

## N-Channel Enhancement Mode MOSFET

### Feature

### Pin Description

- 135V/213A  
R<sub>DS(ON)</sub> = 4.1      @V<sub>GS</sub> = 10V
- 100% Avalanche Tested
- 100% DVDS
- Reliable and Rugged
- Halogen Free and Green Devices Available  
(RoHS Compliant)

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### Applications

- Switching application
- Li-ba-8.002 (06 ((ol)-25-20 (pl)0 Td [S92 (i)5 (D2.008 (S).024 (v)6.004 0 Tc4C)(Li)T0I214.04 Tfro).0242 (r)-3cTd <007A

## Absolute Maximum Ratings

Symbol	Parameter	Rating	Unit	
<b>Common Ratings</b> (Tc=25°C Unless Otherwise Noted)				
V <sub>DSS</sub>	Drain-Source Voltage	135	V	
V <sub>GSS</sub>	Gate-Source Voltage	±20	V	
T <sub>J</sub>	Junction Temperature Range	-55 to 175	°C	
T <sub>STG</sub>	Storage Temperature Range		°C	
I <sub>S</sub>	Source Current-Continuous(Body Diode)	Tc=25°C	213	A
<b>Mounted on Large Heat Sink</b>				
I <sub>DM</sub>	Pulsed Drain Current *	Tc=25°C	768	A
I <sub>D</sub>	Continuous Drain Current	Tc=25°C	213	A
		Tc=100°C	151	A
P <sub>D</sub>	Maximum Power Dissipation	Tc=25°C	455	W
		Tc=100°C	227	W
R <sub>JC</sub>	Thermal Resistance, Junction-to-Case		0.33	°C/W
R <sub>JA</sub>	Thermal Resistance, Junction-to-Ambient **		62.5	°C/W
E <sub>AS</sub>	Single Pulsed-Avalanche Energy ***	L=0.3mH	1381	mJ

Note: \* Repetitive rating; pulse width limited by max.junction temperature.

\*\* Surface mounted on 1in2 FR-4 board.

\*\*\* Limited by T<sub>Jmax</sub>, starting T<sub>J</sub>=25°C, L = 0.3mH, R<sub>G</sub>= 25 Ω, V<sub>GS</sub>=10V.

## Electrical Characteristics(Tc =25°C Unless Otherwise Noted)

Symbol	Parameter	Test Conditions	HYG040N13NS1			Unit
			Min	Typ.	Max	
<b>Static Characteristics</b>						
BV <sub>DSS</sub>	Drain-Source Breakdown Voltage	V <sub>GS</sub> =0V, I <sub>DS</sub> =250 A	135	150	-	V
I <sub>DSS</sub>	Drain-to-Source Leakage Current	V <sub>DS</sub> =135V, V <sub>GS</sub> =0V	-	-	1	A
		T <sub>J</sub> =125°C	-	-	50	A
V <sub>GS(th)</sub>	Gate Threshold Voltage	V <sub>DS</sub> =V <sub>GS</sub> , I <sub>DS</sub> =250 A	2	3.3	4	V
I <sub>GSS</sub>	Gate-Source Leakage Current	V <sub>GS</sub> =±20V, V <sub>DS</sub> =0V	-	-	±100	nA
R <sub>DS(ON)</sub>	Drain-Source On-State Resistance	V <sub>GS</sub> =10V, I <sub>DS</sub> =50A	-	4.1	5	m
<b>Diode Characteristics</b>						
V <sub>SD</sub>	Diode Forward Voltage	I <sub>SD</sub> =50A, V <sub>GS</sub> =0V	-	0.85	1.3	V
t <sub>rr</sub>	Reverse Recovery Time	I <sub>SD</sub> =50A, dI <sub>SD</sub> /dt=100A/	-	117	-	ns
Q <sub>rr</sub>	Reverse Recovery Charge		-	490	-	nC

**Electrical Characteristics (Cont.)** (T<sub>c</sub> =25°C Unless Otherwise Noted)

Symbol	Parameter	Test Conditions	HYG040N13NS1			Unit
			Min	Typ.	Max	
<b>Dynamic Characteristics</b>						
R <sub>G</sub>	Gate Resistance	V <sub>GS</sub> =0V, V <sub>DS</sub> =0V, F=500KHz	-	1.6	-	
C <sub>iss</sub>	Input Capacitance	V <sub>GS</sub> =0V, V <sub>DS</sub> =25V, Frequency=500KHz	-	8308	-	pF
C <sub>oss</sub>	Output Capacitance					
C <sub>rss</sub>	Reverse Transfer Capacitance					
t <sub>d(ON)</sub>	Turn-on Delay Time		V <sub>DD</sub> =75V, R <sub>G</sub> =4 I <sub>DS</sub> =50A, V <sub>GS</sub> =10V	-	37	-
T <sub>r</sub>	Turn-on Rise Time					
t <sub>d(OFF)</sub>	Turn-off Delay Time					
T <sub>f</sub>	Turn-off Fall Time					
<b>Gate Charge Characteristics</b>						
Q <sub>g</sub>	Total Gate Charge(V <sub>GS</sub> =10V)	V <sub>DS</sub> =108V, I <sub>DS</sub> =50A	-	118	-	nC
Q <sub>gs</sub>	Gate-Source Charge					
Q <sub>gd</sub>	Gate-Drain Charge					
V <sub>plateau</sub>	Gate plateau voltage		-	5.4	-	V

Note: \*Pulse test, pulse width 300us, duty cycle 2%

### Typical Operating Characteristics

Figure 1: Power Dissipation

Figure 2: Drain Current

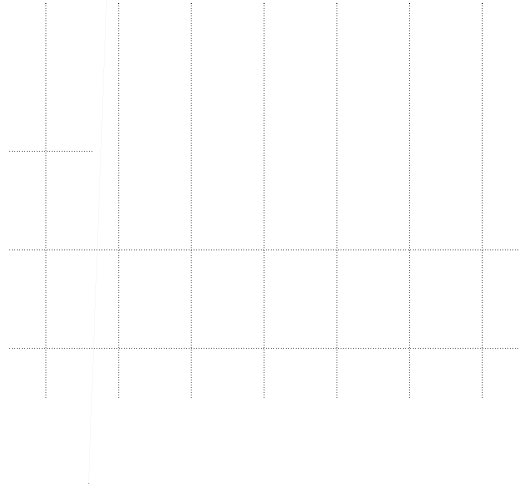
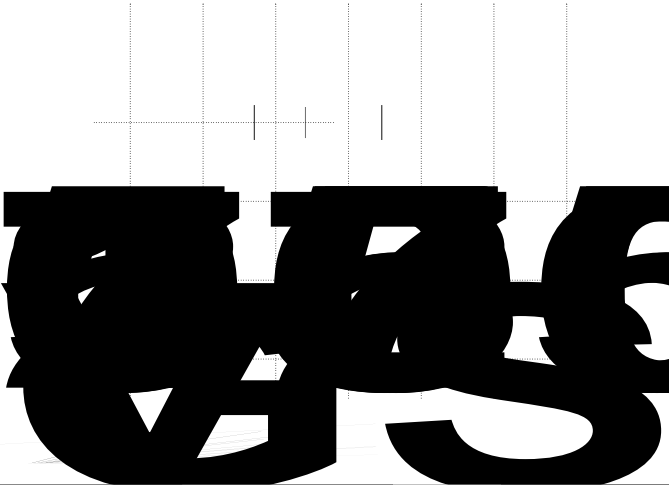


Figure 3: Safe Operation Area

Figure 4: Thermal Transient Impedance

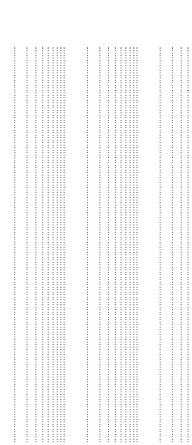
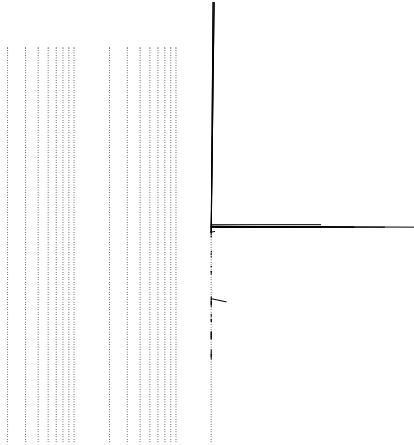
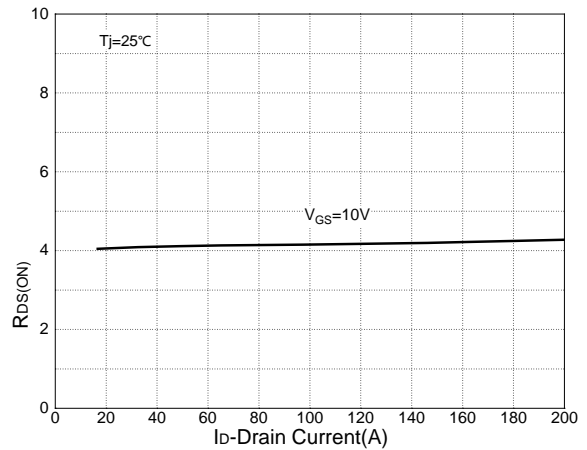
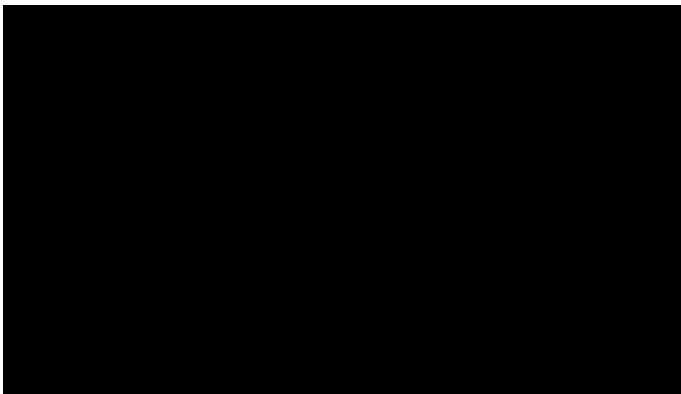


Figure 5: Output Characteristics

Figure 6: Drain-Source On Resistance



**Typical Operating Characteristics(Cont.)**

**Figure 7: On-Resistance vs. Temperature**

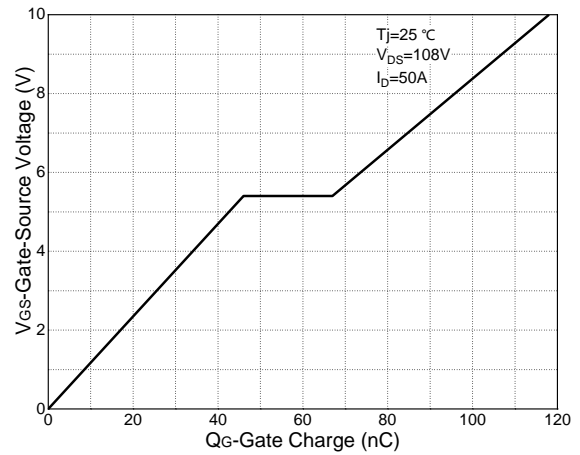
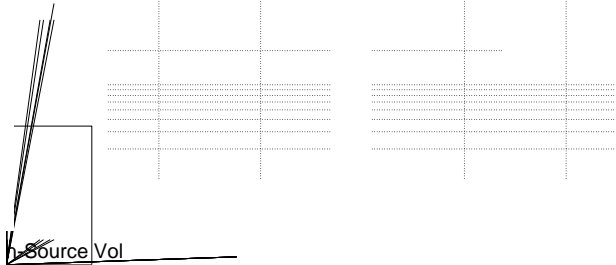
**Figure 8: Source-Drain Diode Forward**

**Q5**

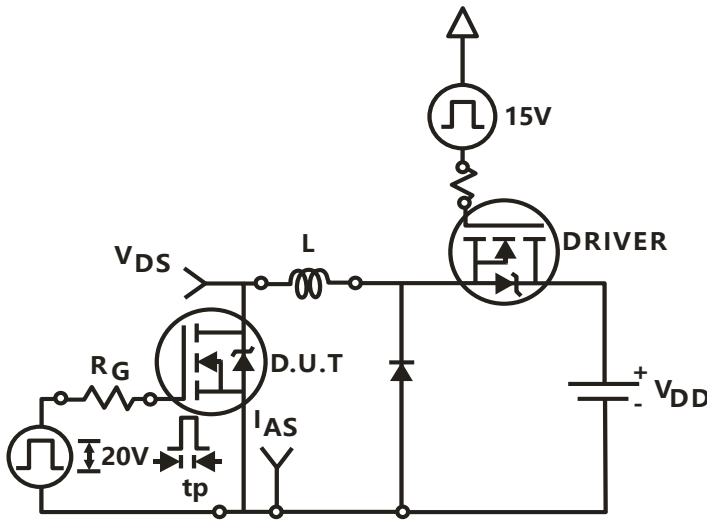
**Figure 9: Capacitance Characteristics**

**Figure 10: Gate Charge Characteristics**

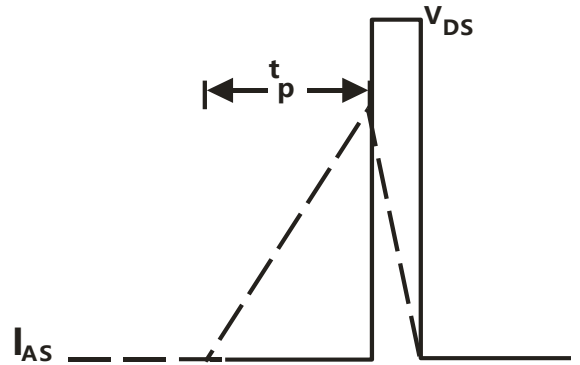
**Q5**



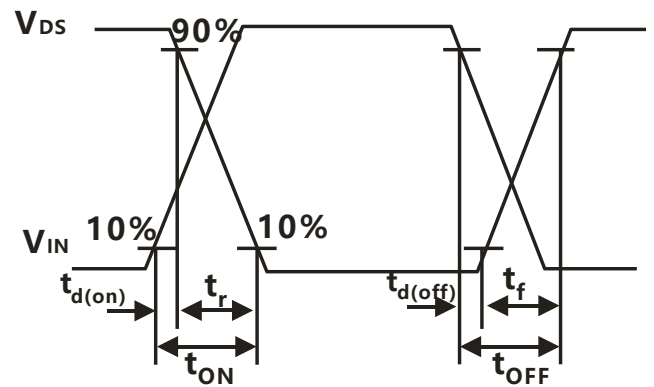
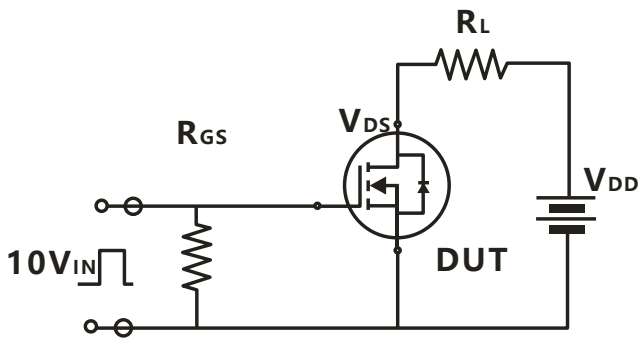
**Avalanche Test Circuit**



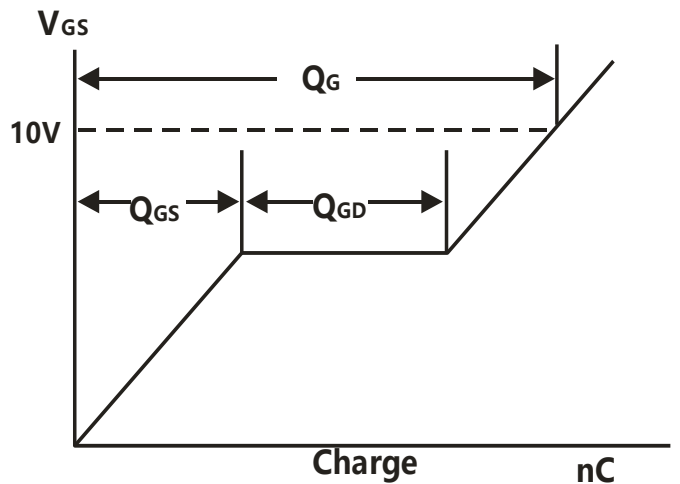
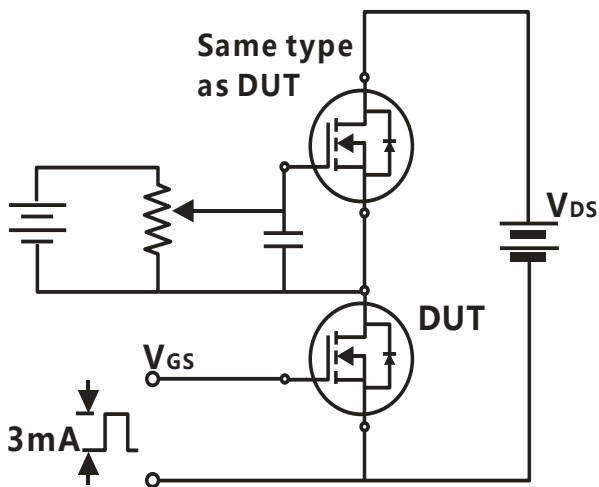
$$E_{AS} = \frac{1}{2} L I_{AS}^2$$



**Switching Time Test Circuit**



**Gate Charge Test Circuit**



## Device Per Unit

Package Type	Unit	Quantity
TO-220FB-3L	Tube	50
TO-263-2L	Reel	800

## Package Information

TO-220FB-3L

COMMON DIMENSIONS			
SYMBOL	mm		
	MIN	NOM	MAX
A	4.37	4.57	4.77
A1	1.25	1.30	1.40
A2	2.20	2.40	2.60
b	0.70	0.80	0.95
b2	1.17	1.27	1.47
c	0.45	0.50	0.60
D	15.10	15.60	16.10
D1	8.80	9.10	9.40
D2	5.50	6.30	7.10
E	9.70	10.00	10.30
E3	7.00	7.80	8.60

e

TO-263-2L

COMMON DIMENSIONS			
SYMBOL	mm		
	MIN	NOM	MIN
A	4.37	4.57	4.77
A1	1.22	1.27	1.42
A2	2.49	2.69	2.89
A3	0	0.13	0.25
b	0.70	0.81	0.96
b1	1.17	1.27	1.47
c	0.30	0.38	0.53
D1	8.50	8.70	8.90
D4	6.60	-	-
E	9.86	10.16	10.36
E5	7.06	-	-
e	2.54 BSC		
H	14.70	15.10	15.50
H2	1.07	1.27	1.47
L	2.00	2.30	2.60
L1	1.40	1.55	1.70
L4	0.25 BSC		
	0°	5°	9°



**Classification Profile**



**Classification Reflow Profiles**

Profile Feature	Sn-Pb Eutectic Assembly	Pb-Free Assembly
<b>Preheat &amp; Soak</b>		
Temperature min ( $T_{smin}$ )	100 °C	150 °C
Temperature max ( $T_{smax}$ )	150 °C	200 °C
Time ( $T_{smin}$ to $T_{smax}$ ) ( $t_s$ )	60-120 seconds	60-120 seconds
Average ramp-up rate ( $T_{smax}$ to $T_P$ )	3 °C/second max.	3°C/second max.
Liquidous temperature ( $T_L$ )	183 °C	217 °C
Time at liquidous ( $t_L$ )	60-150 seconds	60-150 seconds
Peak package body Temperature ( $T_P$ )*	See Classification Temp in table 1	See Classification Temp in table 2
Time ( $t_P$ )** within 5°C of the specified classification temperature ( $T_c$ )	20** seconds	30** seconds
Average ramp-down rate ( $T_P$ to $T_{smax}$ )	6 °C/second max.	6 °C/second max.
Time 25°C to peak temperature	6 minutes max.	8 minutes max.
*Tolerance for peak profile Temperature ( $T_P$ ) is defined as a supplier minimum and a user maximum.		
** Tolerance for time at peak profile temperature ( $t_P$ ) is defined as a supplier minimum and a user maximum.		

Table 1.SnPb Eutectic Process Classification Temperatures (Tc)

Package Thickness	Volume mm <sup>3</sup> <350	Volume mm <sup>3</sup> ≥350
<2.5 mm	235 °C	220 °C
	220 °C	220 °C

Table 2.Pb-free Process Classification Temperatures (Tc)

Package Thickness	Volume mm <sup>3</sup> <350	Volume mm <sup>3</sup> 350-2000	Volume mm <sup>3</sup> ≥2000
<1.6 mm	260 °C	260 °C	260 °C
1.6 mm 2.5 mm	260 °C	250 °C	245 °C
≥2.5 mm	250 °C	245 °C	245 °C

## Reliability Test Program

Test item	Method	Description
SOLDERABILITY	JESD-22, B102	5 Sec, 245°C
HTRB	JESD-22, A108	168/500/1000 Hrs, Bias @ 150°C
HTGB	JESD-22, A108	168/500/1000 Hrs, V <sub>gs</sub> 100% @ 150°C
PCT	JESD-22, A102	96 Hrs, 100%RH, 2atm, 121°C
TCT	JESD-22, A104	250/500/1000 Cycles, -55°C~150°C

## Customer Service

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