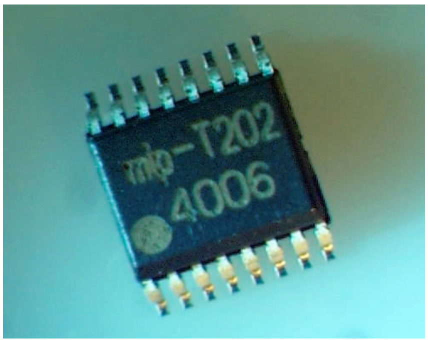
micro-part **mip-T202**

Double Current/voltage interface circuit

Features

- **two current- and two voltage-interfaces**
- **each interface independently adjustable**
- **one adjustable voltage/current reference**
- **processor or sensor supply possible**
- **short circuit and reverse polarity protection**
- **small package: SSOP16**



Operating area

- temperature range: T_a = -40 – 105°C
- supply voltage range: V_{CC} = 8 – 36V
- current output stage: I_{IO} = 0 – 20mA, 100mA
- voltage output stage: V_{VO} = 0 – 10V

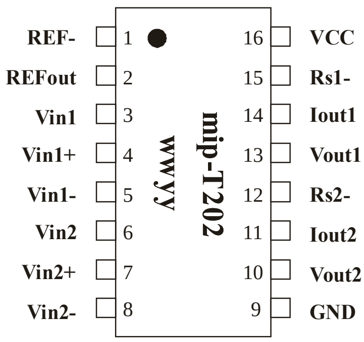
Applications

- sensor signal converter, LED-driver
- processor or sensor supply
- 0 – 5/10V, 0/4 – 20mA interfaces
- industrial, automation

Description

The mip-T202 is an interface and LED driver circuit with two independent current and voltage interfaces and an adjustable voltage/current reference. The reference can supply a sensor cell (voltage/current supply) or a processor (reference output current up to 25mA). Developed for the 0/4 – 20mA interface the circuit is also suitable as LED driver (brightness control possible) or as controllable current source. Depending on the external output transistors currents up to 100mA are possible.

Pinout



SSOP16

pin	designation
VCC	supply voltage
GND	ground
REF-	reference input
REFout	reference output
Vin	current path input
RS-	sense resistor negative
Iout	current output
Vin+	voltage input positive
Vin-	voltage input negative
Vout	voltage output
1 / 2	signal path 1 or 2

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Block diagram

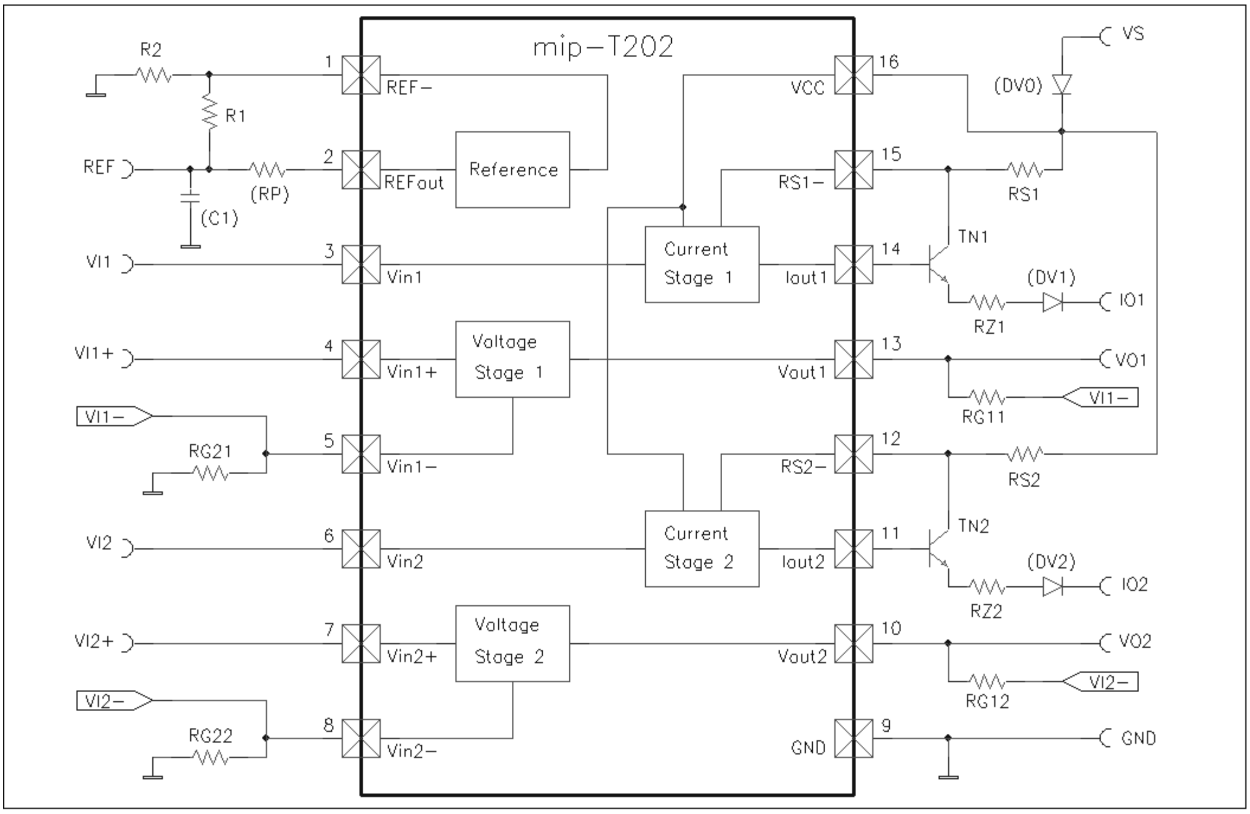


Bild 1: Block diagram of mip-T202 with typical reference- and interface wiring
Components in parentheses only depending on the required application

Boundary conditions

Parameter	**Symbol**	**Description**	**Min.**	**Typ.**	**Max.**	**Unit**
Referenz Resistors	$R_1 + R_2$	voltage-/current-reference	80		220	kΩ
Gain Resistor	R_{G1}	voltage output stages	20			kΩ
Gain Resistors	$R_{G1} + R_{G2}$	voltage output stages	80		220	kΩ
Breakdown Voltage	V_{BR} (D_V)	external (schottky) diodes	40			V
Forward Current Gain	β_F (T_N)	external npn-transistor, I_{IO} = 20mA	60			
	β_F (T_N)	external npn-transistor, I_{IO} = 100mA	250			
Thermal Resistance	R_{th}	SSOP16 plastic package		140		°C/W
Absolute Maximum Ratings						
Supply Voltage Range	V_{CC}		0		40	V
Operating Temperature Range	T_a	ambient temperature	–40		105	°C
Storage Temperature Range	T_s		–55		150	°C
Junction Temperature Range	T_j				150	°C
Lead Temperature	T_l	soldering 10s			300	°C

Electrical specifications

T_a = 25°C, V_{CC} = 16V (unless otherwise noted)

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
Supply Voltage Range	V_{CC}		8		36	V
Supply Current	I_{CC}	$I_{REF} = 0$, $V_{VI} = V_{VI+} = 0$		0.8		mA
	I_{CC}	$I_{REF} = 0$, $V_{VI} + = V_{VI+} = 3V$ (*)		1.2		mA
Adjustable Voltage- / Current-Reference: $V_{REF} = V_{BG} * (R_1 + R_2) / R_2$ or $I_{REF} = V_{BG} / R_2$						
Bandgap Reference	V_{BG}	$V_{CC} > 10V$	1.21	1.25	1.29	V
Bandgap Reference Drift	dV_{BG}/dT	$T_a = -40...+105°C$		±80		ppm/°C
Power Supply Rejection Ratio	PSSR (V_{BG})			86		dB
Output Voltage Drop	V_{DR}	$V_{CC} - V_{REFout}$	3			V
Output Voltage Range	V_{REF}	$R_p = 0$	V_{BG}		$V_{CC} - V_{DR}$	V
Output Current	I_{REF}	$R_p > 0$, respect to power dissipation			25	mA
Load Capacitance	C_L			100		nF
Current Output Stages						
Input Voltage Range	V_{IR}	$V_{CC} \geq 10V$	0		5	V
Offset Voltage	V_{OS}			±2		mV
Offset Voltage Drift	dV_{OS}/dT			±8		µV/°C
Input Bias Current	I_B			16		nA
Sense Resistor	R_S	$I_{IO} = 20mA$	50		250	Ω
Sense Resistor Voltage	V_{RS}			V_{Vin}		V
Sense Resistor Voltage Fullscale	$V_{RS}(FS)$		1		5	V
Output Current Range	I_{IO}	$I_{IO} = V_{VI} / R_S$	0	20	100	mA
Output Offset Current	I_{OS}			–20		µA
Stabilization Resistor	R_Z		$R_S / 4$	$R_S / 3$		Ω
Internal Voltage Drop	V_{DI}	$V_{RS-} - V_{Iout}$, $\beta_F (T_N) \geq 100$	1.2			V
Output Voltage Range	V_{IOR}	$V_C = I_{IOmax}*(R_S + R_Z)+V(T_N, D_V)+V_{DImax}$	0		$V_{CC} - V_C$	V
Output Resistance	R_{IO}		1			MΩ
Load Resistance	R_L	V_{IOmax} / I_{IO}	0	500		Ω
Load Capacitance	C_L		0		50	nF
Slew Rate	SR	$R_L = 100Ω$, $C_L = 1nF$		0.2		V/µs
Linearity				0.05		%FS
Voltage Output Stages						
Adjustable Gain	G_V		1			
Input Voltage Range	V_{IR}		0		$V_{CC} - 4$	V
Offset Voltage	V_{OS}			±1		mV
Offset Voltage Drift	dV_{OS}/dT			±3.5		µV/°C
Input Bias Current	I_B			16		nA
Power Supply Rejection Ratio	PSRR			90		dB
Output Voltage Range	V_{OR}	$R_L = 10kΩ$, $V_O \leq 10V$	0.01		$V_{CC} - 4$	V
Output Current Limitation	I_{LIM}	short circuit protection				mA
Load Resistance	R_L	$R_{G1} + R_{G2} \geq 80$ kΩ, $V_O \leq 10V$	10			kΩ
Load Capacitance	C_L		0	10	50	nF
Slew Rate	SR	$R_L = 2kΩ$, $C_L = 1nF$		0.14		V/µs

(*) all four inputs of the current and voltage interfaces without external currents

Functional description

Current and voltage interfaces are still widespread. Especially for use in sensor systems, which have two (four) analog signal paths (for example pressure and temperature), the double current/voltage interface circuit was developed. The device contains four independent signal paths: two adjustable current and voltage outputs with short circuit and reverse polarity protection. To supply external components, such as a sensor cell or a processor, an adjustable reference is integrated, which provides up to 25mA output current.

The circuit is applicable in the extended temperature range of -40 – 105°C and in the voltage range of 8 – 36V. It is available in a small SSOP16 package. In addition to the current and voltage interfaces, e. g.: 0/4 – 20mA, 0 – 5/10V, the device is also particularly suitable for LED applications as well as for controllable current sources. If only the current outputs are used, the voltage stages can also be used for operational amplifier applications.

The reference, the output currents and the output voltages can be adjusted by external resistors. In addition to these resistors only the two external output transistor $T_{N1,2}$, for reverse polarity protection two diodes $D_{V1,2}$ (towards VCC also D_{V0}) and the capacitor C_1 (for microprocessor supply, the capacity is usualy specified by the manufacturer) are needed. The external transistor reduces the internal power dissipation of the circuit and the diode ensures the protection against reverse polarity of the transistors. By the selection of the transistors their maximum power dissipation has to be considered. Limits for the external components are found in the Boundary Conditions.

The minimum required supply voltage V_S is defined by the reference voltage, the maximum voltages on the current and voltage outputs, the minimum internal voltage drops of the mip-T202 and the required external components: $V_S \geq$ minimal supply to the reference $\mathbf{V_{CCR}}$, the current outputs $\mathbf{V_{CCIO}}$ and the voltage outputs $\mathbf{V_{CCVO}}$.

$$\mathbf{V_S \geq Maximum\ (V_{CCR}, V_{CCIO}, V_{CCVO})}$$

The maximum reference and output stages currents depends on the incurred power loss in the IC. The major blocks are: power dissipation of self-consumption (P_{ICC}), by the reference output current (P_{REF}) and the output currents of the voltage stages ($\mathbf{P_{VO}}$**).**

$$\mathbf{P_{sum} = P_{ICC} + P_{REF} + P_{VO1} + P_{VO2}}$$

The details are described in the individual function blocks and the chapter of the power loss calculation.

1) Voltage/current reference (pins: REF-, REFout)

The reference is set via external resistors (R_1, R_2). It is continuously adjustable from the bandgap voltage V_{BG} (internal) up to the supply voltage V_{CC} minus internal voltage drop V_{DR} (pay attention to the often existing diode against reverse polarity). To minimize power dissipation in the mip-T202, an external resistor R_P between REFout and REF is possible.

The reference voltage is calculated:	$V_{REF} = V_{BG} * (R_1 / R_2 + 1)$
required supply voltage:	$V_{CCR} \geq V_{REF} + V_{DRmin}$, $R_P = 0$
fluctuating power supply:	$VS \pm \Delta V$ -> V_{CCmin} and V_{CCmax}
minimizing internal power dissipation by:	$R_P \leq (V_{CCmin} - V_{DRmin} - V_{REF}) / I_{REFmax}$

➔ maximum power dissipation in R_P: $P_{RPmax} = (I_{REFmax})^2 * R_P$
maximum internal power dissipation: $P_{REFmax} = (V_{CCmax} – R_p * I_{REFmax} – V_{REF}) * I_{REFmax}$

Reference as current source: $I_{REF} = V_{BG} / R_2$, sensor cell instead of R_1

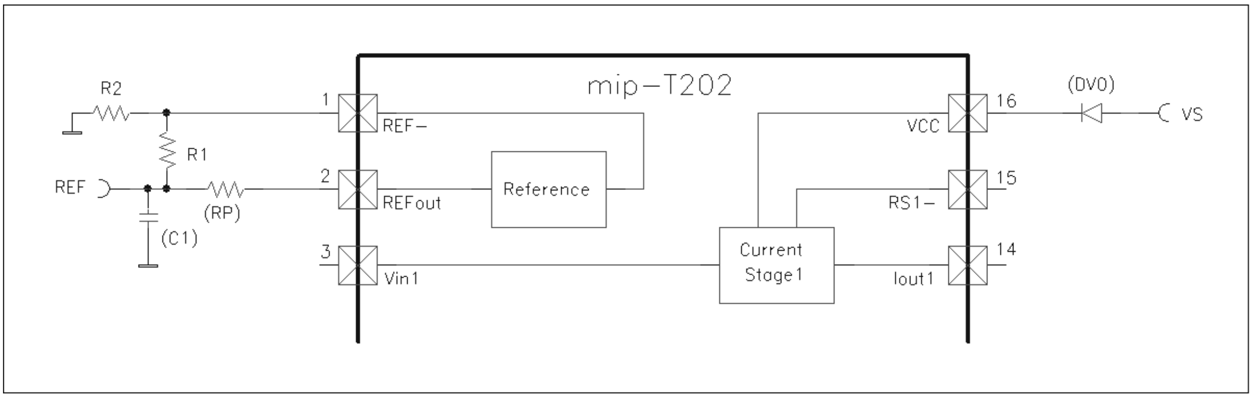


Figure 2: voltage/current reference, REF is the output, by current supply: sensor cell instead of R_1

Example: V_{BG} = 1.25V, V_{REF} = 5V -> R_1 = 100kΩ -> R_2 = 33kΩ
$V_{CCR} \geq$ 5V + 3V = 8V, R_P = 0
V_S = 24V ± 10% -> V_{CCmin} = 21,6V, V_{CCmax} = 26,4V, without diode D_{V0}

V_{CCmin} = 20,8V, V_{CCmax} = 26,0V, with diode D_{V0}, I_{REFmax} = 10mA
$R_P \leq$ (20,8V – 3V – 5V) / 10mA = 1280Ω -> R_P = 1,2kΩ
$P_{RPmax} = (10mA)^2 * 1{,}2k\Omega = 120mW$
$P_{REFmax} = (26V – 1{,}2k\Omega * 10mA – 5V) * 10mA = 90mW$

2) Current outputs (pins: VCC, VI1/2, RS1/2-, Iout1/2)

The current outputs are 0/4 – 20mA interfaces with reverse polarity protection (external diodes D_V). They are voltage-controlled current sources and therefore they are also excellent suitable for driving LEDs (depending on the external transistors each up to 100mA).

Calculation of one current output: The circuit controls the voltage across the sense resistor R_S to the input voltage V_{Vin} and thus produces the output current; the voltage drop across the sense resistor corresponds to the input voltage. This voltage drop can be reduced by reduction of the input voltage via the resistors R_{I1} and R_{I2} (V_{CCmin} too small).

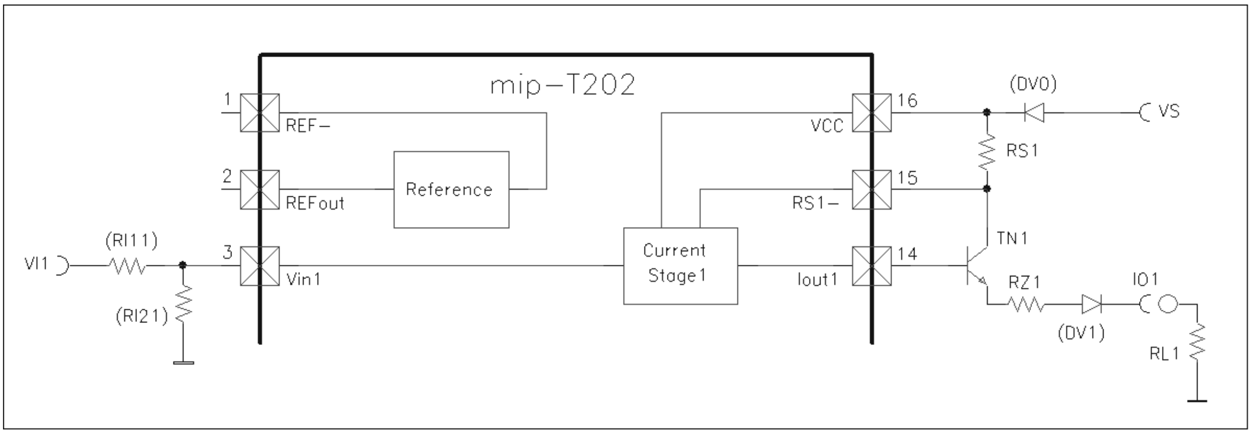


Figure 3: Current interface 1, wiring of stage 2 is identical

The output current is calculated:	$I_{IO} = V_{VI} / R_S$, without R_{I1} and R_{I2}, $V_{VI} \le V_{VImax}$
	$I_{IO} = V_{VI} * R_{I2} / (R_{I1} + R_{I2}) / R_S$
required supply voltage:	$V_{CCIO} \ge I_{IOmax} * R_{sum} + VBE_{TN} + V_{DVmax} + V_{DImax}$
	with $R_{sum} = R_S + R_Z + R_L$, R_L external load resistor
fluctuating power supply:	$V_S \pm \Delta V$ -> V_{CCmin} and V_{CCmax}
voltage drop across T_N:	$VCE_{TN} = V_{CC} - I_{IOmax} * R_{sum} - V_{DV}$
➔ power dissipation in T_N:	$P_{TN} = VCE_{TN} * I_{IO}$
internal power dissipation:	negligible, just drive currents

Example: I_{IO} = 20mA, $R_L = 500\Omega$, V_{VI} = 3V -> $R_S = 150\Omega$ -> $R_Z = 39\Omega$
$V_{CCIO} \ge 20mA * (500\Omega + 150\Omega + 39\Omega) + 2,4V = 16,2V$

$V_S = 24V \pm 10\%$ -> V_{CCmin} = 20,8V, V_{CCmax} = 26,0V, with diode D_{V0}
$VCE_{TNmax} = 26V - 20mA * 189\Omega - 0,4V = 21,8V$, $R_L = 0$
$VCE_{TN} = 26V - 20mA * 689\Omega - 0,4V = 11,8V$, $R_L = 500$

$P_{TNmax} = 21,8V * 20mA = 436mW$, $R_L = 0$ or short circuit
$P_{TN} = 11,8V * 20mA = 236mW$, $R_L = 500$

3) Voltage outputs (pins: VI1/2+, VI1/2-, Vout1/2)

The voltage outputs are well suitable as a 0 – 10V interface, because of their short-circuit and everse polarity protection and because of their driver performance. By the variable gain also other voltages can be set.

The gain G_V is set by the resistors R_{G1} and R_{G2}, thus allows the adjustment of the output over a wide voltage range.

The output voltage is calculated:	$V_{VO} = V_{VI+} * G_V$
adjustable gain:	$G_V = R_{G1} / R_{G2} + 1$,
required supply voltage:	$V_{CCVO} \ge V_{Omax} + V_{DRmin}$
maximum internal power dissipation:	$P_{VOmax} = (V_{CCmax} - V_{VO}) * I_{VOmax}$

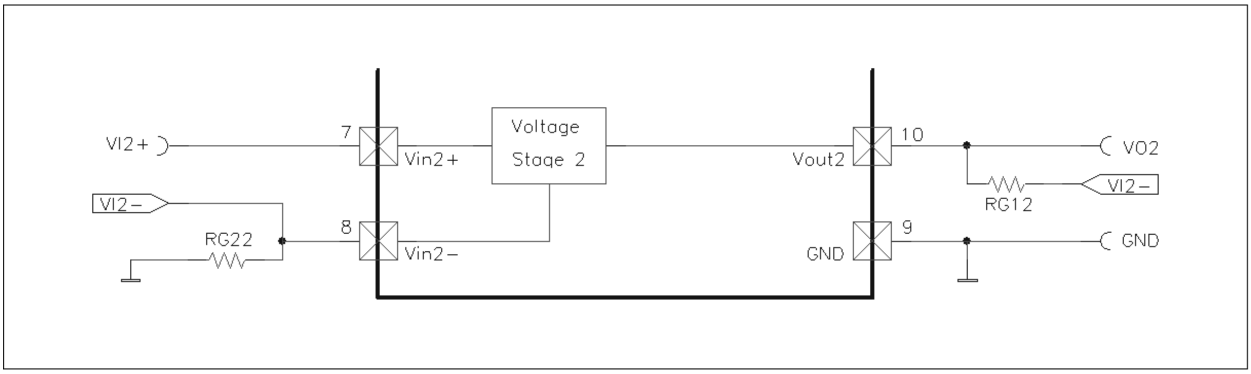


Figure 4: Voltage interface 2, voltage interface 1 wiring is identical

Beispiel: V_{VO} = 10V, V_{VI+} = 5V -> G_A = 2, mit $R_1 = 100k\Omega$ -> $R_2 = 100k\Omega$
$V_{CCVO} \ge 10V + 4V = 14V$, mit $R_L = 10k\Omega$ (externer Lastwiderstand)
$P_{VOmax} = (26V - 10V) * 1mA = 16mW$, mit V_{CCmax} = 26V

Applications

In figure 5 typical applications for the mip-T202 are shown.

In a) all four interfaces are exemplary connected: 4 – 20mA / 1 – 5V and 0 – 20mA / 0 – 10V. for this circuit results in an output current of 4 – 20mA. The illustrated voltages at the inputs are arbitrary, possible is a voltage range of 0 – 5V.

In b) an example circuit with two independent controlled LED-chains is outlined. The LEDs are connected in series from the current outputs IO1/2 to ground (GND). For V_S = 12V up to 5 LEDs can be connected in series depending to each LED voltage and the voltage drop across the sense resistor. The brightness is controlled using the inputs VI1/2 (0 – 1.25V corresponds to 0 – 20mA). In this exemplary application the inputs are connected over 10kΩ resistors to the reference (V_{REF} = 1.25V), thereby the LEDs can be easily turned on and off: input open = 20mA, input connected to ground (GND) = 0mA. Also an external brightness control by connecting a potentiometer or applying a voltage to VI1/2 is possible (the 10kΩ resistors are not required).

Output currents: $I_{IO1/2}$ = 1.25V / 62R, V_{REF} = 1.25V, $I_{IO} = V_{VI} / R_S$

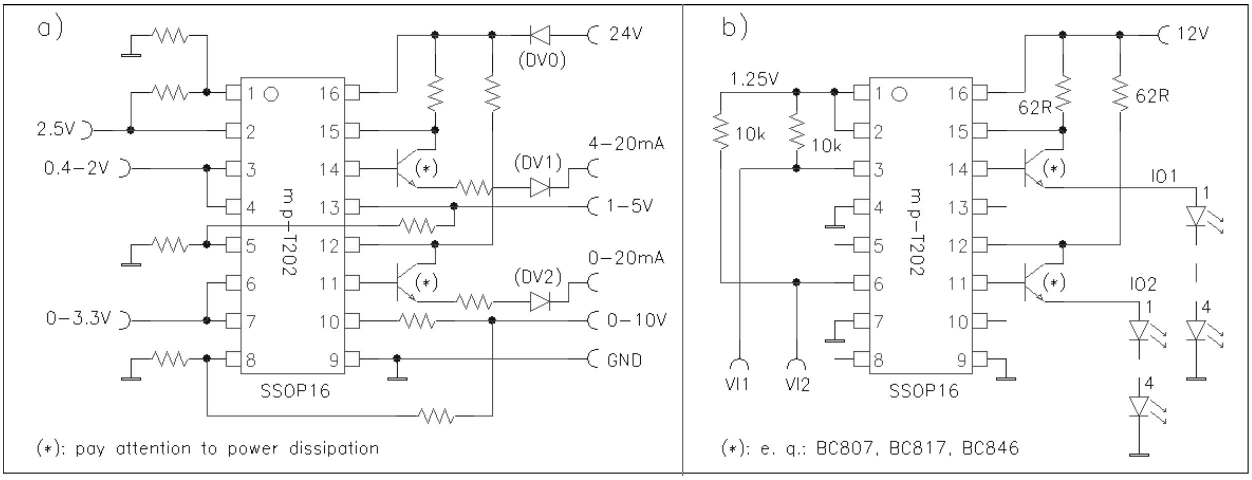


Figure 5: Typical applications: a) current / voltage interface, b) LED control

Applikation boards

The boards are available unassembled with a description.

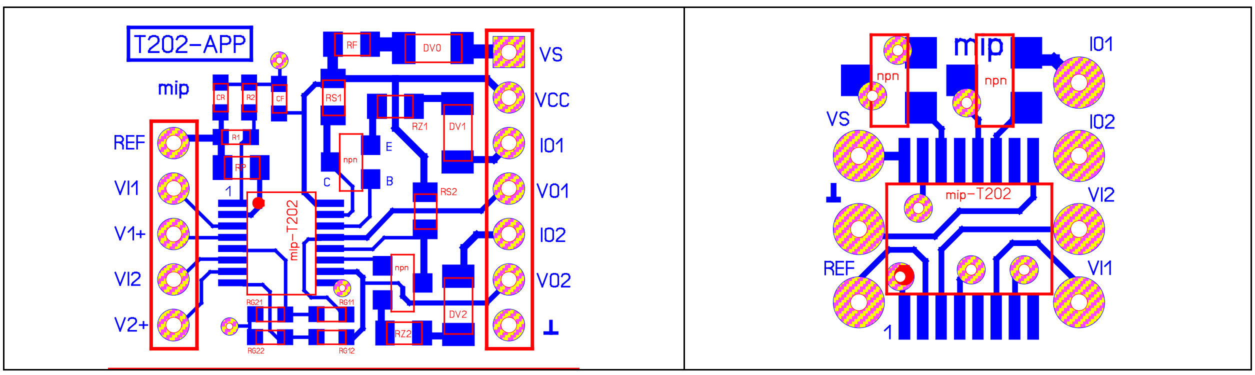


Figure 6: Application boards: a) all variants, such as: current supply / interface, b) LED control

Power dissipation

The possible IC internal power dissipation depends on the desired maximum ambient temperature T_{amax}; the smaller T_{amax} the higher may be the power loss:
T_{amax} = 70°C -> 425mW, T_{amax} = 85°C -> 320mW, T_{amax} = 105°C -> 175mW

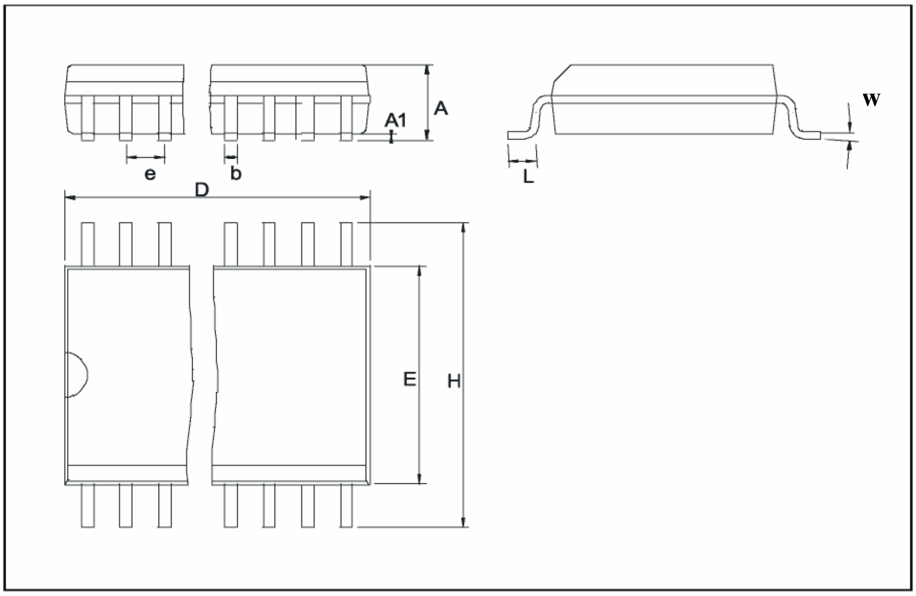
The total power dissipation is the sum of the losses of the individual functional blocks. Significant power loss caused by the self-consumption (P_{ICC}) by the reference output current (P_{REF}) and the output currents of the voltage stages ($P_{VO1/2}$). The detailed calculation for P_{REF} and P_{VO} are listed in the corresponding chapters.

The power dissipation amount is:

$P_{sum} = P_{ICC} + P_{REF} + P_{VO1} + P_{VO2}$
$P_{ICC} = V_{CC} * I_{CC}$
$P_{REF} = (V_{CC} – V_{REFout}) * I_{REF}$, $V_{REFout} = R_p * I_{REF} + V_{REF}$
$P_{VO} = (V_{CC} – V_{VO}) * I_{VO}$

Example: V_{CC} = 24V ± 10%, I_{CC} = 1.2mA, V_{REF} = 5V, I_{REF} = 10mA,
$V_{VO1} = V_{VO2}$ = 10V, $I_{VO1} = I_{VO2}$ = 1mA
➔ P_{ICCmax} = 32mW, P_{REF} = 90mW (mit R_p = 1,2kΩ)
$P_{VO1} + P_{VO2}$ = 32mW -> P_{sum} (V_{CC} = 26V) = 154mW

Package



Shrink Small Outline Package (SSOP) 150 mil – Jedec MO-137, Dimension: mm												
Package-Type		**D**	**E**	**H**	**A**	**A1**	**e**	**b**	**L**	**Copl.**	**w**	**Rth**
SSOP 16	nom max	4,90	3,90	6,00	1,75	0,15	0,635	0,26	0,72	 0,10	4°	140 K/W