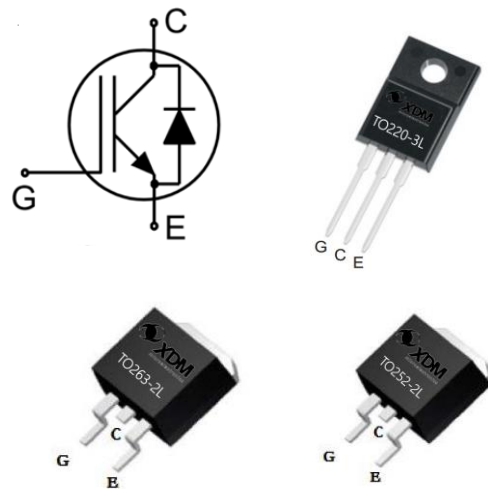


## Trench Field-Stop Technology IGBT

### Features

- 600V, 6A
- $V_{CE(sat)(typ.)} = 1.75V @ V_{GE} = 15V, I_C = 6A$
- Maximum Junction Temperature 175°C
- Pb-free Lead Plating; RoHS Compliant



### Applications

- Solar Converters
- Uninterrupted Power Supply
- Welding Converters
- Mid to High Range Switching Frequency Converters

### Key Performance and Package Parameters

Order codes	$V_{CE}$	$I_C$	$V_{CEsat}, T_{vj}=25^{\circ}C$	$T_{vjmax}$	Marking	Package
XD006H060CX1H3	600V	6A	1.75V	175°C	D6H60CX1H3	TO220F-3L
XD006H060CX1R3	600V	6A	1.75V	175°C	D6H60CX1R3	TO263-2L
XD006H060CX1G3	600V	6A	1.75V	175°C	D6H60CX1G3	TO252-2L

### Absolute Maximum Ratings

Symbol	Parameter	Value	Unit
$V_{CES}$	Collector-Emitter Voltage	600	V
$V_{GES}$	Gate-Emitter Voltage	$\pm 20$	V
$I_C$	Continuous Collector Current ( $T_C = 25^{\circ}C$ )	12	A
	Continuous Collector Current ( $T_C = 100^{\circ}C$ )	6	A
$I_{CM}$	Pulsed Collector Current (Note 1)	18	A
$P_D$	Maximum Power Dissipation ( $T_C = 25^{\circ}C$ ) (Note 2)	89	W
	Maximum Power Dissipation ( $T_C = 100^{\circ}C$ ) (Note 2)	44	W
$T_J$	Operating Junction Temperature Range	-40 to 175	°C
$T_{STG}$	Storage Temperature Range	-55 to 150	°C

### Thermal Data

Symbol	Parameter	Conditioins	Max.	Unit
$R_{\theta JC}$	Thermal Resistance, Junction to Case for IGBT	TO220F-3L	3.6	°C/W
		TO263-2L	1.6	°C/W
		TO252-2L	1.6	°C/W
$R_{\theta JC}$	Thermal Resistance, Junction to Case for Diode	TO220F-3L	3.7	°C/W
		TO263-2L	2.6	°C/W
		TO252-2L	2.2	°C/W

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

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit	
$BV_{CES}$	Collector-Emitter Breakdown Voltage	$V_{GE}=0V, I_C=200\mu A$	600	---	---	V	
$I_{CES}$	Collector-Emitter Leakage Current	$V_{CE}=600V, V_{GE}=0V$	---	---	40	$\mu A$	
$I_{GES}$	Gate Leakage Current, Forward	$V_{GE}=20V, V_{CE}=0V$	---	---	100	nA	
	Gate Leakage Current, Reverse	$V_{GE}=-20V, V_{CE}=0V$	---	---	100	nA	
$V_{GE(th)}$	Gate Threshold Voltage	$V_{GE}=V_{CE}, I_C=200\mu A$	3.2	3.9	4.8	V	
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$V_{GE}=15V, I_C=6A, T_j=25^\circ\text{C}$	---	1.75	2.10	V	
		$V_{GE}=15V, I_C=6A, T_j=150^\circ\text{C}$	---	2.05	---	V	
$Q_G$	Total Gate Charge	$V_{CC}=400V$	---	11.5	---	nC	
$Q_{GE}$	Gate-Emitter Charge	$V_{GE}=15V$	---	3.5	---	nC	
$Q_{GC}$	Gate-Collector Charge	$I_C=6A$	---	3.5	---	nC	
$t_{d(on)}$	Turn-on Delay Time	$V_{CC}=400V$ $V_{GE}=\pm 15V$ $I_C=6A$ $R_G=10\Omega$ Inductive Load $T_C=25^\circ\text{C}$	---	12	---	ns	
$t_r$	Turn-on Rise Time		---	6	---	ns	
$t_{d(off)}$	Turn-off Delay Time		---	14	---	ns	
$t_f$	Turn-off Fall Time		---	154	---	ns	
$E_{on}$	Turn-on Switching Loss		---	91	---	$\mu J$	
$E_{off}$	Turn-off Switching Loss		---	95	---	$\mu J$	
$E_{ts}$	Total Switching Loss		---	186	---	$\mu J$	
$t_{d(on)}$	Turn-on Delay Time		$V_{CC}=400V$ $V_{GE}=\pm 15V$ $I_C=6A$ $R_G=10\Omega$ Inductive Load $T_C=150^\circ\text{C}$		3		ns
$t_r$	Turn-on Rise Time				6		ns
$t_{d(off)}$	Turn-off Delay Time				18		ns
$t_f$	Turn-off Fall Time			214		ns	
$E_{on}$	Turn-on Switching Loss			48		$\mu J$	
$E_{off}$	Turn-off Switching Loss			211		$\mu J$	
$E_{ts}$	Total Switching Loss			259		$\mu J$	
$C_{ies}$	Input Capacitance	$V_{CE}=25V$		---	313	---	pF
$C_{oes}$	Output Capacitance	$V_{GE}=0V$	---	34	---	pF	
$C_{res}$	Reverse Transfer Capacitance	$f=1\text{MHz}$	---	5	---	pF	
SCSOA	Short Circuit Safe Operation Area	$V_{GE}=15V, V_{CC}\leq 400V,$ $T_{J,start}\leq 25^\circ\text{C}$	9	---	---	$\mu s$	

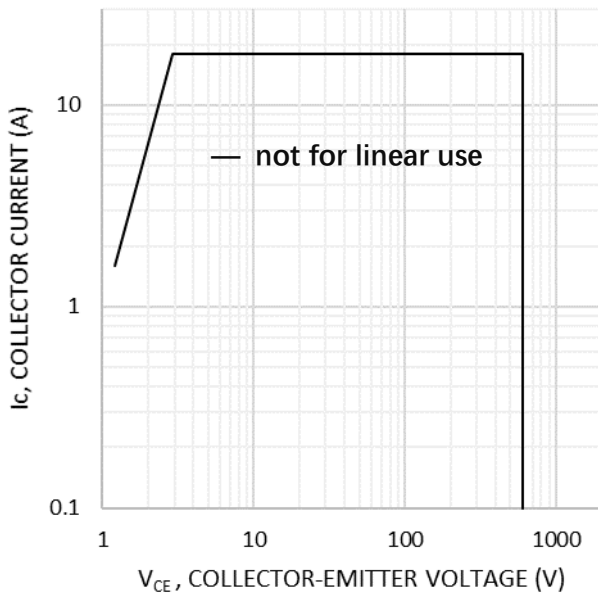
**Diode Characteristics** (  $T_C=25^{\circ}C$  unless otherwise noted)

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
$V_F$	Diode Forward Voltage	$I_F=6A, T_j=25^{\circ}C$	---	1.65	2.10	V
		$I_F=6A, T_j=150^{\circ}C$	---	1.48		V
$t_{rr}$	Diode Reverse Recovery Time	$V_R=400V$	---	46.5	---	ns
$I_{rr}$	Diode peak Reverse Recovery Current	$I_F=6A$ $di_F/dt=20A/us$	---	0.35	---	A
$Q_{rr}$	Diode Reverse Recovery Charge	$T_C=25^{\circ}C$	---	8.5	---	nC
$t_{rr}$	Diode Reverse Recovery Time	$V_R=400V$	---	230	---	ns
$I_{rr}$	Diode peak Reverse Recovery Current	$I_F=6A$ $di_F/dt=20A/us$	---	1	---	A
$Q_{rr}$	Diode Reverse Recovery Charge	$T_C=150^{\circ}C$	---	115	---	uC

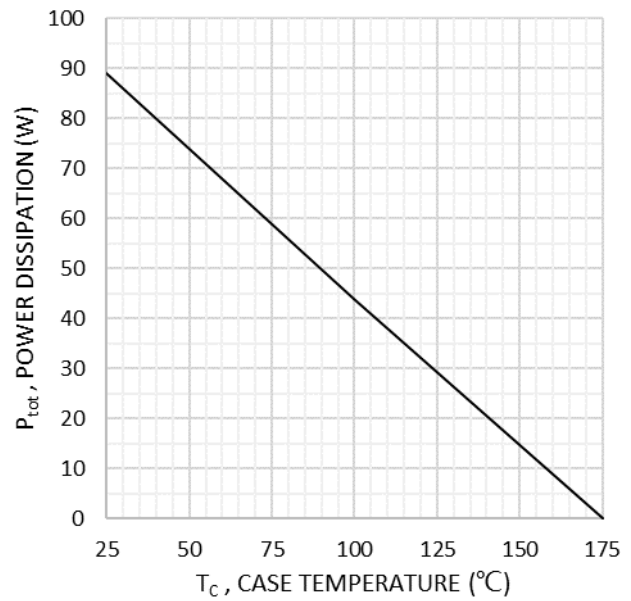
Note1: Repetitive rating, pulse width limited by maximum junction temperature

Note2: For TO-263

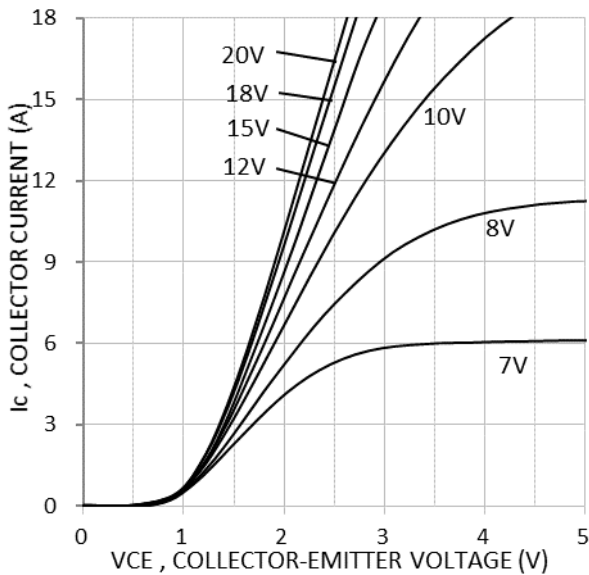
## Typical Characteristics



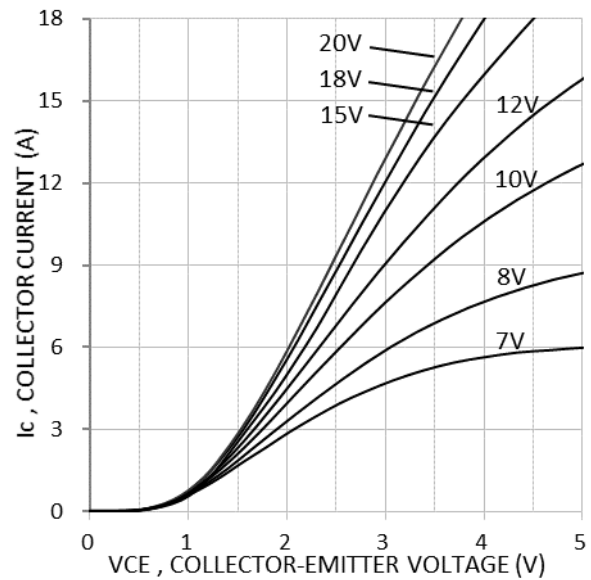
**Fig. 1 Forward bias safe operating area (D=0,  $T_C=25^\circ\text{C}$ ,  $T_{vj}\leq 175^\circ\text{C}$ ;  $V_{GE}=15\text{V}$ )**



**Fig. 2 Power dissipation as a function of case temperature ( $T_{vj}\leq 175^\circ\text{C}$ )**



**Fig. 3 Typical output characteristic ( $T_{vj}=25^\circ\text{C}$ )**



**Fig. 4 Typical output characteristic ( $T_{vj}=150^\circ\text{C}$ )**

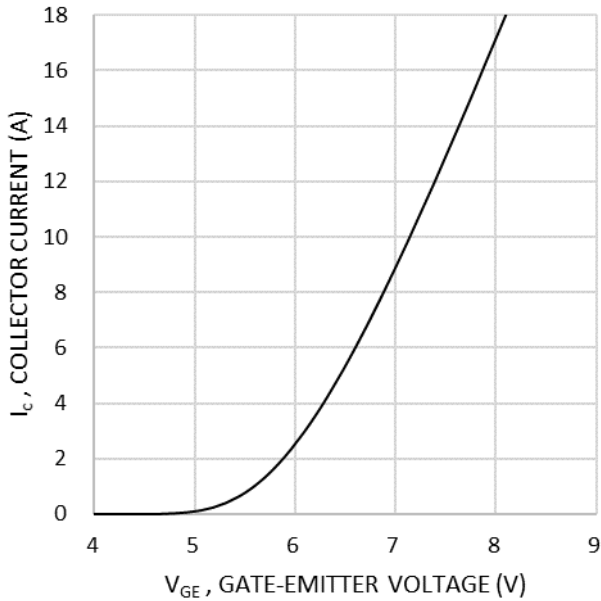


Fig. 5 Typical transfer characteristics ( $V_{CE}=10V$ )

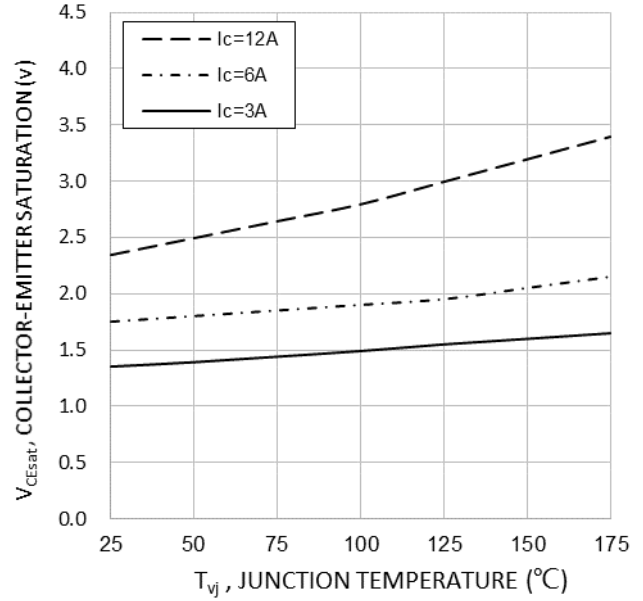


Fig. 6 Typical collector-emitter saturation voltage as a function of junction temperature ( $V_{GE}=15V$ )

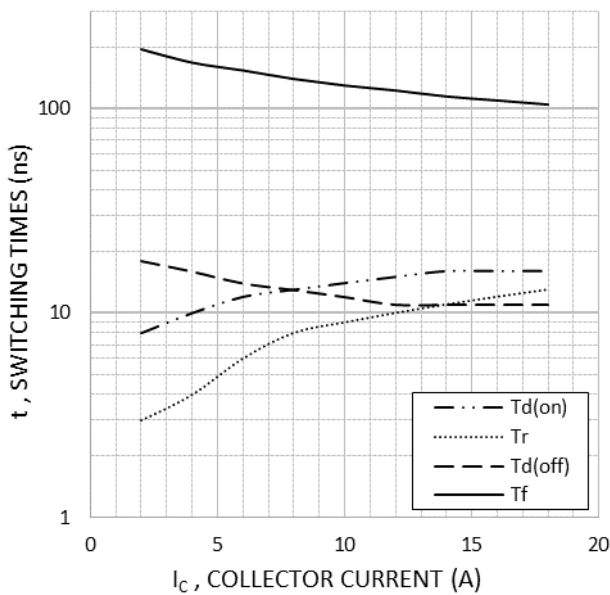


Fig. 7 Typical switching times as a function of collector current (inductive load,  $T_{yj}=25^\circ C$ ,  $V_{CE}=400V$ ,  $V_{GE}=15/0V$ ,  $r_G=10\Omega$ )

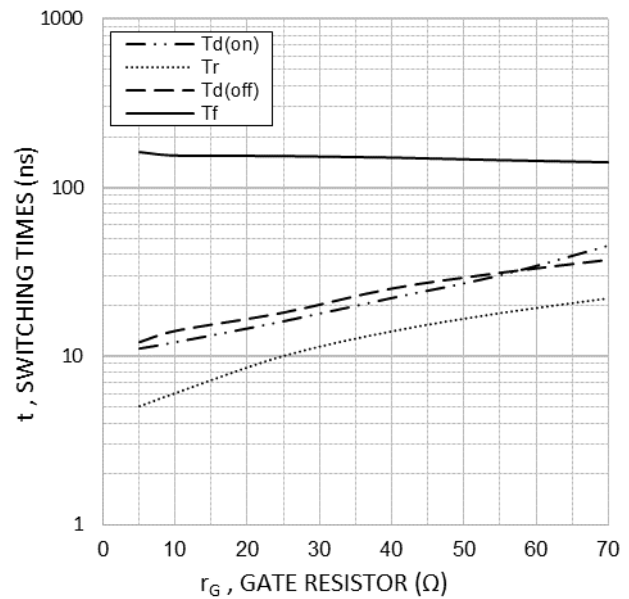
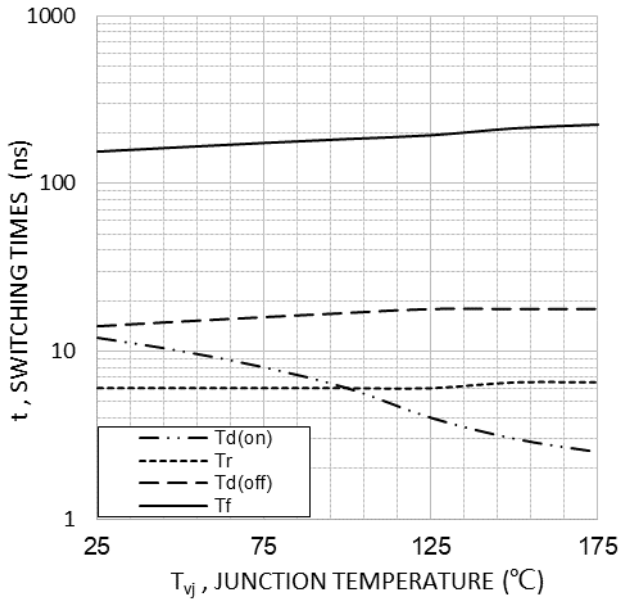
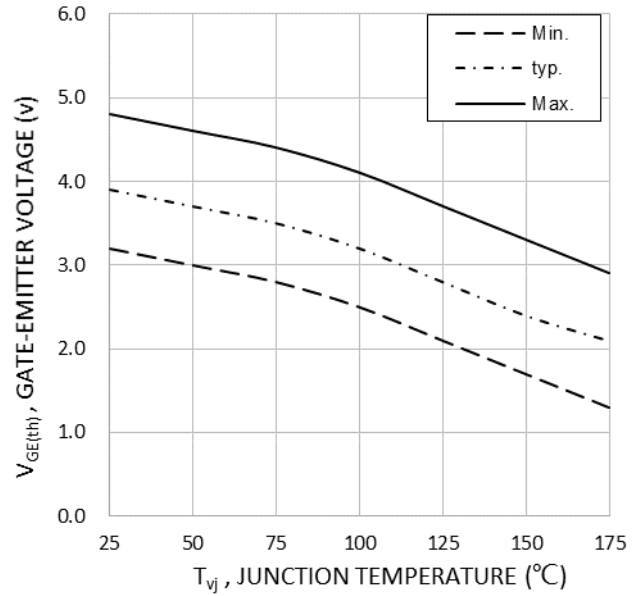


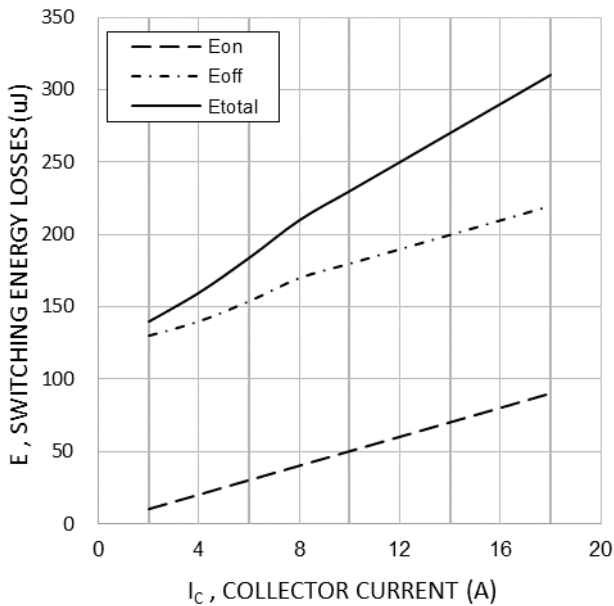
Fig. 8 Typical switching times as a function of gate resistor (inductive load,  $T_{yj}=25^\circ C$ ,  $V_{CE}=400V$ ,  $V_{GE}=15/0V$ ,  $I_C=6A$ )



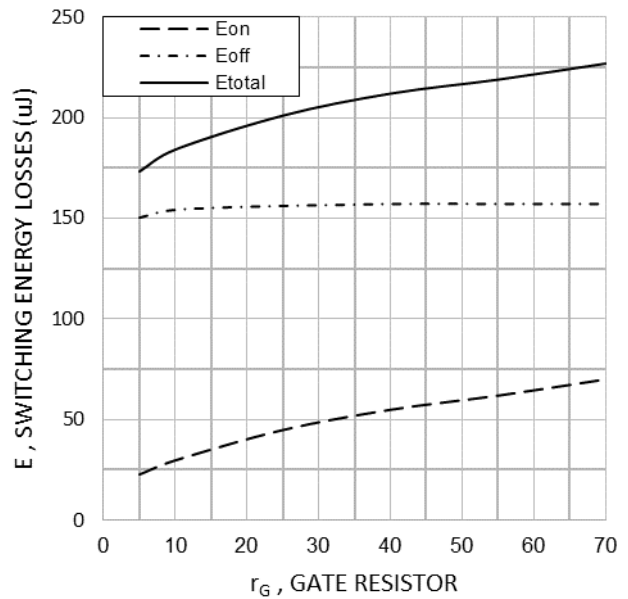
**Fig. 9 Typical switching times as a function of junction temperature (inductive load,  $V_{CE}=400V$ ,  $V_{GE}=15/0V$ ,  $I_C=6A$ ,  $r_G=10\Omega$ )**



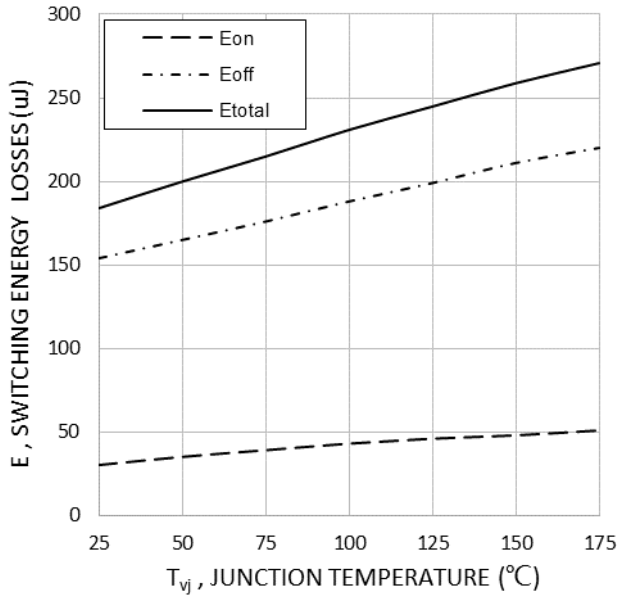
**Fig. 10 Gate-emitter threshold voltage as a function of junction temperature ( $I_C=0.2mA$ )**



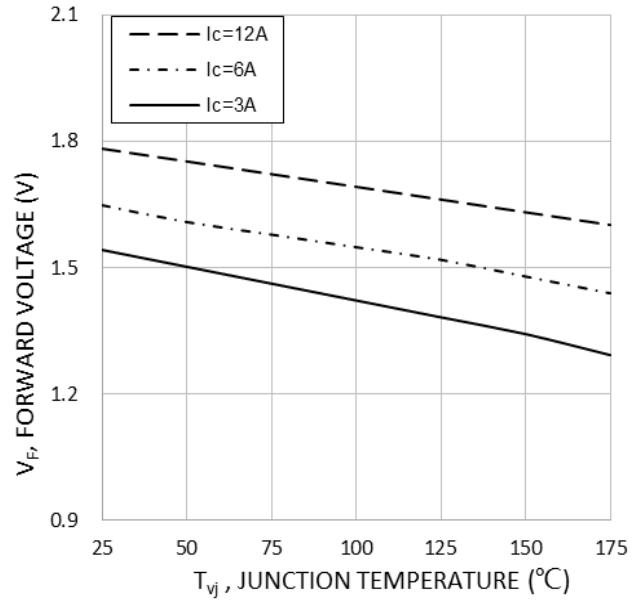
**Fig. 11 Typical switching energy losses as a function of collector current (inductive load,  $T_{j}=25^{\circ}C$ ,  $V_{CE}=400V$ ,  $V_{GE}=15/0V$ ,  $r_G=10\Omega$ )**



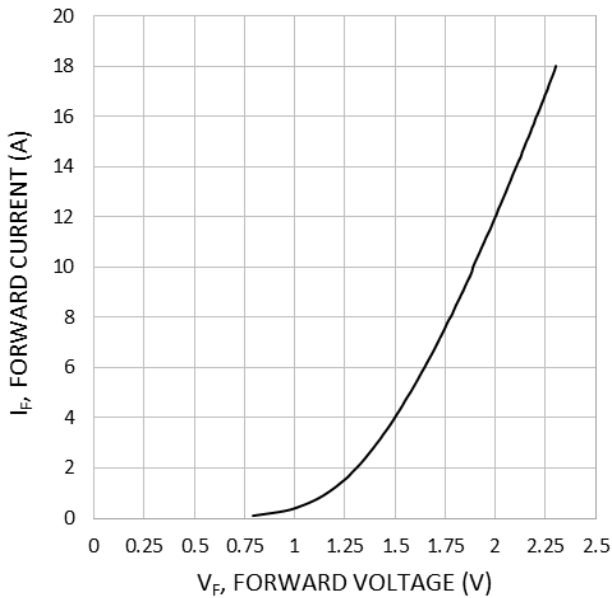
**Fig. 12 Typical switching energy losses as a function of gate resistor (inductive load,  $T_{j}=25^{\circ}C$ ,  $V_{CE}=400V$ ,  $V_{GE}=15/0V$ ,  $I_C=6A$ )**



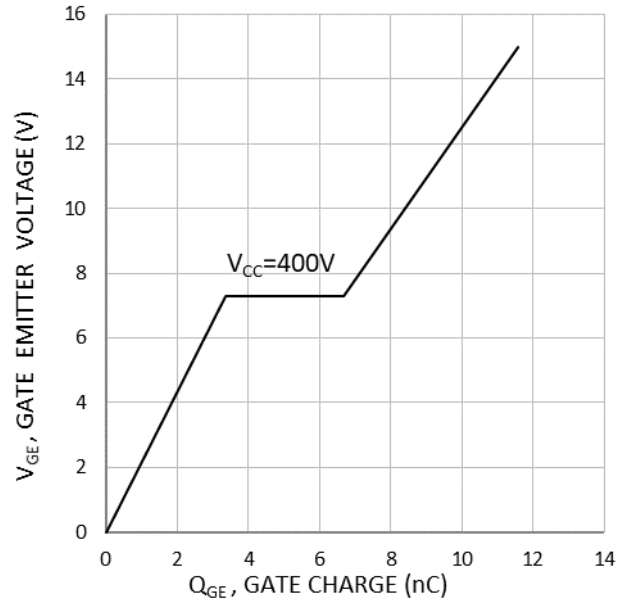
**Fig. 13 Typical switching energy losses as a function of junction temperature (inductive load,  $V_{CE}=600V$ ,  $V_{GE}=15/0V$ ,  $I_C=50A$ ,  $r_G=10\Omega$ )**



**Fig. 14 Typical diode forward voltage as a function of junction temperature**



**Fig. 15 Typical diode forward current as a function of forward voltage**



**Fig. 16 Typical gate charge ( $I_C=6A$ )**

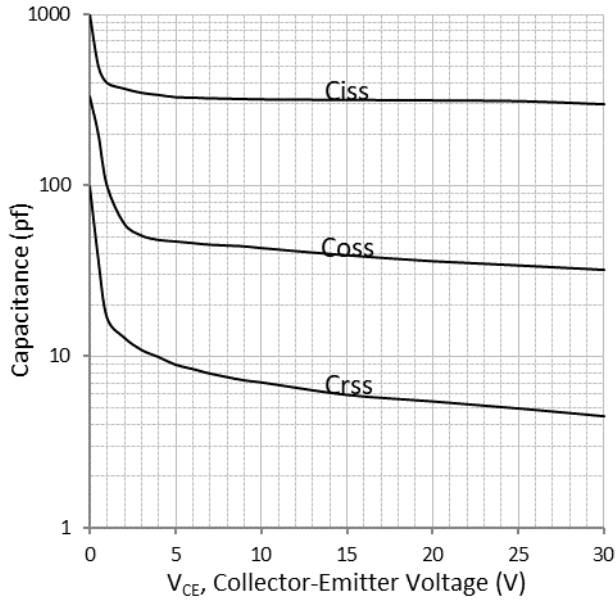


Fig. 17 Typical capacitance as a function of collector-emitter voltage (V<sub>GE</sub>=0V, f=1MHz)

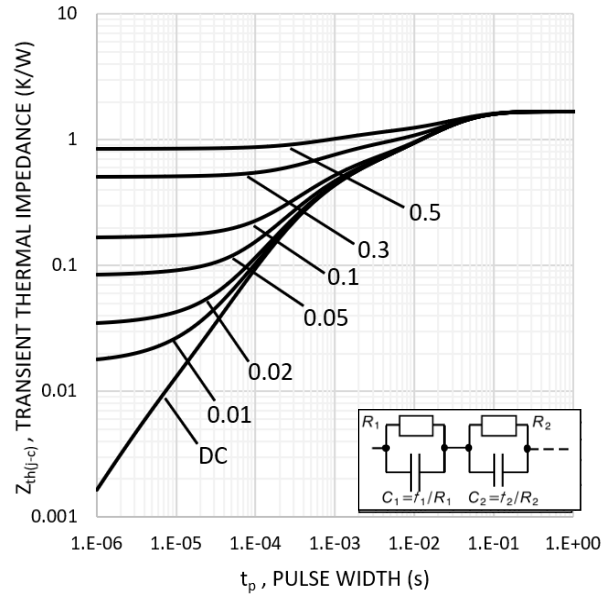


Fig. 18 IGBT transient thermal impedance (D=t<sub>p</sub>/T) (TO-263)

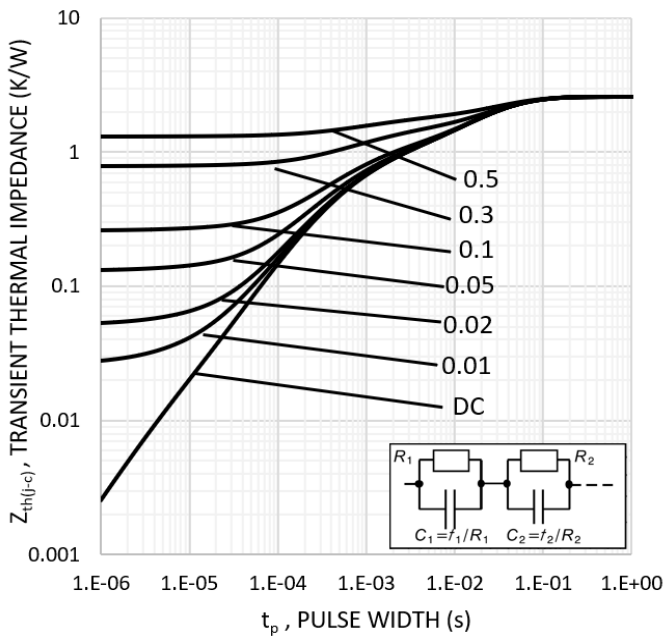
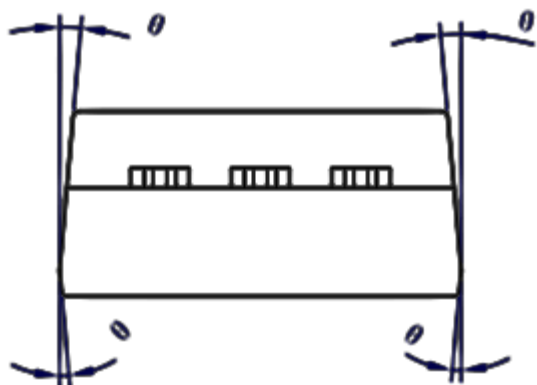
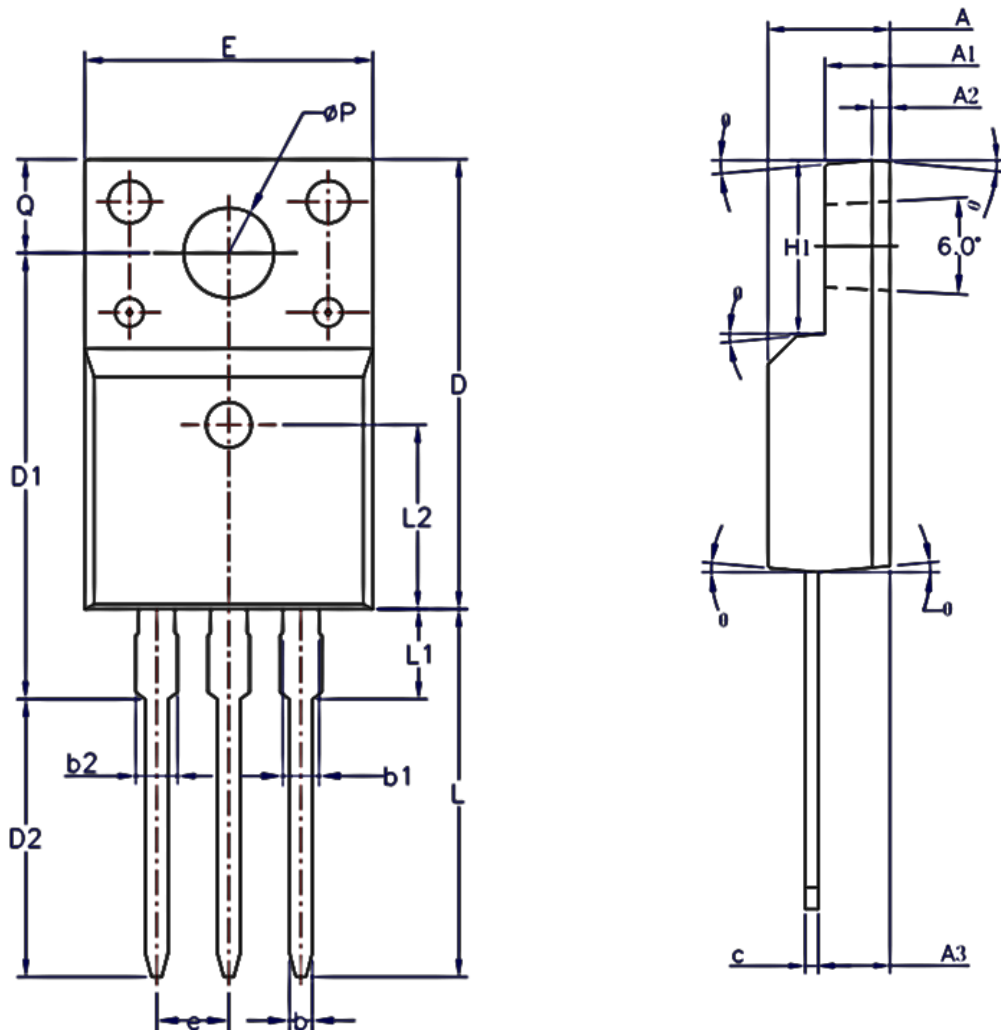


Fig. 19 FRD transient thermal impedance (D=t<sub>p</sub>/T) (TO-263)



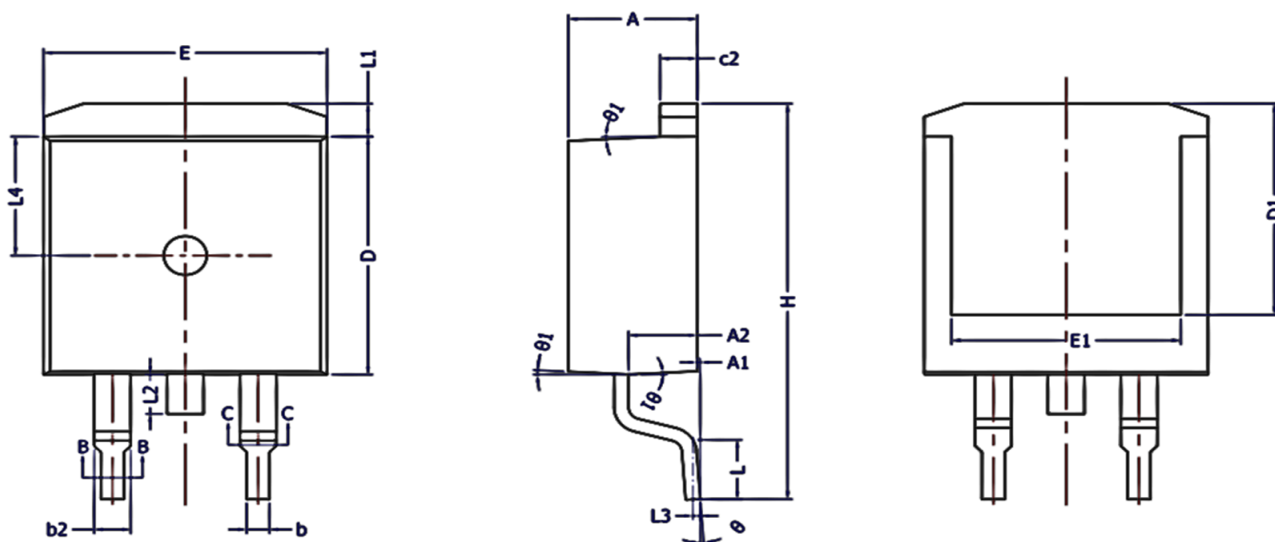
## Package Information

TO-220F-3L



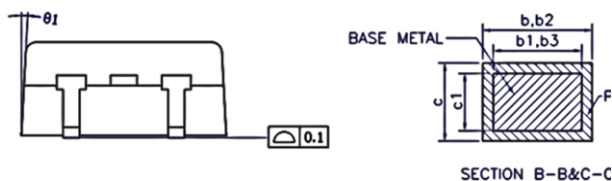
SYMBOL	MIN	NOM	MAX
A	4.50	4.70	4.83
A1	2.34	2.54	2.74
A2	0.70 REF		
A3	2.56	2.76	2.93
b	0.70	-	0.90
b1	1.18	-	1.38
b2	-	-	1.47
c	0.45	0.50	0.60
D	15.67	15.87	16.07
D1	15.55	15.75	15.95
D2	9.60	9.80	10.0
E	9.96	10.16	10.36
e	2.54BSC		
H1	6.48	6.68	6.88
L	12.68	12.98	13.28
L1	-	-	3.50
L2	6.50REF		
$\phi P$	3.08	3.18	3.28
Q	3.20	-	3.40
$\theta$	1°	3°	5°

TO-263-2L



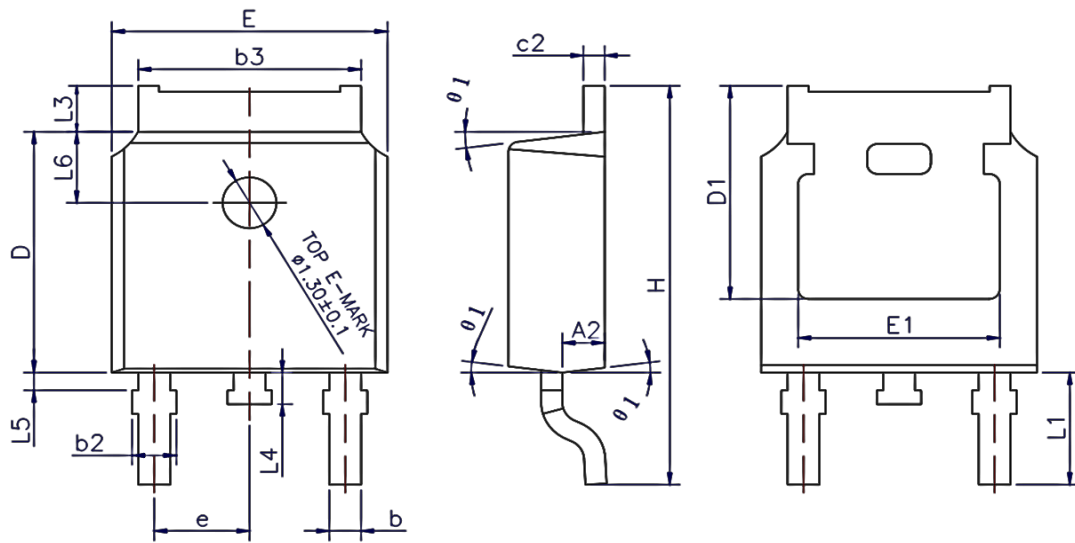
COMMON DIMENSIONS  
(UNITS OF MEASURE =MILLIMETER)

SYMBOL	MIN	NOM	MAX
A	4.40	4.50	4.60
A1	0	0.10	0.25
A2	2.20	2.40	2.60
b	0.76	---	0.89
b1	0.75	0.80	0.85
b2	1.23	---	1.37
b3	1.22	1.27	1.32
c	0.47	---	0.60
c1	0.46	0.51	0.56
c2	1.25	1.30	1.35
D	9.10	9.20	9.30
D1	8.00	---	---
E	9.80	9.90	10.00
E1	7.80	---	---
e	2.54 BSC		
H	14.90	15.30	15.70
L	2.00	2.30	2.60
L1	1.17	1.27	1.40
L2	---	---	1.75
L3	0.25BSC		
L4	4.60 REF		
θ	0°	---	8°
θ1	1°	3°	5°



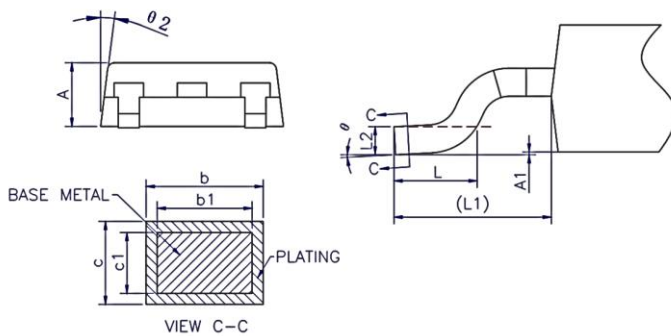
NOTES:  
ALL DIMENSIONS REFER TO JEDEC STANDARD TO-263 AB  
DO NOT INCLUDE MOLD FLASH OR PROTRUSIONS.

TO-252-2L



COMMON DIMENSIONS  
(UNITS OF MEASURE =MILLIMETER)

SYMBOL	MIN	NOM	MAX
A	2.20	2.30	2.38
A1	0	---	0.10
A2	0.90	1.01	1.10
b	0.72	---	0.85
b1	0.71	0.76	0.81
b2	0.72	---	0.90
b3	5.13	5.33	5.46
c	0.47	---	0.60
c1	0.46	0.51	0.56
c2	0.47	---	0.60
D	6.00	6.10	6.20
D1	5.25	---	---
E	6.50	6.60	6.70
E1	4.70	---	---
e	2.186	2.286	2.386
H	9.80	10.10	10.40
L	1.40	1.50	1.70
L1	2.90 REF		
L2	0.508 BSC		
L3	0.90	---	1.25
L4	0.60	0.80	1.00
L5	0.15	---	0.75
L6	1.80 REF		
θ	0°	---	8°
θ1	5°	7°	9°
θ2	5°	7°	9°



NOTES:  
ALL DIMENSIONS REFER TO JEDEC STANDARD  
TO-252 AA DO NOT INCLUDE MOLD FLASH OR  
PROTRUSIONS