# International IƆR Rectifier

## SMPS MOSFET

**IRFB23N20D**
**IRFS23N20D**
**IRFSL23N20D**

HEXFET® Power MOSFET

| V$_{DSS}$ | R$_{DS(on)}$ max | I$_D$ |
|---|---|---|
| **200V** | **0.10Ω** | **24A** |

### Applications
- High frequency DC-DC converters

### Benefits
- Low Gate-to-Drain Charge to Reduce Switching Losses
- Fully Characterized Capacitance Including Effective C$_{OSS}$ to Simplify Design, (See App. Note AN1001)
- Fully Characterized Avalanche Voltage and Current



| TO-220AB | D²Pak | TO-262 |
|---|---|---|
| IRFB23N20D | IRFS23N20D | IRFSL23N20D |
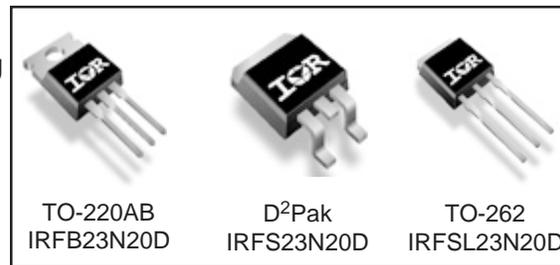
## Absolute Maximum Ratings

| | Parameter | Max. | Units |
|---|---|---|---|
| I$_D$ @ T$_C$ = 25°C | Continuous Drain Current, V$_{GS}$ @ 10V | 24 | |
| I$_D$ @ T$_C$ = 100°C | Continuous Drain Current, V$_{GS}$ @ 10V | 17 | A |
| I$_{DM}$ | Pulsed Drain Current ① | 96 | |
| P$_D$ @T$_A$ = 25°C | Power Dissipation ⑦ | 3.8 | W |
| P$_D$ @T$_C$ = 25°C | Power Dissipation | 170 | |
| | Linear Derating Factor | 1.1 | W/°C |
| V$_{GS}$ | Gate-to-Source Voltage | ± 30 | V |
| dv/dt | Peak Diode Recovery dv/dt ③ | 3.3 | V/ns |
| T$_J$ | Operating Junction and | -55  to + 175 | |
| T$_{STG}$ | Storage Temperature Range | | °C |
| | Soldering Temperature, for 10 seconds | 300 (1.6mm from case ) | |
| | Mounting  torqe, 6-32  or M3  screw⑥ | 10 lbf•in (1.1N•m) | |

## Typical SMPS Topologies

- Telecom 48V input  Forward Converter

Notes ① through ⑤ are on page 11

# IRFB/IRFS/IRFSL23N20D

International
**IOR** Rectifier

## Static @ T$_J$ = 25°C (unless otherwise specified)

| | Parameter | Min. | Typ. | Max. | Units | Conditions |
|---|---|---|---|---|---|---|
| V$_{(BR)DSS}$ | Drain-to-Source Breakdown Voltage | 200 | —— | —— | V | V$_{GS}$ = 0V, I$_D$ = 250µA |
| ΔV$_{(BR)DSS}$/ΔT$_J$ | Breakdown Voltage Temp. Coefficient | —— | 0.26 | —— | V/°C | Reference to 25°C, I$_D$ = 1mA ⑥ |
| R$_{DS(on)}$ | Static Drain-to-Source On-Resistance | —— | —— | 0.10 | Ω | V$_{GS}$ = 10V, I$_D$ = 14A ④ |
| V$_{GS(th)}$ | Gate Threshold Voltage | 3.0 | —— | 5.5 | V | V$_{DS}$ = V$_{GS}$, I$_D$ = 250µA |
| I$_{DSS}$ | Drain-to-Source Leakage Current | —— | —— | 25 | µA | V$_{DS}$ = 200V, V$_{GS}$ = 0V |
| | | —— | —— | 250 | | V$_{DS}$ = 160V, V$_{GS}$ = 0V, T$_J$ = 150°C |
| I$_{GSS}$ | Gate-to-Source Forward Leakage | —— | —— | 100 | nA | V$_{GS}$ = 30V |
| | Gate-to-Source Reverse Leakage | —— | —— | -100 | | V$_{GS}$ = -30V |

## Dynamic @ T$_J$ = 25°C (unless otherwise specified)

| | Parameter | Min. | Typ. | Max. | Units | Conditions |
|---|---|---|---|---|---|---|
| g$_{fs}$ | Forward Transconductance | 13 | —— | —— | S | V$_{DS}$ = 50V, I$_D$ = 14A |
| Q$_g$ | Total Gate Charge | —— | 57 | 86 | nC | I$_D$ = 14A |
| Q$_{gs}$ | Gate-to-Source Charge | —— | 14 | 21 | | V$_{DS}$ = 160V |
| Q$_{gd}$ | Gate-to-Drain ("Miller") Charge | —— | 27 | 40 | | V$_{GS}$ = 10V, ④⑥ |
| t$_{d(on)}$ | Turn-On Delay Time | —— | 14 | —— | ns | V$_{DD}$ = 100V |
| t$_r$ | Rise Time | —— | 32 | —— | | I$_D$ = 14A |
| t$_{d(off)}$ | Turn-Off Delay Time | —— | 26 | —— | | R$_G$ = 4.6Ω |
| t$_f$ | Fall Time | —— | 16 | —— | | V$_{GS}$ = 10V ④ |
| C$_{iss}$ | Input Capacitance | —— | 1960 | —— | pF | V$_{GS}$ = 0V |
| C$_{oss}$ | Output Capacitance | —— | 300 | —— | | V$_{DS}$ = 25V |
| C$_{rss}$ | Reverse Transfer Capacitance | —— | 65 | —— | | $f$ = 1.0MHz⑥ |
| C$_{oss}$ | Output Capacitance | —— | 2200 | —— | | V$_{GS}$ = 0V, V$_{DS}$ = 1.0V, $f$ = 1.0MHz |
| C$_{oss}$ | Output Capacitance | —— | 120 | —— | | V$_{GS}$ = 0V, V$_{DS}$ = 160V, $f$ = 1.0MHz |
| C$_{oss}$ eff. | Effective Output Capacitance | —— | 220 | —— | | V$_{GS}$ = 0V, V$_{DS}$ = 0V to 160V ⑤ |

## Avalanche Characteristics

| | Parameter | Typ. | Max. | Units |
|---|---|---|---|---|
| E$_{AS}$ | Single Pulse Avalanche Energy②⑥ | —— | 250 | mJ |
| I$_{AR}$ | Avalanche Current① | —— | 14 | A |
| E$_{AR}$ | Repetitive Avalanche Energy① | —— | 17 | mJ |

## Thermal Resistance

| | Parameter | Typ. | Max. | Units |
|---|---|---|---|---|
| R$_{θJC}$ | Junction-to-Case | —— | 0.90 | °C/W |
| R$_{θCS}$ | Case-to-Sink, Flat, Greased Surface ⑥ | 0.50 | —— | |
| R$_{θJA}$ | Junction-to-Ambient⑥ | —— | 62 | |
| R$_{θJA}$ | Junction-to-Ambient⑦ | —— | 40 | |

## Diode Characteristics

| | Parameter | Min. | Typ. | Max. | Units | Conditions |
|---|---|---|---|---|---|---|
| I$_S$ | Continuous Source Current (Body Diode) | —— | —— | 24 | A | MOSFET symbol showing the integral reverse p-n junction diode. |
| I$_{SM}$ | Pulsed Source Current (Body Diode) ①⑥ | —— | —— | 96 | | |
| V$_{SD}$ | Diode Forward Voltage | —— | —— | 1.3 | V | T$_J$ = 25°C, I$_S$ = 14A, V$_{GS}$ = 0V ④ |
| t$_{rr}$ | Reverse Recovery Time | —— | 200 | 300 | ns | T$_J$ = 25°C, I$_F$ = 14A |
| Q$_{rr}$ | Reverse RecoveryCharge | —— | 1300 | 1940 | nC | di/dt = 100A/µs ④ |
| t$_{on}$ | Forward Turn-On Time | Intrinsic turn-on time is negligible (turn-on is dominated by L$_S$+L$_D$) | | | | |
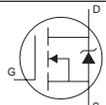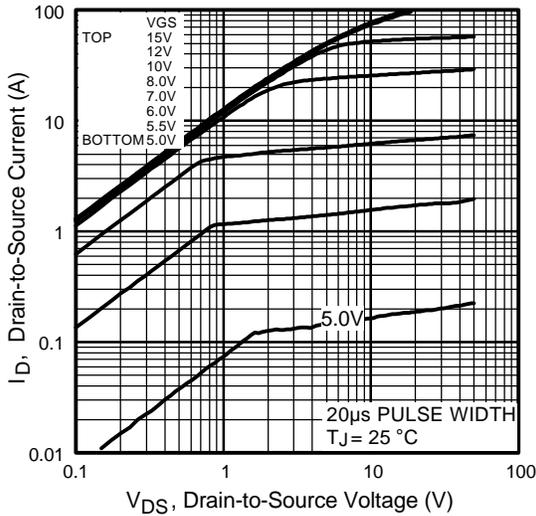
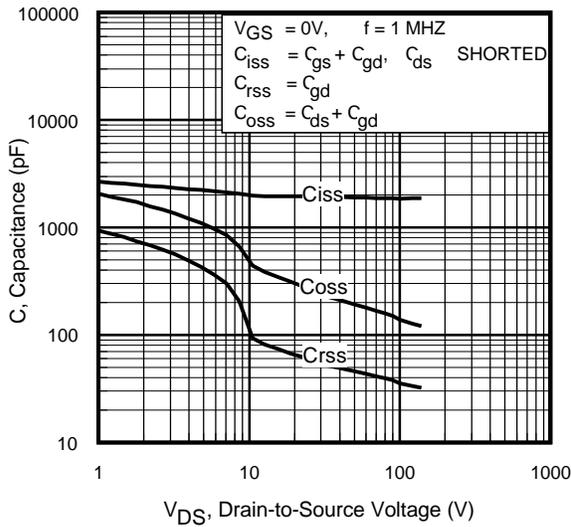**Fig 1.** Typical Output Characteristics
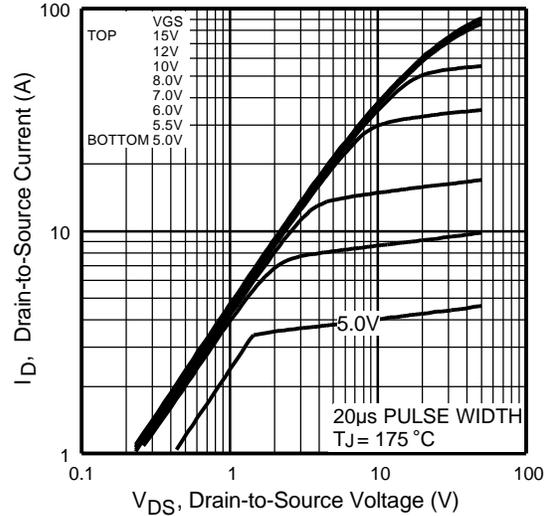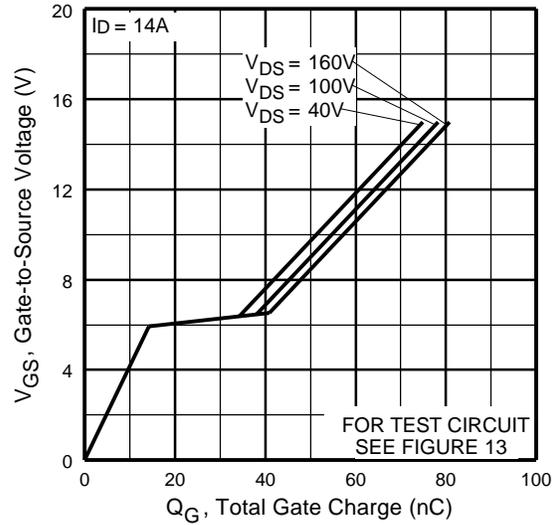


**Fig 2.** Typical Output Characteristics
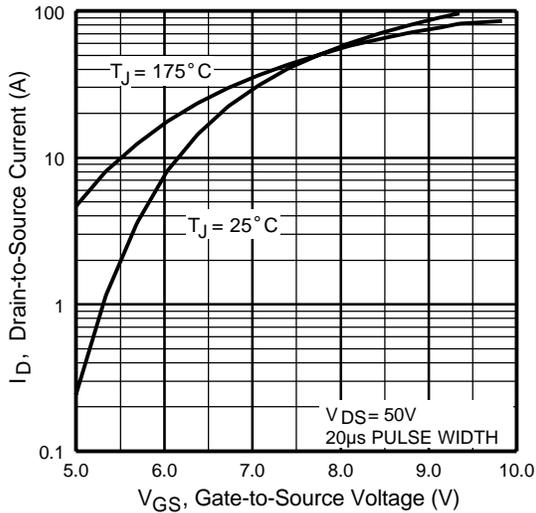


**Fig 3.** Typical Transfer Characteristics
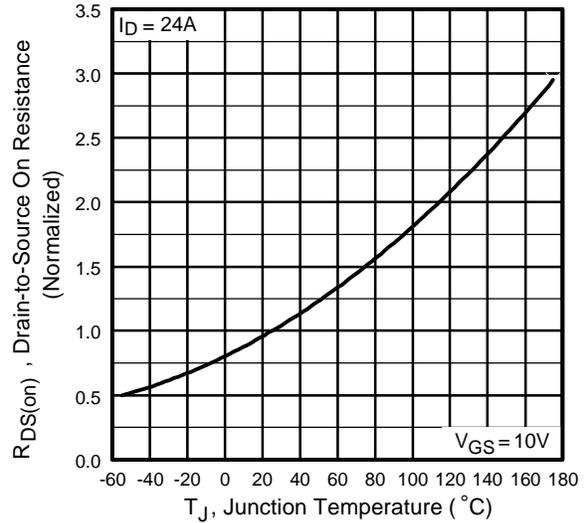


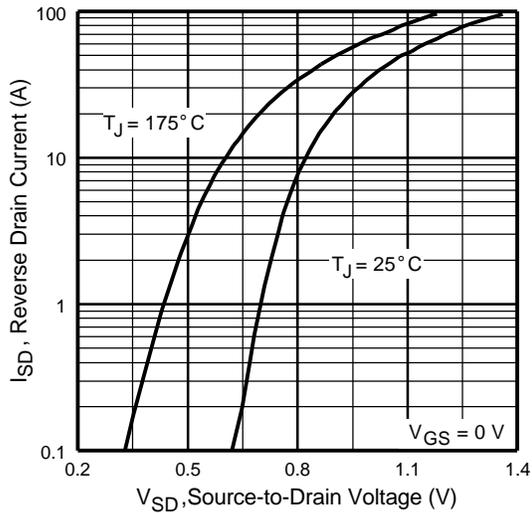**Fig 4.** Normalized On-Resistance
Vs. Temperature

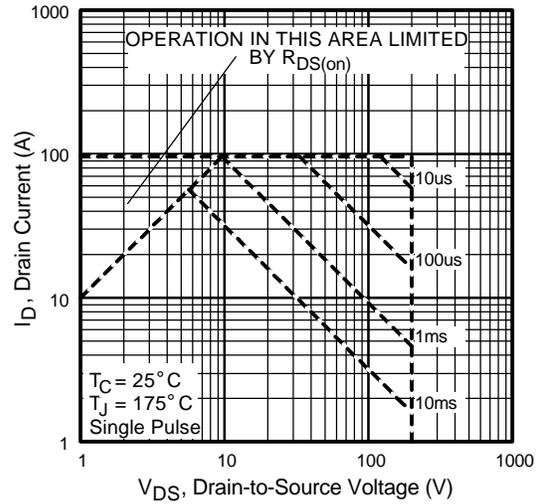# IRFB/IRFS/IRFSL23N20D

International
**IOR** Rectifier



$V_{GS} = 0V$, $f = 1$ MHZ
$C_{iss} = C_{gs} + C_{gd}$, $C_{ds}$ SHORTED
$C_{rss} = C_{gd}$
$C_{oss} = C_{ds} + C_{gd}$

Ciss
Coss
Crss

**Fig 5.** Typical Capacitance Vs.
Drain-to-Source Voltage



$I_D = 14A$

$V_{DS} = 160V$
$V_{DS} = 100V$
$V_{DS} = 40V$

FOR TEST CIRCUIT
SEE FIGURE 13

**Fig 6.** Typical Gate Charge Vs.
Gate-to-Source Voltage



$T_J = 175°C$

$T_J = 25°C$

$V_{GS} = 0$ V

**Fig 7.** Typical Source-Drain Diode
Forward Voltage



OPERATION IN THIS AREA LIMITED
BY $R_{DS(on)}$

10us
100us
1ms
10ms

$T_C = 25°C$
$T_J = 175°C$
Single Pulse

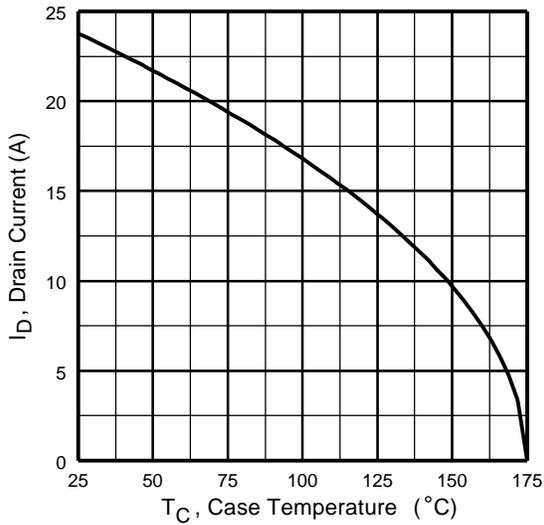**Fig 8.** Maximum Safe Operating Area
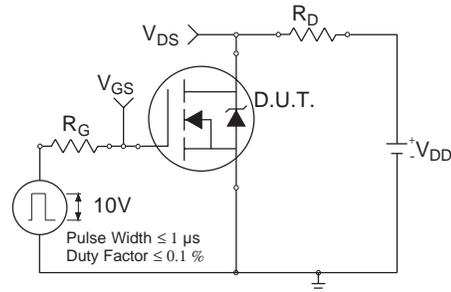
4

**Fig 9.** Maximum Drain Current Vs.
Case Temperature

**Fig 10a.** Switching Time Test Circuit
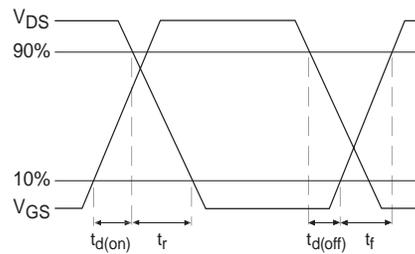
**Fig 10b.** Switching Time Waveforms

SINGLE PULSE
(THERMAL RESPONSE)

Notes:
1. Duty factor D = $t_1 / t_2$
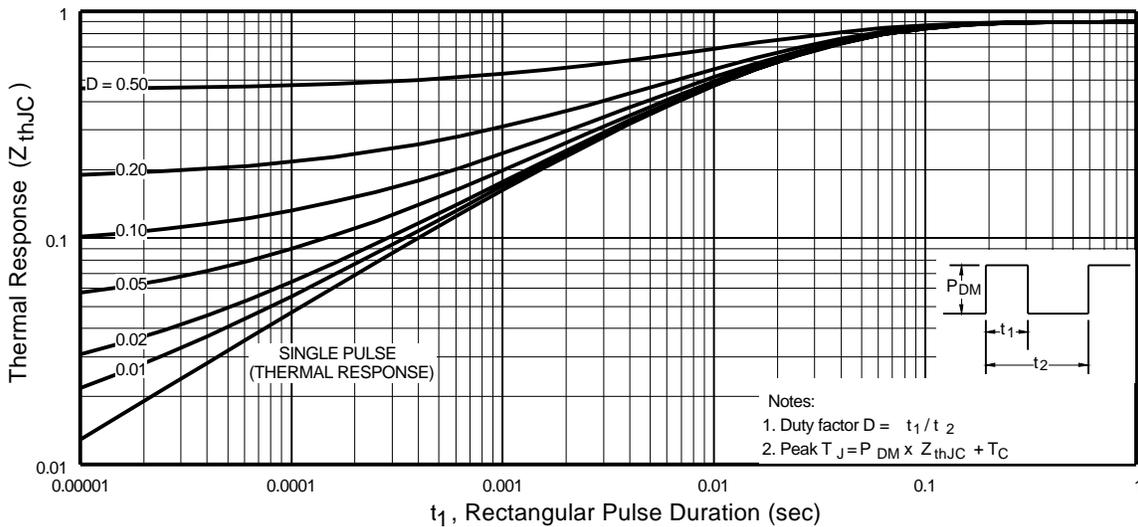2. Peak $T_J = P_{DM}$ x $Z_{thJC}$ + $T_C$

**Fig 11.** Maximum Effective Transient Thermal Impedance, Junction-to-Case

# IRFB/IRFS/IRFSL23N20D
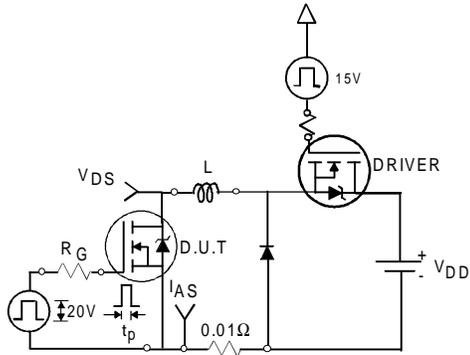
**Fig 12a.** Unclamped Inductive Test Circuit
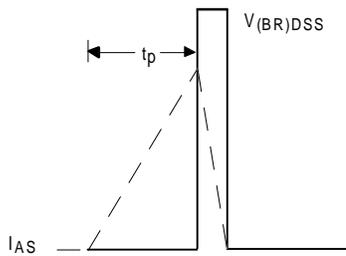


**Fig 12b.** Unclamped Inductive Waveforms



**Fig 12c.** Maximum Avalanche Energy
Vs. Drain Current

|  | $I_D$ |
|---|---|
| TOP | 5.9A |
|  | 10A |
| BOTTOM | 14A |
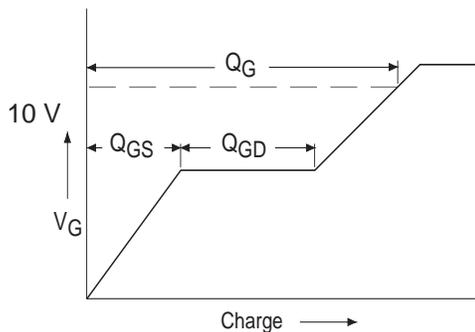


**Fig 13a.** Basic Gate Charge Waveform



**Fig 13b.** Gate Charge Test Circuit

6                                                                    www.irf.com

**Peak Diode Recovery dv/dt Test Circuit**

**D.U.T**

③

Circuit Layout Considerations
- Low Stray Inductance
- Ground Plane
- Low Leakage Inductance Current Transformer

④

②

①

$R_G$

$V_{DD}$

- dv/dt controlled by $R_G$
- Driver same type as D.U.T.
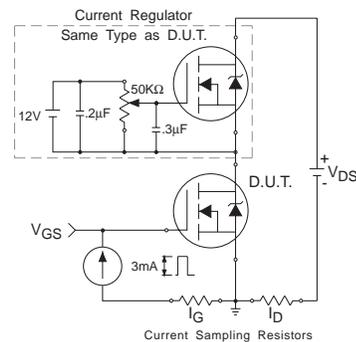- $I_{SD}$ controlled by Duty Factor "D"
- D.U.T. - Device Under Test

① Driver Gate Drive

P.W. — Period

$D = \dfrac{P.W.}{Period}$

$V_{GS}=10V$ *

② D.U.T. $I_{SD}$ Waveform

Reverse Recovery Current

Body Diode Forward Current

di/dt

③ D.U.T. $V_{DS}$ Waveform

Diode Recovery dv/dt

$V_{DD}$

Re-Applied Voltage

Body Diode Forward Drop

④ Inductor Curent

Ripple ≤ 5%

$I_{SD}$

* $V_{GS}$ = 5V for Logic Level Devices

**Fig 14.** For N-Channel HEXFET® Power MOSFETs

# IRFB/IRFS/IRFSL23N20D

## TO-220AB Package Outline

Dimensions are shown in millimeters (inches)

2.87 (.113)
2.62 (.103)

10.54 (.415)
10.29 (.405)

∅ 3.78 (.149)
3.54 (.139)

- A -

6.47 (.255)
6.10 (.240)

15.24 (.600)
14.84 (.584)

1.15 (.045)
MIN

14.09 (.555)
13.47 (.530)

4.06 (.160)
3.55 (.140)

3X 0.93 (.037)
0.69 (.027)

3X 1.40 (.055)
1.15 (.045)

⊕ 0.36 (.014) Ⓜ B A Ⓜ

2.54 (.100)
2X

- B -

4.69 (.185)
4.20 (.165)

1.32 (.052)
1.22 (.048)

LEAD ASSIGNMENTS
1 - GATE
2 - DRAIN
3 - SOURCE
4 - DRAIN

3X 0.55 (.022)
0.46 (.018)

2.92 (.115)
2.64 (.104)

NOTES:

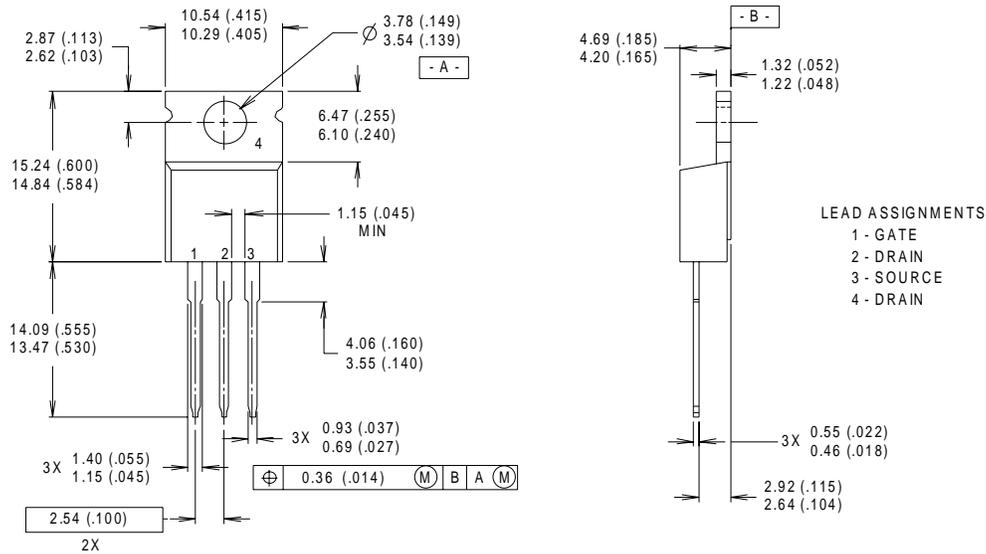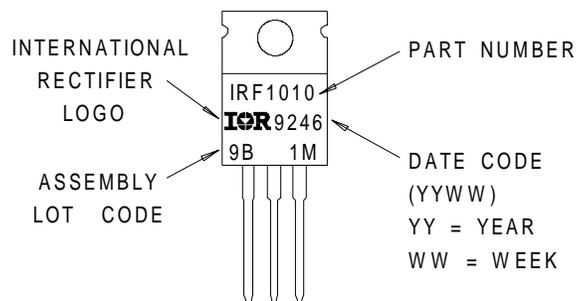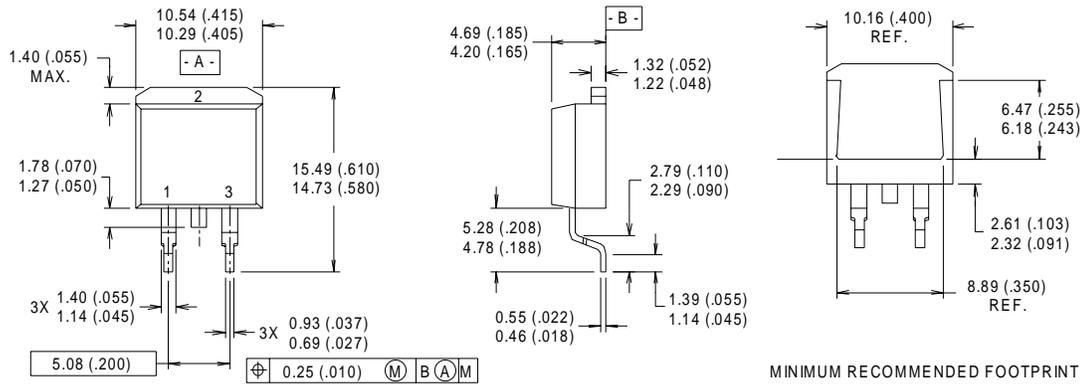1 DIMENSIONING & TOLERANCING PER ANSI Y14.5M, 1982.
2 CONTROLLING DIMENSION : INCH

3 OUTLINE CONFORMS TO JEDEC OUTLINE TO-220AB.
4 HEATSINK & LEAD MEASUREMENTS DO NOT INCLUDE BURRS.

## TO-220AB Part Marking Information

EXAMPLE : THIS IS AN IRF1010
WITH ASSEMBLY
LOT CODE 9B1M

INTERNATIONAL
RECTIFIER
LOGO

PART NUMBER

IRF1010
**IGR** 9246
9B      1M

ASSEMBLY
LOT CODE

DATE CODE
(YYWW)
YY = YEAR
WW = WEEK

## D²Pak Package Outline

10.54 (.415)
10.29 (.405)

- A -

1.40 (.055)
MAX.

2

1.78 (.070)
1.27 (.050)

1          3

15.49 (.610)
14.73 (.580)

3X  1.40 (.055)
    1.14 (.045)

3X  0.93 (.037)
    0.69 (.027)

5.08 (.200)

⊕  0.25 (.010)  Ⓜ  B Ⓐ M

- B -

4.69 (.185)
4.20 (.165)

1.32 (.052)
1.22 (.048)

2.79 (.110)
2.29 (.090)

5.28 (.208)
4.78 (.188)

1.39 (.055)
1.14 (.045)

0.55 (.022)
0.46 (.018)

10.16 (.400)
REF.

6.47 (.255)
6.18 (.243)

2.61 (.103)
2.32 (.091)

8.89 (.350)
REF.

MINIMUM RECOMMENDED FOOTPRINT

11.43 (.450)

8.89 (.350)

17.78 (.700)

3.81 (.150)

2.08 (.082)
2X

2.54 (.100)
2X
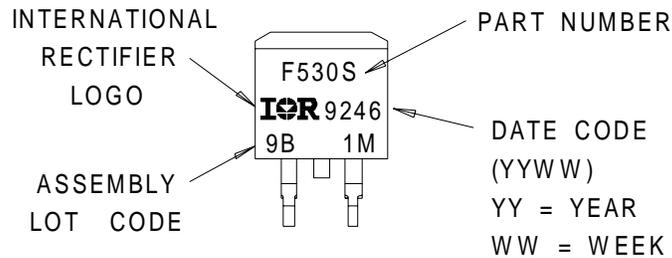
NOTES:
1  DIMENSIONS AFTER SOLDER DIP.
2  DIMENSIONING & TOLERANCING PER ANSI Y14.5M, 1982.
3  CONTROLLING DIMENSION : INCH.
4  HEATSINK & LEAD DIMENSIONS DO NOT INCLUDE BURRS.

LEAD ASSIGNMENTS
1 - GATE
2 - DRAIN
3 - SOURCE

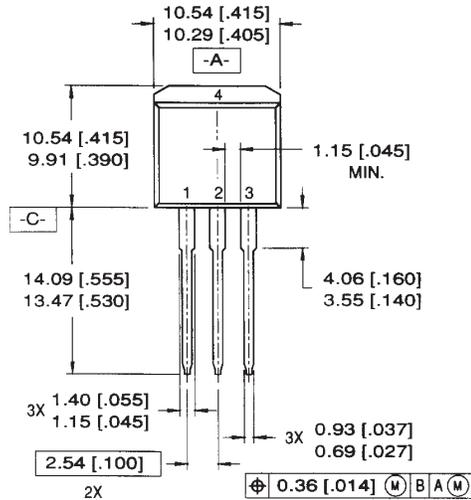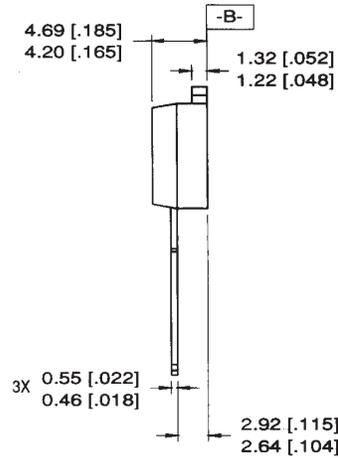## D²Pak Part Marking Information

INTERNATIONAL
RECTIFIER
LOGO

PART NUMBER

F530S

**I⚙R** 9246

9B        1M

ASSEMBLY
LOT  CODE

DATE CODE
(YYWW)
YY = YEAR
WW = WEEK

# IRFB/IRFS/IRFSL23N20D

## TO-262 Package Outline



```
10.54 [.415]
10.29 [.405]
-A-

10.54 [.415]        1.15 [.045]
9.91 [.390]         MIN.
-C-

14.09 [.555]        4.06 [.160]
13.47 [.530]        3.55 [.140]

3X 1.40 [.055]
   1.15 [.045]
                 3X 0.93 [.037]
2.54 [.100]         0.69 [.027]
2X

⊕ 0.36 [.014] Ⓜ B A Ⓜ
```

**LEAD ASSIGNMENTS**

1 = GATE     3 = SOURCE
2 = DRAIN    4 = DRAIN

```
4.69 [.185]
4.20 [.165]         -B-
                 1.32 [.052]
                 1.22 [.048]

3X 0.55 [.022]
   0.46 [.018]
                 2.92 [.115]
                 2.64 [.104]
```
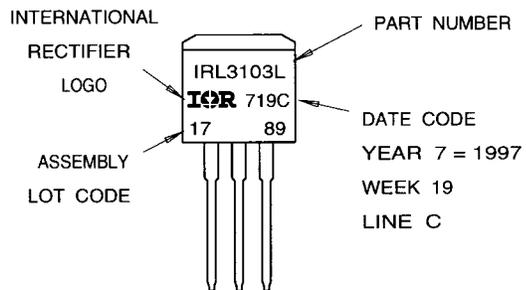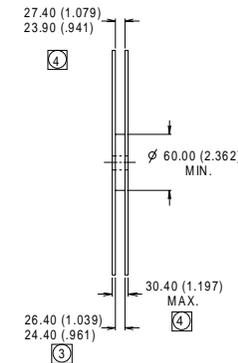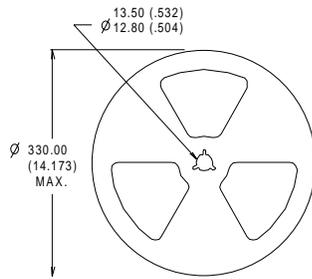
NOTES:
1. DIMENSIONING & TOLERANCING PER ANSI Y14.5M-1982
2. CONTROLLING DIMENSION: INCH.
3. DIMENSIONS ARE SHOWN IN MILLIMETERS [INCHES].
4. HEATSINK & LEAD DIMENSIONS DO NOT INCLUDE BURRS.

## TO-262 Part Marking Information

EXAMPLE:   THIS IS AN IRL3103L
           LOT CODE 1789
           ASSEMBLED ON WW 19, 1997
           IN THE ASSEMBLY LINE "C"



INTERNATIONAL                    PART NUMBER
RECTIFIER
LOGO          IRL3103L
              IGR 719C
                               DATE CODE
ASSEMBLY                       YEAR 7 = 1997
LOT CODE      17    89         WEEK 19
                               LINE C

## D²Pak Tape & Reel Information

TRR

FEED DIRECTION

TRL

FEED DIRECTION

1.60 (.063)
1.50 (.059)

4.10 (.161)
3.90 (.153)

Ø 1.60 (.063)
1.50 (.059)

0.368 (.0145)
0.342 (.0135)

1.85 (.073)
1.65 (.065)

11.60 (.457)
11.40 (.449)

15.42 (.609)
15.22 (.601)

24.30 (.957)
23.90 (.941)

10.90 (.429)
10.70 (.421)

Ø 1.75 (.069)
1.25 (.049)

4.72 (.136)
4.52 (.178)

16.10 (.634)
15.90 (.626)

13.50 (.532)
Ø 12.80 (.504)

27.40 (1.079)
23.90 (.941)
4

Ø 330.00
(14.173)
MAX.

Ø 60.00 (2.362)
MIN.

30.40 (1.197)
MAX.
4

26.40 (1.039)
24.40 (.961)
3
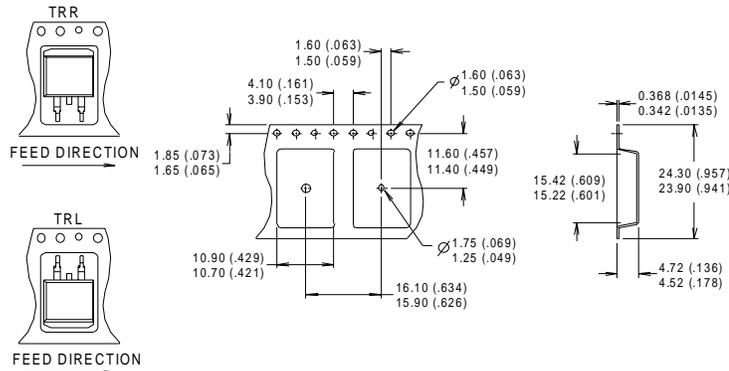
NOTES :
1. CONFORMS TO EIA-418.
2. CONTROLLING DIMENSION: MILLIMETER.
3. DIMENSION MEASURED @ HUB.
4. INCLUDES FLANGE DISTORTION @ OUTER EDGE.

**Notes:**

① Repetitive rating;  pulse width limited by max. junction temperature.

② Starting $T_J$ = 25°C, L = 2.6mH
$R_G$ = 25Ω, $I_{AS}$ = 14A.

③ $I_{SD}$ ≤ 14A, di/dt ≤ 130A/µs, $V_{DD}$ ≤ $V_{(BR)DSS}$, $T_J$ ≤ 175°C

④ Pulse width ≤ 300µs; duty cycle ≤ 2%.

⑤ $C_{oss}$ eff. is a fixed capacitance that gives the same charging time as $C_{oss}$ while $V_{DS}$ is rising from 0 to 80% $V_{DSS}$

⑥ This is only applied to TO-220AB package

⑦ This is applied to D²Pak, when mounted on 1" square PCB ( FR-4 or G-10 Material ).
For recommended footprint and soldering techniques refer to application note #AN-994.

International **I⊕R** Rectifier

Note:  For the most current drawings please refer to the IR website at:
[http://www.irf.com/package/](http://www.irf.com/package/)

# Mouser Electronics

Authorized Distributor


Click to View Pricing, Inventory, Delivery & Lifecycle Information:


[International Rectifier](#):
  [IRFS23N20DTRRP](#)  [IRFS23N20DTRLP](#)