1. Features and Benefits

- Small size, low cost 16x12 pixels IR array
- Easy to integrate
- Industry standard four lead TO39 package
- Factory calibrated
- Noise Equivalent Temperature Difference (NETD) 0.1K @4Hz refresh rate
- I²C compatible digital interface
- Programmable refresh rate 0.5Hz...64Hz
- 3.3V supply voltage
- Current consumption ≈ 12mA
- 2 FOV options – 55°x35° and 110°x75°
- Operating temperature -40°C ± 125°C
- Target temperature -40°C ± 300°C
- Complies with RoHS regulations

2. Application Examples

- High precision non-contact temperature measurements
- Microwave ovens
- Intrusion / Movement detection
- Temperature sensing element for residential, commercial and industrial building air conditioning
- Thermal Comfort sensor in automotive Air Conditioning control system
- Passenger classification
- Industrial temperature control of moving parts
- Visual IR thermometers
- Driver SW for MCU available at: https://github.com/melexis/mlx90641-library.git

3. Description

The MLX90641 is a fully calibrated 16x12 pixels thermal IR array in an industry standard 4-lead TO39 package with digital interface. The MLX90641 contains 192 FIR pixels. An ambient sensor is integrated to measure the ambient temperature of the chip and supply sensor to measure the VDD. The outputs of all sensors IR, Ta and VDD are stored in internal RAM and are accessible through I²C.

![Figure 1 Block diagram](https://github.com/melexis/mlx90641-library.git)
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4. Ordering Information

<table>
<thead>
<tr>
<th>Product</th>
<th>Temperature</th>
<th>Package</th>
<th>Option Code</th>
<th>Custom Configuration</th>
<th>Packing Form</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>MLX90641</td>
<td>E</td>
<td>SF</td>
<td>BCA</td>
<td>000</td>
<td>TU</td>
<td>16x12 IR array</td>
</tr>
<tr>
<td>MLX90641</td>
<td>E</td>
<td>SF</td>
<td>BCB</td>
<td>000</td>
<td>TU</td>
<td>16x12 IR array</td>
</tr>
<tr>
<td>MLX90641</td>
<td>K</td>
<td>SF</td>
<td>BCA</td>
<td>000</td>
<td>TU</td>
<td>16x12 IR array</td>
</tr>
<tr>
<td>MLX90641</td>
<td>K</td>
<td>SF</td>
<td>BCB</td>
<td>000</td>
<td>TU</td>
<td>16x12 IR array</td>
</tr>
</tbody>
</table>

Legend:

**Temperature Code:**
- E: -40°C to 85°C
- K: -40°C to 125°C

**Package Code:**
- “SF” for TO39 package

**Option Code:**
- xA – TGC is disabled and may not be enabled
- xC – TGC is enabled

**Option Code:**
- xxA – FOV = 110°x75°
- xxB – FOV = 55°x35°

**Custom configuration**
- 000 – standard product

**Packing Form:**
- “TU” - Tubes

**Ordering Example:**
- “MLX90641KSF-BCA-000-TU”

*Table 1 Ordering information*
5. Glossary of Terms

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>TC</td>
<td>Temperature Coefficient (in ppm/°C)</td>
</tr>
<tr>
<td>POR</td>
<td>Power On Reset</td>
</tr>
<tr>
<td>IR</td>
<td>Infra-Red</td>
</tr>
<tr>
<td>Ta</td>
<td>Ambient Temperature – the temperature of the TO39 package</td>
</tr>
<tr>
<td>IR data</td>
<td>Infrared data (raw data from ADC proportional to IR energy received by the sensor)</td>
</tr>
<tr>
<td>ADC</td>
<td>Analog To Digital Converter</td>
</tr>
<tr>
<td>TGC</td>
<td>Temperature Gradient Coefficient</td>
</tr>
<tr>
<td>FOV</td>
<td>Field Of View</td>
</tr>
<tr>
<td>nFOV</td>
<td>Field Of View of the N-th pixel</td>
</tr>
<tr>
<td>I2C</td>
<td>Inter-INtegrated Circuit communication protocol</td>
</tr>
<tr>
<td>SDA</td>
<td>Serial Data</td>
</tr>
<tr>
<td>SCL</td>
<td>Serial Clock</td>
</tr>
<tr>
<td>LSB</td>
<td>Least Significant Bit</td>
</tr>
<tr>
<td>MSB</td>
<td>Most Significant Bit</td>
</tr>
<tr>
<td>Fps</td>
<td>Frames per Second – data refresh rate</td>
</tr>
<tr>
<td>MD</td>
<td>Master Device</td>
</tr>
<tr>
<td>SD</td>
<td>Slave Device</td>
</tr>
<tr>
<td>ASP</td>
<td>Analogue Signal Processing</td>
</tr>
<tr>
<td>DSP</td>
<td>Digital Signal Processing</td>
</tr>
<tr>
<td>ESD</td>
<td>Electro Static Discharge</td>
</tr>
<tr>
<td>EMC</td>
<td>Electro Magnetic Compatibility</td>
</tr>
<tr>
<td>NC</td>
<td>Not Connected</td>
</tr>
<tr>
<td>NA</td>
<td>Not Applicable</td>
</tr>
</tbody>
</table>

*Table 2 Glossary of terms*
6. Pin Definitions and Descriptions

<table>
<thead>
<tr>
<th>Pin #</th>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>SDA</td>
<td>I²C serial data (input / output)</td>
</tr>
<tr>
<td>2</td>
<td>VDD</td>
<td>Positive supply</td>
</tr>
<tr>
<td>3</td>
<td>GND</td>
<td>Negative supply (Ground)</td>
</tr>
<tr>
<td>4</td>
<td>SCL</td>
<td>I²C serial clock (input only)</td>
</tr>
</tbody>
</table>

Table 3 Pin definition

7. Absolute Maximum Ratings

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
<th>Unit</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply Voltage (over voltage)</td>
<td>VDD</td>
<td>5</td>
<td></td>
<td>5</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>Supply Voltage (operating max voltage)</td>
<td>VDD</td>
<td>3.6</td>
<td></td>
<td></td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>Reverse Voltage (each pin)</td>
<td></td>
<td>-0.3</td>
<td></td>
<td></td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>Operating Temperature</td>
<td>TAMB</td>
<td>-40</td>
<td></td>
<td>+125</td>
<td>°C</td>
<td></td>
</tr>
<tr>
<td>Storage Temperature</td>
<td>TST</td>
<td>-40</td>
<td></td>
<td>+150</td>
<td>°C</td>
<td>Not in plastic tubes</td>
</tr>
<tr>
<td>ESD sensitivity (AEC Q100 002)</td>
<td></td>
<td>4</td>
<td></td>
<td></td>
<td>kV</td>
<td></td>
</tr>
<tr>
<td>SDA DC sink current</td>
<td></td>
<td></td>
<td></td>
<td>40</td>
<td>mA</td>
<td></td>
</tr>
</tbody>
</table>

Table 4 Absolute maximum ratings

Exceeding the absolute maximum ratings may cause permanent damage. Exposure to absolute maximum-rated conditions for extended periods may affect device reliability.
### 8. General Electrical Specifications

<table>
<thead>
<tr>
<th>Electrical Parameter</th>
<th>Symbol</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
<th>Unit</th>
<th>Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply Voltage</td>
<td>$V_{DD}$</td>
<td>3</td>
<td>3.3</td>
<td>3.6</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>Supply Current</td>
<td>$I_{DD}$</td>
<td>10</td>
<td>12</td>
<td>14</td>
<td>mA</td>
<td></td>
</tr>
<tr>
<td>POR level up analog</td>
<td>$V_{POR_UP}$</td>
<td>2.2</td>
<td></td>
<td>2.7</td>
<td>V</td>
<td>VDD rising</td>
</tr>
<tr>
<td>POR level down analog</td>
<td>$V_{POR_DOWN}$</td>
<td></td>
<td></td>
<td>2.55</td>
<td>V</td>
<td>VDD falling</td>
</tr>
<tr>
<td>POR hysteresis</td>
<td>$V_{POR_hys}$</td>
<td></td>
<td></td>
<td>250</td>
<td>mV</td>
<td></td>
</tr>
<tr>
<td>I²C address (NOTE 3)</td>
<td></td>
<td>0x01</td>
<td>0x33</td>
<td>0x7F</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Input high voltage (SDA, SCL)</td>
<td>$V_{IH}$</td>
<td>0.7*$V_{DD}$</td>
<td></td>
<td></td>
<td>V</td>
<td>Over $V_{DD}$</td>
</tr>
<tr>
<td>Input low voltage (SDA, SCL)</td>
<td>$V_{LOW}$</td>
<td>0.3*$V_{DD}$</td>
<td></td>
<td></td>
<td>V</td>
<td>Over $V_{DD}$</td>
</tr>
<tr>
<td>SDA output low voltage</td>
<td>$V_{OL}$</td>
<td>0.4</td>
<td></td>
<td></td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>SDA leakage</td>
<td>$I_{SDA_leak}$</td>
<td>± 10</td>
<td></td>
<td></td>
<td>µA</td>
<td>$V_{SDA}=3.6V$, $Ta=150°C$</td>
</tr>
<tr>
<td>SCL leakage</td>
<td>$I_{SCL_leak}$</td>
<td>± 10</td>
<td></td>
<td></td>
<td>µA</td>
<td>$V_{SCL}=3.6V$, $Ta=150°C$</td>
</tr>
<tr>
<td>SDA capacitance</td>
<td>$C_{SDA}$</td>
<td>10</td>
<td></td>
<td></td>
<td>pF</td>
<td></td>
</tr>
<tr>
<td>SCL capacitance</td>
<td>$C_{SCL}$</td>
<td>10</td>
<td></td>
<td></td>
<td>pF</td>
<td></td>
</tr>
<tr>
<td>Acknowledge setup time</td>
<td>$T_{SUAC(MD)}$</td>
<td>0.45</td>
<td></td>
<td></td>
<td>µs</td>
<td></td>
</tr>
<tr>
<td>Acknowledge hold time</td>
<td>$T_{DUAC(MD)}$</td>
<td>0.45</td>
<td></td>
<td></td>
<td>µs</td>
<td></td>
</tr>
<tr>
<td>Acknowledge setup time</td>
<td>$T_{SUAC(SD)}$</td>
<td>0.45</td>
<td></td>
<td></td>
<td>µs</td>
<td></td>
</tr>
<tr>
<td>Acknowledge hold time</td>
<td>$T_{DUAC(SD)}$</td>
<td>0.45</td>
<td></td>
<td></td>
<td>µs</td>
<td></td>
</tr>
<tr>
<td>I²C clock frequency</td>
<td>$F_{I^2C}$</td>
<td>0.4</td>
<td></td>
<td>1</td>
<td>MHz</td>
<td></td>
</tr>
<tr>
<td>Erase/write cycles</td>
<td></td>
<td></td>
<td></td>
<td>10</td>
<td>times</td>
<td>$Ta = 25°C$</td>
</tr>
<tr>
<td>Write cell time</td>
<td>$T_{WRITE}$</td>
<td>5</td>
<td></td>
<td></td>
<td>ms</td>
<td></td>
</tr>
</tbody>
</table>

**NOTE 1:** For best performance it is recommended to keep the supply voltage as accurate and stable as possible to 3.3V ± 0.05V

**NOTE 2:** When a data in EEPROM cell to be changed an erase (write 0x0000) must be done prior to writing the new value. After each write at least 5ms delay is needed in order to writing process to take place.

**NOTE 3:** Slave address 0x00 must be avoided.

**NOTE 4:** According to I²C standard the max sink current is specified to be 20mA, however due to the thermal considerations (the dissipated power into the driver) the max current is limited to 10mA. This is the only parameter which does not comply with the FM+ specification.

**NOTE 5:** Max EEPROM I²C speed operations to be done at 400kHz.
9. False pixel correction

The imager can have up to 1 defective pixel, with either no output or out of specification temperature reading. These pixels are identified in the EEPROM table of the sensor and can be read out through the I²C. The defective pixel result can be replaced by an interpolation of its neighboring pixels.

10. Detailed General Description

10.1. Pixel position

The array consists of 192 IR sensors (also called pixels). Each pixel is identified with its row and column position as Pix(i,j) where i is its row number (from 1 to 12) and j is its column number (from 1 to 16)
10.2. Communication protocol

The device uses I\(^2\)C protocol with support of FM+ mode (up to 1MHz clock frequency) and can be only slave on the bus. The SDA and SCL ports are 5V tolerant and the sensor can be directly connected to a 5V I\(^2\)C network. The slave address is programmable and can have up to 127 different slave addresses (SA = 0x00 must be avoided).

10.2.1. Low level

10.2.1.1. Start / Stop conditions

Each communication session is initiated by a START condition and ends with a STOP condition. A START condition is initiated by a HIGH to LOW transition of the SDA while a STOP is generated by a LOW to HIGH transition. Both changes must be done while the SCL is HIGH.

10.2.1.2. Device addressing

The master is addressing the slave device by sending a 7-bit slave address after the START condition. The first seven bits are dedicated for the address and the 8\(^{th}\) is Read/Write (R/W) bit. This bit indicates the direction of the transfer:
- Read (HIGH) means that the master will read the data from the slave
- Write (LOW) means that the master will send data to the slave

10.2.1.3. Acknowledge

During the 9\(^{th}\) clock following every byte transfer the transmitter releases the SDA line. The receiver acknowledges (ACK) receiving the byte by pulling SDA line to low or does not acknowledge (NoACK) by letting the SDA ‘HIGH’.

10.2.1.4. I\(^2\)C command format

![Figure 4 I\(^2\)C write command format](image1)

![Figure 5 I\(^2\)C read command format](image2)
10.3. Measurement mode

In this mode the measurements are constantly running. Depending on the selected frame rate Fps in the control register, the data for IR pixels and Ta will be updated in the RAM each $\frac{1}{F_{ps}}$ seconds. In this mode the external microcontroller has full access to the internal registers and memories of the device.

10.4. Refresh rate

The refresh rate is configured by “Control register 1” (0x800D) i.e. if “Refresh rate control” = 011 → 4Hz this would mean that each 250ms a new data (full frame) is available in the RAM.

NOTE: It is possible to program the desired refresh rate into device EEPROM eliminating the necessity to reconfigure the device every time it is powered on. The corresponding EEPROM cell is at address 0x240C (see Table 7)

Which subpage is updated is indicated by the “Last measured subpage” field.

It is important both subpages to be read as the necessary information for the Ta calculations is only available by combining the data from both subpages i.e. the Ta is refreshed with refresh rate twice as low as the one set in “Refresh rate control”.

When a new data (subpage) is available a dedicated bit is set to indicate this – bit 3 “New data available in RAM” in “Status register” (0x8000). It is up to the customer to reset the bit once the data is dumped.

![Refresh rate timing diagram](image)
10.5. Measurement flow

Following measurement flow is recommended:

**Measurement Flow**

1. **POR**
   - Wait 80ms + delay determined by the refresh rate

2. **Just once after POR**
   - Extract calibration data from EEPROM and store in RAM
   - Absolute temp measurement?
     - Yes
       - **Sub frame “0”**
         - Read meas data
         - Clear bit “New data available in RAM” - Bit3 in 0x8000
         - Calculate the temperature of the sub frame “0”
         - Step mode?
           - Yes
             - Image processing decision making
           - No
             - Wait time determined by RR – 20%
             - Is “New data available in RAM” set
               - No
     - No
       - Wait app 4 min

3. **Sub frame “1”**
   - Read meas data
   - Clear bit “New data available in RAM” - Bit3 in 0x8000
   - Calculate the temperature of the sub frame “1”
   - Step mode?
     - Yes
       - Image processing decision making
     - No
       - Set Start Of Measurement – Bit5 in 0x8000
       - Wait time determined by RR – 20%
       - Is “New data available in RAM” set
         - Yes
           - **Step mode**?
             - Yes
               - Image processing decision making
             - No
               - Set Start Of Measurement – Bit5 in 0x8000
         - No

---

*Figure 7 Recommended measurement flow*
### MLX90641 16x12 IR array

**Datasheet**

**Figure 8 TV mode reading pattern**

**Control register 1 (0x800D) = 0981**

Only highlighted cells are updated at each refresh rate

| Subpage 0 | 0x8000 = 0xFFFF8 |
| Subpage 1 | 0x8000 = 0xFFFF9 |

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10.6. Address map

<table>
<thead>
<tr>
<th>Address</th>
<th>Memory Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>0x0000</td>
<td>ROM</td>
</tr>
<tr>
<td>0x03FF</td>
<td></td>
</tr>
<tr>
<td>0x0400</td>
<td>RAM</td>
</tr>
<tr>
<td>0x05BF</td>
<td></td>
</tr>
<tr>
<td>0x2400</td>
<td>EEPROM</td>
</tr>
<tr>
<td>0x273F</td>
<td></td>
</tr>
<tr>
<td>0x8000</td>
<td>Registers</td>
</tr>
<tr>
<td>0x800C</td>
<td>(MLX reserved)</td>
</tr>
<tr>
<td>0x800D</td>
<td>Registers</td>
</tr>
<tr>
<td>0x8011</td>
<td></td>
</tr>
<tr>
<td>0x8011</td>
<td>Registers</td>
</tr>
<tr>
<td>0x8016</td>
<td>(MLX reserved)</td>
</tr>
</tbody>
</table>

Figure 9 MXL90641 memory map

10.6.1. Internal registers

There are few internal registers that are customer accessible through which the device performance may be customized:

<table>
<thead>
<tr>
<th>B15</th>
<th>B14</th>
<th>B13</th>
<th>B12</th>
<th>B11</th>
<th>B10</th>
<th>B9</th>
<th>B8</th>
<th>B7</th>
<th>B6</th>
<th>B5</th>
<th>B4</th>
<th>B3</th>
<th>B2</th>
<th>B1</th>
<th>B0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Melexis reserved</td>
<td>Enable overwrite</td>
<td>New data available in RAM</td>
<td>Last measured subpage controlled by MLX90641</td>
<td>Status register - 0x8000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0 0 0</td>
<td>Measurement of subpage 0 has been measured</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0 0 1</td>
<td>Measurement of subpage 1 has been measured</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0 1 0</td>
<td>Melexis reserved</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0 1 1</td>
<td>Melexis reserved</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 0 0</td>
<td>Melexis reserved</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 0 1</td>
<td>Melexis reserved</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 1 0</td>
<td>Melexis reserved</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 1 1</td>
<td>Melexis reserved</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

0 No new data is available in RAM (must be reset by the customer)
1 A new data is available in RAM
0 Data in RAM overwrite is disabled
1 Data in RAM overwrite is enabled

Figure 10 Status register (0x8000) bits meaning
### Figure 11 Control register 1 (0x800D) bits meaning

<table>
<thead>
<tr>
<th>Enable subpage mode (Bit 0)</th>
<th>Enable subpage repeat (Bit 3)</th>
<th>Select subpage (Bit 4)</th>
<th>Working mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>-</td>
<td>measure subpage 0 only</td>
</tr>
<tr>
<td>0</td>
<td>1</td>
<td>-</td>
<td>measure subpage 0 only</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>-</td>
<td>$0 \rightarrow 1 \rightarrow 0 \rightarrow 1 \ldots$</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>0</td>
<td>measure subpage 0 only</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>1</td>
<td>measure subpage 1 only</td>
</tr>
</tbody>
</table>

### Table 6 Priorities of subpage controls

<table>
<thead>
<tr>
<th>Enable subpages repeat (Bit 3)</th>
<th>Select subpage (Bit 4)</th>
<th>Working mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>-</td>
<td>measure subpage 0 only</td>
</tr>
<tr>
<td>1</td>
<td>-</td>
<td>measure subpage 0 only</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>measure subpage 0 only</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>measure subpage 0 only</td>
</tr>
<tr>
<td>0</td>
<td>1</td>
<td>measure subpage 0 only</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>measure subpage 1 only</td>
</tr>
</tbody>
</table>
10.6.2. RAM

<table>
<thead>
<tr>
<th>Address</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0x0400</td>
<td>Pixels 1...16 (subpage 0)</td>
</tr>
<tr>
<td>0x0420</td>
<td>Pixels 1...16 (subpage 1)</td>
</tr>
<tr>
<td>0x0440</td>
<td>Pixels 17...32 (subpage 0)</td>
</tr>
<tr>
<td>0x0460</td>
<td>Pixels 17...32 (subpage 1)</td>
</tr>
<tr>
<td>0x0480</td>
<td>Pixels 33...48 (subpage 0)</td>
</tr>
<tr>
<td>0x0500</td>
<td>Pixels 33...48 (subpage 1)</td>
</tr>
<tr>
<td>0x0520</td>
<td>Pixels 49...64 (subpage 0)</td>
</tr>
<tr>
<td>0x0540</td>
<td>Pixels 49...64 (subpage 1)</td>
</tr>
<tr>
<td>0x0560</td>
<td>Pixels 161...176 (subpage 0)</td>
</tr>
<tr>
<td>0x0580</td>
<td>Pixels 161...176 (subpage 1)</td>
</tr>
<tr>
<td>0x05A0</td>
<td>Pixels 177...192 (subpage 0)</td>
</tr>
<tr>
<td>0x05C0</td>
<td>Pixels 177...192 (subpage 1)</td>
</tr>
</tbody>
</table>

Figure 12 I2C configuration register (0x800F) bits meaning

Figure 13 RAM memory map (Interleaved mode - default)
EEPROM

The EEPROM is used to store the calibration constants and the configuration parameters of the device.

<table>
<thead>
<tr>
<th>EEPROM address</th>
<th>Access</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>0x2400</td>
<td>Melexis</td>
<td>Melexis reserved</td>
</tr>
<tr>
<td>0x2401</td>
<td>Melexis</td>
<td>Melexis reserved</td>
</tr>
<tr>
<td>0x2402</td>
<td>Melexis</td>
<td>Melexis reserved</td>
</tr>
<tr>
<td>0x2403</td>
<td>Melexis</td>
<td>Configuration register</td>
</tr>
<tr>
<td>0x2404</td>
<td>Melexis</td>
<td>Melexis reserved</td>
</tr>
<tr>
<td>0x2405</td>
<td>Melexis</td>
<td>Melexis reserved</td>
</tr>
<tr>
<td>0x2406</td>
<td>Melexis</td>
<td>Melexis reserved</td>
</tr>
<tr>
<td>0x2407</td>
<td>Melexis</td>
<td>Device ID1</td>
</tr>
<tr>
<td>0x2408</td>
<td>Melexis</td>
<td>Device ID2</td>
</tr>
<tr>
<td>0x2409</td>
<td>Melexis</td>
<td>Device ID3</td>
</tr>
<tr>
<td>0x240A</td>
<td>Melexis</td>
<td>Device Options</td>
</tr>
<tr>
<td>0x240B</td>
<td>Melexis</td>
<td>Melexis reserved</td>
</tr>
<tr>
<td>0x240C</td>
<td>Customer</td>
<td>Control register_1</td>
</tr>
<tr>
<td>0x240D</td>
<td>Customer</td>
<td>Control register_2</td>
</tr>
<tr>
<td>0x240E</td>
<td>Customer</td>
<td>I2CConfReg</td>
</tr>
<tr>
<td>0x240F</td>
<td>Customer</td>
<td>Melexis reserved / I2C_Address</td>
</tr>
</tbody>
</table>

Table 7 Configuration parameters memory

After POR the device read dedicated EEPROM cells and transfers their content into the control and configuration register of the device. This way the device is configured and prepared for operation. The relation between EEPROM and register address is shown here after (explanation of the bit meaning can be found in section 10.6.1 Internal registers):

<table>
<thead>
<tr>
<th>EEPROM address</th>
<th>Register address</th>
<th>Access</th>
<th>Name</th>
<th>Data [hex]</th>
</tr>
</thead>
<tbody>
<tr>
<td>0x240C</td>
<td>0x800D</td>
<td>Customer</td>
<td>Control_register_1</td>
<td>0901</td>
</tr>
<tr>
<td>0x240D</td>
<td>0x800E</td>
<td>Customer</td>
<td>Control_register_2</td>
<td>0000</td>
</tr>
<tr>
<td>0x240E</td>
<td>0x800F</td>
<td>Customer</td>
<td>I2CConfReg</td>
<td>0000</td>
</tr>
<tr>
<td>0x240F</td>
<td>0x8010</td>
<td>Customer</td>
<td>Melexis internal use (8 bit) I2C_Address (8bit)</td>
<td>BE33</td>
</tr>
</tbody>
</table>

Figure 14 EEPROM to registers mapping
## Table 8: EEPROM Overview (Words)

<table>
<thead>
<tr>
<th>Address</th>
<th>0x2400</th>
<th>Osc Trim</th>
<th>Ana Trim 1</th>
<th>MLX</th>
<th>Conf reg</th>
<th>Ana Trim 2</th>
<th>MLX</th>
<th>MLX</th>
<th>ID 1</th>
<th>ID 2</th>
<th>ID 3</th>
<th>MLX</th>
<th>MLX</th>
<th>Conf reg 1</th>
<th>Conf reg 2</th>
<th>SCL conf</th>
<th>SCL addr</th>
</tr>
</thead>
<tbody>
<tr>
<td>0x2410</td>
<td>Scale occ</td>
<td>Pix ox R1</td>
<td>MLX</td>
<td>Kta_scales</td>
<td>Kta_scales</td>
<td>Kva_scales</td>
<td>Kva_scales</td>
<td>Scale_row 1</td>
<td>0</td>
<td>row1_max</td>
<td>row2_max</td>
<td>row3_max</td>
<td>row4_max</td>
<td>row5_max</td>
<td>row6_max</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0x2420</td>
<td>row5_max</td>
<td>row6_max</td>
<td>KsTa</td>
<td>Emissivity</td>
<td>Gain</td>
<td>Vdd,25</td>
<td>K_vdd</td>
<td>PTAT,25</td>
<td>Kt_PTAT</td>
<td>Kv_PTAT</td>
<td>Alpha_PTAT</td>
<td>Alpha_CP</td>
<td>CF scale</td>
<td>OS 1 CP</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0x2430</td>
<td>OS 2 CP</td>
<td>Kt_CP</td>
<td>Kv_CP</td>
<td>TGC</td>
<td>KT0_scales</td>
<td>KT0,1</td>
<td>KT0,2</td>
<td>KT0,3</td>
<td>KT0,4</td>
<td>KT0,5</td>
<td>CT6</td>
<td>KT0,6</td>
<td>CT7</td>
<td>KT0,7</td>
<td>CT8</td>
<td>KT0,8</td>
<td></td>
</tr>
</tbody>
</table>

192 x Pixel offset - subpage 1

192 x Kta, Kv (i, j)

192 x Pixel offset - subpage 2
| Address | bit 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | ...
|---------|--------|----|----|----|----|----|---|---|---|---|---|---|---|---|---|------|

Table 9 Calibration parameters memory (EEPROM - bits)

**NOTE 1:** In case the pixel calibration data stored in EEPROM (Alpha, offset, Kta and Kv) is equal to 0x0000 this means that this particular pixel has failed and the calculation for To should not be trusted and avoided. Depending on the application, the To value for such pixels can be replaced with a default value such as -273.15°C, can be equal to Ta or one calculate an average value from the adjacent pixels.

**NOTE 2:** The maximum number of deviating pixels is 1 (please check False pixel correction)
11. Calculating Object Temperature

11.1. Restoring calibration data from EERPM and calculations

**NOTE:**
1. All data in the EEPROM are coded as two’s complement (unless otherwise noted).
2. All EEPROM cells are coded using Hamming code for proper data restoring stored in the 5 most significant bits.
3. The calculation bellow are considering only the “valid” data in any particular cell ignoring the Hamming code bits i.e. as the five significant bits of each word “0” for instance if the EEPROM content is “0x9A44” we will work with “0x0244”.

In the example we are restoring calibration data for pixel (6, 9).

The polynom for the Hamming code is as follows:

\[
\begin{align*}
P_0 &= D_0 + D_1 + D_3 + D_4 + D_6 + D_8 + D_{10} \\
P_1 &= D_0 + D_2 + D_3 + D_5 + D_6 + D_9 + D_{10} \\
P_2 &= D_1 + D_2 + D_3 + D_7 + D_8 + D_9 + D_{10} \\
P_3 &= D_4 + D_5 + D_6 + D_7 + D_8 + D_9 + D_{10} \\
P_4 &= D_0 + D_1 + D_2 + D_3 + D_4 + D_5 + D_6 + D_7 + D_8 + D_9 + D_{10} + P_0 + P_1 + P_2 + P_3
\end{align*}
\]

Where \( P_4 \) is the MSBit in the word while \( D_0...D_{10} \) are the data bits.

<table>
<thead>
<tr>
<th>B15</th>
<th>B14</th>
<th>B13</th>
<th>B12</th>
<th>B11</th>
<th>B10</th>
<th>B9</th>
<th>B8</th>
<th>B7</th>
<th>B6</th>
<th>B5</th>
<th>B4</th>
<th>B3</th>
<th>B2</th>
<th>B1</th>
<th>B0</th>
</tr>
</thead>
<tbody>
<tr>
<td>P4</td>
<td>P3</td>
<td>P2</td>
<td>P1</td>
<td>P0</td>
<td>D10</td>
<td>D9</td>
<td>D8</td>
<td>D7</td>
<td>D6</td>
<td>D5</td>
<td>D4</td>
<td>D3</td>
<td>D2</td>
<td>D1</td>
<td>D0</td>
</tr>
</tbody>
</table>

---

11.1.1. Restoring the VDD sensor parameters and VDD calculations

Following formula is used to calculate the VDD of the sensor:

\[
V_{dd} = \frac{\text{Resolution}_{corr} \times \text{RAM}[0x05AA] - V_{dd25}}{K_{Vdd}} + 3.3
\]

\[\text{if } \text{RAM}[0x05AA] > 32767 \Rightarrow \text{RAM}[0x05AA] = \text{RAM}[0x05AA] - 65536\]

Where:

\[
K_{Vdd} = \text{EE}[0x2427] \& 0x07FF
\]

\[\text{if } K_{Vdd} > 1023 \Rightarrow K_{Vdd} = K_{Vdd} - 2048\]

\[
K_{Vdd} = K_{Vdd} \times 2^5
\]

\[
V_{dd25} = \text{EE}[0x2426] \& 0x07FF
\]

\[\text{if } V_{dd25} > 1023 \Rightarrow V_{dd25} = V_{dd25} - 2048\]

\[
V_{dd25} = V_{dd25} \times 2^5
\]

Where \( \text{Resolution}_{corr} \) is restored in 11.1.18.
11.1.2. Restoring the Ta sensor parameters

Following formula is used to calculate the Ta of the sensor:

\[
T_a = \left(\frac{V_{\text{PTATalt}} - V_{\text{PTAT25}}}{K_{\text{PTAT}}}\right) + 25, ^\circ \text{C}
\]

Where:

\[
K_{V_{\text{PTAT}}} = EE[0x242B] \& 0x07FF
\]

if \(K_{V_{\text{PTAT}}} > 1023 \rightarrow K_{V_{\text{PTAT}}} = K_{V_{\text{PTAT}}} - 2048
\]

\[
K_{V_{\text{PTAT}}} = \frac{K_{V_{\text{PTAT}}}}{2^{12}}
\]

\[
K_{T_{\text{PTAT}}} = EE[0x242A] \& 0x07FF
\]

if \(K_{V_{\text{PTAT}}} > 1023 \rightarrow K_{V_{\text{PTAT}}} = K_{V_{\text{PTAT}}} - 2048
\]

\[
K_{T_{\text{PTAT}}} = \frac{K_{T_{\text{PTAT}}}}{2^{3}}
\]

\[
\Delta V = \frac{\text{RAM}[0x05AA] - V_{dd_{25}}}{K_{V_{dd}}}
\]

if \(\text{RAM}[0x05AA] > 32767 \rightarrow \text{RAM}[0x05AA] = \text{RAM}[0x05AA] - 65536
\]

\[
V_{\text{PTAT25}} = 32 \times (EE[0x2428] \& 0x07FF) + EE[0x2429] \& 0x07FF \text{ (unsigned)}
\]

\[
V_{\text{PTATalt}} = \left(\frac{V_{\text{PTAT}}}{V_{\text{PTAT}} \times \alpha_{\text{PTAT}} + V_{BE}}\right) \times 2^{18}
\]

Where:

\[
V_{\text{PTAT}} = \text{RAM}[0x05A0]
\]

if \(V_{\text{PTAT}} > 32767 \rightarrow V_{\text{PTAT}} = V_{\text{PTAT}} - 65536
\]

\[
V_{BE} = \text{RAM}[0x0580]
\]

if \(V_{BE} > 32767 \rightarrow V_{BE} = V_{BE} - 65536
\]

\[
\alpha_{\text{PTAT}} = \frac{EE[0x242C] \& 0x07FF}{2^{7}}
\]

11.1.3. Restoring the offset

There are two sets of offset data for each subpage.

\[
pix_{\text{OSref,SP0}}(i,j) = \text{Offset}_{\text{average}} + \text{offset}_{\text{SP0}}(6,9) \times 2^{\text{Offset}_{\text{scale}}}
\]

\[
pix_{\text{OSref,SP1}}(i,j) = \text{Offset}_{\text{average}} + \text{offset}_{\text{SP1}}(6,9) \times 2^{\text{Offset}_{\text{scale}}}
\]
Offset\_average = 32 \times (EE[0x2411] & 0x07FF) + EE[0x2412] & 0x07FF

If \( \text{Offset\_average} > 32767 \) → \( \text{Offset\_average} = \text{Offset\_average} - 65536 \)

\( \text{offset}_\text{SP0}(6, 9) = EE[0x2498] & 0x07FF \)

If \( \text{offset}_\text{SP0}(6, 9) > 1023 \) → \( \text{offset}_\text{SP0}(6, 9) = \text{offset}_\text{SP0}(6, 9) - 2048 \)

\( \text{offset}_\text{SP1}(6, 9) = EE[0x26D8] & 0x07FF \)

If \( \text{offset}_\text{SP1}(6, 9) > 1023 \) → \( \text{offset}_\text{SP1}(6, 9) = \text{offset}_\text{SP1}(6, 9) - 2048 \)

\[ \text{Offset\_scale} = \frac{EE[0x2410] & 0x07E0}{2^5} \] (unsigned)

### 11.1.4. Restoring the Sensitivity \( \alpha(i, j) \)

Sensitivity is divided into 6 ranges (1...32, 33...64 and so on) and for each range we store a reference value as follows:

- Sensitivity Max value for row 1 (pixels 1...32) is stored at EEPROM address 0x241C
- Sensitivity Max value for row 2 (pixels 33...64) is stored at EEPROM address 0x241D
- Sensitivity Max value for row 3 (pixels 65...96) is stored at EEPROM address 0x241E
- Sensitivity Max value for row 4 (pixels 97...128) is stored at EEPROM address 0x241F
- Sensitivity Max value for row 5 (pixels 129...160) is stored at EEPROM address 0x2420
- Sensitivity Max value for row 6 (pixels 161...192) is stored at EEPROM address 0x2421

\[ \alpha(i, j) = \frac{\alpha\text{pixel}(6, 9)}{2^{i-1}} \times \alpha\text{reference} \]

Where:

\[ \alpha\text{pixel}(6, 9) = EE[0x2538] & 0x07FF \]

\[ \alpha\text{reference} = \frac{EE[0x241C] & 0x07FF}{2^{\alpha\text{scale}row1}} \]

\[ \alpha\text{scale}row1 = EE[0x2419] & 0x07E0 + 20 \]

\[ \alpha\text{reference}_row2 = \frac{EE[0x241D] & 0x07FF}{2^{\alpha\text{scale}row2}} \]

\[ \alpha\text{scale}row2 = EE[0x2419] & 0x001F + 20 \]

\[ \alpha\text{reference}_row3 = \frac{EE[0x241E] & 0x07FF}{2^{\alpha\text{scale}row3}} \]

\[ \alpha\text{scale}row3 = EE[0x241A] & 0x07E0 + 20 \]
\[ \alpha_{\text{reference row}4} = \frac{EE[0x241A] \& 0x001F + 20}{2^{5} \text{scale row}4} \]

\[ \alpha_{\text{scale row}4} = EE[0x241B] \& 0x007E0 + 20 \]

\[ \alpha_{\text{reference row}5} = \frac{EE[0x2420] \& 0x001F + 20}{2^{5} \text{scale row}5} \]

\[ \alpha_{\text{scale row}5} = EE[0x241B] \& 0x0001F + 20 \]

11.1.5. Restoring the \( K_t(i,j) \) coefficient

\[ K_{T_a(6,9)} = \frac{K_{T_a EE(6,9)} \times 2^{K_{T_a \text{scale}2}} + K_{T_a \text{AVERAGE}}}{2^{K_{T_a \text{scale}1}}} \]

Where:

\[ K_{T_a EE(6,9)} = EE[0x2618] \& 0x007E0 \] (depending on pixel number)

If \( K_{T_a EE(6,9)} > 31 \Rightarrow K_{T_a EE(6,9)} = K_{T_a EE(6,9)} - 64 \)

\[ K_{T_a \text{AVERAGE}} = EE[0x2415] \& 0x07FF \]

If \( K_{T_a \text{AVERAGE}} > 1023 \Rightarrow K_{T_a \text{AVERAGE}} = K_{T_a \text{AVERAGE}} - 2048 \)

\[ K_{T_a \text{scale}1} = EE[0x2416] \& 0x001F \] (unsigned)

\[ K_{T_a \text{scale}2} = EE[0x2416] \& 0x0001F \] (unsigned)

11.1.6. Restoring the \( K_v(i,j) \) coefficient

\[ K_{V(6,9)} = \frac{K_{V EE(6,9)} \times 2^{K_{V \text{scale}2}} + K_{V \text{AVERAGE}}}{2^{K_{V \text{scale}1}}} \]

Where:

\[ K_{V EE(6,9)} = EE[0x2618] \& 0x001F \] (depending on pixel number)

If \( K_{V EE(6,9)} > 15 \Rightarrow K_{V EE(6,9)} = K_{V EE(6,9)} - 32 \)

\[ K_{V \text{AVERAGE}} = EE[0x2417] \& 0x07FF \]

If \( K_{V \text{AVERAGE}} > 1023 \Rightarrow K_{V \text{AVERAGE}} = K_{V \text{AVERAGE}} - 2048 \)

\[ K_{V \text{scale}1} = EE[0x2418] \& 0x001F \] (unsigned)

\[ K_{V \text{scale}2} = EE[0x2418] \& 0x0001F \] (unsigned)
11.1.7. Restoring the GAIN coefficient (common for all pixel)

\[
GAIN = 32 \times (EE[0x2424] \& 0x07FF) + EE[0x2425] \& 0x07FF \text{ (unsigned)}
\]

11.1.8. Restoring the KsTa coefficient (common for all pixel)

\[
KsTa = EE[0x2422] \& 0x07FF
\]

If \( KsTa > 1023 \) \( \rightarrow \) \( KsTa = KsTa - 2048 \)

\[
KsTa = \frac{KsTa}{2^{15}}
\]

11.1.9. Restoring corner temperatures (common for all pixel)

The information regarding corner temperatures is stored into device EEPROM and is restored as follows:

\[
CT6 = EE[0x243A] \& 0x07FF \text{ (unsigned)}
\]

\[
CT7 = EE[0x243C] \& 0x07FF \text{ (unsigned)}
\]

\[
CT8 = EE[0x243E] \& 0x07FF \text{ (unsigned)}
\]

Or we can construct the temperatures for the ranges as follows:

CT1 = -40°C (hard coded) < Range 1 > CT2 = -20°C (hard coded) < Range 2 > CT3 = 0°C (hard coded) < Range 3 > CT4 = 80°C (hard coded) < Range 4 > CT5 = 120°C (hard coded) < Range 5 > CT6 < Range 6 > CT7 < Range 7 > CT8 < Range 8

11.1.10. Restoring the KsTo coefficient (common for all pixel)

\[
KsTo_1 = \frac{EE[0x2435] \& 0x07FF}{2^{KsTo\text{scale}}}
\]

If \( KsTo_1 > 1023 \) \( \rightarrow \) \( KsTo_1 = KsTo_1 - 2048 \)

\[
KsTo_2 = \frac{EE[0x2436] \& 0x07FF}{2^{KsTo\text{scale}}}
\]

If \( KsTo_2 > 1023 \) \( \rightarrow \) \( KsTo_2 = KsTo_2 - 2048 \)

\[
KsTo_3 = \frac{EE[0x2437] \& 0x07FF}{2^{KsTo\text{scale}}}
\]

If \( KsTo_3 > 1023 \) \( \rightarrow \) \( KsTo_3 = KsTo_3 - 2048 \)

\[
KsTo_4 = \frac{EE[0x2438] \& 0x07FF}{2^{KsTo\text{scale}}}
\]

If \( KsTo_4 > 1023 \) \( \rightarrow \) \( KsTo_4 = KsTo_4 - 2048 \)

\[
KsTo_5 = \frac{EE[0x2439] \& 0x07FF}{2^{KsTo\text{scale}}}
\]

If \( KsTo_5 > 1023 \) \( \rightarrow \) \( KsTo_5 = KsTo_5 - 2048 \)
\[
K_{S06} = \frac{EE[0x243B] \& 0x07FF}{2^{K_{S06\text{scale}}}}
\]

If \( K_{S06} > 1023 \rightarrow K_{S06} = K_{S06} - 2048 \)

\[
K_{S07} = \frac{EE[0x243D] \& 0x07FF}{2^{K_{S07\text{scale}}}}
\]

If \( K_{S07} > 1023 \rightarrow K_{S07} = K_{S07} - 2048 \)

\[
K_{S08} = \frac{EE[0x243F] \& 0x07FF}{2^{K_{S08\text{scale}}}}
\]

If \( K_{S08} > 1023 \rightarrow K_{S08} = K_{S08} - 2048 \)

Where:

\( K_{S\text{scale}} = EE[0x2434] \& 0x07FF \) (unsigned)

### 11.1.11. Restoring sensitivity correction coefficients for each temperature range

\[
\text{Alpha}_{corr\text{range}1} = \frac{1}{\left(1 + K_{S01} \times (CT2 - CT1)\right)} \times \text{Alpha}_{corr\text{range}2}
\]

\[
\text{Alpha}_{corr\text{range}2} = \frac{1}{\left(1 + K_{S02} \times (CT3 - CT2)\right)}
\]

\( \text{Alpha}_{corr\text{range}3} = 1 \)

\( \text{Alpha}_{corr\text{range}4} = \left(1 + K_{S03} \times (CT4 - CT3)\right) \)

\( \text{Alpha}_{corr\text{range}5} = \left(1 + K_{S04} \times (CT5 - CT4)\right) \times \text{Alpha}_{corr\text{range}4} \)

\( \text{Alpha}_{corr\text{range}6} = \left(1 + K_{S05} \times (CT6 - CT5)\right) \times \text{Alpha}_{corr\text{range}5} \)

\( \text{Alpha}_{corr\text{range}7} = \left(1 + K_{S06} \times (CT7 - CT6)\right) \times \text{Alpha}_{corr\text{range}6} \)

\( \text{Alpha}_{corr\text{range}8} = \left(1 + K_{S07} \times (CT8 - CT7)\right) \times \text{Alpha}_{corr\text{range}7} \)

### 11.1.12. Restoring Emissivity

An emissivity parameter is stored into EEPROM and can have values from -2...1.999

\( Emissivity = EE[0x2423] \& 0x07FF \)

If \( Emissivity > 1023 \rightarrow Emissivity = Emissivity - 2048 \)

\( Emissivity = \frac{Emissivity}{2^9} \)

Default value stored in EEPROM is \( Emissivity = 1 \)
11.1.13. Restoring the Sensitivity $\alpha_{CP}$

\[ \alpha_{CP} = \frac{EE[0x242D] \& 0x07FF}{2^{8}scale_{CP}} \]

Where:

\[ \alpha_{scale_{CP}} = EE[0x242E] \& 0x07FF \]

11.1.14. Restoring the offset of the CP

\[ Off_{CP} = 32 \times (EE[0x242F] \& 0x07FF) + EE[0x2430] \& 0x07FF \text{ (signed)} \]

If \[ Off_{CP} > 32767 \rightarrow Off_{CP} = Off_{CP} - 65536 \]

11.1.15. Restoring the $K_{v}$ CP coefficient

\[ K_{v_{CP}} = \frac{K_{v_{CP,EE}}}{2^{Kv_{scale}}} \]

\[ Kv_{scale} = \frac{EE[0x2432] \& 0x07C0}{2^{6}} \text{ (unsigned)} \]

Where:

\[ K_{v_{CP,EE}} = EE[0x2432] \& 0x003F \text{ (signed)} \]

If \[ K_{v_{CP,EE}} > 31 \rightarrow K_{v_{CP,EE}} = K_{v_{CP,EE}} - 64 \]

11.1.16. Restoring the $K_{ta}$ CP coefficient

\[ K_{ta_{CP}} = \frac{K_{ta_{CP,EE}}}{2^{Kta_{scale,1}}} \]

\[ K_{ta_{scale,1}} = \frac{EE[0x2431] \& 0x07C0}{2^{6}} \text{ (unsigned)} \]

Where:

\[ K_{ta_{CP,EE}} = EE[0x2431] \& 0x003F \text{ (signed)} \]

If \[ K_{ta_{CP,EE}} > 31 \rightarrow K_{ta_{CP,EE}} = K_{ta_{CP,EE}} - 64 \]

11.1.17. Restoring the TGC coefficient

\[ TGC = \frac{TGC_{EE}}{2^{6}} \]

Where:

\[ TGC_{EE} = EE[0x2433] \& 0x01FF \text{ (signed)} \]

If \[ TGC_{EE} > 255 \rightarrow TGC_{EE} = TGC_{EE} - 512 \]
11.1.18. Restoring calibration resolution control settings

For some calculation calibration resolution is needed that is why we store this parameter into EEPROM as well.

\[
Resolution_{EE} = \frac{EE[0x2433] \& 0x0600}{2^9} \text{ (unsigned)}
\]

11.2. Temperature calculation

11.2.1. Example input data

11.2.1.1. Example measurement data

<table>
<thead>
<tr>
<th>Input data name</th>
<th>Input data value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Object temperature</td>
<td>80°C</td>
</tr>
<tr>
<td>Emissivity ((\varepsilon))</td>
<td>0.95</td>
</tr>
<tr>
<td>Control register 1 (Res(_{\text{ctrl}}))</td>
<td>0x0901 (2 decimal)</td>
</tr>
<tr>
<td>RAM[0x0498] (pix[6, 9] data)</td>
<td>0x03CC (972)</td>
</tr>
<tr>
<td>Vbe - RAM[0x0580]</td>
<td>0x4C54 (19540)</td>
</tr>
<tr>
<td>CP - RAM[0x0588]</td>
<td>0xFF97 (-105)</td>
</tr>
<tr>
<td>GAIN - RAM[0x058A]</td>
<td>0x2606 (9734)</td>
</tr>
<tr>
<td>PTAT - RAM[0x05A0]</td>
<td>0x06D8 (1752)</td>
</tr>
<tr>
<td>VDD - RAM[0x05AA]</td>
<td>0xCB8A (-13430)</td>
</tr>
</tbody>
</table>

Table 10 Calculation example input data

11.2.1.2. Calibration data

<table>
<thead>
<tr>
<th>EEPROM address</th>
<th>Calibration parameter name</th>
<th>Parameter value + Ham [ hex ]</th>
<th>Decoded value</th>
</tr>
</thead>
<tbody>
<tr>
<td>0x2410</td>
<td>Scale(_{os})_r1 - 6bits</td>
<td>0x0000</td>
<td>Scale(_{os})_r1 = 0</td>
</tr>
<tr>
<td></td>
<td>Scale(_{os})_r2 - 5bits</td>
<td></td>
<td>Scale(_{os})_r2 = 0</td>
</tr>
<tr>
<td>0x2411</td>
<td>Pix(_{os})_r1_part_1 - 11 bits</td>
<td>0xB7E8</td>
<td>-746</td>
</tr>
<tr>
<td>0x2412</td>
<td>Pix(_{os})_r1_part_2 - 11 bits</td>
<td>0xD016</td>
<td>NA</td>
</tr>
<tr>
<td>0x2413</td>
<td>MLX</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0x2414</td>
<td>MLX</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0x2415</td>
<td>Kta(_{avg}) - 11 bits</td>
<td>0xC2FD</td>
<td>0.00291824</td>
</tr>
<tr>
<td>0x2416</td>
<td>Kta(_{scale})_1 - 6 bits</td>
<td>0x1A43</td>
<td>Kta(_{scale})_1 = 18</td>
</tr>
<tr>
<td></td>
<td>Kta(_{scale})_2 - 5 bits</td>
<td></td>
<td>Kta(_{scale})_2 = 3</td>
</tr>
<tr>
<td>0x2417</td>
<td>Kv(_{avg}) - 11bits</td>
<td>0xCA9A</td>
<td>0.325195313</td>
</tr>
<tr>
<td>0x2418</td>
<td>Kv(_{scale})_1 - 6 bits</td>
<td>0x5164</td>
<td>Kv(_{scale})_1 = 11</td>
</tr>
<tr>
<td></td>
<td>Kv(_{scale})_2 - 5 bits</td>
<td></td>
<td>Kv(_{scale})_2 = 4</td>
</tr>
<tr>
<td>0x2419</td>
<td>Scale(_{row})_1 - 6 bits</td>
<td>0x018C</td>
<td>Scale(_{row})_1 = 32</td>
</tr>
<tr>
<td></td>
<td>Scale(_{row})_2 - 5 bits</td>
<td></td>
<td>Scale(_{row})_2 = 32</td>
</tr>
<tr>
<td>0x241A</td>
<td>Scale(_{row})_3 - 6 bits</td>
<td>0x018C</td>
<td>Scale(_{row})_3 = 32</td>
</tr>
<tr>
<td></td>
<td>Scale(_{row})_4 - 5 bits</td>
<td></td>
<td>Scale(_{row})_4 = 32</td>
</tr>
<tr>
<td>0x241B</td>
<td>Scale(_{row})_5 - 6 bits</td>
<td>0x018C</td>
<td>Scale(_{row})_5 = 32</td>
</tr>
<tr>
<td></td>
<td>Scale(_{row})_6 - 5 bits</td>
<td></td>
<td>Scale(_{row})_6 = 32</td>
</tr>
<tr>
<td>Register</td>
<td>Description</td>
<td>Value</td>
<td>Information</td>
</tr>
<tr>
<td>------------</td>
<td>--------------------------------------------------</td>
<td>------------</td>
<td>-------------------------------------------</td>
</tr>
<tr>
<td>0x241C</td>
<td>row1_max - 11 bits</td>
<td>0x9CB1</td>
<td>2.7962960E-07</td>
</tr>
<tr>
<td>0x241D</td>
<td>row2_max - 11 bits</td>
<td>0x956C</td>
<td>3.2316893E-07</td>
</tr>
<tr>
<td>0x241E</td>
<td>row3_max - 11 bits</td>
<td>0xA5CC</td>
<td>3.4552068E-07</td>
</tr>
<tr>
<td>0x241F</td>
<td>row4_max - 11 bits</td>
<td>0x7DD1</td>
<td>3.4668483E-07</td>
</tr>
<tr>
<td>0x2420</td>
<td>row5_max - 11 bits</td>
<td>0x6D7F</td>
<td>3.2759272E-07</td>
</tr>
<tr>
<td>0x2421</td>
<td>row6_max - 11 bits</td>
<td>0x3CD4</td>
<td>2.8777868E-07</td>
</tr>
<tr>
<td>0x2422</td>
<td>KsTa, fixed scale 15</td>
<td>0x241C</td>
<td>-0.002197266</td>
</tr>
<tr>
<td>0x2423</td>
<td>Emissivity - ±2, 10 bits</td>
<td>0x241D</td>
<td>0.94921875</td>
</tr>
<tr>
<td>0x2424</td>
<td>GainMeasRef_word1</td>
<td>0x241E</td>
<td>9972</td>
</tr>
<tr>
<td>0x2425</td>
<td>GainMeasRef_word2</td>
<td>0x241F</td>
<td>NA</td>
</tr>
<tr>
<td>0x2426</td>
<td>Vdd_25</td>
<td>0x2427</td>
<td>-13568</td>
</tr>
<tr>
<td>0x2427</td>
<td>K_Vdd</td>
<td>0x2428</td>
<td>-3136</td>
</tr>
<tr>
<td>0x2428</td>
<td>PTAT_25_W1</td>
<td>0x2429</td>
<td>12280</td>
</tr>
<tr>
<td>0x2429</td>
<td>PTAT_25_W2</td>
<td>0x2430</td>
<td>NA</td>
</tr>
<tr>
<td>0x242A</td>
<td>Kt_Ptat</td>
<td>0x2431</td>
<td>42.75</td>
</tr>
<tr>
<td>0x242B</td>
<td>Kv_Ptat</td>
<td>0x2432</td>
<td>0.005615234</td>
</tr>
<tr>
<td>0x242C</td>
<td>Alpha PTAT</td>
<td>0x2433</td>
<td>9</td>
</tr>
<tr>
<td>0x242D</td>
<td>Alpha cyclops</td>
<td>0x2434</td>
<td>3.0195224E-09</td>
</tr>
<tr>
<td>0x242E</td>
<td>Alpha cyclop scale</td>
<td>0x2435</td>
<td>38</td>
</tr>
<tr>
<td>0x242F</td>
<td>Offset CP W1</td>
<td>0x2436</td>
<td>-119</td>
</tr>
<tr>
<td>0x2430</td>
<td>Offset CP W2</td>
<td>0x2437</td>
<td>NA</td>
</tr>
<tr>
<td>0x2431</td>
<td>Kta CP scale - 5 bits</td>
<td>0x2438</td>
<td>Kta CP scale = 13</td>
</tr>
<tr>
<td></td>
<td>Kta CP - 6 bits</td>
<td>0x2439</td>
<td>Kta CP = -0.0231936</td>
</tr>
<tr>
<td>0x2432</td>
<td>Kv CP scale - 5 bits</td>
<td>0x243A</td>
<td>KsTo CP scale = 20</td>
</tr>
<tr>
<td></td>
<td>Kv CP - 6 bits</td>
<td>0x243B</td>
<td>TGC = 0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0x243C</td>
<td>CT6 = 200</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0x243D</td>
<td>CT6 = 400</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0x243E</td>
<td>CT6 = 600</td>
</tr>
<tr>
<td>0x243A</td>
<td>CT6</td>
<td>0x243F</td>
<td>KsTo CP = 0.3125</td>
</tr>
</tbody>
</table>

**Table 11 Calculation example calibration data**
11.2.2. Temperature calculation

After the parameters restore the temperature calculation is done using following calculation flow (assuming that the EEPROM data are already extracted):

![Figure 16 To calculation flow](image)

For this example we calculate the temperature of pixel (12, 16) i.e. row=12 and the column=16.

Values marked with green are extracted from device EEPROM

Values marked with grey are final parameter values or are values to be used for next calculations

### 11.2.2.1. Resolution restore

The device is calibrated with default resolution setting = 2 (corresponding to ADC resolution set to 18bit see Fig 11) i.e. if the one chooses to change the ADC resolution setting to a different one a correction of the data must be done.

First, we must restore the resolution at which the device has been calibrated which is stored at EERPOM 0x243.

\[
\text{Resolution}_{\text{corr}} = \frac{\text{Resolution}_{\text{EE}}}{\text{Resolution}_{\text{REG}}}
\]

Where:

\[
\text{Resolution}_{\text{EE}} = \frac{\text{EEPROM}[0x243]}{2^9} = \frac{0x0600}{2^9} = 0x0002 = 2 \text{ (unsigned)}
\]

\[
\text{Resolution}_{\text{REG}} = \frac{\text{RAM}[0x8000] \& 0x0000}{2^{10}} = \frac{0x1901 \& 0x0000}{2^{10}} = 0x0002 = 2 \text{ (unsigned)}
\]
\[
\text{Resolution}_{\text{corr}} = \frac{\text{Resolution}_{\text{EE}}}{\text{Resolution}_{\text{REG}}} = \frac{2^2}{2^2} = 1
\]

In case the ADC resolution is changed the one must multiply the Resolution\textsubscript{corr} coefficient with the RAM data for VDD only. Please note that the data for Vbe, PTAT and IR pixels (including CP) **must** not be changed.

### 11.2.2.2. Supply voltage value calculation (common for all pixel)

\[
V_{dd} = \frac{\text{Resolution}_{\text{corr}} \times \text{RAM}[0x05AA] - V_{dd25} + V_{dd0}}{K_{Vdd}}
\]

\[
\text{RAM}[0x05AA] = 0xCB8A = 52106
\]

If \(52883 > 32767 \Rightarrow \text{RAM}[0x05AA] = 52106 - 65536 = -13430\) LSB

Where:

\[
K_{Vdd} = \frac{EF[0x2426] & 0x07FF = 0x0FF1 & 0x07FF = 0x079E = 1950}{if 1950 > 1023 \Rightarrow K_{Vdd} = 1950 - 2048 = -993}
\]

\[
V_{dd25} = EF[0x2426] & 0x07FF = 0x2658 & 0x07FF = 0x0658 = 1624
\]

If \(1624 > 1023 \Rightarrow V_{dd25} = 1624 - 2048 = -424\)

\[
V_{dd} = \frac{-13430 - (-13568)}{-3136} + 3.3 = \frac{138}{-3136} + 3.3 \approx -0.0440051 + 3.3 \approx 3.255995 V
\]

### 11.2.2.3. Ambient temperature calculation (common for all pixel)

\[
T_a = \left(\frac{V_{PTAT25} - V_{PTAT}}{K_{PTAT}}\right) + 25, ^\circ C
\]

Where:

\[
K_{VPTAT} = \frac{EF[0x2426] & 0x07FF = 0x4617 & 0x07FF = 0x0017 = 23}{if 23 < 1023 \Rightarrow K_{VPTAT} = 0}
\]

\[
K_{VPTAT} = \frac{K_{VPTAT}}{2^{12}} = \frac{23}{4096} = 0.005615234
\]

\[
K_{PTAT} = \frac{EF[0x242A] & 0x07FF = 0x151B & 0x07FF = 0x0156 = 142}{if 342 < 1023 \Rightarrow K_{PTAT} = 0}
\]

\[
K_{PTAT} = \frac{K_{PTAT}}{2^{5}} = \frac{342}{8} = 42.75
\]

\[
\Delta V = \frac{\text{RAM}[0x05AA] - V_{dd25}}{K_{Vdd}}
\]
\[ \text{RAM[0x05AA]} = 0xCB8A = 52106 \]

If \( 52883 \geq 32767 \rightarrow \text{RAM[0x05AA]} = 52106 - 65536 = -13430 \) LSB

\[ \Delta V = \frac{-13430 - (-13568)}{-3136} = \frac{138}{-3136} \approx -0.0440051 \]

\[ V_{PTAT} = 32 \times (EF01\text{2421} & 0x07FF) + \text{EF012429} & 0x07FF \text{ (unsigned)} \]

\[ V_{PTAT} = 32 \times (0x017F & 0x07FF) + \text{EF012429} & 0x07FF \]

\[ V_{PTAT} = 32 \times 0x17F + 0x0018 = 32 \times 281 + 24 = 12256 + 24 = 12280 \]

\[ V_{PTATart} = \left( \frac{V_{PTAT}}{V_{PTAT} \times \text{Alpha}_{PTAT} + V_{BE}} \right) \times 2^{18} \]

Where:

\[ V_{PTAT} = \text{RAM[0x05A0]} = 0x06D8 = 1752 \]

If \( 1752 < 32767 \rightarrow V_{PTAT} = 1752 \]

\[ V_{BE} = \text{RAM[0x0580]} = 0x4C54 = 19540 \]

If \( 19540 < 32767 \rightarrow V_{BE} = 19540 \]

\[ \text{Alpha}_{PTAT} = \frac{EF01\text{2421} & 0x07FF}{2^{7}} = \frac{\text{EF012429} & 0x07FF}{2^{7}} = \frac{0x0480}{2^{7}} = \frac{112}{128} = 0.89 \]

\[ V_{PTATart} = \left( \frac{V_{PTAT}}{V_{PTAT} \times \text{Alpha}_{PTAT} + V_{BE}} \right) \times 2^{18} = \left( \frac{1752}{1752 \times 0.89 + 19540} \right) \times 2^{18} = 13007.71 \]

\[ T_a = \frac{V_{PTATart} - V_{PTAT25}}{K_{PTAT}} + 25 = \frac{13007.71 - 12280}{42.75} + 25 = 17.022 + 25 \approx 42.02^\circ C \]

11.2.2.4. Gain parameter calculation (common for all pixels)

\[ K_{gain} = \frac{GAIN}{\text{RAM[0x058A]}} \]

\[ \text{RAM[0x058A]} = 0x2606 = 9734 \]

If \( 9734 < 32767 \rightarrow \text{RAM[0x058A]} = 9734 \) LSB

\[ GAIN = 32 \times (EF01\text{2421} & 0x07FF) + \text{EF012429} & 0x07FF \text{ (unsigned)} \]

\[ GAIN = 32 \times (0x017F & 0x07FF) + \text{EF012429} & 0x07FF \]

\[ GAIN = 32 \times 0x017F + 0x0014 = 32 \times 281 + 20 = 9952 + 20 = 9972 \]

\[ K_{gain} = \frac{9972}{9734} = 1.02445038 \]
11.2.2.5. Pixel data calculations

The pixel addressing is following the pattern described in Reading pattern as shown in Fig 5:

11.2.2.5.1. Gain compensation

\[ p\text{x}_{\text{gain}}(6, 9) = \text{RAM}[\text{pixel data}] \cdot K_{\text{gain}} = \text{RAM}[0x0498] \cdot K_{\text{gain}} \]

\[ \text{RAM}[0x0498] = 0x03CC = 972 \]

if \( 972 < 32767 \Rightarrow \text{RAM}[0x0498] = 972 \)

\[ p\text{x}_{\text{gain}}(6, 9) = 972 \cdot 1.02445038 = 995.761767708547 \]

11.2.2.5.2. Offset calculation

\[ p\text{x}_{\text{OS,SP0}}(6, 9) = \text{Offset}_{\text{average}} + \text{Offset}_{\text{SP0}}(6, 9) \cdot 2^{\text{Offset}_{\text{scale}}} \]

\[ \text{Offset}_{\text{average}} = 32 \cdot (6470 + 0x07FF) + 6472 & 0x07FF \]

\[ \text{Offset}_{\text{average}} = 32 \cdot (6470 & 0x07FF) + 0x07FF \]

\[ \text{Offset}_{\text{average}} = 32 \cdot 0x07E8 + 0x0016 = 32 \cdot 2024 + 22 = 64768 + 22 = 64790 \]

if \( 64790 < 32767 \Rightarrow \text{Offset}_{\text{average}} = 64790 - 65536 = -746 \)

\[ \text{Offset}_{\text{SP0}}(6, 9) = 6400 + 0x07FF = 64847 & 0x07FF = 0x0049 = 7 \\ \]

if \( 73 < 1023 \Rightarrow \text{Offset}_{\text{SP0}}(6, 9) = 73 \)

\[ \text{Offset}_{\text{scale}} = \frac{6400 \& 0x07E0}{2^5} \text{ (unsigned)} \]

\[ \text{Offset}_{\text{scale}} = \frac{6400 \& 0x07E0}{2^5} = 0 \]

\[ p\text{x}_{\text{OS,SP0}}(6, 9) = -746 + 73 \cdot 2^0 = -673 \text{ LSB} \]

11.2.2.5.3. IR data compensation – offset, VDD and Ta

\[ p\text{x}_{\text{OS,SP0}}(6, 9) = p\text{x}_{\text{gain}}(6, 9) - p\text{x}_{\text{OS,SP0}} \cdot \left(1 + K_{\text{Ta}(6, 9)} \cdot (T_a - T_{\text{ao}}) \right) \cdot \left(1 + K_{V(6, 9)} \cdot (V_{dd} - V_{ddV})\right) \]

The same calculation must be done for the second subpage as well

\[ p\text{x}_{\text{OS,SP1}}(6, 9) = \text{Offset}_{\text{average}} + \text{Offset}_{\text{SP1}}(6, 9) \cdot 2^{\text{Offset}_{\text{scale}}} \]

\[ \text{Offset}_{\text{SP1}}(6, 9) = 6400 + 0x26DB & 0x07FF = 64647 & 0x07FF = 0x0047 = 71 \]

if \( 71 < 1023 \Rightarrow \text{Offset}_{\text{SP1}}(6, 9) = 71 \)

\[ p\text{x}_{\text{OS,SP1}}(6, 9) = -746 + 71 \cdot 2^0 = -671 \text{ LSB} (\text{Offset}_{\text{average}} \text{ and } \text{Offset}_{\text{scale}} \text{ are the same for both subpages}) \]

\[ p\text{x}_{\text{OS,SP1}}(6, 9) = p\text{x}_{\text{gain}}(6, 9) - p\text{x}_{\text{OS,SP1}} \cdot \left(1 + K_{\text{Ta}(6, 9)} \cdot (T_a - T_{\text{ao}}) \right) \cdot \left(1 + K_{V(6, 9)} \cdot (V_{dd} - V_{ddV})\right) \]
NOTE: In the example below calculation are done for subpage 0 only

\[ K_{Ta(6,9)} = \frac{K_{TaEE(6,9)} \times 2^K_{Tascale2} + K_{TaAVG}}{2^K_{Tascale1}} \]

Where:

\[ K_{TaEE(6,9)} = \frac{E0\times2618 \& 0x07E0}{2^5} \text{ (depending on pixel number)} \]

\[ K_{TaEE(6,9)} = \frac{0x00C0 \& 0x07E0}{2^5} = \frac{\text{Hexadecimal value}}{32} = 6 \]

If 6 < 31 \( \Rightarrow K_{TaEE(6,9)} = 6 \)

\[ K_{TaAVG} = EE[0x241E] \& 0x07FF = 1x2E1F \& 0x07FF = 02FD = 765 \]

If 765 < 1023 \( \Rightarrow K_{TaAVG} = 765 \)

\[ K_{Tascale1} = \frac{E0\times2618 \& 0x07E0}{2^5} \text{ (unsigned)} \]

\[ K_{Tascale1} = \frac{0x0240 \& 0x07E0}{2^5} = \frac{\text{Hexadecimal value}}{32} = 18 \]

\[ K_{Tascale2} = EE[0x241E] \& 0x001F \text{ (unsigned)} \]

\[ K_{Tascale2} = 0x1443 \& 0x001F = 0x0003 = 3 \]

\[ K_{Ta(6,9)} = \frac{K_{TaEE(6,9)} \times 2^K_{Tascale2} + K_{TaAVG}}{2^K_{Tascale1}} = \frac{6 \times 2^3 + 765}{2^{18}} = 0.003101349 \]

\[ K_{V(6,9)} = \frac{K_{VEE(6,9)} \times 2^K_{Vscale2} + K_{VAVG}}{2^K_{Vscale1}} \]

Where:

\[ K_{VEE(6,9)} = EE[0x2618] \& 0x001F \text{ (depending on pixel number)} \]

\[ K_{VEE(6,9)} = 0x0800 \& 0x001F = 0x0000 = 0 \]

If 0 < 15 \( \Rightarrow K_{VEE(6,9)} = 0 \)

\[ K_{VAVG} = EE[0x241E] \& 0x07FF \]

\[ K_{VAVG} = 0x4924 \& 0x07FF = 0x029A = 666 \]

If 666 < 1023 \( \Rightarrow K_{VAVG} = 666 \)

\[ K_{Vscale1} = \frac{E0\times2618 \& 0x07E0}{2^5} \text{ (unsigned)} \]

\[ K_{Vscale1} = \frac{0x1660 \& 0x07E0}{2^5} = \frac{\text{Hexadecimal value}}{32} = 11 \]

\[ K_{Vscale2} = EE[0x241E] \& 0x001F \text{ (unsigned)} \]

\[ K_{Vscale2} = 0x5164 \& 0x001F = 0x0004 = 4 \]
\[ K_{V(6,9)} = \frac{K_{\text{EE}(6,9)} \times 2^{K_{\text{scale2}} + K_{\text{AV}}} \times 2^{11}}{2^{K_{\text{scale1}}}} = 0.3251953 \]

\[ \text{pix}_{\text{OS,SP0}}(6,9) = \text{pix}_{\text{gain}}(6,9) - \text{pix}_{\text{OS,ref}} \times \left(1 + K_{T_{a,CP}} \times (T_{a} - T_{\text{os}})\right) \times \left(1 + K_{V(6,9)} \times (V_{\text{dd}} - V_{\text{dd,0}})\right) \]

\[ \text{pix}_{\text{OS,SP0}}(6,9) = 995.761767708547 - (-673) \times (1 + 0.00310135 \times (42.02 - 25)) \times (1 + 0.3251953 \times (3.25599 - 3.3)) \]

\[ \text{pix}_{\text{OS,SP0}}(6,9) = 995.761767708547 - (-673) \times (1 + 0.00310135 \times (42.02 - 25)) \times (1 + 0.3251953 \times (3.25599 - 3.3)) \]

\[ \text{pix}_{\text{OS,SP0}}(6,9) = 1694.145767 \]

### 11.2.2.5.4. IR data Emissivity compensation

\[ \text{Emissivity} = \frac{\text{EXAMPLE} \times 2^{24} + 0 \times 07FF}{1 \times 19FF} \]

If 486 < 1023 \( \rightarrow \) \text{Emissivity} = 486

\[ \text{Emissivity} = \frac{\text{Emissivity}}{2^5} = \frac{486}{512} = 0.949218 \]

### 11.2.2.6. CP data calculations

#### 11.2.2.6.1. Compensating the GAIN of CP pixel

\[ \text{pix}_{\text{gain}}(6,9) = \text{RAM}[0x0588] \times K_{\text{gain}} \]

\[ \text{RAM}[0x0588] = 0xFF97 = 65431 \]

If 65431 > 32767 \( \rightarrow \) \text{RAM}[0x0588] = 65431 - 65536 = -105

CP \text{pix}_{\text{gain}} = -105 \times 1.02445038 = -107.5672899

#### 11.2.2.6.2. Compensating offset, Ta and VDD of CP pixel

\[ \text{CP pix}_{\text{OS}} = \text{CP pix}_{\text{gain}} - \text{pix}_{\text{OS,ref,CP}} \times \left(1 + K_{T_{a,CP}} \times (T_{a} - T_{\text{os}})\right) \times \left(1 + K_{V,CP} \times (V_{\text{dd}} - V_{\text{dd,0}})\right) \]

\[ \text{pix}_{\text{OS,ref,CP}} = 32 \times (\text{CPpix}_{\text{RRR25}} \& 0x07FF) + 1 \times 0x01 \]

\[ \text{pix}_{\text{OS,ref,CP}} = 32 \times (\text{CPpix}_{\text{RRR25}} \& 0x07FF) + 1 \times 0x01 \]

\[ \text{pix}_{\text{OS,ref,CP}} = 32 \times 0x0000 + 0x0009 = 32 \times 0x0009 + 9 = 65408 + 9 = 65417 \]

If 65417 < 32767 \( \rightarrow \) \text{pix}_{\text{OS,ref,CP}} = 65417 - 65536 = -119

\[ K_{V_{CP}} = \frac{K_{V_{CP,E}}}{2^{K_{\text{scale}}}} = \frac{20}{2^6} = 0.3125 \]

\[ K_{\text{scale}} = \frac{0x0000 \& 0x07C0}{2^8} = \frac{0x00180}{2^8} = \frac{384}{2^8} = 6 \text{ (unsigned)} \]

Where:

\[ K_{V_{CP,E}} = \frac{6 \times 0x2432}{2^{12}} \& 0x0003 \text{ (signed)} \]

\[ K_{V_{CP,E}} = \frac{0x1F}{2^{12}} \& 0x0003 \text{F} = 0x00014 = 6 \text{ (signed)} \]
if $20 < 31 \rightarrow K_{VCP,EE} = 20$

$$K_{TACP} = \frac{K_{TACP,EE}}{2} \cdot \frac{19}{213} = 0.0023193359$$

$$K_{T SCALE, 1} = \frac{0 \times 07C0}{2^6} & 0 \times 07C0 = \frac{0 \times 0340}{2^6} = \frac{-13}{2^6} = 13 \text{ (unsigned)}$$

Where:

$$K_{TACP,EE} = \frac{EE[0x2431]}{2^6} & 0 \times 003F = \frac{EE[0x2431]}{2^6} & 0 \times 003F = 0 \times 0013 = 19 \text{ (signed)}$$

$$CP \text{ pix}_{OS} = -107.56727899 - (-119) \times \left(1 + 0.0023193359 \times (42.02 - 25)\right) \times \left(1 + 0.3125 \times (3.25599 - 3.3)\right)$$

$$CP \text{ pix}_{OS} = 144.42901896$$

11.2.2.7. IR data gradient compensation

$$TGC = \frac{T G C_{EE}}{2^6} = \frac{0}{2^6} = 0$$

Where:

$$T G C_{EE} = \frac{EE[0x2431]}{2^6} & 0 \times 01FF = \frac{EE[0x2431]}{2^6} & 0 \times 01FF = 0 \times 0000 = 0 \text{ (signed)}$$

If $0 < 255 \rightarrow T G C_{EE} = 0$

$$V_{IR(6,9)\text{COMPENSATED}} = \frac{pix_{OS,SP0(6,9)}-TGC+CP \text{ pix}_{OS}}{\epsilon} = \frac{1694.145767-0+144.2901896}{0.949218} = 1784.78049 = 1785$$

11.2.2.8. Normalizing to sensitivity

$$a_{(i,j)} = \frac{a_{pix}(6,9)}{2^{11-3}} * a_{\text{reference}}$$

The row for the pixel is calculated as follows:

$$Pixel_{row} = \text{int} \left( \left(\frac{16 \times (\text{row number} - 1) + \text{column number}}{2} - 1\right) + 1 \right) = \text{int} \left( \left(\frac{16 \times (6-1) + 9 - 1}{32} \right) + 1 \right) = \text{int} \left( \frac{88}{32} \right) + 1 = 3$$

$$a_{\text{reference row3}} = \frac{EE[0x2431]}{2^6} & 0 \times 07FF = \frac{EE[0x2431]}{2^6} & 0 \times 07FF$$

$$a_{\text{scale row3}} = \frac{EE[0x2431]}{2^5} & 0 \times 07E0 + 20 = \frac{EE[0x2431]}{2^5} & 0 \times 07E0 + 20 = \frac{0 \times 0180}{32} + 20 = \frac{16}{32} + 20 = 32$$

$$a_{\text{reference row3}} = \frac{EE[0x2431]}{2^5} & 0 \times 07FF = \frac{EE[0x2431]}{2^5} & 0 \times 07FF$$

$$a_{\text{scale row3}} = \frac{EE[0x2431]}{2^5} & 0 \times 07E0 + 20 = \frac{EE[0x2431]}{2^5} & 0 \times 07E0 + 20 = \frac{0 \times 0180}{32} + 20$$

$$a_{\text{pixel}}(6, 9) = \frac{EE[0x255F]}{2^5} & 0 \times 07FF = \frac{EE[0x255F]}{2^5} & 0 \times 07FF$$

$$a_{(6, 9)} = \frac{a_{\text{pixel}}(6, 9)}{2^{11-3}} * a_{\text{reference}} = \frac{2047}{2047} * 3.45520675182343E - 07 = 3.45520675182343E - 07$$

$$a_{CP} = \frac{EE[0x2431]}{2^5} & 0 \times 07FF$$
Let’s assume this temperature which is responsible for the second component of the IR signal namely the reflected part

In order to compensate correctly for the emissivity and achieve best accuracy we need to know the surrounding temperature which is responsible for the reflected part of the IR signal. Let’s denote it as 2. IR signal reflected from the object

As the IR signal received by the sensor has two components:

1. IR signal emitted by the object
2. IR signal reflected from the object (the source of this signal is surrounding environment of the sensor)

Where:

\[ K_{Sta} = \frac{K_s T_a}{215} \]

\[ K_{Sta} = \frac{-72}{215} = -0.002197265625 \]

\[ \alpha_{comp(6,9)} = \left( \alpha_{(6,9)} - TGC \cdot \alpha_{CP} \right) \cdot \left( 1 + K_{Sta} \cdot (T_a - T_0) \right) \]

\[ \alpha_{comp(6,9)} = \left( 3.4552067518234396 - 0.07 - 0 \cdot 3.019522409886129 - 0.09 \right) \cdot \left( 1 + (-0.002197265625) \cdot (42.02 - 25) \right) \]

\[ \alpha_{comp(6,9)} = 3.326418066397312 - 0.002197265625 \cdot 42.02 \]

11.2.2.9. Calculating To for basic temperature range (0°C...80 °C)

\[ K_{Sto} = \frac{FF[0x2422]}{2^{15}} \& 0x07FF = 0x27BD \& 0x07FF = 0x0522 = 3814 \]

If 1314 > 1023 \( \rightarrow K_{Sto} = 1314 - 2048 = -734 \)

\[ K_{Sto} = \frac{-734}{2^{10}} = -0.000699997 \]

Where:

\[ K_{StoScale} = \frac{FF[0x2422]}{2^{15}} \& 0x07FF \] (unsigned)

\[ K_{StoScale} = 0x7814 \& 0x07FF = 0x0014 = 20 \]

As the IR signal received by the sensor has two components:

1. IR signal emitted by the object
2. IR signal reflected from the object (the source of this signal is surrounding environment of the sensor)

In order to compensate correctly for the emissivity and achieve best accuracy we need to know the surrounding temperature which is responsible for the second component of the IR signal namely the reflected part - \( T_r \). In case this \( T_r \) temperature is not available and cannot be provided it might be replaced by \( T_r \approx T_a - 5 \).

Let’s assume \( T_r = 37°C \).

\[ T_{ak4} = (T_a + 273.15)^4 = (42.02 + 273.15)^4 = 315.87^4 = 9866871831.80621 \]

\[ T_{rk4} = (T_r + 273.15)^4 = (37 + 273.15)^4 = 304.15^4 = 9253097577.685506 \]

\[ T_{a-r} = \frac{T_{rk4} - T_{ak4}}{e} = 9253097577.685506 - 9866871831.80621 \]

\[ S_{x(6,9)} = \frac{K_{Sto} \cdot \alpha_{comp(6,9)}^3 \cdot V_{IR(6,9)} \cdot \text{COMPENSATED} + \alpha_{comp(6,9)}^4 \cdot T_{a-r}}{0.95} \]

\[ S_{x(6,9)} = -0.00069997 \cdot \sqrt[3]{3.326418066397312 - 0.07^3 \cdot 1785 + 3.326418066397312 - 0.07^4 \cdot 9899175739.92} \]

\[ S_{x(6,9)} = -8.1846364533495E - 08 \]
In order to extent the object temperature range and get the best possible accuracy an additional calculation cycle is needed.

We can identify 8 object temperature ranges (each temperature range has its own so-called Corner Temperature – CT which is the temperature at which the range starts):

- Object temperature range 1 = -40°C ... -20°C (Corner temperature for this range is -40°C and cannot be changed)
- Object temperature range 2 = -20°C ... 0°C (Corner temperature for this range is -20°C and cannot be changed)
- Object temperature range 3 = 0°C ... 80°C (Corner temperature for this range is 0°C and cannot be changed)
- Object temperature range 4 = 80°C ... 120°C (Corner temperature for this range is 80°C and cannot be changed)
- Object temperature range 5 = 120°C ... CT6°C (Corner temperature for this range is 120°C and cannot be changed)
- Object temperature range 6 = CT6°C ... CT7°C
- Object temperature range 7 = CT7°C ... CT8°C
- Object temperature range 8 = CT8°C ...

In order to be able to carry out temperature calculation for the ranges outside of temperature range 3 (To = 0°C...80°C) an additional parameter is needed and must be extracted from the device EEPROM. Those parameters are:

- So called corner temperature (CTx) i.e. the value of temperature at the beginning of the range. Please note that the temperature ranges for range 1 is fixed to -40°C, corner temperatures for range 2 is fixed to -20°C, corner temperatures for range 3 is fixed to 0°C, corner temperatures for range 4 is fixed to 80°C, corner temperatures for range 5 is fixed to 120°C while CT6, CT7 and CT8 are adjustable
- Sensitivity slope for each range – KsTox
- \( T_{O(x,y)} \) calculated in 11.2.2.9

11.2.2.9.1 Restoring corner temperatures

The information regarding corner temperatures is stored into device EEPROM and is restored as follows:

\[
CT6 = 0x0323 \text{ & } 0x07FF = 0x004B \text{ & } 0x07FF = 0x00C8 = 200°C
\]

\[
CT7 = 0x0323 \text{ & } 0x07FF = 0x3110 \text{ & } 0x07FF = 0x0190 = 400°C
\]

\[
CT8 = 0x0323 \text{ & } 0x07FF = 0x0A48 \text{ & } 0x07FF = 0x0258 = 600°C
\]

Or we can construct the temperatures for the ranges as follows:

CT1 = -40°C (hard coded) \text{< Range 1 >} CT2 = -20°C (hard coded) \text{< Range 2 >} CT3 = 0°C (hard coded) \text{< Range 3 >} CT4 = 80°C (hard coded) \text{< Range 4 >} CT5 = 120°C (hard coded) \text{< Range 5 >} CT6 \text{< Range 6 >} CT7 \text{< Range 7 >} CT8 \text{< Range 8 >}
11.2.2.9.1.2. Restoring the sensitivity slope for each range

\[ K_{st}\text{scale} = 20 \] has been extracted in 11.1.10

\[ K_{st}1 = \text{EE}\[0x2435] & 0x07FF = 0x\text{EE22} & 0x07FF = 0x0522 = 1314 \]

\[ K_{st}1 = \frac{-734}{2^{20}} = -0.000699997 \]

\[ K_{st}2 = \text{EE}\[0x2436] & 0x07FF = 0x\text{EE22} & 0x07FF = 0x0522 = 1314 \]

\[ K_{st}2 = \frac{-734}{2^{20}} = -0.000699997 \]

\[ K_{st}3 = \text{EE}\[0x2437] & 0x07FF = 0x\text{EE22} & 0x07FF = 0x0522 = 1314 \]

\[ K_{st}3 = \frac{-734}{2^{20}} = -0.000699997 \]

\[ K_{st}4 = \text{EE}\[0x2438] & 0x07FF = 0x\text{EE22} & 0x07FF = 0x0522 = 1314 \]

\[ K_{st}4 = \frac{-734}{2^{20}} = -0.000699997 \]

\[ K_{st}5 = \text{EE}\[0x2439] & 0x07FF = 0x\text{EE22} & 0x07FF = 0x0522 = 1314 \]

\[ K_{st}5 = \frac{-734}{2^{20}} = -0.000699997 \]

\[ K_{st}6 = \text{EE}\[0x243A] & 0x07FF = 0x\text{EE22} & 0x07FF = 0x0522 = 1314 \]

\[ K_{st}6 = \frac{-734}{2^{20}} = -0.000699997 \]

\[ K_{st}7 = \text{EE}\[0x243B] & 0x07FF = 0x\text{EE22} & 0x07FF = 0x0522 = 1314 \]

\[ K_{st}7 = \frac{-734}{2^{20}} = -0.000699997 \]

\[ K_{st}8 = \text{EE}\[0x243C] & 0x07FF = 0x\text{EE22} & 0x07FF = 0x0522 = 1314 \]

\[ K_{st}8 = \frac{-734}{2^{20}} = -0.000699997 \]

Now we can calculate sensitivity correction coefficients for each temperature range:
\[ \text{Alpha}_{\text{corr range1}} = \frac{1}{1 + KsTo1 \times (CT2 - (CT1))} \times \text{Alpha}_{\text{corr range2}} \]

\[ \text{Alpha}_{\text{corr range1}} = \frac{1}{1 - 0.000699997 \times (-20 - (-40))} \times 1.014198721 = 1.014198721 \times 1.014198721 = 1.028599 \]

\[ \text{Alpha}_{\text{corr range2}} = \frac{1}{1 + KsTo2 \times (CT3 - (CT2))} \times \frac{1}{1 - 0.000699997 \times (0 - (-20))} = 1.014198721 \]

\[ \text{Alpha}_{\text{corr range3}} = 1 \]

\[ \text{Alpha}_{\text{corr range4}} = (1 + KsTo3 \times (CT4 - (CT3))) = (1 - 0.000699997 \times (80 - 0)) = 0.94400024 \]

\[ \text{Alpha}_{\text{corr range5}} = (1 + KsTo4 \times (CT5 - (CT4))) \times \text{Alpha}_{\text{corr range4}} \]

\[ \text{Alpha}_{\text{corr range5}} = (1 - 0.000699997 \times (120 - 80)) \times 0.94400024 = 0.917568347 \]

\[ \text{Alpha}_{\text{corr range6}} = (1 + KsTo5 \times (CT6 - (CT5))) \times \text{Alpha}_{\text{corr range5}} \]

\[ \text{Alpha}_{\text{corr range6}} = (1 - 0.000699997 \times (200 - 120)) \times 0.917568347 = 0.86618474 \]

\[ \text{Alpha}_{\text{corr range7}} = (1 + KsTo6 \times (CT7 - (CT6))) \times \text{Alpha}_{\text{corr range6}} \]

\[ \text{Alpha}_{\text{corr range7}} = (1 - 0.000699997 \times (400 - 200)) \times 0.86618474 = 0.744919396 \]

\[ \text{Alpha}_{\text{corr range8}} = (1 + KsTo7 \times (CT8 - (CT7))) \times \text{Alpha}_{\text{corr range7}} \]

\[ \text{Alpha}_{\text{corr range8}} = (1 - 0.000699997 \times (600 - 400)) \times 0.744919396 = 0.640631128 \]

11.2.2.9.1.3. Extended To range calculation

The input parameter for this calculation is the object temperature calculated in Calculating To for basic temperature range (0°C...80°C).

If \( T_{0(i,j)} < -20°C \) we are in range 1 and we will use the parameters \( (KsTo1, \text{Alpha}_{\text{corr range1}} \text{ and } CT1 = -40°C) \)

If \(-20°C < T_{0(i,j)} < -40°C \) we are in range 2 and we will use the parameters \( (KsTo2, \text{Alpha}_{\text{corr range2}} \text{ and } CT2 = -20°C) \)

If \( 0°C < T_{0(i,j)} < 80°C \) we are in range 3 and we will use the parameters \( (KsTo3, \text{Alpha}_{\text{corr range3}} \text{ and } CT3 = 0°C) \)

If \( 80°C < T_{0(i,j)} < 120°C \) we are in range 4 and we will use the parameters \( (KsTo4, \text{Alpha}_{\text{corr range4}} \text{ and } CT4 = 80°C) \)

If \( 120°C < T_{0(i,j)} < 200°C \) we are in range 5 and we will use the parameters \( (KsTo5, \text{Alpha}_{\text{corr range5}} \text{ and } CT5 = 120°C) \)

If \( CT6°C < T_{0(i,j)} < CT7°C \) we are in range 6 and we will use the parameters \( (KsTo6, \text{Alpha}_{\text{corr range6}} \text{ and } CT6 = 200°C) \)

If \( CT7°C < T_{0(i,j)} < CT8°C \) we are in range 7 and we will use the parameters \( (KsTo7, \text{Alpha}_{\text{corr range7}} \text{ and } CT7 = 400°C) \)

If \( CT8°C < T_{0(i,j)} \) we are in range 8 and we will use the parameters \( (KsTo8, \text{Alpha}_{\text{corr range8}} \text{ and } CT8 = 600°C) \)

\[ T_{\text{extra range}(i,j)} = \sqrt{\frac{\sqrt{V_{\text{IR(i,j)}}\text{COMPENSATED}}}{a_{\text{comp(i,j)}} \times \text{Alpha}_{\text{corr range}}} \left(1 + KsToX \times (T_{0(i,j)} - CTX)\right) + T_{a-r} - 273.15} \]
12. Performance graphs

12.1. Accuracy

12.1.1. Pixel accuracy

All accuracy specifications apply under settled isothermal conditions only.
Furthermore, the accuracy is only valid if the object fills the FOV of the sensor completely.

Parameter definitions:
Frame accuracy is defined as average value of the all (768) pixels in the frame or for frame $n$ can be expressed as:

$$T_{o, frame}(n) = \frac{1}{768} \sum_{m=1}^{768} T_o(m, n)$$

Frame accuracy $= T_{o, frame}(n) - T_{target}$

Non-uniformity is defined as the maximum deviation of each individual pixel reading vs. the absolute accuracy.

$$Non\, Uniformity = \text{MAX}(|T_o(m) - \overline{T_{o, frame}(n)}|)$$

Pixel absolute accuracy is defined as:

$$T_{o, accuracy}(n) = \text{Frame accuracy} + \text{Non Uniformity}$$

![Figure 17 Temperature absolute accuracy - MLX90641BCA](image-url)
Example: If we assume that the sensor (BCA type, zone 1) is measuring a target at 80°C that would mean that there should be no pixel with error bigger than:

$$T_{\text{accuracy}}(n) = \text{Frame accuracy} + \text{Non Uniformity} = \pm 1 \pm 0.5 = \pm 1.5°C$$

NOTES:

1) For best performance it is recommended to keep the supply voltage as accurate and stable as possible to 3.3V ± 0.05V

2) As a result of long term (years) drift there can be an additional measurement deviation of ± 3°C for object temperatures around room temperature.

### 12.1.2. Ta accuracy

Absolute accuracy for the Ta channel (die temperature):

$$T_{\text{Ta accuracy}} = \pm 0.5°C$$

NOTE: Actual sensor surrounding temperature would be approximately 5°C lower
12.2. Startup time

12.2.1. First valid data

After POR the first valid data is available after (depending on the selected refresh rate) $T_{\text{valid, data}}$ which is calculated as:

$$T_{\text{valid, data}} = 80 + 2 \times 500 \, \text{ms} \quad \text{(Example refresh rate is 2Hz – the default value)}$$

It is always subpage 0 to be measured first after POR then subpage 1 and so on alternating.

**NOTE1**: In case one changes the refresh rate on the fly (by writing new values into device register (0x800D)) the settings will take place only after the subpage under measurement is finished.

**NOTE2**: Although the first subpage is ready after 500ms it is necessary to have data from both subpages in order to be able to calculate the $T_a$ meaning that the valid data are only possible after twice the refresh rate after POR.

![Diagram of Startup Time](image)

12.2.2. Thermal behavior

Although electrically the device is set and running there is thermal stabilization time necessary before the device can reach the specified accuracy – up to 3 min.
12.3. Noise performance and resolution

There are two bits in the configuration register that allow changing the resolution of the MLX90641 measurements. Increasing the resolution decreases the quantization noise and improves the overall noise performance. Measurement conditions for the noise are: \( T_0 = T_a = 25°C \)

NOTE: Due to the nature of the thermal infrared radiation, it is normal that the noise will decrease for high temperature and increase for lower temperatures.

![Figure 20 MLX90641BCx noise vs refresh rate for different device types](image1)

Not all pixels have the same noise performance. Because of the optical performance of the integrated lens, it is normal that the pixels in the corner of the frame are noisier in comparison with the pixels in the middle. The graphs below show the distribution of the noise density versus the pixel position in the frame (pixel number).

![Figure 21 MLX90641BCA noise vs pixel and refresh rate at 1Hz and 2Hz](image2)

![Figure 22 MLX90641BCA noise vs pixel and refresh rate at 4Hz, 8Hz and 16Hz](image3)
**Figure 23** MLX90641BCB noise vs pixel and refresh rate at 1Hz and 2Hz

**Figure 24** MLX90641BCB noise vs pixel and refresh rate at 4Hz, 8Hz and 16Hz

<table>
<thead>
<tr>
<th>NETD (K)</th>
<th>1Hz RMS noise (temperature equivalent), all pixels</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Average</td>
</tr>
<tr>
<td>MLX90641</td>
<td>0.07</td>
</tr>
<tr>
<td>BCA</td>
<td>0.15</td>
</tr>
<tr>
<td>BCB</td>
<td>0.15</td>
</tr>
</tbody>
</table>

*Table 12 Noise performance*
12.4. Field of view (FOV)

The specified FOV is calculated for the wider direction, in this case for the 16 pixels.

<table>
<thead>
<tr>
<th>FOV</th>
<th>X direction</th>
<th>Y direction</th>
<th>Central pointing from normal (X &amp; Y direction)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Typ</td>
<td>Typ</td>
<td>Max</td>
</tr>
<tr>
<td>MLX90641-ESF-BCA</td>
<td>110°</td>
<td>75°</td>
<td>5°</td>
</tr>
<tr>
<td>MLX90641-ESF-BCB</td>
<td>55°</td>
<td>35°</td>
<td>3°</td>
</tr>
</tbody>
</table>

Table 13 Available FOV options
13. Application information

13.1. Optical considerations

As this is an optical device a care must be taking such that the device performs according to the specification. One such parameter is FOV obstruction. It is paramount that the FOV in the optical path is kept clear. The external aperture is designed such to shape the FOV of the device and is installed prior calibration process thus can be considered as part of the device which does not impact the performance but may be used as a reference for the so-called “Optical free zone” – see Figure 27 hereafter.

![Figure 26 Application examples concerning the optical consideration](image)

13.2. Electrical considerations

As the MLX90641Bxx is fully I2C compatible it allows to have a system in which the MCU may be supplied with VDD=2.6V...5V while the sensor itself is supplied from separate supply VDD1=3.3V (or even left with no supply i.e. VDD=0V), with the I2C connection running at supply voltage of the MCU.

![Figure 27 MLX90641Bxx electrical connections](image)
13.3. Using the device in “image mode”

In some applications may not be necessary to calculate the temperature but rather to have just and image (for instance in machine vision systems). In this case it is not necessary to carry out all calculations which would save computation time or allow the one to use weaker CPU.

In order to get thermal image only following computation flow is to be used:

```
<table>
<thead>
<tr>
<th>Supply voltage value calculation - 11.2.2.2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ambient temperature calculation - 11.2.2.3</td>
</tr>
<tr>
<td>---------------------------------------------</td>
</tr>
<tr>
<td>Gain compensation - 11.2.2.5.1</td>
</tr>
<tr>
<td>---------------------------------------------</td>
</tr>
<tr>
<td>IR data compensation – offset, VDD and Ta - 11.2.2.5.3</td>
</tr>
<tr>
<td>---------------------------------------------</td>
</tr>
<tr>
<td>IR data gradient compensation - 11.2.2.7</td>
</tr>
<tr>
<td>---------------------------------------------</td>
</tr>
<tr>
<td>Normalizing to sensitivity - 11.2.2.8</td>
</tr>
<tr>
<td>---------------------------------------------</td>
</tr>
<tr>
<td>Image (data) processing</td>
</tr>
</tbody>
</table>
```

*Figure 28 Calculation flow in thermal image mode*
14. Application Comments

Significant contamination at the optical input side (sensor filter) might cause unknown additional filtering/distortion of the optical signal and therefore result in unspecified errors.

IR sensors are inherently susceptible to errors caused by thermal gradients. There are physical reasons for these phenomena and, in spite of the careful design of the MLX90641Bxx, it is recommended not to subject the MLX90641Bxx to heat transfer and especially transient conditions.

The MLX90641Bxx is designed and calibrated to operate as a non-contact thermometer in settled conditions. Using the thermometer in a very different way will result in unknown results.

Capacitive loading on an I2C can degrade the communication. Some improvement is possible with use of current sources compared to resistors in pull-up circuitry. Further improvement is possible with specialized commercially available bus accelerators. With the MLX90641Bxx additional improvement is possible by increasing the pull-up current (decreasing the pull-up resistor values). Input levels for I2C compatible mode have higher overall tolerance than the I2C specification, but the output low level is rather low even with the high-power I2C specification for pull-up currents. Another option might be to go for a slower communication (clock speed), as the MLX90641Bxx implements Schmidt triggers on its inputs in I2C compatible mode and is therefore not really sensitive to rise time of the bus (it is more likely the rise time to be an issue than the fall time, as far as the I2C systems are open drain with pull-up).

Power dissipation within the package may affect performance in two ways: by heating the “ambient” sensitive element significantly beyond the actual ambient temperature, as well as by causing gradients over the package that will inherently cause thermal gradient over the cap.

Power supply decoupling capacitor is needed as with most integrated circuits. MLX90641Bxx is a mixed-signal device with sensors, small signal analog part, digital part and I/O circuitry. In order to keep the noise low power supply switching noise needs to be decoupled. High noise from external circuitry can also affect noise performance of the device. In many applications a 100nF SMD plus 10µF ceramic capacitors close to the Vdd and Vss pins would be a good choice. It should be noted that not only the trace to the Vdd pin needs to be short, but also the one to the Vss pin. Using MLX90641Bxx with short pins improves the effect of the power supply decoupling.

Check [www.melexis.com](http://www.melexis.com) for most recent application notes about MLX90641Bxx.
15. Mechanical drawings

15.1. FOV 55°

Figure 29 Mechanical drawing of 55° FOV device
15.2. FOV 110°

Figure 30 Mechanical drawing of 110° FOV device
15.3. Device marking

The MLX90641 is laser marked with 10 symbols as follows.

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th></th>
<th>xxxx</th>
<th>xx</th>
<th>Laser marking</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td>A</td>
<td>xxxx</td>
<td>xx</td>
<td>2 digits Split number</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>5 digits LOT number</td>
</tr>
<tr>
<td>A</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>FOV = 110°</td>
</tr>
<tr>
<td>B</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>FOV = 55°</td>
</tr>
<tr>
<td>A</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Device without thermal gradient compensation (TGC = 0 and may not be changed)</td>
</tr>
<tr>
<td>C</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Device with thermal gradient compensation (TGC = -4…+3.992)</td>
</tr>
</tbody>
</table>

Example: “1CA1052801” – Device type MLX90641BCA from lot 10528, sub LOT split 1 and Thermal Gradient Compensation activated.
16. Standard Information

16.1. Assembly of encapsulated ICs

Hand (robotic) soldering and standard wave soldering process may be applied. Avoid heat exposure to the top and the window of the detector.

For Through Hole Devices (THD), the applicable soldering methods are wave, selective wave and robot point-to-point. THD lead pre-forming (cutting and/or bending) is applicable under strict compliance with Melexis

Reflow soldering by pin-in-paste (intrusive) soldering is applicable as well. Care must to be taken to protect the optical window surface from flux contamination during reflow process. Alternatively flux washing must be applied post reflow, however ultrasonic bath shall be avoided as it represents a risk for internal structural damage.

Melexis products soldering on PCB should be conducted according to the requirements of IPC/JEDEC and J-STD-001. Solder quality acceptance should follow the requirements of IPC-A-610.

For other specific process, contact Melexis via www.melexis.com/technical-inquiry

16.2. Environment and sustainability

Melexis is contributing to global environmental conservation by promoting non-hazardous solutions. For more information on our environmental policy and declarations (RoHS, REACH...) visit www.melexis.com/environmental-forms-and-declarations

17. ESD Precautions

Electronic semiconductor products are sensitive to Electro Static Discharge (ESD). Always observe Electro Static Discharge control procedures whenever handling semiconductor products.
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