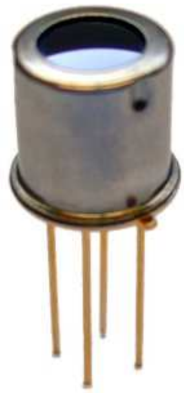
Preliminary Datasheet
Thermopile Array With Lens Optics
Type HTPA 16x4 L5.5

HEIMANN Sensor
HEIMANN SENSOR GMBH

1. Features and Benefits

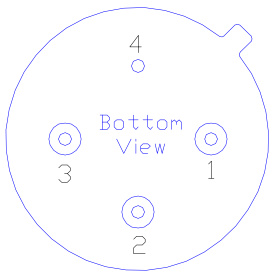
- Single die, low cost 16x4 pixels IR array
- Factory calibrated absolute PTAT temperature sensor for measuring die temperature
- Separate channel for connecting additional IR sensor for error compensation
- Industry standard four lead TO39 package
- I^2C compatible digital interface
- Programmable refresh rate 0.5Hz … 512Hz
- Includes calibration constants in EEPROM
- 3V supply
- Current consumption less than 3mA
- Pixel pitch 220µm
- Pixel size 180µm
- Ta -40 to 85°C
- To -50 to 1000°C
- Complies with RoHS regulations



2. Ordering Information

HTPA → Heimann thermopile array
a x b → number of elements
L xx → „L" lens cap TO39 followed by focal length of lens

3. Pin Configuration



Pin	*Symbol*	*Description*
1	SCL	Digital input, serial clock in SMBus compatible mode
2	SDA	Digital I/O, data input /output in SMBus compatible mode (open drain)
3	VDD	Positive supply voltage
4	VSS	Negative supply voltage / Ground (0V) (connected to housing)

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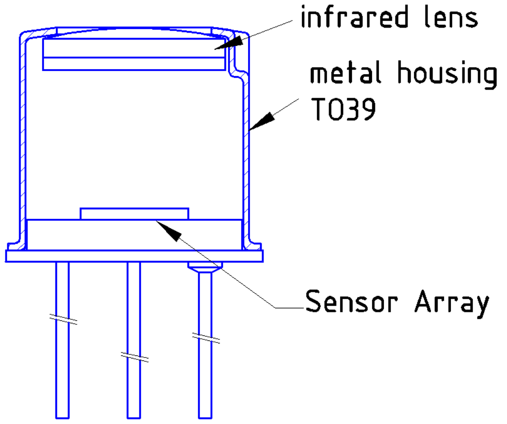
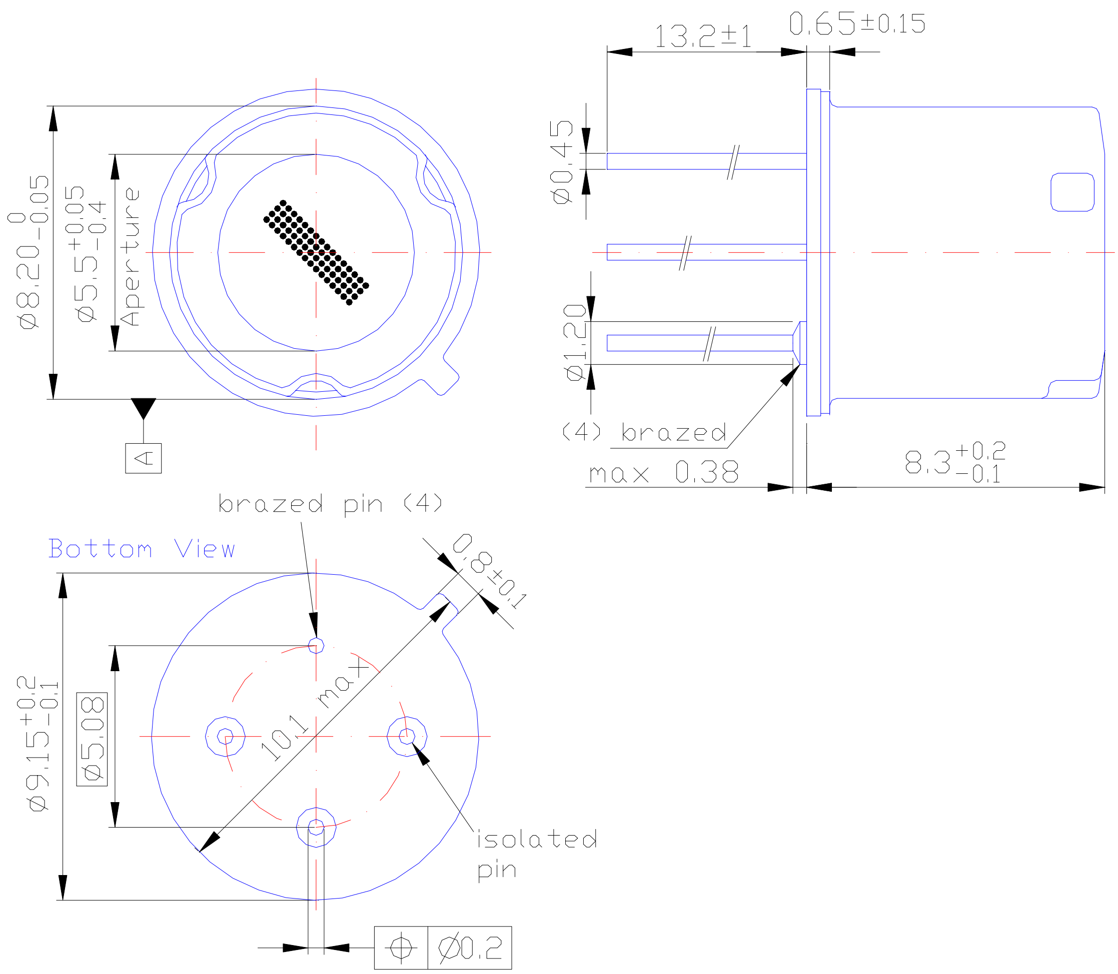
4. Dimensional Drawings





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5. Maximum Ratings

Parameter	*Max. value*	*Unit*	*Condition*
Supply voltage VDD	3.6	V	without external resistor
ESD sensitivity	4	kV	human body
Storage temperature	-40 to 85	°C	max. 85% r.H., non condensating

6. Operating Conditions

Parameter	*Value*	*Unit*	*Condition*
Supply voltage range	2.4 to 3.6	V	
Supply current	max. 3	mA	max. in operating mode
Supply current	max. 0.002	mA	max. in power saving mode
Object temperature range	-50 to 1000	°C	depends on Filter characteristics
Ambient temperature range	-40 to 85	°C	max. 85% r.H., non condensating
Data output rate	0.5 to 512	fps	programmable in 11 steps
Data Memory Organisat-ion: IR-Measure-ment	64x 16bit		converted voltage signal to be converted to temperature by EEPROM constants
Data Memory Organisat-ion: Ta-Measure-ment	80x 16bit		
Interface	2-wire I2C-Bus compatible		

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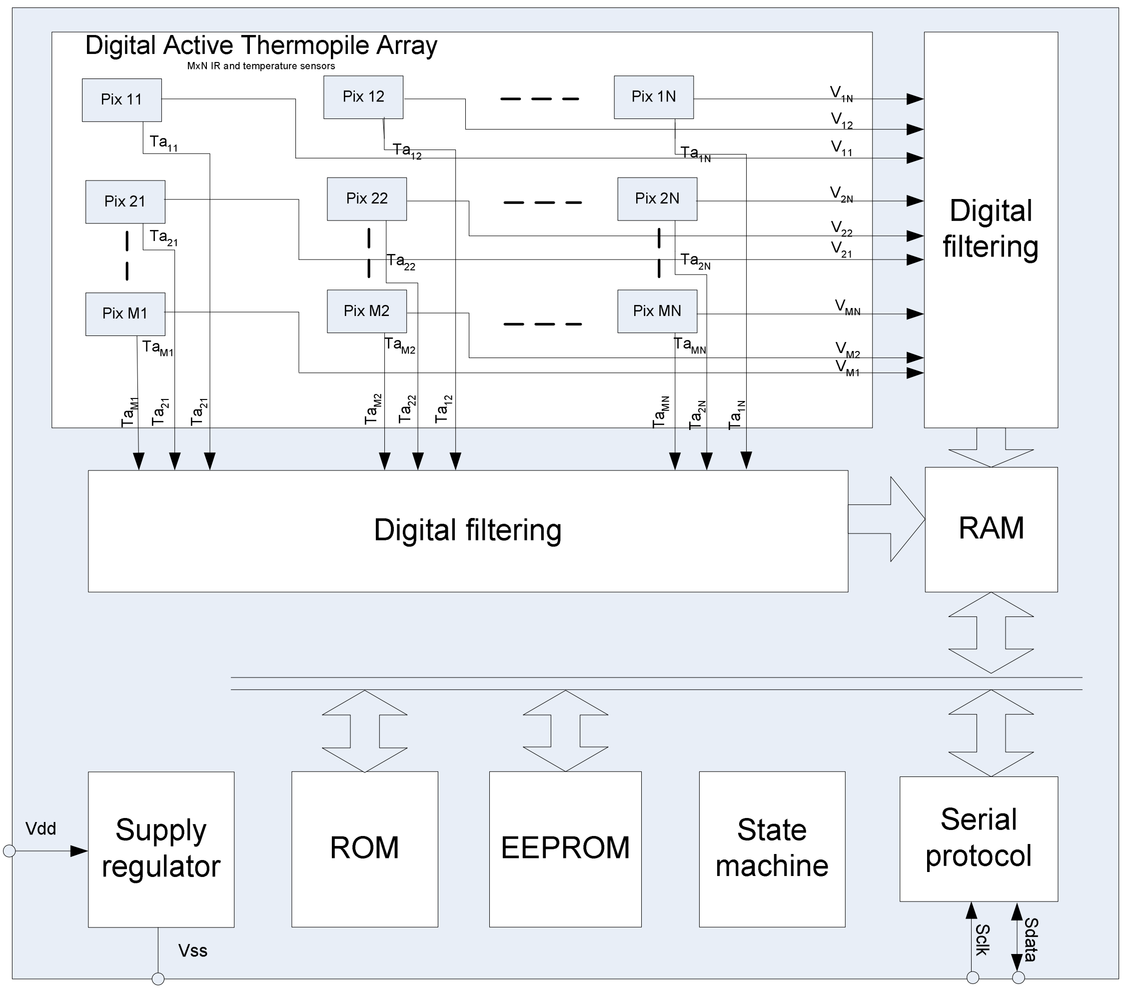
7. Field of View

parameter				*unit*	*conditions*
	Min	*Typical*	*Max*		
Field of View L7.0		28		degree	50% energy points
Field of View L5.5		36		degree	50% energy points
Field of View L3.6		60		degree	50% energy points

8. Block diagram



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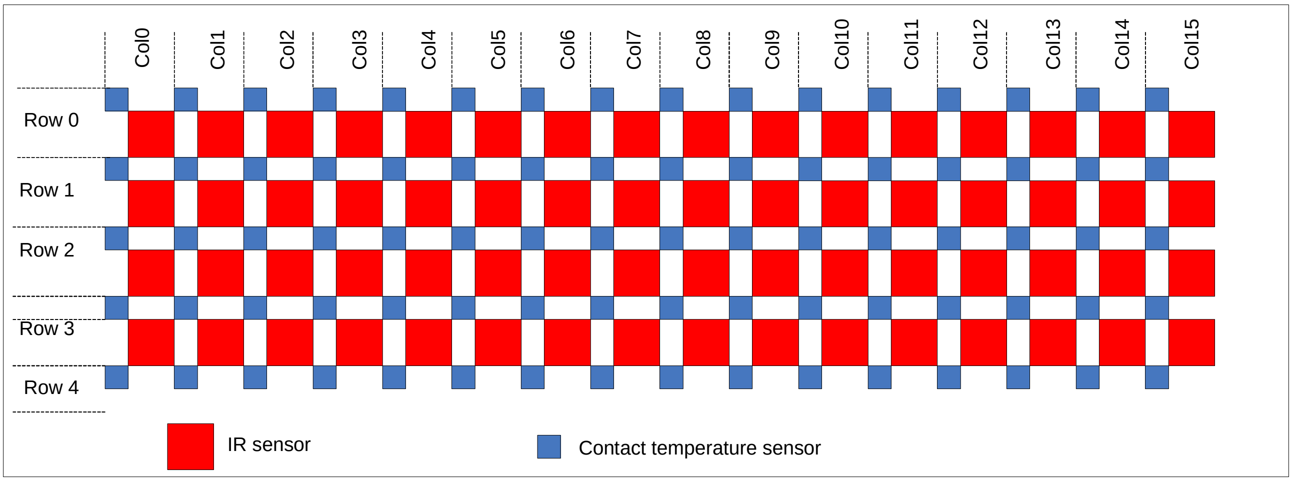
9. Block description

9.1. Array layout



The array consists of 64 IR sensors (called also pixels) and 80 contact temperature sensors (called also Ta sensors) for precise measurement of temperature of cold junction of different pixels. Row 5 has only Ta sensors.
Each pixel is identified with its row and column position as Pix(I,J) where I is its row number and J is its column number.

9.2. RAM

On chip 146x16 RAM is available and accessible for reading via I2C. The RAM is used for storing the results of measurements of pixels and Ta sensors and is distributes as follows:

- 128 bytes (64 words) for IR sensors. 2 bytes will be used to store the output of each pixel. The data will be in 2's complement format with the sign in MS bit of MS byte.
- 2 bytes (1 word) for measurement result of PTAT sensor. This sensor is selected to be a reference Ta for the device. The temperatures of all other Ta sensors are measured relative to this one. The data is 16 bit without sign. Physically this sensor is placed close to Ta(0,0).
- 160 bytes (80 words) for Ta sensors. The data is 16-bit 2's complement with a sign in the MS bit and is showing the temperature difference to the reference sensor
- 2 bytes (1 word) for the additional sensor for temperature gradient compensation

The memory map of the RAM is shown below:

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Address	RAM variable description
0x00	IR sensor (0,0) result
0x01	IR sensor (1,0) result
0x02	IR sensor (2,0) result
0x03	IR sensor (3,0) result
0x04	IR sensor (0,1) result
0x05	IR sensor (1,1) result
0x06	IR sensor (2,1) result
0x07	IR sensor (3,1) result
…	…
0x3C	IR sensor (0,15) result
0x3D	IR sensor (1,15) result
0x3E	IR sensor (2,15) result
0x3F	IR sensor (3,15) result
…	…
0x40	Ta sensor (0,0) result
0x41	Ta sensor (0,1) result
…	…
0x4F	Ta sensor (0,15) result
0x50	Ta sensor (1,0) result
0x51	Ta sensor (1,1) result
…	…
0x5F	Ta sensor (1,15) result
0x60	Ta sensor (2,0) result
	…
0x8F	Ta sensor (4,15) result
0x90	PTAT sensor result
0x91	Cyclops sensor result

For IR sensors results, the addressing can be summarized:
IR(x,y) is on address: x + y*4
For Ta sensors results, the addressing can be summarized:
Ta(x,y) is on address: 64 + 16*x + y

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9.4 EEPROM

A 2kbit, organized as 256x8 EEPROM is built in the HTPA16x4. The EEPROM is on a separate die and is used to store the calibration constants of the device.

The following data is available via I2C:

- 64 bytes to store the individual offset of each pixel. The data is 7-bit q2's complement with a sign pixel in 8th MS Bit.
- 128 bytes for calibration constants of each pixel. The data is 16-bit (No sign)
- 2 bytes for calibration constant of additional sensor for temperature gradient compensation
- 4 bytes to keep the KTa1 and KT2 constants for calculation of the absolute ambient temperature of the device PTAT.
- The rest of 58 bytes are Heimann reserved.
- 1 byte for I2C address

9.5 Internal registers

9.5.1 Configuraton register

The control register defines the chip operating mode. It can be read and written by the I2C communication.

Complete description of the configuration register bits is following:

Bit number	15	14	13	12	11	10	9	8
Bit(s) name	n/a	adc_resolution	frames_per_second_ptat[1:0]		i2c_fmplus_enable	check_bit	ir_meas_running	ta_meas_running
Bit number	7	6	5	4	3	2	1	0
Bit(s) name	sleep_request	meas_step_cont_b	frames_per_second_ta[1:0]		frames_per_second_ir[3:0]			

Parameter frames_per_second_ir[3:0].
This parameter defines the refresh rate for the IR and Cyclops measurements according to the following table:

frames_per_second_ir	Frequency, Hz	Period, ms
15	0.5	2000
14	1	1000
13	2	500
12	4	250
11	8	125
10	16	62.5
9	32	31.25
8	64	15.625
7	128	7.8125
6	256	3.90625
5	512	1.953125

For frame_per_second_ir below 5, it is considered to be 5.

Parameter frames_per_second_ta[2:0].
This parameter defines the refresh rate for the Ta sensors according to the following table:

frames_per_second_ta	Frequency, Hz	Periodx128, ms	Period single, Ta ms
3	0.5	2000	15.625
2	1	1000	7.8125
1	2	500	3.90625
0	4	250	1.953125

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Parameter frames_per_second_ptat[2:0].
This parameter defines the refresh rate for the PTAT sensor according to the following table:

frames_per_second_ptat	Frequency, Hz	Periodx, ms
3	2	500
2	4	250
1	8	125
0	16	62.5

_Parameter meas_step_cont_b.
This parameter defined the measurement mode: continuous (active level – 0) or step mode (active level – 1).

Parameter sleep_request.
Writing 1 to this bit puts the chip in sleep mode. See power management unit.
Writing 0 has no effect.

Flag ir_meas_running.
Shows if there is IR measurement running with active level – 1.
This flag can only be read. Write to it has no effect.

Flag ta_meas_running.
Shows if there is temperature measurement running with active level – 1.
This flag can only be read. Write to it has no effect.

Flag check_bit.
It is zeroed by POR or brown-out.
The master device should write 1 into this bit during configuration.
The master device should check from time to time the value of that bit. It reads 0 – error has happened.

Parameter fmplus_enable (going to analog):
0: The I2C can work in Fast mode plus.
1: The I2C cannot work in Fast mode plus.

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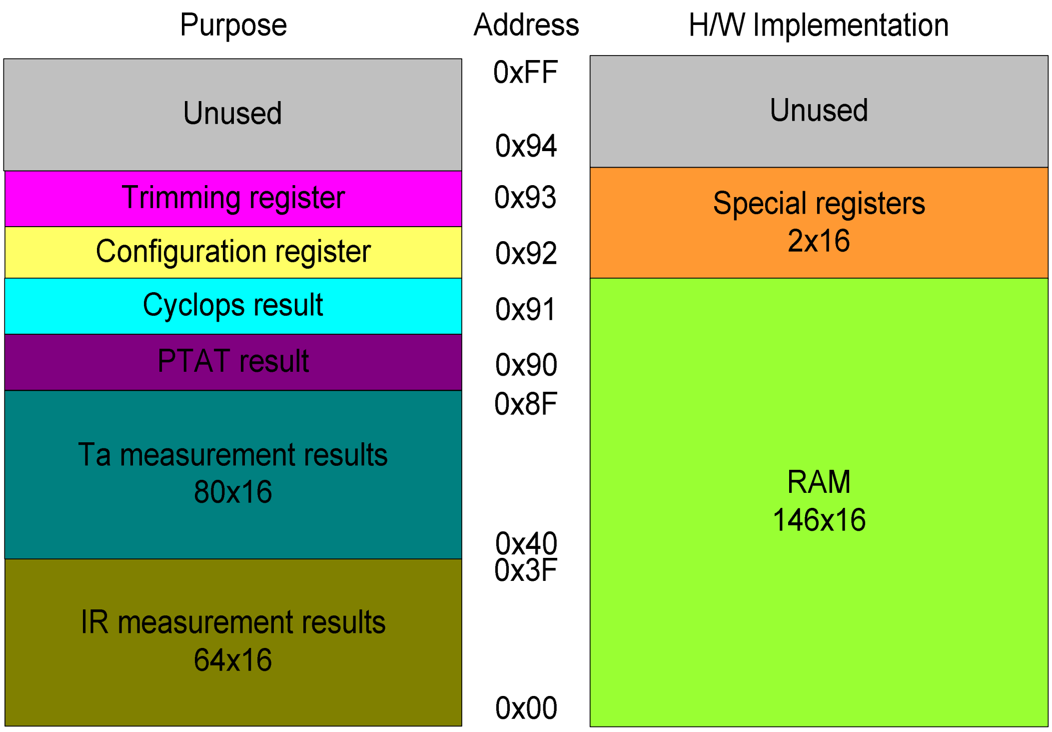
9.5.2 Trimming register

This is one 16bits long trimming register. It saves the oscillator trimming value.
It can be read and written by the I2C communication.
Complete description of the trimming register bits is following:

Bit number	15	14	13	12	11	10	9	8
Bit(s) name	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Bit number	7	6	5	4	3	2	1	0
Bit(s) name	n/a	Oscillator_trimming[6:0]						

9.5.3 HTPA16x4 Address Map



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9.6 Oscillator

An RC oscillator with a typical value of 16MHz is integrated. The oscillator is tuned to 16MHz+/-5% during the factory calibration. The tuning data is written in the internal EEPROM in the Heimann reserved part. During the initialization of the device the SW reads this data and adjusts the oscillator frequency.

9.7 POR

The Power On Reset (POR) is connected to the Vdd supply. The on-chip POR circuit provides an active level of the POR signal when the Vdd voltage rises above approximately 0.5V and holds the entire HTPA16x4 in reset until the Vdd is higher than the specified POR threshold VPOR. After VPOR is reached and after a delay of 16ms the chip will start to execute its initialization procedure.

9.8 Sensor for gradient compensation

The IR sensor readings and accuracy are very sensitive to any temperature gradients over the package. Any temperature difference between the cold junction of thermo-pile and (part of) the package, ‘seen’ by the IR sensor will create an error signal. Such a problem is not very severe for the applications where absolute measurement is not required, because in this case it is important to cancel the distortion.

However for the applications where the picture must be converted to temperatures, seen by the different pixels, such a gradient will introduce huge error in the measurement. The problem will be even more severe if there is a variation of the gradient (unfortunately the most common case, because the gradient comes from power dissipation of electronics on the same pcb, which varies with environmental conditions).

The HTPA16x4 supports one extra IR channel containing amplifier, ADC and digital filter. The input of this chain is connected to bond pads. An additional IR sensor can be placed in the same package and connected to these bond pads. If this sensor is optically ‘blinded’ (seeing only package, not outside) its output can be used to compensate the error readings of the main array.

Heimann Sensor has developed and implemented this approach successfully. The experience shows that the readings of additional sensor allow reduction of the gradient’s error by factor of 10.

9.9 ESD

ESD, 4KV Human Body Model

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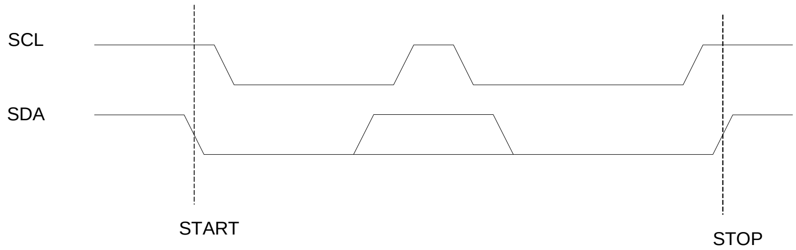
10. Communication protocol

The device will supports fast I2C (up to 400kbpc) and works in slave mode only. The communication is running through 2 digital pins: SCL and SDA. The master device is providing the clock signal SCL for the communication. The data line SDA is driven by either the master or the slave depending on the direction of the communication. A '0' is transmitted by pulling the SDA line to 'LOW' and a '1' by releasing it 'HIGH'. During the data transfer the SDA must remain stable while SCL is HIGH. Changes in SDA are allowed only when SCL is LOW.

10.1. Start condition

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 (see the figure)



10.2. Device addressing

The master is addressing the slave device by sending an 8-bit slave address after the START condition. The first seven bits are dedicated for the address and the 8th 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

The HTPA16x4 is responding to 2 different slave addresses:

1	0	1	0	0	0	0	R/$\overline{W}$	for access to internal EEPROM
1	1	0	0	0	0	0	R/$\overline{W}$	for access to IR array chip

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10.3. Acknowledge

During the 9th lock 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'.

10.4. Communication to EEPROM

See datasheet of 24AA02 from Microchip.

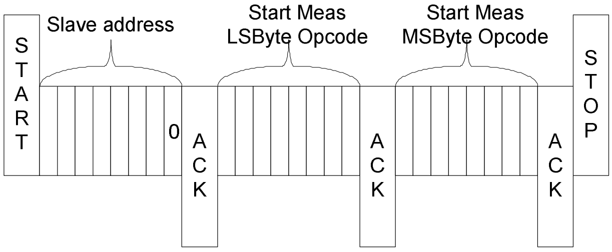
10.5. Communication to IR Array

10.5.1. Start measurement command

Opcode – 0x01 (LSByte), 0x08 (MSByte).

This command is used to start measurement cycle in chip step mode (signal mode_step_cont_b=1).

The command communication is illustrated below:



10.5.2. Read command

Opcode – 0x02.

The read command is used to read measurement, configuration and other data from the chip to the external master.

The read command has the following parameters:

- Start address – 8bits. Address in the chip address space (0 to 255). It is the address of the first word read.
- Address step – 8bits. On every read word the next address is formed by adding the address step to the current address.
- Number of reads – 8bits. Number of the words to be read.

Different combinations are possible in order to read all, one line, one column, one exact pixel of the IR or Ta sensors. They are summarized in the following table:

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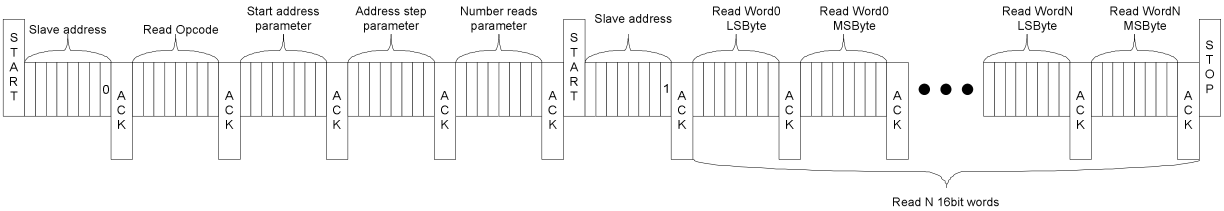
Sensors read	Start address	Address step	Number of reads
All IR	0x00	0x01	0x40
One line IR(i)	i	0x04	0x10
One column IR(j)	j*0x04	0x01	0x04
One pixel IR(i,j)	I + j*0x04	0x00	0x01
All Ta	0x40	0x01	0x50
One line Ta(i)	0x40 + i * 0x10	0x01	0x10
One column Ta(j)	0x40 + j	0x10	0x05
One pixel Ta(i,j)	0x40 + (i * 0x10) + j	0x00	0x01

The command communication is illustrated below:



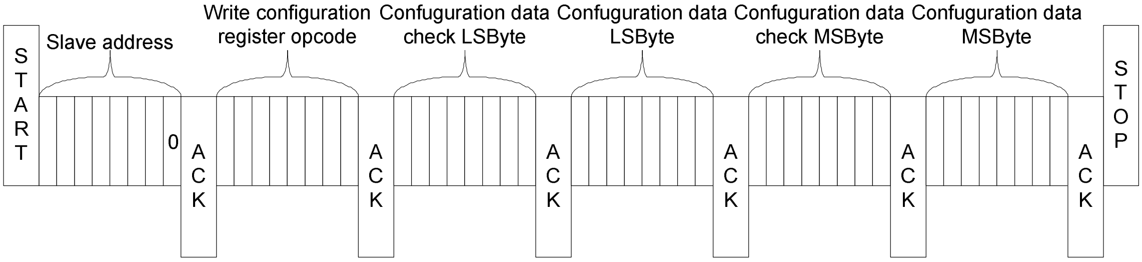
10.5.3. Write configuration register command

Opcode – 0x03.

This command is used to set the configuration register (16bits) value – all configuration settings.

Simple data check is introduced. The two data bytes are sent two times: first time with the true data minus 0x55 and second time – the true data. The chip does the addition with 0x55 internally and checks the second received byte. Only if the addition results match with the received data for the two bytes, the configuration register is updated.

The command communication is illustrated below:



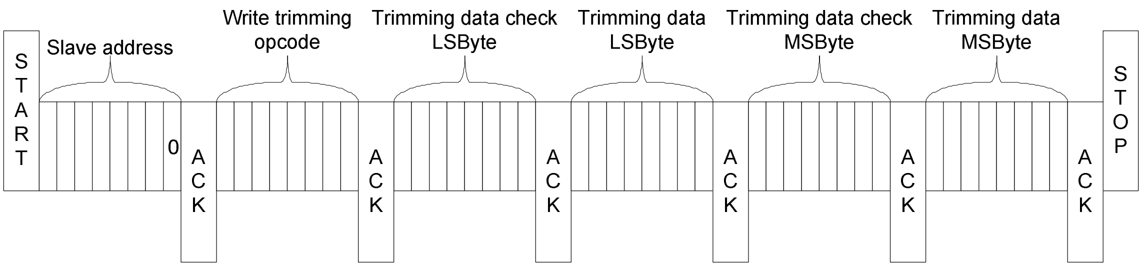
10.5.3. Write trimming command

Opcode – 0x04.

This command is used to set the trimming parameters – oscillator, bandgap, current source trimming bits values.

Simple data check is introduced. The two data bytes are sent two times: first time with the true data minus 0xAA and second time – the true data. The chip does the addition with 0xAA internally and checks the second received byte. Only if the addition results match with the received data for the two bytes, the configuration register is updated.

The command communication is illustrated below:



11. Device modes

The device can operate in following modes:

- Normal mode
- Step mode
- Power saving mode

11.1. Normal mode

In this mode the measurements are constantly running. Depending on the selected frame rate Fps in ConfReg, the data for IR pixels and Ta will be updated in the RAM each 1/Fps seconds. In this mode the external microcontroller has full access to the internal registers and memories of the device (both for HTPA16x4 and EEPROM chip).

11.2. Step mode

This mode is foreseen for single measurements triggered by the external device (microcontroller). Entering this mode is possible by writing the appropriate code in ConfReg. A measurement is triggered by sending the command StartMeas. On detecting the command, the HTPA16x4 will start the measurements immediately after the I2C session is finished (STOP condition detected). The measurement time is 1/Fps

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11.3. Power saving mode

In this mode the device will be completely shutdown and the current consumption will be minimized to less than 2uA. Entering this mode is initiated by setting the bit sleep request in the configuration register. Upon receiving the correct write config command the device will shutdown all electronics, including the internal oscillator. The chip will monitor the I2C line. Each START condition will wake up the oscillator and the chip will receive and evaluate the slave address. If the address is 1100000 (address programmed in HTPA16x4) the device will evaluate the whole command, will execute it and will exit the power saving mode. If not, the oscillator will be switched off again and the chip remains in power saving mode.

12. Initialization

After POR is released the chip executes an initialization procedure, this procedure starts typ. 16ms after POR release and requires only a few ms. In that time the device will read its configuration from the reserved part of the EEPROM and will load it in the registers of the HTPA16x4. The settings that are loaded are:

- Oscillator trimming data
- Bias trimming data
- Regulator control
- ConfReg settings

During that time the HTPA16x4 will work as Master I2C device for the EEPROM chip. Note that this will not affect the external I2C bus, i.e. the information transmitted between HTPA16x4 and EEPROM chip will not be visible externally.

During the initialization, the HTPA16x4 will block any access through external I2C line and will not respond to any commands. This means that a NoACKN will be received by the external MCU if the HTPA16x4 or EEPROM chip is addressed.

13. Liability

The contents of this document are subject to change without notice.
Changes or modifications at the product which haven't influence to the performance and/or quality of the device haven't to be announced to the customers in advance. Customers are requested to consult with Heimann Sensor representatives before the use of Heimann Sensor products in special applications where failure or abnormal operation may directly affect human lives or cause physical injury or property damage. The company or their representatives will not be responsible for damage arising from such use without prior approval.

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