Data Sheet
July 1999

tyco | Electronics

MK010-Series Power Modules: 36 Vdc to 75 Vdc Input; 10 W

The MK010-Series Power Modules use advanced, surface-mount technology and deliver high-quality, compact, dc-dc conversion at an economical price.

Applications

- Communications equipment
- Distributed power architectures

Options

- Higher accuracy output voltage set point
- Plastic case (MW010 Series)
- Long pins: 5.8 mm ± 0.5 mm (0.230 in. ± 0.020 in.)

Features

- Small size: 50.8 mm x 42.9 mm x 12.7 mm (2.00 in. x 1.69 in. x 0.50 in.)
- Metal case with ground pin
- Wide input voltage range: 36 Vdc to 75 Vdc
- High reliability
- Overcurrent protection
- Remote on/off
- Output overvoltage protection
- Input undervoltage lockout
- Input-to-output isolation
- No external filtering required
- Operating ambient temperature range: –40 °C to +85 °C
- *UL** 1950 Recognized, *CSA*† C22.2 No. 950-95 Certified, VDE 0805 (EN60950, IEC950) Licensed
- CE mark meets 73/23/EEC and 93/68/EEC directives‡
- Within FCC Class A radiated limits

* *UL* is a registered trademark of Underwriters Laboratories, Inc.
† *CSA* is a registered trademark of Canadian Standards Association.
‡ This product is intended for integration into end-use equipment. All the required procedures for CE marking of end-use equipment should be followed. (The CE mark is placed on selected products.)

Description

The MK010-Series Power Modules are dc-dc converters that operate over a wide input voltage range of 36 Vdc to 75 Vdc and provide precisely regulated dc outputs. The output is fully isolated from the input, allowing versatile polarity configurations and grounding connections. The MK010A1 and N1 have maximum power ratings of 10 W at a typical full-load efficiency of 80%. The MK010E4, D1, and F1 have maximum output current ratings of 2.0 A at a typical full-load efficiency of 69%. The remote on/off allows the modules to be controlled with an open-collector logic signal. The modules are encapsulated in aluminum cases with ground pins. In a natural convection environment, the modules are rated to full load at 85 °C with no heat sinking or external filtering.

Absolute Maximum Ratings

Stresses in excess of the absolute maximum ratings can cause permanent damage to the device. These are absolute stress ratings only. Functional operation of the device is not implied at these or any other conditions in excess of those given in the operations sections of the data sheet. Exposure to absolute maximum ratings for extended periods can adversely affect device reliability.

Parameter	Device	Symbol	Min	Max	Unit
Input Voltage:					
Continuous	All	V_I	—	80	Vdc
Transient (2 ms)	All	$V_{I,\ trans}$	—	100	V
Operating Ambient Temperature (0.3 m/s (60 ft./min.) with no derating)	All	T_A	–40	85	°C
Storage Temperature	All	T_{stg}	–40	100	°C
I/O Isolation Voltage:					
Continuous	All	—	—	500	Vdc
Transient (1 minute)	All	—	—	850	V

Electrical Specifications

Unless otherwise indicated, specifications apply over all operating input voltage, resistive load, temperature conditions, and on/off configurations.

Table 1. Input Specifications

Parameter	Device	Symbol	Min	Typ	Max	Unit
Operating Input Voltage	All	V_I	36	48	75	Vdc
Maximum Input Current (V_I = 0 V to 75 V; $I_O = I_{O,\ max}$; T_A = 25 °C; see Figures 1, 2, and 3.)	MK010D1, E4	$I_{I,\ max}$	—	—	370	mA
	MK010F1	$I_{I,\ max}$	—	—	470	mA
	MK010A1, N1	$I_{I,\ max}$	—	—	625	mA
Inrush Transient	All	i^2t	—	0.3	1.0	A^2s
Input Reflected-ripple Current, Peak-to-peak (5 Hz to 20 MHz, 12 µH source impedance, T_A = 25 °C; see Figure 12 and Design Considerations section.)	MK010D1, E4, F1	I_I	—	10	—	mAp-p
	MK010A1, N1	I_I	—	25	—	mAp-p
Input Ripple Rejection (120 Hz)	All	—	—	50	—	dB

Fusing Considerations

CAUTION: This power module is not internally fused. An input line fuse must always be used.

This encapsulated power module can be used in a wide variety of applications, ranging from simple stand-alone operation to an integrated part of a sophisticated power architecture. To preserve maximum flexibility, internal fusing is not included; however, to achieve maximum safety and system protection, always use an input line fuse. The safety agencies require a normal-blow fuse with a maximum rating of 5 A in series with the input (see Safety Considerations section). Based on the information provided in this data sheet on inrush energy and maximum dc input current, the same type of fuse with a lower rating can be used. Refer to the fuse manufacturer's data for further information.

Electrical Specifications (continued)

Table 2. Output Specifications

Parameter	Device	Symbol	Min	Typ	Max	Unit
Output Voltage Set Point (V_I = 48 V; $I_O = I_{O,\,max}$; T_A = 25 °C)	MK010D1	$V_{O,\,set}$	1.94	2.00	2.06	Vdc
	MK010E4	$V_{O,\,set}$	2.25	2.32	2.39	Vdc
	MK010F1	$V_{O,\,set}$	3.20	3.30	3.40	Vdc
	MK010A1	$V_{O,\,set}$	4.90	5.0	5.10	Vdc
	MK010N1	$V_{O,\,set}$	5.10	5.2	5.30	Vdc
Output Voltage (Over all operating input voltage, resistive load, and temperature conditions until end of life; see Figure 14.)	MK010D1	V_O	1.88	—	2.12	Vdc
	MK010E4	V_O	2.20	—	2.44	Vdc
	MK010F1	V_O	3.11	—	3.46	Vdc
	MK010A1	V_O	4.85	—	5.15	Vdc
	MK010N1	V_O	5.05	—	5.35	Vdc
Output Regulation:						
Line (V_I = 36 Vdc to 75 Vdc)	MK010D1, E4, F1	—	—	0.05	0.3	%V_O
	MK010A1, N1	—	—	0.02	0.10	%V_O
Load ($I_O = I_{O,\,min}$ to $I_{O,\,max}$)	MK010D1, E4, F1	—	—	0.1	0.7	%V_O
	MK010A1, N1	—	—	0.05	0.15	%V_O
Temperature (T_A = –40 °C to +85 °C)	MK010D1, E4, F1	—	—	10	50	mV
	MK010A1, N1	—	—	15	70	mV
Output Ripple and Noise Voltage (See Figure 13.):						
RMS	MK010D1, E4, F1	—	—	—	12	mVrms
	MK010A1, N1	—	—	—	10	mVrms
Peak-to-peak (5 Hz to 20 MHz)	MK010D1, E4, F1	—	—	—	50	mVp-p
	MK010A1, N1	—	—	—	70	mVp-p
Output Current (At $I_O < I_{O,\,min}$, the converter may exceed output ripple specifications.)	MK010N1	I_O	0.1	—	1.92	A
	All others	I_O	0.1	—	2.0	A
Output Current-limit Inception (V_O = 90% of $V_{O,\,nom}$; see Figures 4 and 5.)	MK010D1, E4, F1	I_O	—	3.7	5.8	A
	MK010A1	I_O	—	3.7	5.5	A
	MK010N1	I_O	—	3.6	5.5	A
Output Current Limit (V_O = 1.0 V)	All	—	—	—	6.3	A
Output Short-circuit Current (V_O = 250 mV; see Figures 4 and 5.)	MK010D1, E4, F1	—	—	4.3	6.9	A
	MK010A1, N1	—	—	3.5	7.0	A
Efficiency (V_I = 48 V, $I_O = I_{O,\,max}$, T_A = 25 °C; see Figures 6, 7, 8, and 14.)	MK010D1, E4	η	66	69	—	%
	MK010F1	η	69	72	—	%
	MK010A1, N1	η	77	80	—	%

Electrical Specifications (continued)

Table 2. Output Specifications (continued)

Parameter	Device	Min	Typ	Max	Unit
Dynamic Response ($\Delta I_O/\Delta t$ = 1 A/10 µs, V_I = 48 V, T_A = 25 °C):					
Load Change from I_O = 50% to 75% of $I_{O,\,max}$:					
Peak Deviation	All	—	140	—	mV
Settling Time (V_O < 10% of peak deviation; see Figure 9.)	All	—	3	—	ms
Load Change from I_O = 50% to 25% of $I_{O,\,max}$:					
Peak Deviation	All	—	140	—	mV
Settling Time (V_O < 10% of peak deviation; see Figure 10.)	All	—	3	—	ms

Table 3. Isolation Specifications

Parameter	Device	Min	Typ	Max	Unit
Isolation Capacitance	All	—	1200	—	pF
Isolation Resistance	All	10	—	—	MΩ

General Specifications

Parameter	Device	Min	Typ	Max	Unit
Calculated MTBF (80% of $I_{O,\,max}$; T_C = 40 °C)	All		7,000,000		hours
Weight	All	—	—	51 (1.8)	g (oz.)

Feature Specifications

Unless otherwise indicated, specifications apply over all operating input voltage, resistive load, and temperature conditions. See Feature Descriptions and Design Considerations sections for further information.

Parameter	Device	Symbol	Min	Typ	Max	Unit
Remote On/Off						
(0 V < V_I < 75 V; open collector or equivalent compatible; signal referenced to V_I(–) terminal; see Figure 15 and Feature Descriptions.):						
Logic Low—Module On						
Logic High—Module Off						
Module Specifications:						
On/Off Current—Logic Low	All	$I_{on/off}$	—	—	1.0	mA
On/Off Voltage:						
Logic Low	All	$V_{on/off}$	0	—	1.2	V
Logic High ($I_{on/off}$ = 0)	All	$V_{on/off}$	—	—	18	V
Open Collector Switch Specifications:						
Leakage Current During Logic High ($V_{on/off}$ = 18 V)	All	$I_{on/off}$	—	—	50	µA
Output Low Voltage During Logic Low ($V_{on/off}$ = 1 mA)	All	$V_{on/off}$	—	—	1.2	V
Turn-on Time (@ 80% of $I_{O,\ max}$; T_A = 25 °C; V_O within ±1% of steady state; see Figure 11.)	MK010D1, E4, F1	—	—	1	—	ms
	MK010A1, N1	—	—	5	—	ms
Output Overvoltage Protection (clamp)	MK010D1, E4	$V_{O,\ clamp}$	2.5	—	5.1	V
	MK010F1	$V_{O,\ clamp}$	3.5	—	5.4	V
	MK010A1, N1	$V_{O,\ clamp}$	5.4	—	7.0	V
Input Undervoltage Lockout:						
Module On	All	—	—	28	36	V
Module Off	All	—	20	24	—	V

Characteristic Curves

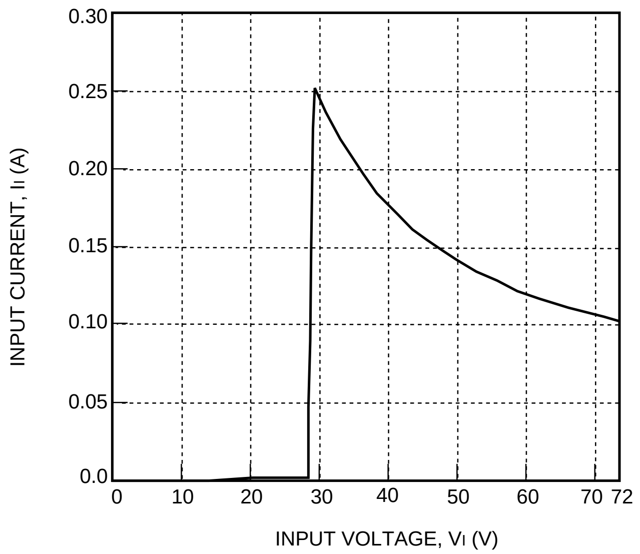


Figure 1. MK010D1, E4 Typical Input Characteristic; $I_O = I_{O,\,max}$; T_A = 25 °C

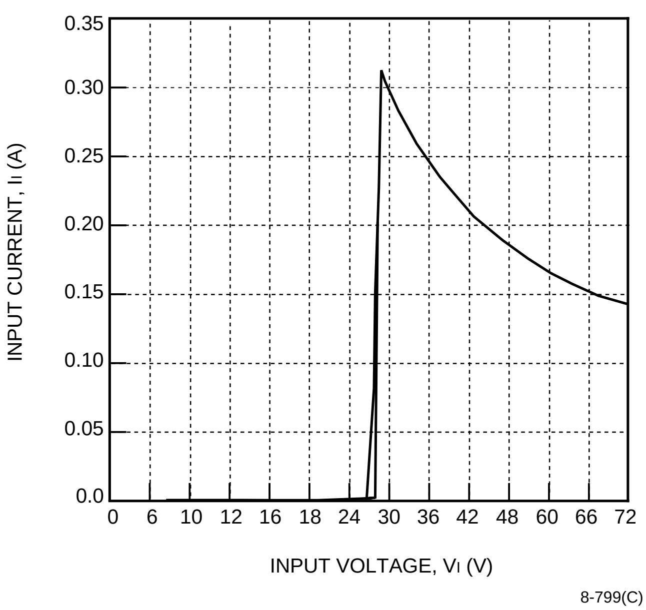


Figure 2. MK010F1 Typical Input Characteristic; $I_O = I_{O,\,max}$; T_A = 25 °C

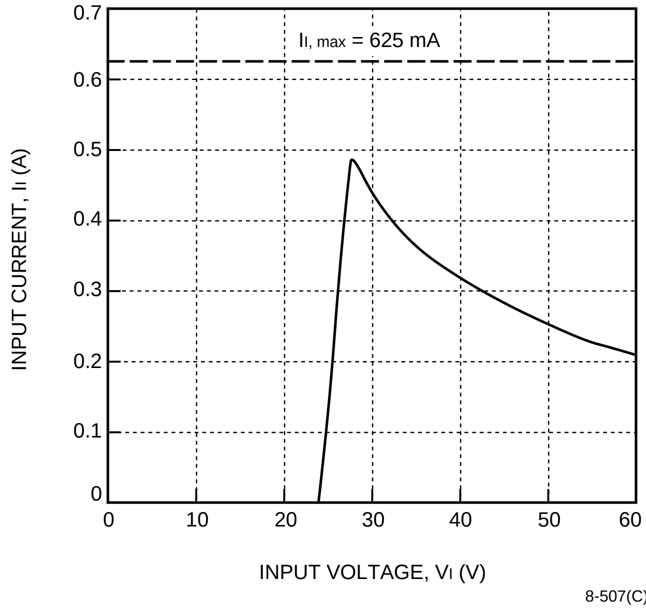


Figure 3. MK010A1, N1 Typical Input Characteristic; $I_O = I_{O,\,max}$; T_A = 25 °C

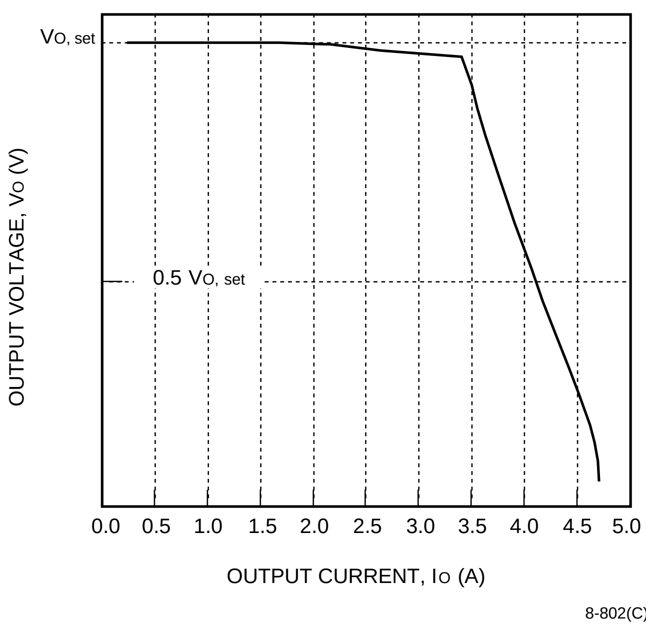


Figure 4. MK010D1, E4, F1 Typical Output Characteristic; V_I = 48 V; T_A = 25 °C

Characteristic Curves (continued)

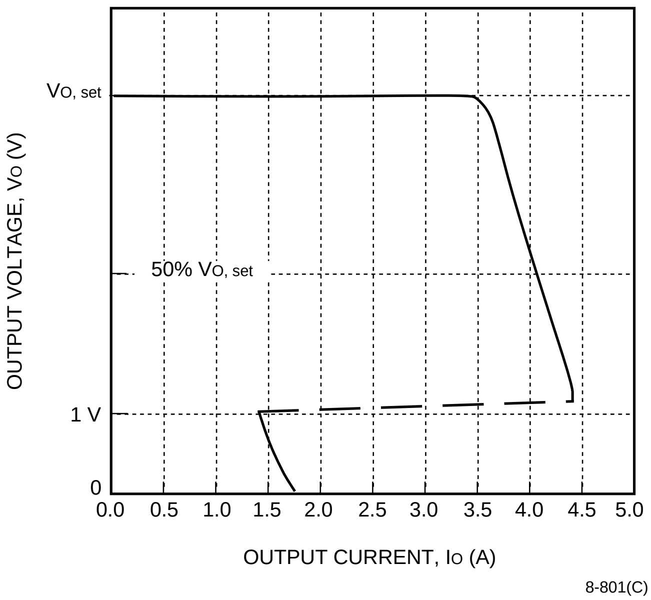


Figure 5. MK010A1, N4 Typical Output Characteristic; V_I = 48 V; T_A = 25 °C

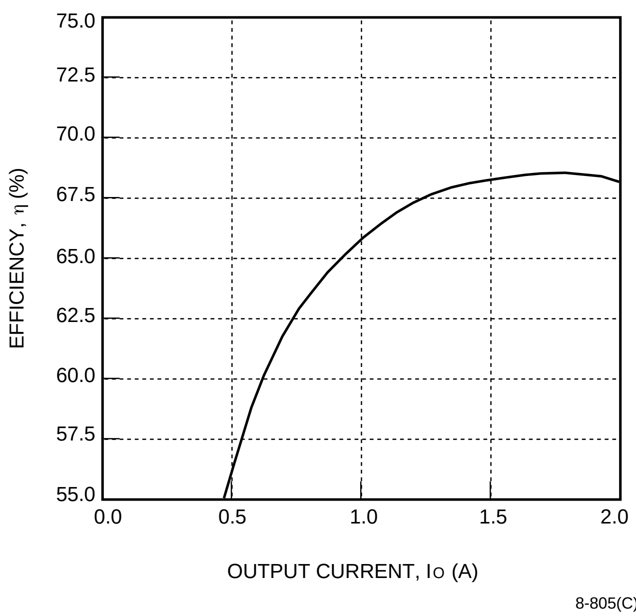


Figure 6. MK010D1, E4 Typical Converter Efficiency as a Function of Output Current; V_I = 48 V; T_A = 25 °C

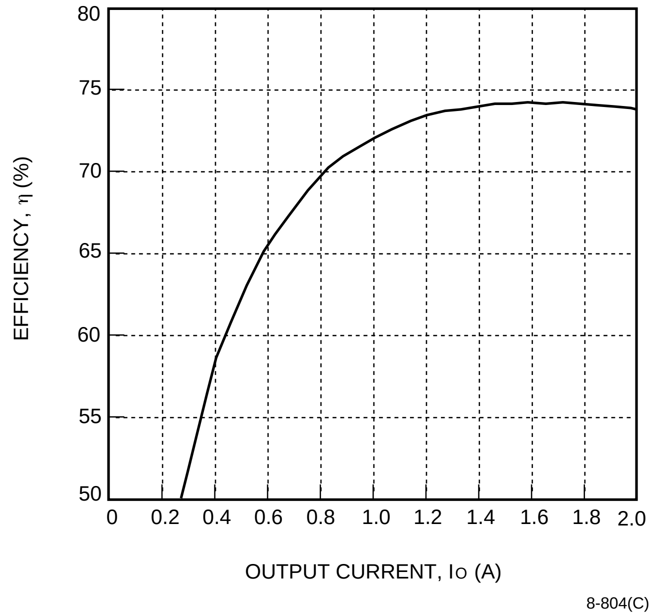


Figure 7. MK010F1 Typical Converter Efficiency as a Function of Output Current; V_I = 48 V; T_A = 25 °C

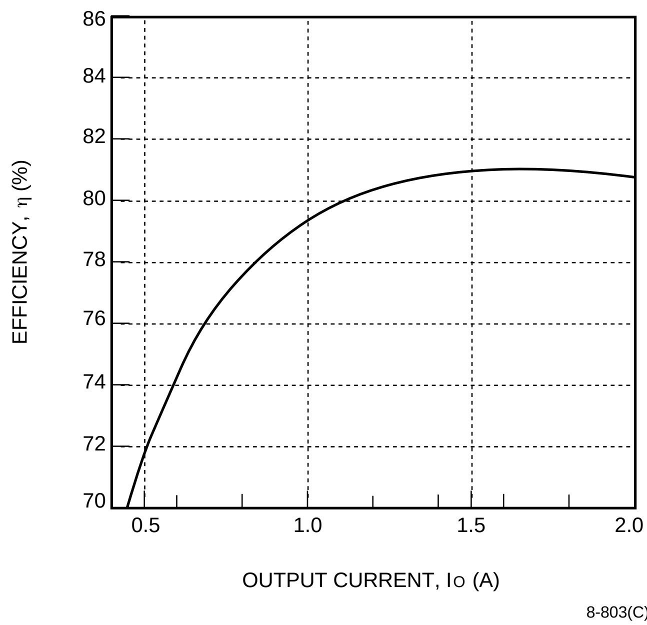


Figure 8. MK010A1, N1 Typical Converter Efficiency as a Function of Output Current; V_I = 48 V; T_A = 25 °C

Characteristic Curves (continued)

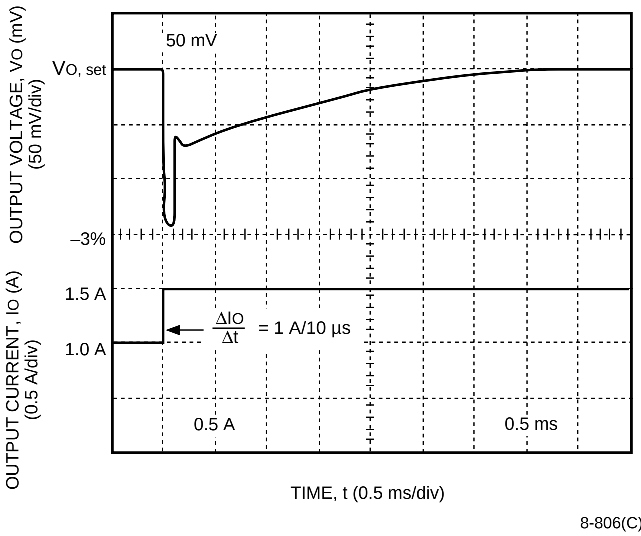


Figure 9. MK010 Typical Output Voltage Waveform for a Step Load Change from 50% to 75% of $I_{O, max}$; V_I = 48 V; T_A = 25 °C

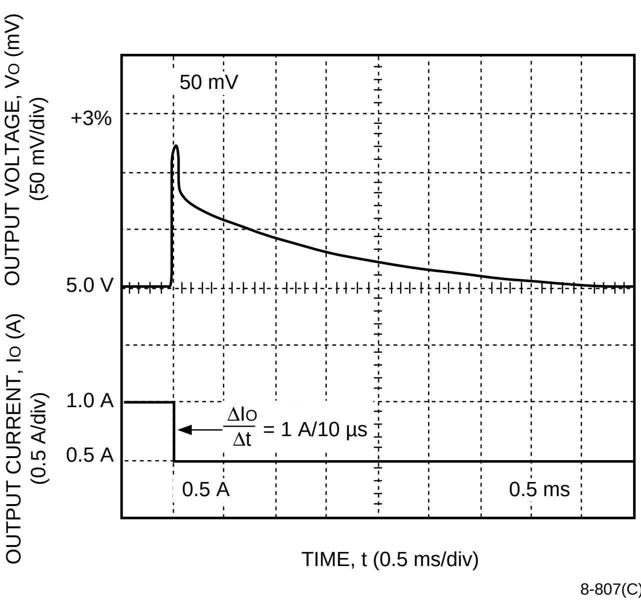


Figure 10. MK010 Typical Output Voltage Waveform for a Step Load Change from 50% to 25% of $I_{O, max}$; V_I = 48 V; T_A = 25 °C

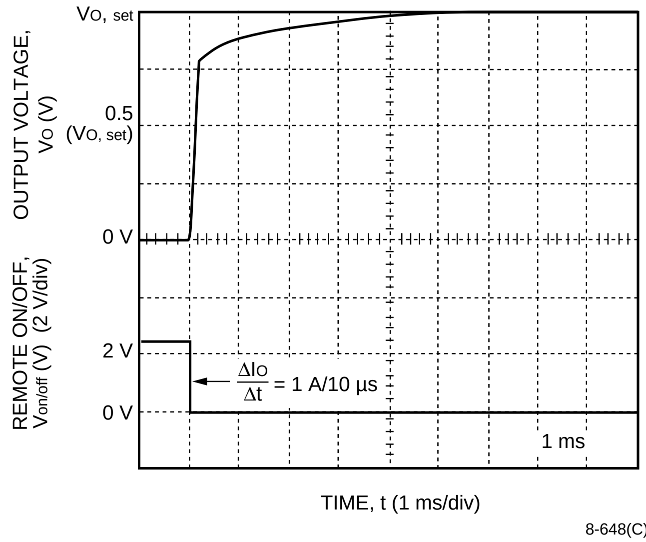
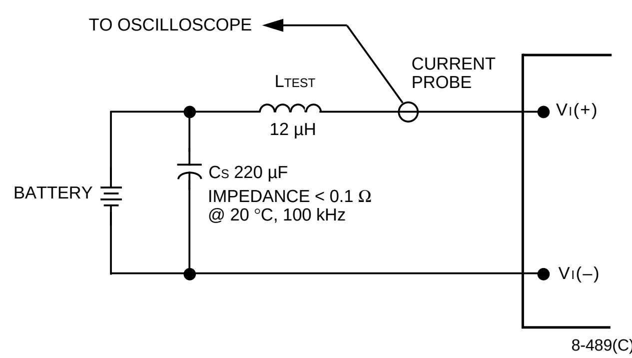


Figure 11. MK010 Typical Output Voltage Start-Up Waveform with Remote On/Off; I_O = 0.8 ($I_{O, max}$); V_I = 48 V; T_A = 25 °C

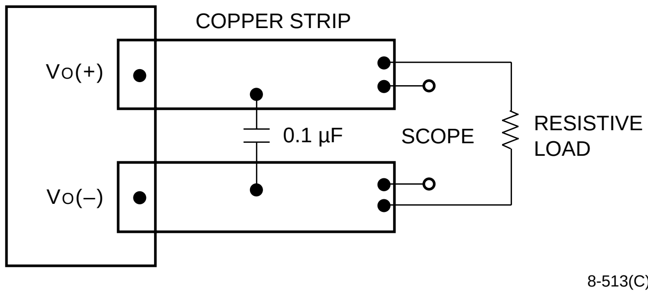
Test Configurations



Note: Input reflected-ripple current is measured with a simulated source impedance (L_{TEST}) of 12 µH. Capacitor C_S offsets possible battery impedance. Current is measured at the input of the module.

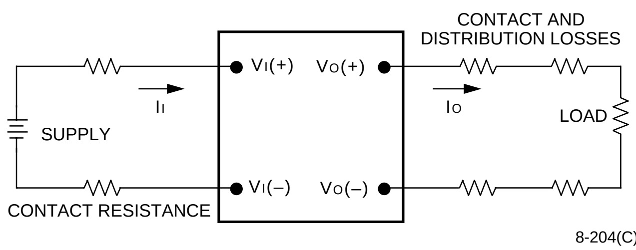
Figure 12. Input Reflected-Ripple Test Setup

Test Configurations (continued)



Note: Use a 0.1 µF ceramic capacitor. Scope measurement should be made using a BNC socket. Position the load between 50 mm and 75 mm (2 in. and 3 in.) from the module.

Figure 13. Peak-to-peak Output Noise Measurement Test Setup



Note: All measurements are taken at the module terminals. When socketing, place Kelvin connections at module terminals to avoid measurement errors due to socket contact resistance.

$$\eta = \left(\frac{[V_O(+) - (V_O(-))]I_O}{[V_I(+) - (V_I(-))]I_I}\right) \times 100 \qquad \%$$

Figure 14. Output Voltage and Efficiency Measurement Test Setup

Design Considerations

Grounding Considerations

The case is not connected internally allowing the user flexibility in grounding.

Input Reflected-Ripple Current

An internal aluminum electrolytic capacitor is used for filtering; therefore, input ripple increases as temperature decreases. (There is approximately two times more ripple at 0 °C than at 25 °C and eight times more ripple at –40 °C than at 25 °C.) The power module functions properly down to –40 °C with no additional filtering. If needed, an external capacitor across the input with an impedance of 0.3 Ω at 100 kHz over the desired temperature range can be added to limit the input ripple current to the typical level given in the Input Specifications table.

Output Voltage Reversal

CAUTION: Applying a reverse voltage across the module output forward biases an internal diode. Attempting to start the module under this condition can damage the module.

Safety Considerations

For safety-agency approval of the system in which the power module is used, the power module must be installed in compliance with the spacing and separation requirements of the end-use safety agency standard, i.e., *UL* 1950, *CSA* C22.2 No. 950-95, and VDE 0805 (EN60950, IEC950).

If the input source is non-SELV (ELV or a hazardous voltage greater than 60 Vdc and less than or equal to 75 Vdc), for the module's output to be considered meeting the requirements of safety extra-low voltage (SELV), all of the following must be true:

- The input source is to be provided with reinforced insulation from any other hazardous voltages, including the ac mains.
- One V_I pin and one V_O pin are to be grounded or both the input and output pins are to be kept floating.
- The input pins of the module are not operator accessible.
- Another SELV reliability test is conducted on the whole system, as required by the safety agencies, on the combination of supply source and the subject module to verify that under a single fault, hazardous voltages do not appear at the module's output.

Safety Considerations (continued)

Note: Do not ground either of the input pins of the module without grounding one of the output pins. This may allow a non-SELV voltage to appear between the output pins and ground.

The power module has extra-low voltage (ELV) outputs when all inputs are ELV.

The input to these units is to be provided with a maximum 5 A normal-blow fuse in the ungrounded lead.

Feature Descriptions

Overcurrent Protection

To provide protection in a fault (output overload) condition, the unit is equipped with internal current limiting and can endure current limiting for an unlimited duration. At the point of current-limit inception, the unit shifts from voltage control to current control. If the output voltage is pulled very low during a severe fault, the current-limit circuit can exhibit either foldback or tailout characteristics (output current decrease or increase). The unit operates normally once the output current is brought back into its specified range.

Remote On/Off

To turn the power module on and off, the user must supply a switch to control the voltage between the on/off terminal and the $V_I(–)$ terminal ($V_{on/off}$). The switch can be an open collector or equivalent (see Figure 15). A logic low is $V_{on/off}$ = 0 V to 1.2 V, during which the module is on. The maximum $I_{on/off}$ during a logic low is 1 mA. The switch should maintain a logic-low voltage while sinking 1 mA.

During a logic high, the maximum $V_{on/off}$ generated by the power module is 18 V. The maximum allowable leakage current of the switch at $V_{on/off}$ = 18 V is 50 µA.

Note: A PWB trace between the on/off terminal and the $V_I(–)$ terminal can be used to override the remote on/off.

Either the user-supplied switch or the override jumper should be wired into the circuit via individual traces not common with the V_I power current path. Connect the switch or jumper at the power module terminals (see Figure 15). Configuring the switch connection in this way prevents noise from falsely triggering the remote on/off. Also, a 0.01 µF ceramic capacitor across remote ON/OFF pin and $V_I(–)$ pin is recommended to eliminate high frequency noise.

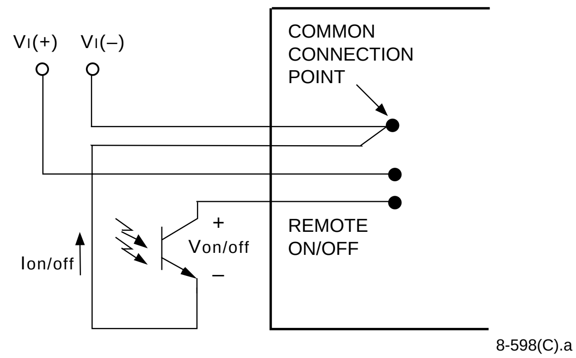


Figure 15. Remote On/Off Wiring Configuration; Top View

Output Overvoltage Protection

The output overvoltage clamp consists of control circuitry, independent of the primary regulation loop, that monitors the voltage on the output terminals. The control loop of the clamp has a set point that is higher than the set point of the primary loop (see Feature Specifications table). This provides a redundant voltage-control that reduces the risk of output overvoltage.

Layout Considerations

Copper paths must not be routed beneath the power module standoffs.

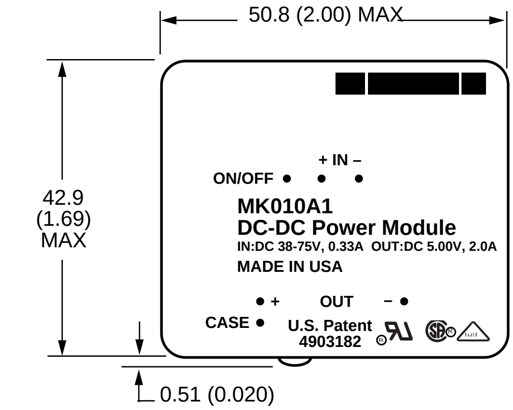
Outline Diagrams

Dimensions are in millimeters and (inches).

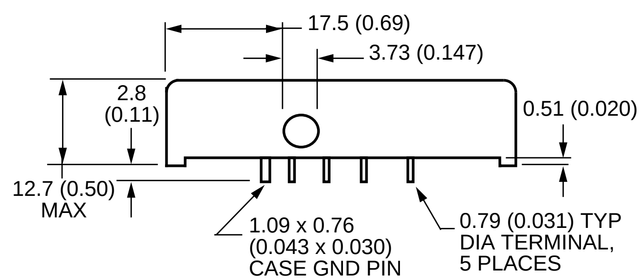
Module tolerances, unless otherwise indicated: x.x ± 0.5 mm (0.02 in.), x.xx ± 0.25 mm (0.010 in.).

Copper paths must not be routed beneath the power module standoffs.

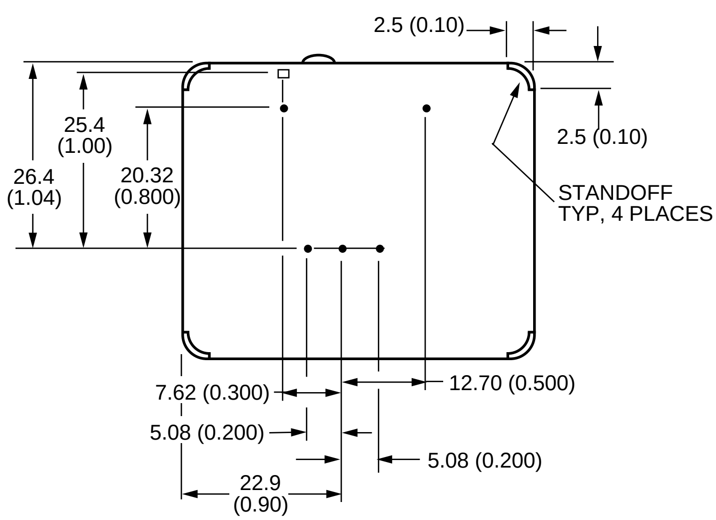
Top View



Side View



Bottom View



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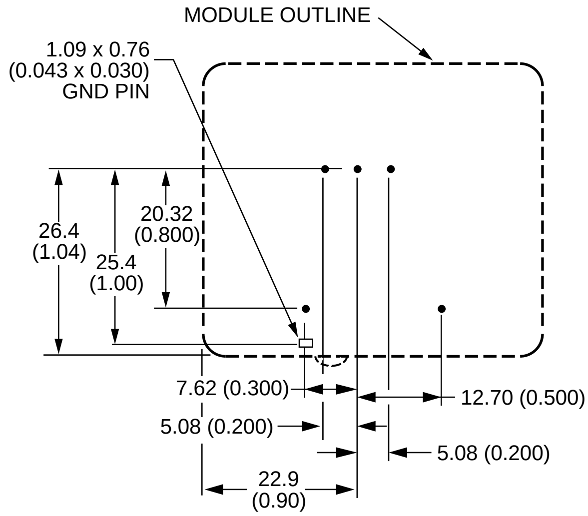
Recommended Hole Pattern

Component-side footprint. Dimensions are in millimeters and (inches).



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Ordering Information

Table 4. Device Codes

Input Voltage	Output Voltage	Output Power	Device Code	Comcode
36 V—75 V	2.0 V	4 W	MK010D1	106741515
36 V—75 V	2.32 V	4.6 W	MK010E4	106302839
36 V—75 V	3.3 V	6.6 W	MK010F1	106741523
36 V—75 V	5.0 V	10 W	MK010A1	106224793
36 V—75 V	5.2 V	10 W	MK010N1	106224785

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DS98-380EPS (Replaces DS96-049EPS)