Sensors for Medical Applications

Motion and pressure sensors designed for high-functionality, accuracy and reliability
OVERVIEW

NXP is a leading high-volume sensor provider with an extensive selection of accelerometers, magnetometers, pressure sensors and touch sensors for medical applications. We combine premium materials, advanced micromachining techniques, thin-film metallization and bipolar semiconductor processing to provide accurate, highly reliable products at competitive prices for optimum patient care and affordability.
Medical Sensor Portfolio Overview

**MEDICAL SENSOR PORTFOLIO**

<table>
<thead>
<tr>
<th>Medical Applications</th>
<th>Pressure Sensors</th>
<th>Motion Sensors</th>
<th>Differentiators</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hearing aid/Earphones</td>
<td></td>
<td>MMA8451, MMA8652, FXLS8962</td>
<td>Tap detect to turn on/off the hearing aid, low-power consumption in active mode, small size, quick capture of the pulse (10-40 ms), accurate pulse detection block, full-scale range</td>
</tr>
<tr>
<td>Insulin pens, pumps and pods</td>
<td>MPL3115</td>
<td>MMA8451, MMA8653</td>
<td>Highly precise pressure, high sensitivity</td>
</tr>
<tr>
<td>Smart Inhalers</td>
<td>MPL3115A2, MPL115A, MPX2010DT1, MPX12GP, MPX700GP, MP3H6115, FXP3115BV</td>
<td>MMA8451, MMA8652, FXLS8972</td>
<td>Small form factor, high sensitivity, high volume production</td>
</tr>
<tr>
<td>Powered Patient Bed</td>
<td>MXP2010DP, MPX5010DP</td>
<td>MMA8451, FXOS8700, FXLS8972</td>
<td>Robust packaging, high sensitivity, fully amplified</td>
</tr>
<tr>
<td>Patient activity monitor</td>
<td>MPL3115A, FXP3115BV</td>
<td>MMA9553L, MMA8652 and MMA8491 combined in the FXOS8700, FXA521002</td>
<td>Active and standby power, auto shutoff when not in use, fits into a small space, full-scale range and bandwidth</td>
</tr>
<tr>
<td>Invasive and non-invasive blood pressure monitors, fetal heart rate monitors</td>
<td>MXP2300DT1, MPX2301DT1, MPXM2053IGS, MPX5050</td>
<td>MMA8451, MMA8491, FXLS8972</td>
<td>High-quality, high-volume production, biocompatibility</td>
</tr>
<tr>
<td>Negative Pressure Wound Management</td>
<td>MPL3115A2, MPL115A, MPX5100G, FXP3115BV</td>
<td>MMA8451, MMA8652, FXLS8972</td>
<td>Small package height, multiple porting options</td>
</tr>
</tbody>
</table>

**Benefits:**
- Robust and reliable designs over temperature and harsh media
- Functional safety and 30+ year auto experience
- Software and algorithm enablement
- NXP portfolio for complete system solutions
- Trusted supplier with long-term product commitments

**Related documentation and products:**
- AN1571—Digital blood pressure meter
- AN3500—Blood pressure monitor using the MPXV5050GP
- AN4010—Low-pressure-sensing MPX2010 pressure sensor

**Target applications:**
- Non-invasive and invasive blood pressure monitors
- Fetal heart rate monitors
- Inhalers and ventilators
- Wound management
- Dialysis systems
- Spirometer and respiratory therapy devices
- Drug delivery systems
- Patient monitoring systems
- Sleep apnea
- Hospital beds
- Hearing aids and earphones
HEARING AIDS AND EARPHONES

Hearing aids amplify incoming sounds to the ear and help hearing impaired individuals hear better in both quiet and noisy situations. Low-power, digital and adaptive filtering are key design elements for reducing environmental noise so that the product only amplifies desired signals and sends them to the speaker. An inertial sensor can enable gesture recognition in high-end units where a shake motion could turn on the hearing aid or change the volume.

Use cases
- Tap detection to turn on/off and modulate volume
- Posture monitoring
- Dizziness detection with accelerometers

Critical factors
- Tap detection for hearing aid power on/off
- Low-power consumption in active mode for extended battery life
- Small size
- Quick pulse capture (10–40 ms)
- Accurate pulse detection block
- Full-scale range
- HPF enabled (remove static g)

### Sensor Use in Specific Products

<table>
<thead>
<tr>
<th>Sensor</th>
<th>Function within Product</th>
</tr>
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<tbody>
<tr>
<td>MMA8652</td>
<td>Small 3-axis accelerometer with low power consumption</td>
</tr>
<tr>
<td>MMA8451</td>
<td>3-axis accelerometer, I2C, 1.91-3.6 V, 2/4/8 g, 14 bit, QFN 16</td>
</tr>
<tr>
<td>FXLS8962</td>
<td>3 axis accelerometer with digital features for inertial event detection</td>
</tr>
</tbody>
</table>

![Diagram of sensor use in products]
INSULIN PENS, PUMPS AND PODS

Insulin pens, pumps and pods deliver insulin as part of a diabetes mellitus treatment. Though diabetes is a very common health concern in today's world, tight glycemic control and early diagnosis can greatly reduce the number and severity of medical complications. True glycemic control maintains a person's blood glucose level within a physiologically acceptable range with a closed-loop insulin delivery system. This system requires miniaturization and coordination of three components: a safe and reliable insulin infusion device, an accurate and stable glucose sensor, and a control system that regulates insulin delivery according to blood glucose variations assessed by the glucose sensor.

Use cases

• Accelerometer to provide wake up and usage monitoring

• Accelerometer to guide handling (i.e., orientation detection, appropriate shaking) for dispersing medicine

  * Accelerometer for activity monitoring correlation

Critical factors

• The U.S. diabetes monitoring, treatment and drug delivery market includes:
  – Traditional glucose blood meters
  – Continuous glucose monitoring (cgm) systems
  – Blood glucose test strips
  – Lancets and lancing devices
  – Modern insulin, insulin syringes
  – Modern insulin pens
  – Pen needles
  – Insulin pumps

Market trends

• Modern insulin is the fastest-growing area of the diabetes monitoring, treatment and drug delivery market

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<th>Sensor</th>
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<tbody>
<tr>
<td>MMA8451</td>
<td>Orientation and shock detection</td>
</tr>
<tr>
<td>MMA8653</td>
<td>Orientation and shock detection</td>
</tr>
<tr>
<td>MPL3115</td>
<td>Pressure readings</td>
</tr>
</tbody>
</table>
Sensor Use in Specific Products

SMART INHALERS

Use cases
- Detects when patient starts breathing into inhaler
- Allows inhaler to deliver the correct amount of medication by utilizing tidal breathing pattern
- Eliminates the need for patient to align breathing with medication release

Critical factors
- Biomedical-compatible component
- Pressure range
- Critical temperature range
- Accuracy
- Repeatability
- Active power consumption
- ODR (100 Hz)
- Sensitivity

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<th>Sensor</th>
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<tr>
<td>FXPQ3115BV</td>
<td>Low-power operation/ cost-effective performance</td>
</tr>
<tr>
<td>MMA8491</td>
<td>3-axis accelerometer with low-power consumption requirements</td>
</tr>
</tbody>
</table>
RESPIRATORY MONITORING

Use cases

• Continuous positive airway pressure (CPAP) - respiratory treatment for sleep apnea
• Gauge pressure sensors measure airflow and barometric pressure sensors are used to avoid altitude deviation of the delivered pressure
• Motion sensors compensate for inaccurate readings due to improper tilt and provide motion tracking information for patient care
• Controlled by smartphone, next-generation non-contact sleep apnea solutions use motion sensors along with an active sonar system with algorithms to extract hypopnea, obstructive apnea, and central apnea information from sonar signal changes; motion sensors track chest and abdomen movements due to breathing

Critical factors

• Biomedical compatible component
• Gauge
• Sensitivity
• Accuracy
• Pressure range
• ODR (~100 Hz)

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<th>Sensor</th>
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<tr>
<td>MPXV5004GC6T1 and MPXV7002DP</td>
<td>Air pressure management</td>
</tr>
<tr>
<td>MPL3115A2 or FXPQ3115BV</td>
<td>Barometric measurement</td>
</tr>
<tr>
<td>MMA8451</td>
<td>Orientation and angle 3-axis accelerometer with embedded functions</td>
</tr>
</tbody>
</table>

Sleep onset
snoring

Cycle of obstructive sleep apnea

Breathing stops
Airway collapses
Sleep disrupted
POWERED PATIENT BED

A simple hospital bed has evolved into a highly networked appliance that integrates sophisticated processors to monitor patient status and control the bed’s power-assisted functions. The result is a more comfortable bed that is easier for healthcare professionals to move and adjust.

Use cases
- Prevent muscle necrosis, pressures sores, or ulceration
- Accelerometer detects accurate angle for comfort
- Accelerometer detects when bed is moving and when it is stable
- The above use cases are applicable for:
  - Therapeutic beds — ICU beds, regular medical beds, birthing beds, pediatric beds, support surfaces
  - Specialized segments — bariatric beds, air fluidized and low air loss bed systems
  - Peripheral segments — bedding, mattress replacements, overlays

Critical factors
- Pressure range
- Accuracy
- Sensitivity
  - Battery life status while in use

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<tr>
<td>MPX5010DP</td>
<td>Accurate high-level analog output signal</td>
</tr>
<tr>
<td>MPXM2010GS</td>
<td>Pressure sensor with strain gauge</td>
</tr>
<tr>
<td>MMA8451, MMA8652</td>
<td>3-axis accelerometer with flexible user programmable options</td>
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NXP® Technology Optional

UART
MIIUART
USB
SPI
CAN Bus
Wired Network
Nursing Station
VoIP Gateway to Public Phone Network
IEEE® 802.11x Wi-Fi®
10/100 Ethernet PHY
Bed Tilt Control
Wheel Motor Control
Pump Control
Accelerometer
Motor Driver
Motor Driver
Pressure Sensor
Motor Driver
Bed Tilt Motors
Wheel Motors
Pump Motors

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Other Devices
Keypad or Touch Screen
LCD Display
MCU/MPU
Infusion Pump
Infusion Pump Control
Sensor Use in Specific Products

LCD Controller
Patient Monitor Control
Patient Monitor
Power Management
Infection Control
Wired| VoIP

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Power Management
Infusion Pump
Motor Driver
Infusion Pump Control
SPA
Wireless Comm
Nursing Station
VoIP Gateway to Public Phone Network
IEEE® 802.11x Wi-Fi®
10/100 Ethernet PHY
Bed Tilt Control
Wheel Motor Control
Pump Control
Accelerometer
Motor Driver
Motor Driver
Pressure Sensor
Motor Driver
Bed Tilt Motors
Wheel Motors
Pump Motors

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NXP® Technology Optional
**PATIENT ACTIVITY MONITOR**

**Use cases**
- Accelerometers for motion wake, tamper detection, patient posture
- Blood pressure monitor module enabling measurement with protective gels and ports and providing flow measurements and barometric pressure measurement for compensation

**Critical factors**
- Low active power to extend battery life status while in use
- Low standby power with auto shutoff when not in use
- Small size to fit into a small space
- Full-scale range and bandwidth to capture full motion profile

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<tr>
<td>MMA8652</td>
<td>3-axis accelerometer with flexible user-programmable options and two configurable interrupt pins for overall power savings</td>
</tr>
<tr>
<td>MMA8491 (combined in the FXOS87000)</td>
<td>Orientation, motion, vibration, shock, fall, g-force, altitude changes</td>
</tr>
<tr>
<td>FXAS21002</td>
<td>Gyroscope to provide the stability needed for drift-free readings</td>
</tr>
<tr>
<td>MPL3115A FXPQ3115BV</td>
<td>Digital pressure sensor for altimetry</td>
</tr>
</tbody>
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BLOOD PRESSURE MONITOR (INVASIVE)

Use cases
- Standard invasive blood pressure monitoring kit — sterile, single-use kit that relays blood pressure info from a pressure monitoring catheter to a patient monitoring system

Critical factors
- Integrated temperature compensation and calibration
- Ratiometric analog output
- Polysulfone case material (medical, class V approved)

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<tr>
<td>MPX2300DT1</td>
<td>Pressure Sensor, 6 V, 0/40 kPa packaged specially for medical applications</td>
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- **Sensor Use in Specific Products**
- **BLOOD PRESSURE MONITOR (INVASIVE)**
- **Use cases**
  - Standard invasive blood pressure monitoring kit — sterile, single-use kit that relays blood pressure info from a pressure monitoring catheter to a patient monitoring system
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NEGATIVE PRESSURE WOUND MANAGEMENT

Use cases
• Non-invasive localized negative pressure for acute, sub-acute, and chronic wounds
• Motion sensors can correlate movement, posture and vibration that may require higher pressure
• Motion sensors provide low-power wakeup and user interface

Critical factors
• Media compatibility
• Biomedical-compatible components (in contact with body)
• Disposable
• Gauge/absolute
• Sensitivity
• Accuracy
• Pressure range

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<tr>
<td>MPL3115A2 or FXPQ3115BV</td>
<td>Vacuum sensor, barometric measurement</td>
</tr>
<tr>
<td>MPXM2053GS, MPXV5100GC6U</td>
<td>Available in differential and gauge configurations</td>
</tr>
<tr>
<td>MMA8451</td>
<td>Orientation and shock detection</td>
</tr>
</tbody>
</table>

[Diagram of negative pressure wound management system]
Sensor Use in Specific Products

SMART PILL BOX AND TELEHEALTH

**Use cases**
- Motion sensors address the functional issues of adherence, portability, monitoring, notification and cleaning by monitoring for tamper detection, handling, and intelligent wakeup.

**Segmentation**
- The global smart pill box market is segmented based on home care vs. patient care.

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<td>MPX5010DP</td>
<td>Differential and gauge, integrated pressure sensor</td>
</tr>
<tr>
<td>MPXM2010GS</td>
<td>Differential/gauge pressure sensor</td>
</tr>
<tr>
<td>MMA8451, MMA8652</td>
<td>Accelerometer with flexible user programmable options</td>
</tr>
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</table>

NXP® Technology

Optional

[Diagram of sensor uses and components]
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