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Data Sheet
Engineering samples

MTCS-TIAM3

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

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INTRODUCTION

MTCS-TIAM4 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-TIAM4 is with an integrated parallel 4-channel amplifier (see also the data sheet MTI04E 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.

1 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

2 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, reduced thickness, lead free
- alike tri-stimulus interference filter for color measurement to DIN 5033 (CIE 1931)
- small LCC package (SMD)
- EU RoHS-compliant²

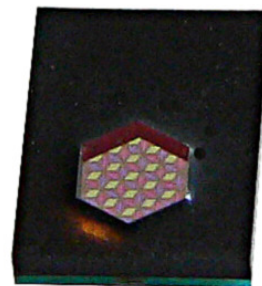


Figure 1: MTCS-TIAM3

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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3 BLOCK DIAGRAM

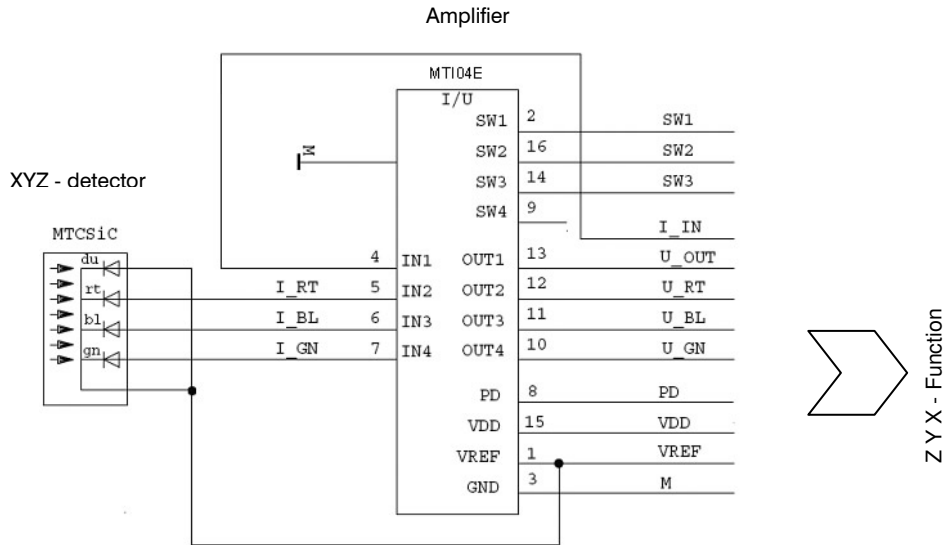


Figure 2: On Chip detector MTCSi and amplifier MTI04E

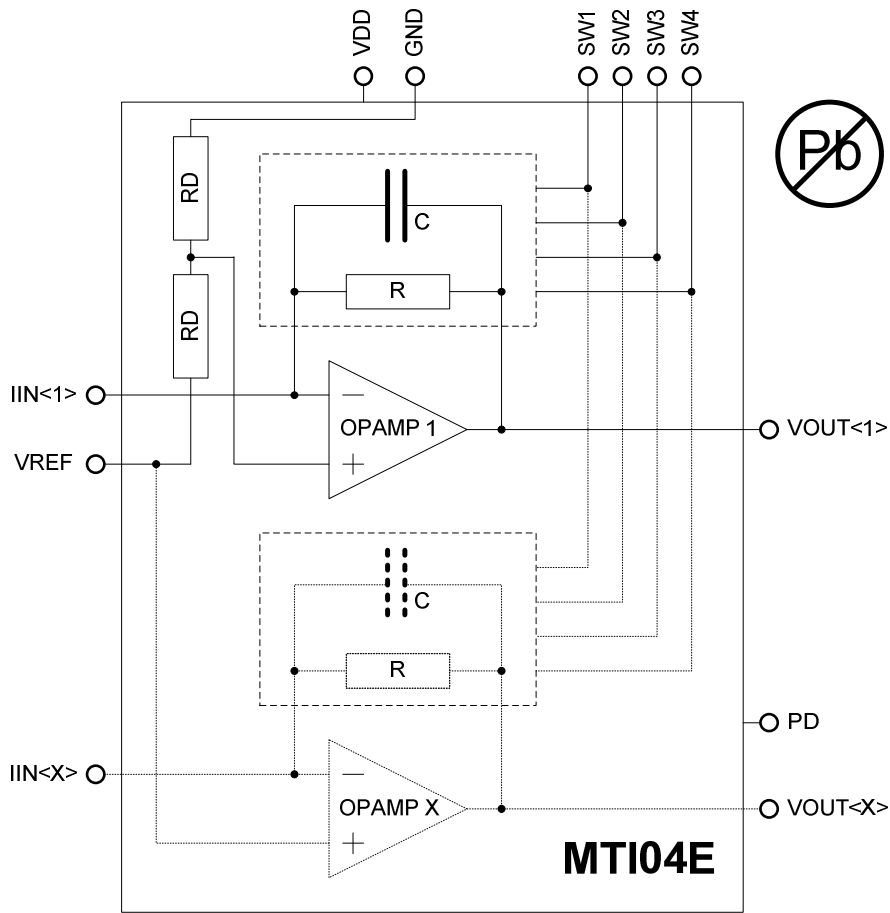


Figure 3: amplifier MTI04E

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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).

4 SPECTRAL CHARACTERISTIC

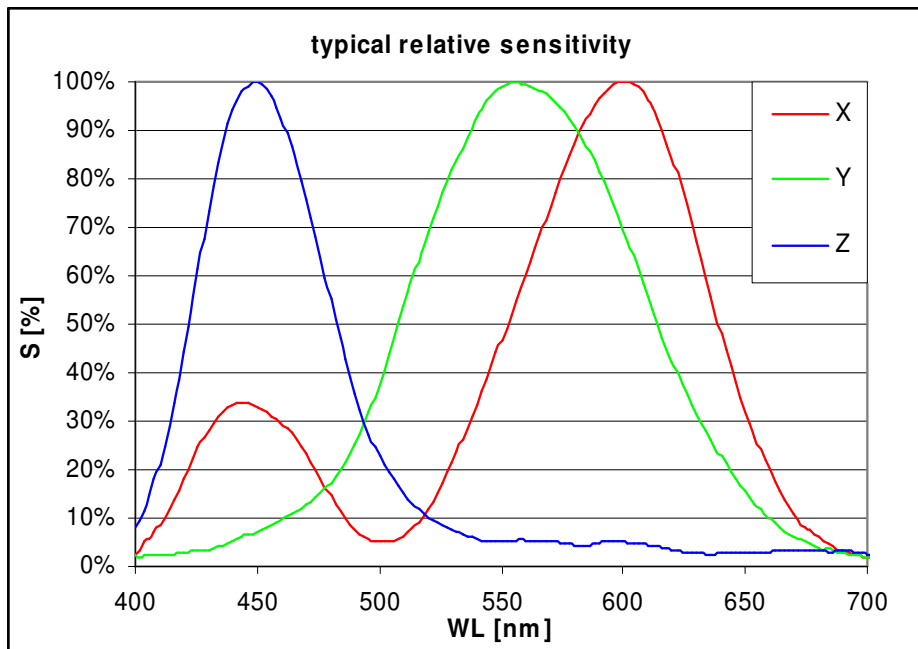


Figure 4: Typical (relative) sensitivity (XYZ) of the color sensor^{3, 4}, scanned by width broadband light (FWHM 30nm) and limited angle of incidence (<10)⁵

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 0

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5 DESCRIPTION OF INTERFACE

signal name	typ.	a/d ⁶	function
VDD	input	a/d	power supply
GND	input	a/d	power supply
VREF	input	a	reference voltage
SW1	input	d	input 1 for adjustment of transimpedance of MTI-amplifier (pull down)
SW2	input	d	input 2 for adjustment of transimpedance of MTI-amplifier (pull down)
SW3	input	d	input 3 for adjustment of transimpedance of MTI-amplifier (pull down)
SW4	input	d	switchable frequency range depends on input capacitance of the photo-sensor (pull down)
PD	input	d	power down modus (pull down)
IIN<X>	input	a	analog current input of amplifier X
VOUT<X>	output	a	analog voltage output of amplifier X

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

Power-down Mode

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

b.) default by pull down

⁶ Analog/digital

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Switch able Frequency Range

settings of digital input	
SW4	allowed capacitance of photo-sensor
VDD	< 5pF
GND	< 80pF

6 DESCRIPTION OF FUNCTION

The MTI-devices are programmable gain transimpedance amplifiers⁷ with different numbers of channels (MTI04E – 4 channels). There is one transimpedance amplifier per channel between a current input IIN<X> and a voltage output⁸ VOUT<X>. Its transimpedance is selectable in 8 stages. This adjustment can be effected by setting of digital inputs SW1, SW3 and SW4 and is valid for all channels simultaneously.

Also simultaneously valid for all channels is a compensation of the input capacitance of photo-sensors for two possible frequency ranges (switch able by SW4).

The pins SW1, SW2, SW3 and SW4 are pull down inputs.

The second input of the transimpedance amplifiers 2 to 4 is used for a *common* supply by a reference voltage necessarily fed in through the pin VREF. The 1st transimpedance amplifier gets half of the reference voltage at pin VREF (internal voltage divider with RT).

All channels are compensated for an external input capacitance of the photo-sensor of smaller than 80pF (SW4 = GND). The power supply for the MTI-devices is typical 3V to 5V between VDD and GND.

The power down mode is adjusted by PD = VDD and switches off the functionality. In that case it must be pointed out that the transimpedance resistor of stage 8 is between the particular inputs and outputs. The amplifiers are switched off (tri-state). Even so there is still a static bias current of $V(VREF) / 2RT$ at pin VREF.

7 SPECIFICATION**ELECTRICAL AND OPTICAL CHARACTERISTICS OF PHOTO DIODE ARRAY**

(T_A = 25°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

⁷ work as inverted amplifiers

⁸ $V(VOUT<X>) = V(VREF) - I(IIN<X>) * R$ for X = 2, 3, 4 and $V(VOUT<1>) = 0,5 * V(VREF) - I(IIN<1>) * R$

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Parameter	Symbol	Condition	min.	typ.	max.	Unit
typical photo diode sensitivity of color ranges	S_{max}	$\lambda_z = 445 \text{ nm}$	0,21	0,23	0,25	A/W
		$\lambda_y = 555 \text{ nm}$	0,30	0,33	0,36	
		$\lambda_{xk} = 445 \text{ nm}$	0,11	0,12	0,13	
		$\lambda_{xl} = 600 \text{ nm}$	0,31	0,35	0,38	
spectral tolerance of filter curve (See also chapter 0)	$\Delta\lambda(\lambda)$				$<1\%*\lambda$	nm
reverse voltage	V_R		0	2,5	5	V
dark current	I_R	$V_R = 2,5V$			10	pA
noise equivalent power	NEP	$f_R = 100 \text{ Hz}$			$<10^{-13}$	W/ \sqrt{Hz} z
cross-talk					<1	%
angle of incidence	φ	$\Delta\lambda_{(Filter)} < 1\%*\lambda$			10	Grad

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

AC/DC-Characteristics

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

Parameter	Symbol	Condition	min.	typ.	max.	Unit
		stage 20M Ω	14000	20000	26700	k Ω
		stage 10M Ω	7000	10000	13350	k Ω
		stage 5M Ω	3500	5000	6700	k Ω

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.

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Parameter	Symbol	Condition	min.	typ.	max.	Unit
gain selection (feedback resistor)	R	stage 2MΩ	1400	2000	2670	kΩ
		stage 1MΩ	700	1000	1335	kΩ
		stage 0,5MΩ	350	500	670	kΩ
		stage 0,1MΩ	70	100	133	kΩ
		stage 0,025MΩ	17	25	34	kΩ
typical photo sensitivity of color ranges at stage 20MΩ	S _{max}	λ _Z = 445 nm λ _Y = 555 nm λ _{Xk} = 445 nm λ _{Xl} = 600 nm		34,9 50,1 18,2 53,2		mV/ (μW/cm ²)
typical photo sensitivity of color ranges at stage 10MΩ	S _{max}	λ _Z = 445 nm λ _Y = 555 nm λ _{Xk} = 445 nm λ _{Xl} = 600 nm		17,5 25,1 9,1 26,6		mV/ (μW/cm ²)
typical photo sensitivity of color ranges at stage 5MΩ	S _{max}	λ _Z = 445 nm λ _Y = 555 nm λ _{Xk} = 445 nm λ _{Xl} = 600 nm		8,7 12,5 4,5 13,3		mV/ (μW/cm ²)
typical photo sensitivity of color ranges at stage 2MΩ	S _{max}	λ _Z = 445 nm λ _Y = 555 nm λ _{Xk} = 445 nm λ _{Xl} = 600 nm		3,5 5,0 1,8 5,3		mV/ (μW/cm ²)
typical photo sensitivity of color ranges at stage 1MΩ	S _{max}	λ _Z = 445 nm λ _Y = 555 nm λ _{Xk} = 445 nm λ _{Xl} = 600 nm		1,75 2,51 0,91 2,66		mV/ (μW/cm ²)

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Parameter	Symbol	Condition	min.	typ.	max.	Unit
typical photo sensitivity of color ranges at stage 0,5MΩ	S_{max}	$\lambda_z = 445 \text{ nm}$ $\lambda_y = 555 \text{ nm}$ $\lambda_{xk} = 445 \text{ nm}$ $\lambda_{xl} = 600 \text{ nm}$		0,874 1,254 0,456 1,330		mV/ ($\mu\text{W}/\text{cm}^2$)
typical photo sensitivity of color ranges at stage 0,1MΩ	S_{max}	$\lambda_z = 445 \text{ nm}$ $\lambda_y = 555 \text{ nm}$ $\lambda_{xk} = 445 \text{ nm}$ $\lambda_{xl} = 600 \text{ nm}$		0,175 0,251 0,091 0,266		mV/ ($\mu\text{W}/\text{cm}^2$)
typical photo sensitivity of color ranges at stage 0,025MΩ	S_{max}	$\lambda_z = 445 \text{ nm}$ $\lambda_y = 555 \text{ nm}$ $\lambda_{xk} = 445 \text{ nm}$ $\lambda_{xl} = 600 \text{ nm}$		0,044 0,063 0,023 0,067		mV/ ($\mu\text{W}/\text{cm}^2$)
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
offset voltage	V_{OFF}^9	T_{OP}	-10		10	mV
capacitive load at $V_{OUT}<X>$	C_{LOAD}	$I_{LOAD} < 0.5\text{mA per output}$			50	pF
⁹ $V_{OFF} = V_{OUT}<X> - V_{REF}$; results from input offset voltage and input leakage current						
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Parameter	Symbol	Condition	min.	typ.	max.	Unit
pull down current SW1, SW2, SW3, SW4, PD	I_{PDPAD}	digital inputs			200	μA
tolerance of the feed- back resistors between the four channels	TOL_R	DC input current; for all stages	1		10	%

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	⇒ 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 ¹⁰	TOP	0	+85	°C
storage temperature	TSTG	0	+85	°C

Note:

All data's are results from tests and qualifications we did under conditions of laboratory. Ensure yourself by tests or ask us if your application deviates from the conditions here, before you start development or mass production.

¹⁰ special on request

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8 PACKAGE AND OUTLINE DIMENSIONS

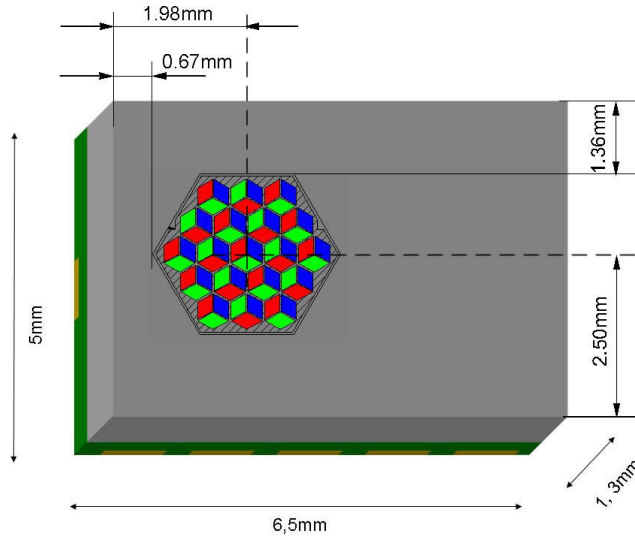


Figure 5: Sizes of packaged MTCS-TIAM4 in LCC (height = 1300±50µm), other tolerances are 100µm

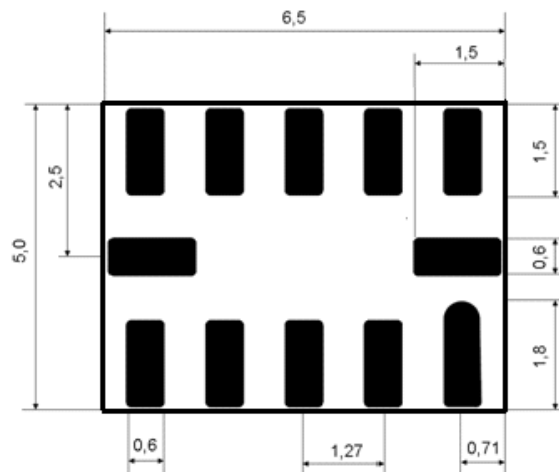


Figure 6: Pad dimensions¹¹

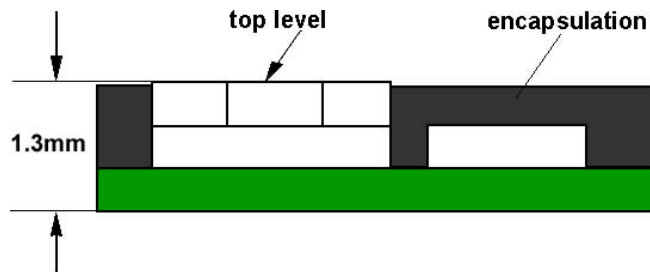


Figure 7: Size top level detector to bottom side package

¹¹ 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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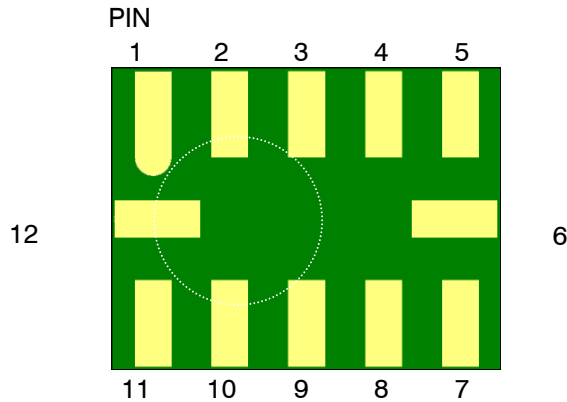


Figure 8: PIN configuration MTCS-TIAM4 - Bottom view

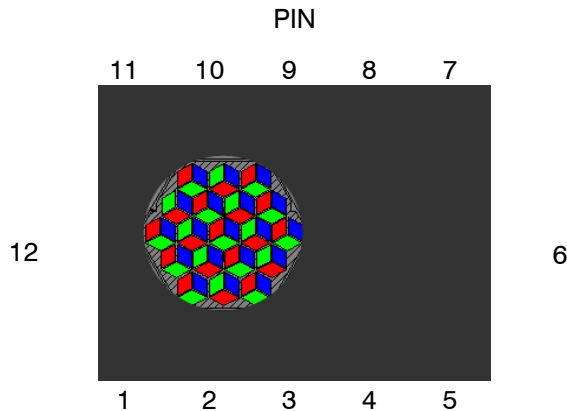


Figure 9: PIN configuration MTCS-TIAM4 Top View

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 ¹²	INPUT	A	current input of external signal

¹² 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

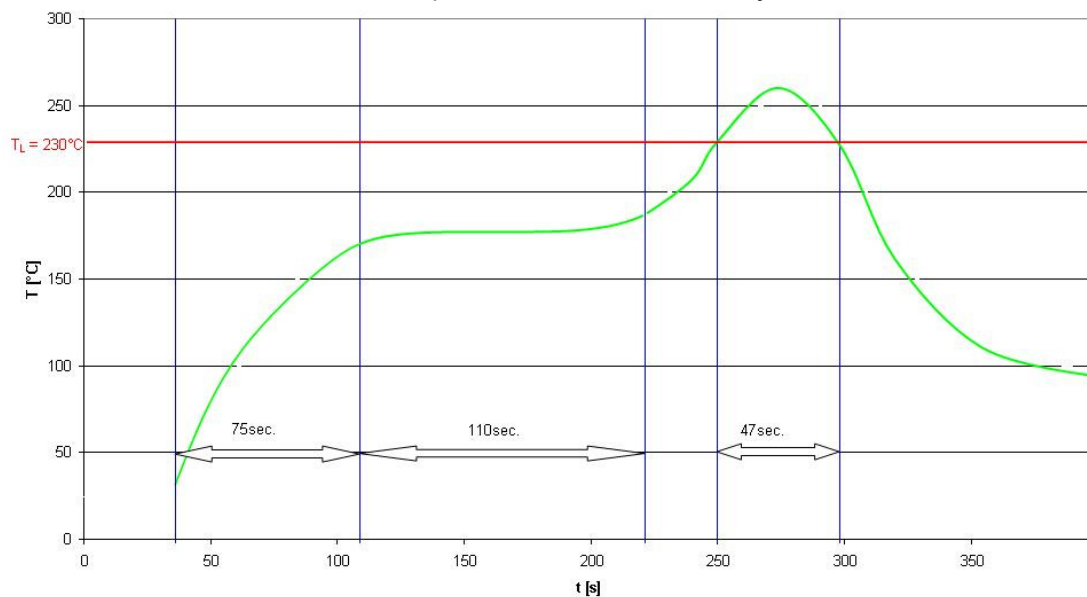


Figure 10: Recommended reflow SOLDERING PROFILE¹³

11 HANDLING

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 sensor element 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 bag as short as possible.

Before soldering the sensors, the sensors must be baked¹⁴. The recommended baking conditions are 24hours at 125°C.

12 PACKING INFORMATION

Standard packing type for the sensor elements is tube or box. Otherwise has to be cleared with our sales team.

¹³ Please note the sensor includes sensitive materials and components. High temperatures and time for soldering more than specified here could damage or destroy the sensor (see also chapter 11).

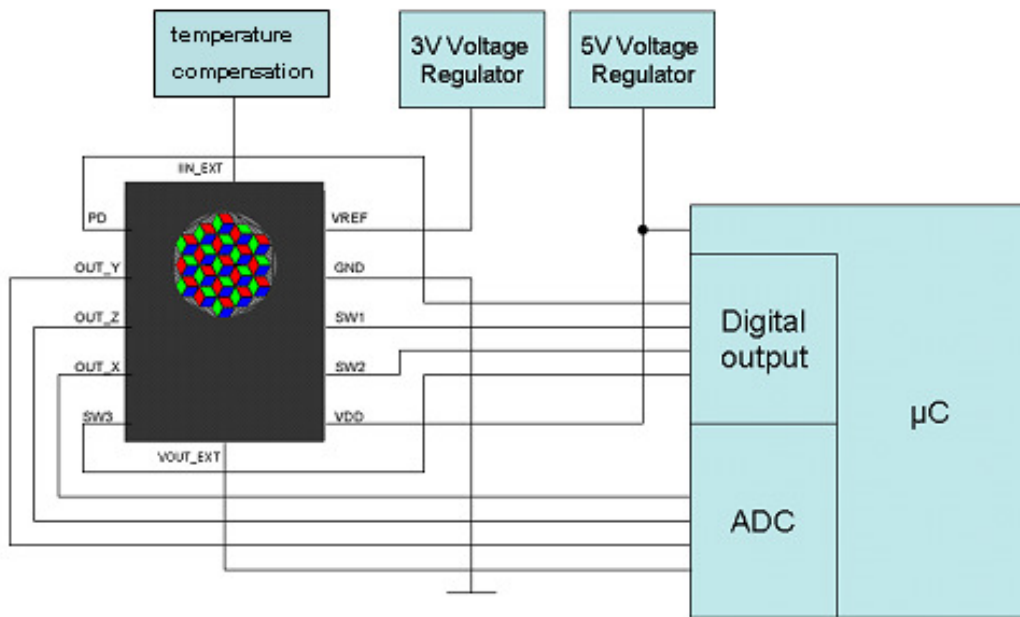
¹⁴ Baking of tape & reel is not applicable (max is <60°C/12hours). For baking at 125°C we recommend to send the components to a Reel Service, they are the experts for de-reeling / baking / re-reeling.

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13 APPLICATION NOTE

Circuit

In the following picture there is an example for connection of MTCS-TIAM4 to a μC -based measurement system. Please note the necessary connection of Vref (e.g. 3V, depend on the used ADC) and Vdd (e.g. 5V). Alternatives are possible within the settings (see chapter 7).



The MTCS-TIAM4 includes a multi-channel 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 0). 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 LimitO and LimitU: Tabvalue[8] = { 4, 5, 2, 2, 3, 2, 2, 1 }

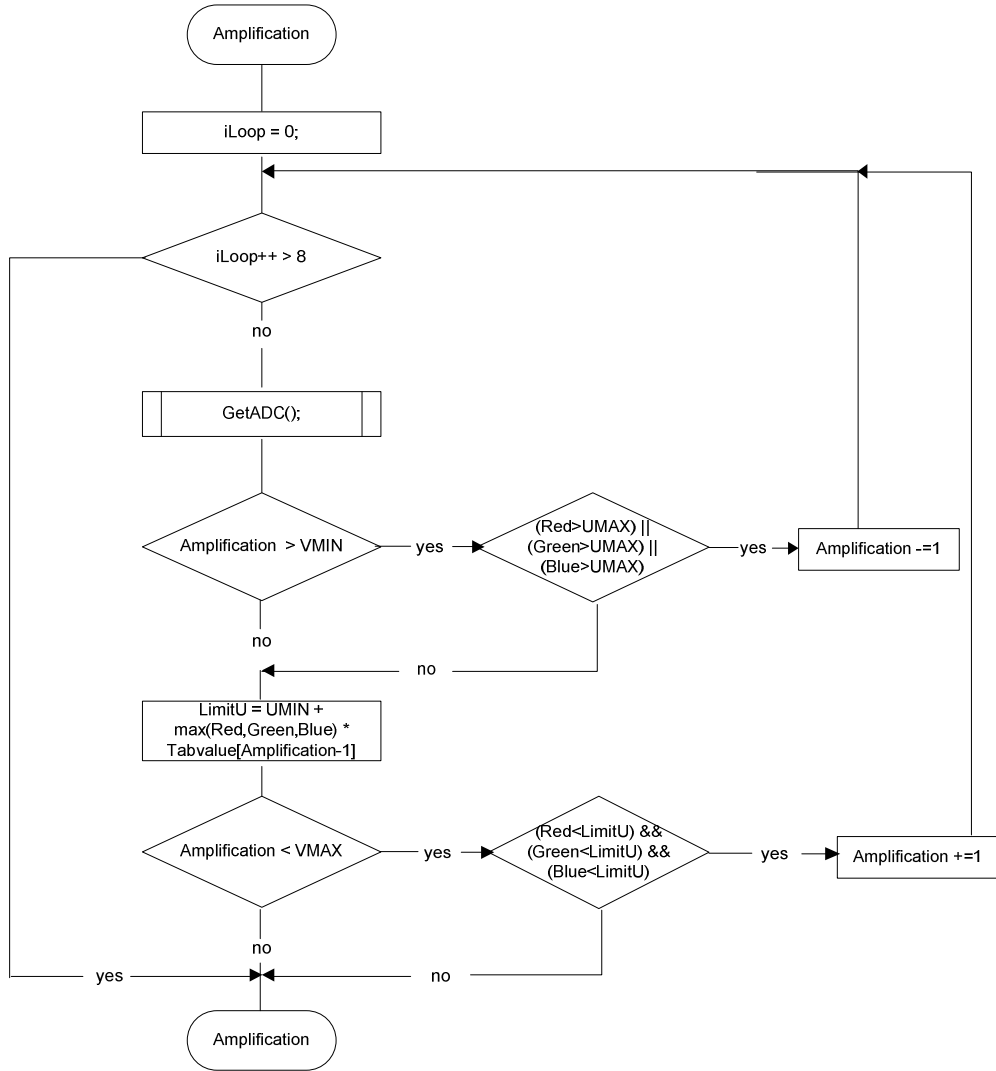


Figure 11: μC-based Algorithm for calculation of an automatic switch of the 8-staged amplification ¹⁵

¹⁵ The algorithm includes the same amplifying stage for xyz-channels. If you expect a different amplifying for one or two sensor channels with referent to the others then expand the algorithm numerous and search for the individual max, min values of the single x- and y- and z-channel.

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Temperature compensation of MTI04E via reference channel

In case of the photo diode’s cathode is connected to VDD the reference voltage input of the 1st channel is internal connected to half of the reference voltage at pin VREF. This channel works as a “reference channel” for temperature compensation.

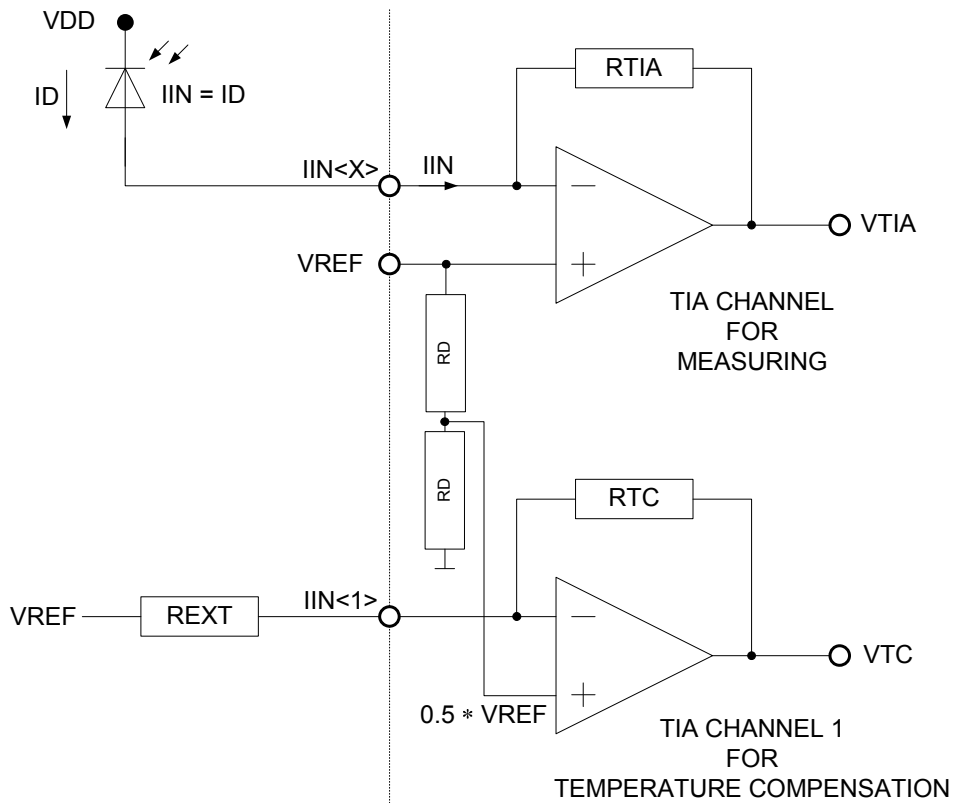


Figure 12: temperature compensation of the MTI04E via reference channel

The following equations result from the circuit.

$$VTIA(T) = VREF(T) - IIN * RTIA(T)$$

$$VTC(T) = 0.5 * VREF(T) - \frac{0.5 * VREF(T)}{REXT(T)} * RTC(T)$$

The voltages ΔVTIA(T) and ΔVTC(T) have to be detected for a temperature compensation using a μController (ΔVTC(T) corresponds to 0.5*VREF!):

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

$$\Delta VTC(T) = 0.5 * VREF(T) - VTC(T)$$

Scaling and correction respectively happen in the following way.

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$$\Delta VTIA_{corrected}(T) = \Delta VTIA(T) * \frac{\Delta VTC(T0)}{\Delta VTC(T)}$$

The resulting temperature coefficient is:

$$TC = TC(REXT) - TC(VREF)$$

Thereby the TC(REXT) is the temperature coefficient of the external resistor and TC(VREF) is the temperature coefficient of the voltage VREF. Broadband source of lighting.

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.

Narrowband luminous sources

The spectral filters of the color sensor ICs 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.

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°.

14 ORDERING INFORMATION

NAME	Status	PACKAGE	Article
MTCS-TIAM3	Engineering Samples	LCC	090400-377-26AEZ00

Engineering samples

The described IC is in development status *engineering sample*. In comparison the series elements will be different in some technical parameters, the 4-th input channel will be out leaded and the series package will be smaller. Ask our sales team for details and/or availabilities of series elements.

Please note the samples were not verified like a series elements. There is no guarantee for function and parameters described in this document. Please don't use these samples not for any development and or series production but only for tests. All technical details represent only a target specification and the results of first measurements. Please ask our sales team for status and availability of series elements.

VERSION		
NO.	ISSUE	ADVANCED
1	V3.1	2010-08-04

15 CONTACT

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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.