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Data Sheet

MTCS-TIAM2

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

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1 INTRODUCTION

MTCS–TIAM2 is a high integrated True Color Sensor IC with integrated trans-impedance amplifier in a small plastic package on a PCB-carrier. It includes the standard XYZ (RGB) filters based on the known observer function CIE 1931. So the sensor is specialized for fast and absolute, high accuracy color measurement.

The True Color Sensors are made of 19 x 3 photo diodes (special PIN silicon technology with blue-enhanced) 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 colored photodiodes the individual sectors were separated from each other by additional structures – separate diode. The photodiodes are sensitized on chip with high-quality and long-time stabile dielectric spectral filters (named True Color Filter[1]). These filters correspond to the primary **color standard CIE 1931(Commission Internationale de l'Eclairage or International Commission on Illumination) and/or the German standard DIN 5033**.

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-compliant[2]

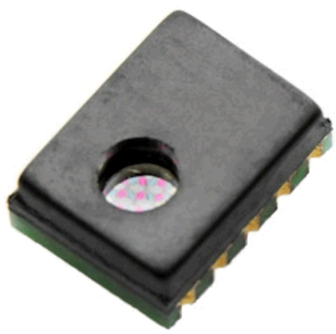

Figure 1: MTCS-TIAM2

[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.

4 BLOCK DIAGRAM

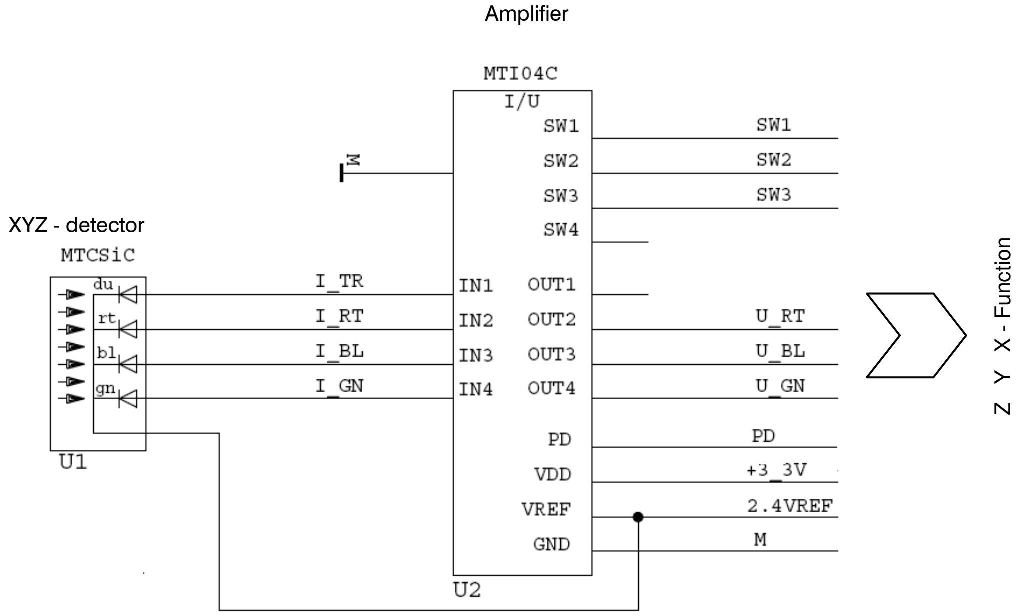

Figure 2: On Chip detector MTCSi and amplifier MTI04C
(without temperature compensation via external resistor)

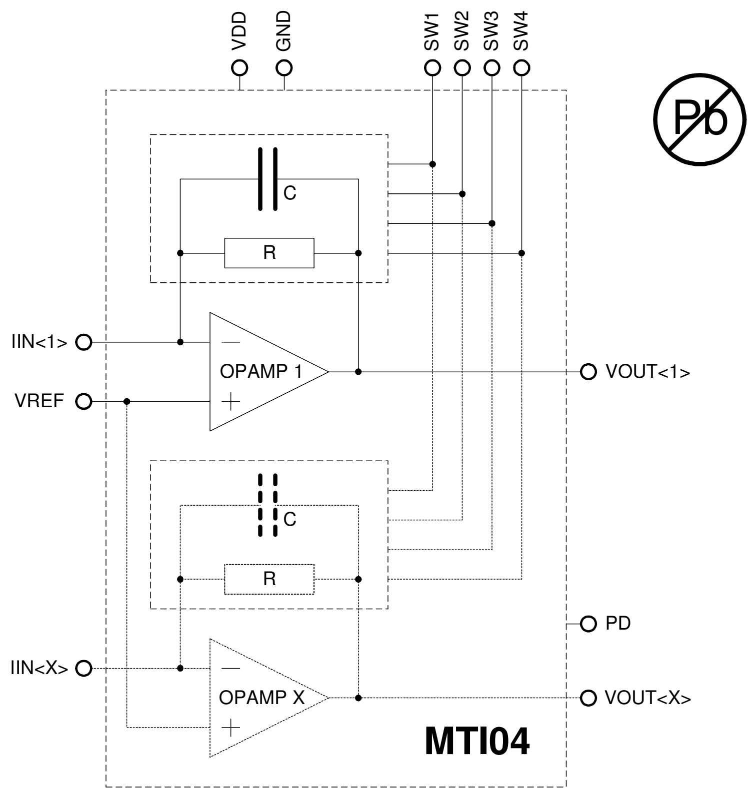

Figure 3: Amplifier MTI04C

The integral XYZ color filters on the photodiode array detect the color components of the light falling on the sensor. The photodiodes converts the XYZ light components into photocurrents. Each photocurrent represents X or Y or Z depend on the spectral response shown in the figure below. 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 CIE1931 / 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 CHARACTERISTIC

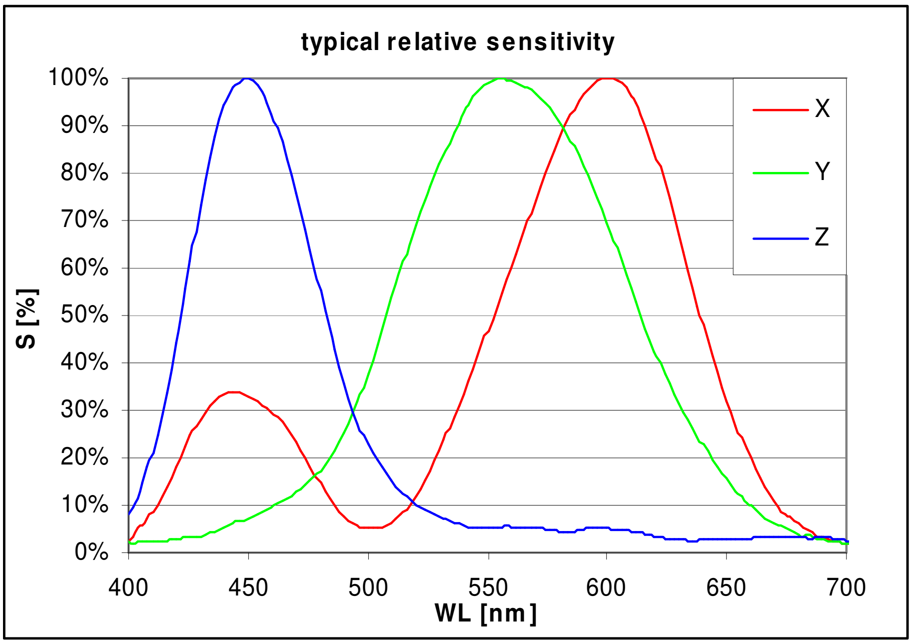

Figure 4: Typical (relative) sensitivity (XYZ) of the color sensor[3, 4]

scanned by width broadband light (FWHM 30nm) and limited angle of incidence (<10°) [5]

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[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

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)

Adjustment of Transimpedance

settings of digital inputs			
SW1	**SW2**	**SW3**	**transimpedance R**
VDD	VDD	VDD	20MΩ – **gain 1**
GND	VDD	VDD	10MΩ – **gain 2**
GND	VDD	GND	5MΩ – **gain 3**
VDD	GND	VDD	2MΩ – **gain 4**
GND	GND	VDD	1MΩ – **gain 5**
VDD	GND	GND	500kΩ – **gain 6**
VDD	VDD	GND	100kΩ – **gain 7**
GND	GND	GND	25kΩ[b] – **gain 8**

a.) default by pull down

Power-down Mode

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

b.) default by pull down

7 SPECIFICATION

ELECTRICAL AND OPTICAL CHARACTERISTICS

(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
typical photo diode sensitivity of color ranges	S_{max}	λ_Z = 445 nm λ_Y = 555 nm λ_{Xk} = 445 nm λ_{Xl} = 600 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 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 Hz			$<10^{-13}$	W/√Hz
cross-talk					<1	%
angle of incidence	φ	$\Delta\lambda_{(Filter)} < 1\%*\lambda$			10	Grad

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°C and VDD = 5V. All voltages are referenced to GND = 0V.

Parameter	Symbol	Condition	min.	typ.	max.	Unit
gain selection (feedback resistor)	R	gain 20MΩ	14000	20000	26700	kΩ
		gain 10MΩ	7000	10000	13350	kΩ
		gain 5MΩ	3500	5000	6700	kΩ
		gain 2MΩ	1400	2000	2670	kΩ
		gain 1MΩ	700	1000	1335	kΩ
		gain 0,5MΩ	350	500	670	kΩ
		gain 0,1MΩ	70	100	133	kΩ
		gain 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/cm²)
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/cm²)
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/cm²)
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/cm²)

Parameter	Symbol	Condition	min.	typ.	max.	Unit
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/cm²)
typical photo sensitivity of color ranges at stage 0,5MΩ	S_{max}	λ_Z = 445 nm λ_Y = 555 nm λ_{Xk} = 445 nm λ_{Xl} = 600 nm		0,874 1,254 0,456 1,330		mV/ (µW/cm²)
typical photo sensitivity of color ranges at stage 0,1MΩ	S_{max}	λ_Z = 445 nm λ_Y = 555 nm λ_{Xk} = 445 nm λ_{Xl} = 600 nm		0,175 0,251 0,091 0,266		mV/ (µW/cm²)
typical photo sensitivity of color ranges at stage 0,025MΩ	S_{max}	λ_Z = 445 nm λ_Y = 555 nm λ_{Xk} = 445 nm λ_{Xl} = 600 nm		0,044 0,063 0,023 0,067		mV/ (µW/cm²)
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

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 feed-back resistors between the four channels	TOL_R[7]	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[8]	TOP	-20	+ 100	°C
storage temperature	TSTG	-40	+ 100	°C

[6] V_{OFF} = VOUT<X> – VREF; results from input offset voltage and input leakage current
[7] up to max. 1% available on request
[8] special on request

8 PACKAGE AND OUTLINE DIMENSIONS

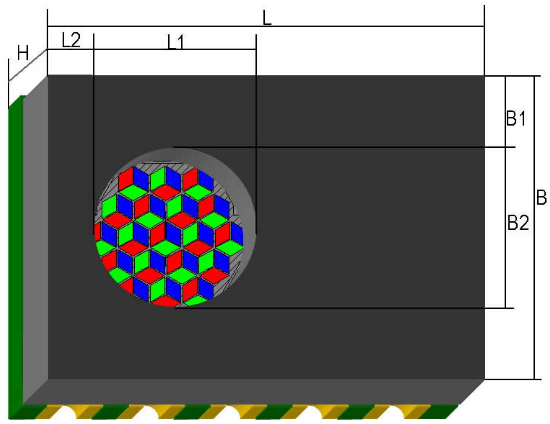


Figure 5: Sizes of LCC packaged MTCS-TIAM2

	H	L	L1	L2	B	B1	B2
mm	2,40	6,50	2,00	0,95	5,00	1,50	2,00
Tol.	±0,10	±0,10	±0,10	±0,10	±0,10	±0,10	±0,10

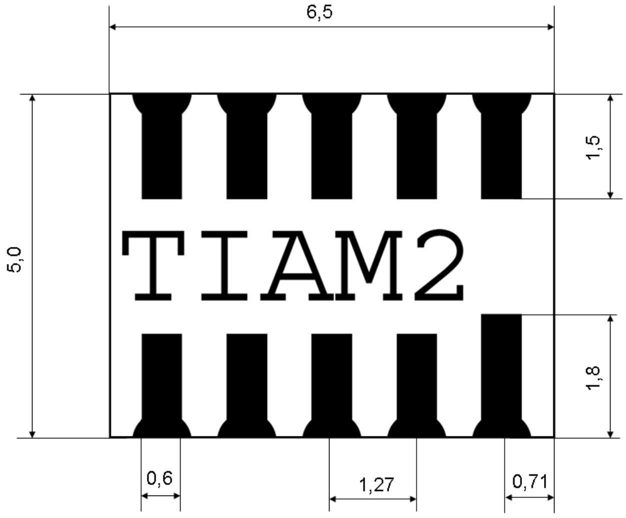


Figure 6: Pad dimensions[9]

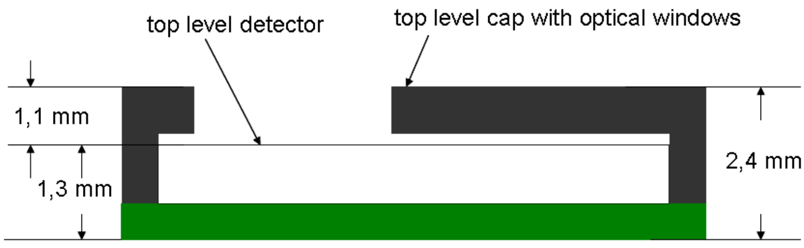


Figure 7: Distance top level cap and detector inside the package

[9] 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.

PIN

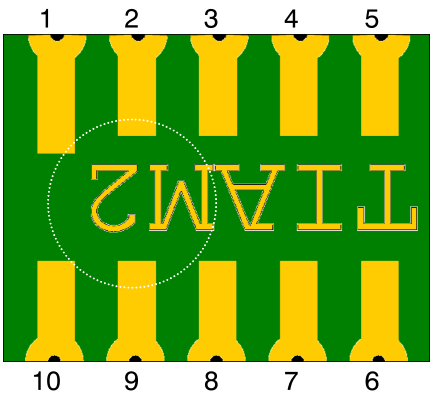


Figure 8: PIN configuration MTCS-TIAM2 - Bottom view

PIN

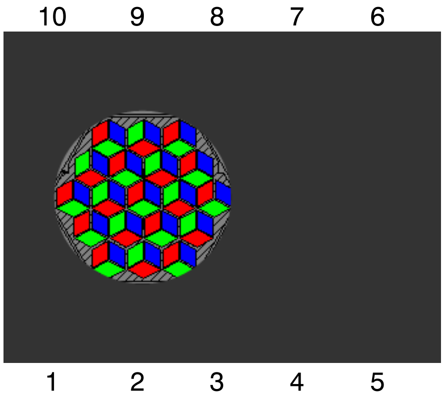


Figure 9: PIN configuration MTCS-TIAM2 Top View

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 transim-pedance of MTI-amplifier (pull down)
6	VDD	INPUT	D/A	power supply
7	SW2	INPUT	D	input 2 for adjustment of transim-pedance of MTI-amplifier (pull down)
8	SW1	INPUT	D	input 1 for adjustment of transim-pedance of MTI-amplifier (pull down)
9	GND	INPUT	D/A	ground
10	VREF	INPUT	A	reference voltage

10 SOLDERING PROFILE

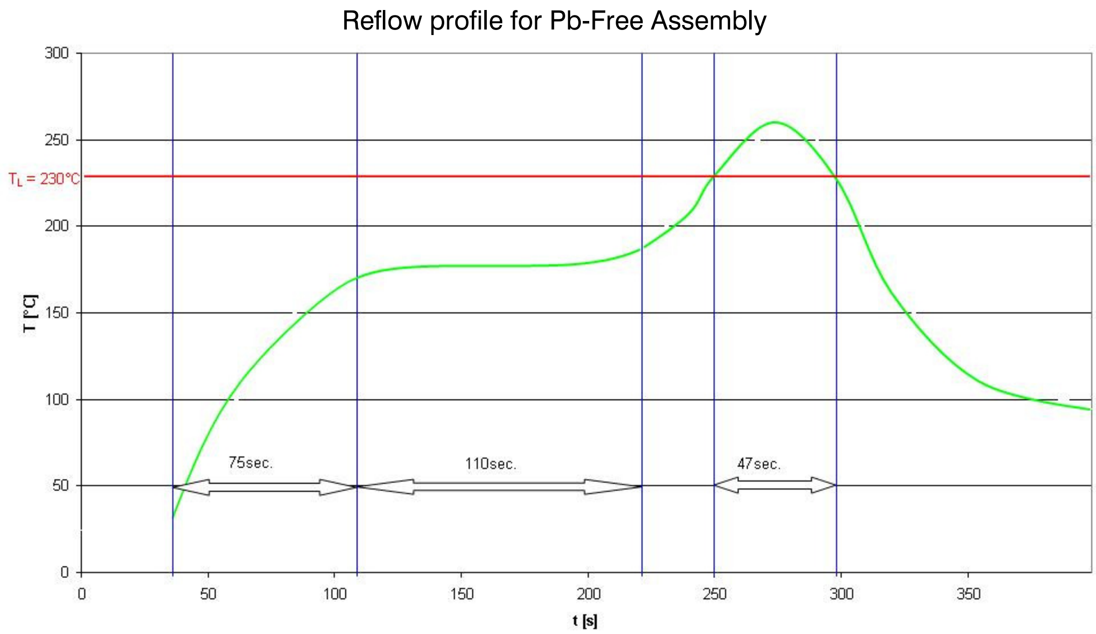


Figure 10: Recommended reflow SOLDERING PROFILE[10]

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 an optical device.

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

Each series 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 moisture bag as short as possible (max. is 72 hours at ≤30°C/60% RH) to avoid baking. If necessary the recommended baking conditions are 24hours at 125°C.

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.

For unsealed packing's the devices must be baked prior soldering. Recommended baking conditions are 24hours at 125°C.

12 PACKING INFORMATION

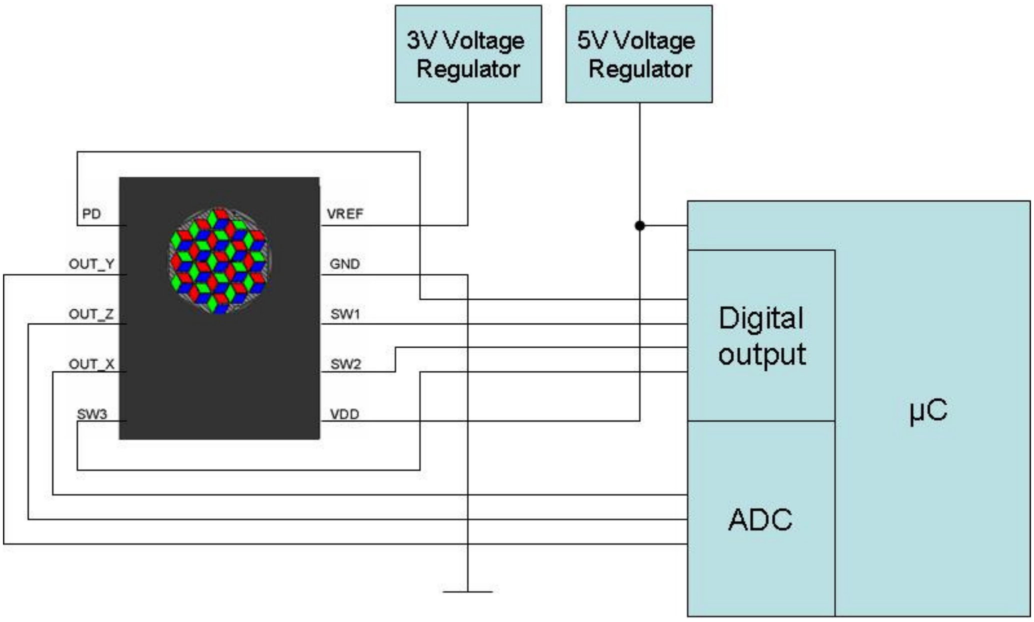
Standard bag is tape, tube or box. Please ask our sales team for variants and general conditions for manufacturing.

[10] 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).

13 APPLICATION NOTE

Circuit

In the following picture there is an example for connection of MTCS- TIAM 2 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-TIAM2 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.

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 }

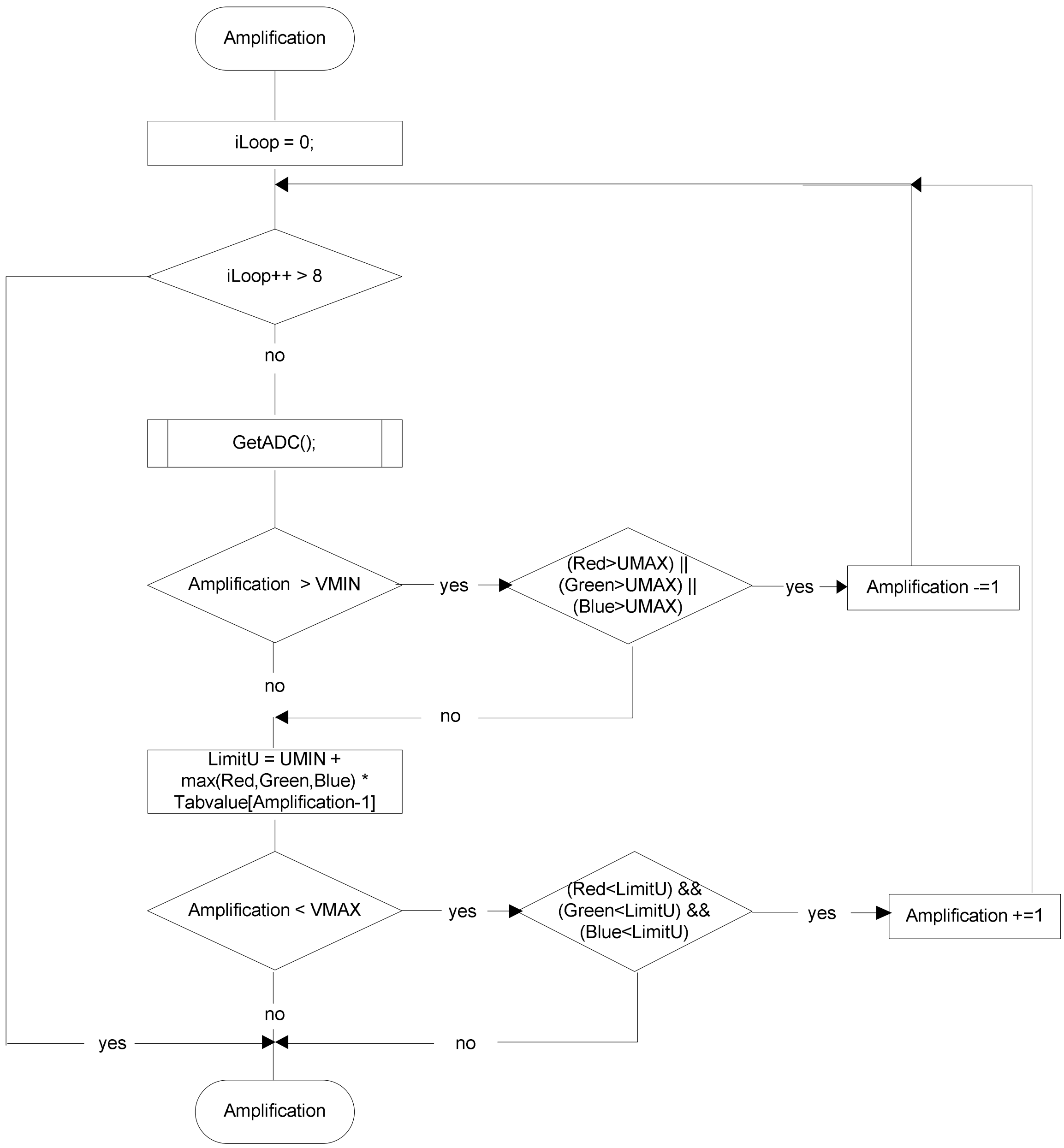


Figure 11: μC-based Algorithm for calculation of an automatic switch of the 8-staged amplification [11]

[11] 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.

Narrowband luminous sources

The spectral filters of the color sensor ICs are specialized for applications with broad-band 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-TIAM2	series	LCC	090400-321-26AEZ00

15 CONTACT

For further information, please feel free to contact:

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