- Efficiency to 86%
- Wide 2:1 Input Voltage Range
- Input π Filter
- Continuous Short Circuit Protection
- UL 1950 Approved File No. E140645
- CSA 22.2 Approved File No. LR 89494
- MTBF Per MIL-HDBK-217F >700,000 Hrs.

2000 and 2500 Series

General Description

The **2000** series and **2500** series of 20 and 25 watt DC/DC converters offer a wide variety of standard input/output voltage combinations. Fifty one models operate over 2:1 input ranges of 9 to 18, 18 to 36 or 36 to 72 VDC providing single, dual or triple output combinations of 5, 6, 12, 15, ± 5, ± 12, ± 15, 5/±12 and 5/±15 VDC. All models have been approved to UL 1950 and CSA 22.2 safety standards.

Standard features include 500 VDC input/output isolation, output ripple & noise of 1% and continuous short circuit protection. Efficiency is as high as 86%. A remote ON/OFF control input and internal π filter are standard on all units.

The MTBF is greater than 700,000 hours at +25°C (ground benign). Each module is packaged in a compact 2.56 x 3.0 x 0.75 inch metal case. Six sided continuous shielding virtually eliminates radiated emissions. Full operation is specified over the wide temperature range of -30°C to +75°C with no derating or heatsinking required. Cooling is by free-air convection.

Optional features allow these converters to be connected in a cascaded configuration (to extend the input voltage range from 2:1 to 4:1), or for parallel operation (to increase output power). Contact the factory for details.

Electrical Specifications

Input Specifications:

Input Voltage Range	See Model Selection Guide
Input Filter	π(Pi) Network
Reverse Polarity Input Current	12A, Max.
Input Surge Current	20A at 10 µSec.
Short Circuit Current Limit	150% of I Input
Overvoltage Shutdown	20, 40 or 74 VDC
Undervoltage Shutdown	8 VDC
Reflected Ripple Current	75 mA, Pk-Pk, Max.
Remote On/Off Control	
Supply On	5.5V or Open Circuit
Supply Off	0 VDC to 0.8 VDC
Logic Input Reference	Negative (-) Input
Logic Compatibility	TTL Open Collector or CMOS Open Drain

Output Specifications:

Voltage and Current Ratings [1]	See Model Selection Guide
Output Voltage Accuracy; [2]	
Single, Dual Output Models	±1%, Max.
Triple Output Models; Primary	±1%, Max. (Adj to Zero)
Auxiliaries	±5%, Max.
Voltage Balance;	
Dual Outputs	±0.5%, Max.
Triple Outputs	±50 mV, Max.
Ripple & Noise (20 MHz BW)	1% Pk-Pk of Vout
Line Regulation;	
Single Output Models	±0.5%
Dual Output Models	±0.4%, Max.
Triple Output Models; Primary	±0.2%, Max.
Auxiliaries	±1.0%, Max.
Load Regulation;	
Single Output Models	±0.5%, Max.
Dual Output Models	±0.5%, Max.
Triple Output Models; Primary	±0.5%, Max.
Auxiliaries	±5.0%, Max.
Minimum Load	10% of FL
Temperature Coefficient @ FL	±0.02%/°C
Temp. Coefficient Balance	±1%
Short Circuit Protection [3]	All outputs, by input current limiting
Short Circuit Duration	Continuous
Short Circuit Restart	Automatic
Over Voltage Protection	See Model Selection Guide

General Specifications:

Efficiency	See Model Selection Guide
Isolation Voltage (1 min.)	500 VDC, Min.
Isolation Resistance	$10^9\Omega$
Switching Frequency	100 kHz, Min.

Environmental Specifications:

Operating Temperature Range (Ambient)	-30°C to +75°C
Storage Temperature Range	-40°C to +125°C
Derating	None Required
Relative Humidity	Up to 95%, Non-condensing
Cooling [4]	Free-air Convection
EMI/RFI	Six-sided Continuous Shielded Metal Case

Physical Characteristics:

Case Size	2.56 x 3.0 x 0.75 inches (66 x 76.2 x 19 mm)
Case Material	Coated Copper
Weight	8.0 Oz (227g)
Shielding	Six-sided, Continuous
Shielding Connection [5]	
12V, 24V Input Models	Pin 3 (- Input)
48V Input Models	Pin 2 (+ Input)

Reliability Specifications: [6]

MTBF; Ground Benign, @ +25°C Ambient	>700,000 Hours

Accessories:

Mounting Socket	MS-2

Specifications typical @+25°C with nominal input voltage and under full output load conditions, unless otherwise noted. Specifications subject to change without notice.

Model Selection Guide

2000 Series

Model Number	Input[7]				Output[8]			Efficiency @FL (%)
	Voltage (VDC)		Current (mA)		Voltage (VDC)	Current (mA)	Over Voltage (VDC)	
	Nominal	Range	No-Load	Full-Load				
2005S12	12	9 - 18	30	2200	5	4000	6.5	75
2005S24	24	18 - 36	30	1030	5	4000	6.5	81
2005S48	48	36 - 72	16	510	5	4000	6.5	81
2006S12	12	9 - 18	30	2160	6	3300	7.5	77
2006S24	24	18 - 36	30	1000	6	3300	7.5	83
2006S48	48	36 - 72	16	485	6	3300	7.5	86
2012S12	12	9 - 18	30	2140	12	1650	15.0	78
2012S24	24	18 - 36	30	1025	12	1650	15.0	80
2012S48	48	36 - 72	16	500	12	1650	15.0	83
2015S12	12	9 - 18	30	2160	15	1325	18.0	77
2015S24	24	18 - 36	30	1025	15	1325	18.0	81
2015S48	48	36 - 72	16	515	15	1325	18.0	81
2012D12	12	9 - 18	40	2140	± 12	± 825	± 15.0	77
2012D24	24	18 - 36	30	1025	± 12	± 825	± 15.0	80
2012D48	48	36 - 72	16	500	± 12	± 825	± 15.0	83
2015D12	12	9 - 18	40	2140	± 15	± 660	± 18.0	77
2015D24	24	18 - 36	30	1025	± 15	± 660	± 18.0	81
2015D48	48	36 - 72	16	500	± 15	± 660	± 18.0	83
2005/12T12	12	9 - 18	40	2220	5/± 12	2000/± 415	6.5/± 15	75
2005/12T24	24	18 - 36	30	1050	5/± 12	2000/± 415	6.5/± 15	79
2005/12T48	48	36 - 72	16	515	5/± 12	2000/± 415	6.5/± 15	81
2005/15T12	12	9 - 18	40	2220	5/± 15	2000/± 330	6.5/± 18	75
2005/15T24	24	18 - 36	30	1050	5/± 15	2000/± 330	6.5/± 18	79
2005/15T48	48	36 - 72	16	515	5/± 15	2000/± 330	6.5/± 18	81

Model Selection Guide

2500 Series

Model Number	Input[7]				Output[8]			Efficiency @FL (%)
	Voltage (VDC)		Current (mA)		Voltage (VDC)	Current (mA)	Over Voltage (VDC)	
	Nominal	Range	No-Load	Full-Load				
2505S12	12	9 - 18	30	2750	5	5000	6.5	76
2505S24	24	18 - 36	30	1300	5	5000	6.5	80
2505S48	48	36 - 72	15	630	5	5000	6.5	83
2506S12	12	9 - 18	30	2700	6	4000	7.5	74
2506S24	24	18 - 36	30	1250	6	4000	7.5	80
2506S48	48	36 - 72	15	590	6	4000	7.5	85
2512S12	12	9 - 18	30	2670	12	2000	15.0	75
2512S24	24	18 - 36	30	1280	12	2000	15.0	78
2512S48	48	36 - 72	15	625	12	2000	15.0	80
2515S12	12	9 - 18	30	2700	15	1600	18.0	74
2515S24	24	18 - 36	30	1280	15	1600	18.0	78
2515S48	48	36 - 72	15	640	15	1600	18.0	78
2505D12	12	9 - 18	40	2770	± 5	± 2500	± 6.5	75
2505D24	24	18 - 36	30	1330	± 5	± 2500	± 6.5	78
2505D48	48	36 - 72	15	650	± 5	± 2500	± 6.5	80
2512D12	12	9 - 18	40	2670	± 12	± 1000	± 15.0	75
2512D24	24	18 - 36	30	1280	± 12	± 1000	± 15.0	78
2512D48	48	36 - 72	15	625	± 12	± 1000	± 15.0	80
2515D12	12	9 - 18	40	2670	± 15	± 800	± 18.0	75
2515D24	24	18 - 36	30	1280	± 15	± 800	± 18.0	78
2515D48	48	36 - 72	15	625	± 15	± 800	± 18.0	80
2505/12T12	12	9 - 18	40	2770	5/± 12	2500/± 520	6.5/± 15	75
2505/15T24	24	18 - 36	30	1300	5/± 12	2500/± 520	6.5/± 15	80
2505/12T48	48	36 - 72	15	640	5/± 12	2500/± 520	6.5/± 15	81
2505/15T12	12	9 - 18	40	2770	5/± 15	2500/± 415	6.5/± 18	75
2505/12T24	24	18 - 36	30	1300	5/± 15	2500/± 415	6.5/± 18	80
2505/15T48	48	36 - 72	15	640	5/± 15	2500/± 415	6.5/± 18	81

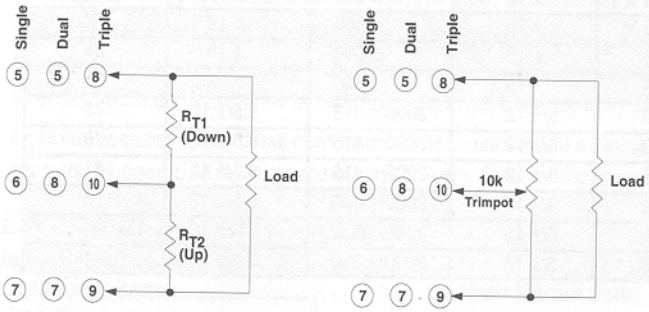
...tions:

...n Subsystems
- Distributed Power Networks
- Process/Industrial Control Systems
- Telecommunications Equipment
- Datacommunications Equipment

2000 and 2500 Series

Specification Notes

1. Total output power should not exceed the specified output currents for any particular model.
2. To trim the output voltage DOWN, connect a 5%, 1/4w resistor (RT1) between the plus (+) output and trim pins of the converter. To trim the output voltage UP, connect a 5%, 1/4w resistor (RT2) between the minus (-) output and trim pins. For UP/DOWN trimming capability, connect a 10 kΩpotentiometer between the plus (+) and minus (-) output pins, with the wiper arm connected to the trim pin. (See figure below)



The trim resistors or potentiometer can be connected at the converter output pins or the load. If connected to the load, the resistance of the runs to the load become part of the feedback loop, improving load regulation. If the load is some distance from the converter, #20 gauge wire is recommended to avoid excessive voltage drops due to circuit resistance.

3. For further protection, it is recommended that an external, slow-blow line fuse be connected to the converter input lines. See the application note "Input Line Protection", Figure 2.
4. Free-air convection cooling requires that the application be properly ventilated. Using a converter in a sealed application, or one in which air movement is severely restricted, could cause thermal runaway.
5. Contact the factory for other shielding connections.
6. MTBF calculations are made per MIL-HDBK-217F.
7. Contact the factory for information on other input/output combinations.
8. The outputs of dual output models and the auxilliary outputs of triple output models may be operated with unbalanced loads. Care must be taken not to exceed the maximum limits of the individual outputs or the overall power rating of the converter. Operating outputs in an unbalanced state may affect some specifications such as output accuracy. For more information on applying a specific model, contact the factory.

* For information on the standard conditions and methods used or approved by **CDI** to test DC/DC converter parameters, see the application note "Testing DC/DC converters" on page 92.

Application Notes:

Minimizing Common Mode Noise & Reflected Ripple Current: When the converter is driven by a low impedance source, no external filter components are required. However, if the input power to the converter comes through long wires, it is recommended that a low ESR capacitor be placed across the input pins (see Figure 1). This capacitor will have the added benefit of extending the converters' hold-up time by approximately 5 µS per 100 µF. The use of "twisted pair" wires to connect the input of the converter to the power source will minimize common mode noise and reflected ripple.

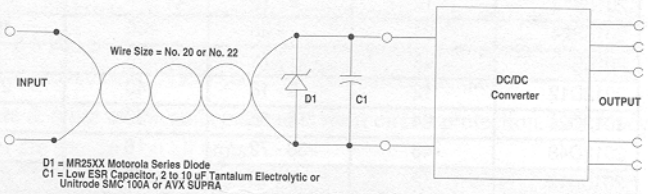


Figure 1

Input Line Protection; Overvoltage and Reverse Voltage: Although the **2000/2500** series includes internal protection circuits, it's recommended the user connect a IN62XX type diode and a slow-blow fuse as shown in Figure 2.

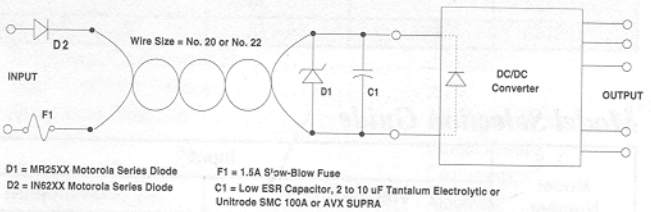


Figure 2

Parallel Operation (Optional): For applications that require higher power, up to five **2000/2500** converters can be connected in parallel (Figure 3). One of the five should be a "master" module while the others are "slaves". To connect the units for parallel operation, connect the sync pin (pin 4) of the master unit to the sync pins of the slaves. Also, connect the corresponding output pins together. For equal current sharing, the voltage outputs should be trimmed to within ±0.1%. Assuming all conductor runs from the converter have equal resistance, use the trim circuit shown to adjust each output to within ±1% of the required voltage. When operating in parallel, care must be taken in the physical placement of the converters. Do not place the converters such that air cannot circulate between them. This will avoid hot spots within the system.

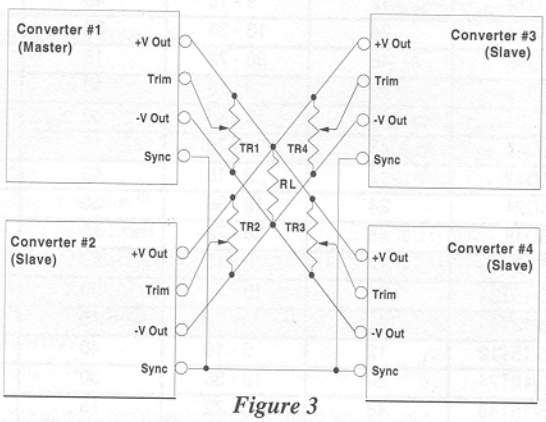


Figure 3

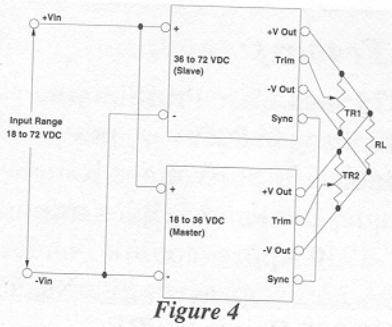


Figure 4

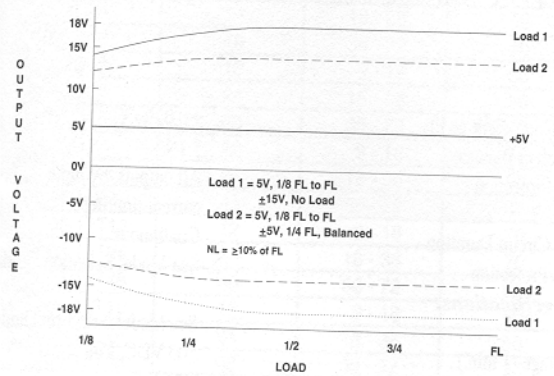
Cascaded Operation (Optional): A unique feature of these converters is that if the input voltage exceeds the specified upper limit, the PWM internally disables the switching transistors, but continues to operate. Taking advantage of this, two converters, (one a master and the other a slave) can be connected in a cascade configuration (Figure 4) to increase the input voltage range. In the example shown, the input network can withstand voltages up to 75 VDC. When the master unit stops functioning, the slave unit takes over, providing the user with continuous power over a 4:1 input voltage range.

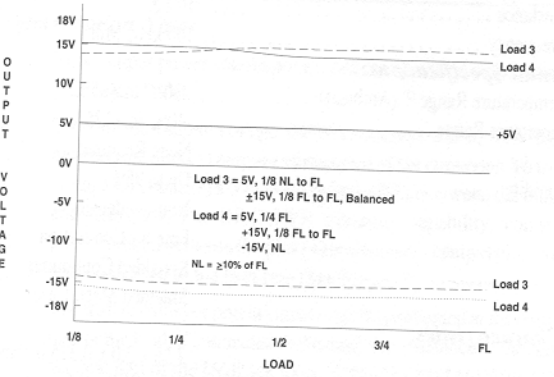
Note: Master and slave converters are factory selectable (to comply with switching frequency requirements). Ordering information:

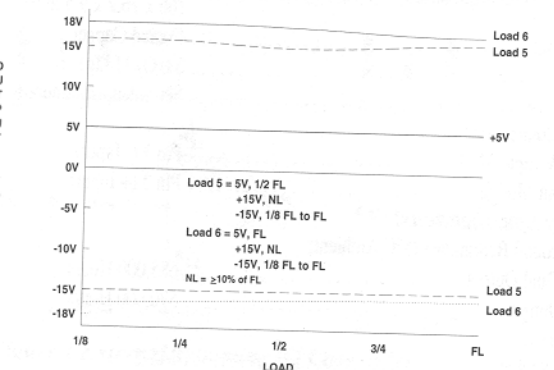
Master - Marked with suffix - M

Slave - Marked with suffix - S

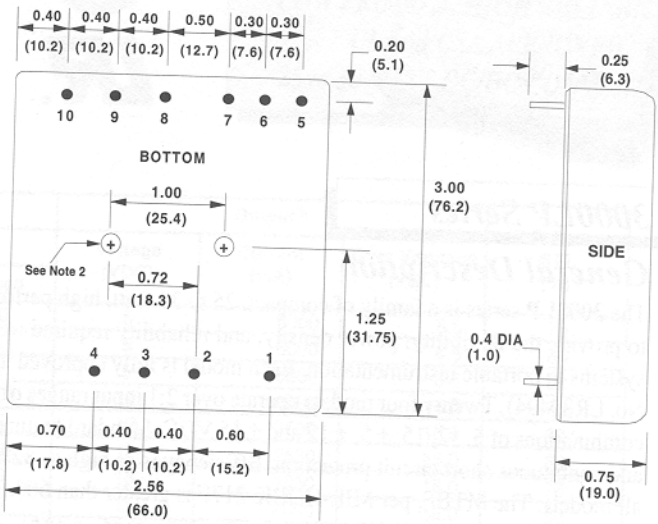
Triple Output Load Regulation







Mechanical Configuration:



Pin-out

Pin	Single Output	Dual Output	Triple Output
1	Remote On/Off	Remote On/Off	Remote On/Off
2	+ Input	+ Input	+ Input
3	- Input	- Input	- Input
4	Sync	Sync	Sync
5	+ Output Sense*	+ Output	+ Output (Aux)
6	Trim	Common	Common (Aux)
7	- Output Sense*	- Output	- Output (Aux)
8	+ Output*	Trim	+5V Output
9	- Output*	No Pin	-5V Output
10	No Pin	No Pin	Trim

Notes: 1. All dimensions are typical in inches (mm).
Tolerance: X.XX = ± 0.02, (± 0.5)
X.XXX = ± 0.010, (± 0.25)
2. Mounting inserts: 4-40X .10 (2.5) Deep

* **Connections for single output models without sensing or external trimming:** For proper operation, externally connect Pin 5 (+Output Sense) to Pin 8 (+Output) and Pin 7 (-Output Sense) to Pin 9 (-Output).

Simplified Block Diagram - Triple Output