MAZeT

ELECTRONIC ENGINEERING & MANUFACTURING SERVICES

DATASHEET

MTCSiCT

Integral True Color Sensor

TO39

Order No.: 090400-201-26AEZ00

Status: certified

INTRODUCTION

The MTCSiCT is a True Color[1] Sensor IC with a filter function based on the color standard CIE 1931/DIN 5033 (human eye perception) in a compact TO39 package. The MTCSiCT is long-term stable over the entire product lifetime and resistant to external influences such as temperature or aging drifts, due to the special JENCOLOR® interference filter technology.

The JENCOLOR® sensors are made of 19x3 photodiodes integrated on-chip (special pin silicon technology with advanced sensitivity). The diodes are aligned as segments of a multiple-element hexagonal matrix structure with the diameter of 2 mm.

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

Based on the TO39 package and the special JENCOLOR® interference filter technology, the MTCSiCT is long-term stable over the entire product lifetime and resistant to external influences such as temperature drifts. The MTCSiCT operates within temperature ranges of -20°C to 100°C.

APPLICATIONS

- General Color measurement and control
- Portable color measurement devices for consumer and industrial applications
- Highly color sensitive sensor for human eye perception “True Color” reproduction and system calibration
- Detector for various light sources, mood lighting, regulated color temperature, CCT and many more
- Active closed-loop systems for LED lighting[2] – regulation of temperature shifts, binning and aging

FEATURES

- JENCOLOR® interference filter technology
- Filter curves based on CIE 1931/DIN 5033
- Human eye perception
- High transmission and blocking
- No aging of the filter
- High temperature stability up to 100°C
- High signal frequency
- Minimal cross talk
- Compact size (diameter of the optical sensitive surface approx. 2 mm)
- Easily compatible with analog and digital signal converters from MAZeT

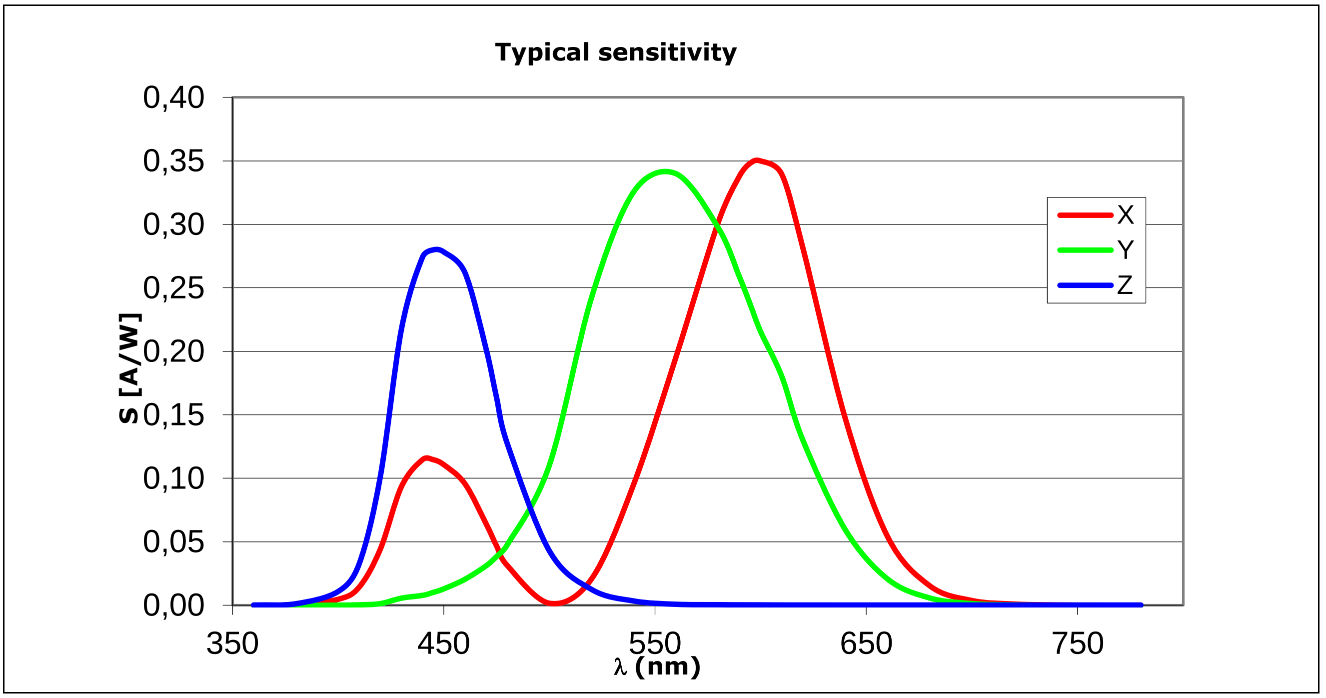
[1] Sensors utilizing the JENCOLOR® interference filter technology implement the standard observer functions as defined under DIN 5033 Part 2 – Color Measurement; CIE 1931 (Commission Internationale de l'Eclairage or International Commission on Illumination) Standard Colorimetric Systems. (see relative sensitivity) This implementation method allows colors to be determined according to the three-range procedure that is defined in part 6 of DIN 5033.

[2] LED lighting control management for solid-state lighting (SSL), LED spotlights, cabin lighting, day-light management / Human and Color Centric Lighting (HCL and CCL), Color Light Output (CLO), ambient light color detection / correction, (O)LED display control and dynamic display color balancing, portable light color measurement.

1 SPECTRAL CHARACTERISTIC

The filter function of MTCSiCT is based on the CIE 1931/DIN 5033 - standard observer function (XYZ). For more information please read: http://en.wikipedia.org/wiki/CIE_1931_color_space.

Figure 1: Typical (relative) sensitivity (XYZ) of the color sensor (MTCSiCT) evaluated via broadband light and limited angle of incidence (<10°)[3] [4]



2 MAXIMUM RATINGS/ CHARACTERISTICS

Table 1: Maximum Ratings/Characteristics (TA = 25°C; per single diode)

DESCRIPTION	SYMBOL	CONDITION	MIN	TYP	MAX	UNIT
Diameter of light sensitivity area	D			2.0		mm
Light sensitivity area per single color array (19 diodes)	A			0.54		mm²
Typical photo sensitivity of color ranges	S_{max}	λ_Z = 445 nm λ_Y = 555 nm λ_{Xk} = 445 nm λ_{Xl} = 600 nm	0.25 0.30 0.10 0.30	0.28 0.34 0.12 0.35	0.31 0.38 0.15 0.40	A/W
Temperature coefficient of photo sensitivity	TK	λ_Z = 445 nm λ_Y = 550 nm λ_{Xk} = 600 nm λ_{Xl} = 670 nm		0 250 500 1000		ppm/K
Spectral tolerance of filter curve	$\Delta\lambda(\lambda)$			<1%*λ		nm
Reverse voltage	V_R		0	0	2.5	V
Dark current	I_R	V_R = 2.5 V			20	pA
Terminal capacitance	C	V_R = 2 V			70	pF

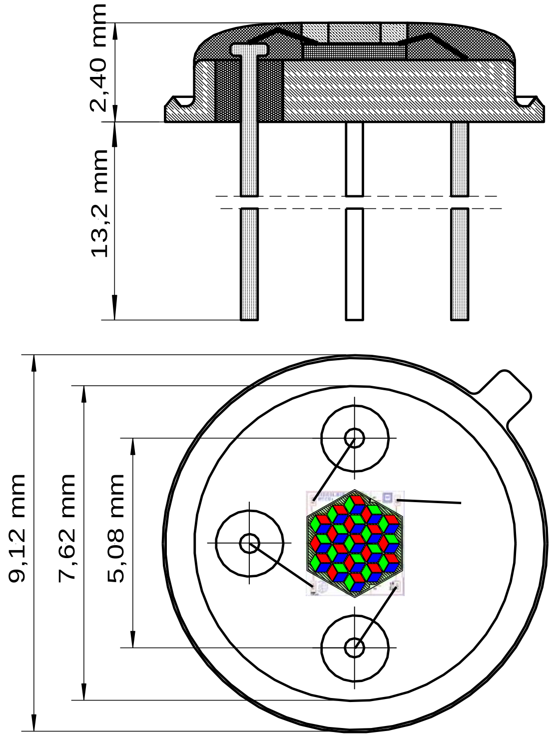
[3] Typical sensitivity characteristics; monitored via monochromatic light at FWHM 27 nm

[4] See chapter 8.2 Angle of Incidence

DESCRIPTION	SYMBOL	CONDITION	MIN	TYP	MAX	UNIT
Rise and fall time of photo-current	t_r, t_f				2	µs
Angle of incidence	φ	$\Delta\lambda_{(Filter)} < 1\% * \lambda$			10	Grad
Standard operating temperatures[5]	T_{op}		-20		+100	°C
Storage temperature range	T_{st}	RH < 70%	-40		+100	°C
Moisture Sensitive Level	MSL	JEDEC *J-STD-020*		3		
Weight	m			0.5		g

3 PACKAGE OVERVIEW[6]

Figure 2: MTCSiCT in TO39 package



[5] Special on request

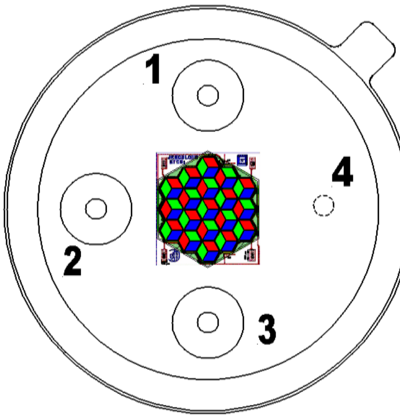
[6] Please protect the sensible surface (translucent globe top) of the sensor against scratches and similar mechanical influences. It will have negative effects on the sensor function.

4 PIN CONFIGURATION

Table 2: Pin configuration

PIN	DESCRIPTION
1	Y - function
2	Z - function
3	X - function
4	common cathode

Figure 3: TO39-package (Top View)



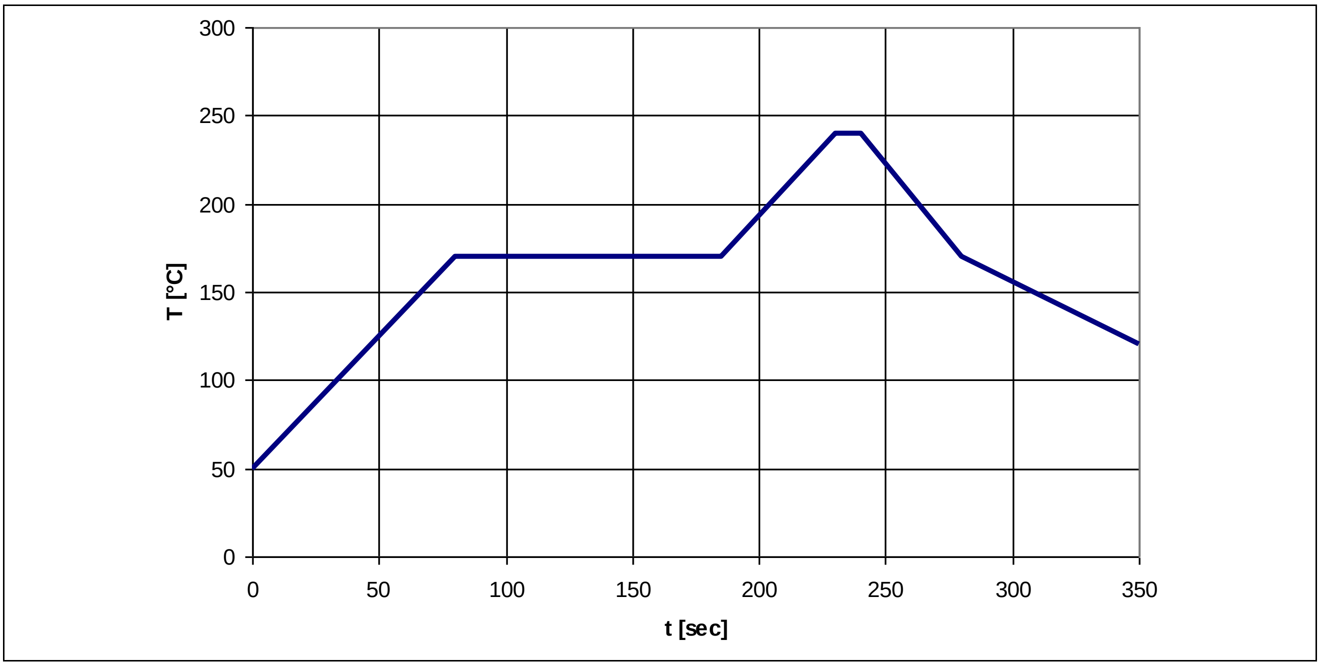
Note: The X Y Z pins are the True Color Sensor signals, cathode is the common connector and TrD is an added isolation-diode to split up the potential of the 3 functional pin diodes XYZ.

TrD is important to shield the single pin diodes for the XYZ detection and minimize crosstalk among the 3 filtered areas/diodes. Chapter 8.4 illustrates how the signal ASICs of MAZeT need to be connected to the sensors. (e.g. MCDC04/ MDDC04) Otherwise ask our sales team for support.

The term "nc" means the contact is not connected internally, it is not required for any electrical function but is important for IC soldering and mechanical functions. In PCB contact all “nc” to common cathode to avoid potential differences between the pin diodes and neigh boarded wires.

5 SOLDERING PROFILE

Figure 4: Recommended Soldering Profile[7]



[7] 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.

6 HANDLING

Take care that the sensor surface is clean at all time. Dust, scratches will adversely affect the sensor parameters. Sensors should be handled with care as any other optical device.

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

7 PACKING INFORMATION

Standard packing is tape and reel. Usually in a moisture barrier bag (MBB sealed aluminized envelope) with desiccant (e.g. silica gel) and humidity indicator card to protect them from ambient moisture during shipping, handling, and storage before use. This package has been assigned a moisture sensitivity level of MSL 3 and the devices should be stored under the following conditions:

- Temperature range 5°C to 50°C
- Relative humidity 60% maximum
- Total time 6 months from the date code on the aluminized envelope — if unopened
- Opening time 168 hours or less

Re-baking is required if the devices have been stored unopened for more than 6 months or if the aluminized envelope has been open for more than 168 hours. If a re-baking process is required, it should be performed at 90°C for 4 hours.

8 APPLICATION NOTES

8.1 Narrowband Luminous Sources

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

8.2 Angle of Incidence

The packaging of the sensor IC has an aperture angle (beam width) of nearly 90°. Traditional interference filter work depending on angle of incidence. Using a <10° angle of incidence will allow the best results with no filter shifts. This can be ensured by using lenses or optical holes that limit the angle of incidence to the sensor device <10°. An angle of incidence of more than 10° will result in a filter shift. The filter response and accuracy will be distorted the greater the angle deviation is. Please note a filter deviation resulting from this fact can differ from standard observer function and/or from the filter functions specified in this document. Please ask our sales team for support.

8.3 Effects of Temperature

The specified operation temperature range and documented parameters regarding temperature influence are described in chapter 2. The functionality of the filters do not depend on any temperature changes. The temperature coefficient of the photo sensitivity and the dark current of the photodiodes need to be considered, since these have an influence on the sensor response in case of changing temperature. Common signal converters do not implement temperature compensation. MAZeT offers various signal ASICs including temperature compensation. Please ask our sales team about the application-specific solution to prevent negative influence caused by temperature shifts.

8.4 Schematic of Typical Design

Figure 5 shows a typical connection of the MTCSiCT to the A/D converter MCDC04[8] from MAZeT. If digital and analog grounds are routed separately onto the printed circuit build, they should be connected together near the device.

Figure 5: Typical connections; (a) common cathode photodiode array, (b) common anode photodiode array

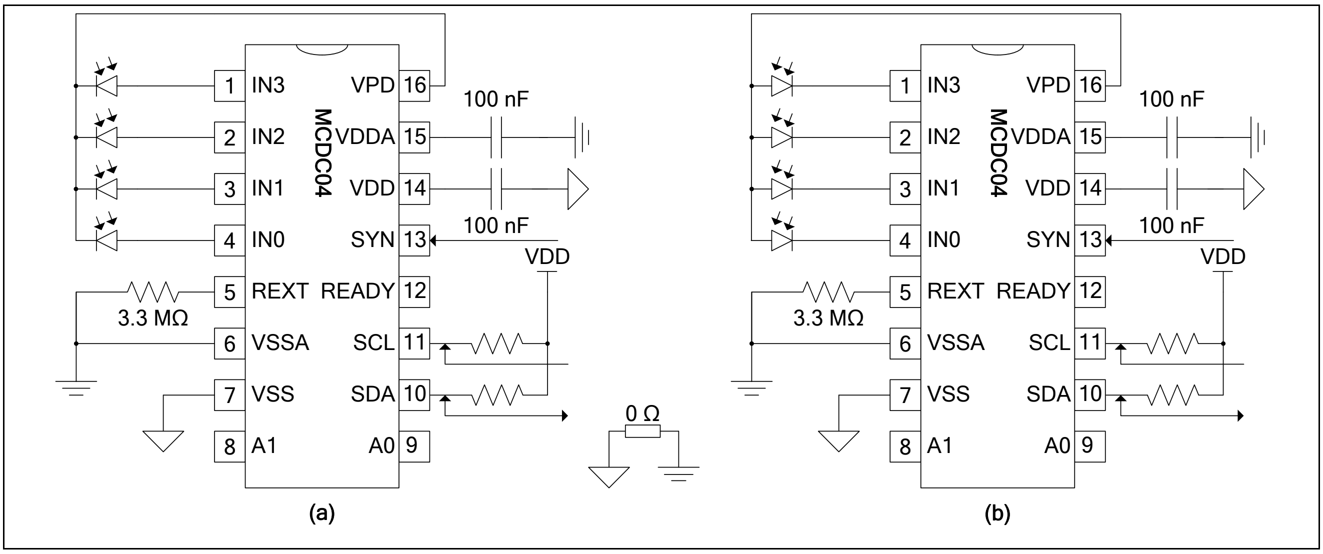
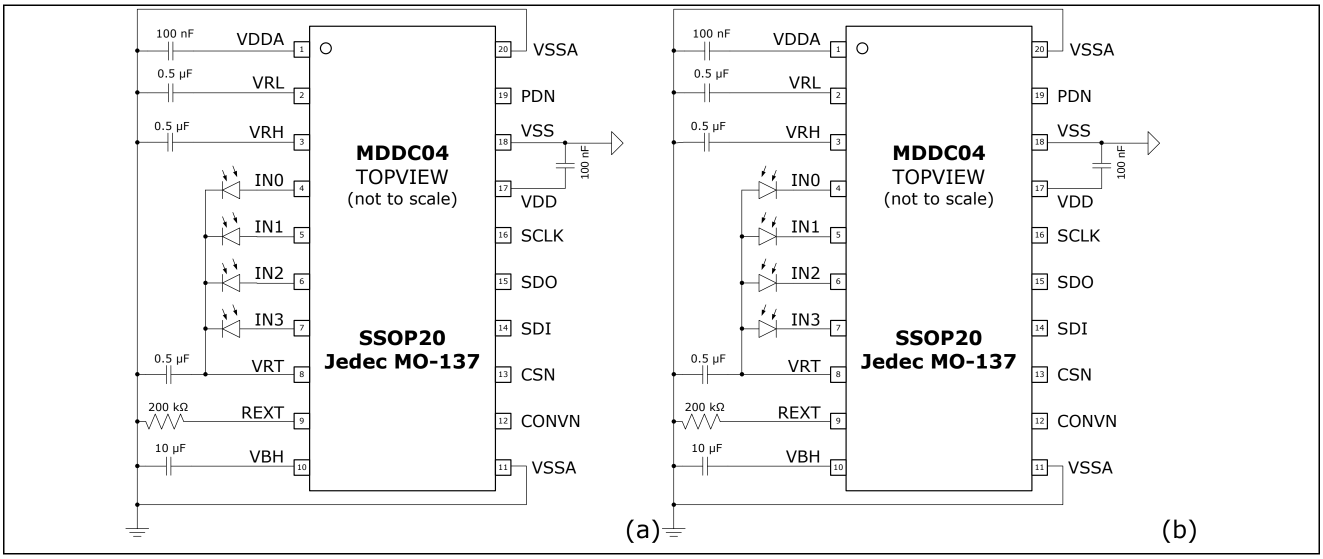


Figure 6 shows typical connections of the MTCSiCT to MAZeTs MDDC04[9]. If digital and analog grounds are routed separately onto the printed circuit build, they should be connected together near the device.

Figure 6: Typical Connection Circuitry – (a) Common Cathode Photodiode Array, (b) Common Anode Photodiode Array



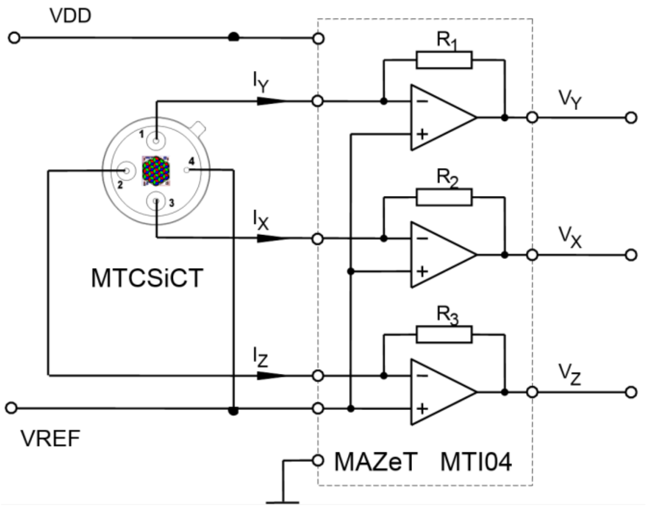
Please make sure that all specified components within the application circuit work according to their operating range and to the parameters in the data sheet. For example, color sensor (input current) and voltage regulators (workspace load current, separated analog and digital or decoupled power supplies based on a common regulator) need special treatment to avoid noise or deviations during operation.

[8] The converter MCDC04 is a low noise sensor interface application specific standard product (ASSP) with I²C interface. It is suitable for coupling of multi-channel optical sensors or sensors using current output. It converts input currents to a digital output (16 bit) and realizes a continuous or triggered measurement via current integration with a high bandwidth (1 : 1,000,000).

[9] The converter MDDC04 is an integrated circuit with a 4 channel transimpedance amplifier, one analog-to-digital converter (12 bit ADC). The transimpedance or gain of each channel is individually programmable.

For more schematic details compare our reference designs provided in our data sheets for the signal ASICs MCDC04EQ, MDDC04AQ or alternatives. These provide special notes for PCB layout of the sensor in combination with the special signal ASIC.

Figure 7: Circuit for the conversion of photo current to an equivalent voltage



$$R_x \approx \frac{V_{Out}}{I_{Photo}}$$

8.5 Notes for PCB Layout

The connections between sensor outputs and converter inputs have to be protected against any kind of electromagnetic coupling and have to be guarded with the potential of *reference voltage*[10] to avoid leakage currents. Confusing leakage currents with equivalent values like the sensor currents can occur, without guarding layers at the inputs of the PCB isolation resistance! Digital signals and circuit lines with high current loads should not be used directly beneath or next to the color sensor as well as the converter.

Often the converter operates internally with minimal currents (pAmps). Therefore, protection measures need to be performed to shield the converter and sensor against EMC stress or external interferences.

The connections between the color sensor (anode and cathode) and the converter should be as short as possible (<10 mm) and without interlayer connections. The signal for cathode(s) or anode(s) should have the same cross-section on the PCB.

Color sensor, converter and its external components for references and/or power supply (e.g. Rext in case of MCDC04EQ) should be placed on the same PCB side.

Around the sensor signal lines a conductor connected with the potential of reference voltage should be created. One level below the signals a *reference voltage* potential area should be used that extends only to the analog inputs and the signal lines.

[10] VRT/VPD – see data sheets of MCDC04EQ and MDDC04EQ

8.6 Sensor Calibration

Since the main variables of color change upon the arrangement of the observer, the object and light - it is essential to optimize and calibrate color measurement tasks to the specific application, especially for absolute color measurements according to the CIE 1931/DIN 5033.The calibration has three functions. It converts the measured values from the amplifier and/or analog-to-digital converter into the color space XYZ/xyY/Luv/Lab or others. Secondly it compensates production-related tolerances of the individual sensors (see chapter 2 for tolerances). Thirdly, the accuracy of the XYZ sensor is extremely sensitive to the opto-mechanical design and variations of the system in which it resides. These influences need to be corrected as other (e.g. external) effects like temperatures or others can influence other components in the sensor system and therefore the overall sensor response.

Depending on the application and system accuracy a sensor calibration will be possible by an individual, system or by an in-series calibration. In the process of calibration there are conditions which are required to receive reliable results in the CIE 1931 color space. Using a standardized illumination source such as A, F2 and D65 as reference, the angle of incidence as well as the arrangement of sensor and illumination are important input variables of the calibration and determine the quality of the XYZ transformation. MAZeT offers special white papers and application notes to find an optimized application-specific solution (time, costs and quality) for calibration. Please ask our sales team.

For calibration the (color) target, measured by a spectrometer (n * XYZ as absolute color values and reference) and the color sensor (n * ADC measured), must be known. By a simple coefficient matrix method the relationship between the measured sensors values and absolute color coordinates in CIE 1931 color space can be made: T (1) is the matrix of the reference measurement (XYZ values of spectrometer), S (EQ1) is the sensor signal matrix (ADC values of Sensor) and K is the transformation matrix (EQ2). After the transposition of S, a transformation matrix K (linear regression) will be calculated (EQ2). The result (EQ3) is the correction matrix K which will be used to transform measured sensor values (ADC result of a color target) into the color space XYZ based in CIE 1931 (EQ4).

(Notice: matrixes are not set up as a square matrix and depend on the number of targets n).

$$T = \begin{pmatrix} X1 & Xn \\ Y1 & Yn \\ Z1 & Zn \end{pmatrix}; \; S = \begin{pmatrix} x\,adc\,1 & x\,adc\,n \\ y\,adc\,1 & y\,adc\,n \\ z\,adc\,1 & z\,adc\,n \end{pmatrix}; \qquad \text{(EQ1)}$$

$$K = (T * S^T) \; * \; (S * S^T)^{-1} \qquad \text{(EQ2)}$$

$$K = \begin{pmatrix} xk1 & xk2 & xkn \\ yk1 & yk2 & yky \\ zk1 & yk3 & zkn \end{pmatrix} \qquad \text{(EQ3)}$$

$$\begin{pmatrix} X\,Sensor \\ Y\,Sensor \\ Z\,Sensor \end{pmatrix} = K * \begin{pmatrix} x\,adc \\ y\,adc \\ z\,adc \end{pmatrix} \qquad \text{(EQ4)}$$

X Sensor, Y Sensor, and Z Sensor are in the CIE system which specifies the color and brightness of particular homogenous visual stimulus. X adc, y adc, z adc are measured values of the sensor. Xn, Yn, Zn are by a spectrometer measured color coordinates of the target for the calibration. Xk…, yk…, zk… are coefficients of the correction matrix. X1, Y1, Z1 …and will be changed based on the system setup.

ORDERING INFORMATION

NAME	Status	PACKAGE	Article
MTCSiCT	Series	TO39	090400-201-26AEZ00

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