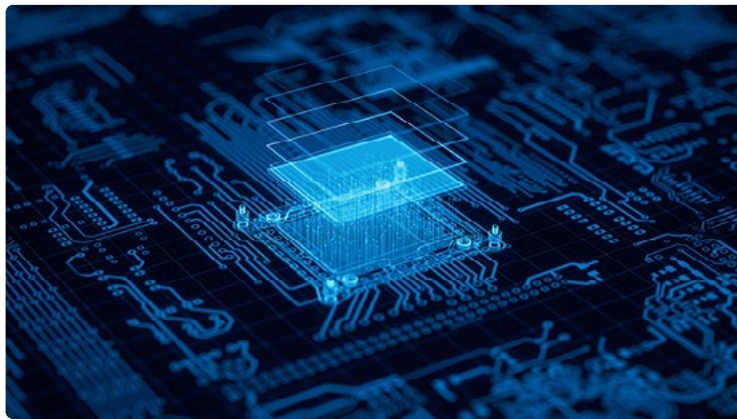


Artificial Intelligence (AI) Semiconductor Market: Testing Solutions for High-Speed Digital Transmission

What are AI Semiconductors?

AI semiconductors are integrated circuits with a dedicated architecture specialized for the mathematical calculations and parallel processing needed for artificial intelligence computations. While conventional CPUs perform general-purpose processing sequentially, AI semiconductors have a parallel computing structure that enables the simultaneous processing of large amounts of data. There are several types of AI semiconductors, including Graphics Processing Units (GPUs), Systems on a Chip (SoCs), and Neural Processing Units (NPUs). Among these, GPUs are processors that were originally designed for image processing, but as a result of their high parallel computing capabilities, they also play a crucial role in AI data processing.



AI Semiconductor Market Trends

The AI semiconductor market is estimated to be worth US\$83.8 billion in 2025 and is projected to reach US\$459 billion by 2032, growing at a compound annual growth rate (CAGR) of 27.5% from 2025 to 2032^[1].

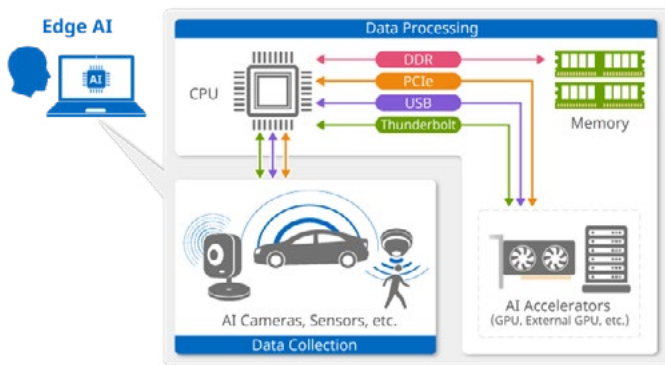
AI technology is rapidly becoming more widespread across multiple fields, including self-driving cars, smart cities, medical diagnostic assistance, natural language processing, computer vision, and edge computing applications. As a result, the amount of data handled in these fields is increasing dramatically. Securing and expanding computing resources is crucial for efficiently and rapidly processing large amounts of data. Therefore, data centers and network infrastructure are increasingly utilizing high-performance hardware, including GPUs, AI-specific ASICs, and AI accelerators. Additionally, advances in printed circuit board design and high-performance connector technology are also playing a crucial role in effectively mounting and connecting these processors. These innovations in hardware technology are supporting the further expansion and sophistication of AI applications.

[1] Source: Global Information Inc.

<https://www.giiresearch.com/report/coh1789563-ai-chips-market-by-technology-by-chip-type-by.html>

Technology Trends

AI technology is rapidly becoming indispensable to modern society. AI-based systems can be categorized into two primary types: edge AI and cloud AI. These differ from each other in the location where the AI processing is performed.



With edge AI, a computer for AI processing (edge device) is installed in a location close to the user, such as within the same network, and the system required to execute AI processing is built at that location.

The key benefits of this arrangement include:

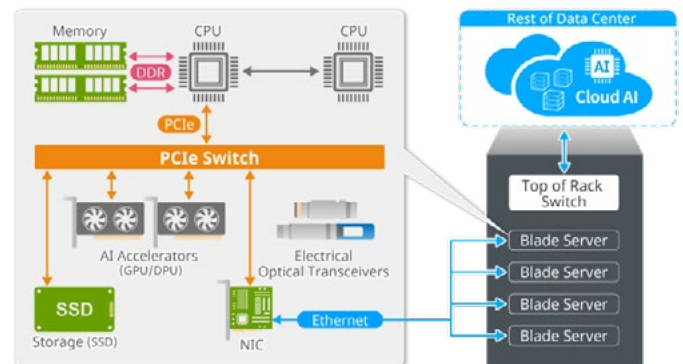
- Quick response
- Reduced the risk of information leakage
- Reduced traffic volume
- System can be built in a short period of time
- Suitable for building small-scale systems

Cloud AI is an AI system that performs AI processing on cloud-based computers. The data required for AI processing is sent to an AI system in the cloud, where the necessary AI processing is performed.

Cloud AI can use high-performance servers in data centers, enabling more advanced calculations and judgments than edge AI, which performs inference on the terminal side.

Key benefits include:

- Large-scale and complex processing is possible
- Can reduce the load on servers and terminals
- Many examples of sample data are available in the cloud
- Easy to introduce



Cloud AI is widely used in multiple fields and industries, providing innovative technologies and services in areas such as image recognition, natural-language processing, predictive analysis, and speech recognition.

Communication Standards Related to AI Semiconductors

In addition to CPUs and AI accelerators, devices with AI semiconductors include memory, SSDs, and interfaces to network interfaces and peripherals. To facilitate communication between these pieces of hardware and external networks, communication standards are adopted based on the application and performance requirements.

Standards	Application
PCI Express® (PCIe®)	AI accelerators, SSDs, and motherboards
Double Data Rate (DDR)	RAM, used as the main memory of a computer
Ethernet	Between computers, between data centers, and between servers within a data center
Universal Serial Bus (USB)	Peripheral devices such as cameras and sensors
Common Electrical Interface (CEI)	Inside semiconductor chips and boards

PCI Express® and PCIe® are registered trademarks of PCI-SIG.

Cloud AI, in particular, requires high-speed digital communications to process huge amounts of data.

Anritsu Test Solutions

Anritsu offers a wide range of test solutions for semiconductors, components, and communication interfaces used in edge AI and cloud AI.

Process	Test Subjects	Exam Content	Measuring Instrument	Page
R&D	Materials, parts	Frequency response	Network Analyzer	3
	Transmission lines, cables	Loss, Reflectance, and Crosstalk	Network Analyzer	3
	Communication interface	Signal waveform, bit error rate	Signal Quality Analyzer Sampling Oscilloscope	6
	Communication interface	Standards-based testing	Signal Quality Analyzer	6
	Optical interface	Frequency response	Optical-Electrical Network Analyzer	8
		Wavelength	Optical Spectrum Analyzer	8
		Signal waveform, bit error rate	Signal Quality Analyzer Sampling Oscilloscope	6
Manufacturing	Materials, parts	Frequency response	Network Analyzer	3
	Communication interface	Signal waveform, bit error rate	Signal Quality Analyzer Sampling Oscilloscope	6
	Optical interface	Signal waveform, bit error rate	Signal Quality Analyzer Sampling Oscilloscope	6

Chip and Printed Circuit Board Evaluation

The materials and components used to fabricate semiconductors and printed circuit boards or to link printed circuit boards together must be evaluated to ensure that their frequency characteristics allow the transmission of high-speed digital signals. It is especially important to quantitatively and accurately understand how these materials and components affect signal transmission and the reflection characteristics in a given frequency band.

For example, a Vector Network Analyzer (VNA) is essential to evaluate the S-parameters (scattering parameters) of the boards, components, and devices used in the millimeter-wave band.

A VNA is used to quantitatively measure the transmission and reflection characteristics to accurately verify the high-frequency performance of the entire system.

R&D



Broadband
Vector Network Analyzer
ME7838A/D/G

Two-port vector network
analyzer capable of
measuring up to 220 GHz.



Broadband 4-port
Vector Network Analyzer
ME7838A4X/D4/G4

Four-port vector network
analyzer for crosstalk
measurement.



Product details here

Manufacturing



Vector Network Analyzer
MS46522B

Two-port vector network
analyzer capable of
measuring up to 43.5 GHz.



Vector Network Analyzer
MS46524B

Four-port vector network
analyzer capable of
measuring up to 43.5GHz.



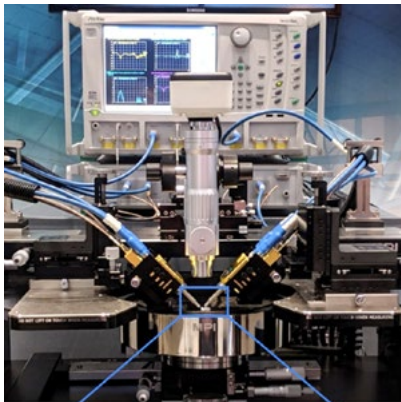
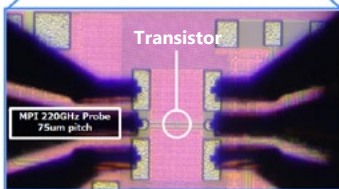
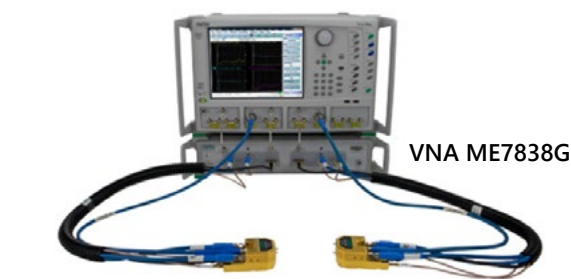
Product details here

Test Solution for Broadband Frequency Response

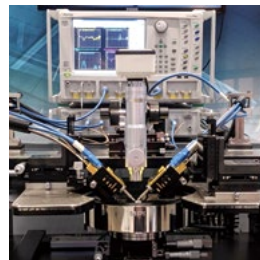
As digital transmission speeds increase, there is a growing need to evaluate a wide range of frequency characteristics, such as S-parameters and the characteristic impedance of chips and printed circuit boards. Traditionally, measurements in the region above 110 GHz have required VNA systems with millimeter-waveguide modules with limited frequency bandwidth.

Therefore, to evaluate broadband devices, it was necessary to reconstruct multiple measurement setups for each frequency band, which complicated and prolonged the measurement process. Furthermore, to use millimeter waveguide modules over multiple frequency bands, users have to use a PC to integrate and synthesize the measurement data acquired in each band.

This process has presented issues related to the data continuity and reproducibility of results. The ME7838G/G4 and Anritsu proprietary millimeter-wave module technology can address this challenge by enabling broadband single-sweep measurements from 70 kHz to 220 GHz.



VNA ME7838G



MPI Probe Station



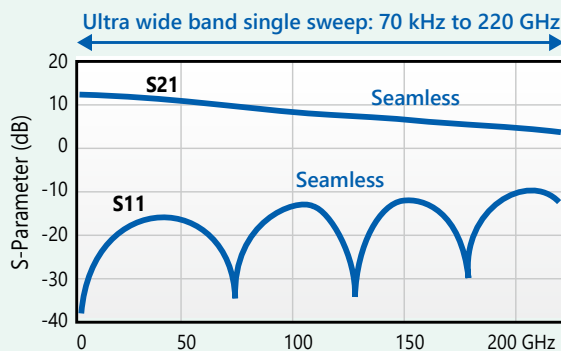
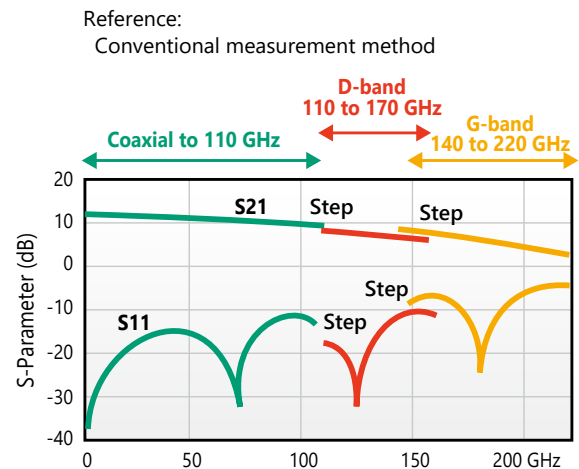
Dedicated probe tip
(MA25400A + probe tip)



Product details here

Features

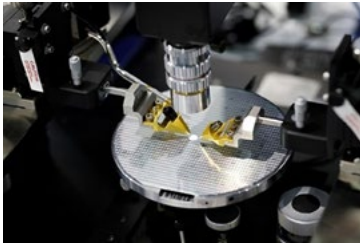
- 70 kHz to 220 GHz Up to 1000mV can be measured at once.
- There is no need to replace waveguide modules, so there are no data splices and no steps.



Reference:
Conventional measurement method

Probes for Evaluating Component and Device Characteristics

Anritsu probes are small and lightweight, making it possible to build a space-saving, compact probe measurement system. Probe stations, probe tips, and calibration boards can be selected to suit your application.



Probe station (example)

Probe tip: Coaxial connector

□ 110 GHz, 1 mm



Broadband Model

70 kHz to 125 GHz

- Broadband VNA ME7838AX
- Millimeter wave module 3743AX (1 mm connector)

Probe tip: Waveguide

□ 110 GHz to 170 GHz, WR-6

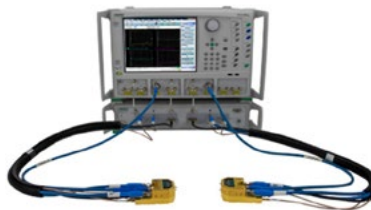


110 GHz to 170 GHz

- VNA MS4644B/MS4647B
- Test Set 3739C
- Millimeter Waveguide Extender Module (WR-6.5)

Probe tip: 0.6 mm coaxial interface

□ Up to 220 GHz, 0.6 mm



Broadband Model

70 kHz to 220 GHz

- Broadband VNA ME7838G
- Millimeter wave module MA25400A (0.6 mm connector)

Probe tip: Waveguide

□ 220 GHz to 325 GHz, WR-3.4



220 GHz to 330 GHz

- VNA MS4644B/MS4647B
- Test Set 3739C
- Millimeter Waveguide Extender Module (WR-3.4)

Digital Signal Quality Evaluation

Hardware configurations for cloud AI and edge AI range from chips, electrical/optical wiring, and connectors. The development of these designs and devices is completed through the R&D processes of prototyping, debugging, and design verification. During these processes, engineers must repeatedly evaluate and improve the transmitter characteristics to minimize the degradation of high-speed digital signals and ensure sufficient operating margins.



Signal Quality Analyzer-R
MP1900A

The MP1900A is an 8-slot modular high-performance BERT. A single unit supports the physical-layer measurements of high-speed network interfaces such as Ethernet with NRZ/ PAM4 signals and high-speed bus interfaces such as PCI Express and USB.



Product details here



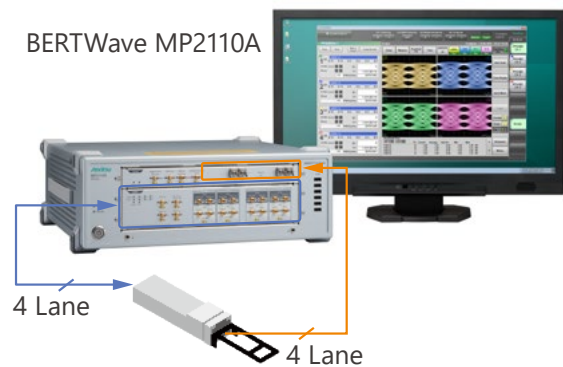
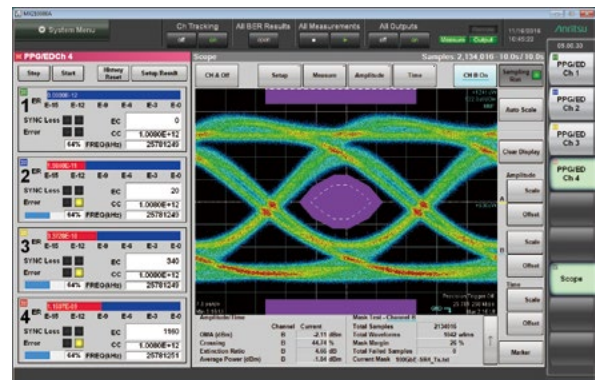
BERTWave Sampling Oscilloscope
MP2110A

The MP2110A is a measurement instrument suitable for the production evaluation of optical modules from 10G to 800G and 1.6T. It combines a 4-channel sampling oscilloscope (eye pattern analysis) and BERT (bit error rate measurement) in a single unit.



Product details here

The Anritsu BERTWave sampling oscilloscope MP2110A performs eye pattern analysis of digital signal waveforms and can evaluate values such as the amplitude, jitter, and skew (time difference) of each eye.



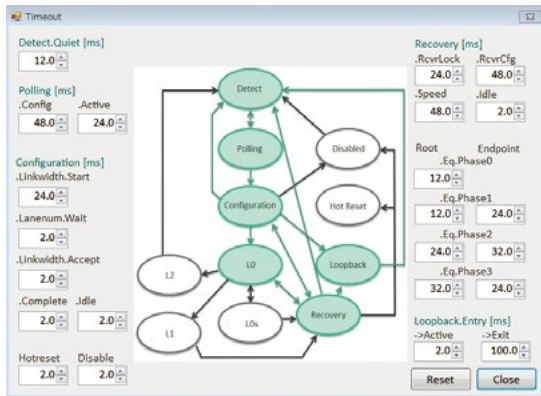
Furthermore, the Signal Quality Analyzer-R MP1900A, which has signal generation (Pulse Pattern Generator: PPG) and bit error rate measurement functions, can be used to apply noise, jitter, and other stresses to digital signals to evaluate the jitter tolerance, crosstalk, and operating margins of USB devices.

Testing in Accordance with Telecommunication Standards

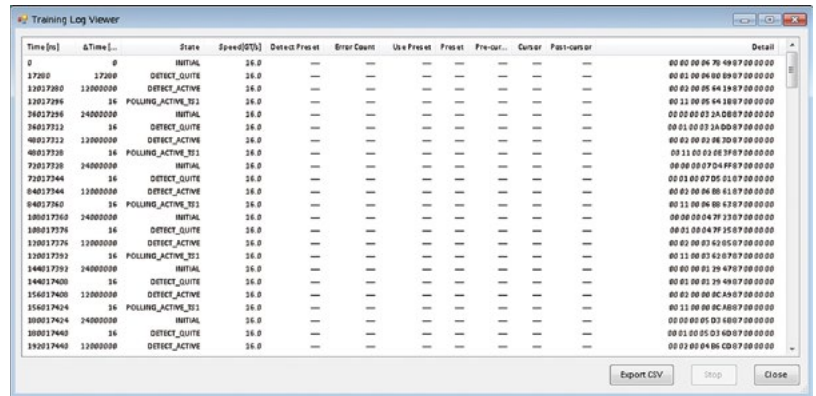
To achieve interoperability between hosts and devices, standards such as PCI Express and the 10-Gbit/s USB 3.2 require that physical layer tests, including jitter tolerance tests, be performed after establishing a link.

The Signal Quality Analyzer-R MP1900A and the High-Speed Serial Data Software MX183000A can be used to test the machine status and error correction capability in compliance with communication standards.

PCI Express Link Training (MX183000A-PL021/PL025/PL026)



PCIe Link Training State Transitions

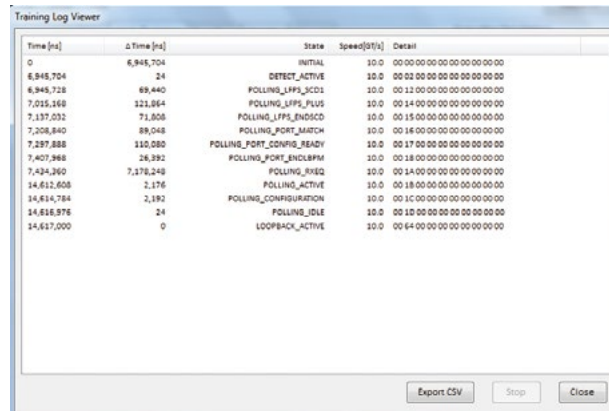


LTSSM logs: detected transitions for each state of the LTSSM

USB Link Training (MX183000A-PL022/PL023)



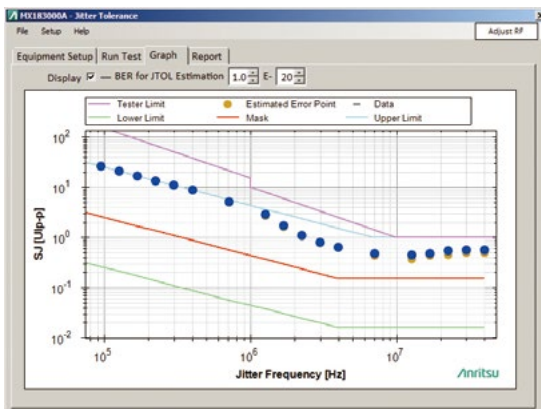
USB Link Training State Transitions



LTSSM logs: detected transitions for each state of the LTSSM

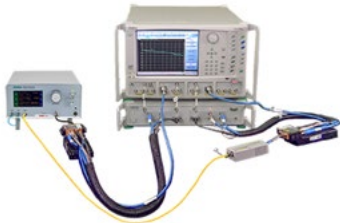
Jitter Tolerance Test Function

Measures the area where the bit error rate is below a specified value by changing the frequency and amplitude of the jitter (fluctuation in the time domain) applied to the signal.



Optical Interface Testing

To reduce the power consumption of data centers, research and development of photonics-electronics convergence technology are underway, intending to replace electricity with light for signals transmitted between boards and chips, such as servers and switches, and even within chips. When testing the optical interfaces implemented in these devices, it is necessary to confirm whether the characteristics such as optical wavelength, optical power, digital transmission waveform, and bit error rate satisfy the various international and industry standards. Verifying that these items conform to standards assures the reliability and performance of the entire system.



Opto-Electronic Network Analyzer
ME7848A

The VectorStar Opto-Electronic Network Analyzer (ONA) ME7848A performs traceable measurements up to 110 GHz on O/E, E/O, and O/O devices at optical wavelengths of 850, 1310, and 1550 nm.



BERTWave Sampling Oscilloscope
MP2110A

The MP2110A is a measuring instrument suitable for the manufacturing evaluation of 10G to 800G and 1.6T optical modules, incorporating a 4-channel sampling oscilloscope (eye pattern analysis) and a BERT (bit error rate measurement) in a single unit.

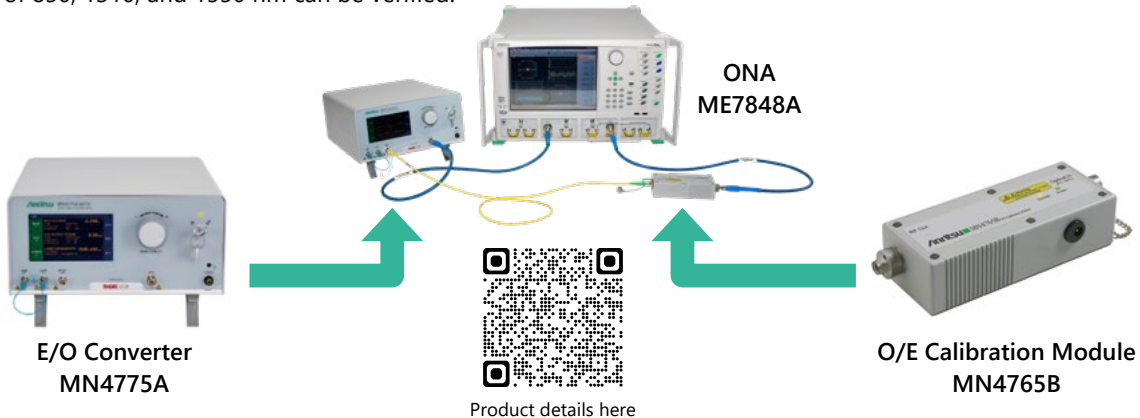
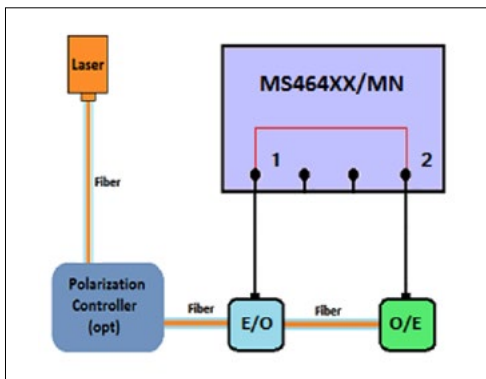


Optical Spectrum Analyzer
MS9740B

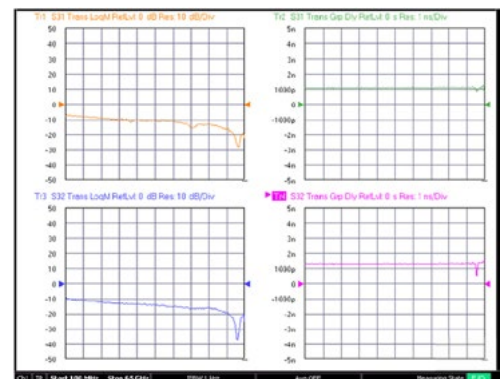
The MS9740B has a wavelength range of 600 nm to 1750 nm and a measurement menu for the optically active devices required for evaluating optical devices. It can simultaneously measure the central wavelength, level, OSNR, spectrum width, and other optical parameters that serve as evaluation standards in the manufacturing process, and then display the analysis results on a single screen.

Frequency Characteristic Evaluation of Optical Components

Anritsu Opto-Electronic Network Analyzer ME7848A can evaluate the insertion loss, reflection characteristics, group delay, etc. of optical communication modules. By using an E/O converter that converts electrical signals to optical signals and an O/E converter that converts optical signals to electrical signals, the E/O, O/E, and O/O characteristics of optical communication modules for optical wavelengths of 850, 1310, and 1550 nm can be verified.



Frequency characteristics calibration of optical devices
using E/O converter and O/E calibration module



Frequency characteristics measurement example
of an optical device

Components for Measuring High-Frequency Signals

Anritsu also offers components such as the coaxial cables, connectors, and bias tees that are essential for measuring high-frequency signals.

 <p>K connectors DC to 40 GHz Compatible with SMA connectors</p> <p>MP1900A MP2110A MS46522B/MS46524B</p>	 <p>V connectors DC to 65 GHz Fits 2.4 mm connector</p> <p>MP1900A ME7848A</p>	 <p>W connectors DC to 110 GHz</p> <p>ME7848A ME7838 series</p>	 <p>DC Block The DC block removes the DC component and allows AC signals to pass through.</p> <p>MP1900A MP2110A</p>
 <p>Bias Tee A bias tee allows you to apply a DC signal to an AC signal.</p> <p>MP1900A ME7838 series</p>	 <p>Fixed Attenuators Attenuators are available according to frequency band and attenuation amount.</p> <p>MP1900A MP2110A ME7838 series</p>	 <p>Coaxial Termination For the termination of an unused port.</p> <p>MP1900A MP2110A</p>	 <p>Adapters Connector conversion adapters, calibration adapters, etc., are available.</p> <p>MP1900A MP2110A ME7838 series MS46522B/MS46524B</p>
 <p>Power Divider Used to divide or combine signal power.</p> <p>MP1900A ME7838 series MS46522B/MS46524B</p>	 <p>Power Splitter Accurately divides signal power for ratio measurements.</p> <p>MP1900A ME7838 series</p>	 <p>Universal Test Fixture For measuring substrate devices such as microstrip lines and coplanar waveguides.</p> <p>ME7838 series MS46522B/MS46524B</p>	 <p>Calibration Kit For calibrating the frequency characteristics of vector network analyzers.</p> <p>ME7838 series ME7848A MS46522B/MS46524B</p>



High Return Loss Connectors and Cables



Instrumentation Grade Adapters



Precision Terminators, Fixed Step Attenuators



Measurement Components and Accessories

For a model number and specifications, refer to the product brochure "[Precision RF & Microwave Components](#)".