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REVISIONS

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Data Sheet

MTI04CS/MTI04CQ

**MULTI-CHANNEL PROGRAMMABLE GAIN
TRANSIMPEDANCE AMPLIFIER**

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1. GENERAL DESCRIPTION

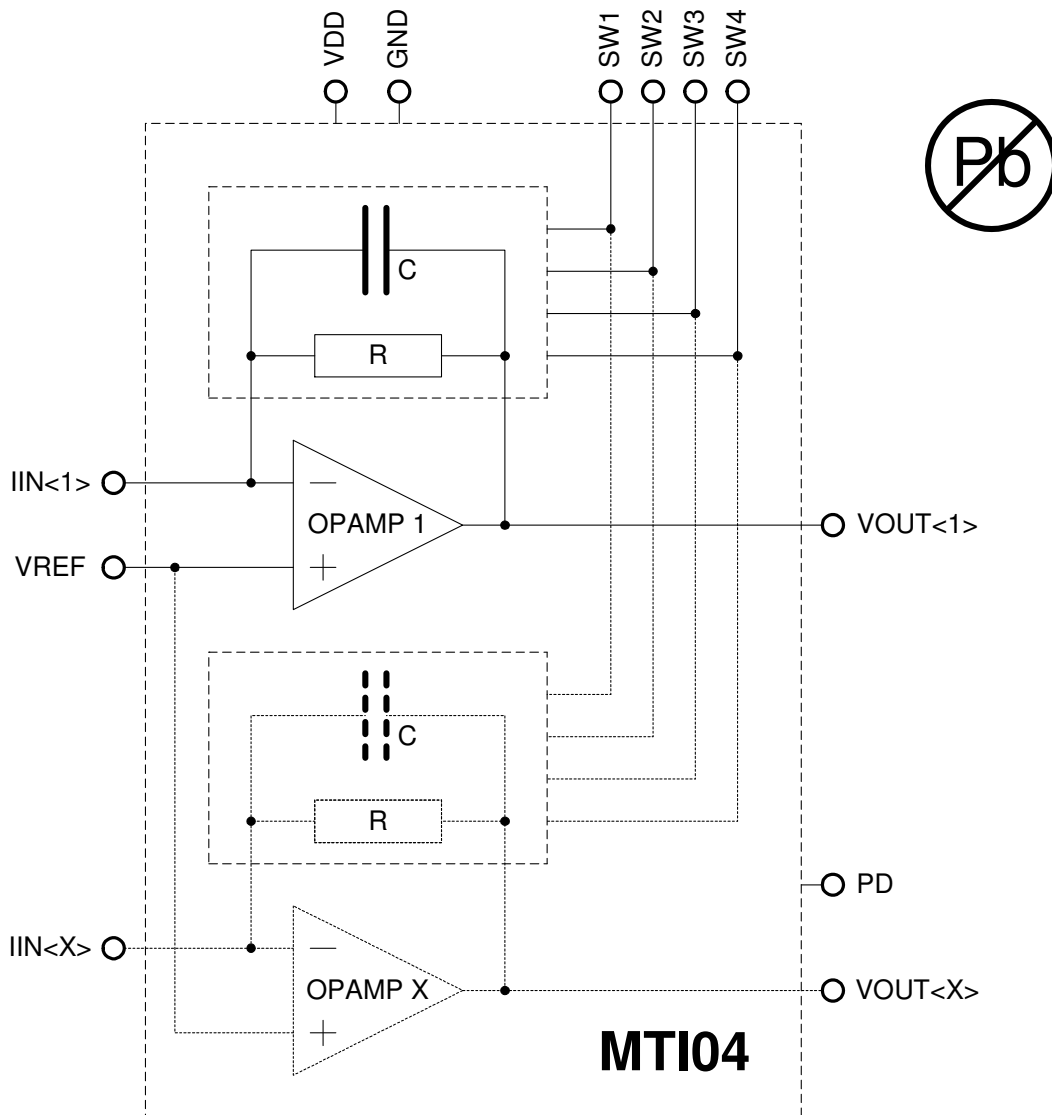
The MTI-devices are a family of integrated circuits of **programmable gain transimpedance amplifiers** with **4 channels** per IC (more custom specific, on request).

The MTI-devices are mainly used for **signal conditioning of sensors with current outputs**. They are especially suitable for connection of photodiodes of **array and row sensors**.

The possibility to **adjust the transimpedance in 8 stages** is a special feature. The adjustment is made by programming three pins and is valid for all channels together.

The device packages (naked chip on request) are ROHS conform and optimized for **COB-mounting and SMD**.

2. BLOCK DIAGRAM



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3. DESCRIPTION OF INTERFACE

3.1 Pin Assignment

signal name	typ.	a/d ^a	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 dependend on input capacitance of the photo-sensor (pull down)
PD	input	d	power down mode (pull down)
IIN<X>	input	a	analog current input of amplifier X
VOOUT<X>	output	a	analog voltage output of amplifier X

a.) analog or digital

3.2 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

b.) default by pull down

3.3 Switchable Frequency Range

settings of digital input	Allowed capacitance of photo-sensor
SW4	
VDD	< 5pF
GND	< 80pF ^c

c.) default by pull down

3.4 Power-down Mode

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

d.) default by pull down

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4. DESCRIPTION OF FUNCTION

The MTI-devices are programmable gain transimpedance amplifiers¹ with different numbers of channels (MTI04 – 4 channels). There is one transimpedance amplifier per channel between a current input IIN<X> and a voltage output² 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 (headline 3.2).

Also simultaneously valid for all channels is a compensation of the input capacitance of photo-sensors for two possible frequency ranges (switchable by SW4, headline 3.3).

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

The second input of all transimpedance amplifiers is used for a *common* supply by a reference voltage necessarily fed in through the pin VREF.

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 (tristate).

5. ELECTRICAL CHARACTERISTICS

5.1 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	name	min.	max.	unit
power supply	VDD	0.3	7.0	V
input and output voltages	⇒ IC-pinning	0.3	VDD+0.3	V
power dissipation	P _{OP}		0.025	W
operating temperature	T _{OP}	-40	125	°C
storage temperature	T _{STG}	-55	155	°C

5.2 Operating Conditions

All voltages are referenced to GND = 0V.

parameter	name	min.	typ.	max.	unit	condition
supply voltage	VDD	2.7	3 to 5	5.5	V	
bias current MTI04	I(VDD)		2.5	4.0	mA	27°C, VDD=5.5V
bias current MTI04	I(VDD)			8	μA	PD=VDD
operating temperature	T _{OP}	-40	27	125	°C	
input high level	V _{IH}	0.7-VDD		VDD+0.3	V	
input low level	V _{IL}	-0.3		0.8	V	
reference voltage	VREF	0.4		VDD-0.4	V	

¹ work as inverted amplifiers

² $V_{OUT} = V_{REF} - I_{in} * R$

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5.3 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	Name	min.	typ.	max.	unit	condition
input current	I(IIN<X>)		0.025		μA	stage 1
			0.05		μA	stage 2
			0.1		μA	stage 3
			0.25		μA	stage 4
			0.5		μA	stage 5
			1		μA	stage 6
			5		μA	stage 7
			20		μA	stage 8
feedback resistor	R	14000	20000	26700	$\text{k}\Omega$	stage 1
		7000	10000	13350	$\text{k}\Omega$	stage 2
		3500	5000	6700	$\text{k}\Omega$	stage 3
		1400	2000	2670	$\text{k}\Omega$	stage 4
		700	1000	1335	$\text{k}\Omega$	stage 5
		350	500	670	$\text{k}\Omega$	stage 6
		70	100	133	$\text{k}\Omega$	stage 7
		17	25	34	$\text{k}\Omega$	stage 8
signal frequency at input SW4 = GND ($C_{\text{PHOTO-SENSOR}} < 80\text{pF}$)	$f_{3\text{dB}}$	4	6	16	kHz	stage 1, $T_{\text{OP}} (5.2)$
		7	11	28	kHz	stage 2, $T_{\text{OP}} (5.2)$
		11	16	42	kHz	stage 3, $T_{\text{OP}} (5.2)$
		18	26	66	kHz	stage 4, $T_{\text{OP}} (5.2)$
		25	35	95	kHz	stage 5, $T_{\text{OP}} (5.2)$
		35	50	130	kHz	stage 6, $T_{\text{OP}} (5.2)$
		80	120	280	kHz	stage 7, $T_{\text{OP}} (5.2)$
signal frequency at input SW4 = VDD ($C_{\text{PHOTO-SENSOR}} < 5\text{pF}$)	$f_{3\text{dB}}$	4	6	16	kHz	stage 1, $T_{\text{OP}} (5.2)$
		7	11	28	kHz	stage 2, $T_{\text{OP}} (5.2)$
		14	21	45	kHz	stage 3, $T_{\text{OP}} (5.2)$
		35	54	130	kHz	stage 4, $T_{\text{OP}} (5.2)$
		70	110	260	kHz	stage 5, $T_{\text{OP}} (5.2)$
		100	160	360	kHz	stage 6, $T_{\text{OP}} (5.2)$
		260	380	780	kHz	stage 7, $T_{\text{OP}} (5.2)$
500	800	1700	kHz	stage 8, $T_{\text{OP}} (5.2)$		
temperature coefficient of the feedback resistor ³	TC_R		-3300		ppm/K	
offset voltage	V_{OFF} ⁴	-10		10	mV	$T_{\text{OP}} (5.2)$
capacitive load at VOUT<X>	C_{LOAD}			50	pF	$I_{\text{LOAD}} < 0.5\text{mA}$ per output
pull down current SW1, SW2, SW3, SW4, PD	I_{PDPAD}			200	μA	digital inputs
input capacitance of external connected photo- sensors	$C_{\text{PHOTO-SENSOR}}$			80	pF	per input SW4 = GND
input capacitance of external connected photo- sensors	$C_{\text{PHOTO-SENSOR}}$			5	pF	per input SW4 = VDD
tolerance of the feed- back resistors between the four channels	TOL_R ⁵	1		10	%	DC input current; for all stages

³ see also chapter 9.2

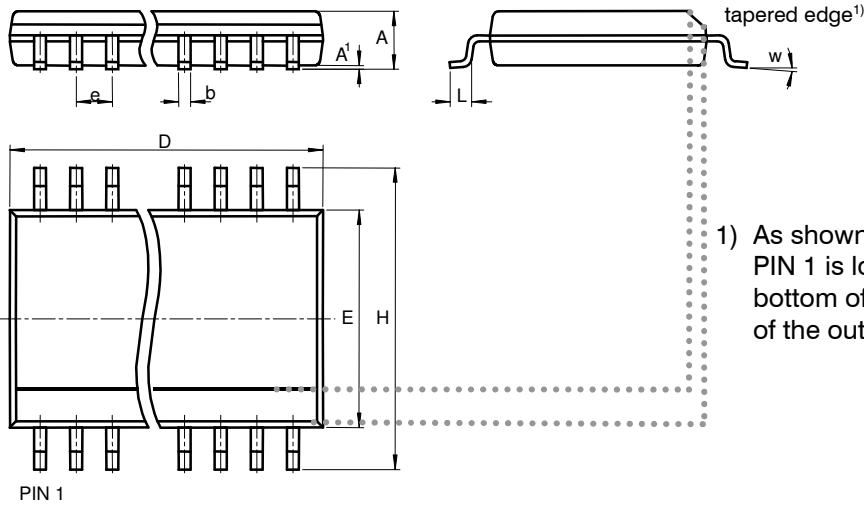
⁴ $V_{\text{OFF}} = \text{VOUT}<X> - \text{VREF}$; results from input offset voltage and input leakage current

⁵ up to max. 1% available on request

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6. PACKAGES

6.1 Shape And Dimensions



dimensions – mm

TYP	PACKAGE	D	E	H	A	A1	e	b	L	w
MTI04CS	SOP16	9.90	3.80	6.00	1.75	0.15	1.27	0.41	0.72	4°
MTI04CQ	QSOP16	4.90	3.80	6.00	1.75	0.15	0.635	0.38	0.72	4°

6.2 Soldering Information

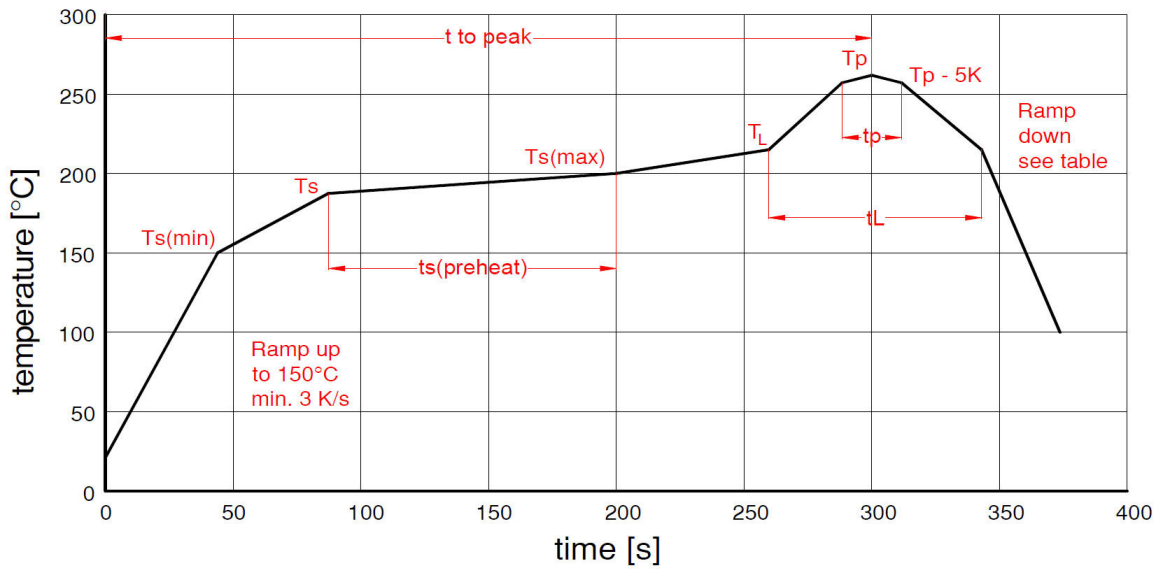
The device package was successful tested with following soldering profile. User should recognize the temperature-time profile and advised not exceed the values given.

Temperature profile parameter:

Profile Features	class 1 (small)
Volume	< 350mm ³
Preheat	
Ramp-Up Rate 20°C to 150°C	min 3K/s (average value over 10s)
Soak Temperature (min): T _s (min)	150°C
Soak Temperature: T _s	190°C
Soak Temperature (max): T _s (max)	200°C
Time between T _s (max) and T _s	min. 110s
Peak	
Ramp-Up Rate from 200°C to T _{peak}	0,5 – 3K/s (average value over 10s)
Liquidus Temperature: T _L	217°C
Time above Liquidus Temperature: t _L	min. 90s
Peak Temperature: T _p	260 (-0)°C
Time within 5°C of Actual Peak Temperature: T _p -5K	min. 40s
Cooling	
Thickness 1,6 - 2,5 mm	-4K/s
General	
Time to Peak: t _{to_peak}	> 300s

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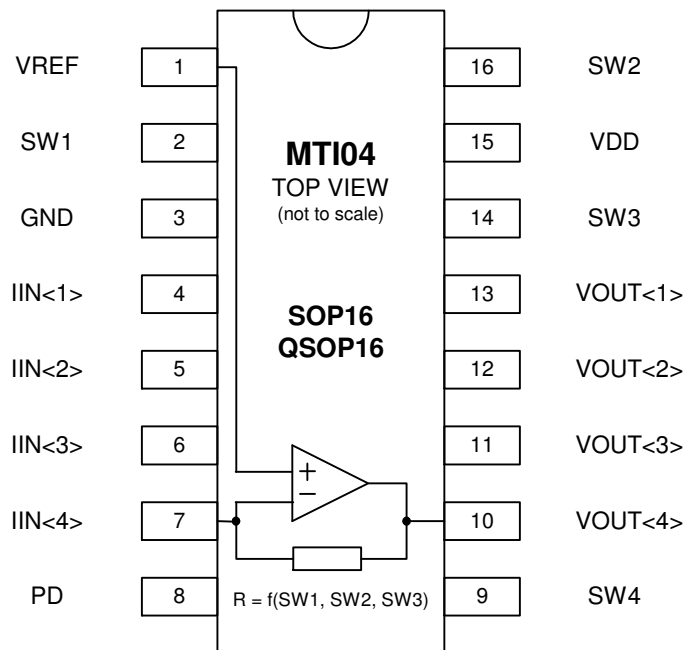
Temperature –Time profile



6.3 MSL-Level

The package corresponds to a moisture level of MSL2. Each device is baked prior packing for shipment to guarantee this level. Devices are packed in a sealed aluminized envelope with humidity indicator card and desiccant. Keep the opening and handling time of moisture bag short (max. is one year at ≤30 °C/60% RH) to avoid re-baking. If re-baking should be necessary the recommended baking conditions are 24hours at 125°C.

6.4 Pin Configuration



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7. ORDERING INFORMATION

NAME OF PRODUCT	PACKAGE	NUMBER OF CHANNELS
MTI04CS	SOP16	4
MTI04CQ	QSOP16	4

8. CONTACT

For further information, please feel free to 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.**

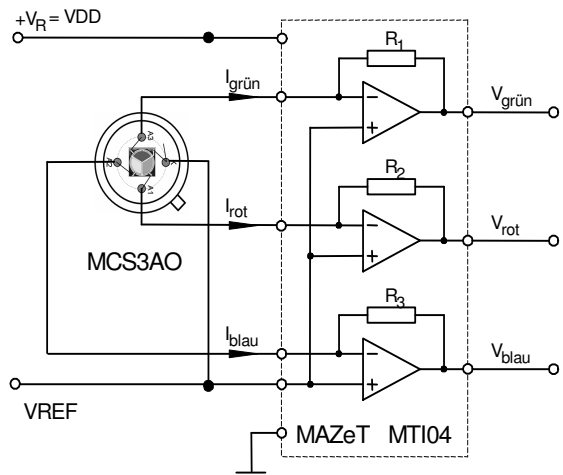
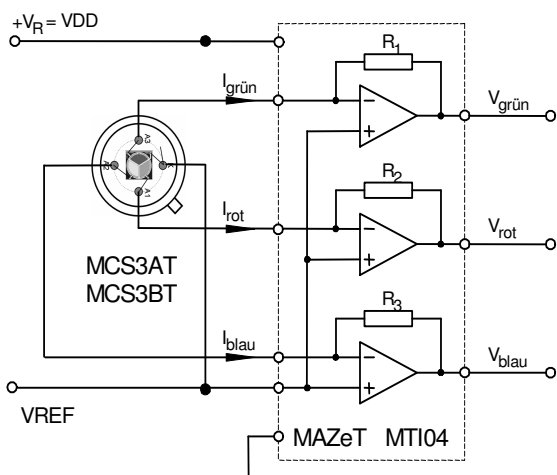
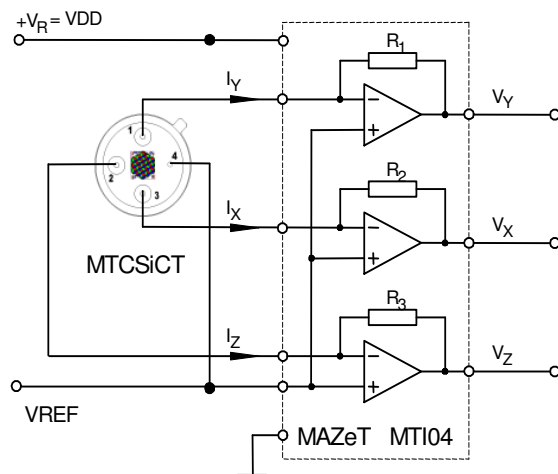
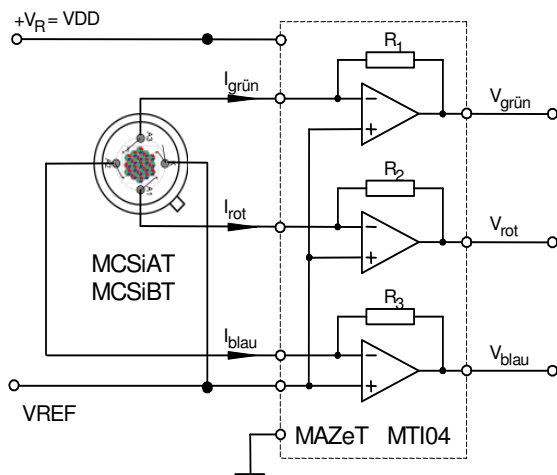
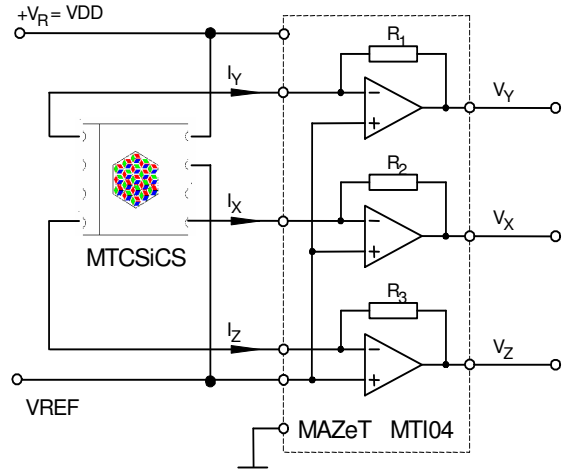
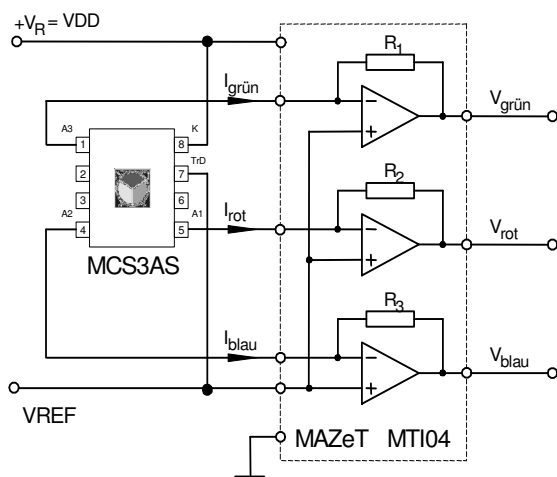
Misuse of Documentation – The information presented in this data sheet is for reference only. Because these products are under development do not use this document as product installation guide. Before you start any development ask your supplier for the latest version of this sheet. **Failure to comply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

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

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9. APPLICATIONS

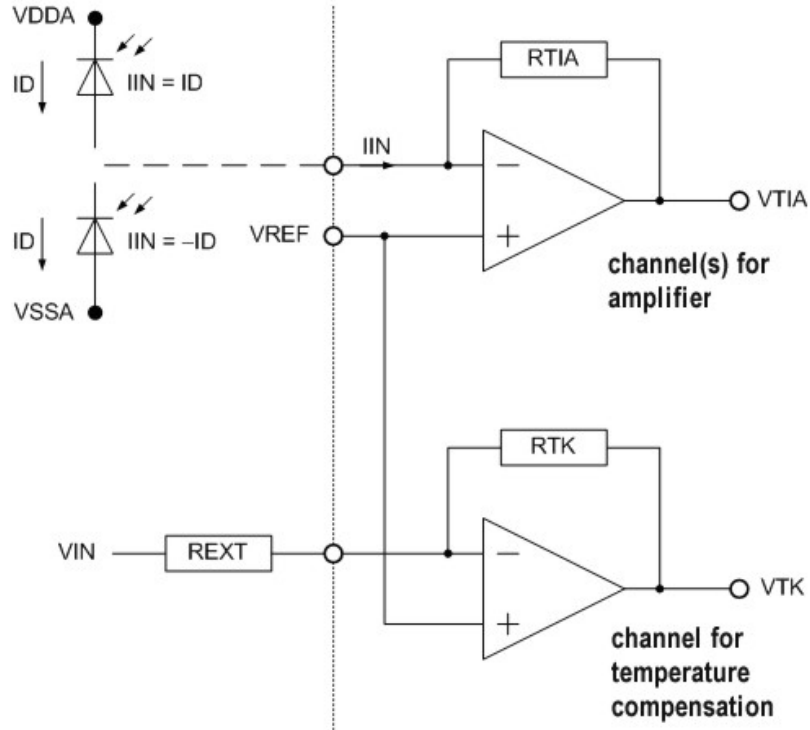
9.1 Connection of MAZeT Colour Sensor



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9.2 Temperature compensation of MTI04 via reference method

The following description shows a possible approach for reduction the temperature dependency of amplifier via reference channel (use the 4th channel of MTI04).



The input of the reference channel 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:

$$(1) V_{TIA}(T) = V_{REF}(T) - I_{IN} * R_{TIA}(T)$$

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

$$(2) V_{TK}(T) = V_{REF}(T) - \frac{V_{IN}(T) - V_{REF}(T)}{R_{EXT}(T)} * R_{TK}(T)$$

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

$$(3) \Delta V_{TIA}(T) = V_{REF}(T) - V_{TIA}(T)$$

$$(4) \Delta V_{TK}(T) = V_{REF}(T) - V_{TK}(T)$$

For example the voltage $\Delta V_{TK}(T_0)$ 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.

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

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.

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

9.3 Output Signals V_{OUT}

MTI04 works by the principle of a connected op-amp:

$$V_{OUT} = V_{REF} - I_{IN} * R \quad \{\text{limited by GROUND ... VREF}\}$$

- a. $I_{IN} = 0$ $\rightarrow V_{OUT} = V_{REF}$
- b. $I_{IN} = \text{max.}$ $\rightarrow V_{OUT} = 0$