PMH 4518 T 3.3-V Input

22-A, 3.3-V Input Non-Isolated
Wide-Output Adjust Power Module

POLA code: PTH03020 W

NOMINAL SIZE = 1.5 in x 0.87 in
(38,1 mm x 22,1 mm)

Features

- Up to 22-A Output Current
- 3.3-V Input Voltage
- Wide-Output Voltage Adjust (0.8 V to 2.5 V)
- Efficiencies up to 93 %
- 120 W/in³ Power Density
- On/Off Inhibit
- Output Voltage Sense
- Pre-Bias Startup
- Margin Up/Down Controls
- Under-Voltage Lockout
- Auto-Track™ Sequencing(1)
- Output Over-Current Protection (Non-Latching, Auto-Reset)
- Over-Temperature Protection
- Operating Temp: –40 to +85 °C
- IPC Lead Free 2
- Safety Agency Approvals: UL 1950, CSA 22.2 950, EN60950 VDE (Pending)
- Point-of-load Alliance (POLA) Compatible

Note: (1) Auto-Track™ is a trademark of Texas Instruments

Description

The PMH 4518 T series of non-isolated power modules offers OEM designers a combination of high performance, small footprint, and industry leading features. As part of a new class of power modules these products provide designers with the flexibility to power the most complex multi-processor digital systems using off-the-shelf catalog parts.

The series employs double-sided surface mount construction and provides high-performance step-down power conversion for up to 22 A of output current from a 3.3-V input bus voltage. The output voltage of the PMH 4518T can be set to any value over the range, 0.8 V to 2.5 V, using a single resistor.

This series includes Auto-Track™. Auto-Track simplifies the task of supply voltage sequencing in a power system by enabling modules to track each other, or any external voltage, during power up and power down.

Other operating features include an on/off inhibit, output voltage adjust (trim), and margin up/down controls. To ensure tight load regulation, an output voltage sense is also provided. A non-latching over-current trip and over-tempterature shutdown provide load fault protection.

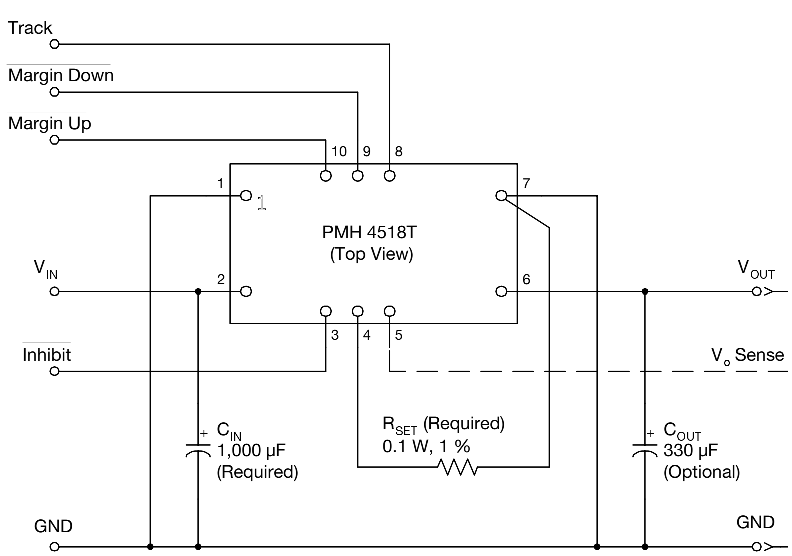
Target applications include complex multi-voltage, multi-processor systems that incorporate the industry's high-speed DSPs, micro-processors and bus drivers.

Pin Configuration

Pin	Function
1	GND
2	V_{in}
3	Inhibit *
4	V_o Adjust
5	V_o Sense
6	V_{out}
7	GND
8	Track
9	Margin Down *
10	Margin Up *

* *Denotes negative logic:*
Open = Normal operation
Ground = Function active

Standard Application



R_{set} = Required to set the output voltage to a value higher than 0.8 V. (See spec. table for values)
C_{in} = Required electrolytic 1,000 µF
C_{out} = Recommended 330 µF electrolytic

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22-A, 3.3-V Input Non-Isolated
Wide-Output Adjust Power Module

Product Table (PMH 4518 T x) (1)

V_{In}	V_O / I_O max	P_O max	Package Code(1)	Description	Ordering No.
2.95-3.65 V	0.8-2.5 V /22 A	55 W	P	Horiz. T/H	PMH 4518 T x(1)
			S	SMD, Standard	

(1) Replace "x"in the Ordering No. with Package Code.

Ordering Information

Delivery Option	M.o.q.	Suffix	Example
Tray	20 pcs	/B	PMH 4518T P /B
Tape & Reel (2)	250 pcs	/C	PMH 4518T S /C

(2) Tape & Reel available only for SMD packages

Pin Descriptions

Vin: The positive input voltage power node to the module, which is referenced to common *GND*.

Vout: The regulated positive power output with respect to the *GND* node.

GND: This is the common ground connection for the *Vin* and *Vout* power connections. It is also the 0 VDC reference for the control inputs.

Inhibit: The Inhibit pin is an open-collector/drain negative logic input that is referenced to *GND*. Applying a low-level ground signal to this input disables the module's output and turns off the output voltage. When the *Inhibit* control is active, the input current drawn by the regulator is significantly reduced. If the *Inhibit* pin is left open-circuit, the module will produce an output whenever a valid input source is applied.

Vo Adjust: A 0.1 W, 1 % tolerance (or better) resistor must be connected between this pin and the *GND* pin to set the output voltage to the desired value. The set point range for the output voltage is from 0.8 V to 2.5 V. The resistor required for a given output voltage may be calculated from the following formula. If left open circuit, the module output will default to its lowest output voltage value. For further information on the adjustment of the output voltage consult the related application note.

$$R_{set} = 10\text{ k} \cdot \frac{0.8\text{ V}}{V_{out} - 0.8\text{ V}} - 2.49\text{ k}$$

The specification table gives the preferred resistor values for a number of standard output voltages.

Vo Sense: The sense input allows the regulation circuit to compensate for voltage drop between the module and the load. For optimal voltage accuracy *Vo Sense* should be connected to *Vout*. It can also be left disconnected.

Track: This is an analog control input that enables the output voltage to follow an external voltage. This pin becomes active typically 20 ms after the input voltage has been applied, and allows direct control of the output voltage from 0 V up to the nominal set-point voltage. Within this range the output will follow the voltage at the *Track* pin on a volt-for-volt basis. When the control voltage is raised above this range, the module regulates at its set-point voltage. The feature allows the output voltage to rise simultaneously with other modules powered from the same input bus. If unused, the input should be connected to V_{in}. *Note: Due to the under-voltage lockout feature, the output of the module cannot follow its own input voltage during power up. For more information, consult the related application note.*

Margin Down: When this input is asserted to *GND*, the output voltage is decreased by 5% from the nominal. The input requires an open-collector (open-drain) interface. It is not TTL compatible. A lower percent change can be accomodated with a series resistor. If unused, this input may be left unconnected. For further information, consult the related application note.

Margin Up: When this input is asserted to *GND*, the output voltage is increased by 5%. The input requires an open-collector (open-drain) interface. It is not TTL compatible. The percent change can be reduced with a series resistor. If unused, this input may be left unconnected. For further information, consult the related application note.

Environmental & Absolute Maximum Ratings (Voltages are with respect to GND)

Characteristics	Symbols	Conditions	Min	Typ	Max	Units
Track Input Voltage	V_{track}		–0.3	—	V_{in} + 0.3	V
Operating Temperature Range	T_a	Over V_{in} Range	–40	—	85	°C
Solder Reflow Temperature	T_{reflow}	Surface temperature of module body or pins			235 (i)	°C
Storage Temperature	T_s	—	–40	—	125	°C
Mechanical Shock		Per Mil-STD-883D, Method 2002.3 1 msec, ½ Sine, mounted	—	500	—	G's
Mechanical Vibration		Mil-STD-883D, Method 2007.2 Suffix H 20-2000 Hz Suffix S	— —	20 10	— —	G's
Weight	—		—	5	—	grams
Flammability	—	Meets UL 94V-O				

Notes: (i) *During reflow of SMD package version do not elevate peak temperature of the module, pins or internal components above the stated maximum.*

Specifications (Unless otherwise stated, T_a =25 °C, V_{in} =3.3 V, V_{out} =2 V, C_{in} =1,000 µF, C_{out} =0 µF, and I_o =$I_o$max)

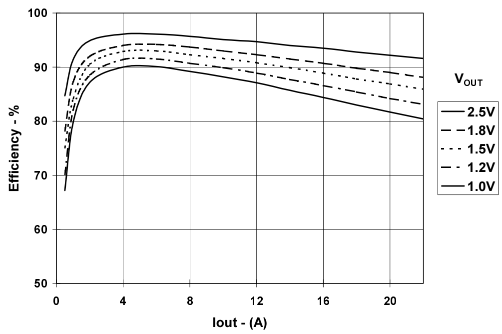
			PMH 4518T			
Characteristics	Symbols	Conditions	Min	Typ	Max	Units
Output Current	I_o	0.8 V ≤ V_o ≤ 2.5 V, 60 °C, 200 LFM airflow 25 °C, natural convection		0 0	— 22 (1) — 22 (1)	A
Input Voltage Range	V_{in}	Over I_o range	2.95 (2)	—	3.65	V
Set-Point Voltage Tolerance	V_o tol		—	—	±2 (3)	%V_o
Temperature Variation	ΔReg_{temp}	–40 °C < T_a < +85 °C	—	±0.5	—	%V_o
Line Regulation	ΔReg_{line}	Over V_{in} range	—	±5	—	mV
Load Regulation	ΔReg_{load}	Over I_o range	—	±5	—	mV
Total Output Variation	ΔReg_{tot}	Includes set-point, line, load, –40 °C ≤ T_a ≤ +85 °C	—	—	±3 (3)	%V_o
Efficiency	η	I_o =10 A R_{SET} = 2.21 kΩ V_o = 2.5 V R_{SET} = 4.12 kΩ V_o = 2.0 V R_{SET} = 5.49 kΩ V_o = 1.8 V R_{SET} = 8.87 kΩ V_o = 1.5 V R_{SET} = 17.4 kΩ V_o = 1.2 V R_{SET} = 36.5 kΩ V_o = 1.0 V	— — — — — —	95 94 93 91 90 88	— — — — — —	%
V_o Ripple (pk-pk)	V_r	20 MHz bandwidth	—	20	—	mVpp
Over-Current Threshold	I_o trip	Reset, followed by auto-recovery	—	41	—	A
Transient Response	 t_{tr} ΔV_{tr}	1 A/µs load step, 50 to 100 % $I_o$max, C_{out} =330 µF Recovery Time V_o over/undershoot	 — —	 50 100	 — —	 µSec mV
Margin Up/Down Adjust	V_o adj		—	± 5	—	%
Margin Input Current (pins 9 /10)	I_{IL} margin	Pin to GND	—	– 8 (4)	—	µA
Track Input Current (pin 8)	I_{IL} track	Pin to GND	—	—	–130 (5)	µA
Track Slew Rate Capability	dV_{track}/dt	C_{out} ≤ C_{out}(max)	—	—	1	V/ms
Under-Voltage Lockout	UVLO	V_{in} increasing V_{in} decreasing	— 2.2	2.8 2.7	2.95 —	V
Inhibit Control (pin3)		Referenced to GND				
Input High Voltage	V_{IH}		V_{in} –0.5	—	Open (5)	V
Input Low Voltage	V_{IL}		–0.2	—	0.8	
Input Low Current	I_{IL} inhibit	Pin to GND	—	–130	—	µA
Input Standby Current	I_{in} inh	Inhibit (pin 3) to GND, Track (pin 8) open	—	10	—	mA
Switching Frequency	f_s	Over V_{in} and I_o ranges	250	300	340	kHz
External Input Capacitance	C_{in}		1,000 (6)	—	—	µF
External Output Capacitance	C_{out}	Capacitance value non-ceramic ceramic	0 0	330 (7) —	11,000 (8) 300	µF
		Equiv. series resistance (non-ceramic)	4 (9)	—	—	mΩ
Reliability	MTBF	Per Bellcore TR-332 50 % stress, T_a =40 °C, ground benign	4.9	—	—	10^6 Hrs

Notes:
(1) *See SOA curves or consult factory for appropriate derating.*
(2) *The minimum input voltage is equal to 2.95 V or Vout + 0.5 V, whichever is greater.*
(3) *The set-point voltage tolerance is affected by the tolerance and stability of R_{SET}. The stated limit is unconditionally met if R_{SET} has a tolerance of 1 % with 100 ppm/°C or better temperature stability.*
(4) *A small low-leakage (<100 nA) MOSFET is recommended to control this pin. The open-circuit voltage is less than 1 Vdc.*
(5) *This control pin has an internal pull-up to the input voltage Vin. If it is left open-circuit the module will operate when input power is applied. A small low-leakage (<100 nA) MOSFET is recommended for control. For further information, consult the related application note.*
(6) *A 1,000 µF electrolytic input capacitor is required for proper operation. The capacitor must be rated for a minimum of 700 mArms of ripple current.*
(7) *An external output capacitor is not required for basic operation. Adding 330 µF of distributed capacitance at the load will improve the transient response.*
(8) *This is the calculated maximum. The minimum ESR limitation will often result in a lower value. Consult the application notes for further guidance.*
(9) *This is the typcial ESR for all the electrolytic (non-ceramic) output capacitance. Use 7 mW as the minimum when using max-ESR values to calculate.*

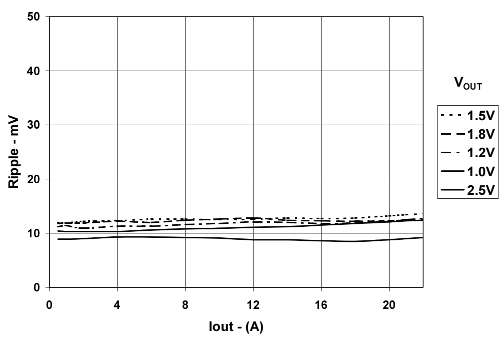
22-A, 3.3-V Input Non-Isolated
Wide-Output Adjust Power Module

Characteristic Data; V_{in} =3.3V *(See Note A)*

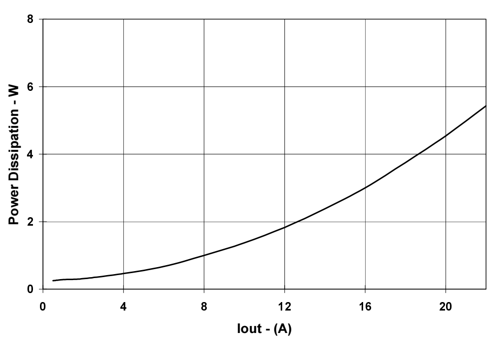
Efficiency vs Load Current



Output Ripple vs Load Current

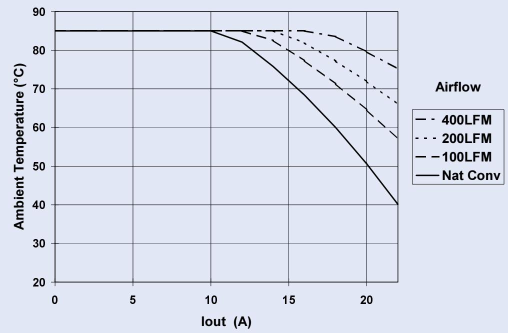


Power Dissipation vs Load Current



Safe Operating Area; V_{in} =3.3 V *(See Note B)*

All Output Voltages



Note A: *Characteristic data has been developed from actual products tested at 25°C. This data is considered typical data for the converter.*
Note B: *SOA curves represent the conditions at which internal components are at or below the manufacturer's maximum operating temperatures. Derating limits apply to modules soldered directly to a 4 in. ´ 4 in. double-sided PCB with 1 oz. copper.*

PMH 5718 T 5-V Input

22-A, 5-V Input Non-Isolated
Wide-Output Adjust Power Module

POLA Point-of-Load Alliance

POLA code: PTH05020 W

NOMINAL SIZE = 1.5 in x 0.87 in
(38,1 mm x 22,1 mm)

Features

- Up to 22 A Output Current
- 5-V Input Voltage
- Wide-Output Voltage Adjust (0.8 V to 3.6 V)
- Efficiencies up to 96 %
- 155 W/in³ Power Density
- On/Off Inhibit
- Output Voltage Sense
- Pre-Bias Startup
- Margin Up/Down Controls
- Under-Voltage Lockout
- Auto-Track™ Sequencing(1)
- Output Over-Current Protection (Non-Latching, Auto-Reset)
- Over-Temperature Protection
- Operating Temp: –40 to +85 °C
- IPC Lead Free 2
- Safety Agency Approvals: UL 1950, CSA 22.2 950,EN60950 VDE (Pending)
- Point-of-Load Alliance (POLA) Compatible

Note: (1) Auto-Track™ is a trademark of Texas Instruments

Description

The PMH 5718T series of non-isolated power modules offers OEM designers a combination of high performance, small footprint, and industry leading features. As part of a new class of power modules these products provide designers with the flexibility to power the most complex multi-processor digital systems using off-the-shelf catalog parts.

The series employs double-sided surface mount construction and provides high-performance step-down power conversion for up to 22 A of output current from a 5-V input bus voltage. The output voltage of the PMH 5718T can be set to any value over the range, 0.8 V to 3.6 V, using a single resistor.

This series includes Auto-Track™. Auto-Track simplifies the task of supply voltage sequencing in a power system by enabling modules to track each other, or any external voltage, during power up and power down.

Other operating features include an on/off inhibit, output voltage adjust (trim), and margin up/down controls. To ensure tight load regulation, an output voltage sense is also provided. A non-latching over-current trip and over-temperature shutdown provides load fault protection.

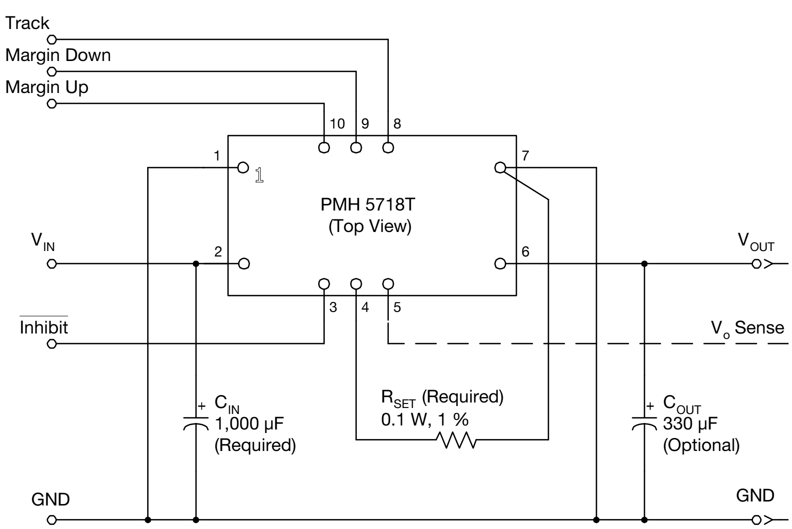
Target applications include complex multi-voltage, multi-processor systems that incorporate the industry's high-speed DSPs, micro-processors and bus drivers.

Pin Configuration

Pin	Function
1	GND
2	V_{in}
3	Inhibit *
4	V_o Adjust
5	V_o Sense
6	V_{out}
7	GND
8	Track
9	Margin Down *
10	Margin Up *

* *Denotes negative logic:*
Open = Normal operation
Ground = Function active

Standard Application



Rset = Required to set the output voltage to a value higher than 0.8 V. (See spec. table for values)
C_{in} = Required electrolytic 1,000 µF
C_{out} = Optional 330 µF electrolytic

22-A, 5-V Input Non-Isolated
Wide-Output Adjust Power Module

Product Table (PMH 5718 T x)(1)

V_{In}	V_O / I_O max	P_O max	Package Code(1)	Description	Ordering No.
4.5-5.5 V	0.8-3.6 V /22 A	79.2 W	P	Horiz. T/H	PMH 5718 T x(1)
			S	SMD, Standard	

(1) Replace "x"in the Ordering No. with Package Code.

Ordering Information

Delivery Option	M.o.q.	Suffix	Example
Tray	20 pcs	/B	PMH 5718T P /B
Tape & Reel (2)	250 pcs	/C	PMH 5718T S /C

(2) Tape & Reel available only for SMD packages

Pin Descriptions

Vin: The positive input voltage power node to the module, which is referenced to common *GND*.

Vout: The regulated positive power output with respect to the *GND* node.

GND: This is the common ground connection for the *Vin* and *Vout* power connections. It is also the 0 VDC reference for the control inputs.

Inhibit: The Inhibit pin is an open-collector/drain negative logic input that is referenced to *GND*. Applying a low-level ground signal to this input disables the module's output and turns off the output voltage. When the *Inhibit* control is active, the input current drawn by the regulator is significantly reduced. If the *Inhibit* pin is left open-circuit, the module will produce an output whenever a valid input source is applied.

Vo Adjust: A 0.1 W, 1 % tolerance (or better) resistor must be connected directly between this pin and pin 7 (*GND)* to set the output voltage to the desired value. The set point range for the output voltage is from 0.8 V to 3.6 V. The resistor required for a given output voltage may be calculated from the following formula. If left open circuit, the module output will default to its lowest output voltage value. For further information on output voltage adjustment consult the related application note.

$$R_{set} = 10\text{ k} \cdot \frac{0.8\text{ V}}{V_{out} - 0.8\text{ V}} - 2.49\text{ k}$$

The specification table gives the preferred resistor values for a number of standard output voltages.

Vo Sense: The sense input allows the regulation circuit to compensate for voltage drop between the module and the load. For optimal voltage accuracy *Vo Sense* should be connected to *Vout*. It can also be left disconnected.

Track: This is an analog control input that enables the output voltage to follow an external voltage. This pin becomes active typically 20 ms after the input voltage has been applied, and allows direct control of the output voltage from 0 V up to the nominal set-point voltage. Within this range the output will follow the voltage at the *Track* pin on a volt-for-volt basis. When the control voltage is raised above this range, the module regulates at its set-point voltage. The feature allows the output voltage to rise simultaneously with other modules powered from the same input bus. If unused this input should be connected to V_{in}. *Note: Due to the under-voltage lockout feature, the output of the module cannot follow its own input voltage during power up. For more information, consult the related application note.*

Margin Down: When this input is asserted to *GND*, the output voltage is decreased by 5% from the nominal. The input requires an open-collector (open-drain) interface. It is not TTL compatible. A lower percent change can be accomodated with a series resistor. For further information, consult the related application note.

Margin Up: When this input is asserted to *GND*, the output voltage is increased by 5%. The input requires an open-collector (open-drain) interface. It is not TTL compatible. The percent change can be reduced with a series resistor. For further information, consult the related application note.

Environmental & Absolute Maximum Ratings (Voltages are with respect to GND)

Characteristics	Symbols	Conditions	Min	Typ	Max	Units
Track Input Voltage	V_{track}		–0.3	—	V_{in} + 0.3	V
Operating Temperature Range	T_a	Over V_{in} Range	–40	—	85	°C
Solder Reflow Temperature	T_{reflow}	Surface temperature of module body or pins			235 (i)	°C
Storage Temperature	T_s	—	–40	—	125	°C
Mechanical Shock		Per Mil-STD-883D, Method 2002.3 1 msec, ½ Sine, mounted	—	500	—	G's
Mechanical Vibration		Mil-STD-883D, Method 2007.2 20-2000 Hz	—	20	—	G's
Weight	—		—	7	—	grams
Flammability	—	Meets UL 94V-O				

Notes: *(i) During reflow of SMD package version do not elevate peak temperature of the module, pins or internal components above the stated maximum.*

Specifications (Unless otherwise stated, T_a =25 °C, V_{in} =5 V, V_{out} =3.3 V, C_{in} =1,000 µF, C_{out} =0 µF, and I_o =$I_o$max)

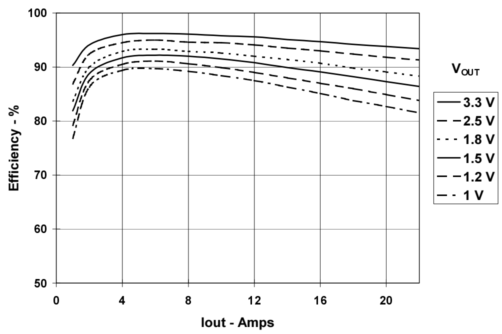
			PMH 5718T			
Characteristics	Symbols	Conditions	Min	Typ	Max	Units
Output Current	I_o	0.8 V ≤ V_o ≤ 3.6 V 60 °C, 200 LFM airflow 25 °C, natural convection		0 0	— 22 (1) — 22 (1)	A
Input Voltage Range	V_{in}	Over I_o range	4.5	—	5.5	V
Set-Point Voltage Tolerance	V_o tol	R_{SET}=698 Ω	—	—	±2 (2)	%V_o
Temperature Variation	ΔReg_{temp}	–40 °C < T_a < +85 °C	—	±0.5	—	%V_o
Line Regulation	ΔReg_{line}	Over V_{in} range	—	±5	—	mV
Load Regulation	ΔReg_{load}	Over I_o range	—	±5	—	mV
Total Output Variation	ΔReg_{tot}	Includes set-point, line, load, R_{SET} =698Ω, –40 °C ≤ T_a ≤ +85 °C	—	—	±3 (2)	%V_o
Efficiency	η	I_o =14 A R_{SET} = 698 Ω R_{SET} = 2.21 kΩ R_{SET} = 5.49 kΩ R_{SET} = 8.87 kΩ R_{SET} = 17.4 kΩ R_{SET} = 36.5 kΩ	V_o = 3.3 V V_o = 2.5 V V_o = 1.8 V V_o = 1.5 V V_o = 1.2 V V_o = 1.0 V	— — — — — —	95 94 91 90 88 86	— — — — — — %
V_o Ripple (pk-pk)	V_r	20 MHz bandwidth	—	20	—	mVpp
Over-Current Threshold	I_o trip	Reset, followed by auto-recovery	—	41	—	A
Transient Response t_{tr} ΔV_{tr}		1 A/µs load step, 50 to 100 % $I_o$max, C_{out} =330 µF Recovery Time V_o over/undershoot	 — —	 70 120	 — —	 µSec mV
Margin Up.Down Adjust	ΔV_o margin		—	± 5	—	%
Margin Input Current (pins 9 /10)	I_{IL} margin	Pin to GND	—	– 8 (3)	—	µA
Track Input Current (pin 8)	I_{IL} track	Pin to GND	—	—	–130 (4)	µA
Track Slew Rate Capability	dV_{track}/dt	C_{out} ≤ C_{out}(max)	—	—	1	V/ms
Under-Voltage Lockout	UVLO	V_{in} increasing V_{in} decreasing	— 3.1	4.3 3.7	4.5 —	V
Inhibit Control (pin3) Input High Voltage Input Low Voltage	 V_{IH} V_{IL}	Referenced to GND	 V_{in} –0.5 –0.2	 — —	 Open (4) 0.8	V
Input Low Current	I_{IL} inhibit	Pin to GND	—	–130	—	µA
Input Standby Current	I_{in} inh	Inhibit (pin 3) to GND, Track (pin 8) open	—	10	—	mA
Switching Frequency	f_s	Over V_{in} and I_o ranges	250	300	340	kHz
External Input Capacitance	C_{in}		1,000 (5)	—	—	µF
External Output Capacitance	C_{out}	Capacitance value non-ceramic ceramic	0 0	330 (6) —	11,000 (7) 300	µF
		Equiv. series resistance (non-ceramic)	4 (8)	—	—	mΩ
Reliability	MTBF	Per Bellcore TR-332 50 % stress, T_a =40 °C, ground benign	4.9	—	—	10^6 Hrs

Notes:
(1) See SOA curves or consult factory for appropriate derating.
(2) The set-point voltage tolerance is affected by the tolerance and stability of R_{SET}. The stated limit is unconditionally met if R_{SET} has a tolerance of 1 %, with 200 ppm/°C or better temperature stability.
(3) A small low-leakage (<100 nA) MOSFET is recommended to control this pin. The open-circuit voltage is less than 1 Vdc.
(4) This control pin has an internal pull-up to the input voltage Vin. If it is left open-circuit the module will operate when input power is applied. A small low-leakage (<100 nA) MOSFET is recommended for control. For further information, consult the related application note.
(5) A 1,000 µF electrolytic input capacitor is required for proper operation. The capacitor must be rated for a minimum of 700 mArms of ripple current.
(6) An external output capacitor is not required for basic operation. Adding 330 µF improves transient response performance.
(7) This is the calculated maximum. The minimum ESR limitation will often result in a lower value. Consult the application notes for further guidance.
(8) This is the typcial ESR for all the electrolytic (non-ceramic) output capacitance. Use 7 mW as the minimum when using max-ESR values to calculate.

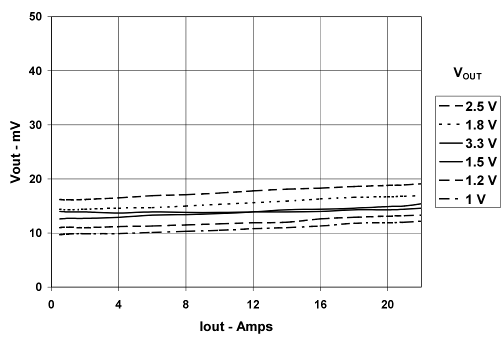
22-A, 5-V Input Non-Isolated
Wide-Output Adjust Power Module

Characteristic Data; V_{in} =5 V *(See Note A)*

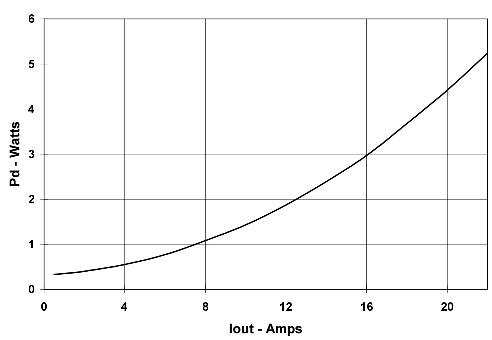
Efficiency vs Load Current



Output Ripple vs Load Current

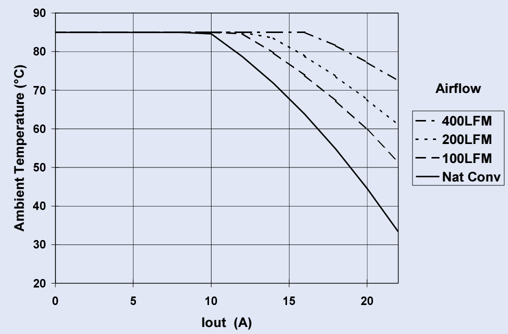


Power Dissipation vs Load Current



Safe Operating Area; V_{in} =5 V *(See Note B)*

Over Output Voltage Range



Note A: *Characteristic data has been developed from actual products tested at 25°C. This data is considered typical data for the Converter.*
Note B: *SOA curves represent the conditions at which internal components are at or below the manufacturer's maximum operating temperatures. Derating limits apply to modules soldered directly to a 4 in. ´ 4 in. double-sided PCB with 1 oz. copper.*

Capacitor Recommendations for the PMH 4518T & PMH 5718T Series of Power Modules

Input Capacitor

The recommended input capacitor(s) is determined by the 1,000 µF (1) minimum capacitance and 700 mArms minimum ripple current rating.

Ripple current and <100 mΩ equivalent series resistance (ESR) values are the major considerations, along with temperature, when designing with different types of capacitors. Unlike polymer tantalum, conventional tantalum capacitors have a recommended minimum voltage rating of 2 × (maximum DC voltage + AC ripple). This is standard practice to ensure reliability.

For improved ripple reduction on the input bus, ceramic capacitors may be substituted for electrolytic types using the minimum required capacitance.

Output Capacitors (Optional)

For applications with load transients (sudden changes in load current), regulator response will benefit from an external output capacitance. The recommended output capacitance of 330 µF will allow the module to meet its transient response specification (see product data sheet). For most applications, a high quality computer-grade aluminum electrolytic capacitor is most suitable. These capacitors provide adequate decoupling over the frequency range, 2 kHz to 150 kHz, and are suitable when ambient temperatures are above 0 °C. For operation below 0 °C, tantalum, ceramic or Os-Con type capacitors are recommended. When using one or more non-ceramic capacitors, the calculated equivalent ESR should be no lower than 4 mΩ (7 mΩ using the manufacturer's maximum ESR for a single capacitor). A list of preferred low-ESR type capacitors are identified in Table 1-1.

Ceramic Capacitors

Above 150 kHz the performance of aluminum electrolytic capacitors becomes less effective. To further improve the reflected input ripple current or the output transient response, multilayer ceramic capacitors can also be added. Ceramic capacitors have very low ESR and their resonant frequency is higher than the bandwidth of the regulator. When used on the output their combined ESR is not critical as long as the total value of ceramic capacitance does not exceed 300 µF. Also, to prevent the formation of local resonances, do not place more than five identical ceramic capacitors in parallel with values of 10 µF or greater.

Tantalum Capacitors

Tantalum type capacitors can be used at both the input and output, and are recommended for applications where the ambient operating temperature can be less than 0 °C. The AVX TPS, Sprague 593D/594/595 and Kemet T495/T510 capacitor series are suggested over many other tantalum types due to their higher rated surge, power dissipation, and ripple current capability. As a caution many general purpose tantalum capacitors have considerably higher ESR, reduced power dissipation and lower ripple current capability. These capacitors are also less reliable when determining their power dissipation and surge current capability. Tantalum capacitors that do not have a stated ESR or surge current rating are not recommended for power applications.

When specifying Os-Con and polymer tantalum capacitors for the output, the minimum ESR limit will be encountered well before the maximum capacitance value is reached.

Capacitor Table

Table 1-1 identifies the characteristics of capacitors from a number of vendors with acceptable ESR and ripple current (rms) ratings. The recommended number of capacitors required at both the input and output buses is identified for each capacitor type.

This is not an extensive capacitor list. Capacitors from other vendors are available with comparable specifications. Those listed are for guidance. The RMS ripple current rating and ESR (at 100kHz) are critical parameters necessary to insure both optimum regulator performance and long capacitor life.

Designing for Very Fast Load Transients

The transient response of the DC/DC converter has been characterized using a load transient with a di/dt of 1 A/µs. The typical voltage deviation for this load transient is given in the data sheet specification table using the optional value of output capacitance. As the di/dt of a transient is increased, the response of a converter's regulation circuit ultimately depends on its output capacitor decoupling network. This is an inherent limitation with any DC/DC converter once the speed of the transient exceeds its bandwidth capability. If the target application specifies a higher di/dt or lower voltage deviation, the requirement can only be met with additional output capacitor decoupling. In these cases special attention must be paid to the type, value and ESR of the capacitors selected.

If the transient performance requirements exceed that specified in the data sheet, or the total amount of load capacitance is above 3,000 µF, the selection of output capacitors becomes more important. For further guidance consult the separate application note, *"Selecting Output Capacitors for PMH Products in High-Performance Applications."*

Table 2-1: Input/Output Capacitors

Capacitor Vendor, Type Series (Style)	Capacitor Characteristics y					Quantit		
	Working Voltage	Value(µF)	Max. ESR at 100 kHz	105°C Maximum Ripple Current (Irms)	Physical Size (mm)	Input Bus	Output Bus	Vendor Part Number
Panasonic, Aluminum:								
FC (Radial)	10 V	560	0.090 Ω	755 mA	10×12.5	2	1	EEUFC1A561
	10 V	1000	0.068 Ω	1050 mA	10×16	1	1	EEUFC1A102
FK (SMD)	25 V	1000	0060 Ω	1100 mA	12.5×13.5	1	1	EEVFK1E102Q
	10 V	1000	0.080 Ω	850 mA	10×10.2	1	1	EEVFK1A102P
United Chemi-con:								
PXA, Poly-Aluminum (SMD)	6.3 V	470	0.020 Ω	4130 mA	10×7.7	2 [1]	≤3	PXA6.3VC471MJ80TP
FX, Os-con (Radial)	6.3 V	1000	0.013 Ω	4935 mA	10×10.5	1	≤2	6FX1000M
LXZ, Aluminum (Radial)	10 V	680	0.090 Ω	760 mA	10×12.5	2	1	LXZ10VB681M10X12LL
	10 V	1000	0.068 Ω	1050 mA	10×16	1	1	LXZ10VB102M10X16LL
Nichicon, Aluminum:							1	UHD0J102MPR
HD (Radial)	6.3 V	1000	0.053 Ω	1030 mA	10×12.5	1	1	UPM1A102MPH6
PM (Radial)	10 V	1000	0.065 Ω	1060 mA	16×15	1		
Sanyo, Os-con:								
SP (Radial)	10 V	470	0.015 Ω	>4500 mA	10×10.5	2 [1]	≤3	10SP470M
SVP (SMD)	10 V	560	0.013 Ω	>5200 mA	10×12.7	2	≤2	10SVP560M
Panasonic, Poly-Aluminum:								
WA (SMD)	10 V	470	0.017 Ω	4500 mA	10×10.2	2 [1]	≤3	EEFWA1A471P
S/SE (SMD)	6.3 V	180	0.005 Ω	4000 mA	7.3×4.3×4.2	6	≤1	EEFSE0J181R
AVX, Tantalum:								
TPS (SMD)	10 V	470	0.045 Ω	1723 mA	7.3L	2 [1]	≤5	TPSE477M010R0045
	10 V	470	0.060 Ω	1826 mA	×5.7W ×4.1H	2 [1]	≤5	TPSV477M010R0060
Kemet (SMD):								
T520, Poly-Tant	10 V	330	0.040 Ω	1800 mA	4.3W	3	≤5	T520X337M010AS
T530, Poly-Tant/Organic	10 V	330	0.015 Ω	>3800 mA	×7.3L	3	≤3	T530X337M010AS
	6.3 V	470	0.012 Ω	4200 mA	×4.0H	2 [1]	≤2	T530X477M006AS
Vishay-Sprague					7.2L ×6W			
595D, Tantalum (SMD)	10 V	470	0.100 Ω	1440 mA	×4.1H	2 [1]	≤5	595D477X0010R2T
94SA, Os-con (Radial)	16 V	1000	0.015 Ω	9740 mA	16×25	1	≤3	94SA108X0016HBP
Kemet, Ceramic X5R (SMD)	16 V	10	0.002 Ω	—	1210 case	1	≤5	C1210C106M4PAC
	6.3 V	47	0.002 Ω		3225 mm	1	≤5	C1210C476K9PAC
Murata, Ceramic X5R (SMD)	6.3 V	100	0.002 Ω	—	1210 case	1	≤3	GRM32ER60J107M
	6.3 V	47			3225 mm	1	≤5	GRM32ER60J476M
	16 V	22				1	≤5	GRM32ER61C226K
	16 V	10					≤5	GRM32DR61C106K
TDK, Ceramic X5R (SMD)	6.3 V	100	0.002 Ω	—	1210 case	1	≤3	C3225X5R0J107MT
	6.3 V	47			3225 mm	1	≤5	C3225X5R0J476MT
	16 V	22				1	≤5	C3225X5R1C226MT
	16 V	10					≤5	C3225X5R1C106MT

(1) Total capacitance of 940 µF is acceptable based on the combined ripple current rating.

Adjusting the Output Voltage of the PMH 4518T & PMH 5718T Wide-Output Adjust Power Modules

The V_o *Adjust* control (pin 4) sets the output voltage of the PMH 4518T and PMH 5718T products. The adjustment range of the PMH 4518T (3.3-V input) is from 0.8 V to 2.5 V [1], and the PMH 5718T (5-V input) from 0.8 V to 3.6 V. The adjustment method requires the addition of a single external resistor, R_{set}, that must be connected directly between the V_o *Adjust* and *GND* pins [2]. Table 2-1 gives the preferred value of the external resistor for a number of standard voltages, along with the actual output voltage that this resistance value provides.

For other output voltages the value of the required resistor can either be calculated using the following formula, or simply selected from the range of values given in Table 2-2. Figure 2-1 shows the placement of the required resistor.

$$R_{set} = 10\ \text{k}\Omega \cdot \frac{0.8\ \text{V}}{V_{out} - 0.8\ \text{V}} - 2.49\ \text{k}\Omega$$

Table 1-1; Preferred Values of R_{set} for Standard Output Voltages

V_{out} (Standard)	R_{set} (Pref'd Value)	V_{out} (Actual)
3.3 V [1]	698 Ω	3.309 V
2.5 V	2.21 kΩ	2.502 V
2 V	4.12 kΩ	2.010 V
1.8 V	5.49 kΩ	1.803 V
1.5 V	8.87 kΩ	1.504 V
1.2 V	17.4 kΩ	1.202 V
1 V	36.5 kΩ	1.005 V
0.8 V	Open	0.8 V

Figure 1-1; V_o Adjust Resistor Placement

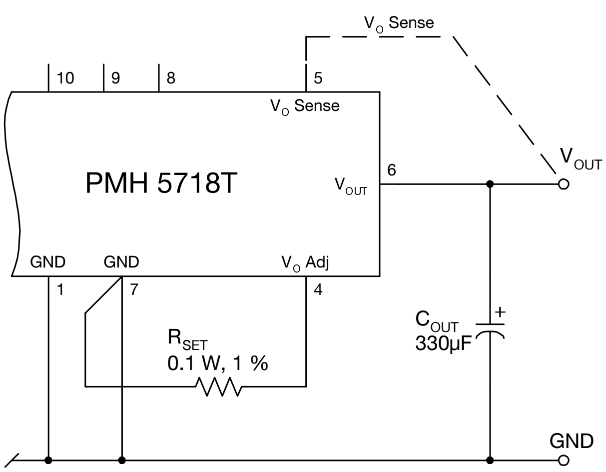


Table 1-2; Output Voltage Set-Point Resistor Values

V_a Req'd	R_{set}	V_a Req'd	R_{set}
0.800	Open	2.00	4.18 kΩ
0.825	318 kΩ	2.05	3.91 kΩ
0.850	158 kΩ	2.10	3.66 kΩ
0.875	104 kΩ	2.15	3.44 kΩ
0.900	77.5 kΩ	2.20	3.22 kΩ
0.925	61.5 kΩ	2.25	3.03 kΩ
0.950	50.8 kΩ	2.30	2.84 kΩ
0.975	43.2 kΩ	2.35	2.67 kΩ
1.000	37.5 kΩ	2.40	2.51 kΩ
1.025	33.1 kΩ	2.45	2.36 kΩ
1.050	29.5 kΩ	2.50	2.22 kΩ
1.075	26.6 kΩ	2.55	2.08 kΩ
1.100	24.2 kΩ	2.60	1.95 kΩ
1.125	22.1 kΩ	2.65	1.83 kΩ
1.150	20.4 kΩ	2.70	1.72 kΩ
1.175	18.8 kΩ	2.75	1.61 kΩ
1.200	17.5 kΩ	2.80	1.51 kΩ
1.225	16.3 kΩ	2.85	1.41 kΩ
1.250	15.3 kΩ	2.90	1.32 kΩ
1.275	14.4 kΩ	2.95	1.23 kΩ
1.300	13.5 kΩ	3.00	1.15 kΩ
1.325	12.7 kΩ	3.05	1.07 kΩ
1.350	12.1 kΩ	3.10	988 Ω
1.375	11.4 kΩ	3.15	914 Ω
1.400	10.8 kΩ	3.20	843 Ω
1.425	10.3 kΩ	3.25	775 Ω
1.450	9.82 kΩ	3.30	710 Ω
1.475	9.36 kΩ	3.35	647 Ω
1.50	8.94 kΩ	3.40	587 Ω
1.55	8.18 kΩ	3.45	529 Ω
1.60	7.51 kΩ	3.50	473 Ω
1.65	6.92 kΩ	3.55	419 Ω
1.70	6.4 kΩ	3.60	367 Ω
1.75	5.93 kΩ		
1.80	5.51 kΩ		
1.85	5.13 kΩ		
1.90	4.78 kΩ		
1.95	4.47 kΩ		

Notes:

1. Modules that operate from a 3.3-V input bus should not be adjusted higher than 2.5 V.
2. Use a 0.1 W resistor. The tolerance should be 1 %, with temperature stability of 100 ppm/°C (or better). Place the resistor as close to the regulator as possible. Connect the resistor directly between pins 4 and 7 using dedicated PCB traces.
3. Never connect capacitors from V_o *Adjust* to either *GND* or V_{out}. Any capacitance added to the V_o *Adjust* pin will affect the stability of the regulator.

PMH 8918 L 12-V Input

18-A, 12-V Input Non-Isolated
Wide-Output Adjust Power Module

POLA code: PTH12020 W

NOMINAL SIZE = 1.5 in x 0.87 in
(38,1 mm x 22,1 mm)

Features

- Up to 18 A Output Current
- 12-V Input Voltage
- Wide-Output Voltage Adjust (1.2 V to 5.5 V)
- Efficiencies up to 95 %
- 195 W/in³ Power Density
- On/Off Inhibit
- Output Voltage Sense
- Margin Up/Down Controls
- Under-Voltage Lockout
- Auto-Track™ Sequencing(1)
- Output Over-Current Protection (Non-Latching, Auto-Reset)
- Over-Temperature Protection
- Operating Temp: –40 to +85 °C
- IPC Lead Free 2
- Safety Agency Approvals: UL 1950, CSA 22.2 950,EN60950 VDE (Pending)
- Point-of-Load Alliance (POLA) Compatible

Note: (1) Auto-Track™ is a trademark of Texas Instruments

Description

The PMH 8918L series of non-isolated power modules offers OEM designers a combination of high performance, small footprint, and industry leading features. As part of a new class of power modules, these products provide designers with the flexibility to power the most complex multi-processor digital systems using off-the-shelf catalog parts.

The series employs double-sided surface mount construction and provides high-performance step-down power conversion for up to 18 A of output current from a 12-V input bus voltage. The output voltage of the PMH 8918L can be set to any value over the range, 1.2 V to 5.5 V, using a single resistor.

This series includes Auto-Track™. Auto-Track simplifies the task of supply voltage sequencing in a power system by enabling modules to track each other, or any external voltage, during power up and power down.

Other operating features include an on/off inhibit, output voltage adjust (trim), and margin up/down controls. To ensure tight load regulation, an output voltage sense is also provided. A non-latching over-current trip and over-temperature shutdown provides load fault protection.

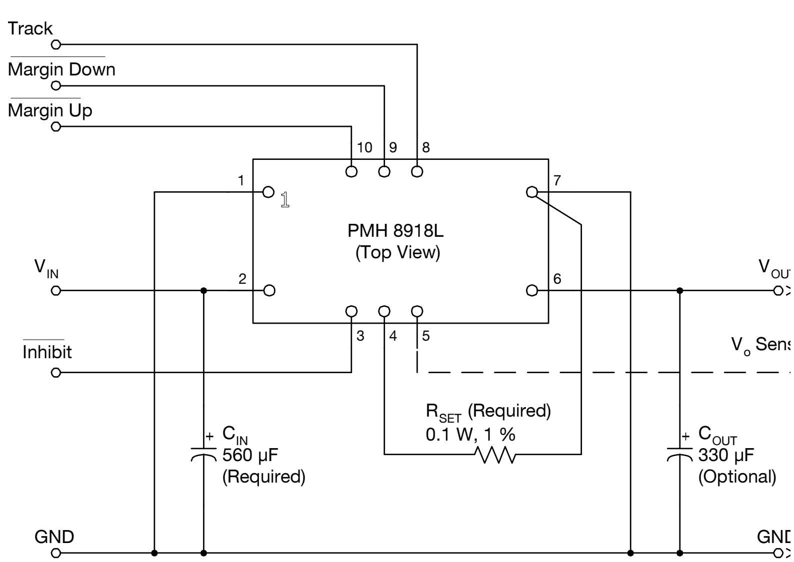
Target applications include complex multi-voltage, multi-processor systems that incorporate the industry's high-speed DSPs, micro-processors and bus drivers.

Pin Configuration

Pin	Function
1	GND
2	V_{in}
3	Inhibit *
4	V_o Adjust
5	V_o Sense
6	V_{out}
7	GND
8	Track
9	Margin Down *
10	Margin Up *

* *Denotes negative logic:*
Open = Normal operation
Ground = Function active

Standard Application



Rset = Required to set the output voltage to a value higher than 1.2 V. (See spec. table for values)
C_{in} = Required electrolytic 560 µF
C_{out} = Optional 330 µF electrolytic

18-A, 12-V Input Non-Isolated
Wide-Output Adjust Power Module

Point-of-Load Alliance

Product Table (PMH 8918 L x)[1]

V_{In}	V_O / I_O max	P_O max	Package Code[1]	Description	Ordering No.
10.8-13.2 V	1.2-5.5 V /18 A	90 W	P	Horiz. T/H	PMH 8918 L x[1]
			S	SMD, Standard	

[1] Replace "x"in the Ordering No. with Package Code.

Ordering Information

Delivery Option	M.o.q.	Suffix	Example
Tray	20 pcs	/B	PMH 8918L P /B
Tape & Reel [2]	250 pcs	/C	PMH 8918L S /C

[2] Tape & Reel available only for SMD packages

Pin Descriptions

Vin: The positive input voltage power node to the module, which is referenced to common *GND*.

Vout: The regulated positive power output with respect to the *GND* node.

GND: This is the common ground connection for the *Vin* and *Vout* power connections. It is also the 0 VDC reference for the control inputs.

Inhibit: The Inhibit pin is an open-collector/drain negative logic input that is referenced to *GND*. Applying a low-level ground signal to this input disables the module's output and turns off the output voltage. When the *Inhibit* control is active, the input current drawn by the regulator is significantly reduced. If the *Inhibit* pin is left open-circuit, the module will produce an output whenever a valid input source is applied.

Vo Adjust: A 0.1 W, 1 % tolerance (or better) resistor must be connected directly between this pin and pin 7 (*GND*) pin to set the output voltage to the desired value. The set point range for the output voltage is from 1.2 V to 5.5 V. The resistor required for a given output voltage may be calculated from the following formula. If left open circuit, the module output will default to its lowest output voltage value. For further information on output voltage adjustment consult the related application note.

$$R_{set} = 10\text{ k} \cdot \frac{0.8\text{ V}}{V_{out} - 1.2\text{ V}} - 1.82\text{ k}$$

The specification table gives the preferred resistor values for a number of standard output voltages.

Vo Sense: The sense input allows the regulation circuit to compensate for voltage drop between the module and the load. For optimal voltage accuracy *Vo Sense* should be connected to *Vout*. It can also be left disconnected.

Track: This is an analog control input that enables the output voltage to follow an external voltage. This pin becomes active typically 20 ms after the input voltage has been applied, and allows direct control of the output voltage from 0 V up to the nominal set-point voltage. Within this range the output will follow the voltage at the *Track* pin on a volt-for-volt basis. When the control voltage is raised above this range, the module regulates at its set-point voltage. The feature allows the output voltage to rise simultaneously with other modules powered from the same input bus. If unused this input should be connected to V_{in}. *Note: Due to the under-voltage lockout feature, the output of the module cannot follow its own input voltage during power up. For more information, consult the related application note.*

Margin Down: When this input is asserted to *GND*, the output voltage is decreased by 5% from the nominal. The input requires an open-collector (open-drain) interface. It is not TTL compatible. A lower percent change can be accomodated with a series resistor. For further information, consult the related application note.

Margin Up: When this input is asserted to *GND*, the output voltage is increased by 5%. The input requires an open-collector (open-drain) interface. It is not TTL compatible. The percent change can be reduced with a series resistor. For further information, consult the related application note.

18-A, 12-V Input Non-Isolated
Wide-Output Adjust Power Module

Point-of-Load Alliance

Environmental & Absolute Maximum Ratings (Voltages are with respect to GND)

Characteristics	Symbols	Conditions	Min	Typ	Max	Units
Track Input Voltage	V_{track}		–0.3	—	V_{in} + 0.3	V
Operating Temperature Range	T_a	Over V_{in} Range	–40	—	85	°C
Solder Reflow Temperature	T_{reflow}	Surface temperature of module body or pins			235 (i)	°C
Storage Temperature	T_s	—	–40	—	125	°C
Mechanical Shock		Per Mil-STD-883D, Method 2002.3 1 msec, ½ Sine, mounted	—	500	—	G's
Mechanical Vibration		Mil-STD-883D, Method 2007.2 20-2000 Hz	—	20	—	G's
Weight	—		—	7	—	grams
Flammability	—	Meets UL 94V-O				

Notes: *(i) During reflow of SMD package version do not elevate peak temperature of the module, pins or internal components above the stated maximum.*

Specifications (Unless otherwise stated, T_a =25 °C, V_{in} =12 V, V_{out} =3.3 V, C_{in} =560 µF, C_{out} =0 µF, and I_o =$I_o$max)

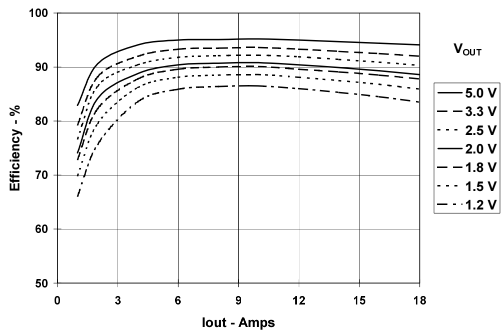
			PMH 8918L			
Characteristics	Symbols	Conditions	Min	Typ	Max	Units
Output Current	I_o	1.2 V ≤ V_o ≤ 5.5 V — 60 °C, 200 LFM airflow 25 °C, natural convection		0 0	— 18 — 18	(1) (1) A
Input Voltage Range	V_{in}	Over I_o range	10.8	—	13.2	V
Set-Point Voltage Tolerance	V_o tol		—	—	±2 (2)	%V_o
Temperature Variation	ΔReg_{temp}	–40 °C < T_a < +85 °C	—	±0.5	—	%V_o
Line Regulation	ΔReg_{line}	Over V_{in} range	—	±5	—	mV
Load Regulation	ΔReg_{load}	Over I_o range	—	±5	—	mV
Total Output Variation	ΔReg_{tot}	Includes set-point, line, load, –40 °C ≤ T_a ≤ +85 °C	—	—	±3 (2)	%V_o
Efficiency	η	I_o =12 A — R_{SET} = 280 Ω, V_o = 5.0 V R_{SET} = 2.0 kΩ, V_o = 3.3 V R_{SET} = 4.32 kΩ, V_o = 2.5 V R_{SET} = 11.5 kΩ, V_o = 1.8 V R_{SET} = 24.3 kΩ, V_o = 1.5 V R_{SET} = open cct., V_o = 1.2 V	— — — — — —	95 93 92 90 88 86	— — — — — —	%
V_o Ripple (pk-pk)	V_r	20 MHz bandwidth — V_o ≤2.5 V	—	32	—	mVpp
		V_o >2.5 V	—	1	—	% V_o
Over-Current Threshold	I_o trip	Reset, followed by auto-recovery	—	30	—	A
Transient Response	 t_{tr} ΔV_{tr}	1 A/µs load step, 50 to 100 % $I_o$max, C_{out} =330 µF Recovery Time V_o over/undershoot	 — —	 70 70	 — —	 µSec mV
Margin Up/Down Adjust	ΔV_o margin		—	± 5	—	%
Margin Input Current (pins 9 /10)	I_{IL} margin	Pin to GND	—	– 8 (3)	—	µA
Track Input Current (pin 8)	I_{IL} track	Pin to GND	—	—	–0.13 (4)	mA
Track Slew Rate Capability	dV_{track}/dt	C_{out} ≤ C_{out}(max)	—	—	1	V/ms
Under-Voltage Lockout	UVLO	V_{in} increasing V_{in} decreasing	— 8.8	9.7 9.2	10.4 —	V
Inhibit Control (pin3) Input High Voltage Input Low Voltage	 V_{IH} V_{IL}	Referenced to GND	 V_{in} –0.5 –0.2	 — —	 Open (4) 0.5	V
Input Low Current	I_{IL} inhibit	Pin to GND	—	–0.24	—	mA
Input Standby Current	I_{in} inh	Inhibit (pin 3) to GND, Track (pin 8) open	—	5	—	mA
Switching Frequency	f_s	Over V_{in} and I_o ranges	260	320	380	kHz
External Input Capacitance	C_{in}		560 (5)	—	—	µF
External Output Capacitance	C_{out}	Capacitance value — non-ceramic ceramic	0 0	330 (6) —	11,000 (7) 300	µF
		Equiv. series resistance (non-ceramic)	4 (8)	—	—	mΩ
Reliability	MTBF	Per Bellcore TR-332 50 % stress, T_a =40 °C, ground benign	5.3	—	—	10^6 Hrs

Notes:
(1) See SOA curves or consult factory for appropriate derating.
(2) The set-point voltage tolerance is affected by the tolerance and stability of R_{SET}. The stated limit is unconditionally met if R_{SET} has a tolerance of 1 %, with 200 ppm/°C or better temperature stability.
(3) A small low-leakage (<100 nA) MOSFET is recommended to control this pin. The open-circuit voltage is less than 1 Vdc.
(4) This control pin has an internal pull-up to the input voltage Vin. If it is left open-circuit the module will operate when input power is applied. A small low-leakage (<100 nA) MOSFET is recommended for control. For further information, consult the related application note.
(5) A 560 µF electrolytic input capacitor is required for proper operation. The capacitor must be rated for a minimum of 800 mA rms of ripple current.
(6) An external output capacitor is not required for basic operation. Adding 330 µF of distributed capacitance at the load will improve the transient response.
(7) This is the calculated maximum. The minimum ESR limitation will often result in a lower value. Consult the application notes for further guidance.
(8) This is the typcial ESR for all the electrolytic (non-ceramic) output capacitance. Use 7 mW as the minimum when using max-ESR values to calculate.

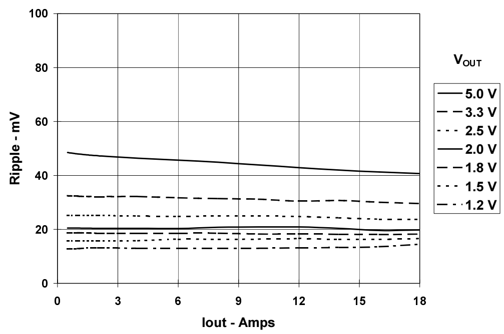
18-A, 12-V Input Non-Isolated
Wide-Output Adjust Power Module

Characteristic Data; V_{in} =12 V *(See Note A)*

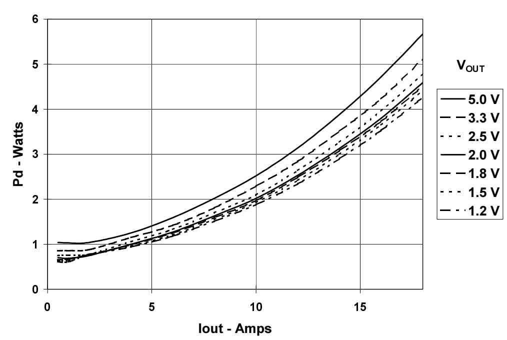
Efficiency vs Load Current



Output Ripple vs Load Current

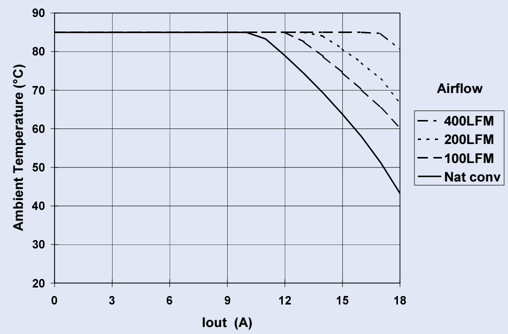


Power Dissipation vs Load Current

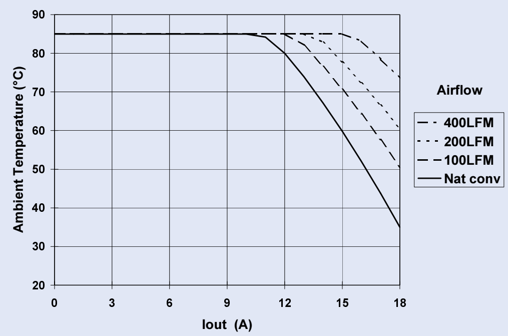


Safe Operating Area; V_{in} =12 V *(See Note B)*

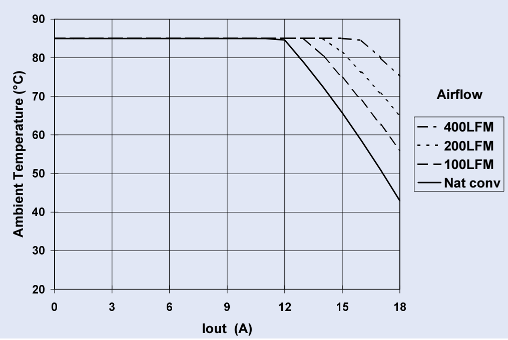
Output Voltage =5 V



Output Voltage =2.5 V



Output Voltage =1.8 V



Note A: *Characteristic data has been developed from actual products tested at 25°C. This data is considered typical data for the Converter.*
Note B: *SOA curves represent the conditions at which internal components are at or below the manufacturer's maximum operating temperatures. Derating limits apply to modules soldered directly to a 4 in. ´ 4 in. double-sided PCB with 1 oz. copper.*

Capacitor Recommendations for the PMH 8918L Series of Power Modules

Input Capacitor

The recommended input capacitor(s) is determined by the 560 µF (1) minimum capacitance and 800 mArms minimum ripple current rating.

Ripple current, less than 100 mΩ equivalent series resistance (ESR), and temperature are major considerations when selecting input capacitors. Unlike polymer-tantalum capacitors, regular tantalum capacitors are not recommended for the input bus. These capacitors require a recommended minimum voltage rating of 2 × (max. DC voltage + AC ripple). This is standard practice to ensure reliability. There were no tantalum capacitors, with sufficient voltage rating, found to meet this requirement. When the operating temperature is below 0 °C, the ESR of aluminum electrolytic capacitors increases. For these applications Os-Con, polymer-tantalum, and polymer-tantalum types should be considered.

Adding a 10-µF ceramic capacitor to the input will reduce the ripple current reflected into the input source.

Output Capacitors (Optional)

For applications with load transients (sudden changes in load current), regulator response will benefit from external output capacitance. The recommended output capacitance of 330 µF will allow the module to meet its transient response specification (see product data sheet). For most applications, a high quality computer-grade aluminum electrolytic capacitor is adequate. These capacitors provide decoupling over the frequency range, 2 kHz to 150 kHz, and are suitable when ambient temperatures are above 0 °C. For operation below 0 °C, tantalum, ceramic or Os-Con type capacitors are recommended. When using one or more non-ceramic capacitors, the calculated equivalent ESR should be no lower than 4 mΩ (7 mΩ using the manufacturer's maximum ESR for a single capacitor). A list of preferred low-ESR type capacitors are identified in Table 1-1.

Ceramic Capacitors

Above 150 kHz the performance of aluminum electrolytic capacitors is less effective. Multilayer ceramic capacitors have very low ESR and a resonant frequency higher than the bandwidth of the regulator. They can be used to reduce the reflected ripple current at the input as well as improve the transient response of the output. When used on the output their combined ESR is not critical as long as the total value of ceramic capacitance does not exceed 300 µF. Also, to prevent the formation of local resonances, do not place more than five identical ceramic capacitors in parallel with values of 10 µF or greater..

Tantalum Capacitors

Tantalum type capacitors can only be used on the output bus, and are recommended for applications where the ambient operating temperature can be less than 0 °C. The AVX TPS, Sprague 593D/594/595 and Kemet T495/T510 capacitor series are suggested over many other tantalum types due to their higher rated surge, power dissipation, and ripple current capability. As a caution many general purpose tantalum capacitors have considerably higher ESR, reduced power dissipation and lower ripple current capability. These capacitors are also less reliable as they have reduced power dissipation and surge current ratings. Tantalum capacitors that have no stated ESR or surge current rating are not recommended for power applications.

When specifying Os-con and polymer tantalum capacitors for the output, the minimum ESR limit will be encountered well before the maximum capacitance value is reached.

Capacitor Table

Table 1-1 identifies the characteristics of capacitors from a number of vendors with acceptable ESR and ripple current (rms) ratings. The recommended number of capacitors required at both the input and output buses is identified for each capacitor type.

This is not an extensive capacitor list. Capacitors from other vendors are available with comparable specifications. Those listed are for guidance. The RMS ripple current rating and ESR (at 100 kHz) are critical parameters necessary to insure both optimum regulator performance and long capacitor life.

Designing for Very Fast Load Transients

The transient response of the DC/DC converter has been characterized using a load transient with a di/dt of 1 A/µs. The typical voltage deviation for this load transient is given in the data sheet specification table using the optional value of output capacitance. As the di/dt of a transient is increased, the response of a converter's regulation circuit ultimately depends on its output capacitor decoupling network. This is an inherent limitation with any DC/DC converter once the speed of the transient exceeds its bandwidth capability. If the target application specifies a higher di/dt or lower voltage deviation, the requirement can only be met with additional output capacitor decoupling. In these cases special attention must be paid to the type, value and ESR of the capacitors selected.

If the transient performance requirements exceed that specified in the data sheet, or the total amount of load capacitance is above 3,000 µF, the selection of output capacitors becomes more important. For further guidance consult the separate application note, "*Selecting Output Capacitors for PMH Products in High-Performance Applications.*"

Table 2-1: Input/Output Capacitors

Capacitor Vendor, Type/ Series (Style)	Capacitor Characteristics y					Quantit		
	Working Voltage	Value (µF)	Max. ESR at 100 kHz	Max. Ripple Current at 85 °C (Irms)	Physical Size (mm)	Input Bus	Optional Output Bus	Vendor Part Number
Panasonic, Aluminum FC (Radial) FK (SMD)	25 V 25 V 25 V 35 V	330 560 1,000 680	0.090 Ω 0.065 Ω 0.060 Ω 0.060 Ω	755 mA 1205 mA 1100 mA 1100 mA	10×12.5 12.5×15 12.5×13.5 12.5×13.5	2 1 1 1	1 1 1 1	EEUFC1E331 EEUFC1E561S EEVFK1E102Q EEVFK1V681Q
United Chemi-Con FX, Os-con (SMD) LXZ, Aluminum (Radial) PS, Poly-Aluminum(Radial) PXA, Poly-Aluminum (SMD)	16 V 16 V 25 V 16 V 16 V	330 330 680 330 330	0.018 Ω 0.090 Ω 0.068 Ω 0.014 Ω 0.014 Ω	4500 mA 760 mA 1050 mA 5060 mA 5050 m A	10×10.5 10×12.5 10×16 10×12.5 10×12.2	2 2 1 2 2	≤3 1 1 ≤3 ≤3	16FX330M LXZ25VB331M10X12LL LXZ16VB681M10X16LL 16PS330MJ12 PXA16VCMJ12
Nichicon, Aluminum HD (Radial) PM (Radial)	25 V 25 V 35 V	560 680 560	0.060 Ω 0.038 Ω 0.048 Ω	1060 mA 1430 mA 1360 mA	12.5×15 10×16 16×15	1 1 1	1 1 1	UPM1E561MHH6 UHD1C681MHR UPM1V561MHH6
Panasonic, Poly-Aluminum A (SMD) S/SE (SMD)	 16 V 6.3 V	 330 180	 0.022 Ω 0.005 Ω	 4100 mA 4000 mA	 10×10.2 7.3×4.3×4.2	 2 N/R [2]	 ≤3 ≤1	 EEFWA1C331P EEFSE0J181R (V_o≤5.1V)
Sanyo TP, Poscap SP, Os-Con SVP, Os-Con (SMD)	 10 V 16 V 16 V	 330 270 330	 0.025 Ω 0.018 Ω 0.016 Ω	 3000 mA >3500 mA 4700 mA	 7.3L ×5.7W 10×10.5 11×12	 N/R [2] 2 [1] 2	 ≤4 ≤3 ≤3	 10TPE330M 16SP270M 16SVP330M
AVX, Tantalum, Series III TPS (SMD)	10 V 10 V	470 330	0.045 Ω 0.045 Ω	>1723 mA >1723 mA	7.3L ×5.7W ×4.1H	N/R [2] N/R [2]	≤5 ≤5	TPSE477M010R0045 (V_o≤5.1V) TPSE337M010R0045 (V_o≤5.1V)
Kemet (SMD): T520, Poly-Tant T530, Poly-Tant/Organic	 10 V 10 V 6.3 V	 330 330 470	 0.040 Ω 0.015 Ω 0.012 Ω	 1800 mA >3800 mA 4200 mA	 4.3W ×7.3L ×4.0H	 N/R [2] N/R [2] N/R [2]	 ≤5 ≤2 ≤2	 T520X337M010AS T530X337M010AS T530X477M006AS (V_o≤5.1V)
Vishay-Sprague 595D, Tantalum (SMD) 94SA, Os-con (Radial)	 10 V 16 V	 470 1,000	 0.100 Ω 0.015 Ω	 1440 mA 9740 mA	7.2L×6W ×4.1H 16×25	 N/R [2] 1	 ≤5 ≤2	 595D477X0010R2T (V_o≤5.1V) 94SA108X0016HBP
Kemet, Ceramic X5R (SMD)	16 V 6.3 V	10 47	0.002 Ω 0.002 Ω	—	1210 case 3225 mm	1 [3] N/R [2]	≤5 ≤5	C1210C106M4PAC C1210C476K9PAC
Murata, Ceramic X5R (SMD)	6.3 V 6.3 V 16 V 16 V	100 47 22 10	0.002 Ω	—	1210 case 3225 mm	N/R [2] N/R [2] 1 [3] 1 [3]	≤3 ≤5 ≤5 ≤5	GRM32ER60J107M GRM32ER60J476M GRM32ER61C226K GRM32DR61C106K
TDK, Ceramic X5R (SMD)	6.3 V 6.3 V 16 V 16 V	100 47 22 10	0.002 Ω	—	1210 case 3225 mm	N/R [2] N/R [2] 1 [3] 1 [3]	≤3 ≤5 ≤5 ≤5	C3225X5R0J107MT C3225X5R0J476MT C3225X5R1C226MT C3225X5R1C106MT

[1] Total capacitance of 540 µF is acceptable based on the combined ripple current rating.
[2] N/R –Not recommended. The voltage rating does not meet the minimum operating limits.
[3] Ceramic capacitors may be used to compliment electrolytic types at the input to further reduce high-frequency ripple current.

Adjusting the Output Voltage of the PMH 8918L Wide-Output Adjust Power Module

The V_o *Adjust* control (pin 4) sets the output voltage of the PMH 8918L product. The adjustment range is from 1.2 V to 5.5 V. To adjust the output voltage above 1.2 V a single external resistor, R_{set}, must be connected directly between the V_o *Adjust* and *GND* pins [1]. Table 2-1 gives the preferred value for the external resistor for a number of standard voltages, along with the actual output voltage that this resistance value provides.

For other output voltages the value of the required resistor can either be calculated using the following formula, or simply selected from the range of values given in Table 2-2. Figure 2-1 shows the placement of the required resistor.

$$R_{set} = 10\ k\Omega \cdot \frac{0.8\ V}{V_{out} - 1.2\ V} - 1.82\ k\Omega$$

Table 1-1; Preferred Values of R_{set} for Standard Output Voltages

V_{out} (Standard)	R_{set} (Pref'd Value)	V_{out} (Actual)
5 V	280 Ω	5.009 V
3.3 V	2 kΩ	3.294V
2.5 V	4.32 kΩ	2.503 V
2 V	8.06 kΩ	2.010V
1.8 V	11.5 kΩ	1.801 V
1.5 V	24.3 kΩ	1.506 V
1.2 V	Open	1.200 V

Figure 1-1; V_o Adjust Resistor Placement

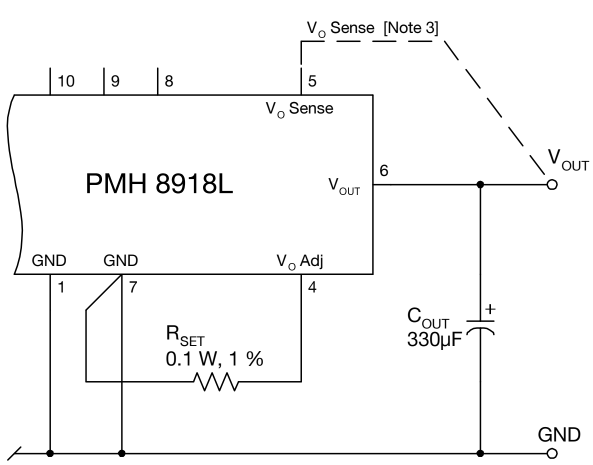


Table 1-2; Output Voltage Set-Point Resistor Values

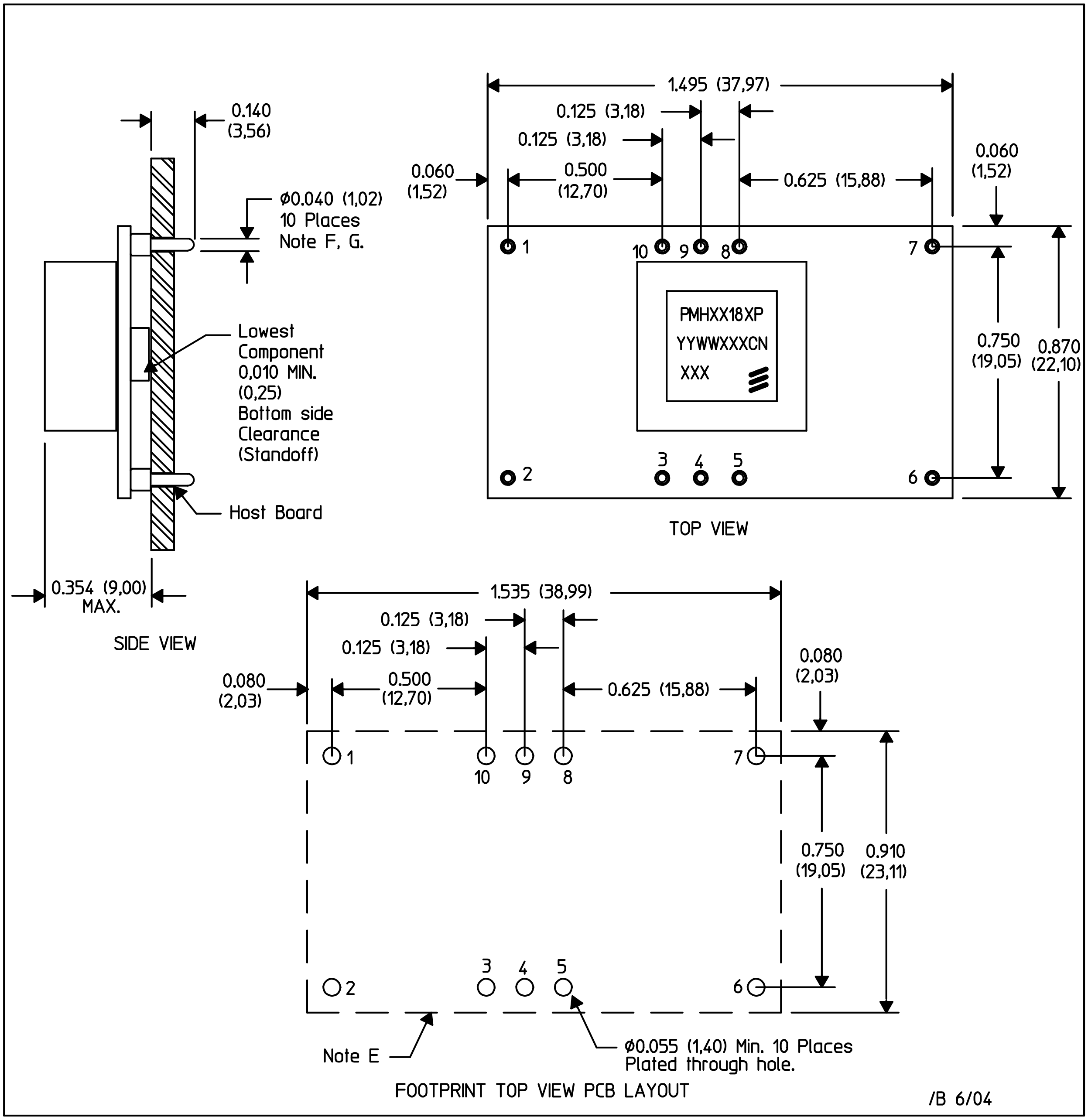
V_a Req'd	R_{set}	V_a Req'd	R_{set}
1.200	Open	2.75	3.34 kΩ
1.225	318 kΩ	2.80	3.18 kΩ
1.250	158 kΩ	2.85	3.03 kΩ
1.275	105 kΩ	2.90	2.89 kΩ
1.300	78.2 kΩ	2.95	2.75 kΩ
1.325	62.2 kΩ	3.00	2.62 kΩ
1.350	51.5 kΩ	3.05	2.5 kΩ
1.375	43.9 kΩ	3.10	2.39 kΩ
1.400	38.2 kΩ	3.15	2.28 kΩ
1.425	33.7 kΩ	3.20	2.18 kΩ
1.450	30.2 kΩ	3.25	2.08 kΩ
1.475	27.3 kΩ	3.30	1.99 kΩ
1.50	24.8 kΩ	3.35	1.9 kΩ
1.55	21 kΩ	3.40	1.82 kΩ
1.60	18.2 kΩ	3.45	1.74 kΩ
1.65	16 kΩ	3.50	1.66 kΩ
1.70	14.2 kΩ	3.55	1.58 kΩ
1.75	12.7 kΩ	3.6	1.51 kΩ
1.80	11.5 kΩ	3.7	1.38 kΩ
1.85	10.5 kΩ	3.8	1.26 kΩ
1.90	9.61 kΩ	3.9	1.14 kΩ
1.95	8.85 kΩ	4.0	1.04 kΩ
2.00	8.18 kΩ	4.1	939 Ω
2.05	7.59 kΩ	4.2	847 Ω
2.10	7.07 kΩ	4.3	761 Ω
2.15	6.6 kΩ	4.4	680 Ω
2.20	6.18 kΩ	4.5	604 Ω
2.25	5.8 kΩ	4.6	533 Ω
2.30	5.45 kΩ	4.7	466 Ω
2.35	5.14 kΩ	4.8	402 Ω
2.40	4.85 kΩ	4.9	342 Ω
2.45	4.85 kΩ	5.0	285 Ω
2.50	4.33 kΩ	5.1	231 Ω
2.55	4.11 kΩ	5.2	180 Ω
2.60	3.89 kΩ	5.3	131 Ω
2.65	3.7 kΩ	5.4	85 Ω
2.70	3.51 kΩ	5.5	41 Ω

Notes:

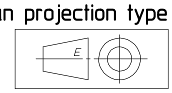
1. Use a 0.1 W resistor. The tolerance should be 1 %, with temperature stability of 100 ppm/°C (or better). Place the resistor as close to the regulator as possible. Connect the resistor directly between pins 4 and 7 using dedicated PCB traces.
2. Never connect capacitors from V_o *Adjust* to either *GND* or V_{out}. Any capacitance added to the V_o *Adjust* pin will affect the stability of the regulator.

PMH Series Mechanical data

Hole mount version. DOUBLE SIDED MODULE

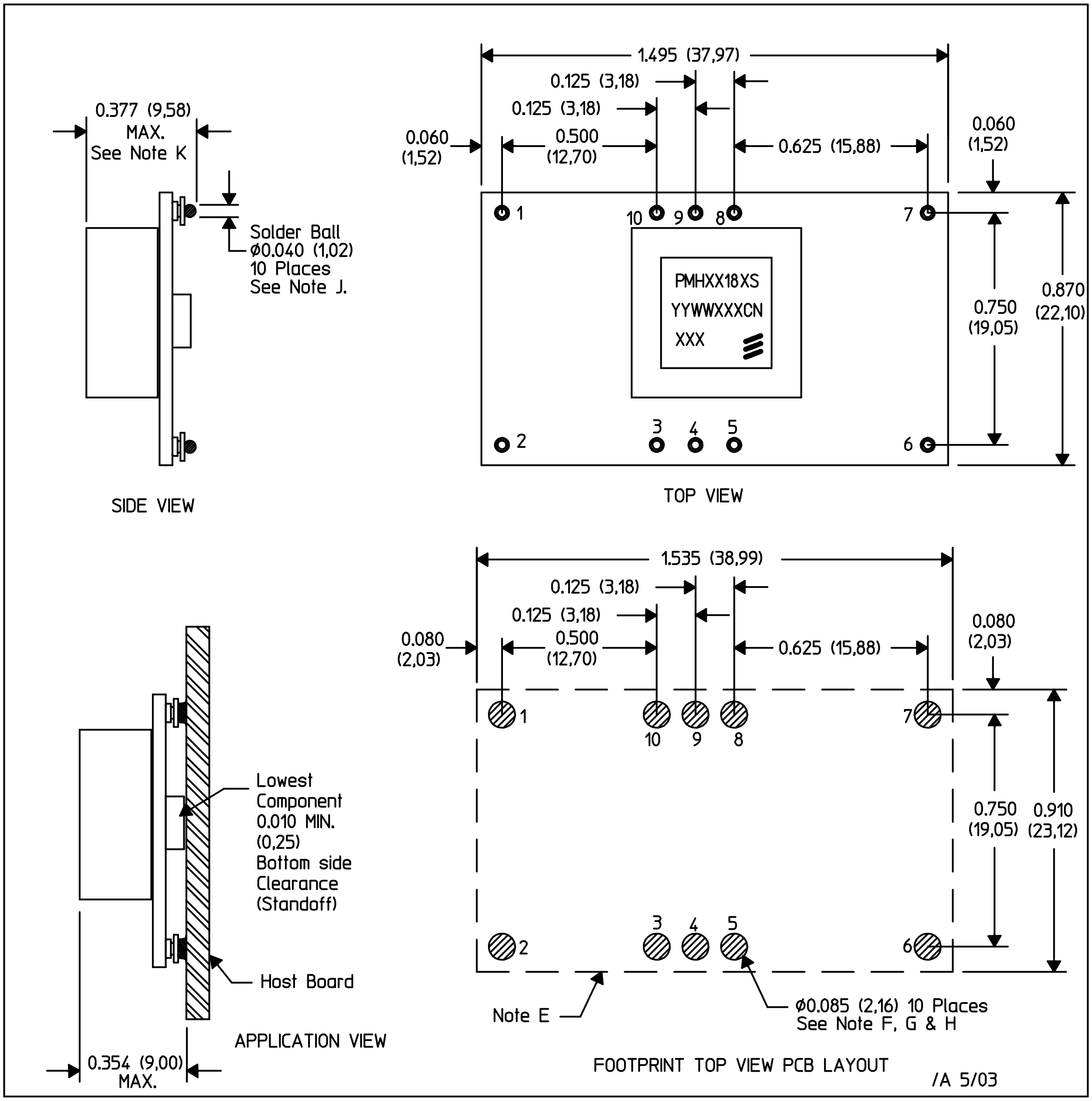


NOTES:
- A. All linear dimensions are in inches (mm).
- B. This drawing is subject to change without notice.
- C. 2 place decimals are ±0.030 (±0,76mm).
- D. 3 place decimals are ±0.010 (±0,25mm).
- E. Recommended keep out area for user components.
- F. Pins are 0.040" (1,02) diameter with 0.070" (1,78) diameter standoff shoulder.
- G. All pins: Material - Copper Alloy
  Finish - Tin (100%) over Nickel plate
- H. European projection type is used.

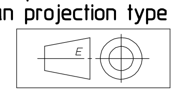


PMH Series Mechanical data

Surface mount version. DOUBLE SIDED MODULE



NOTES:
- A. All linear dimensions are in inches (mm).
- B. This drawing is subject to change without notice.
- C. 2 place decimals are ±0.030 (±0,76mm).
- D. 3 place decimals are ±0.010 (±0,25mm).
- E. Recommended keep out area for user components.
- F. Power pin connection should utilize two or more vias to the interior power plane of 0.025 (0,63) I.D. per input, ground and output pin (or the electrical equivalent).
- G. Paste screen opening: 0.080 (2,03) to 0.085 (2,16). Paste screen thickness: 0.006 (0,15).
- H. Pad type: Solder mask defined.
- J. All pins: Material - Copper Alloy
  Finish - Tin (100%) over Nickel plate
  Solder Ball - See product data sheet.
- K. Dimension prior to reflow solder.
- L. European projection type is used.



Sales Offices and Contact Information

Company Headquarters
Ericsson Power Modules AB
LM Ericssons väg 8
SE-126 25 Stockholm
Sweden

Phone: +46-8-568-69620
Fax: +46-8-568-69599

Hong Kong (Asia Pacific)
Ericsson Ltd.
12/F. Devon House
979 King's Road
Quarry Bay
Hong Kong

Phone: +852-2590-2453
Fax: +852-2590-7152

China
Ericsson Simtek Electronics Co.
33 Fuhua Road
Jiading District
Shanghai 201 818

Phone: +86-21-5951-6258
Fax: +86-21-5951-6188

Italy, Spain (Mediterranean)
Ericsson Power Modules
Via Cadorna 71
20090 Vimodrone (MI)
Italy

Phone: +39-02-265-946-07
Fax: +39-02-265-946-69

France, Switzerland, Benelux
Ericsson Power Modules AB
Bat Sologne
17 Rue des 4 vents
92380 Garches

Phone: +33-1-4741-5244
Fax: +33-1-4741-5244

UK, Eire
Ericsson Power Modules AB
United Kingdom

Phone: +44-1869-233-992
Fax: +44-1869-232-307

North and South America
Ericsson Inc. Power Modules
6300 Legacy Dr.
Plano, TX 75024

Phone: +1-972-583-5254
+1-972-583-6910
Fax: +1-972-583-7839

All other countries
Contact Company Headquarters
or visit our website:
www.ericsson.com/powermodules