National Semiconductor Corporation

PRELIMINARY

HS9151 Micro-Switching Off-Line Power Converter 120 V_{AC}/ +5V @ 3 Amps

General Description

The HS9151—Micro-Switching Off-Line Power Converter is a hybrid power converter housed in a 3.5" x 1.5" x 0.44" metal dual-in-line package.

The high efficiency of the Off-Line Converter is achieved by using advanced switching technology.

A 1 MHz PWM controller with current limiting and temperature protection is incorporated in the package. Also, the input and output rectifiers and magnetics are included as well as an internally adjusted opto-isolator feedback stage.

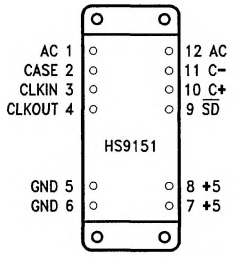
With a 120 V_{AC} nominal input voltage, the HS9151 can supply 3 amps at +5 V_{DC} over a temperature range of −25°C to +85°C and only requiring a heatsink for operation above 40°C.

The HS9151 provides access to the clock input pin for synchronization of several HS9151s from an external clock, or the internal clock of one unit can be used as a master clock for several units. The HS9151 also features softstart at power up.

Features

- 120 V_{AC} or 170 V_{DC} nominal input
- +5 V_{DC} output at 3 amps
- 3.5" x 1.5" x 0.44" size
- 1000 V_{RMS}/1500 V_{DC} Input/Output isolation
- Full 3A output current capability over temperature
- Synchronization
- Shortcircuit/temperature protection
- Softstart and remote shutdown
- 1 MHz switching frequency
- Isolated case

Block and Connection Diagrams



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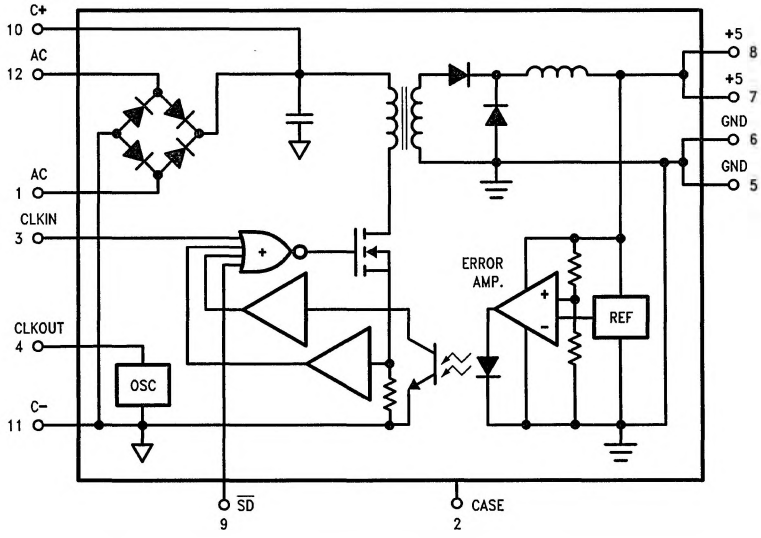
Top View
Order Number HS9151



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Note 1: Caution: this device is operated directly from the 115 Vrms AC line. An isolation transformer must be used when making measurements with test equipment, to prevent personnel exposure to lethal voltage potentials. Standard high voltage safety procedures should also be observed.

Note 2: Pin 2 is connected to case ground.

Absolute Maximum Ratings

If Military/Aerospace specified devices are required, contact the National Semiconductor Sales Office/ Distributors for availability and specifications.

V_{IN}, Input Voltage
- AC Voltage (Pin 1 to Pin 12) 140 V_{AC}
- DC Voltage (Pin 10 to Pin 11) 200 V_{DC}

I_{OUT}, Output Short Circuit Duration: Continuous

T_A, Operating Temperature Range: −25°C to +85°C

T_{CASE}, Operating Case Temperature: 100°C

T_{STG}, Storage Temperature Range: −65°C to +150°C

Voltage Differential Input to Output (1 Min.): 1500 V_{DC}

Non-Repetitive Sinusoidal Surge through Bridge Rectifier (10 ms): 20A

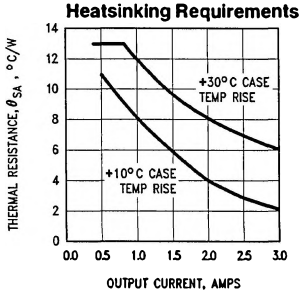
Electrical Characteristics T_A = 25°C, V_{IN} = 120 V_{RMS} AC unless otherwise specified

Parameter	Conditions	Min	Typ	Max	Units
Output Voltage	V_{IN} = 90 to 130 V_{AC} or V_{IN} = 115 to 190 V_{DC} I_{OUT} = 0.5A to 3A	4.875		5.125	V_{DC}
Output Transient Recovery Time	I_{OUT} = 2A to 3A		500		μs
Load Regulation	I_{OUT} = 0.5A to 3A			±1.0	%
Line Regulation	V_{IN} = 90 to 130 V_{AC}			±0.25	% (0–120 Hz)
Peak to Peak Output Ripple	I_{OUT} = 3A (Note 1)		50		mV (0–20 MHz)
Input to Output Isolation		100			MΩ
Efficiency	I_{OUT} = 3A I_{OUT} = 0.5A		75 50		% %
Clock In	Positive Going Threshold V_T^+ Negative Going Threshold V_T^-	10.0		 2.5	V V
External Clock Frequency to Clock In			1		MHz
External Clock	Duty Cycle	48		75	%
Clock Out (no external load)	I_{OUT} = 0.5 mA V_{OL} V_{OH}	 10.0		 0.5	 V V
Shutdown $\overline{SD}$	(See *Figure 2*)			2.5	V

Note 1: The output ripple is dependent on the ESL and ESR of the output filter capacitor (see *Figure 4*).

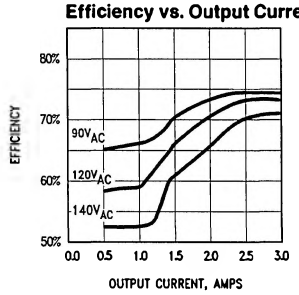
Typical Performance Characteristics

Heatsinking Requirements

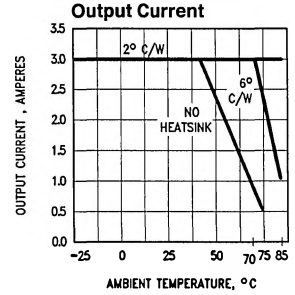


Note: Case temperature should not exceed 100°C.

Efficiency vs. Output Current



Absolute Maximum Output Current



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Note: Assumes $T_{CASE\ (MAX)}$ = 100°C.

Application Information

IN-RUSH CURRENT LIMITING

During start up, the input of the HS9151 presents a very low impedance to the AC line, generally only the ESR of the input filter. If current limit is not provided at the input, the high in-rush current can destroy the input rectifier bridge.

A 10Ω (1 Watt) resistor should be placed in series with the input rectifier bridge and the AC line to limit the current to a non-destructive level. This scheme reduces the efficiency of the power converter by approximately 3% at full load due to the I^2R loss in the resistor (see *Figure 4*).

CLKIN and CLKOUT

The HS9151 provides an internal 1 MHz clock, CLKOUT (pin 4), that allows several units to be synchronized to one master clock in applications where multiple units are used. The logic high is specified at 10.0V (min.) and logic low is specified at 0.5V (max.) when $I_{OUT} = \pm 1$ mA. The CLKIN (pin 3) allows the power converter to use an externally supplied 1 MHz clock instead of using the oscillator provided inside the HS9151. Isolation is required when using an external clock. In applications that do not require synchronization, the CLKIN and CLKOUT pins should be connected together.

Figure 1 below, shows the connection scheme when three HS9151s are synchronized off the same master clock provided by unit #1.

REMOTE SHUTDOWN $\overline{SD}$

A remote shutdown function (pin 9) is also provided in the HS9151. This allows the switching converter to be disabled when pin 9 is brought below 2.5 volts. This feature allows proper power up sequencing of a complex system, and it also enables peripheral equipment to be turned on and off remotely. An input equivalent circuit of the $\overline{SD}$ pin is shown in *Figure 2*.

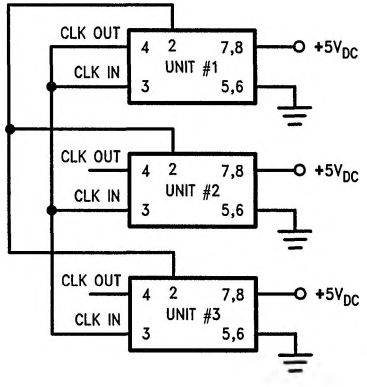

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FIGURE 1. HS9151 Synchronization

Application Information (Continued)

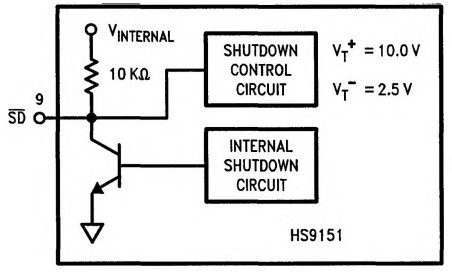

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FIGURE 2. HS9151 Shutdown Block Diagram

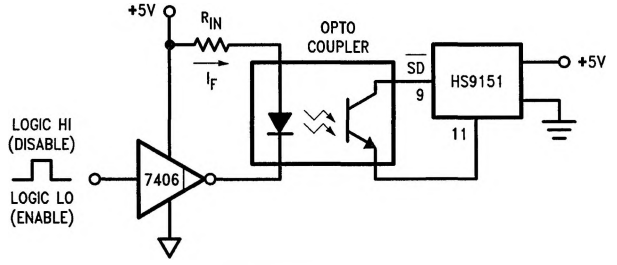

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FIGURE 3. Remote Shutdown Using an Opto Coupler and +5V Logic

Because the shutdown control is located on the primary side of the power converter, it is recommended that the shutdown control signal, $\overline{SD}$, be isolated either optically or by other means. *Figure 3* shows a typical implementation of the remote shutdown function, using an opto coupler for isolation.

When the shutdown feature is used in systems where multiple HS9151s are synchronized from a master clock (see *Figure 1*) and sequenced, the shutdown procedure should be such that the master unit is the last unit to be turned off and the first one to be turned on.

Typical Applications

The HS9151 can be configured into a complete 5V @ 3A power supply by simply adding an input capacitor and two output capacitors. *Figure 4* shows an implementation using a 100 μF input capacitor to provide a holdup time of 16 ms. A 220 μF aluminum electrolytic capacitor in parallel with a 5 μF low ESL capacitor guarantees loop stability under all line and load conditions. The low ESL (equivalent series inductance) capacitor also keeps the output ripple under 50 mV peak to peak. A 130 V_{AC} metal oxide varistor (MOV) is also necessary for input protection and the 10Ω, 1 Watt resistor limits in-rush current to under 20A.

Typical Applications (Continued)

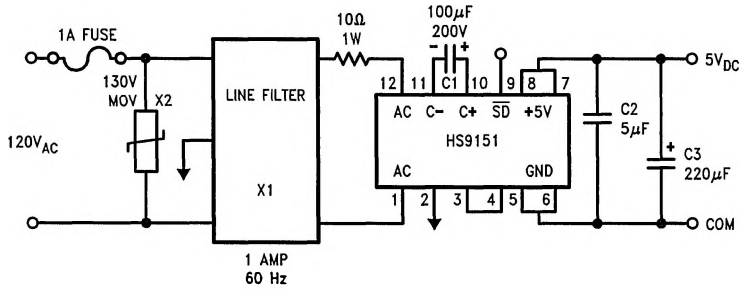

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FIGURE 4. HS9151 Configured as a 15W Power Supply

X1 SAE F15209 Line Filter, TRI-MAG G3-1 or equivalent

X2 GE V130LA1 Metal Oxide Varistor

C1 Mepco/Electra 3476 LK101M200 JMBS or equivalent
200V 100 μF Aluminum Electrolytic

C2 Rel-Cap PPMF505KIR OR Electronic Concepts 5MC 22B 505K
100V, 5 μF Polypropylene 50V, 5 μF Polycarbonate

C3 Mepco/Electra 3481 CE221V025 JDBS or equivalent
25V, 220 μF Aluminum Electrolytic

Reliable Capacitors	Electronic Concepts Inc.	SAE Power Devices	TRI-MAG, Inc.
12931 E. Sunnyside Place	P. O. Box 627	340 Martin Ave.	8204 W. Doe St.
Sante Fe Springs, CA 90670	Eatontown, NJ 07724	Santa Clara, CA 95050-1997	Visalia, CA. 93277
(213) 946-8577	(201) 542-7880	(408) 988-0700	(209)651-2222

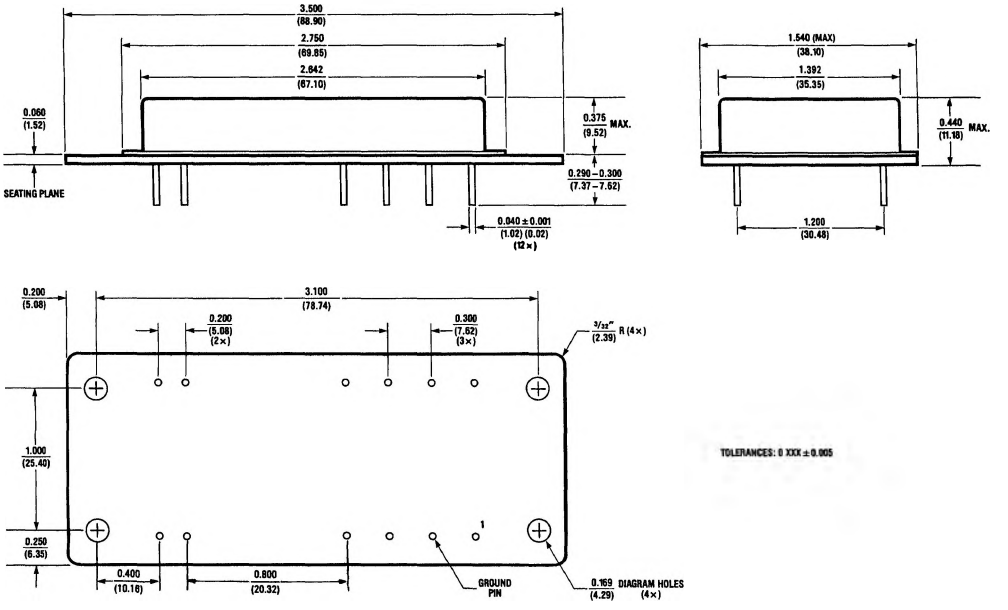
The efficiency of the power supply is a function of the input line voltage and the output load current. At maximum load current, the efficiency is the highest, approaching 75% with V_{in} = 120 VAC. Also, the efficiency varies by less than ±2% when the line voltage changes from low line to high line at maximum output load current (see graph for efficiency versus output current).

THERMAL CONSIDERATIONS

The HS9151 is housed in an all metal hybrid power package measuring only 3.5″ x 1.5″ x 0.44″. The low thermal resistance of this package allows the power converter to operate at full power (5V at 3A) without a heatsink up to an ambient temperature of 40°C. For operation beyond 40°C, some form of heat sinking is recommended. The rise in temperature of the internal components is dependent on the power delivered at the output. Under normal operating conditions, it is recommended that the case temperature of the HS9151 be kept below 90°C. Under these conditions, the junction temperature of the internal integrated circuits are kept below 115°C.

For selecting a proper heatsink consult the graph provided. This information greatly simplifies the task of selecting the proper heatsink for the HS9151 when it is operated at elevated temperatures. For example, when a load current of 3 amperes is drawn from the power converter, and a heatsink with a 2°C/W thermal resistance is used, the case temperature would increase by 10°C. Alternatively, if a 6°C/W heatsink were used, the case temperature would go up by 30°C.

Physical Dimensions inches (millimeters)



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Bottom View

Order Number HS9151