FRED
Ultrafast Soft Recovery Diode Module
400A / 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

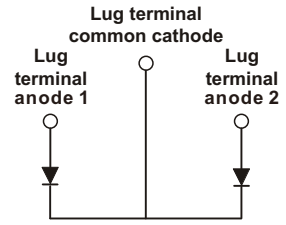
DESCRIPTION

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

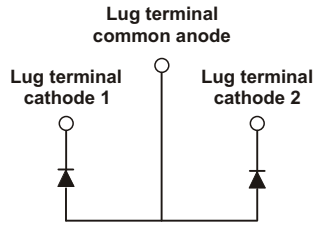
- Power converters
- Motor drives
- Welders
- Switching power supplies
- Uninterruptible power supply (UPS)
- Power factor correction (PFC) circuit
- Inverter
- Choppers
- Battery chargers

IAP (Insulated)



NKFD400-60I

*Add suffix "I" for insulated type



NKFD400-60RI

*Add suffix "R" for common anode

PRODUCT SUMMARY	
$I_{F(AV)}$	400A
V_R	600V
$I_{F(DC)}$ at T_C	220A 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 =115°C, per device	400	
		T_C =115°C, per leg	200	
DC forward current	$I_{F(DC)}$	T_C =100°C	220	
Single pulse forward current	I_{FSM}	Limited by junction temperature, per leg	2400	
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	780	W
		T_C =100°C	330	
Operating junction and storage temperature range	T_J, T_{Stg}		- 55 to 150	°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	-	1.20	1.35	
		I_F = 400 A	-	1.35	1.50	
		I_F = 200 A, T_J = 125 ºC	-	1.0	1.15	
Maximum reverse leakage current per leg	I_{RM}	T_J = 125°C, V_R = 600V	-	0.4	4	mA
		T_J = 25°C, V_R = 600V	-	1.0	10.0	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
Maximum RMS insulation voltage	V_{INS}	50Hz	-	-	2500(1min) 3000(1s)	V

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 dI_F/dt = 200 A/μs V_R = 200 V	-	100	150	
		T_J = 125 ºC		-	300	450	
Peak recovery current	I_{RRM}	T_J = 25 ºC		-	13	24	A
		T_J= 125 ºC		-	19	30	
Reverse recovery charge	Q_{rr}	T_J = 25 ºC		-	800	2300	nC
		T_J= 125 ºC		-	1500	4500	
Peak rate of recovery current	$dI_{(rec)M}/dt$	T_J = 25 ºC		-	280	-	A/μs
		T_J = 125 ºC		-	260	-	

THERMAL AND MECHANICAL SPECIFICATIONS					
PARAMETER	**SYMBOL**	**MIN.**	**TYP.**	**MAX.**	**UNIT**
Maximum junction and storage temperature range	T_J, T_{stg}	-55	-	150	ºC
Thermal resistance, junction to case per leg	R_{thJC}	-	-	0.22	ºC/W
Thermal resistance, junction to case per module	R_{thJC}	-	-	0.11	
Typical thermal resistance, case to heatsink	R_{thCS}	-	0.08	-	
Weight		-	155 (5.47)	-	g (oz.)
Mounting torque (1), M6		-	44.2 (5)	53.1 (6)	(N · m) 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	I
①	②	③	④		⑤	⑥	⑦

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

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

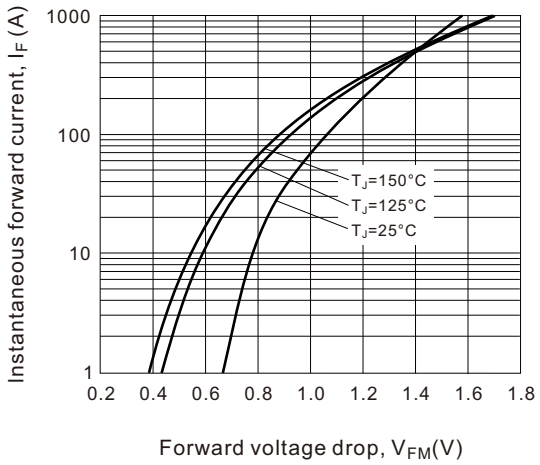


Fig.2 Typical reverse current vs. reverse voltage (per leg)

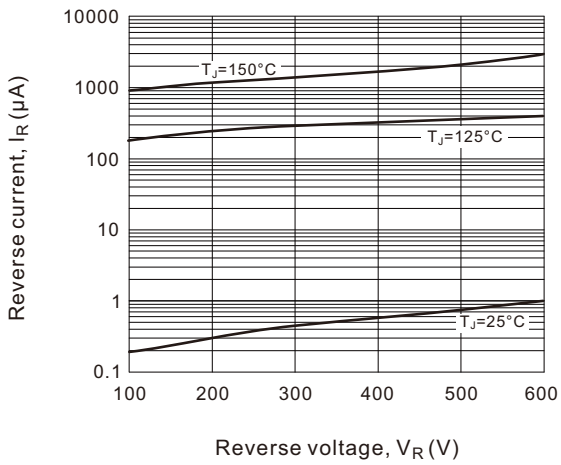


Fig.3 Typical junction capacitance vs. reverse voltage (per leg)

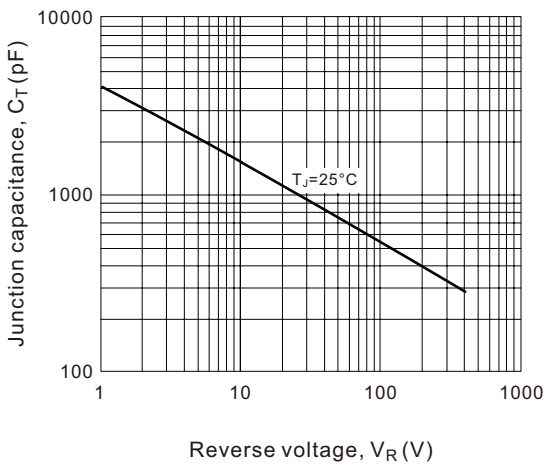


Fig.4 Maximum allowable case temperature vs. forward current (per leg)

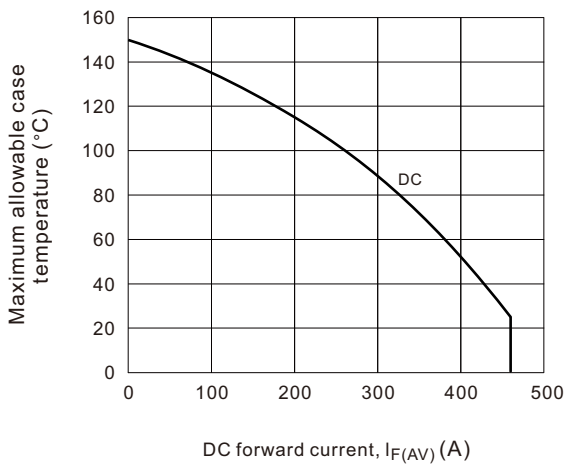


Fig.5 Typical reverse recovery time vs. dI_F/dt (per leg)

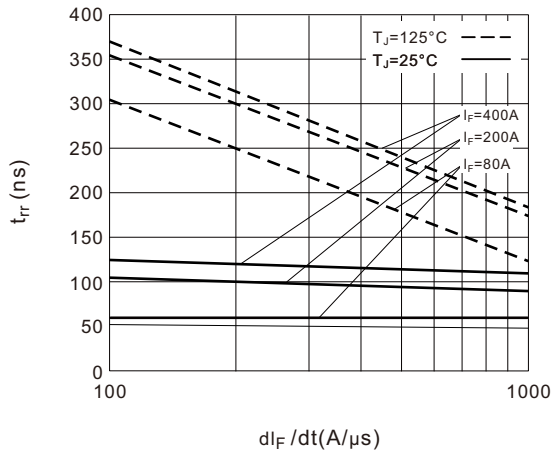


Fig.6 Typical recovery current vs. dI_F/dt (per leg)

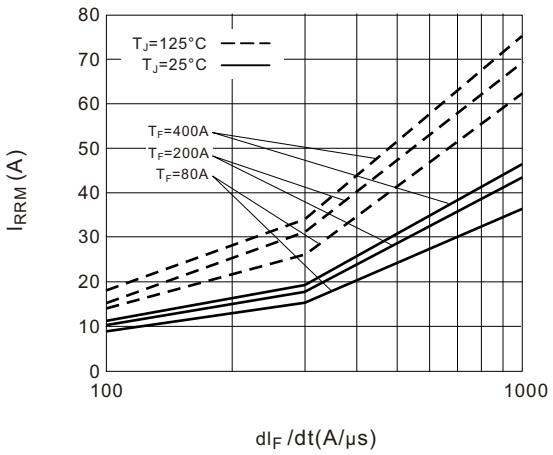


Fig.7 Typical stored charge vs. dI_F/dt (per leg)

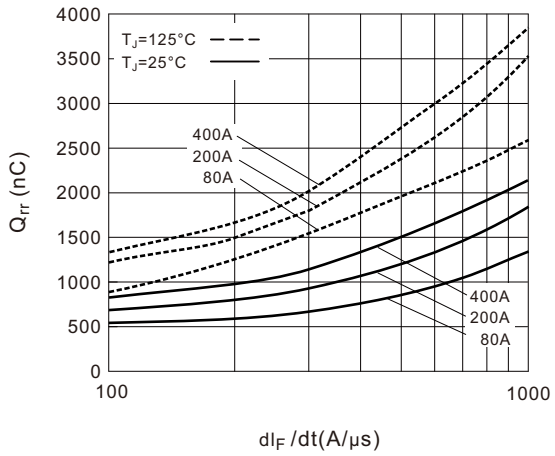


Fig.8 Typical $dI_{(rec)M}/dt$ vs. dI_F/dt (per leg)

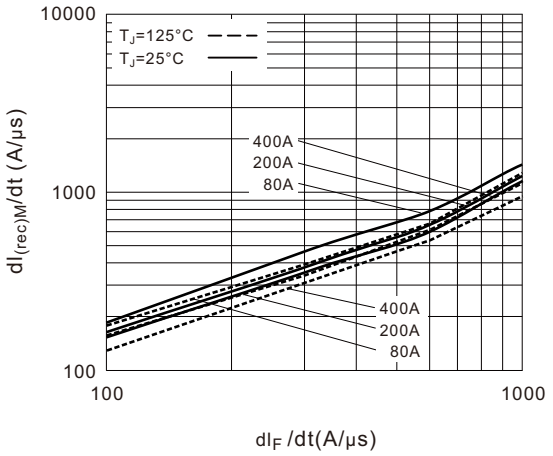


Fig.9 Maximum thermal impedance $R_{th(j-c)}$ characteristics (Per leg)

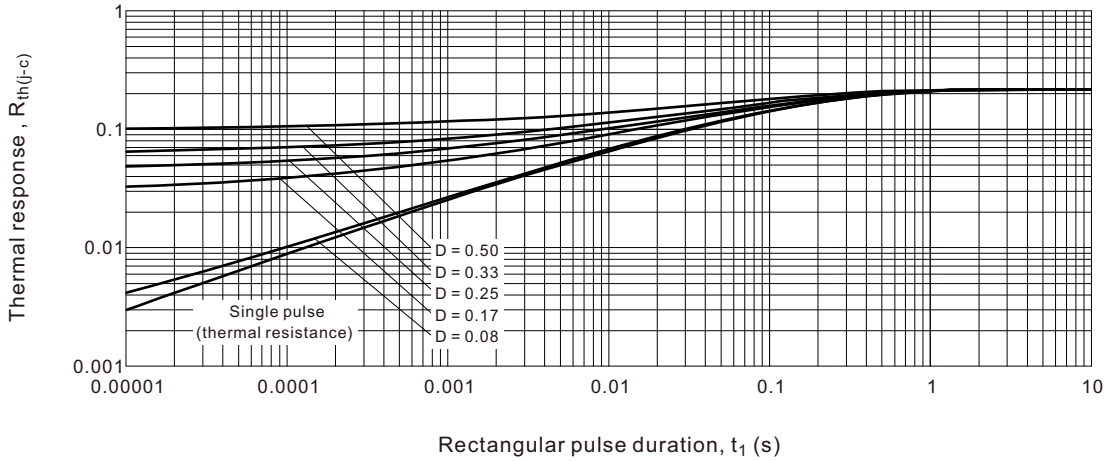


Fig.10 Reverse recovery parameter test circuit

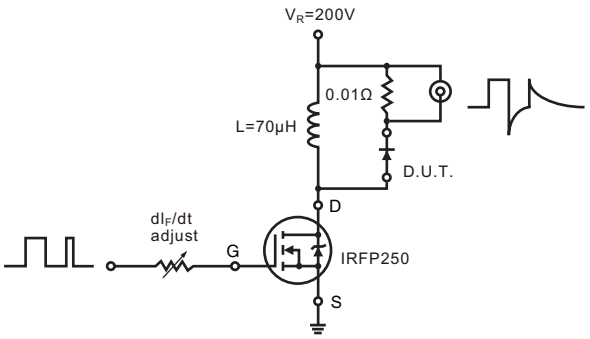
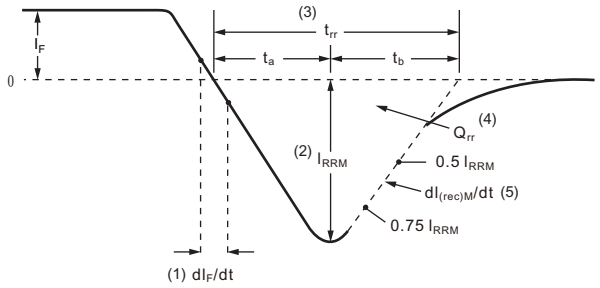


Fig.11 Reverse recovery waveform and definitions



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

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

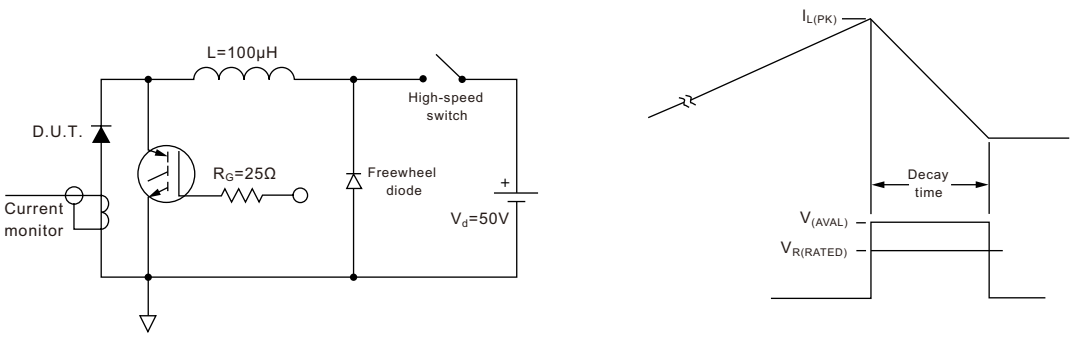
(3) t_{rr} - reverse recovery time measured from zero crossing point of negative going I_F to point where a line passing through 0.75 I_{RRM} and 0.50 I_{RRM} extrapolated to zero current.

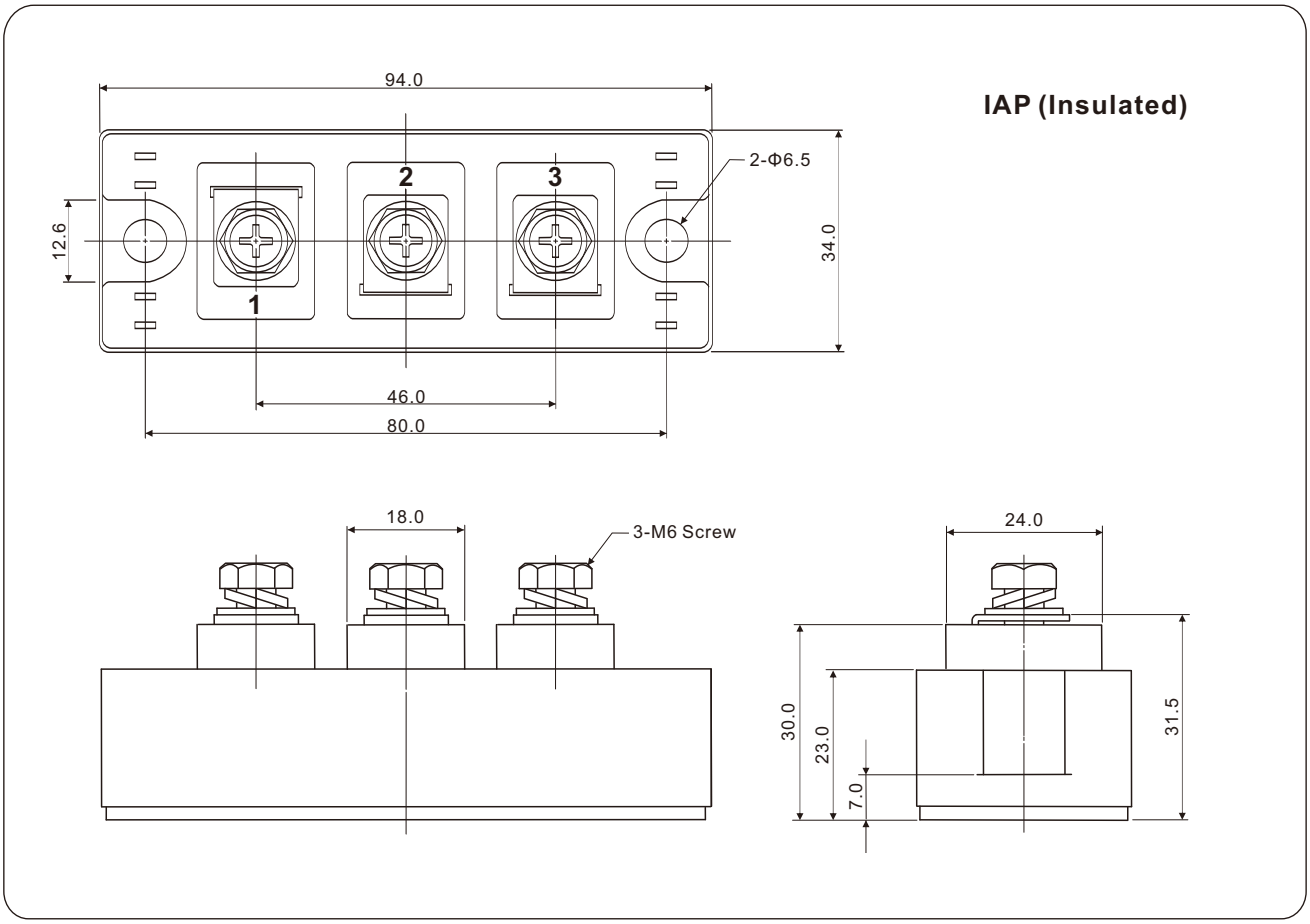
(4) Q_{rr} - area under curve defined by t_{rr} and I_{RRM}

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

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

Fig.12 Avalanche test circuit and waveforms




IAP (Insulated)
94.0
2-Φ6.5
12.6
34.0
2
3
1
46.0
80.0
18.0
3-M6 Screw
24.0
30.0
23.0
7.0
31.5