# FRED
# Ultrafast Soft Recovery Diode Module
# 400A / 600V (200Ax2 / 600V)

## FEATURES

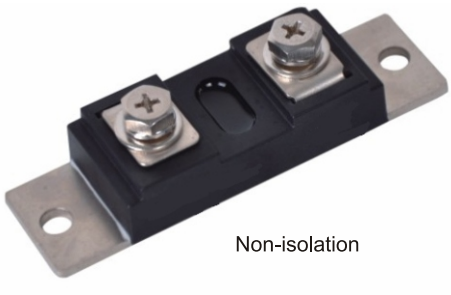
- Very low $Q_{rr}$ and $t_{rr}$
- Lead (Pb)-free
- Designed and qualified for industrial level
- Reduced RFI and EMI
- Industrial standard package
- Planar FRED Chips
- 175°C Junction temperature

## DESCRIPTION

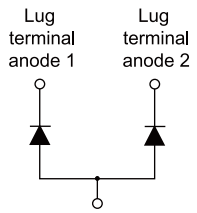
FRED diodes are optimized to reduce losses and EMI/RFI in high frequency power conditioning systems.
An extensive characterization of the recovery behavior for different values of current, temperature and dI/dt simplifies the calculations of losses in the operating conditions. The softness of the recovery eliminates the need for a snubber in most applications.

## TYPICAL APPLICATIONS

- Power converters
- Motor drives
- Welders
- Switching power supplies
- Uninterruptible power supply (UPS)
- Power factor correction (PFC) circuit
- Inverter
- Choppers
- Battery chargers



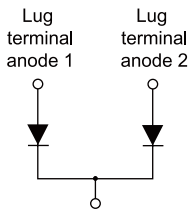
Non-isolation




Baseplate Common Anode

With Suffix " R " for common Anodes to baseplate

**NKFD400-60RD**




Baseplate Common Cathode

**NKFD400-60D**

| PRODUCT SUMMARY | |
|---|---|
| $I_{F(AV)}$ | 400A |
| $V_R$ | 600V |
| $I_{F(DC)}$ at $T_C$ | 280A at 100 °C |

| ABSOLUTE MAXIMUM RATINGS | | | | |
|---|---|---|---|---|
| **PARAMETER** | **SYMBOL** | **TEST CONDITIONS** | **MAX.** | **UNIT** |
| Cathode to anode voltage | $V_R$ | | 600 | V |
| Average forward current | $I_{F(AV)}$ | $T_C$ =25°C, per leg | 460 | A |
| | | $T_C$ =125°C, per device | 400 | |
| | | $T_C$ =125°C, per leg | 200 | |
| DC forward current | $I_{F(DC)}$ | $T_C$ =100°C | 280 | |
| Single pulse forward current | $I_{FSM}$ | Limited by junction temperature, per leg | 2000 | |
| Non-repetitive avalanche energy | $E_{AS}$ | L = 100 µH, duty cycle limited by maximum $T_J$ | 2.2 | mJ |
| Maximum power dissipation per leg | $P_D$ | $T_C$ =25°C | 1000 | W |
| Operating junction and storage temperature range | $T_J$, $T_{Stg}$ | | - 55 to 175 | °C |

## ELECTRICAL SPECIFICATIONS ($T_J$ = 25 ºC unless otherwise specified)

| PARAMETER | SYMBOL | TEST CONDITIONS | MIN. | TYP. | MAX. | UNIT |
|---|---|---|---|---|---|---|
| Cathode to anode breakdown voltage | $V_{BR}$ | $I_R$ = 100 µA | 600 | - | - | V |
| Maximum forward voltage | $V_{FM}$ | $I_F$ = 200 A | - | 1.25 | 1.40 | |
| | | $I_F$ = 400 A | - | - | 1.60 | |
| | | $I_F$ = 200 A, $T_J$ = 125 ºC | - | - | 1.20 | |
| Maximum reverse leakage current per leg | $I_{RM}$ | $T_J$ = 125°C, $V_R$ = 600V | - | 0.2 | 2.0 | mA |
| | | $T_J$ = 25°C, $V_R$ = 600V | - | 0.5 | 5 | µA |
| Junction capacitance | $C_T$ | $V_R$ = 200V | - | 400 | 600 | pF |
| Series inductance | $L_S$ | From top of terminal hole to mounting plane | - | 4.4 | - | nH |

## DYNAMIC RECOVERY CHARACTERISTICS PER LEG ($T_J$ = 25 ºC unless otherwise specified)

| PARAMETER | SYMBOL | TEST CONDITIONS | | MIN. | TYP. | MAX. | UNIT |
|---|---|---|---|---|---|---|---|
| Reverse recovery time | $t_{rr}$ | $I_F$ = 0.5A, $I_R$ = 1.0A, $I_{RR}$ = 0.25A | | - | 130 | 150 | ns |
| | | $I_F$ = 1.0A, $dI_F/dt$=200A/µs, $V_R$ = 30V | | - | 50 | - | |
| | | $T_J$ = 25 ºC | $I_F$= 200A<br>$dI_F/dt$ = 200 A/µs<br>$V_R$ = 200 V | - | 100 | - | |
| | | $T_J$ = 125 ºC | | - | 300 | - | |
| Peak recovery current | $I_{RRM}$ | $T_J$ = 25 ºC | | - | 13 | - | A |
| | | $T_J$ = 125 ºC | | - | 19 | - | |
| Reverse recovery charge | $Q_{rr}$ | $T_J$ = 25 ºC | | - | - | 2300 | nC |
| | | $T_J$ = 125 ºC | | - | - | 4500 | |

## THERMAL AND MECHANICAL SPECIFICATIONS

| PARAMETER | SYMBOL | MIN. | TYP. | MAX. | UNIT |
|---|---|---|---|---|---|
| Maximum junction and storage temperature range | $T_J$, $T_{stg}$ | -55 | - | 175 | ºC |
| Thermal resistance, junction to case per leg | $R_{thJC}$ | - | - | 0.15 | ºC/W |
| Thermal resistance, junction to case per module | $R_{thJC}$ | - | - | 0.075 | |
| Typical thermal resistance, case to heatsink | $R_{thCS}$ | - | 0.08 | - | |
| Weight | | - | 80 (2.82) | - | g (oz.) |
| Mounting torque(1), M6 | | - | 44.2 (5) | 53.1 (6) | (N·m)<br>lbf·in |
| Terminal torque, M6 | | - | 44.2 (5) | 53.1 (6) | |
| Vertical pull | | - | - | 80 | lbf·in |
| 2″ lever pull | | - | - | 35 | |

Note

(1)Mounting surface must be smooth, flat, free of burrs or other protrusions. Apply a thin even film or thermal grease to mounting surface. Gradually tighten each mounting bolt in 5 to 10 lbf. in steps until desired or maximum torque limits are reached.

## Ordering Information Table

Device code

| NK | F | D | 400 | – | 60 | R | D |
|---|---|---|---|---|---|---|---|
| ① | ② | ③ | ④ | | ⑤ | ⑥ | ⑦ |

1 - NPS power module
2 - F for Ultrafast soft recovery diode (FRED)
3 - D for Dual Diodes
4 - Maximum average forward current, A
5 - Voltage rating (60 = 600V)
6 - None for common cathode configuration
"R" for common anode configuration
7 - Package type

**Fig.1 Typical forward voltage drop vs. Instantaneous forward current (per leg)**

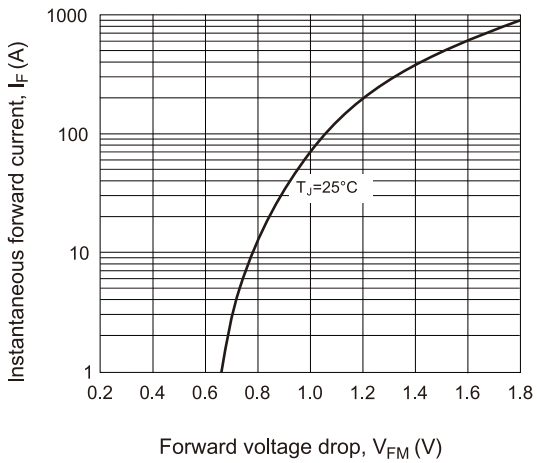



**Fig.2 Typical reverse current vs. reverse voltage (per leg)**

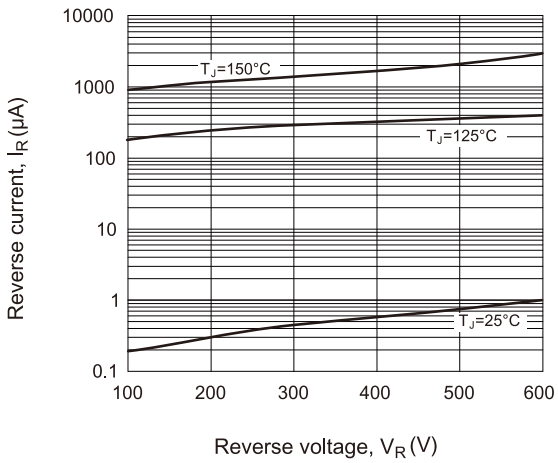



**Fig.3 Typical junction capacitance vs. reverse voltage (per leg)**

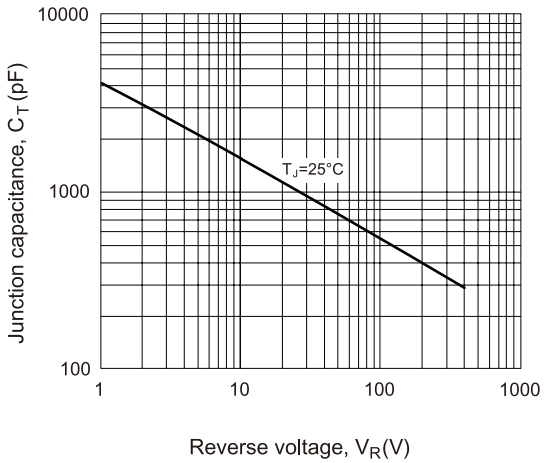



**Fig.4 Maximum allowable case temperature vs. forward current (per leg)**

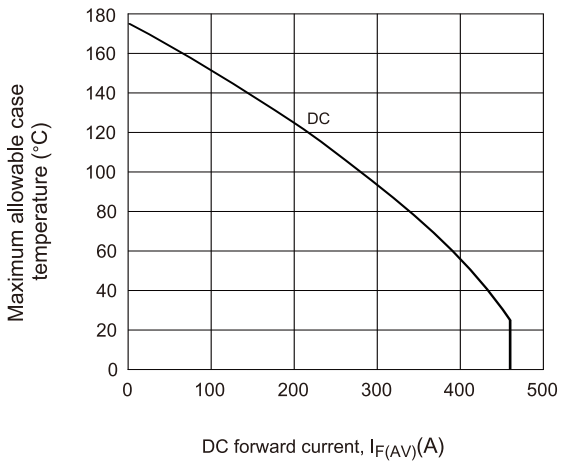


**Fig.5 Typical reverse recovery time vs. $dI_F/dt$ (per leg)**

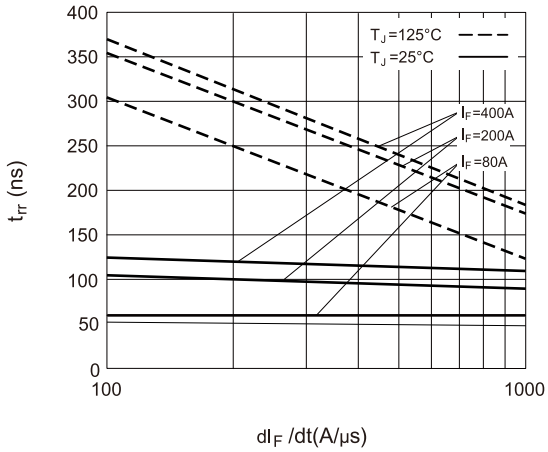



**Fig.6 Maximum thermal impedance $R_{th(j-c)}$ characteristics (Per leg)**

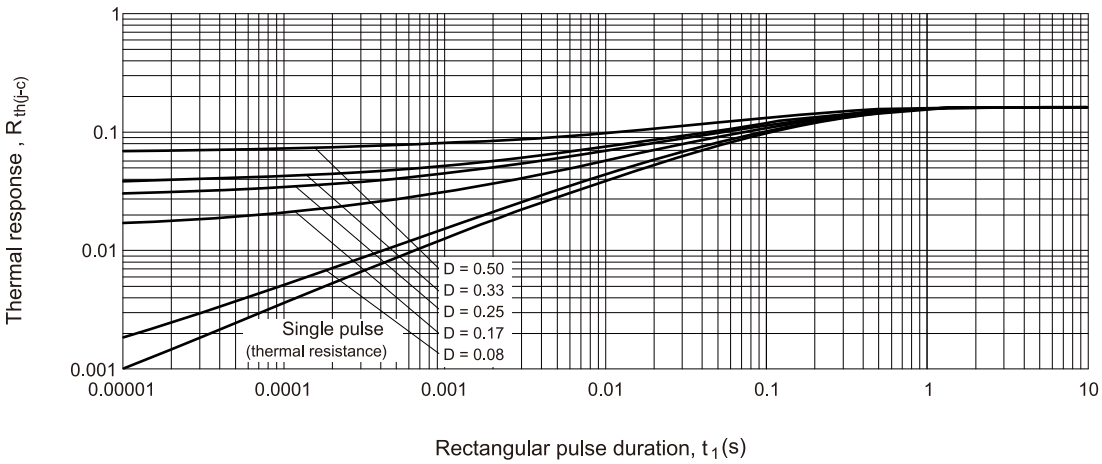



**Fig.7 Reverse recovery parameter test circuit**

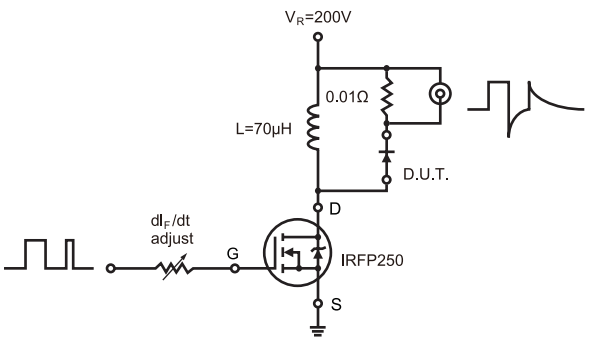
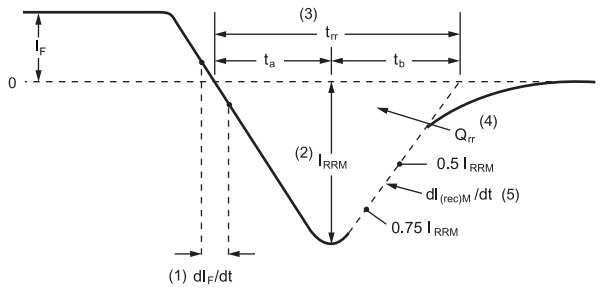


**Fig.08 Reverse recovery waveform and definitions**




(1) $dI_F/dt$ - rate of change of current through zero crossing

(2) $I_{RRM}$ - peak reverse recovery current

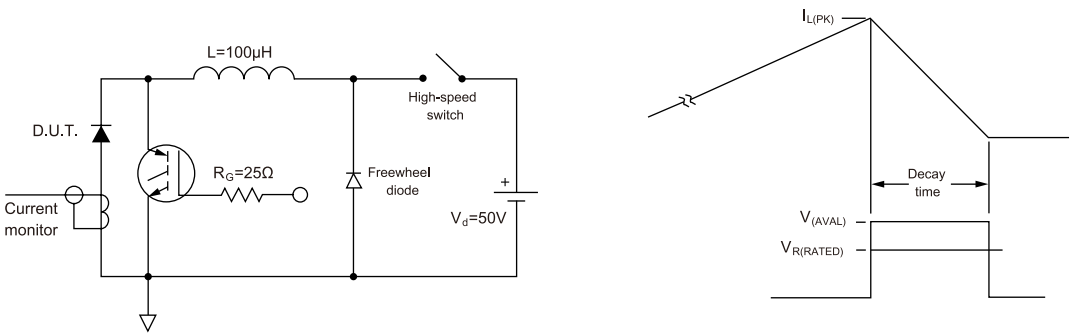
(3) $t_{rr}$ - reverse recovery time measured from zero crossing point of negative going $I_F$ to point where a line passing through 0.75 $I_{RRM}$ and 0.50 $I_{RRM}$ extrapolated to zero current.

(4) $Q_{rr}$ - area under curve defined by $t_{rr}$ and $I_{RRM}$

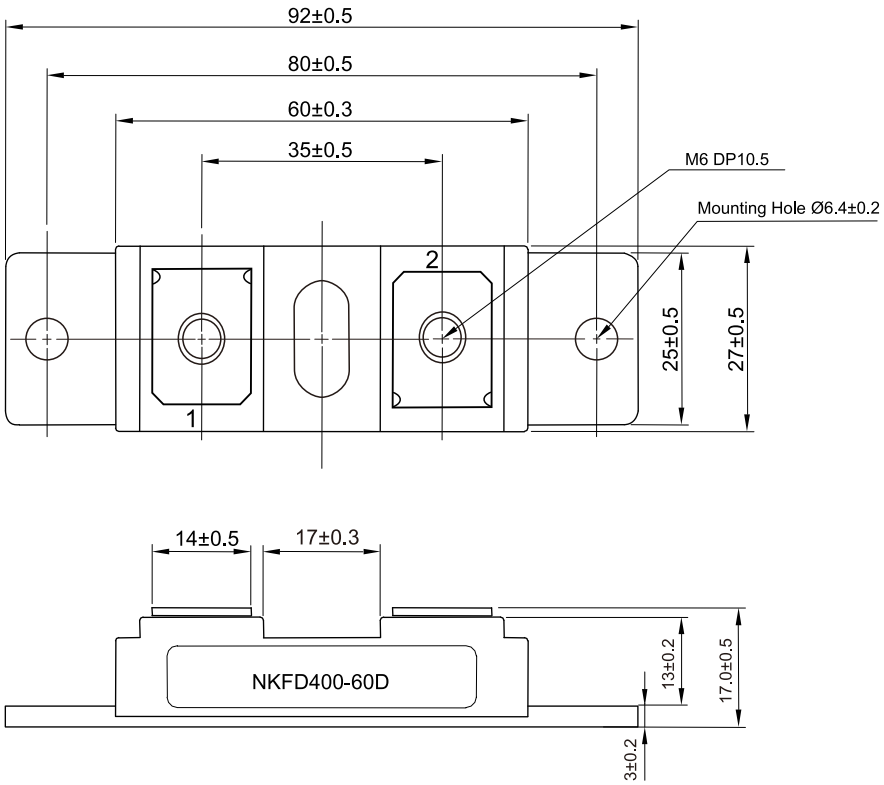
$$Q_{rr} = \frac{t_{rr} \times I_{RRM}}{2}$$

(5) $dI_{(rec)M}/dt$ - peak rate of change of current during $t_b$ portion of $t_{rr}$

**Fig.09 Avalanche test circuit and waveforms**



## Package outline




All dimensions in millimeters