International Rectifier DESIGN TIPS DT 95-2

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IR'S NEW FIFTH GENERATION POWER MOSFETS: A REPLACEMENT GUIDE

This design tip provides a replacement guide for existing power MOSFETs with new devices from IR. Tables 1 & 2 compare some parameters of the new IRFZ34N and IRF1010N side by side with their older generation counterparts as examples. The same comparison points apply to other replacement devices. In considering designs for replacement, the following points must be taken into account:

Chip size:

Fifth generation devices use high density, smaller geometry cell structures, this results in a smaller chip size for a given on resistance.

$R_{DS(on)}$:

Fifth generation replacement devices have 10 to 20% lower $R_{DS(on)}$ than the comparable older generation devices. This results in significant improvements in circuit efficiency. Designs relying on $V_{DS(on)}$ sensing to control circuit behavior (e.g. current limiting) must take this reduction in $R_{DS(on)}$ into account and set new control limits.

Breakdown Voltage:

In some cases, IR's new generation power MOSFETs have a breakdown voltage of 55 volts at 25°C. (50V minimum at -40°C) in replacing a 60V existing part. These breakdown values are mainly due to new epi material and thickness as well as improved substrates used in the process.

Current Ratings:

New devices have lower current ratings due to reduced chip size and increased thermal resistance. Designs which rely on maximum current ratings for proper operation should take this point into account.

Capacitance, Gate Charge and Switching:

Fifth generation devices have higher input capacitance and gate charge values per unit area which would result in slower switching times. However, the contribution from considerable die size reductions has resulted in the net effect of reduced capacitance, lower gate charge and hence, faster switching speeds. Circuits that are relatively sensitive to EMI/RFI should be scrutinized to avoid increased noise. Increasing series gate resistance would normally reduce noise.

Thermal Resistance considerations:

Replacement devices with comparable on resistance have smaller die sizes. This results in a higher thermal resistance for the same package. Replacing existing designs with these devices requires a thorough understanding of the TOTAL thermal resistance of the system. (i.e. device plus heat sink components) and the contribution of the device to the total thermal resistance. The higher the total thermal resistance, the better the chance of direct replacement. This arises from the fact that in systems with low total thermal resistance a small change in device thermal characteristics will adversely affect the total system, whereas designs with higher $R\theta_{ja}$ are relatively immune to variations in device thermal behavior. Figures 1 & 2 show the IRFZ34N and IRF1010N with their respective counterparts. The graphs are based on the basic relation between thermal resistance, power dissipation and junction temperature, or:

$$R\theta_{ja} = R\theta_{jc} + R\theta_{ca} = \Delta T_j / P_d \quad \text{where,}$$

$$P_d = R_{ds(on)} * I_d^2$$

For the same current, the ratio of junction temperatures of the new and old devices becomes:

$$\Delta T_j(new)/\Delta T_j(old) = [R\theta_{ja}(new) * R_{ds(on)}(new)] / [R\theta_{ja}(old) * R_{ds(on)}(old)]$$

The graphs depict the ratio of junction temperatures of the old and replacement devices against various case to ambient thermal resistance values. As an example, replacing an IRFZ34 with the IRFZ34N will cause same or lower operating temperatures when the case to ambient thermal resistance of the system exceeds approximately 2.1 degC/watt. A ratio of 100% or greater indicates higher junction temperature for the new device. In any case, a designer must ensure that the junction temperature does not exceed T_{jmax} as specified in the device data sheets.

V_{sd}, T_{rr}, Q_{rr}:

Use of new epi and substrate materials and smaller chip size are mainly responsible for reduced reverse diode forward drop and recovery characteristics in the new devices. Existing designs using the integral diode should benefit from this in the form of reduced losses.

Table 1 - Comparing IRFZ34N to IRFZ34
(25°C ratings)

Parameter	IRFZ34N	IRFZ34	Net Effect	Reason
Chip Size	85x104 mils	144x152 mils	Lower	High density cell structure
Bvdss (min)	55	60	Lower	New EPI & Substrate
Id @ 25°C	26	30	Lower	Higher Thermal resistance
Id @ 100°C	18	21	Lower	Higher thermal resistance
Rdson (max)	40 mohms max	50 mohm max	Lower	High density cell structure
Rθjc (max)	2.7	1.7	Higher	Smaller chip size
Qg (max)	34	46	Lower	Smaller chip size
Qgs (max)	6.8	11	Lower	Smaller chip size
Qgd (max)	14	22	Lower	Smaller chip size
tdon (typ)	7.0	13	Lower	Smaller chip size
trise (typ)	49	100	Lower	Smaller chip size
tdoff (typ)	31	29		
tfall (typ)	40	52	Lower	Smaller chip size
Ciss (typ)	700	1200	Lower	Smaller chip size
Coss (typ)	240	600	Lower	Smaller chip size
Crss (typ)	100	100		
Vsd (max)	1.6	1.6		
Trr (max)	86nsec	230nsec	Lower	New EPI & Substrate
Qrr (max)	200nC	1400nC	Lower	New EPI & Substrate

Fig 1 - Replacing IRFZ34 with IRFZ34N

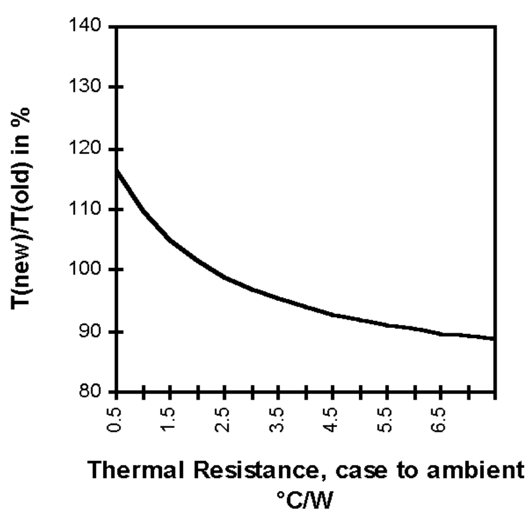
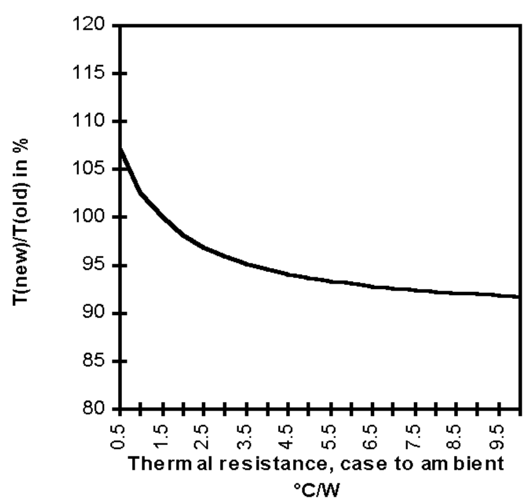


Table 2 - Comparing IRF1010N to IRF1010
(25°C ratings)

Parameter	IRF1010N	IRF1010	Net Effect	Reason
Chip Size	166 x 166 mils	170 x 230 mils	Lower	High density cell structure
Bvdss (min)	55	55	Lower	New EPI & Substrate
Id @ 25°C	68	75	Lower	Higher thermal resistance
Id @ 100°C	48	53	Lower	Higher thermal resistance
Rdson (max)	12.5mohms max	14mohms max	Lower	High density cell structure
Rθjc (max)	1.3degC/w	1.0 degC/w	Higher	Smaller chip size
Qg (max)	110	120	Lower	Smaller chip size
Qgs (max)	22	27	Lower	Smaller chip size
Qgd (max)	43	54	Lower	Smaller chip size
tdon (typ)	13	16	Lower	Smaller chip size
trise (typ)	77	120	Lower	Smaller chip size
tdoff (typ)	46	48	---	
tfall (typ)	60	80	Lower	Smaller chip size
Ciss (typ)	2800	2500	Lower	Smaller chip size
Coss (typ)	810	1300	Lower	Smaller chip size
Crss (typ)	280	350	Lower	
Vsd (max)	1.4	1.4	---	
Trr (max)	130	150	Lower	New EPI & Substrate
Qrr Max)	390nC	540nC	Lower	New EPI & Substrate

Fig 2 - Replacing IRF1010 with IRF1010N



Data and specifications subject to change without notice