

### POWER MANAGEMENT

#### Description

The SC1456 contains two low dropout linear regulators that operate from a +2.5V to +6V input range and deliver up to 150mA. PMOS pass transistors allow a low 110µA supply current per device to remain independent of load, making these devices ideal for battery operated portable equipment such as cellular phones, cordless phones and personal digital assistants.

Each device can be powered from a separate supply voltage or the same supply voltage for maximum flexibility. The output voltage of each device can be preset or adjusted with an external resistor divider. Other features include independent low powered shutdown, short circuit protection, thermal shutdown protection and reverse battery protection for each regulator. The SC1456 comes in the tiny 10 lead MSOP package (lead free, fully WEEE and RoHS compliant available).

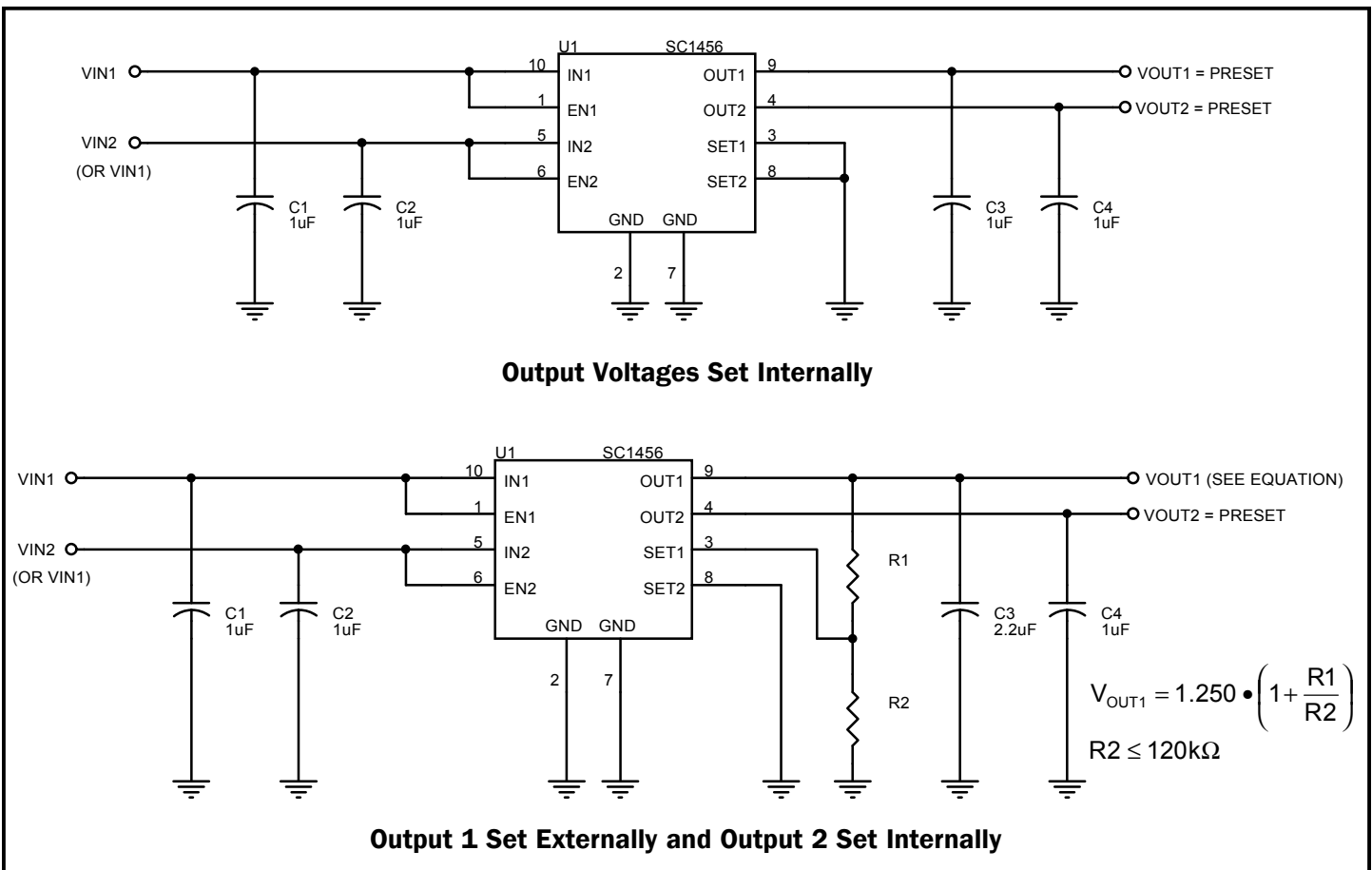
#### Features

- ◆ Two guaranteed 150 mA outputs
- ◆ Designed to operate with ceramic capacitors
- ◆ Fixed or adjustable outputs
- ◆ Very small external components
- ◆ Low 75µV<sub>RMS</sub> output noise
- ◆ Very low supply currents
- ◆ Thermal overload protection
- ◆ Reverse battery protection
- ◆ Individual low power shutdown
- ◆ Full industrial temperature range
- ◆ Surface mount packaging (10 pin MSOP)

#### Applications

- ◆ Battery Powered Systems
- ◆ Cellular Telephones
- ◆ Cordless Telephones
- ◆ Personal Digital Assistants
- ◆ Portable Instrumentation
- ◆ Modems
- ◆ PCMCIA cards

#### Typical Application Circuits



**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 |
|---|---------------|-------------|-------|
| VEN1, VEN2, VSET1, VSET2, VIN1, VIN2, VOUT1, VOUT2 to GND | $V_{PIN}$     | -0.3 to +7  | V     |
| Thermal Resistance, Junction to Ambient                   | $\theta_{JA}$ | 120         | °C/W  |
| Thermal Resistance, Junction to Case                      | $\theta_{JC}$ | 45          | °C/W  |
| Operating Ambient Temperature Range                       | $T_A$         | -40 to +85  | °C    |
| Operating Junction Temperature Range                      | $T_J$         | -40 to +125 | °C    |
| Storage Temperature Range                                 | $T_{STG}$     | -65 to +150 | °C    |
| Lead Temperature (Soldering) 10 sec                       | $T_{LEAD}$    | 300         | °C    |
| ESD Rating  | $V_{ESD}$     | 1.25        | kV    |

**Electrical Characteristics<sup>(1)</sup>**

Unless specified:  $V_{INx} = 3.6V$ ,  $V_{SETx} = GND$ ,  $V_{ENx} = 3.6V$ ,  $T_A = 25^\circ C$ . Values in **bold** apply over full operating ambient temperature range.

| Parameter                      | Symbol         | Test Conditions   | Min          | Typ       | Max          | Units   |
|--------------------------------|----------------|---|--------------|-----------|--------------|---------|
| <b>IN1, IN2</b>                |                |   |              |           |              |         |
| Supply Voltage Range           | $V_{IN}$       |   | <b>2.5</b>   |           | <b>6.0</b>   | V       |
| Supply Current                 | $I_Q$          | $I_{OUT} = 0mA$   |              | 90        | 130          | $\mu A$ |
|                                |                | $50mA \leq I_{OUT} \leq 150mA$                                    |              | 110       | 160          | $\mu A$ |
|                                |                | $V_{EN} = 0V$   |              | 0.0001    | 1            | $\mu A$ |
| <b>OUT1, OUT2</b>              |                |   |              |           |              |         |
| Output Voltage <sup>(2)</sup>  | $V_{OUT}$      | $I_{OUT} = 1mA$   | -2.0%        | $V_{OUT}$ | +2.0%        | V       |
|                                |                | $1mA \leq I_{OUT} \leq 150mA, V_{OUT} + 1V \leq V_{IN} \leq 5.5V$ | <b>-3.5%</b> |           | <b>+3.5%</b> |         |
| Line Regulation <sup>(2)</sup> | $REG_{(LINE)}$ | $2.5V \leq V_{IN} \leq 5.5V, V_{SET} = V_{OUT}, I_{OUT} = 1mA$    |              | 5         | 10           | mV      |
| Load Regulation <sup>(2)</sup> | $REG_{(LOAD)}$ | $I_{OUT} = 0mA$ to 50mA   |              | -10       | -15          | mV      |
|                                |                | $I_{OUT} = 0mA$ to 100mA  |              | -15       | -20          |         |
|                                |                |   |              |           | <b>-25</b>   |         |

**POWER MANAGEMENT**
**Electrical Characteristics (Cont.)<sup>(1)</sup>**

 Unless specified:  $V_{INx} = 3.6V$ ,  $V_{SETx} = GND$ ,  $V_{ENx} = 3.6V$ ,  $T_A = 25^{\circ}C$ . Values in **bold** apply over full operating ambient temperature range.

| Parameter                                | Symbol                | Test Conditions   | Min          | Typ   | Max          | Units         |
|--|-----------------------|---|--------------|-------|--------------|---------------|
| Load Regulation (Cont.) <sup>(2)</sup>   | REG <sub>(LOAD)</sub> | $I_{OUT} = 0mA \text{ to } 50mA, V_{SET} = V_{OUT}$       |              | -2.5  | -7.5         | mV            |
|  |                       |   |              |       | <b>-15.0</b> |               |
|  |                       | $I_{OUT} = 0mA \text{ to } 100mA, V_{SET} = V_{OUT}$      |              | -5    | -15          | mV            |
|  |                       |   |              |       | <b>-30</b>   |               |
| Dropout Voltage <sup>(2)(3)</sup>        | V <sub>D</sub>        | $I_{OUT} = 1mA$   |              | 1.1   |              | mV            |
|  |                       | $I_{OUT} = 50mA$  |              | 55    | 90           | mV            |
|  |                       |   |              |       | <b>120</b>   |               |
|  |                       | $I_{OUT} = 100mA$   |              | 110   | 180          | mV            |
|  |                       |   |              |       | <b>240</b>   |               |
| Current Limit                            | I <sub>LIM</sub>      |   | <b>150</b>   | 240   | <b>350</b>   | mA            |
| Output Voltage Noise                     | e <sub>n</sub>        | 10Hz to 99kHz, $I_{OUT} = 50mA, C_{OUT} = 1\mu F$         |              | 90    |              | $\mu V_{RMS}$ |
|  |                       | 10Hz to 99kHz, $I_{OUT} = 50mA, C_{OUT} = 100\mu F$       |              | 75    |              |               |
| Power Supply Rejection Ratio             | PSRR                  | f = 120Hz   |              | 55    |              | dB            |
| <b>EN1, EN2</b>                          |                       |   |              |       |              |               |
| EN Input Threshold                       | V <sub>IH</sub>       |   | <b>1.8</b>   |       |              | V             |
|  | V <sub>IL</sub>       |   |              |       | <b>0.4</b>   |               |
| EN Input Bias Current <sup>(4)</sup>     | I <sub>EN</sub>       | $V_{EN} = V_{IN}$   |              | 0     | 100          | nA            |
|  |                       |   |              |       | <b>200</b>   |               |
| <b>SET1, SET2</b>                        |                       |   |              |       |              |               |
| Sense/Select Threshold                   | V <sub>TH</sub>       |   | <b>20</b>    | 55    | <b>80</b>    | mV            |
| SET Reference Voltage <sup>(2)</sup>     | V <sub>SET</sub>      | $I_{OUT} = 1mA$   | 1.225        | 1.250 | 1.275        | V             |
|  |                       | $1mA \leq I_{OUT} \leq 150mA, 2.5V \leq V_{IN} \leq 5.5V$ | <b>1.206</b> |       | <b>1.294</b> |               |
| SET Input Leakage Current <sup>(4)</sup> | I <sub>SET</sub>      | $V_{SET} = 1.3V$  |              | 0.015 | 2.500        | nA            |
|  |                       |   |              |       | <b>5.000</b> |               |
| <b>Over Temperature Protection</b>       |                       |   |              |       |              |               |
| High Trip Level                          | T <sub>HI</sub>       |   |              | 170   |              | $^{\circ}C$   |
| Hysteresis                               | T <sub>HYST</sub>     |   |              | 10    |              | $^{\circ}C$   |

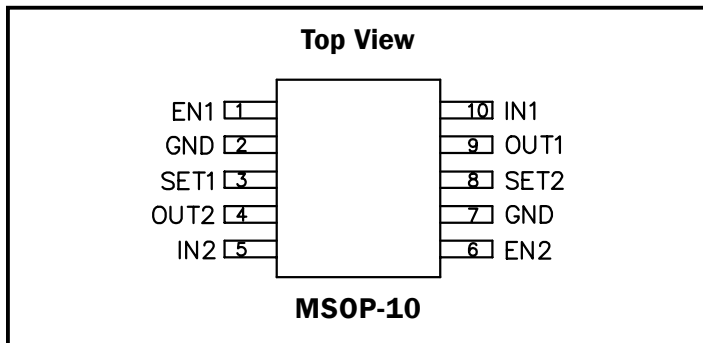
**Notes:**

(1) This device is ESD sensitive. Use of standard ESD handling precautions is required.

(2) Low duty cycle pulse testing with Kelvin connections required.

(3) Defined as the input to output differential at which the output voltage drops 100mV below the value measured at a differential of 2V.

(4) Guaranteed by design.

**POWER MANAGEMENT**
**Pin Configuration**

**Ordering Information**

| Part Number                       | Package |
|-----------------------------------|---------|
| SC1456XIMSTR <sup>(1)(2)</sup>    | MSOP-10 |
| SC1456XIMSTR <sup>(1)(2)(3)</sup> | MSOP-10 |

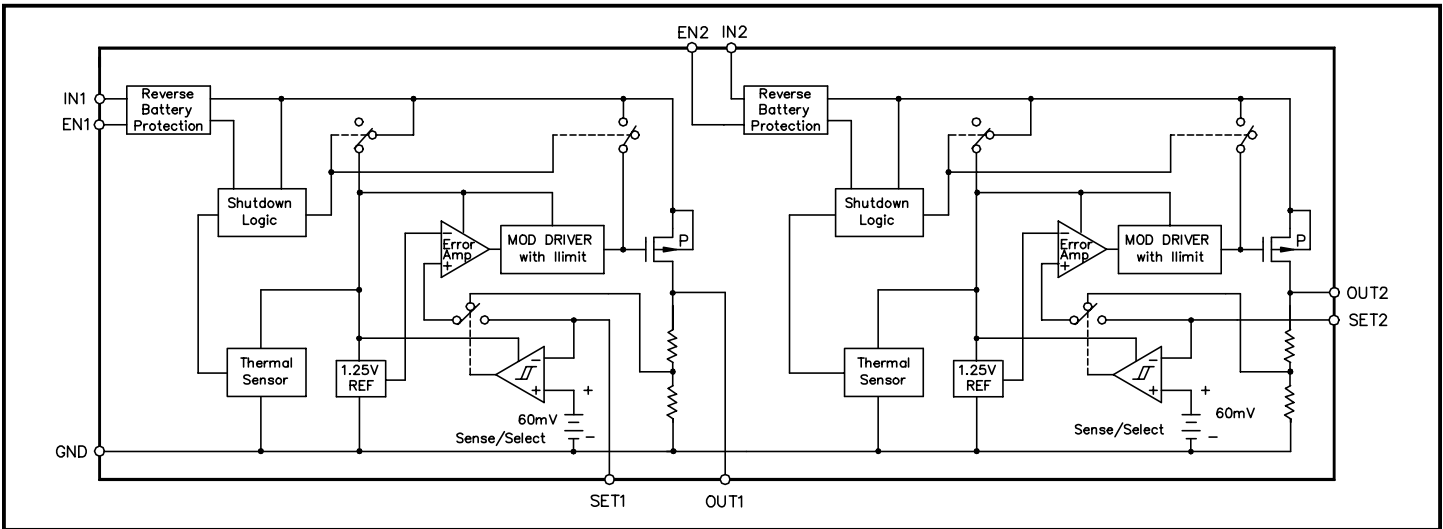
**Notes:**

- (1) Where X denotes voltage options - see table below. Consult factory for other voltage options.  
 (2) Only available in tape and reel packaging. A reel contains 2500 devices.  
 (3) Lead free product. Fully WEEE and RoHS compliant.

**Voltage Options**

Replace X in the part number (SC1456XIMSTR) by the letter shown below for the corresponding voltage options:

| X | V <sub>OUT1</sub> (V) | V <sub>OUT2</sub> (V) |
|---|-----------------------|-----------------------|
| A | 2.5                   | 2.5                   |
| B | 2.8                   | 2.8                   |
| C | 3.0                   | 3.0                   |
| D | 3.3                   | 3.3                   |

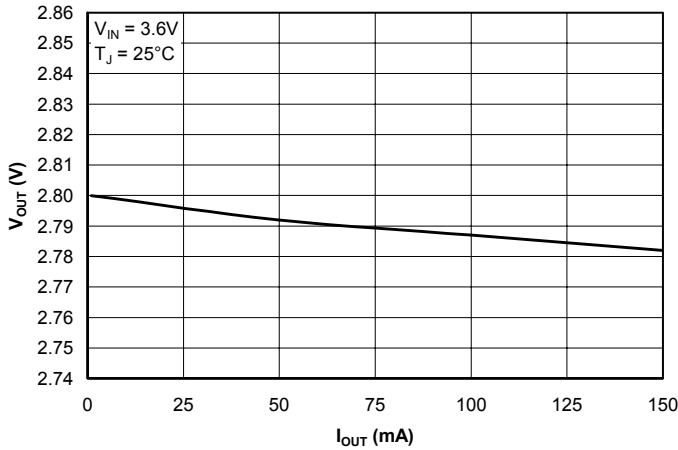
**POWER MANAGEMENT**
**Block Diagram**

**Pin Descriptions**

| Pin | Pin Name | Pin Function   |
|-----|----------|--|
| 1   | EN1      | Active high enable pin for device 1. Connect to $V_{IN1}$ if not being used.   |
| 2   | GND      | Ground pin. Can be used for heatsinking if needed. Electrically connected to pin 7.  |
| 3   | SET 1    | Connecting this pin to ground results in the internally preset value for $V_{OUT1}$ . Connecting to an external resistor divider changes $V_{OUT1}$ to:<br>$V_{OUT1} = 1.250 \cdot \left(1 + \frac{R1}{R2}\right)$ |
| 4   | OUT2     | Regulator output for device 2, sourcing up to 150mA.   |
| 5   | IN2      | Supply input pin for device 2.   |
| 6   | EN2      | Active high enable pin for device 2. Connect to $V_{IN2}$ if not being used.   |
| 7   | GND      | Ground pin. Can be used for heatsinking if needed. Electrically connected to pin 2.  |
| 8   | SET2     | Connecting this pin to ground results in the internally preset value for $V_{OUT2}$ . Connecting to an external resistor divider changes $V_{OUT2}$ to:<br>$V_{OUT2} = 1.250 \cdot \left(1 + \frac{R1}{R2}\right)$ |
| 9   | OUT1     | Regulator output for device 1, sourcing up to 150mA  |
| 10  | IN1      | Supply input pin for device 1.   |

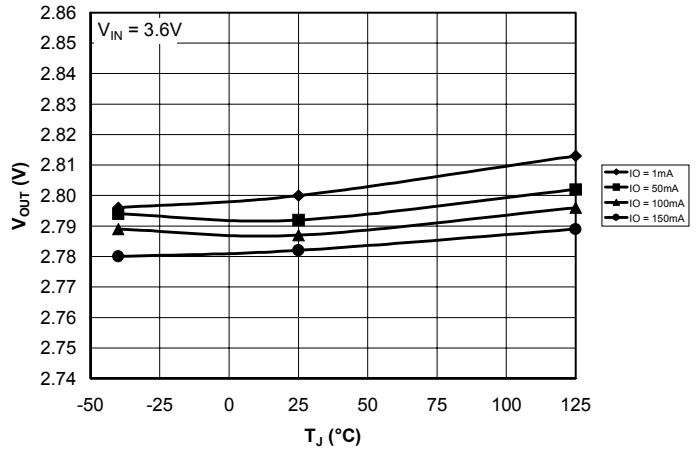
**POWER MANAGEMENT**

**Typical Characteristics**

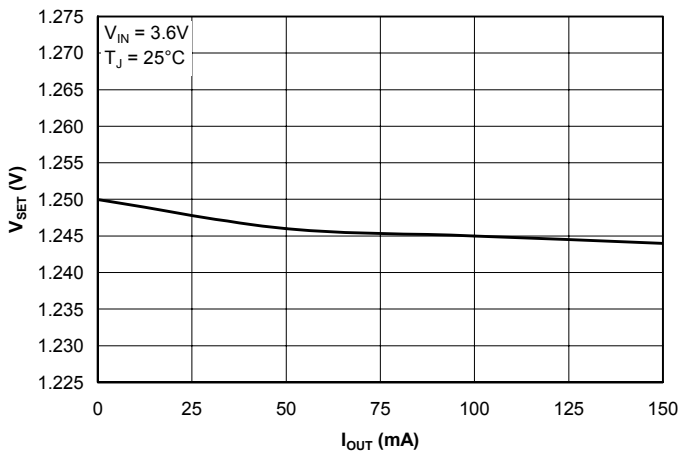
**Output Voltage (2.8V) vs. Output Current**



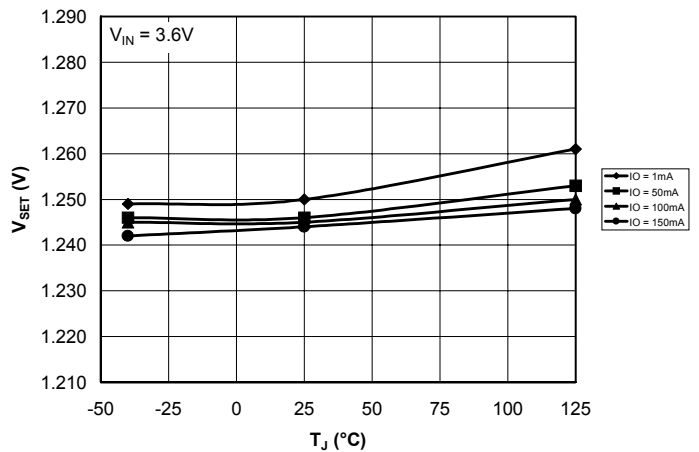
**Output Voltage (2.8V) vs. Junction Temperature vs. Output Current**



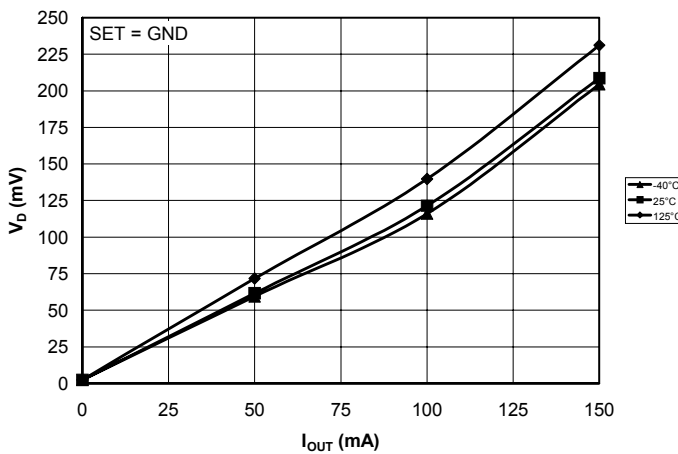
**SET Reference Voltage vs. Output Current**



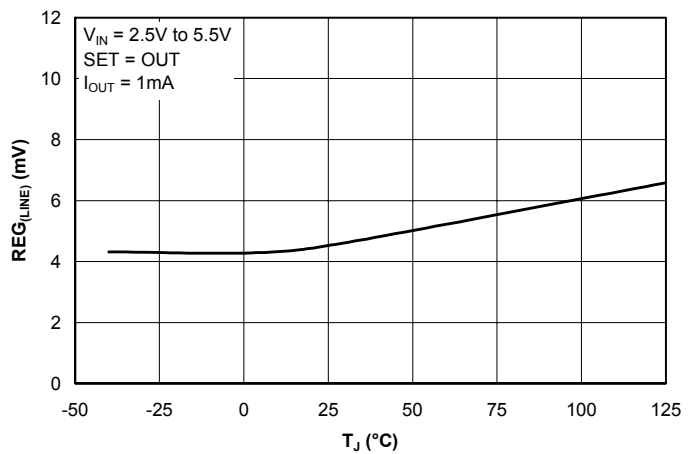
**SET Reference Voltage vs. Junction Temperature vs. Output Current**



**Dropout Voltage vs. Output Current vs. Junction Temperature**



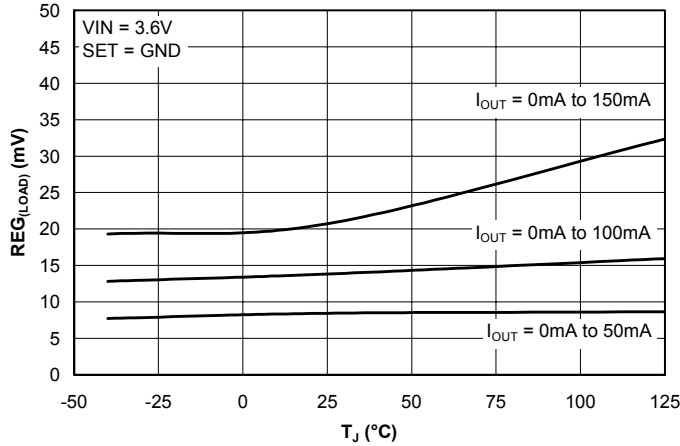
**Line Regulation vs. Junction Temperature**



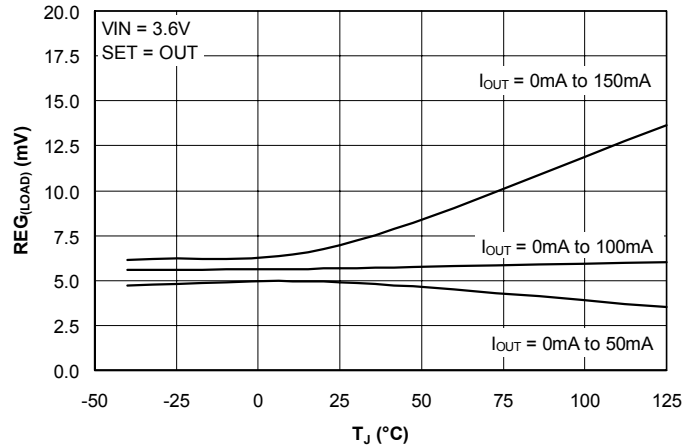
**POWER MANAGEMENT**

**Typical Characteristics (Cont.)**

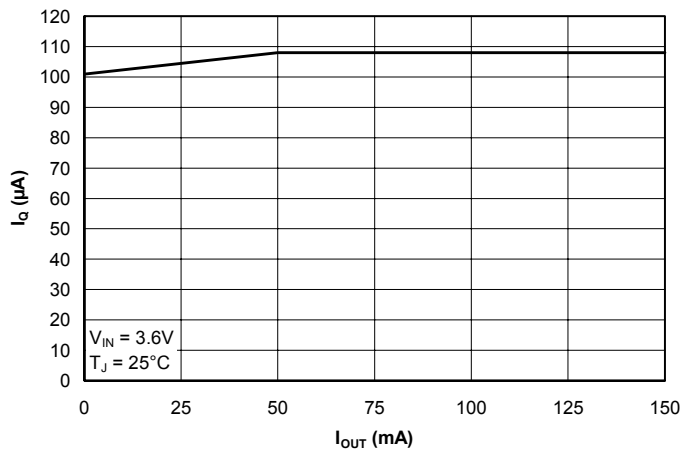
**Load Regulation ( $V_{SET} = GND$ )  
vs. Junction Temperature**



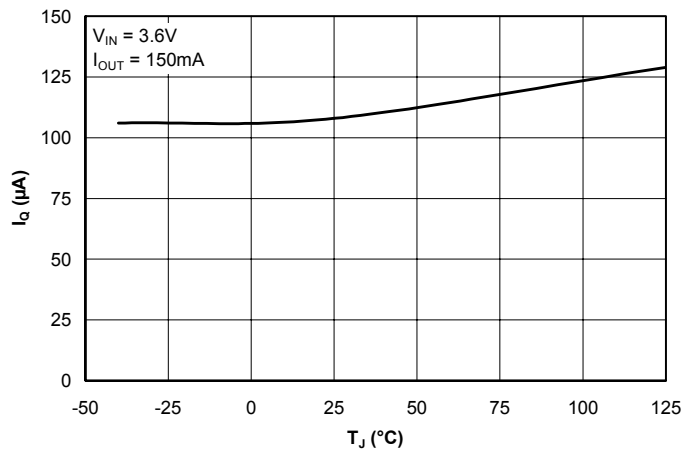
**Load Regulation ( $V_{SET} = V_{OUT}$ )  
vs. Junction Temperature**



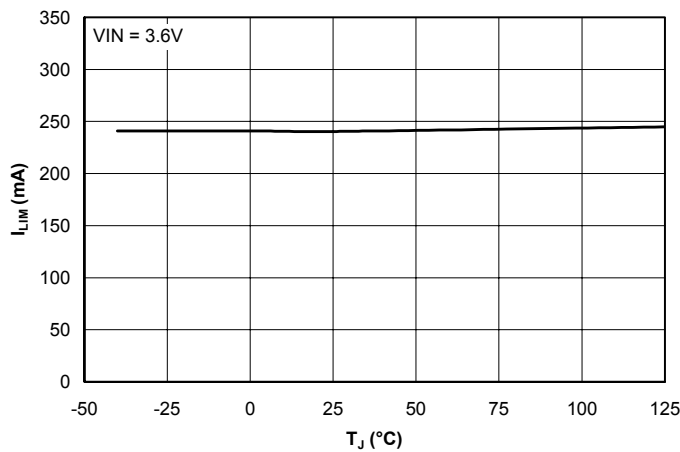
**Supply Current vs.  
Output Current**



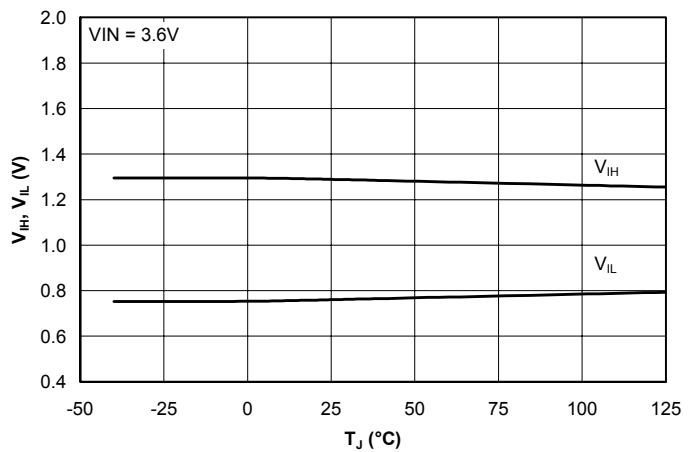
**Supply Current vs.  
Junction Temperature**

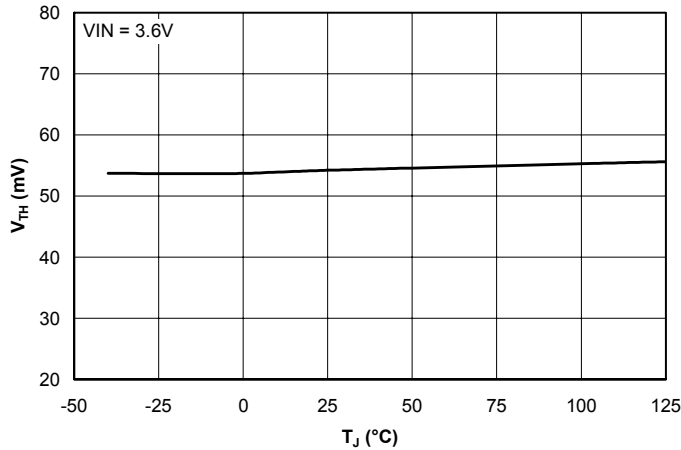
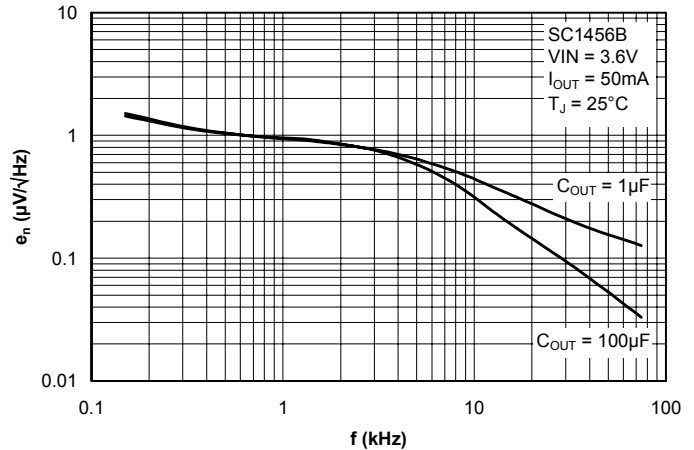


**Current Limit vs.  
Junction Temperature**



**Enable Input Threshold vs.  
Junction Temperature**



**POWER MANAGEMENT**
**Typical Characteristics (Cont.)**
**Sense/Select Threshold vs.  
Junction Temperature**

**Output Spectral Noise Density  
vs. Frequency**

**Applications Information**
**Theory Of Operation**

The SC1456 is intended for applications where very low dropout voltage, low supply current, low output noise and pcb real estate are critical. It provides a very simple, low cost solution for two separate regulated outputs. Internally preset output voltage options require the use of only four external capacitors for operation.

Each regulator has both fixed and adjustable output voltage modes. Grounding the SET pin (pulling it below the Sense/Select threshold of 55mV) will connect the internal resistor divider of that regulator to the error amplifier resulting with the internally preset output voltage. If SET is pulled above this threshold, then the Sense/Select switch will connect the SET pin to the error amplifier. The output will be regulated such that the voltage at SET will equal  $V_{SET}$ , the SET reference voltage (typically 1.250V).

An active high enable pin (EN) is provided for each output to allow the customer to shut down that regulator and enter an extremely low power Off-state. A logic Low signal will reduce the regulator's supply current to 0.1nA.

**Component Selection - General**

**Output capacitor:** Semtech recommends a minimum capacitance of 1µF at each output with an equivalent

series resistance (ESR) of <math><1\Omega</math> over temperature. Ceramic capacitors are ideal for this application. Increasing the bulk capacitance will further reduce output noise and improve the overall transient response.

**Input capacitor:** Semtech recommends the use of a 1µF ceramic capacitor at each input. This allows for the device being some distance from any bulk capacitance on the rail. Additionally, input droop due to load transients is reduced, improving load transient response.

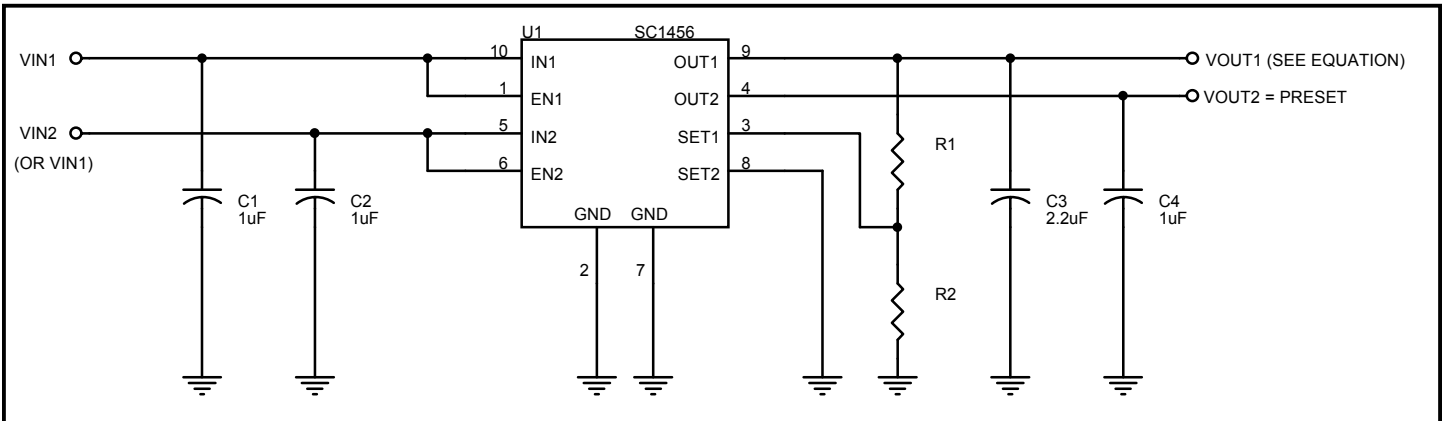
**Component Selection - Externally Set Output**

Please refer to Figure 1 on page 9. The output voltage of both outputs (OUT1 shown here) can be externally adjusted anywhere within the range from 1.25V to  $(V_{IN(MIN)} - V_{D(MAX)})$ . The output voltage will be in accordance with the following equation:

$$V_{OUT} = 1.250 \cdot \left( 1 + \frac{R1}{R2} \right)$$

1% tolerance resistors are recommended. The values of R1 and R2 should be selected such that the current flow through them is  $\geq 10\mu A$  (thus  $R2 \leq 120k\Omega$ ). At high input voltages and/or high output currents, stability may be improved by increasing C2 to 2.2µF and reducing R2 to 10kΩ. See "Component Selection - General" for input capacitor requirements.



**POWER MANAGEMENT**
**Applications Information (Cont.)**

**Figure 1: Output 1 Set Externally and Output 2 Set Internally**
**Thermal Considerations**

The worst-case power dissipation for this part is given by:

$$P_{D(MAX)} = (V_{IN1(MAX)} - V_{OUT1(MIN)}) \cdot I_{OUT1(MAX)} + V_{IN1(MAX)} \cdot I_{Q1(MAX)} + (V_{IN2(MAX)} - V_{OUT2(MIN)}) \cdot I_{OUT2(MAX)} + V_{IN2(MAX)} \cdot I_{Q2(MAX)}$$

For all practical purposes, it can be reduced to:

$$P_{D(MAX)} = (V_{IN1(MAX)} - V_{OUT1(MIN)}) \cdot I_{OUT1(MAX)} + (V_{IN2(MAX)} - V_{OUT2(MIN)}) \cdot I_{OUT2(MAX)}$$

Looking at a typical application:

$$\begin{aligned} V_{IN1(MAX)} &= V_{IN2(MAX)} = 4.2V \\ V_{OUT1(MIN)} &= V_{OUT2(MIN)} = (2.8V - 3.5\%) = 2.702V \text{ worst-case} \\ I_{OUT1} &= I_{OUT2} = 100mA \\ T_A &= 85^\circ C \end{aligned}$$

This gives us:

$$P_{D(MAX)} = 2 \cdot (4.2 - 2.702) \cdot 0.100 = 300mW$$

Using this figure, we can calculate the maximum thermal impedance allowable to maintain  $T_j \leq 125^\circ C$ :

$$\theta_{(J-A)(MAX)} = \frac{(T_{J(MAX)} - T_{A(MAX)})}{P_{D(MAX)}} = \frac{(125 - 85)}{0.300} = 133^\circ C/W$$

With the standard MSOP-10 Land Pattern shown at the end of this datasheet, and minimum trace widths, the thermal impedance junction to ambient for SC1456 is  $113^\circ C/W$ . Thus with no additional heatsinking,  $T_{J(MAX)} = 119^\circ C$ .

The junction temperature can be reduced further by the use of larger trace widths, and connecting pcb copper area to the GND pins (pins 2 and 7), which connect directly to the device substrate. Lower junction temperatures improve overall output voltage accuracy.

**Layout Considerations**

While layout for linear devices is generally not as critical as for a switching application, careful attention to detail will ensure reliable operation.

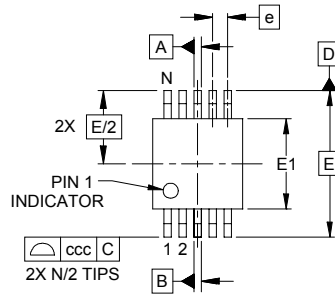
1) Attaching the part to a larger copper footprint will enable better heat transfer from the device, especially on PCBs where there are internal ground and power planes.

2) Place the input and output capacitors close to the device for optimal transient response and device behavior.

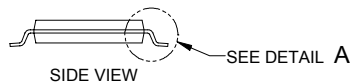
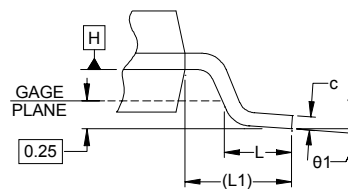
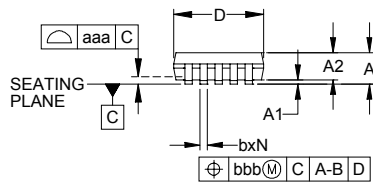
3) Connect all ground connections directly to the ground plane. If there is no ground plane, connect to a common local ground point before connecting to board ground.

**POWER MANAGEMENT**

**Outline Drawing - MSOP-10**



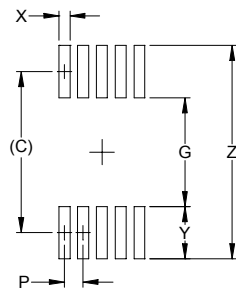
| DIM | INCHES   |      |      | MILLIMETERS |      |      |
|-----|----------|------|------|-------------|------|------|
|     | MIN      | NOM  | MAX  | MIN         | NOM  | MAX  |
| A   | -        | -    | .043 | -           | -    | 1.10 |
| A1  | .000     | -    | .006 | 0.00        | -    | 0.15 |
| A2  | .030     | -    | .037 | 0.75        | -    | 0.95 |
| b   | .007     | -    | .011 | 0.17        | -    | 0.27 |
| c   | .003     | -    | .009 | 0.08        | -    | 0.23 |
| D   | .114     | .118 | .122 | 2.90        | 3.00 | 3.10 |
| E1  | .114     | .118 | .122 | 2.90        | 3.00 | 3.10 |
| E   | .193 BSC |      |      | 4.90 BSC    |      |      |
| e   | .020 BSC |      |      | 0.50 BSC    |      |      |
| L   | .016     | .024 | .032 | 0.40        | 0.60 | 0.80 |
| L1  | (.037)   |      |      | (.95)       |      |      |
| N   | 10       |      |      | 10          |      |      |
| θ1  | 0°       | -    | 8°   | 0°          | -    | 8°   |
| aaa | .004     |      |      | 0.10        |      |      |
| bbb | .003     |      |      | 0.08        |      |      |
| ccc | .010     |      |      | 0.25        |      |      |



NOTES:

1. CONTROLLING DIMENSIONS ARE IN MILLIMETERS (ANGLES IN DEGREES).
2. DATUMS [-A-] AND [-B-] TO BE DETERMINED AT DATUM PLANE [-H-].
3. DIMENSIONS "E1" AND "D" DO NOT INCLUDE MOLD FLASH, PROTRUSIONS OR GATE BURRS.
4. REFERENCE JEDEC STD MO-187, VARIATION BA.

**Land Pattern - MSOP-10**



| DIM | DIMENSIONS |             |
|-----|------------|-------------|
|     | INCHES     | MILLIMETERS |
| C   | (.161)     | (4.10)      |
| G   | .098       | 2.50        |
| P   | .020       | 0.50        |
| X   | .011       | 0.30        |
| Y   | .063       | 1.60        |
| Z   | .224       | 5.70        |

NOTES:

1. THIS LAND PATTERN IS FOR REFERENCE PURPOSES ONLY. CONSULT YOUR MANUFACTURING GROUP TO ENSURE YOUR COMPANY'S MANUFACTURING GUIDELINES ARE MET.

**Contact Information**

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