



## 4N60-E

### Power MOSFET

## 4A, 600V N-CHANNEL POWER MOSFET

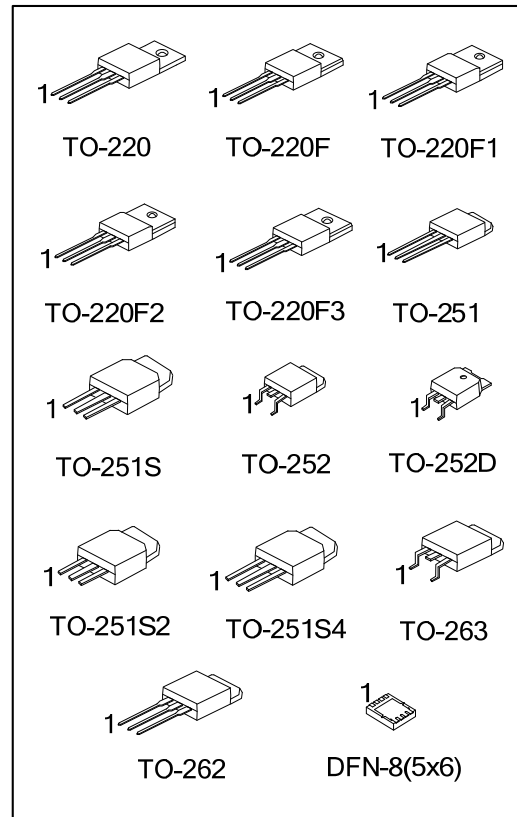
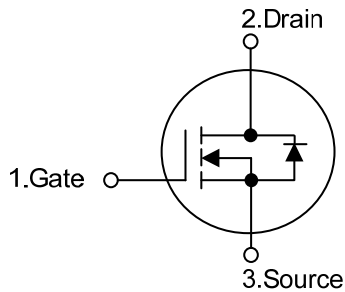
### ■ DESCRIPTION

The UTC 4N60-E is a high voltage power MOSFET and is designed to have better characteristics, such as fast switching time, low gate charge, low on-state resistance and have a high rugged avalanche characteristics. This power MOSFET is usually used at high speed switching applications in power supplies, PWM motor controls, high efficient DC to DC converters and bridge circuits.

### ■ FEATURES

- \*  $R_{DS(ON)} < 2.5\Omega$  @  $V_{GS} = 10V$ ,  $I_D = 2.2A$
- \* Fast Switching Capability
- \* Avalanche Energy Specified
- \* Improved  $dv/dt$  Capability, high RuggednessA

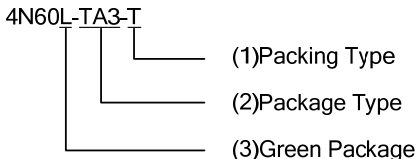
### ■ SYMBOL



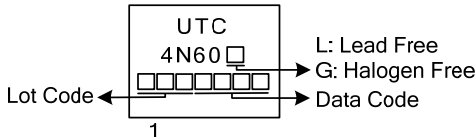
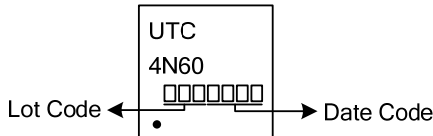
## ORDERING INFORMATION

| Ordering Number |                  | Package    | Pin Assignment |   |   |   |   |   |   |   | Packing   |
|-----------------|------------------|------------|----------------|---|---|---|---|---|---|---|-----------|
| Lead Free       | Halogen Free     |            | 1              | 2 | 3 | 4 | 5 | 6 | 7 | 8 |           |
| 4N60L-TA3-T     | 4N60G-TA3-T      | TO-220     | G              | D | S | - | - | - | - | - | Tube      |
| 4N60L-TF3-T     | 4N60G-TF3-T      | TO-220F    | G              | D | S | - | - | - | - | - | Tube      |
| 4N60L-TF1-T     | 4N60G-TF1-T      | TO-220F1   | G              | D | S | - | - | - | - | - | Tube      |
| 4N60L-TF2-T     | 4N60G-TF2-T      | TO-220F2   | G              | D | S | - | - | - | - | - | Tube      |
| 4N60L-TF3T-T    | 4N60G-TF3T-T     | TO-220F3   | G              | D | S | - | - | - | - | - | Tube      |
| 4N60L-TM3-T     | 4N60G-TM3-T      | TO-251     | G              | D | S | - | - | - | - | - | Tube      |
| 4N60L-TMS-T     | 4N60G-TMS-T      | TO-251S    | G              | D | S | - | - | - | - | - | Tube      |
| 4N60L-TMS2-T    | 4N60G-TMS2-T     | TO-251S2   | G              | D | S | - | - | - | - | - | Tube      |
| 4N60L-TMS4-T    | 4N60G-TMS4-T     | TO-251S4   | G              | D | S | - | - | - | - | - | Tube      |
| 4N60L-TN3-R     | 4N60G-TN3-R      | TO-252     | G              | D | S | - | - | - | - | - | Tape Reel |
| 4N60L-TND-R     | 4N60G-TND-R      | TO-252D    | G              | D | S | - | - | - | - | - | Tape Reel |
| 4N60L-T2Q-T     | 4N60G-T2Q-T      | TO-262     | G              | D | S | - | - | - | - | - | Tube      |
| 4N60L-TQ2-R     | 4N60G-TQ2-R      | TO-263     | G              | D | S | - | - | - | - | - | Tape Reel |
| 4N60L-TQ2-T     | 4N60G-TQ2-T      | TO-263     | G              | D | S | - | - | - | - | - | Tube      |
| -               | 4N60G-K08-5060-R | DFN-8(5×6) | S              | S | S | G | D | D | D | D | Tape Reel |

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

|                                                                                    |                                                                                                                                                                                                                   |
|------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|  | (1) T: Tube, R: Tape Reel                                                                                                                                                                                         |
|                                                                                    | (2) TA3: TO-220, TF1: TO-220F1, TF2: TO-220F2, TF3: TO-220F, TF3T: TO-220F3, TM3: TO-251, TMS: TO-251S, TN3: TO-252, TND: TO-252D, TMS2: TO-251S2, TMS4: TO-251S4, T2Q: TO-262, TQ2: TO-263, K08-3030: DFN-8(5×6) |
|                                                                                    | (3) L: Lead Free, G: Halogen Free and Lead Free                                                                                                                                                                   |

## MARKING

| PACKAGE                                                                    |                                                               | MARKING                                                                              |  |
|----------------------------------------------------------------------------|---------------------------------------------------------------|--------------------------------------------------------------------------------------|--|
| TO-220<br>TO-220F<br>TO-220F1<br>TO-220F2<br>TO-220F3<br>TO-251<br>TO-251S | TO-251S2<br>TO-251S4<br>TO-252<br>TO-252D<br>TO-262<br>TO-263 |  |  |
| DFN-8(5×6)                                                                 |                                                               |  |  |

■ **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                |
| Avalanche Current (Note 2)         |                        | $I_{AR}$  | 4.4        | A                |
| Drain Current                      | Continuous             | $I_D$     | 4.0        | A                |
|                                    | Pulsed (Note 2)        | $I_{DM}$  | 16         | A                |
| Avalanche Energy                   | Single Pulsed (Note 3) | $E_{AS}$  | 200        | mJ               |
|                                    | Repetitive (Note 2)    | $E_{AR}$  | 10.6       | mJ               |
| Peak Diode Recovery dv/dt (Note 4) |                        | dv/dt     | 4.5        | V/ns             |
| Power Dissipation                  | TO-220/TO-262/TO-263   | $P_D$     | 106        | W                |
|                                    | TO-220F/TO-220F1       |           | 36         |                  |
|                                    | TO-220F3               |           | 38         |                  |
|                                    | TO-220F2               |           | 38         |                  |
|                                    | TO-251/TO-252/TO-252D  |           | 50         |                  |
|                                    | TO-251S/TO-251S2       |           | 50         |                  |
|                                    | TO-251S4               |           | 50         |                  |
|                                    | DFN-8(5×6)             |           | 30         |                  |
| Junction Temperature               |                        | $T_J$     | +150       | $^\circ\text{C}$ |
| Operating Temperature              |                        | $T_{OPR}$ | -55 ~ +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.  $L = 30\text{mH}$ ,  $I_{AS} = 3.65\text{A}$ ,  $V_{DD} = 50\text{V}$ ,  $R_G = 25\ \Omega$ , Starting  $T_J = 25^\circ\text{C}$

4.  $I_{SD} \leq 4.4\text{A}$ ,  $di/dt \leq 200\text{A}/\mu\text{s}$ ,  $V_{DD} \leq BV_{DSS}$ , Starting  $T_J = 25^\circ\text{C}$

■ **THERMAL DATA**

| PARAMETER           | PACKAGE               | SYMBOL        | RATINGS | UNIT                      |
|---------------------|-----------------------|---------------|---------|---------------------------|
| Junction to Ambient | TO-220/TO-262/TO-263  | $\theta_{JA}$ | 62.5    | $^\circ\text{C}/\text{W}$ |
|                     | TO-220F/TO-220F1      |               |         |                           |
|                     | TO-220F2/TO-220F3     |               |         |                           |
|                     | TO-251/TO-252/TO-252D |               | 110     |                           |
|                     | TO-251S/TO-251S2      |               |         |                           |
|                     | TO-251S4              |               |         |                           |
|                     | DFN-8(5×6)            |               | 75      |                           |
| Junction to Case    | TO-220/TO-262/TO-263  | $\theta_{JC}$ | 1.18    | $^\circ\text{C}/\text{W}$ |
|                     | TO-220F/TO-220F1      |               | 3.47    |                           |
|                     | TO-220F3              |               | 3.28    |                           |
|                     | TO-220F2              |               | 3.28    |                           |
|                     | TO-251/TO-252/TO-252D |               | 2.5     |                           |
|                     | TO-251S/TO-251S2      |               | 2.5     |                           |
|                     | TO-251S4              |               | 2.5     |                           |
|                     | DFN-8(5×6)            |               | 4.17    |                           |

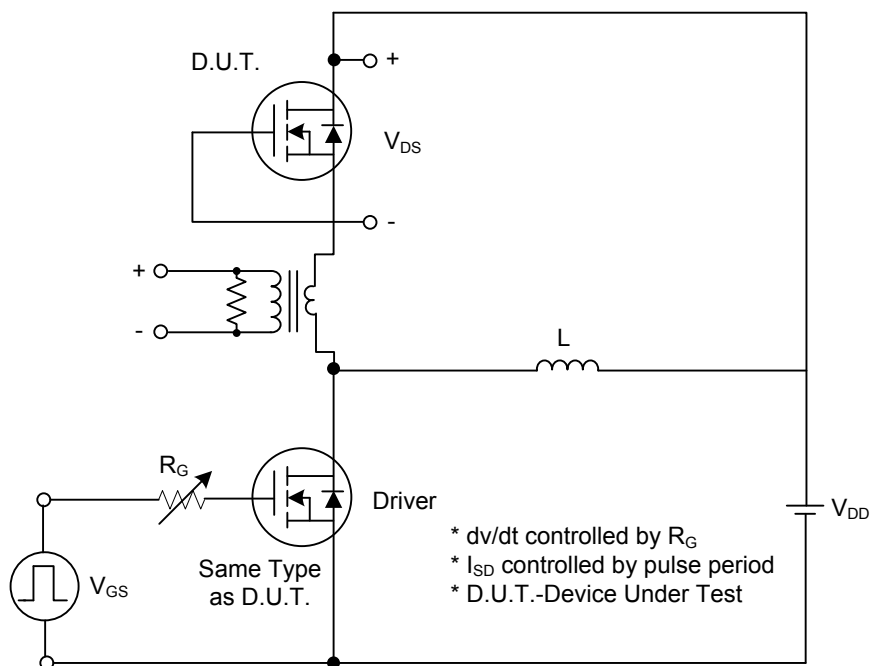
■ ELECTRICAL CHARACTERISTICS (T<sub>C</sub>=25°C, unless otherwise specified)

| PARAMETER                                             |         | SYMBOL                              | TEST CONDITIONS                                                                    | MIN | TYP | MAX  | UNIT |
|-------------------------------------------------------|---------|-------------------------------------|------------------------------------------------------------------------------------|-----|-----|------|------|
| OFF CHARACTERISTICS                                   |         |                                     |                                                                                    |     |     |      |      |
| Drain-Source Breakdown Voltage                        |         | BV <sub>DSS</sub>                   | V <sub>GS</sub> = 0V, I <sub>D</sub> = 250μA                                       | 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   |
| Breakdown Voltage Temperature Coefficient             |         | ΔBV <sub>DSS</sub> /ΔT <sub>J</sub> | I <sub>D</sub> =250μA,Referenced to 25°C                                           |     | 0.6 |      | V/°C |
| ON CHARACTERISTICS                                    |         |                                     |                                                                                    |     |     |      |      |
| Gate Threshold Voltage                                |         | V <sub>GS(TH)</sub>                 | V <sub>DS</sub> = V <sub>GS</sub> , I <sub>D</sub> = 250μA                         | 2.0 |     | 4.0  | V    |
| Static Drain-Source On-State Resistance               |         | R <sub>DS(ON)</sub>                 | V <sub>GS</sub> = 10 V, I <sub>D</sub> = 2.2A                                      |     | 2.3 | 2.5  | Ω    |
| DYNAMIC CHARACTERISTICS                               |         |                                     |                                                                                    |     |     |      |      |
| Input Capacitance                                     |         | C <sub>ISS</sub>                    | V <sub>DS</sub> = 25V, V <sub>GS</sub> = 0V,<br>f = 1MHz                           |     | 520 | 620  | pF   |
| Output Capacitance                                    |         | C <sub>OSS</sub>                    |                                                                                    |     | 55  | 75   | pF   |
| Reverse Transfer Capacitance                          |         | C <sub>RSS</sub>                    |                                                                                    |     | 11  | 15   | pF   |
| SWITCHING CHARACTERISTICS                             |         |                                     |                                                                                    |     |     |      |      |
| Turn-On Delay Time                                    |         | t <sub>D(ON)</sub>                  | V <sub>DD</sub> = 300V, I <sub>D</sub> = 4.0A,<br>R <sub>G</sub> = 25Ω (Note 1, 2) |     | 60  | 130  | ns   |
| Turn-On Rise Time                                     |         | t <sub>R</sub>                      |                                                                                    |     | 60  | 100  | ns   |
| Turn-Off Delay Time                                   |         | t <sub>D(OFF)</sub>                 |                                                                                    |     | 220 | 260  | ns   |
| Turn-Off Fall Time                                    |         | t <sub>F</sub>                      |                                                                                    |     | 70  | 100  | ns   |
| Total Gate Charge                                     |         | Q <sub>G</sub>                      | V <sub>DS</sub> = 480V,I <sub>D</sub> = 4.0A,<br>V <sub>GS</sub> = 10V (Note 1, 2) |     | 65  |      | nC   |
| Gate-Source Charge                                    |         | Q <sub>GS</sub>                     |                                                                                    |     | 6   |      | nC   |
| Gate-Drain Charge                                     |         | Q <sub>GD</sub>                     |                                                                                    |     | 8   |      | nC   |
| SOURCE- DRAIN DIODE RATINGS AND CHARACTERISTICS       |         |                                     |                                                                                    |     |     |      |      |
| Drain-Source Diode Forward Voltage                    |         | V <sub>SD</sub>                     | V <sub>GS</sub> = 0V, I <sub>S</sub> = 4.4A                                        |     |     | 1.4  | V    |
| Maximum Continuous Drain-Source Diode Forward Current |         | I <sub>S</sub>                      |                                                                                    |     |     | 4.4  | A    |
| Maximum Pulsed Drain-Source Diode Forward Current     |         | I <sub>SM</sub>                     |                                                                                    |     |     | 17.6 | A    |
| Reverse Recovery Time                                 |         | t <sub>rr</sub>                     | V <sub>GS</sub> = 0 V, I <sub>S</sub> = 4.4A,                                      |     | 250 |      | ns   |
| Reverse Recovery Charge                               |         | Q <sub>RR</sub>                     | dl <sub>F</sub> /dt = 100 A/μs (Note 1)                                            |     | 1.5 |      | μC   |

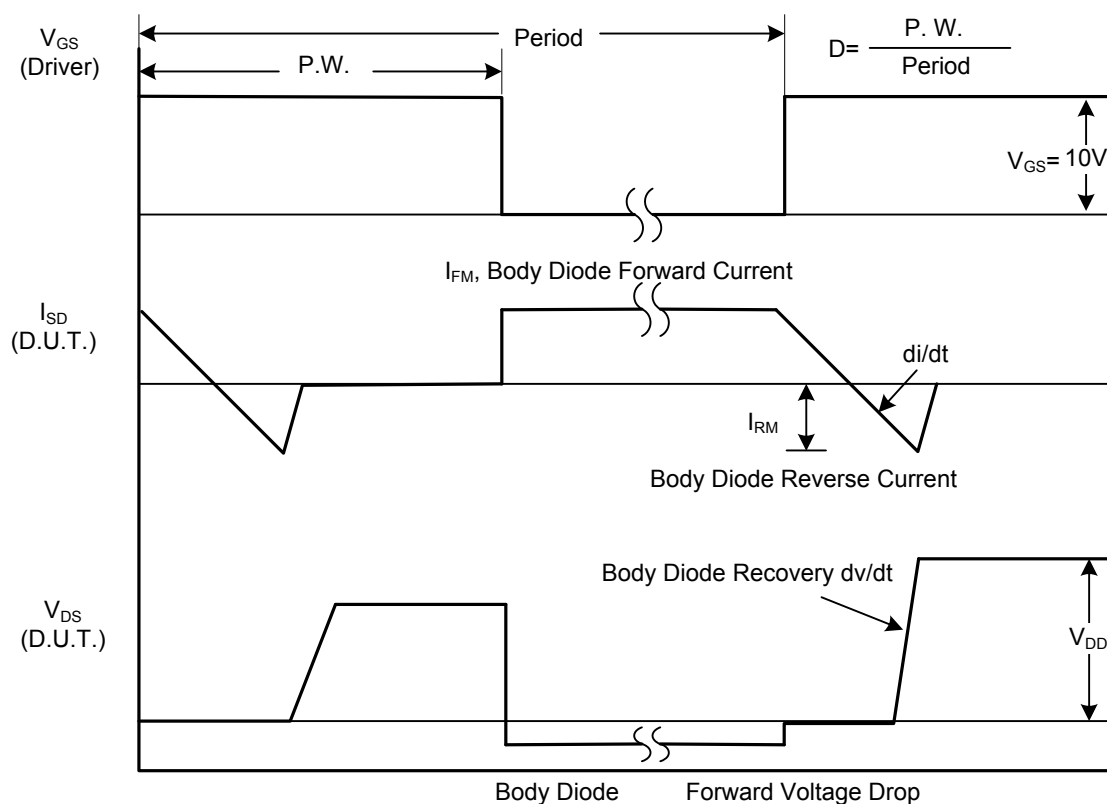
Notes: 1. Pulse Test: Pulse width ≤ 300μs, Duty cycle ≤ 2%

2. Essentially independent of operating temperature

## ■ TEST CIRCUITS AND WAVEFORMS

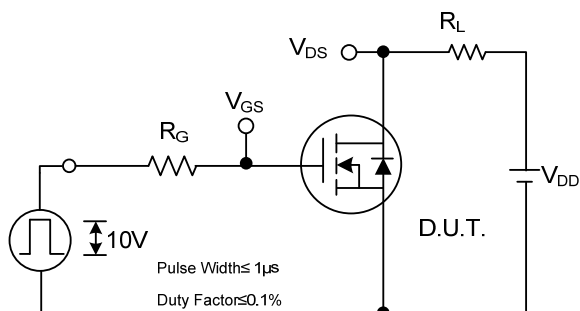


Peak Diode Recovery  $dv/dt$  Test Circuit

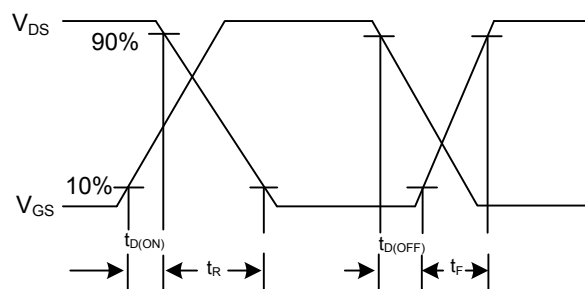


Peak Diode Recovery  $dv/dt$  Waveforms

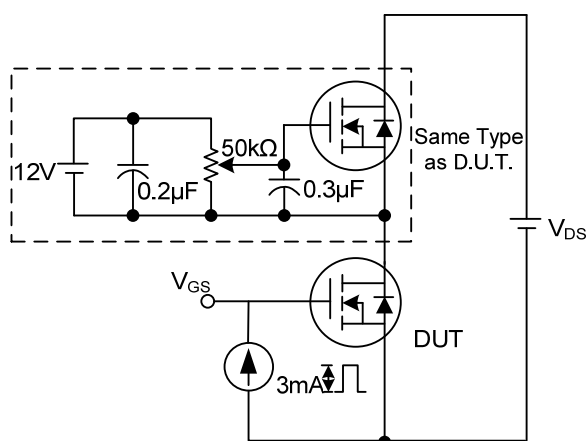
## ■ TEST CIRCUITS AND WAVEFORMS (Cont.)



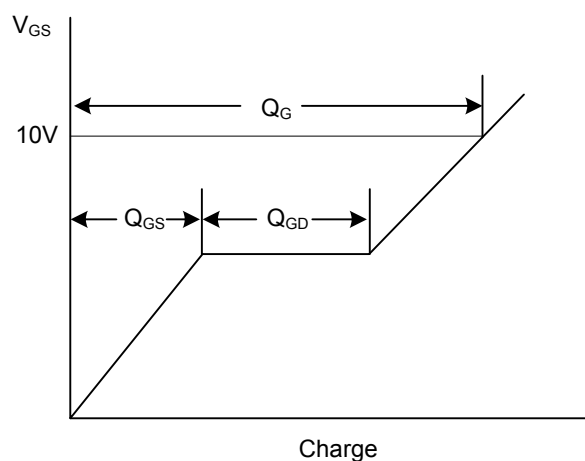
Switching Test Circuit



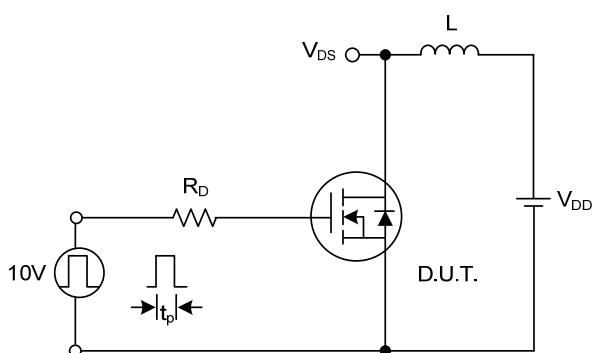
Switching Waveforms



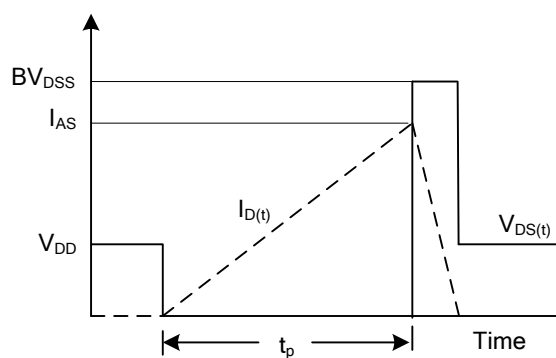
Gate Charge Test Circuit



Gate Charge Waveform



Unclamped Inductive Switching Test Circuit



Unclamped Inductive Switching Waveforms

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