



## 24NM60

Power MOSFET

### 24A, 600V N-CHANNEL SUPER-JUNCTION MOSFET

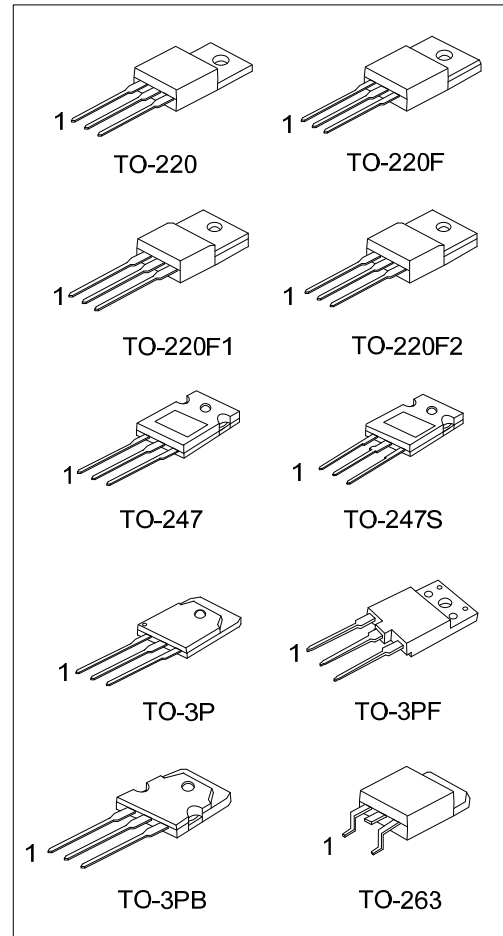
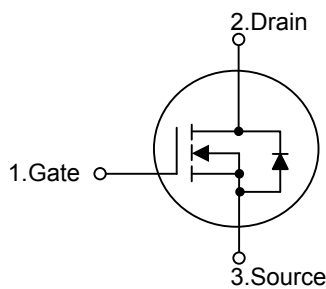
#### DESCRIPTION

The **UTC 24NM60** is a Super Junction MOSFET Structure and is designed to have better characteristics, such as fast switching time, low gate charge, low on-state resistance and a high rugged avalanche characteristics. This power MOSFET is usually used at AC-DC converters for power applications.

#### FEATURES

- \*  $R_{DS(ON)} \leq 0.16\Omega$  @  $V_{GS}=10V$ ,  $I_D=12A$
- \* High Switching Speed
- \* 100% Avalanche Tested

#### SYMBOL



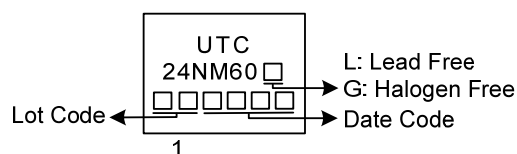
## ■ ORDERING INFORMATION

| Ordering Number |                | Package  | Pin Assignment |   |   | Packing   |
|-----------------|----------------|----------|----------------|---|---|-----------|
| Lead Free       | Halogen Free   |          | 1              | 2 | 3 |           |
| 24NM60L-TA3-T   | 24NM60G-TA3-T  | TO-220   | G              | D | S | Tube      |
| 24NM60L-TF1-T   | 24NM60G-TF1-T  | TO-220F1 | G              | D | S | Tube      |
| 24NM60L-TF2-T   | 24NM60G-TF2-T  | TO-220F2 | G              | D | S | Tube      |
| 24NM60L-TF3-T   | 24NM60G-TF3-T  | TO-220F  | G              | D | S | Tube      |
| 24NM60L-TQ2-T   | 24NM60G-TQ2-T  | TO-263   | G              | D | S | Tube      |
| 24NM60L-TQ2-R   | 24NM60G-TQ2-R  | TO-263   | G              | D | S | Tape Reel |
| 24NM60L-T3P-T   | 24NM60G-T3P-T  | TO-3P    | G              | D | S | Tube      |
| 24NM60L-T3B-T   | 24NM60G-T3B-T  | TO-3PB   | G              | D | S | Tube      |
| 24NM60L-T3F-T   | 24NM60G-T3F-T  | TO-3PF   | G              | D | S | Tube      |
| 24NM60L-T47-T   | 24NM60G-T47-T  | TO-247   | G              | D | S | Tube      |
| 24NM60L-T47S-T  | 24NM60G-T47S-T | TO-247S  | G              | D | S | Tube      |

Note: Pin Assignment: G: Gate D: Drain S: Source

|                                                                                               |                                                                                                                                                                                                                                          |
|-----------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p>24NM60G-TA3-T</p> <p>(1) Packing Type</p> <p>(2) Package Type</p> <p>(3) Green Package</p> | <p>(1) T: Tube, R: Tape Reel</p> <p>(2) TA3: TO-220, TF3: TO-220F, TF1: TO-220F1, TF2: TO-220F2, TQ2: TO-263, T3P: TO-3P, T3B: TO-3PB, T3F: TO-3PF, T47: TO-247 T47S: TO-247S</p> <p>(3) G: Halogen Free and Lead Free, L: Lead Free</p> |
|-----------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

## ■ MARKING



# ■ **ABSOLUTE MAXIMUM RATINGS** ( $T_C=25^{\circ}\text{C}$ , unless otherwise specified)

| PARAMETER                  |                        | SYMBOL    | RATINGS    | UNIT               |
|----------------------------|------------------------|-----------|------------|--------------------|
| Drain-Source Voltage       |                        | $V_{DSS}$ | 600        | V                  |
| Gate-Source Voltage        |                        | $V_{GSS}$ | $\pm 30$   | V                  |
| Drain Current              | Continuous             | $I_D$     | 24         | A                  |
|                            | Pulsed (Note 2)        | $I_{DM}$  | 96         | A                  |
| Avalanche Current (Note 2) |                        | $I_{AR}$  | 5.0        | A                  |
| Avalanche Energy           | Single Pulsed (Note 3) | $E_{AS}$  | 725        | mJ                 |
| Peak Diode Recovery dv/dt  |                        | dv/dt     | 10.5       | V/ns               |
| MOSFET dv/dt Ruggedness    |                        | dv/dt     | 50         | V/ns               |
| Power Dissipation          | TO-220/TO-263          | $P_D$     | 176        | W                  |
|                            | TO-220F/TO-220F1       |           | 34         | W                  |
|                            | TO-220F2               |           |            |                    |
|                            | TO-247/TO-247S         |           | 192        | W                  |
|                            | TO-3P/TO-3PB           |           | 227        | W                  |
|                            | TO-3PF                 |           | 113        | W                  |
| Junction Temperature       |                        | $T_J$     | +150       | $^{\circ}\text{C}$ |
| Storage Temperature        |                        | $T_{STG}$ | -55 ~ +150 | $^{\circ}\text{C}$ |

Notes: 1. Absolute maximum ratings are those values beyond which the device could be permanently damaged.

Absolute maximum ratings are stress ratings only and functional device operation is not implied.

2. Repetitive Rating: Pulse width limited by maximum junction temperature.

3.  $L = 58 \text{ mH}$ ,  $I_{AS} = 5.0 \text{ A}$ ,  $V_{DD} = 50 \text{ V}$ ,  $R_G = 25 \Omega$ , Starting  $T_J = 25^{\circ}\text{C}$

4.  $I_{SD} \leq 24 \text{ A}$ ,  $di/dt \leq 200 \text{ A}/\mu\text{s}$ ,  $V_{DD} \leq BV_{DSS}$ , Starting  $T_J = 25^{\circ}\text{C}$

# ■ **THERMAL CHARACTERISTICS**

| PARAMETER           |                   | SYMBOL        | RATING | UNIT                        |
|---------------------|-------------------|---------------|--------|-----------------------------|
| Junction to Ambient | TO-220/TO-220F    | $\theta_{JA}$ | 62.5   | $^{\circ}\text{C}/\text{W}$ |
|                     | TO-220F1/TO-220F2 |               |        |                             |
|                     | TO-263            |               | 60     | $^{\circ}\text{C}/\text{W}$ |
|                     | TO-247/TO-247S    |               |        |                             |
|                     | TO-3P/TO-3PB      |               |        |                             |
| Junction to Case    | TO-3PF            | $\theta_{JC}$ | 40     | $^{\circ}\text{C}/\text{W}$ |
|                     | TO-220/TO-263     |               | 0.71   | $^{\circ}\text{C}/\text{W}$ |
|                     | TO-220F/TO-220F1  |               | 3.67   | $^{\circ}\text{C}/\text{W}$ |
|                     | TO-220F2          |               |        |                             |
|                     | TO-247/TO-247S    |               | 0.65   | $^{\circ}\text{C}/\text{W}$ |
|                     | TO-3P/TO-3PB      |               | 0.55   | $^{\circ}\text{C}/\text{W}$ |
|                     | TO-3PF            |               | 1.1    | $^{\circ}\text{C}/\text{W}$ |

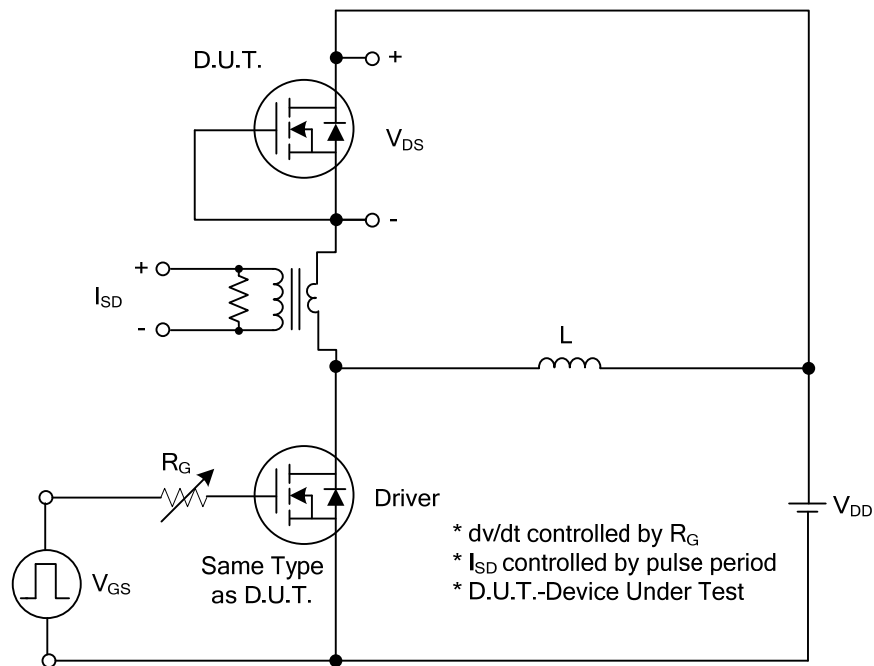
■ ELECTRICAL CHARACTERISTICS ( $T_J=25^\circ\text{C}$ , unless otherwise specified)

| PARAMETER                                       |         | SYMBOL              | TEST CONDITIONS                                                                                     | MIN | TYP   | MAX  | UNIT |
|-------------------------------------------------|---------|---------------------|-----------------------------------------------------------------------------------------------------|-----|-------|------|------|
| OFF CHARACTERISTICS                             |         |                     |                                                                                                     |     |       |      |      |
| Drain-Source Breakdown Voltage                  |         | BV <sub>DSS</sub>   | I <sub>D</sub> =250μA, V <sub>GS</sub> =0V                                                          | 600 |       |      | V    |
| Drain-Source Leakage Current                    |         | I <sub>DSS</sub>    | V <sub>DS</sub> =600V, V <sub>GS</sub> =0V                                                          |     |       | 10   | μA   |
| Gate- Source Leakage Current                    | Forward | I <sub>GSS</sub>    | V <sub>GS</sub> =+30V, V <sub>DS</sub> =0V                                                          |     |       | +100 | nA   |
|                                                 | Reverse |                     | V <sub>GS</sub> =-30V, V <sub>DS</sub> =0V                                                          |     |       | -100 | nA   |
| ON CHARACTERISTICS                              |         |                     |                                                                                                     |     |       |      |      |
| Gate Threshold Voltage                          |         | V <sub>GS(TH)</sub> | V <sub>DS</sub> =V <sub>GS</sub> , I <sub>D</sub> =250μA                                            | 2.5 |       | 4.5  | V    |
| Static Drain-Source On-State Resistance         |         | R <sub>DS(ON)</sub> | V <sub>GS</sub> =10V, I <sub>D</sub> =12A                                                           |     | 0.145 | 0.16 | Ω    |
| DYNAMIC PARAMETERS                              |         |                     |                                                                                                     |     |       |      |      |
| Input Capacitance                               |         | C <sub>ISS</sub>    | V <sub>GS</sub> =0V, V <sub>DS</sub> =25V, f=1.0MHz                                                 |     | 2000  |      | pF   |
| Output Capacitance                              |         | C <sub>OSS</sub>    |                                                                                                     |     | 1100  |      | pF   |
| Reverse Transfer Capacitance                    |         | C <sub>RSS</sub>    |                                                                                                     |     | 110   |      | pF   |
| SWITCHING PARAMETERS                            |         |                     |                                                                                                     |     |       |      |      |
| Total Gate Charge (Note 1)                      |         | Q <sub>G</sub>      | V <sub>DS</sub> =480V, V <sub>GS</sub> =10V, I <sub>D</sub> =24A<br>I <sub>G</sub> =1mA (Note1, 2)  |     | 76    |      | nC   |
| Gate to Source Charge                           |         | Q <sub>GS</sub>     |                                                                                                     |     | 22    |      | nC   |
| Gate to Drain Charge                            |         | Q <sub>GD</sub>     |                                                                                                     |     | 30    |      | nC   |
| Turn-ON Delay Time (Note 1)                     |         | t <sub>D(ON)</sub>  | V <sub>DS</sub> =100V, V <sub>GS</sub> =10V, I <sub>D</sub> =24A,<br>R <sub>G</sub> =25Ω (Note1, 2) |     | 26    |      | ns   |
| Rise Time                                       |         | t <sub>R</sub>      |                                                                                                     |     | 48.2  |      | ns   |
| Turn-OFF Delay Time                             |         | t <sub>D(OFF)</sub> |                                                                                                     |     | 248   |      | ns   |
| Fall-Time                                       |         | t <sub>F</sub>      |                                                                                                     |     | 112.8 |      | ns   |
| SOURCE- DRAIN DIODE RATINGS AND CHARACTERISTICS |         |                     |                                                                                                     |     |       |      |      |
| Maximum Body-Diode Continuous Current           |         | I <sub>S</sub>      |                                                                                                     |     |       | 24   | A    |
| Maximum Body-Diode Pulsed Current               |         | I <sub>SM</sub>     |                                                                                                     |     |       | 96   | A    |
| Drain-Source Diode Forward Voltage (Note 1)     |         | V <sub>SD</sub>     | I <sub>S</sub> =24A, V <sub>GS</sub> =0V                                                            |     |       | 1.4  | V    |
| Body Diode Reverse Recovery Time (Note 1)       |         | t <sub>rr</sub>     | I <sub>S</sub> =24A, V <sub>GS</sub> =0V,                                                           |     | 490   |      | ns   |
| Body Diode Reverse Recovery Charge              |         | Q <sub>rr</sub>     | dl <sub>F</sub> /dt=100A/μs                                                                         |     | 9.3   |      | μC   |

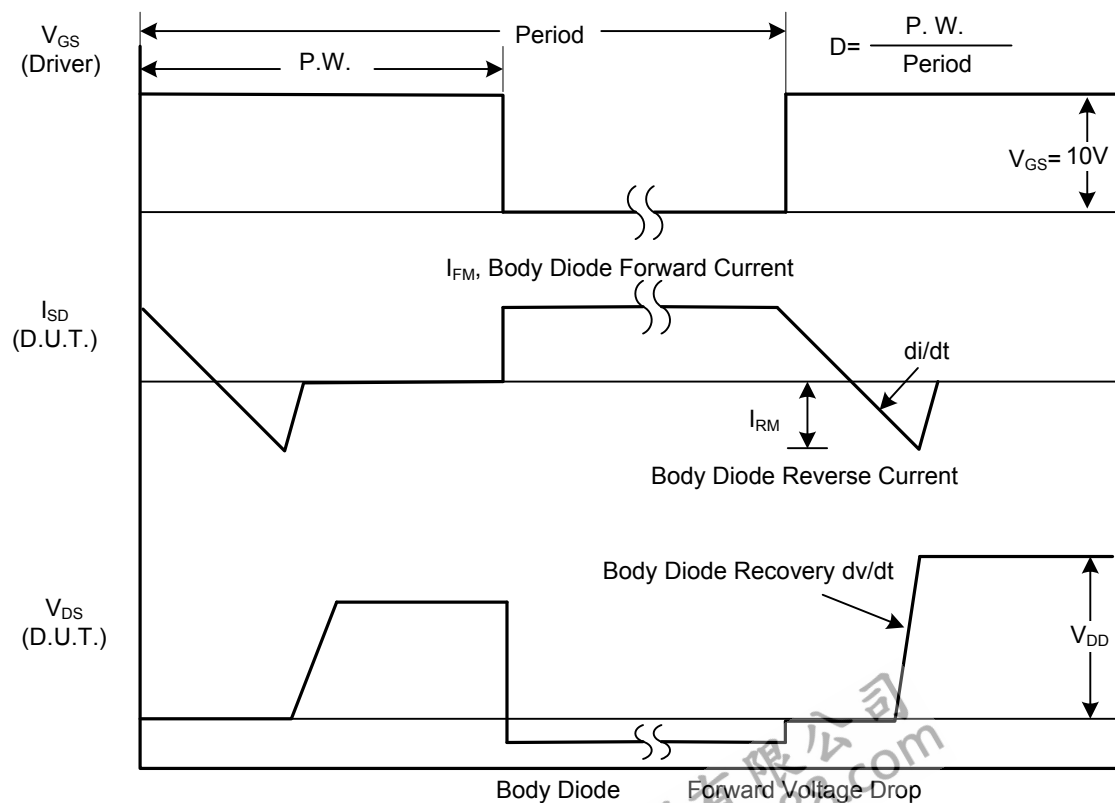
Notes: 1. Pulse Test : Pulse width  $\leq 300\mu\text{s}$ , Duty cycle  $\leq 2\%$ .

2. Essentially independent of operating ambient temperature.

# TEST CIRCUITS AND WAVEFORMS



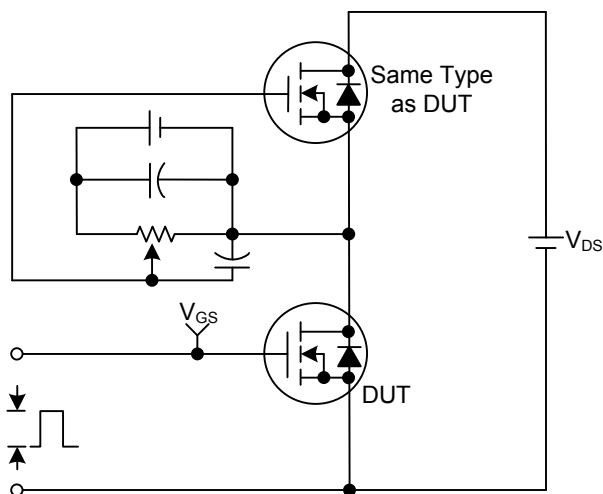
Peak Diode Recovery dv/dt Test Circuit



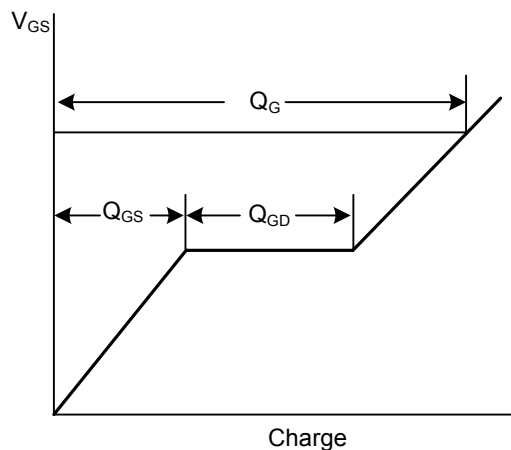
Peak Diode Recovery dv/dt Waveforms

## ■ TEST CIRCUITS AND WAVEFORMS

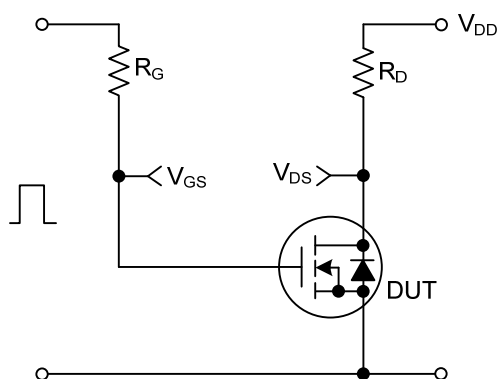
Gate Charge Test Circuit



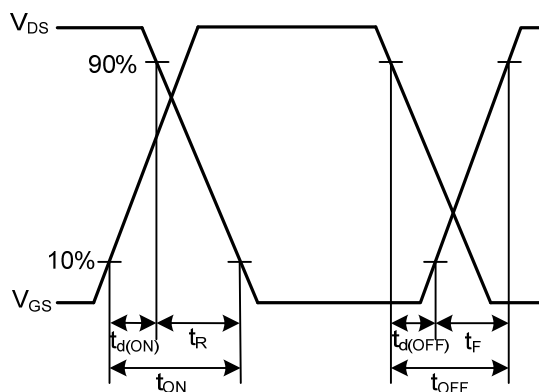
Gate Charge Waveforms



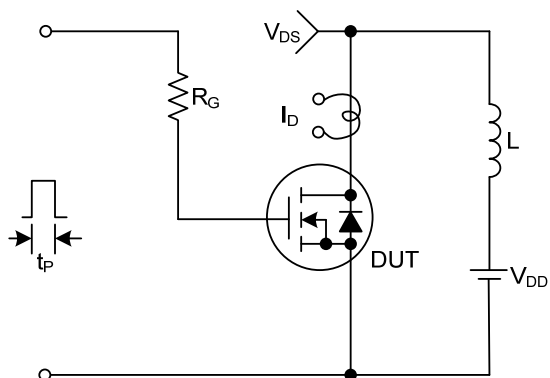
Resistive Switching Test Circuit



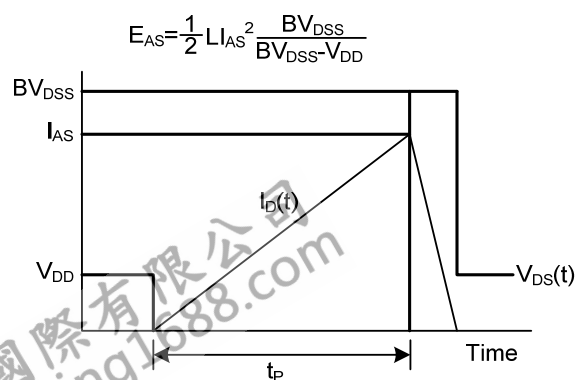
Resistive Switching Waveforms



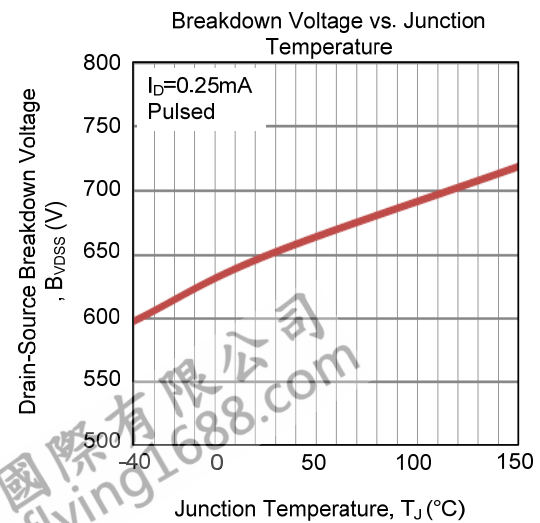
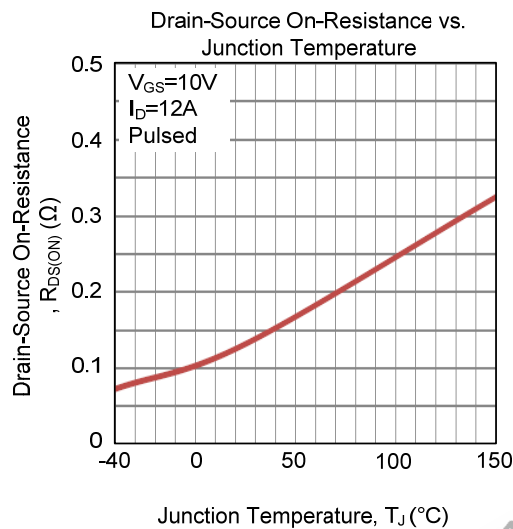
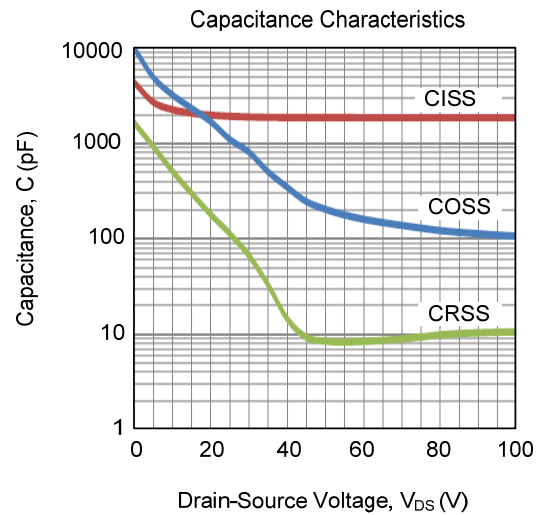
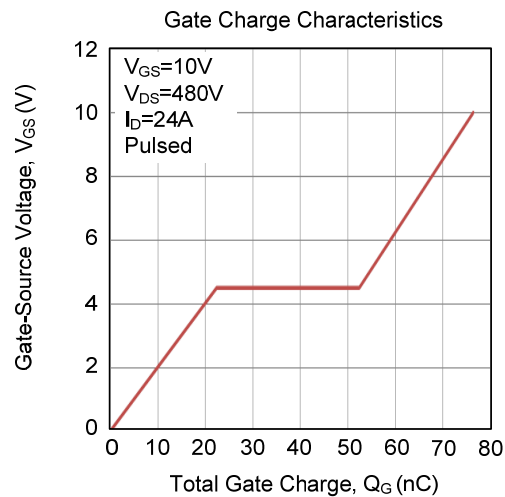
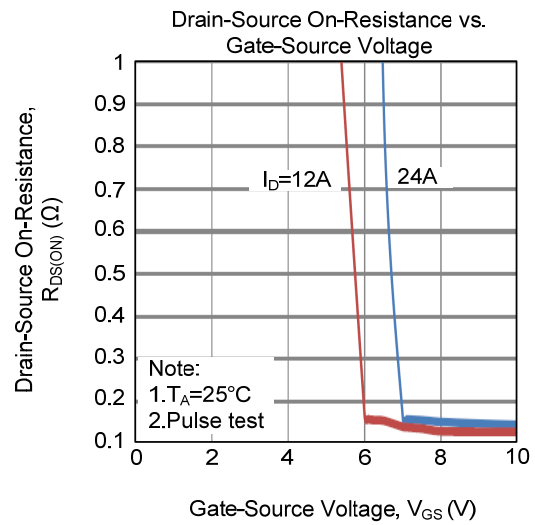
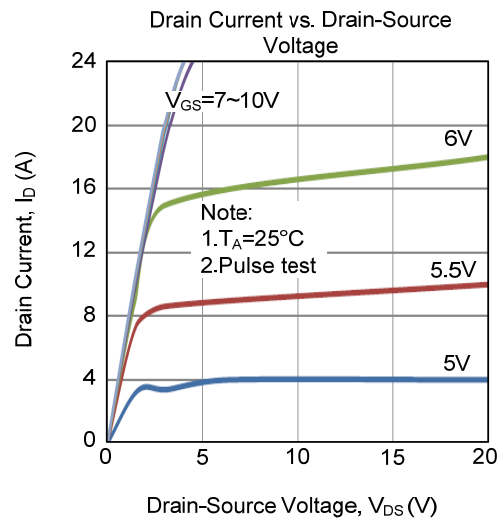
Unclamped Inductive Switching Test Circuit



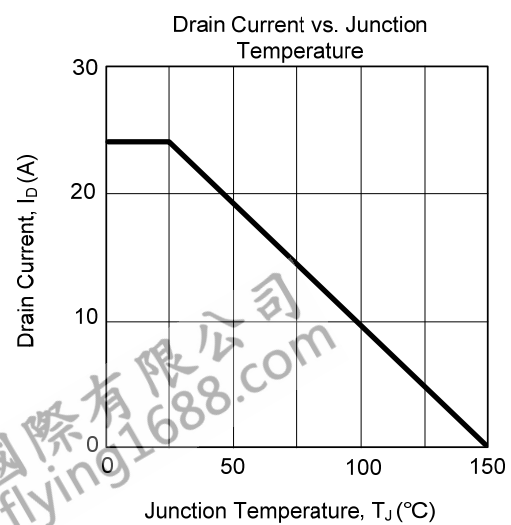
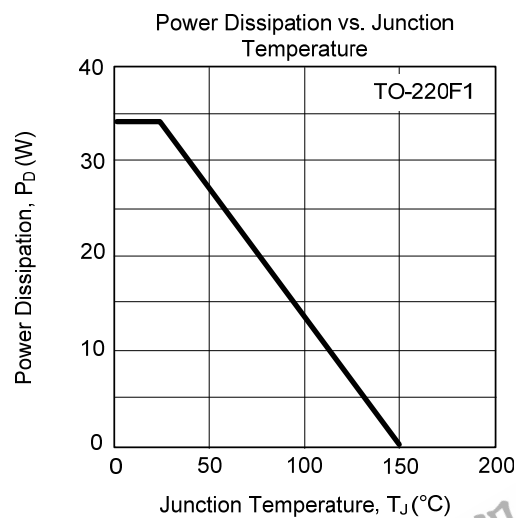
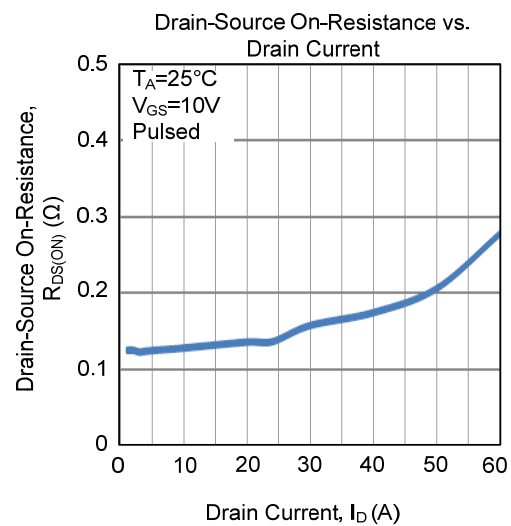
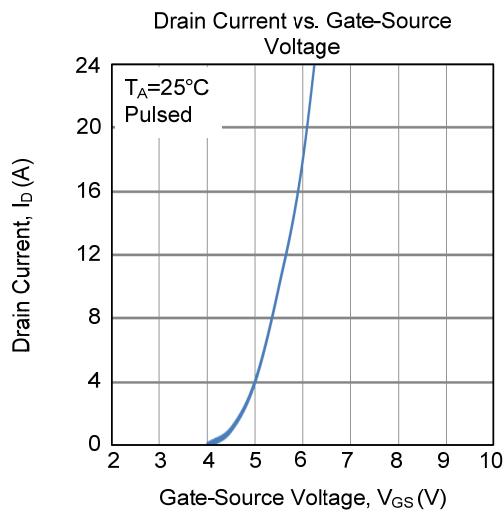
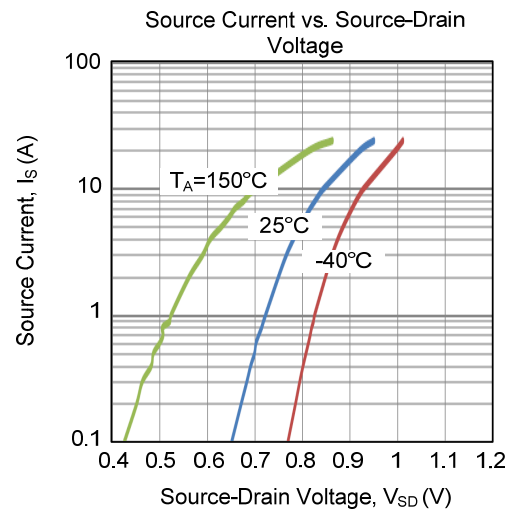
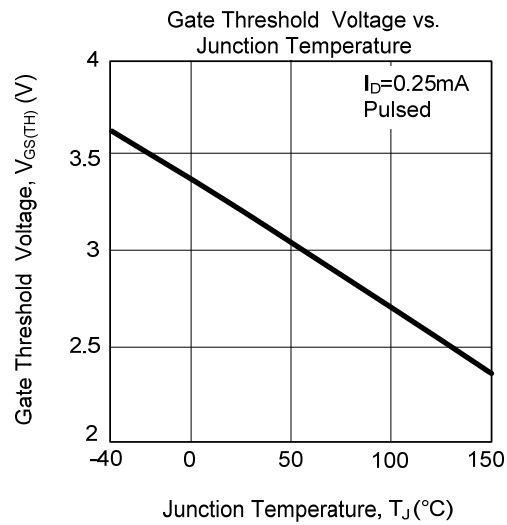
Unclamped Inductive Switching Waveforms



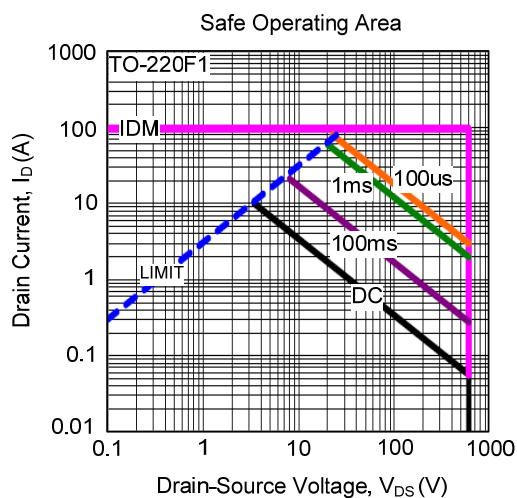
## ■ TYPICAL CHARACTERISTICS



# TYPICAL CHARACTERISTICS (Cont.)



# TYPICAL CHARACTERISTICS (Cont.)



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