

Hi-Rel PNP bipolar transistor 150 V, 0.5 A

Datasheet - production data

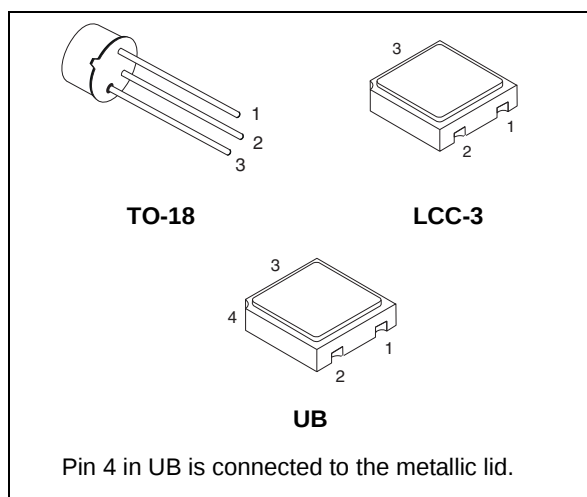
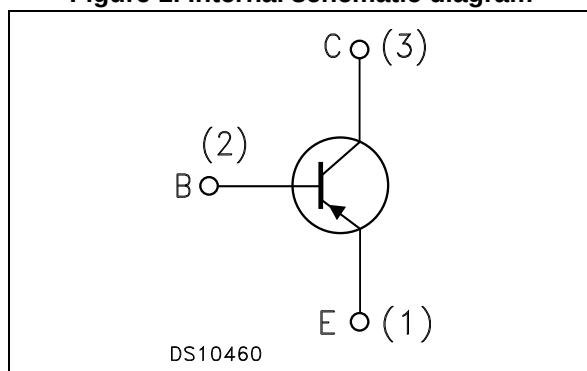


Figure 1. Internal schematic diagram



Features

BV_{CEO}	150 V
I_C (max)	0.5 A
H_{FE} at 10 V - 150 mA	> 60

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

Description

The 2N5401HR is a silicon planar PNP transistor specifically designed and housed in hermetic packages for aerospace and Hi-Rel applications. It is available in the JAN qualification system (MIL-PRF19500 compliance) and in the ESCC qualification system (ESCC 5000 compliance). In case of discrepancies between this datasheet and the relevant agency specification, the latter takes precedence.

Table 1. Device summary

Device	Qualification system	Agency specification	Package	Radiation level	EPPL
JANSR2N5401UBx	JANSR	MIL-PRF-19500/766	UB	100 krad high and low dose rate	-
JANS2N5401UBx	JANS	MIL-PRF-19500/766	UB	-	-
2N5401RUBx	ESCC Flight	5202/014	UB	100 krad - low dose rate	Target
2N5401UBx	ESCC Flight	5202/014	UB	-	Target
SOC5401RHRx	ESCC Flight	5202/014	LCC-3	100 krad - low dose rate	Yes
SOC5401HRx	ESCC Flight	5202/014	LCC-3	-	Yes
2N5401RHRx	ESCC Flight	5202/014	TO-18	100 krad - low dose rate	-
2N5401HRx	ESCC Flight	5202/014	TO-18	-	-

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1 Electrical ratings

Table 2. Absolute maximum ratings

Symbol	Parameter	Value	Unit
V_{CBO}	Collector-base voltage ($I_E = 0$)	-160	V
V_{CEO}	Collector-emitter voltage ($I_B = 0$)	-150	V
V_{EBO}	Emitter-base voltage ($I_C = 0$)	-5	V
I_C	Collector current for TO-18	-0.6	A
	for LCC-3 and UB	-0.5	A
P_{TOT}	Total dissipation at $T_{amb} \leq 25\text{ °C}$ for TO-18	0.36	W
	for LCC-3 and UB	0.36	W
	for LCC-3 and UB ⁽¹⁾	0.58	W
	Total dissipation at $T_c \leq 25\text{ °C}$ for TO-18	1.2	W
T_{STG}	Storage temperature	-65 to 200	°C
T_J	Max. operating junction temperature	200	°C

1. When mounted on a 8x10x0.6 mm ceramic substrate.

Table 3. Thermal data for through-hole package

Symbol	Parameter	Value	Unit
R_{thJC}	Thermal resistance junction-case max	146	°C/W
R_{thJA}	Thermal resistance junction-ambient max	486	°C/W

Table 4. Thermal data for SMD package

Symbol	Parameter	Value	Unit
R_{thJA}	Thermal resistance junction-ambient max	486	°C/W
	Thermal resistance junction-ambient ⁽¹⁾ max	302	°C/W

1. When mounted on a 8x10x0.6 mm ceramic substrate.

2 Electrical characteristics

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

Table 5. Electrical characteristics

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
I_{CBO}	Collector-base cut-off current ($I_{\text{E}} = 0$)	$V_{\text{CB}} = -120\text{ V}$ $V_{\text{CB}} = -120\text{ V}$ $T_{\text{C}} = 150\text{ °C}$		-	-50 -50	nA μA
I_{EBO}	Emitter-base cut-off current ($I_{\text{C}} = 0$)	$V_{\text{EB}} = -3\text{ V}$		-	-50	nA
$V_{(\text{BR})\text{CBO}}$	Collector-base breakdown voltage ($I_{\text{E}} = 0$)	$I_{\text{C}} = -100\text{ }\mu\text{A}$	-160	-		V
$V_{(\text{BR})\text{CEO}}^{(1)}$	Collector-emitter breakdown voltage ($I_{\text{B}} = 0$)	$I_{\text{C}} = -1\text{ mA}$	-150	-		V
$V_{(\text{BR})\text{EBO}}$	Emitter-base breakdown voltage ($I_{\text{C}} = 0$)	$I_{\text{E}} = -10\text{ }\mu\text{A}$	-5	-		V
$V_{\text{CE(sat)}}^{(1)}$	Collector-emitter saturation voltage	$I_{\text{C}} = -10\text{ mA}$ $I_{\text{B}} = -1\text{ mA}$ $I_{\text{C}} = -50\text{ mA}$ $I_{\text{B}} = -5\text{ mA}$		-	-0.2 -0.5	V V
$V_{\text{BE(sat)}}^{(1)}$	Base-emitter saturation voltage	$I_{\text{C}} = -10\text{ mA}$ $I_{\text{B}} = -1\text{ mA}$ $I_{\text{C}} = -50\text{ mA}$ $I_{\text{B}} = -5\text{ mA}$		-	-1 -1	V V
$h_{\text{FE}}^{(1)}$	DC current gain	$I_{\text{C}} = -1\text{ mA}$ $V_{\text{CE}} = -5\text{ V}$ $I_{\text{C}} = -10\text{ mA}$ $V_{\text{CE}} = -5\text{ V}$ $I_{\text{C}} = -50\text{ mA}$ $V_{\text{CE}} = -5\text{ V}$ $I_{\text{C}} = -10\text{ mA}$ $V_{\text{CE}} = -5\text{ V}$ $T_{\text{amb}} = -55\text{ °C}$	50 60 60 20	-	240	
h_{fe}	Small signal current gain	$V_{\text{CE}} = -10\text{ V}$ $I_{\text{C}} = -10\text{ mA}$ $f = 10\text{ MHz}$	5	-		
C_{obo}	Output capacitance ($I_{\text{E}} = 0$)	$V_{\text{CB}} = -10\text{ V}$ $f = 1\text{ MHz}$		-	6	pF

1. Pulsed duration = 300 μs , duty cycle $\leq 2\%$

2.1 Electrical characteristics (curves)

Figure 2. h_{FE} @ $V_{CE} = 5\text{ V}$

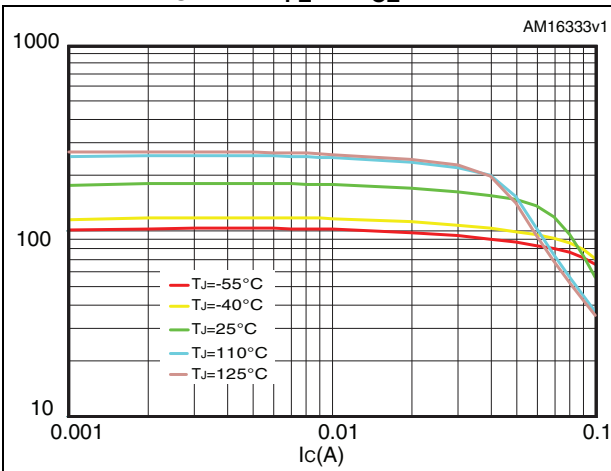


Figure 3. $V_{CE(sat)}$ @ $h_{FE} = 10$

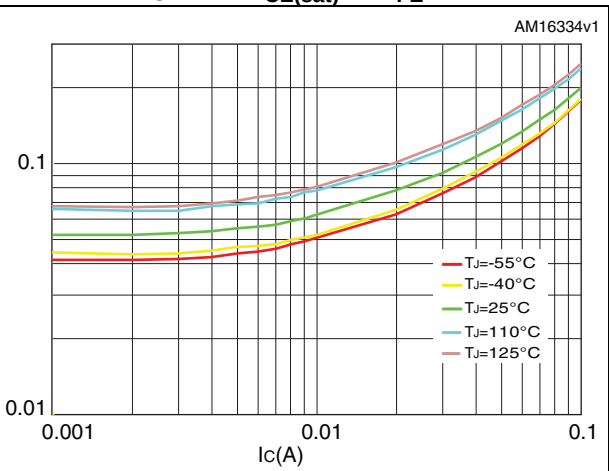
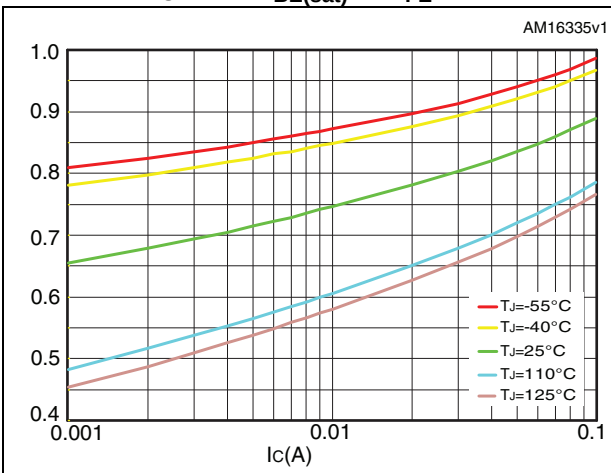


Figure 4. $V_{BE(sat)}$ @ $h_{FE} = 10$



3 Radiation hardness assurance

The products guaranteed in radiation within the JANS system fully comply with the MIL-PRF-19500/766 specification.

The products guaranteed in radiation within the ESCC system fully comply with the ESCC 5201/014 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. On top of the standard JANSR high dose rate by wafer lot guarantee, ST 2N5401HR series include an additional wafer by wafer 100 krad Low dose rate guarantee at 0.1 rad/s, identical to the ESCC 100 krad guarantee. It is supported with the same radiation verification test report provided with each shipment. A brief summary of the standard High Dose Rate by wafer lot JANSR guarantee 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.

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	Value		Unit
			Min.	Max.	
I_{CBO}	Collector to base cutoff current	$V_{CB} = 120 \text{ V}$		100	μA
I_{EBO}	Emitter to base cutoff current	$V_{EB} = 7 \text{ V}$		100	μA
$V_{(BR)CEO}$	Breakdown voltage, collector to emitter	$I_C = 1 \text{ mA}$	150		V
$V_{(BR)BCO}$	Breakdown voltage, base to collector	$I_C = 100 \mu\text{A}$	160		V
$V_{(BR)EBO}$	Breakdown voltage, emitter to base	$I_{EB} = 10 \mu\text{A}$	5		V
h_{FE}	Forward-current transfer ratio	$V_{CE} = 5 \text{ V}; I_C = 1 \text{ mA}$	[25] ⁽¹⁾		
		$V_{CE} = 5 \text{ V}; I_C = 10 \text{ mA}$	[30] ⁽¹⁾	240	
		$V_{CE} = 5 \text{ V}; I_C = 50 \text{ mA}$	[30] ⁽¹⁾		
$V_{CE(sat)}$	Collector-emitter saturation voltage	$I_C = 10 \text{ mA}; I_B = 1 \text{ mA}$		0.2	V
		$I_C = 50 \text{ mA}; I_B = 5 \text{ mA}$		0.5	
$V_{BE(sat)}$	Base-emitter saturation voltage	$I_C = 10 \text{ mA}; I_B = 1 \text{ mA}$		1	V
		$I_C = 50 \text{ mA}; I_B = 5 \text{ mA}$		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 7](#)
- 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 5202/014 post radiation electrical characteristics

Symbol	Parameter	Test conditions	Value		Unit
			Min.	Max.	
I_{CBO}	Collector to base cutoff current	$V_{CB} = 120 \text{ V}$		100	μA
I_{EBO}	Emitter to base cutoff current	$V_{EB} = 7 \text{ V}$		100	μA
$V_{(BR)CEO}$	Breakdown voltage, collector to emitter	$I_C = 1 \text{ mA}$	150		V
$V_{(BR)BCO}$	Breakdown voltage, base to collector	$I_C = 100 \mu\text{A}$	160		V
$V_{(BR)EBO}$	Breakdown voltage, emitter to base	$I_{EB} = 10 \mu\text{A}$	5		V
h_{FE}	Forward-current transfer ratio	$V_{CE} = 5 \text{ V}; I_C = 1 \text{ mA}$	[25] ⁽¹⁾		
		$V_{CE} = 5 \text{ V}; I_C = 10 \text{ mA}$	[30] ⁽¹⁾	240	
		$V_{CE} = 5 \text{ V}; I_C = 50 \text{ mA}$	[30] ⁽¹⁾		
$V_{CE(sat)}$	Collector-emitter saturation voltage	$I_C = 10 \text{ mA}; I_B = 1 \text{ mA}$		0.2	V
		$I_C = 50 \text{ mA}; I_B = 5 \text{ mA}$		0.5	
$V_{BE(sat)}$	Base-emitter saturation voltage	$I_C = 10 \text{ mA}; I_B = 1 \text{ mA}$		1	V
		$I_C = 50 \text{ mA}; I_B = 5 \text{ mA}$		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.

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.

4.1 LCC-3 package information

Figure 5. LCC-3 package outline

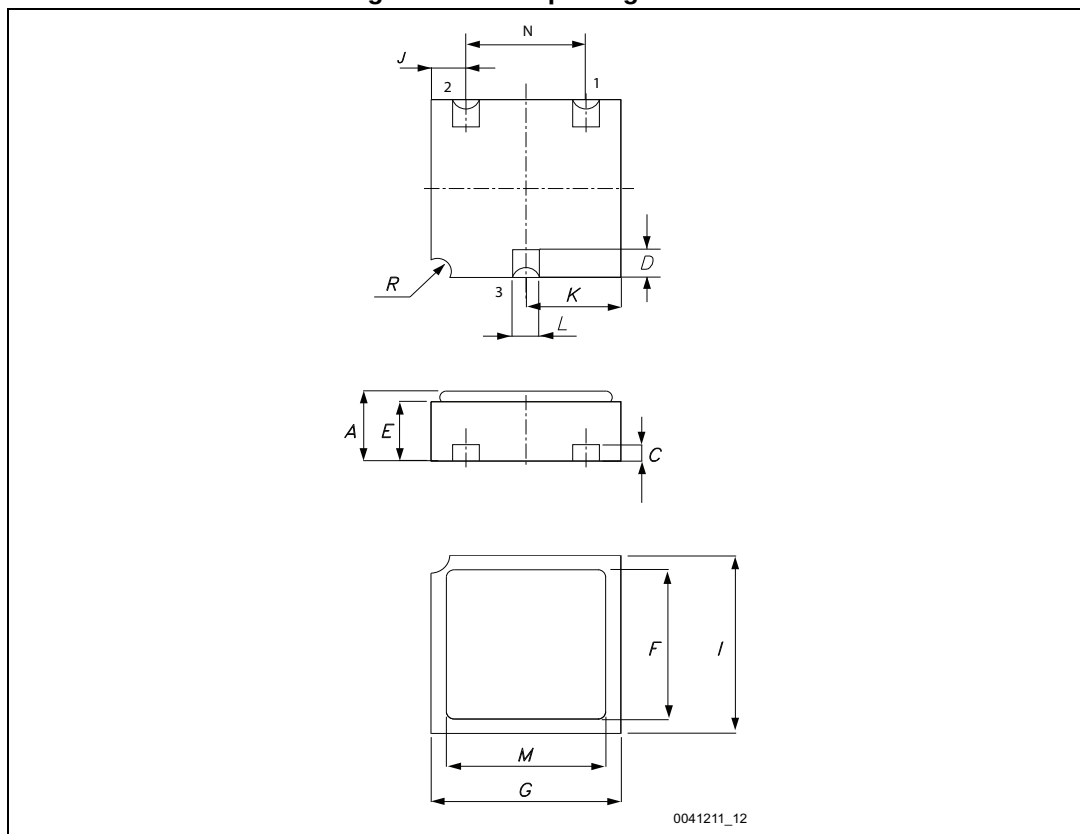


Table 8. LCC-3 mechanical data

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	

4.2 UB package information

Figure 6. UB package outline

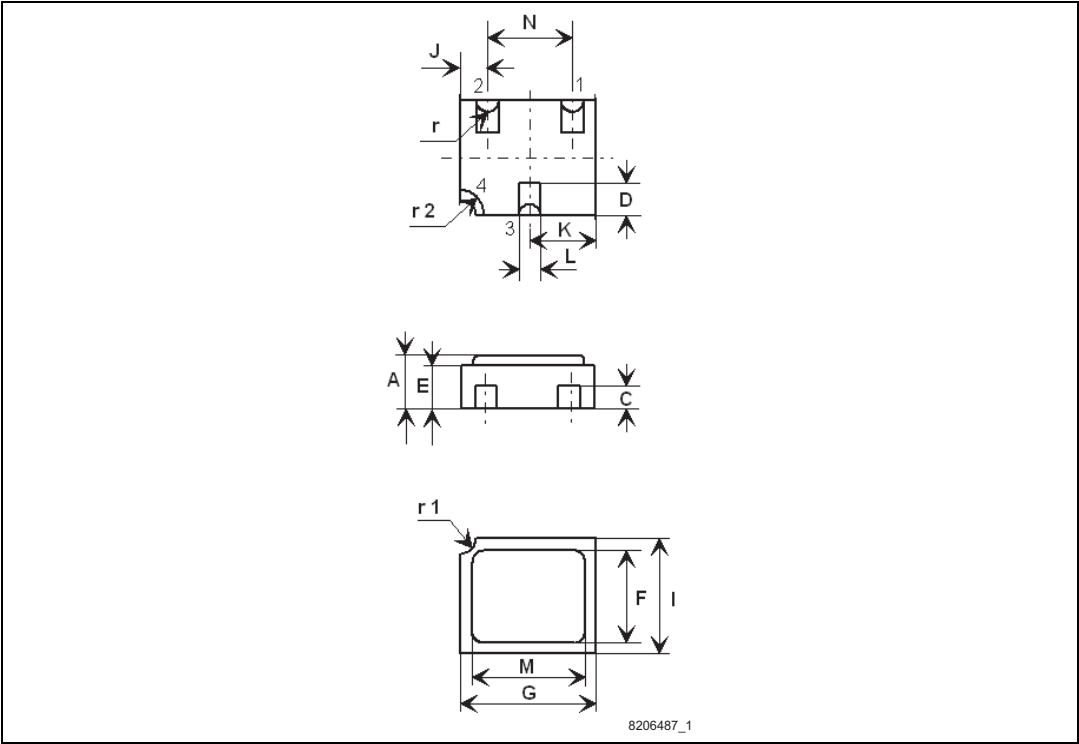


Table 9. UB mechanical data

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	

4.3 TO-18 package information

Figure 7. TO-18 package outline

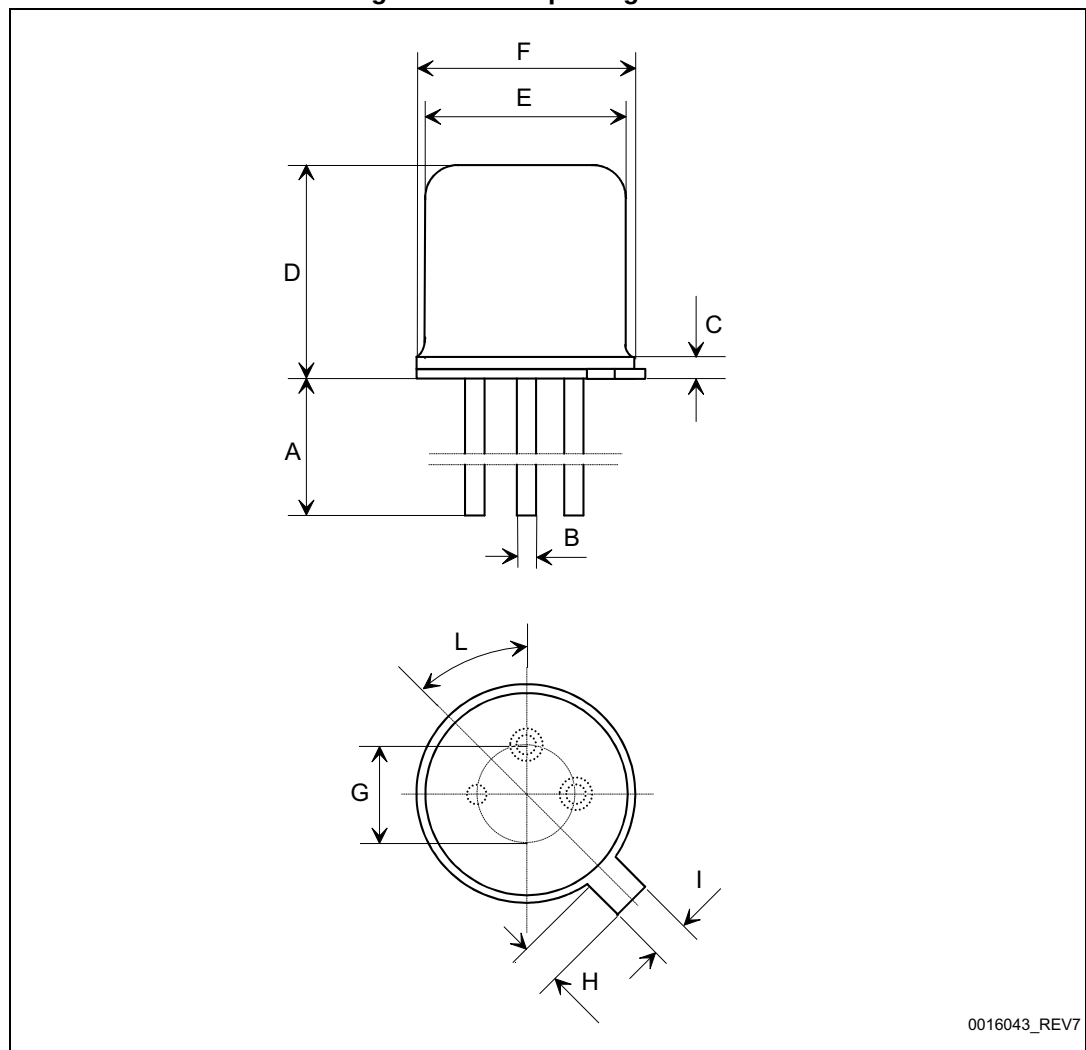


Table 10. TO-18 mechanical data

Dim.	mm.		
	Min.	Typ.	Max.
A	12.70	13.20	14.20
B	0.41	0.45	0.48
C	0.36		0.47
D	4.88		5.33
E	4.63		4.70
F	5.31		5.45
G	2.49	2.54	2.59
H	0.80	0.90	1.00
I	0.95	1.00	1.05
L	42°	45°	48°



5 Order codes

Table 11. Order codes

CPN	Agency specification	EPPL	Quality level	Radiation level ⁽¹⁾	Package	Lead finish	Marking ⁽²⁾	Packing
J2N5401UB1	-	-	Engineering model JANS	-	UB	Gold	J5401UB1	WafflePack
2N5401UB1	-	-	Engineering model ESCC	-	UB	Gold	2N5401UB1	WafflePack
SOC54011	-	-	Engineering model ESCC	-	LCC-3	Gold	SOC54011	WafflePack
JANSR2N5401UBG	MIL-PRF-19500/766	-	JANSR	100 krad high and low dose rate	UB	Gold	JSR5401	WafflePack
JANSR2N5401UBT	MIL-PRF-19500/766	-	JANSR	100 krad high and low dose rate	UB	Solder Dip	JSR5401	WafflePack
JANS2N5401UBG	MIL-PRF-19500/766	-	JANS	-	UB	Gold	JS5401	WafflePack
JANS2N5401UBT	MIL-PRF-19500/766	-	JANS	-	UB	Solder Dip	JS5401	WafflePack
2N5401RUBG	5202/014/06R	Target	ESCC Flight	100 krad low dose rate	UB	Gold	520201406R	WafflePack
2N5401RUBT	5202/014/07R	Target	ESCC Flight	100 krad low dose rate	UB	Solder Dip	520201407R	WafflePack
2N5401UBG	5202/014/06	Target	ESCC Flight	-	UB	Gold	520201406	WafflePack
2N5401UBT	5202/014/07	Target	ESCC Flight	-	UB	Solder Dip	520201407	WafflePack
SOC5401RHRG	5202/014/04R	Yes	ESCC Flight	100 krad low dose rate	LCC-3	Gold	520201404R	WafflePack



Table 11. Order codes (continued)

CPN	Agency specification	EPPL	Quality level	Radiation level ⁽¹⁾	Package	Lead finish	Marking ⁽²⁾	Packing
SOC5401RHRT	5202/014/05R	Yes	ESCC Flight	100 krad low dose rate	LCC-3	Solder Dip	520201405R	WafflePack
SOC5401HRG	5202/014/04	Yes	ESCC Flight	-	LCC-3	Gold	520201404	WafflePack
SOC5401HRT	5202/014/05	Yes	ESCC Flight	-	LCC-3	Solder Dip	520201405	WafflePack
2N5401RHRG	5202/014/01R	-	ESCC Flight	100 krad low dose rate	TO-18	Gold	520201401R	Strip Pack
2N5401RHRT	5202/014/02R	-	ESCC Flight	100 krad low dose rate	TO-18	Solder Dip	520201402R	Strip Pack
2N5401HRG	5202/014/01	-	ESCC Flight	-	TO-18	Gold	520201401	Strip Pack
2N5401HRT	5202/014/02	-	ESCC Flight	-	TO-18	Solder Dip	520201402	Strip Pack

1. High dose rate as per MIL-PRF-19500 specification group D, subgroup 2 inspection. Low dose rate as per ESCC specification 22900.
2. Specific marking only. The full marking includes in addition:
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.

Contact ST sales office for information about the specific conditions for:

- Products in die form
- Other JANS quality levels
- Tape and reel packing

6 Shipping details

6.1 Date code

Date code xyywwz is structured as below table:

Table 12. Date code

	x	yy	ww	z
EM (ESCC & 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 13. Documentation provided for each type of product

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

7 Revision history

Table 14. Document revision history

Date	Revision	Changes
04-Jan-2010	1	Initial release
13-Jul-2010	2	Modified Table 1: Device summary , added Table 11: Order codes
10-Oct-2012	3	Table 1: Device summary and Section 5: Order codes have been updated. Section 4: Package mechanical data has been updated.
12-Nov-2012	4	Added: Section 2.1: Electrical characteristics (curves)
22-Oct-2013	5	Updated Table 1: Device summary and Table 11: Order codes . Minor text changes.
01-Apr-2014	6	Updated Table 1: Device summary , Table 5: Electrical characteristics and Table 11: Order codes . Added Section 3: Radiation hardness assurance and Section 6: Shipping details . Minor text changes.
14-Jul-2014	7	Updated Table 1: Device summary and Table 11: Order codes .
20-Aug-2015	8	Updated: Section 4.3: TO-18 package information Minor text changes

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