Figure 1. Physical Photo of the ATW3A313D

FEATURES

- The world's first window based TEC controller: stands by when the target object temperature is within a pre-set temperature window.
- Programmable set-point temperature window
- High efficiency: ≥90%
- Seebeck voltage available
- Switching frequency synchronizable
- Programmable maximum output current: 0 to 3A
- Programmable maximum output voltage: 0 to VPS
- Actual object temperature monitoring
- Completely shielded: zero EMI
- Compact size
- DIP and SMT packages available
- 100 % lead (Pb)-free and RoHS compliant.

DESCRIPTIONS

The ATW3A313 is a compact electronic module designed to control TECs (Thermo-Electric Coolers) for regulating the target object temperature within a pre-set window at high energy efficiency. When the target object temperature falls within the pre-set temperature window range, the controller puts itself into a standby mode, decreasing energy consumption to a minimum level. When the target object temperature reaches the upper bound of the temperature window, the controller cools down the target object; when the target object temperature reaches the lower bound of the window, the controller heats up the target object, as shown in Figure 3.

The output stage of the ATW3A313 utilizes a patented PWM-Linear topology, resulting in a high efficiency and small size. The output pins to the TEC are filtered from PWM to DC signal, thus eliminating interference to other electronics. Figure 1 is the photo of an actual ATW3A313D.

The ATW3A313 TEC controller module provides interface ports for setting the desired target object temperature window range, from 10°C ~ 40°C as default; the maximum output current; the maximum output voltage across the TEC; shutdown control, standby indication, and switching frequency synchronization input/output. The shut down pin shuts down the whole controller and cuts the power supply current to < 10µA.

The TEC's voltage is monitored in real time. It is worth mentioning that the Seebeck voltage (which is generated by the temperature difference between the 2 TEC plates) can be detected under standby mode, it can be used to measure the temperature difference between the 2 TEC plates.

The TEC's actual current is also monitored in real time.

In addition, the controller has many other functions: temperature measurement and monitoring, TMO; temperature control loop status indication, TMGD; controller working status, SBNO; TEC voltage monitoring, VTEC; and current monitoring, ITEC; current limit settings, ILMC and ILMH; synchronization input and output, soft start, and shut down.

The window TEC controller ATW3A313 comes with a high stability low noise 2.5V voltage reference which can be used for setting the output voltage and current limit, and the desired target object temperature window by using POTs (Potentiometers) or a DAC (Digital to Analog Converter). When using this reference for setting the set-point window temperatures, the error in the actual target object temperature is independent of this reference voltage. This is because the internal temperature measurement network also uses the reference voltage as the reference, the errors in setting the temperature and measuring the temperature cancel with each other. This reference can also be utilized by external ADCs (Analog to Digital Converters). For the same reason, the measurement error will also be independent of the reference voltage change, resulting in a more accurate measurement.

The ATW3A313 is packaged in a 6 sided metal enclosure with the case connected to the ground node of the circuit, which blocks EMIs (Electro-Magnetic Interferences) to prevent the controller and other electronics from interfering with each other.

Warning: Both the surface mount and the through hole types of modules can only be soldered manually on the board by a solder iron at < 310°C (590°F), they cannot go through a reflow oven process.

Figure 2 is the top view of the window TEC controller showing the pin names and locations. The ATW3A313 pin functions are shown in Table 1.

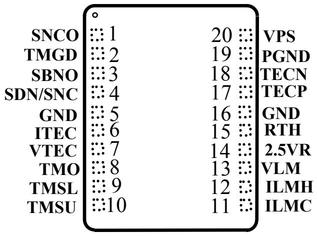

Figure 2. Pin Assignment

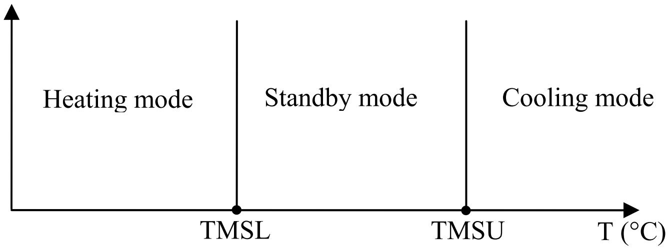

Figure 3. The 3 Operating Modes of the ATW3A313

Table 1. Pin Function Descriptions

Pin #	Pin Name	Type	Description
1	SNCO	Digital output	Synchronization pulse output. It can be used as the synchronization input signal of another switch-mode TEC controllers, laser drivers or power supplies.
2	TMGD	Digital output	Temperature good indication. It goes high when the actual target object temperature is <0.2°C within the temperature window set by TMSL and TMSU pins. This pin can source or sink up to 20mA current.
3	SBNO	Analog output	Standby mode indication output. When goes low, it indicates that the controller is at the standby mode. This pin can either source or sink a current of up to 20mA.
4	SDN/SNC	Digital input	This is a dual digital input pin. Its first function is to shut down the whole controller by pulling this pin to ground and to reduce the total current draw from the VPS port to < 10µA. It is pulled up by a 2MΩ resistor tied to the VPS power supply rail. This pin has another function: synchronization input, it can be pulsed by a digital signal of 550kHz to 800kHz with which the internal switching can be synchronized, to avoiding frequency beating interference with other nearby switch mode electronics, such as switch mode TEC controllers, laser drivers or power supplies.
5	GND	Ground	Signal ground for the potentiometers, ADCs, DACs and the thermistor.
6	ITEC	Analog output	TEC current indication. ITEC is an analog voltage output pin with its voltage proportional to the actual current going through the TEC. There is a 1.25V offset voltage on this pin, it means that when the current is zero, the output voltage of this pin is 1.25V. The relationship between output current and the ITEC pin voltage is: I_{TEC} (A) = 2.4 × [V(ITEC) – 1.25V], where V(ITEC) is the voltage of ITEC pin, when the voltage is 2.5V, the output current is 3A, the TEC works under cooling mode; when this voltage is 0V, the output current is –3A, the TEC works under heating mode. .
7	VTEC	Analog output	TEC voltage indication. VTEC is an analog voltage output pin with a voltage proportional to the actual voltage across the TEC. The same as above, there is a 1.25V offset voltage on this pin: when the output voltage across the TEC is zero volt, the voltage on this pin is 1.25V. The output voltage across the TEC can be derived as: V(TEC) = V(TECP) – V(TECN) = 4 × [V(VTEC) – 1.25V], Where V(TEC) stands for the voltage across the TEC and is defined as the voltage difference between the voltage of the TEC's positive terminal, V(TECP), and the voltage of the TEC's negative terminal, V(TECN). V(VTEC) stands for the voltage on the VTEC pin.
8	TMO	Analog output	Actual target object temperature indication. This pin's voltage represents the actual target object temperature almost linearly. It swings from 0.05V to 2.45V, corresponding to 18°C to 32°C by default. The analytical equation between the temperature vs. the TMO pin voltage is given in page 5.
9	TMSL	Analog input	Sets the lower temperature limit for the set-point temperature window. The relationship between the TMSL voltage and the set-point temperature is: $T(TMSL) = (T_{OU} - T_{OL}) \times V(TMSL)/2.5 + T_{OL}$

			where T(TMSL) is the lower temperature limit of the set-point temperature window, V(TMSL) is the voltage needed for setting the voltage on the TMSL pin, T_{OU} is the upper limit of the entire temperature monitor range and is set by R1, R2, R3 and the thermistor to be used as the temperature sensor. T_{OL} is the lower limit of the entire set-point temperature range and is set by the same way as T_{OU}.
10	TMSU	Analog input	Sets the upper temperature limit for the set-point temperature window. The relationship between the TMSL voltage and the set-point temperature is: $T(TMSU) = (T_{OU} - T_{OL}) \times V(TMSU)/2.5 + T_{OL}$ where T(TMSU) is the upper temperature limit of the set-point temperature window, V(TMSU) is the voltage needed for setting the voltage on the TMSU pin, T_{OU} is the upper limit of the entire set-point temperature range and is set by R1, R2, R3 and the thermistor to be used as the temperature sensor, see the calculation section for R1, R2 and R3. T_{OL} is the lower limit of the entire set-point temperature range and is set by the same way as T_{OU}.
11	ILMC	Analog input	Sets the current limit for cooling mode. Figure 5 shows the connections. To set the maximum cooling current to be Imaxc, the resistance of the resistors R4 and R5 can be calculated as: R4 = R5 = 80 × Imaxc/(3 − Imaxc) (KΩ). Without using the 2 resistors, R4 and R5, the maximum output current is limited to a default value of 3A.
12	ILMH	Analog input	Sets the current limit for heating mode. Figure 5 shows the connections. To set the maximum heating current to be Imaxh, the resistance of the resistors R6 and R7 can be calculated as: R = 80 × Imaxc/(3 − Imaxh) (KΩ). Without using the 2 resistors, R6 and R7, the maximum output current is limited to a default value of 3A.
13	VLM	Analog input	Sets the maximum output voltage across TEC. The maximum voltage applied across the TEC can be limited. To set the maximum output voltage to be Vmax, VLM should be set at VLM = Vmax/5. If no limitation is needed, tie this pin to ground.
14	2.5VR	Analog output	Reference voltage output, 2.5V. It can be used by a POT or DAC for setting the set-point temperature window voltages on the TMSU and TMSL pins and/or a DAC for measuring the temperature through the TMO pin. The maximum sourcing current capability is 1.5mA and the maximum sinking is 4mA with a stability of <50ppm/°C max.
15	RTH	Analog input	Connects to the thermistor for sensing the target object temp. The other end of the thermistors is connected to the signal ground, pin 16, or pin 5. The thermistor's value can range from 1K to 100K@25°C. The most commonly used value is 10K@25°C.
16	GND	Signal ground	Signal ground, internally connected to Pin 5 GND. It can be used for connecting the thermistor and other peripherals for setting the parameters.
17	TECP	Analog power output	Connects to TEC positive terminal.
18	TECN	Analog power output	Connects to TEC negative terminal.
19	PGND	Power ground	Power ground for connecting to the power supply.
20	VPS	Power input	Power supply positive rail, the operating range is 3.1V to 5.5V.

SPECIFICATIONS

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

Parameter	Test Condition	Value	Unit/ Note
Default window temperature range		10 ~ 40	°C
Voltage setting range for TMSL and TMSU pins		0.1 ~ 2.4	V
Controller trigger-in and trigger-out voltage for the |TMO – TMSL| or |TMO – TMSU|		20	mV
Voltage limit VLM set range		0 ~ 1.25	V
Cooling current limit ILMC set range		1.25V ~ 2.5	V
Heating current limit ILMH set range		0 ~ 1.25	V
Max output current	VPS = 5V, $R_{load} = 0.8\Omega$	±3	A
Standby current		5	mA
Shut down current		<10	µA
Efficiency	VPS = 5V, TECP – TECN = 2.5V, $R_{load} = 1\Omega$	≥ 92	%
Power supply voltage range	—	3.1 ~ 5.5	V
Operating ambient temp range	$V_{in} = 5V$, $R_{load} = 0.8\Omega$	–40 ~ 85	°C
Module thermal resistance		10	°C/W

* Target object temperature refers to the actual cold side temperature of the TEC, where the object is mounted.

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

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

**** This TEC controller can only drive the TECs having > 1Ω impedance, which equals Vmax/Imax

BLOCK DIAGRAM

The block diagram of the controller is shown in Figure 4.

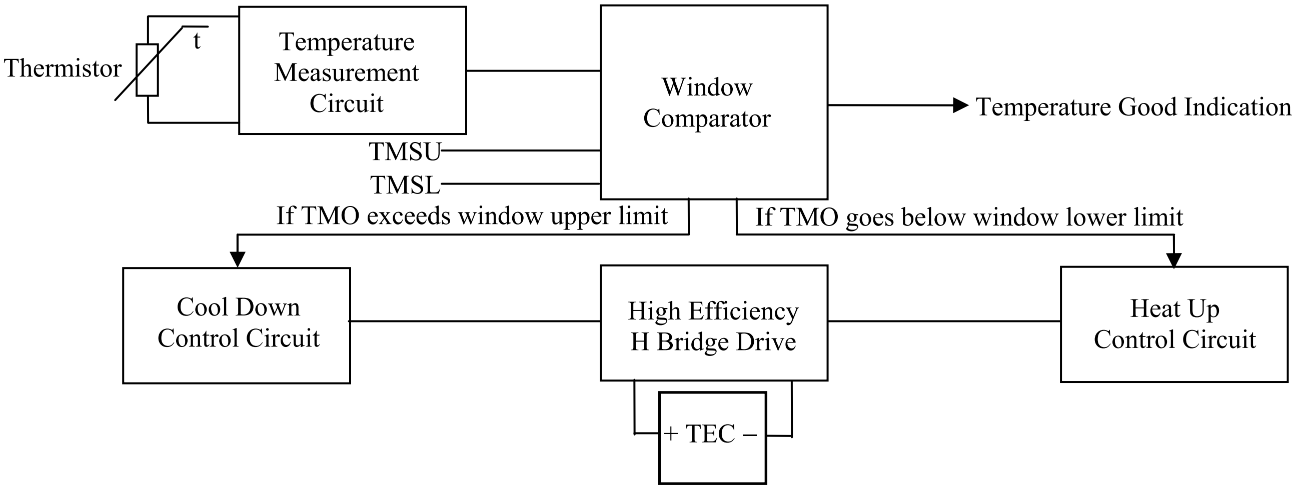

Figure 4. Window TEC Controller Block Diagram

The temperature sensor on the left, the thermistor, senses the temperature of the target object mounted on the cold side of the TEC module. The resistance of the thermistor varies when the temperature changes. The window TEC controller requires using a negative coefficient thermistor, its resistance increases as the temperature decreases.

The temperature measurement circuit converts the resistance change into an output voltage change at the TMO pin of the controller, and reverses the voltage change direction as the temperature changes: the TMO voltage increases as the target object temperature increases.

The window comparator compares the temperature output voltage off the TMO pin, when the TMO voltage exceeds the TMSU voltage, it means that the target object temperature is higher than the upper limit of the temperature window, thus the controller turns on the control circuit, sets it to a cool down mode, and starts to cool down the target object, the thermal load; when the TMO voltage gets lower than the TMSL voltage, it means that the target object temperature is lower than the lower limit of the temperature window, the controller then turns on the control circuit, sets it to a heating up mode, and starts to heat up the target object, the thermal load.

The cool down and heat up control circuits control the high efficiency H bridge for driving the TEC module.

A target object is mounted on the cold side of the TEC module, the thermistor is mounted on the target object. When the target object

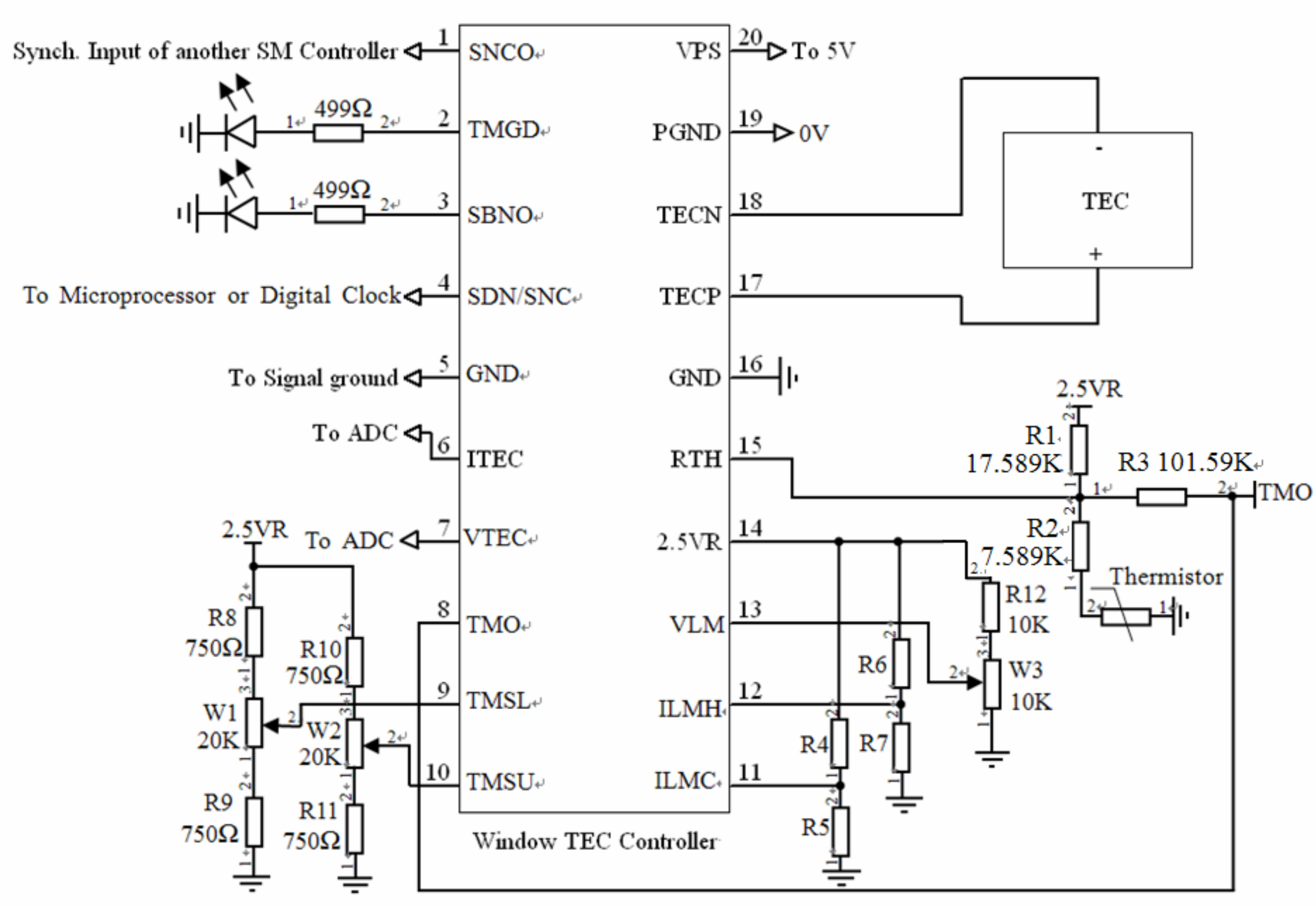

Figure 5. TEC Controller Connections

APPLICATIONS

1. Switch Frequency Synchronization with Another Device

TEC controller connections are shown in Figure 5.

When 2 switch mode devices having similar switching frequencies are present in one system board, there is an interference caused by beating frequency, the frequency difference between the 2 switching frequencies of the 2 switch mode devices. If this beating frequency is high, > 1 KHz, it can be easily filtered out by using LC or RC filters; if the beating frequency is low, it would be difficult to filter interference out. The window TEC controller ATW3A313, being a switch mode device, has the functions for eliminating this interference when it is used adjacent with another switch mode device, such as another switch mode TEC controller, a laser driver, or a power supply. It can be used either as a master unit, providing the synchronization source signal which is generated by the PWM stage of the controller with the same switching frequency, from Pin 1, as the synchronization input signal of the other device, or it can accept a pulse signal, on Pin 4, from the other switch mode device and adjust the PWM circuit to follow the switching frequency of the other switch mode device. When working as a synchronization master unit, make sure that the switching frequency of this window TEC controller, 500 KHz ± 10 KHz, falls within the allowable frequency range of the other switch mode device; when working as a slave unit, make sure that the switching frequency of the other device is between 520 KHz to 600 KHz. The synchronization functions of the window TEC controller works in both working and standby modes, but does not work under shutdown mode.

If another switch mode device does not have synchronization input function, but having a synchronization output signal, configure the other device as the master unit and the window TEC controller as the slave unit.

When the other switch mode devices having a switching frequency that is far away, >100 KHz, from that of the window TEC controller, 500KHz, there is no need to synchronize the other device with the window TEC controller, since the beating frequency is high and it is easy to filter the interference out.

2. The Window Temperature Limits

The window temperature is the temperature within which the target object needs to be regulated. It is defined by 2 temperature values: the lower window limit, T_{WL}, and upper window limit, T_{WU}. These 2 temperature limits are decided by the particular application where the window TEC controller is employed and set by the 2 set-point temperature pins, TMSL and TMSU, respectively. The relationships between, the temperature T_{WL} and the voltage TMSL, and the temperature T_{WU} and the voltage TMSU, are determined by the relationship governs the actual target object temperature T and the temperature monitor voltage on the TMO pin.

3. Determine and Configure Monitoring Temperature Range

The voltage of pin 8, TMO, represents the actual target object temperature. Its temperature monitoring range should be set to cover the window temperature range and is recommended to set it in such a way that the monitoring temperature span is about 20% to 50% wider than the window temperature span. This translates to setting TMSL to be between 0.2V to 0.5V and TMSU to be between 2V to 2.3V, as the TMO pin voltage range is 0.05V to 2.45V.

For example, if we want set the window temperature lower and upper limits, T_{WL} and T_{WU}, to be 20°C to 30°C respectively, the window temperature span is 30°C − 20°C = 10°C, the temperature monitoring span can be set to 14°C, 40% wider than the window temperature span, thus the monitor temperature lower limit, T_{OL}, needs to be configured to 18°C and the upper limit, T_{OU}, needs to be configured to 32°C.

The monitor temperature range is set by a thermistor conditioning network consisted of R1, R2 and R3, as shown in Figure 5.

This is the procedure for calculating these 3 resistors:

A. Based on the monitor temperature range parameters, T_{OL}, and T_{OU}, the lower and upper monitor temperature limits, and T_{OM}, the mid point temperature, where

$$T_{OM} = \frac{T_{OL}+T_{OU}}{2},$$

to find the 3 resistance values of the thermistor corresponding to these 3 temperatures by looking up the R-T table of the thermistor or calculating them by using the formula, all given in the datasheet, R_L, R_M, and R_U respectively. Take our company's thermistor datasheet as an example, http://www.analogtechnologies.com/document/ATH10K1R25.pdf, both the R-T table and the formula are give in this datasheet for the ATH10K1R25 thermistor. The partial $R_{TH}(T)$ data are given in Table 3 as shown in page 7, from which the 3 thermistor values are obtained as:

$R_L = R_{TH}$ (18°C) = 13.683K,

$R_M = R_{TH}$ (25°C) = 10.000K,

$R_U = R_{TH}$ (32°C) = 7.4041K,

where $R_{TH}(T)$ stands for the thermistor resistance at temperature T.

B. Calculate the resistance values of the 3 resistors in the temperature network, R1, R2 and R3. Denote V(TMO) for the voltage at the TMO pin, it is a function of R_{TH}, R1, R2 and R3:

$$V(TMO) = 0.5\times V_{REF}\times R3\times\left[\frac{1}{R3}-\frac{1}{R1}+\frac{1}{R2+R_{TH}(T)}\right].$$

To let *V(TMO)* output the voltage at the 3 temperatures, T_{OL}, T_{OM}, and T_{OU}, to be 0, $0.5V_{REF}$, and V_{REF} respectively, substitute $R_{TH}(T)$ by the 3 resistance values in the equation at the 3 temperature points:

at $T = T_{OL}$, $R_{TH}(T_{OL}) = R_L$:

$$V(TMO) = 0.5\times V_{REF}\times R3\times\left[\frac{1}{R3}-\frac{1}{R1}+\frac{1}{R2+R_L}\right]=0;$$

at $T = T_{OM}$, $R_{TH}(T_{OM}) = R_M$:

$$V(TMO) = 0.5\times V_{REF}\times R3\times\left[\frac{1}{R3}-\frac{1}{R1}+\frac{1}{R2+R_M}\right]=0.5\times V_{REF};$$

at $T = T_{OU}$, $R_{TH}(T_{OU}) = R_U$:

$$V(TMO) = 0.5\times V_{REF}\times R3\times\left[\frac{1}{R3}-\frac{1}{R1}+\frac{1}{R2+R_M}\right]=V_{REF}.$$

After derivation, we achieve the equations listed below for calculating R1, R2 and R3:

$$R1 = R_M + \frac{R_M(R_L+R_U)-2R_U R_L}{R_U+R_L-2R_M} \quad (1),$$

$$R2 = R1 - R_M \quad (2),$$

$$R3 = \frac{R1(R1 + R_L - R_M)}{R_L - R_M} \quad (3).$$

In case the 2nd term in equation (1) turns out to be a negative value, i.e.:

$$\frac{R_M(R_L + R_U) - 2R_U R_L}{R_U + R_L - 2R_M} < 0,$$

Set R1 = RM, and R2 = 0.

Plug-in the above 3 thermistor values obtained:

$R_L = R_{TH}$ (18°C) = 13.683K,

$R_M = R_{TH}$ (25°C) = 10.000K,

$R_U = R_{TH}$ (32°C) = 7.4041K,

into the 3 equations, we get:

R1 = 17.589KΩ,
R2 = 7.589KΩ,
R3 = 101.59KΩ.

The values for R1, R2 and R3 shown in Figure 5 are for setting the monitor temperature range to be between x°C to x°C by using a thermistor of 10kΩ@25°C, β = 3950@25°C, of which the R-T values are shown in Table 3 in the next page.

To set the monitor temperature range to be of other values, these 3 resistors need to be re-calculated based on the monitor temperature range and the thermistor used for sensing the temperature.

In addition to using the NTC (Negative Temperature Coefficient) type thermistors as described above, the window TEC controller ATW3A313D can work with other types of temperature sensors, such as RTD (Resistance Temperature Detector), PTC (Positive Temperature Coefficient) type thermistor, temperature sensor IC, etc. Contact us for further details.

Set output current limit

When driving a TEC module with positive current (the current goes in from the positive terminal), it cools down the thermal load on the cold side, the cooling power reaches the peak value when the current equals to Imax, a parameter of the TEC module determined by the size of the Peltier elements. As the driving current goes beyond the Imax, the cooling power goes down, till zero when the driving current is 2 times of Imax. Beyond this value, the cold side begins to generate heat onto the thermal load, the thermal loop becomes an unstable positive feedback type and the set-point temperature can no longer be achieved. This phenomenon is called "thermal run-away". To prevent this thermal run-away, the maximum output current should be set to the Imax value of the TEC module for the cooling mode. Under the heating mode, there is no maximum limit for the driving current. However, some thermal loads have limits for the temperature they can withstand; therefore, the heating current should also be limited to certain values for such applications. The limiting current can be calculated if the system thermal model is well known or measured by experiments for most application systems of which the thermal models are unknown. The window TEC controller ATW3A313D allows setting the cooling and heating current limits separately, the details are gives in the Table 1 at page 2 and page 3.

Set output voltage limit

To be on the safe side, the window TEC controller ATW3A313D allows limiting the maximum voltage applied to the TEC and this is done by setting the voltage on the pin 13, VLM. The relationship between the maximum output voltage magnitude and the VLM pin voltage is:

VLM = Vmax/5,

where Vmax is the maximum output voltage magnitude, this formula applies for both cooling and heating modes.

Maximize the power efficiency

To achieve high power efficiency, the load resistance must be > 0.8Ω, the higher the value, the higher the power efficiency of the controller.

To achieve the maximum output power, the power supply voltage can be set to 5.5V.

Shut down the controller

The window TEC controller can be shut down by pulling the SDN/SNC pin down. There is an internal 10MΩ resistor pulling this pin to the VPS rail. The pulling down can be done by using a digital I/O port, a mechanical switch, an open-drain port (a pull up resistor tied to the pin 20, VPS, is needed).

Under down, the controller draws < 5uA current from the power supply VPS.

Connecting to the TEC and the thermistor

The TEC module has 2 terminals, 1 marked as positive (red wire) and the other marked as negative (black wire), connect the former to pin 17, TECP; the latter to pin 18, TECN.

The thermistor has 2 terminals, connect one to RTH, pin 15, and the other to GND, pin 16.

Controller status indication

There are 2 indications from the controller: standby and temperature good. The former shows the working mode of the controller: standby mode or driving mode; the latter shows if the target object temperature is within the set-point temperature window.

The standby mode indication is done through pin 3, SBNO, when this pin goes low, the controller is under standby mode; when goes high, the controller is under driving mode. This pin can drive up to 20mA current. Usually this pin drives an LED as shown in Figure 5.

Being under driving mode means the controller is either driving the TEC to cool down or heat up the target object to keep its temperature to be within the set-point temperature window.

The temperature good indication is done through pin 2, TMGD. When this pin goes high, it means the temperature is within the set-point temperature window. This pin can be used for driving an LED as shown in Figure 5, and it's driving capability is also 20mA.

Thermal consideration and PCB layout

The window TEC controller ATW3A313D, the DIP through version, or ATW3A313S, the SMT version, works with high power efficiency, there is no need to provide heat sinks for it to work in a normal room ambient temperature environment. However, if the controller is enclosed in a closed environment, where the ambient temperature can be higher room ambient temperature, proper heat sinking is needed. The maximum case temperature for the controller is 85 degree °C. It always helps cooling down the controller by using large size of the copper area for soldering the pins. The solder pad can be a normal size, adding additional copper area to the pad increases effective heat sinking area for the controller, thus lowering its working temperature.

Warning for soldering

1. **Always use lower temperature iron, <310°C, and solder manually for both the through hole and SMT versions of the controller.**
2. **Always wire wrist wrap to prevent damaging the controller by ESDs.**
3. **Do not wash the controller after soldering. The water trapped inside the controller may damage the circuit.**

Table 3. R_{TH} (T) Data for Thermistor ATH10K1R25

Temp(℃)	Resistance(KΩ)	Temp(℃)	Resistance(KΩ)	Temp(℃)	Resistance(KΩ)
0	32.738	17	14.327	34	6.8109
1	31.104	18	13.683	35	6.5341
2	29.568	19	13.073	36	6.2711
3	28.109	20	12.494	37	6.0180
4	26.729	21	11.943	38	5.7788
5	25.428	22	11.419	39	5.5496
6	24.205	23	10.923	40	5.3302
7	23.041	24	10.449	41	5.1207
8	21.935	25	10.000	42	4.9211
9	20.908	26	9.5730	43	4.7315
10	19.921	27	9.1658	44	4.5478
11	19.984	28	8.7783	45	4.3740
12	18.100	29	8.4085	46	4.2082
13	17.264	30	8.0586	47	4.0484
14	16.471	31	7.7224	48	3.8944
15	15.717	32	7.4041	49	3.7485
16	15.004	33	7.0995	50	3.6085

MECHANICAL DIMENSIONS

In addition to ATW3A313D we also have ATW3A313S, which is SMT packaged. Dimensions of the DIP packaged controller is shown in Figure 6, dimensions of the SMT packaged controller is shown in Figure 7.

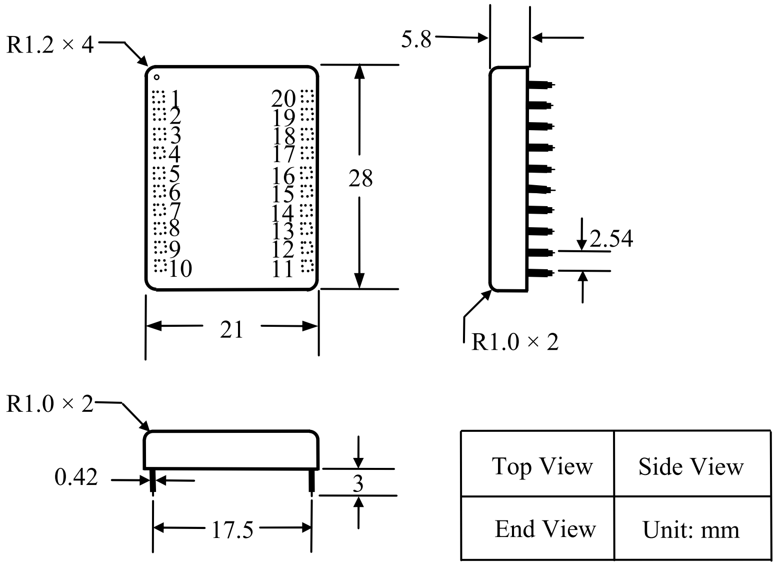

Figure 6. Dimensions of the DIP Package Controller

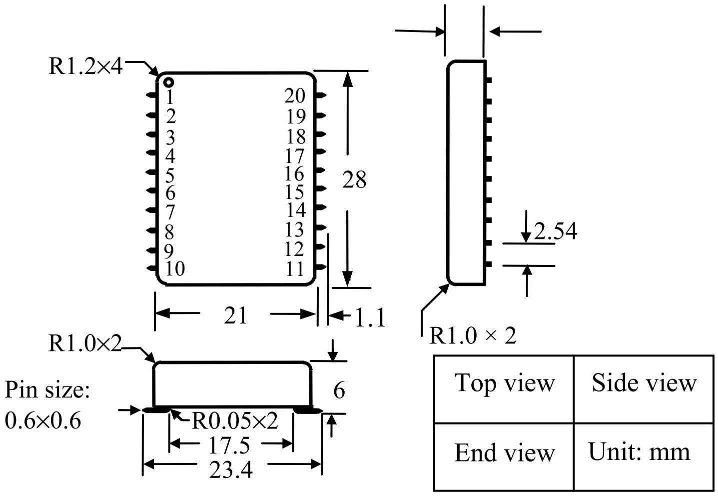

Figure 7. Dimensions of the SMT Package Controller

WARNING: Both the surface mount and the through hole types of modules can only be soldered manually on the board by a solder iron at < 310°C (590°F), they cannot go through a reflow oven process.

ORDERING INFORMATIONS

Table 4. Unit Price

Part#	**Description**	**Price**				
		1 – 9	**10 – 49**	**50 - 199**	**200 – 499**	**≥500**
ATW3A313D	DIP (Dual Inline Package) package	\$92.4	\$87.2	\$81.9	\$76.7	\$71.4
ATW3A313S	SMT (Surface Mount Technology) package	\$92.4	\$87.2	\$81.9	\$76.7	\$71.4

NOTICE

1. ATI warrants performance of its products for one year to the specifications applicable at the time of sale, except for those being damaged by excessive abuse. Products found not meeting the specifications within one year from the date of sale can be exchanged free of charge.
2. ATI reserves the right to make changes to its products or to discontinue any product or service without notice, and advise customers to obtain the latest version of relevant information to verify, before placing orders, that information being relied on is current and complete.
3. All products are sold subject to the terms and conditions of sale supplied at the time of order acknowledgment, including those pertaining to warranty, patent infringement, and limitation of liability. Testing and other quality control techniques are utilized to the extent ATI deems necessary to support this warranty. Specific testing of all parameters of each device is not necessarily performed, except those mandated by government requirements.
4. Customers are responsible for their applications using ATI components. In order to minimize risks associated with the customers' applications, adequate design and operating safeguards must be provided by the customers to minimize inherent or procedural hazards. ATI assumes no liability for applications assistance or customer product design.
5. ATI does not warrant or represent that any license, either express or implied, is granted under any patent right, copyright, mask work right, or other intellectual property right of ATI covering or relating to any combination, machine, or process in which such products or services might be or are used. ATI's publication of information regarding any third party's products or services does not constitute ATI's approval, warranty or endorsement thereof.
6. IP (Intellectual Property) Ownership: ATI retains the ownership of full rights for special technologies and/or techniques embedded in its products, the designs for mechanics, optics, plus all modifications, improvements, and inventions made by ATI for its products and/or projects.