

HTPA8x8dR1L0.8/0.8F5.0

Datasheet for Thermopile Array Sensor with Lens Optic

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Changelog

2019-09-12	Miscellaneous small corrections
2020-05-11	Soldering recommendations corrected to non-SMD
2020-09-05	Stack buffer recommendation; dK in °C calculation
2021-01-30	Order code; change note implementation; reference pin correction
2021-07-13	Added drawing for revised version with changed cap length
2021-08-12	New order code
2022-03-28	Miscellaneous small corrections
2024-08-07	Major error in calculation of thermal offset corrected
2024-12-18	Updated graphic for pixel orientation
2025-01-31	Updated order code, added order code chart w/ available options
2025-04-08	Corrected pin allocations
2025-08-18	Corrected graphic for pixel orientation
2025-10-16	Added max. measurable temperature
2025-11-18	Corrected accuracy specification
2025-03-02	Added calculation formula for CLK_Trim Register

1 Cleaning and Handling of Sensors with Optical Elements

Cleaning of Filter with Isopropyl Alcohol or Acetone

This is the method most universally used for cleaning optical elements with or without coatings. Filters or lenses mounted in our sensors may be cleaned rubbing the surfaces lightly with a clean, soft, all-cotton cloth or cotton swab during immersion in solvent or simply moistened with the solvent. The parts are then immediately wiped dry with another clean, soft, all-cotton cloth or cotton swab.

Cleaning with Detergent and Water

A very mild, non-abrasive detergent (one which does not contain additives) and water may also be used for cleaning optical elements. In general, a detergent and water mixture is an excellent method for removing fingerprints and other smudges. The liquid detergent is first mixed with deionized water (proportions recommended by the manufacturer should be followed). The element is then washed, rinsed, and immediately wiped dry. Use a clean, soft cloth when cleaning and drying. If the part is allowed to dry in air, a permanent stain may result.

Please note:

- Do not use isopropyl alcohol or acetone or detergent if the elements will be mounted in an assembly with a finish which may be soluble by these solvents.
- Please avoid glass isolation being moistened by solvent.
- If the part is allowed to dry in air, a permanent stain may result.

Handling Advice

Sensors with optical elements deserve special consideration in their handling and care. Ordinarily, filters or lenses are cleaned and inspected prior to shipment. If proper care is exercised during handling cleaning should not be necessary prior to use.

- Wear gloves when handling a sensor or optical element. Lightweight nylon or cotton gloves which are relatively lint-free are recommended.
- Avoid touching the surface of filters and lenses.
- Protect devices from static discharge and static fields.
- Thermopile sensors are electrostatic sensitive devices. Sensors should be handled over an electrostatic protected work area.
- Precautions should be taken to avoid reverse polarity of power supply for sensors with integrated signal processing. Reversed polarity of power supply results in a destroyed unit.
- Sensors should rest preferably in a partitioned container where the mounted filters or lenses will be not coming into contact with other material.
- During storage optical surfaces should be covered to avoid contamination from the surrounding environment.

- A covered container can eliminate damage during transportation and storage.
- Sensors or optical elements should be stored in a restricted access area to eliminate handling.
- Do not expose the sensors to aggressive detergents such as freon, trichlorethylen, etc.
- Avoid rotating the sensors when they are soldered into a PCB or something similar.
- Shortening of the pins is not suggested. This may cause cracks in the glass of the pins and result in a leakage.
 - o If this is necessary, a tool for this is recommended. Please contact Heimann Sensor for further information.

Soldering Recommendations

Attention: For all of our array sensors we give no guarantee on the calibration and its performance if the pins are shortened by the customer. Additionally, **we strongly recommend to not solder the sensor with its backplate directly to a PCB.** This will cause different thermal conductivity compared to air and the measurement results could get worse. **Use a minimum gap between PCB and backplate of 2 mm or more.** The glass of the pins to the back plate can get damage by applying high temperatures (during soldering), which will lead into a lower temperature reading what cannot be repaired afterwards.

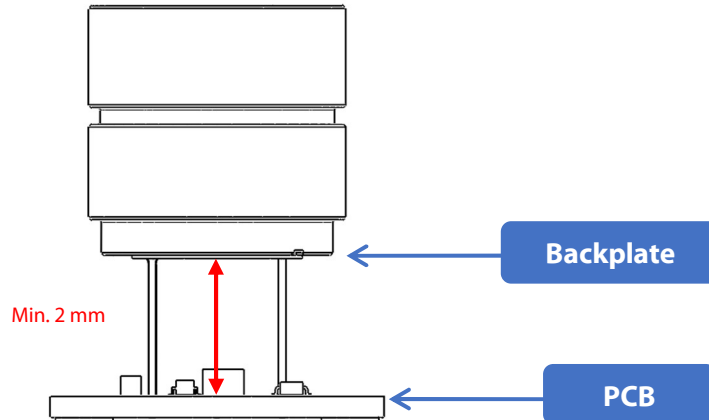


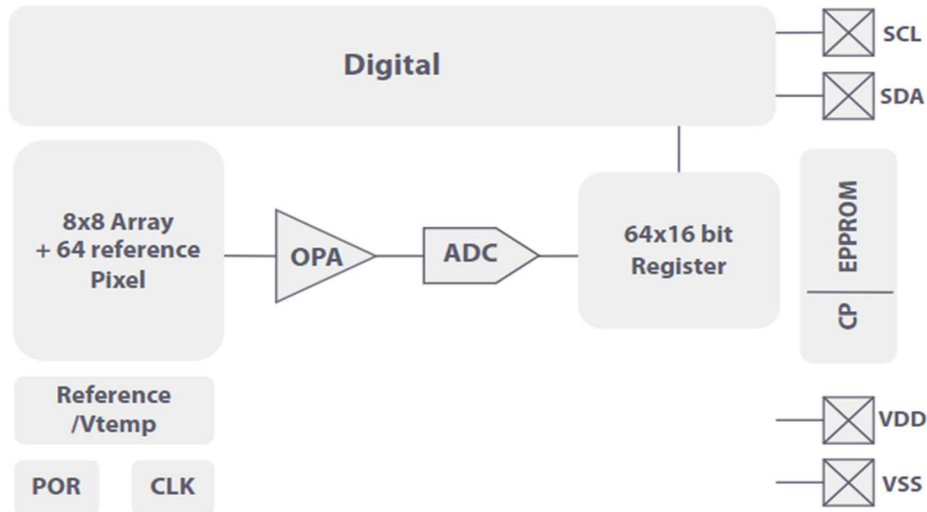
Figure 1: Soldering height

Manual Iron Soldering and Automatic Point-to-Point Iron Soldering

Manual Iron Soldering and Automatic Point-to-Point Iron Soldering methods are allowed for TO packages. It is recommended for through hole applications to shield the package body from soldering heat by PCB or similar.

The soldering iron temperature should be set as low as possible (maximum 350 °C) and should not exceed recommended soldering time (maximum 3 seconds). The minimum distance between the housing body and the liquid solder should be at least 1.5 mm for 350 °C. Reflow soldering is not recommended.

2 Principal Schematic for HTPA8x8d



3 Pin Assignment – Bottom View

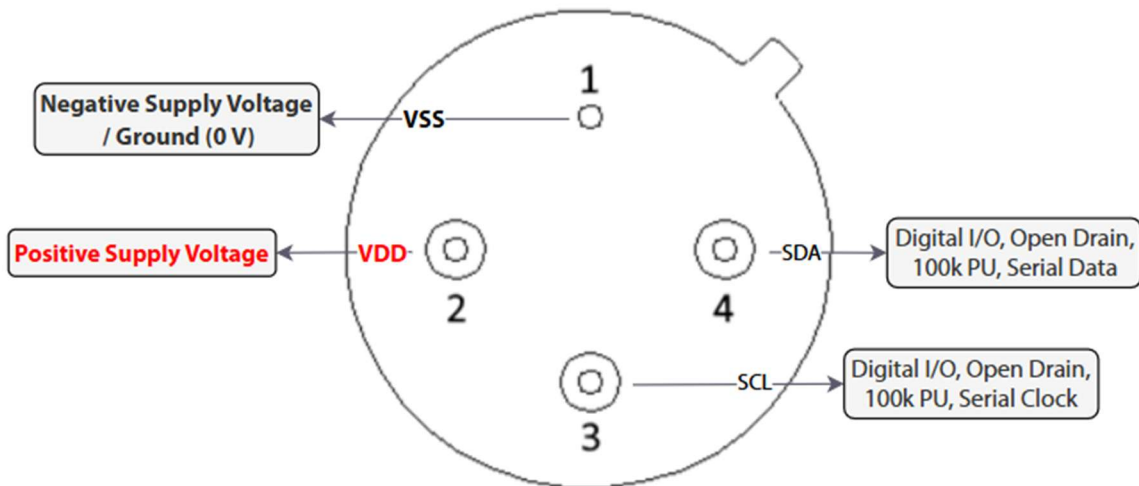
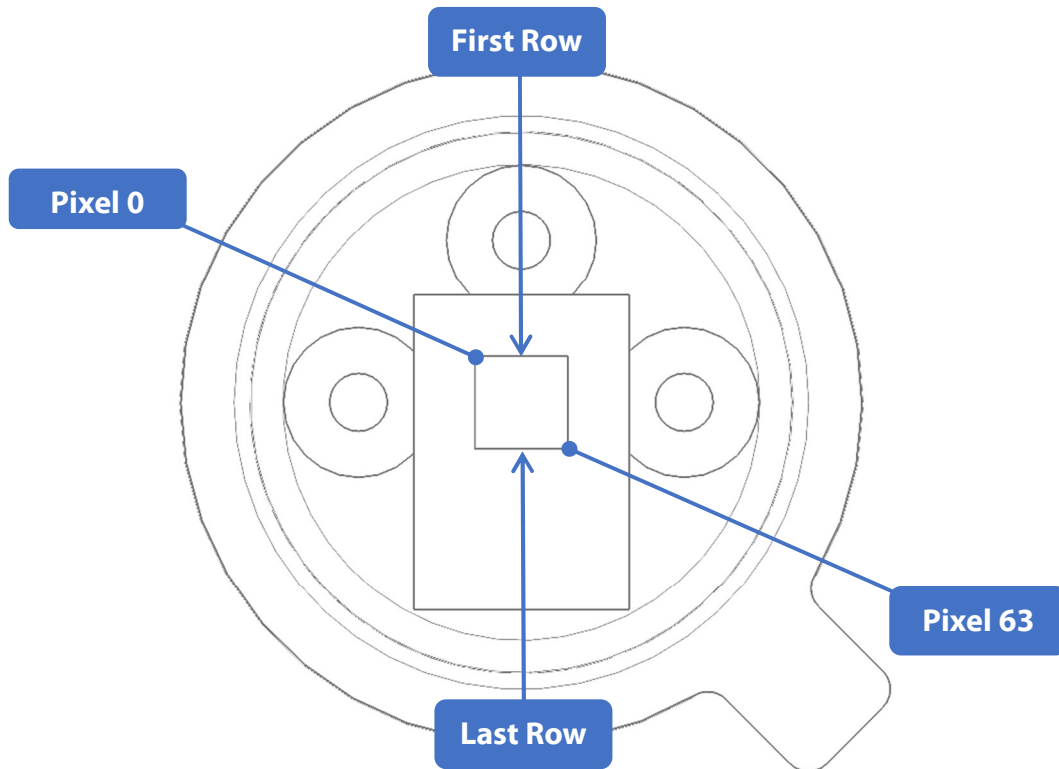
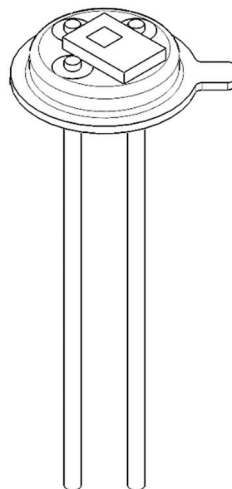


Figure 2: Pin-allocation

4 Optical Orientation



This illustration shows the pixel orientation after mirroring through the lens.



5 Order Code Example

HTPA32x32d	R2	L5.0/0.85	F7.7	e	Hi	M	(UDP)
1	2	3	4	5	6	7	8

		Description
1	Sensor Type	TP Array with 32x32 Pixel For all available HTPA and module combinations contact our support
2	Revision	Silicon revision 2
3	Optics	Focal length/F-Number Focal length: L5.0 = 5.0 mm F-Number: 0.85
4	Filter	F: Filter characteristics Not declared: Broadband AR Coating
5	External Aperture	Not declared: without external aperture e: with external aperture
6	Sensitivity	UH: increased sensitivity Hi: default sensitivity Not declared: lower sensitivity (greater measurement range)
7	Version	A: Application Set: comes with GUI, housing, power supply C: Calibrated sensor M: Modul: HTPA sensor soldered to PCB, calibrated stream
8	Interface	UDP: Ethernet connection, CAT5 PoE: Power over Ethernet, CAT5* i ² C: 4 Pin Connector* USB: Power and data via USB 2.0** * Interface option is only available for modules (HiM) ** Interface option is only available for Application Set (HiA)

6 Application Note

A pull-up resistor of 4.7 k Ω for the I²C pins (SDA and SCL) is recommended. In addition, adding 100 nF and 47 μ F are improving the stability of the supply voltage.

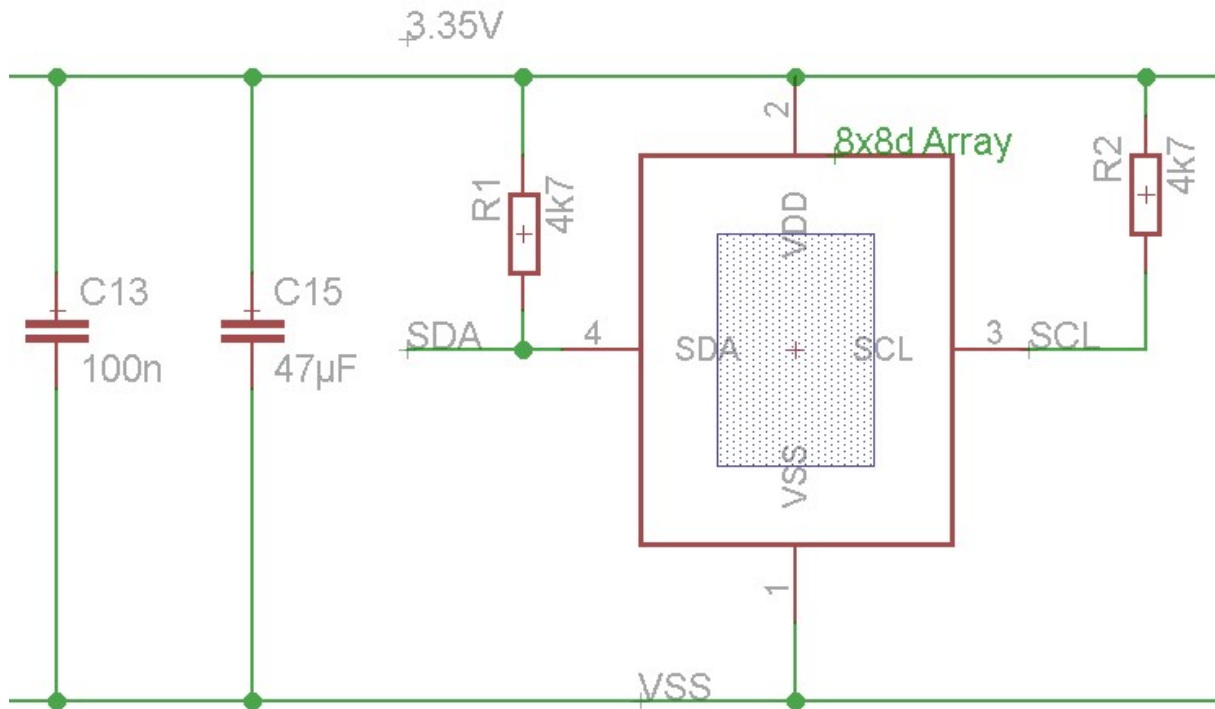


Figure 3: Recommended circuit for operation

The Sensor can be powered directly via 3.35 V if the supply voltage is stable enough, this has to be measured before and tested with the sensor. It is important to not insert any inductor or otherwise the noise will increase.

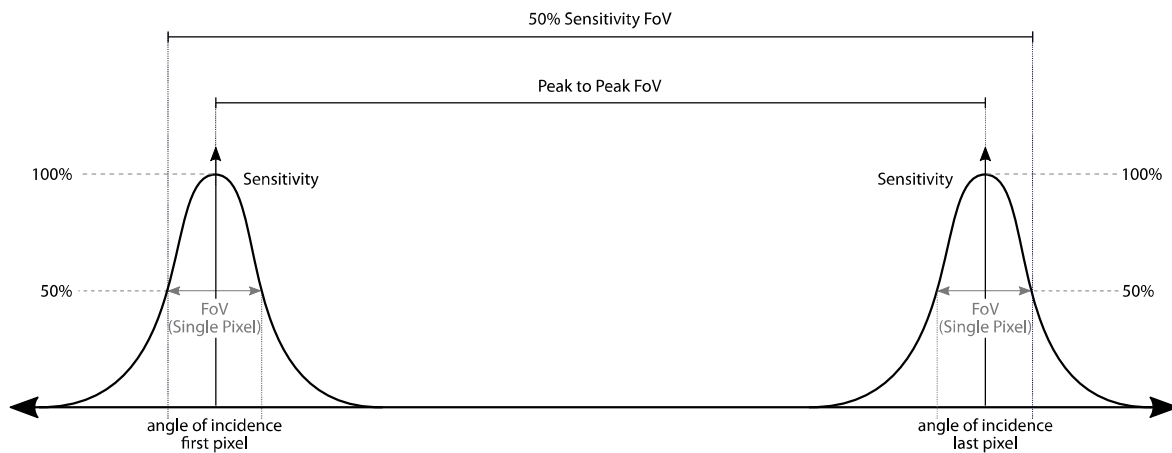
7 Characteristics

7.1 Common Specifications

Technology:	n-poly/p-poly Si
Thermal pixel time constant:	<4 ms
Digital Interface:	I ² C
EEPROM size:	256x16 Bit
Pitch:	90 μm
Absorber size:	44 μm
Max. Framerate:	88 Hz
Max. measurable temperature: (maximum I ² C and sensor clock speed with full ADC-resolution)	700°C with default settings
64 sensitive elements	

7.2 Optical Characteristics

Focal length:	0.8 mm ("L" equals the focal length of the lens)
F-Number:	8-14
Field of view:	51 x 51 deg. (50 % sensitivity FoV)



Accuracy:	±3 % or ±3 K (whatever is larger) in the working ambient temperature range of 5° to 50 °C and object temperatures ≤ to 300 °C
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8 Electric Specifications

Table 1: Absolute Maximum Ratings

Parameter	Symbol	Condition	MIN.	TYP.	MAX.	Unit
Supply Voltage	V _{DD}		-0.3		3.6	V
Voltage at all inputs and outputs	V _{IO}		-0.3		V _{DD} +0.3	V
Storage Temperature	T _{STG}		-40		85	Deg. C

Table 2: Operating Conditions

Parameter	Symbol	Condition	MIN.	TYP.	MAX.	Unit
Supply Voltage	V _{DD}		3.3	3.35	3.6	V
Supply Current (sensor running)	I _{DD}		1.6	2	2.5	mA
Supply Current (sensor in idle state)	I _{SBY}		1.4	1.8	2.3	mA
Standby Current (sensor in sleep state)	I _{SBY}		4	6	8	μA
Operation Temperature	T _A		-20		85	Deg. C
ESD-Protection	Human body model		1.5			kV
	100pF + 1k50hm					

Table 3: Electrical Characteristics

Parameter	Symbol	Condition	MIN.	TYP.	MAX.	Unit
Digital Input						
Internal Clock frequency	F _{CLK}		1	5	13	MHz
Internal I ² C Pull up	R _{PU}		1	100	100	kOhm
BIAS current	I _{BIAS}		1	5	13	μA
BPA current	I _{BPA}		0.2	1.5	4.0	μA
Input voltage high	V _{IH}		0.7xV _{DD}			V
Input voltage low	V _{IL}				0.3xV _{DD}	V
PTAT						
Temperature range			0		85	Deg. C
PTAT gradient			TBD	174	TBD	K/V

Table 4: Preamplifier / ADC

Parameter	Symbol	Condition	MIN.	TYP.	MAX.	Unit
Chopper frequency	F _{CHP}			20		kHz
Preamplifier Noise	N _{PA}	at 20 kHz		72		nV/ Hz ^{1/2}
Frame rate (Full Array)	FR1		7.5	37	88	Hz
ADC pos. Reference	V _{REFP}	REF_CAL 00		1.529		V
		REF_CAL 01		1.442		
		REF_CAL 10		1.355		
		REF_CAL 11		1.268		
ADC neg. Reference	V _{REFN}	REF_CAL 00		0.850		V
		REF_CAL 01		0.901		
		REF_CAL 10		0.968		
		REF_CAL 11		1.056		
ADC resolution	ADC _{LSB}	at 16 Bit		21		μV

9 I²C Timings HTPA8x8d

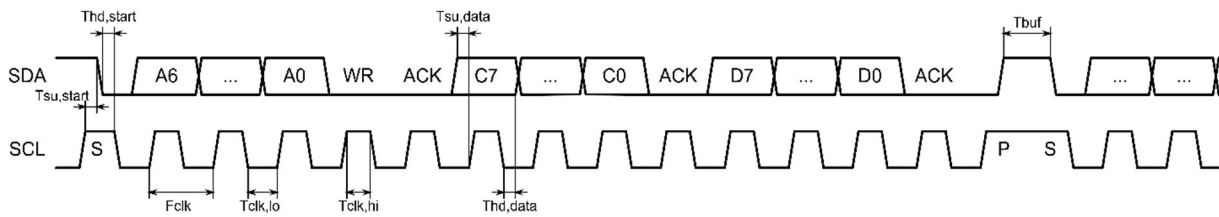


Figure 4: I²C Timings of HTPA8x8d

Table 5: I²C Timings

Parameter	Symbol	Condition	MIN.	TYP.	MAX.	Unit
I ² C clock frequency	F _{CLK}			400	1000	kHz
low pulse duration	T _{CLK,lo}		0.50			μs
high pulse duration	T _{CLK,hi}		0.26			μs
data set up time	T _{SU,data}		0.05			μs
data hold time	T _{hd,data}		0.00			μs
start setup time	T _{SU,start}		0.26			μs
start hold time	T _{hd,start}		0.26			μs
stop setup time	T _{SU,stop}		0.26			μs

Parameter	Symbol	Condition	MIN.	TYP.	MAX.	Unit
stop hold time	$T_{hd,stop}$		0.26			μs
time between STOP / START	T_{buf}		0.50			μs
Time startup (after Power-on Reset)	$T_{startup}$				100	μs
Time wakeup (after sending WAKEUP)	T_{wakeup}				80	μs

10 I²C Communication

The chip uses the 7-bit I²C address 0x1A for configuration and sensor data and the address 0x1B to access the internal EEPROM followed by 1-bit of read/write command. The address byte is followed by an 8-bit command.

10.1 Write Command

In case of a write access to an internal register the command is followed by the data byte. The chip acknowledges each byte with a low active ACK bit.

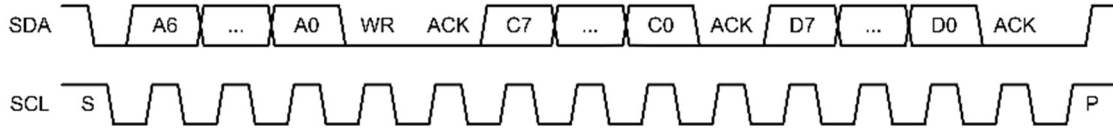


Figure 5: Write Command

10.2 Read Command

To read data from the chip first the address and command must be sent. After the last ACK a new start-bit (repeated start) and the address with a set read-flag initiates the read sequence. There can be bytes read as many as required. The last byte must be denoted by a not-acknowledge. The shown example below can be used e.g. to get the status register.

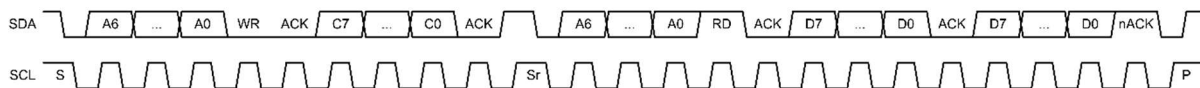


Figure 6: Read Command

10.3 Sensor Commands

The sensor has several registers that can be written and read, they are listed below.

Table 6: Configuration Register (write only)

Addr / CMD	0x1A (7-Bit!) / 0x01							
Config Reg	7	6	5	4	3	2	1	0
Name	RFU				START	VDD_MEAS	BLIND	WAKEUP
Default	0	0	0	0	0	0	0	0

The WAKEUP bit is used to switch on / off the chip and must be set prior all other operations. After the START bit is set the chip starts a conversion of the array or blind elements and enters the idle state (not sleep!) when finished.

If the BLIND bit is set the electrical offsets are sampled instead of the active pixel.

If VDD_MEAS bit is set the VDD voltage is measured instead of the PTAT value.

RFU means reserved for future use and can be subject to change.

Table 7: Status Register (read only)

Addr / CMD	0x1A (7-Bit!) / 0x02							
Status Reg	7	6	5	4	3	2	1	0
Name	RFU							EOC
Default	0	0	0	0	0	0	0	0

If the EOC flag is set a previous started conversion has been finished.

Trim Register 1 (write only)

Addr / CMD	0x1A (7-Bit!) / 0x03							
Trim Reg 1	7	6	5	4	3	2	1	0
Name	RFU				MBIT TRIM			

REF_CAL: selectable amplification

MBIT_TRIM: $m = 4$ to $12 \Rightarrow (m+4)$ bit as ADC resolution

Trim Register 2 (write only)

Addr / CMD	0x1A (7-Bit!) / 0x04							
Trim Reg 2	7	6	5	4	3	2	1	0
Name	RFU				BIAS TRIM			

BIAS_TRIM: 0 to $31 \Rightarrow 1 \mu\text{A}$ to $13 \mu\text{A}$

This setting is used to adjust the BIAS current of the ADC. A faster clock frequency requires a higher BIAS current setting.

Trim Register 3 (write only)

Addr / CMD	0x1A (7-Bit!) / 0x06							
Trim Reg 4	7	6	5	4	3	2	1	0
Name	RFU			CLK TRIM				

CLK_TRIM ranges from 0 to 63 and corresponds the clock frequency F_{CLK} which can be determined via the following formula:

$$F_{CLK} = \left(F_{CLK,min} + \frac{F_{CLK,max} - F_{CLK,min}}{63} \cdot CLK_TRIM \right) \text{ MHz}$$

with

$$F_{CLK,min} = 1 \text{ MHz}$$

$$F_{CLK,max} = 13 \text{ MHz}$$

The measure time depends on the clock frequency settings. One quarter frame takes about:

$$t_{fr4} = \frac{32 \cdot (2^{MBIT} + 4)}{F_{CLK}} \approx 27ms@5MHz$$

MBIT is equal to MBIT TRIM in Trim Register 1.

Trim Register 4 (write only)

Addr / CMD	0x1A (7-Bit!)/ 0x07							
Trim Reg 5	7	6	5	4	3	2	1	0
Name	RFU				BPA TRIM			

BPA_TRIM: 0 to 31 ⇒ 0.2 µA to 4.0 µA

This setting is used to adjust the common mode voltage of the preamplifier.

Trim Register 5 (write only)

Addr / CMD	0x1A (7-Bit!)/ 0x09							
Trim Reg 7	7	6	5	4	3	2	1	0
Name	PU SDA TRIM				PU SCL TRIM			

PU_SDA_TRIM: select internal pull up resistor on SDA (Default: 100 kOhm)

PU_SCL_TRIM: select internal pull up resistor on SCL (Default: 100 kOhm)

“1000” = 100 kOhm; “0100” = 50 kOhm; “0010” = 10 kOhm; “0001” = 1 kOhm

Read Data 1 Command

Addr / CMD	0x1A (7-Bit!)/ 0x0A							
Read Data	7	6	5	4	3	2	1	0
1. Byte / 2. Byte	PTAT MSB / LSB or Vdd MSB / LSB							
3. Byte / 4. Byte	Pixel 0 MSB / LSB							
5. Byte / 6. Byte	Pixel 1 MSB / LSB							
...	...							
129. Byte / 130. Byte	Pixel 63 MSB / LSB							

The complete sensor data must be read at once. If the communication fails somewhere in between, all successive data will be corrupted. The readout can be stopped anywhere by pausing the clock. A new initialized readout proceeds at this stopped byte by continuing the clock, but the index is reset when a new conversion has been started.

If the bit for the electrical offsets (Bit 1 in Config 0x01) is set the electrical offsets are sampled and can be read similar to the active pixel:

Read Data Electrical Offsets

Addr / CMD	0x1A (7-Bit!)/ 0x0A							
Read Data	7	6	5	4	3	2	1	0
1. Byte / 2. Byte	PTAT MSB / LSB or Vdd MSB / LSB							
3. Byte / 4. Byte	electrical offset (0) MSB / LSB							
5. Byte / 6. Byte	electrical offset (1) MSB / LSB							
...	...							
129. Byte / 130. Byte	electrical offset (63) MSB / LSB							

The complete sensor data must be read at once. If the communication fails somewhere in between, all successive data will be corrupted. The readout can be stopped anywhere by pausing the clock. A new initialized readout proceeds at this stopped byte by continuing the clock, but the index is reset when a new conversion has been started.

10.4 EEPROM Commands

To read/write data from/to the internal EEPROM the I2C address 0x1B is used.

EEPROM Commands

Name	CMD	Read / Write	Comment
Standby	0x00	W	
Active	0x01	W	releases all signals to default state wait for 15 μ s when wake up from standby
Normal Erase	0x02	W	program pulse width 5ms
Normal Write	0x03	W	program pulse width 5ms
Block Erase	0x04	W	program pulse width 5ms
Block Write	0x05	W	program pulse width 5ms
Normal Read	0x06	W	program pulse width 5ms
Set Address	0x09	W	program pulse width 5ms
Set Data	0x0A	W	16 bit data, MSB first
Get Data	0x0B	R	16 bit data, MSB first

Note:

The EEPROM must be activated (wake up from standby) prior being used. The active command also initializes the EEPROM to its default state.

Note:

Each word must be erased before it can be written, a write command stores only a "1" to the EEPROM cell. Note: The commands "SET_DATA" / "GET_DATA" will increment the address pointer, except for the first execution after "SET_ADDR".

10.5 I²C Example Sequences – EEPROM Wakeup / Standby

	ADDR	R/W	EEPROM_ACTIVE	
S	0x1B	0	0x01	P

	ADDR	R/W	EEPROM_STANDBY	
S	0x1B	0	0x00	P

10.6 I²C Example Sequences – EEPROM Block Erase / Block Write

	ADDR	R/W	EEPROM_ACTIVE	
S	0x1B	0	0x01	P

	ADDR	R/W	EEPROM_ERASE	
S	0x1B	0	0x04	P

WAIT 5ms

	ADDR	R/W	EEPROM_ACTIVE	
S	0x1B	0	0x01	P

	ADDR	R/W	SET_DATA	DATA_MSB	DATA_LSB	
S	0x1B	0	0x0A	DATA	DATA	P

	ADDR	R/W	BLOCK_WRITE	
S	0x1B	0	0x05	P

10.7 I²C Example Sequences – EEPROM Sequential Erase / Write

	ADDR	R/W	EEPROM_ACTIVE	
S	0x1B	0	0x01	P

	ADDR	R/W	SET_ADDR	EEP_ADDR	
S	0x1B	0	0x09	ADDR	P

	ADDR	R/W	NORMAL_ERASE	
S	0x1B	0	0x02	P

WAIT 5ms

	ADDR	R/W	SET_DATA	DATA_MSB	DATA_LSB	
S	0x1B	0	0x0A	DATA	DATA	P

	ADDR	R/W	NORMAL_WRITE	
S	0x1B	0	0x03	P

WAIT 5ms

	ADDR	R/W	SET_ADDR	EEP_ADDR	
S	0x1B	0	0x09	ADDR	P

	ADDR	R/W	NORMAL_ERASE	
S	0x1B	0	0x02	P

WAIT 5ms

	ADDR	R/W	SET_DATA	DATA_MSB	DATA_LSB	
S	0x1B	0	0x0A	DATA	DATA	P

	ADDR	R/W	NORMAL_WRITE	
S	0x1B	0	0x03	P

WAIT 5ms

	ADDR	R/W	SET_ADDR	EEP_ADDR	
S	0x1B	0	0x09	ADDR	P

	ADDR	R/W	NORMAL_ERASE	
S	0x1B	0	0x02	P

WAIT 5ms

	ADDR	R/W	SET_DATA	DATA_MSB	DATA_LSB	
S	0x1B	0	0x0A	DATA	DATA	P

	ADDR	R/W	NORMAL_WRITE	
S	0x1B	0	0x03	P

WAIT 5ms

10.8 I²C Example Sequence – EEPROM Continuous Erase

	ADDR	R/W	EEPROM_ACTIVE	
S	0x1B	0	0x01	P

	ADDR	R/W	SET_ADDR	EEP_ADDR	
S	0x1B	0	0x09	ADDR	P

	ADDR	R/W	NORMAL_ERASE	
S	0x1B	0	0x02	P

WAIT 5ms

	ADDR	R/W	SET_ADDR	EEP_ADDR	
S	0x1B	0	0x09	ADDR	P

	ADDR	R/W	NORMAL_ERASE	
S	0x1B	0	0x02	P

WAIT 5ms

10.9 I²C Example Sequence – EEPROM Continuous Write

	ADDR	R/W	EEPROM_ACTIVE	
S	0x1B	0	0x01	P

	ADDR	R/W	SET_ADDR	EEP_ADDR	
S	0x1B	0	0x09	ADDR	P

	ADDR	R/W	SET_DATA	DATA_MSB	DATA_LSB	
S	0x1B	0	0x0A	DATA	DATA	P

	ADDR	R/W	NORMAL_WRITE	
S	0x1B	0	0x03	P

WAIT 5ms

	ADDR	R/W	SET_DATA	DATA_MSB	DATA_LSB	
S	0x1B	0	0x0A	DATA	DATA	P

	ADDR	R/W	NORMAL_WRITE	
S	0x1B	0	0x03	P

WAIT 5ms

10.10 I²C Example Sequence – EEPROM Sequential Read

	ADDR	R/W	EEPROM_ACTIVE	
S	0x1B	0	0x01	P

	ADDR	R/W	NORMAL_READ	
S	0x1B	0	0x06	P

	ADDR	R/W	GET_DATA		ADDR	R/W	DATA_MSB	DATA_LSB	
S	0x1B	0	0x0B	SR	0x1B	1	??	??	P

	ADDR	R/W	SET_ADDR	EEP_ADDR	
S	0x1B	0	0x09	ADDR	P

	ADDR	R/W	NORMAL_READ	
S	0x1B	0	0x06	P

	ADDR	R/W	GET_DATA		ADDR	R/W	DATA_MSB	DATA_LSB	
S	0x1B	0	0x0B	SR	0x1B	1	??	??	P

10.11 I²C Example Sequence – EEPROM Continuous Read

	ADDR	R/W	EEPROM_ACTIVE	
S	0x1B	0	0x01	P

	ADDR	R/W	SET_ADDR	EEP_ADDR	
S	0x1B	0	0x09	ADDR	P

	ADDR	R/W	GET_DATA		ADDR	R/W	DATA_MSB	DATA_LSB	
S	0x1B	0	0x0B	SR	0x1B	1	??	??	P

	ADDR	R/W	GET_DATA		ADDR	R/W	DATA_MSB	DATA_LSB	
S	0x1B	0	0x0B	SR	0x1B	1	??	??	P

	ADDR	R/W	GET_DATA		ADDR	R/W	DATA_MSB	DATA_LSB	
S	0x1B	0	0x0B	SR	0x1B	1	??	??	P

	ADDR	R/W	GET_DATA		ADDR	R/W	DATA_MSB	DATA_LSB	
S	0x1B	0	0x0B	SR	0x1B	1	??	??	P

10.12 I²C Example Sequence – Init and Read Thermopile Array

	ADDR	R/W	CONFIG_REG	WAKEUP	
S	0x1A	0	0x01	0x01	P

	ADDR	R/W	TRIM_REG1	MBIT_TRIM	
S	0x1A	0	0x03	0x0C	P

	ADDR	R/W	TRIM_REG2	BIAS_TRIML	
S	0x1A	0	0x04	0x0C	P

	ADDR	R/W	TRIM_REG3	BIAS_TRIMR	
S	0x1A	0	0x05	0x0C	P

	ADDR	R/W	TRIM_REG4	CLK_TRIM	
S	0x1A	0	0x06	0x14	P

	ADDR	R/W	TRIM_REG5	BPA_TRIML	
S	0x1A	0	0x07	0x0C	P

	ADDR	R/W	TRIM_REG6	BPA_TRIMR	
S	0x1A	0	0x08	0x0C	P

	ADDR	R/W	TRIM_REG7	PU_TRIM	
S	0x1A	0	0x09	0x88	P

	ADDR	R/W	CONFIG_REG	START / WAKEUP	
S	0x1A	0	0x01	0x09	P

	ADDR	R/W	STATUS_REG		ADDR	R/W	STATUS	
S	0x1A	0	0x02	Sr	0x1A	1	??	P

WAIT 30ms

	ADDR	R/W	STATUS_REG		ADDR	R/W	STATUS	
S	0x1A	0	0x02	Sr	0x1A	1	??	P

	ADDR	R/W	READ_DATA1		ADDR	R/W	PTAT1 MSB	PTAT1 LSB	P0,0 MSB	P0,0 LSB	...	Px,y MSB	Px,y LSB	
S	0x1A	0	0x0A	Sr	0x1A	1	??	??						P

	ADDR	R/W	READ_DATA2		ADDR	R/W	PTAT1 MSB	PTAT1 LSB	P0,0 MSB	P0,0 LSB	...	Px,y MSB	Px,y LSB	
S	0x1A	0	0x0B	Sr	0x1A	1	??	??						P

	ADDR	R/W	CONFIG_REG	SLEEP	
S	0x1A	0	0x01	0x00	P

11 Temperature Calculation

The object and ambient temperature can be calculated from the sensor output and the stored calibration data. The table below is showing an overview of the EEPROM.

8x8d	0x00	0x01	0x02	0x03	0x04	0x05	0x06	0x07	0x08	0x09	0x0A	0x0B	0x0C	0x0D	0x0E	0x0F
0x00	PixC _{min} [float]		PixC _{max} [float]						gradScale	GlobalGain			TN	epsilon		
0x10											MBIT(PixC)	BIAS(PixC)	CLK(PixC)	BPA(PixC)	PU(PixC)	
0x20	MBIT(user)	BIAS(user)	CLK(user)	BPA(user)	PU(user)											
0x30					PTAT-gradient (float)	PTAT-offset (float)					Device ID [32 bit]					
0x40	ThGrad _i stored as 16 bit signed values															
0x50																
0x60																
0x70																
0x80	ThOffset _i stored as 16 bit signed values															
0x90																
0xA0																
0xB0																
0xC0	P _i stored as 16 bit unsigned values															
0xD0																
0xE0																
0xF0																

All values are stored as unsigned 16 bit values in the little endian format unless they are specified otherwise. Grey marked areas are used during calibration or for future use and are Heimann Sensor reserved.

MBIT(calib), BIAS(calib), CLK(calib), BPA(calib) and PU(calib) are the settings for the registers that have been used during calibration (see chapter 10.3 on how to set them). MBIT(user), BIAS(user), CLK(user), BPA(user) and PU(user) are free to be set by the user. The temperature calculation is only valid if the same settings are used that have been set during calibration!

TN is the table number and has to match the given table number in the sample code.

11.1 Ambient Temperature

The ambient temperature (Ta) is calculated from the measured PTAT value, the PTAT_{gradient} and the PTAT_{offset}. It is recommended to use a stack buffer for the PTAT values in order to get a more stable ambient temperature result.

$$T_a = PTAT_{av} \cdot PTAT_{gradient} + PTAT_{offset} \quad (\text{Value is given back in } \text{dK})$$

where:

$PTAT_{gradient}$	is the gradient of the PTAT stored in the EEPROM as a float value
$PTAT_{offset}$	is the offset of the PTAT stored in the EEPROM as a float value

11.2 Thermal Offset

The thermal offset of the sensor needs to be subtracted for each pixel to compensate for any thermal drifts.

$$V_{ij_Comp} = V_{ij} - \frac{ThGrad_{ij} \cdot Ta}{2gradScale} - ThOffset_{ij}$$

where:

<i>ij</i>	represents the row (i) and column (j) of the pixel
<i>V_{ij_Comp}</i>	is the thermal offset compensated voltage
<i>V_{ij}</i>	is the raw pixel data (digital), readout from the RAM
<i>ThGrad_{ij}</i>	is the thermal gradient, stored in the EEPROM from 0x40 to 0x7F
<i>ThOffset_{ij}</i>	is the thermal offset, stored in the EEPROM from 0x80 to 0xBF
<i>gradScale</i>	is the scaling coefficient for the thermal gradient stored in the EEPROM

11.3 Electrical Offset

The electrical offset is used to compensate changes in the supply voltage. This compensation is only a subtraction so it can be done before or after the thermal offset compensation (here done afterwards). It is recommended to use an electrical offset stack in order to get a more stable electrical offset result and a more stable temperature result at the end. The electrical offsets should be sampled every 8th to 10th frame.

The compensation for is done by using the following formula:

$$V_{ij_Comp}^* = V_{ij_Comp} - elOffset_{ij}$$

where:

<i>ij</i>	represents the row (i) and column (j) of the pixel and electrical offset
<i>V_{ij_Comp}*</i>	is the thermal and electrical offset compensated voltage
<i>V_{ij_Comp}</i>	is the thermal offset compensated voltage
<i>elOffset_{ij}</i>	is the electrical offset belonging to Pixel ij

11.4 Object Temperature

The calculation of the object temperature is done by using a look-up table and doing a bi-linear interpolation, the matching table is given by the table number (TN). The table is supplied in a separate file named "Table.c". If you do not have the file, please ask Heimann Sensor for support.

The sensitivity coefficients ($PixC_{ij}$) are calculated in the following way:

$$PixC_{ij} = \left(\frac{P_{ij} \cdot (PixC_{max} - PixC_{min})}{65535} + PixC_{min} \right) \cdot \frac{\epsilon}{100} \cdot \frac{GlobalGain}{10000}$$

where:

$PixC_{ij}$	is the sensitivity coefficient for each pixel
P_{ij}	is the stored sensitivity coefficient scaled to 16 bit
$PixC_{min}$	is the minimum sensitivity coefficient, used for scaling
$PixC_{max}$	is the maximum sensitivity coefficient, used for scaling
ϵ	is the emissivity factor
$GlobalGain$	is a factor for fine tuning of the sensitivity for all Pixel

Leading to a compensation of the pixel voltage

$$V_{ij_PixC} = \frac{V_{ij_VDDComp} \cdot PCSCALEVAL}{PixC_{ij}}$$

where:

V_{ij_PixC}	is the sensitivity compensated IR voltage
$PCSCALEVAL$	is a defined scaling coefficient, typically set to $1 \cdot 10^8$

12 Example Calculation

$$PTAT = 32357 \text{ Digits}$$

$$PTAT_{gradient} = 0.046 \text{ dK/Digit}$$

$$V_{00} = 34435 \text{ Digits}$$

$$gradScale = 15$$

$$ThGrad_{00} = 56693 \xrightarrow{\text{sign check}} -8842$$

$$ThOffset_{00} = 44$$

$$elOffset_{00} = 35000$$

$$PixC_{00} = 1.1 \cdot 10^8$$

$$PCSCALEVAL = 1.1 \cdot 10^8$$

Calculation of ambient temperature:

$$Ta = PTAT \cdot PTAT_{gradient} + PTAT_{offset} = 32357 \cdot 0.046 + 1511.6 \text{ dK} = 3000 \text{ dK}$$

Compensation of thermal offset:

$$V_{00_Comp} = V_{00} - \frac{ThGrad_{00} \cdot Ta}{2^{gradscale}} - ThOffset_{00} = -\frac{-8842 \cdot 3000}{2^{15}} - 44 = 35200$$

Compensation of electrical offset:

$$V_{00_Comp}^* = V_{00_Comp} - elOffset_{00} = 35200 - 35000 = 200$$

12.1 Example Look-up Table

Look-up table, TO values are given in dK				
TA[dK]/dig	2882	3032	3182	3332
-64	1494	2128	2491	2775
-32	2466	2692	2898	3091
0	2882	3032	3182	3332
32	3170	3285	3406	3530
64	3396	3491	3592	3699
96	3584	3665	3754	3848
128	3746	3818	3897	3981
160	3890	3954	4025	4102
192	4019	4078	4143	4214
224	4137	4191	4251	4317
256	4246	4296	4351	4413
288	4347	4393	4445	4503
320	4441	4485	4534	4588

$$V_{00_Comp} = \frac{200 \cdot 1 \cdot 10^8}{1.1 \cdot 10^8}$$

Ta was calculated before to 3000 dK.

The matching region in the look-up table is already marked yellow, the bi-linear interpolation is leading to an object temperature of 4026 dK = (4026dK-2732dK)/10 = 129.4 °C.

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The matching look-up table has to be taken from the "Table.c" file. Here is just shown an exemplary data for one optic.

dig 1 Tab(dK)	2782	2882	2982	3082	3182	3282	3382
-512					1742	2002	2202
-448					2094	2284	2442
-384					2230	2458	2634
-320					2534	2671	2797
-256					2697	2822	2938
-192	2287	2444	2587	2717	2839	2954	3065
-128	2618	2812	2974	3125	3264	3391	3506
-64	2842	2755	2865	2972	3078	3182	3285
0	2762	2882	2982	3082	3182	3282	3382
64	2908	2998	3089	3183	3278	3373	3473
128	3018	3101	3187	3276	3368	3465	3568
192	3121	3197	3278	3363	3452	3544	3638
256	3216	3286	3363	3445	3531	3621	3715
320	3305	3370	3443	3522	3606	3695	3777
384	3387	3449	3519	3595	3677	3764	3856
448	3465	3524	3590	3664	3745	3831	3922
512	3538	3595	3659	3731	3810	3895	3986
576	3609	3662	3724	3794	3872	3957	4047
640	3676	3727	3787	3855	3932	4016	4106
704	3740	3788	3847	3914	3990	4073	4163
768	3802	3849	3908	3971	4046	4128	4216
832	3861	3905	3960	4023	4100	4182	4271
896	3918	3960	4014	4078	4152	4233	4322
960	3973	4014	4066	4129	4202	4284	4372
1024	4026	4065	4117	4179	4251	4332	4421
1088	4077	4115	4166	4227	4299	4380	4469
1152	4127	4164	4213	4274	4345	4426	4515
1216	4175	4211	4260	4320	4391	4471	4560
1280	4222	4257	4305	4364	4435	4515	4604
1344	4268	4302	4349	4408	4478	4558	4647
1408	4312	4345	4391	4450	4520	4600	4689
1472	4355	4388	4433	4492	4561	4641	4730
1536	4396	4428	4474	4532	4601	4681	4770
1600	4436	4467	4514	4571	4640	4720	4809
1664	4474	4505	4553	4610	4679	4758	4848
1728	4510	4540	4588	4645	4714	4793	4882
1792	4545	4575	4623	4680	4749	4828	4917
1856	4579	4608	4656	4713	4782	4861	4950
1920	4612	4640	4688	4745	4814	4893	4982
1984	4645	4672	4720	4777	4846	4925	5014
2048	4677	4704	4752	4809	4878	4957	5046
2112	4709	4736	4784	4841	4910	4989	5078
2176	4740	4767	4815	4872	4941	5020	5109
2240	4770	4797	4845	4902	4971	5050	5139
2304	4800	4827	4875	4932	5001	5080	5169
2368	4829	4856	4904	4961	5030	5109	5198
2432	4858	4885	4933	4990	5059	5138	5227
2496	4887	4914	4962	5019	5088	5167	5256
2560	4916	4943	4991	5048	5117	5196	5285
2624	4945	4972	5020	5077	5146	5225	5314
2688	4974	5001	5049	5106	5175	5254	5343
2752	5003	5030	5078	5135	5204	5283	5372
2816	5032	5059	5107	5164	5233	5312	5401
2880	5061	5088	5136	5193	5262	5341	5430
2944	5090	5117	5165	5222	5291	5370	5459
3008	5119	5146	5194	5251	5320	5399	5488
3072	5148	5175	5223	5280	5349	5428	5517
3136	5177	5204	5252	5309	5378	5457	5546
3200	5206	5233	5281	5338	5407	5486	5575
3264	5235	5262	5310	5367	5436	5515	5604
3328	5264	5291	5339	5396	5465	5544	5633
3392	5293	5320	5368	5425	5494	5573	5662
3456	5322	5349	5397	5454	5523	5602	5691
3520	5351	5378	5426	5483	5552	5631	5720
3584	5380	5407	5455	5512	5581	5660	5749
3648	5409	5436	5484	5541	5610	5689	5778
3712	5438	5465	5513	5570	5639	5718	5807
3776	5467	5494	5542	5600	5669	5748	5837
3840	5496	5523	5571	5629	5698	5777	5866
3904	5525	5552	5600	5658	5727	5806	5895
3968	5554	5581	5629	5687	5756	5835	5924
4032	5583	5610	5658	5716	5785	5864	5953
4096	5612	5639	5687	5745	5814	5893	5982
4160	5641	5668	5716	5774	5843	5922	6011
4224	5670	5697	5745	5803	5872	5951	6040
4288	5699	5726	5774	5832	5901	5980	6069
4352	5728	5755	5803	5861	5930	6009	6098
4416	5757	5784	5832	5890	5959	6038	6127
4480	5786	5813	5861	5919	5988	6067	6156
4544	5815	5842	5890	5948	6017	6096	6185
4608	5844	5871	5919	5977	6046	6125	6214
4672	5873	5900	5948	6006	6075	6154	6243
4736	5902	5929	5977	6035	6104	6183	6272
4800	5931	5958	6006	6064	6133	6212	6301
4864	5960	5987	6035	6093	6162	6241	6330
4928	5989	6016	6064	6122	6191	6270	6359
4992	6018	6045	6093	6151	6220	6299	6388
5056	6047	6074	6122	6180	6249	6328	6417
5120	6076	6103	6151	6209	6278	6357	6446
5184	6105	6132	6180	6238	6307	6386	6475
5248	6134	6161	6209	6267	6336	6415	6504
5312	6163	6190	6238	6296	6365	6444	6533
5376	6192	6219	6267	6325	6394	6473	6562
5440	6221	6248	6296	6354	6423	6502	6591
5504	6250	6277	6325	6383	6452	6531	6620
5568	6279	6306	6354	6412	6481	6560	6649
5632	6308	6335	6383	6441	6510	6589	6678
5696	6337	6364	6412	6470	6539	6618	6707
5760	6366	6393	6441	6500	6569	6648	6736
5824	6395	6422	6470	6528	6597	6676	6765
5888	6424	6451	6500	6558	6627	6706	6795
5952	6453	6480	6528	6587	6656	6735	6824
6016	6482	6509	6557	6616	6685	6764	6853
6080	6511	6538	6586	6645	6714	6793	6882
6144	6540	6567	6615	6674	6743	6822	6911
6208	6569	6596	6644	6703	6772	6851	6940
6272	6598	6625	6673	6732	6801	6880	6969
6336	6627	6654	6702	6761	6830	6909	6998
6400	6656	6683	6731	6790	6859	6938	7027
6464	6685	6712	6760	6819	6888	6967	7056
6528	6714	6741	6789	6848	6917	6996	7085
6592	6743	6770	6818	6877	6946	7025	7114
6656	6772	6799	6847	6906	6975	7054	7143
6720	6801	6828	6876	6935	7004	7083	7172
6784	6830	6857	6905	6964	7033	7112	7201

6848	6421	6431	6462	6514	6584	6673	6777
6912	6457	6477	6518	6590	6680	6789	6904
6976	6493	6533	6604	6700	6810	6930	7056
7040	6529	6579	6650	6756	6876	7002	7138
7104	6565	6615	6686	6792	6922	7058	7204
7168	6601	6651	6722	6838	6978	7124	7280
7232	6637	6687	6758	6874	7020	7176	7342
7296	6673	6723	6794	6910	7066	7232	7408
7360	6709	6759	6830	6946	7112	7288	7474
7424	6745	6795	6866	6982	7158	7344	7530
7488	6781	6831	6902	7018	7214	7410	7616
7552	6817	6867	6938	7054	7260	7466	7642
7616	6853	6903	6974	7090	7306	7522	7698
7680	6889	6939	7010	7126	7352	7578	7754
7744	6925	6975	7046	7162	7398	7634	7810
7808	6961	7011	7082	7208	7444	7690	7866
7872	6997	7047	7118	7238	7490	7746	7922
7936	7033	7083	7154	7274	7536	7802	7978
8000	7069	7119	7190	7314	7582	7858	8034
8064	7105	7155	7226	7346	7628	7914	8090
8128	7141	7191	7262	7382	7674	7970	8146
8192	7177	7227	7298	7418	7720	8026	8202
8256	7213	7263	7334	7454	7766	8082	8258
8320	7249	7299	7370	7490	7812	8138	8314
8384	7285	7335	7406	7526	7858	8194	8370
8448	7321	7371	7442	7562	7904	8250	8426
8512	7357	7407	7478	7598	7950	8306	8482
8576	7393	7443	7514	7634	7996	8362	8538
8640	7429	7479	7550	7670	8042	8418	8594
8704	7465	7515	7586	7706	8088	8474	8650
8768	7501	7551	7622	7742	8134	8530	8706
8832	7537	7587	7658	7778	8180	8586	8762
8896	7573	7623	7694	7814	8226	8642	8818
8960	7609	7659	7730	7850	8272	8698	8874
9024	7645	7695	7766	7886	8318	8754	8930
9088	7681	7731	7802	7922	8364	8810	8986
9152	7717	7767	7838	7958	8410	8866	9042
9216	7753	7803	7874	7994	8456	8922	9098
9280	7789	7839	7910	8030	8502	8978	9154
9344	7825	7875	7946	8066	8548	9034	9210
9408	7861	7911	7982	8102	8594	9090	9266
9472	7897	7947	8018	8138	8640	9146	

13 Order Code Chart

HTPA8x8d	R1	L0.8/0.8	F5.0	Hi	A	(USB)
HTPA8x8d	R1	L0.8/0.8	F5.0	Hi	A	(UDP)
HTPA8x8d	R1	L0.8/0.8	F5.0	Hi	M	(UDP)
HTPA8x8d	R1	L0.8/0.8	F5.0	Hi	M	(I²C)
HTPA8x8d	R1	L0.8/0.8	F5.0	Hi	C	
HTPA8x8d	R1	L2.1/0.8	F5.0	Hi	A	(USB)
HTPA8x8d	R1	L2.1/0.8	F5.0	Hi	A	(UDP)
HTPA8x8d	R1	L2.1/0.8	F5.0	Hi	M	(UDP)
HTPA8x8d	R1	L2.1/0.8	F5.0	Hi	M	(I²C)
HTPA8x8d	R1	L2.1/0.8	F5.0	Hi	C	

Bold: Selectable options

Regular: Fixed/Not selectable

14 Outer Dimension

