

Surface Mount Small Signal MOSFET

Precautions for use

Outline:

This document provides an overview of the compact surface-mount MOSFET, as well as a description of its construction, features, ratings, and electrical characteristics.

It also compares the characteristics (operating voltage/switching characteristics) between MOSFET and a bipolar transistor with built-in resistor.

Small package MOSFET are used for on/off switches such as 7002 series and load switches of several A or less.

This is for reference only. Do not design the final equipment in this document.

Table of Contents

Outline:	1
1. Structure and Features	3
1.1. Outline of MOSFET	3
1.2. Construction of MOSFET	3
1.3. Features of TOSHIBA CORPORATION Small Size Surface Mount MOSFET	4
2. Maximum rating	6
2.1. Definition of maximum rating	6
2.2. Drain-source voltage V_{DS}	6
2.2.1. Maximum allowable value of the voltage that can be applied between the drain and source	6
2.3. Gated-source voltage V_{GS}	6
2.3.1. Maximum allowable value of the voltage that can be applied between the gate and source	6
2.4. Drain current I_D	7
2.4.1. Maximum allowable value of the drain current that can be supplied by direct current	7
2.5. Power Dissipation (drain dissipation: P_{Dmax})	7
3. Electrical Characteristics	9
3.1. Terms used with MOSFET	9
3.2. Symbols and definitions of switching time in Input/Output waveforms	10
4. Comparison with Built-in Resistor Bipolar Transistor (Digital Transistor)	12
4.1. Comparison of operating voltages	12
4.2. Comparison of switching characteristics	13
5. Reference data	14
5.1. On-Resistor R_{DS} (ON) and Gate-Source Voltage V_{GS}	14
5.2. Temperature Characteristics of On-Resistor R_{DS} (ON)	14
6. Related Links	15
RESTRICTIONS ON PRODUCT USE	16

1. Structure and Features

1.1. Outline of MOSFET

Compared to bipolar transistors, MOSFET,

- (1) Because it is a majority carrier device, there is no accumulation effect of minority carriers switching speed is fast.
- (2) Since the temperature coefficient is negative, problems such as thermal runaway and secondary yield are reduced.
- (3) Since it is not necessary to consider the drive current almost, power saving can be achieved.

With the above features, this is a device widely used for communications equipment, audio visual equipment, etc.

1.2. Construction of MOSFET

MOSFET can be broadly divided into three types, as shown in Figure below.

Figure 1.1 Horizontal D-MOS construction.

This structure makes it possible to reduce the feedback capacitance because the current flows parallel to the surface of the element and the drain contact becomes the surface. It is mainly used for high-frequency MOSFET and is suitable for high-speed switching in the MHz band.

Figure 1.2 Vertical D-MOS construction (planar).

In this structure, the same diffusion window is used for the drain substrate with high resistance, and the gate region to be the channel and the source region to be heavily doped are diffused, and the channel is constructed by utilizing the diffusion difference between the two.

Figure 1.3 Trench construction (U-MOS).

The gate is a U-groove, and the channel is formed vertically to achieve high integration and reduce on-resistance. The on-resistance per unit area of this structure is smaller than that of the planar structure, so the on-resistance can be reduced.

In all the above three types of structures, parasitic diodes enter between the drain and source, so care must be taken in actual design.

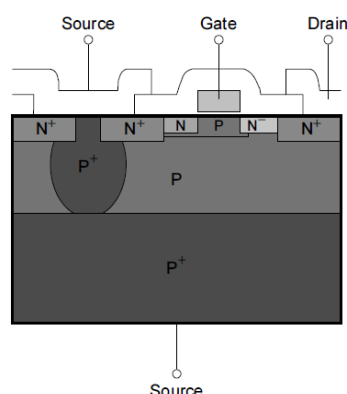


Figure. 1.1 Horizontal D-MOS construction

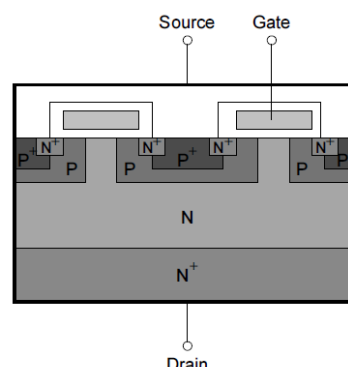


Fig. 1.2 Vertical D-MOS construction (planar)

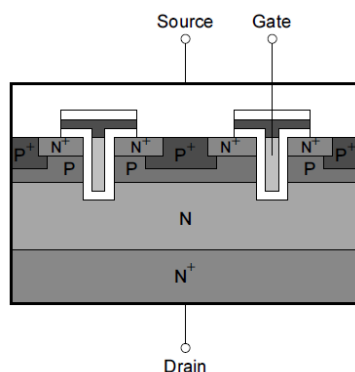


Figure. 1.3 Trench construction (U-MOS)

1.3. Features of TOSHIBA CORPORATION Small Size Surface Mount MOSFET

(1) Drive current not required

Because it is a voltage control element, almost no gate drive current flows, resulting in very low power consumption.

(2) Reduced number of parts

Compared to a transistor with a built-in resistor (digital transistor), there is no selection of a type for each drive voltage, so the number of product types is reduced, which simplifies circuit design and component management.

(3) Driving at low voltage is possible

The lineup is centered on low-voltage drive type, so it is suitable for battery-powered equipment.

(4) Extensive product lineup

Available from general-purpose products with an on-resistance of 20 Ω to ultra-low on-resistance products with an on-resistance of 10 m Ω or less. Drain-source withstand voltage up to 100 V is available for a wide range of circuits.

(5) Excellent switching characteristics

Because it is a majority carrier element, there is no accumulation effect of minority carriers, and excellent switching characteristics are realized.

(6) Compact, high power dissipation surface mount package ideal for high density design

Compact, high power dissipation surface mount package ideal for high density design

In order to accommodate high-density surface-mount with the downsizing and weight reduction of equipment, the lineup is centered on SMDs (Surface Mount Device). LGA(Land Grid

Array), WCSP(Wafer level Chip Scale Package) and flat lead packages can be selected from a compact, high-power dissipation product lineup to suit your application.

2. Maximum rating

2.1. Definition of maximum rating

For semiconductor devices, applied voltage, current, temperature, power loss, and other factors are major factors limiting the operation function.

The maximum rating is the maximum allowable value that must not be exceeded in order to operate the semiconductor element effectively and ensure sufficient reliability, and is specified as the absolute maximum rating.

The absolute maximum rating (hereinafter referred to as the maximum rating) is defined as "the limit value that must not be exceeded either instantaneously or simultaneously, and that must not be reached for any two items at the same time." Operation exceeding the maximum rating may cause breakage, damage or deterioration, and may cause explosion or burn-in hazards.

2.2. Drain-source voltage VDS

2.2.1. Maximum allowable value of the voltage that can be applied between the drain and source

Drain-source breakdown voltage specifications can be classified into V_{DSS} , V_{DSX} , V_{DSR} , V_{DSO} four categories, for example, according to bias conditions between gate-sources.

There is little difference in the size of V_{DSS} , V_{DSX} , V_{DSR} , and the relation of $V_{DSS}=V_{DSX}=V_{DSR}$ holds.

If you specify V_{DSS} in this section, it will be the highest draining-source VDS rating. However, that the above relationship does not hold for the trench-structured element.

Suppose that a voltage lower than V_{DS} max. rating is applied between the drain and source in V_{DSO} mode (gate open). In such cases, MOSFET itself has an extremely high-impedance input. Therefore, the gate/source is biased due to the induction of static electricity, etc., and this may cause the gate/source to become "on" and damage the device. Therefore ,don't use this mode.

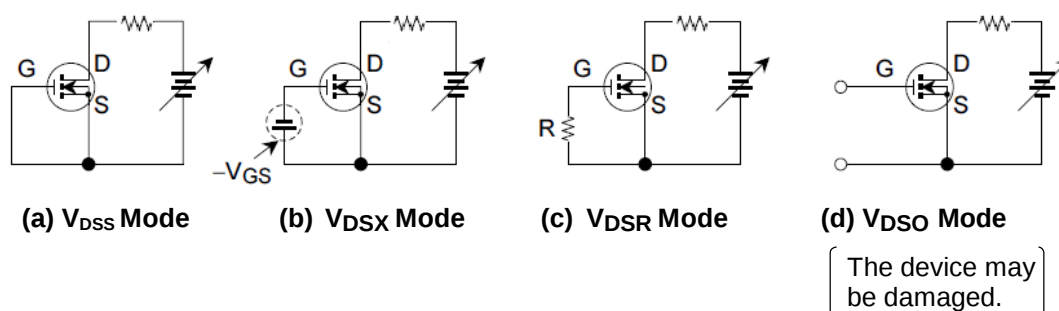


Figure 2.1 Drain-Source Breakdown Voltage

2.3. Gated-source voltage V_{GSS}

2.3.1. Maximum allowable value of the voltage that can be applied between the gate and source

There are two types of V_{GSS} items, one with both positive and negative signs and one with positive and negative signs. Elements with both positive and negative signs may have a bi-directional protection diode inserted between the gate and source to prevent gate breakdown

or may not have a protection diode. A protection diode in one direction is inserted in the element with either sign of positive or negative.

2.4. Drain current I_D

2.4.1. Maximum allowable value of the drain current that can be supplied by direct current

Many elements describe the maximum drain current rating in terms of DC rating and pulse rating. For an element whose pulse rating is not stated, consider that nearly twice the DC rating is the pulse rating.

2.5. Power Dissipation (drain dissipation: P_{Dmax})

The power dissipation of a single MOSFET element depends on the packaging. Please refer to the individual specifications for the power dissipation of each package.

Figures 2.2 and 2.3 show examples of power dissipation characteristics for each package.

In the mounted state, the power dissipation from the lead to the board is increased, which means that the power dissipation is greater than that of a single unit.

The heat dissipation during mounting varies greatly depending on the board material, board area, Pad area, ambient temperature, and other operating environments. Design the product with sufficient heat dissipation in mind when using it.

Please note that the published power dissipation values for each individual product type may differ in some cases.

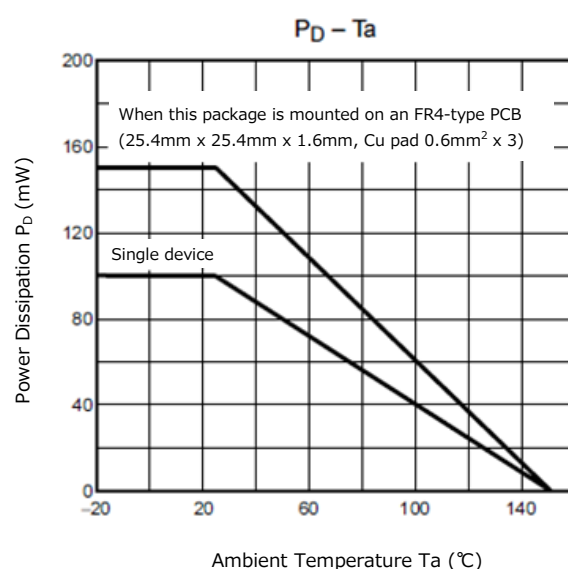


Figure 2.2 Power Dissipation Example for USM Package

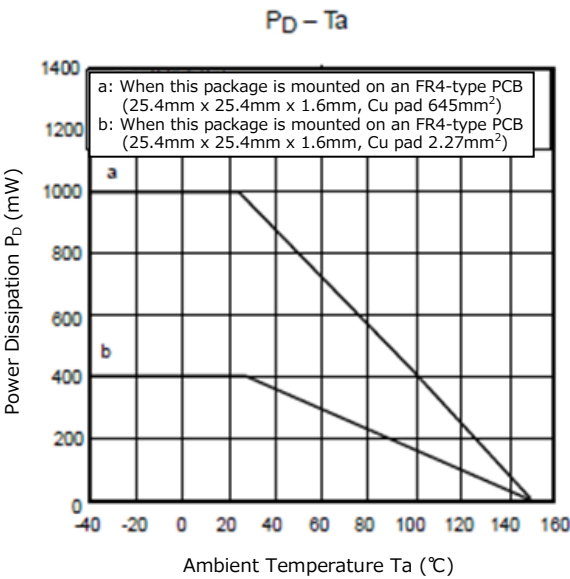


Figure 2.3 Power Dissipation Example for UDFN6B Packag

3. Electrical Characteristics

3.1. Terms used with MOSFET

(1) $|Y_{fs}|$: Forward transfer admittance

$$|Y_{fs}| = \Delta I_D / \Delta V_{GS}$$

$|Y_{fs}|$ expresses MOSFET's sensitivity or amplifying power.

(2) V_{th} : Gate threshold voltage

The gate-source voltage when the drain current begins to flow (in the threshold region) when the gate-source voltage is gradually increased with a voltage applied between the drain and source.

(3) $R_{DS(ON)}$: Drain-source ON-resistance

It corresponds to the collector-emitter saturation-voltage $V_{CE(sat)}$ of the bipolar transistor, and is a guideline for determining the self-loss (dissipation) in the ON state.

(4) $V_{DS(ON)}$: Drain-source ON-voltage

This is the dissipation in the ON state, which is the same as for $R_{DS(ON)}$ and is expressed as a voltage.

(5) C_{iss} , C_{rss} , C_{oss} : Capacitances

C_{iss} , C_{rss} and C_{oss} are input capacitance, feedback capacitance and output capacitance respectively.

When MOSFET is used in switching operation, this capacitance constrains the available frequency or switching speed.

(6) t_{on} , t_{off} , t_r , t_f : Switching time

Because MOSFET is a majority carrier device, its switching properties are much faster than bipolar transistors, and it is superior in high-speed operation and high-frequency operation.

Since this device has no accumulation time due to the accumulation effect of carriers and no temperature dependence of capacitance, the switching characteristics are hardly affected by temperature.

Figure 3.1 shows an example of a switching time measurement circuit and input/output waveforms.

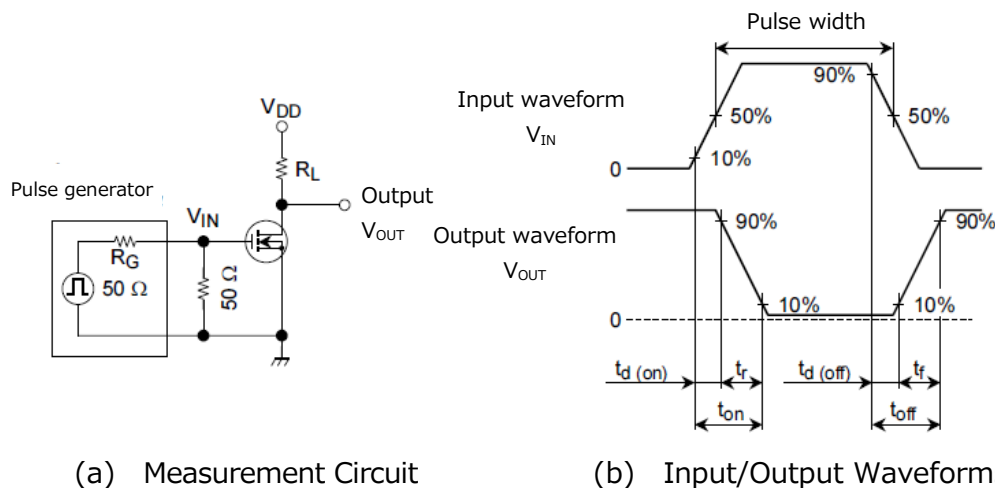


Figure 3.1 Switching Time Measurement Circuit and Input/Output Waveforms

3.2. Symbols and definitions of switching time in Input/Output waveforms

(1) $t_{d(on)}$: Turn-ON delay time

Charge time required to raise the input capacitance C_{iss} to the gate threshold voltage V_{th} .

(2) t_r : Rise time

Charge duration required to pull the charge-based gate-to-source voltage to be charged to the input capacitance from the gate threshold voltage V_{th} to a specified V_{GS} level between the linear and saturated regions.

(3) $t_{d(off)}$: Turn-OFF delay time

Discharge duration required to pull the charge-based potential on the input capacitance down to a specified V_{GS} level in the linear region by the drive voltage in the saturation region.

(4) t_f : Fall time

Time required for the voltage based on the charge charged in the input capacitance to be lowered from the driving voltage in the saturation region to the gate threshold voltage V_{th} level and the output voltage to be raised to the supply voltage.

The switching time can be divided into four times as described above. The sum of the turn-ON delay time $t_{d(on)}$ and the rise time t_r is expressed as a turn-ON time t_{on} , and the sum of the turn-OFF delay time $t_{d(off)}$ and the fall time t_f is expressed as a turn-off time t_{off} .

$$t_{d(on)} + t_r = t_{on}$$

$$t_{d(off)} + t_f = t_{off}$$

Figure. 3.2 shows the switching characteristics (switching time versus drain current I_D)

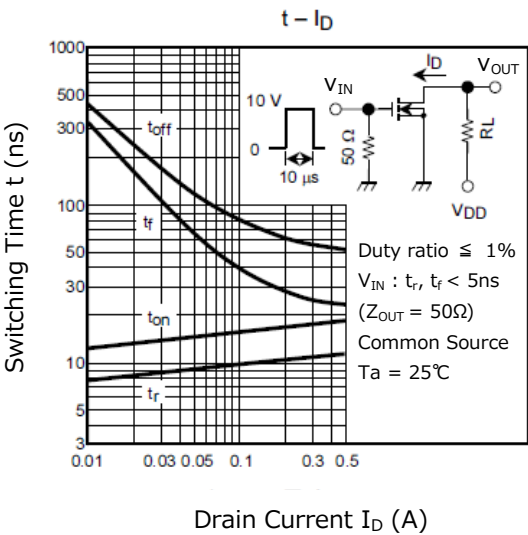
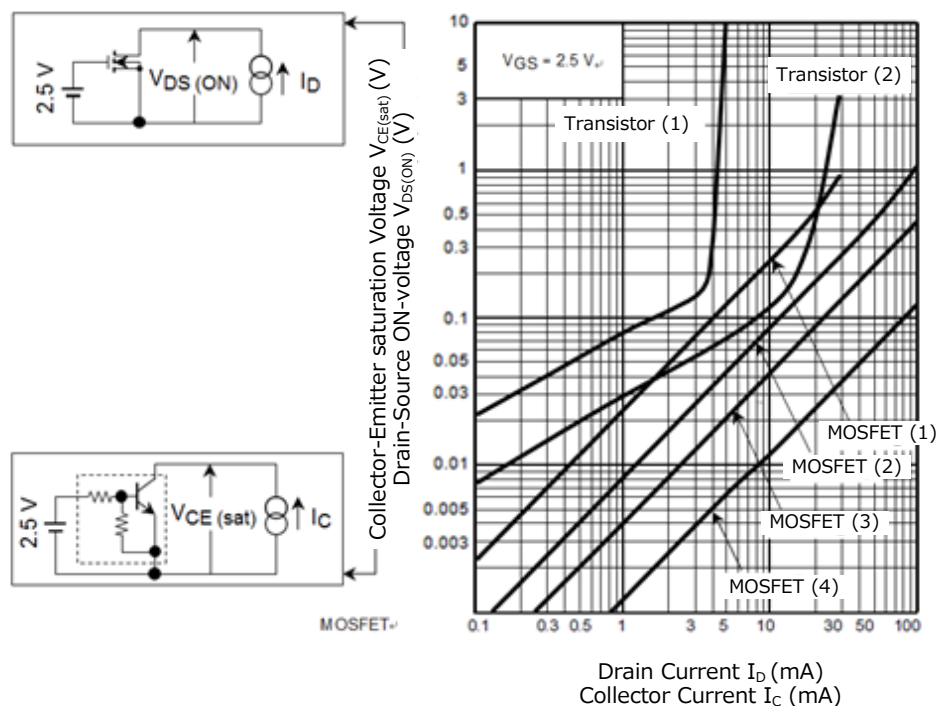


Figure 3.2 Switching Characteristics

4. Comparison with Built-in Resistor Bipolar Transistor (Digital Transistor)

4.1. Comparison of operating voltages

The Drain-Source ON resistance of MOSFET shows a nearly constant value independent of the current value. Therefore, in the low-current region, $V_{DS(ON)}$ of a MOSFET is smaller than $V_{CE(sat)}$ of Built-in Resistor Bipolar Transistor (Digital Transistor).



Transistor (1): Built-in Resistor Bipolar Transistor $R_1 = R_2 = 47k\Omega$
 Transistor (2): Built-in Resistor Bipolar Transistor $R_1 = R_2 = 4.7k\Omega$
 MOSFET(1), (2), (3), (4): No external resister needed

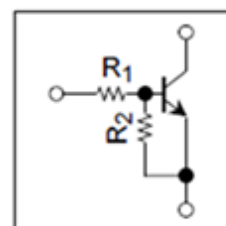


Figure 4.1 Comparing the operating voltages of MOSFET and transistors

4.2. Comparison of switching characteristics

Because MOSFETs are not subject the same charge storage effect as bipolar transistors, they are capable high-speed switching.

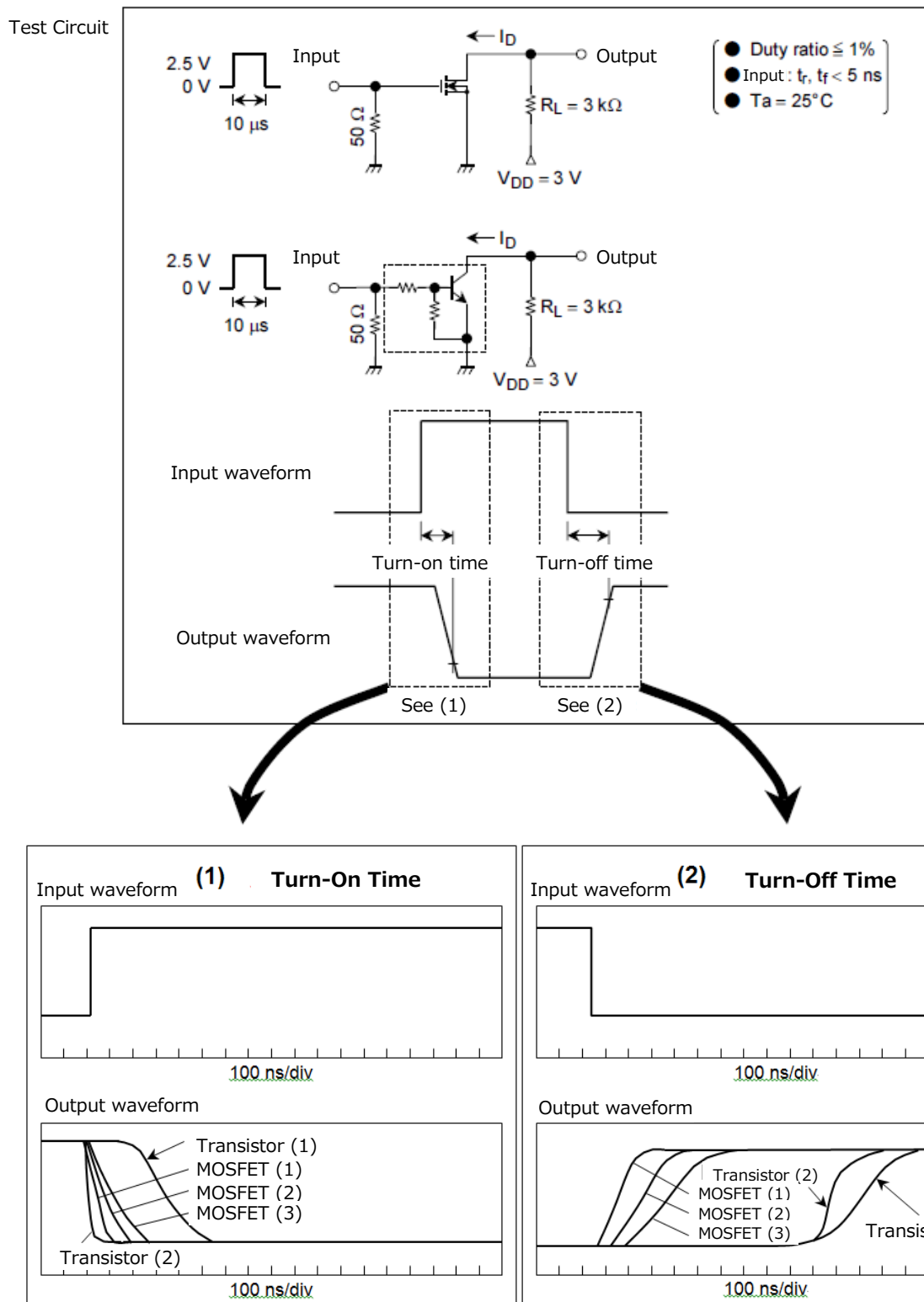


Figure 4.2 MOSFET Turn-On and Turn-Off times

5. Reference data

5.1. On-Resistor $R_{DS(ON)}$ and Gate-Source Voltage V_{GS}

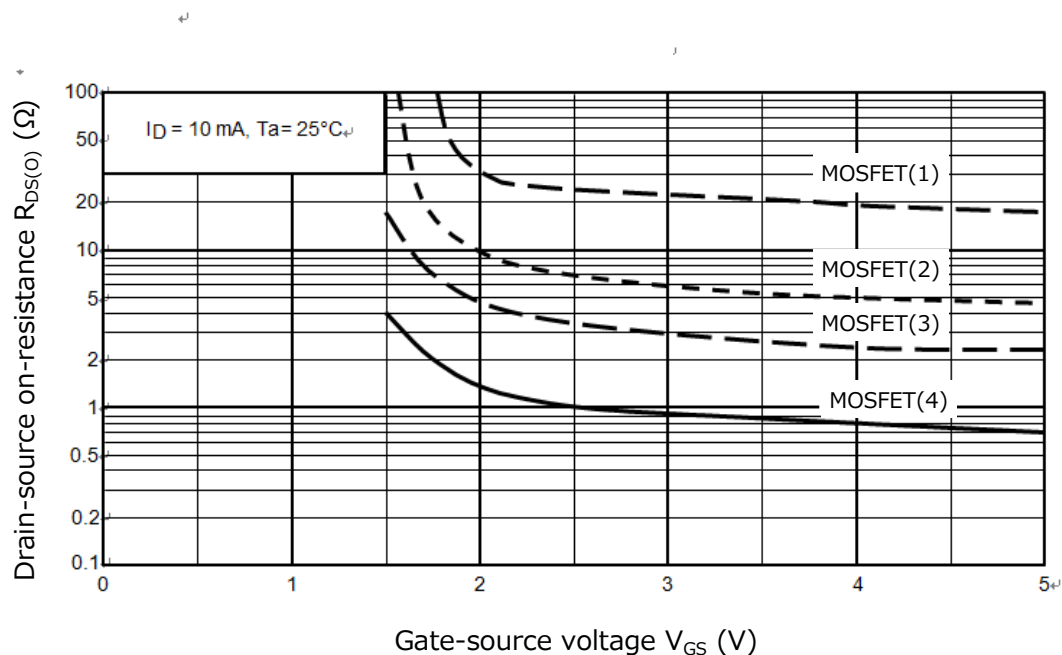


Figure 5.1 $R_{DS(ON)} - V_{GS}$

5.2. Temperature Characteristics of On-Resistor $R_{DS(ON)}$

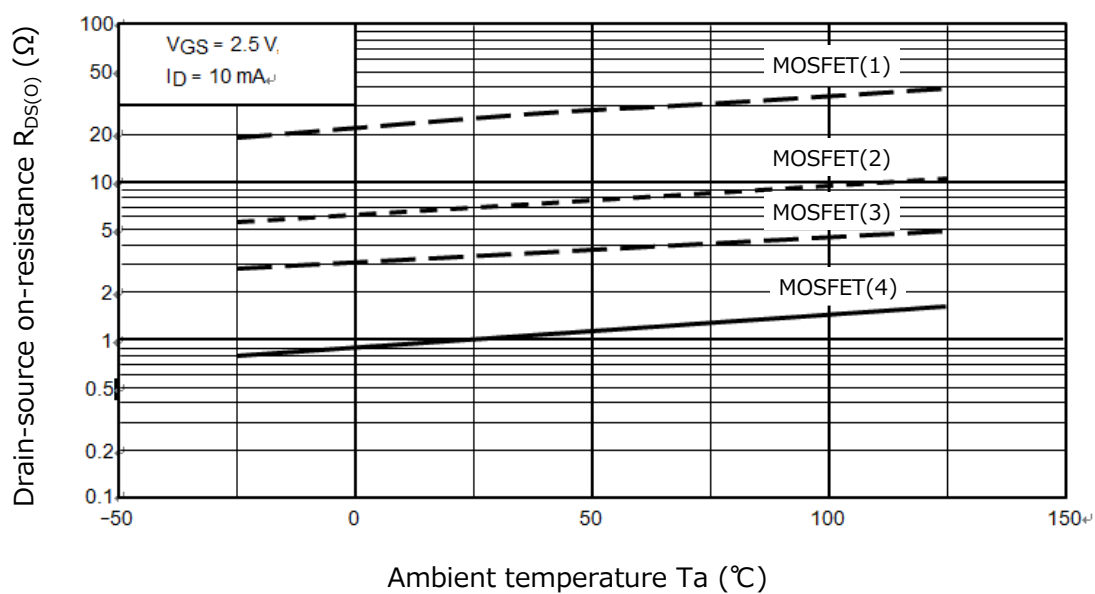


Figure 5.2 $R_{DS(ON)} - T_a$

6. Related Links

■ MOSFETs Lineup

[Click](#)

■ MOSFET (Parametric Search)

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■ Stock Check & Purchase



■ FAQ

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