

# SSM6L56FE

## 1. Applications

- High-Speed Switching

## 2. Features

- (1) 1.5-V drive
- (2) Low drain-source on-resistance

Q1 N-channel:

$$R_{DS(ON)} = 235 \text{ m}\Omega \text{ (max) (@}V_{GS} = 4.5 \text{ V, } I_D = 800 \text{ mA)}$$

$$R_{DS(ON)} = 300 \text{ m}\Omega \text{ (max) (@}V_{GS} = 2.5 \text{ V, } I_D = 600 \text{ mA)}$$

$$R_{DS(ON)} = 480 \text{ m}\Omega \text{ (max) (@}V_{GS} = 1.8 \text{ V, } I_D = 200 \text{ mA)}$$

$$R_{DS(ON)} = 840 \text{ m}\Omega \text{ (max) (@}V_{GS} = 1.5 \text{ V, } I_D = 50 \text{ mA)}$$

Q2 P-channel:

$$R_{DS(ON)} = 390 \text{ m}\Omega \text{ (max) (@}V_{GS} = -4.5 \text{ V, } I_D = -800 \text{ mA)}$$

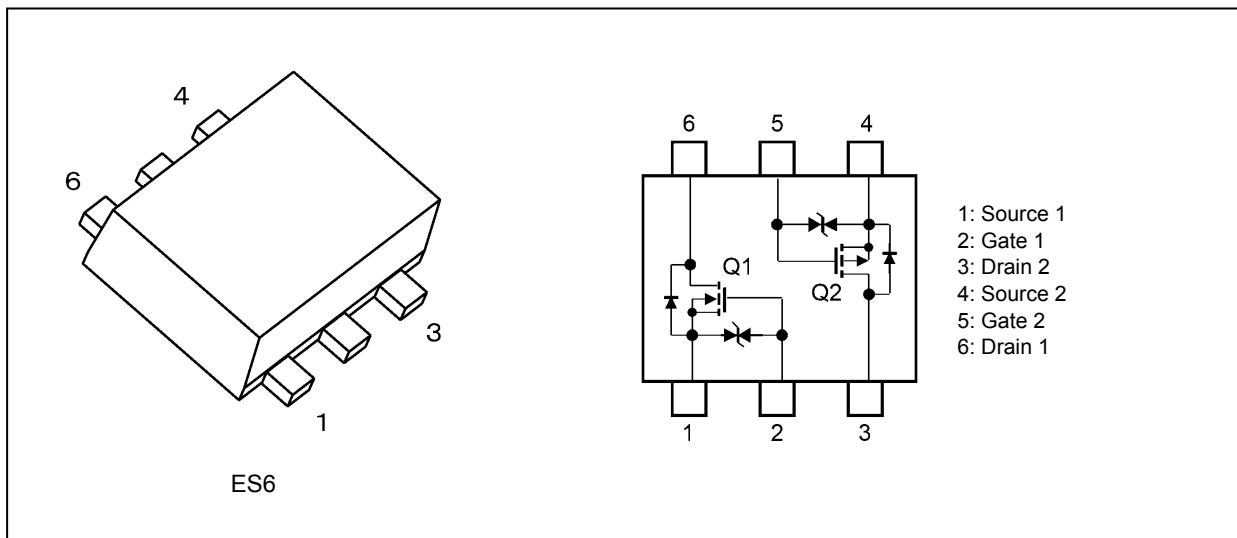
$$R_{DS(ON)} = 480 \text{ m}\Omega \text{ (max) (@}V_{GS} = -2.5 \text{ V, } I_D = -500 \text{ mA)}$$

$$R_{DS(ON)} = 660 \text{ m}\Omega \text{ (max) (@}V_{GS} = -1.8 \text{ V, } I_D = -200 \text{ mA)}$$

$$R_{DS(ON)} = 900 \text{ m}\Omega \text{ (max) (@}V_{GS} = -1.5 \text{ V, } I_D = -100 \text{ mA)}$$

$$R_{DS(ON)} = 4000 \text{ m}\Omega \text{ (max) (@}V_{GS} = -1.2 \text{ V, } I_D = -10 \text{ mA)}$$

## 3. Packaging and Internal Circuit



Start of commercial production  
2019-05

### 4. Absolute Maximum Ratings (Note)

#### 4.1. Q1 Absolute Maximum Ratings (Unless otherwise specified, $T_a = 25\text{ }^\circ\text{C}$ )

Characteristics	Symbol	Rating	Unit
Drain-source voltage	$V_{DSS}$	20	V
Gate-source voltage	$V_{GSS}$	$\pm 8$	
Drain current (DC) (Note 1)	$I_D$	800	mA
Drain current (pulsed) (Note 1)	$I_{DP}$	1600	

Note 1: Ensure that the channel temperature does not exceed  $150\text{ }^\circ\text{C}$ .

#### 4.2. Q2 Absolute Maximum Ratings (Unless otherwise specified, $T_a = 25\text{ }^\circ\text{C}$ )

Characteristics	Symbol	Rating	Unit
Drain-source voltage	$V_{DSS}$	-20	V
Gate-source voltage	$V_{GSS}$	$\pm 8$	
Drain current (DC) (Note 1)	$I_D$	-800	mA
Drain current (pulsed) (Note 1)	$I_{DP}$	-1600	

Note 1: Ensure that the channel temperature does not exceed  $150\text{ }^\circ\text{C}$ .

#### 4.3. Absolute Maximum Ratings (Unless otherwise specified, $T_a = 25\text{ }^\circ\text{C}$ ) (Q1, Q2 Common)

Characteristics	Symbol	Rating	Unit
Power dissipation (Note 1)	$P_D$	150	mW
Power dissipation (Note 2)		250	
Channel temperature	$T_{ch}$	150	$^\circ\text{C}$
Storage temperature	$T_{stg}$	-55 to 150	

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.

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).

Note 1: Device mounted on an FR4 board.(total rating)  
(25.4 mm × 25.4 mm × 1.6 mm, Cu pad: 0.135 mm<sup>2</sup> × 6)

Note 2: Device mounted on an FR4 board.(total rating)  
(25.4 mm × 25.4 mm × 1.6 mm, Cu pad: 645 mm<sup>2</sup>)

Note: The MOSFETs in this device are sensitive to electrostatic discharge. When handling this device, the worktables, operators, soldering irons and other objects should be protected against anti-static discharge.

Note: The channel-to-ambient thermal resistance,  $R_{th(ch-a)}$ , and the drain power dissipation,  $P_D$ , vary according to the board material, board area, board thickness and pad area. When using this device, be sure to take heat dissipation fully into account.

### 5. Electrical Characteristics

#### 5.1. Q1 Static Characteristics (Unless otherwise specified, $T_a = 25\text{ }^\circ\text{C}$ )

Characteristics	Symbol	Test Condition	Min	Typ.	Max	Unit
Gate leakage current	$I_{GSS}$	$V_{DS} = 0\text{ V}, V_{GS} = \pm 6\text{ V}$	—	—	$\pm 1$	$\mu\text{A}$
Drain cut-off current	$I_{DSS}$	$V_{DS} = 16\text{ V}, V_{GS} = 0\text{ V}$	—	—	1	
Drain-source breakdown voltage	$V_{(BR)DSS}$	$I_D = 1\text{ mA}, V_{GS} = 0\text{ V}$	20	—	—	V
Drain-source breakdown voltage (Note 1)	$V_{(BR)DSX}$	$I_D = 1\text{ mA}, V_{GS} = -5\text{ V}$	15	—	—	
Gate threshold voltage (Note 2)	$V_{th}$	$V_{DS} = 3\text{ V}, I_D = 1\text{ mA}$	0.4	—	1.0	
Drain-source on-resistance (Note 3)	$R_{DS(ON)}$	$I_D = 800\text{ mA}, V_{GS} = 4.5\text{ V}$	—	186	235	$\text{m}\Omega$
		$I_D = 600\text{ mA}, V_{GS} = 2.5\text{ V}$	—	230	300	
		$I_D = 200\text{ mA}, V_{GS} = 1.8\text{ V}$	—	290	480	
		$I_D = 50\text{ mA}, V_{GS} = 1.5\text{ V}$	—	360	840	
Forward transfer admittance (Note 3)	$ Y_{fs} $	$V_{DS} = 3\text{ V}, I_D = 200\text{ mA}$	—	1.4	—	S

Note 1: If a reverse bias is applied between gate and source, this device enters  $V_{(BR)DSX}$  mode. Note that the drain-source breakdown voltage is lowered in this mode.

Note 2: Let  $V_{th}$  be the voltage applied between gate and source that causes the drain current ( $I_D$ ) to below (1 mA for this device). Then, for normal switching operation,  $V_{GS(ON)}$  must be higher than  $V_{th}$ , and  $V_{GS(OFF)}$  must be lower than  $V_{th}$ . This relationship can be expressed as:  $V_{GS(OFF)} < V_{th} < V_{GS(ON)}$ .

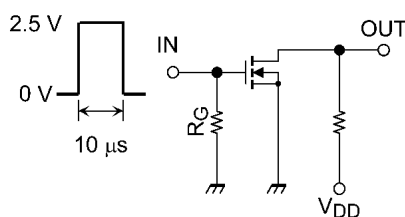
Take this into consideration when using the device.

Note 3: Pulse measurement.

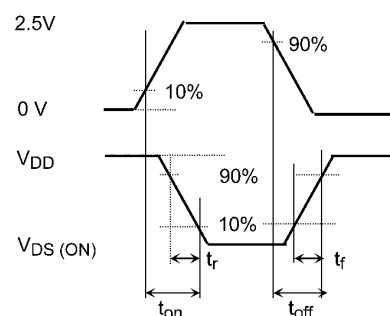
#### 5.2. Q1 Dynamic Characteristics (Unless otherwise specified, $T_a = 25\text{ }^\circ\text{C}$ )

Characteristics	Symbol	Test Condition	Min	Typ.	Max	Unit
Input capacitance	$C_{iss}$	$V_{DS} = 10\text{ V}, V_{GS} = 0\text{ V},$ $f = 1\text{ MHz}$	—	55	—	$\text{pF}$
Reverse transfer capacitance	$C_{rss}$		—	6	—	
Output capacitance	$C_{oss}$		—	16	—	
Switching time (turn-on time)	$t_{on}$	$V_{DD} = 10\text{ V}, I_D = 200\text{ mA},$ $V_{GS} = 0\text{ to }2.5\text{ V}, R_G = 50\ \Omega$	—	5.5	—	ns
Switching time (turn-off time)	$t_{off}$		—	8.5	—	

#### 5.3. Q1 Switching Time Test Circuit



Switching Time Test Circuit



Input Waveform/Output Waveform

#### 5.4. Q1 Gate Charge Characteristics (Unless otherwise specified, $T_a = 25\text{ }^\circ\text{C}$ )

Characteristics	Symbol	Test Condition	Min	Typ.	Max	Unit
Total gate charge (gate-source plus gate-drain)	$Q_g$	$V_{DD} = 10\text{ V}, I_D = 800\text{ mA},$ $V_{GS} = 4.5\text{ V}$	—	1.0	—	nC
Gate-source charge 1	$Q_{gs1}$		—	0.12	—	
Gate-drain charge	$Q_{gd}$		—	0.4	—	

### 5.5. Q1 Source-Drain Characteristics (Unless otherwise specified, $T_a = 25\text{ }^\circ\text{C}$ )

Characteristics	Symbol	Test Condition	Min	Typ.	Max	Unit
Diode forward voltage (Note 1)	$V_{DSF}$	$I_D = -800\text{ mA}$ , $V_{GS} = 0\text{ V}$	—	-0.82	-1.2	V

Note 1: Pulse measurement.

### 5.6. Q2 Static Characteristics (Unless otherwise specified, $T_a = 25\text{ }^\circ\text{C}$ )

Characteristics	Symbol	Test Condition	Min	Typ.	Max	Unit
Gate leakage current	$I_{GSS}$	$V_{DS} = 0\text{ V}$ , $V_{GS} = \pm 8\text{ V}$	—	—	$\pm 1$	$\mu\text{A}$
Drain cut-off current	$I_{DSS}$	$V_{DS} = -20\text{ V}$ , $V_{GS} = 0\text{ V}$	—	—	-1	
Drain-source breakdown voltage	$V_{(BR)DSS}$	$I_D = -1\text{ mA}$ , $V_{GS} = 0\text{ V}$	-20	—	—	V
Drain-source breakdown voltage (Note 1)	$V_{(BR)DSX}$	$I_D = -1\text{ mA}$ , $V_{GS} = 5\text{ V}$	-15	—	—	
Gate threshold voltage (Note 2)	$V_{th}$	$V_{DS} = -3\text{ V}$ , $I_D = -1\text{ mA}$	-0.3	—	-1.0	
Drain-source on-resistance (Note 3)	$R_{DS(ON)}$	$I_D = -800\text{ mA}$ , $V_{GS} = -4.5\text{ V}$	—	310	390	$\text{m}\Omega$
		$I_D = -500\text{ mA}$ , $V_{GS} = -2.5\text{ V}$	—	380	480	
		$I_D = -200\text{ mA}$ , $V_{GS} = -1.8\text{ V}$	—	470	660	
		$I_D = -100\text{ mA}$ , $V_{GS} = -1.5\text{ V}$	—	560	900	
		$I_D = -10\text{ mA}$ , $V_{GS} = -1.2\text{ V}$	—	770	4000	
Forward transfer admittance (Note 3)	$ Y_{fs} $	$V_{DS} = -3\text{ V}$ , $I_D = -100\text{ mA}$	0.5	1.0	—	S

Note 1: If a reverse bias is applied between gate and source, this device enters  $V_{(BR)DSX}$  mode. Note that the drain-source breakdown voltage is lowered in this mode.

Note 2: Let  $V_{th}$  be the voltage applied between gate and source that causes the drain current ( $I_D$ ) to below (-1 mA for this device). Then, for normal switching operation,  $V_{GS(ON)}$  must be higher than  $V_{th}$ , and  $V_{GS(OFF)}$  must be lower than  $V_{th}$ . This relationship can be expressed as:  $V_{GS(OFF)} < V_{th} < V_{GS(ON)}$ .

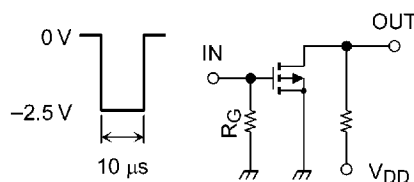
Take this into consideration when using the device.

Note 3: Pulse measurement.

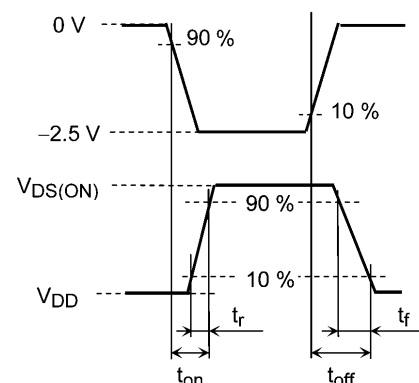
### 5.7. Q2 Dynamic Characteristics (Unless otherwise specified, $T_a = 25\text{ }^\circ\text{C}$ )

Characteristics	Symbol	Test Condition	Min	Typ.	Max	Unit
Input capacitance	$C_{iss}$	$V_{DS} = -10\text{ V}$ , $V_{GS} = 0\text{ V}$ , $f = 1\text{ MHz}$	—	100	—	$\text{pF}$
Reverse transfer capacitance	$C_{rss}$		—	10	—	
Output capacitance	$C_{oss}$		—	16	—	
Switching time (turn-on time)	$t_{on}$	$V_{DD} = -10\text{ V}$ , $I_D = -200\text{ mA}$ , $V_{GS} = 0\text{ to }-2.5\text{ V}$ , $R_G = 50\ \Omega$	—	8	—	ns
Switching time (turn-off time)	$t_{off}$		—	26	—	

### 5.8. Q2 Switching Time Test Circuit



Switching Time Test Circuit



Input Waveform/Output Waveform

### 5.9. Q2 Gate Charge Characteristics (Unless otherwise specified, $T_a = 25\text{ }^\circ\text{C}$ )

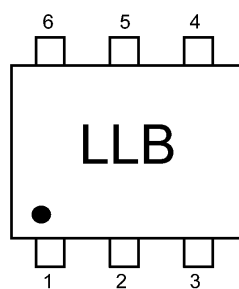
Characteristics	Symbol	Test Condition	Min	Typ.	Max	Unit
Total gate charge (gate-source plus gate-drain)	$Q_g$	$V_{DD} = -10\text{ V}$ , $I_D = -800\text{ mA}$ , $V_{GS} = -4.5\text{ V}$	—	1.6	—	nC
Gate-source charge 1	$Q_{gs1}$		—	0.2	—	
Gate-drain charge	$Q_{gd}$		—	0.4	—	

### 5.10. Q2 Source-Drain Characteristics (Unless otherwise specified, $T_a = 25\text{ }^\circ\text{C}$ )

Characteristics	Symbol	Test Condition	Min	Typ.	Max	Unit
Diode forward voltage (Note 1)	$V_{DSF}$	$I_D = 800\text{ mA}$ , $V_{GS} = 0\text{ V}$	—	0.9	1.2	V

Note 1: Pulse measurement.

## 6. Marking



Marking

### 7. Characteristics Curves (Note)

#### 7.1. Q1 Characteristics Curves

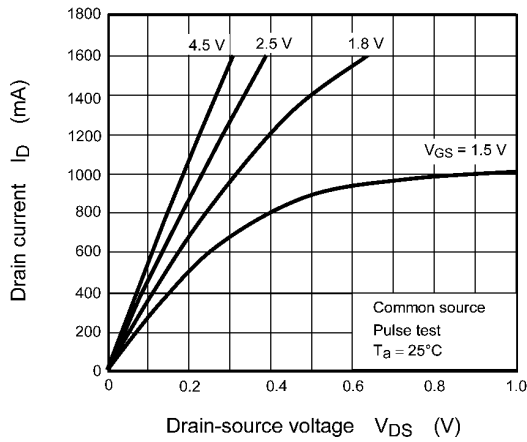


Fig. 7.1.1  $I_D - V_{DS}$

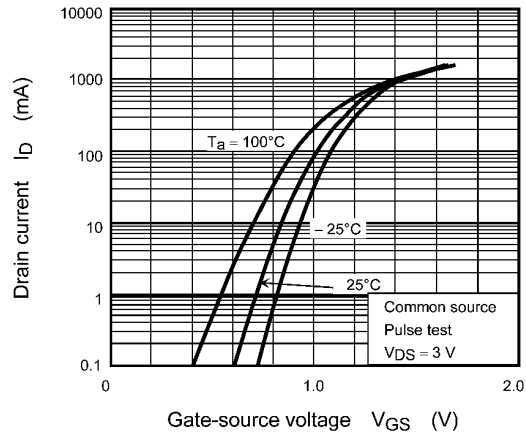


Fig. 7.1.2  $I_D - V_{GS}$

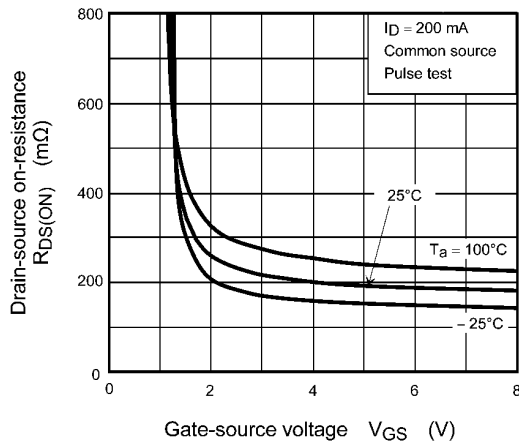


Fig. 7.1.3  $R_{DS(ON)} - V_{GS}$

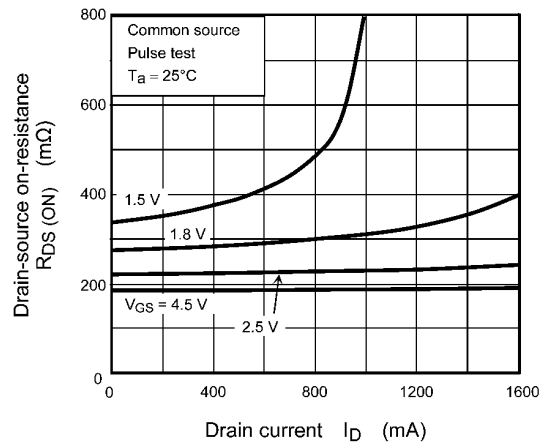


Fig. 7.1.4  $R_{DS(ON)} - I_D$

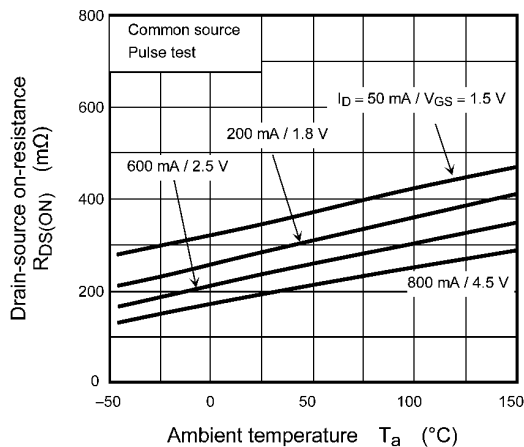


Fig. 7.1.5  $R_{DS(ON)} - T_a$

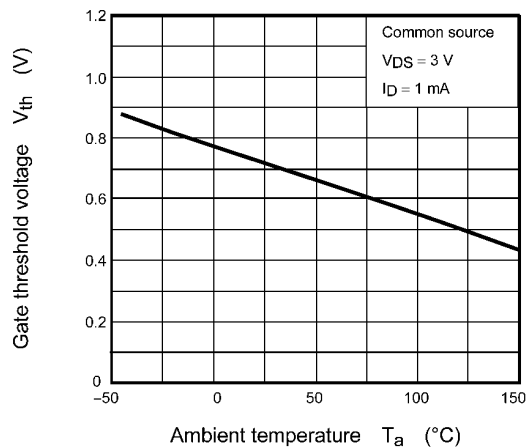


Fig. 7.1.6  $V_{th} - T_a$

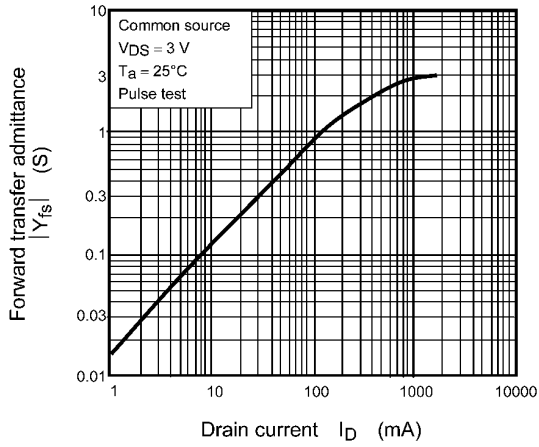


Fig. 7.1.7  $|Y_{fs}| - I_D$

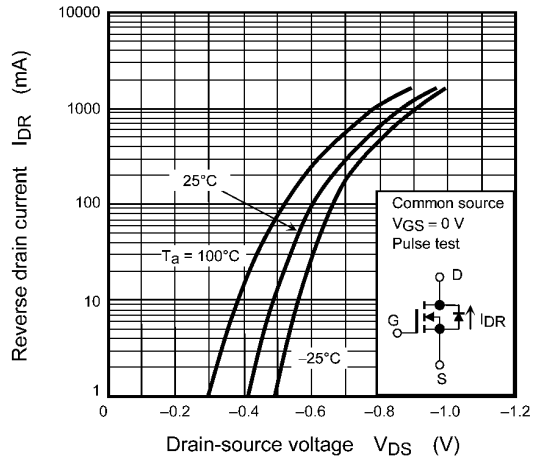


Fig. 7.1.8  $I_{DR} - V_{DS}$

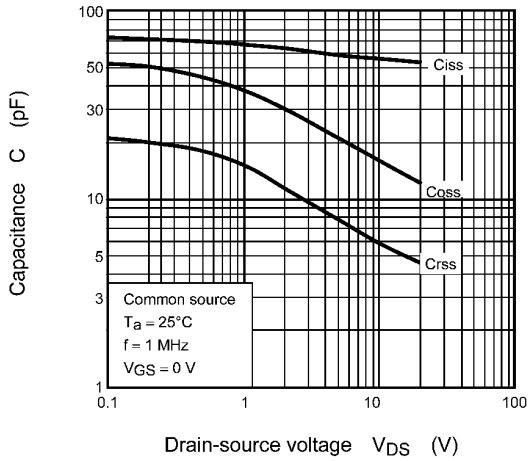


Fig. 7.1.9  $C - V_{DS}$

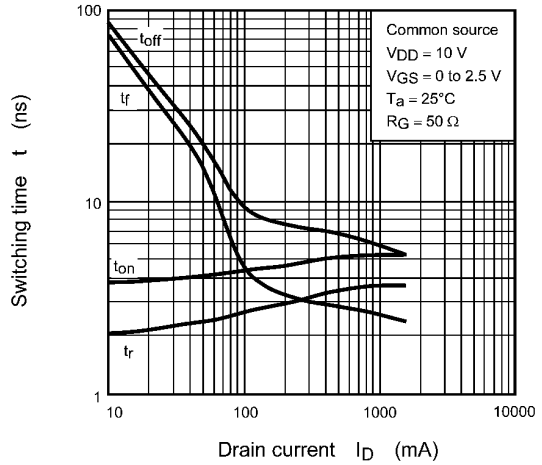


Fig. 7.1.10  $t - I_D$

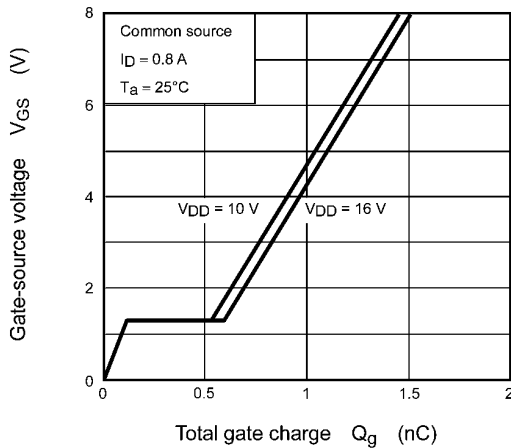
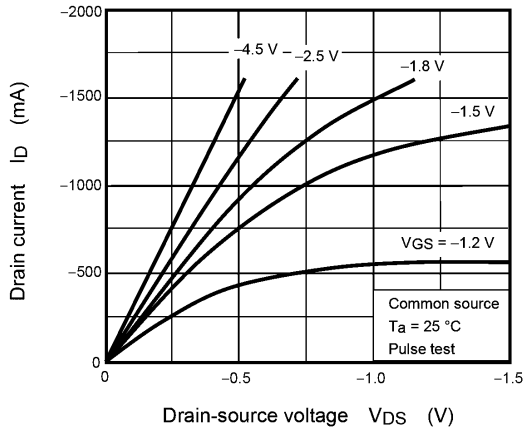
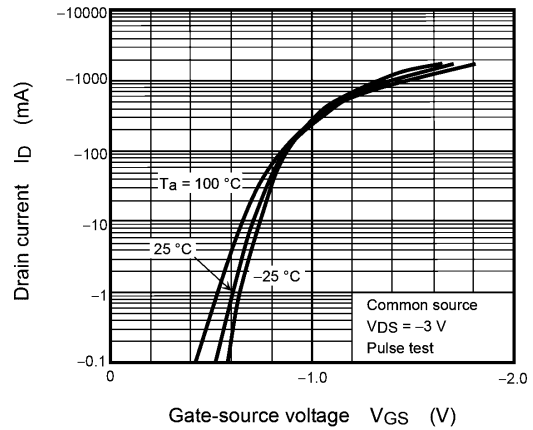


Fig. 7.1.11 Dynamic Input Characteristics

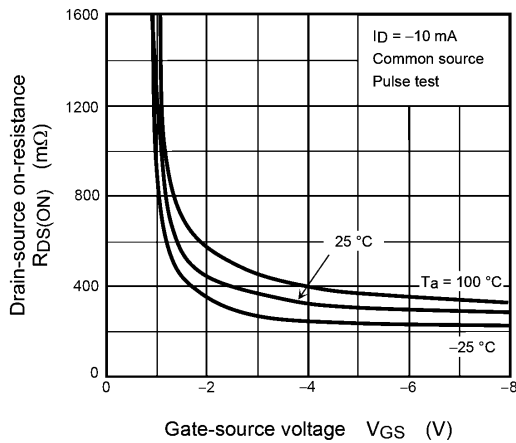
## 7.2. Q2 Characteristics Curves



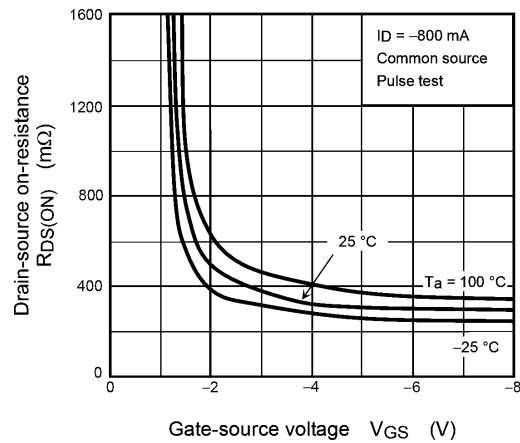
**Fig. 7.2.1  $I_D - V_{DS}$**



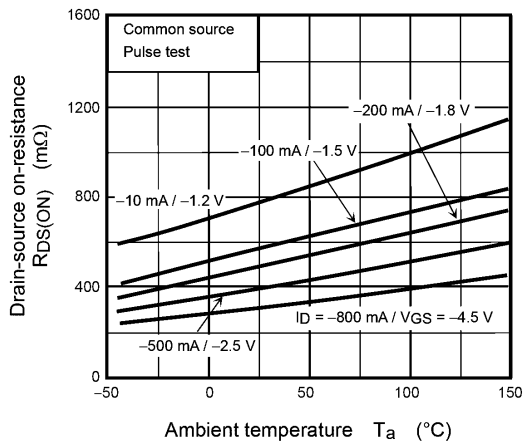
**Fig. 7.2.2  $I_D - V_{GS}$**



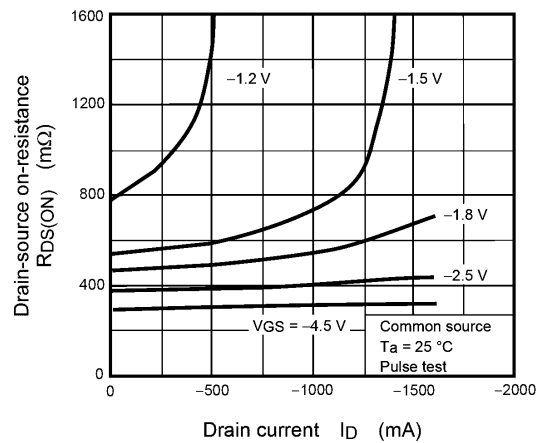
**Fig. 7.2.3  $R_{DS(ON)} - V_{GS}$**



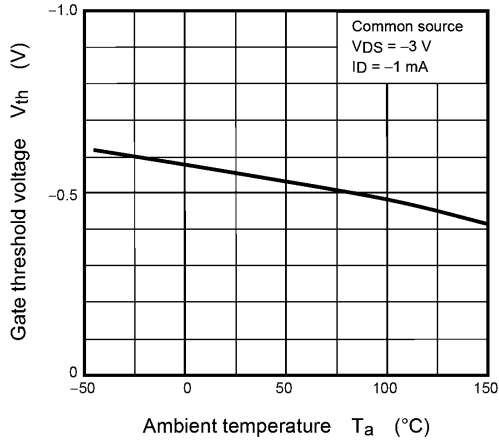
**Fig. 7.2.4  $R_{DS(ON)} - V_{GS}$**



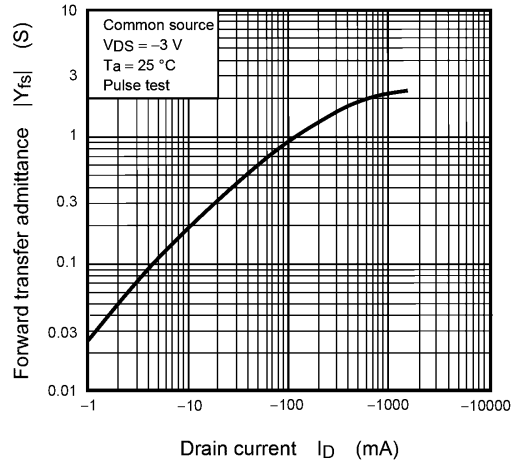
**Fig. 7.2.5  $R_{DS(ON)} - T_a$**



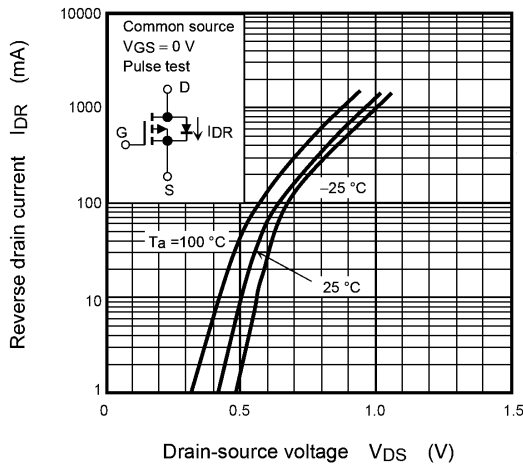
**Fig. 7.2.6  $R_{DS(ON)} - I_D$**



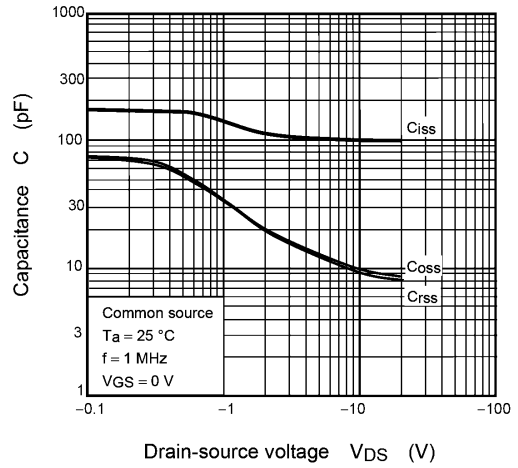
**Fig. 7.2.7**  $V_{th} - T_a$



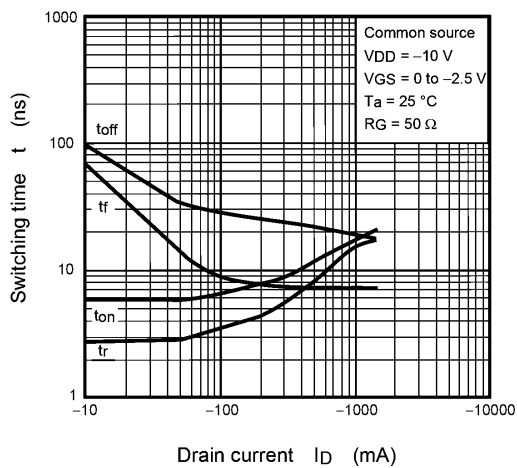
**Fig. 7.2.8**  $|Y_{fs}| - I_D$



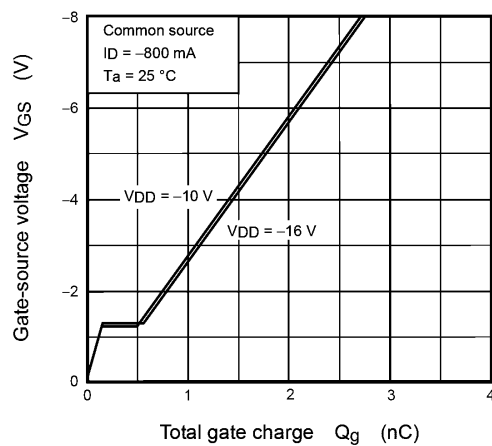
**Fig. 7.2.9**  $I_{DR} - V_{DS}$



**Fig. 7.2.10**  $C - V_{DS}$



**Fig. 7.2.11**  $t - I_D$



**Fig. 7.2.12** Dynamic Input Characteristics

7.3. Characteristics Curves (Q1, Q2 Common)

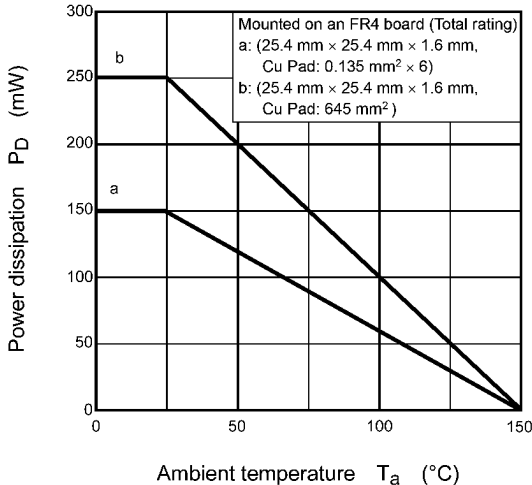
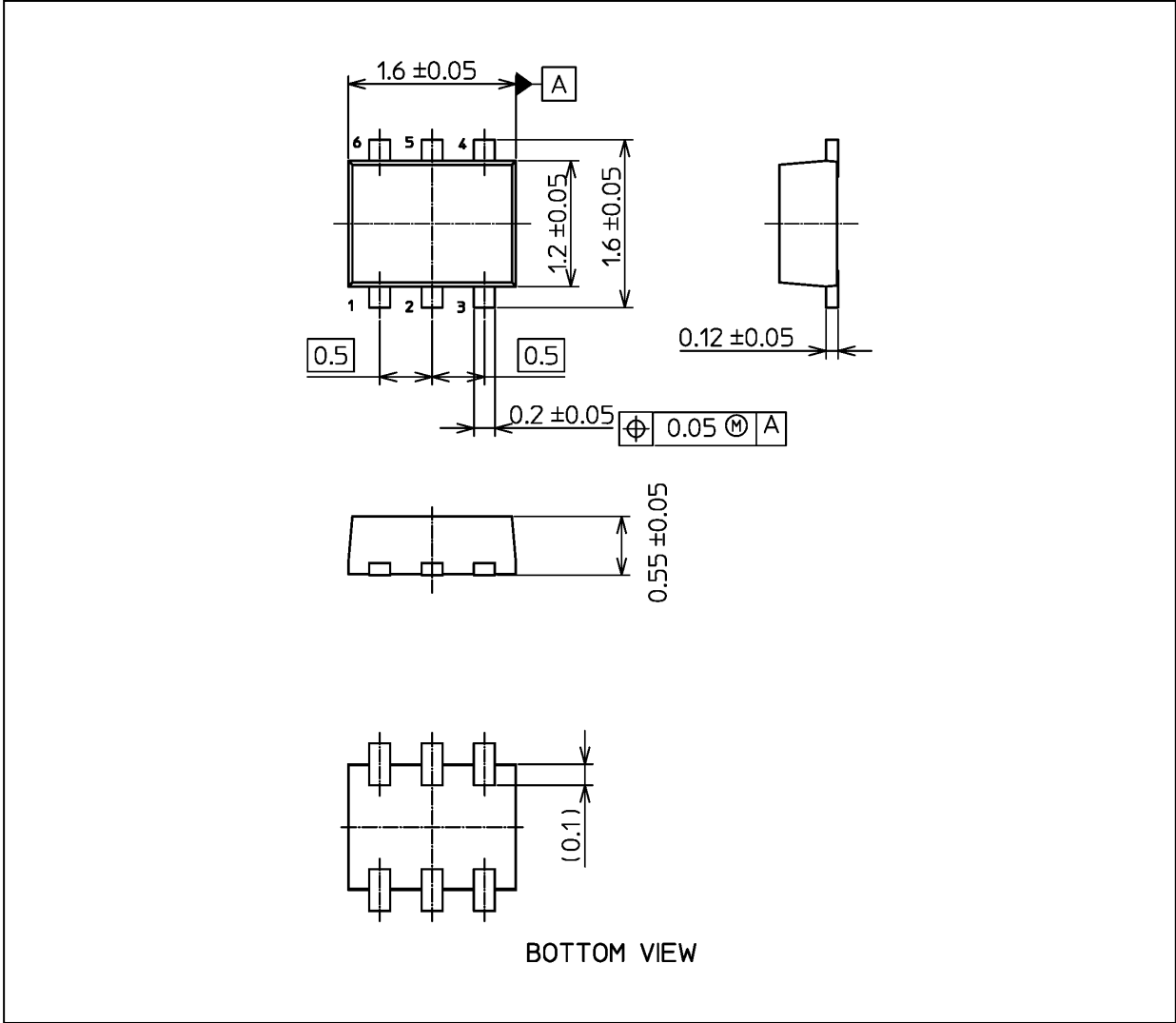


Fig. 7.3.1  $P_D - T_a$

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

Package Dimensions

Unit: mm



Weight: 3.0 mg (typ.)

Package Name(s)
Nickname: ES6

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