5080 Application Notes

The 5080 series are radiation hardened, non-isolated, synchronous switching regulators.

Non-isolated DC-DC converters are three terminal devices, having an input terminal, an output terminal and a common terminal.

Non isolated DC-DC converters may be described as “buck” converters, or as “boost” converters. Buck converters generate an output voltage that is lower than the input voltage, while boost converters generate a voltage that is higher than the input voltage. Converters that produce a negative output voltage are boost converters, since the magnitude of the input voltage plus output voltage is always grater than the input voltage.

In simplest form, the buck or boost converter uses a FET, a diode and an inductor. The buck and boost converters are topologically similar, but differ in grounding arrangements.

In order to obtain a higher power efficiency, the rectifying diode in the non-isolated DC-DC converter is replaced with a second FET. The forward voltage drop of the diode is usually higher than the drop across the second FET, therefore power losses are lower. The FET must be switched in synchronism with the waveform that would appear across the diode. Therefore, DC-DC converters that use a second FET to perform the action of the diode are called synchronous rectification devices.

Simplified Block Diagram

The block diagram of the model 5080 shows that input power is applied to a power switch. The switch is driven at a 100 kHz. rate by the pulse width modulator (PWM) circuit.

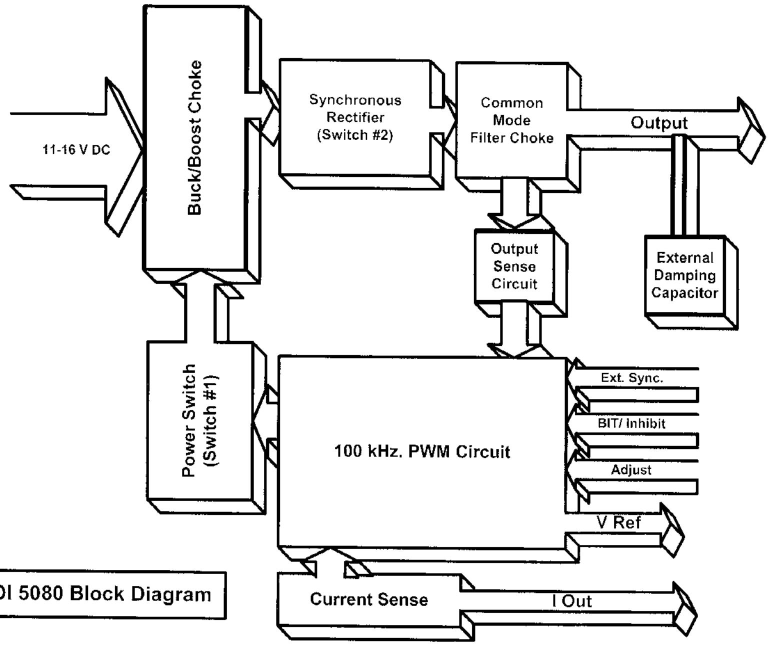
The switched waveform is then applied to the Buck/Boost choke. For the positive output models, the choke is connected between the power switch and the output load. For the negative output models, the choke is connected between the power switch and ground.

A second switch serves as the output rectifier. For the positive output models, the second switch is connected between the switch #1 output and ground. For the negative output models, the second switch is connected between the switch #1 output and the negative output.

The ripple filtered output passes through a common mode inductor to reduce output spike voltages. The external damping capacitor is supplied by the user to optimize load application and load removal transients, as well as to lower the output ripple.

The output voltage is passed through the output sense circuit, which permits voltage sensing directly at the 5080’s output pins for best static load regulation.

Input pins are provided for external sync (this can also be used for phase staggering of multiple 5080’s), an inhibit pin and a voltage adjust pin. Output pins include a 5 VDC voltage reference (for output voltage adjustment, a BIT analog output and a current telemetry output (useful in paralleling multiple converters).



MDI 5080 Block Diagram

Input Voltage Source:

The 5080 converters are intended to operate from an intermediate bus. This intermediate bus is a voltage of 11 to 16 VDC that is supplied by another, front end power converter. The front end power converter developing the intermediate bus is exposed to the bus variations and transients. Also, it is expected that the EMI filtering requirements of the system will be accommodated by the front end converter.

Therefore, the 5080 converters are rated strictly for the 11 to 16 VDC input range and also do not contain internal EMI filters.

Each fully loaded 5080 module can draw up to 1000 mA ripple current at its switching frequency of 100 kHz. Therefore, the front end DC-DC converter should provide appropriate decoupling capacitance to supply this maximum ripple current. A minimum decoupling capacitance of 30 microfarads (ceramic MLC or low ESR types) per 5080 module is recommended.

For most applications, an input voltage source that is nominally 12 VDC will provide the best electrical performance. A nominal 15 VDC source may also be used, however, the conversion efficiencies will be slightly lower.

Output Voltage:

There are nine 5080 models that produce a positive output voltage and three models that produce a negative output voltage. Output voltage types and adjustment ranges are shown on the 5080 data sheet.

Output Current:

Output current of the 5080 units is limited to 4 amperes or to the current produced at 10 watts output (considering the nominal output voltage), whichever is lower. The maximum output current is constant current limited.

External Output Capacitance:

Due to the small size of the 5080, the internal output capacitance is limited in value to that necessary for high frequency filtering. For good load transient response, the 5080 data sheet shows a recommended minimum and maximum external capacitance that should be supplied by the user or present in the user's load. The use of low ESR types, such as multiple solid Tantalum chips in parallel is encouraged, as ripple voltage will also be reduced.

Use of Output "OR"ing Diodes

Although it is perfectly safe to connect the outputs of two like converters together, some applications require the use of separate external diodes when connecting two or more redundant diodes to the same point.

When ORing diodes are used, there is an additional voltage drop. On Model 5080 units, the output can usually be adjusted upwards to compensate for the drop in the external diode.

Output Voltage Temperature Coefficients

Voltage limits for Model 5080 parts shown in the MDI data sheets are the nominal 25°C values. At temperatures outside 25°C, the output voltage may vary +/- 100PPM/°C maximum with base temperature.

Output Ripple

Due to its small size, the internal capacitance of the 5080 is limited. For good load removal and load application response, a minimum value of external capacitance is recommended.

When selecting external capacitors, low ESR solid tantalum capacitors are preferred. Capacitor leads with excessive series inductance should not be used, since this will add impedance and negate the benefit of the external capacitance. Relatively large amounts of external capacitance may be added, but do not exceed the data sheet guidelines without consulting MDI.

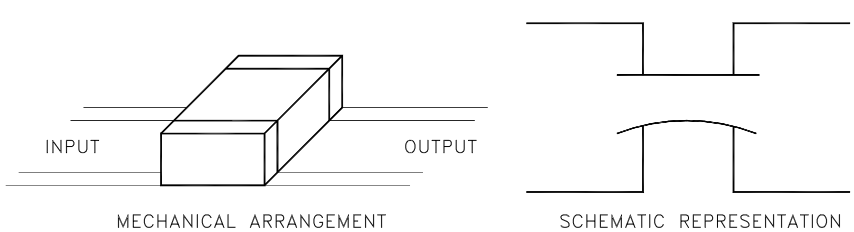


Figure 5
Four Terminal Capacitor
Method for Improved Filtering

To reduce high frequency spikes, multilayer ceramic capacitors in surface mount chip form can be used. For best results, the capacitor should be connected as a four terminal device (see illustration on previous page). An external series common mode inductor or ferrite beads can also be used between the converter and the capacitor.

Output Ripple Vs. Temperature

The fundamental output ripple of the 5080 converters is primarily dependent on the absolute capacitance value of the external output capacitors (when the output capacitors are multilayer ceramic types), or the ESR of the output capacitors (when the output capacitors are solid tantalum types). The selection of output capacitor depends on the output voltage and type of converter. However, the following effects occur at temperature. For units using ceramic output capacitors, the capacitance falls off sharply at high and low temperature extremes. Although the low ESR of ceramic capacitors results in very low ripple voltages, it is not unusual for ripple voltage to double at the high and low temperature extremes. For units using solid tantalum output capacitors, the ESR also rises sharply at low temperature extremes.

Therefore, users should conservatively assume a ripple temperature coefficient of 1% per °C increase over the 25°C base numbers.

Short Circuit and Overload Protection

Model 5080 DC/DC converters contain constant current limiting for protection against inadvertent output short circuits and overloads. The current limiting set point is approximately 125% of rated output current.

Output Over Voltage Protection

Model 5080 DC/DC converters do not contain any internal over voltage protection circuitry. If this function is required, it should be implemented externally by the user.

Output Load Transient response

The output load removal and load application transient voltage is a function of the external capacitance and the magnitude of the current step. The following table lists the magnitude of the output voltage transient for a 25% to 75% rated load change, with the minimum recommended external capacitance.

Nom.Vout	Ext C (min.), uF	Zout (ohms)	Delta V for 50% step	Ext C (max.), uF	Zout (ohms)	Delta V for 50% step
7.5	500	0.6146	0.4087	2000	0.3162	0.2103
5	500	0.302	0.302	2000	0.1577	0.1577
3.3	1000	0.2951	0.4426	4000	0.1119	0.1679
2.5	1000	0.1063	0.2127	4000	0.0557	0.1113
2	1000	0.1063	0.2127	4000	0.0557	0.1113
1.8	1000	0.1063	0.2127	4000	0.0557	0.1113
1.5	1000	0.1063	0.2127	4000	0.0557	0.1113
1.2	1000	0.1063	0.2127	4000	0.0557	0.1113
1	1000	0.1063	0.2127	4000	0.0557	0.1113
-3.3	1000	0.2951	0.4426	4000	0.1119	0.1679
-5	500	0.302	0.302	2000	0.1577	0.1577

Back Voltage

A back voltage may be applied to the output of the DC/DC Converter, whether it be energized or de-energized. Up to 20% above the output voltage rating may be applied.

Pin Functions

Pin 1 Positive Input Power (internally paralleled with pins 2 and 3)
Pin 2 Positive Input Power (internally paralleled with pins 1 and 3)
Pin 3 Positive Input Power (internally paralleled with pins 1 and 2)

Pin 4 Input/Output Common (internally paralleled with pins 5 and 6)
Pin 5 Input/Output Common (internally paralleled with pins 4 and 6)
Pin 6 Input/Output Common (internally paralleled with pins 4 and 5)

Pin 7 Output (internally paralleled with pins 8 and 9)
Pin 8 Output (internally paralleled with pins 7 and 9)
Pin 9 Output (internally paralleled with pins 7 and 8)

Pin 10 Case Ground

Pin 11 No Connect
Pin 12 No Connect

Pin 13 V ref : A nominal +5 VDC reference used for output voltage trimming

Pin 14 Adjust: Input pin used for voltage trimming and paralleling

Pin 15 I out: Signal proportional to output current, used for paralleling

Pin 16 Sync Input: Input pin used to accept external 100 kHz. sync signal

Pin 17 BIT: An analog output line indicating the module status

Pin 18 Inhibit: Ground to inhibit converter

Voltage Reference (Pin 13)

The voltage reference pin is primarily used for downward voltage adjustment of the output. However, it may also be used for other applications. Up to 10 milliamperes may be drawn by the user. This current, if used, is ultimately drawn from the input voltage.

Output Voltage Adjustment (Pin 14)

The adjust pin function (pin 14) allows the user to set the 5080 output voltage slightly above or below it’s initial set point. The recommended adjust range for each part type is listed in the data sheet.

When trimming for an increased output magnitude (of either polarity), the adjust resistor is connected to the common ground. When trimming for an decreased output magnitude (of either polarity), the adjust resistor is connected to the V ref pin (pin 13).

The adjust pin is connected to an internal 10K resistor, whose purpose is to prevent damage to the internal circuits and to reduce noise pickup.

The following table gives applicable resistor values for each 5080 type, as well as which equations to use to calculate the external adjust resistor value. For purposes of computing the external adjust resistor power dissipation, a maximum of 2.5 VDC appears across the external adjustment resistor.

If the external adjust feature is not used, both the adjust pin (14) and the V ref pin (13) should be left unconnected.

When the converter is adjusted upwards, the output power should be limited to 10 watts, or the output current should be limited to 4 amperes, whichever is lower.

Vout	R1	R2	R3	Equation for Upward Adjust	Equation for Downward Adjust
7.5	20K	10K	10K	Equations 1A and 3	Equations 2A and 3
5	10K	10K	10K	Equations 1A and 3	Equations 2A and 3
3.3	16K	50K	10K	Equations 1A and 3	Equations 2A and 3
2.5	10K	Infinity	10K	Equations 1A and 3	Equations 2A and 3
2	10K	50K	10K	Equations 1B and 3	Equations 2B and 3
1.8	10K	35.7K	10K	Equations 1B and 3	Equations 2B and 3
1.5	10K	25K	10K	Equations 1B and 3	Equations 2B and 3
1.2	10K	19.23K	10K	Equations 1B and 3	Equations 2B and 3
1	10K	16.67K	10K	Equations 1B and 3	Equations 2B and 3
-3.3	16K	50K	10K	Equations 1A and 3	Equations 2A and 3
-5	10K	10K	10K	Equations 1A and 3	Equations 2A and 3

Equation 1A $$\frac{V_{Adj}-2.5}{R_1}=\frac{2.5}{R_2}+\frac{2.5}{R_4}$$

Equation 1B $$\frac{2.5-V_{Adj}}{R_1}=\frac{2.5}{R_2}-\frac{2.5}{R_4}$$

Equation 2A $$\frac{V_{Adj}-2.5}{R_1}=\frac{2.5}{R_2}-\frac{2.5}{R_4}$$

Equation 2B $$\frac{2.5-V_{Adj}}{R_1}=\frac{2.5}{R_2}+\frac{2.5}{R_4}$$

Equation 3 $$R_{Adj}=R_4-10k$$

Output Current (Pin 15)

An analog of the output current is provided in pin 15. This is useful in paralleling applications.

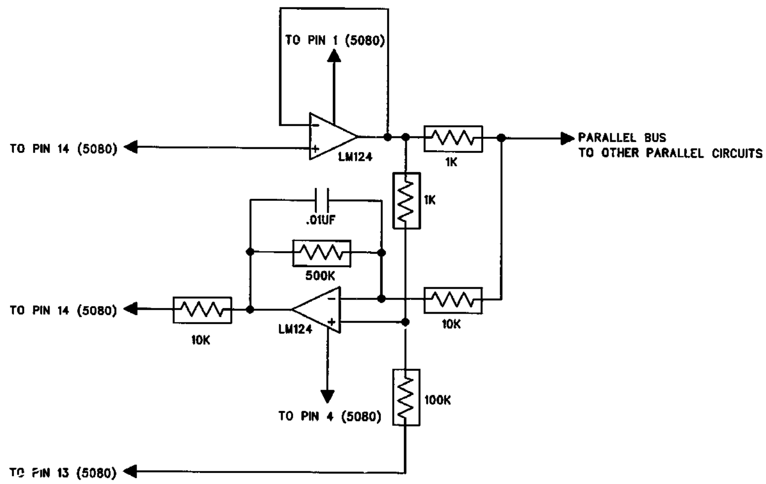
Connecting 5080 Units in parallel for higher output current

The outputs of like converters may be connected in parallel without damage. However, they will not share the output load to any determinate extent without some external ballasting resistance or external circuitry. A suggested circuit for forcing current sharing of two or more 5080 DC/DC converters is shown. This circuit may be extended to multiple converters.

Model 5080 Pin 15 millivolts per ampere scaling

Nom.Vout	Vin=12 VDC	Vin=15 VDC
7.5	205	164
5	136	109
3.3	90	72
2.5	68	55
2	55	44
1.8	49	39
1.5	41	33
1.2	32	26
1	27	22
-3.3	90	72
-5	136	109

Figure 2
Active Parallel Circuit



Sync Input (Pin 16)

Pin 16 is the Sync Input. The 5080 hybrid operates at approximately 95 kHz and may be synchronized to frequencies from 95 to 105 kHz. The sync input pulse should meet the following levels as shown in the diagram. The sync input should sit at nominal 5 VDC and transition to ground level at a 10% ± 1% duty cycle. It should be noted that the internal oscillator runs at the switching frequency. Other frequencies are also available on special order. Contact MDI's Sales and Marketing Department for other sync frequencies.

Synchronizing the power conversion units within an extremely sensitive system ensures that any noise generation is coincident with the system clock.

If two or more 5080 units are used, a phase staggered sync signal may be applied in order to reduce the overall input and output ripple.

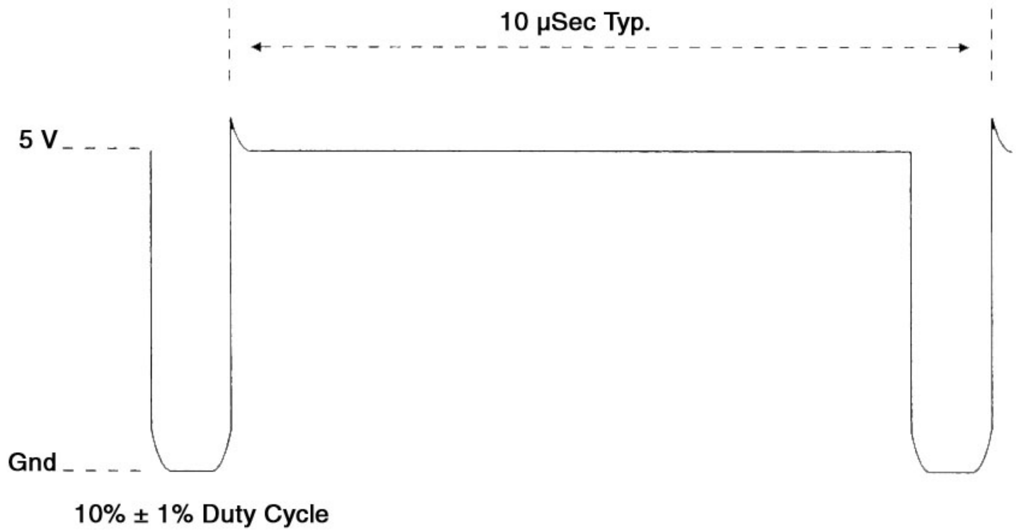


Figure 10
Typical Sync
Waveform

The "sync pin" should be left open if unused.

BIT (Pin 17)

Pin17 is the BIT pin. The BIT signal is an analog signal which is the buffered output of the internal PWM error amplifier. The source impedance of the BIT line is approximately 50K ohms.

The normal voltage range of the BIT line is 0.9 VDC to 3.3 VDC. A voltage lower or higher than these values indicates that the internal regulating loop considers the output voltage to be too high or too low, respectively.

The BIT line may be connected to an external comparator window detector to produce a discrete BIT signal.

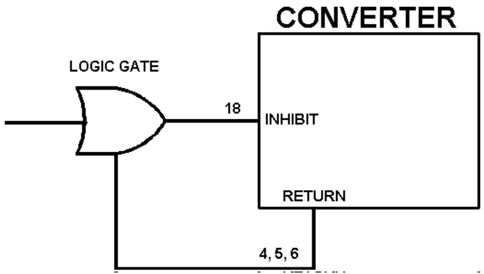
Inhibit (Pin 18)

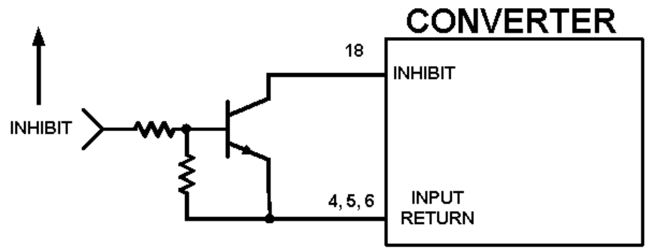
Pin18 is the Inhibit pin. To inhibit the output voltage, the inhibit input should be returned to the common ground pins, within 0.5 VDC. When the inhibit pin is connected to the common ground, the inhibit current is approximately 1 milliampere.

An open collector transistor may be use to actuate the inhibit. However, the inhibit pins may be safely connected to any positive voltage up to 16 VDC. Therefore, the inhibit pins may also be safely driven by standard 3.3 or 5 VDC logic devices.

When not inhibited, pin 18 should either be floating or returned to a voltage higher than 3.3 VDC.

Inhibit Circuits
Preferred Circuit Interface for Inhibit





5080 Heat Removal and Mounting Recommendations

The Model 5080 Hybrid DC/DC Converters are power supplies that are fabricated with bare die as compared to using packaged parts. Elimination of the intermediate packages allows the size of the 5080 DC/DC Converter to be dramatically reduced. All internal parts are mounted on ceramic substrates that are well attached to the baseplate of the package.

Heat can be transferred by conduction (heat flow through solid material), convection (heat flow through air movement) and radiation to a cooler surrounding. Model 5080 DC/DC Converters are designed to be cooled by conduction cooling from the baseplate, which is commonly known as heat sinking.

The maximum heat is dissipated by a 5080 DC/DC converter under full load normal operating conditions is 2.5 watts. Dissipation may increase when the part is short circuited or overloaded. The operating efficiency may drop when the part is lightly loaded compared to full load ratings.

The 5080 DC/DC Converters are rated at a maximum of 125C baseplate temperature. It is the responsibility of the user to assure that the baseplate temperature of the converter does not exceed the rated value. The power dissipation of the elements is concentrated in a number of small areas. However, the thickness of the substrate and hybrid package do a good job of spreading the heat over the hybrid base plate area. In order to get the maximum benefit out of the hybrid, or maximum reliability, the surface on which the hybrid is mounted must be maintained at or below the hybrid's rated temperature. If the heat sink below the hybrid is very thin, the area under the DC/DC Converter's baseplate will be hotter than necessary. A thin heat sink may not conduct heat away from the hybrid very well. If the heat sink is very thick and connections to the DC/DC Converter's pins are difficult to wire, the heat sink may be locally counter bored in the vicinity of the pins.

Some Common Application Mistakes:

Running the 5080 hybrid DC/DC Converter without a heat sink: This is occasionally done during incoming inspection. The hybrid DC/DC Converter's small thermal mass allows the temperature to rise rapidly to high temperatures that may exceed the DC/DC Converter's rating.

Trying to use a printed wiring board as a heat sink: A printed wiring board or copper traces on the printed wiring board will conduct heat. However, the thermal resistance may be very high. Special types of boards that have higher thermal conductivity are available. The mistake made in this instance is in using a printed wiring board as a conductive heat path, but not computing the thermal resistance of this path to the heat sink.

Connecting a heat sink to the top of the case: The top of the case is typically quite thin and only attached to the baseplate at the periphery of the baseplate. Therefore, heat is conducted from the baseplate to the case, however, the thermal resistance is less than optimum. This results in an unsatisfactory part utilization.

Using a heat sink that is too small or too thin: The temperature drop from the baseplate to the ultimate heat sink is too high because the thermal resistance is too high for the power flux and the desired temperature rise through the heat sink. Therefore, the converter operates at an unsatisfactorily high baseplate temperature.

Trying to cool by convection or radiation in thin air or vacuum: The following true anecdote illustrates this point. A customer mounted a DC/DC Converter for a space application on a printed wiring board. The board was mounted inside a unit and extensively tested. The converter operated perfectly until the customer performed a thermal vacuum test. The converter then failed. The unit was disassembled and examined. It was apparent that the DC/DC Converter had been exposed to extremely high temperatures. While operating at normal atmospheric pressure, the converter was cooled by free convection to some extent. When the atmosphere was removed for the thermal vacuum test, the heat removal provided by free convection was not available, and the converter overheated.

In high altitude aircraft applications, the air available for free convection is also practically nil, therefore to be conservative, all conduction should be designed to be satisfied by conduction cooling.

Controlling the temperature of the mounting, not the base plate of the DC/DC Converter: The heat of the baseplate of the DC/DC Converter is the controlling variable for controlling the temperature of the internal components. Controlling the heat of the mounting surface alone is not sufficient. Moreover, as heat flows from the DC/DC Converter through to the underlying heat sink, the temperature of the underlying heat tends to be increased by the heat flux. This must be accounted by the analysis.

Mounting on a non-flat surface: Both the hybrid DC/DC Converters and the underlying mounting surfaces tend to have irregularities. Therefore, the tendency would be that contact between the DC/DC Converter and the mounting surface is only made at a few points. This results in a higher than desirable thermal resistance. The way to improve this situation is to use a thermal gap filler. This can be a high thermal conductivity grease or a high thermal conductivity silicone rubber pad. Since the case of the DC/DC Converter is usually electrically isolated from the internal circuitry, the gap filler does not need to be electrically isolating. In fact, the gap filler should be as thin as possible but still fill in the irregularities. Excess gap filler will raise the temperature.

When securing the hybrid to the cooling surface, use adequate pressure to minimize the thermal resistance from the hybrid DC/DC Converter to the mounting surface. It is always the responsibility of the user to insure that the bottom of the hybrid's mounting surface is maintained at a safe temperature.

BROOKHAVEN R&D PLAZA • ONE RONED ROAD • SHIRLEY, NEW YORK 1196?
Tel 1-888-MDI-POWER • 631-345-3100 • Fax 631-345-3106
Web www.mdipower.com • E-mail sales@mdipower.com