

# DATA SHEET

## **LBE2003S; LBE2009S; LCE2009S** NPN microwave power transistors

Product specification  
Supersedes data of November 1994  
File under Discrete Semiconductors, SC15

1997 Mar 03

NPN microwave power transistors

LBE2003S;  
LBE2009S; LCE2009S

FEATURES

- Diffused emitter ballasting resistors
- Self-aligned process entirely ion implanted and gold metallization
- Optimum temperature profile
- Excellent performance and reliability.

APPLICATIONS

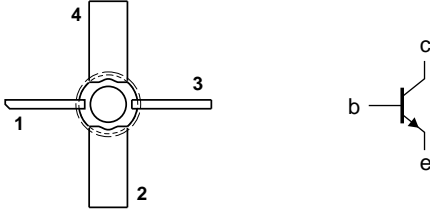
- Common emitter class-A linear power amplifiers up to 4 GHz.

DESCRIPTION

The LBE2003S and LBE2009S are NPN silicon planar epitaxial microwave power transistors in a SOT441A metal ceramic studless package. The LCE2009S is a maintenance type in a SOT442A metal ceramic capstan package.

PINNING

PIN	DESCRIPTION
1	collector
2	emitter
3	base
4	emitter

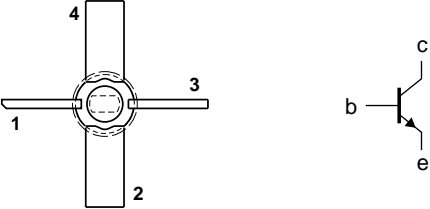


Top view

MAM329

Marking code: LBE2003S = 407; LBE2009S = 409.

Fig.1 Simplified outline and symbol (SOT441A).



Top view

MAM330

Marking code: LCE2009S = 408.

Fig.2 Simplified outline and symbol (SOT442A).

QUICK REFERENCE DATA

Microwave performance up to  $T_{mb} = 25\text{ }^{\circ}\text{C}$  in a common emitter class-A amplifier.

TYPE NUMBER	MODE OF OPERATION	f (GHz)	$V_{CE}$ (V)	$I_C$ (mA)	$P_{L1}$ (mW)	$G_{po}$ (dB)	$Z_i$ ( $\Omega$ )	$Z_L$ ( $\Omega$ )
LBE2003S	Class-A (CW) linear	2	18	30	$\geq 200$	$\geq 10$	$6.2 + j30$	$17.5 + j7$
LBE2009S	Class-A (CW) linear	2	18	110	$\geq 700$	$\geq 9$	$7.5 + j15$	$17.5 + j39$
LCE2009S								

WARNING

Product and environmental safety - toxic materials

This product contains beryllium oxide. The product is entirely safe provided that the BeO disc is not damaged. All persons who handle, use or dispose of this product should be aware of its nature and of the necessary safety precautions. After use, dispose of as chemical or special waste according to the regulations applying at the location of the user. It must never be thrown out with the general or domestic waste.

LCE2009S IS A MAINTENANCE TYPE - NOT RECOMMENDED FOR NEW DESIGNS; SEE INDEX SECTION OF SC15

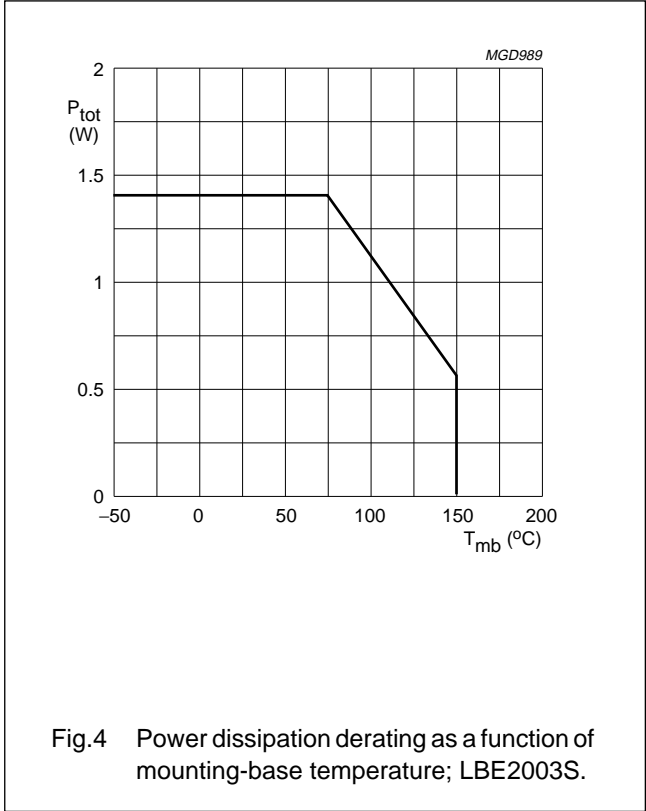
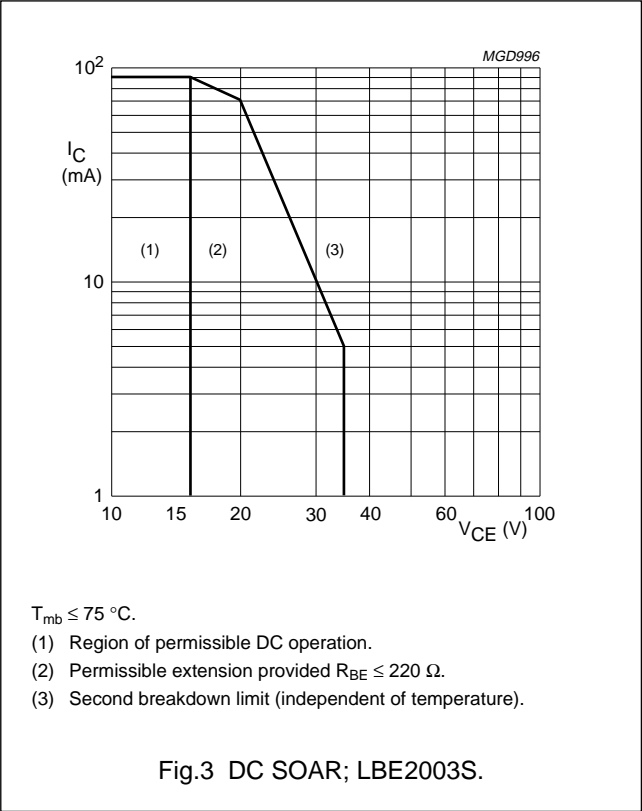
NPN microwave power transistors

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LIMITING VALUES

In accordance with the Absolute Maximum Rating System (IEC 134).

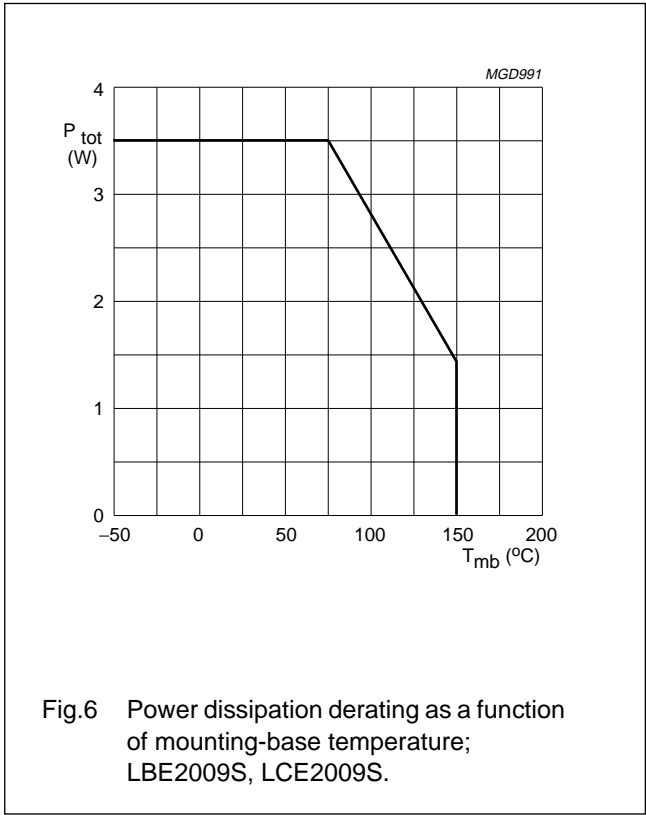
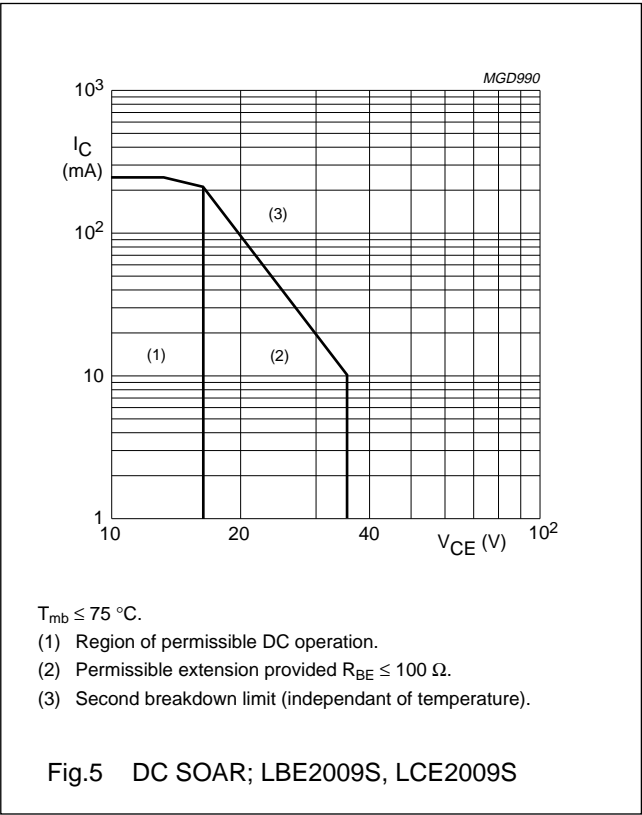
SYMBOL	PARAMETER	CONDITIONS	MIN.	MAX.	UNIT
V <sub>CBO</sub>	collector-base voltage	open emitter		40	V
V <sub>CER</sub>	collector-emitter voltage LBE2003S LBE2009S; LCE2009S	R <sub>BE</sub> = 220 Ω	–	35	V
		R <sub>BE</sub> = 100 Ω	–	35	V
V <sub>CEO</sub>	collector-emitter voltage	open base	–	16	V
V <sub>EBO</sub>	emitter-base voltage	open collector	–	3	V
I <sub>C</sub>	collector current (DC) LBE2003S LBE2009S; LCE2009S		–	90	mA
			–	250	mA
P <sub>tot</sub>	total power dissipation LBE2003S LBE2009S; LCE2009S	T <sub>mb</sub> ≤ 75 °C	–	1.4	W
			–	3.5	W
T <sub>stg</sub>	storage temperature		–65	+150	°C
T <sub>j</sub>	operating junction temperature		–	200	°C
T <sub>sld</sub>	soldering temperature	at 0.3 mm from case; t = 10 s	–	235	°C



LCE2009S IS A MAINTENANCE TYPE - NOT RECOMMENDED FOR NEW DESIGNS; SEE INDEX SECTION OF SC15

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THERMAL CHARACTERISTICS

SYMBOL	PARAMETER	CONDITIONS	MAX.	UNIT
$R_{th\ j-mb}$	thermal resistance from junction to mounting-base	$T_j = 75^\circ\text{C}$ ; note 1		
	LBE2003S		65	K/W
	LBE2009S; LCE2009S		36	K/W
$R_{th\ mb-h}$	thermal resistance from mounting-base to heatsink	$T_j = 75^\circ\text{C}$ ; note 1	1.5	K/W

Note

1. See “Mounting recommendations in the General part of handbook SC15”.

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## NPN microwave power transistors

LBE2003S; LBE2009S;  
LCE2009S

## CHARACTERISTICS

 $T_{mb} = 25\text{ }^{\circ}\text{C}$  unless otherwise specified.

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
$I_{CBO}$	collector cut-off current	$V_{CB} = 20\text{ V}; I_E = 0$	—	—	0.1	$\mu\text{A}$
$I_{CBO}$	collector cut-off current	$V_{CB} = 40\text{ V}; I_E = 0$	—	—	150	$\mu\text{A}$
	LBE2003S		—	—	250	$\mu\text{A}$
	LBE2009S; LCE2009S		—	—	250	$\mu\text{A}$
$I_{CER}$	collector cut-off current	$V_{CB} = 35\text{ V}; R_{BE} = 220\text{ }\Omega$	—	—	500	$\mu\text{A}$
	LBE2003S	$V_{CB} = 35\text{ V}; R_{BE} = 100\text{ }\Omega$	—	—	1000	$\mu\text{A}$
	LBE2009S; LCE2009S		—	—	1000	$\mu\text{A}$
$I_{EBO}$	emitter cut-off current	$V_{EB} = 1.5\text{ V}; I_C = 0$	—	—	0.05	$\mu\text{A}$
	LBE2003S		—	—	0.2	$\mu\text{A}$
	LBE2009S; LCE2009S		—	—	0.2	$\mu\text{A}$
$h_{FE}$	DC current gain	$V_{CE} = 5\text{ V}; I_C = 30\text{ mA}$	15	—	150	
		$V_{CE} = 5\text{ V}; I_C = 110\text{ mA}$	15	—	150	
$C_{cb}$	collector-base capacitance	$V_{CB} = 18\text{ V}; V_{EB} = 1.5\text{ V};$ $I_E = I_C = 0; f = 1\text{ MHz}$	—	0.3	—	pF
	LBE2003S		—	0.6	—	pF
	LBE2009S; LCE2009S		—	0.6	—	pF
$C_{ce}$	collector-emitter capacitance	$V_{CE} = 18\text{ V}; V_{EB} = 1.5\text{ V};$ $I_E = I_C = 0; f = 1\text{ MHz}$	—	0.45	—	pF
	LBE2003S		—	0.6	—	pF
	LBE2009S; LCE2009S		—	0.6	—	pF
$C_{eb}$	emitter-base capacitance	$V_{CB} = 10\text{ V}; V_{EB} = 1\text{ V};$ $I_E = I_C = 0; f = 1\text{ MHz}$	—	1.7	—	pF
	LBE2003S		—	3.3	—	pF
	LBE2009S; LCE2009S		—	3.3	—	pF

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## NPN microwave power transistors

LBE2003S; LBE2009S;  
LCE2009S**Table 1** Scattering parameters LBE2003S:  $V_{CE} = 18\text{ V}$ ;  $I_C = 30\text{ mA}$  ( $V_{CE}$  and  $I_C$  regulated);  $T_{mb} = 25\text{ °C}$ ;  $Z_0 = 50\text{ }\Omega$ ; typical values. (The figures given between brackets are values in dB).

f (MHz)	S <sub>11</sub>		S <sub>21</sub>		S <sub>12</sub>		S <sub>22</sub>	
	MAGNITUDE (ratio)	ANGLE (deg)	MAGNITUDE (ratio)	ANGLE (deg)	MAGNITUDE (ratio)	ANGLE (deg)	MAGNITUDE (ratio)	ANGLE (deg)
500	0.56	-143	0.037 (-28.6)	41	9.50 (19.6)	101	0.56	-34
600	0.55	-154	0.040 (-28.0)	39	8.28 (18.4)	93	0.51	-35
700	0.55	-164	0.040 (-27.9)	40	7.13 (17.1)	88	0.50	-36
800	0.55	-171	0.041 (-27.7)	40	6.35 (16.1)	82	0.49	-37
900	0.55	-178	0.043 (-27.4)	41	5.69 (15.1)	77	0.47	-38
1000	0.55	176	0.045 (-26.9)	40	5.14 (14.2)	72	0.46	-39
1100	0.55	170	0.048 (-26.4)	40	4.72 (13.5)	68	0.46	-39
1200	0.55	165	0.051 (-25.9)	41	4.37 (12.8)	64	0.45	-41
1300	0.56	159	0.056 (-25.1)	41	4.05 (12.2)	60	0.44	-44
1400	0.55	158	0.060 (-24.5)	41	3.76 (11.5)	57	0.45	-46
1500	0.55	149	0.062 (-24.2)	40	3.52 (10.9)	53	0.43	-48
1600	0.55	146	0.065 (-23.8)	42	3.33 (10.5)	50	0.43	-50
1700	0.56	142	0.068 (-23.3)	42	3.15 (10.0)	46	0.43	-53
1800	0.57	137	0.070 (-23.1)	41	2.96 (9.4)	42	0.43	-54
1900	0.57	132	0.072 (-22.9)	40	2.80 (8.9)	39	0.43	-56
2000	0.58	128	0.074 (-22.7)	40	2.66 (8.5)	36	0.42	-57
2200	0.60	121	0.081 (-21.8)	39	2.43 (7.7)	28	0.41	-61
2400	0.62	114	0.091 (-20.8)	37	2.24 (7.0)	23	0.40	-67
2600	0.64	108	0.099 (-20.1)	36	2.08 (6.4)	16	0.39	-75
2800	0.66	102	0.105 (-19.6)	33	1.90 (5.6)	10	0.38	-82
3000	0.68	96	0.108 (-19.4)	31	1.79 (5.1)	4	0.39	-87
3200	0.71	92	0.124 (-18.7)	29	1.63 (4.3)	-2	0.37	-94
3400	0.73	89	0.125 (-18.0)	27	1.58 (4.0)	-7	0.40	-101
3600	0.75	86	0.137 (-17.3)	25	1.46 (3.3)	-13	0.39	-112
3800	0.76	82	0.142 (-17.0)	23	1.40 (2.9)	-18	0.38	-120
4000	0.77	79	0.149 (-16.6)	20	1.31 (2.3)	-24	0.38	-128
4200	0.78	75	0.155 (-16.2)	17	1.25 (1.9)	-28	0.38	-133
4400	0.80	73	0.167 (-15.5)	15	1.20 (1.6)	-34	0.39	-142
4600	0.81	69	0.177 (-15.0)	12	1.14 (1.1)	-38	0.39	-151
4800	0.81	68	0.187 (-14.6)	10	1.10 (0.8)	-43	0.42	-159
5000	0.81	65	0.194 (-14.3)	6	1.04 (0.4)	-47	0.44	-165
5200	0.80	60	0.203 (-13.8)	4	1.03 (0.3)	-53	0.47	-169
5400	0.81	56	0.219 (-13.2)	-1	0.98 (-0.2)	-57	0.48	-175
5600	0.81	51	0.229 (-12.8)	-3	0.97 (-0.3)	-62	0.49	-178
5800	0.81	48	0.243 (-12.3)	-8	0.92 (-0.7)	-68	0.51	-171
6000	0.80	44	0.245 (-12.2)	-12	0.90 (-0.9)	-72	0.55	-165

## NPN microwave power transistors

LBE2003S; LBE2009S;  
LCE2009S**Table 2** Scattering parameters LBE2009S; LCE2009S:  $V_{CE} = 18\text{ V}$ ;  $I_C = 110\text{ mA}$  ( $V_{CE}$  and  $I_C$  regulated);  $T_{mb} = 25\text{ °C}$ ;  $Z_0 = 50\text{ }\Omega$ ; typical values. (The figures given between brackets are values in dB).

f (MHz)	S <sub>11</sub>		S <sub>21</sub>		S <sub>12</sub>		S <sub>22</sub>	
	MAGNITUDE (ratio)	ANGLE (deg)	MAGNITUDE (ratio)	ANGLE (deg)	MAGNITUDE (ratio)	ANGLE (deg)	MAGNITUDE (ratio)	ANGLE (deg)
500	0.70	177	0.029 (–30.7)	50	7.55 (17.6)	83	0.25	–48
600	0.70	171	0.033 (–29.6)	51	6.43 (16.2)	77	0.22	–50
700	0.70	168	0.036 (–29.0)	53	5.46 (14.6)	73	0.23	–52
800	0.70	163	0.039 (–28.4)	54	4.80 (13.6)	68	0.22	–54
900	0.71	159	0.041 (–27.8)	54	4.27 (12.6)	64	0.22	–56
1000	0.71	155	0.045 (–27.0)	55	3.84 (11.7)	60	0.21	–59
1100	0.71	151	0.049 (–26.2)	54	3.53 (11.0)	56	0.21	–62
1200	0.71	148	0.054 (–25.4)	54	3.27 (10.3)	52	0.21	–65
1300	0.71	144	0.060 (–24.5)	53	3.01 (9.6)	48	0.20	–74
1400	0.72	143	0.066 (–23.6)	54	2.80 (9.0)	45	0.20	–79
1500	0.72	136	0.070 (–23.1)	52	2.61 (8.3)	41	0.21	–80
1600	0.72	133	0.075 (–22.5)	53	2.47 (7.9)	38	0.21	–83
1700	0.72	130	0.080 (–21.9)	51	2.33 (7.3)	34	0.22	–87
1800	0.73	127	0.084 (–21.5)	49	2.18 (6.8)	30	0.22	–90
1900	0.73	123	0.087 (–21.2)	48	2.05 (6.3)	26	0.22	–94
2000	0.74	120	0.090 (–20.9)	46	1.97 (5.9)	23	0.22	–97
2200	0.75	114	0.100 (–20.0)	43	1.78 (5.0)	15	0.22	–109
2400	0.77	108	0.112 (–19.0)	40	1.63 (4.3)	10	0.21	–122
2600	0.79	103	0.123 (–18.2)	37	1.51 (3.6)	2	0.24	–133
2800	0.80	97	0.129 (–17.8)	33	1.36 (2.7)	–4	0.25	–143
3000	0.81	92	0.134 (–17.5)	30	1.28 (2.1)	–11	0.27	–151
3200	0.83	88	0.143 (–16.9)	26	1.15 (1.2)	–17	0.28	–163
3400	0.85	85	0.152 (–16.4)	24	1.10 (0.9)	–21	0.30	–173
3600	0.86	82	0.163 (–15.8)	20	1.00 (0)	–28	0.34	178
3800	0.87	79	0.168 (–15.5)	17	0.96 (–0.4)	–32	0.37	173
4000	0.88	75	0.175 (–15.2)	14	0.88 (–1.1)	–39	0.41	168
4200	0.88	71	0.180 (–14.9)	11	0.83 (–1.6)	–42	0.42	162
4400	0.89	69	0.193 (–14.3)	8	0.79 (–2.1)	–48	0.45	155
4600	0.90	66	0.200 (–14.0)	5	0.74 (–2.6)	–51	0.48	149
4800	0.90	64	0.211 (–13.5)	2	0.71 (–3.0)	–56	0.52	145
5000	0.90	61	0.214 (–13.4)	–2	0.66 (–3.6)	–59	0.55	144

LCE2009S IS A MAINTENANCE TYPE - NOT RECOMMENDED FOR NEW DESIGNS; SEE INDEX SECTION OF SC15

NPN microwave power transistors

LBE2003S; LBE2009S;  
LCE2009S

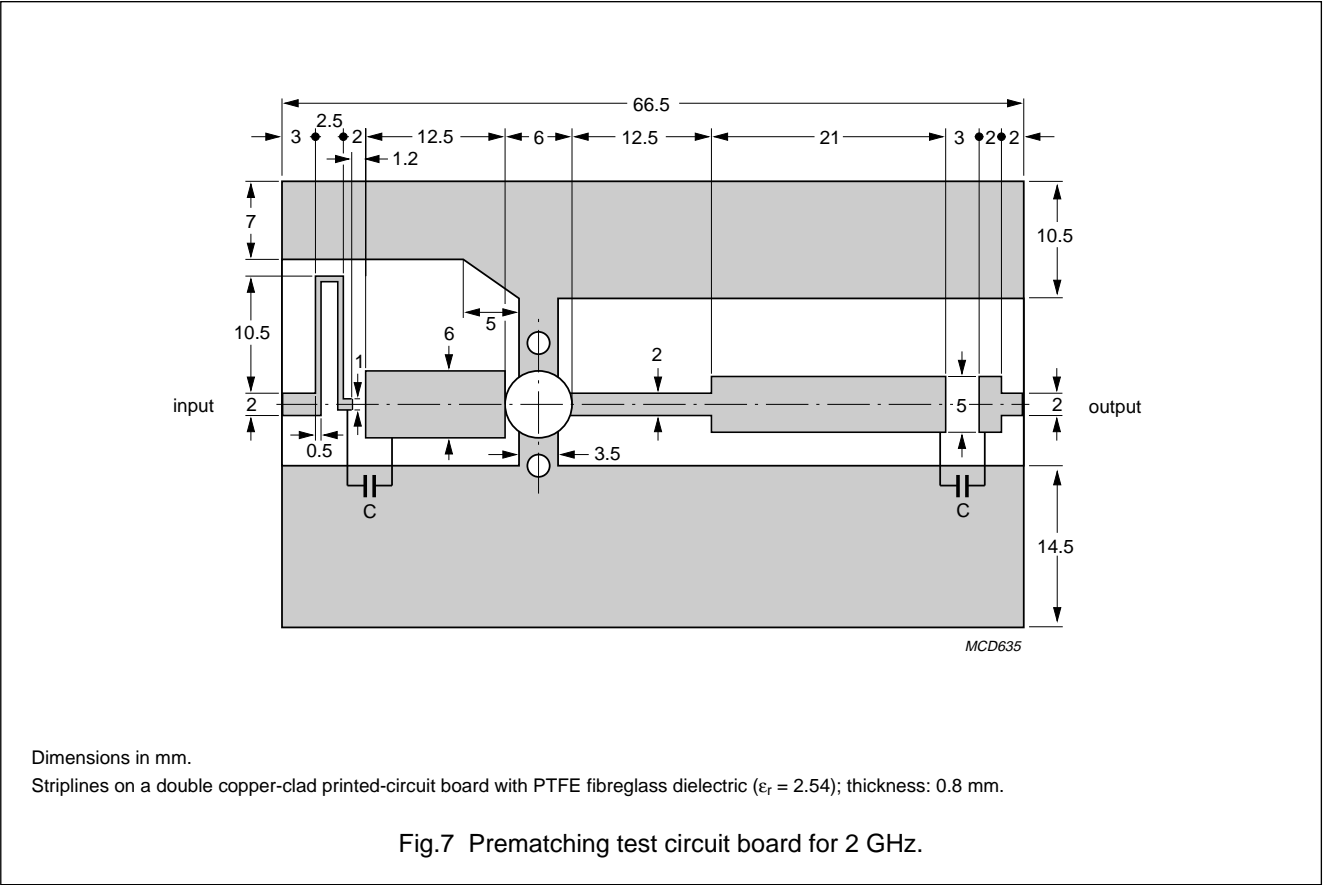
APPLICATION INFORMATION

Microwave performance for LBE2003S up to  $T_{mb} = 25\text{ }^{\circ}\text{C}$  in a common emitter class-A test circuit; note 1.

MODE OF OPERATION	f (GHz)	V <sub>CE</sub> (V) <sup>(2)</sup>	I <sub>C</sub> (mA) <sup>(2)</sup>	P <sub>L1</sub> (mW) <sup>(3)</sup>	G <sub>po</sub> (dB) <sup>(4)</sup>	Z <sub>i</sub> (Ω)	Z <sub>L</sub> (Ω)
Class-A (CW)	2	18	30	≥200 (23) typ. 250 (24)	≥10 typ. 11	6.2 + j30	17.5 + j7

Notes

1. Circuit consists of prematching circuit boards in combination with complementary input and output slug tuners.
2. I<sub>C</sub> and V<sub>CE</sub> regulated.
3. Load power for 1 dB compressed power gain.
4. Low level power gain associated with P<sub>L1</sub>.

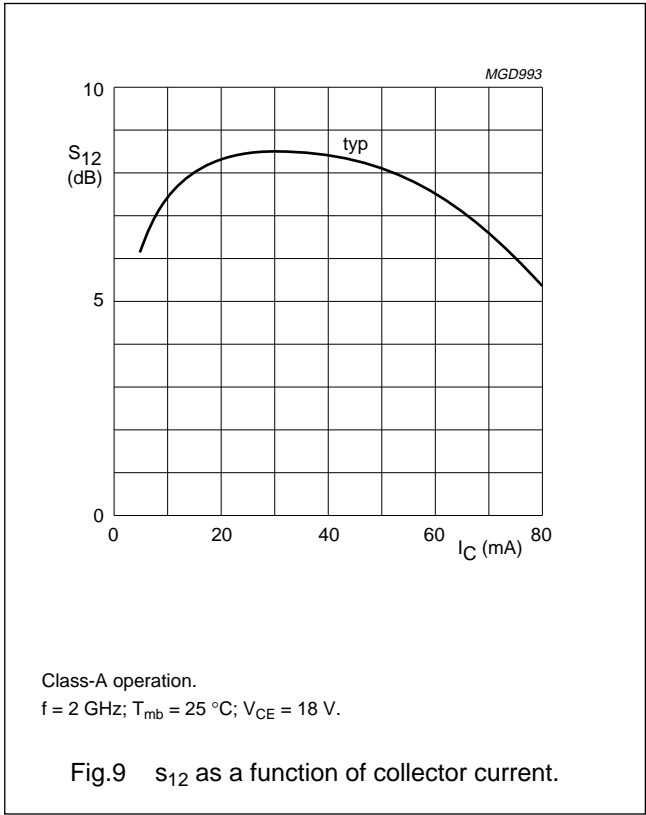
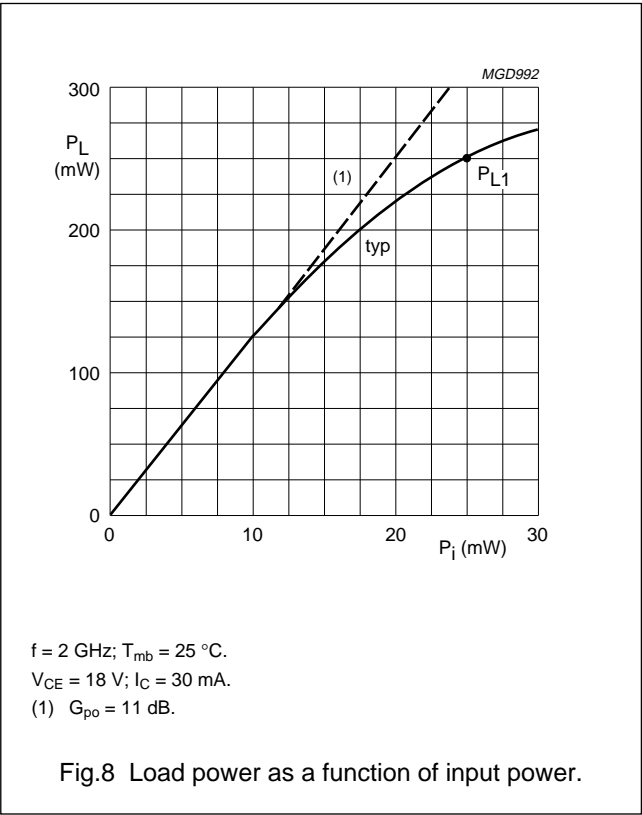


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NPN microwave power transistors

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NPN microwave power transistors

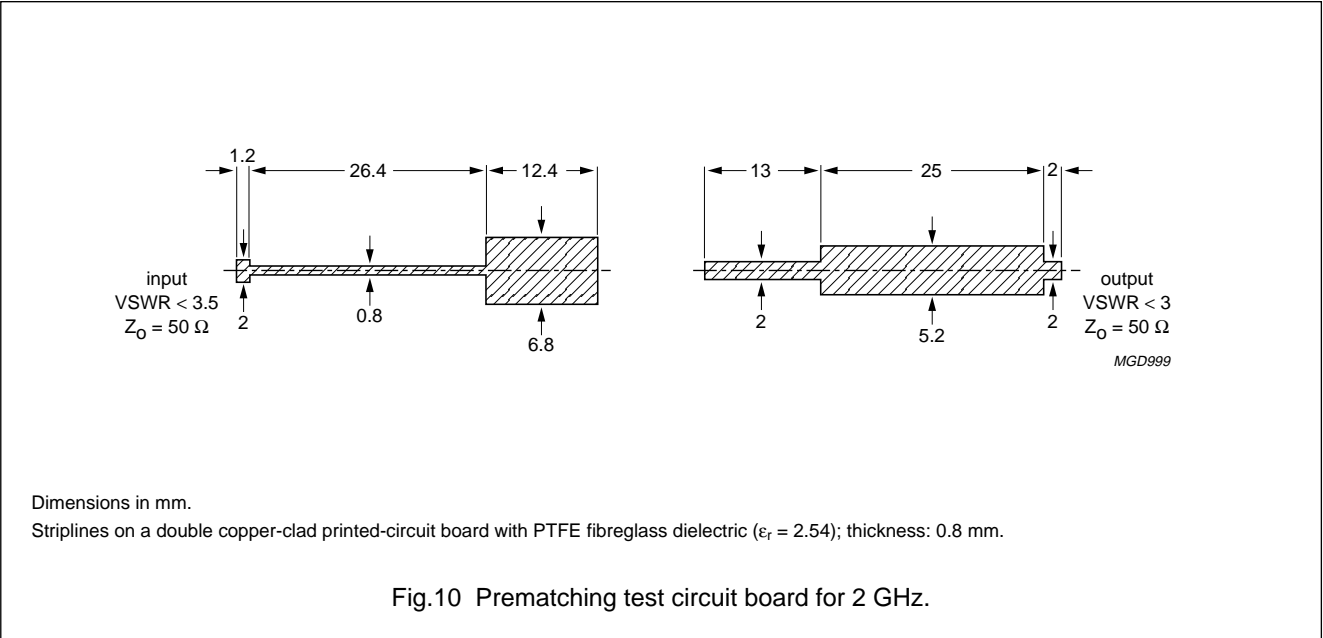
LBE2003S; LBE2009S;  
LCE2009S

Microwave performance for LBE2009S; LCE2009S up to  $T_{mb} = 75\text{ }^{\circ}\text{C}$  in a common emitter class-A test circuit; note 1.

MODE OF OPERATION	f (GHz)	V <sub>CE</sub> (V) <sup>(2)</sup>	I <sub>C</sub> (mA) <sup>(2)</sup>	P <sub>L1</sub> (mW) <sup>(3)</sup>	G <sub>po</sub> (dB) <sup>(4)</sup>	Z <sub>i</sub> (Ω)	Z <sub>L</sub> (Ω)
Class-A (CW)	2	18	110	≥700 (28.5) typ. 900 (29.5)	≥9 typ. 9.8	7.5 + j14.5	17.5 + j38.5

Notes

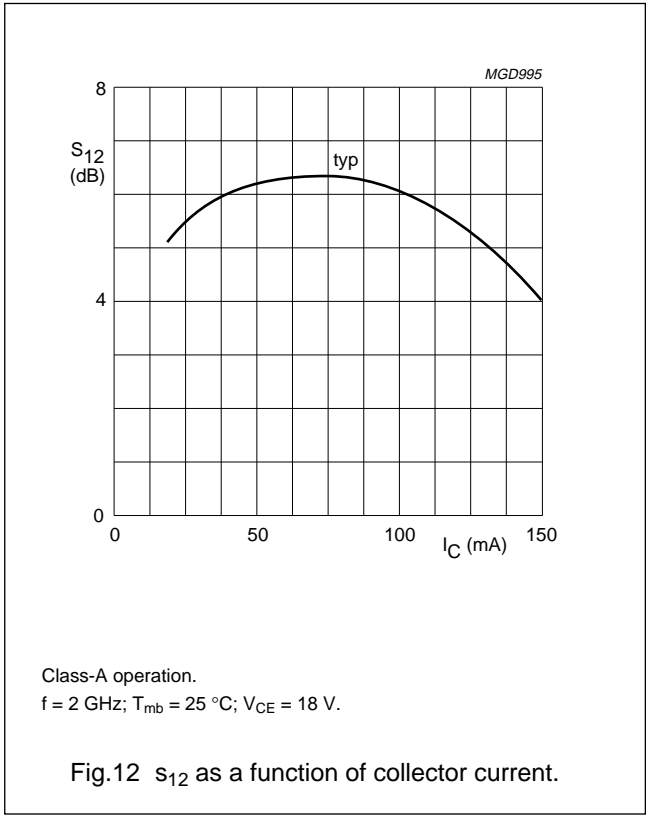
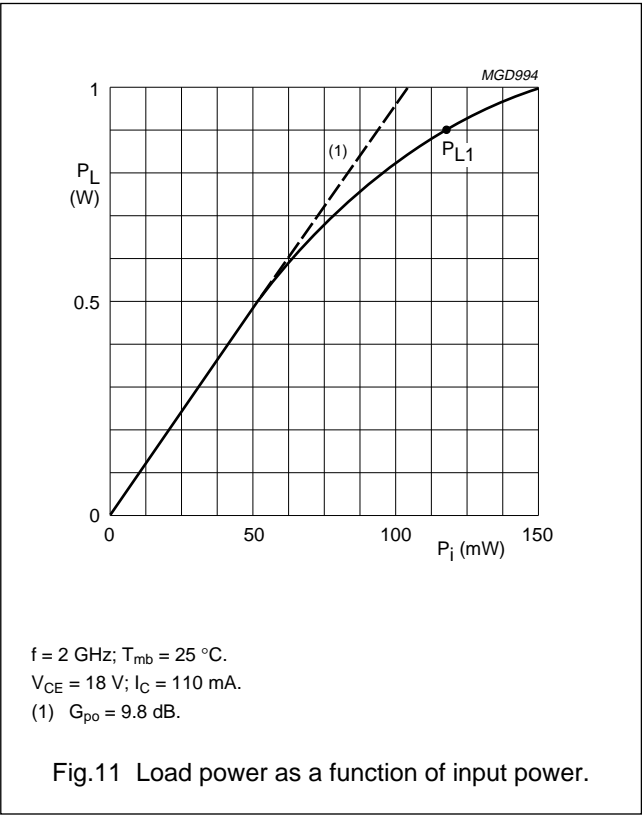
1. Circuit consists of prematching circuit boards in combination with complementary input and output slug tuners.
2. I<sub>C</sub> and V<sub>CE</sub> regulated.
3. Load power for 1 dB compressed power gain.
4. Low level power gain associated with P<sub>L1</sub>.



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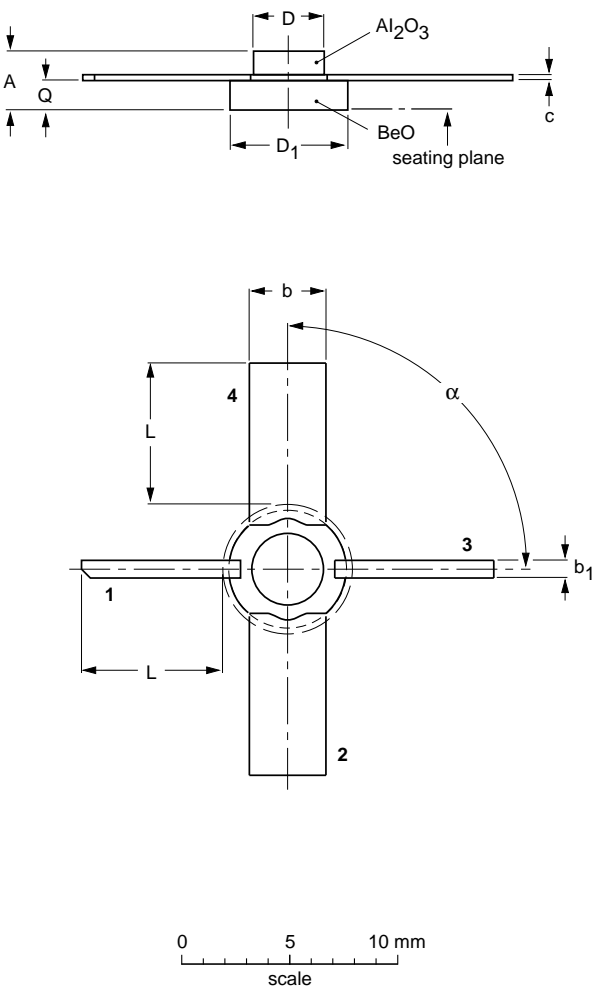
NPN microwave power transistors

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PACKAGE OUTLINES

Studless ceramic package; 4 leads

SOT441A



DIMENSIONS (mm are the original dimensions)

UNIT	A max.	b	b <sub>1</sub>	c	D	D <sub>1</sub>	L min.	Q	α
mm	2.4	3.2	0.75	0.125	3.38 3.08	5.28 5.12	6	1.3 1.0	90°

Note

1. This device incorporates naked beryllium oxide, the dust of which is toxic.

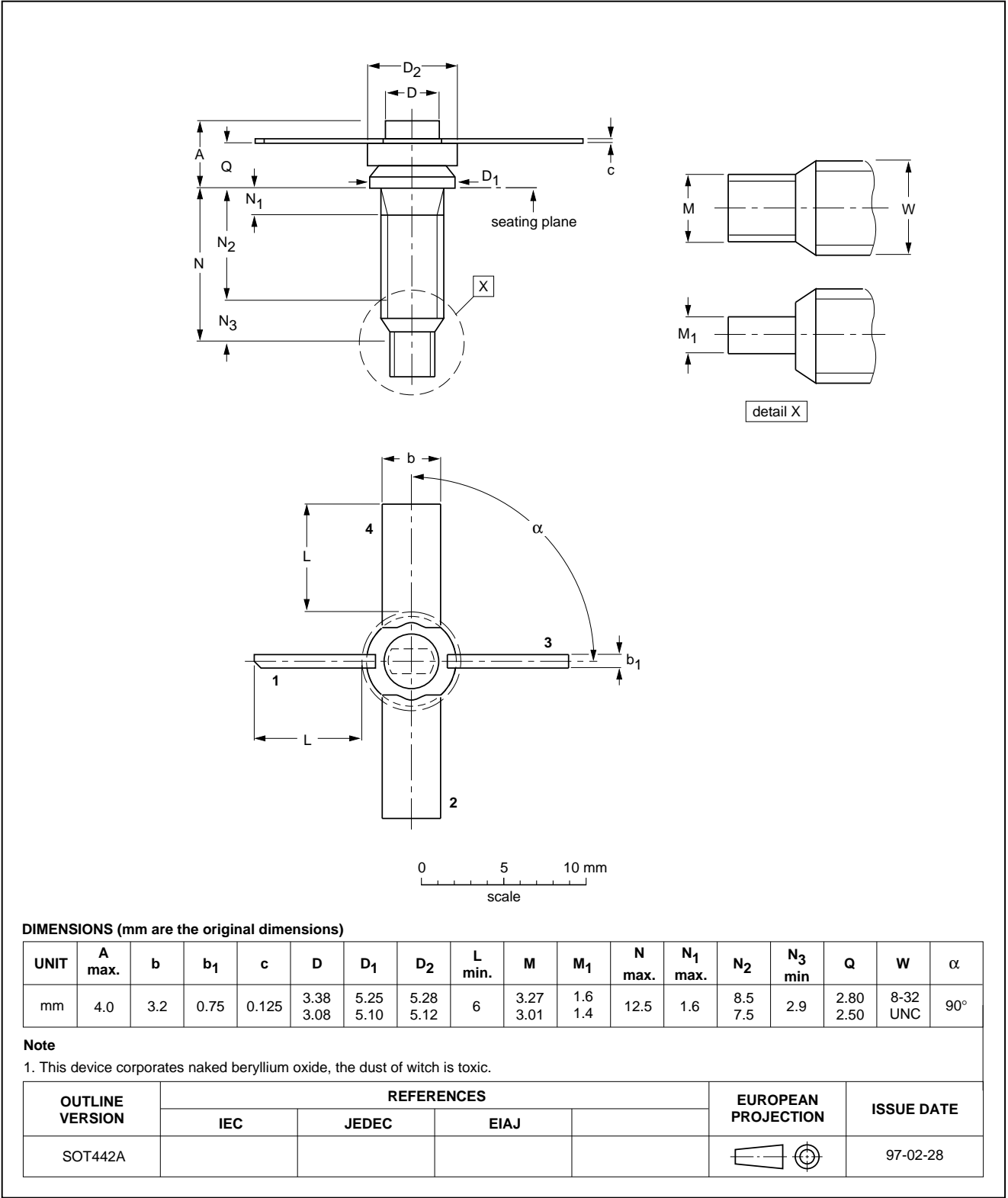
OUTLINE VERSION	REFERENCES				EUROPEAN PROJECTION	ISSUE DATE
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SOT441A						97-02-28

NPN microwave power transistors

LBE2003S; LBE2009S;  
LCE2009S

Studded ceramic package; 4 leads

SOT442A



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**NPN microwave power transistors****LBE2003S; LBE2009S;  
LCE2009S**

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**DEFINITIONS**

<b>Data Sheet Status</b>	
Objective specification	This data sheet contains target or goal specifications for product development.
Preliminary specification	This data sheet contains preliminary data; supplementary data may be published later.
Product specification	This data sheet contains final product specifications.
<b>Limiting values</b>	
Limiting values given are in accordance with the Absolute Maximum Rating System (IEC 134). Stress above one or more of the limiting values may cause permanent damage to the device. These are stress ratings only and operation of the device at these or at any other conditions above those given in the Characteristics sections of the specification is not implied. Exposure to limiting values for extended periods may affect device reliability.	
<b>Application information</b>	
Where application information is given, it is advisory and does not form part of the specification.	

**LIFE SUPPORT APPLICATIONS**

These products are not designed for use in life support appliances, devices, or systems where malfunction of these products can reasonably be expected to result in personal injury. Philips customers using or selling these products for use in such applications do so at their own risk and agree to fully indemnify Philips for any damages resulting from such improper use or sale.

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**NOTES**

# Philips Semiconductors – a worldwide company

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