



TE SENSOR SOLUTIONS FOR MEDICAL APPLICATIONS

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TE Connectivity (TE) is now one of the largest sensor companies in the world, with innovative sensor solutions that help customers transform concepts into smart, connected creations. Electronic systems in medical equipment, devices and probes rely on sensor signals as a basis for control activities, accurate diagnosis and treatment. TE Connectivity designs and manufactures sensors to exacting specifications for the rigors of medical applications, with ISO 13485 certification and FDA registration for various products. Our engineers provide full support of application-specific, standard and custom requirements, from product concept through manufacturing.



SENSOR TYPES

- AIR BUBBLE
- FORCE
- HUMIDITY
- LIQUID LEVEL
- PIEZO FILM
- POSITION
- PRESSURE
- PULSE OXIMETRY
- TEMPERATURE
- VIBRATION

QUALITY CERTIFICATION AND AUDITED PROCESSES

- ISO 13485
- ISO 9001
- CE-MDD
- FDA
- CMDR-Health Canada



CARDIOVASCULAR MONITORING AND DIAGNOSIS



Disposable Blood Pressure Sensor

- Miniature silicon in-line Microelectromechanical Systems (MEMS) pressure sensor with IV to monitor patient blood pressure.

Electronic Stethoscope

- Piezo film for contact microphone to detect heartbeat and breathing sounds.

Heart Rhythm Monitoring

- Piezo film sensor monitors heart rhythms.

Pulse Oximetry

- Photo optic sensors measure blood oxygen saturation (SpO₂) and pulse.

Thermo Dilution Sensor

- Miniature Negative Temperature Coefficient (NTC) thermistors at catheter tip provide temperature data to calculate cardiac output.

Ultrasound Imaging

- Piezo ultrasonic transducers designed into miniature imaging probes for custom configurations.
- Temperature sensors used to monitor the operating temperature of ultrasound head.

CARDIOVASCULAR TREATMENT



Ablation Catheter

- Force and pressure sensors for irrigated ablation systems.
- Temperature sensor monitors Radio Frequency (RF) energy used for ablation.

Angioplasty Balloon Inflating Pump

- Silicon MEMS pressure sensor monitors inflation of angioplasty balloon.
- Temperature sensor measures cryogenic gas in the balloon or tank.

Blood Transfusion and Oxygenation

- Silicon MEMS stainless steel pressure sensor used in a blood separation device and temperature sensor measures return blood.

Contrast Dye Infusion

- Silicon MEMS pressure sensor monitors the injection of contrast solution during angioplasty procedure.
- Temperature sensors for solution temperature control.

Discrete Vital Signs Monitoring

- Piezo film can monitor heart beat and respiration rate.

Myocardial Needle Probes

- As the heart is cooled during surgery, hypodermic needles are inserted into myocardial muscles to monitor temperature.

Pacemaker

- Piezo film sensor acts as an activity monitor that detects patient movement. Heart rate and blood flow is subsequently increased.
- Position Magneto-resistive (MR) sensor used to detect body position.

Ventilator and Respirator

- Silicon MEMS pressure sensor measures air flow in breathing machine.
- Humidity and temperature sensors monitor air intake.
- Liquid level for water tank level.
- Position sensors for cabinet safety interlock.
- Optical sensors measure SpO₂.

PATIENT MONITORING AND DIAGNOSIS



Body Weight

- Microfused load cell embedded in scale for patient weighing.

Bone Density

- Piezoelectric material can be deployed as an ultrasonic transducer to measure bone density.

Hospital Bed Vital Signs

- Piezo film monitors breathing patterns and heart rate.

Skin Temperature

- Reusable or disposable skin sensors for continuous monitoring.

Urinary Catheters and Urodynamic Testing

- Temperature sensors monitor the core body temperature during bladder draining.
- Pressure sensors at tip of probe (or situated externally) used to measure bladder pressure under different conditions.

Sleep Apnea Studies

- Pressure sensors monitor breathing cycles and positive air pressure.
- Photo optic sensors measure blood oxygen saturation (SpO₂) and pulse.
- Piezo film monitors breathing patterns, heart rate, and body/limb movements.

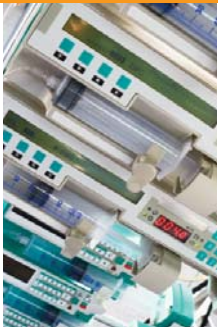
Non-Contact Thermometry

- Thermopile sensors in digital thermometers (ear and forehead) allow non-contact temperature measurements.

Contact Thermometry

- Thermistors placed in industry standard NTC probes (skin, esophageal and rectal) are used with patient monitoring equipment worldwide.

PATIENT TREATMENT



Insulin Pump

- MR sensors control insulin dosage.

Bubble and Level Detection

- Ultrasonic sensors detect bubbles or medication levels during infusion.

Dialysis Machines

- Air-bubble sensors for detection in return tube.
- Liquid level sensors for bottle volume.
- Pressure/force sensors for in-line pressure.
- Temperature sensors for fluid temperature.

Infusion Pump

- Silicon MEMS pressure sensors or Microfused load cells used to detect presence and/or rate of flow, occlusion, presence of needle.
- Magnetic encoders in peristaltic pumps and linear position sensors in syringe pumps for flow control.
- Ultrasonic sensors detect air bubbles in infusion liquids.

Smart Beds

- Optical encoders define the tilt angle of the back rest.
- Load cells placed on the four legs of the bed record patient weight.
- Linear string potentiometers monitor bed height.

Hospital Gas Monitoring

- Silicon MEMS pressure sensors detect gas pressure for hospital medical gas systems.

Premature Newborn Cabinet

- Humidity and temperature sensors control air flow and humidity levels to ensure optimized, safe ambience.

Ventilator and Respirator

- High sensitivity Silicon MEMS low pressure sensor controls positive airflow to breathing mask.
- Photo optic SpO₂ sensor monitors blood oxygen levels.
- Pressure sensors detect the trigger point between inspiration and expiration. Also assists in light and heavy breathing.
- Thermopile sensors monitor the CO₂ levels in a patient's exhalation pattern.
- Humidity sensors monitor and control proper humidity levels.
- Temperature sensors measure and regulate air intake.

SURGICAL/DELIVERY



Assisted Baby Delivery

- Silicon MEMS pressure sensor monitors pressure in vacuum-assisted baby delivery systems.
- Piezo film to measure contraction.

Brain Tumor Hypodermic Needle Probes

- Miniature temperature sensors at needle tip monitor freezing or warming of the brain during procedure to kill cancerous cells.

Endoscopic Surgery

- Force and pressure sensors are used for control of irrigation pumps.

Intrauterine Pressure Sensor

- Low-cost miniature silicon MEMS pressure sensor monitors contraction frequency and amplitude during labor.

Ocular Surgery

- Silicon MEMS pressure sensor maintains fluid pressures in the eyeball during surgery.

Patient Warming/Cooling

- Temperature sensors monitor patient temperature during/after surgery to improve recovery time.



Robotic Surgery

- Cable extension sensors and rotary encoders accurately monitor the position of surgical tools.

Surgical Devices and Instruments for Orthopedic, Cosmetic and other Surgeries

- NTC temperature sensors to measure temperature during freezing or RF ablation.
- Force and pressure sensors control irrigation pumps.
- Force and Linear Variable Differential Transformer (LVDT)/MR position sensors measure depth, position and force of surgical tools.
- MR sensors measure Revolutions Per Minute (RPM) of surgical tool.

Anesthesia Delivery

- Piezo film as Neuromuscular Transmission (NMT) sensor for monitoring depth of anesthesia.

HOME AND MOBILE HEALTH CARE/WEARABLE MEDICAL DEVICES



Wearable Health Devices

- Piezo electric film on wearable patches detects heart rhythm and respiratory signals.
- Photo optic sensors measure blood oxygen saturation (SpO₂) and pulse.

Mobile Infusion and Insulin Pumps

- Piezo film sensors monitor bubbles, fluid level, empty bag and flow rates.
- Ultrasonic piezo film sensors detect air bubbles in dosing applications.

Mobile Oxygen Delivery

- Low pressure MEMS sensors enable oxygen tanks to conserve gas by detecting the inhalation sequence of a patient's breathing.
- Tension load cells placed in the handle and compression load cells at the base determine the quantity of gas still in reserve.



Organ Transportation

- Disposable blood pressure sensors monitor flow of the nutrients through organs during transport to extend organ life.
- Temperature sensors monitor ambience of organ container.

Patient Fall Detection

- High resolution altitude pressure sensors detect the sudden collapse of a patient.

Sleep Apnea Treatment/CPAP

- Low pressure sensors control positive airflow to breathing mask.
- Pressure sensors detect the trigger point between inspiration and expiration.
- Humidity sensors monitor and assist in the control of proper humidity levels.

TE SENSOR SOLUTIONS FOR MEDICAL APPLICATIONS

For application support and custom solutions, please contact your local representative.



Technology	SpO ₂	SpO ₂	Air Bubble	Vibration
Sensor Type	Photo optic lead frame emitter / detector	Biocompatible SpO ₂ sensor	Ultrasonic air-in-liquid detectors	Piezoelectrical film sensors
Product Example	MEAS ELM 4000 / EPM 4001	MEAS Photo optic finger clip sensor, disposable SpO ₂ sensor	MEAS AD-101	MEAS LDTC family, MiniSense 100, custom designs
Dimensions (mm)	4.4 x 5.1 x 1.9	Application dependent	Application dependent	19.05 x 6.35 x 6.35
Accuracy	Sensor dependent	Sensor dependent	Application dependent	±20.0% (Typical)
Range	660 - 940 nm	Adult / neonatal	Detects bubbles 4 µl and larger (Standard; consult factory for 1 µl and smaller bubble size)	±10 g (Typical)
Unique Features	<ul style="list-style-type: none"> • Low cost • Dual drive • Clear epoxy lens 	<ul style="list-style-type: none"> • Soft pads • Lightweight • Easily cleaned 	<ul style="list-style-type: none"> • Bubble detection from 1 mm tube • Temperature option • Occlusion option • Fluid differentiation • 3.3 and 5 V input option 	<ul style="list-style-type: none"> • Very low cost • High sensitivity (1 V/g) • Ultra low power (Self generating)
Typical Applications	Pulse oximetry, finger and ear probes, disposable	Pulse oximetry	Infusion pumps, dialysis machines, apheresis, auto-transfusion	Wake-up switch, impact sensing, vital signs monitoring



Technology	Force	Force	Position	Position
Sensor Type	Miniature low cost force sensor	Miniature force sensor	Cable extension transducer	Magnetorestrictive linear and angular sensors
Product Example	MEAS FX1901	MEAS FS20 / FC22	MEAS SM, SP	MEAS MS32 / KMA36
Dimensions (mm)	Ø 25.00 x 29.50 x 8.00	30.708 x 17.272 x 8.255 / Ø 26.00 x 42.00 x 19.50	43 x 45 x 68	TDFN: 2.5 x 2.5 x 0.8 / TSSOP20: 6.5 x 6.4 x 1.2
Accuracy	±1% FSO (CNL&H)	±1% FSO (CNL&H)	±0.25% to ±1%	Typ. 0.1 kA/m / typ. 0.3°
Range	10, 25, 50, 100 Lbf	1.5, 3 / 25, 50, 100 Lbf	0 - 2.5 to 0 - 50 inches	1 to 3 kA/m magnetic switching field / 360° angle
Unique Features	<ul style="list-style-type: none"> • Low cost, low strain design • Ultra high cycle life • Digital / analog output 	<ul style="list-style-type: none"> • Low range • High overload protection • Ultra high cycle life • Digital / analog output 	<ul style="list-style-type: none"> • Compact design • Low cost, high value stringpot • Custom configurations available for OEM customers 	<ul style="list-style-type: none"> • Ultra low cost • Ultra small size • High accuracy • Digital / analog output
Typical Applications	Physical therapy, pumps, medical devices, patient weight	Medical devices, physical therapy, oxygen tank, infusion pumps	Medical imaging systems, surgical robots	Various position control applications

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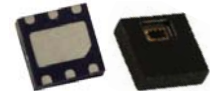
Technology	Contact Temperature
Sensor Type	Micro thermocouple / micro thermistors
Product Example	MEAS model 600 / G22K7MCD8
Dimensions (mm)	From 0.23 OD
Accuracy	From $\pm 0.1^{\circ}\text{C}$
Range	Thermocouple type T, K / NTC from 1K to 100K Ω
Unique Features	<ul style="list-style-type: none"> • Welded or soldered junction (Thermocouple) • Low profile, fast response • Polyesterimide wire insulation
Typical Applications	Medical catheters



Technology	Contact Temperature
Sensor Type	Patient monitoring probes
Product Example	MEAS 400 AC series reusable / 4400 series disposable
Dimensions (mm)	Reusable: 3 m cable with sensor Disposable: Sensor <1 m; 3 m reusable adapter cable
Accuracy	Probes meet both: EN-12470: $\pm 0.1^{\circ}\text{C}$ at 25°C to 45°C ISO-80601-2-56: $\pm 0.2^{\circ}\text{C}$ at 35°C to 42°C
Range	400 series, 700 series (Reusable only)
Unique Features	<ul style="list-style-type: none"> • Autoclavable reusables • Sterile disposables • Developed by YSI temperature
Typical Applications	Patient monitoring



Technology	Non-Contact Temperature
Sensor Type	Thermopiles
Product Example	MEAS TS
Dimensions (mm)	9 x 9 x 17.6
Accuracy	Application dependent
Range	-20 to +85 $^{\circ}\text{C}$ (Permanent) 20 to +100 $^{\circ}\text{C}$ (Non-permanent)
Unique Features	<ul style="list-style-type: none"> • High signal output • Accurate reference sensors
Typical Applications	Medical thermometer (Ear and forehead), pyrometer



Technology	Humidity
Sensor Type	Digital miniature humidity and temperature sensor
Product Example	MEAS HTU2x
Dimensions (mm)	3.0 x 3.0 x 1.0
Accuracy	$\pm 3\%$ RH at 25°C (10 to 95% RH) $\pm 0.3^{\circ}\text{C}$ at 25°C
Range	0 to 100% RH
Unique Features	<ul style="list-style-type: none"> • Low power consumption • Fast response time • Very low temperature coefficient • I²C interface or PWM interface or SDM interface
Typical Applications	Humidifier for medical ventilator



Technology	Pressure
Sensor Type	Invasive blood pressure monitoring
Product Example	MEAS 1620, 1630
Dimensions (mm)	1620: 11.43 x 8.13 x 4.20 1630: 12.7 x 5.08 x 3.94
Accuracy	1.0% FSO
Range	-30 to 300 mmHg
Unique Features	<ul style="list-style-type: none"> • Low cost, disposable design • Supplied in tape and reel • Compliant to AAMI spec
Typical Applications	Disposable blood pressure, surgical procedures, ICU, kidney dialysis machines, medical instrumentation



Technology	Pressure
Sensor Type	Media isolated pressure sensor for aggressive fluids
Product Example	MEAS 85 flush mount
Dimensions (mm)	\varnothing 17.2 x 11.4
Accuracy	$\pm 0.1\%$ FSO non-linearity
Range	0 - 1, 2, 3, 7, 21, 34 bar / 0 - 15, 30, 50, 100, 300, 500 psi
Unique Features	<ul style="list-style-type: none"> • High performance • High stability • Minimizes trapped volume
Typical Applications	Dialysis machines, infusion pumps, medical systems



Technology	Pressure
Sensor Type	Miniature board mounted pressure sensors
Product Example	MEAS MS5637
Dimensions (mm)	3 x 3 x 0.9
Accuracy	± 2.0 mbar / ± 0.03 psi at 25°C
Range	10 to 2000 mbar abs. / 0.15 to 29 psi abs.
Unique Features	<ul style="list-style-type: none"> • 24-bit digital sensor • Altitude resolution of less than 15 cm • Supply voltage: 1.5 to 3.6 V • Low power, 0.6 μA (Standby ≤ 0.1 μA at 25°C) • Digital temperature readout
Typical Applications	Fall detection, pneumatic handheld drills, respirators / ventilators



Technology	Pressure
Sensor Type	Miniature board mounted pressure sensors
Product Example	MEAS MS45xx, MS55xx
Dimensions (mm)	12.5 x 9.9
Accuracy	0.25% / 1% TEB
Range	0 - 2, 4, 5, 10, 20, 30, H ₂ O (MS4515/DO) 0 - 1, 2, 4, 5, 10, 30, 50, 150 psi (MS4525/DO)
Unique Features	<ul style="list-style-type: none"> • MS4515/25 (12-bit DAC analog) • MS4515DO/25DO (14-bit digital SPI or I²C) • MS5525DSO (24-bit digital SPI or I²C) • Wide supply voltage: 1.8 to 5.7 VDC • Small package footprint • Varied port configurations
Typical Applications	Medical instruments, respirators / ventilators

TE CONNECTIVITY SENSOR TECHNOLOGIES

Pressure

- Piezoresistive MEMS silicon chip
- Microfused bonded silicon strain gage
- Media isolated pressure capsules
- Bonded Foil Strain Gage (BFSG)
- Miniature MEMS strain gage

Temperature

- NTC thermistors
- Miniature thermocouples
- Non-contact thermopiles (Passive IR)
- Platinum thin film Resistance Temperature Detector (RTD)
- Digital temperature chip technology

Humidity

- Proprietary capacitive
- Combination humidity and temperature modules

Photo Optic

- Dual-wavelength
- Photo diode sensors
- Combination emitter and sensor module

Force and Load

- Piezoresistive MEMS silicon chip
- Microfused bonded silicon strain gage
- Bonded Foil Strain Gage (BFSG)

Piezoelectric

- Piezo polymer film
- Piezo ceramic

Liquid Level

- Single point reed switch
- Single point ultrasonic
- Continuous ultrasonic
- Invasive
- Non-invasive

Position

- Linear LVDT
- Rotary Variable Differential Transformer (RVDT)
- Cable extension (Stringpot)
- Linear magnetostrictive
- Rotary magnetostrictive
- Tilt and angle sensors

Vibration and Acceleration

- MEMS based accelerometer
- Piezoelectric based accelerometer
- Single, biaxial and triaxial configurations

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