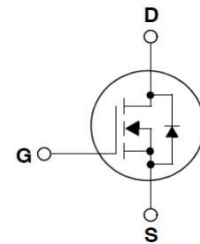


**650V, 580mΩ typ., 12A N-Channel Power MOSFET**
**Features**

- $V_{DS}=650V$ ,  $I_D=12A$   
 $R_{DS(ON)}=580m\Omega$  (Type) @  $V_{GS}=10V$
- Low Gate Charge(Typ. 48nC)
- Low  $C_{rss}$ (Typ. 11pF)
- Fast Switching
- Improved  $dv/dt$  Capability
- 100% Avalanche Tested
- Lead Free Available(RoHS Compliant)
- TO-220AB and TO-220F Package

**Applications**

- Switch mode power supplies(SMPS)
- Power factor correction(PFC)
- Uninterruptible power supply ( UPS )

 TO-220AB/TO-220F  
Top View


N-Channel MOSFET

**Package Marking and Ordering Information**

| Device         | Marking <sup>[1]</sup> | Device Package | Quantity    |
|----------------|------------------------|----------------|-------------|
| HCR12N65PT22BP | HCR12N65Pxx            | TO-220AB       | 1000pcs/Box |
| HCR12N65FT2FBP | HCR12N65Fxx            | TO-220F        | 1000pcs/Box |

Note [1]. The "xx" is date code.

**ABSOLUTE MAXIMUM RATINGS (T<sub>c</sub> = 25°C UNLESS OTHERWISE NOTED)**

| Parameter                                                    |                       | Symbol                          | HCR12N65P  | HCR12N65F | Unit |
|--------------------------------------------------------------|-----------------------|---------------------------------|------------|-----------|------|
| Drain - Source Voltage (V <sub>GS</sub> =0V)                 |                       | V <sub>DS</sub>                 | 650        |           | V    |
| Gate - Source Voltage ( V <sub>DS</sub> =0V ), AC( f > 1Hz ) |                       | V <sub>GS</sub>                 | ±30        |           | V    |
| Continuous Drain Current                                     | T <sub>c</sub> =25°C  | I <sub>D</sub> (DC)             | 12         | 12*       | A    |
| Continuous Drain Current                                     | T <sub>c</sub> =100°C | I <sub>D</sub> (DC)             | 7.4        | 7.4*      | A    |
| Pulsed Drain Current                                         |                       | I <sub>DM</sub> (Pulse)         | 48         | 48*       | A    |
| Maximum Power Dissipation                                    | T <sub>c</sub> =25°C  | P <sub>D</sub>                  | 182        | 48.2      | W    |
|                                                              | -Derate above 25°C    | -                               | 1.8        | 0.41      | W/°C |
| Single Pulsed Avalanche Energy <sup>note2</sup>              |                       | E <sub>AS</sub>                 | 180        |           | mJ   |
| Operating and Storage Temperature Range                      |                       | T <sub>J</sub> T <sub>STG</sub> | -55 to 150 |           | °C   |
| Maximum Lead Temperature for Soldering Purposes              |                       | T <sub>L</sub>                  | 300        |           | °C   |
| Thermal Resistance, Junction-to-Case(Maximum)                |                       | R <sub>QJC</sub>                | 0.56       | 2.45      | °C/W |
| Thermal Resistance, Junction-to-Ambient(Maximum)             |                       | R <sub>QJA</sub>                | 62.5       | 62.5      | °C/W |

Note " \* ", Drain current limited by maximum junction temperature.

 Note 2. The EAS data shows Max. rating .The test condition is V<sub>DD</sub>=50V , R<sub>G</sub>=25Ω , L=10mH , I<sub>AS</sub>=6A.

**650V, 580mΩ typ., 12A N-Channel Power MOSFET**

Electrical Characteristics (TA = 25°C unless otherwise noted)

| Parameter                                 | Symbol      | Test Conditions                                        | Model |      |      | Unit |
|-------------------------------------------|-------------|--------------------------------------------------------|-------|------|------|------|
|                                           |             |                                                        | Min   | Typ  | Max  |      |
| On/Off States                             |             |                                                        |       |      |      |      |
| Drain -Source Breakdown Voltage           | BVDSS       | VGS=0V, ID = 250uA                                     | 650   | -    | -    | V    |
| Breakdown Voltage Temperature Coefficient | ΔBVDSS /ΔTJ | ID=250uA, Referenced to 25°C                           | -     | 0.65 | -    | V/°C |
| Zero Gate Voltage Drain Current           | IDSS        | VDS=650V, VGS=0V, TC=25°C                              | -     | -    | 1    | uA   |
|                                           |             | VDS=520V, TC=125°C                                     | -     | -    | 10   |      |
| Gate-Body Leakage Current                 | IGSS        | VDS=0V, VGS= ±30V                                      | -     | -    | ±100 | nA   |
| Gate-Threshold Voltage                    | VGS(th)     | VGS=VDS, ID= 250uA                                     | 2.0   | 3.0  | 4.0  | V    |
| Drain-Source-On-Resistance                | RDS(on)     | VGS=10V, ID=6A                                         | -     | 580  | 700  | mΩ   |
| Forward Transconductance                  | gfs         | VDS= 10V, ID=6A <sup>note3</sup>                       | -     | 13   | -    | S    |
| Dynamic Characteristics                   |             |                                                        |       |      |      |      |
| Input Capacitance                         | CISS        | VDS=25V, VGS= 0V f=1MHz                                | -     | 1960 | -    | pF   |
| Output Capacitance                        | COSS        |                                                        | -     | 182  | -    |      |
| Reverse Transfer Capacitance              | CRSS        |                                                        | -     | 11   | -    |      |
| Switching Characteristics                 |             |                                                        |       |      |      |      |
| Total Gate Charge                         | Qg          | VDS= 520V, VGS= 10V<br>ID=12A <sup>note 3,4</sup>      | -     | 48   | -    | nC   |
| Gate-Source Charge                        | Qgs         |                                                        | -     | 8.5  | -    |      |
| Gate-Drain Charge                         | Qgd         |                                                        | -     | 20   | -    |      |
| Turn-On Delay Time                        | td(ON)      | VDS=320V,ID=12A,<br>VGS=10V, RG=25Ω <sup>note3,4</sup> | -     | 30   | -    | ns   |
| Rise Time                                 | tr          |                                                        | -     | 85   | -    |      |
| Turn-Off Delay Time                       | td(OFF)     |                                                        | -     | 155  | -    |      |
| Fall Time                                 | tf          |                                                        | -     | 90   | -    |      |
| Drain-Source Diode Characteristics        |             |                                                        |       |      |      |      |
| Source-Drain Current(Body Diode)          | ISD         | VG=VD=0V, Force Current                                | -     | -    | 12   | A    |
| Pulsed Source-Drain Current(Body Diode)   | ISDM        |                                                        | -     | -    | 48   | A    |
| Diode Forward Voltage                     | VSD         | TJ=25°C, VGS=0V, ISD=12A                               | -     | -    | 1.4  | V    |
| Reverse Recovery Time                     | trr         | TJ=25°C, VGS=0V, IS=12A                                | -     | 420  | -    | nS   |
| Reverse Recovery Charge                   | Qrr         | di/dt=100A/us <sup>note3</sup>                         | -     | 4.9  | -    | uC   |

note 3. Pulse Test: Pulse Width ≤300us, Duty Cycle≤2%

4. Essentially independent of operating temperature

**650V, 580mΩ typ., 12A N-Channel Power MOSFET**

Typical Characteristics ( $T_J = 25^\circ\text{C}$  unless otherwise noted)

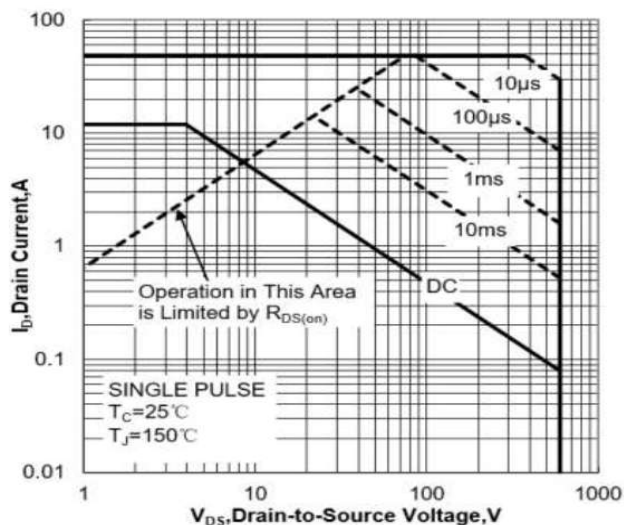


Figure 1. Safe Operating Area(No FullPAK)

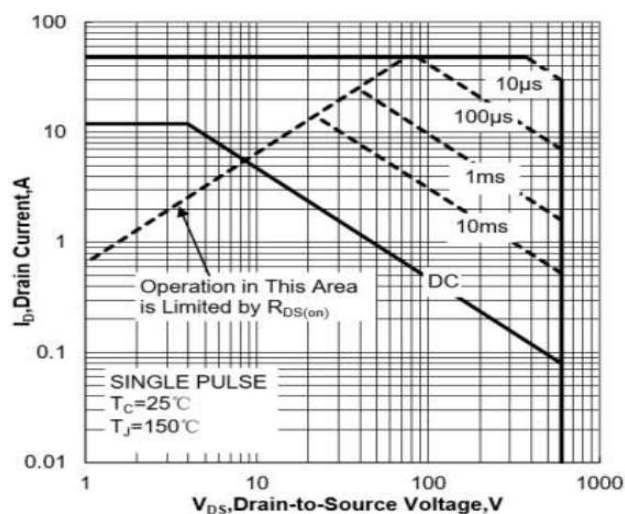


Figure 2. Safe Operating Area(FullPAK)

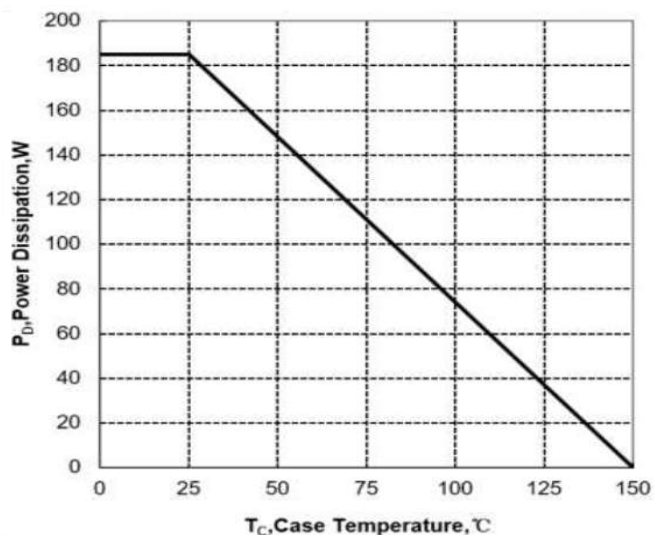


Figure 3. Power Dissipation(No FullPAK)

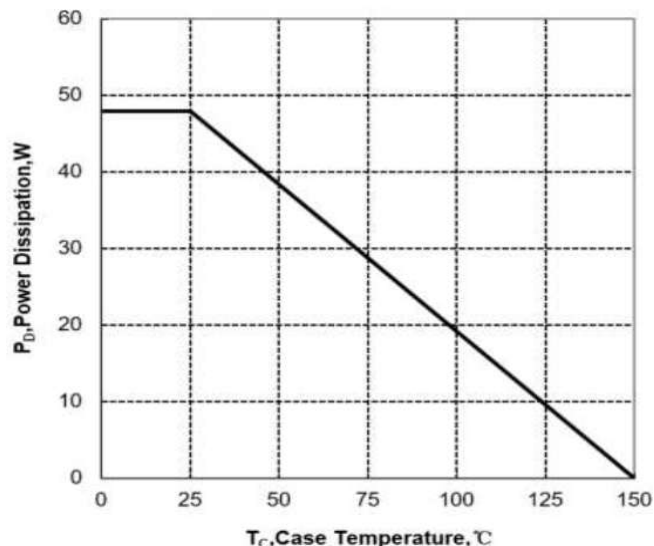


Figure 4. Power Dissipation(FullPAK)

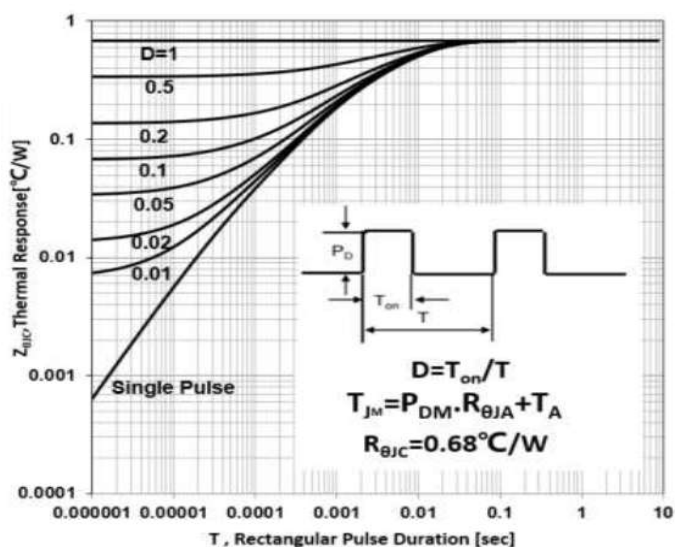


Figure 5. Max Thermal Impedance(No FullPAK)

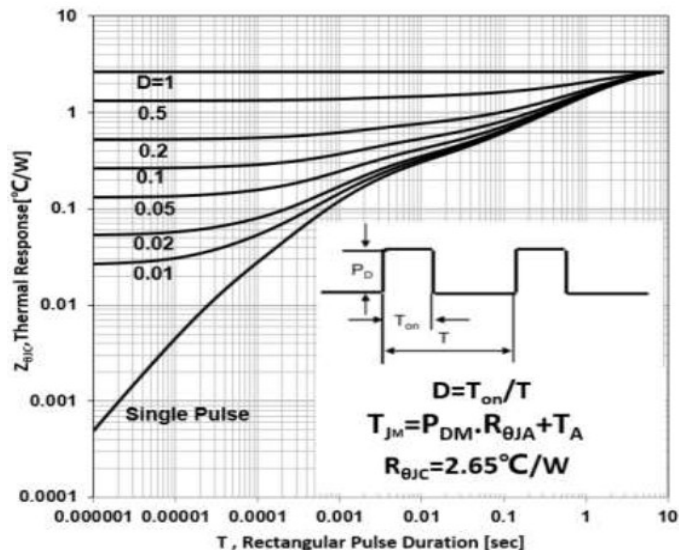


Figure 6. Max Thermal Impedance(FullPAK)

## 650V, 580mΩ typ., 12A N-Channel Power MOSFET

Typical Characteristics ( $T_J = 25^\circ\text{C}$  unless otherwise noted)(Con.)

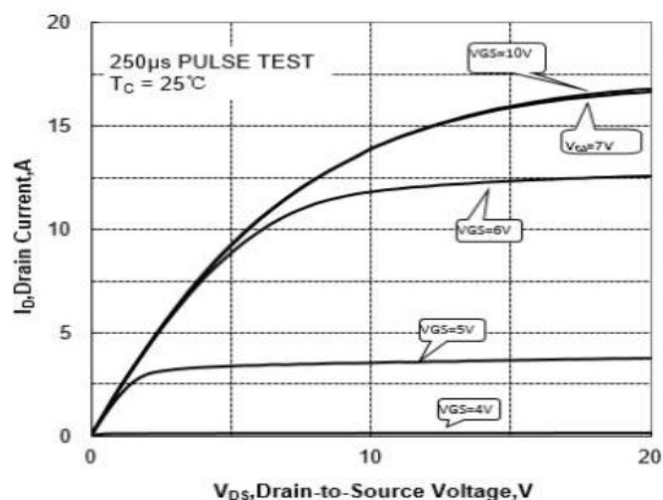


Figure 7. Typical Output Characteristics

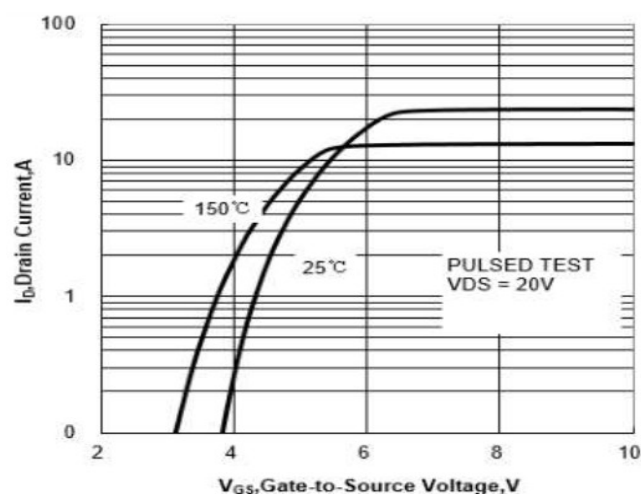


Figure 8. Typical Transfer Characteristics

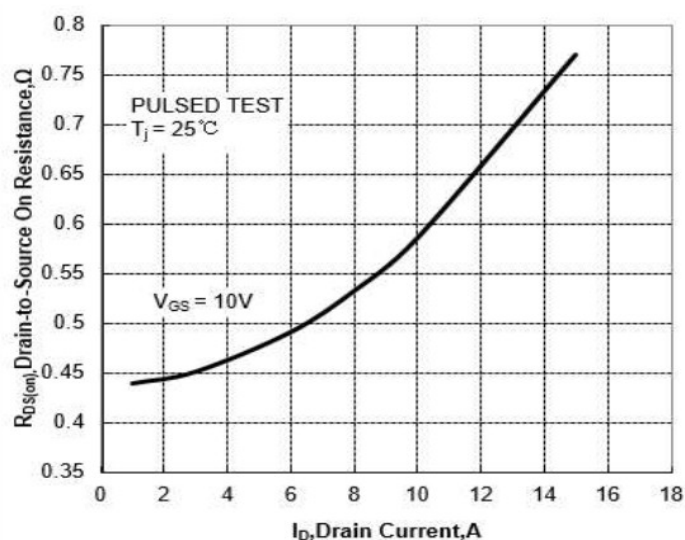


Figure 9. Typical Drain to Source ON Resistance vs Drain Current

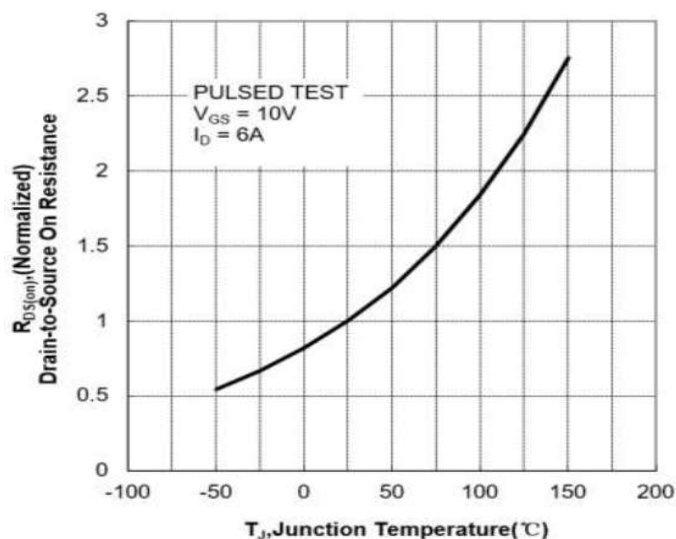


Figure 10. Typical Drain to Source ON Resistance vs Junction Temperature

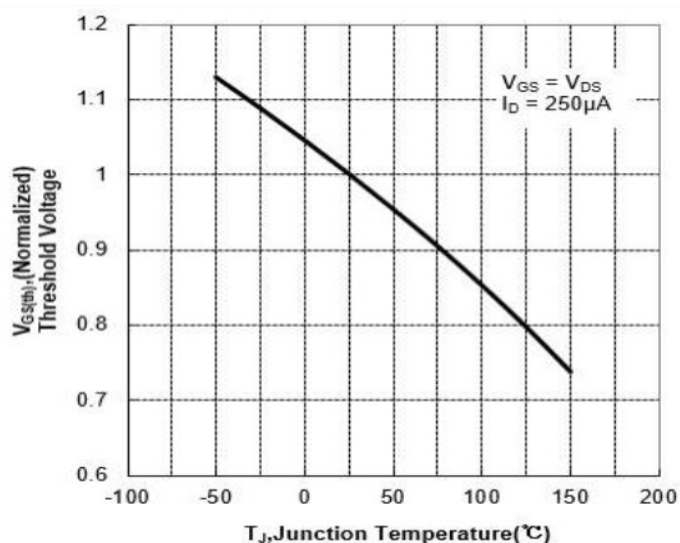


Figure 11. Typical Theshold Voltage vs Junction Temperature

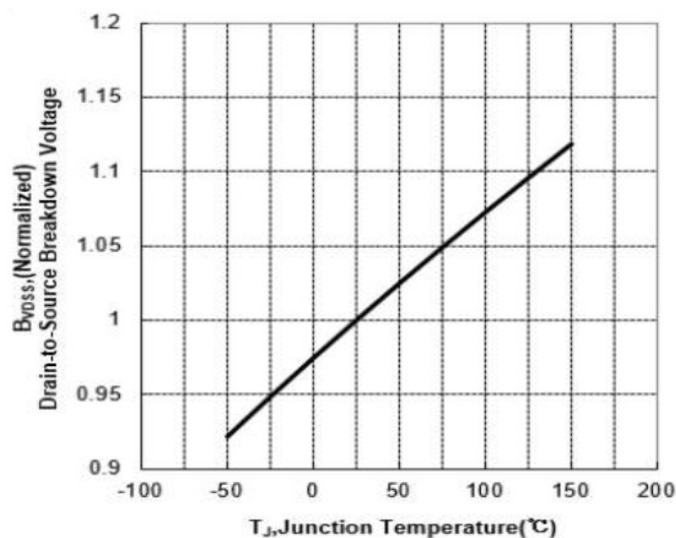


Figure 12. Typical Breakdown Voltage vs Junction Temperature

**650V, 580mΩ typ., 12A N-Channel Power MOSFET**

Typical Characteristics ( $T_J = 25^\circ\text{C}$  unless otherwise noted)(Con.)

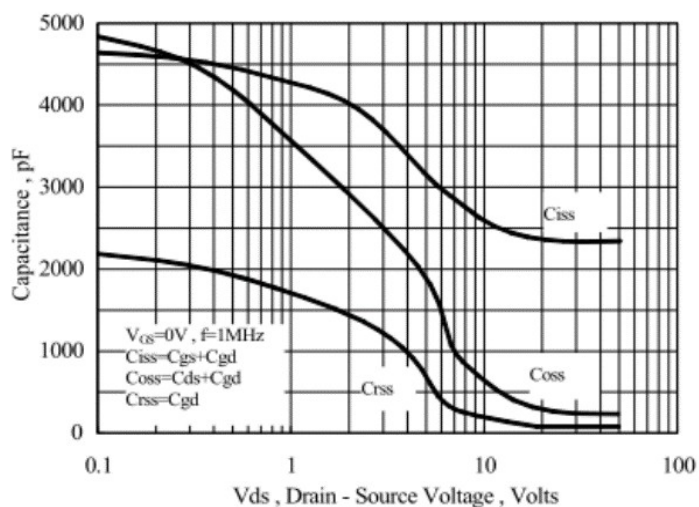


Figure 13. Typical Capacitance vs Drain to Source Voltage

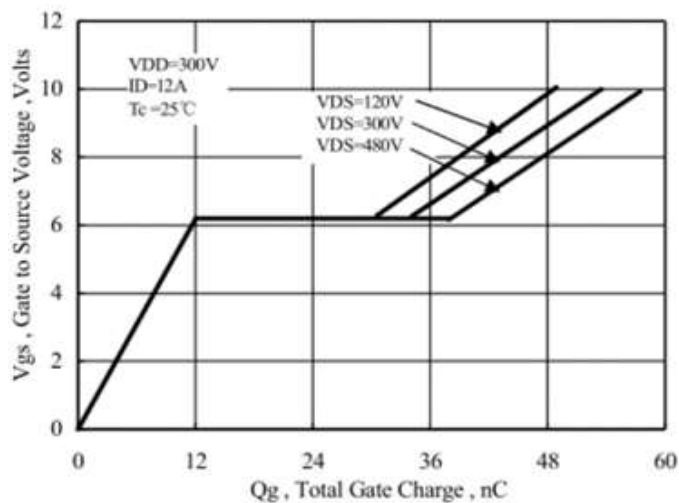


Figure 14. Typical Gate Charge vs Gate to Source Voltage

### Test Circuit

#### - Gate Charge test circuit & Waveform

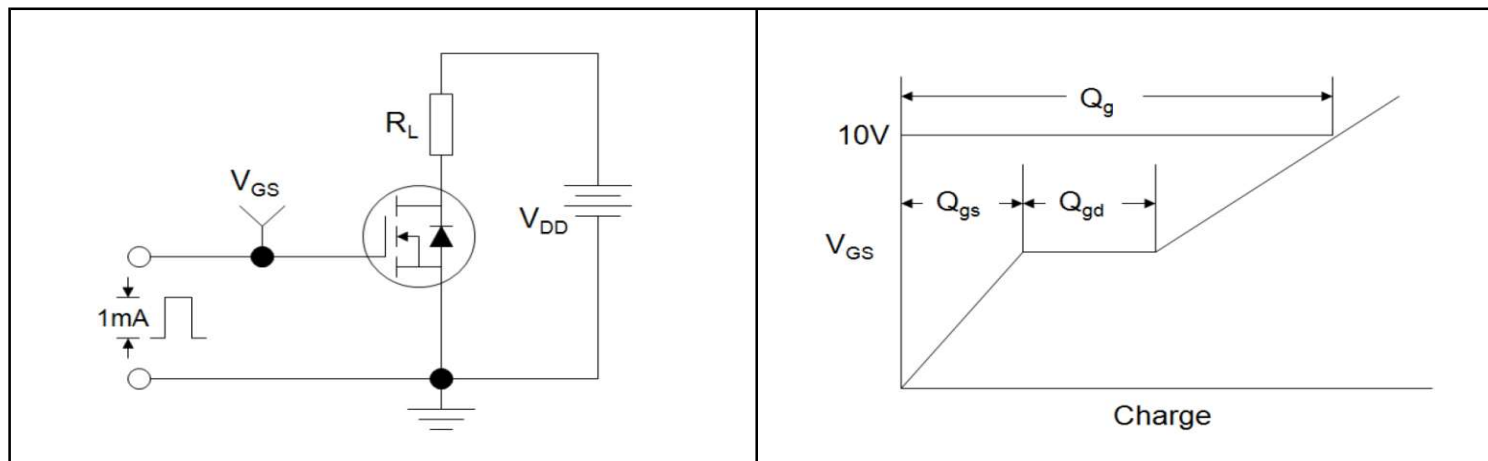


Figure 15. Gate Charge test circuit & Waveform

#### - Resistive Switching Test Circuit & Waveform

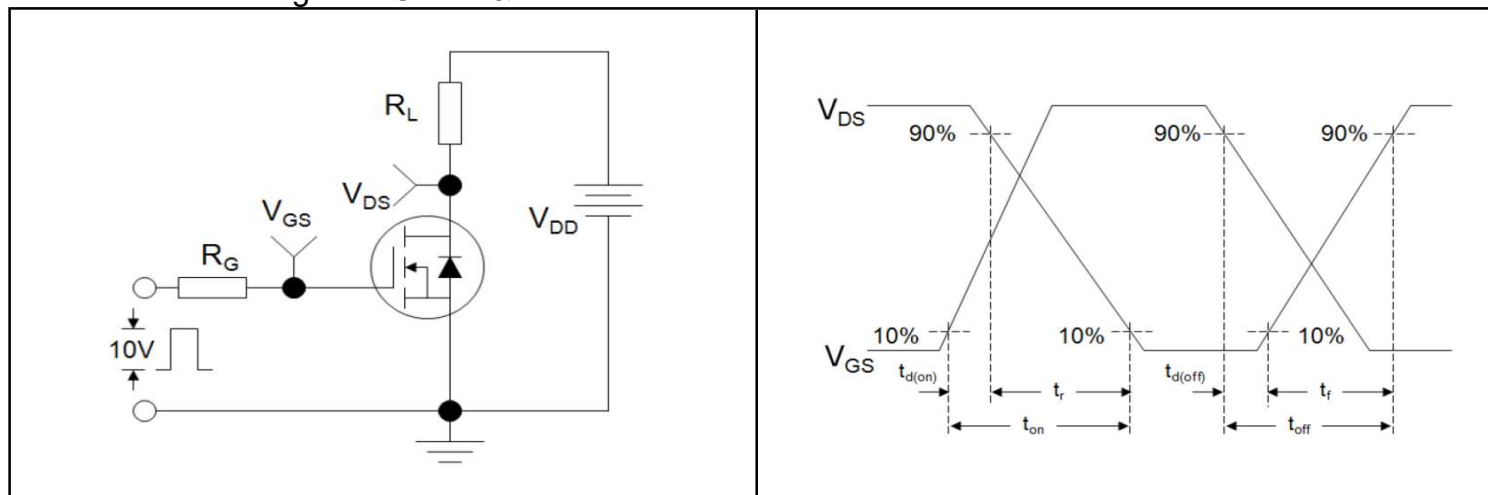


Figure 16. Resistive Switching Test Circuit & Waveform

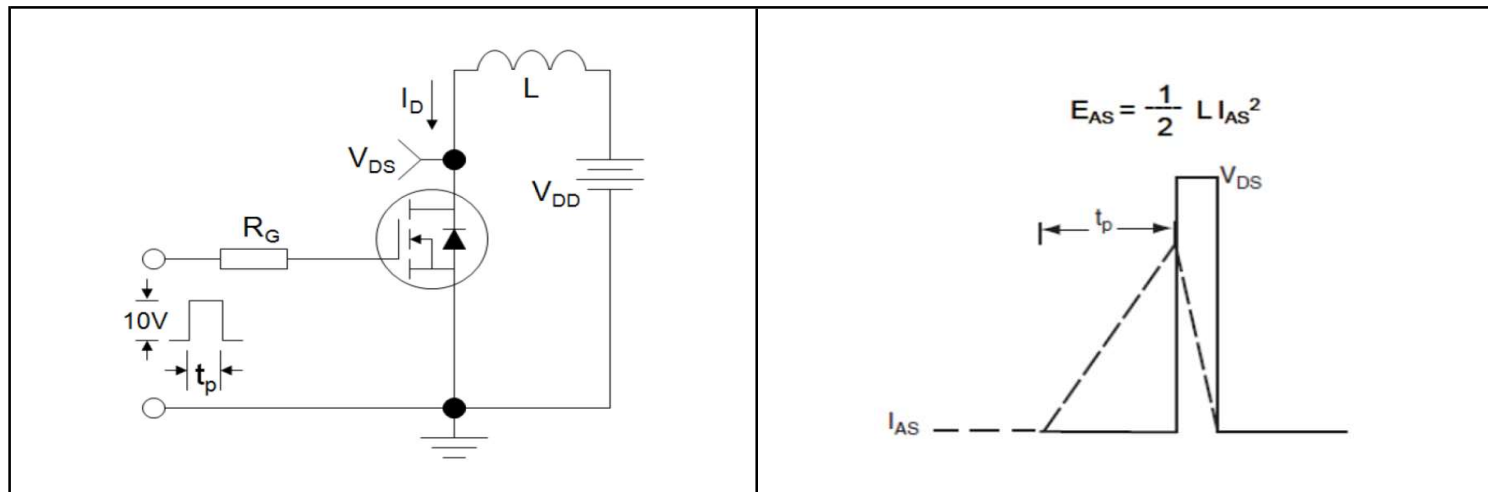
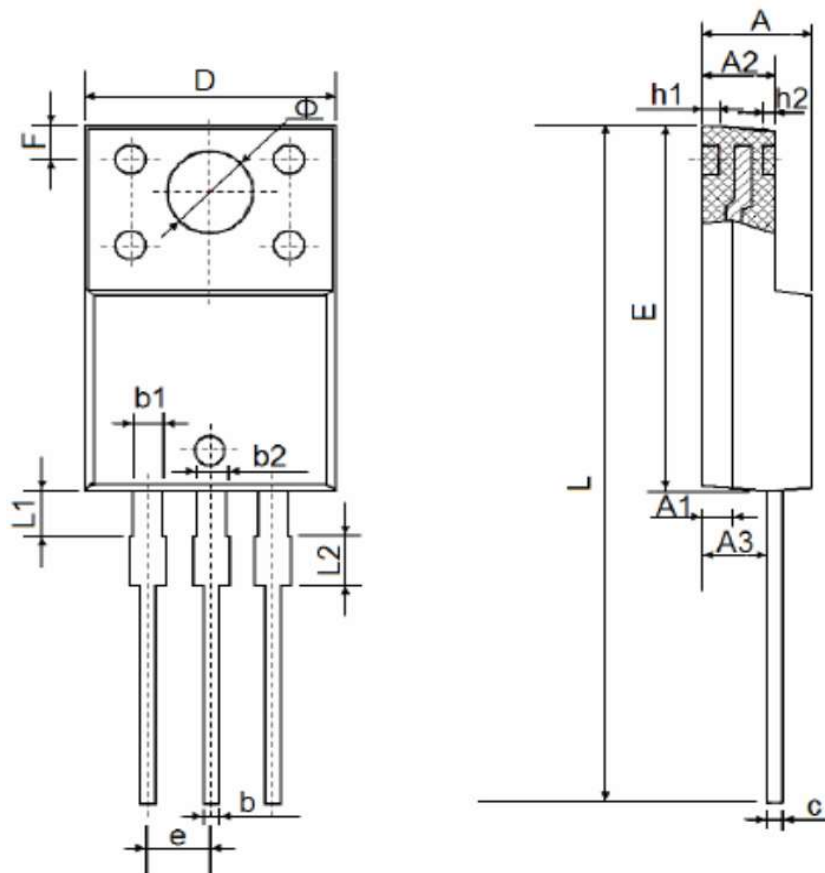
**650V, 580mΩ typ., 12A N-Channel Power MOSFET**
**Test Circuit (con.)**
**- Unclamped Inductive Switching Test Circuit & Waveforms**


Figure 17. Unclamped Inductive Switching Test Circuit & Waveforms

**Packaging Information**

PKG: TO-220F Package

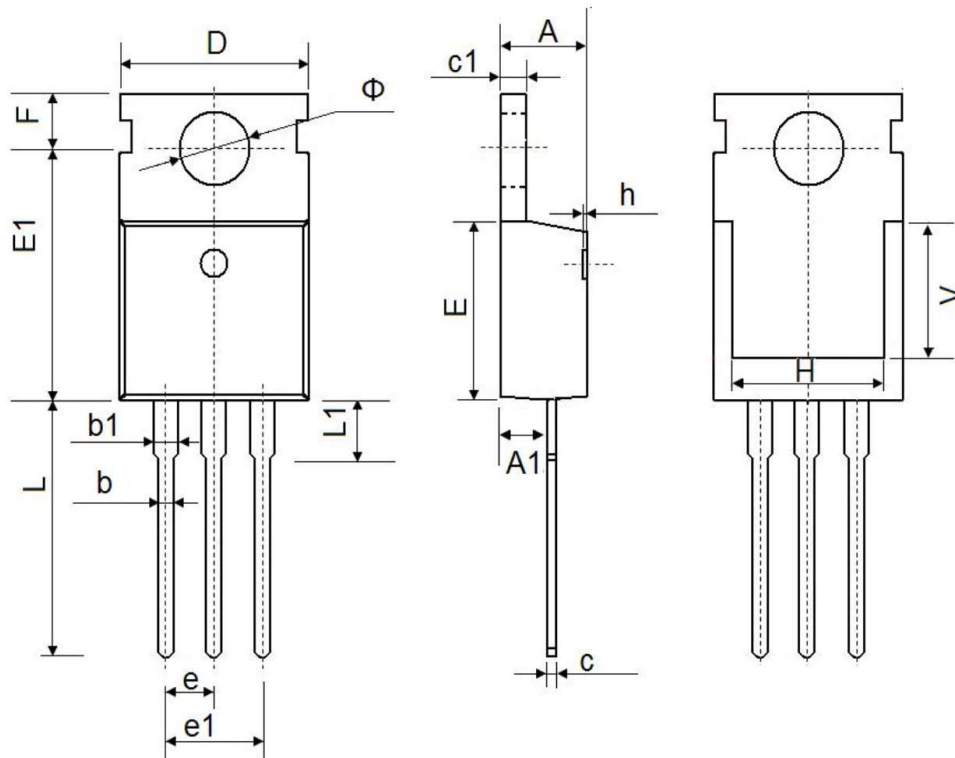
unit : mm



| Symbol | Dimensions In Millimeters |        | Dimensions In Inches |       |
|--------|---------------------------|--------|----------------------|-------|
|        | Min.                      | Max.   | Min.                 | Max.  |
| A      | 4.300                     | 4.700  | 0.169                | 0.185 |
| A1     | 1.300REF                  |        | 0.051REF             |       |
| A2     | 2.800                     | 3.200  | 0.110                | 0.126 |
| A3     | 2.500                     | 2.900  | 0.098                | 0.114 |
| b      | 0.500                     | 0.750  | 0.020                | 0.030 |
| b1     | 1.100                     | 1.350  | 0.043                | 0.053 |
| b2     | 1.500                     | 1.750  | 0.059                | 0.069 |
| c      | 0.500                     | 0.750  | 0.020                | 0.030 |
| D      | 9.960                     | 10.360 | 0.392                | 0.408 |
| E      | 14.800                    | 15.200 | 0.583                | 0.598 |
| e      | 2.540TYP.                 |        | 0.100TYP             |       |
| F      | 2.700REF                  |        | 0.106REF             |       |
| Φ      | 3.500REF                  |        | 0.138REF             |       |
| h1     | 0.800REF                  |        | 0.031REF             |       |
| h2     | 0.500REF                  |        | 0.020REF             |       |
| L      | 28.000                    | 28.400 | 1.102                | 1.118 |
| L1     | 1.700                     | 1.900  | 0.067                | 0.075 |
| L2     | 1.900                     | 2.100  | 0.075                | 0.083 |

**Packaging Information(Con.)**
**PKG: TO-220AB Package**

unit : mm



| Symbol | Dimensions In Millimeters |        | Dimensions In Inches |       |
|--------|---------------------------|--------|----------------------|-------|
|        | Min.                      | Max.   | Min.                 | Max.  |
| A      | 4.400                     | 4.600  | 0.173                | 0.181 |
| A1     | 2.250                     | 2.550  | 0.089                | 0.100 |
| b      | 0.710                     | 0.910  | 0.028                | 0.036 |
| b1     | 1.170                     | 1.370  | 0.046                | 0.054 |
| c      | 0.330                     | 0.650  | 0.013                | 0.026 |
| c1     | 1.200                     | 1.400  | 0.047                | 0.055 |
| D      | 9.910                     | 10.250 | 0.390                | 0.404 |
| E      | 8.9500                    | 9.750  | 0.352                | 0.384 |
| E1     | 12.650                    | 12.950 | 0.498                | 0.510 |
| e      | 2.540 TYP.                |        | 0.100 TYP.           |       |
| e1     | 4.980                     | 5.180  | 0.196                | 0.204 |
| F      | 2.650                     | 2.950  | 0.104                | 0.116 |
| H      | 7.900                     | 8.100  | 0.311                | 0.319 |
| h      | 0.000                     | 0.300  | 0.000                | 0.012 |
| L      | 12.900                    | 13.400 | 0.508                | 0.528 |
| L1     | 2.850                     | 3.250  | 0.112                | 0.128 |
| V      | 7.500 REF.                |        | 0.295 REF.           |       |
| Φ      | 3.400                     | 3.800  | 0.134                | 0.150 |