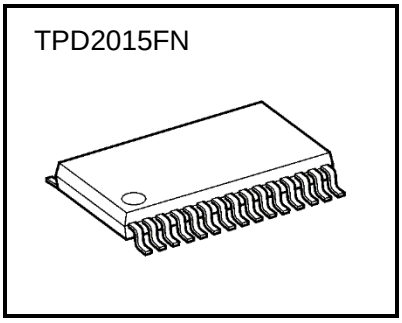
Toshiba Intelligent Power Device Silicon Monolithic MOS Integrated Circuit

# TPD2015FN

High side power switch array (8-channels) for motors, solenoids, lamp drives

## 1. Description

TPD2015FN is a high-side switch array (8-channels) with MOSFET outputs. This is the monolithic power IC that can be driven directly from CMOS, TTL logic circuitry (MCU, etc.) and have over current and over temperature protection features.




SSOP30-P-300-0.65

## 2. Applications

- Programmable logic controller for Industrial Use.
- Driving resistant load and inductive load

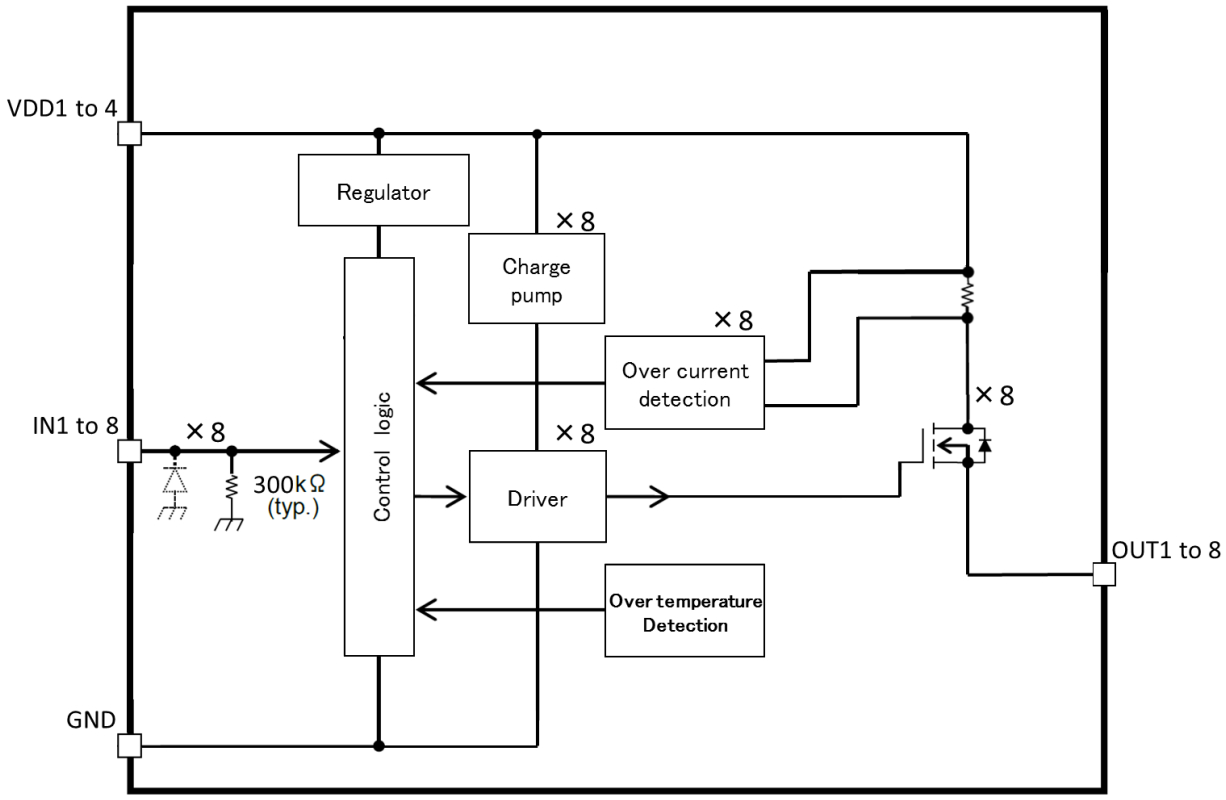
## 3. Features

- 8-channels of N-channel MOSFET and charge pump are built-in.
- This IC can drive the power load directly.
- Built-in protection against over temperature and over current.
- 8-channels access enables space-saving design.
- High voltage operation is possible : 40 V
- Low on resistance : 0.55Ω (max) @ $V_{DD}$ = 12V, $I_{OUT}$ = 0.5A, $T_j$ = 25℃ (per channel)
- Parallel operation is possible.
- Package is SSOP30 (300 mil) and packing form is embossed taping.

Note:This product has a MOS structure and is sensitive to electrostatic discharge.

Start of commercial production
2022-05

## 4. Block Diagram




Note: Some of the functional blocks, circuits, constants, etc. in the block diagram are omitted or simplified.

**Figure 4.1 Block Diagram**

## 5. Pin Assignments

(TOP VIEW)

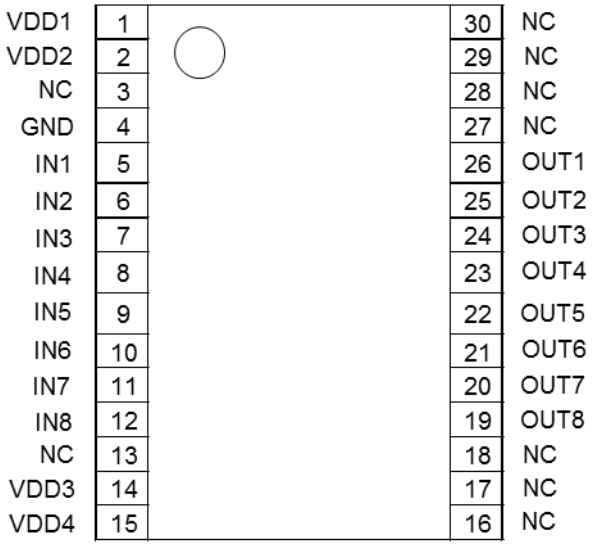



**Figure 5.1 Pin Assignments**

## 6. Pin Description

**Table 6.1 Pin Description**

| Pin No. | Symbol | I/O | Pin Description |
|---|---|---|---|
| 1 | VDD1 | - | Power supply pin. |
| 2 | VDD2 | - | Power supply pin. |
| 3 | NC | - | No-Connect pin. |
| 4 | GND | - | GND pin. |
| 5 | IN1 | IN | Input pin for channel 1. Built in pull down resistor (300kΩ typ.). |
| 6 | IN2 | IN | Input pin for channel 2. Built in pull down resistor (300kΩ typ.). |
| 7 | IN3 | IN | Input pin for channel 3. Built in pull down resistor (300kΩ typ.). |
| 8 | IN4 | IN | Input pin for channel 4. Built in pull down resistor (300kΩ typ.). |
| 9 | IN5 | IN | Input pin for channel 5. Built in pull down resistor (300kΩ typ.). |
| 10 | IN6 | IN | Input pin for channel 6. Built in pull down resistor (300kΩ typ.). |
| 11 | IN7 | IN | Input pin for channel 7. Built in pull down resistor (300kΩ typ.). |
| 12 | IN8 | IN | Input pin for channel 8. Built in pull down resistor (300kΩ typ.). |
| 13 | NC | - | No-Connect pin. |
| 14 | VDD3 | - | Power supply pin. |
| 15 | VDD4 | - | Power supply pin. |
| 16 | NC | - | No-Connect pin. |
| 17 | NC | - | No-Connect pin. |
| 18 | NC | - | No-Connect pin. |
| 19 | OUT8 | OUT | Output pin of channel 8. |
| 20 | OUT7 | OUT | Output pin of channel 7. |
| 21 | OUT6 | OUT | Output pin of channel 6. |
| 22 | OUT5 | OUT | Output pin of channel 5. |
| 23 | OUT4 | OUT | Output pin of channel 4. |
| 24 | OUT3 | OUT | Output pin of channel 3. |
| 25 | OUT2 | OUT | Output pin of channel 2. |
| 26 | OUT1 | OUT | Output pin of channel 1. |
| 27 | NC | - | No-Connect pin. |
| 28 | NC | - | No-Connect pin. |
| 29 | NC | - | No-Connect pin. |
| 30 | NC | - | No-Connect pin. |

# 7. Operational Description

## 7.1. Over temperature protection

To prevent damage due to temperature rise, the outputs are turned off when the junction temperature of this product exceeds the over temperature detection temperature ($T_{SD}$).If the junction temperature falls below the hysteresis set temperature ($T_{SD}$-$\Delta T_{SD}$), the product will return to normal operation.

## 7.2. Over current protection

When the output current exceeds the over current detection value ($I_{OC}$) due to a load short circuit, etc., the output is turned off during the over current protection operating time ($t_{OFF\text{-}DUTY}$).After that, the output returns, but if the over current condition continues, the output is turned off again for the over current protection operating time ($t_{OFF\text{-}DUTY}$).

## 7.3. Timing chart

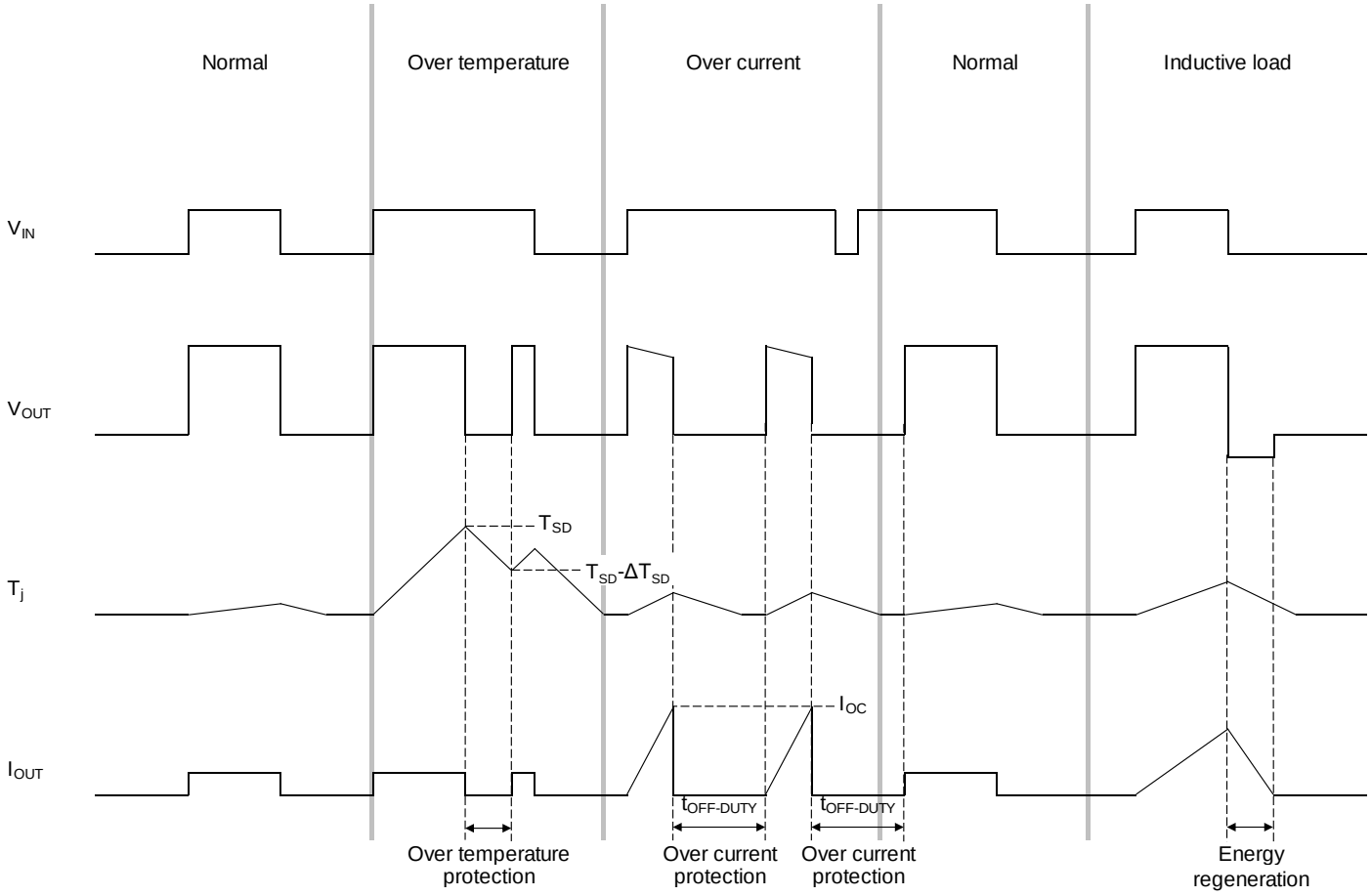



**Figure 7.1 Timing chart**

## 7.4. Truth table

**Table 7.1 Truth table**

| Input | Output | Operating state |
|---|---|---|
| L | L | Normal |
| H | H | |
| L | L | Over current protection ( Load short circuit ) |
| H | Switching | |
| L | L | Over temperature protection |
| H | L | |

# 8. Absolute Maximum Ratings

**Table 8.1 Absolute Maximum Ratings**

($T_a$ = 25°C unless otherwise specified)

| Characteristics | Symbol | Rating | Unit |
|---|---|---|---|
| **Supply voltage** | $V_{DD}$ | −0.3 to 40.0 | V |
| **Input voltage** | $V_{IN}$ | −0.3 to 6.0 | V |
| **VDDx - OUTx withstand voltage** | $V_{DSS}$ | 50.0[1)] | V |
| **Output current** | $I_{OUT}$ | Internally limited | A |
| **Power dissipation** | $P_D$ | 1.8 | W |
| **Operating temperature** | $T_{opr}$ | −40 to 110 | °C |
| **Junction temperature** | $T_j$ | 150 | °C |
| **Storage temperature** | $T_{stg}$ | −55 to 150 | °C |

1) Not subject to production test.

Note: Using continuously under heavy loads (e.g. the application of high temperature/current/voltage and the significant change in temperature, etc.) may cause this product to decrease in the reliability significantly even if the operating conditions (i.e. operating temperature/current/voltage, etc.) are within the absolute maximum ratings and the operating ranges.
Please design the appropriate reliability upon reviewing the Toshiba Semiconductor Reliability Handbook (“Handling Precautions”/“Derating Concept and Methods”) and individual reliability data (i.e. reliability test report and estimated failure rate, etc).

## 8.1. Thermal Resistance

**Table 8.2 Thermal resistance**

| Characteristics | Symbol | Rating | Unit |
|---|---|---|---|
| **Thermal resistance ( junction-to-ambient )** | $R_{th\ (j-a)}$ | 70 | °C / W |

Note: JEDEC Standard.
Glass epoxy board
Material: FR-4(4 layer)
Board size: 76.2mm x 114.3mm x 1.6mm

## 9. Operating Ranges

**Table 9.1 Operating supply voltage**

| Characteristics | Symbol | Condition | Min | Typ. | Max | Unit |
|---|---|---|---|---|---|---|
| **Operating supply voltage** | $V_{DD(opr)}$ | $T_j$ = 25°C | 8 | - | 40 | V |

## 10. Electrical Characteristics

**Table 10.1 Electrical Characteristics**

($T_j$ = 25°C, $V_{DD}$ = 8 to 40V unless otherwise specified)

| Characteristics | | Symbol | Note or Test Condition | Min | Typ. | Max | Unit |
|---|---|---|---|---|---|---|---|
| **Supply current** | | $I_{DD(OFF)}$ | $V_{DD}$ =24V, $V_{IN}$ = 0V | - | 1.9 | 2.6 | mA |
| | | $I_{DD(ON)}$ | $V_{DD}$ =24V, $V_{IN}$ = 5V, All outputs open | - | 3.1 | 4.2 | mA |
| **Input voltage** | **"L" level** | $V_{IL}$ | - | - | - | 0.8 | V |
| | **"H" level** | $V_{IH}$ | - | 2.0 | - | - | |
| **Input current** | | $I_{IL}$ | $V_{IN}$ = 0V | −1 | - | 1 | µA |
| | | $I_{IH}$ | $V_{IN}$ = 5V | - | 16 | 23 | |
| **On resistance** | | $R_{DS(ON)}$ | $V_{DD}$ = 12V, $V_{IN}$ = 5V, $I_{OUT}$ = 0.5A | - | 0.40 | 0.55 | Ω |
| **Output leakage current** | | $I_{OL}$ | $V_{DD}$ = 40V, $V_{IN}$ = 0V, Per output | - | - | 1 | µA |
| **Over current protection** | | $I_{OC}$ | - | 1.0 | 1.8 | 2.8 | A |
| **Over current protection operating time** | | $t_{OFF-DUTY}$ | - | 1.5 | 3.0 | 4.5 | ms |
| **Over temperature detection** | **Temperature** | $T_{SD}$ | - | 150 | 175 | 200 | °C |
| | **Hysteresis** | $\Delta T_{SD}$ | - | 10 | 20 | 30 | |
| **Switching time** | | $t_{ON}$ | Refer to test circuit 1 | 5 | 10 | 15 | µs |
| | | $t_{OFF}$ | | 3 | 6 | 9 | |
| **Single pulse avalanche energy** | | $E_S$ | $T_a$ = 25°C, $I_{OUT}$ = 0.75A (1-channel operation) | 30 | 150[2)] | - | mJ |

2) Not subject to production test.

# 11. Test circuit

## 11.1. Test circuit 1

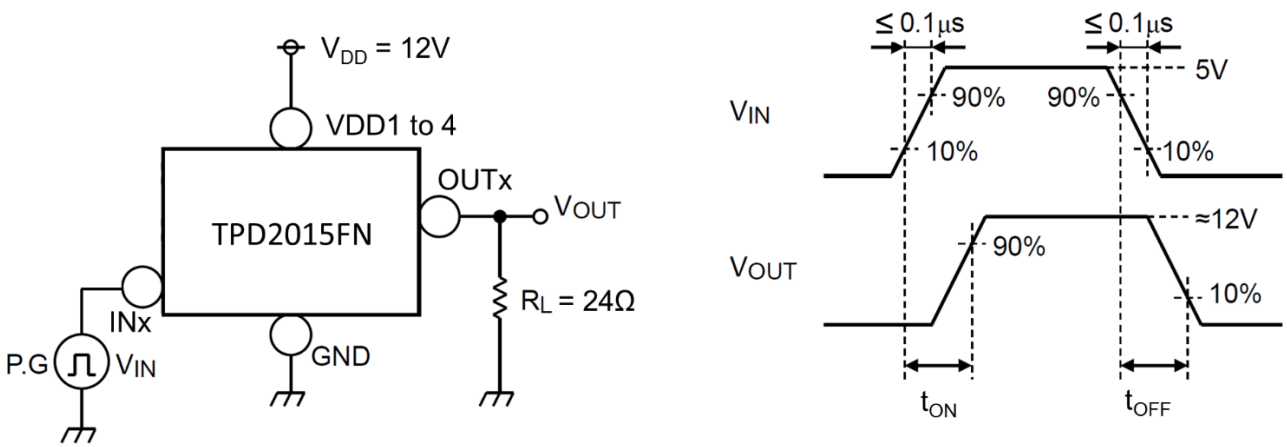
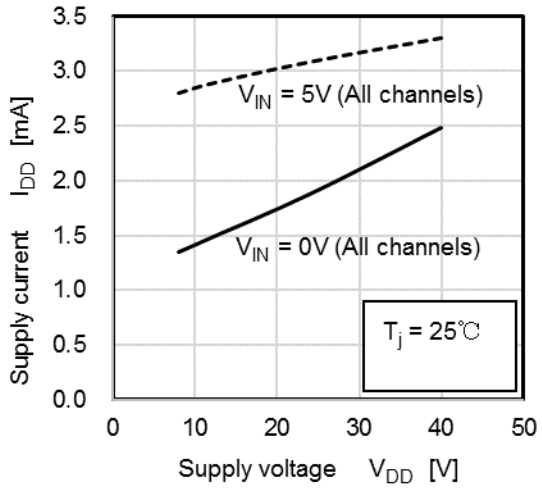



**Figure 11.1 Switching time measurement circuit**

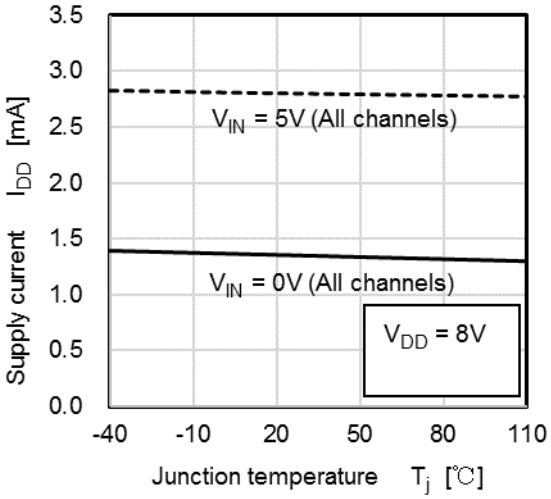
## 12. Characteristic curves

The below characteristics curves are presented for reference only and not guaranteed by production test, unless otherwise noted.

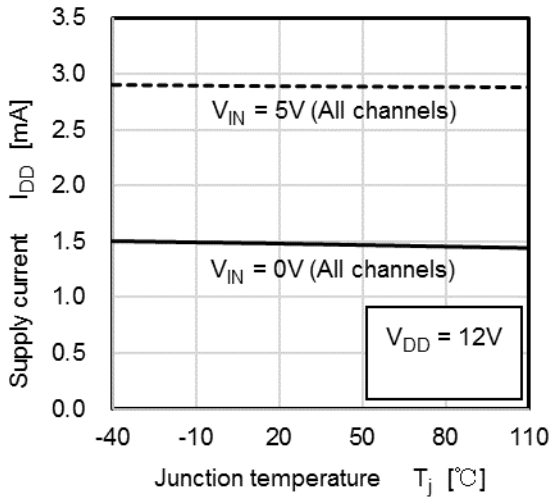
$I_{DD}$ - $V_{DD}$



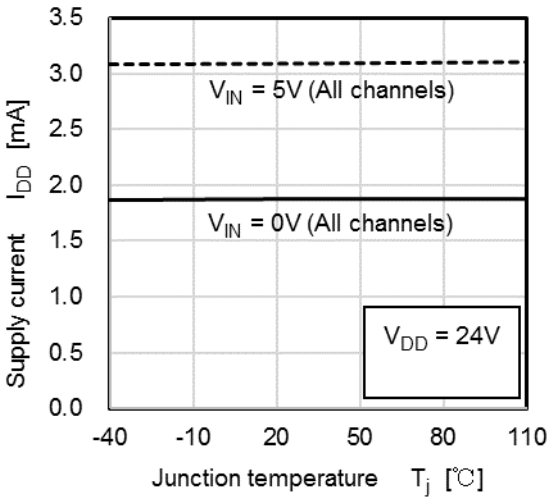

$I_{DD}$ - $T_j$



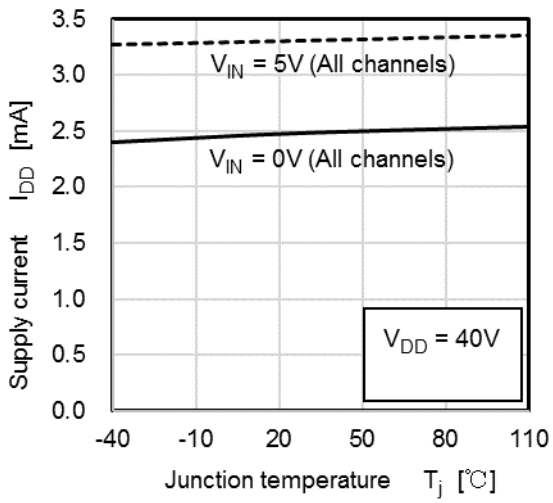

$I_{DD}$ - $T_j$



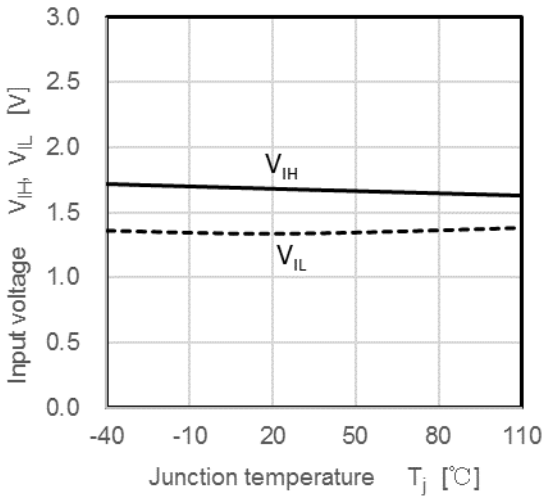

$I_{DD}$ - $T_j$



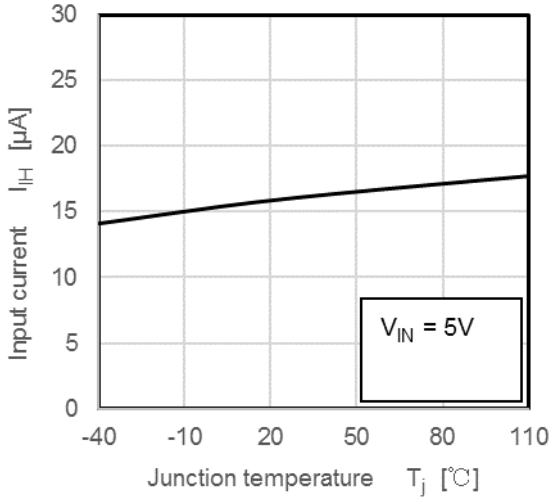

$I_{DD}$ - $T_j$



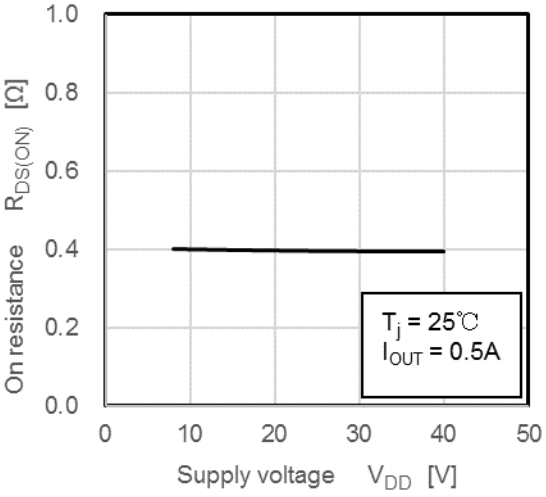
$V_{IH}$, $V_{IL}$ - $T_j$



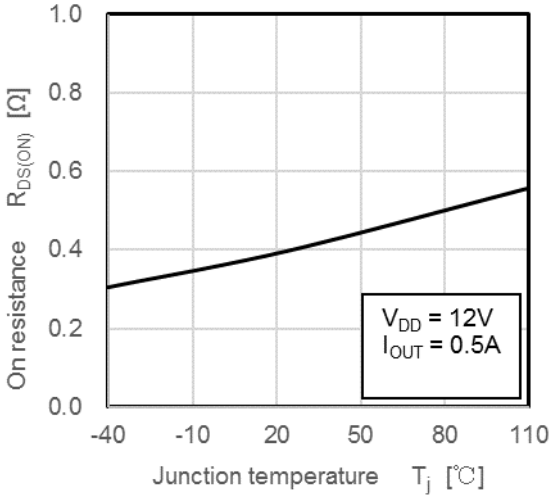

$I_{IH}$ - $T_j$



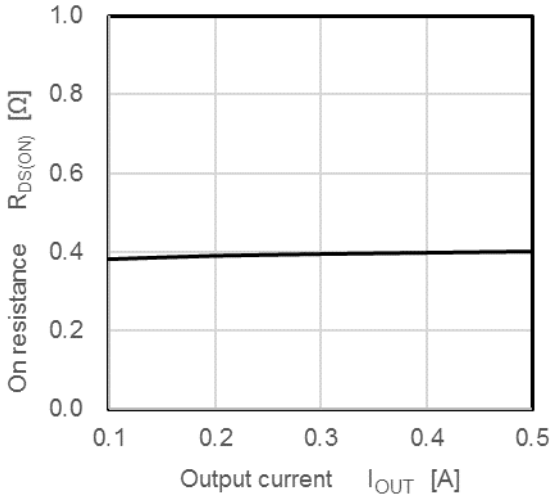

$R_{DS(ON)}$ - $V_{DD}$



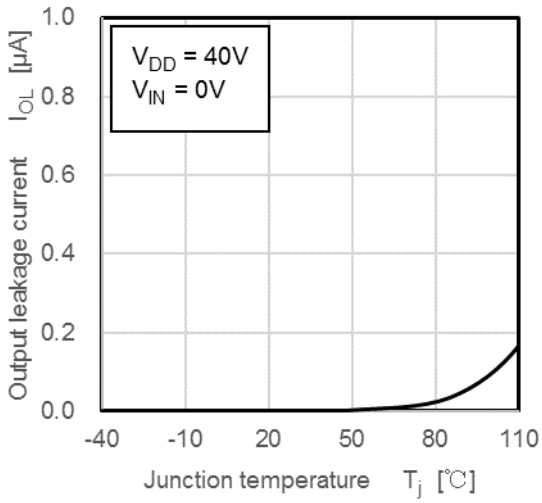

$R_{DS(ON)}$ - $T_j$



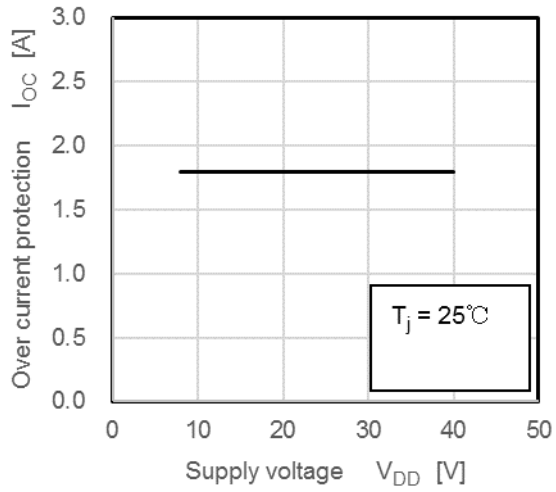

$R_{DS(ON)}$ - $I_{OUT}$



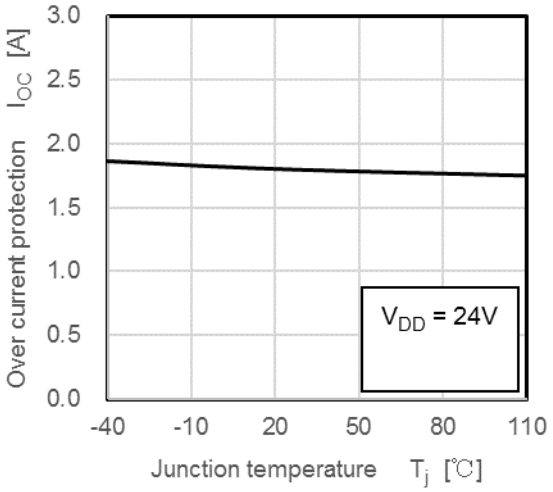

$I_{OL}$ - $T_j$



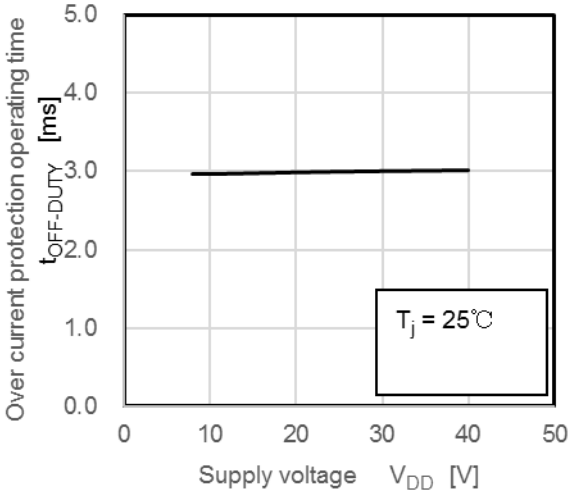
$I_{OC}$ - $V_{DD}$



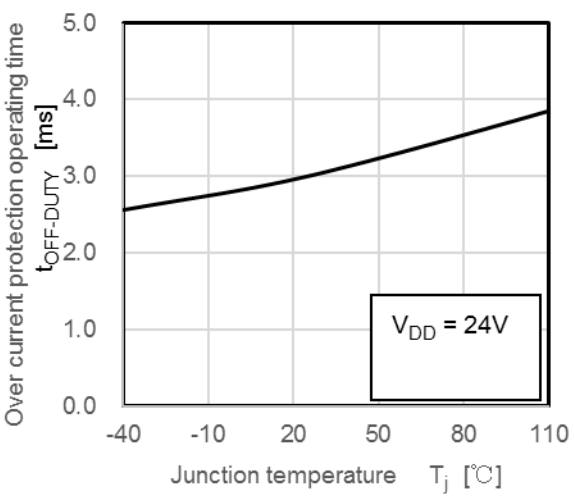

$I_{OC}$ - $T_j$



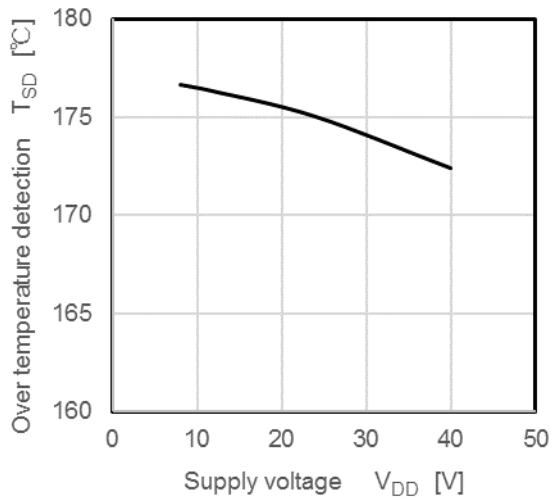

$t_{OFF-DUTY}$ - $V_{DD}$



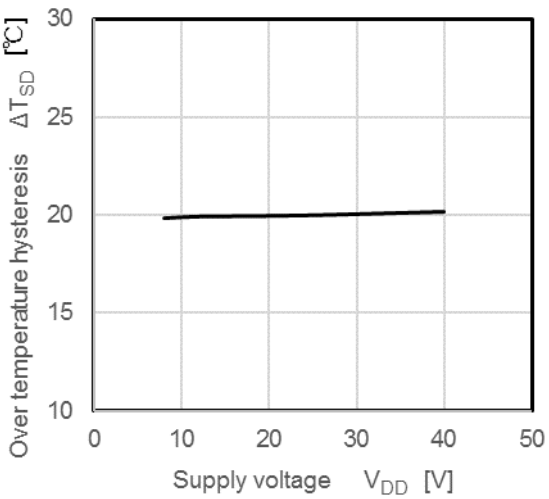

$t_{OFF-DUTY}$ - $T_j$



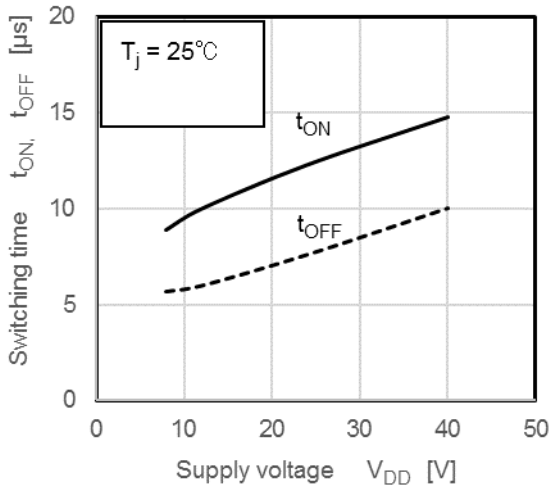

$T_{SD}$ - $V_{DD}$



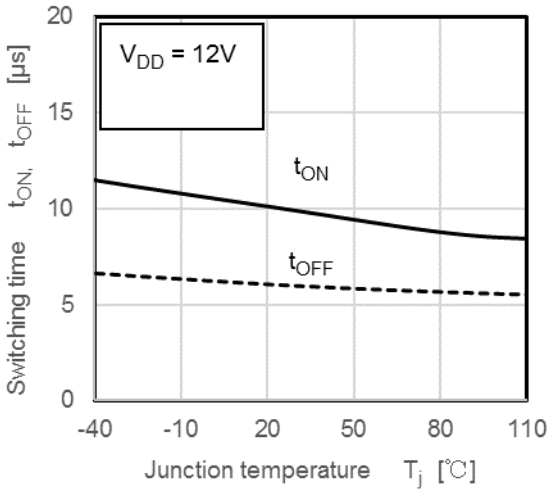

$\Delta T_{SD}$ - $V_{DD}$



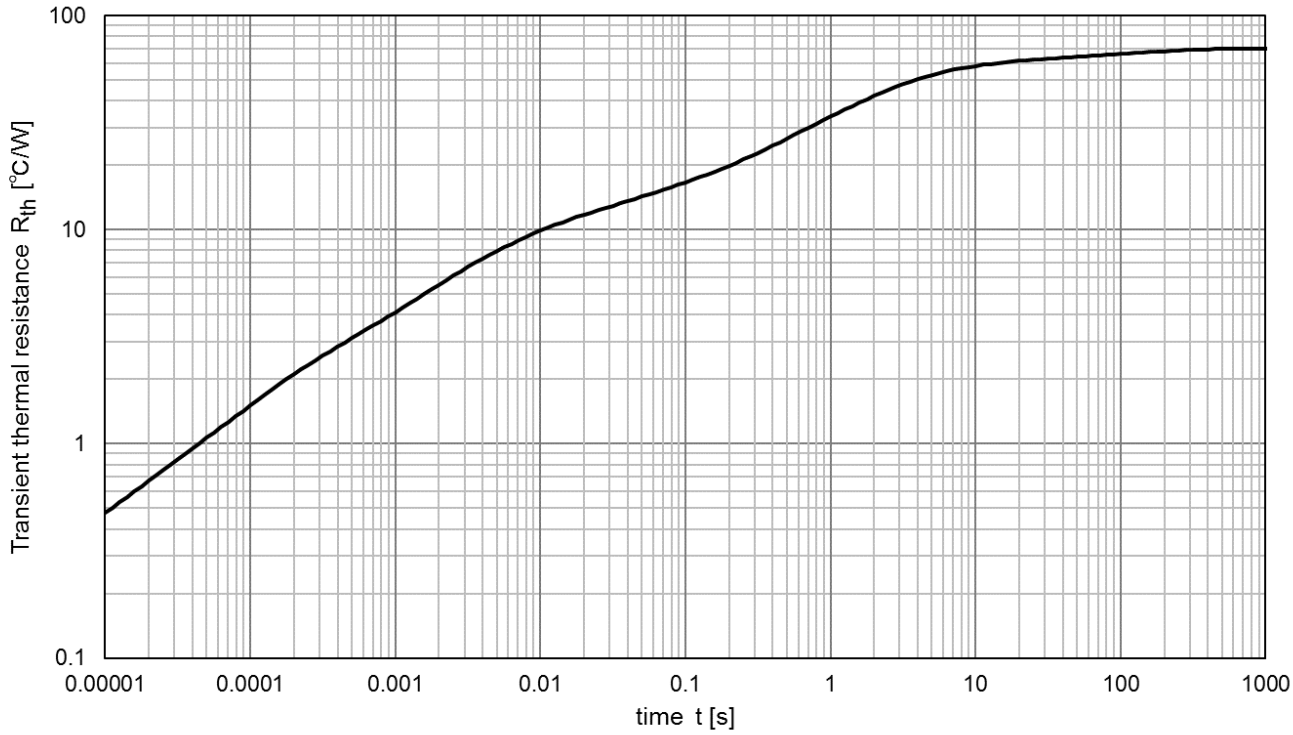
$t_{ON}$, $t_{OFF}$ - $V_{DD}$




$t_{ON}$, $t_{OFF}$ - $T_j$



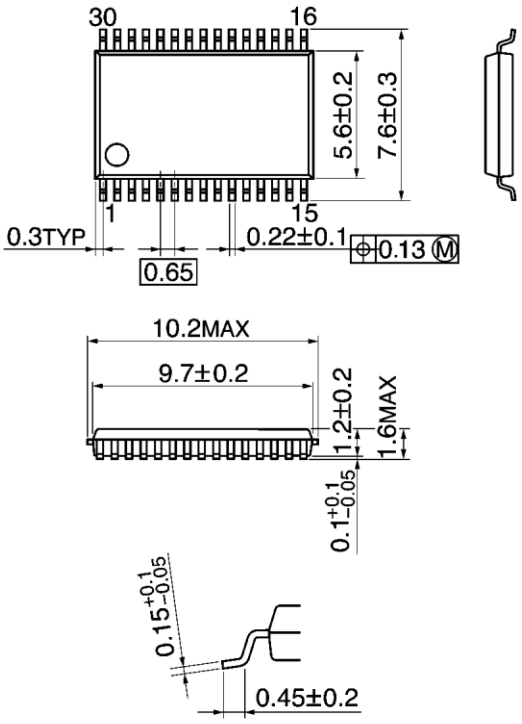

$R_{th}$ - t (1-channel operation)



# 13. Package Information

## 13.1. Package Dimensions

**Unit: mm**




**Weight: 0.176 g (Typ.)**

**Figure 13.1 Package Dimensions**

### 13.2. Marking

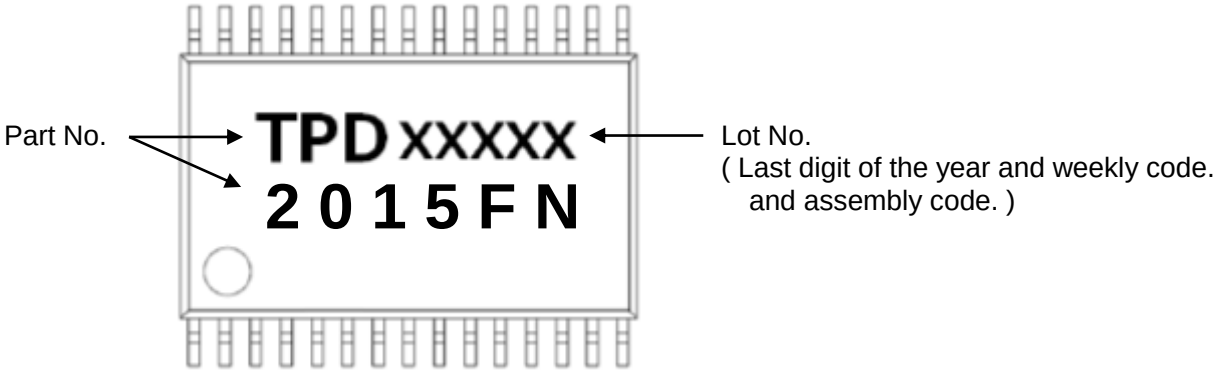



**Figure 13.2 Marking**

### 13.3. Land Pattern Dimensions for Reference only

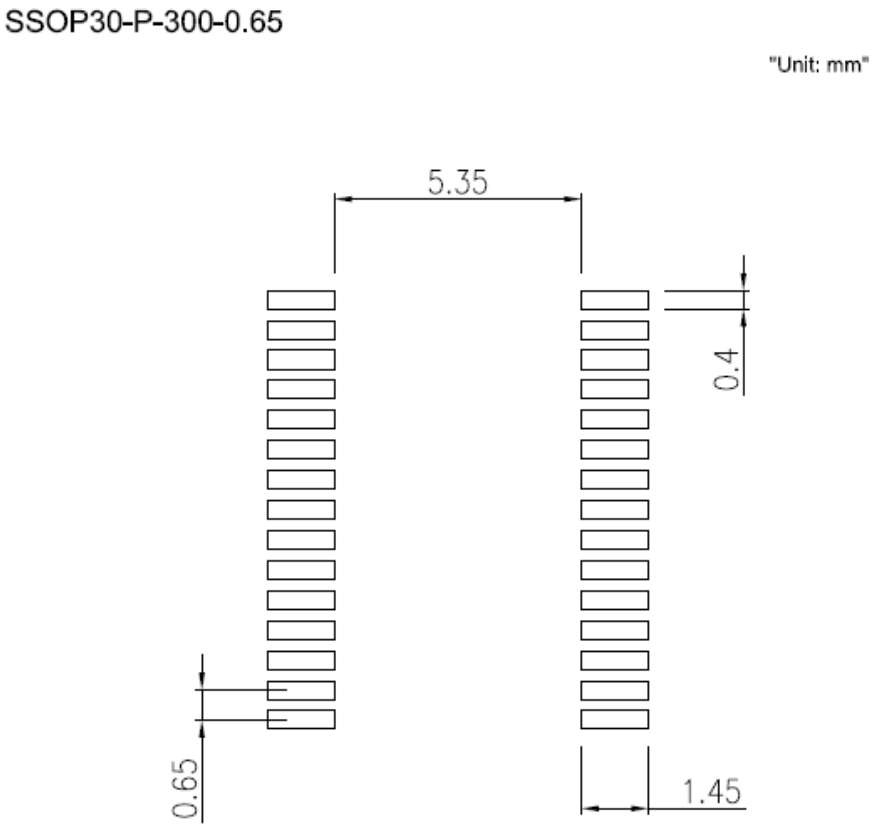



**Figure 13.3 Land Pattern Dimensions for Reference only**

# 14. IC Usage Considerations

## 14.1. Notes on handling of ICs

The absolute maximum ratings of a semiconductor device are a set of ratings that must not be exceeded, even for a moment.

Since the power supply reverse connection protection is not built-in, take measures with an external circuit.

Since the negative bias protection circuit of the output terminal is not built-in, when a negative bias is applied to the output terminal, be sure to connect a diode for back electromotive voltage absorption (FWD) between OUT and GND.

## 14.2. Notes on moisture-proof packaging

After opening the moisture-proof package, mount it within 168 hours in an environment of 30 °C and RH 60% or less.
Since it cannot be baked due to embossing, be sure to use it within the permissible range after opening the moisture-proof packaging.
The standard packing quantity for taping is 2000 pieces / reel.

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