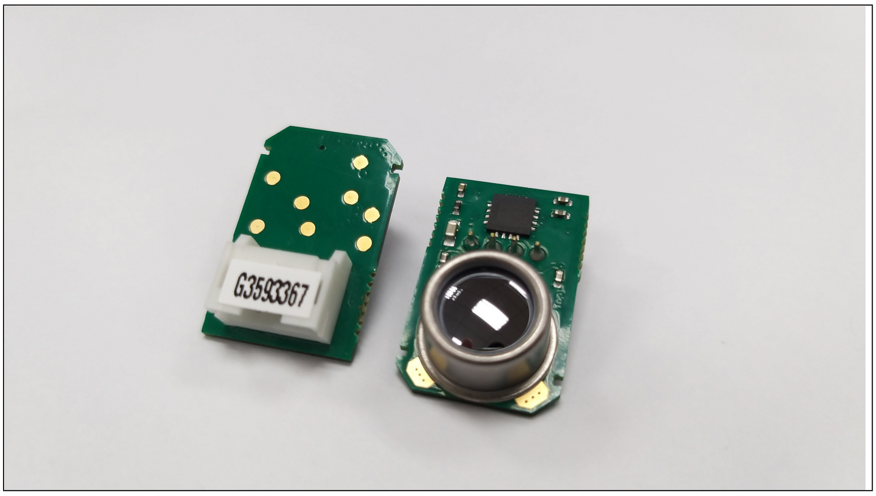
CoolEYE™

Infrared Sensing Solutions

TPL 32C 3774 L4.7 A60 P13 / 4320

Product Specification



Features

- High sensitivity thermopiles
- 32 × 1 pixel
- 59° field of view
- Calibrated temperature output
- SMBus interface
- On PCB with connector

Applications

- Remote temperature measurement
- Room temperature control
- Presence detection
- Industrial temperature monitoring

Calibrated Thermopile Focal Plane Array

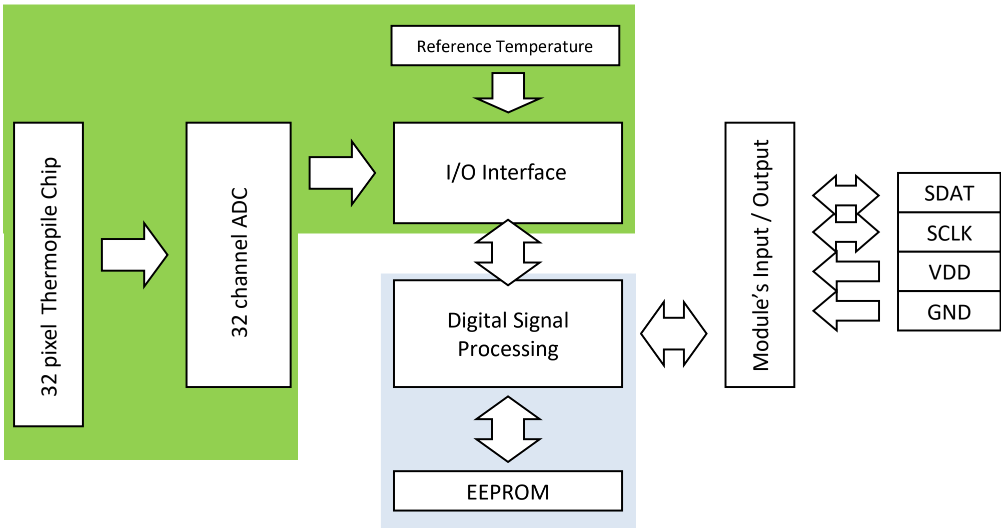
The TPL 32C 3774 L4.7 A60 P13 consists of a 32 element thermopile chip with corresponding ADC inputs. The integrated signal processing calculates temperatures and provides a digital interface to the data. The sensor module provides an output signal which represents real temperature data for each pixel. It has a lens optic to meet the Field of View (FOV) requirements of the specific application. This module is supplied as 'A' version which is calibrated and includes fast internal temperature compensation for ambient error correction.

EXCELITAS TECHNOLOGIES®

Contents

1 Functional Diagram

Figure 1: Functional Diagram



The functional diagram 1 illustrates the functional blocks of the TPL 32C 3774 L4.7 A60 P13 . The 32×1 thermopile pixels are fed into 32 high resolution analogue to digital converters (ADC) into a digital inteface. The close proximity of those components ensures best signal-to-noise (SN) radtios. The reference sensor temperature channel (PTAT) is also located close to the thermopile chip and accessed through the same interface,Tthe data is serialized into the external microcontroller on the PCB. The microcontroller uses the stored factory calibration data to calculate the sensor temperature and the object temperature. The SMBus interface is used to access the raw data as well as the calculated temperatures of the sensor.

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Product Specification

2 Absolute Maximum Ratings

Table 1: Absolute Maxiumum Ratings. Data applicable to operation at free-air temperature range.

Parameter	Symbol	Min	Typ	Max	Unit	Remarks/Conditions
Voltage at any pin	V_{DD}	−0.3		3.6	V	
Current into any pin	I_{pin}	−20		20	mA	
Storage Temperature		−40		100	°C	$<$ 60 % r.H.
Operating Temperature		−25		85	°C	

Stresses beyond the limits listed in table 1 may cause permanent damage to the device. Exposure to absolute maximum ratings for long time may affect the device reliability and may lead to deterioration of any parameter.

3 Electrical Characteristics

Unless otherwise indicated, all limits are specified for T_{AMB} at 25 °C, V_{DD} at 3.3 V .

Table 2: Power Supply

Symbol	Parameter	Min	Typ	Max	Unit	Remarks / Conditions
V_{DD}	Supply Voltage	2.7	3.3	3.6	V	
I_{DD}	Supply Current		18	20	mA	

Table 3: Serial Interface (SDAT & SCLK)

Symbol	Parameter	Min	Typ	Max	Unit	Remarks / Conditions
V_{iL}	Low level input voltage			$0.2 \cdot V_{DD}$	V	Falling edge
V_{iH}	High level input voltage		$0.8 \cdot V_{DD}$	$V_{DD} + 0.3$	V	Rising edge
V_{oL}	Low level output voltage			0.4	V	SDAT and SCLK are open drain. $I_{sink} = 2$ mA
V_{oH}	High level output voltage	$V_{DD} - 0.1$			V	$I_{source} = 2$ mA

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4 Temperature Sensing Characteristics

The calibrated temperature range and the sensor resolution is depicted in table 4. For the accuracy refer to table 5.

Table 4: Calibration settings

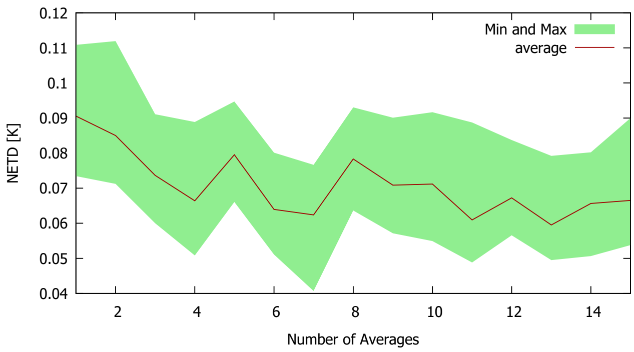
Symbol	Parameter	Min	Typ	Max	Unit	Remarks / Conditions
T_{OBJ}	Calibrated object temperature range	10.0		60	°C	Emissivity at 99.9 %
$Resolution_{TOBJ}$	Resolution of object temperature	0.1			°C	
T_{AMB}	Calibrated ambient temperature range	0.0		70.0	°C	
$Resolution_{TAMB}$	Resolution of ambient temperature	0.1			°C	

Table 5: T_{OBJ} output range production tolerances. The allowed RAM Address 1 to 32 range in respect to the real object temperature. The output is Temperature·10°C. For details refer to section 9.

T_{OBJ} °C	T_{OBJ} Output Min	T_{OBJ} Output Typ	T_{OBJ} Output Max
0.0	65 510	0	25
5.0	25	50	75
10.0	75	100	125
15.0	125	150	175
20.0	175	200	225
25.0	225	250	275
30.0	275	300	325
35.0	325	350	375
40.0	385	400	415
45.0	425	450	475
50.0	475	500	525
55.0	525	550	575
60.0	575	600	625

NOTE: Accuracy for T_{OBJ} between 25 °C and 60 °C are measured in Excelitas Lab. For T_{OBJ} below 25 °C, accuracy is estimated.

Figure 2: Typical mean NETD at 25 °C as a function of the filter setting. The NETD improves for higher object temperatures.



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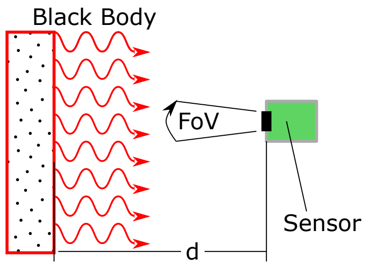
4.1 Calibration Conditions

The thermopile output is related to the net IR-radiation. The net IR-radiation can be correlated with the object temperature for a specific fixed set-up. The set-up valid for the factory calibration constants is shown in sketch 3.

Figure 3: Measurement conditions



A fluid heated plane black body with an outer dimension covering at least 4 times the sensors field-of-view (FoV) and an emissivity of better than 95 % has a surface temperature T_{obj} of 40 °C. The surface temperature uniformity is better than 0.2 °C. The ambient temperature T_{amb} is at 25 °C ± 3 °C. The TPL 32C 3774 L4.7 A60 P13 sensor is mounted at a distance d of 26 mm to the black body.

Conditions other than described in this document generally require a customized object calibration. Otherwise sensor performance may be different than specified here. Please contact our local representative for more details.

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5 AC Characteristics

Unless otherwise indicated, all limits are specified for T_{AMB} at 25 °C, V_{DD} at 3.3 V .

Table 6: Time constants

Symbol	Parameter	Min	Typ	Max	Unit	Remarks / Conditions
t_{start}	Module time to response after power ON			500	ms	
$t_{latency}$	Latency time for T_{OBJ}		190		ms	No filter applied
$t_{pix\ refresh}$	Pixel signal refresh time		190		ms	
$t_{PTAT\ refresh}$	PTAT signal refresh time			90	ms	

Table 7: Amplifier

Symbol	Parameter	Min	Typ	Max	Unit	Remarks / Conditions
O_N	Output noise			12	counts	Applicable for $V_{Pix\ i}$ at default filter setting

Table 8: Serial Interface

Symbol	Parameter	Min	Typ	Max	Unit	Remarks / Conditions
f_{SMB}	Operating frequency	10		100	kHz	Please refer to section 8.4 for specifc conditions applicable

Table 9: EEPROM

Symbol	Parameter	Min	Typ	Max	Unit	Remarks / Conditions
	Data retention time	10			Years	Max T_{AMB} at 85 °C
t_{WR}	Write cycle time	250			ms	

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6 Optical Characteristics

6.1 Field of View

Figure 4 illustrates the measurement of the sensor's field of view (FOV). A hot point like heat source radiates almost parallel infrared light in a distance to the sensor. The sensor's housing is rotated around its sensor plane in all directions while recording the sensor data. A typical measurement result is shown in figure 5. The result is normalized to the peak value of the measurement. The resulting parameters are depicted in table 10.

Figure 4: Illustration of the FOV measurement setup. For details see the text.

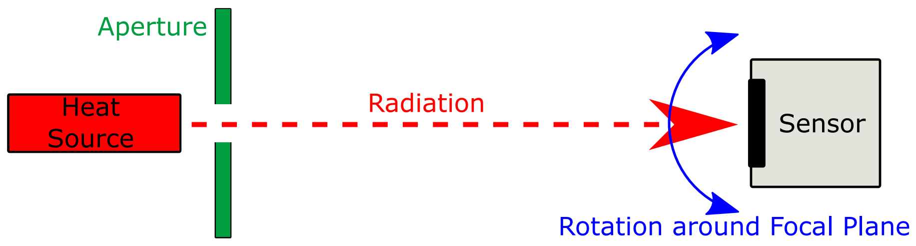


Figure 5: Typical FoV measurement result

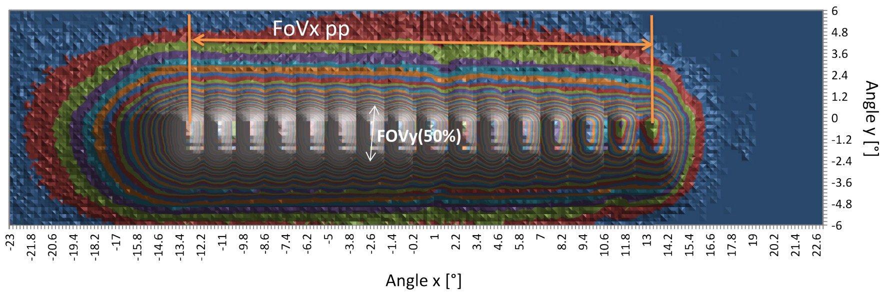


Table 10: Optical Parameters for Cap type chip-on board L4.7

Symbol	Parameter	Min	Typ	Max	Unit	Remarks / Conditions
FOV_X	Field of View X Direction	55	59	63	°	See fig. 4
FOV_Y	Field of View Y Direction	1.5	3	4.5	°	See fig. 4
FOV_{pixel} 50 %	Single Pixel FOV	1.5	3.0	4.5	°	
OA	Optical Axis	−6.5	0	6.5	°	

Figure 6 illustrates the definition of the optical axis. It includes all degrees of freedom of the assembly into one parameter, which represents a tilt of the typical field of view center axis in respect to the outer package. The physical pixel orientation is shown in figure 7. Note that the projected image of an object behind a lens appears mirrored.

Figure 6: Illustration of optical axis

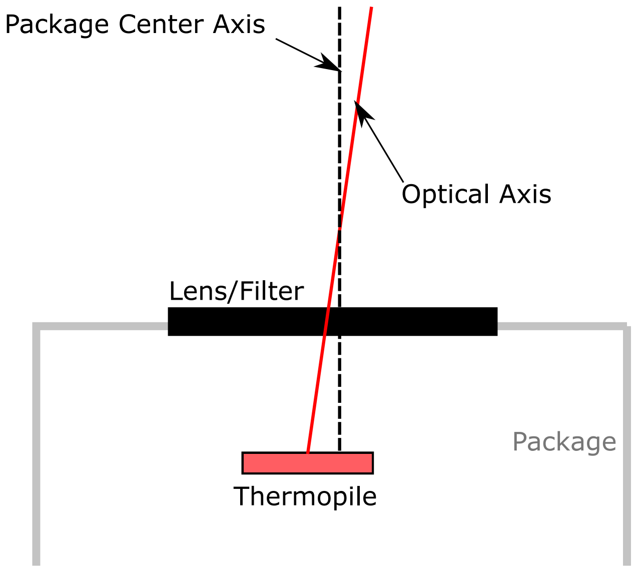
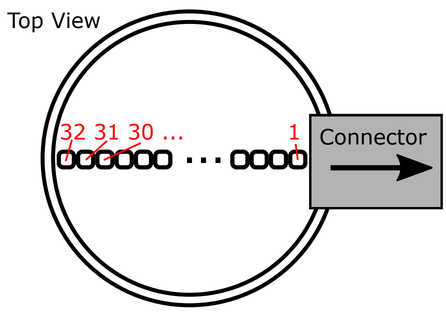


Figure 7: Physical pixel orientation relative to the sensor's tab



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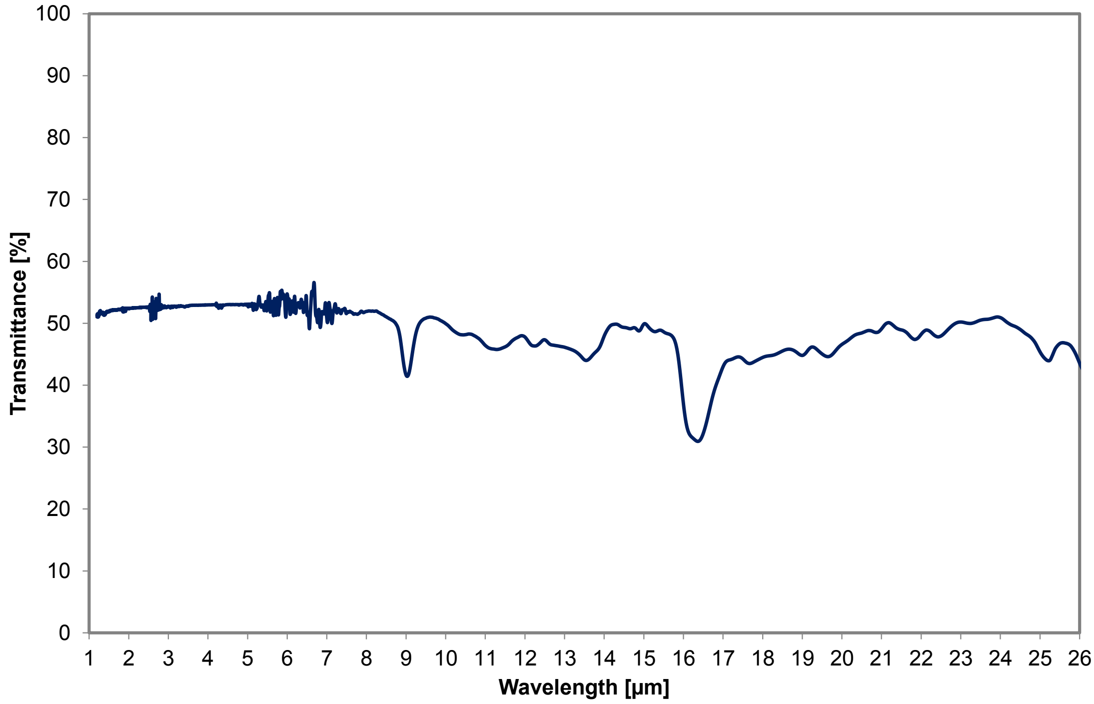
6.2 Filter Properties

Table 11: Filter properties

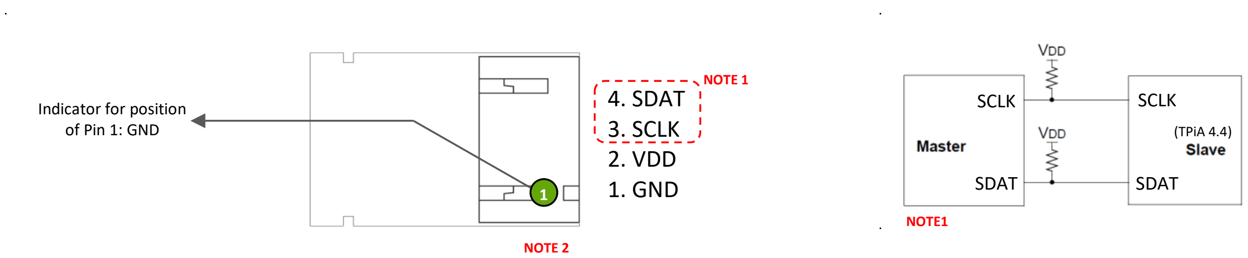
Parameter	Symbol	Min	Typ	Max	Unit	Remarks / Conditions
Average Filter Transmittance	T_A		50		%	$2\,\mu m < \lambda < 15\,\mu m$

Figure 8: Filter transmittance, typical curve



7 Connection Information

Figure 9: Connection Information. For details see the text.



NOTE 1: The SCLK and SDAT pins are open collector. Apply appropriate pull up resistors (e.g. 4.7 kΩ) on the SMBus master device.
NOTE 2: Module connector employed: : CVILUX CI0104M1HR0-LF or JST S4B-PH or equivalent.

8 Serial Interface: SMBUS and Data Communication Information

A '2-wire', bi-directional SMBus compatible serial interface is provided for communication of sensors' data to and from target applications. TPiA 4.4T Application Note: SMBus Communication, provides examples to understand and to operate the SMBus communication protocol. For complete SMBus specification, please refer to the following webpage: http://www.smbus.org/specs
There are 2 types of memory in the TPiA 4.4T device:

1. EEPROM - holds configuration data
2. RAM - holds temperature data.

Only READ operation is applicable to RAM data; READ / WRITE operations are applicable to EEPROM data. The following sub-sections specify the SMBus protocol required to: (1) WRITE Word, and (2) READ Word; according to legend shown in 10.

Figure 10: Legend for Protocol illustrations

S	START Condition
Sr	Repeated START Condition
Rd	READ (bit value 1)
Wr	WRITE (bit value 0)
A	ACKNOWLEDGE (ACK)
Ā	NOT ACKNOWLEDGE (NACK)
P	STOP Condition
PEC	Packet Error Code (CRC: Cyclic Redundancy Check)
	Data Direction: MASTER send to SLAVE
	Data Direction: SLAVE send to MASTER

Figure 11: Protocol illustration for WRITE Word

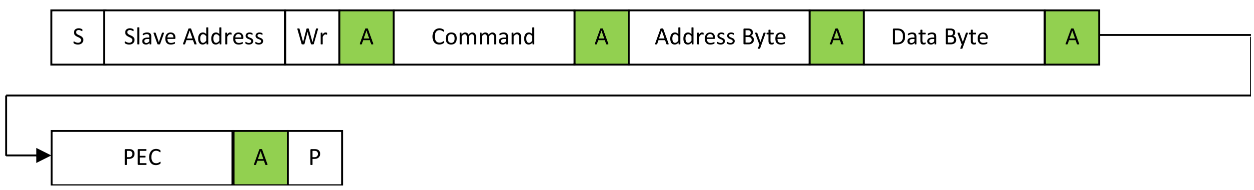
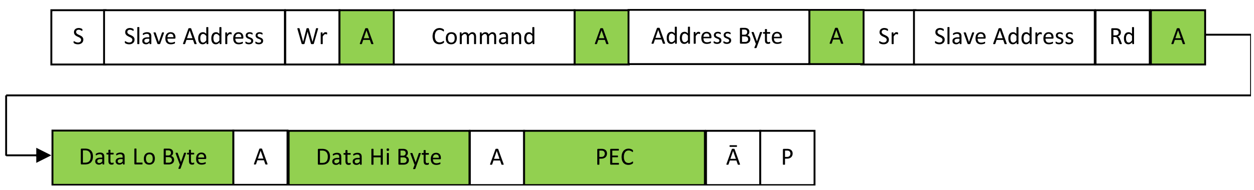


Figure 12: Protocol illustration for READ Word



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8.1 Command

The command is a byte used by the master device to tell the CoolEYE™ which operation is requested or executed. The command types are listed in table 12.

Table 12: Command Types

Command	Descriptions
0x01	Read WORD RAM
0x81	Read/Write BYTE EEPROM
0x02	Block read of all pixel temperatures including the internal reference
0x03	Block read of all even pixel temperatures including the internal reference
0x04	Block read of all odd pixel temperatures including the internal reference

NOTE: Addresses of RAM and EEPROM are described in the sections: OUTPUT DATA INFORMATION and CONFIGURATION PARAMETERS and DESCRIPTIONS

8.2 SMBus Protocol: Block Read

In addition to the above READ Word, a BLOCK READ protocol can be activated in order to output in one sequence the data refreshed from RAM Addresses 1 to 32 (T_{AMB}, $T_{OBJ\ PIX1}$, $T_{OBJ\ PIX2}$ ... $T_{OBJ\ PIX32}$) by providing a single COMMAND byte 0x02. The byte count reflects the number of following bytes which the sensor will transmit to the Master, including the PEC. When reading all pixels the byte count witll be $2 \cdot 33 + 1 = 67$.

Figure 13: Command for Block Read

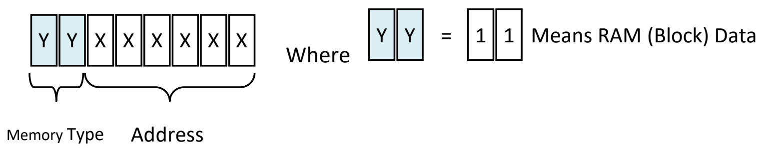
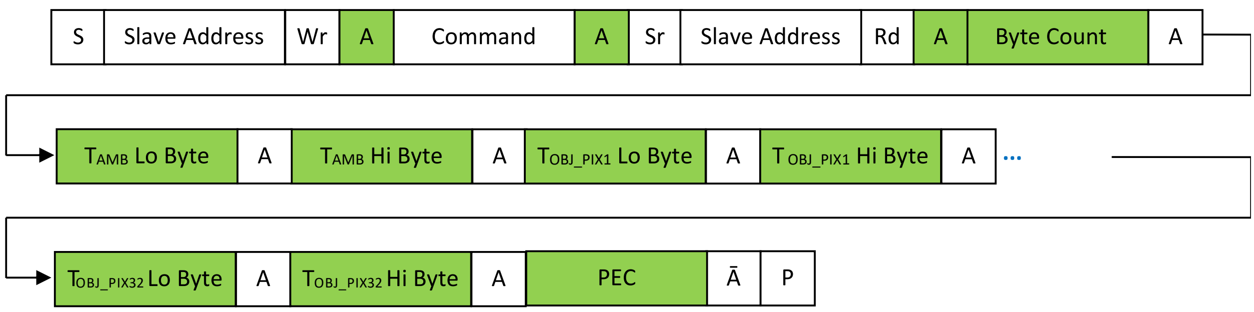


Figure 14: Protocol illustration for Block Read



8.3 PEC: Cyclic Redundancy Check

Each bus transaction requires a Packet Error Code (PEC) calculation by both the MASTER and the SLAVE devices to ensure physical correctness of transmitted data. The PEC includes all bits of a transaction except the START, REPEATED START, STOP, ACK, and NACK bits.

The PEC is a CRC-8 with polynomial PEC= $x8 + x2 + x1 + 1 = 107$hex and must be calculated in the order of the bits as received. A possible implementation might look like:

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```
#define POLYNOMIAL      (0x107 << 7)
unsigned char calc_crc8(unsigned char inCrC, unsigned char inData)
{
    int i;
    unsigned int data;
    data = inCrC ^ inData;
    data <<= 8;
    for (i = 0; i < 8; i++){
        if ((data &0x8000) != 0)
            data = data ^POLYNOMIAL;
        data = data << 1;
    }
    return(unsigned char) (data >> 8);
}
```

8.4 Clock Low Extension and Data Preparation Time

The sensor uses clock low extension, t_{EXT} where necessary in order to extend the low period of SCLK in order to gain time for data processing, or data preparation for transmission. For this reason, there are also minimum timing conditions represented by data preparation time, $t_{Data\ Prep}$ required to ensure reliable SMBus communication with the sensor. The diagram below shows the READ Word command as an example. In order to ensure stable SMBus communication, the MASTER Device is required to apply $t_{Data\ Prep}$ at the various positions as indicated. **NOTE**: t_{EXT} is generated automatically by the sensor, therefore the Master Device does not need to apply a time delay for these.

Figure 15: Possible occurences for clock low extensions driven by the host

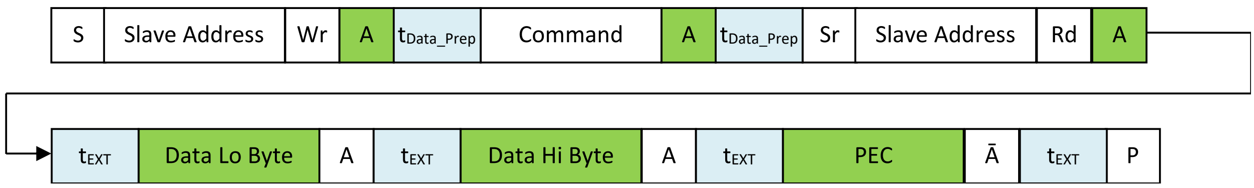

Table 13: required settings for t_{EXT} and $t_{Data\ Prep}$ at given SCLK frequencies

Symbol	Parameter	Min	Typ	Max	Unit	Remarks / Conditions
t_{EXT}	SCLK signal clock low extension	4.7			µs	
$t_{Data\ Prep}$	Time delay required by master device during data preparation			150	µs	SCLK freq = 100 kHz
$t_{LOW:S\ EXT}$	Cumulative clock low extend time			25	ms	Sum of t_{Delay} and t_{EXT}

8.5 SMBus Timeout

TPiA sensor provides a Time-out mechanism for SMBus communication self recovery in the event that the SMBus protocol sequence is interrupted or disturbed. Every time a new SMBus transaction is recognized by a Slave Address match, a timer is activated. If the subsequent SMBus protocol events do not occur within a span of 30 ms, a Timeout occurs and as a reaction the SMBus communication sequence will be reset to be ready for a new transaction.

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8.6 SMBus Signals:Timing Characteristics

Figure 16: SMBus Timing Characteristics

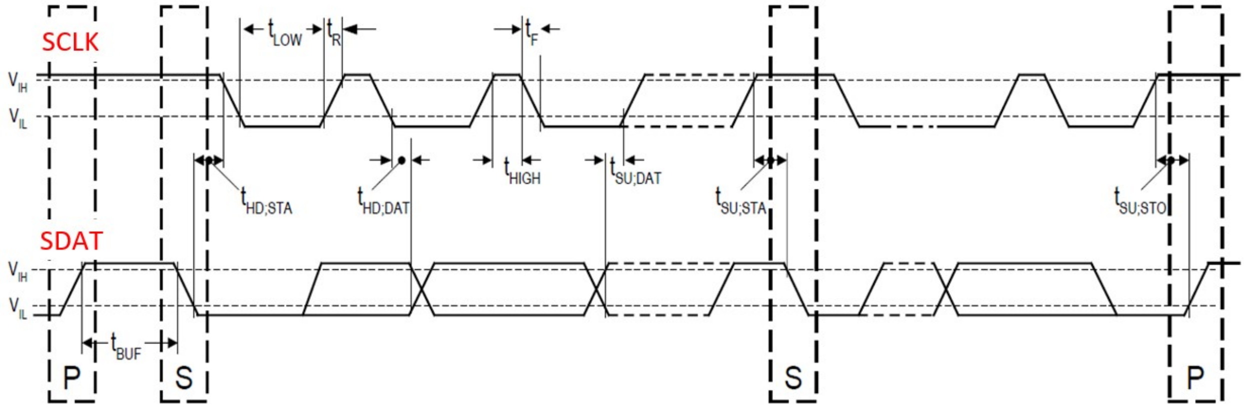

Table 14: SMBus timings. Unless otherwise indicated, all limits are specified for T_{AMB} at 25 °C, V_{DD} at 3.3 V .

Symbol	Parameter	Min	Typ	Max	Unit	Remarks / Conditions
t_{BUF}	Bus free time between STOP and START condition.	10			µs	
$t_{HD:STA}$	Hold time after (Repeated) START Condition. After this period, the first clock is generated.	4.0			µs	
$t_{SU:STA}$	Repeated START Condition setup time.	4.7			µs	
$t_{SU:STO}$	STOP Condition setup time	4.0			µs	
$t_{HD:DAT}$	Data hold time	0.3			µs	
$t_{SU:DAT}$	Data setup time	0.25			µs	
t_{Low}	Clock low period	4.7		30 000	µs	see sec. 8.5
t_{High}	Clock high period	4.7		50	µs	see sec. 8.5
t_F	Clock / Data fall time			0.3	µs	
t_R	Clock / Data rise time			1	µs	

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9 Output Data Information

Temperature outputs of the sensor are updated into the RAM memory. The address(es) of the RAM Data are defined by the Table 15.

Table 15: RAM content

RAM Address	Bit	Data	Description of Data	Value Range
0	15 to 0	T_{AMB}	Calculated Ambient Temperature: Value = $10 \cdot T_{AMB}$ [in °C]	0 to 65 535
1 to 32[NOTE 1]	15 to 0	$T_{OBJ[1...32]}$	Calculated Object Temperature (T_{AMB} Compensated): Value = $10 \cdot T_{OBJ}$[in °C]	0 to 65 535
65	15 to 0	V_{PTAT}	PTAT raw data ADC value	0 to 65 535
1 to 32	15 to 0	$VPIX_{[1 ... 32]}$	TP pixel raw data ADC value	0 to 65 535

NOTE: The data of RAM ADDRESS 65 to 97 is used for factory calibration only and not relevant for customer application.
NOTE 1: Negative temperature output are represented as follows, eg. $-5\,°C \rightarrow 65535 - 50 = 65485$.

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10 Configuration Parameters and Descriptions

Table 16: The address(es) of customer accessible EEPROM Data and the content

EEPROM Addr. (MSB,LSB)	**Bits**	**Name**	**Meaning**	**Mode**	**Value Range**
0.1	15 to 0	ID[NOTE 1]	Unique Sensor ID identical to corresponding sticker label applied on module	R/W	0 to 2×10^{16}
4.5	6 to 0	SA	Unique SMBus Slave Address	R/W	0 to 127 (Default = $0A_{Hex}$)
8.9	15 to 0	Device Type	Ambient temperatue compensation: dec 4 = ON, dec 0 = OFF	R/W	NA
12.13	15 to 0	Average Count	The internal ADC data can be averaged to improve SN	R/W	NO Averaging = 1 (Default = 13)

NOTE: Configuration and Calibration changes are scalable. Other EEPROM addresses are locked from changes. Default settings may be optimised and changed in order to fit specific application requirements.
NOTE 1: ID may not apply for engineering samples.

11 EEPROM Writing

EEPROM Writing is performed asynchronously to SMBus communication. The write cycle time t_{WR} is the time from a valid STOP condition of a WRITE WORD command sequence to the end of physical transfer of received data into EEPROM cell. Please refer to table 9 for the t_{WR} specification.

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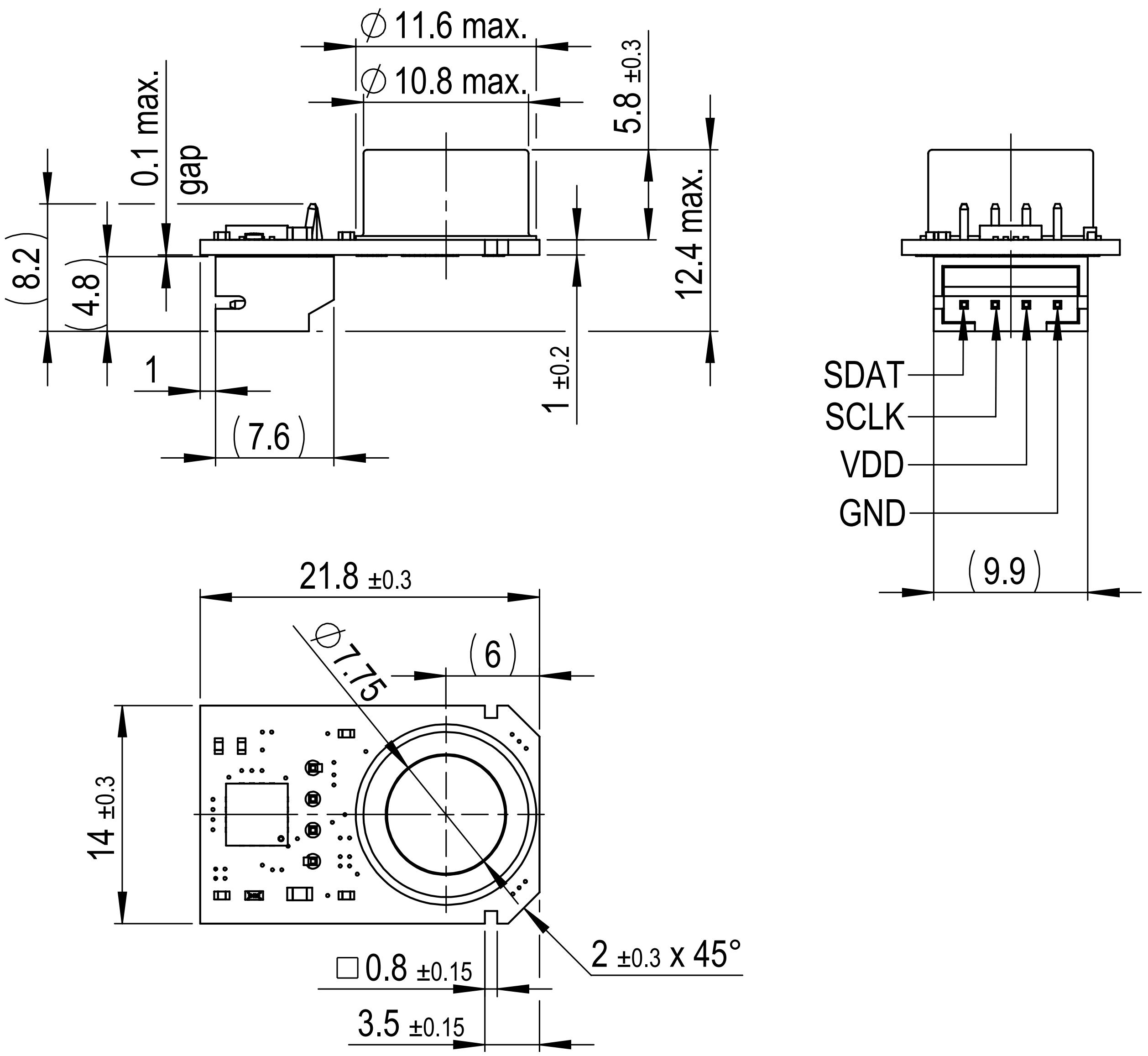
12 Mechanical Information

Figure 17: Device drawing. Dimensions are given in mm.



13 Soldering

The sensor is a lead-free component and fully complies with the RoHS regulations, especially with existing roadmaps of lead-free soldering.
NOTE: This may not apply for engineering samples.

14 Labeling

For manufacturing traceability, each sensor and module is labelled using the following format.

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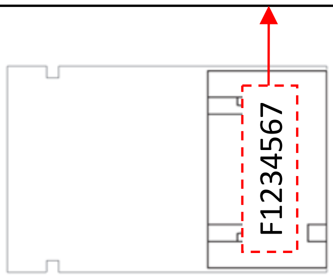
Figure 18: Labeling on Sensors and Modules

Each device is marked by a label with a letter and a consecutive serial number. The letter describes the place of manufacturing (E = engineering sample, other alphabets (C, D, F...) = made in Indonesia).



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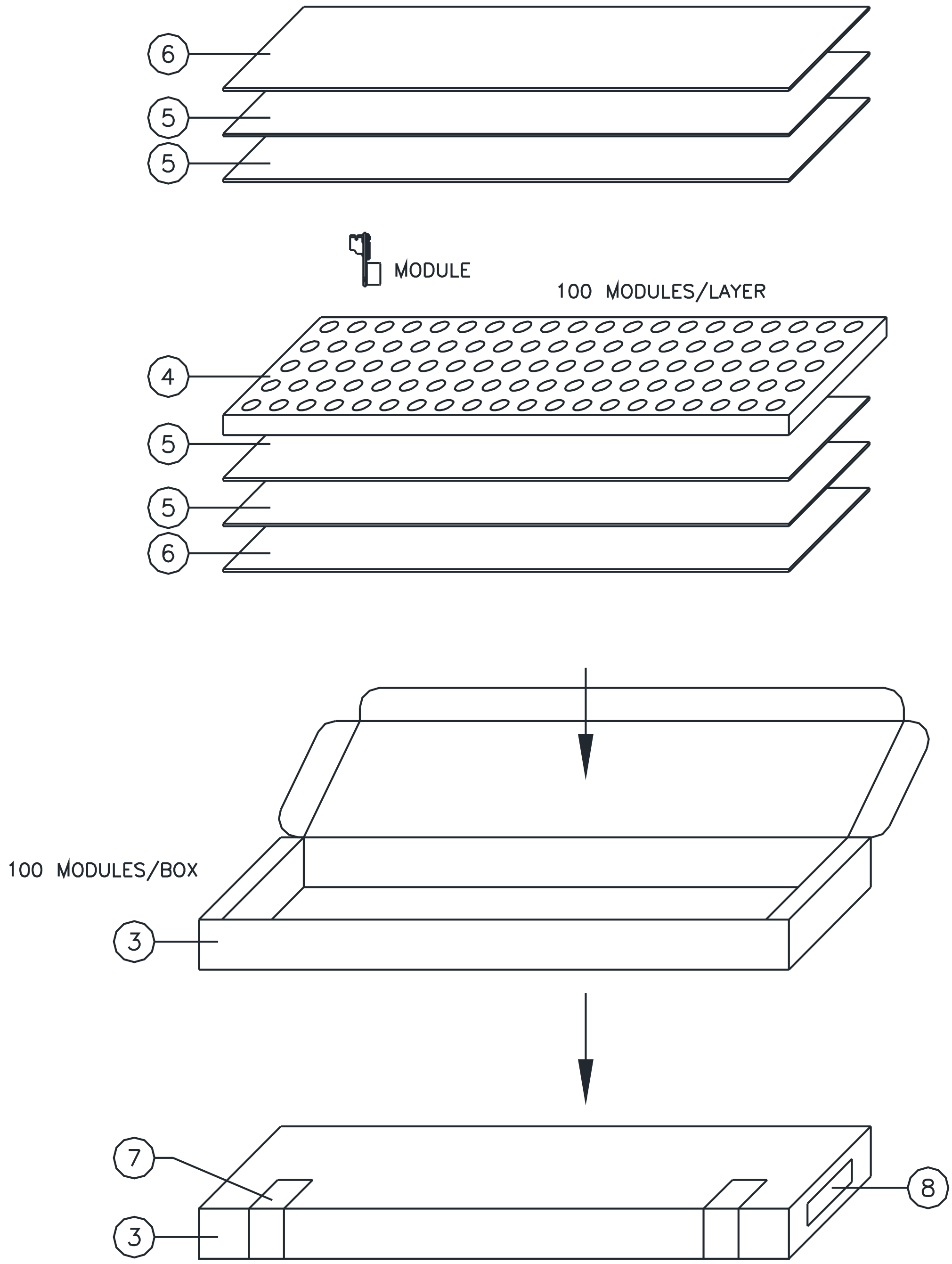
15 Packaging Specification

15.1 General Information

The Excelitas Technologies sponge packaging system protects the product from mechanical and electrical damage and is designed for manual unloading. The system consists of sponges which are protected against ESD. Up to 100 parts are filled into one box. Information labels, ESD labels and bar-code Labels (optional) are placed on the box. Figure 19 shows the basic outline.

Figure 19: Sponge packaging system for manual unload.



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16 Statements

Quality Excelitas Technologies is a ISO 9001:2015 certified manufacturer with established SPC and TQM. Excelitas Technologies is certified for it's Environmental Management System according to ISO 14001:2015 and for the Occupational Safety and Health Management System according to ISO 45001:2018.
All devices employing PCB assemblies are manufactured according IPC-A-610 class 2 guidelines.
The infra-red detection product line is certified for ANSI/ESD S.20.20:2014.

Moisture Sensitivity Level Moisture sensitivity level classification does not apply to TO-can products. Storage at high humidities should be avoided.

Electrostatic Discharge Performance All pins pass the electrostatic discharge sensitivity (ESD) test level 1 (±2 kV) according to IEC 61000-4-2. Please make sure not to confuse this norm with other norms such as ANSI/ESDA-JEDEC JS-001-2010 (Human Body Model), ESD DS5.3.1 (Charge Device Model) or ESD STM5.2 (Machine Model).

RoHS This sensor is a lead-free component and complies with the current RoHS regulations, especially with existing road-maps of lead-free soldering.

Liability Policy The contents of this document are subject to change. The details of this document are valid by the specified revision date. Excelitas reserves the right to change at any time total or part of the content of this specifications without individual notification. Customers should consult with Excelitas Technologies' representatives to ensure updated specifications before ordering.
Customers considering the use of Excelitas Technologies devices in applications where failure may cause personal injury or property damage, or where extremely high levels of reliability are demanded, are requested to discuss their concerns with Excelitas Technologies representatives before such use.
The Company's responsibility for damages will be limited to the repair or replacement of defective product. As with any semiconductor device, thermopile sensors or modules have a certain inherent rate of failure. To protect against injury, damage or loss from such failures, customers are advised to incorporate appropriate safety design measures into their product.

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