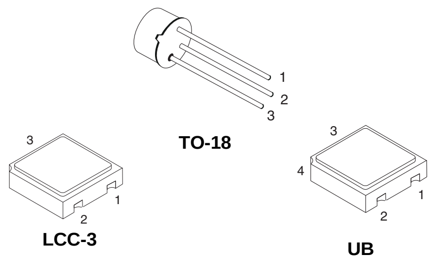
2N3700HR

life.augmented

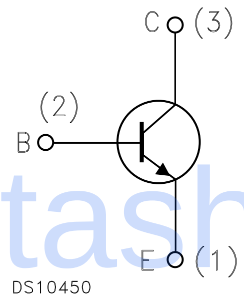
Hi-Rel 80 V, 1 A NPN transistor

Datasheet - production data



Pin 4 in UB is connected to the metallic lid

Figure 1. Internal schematic diagram



Features

BVCEO	80 V
IC(max)	1 A
HFE at 10 V - 150 mA	>100

- Hermetic packages
- ESCC qualified
- Up to 100 krad(Si) low dose rate

Description

The 2N3700HR is a NPN transistor specifically designed for aerospace and Hi-Rel applications. It is available in the JAN qualification system (MIL-PRF19500) and in the ESCC qualification system (ESCC 5000). In case of discrepancies between this datasheet and the relevant agency specification, the latter takes precedence.

Table 1. Device summary

Device	Qualification	Agency spec	Package	Radiation level	EPPL
2N3700UBxx				-	Yes
2N3700UBxxSW			UB	100 krad SW	Yes
2N3700RUBx				100 krad ESCC	Target
SOC3700HRB				-	Yes
SOC3700xxSW	ESCC	5201/004	LCC-3	100 krad SW	Yes
SOC3700RHRx				100 krad ESCC	Target
2N3700HR				-	-
2N3700SW			TO-18	100 krad SW	-
2N3700RHRx				100 krad ESCC	-
J2N3700UB1					-
JANSR2N3700UBG				100 krad	-
JANSR2N3700UBT	JANS	MIL-PRF-19500/391	UB	100 krad	-
JANS2N3700UBG					-
JANS2N3700UBT					-

This is information on a product in full production.

Contents

1 Electrical ratings

Table 2. Absolute maximum ratings

Symbol	Parameter		Value	Unit
V_{CBO}	Collector-base voltage ($I_E = 0$)		140	V
V_{CEO}	Collector-emitter voltage ($I_B = 0$)		80	V
V_{EBO}	Emitter-base voltage ($I_C = 0$)		7	V
I_C	Collector current		1	A
P_{tot}	Total dissipation at $T_{amb} \leq 25$ °C	for 2N3700HR	0.5	W
		for SOC3700HRB	0.5	W
		for SOC3700HRB (1)	0.76	W
	Total dissipation at $T_c \leq 25$ °C	for 2N3700HR	1.8	W
T_{stg}	Storage temperature		-65 to 200	°C
T_J	Max. operating junction temperature		200	°C

1. When mounted on a 15 x 15 x 0.6 mm ceramic substrate.

Table 3. Thermal data

Symbol	Parameter	LCC-3 and UB	TO-18	Unit
R_{thJC}	Thermal resistance junction-case (max) for JAN	-	-	°C/W
	Thermal resistance junction-case (max) for ESCC	350	97	
$R_{thJSP(IS)}$	Thermal resistance junction-solder pad (infinite sink) (max) for JAN	90	-	
	Thermal resistance junction-solder pad (infinite sink) (max) for ESCC	-	-	
R_{thJA}	Thermal resistance junction-ambient (max) for JAN	325	-	
	Thermal resistance junction-ambient (max) for ESCC	240(1)	350	

1. When mounted on a 15 x 15 x 0.6 mm ceramic substrate.

2 Electrical characteristics

JANS and ESCC version of the products are assembled and tested in compliance with the agency specification it is qualified in. The electrical characteristics of each version are provided in dedicated tables.

T_{case} = 25 °C unless otherwise specified.

2.1 JANS electrical characteristics

Table 4. JANS electrical characteristics

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
I_{CBO}	Collector cut-off current (I_E = 0)	V_{CB} = 140 V		-	10	µA
I_{CES}	Collector cut-off current (I_E = 0)	V_{CE} = 90 V V_{CE} = 90 V, T_{amb}= 150°C		-	10 5	nA µA
I_{EBO}	Emitter cut-off current (I_C = 0)	V_{EB} = 5 V V_{EB} = 7 V		-	10 10	nA µA
$V_{(BR)CEO}$	Collector-emitter breakdown voltage (I_B = 0)	I_C = 30 mA		-	80	V
$V_{CE(sat)}$	Collector-emitter saturation voltage	I_C = 150 mA I_B = 15 mA I_C = 500 mA I_B = 50 mA		-	0.2 0.5	V V
$V_{BE(sat)}$	Base-emitter saturation voltage	I_C = 150 mA I_B = 15 mA		-	1.1	V
h_{FE}	DC current gain	I_C = 0.1 mA V_{CE} = 10 V	25	-	200	
		I_C = 10 mA V_{CE} = 10 V	45	-		
		I_C = 150 mA V_{CE} = 10 V	100	-	300	
		I_C = 150 mA V_{CE} = 10 V T_{amb}= 150°C	40	-		
		I_C = 500 mA V_{CE} = 10 V	50	-	200	
		I_C = 1 A V_{CE} = 10 V	15	-		
h_{fe}	Small signal current gain	V_{CE} = 5 V I_C = 1 mA f = 1 kHz	80	-	400	
		V_{CE} = 10 V I_C = 50 mA f = 20 MHz	5	-	20	
C_{obo}	Output capacitance (I_E = 0)	V_{EB} = 0.5 V 100 kHz ≤ f ≤ 1 MHz		-	12	pF
C_{ibo}	Output capacitance (I_E = 0)	V_{EB} = 0.5 V 100 kHz ≤ f ≤ 1 MHz		-	60	pF

Table 4. JANS electrical characteristics (continued)

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
NF	Noise figure	V_{CE} = 10 V I_C = 100 μA R_g = 1 kΩ, power bandwidth		-	4	dB
r'b,Cc(1)	Collector-base time constant	V_{CB} =10 V; I_C=10 mA; f=79.8 MHz			400	ps
t_{off} + t_{off}	Switching times	see circuit *Figure 6*		-	30	ns

1. This parameter may be determined by applying an rf signal voltage of 1.0 volt (rms) across the collector-base terminals, and measuring the ac voltage drop (Veb) with a high- impedance rf voltmeter across the emitter-base terminals. With f = 79.8 MHz used for the 1.0 volt signal, the following computation applies: r'b , Cc(ps) = 2 X Veb (mV).

2.2 ESCC electrical characteristics

Table 5. ESCC 5201/004 post radiation electrical characteristics

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
I_{CBO}	Collector cut-off current (I_E = 0)	V_{CB} = 90 V		-	10	nA
I_{EBO}	Emitter cut-off current (I_C = 0)	V_{EB} = 5 V		-	10	nA
$V_{(BR)CBO}$	Collector-base breakdown voltage (I_E = 0)	I_C = 100 μA	140	-		V
$V_{(BR)CEO}$(1)	Collector-emitter breakdown voltage (I_B = 0)	I_C = 30 mA	80	-		V
$V_{(BR)EBO}$	Emitter-base breakdown voltage (I_C = 0)	I_E = 100 μA	7	-		V
$V_{CE(sat)}$ (1)	Collector-emitter saturation voltage	I_C = 150 mA I_B = 15 mA I_C = 500 mA I_B = 50 mA		-	0.2 0.5	V V
$V_{BE(sat)}$ (1)	Base-emitter saturation voltage	I_C = 150 mA I_B = 15 mA			1	V
[h_{FE}] (1)	Post irradiation gain calculation (2)	I_C = 10 mA V_{CE} = 10 V I_C = 150 mA V_{CE} = 10 V I_C = 500 mA V_{CE} = 10 V	[45] [50] [25]	-	[300]	

1. Pulsed duration = 300 μs, duty cycle ≤ 2 %
2. The post-irradiation gain calculation of [h_{FE}], made using h_{FE} measurements from prior to and on completion of irradiation testing and after each annealing step if any, shall be as specified in MILSTD-750 method 1019.

2.3 Electrical characteristics (curves)

Figure 2. DC current gain (V_{CE}=1 V)

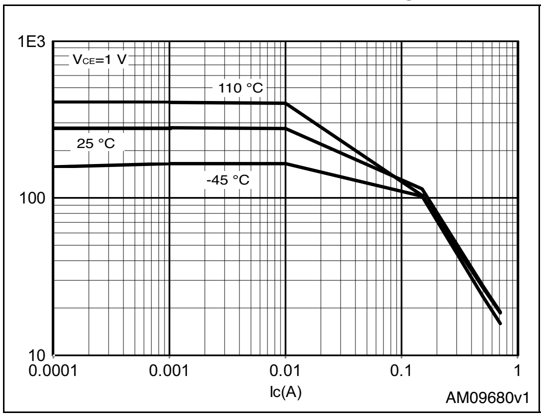


Figure 3. DC current gain (V_{CE}=10 V)

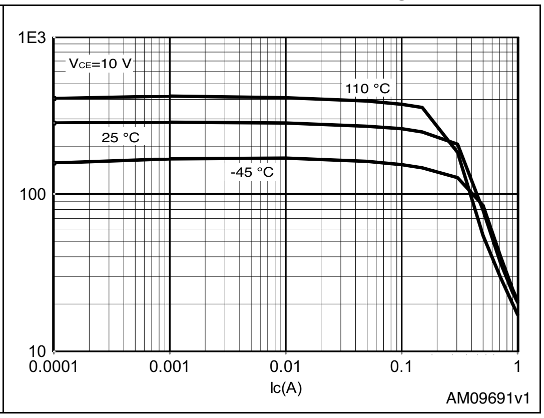


Figure 4. Collector emitter saturation voltage

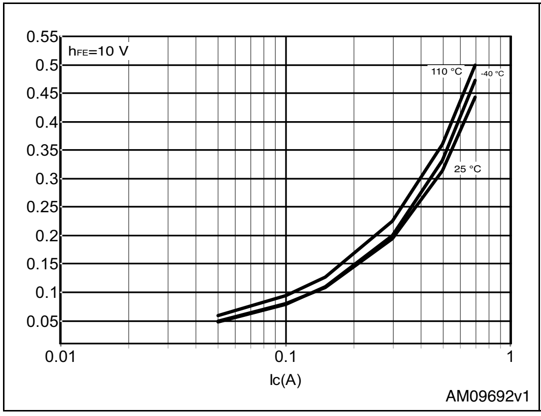
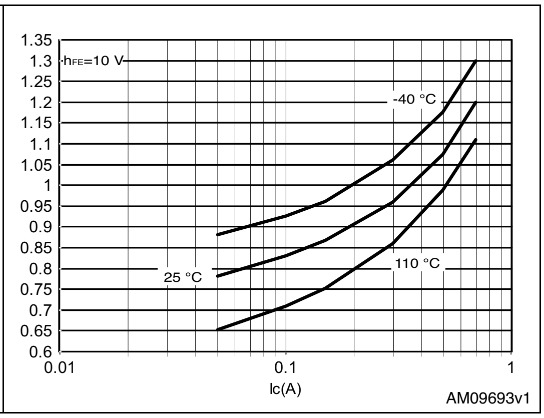
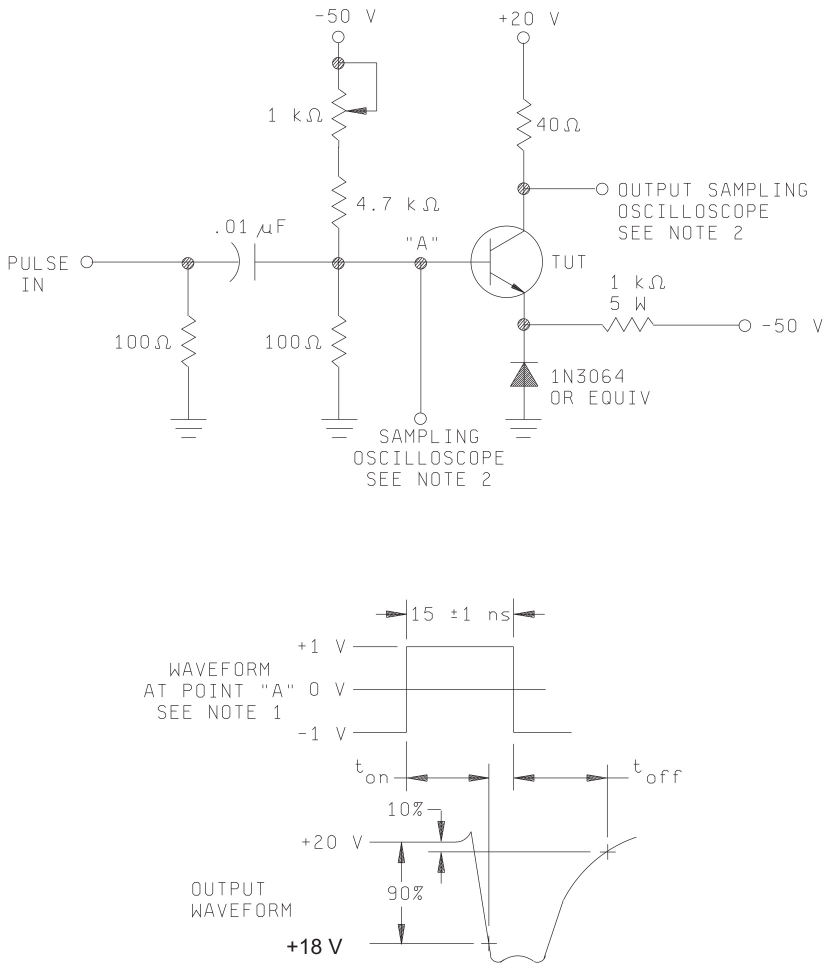


Figure 5. Base emitter saturation voltage



2.4 Test circuits

Figure 6. JANS non saturated switching-time test circuit



NOTES:

1. The rise time (t_r) of the applied pulse shall be ≤ 2.0 ns, duty cycle ≤ 2 percent and the generator source impedance shall be 50 ohms.
2. Sampling oscilloscope: Z_{IN} ≥ 100 kΩ, C_{IN} ≤ 12 pF, rise time ≤ 2.0 ns.

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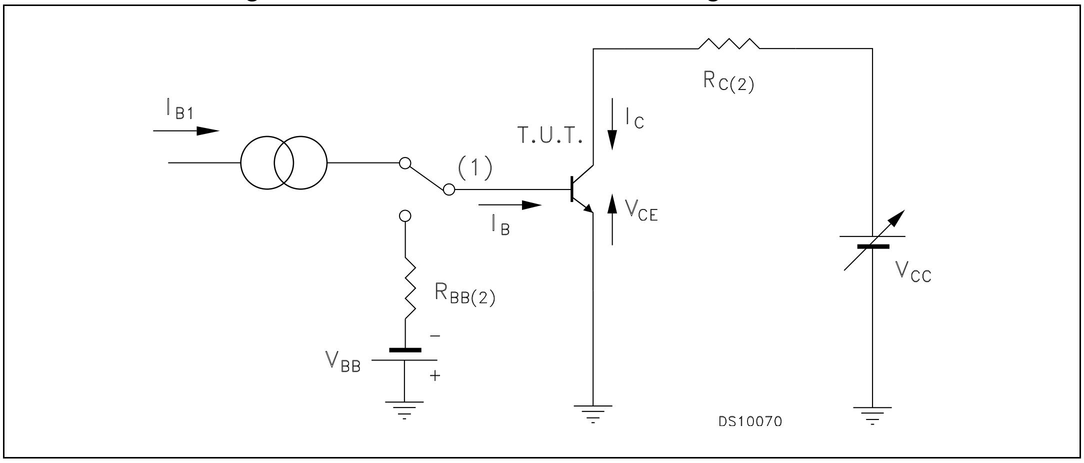
Figure 7. ESCC resistive load switching test circuit



1. Fast electronic switch
2. Non-inductive resistor

3 Radiation hardness assurance

The products guaranteed in radiation within the JANS system fully comply with the MIL-PRF-19500/255 specification.

The products guaranteed in radiation within the ESCC system fully comply with the ESCC 5201/004 and ESCC 22900 specifications.

JANS radiation assurance

ST JANS parts guaranteed at 100 krad (Si), tested, in full compliancy with the MIL-PRF-19500 specification, specifically the Group D, subgroup 2 inspection, between 50 and 300 rad/s. A brief summary is provided below:

- All test are performed in accordance to MIL-PRF-19500 and test method 1019 of MIL-STD-750 for total Ionizing dose.
- Each wafer of each lot is tested. The table below provides for each monitored parameters of the test conditions and the acceptance criteria.

Table 6. MIL-PRF-19500 (test method 1019) post radiation electrical characteristics

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
I_{CBO}	Collector cut-off current (I_E = 0)	V_{CB} = 140 V		-	20	μA
I_{CES}	Collector-emitter cut-off current	V_{CE} = 90 V			20	nA
I_{EBO}	Emitter cut-off current (I_C = 0)	V_{EB} = 5 V V_{EB} = 7 V		-	20 20	nA μA
$V_{(BR)CEO}$	Collector-emitter breakdown voltage (I_B = 0)	I_C = 30 mA		-	80	V
$V_{CE(sat)}$	Collector-emitter saturation voltage	I_C = 150 mA I_B = 15 mA I_C = 500 mA I_B = 50 mA		-	0.23 0.58	V V
$V_{BE(sat)}$	Base-emitter saturation voltage	I_C = 150 mA I_B = 15 mA			1.1	V
$[h_{FE}]$	Post irradiation gain calculation	I_C = 150 mA V_{CE} = 10 V	[50](1)		300	
		I_C = 0.1 mA V_{CE} = 10 V	[25](1)		200	
		I_C = 10 mA V_{CE} = 10 V	[45](1)			
		I_C = 500 mA V_{CE} = 10 V	[25](1)		200	
		I_C = 1.0 A V_{CE} = 10 V	[7.5](1)			

1. See method 1019 of MIL-STD-750 for how to determine $[h_{FE}]$ by first calculating the delta $(1/h_{FE})$ from the pre- and post-radiation h_{FE}. Notice the $[h_{FE}]$ is not the same as h_{FE} and cannot be measured directly. The $[h_{FE}]$ value can never exceed the pre-radiation minimum h_{FE} that it is based upon.

ESCC radiation assurance

Each product lot is tested according to the ESCC basic specification 22900, with a minimum of 11 samples per diffusion lot and 5 samples per wafer, one sample being kept as unirradiated sample, all of them being fully compliant with the applicable ESCC generic and/or detailed specification.

ST goes beyond the ESCC specification by performing the following procedure:

- Test of 11 pieces by wafer, 5 biased at least 80% of $V_{(BR)CEO}$, 5 unbiased and 1 kept for reference
- Irradiation at 0.1 rad (Si)/s
- Acceptance criteria of each individual wafer if as 100 krad guaranteed if all 10 samples comply with the post radiation electrical characteristics provided in Table XX???
- Delivery together with the parts of the radiation verification test (RVT) report of the particular wafer used to manufacture the products. This RVT includes the value of each parameter at 30, 50, 70 and 100 krad (Si) and after 24 hour annealing at room temperature and after an additional 168 hour annealing at 100°C.

Table 7. ESCC 5201/004 post radiation electrical characteristics

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
I_{CBO}	Collector cut-off current ($I_E = 0$)	$V_{CB} = 90$ V		-	10	nA
I_{EBO}	Emitter cut-off current ($I_C = 0$)	$V_{EB} = 5$ V		-	10	nA
$V_{(BR)CBO}$	Collector-base breakdown voltage ($I_E = 0$)	$I_C = 100\ \mu A$	140	-		V
$V_{(BR)CEO}$ (1)	Collector-emitter breakdown voltage ($I_B = 0$)	$I_C = 30$ mA	80	-		V
$V_{(BR)EBO}$	Emitter-base breakdown voltage ($I_C = 0$)	$I_E = 100\ \mu A$	7	-		V
$V_{CE(sat)}$ (1)	Collector-emitter saturation voltage	$I_C = 150$ mA $I_B = 15$ mA $I_C = 500$ mA $I_B = 50$ mA		-	0.2 0.5	V V
$V_{BE(sat)}$ (1)	Base-emitter saturation voltage	$I_C = 150$ mA $I_B = 15$ mA			1	V
$[h_{FE}]$ (1)	Post irradiation gain calculation (2)	$I_C = 10$ mA $V_{CE} = 10$ V $I_C = 150$ mA $V_{CE} = 10$ V $I_C = 500$ mA $V_{CE} = 10$ V	[45] [50] [25]	-	[300]	

1. Pulsed duration = 300 μs, duty cycle ≤ 2 %
2. The post-irradiation gain calculation of $[h_{FE}]$, made using h_{FE} measurements from prior to and on completion of irradiation testing and after each annealing step if any, shall be as specified in MILSTD-750 method 1019.

Table 8. Radiation summary

Radiation test	100 krad “SW”	100 krad ESCC
Wafer tested	each	each
Part tested	5 biased	5 biased + 5 unbiased
Dose rate	0.1 rad/s	0.1 rad/s
Acceptance	Fixed values (1)	MIL-STD-750 method 1019
Displacement damage	Optional	Optional
Agency part number (ex)	5202/001/04 (2)	5202/001/04R (2)
ST part number (ex)	SOC3700SW	SOC3700ARHRG
Documents	CoC +RVT	CoC +RVT

1. Part numbers with suffix "SW" have same pre and post irradiation electrical.
2. Example of the 2N3700 in LCC-3 gold finish.

4 Package mechanical data

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

Table 9. UB mechanical data

Dim.	mm.		
	Min.	Typ.	Max.
A	1.16		1.42
C	0.46	0.51	0.56
D	0.56	0.76	0.96
E	0.92	1.02	1.12
F	1.95	2.03	2.11
G	2.92	3.05	3.18
I	2.41	2.54	2.67
J	0.42	0.57	0.72
K	1.37	1.52	1.67
L	0.41	0.51	0.61
M	2.46	2.54	2.62
N	1.81	1.91	2.01
r		0.20	
r1		0.30	
r2		0.56	

Figure 8. UB drawings

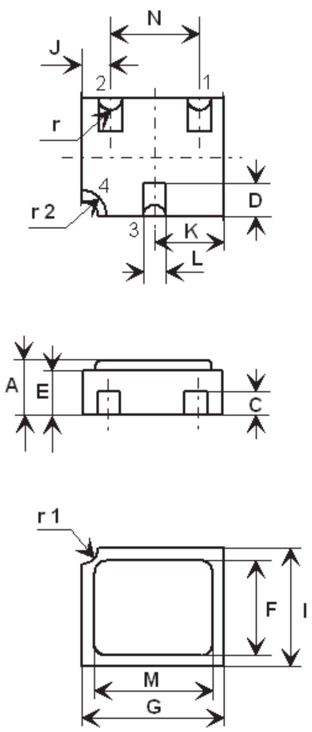


Table 10. LCC-3 mechanical data

Dim.	mm.		
	Min.	Typ.	Max.
A	1.16		1.42
C	0.45	0.50	0.56
D	0.60	0.76	0.91
E	0.91	1.01	1.12
F	1.95	2.03	2.11
G	2.92	3.05	3.17
I	2.41	2.54	2.66
J	0.42	0.57	0.72
K	1.37	1.52	1.67
L	0.40	0.50	0.60
M	2.46	2.54	2.62
N	1.80	1.90	2.00
R		0.30	

Figure 9. LCC-3 drawings

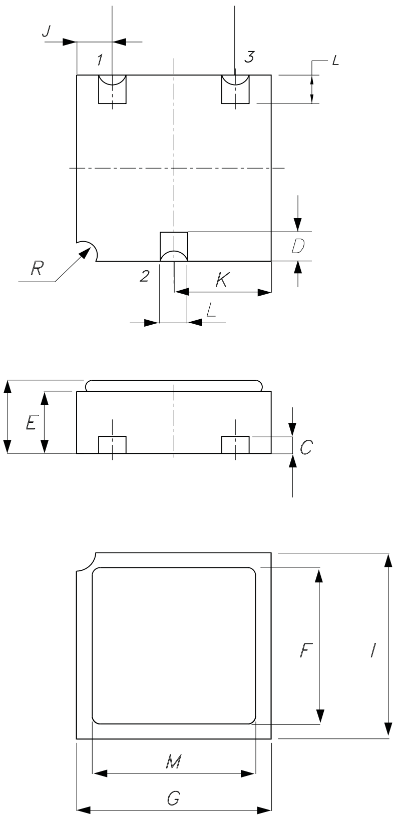
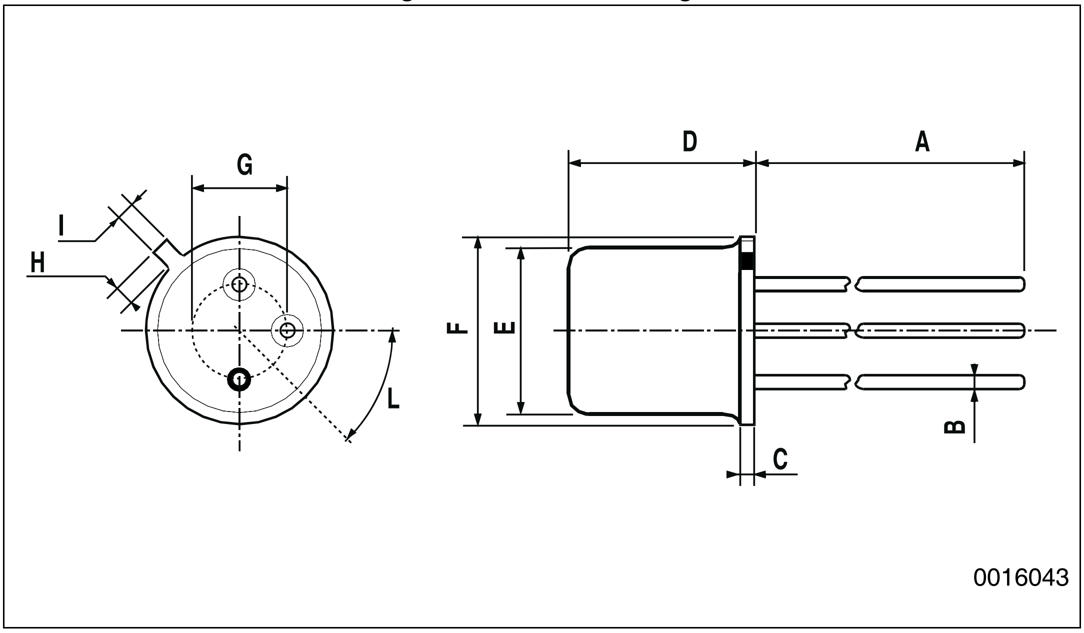


Table 11. TO-18 mechanical data

Dim.	mm.		
	Min.	Typ.	Max.
A		12.7	
B			0.49
D			5.3
E			4.9
F			5.8
G	2.54		
H			1.2
I			1.16
L	45°		

Figure 10. TO-18 drawings



5 Order codes

Table 12. Order codes

CPN	Agency specification	EPPL	Quality level	Radiation level	Package	Lead finish	Marking(1)	Packing
2N3700UB1	-	-	Engineering model ESCC	-	UB	Gold	U20	Waffle pack
SOC3700	-	-	Engineering model ESCC	-	LCC-3	Gold	N20	Waffle pack
2N3700RUBG	5201/004/06R	Target	ESCC flight	100 krad ESCC	UB	Gold	520100406R	Waffle pack
2N3700RUBT	5201/004/07R	Target	ESCC flight	100 krad ESCC	UB	Solder Dip	520100407R	Waffle pack
2N3700UB06SW (2)	5201/004/06	Y	ESCC flight	100 krad SW	UB	Gold	520100406	Waffle pack
2N3700UB07SW (2)	5201/004/07	Y	ESCC flight	100 krad SS	UB	Solder Dip	520100407	Waffle pack
SOC3700RHRG	5201/004/04R	Target	ESCC flight	100 krad ESCC	LCC-3	Gold	520100404R	Waffle pack
SOC3700RHRT	5201/004/05R	Target	ESCC flight	100 krad ESCC	LCC-3	Solder Dip	520100405R	Waffle pack
SOC3700SW (3)	5201/004/04 or 05 (3)	Y	ESCC flight	100 krad SW	LCC-3	Gold or solder dip (1)	520100404 or 05 (3)	Waffle pack
SOC3700HRB	5201/004/04 or 05 (3)	Y	ESCC flight	-	LCC-3	Gold or Solder Dip (1)	520100404 or 05 (3)	Waffle pack
2N3700HR	5201/004/01 or 02 (3)	-	ESCC flight	-	TO-18	Gold or Solder Dip (1)	520100401 or 02 (3)	Waffle pack
J2N3700UB1	-	-	Engineering model JANS		UB	Gold	JN3700	Waffle pack
JANSR2N3700UBG	MIL-PRF-19500/391	-	JANSR	100 krad	UB	Gold	JSR3700	Waffle pack

Table 12. Order codes (continued)

CPN	Agency specification	EPPL	Quality level	Radiation level	Package	Lead finish	Marking(1)	Packing
JANSR2N3700UBT	MIL-PRF-19500/391	-	JANSR	100 krad	UB	Solder Dip	JSR3700	Waffle pack
JANS2N3700UBG	MIL-PRF-19500/391	-	JANS		UB	Gold	JS3700	Waffle pack
JANS2N3700UBT	MIL-PRF-19500/391	-	JANS		UB	Solder Dip	JS3700	Waffle pack

1. Specific marking only. The full marking includes in addition:
   For the engineering models : ST logo, date code, country of origin (FR)
   For ESCC Flight parts : ST logo, date code, country of origin (FR), ESA logo, serial number of the part within the assembly lot
   For JANS Flight parts : ST logo, date code, country of origin (FR), Manufacturer code (CSTM), serial number of the part within the assembly lot
2. Not recommended for new design
3. Depending ESCC part number mentioned on the purchase order

6 Shipping details

6.1 Date code

Data code xyywwz is structured as described below:

Table 13. Date code

	x	yy	ww	z
EM (ESCC and JANS)	3	last two digits of the year	week digits	lot index in the week
ESCC flight	-			
JANS flight (diffused in Singapore)	W			

6.2 Documentation

Table 14. Documentation provided for each type of product

Quality level	Radiation level	Documentation
Engineering model	-	-
JANS Flight	-	Certificate of conformance
JANSR Flight	100 krad	Certificate of conformance 50 rad/s radiation verification test report
ESCC Flight	-	Certificate of conformance
	100 krad	Certificate of conformance
		0.1 rad/s radiation verification test report

7 Revision history

Table 15. Document revision history

Date	Revision	Changes
10-Jan-2008	1	Initial release
07-Jan-2010	2	Modified *Table 1 on page 1*
26-Jul-2010	3	Modified *Table 1 on page 1*, added *Table 10 on page 14*
30-Nov-2011	4	– Modified: *Table 6 on page 9* – Added: *Section 2.3: Electrical characteristics (curves)* – Minor text change in the document title on the coverpage
17-Apr-2013	5	Added: *Section 3: Radiation hardness assurance*
11-Jun-2013	6	Updated order codes in *Table 1: Device summary* and *Table 12: Order codes*. Updated *Section 3: Radiation hardness assurance*. Minor text changes.