NOVA SENSOR

# NPX2

## NovaSensor RTPM Sensor

The NPX2 sensor represents the next-generation if remote tire pressure monitoring (RTPM).

The NPX2 sensor includes a pressure sensor, motion detector, an 8-bit RISC processor and a LF input stage to meet demands for a solution that is flexible and reduces overall system cost.

This programmable version of the sensor is available for development and production, there by allowing customers to download their application code and verify the robustness of their software. In order to ensure reliability, the measurement routines for pressure, temperature, acceleration and supply voltage are implemented in ROM.

## Features

- Standard pressure ranges: 450, 700 and 1400 kPa
- Single packaged pressure sensor, ASIC and motion detector
- Low power consumption
- Six LSB pressure accuracy 0 to 50 C
- 2.1 to 3.6 volt operation
- 10x overpressure

**Amphenol**

**Advanced Sensors**

# NPX2 Specifications

This data sheet contains the overall specifications for the NPX2 family of RTPM sensors. The NPX2 adds the level of integration by including a micro-controller (µC) and a LF-input stage to meet market demands for flexible, customer specific solutions and overall system cost reduction.

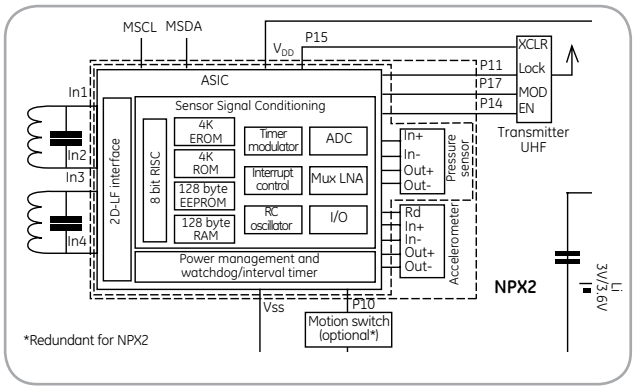
The programmable version of the NPX is available for development and production purposes, that allows the user to download the µC program in an electrically programmable ROM (E-ROM version). This sensor is intended for developing the application program before migrating in order to ensure high reliability, the production version of the sensor will have the application program implemented in a mask ROM (M-ROM version).

## Library Functions

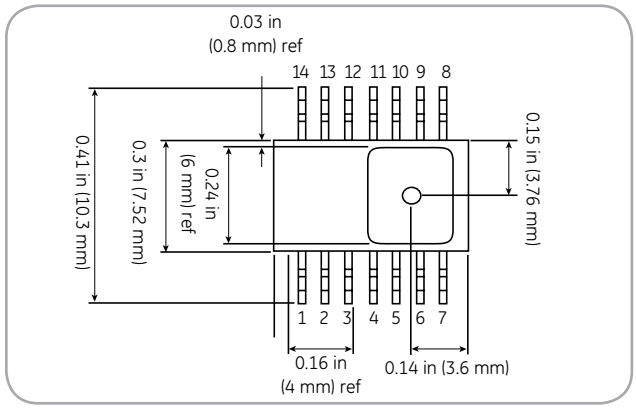
The NPX sensor is designed for RTPM applications. It consists of a RISC core with a number of peripherals. In a supplier-designed part of the firmware memory, implemented library function will include:

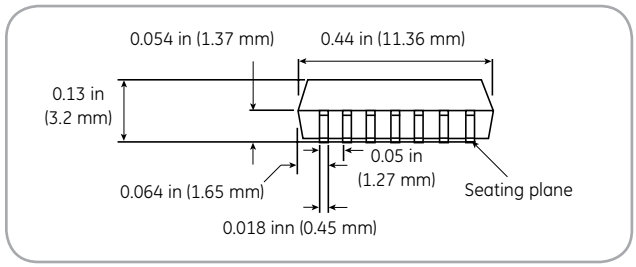
- Measure and compensate acceleration
- Measure and compensate pressure
- Measure and compensate temperature
- Measure and compensate battery voltage

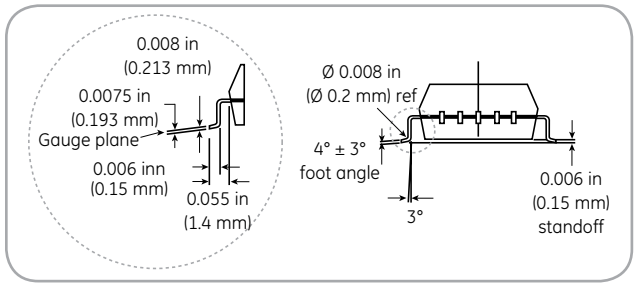
The NPX2 device with accelerometer consists of




*NPX2 functional diagram*




*NPX2 top ported dimensions*

| PIN | NAME | FUNCTION | NOTE |
|---|---|---|---|
| 1 | IN4 | Input, LF interface (coil 2, negative input) | |
| 2 | P10 | General purpose I/O with internal pull-up, wake-up sense | |
| 3 | P11 | General purpose I/O with internal pull-up, wake-up sense | |
| 4 | MSDA | ROM Monitor Serial Data I/O with internal pull-up | 1, 2 |
| 5 | MSCL | ROM Monitor Serial Clock | |
| 6 | VDD | Battery supply voltage (positive terminal) | |
| 7 | NC | No function | |
| 8 | VSS | Common ground (negative terminal) | |
| 9 | P17 | General purpose I/O or digital modulator output | |
| 10 | P15 | General purpose I/O or external system clock reference input | |
| 11 | P14 | General purpose I/O or digital modulator output | |
| 12 | IN1 | Input, LF interface (coil 1, positive input) | |
| 13 | IN2 | Input, LF interface (coil 1, negative input) | |
| 14 | IN3 | Input, LF interface (coil 2, positive input) | |

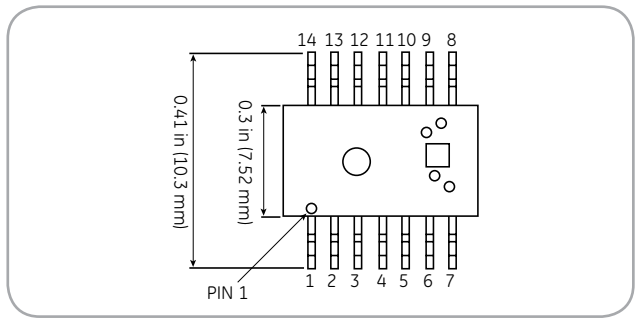
1. *Actual pad function and operation are determined during the device boot sequence.*
2. *MSCL is an output and must be left unconnected in the application. MSDA feature and on-chip p'up and VBAT may be left open or terminated to VBAT in the application. For field use, the device shall be configured for protected mode, after having flashed the application code, pressure sensor.*

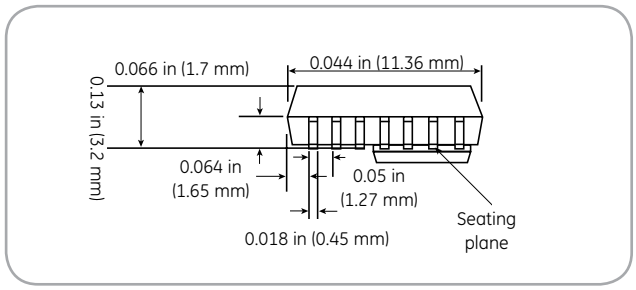
# NPX2 Specifications

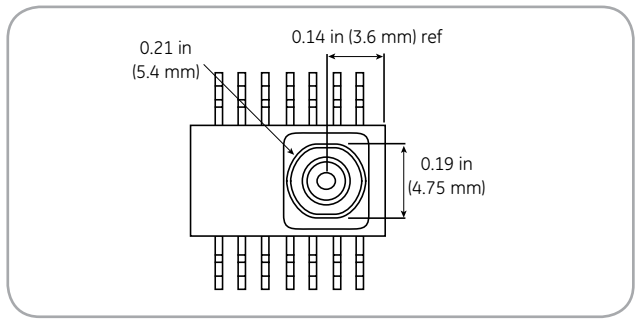
three chips: a piezoresistive absolute pressure sensor, a piezoresistive accelerometer, and a CMOS based ASIC, assembled in a standard surface-mount SOIC 14L package. The ASIC is powered by a low power 8-bit RISC processor, performing signal conditioning and data framing according to the application needs. A number of general purpose I/O's are provided to sense and control external circuitry, like a UHF transmitter or additional sensor circuitry. The device incorporates the following features:

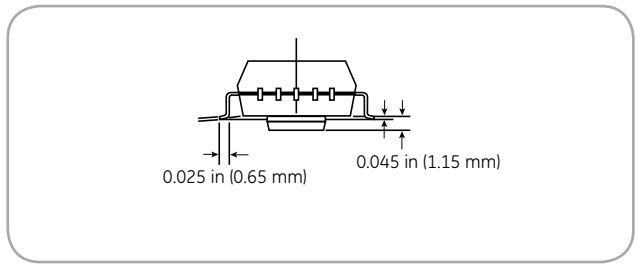
- 2D wake-up LF interface
- Front-end low noise amplifier (LNA)
- ADC configurable from 5 to 12 bits
- Temperature sensor
- Battery voltage detection
- 4 Kbyte ROM
- 4 Kbyte flash EROM
- 128 byte EEPROM
- 128 byte RAM

The device employs digital sensor signal compensation with the calibration coefficients stored in EEPROM. The device is in run mode only when demanded by the system, in order to maximize the battery life, returning to either a power down or idle mode. The device can be activated using the integrated accelerometer wake-up to begin execution of the data acquisition routine.




*NPX2 bottom ported dimensions*

| PIN | NAME | FUNCTION | NOTE |
|---|---|---|---|
| 1 | IN3 | Input, LF Interface (Coil 2, positive input) | |
| 2 | IN2 | Input, LF Interface (Coil 1, negative input) | |
| 3 | IN1 | Input, LF Interface (Coil 1, positive input) | |
| 4 | P14 | General purpose I/O, digital modulator output | |
| 5 | P15 | General purpose I/O, external system clock reference input | |
| 6 | P17 | General purpose I/O, digital modulator output | |
| 7 | VSS | Common ground (negative terminal) | |
| 8 | NC | No function | |
| 9 | VDD | Battery supply voltage (positive terminal) | |
| 10 | MSCL | ROM Monitor Serial Clock | |
| 11 | MSDA | ROM Monitor Serial Data I/O with internal pull-up | 1, 2 |
| 12 | P11 | General purpose I/O with internal pull-up, WakeUp sense | |
| 13 | P10 | General purpose I/O with internal pull-up, WakeUp sense | |
| 14 | IN4 | Input, LF Interface (Coil 2, negative input) | |

1. *Actual pad function and operation are determined during the device boot sequence.*
2. *MSCL is an output and must be left unconnected in the application. MSDA feature and on-chip p'up and VBAT may be left open or terminated to VBAT in the application. For field use, the device shall be configured for protected mode, after having flashed the application code, pressure sensor.*

# NPX2 Specifications

## Pressure Sensor

The pressure sensor consists of a bulk micro-machined single crystal silicon membrane with an integrated full wheatstone piezoresistive bridge. The pressure sensor contains an absolute pressure reference cavity within the silicon structure. The piezoresistors are placed on the top of the membrane, which in turn are protected by use of a dielectric gel coating that provides the active surface in contact with the tire pressure media.

## Accelerometer

The accelerometer consists of a single-crystal silicon, bulk micro-machined beam with an integred full wheatstone piezoresistive bridge. The whole beam is placed inside a hermetically sealed chamber (filled with argon) and is therefore well protected from the environment. A diagnostic resistor, Rd, is integrated along the edge of the beam to be used to check the mechanical integrity of the beam.

## Temperature Sensor

The temperature sensor is placed on the ASIC and features a proportional $T_O$ absolute temperature (PTAT) circuit.

## Voltage Sensor

The voltage sensor features a circuit that gives out a voltage proportional to the battery voltage. The battery voltage can then be monitored by the ADC, against an on-chip bandgap voltage used as a reference.

## Typical Transfer Functions and Output Data Format

**450 kPa Pressure**
$P_O$ = 0.7286 P - 72.8571
P = Pressure in kPa
$P_O$ = 8 bit scaled output pressure

**700 kPa Pressure**
$P_O$ = 0.4250 P - 42.5
P = Pressure in kPa
$P_O$ = 8 bit scaled output pressure

**1400 kPa Pressure**
$P_O$ = 0.1818 P
P = Pressure in kPa
$P_O$ = 8 bit scaled output pressure

**Acceleration**
$A_O$ = 2 (A + 12)
A = Acceleration (g)
$A_O$ = 8 bit scaled output acceleration

**Temperature**
$T_O$ = T + 50
T = Temperature in °F (°C)
$T_O$ = 8 bit scaled output temperature

**Battery Voltage**
$V_O$ = 92.5926 (4 - V)
V = Battery voltage in VDC
$V_O$ = 8 bit scaled output Vbattery

## General

**Operating Supply Voltage**
2.1 to 3.6 V

**Supply Current (2 MHz, Instruction Clock)**
400 :A

**Power-Down Current**
0.5 :A

**EROM, User Application Code**
4 Kbyte

**ROM, System Code**
**(Device-Related Firmware, DSSP Routines)**
4 Kbyte

**RAM**
128 byte

**Flag Register (Battery-Backed Flag Register)**
16 byte
**EEPROM (Chip Calibration Configuration Data)**
128 byte

**RISC Operating Speed, as Derived from On-Chip RC Oscillator**
0.125 to 2.0 MHz

# NPX2 Specifications

## Limiting Values

All values are in accordance with absolute maximum rating system (IEC 134)

**Temperature Range**
- Operating range: -40°F to 257°F (-40°C to 125°C)
- Survival range[1,2]: 347°F (175°C)
- Storage range[1,3]: -67°F to 257°F (-55°C to 125°C)

**Voltage at Any I/O Pin and $V_{BAT}$ Pin to Vss[4]**
-0.5 to 4.0 V

**Voltage at Any I/O Pin to Vss[5]**
-0.5 to $V_{BAT}$ 0.3 V

**Peak Input Current for Pin IN1 and IN2**
30 mA

**Latch-Up Current[6]**
100 mA

**ESD**
- Human Body Model[7]: 2 kV
- Machine Model[8]: 200 V

**Power Dissipation**
120 mW

**Vibration (10 to 2000 Hz, Three Axis)**
152 g

**Static Acceleration (±Z axis)**
2000 g

1. *At temperature above the operating temperature range, only the flag register and thermal shutdown are active.*
2. *Maximum temperature budget: 302°F to 347°F (150°C to 175°C), 3X 10 minute.*
3. *Maximum temperature budget: 257°F to 302°F (125°C to 150°C), 24h accumulated.*
4. *Because of the device concept and design, pin IN1 and IN2 may show a higher voltage during normal device operation, caused by a corresponding input signal applied to IN1 and IN2.*
5. *Voltage must not exceed 4.0 V*
6. *According to JEDEC, JESD 17*
7. *According to JEDEC, JESD 22-A114*
8. *According to JEDEC, JESD 22-A115*

## Operating Conditions

**Tamb = -40°F to 257°F (-40°C to 125°C), $V_{BAT}$ = 3.0 V, $V_{SS}$ = 0 V. Unless otherwise specified.**

| Symbol | Parameter | Condition | Min. | Typical | Max. | Unit |
|---|---|---|---|---|---|---|
| **Battery Mode (Battery Supply)** | | | | | | |
| $V_{BAT}$ | Battery supply voltage | Note [1,2] | 1.8 | — | — | V |
| $V_{BAT}$ | Battery supply voltage | | 2.1 | — | 3.6 | V |
| $I_{CC}$ | Supply current, RC oscillator (CSL = 0) | ADC = 0, POEE = 0 | | | | |
| | Run mode @ Tsys = 2 MHz | | — | 520 | 700 | µA |
| | Run mode @ Tsys = 125 kHz | | — | 70 | 90 | µA |
| | Idle mode | | — | 35 | 45 | µA |
| **Device Executes from EROM, $V_{BAT}$ = 3.0 V** | | | | | | |
| $I_{CC}$ | Supply current RC oscillator (CSL = 0 | ADC=0, POEE=0 | | | | |
| | Run mode @ Tsys = 2 MHz | | — | 630 | 900 | µA |
| | Run mode @ Tsys = 125 kHz | | — | 70 | 150 | µA |
| $I_{QQ}$ | Power down quiescent current | $V_{BAT}$ = 3.6 V, Tamb = -40°F to 140°F (-40°C to 60°C)[3] | — | 0.6 | 1.0 | µA |
| | | Tamb = 140°F to 257°F (60°C to 125°C) | — | 2 | 15 | µA |
| $I_{QQ-1DLF}$ | Power down quiescent current, LF Interface Active | $V_{BAT}$ = 3.6 V, Tamb = -40°F to 140°F (-40°C to 60°C)[3] | — | 3.5 | 7.0 | µA |
| | | Tamb = 140°F to 257°F (60°C to 125°C) | — | 5 | 21 | µA |
| $I_{QQ-2DLF}$ | Power down quiescent current, LF interface active | $V_{BAT}$ = 3.6 V, Tamb = -40°F to 140°F (-40°C to 60°C)[3] | — | 4.5 | 9.0 | µA |
| $I_{QQ-SHTD}$ | Power down quiescent current | $V_{BAT}$ = 3.6 V, Tamb = 257°F (-125°C)[4] | — | — | 30 | µA |

1. *Some functions or operations are not supported:*
   *- LNA, measurement of pressure and ambient temperature*
   *- LF wake-up with reduced performance*
2. *Temperature shut-down active*
   *Device timer tick on*
   *Device operation down to VTHR is granted, however, parameters may be out of specification.*

## Measurement Performance

Four main measurements can be selected: Pressure (P), acceleration (A), temperature (T) and battery voltage (V). This section describes the performance of each measurement.

# NPX2 Specifications

## Pressure Measurement

The present performance reflects the use of 12-bit sampling of pressure signal by using a two-temperature calibration methodology.

| Parameter | Specification | | | Ambient Conditions | | Comments | |
|---|---|---|---|---|---|---|---|
| | Min | Typ | Max | Unit | Temp | VDD | |
| Pressure Range | | | | | | | |
| *450 kPa* | 100 | — | 450 | kPa | -40°F to 257°F (-40°C to 125°C) | 2.1 to 3.6 V | — |
| *700 kPa* | 100 | — | 700 | kPa | -40°F to 257°F (-40°C to 125°C) | 2.1 to 3.6 V | — |
| *1400 kPa* | 0 | — | 1402.5 | kPa | -40°F to 257°F (-40°C to 125°C) | 2.1 to 3.6 V | — |
| Resolution | | | | | | | |
| *450 kPa* | — | 1.3789 | — | kPa/LSB | -40°F to 257°F (-40°C to 125°C) | 2.1 to 3.6 V | — |
| *700 kPa* | — | 2.3529 | — | kPa/LSB | -40°F to 257°F (-40°C to 125°C) | 2.1 to 3.6 V | — |
| *1400 kPa* | — | 5.50 | — | kPa/LSB | -40°F to 257°F (-40°C to 125°C) | 2.1 to 3.6 V | — |
| Measurement Accuracy | -6 | — | 6 | LSB | 32°F to 122°F (0°C to 50°C) | 2.1 to 3.6 V | — |
| | -8 | — | 8 | LSB | -40°F to 257°F (-40°C to 125°C) | 2.1 to 3.6 V | — |
| Overpressure | — | 10X | — | — | — | — | — |
| Measurement | — | 3.7 | 4.2 | µC | 77°F (25°C) | 3.0 V | 11-bit sampling |
| Charge | — | 3.9 | 4.5 | µC | -40°F (-40°C) | 3.0 V | 11-bit sampling |
| Consumption | — | 3.5 | 4.0 | µC | 257°F (125°C) | 3.0 V | 11-bit sampling |

*Measurement accuracy verification performed at 77°F and 257°F (25°C and 125°C) in production test. Capability proved through qualification at < 77°F (< 25°C).*

## Acceleration Measurement

The present performance reflects the use of 12-bit sampling of pressure signal by using a two-temperature calibration methodology.

| Parameter | Specification | | | Ambient Conditions | | Comments | |
|---|---|---|---|---|---|---|---|
| | Min | Typ | Max | Unit | Temp | VDD | |
| Rolling/Stationary Mode Threshold Acceleration | 2 | — | 17 | g | -40°F to 257°F (-40°C to 125°C) | 2.1 to 3.6 V | — |
| Input Range | -12 | | 115 | g | -40°F to 257°F (-40°C to 125°C) | 2.1 to 3.6 V | — |
| Resolution | — | 0.5 | — | g/LSB | -40°F to 257°F (-40°C to 125°C) | 2.1 to 3.6 V | — |
| Sensitivity Accuracy | -15 | — | 15 | % | -40°F to 257°F (-40°C to 125°C) | 2.1 to 3.6 V | — |
| Offset Accuracy | -8 | — | 8 | g | -40°F to 257°F (-40°C to 125°C) | 2.1 to 3.6 V | — |
| Measurement | — | 6.3 | 7.2 | µC | 77°F (25°C) | 3.0 V | — |
| Charge | — | 6.5 | 7.5 | µC | -40°F (-40°C) | 3.0 V | — |
| Consumption | — | 6.1 | 7.0 | µC | 257°F (125°C) | 3.0 V | — |

*Measurement accuracy verification performed at 77°F and 257°F (25°C and 125°C) in production test. Capability proved through qualification at < 77°F (< 25°C).*

# NPX2 Specifications

## Temperature Measurement

The present performance reflects the use of 10-bit sampling of temperature signal.

| Parameter | Specification | | | Ambient Conditions | | Comments | |
|---|---|---|---|---|---|---|---|
| | Min | Typ | Max | Unit | Temp | VDD | |
| Temperature Range | -40° | — | 257° | F | — | — | -40°C to 125°C |
| Resolution | — | 1.0 | — | °C/LSB | — | — | 401°F - (-58°F)/255<br>205°C - (-50°C)/255 |
| Measurement Accuracy | -5<br>-3 | —<br>— | 7<br>3 | LSB<br>LSB | -40°F to 257°F<br>-4°F to 158°F | 2.1 to 3.6 V<br>2.1 to 3.6 V | -40°C to 125°C<br>-20°C to 70°C |
| Measurement Charge Consumption | —<br>—<br>— | 1.0<br>1.1<br>1.0 | 1.1<br>1.2<br>1.15 | µC<br>µC<br>µC | 77°F (25°C)<br>-40°F (-40°C)<br>257°F (125°C) | 3.0 V<br>3.0 V<br>3.0 V | —<br>—<br>— |

*Measurement accuracy verification performed at 77°F and 257°F (25°C and 125°C) in production test. Capability proved through qualification at < 77°F (< 25°C).*

## Battery Voltage Measurement

The present performance reflects the use of 9-bit sampling of battery voltage signal.

| Parameter | Specification | | | Ambient Conditions | | Comments | |
|---|---|---|---|---|---|---|---|
| | Min | Typ | Max | Unit | Temp | VDD | |
| Resolution | — | 10.8 | — | mV/LSB | — | — | (4.0 -1.246)/255 |
| Measurement Accuracy | -6 | — | 6 | LSB | -40°F to 257°F (-40°C to 125°C) | 2.1 to 3.6 V | — |
| Measurement Charge Consumption | —<br>—<br>— | 0.50<br>0.55<br>0.50 | 0.55<br>0.6<br>0.55 | µC<br>µC<br>µC | 77°F (25°C)<br>-40°F (-40°C)<br>257°F (125°C) | 3.0 V<br>3.0 V<br>3.0 V | —<br>—<br>— |

*Measurement accuracy verification performed at 77°F and 257°F (25°C and 125°C) in production test. Capability proved through qualification at < 77°F (< 25°C).*

# NPX2 Specifications

## Abbreviation and definitions

The following abbreviations and definitions are used throughout the document:

| | |
|---|---|
| ABC | Analog to Digital Converter |
| ASIC | Application Specific Integrated Circuit |
| CMOS | Complementary metal oxide semiconductor |
| EEPROM | Electrically erasable programmable read-only memory |
| I/O | Input and output |
| LNA | Low Noise Amplifier |
| LF | Low Frequency |
| LSB | Least significant bit |
| %FS | % referred to range (max - min) |
| PTAT | Proportional to Absolute Temperature |
| RISC | Reduced Instruction-Set Computing |
| ROM | Read Only Memory |
| RTPM | Remote Tire Pressure Monitoring |
| SFR | Special Function Register |
| TBC | To Be Confirmed |
| TBD | To Be Defined |

Amphenol
Advanced Sensors

www.amphenol-sensors.com



AAS-920-333A-04/2014