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High Efficiency Micro TEC Controller

TEC14M5V3R5AS

DESCRIPTION

The TEC14M5V3R5AS is an ultra compact, low profile, and fully molded TEC controller designed for driving TECs (Thermo-Electric Coolers) with high electrical and mechanical reliability that can achieve high temperature stability for regulating the object temperature. Figure 1 shows its photos of TEC14M5V3R5AS.

The module provides interface ports for setting the main target object set-point temperature range, i.e. set-point temperature range; maximum voltage across TEC, i.e. maximum TEC voltage; and the compensation network. The compensation network compensates the high order thermal load and thus stabilizes the temperature control loop.

It provides these functions: thermistor T-R curve linearization, temperature measurement and monitoring, temperature control loop status indication, TEC voltage monitoring, power up delay, and shut down.

The TEC14M5V3R5AS comes with a high stability low noise 2.5V voltage reference which can be used for setting the desired object temperature by using a POT (Potentiometer) or a DAC (Digital to Analog Converter). When using this reference for setting the set-point temperature, the set-point temperature error is independent of this reference voltage. This is because the internal temperature measurement network also uses this voltage as the reference, the errors in setting the temperature and measuring the temperature cancel with each other, setting the object temperature with higher stability. This reference can also be utilized by an ADC (Ancalog to Digital Converter), for the same reason, the measurement error will calso be independent of the reference voltage, resulting in a more accurate measurement.

Figure 2 is the real size top view of the controller showing the pin names and locations with the actual size. The pin functions are shown in Table 1.
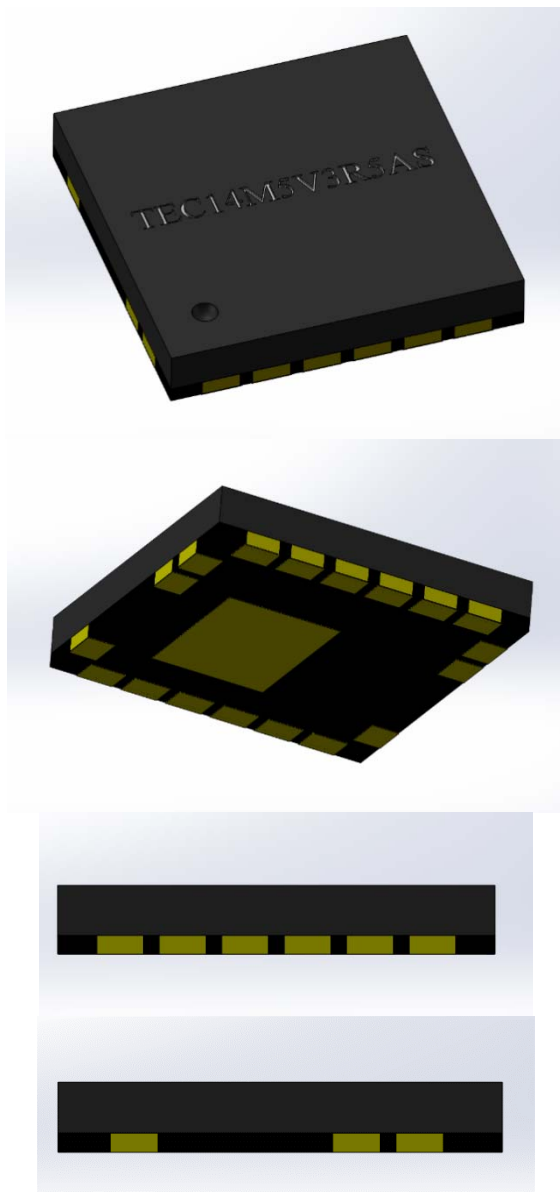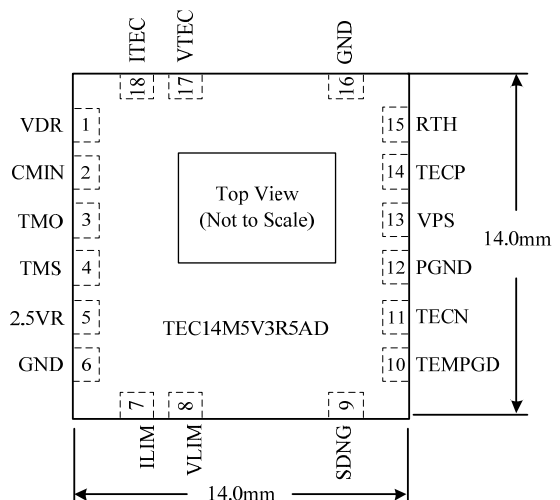

Figure 1. The Photos of TEC14M5V3R5AS

FEATURES

- Compact Size: 0.55"×0.55"×0.09" (14.0mm×14.0mm×2.2mm)
- Low Profile: 0.09" (2.2mm)
- High Reliability: fully molded
- Surface Mount
- Bottom Thermal Pad: allows high power heat sinking
- Efficiency: 90%
- Maximum Output Current: 3.5A
- Maximum Output Voltage: 5V
- Actual Object Temperature Monitoring
- High Temperature Stability: 0.001°C
- Low Cost
- 100 % lead (Pb)-free and RoHS compliant

Figure 2. Pin Names and Locations

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SPECIFICATIONS

Table 1. Pin Function Descriptions

Pin #	Pin Name	Type	Description
1	VDR	Analog Output	When V_{VDR} is < 0.5V_{REF}, it is in cooling mode; when V_{VDR} is > 0.5V_{REF}, it is in heating mode.
2	CMIN	Analog Input	Compensation input pin for the thermal control loop. Leave it open in production.
3	TMO	Analog Output	Actual object temperature. 0.1V to 2.5V indicates the default temperature network from 15°C to 35°C.
4	TMS	Analog Input	Object set-point temperature input port. It is internally tied by a 500k resistor to the half value of the reference voltage, 1.25V. The open circuit voltage of this pin is thus 1.25V, 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 voltage reference. The lower limit of the setting voltage for this pin is 0.1V. Setting this pin to a <0.1V voltage may cause the controller over cooling the object.
5	2.5VR	Analog Output	2.5V Reference Output.
6	GND	Ground	Signal ground for the POT, ADC, DAC and the thermistor.
7	ILIM	Analog Input	Current Limit. This pin sets the TEC cooling and heating current limits. $V_{ILIM\_HEATING} = 2.5V \times Rd/(Rc + Rd)$ $V_{ILIM\_COOLING} = V_{ILIM\_HEATING} + 40\mu A \times Rc \parallel Rd$ $I_{TEC\_MAX\_COOLING} = (V_{ILIM\_COOLING} - 1.25V)/0.285$ $I_{TEC\_MAX\_HEATING} = (1.25V - V_{ILIM\_HEATING})/0.285$ $V_{ILIM\_HEATING}$ must not exceed 1.2V and $V_{ILIM\_COOLING}$ must be more than 1.3V to leave proper margins between the heating and the cooling modes.
8	VLIM	Analog Output	Voltage Limit. This pin sets the TEC cooling and heating voltage limits. $V_{VLIM\_COOLING} = 2.5V \times Rb/(Ra+Rb)$ $V_{VLIM\_HEATING} = V_{VLIM\_COOLING} - 10\mu A \times Ra \parallel Rb$ $V_{TEC\_MAX\_COOLING} = V_{VLIM\_COOLING} \times 2V$ $V_{TEC\_MAX\_HEATING} = V_{VLIM\_HEATING} \times 2V$
9	SDNG	Both Analog Input and Output	Shutdown/Temperature good. When this pin is pulled low, the device shuts down. If this pin is left unconnected: When the actual temperature is lower than the preset temperature, the output voltage is 0.5V_{VPS}; when the actual temperature reaches the preset one, the output voltage is V_{VPS}.
10	TEMPGD	Digital Output	Temperature good indication.
11	TECN	Analog Power Output	Connects to TEC negative terminal
12	PGND	Power Ground	Power ground for connecting to the power supply
13	VPS	Power Input	Positive power supply rail. The value is 5V.
14	TECP	Analog Power Output	Connects to TEC positive terminal

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15	**RTH**	Analog Input	Inverting input to error amplifier.
16	**GND**	Ground	Signal ground for the POT, ADC, DAC and the thermistor.
17	**VTEC**	Analog Output	TEC voltage indication.
18	**ITEC**	Analog Output	TEC current output. $I_{TEC} = (V_{ITEC} - 1.25)/0.285$, where I_{TEC} is the TEC current, defined as the current flowing into the positive TEC terminal (TEC+) and out of the negative TEC terminal (TEC−).

Table 2. Characteristics ($T_{ambient}$=25°C)

Parameter	Test Condition	Value	Unit/Note
Object* temp. stability vs. ambient temp	V_{VPS}=5V, R_{load}=1.2Ω	0.0002	°C/°C
Object temp.vs.set-point.offset	$T_{ambient}$ is 0 ~ 50°C, set-point temp. is 15°C ~35°C	±0.1°C or ±15mV	
Object temp. response time	≤0.1 to the set-point temperature at a 1°C step	<5	seconds
Efficiency	V_{VPS}=5V, R_{load}=3.2Ω	≥90%	-
Max. output current	V_{VPS} =5V, R_{load}=3.2Ω	3	A
Max. output voltage	V_{VPS} =5V, R_{load}=3.2Ω	0 ~ (V_{VPS} − 0.2)	V
PWM frequency		2	MHz
Power supply voltage	—	4.75 ~ 5.25 (typically 5)	V
Set-point temp.** control voltage	V_{VPS}=5V, R_{load}=3.2Ω	0.1 ~ 2.5	V
Default set-point temp. range***	V_{VPS}=3V	15 ~ 35	°C
Operating temp. range	V_{VPS} =5V, R_{load}=3.2Ω	−40 ~ 85	°C
Storage temp. range		−55 ~ 125	°C

*   Object temperature refers to the actual cold side temperature of the TEC, on which the target is mounted.

**   Set-point temperature is the temperature desired to have on the target.

*** Can be customized to any range according to the requirement.

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

2. After many experiments, according to the parameter and the figuring method of R_{load}, we advise to use R_{load}=3.2Ω.

BLOCK DIAGRAM

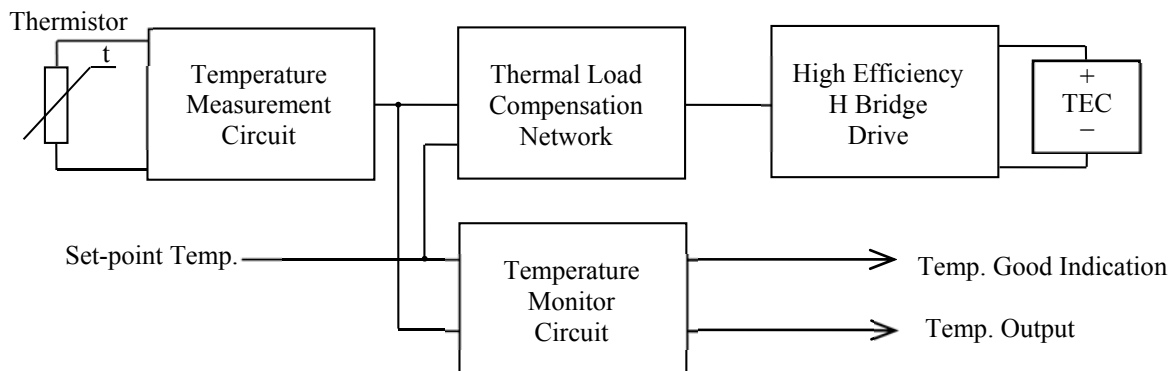The block diagram of the controller is shown in Figure 3.

Figure 3. TEC Controller Block Diagram

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APPLICATIONS

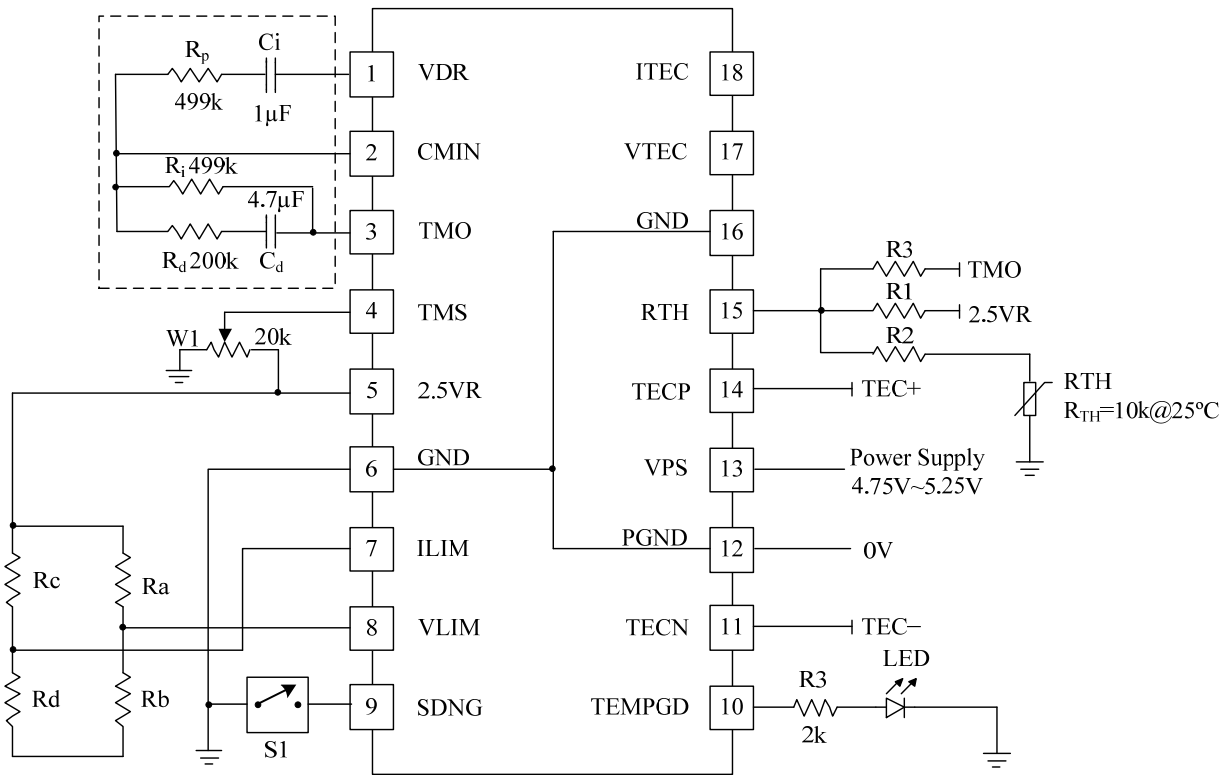TEC controller connections are shown in Figure 4.

Figure 4. TEC Controller Connections

If you want to use this TEC controller for other applications not discussed here, such as using it with wave locker controllers, please consult us. The same as to other customizations, such as setting the TMS by using a voltage source swings above 2.5V and/or VPS.

This controller comes with a default temperature setting network, it sets the set-point temperature to be between 15°C to 35°C when setting the TMS pin voltage to be between 0.1V to 2.5V linearly and using a specific de-facto "standard" 10k @ 25°C thermistor. When using different thermistors and/or needing different set-point temperature ranges, please contact us, we will configure the internal temperature network for you.

Note: This TEC controller doesn't come with an internal compensation network and we don't recommend using internal compensation network either. The compensation network is made of 5 components: 3 resistors and 2 capacitors and the values of the components in the network are the default values shown in Figure 4. Implementing the network externally is highly recommended since it can be modified for driving different thermal load and/or the thermal load characteristics is not certain or fixed at the early design stage.

Resistor Values

R1, R2, R3 are TEC temperature control parameters, see Figure 4. Required temperature parameters can be achieved through adjusting R1, R2 and R3, thus the TEC controller can detect the temperature range that users require.

In different temperature ranges, R1, R2 and R3 have different corresponding resistances. R1, R2 and R3 can be determined by:

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

$$R2 = R1 - R_{MID}$$

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

Where R_{HIGH} is the resistance of R_{TH} in the highest temperature of the set temperature range; R_{MID} is the resistance of R_{TH} in the medium temperature of the set temperature range; R_{LOW} is the resistance of R_{TH} in the lowest temperature of the set temperature range.

MECHANICAL DIMENSIONS

The controller comes in SMT package. Dimensions of the TEC14M5V3R5AS is shown in Figure 5. A recommended PCB layout is shown in Figure 6.
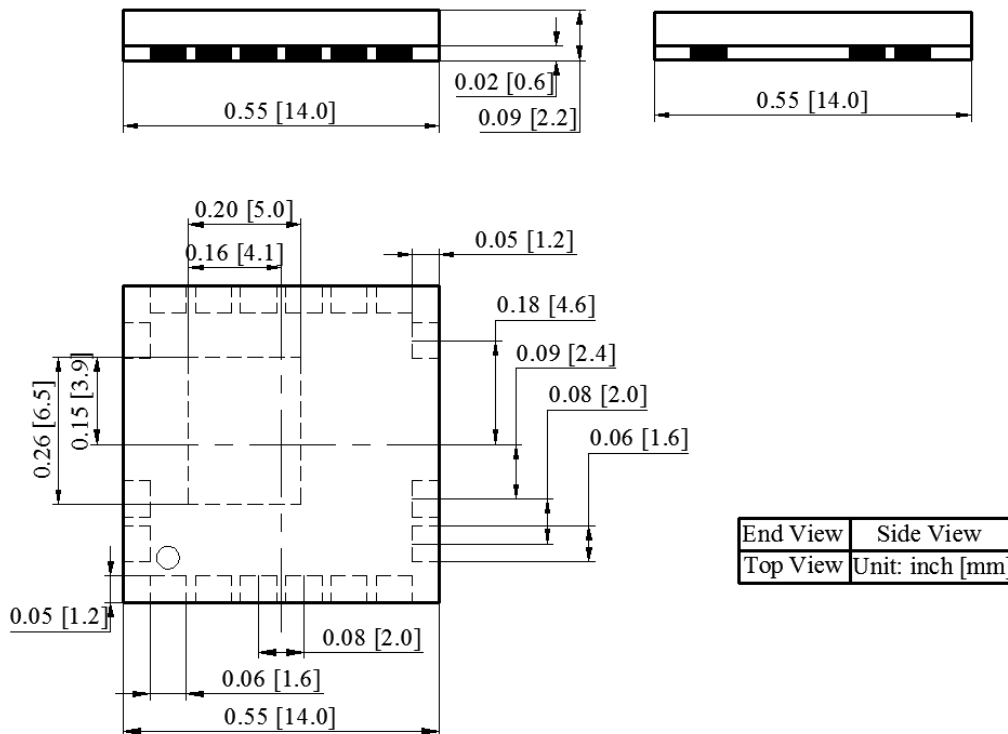

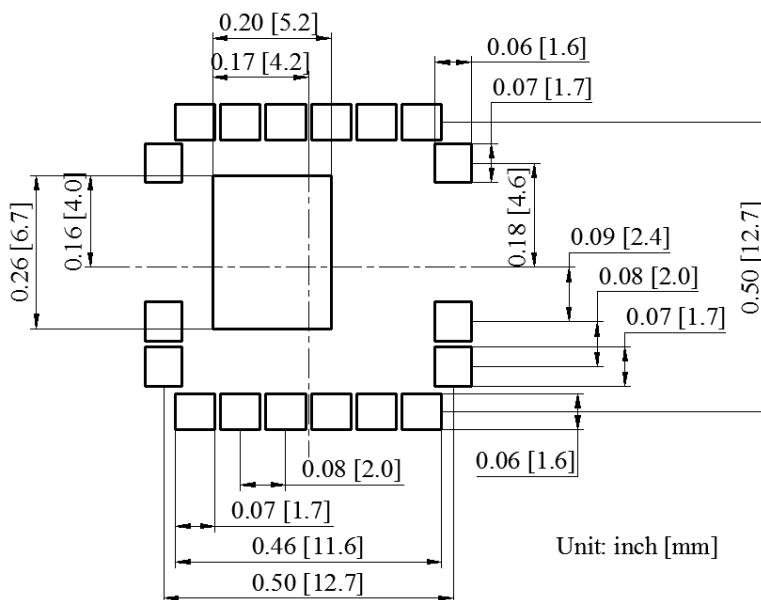Figure 5. Dimensions of the TEC14M5V3R5AS

Recommended PCB Layout (Top Side)
(PCB Board Tolerance±0.05)

Figure 6. Recommended PCB Layout (Top Side)

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NOTE: **The power supply may have overshoot, when happens, it may exceed the maximum allowed input voltage, 6V, of the controller and damage the controller permanently. To avoid this from happening, do the followings:**

1. Connect the controller solid well with the power supply before turning on the power.

2. Make sure that the power supply has sufficient output current. It is suggested that the power supply can supply 1.2 to 1.5 times the maximum current the controller requires.

3. When using a bench top power supply, set the current limit to >1.5 times higher than the maximum current the controller requires.

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