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# 1 Electrical ratings

**Table 2. Absolute maximum ratings**

Symbol	Parameter	Value			Unit
		TO-247	TO-220FP	TO-3PF	
$V_{CES}$	Collector-emitter voltage ( $V_{GE} = 0$ )	600			V
$I_C$	Continuous collector current at $T_C = 25$ °C	60	19	36	A
$I_C$	Continuous collector current at $T_C = 100$ °C	35	12	18	A
$I_{CP}^{(1)}$	Pulsed collector current	150			A
$I_{CL}^{(2)}$	Turn-off latching current	80			A
$V_{GE}$	Gate-emitter voltage	$\pm 20$			V
$V_{ISO}$	Insulation withstand voltage (RMS) from all three leads to external heat sink ( $t = 1$ s; $T_C = 25$ °C)		2500		V
$P_{TOT}$	Total dissipation at $T_C = 25$ °C	200	40	88	W
$T_{stg}$	Storage temperature	- 55 to 150			°C
$T_J$	Operating junction temperature				

1. Pulse width limited by maximum junction temperature and turn-off within RBSOA

2.  $V_{CLAMP} = 80\% (V_{CES})$ ,  $V_{GE} = 15$  V,  $R_G = 10$   $\Omega$ ,  $T_J = 150$  °C

**Table 3. Thermal data**

Symbol	Parameter	Value			Unit
		TO-247	TO-220FP	TO-3PF	
$R_{thj-case}$	Thermal resistance junction-case	0.63	3.1	1.41	°C/W
$R_{thj-amb}$	Thermal resistance junction-ambient	50	62.5	50	°C/W

## 2 Electrical characteristics

( $T_J = 25\text{ °C}$  unless otherwise specified)

**Table 4. Static**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$V_{(BR)CES}$	Collector-emitter breakdown voltage ( $V_{GE} = 0$ )	$I_C = 1\text{ mA}$	600			V
$V_{CE(sat)}$	Collector-emitter saturation voltage	$V_{GE} = 15\text{ V}, I_C = 20\text{ A}$		2	2.5	V
		$V_{GE} = 15\text{ V}, I_C = 20\text{ A}, T_J = 125\text{ °C}$		1.65		
$V_{GE(th)}$	Gate threshold voltage	$V_{CE} = V_{GE}, I_C = 1\text{ mA}$	3.75		5.75	V
$I_{CES}$	Collector cut-off current ( $V_{GE} = 0$ )	$V_{CE} = 600\text{ V}$ $V_{CE} = 600\text{ V}, T_J = 125\text{ °C}$			250 1	$\mu\text{A}$ mA
$I_{GES}$	Gate-emitter leakage current ( $V_{CE} = 0$ )	$V_{GE} = \pm 20\text{ V}$			$\pm 100$	nA

**Table 5. Dynamic**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$C_{ies}$	Input capacitance	$V_{CE} = 25\text{ V}, f = 1\text{ MHz},$ $V_{GE} = 0$	-	2400	-	pF
$C_{oes}$	Output capacitance			235		pF
$C_{res}$	Reverse transfer capacitance			50		pF
$Q_g$	Total gate charge	$V_{CE} = 400\text{ V}, I_C = 20\text{ A},$ $V_{GE} = 15\text{ V},$ (see <a href="#">Figure 18</a> )	-	140	-	nC
$Q_{ge}$	Gate-emitter charge			13		nC
$Q_{gc}$	Gate-collector charge			52		nC

**Table 6. Switching on/off (inductive load)**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$t_{d(on)}$	Turn-on delay time	$V_{CC} = 400\text{ V}$ , $I_C = 20\text{ A}$		30		ns
$t_r$	Current rise time	$R_G = 10\ \Omega$ , $V_{GE} = 15\text{ V}$ , (see <a href="#">Figure 17</a> )	-	15	-	ns
$(di/dt)_{on}$	Turn-on current slope			1650		A/ $\mu$ s
$t_{d(on)}$	Turn-on delay time	$V_{CC} = 400\text{ V}$ , $I_C = 20\text{ A}$		30		ns
$t_r$	Current rise time	$R_G = 10\ \Omega$ , $V_{GE} = 15\text{ V}$ , $T_J = 125\text{ }^\circ\text{C}$ (see <a href="#">Figure 17</a> )	-	15	-	ns
$(di/dt)_{on}$	Turn-on current slope			1600		A/ $\mu$ s
$t_r(V_{off})$	Off voltage rise time	$V_{CC} = 400\text{ V}$ , $I_C = 20\text{ A}$ , $R_{GE} = 10\ \Omega$ , $V_{GE} = 15\text{ V}$		30		ns
$t_{d(off)}$	Turn-off delay time	(see <a href="#">Figure 17</a> )	-	175	-	ns
$t_f$	Current fall time			40		ns
$t_r(V_{off})$	Off voltage rise time	$V_{CC} = 400\text{ V}$ , $I_C = 20\text{ A}$ , $R_{GE} = 10\ \Omega$ , $V_{GE} = 15\text{ V}$ , $T_J = 125\text{ }^\circ\text{C}$		50		ns
$t_{d(off)}$	Turn-off delay time	(see <a href="#">Figure 17</a> )	-	225	-	ns
$t_f$	Current fall time			70		ns

**Table 7. Switching energy (inductive load)**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$E_{on}^{(1)}$	Turn-on switching losses	$V_{CC} = 400\text{ V}$ , $I_C = 20\text{ A}$		290		$\mu$ J
$E_{off}$	Turn-off switching losses	$R_G = 10\ \Omega$ , $V_{GE} = 15\text{ V}$ , (see <a href="#">Figure 19</a> )	-	185		$\mu$ J
$E_{ts}$	Total switching losses			475		$\mu$ J
$E_{on}^{(1)}$	Turn-on switching losses	$V_{CC} = 400\text{ V}$ , $I_C = 20\text{ A}$		420		$\mu$ J
$E_{off}$	Turn-off switching losses	$R_G = 10\ \Omega$ , $V_{GE} = 15\text{ V}$ , $T_J = 125\text{ }^\circ\text{C}$ (see <a href="#">Figure 19</a> )	-	350	530	$\mu$ J
$E_{ts}$	Total switching losses			770		$\mu$ J

1.  $E_{on}$  is the turn-on losses when a typical diode is used in the test circuit in [Figure 19](#). If the IGBT is offered in a package with a co-pak diode, the co-pak diode is used as external diode. IGBTs and diode are at the same temperature (25  $^\circ\text{C}$  and 125  $^\circ\text{C}$ ).  $E_{on}$  includes diode recovery energy.

2.1 Electrical characteristics (curves)

Figure 2. Output characteristics

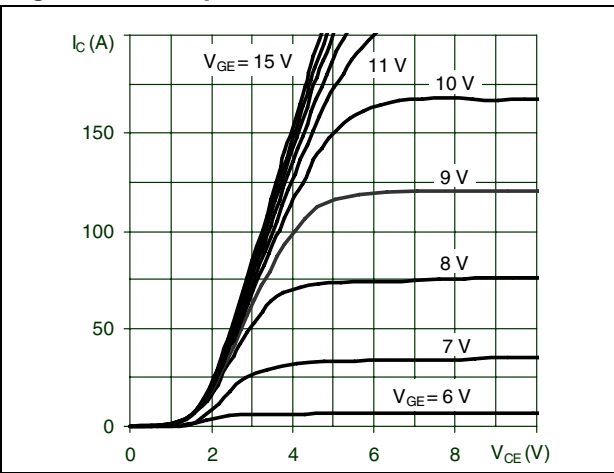


Figure 3. Transfer characteristics

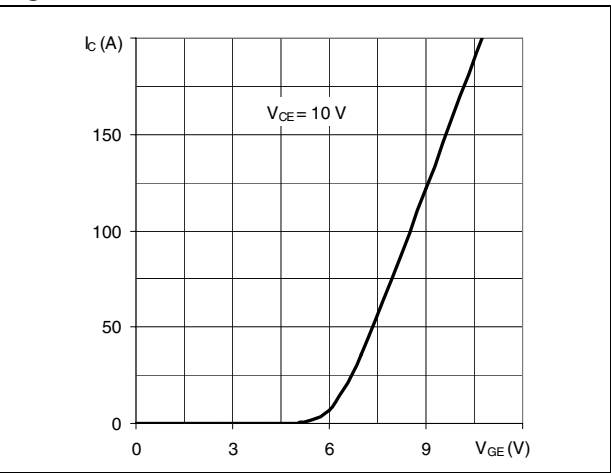


Figure 4. Normalized  $V_{CE(sat)}$  vs.  $I_C$

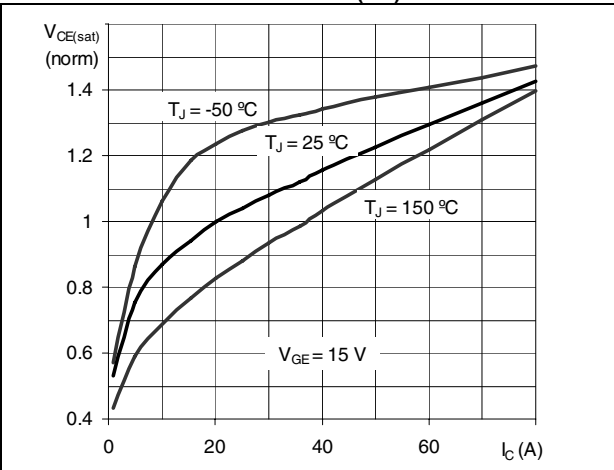


Figure 5. Normalized  $V_{CE(sat)}$  vs. temperature

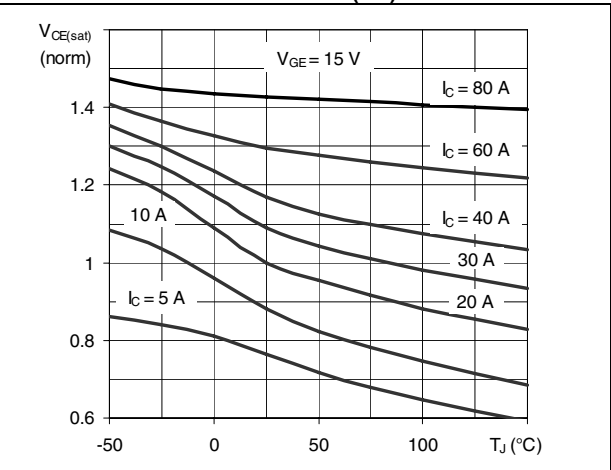


Figure 6. Normalized breakdown voltage vs. temperature

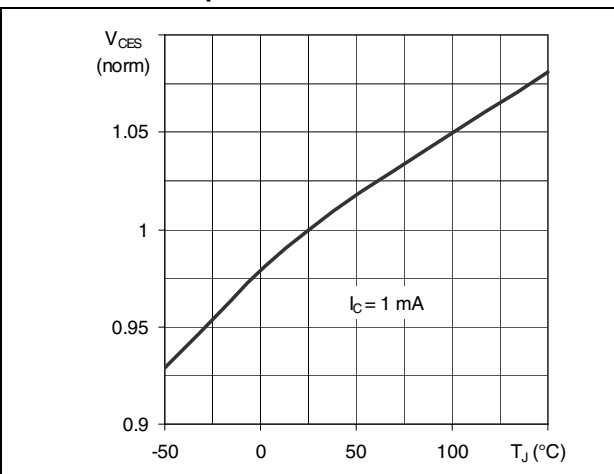


Figure 7. Normalized gate threshold voltage vs. temperature

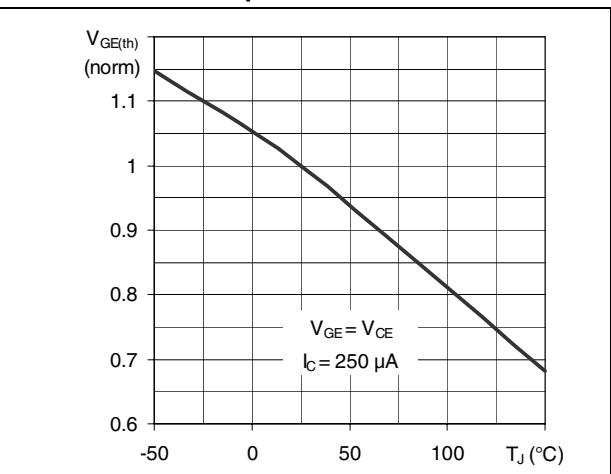


Figure 8. Gate charge vs. gate-emitter voltage

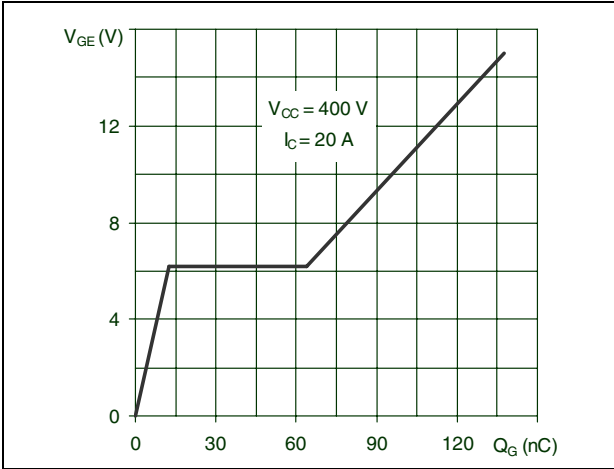


Figure 9. Capacitance variations

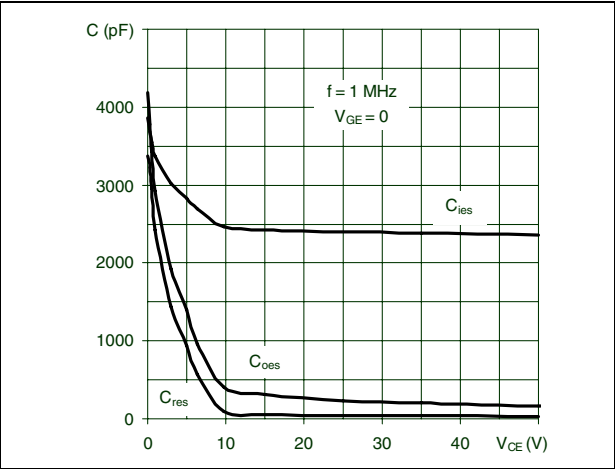


Figure 10. Switching losses vs. temperature

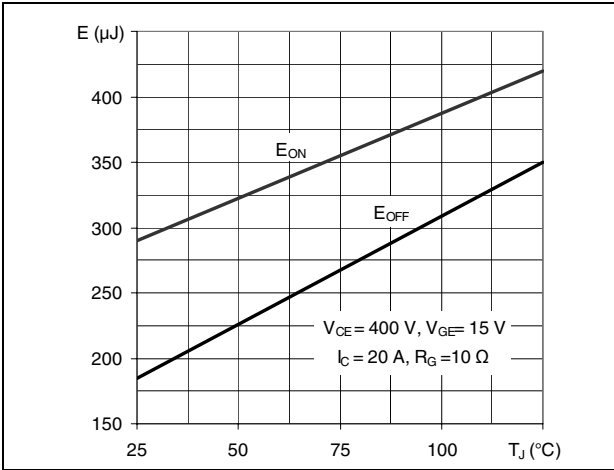


Figure 11. Switching losses vs. gate resistance

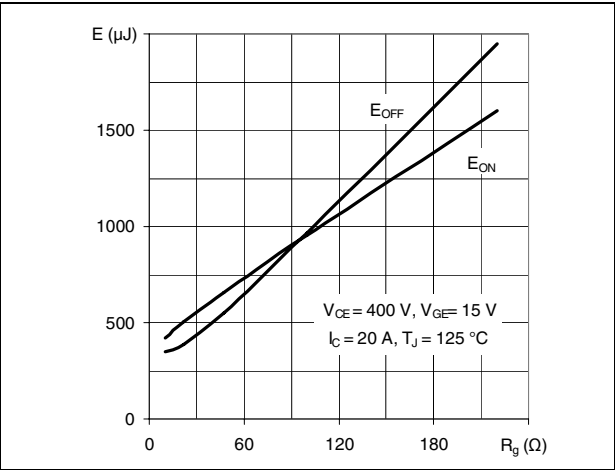


Figure 12. Switching losses vs. collector current

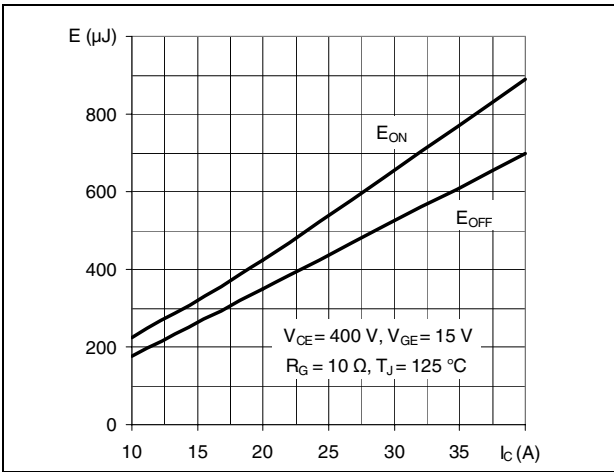


Figure 13. Turn-off SOA

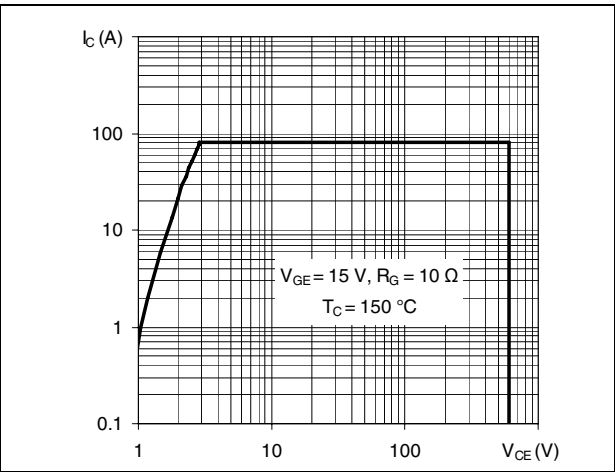


Figure 14. Thermal impedance for TO-247

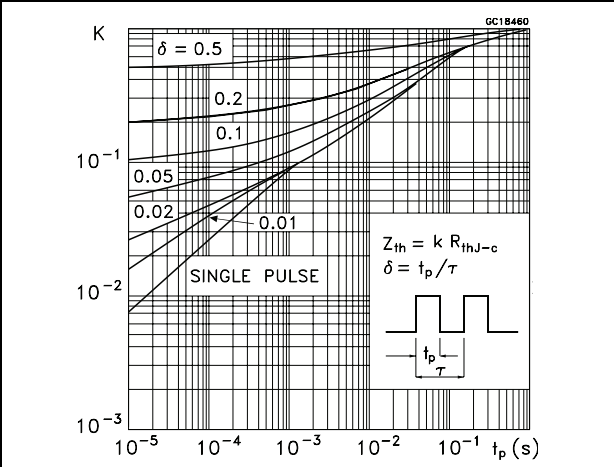


Figure 15. Thermal impedance for TO-220FP

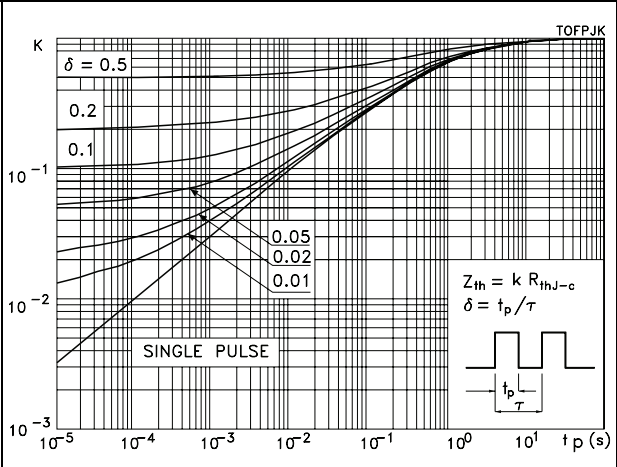
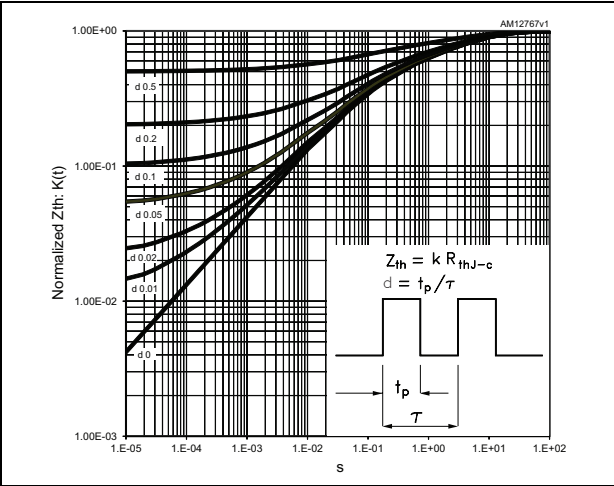


Figure 16. Thermal impedance for TO-3PF



# 3 Test circuits

Figure 17. Test circuit for inductive load switching

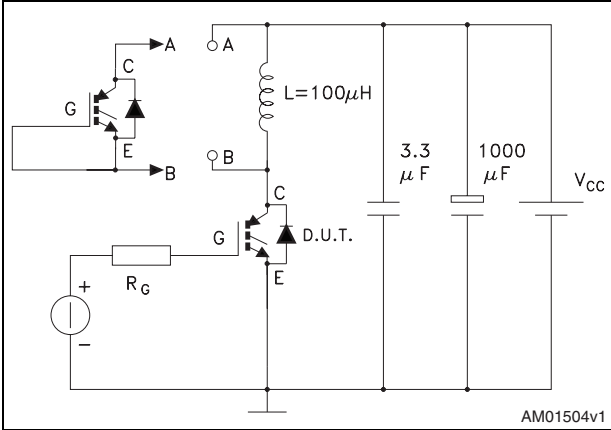


Figure 18. Gate charge test circuit

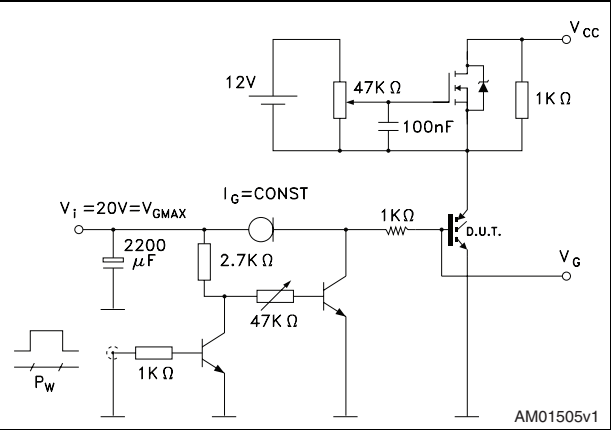
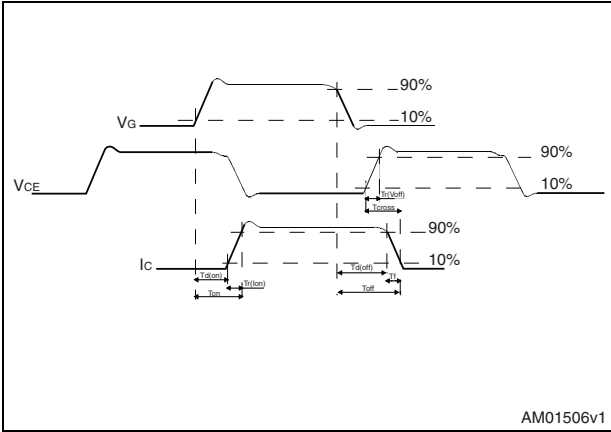


Figure 19. Switching waveform





## 4 Package mechanical data

In order to meet environmental requirements, ST offers these devices in different grades of ECOPACK<sup>®</sup> packages, depending on their level of environmental compliance. ECOPACK<sup>®</sup> specifications, grade definitions and product status are available at: [www.st.com](http://www.st.com). ECOPACK<sup>®</sup> is an ST trademark.

**Table 8. TO-220FP mechanical data**

Dim.	mm		
	Min.	Typ.	Max.
A	4.4		4.6
B	2.5		2.7
D	2.5		2.75
E	0.45		0.7
F	0.75		1
F1	1.15		1.70
F2	1.15		1.70
G	4.95		5.2
G1	2.4		2.7
H	10		10.4
L2		16	
L3	28.6		30.6
L4	9.8		10.6
L5	2.9		3.6
L6	15.9		16.4
L7	9		9.3
Dia	3		3.2

Figure 20. TO-220FP drawing

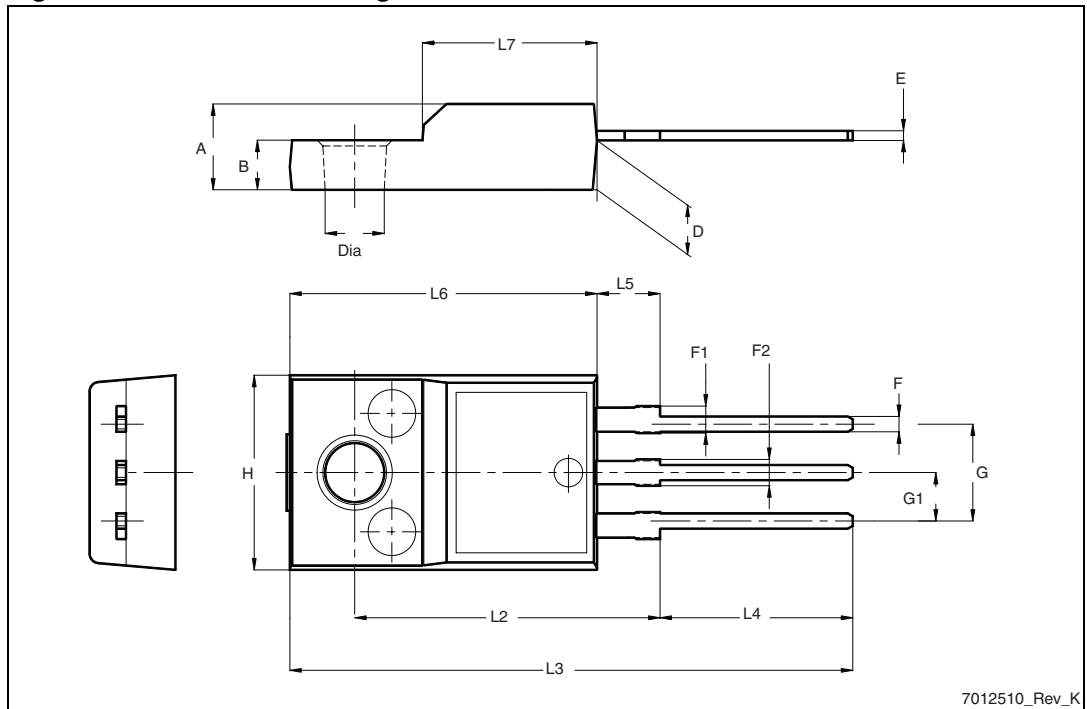


Table 9. TO-247 mechanical data

Dim.	mm		
	Min.	Typ.	Max.
A	4.85		5.15
A1	2.20		2.60
b	1.0		1.40
b1	2.0		2.40
b2	3.0		3.40
c	0.40		0.80
D	19.85		20.15
E	15.45		15.75
e		5.45	
L	14.20		14.80
L1	3.70		4.30
L2		18.50	
ØP	3.55		3.65
ØR	4.50		5.50
S		5.50	

Figure 21. TO-247 drawing

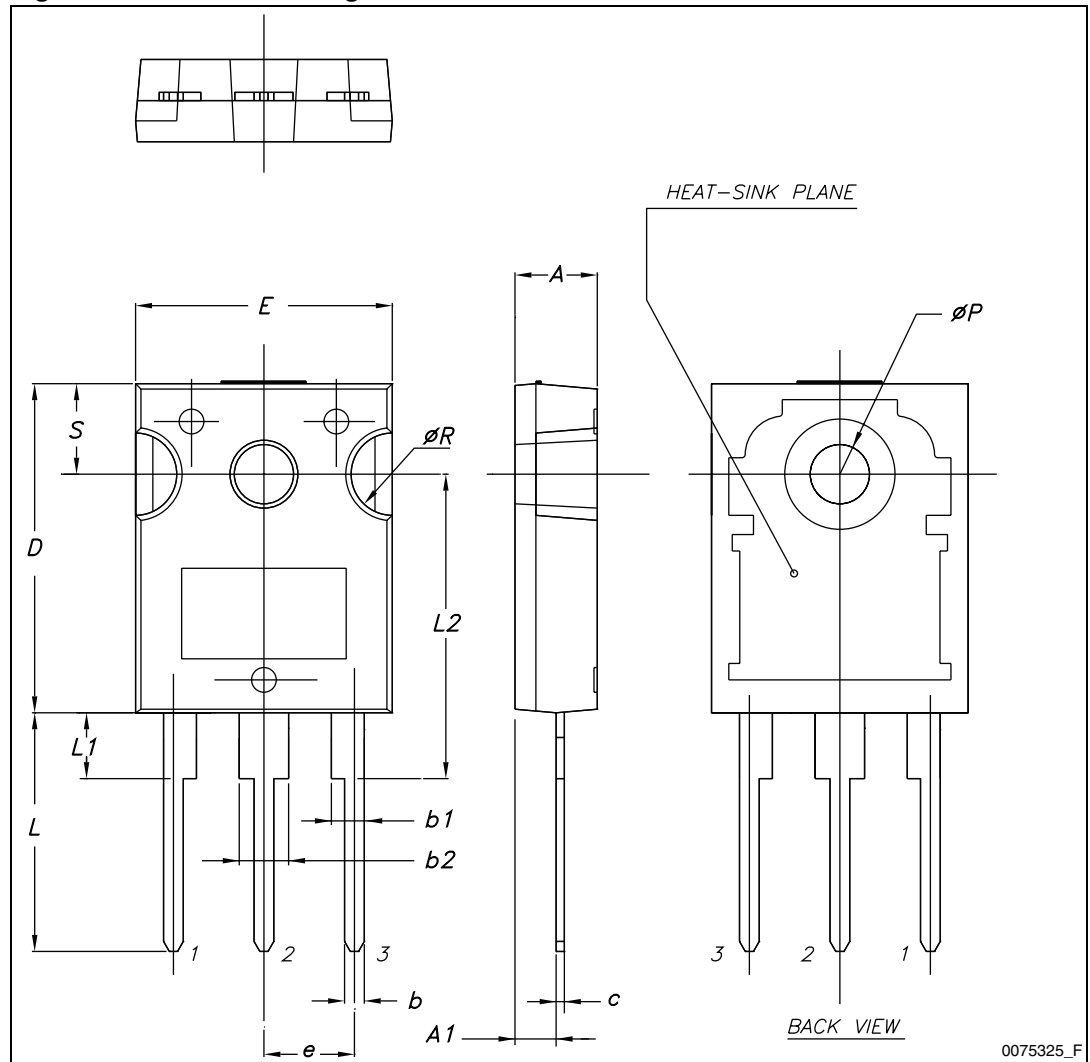
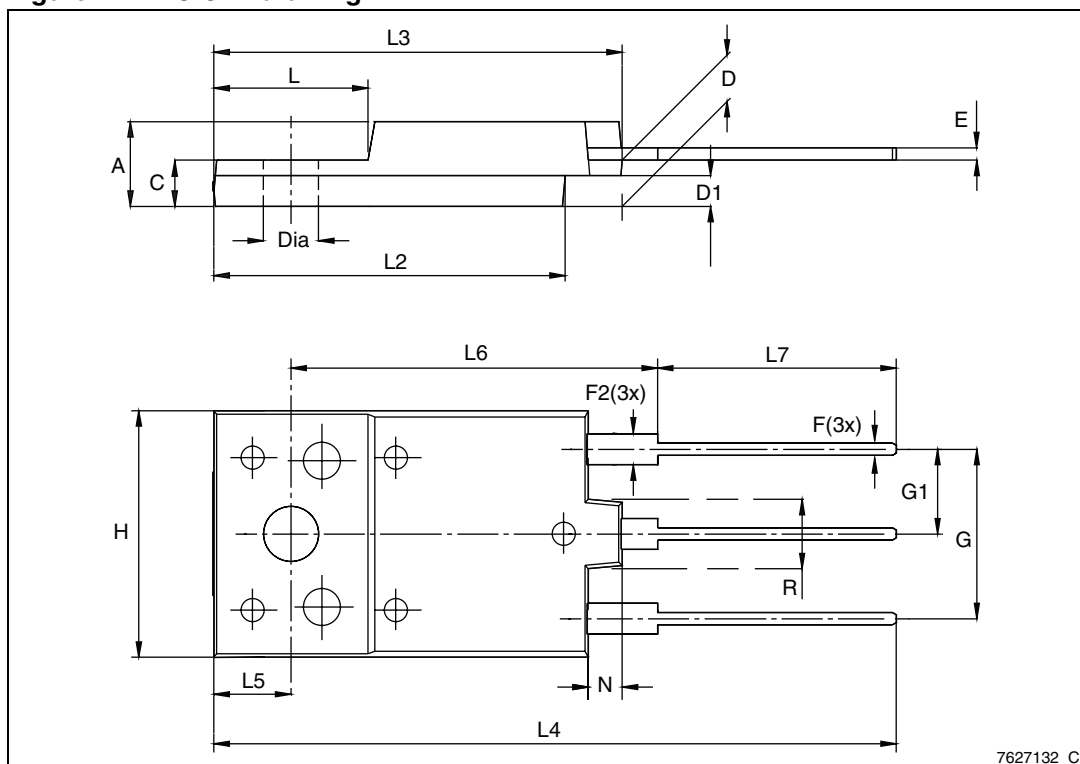


Table 10. TO-3PF mechanical data

Dim.	mm		
	Min.	Typ.	Max.
A	5.30		5.70
C	2.80		3.20
D	3.10		3.50
D1	1.80		2.20
E	0.80		1.10
F	0.65		0.95
F2	1.80		2.20
G	10.30		11.50
G1		5.45	
H	15.30		15.70
L	9.80	10	10.20
L2	22.80		23.20
L3	26.30		26.70
L4	43.20		44.40
L5	4.30		4.70
L6	24.30		24.70
L7	14.60		15
N	1.80		2.20
R	3.80		4.20
Dia	3.40		3.80

Figure 22. TO-3PF drawing



## 5 Revision history

**Table 11. Document revision history**

Date	Revision	Changes
17-May-2010	1	Initial release.
14-Dec-2010	2	Document status promoted from preliminary data to datasheet. Inserted new order code STGF35HF60W in TO-220FP package.
24-Jul-2012	3	Inserted new order code STGFW35HF60W in TO-3PF package.

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