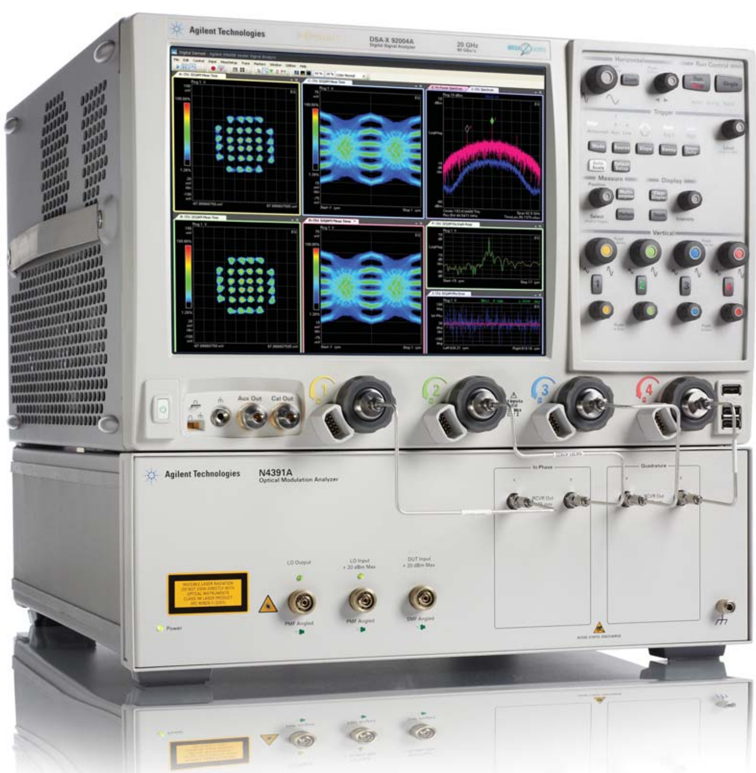
Agilent N4391A
Optical Modulation Analyzer

Measure with confidence

Your physical layer probe
for vector modulated signals
Data Sheet



Agilent Technologies

Measure with confidence

The N4391A provides you the highest confidence in tour test results.

This is achieved by providing system performance specification measured with the same parameter as you will specify the quality of your signal. This gives you the confidence that then N4391A measurement results really show the signal and not the instruments performance. This can be verified by you with a very easy setup within minutes.

The N4391A offers most sophisticated signal processing algorithms with highest flexibility

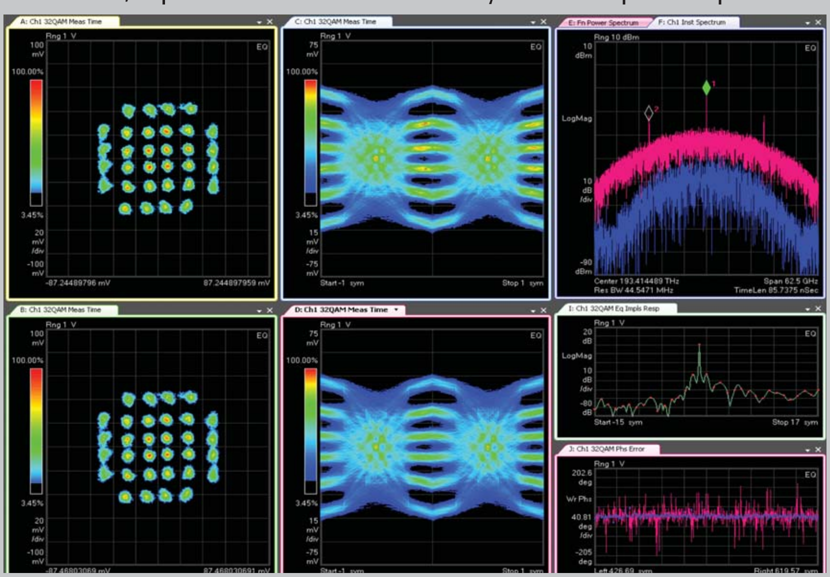
The algorithms provided with the instrument

- Detection of single and dual polarized user signals
- Transparent to most modulation formats
- In-Channel CD and PMD measurement and compensation
- Easy and flexible adoption of algorithm internal parameters to your needs
- In line Matlab debugging capabilities

The N4391A offers a powerful toolset to debug the most challenging errors, with tools proven by thousands of RF engineers

The analysis software is based on the industry standard Agilent Vector Signal Analysis (VSA) software with extensions for the optical requirements like dual polarization data processing. This analysis software is the work horse in RF and mobile engineering labs and offers all tools needed to analyze complex modulated (or vector modulated) optical signals. It provides a number of parameters that qualifies the signal integrity of your measured signal. The most common one is the normalized geometric error of the Error Vector Magnitude (EVM) of up to 4096 symbols. In addition the functionality can be extended with math and macro functions according to your needs.

Optical constellation 32 QAM, X plane	Color coded 32 QAM I -eye	Power spectrum Amplitude spectrum



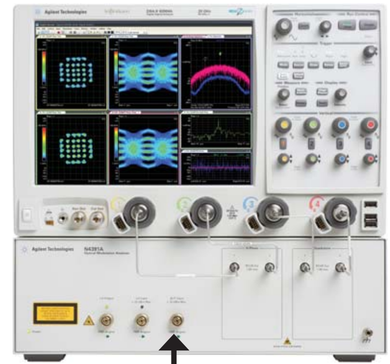
Optical constellation 32 QAM, Y plane	Color coded 32 QAM Q -eye	Equalizer response Phase error

Figure 1.

Features and Benefits

- Up to 32 GHz true analog bandwidth
- Up to 60 Gbaud symbol rate analysis capability
- Performance verification within minutes
- 4 times better noise floor than typical optical QPSK transmitters
- Economic light version available
- 4 channel polarization-diverse detection
- Real-time sampling for optimal phase tracking
- User selectable phase-tracking bandwidth.
- Specified instrument performance.
- Support of modulation formats for 100G and upcoming terabit transmission
- Uses error vector concept well-accepted in the RF world.
- No clock input or hardware clock recovery necessary.
- Analyzes any PRBS or real data.
- Real-time high resolution spectral analysis
- Laser line-width measurement
- Bit Error Analysis, even with polarization multiplexed signals
- CD and 1st-order PMD compensation and measurement.

Transmitter signal qualification application



Transmitter signal integrity characterization
- Transmitter performance verification
- Transmitter optimal alignment during manufacturing
- Transmitter vendor qualification
- Final pass fail test in manufacturing
- Evaluation of transmitter components for best signal fidelity

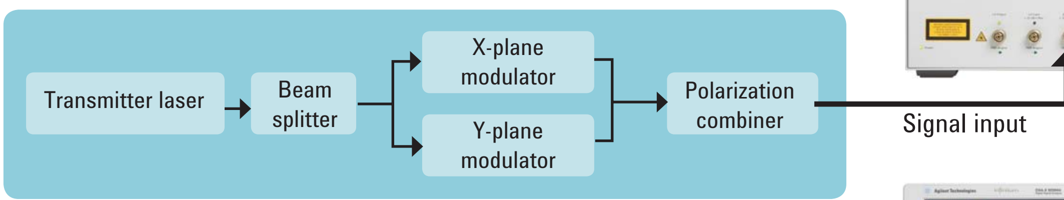
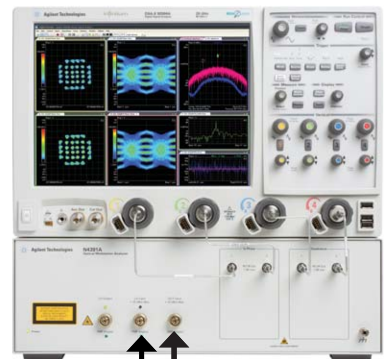


Figure 2.



Homodyne component characterization
- Component evaluation independent of carrier laser phase noise
- Modulator in system qualification
- Modulator-driver in-system amplifier performance verification
- Advanced debugging in R&D

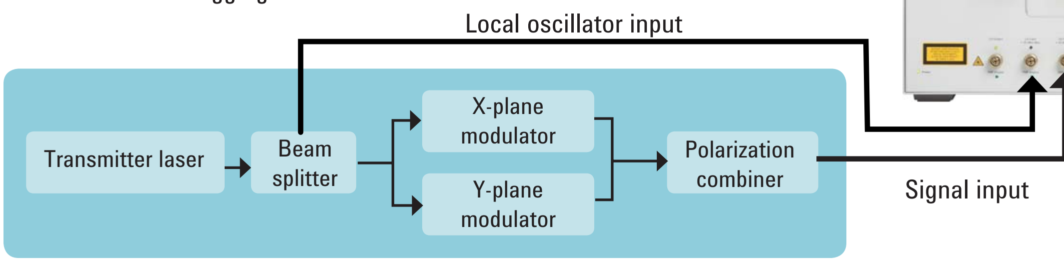
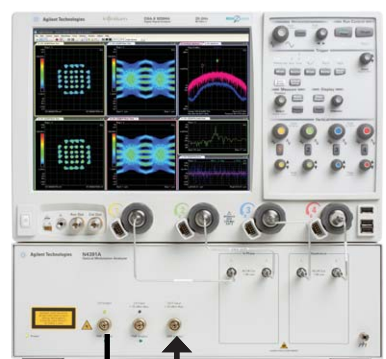


Figure 3.



Component evaluation
- Cost effective modulator evaluation
- Cost effective modulator driver evaluation
- Final specification test in application of IQ modulator
- Advanced research

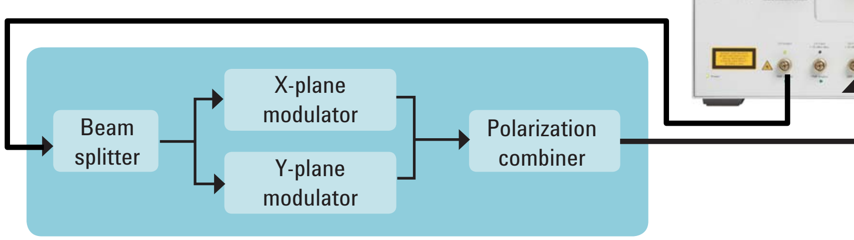


Figure 4.

Additional transmitter test applications
- Advanced research in highly efficient modulation formats
- Advanced debugging during development of a transmitter
- Carrier laser qualification
- BER verification at physical layer
- Signal analysis in Stokes-Space to verify polarization behavior of transmitter output. Figure 5 shows an example of an DP-QPSK signal distribution in the stokes space.

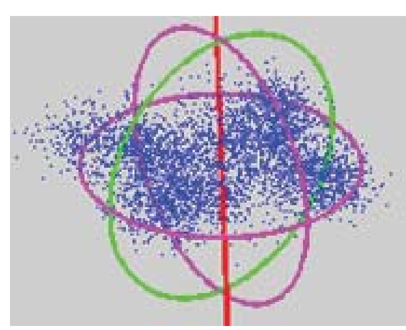


Figure 5.

Link test application

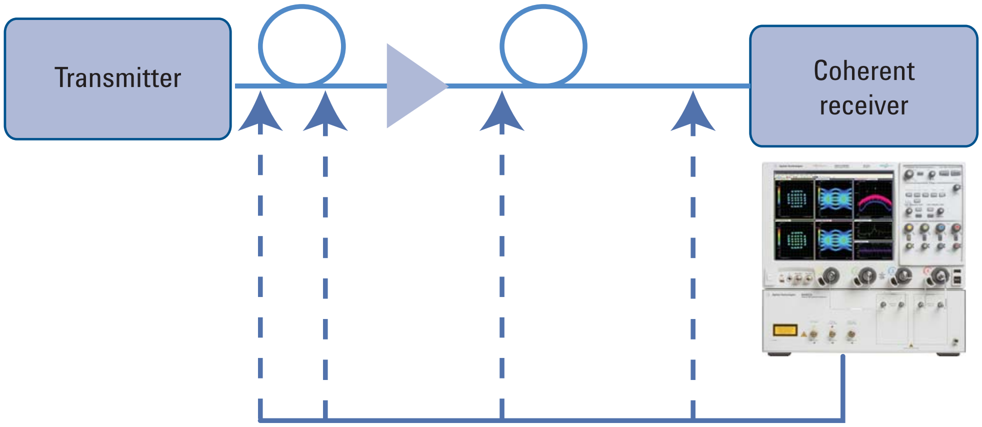


Figure 5.

Link qualification

New tools allow optical links to be characterized by measuring the link impairments on the vector modulated signal. Research engineers and scientists, who are interested in characterization of the performance of an optical link, now get the tools at hand to characterize vector modulated signals along the link down to the receiver.

Tools for link test

- CD compensation
- In-channel CD measurement
- PMD compensation
- In-channel 1-st order PMD measurement
- Trigger mode (gating) for loop experiments
- Selection of 4 different CD compensation algorithms
- Selection of 4 different PMD algorithms
- Error vector magnitude measurements as figure of merit for signal quality
- Physical layer BER
- Support of user defined algorithms

By using these tools it is very easy to create diagrams showing the signal quality influenced by various link impairment such as CD, PMD, Loss or PDL. Even the effect of non-linear link impairments can be qualified with EVM.

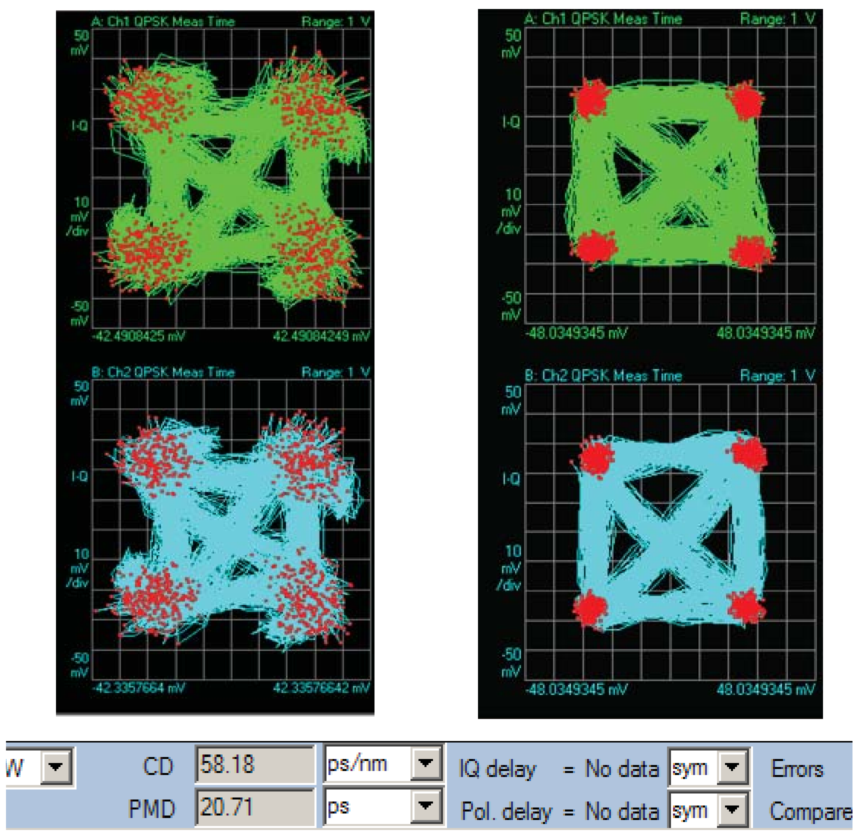


Figure 6.
Left screen shot shows the signal before CD compensation, right screen show's the constellation after applying one of the available CD compensation algorithms

CD, PMD measurement

Impairments along an optical link will distort the received signal and are visible in a distorted constellation. Algorithms to compensate this very effectively in real time are under active research. The highly sophisticated CD and PMD algorithms of the N4391A are able not only to compensate for this distortion, but can also measure in-channel CD and first-order in-channel PMD.

Algorithm development

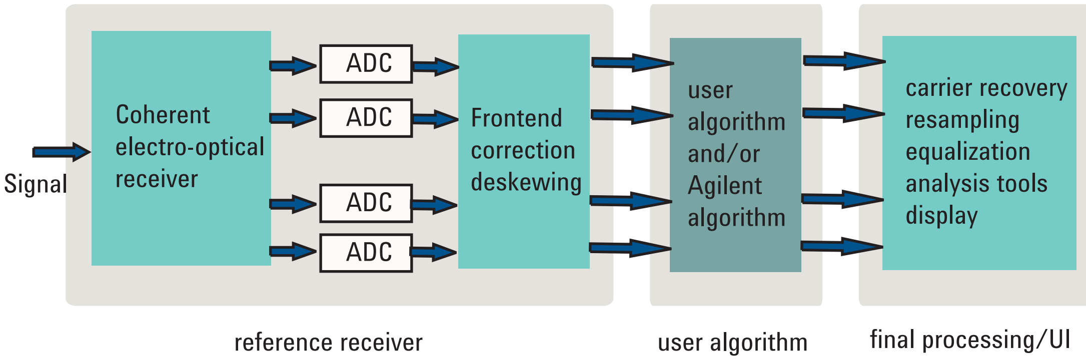


Figure 7.
Principle of signal flow of the N4391A with reference receiver preprocessing, final processing, decoding and display

User algorithm integration

Being able to work with a well defined and specified reference system will speed up the development process of a coherent receiver significantly and leads to additional confidence in the test results. The algorithm development can be started even if the first hardware for the receiver under development is unavailable.
In Figure 7 the signal flow of the optical modulation analyzer is outlined. The reference receiver comprises the whole block covering coherent signal detection, analog-to-digital conversion and correction for all physical impairments coming from the optical hybrid and signal detection. This reflects a close to ideal receiver with up to 32 GHz true analog bandwidth.
This signal is the input to the data post processing system which can incorporate Agilent's provided algorithms and/or user algorithms. The sequence of the algorithm can be selected without limitation and can be changed during the measurement.
In addition, this nearly ideal reference raw data can now be recorded, stored and replayed for later analysis with different parameter settings or with a different user algorithm adding flexibility for the user for post-processing one time recorded data.
The programming environment can be any widely used tools like native C, C++ or Matlab®.
Templates for Matlab® and Visual C# programming environments are part of the instrument software to help get a running start with user algorithm.

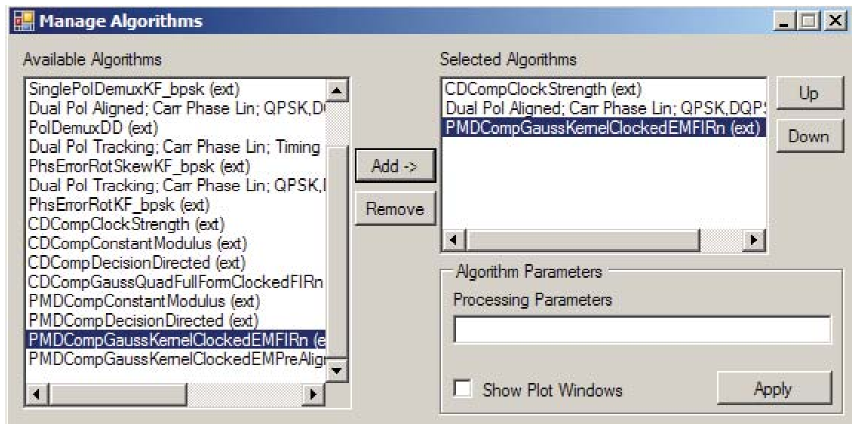
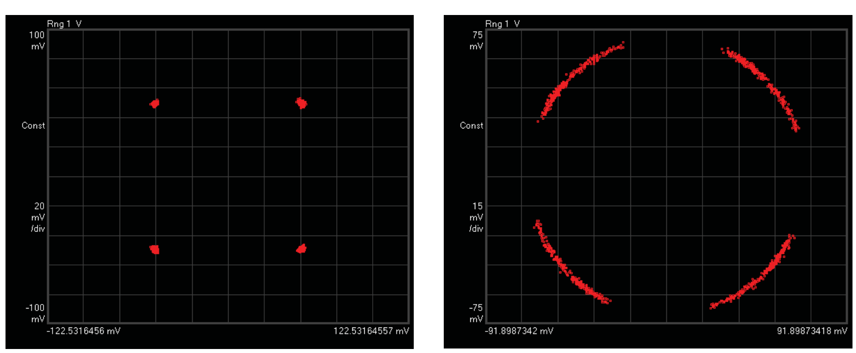


Figure 8
N4391A window to manage user and Agilent provided algorithm. In the right selection the sequence can be changed on the fly even during a running measurement.

User selectable polarization and phase tracking loop gain

The well known very flexible algorithm for polarization and phase tracking, that already work for all QAM, and PSK formats has been enhanced. Now the user can modify the loop gain of the polarization and phase tracking.

This allows the N4391A to measure with the same tracking gain as the user's receiver providing results closest to those of the final transmission system.



Phase tracking high loop gain *Phase tracking low loop gain*
Figure 9
N4391A analysis with two different phase tracking loop gain settings of same input signal.

Constellation and Eye Diagram Analysis

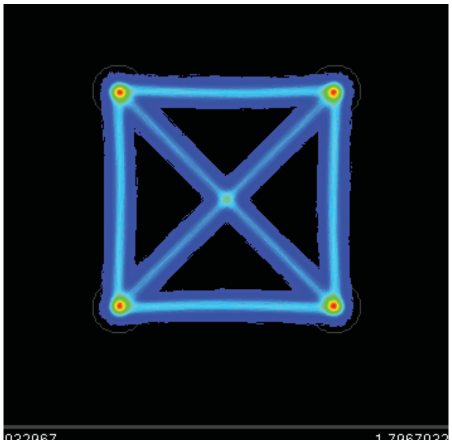


Figure 10.

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. Color-coded display make complex data statistics clear and concise

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.

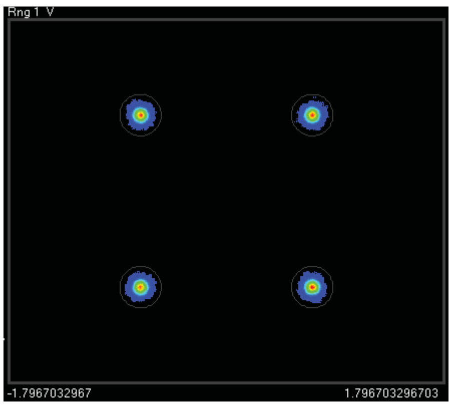


Figure 11

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.

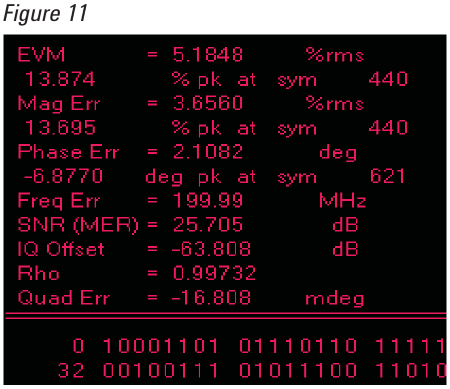


Figure 12.

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

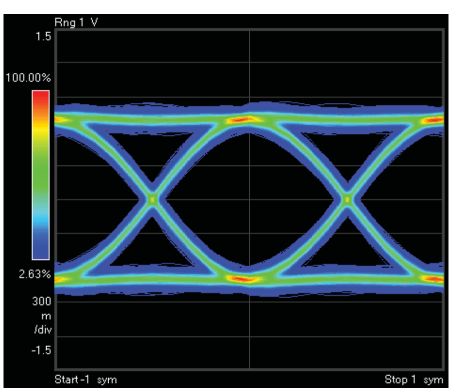


Figure 13.

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.

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.

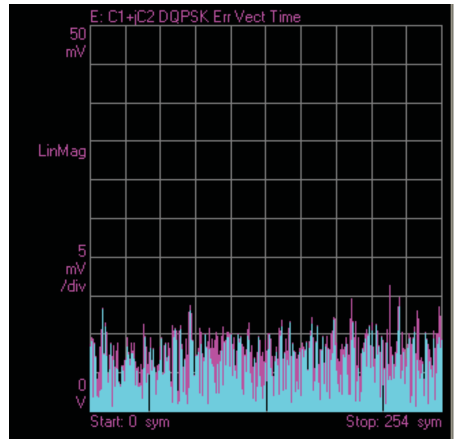


Figure 14

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

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

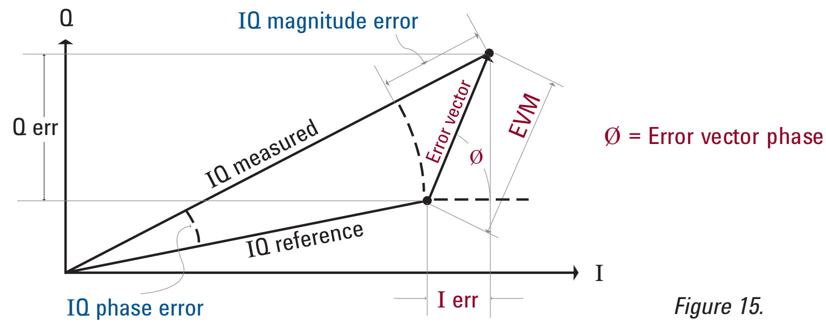


Figure 15.

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 15.) 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.

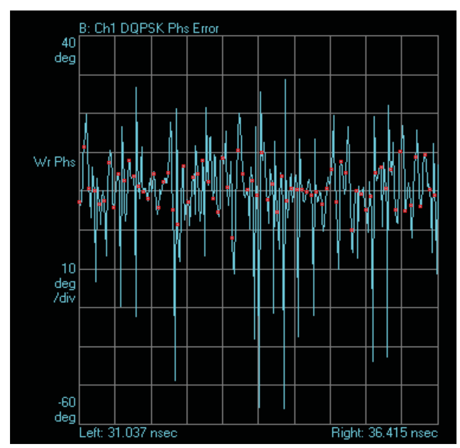


Figure 15.

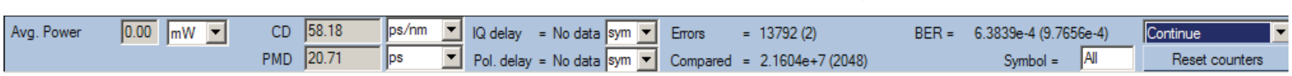


Figure 16.

Bit/Symbol/Error analysis

Beside the wide variety of physical parameters that can be analyzed, the optical modulation analyzer also offers the bit and symbol error analysis. 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 actually count the symbol errors and measure the bit error ratio during a burst.

Having these analysis tools, it is now very easy to identify the error causing element, - 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 on 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

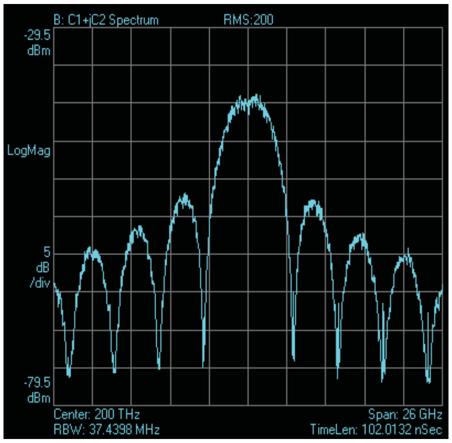


Figure 17

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 17).

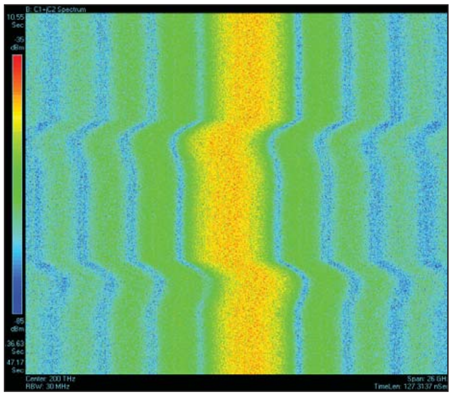


Figure 18.

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.

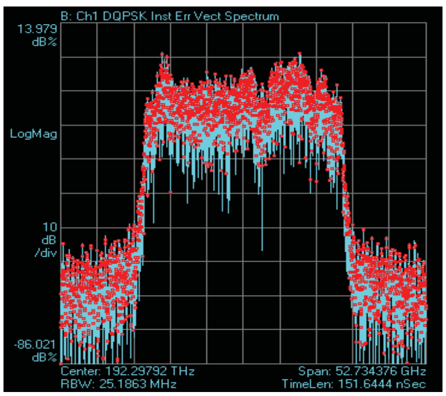


Figure 19.

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 possibility to detect spurs that are overlaid 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.

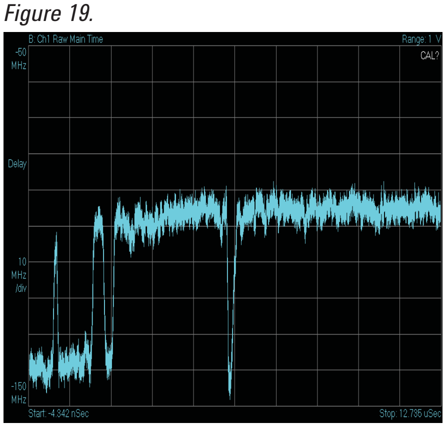


Figure 20.

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 also display the frequency deviation of an unmodulated transmitter laser over a measured time period.
In Figure 20, the frequency deviation of a DFB laser is displayed on the Y-axis and the x-axis is scaled in measured time.
This gives an excellent insight into the time-resolved frequency stability of a laser and helps in detecting error causing mode-hops.

Generic APSK decoder

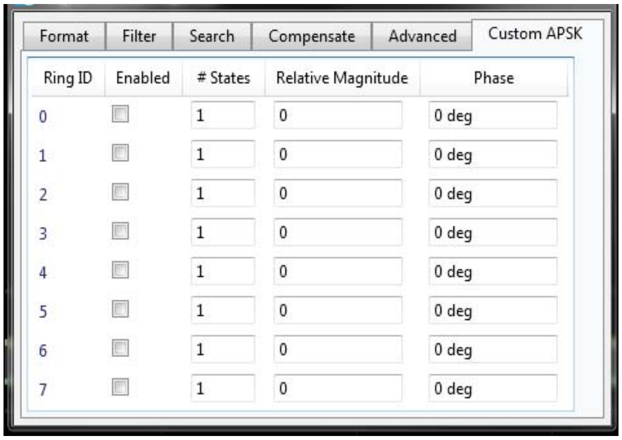


Figure 21.

Customer configurable APSK decoder

This new generic decoder allows the user to configure a custom decoding scheme in accordance with the applied IQ signal.
Up to 8 amplitude levels can be combined freely with up to 256 phase levels. This provides nearly unlimited freedom in research to define and evaluate the transmission behavior of a proprietary modulation format.
The setup is easy and straightforward. Some examples are shown below.

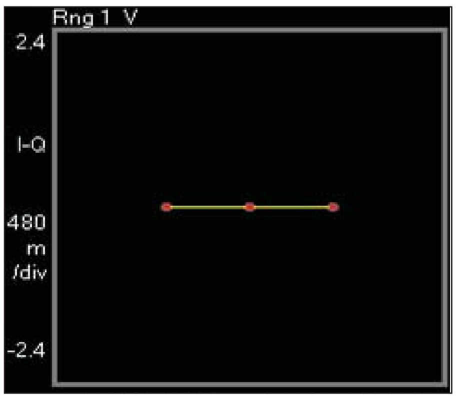


Figure 22.

Optical duobinary decoder

In 40G transmission systems, an optical duobinary format is often used. In order to test the physical layer signal at the transmitter output or along a link, the analysis software now supports this commonly used optical format.
A predefined setting that has a preconfigured optical duo binary decoder is part of the instrument and the analysis software.

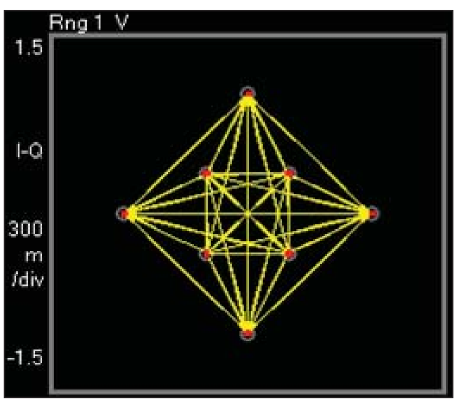


Figure 23.

Optical 8 QAM decoder

This example of a coding scheme can code 3 bits per symbol with a maximum distance between the constellation points, providing a good signal to noise ratio.

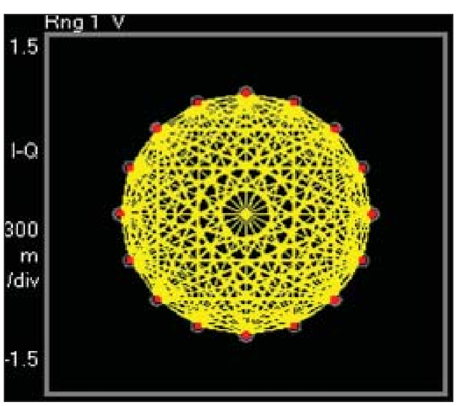


Figure 24.

Optical 16 PSK decoder

This is another example of a more complex pure phase modulated optical signal that is sometimes used in research. With the custom-defined APSK decoder, the same analysis tools are available as in the predefined decoders.

Generic OFDM decoder

Format	
FFT Length	64
Guard Interval	0.25
Guard Lower Subcarriers	1 Subcarriers
Guard Upper Subcarriers	0 Subcarriers
OFDM System Sample Frequency	20 GHz
Format: Details	
Pilot IQ Values	-0.95, 0, 0.95, 0, -0.95, 0, 0.95, 0
Preamble IQ Values	
QAM Identifiers	0, 1, 2, 3, 4, 5
QAM Levels	0, 1, 2, 4, 4, 8
Resource Map	0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
Resource Modulation	4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 1, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4,
Resource Repeat Index	1 Symbols
Signal is Bursted	☐
Transmitter Antennas	1
Transmitter Window Beta	0.005

Figure 25.

Customer configurable generic OFDM decoder

OFDM is a very complex modulation scheme as it distributes the information not only over time with sequential vectors but also over frequency via a customizable number of subcarriers. Each subcarrier can have a different modulation format. In addition in most cases pilot tones need to be detected for synchronization. With this custom configurable OFDM decoder nearly every variation of a digital ODFM signal can be set up and then detected and analyzed in various ways. Some examples are shown below.

	Ch1	Ch2	Ch3	Ch4	Avg
EVM	5.0314	***	***	***	5.0314
EVMPeak	23.163	***	***	***	23.16
PilotEVM	3.7636	***	***	***	3.763
DataEVM	5.0992	***	***	***	5.0992
PmblEVM	***	***	***	***	***
FreqErr	***	***	***	***	-279.9
SymClkErr	0.22455	***	***	***	0.2245
CPE	2.1757	***	***	***	2.1757
SyncCorr	***	***	***	***	99.81
IQOffset	-27.492	***	***	***	-27.49
IQQuadErr	0.01842	***	***	***	0.0184
IQGainImb	-0.0030	***	***	***	-0.003
IQTimeSkew	***	***	***	***	***

Figure 26.

OFDM Error summary

Besides various graphical analysis tools like constellation diagram and EVM over symbols, a detailed error table of relevant error calculations is available. This feature offers the possibility to specify one or more OFDM signal quality parameters at the transmitter output or along the link, which might be useful for transmitter and link performance evaluation.

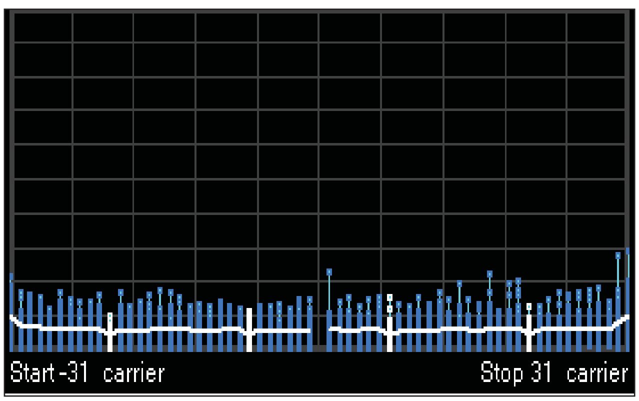


Figure 27.

EVM of a symbol

Like in a QPSK or M-QAM signal, an EVM (%rms) value can be calculated for each carrier and displayed along the horizontal axis. This gives an indication of modulation quality on all carriers. The individual bars describe the error vector of each symbol in that carrier, giving additional information about the distribution of the error symbols.

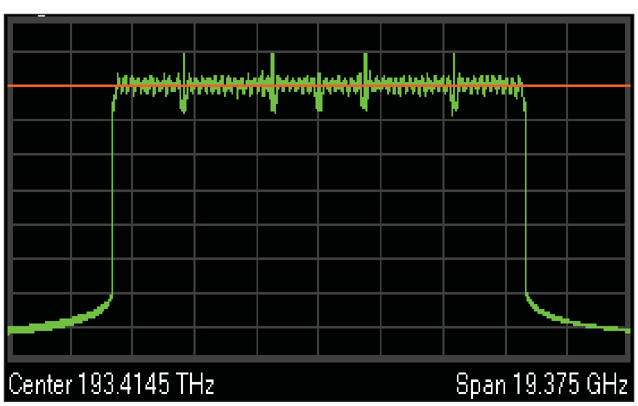


Figure 28.

OFDM high resolution spectrum

An ODFM signal is a set of carriers that are orthogonal and very closely spaced in frequency domain, which lets the spectrum appear rectangular in a perfect signal. In addition a ODFM signal often carries pilot and synchronization information at different power levels. With high resolution spectral display, a quantitative analysis of the OFDM signal can be done in parallel with the other analysis tools.

N4391A Block Diagram

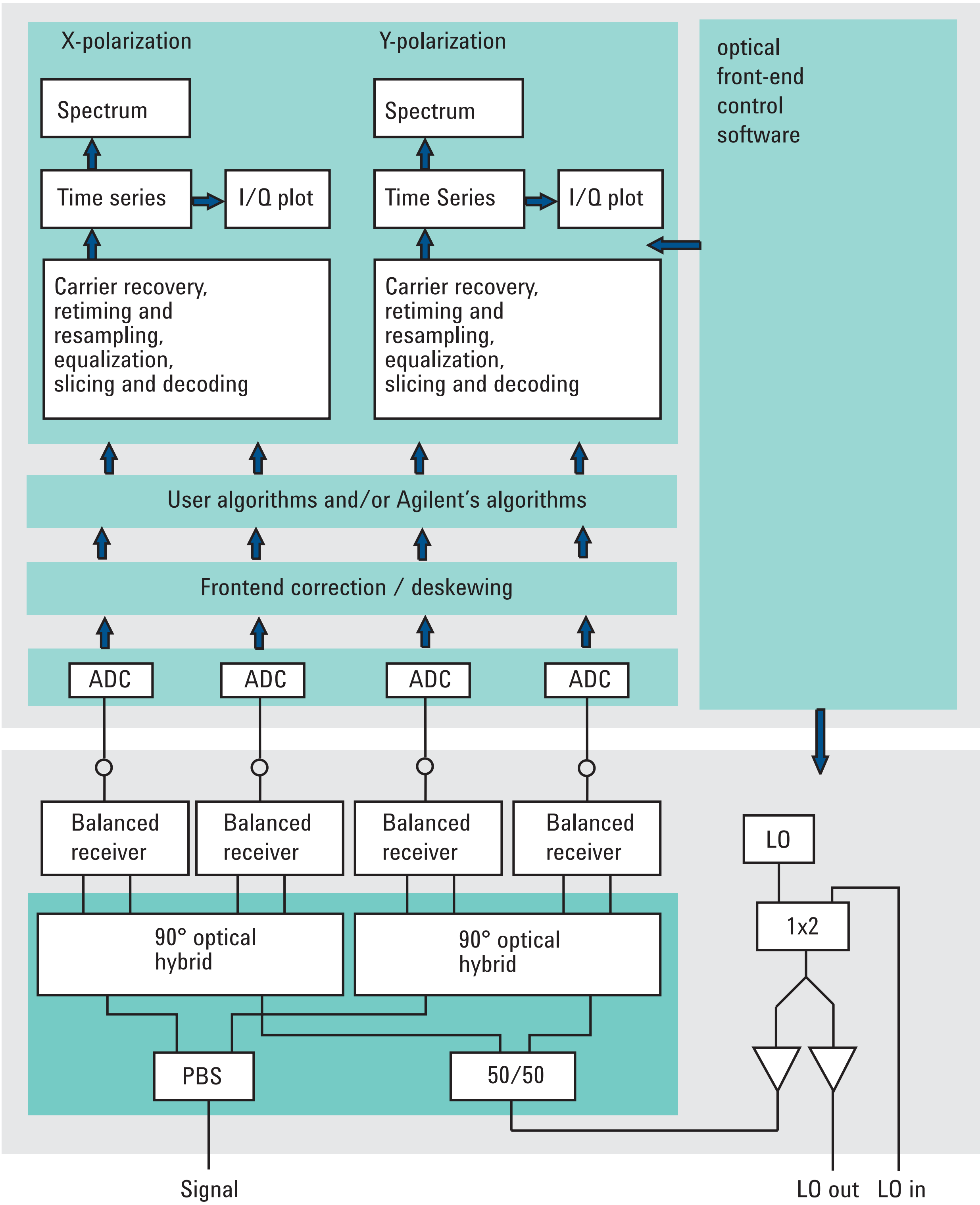


Figure 29. Block diagram of the optical modulation analyzer

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 series or
  DSOX 92xxxA series
- 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

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

Optical receiver: max. 300 VA

Data aquisition unit

Depnding on customer selection,

Storage temperature range

-40° C to +70° C

Operating temperature range

+5° C to +35° C

Humidity

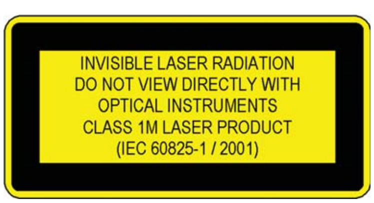
15% to 80% relative humidity, non-condensing

Altitude (operating)

0 ... 2000 m

Recommended re-calibration period

1 year



Shipping contents

1 x	N4391A optical modulation analyzer including
1 x	Oscilloscope, depending on order
4 x	RF Cable, receiver to oscilloscope (cable type depend 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

Shipping contents for two scopes arrangement

1 x	Oscilloscope depending on orders ystem in separate package
2 x	BNC cable

Optional

1x Optical Modulation Analyzer Bit Error Ratio measurement software license
1x Optical Modulation Analyzer CD, PMD 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 PMF angled, 81000 connector interfaces
LO output	+ 20 dBm max 9 µm PMF 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.

Specifications

Table 1. Typical Specifications, if not specified otherwise

Optical modulation analyzer		
Description		
Maximum detectable baud rate		up to 60 Gbaud
Maximum detecable bit rate for DP-DQPSK		up to 240 GBit/s
Sample rate		up to 80 Gs/s
Number of polarization alignment algorithms		6
Digital demodulation uncertainty		
Error vector magnitude noise floor		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
Sensitivity		- 20 dBm
Supported modulation formats 1)		
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	Generic APSK decoder	

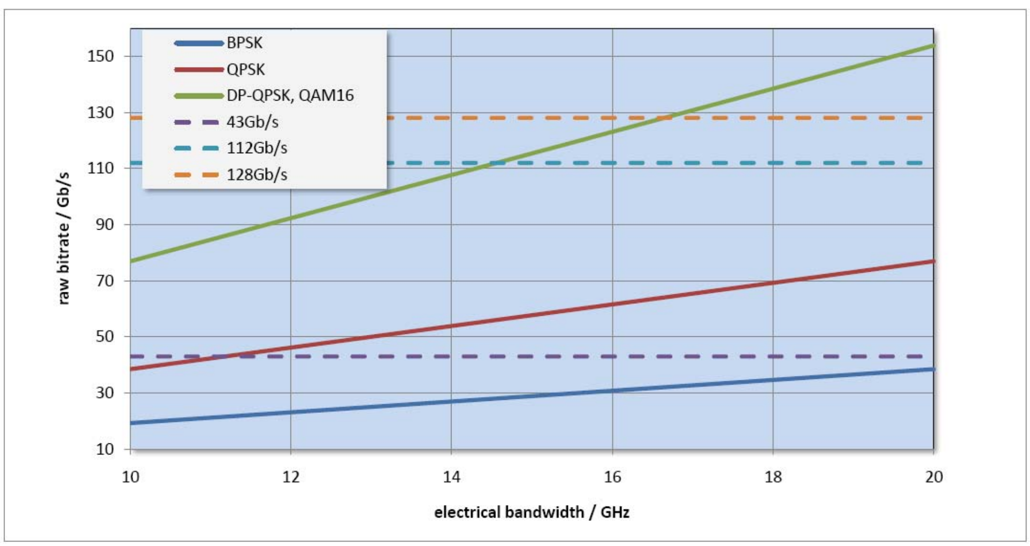


Figure 30. Detectable transmission rate, depending on detection bandwidth and modulation format

1) For Light version only BPSK, DP-BPSK, DPSK, DP-DPSK, QPSK, DP-QPSK are supported

Table 2. Typical Specifications, if not specified otherwise

Coherent reference 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	Standard version Light version (software upgradable)	43 GHz, 37 GHz guaranteed, 22 GHz
Optical phase angle of I-Q mixer after correction (1529nm to 1630nm)		90° ± 0.5°
Relative skew after correction (1529nm to 1630nm)		±1 ps

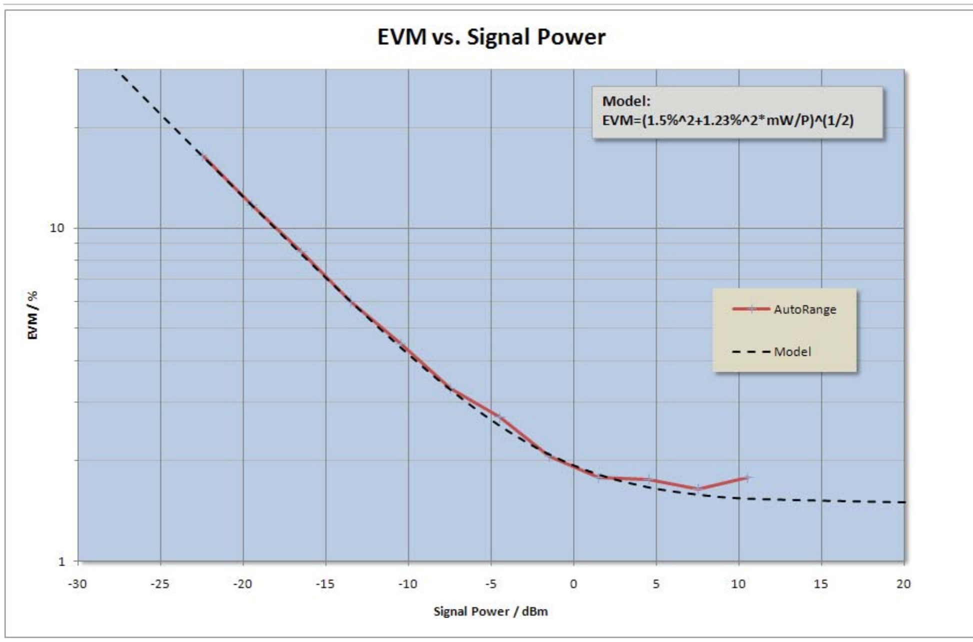


Figure 31 EVM %rms dependend on average optical input power

This diagram shows the %rms Error Vector Magnitude (EVM) normalized to the highest error vector within an analysis record of 500 symbols as a function of signal input power. The EVM %rms 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 %rms noise floor in the offset term.

Table 3. Typical Specifications, if not specified otherwise

Data Acquisition (for Agilent 90000-X series Oscilloscopes)	
Description	
Sample rate	up to 80 GSa/s on each channel
Data acquisition bandwidth	16/20/25/32 GHz upgradable
Jitter between channels	typ 700fs
Noise	0.6mV rms @ 10mV range, 32 GHz bw
ADC resolution	8 bit / 16 bit (interpolated)
Sample memory per channel	up to 2 Gs/channel

Local oscillator (LO) (guaranteed specification if not mentioned otherwise)			
Description		**Option -500, 501**	**Option -510**
Wavelength range	option 500 option 501	1527.6 to 1565.5 nm (196.25 to 191.50 THz) 1570.0 to 1608.8 nm (190.95 to 186.35 THz)	1528 nm to 1630 nm
Minimum wavelength step		25 GHz	1 pm
Tuning time/ sweep speed		< 30 s	50 nm/s
Absolute wavelength accuracy		± 22 pm	± 20 pm, ± 5 pm typical
Stability (short term)		100 kHz	100 kHz
Sidemode suppression ratio		50 dB typical	≥50 dB
RIN		-145 dB/Hz (10 Mhz to 40GHz) typical	- 145 dB/Hz (0.1 to 6 GHz) typical

High resolution spectrometer		
Description		
Maximum Frequency span		31.25/40/50/62.5 GHz
LO wavelength range		1528 nm to 1630 nm
Image suppression		> 35 dB
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

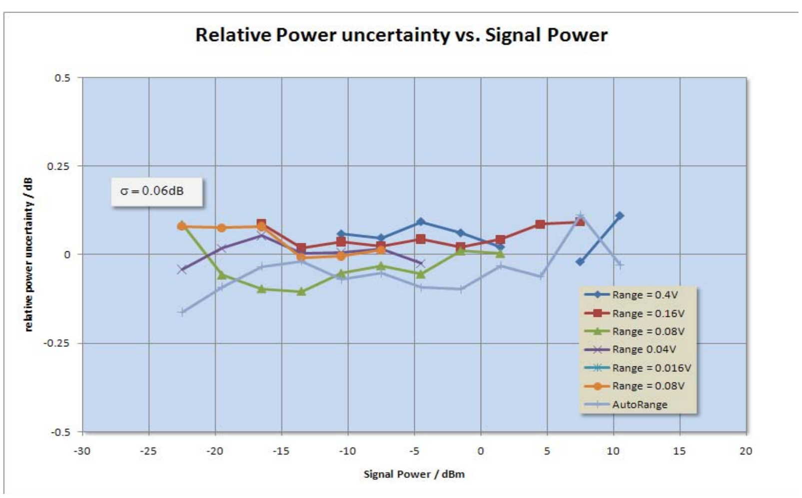


Figure 32. Relative power uncertainty of N4391A

[1] with internal local oscillator @ 1550 nm

Table 4. Analysis Tools

Measurement display and analysis tools		
Description	Standard N4391A	N4391A Light Version
Constellation diagram	yes	yes
I-Q diagram	yes	yes
Eye diagram for I and Q signal	yes	yes
Error vector magnitude	yes	yes
Spectrum	yes	yes
Spectrogram	yes	yes
Spectral analysis tools	yes	yes
Error vector spectrum	yes	yes
Detected bits	yes	yes
Phase error	yes	yes
Amplitude error	yes	yes
Raw data vs time	yes	yes
Phase vs time	yes	yes
Group delay	yes	yes
Frequency offset	yes	yes
Quadrature error	yes	yes
IQ offset	yes	yes
IQ Gain imbalance	yes	yes
Adaptive equalizer	yes	yes
Selectable phase tracking bandwidth	yes	yes
Reference signal from detected symbols	yes	yes
Symbol polarization on poincare sphere	yes	no
Raw data replay with different parameter setting	yes	no
Raw data display	yes	yes
Result export formats	Matlab(Version 4, 5), csv, txt, sdf, sdf fast,	Matlab(Version 4, 5), csv, txt,
Adaptive equalization	yes	yes
Bit Error Ratio measurements	Number of counted bits/symbols	Number of counted bits/symbols
	Numbers of errors detected	Numbers of errors detected
	Bit error ratio	Bit error ratio
	Stop acquisition on detected error	Stop acquisition on detected error
CD PMD compensation and measurement	yes	no
Configurable APSK decoder	yes	no
Coupled markers over different displays	yes	yes
Macro programming with VBA and C#	yes	no
Block mode (analysis of > 4096 symbols in one concatenated block)	yes	no
Trigger support for loop test	yes	no
User algorithm in data processing	yes, unlimited number of algorithms	limited to one algorithm
Available number of algorithm	6	6

Mechanical Outlines for 90000 series data acquisition (dimensions in mm)

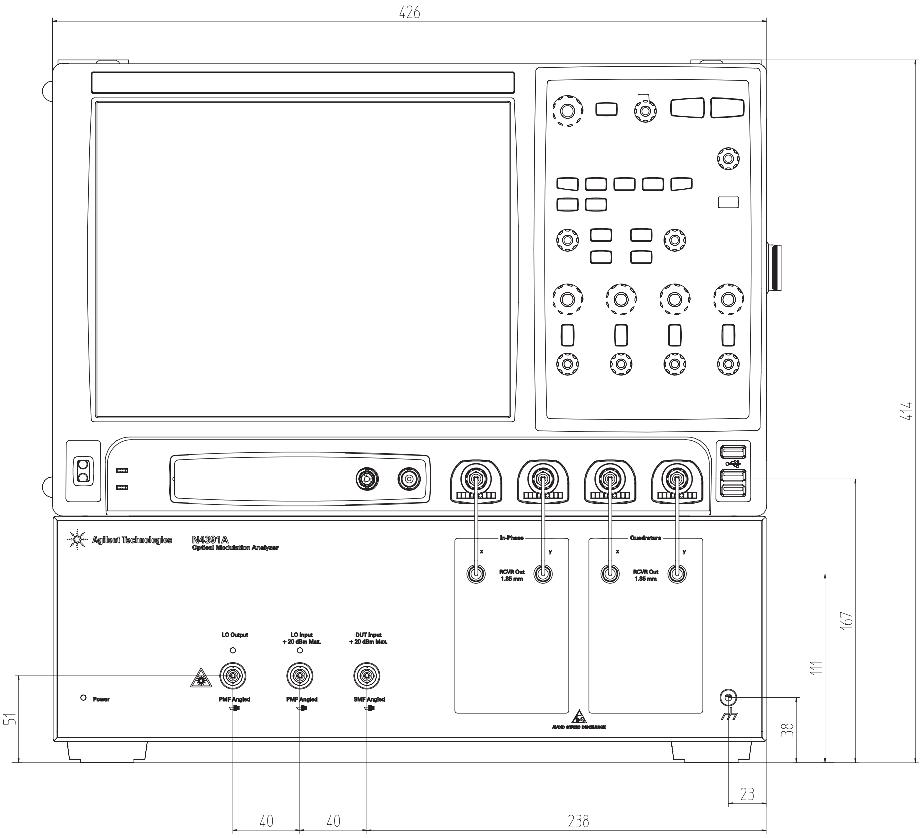


Figure 33.

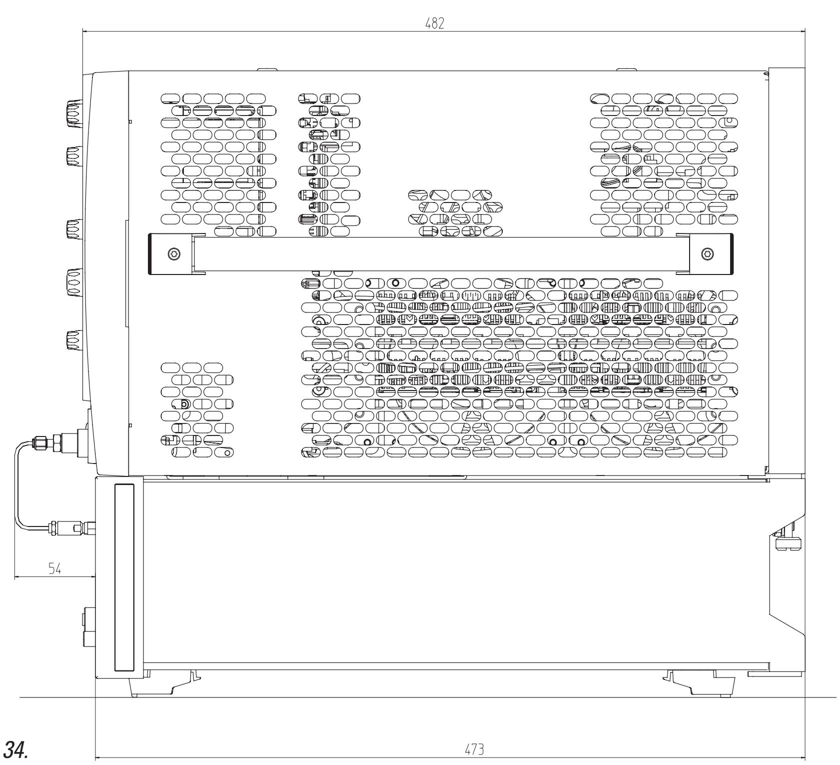


Figure 34.

Hardware Options Description

Table 4 provides a description and a block diagram of the available hardware configurations.
In addition a selection of tree types of local oscillators are offered.

Product number	Hardware configuration description

Optical modulation analyzer with 4 channel receiver and analysis software.
This option is the core hardware with analysis software and has always to be ordered.

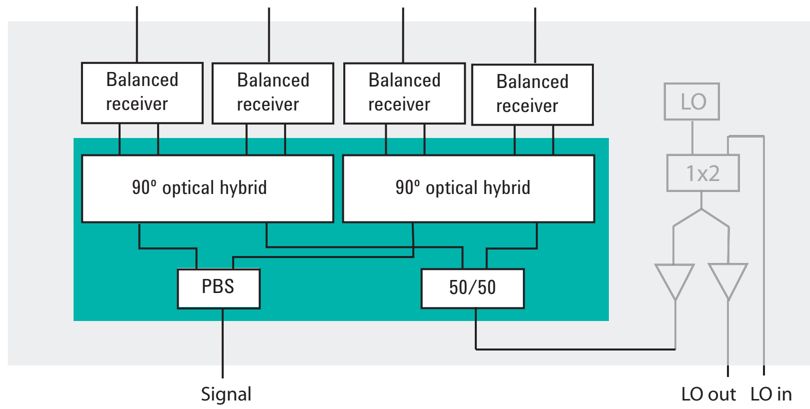


Figure 18. N4391A-110

Internal Local Oscillator.
For the internal local oscillator a selection of 3 types of laser is provided. C or L band iTLA with slow tuning speed or fast 50nm/s tuning C & L band laser.
Select the laser type with option block 5xx

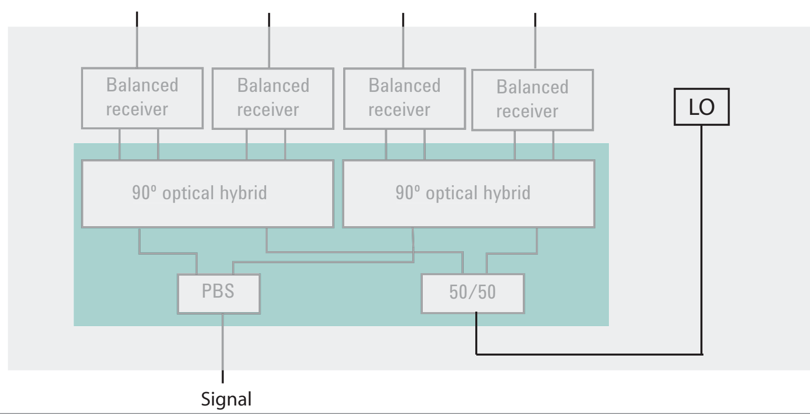


Figure 19. N4391A-210

Internal Local Oscillator and External Local Oscillator Input and Local Oscillator.
For the internal local oscillator a selection of 3 types of laser is provided. C or L band iTLA with slow tuning or 50nm/s tuning C & L band laser.
Select the laser type with option block 5xx. In addition a semiconductor amplified output of the local oscillator signal is provided at the instrument's output and an external local oscillator signal can be feed into the receiver for homodyne test setups.

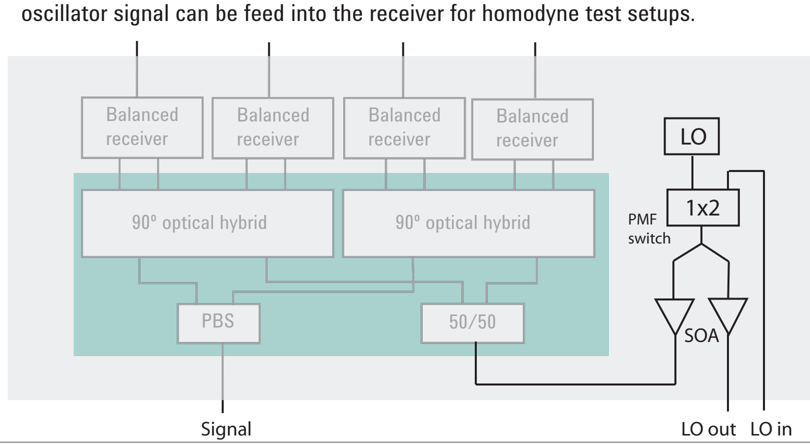


Figure 20. N4391A-220

Ordering Information

Table 5. Configuration and ordering information

Optical modulation analyzer product configuration	
Model number	Receiver options
N4391A -110	Optical modulation analyzer with 4 channel receiver and analysis software
	Local oscillator options
N4391A -210	Internal Local Oscillator
N4391A -220	Internal Local Oscillator and External Local Oscillator Input and Local Oscillator Output
	Tunable laser options
N4391A-500	C band iTLA internal Local Oscillator
N4391A-501	L band iTLA internal Local Oscillator
N4391A-510	Fast tunable C & L band Local Oscillator
	Software analysis licenses
N4391A-420	User configurable OFDM decoder
N4391AU-450	Optical Modulation analyzer analysis software license (stand alone)
N4391AU-451	Optical Modulation analyzer hardware connection license for -450
I	Data acquisition
N4391A-300	Data acquisition with 20 Ms per channel memory (DSA91304)
N4391A-301	Data acquisition with 100 Ms per channel memory (DSA91304)
N4391A-302	Data acquisition with 1 Gs per channel memory (DSA91304)
N4391A-320	Infiniium Oscilloscope 20 GHz 80 GSa/s 2Ch, 20Ms/Ch Memory (1x DSOX92004A)
N4391A-321	Infiniium Oscilloscope 25 GHz 80 GSa/s 2Ch, 20Ms/Ch Memory (1x DSOX92504A)
N4391A-322	Infiniium Oscilloscope 32 GHz 80 GSa/s 2Ch, 20Ms/Ch Memory (1x DSOX93204A)
N4391A-323	Infiniium Oscilloscope 30 GHz 80 GSa/s 4Ch, 20Ms/Ch Memory (1x DSO93004L)
N4391A-325	Infiniium Oscilloscope 20 GHz 80 GSa/s 4Ch, 20Ms/Ch Memory (2x DSOX92004A)
N4391A-326	Infiniium Oscilloscope 25 GHz 80 GSa/s 4Ch, 20Ms/Ch Memory (2x DSOX92504A)
N4391A-327	Infiniium Oscilloscope 32 GHz 80 GSa/s 4Ch, 20Ms/Ch Memory (2x DSOX93204A)
N4391A-328	Infiniium Oscilloscope 30 GHz 80 GSa/s 4Ch, 20Ms/Ch Memory (2x DSO93004L)
	Oscilloscope integration
N4391A-M00	Integration of Agilent 90000 oscilloscope (up to 4x13 GHz)
N4391A-M01	Integration of Agilent 90000-X oscilloscope (up to 4x16 or 2x32 GHz)
N4391A-M02	Integration of two identical Agilent 90000-X oscilloscopes (up to 4x32 GHz)
	Light Version
N4391A-CONF01	Consists of -110 (Bandwidth 22 GHz limited), -210, -500, Mxx as fixed configuration
N4391A-CONF11	SW upgrade to full feature set and up to 32 GHz system bandwidth
	Upgrade options
N4391AU-M01	Integration of Customer owned single 90000-X Series Infiniium Oscilloscope with Customers N4391A Optical Receiver
N4391AU-M02	Upgrade from single to dual 90000-X Oscilloscope
N4391AU-M03	Integration of customer owned dual 90000-X Series Infiniium Oscilloscope with Customers N4391A Optical Receiver
N4391AU-E02	Upgrade N4391A Option 210 to Option 220
	Training
PS-S20	1 day startup training (highly recommended)

N4391A related literature

Table 6. Agilent publications

Publication title	Pub number
N4391A Optical Modulation Analyzer Data Sheet	5990-3509EN
Metrology of Optical Advanced Modulation Formats, White Paper	5990-3748EN
Kalman Filter Based Estimation and Demodulation of Complex Signals, White paper	5990-6409EN
Webinar: "Coherent Detection of Polarization Multiplexed Amplitude and Phase Modulated Optical Signals"	
Webinar: "Rating optical signal quality using constellation diagrams"	
Webinar: "Test and measurement challenges as we approach the terabit era"	
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 90000-X Series Real-Time Oscilloscope Data Sheet	5989-5271EN

www.agilent.com
www.agilent.com/find/oma

Agilent Email Updates

www.agilent.com/find/emailupdates
Get the latest information on the products and applications you select.

www.axiestandard.org AdvancedTCA® Extensions for Instrumentation and Test (AXIe) is an open standard that extends the AdvancedTCA® for general purpose and semiconductor test. Agilent is a founding member of the AXIe consortium.

www.lxistandard.org
LAN eXtensions for Instruments puts the power of Ethernet and the Web inside your test systems. Agilent is a founding member of the LXI consortium.

http://www.pxisa.org
PCI eXtensions for Instrumentation (PXI) modular instrumentation delivers a rugged, PC-based high-performance measurement and automation system.

Agilent Channel Partners

www.agilent.com/find/channelpartners
Get the best of both worlds: Agilent's measurement expertise and product breadth, combined with channel partner convenience.

Agilent Advantage Services

Agilent Advantage Services is committed to your success throughout your equipment's lifetime. We share measurement and service expertise to help you create the products that change our world. To keep you competitive, we continually invest in tools and processes that speed up calibration and repair, reduce your cost of ownership, and move us ahead of your development curve.

www.agilent.com/find/advantageservices

Agilent Electronic Measurement Group
KEMA Certified
ISO 9001:2008
Quality Management System

www.agilent.com/quality

For more information on Agilent Technologies' products, applications or services, please contact your local Agilent office. The complete list is available at:

www.agilent.com/find/contactus

Americas	
Canada	(877) 894 4414
Brazil	(11) 4197 3500
Mexico	01800 5064 800
United States	(800) 829 4444

Asia Pacific	
Australia	1 800 629 485
China	800 810 0189
Hong Kong	800 938 693
India	1 800 112 929
Japan	0120 (421) 345
Korea	080 769 0800
Malaysia	1 800 888 848
Singapore	1 800 375 8100
Taiwan	0800 047 866
Other AP Countries	(65) 375 8100

Europe & Middle East	
Belgium	32 (0) 2 404 93 40
Denmark	45 70 13 15 15
Finland	358 (0) 10 855 2100
France	0825 010 700*
	*0.125 €/minute
Germany	49 (0) 7031 464
6333	
Ireland	1890 924 204
Israel	972-3-9288-504/544
Italy	39 02 92 60 8484
Netherlands	31 (0) 20 547 2111
Spain	34 (91) 631 3300
Sweden	0200-88 22 55
United Kingdom	44 (0) 118 9276201

For other unlisted Countries:
www.agilent.com/find/contactus

Revised: September 15, 2011

Product specifications and descriptions in this document subject to change without notice.

Printed in USA, Sept 26, 2011
5990-3509EN

Agilent Technologies