TEC28V15AD

S. #: A001080119

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Figure 1. 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%
  @V_{VPS}=28V & V_{TEC}=14V & I_{TEC}=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: 35.96×35.96×8.2 (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 5V to 28V and the output current can go up to 15A without using a heat sink. Figure 1

is 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 for the thermal load automatically. No need to use any external components for forming a compensation network, nor requires tuning.*

*Firmware PID control – currently not available.

Conservative users can still select the conventional analog compensation network. The same as in the past, it requires a onetime pre-tuning 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 2 is the top view of the controller, showing the pin names and the locations. There are a total of 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

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temperature, since the thermistor has a negative temperature coefficient. These 2 circuits together are called temperature measurement circuit. See Figure 6.

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.
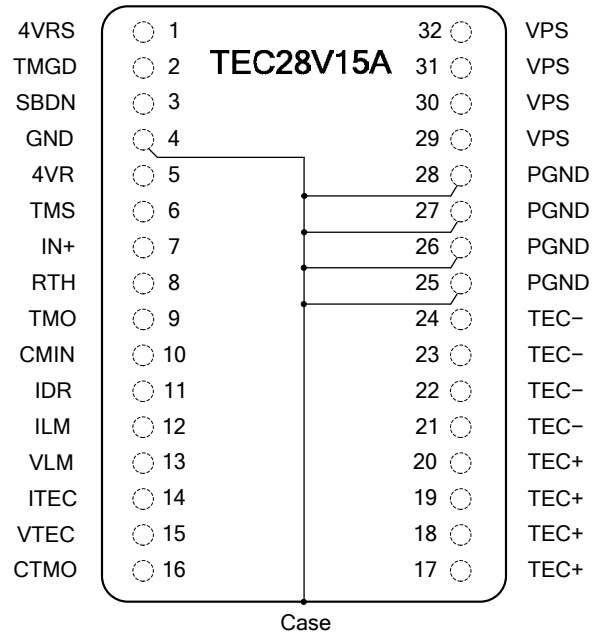

4VRS	1	32	VPS
TMGD	2	31	VPS
SBDN	3	30	VPS
GND	4	29	VPS
4VR	5	28	PGND
TMS	6	27	PGND
IN+	7	26	PGND
RTH	8	25	PGND
TMO	9	24	TEC−
CMIN	10	23	TEC−
IDR	11	22	TEC−
ILM	12	21	TEC−
VLM	13	20	TEC+
ITEC	14	19	TEC+
VTEC	15	18	TEC+
CTMO	16	17	TEC+

TEC28V15A

Case

Figure 2. Pin Names and Location

SPECIFICATIONS

Table 1. Pin Function Descriptions

Pin #	Name	Note	Description
1*	**4VRS**	Analog output	4VR switch output. This pin outputs a switching pulse 4VR signal, from 0V to 4V, 85Hz, as a reference for the thermistor.
	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 $|V_{TMO}-V_{TMS}| < 0.5mV$.
3	**SBDN**	Analog /Digital input	Standby and shut down control. This SBDN pin is internally floated and series with 1k resistor. It's suggested to pull this pin up to VPS power supply by a 4.99MΩ resistor. If pulled to ground, it shuts down the entire controller. This pin has 2 threshold voltages: 1.5V and 2.0V. See Figure 5. SHUT DOWN: $V_{SBDN} < 0.3V$, the controller is set to non-working state. STANDBY: $1.9V > V_{SBDN} > 1.5V$, all components are set to working state except the output stages for TEC+ and TEC−. OPERATION: $V_{SBDN} > 2.0V$, the whole controller is set to working state.
4	**GND**	Ground	Signal ground. Connect this pin to the signal ground of ADCs, DACs, and the signal sources. It can also be used as analog output pin ground.

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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 0V to 4V. 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. Its 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 0V to 4V, 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 0A to 15A: $V_{ILM} = \dfrac{\left|I_{OUT}(A)\right|_{MAX}}{3.75}$
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 to the TEC voltage magnitude limit being from 0 to 30V: $V_{VLM} = \dfrac{\left|V_{TEC+} - V_{TEC-}\right|_{MAX}}{7.5}$

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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. $V_{ITEC} = \dfrac{I_{OUT}(A)}{7.5} + 2V$, 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. $V_{VTEC} = \dfrac{V_{TEC+} - V_{TEC-}}{15} + 2V$
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. 0V to 4V sets the internal temperature from −55°C to 125°C linearly.
17, 18, 19, 20	**TEC+**	Analog power output	This pin is for connecting to the positive terminal of the TEC module, all 4 pins are internally connected for increasing the current capability.
21, 22, 23, 24	**PGND**	Power ground	Power ground for connecting to the power supply 0V return node, all 4 pins are internally connected.
25, 26, 27, 28	**TEC−**	Analog power output	This pin is for connecting to the negative terminal of the TEC module, all 4 pins are internally connected.
29, 30, 31, 32	**VPS**	Power input	Power supply voltage positive node. The normal operating voltage range is 5V to 28V, the maximum value is 30V. All 4 pins are internally connected.

*There are two part numbers for selection, TEC28V15A and TEC28V15ASNCO. The former's pin 1 is 4VRS, and the latter's pin 1 is SNCO. It's recommended to use TEC28V15A.

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Table 2. Electrical characteristics.

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Units
Reference Voltage Pulse Output Mode: 4VRS pin (Or Synchronization Output: SNCO pin), pin 1						
Output Voltage Range	$V_{4VRSOUT}$	$T_A=25°C$	4.0925	4.096	4.0995	V
Initial Error	V_E	$T_A=25°C$	−0.05		0.05	%
Temperature Coefficient	T_C			±3	±8	ppm/°C
Maximum Load Current	I_{4VRMAX}	$T_A=25°C$	−20		+20	mA
Switch frequency	F_{4VRS}		83	85	87	Hz
Output Voltage (Open circuit)	$V_{SNCOOUT}$	Open circuit voltage = 0V~4V PWM	0		4	V
Voltage Range (with load)	$V_{SNCOOUT}$	Open circuit voltage = 0V~4V PWM	0.1		3.9	V
Frequency	F_{SNCO}	Open circuit voltage = 0V~4V PWM		600		kHz
Temperature Good Indication: TMGD pin, pin 2						
Voltage Range (Open circuit)	$V_{TMGDOUT}$	Open circuit voltage=4V	0		4	V
Voltage Range (with load)	$V_{TMGDOUT}$	Open circuit voltage=4V	0		4	V
Maximum Sourcing Current	I_{TMGDSC}	Open circuit voltage=4V	1		15	mA
Maximum Sourcing Voltage	V_{TMGDSC}	Open circuit voltage=4V	3.7		4	V
Maximum Sinking Current	I_{TMGDSK}	Open circuit voltage=4V	3		20	mA
Maximum Sinking Voltage	V_{TMGDSK}	Open circuit voltage=4V	0		0.6	V
Standby Shutdown Control: SBDN pin, pin 3						
Input Current	I_{SBDNIN}	$V_{SBDN}=0V$	0.1		0.3	µA
		$V_{SBDN}=4V$	4		6	
		$V_{SBDN}=30V$	30		50	
Input Voltage Range	V_{SBDNIN}	Open circuit voltage=5V	0		28	V
Shutdown Logic Low	$V_{SBDNSDL}$	Open circuit voltage=5V	0			V
Shutdown Logic High	$V_{SBDNSDH}$	Open circuit voltage=5V			0.7	V
Standby Logic Low	$V_{SBDNSBL}$	Open circuit voltage=5V	1.4			V
Standby Logic High	$V_{SBDNSBH}$	Open circuit voltage=5V			1.9	V

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Operation Logic Low	$V_{SBDNOPL}$	Open circuit voltage＝5V	2.0			V
Operation Logic High	$V_{SBDNOPH}$	Open circuit voltage＝5V			5	V
Reference Voltage Output: 4VR pin, pin 5						
Output Voltage Range	V_{4VROUT}	$T_A＝25°C$	4.0925	4.096	4.0995	V
Initial Error	V_E	$T_A＝25°C$		0.05		%
Temperature Coefficient	T_C	$T_A＝−40°C \sim 125°C$		3	8	ppm/°C
Maximum Load Current	I_{4VRMAX}	$T_A＝25°C$	−20		+20	mA
Maximum Load Capacitance	C_{4VRMAX}		0.1		1	uF
Temperature Set: TMS pin, pin 6						
Input Impedance (See Figure 3 in Page 8 for input equivalent circuit)	Z_{TMSIN}			5		MΩ
Input Voltage Range	V_{TMSIN}		0		4	V
Open Circuit Voltage	V_{TMSOP}			2		V
Temperature Signal Input: IN+ pin, pin 7						
Input Voltage Range	V_{IN+}		0		4	V
Thermistor Connection Port: RTH pin, pin 8						
Input Voltage Range	V_{RTHIN}		0		4	V
Actual Target Object Temperature Indication: TMO pin, pin 9						
Output Voltage Range	V_{TMOOUT}	$R_{LOAD}＝10kΩ$ to 2V $−40°C \leq T_A \leq +125°C$	0		4	V
Output Current	I_{TMOOUT}	$V_{SS}＝0V$ $T_A＝25°C$	−12		12	mA
Compensation Input: CMIN pin, pin 10						
Input Voltage Range	V_{CMIN}	$R_{LOAD}＝10kΩ$ to 2V $−40°C \leq T_A \leq +125°C$	0		4	V
Input Current	I_{CMIN}	$−40°C \leq T_A \leq +125°C$		90	200	pA
Compensation Output: IDR pin, pin 11						
Output Voltage Range	V_{IDROUT}	$R_{LOAD}＝10kΩ$ to 2V $−40°C \leq T_A \leq +125°C$	0		4	V

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TEC Current Limit: ILM pin, pin 12						
Input Impedance	Z_{ILM}			21		kΩ
Input Voltage Range	V_{ILMIN}		0		4	V
TEC Voltage Limit: VLM pin, pin 13						
Input Impedance (See Figure 4 in Page 8 for input equivalent circuit)	Z_{VLM}			10		kΩ
Input Voltage Range	V_{VLMIN}		0		4	V
TEC Current Indication: ITEC pin, pin 14 TEC Voltage Indication: VTEC pin, pin 15 Controller Temperature Indication: CTMO pin, pin 16						
Output Voltage Range	V_{CTMO}	$T_A=25°C$	0		4	V
Maximum Load Current	$I_{CTMOOUT}$	$T_A=25°C$	−12		12	mA
TEC+/TEC− pin, pin 17~20/pin 25~28						
Maximum Output Current	$\lvert I_{MAXTEC+}\rvert$ $\lvert I_{MAXTEC-}\rvert$	$V_{PS}=9V\sim28V$ $T_A=25°C$	0		15	A
Maximum Output Voltage	$\lvert V_{OUTMAX}\rvert$	$V_{VPS}=28V$	0		28	V
Power Supply Input: VPS pin, pin 29~32						
Input Voltage Range	V_{VPS}		5		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
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

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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$_{MAX}$.
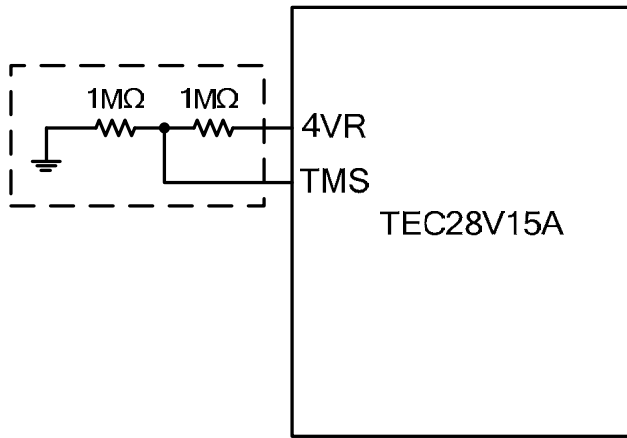
Figure 3. TMS Input Equivalent Circuit
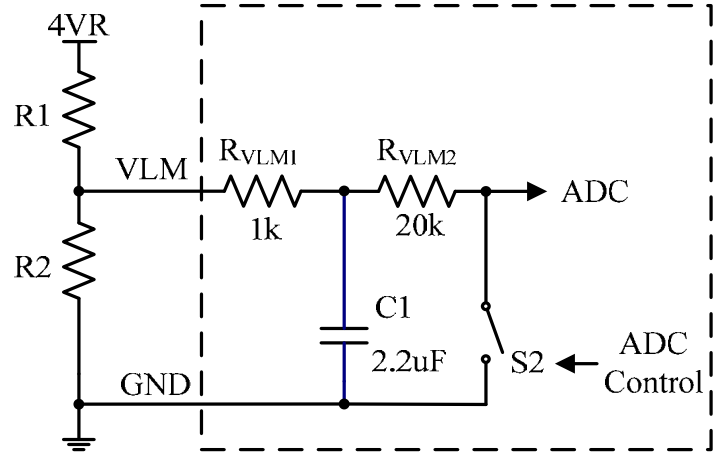
Figure 4. VLM Input Equivalent Circuit
The switch S2 is closed @ heating, and open @ cooling

Figure 5. Controller States
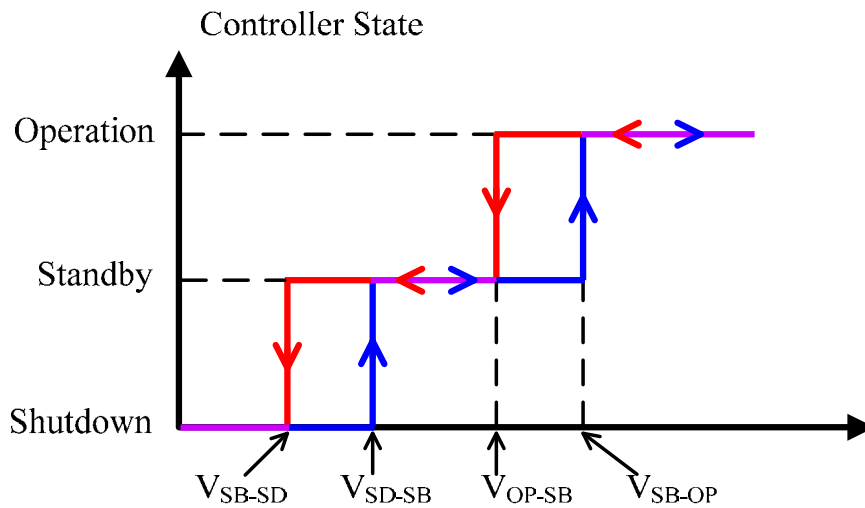
V$_{SB-SD}$: Going down logic low from standby to shutdown

V$_{SD-SB}$: Going up logic high from shutdown to standby

V$_{OP-SB}$: Going down logic low from operation to standby

V$_{SB-OP}$: Going up logic high from standby to operation

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BLOCK DIAGRAM

The block diagram of the controller is shown in Figure 6.
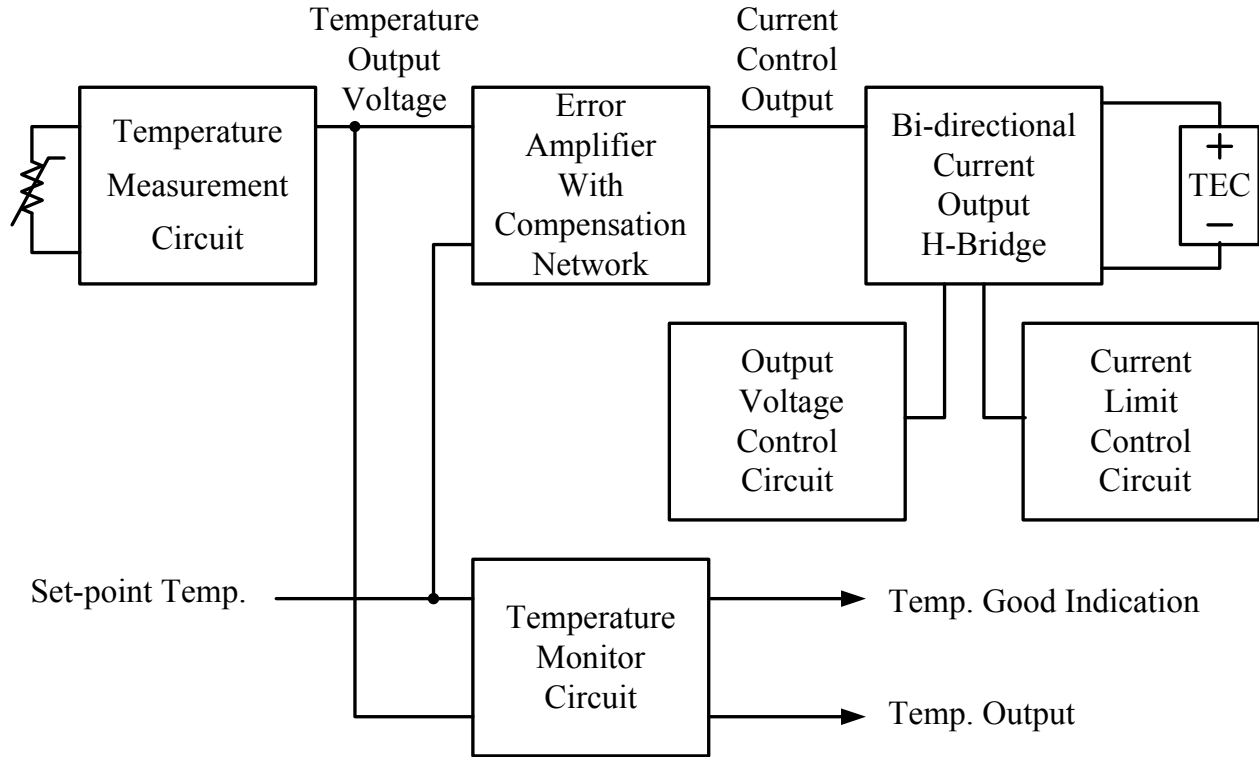
Figure 6. TEC Controller Block Diagram

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APPLICATIONS

TEC controller connections are shown in Figure 7.
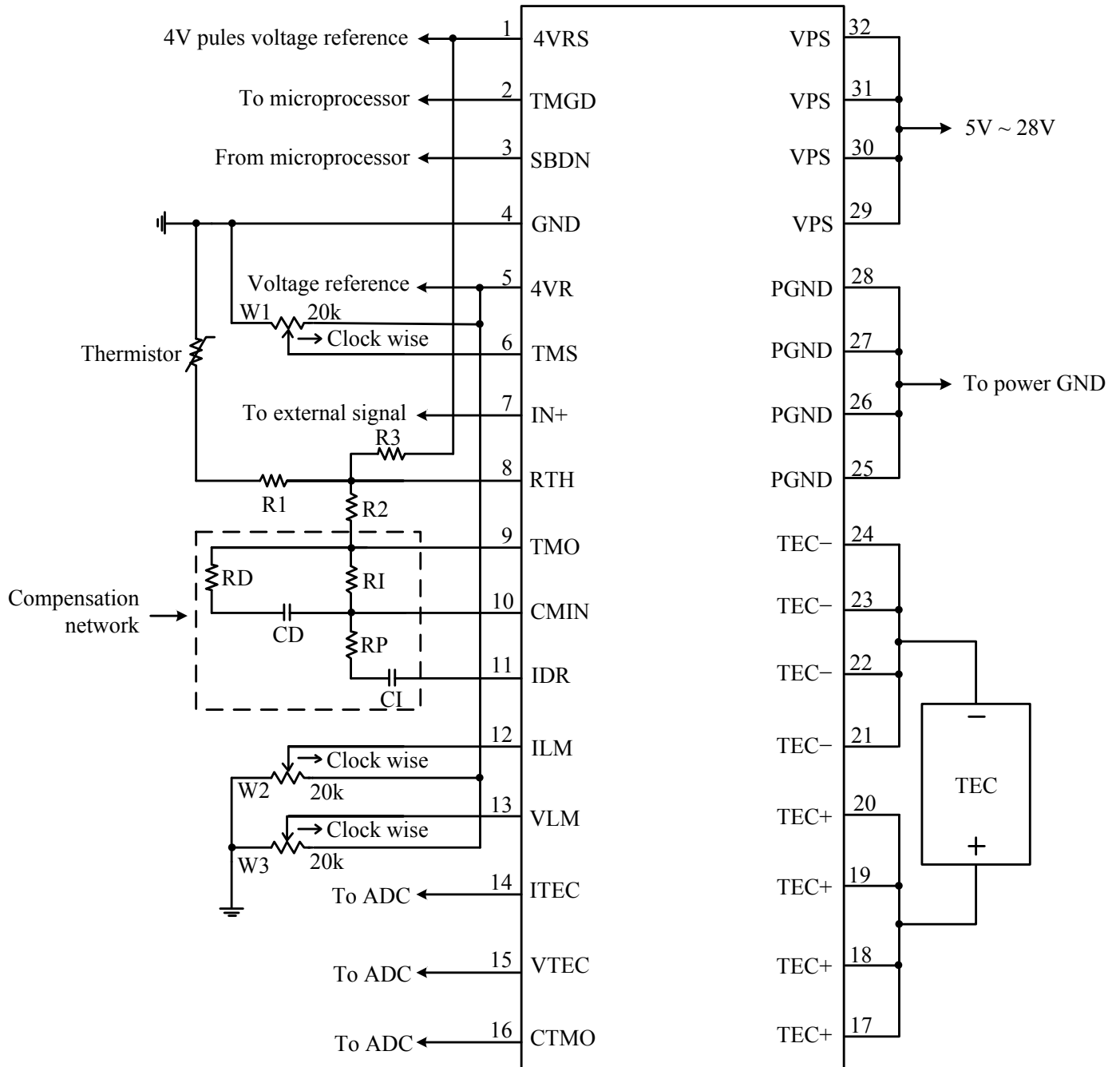
Figure 7. TEC Controller Connection

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SBDN

Table 3. External Detector Selection.

No.	Input	Voltage	External Detector
1	SBDN	0V~0.5V	SD
2	SBDN	1.5V~1.9V	SB
3	SBDN	2V~2.3V	Temperature sensor
4	SBDN	2.4V~2.6V	RTD/RTH
5	SBDN	3.1V~4.0V	RTH (pulse mode)

Note: Do not set the SBDN pin to 2.7V to 3V, otherwise the controller will lose control.

Temperature Sensor Selections

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

1. Thermistor
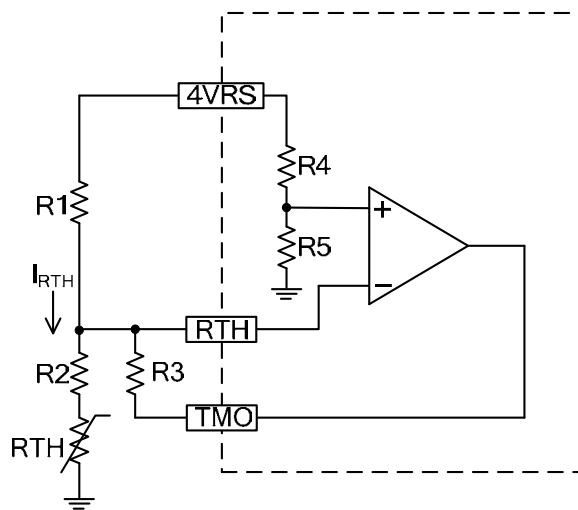
Figure 8.1. RTH (Pulse Mode)
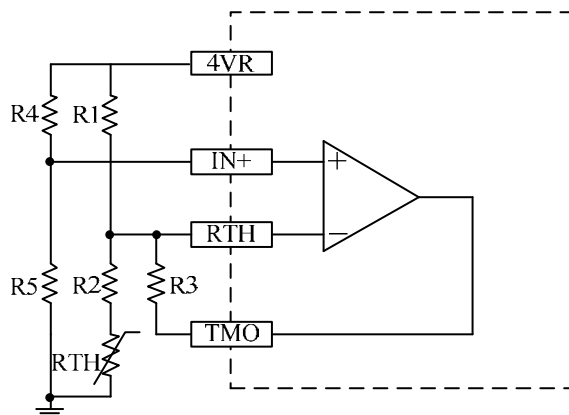
Note: R4=R5

Figure 8.2. RTH

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.

$R_{HIGH} = 6.9k\Omega$

$R_{MID} = 10k\Omega$

$R_{LOW} = 14.8k\Omega$

Note that Equation 1 to Equation 3 result in

$R1 = 17.5k\Omega$

$R2 = 7.5k\Omega$

$R3 = 81.3k\Omega$

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.

It's recommended to connect R1 to 4VRS, and the controller will measure temperature at intervals that will reduce the error caused by the RTH self-heating. At the same time, the SBDN pin should be between 3.1V and 4V. See Table 3.

We can also connect R1 to 4VR, but it may lead to some errors caused by RTH self-heating. At the same time, SBDN pin should be between 2.4V and 2.6V. See Table 3.

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 approximate linear resistance-temperature relationship.
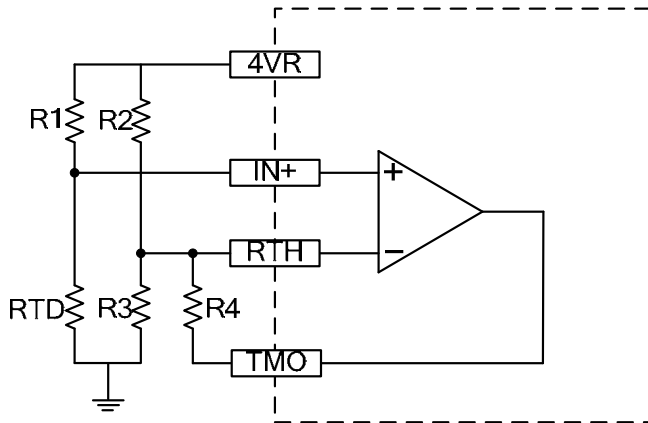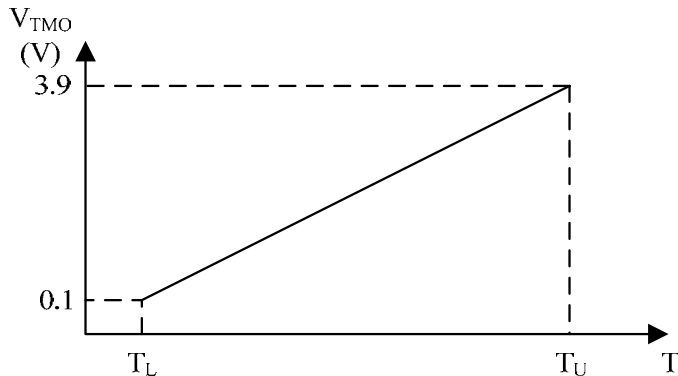

Figure 9. RTD

Figure 10. 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. $P_{RTD} \leq 1mW$, $R_{TD} = 1000\Omega$

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

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

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

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

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

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

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

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

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

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

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

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

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

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

2. IC

IC temperature sensor has lower self-heating effect.

We use LM62BIM temperature sensor. The temperature range is from 10°C to 50°C, corresponding to $T_L = 0.636V$, and $T_U = 1.260V$. $R1 = 16.4k$, $C1 = 4.7uF$, $R2 = 100k$, $R3 = 97.8k$, $R4 = 19.7k$, $R5 = 100k$. See Figure 11.
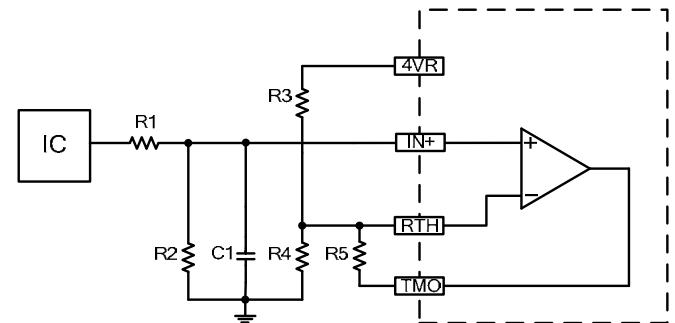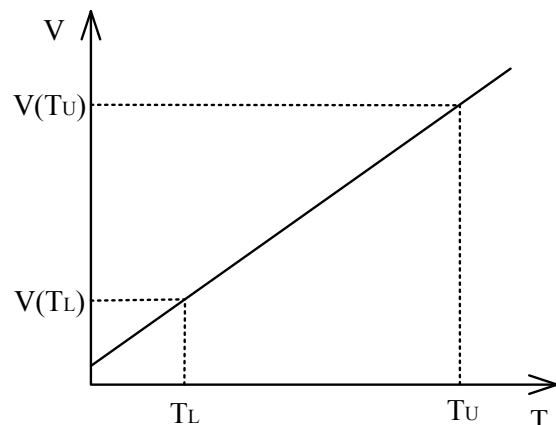

Figure 11. IC temperature sensor

Figure 12. Temperature sensor IC characteristics

$V_{TMO}(T_L) = 0.1V$, $V_{TMO}(T_U) = 3.9V$

$$G = \frac{\Delta V_O}{\Delta Vi} = \frac{V_{(TMO)}(T_U) - V_{(TMO)}(T_L)}{V(T_U) - V(T_L)}$$

$$G = \frac{R2}{R1} = \frac{R5}{R3 // R4}$$

$$V_{IM} = \frac{V_{(TU)} + V_{(TL)}}{2}, \quad V_{OM} = \frac{3.9V + 0.1V}{2} = 2V$$

$$V_I = V_{IM}, \quad V_{OM} = 2V$$

V_I is the output voltage of IC, and V_O is the voltage of TMO pin.

$$V_{IN+} = \frac{R2}{R1 + R2} V_{im}, \quad V_{RTH} = V_{IN+}$$

$$\frac{4V - V_{IN+}}{R3} + \frac{V_{om} - V_{IN+}}{R5} = \frac{V_{IN+}}{R4}$$

R5=100k, R1=R3//R4, R2=R5.

$$R4 = \frac{400}{4G - V_{IN+} - V_{IN+}G + 2}$$

$$R3 = \frac{400}{V_{IN+} + V_{IN+}G - 2}$$

SBDN

SBDN is suggested to be pulled up to VPS with a 10µA current and contains a 1.50V logic threshold. 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.

ITEC and ILM

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.
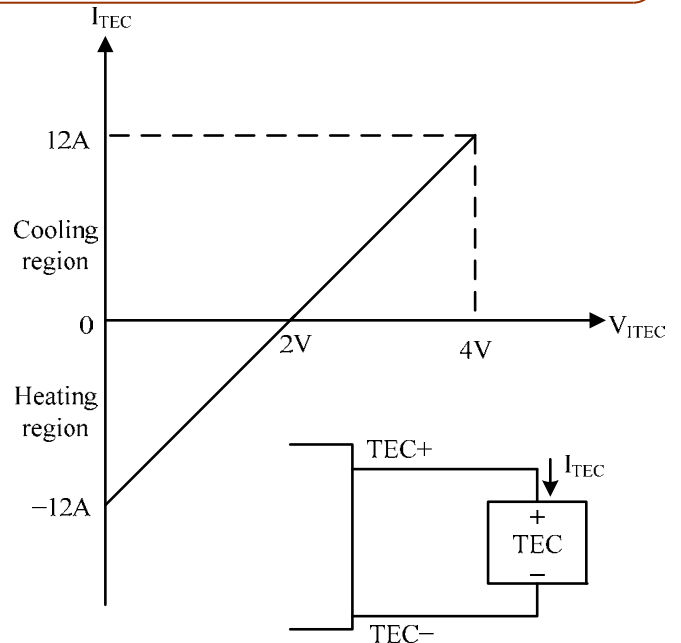

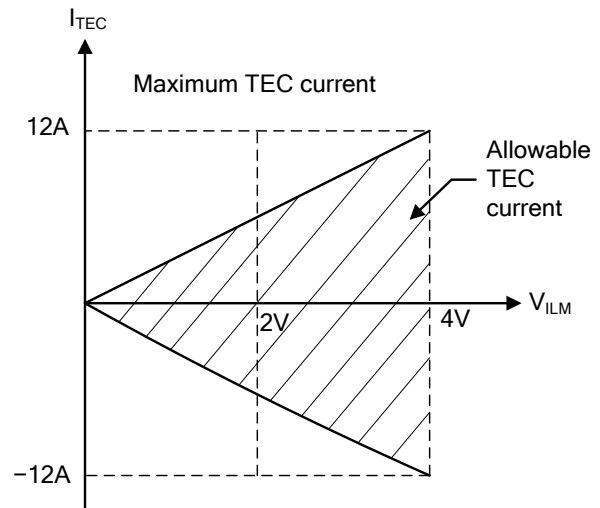Figure 13. V_{ITEC} vs. I_{TEC}
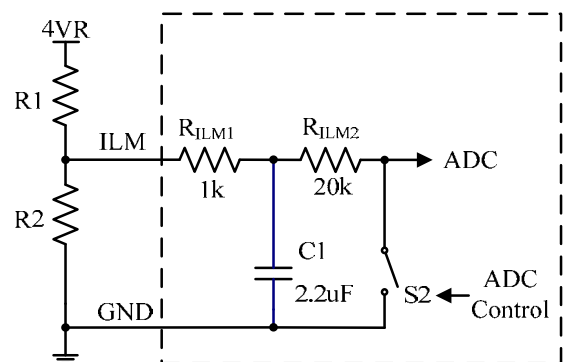

Figure 14. V_{ILM} vs. I_{TEC}

Figure 15. ILM vs. Cooling and Heating Control

The switch S1 is closed @ heating, and open @ cooling

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

1. Cooling region

$I_{TEC} \geq 0A$, $V_{ILM} \geq 2V$, 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

$I_{TEC} < 0A$, $V_{ILM} < 2V$, 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

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

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

KHC = maximum heating current / maximum cooling current

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

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

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

VTEC and VLM
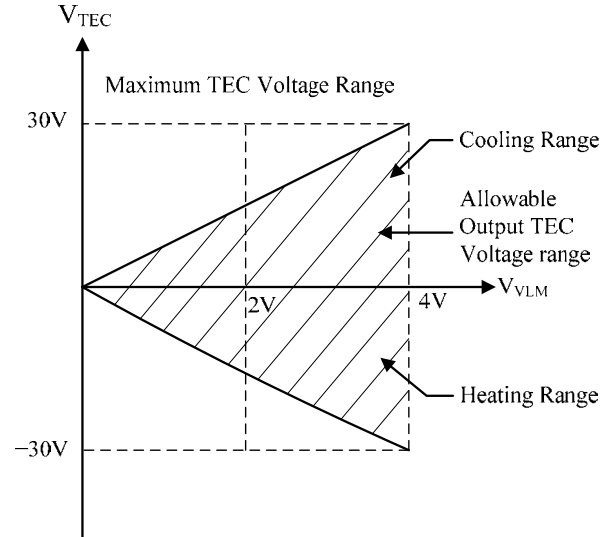
VTEC = $V_{TEC+} - V_{TEC-}$, as shown in Figure 17.

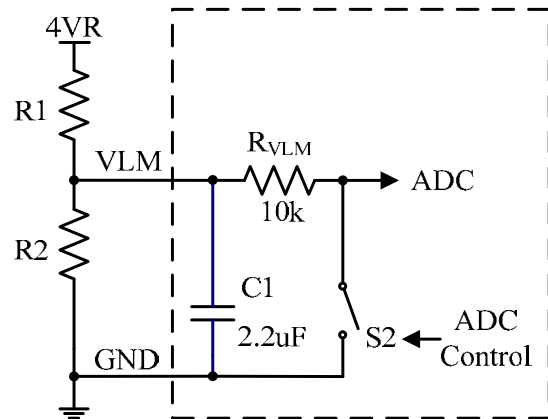Figure 16. V_{TEC} vs. V_{VLM}

Figure 17. VLM vs. Cooling and Heating Control

The switch S2 is closed @ heating, and open @ cooling
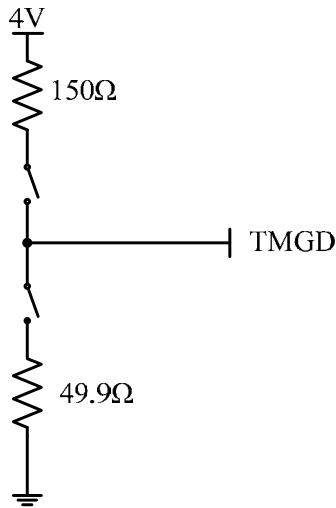

TMGD

Figure 18. TMGD Output Voltage Range

The TMGD pin outputs the maximum source current and sink current of 20mA. The output current will cause voltage drop, see Figure 18.

VLM and ILM

If you want to use this TEC controller for other applications not discussed here, such as with wave locker controllers, consult with us. The same for other customizations, such as setting the ILM and VLM by using 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 10kΩ. See Figure 19.

For example, the voltage midpoint of the ILM pin (V_m) is 2V. Adjust the external voltage, and make the voltage range 1V, but it is only with the center of 2V (V_m). If you adjust the resistor W2, you can move the limit of the cooling to be greater than the limit of the heating. It is shown in Figure 20 and Figure 21.
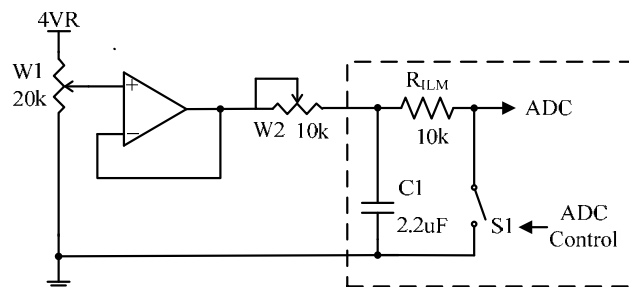

Figure 19. ILM vs. Cooling and Heating Control 2
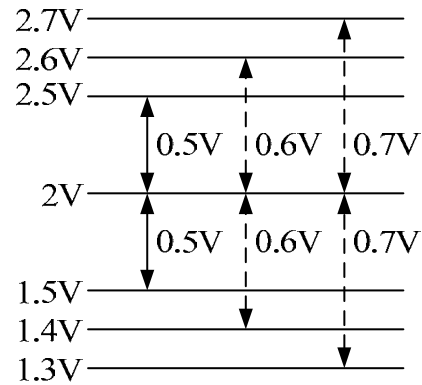

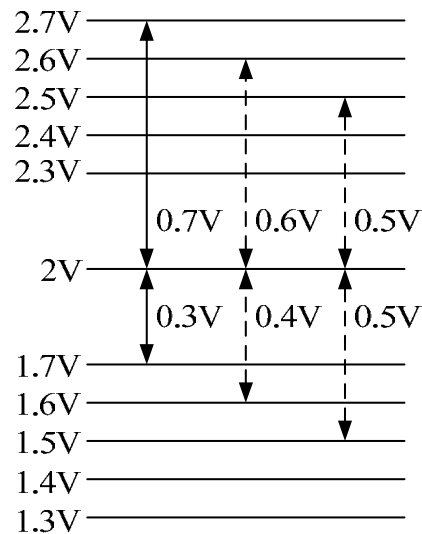Figure 20. Adjust the External Voltage
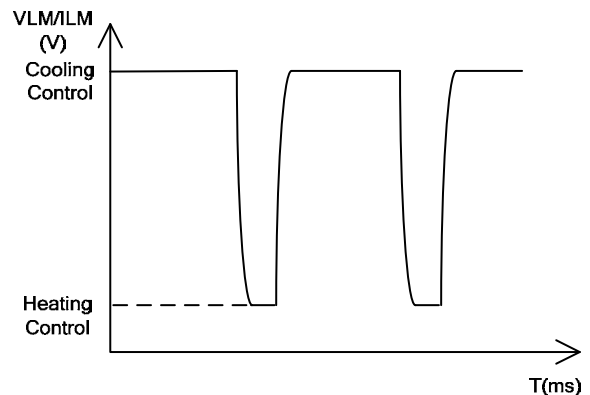

Figure 21. Adjust the Resistor

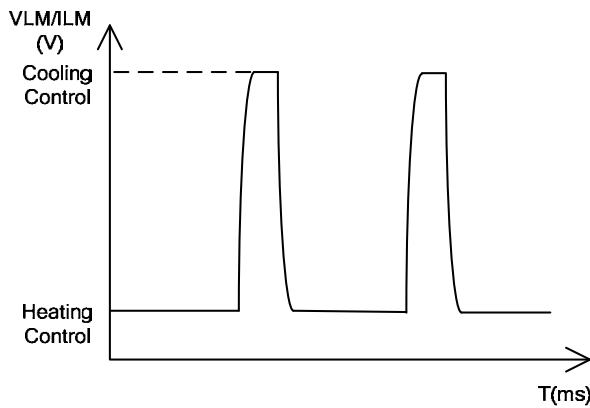Figure 22. The Waveform on the VLM or ILM Pin @ SB State

Figure 23. The Waveform on the VLM or ILM Pin @ Operation State

We can tell the VLM or ILM voltage in cooling control or heating control through the waveforms on the VLM or ILM pin, see Figure 22 and Figure 23. The duty cycle in Figure 22 is 99% and 1% in Figure 24. We can also measure both voltages by a multimeter. When the controller is in the Standby State, the voltage measured by the multimeter is the VLM or ILM voltage in cooling control. When the controller is in Operation State, the voltage measured by the multimeter is the VLM or ILM voltage in heating control.

Temperature-Network

TEC28V15A comes with a customized internal compensational network for which the component values are specified by the customer. See Figure 7.

TEC28V15A comes with a customized Temperature network. See Figure 6 and Figure 7.

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					

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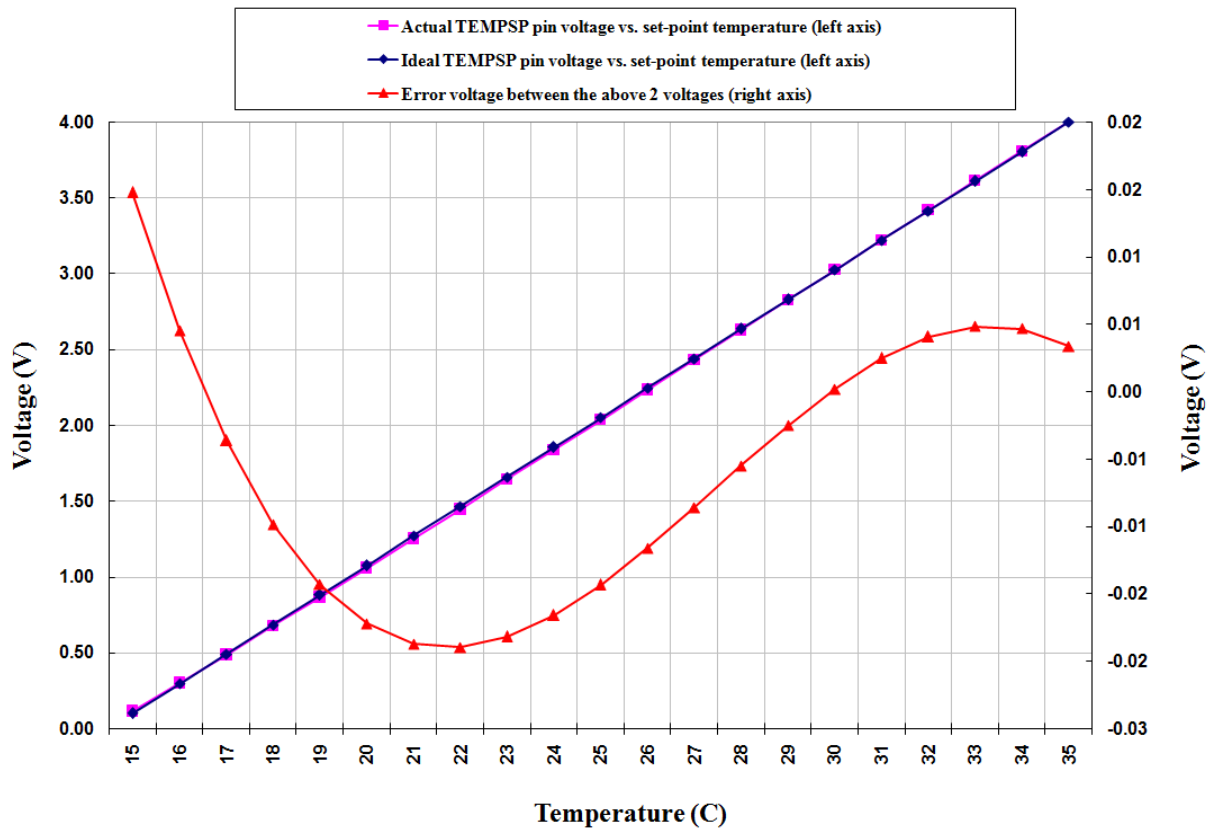
Figure 24. TMO Pin Voltage vs. Set-point Temperature

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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 25 and Figure 26.
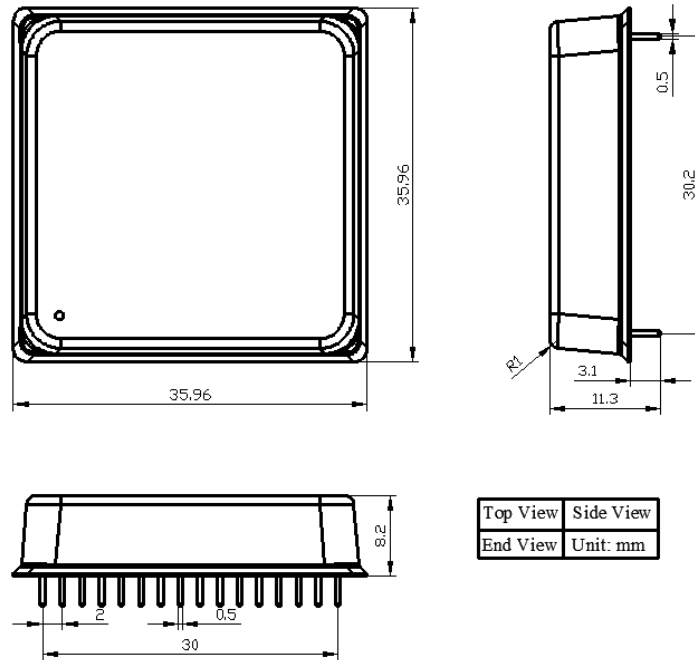
Figure 25. Dimensions of DIP Package
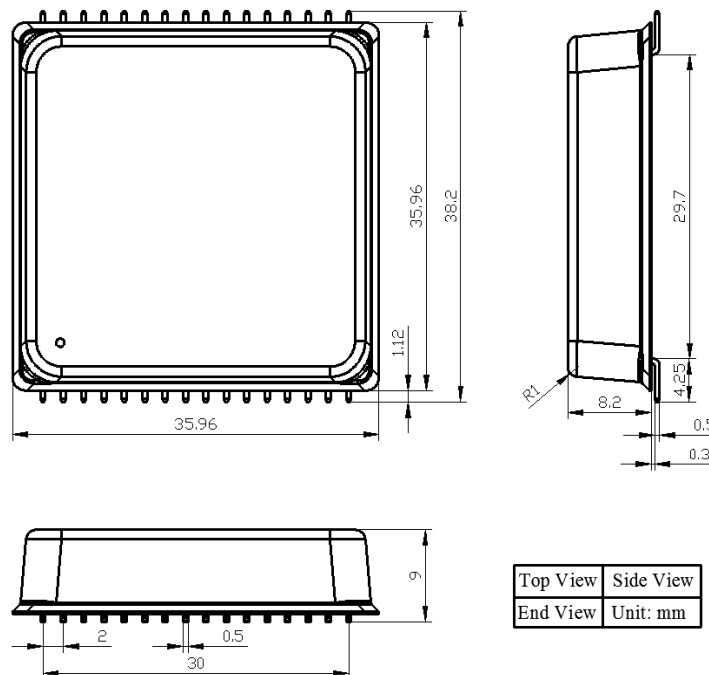
Figure 26. Dimensions of SMT Package

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ORDERING INFORMATION

Table 5. Part Number

Part Number	Description
TEC28V15AD	High voltage high current TEC controller with Pin 1 4VRS in DIP package
TEC28V15AS	High voltage high current TEC controller with Pin 1 4VRS in SMT package
TEC28V15ASNCOD	High voltage high current TEC controller with Pin 1 SNCO in DIP package
TEC28V15ASNCOS	High voltage high current TEC controller with Pin 1 SNCO 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
TEC28V15ASNCOD	$272	$258	$242	$228	$212	$198
TEC28V15ASNCOS	$272	$258	$242	$228	$212	$198

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