Using the **78SR** Series Integrated Switching Regulator **(ISR)**

The Integrated Switching Regulator (ISR) by Power Trends is a complete switch-mode power regulator capable of delivering regulated voltages at currents up to 1.5 Amps. The ISR utilizes current mode control in a Buck regulator topology operating at a nominal frequency of 650 kHz.

Input Source Requirements Power Trends' 78/79 Series ISR does not incorporate a "soft start" circuit. This may result in large transient voltages briefly appearing at the output of the ISR (usually less than 100 µsec) when it is first turned on. To prevent this situation from harming voltage-sensitive loads, a 5 watt zener diode, 1N53xxB or equivalent, should he placed across the output terminals of the TSR. This zener will also provide effective over-voltage protection for the load. Also, an electrolytic capacitor can be placed across the input terminals to reduce the amount of "upstream" ripple. In applications with large load transients, a 78ST series ISR will provide improved transient response.

Ripple and Noise Typically, the 78SR105 has an output ripple/noise of 50mVpp (@I_o= 1 .5 Amp, V_{in}=+8VDC). This output ripple/noise increases with increasing input voltage. To reduce the amount of output ripple/noise, additional output capacitance may he added directly at the terminals of the ISR Adding a 1µF ceramic capacitor will decrease the output ripple/noise by 3 3%. Capacitors (electrolytic or other) placed at least 2" away from the ISR will not affect its operation.

Over-Current Protection Two independent output current detection circuits protect the ISR from damage if the output is over-loaded or shorted. The first circuit limits the output current to a maximum of 2 to 3 Amps. The second circuit shuts down the ISR if the peak output current reaches 3.5 Amps. The unit will automatically restart 10µsec after the over-load or short-circuit condition is removed.

Minimum Input Voltage Unlike a linear regulator w-here the output voltage decreases as V_{in} decreases, 78/79 Series ISRs have a minimum input voltage threshold. The control IC inside the package will not operate below an input voltage of +6 VDC. Above V_o+2 (V_o+2.5 for + 12VDC and above) the output voltage will be the specified output voltage and extremely well regulated. (See Minimum V_{in} Graphs)

Using the **78ST** Series Fast Transient Response **ISRs**

The 78ST Series ISRs are designed to have extremely fast transient response for use in application5 with large and/or fast changes in output current such as **disk** drives, relays, LED's, etc. These units are designed to use a 100µF electrolytic or tantalum capacitor on the output. This capacitor is necessary for stable operation.

The transient response to large load changes is excellent. The overshoot or undershoot from a fast load change (less than 10µsec) of0.5 Amps to 1.5 Amps is less than ± 150 mV. The recovery time to within 1% of the nominal output voltage is typically 100µs.

Efficiency and output ripple voltage is the same as the 78SR Series of ISRs. The addition of the 100µF electrolytic capacitor on the output has a negligible effect on reducing output ripple. Additional output capacitors may be added to the output as long as they are located a minimum of 1" away from the unit.

Suggested OVP Zener Diodes **for 78/79** Series **ISRs**

The 78SR1, 78ST2, 78HT2, and 78ST3 ISRs require an over-voltage protection (OVP) zener diode on the output to prevent turn-on overshoot. The table below lists the appropriate zener voltage and suggested zener diode part number. We recommend the 1N53xxB series because of its surge current rating.

Table 6

SUGGESTED OVP **ZENER DIODES (D1)**

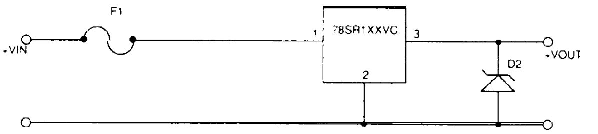
ISR output Voltage	Required **Zener** Voltage	**Suggested Zener P/N**
5.0V	5.6V	1N5339B
5.25V	6.0V	1N5340B
6.0V	6.8V	1N5342B
7.15V	8.2V	1N5344B
8.0V	9.1V	1N5346B
9.0V	10V	1N5347B
10.0V	11V	1N5348B
12.0V	14V	1N5351B
13.9V	16V	1N5353B
15.0V	17V	1N5354B

Power Trends, Inc. 1101 North Raddant Road, Batavia, IL 60510 (800) 531-5782 Fax: (70X) 406-0901

Vehicular Power Adapter Using ISRs

The Power Trends' Integrated Switching Regulators (ISRs) can be used in vehicular power adapter applications with the addition of one external component (excluding the fuse and casework). The basic circuit diagram is shown below.

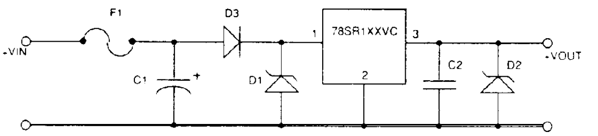
***Figure** 8*



***D2** - Prevents over-voltage to the load when it is first plugged in and in case of a fault. The ISR requires up to a few milliseconds to begin regulating when power is first applied. We recommend you use a 1N53xxB series zener diode with zener voltage about 0.5 to 1.0 volts greater than the output voltage. This zener diode is required across the output of the ISR.*

Since vehicular eiectical power is somewhat hostile toward electronic circuitry, you might want to consider using a more conservative approach by including a few additional components. These optional components are shown in the schematic diagram below. The decision to acid these components should be based on the projected use assumptions of the consumer versus the incremental costs.

Figure 9



Optional Component Notes:

***C1** - The ISR draws its current in 650 kHz pulses and too much series inductance from the vehicular wiring may cause it to "ring". We suggest you use a 10µF/35V electrolytic capacitor on the input. This capacitor will also reduce the "upstream" conducted noise into the vehicle's electrical system.*

***D1** - This component will prevent damage from vehicular "load dumps" and spikes above 28 volts. We suggest you use a 1N5362B (28 volt) zener diode or an equivalent over-voltage protection device. This component may be eliminated if the maximum input voltage to the unit will not exceed 30 volts.*

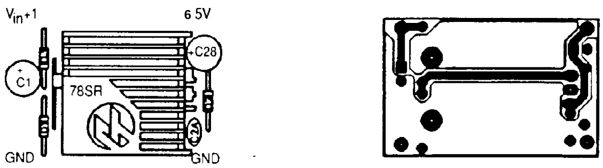
***C2** - The ISR has about 75mVpp of ripple @ 650 kHz on the output. If it is necessary to reduce this output ripple, use a couple of 1µF ceramic capacitors. Adding 2µF to the output will attenuate the ripple down to about 25mVpp. If the end equipment has a battery installed and it is on-line, the battery makes an excellent filter.*

***D3** - This diode will prevent damage to the unit in case the input polarity is reversed. Any general purpose 1 Amp diode will do, such as a 1N4001. If polarity reversal is not a cause of concern, or you don't mind the fuse being blown under this condition, then it does not need to be included.*

Below is a proposed PC board layout for the circuitry shown below (Figure 10). The layout is shown close to actual size (1.0" x 1.55"). A scale drawing of this layout is available from Power Trends.

***Figure** 10*

COMPONENT SIDE | ***SOLDER** SIDE*



(If D3 is not installed, a wire jumper must be substituted.)

78/79 Series ISR Thermal Considerations

The 78/79 Series Integrated Switching Regulator (TSR) is protected from thermal overload by an internal over-temperature shutdoun circuit. The ISR will operate at ambient temperatures as high as 85°C, but requires derating ofeithcr the input voltage and/or output current to do so, as shown in the ISR derating graphs. Additional cooling air or heatsinking, as described below, will significantly decrease the amount of this derating. Power dissipation in the ISR is directly related to the magnitude of the input voltage and/or output current as shown by the efficiency curves on the data sheet.

Thermal Shutdown Sequence When the junction temperature of the custom IC used in the ISR reaches 135°C. the ISR turns itself off. The ISR will automatically restart when the junction temperature cools to 120°C. In an extreme environment, where the ambient temperature is too high for the input voltage/output current operating point, the ISR will cycle on and off continuously.

PC Board Considerations The data used to develop the derating graphs was obtained using a 2oz. single-sided printed circuit board with a foil layout as shown in Figure 11. An internal copper leadframe provides excellent heat transfer to the leads. By simply increasing the copper area of the PC board attached to the leads, such as shown in Figure 1 I, the ISR will conduct a significant amount of heat out through the leads using the PC board copper as a heatsink.

78 & 79 ISR Series

Figure 11

RECOMMENDED PC BOARD LAYOUT FOR ISR

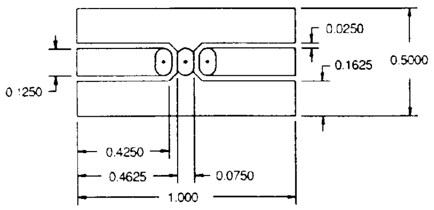


Figure 12

MEAN TIME BETWEEN FAILURES

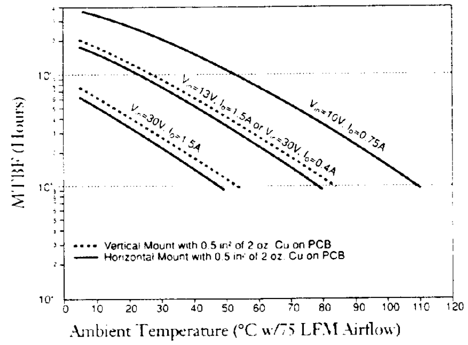
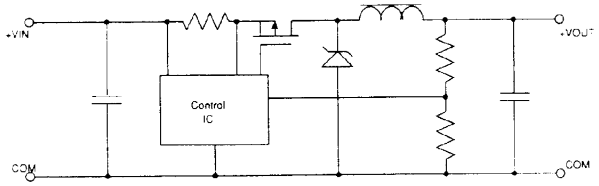


Figure 13

78SR SERIES ISR BLOCK DIAGRAM



Airflow Considerations The 40 to 60 LFM noted on the derating graphs is just enough airflow to keep the air surrounding the ISR at a constant temperature, but not enough to cool it. Increasing the airflow will increase the operating range of the ISR. Airflow above 100 LFM across the ISR will dramatically improve the ambient temperature characteristics of the ISR.

Junction Temperature Vs Operating Temperature The internal junction temperature of the components is dependent on the operating environment and condition. The temperature rise between the internal IC and surrounding ambient air, without heatsinking, is 45°C/Watt of internally dissipated power. This number decreases significantly when the ground lead and the optional horizontal mounting tab are soldered to 3 to 5 square inches of copper in the ground plane. This provides an effective heatsink for the ISR and will substantially decrease its junction temperature and thereby increase its reliability.

78/79 Series ISR Reliability

Power Trend's 78/79 Series (ISRs) are designed for long reliable operation by using conservative derating factors and integral over-current and over-temperature protection. The ISR circuit utilizes a "buck" regulator topology, as shown in Figure 13. The calculations used to determine the Mean Time Between Failure (MTBF) are based on MIL-STD-217F, and are conservative. Under normal operating conditions, the ISR has a calculated MTBF of over 1,000,000 hours.

Demonstrated MTBF

Empirical verification of the computed MTBF has continued since product introduction with no failures in over 1,500,000 device hours of operation with a 24 volt input and a load of 1.5 Amps.

Construction The 78/79 Series ISR is an assembly of 12 surface mount components and one integrated magnetic inductor mounted on a printed circuit board made from FR-4 material. A tin-plated, copper leadframe is soldered to the opposite side of the PC board using a high temperature solder. This leadframe is used for the power connections to the ISR. This assembly is then mounted into a nylon case molded from high-temperature 30% glass filled-nylon #4-6, which is resistant to all solvents except 1,1,1 trichlorethane.

Components All of the components used in the ISR are shown in Table 7. The components are the highest quality commercial/industrial parts available. Also shown are the components' operating characteristics and stress factor(s) when operating a +5 VDC ISR with an input voltage of +30VDC and an output current of 1.5 Amps. This is the worst-case operating stress that the unit will experience.

Calculations MIL-STD-217F formulae and tables were used to generate the graph of MTBF versus ambient temperature shown in Figure 12. The environmental conditions are assumed to be ground benign. The quality factor derating multiplier for commercial, plastic case components was used.

Power Trends, Inc. 1101 North Raddant Road, Batavia, IL 60510 **(800) 531-5782** Fax: (708) 406-0901

Table 7

78SR SERIES 1.0 AMP ISRs SAMPLE STRESS EVALUATION

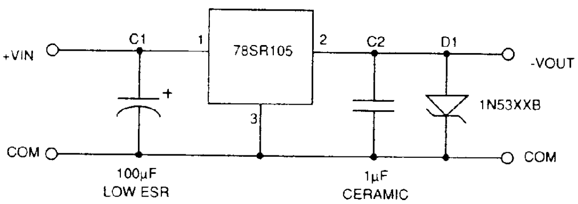
Description	Device Rating	Maximum Operating Condition	Stress Factor
Input Capacitor	50 VDC	30 VDC	0.600
Output Capacitor	25 VDC	5 VDC	0.200
Stability Capacitors	50 VDC	2.5 VDC	0.050
Output Rectifier	40 VDC 5A Avg	30 VDC 1.2A Avg	0.750 0.240
Power Transistor	50 VDC 9.9 ADC 40A Pulse 42W	30VDC 2A Peak 0.79W	0.600 0.050 0.020
Voltage Divider and Frequency Resistor	100 VDC 62.5 mW	2.5 VDC 0.125 mW	0.025 0.002
Current Sense Resistor	200VDC 125 mW	0.25 VDC 35 mW	0.001 0.280
Inductor	150°C	—	—
Custom IC	40 VDC	30 VDC	0.750

Positive Input/Negative Output ISRs

In applications with input voltages greater than 7V, the 78SR1 series ISR can also be configured as a "buck-boost" converter, as shown in Figure 14, to produce a negative output voltage from a positive voltage source with up to 5 watts of output power.

Figure 14

BUCK-BOOST CONFIGURATION



Input Voltage Range The maximum allowable voltage across the internal circuitry is equal to the absolute difference between V_{in} and V_{out} which is limited to 30 volts. The maximum input voltage is shown in the table below. The minimum input voltage in all cases is +7VDC.

Table 8

SPECIFICATIONS

Part Number	V_o (Volts)	Max V_{in} (Volts)	Max I_o (Amps)
78SR105□C	-5.0	+25	1.000
78SR109□C	-9.0	+21	0.500
78SR112□C	-12.0	+18	0.400
78SR115□C	-15.0	+15	0.300

Part Number	Efficiency* (%)	Ripple* (mVpp)
78SR105□C	71	170
78SR109□C	79	75
78SR112□C	78	75
78SR115□C	77	50

*@ V_{in}=10V, I_o=Max.

External Components A low ESR electrolytic capacitor (C1), typically 100µF, must be added to the V_{in} bus. A maximum of 5µF (C2) of ceramic capacitance can be added to the output of the ISR. Also, a 1N53xxB zener diode should be added as shown in Fig. 14 to the output for over-voltage protection. The ISR in this configuration has the same over-temperature and over-current protection as when used as a step-down regulator.

Efficiency In the "buck-boost" configuration, the efficiency of the ISRs is lower than when used as a step-down regulator. This is due to the increased voltage and current across the internal circuitry.

Graphs of efficiency, ripple and noise, minimum input voltage, power on characteristics, and power dissipation are shown on the following page for the -5, -12, and -15V applications.

78 & 79 ISR Series

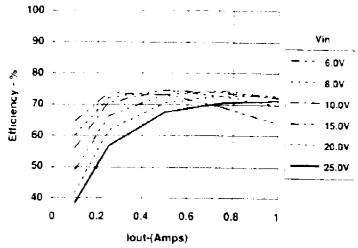
Buck Boost Configuration (+V_{in} to -V_{out})

CHARACTERISTIC DATA

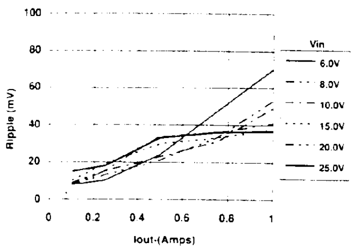
78SR105, -5.0 VDC

(See Note 1)

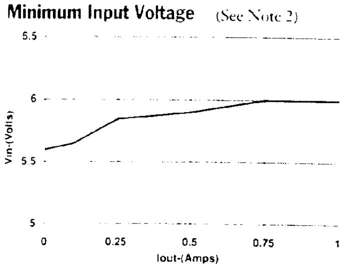
Efficiency vs Output Current



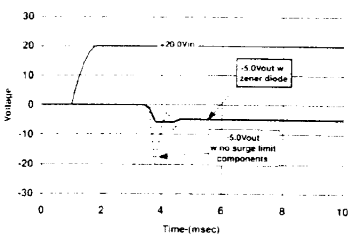
Ripple vs Output Current



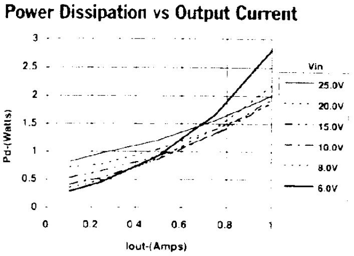
Minimum Input Voltage (See Note 2)



Power On vs Output Voltage (See Note 4)



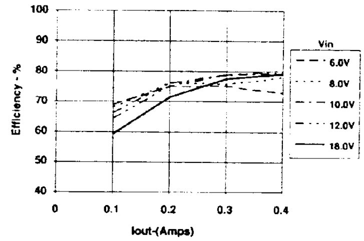
Power Dissipation vs Output Current



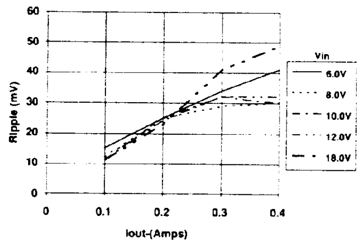
78SR112, -12.0 VDC

(See Note 1)

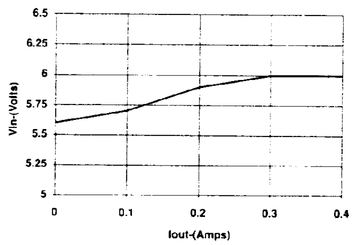
Efficiency vs Output Current



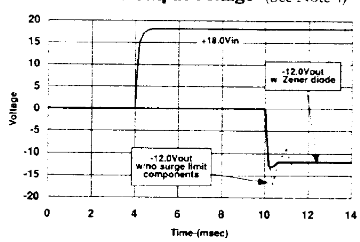
Ripple vs Output Current



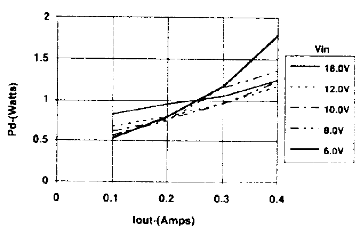
Minimum Input Voltage (See Note 2)



Power On vs Output Voltage (See Note 4)



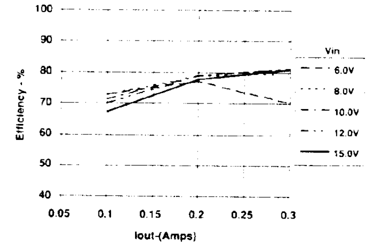
Power Dissipation vs Output Current



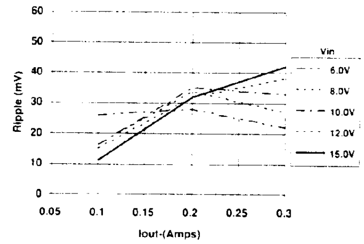
78SR115, -15.0 VDC

(See Note 1)

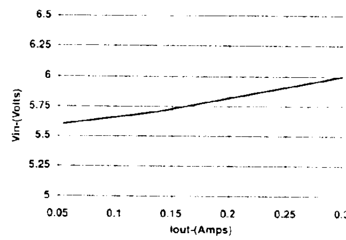
Efficiency vs Output Current



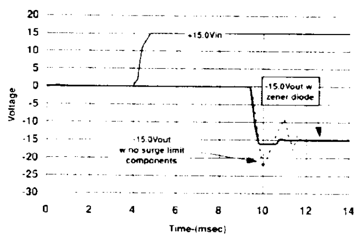
Ripple vs Output Current



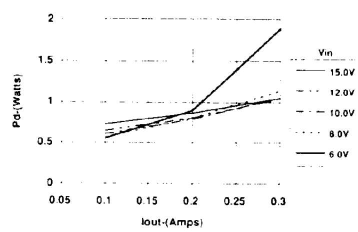
Minimum Input Voltage (See Note 2)



Power On vs Output Voltage (See Note 4)



Power Dissipation vs Output Current



Note 1: *All data listed in the above graphs, except for derating data, has been developed from actual products tested at 25°C. This data is considered typical data for the ISR.*
Note 2: *Minimum V_{in} data is the input voltage required to initiate conduction of the ISR in a Free Ambient Convection 25°C environment.*
Note 3: *Current overshoot indicated are typical conditions encountered during the start up mode of the ISR.*
Note 4: *Output Voltage overshoot-(more negative)-is typical with applied power-on for this V_{in} Charges to V_{in} and I_{out} will have similar V_{out} deviations. (See Zener Diode Applications note).*

Power Trends, Inc. 1101 North Raddant Road, Batavia, IL 60510 **(800) 531-5782** Fax: (708) 406-0901

ISR Qualification Process

Introduction All new Power Trends ISRs (Integrated Switching Regulators) go through a rigorous qualification process before they are introduced into production. The qualification process includes electrical design characterization and verification testing, mechanical package integrity testing, and environmental endurance testing. The tests are designed to meet customer requirements and industry standards for sub-assemblies. All of the environmental testing is performed according to industry standard test procedures (see tables 11, 12, and 13). Electrical testing is performed to verify compliance with Power Trends' published specifications.

Electrical design characterization and verification includes tests for efficiency, ripple, current limit, loop stability, and thermal derating. The ISRs are evaluated at room temperature, and at the lowest and highest operating temperatures listed on the data sheet . Typical evaluation temperatures are -40°C, 25°C and 70°C.

Mechanical qualification consists of mechanical shock and vibration testing and characterization. The mechanical shock test is performed with the test units clamped in a fixture. This test is designed to simulate an ISR during shipping or mishandling. The mechanical vibration test is performed with the test units soldered into a PC board. All mounting configurations and package styles are tested: Vertical Through Hole, Horizontal Through Hole, and Surface Mount.

Environmental endurance testing consists of thermal shock, humidity and accelerated life testing. The thermal shock testing cycles the ISRs in a shuttle temperature chamber from maximum temperatures of 125°C to minimum temperatures of -40°C at 15 minute intervals for 100 cycles. Thermal shock tests the assembly integrity of the components and ensures that there are no stress defects which would cause the product to fail over time.

Humidity testing determines a product's resistance to moisture and resulting corrosion. The humidity test is carried out in a 70°C environment with the test units operating from their maximum input voltage while supplying a minimum load current. Units are subjected to 85% relative humidity for 240 hours. Accelerated life tests determine a product's long term reliability. The accelerated life test operates the ISRs at maximum input voltage, full load current, and the highest ambient temperature possible without thermal shutdown for a period of 1,000 hours.

Qualification Similarities Although all ISRs are individually electrically tested, in other tests, a representative product may be tested for the group. For mechanical testing, every unique package is tested. For environmental and ESD testing, the PT6100 ISR is tested for all PT6000 and PT5000 ISRs and the 78ST105 is tested for all the 78 and 79 ISRs because their electrical specifications, component types and construction are virtually the same. Table 9 summarizes the various qualification tests.

Table 9

Test	Criteria
Electrical Design Verification and Characterization	All ISR Products
Mechanical Qualification	Every unique package style
Environmental Endurance	Representative circuit designs
ESD	Representative circuit designs

Electrical Qualification and Testing Electrical qualification and testing is performed to verify the product design and to create detailed characteristic information on the product. Every new Power Trends product is tested and qualified to a qualification test procedure based on the product's electrical specification.

The process has tests and procedures for measuring efficiency, ripple voltage, current limit, short circuit current, transient load response, response to step input, minimum input voltage, and thermal derating. Each test is detailed in Table 10.

Table 10

ELECTRICAL TESTS

Test	Description
Efficiency	Characterize the efficiency across the range of minimum input voltage to maximum input voltage, from minimum rated output current to maximum rated output current.
Ripple Voltage	Characterize the output ripple voltage across the range of minimum input voltage to maximum input voltage, from minimum rated output current to maximum rated output current.
Current Limit	Record the output current point at which the output voltage drops by 1% at input voltages from minimum to maximum.
Short Circuit Current	Measure the magnitude of the output current with dead short placed across the output at input voltages from minimum to maximum.
Transient Load	Measure the magnitude of the over/undershoot when the load changes from 50% of maximum rated to 100% of maximum rated at input voltages from minimum to maximum. Measure the time from start of over/undershoot to recovery within 1%.
Hot Start	Measure the amount of overshoot present on the output voltage when a step input is applied to the product over current and input voltage ranges. Measure time from application of the step input to regulated output voltage.
Min Input Voltage	Measure the minimum input voltage for regulated output voltage across rated current range.
Thermal Shutdown	In a thermal chamber with 40-60 LFM of regulated airflow determine the max current/voltage operating point before thermal shutdown.

Mechanical Qualification and Testing Mechanical testing is performed on every product packaging type. The testing is designed to verify the package integrity when the product is exposed to a mechanical shock or when the product is used in a vibration environment.

All Products

All Products

Mechanical shock testing extensively evaluates the package's ability to endure repeated shocks in each axis. This testing is performed with the product mounted in a test fixture per the methods listed in Table 11. The parts are electrically tested before and after being shocked.

Mechanical vibration testing is performed to characterize the maximum level at which the package style will survive without mechanical damage. This test is performed with the leads soldered into a 0.062" thick PCB. The levels of vibration are incrementally increased until the product fails. Once a failure occurs, new product is tested starting at the previous failure level. If it passes, vibration is increased until succesive new products fail at the same level, which is recorded.

Table 11

MECHANICAL QUALIFICATION TESTS

Test	Method	Conditions	# Units
Mechanical Shock	MIL-STD-883D, Method 2002.3	Condition A, 50G peak, 1 mSec, Half Sine, 5 Shocks, 2 directions, 3 axis, (30 shocks total)	3
Mechanical Vibration	MIL-STD-883D, Method 2007.2	Condition A, 4 four minute sweeps each axis, 20 to 2000 Hz logarithmically	3

Environmental Endurance Qualification and Testing

Environmental endurance testing is performed on each different package. The testing is designed to demonstrate the product's ruggedness and reliability. The products are electrically tested before and after each of the following tests.

The thermal shock test subjects the products to 100 cycles of -40°C to 125°C of thermal stress. A 15 minute dwell time is used to assure that the parts internally reach the set temperature. The ISRs are not powered.

The humidity test is carried out in a humidity chamber with 85% relative humidity and a chamber temperature of 70°C for 240 hours or 10 days. Maximum input voltage and minimum output loading are present on the units.

The accelerated life test is performed in a high temperature environment. The applied input voltage/ambient temperature is as high as possible to avoid thermal shutdown. The ISRs are loaded to the maximum output current listed on the data sheet.

Table 12

ENVIRONMENTAL ENDURANCE TESTING

Test	Method	Conditions	# Units
Thermal Shock	MIL-STD-202F, Method 107	100 cycles, -40°C to +125°C, 15 minute dwell time	38
Humidity	MIL-STD-202F, Method 103	85% Rel. Humidity (Non-condensing), 70°C Ambient, 240 Hours, Vin=Vmax, Iout=Imin	38
Accelerated Life	MIL-STD-202F, Method 108	1000 Hours, 60°C ambient, Vin=Vmax, Iout=Imax	38

Characterization Testing Products are characterized as to their Electrostatic Discharge, ESD, breakdown level using the guidelines of MIL-STD-883D. Each pin is subjected to multiple shocks until 5000 Vdc or failure occurs. The parts are electrically tested before and after each voltage level.

Table 13

ESD QUALIFICATION TESTS

Special:

Test	Method	Conditions	# Units
ESD	MIL-STD-883D, Method 3015	High Voltage Breakdown Method, all pins until fail or 5000 volts maximum	3

Qualification Results

PT5000 SERIES (PT5101, PT5102, PT5103)

Test	Standard	Description	# Tested	# Defects	Result
Electrical Qualification and Characterization	PTI Qualification Spec. #82-00140	Efficiency, Ripple, Current Limit, Minimum Input Voltage, Thermal Derating	2 Each Type	0	Pass
Mechanical Shock	MIL-STD-883D, Method 2002.3	Condition A, 50G peak, 1mSec, Half Sine, 5 Shocks, 2 Directions, 3 Axis, (30 Shocks Total)	3	0	Pass
Mechanical Vibration: Horizontal, Vertical Surface Mount	MIL-STD-883D, Method 2007.2	Condition A, 4 four minute sweeps each axis, 20 to 2000 Hz logarithmically	3	0	Pass (5 G's)
Thermal Shock	MIL-STD-202F, Method 107	100 cycles, -40°C to +125°C, 15 minute dwell time	38	0	Pass*
Humidity	MIL-STD-202F, Method 103	85% Relative Humidity (Non-condensing), 70°C Ambient, 240 Hours, Vin=Vmax, Iout=Imin	38	0	Pass*
Accelerated Life	MIL-STD-202F, Method 108	1000 Hours, 60°C ambient, Vin=Vmax, Iout=Imax	38	0	Pass*
Electrostatic Discharge Sensitivity	MIL-STD-883D, Method 3015	High Voltage Breakdown Method, all pins until fail or 5000 volts maximum	3	0	Pass** 5 KV**

* Actual product tested was PT6101   ** Actual product tested was 78ST105

Power Trends, Inc. 1101 North Raddant Road, Batavia, IL 60510 (800) 531-5782 Fax: (708) 406-0901

All Products

Qualification Results

PT6000 SERIES (PT6101, PT6102, PT6103, PT6202, PT6203, PT6204, PT6302, PT6303, PT6304)

Test	Standard	Description	# Tested	# Defects	Result
Electrical Qualification and Characterization	PTI Qualification Spec. #82-00140	Efficiency, Ripple, Current Limit, Minimum Input Voltage, Thermal Derating	2 Each Type	0	Pass
Mechanical Shock	MIL-STD-883D, Method 2002.3	Condition A, 50G peak, 1mSec, Half Sine, 5 Shocks, 2 Directions, 3 Axis, (30 Shocks Total)	3	0	Pass
Mechanical Vibration: Horizontal, Vertical Surface Mount	MIL-STD-883D, Method 2007.2	Condition A, 4 four minute sweeps each axis, 20 to 2000 Hz logarithmically	3	0	Pass (15 G's)
Thermal Shock	MIL-STD-202F, Method 107	100 cycles, -40°C to +125°C, 15 minute dwell time	38	0	Pass*
Humidity	MIL-STD-202F, Method 103	85% Relative Humidity, (Non-condensing), 70°C Ambient, 240 Hours, Vin=Vmax, Iout=Imin	38	0	Pass*
Accelerated Life	MIL-STD-202F, Method 108	1000 Hours, 60°C Ambient, Vin=Vmax, Iout=Imax	38	0	Pass*
Electrostatic Discharge Sensitivity	MIL-STD-883D, Method 3015	High Voltage Breakdown Method, all pins until fail or 5000 volts maximum	3	0	Pass 2 KV*

* Actual product tested was PT6101

PT6305 SERIES (PT6305, PT6306, PT6307, PT6308)

Test	Standard	Description	# Tested	# Defects	Result
Electrical Qualification and Characterization	PTI Qualification Spec. #82-00140	Efficiency, Ripple, Current Limit, Minimum Input Voltage, Thermal Derating	2 Each Type	0	Pass
Mechanical Shock	MIL-STD-883D, Method 2002.3	Condition A, 50G peak, 1mSec, Half Sine, 5 Shocks, 2 Directions, 3 Axis, (30 Shocks Total)	3	0	Pass
Mechanical Vibration: Horizontal, Vertical Surface Mount	MIL-STD-883D, Method 2007.2	Condition A, 4 four minute sweeps each axis, 20 to 2000 Hz logarithmically	3	0	Pass (15 G's)
Thermal Shock	MIL-STD-202F, Method 107	100 cycles, -40°C to +125°C, 15 minute dwell time	38	0	Pass*
Humidity	MIL-STD-202F, Method 103	85% Relative Humidity, (Non-condensing), 70°C Ambient, 240 Hours, Vin=Vmax, Iout=Imin	38	0	Pass*
Accelerated Life	MIL-STD-202F, Method 108	1000 Hours, 60°C Ambient, Vin=Vmax, Iout=Imax	38	0	Pass*
Electrostatic Discharge Sensitivity	MIL-STD-883D, Method 3015	High Voltage Breakdown Method, all pins until fail or 5000 volts maximum	3	0	Pass 2 KV*

* Actual product tested was PT6101

78S SERIES (78SR1, 78ST1, 78HT2, 79SR1)

Test	Standard	Description	# Tested	# Defects	Result
Electrical Qualification and Characterization	PTI Qualification Spec. #82-00140	Efficiency, Ripple, Current Limit, Minimum Input Voltage, Thermal Derating	2 Each Type	0	Pass
Mechanical Shock	MIL-STD-883D, Method 2002.3	Condition A, 50G peak, 1mSec, Half Sine, 5 Shocks, 2 Directions, 3 Axis, (30 Shocks Total)	3	0	Pass
Mechanical Vibration: Horizontal, Vertical Surface Mount	MIL-STD-883D, Method 2007.2	Condition A, 4 four minute sweeps each axis, 20 to 2000 Hz logarithmically	3	0	Pass (10 G's)
Thermal Shock	MIL-STD-202F, Method 107	100 cycles, -40°C to +125°C, 15 minute dwell time	38	0	Pass*
Humidity	MIL-STD-202F, Method 103	85% Relative Humidity, (Non-condensing), 70°C Ambient, 240 Hours, Vin=Vmax, Iout=Imin	38	0	Pass*
Accelerated Life	MIL-STD-202F, Method 108	1000 Hours, 60°C Ambient, Vin=Vmax, Iout=Imax	38	0	Pass*
Electrostatic Discharge Sensitivity	MIL-STD-883D, Method 3015	High Voltage Breakdown Method, all pins until fail or 5000 volts maximum	3	0	Pass 5 KV*

* Actual product tested was 78ST105

All Products

EMI Considerations for DC to DC Converters and Integrated Switching Regulators

Electromagnetic energy, whether intentionally or unintentionally generated, results in Electromagnetic Interference (EMI) with other equipment. Power Trends' products are designed to minimize the amount of electromagnetic energy produced during normal operation. The permissible level of conducted and radiated EMI generated by any end product is regulated by a number of governing bodies throughout the world. Their function is to insure Electromagnetic Compatibility (EMC) of all electronic equipment. To assist designers with compliance in the U.S. and European markets, Power Trends has designed and tested its products to several important standards. The table below shows a comparison of several key standards that define radiated emissions levels.

Table 14

Specification	Frequency Limits (MHz) Lower	Upper	Radiated Emissions Limit for Class A (Industrial Equipment) dB(μV/meter) @ 10 meters	Radiated Emissions Limit for Class B (Unrestricted Use) dB(μV/meter) @ 3 meters
FCC (CFR)	30	88	39.1	40.0
Title 47,	88	216	43.5	43.5
Part 15,	216	960	46.4	46.0
Subpart B	960	1000	49.5	54.0
Bellcore	.01	.024	88.6	139
NWT-TR-	.024	.80	56.2 - 20log (f)	87.6 - 20log (f)
001089	.80	1.59	58.2	108.7
Electric Field	1.59	4.77	66.2 - 40log (f)	—
Strength	4.77	88	39.1	—
	1.59	20.17	—	97.6 - 40log (f)
	20.17	88	—	40.0
	88	216	43.5	43.5
	216	960	46.4	46.0
	960	10000	49.5	54.0
CISPR 22	30	230	40	30*
Electric Field	230	1000	47	37*
Strength				
VDE 0871	.01	1	—	171.5 - 20log (f)
Magnetic	1	30	—	94.1 - 7.1log (f)
Field Strength				
VDE 0871	30	470	—	34*
Electric Field	470	1000	—	40*

* Limit @ 10 meters

Note: The conversion factor for 10 meter intensity to 3 meter intensity is 20log (10/3) or10.5dB(μV/meter)

Power Trends' products are carefully designed to minimize the amount of conducted and radiated EMI. All printed circuit board layouts are designed to minimize trace lengths and subsequent parasitics. Consideration is taken to eliminate ground loops and to control circuit rise times which are major contributors to radiated emissions. High-frequency ceramic capacitors are used on the input and the output to minimize conducted emissions. Thorough end-product testing is used to verify designs as electromagnetic compatible.

The following tables summarize the results of Power Trends' products tested in accordance with the above agency specifications. These tests were conducted by an independent test laboratory at an FCC approved open field test site. The results given here are for specific products that were chosen to be representative of a given product series. Since their circuit layouts are identical, the results for individual products within a series will not vary substantially.

PT3100 Series – The PT3100 series was qualified for EMI by testing a PT3101A at nominal input voltage and full output current. All products in the PT3100 series use the same PCB layout and magnetic components design.

Table 15

Specification	Test Results	Conditions
FCC (CFR) Part 15	Pass Class B	Electric Field tested at 10 meters
NWT-TR-001089	Pass Class B	Magnetic Field tested at 3 meters Electric Field tested at 10 meters
CISPR 22	Pass Class B	Electric Field tested at 10 meters
VDE 0871	Pass Class A Pass Class B	Magnetic Field tested at 3 meters Electric Field tested at 10 meters

78ST1 Series – The 78ST1 series was qualified for EMI by testing a 78ST105VC at nominal input voltage and full output current. All products in the 78ST1 series use the same PCB layout and magnetic component design.

Table 16

Specification	Test Results	Conditions
FCC (CFR) Part 15	Pass Class B	Electric Field tested at 10 meters
CISPR 22	Pass Class B	Electric Field tested at 10 meters
VDE 0871	Pass Class B	Magnetic Field tested at 3 meters Electric Field tested at 10 meters

PT6100 Series – The PT6100 series was qualified for EMI by testing a PT6101N at nominal input voltage and full output current. All products in the PT6100 series use the same PCB layout and magnetic component design.

Table 17

Specification	Test Results	Conditions
FCC (CFR) Part 15	Pass Class B	Electric Field tested at 10 meters
CISPR 22	Pass Class B	Electric Field tested at 10 meters
VDE 0871	Pass Class B	Magnetic Field tested at 3 meters Electric Field tested at 10 meters

Although these results indicate a sound product design, radiated and conducted EMI must still be considered in the application of these products. Long traces and signal loops act as antennae that can easily receive and transmit high levels of EMI. When possible, use a multilayer board with a ground plane since this can add as much as 20dB of high frequency attenuation above a 2-sided board. Component location and routing should be checked and appropriate bypass capacitors should be selected. EMI filters and shielded cables are important when running long cables. Realizing its existence and understanding how emissions are generated and suppressed can greatly assist in improving reliability and reducing development costs, while complying with agency requirements.

Using the PT3100/4100 Series 15-Watt Isolated DC-DC Converter

The PT3100/4100 Series of 15W Isolated DC-DC Converters from Power Trends are designed for Industrial, Telecom, Computer, Medical and other distributed power applications requiring input to output isolation. These high power density converters are capable of delivering a regulated 15 watts of output power at 5, 9, 12, and 15 volts DC with a wide input voltage range. The overall dimensions of the regulator are 1.64" x 1.45" x 0.38" (H). The PT3100/4100 Series can deliver its full rated load over an operating ambient temperature range of -20° to +70°C or -40° to +85°C.

The key features of the PT3100/4100 Series are:

- Power Density of 15 Watts/In^3
- 2:1 Input Voltage Range
- Operating Temperature Range of -20° to +70°C (PT3100) or -40° to +85°C (PT4100)
- Efficiency > 80% @ full load
- Excellent Line and Load Regulation
- Short Circuit Protection
- Over-Temperature Protection
- 500 VDC or 1500 VDC Isolation
- Laser Trim adjustments for Output Voltage, Switching Frequency, and Current Limit
- Fixed Switching Frequency
- Remote ON/OFF Control
- Planar Magnetics
- Complete Surface Mount Assembly
- MTBF > 1,000,000 Hours
- Fast Transient Response

In view of these key features, the PT3100/4100 Series can be used in all distributed power applications requiring input to output isolation. Also, its electrical isolation allows the input or output to be configured for either positive or negative DC voltages.

Input Source Requirements The PT3100/4100 Series Isolated DC-DC Converter can operate from a variable or semi-regulated DC source. The DC source should be capable of supplying the necessary peak and inrush current requirements (1A for 5 µsec) to operate. Although the PT3100/4100 Series has a 1.5µF capacitor as an input filter, "upstream" ripple, reflected ripple current, and conducted RFI can be reduced to a lower level by adding a small LC filter at the input terminals.

Ripple and Noise Typically, the PT3101A (48/5V) Converter produces output ripple/noise of 50 mV pp at its maximum rated load. The output ripple/noise increases with increasing output load current. To reduce the amount of output ripple/noise, additional output capacitance may be added directly at the output terminals. However, care should be taken in the selection of a capacitor, because it may affect the stability of the Converter. Ceramic capacitors of 1µF to 4.7µF are the preferable choice.

Over-Temperature Protection When the internal junction temperature of the custom control IC in the Converter reaches 125°C, the PT3100/4100 Series will automatically shut down. It will automatically restart when the junction temperature cools below 115°C. In an extreme environment, where the ambient temperature is too high for the input voltage/output current operating point, the Converter will cycle on and off continuously at a frequency as high as 2 to 3 kHz.

Over Current Protection Two independent output current detection circuits protect the PT3100/4100 Series from any damage if the output is overloaded or shorted. Due to its current mode control and laser trimming of the current sense resistor, a precision current limit operating point is set. During an overload condition, the output voltage and duty cycle are reduced. When a short-circuit or very low impedance condition, such as a shorted capacitor, is present, the Converter operates at a very narrow duty cycle to limit its internal power dissipation. The Converter will automatically resume normal operation after the overload or short circuit condition is removed.

Reliability The reliability of the PT3100/4100 Series is calculated to be 401 FIT using the parts count method from the Bellcore specification TR-NWT-000332.

Remote ON/OFF This feature allows the PT3100/4100 Series to turn off or start up with external control by using an external open collector NPN transistor or mechanical switch. The Converter turns off when the voltage at the remote on/off pin is 0.8V or less with respect to the negative input pin. The Converter operates normally when the remote on/off pin is left floating. The remote on/off pin can also be used to provide an input over-voltage or under voltage lockout function. On/Off control inputs require a rise time of less than 10µsec.

PC Board Considerations The PT3100/4100 Series is encapsulated in a thermally conductive epoxy compound which provides heat transfer to the metal case. An internal copper leadframe provides excellent heat transfer to the leads of the Converter. By simply increasing the PC board copper area attached to the leads, a significant amount of heat will be conducted away, effectively using the PC board copper as a heatsink. For better thermal performance, it is recommended that the printed circuit board utilize 2 oz. copper traces.

Isolated DC-DC Converters

Adding Undervoltage Lockouts to the PT3100/4100 Series

Power Trends' PT3100/4100 Series Isolated DC-DC Converters are designed to operate over an input voltage range of 36 to 72 or 18 to 40 VDC. If the rise time of the input voltage source is very slow, a few hundred milliseconds for instance, the PT3100/4100 Series will draw excessive current during start-up as long as the source voltage is less than the minimum rated voltage. In these situations, an undervoltage lockout circuit can be added as shown in Figure 15 below.

Circuit Operation When the input voltage is below the zener voltage of D1, the remote ON/OFF pin is pulled to the same potential as the minus input pin through resistor R1, keeping the converter off. When the input voltage rises above the zener voltage D1 will conduct, producing a voltage drop across resistor R1 greater than 1.8V above the minus input pin, turning the converter on. Diode D2 enables the remote ON/OFF pin to function normally with other external circuitry.

Figure 15

UNDERVOLTAGE LOCKOUT CIRCUIT

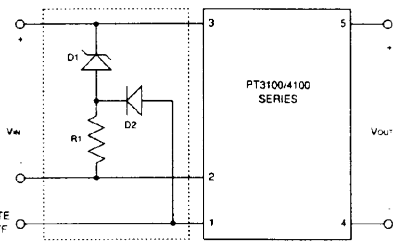


Table 18

UNDERVOLTAGE LOCKOUT CIRCUIT COMPONENTS

	P/N	Description PT3101/3	Description PT3104/6
D1		1N4751B Zener Diode 30V, 1W, 5%	1N4745B Zener Diode 16V, 1W, 5%
D2	MBR190	Schottky Diode 90V, 1A	Schottky Diode 90V, 1A
R1		Resistor, Film 10KΩ, 1/2W, 5%	Resistor, Film 10KΩ, 1/2W, 5%

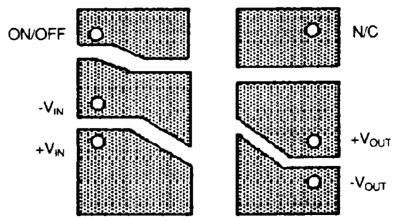
This undervoltage lockout circuit will keep the PT3100/4100 Series off until the input voltage source reaches the Zener voltage. Performance specifications will not be affected by the addition of this circuit.

PT3100/4100 Series Thermal Considerations

The PT3100/4100 Series is designed for very low thermal resistance from the internal components to the outer case. The product utilizes all surface-mount components on a ceramic substrate. Ceramic substrates have 70 to 100 times the thermal conductivity of FR-4 material. Two ounce copper traces are used on the ceramic substrate to provide very low electrical resistance and excellent thermal conductivity. Tin plated copper leads are used for input and output power and readily conduct excess heat to the copper pads on the host PC board, effectively using it as a heatsink. Consequently, the thermal performance of the PT3100/4100 Series can be enhanced by maximizing the copper area around the pins of the converter. Figure 16 shows a recommended layout pattern which maximizes this copper area. Two ounce copper is recommended for optimum performance.

Figure 16

SOLDER SIDE COPPER



Recommended PCB Layout

The ceramic substrate of the PT3100/4100 Series is also thermally connected to a black anodized aluminum case. By creating very low thermal resistance, heat is readily conducted and evenly distributed to the case. This prevents "hot spots" and allows the internal component temperatures to remain close to the case temperature.

The thermal performance of the PT3100/4100 Series is very dependent on the amount of ambient airflow. Bellcore specifications TR-NWT-000063 defines "free air convection" to be up to 60 linear feet per minute (LFM) of air flow.

The PT3100/4100 Series DC-DC Converters are also protected from thermal overload by an internal over-temperature shutdown circuit. When the junction temperature of the control IC reaches 125°C, the converter will cycle on and off continuously at frequencies as high as 3KHz until the unit is sufficiently cooled.

Power Trends, Inc. 1101 North Raddant Road, Batavia, IL 60510 (800) 531-5782 Fax: (708) 406-0901

To calculate the PT3100/4100's maximum case temperature (T_C max) and the maximum ambient operating temperature (T_A max), use the following formulas:

(1) $T_C\ max = T_J\ max - (\theta_{JC} \times P_{DIS})$
(2) $T_A\ max = T_J\ max - (\theta_{JA} \times P_{DIS})$

The junction temperature (T_J) is the internal temperature of the unit when thermal protection circuit is activated, 125°C. The thermal resistance from junction to case, θ_{JC}, is 10°C per watt of power dissipated in the unit. P_{DIS} is the power dissipated in the unit and is calculated as follows:

(3) $P_{DIS} = P_{IN} - P_{OUT}$ or
(4) $P_{DIS} = (1/\text{Efficiency} - 1) \times P_{OUT}$

θ_{JA} is non-linear with respect to power dissipation of the converter as shown in Figure 17 for free air convection. Figure 18 is the maximum ambient temperature verses power dissipation with free air convection.

Figure 17
THERMAL RESISTANCE VS POWER DISSIPATED

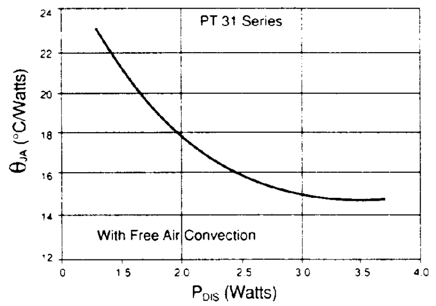
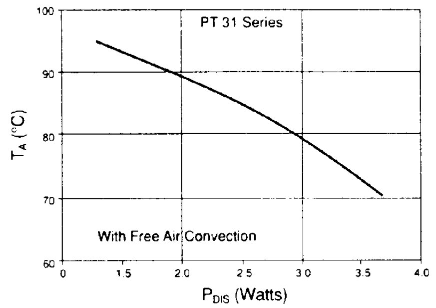


Figure 18
AMBIENT TEMPERATURE VS POWER DISSIPATED



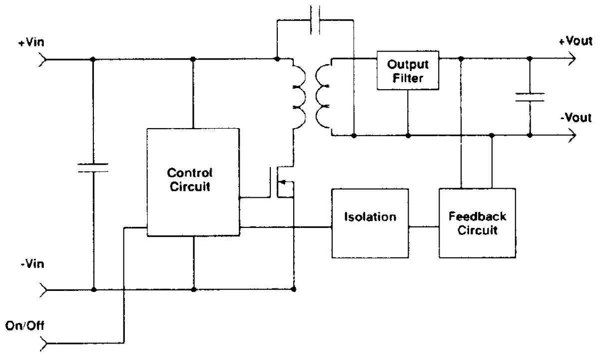
Reliability Prediction for PT3100/4100 Isolated DC-DC Converters

Power Trends' isolated DC-DC converters are designed for high efficiency, small size, and high reliability.

Reliability prediction is used not only for estimating time to failure but also as an important design tool. The calculations can help locate problem areas by identifying overstressed parts or finding the highest contributor to failure. It determines the reliability impact of design changes as well as the degree of environmental control needed to achieve a desired reliability objective. To attain the best reliability, Power Trends uses the latest and most advanced technology in power supply components and very low thermal resistance materials for packaging.

Design and Construction The Power Trends' PT3100/4100 Series uses a forward converter topology as shown in Figure 19. These converters switch at fixed frequencies of 650Khz or 850Khz depending on the unit. The high frequency allows for small magnetics and capacitors. The unit is packaged using a copper leadframe, ceramic printed circuit board, and aluminum case. It is designed to have very low thermal resistance from the internal components to the outer case. Thermal characteristics are important to understand because device temperature is a significant variable in reliability calculations.

Figure 19
PT3100/4100 SERIES BLOCK DIAGRAM



Reliability Prediction Methods While several prediction standards exist, no one standard can be considered optimum for all situations. A particular standard must be chosen based on the operating conditions and the operating environment that best reflects the end application.

PT3100/4100 Series

The telecommunications industry uses Bellcore's Technical Reference **TR-NWT-000332,** *Reliability Prediction Procedure for Electronic Equipment* as their standard. This document includes 3 different prediction methods – "Parts Count Method," "Combining Laboratory Data With Parts Count Data," and "Predictions From Field Tracking." Within each method are several different cases that define the various conditions.

MIL-HDBK-217, *Reliability Prediction of Electronic Equipment* is a widely used standard that defines two prediction methods – Part Stress Analysis Prediction that is applicable during later design phases and Parts Count Reliability Prediction that is applicable during early design phase and during proposal formulation.

Bellcore Using Bellcore's TR-NWT-000332, Method 1, Case 1, the predicted reliability for the PT3100/4100 Series is 250 FITs (Failures in 10^9 hours) or an MTBF (Mean Time Between Failure) of 4,000,000 Hours. See Table 19. MTBF is the inverse of FIT. This number is derived using the parts count method and it assumes that all components have 50% stress and an ambient temperature of 40°C in a ground, fixed, controlled environment. TR-NWT-000332 states that Method 1 prediction must be provided for all units unless the requesting organization allows otherwise. Using the same method but for a ground, fixed, uncontrolled environment, the calculated reliability would be 375 FIT or an MTBF of 2,666,667 Hours.

MIL-HDBK-217F For a Part Stress Analysis Prediction, reliability is determined by adding the failure rate of each part. The failure rate of each part is evaluated individually and is calculated by including the variables of temperature, stress level, base failure rate, power rating, part quality factor, and operating environment factor. For example, Equation (1) is the formula for calculating the part failure rate, λ_p, for a fixed film resistor.

Equation (1)

$$\lambda_p = \lambda_b \times \pi_R \times \pi_Q \times \pi_E \quad \text{Failures}/10^6 \text{ Hours}$$

where,

$$\lambda_b = 5 \times 10^{-5}(3.5^{\frac{T+273}{398}}) \exp(S(\tfrac{T+273}{273}))$$

π_R = Resistance factor
π_Q = Quality factor
π_E = Environment factor

λ_b is the base failure rate where T is the ambient temperature in degrees C and S is the ratio of operating power to rated power. The values are found in lookup tables within MIL-HDBK-217. The MTBF is equal to the inverse of the sum of all the part failure rates:

Equation (2)

$$\text{MTBF} = \frac{1}{\Sigma \lambda_p}$$

The PT3100/4100 Series has a predicted reliability of over 1,000,000 hours MTBF in a ground benign environment. See Table 19. The part quality factor used as stated in MIL-HDBK-217 is equal to "lower" (lower than military rated components). The operating conditions are 48 volts input and maximum load current in a 25°C ambient temperature environment.

Figures 20 and 21 show the MTBF with respect to temperature, input voltage, and output load. The MTBF decreases exponentially with temperature. The graphs also show that reliability decreases as the input voltage increases because the voltage stress ratio and component junction temperatures increase. Higher output loads also raise the component junction temperatures and decrease the reliability. In essence, a high efficiency design using good thermal management maximizes the reliability by reducing junction and case temperatures.

Table 19

PREDICTED RELIABILITY FOR PT3100/4100 SERIES

Method	Parameter: FITs (Failures in 10^9 hours)	MTBF (Hours) (Mean Time Between Failures)
Bellcore TR-NWT-000332 Parts Count (ground fixed, controlled environment)	250	4,000,000
(ground fixed, uncontrolled environment)	375	2,666,667
MIL-HDBK-217F Part Stress Analysis (Ta= 25°C, ground benign)	963	1,038,000

Figure 20

MTBF VS TEMPERATURE AND INPUT VOLTAGE

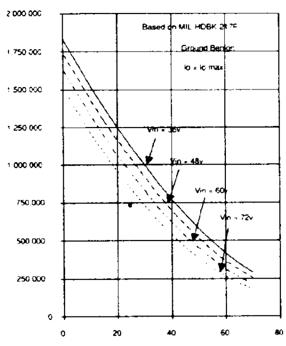
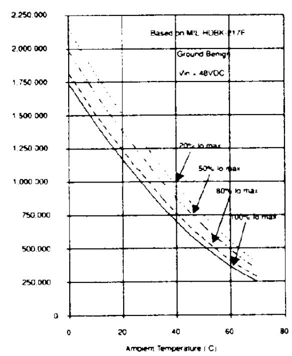


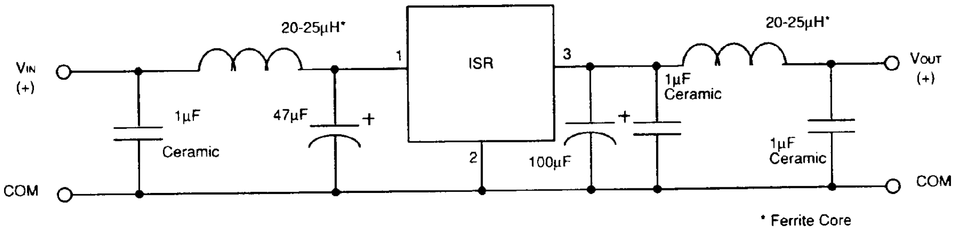
Figure 21

MTBF VS TEMPERATURE AND OUTPUT CURRENT

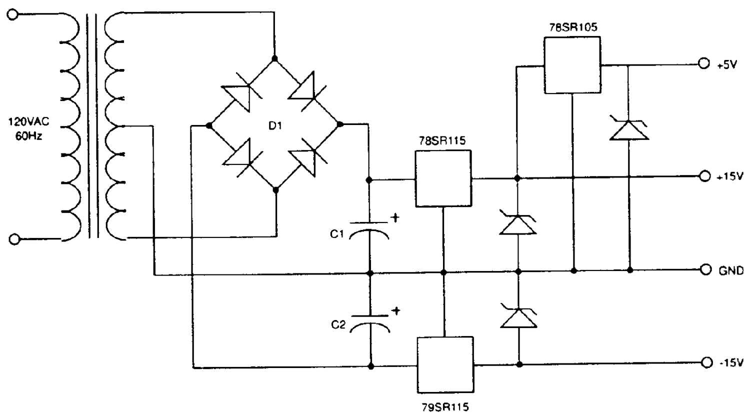


Power Trends, Inc. 1101 North Raddant Road, Batavia, IL 60510 **(800) 531-5782** Fax: (708) 406-0901

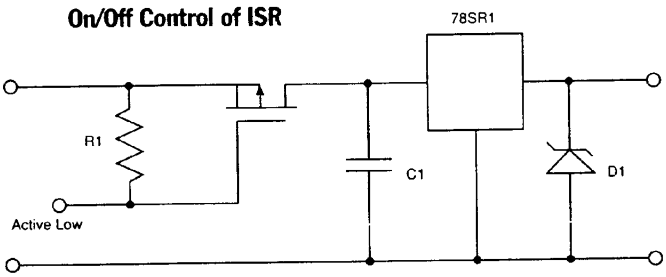
External Filtering



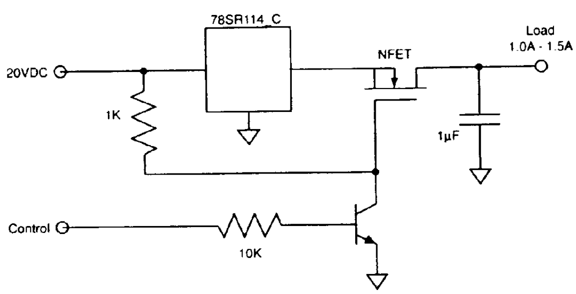
Off-Line Power Supply



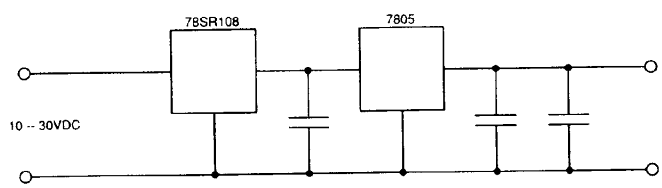
On/Off Control of ISR



Battery Charger



Improving the Efficiency of a Linear Regulator



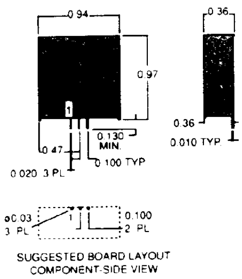
3 Pin Standard
PT5100, PT5020, PT5040 Series

PACKAGE INFORMATION AND DIMENSIONS

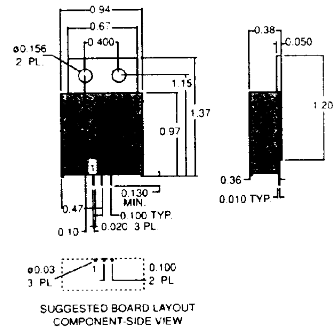
Note 1: *All dimensions are in inches.*
Note 2: *All tolerances for 2-place decimals are ±.030.*
Note 3: *All 3-place decimals are ±.010 except lead thickness and width which are ±.002*

No Heat Tab	Top Heat Tab

Vertical Through-Hole

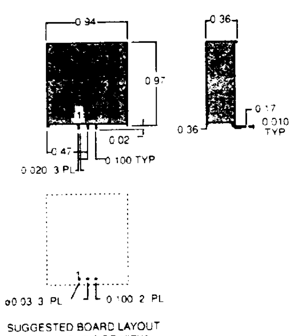


Package N

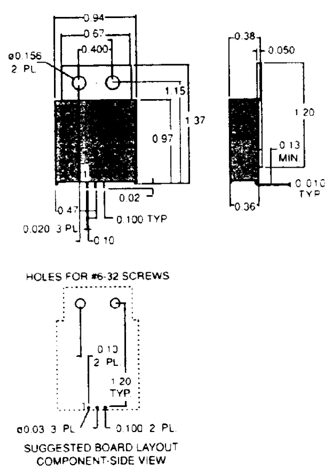


Package S

Horizontal Through-Hole

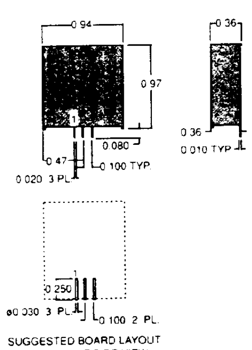


Package A

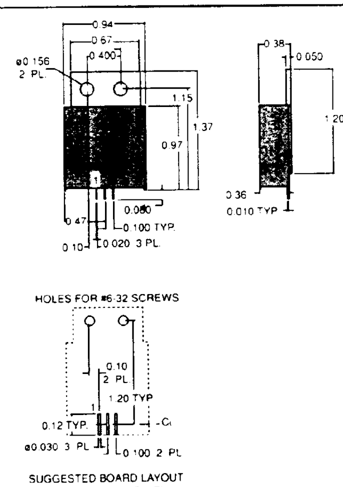


Package H

Horizontal Surface Mount



Package C



Package J

Power Trends, Inc. 1101 North Raddant Road, Batavia, IL 60510 **(800) 531-5782** Fax: (708) 406-0901

14 Pin Standard

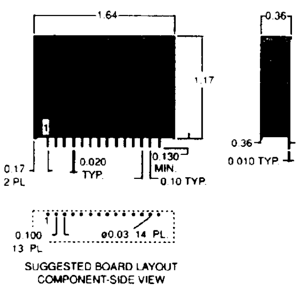
PT6500 Series

PACKAGE INFORMATION AND DIMENSIONS

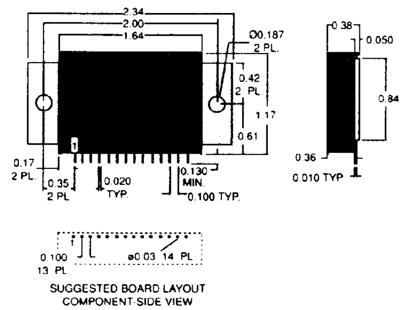
Note 1: *All dimensions are in inches.*
Note 2: *All tolerances for 2-place decimals are ±.030.*
Note 3: *All 3-place decimals are ±.010 except lead thickness and width which are ±.002.*

No Heat Tab | **Side Heat Tab**

Vertical Through-Hole

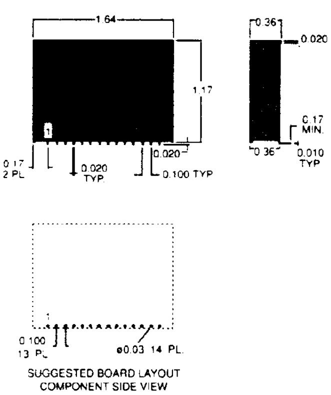


Package N

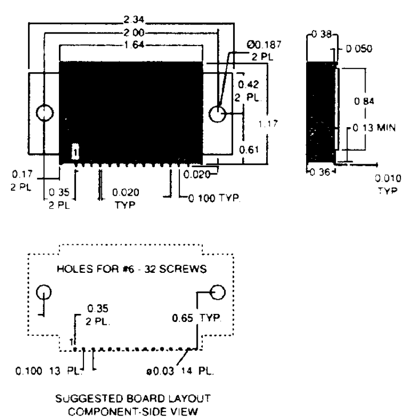


Package R

Horizontal Through-Hole

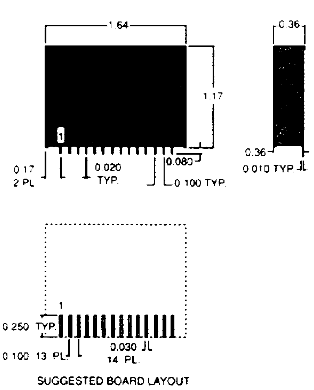


Package A

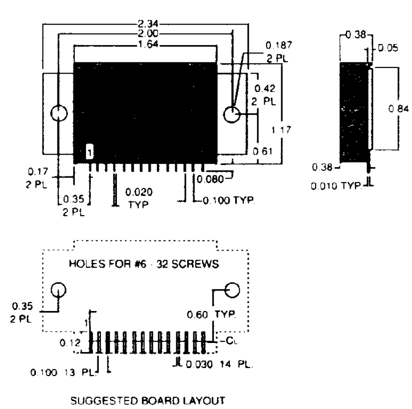


Package G

Horizontal Surface Mount



Package C

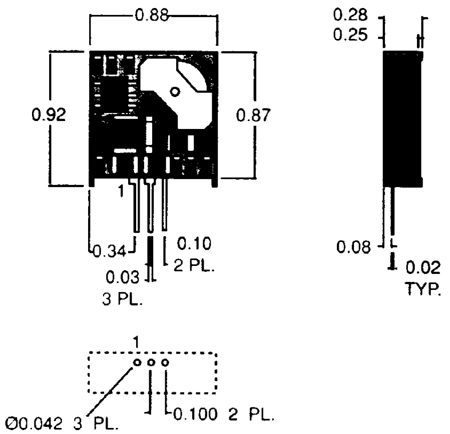


Package B

PACKAGE INFORMATION AND DIMENSIONS

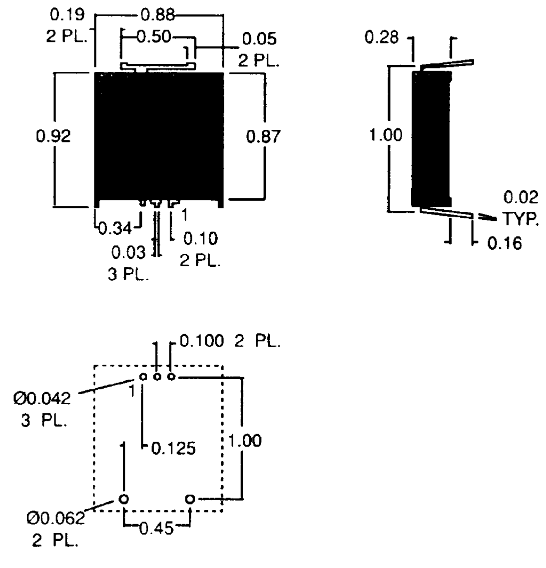
Note 1: *All dimensions are in inches.*
Note 2: *All tolerances for 2-place decimals are ±.030.*
Note 3: *All 3-place decimals are ±.010 except lead thickness and width which are ±.00*

Vertical Mount



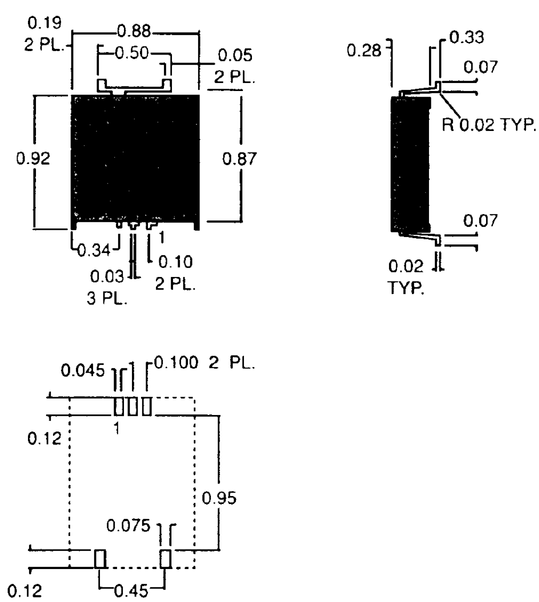
SUGGESTED BOARD LAYOUT
COMPONENT-SIDE VIEW

Horizontal Mount



SUGGESTED BOARD LAYOUT
COMPONENT-SIDE VIEW

Surface Mount



SUGGESTED BOARD LAYOUT
COMPONENT-SIDE VIEW

Power Trends, Inc. 1101 North Raddant Road, Batavia, IL 60510 **(800) 531-5782** Fax: (708) 406-0901

12 Pin Low Profile

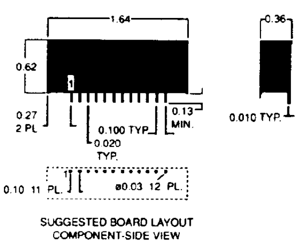
PT 6100/6200/6300 Series

PACKAGE INFORMATION AND DIMENSIONS

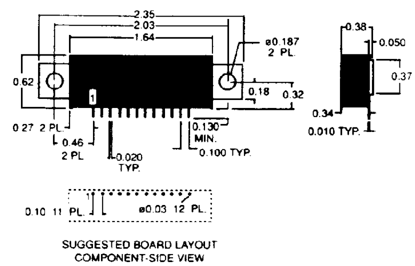
Note 1: *All dimensions are in inches.*
Note 2: *All tolerances for 2-place decimals are ±.030.*
Note 3: *All 3-place decimals are ±.010 except lead thickness and width which are ±.002.*

No Heat Tab	Side Heat Tab

Vertical Through-Hole

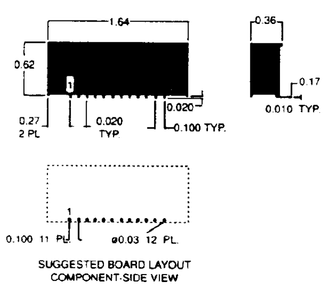


Package N

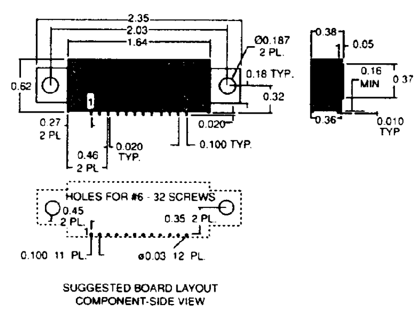


Package R

Horizontal Through-Hole

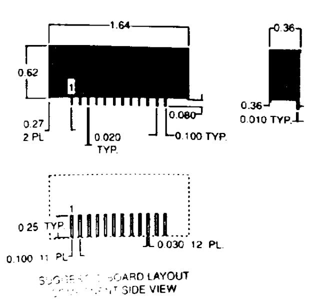


Package A

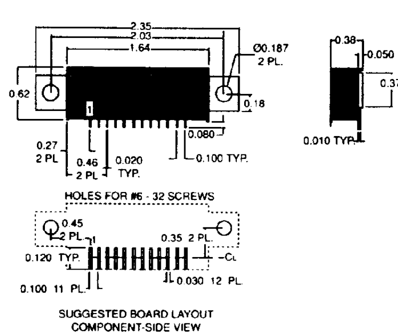


Package G

Horizontal Surface Mount



Package C



Package B

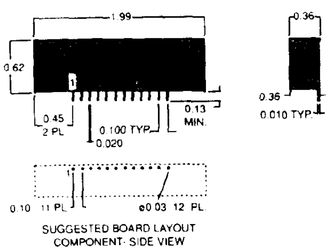
12 Pin Low Profile XL
PT 6305/6306/6307/6308 Series

PACKAGE INFORMATION AND DIMENSIONS

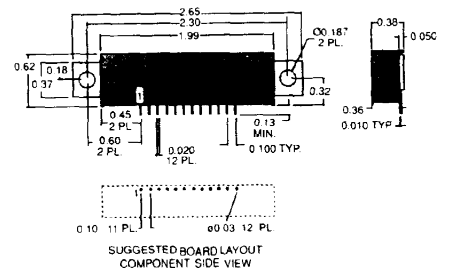
Note 1: *All dimensions are in inches.*
Note 2: *All tolerances for 2-place decimals are ±.030.*
Note 3: *All 3-place decimals are ±.010 except lead thickness and width which are ±.0*

No Heat Tab | **Side Heat Tab**

Vertical Through-Hole

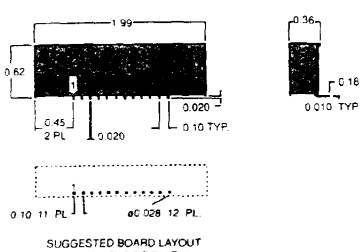


Package N

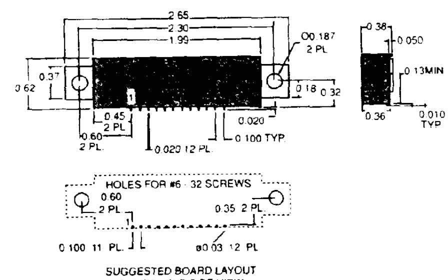


Package R

Horizontal Through-Hole

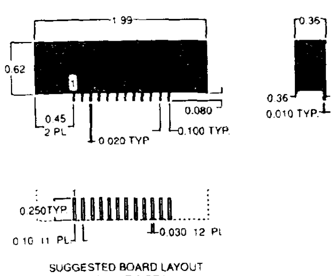


Package A

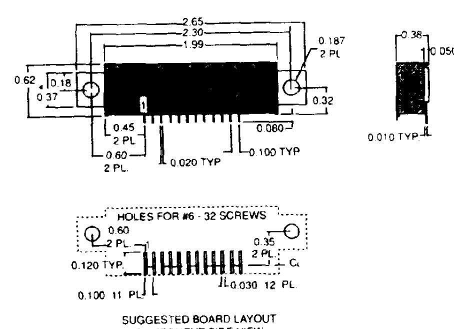


Package G

Horizontal Surface Mount



Package C



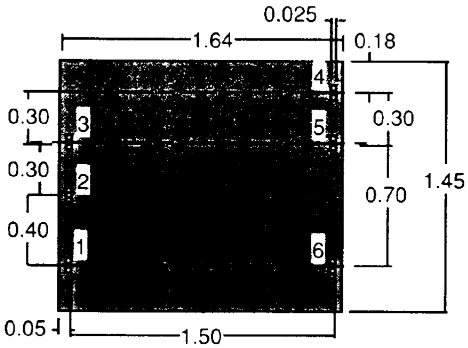
Package B

Power Trends, Inc. | 1101 North Raddant Road, Batavia, IL 60510 **(800) 531-5782** Fax: (708) 406-0901

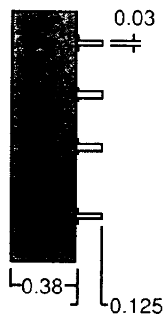
PT 3100/4100 Series

PACKAGE INFORMATION AND DIMENSIONS

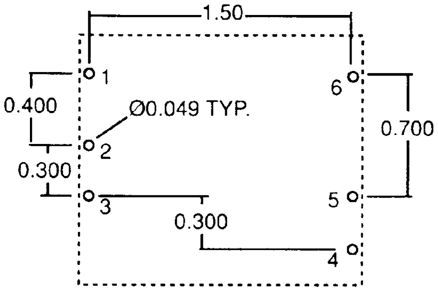
Note 1: *All dimensions are in inches.*
Note 2: *All tolerances for 2-place decimals are ±.030.*
Note 3: *All 3-place decimals are ±.010 except lead thickness and width which are ±.002*



BOTTOM VIEW



SIDE VIEW



SUGGESTED BOARD LAYOUT
COMPONENT-SIDE VIEW

Pin Connections

Pin No.	Function
1	Remote ON/OFF
2	$-V_{in}$
3	$+V_{in}$
4	$-V_{out}$
5	$+V_{out}$
6	N/C

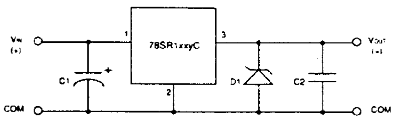
78SR1

1.5 AMP POSITIVE STEP-DOWN INTEGRATED SWITCHING REGULATOR

- High Efficiency > 85%
- Self-Contained Inductor
- Internal Short Circuit and Over-Temperature Protection
- Pin Compatible with Existing Linear 3-Terminal, "78" Series, Regulators
- Can be configured to provide negative output voltage (Buck-Boost) see page 51.

The 78SR1 Series is a line of 3-terminal Integrated Switching Regulators (ISRs) that are as easy to use as linear 3-terminal regulators. These ISRs have a maximum output current of 1.5 Amps and an output voltage that is laser trimmed to industry standard voltages. They have excellent line and load regulation with internal short circuit and over-temperature protection. Offered in 10 standard output voltages, these ISRs can power a diversity of circuits used in a wide variety of industrial applications.

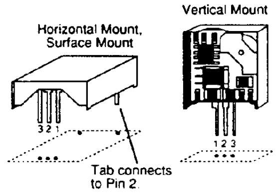
Standard Application



C_1 = Optional electrolytic (10µF)
D_1 = Zener diode required to clamp turn-on overshoot (see page 48)
C_2 = Optional ceramic (1µF)

Pin-Out Information

Pin No.	Function
1	Input
2	Common
3	Output



Suggested board layout
Component-side view

Ordering Information

1.5 Amp Positive Integrated Switching Regulator

78SR1 [XX] [Y] C

Output Voltage	Package Style A
05 = 5.0 Volts	**V** = Vertical Mount
53 = 5.25 Volts	**S** = Surface Mount
06 = 6.0 Volts	**H** = Horizontal Mount
74 = 7.15 Volts	
08 = 8.0 Volts	
09 = 9.0 Volts	
10 = 10.0 Volts	
12 = 12.0 Volts	(For dimensions, see page 64.)
14 = 13.9 Volts	
15 = 15.0 Volts	

Specifications

Characteristics (T_a=25°C unless noted)	Symbols	Conditions	78SR1 SERIES Min	Typ	Max	Units
Output Current	I_o	Over V_{in} range	0.1**	—	1.5	Amps
Current Limit	I_{cl}	V_{in}=8V V_o=5V	—	3.0	—	Amps
Short Circuit Current	I_{sc}	V_{in}=V_o+3V	—	3.5	—	Apk
Input Voltage Range	V_{in}	0.10 ≤ I_o ≤ 1.5 Amp V_o=5V V_o=12V	7 14.5	— —	30 30	VDC VDC
Static Voltage Tolerance	ΔV_o	Over V_{in} range, I_o=1 Amp T_a=-40°C to shutdown	—	±1.0	±2.0	%V_o
Ripple Rejection	RR	Over V_{in} range @ 120 Hz	—	45	—	dB
Line Regulation	Reg_{line}	Over V_{in} range	—	±0.2	±0.4	%V_o
Load Regulation	Reg_{load}	0.10 ≤ I_o ≤ 1.5 Amp	—	±0.1	±0.2	%V_o
Ripple/Noise	V_n	V_{in}=8V, I_o=1.5A, V_o=5V V_{in}=15V, I_o=1.5A, V_o=12V	—	50 80	—	mV_{pp} mV_{pp}
Transient Response	t_{tr}	50% load change V_o over/undershoot	— —	100 30	— —	µSec %V_o
Efficiency	η	V_{in}=10V, I_o=1A, V_o=5V V_{in}=17V, I_o=1A, V_o=12V	— —	85 90	— —	% %
Switching Frequency	f_o	Over V_{in} range, I_o=1.5 Amp	600	650	700	KHz
EMI/RFI	—	Over V_{in} range, I_o=1.5 Amp	Meets FCC Class B for Radiated Emission			
Operating Temperature	T_a	Free Air Convection, (40-60LFM) V_o=5V Over V_{in} and I_o Ranges V_o=12V	-40 -40	— —	+60* *	°C °C
Thermal Resistance	θ_{JA}	Free Air Convection, (40-60LFM)	—	45	—	°C/W
Storage Temperature	T_s	—	-40	—	+125	°C
Mechanical Shock		Per Mil-STD-883C, Method 2002.3 Condition C	—	—	50	G's
Mechanical Vibration		Per Mil-STD-883D, Method 2007.2 Condition A, 20-2000 Hz, soldered in a PC board	—	10	—	G's
Weight	—	—	—	0.25 7.0	—	Ounces Grams
Relative Humidity	—	Non-condensing	0	—	95	%

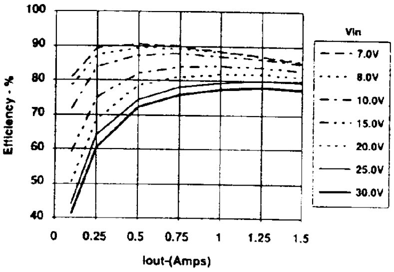
*See Thermal Derating chart.   ** ISR will operate down to no load with reduced specifications.

Power Trends, Inc. 1101 North Raddant Road, Batavia, IL 60510 (800) 531-5782 Fax: (708) 406-0901

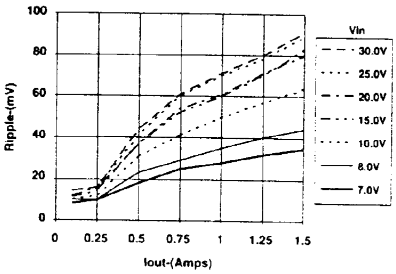
78SR105, 5.0 VDC

(See Note 1)

Efficiency vs Output Current

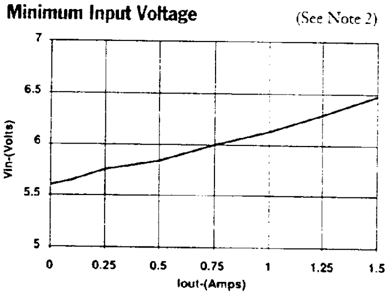


Ripple vs Output Current



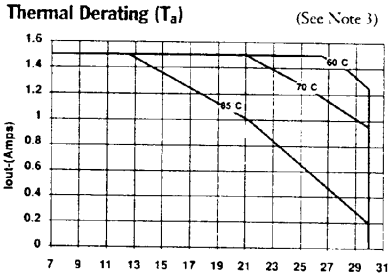
Minimum Input Voltage

(See Note 2)

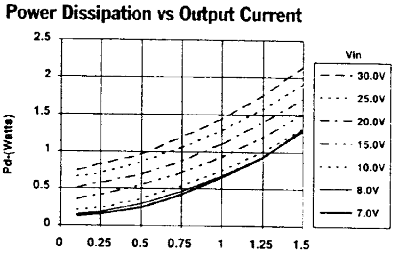


Thermal Derating (T_a)

(See Note 3)



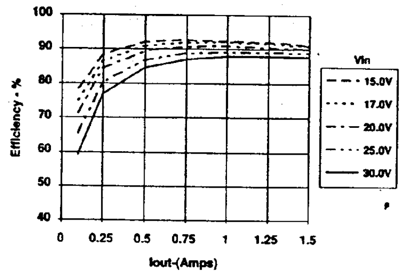
Power Dissipation vs Output Current



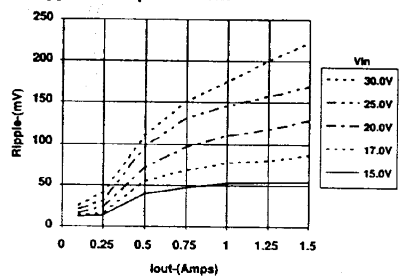
78SR112, 12.0 VDC

(See Note 1)

Efficiency vs Output Current

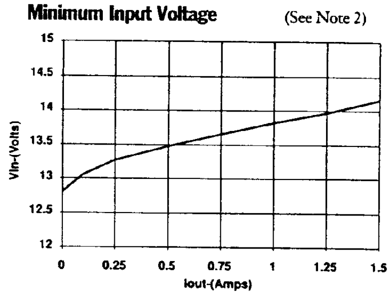


Ripple vs Output Current



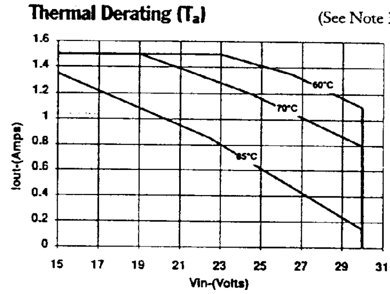
Minimum Input Voltage

(See Note 2)

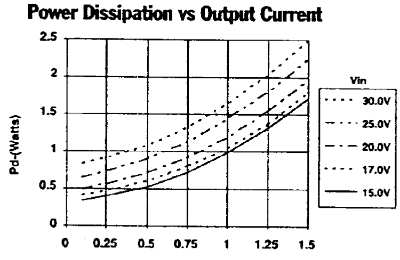


Thermal Derating (T_a)

(See Note 3)



Power Dissipation vs Output Current



Note 1: *All data listed in the above graphs, except for derating data, has been developed from actual products tested at 25°C. This data is considered typical data for the ISR.*
Note 2: *Minimum V_{in} data is typical and is not guaranteed. The data corresponds to a 2% output voltage drop.*
Note 3: *Thermal derating graphs are developed in free air convection cooling of 40-60 LFM soldered in a printed circuit board. (See Thermal Application Notes on page 49).*