SEMTECH

# VERY LOW DROPOUT 1.5 AMP REGULATOR WITH ENABLE

# SC1565

October 3, 2000

TEL:805-498-2111 FAX:805-498-3804 WEB:http://www.semtech.com

## DESCRIPTION

The SC1565 is a high performance positive voltage regulator designed for use in applications requiring very low dropout voltage at up to 1.5 Amps. Since it has superior dropout characteristics compared to regular LDOs, it can be used to supply 2.5V on motherboards or 2.8V on peripheral cards from the 3.3V supply thus allowing the elimination of costly heatsinks. Additionally, the 5-lead TO-220 and SO-8 versions have an enable pin to further reduce power dissipation while shut down. The SC1565 provides excellent regulation over variations in line, load and temperature.

The SC1565 is available in the popular SO-8 surface mount package with two internally preset output voltage options, which are also adjustable using external resistors. Also available are 5-lead and 3-lead TO-220 2.5V options (fixed output only for the 3-lead option) and fixed output SOT-223 options.

## FEATURES

- 350mV dropout @ 1.5A
- Adjustable output from 1.2V to 4.8V(1)
- 2.5V and 1.8V options (adjustable externally using resistors)(1)
- Over current and over temperature protection
- Enable pin(1)
- 10µA quiescent current in shutdown(1)
- Low reverse leakage (output to input)
- Surface mount and through-hole packages
- Full industrial temperature range

Note:
(1) SO-8 and TO-220-5L packages only.

## APPLICATIONS

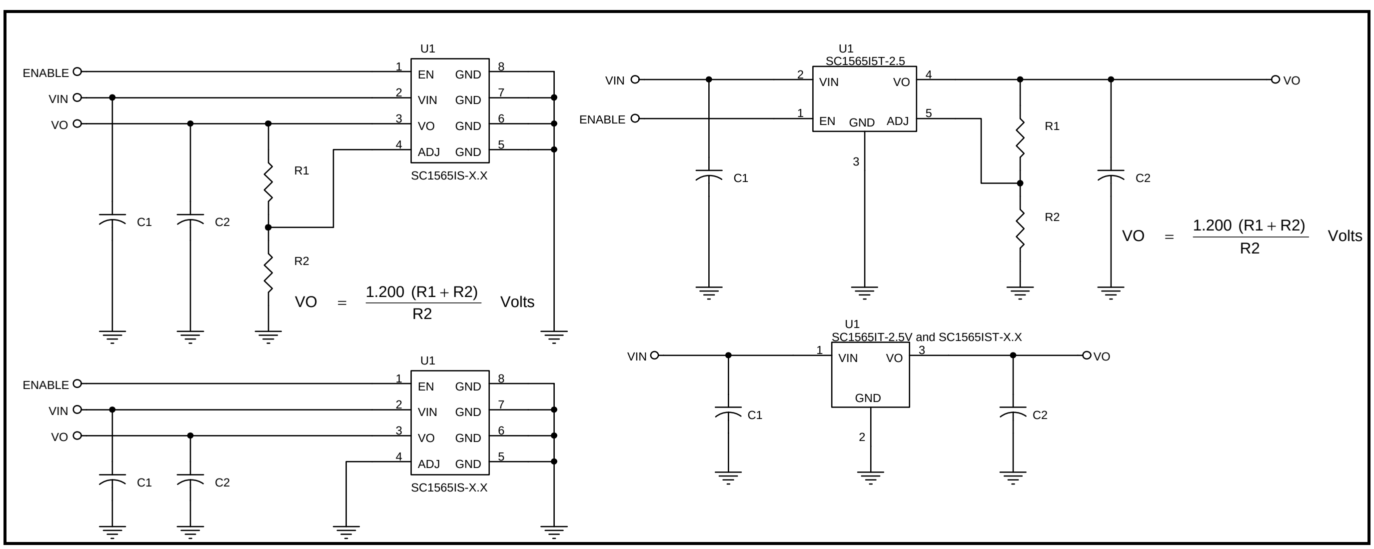
- Battery powered systems
- Motherboards
- Peripheral cards
- PCMCIA cards

## ORDERING INFORMATION

| DEVICE(1) | PACKAGE |
|---|---|
| SC1565IS-X.X.TR(2) | SO-8 |
| SC1565IST-X.X.TR(2) | SOT-223 |
| SC1565IT-X.X(3) | TO-220-3 |
| SC1565I5T-X.X(3) | TO-220-5 |

Notes:
(1) Where -X.X denotes voltage options. Available voltages are: 2.5V and 1.8V. Output voltage can be adjusted (except SOT-223 and TO-220-3) using external resistors, see Pin Description.
(2) Only available in tape and reel packaging. A reel contains 2500 devices.
(3) Only available in tube packaging (no suffix required).

## TYPICAL APPLICATIONS




Notes:
(1) Maximum VO setpoint for 1.8V parts = 5.4V.
(2) This device is designed to operate with ceramic input and output capacitors.





652 MITCHELL ROAD NEWBURY PARK CA 91320

October 3, 2000

## ABSOLUTE MAXIMUM RATINGS

| Parameter | Symbol | Max | Units |
|---|---|---|---|
| Input Voltage | $V_{IN}$ | 5.5 | V |
| Power Dissipation | $P_D$ | Internally Limited | W |
| Thermal Resistance Junction to Ambient<br>SO-8[1]<br>SOT-223<br>TO-220-X | $\theta_{JA}$ | 65<br>63<br>50 | °C/W |
| Thermal Resistance Junction to Case<br>SO-8<br>SOT-223<br>TO-220-X | $\theta_{JC}$ | 39<br>27<br>3 | °C/W |
| Operating Ambient Temperature Range | $T_A$ | -40 to 85 | °C |
| Operating Junction Temperature Range | $T_J$ | -40 to 150 | °C |
| Storage Temperature Range | $T_{STG}$ | -65 to 150 | °C |
| Lead Temperature (Soldering) 10 Sec. | $T_{LEAD}$ | 300 | °C |
| ESD Rating (Human body model) | ESD | 4 | kV |

Note:
(1) 1 square inch of FR-4, double sided, 1 oz. minimum copper weight.

## ELECTRICAL CHARACTERISTICS

Unless specified: $V_{EN} = V_{IN}$
Adjustable Option ($V_{ADJ} > V_{TH(ADJ)}$): $V_{IN}$ = 2.2 to 5.5V and $I_O$ = 10µA to 1.5A
Fixed Options ($V_{ADJ}$ = GND): $V_{IN} = (V_O + 0.7V)$ to 5.5V and $I_O$ = 0A to 1.5A
Values in **bold** apply over the full operating temperature range.

| Parameter | Symbol | Test Conditions | Min | Typ | Max | Units |
|---|---|---|---|---|---|---|
| **VIN** | | | | | | |
| Supply Voltage Range | VIN | | **2.2** | | **5.5** | V |
| Quiescent Current | $I_Q$ | $V_{IN}$ = 3.3V | | 0.75 | **1.75** | mA |
| | | $V_{IN}$ = 5.5V, $V_{EN}$ = 0V | | 10 | **35** | µA |
| **VO** | | | | | | |
| Output Voltage[1] | $V_O$ | $V_{IN} = V_O + 0.7V$, $I_O$ = 10mA | $0.99V_O$ | $V_O$ | $1.01V_O$ | V |
| (Internal Fixed Voltage) | | | $\mathbf{0.98V_O}$ | $\mathbf{V_O}$ | $\mathbf{1.02V_O}$ | |
| Line Regulation[1] | $REG_{(LINE)}$ | $V_{IN} = (V_O + 0.25V)$ to 5.5V, $I_{OUT}$ = 10mA | | 0.035 | **0.3** | % |
| Load Regulation[1] | $REG_{(LOAD)}$ | $V_{IN} = V_O + 0.7V$ | | 0.2 | **0.4** | % |

October 3, 2000

## ELECTRICAL CHARACTERISTICS

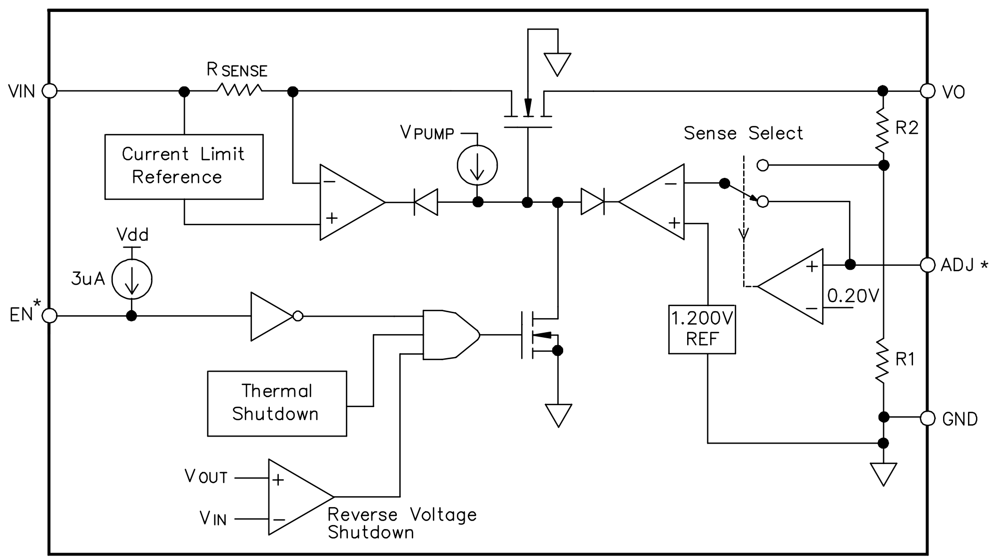
Unless specified: $V_{EN} = V_{IN}$
Adjustable Option ($V_{ADJ} > V_{TH(ADJ)}$): $V_{IN}$ = 2.2 to 5.5V and $I_O$ = 10µA to 1.5A
Fixed Options ($V_{ADJ}$ = GND): $V_{IN} = (V_O + 0.7V)$ to 5.5V and $I_O$ = 0A to 1.5A
Values in **bold** apply over the full operating temperature range.

| Parameter | Symbol | Test Conditions | Min | Typ | Max | Units |
|---|---|---|---|---|---|---|
| Dropout Voltage[2] | $V_D$ | $I_{LOAD}$ = 10mA | | 2.5 | 10 | mV |
| | | | | | **20** | |
| | | $I_{LOAD}$ = 500mA | | 115 | 300 | mV |
| | | | | | **400** | |
| | | $I_{LOAD}$ = 1A | | 225 | 400 | mV |
| | | | | | **500** | |
| | | $I_{LOAD}$ = 1.5A | | 350 | 500 | mV |
| | | | | | **600** | |
| Minimum Load Current[3] | $I_O$ | $V_{IN} = V_O + 0.7V$ | | 1 | **10** | µA |
| Current Limit | $I_{CL}$ | | **1.50** | 2.50 | **3.50** | A |
| **ADJ** | | | | | | |
| Reference Voltage[1] | $V_{REF}$ | $V_{IN} = 2.2V$, $V_{ADJ} = V_{OUT}$, $I_O$ = 10mA | 1.188 | 1.200 | 1.212 | V |
| | | | **1.176** | | **1.224** | |
| Adjust Pin Current[4] | $I_{ADJ}$ | $V_{ADJ} = V_{REF}$ | | 10 | **50** | nA |
| Adjust Pin Threshold[5] | $V_{TH(ADJ)}$ | | **0.10** | 0.20 | **0.40** | V |
| **EN** | | | | | | |
| Enable Pin Current | $I_{EN}$ | $V_{EN} = 0V$, $V_{IN} = 3.3V$ | | 1.5 | **10** | µA |
| Enable Pin Threshold | $V_{IH}$ | $V_{IN} = 3.3V$ | **1.8** | | | V |
| | $V_{IL}$ | $V_{IN} = 3.3V$ | | | **0.4** | |
| **OVER TEMPERATURE PROTECTION** | | | | | | |
| High Trip level | $T_{HI}$ | | | 170 | | °C |
| Hysteresis | $T_{HYST}$ | | | 20 | | °C |

**NOTES:**
(1) Low duty cycle pulse testing with Kelvin connections required.
(2) Defined as the input to output differential at which the output voltage drops to 1% below the value measured at a differential of 0.7V.
(3) Required to maintain regulation. Voltage set resistors R1 and R2 are usually utilized to meet this requirement. Adjustable versions only.
(4) Guaranteed by design.
(5) When $V_{ADJ}$ exceeds this threshold, the “Sense Select” switch disconnects the internal feedback chain from the error amplifier and connects $V_{ADJ}$ instead.

October 3, 2000

## BLOCK DIAGRAM



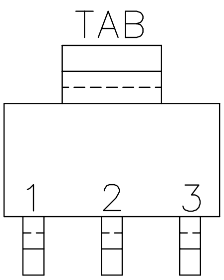

* Not on 3-lead TO-220

## PIN DESCRIPTIONS

| Pin Name | Pin Functiom |
|---|---|
| ADJ | This pin, when grounded, sets the output voltage to that set by the internal feedback resistors. If external feedback resistors are used, the output voltage will be (See Application Circuit): $VO = \frac{1.200\ (R1 + R2)}{R2}$ Volts |
| EN | Enable Input. Pulling this pin below 0.4V turns the regulator off, reducing the quiescent current to a fraction of its operating value. The device will be enabled if this pin is left open. Connect to VIN if not being used. |
| GND | Reference ground. Use all four pins on the SO-8 device for heatsinking. Use the tab on the TO-220 devices for heatsinking. |
| VIN | Input voltage. For regulation at full load, the input to this pin must be between (VO + 0.7V) and 5.5V. Minimum VIN = 2.2V. |
| VO | This pin is the power output of the device. |

October 3, 2000

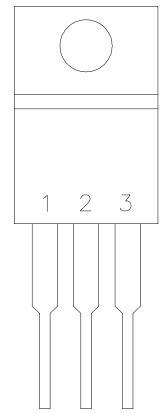
## PIN CONFIGURATIONS




| PIN | FUNCTION |
|---|---|
| 1 | VIN |
| 2 | GND |
| 3 | VO |
| TAB IS GROUND | |

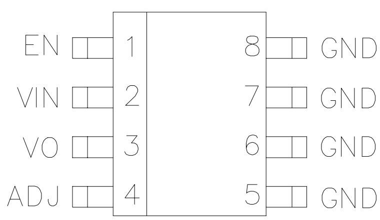
SOT-223

| SC1565 3-PIN VERSIONS | |
|---|---|
| PIN | FUNCTION |
| 1 | VIN |
| 2 | GND |
| 3 | VO |
| TAB IS GROUND | |



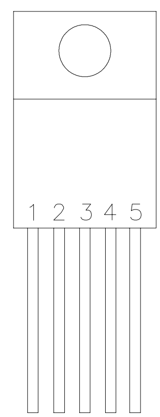

TO-220-3

Top View




SO-8

| SC1565 5-PIN VERSIONS | |
|---|---|
| PIN | FUNCTION |
| 1 | EN |
| 2 | VIN |
| 3 | GND |
| 4 | VO |
| 5 | ADJ |
| TAB IS GROUND | |

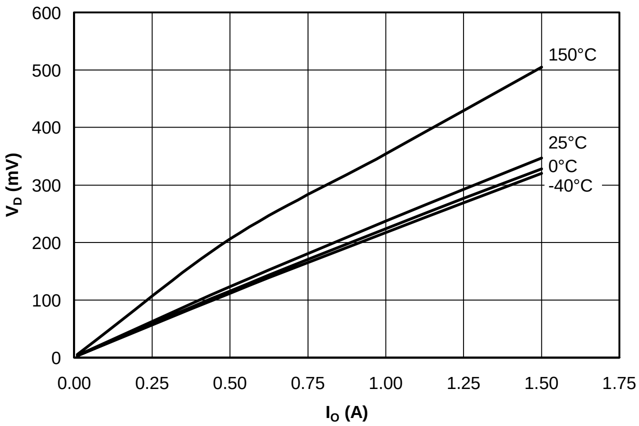



TO-220-5

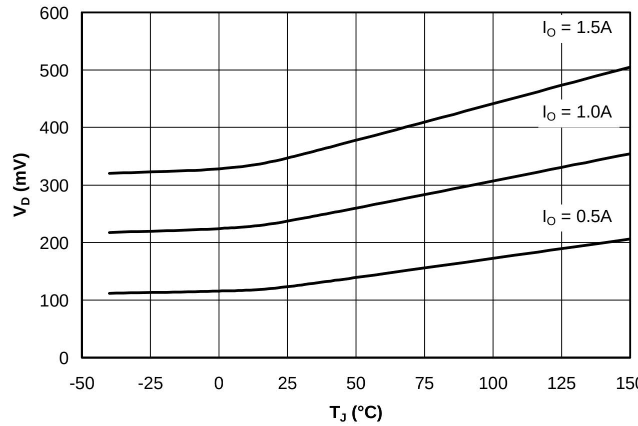
October 3, 2000

## TYPICAL CHARACTERISTICS

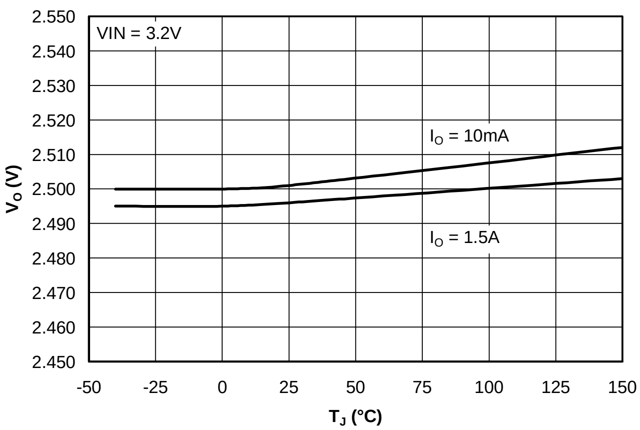
**Dropout Voltage vs. Output Current vs. Junction Temperature**



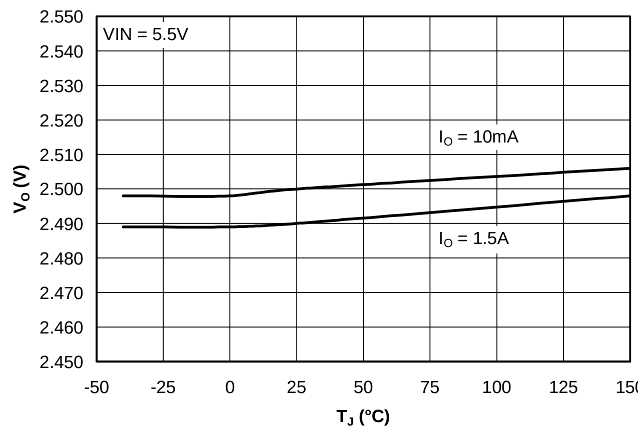

**Dropout Voltage vs. Junction Temperature vs. Output Current**



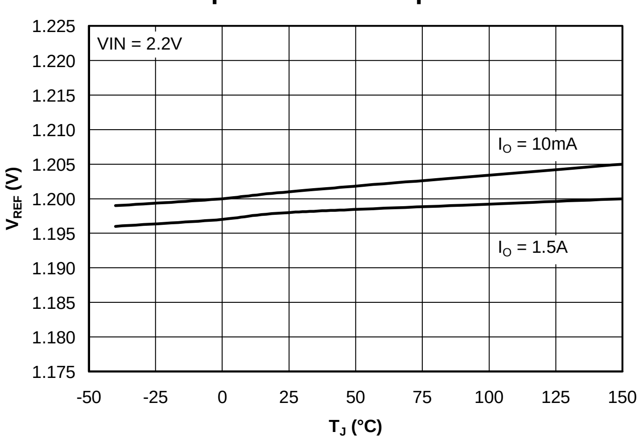

**Output Voltage (2.5V) vs. Junction Temperature vs. Output Current**



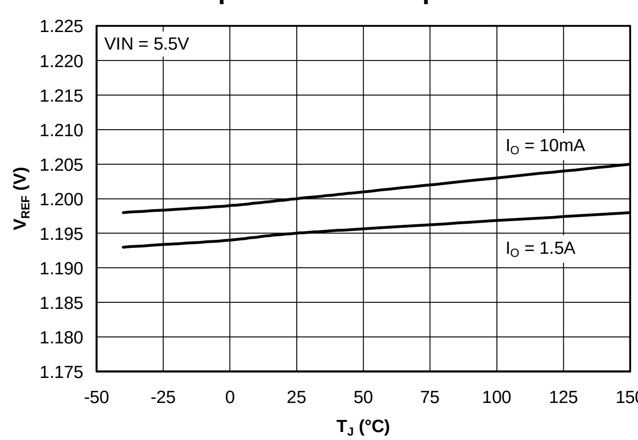

**Output Voltage (2.5V) vs. Junction Temperature vs. Output Current**




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




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



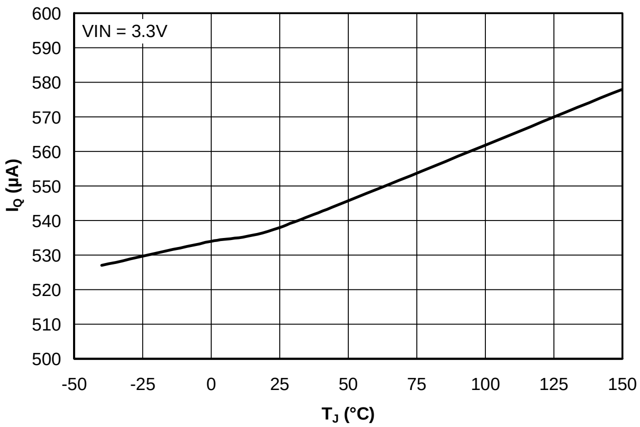


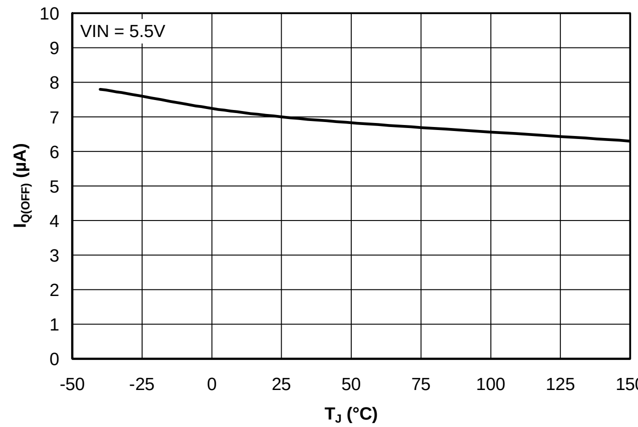
October 3, 2000

## TYPICAL CHARACTERISTICS (Cont.)

**Quiescent Current vs.
Junction Temperature**




**Off-State Quiescent Current vs.
Junction Temperature**




## APPLICATIONS INFORMATION

### Introduction

The SC1565 is intended for applications such as graphics cards where high current capability and very low dropout voltage are required. It provides a very simple, low cost solution that uses very little pcb real estate. Additional features include an enable pin to allow for a very low power consumption standby mode, and a fully adjustable output.

### Component Selection

Input capacitor - a 4.7µF ceramic capacitor is recommended. 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. Additional capacitance may be added if required by the application.

Output capacitor - a minimum bulk capacitance of 10µF, along with a 0.1µF ceramic decoupling capacitor is recommended. Increasing the bulk capacitance will improve the overall transient response. The use of multiple lower value ceramic capacitors in parallel to achieve the desired bulk capacitance will not cause stability issues. Although designed for use with ceramic output capacitors, the SC1565 is extremely tolerant of output capacitor ESR values and thus will also work comfortably with tantalum output capacitors.

External voltage selection resistors - the use of 1% resistors, and designing for a current flow ≥ 10µA is recommended to ensure a well regulated output (thus R2 ≤ 120kΩ).

### Thermal Considerations

The power dissipation in the SC1565 is approximately equal to the product of the output current and the input to output voltage differential:

$$P_D \approx (VIN - VOUT) \bullet I_O$$

The absolute worst-case dissipation is given by:

$$P_{D(MAX)} = (VIN_{(MAX)} - VOUT_{(MIN)}) \bullet I_{O(MAX)} + VIN_{(MAX)} \bullet I_{Q(MAX)}$$

For a typical scenario, VIN = 3.3V ± 5%, VOUT = 2.8V and $I_O$ = 1.5A, therefore:

$VIN_{(MAX)}$ = 3.465V, $VOUT_{(MIN)}$ = 2.744V and $I_{Q(MAX)}$ = 1.75mA,

Thus $P_{D(MAX)}$ = 1.09W.

Using this figure, and assuming $T_{A(MAX)}$ = 70°C, we can calculate the maximum thermal impedance allowable to maintain $T_J \le 150$°C:

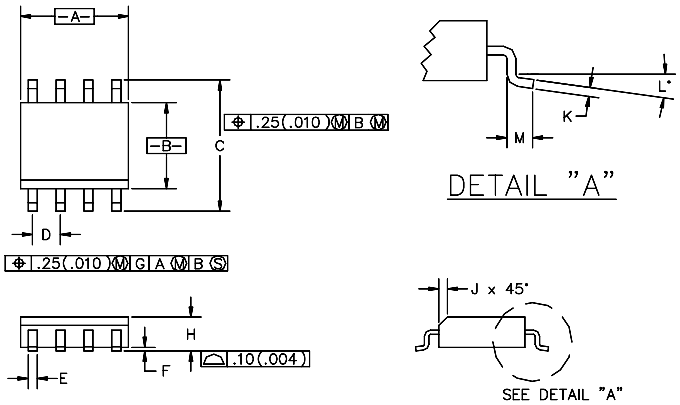
$$R_{TH(J-A)(MAX)} = \frac{(T_{J(MAX)} - T_{A(MAX)})}{P_{D(MAX)}} = \frac{(150 - 70)}{109} = 73.4^\circ C / W$$

This should be achievable for the SO-8 package using pcb copper area to aid in conducting the heat away, such as one square inch of copper connected to the ground pins of the device. The SOT-223 and TO-220 packages would not require heatsinking. Internal ground/power planes and air flow will also assist in removing heat. For higher ambient temperatures it may be necessary to use additional copper area.

October 3, 2000

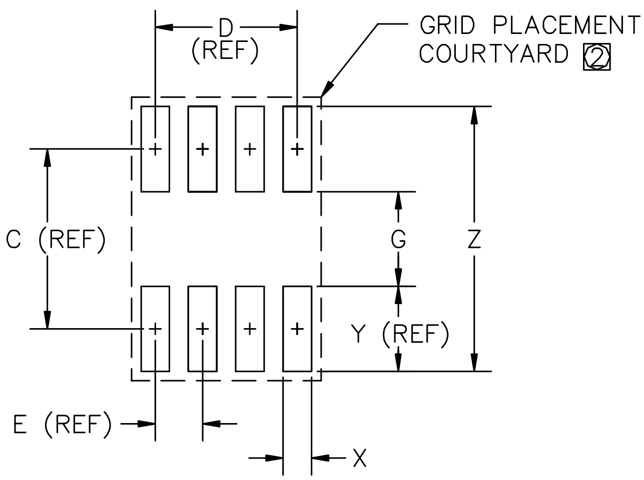
## OUTLINE DRAWING - SO-8

JEDEC
REF: MS-012AA




| DIMENSIONS | | | | | |
|---|---|---|---|---|---|
| DIM^N | INCHES | | MM | | NOTE |
| | MIN | MAX | MIN | MAX | |
| A | .188 | .197 | 4.80 | 5.00 | |
| B | .149 | .158 | 3.80 | 4.00 | |
| C | .228 | .244 | 5.80 | 6.20 | |
| D | .050 BSC | | 1.27 BSC | | |
| E | .013 | .020 | 0.33 | 0.51 | |
| F | .004 | .010 | 0.10 | 0.25 | |
| H | .053 | .069 | 1.35 | 1.75 | |
| J | .011 | .019 | 0.28 | 0.48 | |
| K | .007 | .010 | .19 | .25 | |
| L | 0° | 8° | 0° | 8° | |
| M | .016 | .050 | 0.40 | 1.27 | |

## LAND PATTERN - SO-8



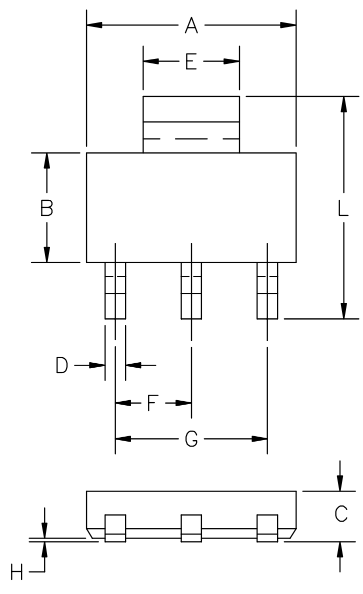

| DIMENSIONS 1 | | | | | |
|---|---|---|---|---|---|
| DIM^N | INCHES | | MM | | NOTE |
| | MIN | MAX | MIN | MAX | |
| C | – | .19 | – | 5.00 | – |
| D | – | .15 | – | 3.81 | – |
| E | – | .05 | – | 1.27 | – |
| G | .10 | .11 | 2.60 | 2.80 | – |
| X | .02 | .03 | .60 | .80 | – |
| Y | – | .09 | – | 2.40 | – |
| Z | – | .29 | 7.20 | 7.40 | – |

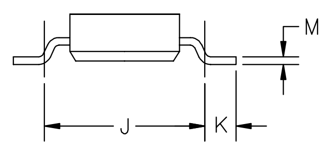
2 GRID PLACEMENT COURTYARD IS 12x16 ELEMENTS (6 mm X 8mm) IN ACCORDANCE WITH THE INTERNATIONAL GRID DETAILED IN IEC PUBLICATION 97.

1 CONTROLLING DIMENSION: MILLIMETERS

October 3, 2000

## DEVICE OUTLINE SOT-223

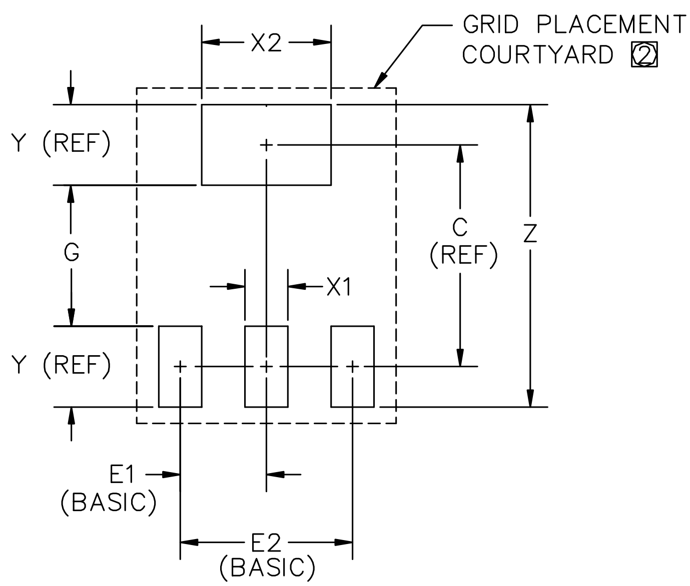



| DIMN | INCHES | | MM | | NOTE |
|---|---|---|---|---|---|
| | MIN | MAX | MIN | MAX | |
| A | .248 | .264 | 6.30 | 6.70 | – |
| B | .13 | .146 | 3.30 | 3.70 | – |
| C | .060 | .071 | 1.52 | 1.80 | – |
| D | .024 | .031 | .60 | .80 | – |
| E | .114 | .122 | 2.90 | 3.10 | – |
| F | – | .090 | – | 2.30 | BSC |
| G | – | .181 | – | 4.60 | BSC |
| H | .001 | .004 | .020 | .100 | – |
| J | .164 | .215 | 4.16 | 5.46 | – |
| K | .036 | .05 | .91 | 1.27 | – |
| L | .264 | .287 | 6.70 | 7.30 | – |
| M | .009 | .013 | .24 | .32 | – |

CONTROLLING DIMENSIONS: MILLIMETERS.

## LAND PATTERN SOT-223



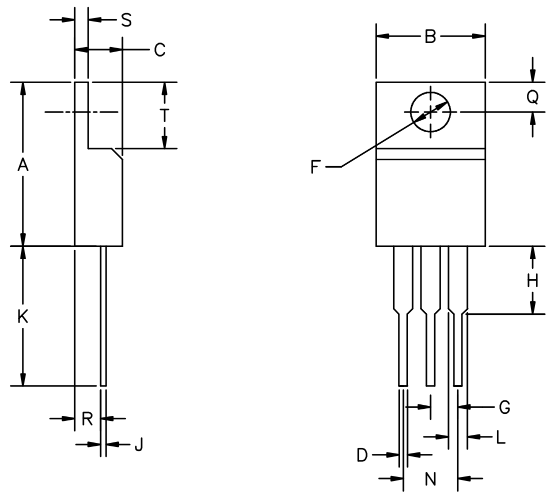

| DIMN | DIMENSIONS 1 INCHES | | MM | | NOTE |
|---|---|---|---|---|---|
| | MIN | MAX | MIN | MAX | |
| C | – | .24 | – | 6.20 | – |
| E1 | – | .09 | – | 2.30 | – |
| E2 | – | .18 | – | 4.60 | – |
| G | .15 | .16 | 4.00 | 4.20 | – |
| X1 | .03 | .04 | 1.00 | 1.20 | – |
| X2 | .13 | .14 | 3.40 | 3.60 | – |
| Y | – | .09 | – | 2.20 | – |
| Z | .32 | .33 | 8.20 | 8.40 | – |

2 GRID PLACEMENT COURTYARD IS 18 x 14 ELEMENTS (9 mm X 7mm) IN ACCORDANCE WITH THE INTERNATIONAL GRID DETAILED IN IEC PUBLICATION 97.

1 CONTROLLING DIMENSION: MILLIMETERS

October 3, 2000

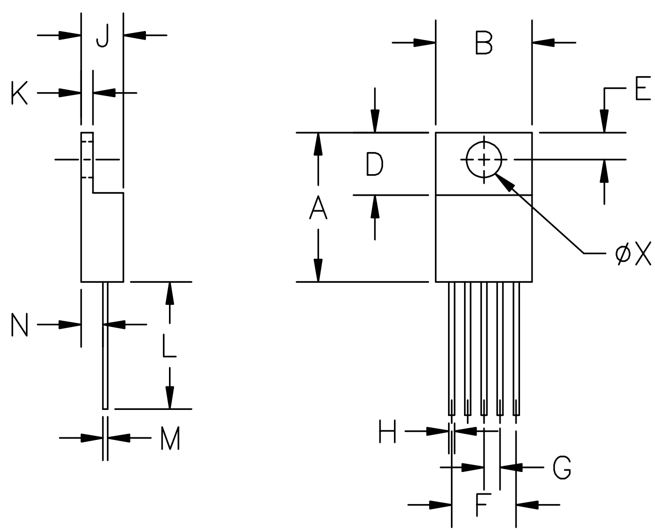
## DEVICE OUTLINE - TO-220-3L




| DIM$^N$ | INCHES MIN | INCHES MAX | MM MIN | MM MAX | NOTE |
|---|---|---|---|---|---|
| A | .560 | .650 | 14.23 | 16.51 | |
| B | .380 | .420 | 9.66 | 10.66 | |
| C | .140 | .190 | 3.56 | 4.82 | |
| D | .020 | .045 | 0.51 | 1.14 | |
| F | .139 | .161 | 3.54 | 4.08 | |
| G | .090 | .110 | 2.29 | 2.79 | |
| H | – | .250 | – | 6.35 | |
| J | .012 | .045 | .31 | 1.14 | |
| K | .500 | .580 | 12.70 | 14.73 | |
| L | .070 | .095 | 1.77 | 2.41 | |
| N | .190 | .210 | 4.83 | 5.33 | |
| Q | .100 | .135 | 2.54 | 3.42 | |
| R | .080 | .115 | 2.04 | 2.92 | |
| S | .020 | .055 | .51 | 1.39 | |
| T | .230 | .270 | 5.85 | 6.85 | |

JEDEC TO–220

## DEVICE OUTLINE - TO-220-5L




| DIM$^N$ | INCHES MIN | INCHES MAX | MM MIN | MM MAX | NOTE |
|---|---|---|---|---|---|
| A | .560 | .650 | 14.22 | 16.51 | — |
| B | .380 | .420 | 9.65 | 10.67 | — |
| D | .230 | .260 | 5.84 | 6.60 | — |
| E | .100 | .135 | 2.54 | 3.43 | — |
| F | .263 | .273 | 6.68 | 6.94 | — |
| G | .062 | .072 | 1.57 | 1.83 | — |
| H | .025 | .040 | .63 | 1.02 | — |
| J | .140 | .190 | 3.55 | 4.83 | — |
| K | .045 | .055 | 1.14 | 1.40 | — |
| L | .540 | .560 | 13.72 | 14.22 | — |
| M | .014 | .022 | .35 | .56 | — |
| N | .080 | .120 | 2.03 | 3.05 | — |
| øX | .139 | .161 | 3.53 | 4.09 | — |

JEDEC TO–220

ECN00-1357