# Small switching

## US6M1

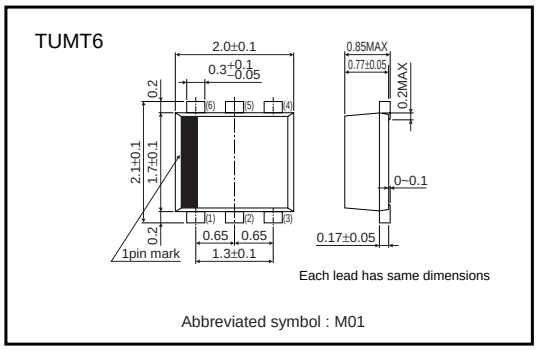
### ●Features

1) Low on-resistance.
2) Built-in G-S Protection Diode.
3) Small and Surface Mount Package (TUMT6).

### ●Application

Power switching, DC / DC converter.

### ●External dimensions (Unit : mm)

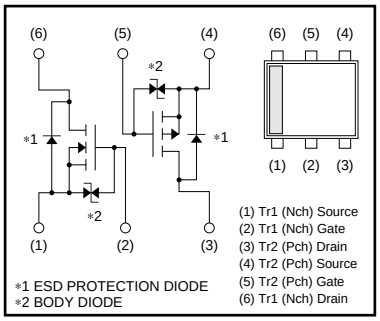



### ●Absolute maximum ratings (Ta=25°C)

| Parameter | | Symbol | Limits | | Unit | |
|---|---|---|---|---|---|---|
| | | | Tr1 : Nchannel | Tr2 : Pchannel | | |
| Drain-source voltage | | $V_{DSS}$ | 30 | −20 | V | |
| Gate-source voltage | | $V_{GSS}$ | 20 | −12 | V | |
| Drain current | Continuous | $I_D$ | ±1.4 | ±1 | A | |
| | Pulsed | $I_{DP}$ | ±5.6 | ±4 | A | *1 |
| Source current (Body diode) | Continuous | $I_S$ | 0.6 | −0.4 | A | |
| | Pulsed | $I_{SP}$ | 5.6 | −4 | A | *1 |
| Total power dissipation ($T_C$=25°C) | | $P_D$ | 1 | 1 | W | *2 |
| Channel temperature | | Tch | 150 | 150 | °C | |
| Storage temperature | | Tstg | −55 to +150 | −55 to +150 | °C | |

*1 Pw≤10μs, Duty cycle≤1%
*2 With each pin mounted on the recommended lands.

### ●Equivalent circuit




### ●Thermal resistance (Ta=25°C)

| Parameter | Symbol | Limits | Unit |
|---|---|---|---|
| Channel to ambient | Rth (ch-A) | 125 | °C / W |

●**Electrical characteristics** (Ta=25°C)

**<Tr1. N-ch MOSFET>**

| Parameter | Symbol | Min. | Typ. | Max. | Unit | Conditions |
|---|---|---|---|---|---|---|
| Gate-source leakage | $I_{GSS}$ | – | – | 10 | μA | $V_{GS}$=20V, $V_{DS}$=0V |
| Drain-source breakdown voltage | $V_{(BR)\ DSS}$ | 30 | – | – | V | $I_D$=1mA, $V_{GS}$=0V |
| Zero gate voltage drain current | $I_{DSS}$ | – | – | 1 | μA | $V_{DS}$=30V, $V_{GS}$=0V |
| Gate threshold voltage | $V_{GS\ (th)}$ | 1.0 | – | 2.5 | V | $V_{DS}$=10V, $I_D$=1mA |
| Static drain-source on-state resistance | $R_{DS\ (on)}$ * | – | 170 | 240 | mΩ | $I_D$=1.4A, $V_{GS}$=10V |
| | | – | 250 | 350 | | $I_D$=1.4A, $V_{GS}$=4.5V |
| | | – | 270 | 380 | | $I_D$=1.4A, $V_{GS}$=4V |
| Forward transfer admittance | $\|Y_{fs}\|$ * | 1.0 | – | – | S | $I_D$=1.4A, $V_{DS}$=10V |
| Input capacitance | $C_{iss}$ | – | 70 | – | pF | $V_{DS}$=10V |
| Output capacitance | $C_{oss}$ | – | 15 | – | pF | $V_{GS}$=0V |
| Reverse transfer capacitance | $C_{rss}$ | – | 12 | – | pF | f=1MHz |
| Turn-on delay time | $t_{d\ (on)}$ * | – | 6 | – | ns | $I_D$=0.7A, $V_{DD}$≒15V |
| Rise time | $t_r$ * | – | 6 | – | ns | $V_{GS}$=10V |
| Turn-off delay time | $t_{d\ (off)}$ * | – | 13 | – | ns | $R_L$=21Ω |
| Fall time | $t_f$ * | – | 8 | – | ns | $R_{GS}$=10Ω |
| Total gate charge | $Q_g$ * | – | 1.4 | 2.0 | nC | $V_{DD}$≒15V $R_L$≒10.7Ω |
| Gate-source charge | $Q_{gs}$ * | – | 0.6 | – | nC | $V_{GS}$=5V $R_{GS}$=10Ω |
| Gate-drain charge | $Q_{gd}$ * | – | 0.3 | – | nC | $I_D$=1.4A |

*Pulsed

●**Body diode characteristics** (Source-Drain) (Ta=25°C)

**<Tr1. N-ch MOSFET>**

| Parameter | Symbol | Min. | Typ. | Max. | Unit | Test Conditions |
|---|---|---|---|---|---|---|
| Forward voltage | $V_{SD}$ * | – | – | 1.2 | V | $I_S$=1.4A, $V_{GS}$=0V |

*Pulsed

●**Electrical characteristics** (Ta=25°C)

**<Tr2. P-ch MOSFET>**

| Parameter | Symbol | Min. | Typ. | Max. | Unit | Conditions |
|---|---|---|---|---|---|---|
| Gate-source leakage | $I_{GSS}$ | – | – | 10 | μA | $V_{GS}$=12V, $V_{DS}$=0V |
| Drain-source breakdown voltage | $V_{(BR)\ DSS}$ | −20 | – | – | V | $I_D$= −1mA, $V_{GS}$=0V |
| Zero gate voltage drain current | $I_{DSS}$ | – | – | −1 | μA | $V_{DS}$= −20V, $V_{GS}$=0V |
| Gate threshold voltage | $V_{GS\ (th)}$ | −0.7 | – | −2.0 | V | $V_{DS}$= −10V, $I_D$= −1mA |
| Static drain-source on-state resistance | $R_{DS\ (on)}$ * | – | 280 | 390 | mΩ | $I_D$= −1A, $V_{GS}$= −4.5V |
| | | – | 310 | 430 | | $I_D$= −1A, $V_{GS}$= −4V |
| | | – | 570 | 800 | | $I_D$= −0.5A, $V_{GS}$= −2.5V |
| Forward transfer admittance | $\|Y_{fs}\|$ * | 0.7 | – | – | S | $I_D$= −0.5A, $V_{DS}$= −10V |
| Input capacitance | $C_{iss}$ | – | 150 | – | pF | $V_{DS}$= −10V |
| Output capacitance | $C_{oss}$ | – | 20 | – | pF | $V_{GS}$=0V |
| Reverse transfer capacitance | $C_{rss}$ | – | 20 | – | pF | f=1MHz |
| Turn-on delay time | $t_{d\ (on)}$ * | – | 9 | – | ns | $I_D$= −0.5A, $V_{DD}$≒ −15V |
| Rise time | $t_r$ * | – | 8 | – | ns | $V_{GS}$= −4.5V |
| Turn-off delay time | $t_{d\ (off)}$ * | – | 25 | – | ns | $R_L$=30Ω |
| Fall time | $t_f$ * | – | 10 | – | ns | $R_{GS}$=10Ω |
| Total gate charge | $Q_g$ * | – | 2.1 | – | nC | $V_{DD}$≒ −15V $R_L$=15Ω |
| Gate-source charge | $Q_{gs}$ * | – | 0.5 | – | nC | $V_{GS}$= −4.5V $R_{GS}$=10Ω |
| Gate-drain charge | $Q_{gd}$ * | – | 0.5 | – | nC | $I_D$= −1A |

*Pulsed

●**Body diode characteristics** (Source-Drain) (Ta=25°C)

**<Tr2. P-ch MOSFET>**

| Parameter | Symbol | Min. | Typ. | Max. | Unit | Test Conditions |
|---|---|---|---|---|---|---|
| Forward voltage | $V_{SD}$ * | – | – | −1.2 | V | $I_S$= −0.4A, $V_{GS}$=0V |

*Pulsed

**N-ch**

**●Electrical characteristic curves**

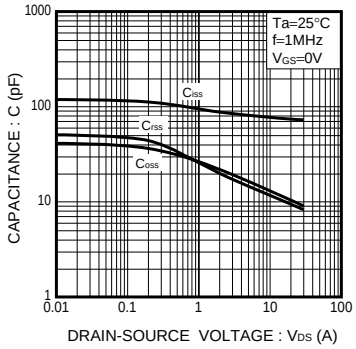



Fig.1 Typical Capacitance vs. Drain-Source Voltage

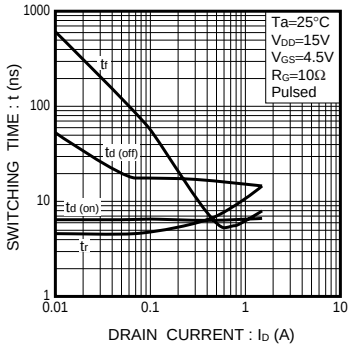



Fig.2 Switching Characteristics

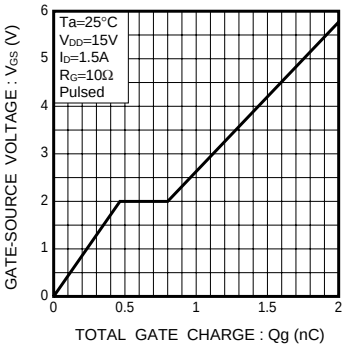



Fig.3 Dynamic Input Characteristics

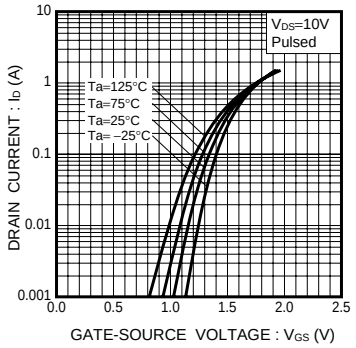



Fig.4 Typical Transfer Characteristics

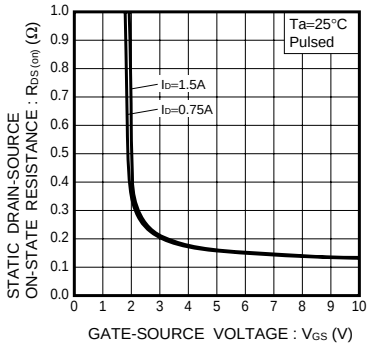



Fig.5 Static Drain-Source On-State Resistance vs. Gate-Source Voltage

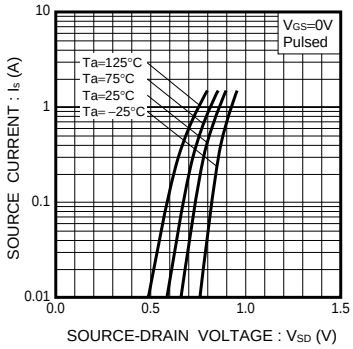



Fig.6 Source Current vs. Source-Drain Voltage

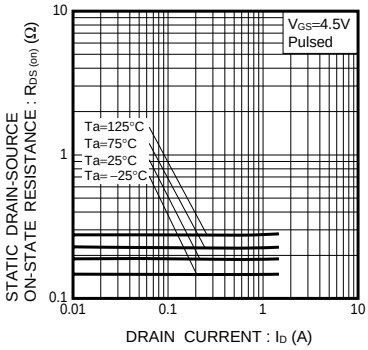



Fig.7 Static Drain-Source On-State Resistance vs. Drain Current (I)

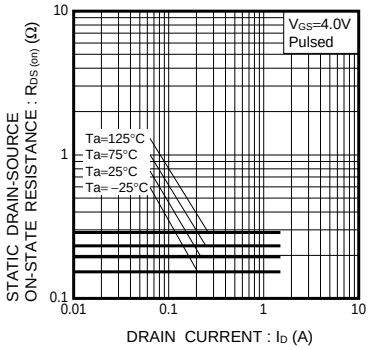



Fig.8 Static Drain-Source On-State Resistance vs. Drain Current (II)

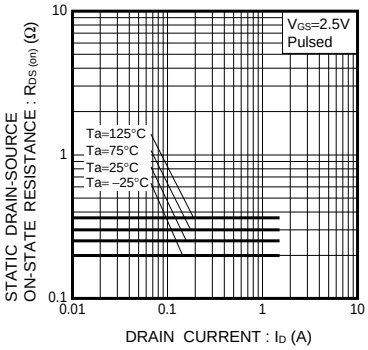



Fig.9 Static Drain-Source On-State Resistance vs. Drain Current (III)

**P-ch**

**●Electrical characteristic curves**

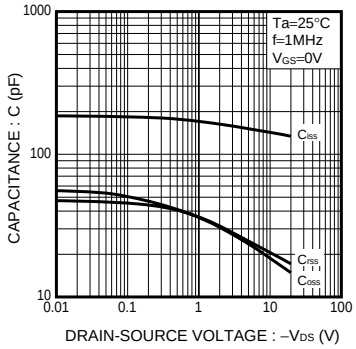



Fig.1 Typical Capacitance vs. Drain-Source Voltage

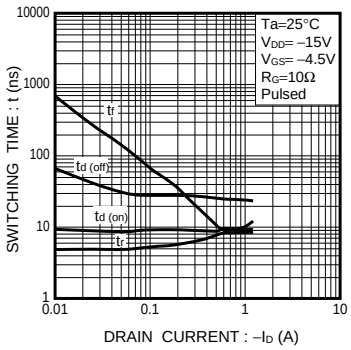



Fig.2 Switching Characteristics

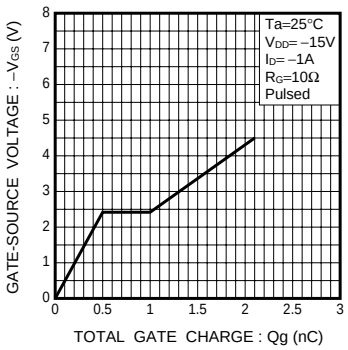



Fig.3 Dynamic Input Characteristics

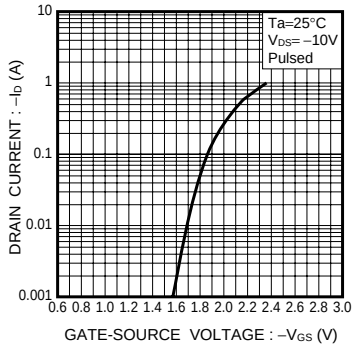



Fig.4 Typical Transfer Characteristics

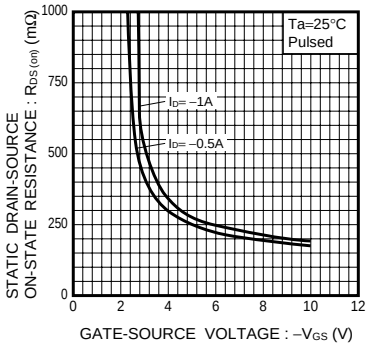



Fig.5 Static Drain-Source On-State Resistance vs. Gate-Source Voltage

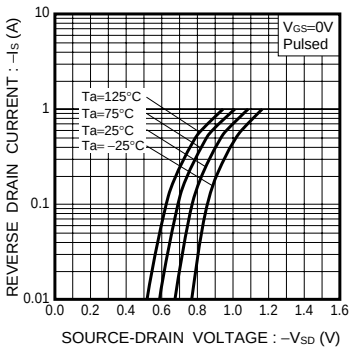



Fig.6 Source Current vs. Source-Drain Voltage

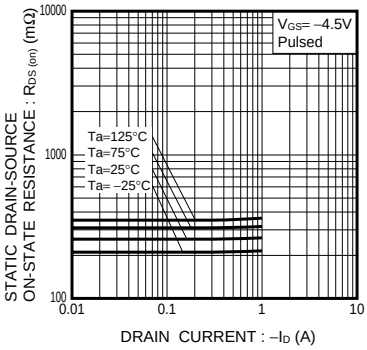



Fig.7 Static Drain-Source On-State Resistance vs. Drain Current (I)

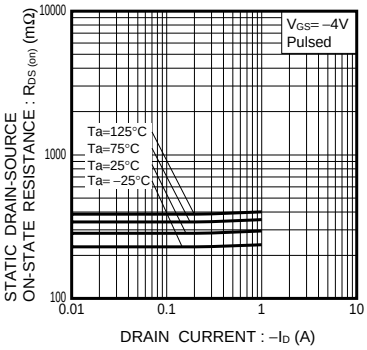



Fig.8 Static Drain-Source On-State Resistance vs. Drain Current (II)

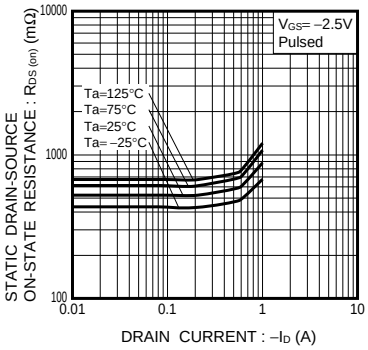



Fig.9 Static Drain-Source On-State Resistance vs. Drain Current (III)

**N-ch**

**●Measurement circuit**

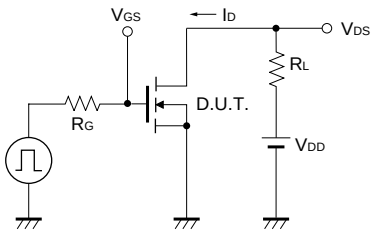



Fig.1-1 Switching Time Measurement Circuit

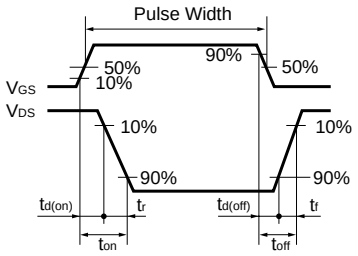



Fig.1-2 Switching Waveforms

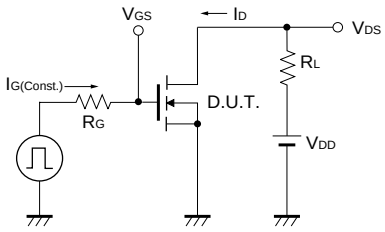



Fig.2-1 Gate Charge Measurement Circuit

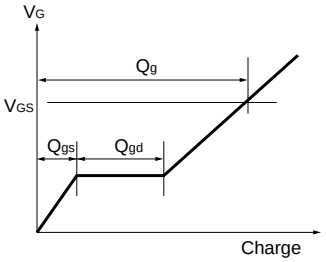



Fig.2-2 Gate Charge Waveform

**P-ch**

**●Measurement circuit**

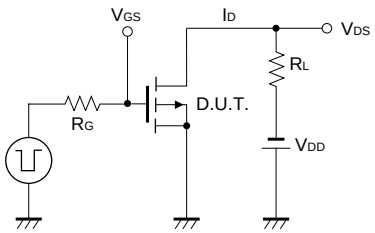



Fig.3-1 Switching Time Measurement Circuit

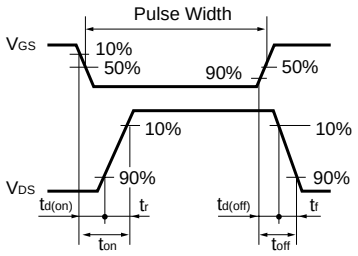



Fig.3-2 Switching Waveforms

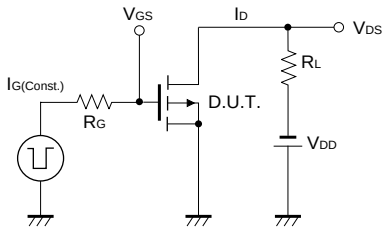



Fig.4-1 Gate Charge Measurement Circuit

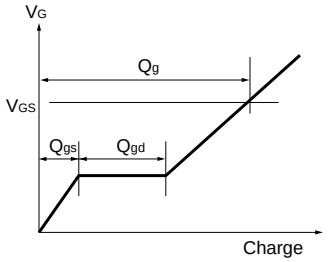



Fig.4-2 Gate Charge Waveform