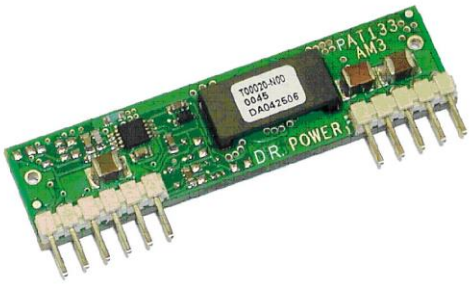
SMT Non-Isolated
18V – 36V input, 5V-15.5V 9A/60W output



Features

- **High Efficiency: 94% (24Vin, 12Vout@5A)**
- **Optimal thermal performance**
- **Low profile in standard footprint**
- **Wide input-voltage range: 18 - 36V**
- **Wide output-voltage range: 5V to 15.5V**
- **Remote sense, On/Off control**
- **Monotonic start-up into pre-biased load**

For High Reliability Applications

Options

- **Baseplate**
- **Negative/Positive enable logic**
- **Output over-voltage protection**
- **Output voltage tracking/Sequence**

Part Numbering System

PAT	3	X	X	09	S	X	X	X
Series Name	**Input Voltage Range**	**temperature grade**	**Enabling Logic**	**Rated Output Current**	**Pin Length**	**Electrical Option**	**Mechanical Options**	**Lead-free, ROHS Compliant**
PAT	3: 18 – 36V	C: -40 - 80˚C H: -40 - 100˚C M: -55 - 100˚C	P: Positive N: Negative	Unit: 09: 9A	S: SMT	0: None 1: Voltage Tracking 2: OVP 3: Both VT & OVP	0: Open-frame 2: Baseplate	G: Lead-free

General Specification

Absolute Maximum Rating

Excessive stresses over these absolute maximum ratings can cause permanent damage to the converter. Also, exposure to absolute maximum ratings for extended periods of time can adversely affect the reliability of the converter. Operation should be limited to the conditions outlined under the Electrical Specification Section.

Parameter	Symbol	Min	Max	Unit
Input Voltage (continuous)	Vi	-0.5	38.5	Vdc
Operating Ambient Temperature	To			
"C" Temperature grade		-40	80	˚C
"M" Temperature grade		-55	100	˚C
"H" Temperature grade		-40	100	˚C
Storage Temperature	Tstg	-55	125	˚C

Electrical Specifications

The specifications are valid over all operating conditions including input voltage, resistive load, and temperature except as noted.

Input Specifications

Parameter	Symbol	Min	Typ	Max	Unit
Input Voltage	Vi	18	24	36	Vdc
Input Current	Ii,max	-	-	4	A
Quiescent Input Current (Vin = 24, Vo = 3.3V)	Ii,Qsnt	-	50	70	mA
Standby Input Current	Ii,stdby	-	2		mA
Inrush Transient	I^2t	-	-	0.5	A^2s
Input Reflected-ripple Current, Peak-to-peak (5 Hz to 20 MHz, 1 µH source impedance)	-	-	20	-	mAp-p
Input Ripple Rejection (120 Hz)	-		30	-	dB
Input Turn-on Voltage Threshold	-		17		V

Output Specifications

Parameter	Symbol	Min	Typ	Max	Unit
Output Voltage Set Point Tolerance (Vi = 24 V; Io = Iomax; Ta = 25°C)	-	-2.0	-	2.0	%
Output Voltage Set Point Tolerance (over all conditions)	-	-2.5	-	3.50	%
Output Regulaton:					
Line Regulation (Vi = 9V to 36V, Io = 1/2 of load)	-	-	0.2		%Vo
Load Regulation (Io = Io,min to Io,max, Vi = 24V)	-	-	0.3		%Vo
Temperature (Ta = -55°C to 100 °C)	-	-	0.2		%Vo
Output Ripple and Noise Voltage (5 Hz to 20 MHz bandwidth, Vin = 24V)	Peak-to-peak -	-	2		%Vo
	RMS			1	%Vo
External Load Capacitance	-	-	-	2,000	µF
Output Current	Io	0	-	9	A
Output Power	Po	0		60	W
Output Current-limit Trip Point	Io,cli	-	170	-	%Iomax
Output Short-circuit Current, hiccup mode			2		A
Switching frequency	-	405	450	495	kHz
Output Over Voltage trip point (optional, hiccup mode)		115	125	135	%Vo
Voltage Tracking/Sequencing Slew Rate – Power UP				2	V/ms
Voltage Tracking/Sequencing Slew Rate – Power down				1	V/ms

Output Specifications (continued)

Parameter		Symbol	Min	Typ	Max	Unit
Efficiency	Vo = 5V, Io = 9A	η		88		%
(Vi = 24V; T_A = 25ºC)	Vo = 12V, Io = 5A			94		%
Dynamic Response (Vi = 24V; Ta = 25°C; Load transient 0.1A/μs) Load step from 75% to 100% of full load: Peak deviation Settling time (to 10% band of Vo deviation) Load step from 100% to 75% of full load Peak deviation Settling time (to 10% band of Vo deviation)						 mV μs mV μs

General Specifications

Parameter	Symbol	Min	Typ	Max	Unit
Remote Enable Negative Logic: Logic Low – Module On Logic High – Module Off Positive Logic: Logic High – Module On Logic Low – Module Off	-	-	-	-	-
Logic Low: $I_{ON/OFF}$ = 1.0mA $V_{ON/OFF}$ = 0.0V Logic High: $I_{ON/OFF}$ = 0.0μA Leakage Current	 $V_{ON/OFF}$ $I_{ON/OFF}$ $V_{ON/OFF}$ $I_{ON/OFF}$	 0 - - -	 - - - -	 1.2 1.0 15 50	 V mA V μA
Over-temperature Protection	To	-	120	-	°C
Turn-on Time (Io = full load, Vo within 1% of setpoint)	-	-	6	-	ms
Calculated MTBF (Bellcore TR-332, 40°C, full load)			> 5		10^6 -hour

Feature Descriptions

The converter can be turned on and off by changing the voltage or resistance between the ON/OFF pin and GND. The PBS converters can be ordered with factory selectable positive logic or negative enabling logic.

For the negative control logic, the converter is ON when the ON/OFF pin is at a logic low level, and OFF when the ON/OFF pin is at a logic high level. With positive control logic, the converter is ON when the ON/OFF pin is at a logic high level and OFF when the ON/OFF pin is at a logic low level. The converter is ON no matter what control logic is when ON/OFF pin is left open (unconnected).

With the internal pull-up circuitry, a simple external switch between the ON/OFF pin and Vin(-) can control the converter. A few example circuits for controlling the ON/OFF pin are shown in Fig. 1,2and 3.

The logic-low level is from 0V to 0.5V, and the maximum switch current during logic low is 2mA. The external switch must be capable of maintaining a logic-low level while sinking this current.

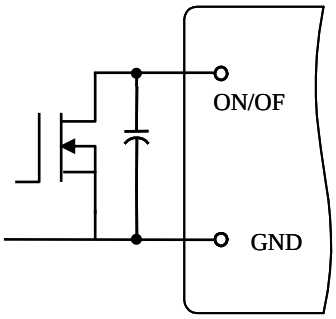


Fig. 1 Circuit for Positive Logic Control

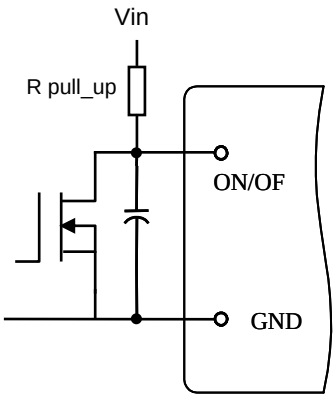


Fig. 2 Circuit for Negative Logic Control

Remote SENSE

The remote SENSE pins are used to sense the voltage at the load point to accurately regulate the load voltage and eliminate the impact of the voltage drop in the power distribution path.

he SENSE pin should be connected to the point where regulation is desired. The voltage difference between the output pins must not exceed the operating range of this converter shown in the specification table.

When remote sense is not used, the SENSE pin can be connected to the positive output terminals. If the SENSE pins are left floating, the converter will deliver an output voltage slightly higher than its specified typical output voltage. The OVP (output over-voltage protection) circuit senses the voltage across the output pins, so the total voltage rise should not exceed the minimum OVP setpoint given in the Specifications Table in operation.

Output Voltage Programming and Adjustment

The output voltage of this converter is preset to 5.021V as a default. Customers can also order 12V or 15V as the preset voltage by indicating the desired voltage in the part number. The output voltage be trimmed up to 15.5V using an external trim resistor. To trim the voltage lower than the preset voltage, an external voltage higher than the nominal voltage has to be applied to the Trim pin.
The trim pin allows the user to adjust the output voltage set point with an external resistor or voltage. If the trim pin is open, the converter outputs preset voltage. If the trim pin is shorted to GND, the converter outputs 15.521V. To program the output voltage, a resistor should be connected between the Trim pin and the GND pin. The output voltage can be adjusted down by changing the value of the external resistor using the equation below:

$$Rtrim = (\frac{10.5}{\Delta} - 1)(k\Omega)$$

Where $\Delta = Vo - Vonom$

$Vonom = 5.021$ as a default, or is the preset voltage ordered.

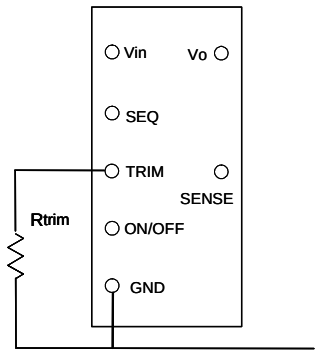


Fig. 4 Circuit to Trim Output Voltage

The circuit configuration for trim operation is shown in Figure 4. Because PAT converters use GND as the reference for control, Rtrim should be placed as close to GND pin as possible, and the trace connecting GND pin and Rtrim should not carry significant current, to reduce the effect of voltage drop on the GND trace/plain on the output voltage accuracy.

Input Under-Voltage Lockout

This feature prevents the converter from turning on until the input voltage reaches about 17V.

Output Over-Current/Short-Circuit Protection

This converter is designed to operate within 3.5A of output current and 18W of output current if the output voltage is higher than 7V. The converter turns off when the load current exceeds the current limit. If the over-current or short circuit condition persist, the converter will operate in a hiccup mode (repeatedly trying to restart) until the over-current condition is cleared.

Thermal Shutdown

The converter utilizes the thermal protection feature of the controller IC to perform over temperature protection. When temperature at TMP1 (shown in Fig. 16) reaches 140°C, the converter will shutdown. The converter will resume operation after the converter cools down. However, in practical application, it is strongly recommended that proper cooling should be provided and verified. The Thermal shutdown feature should not be considered as a guarantee for survival under over stress conditions beyond its rating.

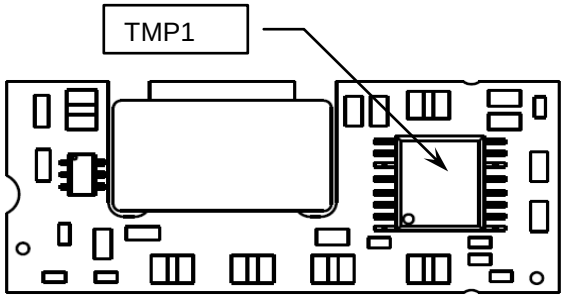


Fig. 5 **PAT3 Bottom View —** Temperature Monitoring Point TMP1 for Thermal Shutdown

Voltage Tracking/Sequencing

An optional voltage tracking/sequencing feature is available with this converter for output voltage up to 8V. This feature is compatible with the “Voltage Sequencing” feature (DOSA) or the “Voltage Tracking” feature (POLA) seen in industry standards. If this feature is not used, the corresponding SEQ pin should be left open, or tied to a voltage higher than the output voltage but less than 10V.

The tracking feature is not available when output voltage is higher than 8V.
This feature basically forces the output of the converter to follow the voltage at the SEQ pin until it reaches the setpoint during startup, or is completely shutdown during turnoff. The converter’s output voltage is controlled to be the same magnitude as the voltage on the SEQ pin, on a 1:1 basis. When using this function, one should pay careful attention to the following aspects:
1). This feature is intended mainly for startup and shutdown sequencing control. In normal operation, the

voltage at SEQ pin should be maintained higher than the required output voltage, or the SEQ pin is left unconnected;
2). The input voltage should be valid for this feature to work. During startup, it is recommended to have a delay of at least 10 ms between the establishment of a valid input voltage, and the application of a voltage at the SEQ pin;
3). The ON/OFF pin should be in "Enabled" state when this function is effective.
4). The converter's pre-bias startup is affected by this function. The converter will still be able to start under a pre-bias condition, but the output voltage waveform will have a glitch during startup.

The tracking feature is not available when output voltage is higher than 8V.

Design Considerations

Input Source Impedance

As with any DC/DC converter, the stability of the PAT converters may be compromised if the source impedance is too high or inductive. It's desirable to keep the input source ac-impedance as low as possible. Although the converters are designed to be stable without an additional input capacitor for typical source impedance, it is recommended to use at least a 33 - 100 μF low ESR electrolytic capacitor at the input of the converter to reduce the potential impact of the source impedance. This electrolytic capacitor should have sufficient RMS current rating over the operating temperature range.

Safety Considerations

The PAT Series of converters are designed in accordance with EN 60950 Safety of Information Technology Equipment Including Electrical Equipment. The converters are recognized by UL in both USA and Canada to meet 1500V Basic Insulation requirements in UL 60950, Safety of Information Technology Equipment and applicable Canadian Safety Requirement, and ULc 60950. Flammability ratings of the PWB and plastic components in the converter meet 94V-0.

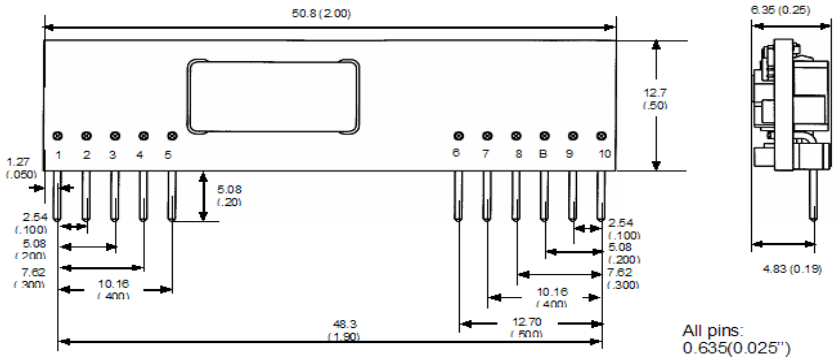
To protect the converter and the system, an input line fuse is highly recommended on the un-grounded input end.

Thermal Considerations

The PAT Series of converters can operate in various thermal environments. Due to the high efficiency and optimal heat distribution, these converters exhibit excellent thermal performance. Proper cooling can be verified by monitoring the temperature of the case not continuously exceeding 120 °C.

The maximum allowable output power of any power converter is usually determined by the electrical design and the maximum operating temperature of its components.

Mechanical Diagrams



Pin#	1	2	3	4	5	6	7	8	B	9	10
Function	Vo	Vo	Sense	Vo	GND	GND	Vin	Vin	SEQ	Trim	ON/OFF

For more information, please contact
Dr. Power's China Representative:

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Warranty

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