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VERSION CHANGE

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Data Sheet

MTCS-TIAM3

**Integral True Color Sensor IC
XYZ Tri-stimulus function
with integrated amplifier**

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1 INTRODUCTION

MTCS-TIAM3 is a True Color Sensor IC with integrated amplifier. The IC is packaged into a FR4-board / plastic package. It includes XYZ (RGB) filters and is specialized for color measurements based on the tri-stimulus function.

The True Color Sensors are made of 19 x 3 photo diodes (special PIN silicon technology with extended sensibility) integrated on chip. The diodes are carried out as segments of a multiple-element hexagonal matrix structure with the diameter of 2,0 mm.

The design as Si-PIN photo diodes allows signal frequencies up to high-range. In order to achieve a small cross talk between the photodiodes the individual sectors are separated from each other by additional structures.

Each of these photodiodes is sensitized with new dielectric spectral filter (named True Color Filter¹) for its color range, preferably for the primary color standard **CIE (Commission Internationale de l'Eclairage or International Commission on Illumination) color space**.

The MTCS-TIAM3 comes with an integrated parallel 4-channel amplifier (see also the data sheet MTI04C of MAZeT) with the ability to set customized the transimpedance at eight different levels.

The current input and voltage output for the external signal (fourth channel which is not directly used for color measurement) is also connected for custom specific applications for instance additional temperature compensation.

2 APPLICATION

- General Color Measurements, checks and regulations
- Portable color reader for consumer and industrial applications
- Closed loop for RGB lighting (SSL) – regulation of temperature shifts
- Sensor for display color adjustment and backlight/contrast control
- Color sensitive sensor for “True Color” reproduction and system calibration
- Detector for various light sources, mood lighting, regulated color temperature

3 FEATURES

- high-resolution conversion of colored light to voltages
- simultaneous measurement of XYZ three colors
- high sensitiveness, transmission, signal frequency
- no ageing of the filter, high temperature stability
- reduced cross talk and linear amplifying
- programmable adjustment of transimpedance
- power down feature
- small in size, lead free
- alike tri-stimulus interference filter for color measurement to DIN 5033 (CIE 1931)
- LCC package (SMD)
- EU RoHS-compliant²



Figure 1: TIAM3

¹ The new generation of JENCOLOR sensors is committed to implementing (see relative sensitivity) the standard distribution functions as defined under DIN 5033 Part 2 – Color Measurement; CIE 1931 Standard Colorimetric Systems. This implementation method allows colors to be determined according to the three-range procedure that is defined in part 6 of DIN 5033.

² EU RoHS: Directive 2002/95/EC of the European Parliament and of the Council of 27 January 2003 on the restriction of the use of certain hazardous substances in electrical and electronic equipment.

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4 BLOCK DIAGRAM

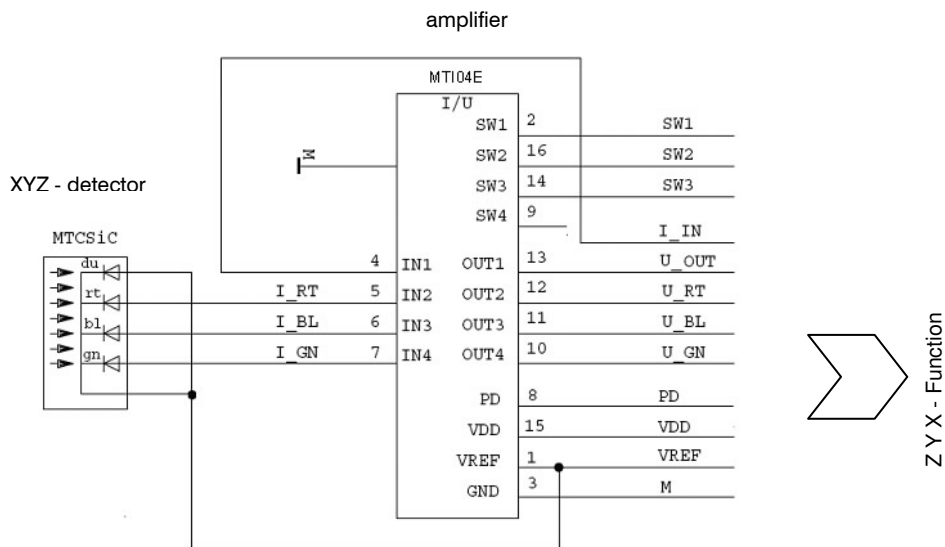


Figure 2: on Chip detector MTCSi and amplifier MTI04E

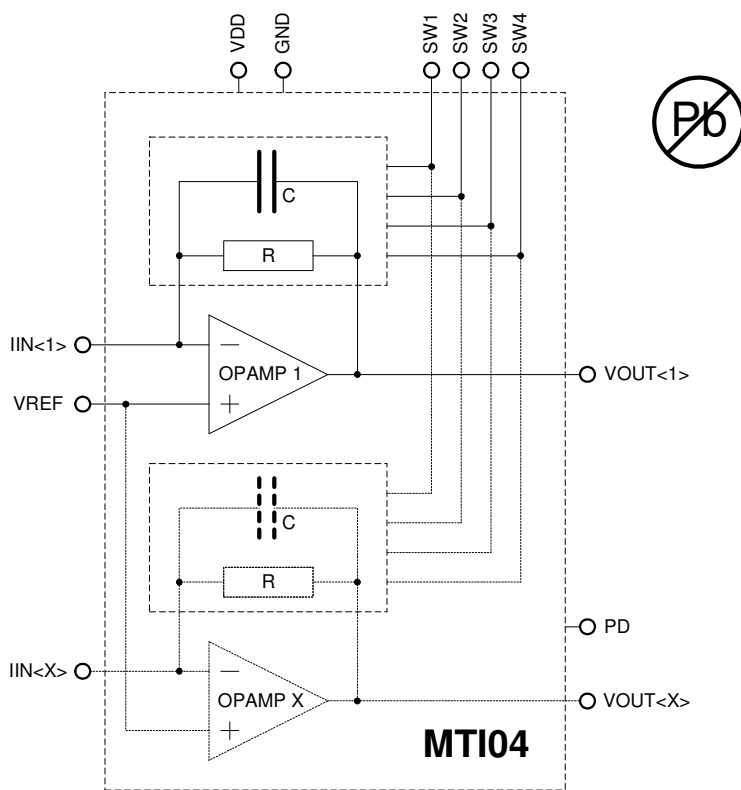


Figure 3: amplifier correspond near MTI04C
(identical functions and parameters, different pinning)

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The integral XYZ color filters on the photodiode array detect the color components of the light falling on the sensor. The photodiodes convert the XYZ light components into photocurrents. Each photocurrent represents X or Y or Z depend on the spectral response shown in. The integrated transimpedance amplifiers convert the photocurrents to analog voltage outputs. After an offset-correction and calibration these voltages are direct coordinates for the standard CIE1991 / DIN5033 color space. The voltage output of each XYZ channel increases linearly with increasing light intensity.

Please note also the different manner and stages for the transimpedance amplifiers. The amplifier could be switched in process into a higher/lower sensitiveness depend on the light intensity falling on the sensor (see adjustment of transimpedance).

5 SPECTRAL RESPONSE

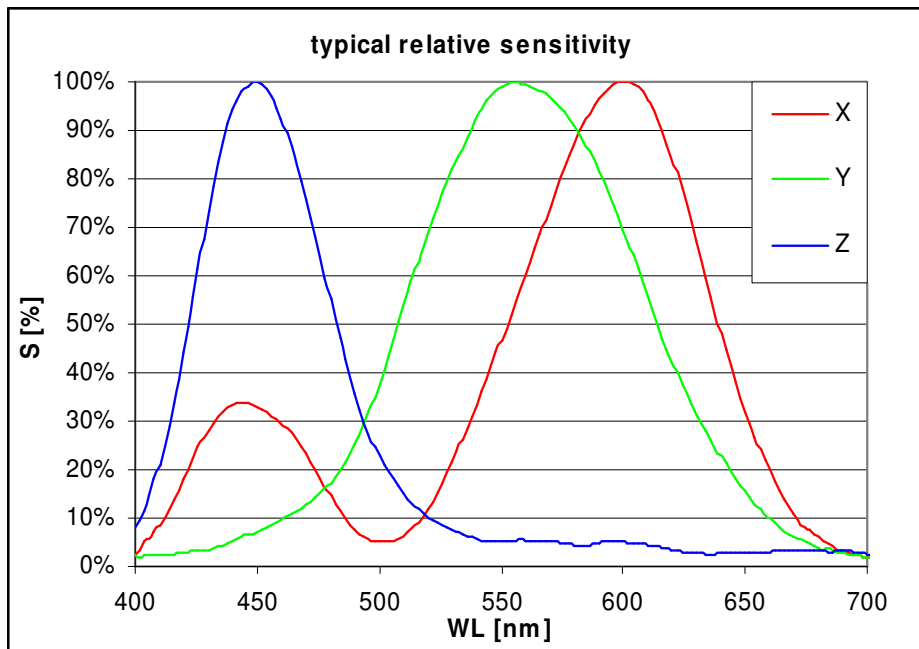


Figure 4: typical (relative) sensitivity (XYZ) of the color sensor3, 4, scanned by width broadband light (FWHM 30nm) and limited angle of incidence (<10) ⁵

³ Typical characteristic sensitivity; scanned by monochromatic light with FWHM 27nm, see also chapter 13.2.

⁴ Please note, there are some technical differences between the national or international standards for color measurement based on the tri-stimulus observer function and our realized sensor function.

Furthermore each sensor has small production based tolerances of nearly 1% variation referred to the wavelengths. So we recommend calibrating the sensor to achieve best results with a small error in the color space.

The calibration depends on different conditions - the sensor, light source, color target, algorithm for calibration and all interferences hit the sensor. In most of cases it's possible to achieve always better results than human eyes. Please ask our technical staff for support if you want to calibrate your sensor system.

⁵ See chapter 13.3

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6 DESCRIPTION OF INTERFACE

signal name	typ.	function
VDD	input	power supply
GND	input	power supply
VREF	input	reference voltage
SW1	input	input 1 for adjustment of transimpedance of MTI-amplifier (pull down)
SW2	input	input 2 for adjustment of transimpedance of MTI-amplifier (pull down)
SW3	input	input 3 for adjustment of transimpedance of MTI-amplifier (pull down)
PD	input	power down modus (pull down)
VOUT X Y Z	output	analog voltage output of amplifier channel n for X Y Z function of detector (see chapter 0)
IIN_EXT	input	current input of external signal
V_OUT_EXT	output	voltage output of external signal

6.1 Adjustment of Transimpedance

settings of digital inputs			transimpedance R
SW1	SW2	SW3	
VDD	VDD	VDD	20M Ω – stage 1
GND	VDD	VDD	10M Ω – stage 2
GND	VDD	GND	5M Ω – stage 3
VDD	GND	VDD	2M Ω – stage 4
GND	GND	VDD	1M Ω – stage 5
VDD	GND	GND	500k Ω – stage 6
VDD	VDD	GND	100k Ω – stage 7
GND	GND	GND	25k Ω^b – stage 8

a.) default by pull down

6.2 Power Down Modus

settings of digital input	bias current of the IC	
PD = 1		
VDD		< 8 μ A
GND		typical ^c

b.) default by pull down

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7 SPECIFICATION

7.1 ELECTRICAL AND OPTICAL CHARACTERISTICS OF PHOTO DIODE ARRAY

($T_A = 25^\circ\text{C}$; per single diode)

Parameter	Symbol	Condition	min.	typ.	max.	Unit
Diameter of the light sensitivity area	D			2,0		mm
Light sensitivity area per single color array (19 diodes)	A			0,76		mm ²
Typical photo diode sensitivity of color ranges	S_{\max}	$\lambda_z = 445 \text{ nm}$ $\lambda_y = 555 \text{ nm}$ $\lambda_{xk} = 445 \text{ nm}$ $\lambda_{xl} = 600 \text{ nm}$	0,21 0,30 0,11 0,31	0,23 0,33 0,12 0,35	0,25 0,36 0,13 0,38	A/W
Spectral tolerance of filter curve See also chapter 13.3	$\Delta\lambda(\lambda)$				$<1\%*\lambda$	nm
Reverse voltage	V_R		0	2,5	5	V
Dark current	I_R	$V_R = 2,5\text{V}$			10	pA
Noise equivalent power	NEP	$f_R = 100 \text{ Hz}$			$<10^{-13}$	W/ $\sqrt{\text{Hz}}$
Cross-talk					<1	%
Angle of incidence	φ	$\Delta\lambda_{(\text{Filter})} < 1\%*\lambda$			10	Grad

7.2 ELECTRICAL CHARACTERISTICS

All voltages are referenced to GND = 0V.

Parameter	Symbol	Condition	min.	typ.	max.	Unit
power supply	VDD		2.7	3 to 5	5.5	V
bias current MTI04	I(VDD)	27°C, VDD=5.5V		2.5	4.0	mA
bias current MTI04 (power down mode)	I(VDD)	PD=VDD			8	μA
reference voltage	VREF		0.4		VDD-0.4	V

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7.3 AC/DC-Characteristics

Unless otherwise specified the data in this table is valid for $T_{OP} = 27^{\circ}\text{C}$ and $V_{DD} = 5\text{V}$. All voltages are referenced to $\text{GND} = 0\text{V}$.

Parameter	Symbol	Condition	min.	typ.	max.	Unit
feedback resistor	R	stage 20M Ω	14000	20000	26700	k Ω
		stage 10M Ω	7000	10000	13350	k Ω
		stage 5M Ω	3500	5000	6700	k Ω
		stage 2M Ω	1400	2000	2670	k Ω
		stage 1M Ω	700	1000	1335	k Ω
		stage 0,5M Ω	350	500	670	k Ω
		stage 0,1M Ω	70	100	133	k Ω
		stage 0,025M Ω	17	25	34	k Ω
Typical photo sensitivity of color ranges at stage 20M Ω	S_{\max}	$\lambda_z = 445 \text{ nm}$ $\lambda_y = 555 \text{ nm}$ $\lambda_{xk} = 445 \text{ nm}$ $\lambda_{xl} = 600 \text{ nm}$		34,9 50,1 18,2 53,2		mV/ ($\mu\text{W}/\text{cm}^2$)
Typical photo sensitivity of color ranges at stage 10M Ω	S_{\max}	$\lambda_z = 445 \text{ nm}$ $\lambda_y = 555 \text{ nm}$ $\lambda_{xk} = 445 \text{ nm}$ $\lambda_{xl} = 600 \text{ nm}$		17,5 25,1 9,1 26,6		mV/ ($\mu\text{W}/\text{cm}^2$)
Typical photo sensitivity of color ranges at stage 5M Ω	S_{\max}	$\lambda_z = 445 \text{ nm}$ $\lambda_y = 555 \text{ nm}$ $\lambda_{xk} = 445 \text{ nm}$ $\lambda_{xl} = 600 \text{ nm}$		8,7 12,5 4,5 13,3		mV/ ($\mu\text{W}/\text{cm}^2$)
Typical photo sensitivity of color ranges at stage 2M Ω	S_{\max}	$\lambda_z = 445 \text{ nm}$ $\lambda_y = 555 \text{ nm}$ $\lambda_{xk} = 445 \text{ nm}$ $\lambda_{xl} = 600 \text{ nm}$		3,5 5,0 1,8 5,3		mV/ ($\mu\text{W}/\text{cm}^2$)

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Parameter	Symbol	Condition	min.	typ.	max.	Unit
Typical photo sensitivity of color ranges at stage 1MΩ	S_{max}	$\lambda_z = 445 \text{ nm}$		1,75		mV/ ($\mu\text{W}/\text{cm}^2$)
		$\lambda_y = 555 \text{ nm}$		2,51		
		$\lambda_{xk} = 445 \text{ nm}$		0,91		
		$\lambda_{xl} = 600 \text{ nm}$		2,66		
Typical photo sensitivity of color ranges at stage 0,5MΩ	S_{max}	$\lambda_z = 445 \text{ nm}$		0,874		mV/ ($\mu\text{W}/\text{cm}^2$)
		$\lambda_y = 555 \text{ nm}$		1,254		
		$\lambda_{xk} = 445 \text{ nm}$		0,456		
		$\lambda_{xl} = 600 \text{ nm}$		1,330		
Typical photo sensitivity of color ranges at stage 0,1MΩ	S_{max}	$\lambda_z = 445 \text{ nm}$		0,175		mV/ ($\mu\text{W}/\text{cm}^2$)
		$\lambda_y = 555 \text{ nm}$		0,251		
		$\lambda_{xk} = 445 \text{ nm}$		0,091		
		$\lambda_{xl} = 600 \text{ nm}$		0,266		
Typical photo sensitivity of color ranges at stage 0,025MΩ	S_{max}	$\lambda_z = 445 \text{ nm}$		0,044		mV/ ($\mu\text{W}/\text{cm}^2$)
		$\lambda_y = 555 \text{ nm}$		0,063		
		$\lambda_{xk} = 445 \text{ nm}$		0,023		
		$\lambda_{xl} = 600 \text{ nm}$		0,067		
Signal frequency	f_{3dB}	stage 20MΩ, T_{OP}	4	6	16	kHz
		stage 10MΩ, T_{OP}	7	11	28	kHz
		stage 5MΩ, T_{OP}	11	16	42	kHz
		stage 2MΩ, T_{OP}	18	26	66	kHz
		stage 1MΩ, T_{OP}	25	35	95	kHz
		stage 0,5MΩ, T_{OP}	35	50	130	kHz
		stage 0,1MΩ, T_{OP}	80	120	280	kHz
		stage 0,025MΩ, T_{OP}	160	300	580	kHz
Temperature coefficient of the feedback resistor	TC_R			-3300		ppm/K
The information contained in these documents reflects the current state of the art at the time of publication and is of a provisional nature. MAZeT explicitly reserves the right to make technical changes to the equipment and components described in the documentation. Before starting developments, please contact our sales to get up-to-date information.					DOC. NO: DB-08-239E	Page 8 of 17

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Parameter	Symbol	Condition	min.	typ.	max.	Unit
Offset voltage	V_{OFF}^6	T_{OP}	-10		10	mV
Capacitive load at VOUT<X>	C_{LOAD}	$I_{LOAD} < 0.5mA$ per output			50	pF
Pull down current SW1, SW2, SW3, SW4, PD	I_{PDPAD}	digital inputs			200	μA
Tolerance of the feedback resistors between the four channels	TOL_R	DC input current; for all stages	1		10	%

7.4 Maximum Conditions

Violations of absolute maximum conditions are not allowed under any circumstances, otherwise the IC can be destroyed. All voltages are referenced to GND = 0V.

Parameter	Symbol	min.	max.	Unit
Power supply	VDD	0.3	7.0	V
Input and output voltages	\Rightarrow IC-pinning	0.3	VDD+0.3	V
Input high level	V_{IH}	0.7*VDD	VDD+0.3	V
Input low level	V_{IL}	-0,3	0,8	V
Power dissipation	POP		0.025	W
Standard operating temperatures ⁷	TOP	-20	+ 100	$^{\circ}C$
Storage temperature	TSTG	-40	+ 100	$^{\circ}C$

⁶ $V_{OFF} = V_{OUT} < X > - V_{REF}$; results from input offset voltage and input leakage current

⁷ special on request

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8 PACKAGE AND OUTLINE DIMENSIONS

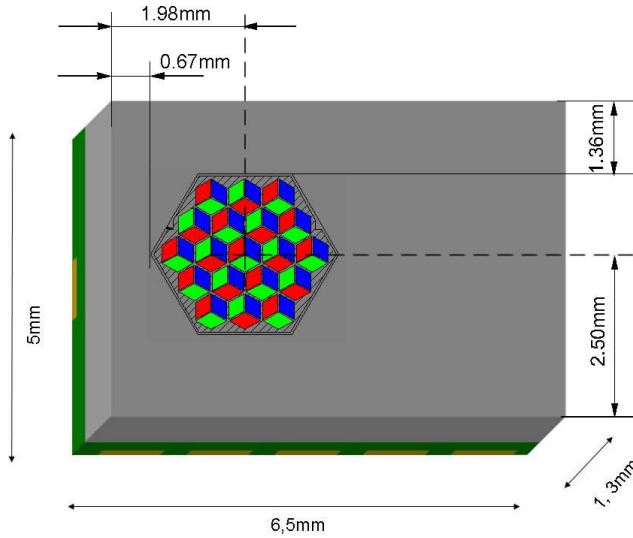


Figure 5: Sizes of packaged MTCS-TIAM3 (height = 1300±50µm), other tolerances are 100µm

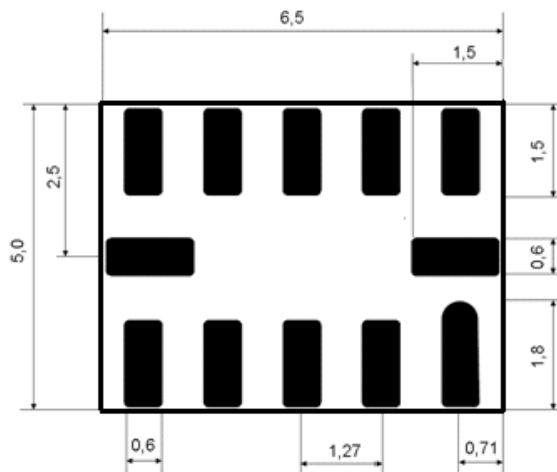


Figure 6: Pad dimensions⁸

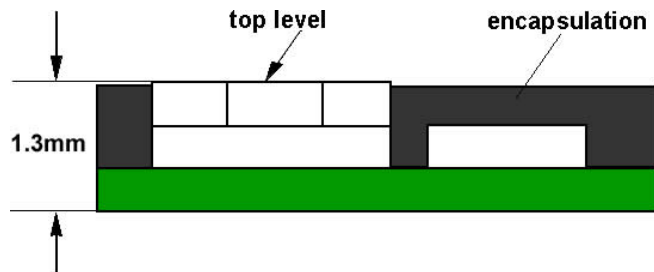


Figure 7: Size top level detector to bottom side package

⁸ Please note that on the back side of the package in midsize a blank metallic label with the name of the sensor could be. Please check it and note such a label before you use the components.

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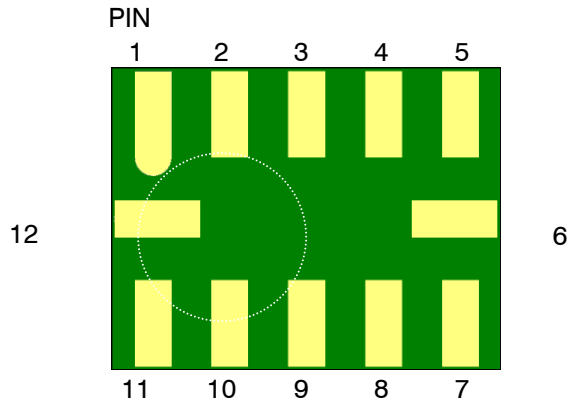


Figure 7: PIN configuration MTCS-TIAM3 - Bottom view

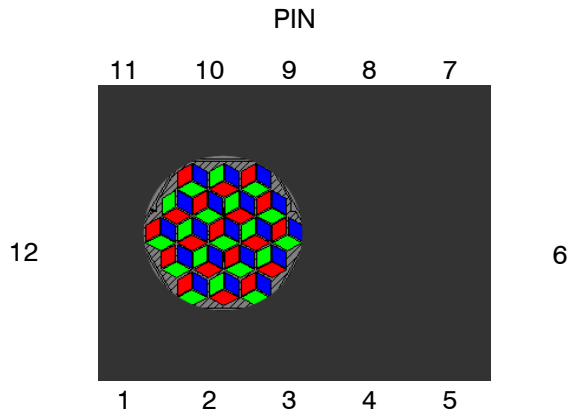


Figure 8: PIN configuration MTCS-TIAM3 Top View

9 PIN-CONFIGURATION

Pin	Name	IN-/OUTPUT	A/D	Description
1	PD	INPUT	D	power down modus (pull down)
2	VOUT Y	OUTPUT	A	analogue voltage output Y
3	VOUT Z	OUTPUT	A	analogue voltage output Z
4	VOUT X	OUTPUT	A	analogue voltage output X
5	SW3	INPUT	D	input 3 for adjustment of transimpedance of MTI-amplifier (pull down)
6	VOUT_EXT	OUTPUT	A	voltage output of external signal
7	VDD	INPUT	D/A	power supply
8	SW2	INPUT	D	input 2 for adjustment of transimpedance of MTI-amplifier (pull down)
9	SW1	INPUT	D	input 1 for adjustment of transimpedance of MTI-amplifier (pull down)
10	GND	INPUT	D/A	ground
11	VREF	INPUT	A	reference voltage
12	IIN_EXT ⁹	INPUT	A	current input of external signal

⁹ optional to be connect with an external resistor to consider temperature changes of the amplifier – see also PIN VOUT-EXT – this function is only an addition and doesn't have any effects to the function or parameter of the amplifier

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10 SOLDERING PROFILE

Reflow profile for Pb-Free Assembly

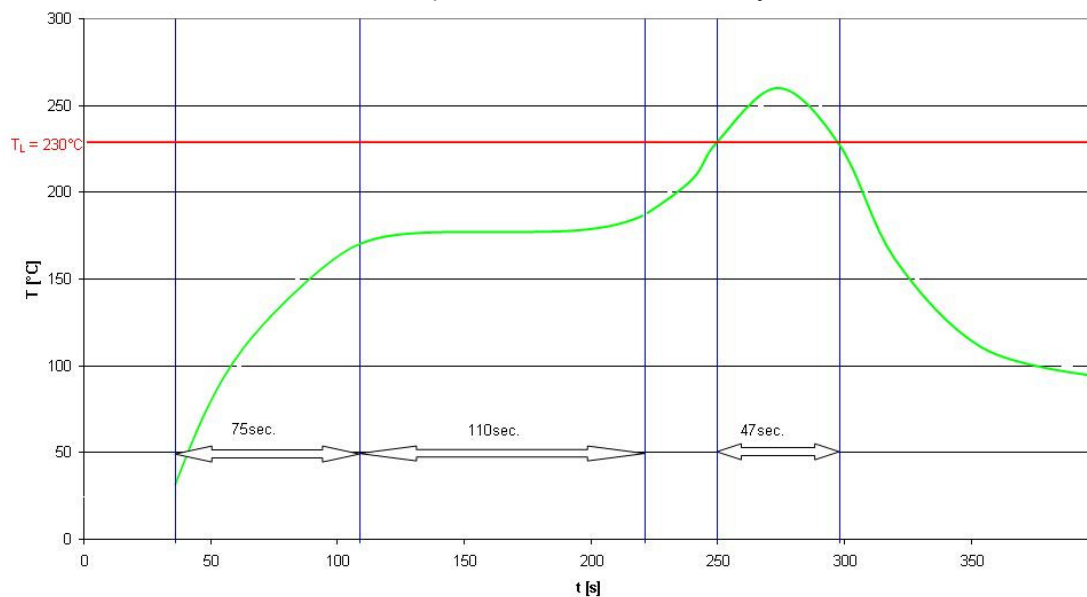


Figure 9: Recommended reflow SOLDERING PROFILE

11 HANDLING AND STORAGE

Care should be taken to keep the sensor surface clean. Dust, scratches will adversely affect the sensor parameters. Sensors should be handled as optical device.

It is important to use normal ESD handling and precautions for ESD sensitive devices.

Each device is baked prior packing for shipment (24hours at 125°C).

Devices are packed in a sealed aluminized envelope with humidity indicator card and desiccant. Keep the opening and handling time of moisture bag as short as possible. We recommended re-baking before soldering.

12 PACKING INFORMATION

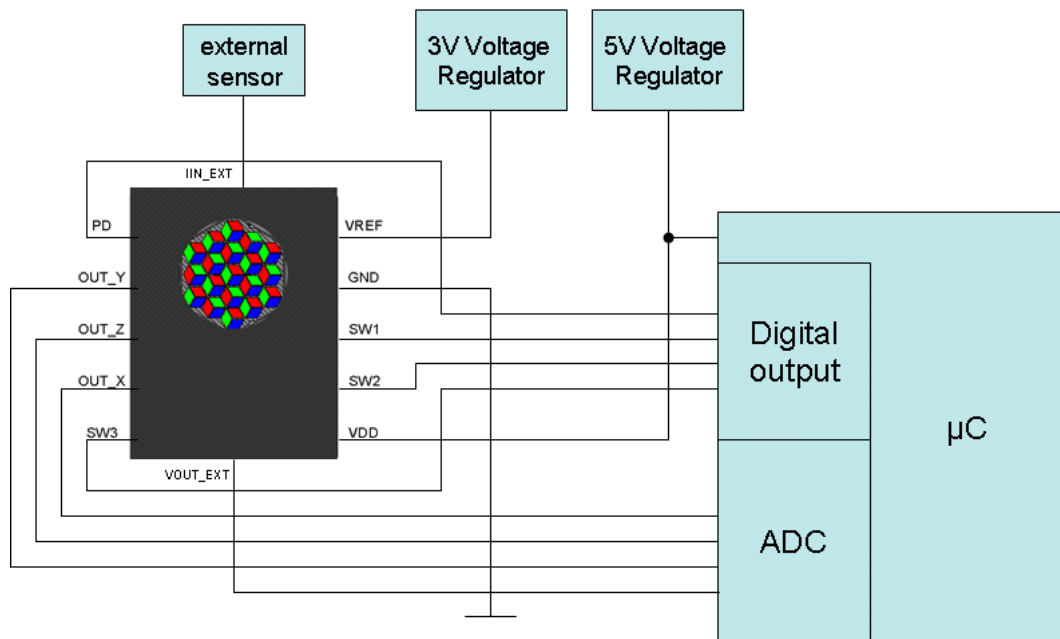
Standard packing type is tube. Otherwise has to be cleared with sales, see chapter 14.

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13 APPLICATION NOTE

13.1 Circuit

In the following there is an example for connection of MTCS-TIAM3 to a μC -based measurement system. Please note the necessary connection of V_{ref} (e.g. 3V, depend on the used ADC) and V_{dd} (e.g. 5V). Alternatives are possible within the settings (see chapter 7).



The MTCS-TIAM3 includes an multichannel amplifier of MAZeT. The amplifier can be switched smoothly to the required amplification stage via μC programming, e.g. if input variables fail to reach or exceed a set threshold. Transimpedance programming is carried out via three inputs and affects all channels simultaneously (see also chapter 6.1). In the following there is a preposition for an algorithm to switch automatically the required amplification via μC .

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defines: VMIN = 1, VMAX = 8 UMAX = 0x3ff, UMIN = 0x1ff
 Values for calculation LimitU: Tabvalue[8] = { 4, 5, 2, 2, 3, 2, 2, 1 }

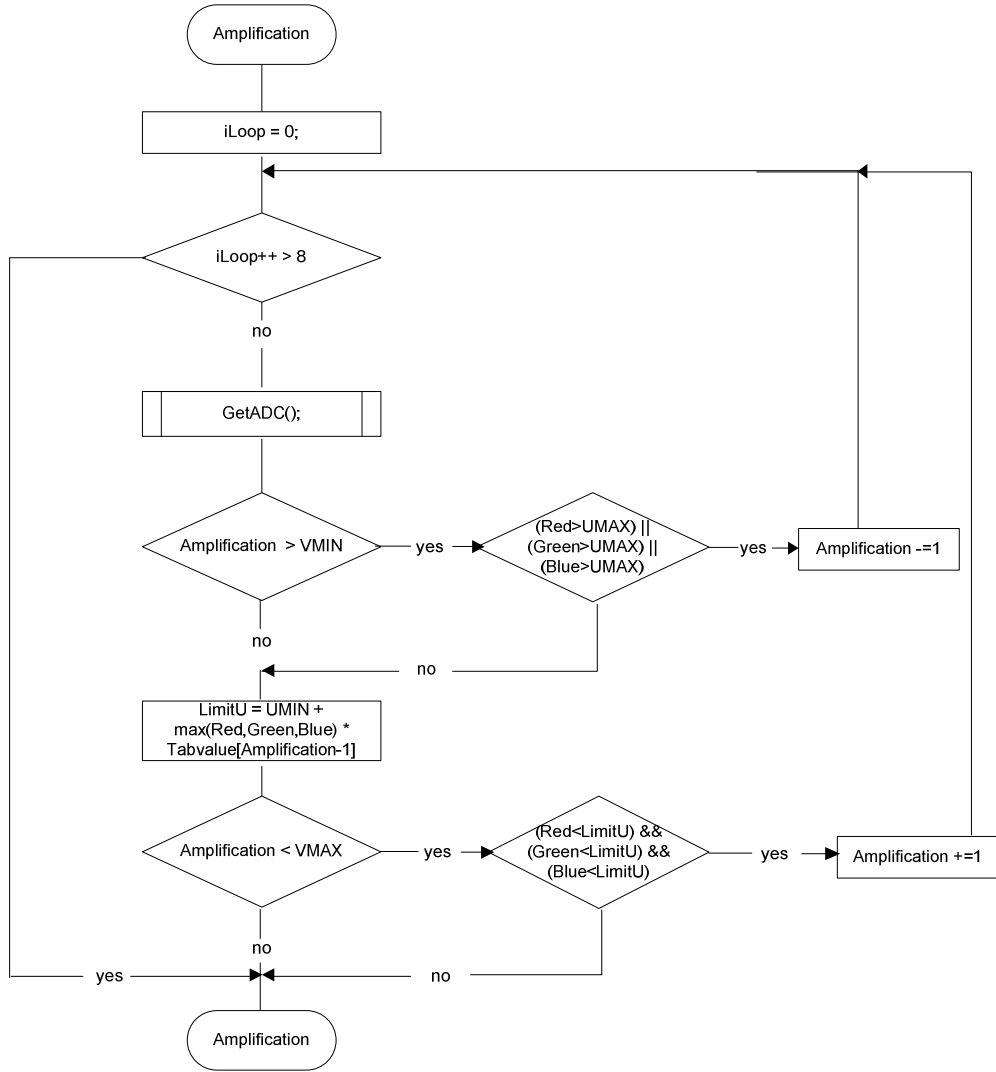
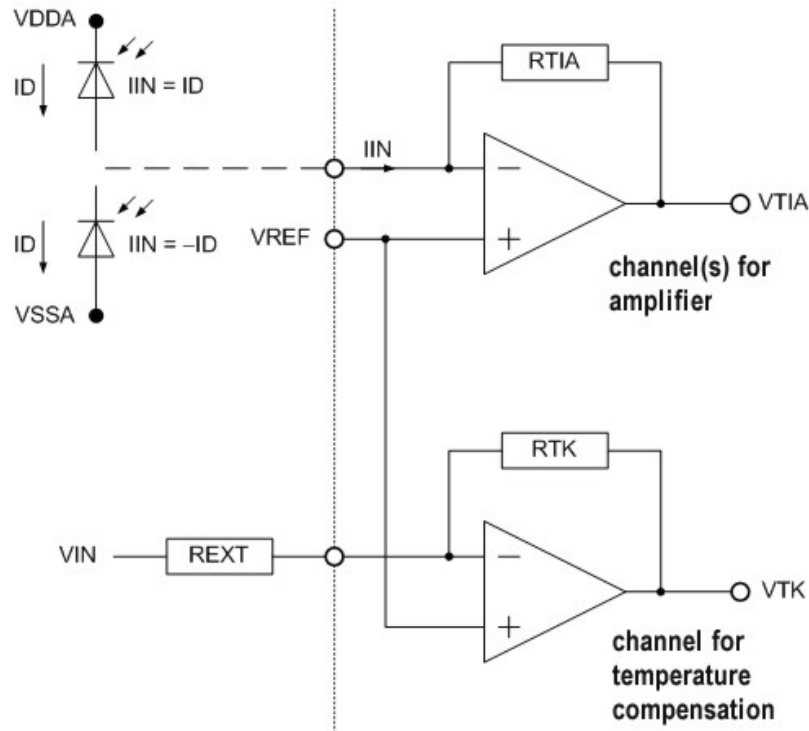


Figure 10: μ C-based Algorithm for calculation of an automatic switch of the 8-staged amplification

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Temperature compensation of MTI04 via reference method

Due to the technology the temperature coefficient (TC) of the internal used resistors in the ASIC is very high (typ. -3300ppm/K). The following description shows a possible approach for reduction the temperature dependency of amplifier via reference channel (use the 4th channel of internal amplifier – see Pinout IIN_EXT; VOUT_EXT).



The input of the reference channel (use IIN_EXT) is connected with an external resistor that will load with an input voltage which is different to VREF.

The output voltage of the measuring channel is explained in the coming formula:

$$(1) \quad VTIA(T) = VREF(T) - IIN * RTIA(T)$$

IIN is the input current, which is supplied by the external sensor. The output voltage of the channel for the temperature compensation is defined:

$$(2) \quad VTK(T) = VREF(T) - \frac{VIN(T) - VREF(T)}{REXT(T)} * RTK(T)$$

The following voltages will calculate for temperature compensation with a resistor.

$$(3) \quad \Delta VTIA(T) = VREF(T) - VTIA(T)$$

$$(4) \quad \Delta VTK(T) = VREF(T) - VTK(T)$$

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For example the voltage $\Delta VTK(T_0)$ will detect during the initialization of the system. The value is equivalent to a constant for the temperature T_0 , which prevailed at the time of initialization. All further measurements will calibrate by this value.

$$(5) \Delta VTIA_{korrigiert}(T) = \Delta VTIA(T) * \frac{\Delta VTK(T_0)}{\Delta VTK(T)}$$

All variables of the channel for temperature compensation are affected by temperature effects. Therefore there is an additional coefficient necessary. That coefficient should be highly reduced opposite to the named above value of the RTIA (typical -3300ppm/K).

$$(6) TK = TK(REXT) - \frac{VIN}{VIN - VREF} * TK(VIN) + \frac{VREF}{VIN - VREF} * TK(VREF)$$

„TK(REXT)“ is the temperature coefficient of the external resistor, „TK(VIN)“ is the temperature coefficient of the input voltage and „TK(VREF)“ is the temperature coefficient of the reference voltage.

Please consider the following interrelationship by the choice of resistors REXT and RTK in term of the selected voltages VIN and VREF(values from (2) and (4)).

$$(7) \frac{REXT}{RTK} > \left| \frac{VIN}{VREF} - 1 \right|$$

The adherence of this non-equation ensures, that the voltage VTK is located in the working range. That means the amplifier of the channel for temperature compensation doesn't go into saturation.

Furthermore you can calculate the absolute value of the transimpedance resistor RTK for a certain actual existing temperature.

$$(8) RTK(T) = REXT(T) * \frac{VREF(T) - VTK(T)}{VIN(T) - VREF(T)}$$

13.2 Limitations

The spectral filters of our color sensors are specialized for applications with broadband source of lighting >10nm. Please ask our sales team before you use our sensor in combination with narrowband luminous sources.

13.3 Angle of incidence

In reliance on the packaging the sensor IC has an aperture angle (beam width) of nearly 90°. Traditional an interference filter works depends on angle of incidence. So a bumped light beam with different angles to vertical until 10° will not causes any filter shifts. Make sure by using lenses or optical holes that the angle of incidence for the sensor device will be smaller than 10°.

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14 ORDERING INFORMATION

True Color sensor with integrated amplifier

MTCS-TIAM3

For further information please contact:

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Phone: +49 3641 2809-0

Fax: +49 3641 2809-12

E-Mail: sales@MAZeT.de

URL: <http://www.MAZeT.de>

WARNINGS

WARNINGS

Personal Injury – Do not use these products as safety or emergency stop devices or in any other applications where failure of the product could result in personal injury. **Failure to comply with these instructions could result in death or serious injury.**

Misuse of Documentation – The information presented in this data sheet is for reference only. Because these products are under development do not use this document as product installation guide. Before you start any development ask your supplier for the latest version of this sheet. **Failure to comply with these instructions could result in death or serious injury.**

ESD Warning – Standard CMOS handling precautions should be observed to avoid static discharge.