

### POWER MANAGEMENT

#### Description

The SC1159 is a synchronous-buck switch-mode controller designed for use in single ended power supply applications where efficiency is the primary concern. The controller is a hysteretic type, with a user selectable hysteresis. The SC1159 is ideal for implementing DC/DC converters needed to power advanced microprocessors such as Pentium® III and Athlon®, in both single and multiple processor configurations. Inhibit, under-voltage lock-out and soft-start functions are included for controlled power-up.

SC1159 features include an integrated 5 bit D/A converter, temperature compensated voltage reference, current limit comparator, over-current protection, and an adaptive deadtime circuit to prevent shoot-through of the power MOSFET during switching transitions. Power good signaling, logic compatible shutdown, and over-voltage protection are also provided. The integrated D/A converter provides programmability of output voltage from 1.050V to 1.825V in 25mV increments.

The SC1159 high side driver can be configured as either a ground-referenced or as a floating bootstrap driver. The high and low side MOSFET drivers have a peak current rating of 2 amps.

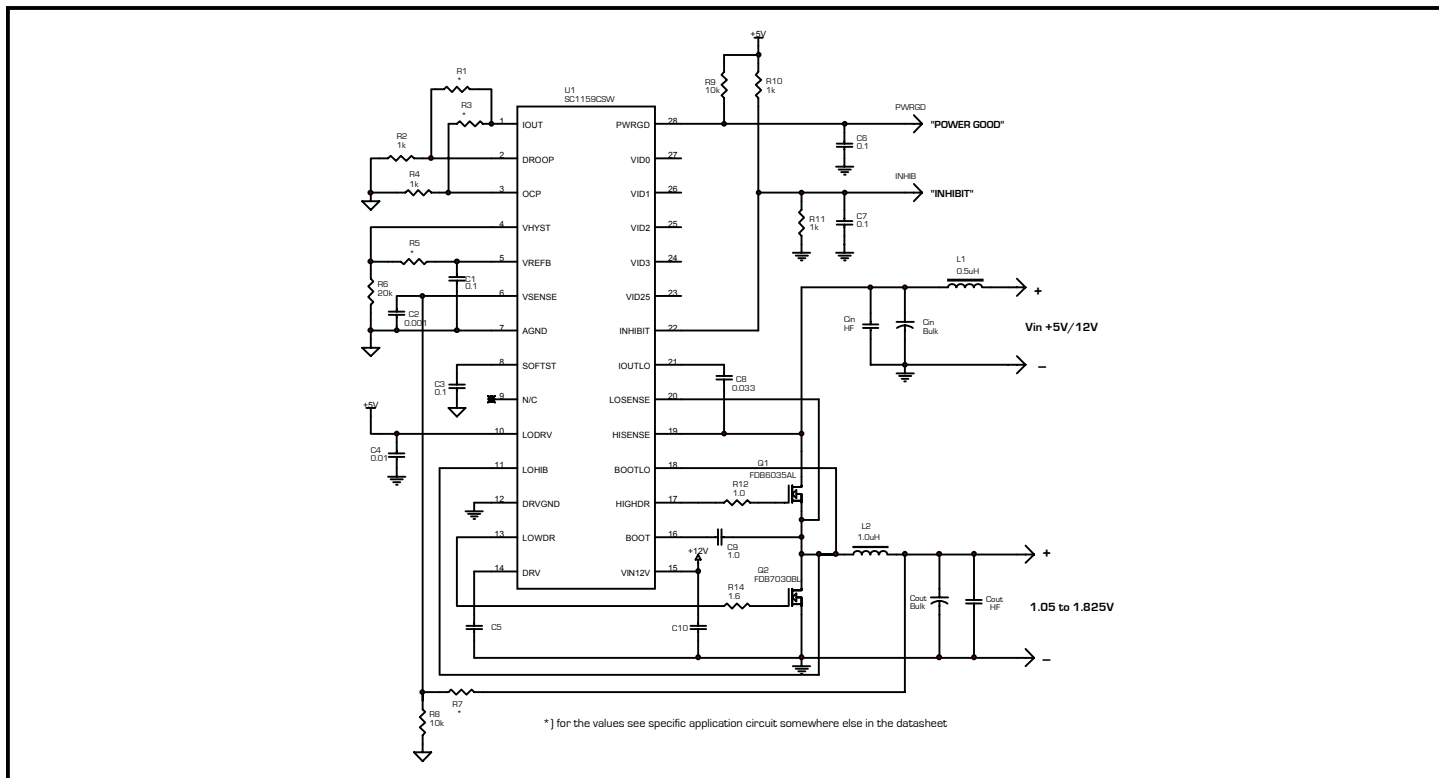
#### Typical Application Circuit

#### Features

- ◆ Programmable hysteresis
- ◆ 5 bit DAC programmable output (1.050V-1.825V)
- ◆ On-chip power good and OVP functions
- ◆ Designed to meet latest Intel specifications
- ◆ Up to 95% efficiency
- ◆ VIDs pulled up to +3.3V

#### Applications

- ◆ Server Systems and Workstations
- ◆ Pentium® III Core Supplies
- ◆ AMD Athlon® Core Supplies
- ◆ Multiple Microprocessor Supplies
- ◆ Voltage Regulator Modules



## POWER MANAGEMENT

### Absolute Maximum Ratings

Exceeding the specifications below may result in permanent damage to the device, or device malfunction. Operation outside of the parameters specified in the Electrical Characteristics section is not implied.

| Parameter                                              | Symbol        | Maximum     | Units            |
|--------------------------------------------------------|---------------|-------------|------------------|
| VIN12V                                                 | $V_{IN\_MAX}$ | -0.3 to 14  | V                |
| BOOT to DRVGN                                          |               | -0.3 to 25  | V                |
| BOOT to BOOTLO                                         |               | -0.3 to 15  | V                |
| Digital Inputs                                         |               | -0.3 to 7.3 | V                |
| AGND to DRVGN                                          |               | ±0.5        | V                |
| LOHIB to AGND                                          |               | -0.3 to 14  | V                |
| LOSENSE to AGND                                        |               | -0.3 to 14  | V                |
| IOTLO to AGND                                          |               | -0.3 to 14  | V                |
| HISENSE to AGND                                        |               | -0.3 to 14  | V                |
| VSENSE to AGND                                         |               | -0.3 to 5   | V                |
| Continuous Power Dissipation, $T_A = 25^\circ\text{C}$ | $P_D$         | 1.2         | W                |
| Continuous Power Dissipation, $T_C = 25^\circ\text{C}$ | $P_D$         | 6.25        | W                |
| Operating Junction Temperature Range                   | $T_J$         | 0 to +125   | $^\circ\text{C}$ |
| Lead Temperature (Soldering) 10 Sec.                   | $T_{LEAD}$    | 300         | $^\circ\text{C}$ |
| Storage Temperature                                    | $T_{STG}$     | -65 to 150  | $^\circ\text{C}$ |

### DC Electrical Characteristics

Unless specified:  $0 < T_J < 125^\circ\text{C}$ , VIN = 12V

| Parameter                                   | Symbol      | Conditions                                                                                                                             | Min  | Typ | Max | Units |
|---------------------------------------------|-------------|----------------------------------------------------------------------------------------------------------------------------------------|------|-----|-----|-------|
| Supply Voltage Range                        | VIN12V      |                                                                                                                                        | 11.4 | 12  | 13  | V     |
| Supply Current (Quiescent)                  | $I_{INQ}$   | INH = 5V, Vin above UVLO threshold during start-up,<br>$f_{sw} = 200\text{ kHz}$ , BOOTLO = 0V,<br>$C_{DH} = C_{DL} = 50\text{ pF}$    |      | 15  |     | mA    |
| High Side Driver Supply Current (Quiescent) | $I_{BOOTQ}$ | INH = 0V or Vin below UVLO threshold during start-up,<br>BOOT = 13V, BOOTLO = 0V                                                       |      | 2   |     | mA    |
|                                             |             | INH = 5V, VIN above UVLO threshold during start-up,<br>$f_{sw} = 200\text{ kHz}$ , BOOT = 13V, BOOTLO = 0V,<br>$C_{DH} = 50\text{ pF}$ |      | 5   |     | mA    |

**POWER MANAGEMENT**
**DC Electrical Characteristics (Cont)**

Unless specified:  $0 < T_J < 125^{\circ}\text{C}$ ,  $V_{IN} = 12\text{V}$

| Parameter                               | Symbols             | Conditions                                                                                                                                      | Min  | Typ   | Max   | Units         |
|-----------------------------------------|---------------------|-------------------------------------------------------------------------------------------------------------------------------------------------|------|-------|-------|---------------|
| <b>Reference/Voltage Identification</b> |                     |                                                                                                                                                 |      |       |       |               |
| Reference Voltage Accuracy              | $V_{REF}$           | $11.4\text{V} < V_{IN} < 12.6\text{V}$ , over full VID range (see Output Voltage Table)                                                         | -1.2 |       | 1.2   | %             |
| VID0 - VID25mV High Threshold Voltage   | $V_{TH(H)}$         |                                                                                                                                                 | 2.25 |       |       | V             |
| VID0 - VID25mV Low Threshold Voltage    | $V_{TH(L)}$         |                                                                                                                                                 |      |       | 1     | V             |
| <b>Power Good</b>                       |                     |                                                                                                                                                 |      |       |       |               |
| Undervoltage Threshold                  | $V_{TH(PWRGD)}$     |                                                                                                                                                 | 82   |       | 88    | % $V_{REF}$   |
| Output Saturation Voltage               | $V_{SAT}$           | $I_O = 5\text{mA}$                                                                                                                              |      | 0.5   |       | V             |
| Hysteresis                              | $V_{HYS(PWRGD)}$    |                                                                                                                                                 |      | 10    |       | mV            |
| <b>Over Voltage Protection</b>          |                     |                                                                                                                                                 |      |       |       |               |
| OVP Trip Point                          | $V_{OVP}$           |                                                                                                                                                 | 12   | 15    | 20    | % $V_{OUT}$   |
| Hysteresis <sup>(1)</sup>               | $V_{HYS(OVP)}$      |                                                                                                                                                 |      | 10    |       | mV            |
| <b>Soft Start</b>                       |                     |                                                                                                                                                 |      |       |       |               |
| Charge Current                          | $I_{CHG}$           | $V_{SS} = 0.5\text{V}$ , resistance from VREFB pin to AGND = $20\text{k}\Omega$ , $V_{REFB} = 1.3\text{V}$<br>Note: $I_{CHG} = (I_{VREFB} / 5)$ | 10.4 | 13    | 15.6  | $\mu\text{A}$ |
| Discharge Current                       | $I_{DISCHG}$        | $V_{(SS)} = 1\text{V}$                                                                                                                          |      | 1     |       | mA            |
| <b>Inhibit Comparator</b>               |                     |                                                                                                                                                 |      |       |       |               |
| Start Threshold                         | $V_{start(NH)}$     |                                                                                                                                                 | 1    | 2.0   | 2.4   | V             |
| <b>VIN 12V UVLO</b>                     |                     |                                                                                                                                                 |      |       |       |               |
| Start Threshold                         | $V_{start_{UVLO}}$  |                                                                                                                                                 | 9.25 | 10.25 | 11.25 | V             |
| Hysteresis                              | $V_{hys_{UVLO}}$    |                                                                                                                                                 | 1.8  | 2.1   | 2.4   | V             |
| <b>Hysteretic Comparator</b>            |                     |                                                                                                                                                 |      |       |       |               |
| Input Offset Voltage                    | $V_{os_{HYSCMP}}$   | $V_{DROOP}$ pin grounded                                                                                                                        |      |       | 5     | mV            |
| Input Bias Current                      | $I_{bias_{HYSCMP}}$ |                                                                                                                                                 |      |       | 1     | $\mu\text{A}$ |
| Hysteresis Accuracy                     | $V_{HYS ACC}$       |                                                                                                                                                 |      |       | 7     | mV            |
| Hysteresis Setting                      | $V_{HYS SET}$       |                                                                                                                                                 |      |       | 60    | mV            |

**POWER MANAGEMENT**
**DC Electrical Characteristics (Cont.)**

 Unless specified:  $0 < T_j < 125^{\circ}\text{C}$ ,  $V_{IN} = 12\text{V}$ 

| Parameter                        | Symbols                        | Conditions                                                                                                  | Min  | Typ | Max  | Units         |
|----------------------------------|--------------------------------|-------------------------------------------------------------------------------------------------------------|------|-----|------|---------------|
| <b>Droop Compensation</b>        |                                |                                                                                                             |      |     |      |               |
| Initial Accuracy                 | $V_{\text{DROOP ACC}}$         | $V_{\text{DROOP}} = 50 \text{ mV}$                                                                          |      |     | 8    | mV            |
| <b>Overcurrent Protection</b>    |                                |                                                                                                             |      |     |      |               |
| OCP Trip Point                   | $V_{\text{OCP}}$               |                                                                                                             | 0.09 | 0.1 | 0.11 | V             |
| Input Bias Current               | $I_{\text{bias OCP}}$          |                                                                                                             |      |     | 100  | nA            |
| <b>High-Side VDS Sensing</b>     |                                |                                                                                                             |      |     |      |               |
| Gain                             |                                |                                                                                                             |      | 2   |      | V/V           |
| Initial Accuracy                 | $V_{\text{IOUT ACC}}$          | $V_{\text{HISENSE}} = 12\text{V}$ , $V_{\text{IOUTLO}} = 11.9\text{V}$                                      |      |     | 6    | mV            |
| IOUT Source                      | $I_{\text{source IOUT}}$       | $V_{\text{IOUT}} = 0.5\text{V}$ , $V_{\text{HISENSE}} = 12\text{V}$ ,<br>$V_{\text{IOUTLO}} = 11.5\text{V}$ | 500  |     |      | $\mu\text{A}$ |
| IOUT Sink Current                | $I_{\text{sink IOUT}}$         | $V_{\text{IOUT}} = 0.05\text{V}$ , $V_{\text{HISENSE}} = 12\text{V}$ ,<br>$V_{\text{IOUTLO}} = 12\text{V}$  | 38   | 50  |      | $\mu\text{A}$ |
| VIOUT Voltage Swing              | $V_{\text{IOUT}(11)}$          | $V_{\text{HISENSE}} = 11\text{V}$ , $R_{\text{IOUT}} = 10\text{K } \Omega$                                  | 0    |     | 3.75 | V             |
|                                  | $V_{\text{IOUT}(4.5\text{V})}$ | $V_{\text{HISENSE}} = 4.5\text{V}$ , $R_{\text{IOUT}} = 10\text{k } \Omega$                                 | 0    |     | 2.0  | V             |
|                                  | $V_{\text{IOUT}(3\text{V})}$   | $V_{\text{HISENSE}} = 3\text{V}$ , $R_{\text{IOUT}} = 10\text{k } \Omega$                                   | 0    |     | 1.0  | V             |
| LOSENSE High Level Input Voltage | $V_{\text{ih LOSENSE}}$        | $V_{\text{HISENSE}} = 4.5\text{V}$ (Note 1)                                                                 | 2.85 |     |      | V             |
| LOSENSE Low Level Input Voltage  | $V_{\text{il LOSENSE}}$        | $V_{\text{HISENSE}} = 4.5\text{V}$ (Note 1)                                                                 |      |     | 1.8  | V             |
| Sample/Hold Resistance           | $R_{\text{S/H}}$               | (Note 1)                                                                                                    | 50   | 65  | 80   | $\Omega$      |
| <b>Buffered Reference</b>        |                                |                                                                                                             |      |     |      |               |
| VREFB Load Regulation            | $V_{\text{ldreg REFB}}$        | $10\mu\text{A} < I_{\text{REFB}} < 500\mu\text{A}$                                                          |      | 2   |      | mV            |
| <b>Deadtime Circuit (1)</b>      |                                |                                                                                                             |      |     |      |               |
| LOHIB High Level Voltage         | $V_{\text{ih LOHIB}}$          |                                                                                                             | 2    |     |      | V             |
| LOHIB Low Level Input Voltage    | $V_{\text{il LOHIB}}$          |                                                                                                             |      |     | 1.0  | V             |
| LOWDR High Level Input Voltage   | $V_{\text{ih LOWDR}}$          |                                                                                                             | 2    |     |      | V             |
| LOWDR Low Level Input Voltage    | $V_{\text{il LOWDR}}$          |                                                                                                             |      |     | 1.0  | V             |
| <b>Drive Regulator</b>           |                                |                                                                                                             |      |     |      |               |
| DRV Voltage                      | $V_{\text{DRV}}$               | $11.4 < V_{\text{IN}} < 12.6\text{V}$ , $I_{\text{DRV}} = 50\text{mA}$                                      | 7    |     | 9    | V             |
| Load Regulation                  | $V_{\text{ldreg DRV}}$         | $1\text{mA} < I_{\text{DRV}} < 50\text{mA}$                                                                 |      | 100 |      | mV            |
| Short Circuit Current            | $I_{\text{short DRV}}$         |                                                                                                             | 100  |     |      | mA            |

## POWER MANAGEMENT

### DC Electrical Characteristics (Cont.)

Unless specified:  $0 < T_J < 125^{\circ}\text{C}$ ,  $V_{IN} = 12\text{V}$

| Parameter                    | Symbol                                  | Conditions                                                                                                                                                                      | Min | Typ | Max | Units    |
|------------------------------|-----------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|-----|-----|----------|
| High-Side Output Driver      |                                         |                                                                                                                                                                                 |     |     |     |          |
| Peak Output Current          | $I_{src\_HIGHDR}$<br>$I_{sink\_HIGHDR}$ | duty cycle < 2%, tpw < 100us,<br>$T_J = 125^{\circ}\text{C}$<br>$V_{BOOT} - V_{BOOTLO} = 6.5\text{V}$ , $V_{HIGHDR} = 1.5\text{V}$ (src),<br>or $V_{HIGHDR} = 5\text{V}$ (sink) | 2   |     |     | A        |
| Equivalent Output Resistance | $R_{src\_HIGHDR}$                       | $T_J = 125^{\circ}\text{C}$<br>$V_{BOOT} - V_{BOOTLO} = 6.5\text{V}$ , $V_{HIGHDR} = 6\text{V}$                                                                                 |     |     | 45  | $\Omega$ |
|                              | $R_{sink\_HIGHDR}$                      | $T_J = 125^{\circ}\text{C}$<br>$V_{BOOT} - V_{BOOTLO} = 6.5\text{V}$ , $V_{HIGHDR} = 0.5\text{V}$                                                                               |     |     | 5   |          |
| Low-Side Output Driver       |                                         |                                                                                                                                                                                 |     |     |     |          |
| Peak Output Current          | $I_{src\_LOWDR}$<br>$I_{sink\_LOWDR}$   | duty cycle < 2%, tpw < 100us,<br>$T_J = 125^{\circ}\text{C}$<br>$V_{DRV} = 6.5\text{V}$ , $V_{LOWDR} = 1.5\text{V}$ (src), or<br>$V_{LOWDR} = 5\text{V}$ (sink)                 | 2   |     |     | A        |
| Equivalent Output Resistance | $R_{src\_LOWDR}$                        | $T_J = 125^{\circ}\text{C}$<br>$V_{DRV} = 6.5\text{V}$ , $V_{LOWDR} = 6\text{V}$                                                                                                |     |     | 45  | $\Omega$ |
|                              | $R_{sink\_LOWDR}$                       | $T_J = 125^{\circ}\text{C}$<br>$V_{DRV} = 6.5\text{V}$ , $V_{LOWDR} = 0.5\text{V}$                                                                                              |     |     | 5   |          |

### AC Electrical Characteristics (Note 1)

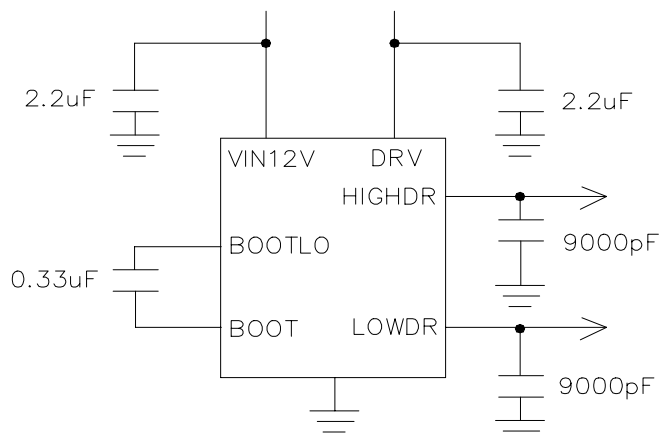
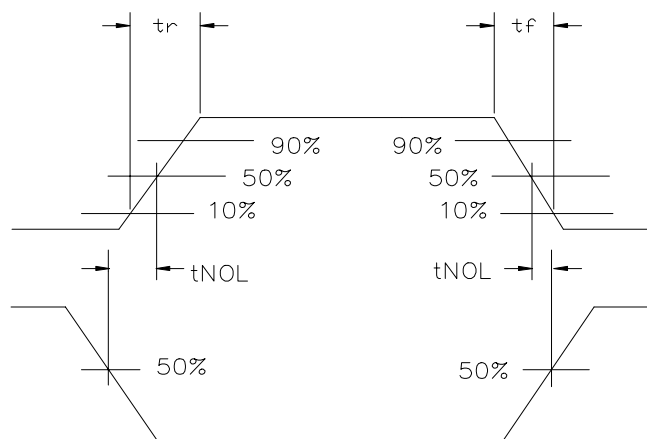
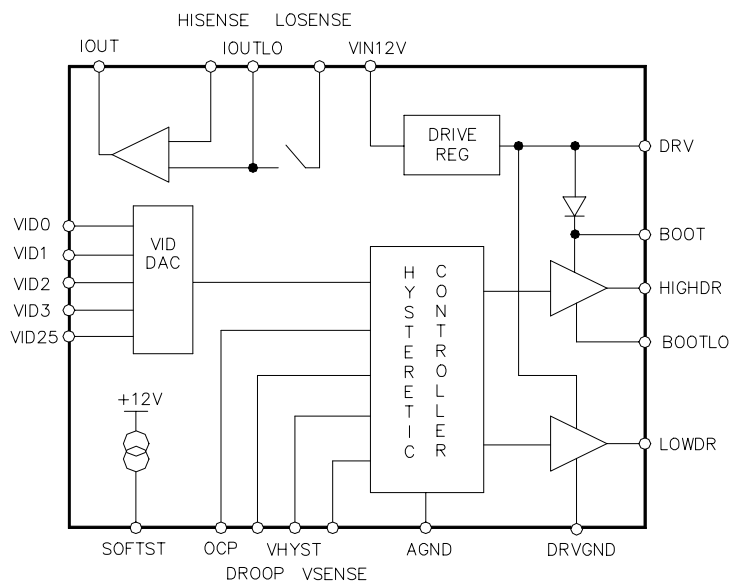
| Parameter                                                                  | Symbol                             | Conditions                                                                                                     | Min | Typ | Max | Units   |
|----------------------------------------------------------------------------|------------------------------------|----------------------------------------------------------------------------------------------------------------|-----|-----|-----|---------|
| <b>Hysteretic Comparators</b>                                              |                                    |                                                                                                                |     |     |     |         |
| Propagation Delay Time from VSENSE to HIGHDR or LOWDR (excluding deadtime) | $t_{HCPROP}$                       | 10mV overdrive,<br>$1.3\text{V} \leq V_{ref} \leq 1.8\text{V}$                                                 |     | 150 | 250 | ns      |
| <b>Output Drivers</b>                                                      |                                    |                                                                                                                |     |     |     |         |
| HIGHDR rise/fall time                                                      | $t_{r\_HIGHDR}$<br>$t_{f\_HIGHDR}$ | $CI = 9\text{nF}$ , $V_{BOOT} = 6.5\text{V}$ , $V_{BOOTLO} = \text{grounded}$ ,<br>$T_J = 125^{\circ}\text{C}$ |     |     | 60  | ns      |
| LOWDR rise/falltime                                                        | $t_{r\_LOWDR}$<br>$t_{f\_LOWDR}$   | $CI = 9\text{nF}$ , $V_{DRV} = 6.5\text{V}$ ,<br>$T_J = 125^{\circ}\text{C}$                                   |     |     | 60  | ns      |
| <b>Overcurrent Protection</b>                                              |                                    |                                                                                                                |     |     |     |         |
| Comparator Propagation Delay Time                                          | $t_{OVPROP}$                       |                                                                                                                |     | 1   |     | $\mu s$ |
| Deglintch Time (Includes comparator propagation delay time)                | $t_{OVDGL}$                        |                                                                                                                | 2   |     | 5   | $\mu s$ |

**POWER MANAGEMENT**
**AC Electrical Characteristics (Cont.) (Note 1)**

| Parameter                                                  | Symbols         | Conditions                                                                              | Min | Typ | Max | Units   |
|------------------------------------------------------------|-----------------|-----------------------------------------------------------------------------------------|-----|-----|-----|---------|
| <b>Overvoltage Protection</b>                              |                 |                                                                                         |     |     |     |         |
| Comparator Propagation Delay Time                          | $t_{OVPROP}$    |                                                                                         |     | 1   |     | $\mu s$ |
| Deglintch Time (Includes comparator protection delay time) | $t_{OVDGL}$     |                                                                                         | 1   |     | 3   | $\mu s$ |
| <b>High-Side Vds Sensing</b>                               |                 |                                                                                         |     |     |     |         |
| Response Time                                              | $t_{VDSRESP}$   | $V_{HISENSE} = 12V$ , $V_{IOUTLO}$ pulsed from 12V to 11.9V, 100ns rise and fall times  |     |     | 2   | $\mu s$ |
|                                                            |                 | $V_{HISENSE} = 4.5V$ , $V_{IOUTLO}$ pulsed from 4.5V to 4.4V, 100ns rise and fall times |     |     | 3   | $\mu s$ |
|                                                            |                 | $V_{HISENSE} = 3V$ , $V_{IOUTLO}$ pulsed from 3.0V to 2.9V, 100ns rise and fall times   |     |     | 3   | $\mu s$ |
| Short Circuit Protection Rising Edge Delay                 | $t_{VDSRED}$    | LOSENSE grounded                                                                        | 300 |     | 500 | ns      |
| Sample/Hold Switch turn-on/turn-off Delay                  | $t_{SWXDLY}$    | $3V < V_{HISENSE} < 11V$<br>$V_{LOSENSE} = V_{HISENSE}$                                 | 30  |     | 100 | ns      |
| <b>Power Good</b>                                          |                 |                                                                                         |     |     |     |         |
| Comparator Propagation Delay                               | $t_{PWRGD}$     |                                                                                         |     | 1   |     | $\mu s$ |
| <b>Softstart</b>                                           |                 |                                                                                         |     |     |     |         |
| Comparator Propagation Delay                               | $t_{SLST}$      | overdrive = 10mV                                                                        |     | 560 | 900 | ns      |
| <b>Deadtime</b>                                            |                 |                                                                                         |     |     |     |         |
| Driver Non-overlap Time                                    | $t_{NOL}$       | $C_{LOWDR} = 9nF$ , 10% threshold on LOWDR                                              | 30  |     | 100 | ns      |
| <b>LODRV</b>                                               |                 |                                                                                         |     |     |     |         |
| Propagation Delay                                          | $T_{LODRV DLY}$ |                                                                                         |     |     | 400 | ns      |

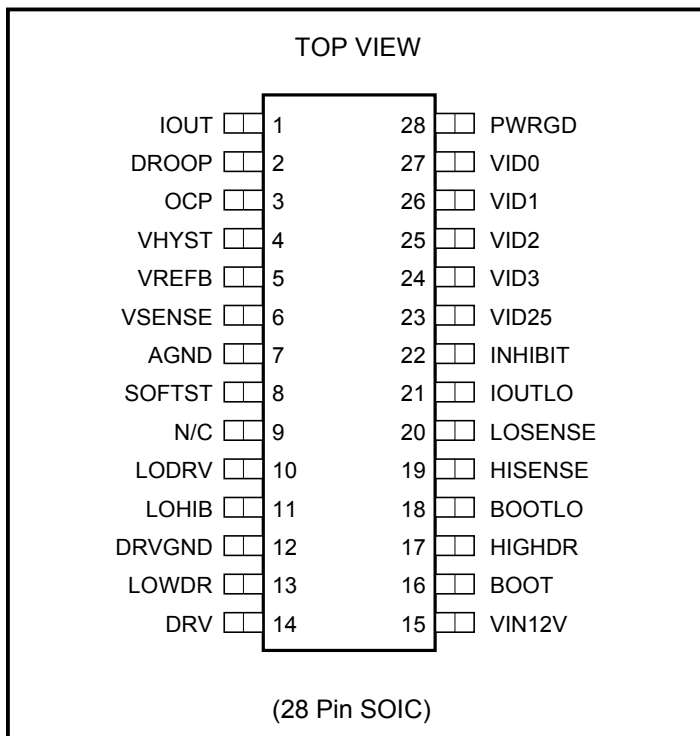
**Note:**

- (1) Guaranteed, but not tested.
- (2) This device is ESD sensitive. Use of standard ESD handling precautions is required.

**POWER MANAGEMENT**
**Test Circuit**

**Timing Diagram**

**Simplified Block Diagram**


## POWER MANAGEMENT

### Pin Configuration



### Ordering Information

| Device <sup>(1)</sup> | Package          | Temp Range (T <sub>J</sub> ) |
|-----------------------|------------------|------------------------------|
| SC1159SWTR            | SO-28            | 0° to 125°C                  |
| SC1159EVB             | Evaluation Board |                              |

Note:

(1) Only available in tape and reel packaging. A reel contains 1000 devices.

### Pin Descriptions

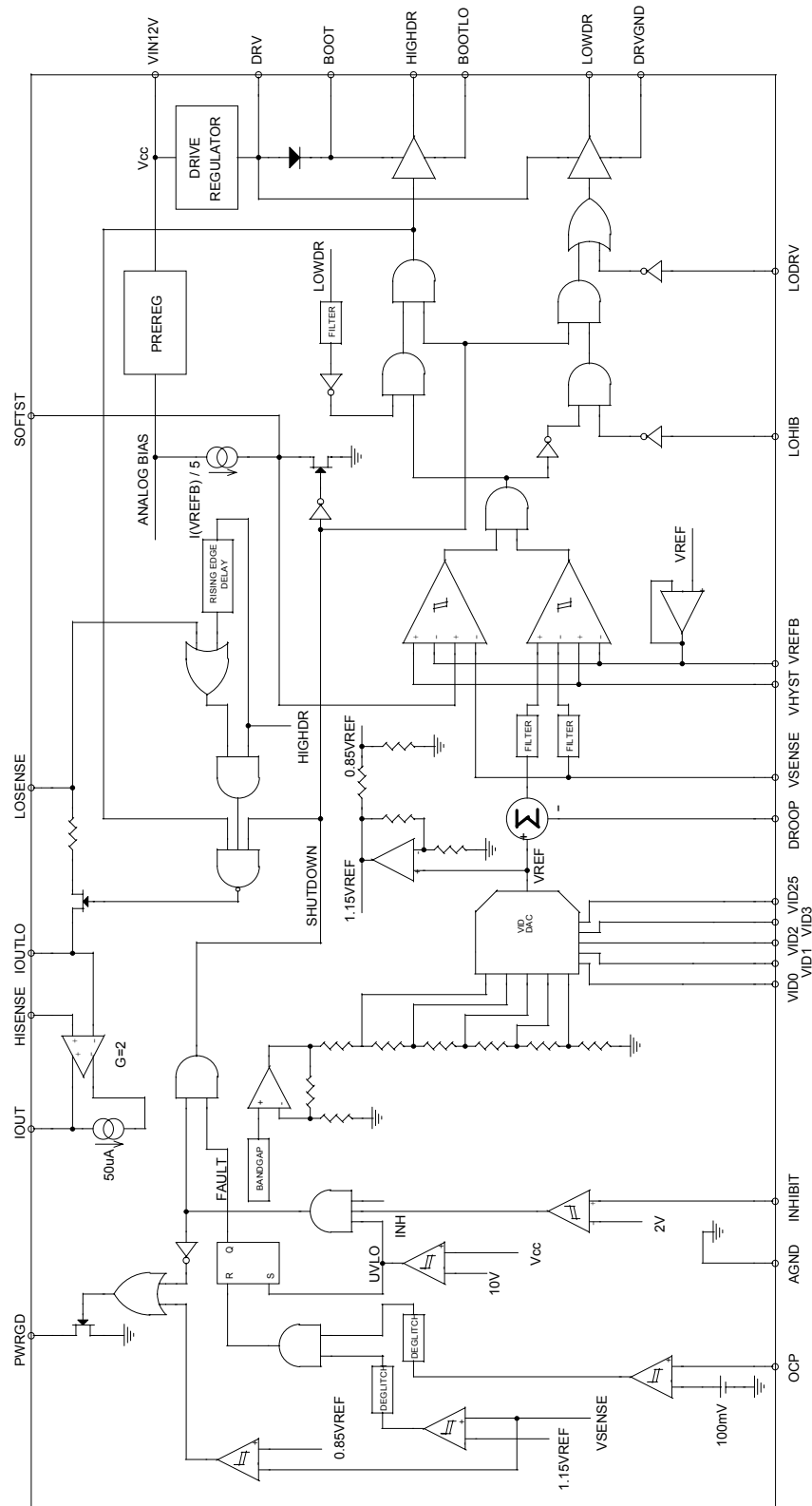
| Pin # | Pin Name | Pin Function                                                                                                                                                                                      |
|-------|----------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1     | IOUT     | Current Out. The output voltage on this pin is proportional to the load current as measured across the high side MOSFET, and is approximately equal to $2 \times R_{D_{S(ON)}} \times I_{LOAD}$ . |
| 2     | DROOP    | Droop Voltage. This pin is used to set the amount of output voltage set-point droop as a function of load current. The voltage is set by a resistor divider between IOUT and AGND.                |
| 3     | OCP      | Over Current Protection. This pin is used to set the trip point for over current protection by a resistor divider between IOUT and AGND.                                                          |
| 4     | VHYST    | Hysteresis Set Pin. This pin is used to set the amount of hysteresis required by a resistor divider between VREFB and AGND.                                                                       |
| 5     | VREFB    | Buffered Reference Voltage (from VID circuitry).                                                                                                                                                  |
| 6     | VSENSE   | Output Voltage Sense.                                                                                                                                                                             |
| 7     | AGND     | Small Signal Analog and Digital Ground.                                                                                                                                                           |
| 8     | SOFTST   | Soft Start. Connecting a capacitor from this pin to AGND sets the time delay.                                                                                                                     |
| 9     | NC       | Not connected.                                                                                                                                                                                    |
| 10    | LODRV    | Low Drive Control. Connecting this pin to +5V enables normal operation. When LOHIB is grounded, this pin can be used to control LOWDR.                                                            |
| 11    | LOHIB    | Low Side Inhibit. This pin is used to eliminate shoot-thru current.                                                                                                                               |
| 12    | DRVGND   | Power Ground. Insure output capacitor ground is connected to this pin.                                                                                                                            |
| 13    | LOWDR    | Low Side Driver Output. Connect to gate of low side MOSFET.                                                                                                                                       |

**POWER MANAGEMENT**
**Pin Descriptions (Cont.)**

| Pin # | Pin Name | Pin Function                                                                                                                                            |
|-------|----------|---------------------------------------------------------------------------------------------------------------------------------------------------------|
| 14    | DRV      | Drive Regulator for the MOSFET Drivers.                                                                                                                 |
| 15    | VIN12V   | 12V Supply. Connect to 12V power rail.                                                                                                                  |
| 16    | BOOT     | Bootstrap. This pin is used to generate a floating drive for the high side FET driver.                                                                  |
| 17    | HIGHDR   | High Side Driver Output. Connect to gate of high side MOSFET.                                                                                           |
| 18    | BOOTLO   | Bootstrap Low. In desktop applications, this pin connect to DRVGND.                                                                                     |
| 19    | HISENSE  | High Current Sense. Connected to the drain of the high side FET, or the input side of a current sense resistor between the input and the high side FET. |
| 20    | LOSENSE  | Low Current Sense. Connected to the source of the high side FET, or the FET side of a current sense resistor between the input and the high side FET.   |
| 21    | IOUTLO   | This is the sampling capacitors bottom leg. Voltage on this pin is voltage on the LOSENSE pin when the high side FET is on.                             |
| 22    | INHIBIT  | Inhibit. If this pin is grounded, the MOSFET drivers are disabled. Usually connected to +5V through a pull-up resistor.                                 |
| 23    | VID25    | Programming Input .                                                                                                                                     |
| 24    | VID3     | Programming Input.                                                                                                                                      |
| 25    | VID2     | Programming Input.                                                                                                                                      |
| 26    | VID1     | Programming Input.                                                                                                                                      |
| 27    | VID0     | Programming Input .                                                                                                                                     |
| 28    | PWRGD    | Power Good. This open collector logic output is high if the output voltage is within 15% of the set point.                                              |

# POWER MANAGEMENT

## Block Diagram



**POWER MANAGEMENT**
**Output Voltage Table**

0 = GND, 1 = OPEN

| VID25mV <sup>(2)</sup> | VID3 <sup>(1)</sup> | VID2 <sup>(1)</sup> | VID1 <sup>(1)</sup> | VID0 <sup>(1)</sup> | VDC (V) |
|------------------------|---------------------|---------------------|---------------------|---------------------|---------|
| 0                      | 0                   | 1                   | 0                   | 0                   | 1.05    |
| 1                      | 0                   | 1                   | 0                   | 0                   | 1.075   |
| 0                      | 0                   | 0                   | 1                   | 1                   | 1.10    |
| 1                      | 0                   | 0                   | 1                   | 1                   | 1.125   |
| 0                      | 0                   | 0                   | 1                   | 0                   | 1.15    |
| 1                      | 0                   | 0                   | 1                   | 0                   | 1.175   |
| 0                      | 0                   | 0                   | 0                   | 1                   | 1.20    |
| 1                      | 0                   | 0                   | 0                   | 1                   | 1.225   |
| 0                      | 0                   | 0                   | 0                   | 0                   | 1.25    |
| 1                      | 0                   | 0                   | 0                   | 0                   | 1.275   |
| 0                      | 1                   | 1                   | 1                   | 1                   | 1.30    |
| 1                      | 1                   | 1                   | 1                   | 1                   | 1.325   |
| 0                      | 1                   | 1                   | 1                   | 0                   | 1.35    |
| 1                      | 1                   | 1                   | 1                   | 0                   | 1.375   |
| 0                      | 1                   | 1                   | 0                   | 1                   | 1.40    |
| 1                      | 1                   | 1                   | 0                   | 1                   | 1.425   |
| 0                      | 1                   | 1                   | 0                   | 0                   | 1.45    |
| 1                      | 1                   | 1                   | 0                   | 0                   | 1.475   |
| 0                      | 1                   | 0                   | 1                   | 1                   | 1.50    |
| 1                      | 1                   | 0                   | 1                   | 1                   | 1.525   |
| 0                      | 1                   | 0                   | 1                   | 0                   | 1.55    |
| 1                      | 1                   | 0                   | 1                   | 0                   | 1.575   |
| 0                      | 1                   | 0                   | 0                   | 1                   | 1.60    |
| 1                      | 1                   | 0                   | 0                   | 1                   | 1.625   |
| 0                      | 1                   | 0                   | 0                   | 0                   | 1.65    |
| 1                      | 1                   | 0                   | 0                   | 0                   | 1.675   |
| 0                      | 0                   | 1                   | 1                   | 1                   | 1.70    |
| 1                      | 0                   | 1                   | 1                   | 1                   | 1.725   |
| 0                      | 0                   | 1                   | 1                   | 0                   | 1.75    |
| 1                      | 0                   | 1                   | 1                   | 0                   | 1.775   |
| 0                      | 0                   | 1                   | 0                   | 1                   | 1.80    |
| 1                      | 0                   | 1                   | 0                   | 1                   | 1.825   |

**NOTE:**

(1) VID (3:0) correspond to legacy VRM 8.4 voltage levels for 1.3V - 1.8V.

(2) VID 25mV provides a 25mV increment.

## POWER MANAGEMENT

### Applications Information - Functional Description

#### Reference/Voltage Identification

The reference/voltage identification (VID) section consists of a temperature compensated bandgap reference and a 5-bit voltage selection network. The 5 VID pins are TTL compatible inputs to the VID selection network. They are internally pulled up to +3.3V generated from the +12V supply by a resistor divider, and provide programmability of output voltage from 1.050V to 1.825V in 25mV increments.

Refer to the Output Voltage Table for the VID code settings. The output voltage of the VID network, VREF is within 1% of the nominal setting over the full input and output voltage range and junction temperature range. The output of the reference/VID network is indirectly brought out through a buffer to the REFB pin. The voltage on this pin will be within 3mV of VREF. It is not recommended to drive loads with REFB other than setting the hysteresis of the hysteretic comparator, because the current drawn from REFB sets the charging current for the soft start capacitor. Refer to the soft start section for additional information.

#### Hysteretic Comparator

The hysteretic comparator regulates the output voltage of the synchronous-buck converter. The hysteresis is set by connecting the center point of a resistor divider from REFB to AGND to the HYST pin. The hysteresis is set by connecting the center point of a resistor divider from REFB to AGND to the HYST pin. The hysteresis of the comparator will be equal to twice the voltage difference between REFB and HYST, and has a maximum value of 60mV. The maximum propagation delay from the comparator inputs to the driver outputs is 250ns.

#### Low Side Driver

The low side driver is designed to drive a low  $R_{DS(ON)}$  N-channel MOSFET, and is rated for 2 amps source and sink. The bias for the low side driver is provided internally from VDRV.

#### High Side Driver

The high side driver is designed to drive a low  $R_{DS(ON)}$  N-channel MOSFET, and is rated for 2 amps source and sink current. It can be configured either as a ground referenced driver or as a floating bootstrap driver. When

configured as a floating driver, the bias voltage to the driver is developed from the DRV regulator. The internal bootstrap diode, connected between the DRV and BOOT pins, is a Schottky for improved drive efficiency. The maximum voltage that can be applied between the BOOT pin and ground is 25V. The driver can be referenced to ground by connecting BOOTLO to PGND, and connecting +12V to the BOOT pin.

#### Deadtime Control

Deadtime control prevents shoot-through current from flowing through the main power FETs during switching transitions by actively controlling the turn-on times of the FET drivers. The high side driver is not allowed to turn on until the gate drive voltage to the low-side FET is below 2 volts, and the low side driver is not allowed to turn on until the voltage at the junction of the 2 FETs (VPHASE) is below 2 volts. An internal low-pass filter with an 11MHz pole is located between the output of the low-side driver (DL) and the input of the deadtime circuit that controls the high-side driver, to filter out noise that could appear on DL when the high-side driver turns on.

#### Current Sensing

Current sensing is achieved by sampling and holding the voltage across the high side FET while it is turned on. The sampling network consists of an internal 50Ω switch and an external 0.033μF hold capacitor. Internal logic controls the turn-on and turn-off of the sample/hold switch such that the switch does not turn on until VPHASE transitions high and turns off when the input to the high side driver goes low. Thus sampling will occur only when the high side FET is conducting current. The voltage at the IO pin equals 2 times the sensed voltage. In applications where a higher accuracy in current sensing is required, a sense resistor can be placed in series with the high side FET and the voltage across the sense resistor can be sampled by the current sensing circuit.

#### Droop Compensation

The droop compensation network reduces the load transient overshoot/undershoot at VOUT, relative to VREF. VOUT is programmed to a voltage greater than VREF equal to  $VREF \cdot (1 + R7/R8)$  (see Typ. App. Circuit, Pg 1) by an external resistor divider from VOUT to the VSENSE pin to reduce the undershoot on VOUT during a low to high load

**POWER MANAGEMENT****Applications Information - Functional Description (Cont.)**

current transient. The overshoot during a high to low load current transient is reduced by subtracting the voltage that is on the DROOP pin from VREF. The voltage on the IO pin is divided down with an external resistor divider, and connected to the DROOP pin. Thus, under loaded conditions, VOUT is regulated to:

$$VOUT = VREF \cdot (1 + R7/R8) - IOUT \cdot R2/(R1 + R2).$$

**Inhibit**

The inhibit pin is a TTL compatible digital pin that is used to enable the controller. When INH is low, the output drivers are low, the soft start capacitor is discharged, the soft start current source is disabled, and the controller is in a low  $I_Q$  state. When INH goes high, the short across the soft start capacitor is removed, the soft start current source is enabled, and normal converter operation begins. When the system logic supply is connected to INH, it controls power sequencing by locking out controller operation until the system logic supply exceeds the input threshold voltage of the INH circuit; thus the +12V supply and the system logic supply (either +5V or 3.3V) must be above UVLO thresholds before the controller is allowed to start up.

**VIN**

The VIN undervoltage lockout circuit disables the controller while the +12V supply is below the 10V start threshold during power-up. While the controller is disabled, the output drivers will be low, the soft start capacitor will be shorted and the soft start current is disabled and the controller will be in a low  $I_Q$  state. When VIN exceeds the start threshold, the short across the soft start capacitor is removed, the soft start current source is enabled and normal converter operation begins. There is a 2V hysteresis in the undervoltage lockout circuit for noise immunity.

**Soft Start**

The soft start circuit controls the rate at which VOUT powers up. A capacitor is connected between SS and AGND and is charged by an internal current source. The value of the current source is proportional to the reference voltage so the charging rate of  $C_{SS}$  is also proportional to the reference voltage. By making the charging current

proportional to VREF, the power-up time for VOUT will be independent of VREF. Thus,  $C_{SS}$  can remain the same value for all VID settings. The soft start charging current is determined by the following equation:  $I_{SS} = I_{REFB}/5$ . Where  $I_{REFB}$  is the current flowing out of the REFB pin. It is recommended that no additional loads be connected to REFB, other than the resistor divider for setting the hysteresis voltage. Thus these resistor values will determine the soft start charging current. The maximum current that can be sourced by REFB is 500 $\mu$ A.

**Power Good**

The power good circuit monitors for an undervoltage condition on VOUT. If VSENSE is 15% (nominal) below VREF, then the power good pin is pulled low. The PWRGD pin is an open drain output.

**Overvoltage Protection**

The overvoltage protection circuit monitors VOUT for an overvoltage condition. If VSENSE is 15% above VREF, then a fault latch is set and both output drivers are turned off. The latch will remain set until VIN goes below the undervoltage lockout value. A 1ms deglitch timer is included for noise immunity.

**Overcurrent Protection**

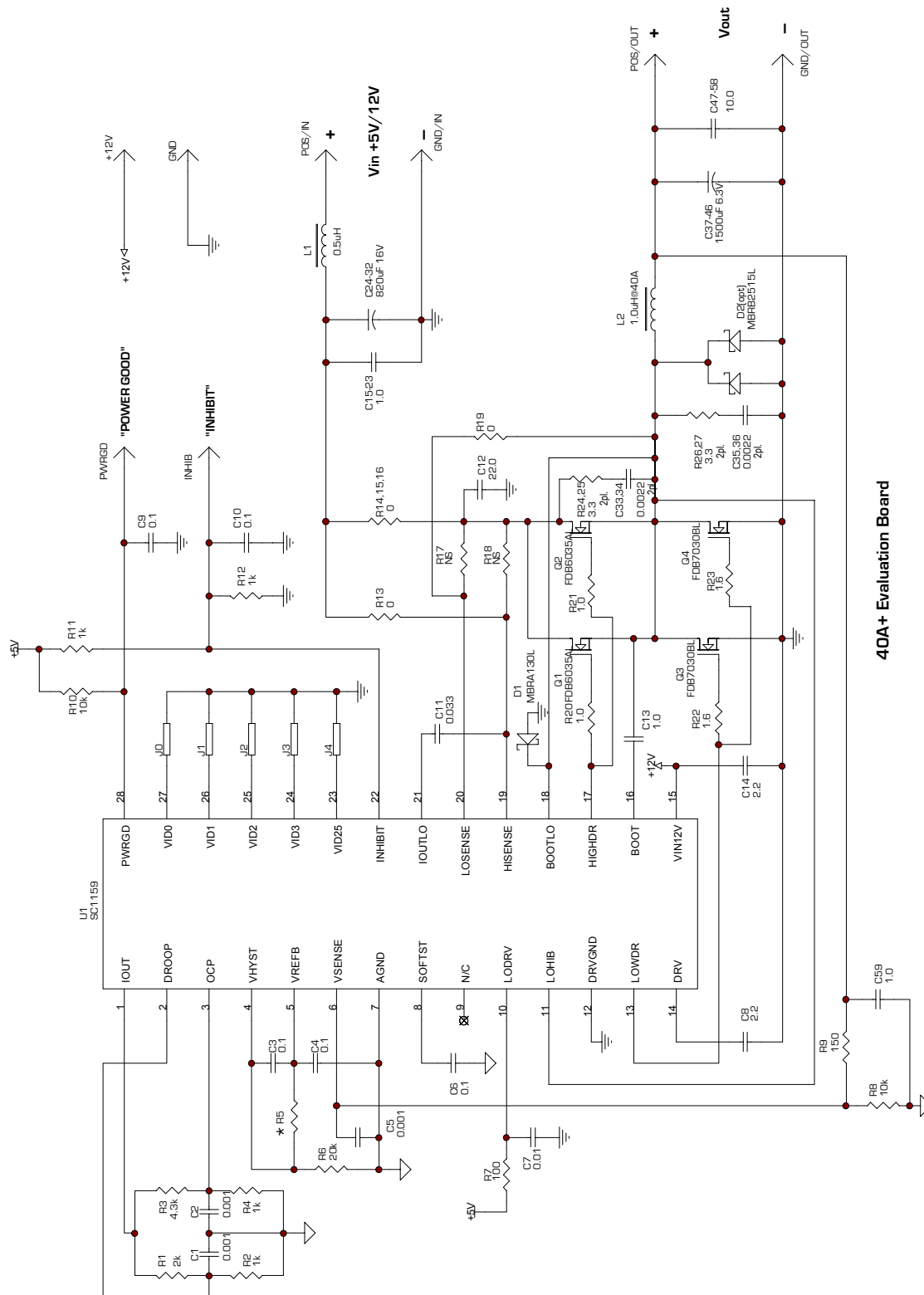
The overcurrent protection circuit monitors the current through the high side FET. The overcurrent threshold is adjustable with an external resistor divider between IO and AGND, with the divider voltage connected to the OCP pin. If the voltage on the OCP pin exceeds 100mV, then a fault latch is set and the output drivers are turned off. The latch will remain set until VIN goes below the undervoltage lockout value. A 1ms deglitch timer is included for noise immunity. The OCP circuit is also designed to protect the high side FET against a short-to-ground fault on the terminal common to both power FETs (VPHASE).

**Drive Regulator**

The drive regulator provides drive voltage to the low side driver, and to the high side driver when the high side driver is configured as a floating driver. The minimum drive voltage is 7V. The minimum short circuit current is 100mA.

# POWER MANAGEMENT

## Application Circuit

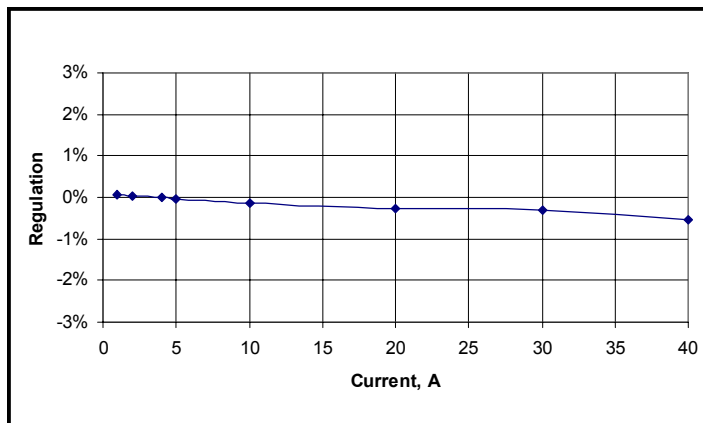
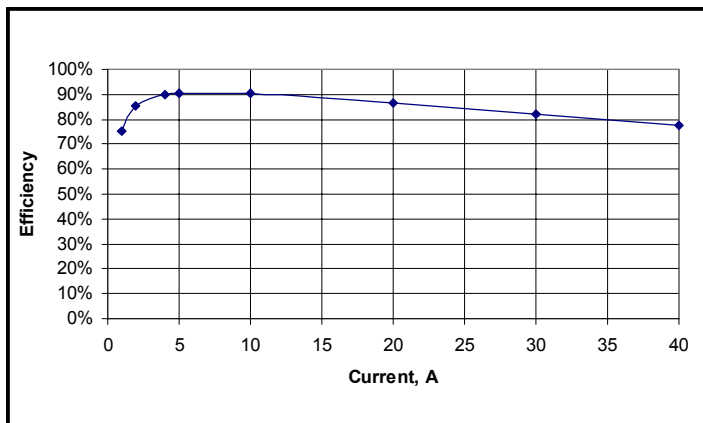


40A+ Evaluation Board

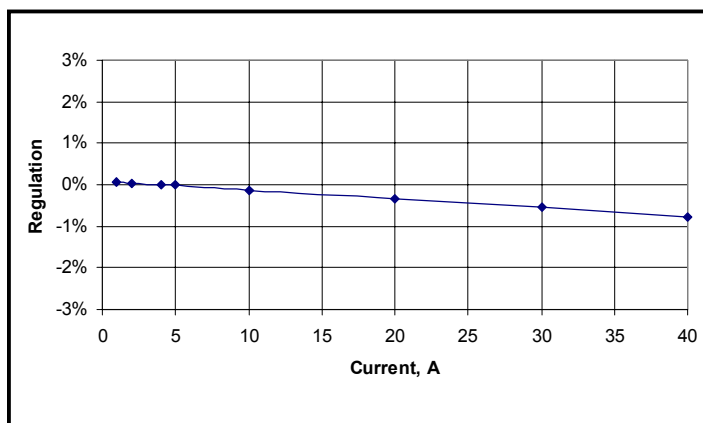
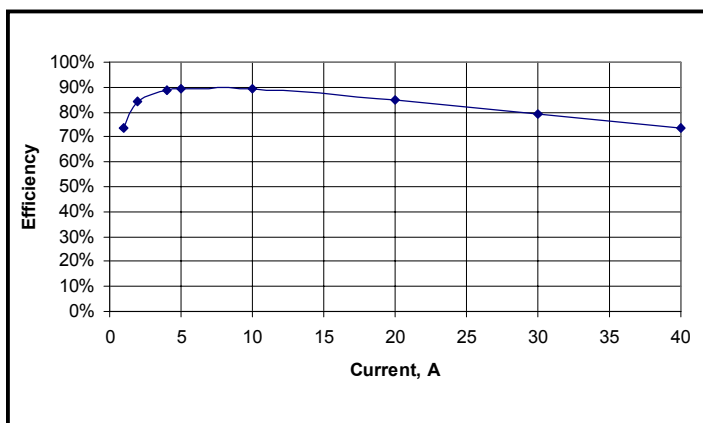
**POWER MANAGEMENT**
**Typical Characteristics**

$V_{IN} = 5V$ ;  $I_{OUT} = 0A$  to  $40A$   
 “Droop” & “Offset” Disabled

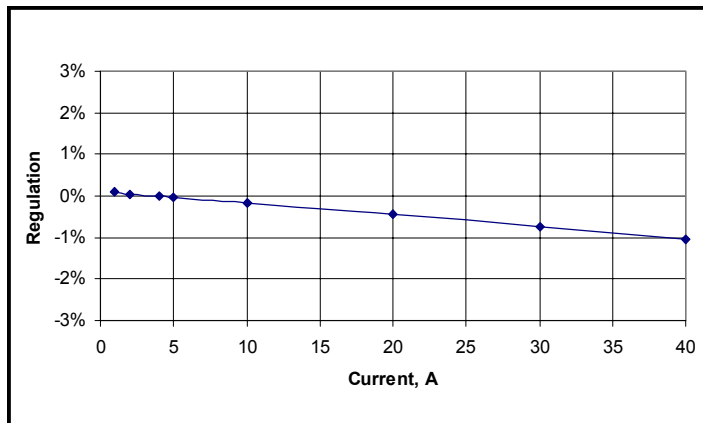
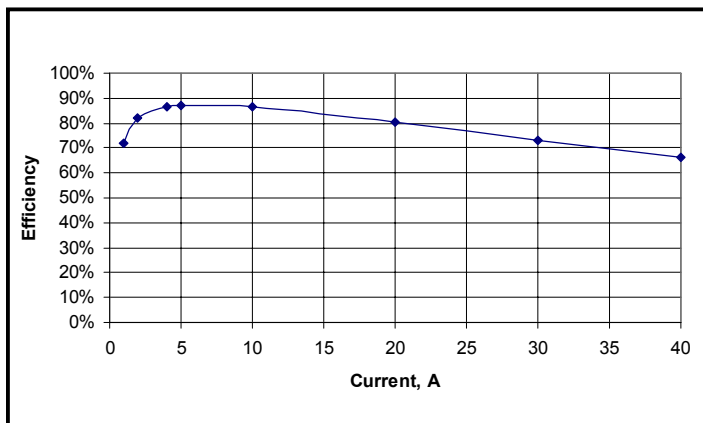
$V_{OUT} = 1.8V$



$V_{OUT} = 1.5V$



$V_{OUT} = 1.1V$

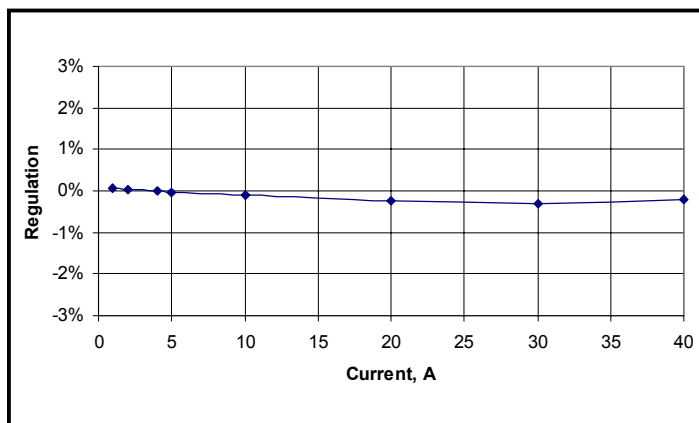
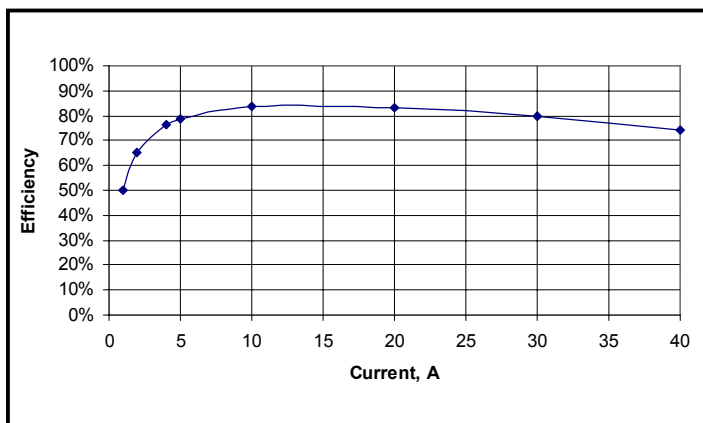


**POWER MANAGEMENT**
**Typical Characteristics (Cont.)**

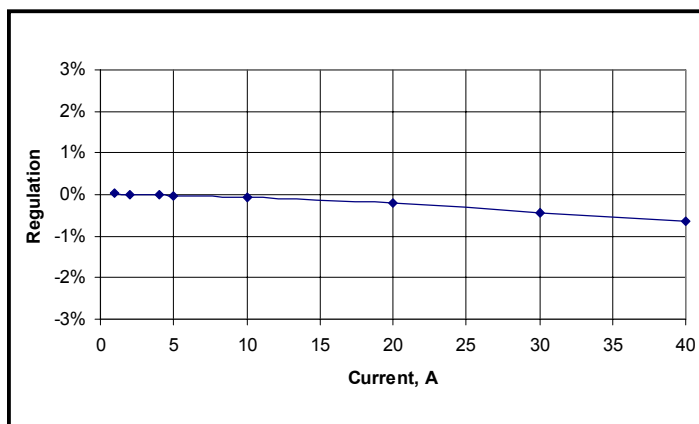
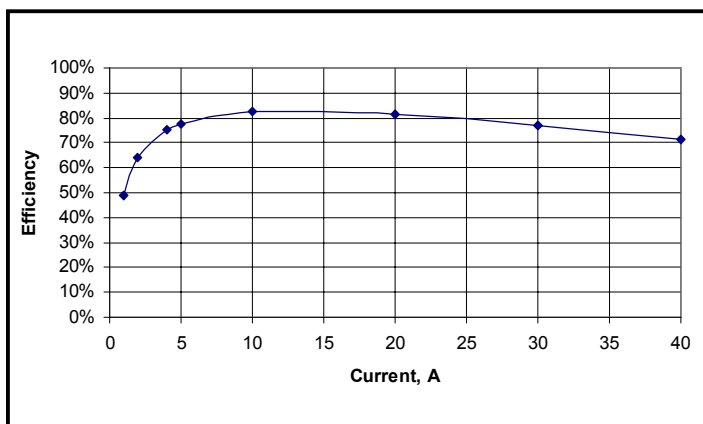
$V_{IN} = 12V$ ;  $I_{OUT} = 0A$  to  $40A$

“Droop” & “Offset” Disabled

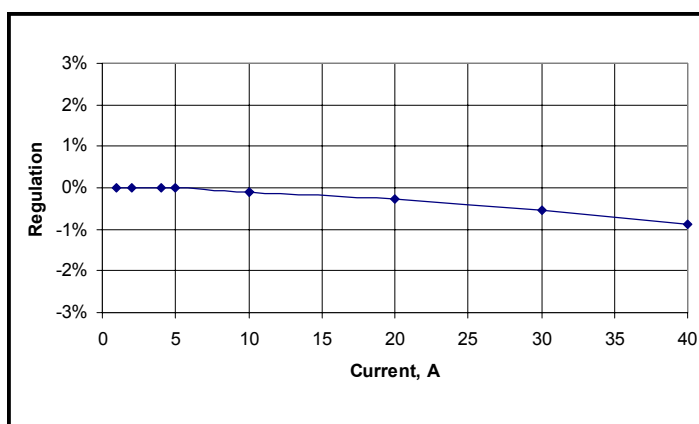
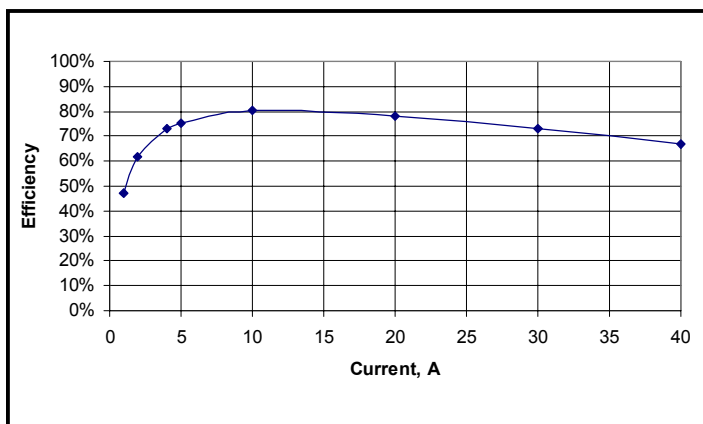
$V_{OUT} = 1.8V$

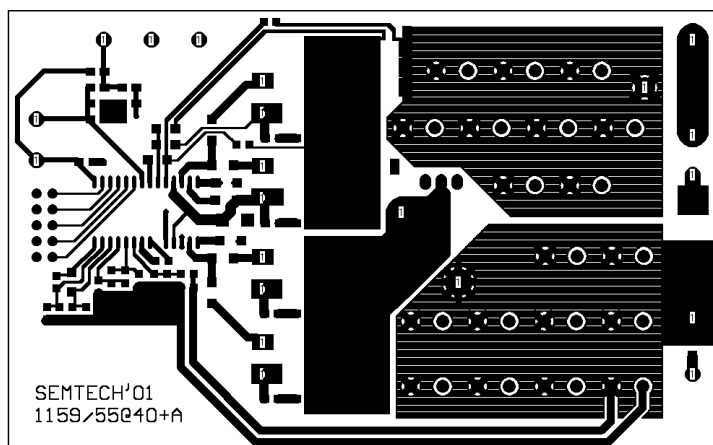
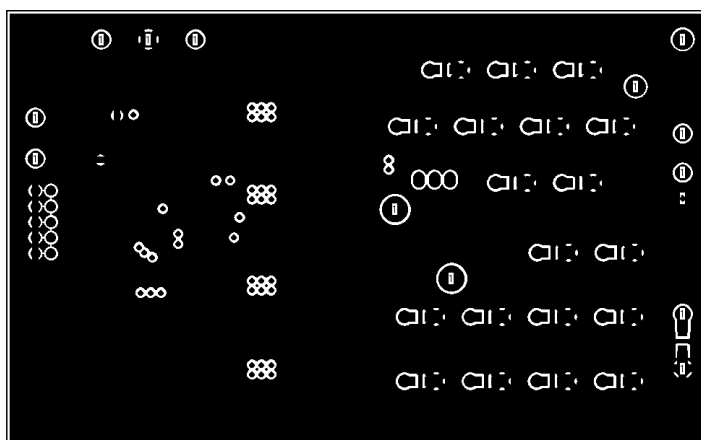
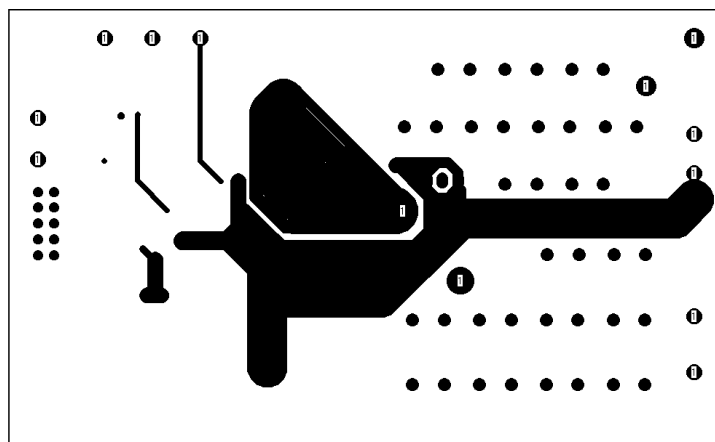


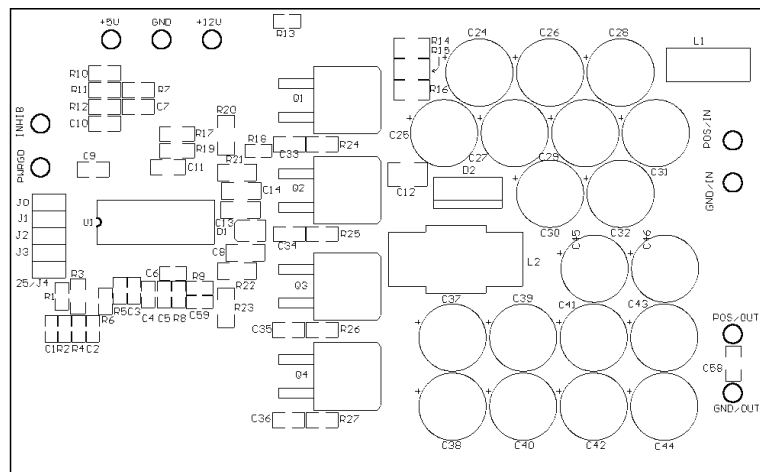
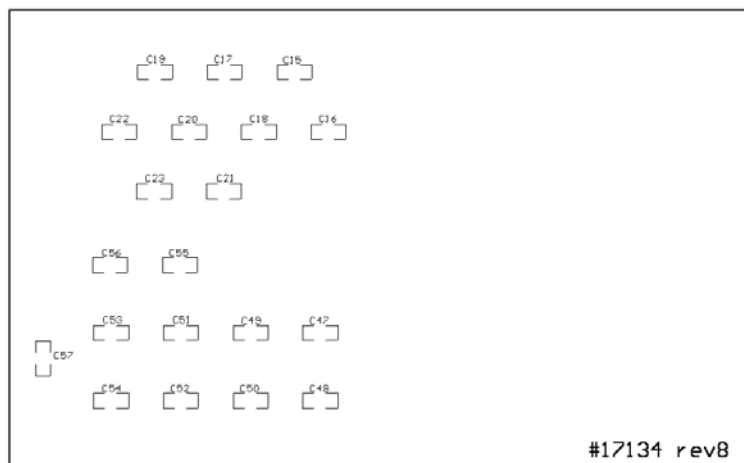
$V_{OUT} = 1.5V$



$V_{OUT} = 1.1V$



**POWER MANAGEMENT**
**Evaluation Board Artwork**
**Top Layer**

**Bottom Layer**

**Mid Layer**


**POWER MANAGEMENT**
**Evaluation Board Artwork (Cont.)**
**Top Overlay**

**Bottom Overlay**


#17134 rev8

**POWER MANAGEMENT**
**Materials List**

| Quantity | Reference          | Part/Description              | Vendor                             |
|----------|--------------------|-------------------------------|------------------------------------|
| 3        | C1,C2,C5           | 0.001 $\mu$ F                 | TDK, Murata, Taiyo-Yuden           |
| 6        | C3,C4,C6,C7,C9,C10 | 0.1 $\mu$ F                   | any                                |
| 1        | C11                | 0.033 $\mu$ F                 | any                                |
| 1        | C12                | 22 $\mu$ F                    | any                                |
| 11       | C13, C15-C23, C59  | 1 $\mu$ F                     | any                                |
| 2        | C8,C14             | 2.2 $\mu$ F                   | any                                |
| 9        | C24 - C32          | 820 $\mu$ F, 16V              | SANYO P/N: 16MV820AX               |
| 10       | C37 - C46          | 1500 $\mu$ F, 6.3V, thru hole | SANYO P/N: 6R3MV1500AX             |
| 12       | C47 - C58          | 10 $\mu$ F                    | any                                |
| 4        | C33 - C36          | .0022 $\mu$ F                 | any                                |
| 1        | D1                 | MBRA130L. Schottky            | ON Semi                            |
| 1        | D2 (optional)      | MBRB2515L                     | ON Semi                            |
| 1        | L1                 | 0.5uH, Toroid                 | Micrometals P/N: T51-26C, 18 AWG   |
| 1        | L2                 | 1.0uH, Toroid                 | Magnetics, #77310, 3ts, 4 X 20 AWG |
| 2        | Q1,Q2              | D2Pak, MOSFET                 | Fairchild P/N: FDB6035AL           |
| 2        | Q3,Q4              | D2Pak, MOSFET                 | Fairchild P/N: FDB7030BL           |
| 1        | R1                 | 2k                            | any                                |
| 4        | R2,R4,R11,R12      | 1k                            | any                                |
| 1        | R3                 | 4.3k                          | any                                |
| 1        | R6                 | 20k                           | any                                |
| 1        | R5                 | *150                          | any                                |
| 1        | R7                 | 100                           | any                                |
| 2        | R8,R10             | 10k                           | any                                |
| 1        | R9                 | 150                           | any                                |
| 2        | R20,R21            | 1                             | any                                |
| 2        | R22,R23            | 1.6                           | any                                |
| 4        | R24,R25,R26,R27    | 3.3                           | any                                |
| 1        | U1                 | SC1159CSW.TR                  | Semtech Corp. 805-498-2111         |

## POWER MANAGEMENT

### Layout Guidelines (See pg. 1)

1. Locate R8 and C2 close to pins 6 and 7.
2. Locate C1 close to pins 5 and 7.
3. Components connected to IOUT, DROOP, OCP, VHYST, VREFB, VSENSE, and SOFTST should be referenced to AGND.
4. The bypass capacitors C5 and C10 should be placed close to the IC and referenced to DRVGN.
5. Locate bootstrap capacitor C13 close to the IC.
6. Place bypass capacitor close to Drain of the top FET and Source of the bottom FET to be effective.
7. Route HISENSE and LOSENSE close to each other to minimize induced differential mode noise.
8. Bypass a high frequency disturbance with ceramic capacitor at the point where HISENSE is connected to Vin.
9. Input bulk capacitors should be placed as close as possible to the power FETs because of the very high ripple current flow in this pass.

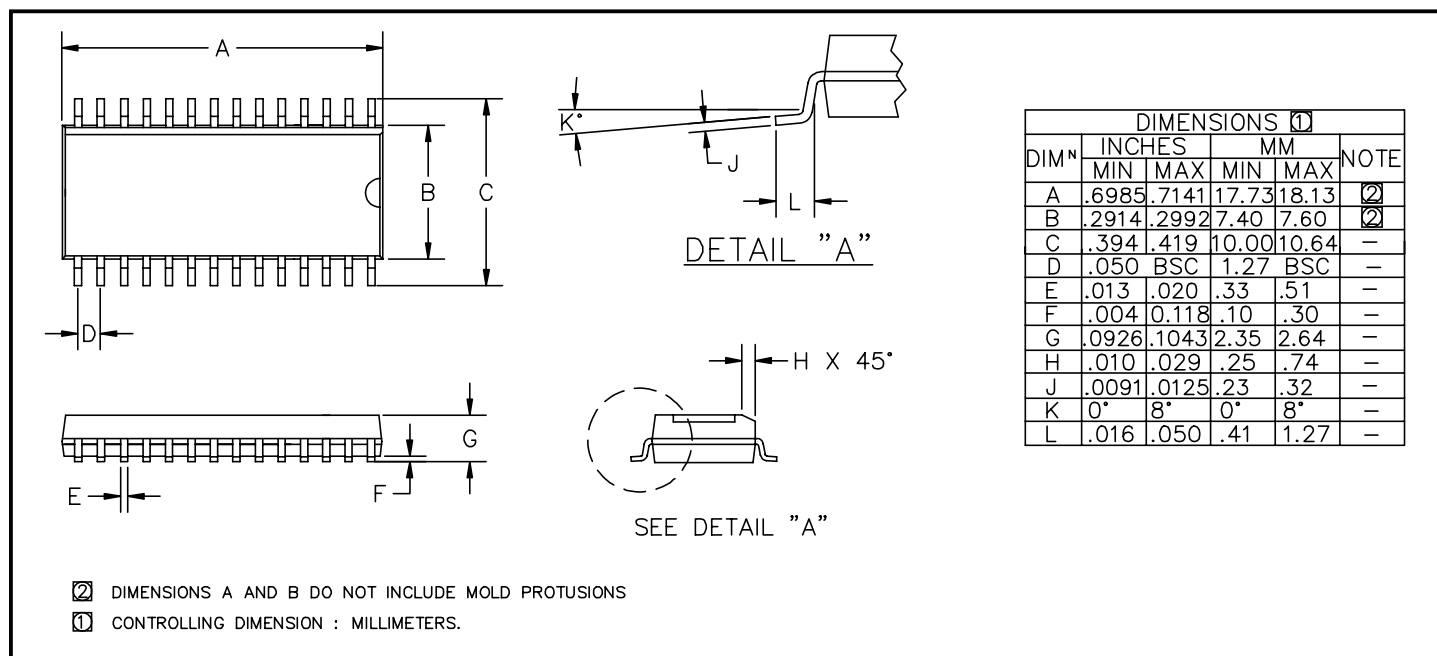
10. If Schottky diode used in parallel with a synchronous (bottom) FET, to achieve a greater efficiency at lower Vout settings, it needs to be placed next to the aforementioned FET in very close proximity.

11. Since the feedback path relies on the accurate sampling of the output ripple voltage, the best results can be achieved by connecting the AGND to the ground side of the bulk output capacitors.

12. DRVGN pin should be tight to the main ground plane utilizing very low impedance connection, e.g., multiple vias.

13. In order to prevent substrate glitching, a small (0.5A) Schottky diode should be placed in close proximity to the chip with the cathode connected to BOOTLO and anode connected to DRVGN.

### Outline Drawing - SO-28



### Contact Information

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