

# MOSFET

Metal Oxide Semiconductor Field Effect Transistor

## CoolMOS C6

600V CoolMOS™ C6 Power Transistor  
IPW60R041C6

## Data Sheet

Rev. 2.1, 2010-07-12  
Final

Industrial & Multimarket

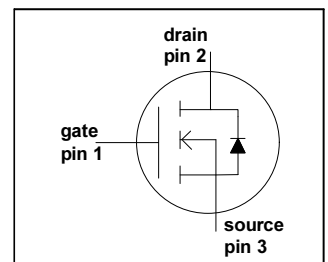
## 1 Description

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
$R_{DS(on),max}$	0.041	$\Omega$
$Q_{g,typ}$	290	nC
$I_{D,pulse}$	272	A
$E_{oss} @ 400V$	22	$\mu J$
Body diode $di/dt$	300	A/ $\mu s$

### Related Links

- [IFX C6 Product Brief](#)
- [IFX C6 Portfolio](#)
- [IFX CoolMOS Webpage](#)
- [IFX Design tools](#)

Type	Package	Marking
IPW60R041C6	PG-TO247	6R041C6

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>	$I_D$	-	-	77.5	A	$T_C = 25\text{ °C}$
				49		$T_C = 100\text{ °C}$
Pulsed drain current <sup>2)</sup>	$I_{D,pulse}$	-	-	272	A	$T_C = 25\text{ °C}$
Avalanche energy, single pulse	$E_{AS}$	-	-	1954	mJ	$I_D = 13.4\text{ A}, V_{DD} = 50\text{ V}$ (see table 17)
Avalanche energy, repetitive	$E_{AR}$	-	-	2.96		$I_D = 13.4\text{ A}, V_{DD} = 50\text{ V}$
Avalanche current, repetitive	$I_{AR}$	-	-	13.4	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	$P_{tot}$	-	-	481	W	$T_C = 25\text{ °C}$
Operating and storage temperature	$T_j, T_{stg}$	-55	-	150	°C	
Mounting torque		-	-	60	Ncm	M3 and M3.5 screws
Continuous diode forward current	$I_S$	-	-	67.2	A	$T_C = 25\text{ °C}$
Diode pulse current <sup>2)</sup>	$I_{S,pulse}$	-	-	272	A	$T_C = 25\text{ °C}$
Reverse diode dv/dt <sup>3)</sup>	dv/dt	-	-	15	V/ns	$V_{DS} = 0 \dots 400\text{ V}, I_{SD} \leq I_D,$ $T_j = 25\text{ °C}$
Maximum diode commutation speed <sup>3)</sup>	$di/dt$	-	-	300	A/ $\mu\text{s}$	(see table 18)

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-247**

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Thermal resistance, junction - case	$R_{thJC}$	-	-	0.26	°C/W	
Thermal resistance, junction - ambient	$R_{thJA}$	-	-	62		leaded
Soldering temperature, wavesoldering only allowed at leads	$T_{sold}$	-	-	260	°C	1.6 mm (0.063 in.) from case for 10 s

## 4 Electrical characteristics

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

**Table 4 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		$V_{DS}=V_{GS}$ , $I_D=2.96\text{ mA}$
Zero gate voltage drain current	$I_{DSS}$	-	-	5	$\mu\text{A}$	$V_{DS}=600\text{ V}$ , $V_{GS}=0\text{ V}$ , $T_J=25\text{ °C}$
		-	50	-		$V_{DS}=600\text{ V}$ , $V_{GS}=0\text{ V}$ , $T_J=150\text{ °C}$
Gate-source leakage current	$I_{GSS}$	-	-	100	nA	$V_{GS}=20\text{ V}$ , $V_{DS}=0\text{ V}$
Drain-source on-state resistance	$R_{DS(on)}$	-	0.037	0.041	$\Omega$	$V_{GS}=10\text{ V}$ , $I_D=44.4\text{ A}$ , $T_J=25\text{ °C}$
		-	0.096	-		$V_{GS}=10\text{ V}$ , $I_D=44.4\text{ A}$ , $T_J=150\text{ °C}$
Gate resistance	$R_G$	-	0.7	-	$\Omega$	$f=1\text{ MHz}$ , open drain

**Table 5 Dynamic characteristics**

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Input capacitance	$C_{iss}$	-	6530	-	pF	$V_{GS}=0\text{ V}$ , $V_{DS}=100\text{ V}$ , $f=1\text{ MHz}$
Output capacitance	$C_{oss}$	-	360	-		
Effective output capacitance, energy related <sup>1)</sup>	$C_{o(er)}$	-	235	-		
Effective output capacitance, time related <sup>2)</sup>	$C_{o(tr)}$	-	1210	-		$I_D=\text{constant}$ , $V_{GS}=0\text{ V}$ $V_{DS}=0\dots480\text{ V}$
Turn-on delay time	$t_{d(on)}$	-	23	-	ns	$V_{DD}=400\text{ V}$ , $V_{GS}=13\text{ V}$ , $I_D=44.4\text{ A}$ , $R_G=1.7\Omega$ (see table 16)
Rise time	$t_r$	-	10	-		
Turn-off delay time	$t_{d(off)}$	-	130	-		
Fall time	$t_f$	-	7	-		

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 6 Gate charge characteristics**

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Gate to source charge	$Q_{gs}$	-	36	-	nC	$V_{DD}=480\text{ V}$ , $I_D=44.4\text{ A}$ , $V_{GS}=0\text{ to }10\text{ V}$
Gate to drain charge	$Q_{gd}$	-	150	-		
Gate charge total	$Q_g$	-	290	-		
Gate plateau voltage	$V_{plateau}$	-	5.4	-	V	

**Table 7 Reverse diode characteristics**

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Diode forward voltage	$V_{SD}$	-	0.9	-	V	$V_{GS}=0\text{ V}$ , $I_F=44.4\text{ A}$ , $T_j=25\text{ °C}$
Reverse recovery time	$t_{rr}$	-	950	-	ns	$V_R=400\text{ V}$ , $I_F=44.4\text{ A}$ ,
Reverse recovery charge	$Q_{rr}$	-	32	-	$\mu\text{C}$	$di_F/dt=100\text{ A}/\mu\text{s}$ (see table 18)
Peak reverse recovery current	$I_{rrm}$	-	62	-	A	

5 Electrical characteristics diagrams

Table 8

Power dissipation	Max. transient thermal impedance
$P_{tot} = f(T_c)$	$Z_{th(jc)} = f(t_p)$ ; parameter: $D = t_p / T$

Table 9

Safe operating area $T_c = 25\text{ °C}$	Safe operating area $T_c = 80\text{ °C}$
$I_D = f(V_{DS}); T_c = 25\text{ °C}; D = 0$ ; parameter $t_p$	$I_D = f(V_{DS}); T_c = 80\text{ °C}; D = 0$ ; parameter $t_p$

Table 10

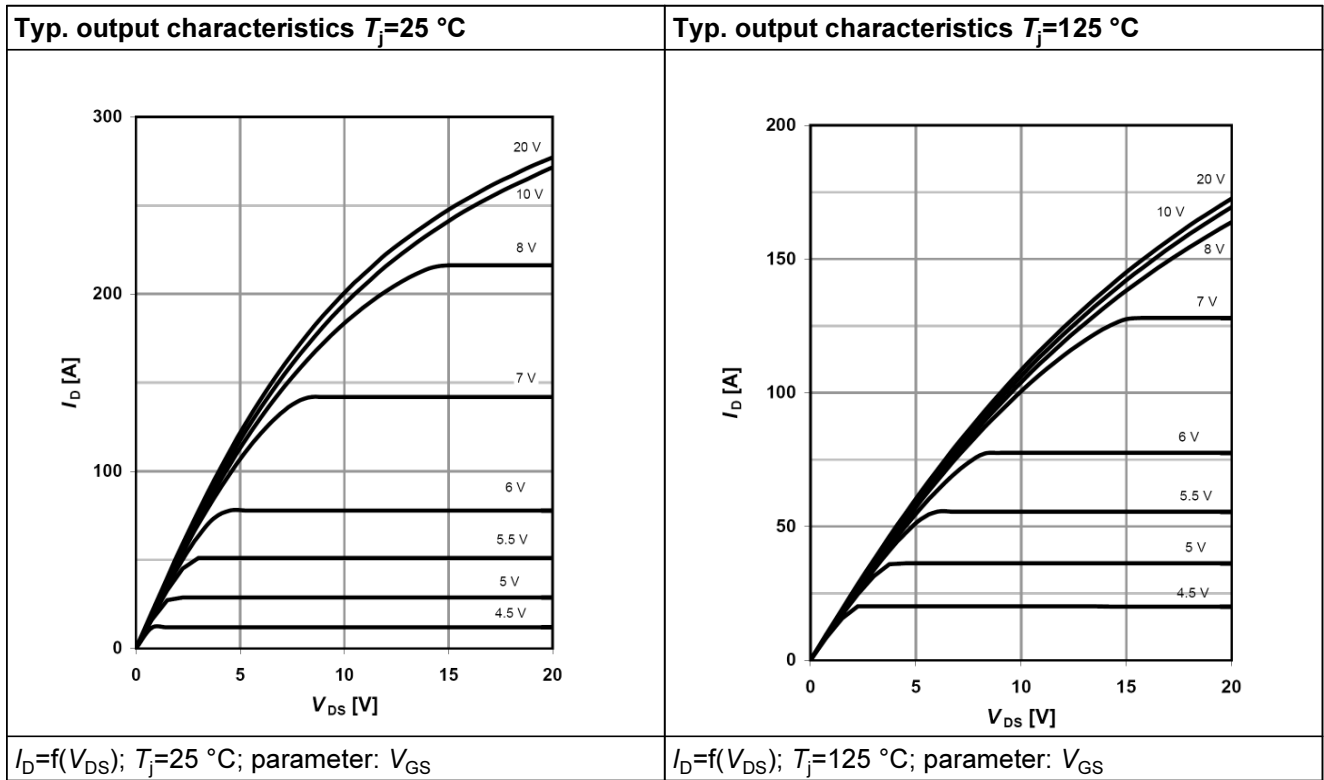


Table 11

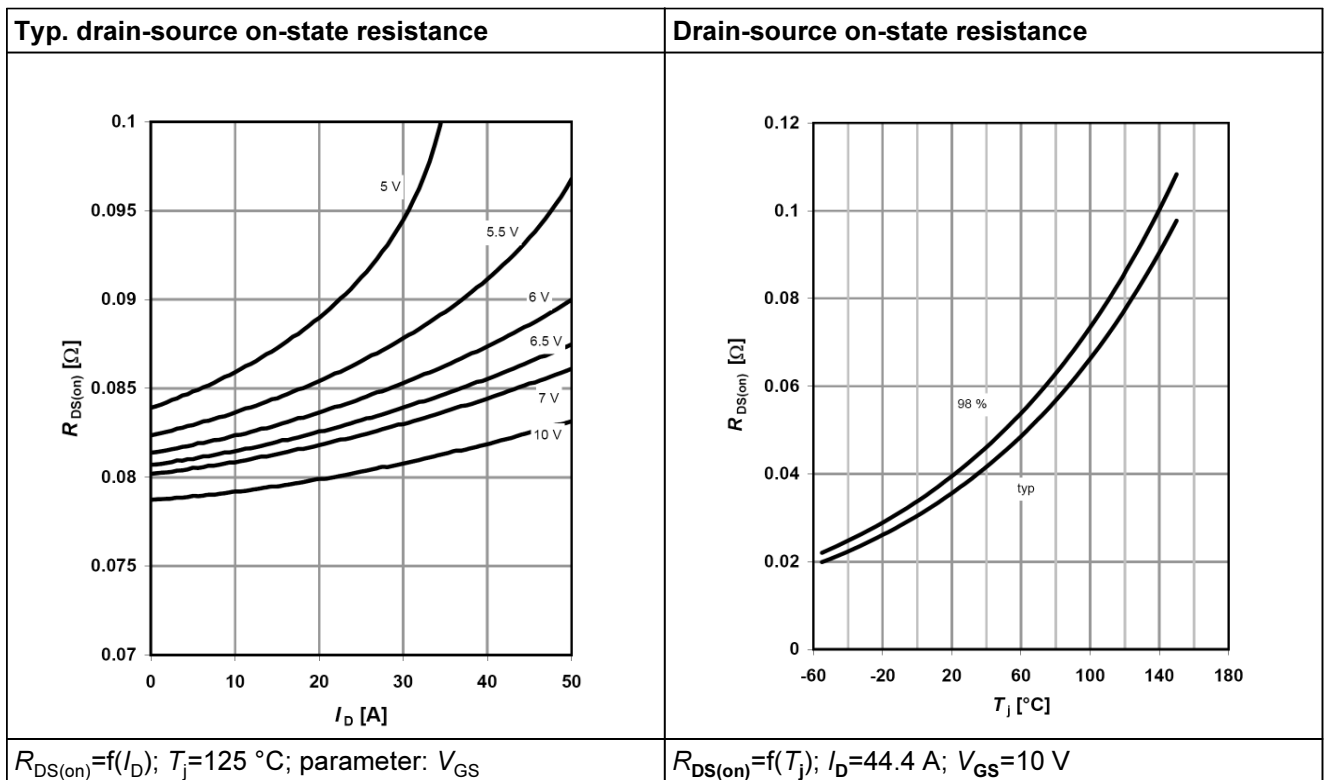




Table 12

Typ. transfer characteristics	Typ. gate charge
$I_D = f(V_{GS}); V_{DS} = 20V$	$V_{GS} = f(Q_{gate}); I_D = 44.4 \text{ A pulsed}$

Table 13

Avalanche energy	Drain-source breakdown voltage
$E_{AS} = f(T_j); I_D = 13.4 \text{ A}; V_{DD} = 50 \text{ V}$	$V_{BR(DSS)} = f(T_j); I_D = 0.25 \text{ mA}$

Table 14

Typ. capacitances	Typ. $C_{oss}$ stored energy
<p>The graph shows three capacitance curves against drain-source voltage <math>V_{DS}</math> from 0 to 600 V. The y-axis is capacitance <math>C</math> in pF on a logarithmic scale from <math>10^0</math> to <math>10^5</math>. <math>C_{iss}</math> is a horizontal line at <math>10^4</math> pF. <math>C_{oss}</math> starts at <math>10^4</math> pF and drops to <math>10^2</math> pF. <math>C_{rss}</math> starts at <math>10^4</math> pF, drops to a minimum of <math>10^1</math> pF at 100 V, and then rises to <math>10^2</math> pF at 600 V.</p>	<p>The graph shows stored energy <math>E_{oss}</math> in <math>\mu J</math> against <math>V_{DS}</math> from 0 to 600 V. The y-axis is linear from 0 to 40. The curve starts at (0,0) and increases to approximately 35 <math>\mu J</math> at 600 V.</p>
<p><math>C=f(V_{DS}); V_{GS}=0\text{ V}; f=1\text{ MHz}</math></p>	<p><math>E_{Oss}=f(V_{DS})</math></p>

Table 15

Forward characteristics of reverse diode
<p>The graph shows forward current <math>I_F</math> in A against reverse diode voltage <math>V_{SD}</math> from 0 to 2 V. The y-axis is logarithmic from <math>10^{-1}</math> to <math>10^3</math>. Two curves are shown for <math>125^\circ\text{C}</math> and <math>25^\circ\text{C}</math>. The <math>125^\circ\text{C}</math> curve is shifted to the left of the <math>25^\circ\text{C}</math> curve, indicating higher current for the same voltage at higher temperature.</p>
<p><math>I_F=f(V_{SD}); \text{parameter: } T_j</math></p>

## 6 Test circuits

Table 16 Switching times test circuit and waveform for inductive load

Switching times test circuit for inductive load	Switching time waveform

Table 17 Unclamped inductive load test circuit and waveform

Unclamped inductive load test circuit	Unclamped inductive waveform

Table 18 Test circuit and waveform for diode characteristics

Test circuit for diode characteristics	Diode recovery waveform

7 Package outlines

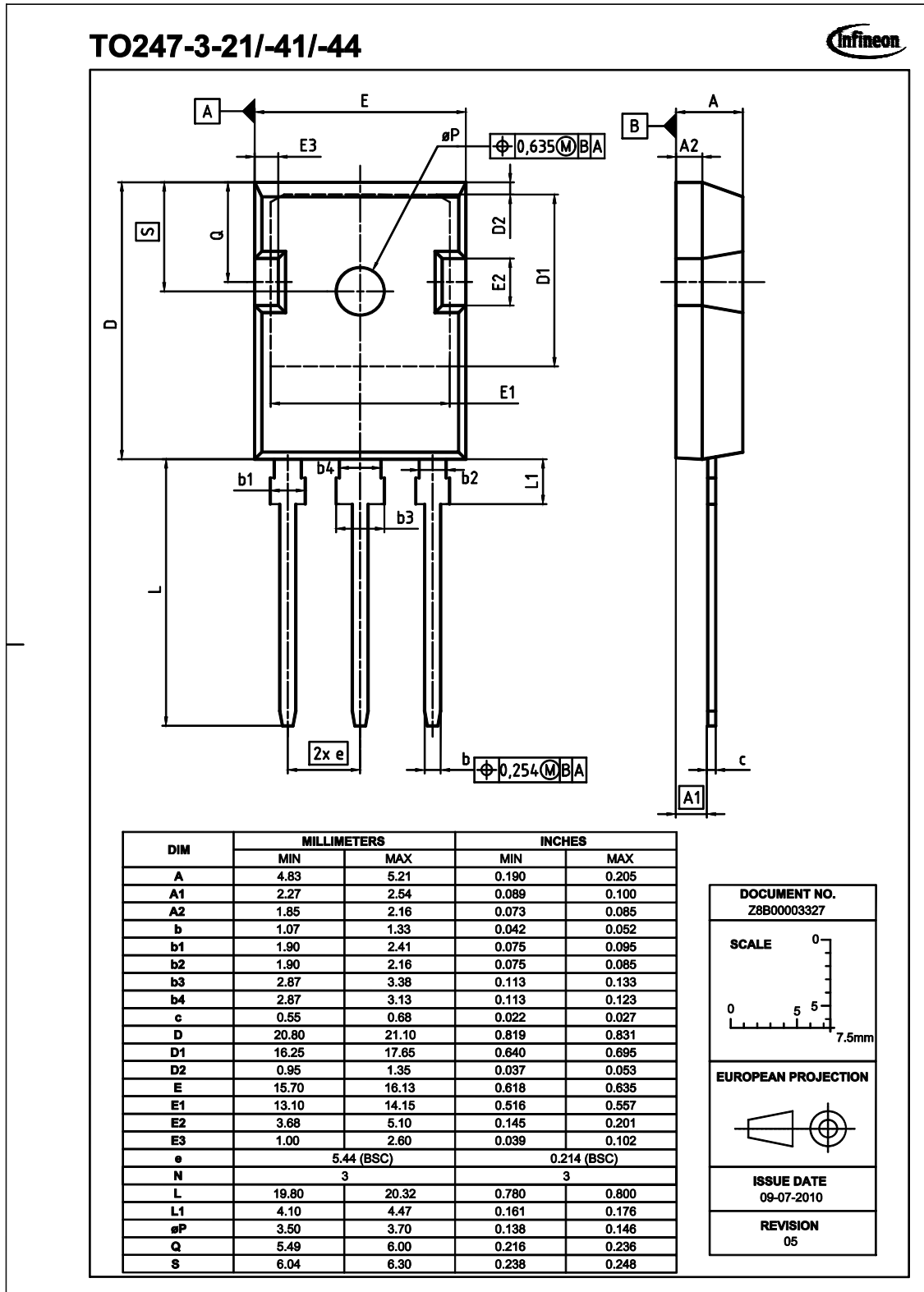


Figure 1 Outlines TO-247, dimensions in mm/inches

## 8 Revision History


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