BostonElectronics

Infrared detector arrays
Low cost thermal imaging

HEIMANN Sensor

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Heimann Sensor - Thermopile imaging arrays - Analog output

Array	Package	Fill gas	Lens FL (mm)/f#	Application Set (Ready to go just add your PC)	Array plus SPI module	Array plus UDP module	Sensor only Quantity		
							2	20	200
8x8	TO-39	N_2	2.85/0.9	$280			$38.00	$25.90	$17.60
			3.6/0.9						
			5.5/1.0						
			7.0/1.2						
32x31	TO-8	Xe	10/0.8	$395	$230	$270	$145.00	$99.00	$67.00
			17/0.8						
64x62	TO-8	Xe	10/0.8	$395	$260	$300	$175.00	$121.00	$83.00
			17/0.8						

New thermopile arrays - Digital output (I2C or SPI)

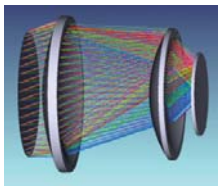
Array	Package	Fill gas	Lens FL (mm)	Application Set (Ready to go just add your PC)			Sensor Only** Quantity		
							2	20	200
8x8	TO-46	N_2	2.1	$280			$51.00	$31.00	$19.20
			2.85						
	TO-39		3.6						
32x32	TO-39	N_2	2.1	$280			$79.00	$56.00	$40.00
			2.85						
			3.6						
80x64	TO-8	N_2	10.0	$320			$285.00	$222.00	$173.00

** Calibrated array prices - uncalibrated arrays available at a lower price

HTPA - Thermopile Arrays

NETD - Noise Equivalent Temperature Difference at 9.5 Hz and 1 Hz

Array type (gas fill)	Lens configuration focal length/aperture (lens material)	NETD (9.5 Hz) [K]	NETD (1 Hz) [K]	Remarks
32x31 (nitrogen)	10 mm/0.8 (AR coated germanium)	0.35	0.12	Ambient= 25° C T_{BB}= 100° C
32x31 (xenon)	10 mm/0.8 (AR coated germanium)	0.16	0.06	
32x31 (nitrogen)	10 mm/1.0 (silicon)	0.86	0.27	
32x31 (xenon)	10 mm/1.0 (AR coated germanium)	0.48	0.16	Ambient= 25° C T_{BB}= 25° C
32x31 (xenon)	10 mm/1.0 (AR coated germanium)	0.27	0.09	Ambient= 25° C T_{BB}= 100° C
32x31 (nitrogen)	5.8 mm/1.5 (silicon)	1.39	0.43	



HTPA Series Standard Optics

	TO46	TO39			TO8		
	HTPA 8x8d	HTPA 16x4d	HTPA 16x16d	HTPA 32x32d	HTPA 32x31	HTPA 64x62	HTPA 80x64d
IR L2.1/0.8[Si]F5.0 	23° X 23°	120° X 30°	45° X 45°	90° X 90°			
IR L3.6/0.9[Si]uncoated 		60° X 15°					
IR L5.5/1.1[Si]uncoated 		35.4° X 9.1°					
IR L5.0/0.85[Ge]F7.7 				33° X 33°			
IR L5.0/1.0[Ge]ARC 					86° X 83°	86° X 83°	88° X 70°
IR L10/0.7[Ge]F7.7 					40° X 39°	40° X 39°	41° X 33°
IR L10/1.0[Ge]F7.7 					40° X 39°		
IR L10/1.0[Si]F7.7 					40° X 39°		
IR L10.5/0.95[Ge]F7.7 							39° X 31°
IR L11/1.0[Si]F7.7 							38° X 31°
IR L17/0.8[Ge]ARC 					24° X 23°	24° X 23°	24° X 20°
IR L22.5/1.0[Ge]ARC 					18° X 17°	18° X 17°	18° X 14°

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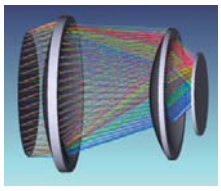
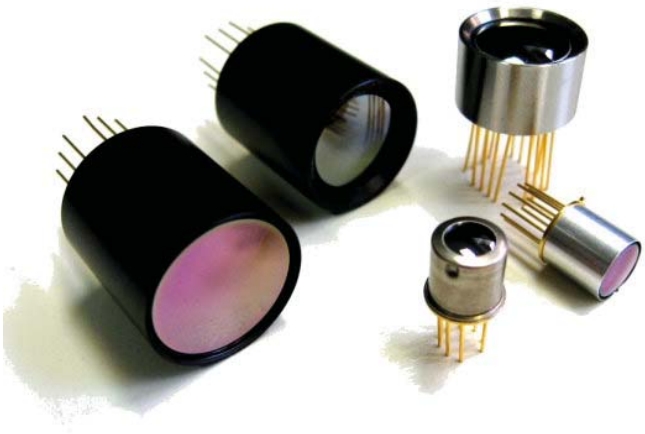


Field of View Calculation



The FOV can be easily calculated, according to the ray law

$$FOV = 2 \cdot arctan\left(\frac{N_{Col/Row} \cdot P}{2 \cdot f}\right)$$

f= focal length of the lens
P=Pitch of the sensitive elements
NCol/Row=Number of elements in Column or Row, depending if the FOV in horizontal or vertical direction should be calculated

Due to spherical aberrations we will provide detailed information concerning field curvature and distortion, if required.

If the application requires different types of coatings, we can also provide these, including LWP and band pass filters.

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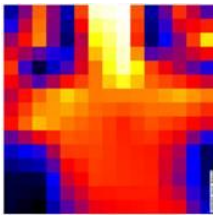


(Picture shows a human holding the hands up)

HTPA8x8d

Infrared Thermopile Array Sensor

The HTPA8x8d is the world smallest infrared array sensor with a resolution of 8x8 Pixel inside a TO46 housing. Due to the digital I²C interface only 4 pins are needed. It has a built in EEPROM to store all calibration data and a 16-bit ADC. The Speed can be set internally via the sensor clock and ADC-resolution up to 89 Hz (highest resolution) or up to 800 Hz (lowest resolution).

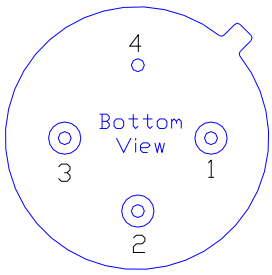
Parameter	*Value*	*Tolerance*	*Units*
Supply Voltage (DC)	3.3	± 0.3	V
Current consumption	4	± 0.5	mA
Ambient temperature range	-20 to 85		°C
Object temperature range	-20 to >1000		°C
Framerate	7 to 800		Hz
NETD (estimated)	100		mK@1Hz

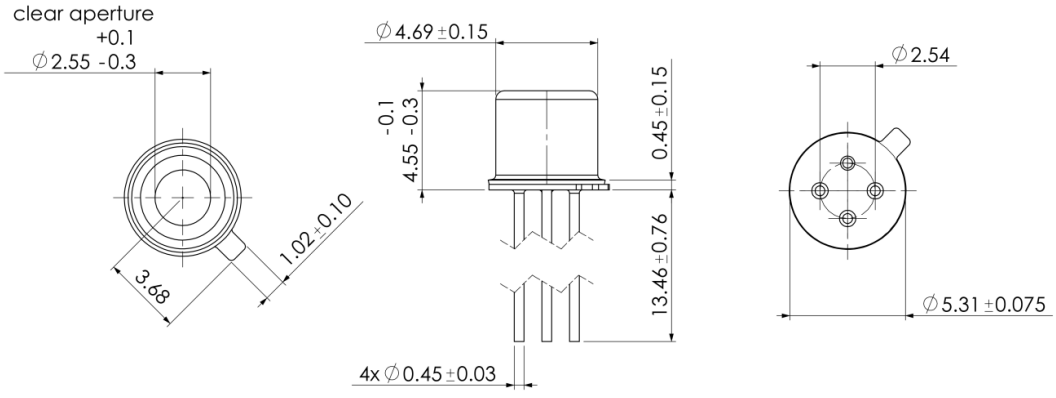
Available Optics

Optic	*FoV [°]*
L2.1 (TO46)	20 (calculated)
L2.1 to L7.0 (TO39)	20 to 6 (calculated)

Pin Configuration

Pin	*Function*
1	SDA (I²C)
2	Clock (I²C)
3	3.3 V supply
4	Ground





Modifications reserved Rev.03 / 15.02.2016

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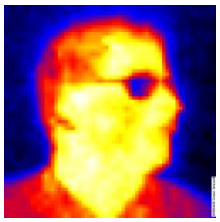

(Picture shows a human head watching to the side, taken with the HTPA32x32dL5.0)

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HTPA32x32d

Infrared Thermopile Array Sensor

The HTPA32x32d is an infrared array sensor with a resolution of 32x32 Pixel in a TO39 housing. Due to the digital I²C interface only 4 pins are needed. It has a built in EEPROM to store all calibration data and a 16-bit ADC. The Speed can be set internally via the sensor clock and ADC-resolution up to 15 Hz (highest resolution) or up to 60 Hz (lowest resolution).

Parameter	*Value*	*Tolerance*	*Units*
Supply Voltage (DC)	3.3	± 0.3	V
Current consumption	8	± 1	mA
Clock Frequency (Sensor)	5	± 3	MHz
Ambient temperature range	-20 to 85		°C
Object temperature range	-20 to >1000		°C
Framerate (full frame)	2 to 60		Hz
Framerate (quarter frame)	8 to 240		Hz
NETD (estimated)	150		mK@1Hz

Available Optics:

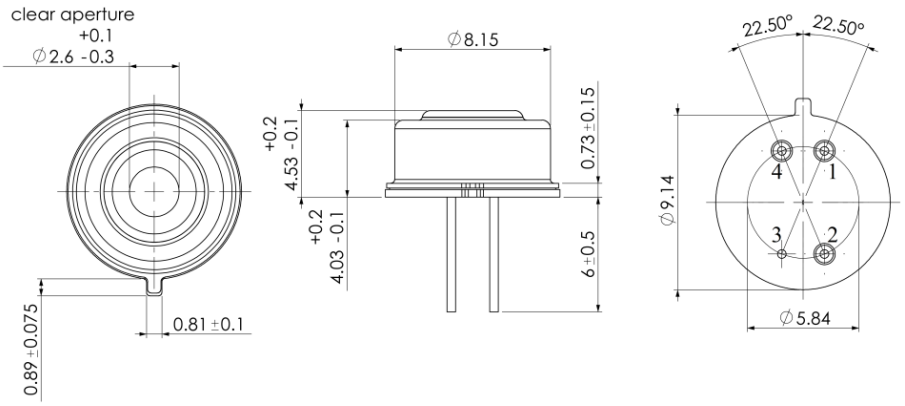
Optic	L2.1[Si]	L3.6[Si]	L5.0[Ge]*	L7.0[Si]	L5.0[Ge]**
FoV [°]	90	43	33	23	33
Length of cap [mm]	4.53	6.71	7.63	9.4	10.41
F-number	0.8	0.9	0.85	1.2	0.85

*: Ge optics are having the best performance but are more expensive
**: Same optics, but an external aperture for better performance is added

Package outline:

HTPA32x32L2.1, TO39 housing
(Other optics are available)

Pin	*Function*
1	Clock (I²C)
2	3.3 V supply
3	Ground
4	SDA (I²C)



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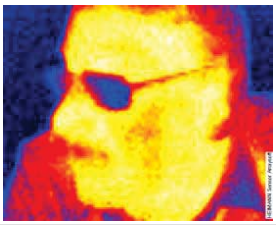


(Picture shows a human head watching to the side)

(Infrared picture of a rabbit)

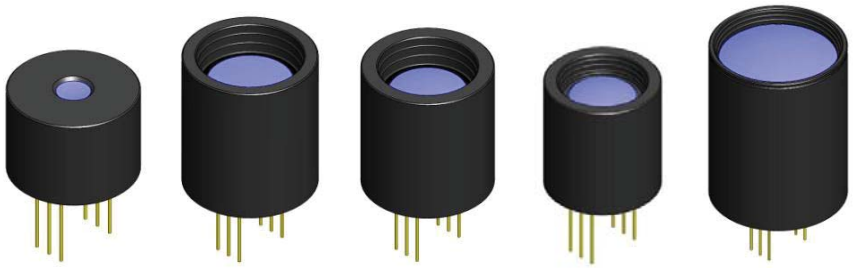
HTPA80x64d

Infrared Thermopile Array Sensor

The HTPA80x64d is the bigger brother of the 32x32d infrared array sensor with a resolution of 80x64 Pixel inside a TO8 housing. Due to the digital SPI interface only 6 pins are needed. It has a built in EEPROM to store all calibration data and a 16-bit ADC. The Speed can be set internally via the sensor clock and ADC-resolution up to 20 Hz (highest resolution) or up to 200 Hz (lowest resolution).

Parameter	*Value*	*Tolerance*	*Units*
Supply Voltage (DC)	3.3	± 0.3	V
Current consumption	30		mA
Ambient temperature range	-20 to 85		°C
Object temperature range	-20 to >1000		°C
Framerate (full frame)	1 to 200		Hz
Framerate (quarter frame)	4 to 800		Hz
NETD (best optic)	150		mK@1Hz

Available Optics:

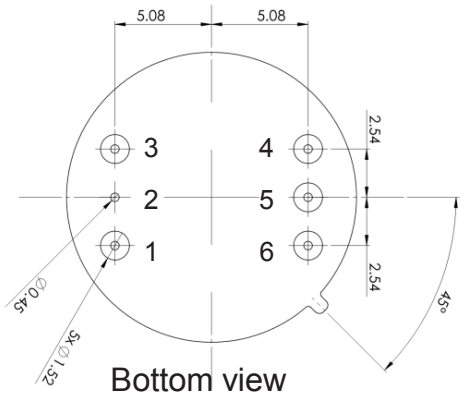


Optic	L5.0	L10	L10.5	L11[Si]*	L22.5
FoV [°]	88 x 70	41 x 33	39 x 31	38 x 31	18 x 14
Length of cap [mm]	14.4	25.7	24.1	21.3	36.5
F-number	0.95	0.7	0.95	1.0	1.0

*: Si optics are having a worse NETD but are cheaper

Pin Configuration (SPI)

Pin	*Function*
1	3.3 V supply
2	Ground
3	SSEL
4	MISO
5	MOSI
6	SCLK



Bottom view

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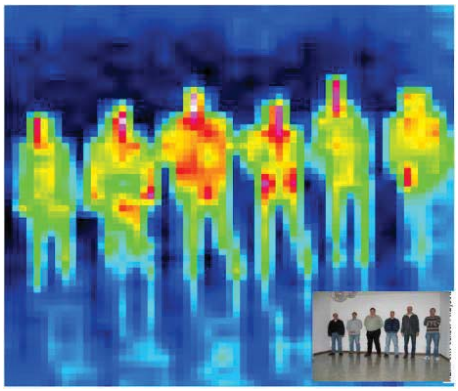
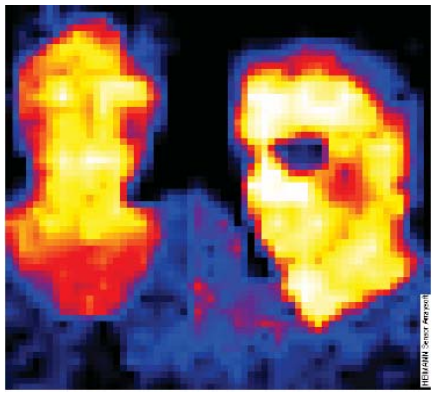
Quick Start Application Set

For thermal imaging and easy application of our arrays we designed an evaluating processor unit in a modular metal case for better handling. The module's field of view depends on housing, the built-in lens and can be varied on demand.
The object temperature range can be easily changed by software.
The digital data stream is transferred from the module to the PCB via SPI and contains the signal voltages of the elements, the offset of the amplifiers and the ambient temperature information of the module. The analogous data stream contains the same information and can be sampled by an external ADC. The microcontroller processes the data and communicates via Ethernet/UDP to a PC. On PC side the data stream is logged and visualized with a Graphical User Interface. The given software allows you to start your measurements and testing almost immediately.

Applications

- Person detection
- Fire detection
- Hotspot detection
- Energy management
- Security cameras
- Industrial process control
- Air condition control
- Out of position



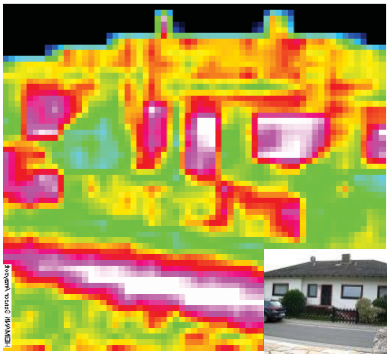


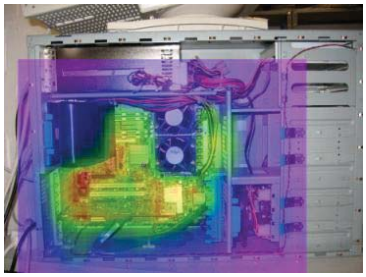
Benefit

- Low cost TO8/TO39 housing
- Low power consumption
- Short time constant
- High sensitivity of the system
- No need for shutter and thermal stabilization

Features:

- Communications via RJ45/Ethernet/UDP
- False color images with auto scaling
- Selectable frame rate
- Data log mode
- Contrast adjustment
- Interpolation
- Temperature display
- Several lenses for different field of view





Included in delivery:

- Array module
- Cable interface
- AC adapter (100V~ … 240V~)
- Tripod
- Software

Module dimension:

- Diameter 28 mm; length approx. 55 mm (length depends on chosen lens)

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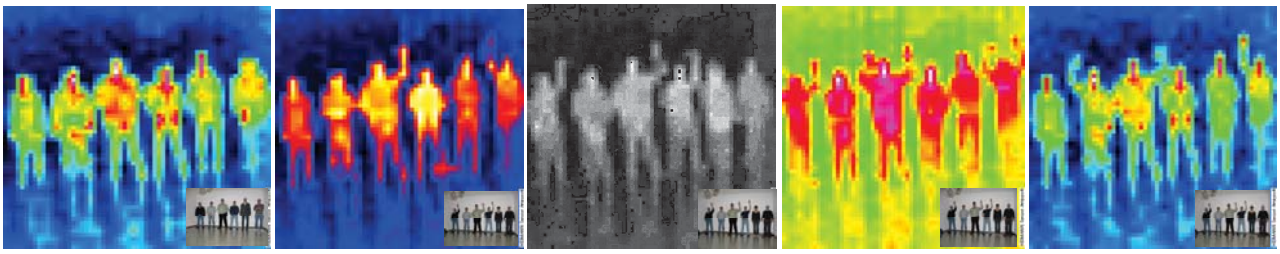
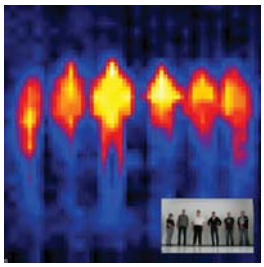
Thermal Images with 32x31 Array Modules

a) Person detection:
32x31 Array with high performance (multi lens optics)
– difference 1…5 is only various false colour modes of quick start kit:

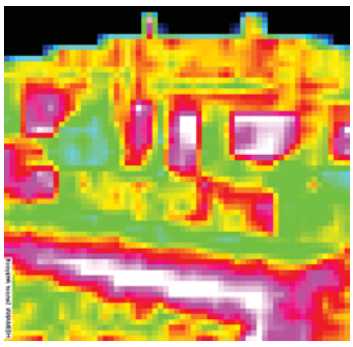
1 2 3 4 5



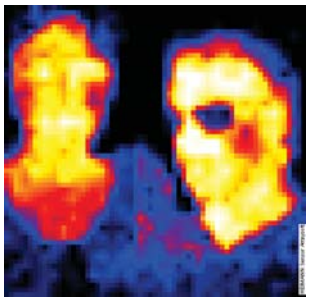
b) Person detection - Low cost option: 32x31 Array with single Ge lens f= 7 mm
- Colour mode is same as Number 2 with multi lens

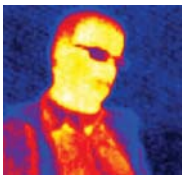


c) Building Thermography (32x31 Array with multi lens optics):



d) Fever detection (32x31 Array with multi lens optics):

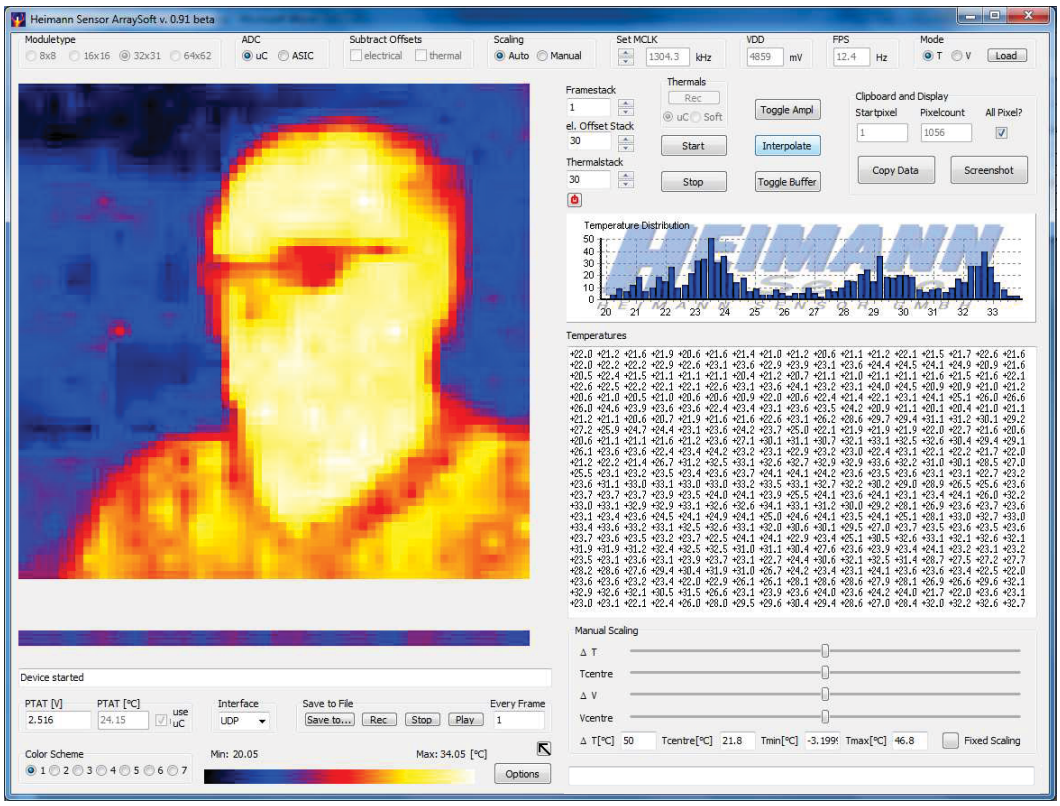




Heimann Sensor ArraySoft

Graphical User Interface for HTPA Modules and Application sets

The HTPA application set comes with our comprehensive Graphical User Interface (GUI) “ArraySoft” which provides a lot of features and is constantly updated. It can be used instantly with our UDP-Modules, SPI-SDK for the HTPA series and our application sets. Furthermore, it is possible to use it with our UART modules by connecting the module via a transceiver to the RS232 interface of your PC.



Features:

- 7 false color scales
- Auto and manual scaling (7 scaling modes)
- Temperature and voltage mode
- Data streaming into files
- AVI export
- Interpolation mode
- Complete control of the device
- Multiple devices can be controlled
- The data stream of 4 devices can be displayed at the same time
- Histogram
- Selectable temperature or voltage profile
- Minimum and Maximum Temperature / Voltage info
- Suitable for all HTPA types (8x8 to 64x62)
- Frames per second indicator
- Alignment for offset corrected frames
- Temperatures in Kelvin or degree Celsius
- IR-Frame can be mirrored in both axis
- Single Pixel information accessible
- Temperature calculation with the respect to object emissivity
- Screenshot ability (JPG or ASCII data)
- Recorded data streams can be played in selectable speed
  →Make your own “thermal movie”

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HTPA Modules

For easy development of thermal imaging, hotspot detection, person detection and other thermo graphical devices our calibrated modules are the ideal solution. We provide them for all the HTPA types (8x8, 16x16, 32x31 and 64x62). The module‘s field of view depends on the optics and can be varied on demand.
Furthermore, we offer three different interfaces: UDP, UART and SPI. Which interface should be chosen, depends on the needs of the customer. For example, the UDP module is ready to plug via a CAT5 cable to network and can be controlled via a customized software or the Heimann Sensor HTPA ArraySoft. The UART module is the ideal solution for embedding the module i.e. in handheld devices. Limitations of the UART interface are the limited MCLK frequency of max. 2.2 MHz. It is possible to connect the UART module to a standard RS232 transceiver and to use it with the Heimann GUI (Graphical User Interface). If the customer wants to connect more than one module (or a module with MCLK > 2.2 MHz) to a microcontroller, the SPI interface should be chosen. For the SPI version there is our SDK available, which also transfers the fetched SPI data to the GUI via Ethernet.
It is possible to build customer specific optics, as well as to use customer specific measurement ranges for calibration.

Module dimension:
- UDP Module: Diameter 26mm
  (circular PCB, rectangular PCB will be available soon)
- SPI / UART Module: 28x35 mm²

Benefit:
- Different optics available
- Calibrated, ready to assemble

SPI Module SDK

Since the controlling of the HTPA SPI module is much more complicated than the other versions, we offer a SDK (Software Development Kit) for this module type. The SDK was designed to do all the necessary settings of the module, fetch single frames and data streams and forward them via UDP to the GUI. The program running on the SDK is open source and is delivered with the SDK. For development a programming tool from Microchip Technology is required (not included) as well as the MPLAB IDE (downloadable free of charge at www.microchip.com). The SDK has several test pads and LED’s for easy debugging. Furthermore, it is equipped with a 128kbit EEPROM. The circuitry of the SDK PCB is supplied, too.

Benefits:

- Fast development
- Workspace and circuitry can be easily
  adapted for the control of several modules
- Fully compatible designed to Heimanns GUI

Disclaimer: MPLAB IDE is a registered trade mark of Microchip Technology Inc.

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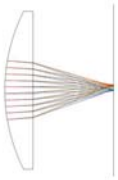

HTPA Series Standard Optics

Heimann Sensor offers several kind of standard optics. We offer high performance dual germanium lens optics, as well as low cost uncoated, single silicon lenses. Naturally, it is possible to create new solutions, which fit to the individual needs of the customer.

Possible Combinations						
Lens	HTPA8x8 TO39	HTPA8x8 TO8	HTPA16x16	HTPA32x31	HTPA64x62	Remarks
L3	X	X	X	-	-	f/<1.0 Ge
L4	-	X	X	X	X	f/<1.0 Ge
L5.5	X	-	-	-	-	f/1.0 Si
L7/0.7	-	X	X	X	X	f/<1.0 Ge
L7/1.0	X	-	-	-	-	f/0.98 Ge
L10/0.8	-	X	X	X	X	f/0.8 Dual Ge
L10/1.0	-	X	X	X	X	f/1.0 Dual Ge

Resulting Field of View [°]				
Lens	HTPA8x8	HTPA16x16	HTPA32x31	HTPA64x62
L3	43.6	60.8	-	-
L4	33.4	47.5	82.7	82.7
L5.5	24.6	-	-	-
L7	19.5	28.2	53.4	53.4
L10	13.7	20.0	38.8	38.8

The FOV can be easily calculated, according to the ray law:

$$FOV = 2 \cdot \arctan\left(\frac{N_{Col/Row} \cdot P}{2 \cdot f}\right)$$

f= focal length of the lens

P=Pitch of the sensitive elements

$N_{Col/Row}$=Number of elements in Column or Row, depending if the FOV in horizontal or vertical direction should be calculated

Likewise, if the FOV is given, the needed focal length can be calculated by:

$$f = \frac{N_{Col/Row} \cdot P}{2 \cdot \tan\left(\frac{FOV}{2}\right)}$$

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HTPA - Thermopile Arrays

NETD - Noise Equivalent Temperature Difference at 9.5 Hz and 1 Hz

Array type (gas fill)	Lens configuration focal length/aperture (lens material)	NETD (9.5 Hz) [K]	NETD (1 Hz) [K]	Remarks
32x31 (nitrogen)	10 mm/0.8 (AR coated germanium)	0.35	0.12	Ambient= 25° C T_{BB}= 100° C
32x31 (xenon)	10 mm/0.8 (AR coated germanium)	0.16	0.06	
32x31 (nitrogen)	10 mm/1.0 (silicon)	0.86	0.27	
32x31 (xenon)	10 mm/1.0 (AR coated germanium)	0.48	0.16	Ambient= 25° C T_{BB}= 25° C
32x31 (xenon)	10 mm/1.0 (AR coated germanium)	0.27	0.09	Ambient= 25° C T_{BB}= 100° C
32x31 (nitrogen)	5.8 mm/1.5 (silicon)	1.39	0.43	

Specification for HTPA32x31L10/0.8HiM(UDP)

Rev.0: 2013.04.26 Hu

The HTPA32x31L_/_M(UDP) is a fully calibrated, low cost thermopile array module, with fully digital UDP interface. The module delivers an electrical offset and ambient temperature compensated output stream, which can be already used for image processing, pattern recognition and presence detection purposes. Object temperatures can be easily obtained by this data stream.

Order Code Example

HTPA32x31L10/0.8HiM(UDP)[Si]

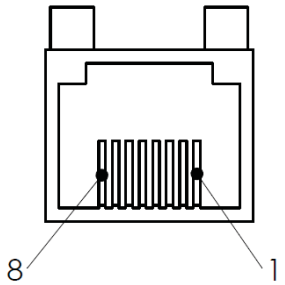
- Lens material: Si→Silicon, if not declared Germanium
- Interface: SPI→ SPI device (14bit ADC)
  LC→SPI, 12bit ADC, low speed, external processing required
  UDP→Ethernet, CAT5 cable connection
  UART→RS232-like, Level: 3.3V
- Type: A→Application set: comes with GUI, housing, power supply
  M→Module: HTPA sensor soldered to PCB, calibrated stream
  S→Sensor: HTPA sensor only. Analogous output.
- Sensitivity: Hi→Increased sensitivity
  Without "Hi"→ Standard sensitivity
- Optics: L→focal length: In example L10 = 10 mm focal length.
  /→ F-Number: In example /0.8
  For optics see also "HTPA standard optics"
- Type: HTPA32x31 (Please contact support for all available HTPA and module combinations.

For modules, M(UART) and M(LC) are not recommended anymore. M(SPI) and M(UDP) offer a wider input voltage range, better ADC resolution and a wider measurement range.

Pinout

Pin Assignment HTPA32x31M(UDP)

Pin	Name	Description	Type
1	TPOut+	Differential Signal Output	Digital Output
2	VDD	Positive supply voltage	Power
3	TPOut-	Differential Signal Output	Digital Output
4	TPIn+	Differential Signal Input	Digital Input
5		not connected	
6	TPIn-	Differential Signal Input	Digital Input
7		not connected	
8	VSS	Ground reference	Power



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Ethernet-Interface:

Protocol Specifications:

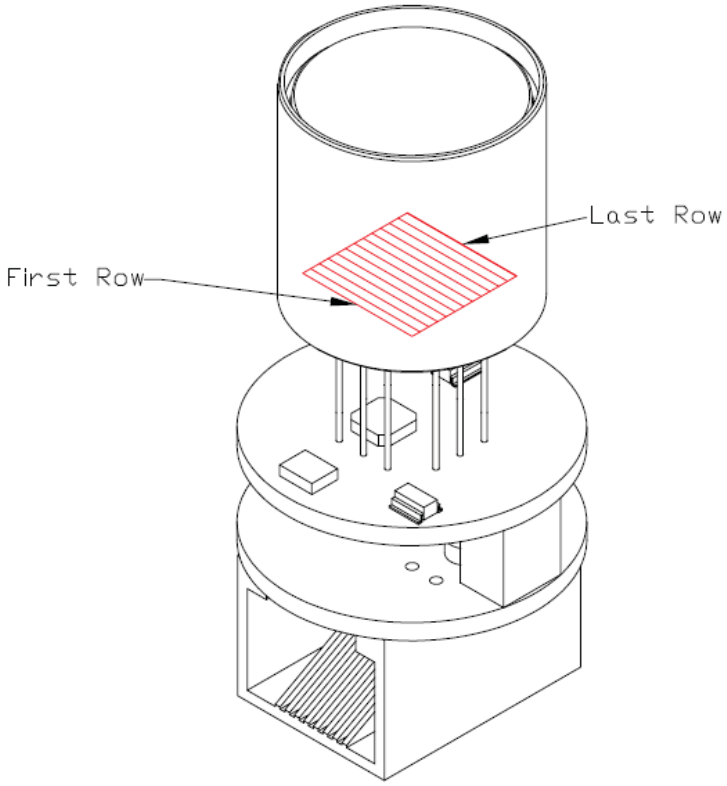
Protocol type:	UDP
All communication on Port:	30444

Power connection at Ethernet device:

1	VSS	(-)	GND
2	VDD	(+)	Supply (+3.3V DC)

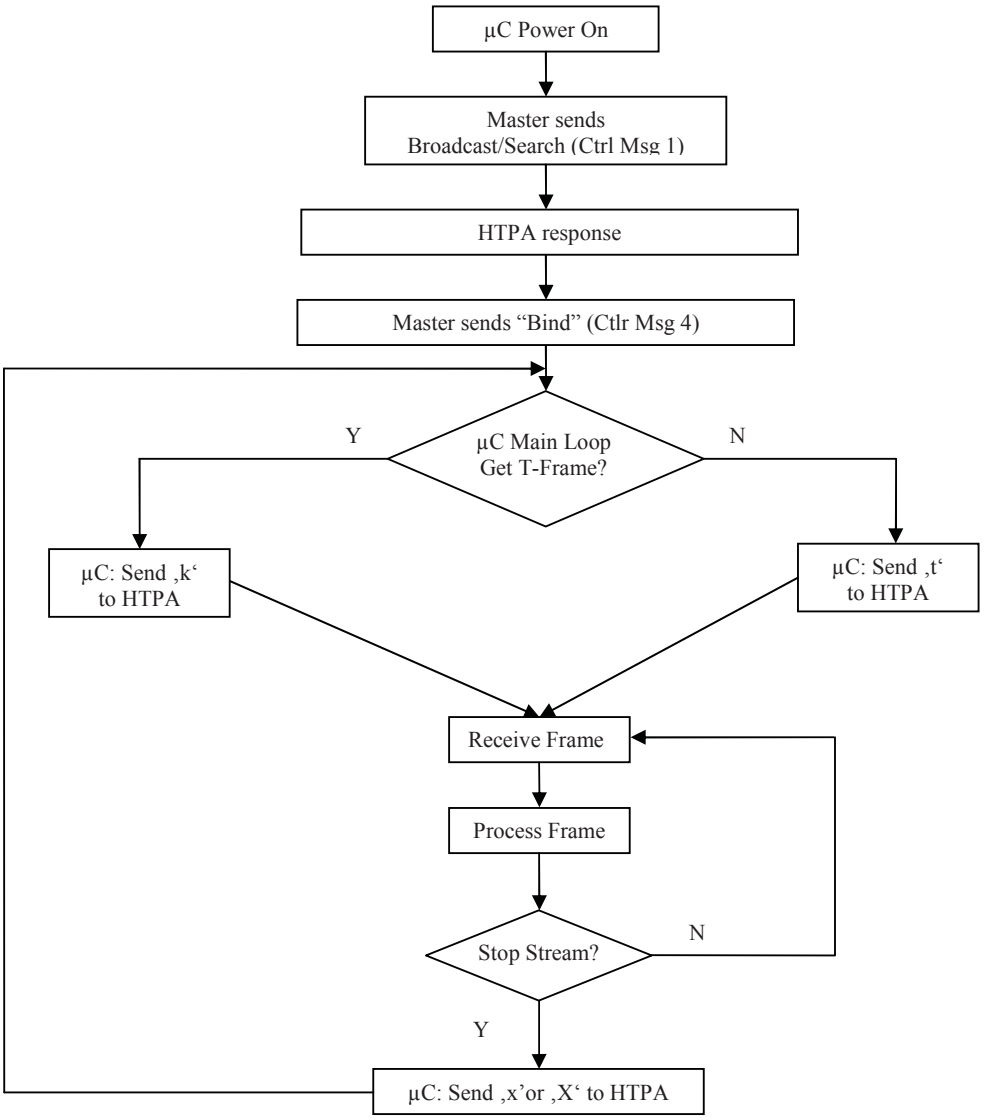
Power Supply: **3.3** VDC +/- 5%, 300mA

HTPA32x31L10/0.8M(UDP) Optical Orientation of Pixels:



Communication and Timings:

Proposed flow chart of communication. (Master is referred as µC, Slave as HTPA module)



Communication:

Communication via Terminal / UDP				
Sent Char	**HTPA8x8**	**HTPA16x16**	**HTPA32x31 HTPA64x62**	**Result/Received message**
'a'	X	X	X	Decreases the operating frequency of the array
'A'	X	X	X	Increases the operating frequency of the array
'b'	X	X	X	Measure VDD (referenced to VREF1225)
'C'	X	X		Capture single voltage frame. Use ADC of ASIC. Output via ASCII if sent via UART, binary if sent via UDP.
'c'	X	X	X	Capture single voltage frame. Use ADC of µC. Output via ASCII if sent via UART, binary if sent via UDP.
'd'/'D'	X	X		Toggle POR_N
'f'	X	X	X	Toggle Resetbit
'F'	X	X		Analog operating point is at start of AD-range, only positive signals convertable
'G'	X	X		Analog operating point is in the middle of AD-range, positive and negative signals convertable
'g'	X	X		Analog operating point is at end of AD-range, only negative signals convertable
'h'	X	X	X	pushes binary EEDATA out
'i'			X	Read single voltage frame. Output in ASCII format. Serial order: Pixeldata[K*10], el. Offsets, Ambient Temperature
'I'			X	Read single temperature frame. Output in ASCII format. Serial order: Pixeldata[K*10], el. Offsets, Ambient Temperature
'J'	X	X	X	Toggle Amplification
'k'	X	X	X	Read single temperature frame. Output in binary format.
'K'	X	X	X	send continous binary temperature datastream(µC-ADC)[K*10] Output of a complete cycle in this order: *HTPA 8x8 and HTPA16x16: Pixel0,Pixel1, ….PixelX, el.Offset0, el.Offset1,…, el.OffsetY,PTAT0,PTAT1,…,PTATZ* *HTPA32x31: see Table2.* ***For a detailed Description of the serial order see Table2.*** 16x16 Array: X=255; Y=7; Z=7 — 8x8 Array: X=63; Y=4; Z=4 One dataset has exactly 2 bytes: first the low-Byte is send, then the high-byte. Each Dataset contains the measured Temperature in Kelvin*10. The first 4 datasets *el.Offset0…el.Offset3* after the last Pixel voltage *PixelX* transmit additional the current VDD in the MSB's:
'l'	X	X	X	Get Ambient Temperature (Calculates the Ambient Temperature from the **last measured** Frame)
'm'	X	X	X	Toggle usage of µC-Buffer for el. Offsets (Stack depth = 64 for HTPA8x8 and HTPA16x16; Stack depth = 32 for HTPA32x31)
'M'	X	X	X	Shows current and calibration settings. Device prints the following stream: **"HTPA series responsed! I am Arraytype X"** Possible values for X: "0"=HTPA8x8, "1"=HTPA16x16, "3"=HTPA32x31 **"Firmware v.X.XX written by B.Forg; Heimann Sensor GmbH; YYYY-MM-DD"** Version information. **"I am running on XXXX.X kHz"** Actual MCLK-setting in kHz **"Amplification is X" Actual set amplification.** Possible strings for X: "low" or "high" **"MAC-ID: X IP: Y DevID: Z\r\n"** (Only Ethernet devices show a MAC-ID, DevID is shown in any case) X= MAC-ID of the device, i.e. "00.97.FF.00.10.08"; Y=current IP of the device, Z=user setable ID, range 00000…65535 **"PIXCvsTA *X*, BFL3 *X*, F8_14 *X*, THvsTA *X* IGNORE_ELOFF *X* ELOFF32 *X* SBY *Y* FC *X* EXP *Z*"**

VDD and TAmb for HTPA8x8 and HTPA16x16:

Dataset	Bit15	Bit14	Bit13	Bit12	Bit11	Bit10	…	Bit1	Bit0
elOff0	MSB VDD	…	…	Bit12 VDD	MSB elOff0	…	…	…	LSB elOff0
elOff1	Bit11 VDD	…	…	Bit8 VDD	MSB elOff1	…	…	…	LSB elOff1
elOff2	Bit7 VDD	…	…	Bit4 VDD	MSB elOff2	…	…	…	LSB elOff2
elOff3	Bit3 VDD	…	…	LSB VDD	MSB elOff3	…	…	…	LSB elOff3

The Sensor temperature is available in the datasets after *el.Offset3* :

Dataset	Bit15	Bit14	Bit13	Bit12	Bit11	Bit10	…	Bit1	Bit0
elOff3+1	MSB TAmb	…	…	Bit12 TAmb	MSB elOff3+1	…	…	…	LSB elOff3+1
elOff3+2	Bit11 TAmb	…	…	Bit8 TAmb	MSB elOff3+2	…	…	…	LSB elOff3+2
elOff3+3	Bit7 TAmb	…	…	Bit4 TAmb	MSB elOff3+3	…	…	…	LSB elOff3+3
elOff3+4	Bit3 TAmb	…	…	LSB TAmb	MSB elOff3+4	…	…	…	LSB elOff3+4
elOff3+5	0	0	0	0	MSB elOff3+5	…	…	…	LSB elOff3+5

Table 1a: Control Characters

<table>
<tr><th colspan="5">Communication via Terminal / UDP</th></tr>
<tr><th>Sent Char</th><th>HTPA8x8</th><th>HTPA16x16</th><th>HTPA32x31
HTPA64x62</th><th>Result/Received message</th></tr>
<tr><td>'o'</td><td></td><td>X</td><td>X</td><td>Use external reference voltages</td></tr>
<tr><td>'O'</td><td></td><td>X</td><td>X</td><td>Use internal reference voltages</td></tr>
<tr><td>'q'/'Q'</td><td>X</td><td>X</td><td>X</td><td>Allow Changes (required for Calibration)</td></tr>
<tr><td>'t'</td><td>X</td><td>X</td><td>X</td><td>Continuous binary voltage data of the µC-ADC is transmitted.
Output of a complete cycle in this order:

HTPA 8x8 and HTPA16x16: Pixel0,Pixel1, ….PixelX, el.Offset0, el.Offset1,…, el.OffsetY,PTAT0,PTAT1,…,PTATZ
HTPA32x31: see Table2.
For a detailed Description of the serial order see Table2.

16x16 Array: X=255; Y=7; Z=7   8x8 Array: X=63; Y=4; Z=4

One dataset has exactly 2 bytes: first the low-Byte is send, then the high-byte. Each Dataset contains the ADC-Data in digits and The first 4 datasets el.Offset0…el.Offset3 after the last Pixel voltage PixelX transmit additional the current VDD in the MSB's:

VDD for HTPA8x8 and HTPA16x16:
<table>
<tr><td>Dataset</td><td>Bit15</td><td>Bit14</td><td>Bit13</td><td>Bit12</td><td>Bit11</td><td>Bit10</td><td>…</td><td>Bit1</td><td>Bit0</td></tr>
<tr><td>elOff0</td><td>MSB VDD</td><td>…</td><td>…</td><td>Bit12 VDD</td><td>MSB elOff0</td><td>…</td><td>…</td><td>…</td><td>LSB elOff0</td></tr>
<tr><td>elOff1</td><td>Bit11 VDD</td><td>…</td><td>…</td><td>Bit8 VDD</td><td>MSB elOff1</td><td>…</td><td>…</td><td>…</td><td>LSB elOff1</td></tr>
<tr><td>elOff2</td><td>Bit7 VDD</td><td>…</td><td>…</td><td>Bit4 VDD</td><td>MSB elOff2</td><td>…</td><td>…</td><td>…</td><td>LSB elOff2</td></tr>
<tr><td>elOff3</td><td>Bit3 VDD</td><td>…</td><td>…</td><td>LSB VDD</td><td>MSB elOff3</td><td>…</td><td>…</td><td>…</td><td>LSB elOff3</td></tr>
</table></td></tr>
<tr><td>'T'</td><td>X</td><td>X</td><td></td><td>Continuous binary data of the ASIC-ADC is transmitted.
Output order is equal to 't'.</td></tr>
<tr><td>'u'</td><td>X</td><td>X</td><td></td><td>Continuous binary data of the ASIC-ADC is transmitted. PTAT-Voltages are sampled with the uC-ADC.
Output order is equal to 't'.</td></tr>
<tr><td>'U'</td><td>X</td><td>X</td><td></td><td>Capture single frame. Use ADC of ASIC. Output via ASCII. PTAT-Voltages are sampled with the uC-ADC.</td></tr>
<tr><td>'v'</td><td>X</td><td>X</td><td>X</td><td>Announce IP (Only Ethernet devices)</td></tr>
<tr><td>'V'</td><td>X</td><td>X</td><td>X</td><td>Device awaits control message (only non-Ethernet devices)</td></tr>
<tr><td>'w'</td><td>X</td><td>X</td><td>X</td><td>shows Calibration-constants</td></tr>
<tr><td>'W'</td><td>X</td><td>X</td><td>X</td><td>Calibration. ATTENTION! Old Dataset cannot be restored!</td></tr>
<tr><td>'x'</td><td>X</td><td>X</td><td>X</td><td>Stops Stream without prompt.</td></tr>
<tr><td>'X'</td><td>X</td><td>X</td><td>X</td><td>Stops Stream by sending "STOP!\r\n"</td></tr>
<tr><td>'y'</td><td>X</td><td>X</td><td>X</td><td>switch off ASIC-Supply (5V)</td></tr>
<tr><td>'Y'</td><td>X</td><td>X</td><td>X</td><td>switch on ASIC-Supply (5V)</td></tr>
</table>

Table 1b: Control Characters (continuation)

Please be aware, that the source and destination port has to be 30444

Serial order of data in stream:

HTPA32x31 Temperature Mode	
Dataset	Value
0	Temperature of Pixel0 in K*10
1	Temperature of Pixel16 in K*10
2	Temperature of Pixel1 in K*10
3	Temperature of Pixel17 in K*10
…	…
30	Temperature of Pixel15 in K*10
31	Temperature of Pixel31 in K*10
32	Temperature of Pixel32 in K*10
33	Temperature of Pixel48 in K*10
…	…
991	Temperature of Pixel991 in K*10
992	elOff0 in digits
993	elOff16 in digits
994	elOff1 in digits
995	elOff17 in digits
…	…
1022	elOff15 in digits
1023	elOff31 in digits
1024	least significant 12 bits of VDD
1025	most significant 4 bits of VDD
1026	least significant 12 bits of TAmb
1027	most significant 4 bits of TAmb
1028	no value, ignore
1029	no value, ignore
…	…
1039	no value, ignore
1040	PTAT0 in digits
1041	no value, ignore
1042	PTAT1 in digits
…	…
1053	no value, ignore
1054	PTAT7 in digits
1055	no value, ignore

HTPA32x31 Voltage Mode	
Dataset	Value
0	absolute Voltage of Pixel0 in digits
1	absolute Voltage of Pixel16 in digits
2	absolute Voltage of Pixel1 in digits
3	absolute Voltage of Pixel17 in digits
…	…
30	absolute Voltage of Pixel15 in digits
31	absolute Voltage of Pixel31 in digits
32	absolute Voltage of Pixel32 in digits
33	absolute Voltage of Pixel48 in digits
…	…
991	absolute Voltage of Pixel991 in digits
992	elOff0 in digits
993	elOff16 in digits
994	elOff1 in digits
995	elOff17 in digits
…	…
1022	elOff15 in digits
1023	elOff31 in digits
1024	least significant 12 bits of VDD
1025	most significant 4 bits of VDD
1026	no value, ignore
1027	no value, ignore
1028	no value, ignore
1029	no value, ignore
…	…
1039	no value, ignore
1040	PTAT0 in digits
1041	no value, ignore
1042	PTAT1 in digits
…	…
1053	no value, ignore
1054	PTAT7 in digits
1055	no value, ignore

Table 2: Serial order of data in stream

Each dataset consists of a 16 bit value. If a frame consists out of more than one packet, packets are appended.

Pixel Map:

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

Table 3: Pixelmap

Packets (UDP, only Ethernet device):

Number of packets	Packet size [byte]	HTPA type	Comments
1	144	HTPA8x8	-
1	544	HTPA16x16	-
2	1058+1054	HTPA32x31	see below for details
8	1101+621	HTPA64x62	see below for details

Packet details for HTPA32x31		
Packet No.	Packet size	Packet contains
1	1058	Data of Pixel0 - Pixel528
2	1054	Data of Pixel529 to end of frame

Each dataset (except of packet index) consists out of a 16 bit value. For serial order of the datasets refer to section “serial order in Frame”.

Control Messages:

In the set of control messages, expressions in angled braces have to be substituted by following strings:

[IP] insert IP in ASCII format, i.e.: *"192.168.240.122"*

[MACID] insert MAC ID in ASCII format and hexadecimal, i.e.: *"00.1A.22.33.44.55"*

[AT] insert index of array types in ASCII format

Array type	Index
HTPA 8x8	*"0"*
HTPA 16x16	*"1"*
HTPA 32x31	*"3"*
HTPA 64x62	*"5"*

[MCLK] insert Frequency of MCLK in ASCII format and kHz, i.e.: *"1050.1"*

[AMP] insert state of amplification in ASCII format:

State	String
Low	*"low"*
High	*"high"*

[MSK] insert subnet mask in ASCII format, i.e.: *"255.255.255.000"*

[DEVID] insert 5 digit device ID in ASCII format, i.e. *"00197"* Range: 00000… 65535

Set of control messages:

Message1: "Calling HTPA series devices" (only Ethernet device)
Conditions: Can be sent as Broadcast, or if device already known as normal packet.
Answer: "HTPA series responsed! I am Arraytype **[AT]**"
Firmware version, date and author information.
"I am running on **[MCLK]** kHz"
"Amplification is **[AMP]**\r\n"
"MAC-ID: **[MACID]** IP: **[IP]**\r\n"
A second packet with calibration depending information is send.

Message2: "x Release HTPA series device" (only Ethernet device)
Result: Device disables hardware IP filter. All packets except ARP's, DHCP requests, Broadcasts, Message1, Message3 and Message4 are discarded.
Answer: "HW-Filter released\r\n"

Message3: "HTPA device IP change request to **[IP]**.**[MSK]**." (only Ethernet device)
Result: The device changes the IP and the subnet mask to the given value and writes it to EEPROM. The IP becomes the default IP, therefore the device will use it at the next reset, if no DHCP is found.
Answer: "Device changed IP to **[IP]**. and Subnet to **[MSK]**.\r\n"

Message4: "Bind HTPA series device" (only Ethernet device)
Result: Device enables hardware IP filter. Only packets from sender IP, ARP's, DHCP requests and Broadcasts are accepted. Device accepts now the control characters listed in **Table 1.**
Answer: "HW Filter is **[IP]** MAC **[MACID]**\n\r""
Insert in the above string the IP and MAC-ID of the Sender from Message4.

Control Messages [continued]:

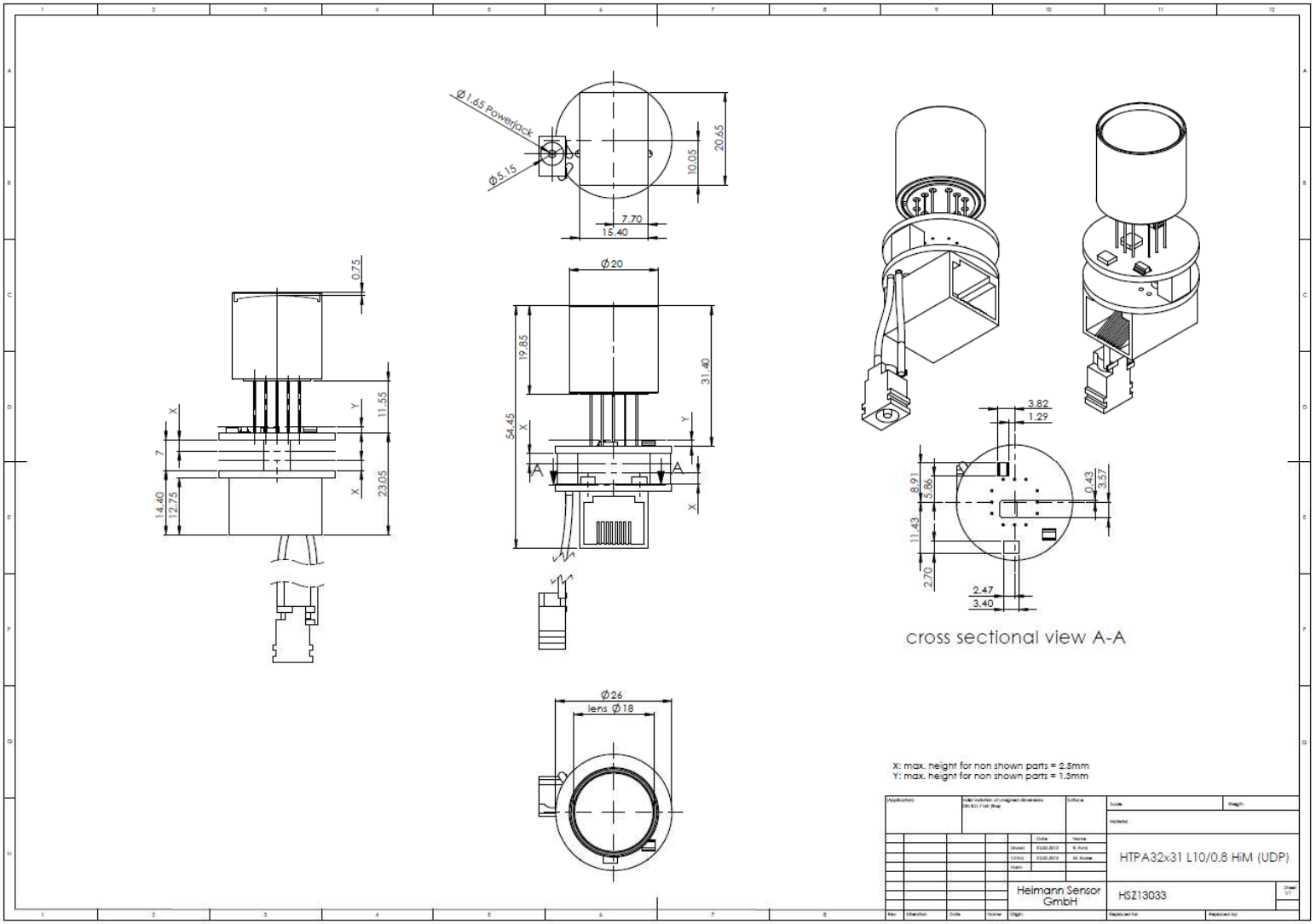
Message5:	"Set EEPROM data"
Conditions:	Only possible if Message 4 already successful sent. **ATTENTION!** Calibration data is overwritten!!!
Result:	Writes the next received packets into EEPROM, if packet size is equal to 1024 bytes. Device writes to EEPROM, until EEPROM is completely filled. EEPROM size depends on Device type: HTPA8x8, HTPA16x16 and HTPA32x31: 16384 byte; HTPA64x62: 65536 byte.
Answer:	"Write was successful.\n\r"

Message6:	"Set DeviceID to **[DEVID]**"
Result:	The given Device ID **[DEVID]** is written to EEPROM. This ID is shown on receive of 'M'. The eDevice ID can be used for customer specific purposes.
Answer:	"DeviceID changed to **[DEVID]**\r\n"

Specification for HTPA32x31L10/0.8HiM(UDP)

Rev.0: 2013.04.26 Hu

Dimensions:



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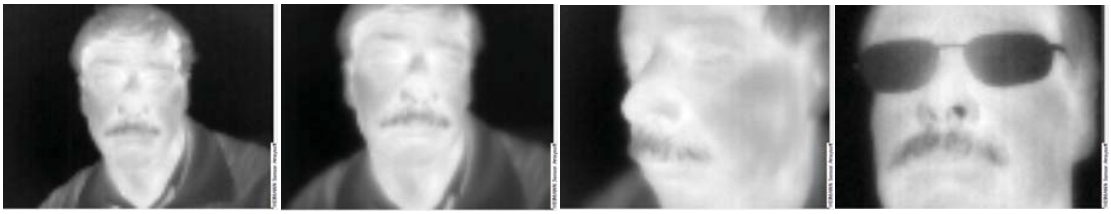
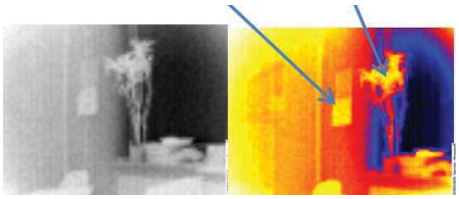
Thermal Images taken with 82x62 array and L17 or L11 optics:

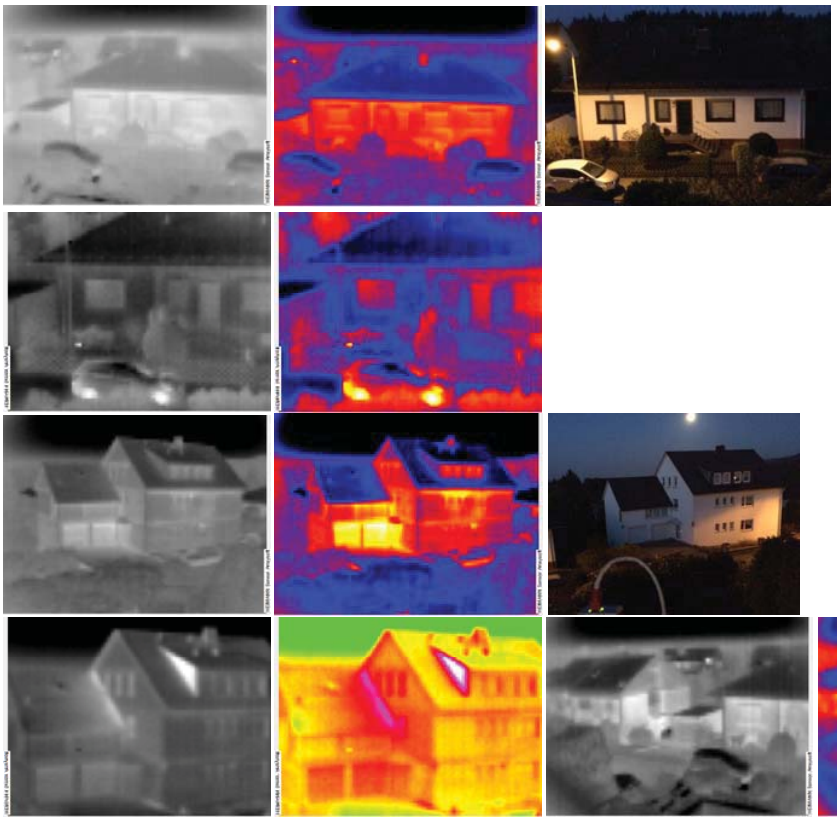
Portraits:



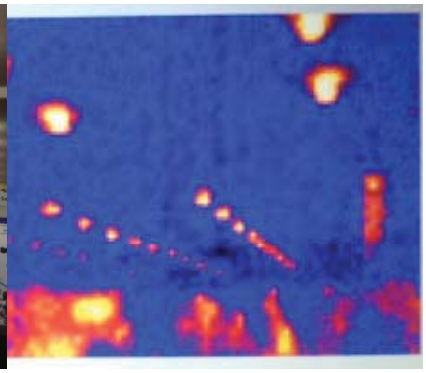
Sheet almanac and Flower pot:



Looking out for buildings at nighttime, outside temp. +2 °C:

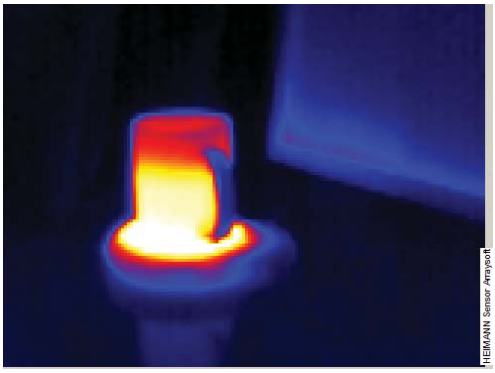


Visible camera



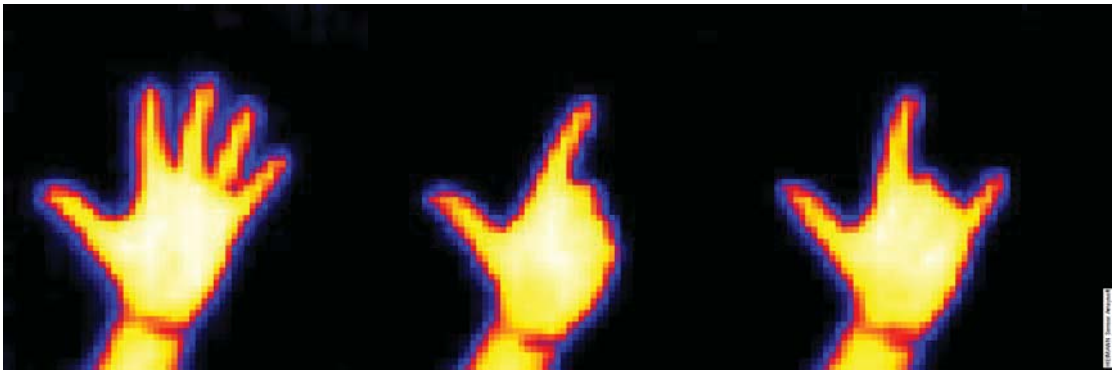
HTPA 64x62

Exhibit hall



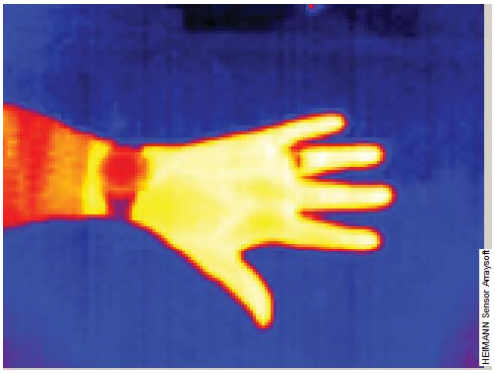
HTPA 82x62

Coffee mug on warmer



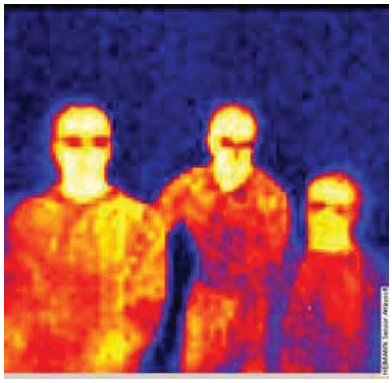
HTPA 32x31

Hand gesture recognition



HTPA 82x62

Hand with watch and ring

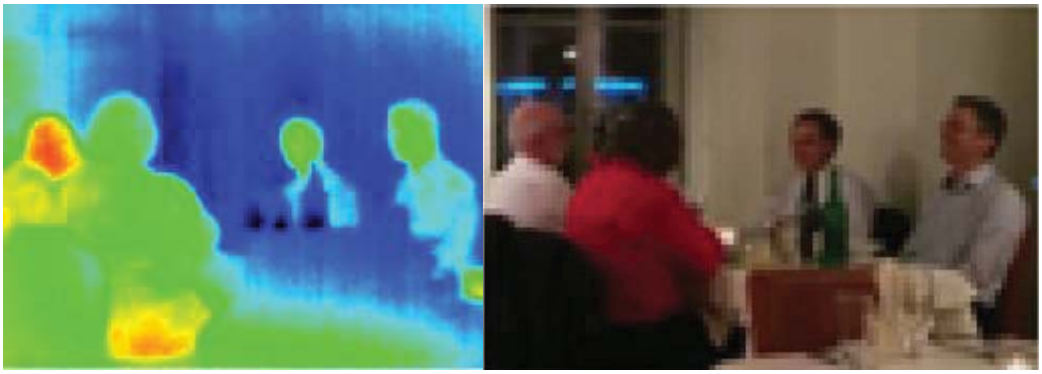


HTPA 64x62

Group photo

HTPA 64x62

Portrait of the boss



HTPA 82x62

Fever detection