

# M54128L/FP

## EARTH LEAKAGE CURRENT DETECTOR

### DESCRIPTION

The M54128 is a semiconductor integrated circuit designed for high-speed type earth leakage breakers. This IC includes leakage and abnormal voltage detecting functions.

### FEATURES

- Improvement of ability against unwanted tripping due to lightning -surge.
  - Adopt the two times counting system.
  - Improvement of ability against needless action due to lightning-impulse.
- It is a possible that cope with IEC owing to mode change.
  - Adopt the 1.5 times counting system.
- High input impedance :
  - Filter circuit can be formed with externally attached C/R.
  - Improvement of ability against needless action due to high frequency and high harmonics.
- High input sensitivity :  $V_T = 6.5\text{mVrms}$
- Abnormal voltage detecting (neutral conductor open-phase protection) function :
  - Neutral conductor open-phase protection at single-phase three-wire system
  - In case of no use this function, stop this function and reduction of circuit current, possible.
- Low voltage operation : 7 to12V (conventional Mitsubishi ICs : 12 to 20V)
- Low current dissipation :
  - In stand-by condition :  $820\mu\text{A}$  typical ( $V_S = 9\text{V}$ ,  $T_a = 25^\circ\text{C}$ )
  - When SCR is ON :  $740\mu\text{A}$  typical ( $V_S = 9\text{V}$ ,  $T_a = 25^\circ\text{C}$ )
- Highly stable design : Employment of circuits of which characteristics fluctuations resulting from changes in supply voltage/ambient temperature are small.

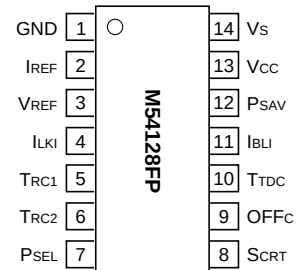
### APPLICATION

Earth leakage breaker

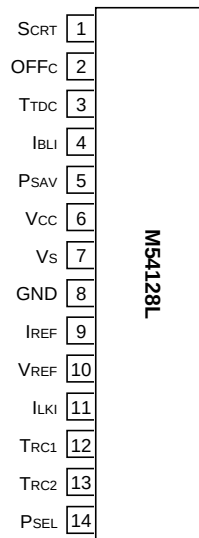
### RECOMMENDED OPERATING CONDITIONS

Supply voltage range .....7 to12V  
 Operating ambient temperature..... -20 to +85°C

### PIN CONFIGURATION (TOP VIEW)

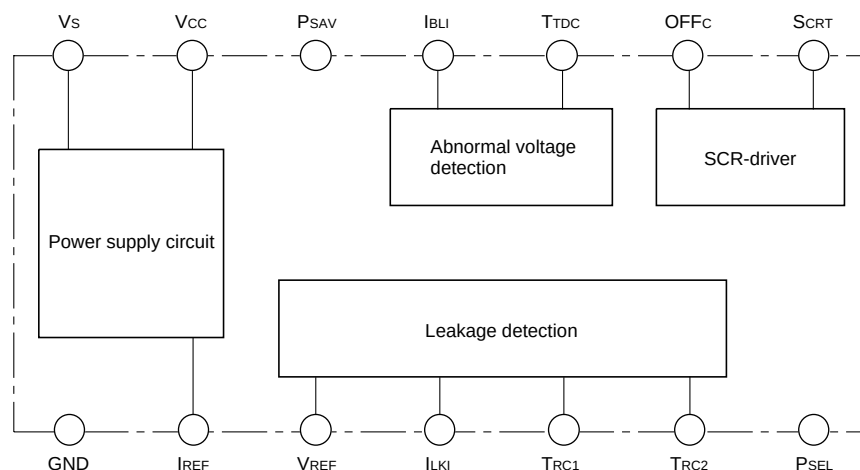


Outline 14P2N-A



Outline 14P5A

### BLOCK DIAGRAM



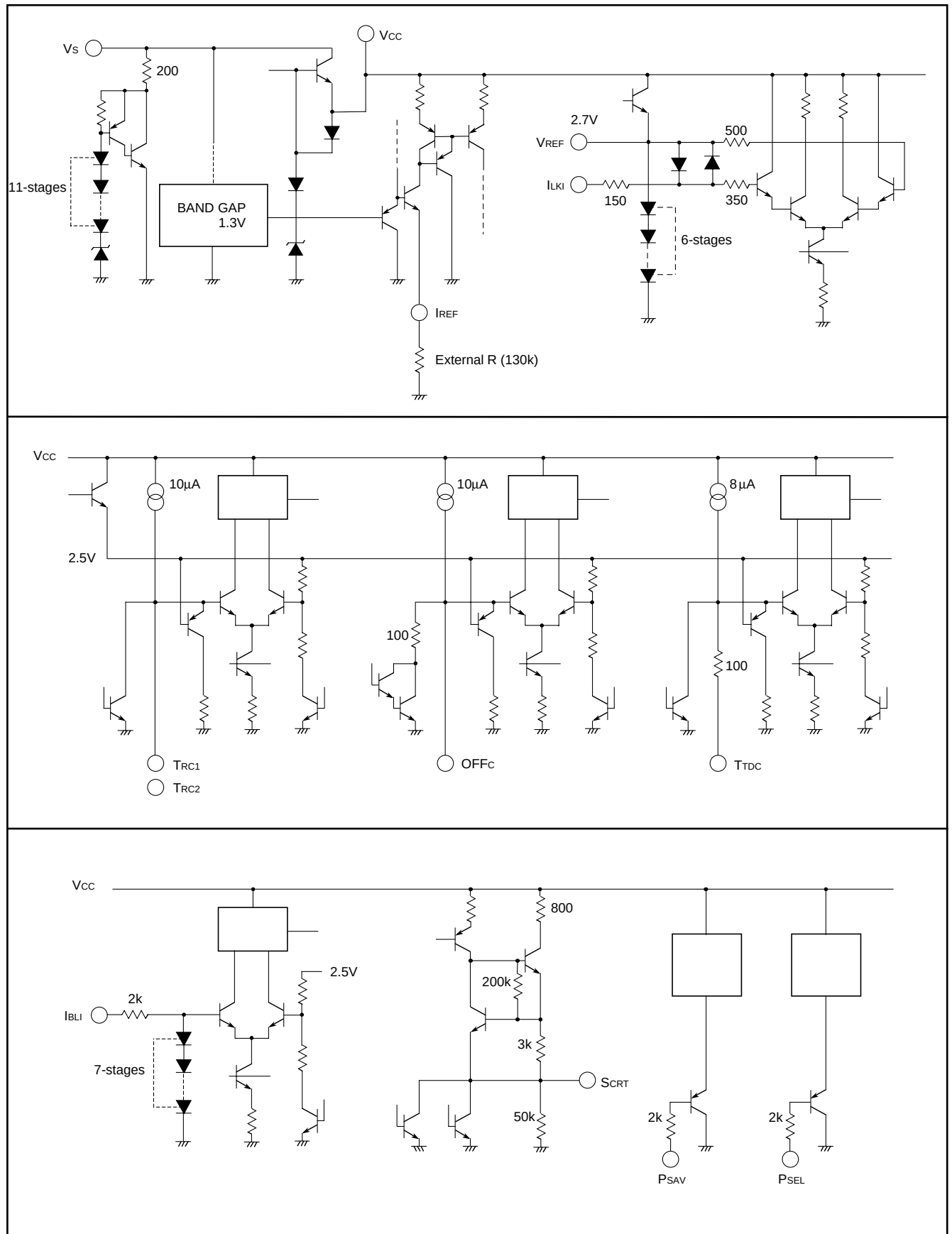
**M54128L/FP****EARTH LEAKAGE CURRENT DETECTOR****PIN FUNCTION DESCRIPTION**

| Pin No.                                                           |    | Pin name          | Function                                                                                                                                                                                                                                                                                                                      |
|-------------------------------------------------------------------|----|-------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| L                                                                 | FP |                   |                                                                                                                                                                                                                                                                                                                               |
| Common                                                            |    |                   |                                                                                                                                                                                                                                                                                                                               |
| ⑦                                                                 | ⑭  | V <sub>S</sub>    | Power supply                                                                                                                                                                                                                                                                                                                  |
| ⑥                                                                 | ⑬  | V <sub>CC</sub>   | Output pin of internal constant-voltage circuit. Connects to capacitor for decoupling.                                                                                                                                                                                                                                        |
| ⑨                                                                 | ②  | I <sub>REF</sub>  | Connects to resistor which sets constant current of each internal circuit. Approx. 1.3V.                                                                                                                                                                                                                                      |
| ⑧                                                                 | ①  | GND               | Grounding                                                                                                                                                                                                                                                                                                                     |
| ⑤                                                                 | ⑫  | P <sub>SAV</sub>  | When in normal use, connect the pin to V <sub>CC</sub> pin. When the abnormal voltage detection function is not in use, ground the pin. Circuit current can be reduced. Ground I <sub>BLI</sub> pin and T <sub>TDC</sub> pin also.                                                                                            |
| Leakage detection, abnormal voltage detection, SCR drive circuits |    |                   |                                                                                                                                                                                                                                                                                                                               |
| ⑩                                                                 | ③  | V <sub>REF</sub>  | Input reference level pin of the leakage detection circuit. Approx. 2.7V.                                                                                                                                                                                                                                                     |
| ⑪                                                                 | ④  | I <sub>LKI</sub>  | Another input pin of the leakage detection circuit.                                                                                                                                                                                                                                                                           |
| ⑫                                                                 | ⑤  | T <sub>RC1</sub>  | Connects to capacitor for integrating output signals of the leakage input signal level discriminator.                                                                                                                                                                                                                         |
| ⑬                                                                 | ⑥  | T <sub>RC2</sub>  | Connects to condenser for removing noise.                                                                                                                                                                                                                                                                                     |
| ⑭                                                                 | ⑦  | P <sub>SEL</sub>  | Logic function switching pin used when detecting leakage.<br>When the pin is grounded, S <sub>CR</sub> T operates with the logic flow of negative input → positive input → negative input.<br>when it is connected to V <sub>CC</sub> pin, S <sub>CR</sub> T operates with the logic flow of negative input → positive input. |
| ②                                                                 | ⑨  | OFF <sub>C</sub>  | This IC will be restored to the initial condition after the specified period if :<br>leakage input signal does not continue ; abnormal voltage input signal does not continue ; or<br>leakage/abnormal voltage is detected and SCR becomes ON.<br>The pin connects to capacitor for time settinng of this function.           |
| ④                                                                 | ⑪  | I <sub>BLI</sub>  | Input pin of the abnormal voltage detection circuit.                                                                                                                                                                                                                                                                          |
| ③                                                                 | ⑩  | T <sub>TDC</sub>  | Connects to capacitor for time setting of the abnormal voltage detection circuit.                                                                                                                                                                                                                                             |
| ①                                                                 | ⑧  | S <sub>CR</sub> T | Output pin for drive a SCR.                                                                                                                                                                                                                                                                                                   |

# M54128L/FP

## EARTH LEAKAGE CURRENT DETECTOR

### I/O EQUIVALENT CIRCUIT



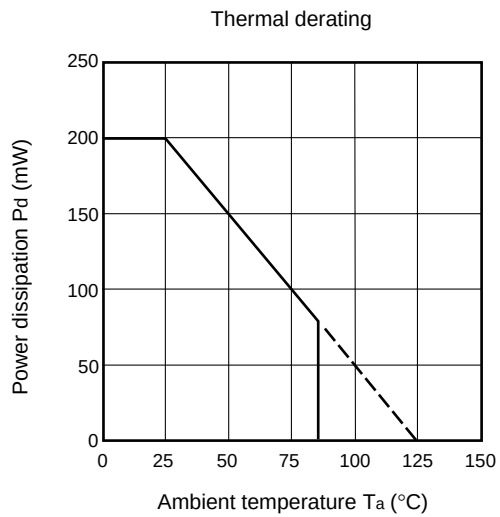
# M54128L/FP

## EARTH LEAKAGE CURRENT DETECTOR

### ABSOLUTE MAXIMUM RATINGS (Ta = 25°C, unless otherwise noted)

| Symbol          | Parameter             | Conditions  | Ratings      | Unit |
|-----------------|-----------------------|-------------|--------------|------|
| Is              | Source current        |             | 4            | mA   |
| Vs MAX          | Max. supply voltage   |             | 15           | V    |
| $\Delta V_{IL}$ | Input voltage         | ILKI - VREF | -1.4 to +1.4 | V    |
| IIL             | Input current         | ILKI - VREF | -5 to +5     | mA   |
| IIG             | Input current         | VREF - GND  | 10           | mA   |
| VIBL            | Input voltage         | IBLI - GND  | -0.3 to +4.0 | V    |
| IBL             | Input current         | IBLI - GND  | 4            | mA   |
| Pd              | Power dissipation     |             | 200          | mW   |
| Topr            | Operating temperature |             | -20 to 85    | °C   |
| Tstg            | Storage temperature   |             | -55 to 125   | °C   |

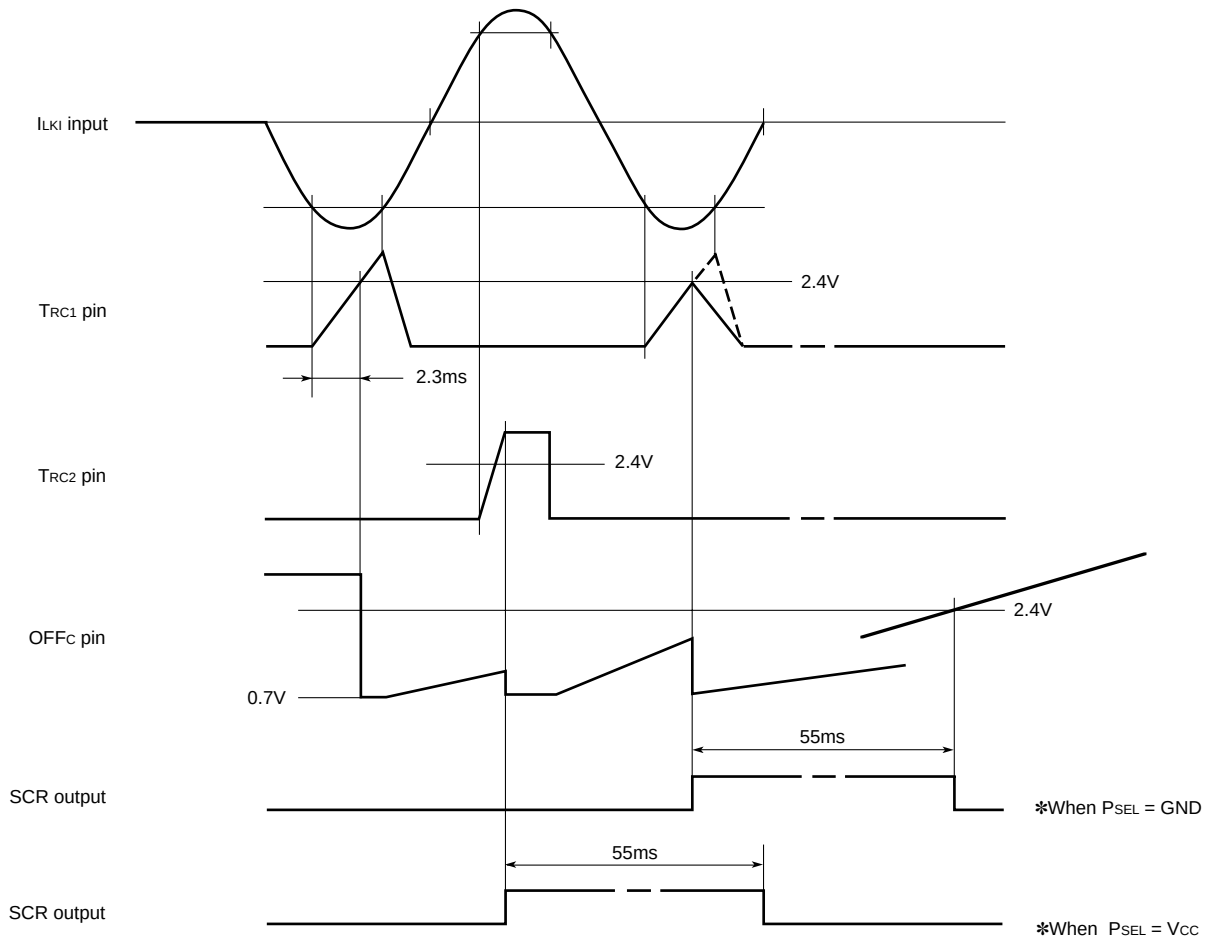
### TYPICAL CHARACTERISTICS



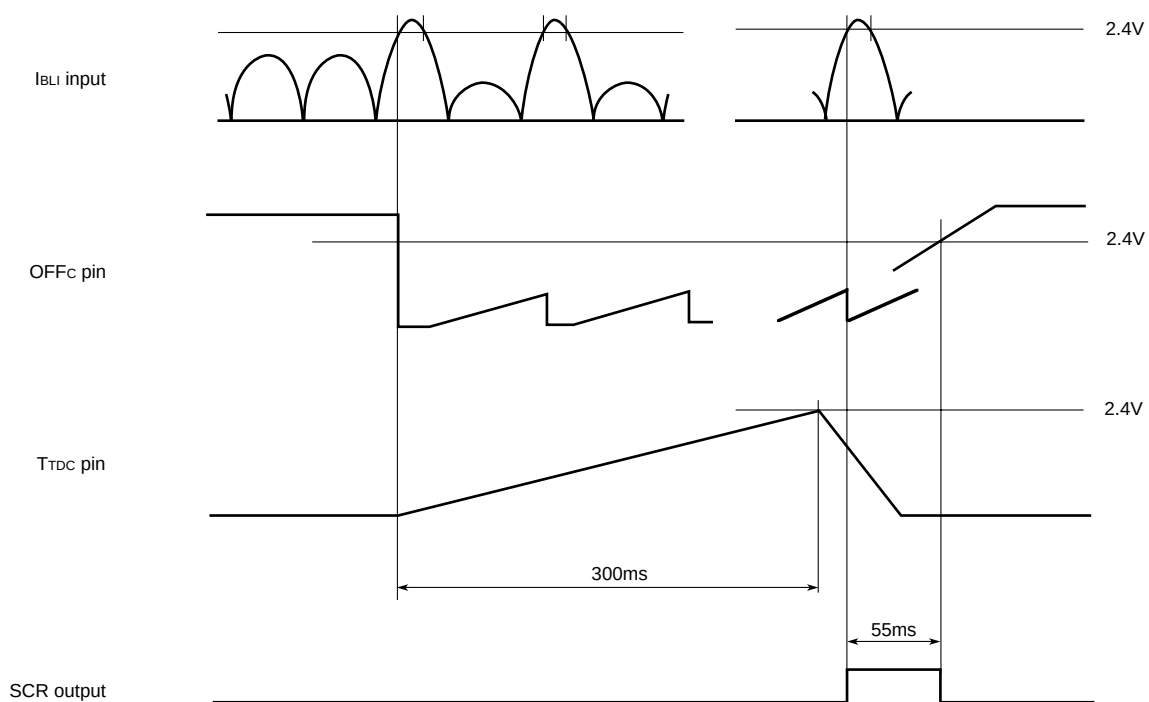
**ELECTRICAL CHARACTERISTICS** (Ta = 25°C, unless otherwise noted)

| Symbol | Parameter                          |                                                  | Vs                                     | Test conditions                   | Limits           |       |       | Unit   |      |
|--------|------------------------------------|--------------------------------------------------|----------------------------------------|-----------------------------------|------------------|-------|-------|--------|------|
|        |                                    |                                                  |                                        |                                   | Min.             | Typ.  | Max.  |        |      |
| Is0    | Power supply circuit               | Source current: In stand-by condition            | 9V                                     | PSAV = VCC                        | 570              | 820   | 950   | μA     |      |
| Is1    |                                    | Source current: While detecting leakage          |                                        |                                   | 570              | 840   | 950   | μA     |      |
| Is2    |                                    | Source current: While detecting abnormal voltage |                                        |                                   | 570              | 810   | 950   | μA     |      |
| Is3    |                                    | Source current: Immediately after driving of SCR |                                        |                                   | 520              | 740   | 870   | μA     |      |
| Is0'   |                                    | Source current: In stand-by condition            | 9V                                     | PSAV = GND                        | 520              | 740   | 870   | μA     |      |
| Is1'   |                                    | Source current: While detecting leakage          |                                        |                                   | 520              | 760   | 870   | μA     |      |
| Is3'   |                                    | Source current: Immediately after driving of SCR |                                        |                                   | 520              | 740   | 870   | μA     |      |
| —      |                                    |                                                  | Iso variation with ambient temperature | 9V                                | Ta = -20 to 85°C | —     | -0.07 | —      | %/°C |
| VS max |                                    |                                                  | Maximum current voltage                | —                                 | Is = 4mA         | —     | 13.9  | 15     | V    |
| Vion   | Leakage detection circuit          | Leakage detecting DC input voltage               | 9V                                     | ILKI -VREF                        | —                | ±7.5  | —     | mVdc   |      |
| IiH    |                                    | ILKI pin input bias current                      |                                        | VIN = VREF                        | —                | 2     | 15    | nA     |      |
| Vo     |                                    | VREF pin output voltage                          |                                        | —                                 | 2.7              | —     | V     |        |      |
| VILKI  |                                    | ILKI-VREF input clamp voltage                    |                                        | —                                 | ±1.2             | —     | V     |        |      |
| VRCL   |                                    | VREF-GND clamp voltage                           |                                        | IRCL = 5mA                        | —                | 4.6   | —     | V      |      |
| EIOH   | 2ms circuit                        | TRC1 pin “H” output current precision            | 9V                                     | Vo = 0V : IOH = -10.4μA           | -20              | —     | 20    | %      |      |
| VTH    |                                    | TRC1 threshold voltage                           |                                        | —                                 | 2.4              | —     | V     |        |      |
| ETw1   |                                    | Tw1 pulse width precision                        |                                        | C = 0.01μF : Tw1 = 2.3ms          | -15              | —     | 15    | %      |      |
| —      |                                    | Tw1 variation with ambient temperature           |                                        | Ta = -20 to 85°C                  | —                | -0.06 | —     | %/°C   |      |
| EIOH   | 1ms circuit                        | TRC2 pin “H” output current precision            | 9V                                     | Vo = 0V : IOH = -10.4μA           | -20              | —     | 20    | %      |      |
| VTH    |                                    | TRC2 threshold voltage                           |                                        | —                                 | 2.4              | —     | V     |        |      |
| ETw2   |                                    | Tw2 pulse width precision                        |                                        | C = 0.0047μF : Tw2 = 1.1ms        | -15              | —     | 15    | %      |      |
| —      |                                    | Tw2 variation with ambient temperature           |                                        | Ta = -20 to 85°C                  | —                | -0.06 | —     | %/°C   |      |
| Vt     |                                    | Total leakage detecting AC voltage               | 9V                                     | 60Hz                              | —                | 6.5   | —     | mVrms  |      |
| —      |                                    | Vt variation with ambient temperature            | 9V                                     | Ta = 25 → 85°C<br>Ta = 25 → -20°C | —                | -4.0  | —     | %<br>% |      |
| VBLT   | Abnormal voltage detecting circuit | Abnormal voltage detecting voltage               | 9V                                     |                                   | 2.2              | 2.4   | 2.6   | V      |      |
| —      |                                    | VBLT variation with supply voltage               | —                                      |                                   | —                | 0.01  | —     | %/V    |      |
| —      |                                    | VBLT variation with ambient temperature          |                                        | Ta = -20 to 85°C                  | —                | 0.06  | —     | %/°C   |      |
| IIBLT  |                                    | IBLI pin input bias current                      | 9V                                     | VIN = VREF                        | —                | 120   | 300   | nA     |      |
| VIBLC  |                                    | IBLI-GND clamp voltage                           |                                        | IIN = 1mA                         | —                | 7.2   | —     | V      |      |
| EIOH   |                                    | TTDC pin “H” output current precision            | 9V                                     | Vo = 0V : IOH = -8μA              | -20              | —     | 20    | %      |      |
| VTH    |                                    | TTDC threshold voltage                           |                                        | —                                 | 2.4              | —     | V     |        |      |
| ETw4   |                                    | Delay time pulse width precision                 |                                        | C = 1.0μF : Tw4 = 300ms           | -30              | —     | 30    | %      |      |
| EIOH   | Reset circuit                      | OFFC pin “H” output current precision            | 9V                                     | Vo = 0V : IOH = -10μA             | -20              | —     | 20    | %      |      |
| VTH    |                                    | OFFC threshold voltage                           |                                        | —                                 | 2.4              | —     | V     |        |      |
| ETw3   |                                    | Reset timer pulse width precision                | 9V                                     | C = 0.33μF : Tw3 = 55ms           | -30              | —     | 30    | %      |      |
| Vol8   | SCR drive circuit                  | SCRT pin “L” output voltage                      | 9V                                     | IOL = 200μA                       | —                | 0.1   | 0.2   | V      |      |
| IOHc   |                                    | SCRT pin “H” output current                      | 9V                                     | Vo = 0.8V                         | Ta = -20°C       | -200  | -260  | —      | μA   |
| IOHn   |                                    |                                                  |                                        |                                   | Ta = 25°C        | -100  | -220  | —      | μA   |
| IOHh   |                                    |                                                  |                                        |                                   | Ta = 85°C        | -70   | -180  | —      | μA   |
| Vsoff  |                                    | IOH holding supply voltage                       | —                                      |                                   | —                | 3.0   | 4.5   | V      |      |

### EARTH LEAKAGE DETECTION



### ABNORMAL VOLTAGE DETECTION

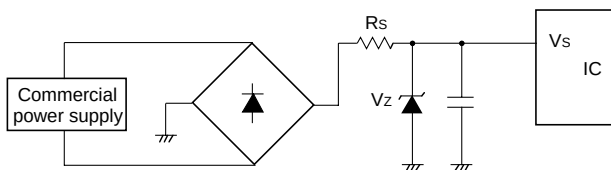


## PRECAUTIONS FOR APPLICATION

Note that the improvement examples in the following precautions for application of M54128FP/L are merely examples.

### 1. VS applied voltage

- (1) Is circuit current (clamp circuit characteristics of the equivalent circuit) is as shown in TYPICAL CHARACTERISTICS figure 1 on page 9. Attention should be given to the circuit current when designing the power supply circuit.



- (2) Use of the IC by rectifying commercial power supply
  - a) As Vz, be sure to use zener diode of 12V or less (not exceeding the absolute maximum rating of 15V).
  - b) At high temperatures, clamp voltage decreases and Is increases. Increase of Is will be restricted at Rs, however.
- (3) If normal DC power supply is used, use the IC at Vs=7to10V.

### 2. Resistor of IREF pin (R = 130kΩ)

Reference constant current source of the IC (for restraining fluctuations in supply voltage characteristics and ambient temperature characteristics). Since this resistor determines the characteristics of each circuit, use of high-precision resistor ( $\pm 2\%$ ) is recommended.

### 3. Layout of printed circuit board

External noise (noise simulator etc.) may cause faulty operation of the IC.

To improve the noise immunity, layout the printed circuit board so that the wiring of the external C and R is made as short as possible.

Special attention should be given to the wiring of the condensers connected to Vs, Vcc and SCRT pins.

### 4. Be careful that the voltage of SCRT output pin does not become lower than the GND level.

### 5. Change in sensitivity due to insulation deterioration

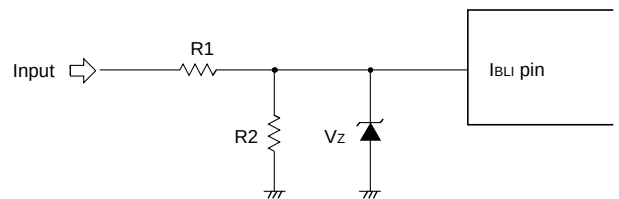
If the insulation of ZCT input pin from the high voltage part might deteriorate, improvement might be expected by connecting a resistor of about  $R=100k\Omega$  between VREF pin and GND.

It should be noted that the circuit current will increase at  $I \approx 2.7V/R$  (approx.).

### 6. Clamp diode of IBLI input pin

As shown in the equivalent circuit, it is made up of series resistor (approx.  $2k\Omega$ ) and seven stages of forward diode.

- (1) At high temperatures, the drop in diode  $V_F$  may decrease the clamp voltage of the pin. If the voltage approaches the reference level of the comparator (2.4V) and current leaks occur, the overvoltage detection level may slightly fluctuate. Form the detection circuit as the figure below. It is recommended that R1, R2 and Vz be set as shown below.



$$\bullet R_1 + R_2 > 200k\Omega$$

$$\bullet \frac{R_1 \times R_2}{R_1 + R_2} < 7k\Omega$$

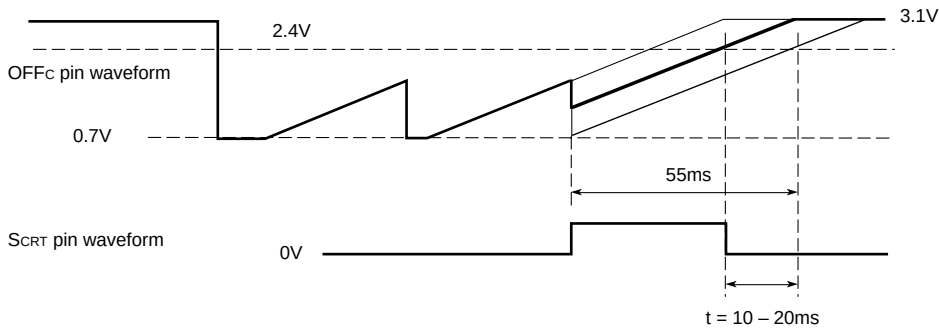
- (2) During excessive input, as shown above, setting should be made so that the input pin voltage becomes 4.3V or lower (to prevent the saturated comparator circuit from operating).
  - $V_z \approx 4.0V$

**7. Reset time in reset circuit**

This circuit is designed as a timer circuit of  $V_L = 0.7V$ ,  $V_H = 2.5V$  and  $I_o = 10\mu A$ . When SCR is ON, the power supply route of the leakage detection and abnormal voltage detection circuits are shut off,  $V_L$  does not drop to  $0.7V$  as shown below and therefore reset time may become shorter.

Set the reset time somewhat longer in advance.

$$T = \frac{C \times (V_H - V_L)}{I} = \frac{0.33\mu F \times (2.4 - 0.7)}{10\mu A} \approx 55ms$$

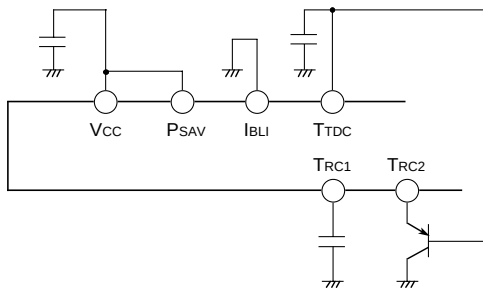


- In the case of leakage detection :  
May become 10ms (50Hz) shorter
- In the case of abnormal voltage detection :  
May become 20ms (50Hz) shorter

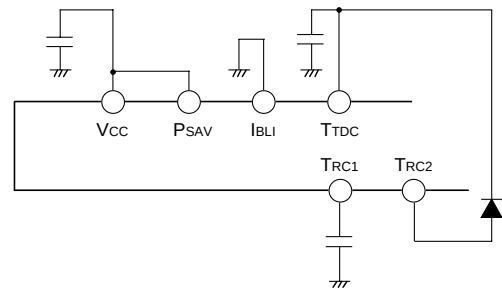
Note. t : time shorter than setting value

**8. Application of leakage detection function to time delay function**

As shown in the figure below, by applying the neutral conductor open-phase protection function, it is possible to provide the leakage detection function with time delay function (several 100ms). In this case, however, the neutral conductor open-phase protection function disappears. Pin No. in parentheses are of L type.



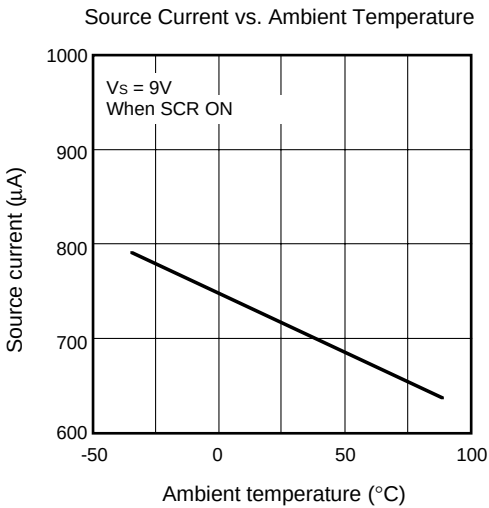
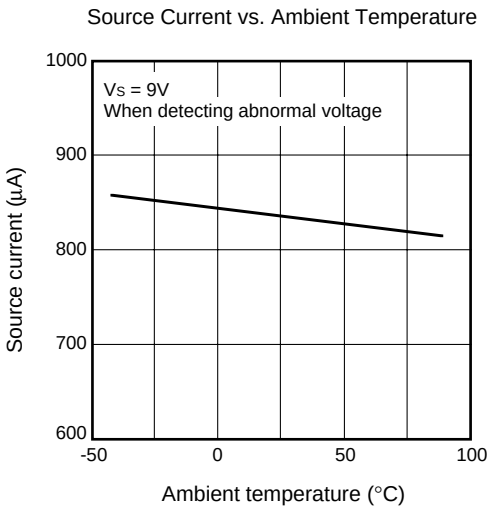
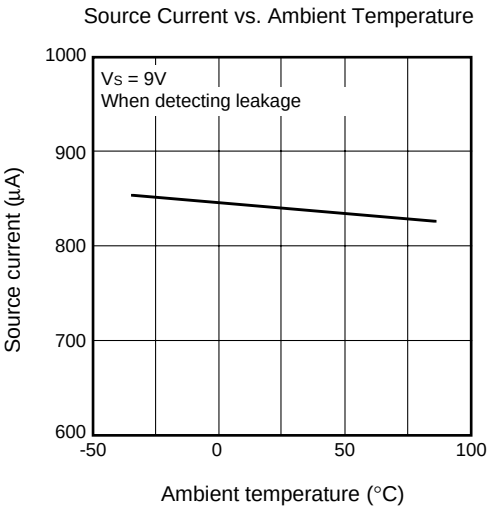
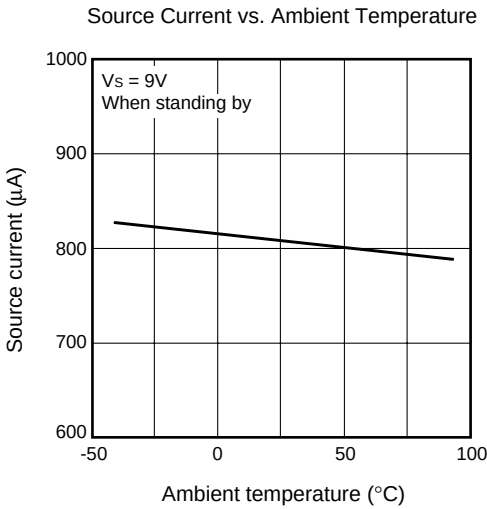
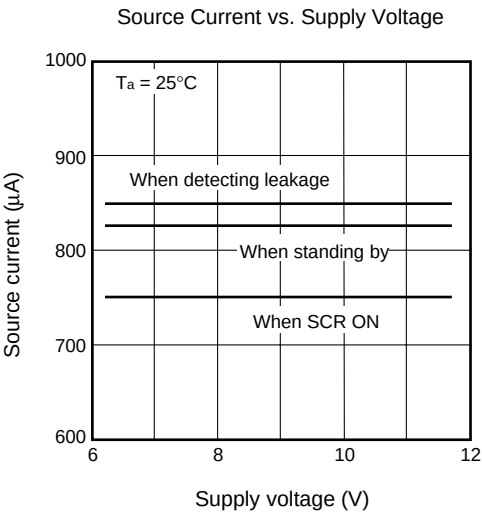
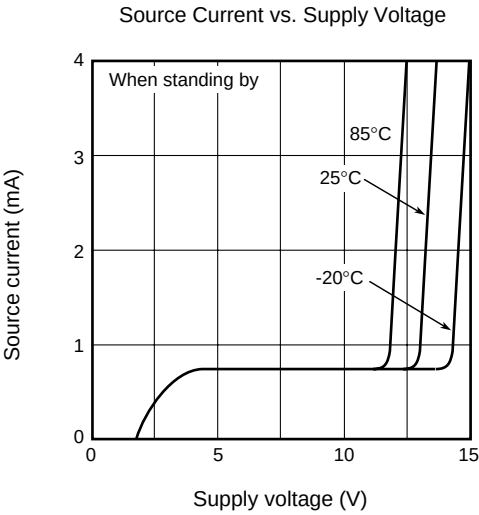
(Example 1)

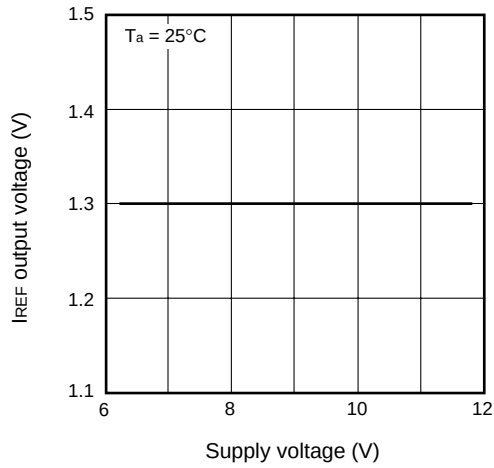
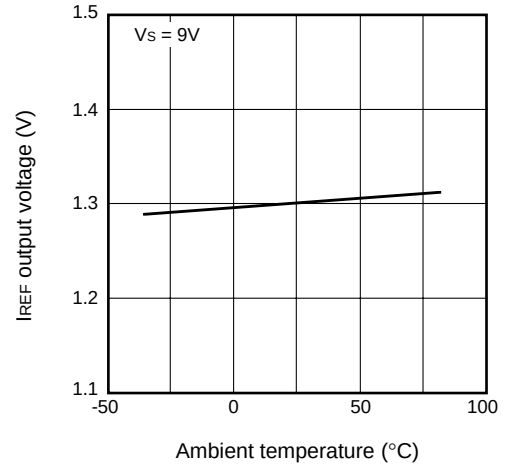
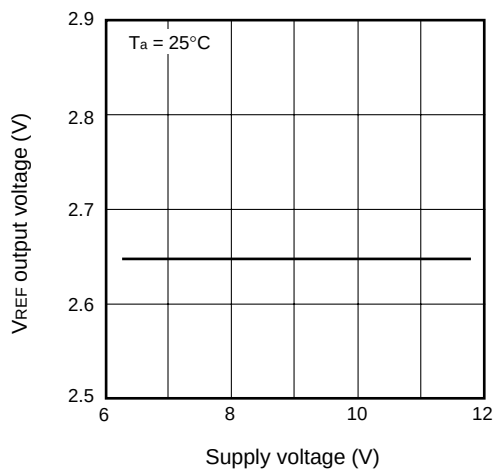
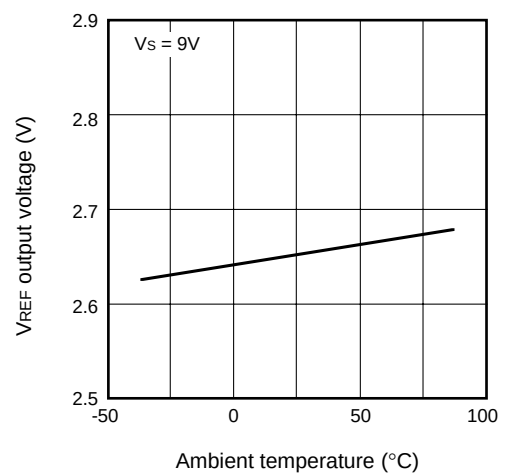
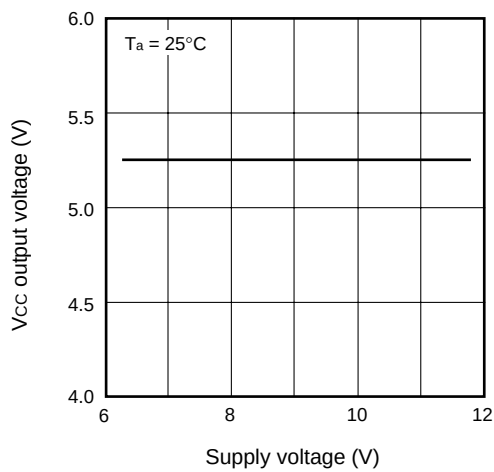
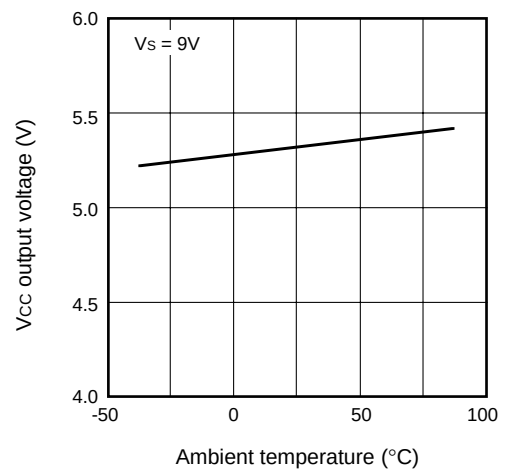


(Example 2)

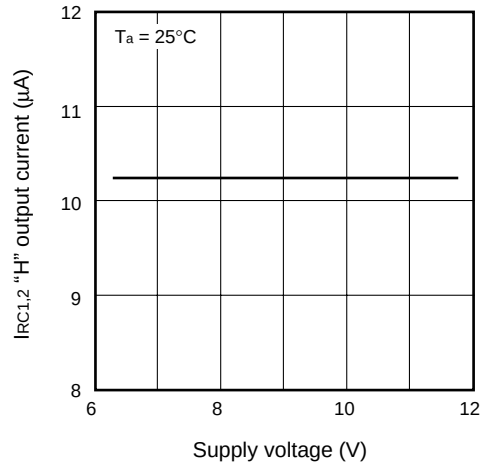


TYPICAL CHARACTERISTICS

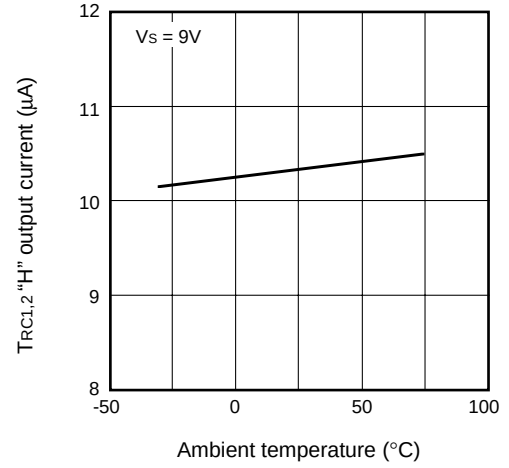


I<sub>REF</sub> Output Voltage vs. Supply VoltageI<sub>REF</sub> Output Voltage vs. Ambient TemperatureV<sub>REF</sub> Output Voltage vs. Supply VoltageV<sub>REF</sub> Output Voltage vs. Ambient TemperatureV<sub>CC</sub> Output Voltage vs. Supply VoltageV<sub>CC</sub> Output Voltage vs. Ambient Temperature

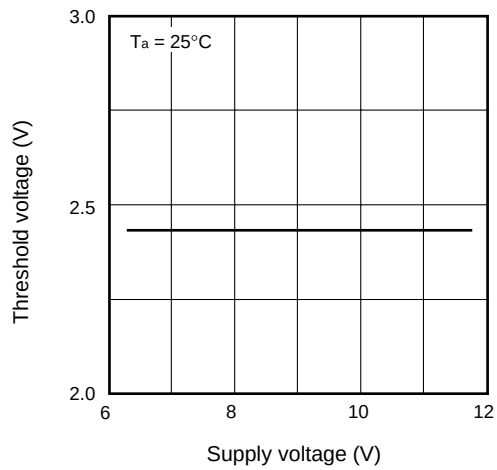
TRC1,2 "H" Output Current vs. Supply Voltage



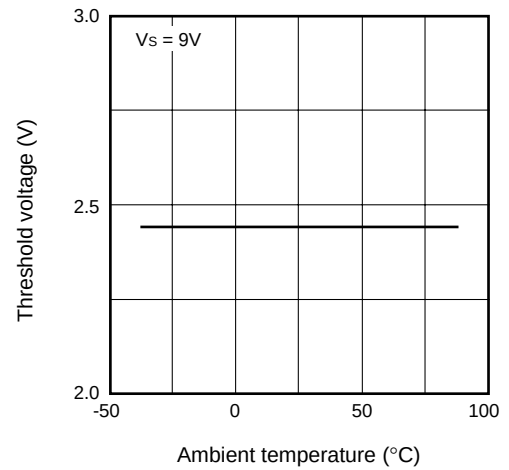
TRC1,2 "H" Output Current vs. Ambient Temperature



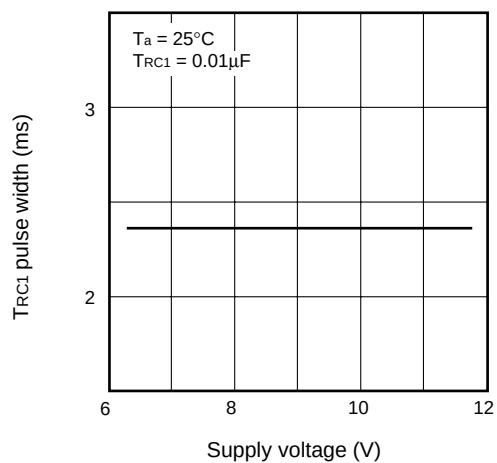
TRC1,2/OFFC/IBLI/T<sub>TDC</sub> Threshold Voltage vs. Supply Voltage



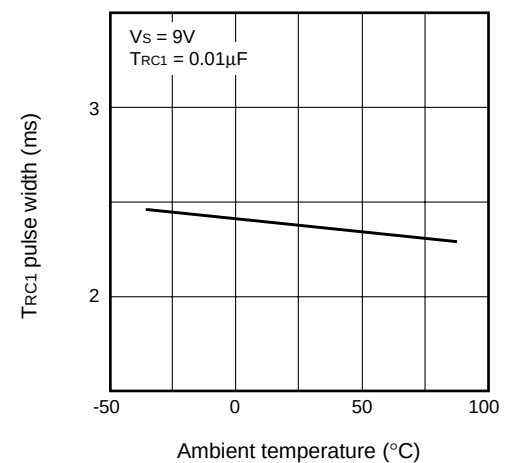
TRC1,2/OFFC/IBLI/T<sub>TDC</sub> Threshold Voltage vs. Ambient Temperature



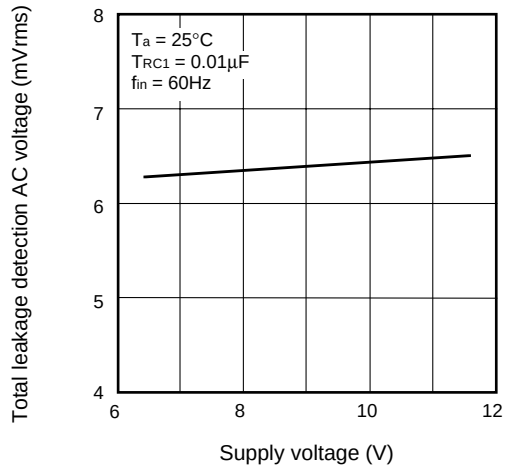
TRC1 Pulse Width vs. Supply Voltage



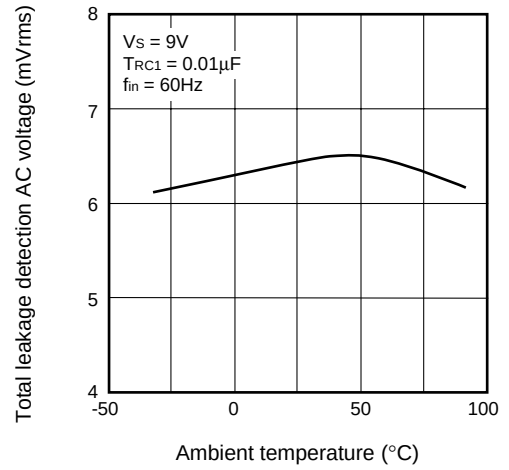
TRC1 Pulse Width vs. Ambient Temperature



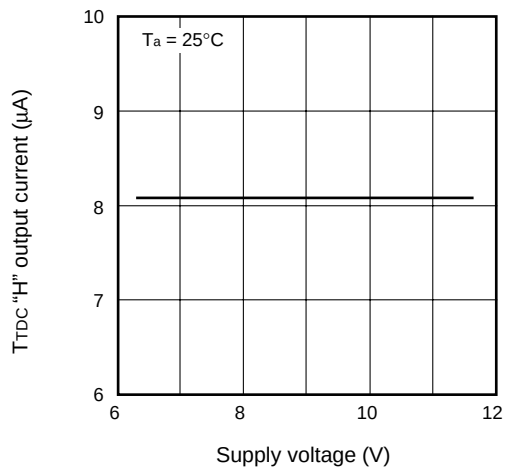
Total Leakage Detection AC Voltage vs. Supply Voltage



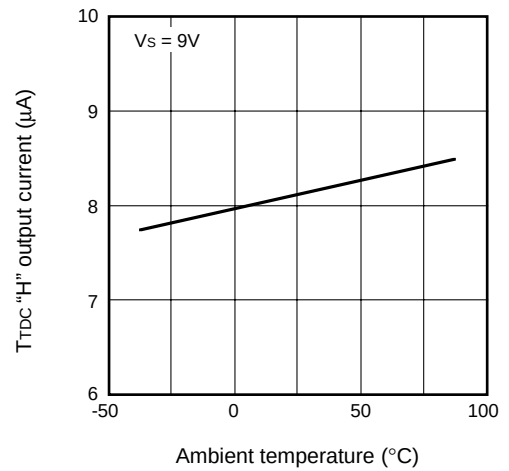
Total Leakage Detection AC Voltage vs. Ambient Temperature



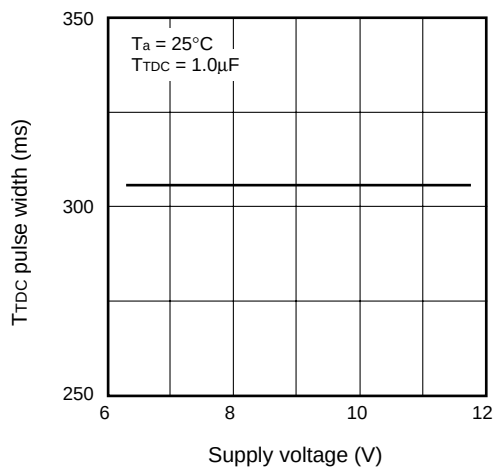
T<sub>TDC</sub> "H" Output Current vs. Supply Voltage



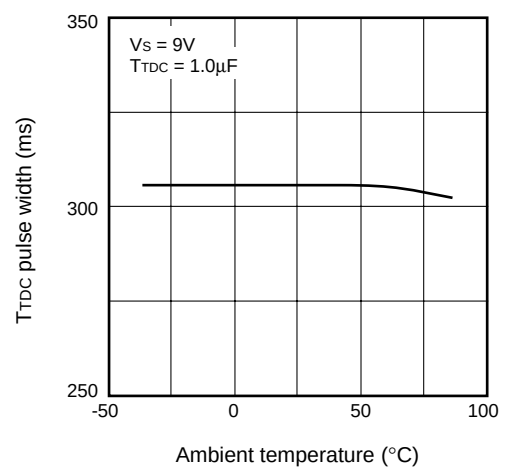
T<sub>TDC</sub> "H" Output Current vs. Ambient Temperature



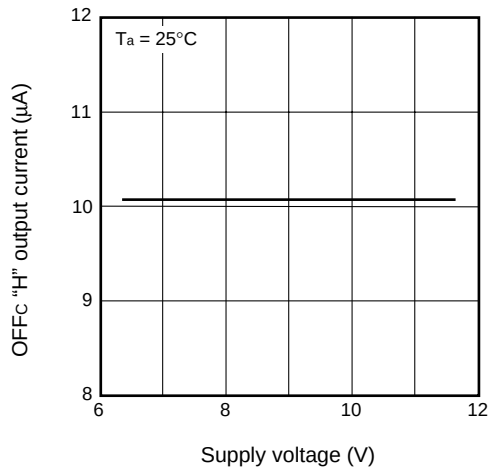
T<sub>TDC</sub> Pulse Width vs. Supply Voltage



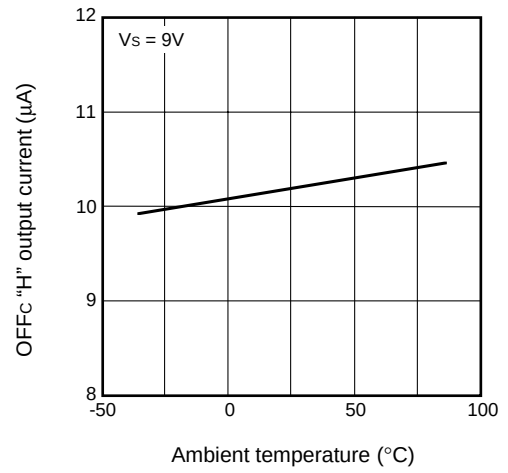
T<sub>TDC</sub> Pulse Width vs. Ambient Temperature



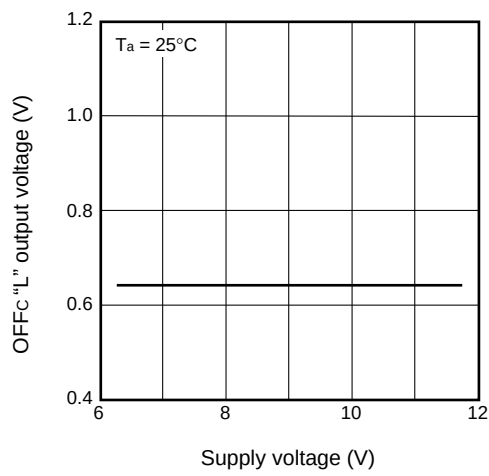
OFFc "H" Output Current vs. Supply Voltage



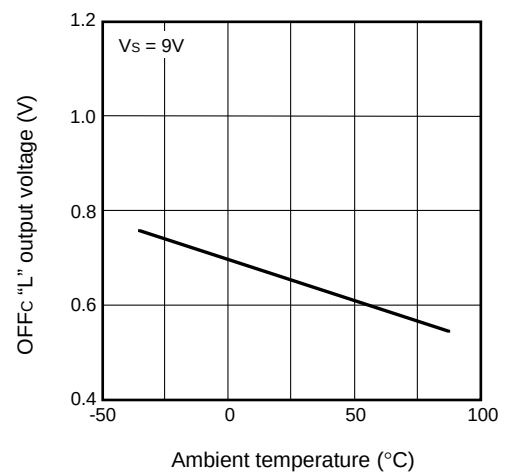
OFFc "H" Output Current vs. Ambient Temperature



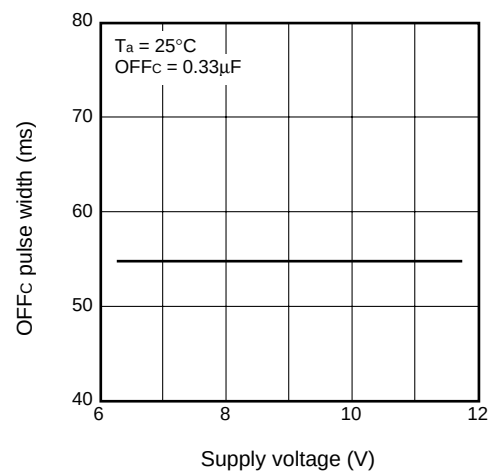
OFFc "L" Output Voltage vs. Supply Voltage



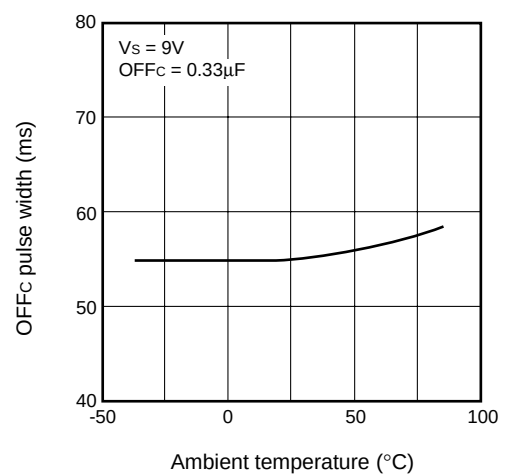
OFFc "L" Output Voltage vs. Ambient Temperature



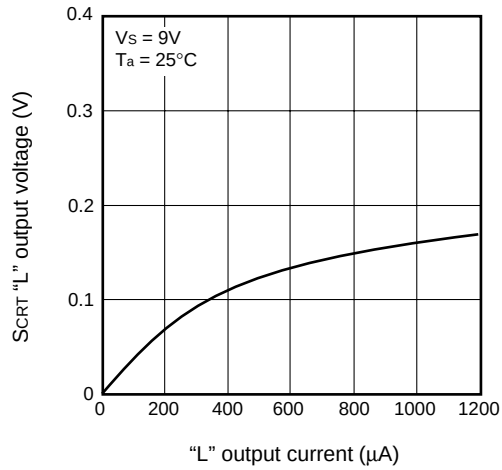
OFFc Pulse Width vs. Supply Voltage



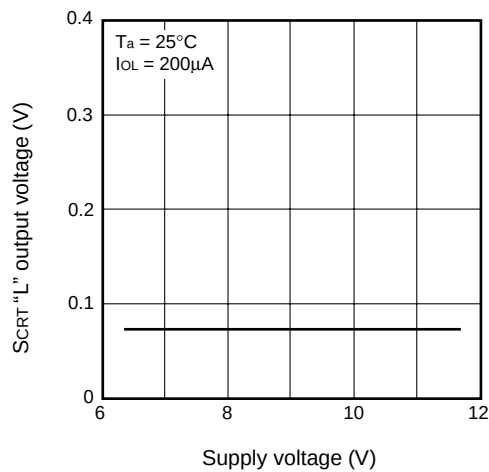
OFFc Pulse Width vs. Ambient Temperature



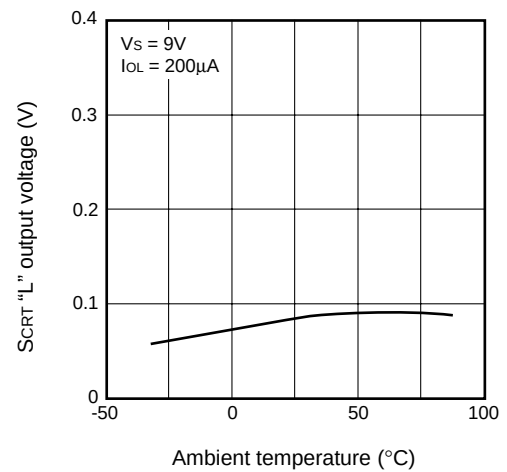
SCRT "L" Output Voltage vs. "L" Output Current



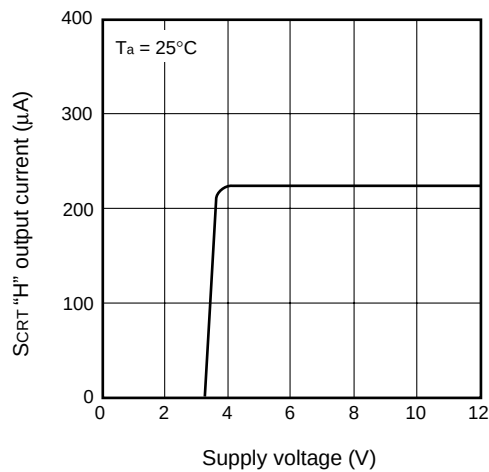
SCRT "L" Output Voltage vs. "L" Supply Voltage



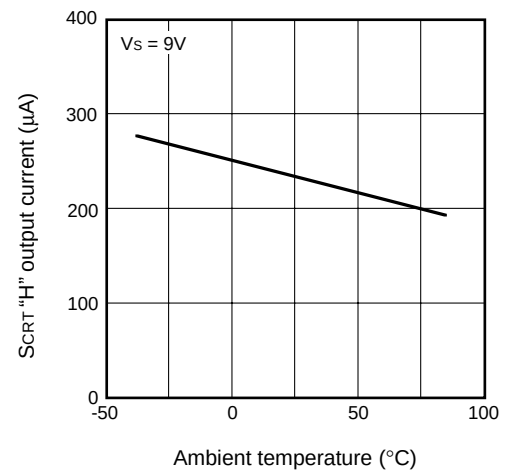
SCRT "L" Output Voltage vs. Ambient Temperature



SCRT "H" Output Current vs. Supply Voltage



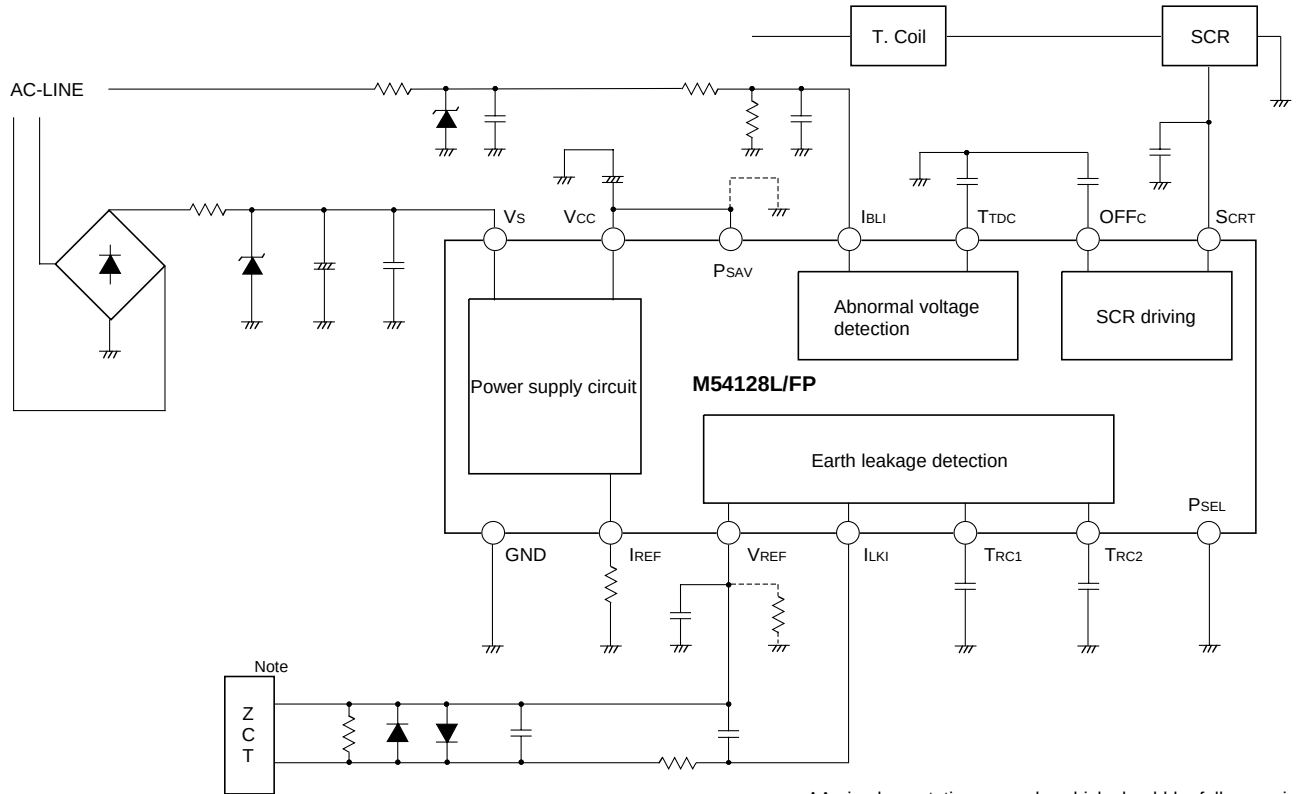
SCRT "H" Output Current vs. Ambient Temperature



# M54128L/FP

## EARTH LEAKAGE CURRENT DETECTOR

### APPLICATION EXAMPLE



\*An implementation example, which should be fully examined.

Note : MZ Core Series by Soryo Denshi Kagaku Co., Ltd (Mitsubishi Subsidiary)  
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