

# ICE10N65FP N-Channel Enhancement Mode MOSFET

RoHS  
compliant  
2011/65/EU



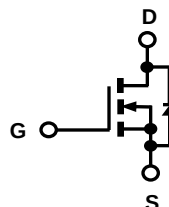
HALOGEN  
FREE

## Features

- Low  $r_{DS(on)}$
- Ultra Low Gate Charge
- High dv/dt capability
- High Unclamped Inductive Switching (UIS) capability
- High peak current capability
- Increased transconductance performance
- Optimized design for high performance power systems

ICEMOS AND ITS SISTER COMPANY 3D SEMI OWN THE FUNDAMENTAL PATENTS FOR SUPERJUNCTION MOSFETS. THE MAJORITY OF THESE PATENTS HAVE 17 to 20 YEARS OF REMAINING LIFE. THIS PORTFOLIO HAS GRANTED PATENTS ISSUED IN USA, CHINA, KOREA, JAPAN, TAIWAN & EUROPE.

| Product Summary |                        |      |     |
|-----------------|------------------------|------|-----|
| $I_D$           | $T_A=25^\circ\text{C}$ | 9.5A | Max |
| $V_{(BR)DSS}$   | $I_D=250\mu\text{A}$   | 650V | Min |
| $r_{DS(on)}$    | $V_{GS}=10\text{V}$    | 0.35 | Typ |
| $Q_g$           | $V_{DS}=480\text{V}$   | 41nC | Typ |



**T0220 Full-PAK  
Isolated (T0-220)**

1=Gate, 2=Drain,  
3=Source

**Maximum ratings**<sup>b</sup>, at  $T_j=25^\circ\text{C}$ , unless otherwise specified

| Parameter                         | Symbol                | Conditions                                                            | Value       | Unit             |
|-----------------------------------|-----------------------|-----------------------------------------------------------------------|-------------|------------------|
| Continuous drain current          | $I_D$                 | $T_c=25^\circ\text{C}$                                                | 9.5         | A                |
| Pulsed drain current              | $I_{D, \text{pulse}}$ | $T_c=25^\circ\text{C}$                                                | 28.5        | A                |
| Avalanche energy, single pulse    | $E_{AS}$              | $I_D=8.3\text{A}$                                                     | 340         | mJ               |
| Avalanche current, repetitive     | $I_{AR}$              | limited by $T_{j\text{max}}$                                          | 5           | A                |
| MOSFET dv/dt ruggedness           | dv/dt                 | $V_{DS}=480\text{V}$ , $I_D=9.5\text{A}$ ,<br>$T_j=125^\circ\text{C}$ | 50          | V/ns             |
| Gate source voltage               | $V_{GS}$              | static                                                                | $\pm 20$    | V                |
|                                   |                       | AC ( $f>1\text{Hz}$ )                                                 | $\pm 30$    |                  |
| Power dissipation                 | $P_{\text{tot}}$      | $T_c=25^\circ\text{C}$                                                | 35          | W                |
| Operating and storage temperature | $T_j, T_{\text{stg}}$ |                                                                       | -55 to +150 | $^\circ\text{C}$ |
| Mounting torque                   |                       | M 2.5 screws                                                          | 50          | Ncm              |

a When mounted on 1inch square 2oz copper clad FR-4

b Preliminary Data Sheet – Specifications subject to change

| Parameter | Symbol | Conditions | Values |     |     | Unit |
|-----------|--------|------------|--------|-----|-----|------|
|           |        |            | Min    | Typ | Max |      |

### Thermal characteristics

|                                                             |            |                                     |   |   |     |      |
|-------------------------------------------------------------|------------|-------------------------------------|---|---|-----|------|
| Thermal resistance, junction-case <sup>a</sup>              | $R_{thJC}$ |                                     | - | - | 3.5 | °C/W |
| Thermal resistance, junction-ambient <sup>a</sup>           | $R_{thJA}$ | leaded                              | - | - | 80  |      |
| Soldering temperature, wave soldering only allowed at leads | $T_{sold}$ | 1.6mm (0.063in.) from case for 10 s | - | - | 260 | °C   |

### Electrical characteristics <sup>b</sup>, at $T_j=25^{\circ}\text{C}$ , unless otherwise specified

#### Static characteristics

|                                  |               |                                                                 |     |      |      |               |
|----------------------------------|---------------|-----------------------------------------------------------------|-----|------|------|---------------|
| Drain-source breakdown voltage   | $V_{(BR)DSS}$ | $V_{GS}=0\text{ V}, I_D=250\mu\text{A}$                         | 650 | 675  | -    | V             |
| Gate threshold voltage           | $V_{GS(th)}$  | $V_{DS}=V_{GS}, I_D=250\mu\text{A}$                             | 2.1 | 3    | 3.9  |               |
| Zero gate voltage drain current  | $I_{DSS}$     | $V_{DS}=650\text{V}, V_{GS}=0\text{V}, T_j=25^{\circ}\text{C}$  | -   | 0.1  | 1    | $\mu\text{A}$ |
|                                  |               | $V_{DS}=650\text{V}, V_{GS}=0\text{V}, T_j=150^{\circ}\text{C}$ | -   | -    | 100  |               |
| Gate source leakage current      | $I_{GSS}$     | $V_{GS}=\pm 20\text{ V}, V_{DS}=0\text{V}$                      | -   | -    | 100  | nA            |
| Drain-source on-state resistance | $R_{DS(on)}$  | $V_{GS}=10\text{V}, I_D=4.75\text{A}, T_j=25^{\circ}\text{C}$   | -   | 0.35 | 0.38 | $\Omega$      |
|                                  |               | $V_{GS}=10\text{V}, I_D=4.75\text{A}, T_j=150^{\circ}\text{C}$  | -   | 0.63 | -    |               |
| Gate resistance                  | $R_G$         | $f=1\text{ MHz}$ , open drain                                   | -   | 5    | -    | $\Omega$      |

#### Dynamic characteristics

|                              |              |                                                                                     |   |      |   |    |
|------------------------------|--------------|-------------------------------------------------------------------------------------|---|------|---|----|
| Input capacitance            | $C_{iss}$    | $V_{GS}=0\text{ V}, V_{DS}=25\text{ V}, f=1\text{ MHz}$                             | - | 1250 | - | pF |
| Output capacitance           | $C_{oss}$    |                                                                                     | - | 600  | - |    |
| Reverse transfer capacitance | $C_{rss}$    |                                                                                     | - | 5    | - |    |
| Transconductance             | $g_{fs}$     | $V_{DS}>2*I_D*R_{DS}, I_D=4.75\text{A}$                                             | - | 12   | - | S  |
| Turn-on delay time           | $t_{d(on)}$  | $V_{DS}=380\text{V}, V_{GS}=10\text{V}, I_D=9.5\text{A}, R_G=4\Omega$<br>(External) | - | 6    | - | ns |
| Rise time                    | $t_r$        |                                                                                     | - | 3.5  | - |    |
| Turn-off delay time          | $t_{d(off)}$ |                                                                                     | - | 54   | - |    |
| Fall time                    | $t_f$        |                                                                                     | - | 7    | - |    |

| Parameter | Symbol | Conditions | Values |     |     | Unit |
|-----------|--------|------------|--------|-----|-----|------|
|           |        |            | Min    | Typ | Max |      |

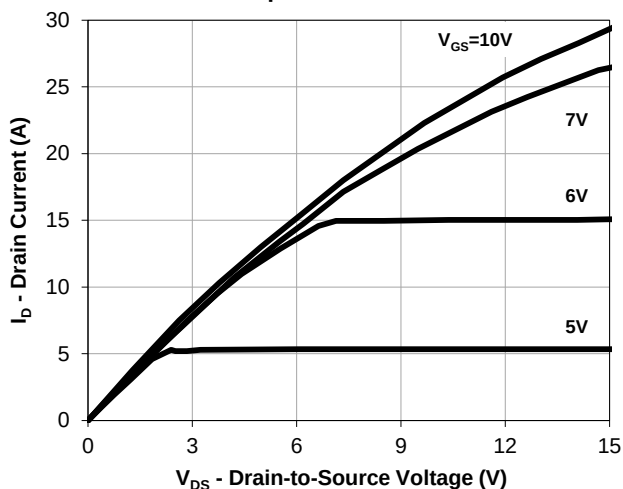
### Gate charge characteristics

|                       |               |                                                                              |   |      |   |    |
|-----------------------|---------------|------------------------------------------------------------------------------|---|------|---|----|
| Gate to source charge | $Q_{gs}$      | $V_{DS}=480\text{ V}, I_D=9.5\text{ A},$<br>$V_{GS}=0\text{ to }10\text{ V}$ | - | 7.1  | - | nC |
| Gate to drain charge  | $Q_{gd}$      |                                                                              | - | 14.5 | - |    |
| Gate charge total     | $Q_g$         |                                                                              | - | 41   | - |    |
| Gate plateau voltage  | $V_{plateau}$ |                                                                              | - | 5.2  | - | V  |

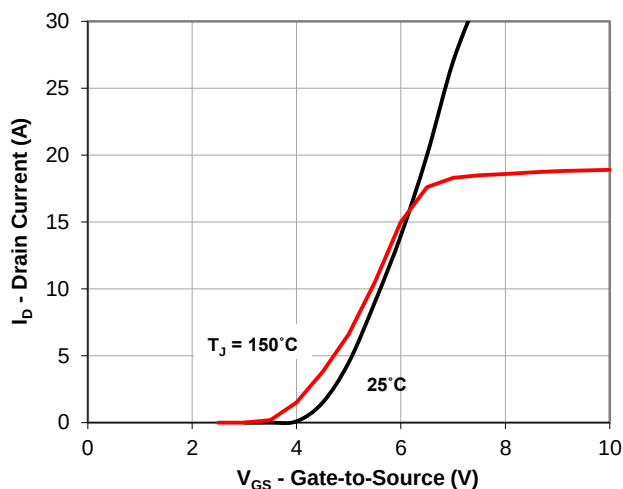
### Reverse Diode

|                               |          |                                                                          |   |      |     |               |
|-------------------------------|----------|--------------------------------------------------------------------------|---|------|-----|---------------|
| Diode forward voltage         | $V_{SD}$ | $V_{GS}=0\text{ V}, I_S=I_F$                                             | - | 0.9  | 1.2 | V             |
| Reverse recovery time         | $t_{rr}$ | $V_{RR}=300\text{ V}, I_S=I_F,$<br>$d_{iF}/d_t=100\text{ A}/\mu\text{S}$ | - | 332  | -   | ns            |
| Reverse recovery charge       | $Q_{rr}$ |                                                                          | - | 4.4  | -   | $\mu\text{C}$ |
| Peak reverse recovery current | $I_{rm}$ |                                                                          | - | 25.6 | -   | A             |

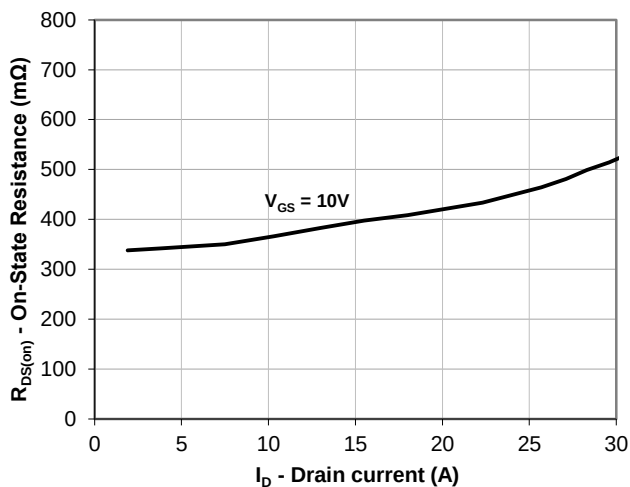
Output Characteristics



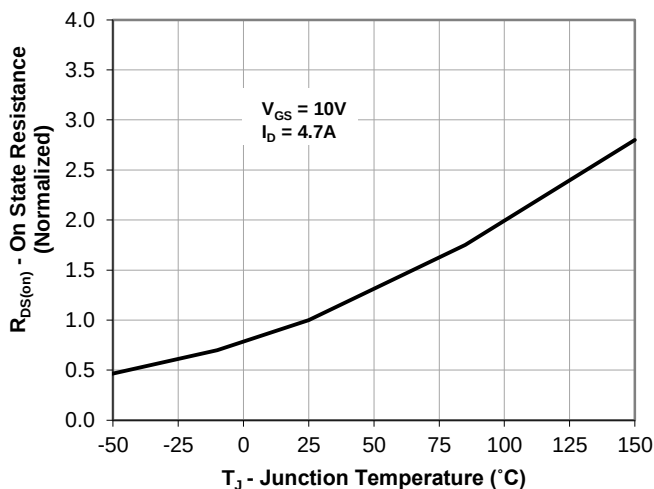
Transfer Characteristics



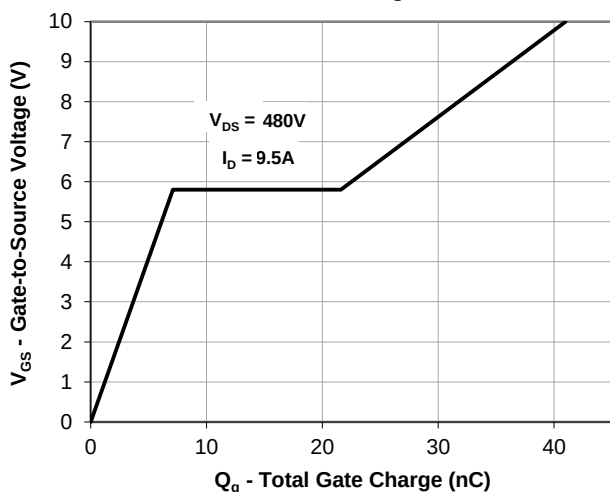
On Resistance vs Drain Current



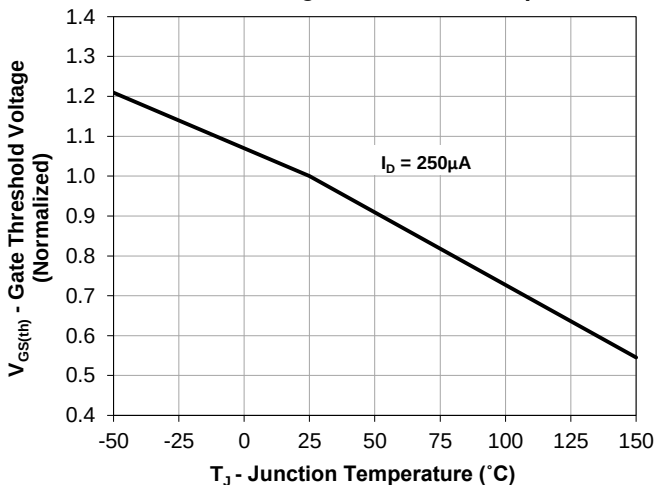
On Resistance vs Junction Temperature



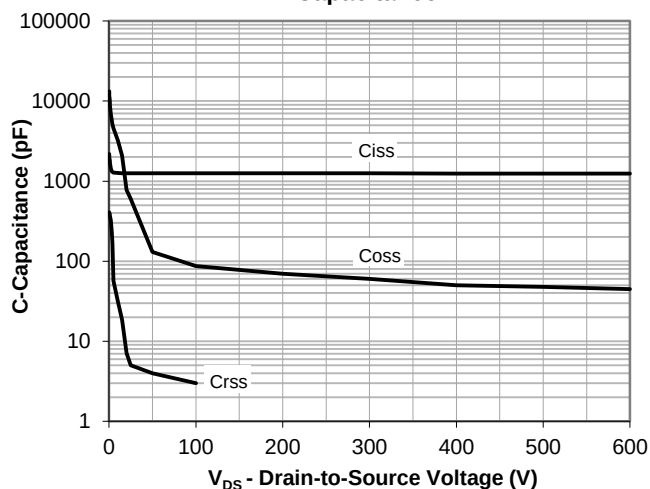
Gate Charge



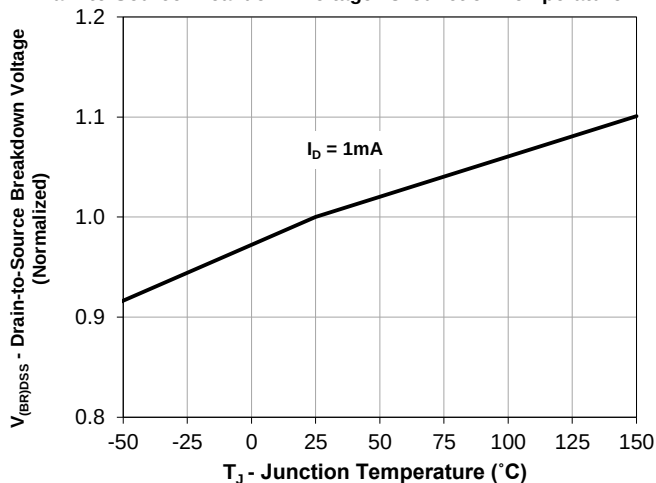
Gate Threshold Voltage vs Junction Temperature



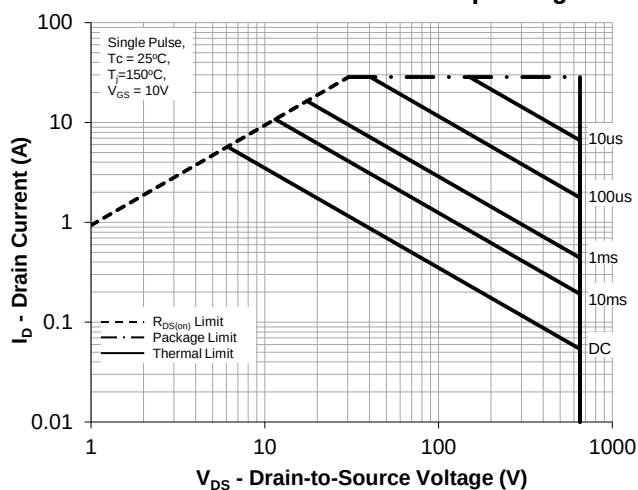
### Capacitance



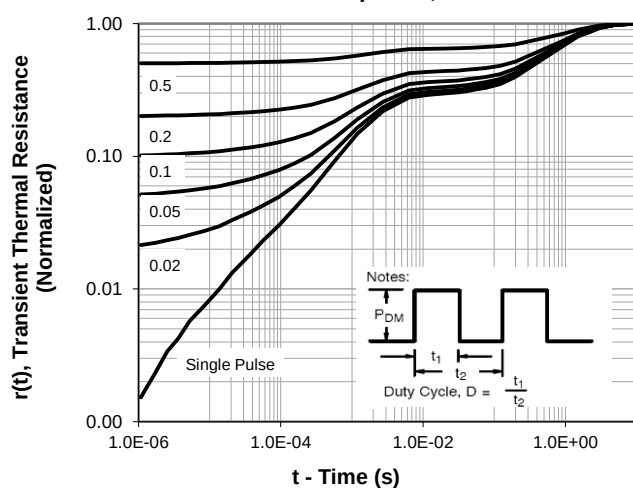
### Drain-to-Source Breakdown Voltage vs. Junction Temperature

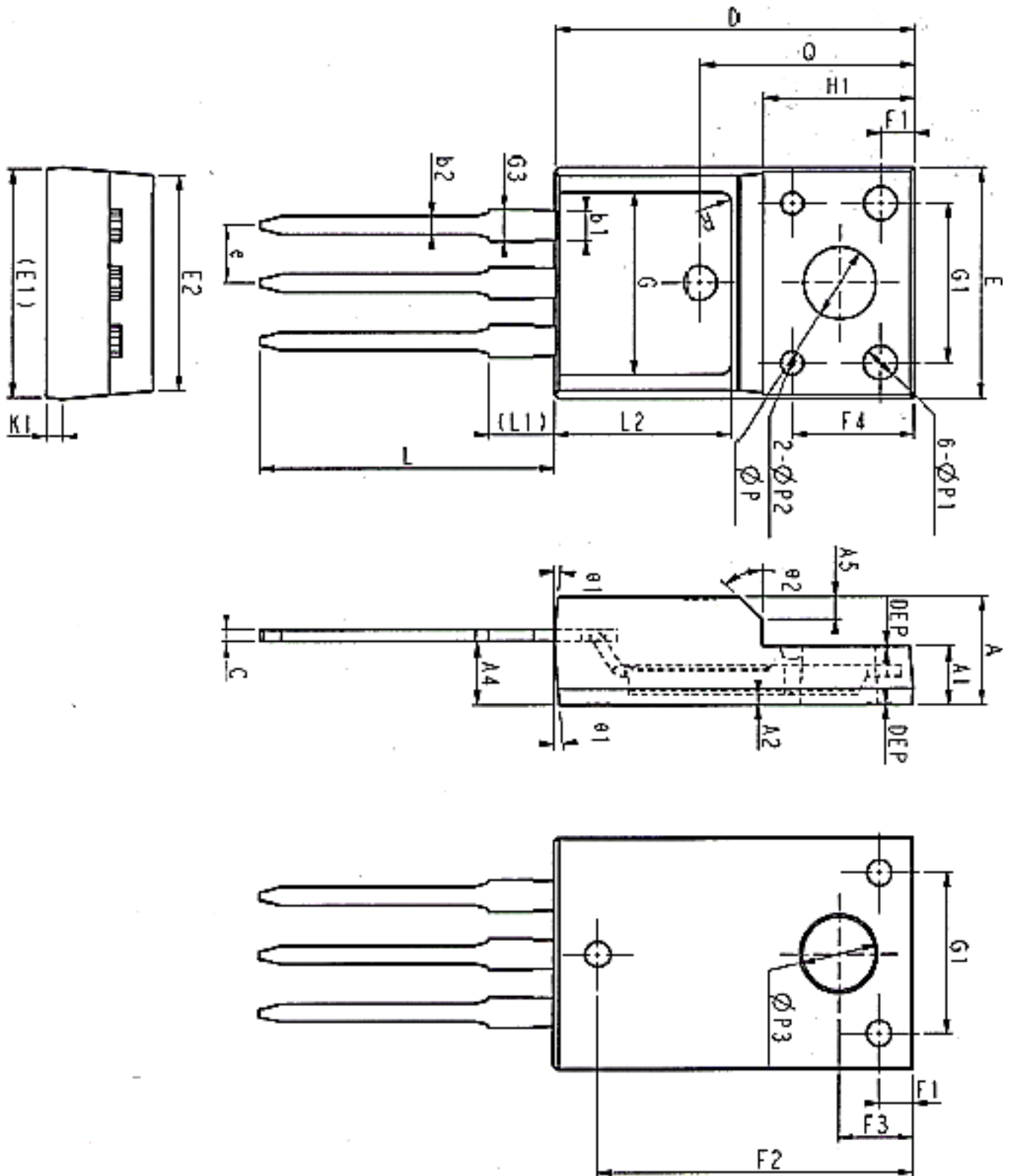


### Maximum Rated Forward Biased Safe Operating Area



### Transient Thermal Response, Junction-to-Case





| COMMON DIMENSIONS |         |       |       |          |       |       |
|-------------------|---------|-------|-------|----------|-------|-------|
| SYMBOL            | MM      |       |       | INCH     |       |       |
|                   | MIN     | NOM   | MAX   | MIN      | NOM   | MAX   |
| E                 | 9.63    | 10.19 | 10.75 | 0.38     | 0.40  | 0.42  |
| E1                | 9.94    | 10.04 | 10.14 | 0.39     | 0.40  | 0.40  |
| E2                | 9.36    | 9.46  | 9.56  | 0.37     | 0.37  | 0.38  |
| A                 | 4.30    | 4.60  | 4.90  | 0.17     | 0.18  | 0.19  |
| A1                | 2.34    | 2.77  | 3.20  | 0.092    | 0.11  | 0.126 |
| A2                | 0.43    | 0.87  | 1.30  | 0.017    | 0.03  | 0.051 |
| A4                | 2.51    | 2.72  | 2.93  | 0.10     | 0.11  | 0.12  |
| A5                | 1.00REF |       |       | 0.39REF  |       |       |
| c                 | 0.33    | 0.54  | 0.75  | 0.013    | 0.021 | 0.030 |
| D                 | 15.67   | 15.9  | 16.13 | 0.617    | 0.626 | 0.635 |
| Q                 | 9.4REF  |       |       | 0.370REF |       |       |
| H1                | 6.7REF  |       |       | 0.264REF |       |       |
| E                 | 2.54BSC |       |       | 0.100BSC |       |       |
| ΦP                | 3.18REF |       |       | 0.125REF |       |       |
| L                 | 12.78   | 13.25 | 13.72 | 0.50     | 0.52  | 0.54  |
| L1                | 2.83    | 3.25  | 3.67  | 0.11     | 0.13  | 0.14  |
| L2                | 7.70    | 7.80  | 7.90  | 0.30     | 0.31  | 0.31  |
| ΦP1               | 1.4     | 1.5   | 1.6   | 0.055    | 0.059 | 0.063 |
| ΦP2               | 1.15    | 1.2   | 1.25  | 0.045    | 0.047 | 0.049 |
| ΦP3               | 3.45REF |       |       | 0.136REF |       |       |
| θ1                | 3°      | 5°    | 7°    | 3°       | 5°    | 7°    |
| θ2                | -       | 45°   | -     | -        | 45°   | -     |
| DEP               | 0.05    | 0.10  | 0.15  | 0.002    | 0.004 | 0.006 |
| F1                | 1.0     | 1.50  | 2.0   | 0.039    | 0.059 | 0.079 |
| F2                | 13.8    | 13.90 | 14.0  | 0.543    | 0.547 | 0.551 |
| F3                | 3.20    | 3.30  | 3.40  | 0.126    | 0.130 | 0.134 |
| F4                | 5.30    | 5.40  | 5.50  | 0.209    | 0.213 | 0.217 |
| G                 | 7.80    | 8.00  | 8.20  | 0.307    | 0.315 | 0.323 |
| G1                | 6.05    | 6.58  | 7.10  | 0.238    | 0.259 | 0.280 |
| G3                | 1.25    | 1.35  | 1.45  | 0.049    | 0.053 | 0.057 |
| b1                | 1.23    | 1.31  | 1.38  | 0.048    | 0.051 | 0.054 |
| b2                | 0.61    | 0.78  | 0.94  | 0.024    | 0.031 | 0.037 |
| K1                | 0.65    | 0.70  | 0.75  | 0.026    | 0.028 | 0.030 |
| R                 | 0.50REF |       |       | 0.020REF |       |       |

## **ICEMOS SUPERJUNCTION PATENT PORTFOLIO**

### **ICEMOS GRANTED PATENTS**

**US7,429,772**

**US7,439,178**

**US7,446,018**

**US7,579,607**

**US7,723,172**

**US7,795,045**

**US7,846,821**

**US7,944,018**

**US8,012,806**

**US8,030,133**

### **3D SEMI PATENTS LICENSED TO ICEMOS**

**US7,041,560B2**

**US7,023,069B2**

**US7,364,994**

**US7,227,197B2**

**US7,304,944B2**

**US7,052,982B2**

**US7,339,252**

**US7,410,891**

**US7,439,583**

**US7,227,197B2**

**US6,635,906**

**US6,936,867**

**US7,015,104**

**US9,109,110**

**US7,271,067**

**US7,354,818**

**US7,052,982,**

**US7,199,006B2**

**Note: additional patents in China, Korea, Japan, Taiwan, Europe have also been granted to IceMOS and 3D Semi for Superjunction MOSFETs with 70 additional Patent applications in process in the USA and the above listed countries.**



## Marking Information

**YY** = Last two digits of the year

**WW** = Work week calendar on Icemos subcon assembly & test house

**\*** = Initial for Icemos subcon assembly and test house

**XXXX** = Wafer Lot ID

**00** = may be used for wafer ID in a special case.

= "00" is used unless specified.

**ICE10N65** = ICE is Icemos logo and 10N65 is a designated device part number

