Figure 1. Physical Photo of TEC28V15A

Figure 2. Physical Photo of TEC28V15A

FEATURES

- Built-in Smart Auto PID Control – the World's First
- High Output Voltage: 28V
- High Output Current: 15A
- High Efficiency: >92% @VPS = 28V & VTEC = 14V & ITEC = 15A
- High Temperature Stability: <±0.001°C
- Low Thermistor Injection Current: <1µA
- Continuous Bi-directional Output
- Programmable Output Current and Voltage Limits
- Real Time Temperature, Current and Voltage Signals
- Selectable Temperature Sensor Types: thermistor, RTD, or temperature sensor IC
- High Reliability and Zero EMI
- Compact Size: 39×34×7.5(mm)
- 100 % lead (Pb)-free and RoHS compliant

APPLICATIONS

Driving high power TEC modules at high efficiency

DESCRIPTION

TEC (Thermo-Electric Cooler) is a semiconductor device which can cool down or heat up the temperature of an object by injecting an electrical current in one or the other direction. This TEC controller, TEC28V15A, is designed to drive a TEC at high efficiency for regulating the object temperature precisely by controlling the direction and magnitude of the current going through the TEC. It is powered by a DC voltage between 9V to 28V and output current can go up to 15A without using a heat sink. Figure 1 and Figure 2 are photos of the actual controller TEC28V15AD, one shows the signal pins, and the other shows the power pins.

The controller TEC28V15A allows setting the set-point temperature, maximum output voltage magnitude, and the maximum output current magnitude respectively. These three settings are the input parameters for the three control loops: constant temperature, constant current, and constant voltage. Before hitting the maximum output voltage magnitude or the maximum output current magnitude, the temperature loop is in control. When hitting the maximum output voltage magnitude, either outputting a positive or negative value across the TEC, the voltage loop takes over the control, the controller will be outputting a constant voltage to the TEC; when hitting the maximum output current magnitude, the current loop takes over the control, the controller will be outputting a constant output current to the TEC. The highest output voltage magnitude is limited by the maximum power supply voltage, and the maximum output current magnitude is 15A.

The temperature signal can be obtained by using one of these 3 temperature sensors: thermistor, RTD or temperature sensor IC. When using a thermistor, the set-point temperature range is determined by an external temperature network formed by 3 resistors. In order to reduce the injection current to the thermistor to reduce the errors caused by the self-heating effect, the injection current is provided in pulse mode, reducing the current by 10 times as opposed to a continuous current.

One advanced feature of this TEC controller is that it comes with a smart auto PID control micro-processor, it continuously senses and compensates the thermal load automatically. No need to use any external components for forming a compensation network, nor requires tuning.

Conservative users can still select using the conventional analog compensation network. The same as in the past, it requires a onetime pre-tuning the network to match the thermal load, but provides reliable and high accuracy control. For fixed thermal load applications, conventional analog compensation can be selected; while for applications with variable or multiple different thermal loads – one type at a time, the automatic PID control is more suitable.

Figure 3 is the top view of the controller, showing the pin names and the locations. There are totally 32 pins in 2mm pitch. All the pins on the left are for either control input or indication output signals; all the right pins are power input or output.

The pin function details are given in Table 1.

At the thermistor input, there is a linearization circuit for the thermistor, to make the temperature output voltage be more linearly proportional to the actual thermistor temperature. There is a voltage inverter circuit, and it makes the temperature output voltage be positively proportional to the temperature, since the thermistor has a negative temperature coefficient. These 2 circuits together is called temperature measurement circuit. See Figure 5.

The set-point temperature voltage and the voltage representing the actual temperature are sent to an error amplifier. There is a compensation network inserted in the loop, to stop the oscillation of the controller caused by phase delay effects of the thermal load. Therefore, the compensation network must match the need for driving a particular thermal load. To simplify the tuning, a tunable compensation network is provided by the evaluation board for this TEC controller. A detailed guidance about how to tune the compensation network with a thermal load is given in the evaluation board application note.

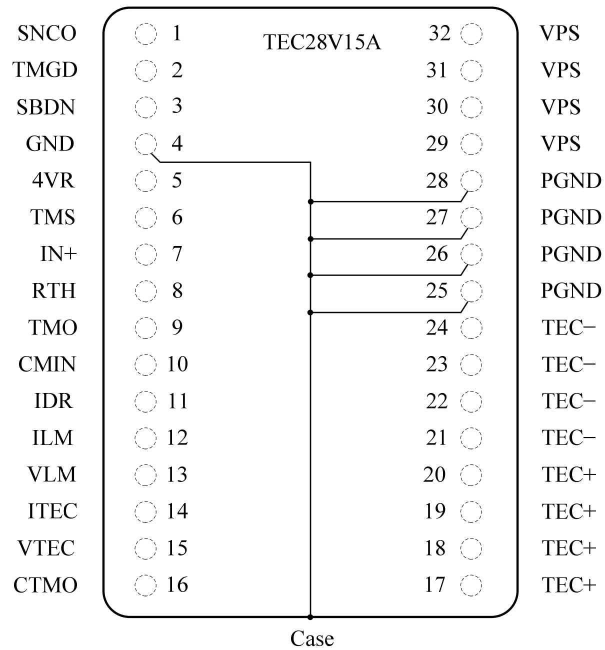


Figure 3. Pin Names and Locations

SPECIFICATIONS

Table 1. Pin Function Descriptions

Pin #	Name	Note	Description
1	**SNCO**	Digital output	Synchronization output. This pin outputs a switching pulse signal, from 0V to 5V, 600kHz. It can be sent to the synchronization input of another SM (Switch Mode) controller or power supply, to eliminate the beating interference between this TEC controller and the other SM device.
2	**TMGD**	Digital output	Temperature good indication. Active high. Indicates when actual temperature, equals to the set-point temperature, of the target object. That is, the target object temperature is within 0.001°C away from the set-point temperature, provided the set-point temperature range is 40°C. Or $\lvert V_{TMO}–V_{TMS}\rvert < 0.1$mV.
3	**SBDN**	Analog /Digital input	Standby and shut down control. This SBDN pin is internally pulled up to VPS power supply by a 20MΩ resistor. If not connected, it goes high by itself. If pulled to ground, it shuts down the entire controller. This pin has 2 threshold voltages: 1.24V and 2.49V. See Figure 4. SHUT DOWN: $V_{SBDN} < 0.8$V, the controller is set to non-working state. STANDBY: $2.8V > V_{SBDN} > 1.8V$, all components is set to working state except the output stages for TEC+ and TEC–. WORK: $V_{SBDN} > 3.0$V, the whole controller is set to working state.
4	**GND**	Ground	Signal ground. Connect this pin to the signal ground of ADCs, DACs, the signal sources, and as it as analog output pin ground.

5	**4VR**	Analog output	Reference voltage output, 4.096V. It can be used as the voltage reference by the potentiometers or DACs for setting the analog ports, such as TMS, ILM, VLM, etc. It can also be used by ADCs for sensing the analog output ports: TMO, CTMO, ITEC and VTEC. The initial accuracy is 0.1%, and the temperature coefficient is <50ppm/°C max.
6	**TMS**	Analog input	Analog Input port for setting the set-point temperature for the target object. It is internally tied a 1MΩ resistor to the half value of the reference voltage, 2V. The open circuit voltage of this pin is thus 2V, corresponding to a set-point temperature of 25°C by using the default temperature network (with the set-point temperature range being from 15°C to 35°C). It is highly recommended to set this pin's voltage by using the controller's 4V voltage reference. This pin can be set by using a POT or DAC. When the set-point temperature needs to be at 25°C, leave this pin unconnected.
7	**IN+**	Analog input	Receive external temperature signal (thermistor and temperature sensor, etc.)
8	**RTH**	Analog input	Thermistor connection port. Connect to the thermistor which is mounted on the target object for sensing its temperature. By using the default internal temperature network, a 10kΩ@25°C thermistor can be used. Other type of thermistors or temperature sensors can also be used, see the Application section for details.
9	**TMO**	Analog output	Actual target object temperature indication. It swings from 0.1V to 3.9V. By using a default internal temperature network, it represents 15°C to 35°C when this pin's voltage swings 0.1V to 3.9V linearly, provided a standard 10kΩ thermistor is used as the temperature sensor device.
10	**CMIN**	Analog input	Compensation input pin for the thermal control loop.
11	**IDR**	Analog input and output	This voltage is derived from the temperature error detection circuit and used as the input control signal of the current loop for the TEC. It's internal impedance is 10kΩ and can be over-driven by an external analog signal which is able to over-ride the 10kΩ resistor. The voltage range is from 0.1V to 3.9V, corresponding to −15A to +15A output current. Setting this pin voltage to 2V forces the output current to zero.
12	**ILM**	Analog input	This pin sets the TEC Current Limit. The maximum limit current is 15A. Setting this pin's voltage from 0V to 4V corresponds to setting the current magnitude limit from 0 to 15A: $V_{ILM} = \frac{\left\|I_{OUT}(A)\right\|_{MAX}}{3.75}$
13	**VLM**	Analog input	This pin sets the TEC voltage Limit. The maximum limit voltage is 30V. Setting this pin's voltage from 0V to 4V corresponds the TEC voltage magnitude limit

			being from 0 to 30V: $V_{VLM} = \frac{\lvert V_{TEC+} - V_{TEC-} \rvert_{MAX}}{7.5}$
14	**ITEC**	Analog output	TEC current indication. ITEC is an analog voltage output pin with a voltage proportional to the actual current through the TEC. ITEC's center voltage is 2V, corresponding to zero current through the TEC. $V_{ITEC} = \frac{I_{OUT}(A)}{7.5} + 2V$, where I_{OUT} is the actual output current of the controller, flowing out from TEC+ port and flowing in to TEC− pin.
15	**VTEC**	Analog output	TEC voltage indication. VTEC is an analog voltage output pin with a voltage proportional to the actual voltage across the TEC. It swings from 0V to 4V to indicate the output voltage being from −30V to 30V, so the center voltage is 2V. $V_{VTEC} = \frac{V_{TEC+} - V_{TEC-}}{15} + 2V$
16	**CTMO**	Analog output	The controller internal temperature indication output. It can be used for sensing the actual temperature of the controller, to avoid over-heating.
17, 18, 19, 20	**TEC+**	Analog power output	This pin is for connecting to the positive terminal of the TEC module, all the 4 pins are internally connected for increasing the current capability.
21, 22, 23, 24	**TEC−**	Analog power output	This pin is for connecting to the negative terminal of the TEC module, all the 4 pins are internally connected.
25, 26, 27, 28	**PGND**	Power ground	Power ground for connecting to the power supply 0V return node, all the 4 pins are internally connected.
29, 30, 31, 32	**VPS**	Power input	Power supply voltage positive node. The normal operating voltage range is 9V to 28V, the maximum value is 30V. All the 4 pins are internally connected.

Table 2. Electrical characteristics.

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Units
Power Supply Input: VPS pin, pin 29~32						
Input Range	V_{VPS}		9		28	V
Input Current	I_{VPS}	Operation mode	0.05		16	A
	I_{VPSSB}	Standby mode	5		20	mA
	I_{VPSSD}	Shutdown mode			50	µA
Synchronization Output: SNCO pin, pin 1						
Output Voltage (Open circuit)	$V_{SNCOOUT}$	Open circuit	0		4.3	V

		voltage=4.4V				
Voltage Range (with load)	$V_{SNCOOUT}$	Open circuit voltage=4.4V	0.1		3.9	V
Frequency	F_{SNCO}	Open circuit voltage=4.4V		600		kHz
Temperature Good Indication: TMGD pin, pin 2						
Voltage Range (Open circuit)	$V_{TMGDOUT}$	Open circuit voltage=4.4V	0		4	V
Voltage Range (with load)	$V_{TMGDOUT}$	Open circuit voltage=4.4V				V
Maximum Sourcing Current	I_{TMGDSC}	Open circuit voltage=4.4V	3			mA
Maximum Sourcing Voltage	V_{TMGDSC}	Open circuit voltage=4.4V	3.7			V
Maximum Sinking Current	I_{TMGDSK}	Open circuit voltage=4.4V			7	mA
Maximum Sinking Voltage	V_{TMGDSK}	Open circuit voltage=4.4V			0.6	V
Standby Shutdown Control: SBDN pin, pin 3						
Input Current	I_{SBDNIN}	V_{SBDN}=0V	0.1			µA
		V_{SBDN}=4V			6	
		V_{SBDN} =30V			50	
Input Voltage Range	V_{SBDNIN}	Open circuit voltage=4.4V	0.4		30	V
Shutdown Logic Low	$V_{SBDNSDL}$		0		0.8	V
Shutdown Logic High	$V_{SBDNSDH}$		1.8			V
Standby Logic Low	$V_{SBDNSBL}$		2.8			V
Standby Logic High	$V_{SBDNSBH}$				4.5	V
Operation Logic Low	$V_{SBDNOPL}$		8.0		9.0	V
Operation Logic High	$V_{SBDNOPH}$				30.0	V

TEC Current Indication: ITEC pin, pin 14 TEC Voltage Indication: VTEC pin, pin 15 Controller Temperature Indication: CTMO pin, pin 16						
Output Range	$V_{ITECOUT}$	R_{LOAD}=10kΩ to V_{PS}/2	0.1		3.9	V
	$V_{VTECOUT}$		0.1		3.9	V
	$V_{CTMOOUT}$		0.1		3.9	V
Output Current	$I_{ITECOUT}$	V_{DD}=5.5V V_{SS}=0V T_A=25°C	−35		35	mA
	$I_{VTECOUT}$		−35		35	mA
	$I_{CTMOOUT}$		−33		33	mA
Compensation Output: IDR pin, pin 11						
Output Range	V_{IDROUT}	Open circuit voltage=4.4V	0.1		3.9	V
Compensation Input: CMIN pin, pin 10						
Input Range	V_{CMIN}	R_{LOAD}=10kΩ to V_{PS}/2 −40°C≤ T_A≤+125°C	0		5	V
Input Current	I_{CMIN}	−40°C≤ T_A≤+125°C		90	200	pA
Actual Target Object Temperature Indication: TMO pin, pin 9						
Output Range	V_{TMOOUT}	Open circuit voltage=5.5V T_A=25°C	0.1		3.9	V
Output Current	I_{TMOOUT}	Open circuit voltage =5.5V V_{SS}=0V T_A=25°C	−35		35	mA
Thermistor Connection Port: RTH pin, pin 8						
Output Range	V_{RTHOUT}	Open circuit voltage=4.4V	0.1		3.9	V

Temperature Signal Input: IN+ pin, pin 7						
Input Range	V_{IN+}		0.1		3.9	V
Reference Voltage Output: 4VR pin, pin 5						
Output Range	V_{4VROUT}	T_A = 25°C	4.0925	4.096	4.0995	V
Initial Error		T_A = 25°C		0.1		%
Temperature Coefficient	T_C			10	50	ppm/°C
Maximum Load Current	I_{4VRMAX}	T_A = 25°C 4V option	−20		+20	mA
Maximum Load Capacitance	C_{4VRMAX}		0.1		1	uF
Temperature Set: TMS pin, pin 6						
Input Impedance (See Figure 4 in Page 7 for input equivalent circuit)	Z_{TMSIN}			5		MΩ
Input Voltage Range	V_{TMSIN}		0		4	V
Open Circuit Voltage	V_{TMSOP}			2		V
TEC Voltage Limit: VLM pin, pin 13						
Input Impedance (See Figure 5 in Page 7 for input equivalent circuit)	Z_{VLM}			20		kΩ
Input Voltage Range	V_{VLMIN}		0		4	V
TEC Current Limit: ILM pin, pin 12						
Input Impedance	Z_{ILM}			20		kΩ
Input Voltage Range	V_{ILMIN}		0		4	V
TEC+/TEC− pin, pin 17~20/pin 21~24						
Maximum Output Current	$\|I_{MAXTEC+}\|$ $\|I_{MAXTEC-}\|$	V_{PS}=9V~28V T_A=25°C	0		15	A
Maximum Output Voltage	$\|V_{OUTMAX}\|$	V_{VPS}=28V	0		28	V
Temperature Stability						
Temperature Error Voltage	$V_{TMO}-V_{TMS}$		−0.47	0.02	0.47	mV

Efficiency	η	V_{VPS}=28V $\lvert V_{TEC+} - V_{TEC-}\rvert$=14V $\lvert I_{TEC+} - I_{TEC-}\rvert$= 15A		≥92		%
Case Operating Temperature Range	T_{CS}		−40		110	°C
Ambient Operating Temperature Range	T_A		−40		65	°C
Storage Temp. Range	T_{STG}		−40		125	°C
Controller Case Thermal Resistance	R_{TH}			9		°C /W

This TEC controller can only drive the TECs having >1Ω impedance, which equals V_{MAX} / I_{MAX}.

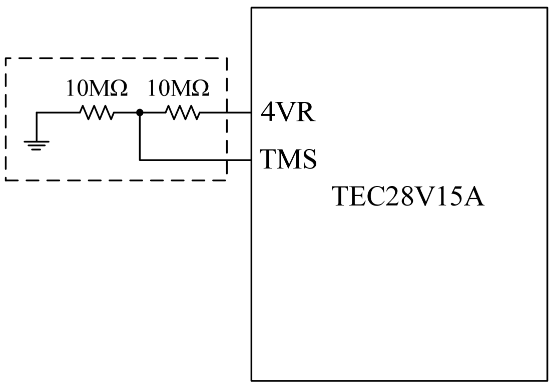


Figure 4. TMS Input Equivalent Circuit

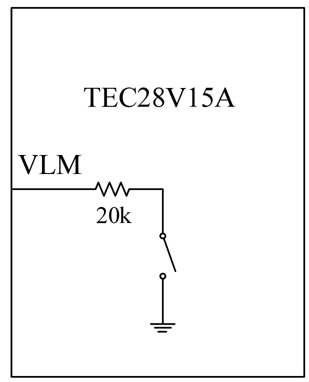
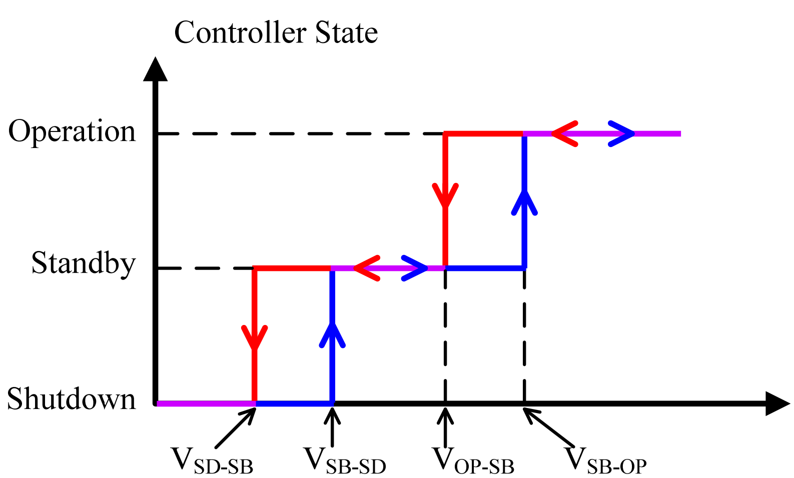


Figure 5. VLM Input Equivalent Circuit

The Switch is closed @ heating, and opens @ cooling



$V_{SD\text{-}SB}$: Going up logic high from shutdown to standby

$V_{SB\text{-}SD}$: Going down logic low from standby to shutdown

$V_{OP\text{-}SB}$: Going down logic low from operation to standby

$V_{SB\text{-}OP}$: Going up logic high from standby to operation

Figure 6. Controller States

BLOCK DIAGRAM

The block diagram of the controller is shown in Figure 7.

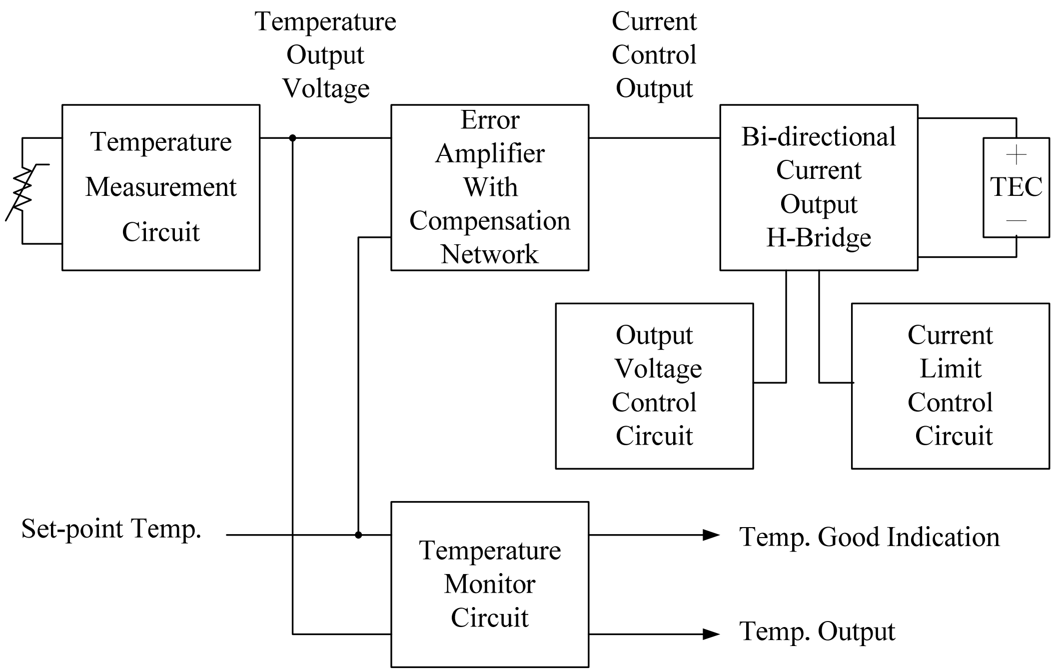


Figure 7. TEC Controller Block Diagram

APPLICATIONS

TEC controller connections are shown in Figure 8.

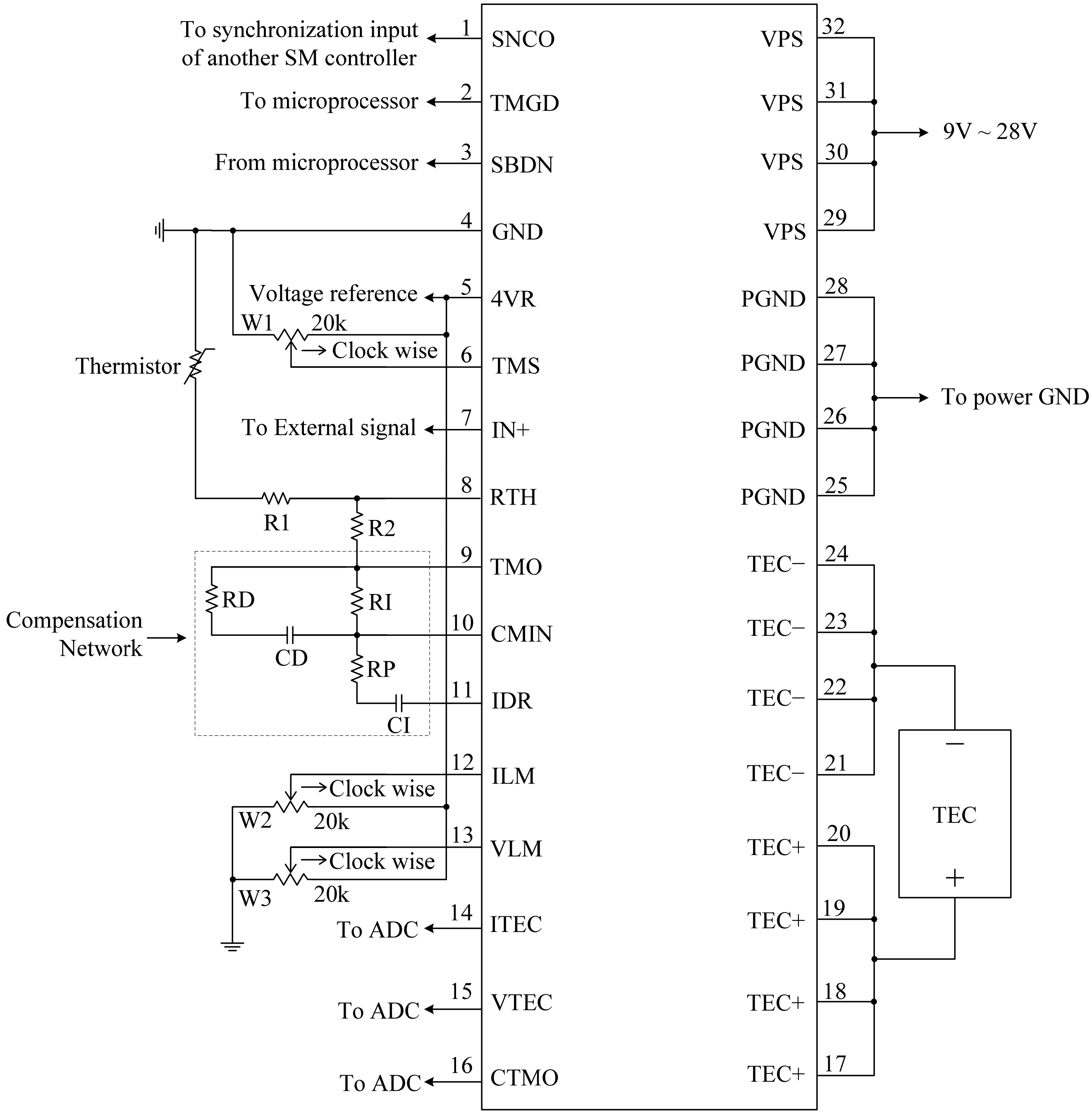


Figure 8. TEC Controller Connection

SNCO

Table 3. External Detector Selection.

No.	Output		External Detector
1	SNCO		Thermistor
2	SNCO		Thermistor
3	SNCO		Temperature sensor

Figure 9 is the schematic diagram for the third one in the list above.

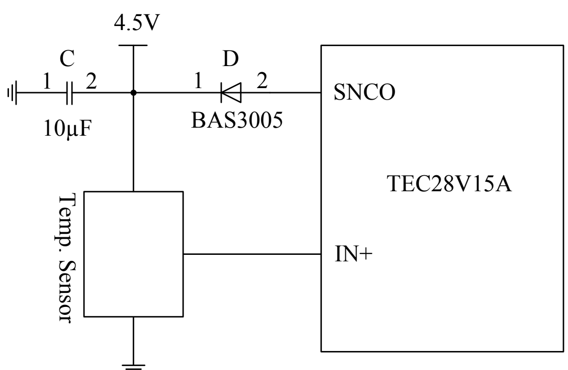


Figure 9. The Schematic Diagram for Temperature Sensor

Temperature Sensor Selections

There are usually three temperature sensors, thermistor, RTD (Resistance Temperature Detector), and IC (Integrated Circuit) temperature sensors.

1. Thermistor

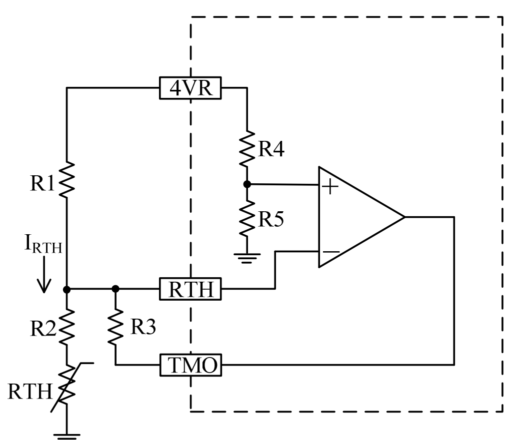


Figure 10. Thermistor

2. RTD

RTD is short for resistance temperature detector, which features high accuracy and low drift. It usually generates heat when the current flows through the RTD, which is called self-heating effect. Moreover, RTD has an approximately linear resistance-temperature relationship.

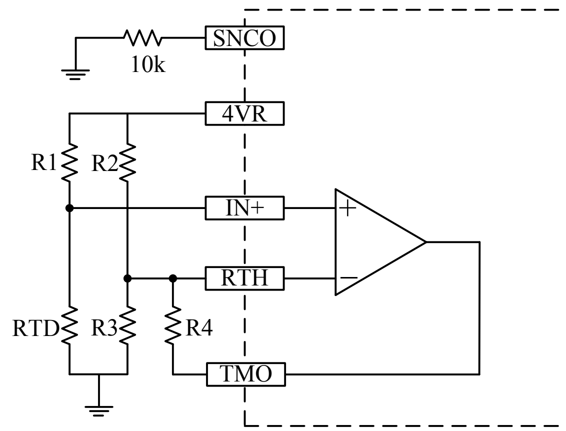


Figure 11. RTD

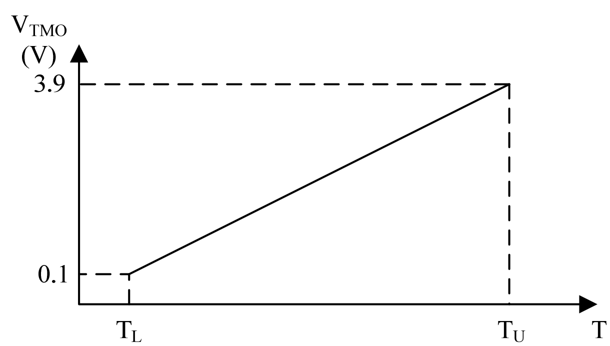


Figure 12. Linear Relationship Between V_{TMO} and Temperature

$R_{TD} = R_0 \times (1+0.00385T)$

e.g. $R_0 = 1k\Omega$

When T = 10°C, $R_{TD}(10) = 1.0385k\Omega$

When T = 40°C, $R_{TD}(40) = 1.154k\Omega$

Choose R1

A. $P_{RTD} \le 1mW$, $R_{TD} = 1000\Omega$

$P_{RTD} = (I_{RTD})^2 \times 1000\Omega = 0.001W$

$$I_{RTD} = 1mA = \frac{VR}{R1 + R_{TD}} = \frac{4}{R1+1} \Rightarrow R1 = 3k\Omega$$

B. $P_{RTD} \le 1mW$, $R_{TD} = 100\Omega$

$P_{RTD} = (I_{RTD})^2 \times 100\Omega = 0.001W$

$$I_{RTD} = 3.16mA = \frac{VR}{R1 + R_{TD}} = \frac{4}{R1+0.1} \Rightarrow R1 = 1.15k\Omega$$

$$V_{TMO} = \frac{4 \times R_{TD}}{R1 + R_{TD}} \times \left[1 + \frac{R4 \times (R2 + R3)}{R2 \times R3}\right] - \frac{4 \times R4}{R2}$$

I. When T = 10°C, R1 = 3kΩ, $R_{TD}(T_L) = 1.0385k\Omega$,

$$0.93 = \frac{R4 \times (2.97R3 - 1.03R2)}{R2 \times R3}$$

When T = 40°C, R1 = 3kΩ, $R_{TD}(T_U) = 1.154k\Omega$,

$$2.79 = \frac{R4 \times (1.11R2 - 2.89R3)}{R2 \times R3}$$

II. When T = 10°C, R1 = 1.15kΩ, $R_{TD}(T_L) = 1.0385k\Omega$,

$$1.8 = \frac{R4 \times (2.1R3 - 1.9R2)}{R2 \times R3}$$

When T = 40°C, R1 = 1.15kΩ, $R_{TD}(T_U) = 1.154k\Omega$,

$$1.9 = \frac{2 \times R4 \times (R2 - R3)}{R2 \times R3}$$

SBDN

SBDN is pulled up to 5V with a 10µA current, and contains a 1.24V logic threshold (voltage range is from 1.12V to 1.36V). Drive this pin to a logic-high to enable the TEC28V15A. Drive to a logic-low to disable the TEC controller and enter micro-power shutdown mode.

SBDN can be directly connected to open drain output or external triode, but it does not have stand by.

ITEC

When the voltage of the ITEC is V_{ITEC} =2V, the current of the TEC Controller I_{TEC}=0A. When V_{ITEC} =0V, I_{TEC} has the maximum reverse current, −15A. When V_{ITEC} =4V, I_{TEC} has the maximum forward current, 15A.

TEC controller is working on the cooling region, when it has forward current. On the opposite, it works on the heating region when reversing the current, as shown in Figure 13.

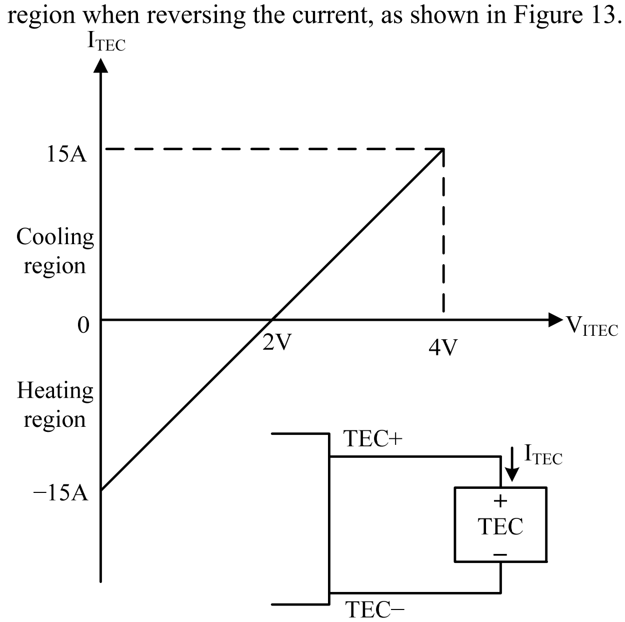


Figure 13. V_{ITEC} vs. I_{TEC}

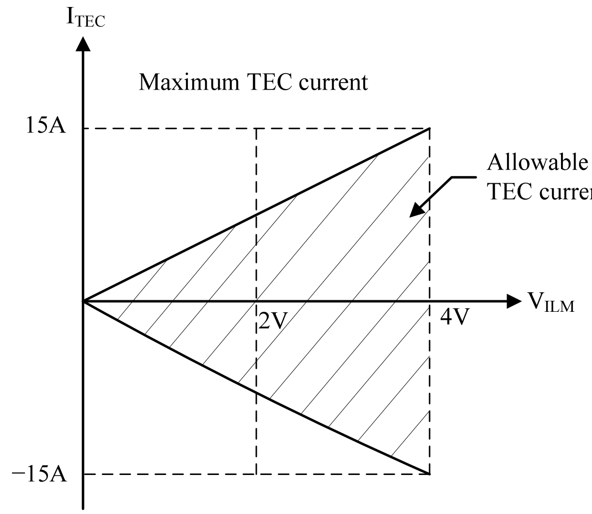


Figure 14. V_{ILM} vs. I_{TEC}

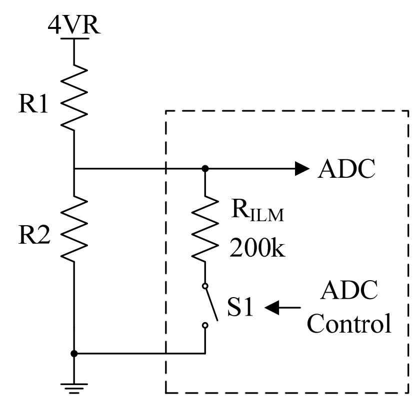


Figure 15. ILM vs. Cooling and Heating Control

Calculate the maximum current in cooling and heating region according to Figure 15.

1. Cooling region

$I_{TEC} \geq 0$, $V_{ILM} \geq 2V$, Cooling region => S1= Open ;

Maximum cooling current:

$$I_{TEC} \leq \frac{V_{ILM}}{4V} \times 15A = \frac{R2}{R1+R2} \times 15A$$

2. Heating region

$I_{TEC} < 0$, $V_{ILM} < 2V$, Heating region => S1 = Close ;

Maximum heating current:

$$|I_{TEC}|_{MAX} \leq \frac{V_{ILM}}{4V} \times 15A = \frac{R2//R_{ILM}}{R1+R2//R_{ILM}} \times 15A$$

3. After deciding the heating current shrinking ratio, we can determine the value for R1 & R2.

Calculate R1 & R2 ratio

$$I_{COOLMAX} = \frac{R1}{R1+R2} \times 15A \qquad \text{--------------(1)}$$

Calculate R1 & R2 value by deciding the heating current shrinking ratio:

KHC = maximum heating current / maximum cooling current

$$= \frac{I_{ITEC-(TH-MAX)}}{I_{ITEC-(CL-MAX)}} \qquad \text{--------------(2)}$$

$$= \frac{\frac{R2//R_{ILM}}{R1+R2//R_{ILM}}}{\frac{R2}{R1+R2}}$$

$$= \frac{200 \times (R1+R2)}{R1 \times R2 + 200 \times (R1+R2)}$$

VTEC and VLM

VTEC = $V_{TEC+} - V_{TEC-}$, as shown in Figure 16.

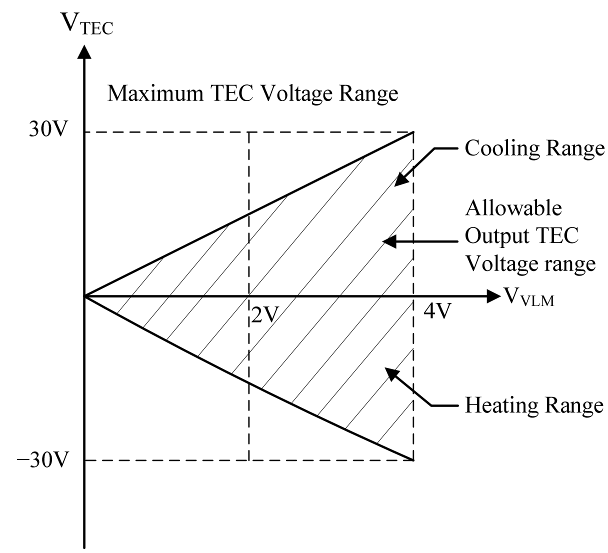


Figure 16. V_{TEC} vs. V_{VLM}

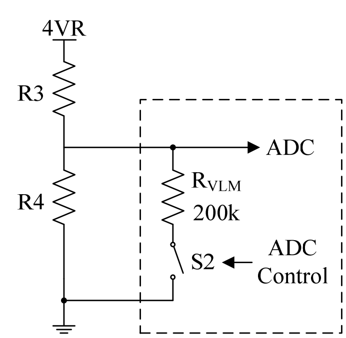


Figure 17. VLM vs. Cooling and Heating Control

$V_{VLM} \geq 2V$, Cooling Mode => S2=Open;

V_{VLM} < 2V, Heating mode => S2=Close;

Decide: $V_{TEC\text{-}CL\text{-}Max}$ and $V_{TEC\text{-}HT\text{-}Max}$

$$V_{TEC\text{-}CL\text{-}Max} = \frac{R3}{R3+R4} \times 30V \quad \text{-------(3)}$$

$$V_{TEC\text{-}HT\text{-}Max} = \frac{R4//R_{VLM}}{R3+R4//R_{VLM}} \times 30V \quad \text{-------(4)}$$

TMGD

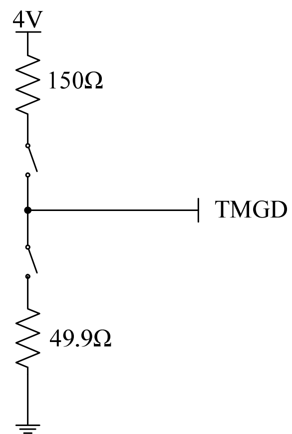


Figure 18. TMGD Output Voltage Range

VLM and ILM

If you want to use this TEC controller for other applications not discussed here, such as use it with wave locker controllers, and please consult with us. The same to other customizations, such as setting the ILM and VLM by using a voltage source swings above 4V and/or VPS.

An external voltage connects the ILM pin through a resistor. This voltage can be used to adjust the voltage range of cooling or heating, and advice is 1.5V. The resistor can be used to adjust the difference of cooling and heating, and advice is 100kΩ.

For example, the voltage midpoint of the ILM pin (V_m) is 2V. Adjust the external voltage, and make the voltage range is 1V, but it is only with the center of 2V(V_m). If you adjust the resistor, it can be moved the limit of the cooling to be greater than the limit of the heating. It is shown in Figure 19 and Figure 20.

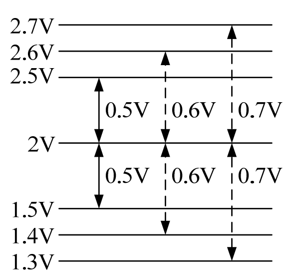


Figure 19. Adjust the External Voltage

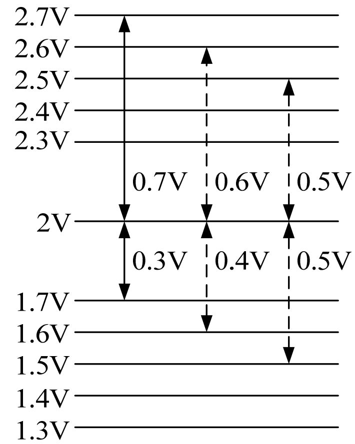


Figure 20. Adjust the Resistor

Temperature Network

TEC28V15A comes with a customized internal compensational network for which the component values are specified by the customer.

TEC28V15A comes with a customized Temperature network. But have not R2, so the customer must have an external resistor.

To achieve the required V_{TMO} outputs at the three different setting point temperatures in the Temperature Network, use the equation

$$R1 = R_{MID} + \frac{R_{MID} \times (R_{LOW} + R_{HIGH}) - 2 \times R_{HIGH} \times R_{LOW}}{R_{HIGH} + R_{LOW} - 2 \times R_{MID}} \quad (1)$$

$$R2 = R1 - R_{MID} \quad (2)$$

$$R3 = \frac{R1 \times (R1 + R_{LOW} - R_{MID})}{R_{LOW} - R_{MID}} \quad (3)$$

For example, setting the high set-point temperature at 35°C and the low set-point temperature at 15°C results in a middle set-point temperature (35 + 15)/2 = 25°C. Use the R-T table of a thermistor.

R_{HIGH} = 6.9kΩ

R_{MID} = 10kΩ

R_{LOW} = 14.8kΩ

Note that Equation 1 to Equation 3 result in

R1 = 17.5kΩ

R2 = 7.5kΩ

R3 = 81.3kΩ

TYPICAL CHARACTERISTICS

Table 4. Measurement Data of Rth vs. Temperature

Temp. (°C)	Rth (kΩ)	TMO (V)	Ideal Linear (V)	Error	Temp. (°C)	Rth (kΩ)	TMO (V)	Ideal Linear (V)	Error
15	15.7049	0.05	0.1	−0.05	**26**	9.5718	2.23	2.25	−0.02
16	14.9944	0.24	0.3	−0.06	**27**	9.1642	2.44	2.44	0
17	14.3198	0.43	0.49	−0.06	**28**	8.776	2.64	2.64	0
18	13.6792	0.63	0.69	−0.06	**29**	8.4063	2.85	2.83	0.02
19	13.0705	0.82	0.88	−0.06	**30**	8.0541	3.05	3.03	0.02
20	12.4922	1.02	1.08	−0.06	**31**	7.7184	3.25	3.22	0.03
21	11.9425	1.22	1.27	−0.05	**32**	7.3985	3.46	3.42	0.04
22	11.4198	1.42	1.47	−0.05	**33**	7.0935	3.66	3.61	0.05
23	10.9227	1.62	1.66	−0.04	**34**	7.0935	3.86	3.81	0.05
24	10.4499	1.82	1.86	−0.04	**35**	6.5251	4.06	4.00	0.06
25	10	2.03	2.05	−0.02					

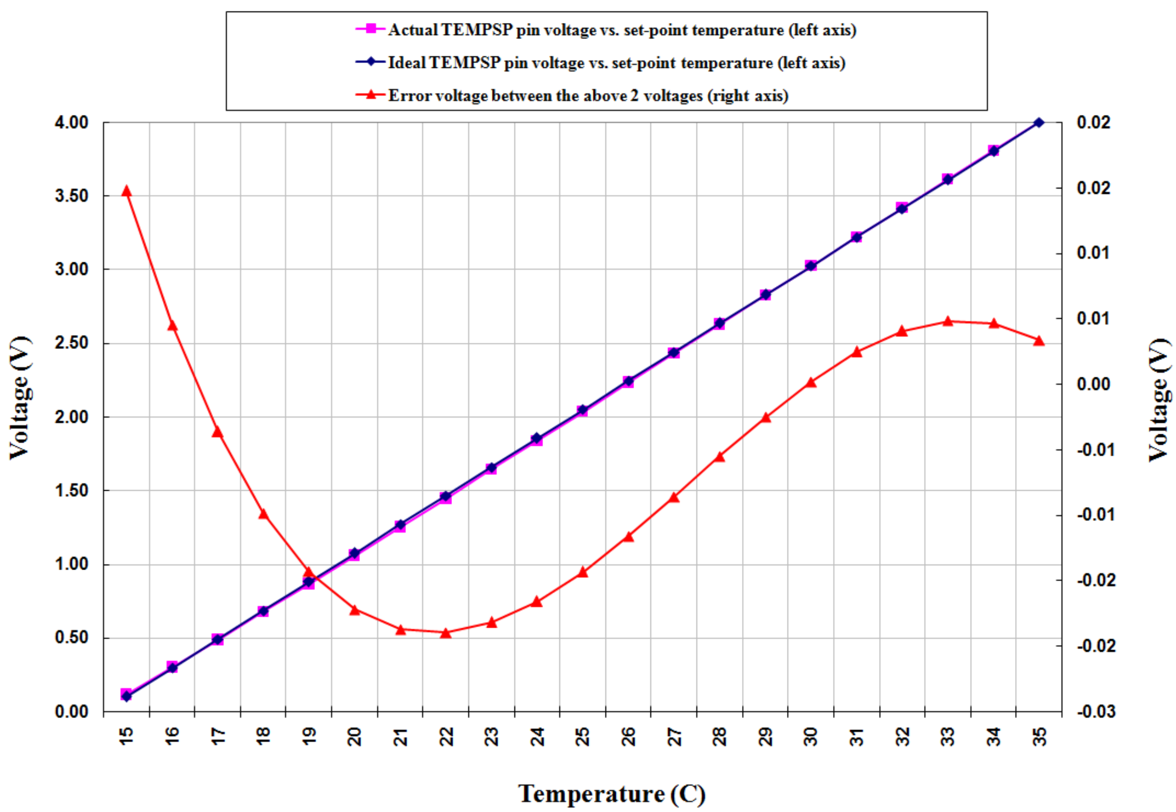


Figure 21. TMO Pin Voltage vs. Set-point Temperature

MECHANICAL DIMENSIONS

The controller comes in 2 packages: through hole mount and surface mount. The former is often called DIP (Dual Inline package) or D (short for DIP) package and has a part number: TEC28V15AD, and the latter is often called SMT (Surface Mount Technology) or SMD (Surface Mount Device) package and has a part number: TEC28V15AS. Dimensions of this controller is shown in Figure 22 and Figure 23.

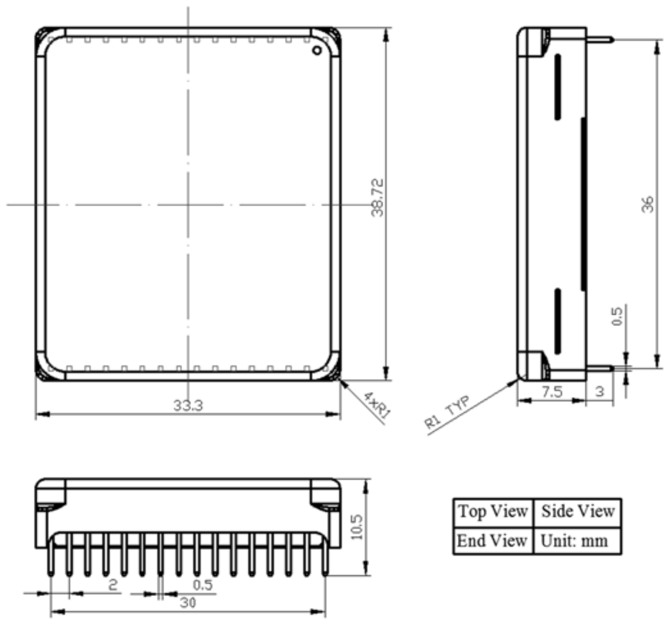


Figure 22. Dimensions of DIP Package

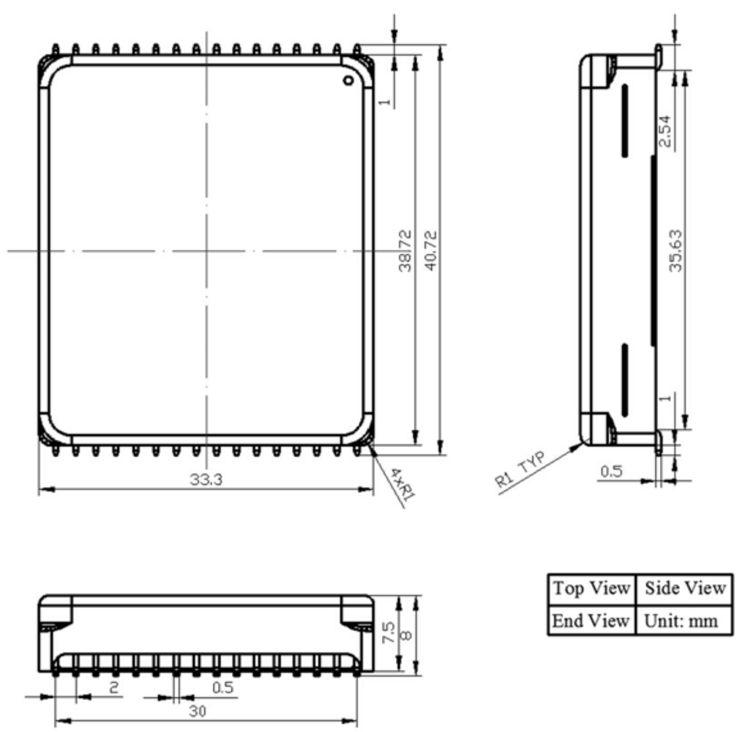


Figure 23. Dimensions of SMT Package

ORDERING INFORMATION

Table 5. Part Number

Part Number	Description
TEC28V15AD	High voltage high current TEC controller in DIP package
TEC28V15AS	High voltage high current TEC controller in SMT package

Table 6. Unit Price

Quantity (pcs)	1 – 4	5 – 24	25 – 99	100 – 249	250 – 499	≥500
TEC28V15AD	$272	$258	$242	$228	$212	$198
TEC28V15AS	$272	$258	$242	$228	$212	$198

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