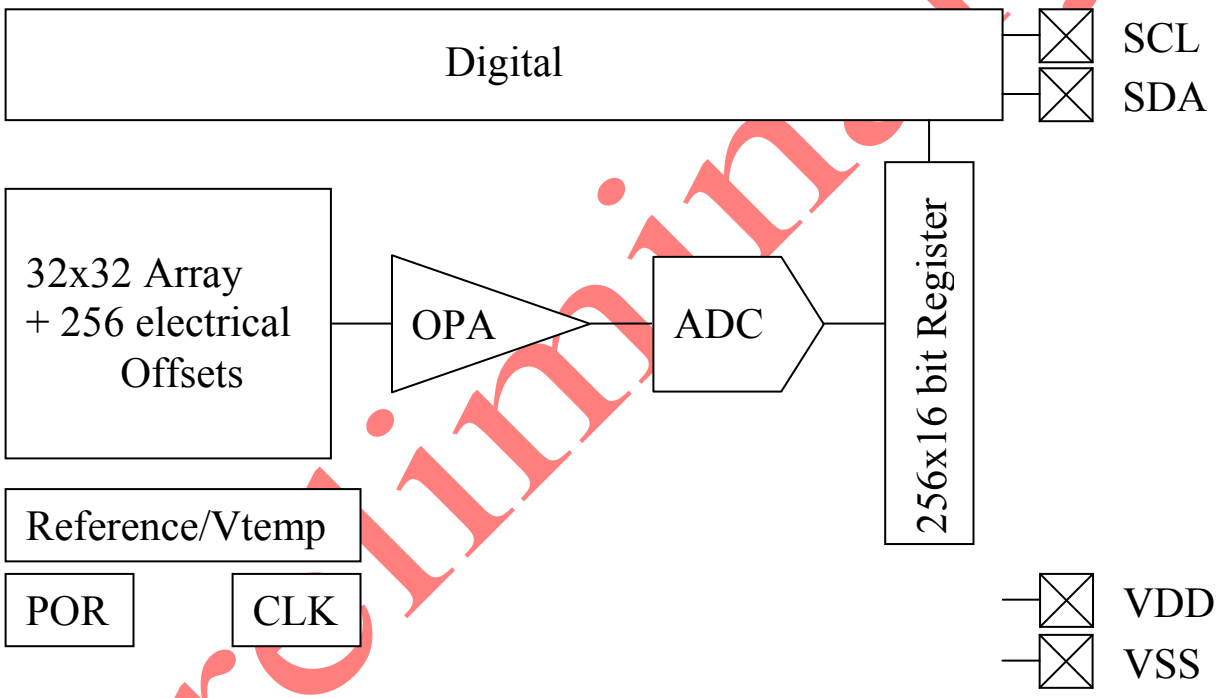
This datasheet is valid for following parts:

HTPA32x32dL2.1/0.8HiC[Si]
HTPA32x32dL2.1/0.8C[Si]
HTPA32x32dL2.1/0.8HiS[Si]
HTPA32x32dL2.1/0.8S[Si]

1 Principal Schematic for HTPA32x32d:



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Pin Assignment– Bottom View:

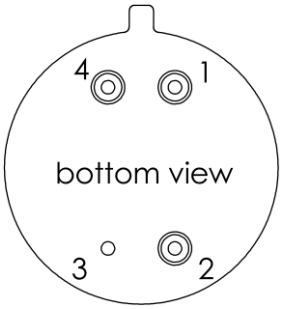
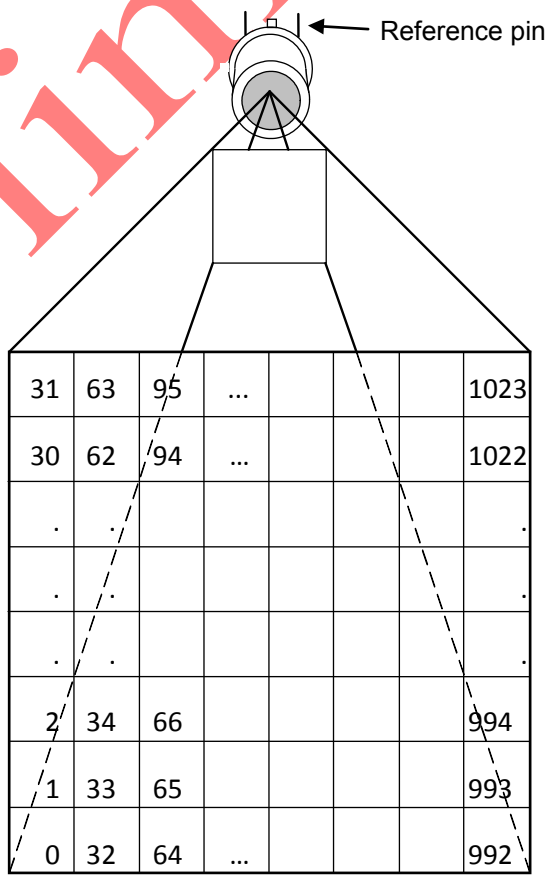


Figure 1: pin-allocation

Pin	Symbol	Description
1	SCL	Digital I/O, Open Drain, 100k PU, Serial Clock
2	VDD	Positive supply voltage
3	VSS	Negative supply voltage / Ground (0V) (connected to housing)
4	SDA	Digital I/O, Open Drain, 100k PU, Serial Data

2 Optical Orientation:



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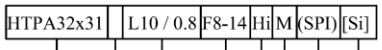
3 Order Code Example



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

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

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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4 Serial Order of Frame

The sensor is divided into two parts (top and bottom half) which are again separated into 4 blocks. The readout order is shown below for the different blocks.

Block 0 (top)
Block 1 (top)
Block 2 (top)
Block 3 (top)
Block 3 (bottom)
Block 2 (bottom)
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 128 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.

32x32d active Pixel

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
256	257	258	259	260	261	262	263	264	265	266	267	268	269	270	271	272	273	274	275	276	277	278	279	280	281	282	283	284	285	286	287
288	289	290	291	292	293	294	295	296	297	298	299	300	301	302	303	304	305	306	307	308	309	310	311	312	313	314	315	316	317	318	319
320	321	322	323	324	325	326	327	328	329	330	331	332	333	334	335	336	337	338	339	340	341	342	343	344	345	346	347	348	349	350	351
352	353	354	355	356	357	358	359	360	361	362	363	364	365	366	367	368	369	370	371	372	373	374	375	376	377	378	379	380	381	382	383
384	385	386	387	388	389	390	391	392	393	394	395	396	397	398	399	400	401	402	403	404	405	406	407	408	409	410	411	412	413	414	415
416	417	418	419	420	421	422	423	424	425	426	427	428	429	430	431	432	433	434	435	436	437	438	439	440	441	442	443	444	445	446	447
448	449	450	451	452	453	454	455	456	457	458	459	460	461	462	463	464	465	466	467	468	469	470	471	472	473	474	475	476	477	478	479
480	481	482	483	484	485	486	487	488	489	490	491	492	493	494	495	496	497	498	499	500	501	502	503	504	505	506	507	508	509	510	511
512	513	514	515	516	517	518	519	520	521	522	523	524	525	526	527	528	529	530	531	532	533	534	535	536	537	538	539	540	541	542	543
544	545	546	547	548	549	550	551	552	553	554	555	556	557	558	559	560	561	562	563	564	565	566	567	568	569	570	571	572	573	574	575
576	577	578	579	580	581	582	583	584	585	586	587	588	589	590	591	592	593	594	595	596	597	598	599	600	601	602	603	604	605	606	607
608	609	610	611	612	613	614	615	616	617	618	619	620	621	622	623	624	625	626	627	628	629	630	631	632	633	634	635	636	637	638	639
640	641	642	643	644	645	646	647	648	649	650	651	652	653	654	655	656	657	658	659	660	661	662	663	664	665	666	667	668	669	670	671
672	673	674	675	676	677	678	679	680	681	682	683	684	685	686	687	688	689	690	691	692	693	694	695	696	697	698	699	700	701	702	703
704	705	706	707	708	709	710	711	712	713	714	715	716	717	718	719	720	721	722	723	724	725	726	727	728	729	730	731	732	733	734	735
736	737	738	739	740	741	742	743	744	745	746	747	748	749	750	751	752	753	754	755	756	757	758	759	760	761	762	763	764	765	766	767
768	769	770	771	772	773	774	775	776	777	778	779	780	781	782	783	784	785	786	787	788	789	790	791	792	793	794	795	796	797	798	799
800	801	802	803	804	805	806	807	808	809	810	811	812	813	814	815	816	817	818	819	820	821	822	823	824	825	826	827	828	829	830	831
832	833	834	835	836	837	838	839	840	841	842	843	844	845	846	847	848	849	850	851	852	853	854	855	856	857	858	859	860	861	862	863
864	865	866	867	868	869	870	871	872	873	874	875	876	877	878	879	880	881	882	883	884	885	886	887	888	889	890	891	892	893	894	895
896	897	898	899	900	901	902	903	904	905	906	907	908	909	910	911	912	913	914	915	916	917	918	919	920	921	922	923	924	925	926	927
928	929	930	931	932	933	934	935	936	937	938	939	940	941	942	943	944	945	946	947	948	949	950	951	952	953	954	955	956	957	958	959
960	961	962	963	964	965	966	967	968	969	970	971	972	973	974	975	976	977	978	979	980	981	982	983	984	985	986	987	988	989	990	991
992	993	994	995	996	997	998	999	1000	1001	1002	1003	1004	1005	1006	1007	1008	1009	1010	1011	1012	1013	1014	1015	1016	1017	1018	1019	1020	1021	1022	1023

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.

32x32d electrical Offset

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

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5 Characteristics:

5.1 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 internal operational amplifiers and ADC's
1024 sensitive elements

5.2 Optical characteristics:

Focal length:	2.1 mm ("L" equals the focal length of the lens)
F-Number:	0.8
Field of view:	90 x 90 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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5.3 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}		7.9	8.2	9.0	mA
Supply Current (sensor in idle state)	I_{DD}		7.4	7.7	8.6	mA
Standby Current (sensor in sleep state)	I_{SBY}		2.0	2.1	2.5	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			170	174	178	K/V

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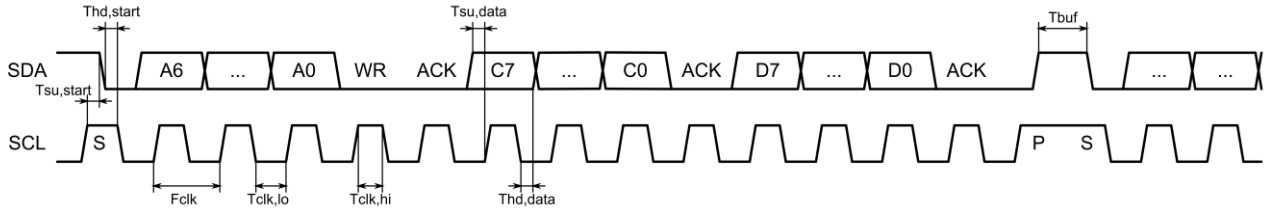
Preamplifier / ADC

Parameter	Symbol	Condition	MIN.	TYP.	MAX.	Unit
Pixel / Channel	N_{MUX}			4		
Chopper frequency	F_{CHP}			20		kHz
Preamplifier Noise	N_{PA}	at 20 kHz		72		$nV/HZ^{1/2}$
Preamplifier Gain	A_{PA}			40		
Frame rate (Full Array)	FR1		2	9	60	Hz
Frame rate (Quarter Array)	FR4		8	36	240	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

6 I²C Timings HTPA32x32d:



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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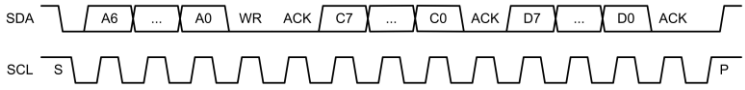
7 I²C Communication:

The chip uses the 7-bit I²C address 0x1A for configuration and sensor data and the address 0xA0 to access the internal EEPROM. The address byte is followed by an 8-bit command.

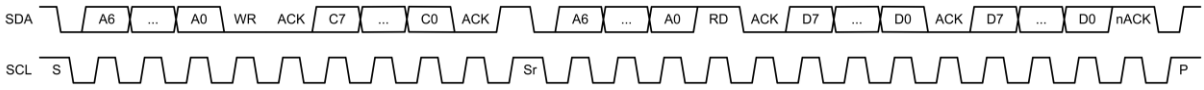
7.1 Write Command:

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.



7.2 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.



7.3 Sensor Commands:

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

Configuration register (write only)

Addr / CMD	0x1A / 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.

Status Register (read only)

Addr / CMD	0x1A / 0x02							
Status Reg	7	6	5	4	3	2	1	0
Name	RFU				BLOCK		RUN	EOC
Default	0	0	0	0	0	0	0	0

The user can query the current state by polling the RUN flag. If the EOC flag is set a previous started conversion has been finished.

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Trim Register 1 (write only)

Addr / CMD	0x1A / 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	0x1A / 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	0x1A / 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	0x1A / 0x06							
Trim Reg 4	7	6	5	4	3	2	1	0
Name	RFU		CLK TRIM					
Default	0	0	0	1	0	1	0	0

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	0x1A / 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	0x1A / 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	0x1A / 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	0x1A / 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*128) MSB / LSB							
5. Byte / 6. Byte	Pixel (1+BLOCK*128) MSB / LSB							
…	…							
257. Byte / 258. Byte	Pixel (127+BLOCK*128) MSB / LSB							

Read Data 2 Command (Bottom Half of Array)

Addr / CMD	0x1A / 0x0B							
Read Data	7	6	5	4	3	2	1	0
1. Byte / 2. Byte	PTAT 2 MSB / LSB							
3. Byte / 4. Byte	Pixel (992-BLOCK*128) MSB / LSB							
5. Byte / 6. Byte	Pixel (993-BLOCK*128) MSB / LSB							
…								
65. Byte / 66. Byte	Pixel (1023-BLOCK*128) MSB / LSB							
67. Byte / 68. Byte	Pixel (960-BLOCK*128) MSB / LSB							
69. Byte / 70. Byte	Pixel (961-BLOCK*128) MSB / LSB							
…								
129. Byte / 130. Byte	Pixel (991-BLOCK*128) MSB / LSB							
131. Byte / 132. Byte	Pixel (928-BLOCK*128) MSB / LSB							
…								
257. Byte / 258. Byte	Pixel (927-BLOCK*128) 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. A new initialized readout proceeds at this stopped byte, 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	0x1A / 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							
…	…							
257. Byte / 258. Byte	electrical offset (127) MSB / LSB							

Read Data electrical offsets (Bottom Half of Array)

Addr / CMD	0x1A / 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 (128) MSB / LSB							
5. Byte / 6. Byte	electrical offset (129) MSB / LSB							
…	…							
257. Byte / 258. Byte	electrical offset (255) 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. A new initialized readout proceeds at this stopped byte, but the index is reset when a new conversion has been started.

7.4 EEPROM communication

The built-in EEPROM (24AA64 from Microchip) consists of 8 blocks of 1K x 8-bit. The chip select of the EEPROM is set to 000 (A2 to A0). For further information please see the corresponding datasheet:
http://ww1.microchip.com/downloads/en/DeviceDoc/21189f.pdf

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7.5 I²C Example Sequences – 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_DATA 1		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_DATA 2		ADDR	R/W	PTAT2 MSB	PTAT2 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

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8 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.

32x32d	0x00	0x01	0x02	0x03	0x04	0x05	0x06	0x07	0x08	0x09	0x0A	0x0B	0x0C	0x0D	0x0E	0x0F
0x0000	PixCmin [float]				PixCmax [float]				gradScale				TN	epsilon		
0x0010											MBIT(calib)	BIAS(calib)	CLK(calib)	BPA(calib)	PU(calib)	
0x0020																
0x0030					PTAT-gradient (float)				PTAT-offset (float)							
0x0040																
0x0050																
0x0060	MBIT(user)	BIAS(user)	CLK(user)	BPA(user)	PU(user)											
0x0070					DeviceID											
0x0080 ... 0x0730	free to use															
0x0740 ... 0x0F30	$ThGrad_{ij}$ stored as 16 bit signed values															
0x0F40 ... 0x1730	$ThOffset_{ij}$ stored as 16 bit unsigned values															
0x1740 ... 0x1F30	P_{ij} stored as 16 bit unsigned values															

All values are stored as unsigned 8 bit values 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 7.3 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!

The corresponding order of the $ThGrad_{ij}$, $ThOffset_{ij}$ and P_{ij} to the Pixelnumber is given by the following overview:

$ThGrad_{0,0}$ → Pixel 0 $ThGrad_{0,1}$ → Pixel 1 … $ThGrad_{0,31}$ → Pixel 31
$ThGrad_{1,0}$ → Pixel 32 $ThGrad_{1,1}$ → Pixel 33 … $ThGrad_{1,31}$ → Pixel 63
.
.
.
$ThGrad_{15,0}$ → Pixel 480 $ThGrad_{15,1}$ → Pixel 481 … $ThGrad_{15,31}$ → Pixel 511
$ThGrad_{16,0}$ → Pixel 992 $ThGrad_{16,1}$ → Pixel 993 … $ThGrad_{16,31}$ → Pixel 1023
$ThGrad_{17,0}$ → Pixel 960 $ThGrad_{17,1}$ → Pixel 961 … $ThGrad_{17,31}$ → Pixel 991
.
.
.
$ThGrad_{31,0}$ → Pixel 512 $ThGrad_{31,1}$ → Pixel 513 … $ThGrad_{31,31}$ → Pixel 543

8.1 Ambient Temperature:

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

$$Ta = PTAT \cdot PTAT_{gradient} + PTAT_{offset}$$ (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

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8.2 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 0x40 to 0x7F
$ThOffset_{ij}$	is the thermal offset, stored in the EEPROM from 0x80 to 0xBF
$gradScale$	is the scaling coefficient for the thermal gradient

8.3 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 4 for the serial order.

8.4 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

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$PixC_{max}$ is the maximum sensitivity coefficient, used for scaling

epsilon is the emissivity factor

Leading to a compensation of the pixel voltage

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

where:

V_{ij_PixC} is the sensitivity compensated IR voltage

PCSCALEVAL is a scaling coefficient, typically $1 \cdot 10^{8}$

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8.5 Example calculation:

Example values:

$PTAT = 32357\ Digits$

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

$PTAT_{offset} = 1511.6\ dK$

$V_{00} = 34435\ Digits$

$gradSCale = 15$

$ThGrad_{00} = 56693 \xrightarrow[sign\,check]{} -8842$

$ThOffset_{00} = 44$

$elOffset[0] = 35000$

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

$PCSCALEVAL = 1 \cdot 10^8$

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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8.6 Look-up Table

dig \ Ta[dK]	2782	2882	2982	3082	3182	3282	3382
-256			0	1159	1804	2115	2343
-192	To in dK		7	2211	2407	2576	2727
-128			5	2605	2742	2872	2995
-64			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
17408	8648	8697	8761	8839	8928	9029	9140
17472	8656	8705	8769	8847	8936	9037	9148
17536	8664	8713	8777	8854	8944	9045	9156
17600	8671	8721	8785	8862	8952	9053	9164
17664	8679	8729	8793	8870	8960	9061	9172
17728	8687	8737	8801	8878	8968	9069	9181
17792	8695	8745	8809	8886	8976	9077	9189
17856	8702	8752	8816	8894	8984	9085	9197
17920	8710	8760	8824	8902	8992	9093	9205
17984	8718	8768	8832	8910	9000	9101	9213
18048	8725	8775	8840	8917	9008	9109	9221
18112	8733	8783	8847	8925	9016	9117	9229
18176	8741	8791	8855	8933	9023	9125	9237
18240	8748	8798	8863	8941	9031	9133	9245
18304	8756	8806	8871	8949	9039	9141	9253
18368	8764	8814	8878	8956	9047	9149	9261
18432	8771	8821	8886	8964	9055	9157	9269
18496	8779	8829	8893	8972	9062	9164	9277
18560	8786	8836	8901	8979	9070	9172	9285
18624	8794	8844	8909	8987	9078	9180	9292
18688	8801	8851	8916	8994	9085	9188	9300
18752	8808	8859	8924	9002	9093	9195	9308
18816	8816	8866	8931	9010	9101	9203	9316
18880	8823	8874	8939	9017	9108	9211	9324
18944	8831	8881	8946	9025	9116	9218	9331
19008	8838	8889	8954	9032	9123	9226	9339
19072	8845	8896	8961	9040	9131	9234	9347
19136	8853	8903	8968	9047	9138	9241	9354
19200	8860	8911	8976	9055	9146	9249	9362
19264	8867	8918	8983	9062	9153	9256	9370
19328	8875	8925	8991	9069	9161	9264	9377
19392	8882	8933	8998	9077	9168	9272	9385
19456	8889	8940	9005	9084	9176	9279	9393
19520	8896	8947	9013	9092	9183	9287	9400
19584	8904	8954	9020	9099	9191	9294	9408
19648	8911	8962	9027	9106	9198	9302	9415
19712	8918	8969	9034	9114	9205	9309	9423
19776	8925	8976	9042	9121	9213	9316	9430
19840	8932	8983	9049	9128	9220	9324	9438
19904	8939	8990	9056	9135	9228	9331	9445
19968	8947	8998	9063	9143	9235	9339	9453
20032	8954	9005	9070	9150	9242	9346	9460
20096	8961	9012	9077	9157	9249	9353	9468
20160	8968	9019	9085	9164	9257	9361	9475
20224	8975	9026	9092	9171	9264	9368	9483
20288	8982	9033	9099	9179	9271	9375	9490
20352	8989	9040	9106	9186	9278	9383	9497
20416	8996	9047	9113	9193	9285	9390	9505
20480	9003	9054	9120	9200	9293	9397	9512
20544	9010	9061	9127	9207	9300	9404	9519
20608	9017	9068	9134	9214	9307	9411	9527
20672	9024	9075	9141	9221	9314	9419	9534
20736	9031	9082	9148	9228	9321	9426	9541
20800	9038	9089	9155	9235	9328	9433	9548
20864	9044	9096	9162	9242	9335	9440	9555
20928	9051	9103	9169	9249	9342	9447	9563
20992	9058	9110	9176	9256	9349	9454	9570
21056	9065	9116	9183	9263	9356	9461	9577
21120	9072	9123	9190	9270	9363	9469	9584
21184	9079	9130	9197	9277	9370	9476	9591
21248	9085	9137	9203	9284	9377	9483	9598
21312	9092	9144	9210	9291	9384	9490	9606
21376	9099	9151	9217	9298	9391	9497	9613
21440	9106	9157	9224	9305	9398	9504	9620
21504	9112	9164	9231	9311	9405	9511	9627
21568	9119	9171	9238	9318	9412	9518	9634
21632	9126	9178	9244	9325	9419	9525	9641
21696	9132	9184	9251	9332	9426	9532	9648
21760	9139	9191	9258	9339	9433	9538	9655
21824	9146	9198	9264	9345	9439	9545	9662
21888	9152	9204	9271	9352	9446	9552	9669

21952	9159	9211	9278	9359	9453	9559	9676
22016	9166	9218	9285	9366	9460	9566	9683
22080	9172	9224	9291	9372	9467	9573	9690
22144	9179	9231	9298	9379	9473	9580	9697
22208	9185	9237	9305	9386	9480	9586	9703
22272	9192	9244	9311	9393	9487	9593	9710
22336	9199	9251	9318	9399	9494	9600	9717
22400	9205	9257	9324	9406	9500	9607	9724
22464	9212	9264	9331	9412	9507	9614	9731
22528	9218	9270	9338	9419	9514	9620	9738
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22656	9231	9283	9351	9432	9527	9634	9751
22720	9237	9290	9357	9439	9534	9641	9758
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22848	9250	9303	9370	9452	9547	9654	9772
22912	9257	9309	9377	9458	9554	9661	9778
22976	9263	9316	9383	9465	9560	9667	9785
23040	9270	9322	9390	9472	9567	9674	9792
23104	9276	9328	9396	9478	9573	9680	9799
23168	9282	9335	9402	9485	9580	9687	9805
23232	9289	9341	9409	9491	9586	9694	9812
23296	9295	9348	9415	9497	9593	9700	9819
23360	9301	9354	9422	9504	9599	9707	9825
23424	9308	9360	9428	9510	9606	9713	9832
23488	9314	9367	9434	9517	9612	9720	9838
23552	9320	9373	9441	9523	9619	9726	9845
23616	9327	9379	9447	9530	9625	9733	9852
23680	9333	9385	9453	9536	9632	9739	9858
23744	9339	9392	9460	9542	9638	9746	9865
23808	9345	9398	9466	9549	9644	9752	9871
23872	9351	9404	9472	9555	9651	9759	9878
23936	9358	9410	9479	9561	9657	9765	9884
24000	9364	9417	9485	9568	9664	9772	9891
24064	9370	9423	9491	9574	9670	9778	9897
24128	9376	9429	9497	9580	9676	9785	9904
24192	9382	9435	9504	9586	9683	9791	9910
24256	9389	9442	9510	9593	9689	9797	9917
24320	9395	9448	9516	9599	9695	9804	9923
24384	9401	9454	9522	9605	9702	9810	9930
24448	9407	9460	9528	9611	9708	9816	9936
24512	9413	9466	9535	9618	9714	9823	9942
24576	9419	9472	9541	9624	9720	9829	9949
24640	9425	9478	9547	9630	9727	9835	9955
24704	9431	9484	9553	9636	9733	9842	9962
24768	9437	9491	9559	9642	9739	9848	9968
24832	9443	9497	9565	9649	9745	9854	9974
24896	9449	9503	9571	9655	9752	9861	9981
24960	9455	9509	9578	9661	9758	9867	9987
25024	9461	9515	9584	9667	9764	9873	9993
25088	9467	9521	9590	9673	9770	9879	10000
25152	9473	9527	9596	9679	9776	9886	10006
25216	9479	9533	9602	9685	9782	9892	10012
25280	9485	9539	9608	9691	9789	9898	10018
25344	9491	9545	9614	9697	9795	9904	10025
25408	9497	9551	9620	9704	9801	9910	10031
25472	9503	9557	9626	9710	9807	9916	10037
25536	9509	9563	9632	9716	9813	9923	10043
25600	9515	9569	9638	9722	9819	9929	10050
25664	9521	9575	9644	9728	9825	9935	10056
25728	9527	9580	9650	9734	9831	9941	10062
25792	9533	9586	9656	9740	9837	9947	10068
25856	9539	9592	9662	9746	9843	9953	10074
25920	9544	9598	9667	9752	9849	9959	10080
25984	9550	9604	9673	9757	9855	9965	10087
26048	9556	9610	9679	9763	9861	9971	10093
26112	9562	9616	9685	9769	9867	9977	10099
26176	9568	9622	9691	9775	9873	9983	10105
26240	9574	9627	9697	9781	9879	9989	10111
26304	9579	9633	9703	9787	9885	9995	10117
26368	9585	9639	9709	9793	9891	10002	10123
26432	9591	9645	9714	9799	9897	10007	10129
26496	9597	9651	9720	9805	9903	10013	10135
26560	9602	9656	9726	9811	9909	10019	10141
26624	9608	9662	9732	9816	9915	10025	10147
26688	9614	9668	9738	9822	9921	10031	10153
26752	9620	9674	9743	9828	9926	10037	10159
26816	9625	9679	9749	9834	9932	10043	10165
26880	9631	9685	9755	9840	9938	10049	10171
26944	9637	9691	9761	9846	9944	10055	10177
27008	9642	9696	9766	9851	9950	10061	10183
27072	9648	9702	9772	9857	9956	10067	10189
27136	9654	9708	9778	9863	9962	10073	10195
27200	9659	9714	9784	9869	9967	10079	10201
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27328	9671	9725	9795	9880	9979	10090	10213
27392	9676	9730	9801	9886	9985	10096	10219
27456	9682	9736	9806	9892	9990	10102	10225
27520	9687	9742	9812	9897	9996	10108	10231
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27648	9699	9753	9823	9909	10008	10119	10242
27712	9704	9759	9829	9914	10013	10125	10248
27776	9710	9764	9835	9920	10019	10131	10254
27840	9715	9770	9840	9926	10025	10137	10260
27904	9721	9775	9846	9931	10031	10142	10266
27968	9726	9781	9851	9937	10036	10148	10272
28032	9732	9786	9857	9943	10042	10154	10277
28096	9737	9792	9863	9948	10048	10160	10283
28160	9743	9797	9868	9954	10053	10165	10289
28224	9748	9803	9874	9959	10059	10171	10295
28288	9754	9809	9879	9965	10065	10177	10300
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28416	9765	9820	9890	9976	10076	10188	10312
28480	9770	9825	9896	9982	10081	10194	10318
28544	9776	9830	9901	9987	10087	10199	10323
28608	9781	9836	9907	9993	10093	10205	10329
28672	9787	9841	9912	9998	10098	10211	10335
28736	9792	9847	9918	10004	10104	10216	10341
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28864	9803	9858	9929	10015	10115	10228	10352
28928	9808	9863	9934	10020	10120	10233	10358
28992	9814	9869	9940	10026	10126	10239	10363
29056	9819	9874	9945	10031	10131	10244	10369
29120	9824	9879	9950	10037	10137	10250	10375
29184	9830	9885	9956	10042	10143	10256	10380
29248	9835	9890	9961	10048	10148	10261	10386
29312	9840	9895	9967	10053	10154	10267	10391
29376	9846	9901	9972	10059	10159	10272	10397
29440	9851	9906	9977	10064	10164	10278	10403
29504	9856	9912	9983	10069	10170	10283	10408
29568	9862	9917	9988	10075	10175	10289	10414
29632	9867	9922	9994	10080	10181	10294	10419
29696	9872	9927	9999	10086	10186	10300	10425
29760	9878	9933	10004	10091	10192	10305	10430
29824	9883	9938	10010	10096	10197	10311	10436

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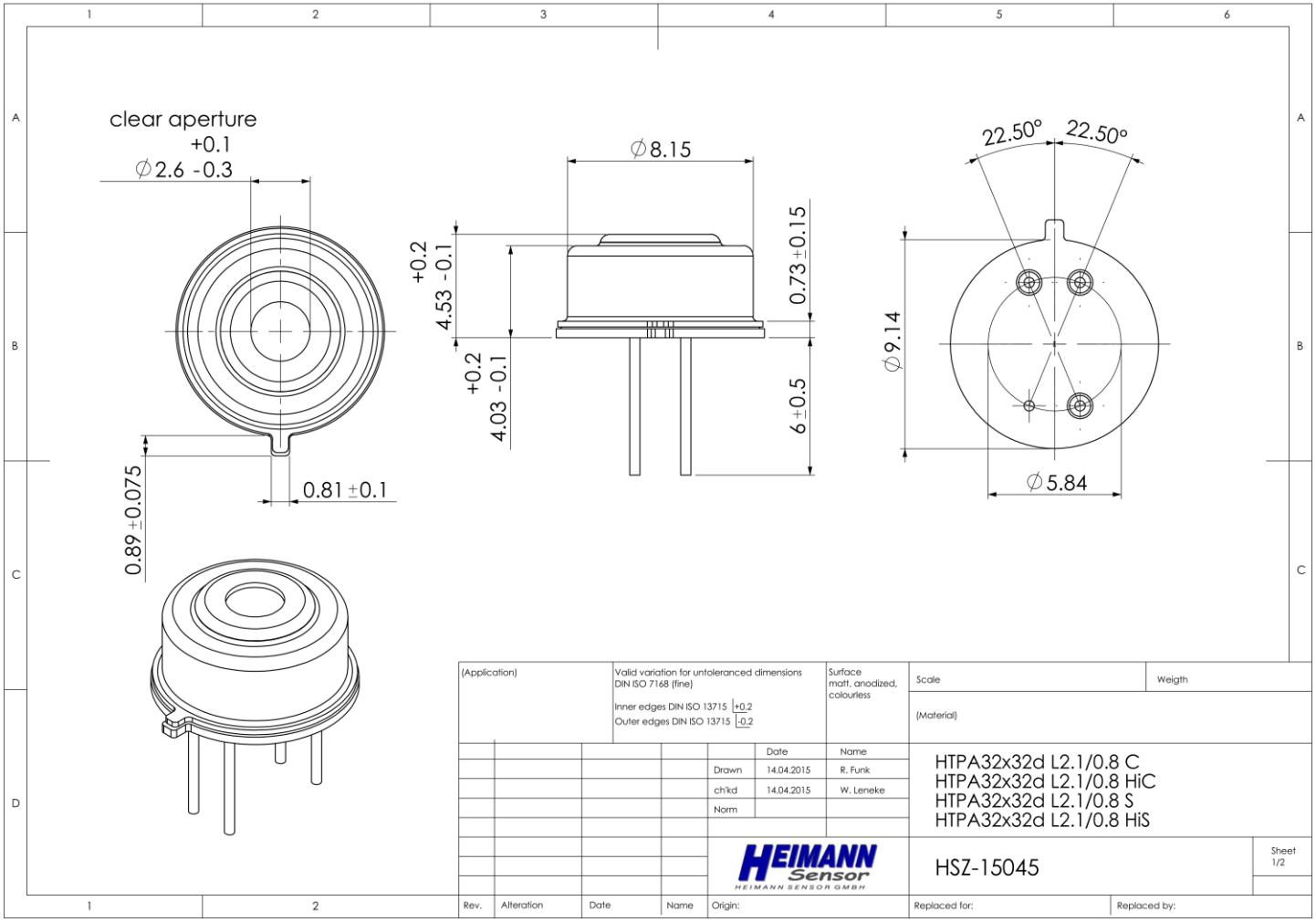
9 Outer Dimensions:



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