# M54125L/P

EARTH LEAKAGE CURRENT DETECTOR

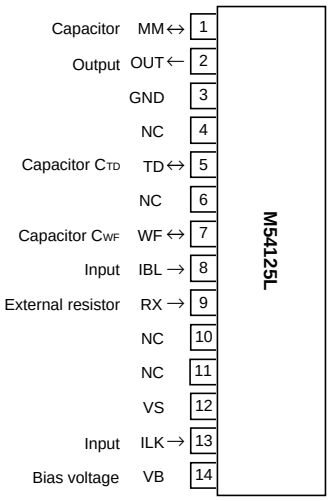
## DESCRIPTION
The M54125 is a semiconductor integrated circuit consisting of an amplifier for high-speed earth leakage circuit breaker.

## FEATURES
- Satisfies JIS C 8371
- Temperature-stable input current trigger threshold ($V_{LKT}$ = 9mV)
- Capable of detecting a lost phase on the neutral line
- Economical, low external component count
- Highly resistant to noise and power surges
- Wide operating temperature range (Ta = -20 – +80°C)

## APPLICATION
High-speed earth-leakage circuit breakers

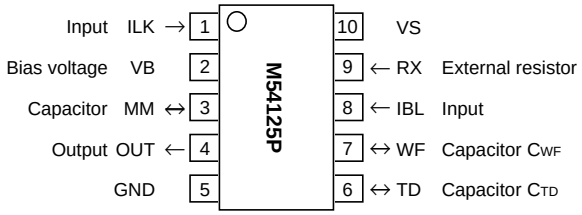
## FUNCTION
The M54125 is a semiconductor integrated circuit for use in the amplifier section of earth-leakage circuit breakers. It consists of a differential amplifier, one-shot circuit, output circuit, current regulator, waveform regulator and delay circuit. The following description refers to the block diagram, application example, and operational waveforms.

## PIN CONFIGURATION (TOP VIEW)



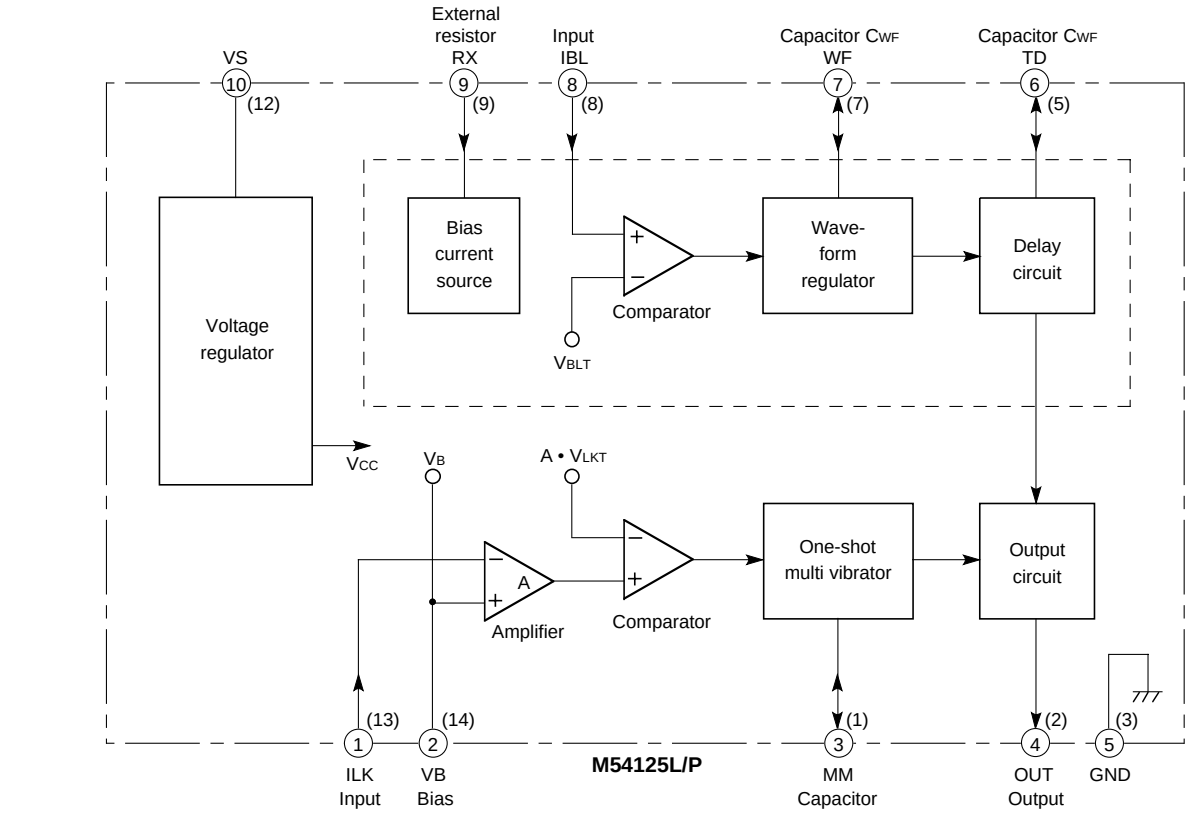

Outline 14P5A

N.C: no connection




Outline 10P2-C

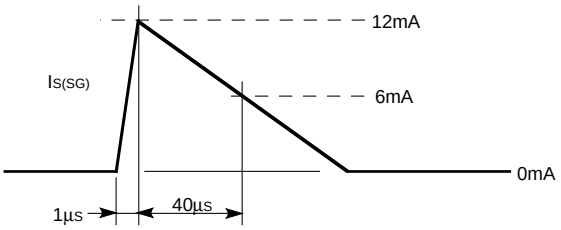
## BLOCK DIAGRAM (Note: Pin No. in parentheses are of M54125L)



## ABSOLUTE MAXIMUM RATINGS (Ta = -20 – 80°C unless otherwise noted)

| Symbol | Parameter | Conditions | Ratings | Unit |
|---|---|---|---|---|
| $I_S$ | Supply voltage | Average supply current frequency per cycle | 0 – 6 | mA |
| $I_{S(SO)}$ | Supply surge current | (Note 1) | 0 – 12 | mA |
| $\Delta V_{ILK}$ | ILK input voltage | Pin VB serves as the voltage reference | -1.8 – +1.8 | V |
| $V_{IBL}$ | IBL input voltage | | -0.3 – 6 | V |
| $V_{OUT}$ | OUT applied voltage | When external voltage is applied | -0.3 – 4 | V |
| $P_d$ | Power dissipation | | 160 | mW |
| $T_{opr}$ | Operating temperature | | -20 – 80 | °C |
| $T_{stg}$ | Storage temperature | | -55 – 125 | °C |

Note 1: $I_{S(SG)}$ current waveform, which is given in the following diagram, shall be one shot or less per minute.




## RECOMMENDED OPERATING CONDITIONS (Ta = -20 – 80°C unless otherwise noted)

| Symbol | Parameter | | Limits | | | Unit |
|---|---|---|---|---|---|---|
| | | | Min. | Typ. | Max. | |
| $V_S$ | Supply voltage | When output OUT is OFF | 12 | | | V |
| $I_S$ | Supply current | Average power supply current per cycle | | | 5.6 | mA |
| $C_{MM}$ | External capacitor MM | | | 0.22 | | µF |
| $C_{WF}$ | External capacitor WF | | | 1 | | µF |
| $C_{TD}$ | External capacitor TD | | | 6.8 | | µF |
| $R_X$ | External resistor $R_X$ | | | 27 | | kΩ |

Handling of unused pins when the abnormal voltage detection function is not used
- Pin $R_X$ must be left open
- Pin TD must be shorted to GND
- Pin WF and pin IBL may be left open or shorted to GND

## LEAKAGE DETECTION FUNCTION

When leakage current current Ig appears on the primary side of zero-current transformer, ZCT, leakage signal voltage $V_{ILK}$ appears on the secondary side and is input at ILK with bias VB as the reference. In the half cycle when $V_{ILK}$ is negative, capacitor $C_{MM}$ connected to MM charges until $V_{ILK}$ reaches the DC trip voltage.

If the voltage at MM does not reach the MM positive threshold voltage, when the charging phase is completed, capacitor $C_{MM}$ discharges at a small current. The output OUT is reset to the off state (in which output current flows in) when $V_{MM}$ descends to the MM negative threshold voltage.

Earth-leakage currents are detected when the amplitude of input voltage $V_{ILK}$ exceeds the DC trip voltage $V_{LKT}$ for longer than the detection time $t_{MM}$. The output OUT turns on for time $t_{OUT}$. The output current is used to turn on the thyristor that opens the breaker contacts.

## ABNORMAL VOLTAGE DETECTION FUNCTION

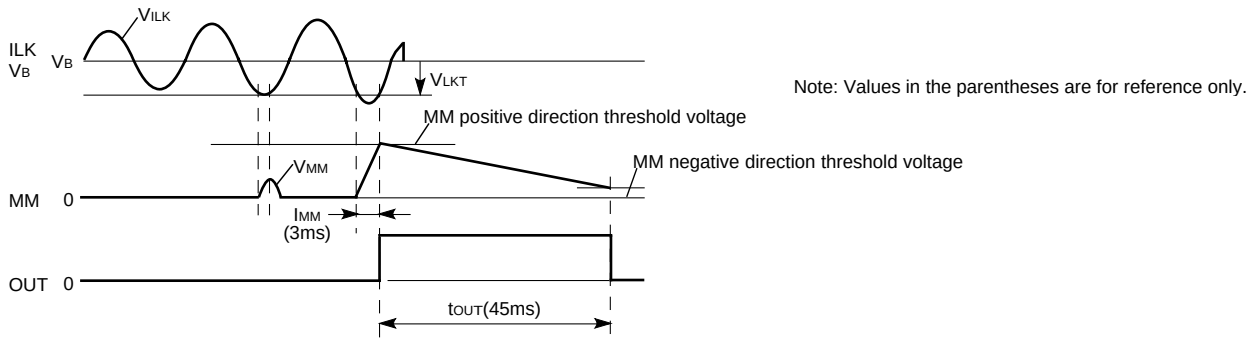
Normally $V_{IBL}$, fixed amplitude AC supply that has been rectified and divided by a resistor, is input to abnormal voltage input IBL. When a fault occurs in the neutral line N, successive peaks of $V_{IBL}$ become alternately small and large, with the levels determined by the load on the AC power lines A and B.

When the amplitude of $V_{IBL}$ exceeds the abnormal voltage trip voltage $V_{BLT}$, capacitor $C_{WF}$ connected to pin WF discharges. After the discharge shase is completed, charging begins again.) When voltage $V_{WF}$ at WF drops below the WF threshold voltage, capacitor $C_{TD}$ at TD charges, and after delay time $t_{TD}$, when voltage $V_{TD}$ at TD reaches the TD threshold voltage, output OUT turns on, activating the circuit breaker. To avoid misoperation due to the effect of repeated one-shot noise that brings $V_{IBL}$ above $V_{BLT}$, the voltage drops to the initial value only after time $t_{WF}$.

This abnormal voltage detection circuit is enabled only when an external resistor Rx is connected to pin Rx to enable the current flow.

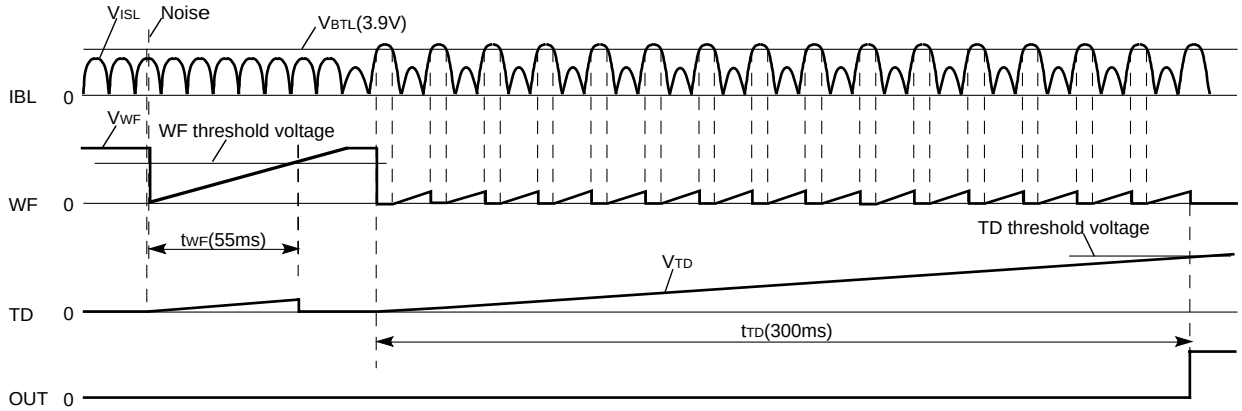
## WAVEFORM DIAGRAM

1) Voltage waveform when earth leakage is detected.




Note: Values in the parentheses are for reference only.

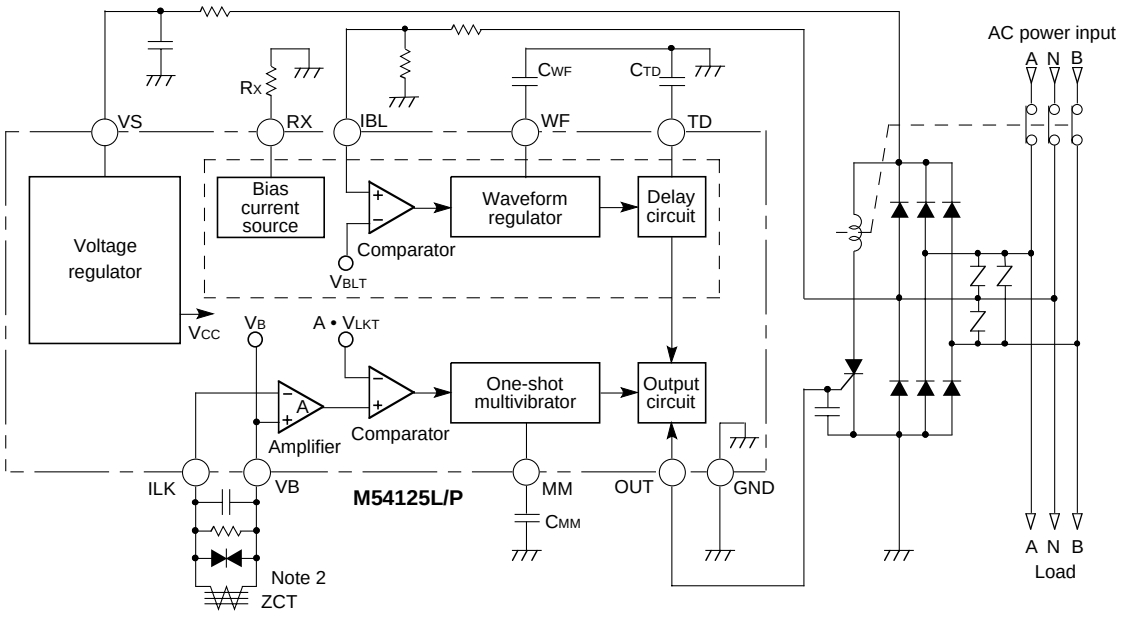
2) Voltage waveform when abnormal voltage is detected.



## ELECTRICAL CHARACTERISTICS ($V_{CC}$ = 5V and Ta = -20 – 80°C unless otherwise noted)

| Symbol | Parameter | | Test conditions | Limits | | | Unit | Test circuit |
|---|---|---|---|---|---|---|---|---|
| | | | | Temperature | Min. | Max. | | |
| $I_{S1}$ | Supply current 1 | Pin VS | $V_S$ = 12V, $\Delta V_{ILK}$ = 0mV, Out : "OFF" | | | 0.7 | mA | 1 |
| $I_{S2}$ | Supply current 2 | Pin VS | $V_S$ = 16V, $\Delta V_{ILK}$ = -15mV, Out : "ON" | | | 1.2 | mA | 1 |
| $V_{LKT}$ | Trip voltage | Pin ILK and VB | $V_S$ = 16V, $V_{LKT}$ : 60Hz Test circuit 3 | | 4 | 9 | mVrms | |
| $I_{MM+}$ | Sink current | Pin MM | $V_S$ = 16V, $\Delta V_{ILK}$ = 0mV, $V_{MM}$ = 0.8V | 25 | 170 | 370 | µA | 4 |
| $I_{MM-}$ | Source current | Pin MM | $V_S$ = 16V, $\Delta V_{ILK}$ = -15mV, $V_{MM}$ = 0.8V | 25 | -110 | -250 | µA | 4 |
| $t_{MM}$ | Detect inhibit time | Pin MM | $V_S$ = 16V | | 1.7 | 4 | ms | 10 |
| $I_{OU+}$ | Sink current | Pin OUT | $V_S$ = 16V, $\Delta V_{ILK}$ = 0mV, $V_{OUT}$ = 0.2V | | 150 | | µA | 5 |
| $I_{OU-}$ | Source current | Pin OUT | $V_S$ = 16V, $\Delta V_{ILK}$ = -15mV $V_{OUT}$ = 0.8V | -20 | -200 | | µA | 5 |
| | | | | 25 | -100 | | | |
| | | | | 80 | -70 | | | |
| $t_{OUT}$ | Output pulse width | Pin OUT | $V_S$ = 16V | | 25 | 100 | ms | 10 |
| $V_{SM}$ | Maximum current voltage | Pin VS | $I_S$ = 3.5mA | 25 | 20 | 26 | V | 6 |
| $I_{S3}$ | Supply current 3 | Pin VS | $V_S$ = 12V, $V_{ILK}$ : 0mV $V_{IBL}$ = 0V, OUT : "OFF" Test circuit 2 | | | 1 | mA | |
| $I_{S4}$ | Supply current 4 | Pin VS | $V_S$ = 12V, $V_{ILK}$ : -15mV $V_{IBL}$ = 12V, OUT : "ON" Test circuit 2 | | | 1.4 | mA | |
| $V_{BLT}$ | Trip voltage | Pin IBL | $V_S$ = 16V | | 3.6 | 4.1 | V | 7 |
| $I_{IBL}$ | Input current | Pin IBL | $V_S$ = 16V, $V_{IBL}$ = 4.5V Test circuit 7 | 25 | | 0.8 | µA | |
| $I_{WF+}$ | Sink current | Pin WF | $V_S$ = 16V, $V_{IBL}$ = 4.5V, $V_{WF}$ = 0.5V | 25 | 1 | | mA | 8 |
| $I_{WF-}$ | Source current | Pin WF | $V_S$ = 16V, $V_{IBL}$ = 0V, $V_{WF}$ = 0.5V | 25 | -22 | -30 | µA | 8 |
| $t_{WF}$ | Recovery time | Pin WF | $V_S$ = 16V | | 35 | 70 | ms | 11 |
| $I_{TD+}$ | Sink current | Pin TD | $V_S$ = 16V, $V_{IBL}$ = 0V, $V_{TD}$ = 0.5V | 25 | 1 | | mA | 9 |
| $I_{TD-}$ | Source current | Pin TD | $V_S$ = 16V, $V_{IBL}$ = 4.5V, $V_{TD}$ = 0.5V | 25 | -22 | -30 | µA | 9 |
| $t_{DT}$ | Delay time | Pin TD | $V_S$ = 16V | | 200 | 420 | ms | 12 |

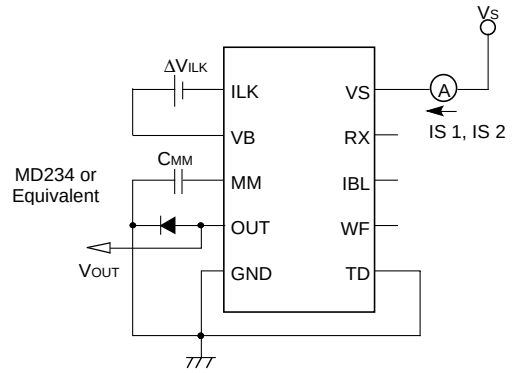
## APPLICATION EXAMPLE




Note 2 : MZ Core Series by Soryo Denshi Kagaku Co., Ltd (Mitsubishi Subsidiary)
Tel. +81-427-74-7813

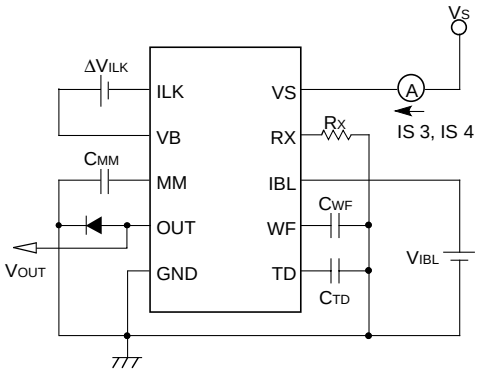
**TEST CIRCUIT** ($C_{MM}$ = 0.22µF, $C_{TD}$ = 6.8µF and $R_X$ = 27kΩ unless otherwise noted)

**1** IS 1 and IS 2 Measurement



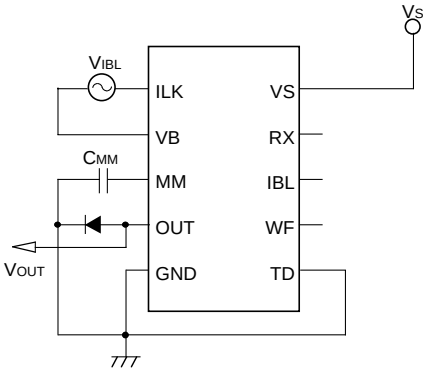

∗: IS 2 is the value after OUT turns on. ($V_{out}$ > 0.5V)

**2** IS 3 and IS 4 Measurement



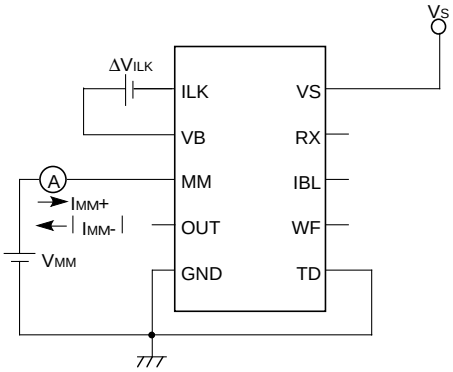

∗: IS 4 is the value after OUT turns on.

**3** $V_{LKT}$

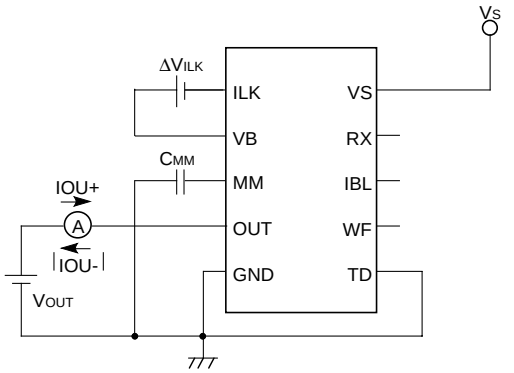



∗: $V_{LKT}$ is the value of $V_{IBL}$ when OUT turns on as $V_{IBL}$ is gradually increased.

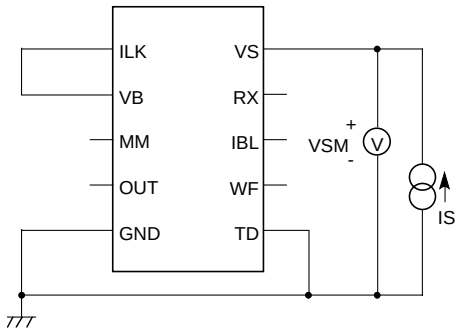
**4** IMM+ and IMM- Measurement



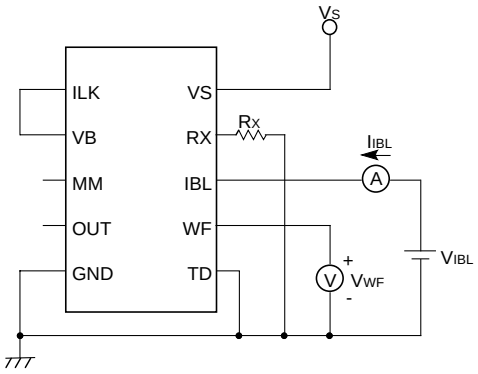

**5** IOU+, IOU- Measurement




**6** VSM Measurement

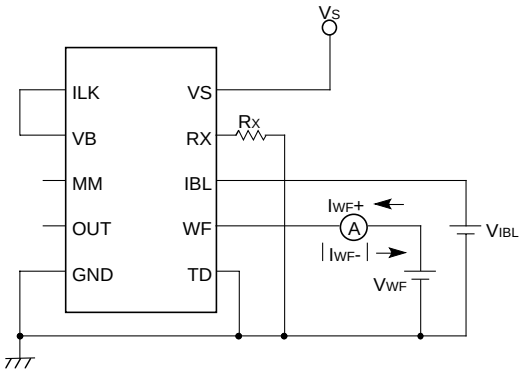


## 7 $V_{BLT}$, $I_{IBL}$ Measurement

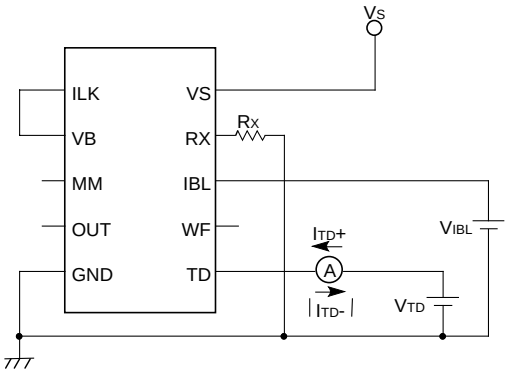



∗: $V_{BLT}$ is the value of $V_{IBL}$ when VF = 0.5V.

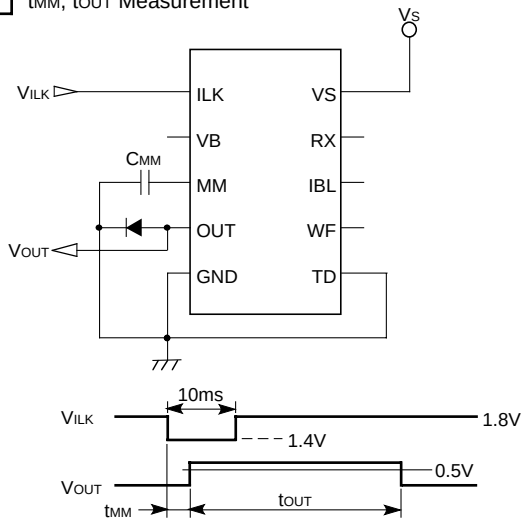
## 8 $I_{WF+}$, $I_{WF-}$ Measurement



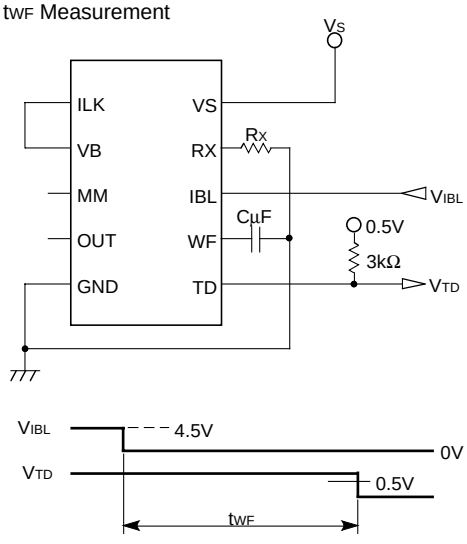

## 9 $I_{TD+}$, $I_{TD-}$ Measurement




## 10 $t_{MM}$, $t_{OUT}$ Measurement




## 11 $t_{WF}$ Measurement




## 12 $t_{TD}$ Measurement