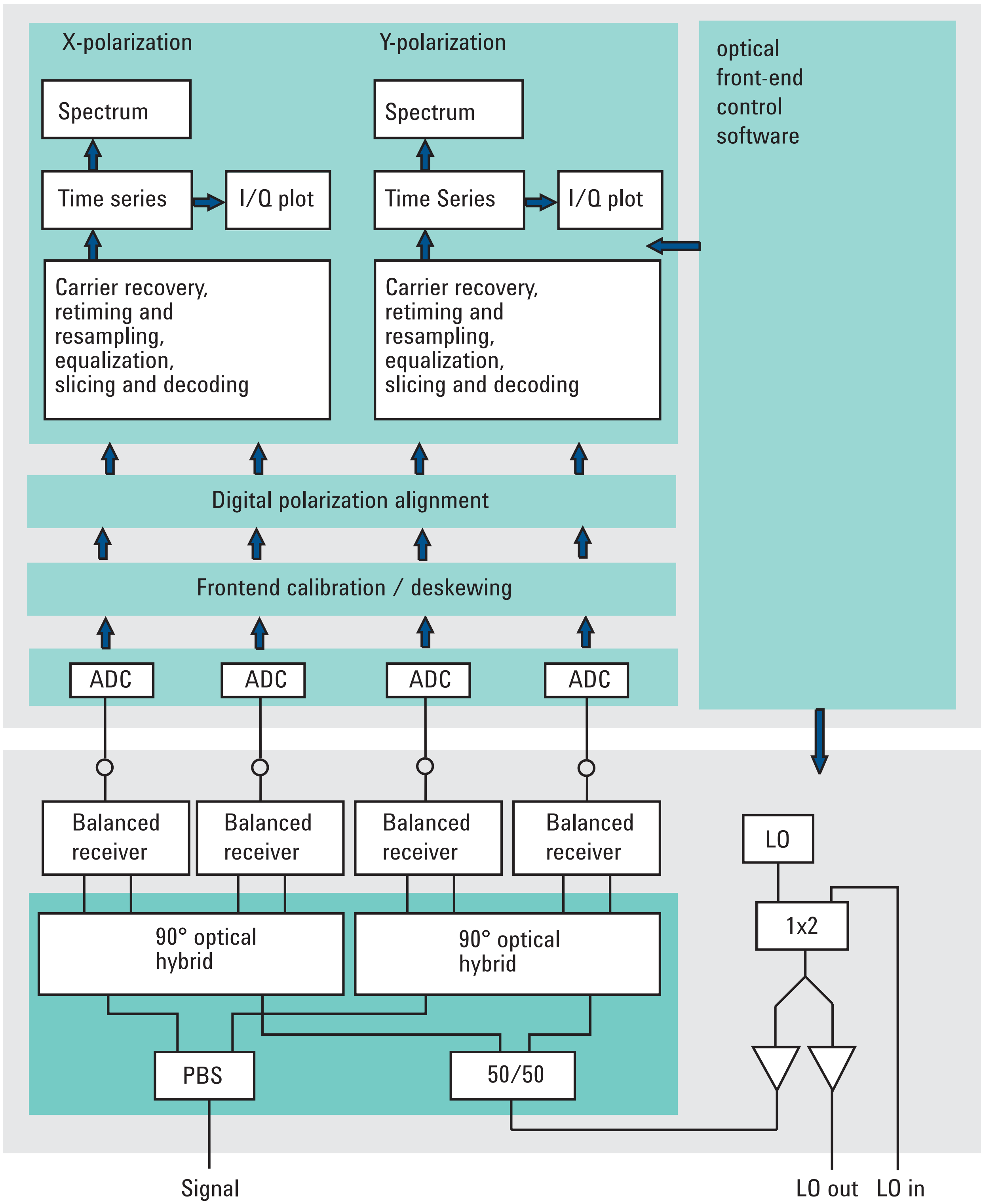


Figure 21. Block diagram of the optical modulation analyzer

Theory of Operation

The optical modulation analyzer makes use of the most advanced optical detection technology with a combination of coherent and polarization sensitive detection. The core building blocks are:

1. The optical polarization-diverse coherent receiver
2. The data acquisition unit
3. Polarization alignment
4. The 89600 vector signal analyzer software

Optical polarization-diverse coherent detection

The input signal provided to the receiver is split into x and y polarization planes and fed into an optical I-Q mixer (optical hybrid), for each polarization plane. The optical local oscillator beats with the signal in the I-Q mixer, resulting in a differential output signal of the I-Q mixer. For both polarization planes, I and Q differential signals are generated in the mixer. The four differential signals are detected with balanced detectors which convert the optical signals to RF signals.

The local oscillator is a tunable laser that is tuned to the ITU channel or wavelength selected by the user. The wavelength is constant during the data acquisition process. As the local oscillator will not match the carrier frequency exactly, a small signal offset will remain in the data. As long as this offset is within the signal bandwidth, this detection is called intradyne. The remaining offset will be removed later in the signal processing after the data acquisition.

To provide additional flexibility to the user, an external input with an SOA can be used instead of the internal local oscillator (see application description). The amplified external local oscillator signal is fed via a PMF switch, a beam splitter and a second SOA into the I-Q mixer.

The other output of the beam splitter provides the local oscillator output to the LO output of the instrument. Depending on the switch setting, either the internal local oscillator or the external local oscillator of the instrument is present at the local oscillator output and of course at the I-Q mixer.

Data acquisition unit

The optical modulation analyzer is based on a real-time sampling data acquisition system. This is the only way to keep track of phase changes in the optical signal, in contrast to sampling techniques that lose track of the optical phase. (For more details on this see white paper "*Comparing Concepts of Optical Modulation Analysis*").

The bandwidth of the data acquisition unit in combination with the selected modulation format determines the maximum baud rate that the optical modulation analyzer can detect.

The data acquisition memory stores all samples before signal processing starts. The size of this memory determines the pattern length that can be analyzed by the instrument.

Digital polarization alignment

The four differential signals represent the in-phase and quadrature terms for the x and y polarization planes defined by the receiver optics. These signals are not aligned with the horizontal and vertical polarization axis of the transmitter due to rotation of the polarization frames and polarization mode dispersion in the optical fiber. Mathematically this change can be described using a Jones matrix, which is a complex-valued 2 x 2 matrix. The polarization alignment algorithm calculates this matrix by a new proprietary algorithm. The two sets of in-phase and quadrature signals that represent the polarization planes of the transmitter are calculated by applying the inverse of the estimated Jones matrix that describes the optical connection.

89600 vector signal analyzer data processing

The heart of the digital demodulation process in the VSA is the digital demodulator. Figure 2 (next page) shows a simplified block diagram of the digital demodulator implementation used in the Agilent 89600 VSA. This general purpose demodulator only requires a minimum of prior information about the input signal to perform demodulation, and can be used on a wide variety of modulation formats. The demodulator provides carrier lock, symbol clock recovery, and bit recovery (decodes the actual raw bits), and produces the I-Q measured waveforms. The demodulator also produces ideal I-Q waveforms that are synthesized from the actual recovered bits (called I-Q reference waveforms). The I-Q measured and I-Q reference waveforms are subtracted to produce I-Q error waveforms.

The I-Q error waveforms are analyzed to generate the modulation quality data results, which can be viewed in various data formats and display outputs.

The demodulation process begins by configuring the demodulator to the specific digital modulation format.

The demodulator block diagram shown in Figure 2 shows the internal demodulator processes (enclosed in rectangular boxes) and the configuration parameters that you can set (enclosed by ovals or rounded rectangular boxes). The items enclosed by an oval identify configuration parameters that are required to define the demodulator for a measurement. The rounded rectangular boxes identify user-adjustable input parameters. At a minimum, the modulator requires the modulation format (QPSK, FSK, for example), the symbol rate, the baseband filter type, and filter alpha/BT (bandwidth time product). This set of parameters is generally sufficient for

the demodulator to lock to the signal and recover the symbols.
The VSA receives two independent I-Q data streams from the digital polarization processing stage. The demodulator uses the selected center frequency and symbol rate to lock to the carrier and recover the symbol clock from the modulated carrier. *Note that the demodulator reference clock does not need to be locked with the source clock*.

The demodulator automatically provides carrier and symbol lock; *there is no need to supply an external source clock.* The signal then goes through a compensation process that applies gain and phase correction. The compensation data (such as amplitude droop and I-Q offset error data) are stored and can be viewed in the error summary table.

Digital baseband filtering is then applied to recover the baseband I-Q waveforms (I-Q Meas Time data). The recovered I-Q waveforms are applied to a symbol detector that attempts to determine what symbols were transmitted, based upon the specified modulation format. From this block of symbols, the serial data bits (1s and 0s) are decoded and recovered.

Error detection concept

The reference generator uses the detected symbols in conjunction with the modulation format, the symbol rate, and the specified filtering, to synthesize an ideal set of I-Q reference baseband waveforms (I-Q ref time data). Finally, the measured I/Q wave-forms and reference I-Q waveforms are compared to produce a host of error characteristics (deviation from ideal) such as phase error, magnitude error, and error vector magnitude (EVM).

The quality of an I-Q modulated signal can be analyzed by comparing the measured signal to an ideal reference signal. The demodulator produces two waveforms: an I-Q measured wave-form and an I-Q reference waveform.

The I-Q measured waveform is the demodulated baseband I-Q data for the measured input signal, also called I-Q meas time. The I-Q reference wave-form is the baseband I-Q data that would result after demodulating the input signal, if the input signal were ideal (contained no errors), also called I-Q ref time.

The I-Q reference waveform is mathematically derived from the I-Q measured waveform recovered data bits, providing that the original data sequence can be recovered. The I-Q reference waveform generation begins by recovering the actual symbol bits from the demodulated I-Q measured waveform, and then reconstructing a sequence of ideal I and Q states. These states are then treated as ideal impulses and are baseband filtered according to the reference channel filtering, producing an ideal I-Q refer-ence waveform. The quality of the input signal can then be analyzed by comparing the I-Q measured waveform to the I-Q reference waveform. Subtracting the reference waveform from the measured waveform provides the error vector waveform, or I-Q error waveform. This technique can expose very subtle signal variations, which translates into signal quality informa-tion not available from traditional modulation quality measurement methods.

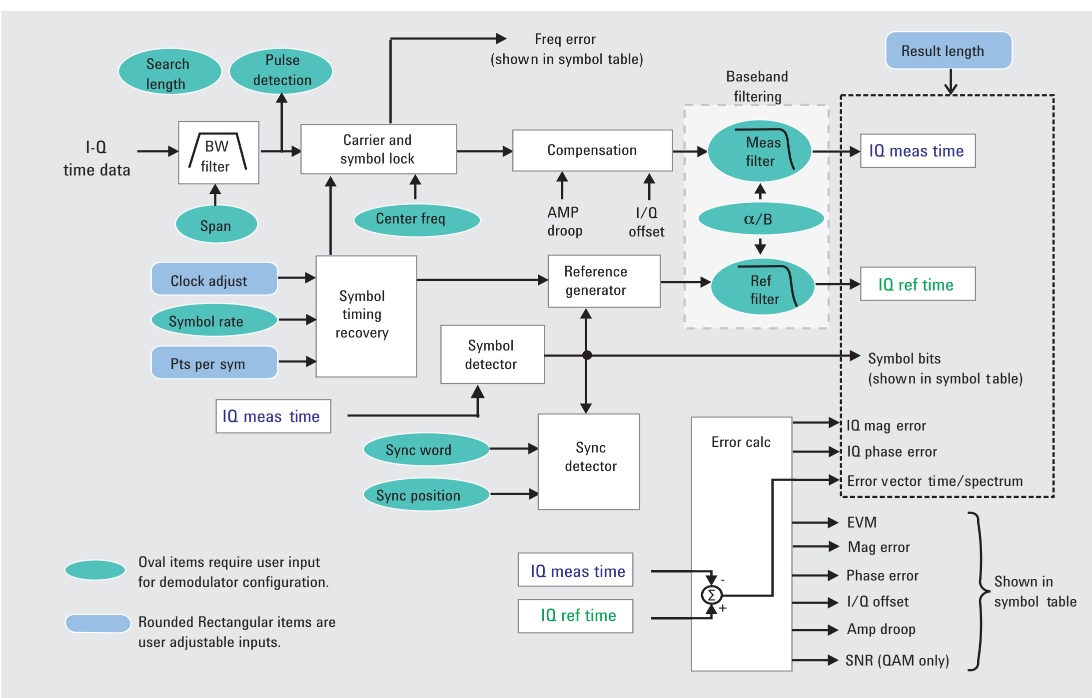


Figure 22. Block diagram: 89600 vector signal analysis software

Bit Error Ratio (BER)

The BER measurement is the logical extension of the error vector concept. Being able to detect the bits of the incoming signal it is a natural step to compare the received data to the sent data. After telling the system which PRBS polynomial was sent, the modulation analyzer is able to count the errors and calculate the BER by comparing the errors to the whole number of bits sent and detected by the N4391A. In addition a user defined vector can also be used, when the system gets the information in a stored data vector.
In modulated signals which are coded with more than one bit per symbol, there is always ambiguity in mapping the symbols to a bit sequence. This ambiguity must be resolved for BER measurements.
This is done in the optical modulation analyzer by starting with BER count at all four (for the case of QPSK) possible starting points of the bit sequence for the in case of a (D)QPSK signal. The BER corresponding to correct alignment with sent pattern will have the lowest BER, whereas all other have a higher number of errors. The phase alignment corresponding to the lowest BER during this first synchronization period will is used for the remaining symbols that have to be analyzed.
For signals that have a polarization-multiplexed data stream, this analysis can only be performed after the correct polarization alignment, since otherwise a stable constellation is not present and no bits can be detected.
In Figure 23 a relation between the EVM measured in %rms and the BER is displayed. Based on a simulation assuming Gaussian noise distribution around the constellation points of a Gray-coded QPSK signal with zero gain imbalance and no quadrature error.

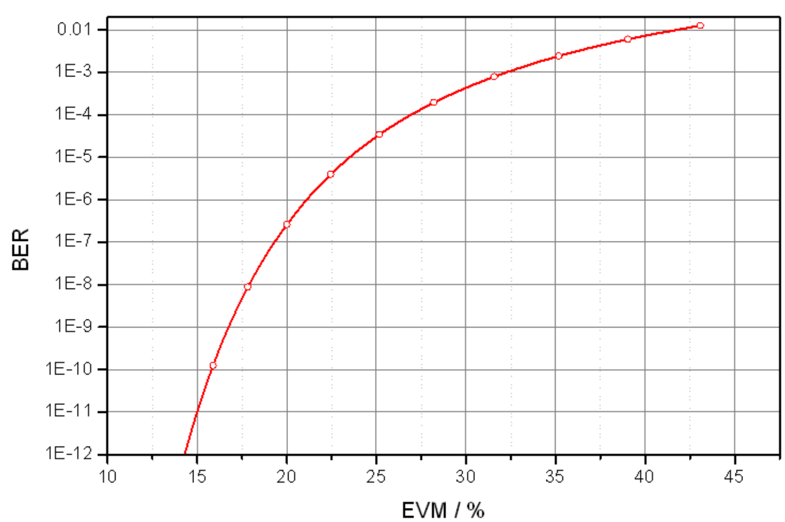


Figure 23. Simulated relation between BER and Error Vector Magnitude %rms

Definitions

Generally, all specifications are valid at the stated operating and measurement conditions and settings, with uninterrupted line voltage.

Specifications (guaranteed)

Describes warranted product performance that is valid under the specified conditions.
Specifications include guard bands to account for the expected statistical performance distribution, measurement uncertainties changes in performance due to environmental changes and aging of components.

Typical values (characteristics)

Characteristics describe the product performance that is usually met but not guaranteed. Typical values are based on data from a representative set of instruments.

General characteristics

Give additional information for using the instrument. These are general descriptive terms that do not imply a level of performance.

Digital Demodulation Measurement Conditions

- Data acquisition: DSA 91304A
- Office environment
- Signal power +7.5 dBm
- Scope range 20mV/div
- I-Q bandwidth 12.5 GHz
- (D)QPSK demodulation
- Single polarization aligned; carrier, phase linearization algorithm
- 500 symbols per analysis record
- Test wavelength 1550nm

Specifications

Table 1. Typical Specifications, if not specified otherwise

Optical modulation analyzer		
Description		
Maximum detectable bit rate		see Figue 24 below
Sampling record length		20 Ms/100 Ms/1 Gs per channel
Maximum recordable time at 40Gs/s		0.5 ms / 2.5 ms / 25 ms
Number of polarization alignment algorithms		6
Digital demodulation uncertainty		
Error vector magnitude		1.8 %rms
Amplitude error		1.1 %rms
Phase error		0.9°
Quadrature Error		0.05°
Gain imbalance between I and Q		< 0.007 dB
Image suppression		> 35 dB
S/N		> 60 dB
Supported modulation formats		
BPSK, 8BPSK, VSB -8, -16,	FSK 2-,4-,8,16 level	EDGE
Offset QPSK, QPSK, Pi/4 QPSK	DQPSK, D8PSK	DVB QAM 16, 32, 64, 128, 256
QAM 16-, 32- ,64-, 128-, 256-, 512-, 1028-	MSK type 1, type 2 CPM (FM)	APSK 16/32 (12/4 QAM)
StarQAM -16, -32		

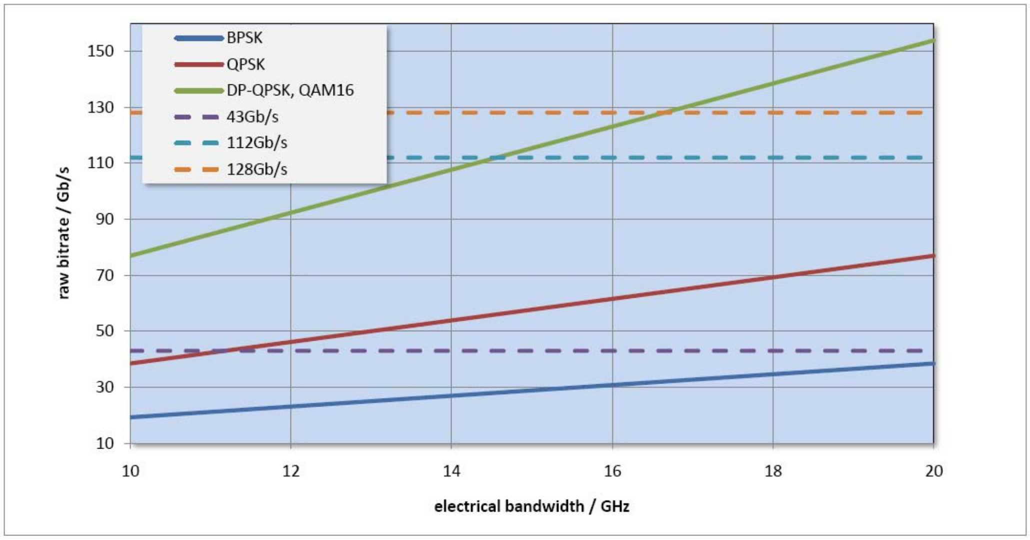


Figure 24. Detectable transmission rate, depending on detection bandwidth and modulation format

Table 2. Typical Specifications, if not specified otherwise

Coherent receiver	
Description	
Optical DUT input	
Optical input wavelength range	1528 nm to 1630 nm
Maximum input power	+14 dBm
Maximum input power, damage level	+20 dBm
Receiver polarization extinction ratio	> 40 dB
Average input power monitor accuracy	±0.5 dB
Optical local oscillator output	
Optical CW output power[1]	> +14 dBm
Wavelength range	1528 nm to 1630 nm
External local oscillator input	
Optical input wavelength range	1528 nm to 1630 nm
External local oscillator input power range	0 dBm to +14 dBm
Maximum input peak power (damage level)	+ 20 dBm
Small signal gain, external laser input to local oscillator output (-20 dBm LO input power)	28 dB @ 1550 nm
Saturation output power @ -3 dB compression	15 dBm
Other	
Electrical bandwidth	43 GHz, 37 GHz guaranteed,
Optical phase angle of I-Q mixer after correction	90° ± 0.5°
Skew after correction	±1 ps

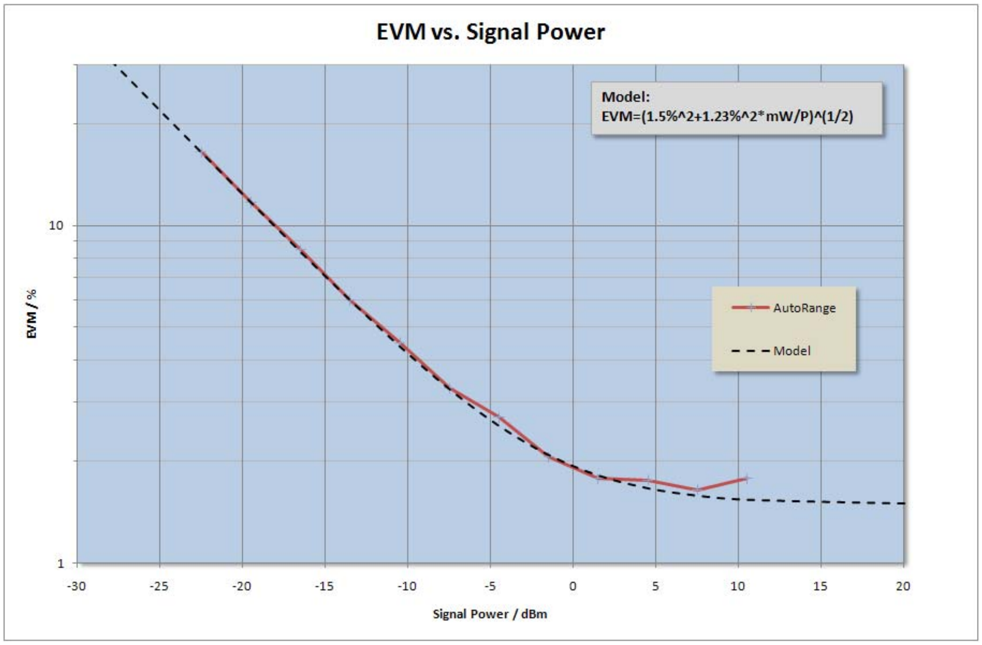


Figure 25. EVM %rms dependend on average optical input power

This diagram shows the % Error Vector Magnitude (EVM) normalized to the highest error vector within the analysis record of 500 symbols as a function of signal input power. The EVM % level at higher power levels results from the instrument noise level. The increase at lower signal power levels is a result of decreasing signal to noise ratio. The fitted model reveals the EVM % noise floor in the offset term.

Table 3. Typical Specifications, if not specified otherwise

Data Acquisition	
Description	
Sample rate	40 GSa/s on each channel
Data acquisition bandwidth	13 GHz
DC gain accuracy	2 %
Noise	3.37 mVrms
ADC resolution	8 bit / 16 bit (interpolated)
Sample memory per channel (option 300 / 301 / 302)	20Ms/ 100Ms / 1Gs

Local oscillator (LO)	
Description	
Wavelength range	1528 nm to 1630 nm
Minimum wavelength step	1 pm
Minimum frequency step	100 MHz
Absolute wavelength accuracy	± 5 pm
Stability (short term)	100 kHz
Sidemode suppression ratio	≥50 dB
External LO supported	options -200, -211, -220

High resolution spectrometer		
Description		
Maximum Frequency span		LO frequency ±13 GHz
LO wavelength range		1528 nm to 1630 nm
Image suppression		> 35dB
Number of FFT points		409601
Minimum RBW (record length 10^6 points)		4 kHz
Signal to noise ratio		60 dB@ 7.5 dBm signal input power
Frequency accuracy	absolute	± 5 pm

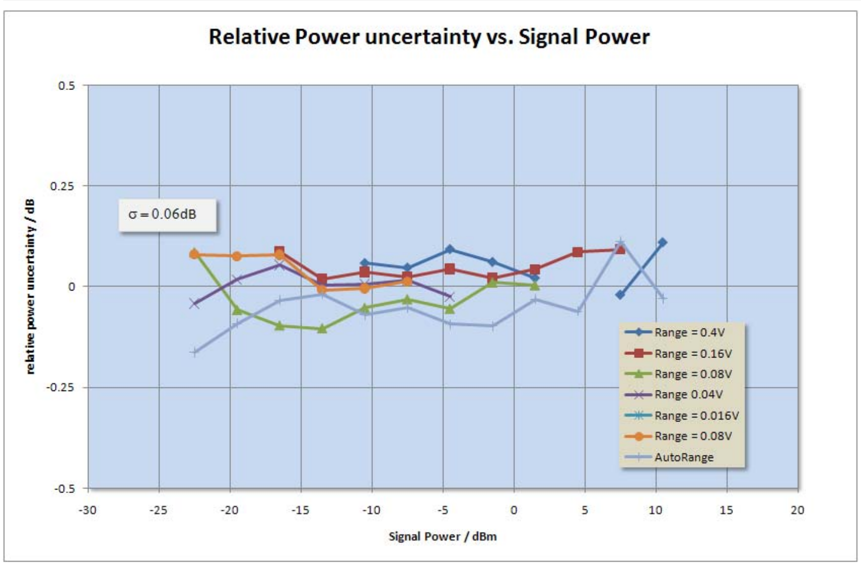


Figure 26. Relative power uncertainty of N4391A

[1] with internal local oscillator @ 1550 nm

Table 4. Analysis Tools

Measurement display and analysis tools	
Description	
Constellation diagram	
I-Q diagram	
Eye diagram for I and Q signal	
Error vector magnitude	
Spectrum	
Spectrogram	
Spectral analysis tools	band power, various peak search markers, limit detection
Error vector spectrum	
Detected bits	
Phase error	
Amplitude error	
Raw data vs time	
Phase vs time	
Group delay	
Frequency offset	
Quadrature error	
IQ offset	
Gain imbalance	
Data recoding	
Data export formats	Matlab(Version 4, 5), csv, txt, sdf, sdf fast,
Raw data replay with different parameter setting	
Adaptive equalization	
Bit Error Ratio measurements	Number of counted bits/symbols
	Numbers of errors detected
	Bit error ratio
	Stop acquisition on detected error
Coupled markers over different displays	
Off-line processing	using Agilent 89600 Vector Signal Analyzer software on separate PC

Mechanical Outlines (dimensions in mm)

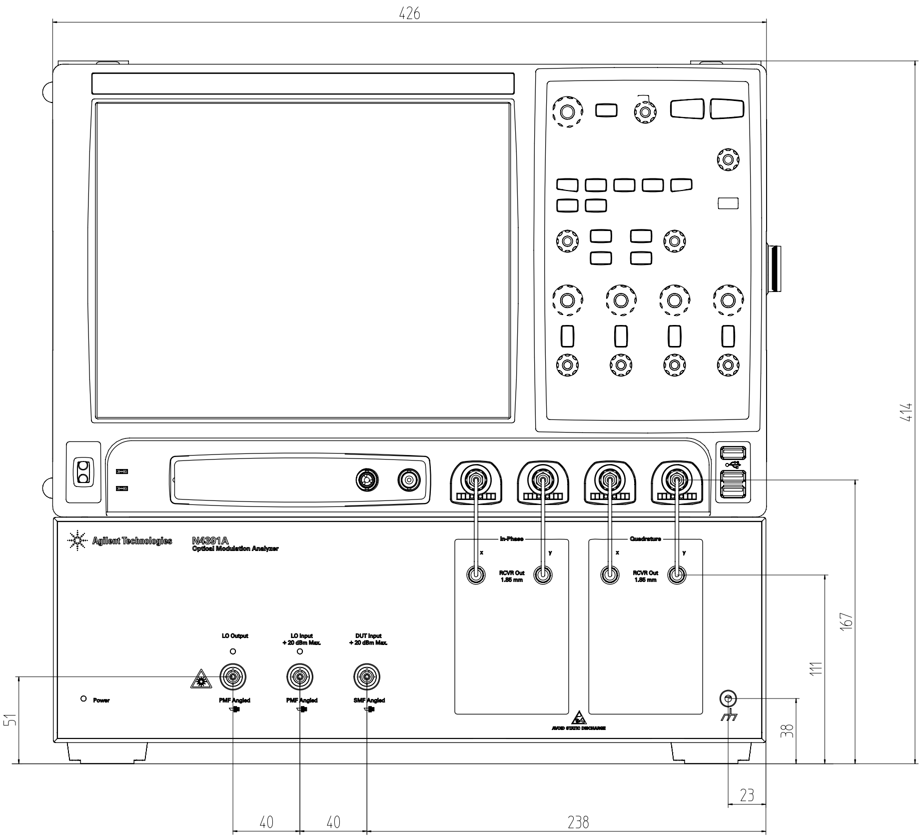


Figure 15.

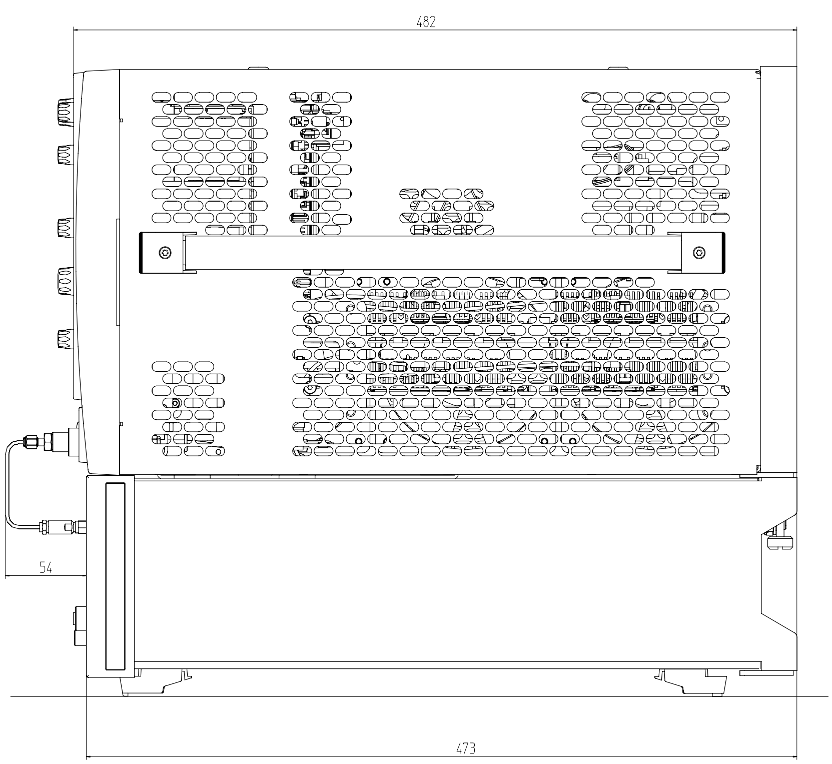


Figure 25.

General Characteristics

Assembled dimensions: (H x W x D)

41.4 cm x 42.6 cm x 47.3 cm,
(16.3 in x 16.8 in x 18.6 in)

Weight

Product net weight:
Optical receiver 15 kg (33 lbs)
DSA 91304 20 kg (44 lbs)

Packaged product:
60 kg (132 lbs)

Power requirements

100 to 240 V~, 50 to 60 Hz
2 power cables

DSA 91304	max.	800 VA
Optical receiver:	max.	300 VA

Data aquisition unit

Option 300	DAS 91304A-20M
Option 301	DAS 91304A-100
Option 302	DAS 91304A-01G

Storage temperature range

-40° C to +70° C

Operating temperature range

+5° C to +35° C

Humidity

15% to 80% relative humidity, non-condensing

Altitude (operating)

0 ... 2000 m

Recommended re-calibration period

1 year

Shipping contents

1 x	N4391A optical modulation analyzer including DSA91304 Infiniium oscilloscope, depending on ordered configuration
2/4 x	RF Cable, receiver to oscilloscope (quantity depends on configuration)
1-3 x	81000NI FC/APC connector interface (quantity depends on selected option)
2/4 x	Precision BNC connector (quantity depends on configuration)
1x	USB type A to type B cable
1x	Keyboard
1x	Mouse
1x	Local power cord
1x	Local high power cord
1x	Getting started manual
1x	Calibration cable
1x	Torque wrench
1x	8 mm wrench
1x	Wrist band for ESD protection
3x	Stylus for touch screen

Optional

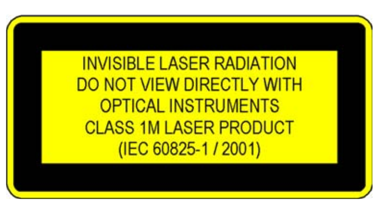
1x Optical Modulation Analyzer Bit Error Ratio measurement software license

Coherent receiver optical input

DUT input	+ 20 dBm max, 9 µm single-mode angled, 81000 connector interfaces
LO input	+ 20 dBm 9 µm single-mode angled, 81000 connector interfaces
LO output	+ 20 dBm max 9 µm single-mode angled, 81000 connector interfaces

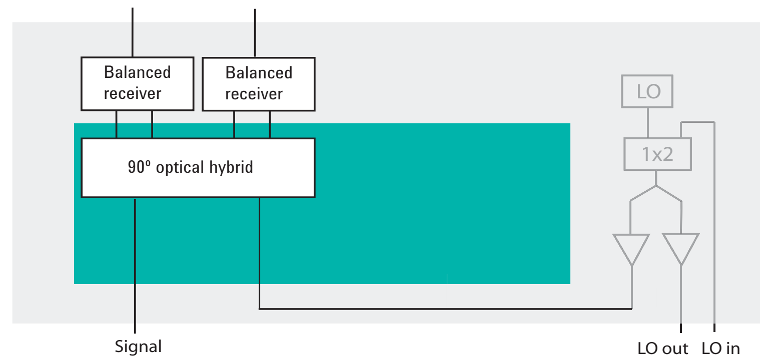
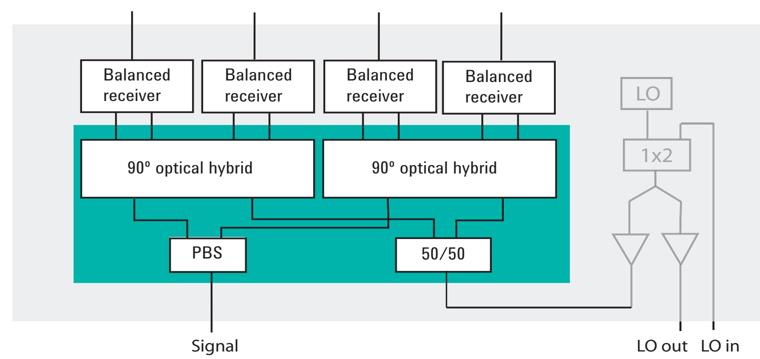
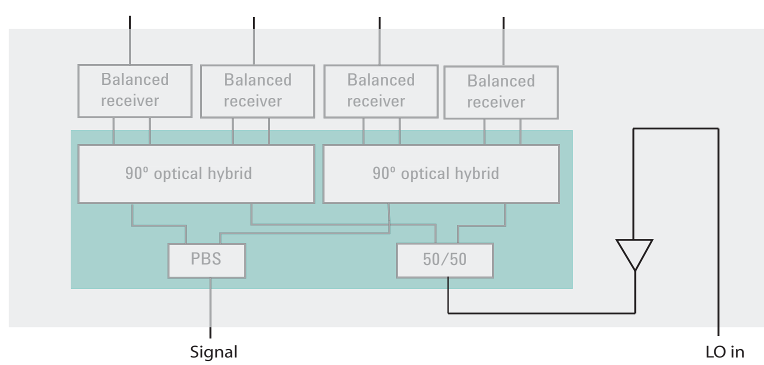
Laser safety information

All laser sources listed above are classified as Class 1M according to IEC 60825 1 (2001). All laser sources comply with 21 CFR 1040.10 except for deviations pursuant to Laser Notice No. 50, dated 2001-July-26.



Receiver Options Description

Table 4 provides a description and a block diagram of the optical receiver for each configuration. Note that Options 100 and 110 can be combined with each of the 2xx option blocks.

<table>
<tr><th>Product number</th><th>Option description</th></tr>
<tr><td>Figure 17. N4391A-100</td><td>2 channel optical coherent receiver, if no polarization multiplex is required.
This option can be combined with any of the Options #200 - #220.
External polarization controller is required.

</td></tr>
<tr><td>Figure 18. N4391A-110</td><td>4 channel optical coherent receiver for polarization multiplexed signals.
This option can be combined with any of the Options #200 - #220.

</td></tr>
<tr><td>Figure 19. N4391A-200</td><td>Coherent optical receiver without internal local oscillator. Local oscillator must be provided by the user and is amplified by an internal semiconductor amplifier (SOA).
This option can be combined with Options 100 or 110.

</td></tr>
</table>

Product number	Option description
	Internal local oscillator only. This option can be combined with Options 100 or 110.

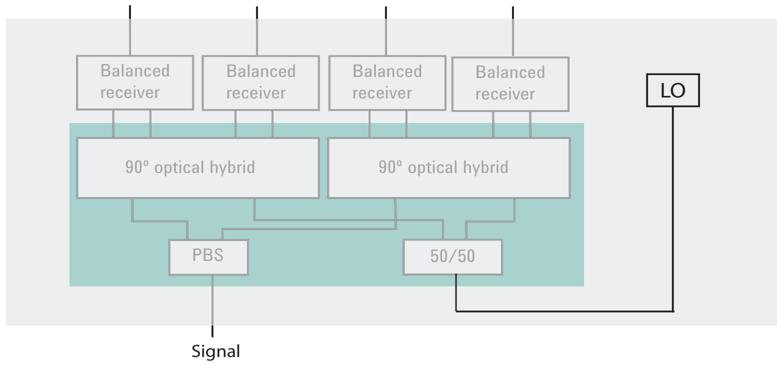


Figure 20. N4391A-210

Internal local oscillator with local oscillator output.
This option can be combined with Options 100 or 110.

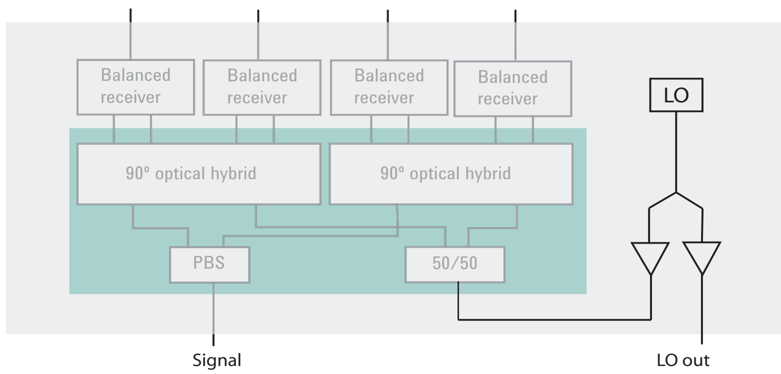


Figure 21. N4391A-211

Internal and external local oscillator can be used to down-convert the optical signal. Depending on the selection in the user interface, either the internal or the external local oscillator is provided to the instrument. This option can be combined with Options 100 or 110.

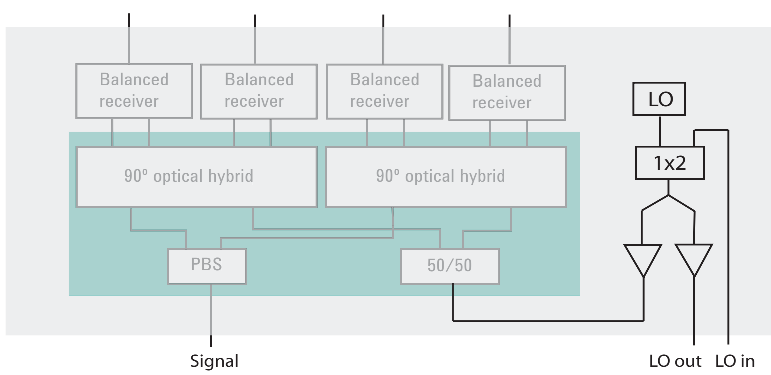


Figure 22. N4391A-220

Ordering Information

Table 5. Configuration and ordering information

Select from each block (-1xx to -3xx) one option. Extended analysis packages (-4xx) are optional.

Optical modulation analyzer	
Model number	Receiver options
N4391A -100	Optical modulation analyzer 100G with 2 channel receiver
N4391A -110	Optical modulation analyzer 100G with 4 channel receiver
	Local oscillator options
N4391A -200	External local oscillator input
N4391A -210	Internal local oscillator
N4391A -211	Internal local oscillator with local oscillator out
N4391A -220	Internal local oscillator and external local oscillator input with local oscillator out
	Data acquisition options
N4391A-300	Data acquisition with 20 M memory (DSA91304)
N4391A-301	Data acquisition with 100 M memory (DSA91304)
N4391A-302	Data acquisition with 1 G memory (DSA91304)
N4391A-310	Integration of customer's DSA/DSO91304A
N4391A-E01	Integration of non-Agilent data acquisition (no system specifications)
	Extended analysis options
N4391A-400	BER analysis license

Warranty	Description
R-51B-001-3C	1-year return-to-Agilent warranty extended to 3-years
R-51B-001-5C	1-year return-to-Agilent warranty extended to 5-years

Calibration	Description
R-50C-011-3	Agilent calibration plan, 3 year coverage
R-50C-011-5	Agilent calibration plan, 5 year coverage

Related Agilent Literature

Table 6. Other publications

Publication title	Pub number
N4391A Optical Modulation Analyzer Data Sheet	5990-3509EN
Metrology of Optical Advanced Modulation Formats, White Paper	5990-3748EN
Webinar: "Coherent Detection of Polarization Multiplexed Amplitude and Phase Modulated Optical Signals"	
Webinar: "Rating optical signal quality using constellation diagrams"	
89600 Series Vector Signal Analysis Software 89601A/89601AN/89601N12 Technical Overview	5989-1679EN
AN 150-15: Vector Signal Analysis Basics Application Note	5989-1121EN
AN 1298: Digital Modulation in Communication Systems - An Introduction, Application Note	5965-7160E
Infiniium DSO/DSA 90000A Series Real-Time Oscilloscope Data Sheet	5989-7819EN

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