Test&Measurement

YOKOGAWA

# Measurement solutions for medical device development

Precision Making

LF MEDICAL-01EN

**Health and medical devices are playing a vital role in protecting health, preventing future health problems and saving lives. With continued advancements in technology and evolving, stringent safety standards, these instruments require very high degree of reliability in their operation and accuracy in their measurements. To develop these devices, manufacturers need equally highly accurate and precise test and measurement equipment.**

**One of the major needs in medical treatment is the supply and control of gasses such as oxygen and $CO_2$. Ensuring the valves and pressure sensors used in this equipment are operating normally and providing the right pressure reading is essential to maintain patient health.**

**Lasers and other optical methods are rapidly expanding as major medical tools. The ability to measure their wavelengths at high resolution is key to developing medical lasers and other optical instruments that can target the correct cells or characterise the right body tissue.**

**Yokogawa offers a range of solutions for R&D and manufacturing, including the MT300 digital manometer providing high accuracy and stability to ensure measured pressure values can be relied on, while laser light characteristic analysis instrument such as the AQ6370 series of Optical Spectrum Analyzer and the DL950 ScopeCorder offer the high resolution to view waveforms in fine detail.**

**Accuracy** – With a relative accuracy of pressure measurement of 0.01%, the MT300 Digital Manometer is ideal for developing gas transfer medical applications. Variants are available for fine differential pressure (1 kPa) to high pressure (Gauge pressure 70 MPa).

**Resolution** – Offering high sensitivity and high resolution, the AQ6370 series of Optical Spectrum Analyzer is ideal for developing optical and laser medical devices. Models are available covering a wide wavelength range from visible to mid-infrared (350 to 5500 nm).

**Versatility** – Medical devices are often a complex amalgam of mechanical, electrical and electronic systems, requiring a versatile instrument able to capture multiple data points. The DL950 ScopeCorder can use 21 types of plug-in modules to conduct complex measurements on interrelated subsystems.


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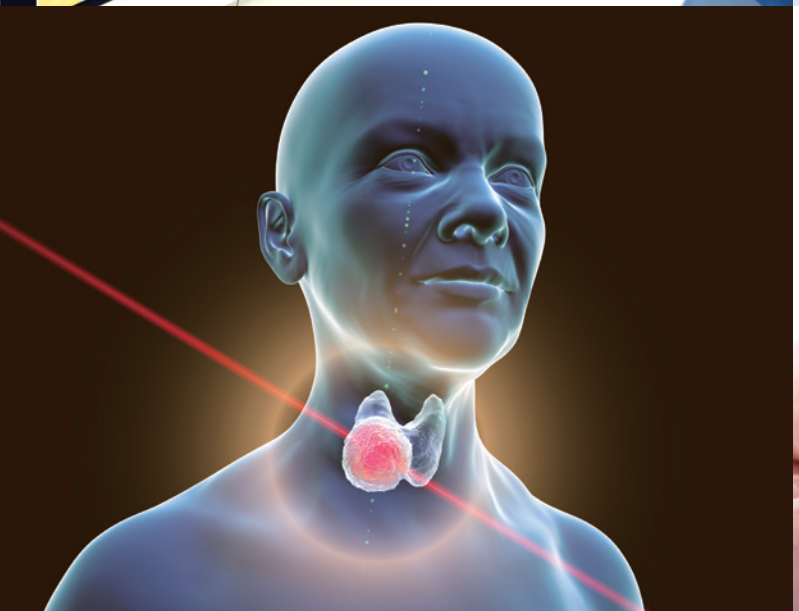


# Supporting patients through surgery

Achieving accurate pressure readings in medical equipment such as ventilators and heart-lung machines is vital. Pressure sensors and pumps on these devices, as well as those on endoscopes, need to be tested and assessed for accurate performance. Air filters that maintain clean air for patients also need to be evaluated for pressure losses before and after the filter. All these tasks can be performed by Yokogawa's MT300 digital manometer, which offers the high accuracy and stable testing environment needed to assess medical devices.

## Ventilators

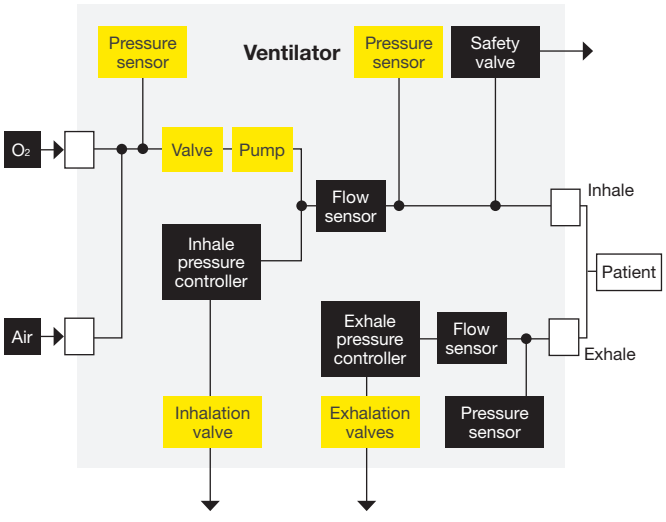
Medical devices that assist breathing, such as ventilators, are equipped with numerous sensors to regulate the amount of oxygen supplied to patients. It is vital that the pressure valve that operates between inspiration and expiration, as well as the safety valve that prevents excessive pressure, are working properly.

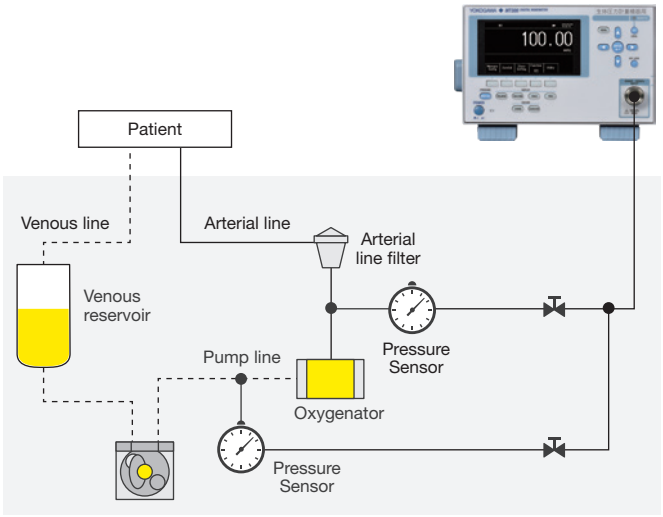
Testing these devices is the role of Yokogawa's MT300 digital manometer. The MT300's silicon resonant sensor offers excellent measurement accuracy, stability and reproducibility and provides a testing environment with long-term stability for the measurement of critical medical devices. The MT300 differential pressure model can be used for a range of applications, such as piping inspection by measuring the pressure loss in a flow channel, testing pressure sensor output or a pressure valve's operating pressure, and the calibration of pressure sensors.

## Heart-lung machines

The MT300 also finds use in the development of heart-lung machines that take on the role of these vital organs during surgery. These devices have a large number of pressure sensors to warn of clogging due in centrifugal pump or a thrombus of the artificial lung.

These installed sensors need high measurement accuracy to ensure they can monitor the minute pressure changes due to thrombi. The MT300 offers this accuracy, as well as a high display resolution, allowing the performance of the sensor to be more precisely verified.

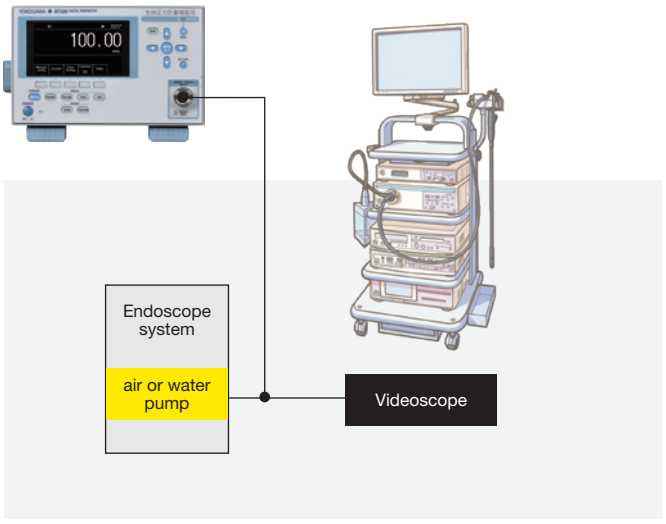


## Endoscope system gas pressure measurement

An endoscope system is designed to pump air or $CO_2$ into or out of a human body. The pumps and sensors used in the system must provide accurate pressure output and display to avoid placing an undue strain on the human body.

Offering high stability and measurement accuracy in the range of human body pressure, the MT300 can help maintain the functions and performance required for endoscopic systems. Because liquid can be used as a measuring medium, the MT300 can also be used to investigate the performance of water pumps.

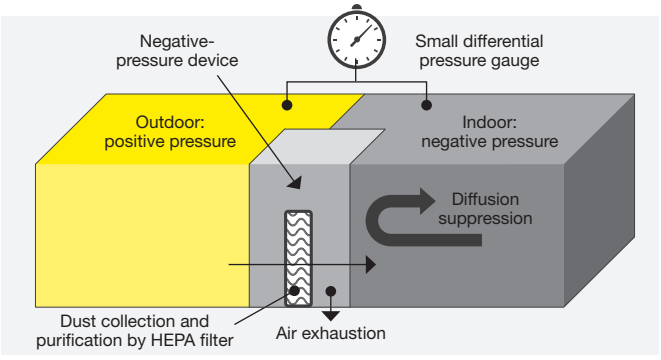



## Keeping infections under control

Many areas in a hospital need clean air, including infection control rooms, operating rooms, and ICUs. To achieve this, positive and negative air pressures are controlled. Air will move from higher pressure to lower pressure, so controlling the flow of air into a room prevents the spread of viruses.

The cleanliness of the air itself is maintained using HEPA filters. IEC 26431, a standard for evaluating the performance of air filters, requires measurement of the pressure loss before and after the filter.

The differential pressure model of the MT300 can measure slight differential pressure with high accuracy and can be used to evaluate the performance of negative pressure devices equipped with HEPA filters for dust collection. The MT300 can be battery powered, giving it the portability to calibrate differential pressure gauges installed at various facilities. This makes periodic inspection and testing work much more efficient.

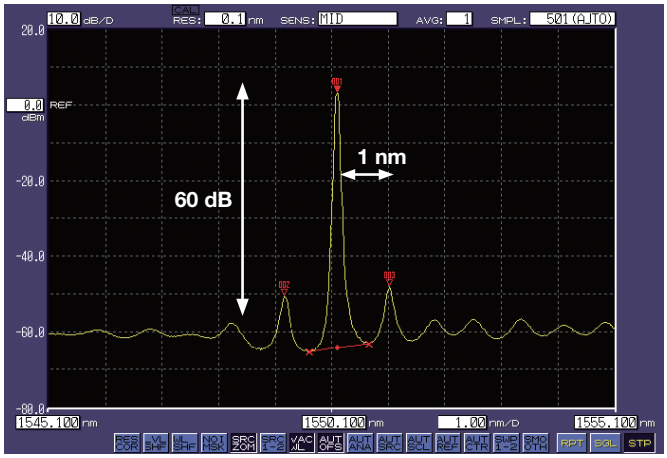


# Developing medical laser techniques

Lasers and other light sources are a major tool in modern medical treatment and diagnosis. A critical factor for lasers is ensuring they emit the correct wavelength of light to destroy target cells while avoiding damaging good cells. Specific wavelengths of light are also used in examination techniques such as endoscopy, which employs filters to ensure correct observation of tissue damage. Assessing the performance of these devices requires an optical spectrum analyzer with high wavelength accuracy and resolution, such as the Yokogawa AQ6374.

## Laser light sources for medical laser treatment

Laser treatment devices use lasers with different wavelengths to suit the treatment target. Because the laser requires a monochromatic wavelength to avoid affecting areas other than the target, an optical spectrum analyzer (OSA) is used to determine whether light of the correct wavelength is being emitted. Measuring the optical spectrum quality of a laser requires an OSA with a high wavelength resolution, a wide measurement dynamic range, and high sensitivity.



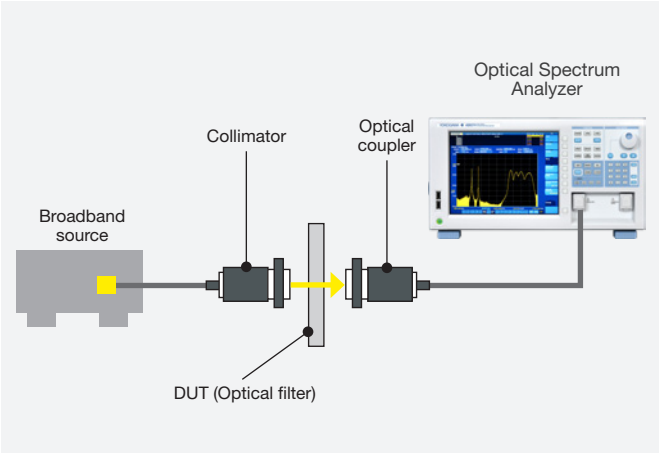

**High resolution and wide dynamic range spectrum analysis using the AQ6374 OSA**

## Characterization of light sources and optical filters for medical use

One of the functions of endoscopes is special light observation. This is performed using a specific wavelength of light to detect lesions and abnormalities that cannot be observed by white light endoscopy. This wavelength of light can be obtained by passing white light, usually from a xenon lamp, through an optical filter. The performance of the optical filter, which determines the wavelength and spectral width of light, is critical in allowing clear observation of lesions and abnormalities and must be measured accurately.

Optical Coherence Tomography or OCT, an examination technique used in ophthalmology, uses a Tunable Laser Source (TLS), which oscillates at a single wavelength and can scan that wavelength at high speed. The technique also uses a Super Luminescent Diode (SLD), which emits light with a large spectral width. Each of them must have extremely high optical spectral quality.

To measure the characteristics of these optical filters and the wavelength of the light source accurately, an OSA with high wavelength accuracy and high wavelength resolution is required, such as the AQ6374 Optical Spectrum Analyzer.



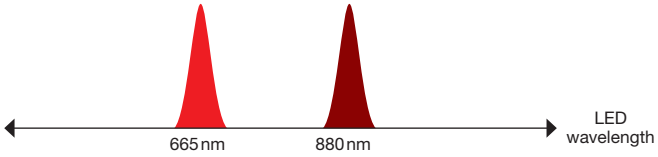
# Investigating tissue samples

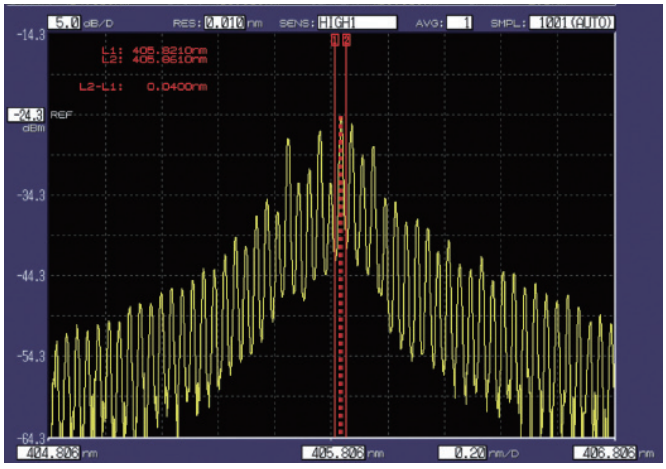
Tissue such as blood and other cells are often examined using light sources. Blood oxygen levels are measured using highly accurate red light and infrared LEDs. Similarly, bio-imaging uses infrared LEDs to see deep inside the tissue sample. These LEDs need a high-performance optical spectrum analyzer to ensure they have the high wavelength accuracies required. The Yokogawa AQ6370 series OSA fits the bill.

## Assessing blood samples

A pulse oximeter measures oxygen saturation using the difference in the absorption characteristics of $HbO_2$ (oxidized haemoglobin) and Hb (reduced haemoglobin) in blood. Two LEDs with wavelengths of 665 nm (red light) and 880 nm (infrared light) are used for this measurement.

Since the absorption characteristics of $HbO_2$ and Hb change greatly depending on the wavelength, a LED with high wavelength accuracy is required for accurate measurement of oxygen saturation. For this reason, the LED testing requires an optical spectrum analyzer with a wavelength measurement accuracy of approximately ±0.5 nm or less.



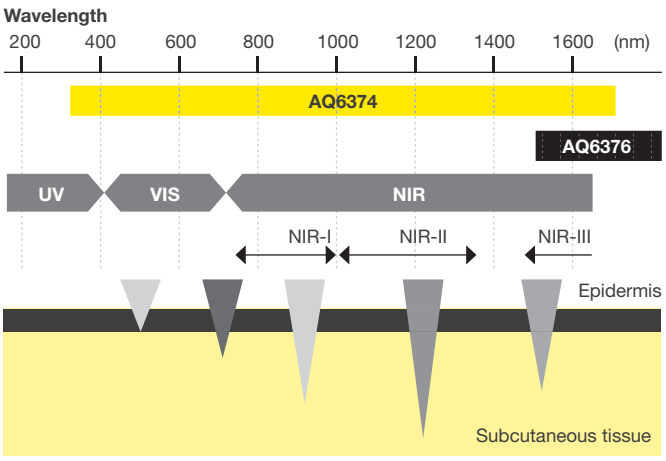

**FP Laser Spectrum Analysis with OSA**
FP:Fabry-Perot

## Bio-imaging

Near-infrared light (700 nm to 2,500 nm) is used to observe not only the surface of biological objects but also their deeper structures. Because the degree of refraction at the interface of objects with different refractive indices decrease as the wavelength increases, near-infrared light scatters less in biological objects, making it possible to image deeper into the tissue.

**Optical Spectrum Analyzer**
AQ6374: 350-1750 nm

**Optical Spectrum Analyzer**
AQ6376: 1500-3400 nm



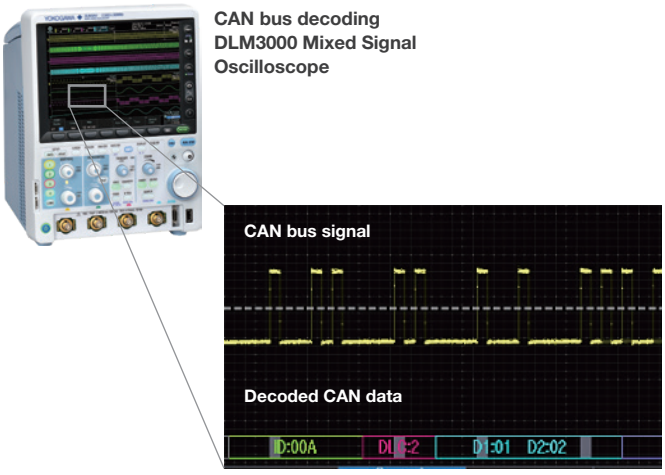
# Evaluating power and data in medical devices


Power and data are fundamental to a large number of medical devices. Many use buses for transferring data, so decoding embedded signals to debug software is vital for developers. Medical centrifuges present measurement challenges as both electrical and mechanical signals must be captured and displayed on the same device – this can be achieved using modules feeding into the Yokogawa DL950 ScopeCorder, which can also measure the floating signals of circuits used to isolate patients from electric shock. Wireless power charging is also a trend for medical devices – the Yokogawa PX8000 Precision Power Scope can measure the high frequency power involved.

## Using CAN Bus in medical devices

Controller Area Network (CAN) bus is a data transfer protocol. It is used in medical devices, for example, for communication between optional interfaces for CT equipment, to control devices from different manufacturers and for communication between controllers for medical robots.

Using an oscilloscope to decode CAN bus signals is very useful for debugging embedded software. Yokogawa's DLM series instruments support CAN, CAN FD, I²C, SPI, UART and LIN, enabling simultaneous evaluation of multiple buses.

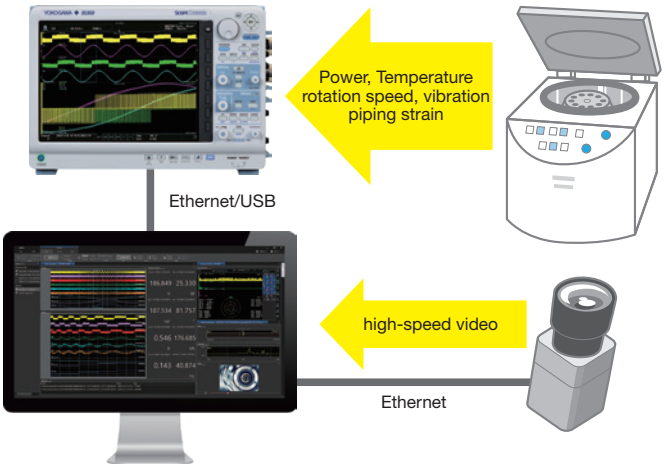



## Testing medical centrifuges

Evaluating a medical centrifuge requires a variety of measurements, including rotation state, temperature, power, and piping strain of the refrigeration cycle evaporator.

The Yokogawa DL950 ScopeCorder can perform various measurements simultaneously, using a wide variety of modules with built-in amplifiers. With an optional large memory, the DL950 makes it possible to simultaneously observe electrical signals captured at high-speed sampling rates, temperature, rotation speed, vibration, and other parameters. This allows the relationship between commands and their operations can be well understood.

In addition, with the IS8000 Integrated Software Platform, measurement data from the DL950 can be synchronized with high-speed camera videos and WT5000 power measurement data.

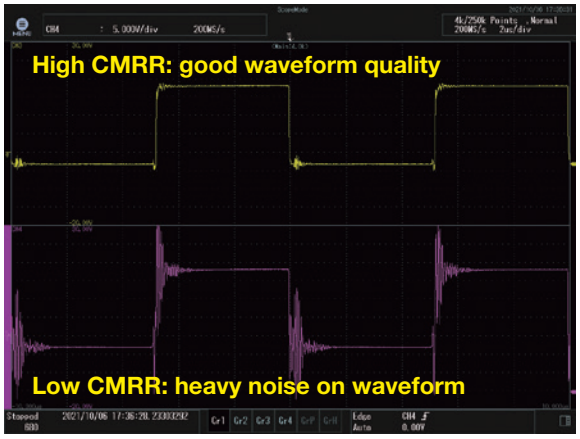


## Waveform evaluation of floating devices

Many medical devices, such as electrocardiographs and electroencephalographs, protect the patient from electric shock by isolating the circuitry in contact with a patient from the medical device.

Because the reference potential of such floating circuits is not grounded, measuring instruments with isolated inputs are convenient for observing signals. It is also important for the instrument to have a high common-mode rejection ratio (CMRR) and good noise immunity to accurately capture weak biosignals.

The DL950 ScopeCorder is a waveform measuring instrument with isolated input channels. Its high CMRR and circuit configuration make it less susceptible to external noise, giving an accurate representation of the true waveform of floating signals.

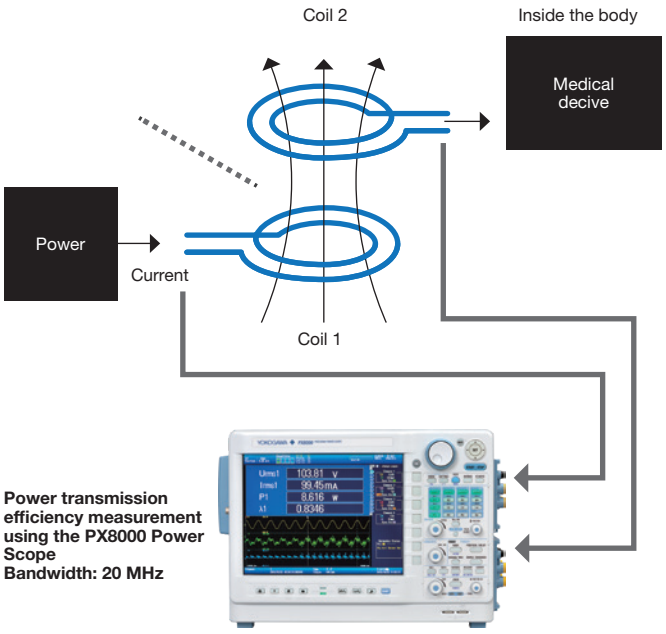



**Inverter circuit observation ($V_{GS}$)**

## Devices using wireless power charging

Wireless power charging is being developed for use in medical applications. Non-contact power transmission methods include electromagnetic induction and magnetic resonance. Because power is transmitted in the frequency band of 100 kHz to 200 kHz, measuring power transmission efficiency requires a measuring instrument capable of capturing high-frequency power.

This ability is offered by the Yokogawa PX8000 Precision Power Scope, which can measure current and voltage in the frequency range up to 20 MHz.




**Power transmission efficiency measurement using the PX8000 Power Scope**
**Bandwidth: 20 MHz**

## MT300
Digital Manometer

- Relative accuracy of pressure measurement: 0.01%
- Accuracy guarantee period: 12 months
- Extensive lineup from fine differential pressure (1 kPa) to high pressure (Gauge pressure 70 MPa)
- mmHg display is available
- Battery operation available
- DCV/DCA measurement, 24 VDC output (option)
- DA conversion output (option)

## AQ6370 Series
Optical Spectrum Analyzer

- 6 models covering a wide wavelength range from visible to mid-infrared (350 to 5500 nm)
- Best-in-class optical performance
  High sensitivity/High resolution/High dynamic range models
- Support for a variety of optical fibers
- Gas purging feature

## DLM3000/DLM5000 Series
Mixed Signal Oscilloscopes

- Analog 4 ch / 3 ch+8 bits / 8 ch+16 bits analog and logic mixed input
- Bandwidth:
  DLM3000 200 MHz/350 MHz/500 MHz
  DLM5000 350 MHz/500 MHz
- Max. sampling rate: 2.5 GS/s (All channels)
- Max. record length: 500 Mpoints
- $I^2C$/SPI/UART/CAN/CAN FD/LIN and more
  Serial bus trigger/analysis (option)

## DL950
ScopeCorder

- Complex measurements with 21 types of plug-in modules
- Max. 200 MS/s sampling rate, 14-bits isolation analog input
- 4-CH 10 MS/s 16 Bit isolation analog input module 720256
- Up to 8 Gpoints large memory
- Synchronized operation of up to 5 units connected with optical fiber cords
- 10 Gbps Ethernet high-speed data transfer to a PC
- Time synchronization with other measuring instruments using IEEE1588

## PX8000
Precision Power Scope

- Max. 100 MS/s sampling rate, 12-bit resolution, 20 MHz bandwidth
  Up to 4 inputs for wide range power measurement (voltage/current)
- Direct input of 1000 Vrms, 5 Arms
  (use a current sensor for high currents.)
- Waveform & power measurement instrument suitable for evaluation of high frequency power transmission systems

## IS8000
Integrated Software Platform

- Remote control and synchronized operation of DL950, WT5000, DLM series instruments
- Synchronized measurement of high-speed camera images and electrical signals
- Offline analysis of waveform data from Oscilloscopes and ScopeCorders

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