



# 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.

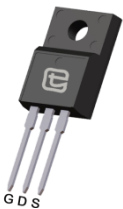
## Features

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

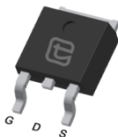
## Applications

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

TO-220F



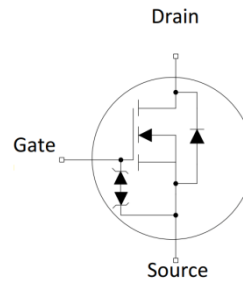
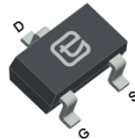
TO-252



TO-251



SOT-223-2L



## 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
$V_{DS} @ T_{j,max}$	700	V
$R_{DS(on),max}$	1.5	$\Omega$
$Q_{g,typ}$	7	nC
$I_D$	3	A
$I_{D,pulse}$	9	A
ESD class (HBM)	1C	
$E_{OSS} @ 400V$	0.79	$\mu J$
Body Diode $di_f/dt$	500	A/ $\mu s$



<b>Absolute Maximum Ratings</b> $T_C = 25^{\circ}\text{C}$ , unless otherwise noted				
Parameter		Symbol	Value	Unit
Continuous Drain Current	$T_C = 25^{\circ}\text{C}$	$I_D$	3	A
	$T_C = 100^{\circ}\text{C}$		1.8	
Pulsed Drain Current	(note1)	$I_{D,pulse}$	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, $V_{DS} = 0 \dots 480\text{V}$		dv/dt	50	V/ns
Power Dissipation For TO-220F		$P_D$	25	W
Power Dissipation For TO-252,TO-251			28	
Power Dissipation For SOT-223-2L			6.2	
Continuous Diode Forward Current		$I_S$	2.5	A
Diode Pulsed Current	(note1)	$I_{S,pulse}$	33	
Reverse Diode dv/dt	(note3)	dv/dt	15	V/ns
Maximum Diode Commutation Speed	(note3)	$di_f/dt$	500	A/ $\mu\text{s}$
Operating Junction and Storage Temperature Range		$T_J, T_{stg}$	-55~+150	$^{\circ}\text{C}$

<b>Thermal Resistance For TO-220F</b>				
Parameter		Symbol	Value	Unit
Thermal Resistance, Junction-to-Case		$R_{thJC}$	5	$^{\circ}\text{C}/\text{W}$
Thermal Resistance, Junction-to-Ambient		$R_{thJA}$	80	

<b>Thermal Resistance For TO-252,TO-251</b>				
Parameter		Symbol	Value	Unit
Thermal Resistance, Junction-to-Case		$R_{thJC}$	4.4	$^{\circ}\text{C}/\text{W}$
Thermal Resistance, Junction-to-Ambient		$R_{thJA}$	160	

<b>Thermal Resistance For SOT-223-2L</b>				
Parameter		Symbol	Value	Unit
Thermal Resistance, Junction-to-Case		$R_{thJC}$	20	$^{\circ}\text{C}/\text{W}$
Thermal Resistance, Junction-to-Ambient		$R_{thJA}$	160	



Electrical Characteristics $T_J = 25^{\circ}\text{C}$ , unless otherwise noted						
Parameter	Symbol	Test Conditions	Value			Unit
			Min.	Typ.	Max.	
<b>Static Characteristics</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 Current	$I_{GSS}$	$V_{GS} = \pm 20V$	--	--	$\pm 1$	$\mu\text{A}$
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-State-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 Characteristics</b>						
Input Capacitance	$C_{iss}$	$V_{GS} = 0V,$ $V_{DS} = 100V,$ $f = 1.0\text{MHz}$	--	225	--	$\text{pF}$
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	--	$\text{nC}$
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	--	$\text{ns}$
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 Forward Voltage	$V_{SD}$	$T_J = 25^{\circ}\text{C}, I_{SD} = 1.5A, V_{GS} = 0V$	--	0.9	1.2	V
Reverse Recovery Time	$t_{rr}$	$V_R = 400V, I_F = 3A,$ $di_F/dt = 100\text{A}/\mu\text{s}$	--	155	--	$\text{ns}$
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

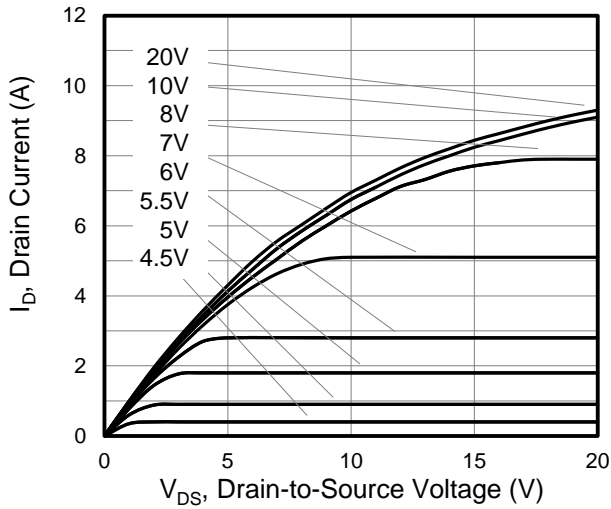


Figure 2. Transfer Characteristics

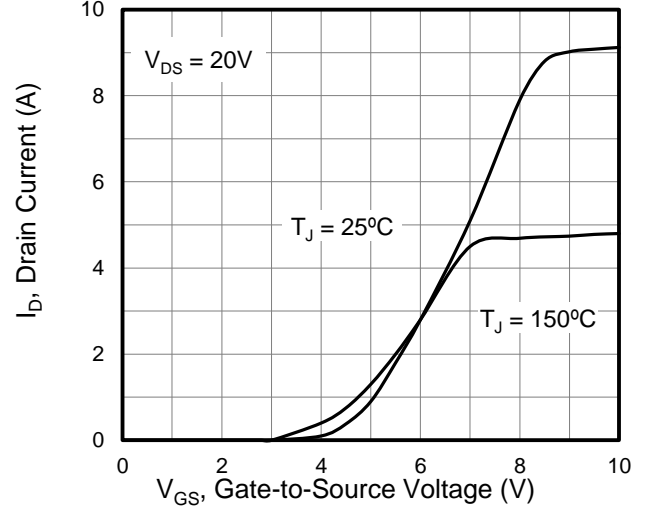


Figure 3. On-Resistance vs. Drain Current

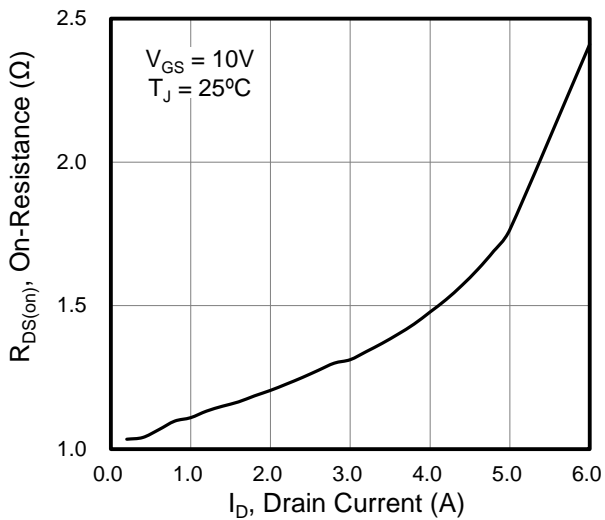


Figure 4. Capacitance

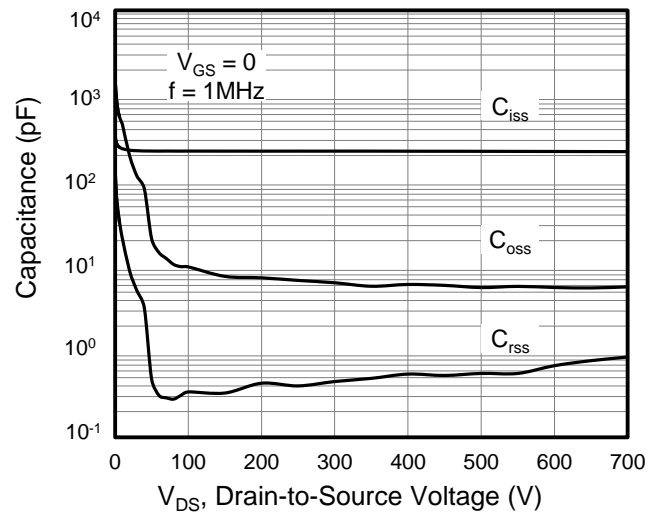


Figure 5. Gate Charge

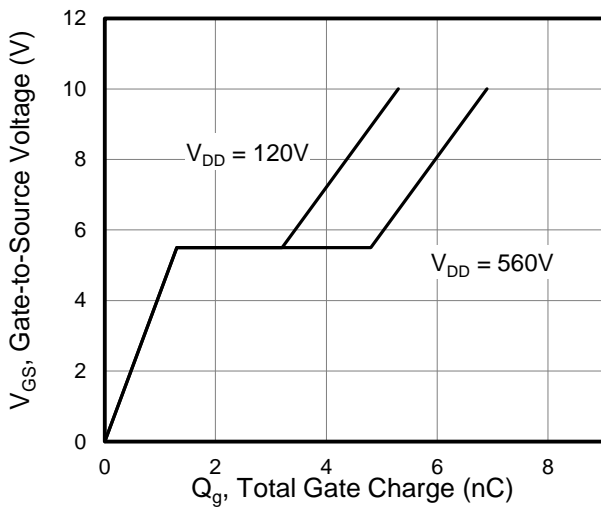
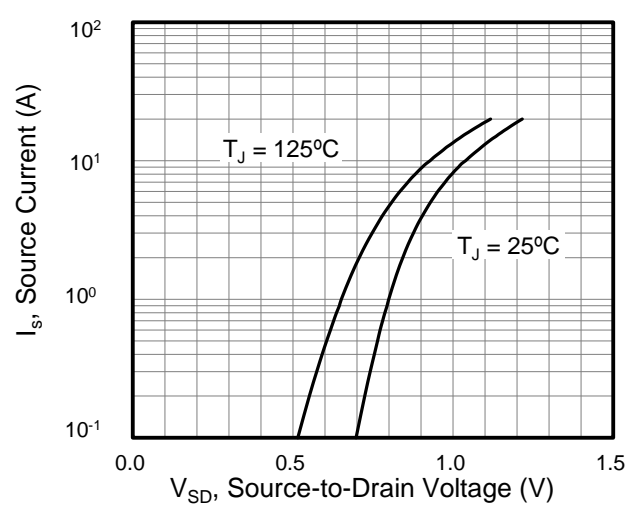


Figure 6. Body Diode Forward Voltage





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

Figure 7. On-Resistance vs. Temperature

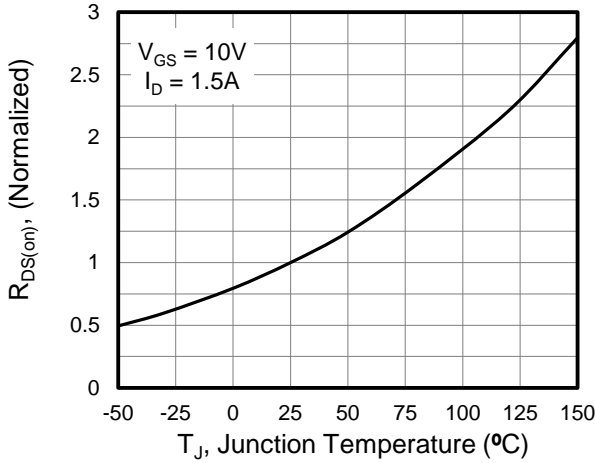


Figure 8. Breakdown voltage vs. Junction Temperature

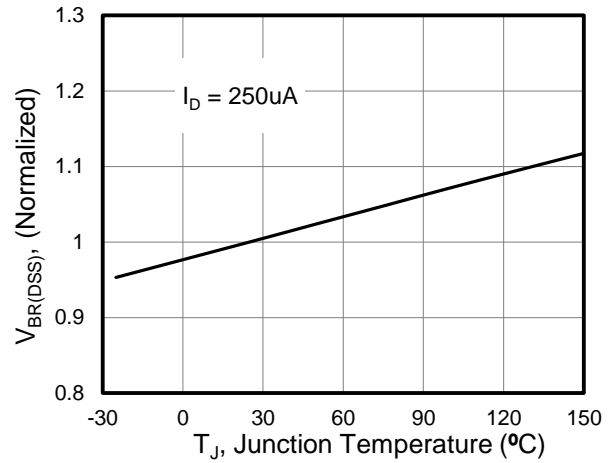


Figure 9. Transient Thermal Impedance For TO-220F

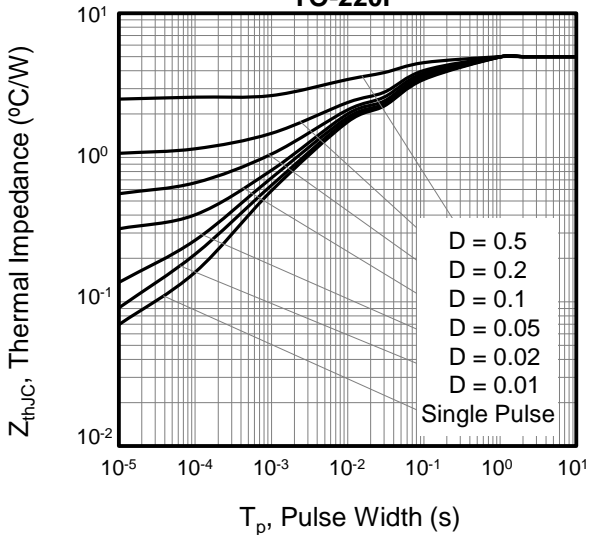


Figure 10. Safe Operation Area For TO-220F

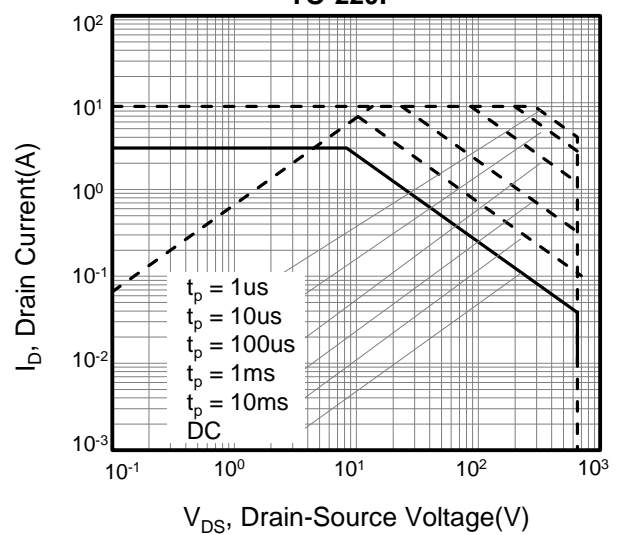


Figure 11. Transient Thermal Impedance For TO-252/TO-251

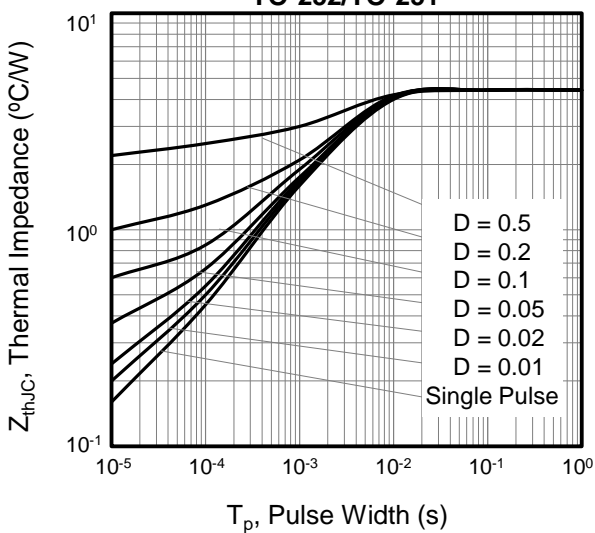
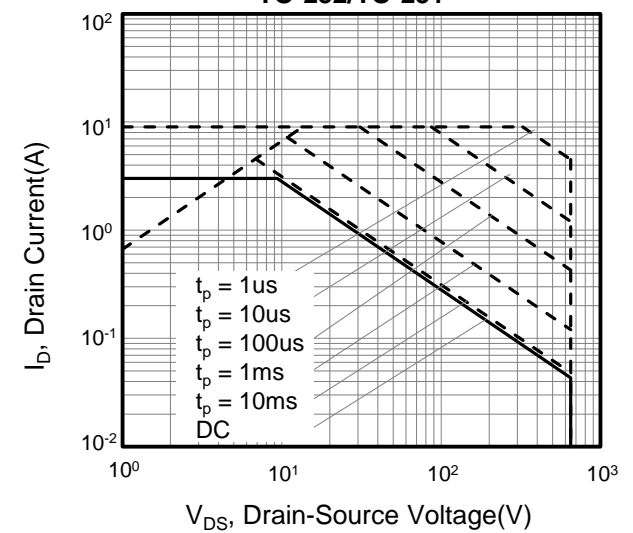


Figure 12. Safe Operation Area For TO-252/TO-251





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

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

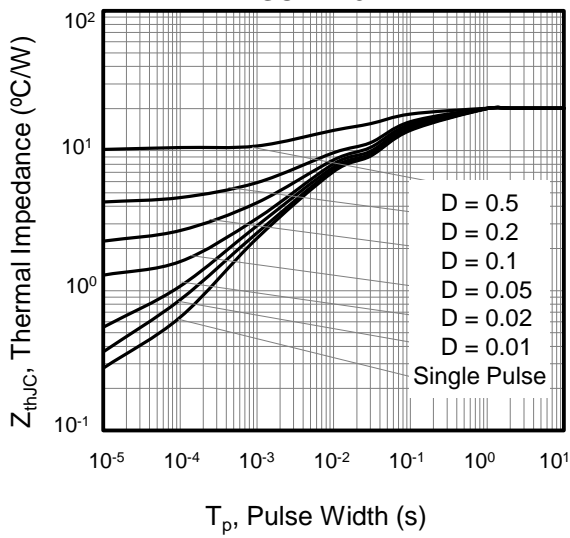


Figure 14. Safe Operation Area For SOT-223-2L

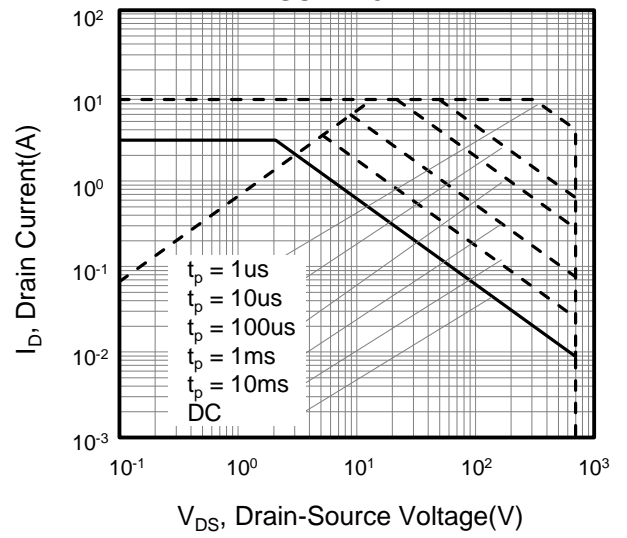


Figure 15. Typ. Coss Stored Energy

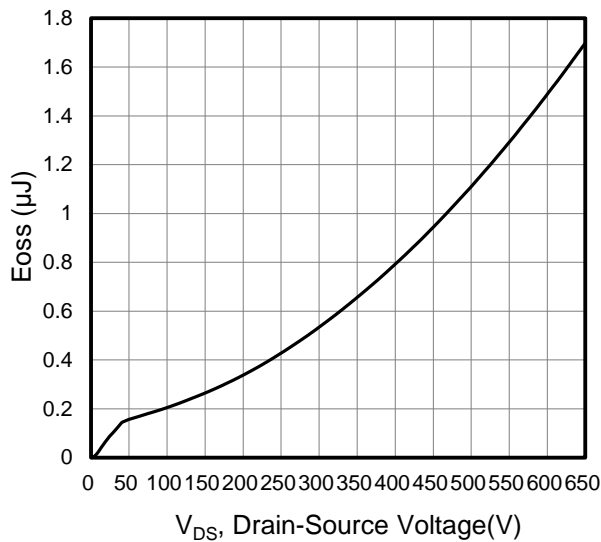




Figure A: Gate Charge Test Circuit and Waveform

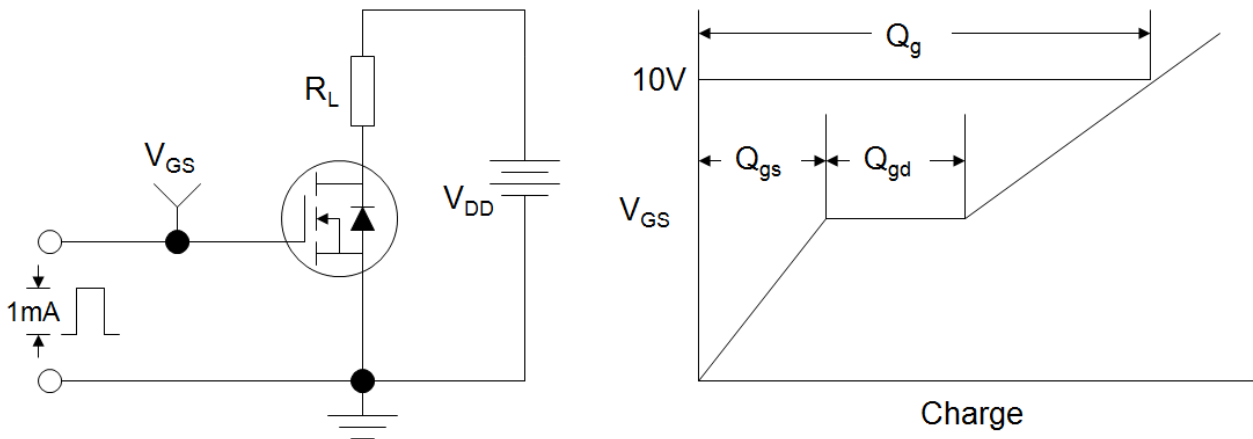


Figure B: Resistive Switching Test Circuit and Waveform

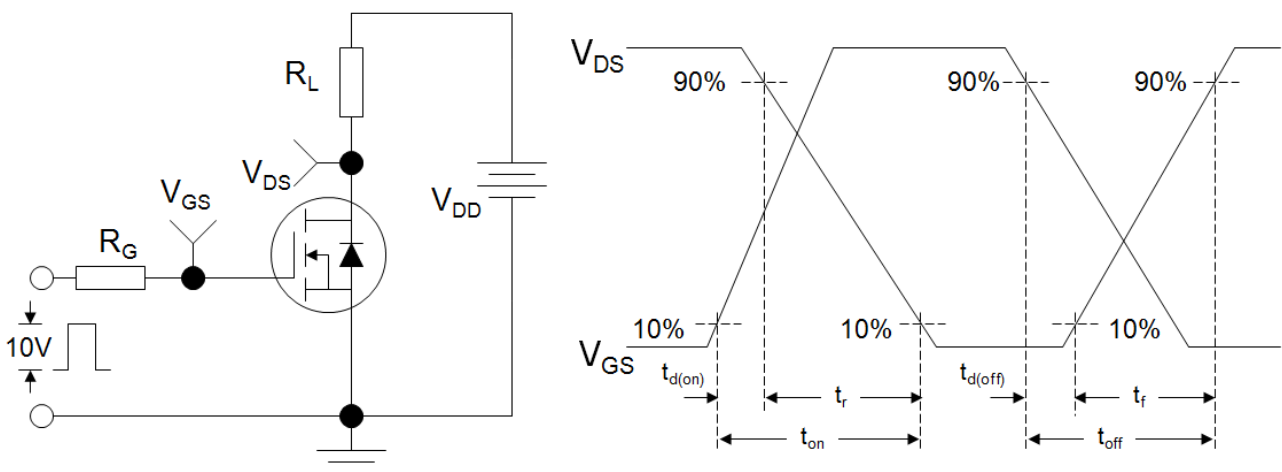
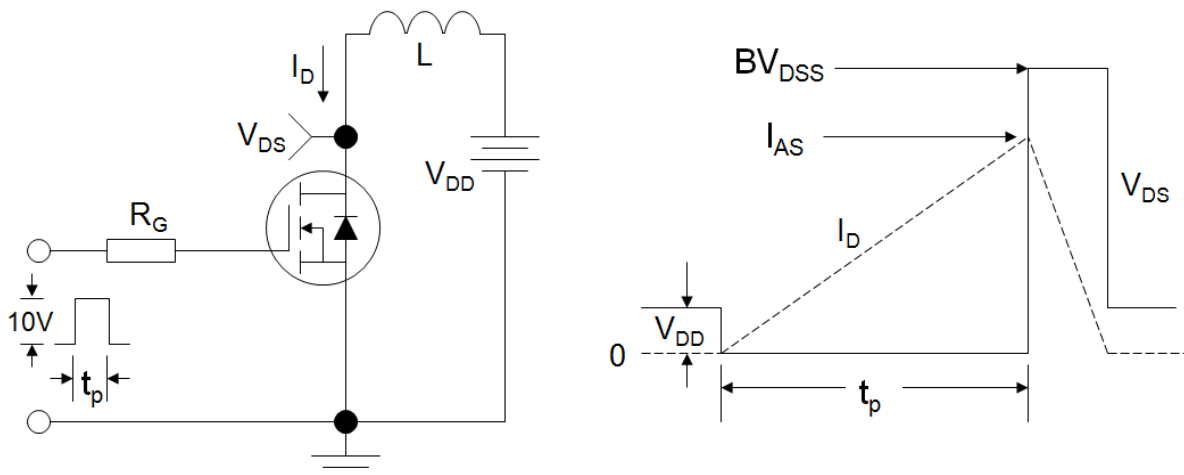
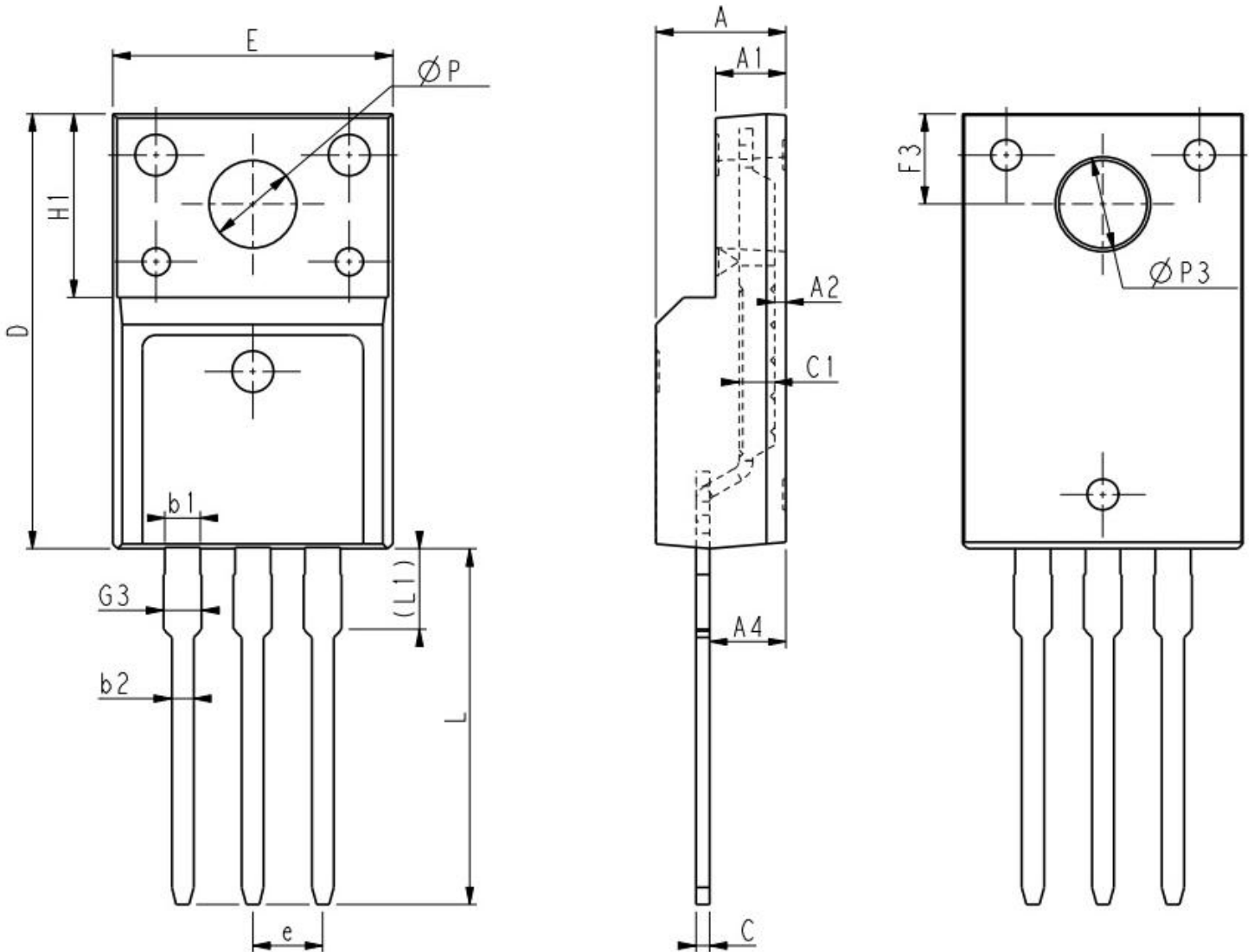


Figure C: Unclamped Inductive Switching Test Circuit and Waveform





### TO-220F



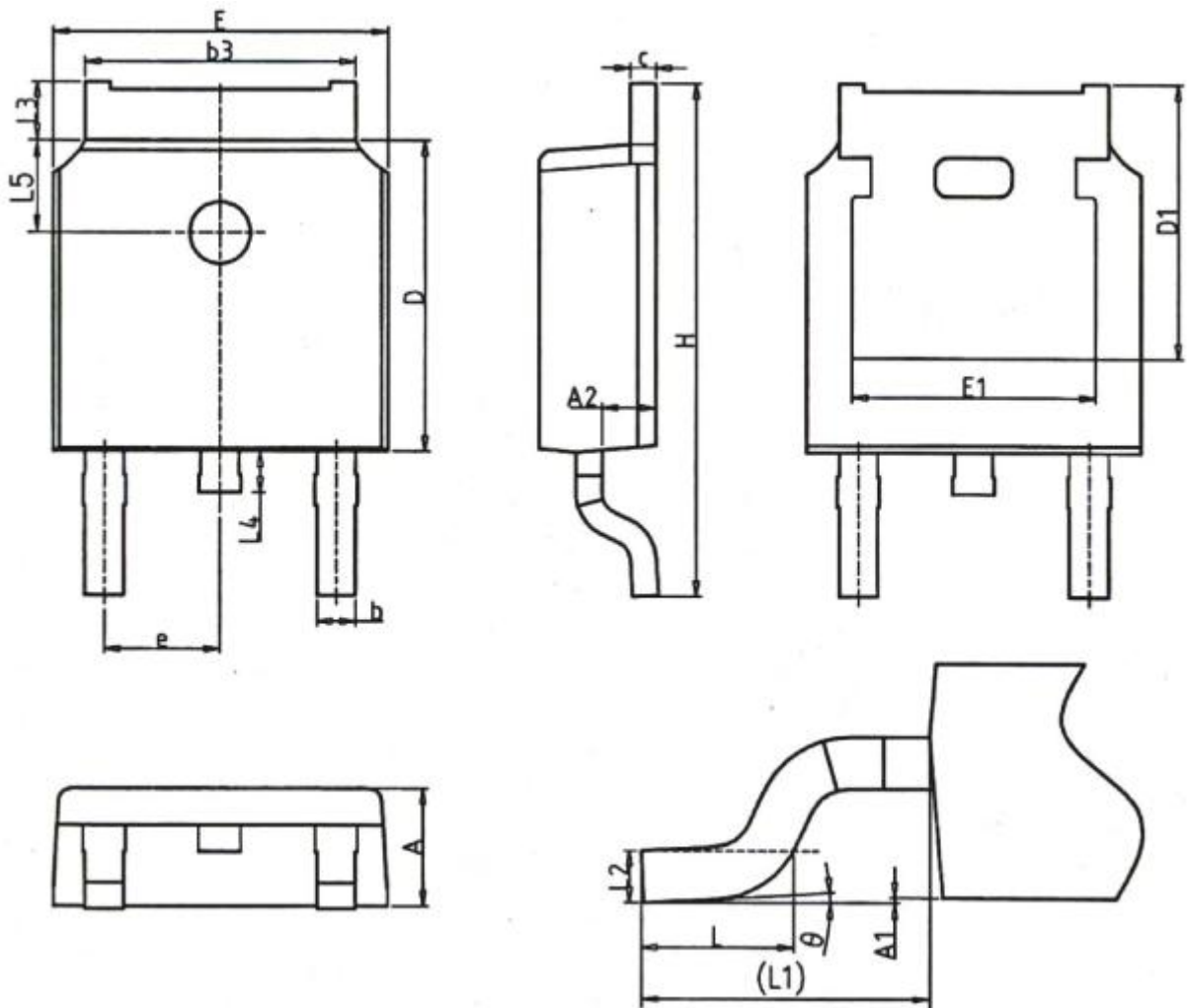
Unit:mm			
Symbol	Min.	Nom	Max.
E	9.96	10.16	10.36
A	4.50	4.70	4.90
A1	2.34	2.54	2.74
A2	0.30	0.45	0.60
A4	2.56	2.76	2.96
c	0.40	0.50	0.65
c1	1.20	1.30	1.35
D	15.57	15.87	16.17
H1	6.70REF		

Unit:mm			
Symbol	Min.	Nom	Max.
e	2.54BSC		
L	12.68	12.98	13.28
L1	2.93	3.03	3.13
$\Phi P$	3.03	3.18	3.38
$\Phi P3$	3.15	3.45	3.65
F3	3.15	3.30	3.45
G3	1.25	1.35	1.55
b1	1.18	1.28	1.43
b2	0.70	0.80	0.95





### TO-252

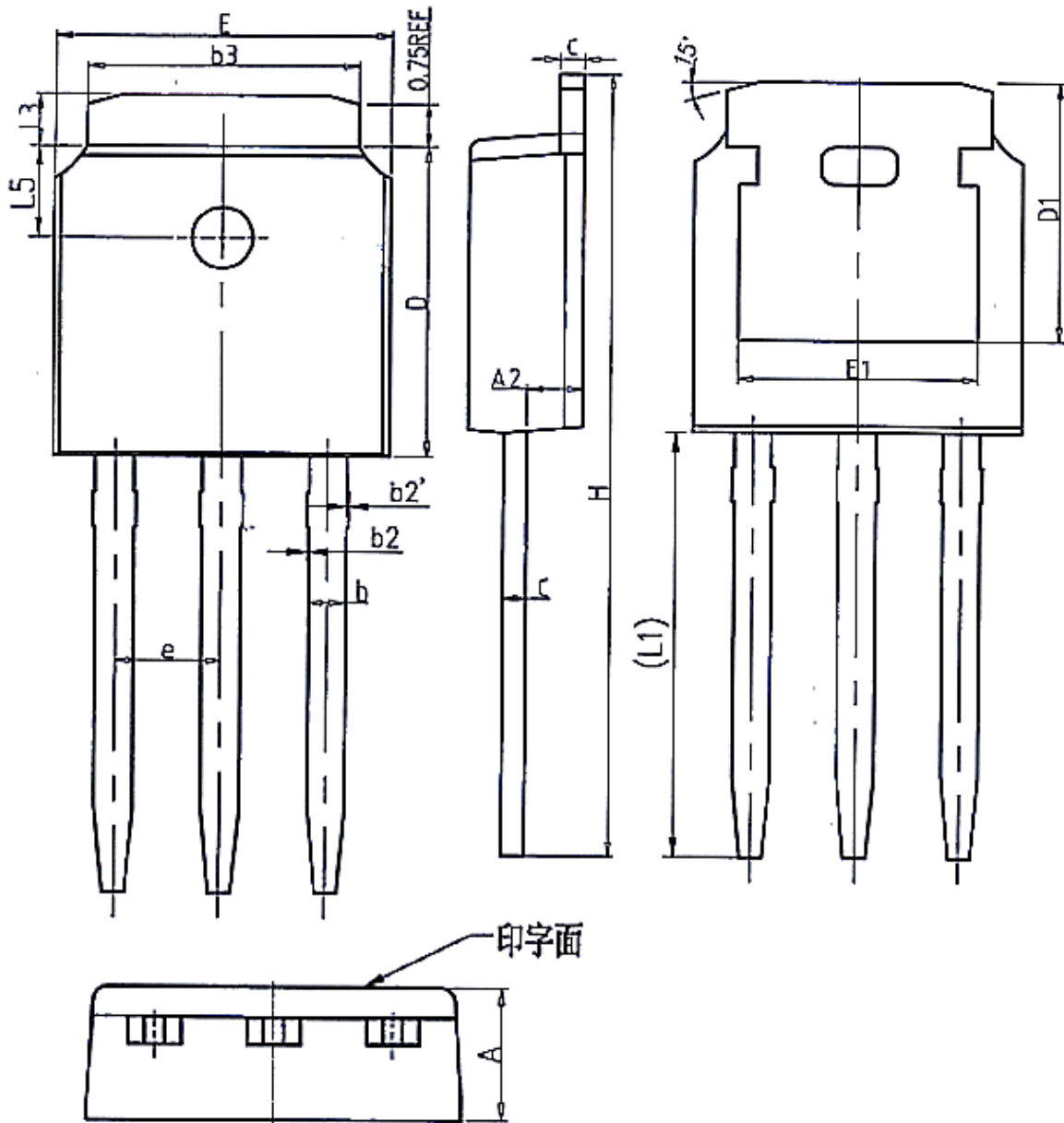


Unit:mm			
Symbol	Min.	Nom	Max.
A	2.20	2.30	2.40
A1	0.00	-	0.20
A2	0.97	1.07	1.17
b	0.68	0.78	0.90
b3	5.20	5.33	5.50
c	0.43	0.53	0.63
D	5.98	6.10	6.22
D1	5.30 REF		
E	6.40	6.60	6.80
E1	4.63	-	-

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

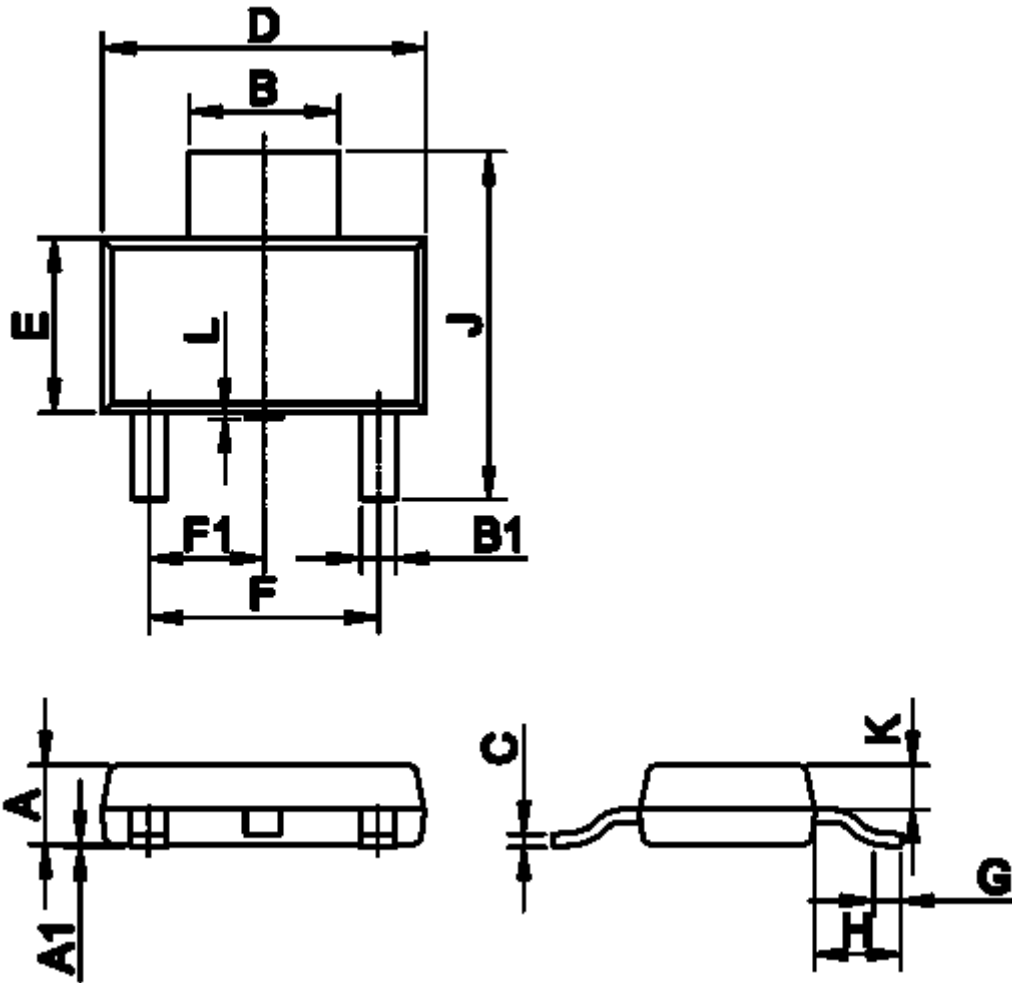


Unit:mm			
Symbol	Min.	Nom	Max.
A	2.20	2.30	2.40
A2	0.97	1.07	1.17
b	0.68	0.78	0.90
b2	0.00	0.04	0.10
b2'	0.00	0.04	0.10
b3	5.20	5.33	5.50
c	0.43	0.53	0.63
D	5.98	6.10	6.22

Unit:mm			
Symbol	Min.	Nom	Max.
D1	5.30 REF		
E	6.40	6.60	6.80
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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