

P R B X

POWERBOX Industrial Line
 MAH42 Series
 20-30W 4:1 Single Output
 DC/DC Converter
 Manual V10

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1. Introduction

The MAH42 series offer 30 watts of output power in a 2.00x1.60x0.4 inches copper packages. The MAH42 series has a 4:1 wide input voltage range of 9-36 and 18-75VDC, and provides a precisely regulated output. This series has features such as high efficiency, 1500VDC of isolation and allows an ambient operating temperature range of -40°C to 85°C (de-rating above 60 °C). The modules are fully protected against input UVLO (under voltage lock out), output over-current, over-voltage and over-temperature and short circuit conditions. Furthermore, the standard control functions include remote on/off and adjustable output voltage. All models are very suitable for distributed power architectures, telecommunications, battery operated equipment and industrial applications.

2. DC/DC Converter Features

20-30W isolated output

High efficiency up to 91%

2" x 1.6" six-sided shield metal case

4:1 wide input range

Regulated outputs

Fixed 300KHz switching frequency

Continuous short circuit protection

Industry standard pin-out

CE mark meets 2004/108/EC

Safety meets UL60950-1, EN60950-1, and IEC60950-1

3. Electrical Block Diagram

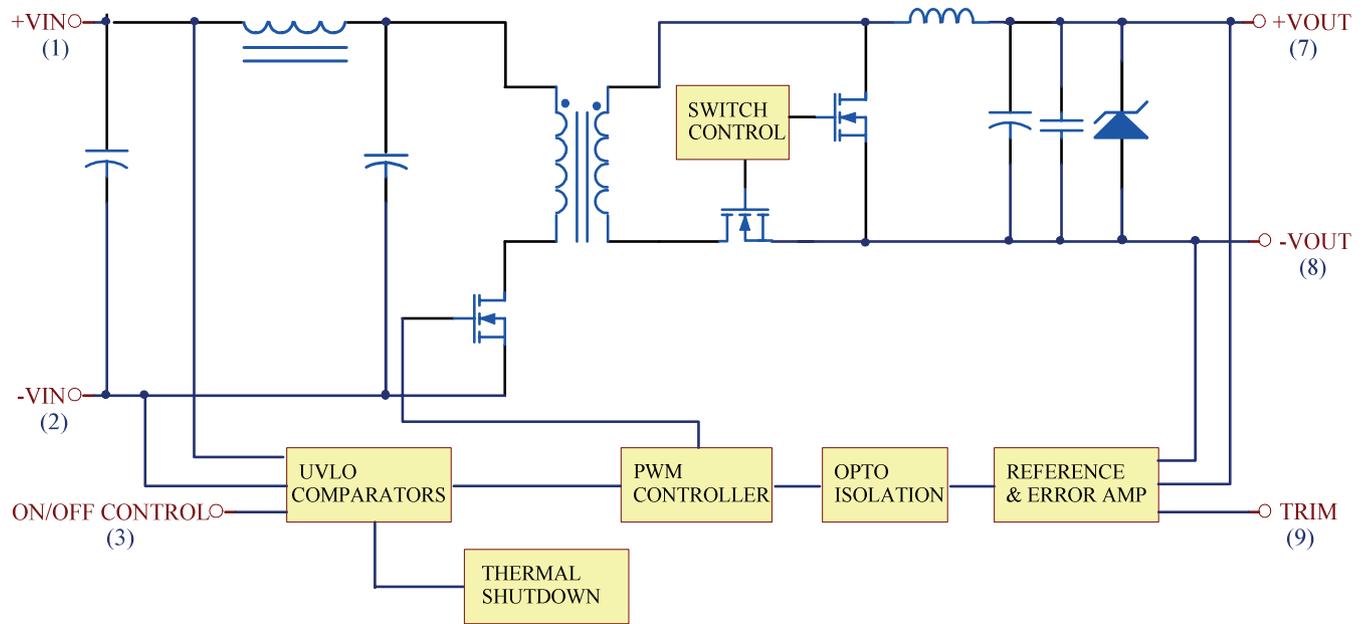


Figure 1 Electrical Block Diagram for Single Output Modules

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
<i>Input voltage</i>						
Continuous		24Vin	9	24	36	VDC
		48Vin	18	48	75	VDC
Transient	100ms	24Vin			50	VDC
		48Vin			100	VDC
Operating ambient temperature	De-rating, above 60 °C	All	-40		+85	°C
Case temperature		All			100	°C
Storage temperature		All	-55		+125	°C
Input/output isolation voltage	1 minute	All			1500	VDC

Input Characteristics

Parameters	Notes and Conditions	Device	Min	Typical	Max	Units
Operating input voltage		24Vin	9	24	36	VDC
		48Vin	18	48	75	VDC
<i>Input Under Voltage Lockout</i>						
Turn-on voltage threshold		24Vin	8	8.5	8.8	VDC
		48Vin	16.5	17	17.5	VDC
Turn-off voltage threshold		24Vin	7.7	8	8.3	VDC
		48Vin	15.5	16	16.5	VDC
Lockout hysteresis voltage		24Vin		0.6		VDC
		48Vin		0.9		VDC
Maximum input current	100% Load, Vin=9V	24Vin		3850		mA
	100% Load, Vin =18V	48Vin		1900		mA
No-load input current	Vin=24V	MAH 42 003		50		mA
		MAH 42 006		60		mA
		MAH 42 009		80		mA
		MAH 42 012		50		mA
	Vin=48V	MAH 42 030		30		mA
		MAH 42 033		30		mA
		MAH 42 036		40		mA
		MAH 42 039		50		mA
Inrush current (I ² t)	As per ETS300 132-2	All			0.1	A ² s
Input reflected ripple current	P-P thru 12uH inductor, 5Hz to 20Mhz	All			30	mA

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Output Characteristics

Parameters	Notes and Conditions	Device	Min	Typical	Max	Units
Output voltage set point	Vin=nominal input, Io= Iomax	Vo=3.3	3.2505	3.3	3.3495	VDC
		Vo=5.0	4.925	5	5.075	VDC
		Vo=12	11.82	12	12.18	VDC
		Vo=15	14.775	15	15.225	VDC
<i>Output voltage regulation</i>						
Load regulation	Io=full load to min load	Single			±0.5	%
Line regulation	Vin=high line to low line, full load	Single			±0.5	%
Temperature coefficient	TC=-40°C to +85°C				±0.02	%/°C
<i>Output voltage ripple and noise 5Hz to 20MHz bandwidth</i>						
Peak-to-Peak	Full load, 0.1uF ceramic capacitor	Vo=3.3V			75	mV
		Vo=5V			75	mV
		Vo=12V			100	mV
		Vo=15V			100	mV
Operating output current range		Vo=3.3V			7500	mA
		Vo=5V			6000	mA
		Vo=12V			2500	mA
		Vo=15V			2000	mA
Output DC current limit inception	Vo=90% Vo, nominal		110	130	150	%
Maximum output capacitance	Full load (resistive)	Vo=3.3V			7500	uF
		Vo=5V			6000	uF
		Vo=12V			2500	uF
		Vo=15V			2000	uF

Dynamic Characteristics

Parameters	Notes and Conditions	Device	Min	Typical	Max	Units
<i>Output voltage current transient</i>						
Step change in output current	75% to 100% of Io,max.,				±5	%
Setting time (within 1% Vout nominal)	di/dt=0.1A/us				300	us
<i>Turn-on delay and rise time</i>						
Turn-on delay time, from on/off control	Von/off to 10%Vo, set	All		1		ms
Turn-on delay time, from input	Vin, min to 10%Vo, set	All		3		ms
Output voltage rise time	10%Vo, set to 90%Vo, set	All		5		ms

Efficiency

Parameters	Notes and Conditions	Device	Min	Typical	Max	Units
100% load	Vin=24V	MAH 42 003		88		%
		MAH 42 006		89		%
		MAH 42 009		91		%
	Vin=48V	MAH 42 012		91		%
		MAH 42 030		88		%
		MAH 42 033		90		%
		MAH 42 036		91		%
		MAH 42 039		91		%

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Isolation Characteristics

Parameters	Notes and Conditions	Device	Min	Typical	Max	Units
Input to output	1 minute	All			1500	VDC
Isolation resistance		All	100			MΩ
Isolation capacitance		All		1000		pF

Feature Characteristics

Parameters	Notes and Conditions	Device	Min	Typical	Max	Units
Switching frequency	V _{in} =24V	24V _{in}		300		KHz
	V _{in} =48V	48V _{in}		250		KHz
<i>ON/OFF control, positive remote On/Off logic</i>						
Logic low (module off)	V _{on/off} at I _{on/off} =1.0mA	All			1.2	V
Logic high (module on)	V _{on/off} at I _{on/off} =0.1uA	All	3.5 or open circuit		75	V
ON/OFF current (for both remote on/off logic), I _{on/off} at V _{on/off} =0.0V				0.3	1	mA
Leakage current (for both remote on/off logic), logic high, V _{on/off} =15V					30	uA
Off converter input current	Shutdown input idle current			4	10	mA
Output voltage trim range	P _{out} =max rated power	All	-10		+10	%
Output over voltage protection	Zener or TVS clamp	V _o =3.3V		3.9		VDC
		V _o =5.0V		6.2		VDC
		V _o =12V		15		VDC
		V _o =15V		18		VDC
Over temperature shutdown				110		°C

General Specifications

Parameters	Notes and Conditions	Device	Min	Typical	Max	Units
MTBF	I _o =100% of I _o , max:			650		Khours
	T _a =25°C per MIL-HDBK-217F					
Weight				50		grams

5. Main Features and Functions

5.1 Operating Temperature Range

The MAH42 series converters can be operated by a wide ambient temperature range from -40°C to 85°C (de-c above 60°C). The standard model has a copper case and case temperature can not over 100°C at normal operating.

5.2 UVLO (Unde Voltage Lock Out)

Input under voltage lockout is standard on the MAH42 unit. The unit will shut down when the input voltage drops below a threshold, and the unit will operate when the input voltage goes above the upper threshold.

5.3 Over Voltage Protection

The over-voltage protection consists of a zener diode to limiting the out voltage.

5.4 Over Temperature Protection (OTP)

The MAH42 series converters are equipped with non-latching over-temperature protection. If the temperature exceeds a threshold of 110°C (typical) the converter will shut down, disabling the output. When the temperature has decreased the converter will automatically restart. The over-temperature condition can be induced by a variety of reasons such as external overload condition or a system fan failure.

5.5 Output Voltage Adjustment

Section 6.6 describes in detail how to trim the output voltage with respect to its set point. The output voltage on all models is adjustable within the range of +10% to -10%. (Single output models only)

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 as Figure 2.

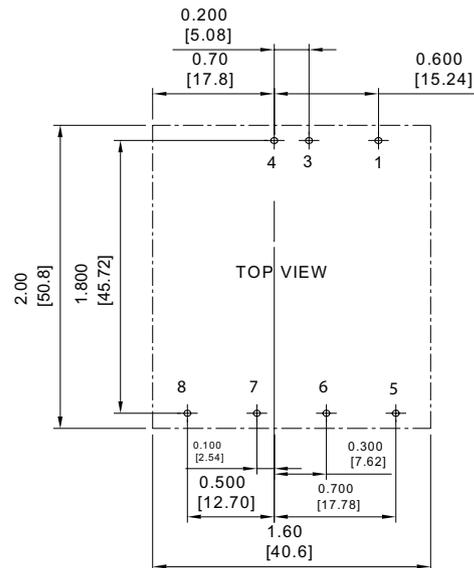
All Dimensions In Inches(mm)

Tolerances Inches: X.XX= ±0.04 , X.XXX= ±0.010

Millimeters: X.X= ±1.0 , X.XX=±0.25

1.3mm PLATED THROUGH HOLE

2.0mm PAD SIZE



Lead Free Wave Soldering Profile

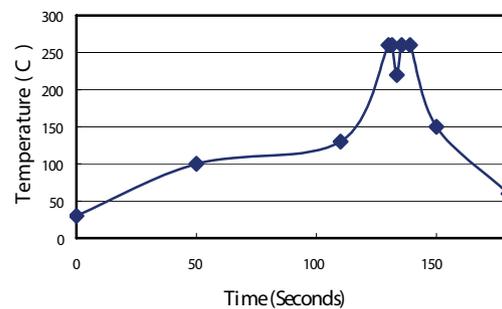


Figure2

Recommended PCB Layout Footprint and 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)

6.2 Power De-Rating Curves

Operating ambient temperature range: $-40^{\circ}\text{C} \sim 85^{\circ}\text{C}$ with de-rating.
Maximum case temperature under any operating condition should not exceed 100°C .

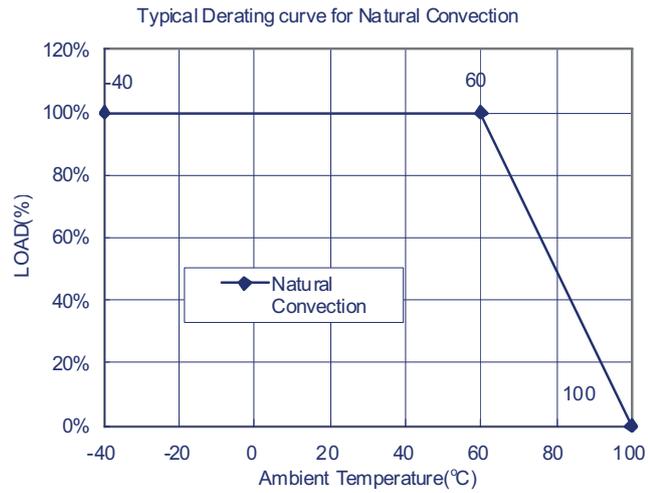
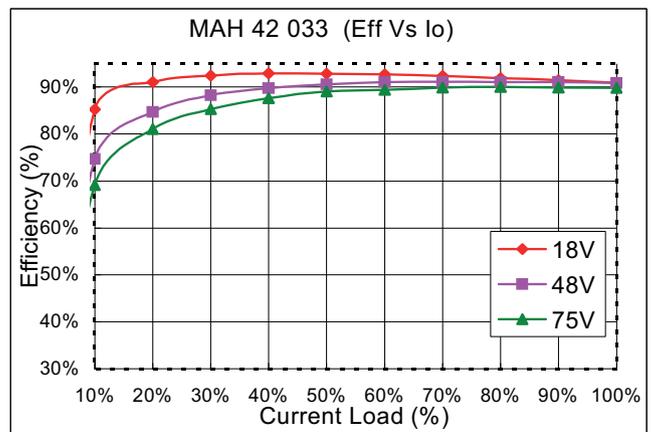
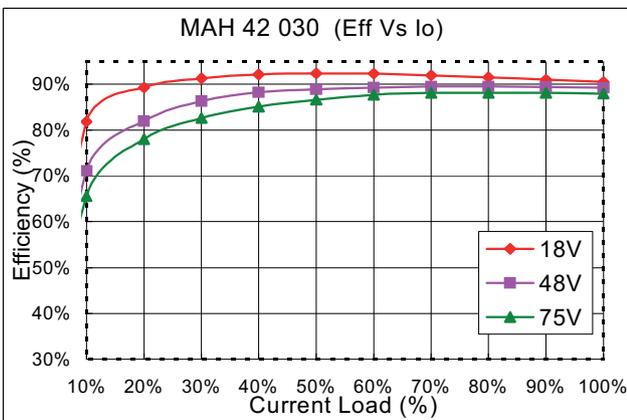
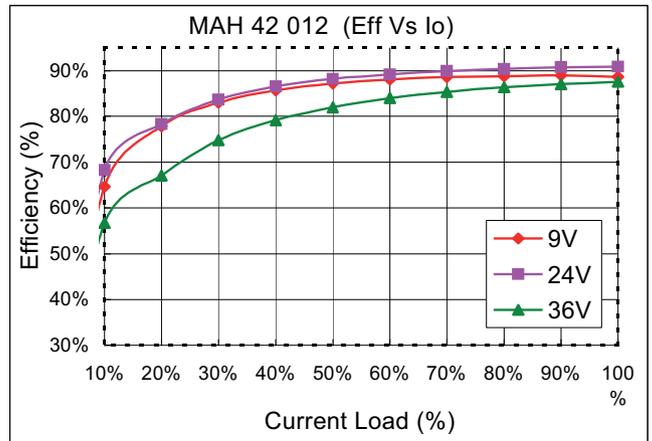
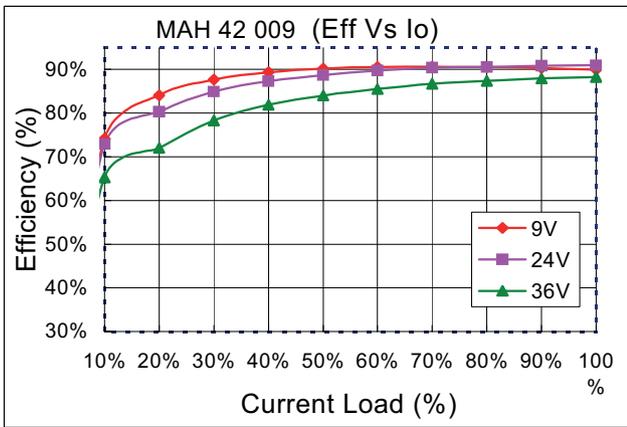
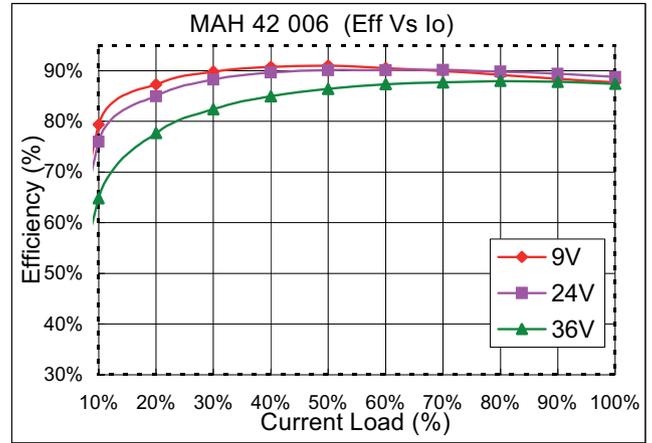
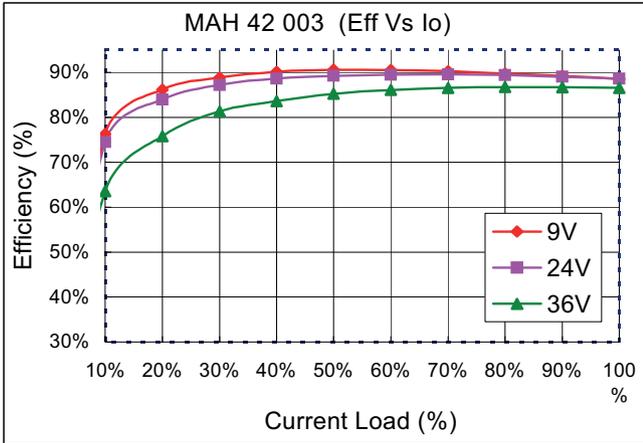
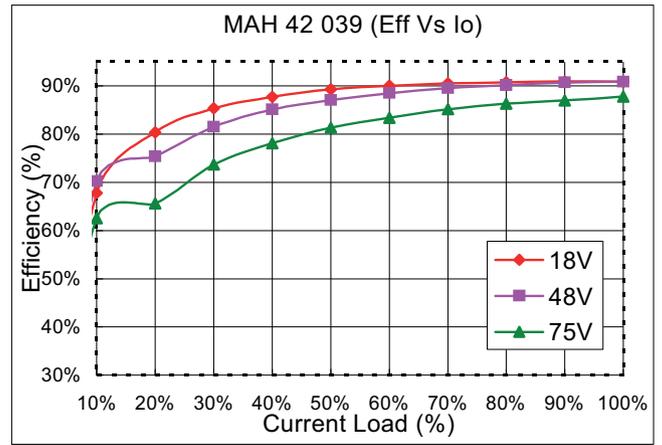
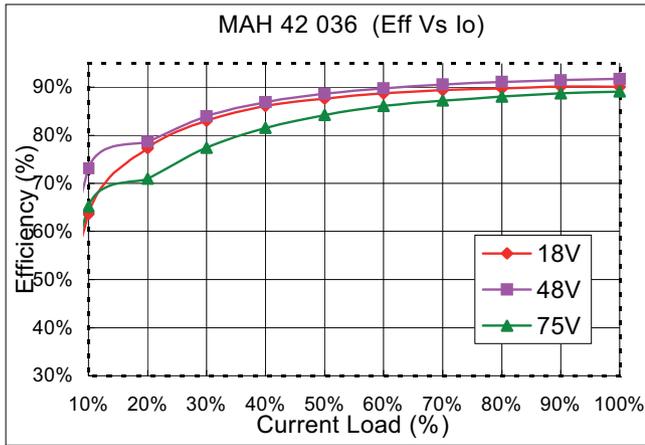


Figure3 Typical Power De-rating Curve for MAH42 Series

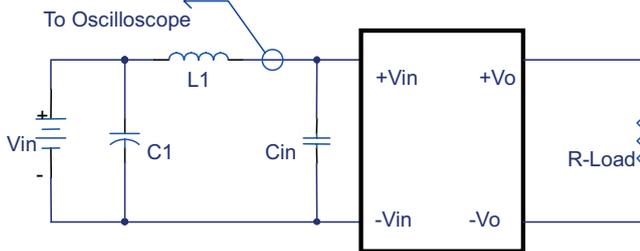
6.3 Efficiency VS. Load





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 <0.1ohm @100KHz.
 Cin: 33uF ESR<0.7ohm @100KHz

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:

$$\eta = \frac{V_o \times I_o}{V_{in} \times I_{in}} \times 100\%$$

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

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.

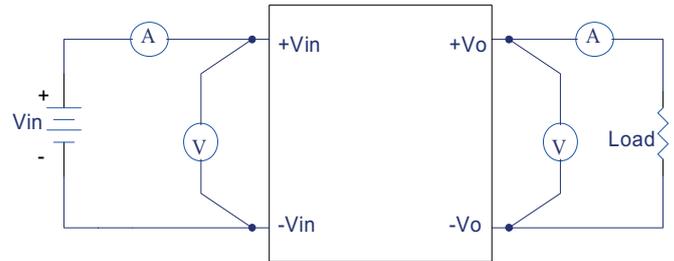


Figure 5 MAH42 Series Test Setup

6.6 Output Voltage Adjustment

In order to trim the voltage up or down one needs to connect the trim resistor either between the trim pin and -Vo for trim-up and between trim pin and +Vo for trim-down. The output voltage trim range is ±10%. (Single output models only) This is shown in Figure 6 and 7:

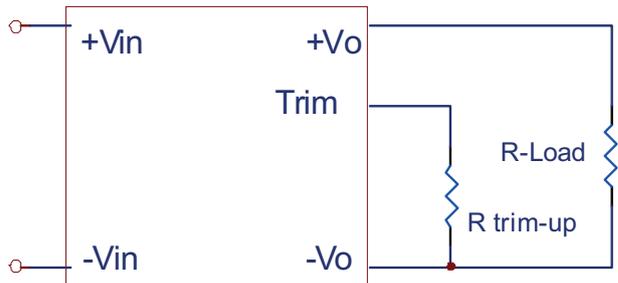


Figure 6 Trim-up Voltage Setup

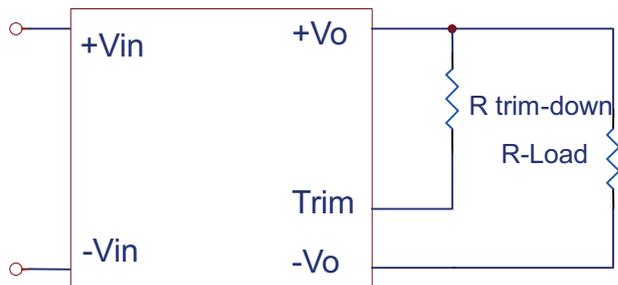


Figure 7 Trim-down Voltage Setup

1. The value of Rtrim-up defined as:

$$R_{trim-up} = \frac{(V_r \times R1 \times (R2 + R3))}{(V_o - V_o, nom) \times R2} R_t \text{ (K}\Omega\text{)}$$

Where

Rtrim-up is the external resistor in Kohm.

VO, nom is the nominal output voltage.

VO is the desired output voltage.

R1, Rt, R2, R3 and Vr are internal to the unit and are defined in Table 1.

Table 1 – Trim up and Trim down Resistor Values

Model No.	Output Voltage(V)	R1 (KΩ)	R2 (KΩ)	R3 (KΩ)	Rt (KΩ)	Vr (V)
MAH 42 003	3.3	2.74	1.8	0.27	9.1	1.24
MAH 42 030						
MAH 42 006	5.0	2.32	2.32	0	8.2	2.5
MAH 42 033						
MAH 42 009	12.0	6.8	2.4	2.32	22	2.5
MAH 42 036						
MAH 42 012	15.0	8.06	2.4	3.9	27	2.5
MAH 42 039						

For example, to trim-up the output voltage of 5V module (MAH 42 006)

by 10% to 5.5V, R trim-up is calculated as follows:

$$V_o - V_o, nom = 5.5 - 5 = 0.5V$$

$$R1 = 2.32 \text{ K}\Omega$$

$$R2 = 2.32 \text{ K}\Omega$$

$$R3 = 0 \text{ K}\Omega$$

$$Rt = 8.2 \text{ K}\Omega$$

$$Vr = 2.5 \text{ V}$$

$$R_{trim-up} = \frac{(2.5 \times 2.32 \times (2.32 + 0))}{0.5 \times 2.32} 8.2 = 3.4 \text{ (K}\Omega\text{)}$$

2. The value of Rtrim-down defined as:

$$R_{trim-down} = R1 \times \left(\frac{V_r \times R1}{(V_o, nom - V_o) \times R2} - 1 \right) - R_t \text{ (K}\Omega\text{)}$$

Where

Rtrim-down is the external resistor in Kohm.

VO, nom is the nominal output voltage.

VO is the desired output voltage.

R1, Rt, R2, R3 and Vr are internal to the unit and are defined in Table 1

For example, to trim-down the output voltage of 5.0V module (MAH 42

006) by 10% to 4.5V, R trim-down is calculated as follows:

$$V_o, nom - V_o = 5.0 - 4.5 = 0.5V$$

$$R1 = 2.32 \text{ K}\Omega$$

$$R2 = 2.32 \text{ K}\Omega$$

$$R3 = 0 \text{ K}\Omega$$

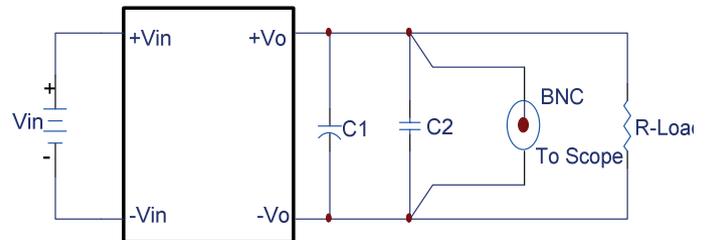
$$Rt = 8.2 \text{ K}\Omega$$

$$Vr = 2.5 \text{ V}$$

$$R_{trim-down} = 2.32 \times \left(\frac{(2.5 \times 2.32)}{0.5 \times 2.32} - 1 \right) - 8.2 = 1.08 \text{ (K}\Omega\text{)}$$

6.7 Output Ripple and Noise Measurement

The test set-up for noise and ripple measurements is shown in Figure 8. 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 bandwidth.



Note: C1: none

C2: 0.1uF ceramic capacitor

Figure 8 Output Voltage Ripple and Noise Measurement Set-Up

6.8 Output Capacitance

The MAH42 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 MAH42 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 6A for 24Vin models and 3A for 48Vin modules. Figure 9 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.

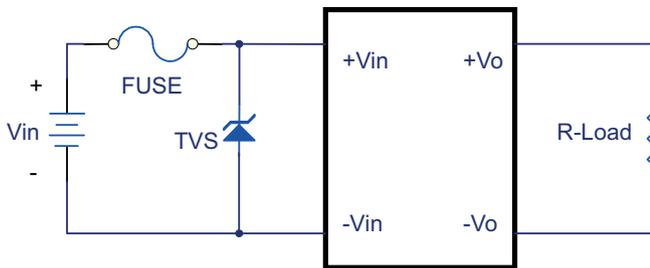


Figure 9 Input Protection

7.2 EMC Considerations

EMI Test standard: EN55022 Class A or Class B Conducted Emission

Test Condition: Nominal Input, Full Load at 25°C.

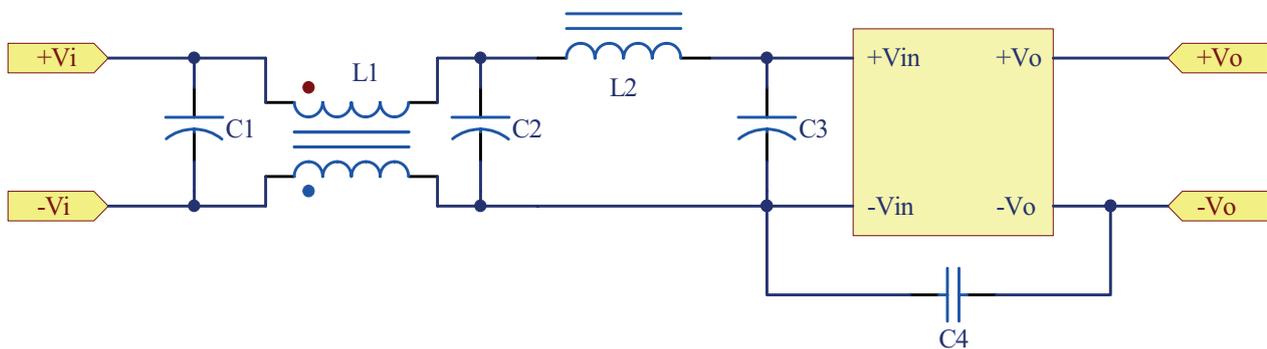


Figure 10 Connection circuit for conducted EMI testing

Model No.	EN55022 Class A		EN55022 Class B		C4	L1	L2	C1	C2	C3	C4	L1	L2
	C1	C2	C3	C4									
MAH 42 003													
MAH 42 006	NC	10uF/50V KY	22uF/50V KY	NC		Short	3.4uH	NC	100uF/100V PW	100uF/100V PW	2200pF	0.65mH	3.4uH
MAH 42 009													
MAH 42 012													
MAH 42 030													
MAH 42 033	NC	NC	220uF/100V KMF	NC		Short	Short	NC	100uF/100V PW	100uF/100V PW	2200pF	0.65mH	3.4uH
MAH 42 036													
MAH 42 039													

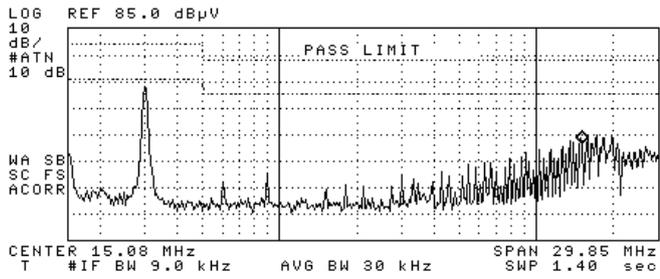


Figure 11 Conducted Class A of MAH 42 003

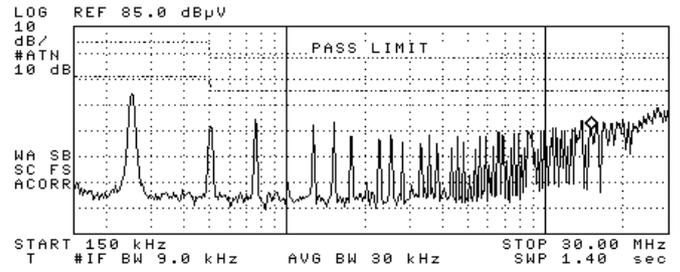


Figure 15 Conducted Class A of MAH 42 030

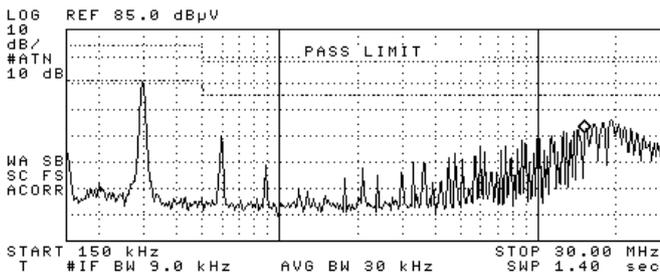


Figure 12 Conducted Class A of MAH 42 006

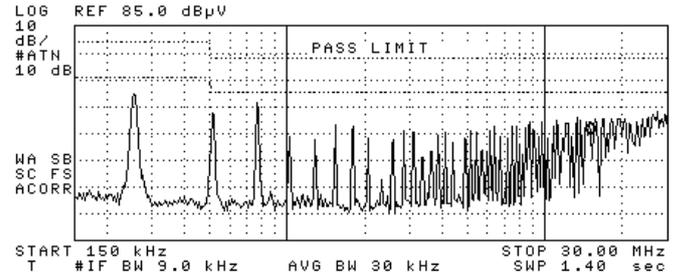


Figure 16 Conducted Class A of MAH 42 033

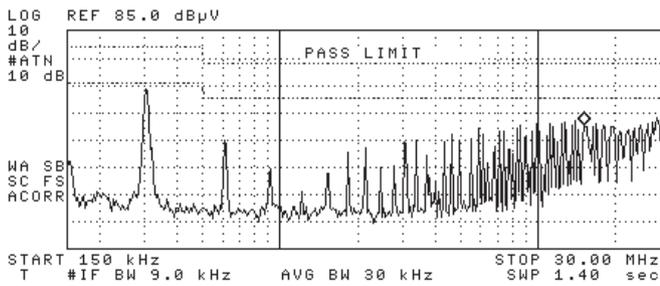


Figure 13 Conducted Class A of MAH 42 009

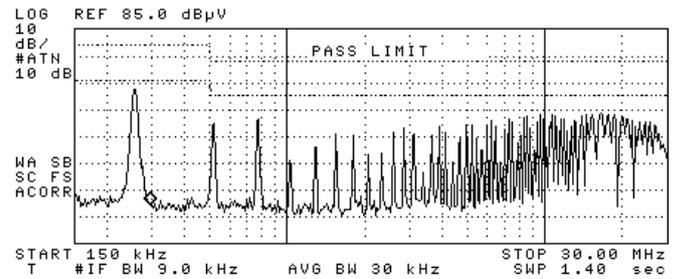


Figure 17 Conducted Class A of MAH 42 036

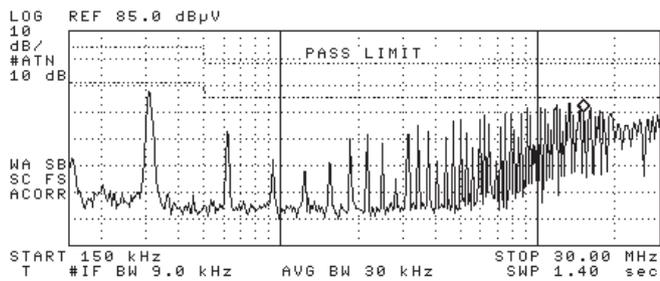


Figure 14 Conducted Class A MAH 42 012

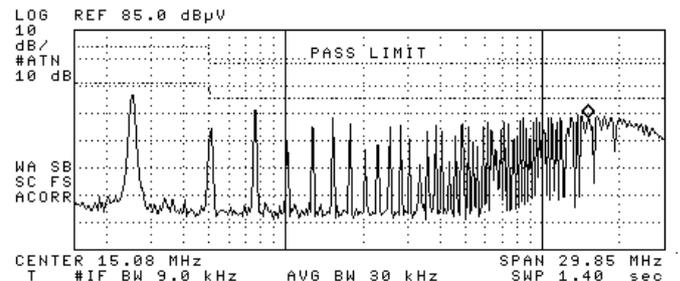


Figure 18 Conducted Class A of MAH 42 039

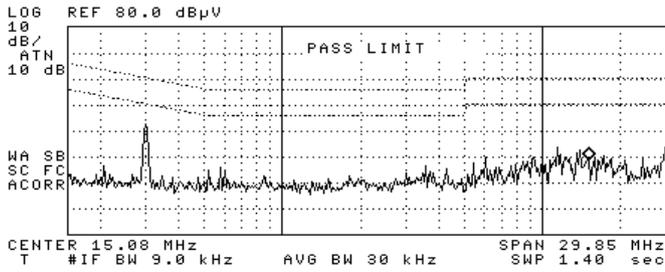


Figure 19 Conducted Class B of MAH 42 003

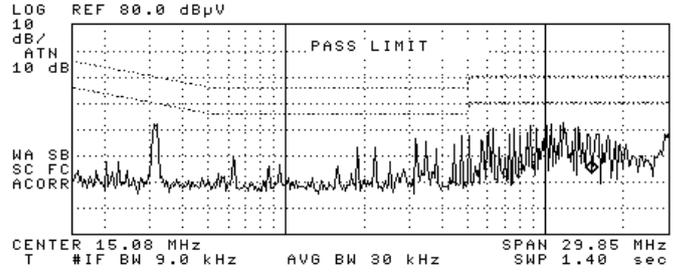


Figure 22 Conducted Class B of MAH 42 012

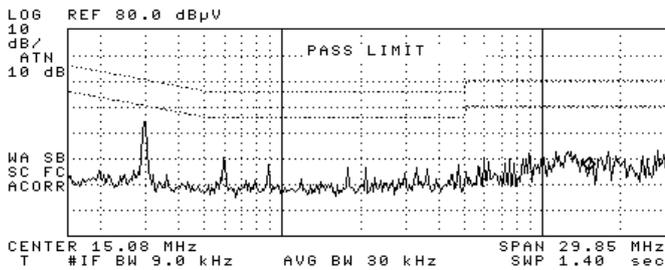


Figure 20 Conducted Class B of MAH 42 006

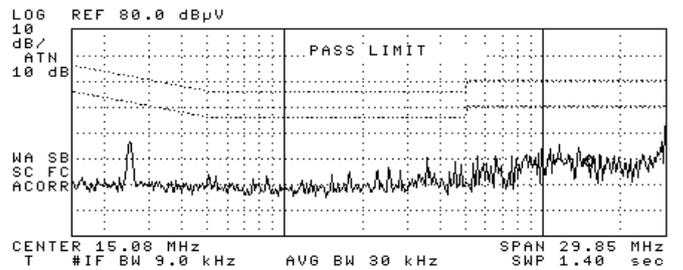


Figure 23 Conducted Class B of MAH 42 030

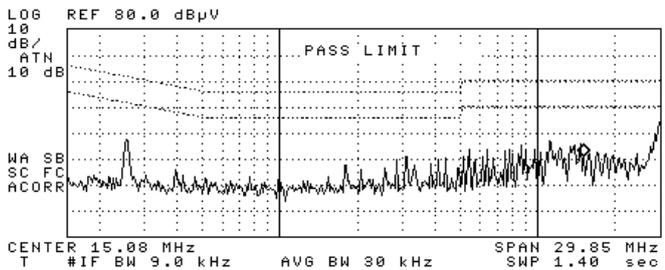


Figure 21 Conducted Class B of MAH 42 009

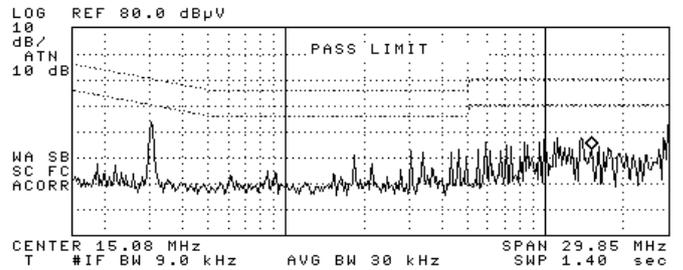


Figure 24 Conducted Class B of MAH 42 033

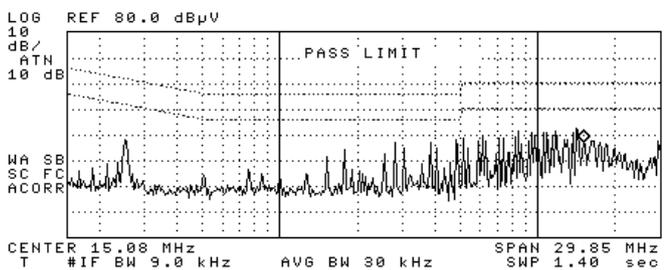


Figure 25 Conducted Class B of MAH 42 036

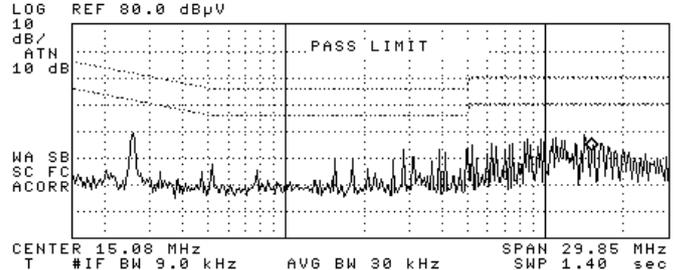
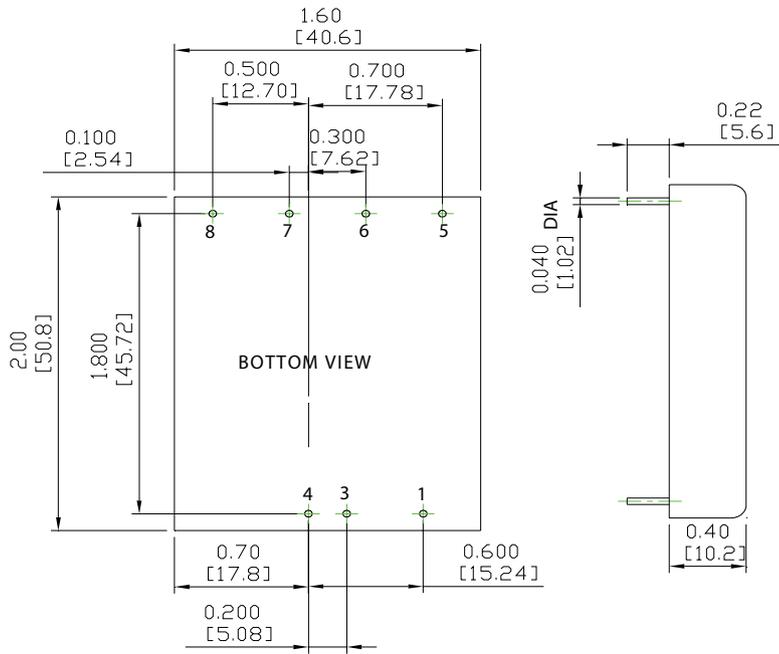


Figure 26 Conducted Class B of MAH 42 039

8. Mechanical Outline Diagrams



PIN CONNECTIONS	
Pin	Function
1	On/Off Control
3	-Vin
4	+Vin
5	Trim
6	-Vout
7	+Vout
8	No Pin