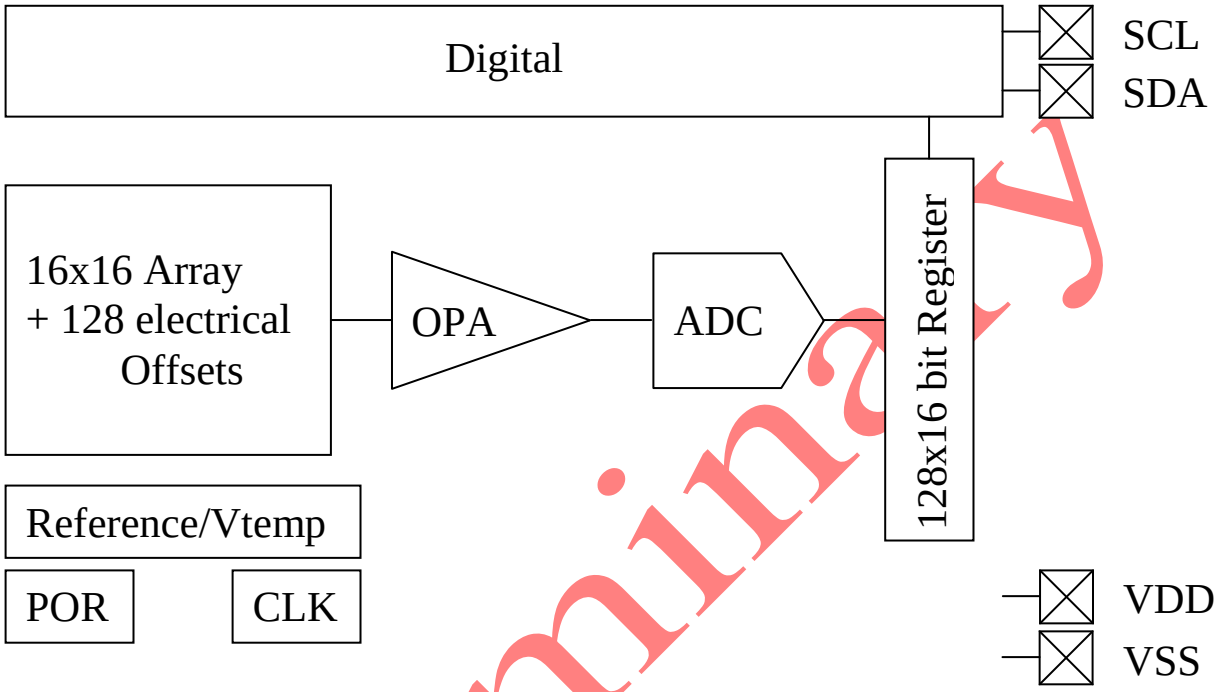
1 Principal Schematic for HTPA16x16d:



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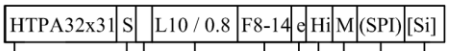
2 Order Code Example



Type:

HTPA32x31	Please contact support for all available HTPA and module combinations.

Package:

S	SMD variant
Not declared	TO can variant

Output:

d	HTPA sensor with digital output
Not declared	HTPA sensor with analogous output

Optics:

L	Focal length: In example L10 = 10.0 mm focal length
/	F-Number: In example /0.8
	For optics see also “HTPA standard optics”

Filter:

F	Filter characteristics. In example F8-14 (µm, Bandpass)
Not declared	Broad band ARC

External aperture:

Not declared	without external aperture
e	with external aperture

Sensitivity:

Hi	Increased sensitivity
Not declared	Standard sensitivity

Version:

A	Application set: comes with GUI, housing, power supply. Always UDP Interface.
C	Calibrated sensor (only digital). Carries calibration constants on internal EEPROM
M	Module: HTPA sensor soldered to PCB, calibrated stream
S	HTPA sensor only. Raw voltage output, not calibrated

Interface:

SPI	SPI device; Three variants: HTPA82x62: 16bit ADC all other analogous HTPAs: 14bit ADC Digital HTPA: 12bit ADC
LC	SPI,Only Analogous HTPA, 12bit ADC low speed, external processing required
UDP	Ethernet, CAT5 cable connection
PoE	Power over Ethernet, CAT5 connection, UDP protocol

Lens Material:

Si	Silicon
Not declared	Germanium

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3 Serial Order of Frame

The sensor is divided into two parts (top and bottom half) which are again separated into 2 blocks. The readout order is shown below for the different blocks.

Block 0 (top)
Block 1 (top)
Block 1 (bottom)
Block 0 (bottom)

Whenever a conversion is started the Block x of the top and bottom half are measured at the same time. Each block consists of 64 Pixel that are sampled fully parallel. The readout order on the bottom half is mirrored compared to the top half so that the central lines are always read last.

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47
48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63
64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79
80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
96	97	98	99	100	101	102	103	104	105	106	107	108	109	110	111
112	113	114	115	116	117	118	119	120	121	122	123	124	125	126	127
128	129	130	131	132	133	134	135	136	137	138	139	140	141	142	143
144	145	146	147	148	149	150	151	152	153	154	155	156	157	158	159
160	161	162	163	164	165	166	167	168	169	170	171	172	173	174	175
176	177	178	179	180	181	182	183	184	185	186	187	188	189	190	191
192	193	194	195	196	197	198	199	200	201	202	203	204	205	206	207
208	209	210	211	212	213	214	215	216	217	218	219	220	221	222	223
224	225	226	227	228	229	230	231	232	233	234	235	236	237	238	239
240	241	242	243	244	245	246	247	248	249	250	251	252	253	254	255

readout order top

readout order bottom

The electrical offset is sampled parallel for the top and bottom half. The matching lines for the corresponding electrical offsets and active Pixel are marked with the same color.

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47
48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63
64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79
80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
96	97	98	99	100	101	102	103	104	105	106	107	108	109	110	111
112	113	114	115	116	117	118	119	120	121	122	123	124	125	126	127

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4 Characteristics:

4.1 Common Specifications:

Technology	n-poly/p-poly Si
Element Resistance	approx. 300 kOhms
Sensitivity	approx. 450 V/W without optics and filter
Thermal pixel time constant	<4 ms
Digital Interface	I²C
Analog Output	No
selectable Clock	1 to 13 MHz
EEPROM size	64 kBit

Pitch	90 µm
Absorber size	77 µm
Max. Framerate	60 Hz

(complete frame with maximum I²C and sensor clock speed and reduced ADC resolution)
256 sensitive elements

4.2 Optical characteristics:

Focal length:	1.6 mm (“L” equals the focal length of the lens)
F-Number:	0.8
Field of view:	53 x 53 deg
Lens coating:	AR-Coating; average reflectance per surface < 3% for 8µm < λ < 11.5 µm Environment acc. for MIL-C-48497

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4.3 Electric Specifications:

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

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}			TBD		mA
Supply Current (sensor in idle state)	I_{DD}			TBD		mA
Standby Current (sensor in sleep state)	I_{SBY}			TBD		µA
Operation Temperature	T_A		-20		85	Deg. C
ESD-Protection		Human body model 100pF + 1k5Ohm	2.0			kV

Electrical Characteristics

Parameter	Symbol	Condition	MIN.	TYP.	MAX.	Unit
Digital Input						
Internal Clock frequency	F_{CLK}		1	5	13	MHz
Internal I²C 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			TBD		TBD	Deg. C
PTAT gradient				TBD		K/V

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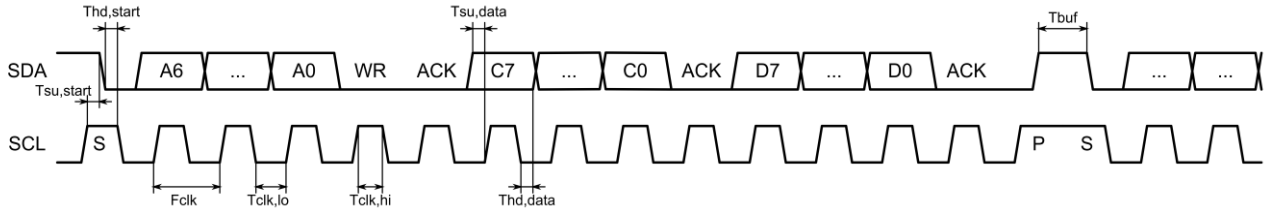
Preamplifier / ADC

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			18		Hz
Frame rate (Half Array)	FR4			36		HZ
ADC pos. Reference	V_{REFP}			1.6		V
ADC neg. Reference	V_{REFN}			0.9		V
ADC resolution	ADC_{LSB}	at 16 Bit		21		µV

5 I²C Timings HTPA16x16d:



Parameter	Symbol	Condition	MIN.	TYP.	MAX.	Unit
I²C 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
stop hold time	$T_{hd,stop}$		0.26			µs
time between STOP / START	T_{buf}		0.50			µs

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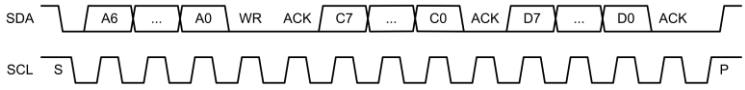
6 I²C Communication:

The chip uses the 7-bit I²C address 0x34 for configuration and sensor data and the address 0xA0 to access the internal EEPROM. The address byte is followed by an 8-bit command.

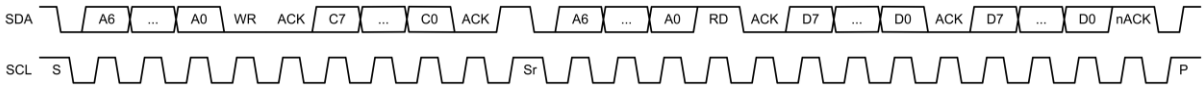
6.1 Write Command:

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.



6.2 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.



6.3 Sensor Commands:

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

Configuration register (write only)

Addr / CMD	0x34 / 0x01							
Config Reg	7	6	5	4	3	2	1	0
Name	RFU		BLOCK		START	RFU	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. The BLOCK selects one of the four multiplexed array blocks.
If the BLIND bit is set the electrical offsets are sampled instead of the active pixel and the setting of the BLOCK is ignored.

Status Register (read only)

Addr / CMD	0x34 / 0x02							
Status Reg	7	6	5	4	3	2	1	0
Name	RFU				BLOCK		RFU	EOC
Default	0	0	0	0	0	0	0	0

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

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Trim Register 1 (write only)

Addr / CMD	0x34 / 0x03							
Trim Reg 1	7	6	5	4	3	2	1	0
Name	RFU				MBIT TRIM			
Default	0	0	0	0	1	1	0	0

MBIT_TRIM: m = 4 to 12 ⇒ (m+4) bit as ADC resolution (Default: m=12)

Trim Register 2 (write only)

Addr / CMD	0x34 / 0x04							
Trim Reg 2	7	6	5	4	3	2	1	0
Name	RFU			BIAS TRIM TOP				
Default	0	0	0	0	1	1	0	0

BIAS_TRIM_TOP: 0 to 31 ⇒ 1µA to 13µA (Default: 5µA)
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	0x34 / 0x05							
Trim Reg 3	7	6	5	4	3	2	1	0
Name	RFU			BIAS TRIM BOT				
Default	0	0	0	0	1	1	0	0

BIAS_TRIM_BOT: 0 to 31 ⇒ 1µA to 13µA (Default: 5µA)
This setting is used to adjust the bias current of the ADC. A faster clock frequency requires a higher bias current setting.

Trim Register 4 (write only)

Addr / CMD	0x34 / 0x06							
Trim Reg 4	7	6	5	4	3	2	1	0
Name	RFU		CLK TRIM					
Default	0	0	0	1	0	1	0	1

CLK_TRIM: 0 to 63 ⇒ 1MHz to 13MHz (Default: 5MHz)
NOTE: The measure time depends on the clock frequency settings. One quarter frame takes about:

$$t_{FR4} = \frac{32 \cdot \left(2^{MBIT} + 4\right)}{F_{CLK}} \approx 27ms@5MHz$$

Trim Register 5 (write only)

Addr / CMD	0x34 / 0x07							
Trim Reg 5	7	6	5	4	3	2	1	0
Name	RFU			BPA TRIM TOP				
Default	0	0	0	0	1	1	0	0

BPA_TRIM_TOP: 0 to 31 ⇒ 0.2µA to 4.0µA (Default: 1.5µA)
This setting is used to adjust the common mode voltage of the preamplifier.

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Trim Register 6 (write only)

Addr / CMD	0x34 / 0x08							
Trim Reg 6	7	6	5	4	3	2	1	0
Name	RFU			BPA TRIM BOT				
Default	0	0	0	0	1	1	0	0

BPA_TRIM_BOT: 0 to 31 ⇒ 0.2µA to 4.0µA (Default: 1.5µA)
This setting is used to adjust the common mode voltage of the preamplifier.

Trim Register 7 (write only)

Addr / CMD	0x34 / 0x09							
Trim Reg 7	7	6	5	4	3	2	1	0
Name	PU SDA TRIM				PU SCL TRIM			
Default	1	0	0	0	1	0	0	0

PU_SDA_TRIM: select internal pull up resistor on SDA (Default: 100kOhm)
PU_SCL_TRIM: select internal pull up resistor on SCL (Default: 100kOhm)
"1000" = 100 kOhm; "0100" = 50 kOhm; "0010" = 10 kOhm; "0001" = 1 kOhm

Read Data 1 Command (Top Half of Array)

Addr / CMD	0x34 / 0x0A							
Read Data	7	6	5	4	3	2	1	0
1. Byte / 2. Byte	PTAT 1 MSB / LSB							
3. Byte / 4. Byte	Pixel (0+BLOCK*64) MSB / LSB							
5. Byte / 6. Byte	Pixel (1+BLOCK*64) MSB / LSB							
…	…							
129. Byte / 130. Byte	Pixel (63+BLOCK*64) MSB / LSB							

Read Data 2 Command (Bottom Half of Array)

Addr / CMD	0x34 / 0x0B							
Read Data	7	6	5	4	3	2	1	0
1. Byte / 2. Byte	PTAT 2 MSB / LSB							
3. Byte / 4. Byte	Pixel (240-BLOCK*64) MSB / LSB							
5. Byte / 6. Byte	Pixel (241-BLOCK*64) MSB / LSB							
…								
33. Byte / 34. Byte	Pixel (255-BLOCK*64) MSB / LSB							
35. Byte / 36. Byte	Pixel (224-BLOCK*64) MSB / LSB							
37. Byte / 38. Byte	Pixel (225-BLOCK*64) MSB / LSB							
…								
65. Byte / 66. Byte	Pixel (239-BLOCK*64) MSB / LSB							
67. Byte / 68. Byte	Pixel (192-BLOCK*64) MSB / LSB							
…								
129. Byte / 130. Byte	Pixel (207-BLOCK*64) 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.

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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 (Top Half of Array)

Addr / CMD	0x34 / 0x0A							
Read Data	7	6	5	4	3	2	1	0
1. Byte / 2. Byte	PTAT 1 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							

Read Data electrical offsets (Bottom Half of Array)

Addr / CMD	0x34 / 0x0B							
Read Data	7	6	5	4	3	2	1	0
1. Byte / 2. Byte	PTAT 2 MSB / LSB							
3. Byte / 4. Byte	electrical offset (112) MSB / LSB							
5. Byte / 6. Byte	electrical offset (113) MSB / LSB							
…	…							
33. Byte / 34. Byte	electrical offset (127) MSB / LSB							
35. Byte / 36. Byte	electrical offset (96) MSB / LSB							
…	…							
129. Byte / 130. Byte	electrical offset (79) 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.

6.4 EEPROM communication

TBD

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6.5 I²C Example Sequences – Init and Read Thermopile Array

(There should be a delay of at least 5 ms between the write of each Configuration Register)

	ADDR	R/W	CONFIG_REG	WAKEUP	
S	0x34	0	0x01	0x01	P

	ADDR	R/W	TRIM_REG1	MBIT_TRIM	
S	0x34	0	0x03	0x0C	P

	ADDR	R/W	TRIM_REG2	BIAS_TRIML	
S	0x34	0	0x04	0x0C	P

	ADDR	R/W	TRIM_REG3	BIAS_TRIMR	
S	0x34	0	0x05	0x0C	P

	ADDR	R/W	TRIM_REG4	CLK_TRIM	
S	0x34	0	0x06	0x14	P

	ADDR	R/W	TRIM_REG5	BPA_TRIML	
S	0x34	0	0x07	0x0C	P

	ADDR	R/W	TRIM_REG6	BPA_TRIMR	
S	0x34	0	0x08	0x0C	P

	ADDR	R/W	TRIM_REG7	PU_TRIM	
S	0x34	0	0x09	0x88	P

	ADDR	R/W	CONFIG_REG	START|WAKEUP	
S	0x34	0	0x01	0x09	P

	ADDR	R/W	STATUS_REG		ADDR	R/W	STATUS	
S	0x34	0	0x02	Sr	0x34	1	??	P

Wait 30 ms

	ADDR	R/W	STATUS_REG		ADDR	R/W	STATUS	
S	0x34	0	0x02	Sr	0x34	1	??	P

	ADDR	R/W	READ_DATA 1		ADDR	R/W	PTAT1 MSB	PTAT1 LSB	P0,0 MSB	P0,0 LSB	…	Px,y MSB	Px,y LSB	
S	0x34	0	0x0A	Sr	0x34	1	??	??	??	??	…	??	??	P

	ADDR	R/W	READ_DATA 2		ADDR	R/W	PTAT2 MSB	PTAT2 LSB	P0,0 MSB	P0,0 LSB	…	Px,y MSB	Px,y LSB	
S	0x34	0	0x0B	Sr	0x34	1	??	??	??	??	…	??	??	P

	ADDR	R/W	CONFIG_REG	SLEEP	
S	0x34	0	0x01	0x00	P

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7 Temperature calculation

TBD

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7.1 Ambient Temperature:

The ambient temperature (Ta) is calculated from the average measured PTAT value, the $PTAT_{gradient}$ and the $PTAT_{offset}$.

$$Ta = \frac{\sum_{i=0}^{3} PTAT_i}{4} \cdot PTAT_{gradient} + PTAT_{offset} \qquad \text{(Value is given back in dK)}$$

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

7.2 Thermal Offset:

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

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

where:

ij	represents the row (i) and column (j) of the pixel
V_{ij_Comp}	is the thermal offset compensated voltage
V_{ij}	is the raw pixel data (digital), readout from the RAM
$ThGrad_{ij}$	is the thermal gradient, stored in the EEPROM from 0x740 to 0xF3F
$ThOffset_{ij}$	is the thermal offset, stored in the EEPROM from 0xF40 to 0x173F
$gradScale$	is the scaling coefficient for the thermal gradient

7.3 Electrical Offset

The electrical offset is used to compensate changes in the supply voltage. This compensation is only a substraction so it can be done before or after the thermal offset compensation (here done afterwards).
The compensation for the top half is done by using the following formula:

$$V_{ij\_Comp}{}^{*} = V_{ij\_Comp} - elOffset\left[j + (i:4) \cdot 32\right]$$

and the bottom half analogue with this formula:

$$V_{ij\_Comp}{}^{*} = V_{ij\_Comp} - elOffset\left[j + (i:4) \cdot 32 + 128\right]$$

where:

ij	represents the row (i) and column (j) of the pixel and electrical offset
$V_{ij\_Comp}{}^{*}$	is the electrical offset compensated voltage
V_{ij_Comp}	is the thermal offset compensated voltage
$elOffset[ij]$	is the electrical offset belonging to Pixel ij
$i:4$	is the rest of the integer division of i by 4 (e.g. 7:4=3)

Please see chapter 3 for the serial order.

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7.4 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 tablenumber (TN). The table is supplied in a separate file named “Table.c”.
The sensitivity coefficients ($PixC_{ij}$) are calculated in the following way:

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

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
epsilon	is the emissivity factor

Leading to a compensation of the pixel voltage

$$V_{ij\_PixC} = \frac{V_{ij\_Comp}^{*} \cdot \text{PCSCALEVAL}}{PixC_{ij}}$$

where:

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

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7.5 Example calculation:

Example values:

$PTAT = 32357\ Digits$

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

$PTAT_{offset} = 1511.6\ dK$

$V_{00} = 34435\ Digits$

$gradScale = 15$

$ThGrad_{00} = 56693 \xrightarrow[signcheck]{} -8842$

$ThOffset_{00} = 44$

$elOffset[0] = 35000$

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

$PCSCALEVAL = 1 \cdot 10^8$

Calculation of ambient temperature:

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

Compensation of thermal offset:

$$V_{00\_Comp} = V_{00} - \frac{ThGrad_{00} \cdot Ta}{2^{gradScale}} - ThOffset_{00} = 34435 - \frac{-8842 \cdot 3000}{2^{15}} - 44 = 35200$$

Compensation of electrical offset:

$$V_{00\_Comp}{}^{*} = V_{00\_Comp} - elOffset[0] = 35200 - 35000 = 200$$

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Example look-up table:

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

$$V_{00\_PixC} = \frac{200 \cdot 1 \cdot 10^8}{1.1 \cdot 10^8} = 182$$

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 3941 dK = 120.9 °C.

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7.6 Look-up Table

To in dK

dig \ Ta[dK]	2782	2882	2982	3082	3182	3282	3382
-256	0	0	0	1159	1804	2115	2343
-192	0	0	7	2211	2407	2576	2727
-128	0	0	5	2605	2742	2872	2995
-64	0	0	6	2873	2986	3097	3206
0	2782	2882	2982	3082	3182	3282	3382
64	2993	3078	3166	3256	3347	3440	3534
128	3167	3243	3322	3405	3491	3579	3669
192	3316	3385	3459	3537	3619	3703	3790
256	3448	3512	3582	3656	3734	3816	3901
320	3565	3626	3693	3764	3840	3920	4003
384	3673	3731	3794	3864	3938	4016	4097
448	3771	3827	3889	3956	4029	4105	4186
512	3863	3916	3977	4043	4114	4189	4269
576	3948	4000	4059	4124	4194	4269	4348
640	4028	4079	4137	4200	4270	4344	4423
704	4104	4154	4210	4273	4342	4415	4494
768	4176	4224	4280	4342	4410	4484	4561
832	4244	4292	4346	4408	4476	4549	4626
896	4309	4356	4410	4471	4538	4611	4689
960	4371	4417	4471	4532	4599	4671	4748
1024	4431	4476	4530	4590	4657	4729	4806
1088	4488	4533	4586	4646	4713	4785	4862
1152	4543	4588	4641	4700	4767	4839	4916
1216	4597	4641	4693	4753	4819	4891	4968
1280	4648	4692	4744	4803	4869	4941	5018
1344	4698	4742	4793	4852	4918	4990	5068
1408	4746	4790	4841	4900	4966	5038	5115
1472	4793	4836	4888	4946	5012	5084	5162
1536	4839	4881	4933	4991	5057	5129	5207
1600	4883	4926	4977	5035	5101	5173	5251
1664	4926	4968	5019	5078	5144	5216	5294
1728	4968	5010	5061	5120	5185	5258	5336
1792	5009	5051	5102	5160	5226	5299	5377
1856	5049	5091	5142	5200	5266	5338	5417
1920	5088	5130	5180	5239	5305	5377	5456
1984	5126	5168	5218	5277	5343	5416	5494
2048	5164	5205	5256	5314	5380	5453	5532
2112	5200	5242	5292	5351	5417	5490	5569
2176	5236	5277	5328	5386	5453	5526	5605
2240	5271	5312	5363	5421	5488	5561	5640
2304	5305	5347	5397	5456	5522	5595	5675
2368	5339	5380	5431	5490	5556	5629	5709
2432	5372	5413	5464	5523	5589	5663	5742
2496	5405	5446	5496	5555	5622	5695	5775
2560	5437	5478	5528	5587	5654	5728	5808
2624	5468	5509	5560	5619	5685	5759	5840
2688	5499	5540	5590	5649	5716	5790	5871
2752	5529	5570	5621	5680	5747	5821	5902
2816	5559	5600	5651	5710	5777	5851	5932
2880	5588	5629	5680	5739	5806	5881	5962
2944	5617	5658	5709	5768	5836	5910	5992
3008	5646	5687	5737	5797	5864	5939	6021
3072	5674	5715	5765	5825	5893	5968	6049
3136	5701	5742	5793	5853	5920	5996	6078
3200	5729	5770	5820	5880	5948	6023	6105
3264	5756	5797	5847	5907	5975	6051	6133
3328	5782	5823	5874	5934	6002	6078	6160
3392	5808	5849	5900	5960	6028	6104	6187
3456	5834	5875	5926	5986	6054	6130	6213
3520	5859	5900	5951	6012	6080	6156	6239
3584	5885	5926	5977	6037	6105	6182	6265
3648	5909	5950	6001	6062	6131	6207	6290
3712	5934	5975	6026	6086	6155	6232	6315
3776	5958	5999	6050	6111	6180	6257	6340
3840	5982	6023	6074	6135	6204	6281	6365
3904	6006	6047	6098	6159	6228	6305	6389
3968	6029	6070	6121	6182	6252	6329	6413
4032	6052	6093	6145	6205	6275	6352	6437
4096	6075	6116	6167	6228	6298	6376	6460
4160	6097	6139	6190	6251	6321	6399	6484
4224	6120	6161	6213	6274	6344	6421	6507
4288	6142	6183	6235	6296	6366	6444	6529
4352	6164	6205	6257	6318	6388	6466	6552
4416	6185	6227	6278	6340	6410	6488	6574
4480	6207	6248	6300	6361	6432	6510	6596
4544	6228	6269	6321	6383	6453	6532	6618
4608	6249	6290	6342	6404	6475	6553	6639
4672	6269	6311	6363	6425	6496	6575	6661
4736	6290	6332	6384	6446	6516	6596	6682
4800	6310	6352	6404	6466	6537	6616	6703
4864	6330	6372	6424	6486	6558	6637	6724
4928	6350	6392	6444	6507	6578	6657	6744
4992	6370	6412	6464	6527	6598	6678	6765
5056	6390	6431	6484	6546	6618	6698	6785
5120	6409	6451	6503	6566	6638	6718	6805
5184	6428	6470	6523	6585	6657	6737	6825
5248	6447	6489	6542	6605	6677	6757	6845
5312	6466	6508	6561	6624	6696	6776	6864
5376	6485	6527	6580	6643	6715	6795	6884
5440	6504	6546	6598	6661	6734	6815	6903
5504	6522	6564	6617	6680	6752	6833	6922
5568	6540	6582	6635	6699	6771	6852	6941
5632	6558	6600	6654	6717	6789	6871	6960
5696	6576	6618	6672	6735	6808	6889	6978
5760	6594	6636	6690	6753	6826	6907	6997
5824	6612	6654	6707	6771	6844	6926	7015
5888	6629	6672	6725	6789	6862	6944	7033
5952	6647	6689	6742	6806	6879	6961	7051
6016	6664	6706	6760	6824	6897	6979	7069
6080	6681	6723	6777	6841	6914	6997	7087
6144	6698	6741	6794	6858	6932	7014	7104
6208	6715	6757	6811	6875	6949	7031	7122
6272	6732	6774	6828	6892	6966	7049	7139
6336	6748	6791	6845	6909	6983	7066	7156
6400	6765	6807	6861	6926	7000	7083	7174
6464	6781	6824	6878	6942	7016	7100	7191
6528	6797	6840	6894	6959	7033	7116	7207
6592	6813	6856	6910	6975	7050	7133	7224
6656	6830	6872	6927	6991	7066	7149	7241
6720	6845	6888	6943	7007	7082	7166	7257
6784	6861	6904	6958	7023	7098	7182	7274

6848	6877	6920	6974	7039	7114	7198	7290
6912	6892	6936	6990	7055	7130	7214	7306
6976	6908	6951	7006	7071	7146	7230	7322
7040	6923	6966	7021	7086	7162	7246	7338
7104	6939	6982	7036	7102	7177	7262	7354
7168	6954	6997	7052	7117	7193	7277	7370
7232	6969	7012	7067	7133	7208	7293	7386
7296	6984	7027	7082	7148	7223	7308	7401
7360	6999	7042	7097	7163	7239	7324	7417
7424	7014	7057	7112	7178	7254	7339	7432
7488	7028	7072	7127	7193	7269	7354	7447
7552	7043	7086	7141	7207	7284	7369	7462
7616	7057	7101	7156	7222	7298	7384	7478
7680	7072	7115	7171	7237	7313	7399	7493
7744	7086	7130	7185	7251	7328	7414	7507
7808	7100	7144	7199	7266	7342	7428	7522
7872	7114	7158	7214	7280	7357	7443	7537
7936	7129	7172	7228	7294	7371	7457	7552
8000	7143	7186	7242	7309	7386	7472	7566
8064	7156	7200	7256	7323	7400	7486	7581
8128	7170	7214	7270	7337	7414	7500	7595
8192	7184	7228	7284	7351	7428	7515	7609
8256	7198	7242	7298	7365	7442	7529	7624
8320	7211	7255	7311	7378	7456	7543	7638
8384	7225	7269	7325	7392	7470	7557	7652
8448	7238	7282	7338	7406	7483	7570	7666
8512	7252	7296	7352	7419	7497	7584	7680
8576	7265	7309	7365	7433	7511	7598	7694
8640	7278	7322	7379	7446	7524	7612	7708
8704	7291	7336	7392	7460	7538	7625	7721
8768	7304	7349	7405	7473	7551	7639	7735
8832	7317	7362	7418	7486	7564	7652	7748
8896	7330	7375	7431	7499	7578	7665	7762
8960	7343	7388	7444	7512	7591	7679	7775
9024	7356	7401	7457	7525	7604	7692	7789
9088	7369	7413	7470	7538	7617	7705	7802
9152	7382	7426	7483	7551	7630	7718	7815
9216	7394	7439	7496	7564	7643	7731	7828
9280	7407	7451	7508	7577	7656	7744	7841
9344	7419	7464	7521	7589	7668	7757	7854
9408	7432	7476	7533	7602	7681	7770	7867
9472	7444	7489	7546	7614	7694	7783	7880
9536	7456	7501	7558	7627	7706	7795	7893
9600	7468	7513	7571	7639	7719	7808	7906
9664	7481	7526	7583	7652	7731	7821	7919
9728	7493	7538	7595	7664	7744	7833	7931
9792	7505	7550	7607	7676	7756	7846	7944
9856	7517	7562	7619	7688	7768	7858	7956
9920	7529	7574	7631	7701	7781	7870	7969
9984	7541	7586	7643	7713	7793	7883	7981
10048	7553	7598	7655	7725	7805	7895	7994
10112	7564	7610	7667	7737	7817	7907	8006
10176	7576	7621	7679	7749	7829	7919	8018
10240	7588	7633	7691	7760	7841	7931	8030
10304	7599	7645	7703	7772	7853	7943	8042
10368	7611	7656	7714	7784	7865	7955	8055
10432	7622	7668	7726	7796	7876	7967	8067
10496	7634	7679	7737	7807	7888	7979	8078
10560	7645	7691	7749	7819	7900	7991	8090
10624	7657	7702	7760	7830	7911	8002	8102
10688	7668	7713	7772	7842	7923	8014	8114
10752	7679	7725	7783	7853	7935	8026	8126
10816	7690	7736	7794	7865	7946	8037	8138
10880	7702	7747	7806	7876	7957	8049	8149
10944	7713	7758	7817	7887	7969	8060	8161
11008	7724	7769	7828	7899	7980	8072	8172
11072	7735	7781	7839	7910	7991	8083	8184
11136	7746	7792	7850	7921	8003	8094	8195
11200	7757	7803	7861	7932	8014	8106	8207
11264	7767	7813	7872	7943	8025	8117	8218
11328	7778	7824	7883	7954	8036	8128	8229
11392	7789	7835	7894	7965	8047	8139	8241
11456	7800	7846	7905	7976	8058	8150	8252
11520	7811	7857	7916	7987	8069	8161	8263
11584	7821	7867	7926	7998	8080	8173	8274
11648	7832	7878	7937	8008	8091	8183	8285
11712	7842	7889	7948	8019	8102	8194	8296
11776	7853	7899	7958	8030	8112	8205	8307
11840	7863	7910	7969	8040	8123	8216	8318
11904	7874	7920	7980	8051	8134	8227	8329
11968	7884	7931	7990	8062	8145	8238	8340
12032	7895	7941	8000	8072	8155	8248	8351
12096	7905	7951	8011	8083	8166	8259	8362
12160	7915	7962	8021	8093	8176	8270	8372
12224	7925	7972	8032	8104	8187	8280	8383
12288	7936	7982	8042	8114	8197	8291	8394
12352	7946	7992	8052	8124	8208	8301	8404
12416	7956	8003	8062	8135	8218	8312	8415
12480	7966	8013	8073	8145	8228	8322	8426
12544	7976	8023	8083	8155	8239	8333	8436
12608	7986	8033	8093	8165	8249	8343	8446
12672	7996	8043	8103	8175	8259	8353	8457
12736	8006	8053	8113	8185	8269	8364	8467
12800	8016	8063	8123	8195	8279	8374	8478
12864	8026	8073	8133	8205	8290	8384	8488
12928	8035	8082	8143	8215	8300	8394	8498
12992	8045	8092	8153	8225	8310	8404	8508
13056	8055	8102	8162	8235	8320	8414	8519
13120	8065	8112	8172	8245	8330	8424	8529
13184	8074	8122	8182	8255	8340	8435	8539
13248	8084	8131	8192	8265	8349	8444	8549
13312	8094	8141	8201	8275	8359	8454	8559
13376	8103	8150	8211	8284	8369	8464	8569
13440	8113	8160	8221	8294	8379	8474	8579
13504	8122	8170	8230	8304	8389	8484	8589
13568	8132	8179	8240	8313	8398	8494	8599
13632	8141	8189	8249	8323	8408	8504	8609
13696	8151	8198	8259	8333	8418	8513	8619
13760	8160	8207	8268	8342	8427	8523	8628
13824	8169	8217	8278	8352	8437	8533	8638
13888	8179	8226	8287	8361	8446	8542	8648
13952	8188	8236	8297	8370	8456	8552	8658

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14016	8197	8245	8306	8380	8465	8562	8667
14080	8206	8254	8315	8389	8475	8571	8677
14144	8216	8263	8325	8399	8484	8581	8687
14208	8225	8272	8334	8408	8494	8590	8696
14272	8234	8282	8343	8417	8503	8600	8706
14336	8243	8291	8352	8426	8512	8609	8715
14400	8252	8300	8361	8436	8522	8618	8725
14464	8261	8309	8371	8445	8531	8628	8734
14528	8270	8318	8380	8454	8540	8637	8744
14592	8279	8327	8389	8463	8549	8646	8753
14656	8288	8336	8398	8472	8559	8656	8762
14720	8297	8345	8407	8481	8568	8665	8772
14784	8306	8354	8416	8490	8577	8674	8781
14848	8315	8363	8425	8499	8586	8683	8790
14912	8323	8372	8434	8508	8595	8692	8800
14976	8332	8380	8442	8517	8604	8702	8809
15040	8341	8389	8451	8526	8613	8711	8818
15104	8350	8398	8460	8535	8622	8720	8827
15168	8358	8407	8469	8544	8631	8729	8836
15232	8367	8416	8478	8553	8640	8738	8845
15296	8376	8424	8487	8562	8649	8747	8855
15360	8384	8433	8495	8570	8658	8756	8864
15424	8393	8442	8504	8579	8666	8765	8873
15488	8402	8450	8513	8588	8675	8774	8882
15552	8410	8459	8521	8597	8684	8782	8891
15616	8419	8467	8530	8605	8693	8791	8900
15680	8427	8476	8538	8614	8702	8800	8908
15744	8436	8484	8547	8623	8710	8809	8917
15808	8444	8493	8556	8631	8719	8818	8926
15872	8453	8501	8564	8640	8728	8826	8935
15936	8461	8510	8573	8648	8736	8835	8944
16000	8469	8518	8581	8657	8745	8844	8953
16064	8478	8527	8590	8665	8753	8852	8961
16128	8486	8535	8598	8674	8762	8861	8970
16192	8494	8543	8606	8682	8771	8870	8979
16256	8503	8552	8615	8691	8779	8878	8988
16320	8511	8560	8623	8699	8788	8887	8996
16384	8519	8568	8631	8708	8796	8895	9005
16448	8527	8577	8640	8716	8804	8904	9013
16512	8536	8585	8648	8724	8813	8912	9022
16576	8544	8593	8656	8733	8821	8921	9031
16640	8552	8601	8664	8741	8830	8929	9039
16704	8560	8609	8673	8749	8838	8938	9048
16768	8568	8617	8681	8757	8846	8946	9056
16832	8576	8626	8689	8766	8854	8954	9065
16896	8584	8634	8697	8774	8863	8963	9073
16960	8592	8642	8705	8782	8871	8971	9081
17024	8600	8650	8713	8790	8879	8979	9090
17088	8608	8658	8721	8798	8887	8988	9098
17152	8616	8666	8729	8806	8896	8996	9106
17216	8624	8674	8737	8814	8904	9004	9115
17280	8632	8682	8745	8822	8912	9012	9123
17344	8640	8690	8753	8831	8920	9021	9131
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17472	8656	8705	8769	8847	8936	9037	9148
17536	8664	8713	8777	8854	8944	9045	9156
17600	8671	8721	8785	8862	8952	9053	9164
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17792	8695	8745	8809	8886	8976	9077	9189
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29824	9883	9938	10010	10096	10197	10311	10436

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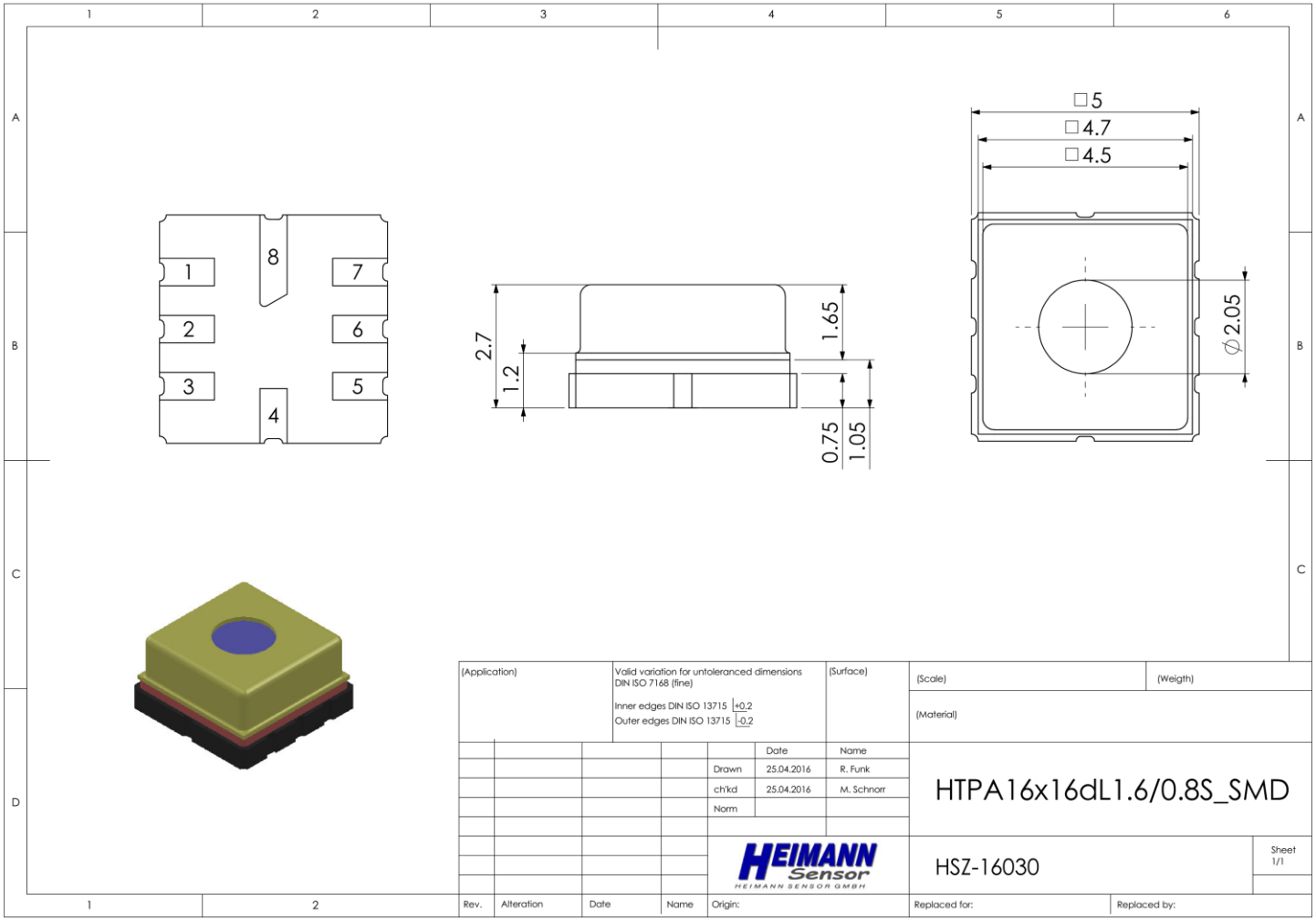
8 Outer Dimensions:



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