

Preliminary Sample Specification: Thermopile Array Sensors

TPL 086 L5.5 / Module
TPA 166 L3.9 / Module
TPL 166 L5.5 / Module

The integrated ThermoPile Linear or Matrix Array Sensors consist of an 1 x 8, 4 x 4 or 1 x 16 -element thermopile chip connected to an integrated multiplexing and signal conditioning circuit. The components are available in a TO39 metal housing with an integrated lens. Lenses for different field of views are available on demand. The sensor is equipped with an internal reference temperature sensor for correct target temperature determination. All analogue signals including the ambient temperature are given out in a fixed frame, containing all information in one serial stream. We offer also a module version where the sensor is mounted on a small pcb and the calibration data for this specific sensor are stored in an E_PROM.

Customer :

Type :

Number of Samples :

Date :

Checked by :

Sample data:

Sensor No.	Type	Protocol	CW	Year	PTSlope	PTOffset	overall component sensitivity		
							μV	mV/V	

Sensor No.	rel. P. s	Offset	rel. P. s	Offset	rel. P. s	Offset	rel. P. s	Offset	rel. P. s	Offset	rel. P. s	Offset	rel. P. s	Offset	rel. P. s	Offset
	Pixel 1	Pixel 1	Pixel 2	Pixel 2	Pixel 3	Pixel 3	Pixel 4	Pixel 4	Pixel 5	Pixel 5	Pixel 6	Pixel 6	Pixel 7	Pixel 7	Pixel 8	Pixel 8

Sensor No.	rel. P. s	Offset	rel. P. s	Offset	rel. P. s	Offset	rel. P. s	Offset	rel. P. s	Offset	rel. P. s	Offset	rel. P. s	Offset	rel. P. s	Offset
	Pixel 9	Pixel 9	Pixel 10	Pixel 10	Pixel 11	Pixel 11	Pixel 12	Pixel 12	Pixel 13	Pixel 13	Pixel 14	Pixel 14	Pixel 15	Pixel 15	Pixel 16	Pixel 16

offset in mV	relative pixel sensitivity in % (of overall component sensitivity)
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Handling

Electrostatic charges may destroy the detector. We recommend to apply precautions necessary for ESD sensitive devices to avoid damages. Do not apply physical force to detector leads.

Geometrical Dimensions

see attached drawings

Solderability, Sensor Version

leads pre-tinned

Temperature Ranges

Parameter	Min	Typical	Max	Unit	Condition
storage	-40		100	°C	
operating	-20		100 / 85	°C	sensor / module
object	-20		100	°C	limited only by output voltage range

Optics

silicon planoconvex lens, no coating

Parameter	Min	Typical	Max	Unit	Condition
optical axis	-3.5	0	3.5	°	in ref. to sym. axis of cap f= 5.5mm
optical axis	-6.5	0	6.5	°	in ref. to sym. axis of cap f=3.5mm
sensor axis rotation	-3	0	3	°	in ref. to tab position,

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Available Sensor / Lens combinations

Typical value field of view /°	full fov x	full fov y	peakpeak x	peakpeak y
TPL086L5.5	41	6	33	-
TPL086L10.6	21.5	3	16.5	-
TPL166L5.5	36	8	32	-
TPA166L3.5	48	36	36	24
TPA166L3.9	41	32	30	22
TPA166L5.5	27	21	21	14
TPA166L10.6	15	11	11.5	8.5

Also available on special request

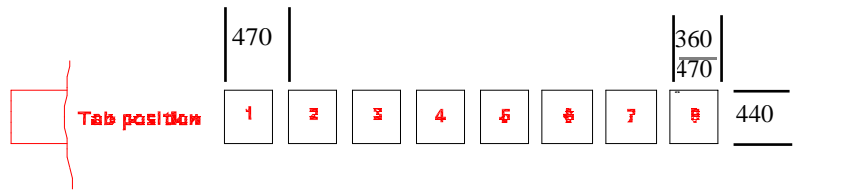
Typical value field of view /°	full fov x	full fov y	peakpeak x	peakpeak y
TPL086L3.0	87	14	75	
TPL086L3.9	56	8	48	
TPL086L4.7	47	7	39	
TPL086L8.0	26	3.5	22	
TPL166L3.9	51	9	47	
TPA166L3.0	61	48	44	30
TPA166L4.7	31	24	25	17
TPA166L8.0	19	14.5	14.5	10

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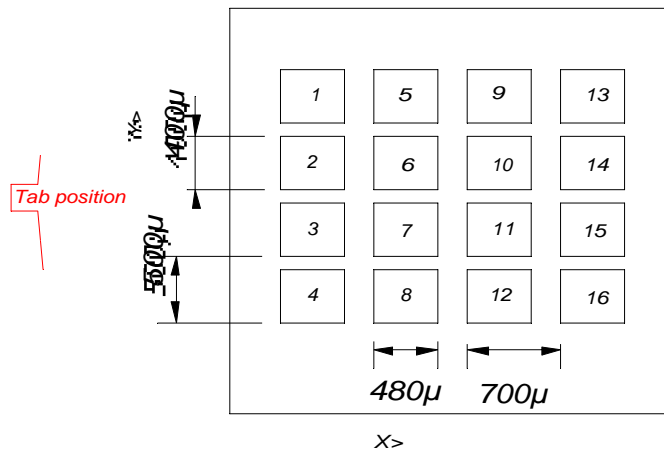
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Pixel Numbering

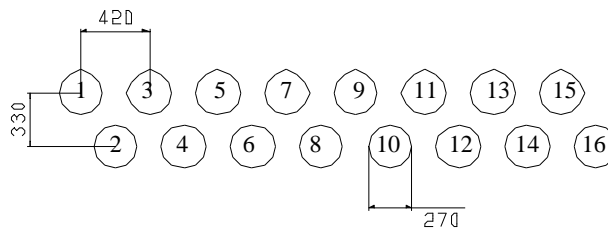
TPL086



TPA166



TPL166



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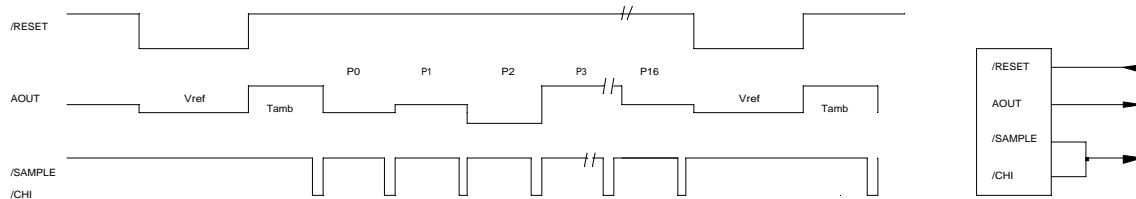
Sensor Operation

Automatic Increment Mode

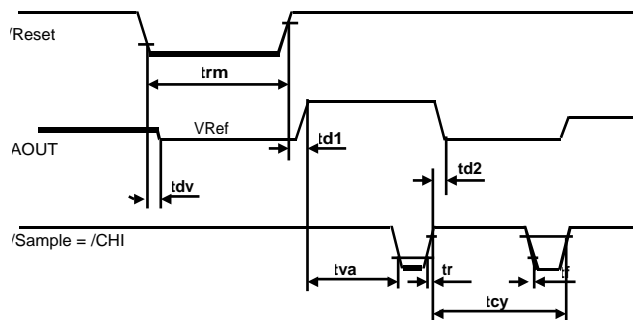
In this operation mode the /SAMPLE pin is directly connected to the /CHI pin to achieve an automatic increment of the integrated multiplexer. For synchronisation as well as for ambient temperature readout the sensor can be reset by activating pin /RESET as shown below.

During /RESET active, an internal reference Voltage “Vref” (nominal Vdd/2) is connected to AOUT. After releasing /RESET the ambient temperature signal appears on the rising edge of /SAMPLE. Subsequently all pixel signals are output according to the diagram below. After pixel 16 (type TPL086: 8 valid pixels followed by 8 dummy pixels) the sequence repeats with (dummy-) pixel P0 again. AOUT is not valid during /SAMPLE active.

The last row shows that the subsequent pixel is being processed while current pixel is given out.



Timing Auto Increment Mode



Parameter	Symbol	Min	Typ	Max	Condition	Unit	
Delay time output voltage valid to /RESET high	td1	5	10	20		µs	
Delay time output voltage valid to /SAMPLE high	td2	5	10	20		µs	
Output voltage valid	tva	270	300	400		µs	
Minimum time /RESET active	trm	20				µs	
Maximum rise time /SAMPLE output	tr	10	20	50	100pF	ns	
Maximum fall time /SAMPLE output	tf	10	15	30	100pF	ns	
Cycle time	tcy	250	320	500		µs	

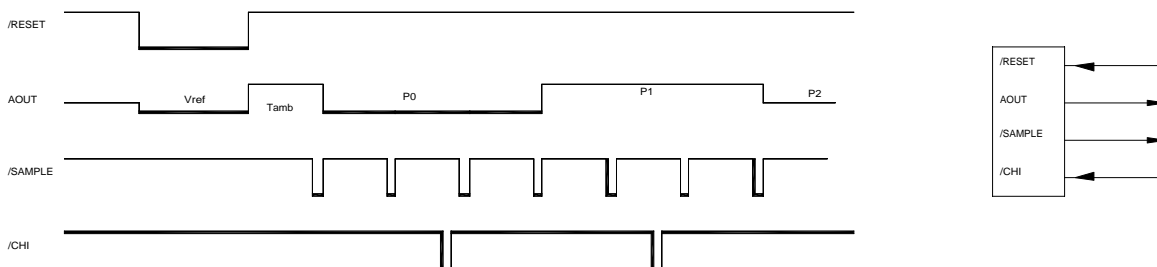
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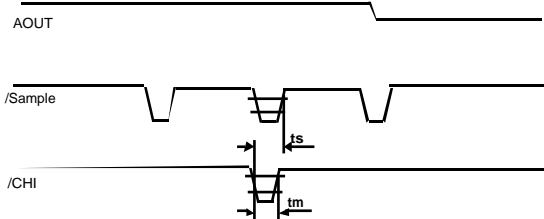
Manual Increment Mode

In this operation mode the /SAMPLE and /CHI pin are separated and allow the user to increment the multiplexer manually. In general the sensor behaves similar to the automatic increment mode, however the AOUT pin shows the same pixel until /CHI is triggered to the next channel. This mode is to be preferred if the performance of the ADU and/or ACU is slower than the output frequency of the TPA166L3.5

Each channel signal can be read out after 2nd pulse of /sample.



Timing Manual Increment Mode



Parameter	Symbol	Min	Typ	Max	Condition	Unit	
Setup time falling /CHI to rising /SAMPLE	ts	200				ns	
Minimum time /CHI active	tm	150	300	500		ns	

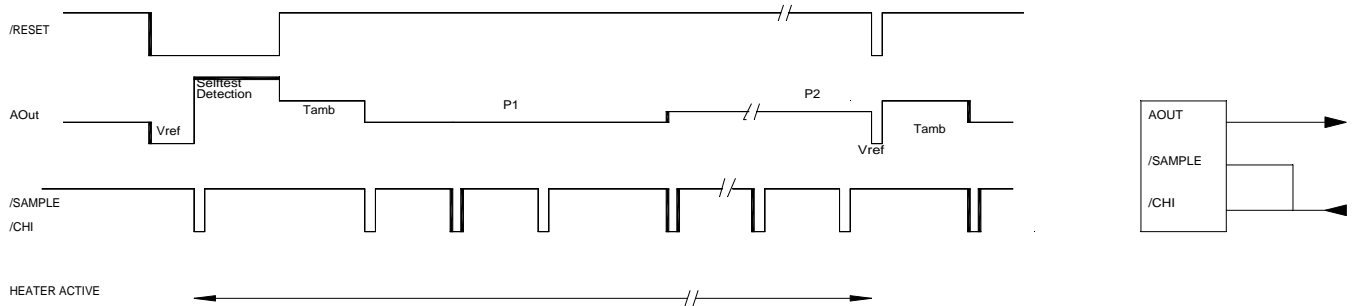
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Self test control function (only TPA166)

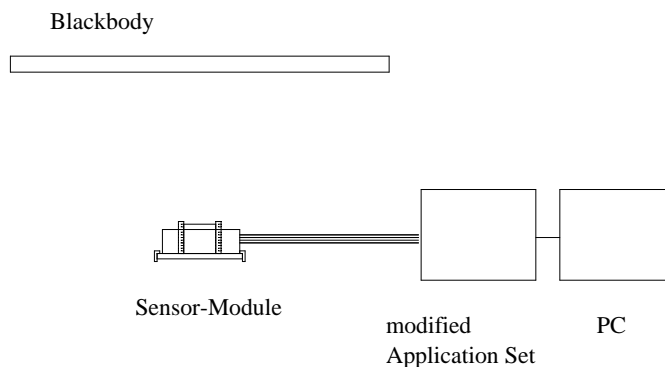
The sensor is equipped with an internal self test function. Physically this self test is implemented by a heater structure on the focal plane which surrounds the sensitive areas. The flow of heating current can be started by an input pulse at the /CHI pin during /RESET active and stopped by a following /RESET command. During /RESET active the /SAMPLE-output is switched to an input with internal pull-up for easier interface.

For further security the active self test is shown in the running cycle by a voltage close to the positive supply voltage during /RESET is kept low.



Test Conditions Sensitivity

Blackbody Temperature	80 °C
Distance between blackbody and thermopile array/module	200 mm



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Maximum Rating

Parameter	Min	Typical	Max	Unit	Condition
Power supply voltage	-0.5		7	V	
Input voltage	0		V_{DD}	V	/CHI and /SAMPLE
ESD protection			2.5	kV	

Electrical Parameter

Parameter	Min	Typical	Max	Unit	Condition
Sensitivity TPL 086 L5.5 $V_{P4/5} - V_{P0}$		0.95		V	full field covered by black body $T_{BB} = 80^{\circ}\text{C}$, $T_{amb} = 20^{\circ}\text{C}$, distance=200mm
Sensitivity TPA 166 L3.9 $V_{P4/5} - V_{P0}$		0.95		V	full field covered by black body $T_{BB} = 80^{\circ}\text{C}$, $T_{amb} = 20^{\circ}\text{C}$, distance=200mm
Sensitivity TPL 166 L5.5 $V_{P4/5} - V_{P0}$		0.35		V	full field covered by black body $T_{BB} = 80^{\circ}\text{C}$, $T_{amb} = 20^{\circ}\text{C}$, distance=200mm
Thermal time const.		18	30	ms	will not be tested
Output Noise Voltage		0.4	0.8	$\text{mV}/\sqrt{\text{Hz}}$	0.5..20 Hz, will not be tested
distance dependency (calculated temperature)		-0.02		K/mm	between 50mm and 300 mm $T_{obj} = 80^{\circ}\text{C}$ @ 25°C T_{amb}
Operating voltage V_{DD}	4.7	5	5.3	V	
Operating Current		1	1.2	mA	@ 5V, 25°C
Zero signal offset V_{ref}	$V_{DD}/2.1$	$V_{DD}/2$	$V_{DD}/1.9$	V	
Output voltage range	$V_{SS}+0.5$		$V_{DD}-0.5$	V	
Output resistance			200	Ω	
Output load	50 k Ω		50 pF		
Low Level Input	0		1.5	V	
High Level Input	3.5		V_{DD}	V	
Power up time		0.3	0.5	s	
Sample Frequency	2	3	4	kHz	
Duration of sample pulse	3.9	5	7.8	μs	
PTAT:					Sensor Temperature Reference
Temp. Ref. Slope PS	9.3	10	10.296	mV/K	$V_{temp} = PS \cdot T_{amb}/K + PO$
Temp. Ref. Offset PO	-150		150	mV	
PTAT Accuracy	-0.4	0	0.4	$^{\circ}\text{C}$	Protocol vers.3, accuracy of voltage measurement at least 1.2mV

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Temperature Calculation based on the E_PROM content (Module version, Optics without filter coating)

Signal Filtering

After analog-digital conversion any type of lowpass filtering should be implemented to reduce the bandwidth according to the application. This reduces the fluctuation of the sensor signals. Because the ambient temperature (sensor temp.) is used as a base for the calculation, the lowpass filter for the ambient temperature can be set to 0.1Hz. Due to thermal mass of component and a preferred weak thermal coupling to environment, the sensor temp. is changing slowly.

EEPROM Operation

Write Operations

BYTE WRITE: Following a start condition, a write operation requires a 7-bit data word address and a low write bit. Upon receipt of this address, the EEPROM will again respond with a zero and then clock in the first 8-bit data word. Following receipt of the 8-bit data word, the EEPROM will out-put a zero and the addressing device, such as a microcontroller, must terminate the write sequence with a stop condition. At this time the EEPROM enters an internally-timed write cycle to the nonvolatile memory. All inputs are disabled during this write cycle , t_{WR} , and the EEPROM will not respond until the write is complete.

WARNING: The EEPROM has no write protection. A write operation can change the stored calibration data.

Read Operations

Read operations are initiated the same way as write operations with the exception that the read/write select bit in the device address word is set to one. There are two read operations: byte read and sequential read.

BYTE READ: A byte read is initiated with a start condition followed by a 7-bit data word address and a high read bit. The EEPROM will respond with an acknowledge and then serially output 8 data bits. The microcontroller does not respond with a zero but does generate a following stop condition (refer to Figure 1).

SEQUENTIAL READ: Sequential reads are initiated the same as a byte read. After the microcontroller receives an 8-bit data word, it responds with an acknowledge. As long as the EEPROM receives an acknowledge, it will continue to increment the data word address and serially clock out sequential data words. When the memory address limit is reached, the data word address will "roll over" and the sequential read will continue. The sequential read operation is terminated when the microcontroller does not respond with an input zero but does generate a following stop condition (refer to Figure 2).

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Figure 1. Byte Read

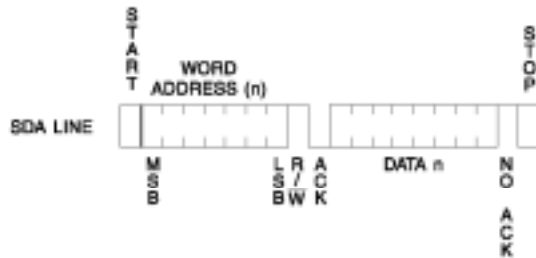
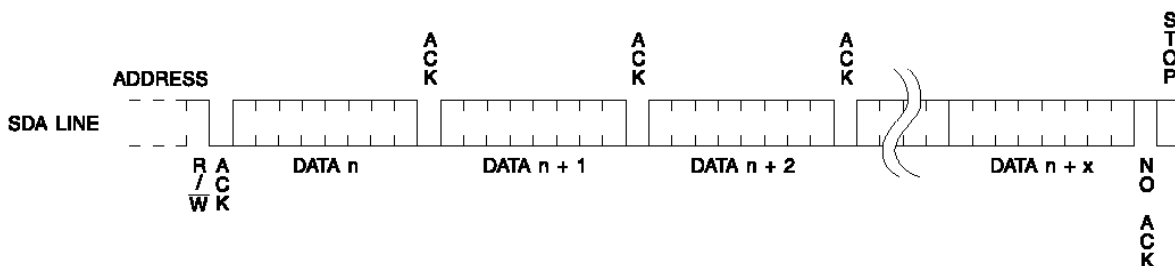


Figure 2. Sequential Read



CLOCK and DATA TRANSITIONS: The SDA pin is normally pulled high with an external device. Data on the SDA pin may change only during RESET/SCL low time periods (refer to Data Validity timing diagram). Data changes during RESET/SCL high periods will indicate a start or stop condition as defined below.

START CONDITION: A high-to-low transition of SDA with RESET/SCL high is a start condition which must precede any other command (refer to Start and Stop Definition timing diagram).

STOP CONDITION: A low-to-high transition of SDA with RESET/SCL high is a stop condition which terminates all communications. After a read sequence, the stop command will place the EEPROM in a standby power mode (refer to Start and Stop Definition timing diagram).

ACKNOWLEDGE: All addresses and data words are serially transmitted to and from the EEPROM in 8-bit words. Any device on the system bus receiving data (when communicating with the EEPROM) must pull the SDA bus low to acknowledge that it has successfully received each word. This must happen during the ninth clock cycle after each word received and after all other system devices have freed the SDA bus. The EEPROM will likewise acknowledge by pulling SDA low after receiving each address or data word (refer to Acknowledge Response from Receiver timing diagram).

STANDBY MODE: The EEPROM features a low power standby mode which is enabled:

- (a) upon power-up and
- (b) after the receipt of the STOP bit and the completion of any internal operations.

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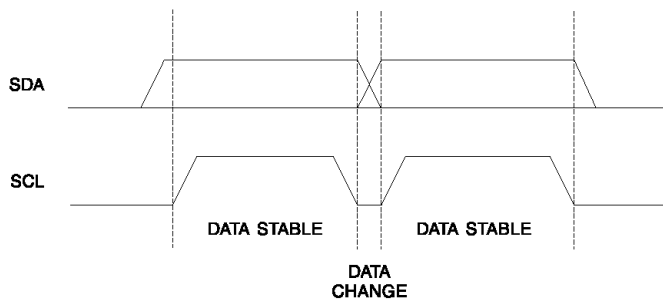
MEMORY RESET: After an interruption in protocol, power loss or system reset, any 2-wire part can be reset by following these steps:

- (a) Clock up to 9 cycles,
- (b) look for SDA high in each cycle while RESET/SCL is high and then
- (c) create a start condition as SDA is high.

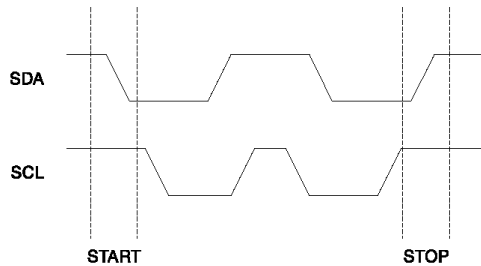
BUS TIMING: For details see attached EEPROM Specification

Data Validity

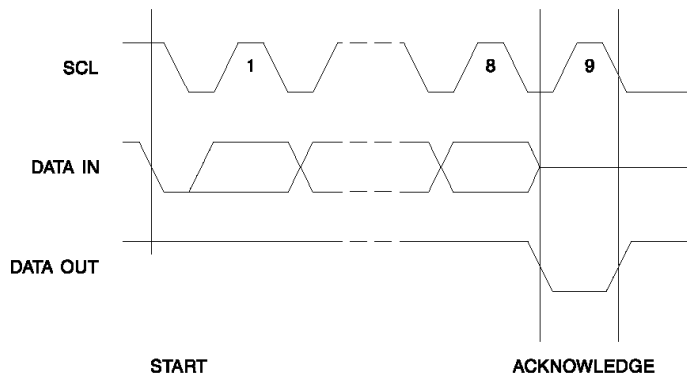
SCL: RESET / Serial Clock
 SDA: Serial Data I/O



Start and Stop Definition



Output Acknowledge



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Module - Stored Data (L 5.5, L3.9, L3.5 types)

Byte-Offset	Type	ID	Meaning	Effective range		Resolution per digit	units	Length in Byte
				low	high			
0-3	Uint8		set to zero					
4	Uint8	PR	Protocol, for this protocol version "3" is defined.	0	255	-		1
5	Uint8	DS	Data Size, for this type of ROM a "1" (128byte) is defined.	0	255	-		1
6	Uint8	CB	Checksum (EXOR- of remaining 127 byte of data) for consistency check	0	255	-		1
7	Uint8	PS	PTAT internal temperature sensor Slope	9.3	10.296	0.003906	mV/K	1
8	Uint8	PO	PTAT internal temperature sensor Offset	-156	155.1	1.22	mV	1
9	Uint16	SC	Component Sensitivity, outputvoltage V-V ₀ div. by radiated power density	0	13107	0.2	μV/W/m ₂	2
11	Uint8	S[1..16]	Pixel-Sensitivity in relation to component sensitivity (=100%)	70	138.9	0.27	%	16
27	Uint8	O[1..16]	Pixel-Offset, offset deviation for individual pixel	-256	254	2	mV	16
43	Uint16	CT	Component Type	0	6.5e4	-		2
44	Uint32	NO	Component Identifier unique number for retracing	0	4.29e9	-		4
49	Uint8	TP	Testparameter represents calibration procedure	0	255	-		1
50	Uint8	KW	Calendar Week	0	255	-		1
51	Uint8	KY	Calendar Year	0	255	-		1
52-127	tbd		Regressions-Factors not in use for uncoated lenses	0	255	-		76

For Parameters using more than 1byte the most significant byte is always at the lower address.

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Module - Stored Data (<L3.5 Types)

Byte-Offset	Type	ID	Meaning	Effective range low	Effective range high	Resolution per digit	units	Length in Byte
0-3	Uint8		set to zero					
4	Uint8	PR	Protocol, for this protocol version “4” is defined.	0	255	-		1
5	Uint8	DS	Data Size, for this type of ROM a “1” (128byte) is defined.	0	255	-		1
6	Uint8	CB	Checksum (EXOR- of remaining 127 byte of data) for consistency check	0	255	-		1
7	Uint8	PS	PTAT internal temperature sensor Slope	9.3	10.296	0.003906	mV/K	1
8	Uint8	PO	PTAT internal temperature sensor Offset	-156	155.1	1.22	mV	1
9	Uint16	SC	Component Sensitivity, outputvoltage $V-V_0$ div. by radiated power density	0	13107	0.2	$\mu\text{V/W/m}^2$	2
11	Uint8	S[1..16]	Pixel-Sensitivity in relation to component sensitivity (=:100%)	50	139.3	0.35	%	16
27	Uint8	O[1..16]	Pixel-Offset, offset deviation for individual pixel	-256	254	2	mV	16
43	Uint16	CT	Component Type	0	6.5e4	-		2
44	Uint32	NO	Component Identifier unique number for retracing	0	4.29e9	-		4
49	Uint8	TP	Testparameter represents calibration procedure	0	255	-		1
50	Uint8	KW	Calendar Week	0	255	-		1
51	Uint8	KY	Calendar Year	0	255	-		1
52-127	tbd		Regressions-Factors not in use for uncoated lenses	0	255	-		76

For Parameters using more than 1byte the most significant byte is always at the lower address.

Temperature Calculation (optics without filter coating, module version)

$$T_{\text{ambient/sensor}} = \frac{V_{T_{\text{amb}}} - PO_{(PTAT \text{ Offset})}}{PS_{(PTAT \text{ Slope})}}$$

$$T_{\text{obj}} = \sqrt[4]{\frac{V_{P_n} - V_{P_0} - O_n}{5.67 \cdot 10^{-8} \text{ Wm}^{-2} \text{ K}^{-4} \cdot SC \cdot S_n}} + T_{\text{amb}}^4$$

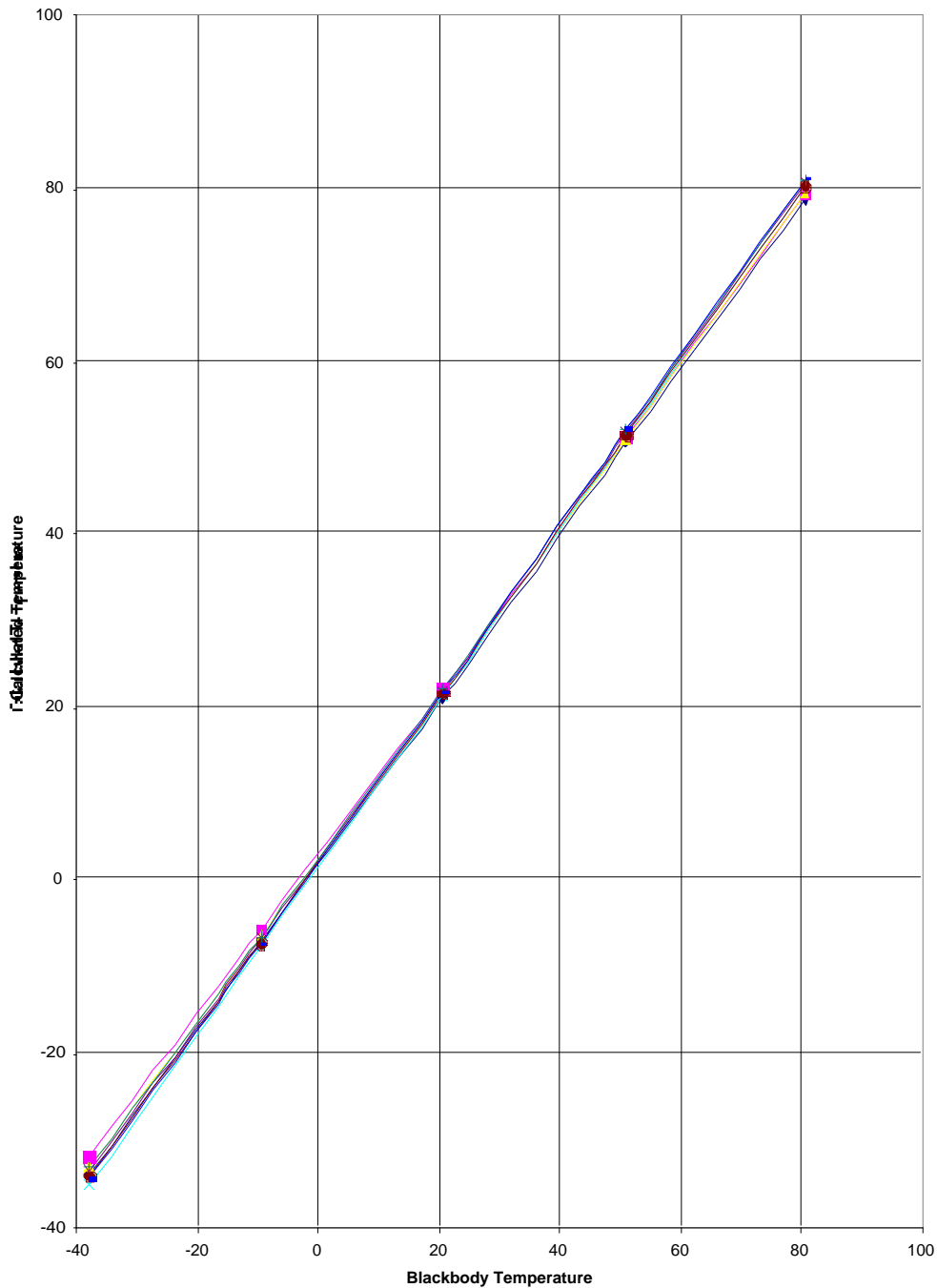
$V_{P_n}, V_{P_0}, V_{T_{\text{amb}}}$ = measured voltages, Temperatures $T_{\text{amb}}, T_{\text{obj}}$ in K

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Typical Temperature Calculation Result

Temperature Curve No. L316



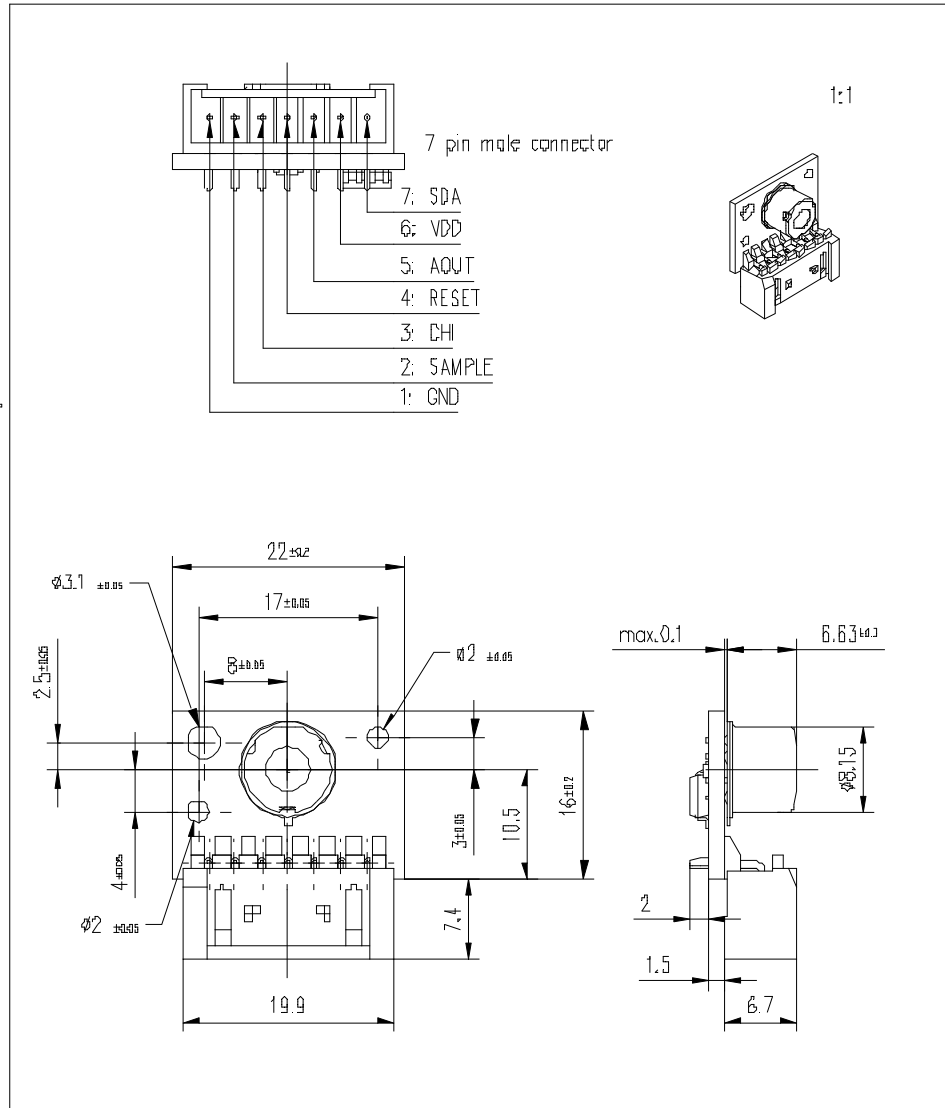
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Module - Geometrical Dimensions and Pin Assignment TPAM

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Allgemein toleranzen GENERAL TOLERANCES				Verfahrens-/LÖTLÖS-ANFORDERUNGEN METHODS ACC. DIN 624		Form- u. Lage toleranzen GEOMETRICAL TOLERANCES	
	Datum DATE	Name NAME	Werkstoff MATERIAL		 PerkinElmer optoelectronics.		
Gez. DRAWN BY	28.07.00	Tkocz					
Gepr. CHECKED BY							
Messstab SCALE	Benennung/TITLE			Zeichnung Nr./DRAWING NO.			
	2:1 (1:1)			2/71132			
	TPAM 166 L3.9 THERMOPILE MATRIX ARRAY (16 ELEMENTS) WITH MULTIPLEXER			Uberschrift/SPECIFICATION			
				Ersatz für/REPLACEMENT FOR			
				Ersatz durch/REPLACED BY			

A4.dwg