

Dual PCMCIA  
VPP Driver/Regulator

## FEATURES

- **Digital Selection of 0V, V<sub>CC</sub>, 12V or Hi-Z**
- **Output Current Capability: 120mA**
- **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
- Output Capacitors: 1μF
- Quiescent Current in Hi-Z or 0V Mode: 60μA
- Independent VPP Valid Status Feedback Signals
- No VPP Overshoot

## APPLICATIONS

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

## DESCRIPTION

The LT<sup>®</sup>1313 is a member of Linear Technology Corporation's PCMCIA driver/regulator family. It provides 0V, 3.3V, 5V, 12V and Hi-Z regulated power to the VPP pins of two PCMCIA card slots from a single unregulated 13V to 20V supply. When used in conjunction with a PC Card Interface Controller, the LT1313 forms a complete minimum component-count interface for palmtop, pen-based and notebook computers. The two VPP output voltages are independently selected by four logic compatible digital inputs which interface directly with industry standard PC Card Interface Controllers.

Automatic 3.3V to 5V switching is provided by two independent comparators which continuously monitor each PC card  $V_{CC}$  supply voltage and automatically adjust the VPP output to match the associated  $V_{CC}$  pin voltage when the VPP =  $V_{CC}$  mode is selected.

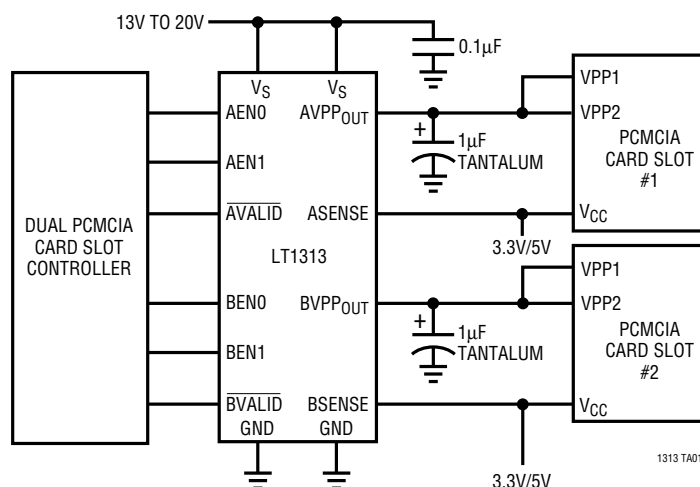
Two open-collector VPP  $\overline{\text{VALID}}$  outputs are provided to indicate when the VPP outputs are in regulation at 12V.

The LT1313 is available in 16-pin SO packaging.

 LTC and LT are registered trademarks of Linear Technology Corporation.

## TYPICAL APPLICATION

### Typical PCMCIA Dual Slot VPP Driver



## Linear Technology PCMCIA Product Family

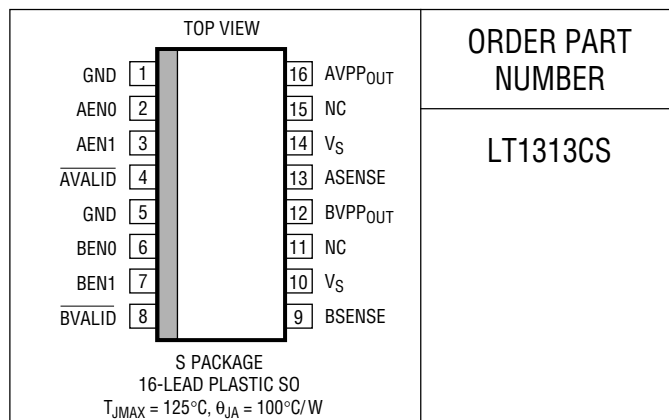
| DEVICE   | DESCRIPTION                                     | PACKAGE     |
|----------|-------------------------------------------------|-------------|
| LT1312   | SINGLE PCMCIA VPP DRIVER/REGULATOR              | 8-PIN SO    |
| LT1313   | DUAL PCMCIA VPP DRIVER/REGULATOR                | 16-PIN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

ORDER PART  
NUMBER

LT1313CS

Consult factory for Industrial and Military grade parts.

ELECTRICAL CHARACTERISTICS  $V_S = 13V$  to  $20V$ ,  $T_A = 25^\circ C$  (Note 1), 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 2)                | ● | 11.52 | 12.00 | 12.48 | V     |
|                       |                                             | Program to 5V, I <sub>OUT</sub> ≤ 30mA (Note 2)                  | ● | 4.75  | 5.00  | 5.25  | V     |
|                       |                                             | Program to 3.3V, I <sub>OUT</sub> ≤ 30mA (Note 2)                | ● | 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                              | Both Channels Programmed to 0V                                   | ● |       | 60    | 100   | μA    |
|                       |                                             | Both Channels Programmed to Hi-Z                                 | ● |       | 60    | 100   | μA    |
|                       |                                             | One Channel Programmed to 12V, No Load (Note 3)                  | ● |       | 260   | 400   | μA    |
|                       |                                             | One Channel Programmed to 5V, No Load (Note 3)                   | ● |       | 105   | 150   | μA    |
|                       |                                             | One Channel Programmed to 3.3V, No Load (Note 3)                 | ● |       | 85    | 120   | μA    |
|                       |                                             | One Channel Programmed to 12V, I <sub>OUT</sub> = 120mA (Note 3) | ● |       | 126   | 132   | mA    |
|                       |                                             | One Channel Programmed to 5V, I <sub>OUT</sub> = 30mA (Note 3)   | ● |       | 31    | 33    | mA    |
|                       |                                             | One Channel Programmed to 3.3V, I <sub>OUT</sub> = 30mA (Note 3) | ● |       | 31    | 33    | mA    |
| I <sub>LIM</sub>      | Current Limit                               | Program to 3.3V, 5V or 12V (Note 3)                              |   |       | 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 (Note 4)                         | ● | 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 (Note 4)                         | ● | 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, (Note 5)                                         | ● | 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, (Note 5)              |   | 1     | 3.3   |       | mA    |
|                       | VPP <sub>VALID</sub> Output Leakage Current | Program to 0V, V <sub>VALID</sub> = 12V, (Note 5)                |   |       | 0.1   | 10    | μA    |

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

**Note 1:** Both  $V_S$  pins (10, 14) must be connected together, and both ground pins (1, 5) must be connected together.

**Note 2:** For junction temperatures greater than 110°C, a minimum load of 1mA is recommended.

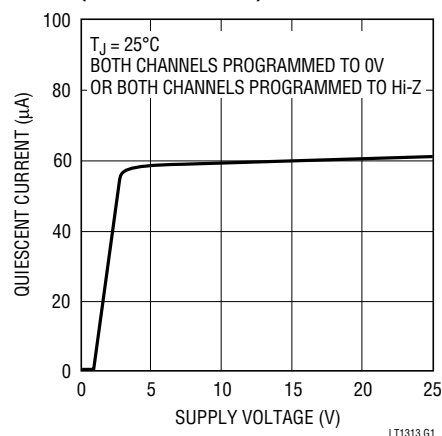
**Note 3:** The other channel is programmed to the 0V mode ( $XEN0 = XEN1 = 0V$ ) during this test.

**Note 4:** The  $V_{CC}$  sense threshold voltage tests are performed independently.

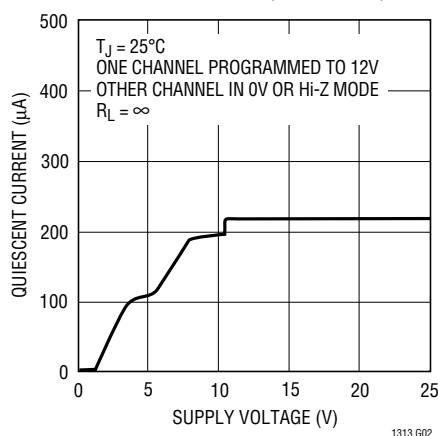
**Note 5:** The  $V_{PP_{VALID}}$  tests are performed independently.

# TYPICAL PERFORMANCE CHARACTERISTICS

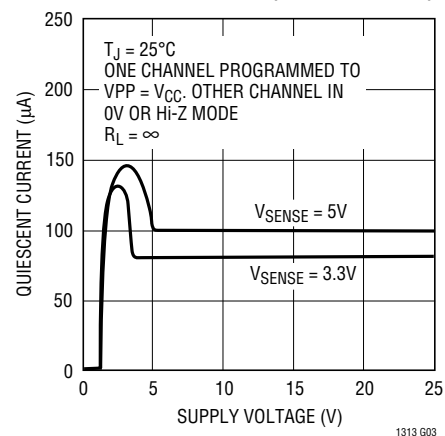
**Quiescent Current  
(0V or Hi-Z Mode)**



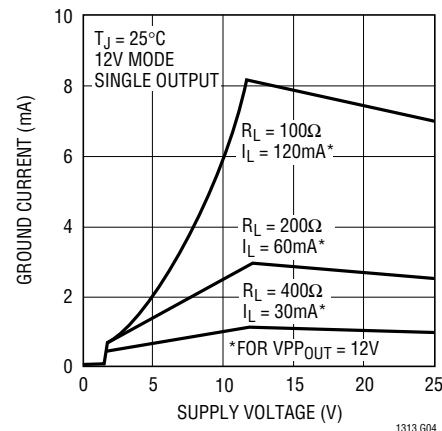
**Quiescent Current (12V Mode)**



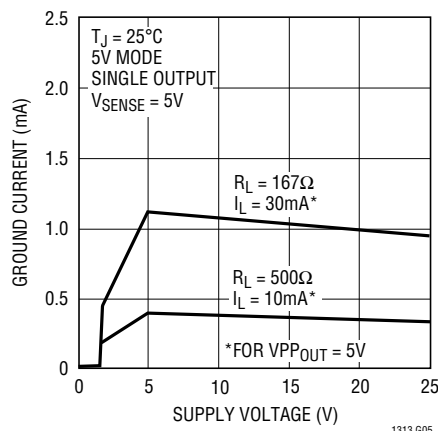
**Quiescent Current (3.3V/5V Mode)**



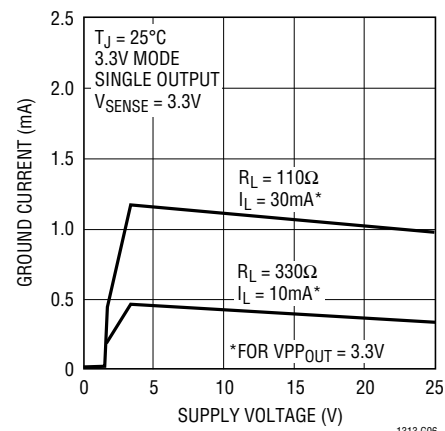
**Ground Pin Current (12V Mode)**



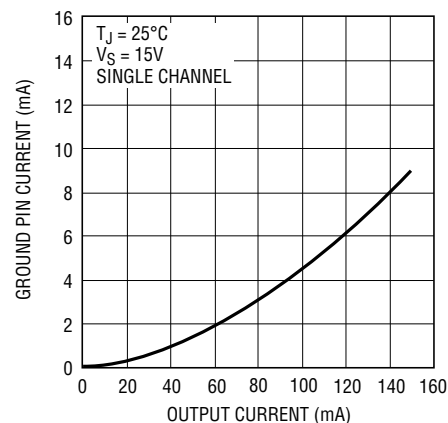
**Ground Pin Current (5V Mode)**



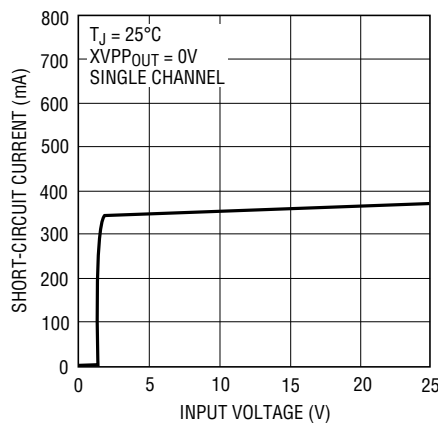
**Ground Pin Current (3.3V Mode)**



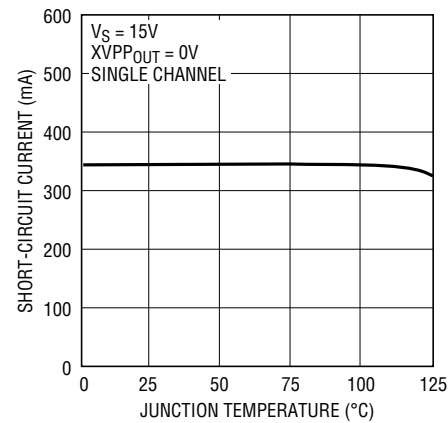
**Ground Pin Current**



**Current Limit**

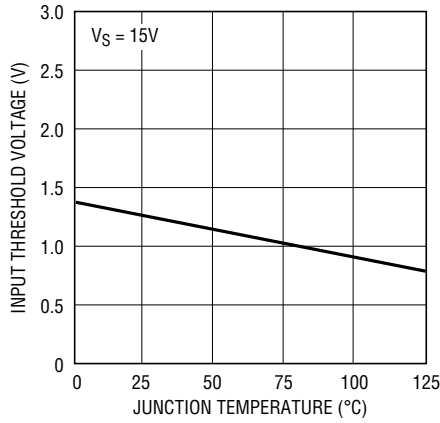


**Current Limit**

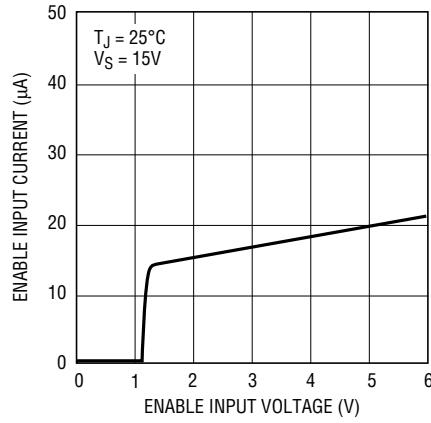


# TYPICAL PERFORMANCE CHARACTERISTICS

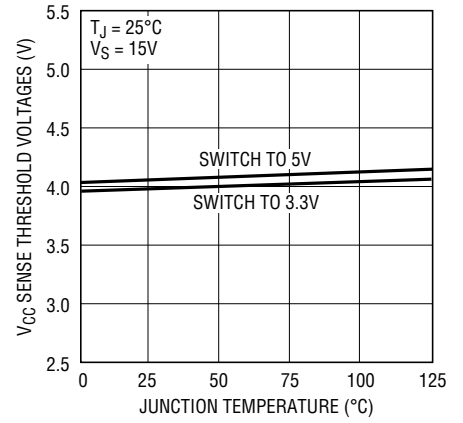
Enable Input Threshold Voltage



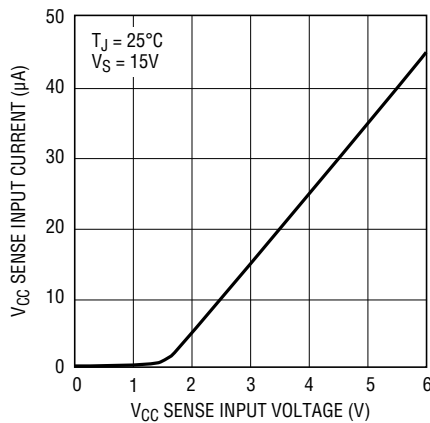
Enable Input Current



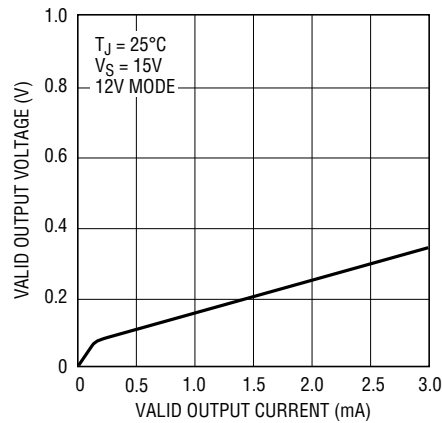
V<sub>CC</sub> Sense Threshold Voltage



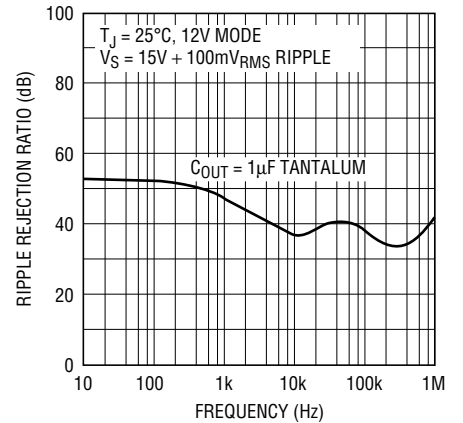
V<sub>CC</sub> Sense Input Current



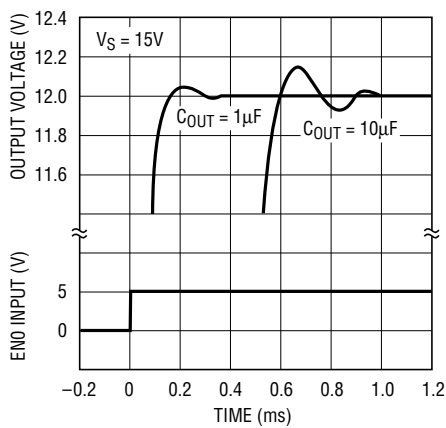
VALID Output Voltage



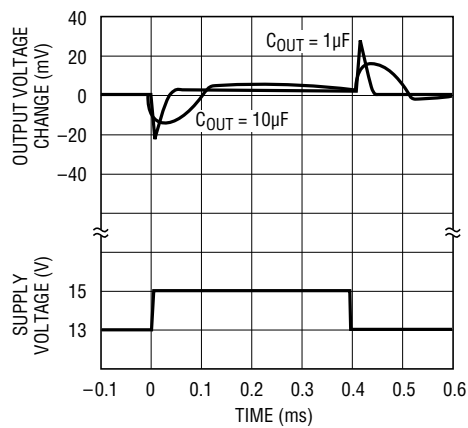
Ripple Rejection (12V)



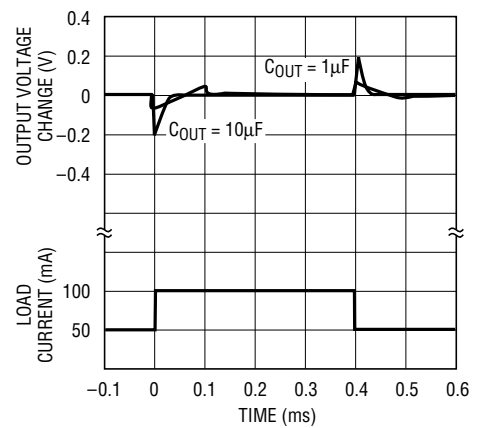
12V Turn-On Waveform



Line Transient Response (12V)



Load Transient Response (12V)



## PIN FUNCTIONS

**Supply Pins:** Power is supplied to the device through the two supply pins *which must be connected together at all times*. The supply pins should be bypassed to ground if the device is more than six 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 LT1313 can be loosely regulated between 13V and 20V.

**VPP<sub>OUT</sub> Pins:** Each regulated output supplies power to the two PCMCIA card VPP pins which are typically tied together at the socket. Each 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.

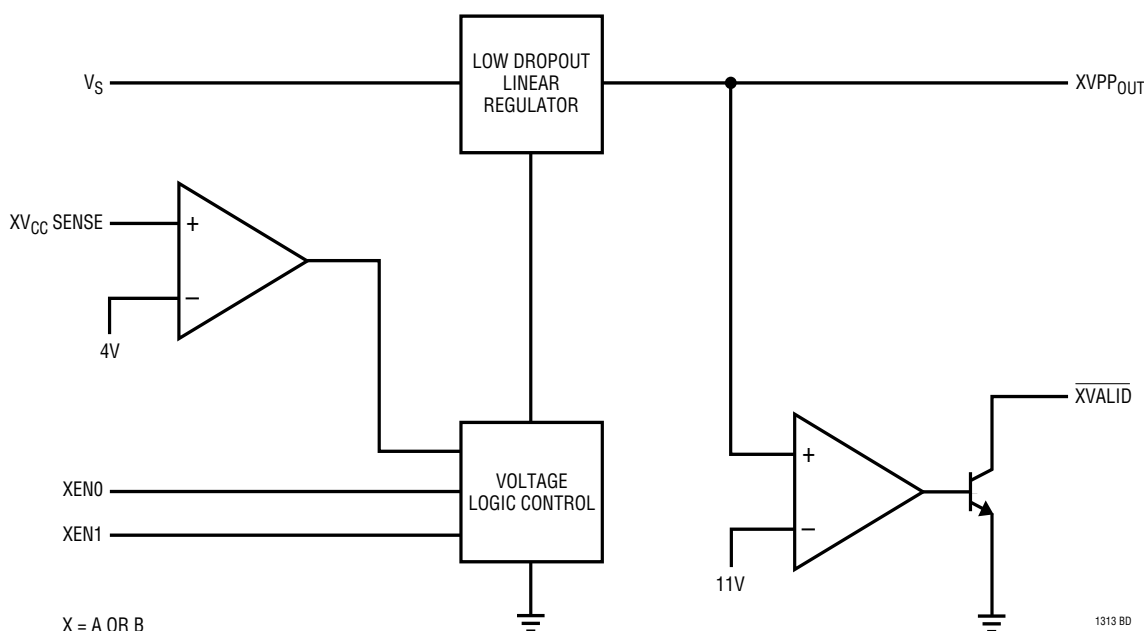
**Input Enable Pins:** The four digital input pins are high impedance inputs with approximately 20 $\mu$ A input current at 2.4V. The input thresholds are compatible with CMOS controllers and can be driven from either 5V or 3.3V CMOS logic. ESD protection diodes limit input excursions to 0.6V below ground.

**VALID Output Pins:** These pins are open-collector NPN outputs which are driven low when the corresponding VPP<sub>OUT</sub> pin is in regulation, i.e., when it is above 11V. Two external 51k pull-up resistors are connected between these outputs and the same 5V or 3.3V logic supply powering the PCMCIA compatible control logic.

**V<sub>CC</sub> Sense Pins:** Two independent comparators and 4V references automatically switch the VPP<sub>OUT</sub> outputs from 5V to 3.3V depending upon the voltage sensed at the corresponding PCMCIA card socket V<sub>CC</sub> pin. The input current for these pins is approximately 30 $\mu$ A. For 5V only operation, connect the Sense pins directly to ground. An ESD protection diode limits the input voltage to 0.6V below ground.

**Ground Pins:** *The two ground pins must be connected together at all times.*

## BLOCK DIAGRAM (One Channel)



## OPERATION

The LT1313 is two programmable output voltage, low-dropout linear regulators designed specifically for PCMCIA VPP drive applications. Input power is typically obtained from a loosely regulated input supply between 13V and 20V. The LT1313 consists of the following blocks:

**Two Low Dropout Voltage Linear Regulators:** The heart of the LT1313 is two PNP-based low-dropout voltage regulators which drop the unregulated supply voltage from 13V to 20V down to 12V, 5V, 3.3V, 0V or Hi-Z depending upon the state of the four Enable inputs and the two  $V_{CC}$  Sense inputs. The regulators have built-in current limiting and thermal shutdown to protect the device, the loads, and the sockets against inadvertent short circuiting to ground.

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

**$V_{CC}$  Sense Comparators:** When the  $V_{CC}$  mode is selected, the LT1313 automatically adjusts each regulated VPP output voltage to 3.3V or 5V depending upon the voltage present

at the corresponding PC card  $V_{CC}$  supply pin. The threshold voltage for these comparators is set at 4V and there is approximately 50mV of hysteresis provided to ensure clean switching between 3.3V and 5V.

**VPP  $\overline{VALID}$  Comparator:** Two voltage comparators monitor each output voltage when the 12V mode is selected and are driven low when the output is in regulation above 11V. These two outputs function separately.

**LT1313 Truth Table**

| AEN0 | AEN1 | ASENSE       | AVPP <sub>OUT</sub> | A $\overline{VALID}$ |
|------|------|--------------|---------------------|----------------------|
| 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

| BEN0 | BEN1 | BSENSE       | BVPP <sub>OUT</sub> | B $\overline{VALID}$ |
|------|------|--------------|---------------------|----------------------|
| 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                    |

Note: Each channel is independently controlled.

## APPLICATIONS INFORMATION

The LT1313 is two voltage programmable linear regulators designed specifically for PCMCIA VPP driver applications. The device operates with very low quiescent current (60 $\mu$ A) in the 0V and Hi-Z modes of operation. In the Hi-Z mode, the output leakage current falls to 1 $\mu$ A. In addition to the low quiescent currents, the LT1313 incorporates several protection features which make it ideal for PCMCIA applications. The LT1313 has built-in current limiting (330mA) and thermal shutdown to protect the device and the socket VPP pins against inadvertent short-circuit conditions.

### Output Capacitance

The LT1313 is designed to be stable with a wide range of output capacitors. The minimum recommended value is a 1 $\mu$ F with an ESR of 3 $\Omega$  or less. The capacitor is connected directly between the output pin and ground. For applications where space is very limited, capacitors as low as 0.33 $\mu$ F can

be used. Extremely low ESR ceramic capacitors with values less than 1 $\mu$ F must have a 2 $\Omega$  resistor added in series with the output capacitor.

### Transient and Switching Performance

The LT1313 is designed to produce minimal overshoot with capacitors in the range of 1 $\mu$ F to 10 $\mu$ F. 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 40 $\mu$ s and the rise time for a 10 $\mu$ F capacitor is roughly 400 $\mu$ s (see the Transient Response curves in the Typical Performance Characteristics section).

## APPLICATIONS INFORMATION

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 LT1313 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. 16-Pin SO Package\***

| COPPER AREA |            | BOARD AREA | THERMAL RESISTANCE<br>(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 on topside.

### Calculating Junction Temperature

Example: given an output voltage of 12V, an input supply voltage of 14V, and an output current of 100mA (one VPP output), 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:

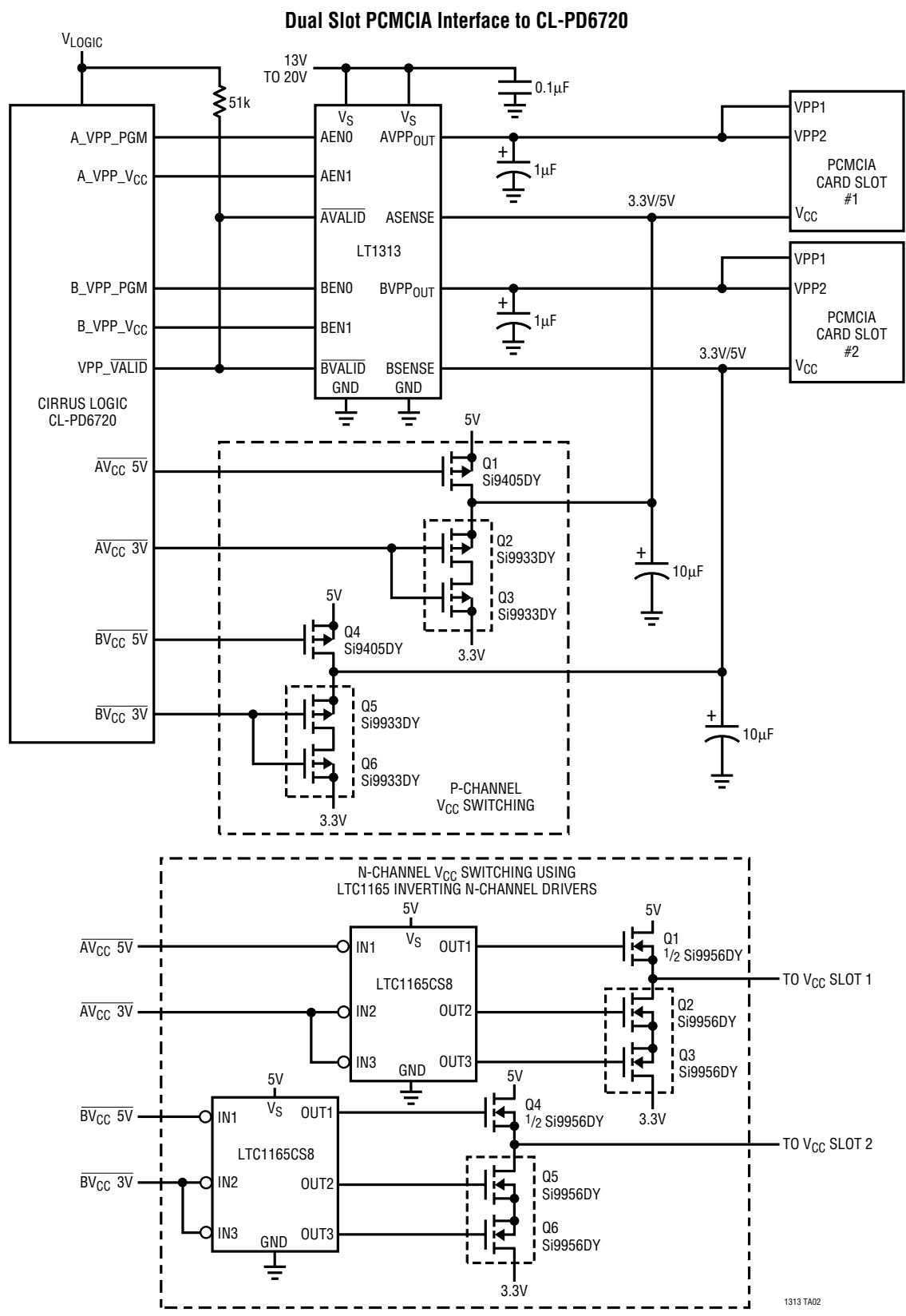
$$0.275\text{W} \times 131^\circ\text{C/W} = 36^\circ\text{C}$$

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

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

*For more detailed applications information, see the LT1312 Single PCMCIA VPP Driver/Regulator data sheet.*

TYPICAL APPLICATIONS



[illegible]

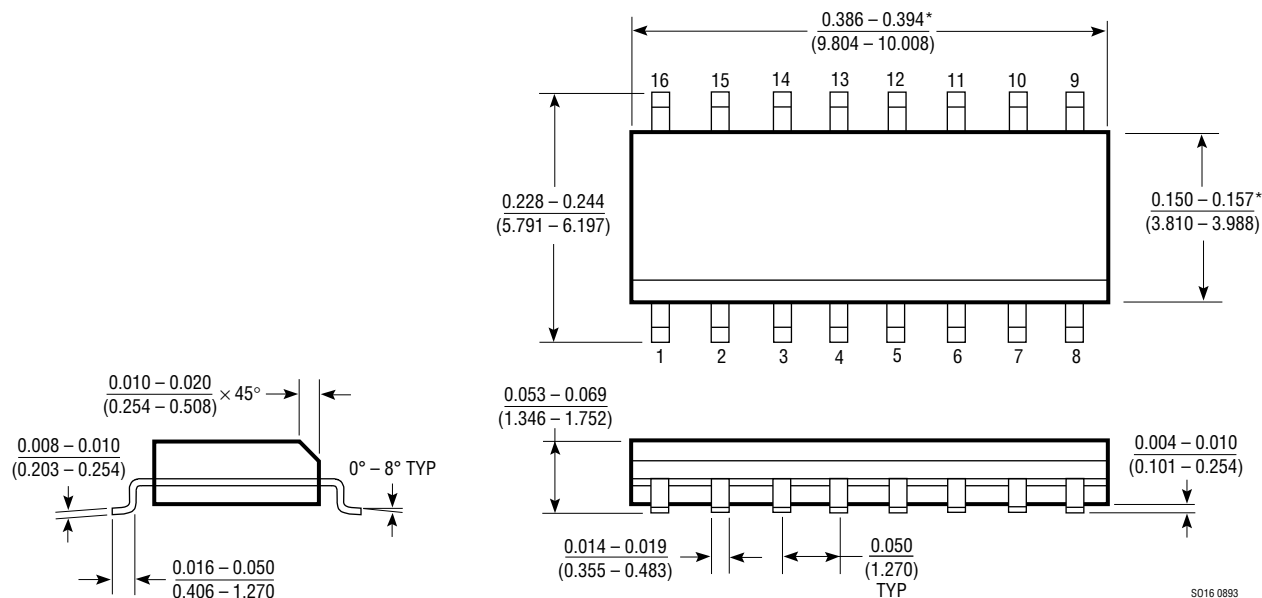
[illegible]

NOTE: SEE LT1312 DATA SHEET APPLICATIONS SECTION FOR FURTHER DETAILS ON THIS CIRCUIT

# PACKAGE DESCRIPTION

Dimensions in inches (millimeters) unless otherwise noted.

## S Package 16-Lead Narrow Plastic SOIC



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

SD16 0893

LT1313

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## RELATED PARTS

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