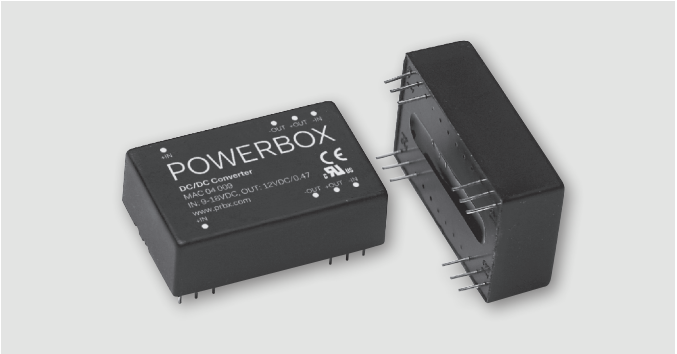
POWERBOX Industrial Line
MAC04 Series
5-6W 2:1 Single and Dual Output
DC/DC Converter
Manual V20



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1. Introduction

The MAC04 series offer 3.3-6 watts of output power in a 24 pin DIP and SMD copper package. The MAC04 series has a 2:1 wide input voltage range of 9-18VDC, 18-36VDC and 36-72VDC, and provides a precisely regulated output. This series has features such as high efficiency, 500VDC, 1500VDC, 3KVDC of isolation and allows an ambient operating temperature range of –25°C to 71°C (de-rating above 71 °C). The modules are fully protected against output short circuit. All models are very suitable for distributed power architectures, telecommunications, battery operated equipment and industrial applications.

2. DC/DC Converter Features

- 3.3-6W isolated output
- DIP-24/SMD package
- Efficiency up to 84%
- 2:1 input tange
- Regulated outputs
- PI input filter
- Continuous short circuit protection
- Meets EN55022 Class B conducted
- Remote On/Off (option)
- UL60950-1 approval for H/HM versions only

3. Electrical Block Diagram

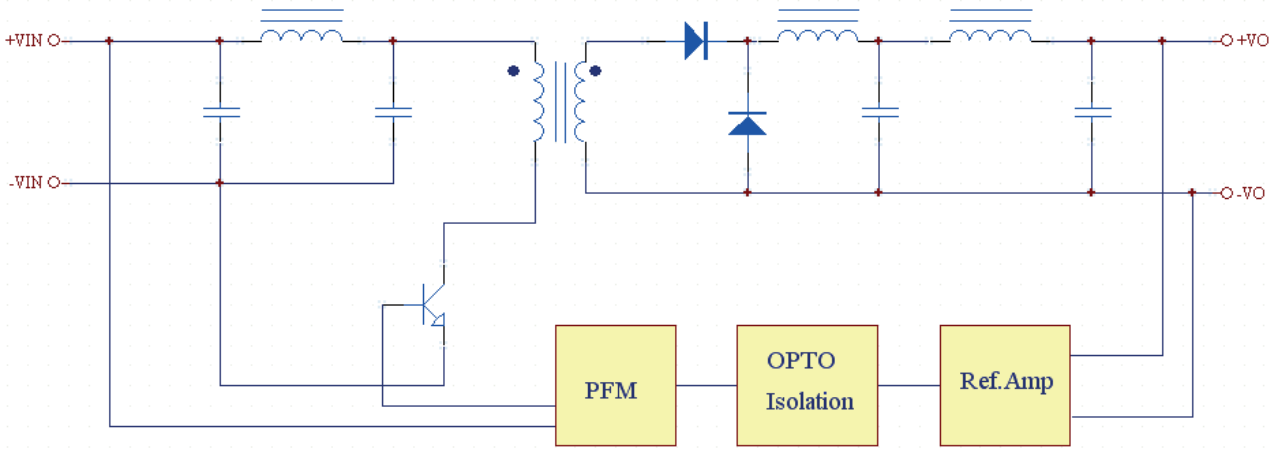


Figure 1 Electrical Block Diagram of single output module

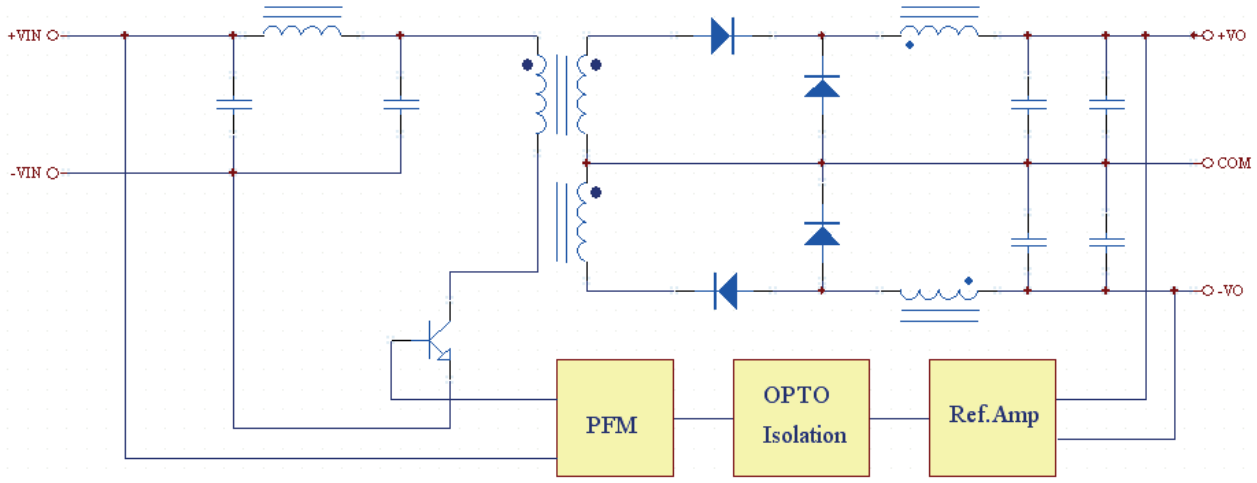


Figure 2 Electrical Block Diagram of dual output module

4. Technical Specifications

(All specifications are typical at nominal input, full load at 25°C unless otherwise noted.)

Absolute Maximum Ratings

Parameters	Notes and Conditions	Device	Min	Typical	Max	Units
Input voltage						
Continuous		12Vin	-0.3		18	VDC
		24Vin	-0.3		36	VDC
		48Vin	-0.3		72	VDC
Transient	100ms	12Vin			25	VDC
		24Vin			50	VDC
		48Vin			100	VDC
Operating ambient temperature	De-rating, above 71 °C	All	-25		+71	°C
Case temperature	Plastic case	All			95	°C
	Copper case	All			100	°C
Storage temperature		All	-40		+100	°C
Input/output isolation voltage	1 minute	MAC 04 (M/MS)	500			VDC
		MAC 04 XXX H	3K			VDC
		MAC 04 XXX HM(HMS)	1.5			VDC

Input Characteristics

Parameters	Notes and Conditions	Device	Min	Typical	Max	Units
Operating input voltage		12Vin	9	12	18	VDC
		24Vin	18	24	36	VDC
		48Vin	36	48	72	VDC
Maximum input current	Full load, Vin=9V	12Vin		800		mA
	Full load, Vin =18V	24Vin		400		mA
	Full load, Vin =36V	48Vin		200		mA
No-load input current	Vin=12V	Vo=3.3VDC		7.5		mA
		Vo=5VDC		7.5		mA
		Vo=12VDC		7.5		mA
		Vo=15VDC		7.5		mA
		Vo=±5VDC		12		mA
		Vo=±12VDC		12		mA
		Vo=±15VDC		12		mA
	Vin=24V	Vo=3.3VDC		5		mA
		Vo=5VDC		5		mA
		Vo=12VDC		5		mA
		Vo=15VDC		5		mA
		Vo=±5VDC		7.5		mA
		Vo=±12VDC		7.5		mA
		Vo=±15VDC		7.5		mA

Parameters	Notes and Conditions	Device	Min	Typical	Max	Units
	Vin=48V	Vo=3.3VDC		3		mA
		Vo=5VDC		2		mA
		Vo=12VDC		2		mA
		Vo=15VDC		2		mA
		Vo=±5VDC		3		mA
		Vo=±12VDC		3		mA
		Vo=±15VDC		3		mA
Inrush current (I^2t)	As per ETS300 132-2	All			0.1	A^2s
Input reflected ripple current	P-P thru 12uH inductor, 5Hz to 20MHz	All		TBD		mA

Output Characteristics

Parameters	Notes and Conditions	Device	Min	Typical	Max	Units
Output voltage set point	Vin=Nominal Vin, Io = Io_max	Vo=3.3VDC	3.234	3.3	3.366	VDC
		Vo=5VDC	4.9	5	5.1	VDC
		Vo=12VDC	11.76	12	12.24	VDC
		Vo=15VDC	14.7	15	15.3	VDC
		Vo=±5VDC	±4.9	±5	±5.1	VDC
		Vo=±12VDC	±11.76	±12	±12.24	VDC
		Vo=±15VDC	±14.7	±15	±15.3	VDC
Output voltage balance	Vin nominal input, Io=Io_max	Dual			±1.0	%
Output voltage regulation						
Load regulation	Io=full load to 10% load	Single			±0.5	%
	Io=full load to 25% load	Dual			±1.0	%
Line regulation	Vin=low line to high line, full load	Single			±0.5	%
		Dual			±1.0	%
Temperature coefficient	TC=-25°C to +71°C	All			±0.05	%/°C
Output voltage ripple and noise (5Hz to 20MHz bandwidth)						
Peak-to-Peak	Vin=nominal input, Io= full load	Vo=3.3VDC			100	mV
	(with 0.1uF MLCC for SMD package	Vo=5VDC			100	mV
		Vo=±5VDC			100	mV
		Vo=12VDC			120	mV
		Vo=±12VDC			120	mV
		Vo=15VDC			150	mV
		Vo=±15VDC			150	mV
Operating output current range		Vo=3.3VDC			1000	mV
		Vo=5VDC			1000	mV
		Vo=12VDC			470	mV
		Vo=15VDC			400	mV
		Vo=±5VDC			±500	mV
		Vo=±12VDC			±230	mV
		Vo=±15VDC			±190	mV
Output DC current limit inception	Vo=90% Vo, nominal	All	120			%

Dynamic Characteristics

Parameters	Notes and Conditions	Device	Min	Typical	Max	Units
Turn-on delay and rise time						
Turn-on delay time, from input	Vin, Nominal. to 90%Vo,set	All		6	10	ms
Output voltage rise time	10%Vo, set to 90%Vo,set	All		3		ms

Efficiency

Parameters	Notes and Conditions	Device	Min	Typical	Max	Units
100% load	Vin=12V	MAC 04 006		76		%
		MAC 04 009		80		%
		MAC 04 012		81		%
		MAC 04 018		81		%
		MAC 04 021		81		%
		MAC 04 015		76		%
		MAC 04 003		72		%
Vin=12V	Vin=24V	MAC 04 027		79		%
		MAC 04 030		83		%
		MAC 04 033		84		%
		MAC 04 039		81		%
		MAC 04 042		82		%
		MAC 04 036		79		%
		MAC 04 024		73		%
Vin=12V	Vin=48V	MAC 04 048		79		%
		MAC 04 051		82		%
		MAC 04 054		81		%
		MAC 04 060		81		%
		MAC 04 063		80		%
		MAC 04 057		79		%
		MAC 04 045		73		%

Isolation Characteristics

Parameters	Notes and Conditions	Device	Min	Typical	Max	Units
Isolation voltage	Input to output, 1 minute	MAC 04 (M/MS)	500			VDC
		MAC 04 H	3K			VDC
		MAC 04 HM(HMS)	1.5			VDC
Isolation resistance		All	1000			MΩ
Isolation capacitance	Input to output	MAC 04 H		300		pF
		Others		500		pF

Feature Characteristics

Parameters	Notes and Conditions	Device	Min	Typical	Max	Units
Switching frequency		All	100			KHz
ON/OFF control, positive remote On/Off logic						
Logic low (module off)	Von/off at Ion/off=1.0mA	All	0		1.8	V
Logic high (module on)	Von/off at Ion/off=0.1uA	All	5.5 or open circuit		10	V
Off converter input current	Shutdown input idle current	All			10	mA

General Specifications

Parameters	Notes and Conditions	Device	Min	Typical	Max	Units
MTBF	Io=100% of Io.max; Ta=25°C per MIL-HDBK-217F	All		2100		Khours
Weight		All		15		grams

5. Main Features and Functions

5.1 Operating Temperature Range

The MAC04 series converters can be operated by a wide ambient temperature range from -25°C to 71°C (de-rating above 71°C). The standard models case temperature should not be exceeded 95°C (plastic case), 100°C (Copper Case) at normal operating (detail see content 6.2).

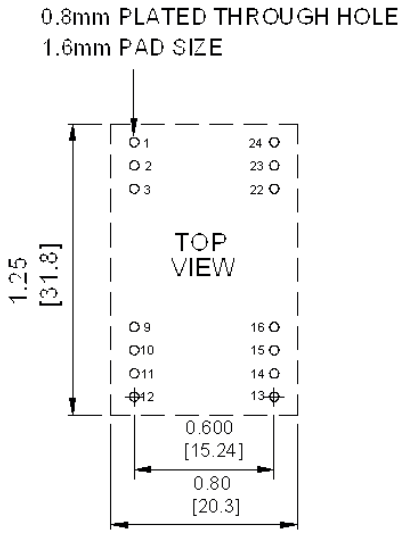
5.2 Over Current Protection

All models have internal over current and continuous short circuit protection. The unit operates normally once the fault condition is removed. At the point of current limit inception, the converter will go into over current protection.

6. Applications

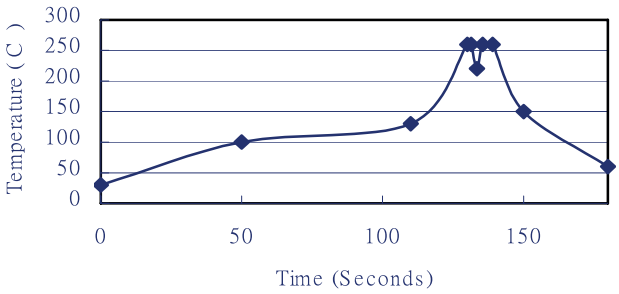
6.1 Recommended Layout, PCB Footprint and Soldering Information

The system designer or the end user must ensure that other components and metal in the vicinity of the converter meet the spacing requirements to which the system is approved. Low resistance and low inductance PCB layout traces are the norm and should be used where possible. Due consideration must also be given to proper low impedance tracks between power module, input and output grounds. The recommended footprints and soldering profiles are shown below.

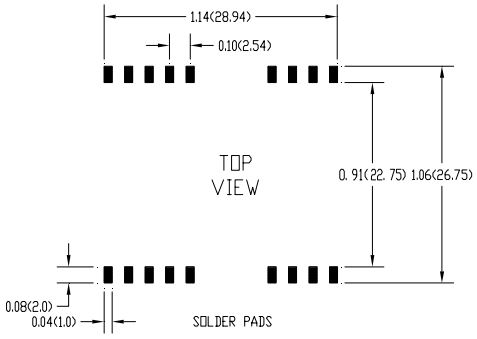


Note: Dimensions are in inches (millimeters)

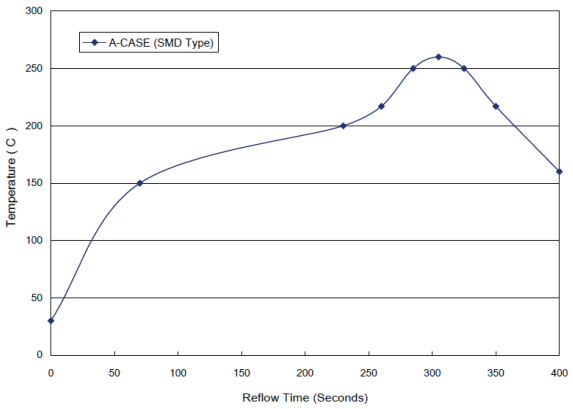
Lead Free Wave Soldering Profile



Note:
1. Soldering Materials : Sn/Cu/Ni
2. Ramp up rate during preheat : 1.4°C/Sec (From 50°C to 100°C)
3. Soaking temperature : 0.5°C/Sec (From 100°C to 130°C), 60±20 seconds
4. Peak temperature : 260°C, above 250°C 3~6 Seconds
5. Ramp up rate during cooling : -10.0°C/Sec (From 260°C to 150°C)



Lead Free Hot Air Reflow Profile



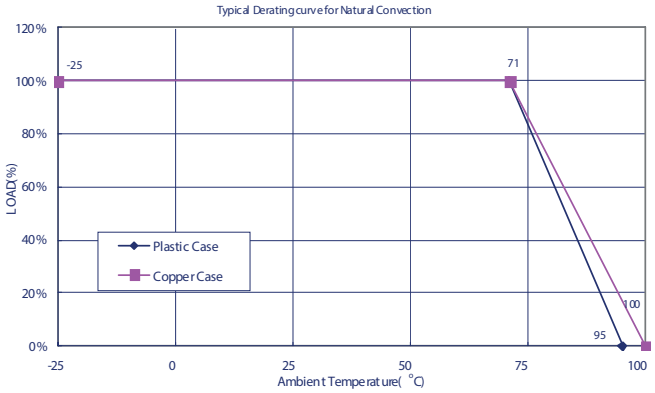
Note:

1. Soldering Paste: SHENMAO PF610-P (Sn/Ag/Cu)
2. Ramp up rate during preheat: 1.71°C/Sec (From 30°C to 150°C)
3. Soaking temperature: 0.31°C/Sec (From 150°C to 200°C), 160±10 seconds
4. Ramp up rate during reflow: 0.96°C/Sec (From 217°C to 260°C)
5. Peak temperature: 260°C, above 217°C 90 Seconds
6. Ramp up rate during cooling: -1.2°C/Sec (From 260°C to 160°C)

Figure 3 Recommended PCB Layout Footprints and Wave Soldering Profiles for DIP-24 and SMD packages.

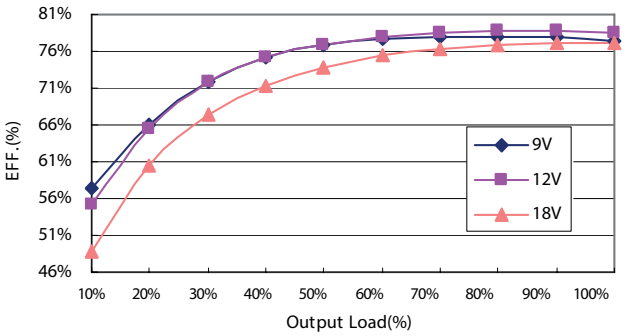
6.2 Power De-Rating Curves

Operating Ambient temperature Range: -25°C ~ 71°C with de-rating above 71°C. Maximum case temperature under any operating condition should not exceed 95°C (plastic case), 100°C (copper case).

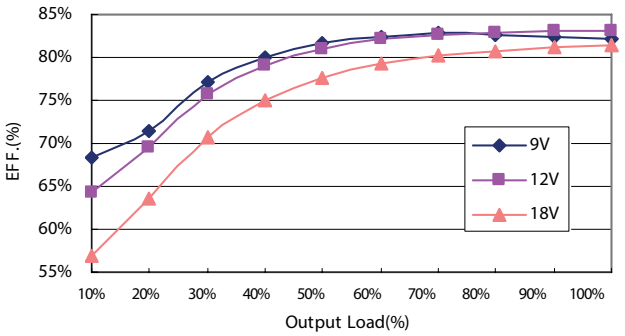


6.3 Efficiency VS. Load

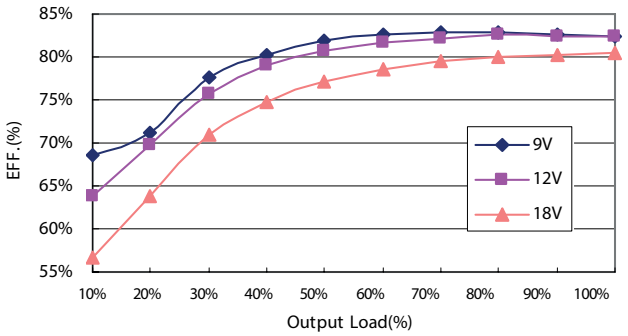
MAC 04 006 Load VS EFF.



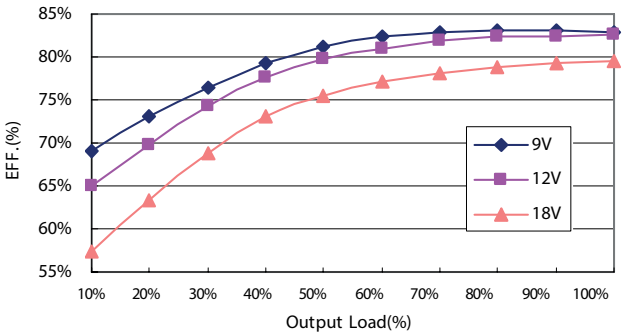
MAC 04 009 Load VS EFF.



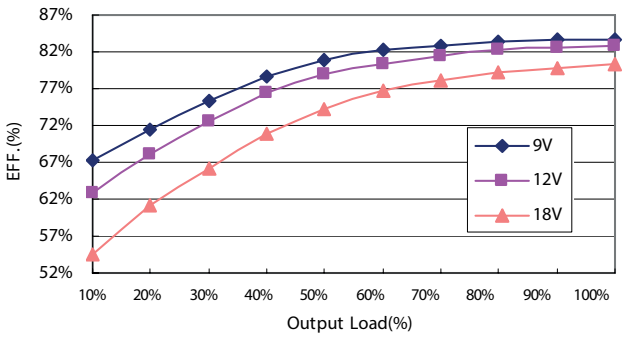
MAC 04 012 Load VS EFF.



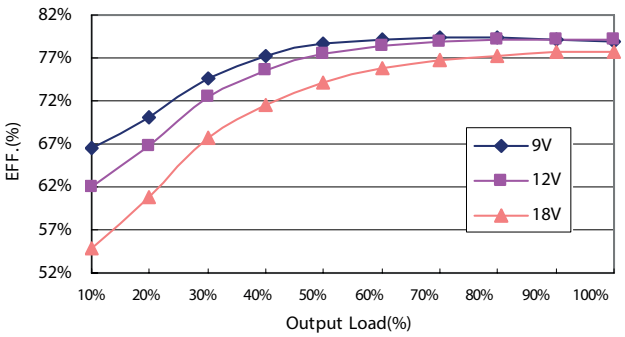
MAC 04 018 Load VS EFF.



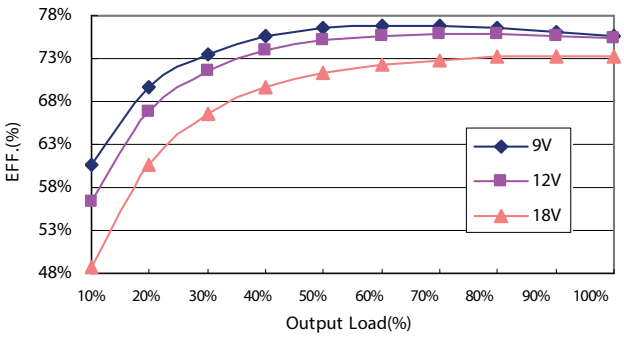
MAC 04 021 Load VS EFF.



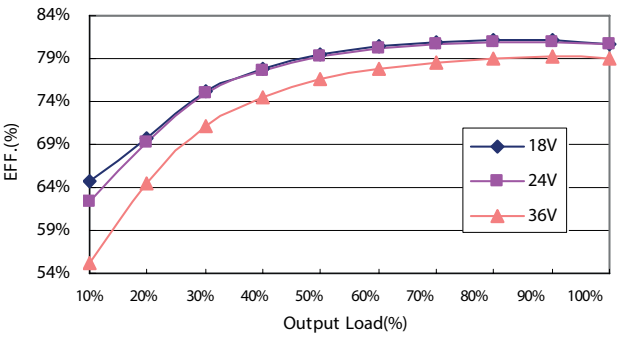
MAC 04 015Load VS EFF.



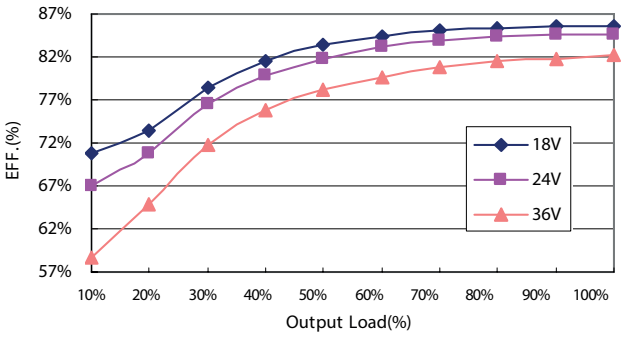
MAC 04 003 Load VS EFF.



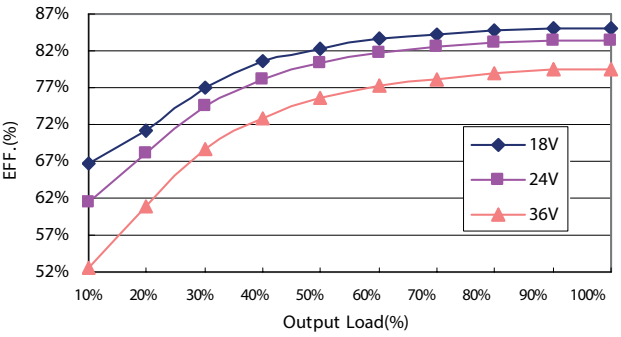
MAC 04 027 Load VS EFF.



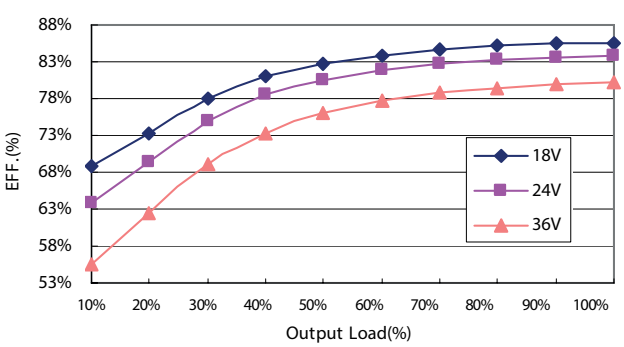
MAC 04 030 Load VS EFF.



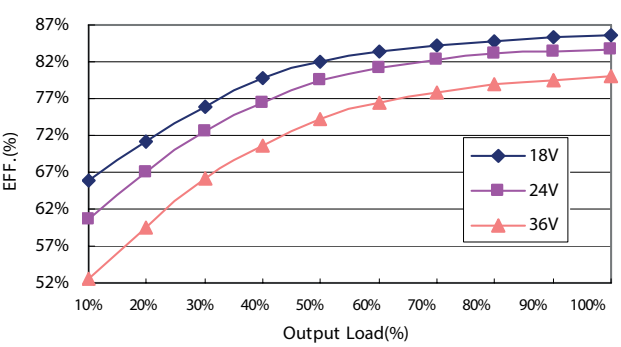
MAC 04 033 Load VS EFF.



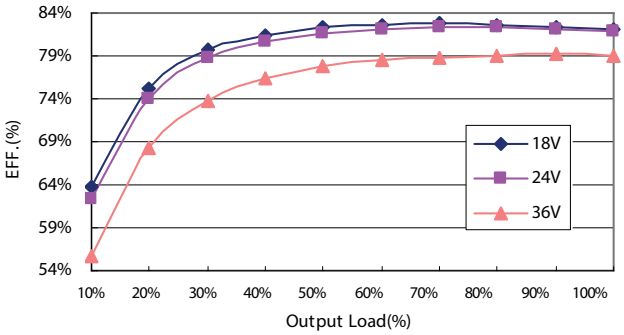
MAC 04 039 Load VS EFF.



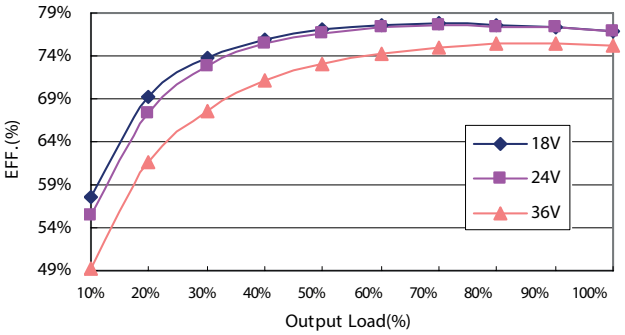
MAC 04 042 Load VS EFF.



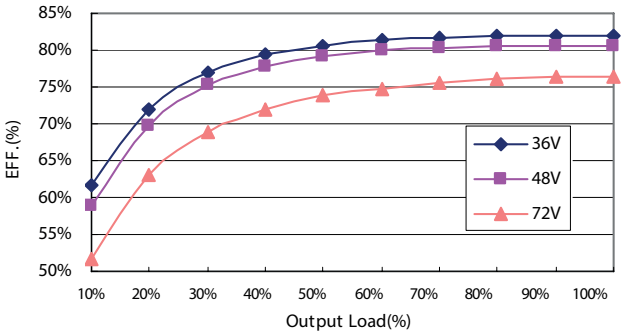
MAC 04 036 Load VS EFF.



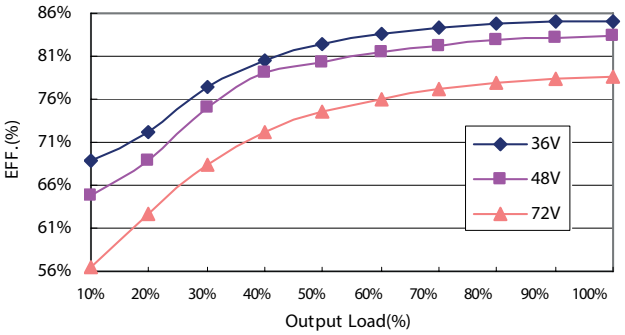
MAC 04 024 Load VS EFF.



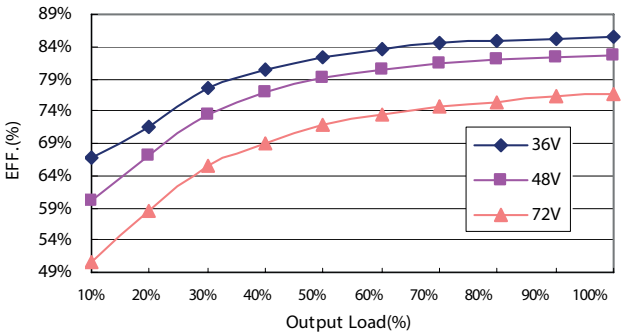
MAC 04 048 Load VS EFF.



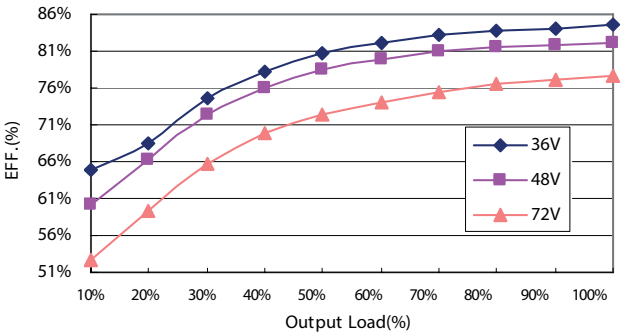
MAC 04 051 Load VS EFF.



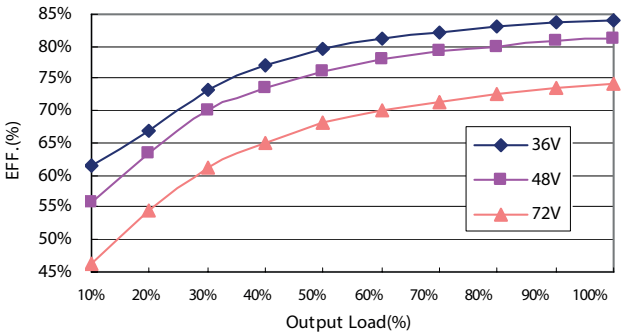
MAC 04 054 Load VS EFF.



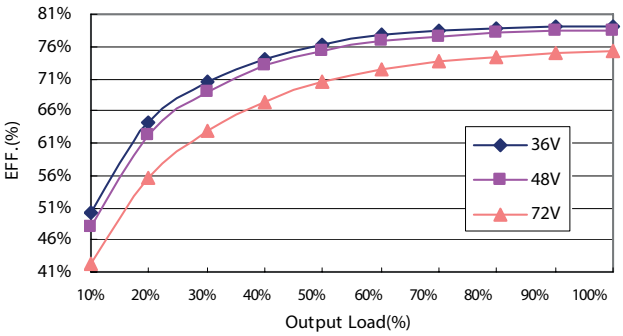
MAC 04 060 Load VS EFF.



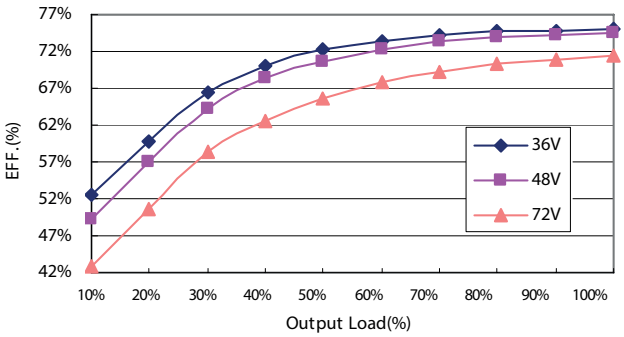
MAC 04 063 Load VS EFF.



MAC 04 057 Load VS EFF.

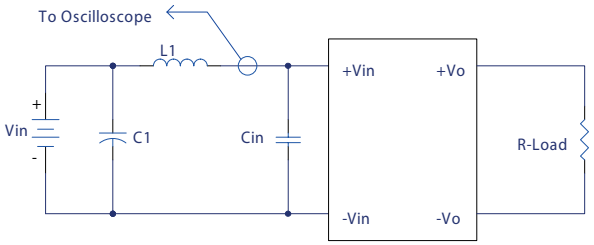


MAC 04 045 Load VS EFF.



6.4 Input Capacitance at the Power Module

The converters must be connected to low AC source impedance. To avoid problems with loop stability source inductance should be low. Also, the input capacitors (Cin) should be placed close to the converter input pins to de-couple distribution inductance. However, the external input capacitors are chosen for suitable ripple handling capability. Low ESR capacitors are good choice. Circuit as shown in Figure 4 represents typical measurement methods for reflected ripple current. C1 and L1 simulate a typical DC source impedance. The input reflected-ripple current is measured by current probe to oscilloscope with a simulated source Inductance (L1).



L1: 12uH.
C1: 220uF ESR <0.1 Ω @ 20 ℃, 100KHz.
Cin: None

Figure 4 Input Reflected-Ripple Test Setup

6.5 Test Set-Up

The basic test set-up to measure parameters such as efficiency and load regulation is shown in Figure 5. When testing the modules under any transient conditions please ensure that the transient response of the source is sufficient to power the equipment under test. We can calculate the

· Efficiency
· Load regulation and line regulation.

The value of efficiency is defined as:

$$\eta = \frac{Vo \times Io}{Vin \times Iin} \times 100\%$$

Where:
V_o is output voltage,
I_o is output current,
V_{in} is input voltage,
I_{in} is input current.

The value of load regulation is defined as:

$$Load.reg = \frac{V_{FL} - V_{NL}}{V_{NL}} \times 100\%$$

Where:
V_{FL} is the output voltage at full load
V_{NL} is the output voltage at 10% load (single output)
V_{NL} is the output voltage at 25% load (dual output)

The value of line regulation is defined as:

$$Line.reg = \frac{V_{HL} - V_{LL}}{V_{LL}} \times 100\%$$

Where: V_{HL} is the output voltage of maximum input voltage at full load.
V_{LL} is the output voltage of minimum input voltage at full load.

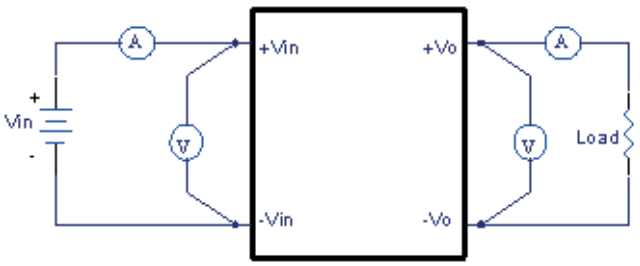
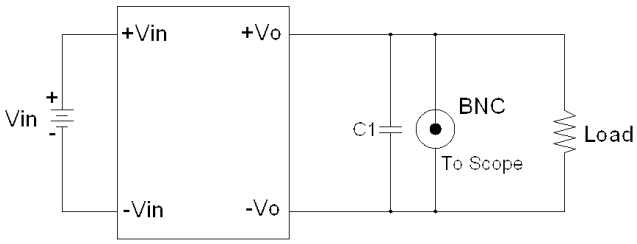


Figure 5 Test Setup

6.6 Output Ripple and Noise Measurement

The test set-up for noise and ripple measurements is shown in Figure 6 and 7. A coaxial cable was used to prevent impedance mismatch reflections disturbing the noise readings at higher frequencies. Measurements are taken with output appropriately loaded and all ripple/ noise specifications are from 5Hz to 20MHz Band Width.



Note: C1: 0.1uF Ceramic capacitor for SMD Models Only

Figure 6 Using BNC to Measure Output Ripple and Noise

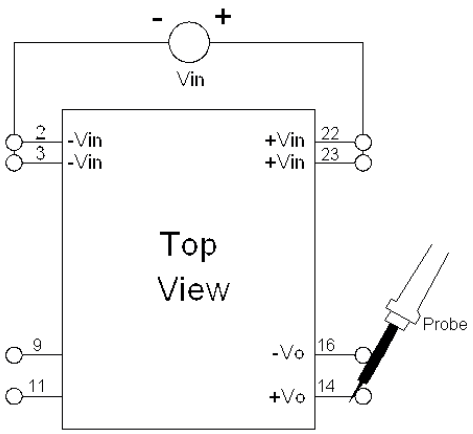


Figure 7 Using Probe to Measure Output Ripple and Noise

6.7 Output Capacitance

The MAC04 series converters provide unconditional stability with or without external capacitors. For good transient response low ESR output capacitors should be located close to the point of load. These series converters are designed to work with load capacitance to see technical specifications.

7. Safety & EMC

7.1 Input Fusing and Safety Considerations

The MAC04 series converters have not an internal fuse. However, to achieve maximum safety and system protection, always use an input line fuse. We recommended a time delay fuse 1.25A for 12Vin models, 0.63A for 24Vin models and 0.3A for 48Vin modules. Figure 8 circuit is recommended by a Transient Voltage Suppressor diode across the input terminal to protect the unit against surge or spike voltage and input reverse voltage.

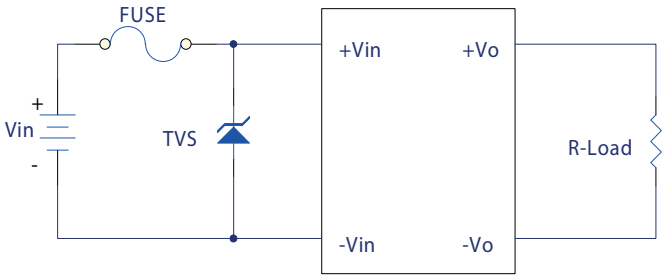


Figure 8 Input Protection

7.2 EMC Considerations

EMI Test standard: EN55022 Class B

Test Condition: Input Voltage: Nominal, Output Load: Full Load without External Input Filter

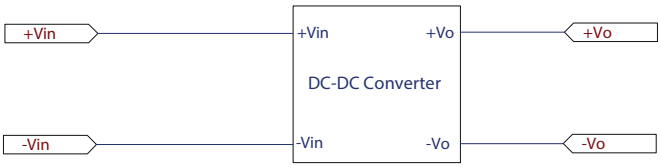
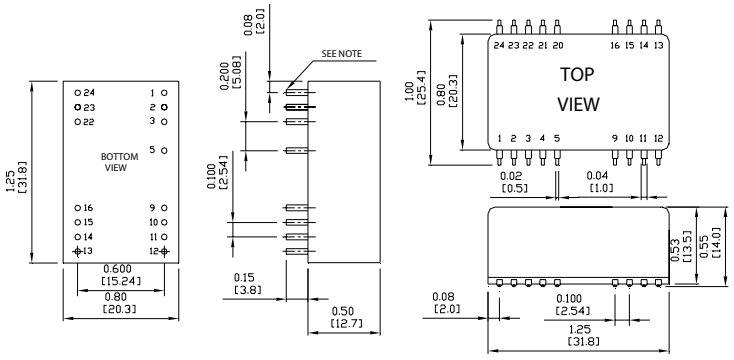


Figure 9 Connection circuit for conducted EMI testing

8. Mechanical Specifications

NOTE:Pin Size is 0.02±0.002 Inch (0.5±0.05 mm) DIA
All Dimensions In Inches (mm)
Tolerances Inches: X.XX= ±0.02 , X.XXX= ±0.010
Millimeters: X.X= ±0.5 , X.XX=±0.25

CASE AS



PIN CONNECTION									
	500 VDC					1.5K & 3K VDC			
Pin	Single Output		Dual Output		Pin	Single Output		Dual Output	
	DIP	SMD	DIP	SMD		DIP	SMD	DIP	SMD
1,24	+V Input		+V Input		1,24	NP	NC	NP	NC
2,23	NC		-V Output		2,3	-V Input		-V Input	
3,22	NC		Common		4	NP	NC	NP	NC
4	NP	NC	NP	NC	5	NP/ Remote On/Off	NC/ Remote On/Off	NP/ Remote On/Off	NC/ Remote On/Off
5	NP	NC	NP	NC	9	NC		Common	
9	NP	NC	NP	NC	10,15	NC		NC	
10,15	-V Output		Common		11	NC		-V Output	
11,14	+V Output		+V Output		12,13	NP	NC	NP	NC
12,13	-V Input		-V Input		14	+V Output		+V Output	
16	NP	NC	NP	NC	16	-V Output		Common	
20	NP	NC	NP	NC	20,21	NP	NC	NP	NC
21	NP	NC	NP	NC	22,23	+V Input		+V Input	

* NC-NO CONNECTION WITH PIN
* NP-NO PIN
* Remote On/Off (Option)