# M54134FP/GP

## Earth Leakage Current Detector

REJ03F0030-0100Z
Rev.1.0
Sep.16.2003

### Description

The M54134FP/GP is a semiconductor integrated circuit developed for use in high-speed earth leakage breakers incorporating functions to protect against voltage surges and inverter noise.

### Features

- Lightning surge protection
  Two-count method adopted
  Improved dead-time performance for lightning impulses
- Inverter support
  For active/low-pass filter use
  Internal op-amp (low current consumption)
  Improved high-frequency, high harmonic superposition performance
- Internal time delay function
  A time delay function can be configured
- High input sensitivity
  VT=11.5 $mV_{rms}$
- Low current consumption
  Standby: 610 µA (typical)
  Leakage detection: 650 µA (typical)
- High-stability design
  Adopts a circuit with minimal characteristic fluctuation when changes occur in the power supply voltage or ambient temperature

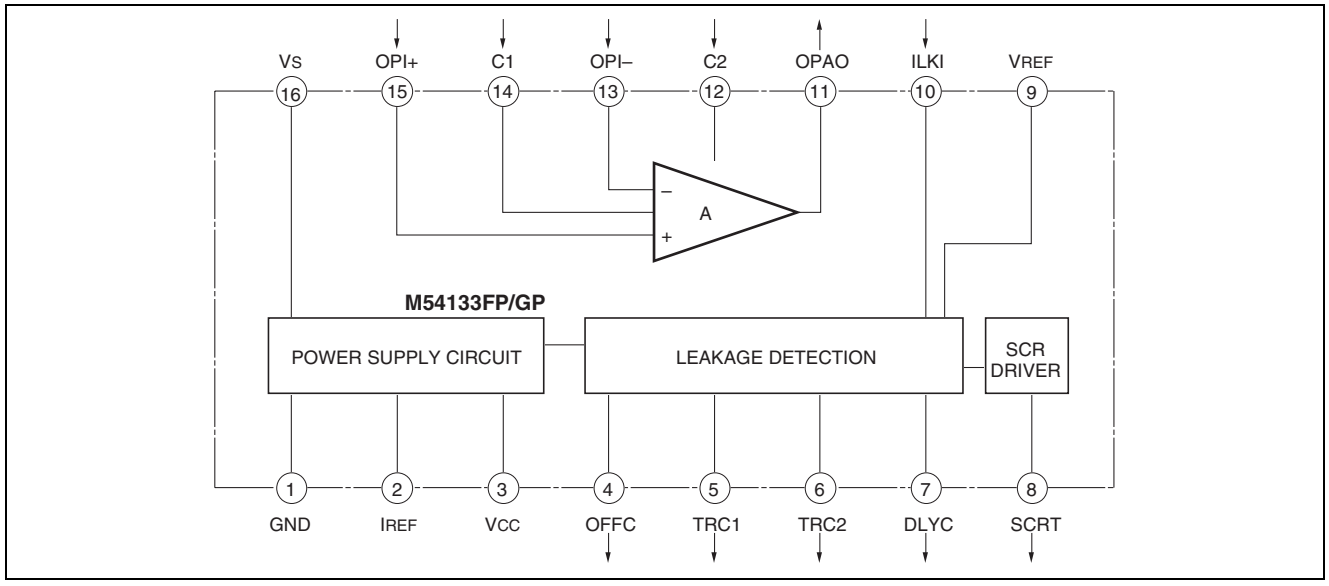
### Applications

- Earth leakage breaker

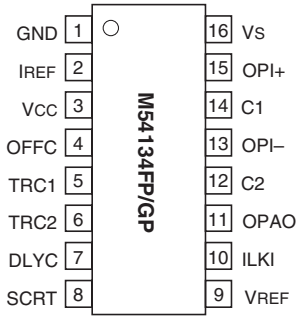
### Recommended Operating Conditions

- Operating power supply voltage range: 7 to 12 V
- Operating ambient temperature: –20 to 85°C

## Block Diagram



## Pin Configuration




Outline 16P2N-A(FP)
16P2E-A(GP)

## Pin Description

| Pin no. | Name | Function |
|---|---|---|
| 16 | VS | Power supply |
| **• Common** | | |
| 3 | VCC | Output pin for internal constant-voltage circuit; connected to decoupling capacitor |
| 2 | IREF | Pin for connection to resistor to set constant current for internal circuits; approx. 1.3 V |
| 1 | GND | Ground |
| **• Op-amp** | | |
| 13 | CPI– | Op-amp input pins |
| 15 | CPI+ | |
| 14 | C1 | Pin for connection to capacitors to prevent noise-induced erroneous operation; connected between pins [13], [14] and pins [15], [14] |
| 12 | C2 | Pin for connection to capacitor to prevent oscillation; connected with pin [11]. |
| 11 | OPAO | Op-amp output pin |
| **• Leakage detection, SCR driving circuit** | | |
| 9 | VREF | Input reference level pin for leak detection circuit; approx. 2.4 V |
| 10 | ILKI | Another input pin for leak detection circuit |
| 5 | TRC1 | Pin to connect a capacitor used to integrate the level discriminator output signal of the leak input signal |
| 6 | TRC2 | Pin to connect a capacitor for noise elimination |
| 4 | OFFC | When leak input signal is not continued<br>When a leak is detected and SCR is turned on<br>After a prescribed amount of time, this IC is returned to the initial state.<br>A capacitor to set the time for this function is connected. |
| 7 | DRYC | Pin to connect a capacitor to set the time when using the time delay function |
| 8 | SCRT | Thyristor driving output pin |

## Absolute Maximum Ratings

(Unless otherwise noted, Ta = 25°C)

| Symbol | Parameter | Test conditions | Ratings | Unit |
|---|---|---|---|---|
| $I_S$ | Power supply current | | 4 | mA |
| $IV_{Smax.}$ | Maximum power supply voltage | | 15 | V |
| Vid | Differential input voltage | Across OPI+ and OPI– | –0.8 to 0.8 | V |
| $I_{IOP}$ | Differential input current | Across OPI+ and OPI– | –5 to 5 | mA |
| $I_{IG}$ | Input current | Across VREF and GND | 10 | mA |
| Pd | Power consumption | | 200 | mW |
| Topr | Operating ambient temperature | | –20 to 85 | °C |
| Tstg | Storage temperature | | –55 to 125 | °C |

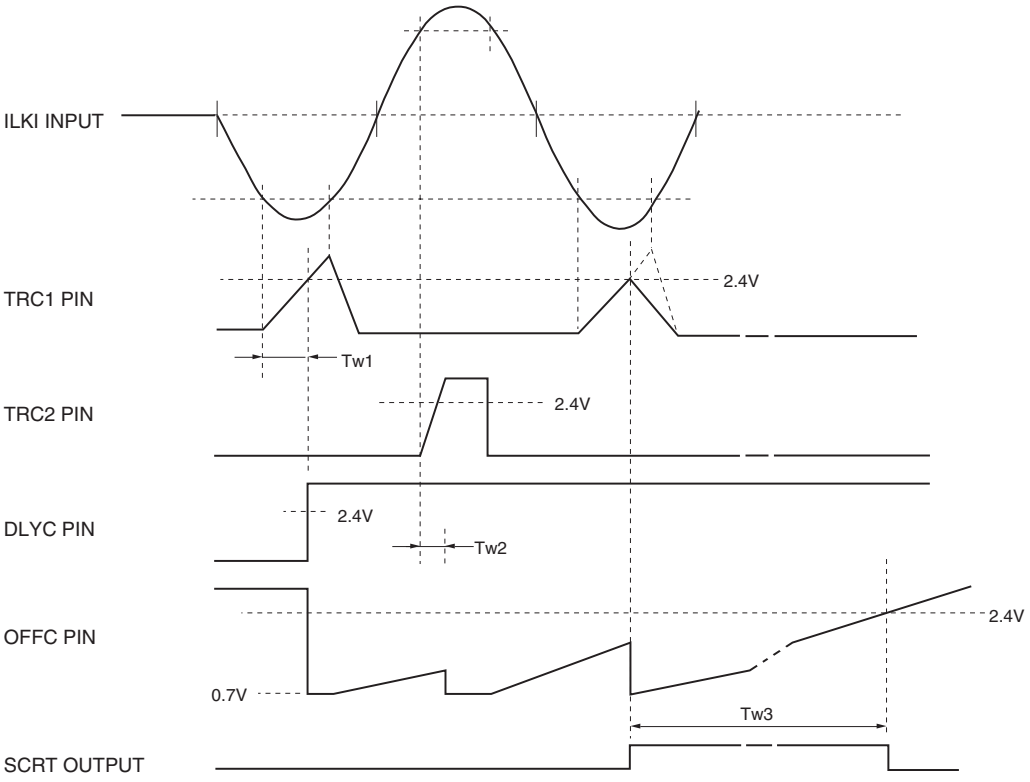
## Electrical Characteristics

(Unless otherwise noted, Ta = 25°C)

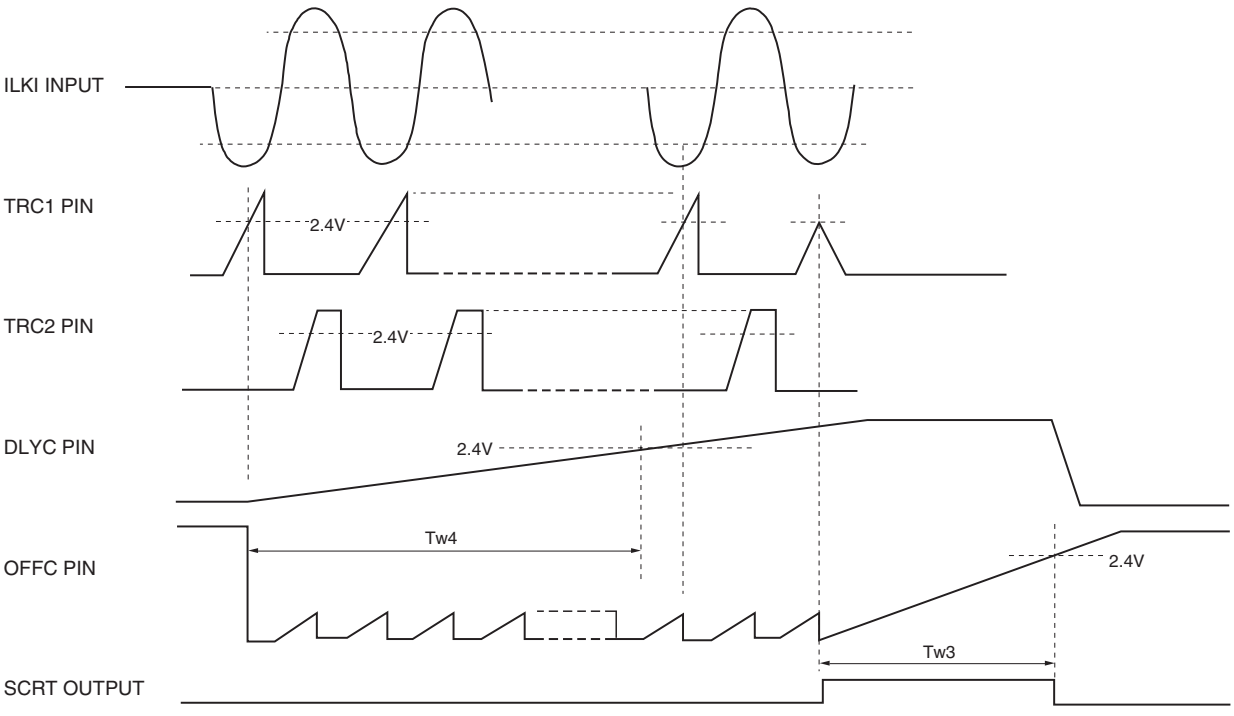
| Sym-bol | Quantity | | Measurement conditions | | | Ratings | | | Units |
|---|---|---|---|---|---|---|---|---|---|
| | | | Vs | | | Min. | Typ. | Max. | |
| $I_{s0}$ | Power supply circuit | Power supply current, during standby | 9 V | | | 520 | 610 | 700 | µA |
| $I_{s1}$ | | Power supply current, during leak detection | | | | 560 | 650 | 740 | µA |
| $I_{s2}$ | | Power supply current, immediately after SCR driving | | | | 480 | 570 | 660 | µA |
| — | | Is0 ambient temp. storage dependence | 9 V | Ta = –20 to 85°C | | — | –0.2 | — | %/°C |
| $V_{Smax.}$ | | Voltage at max. current | — | $I_S$ = 4 mA | | — | 13.9 | 15 | V |
| $V_{CC}$ | | VCC pin output voltage | 9 V | $I_{OH}$ = –1 mA | | — | 5.2 | — | V |
| $G_V$ | Op-amp | Voltage amplification | 9 V | f = 1 kHz | | — | 40 | — | dB |
| $B_W$ | | Frequency band | | –3 dB | | — | 6 | — | kHz |
| $V_O$ | | Maximum output voltage | | | | — | 3.5 | — | Vpp |
| $I_{SOURCE}$ | | OPAO pin "H" output current | | | | — | 2.8 | — | mA |
| $I_{SINK}$ | | OPAO pin "L" output current | | | | — | 0.8 | — | mA |
| $V_{OF}$ | | Output offset voltage | | | | — | 0 | — | mV |
| $I_{IB}$ | | Input bias current | | | | — | 125 | — | nA |
| $V_{IB}$ | | Differential input clamping voltage | | Iidc = ±4 mA | | — | ±0.8 | — | V |
| $V_{ION}$ | Leak-age detec-tion circuit | Leakage detection DC input voltage | 9 V | vs. VREF | | — | ±14 | — | mVdc |
| $I_{IH}$ | | ILK1 pin input bias current | | $V_{IN}$ = VREF | | — | 220 | — | nA |
| $V_{REF}$ | | VREF pin output voltage | | $I_{OH}$ = –200 µA | | — | 2.4 | — | V |
| $V_{CL}$ | | VREF-GND clamping voltage | | $I_{RCL}$ = 5 mA | | — | 4.7 | — | V |
| $E_{IOH1}$ | 3 ms circuit | TRC1 pin "H" output current precision | 9 V | $V_O$ = 0; $I_{OH}$ = –7.6 µA | | –10 | — | 10 | % |
| $V_{TH1}$ | | TRC1 pin threshold voltage | | | | — | 2.4 | — | V |
| $E_{TW1}$ | | Tw1 pulse width precision | | $C_1$ = 0.01 µF; $T_{W1}$ = 3 ms | | –15 | — | 15 | % |
| — | | Tw1 ambient temperature dependence | | Ta = –20 to 85°C | | — | 0 | — | %/°C |
| $E_{IOH2}$ | 1 ms circuit | TRC2 pin "H" output current precision | 9 V | $V_O$ = 0; $I_{OH}$ = –7.6 µA | | –10 | — | 10 | % |
| $V_{TH2}$ | | TRC2 pin threshold voltage | | | | — | 2.4 | — | V |
| $E_{TW2}$ | | Tw2 pulse width precision | | $C_2$ = 0.0047 µF; $T_{W2}$ = 1.5 ms | | –15 | — | 15 | % |
| — | | Tw2 ambient temperature dependence | | Ta = –20 to 85°C | | — | 0 | — | %/°C |
| $E_{IOH3}$ | Reset circuit | OFFC pin "H" output current precision | 9 V | $V_O$ = 0; $I_{OH}$ = –7.6 µA | | –10 | — | 10 | % |
| $V_{TH3}$ | | OFFC threshold voltage | | | | — | 2.4 | | V |
| $E_{TW3}$ | | Reset timer pulse width precision | 9 V | $C_3$ = 0.33 µF; $T_{W2}$ = 75 ms | | –30 | — | 30 | % |
| $E_{IOH4}$ | Time delay circuit | DLYC pin "H" output current precision | 9 V | $V_O$ = 0; $I_{OH}$ = –7.6 µA | | –10 | — | 10 | % |
| $V_{TH4}$ | | DLYC threshold voltage | | | | — | 2.4 | | V |
| $E_{TW4}$ | | Time delay timer pulse width precision | 9 V | $C_4$ = 1.0 µF; $T_{W2}$ = 300 ms | | –30 | — | 30 | % |
| $V_{OL8}$ | SCR driver circuit | SCRT pin "L" output voltage | 9 V | $I_{OL}$ = 200 µA | | — | 0.1 | 0.2 | V |
| $I_{OHc}$ | | SCRT pin "H" output current | 9 V | $V_O$ = 0.8 V | Ta = –20°C | –100 | –160 | — | µA |
| $I_{OHn}$ | | | | | Ta = 25°C | –50 | –130 | — | µA |
| $I_{OHh}$ | | | | | Ta = 85°C | –30 | –100 | — | µA |
| Vsoff | | IOH hold power supply voltage | — | | | — | 3.0 | 4.0 | V |
| $V_T$ | Over-all trip | Overall leak detection AC voltage | 9 V | 60 Hz | | — | 11.5 | — | mVrms |
| — | | VT ambient temperature dependence | | Ta = +25 to 80°C | | — | –8.0 | — | %/°C |
| | | | | Ta = +25 to –20°C | | — | +2.0 | — | |

## Timing Charts

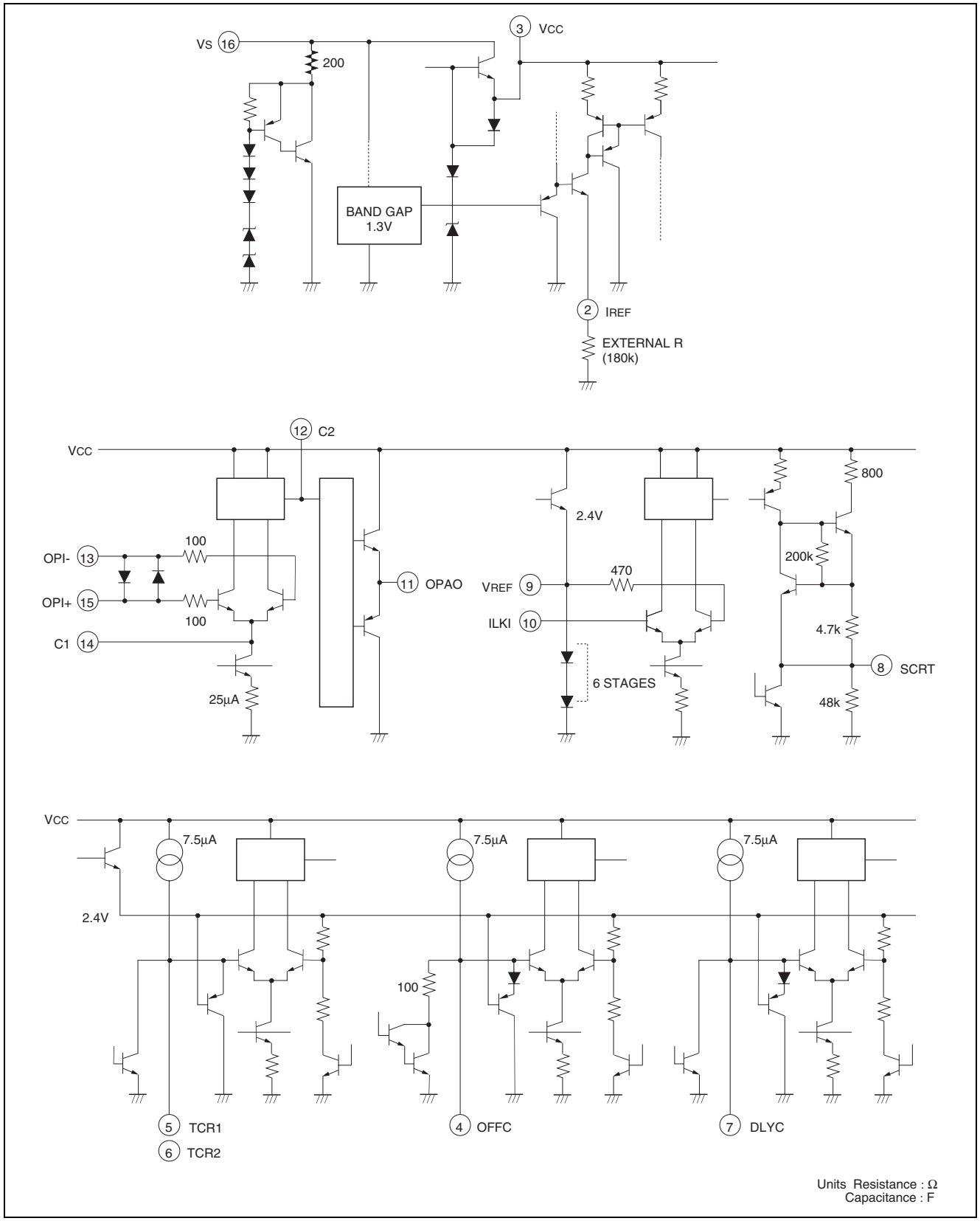
### WITHOUT DELAY FUNCTION




### USING DELAY FUNCTION



## Input/Output Equivalent Circuit



## Precaution for Application

Described below are precautions on usage of the M54134FP and the M54134GP. Note that each precaution presents a still better example. It is advisable to review it carefully to learn optimal conditions.

### 1. Voltage applied to $V_S$

(1) Fig.1 shows characteristics of circuit current $I_S$. ($I_S$ characterizes clamp circuit shown in INPUT/OUTPUT equivalent circuits.) To design power supply, adapt it to IC, considering $I_S$ characteristics.
(2) Rectification for use of commercial AC line as power source.

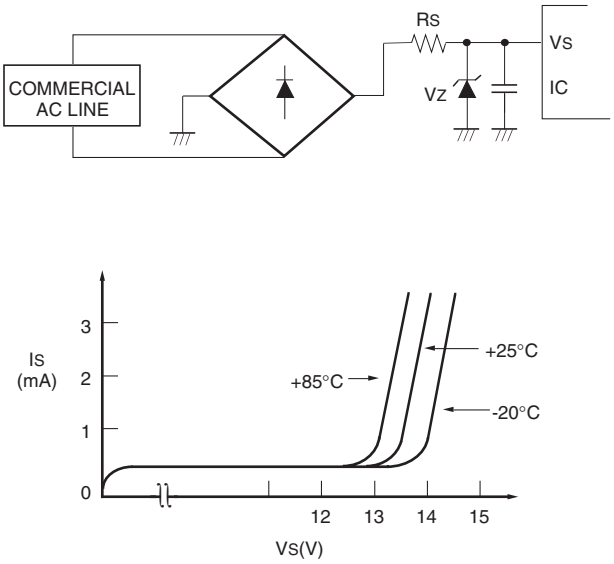



**Fig. 1 CHARACTERISTICS OF Vs TO Is**

a) For $V_Z$, select zener diode of 12V or less. (Prevent supply voltage $V_S$ from exceeding absolute maximum rating of 15V.)
b) Escalated temperature may decrease supply voltage to produce large current $I_S$. In this case, $R_S$ limits $I_S$.

(3)For use of common DC power supply, set supply voltage $V_S$ within range of 7 to 12V.

### 2. Resistor (R = 180kΩ) at $I_{REF}$ pin

This resistor provides constant-reference-current source for IC. (Constant current source protects IC against fluctuations in supply voltage and ambient temperature.)

Since every circuit is characterized by resistance of this resistor, the use of high-precision resistor (accuracy of ±2%) is recommended.

### 3. Laying out printed-circuit board

Foreign noise (from noise simulator, for example) may cause malfunctions.

To improve noise resistance, lay out printed-circuit patterns so that wirings of IC to additional capacitors and resistors can be made as short as possible.

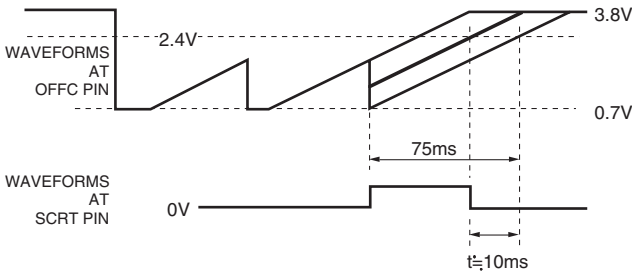
Carefully design patterns especially for wiring capacitors to $V_S$ of [16] pin , $V_{CC}$ of [3] pin , and SCRT of [8] pin.

### 4. Avoid SCRT output pin voltage from falling negative below GND level.

### 5. Reset time applicable to reset timer circuit

The M54134 has reset timer circuit of $V_L$=0.7V, $V_H$=2.4V, and $I_O$=7.5µA. When SCR is on, power supply path is disconnected from leak detector circuit. As shown in illustration below, disconnection may inhibit $V_L$ from falling to 0.7V. Accordingly, reset time may get shortened. To avoid shortage, predetermine a reset time that includes extra time.

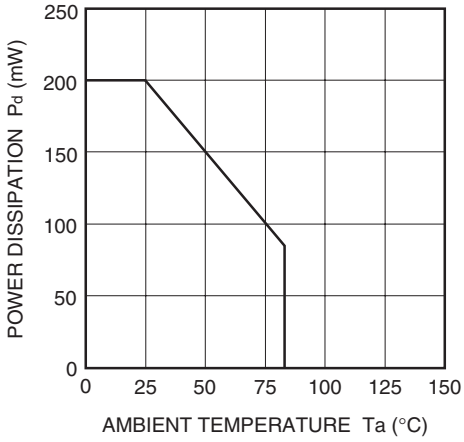
$$T = \frac{C_X(V_H - V_L)}{I_O} = \frac{0.33\mu F \times (2.4 - 0.7)}{7.5\mu A} \fallingdotseq 75ms$$



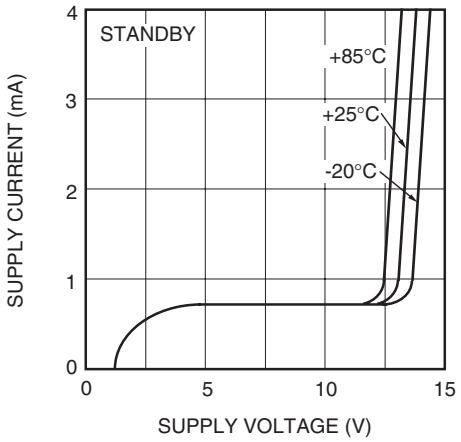

Note. Predetermined reset time may get shortened by t.

## Typical Characteristics

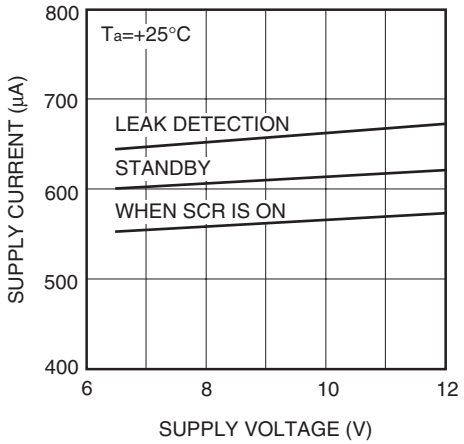
THERMAL DERATING
(MAXIMUM RATING)



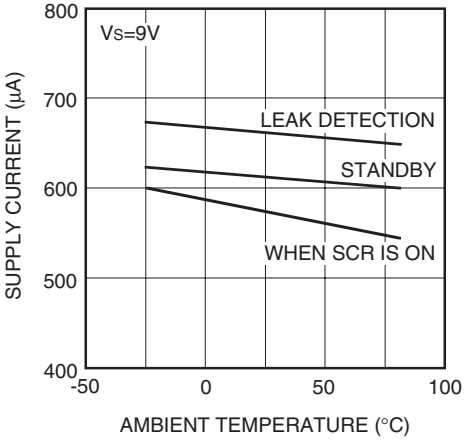

SUPPLY CURRENT VS. SUPPLY VOLTAGE
CHARACTERISTICS



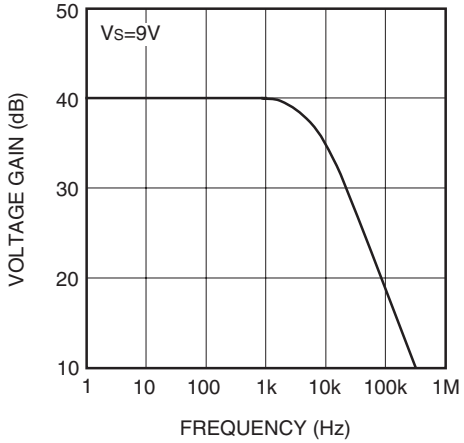

SUPPLY CURRENT VS. SUPPLY VOLTAGE
CHARACTERISTICS



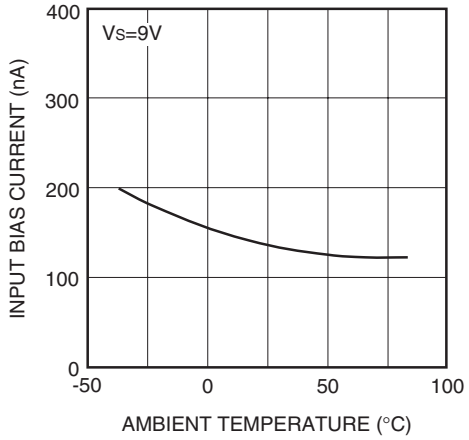

SUPPLY CURRENT VS. AMBIENT TEMPERATURE
CHARACTERISTICS



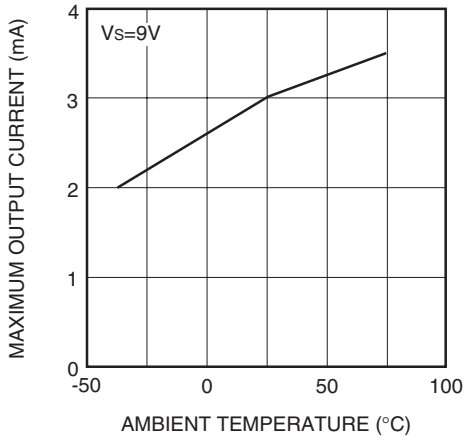

VOLTAGE GAIN VS. FREQUENCY
CHARACTERISTICS



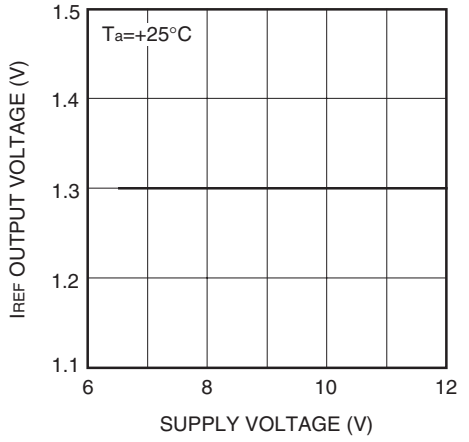
**OPERATIONAL AMPLIFIER INPUT CURRENT BIAS VS. AMBIENT TEMPERATURE CHARACTERISTICS**



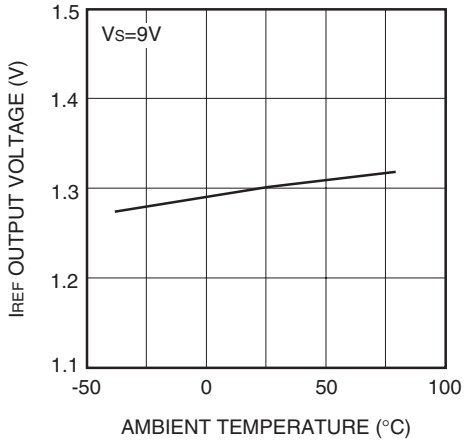

**MAXIMUM OPERATIONAL AMPLIFIER OUTPUT CURRENT VS. AMBIENT TEMPERATURE CHARACTERISTICS**



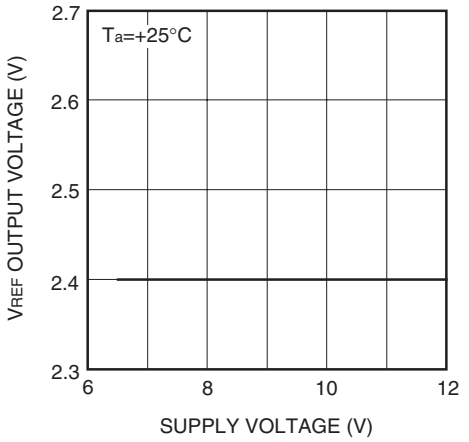

**IREF OUTPUT VOLTAGE VS. SUPPLY VOLTAGE CHARACTERISTICS**



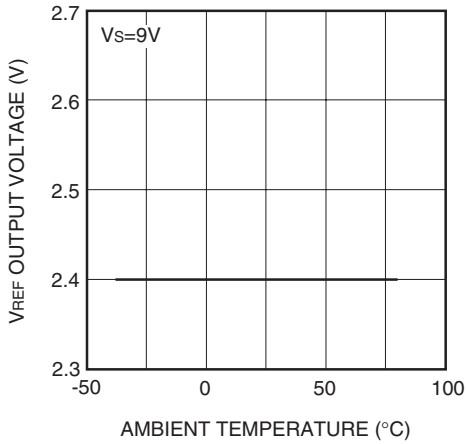

**IREF OUTPUT VOLTAGE VS. AMBIENT TEMPERATURE CHARACTERISTICS**



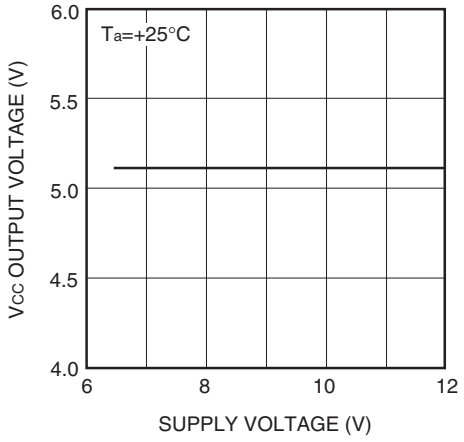

**VREF OUTPUT VOLTAGE VS. SUPPLY VOLTAGE CHARACTERISTICS**



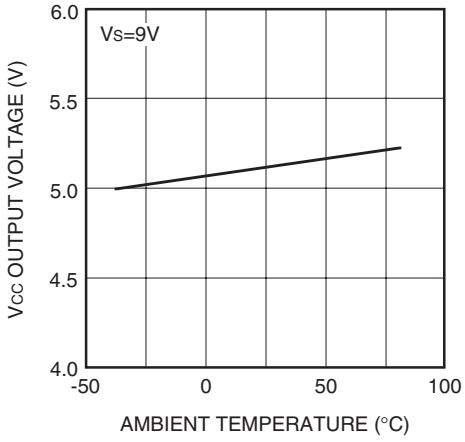

**VREF OUTPUT VOLTAGE VS. AMBIENT TEMPERATURE CHARACTERISTICS**



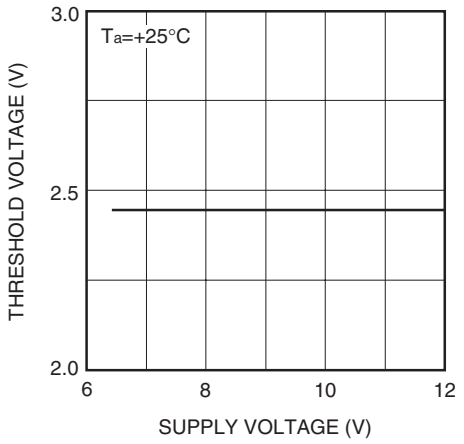
**Vcc OUTPUT VOLTAGE VS. SUPPLY VOLTAGE CHARACTERISTICS**



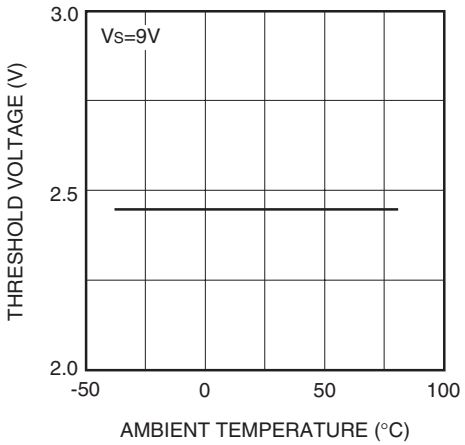

**Vcc OUTPUT VOLTAGE VS. AMBIENT TEMPERATURE CHARACTERISTICS**



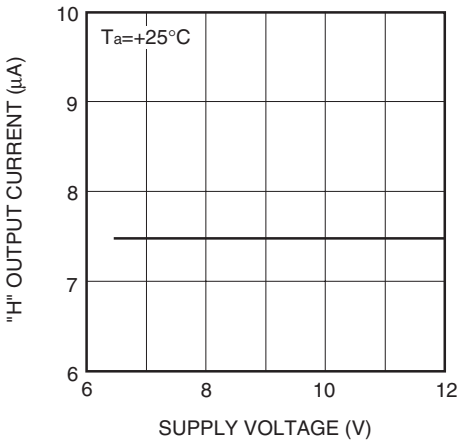

**TRC1/TRC2/OFFC/DLYC THRESHOLD VOLTAGE VS. SUPPLY VOLTAGE CHARACTERISTICS**



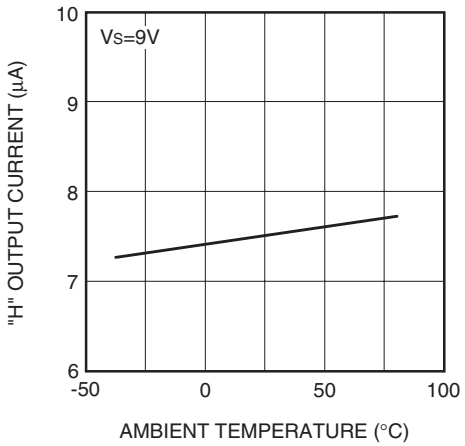

**TRC1/TRC2/OFFC/DLYC THRESHOLD VOLTAGE VS. AMBIENT TEMPERATURE CHARACTERISTICS**



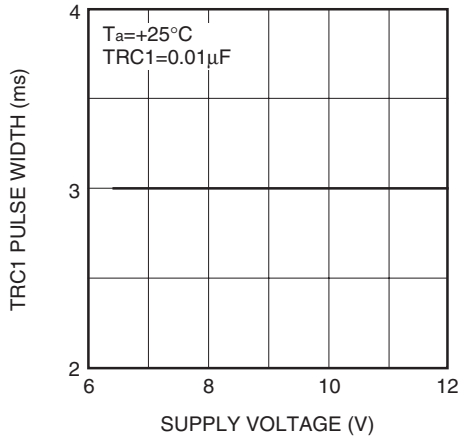

**TRC1/TRC2/OFFC/DLYC "H" OUTPUT CURRENT VS. SUPPLY VOLTAGE CHARACTERISTICS**



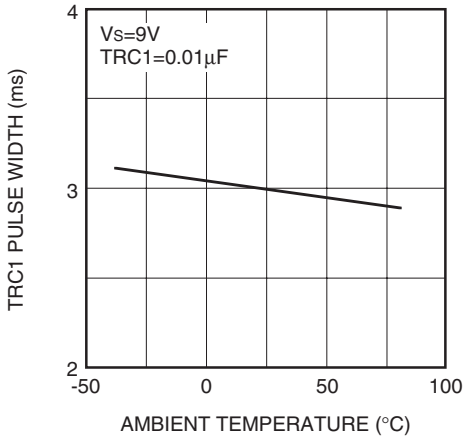

**TRC1/TRC2/OFFC/DLYC "H" OUTPUT CURRENT VS. AMBIENT TEMPERATURE CHARACTERISTICS**



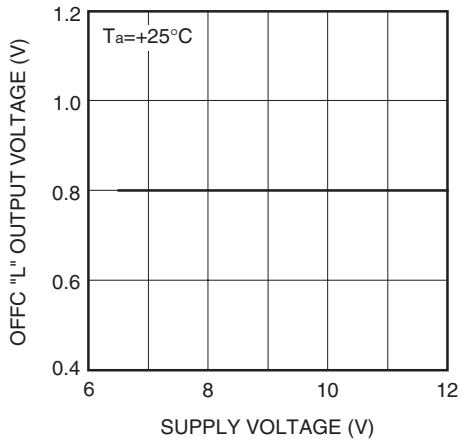
**TRC1 PULSE WIDTH VS. SUPPLY VOLTAGE CHARACTERISTICS**



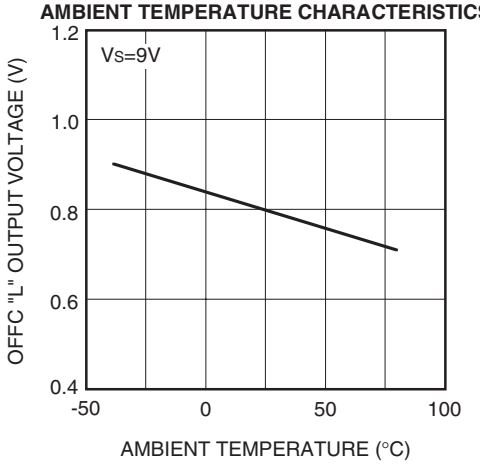

**TRC1 PULSE WIDTH VS. AMBIENT TEMPERATURE CHARACTERISTICS**



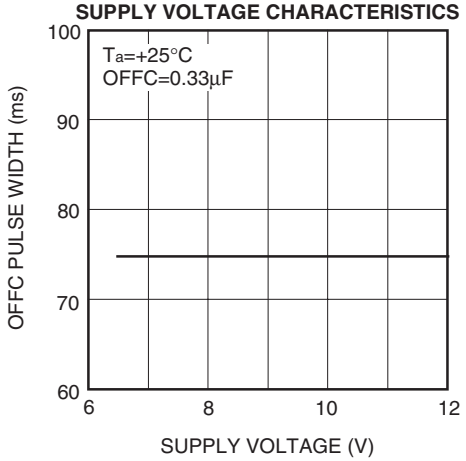

**OFFC "L" OUTPUT VOLTAGE VS. SUPPLY VOLTAGE CHARACTERISTICS**



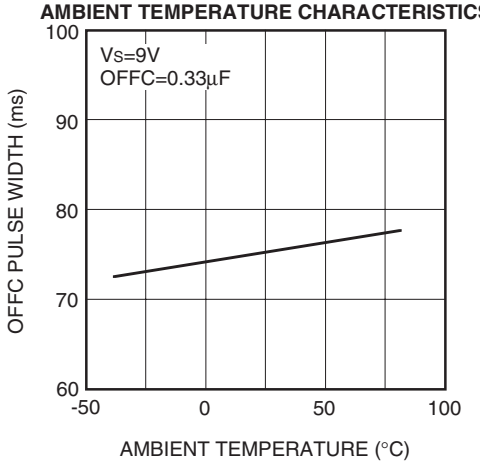

**OFFC "L" OUTPUT VOLTAGE VS. AMBIENT TEMPERATURE CHARACTERISTICS**



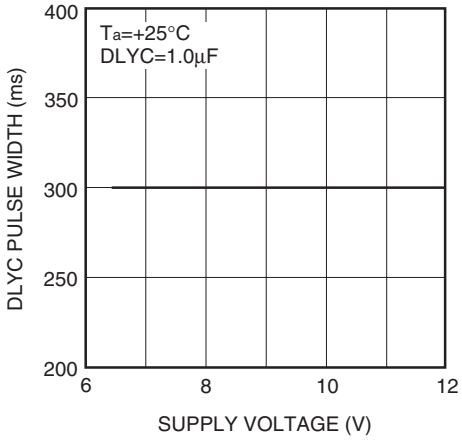

**OFFC PULSE WIDTH VS. SUPPLY VOLTAGE CHARACTERISTICS**



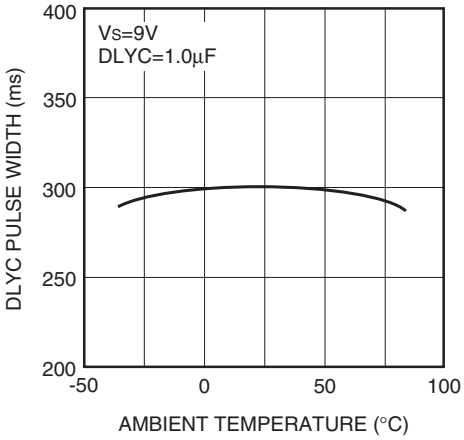

**OFFC PULSE WIDTH VS. AMBIENT TEMPERATURE CHARACTERISTICS**



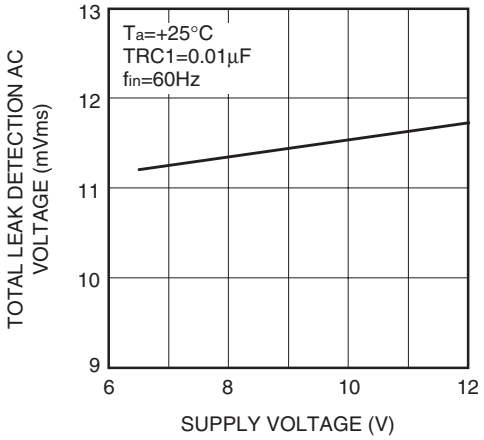
**DLYC PULSE WIDTH VS. SUPPLY VOLTAGE CHARACTERISTICS**



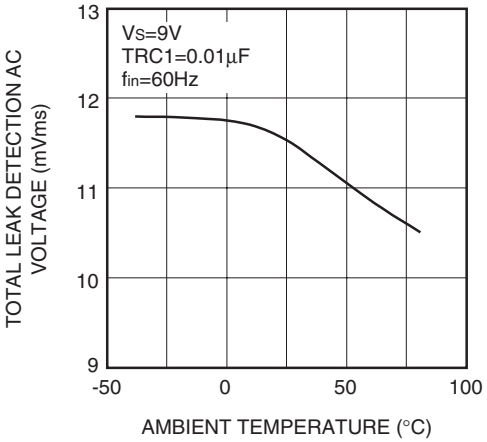

**DLYC PULSE WIDTH VS. AMBIENT TEMPERATURE CHARACTERISTICS**



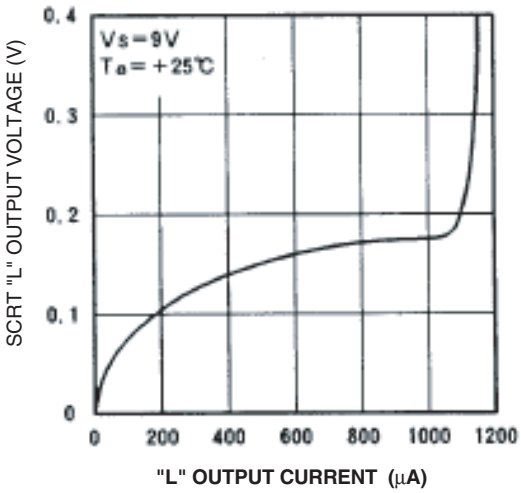

**TOTAL LEAK DETECTION AC VOLTAGE VS. SUPPLY VOLTAGE CHARACTERISTICS**



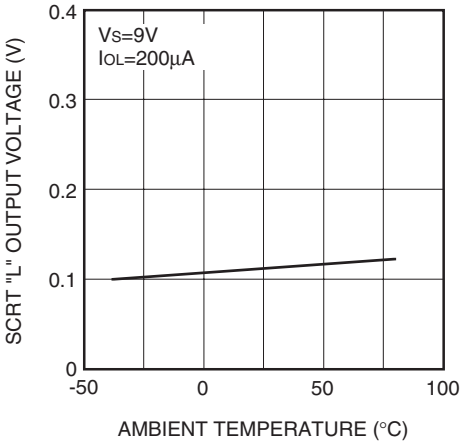

**TOTAL LEAK DETECTION AC VOLTAGE VS. AMBIENT TEMPERATURE CHARACTERISTICS**



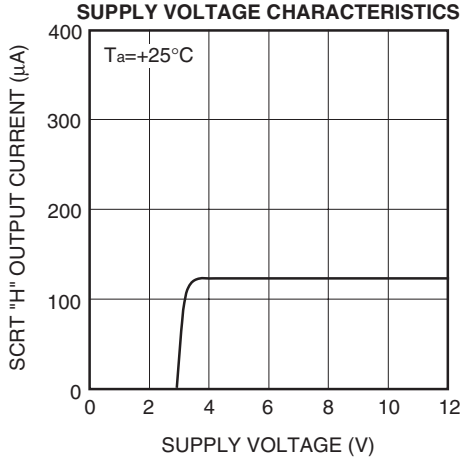

**SCRT "L" OUTPUT VOLTAGE VS. "L" OUTPUT CURRENT CHARACTERISTICS**



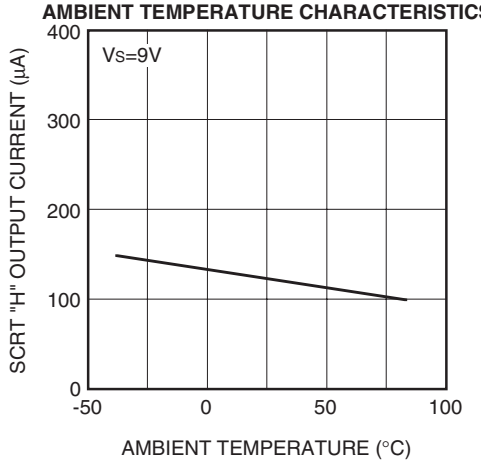

**SCRT "L" OUTPUT VOLTAGE VS. AMBIENT TEMPERATURE CHARACTERISTICS**



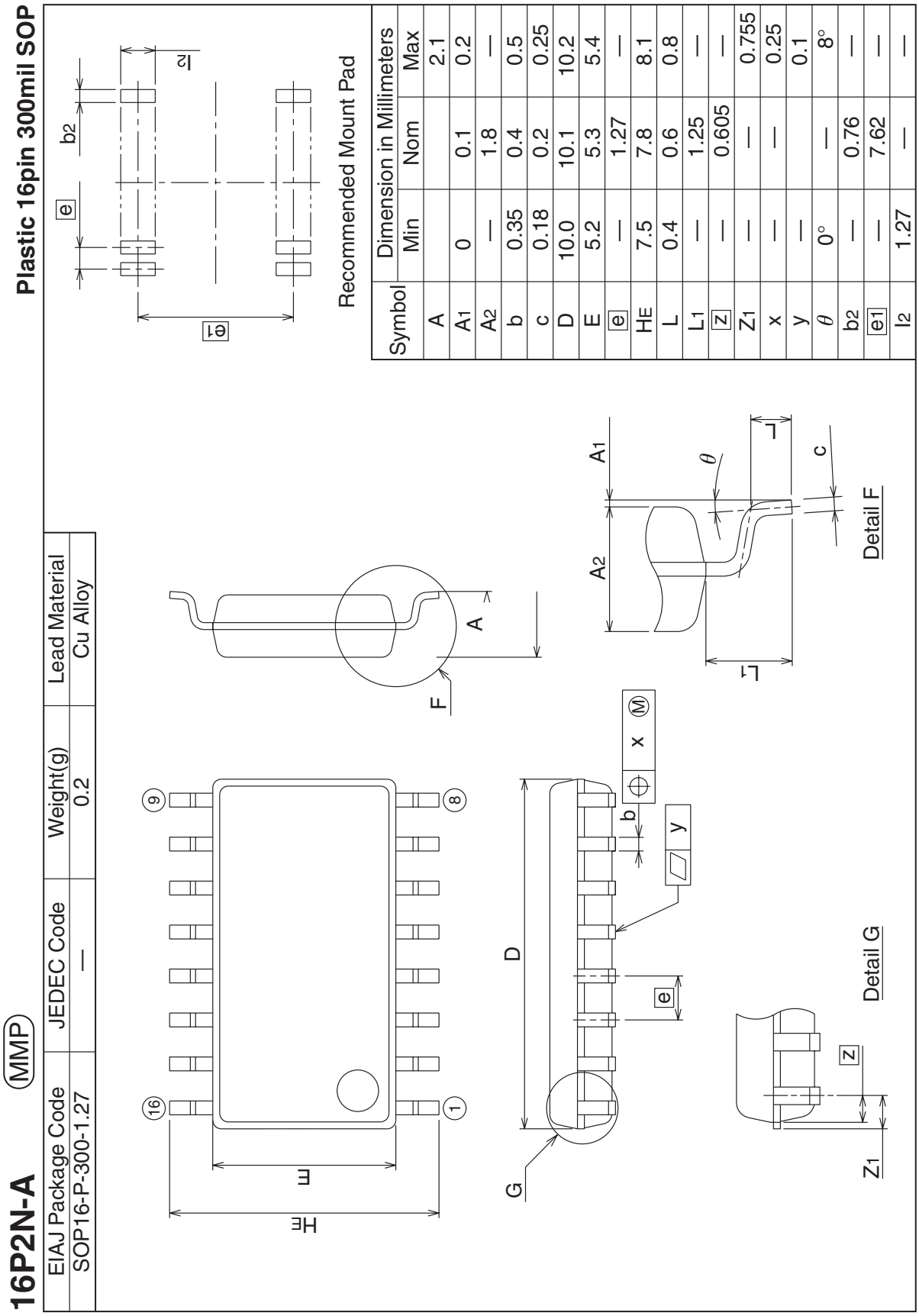
SCRT "H" OUTPUT CURRENT VS.
SUPPLY VOLTAGE CHARACTERISTICS




SCRT "H" OUTPUT CURRENT VS.
AMBIENT TEMPERATURE CHARACTERISTICS



## Package Dimensions

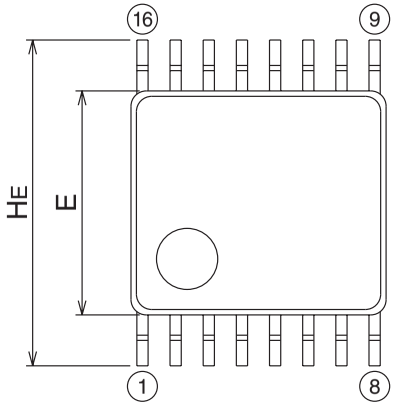


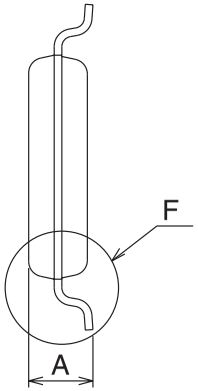

| Symbol | Dimension in Millimeters | | |
|---|---|---|---|
| | Min | Nom | Max |
| A | | | 2.1 |
| $A_1$ | 0 | 0.1 | 0.2 |
| $A_2$ | — | 1.8 | — |
| b | 0.35 | 0.4 | 0.5 |
| c | 0.18 | 0.2 | 0.25 |
| D | 10.0 | 10.1 | 10.2 |
| E | 5.2 | 5.3 | 5.4 |
| e | — | 1.27 | — |
| HE | 7.5 | 7.8 | 8.1 |
| L | 0.4 | 0.6 | 0.8 |
| $L_1$ | — | 1.25 | — |
| z | — | 0.605 | — |
| $Z_1$ | — | — | 0.755 |
| x | — | — | 0.25 |
| y | — | | 0.1 |
| θ | 0° | — | 8° |
| b2 | — | 0.76 | — |
| e1 | — | 7.62 | — |
| l2 | 1.27 | — | — |

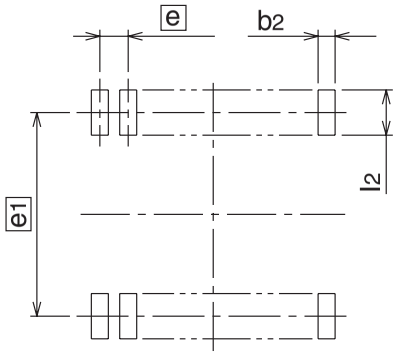
# 16P2E-A

## Plastic 16pin 225mil SSOP

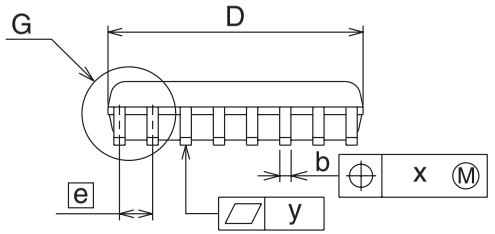
| EIAJ Package Code | JEDEC Code | Weight(g) | Lead Material |
|---|---|---|---|
| SSOP16-P-225-0.65 | — | 0.06 | Alloy 42 |

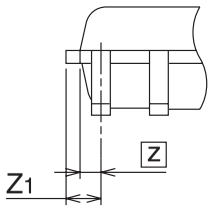


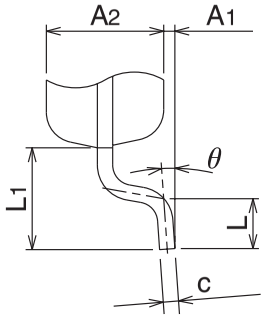




Recommended Mount Pad




Detail G




Detail F

| Symbol | Dimension in Millimeters | | |
|---|---|---|---|
| | Min | Nom | Max |
| A | — | — | 1.45 |
| $A_1$ | 0 | 0.1 | 0.2 |
| $A_2$ | — | 1.15 | — |
| b | 0.17 | 0.22 | 0.32 |
| c | 0.13 | 0.15 | 0.2 |
| D | 4.9 | 5.0 | 5.1 |
| E | 4.3 | 4.4 | 4.5 |
| e | — | 0.65 | — |
| $H_E$ | 6.2 | 6.4 | 6.6 |
| L | 0.3 | 0.5 | 0.7 |
| $L_1$ | | 1.0 | — |
| z | — | 0.225 | — |
| $Z_1$ | — | — | 0.375 |
| x | — | — | 0.13 |
| y | — | — | 0.1 |
| θ | 0° | — | 10° |
| $b_2$ | — | 0.35 | |
| $e_1$ | — | 5.8 | — |
| $l_2$ | 1.0 | — | — |

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