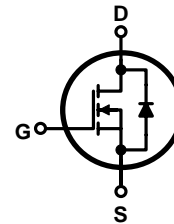
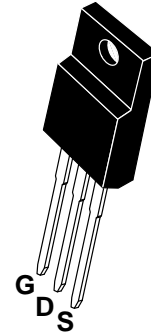


**PIN Connection TO-220F**

**Marking Diagram**


Y = Year  
 A = Assembly Location  
 WW = Work Week  
 FIR10N65F = Specific Device Code

**Switchng Regulator Application**
**Features**

- High Voltage :  $BV_{DSS}=650V(\text{Min.})$
- Low  $C_{rSS}$  :  $C_{rSS}=16pF(\text{Typ.})$
- Low gate charge :  $Qg=35nC(\text{Typ.})$
- Low  $R_{DS(on)}$  :  $R_{DS(on)}=0.8\Omega$

**Absolute maximum ratings ( $T_C=25^\circ\text{C}$  unless otherwise noted)**

Characteristic	Symbol	Rating	Unit
Drain-source voltage	$V_{DSS}$	650	V
Gate-source voltage	$V_{GSS}$	$\pm 30$	V
Drain current (DC) *	$I_D$	$T_C=25^\circ\text{C}$	10
		$T_C=100^\circ\text{C}$	5.5
Drain current (Pulsed) *	$I_{DM}$	40	A
Power dissipation	$P_D$	50	W
Avalanche current (Single) ②	$I_{AS}$	10	A
Single pulsed avalanche energy ②	$E_{AS}$	608	mJ
Avalanche current (Repetitive) ①	$I_{AR}$	10	A
Repetitive avalanche energy ①	$E_{AR}$	11.6	mJ
Junction temperature	$T_J$	150	$^\circ\text{C}$
Storage temperature range	$T_{stg}$	-55~150	

\* Limited by maximum junction temperature

Characteristic	Symbol	Typ.	Max.	Unit
Thermal resistance	Junction-case	$R_{th(J-C)}$	-	2.5
	Junction-ambient	$R_{th(J-A)}$	-	120

**Electrical Characteristics** ( $T_C=25^\circ\text{C}$  unless otherwise noted)

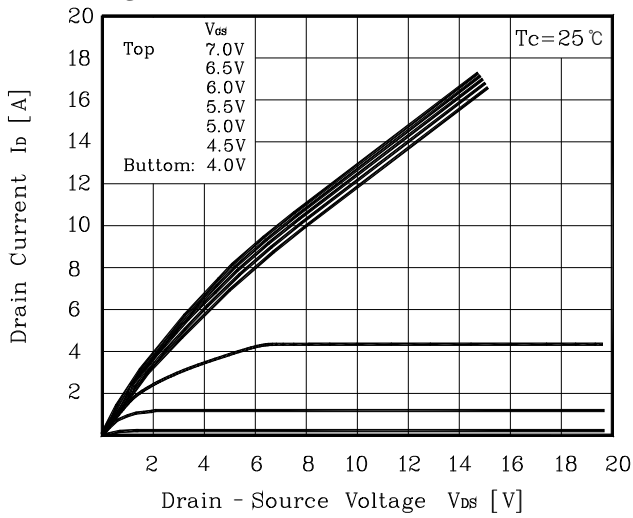
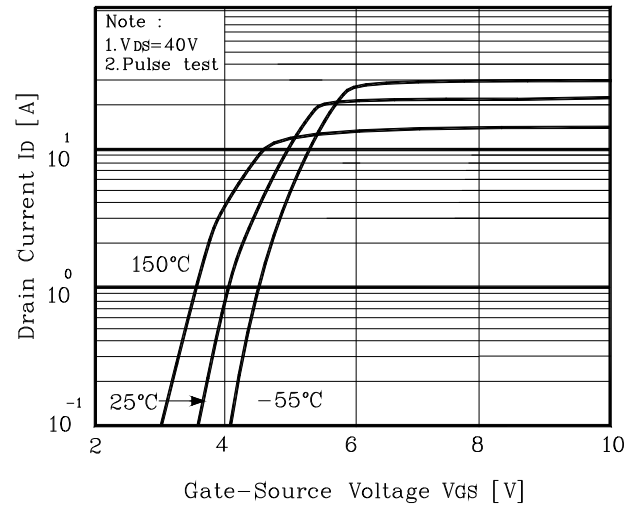
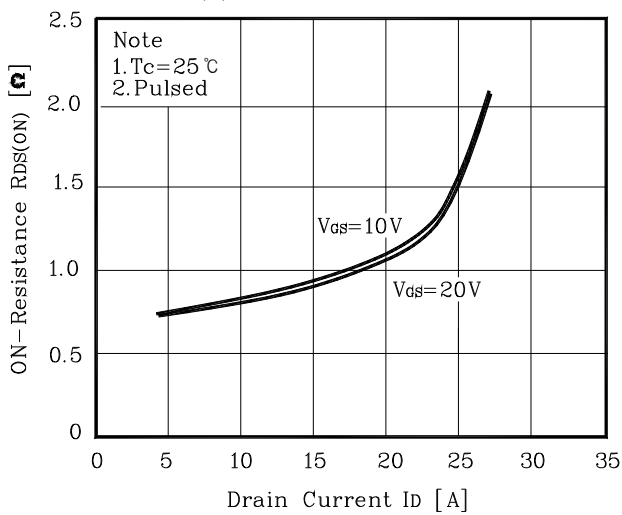
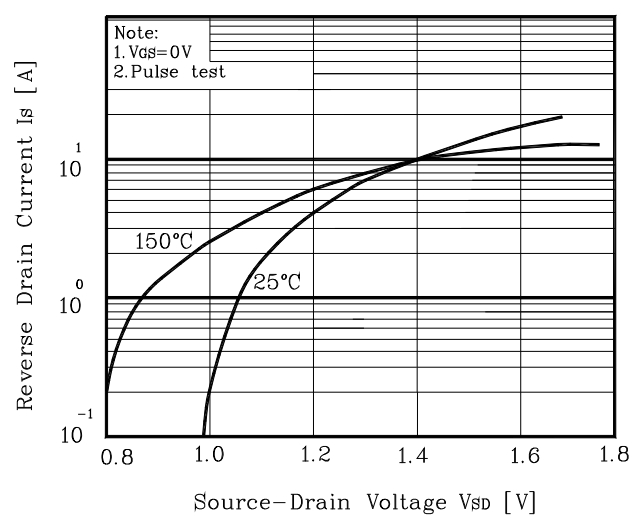
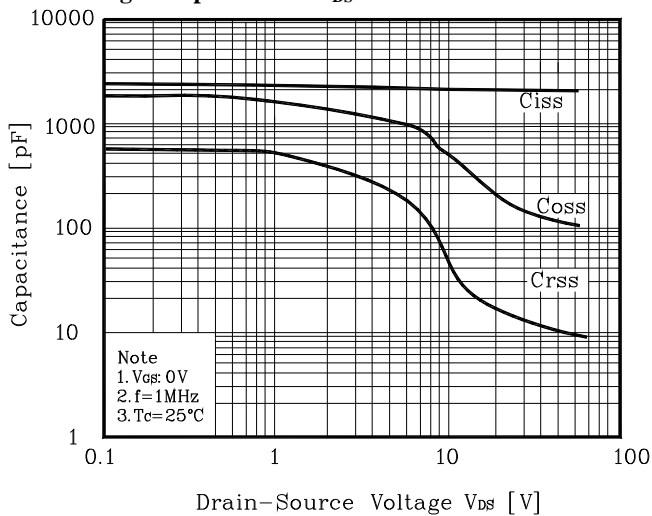
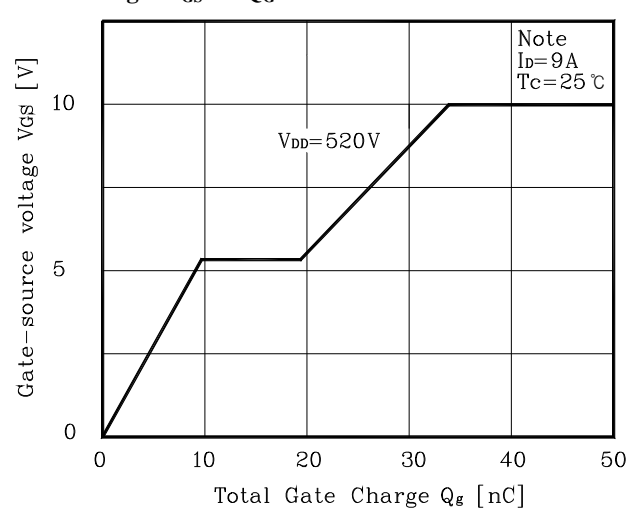
Characteristic	Symbol	Test Condition	Min.	Typ.	Max.	Unit
Drain-source breakdown voltage	$BV_{DSS}$	$I_D=250\mu\text{A}, V_{GS}=0\text{V}$	650	-	-	V
Gate threshold voltage	$V_{GS(th)}$	$I_D=250\mu\text{A}, V_{DS}=V_{GS}$	2.0	-	4.0	V
Drain-source cut-off current	$I_{DSS}$	$V_{DS}=650\text{V}, V_{GS}=0\text{V}$	-	-	1	$\mu\text{A}$
Gate leakage current	$I_{GSS}$	$V_{DS}=0\text{V}, V_{GS}=\pm 30\text{V}$	-	-	$\pm 100$	nA
Drain-source on-resistance ④	$R_{DS(on)}$	$V_{GS}=10\text{V}, I_D=5.0\text{A}$	-	0.8	1.0	$\Omega$
Forward transfer conductance ④	$g_{fs}$	$V_{DS}=10\text{V}, I_D=5.0\text{A}$	-	11	-	S
Input capacitance	$C_{iss}$	$V_{GS}=0\text{V}, V_{DS}=25\text{V}$ $f=1\text{ MHz}$	-	1143.2		pF
Output capacitance	$C_{oss}$		-	128		
Reverse transfer capacitance	$C_{rss}$		-	3.5		
Turn-on delay time	$t_{d(on)}$	$V_{DD}=300\text{V}, I_D=10\text{A}$ $R_G=25\Omega$	-	40	-	ns
Rise time	$t_r$		-	73.67		
Turn-off delay time	$t_{d(off)}$		-	52.13		
Fall time	$t_f$		-	34.8		
Total gate charge	$Q_g$	$V_{DS}=520\text{V}, V_{GS}=10\text{V}$ $I_D=10\text{A}$	-	20		nC
Gate-source charge	$Q_{gs}$		-	7.47		
Gate-drain charge	$Q_{gd}$		-	6.48		

**Source-Drain Diode Ratings and Characteristics** ( $T_C=25^\circ\text{C}$  unless otherwise noted)

Characteristic	Symbol	Test Condition	Min.	Typ.	Max.	Unit
Source current (DC)	$I_S$	Integral reverse diode in the MOSFET	-	-	10	A
Source current (Pulsed) ①	$I_{SM}$		-	-	40	
Forward voltage ④	$V_{SD}$	$V_{GS}=0\text{V}, I_S=10\text{A}$	-	-	1.3	V
Reverse recovery time	$t_{rr}$	$I_S=10\text{A}, V_{GS}=0\text{V}$ $dI_F/dt=100\text{A}/\mu\text{s}$	-	450	-	ns
Reverse recovery charge	$Q_{rr}$		-	4.2	-	$\mu\text{C}$

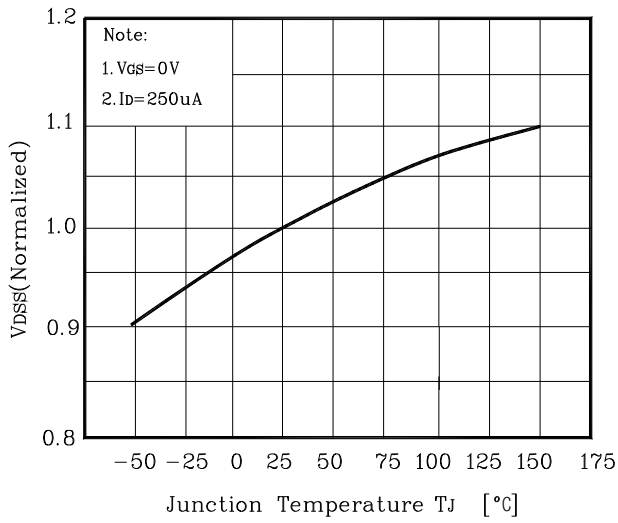
Note ;

- ① Repetitive rating : Pulse width limited by maximum junction temperature
- ②  $L=5.7\text{mH}, I_{AS}=10\text{A}, V_{DD}=50\text{V}, R_G=25\Omega$ , Starting  $T_J=25^\circ\text{C}$
- ③ Pulse Test : Pulse width $\leq 300\mu\text{s}$ , Duty cycle $\leq 2\%$
- ④ Essentially independent of operating temperature

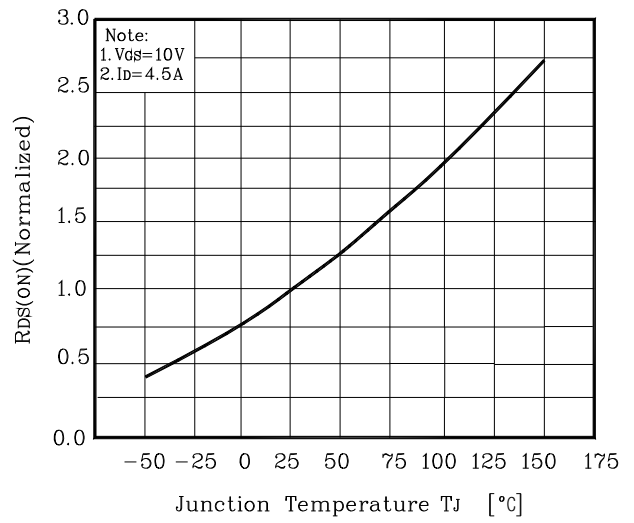
**Electrical Characteristic Curves**
**Fig. 1  $I_D - V_{DS}$** 

**Fig. 2  $I_D - V_{GS}$** 

**Fig. 3  $R_{DS(on)} - I_D$** 

**Fig. 4  $I_S - V_{SD}$** 

**Fig. 5 Capacitance -  $V_{DS}$** 

**Fig. 6  $V_{GS} - Q_G$** 


## Electrical Characteristic Curves

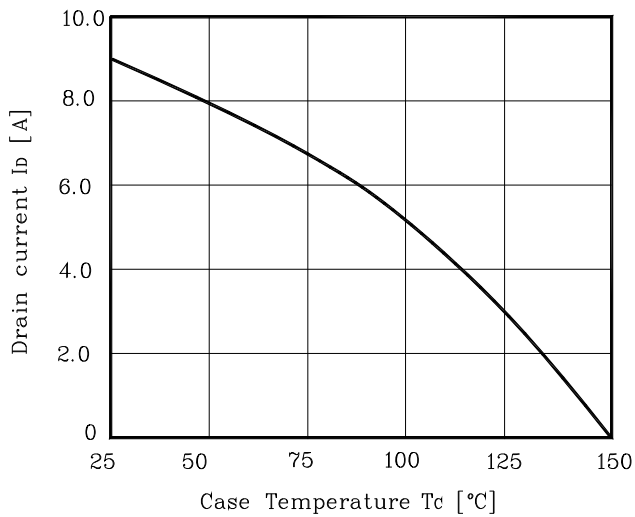
**Fig. 7  $V_{DSS} - T_J$**



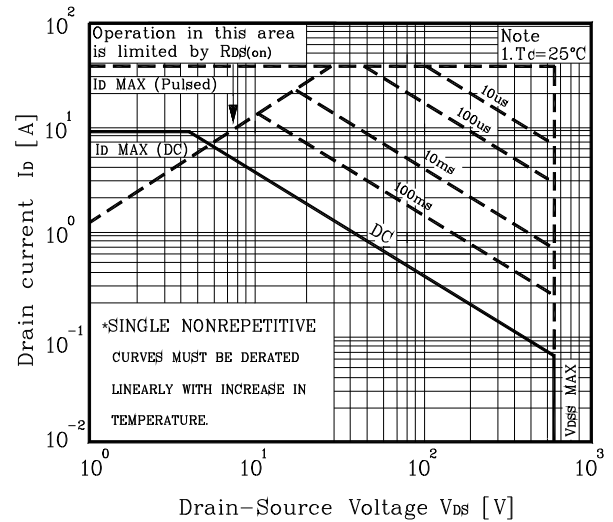
**Fig. 8  $R_{DS(on)} - T_J$**



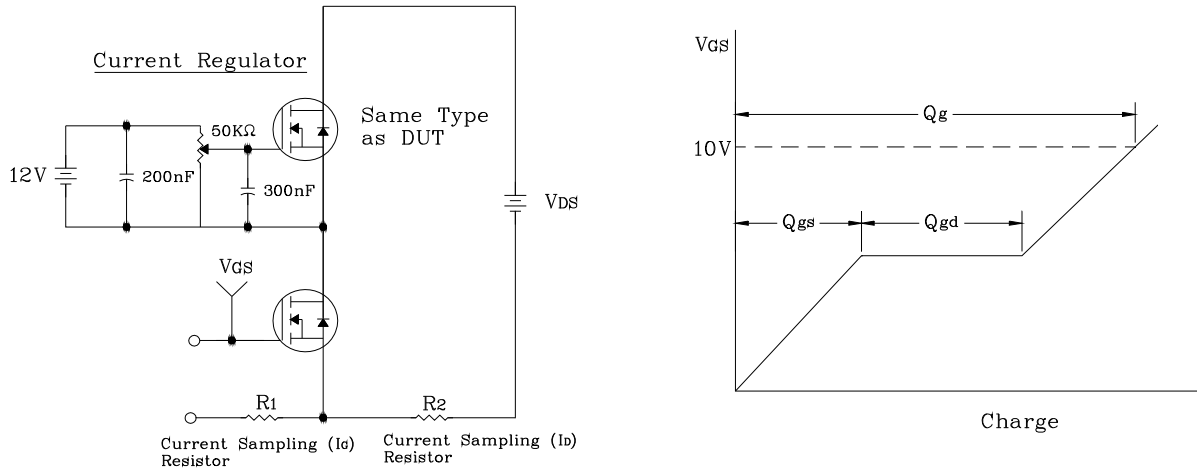
**Fig. 9  $I_D - T_C$**



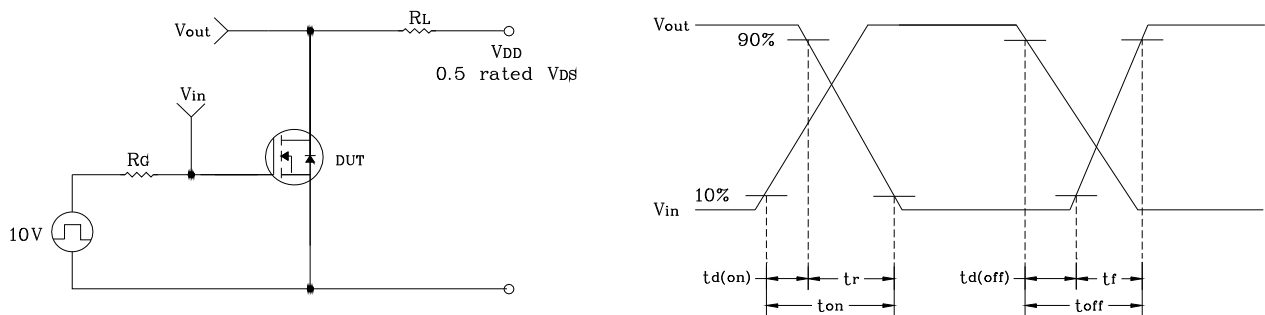
**Fig. 10 Safe Operating Area**



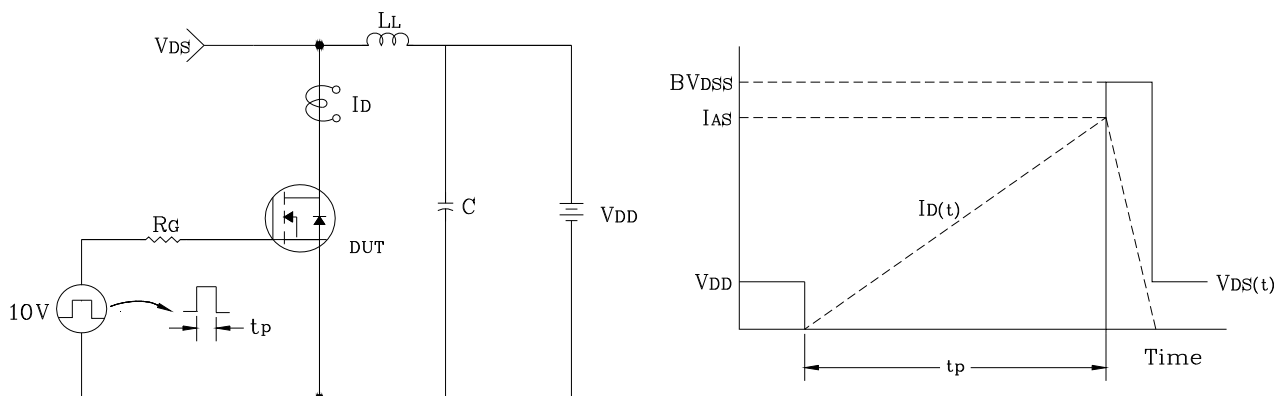
**Fig. 11 Gate Charge Test Circuit & Waveform**

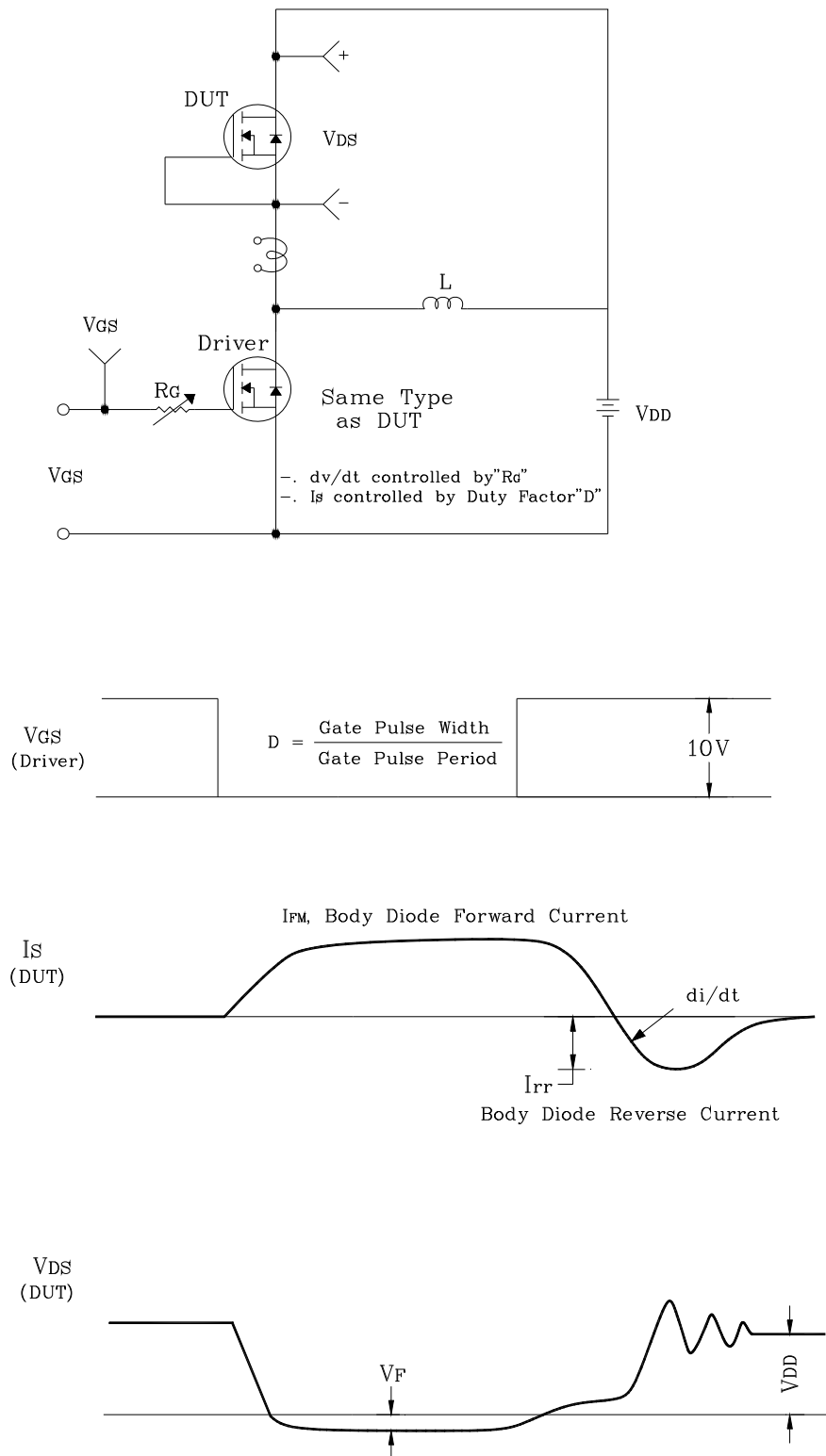


**Fig. 12 Resistive Switching Test Circuit & Waveform**



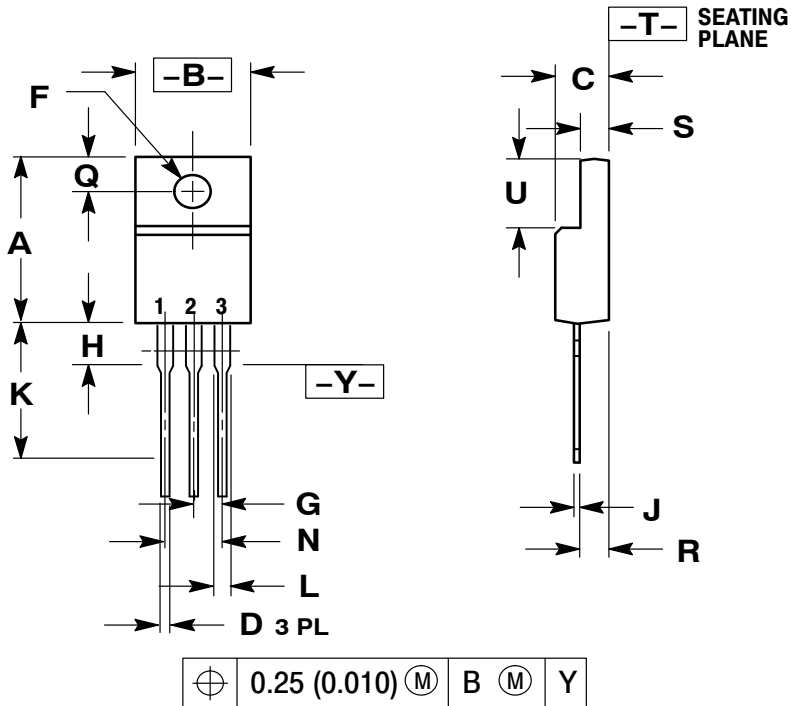
**Fig. 13 E<sub>AS</sub> Test Circuit & Waveform**



**Fig. 14 Diode Reverse Recovery Time Test Circuit & Waveform**


## Package Dimensions

### TO-220F



NOTES:

1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH
3. 221D-01 THRU 221D-02 OBSOLETE, NEW STANDARD 221D-03.

DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	0.617	0.635	15.67	16.12
B	0.392	0.419	9.96	10.63
C	0.177	0.193	4.50	4.90
D	0.024	0.039	0.60	1.00
F	0.116	0.129	2.95	3.28
G	0.100 BSC		2.54 BSC	
H	0.118	0.135	3.00	3.43
J	0.018	0.025	0.45	0.63
K	0.503	0.541	12.78	13.73
L	0.048	0.058	1.23	1.47
N	0.200 BSC		5.08 BSC	
Q	0.122	0.138	3.10	3.50
R	0.099	0.117	2.51	2.96
S	0.092	0.113	2.34	2.87
U	0.239	0.271	6.06	6.88