FEATURES

- 860MHz-960MHz operation
- EPC Class-1 G2 compliant
- ISO 18000-6 Type C compliant
- 96-bit EPC & 32-bit TID
- Absolute pressure sensor
  - Pressure range: 0 bar to 14 bar
  - Pressure accuracy: ±140 mbar
  - Pressure resolution: 14 mbar
- Ambient temperature sensor
  - Temperature range: -30°C to 85°C
  - Temperature accuracy: ±1°C
  - Temperature resolution: 0.1°C
- Contact temperature sensor
  - Temperature range: -30°C to 85°C
  - Temperature accuracy: ±1°C

DESCRIPTION

TRUCK-PT is an EPC Class-1 Generation-2 (C1G2) RFID tag based on Farsens’ batteryless sensor technology. Built in a compact PCB format and encapsulated in a cushion gum housing, the tag includes a MS5803-14BA pressure and ambient temperature sensor from Measurements Specialties with an absolute pressure range from 0 bar to 30 bar and ambient temperature range from -40°C to 85°C. Additionally, the tag includes a thermistor in the tire contact side for contact temperature monitoring.

These RFID sensor tags are compatible with commercial UHF RFID readers (EPC C1G2). With a 2W ERP setup the battery-less temperature sensor can communicate to over one meter and a half - 5 feet.

BLOCK DIAGRAM

The TRUCK-PT tag consists of an ANDY100 IC for energy harvesting and wireless communication, a start-up circuitry based on a voltage monitor and a voltage regulator, a micro-controller for interface conversion, a NCP18XH103F03RB thermistor and a MS5803-14BA pressure and ambient temperature sensor.
The ANDY100 IC includes a RF frontend for UHF RFID power harvesting and communication, a power supply module to generate the required voltage levels, an EPC C1G2/ISO18000-6C digital processor including a trimmed clock oscillator, a non volatile memory and a SPI master module. The SPI master module can be controlled via EPC C1G2 standard memory access commands.

In order to isolate the supply of the RFID tag from the supply of the rest of the system, the diode D1 is included. The capacitor C1 acts as an energy storage unit to support current peaks of the system during active operation, such as initialization and measurement.

A voltage monitor is included to connect the sensor system only after the energy storage capacitor has been charged. The voltage monitor connects the sensor system when the voltage in the capacitor is over 2.4V and disconnects the sensor system when the voltage falls below 1.8V. This architecture avoids oscillation of the system during initialization.

The sensor included in this tag is the MS5803-14BA, which contains all the subsystems required to capture pressure and temperature data. The pressure sensing element is based on leading MEMS technology. The outputs of both sensors are multiplexed to the programmable gain amplifier, and the data is digitized with the integrated ADC. The digital interface delivers both, temperature and pressure data, through the SPI interface to the interface conversion micro-controller.

Additionally, this tag includes a NCP18XH103F03RB thermistor for tire contact temperature monitoring. A signal conditioning circuitry allows the thermistor to be powered just during measurement acquisition in order to save power the rest of the time.

The low power micro-controller included in the TRUCK-PT is an ARM Cortex-M3. Every time a new measurement
is triggered, the microcontroller gets digital data from the MSS803-14BA sensor and controls the signal conditioning of the thermistor to get an ADC reading. For the pressure and ambient temperature data, all the calibration parameters are read during start-up, and every time a new measurement is performed, the raw temperature and pressure values are converted to actual physical magnitudes. The temperature compensation of the pressure is also done in this step. This way, the data delivered to the ANDY100, and thus to the RFID reader is the absolute value. There is no need for further data conversion in the reader side. For the contact temperature instead, the data delivered to the reader is the ADC reading and the conversion to actual temperature has to be processed in the reader side.
## CHARACTERISTICS

<table>
<thead>
<tr>
<th>SYMBOL</th>
<th>PARAMETER</th>
<th>MIN</th>
<th>TYP</th>
<th>MAX</th>
<th>UNIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>RFSENS</td>
<td>RF sensitivity fully passive</td>
<td>-4</td>
<td>-2</td>
<td>0</td>
<td>dBm</td>
</tr>
<tr>
<td>TOP_TOP</td>
<td>Operating temperature range</td>
<td>-30</td>
<td>85</td>
<td>°C</td>
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### PRESSURE

<table>
<thead>
<tr>
<th>SYMBOL</th>
<th>PARAMETER</th>
<th>MIN</th>
<th>TYP</th>
<th>MAX</th>
<th>UNIT</th>
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</thead>
<tbody>
<tr>
<td>Prange</td>
<td>Pressure range</td>
<td>0</td>
<td></td>
<td>14</td>
<td>bar</td>
</tr>
<tr>
<td>Pacc</td>
<td>Pressure accuracy</td>
<td>±140</td>
<td></td>
<td></td>
<td>mbar</td>
</tr>
<tr>
<td>Pres</td>
<td>Pressure resolution</td>
<td>14</td>
<td></td>
<td></td>
<td>mbar</td>
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### AMBIENT TEMPERATURE

<table>
<thead>
<tr>
<th>SYMBOL</th>
<th>PARAMETER</th>
<th>MIN</th>
<th>TYP</th>
<th>MAX</th>
<th>UNIT</th>
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</thead>
<tbody>
<tr>
<td>Trange</td>
<td>Temperature range</td>
<td>-30</td>
<td>85</td>
<td></td>
<td>g</td>
</tr>
<tr>
<td>Tacc</td>
<td>Temperature accuracy</td>
<td>±1</td>
<td></td>
<td></td>
<td>°C</td>
</tr>
<tr>
<td>Trres</td>
<td>Temperature resolution</td>
<td>0.1</td>
<td></td>
<td></td>
<td>°C</td>
</tr>
</tbody>
</table>

### CONTACT TEMPERATURE

<table>
<thead>
<tr>
<th>SYMBOL</th>
<th>PARAMETER</th>
<th>MIN</th>
<th>TYP</th>
<th>MAX</th>
<th>UNIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trange</td>
<td>Temperature range</td>
<td>-30</td>
<td>85</td>
<td></td>
<td>g</td>
</tr>
<tr>
<td>Tacc</td>
<td>Temperature accuracy</td>
<td>±1</td>
<td></td>
<td></td>
<td>°C</td>
</tr>
</tbody>
</table>
OPERATION

EPC reading

In order to read the EPC of the tag, commercial EPC C1G2 readers can be used. However, some considerations have to be taken into account.

As the tag has a significant supply capacitor connected to VDD, the power-up of the system will be slow. It can last several seconds. In order to speed up the charge process, the reader shall be configured to send power as continuously as possible. Refer to the application note External capacitor on VDD of ANDY100 for detailed instructions on how to set up the reader for best performance.

Once the supply capacitor is charged, the tag will respond with its EPC. From this point on, memory access commands can be used to control additional functionalities via the SPI bridge.

Read pressure and ambient temperature

Read $P$ and $T_A$

| Operation: Read |
|-----------------|----------------|
| Memory bank: User Memory |
| Word Pointer: 0x05 |
| Word Count: 6 |

The answer from the tag to such a request will contain 12 bytes of data. The EPC word size is 16bits and the SPI word size is 8bits. The answer received from the SPI interface is right aligned in the EPC words. Assuming that the reader returns the received data in the buffer of bytes $rawdata$, the content of the answer is defined as follows:

- `synch`: synchronization byte. Default value 0x10.
- `P[H:L]`: (uint16) absolute pressure value. Resolution of 1mbar per LSB.
- `T[H:L]`: (int16) temperature value. Resolution of 0.01°C per LSB.
- `dummy`: dummy byte. Default value 0x00.

Due to timing issues between the micro-controller and the ANDY100 SPI, sometimes all the data stream is shifted 1 or 2 bits to the right. In order to fix this, the `synch` byte is included. Before extracting the measured values, the synchronization byte has to be found. The following example code shows a simple way to find the `synch` byte and extract sensor data.
// Find sync 0x10
while (!(rawdata[1] & 0x10))
{
    // Shift one bit to the left
    for (int i = 0; i < 12; i++)
    {
        rawdata[i] = (byte)(((byte)rawdata[i] << 1) |
                             (byte)(rawdata[i + 1] >> 7));
    }
}

// Extract sensor data
uint16 pressure = (uint16)((data[3] << 8) | data[5]);
int16 ambient_temperature = ((data[7] << 8) | data[9]);

// Set correct scale
double pressure_bar = pressure/1000.0;
double ambient_temperature_C = ambient_temperature/100.0;

Read pressure and contact temperature

Read P and T<sub>C</sub>  
Operation: Read  
Memory bank: User Memory  
Word Pointer: 0x0F  
Word Count: 6

The answer from the tag to such a request will contain 12 bytes of data. The EPC word size is 16bits and the SPI word size is 8bits. The answer received from the SPI interface is right aligned in the EPC words. Assuming that the reader returns the received data in the buffer of bytes rawdata, the content of the answer is defined as follows:

<table>
<thead>
<tr>
<th>rawdata</th>
<th>Byte 0</th>
<th>Byte 1</th>
<th>Byte 2</th>
<th>Byte 3</th>
<th>Byte 4</th>
<th>Byte 5</th>
<th>Byte 6</th>
<th>Byte 7</th>
<th>Byte 8</th>
<th>Byte 9</th>
<th>Byte 10</th>
<th>Byte 11</th>
</tr>
</thead>
<tbody>
<tr>
<td>content</td>
<td>0x00</td>
<td>synch</td>
<td>0x00</td>
<td>P_H</td>
<td>0x00</td>
<td>P_L</td>
<td>0x00</td>
<td>T_H</td>
<td>0x00</td>
<td>T_L</td>
<td>0x00</td>
<td>dummy</td>
</tr>
</tbody>
</table>

- synch: synchronization byte. Default value 0x10.
- P[H:L]: (uint16) absolute pressure value. Resolution of 1mbar per LSB.
- T[H:L]: (int16) ADC reading.
- dummy: dummy byte. Default value 0x00.

Due to timing issues between the micro-controller and the ANDY100 SPI, sometimes all the data stream is shifted 1 or 2 bits to the right. In order to fix this, the synch byte is included. Before extracting the measured values, the synchronization byte has to be found. The following example code shows a simple way to find the synch byte and extract sensor data.
// Define NCP18XH103F03RB thermistor constants
#define T0 25
#define R0 10000
#define B 3380

// Find sync 0x10
while (!(rawdata[1] & 0x10))
{
    // Shift one bit to the left
    for (int i = 0; i < 12; i++)
    {
        rawdata[i] = (byte)(((byte)rawdata[i] << 1) | (byte)(rawdata[i + 1] >> 7));
    }
}

// Extract sensor data
uint16 pressure = (uint16)((raw_data[3] << 8) | raw_data[5];
int16 ADCval = ((raw_data[7] << 8) | raw_data[9]);

// Set correct scale for pressure data
double pressure_bar = pressure/1000.0;

// Calculate measured R of thermistor
short Rsens = (1023.0 / ADCval - 1) * 10000;

// Operate contact temperature
double T0_K = T0 + 273.15;
double Rinf = R0 * Math.Exp(-B / T0_K);
double contact_temperature = B / (Math.Log(Rsens / Rinf)) - 273.15;
DEMO SOFTWARE

Demonstration software to read and control the TRUCK-PT is available in the web. Download the latest software and user guide at: http://www.farsens.com/software.php. Currently, the software is compatible with the following UHF RFID readers:

Fixed readers

- Alien ALR9900
- AMS Radon
- Caen Muon DevKit - RS232
- CSL CS203
- Impinj R420
- Thingmagic M6
- Thingmagic M6e DevKit6
- Motorola FX9500
- Motorola FX7400/FX7500
- Nordic ID Sampo
- Nordic ID Stix
- RF-Embedded PUR500U
- Sirit IN610

Handheld readers

- Nordic ID Merlin
- Nordic ID Morphic
- Motorola MC9090G
- Motorola MC9190Z
REFERENCES

The next table shows the available references of the TRUCK-PT.

<table>
<thead>
<tr>
<th>Ref.</th>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>32902</td>
<td>TRUCK-PT-868</td>
<td>Tire Pressure Monitoring System with pressure and tire contact temperature for heavy duty trucks for 868MHz frequency</td>
</tr>
<tr>
<td>35102</td>
<td>TRUCK-PT-915</td>
<td>Tire Pressure Monitoring System with pressure and tire contact temperature for heavy duty trucks for 915MHz frequency</td>
</tr>
</tbody>
</table>

For custom references with other antennas and housings, please contact us at info@farsens.com.
MECHANICAL DIMENSIONS

All dimensions are in millimeters.

DCG

Valid for reference(s): 32902, 35102

Maximum height: 6mm