

## MOSFET

Metal Oxide Semiconductor Field Effect Transistor

### CoolMOS™ C6 600V

600V CoolMOS™ C6 Power Transistor  
IPx60R190C6

## Data Sheet

Rev. 2.3  
Final

## 600V CoolMOS™ C6 Power Transistor

IPA60R190C6, IPB60R190C6  
 IPI60R190C6, IPP60R190C6  
 IPW60R190C6

### 1 Description

CoolMOS™ is a revolutionary technology for high voltage power MOSFETs, designed according to the superjunction (SJ) principle and pioneered by Infineon Technologies. CoolMOS™ C6 series combines the experience of the leading SJ MOSFET supplier with high class innovation. The offered devices provide all benefits of a fast switching SJ MOSFET while not sacrificing ease of use. Extremely low switching and conduction losses make switching applications even more efficient, more compact, lighter, and cooler.

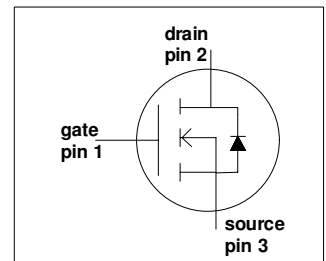
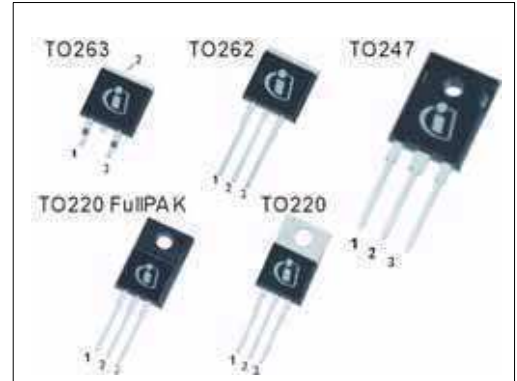
#### Features

- Extremely low losses due to very low FOM  $R_{DS(on)} \cdot Q_g$  and  $E_{oss}$
- Very high commutation ruggedness
- Easy to use/drive
- JEDEC<sup>1)</sup> qualified, Pb-free plating, Halogen free

#### Applications

PFC stages, hard switching PWM stages and resonant switching PWM stages for e.g. PC Silverbox, Adapter, LCD & PDP TV, Lighting, Server, Telecom and UPS.

*Please note: For MOSFET paralleling the use of ferrite beads on the gate or separate totem poles is generally recommended.*



**Table 1 Key Performance Parameters**

Parameter	Value	Unit
$V_{DS} @ T_{j,max}$	650	V
$R_{DS(on),max}$	0.19	$\Omega$
$Q_{g,typ}$	63	nC
$I_{D,pulse}$	59	A
$E_{oss} @ 400V$	5.2	$\mu J$
Body diode $di/dt$	500	A/ $\mu s$

Type / Ordering Code	Package	Marking	Related Links
IPW60R190C6	PG-TO247	6R190C6	<a href="#">IFX C6 Product Brief</a> <a href="#">IFX C6 Portfolio</a> <a href="#">IFX CoolMOS Webpage</a> <a href="#">IFX Design tools</a>
IPB60R190C6	PG-TO263		
IPI60R190C6	PG-TO262		
IPP60R190C6	PG-TO220		
IPA60R190C6	PG-TO220 FullPAK		

1) J-STD20 and JESD22

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## 2 Maximum ratings

at  $T_j = 25\text{ °C}$ , unless otherwise specified.

**Table 2 Maximum ratings**

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Continuous drain current <sup>1)</sup>	$I_D$	-	-	20.2	A	$T_C = 25\text{ °C}$
				128		$T_C = 100\text{ °C}$
Pulsed drain current <sup>2)</sup>	$I_{D,pulse}$	-	-	59	A	$T_C = 25\text{ °C}$
Avalanche energy, single pulse	$E_{AS}$	-	-	418	mJ	$I_D = 3.4\text{ A}, V_{DD} = 50\text{ V}$ (see table 21)
Avalanche energy, repetitive	$E_{AR}$	-	-	0.63		$I_D = 3.4\text{ A}, V_{DD} = 50\text{ V}$
Avalanche current, repetitive	$I_{AR}$	-	-	3.4	A	
MOSFET dv/dt ruggedness	dv/dt	-	-	50	V/ns	$V_{DS} = 0 \dots 480\text{ V}$
Gate source voltage	$V_{GS}$	- 20	-	20	V	static
		- 30		30		AC ( $f > 1\text{ Hz}$ )
Power dissipation for TO-220, TO-247, TO-262, TO-263	$P_{tot}$	-	-	151	W	$T_C = 25\text{ °C}$
Power dissipation for TO-220 FullPAK	$P_{tot}$	-	-	34		
Operating and storage temperature	$T_j, T_{stg}$	- 55	-	150	°C	
Mounting torque TO-220, TO-247		-	-	60	Ncm	M3 and M3.5 screws
Mounting torque TO-220 FullPAK				50		M2.5 screws
Continuous diode forward current	$I_S$	-	-	17.5	A	$T_C = 25\text{ °C}$
Diode pulse current <sup>2)</sup>	$I_{S,pulse}$	-	-	59	A	$T_C = 25\text{ °C}$
Reverse diode dv/dt <sup>3)</sup>	dv/dt	-	-	15	V/ns	$V_{DS} = 0 \dots 400\text{ V}, I_{SD} \sim I_D,$
Maximum diode commutation speed <sup>3)</sup>	di/dt	-	-	500	A/ $\mu\text{s}$	$T_j = 25\text{ °C}$ (see table 22)
Insulation withstand voltage TO-220 FullPAK	$V_{ISO}$	-	-	2500	V	$V_{RMS}, T_C = 25\text{ °C}, t = 1\text{ min}$

1) Limited by  $T_{j,max}$ . Maximum duty cycle  $D = 0.75$

2) Pulse width  $t_p$  limited by  $T_{j,max}$

3) Identical low side and high side switch with identical  $R_G$

### 3 Thermal characteristics

**Table 3 Thermal characteristics TO-220 (IPP60R190C6), TO-247 (IPW60R190C6), TO-262 (IPI60R190C6)**

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Thermal resistance, junction - case	$R_{thJC}$	-	-	0.83	°C/W	leaded
Thermal resistance, junction - ambient	$R_{thJA}$	-	-	62		
Soldering temperature, wavesoldering only allowed at leads	$T_{sold}$	-	-	260	°C	1.6 mm (0.063 in.) from case for 10 s

**Table 4 Thermal characteristics TO-220 FullPAK (IPA60R190C6)**

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Thermal resistance, junction - case	$R_{thJC}$	-	-	3.7	°C/W	leaded
Thermal resistance, junction - ambient	$R_{thJA}$	-	-	80		
Soldering temperature, wavesoldering only allowed at leads	$T_{sold}$	-	-	260	°C	1.6 mm (0.063 in.) from case for 10 s

**Table 5 Thermal characteristics TO-263 (IPB60R190C6)**

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Thermal resistance, junction - case	$R_{thJC}$	-	-	0.83	°C/W	SMD version, device on PCB, minimal footprint
Thermal resistance, junction - ambient	$R_{thJA}$	-	-	62		
				35		
Soldering temperature, wave- & reflow soldering allowed	$T_{sold}$	-	-	260	°C	reflow MSL1

1) Device on 40mm\*40mm\*1.5mm one layer epoxy PCB FR4 with 6cm<sup>2</sup> copper area (thickness 70μm) for drain connection. PCB is vertical without air stream cooling.

## 4 Electrical characteristics

Electrical characteristics, at  $T_J=25\text{ °C}$ , unless otherwise specified.

**Table 6 Static characteristics**

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Drain-source breakdown voltage	$V_{(BR)DSS}$	600	-	-	V	$V_{GS}=0\text{ V}$ , $I_D=0.25\text{ mA}$
Gate threshold voltage	$V_{GS(th)}$	2.5	3	3.5		$V_{DS}=V_{GS}$ , $I_D=0.63\text{ mA}$
Zero gate voltage drain current	$I_{DSS}$	-	-	1	$\mu\text{A}$	$V_{DS}=600\text{ V}$ , $V_{GS}=0\text{ V}$ , $T_J=25\text{ °C}$
		-	10	-		$V_{DS}=600\text{ V}$ , $V_{GS}=0\text{ V}$ , $T_J=150\text{ °C}$
Gate-source leakage current	$I_{GSS}$	-	-	100	nA	$V_{GS}=20\text{ V}$ , $V_{DS}=0\text{ V}$
Drain-source on-state resistance	$R_{DS(on)}$	-	0.17	0.19	$\Omega$	$V_{GS}=10\text{ V}$ , $I_D=9.5\text{ A}$ , $T_J=25\text{ °C}$
		-	0.44	-		$V_{GS}=10\text{ V}$ , $I_D=9.5\text{ A}$ , $T_J=150\text{ °C}$
Gate resistance	$R_G$	-	8.5	-	$\Omega$	$f=1\text{ MHz}$ , open drain

**Table 7 Dynamic characteristics**

Parameter	Symbol	Values			Unit	Note / Test Condition	
		Min.	Typ.	Max.			
Input capacitance	$C_{iss}$	-	1400	-	pF	$V_{GS}=0\text{ V}$ , $V_{DS}=100\text{ V}$ , $f=1\text{ MHz}$	
Output capacitance	$C_{oss}$	-	85	-			
Effective output capacitance, energy related <sup>1)</sup>	$C_{o(er)}$	-	56	-			$V_{GS}=0\text{ V}$ , $V_{DS}=0\dots480\text{ V}$
Effective output capacitance, time related <sup>2)</sup>	$C_{o(tr)}$	-	266	-			$I_D=\text{constant}$ , $V_{GS}=0\text{ V}$ $V_{DS}=0\dots480\text{ V}$
Turn-on delay time	$t_{d(on)}$	-	15	-	ns	$V_{DD}=400\text{ V}$ , $V_{GS}=13\text{ V}$ , $I_D=9.5\text{ A}$ , $R_G=3.4\Omega$ (see table 20)	
Rise time	$t_r$	-	11	-			
Turn-off delay time	$t_{d(off)}$	-	110	-			
Fall time	$t_f$	-	9	-			

1)  $C_{o(er)}$  is a fixed capacitance that gives the same stored energy as  $C_{oss}$  while  $V_{DS}$  is rising from 0 to 80%  $V_{(BR)DSS}$

2)  $C_{o(tr)}$  is a fixed capacitance that gives the same charging time as  $C_{oss}$  while  $V_{DS}$  is rising from 0 to 80%  $V_{(BR)DSS}$

**Table 8 Gate charge characteristics**

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Gate to source charge	$Q_{gs}$	-	7.6	-	nC	$V_{DD}=480\text{ V}$ , $I_D=9.5\text{ A}$ , $V_{GS}=0\text{ to }10\text{ V}$
Gate to drain charge	$Q_{gd}$	-	32	-		
Gate charge total	$Q_g$	-	63	-		
Gate plateau voltage	$V_{\text{plateau}}$	-	5.4	-	V	

**Table 9 Reverse diode characteristics**

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Diode forward voltage	$V_{SD}$	-	0.9	-	V	$V_{GS}=0\text{ V}$ , $I_F=9.5\text{ A}$ , $T_j=25\text{ °C}$
Reverse recovery time	$t_{rr}$	-	430	-	ns	$V_R=400\text{ V}$ , $I_F=9.5\text{ A}$ , $di_F/dt=100\text{ A}/\mu\text{s}$ (see table 22)
Reverse recovery charge	$Q_{rr}$	-	6.9	-	$\mu\text{C}$	
Peak reverse recovery current	$I_{rrm}$	-	30	-	A	

5 Electrical characteristics diagrams

Table 10

Power dissipation TO-220, TO-247, TO-262, TO-263	Power dissipation TO-220 FullPAK
$P_{tot} = f(T_C)$	$P_{tot} = f(T_C)$

Table 11

Max. transient thermal impedance TO-220, TO-247, TO-262, TO-263	Max. transient thermal impedance TO-220 FullPAK
$Z_{(thJC)} = f(t_p)$ ; parameter: $D = t_p / T$	$Z_{(thJC)} = f(t_p)$ ; parameter: $D = t_p / T$



Table 12

<p>Safe operating area <math>T_C=25\text{ °C}</math> TO-220, TO-247, TO-262, TO-263</p>	<p>Safe operating area <math>T_C=25\text{ °C}</math> TO-220 FullPAK</p>
<p><math>I_D=f(V_{DS}); T_C=25\text{ °C}; D=0; \text{parameter } t_p</math></p>	<p><math>I_D=f(V_{DS}); T_C=25\text{ °C}; D=0; \text{parameter } t_p</math></p>

Table 13

<p>Safe operating area <math>T_C=80\text{ °C}</math> TO-220, TO-247, TO-262, TO-263</p>	<p>Safe operating area <math>T_C=80\text{ °C}</math> TO-220 FullPAK</p>
<p><math>I_D=f(V_{DS}); T_C=80\text{ °C}; D=0; \text{parameter } t_p</math></p>	<p><math>I_D=f(V_{DS}); T_C=80\text{ °C}; D=0; \text{parameter } t_p</math></p>

Table 14

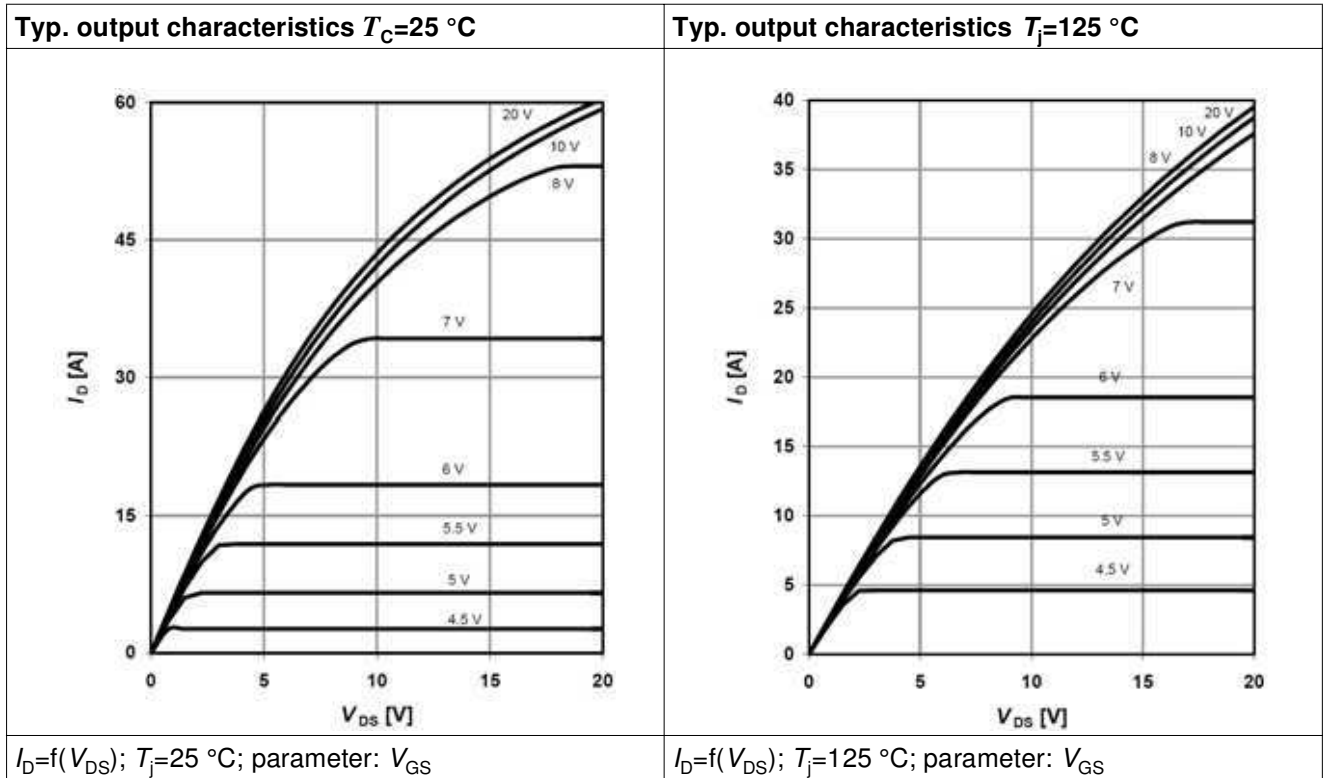


Table 15

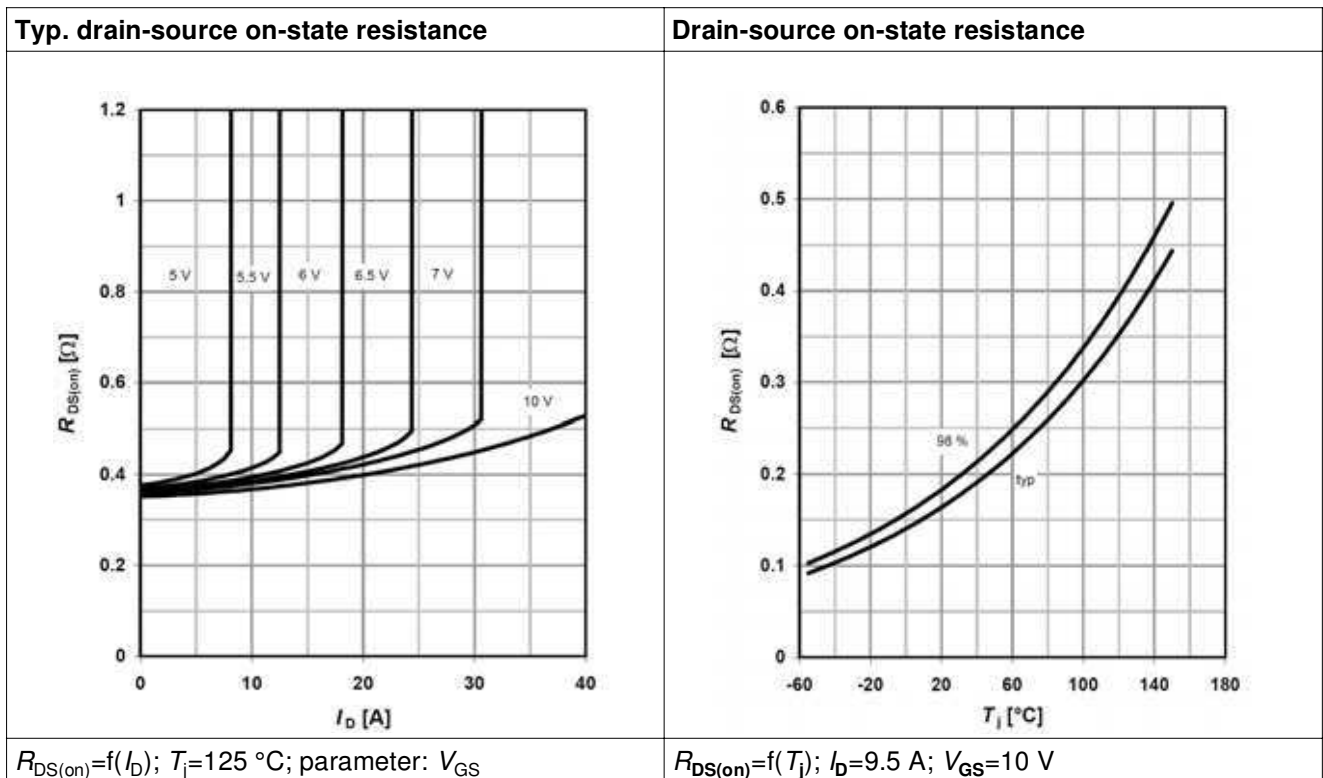


Table 16

Typ. transfer characteristics	Typ. gate charge
$I_D = f(V_{GS}); V_{DS} = 20V$	$V_{GS} = f(Q_{gate}), I_D = 9.5A \text{ pulsed}$

Table 17

Avalanche energy	Drain-source breakdown voltage
$E_{AS} = f(T_j); I_D = 3.4 A; V_{DD} = 50 V$	$V_{BR(DSS)} = f(T_j); I_D = 0.25 \text{ mA}$

Table 18

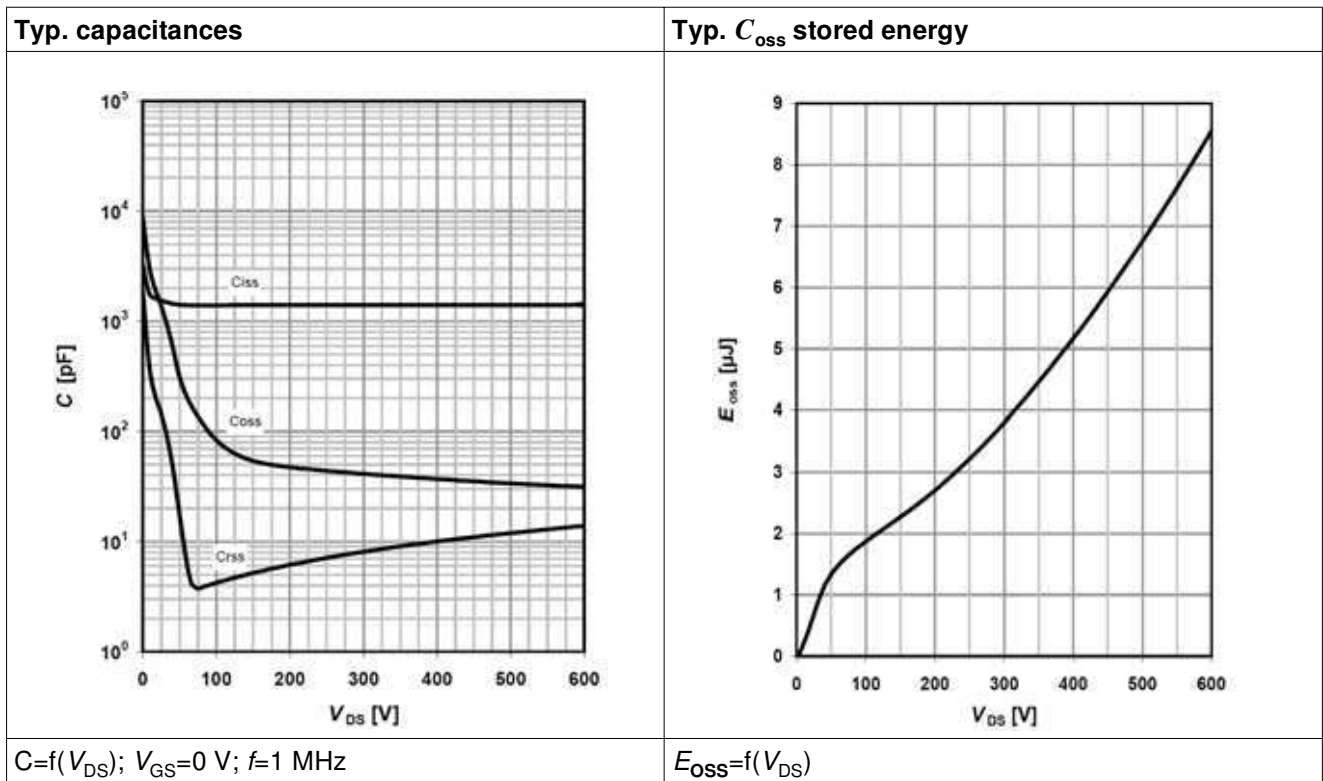
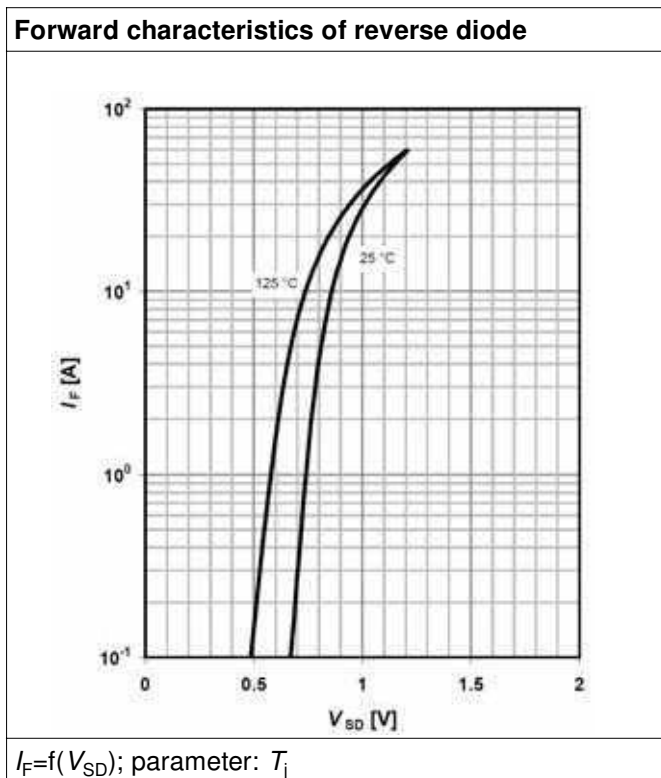


Table 19



## 6 Test circuits

Table 20 Switching times test circuit and waveform for inductive load

Switching times test circuit for inductive load	Switching time waveform

Table 21 Unclamped inductive load test circuit and waveform

Unclamped inductive load test circuit	Unclamped inductive waveform

Table 22 Test circuit and waveform for diode characteristics

Test circuit for diode characteristics	Diode recovery waveform

7 Package outlines

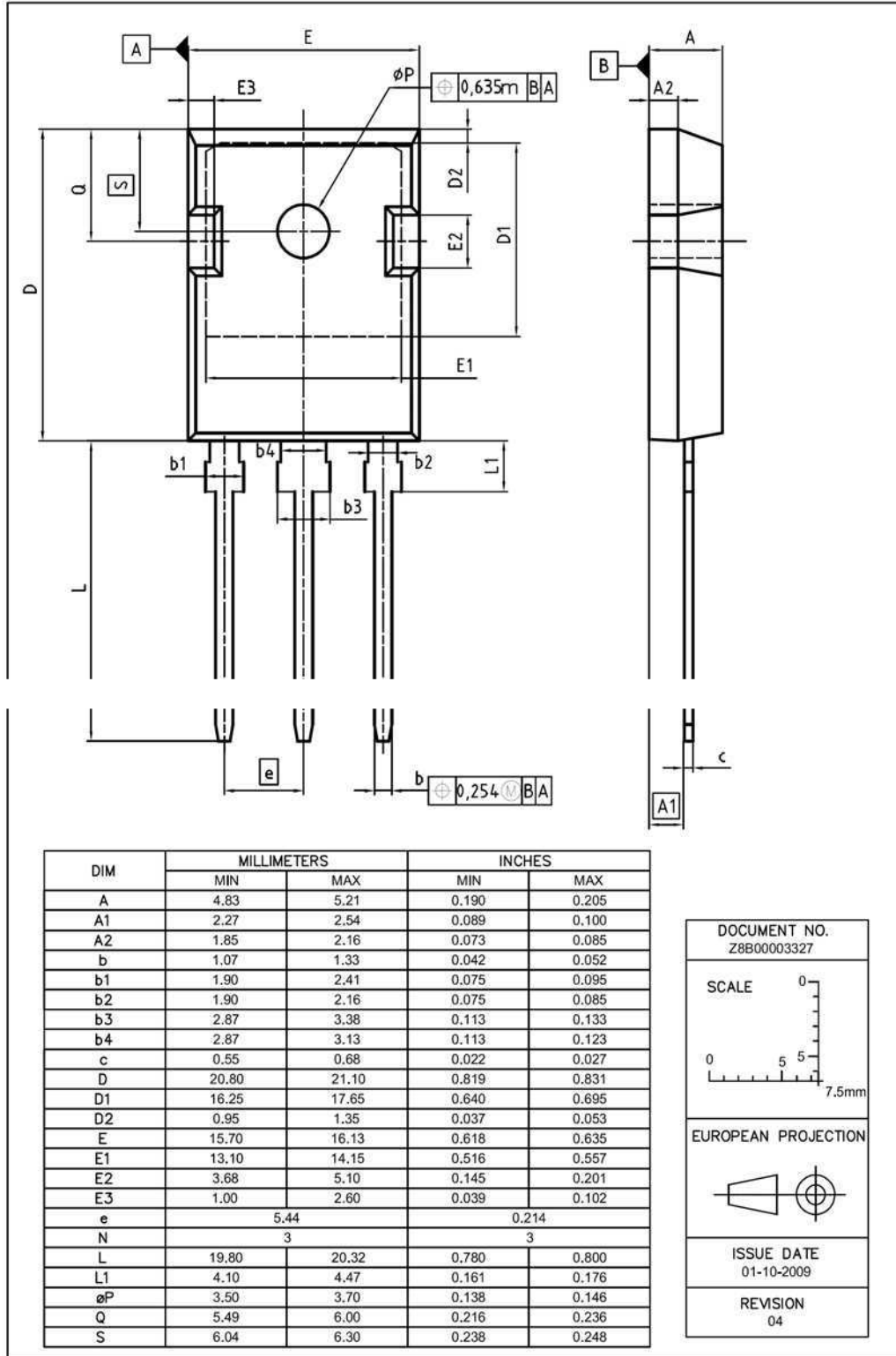
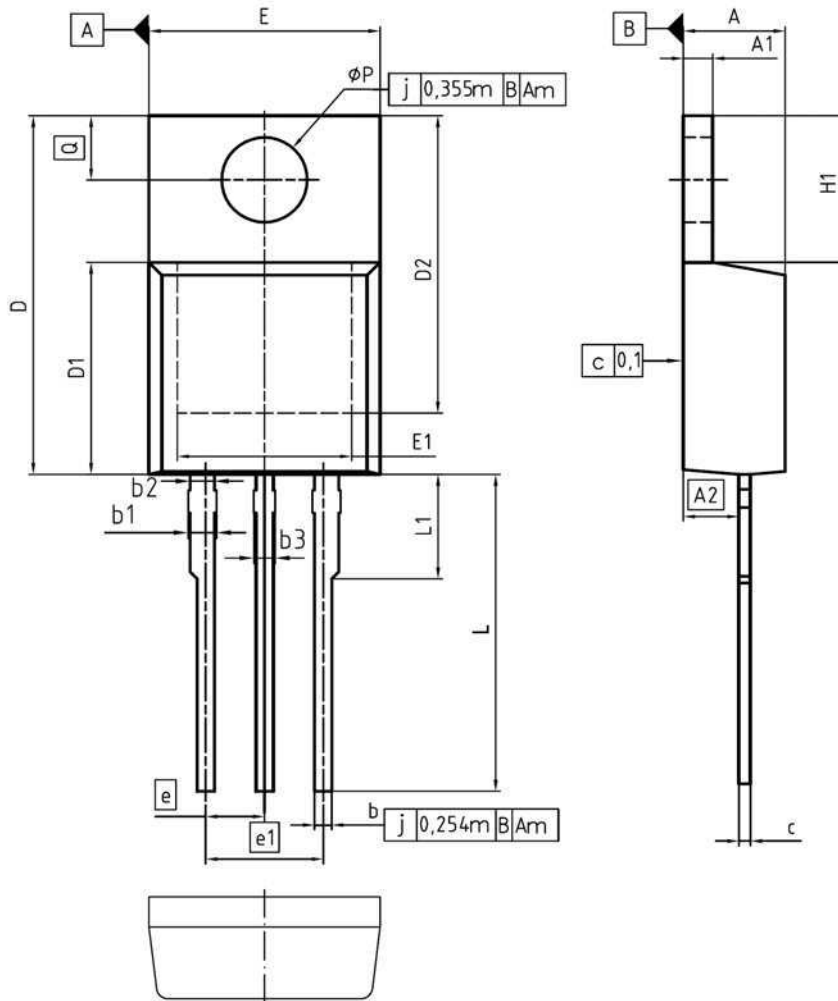


Figure 1 Outlines TO-247, dimensions in mm/inches





DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	4.30	4.57	0.169	0.180
A1	1.17	1.40	0.046	0.055
A2	2.15	2.72	0.085	0.107
b	0.65	0.86	0.026	0.034
b1	0.95	1.40	0.037	0.055
b2	0.95	1.15	0.037	0.045
b3	0.65	1.15	0.026	0.045
c	0.33	0.60	0.013	0.024
D	14.81	15.95	0.583	0.628
D1	8.51	9.45	0.335	0.372
D2	12.19	13.10	0.480	0.516
E	9.70	10.36	0.382	0.408
E1	6.50	8.60	0.256	0.339
e	2.54		0.100	
e1	5.08		0.200	
N	3		3	
H1	5.90	6.90	0.232	0.272
L	13.00	14.00	0.512	0.551
L1	-	4.80	-	0.189
øP	3.60	3.89	0.142	0.153
Q	2.60	3.00	0.102	0.118

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Figure 2 Outlines TO-220, dimensions in mm/inches

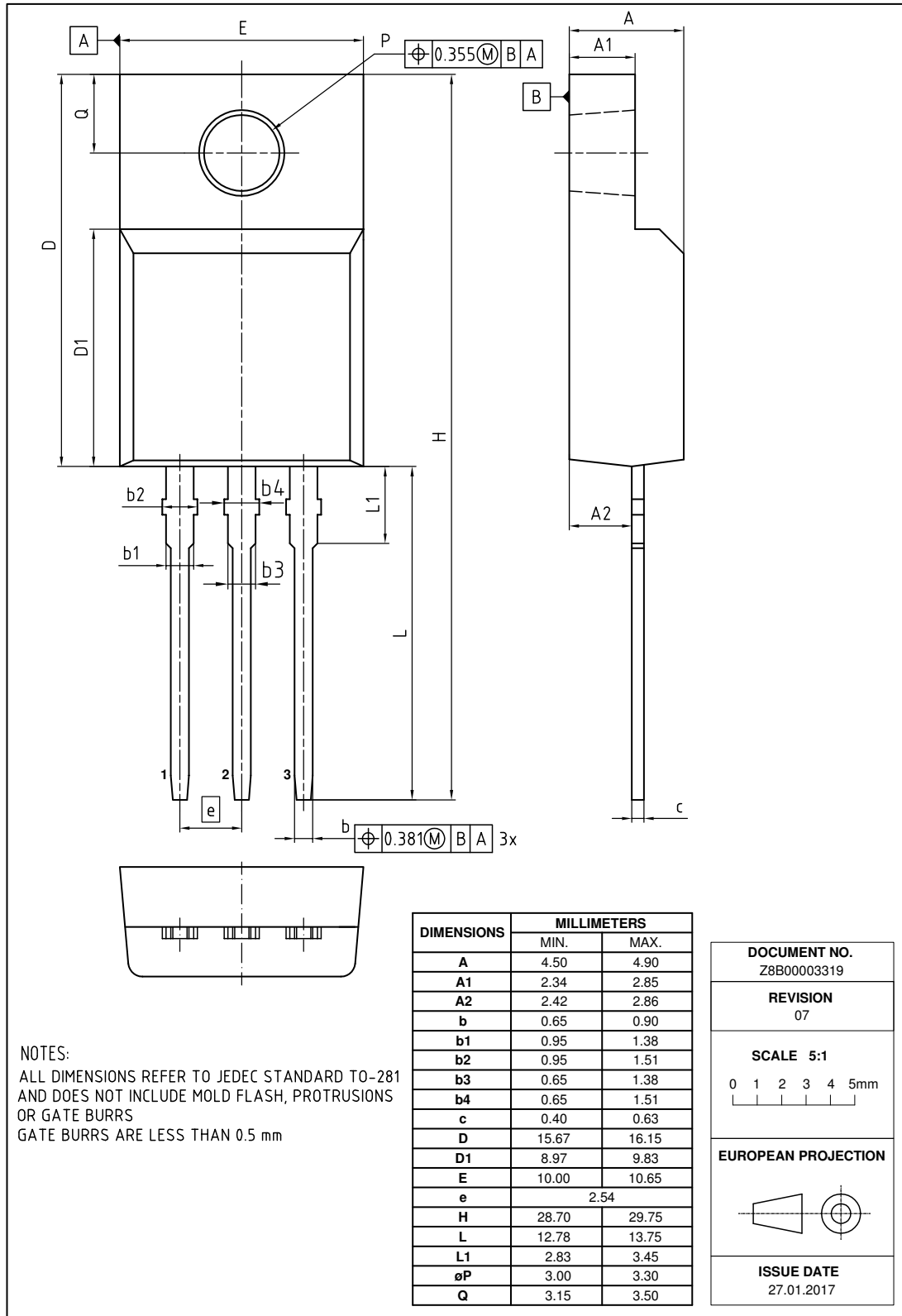
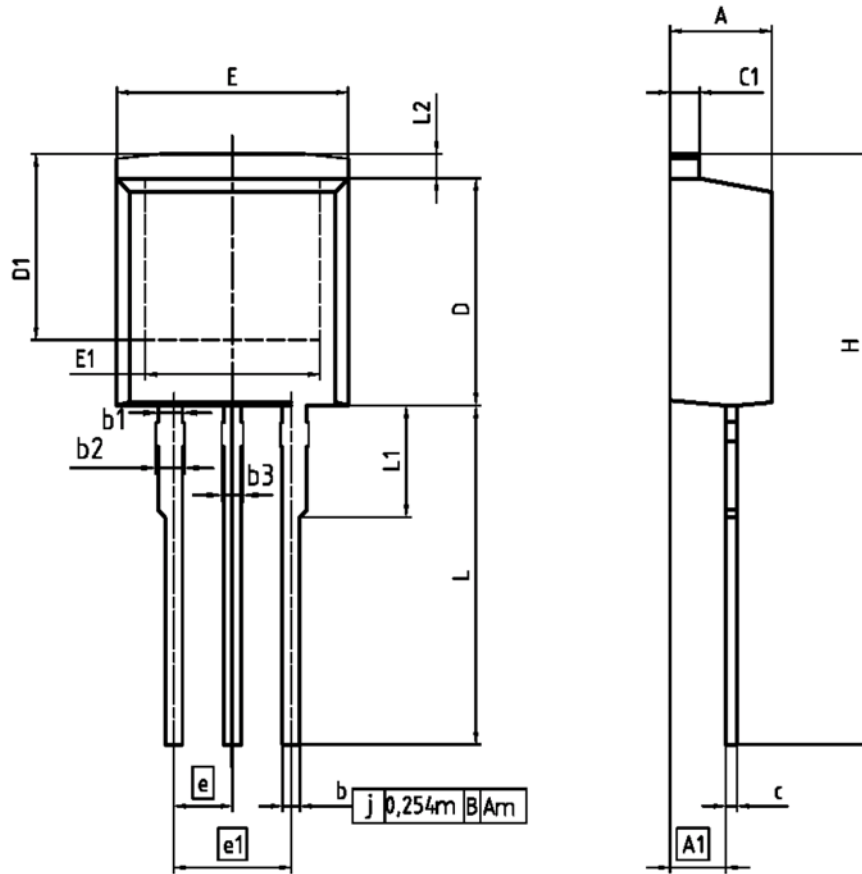


Figure 3 Outline PG-TO-220 FullPAK dimensions in mm





DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	4.300	4.572	0.169	0.180
A1	2.150	2.718	0.085	0.107
b	0.650	0.864	0.026	0.034
b1	0.950	1.093	0.037	0.043
b2	0.950	1.400	0.037	0.055
b3	0.650	1.118	0.026	0.044
c	0.330	0.600	0.013	0.024
c1	1.170	1.400	0.046	0.055
D	8.509	8.450	0.335	0.372
D1	6.900	-	0.272	-
E	9.700	10.363	0.382	0.408
E1	6.500	8.600	0.256	0.339
e	2.540		0.100	
e1	5.080		0.200	
N	3		3	
L	13.000	14.000	0.512	0.551
L1	-	4.800	-	0.189
L2	-	1.727	-	0.068

REFERENCE  
JEDEC TO262

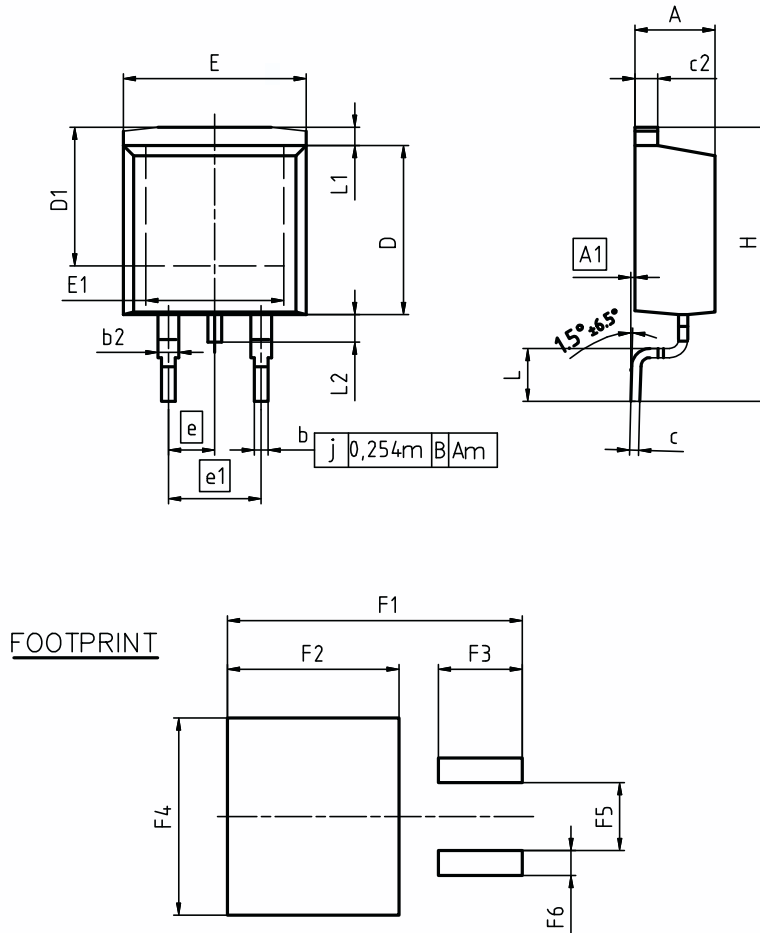
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Figure 4 Outlines TO-262, dimensions in mm/inches



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	4.30	4.57	0.169	0.180
A1	0.00	0.25	0.000	0.010
b	0.65	0.85	0.026	0.033
b2	0.95	1.15	0.037	0.045
c	0.33	0.65	0.013	0.026
c2	1.17	1.40	0.046	0.055
D	8.51	9.45	0.335	0.372
D1	7.10	7.90	0.280	0.311
E	9.80	10.31	0.386	0.406
E1	6.50	8.60	0.256	0.339
e	2.54		0.100	
e1	5.08		0.200	
N	2		2	
H	14.61	15.88	0.575	0.625
L	2.29	3.00	0.090	0.118
L1	0.70	1.60	0.028	0.063
L2	1.00	1.78	0.039	0.070
F1	16.05	16.25	0.632	0.640
F2	9.30	9.50	0.366	0.374
F3	4.50	4.70	0.177	0.185
F4	10.70	10.90	0.421	0.429
F5	3.85	3.85	0.144	0.152
F6	1.25	1.45	0.049	0.057

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Figure 5 Outlines TO-263, dimensions in mm/inches

# 600V CoolMOS™ C6 Power Transistor

## IPx60R190C6

### Revision History

IPx60R190C6

**Revision: 2018-03-04, Rev. 2.3**

Previous Revision

Revision	Date	Subjects (major changes since last revision)
2.0	2011-06-08	Release of final data sheet
2.1	2011-09-14	-
2.2	2015-02-09	PG-TO220 FullPAK package outline update (creation:2014-12-02)
2.3	2018-03-04	Outline PG-TO220 FullPAK update

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[SSM6P54TU,LF](#) [SSM6P69NU,LF](#) [DMP22D4UFO-7B](#)