



## 650V Super-junction Power MOSFET

### DESCRIPTION

#### 650V Super-junction Power MOSFET

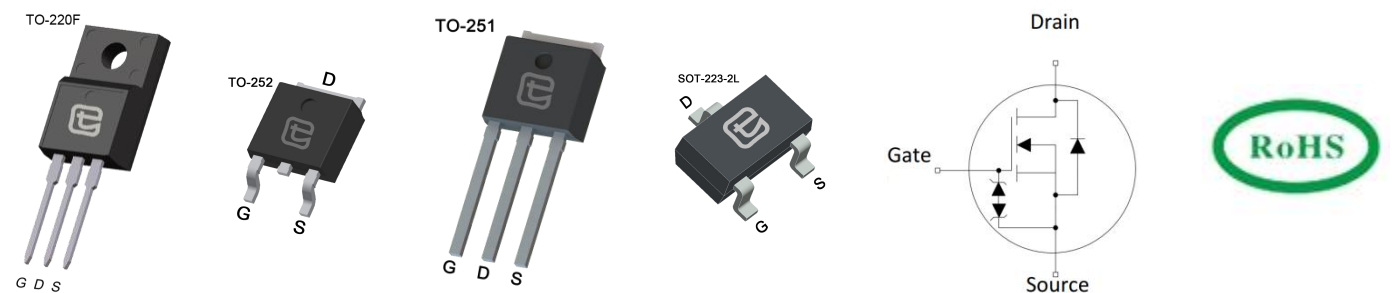
Super-junction power MOSFET is a revolutionary technology for high voltage power MOSFETs, designed according to the SJ principle. The Multi-EPI SJ MOSFET provide an extremely low switching, communication and conduction losses device with highest robustness make especially resonant switching applications more reliable, more efficient, lighter and cooler, designed by Wuxi Unigroup Microelectronics Company.

### FEATURES

- Very low FOM  $R_{DS(on)} \times Q_g$
- 100% avalanche tested
- Easy to use/drive
- RoHS compliant
- Integrated ESD protection diode

### APPLICATIONS

- Switch Mode Power Supply (SMPS)
- Uninterruptible Power Supply (UPS)
- Power Factor Correction (PFC)
- Charger



### Device Marking and Package Information

Device	Package	Marking
TPA65R1K5M	TO-220F	65R1K5M
TPD65R1K5M	TO-252	65R1K5M
TPU65R1K5M	TO-251	65R1K5M
TPY65R1K5MB	SOT-223-2L	65R1K5M

### Key Performance Parameters

Parameter	Value	Unit
$V_{DS} @ T_{j,max}$	650	V
$R_{DS(on),max}$	1.5	$\Omega$
$I_D$	3	A
$Q_{g,typ}$	7	nC
$I_{DM}$	9	A
ESD class (HBM)	1C	



Absolute Maximum Ratings $T_C = 25^\circ\text{C}$ , unless otherwise noted					
Parameter	Symbol	Value			Unit
		TO-220F	TO-252/TO-251	SOT-223-2L	
Drain-Source Voltage ( $V_{GS} = 0V$ )	$V_{DSS}$	650			V
Continuous Drain Current	$I_D$	$T_C = 25^\circ\text{C}$			A
		$T_C = 100^\circ\text{C}$			
Pulsed Drain Current (note1)	$I_{DM}$	9			A
Gate-Source Voltage	$V_{GSS}$	$\pm 20$			V
Single Pulse Avalanche Energy (note2)	$E_{AS}$	26			mJ
Repetitive Avalanche Energy (note2)	$E_{AR}$	0.10			mJ
Avalanche Current	$I_{AR}$	0.6			A
MOSFET dv/dt ruggedness, $V_{DS} = 0 \dots 480V$	dv/dt	50			V/ns
Power Dissipation	$P_D$	25	28	6.2	W
Continuous Body Diode Current	$I_S$	2.5			A
Pulsed Diode Forward Current (note1)	$I_{SM}$	33			
Reverse diode dv/dt (note3)	dv/dt	15			V/ns
Maximum diode commutation speed (note3)	$di_f/dt$	500			A/us
Operating Junction and Storage Temperature Range	$T_J, T_{stg}$	-55~+150			$^\circ\text{C}$

Thermal Resistance					
Parameter	Symbol	Value			Unit
		TO-220F	TO-252/TO-251	SOT-223-2L	
Thermal Resistance, Junction-to-Case	$R_{thJC}$	5	4.4	20	$^\circ\text{C/W}$
Thermal Resistance, Junction-to-Ambient	$R_{thJA}$	80	62	160	



Specifications $T_J = 25^{\circ}\text{C}$ , unless otherwise noted						
Parameter	Symbol	Test Conditions	Value			Unit
			Min.	Typ.	Max.	
<b>Static</b>						
Drain-Source Breakdown Voltage	$V_{(BR)DSS}$	$V_{GS} = 0V, I_D = 250\mu\text{A}$	650	--	--	V
Zero Gate Voltage Drain Current	$I_{DSS}$	$V_{DS} = 650V, V_{GS} = 0V, T_J = 25^{\circ}\text{C}$	--	--	1	$\mu\text{A}$
		$V_{DS} = 650V, V_{GS} = 0V, T_J = 150^{\circ}\text{C}$	--	--	100	
Gate-Source Leakage	$I_{GSS}$	$V_{GS} = \pm 20V$	--	--	$\pm 1$	$\mu\text{A}$
Gate-Source Threshold Voltage	$V_{GS(th)}$	$V_{DS} = V_{GS}, I_D = 250\mu\text{A}$	2.5	--	4.0	V
Drain-Source On-Resistance	$R_{DS(on)}$	$V_{GS} = 10V, I_D = 1.5A$	--	1.3	1.5	$\Omega$
Gate resistance	$R_G$	$f = 1.0\text{MHz}$ open drain	--	5.5	--	$\Omega$
<b>Dynamic</b>						
Input Capacitance	$C_{iss}$	$V_{GS} = 0V,$ $V_{DS} = 100V,$ $f = 1.0\text{MHz}$	--	225	--	$\mu\text{F}$
Output Capacitance	$C_{oss}$		--	10	--	
Reverse Transfer Capacitance	$C_{rss}$		--	0.4	--	
Total Gate Charge	$Q_g$	$V_{DD} = 560V, I_D = 3A,$ $V_{GS} = 10V$	--	7	--	nC
Gate-Source Charge	$Q_{gs}$		--	1.3	--	
Gate-Drain Charge	$Q_{gd}$		--	3.5	--	
Turn-on Delay Time	$t_{d(on)}$	$V_{DD} = 400V, I_D = 3A,$ $R_G = 25\Omega$	--	8.5	--	ns
Turn-on Rise Time	$t_r$		--	7.7	--	
Turn-off Delay Time	$t_{d(off)}$		--	19.0	--	
Turn-off Fall Time	$t_f$		--	16.5	--	
<b>Drain-Source Body Diode Characteristics</b>						
Body Diode Voltage	$V_{SD}$	$T_J = 25^{\circ}\text{C}, I_{SD} = 1.5A, V_{GS} = 0V$	--	0.9	1.2	V
Reverse Recovery Time	$t_{rr}$	$V_R = 400V, I_F = 3A,$ $di_F/dt = 100A/\mu\text{s}$	--	155	--	ns
Reverse Recovery Charge	$Q_{rr}$		--	0.85	--	$\mu\text{C}$
Peak Reverse Recovery Current	$I_{rrm}$		--	11	--	A

**Notes**

1. Repetitive Rating: Pulse width limited by maximum junction temperature
2.  $I_{AS} = 0.6A, V_{DD} = 50V, R_G = 25\Omega$ , Starting  $T_J = 25^{\circ}\text{C}$
3. Identical low side and high side switch with identical  $R_G$



Typical Characteristics  $T_J = 25^\circ\text{C}$ , unless otherwise noted

Figure 1. Output Characteristics

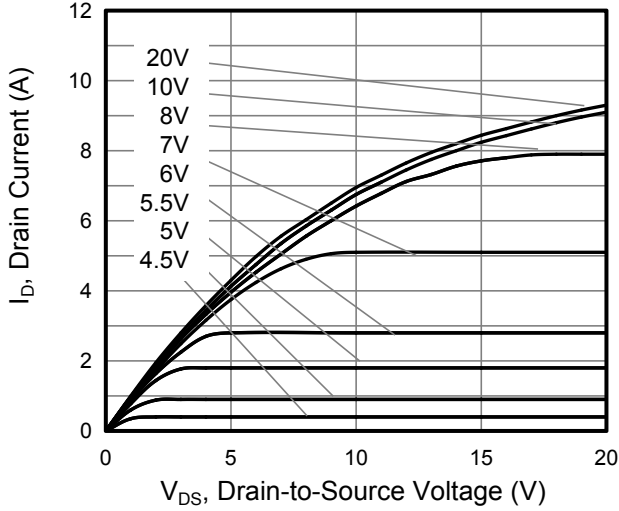


Figure 2. Transfer Characteristics

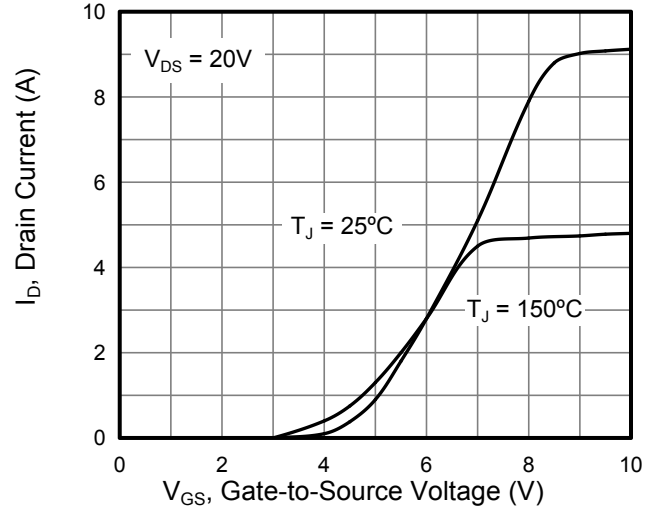


Figure 3. On-Resistance vs. Drain Current

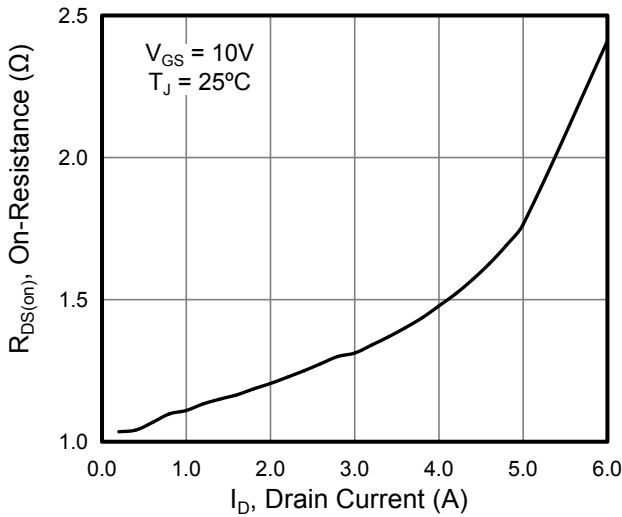


Figure 4. Capacitance

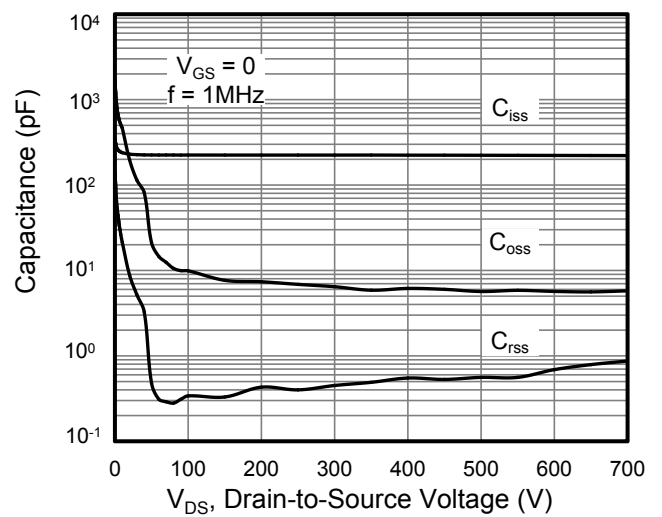


Figure 5. Gate Charge

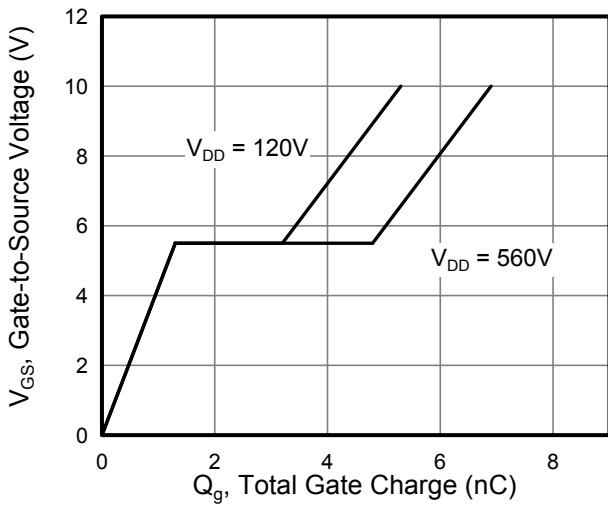
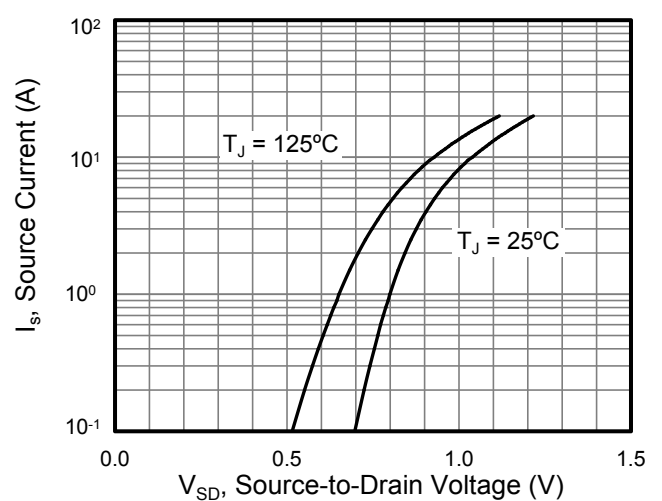


Figure 6. Body Diode Forward Voltage





Typical Characteristics  $T_J = 25^\circ\text{C}$ , unless otherwise noted

Figure 7. On-Resistance vs. Junction Temperature

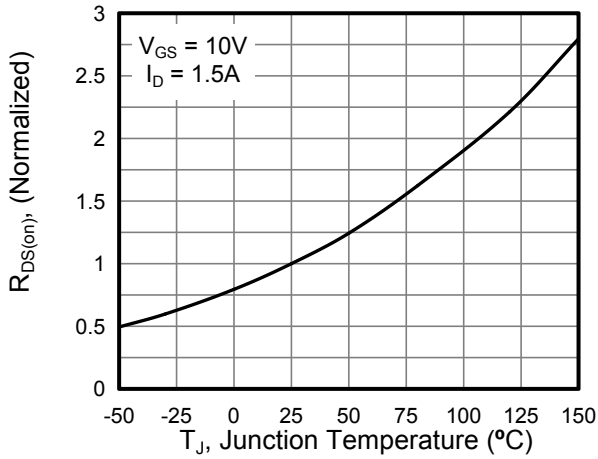


Figure 8. Breakdown voltage vs. Junction Temperature

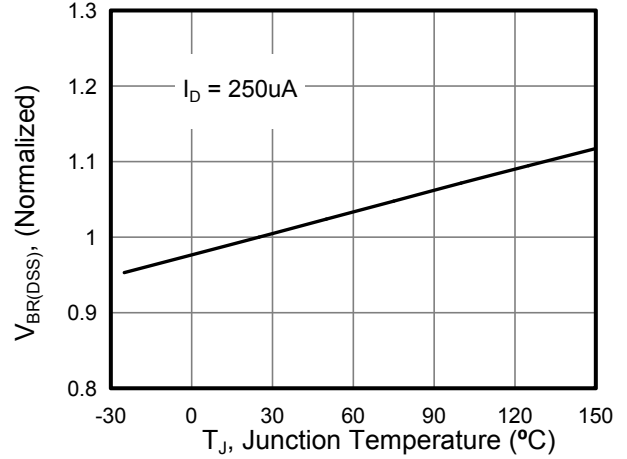


Figure 9. Transient Thermal Impedance for TO-220F

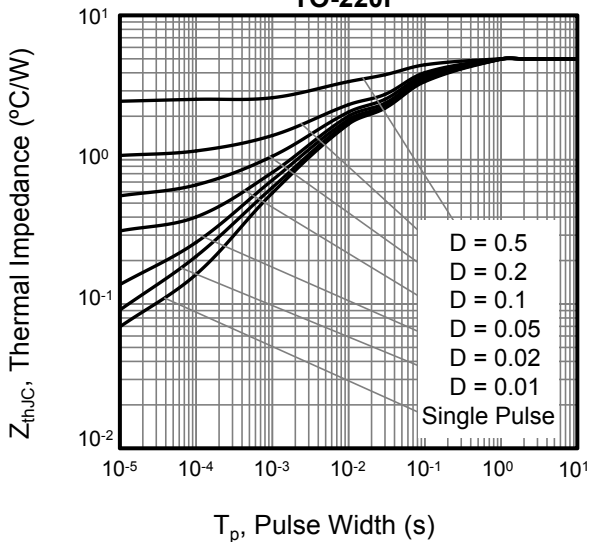


Figure 10. Safe operation area for TO-220F

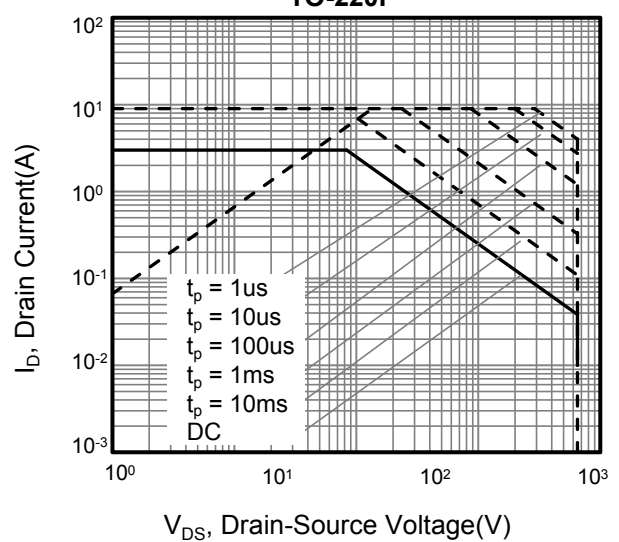


Figure 11. Transient Thermal Impedance for TO-252/TO-251

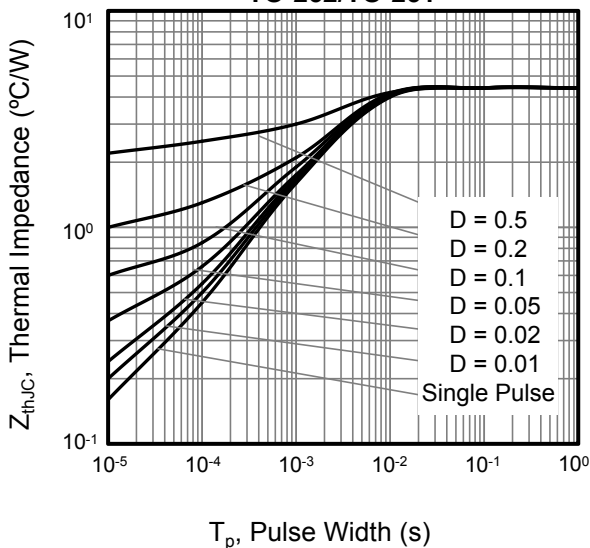
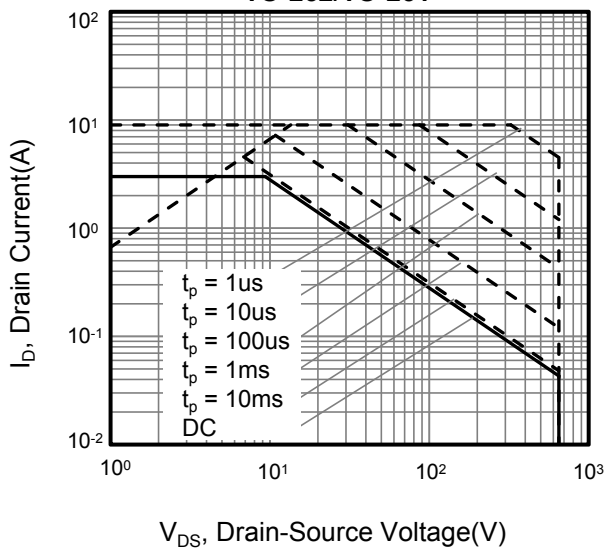


Figure 12. Safe operation area for TO-252/TO-251





Typical Characteristics  $T_j = 25^\circ\text{C}$ , unless otherwise noted

Figure 13. Transient Thermal Impedance for SOT-223-2L

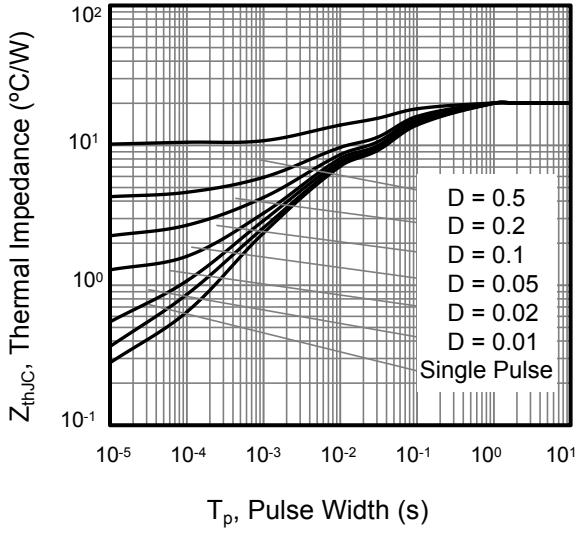


Figure 14. Safe operation area for SOT-223-2L

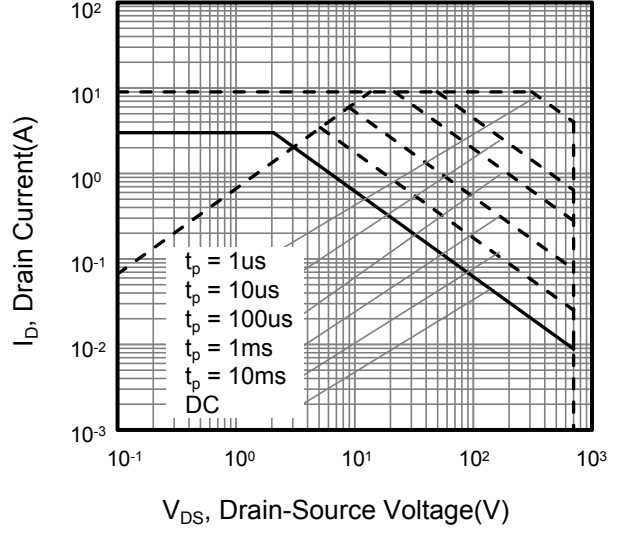




Figure A: Gate Charge Test Circuit and Waveform

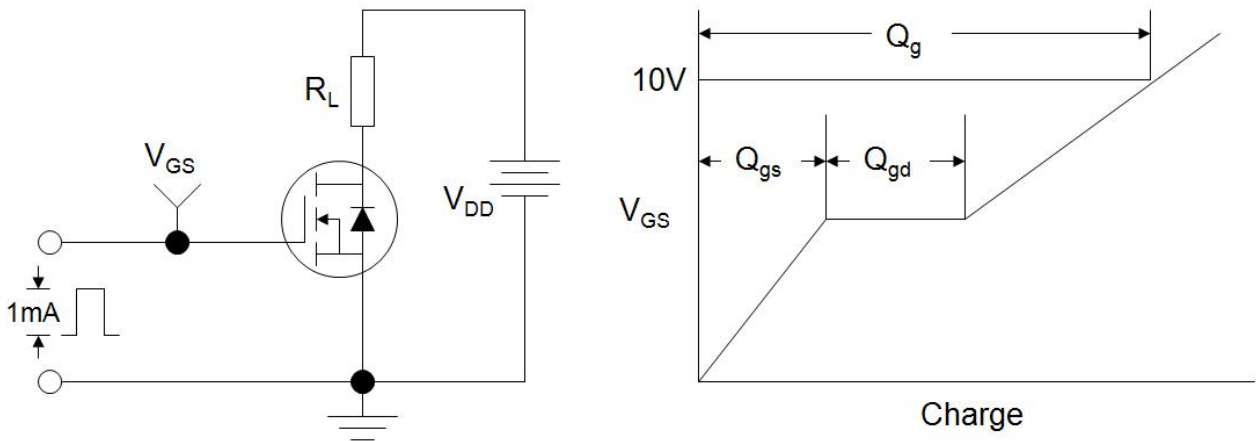


Figure B: Resistive Switching Test Circuit and Waveform

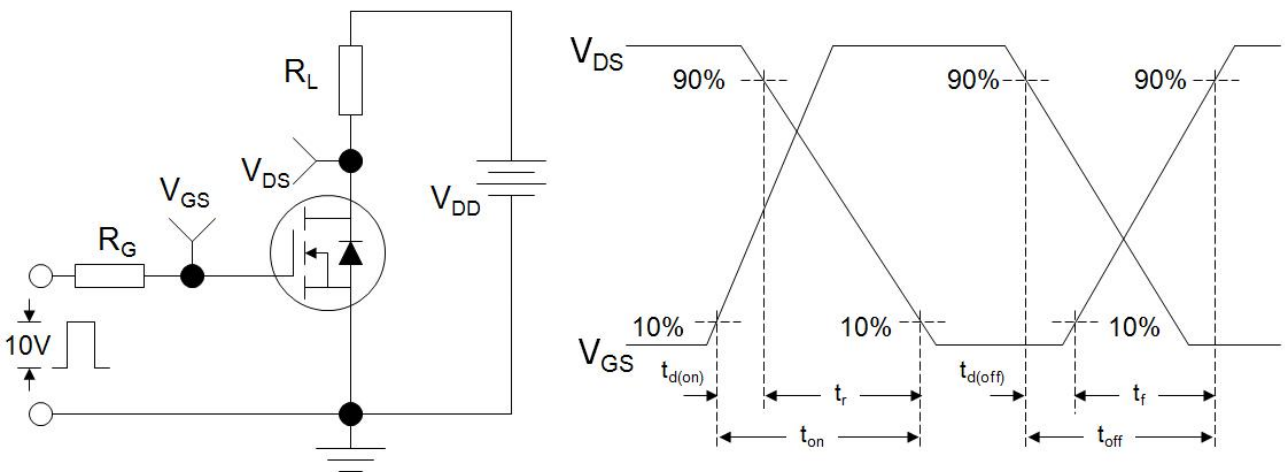
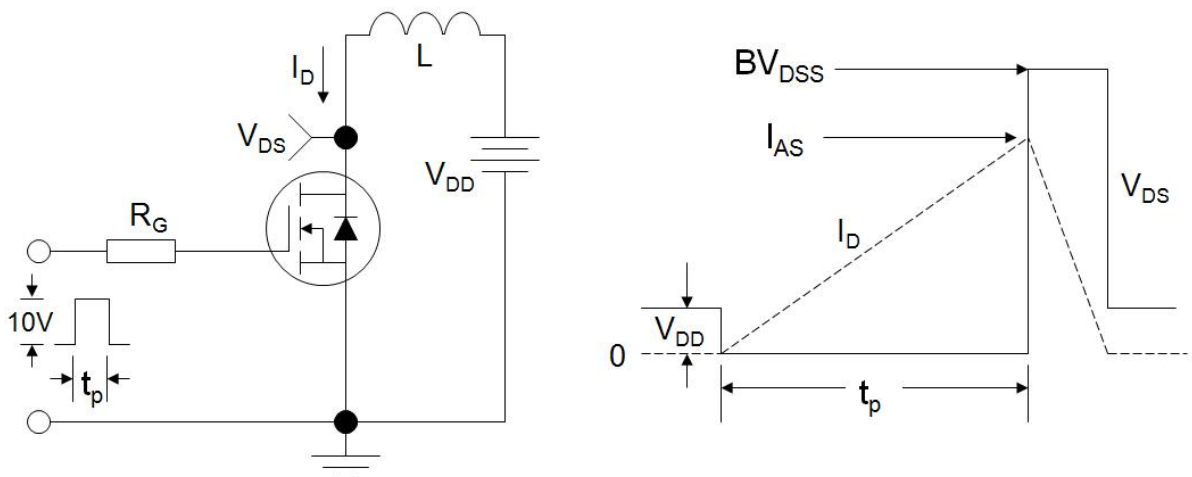
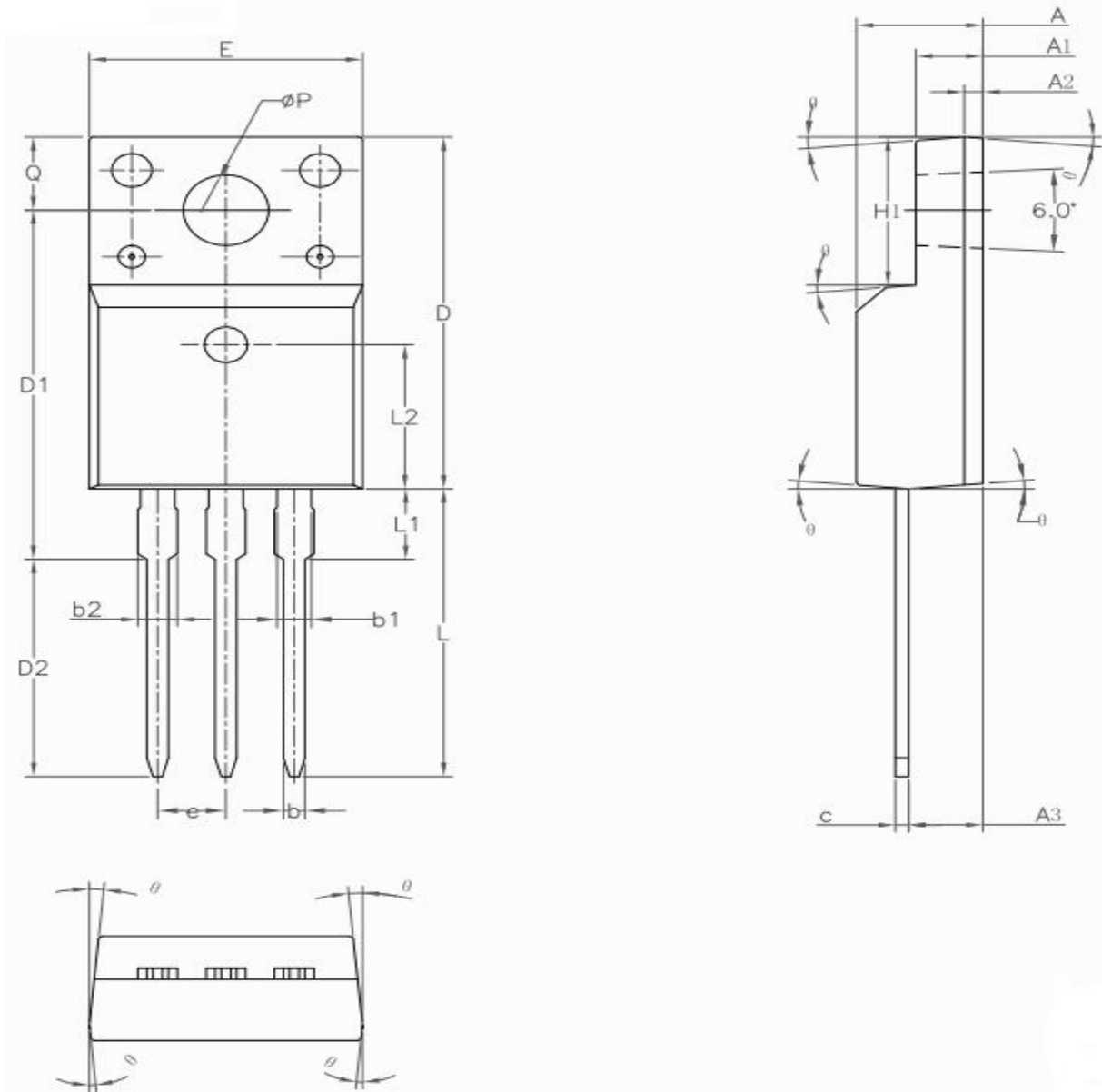


Figure C: Unclamped Inductive Switching Test Circuit and Waveform





### TO-220F



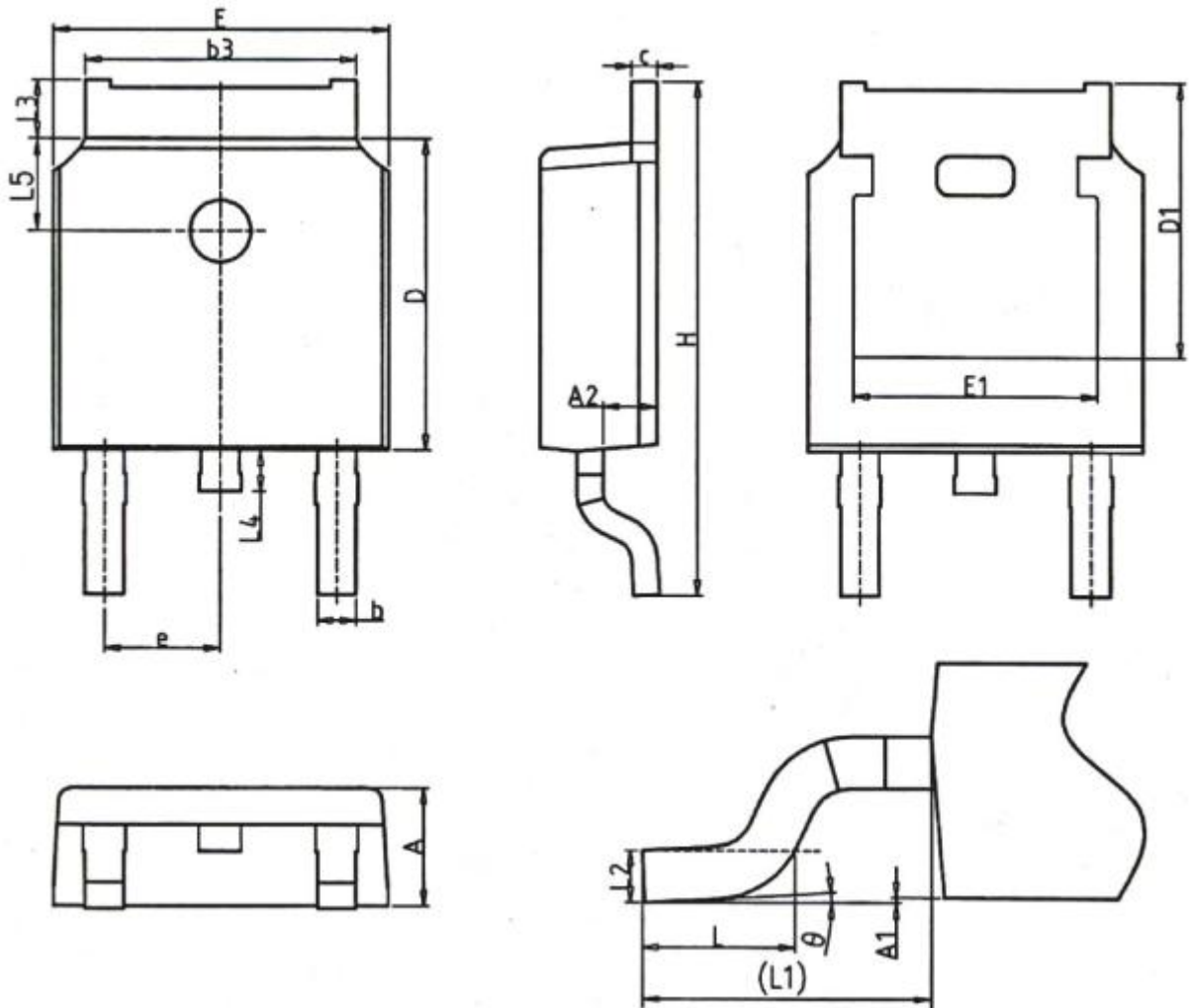
Unit:mm			
Symbol	Min.	Nom	Max.
A	4.5	4.70	4.83
A1	2.34	2.54	2.74
A2	0.70 REF		
b	0.70	-	0.90
b1	1.18	-	1.38
b2	-	-	1.47
c	0.45	0.50	0.60
D	15.67	15.87	16.07
D1	15.55	15.75	15.95
D2	9.60	9.80	10.00

Unit:mm			
Symbol	Min.	Nom	Max.
E	9.96	10.16	10.36
e	2.54 BSC		
H1	6.48	6.68	6.88
L	12.68	12.98	13.28
L1	-	-	3.50
L2	6.50 REF		
$\phi P$	3.08	3.18	3.28
Q	3.20	-	3.40
$\theta 1$	$1^\circ$	$3^\circ$	$5^\circ$





### TO-252

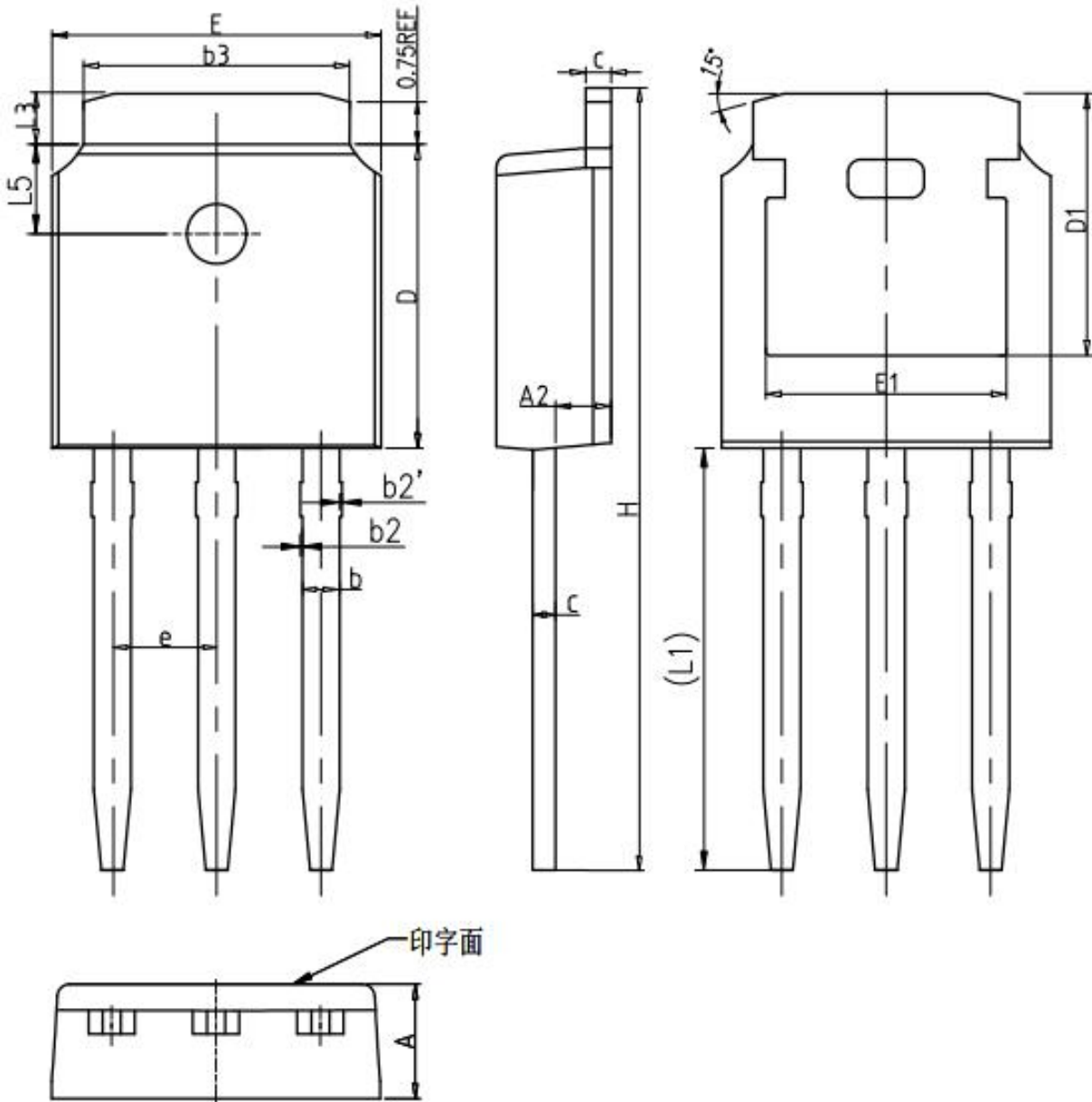


Unit:mm			
Symbol	Min.	Nom	Max.
A	2.20	2.30	2.40
A1	0.00	-	0.20
A2	0.97	1.07	1.17
b	0.68	0.78	0.90
b3	5.20	5.33	5.50
c	0.43	0.53	0.63
D	5.98	6.10	6.22
D1	5.30 REF		
E	6.40	6.60	6.80
E1	4.63	-	-

Unit:mm			
Symbol	Min.	Nom	Max.
e	2.286 BSC		
H	9.40	10.10	10.50
L	1.38	1.50	1.75
L1	2.90 REF		
L2	0.51 BSC		
L3	0.88	-	1.28
L4	-	-	1.00
L5	1.65	1.80	1.95
θ	0°	-	8°



### TO-251

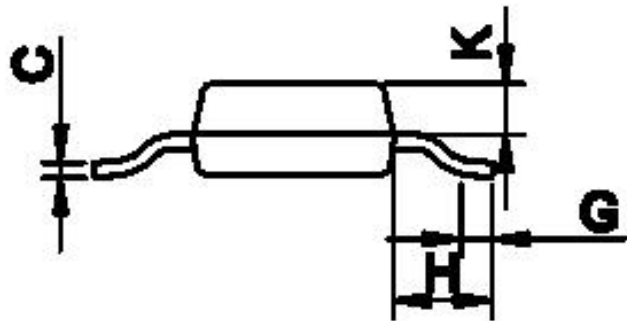
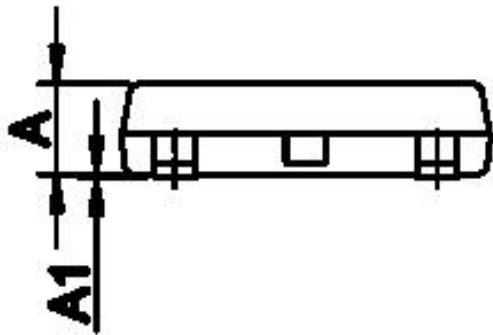
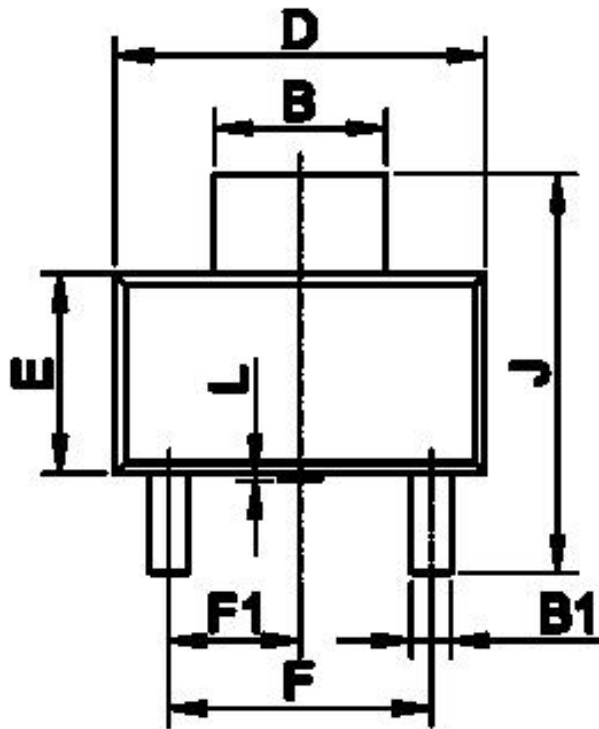


Unit:mm			
Symbol	Min.	Nom	Max.
A	2.20	2.30	2.38
A2	0.97	1.07	1.17
b	0.68	0.78	0.90
b2	0.00	0.04	0.10
b2'	0.00	0.04	0.10
b3	5.20	5.33	5.46
c	0.43	0.53	0.61
D	5.98	6.10	6.22

Unit:mm			
Symbol	Min.	Nom	Max.
D1	5.30 REF		
E	6.40	6.60	6.73
E1	4.63	-	-
e	2.286 BSC		
H	16.22	16.52	16.82
L1	9.15	9.40	9.65
L3	0.88	1.02	1.28
L5	1.65	1.80	1.95



### SOT-223-2L



Unit:mm			
Symbol	Min.	Typ.	Max.
A	1.50	1.60	1.80
A1	0.01	0.06	0.10
B	2.90	3.00	3.10
B1	0.60	0.07	0.80
C	0.22	0.254	0.32
D	6.30	6.50	6.70
E	3.30	3.50	3.70

Unit:mm			
Symbol	Min.	Typ.	Max.
F		4.60	
F1		2.30	
G	0.70	0.90	1.10
H	1.50	1.75	2.00
J	6.70	7.00	7.30
K		0.90	
L	0	0.10	0.20



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