Model 73635 Inrush Limiter
Application Notes

The 73635 series comprises single channel normally open, radiation hardened, positive leg, non-isolated, current limited inrush limiters using MDI's patented 100K+ (™) technology. These parts are intended to control the power input and inrush current when series connected ahead of downstream DC-DC converters, which typically have relatively high values of input capacitance.

This series has four variations for input voltage. Model numbers are prefixed with a 5, 7, 8 or 9 denoting 28, 50, 70 and 100VDC nominal input variants respectively. They coordinate with all popular satellite bus voltages and harmonize with MDI's comprehensive line of 100K+™Proton Rad Hard DC-DC converters. The information in this application note that references model 73635 applies to all models in the series.

The 73635 has two types of inputs: the power bus input, and an inhibit input. Similarly, there are two types of outputs: the power bus output and the inhibit output. The inputs and outputs are sequenced to first provide initial power application and then inhibit the downstream converters on.

When the inhibit input to the 73635 is un-asserted, the power bus output is inhibited and the inhibit output is un-asserted. When the inhibit input of the 73635 is released, the power bus output turns on, at a limited current. The inhibit output remains un-asserted during the turn on interval until the output power bus is fully saturated at which time it changes state. This function allows the downstream DC-DC converters to be sequenced by the inrush limiter so that the converters are not released from inhibit until their input capacitors are charged and the power bus has reached steady state values.

Referring to the block diagram, a nominal 15VDC bias voltage is developed relative to the positive input rail.

This bias voltage powers a constant current error amplifier. The input signal for the error amp is derived from a precision shunt on the output of the inrush limiter. The limit is factory set to 4 amperes, but a provision is afforded the user to adjust it via an external trim resistor. The current gain of the amplifier is largely invariant over line, load, temperature, radiation and life.

An undervoltage lockout is provided so that the output will not start until the lower limit of input voltage range is reached. This ensures that the bus is within operating range before downstream converters begin drawing current. A slight hysteresis is built in to prevent chatter.

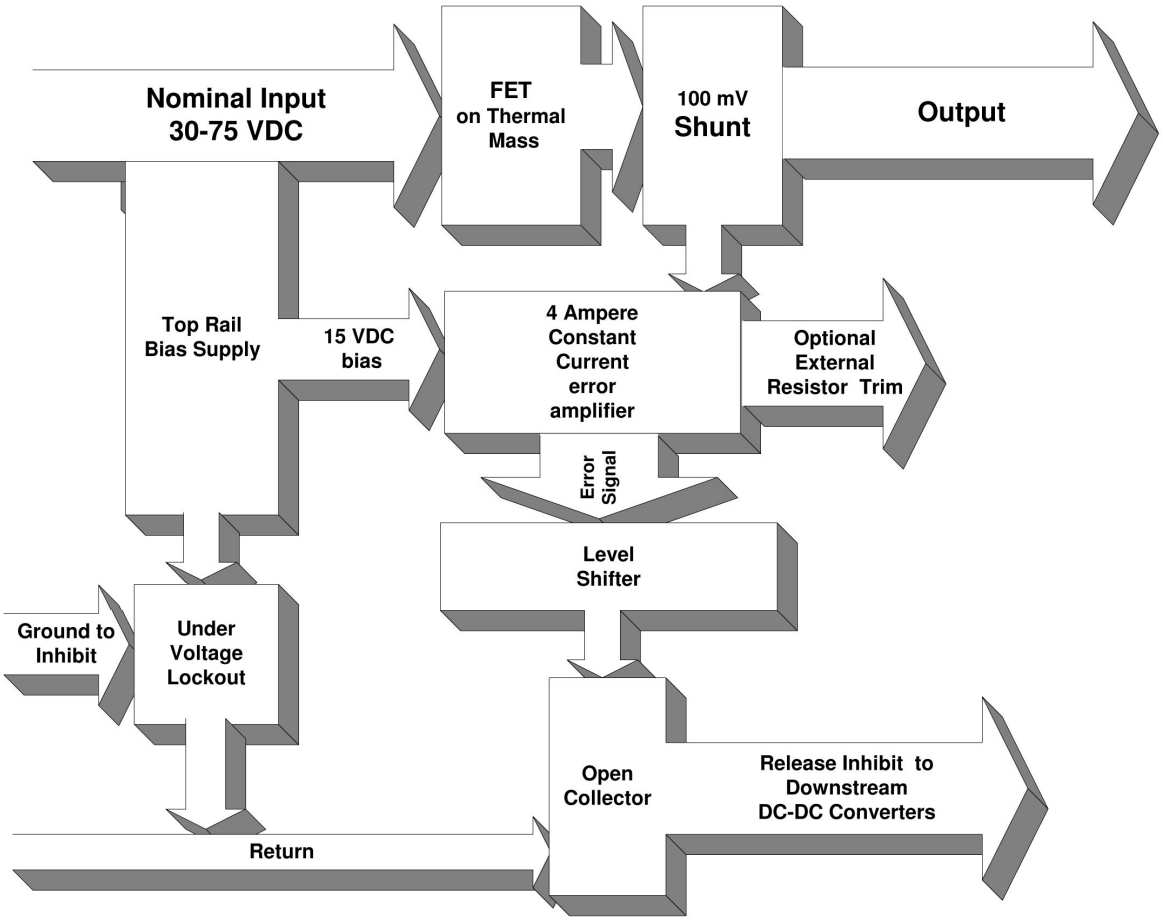
An inhibit interlock is provided for downstream converters so that they remain inhibited OFF until the inrush to their input capacitors is completed. This reduces current surges and minimizes dissipation in the inrush limiter FET, itself fully saturated before downstream converts begin active switching. The error signal of the constant current amplifier is level shifted to ground as the FET achieves saturation, releasing the clamp on the open collector inhibit output transistor.

An important feature of the 73635 inrush limiters is their user selectable output current limit via external resistor. The resistor should be connected between the Rext pin and either power input

pin. With the external resistor open, the output current limit is the tabulated value. With a 4K external resistor, the current limit is reduced to 50% of the tabulated value. This feature permits peak output current to be tailored to application requirements and user preference.

Superior stress derating is achieved by close coupling the Inrush Limiter FET to an intrinsic thermal mass. The energy pulse to charge capacitive loads, described as $1/2CV^2$ divided by the time constant, can create significant thermal dissipation in the FET. Close thermal coupling to the intrinsic mass integrates the temperature rise effects in the FET caused by transient power dissipation.

Simplified Block Diagram



Pin Functions

Pin 1	NC
Pin 2	NC
Pin 3	NC
Pin 4	Case Ground
Pin 5	NC
Pin 6	NC
Pin 7	NC
Pin 8	Input Inhibit Not
Pin 9	Inhibit Common Return
Pin 10	Output Inhibit Not
Pin 11	NC
Pin 12	Rext (Connect resistor to pins 17,18)
Pin 13	NC
Pin 14	Output
Pin 15	Output
Pin 16	NC
Pin 17	Input
Pin 18	Input

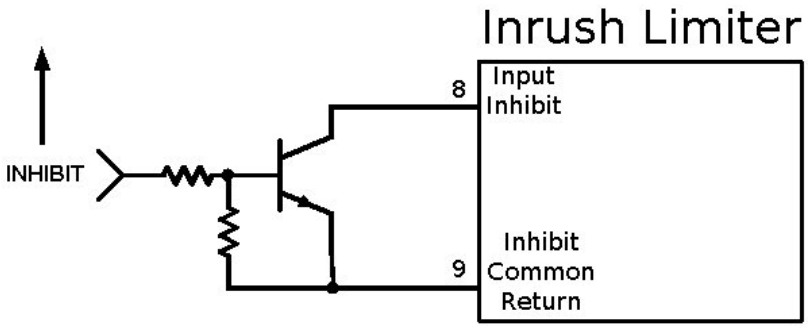
Pin 8 is the Input Inhibit pin; pin 9 is the common return

To inhibit the output voltage, the inhibit input should be connected to the common ground pins, within 0.5 VDC. When the inhibit pin is connected to the common ground, the inhibit current is approximately 100 microamperes.

An open collector transistor may be used to actuate the input inhibit.

Connect pin 9 to input return.

Input Inhibit Circuit
Preferred Circuit Interface for Input Inhibit



Pin 10 is the Output Inhibit pin

Pin 10 is connected to the downstream converter(s) inhibit not input pin. Pin 10 asserts the converters on after the inrush interval is complete and the power bus has reached steady state range.

Pins 17 and 18 are the Input pins to the 73635 Inrush Limiter
Pins 13 and 14 are the Output pins

The FET switch in the 73635 is polarized and the positive input pins should be connected to the positive external circuit point. A body diode is internally connected in the reverse direction. The current rating of the body diode is the same as the switch current rating.

Pin 12 is Rext
Connecting a resistor between pin 12 and pin 17 or 18 limits the output current of the inrush limiter. As much as 4K ohms may be added for a 50 percent reduction in tabulated values of output current. This function permits the user to program the current limit and thus, the output rise time into any given capacitive load.

73635 Ratings:

The 73635 inrush limiter ratings and characteristics are as described in the table below;

Model Number	Application Bus Voltage	Application Input Voltage Range	Maximum Recommended Input Voltage	Absolute Maximum Input Range	Current Limit	Undervoltage Lockout	Initial On Time	Leakage Current at Max Recommended Input Voltage	Volt Drop at Rated Current	Quiescent Current at Nominal Input
	Vdc	Vdc	Vdc	Vdc	A	V	µSec	µA	V	mA
93635	100	80-120	120	-0.6-200	1.5	75	500	20	1	2.5
83635	70	55-90	120	-0.6-200	1.5	55	350	20	1	2.5
73635	50	30-75	75	-0.6-100	4	28	250	200	0.5	3.5
53635	28	18-50	75	-0.6-100	4	20	250	200	0.5	3.5

- Application Bus Voltage in the commonly available satellite bus voltage ranges. These ratings harmonize with the input voltage ranges for MDI 5000, 7000, 8000 and 9000 series converters.
- Maximum Recommended Input Voltage is the maximum factory recommendation considering single event radiation effects.
- Absolute Maximum Input Range - No damage.
- Current Limit - Maximum limit current.
- Undervoltage Lockout - minimum nominal value.
- Initial On Time - Typical values, via Inhibit Input release.
- Leakage Current at Max Recommended Input Voltage OFF State - Typical values.
- Volt Drop - Maximum values at limit current.
- Quiescent Current at Nominal Input - Typical values, input inhibit not asserted.

Power Dissipation:

Total steady state power dissipation of the model 73635 package is limited to 4 watts.

Turn on Time with External Load Capacitance

Turning on into a capacitance causes an inrush current. However, the controlled output current of the model 73635 limits this inrush current. The turn on time will depend on the output load capacitance and the rated output current of the 73635, as adjusted by the external current program resistor (if used).

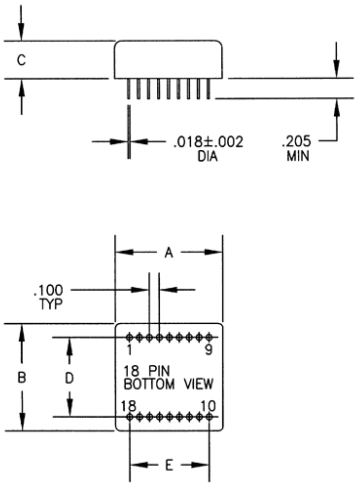
Short Circuit and Overload Protection

Model 73635 inrush limiters provide constant current limiting for protection against inadvertent output short circuits and overloads. However, the duration of the short circuit or overload should be limited by thermal constraints.

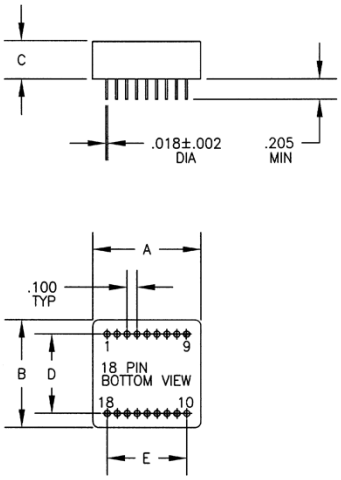
73635 Heat Removal and Mounting Recommendations

See MDI application notes on mounting considerations for DC/DC Converters.

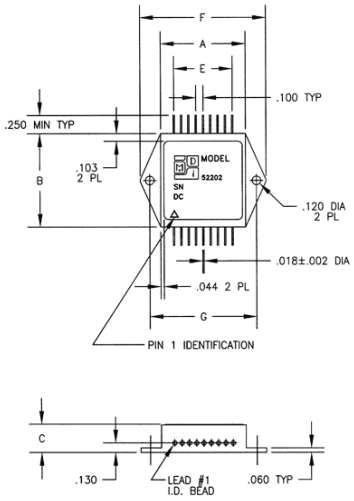
Case Style 1



Case Style 14



Case Style 15



Model No.	Case Style	Pin Count	Mounting
*3635	1	18	Solder Sealed Flangeless PCB Mount
*3635 D	14	18	Seam Weld Flangeless PCB Mount
*3635 TF	15	18	Seam Weld Chassis Mount with Flange

Case Dimensions

Units: inches | millimeters

Case Style	A	B	C	D	E	F	G
1	1.080 | 27.432	1.080 | 27.432	0.380 | 9.652	0.800 | 20.320	0.800 | 20.320	— | —	— | —
14 D	1.090 | 27.686	1.090 | 27.686	0.380 | 9.652	0.800 | 20.320	0.800 | 20.320	— | —	— | —
15 TF	1.160 | 29.464	1.283 | 32.588	0.380 | 9.652	— | —	0.800 | 20.320	1.754 | 44.552	1.460 | 37.084

Pin Out Chart

Pin 1	N/C	Pin 7	N/C	Pin 13	N/C
Pin 2	N/C	Pin 8	Input Inhibt Not	Pin 14	Output
Pin 3	N/C	Pin 9	Inhibit Common Rtn.	Pin 15	Output
Pin 4	Case	Pin 10	Output Inhibit Not	Pin 16	N/C
Pin 5	N/C	Pin 11	N/C	Pin 17	Input
Pin 6	N/C	Pin 12	Rext	Pin 18	Input

Part Numbering System

The model 73635 part numbering system is similar to that used with MDI DC/DC converters For example:

73635 SE-TF

73635= Model number for a 50 VDC nominal Inrush Limiter
SE= grade (available as EU, R,S, RE and SE)
TF= Seam welded chassis mount package with flange (also available in D and case style 1 packages)

Specifications

Static Characteristics:

Voltage Drop see table
I limit max see table
V input see table
Leakage current at Voff see table
Quiescent Bias Current 15 mA typical

Inhibit Input Circuit Current 1 mA typical at 5 VDC
Control Trip Point 1.5 VDC nominal
Inhibit Output: Drives up to 4 MDI DC-DC Converters

Isolation, All pins to Case 500 VDC

Operating temperature Range –55C to 85C (R or S) or 125C (RE or SE)
Storage temperature Range -65C to 150C
Steady State Power Dissipation 4 watts

Total Ionizing Dose 100K^{+} ™
SEE 82 MEV*CM^2/mG

MODULAR DEVICES, INC.
ONE RONED ROAD • SHIRLEY, NEW YORK 11967
WWW.MDIPOWER.COM • FAX 631.345.3106 • TEL 631.345.3100