

## FEATURES

- Digital Selection of 0V,  $V_{CC}$ , 12V or Hi-Z
- 120mA Output Current Capability
- Internal Current Limiting and Thermal Shutdown
- Automatic Switching from 3.3V to 5V
- Powered from Unregulated 13V to 20V Supply
- Logic Compatible with Standard PCMCIA Controllers
- 1 $\mu$ F Output Capacitor
- 30 $\mu$ A Quiescent Current in Hi-Z or 0V Mode
- VPP Valid Status Feedback Signal
- No VPP Overshoot
- 8-Pin SO Packaging

## APPLICATIONS

- Notebook Computers
- Palmtop Computers
- Pen-Based Computers
- Handi-Terminals
- Bar-Code Readers
- Flash Memory Programming

## DESCRIPTION

The LT<sup>®</sup>1312 is a member of Linear Technology Corporation's family of PCMCIA drivers/regulators. The LT1312 provides 0V, 3.3V, 5V, 12V and Hi-Z regulated power to the VPP pin of a PCMCIA card slot from a single unregulated 13V to 20V supply. When used in conjunction with a PC card interface controller, the LT1312 forms a complete minimum component-count interface for palm-top, pen-based and notebook computers. The VPP output voltage is selected by two logic compatible digital inputs which interface directly with industry standard PC card interface controllers.

Automatic 3.3V to 5V switching is provided by an internal comparator which continuously monitors the PC card  $V_{CC}$  supply and automatically adjusts the regulated VPP output to match  $V_{CC}$  when the VPP =  $V_{CC}$  mode is selected.

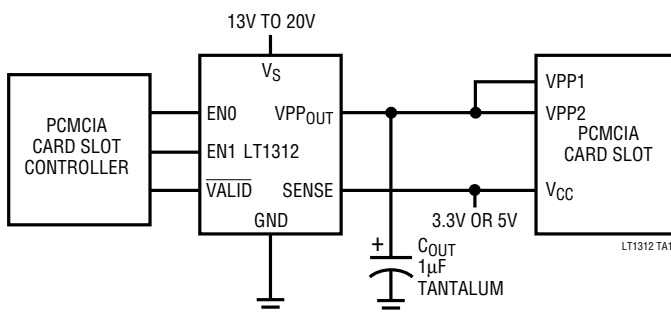
An open-collector VPP  $\overline{\text{VALID}}$  output is driven low when VPP is in regulation at 12V.

The LT1312 is available in an 8-pin SO package.

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## TYPICAL APPLICATION

Typical PCMCIA Single Slot VPP Driver



LT1312 TRUTH TABLE

EN0	EN1	SENSE	VPP <sub>OUT</sub>	VALID
0	0	X	0V	1
1	0	X	12V	0
0	1	3.0V TO 3.6V	3.3V	1
0	1	4.5V TO 5.5V	5V	1
1	1	X	Hi-Z	1

X = DON'T CARE

Linear Technology PCMCIA Product Family

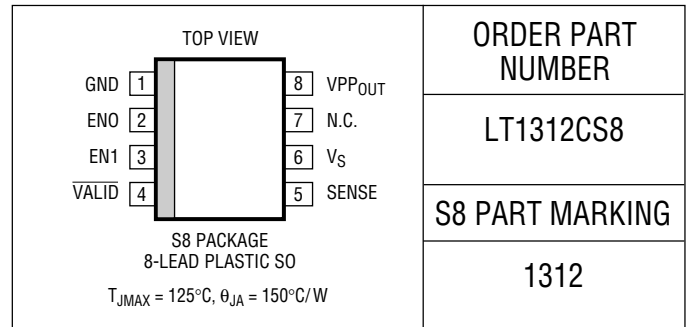
DEVICE	DESCRIPTION	PACKAGE
LT1312	SINGLE PCMCIA VPP DRIVER/REGULATOR	8-PIN SO
LT1313	DUAL PCMCIA VPP DRIVER/REGULATOR	16-PIN SO*
LTC <sup>®</sup> 1314	SINGLE PCMCIA SWITCH MATRIX	14-PIN SO
LTC1315	DUAL PCMCIA SWITCH MATRIX	24-PIN SSOP
LTC1470	PROTECTED $V_{CC}$ 5V/3.3V SWITCH MATRIX	8-PIN SO
LTC1472	PROTECTED $V_{CC}$ AND VPP SWITCH MATRIX	16-PIN SO*

\*NARROW BODY

**ABSOLUTE MAXIMUM RATINGS**

Supply Voltage ..... 22V  
 Digital Input Voltage ..... 7V to (GND – 0.3V)  
 Sense Input Voltage ..... 7V to (GND – 0.3V)  
 Valid Output Voltage ..... 15V to (GND – 0.3V)  
 Output Short-Circuit Duration ..... Indefinite  
 Operating Temperature ..... 0°C to 70°C  
 Junction Temperature ..... 0°C to 125°C  
 Storage Temperature Range ..... –65°C to 150°C  
 Lead Temperature (Soldering, 10 sec) ..... 300°C

**PACKAGE/ORDER INFORMATION**



Consult factory for Industrial and Military grade parts.

**ELECTRICAL CHARACTERISTICS**  $V_S = 13V$  to  $20V$ ,  $T_A = 25^\circ C$ , unless otherwise noted.

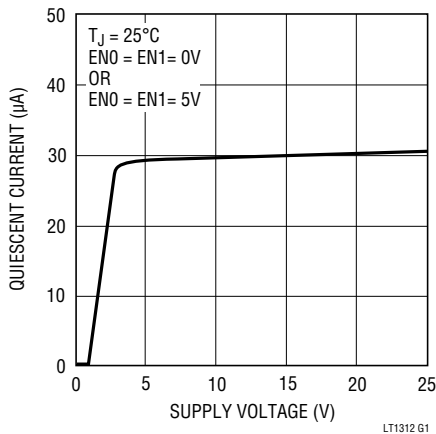
SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS	
VPP <sub>OUT</sub>	Output Voltage	Program to 12V, I <sub>OUT</sub> ≤ 120mA (Note 1)	●	11.52	12.00	12.48	V
		Program to 5V, I <sub>OUT</sub> ≤ 30mA (Note 1)	●	4.75	5.00	5.25	V
		Program to 3.3V, I <sub>OUT</sub> ≤ 30mA (Note 1)	●	3.135	3.30	3.465	V
		Program to 0V, I <sub>OUT</sub> = –300μA			0.42	0.60	V
I <sub>LKG</sub>	Output Leakage	Program to Hi-Z, 0V ≤ VPP <sub>OUT</sub> ≤ 12V	●	–10	10	μA	
I <sub>S</sub>	Supply Current	Program to 0V	●		30	50	μA
		Program to Hi-Z	●		30	50	μA
		Program to 12V, No Load	●		230	360	μA
		Program to 5V, No Load	●		75	120	μA
		Program to 3.3V, No Load	●		55	90	μA
		Program to 12V, I <sub>OUT</sub> = 120mA	●		126	132	mA
		Program to 5V, I <sub>OUT</sub> = 30mA	●		31	33	mA
Program to 3.3V, I <sub>OUT</sub> = 30mA	●		31	33	mA		
I <sub>LIM</sub>	Current Limit	Program to 3.3V, 5V or 12V		330	500	mA	
V <sub>ENH</sub>	Enable Input High Voltage		●	2.4		V	
V <sub>ENL</sub>	Enable Input Low Voltage		●		0.4	V	
I <sub>ENH</sub>	Enable Input High Current	2.4V ≤ V <sub>IN</sub> ≤ 5.5V		20	50	μA	
I <sub>ENL</sub>	Enable Input Low Current	0V ≤ V <sub>IN</sub> ≤ 0.4V		0.01	1	μA	
V <sub>SEN5</sub>	V <sub>CC</sub> Sense Threshold	VPP <sub>OUT</sub> = 3.3V to 5V	●	3.60	4.05	4.50	V
V <sub>SEN3</sub>	V <sub>CC</sub> Sense Threshold	VPP <sub>OUT</sub> = 5V to 3.3V	●	3.60	4.00	4.50	V
I <sub>SEN</sub>	V <sub>CC</sub> Sense Input Current	V <sub>SENSE</sub> = 5V		38	60	μA	
		V <sub>SENSE</sub> = 3.3V		18	30	μA	
V <sub>VALID TH</sub>	VPP <sub>VALID</sub> Threshold Voltage	Program to 12V	●	10.5	11	11.5	V
I <sub>VALID</sub>	VPP <sub>VALID</sub> Output Drive Current	Program to 12V, V <sub>VALID</sub> = 0.4V		1	3.3		mA
	VPP <sub>VALID</sub> Output Leakage Current	Program to 0V, V <sub>VALID</sub> = 12V			0.1	10	μA

The ● denotes the specifications which apply over the full operating temperature range.

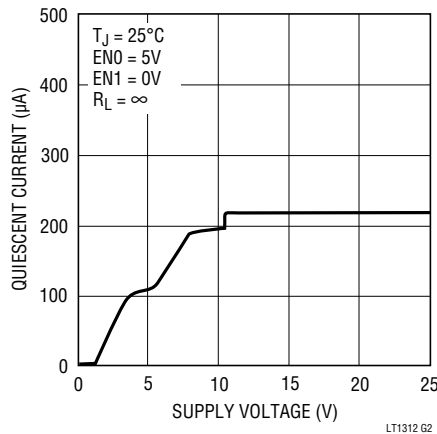
**Note 1:** For junction temperatures greater than 110°C, a minimum load of 1mA is recommended.

# TYPICAL PERFORMANCE CHARACTERISTICS

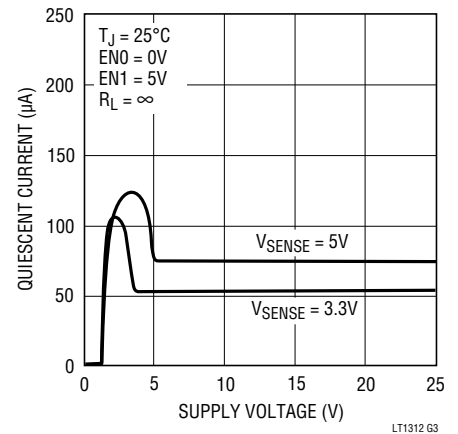
**Quiescent Current (0V or Hi-Z Mode)**



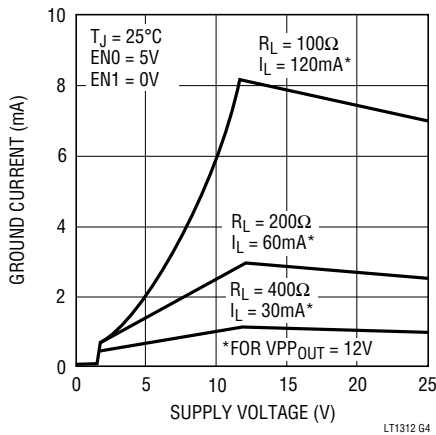
**Quiescent Current (12V Mode)**



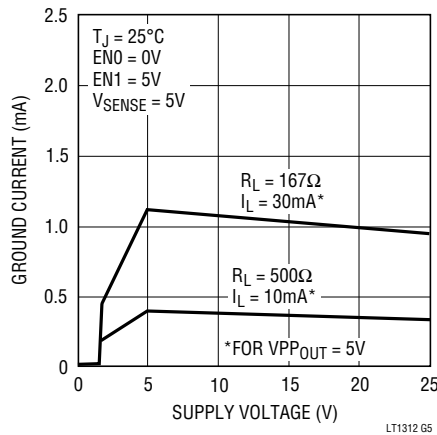
**Quiescent Current (3.3V/5V Mode)**



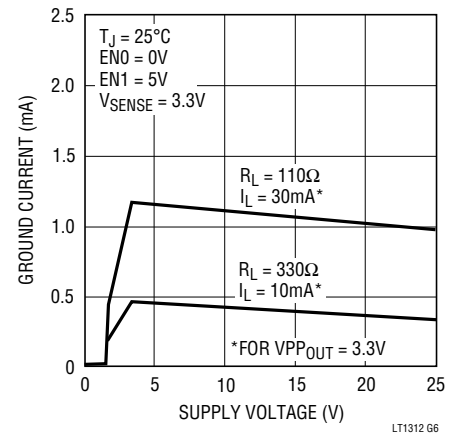
**Ground Pin Current (12V Mode)**



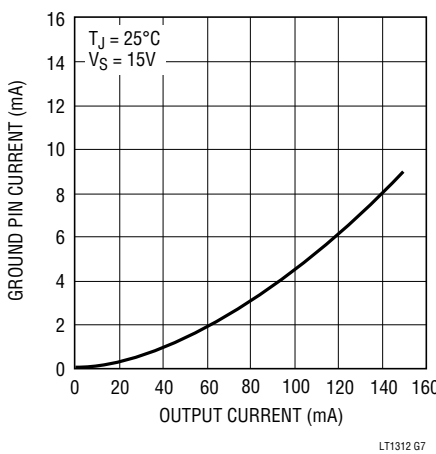
**Ground Pin Current (5V Mode)**



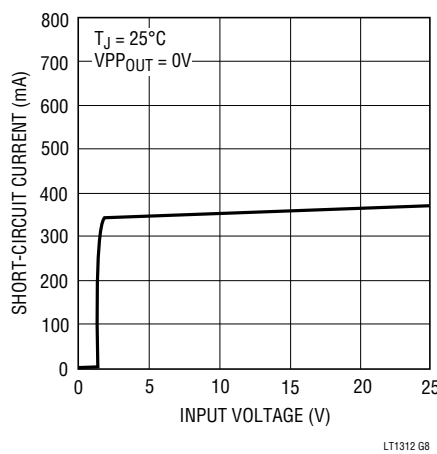
**Ground Pin Current (3.3V Mode)**



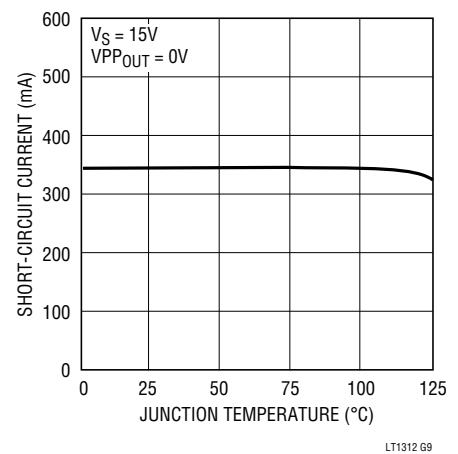
**Ground Pin Current**



**Current Limit**

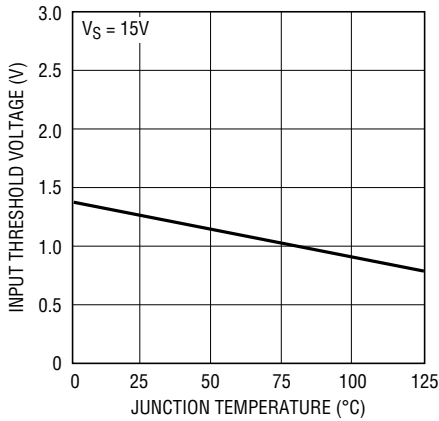


**Current Limit**



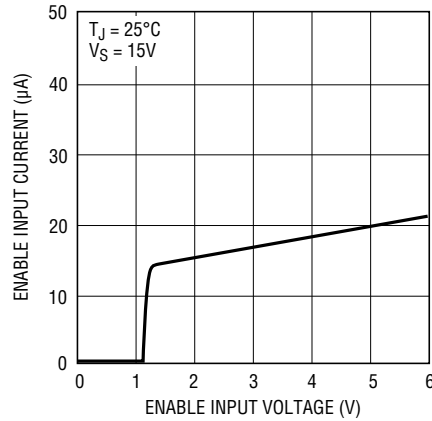
# TYPICAL PERFORMANCE CHARACTERISTICS

**Enable Input Threshold Voltage**



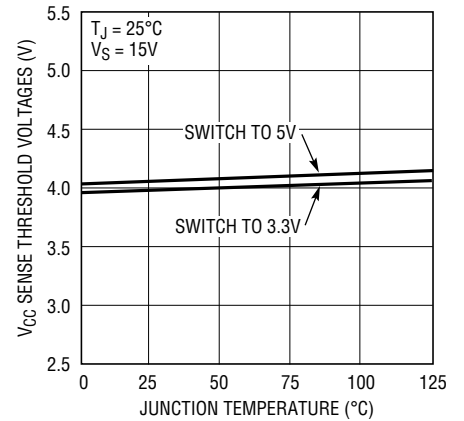
LT1312 G10

**Enable Input Current**



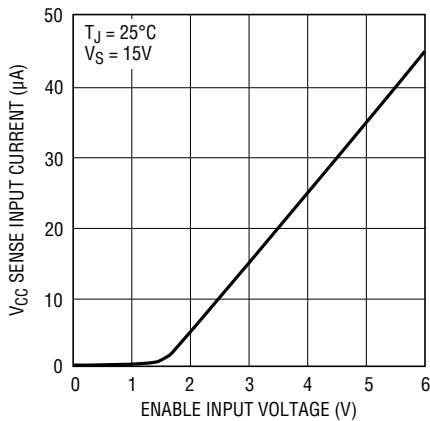
LT1312 G11

**V<sub>CC</sub> Sense Threshold Voltage**



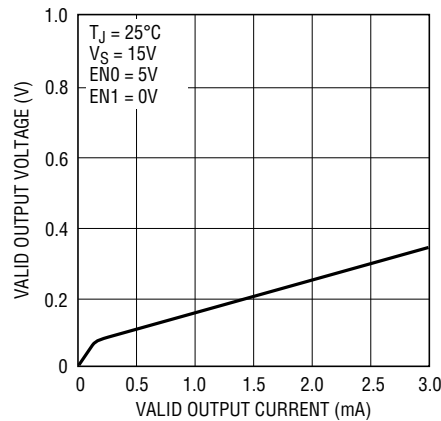
LT1312 G12

**V<sub>CC</sub> Sense Input Current**



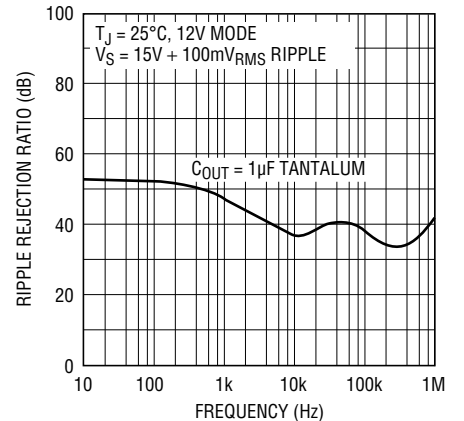
LT1312 G13

**VALID Output Voltage**



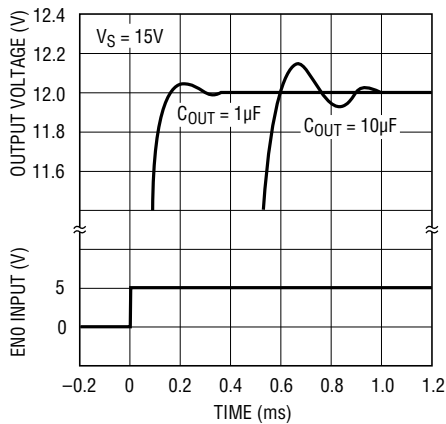
LT1312 G14

**Ripple Rejection (12V)**



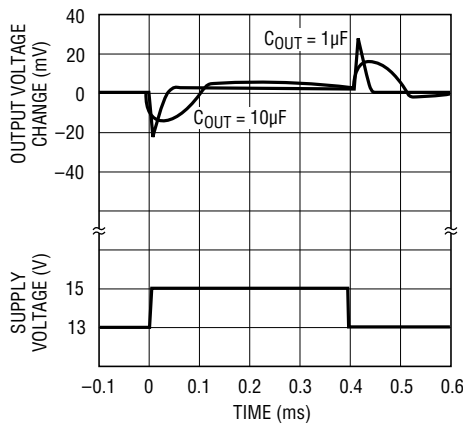
LT1312 G15

**12V Turn-On Waveform**



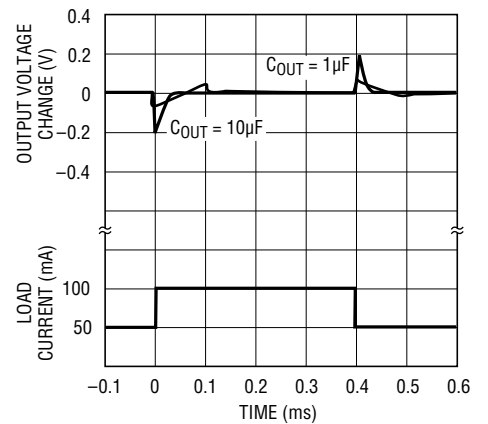
LT1312 G16

**Line Transient Response (12V)**



LT1312 G17

**Load Transient Response (12V)**



LT1312 G18

## PIN FUNCTIONS

**Supply Pin:** Power is supplied to the device through the supply pin. The supply pin should be bypassed to ground if the device is more than 6 inches away from the main supply capacitor. A bypass capacitor in the range of 0.1 $\mu$ F to 1 $\mu$ F is sufficient. The supply voltage to the LT1312 can be loosely regulated between 13V and 20V. See Applications Information section for more detail.

**VPP<sub>OUT</sub> Pin:** This regulated output supplies power to the PCMCIA card VPP pins which are typically tied together at the card socket. The VPP<sub>OUT</sub> output is current limited to approximately 330mA. Thermal shutdown provides a second level of protection. A 1 $\mu$ F to 10 $\mu$ F tantalum output capacitor is recommended. See Applications Information section for more detail on output capacitor considerations.

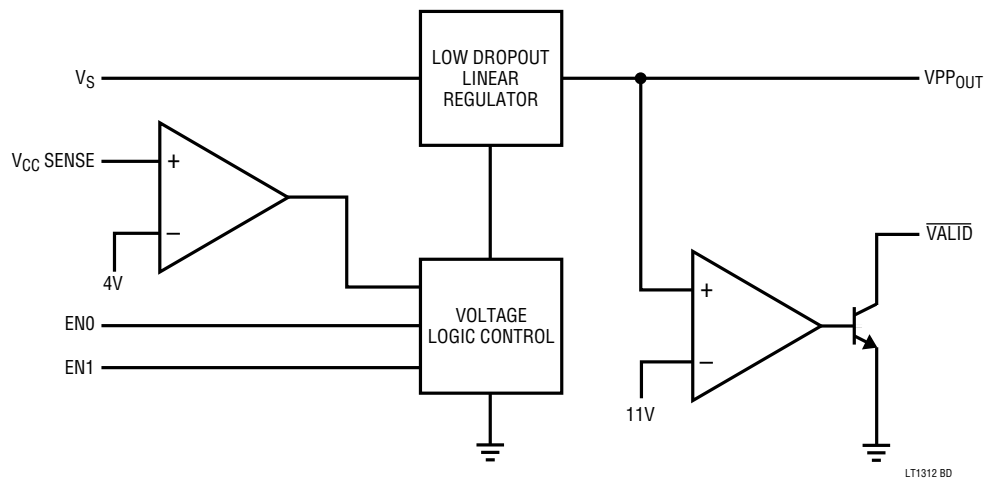
**Input Enable Pins:** The two digital input pins are high impedance inputs with approximately 20 $\mu$ A input current

at 2.4V. The input thresholds are compatible with CMOS controllers and can be driven from either 5V or 3.3V CMOS logic. ESD protection diodes limit input excursions to 0.6V below ground.

**VALID Output Pin:** This pin is an open-collector NPN output which is driven low when the VPP<sub>OUT</sub> pin is in regulation, i.e., when it is above 11V. An external 51k pull-up resistor is connected between this output and the same 5V or 3.3V logic supply powering the PCMCIA compatible control logic.

**V<sub>CC</sub> Sense Pin:** A built-in comparator and 4V reference automatically switches the VPP<sub>OUT</sub> from 5V to 3.3V depending upon the voltage sensed at the PCMCIA card socket V<sub>CC</sub> pin. The input current for this pin is approximately 30 $\mu$ A. For 5V only operation, connect the Sense pin directly to ground. An ESD protection diode limits the input voltage to 0.6V below ground.

## BLOCK DIAGRAM



## OPERATION

The LT1312 is a programmable output voltage, low-dropout linear regulator designed specifically for PCMCIA VPP drive applications. Input power is typically obtained from a loosely regulated input supply between 13V and 20V (see Applications Information section for more detail on the input power supply). The LT1312 consists of the following blocks:

**Low Dropout Voltage Linear Regulator:** The heart of the LT1312 is a PNP-based low-dropout voltage regulator which drops the unregulated supply voltage from 13V to 20V down to 12V, 5V, 3.3V, 0V or Hi-Z depending upon the state of the two Enable inputs and the  $V_{CC}$  Sense input. The regulator has built-in current limiting and thermal shut-down to protect the device, the load, and the socket against inadvertent short circuiting to ground.

**Voltage Control Logic:** The LT1312 has five possible output modes: 0V, 3.3V, 5V, 12V and Hi-Z. These five modes are selected by the two Enable inputs and the  $V_{CC}$  Sense input as described by the Truth Table.

**$V_{CC}$  Sense Comparator:** When the  $V_{CC}$  mode is selected, the LT1312 automatically adjusts the regulated VPP output voltage to 3.3V or 5V depending upon the voltage present at the PC card  $V_{CC}$  supply pin. The threshold voltage for the comparator is set at 4V and there is approximately 50mV of hysteresis provided to ensure clean switching between 3.3V and 5V.

**VPP VALID Comparator:** A voltage comparator monitors the output voltage when the 12V mode is selected and is driven low when the output is in regulation above 11V.

## APPLICATIONS INFORMATION

The LT1312 is a voltage programmable linear regulator designed specifically for PCMCIA VPP driver applications. The device operates with very low quiescent current (30 $\mu$ A) in the 0V and Hi-Z modes of operation. In the Hi-Z mode, the output leakage current falls to 1 $\mu$ A. Unloaded quiescent current rises to only 55 $\mu$ A and 75 $\mu$ A when programmed to 3.3V and 5V respectively. In addition to the low quiescent currents, the LT1312 incorporates several protection features which make it ideal for PCMCIA applications. The LT1312 has built-in current limiting (330mA) and thermal shutdown to protect the device and the socket VPP pins against inadvertent short-circuit conditions.

### AUXILIARY WINDING POWER SUPPLIES

Because the LT1312 provides excellent output regulation, the input power supply may be loosely regulated. One convenient (and economic) source of power is an auxiliary winding on the main 5V switching regulator inductor in the main system power supply.

#### LTC<sup>®</sup>1142HV Auxiliary Winding Power Supply

Figure 1 is a schematic diagram which describes how a loosely regulated 14V power supply is created by adding

an auxiliary winding to the 5V inductor in a split 3.3V/5V LTC1142HV power supply system. A turns ratio of 1:1.8 is used for transformer T1 to ensure that the input voltage to the LT1312 falls between 13V and 20V under all load conditions. The 9V output from this additional winding is rectified by diode D2, added to the main 5V output and applied to the input of the LT1312. (Note that the auxiliary winding must be phased properly as shown in Figure 1.)

The auxiliary winding is referenced to the 5V output which provides DC current feedback from the auxiliary supply to the main 5V section. The AC transient response is improved by returning the negative lead of C5 to the 5V output as shown.

When the 12V output is activated by a TTL high on the Enable line, the 5V section of the LTC1142HV is forced into continuous mode operation. A resistor divider composed of R2, R3 and switch Q3 forces an offset which is subtracted from the internal offset at the Sense<sup>-</sup> input (pin 14) of the LTC1142HV. When this external offset cancels the built-in 25mV offset, Burst Mode<sup>™</sup> operation is inhibited and the LTC1142HV is forced into continuous mode operation. (See the LTC1142HV data sheet for further detail). In this mode, the 14V auxiliary supply can be

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APPLICATIONS INFORMATION

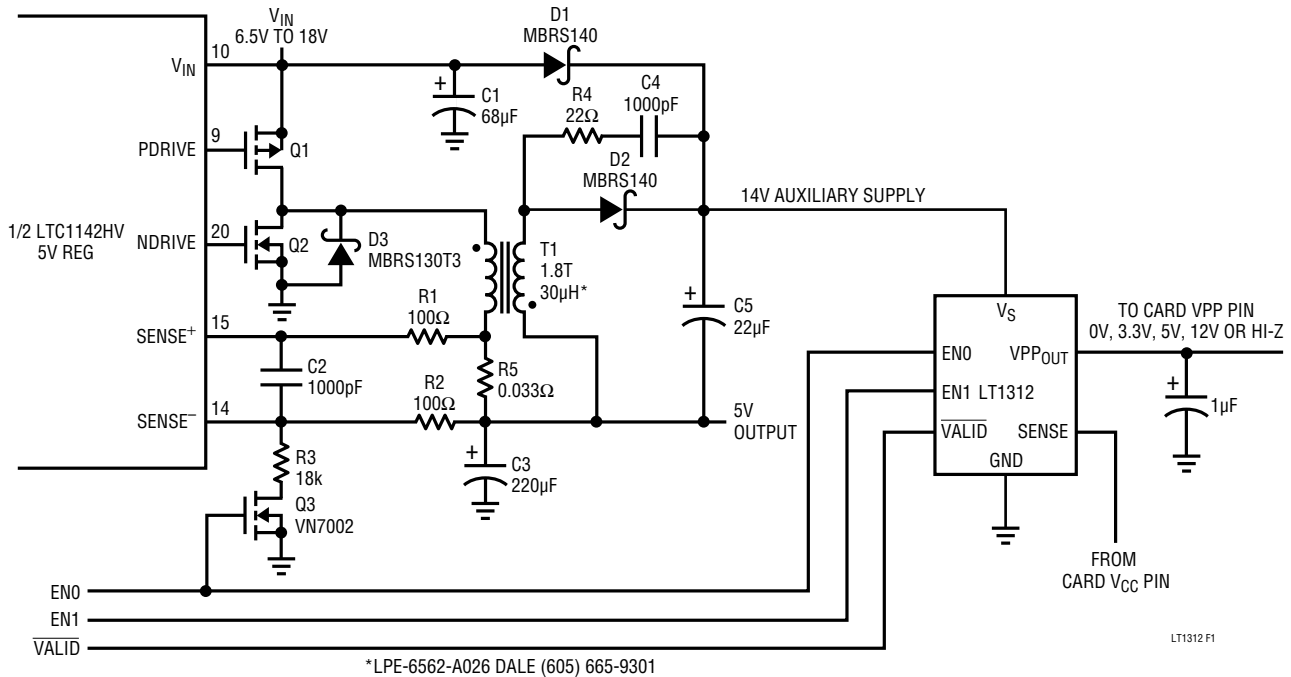


Figure 1. Deriving 14V Power from an Auxiliary Winding on the LTC1142HV 5V Regulator

loaded without regard to the loading on the 5V output of the LTC1142HV.

Continuous mode operation is only invoked when the LT1312 is programmed to 12V. If the LT1312 is programmed to 0V, 3.3V or 5V, power is obtained directly from the main power source (battery pack) through diode D1. Again, the LT1312 output can be loaded without regard to the loading of the main 5V output.

R4 and C4 absorb transient voltage spikes associated with the leakage inductance inherent in T1's secondary winding and ensure that the auxiliary supply does not exceed 20V.

Figure 2 is a graph of output voltage versus output current for the auxiliary 14V supply shown in Figure 1. Note that the auxiliary supply voltage is slightly higher when the 5V output is heavily loaded. This is due to the increased energy flowing through the main 5V inductor.

LTC1142 Auxiliary Power from the 3.3V Output

The circuit of Figure 1 can be modified for operation with low-battery count applications (6 cell). As the input voltage falls, the 5V duty cycle increases to the point where

there is simply not enough time to transfer energy from the 5V primary to the auxiliary winding. For applications where heavy 12V load currents exist in conjunction with low input voltages (<6.5V), the auxiliary winding can be derived from the 3.3V section instead of the 5V section of the LTC1142. In this case, a transformer with a turns ratio of 1:3.4 to 1:3.6 should be used in place of the 3.3V section

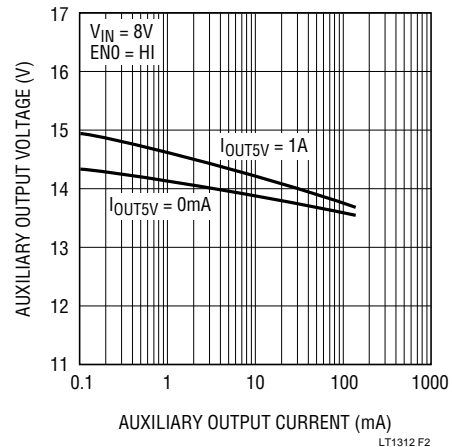


Figure 2. LTC1142 Auxiliary Supply Voltage

## APPLICATIONS INFORMATION

inductor as shown in Figure 3. MOSFET Q4 and diode D4 have been added and diode D1 is no longer used. In the previous circuit, power is drawn directly from the batteries through D1, when the LTC1142 is in Burst Mode operation and the VPP pin requires 3.3V or 5V. For these lower input voltages this technique is no longer valid as the input will fall below the LT1312 regulator's dropout voltage. To correct for this situation, the additional switch Q4 forces the switching regulator into continuous mode operation whenever 3.3V, 5V or 12V is selected.

### LINE POWERED SUPPLIES

In line operated products such as: desktop computers, dedicated PC card readers/writers, medical equipment, test and measurement equipment, etc., it is possible to derive power from a relatively "raw" source such as a 5V or 12V power supply. The 12V supply line in a desktop computer however, is usually too "dirty" to apply directly to the VPP pins of a PCMCIA card socket. Power supply switching and load transients may create voltage spikes

on this line that may damage sensitive PCMCIA flash memory cards if applied directly to the VPP pins.

### Flash Memory Card VPP Power Considerations

PCMCIA compatible flash memory cards require tight regulation of the 12V VPP programming supply to ensure that the internal flash memory circuits are never subjected to damaging conditions. Flash memory circuits are typically rated with an absolute maximum of 13.5V and VPP must be maintained at 12V  $\pm$ 5% under all possible load conditions during erase and program cycles. Undervoltage can decrease specified flash memory reliability and overvoltage can damage the device<sup>1</sup>.

### Generating 14V from 5V or 12V

It is important that the 12V VPP supply for the two VPP lines to the card be free of voltage spikes. There should be little or no overshoot during transitions to and from the 12V level.

<sup>1</sup>See Application Note AP-357, "Power Supply Solutions for Flash Memory," Intel Corporation, 1992.

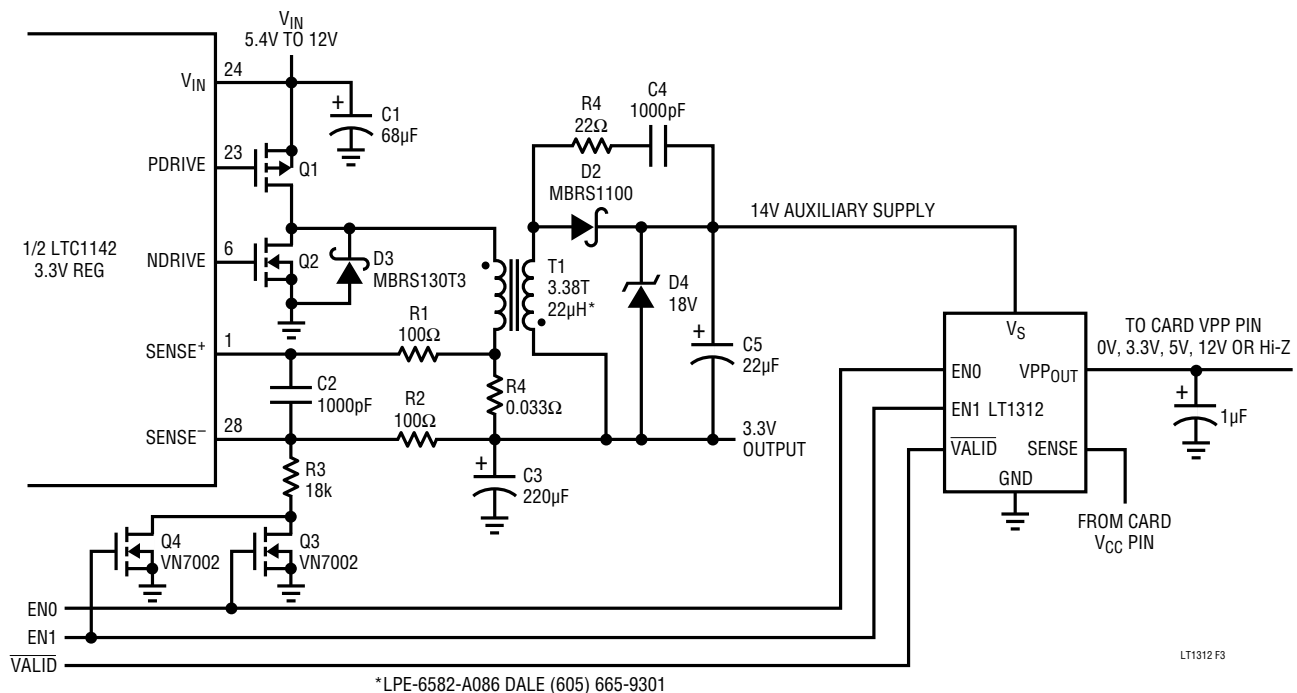


Figure 3. Deriving Auxiliary 14V Power from an LTC1142 3.3V Regulator



## APPLICATIONS INFORMATION

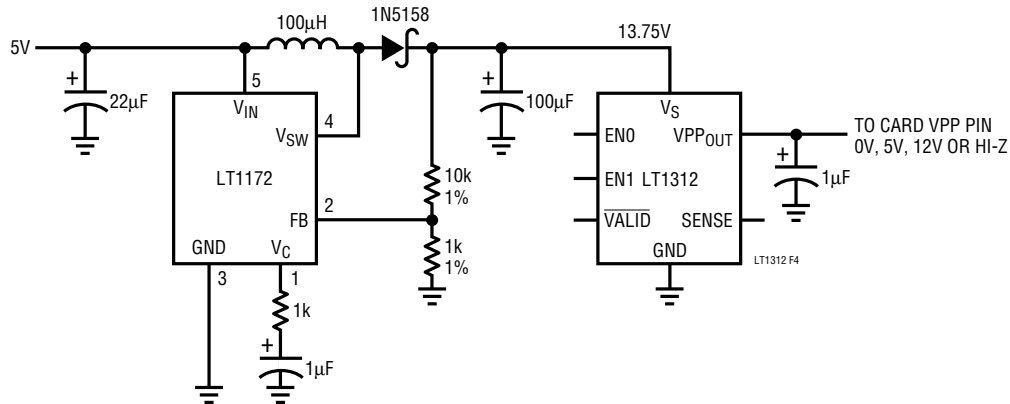


Figure 4. Local 5V to 15V Boost Regulator for Line Operated Applications

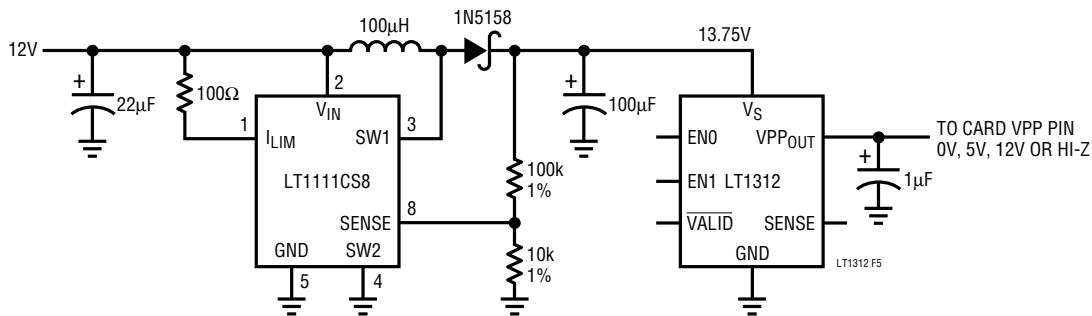


Figure 5. Local 12V to 15V Boost Regulator for Line Operated Applications

This is easily accomplished by generating a local 14V supply from a relatively “dirty” 5V or 12V supply as shown in Figures 4 and 5. Precise voltage control (and further filtering) is provided by the LT1312 driver/regulator. A further advantage to this scheme is that it adds current limit in series with the VPP pins to eliminate possible damage to the card socket, the PC card, or the switching power supply in the event of an accidental short circuit.

### Output Capacitance

The LT1312 is designed to be stable with a wide range of output capacitors. The minimum recommended value is a 1µF with an ESR of 3Ω or less. The capacitor is connected directly between the output pin and ground as shown in Figure 6.

For applications where space is very limited, capacitors as low as 0.33µF can be used. Extremely low ESR ceramic capacitors with values less than 1µF must have a 2Ω resistor added in series with the output capacitor as shown in shown in Figure 7.

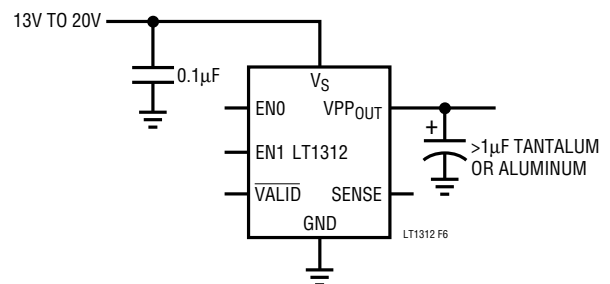


Figure 6. Recommended >1µF Tantalum Output Capacitor

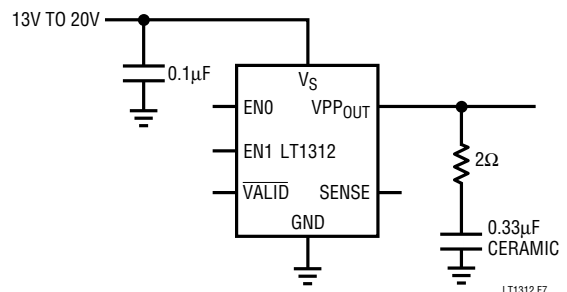


Figure 7. Using a 0.33µF to 1µF Output Capacitor

## APPLICATIONS INFORMATION

### Transient and Switching Performance

The LT1312 is designed to produce minimal overshoot with capacitors in the range of 1µF to 10µF. Larger capacitor values can be used with a slowing of rise and fall times.

The positive output slew rate is determined by the 330mA current limit and the output capacitor. The rise time for a 0V to 12V transition is approximately 40µs, the rise time for a 10µF capacitor is roughly 400µs (see the Transient Response curves in the Typical Performance Characteristics section).

The fall time from 12V to 0V is set by the output capacitor and an internal pull-down current source which sinks about 30mA. This source will fully discharge a 1µF capacitor in less than 1ms.

### Thermal Considerations

Power dissipated by the device is the sum of two components: output current multiplied by the input-output differential voltage  $I_{OUT} \times (V_{IN} - V_{OUT})$ , and ground pin current multiplied by supply voltage  $I_{GND} \times V_{IN}$ .

The ground pin current can be found by examining the Ground Pin Current curves in the Typical Performance Characteristics section.

Heat sinking, for surface mounted devices, is accomplished by using the heat spreading capabilities of the PC board and its copper traces.

The junction temperature of the LT1312 must be limited to 125°C to ensure proper operation. Use Table 1 in conjunction with the typical performance graphs, to calculate the power dissipation and die temperature for a particular application and ensure that the die temperature does not exceed 125°C under any operating conditions.

Table 1. S8 Package\*

COPPER AREA		BOARD AREA	THERMAL RESISTANCE (JUNCTION-TO-AMBIENT)
TOPSIDE	BACKSIDE		
2500 sq mm	2500 sq mm	2500 sq mm	120°C/W
1000 sq mm	2500 sq mm	2500 sq mm	120°C/W
225 sq mm	2500 sq mm	2500 sq mm	125°C/W
1000 sq mm	1000 sq mm	1000 sq mm	131°C/W

\*Device is mounted topside.

### Calculating Junction Temperature

Example: given an output voltage of 12V, an input supply voltage of 14V, an output current of 100mA, and a maximum ambient temperature of 50°C, what will the maximum junction temperature be?

Power dissipated by the device will be equal to:

$$I_{OUT} \times (V_S - V_{PP_{OUT}}) + (I_{GND} \times V_{IN})$$

where:

$$I_{OUT} = 100\text{mA}$$

$$V_{IN} = 14\text{V}$$

$$I_{GND} \text{ at } (I_{OUT} = 100\text{mA}, V_{IN} = 14\text{V}) = 5\text{mA}$$

so,

$$P_D = 100\text{mA} \times (14\text{V} - 12\text{V}) + (5\text{mA} \times 15\text{V}) = 0.275\text{W}$$

Using Table 1, the thermal resistance will be in the range of 120°C/W to 131°C/W depending upon the copper area. So the junction temperature rise above ambient will be less than or equal to:

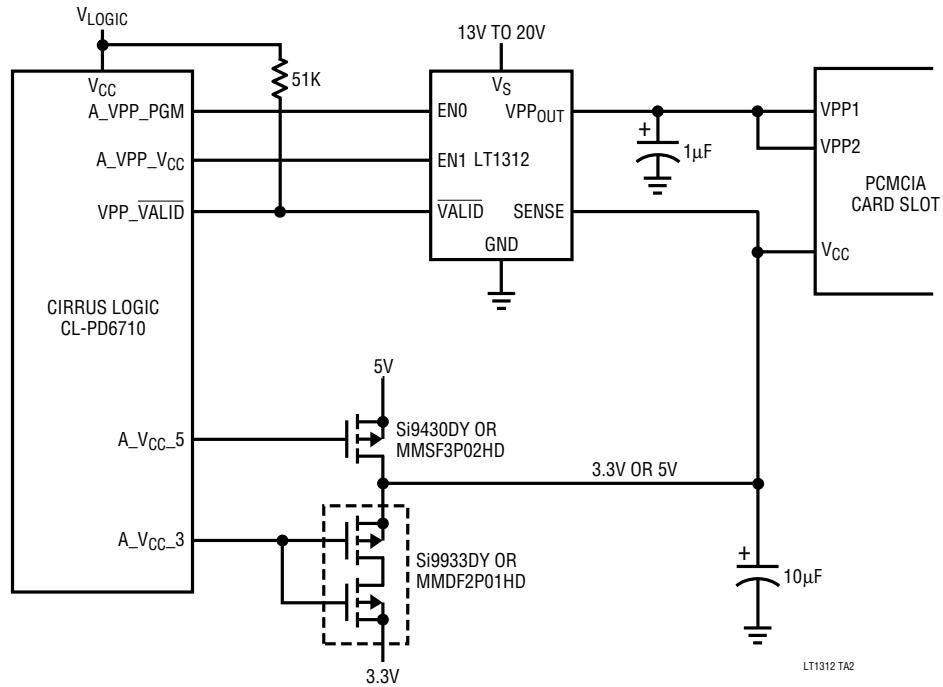
$$0.275\text{W} \times 131^\circ\text{C/W} = 36^\circ\text{C}$$

The maximum junction temperature will then be equal to the junction temperature rise above ambient plus the maximum ambient temperature or:

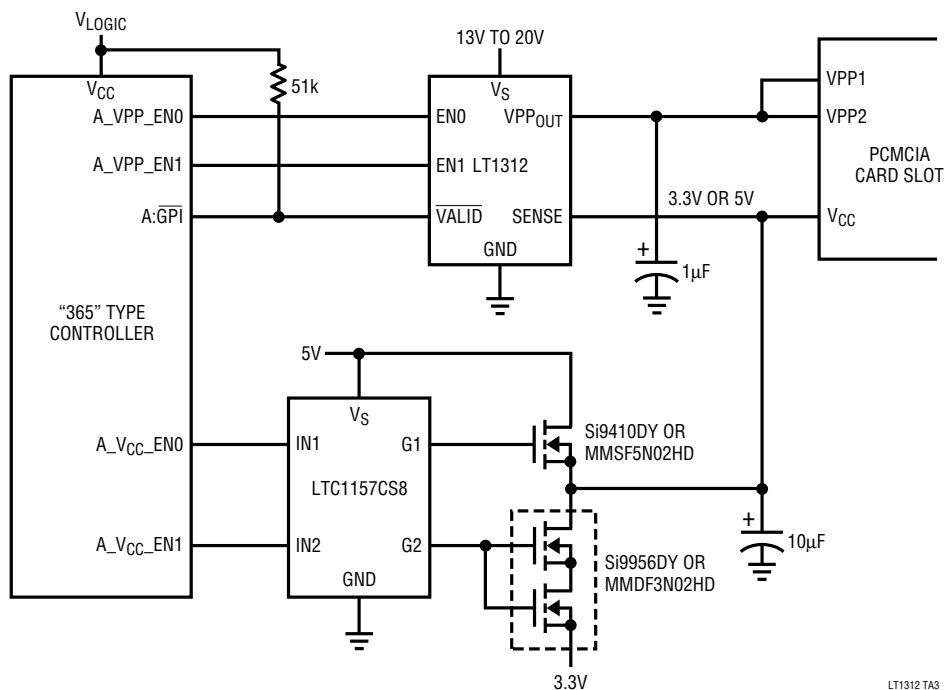
$$T_{JMAX} = 50^\circ\text{C} + 36^\circ\text{C} = 86^\circ\text{C}.$$

# TYPICAL APPLICATIONS

## Single Slot Interface to CL-PD6710

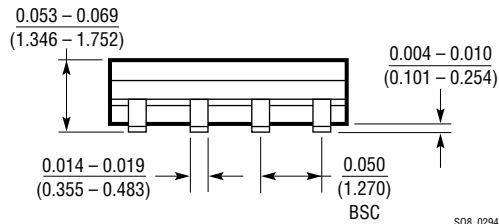
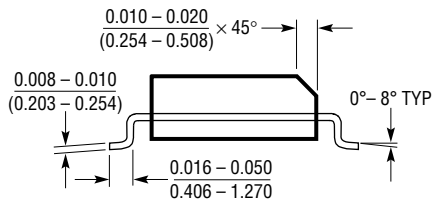
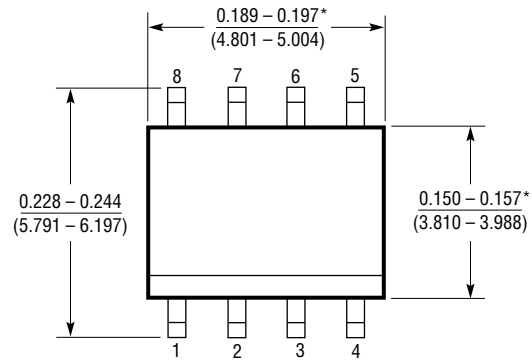


## Single Slot Interface to "365" Type Controller



**PACKAGE DESCRIPTION** Dimensions in inches (millimeters) unless otherwise noted.

**S8 Package  
8-Lead Plastic SOIC**



\*THESE DIMENSIONS DO NOT INCLUDE MOLD FLASH OR PROTRUSIONS.  
MOLD FLASH OR PROTRUSIONS SHALL NOT EXCEED 0.006 INCH (0.15mm).

S08 0294

**RELATED PARTS**

See PCMCIA Product Family table on the first page of this data sheet.