

Hi-Rel 40 V, 0.8 A NPN transistor

Datasheet - production data

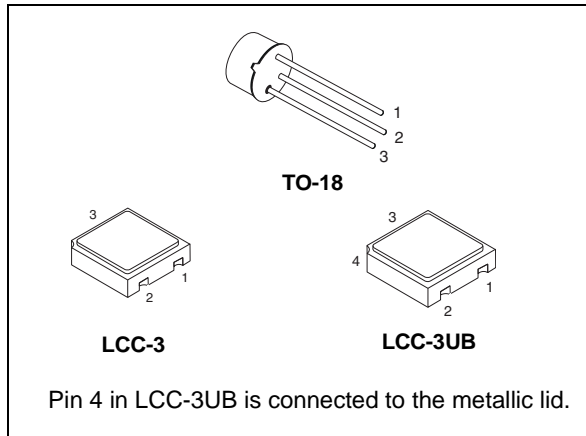
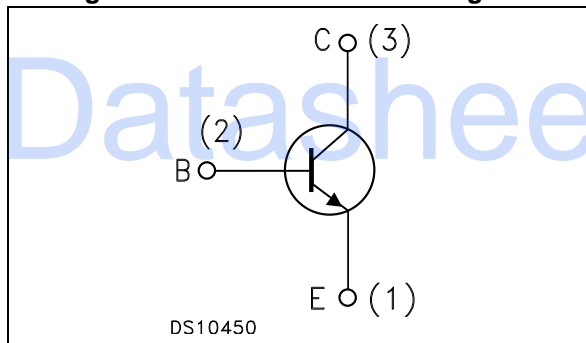


Figure 1. Internal schematic diagram



Features

Parameter	ESCC	JANS
$BV_{CEO \text{ min}}$	40 V	50 V
$I_C \text{ (max)}$	0.8 A	
$h_{FE} \text{ at } 10 \text{ V} - 150 \text{ mA}$	100	

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

Description

The 2N2222AHR is a silicon planar NPN 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. Devices summary

Device	Qualification	Agency spec.	Package	Radiation level	EPPL
JANS2N2222AUBx	JANS	MIL-PRF-19500/255	LCC-3UB	-	-
JANSR2N2222AUBx				100 krad	-
2N2222AUBxx	ESCC	5201/002	LCC-3UB	-	Yes
2N2222AUBxxSW				100 krad	Yes
2N2222ARUBx				100 krad	Target
SOC2222AHRB			LCC-3	-	Yes
SOC2222AxxSW				100 krad	Yes
SOC2222ARHRx				100 krad	Target
2N2222AHR			TO-18	-	-
2N2222ASW				100 krad	-
2N2222ARHRx				100 krad	-

Contents

- 1 Electrical ratings 3**

- 2 Electrical characteristics 4**
 - 2.1 JANS electrical characteristics 4
 - 2.2 ESCC electrical characteristics 5
 - 2.3 Electrical characteristics (curves) 6
 - 2.4 Test circuits 7

- 3 Radiation hardness assurance 9**

- 4 Package mechanical data 12**

- 5 Order codes 16**

- 6 Shipping details 18**
 - 6.1 Data code 18
 - 6.2 Documentation 18

- 7 Revision history 19**

1 Electrical ratings

Table 2. Absolute maximum ratings

Symbol	Parameter	Value	Unit
V_{CBO}	Collector-base voltage ($I_E = 0$)	75	V
V_{CEO}	Collector-emitter voltage ($I_B = 0$) for JANS devices	50	V
	Collector-emitter voltage ($I_B = 0$) for ESCC devices	40	V
V_{EBO}	Emitter-base voltage ($I_C = 0$)	6	V
I_C	Collector current	0.8	A
P_{TOT}	Total dissipation at $T_{amb} \leq 25\text{ °C}$		
	ESCC: TO-18	0.5	W
	LCC-3 and LCC-3UB	0.5	
	LCC-3 and LCC-3UB ⁽¹⁾	0.73	
	JANS: LCC-3UB	0.5	
Total dissipation at $T_{case} \leq 25\text{ °C}$			
ESCC: TO-18	1.8		
P_{TOT}	Total dissipation at $T_{sp(IS)} = 25\text{ °C}$		
	JANS: LCC-3UB	1	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 LCC-3UB	TO-18	Unit
R_{thJC}	Thermal resistance junction-case (max) for JANS	-	-	°C/W
	Thermal resistance junction-case (max) for ESCC	-	97	
$R_{thJSP(IS)}$	Thermal resistance junction-solder pad (infinite sink) (max) for JANS	90	-	
	Thermal resistance junction-solder pad (infinite sink) (max) for ESCC	-	-	
R_{thJA}	Thermal resistance junction-ambient (max) for JANS	325	-	
	Thermal resistance junction-ambient (max) for ESCC	350 240 ⁽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.

$T_{case} = 25\text{ °C}$ 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 ($I_E = 0$)	$V_{CB} = 75\text{ V}$ $V_{CB} = 60\text{ V}$ $V_{CB} = 60\text{ V}$ $T_{amb} = 150\text{ °C}$		-	10 10 10	μA nA μA
I_{CES}	Collector cut-off current ($I_E = 0$)	$V_{CE} = 50\text{ V}$		-	50	nA
I_{EBO}	Emitter cut-off current ($I_C = 0$)	$V_{EB} = 6\text{ V}$ $V_{EB} = 4\text{ V}$		-	10 10	μA nA
$V_{(BR)CEO}^{(1)}$	Collector-emitter breakdown voltage ($I_B = 0$)	$I_C = 10\text{ mA}$	50	-		V
$V_{CE(sat)}^{(1)}$	Collector-emitter saturation voltage	$I_C = 150\text{ mA}$ $I_B = 15\text{ mA}$ $I_C = 500\text{ mA}$ $I_B = 50\text{ mA}$		-	0.3 1	V V
$V_{BE(sat)}^{(1)}$	Base-emitter saturation voltage	$I_C = 150\text{ mA}$ $I_B = 15\text{ mA}$ $I_C = 500\text{ mA}$ $I_B = 50\text{ mA}$	0.6		1.2 2	V V
$h_{FE}^{(1)}$	DC current gain	$I_C = 0.1\text{ mA}$ $V_{CE} = 10\text{ V}$ $I_C = 1\text{ mA}$ $V_{CE} = 10\text{ V}$ $I_C = 10\text{ mA}$ $V_{CE} = 10\text{ V}$ $I_C = 150\text{ mA}$ $V_{CE} = 10\text{ V}$ $I_C = 500\text{ mA}$ $V_{CE} = 10\text{ V}$ $I_C = 10\text{ mA}$ $V_{CE} = 10\text{ V}$ $T_{amb} = -55\text{ °C}$	50 75 100 100 30 35	-	325 300	
h_{fe}	Small signal current gain	$V_{CE} = 20\text{ V}$ $I_C = 20\text{ mA}$ $f = 100\text{ MHz}$ $V_{CE} = 10\text{ V}$ $I_C = 1\text{ mA}$ $f = 1\text{ kHz}$	2.5 50	-		
C_{obo}	Output capacitance ($I_E = 0$)	$V_{CB} = 10\text{ V}$ $100\text{ kHz} \leq f \leq 1\text{ MHz}$		-	8	pF
C_{ibo}	Output capacitance ($I_E = 0$)	$V_{EB} = 0.5\text{ V}$ $100\text{ kHz} \leq f \leq 1\text{ MHz}$		-	25	pF

Table 4. JANS electrical characteristics (continued)

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
t_{on}	Turn-on time	$V_{CC} = 30\text{ V}$ $I_C = 150\text{ mA}$ $I_{B1} = 15\text{ mA}$		-	35	ns
t_{off}	Turn-off time	$V_{CC} = 30\text{ V}$ $I_C = 150\text{ mA}$ $I_{B1} = -I_{B2} = 15\text{ mA}$		-	300	ns

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

2.2 ESCC electrical characteristics

Table 5. ESCC electrical characteristics

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
I_{CBO}	Collector cut-off current ($I_E = 0$)	$V_{CB} = 60\text{ V}$ $V_{CB} = 60\text{ V}$ $T_{amb} = 150\text{ }^\circ\text{C}$		-	10 10	nA μA
I_{EBO}	Emitter cut-off current ($I_C = 0$)	$V_{EB} = 3\text{ V}$		-	10	nA
$V_{(BR)CBO}$	Collector-base breakdown voltage ($I_E = 0$)	$I_C = 100\text{ }\mu\text{A}$	75	-		V
$V_{(BR)CEO}^{(1)}$	Collector-emitter breakdown voltage ($I_B = 0$)	$I_C = 30\text{ mA}$	40	-		V
$V_{(BR)EBO}$	Emitter-base breakdown voltage ($I_C = 0$)	$I_E = 100\text{ }\mu\text{A}$	6	-		V
$V_{CE(sat)}^{(1)}$	Collector-emitter saturation voltage	$I_C = 150\text{ mA}$ $I_B = 15\text{ mA}$		-	0.3	V
$V_{BE(sat)}^{(1)}$	Base-emitter saturation voltage	$I_C = 150\text{ mA}$ $I_B = 15\text{ mA}$		0.87	1.2	V
$h_{FE}^{(1)}$	DC current gain	$I_C = 0.1\text{ mA}$ $V_{CE} = 10\text{ V}$ $I_C = 10\text{ mA}$ $V_{CE} = 10\text{ V}$ $I_C = 150\text{ mA}$ $V_{CE} = 10\text{ V}$ $I_C = 500\text{ mA}$ $V_{CE} = 10\text{ V}$ $I_C = 10\text{ mA}$ $V_{CE} = 10\text{ V}$ $T_{amb} = -55\text{ }^\circ\text{C}$	35 75 100 40 35	-	300	
h_{fe}	Small signal current gain	$V_{CE} = 20\text{ V}$ $I_C = 20\text{ mA}$ $f = 100\text{ MHz}$	3	-	10	
C_{obo}	Output capacitance ($I_E = 0$)	$V_{CB} = 10\text{ V}$ $100\text{ kHz} \leq f \leq 1\text{ MHz}$		-	8	pF

Table 5. ESCC electrical characteristics (continued)

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
t_{on}	Turn-on time	$V_{CC} = 30\text{ V}$ $I_C = 150\text{ mA}$ $I_{B1} = 15\text{ mA}$		-	35	ns
t_{off}	Turn-off time	$V_{CC} = 30\text{ V}$ $I_C = 150\text{ mA}$ $I_{B1} = -I_{B2} = 15\text{ mA}$		-	285	ns

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

2.3 Electrical characteristics (curves)

Figure 2. DC current gain

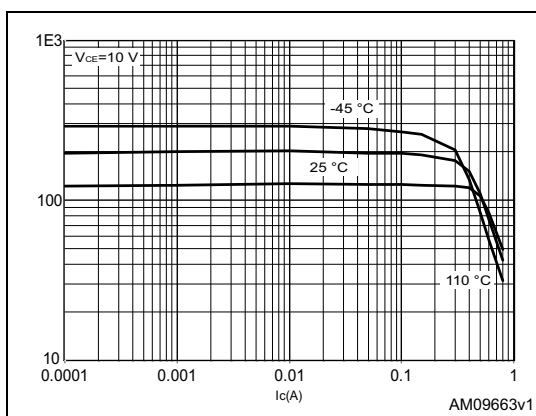


Figure 3. Collector emitter saturation voltage

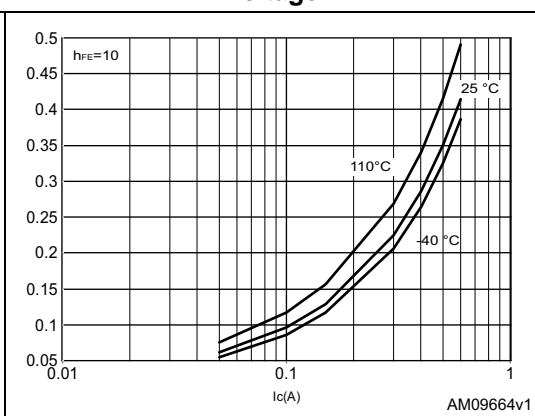
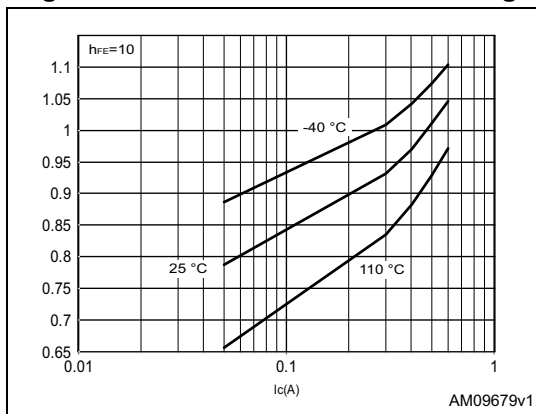


Figure 4. Base emitter saturation voltage



2.4 Test circuits

Figure 5. JANS saturated turn-on switching time test circuit

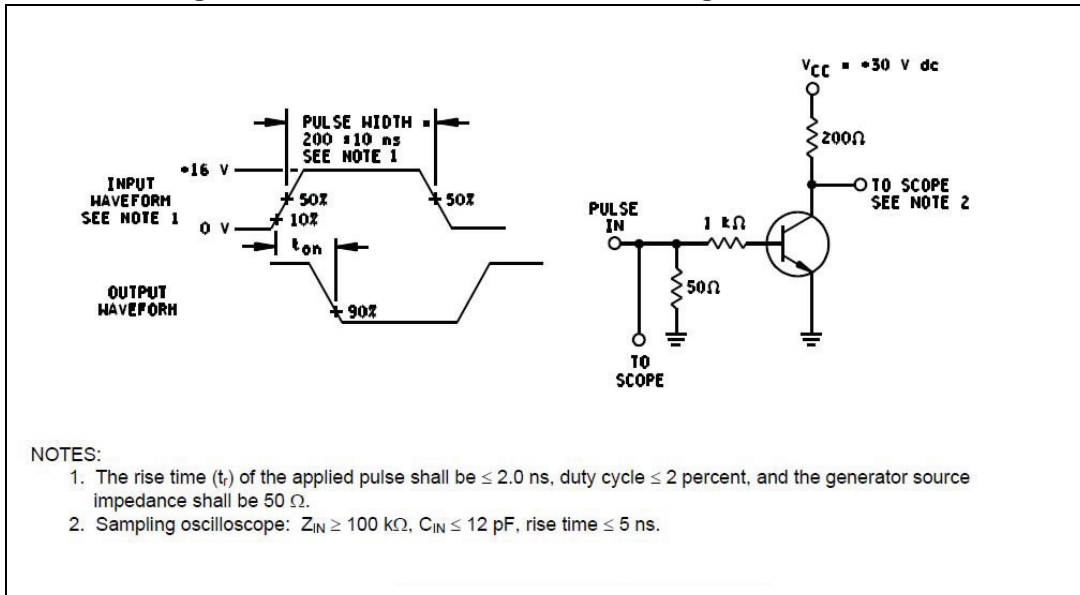


Figure 6. JANS saturated turn-off switching time test circuit

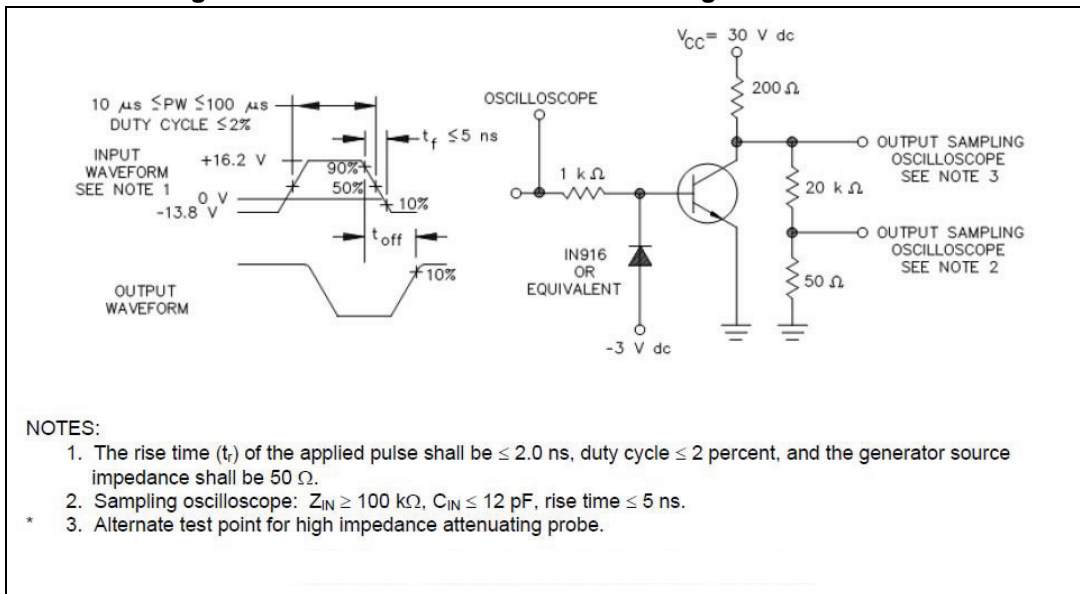
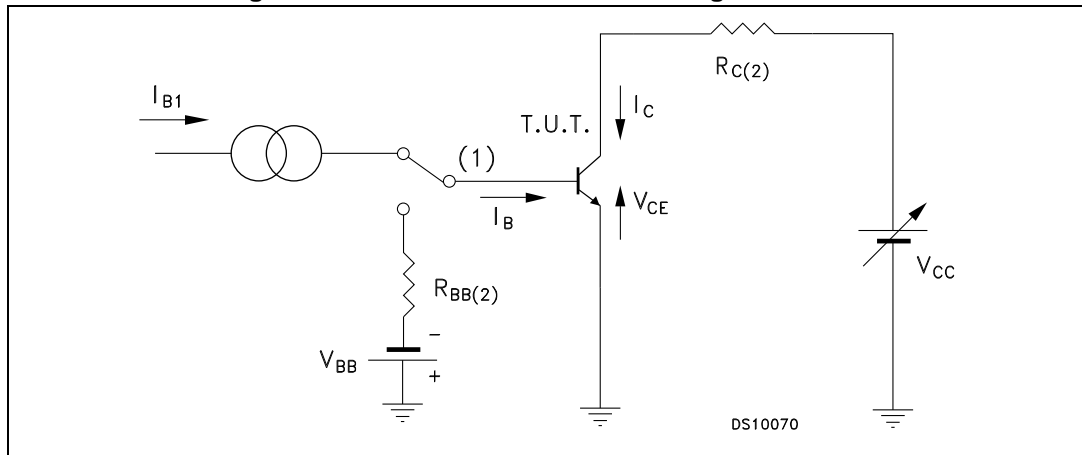


Figure 7. ESCC resistive load switching test circuit



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 5201/002 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	Value		Unit
			Min.	Max.	
I_{CBO}	Collector to base cutoff current	$V_{CB} = 75$		20	μA
		$V_{CB} = 60 V$		20	nA
I_{EBO}	Emitter to base cutoff current	$V_{EB} = 6 V$		20	μA
		$V_{EB} = 4 V$		20	nA
$V_{(BR)CEO}$	Breakdown voltage, collector to emitter	$I_C = 10 mA$	50		V
I_{CES}	Collector to emitter cutoff current	$V_{CE} = 50 V$		100	nA
h_{FE}	Forward-current transfer ratio	$V_{CE} = 10 V; I_C = 0.1 mA$	[25] ⁽¹⁾		
		$V_{CE} = 10 V; I_C = 1.0 mA$	[37.5] ⁽¹⁾	325	
		$V_{CE} = 10 V; I_C = 10 mA$	[50] ⁽¹⁾		
		$V_{CE} = 10 V; I_C = 150 mA$	[50] ⁽¹⁾	300	
		$V_{CE} = 10 V; I_C = 500 mA$	[15] ⁽¹⁾		
$V_{CE(sat)}$	Collector-emitter saturation voltage	$I_C = 150 mA; I_B = 15 mA$		0.35	V
		$I_C = 500 mA; I_B = 50 mA$		1.15	
$V_{BE(sat)}$	Base-emitter saturation voltage	$I_C = 150 mA; I_B = 15 mA$	0.6	1.38	V
		$I_C = 500 mA; I_B = 50 mA$		2.3	

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 8](#)
- 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. Radiation summary

Radiation test	100 krad "SW"	100 krad ESCC
Wafer test	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)	5202/001/02 ⁽²⁾	5202/001/02 ⁽²⁾
ST part number (ex)	SOC2222ASW	SOC2222ARHRG
Documents	CoC + RVT	CoC + RVT

1. Part numbers with suffix "SW" have same pre and post irradiation electrical
2. Example of the 2N2222A in LCC-3 Gold finish

Table 8. ESCC 5201/002 post radiation electrical characteristics

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
I_{CBO}	Collector cut-off current ($I_E = 0$)	$V_{CB} = 60 \text{ V}$		-	10	nA
I_{EBO}	Emitter cut-off current ($I_C = 0$)	$V_{EB} = 3 \text{ V}$		-	10	nA
$V_{(BR)CBO}$	Collector-base breakdown voltage ($I_E = 0$)	$I_C = 100 \mu\text{A}$	75	-		V
$V_{(BR)CEO}^{(1)}$	Collector-emitter breakdown voltage ($I_B = 0$)	$I_C = 30 \text{ mA}$ $I_C = 10 \text{ mA}$	40 50	-		V V
$V_{(BR)EBO}$	Emitter-base breakdown voltage ($I_C = 0$)	$I_E = 100 \mu\text{A}$	6	-		V
$V_{CE(sat)}^{(1)}$	Collector-emitter saturation voltage	$I_C = 150 \text{ mA}$ $I_B = 15 \text{ mA}$		-	0.3	V
$V_{BE(sat)}^{(1)}$	Base-emitter saturation voltage	$I_C = 150 \text{ mA}$ $I_B = 15 \text{ mA}$			1.2	V
$[h_{FE}]^{(1)}$	Post irradiation gain calculation ⁽²⁾	$I_C = 0.1 \text{ mA}$ $V_{CE} = 10 \text{ V}$ $I_C = 10 \text{ mA}$ $V_{CE} = 10 \text{ V}$ $I_C = 150 \text{ mA}$ $V_{CE} = 10 \text{ V}$ $I_C = 500 \text{ mA}$ $V_{CE} = 10 \text{ V}$	[17.5] [37.5] [50] [20]	-	300	

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

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.

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. Product mass summary

Package	Mass (g)
LCC-3UB	0.06
LCC-3	0.06
TO-18	0.40

Table 10. LCC-3UB 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. LCC-3UB drawings

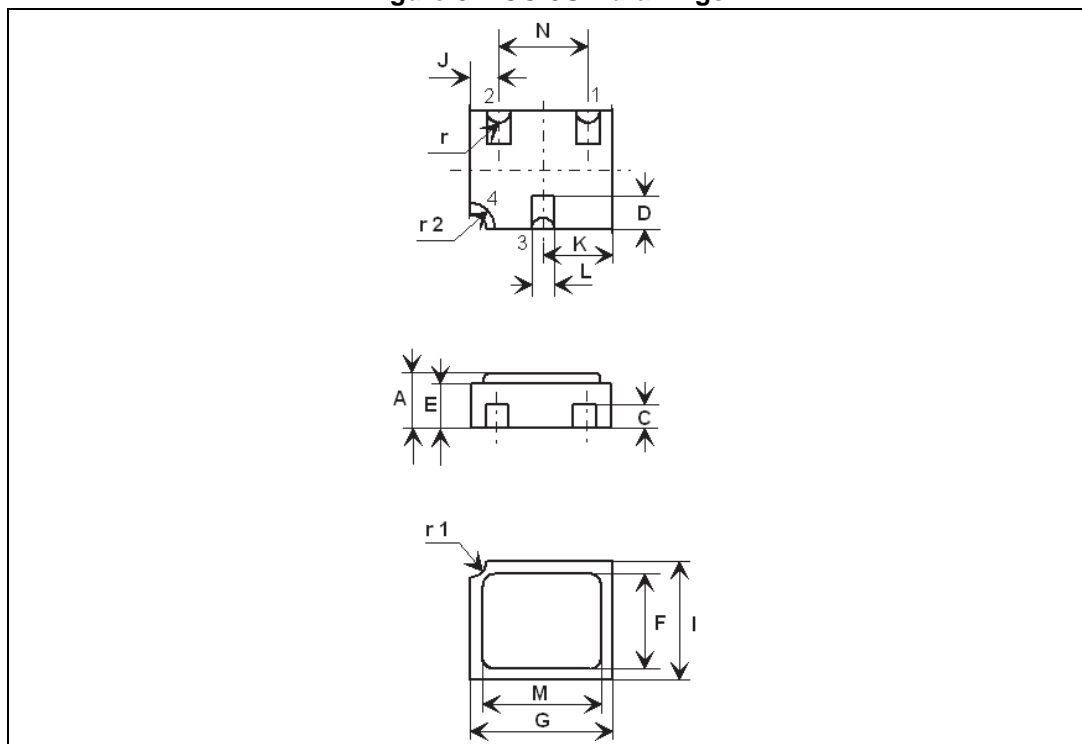


Table 11. LCC-3 mechanical data

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

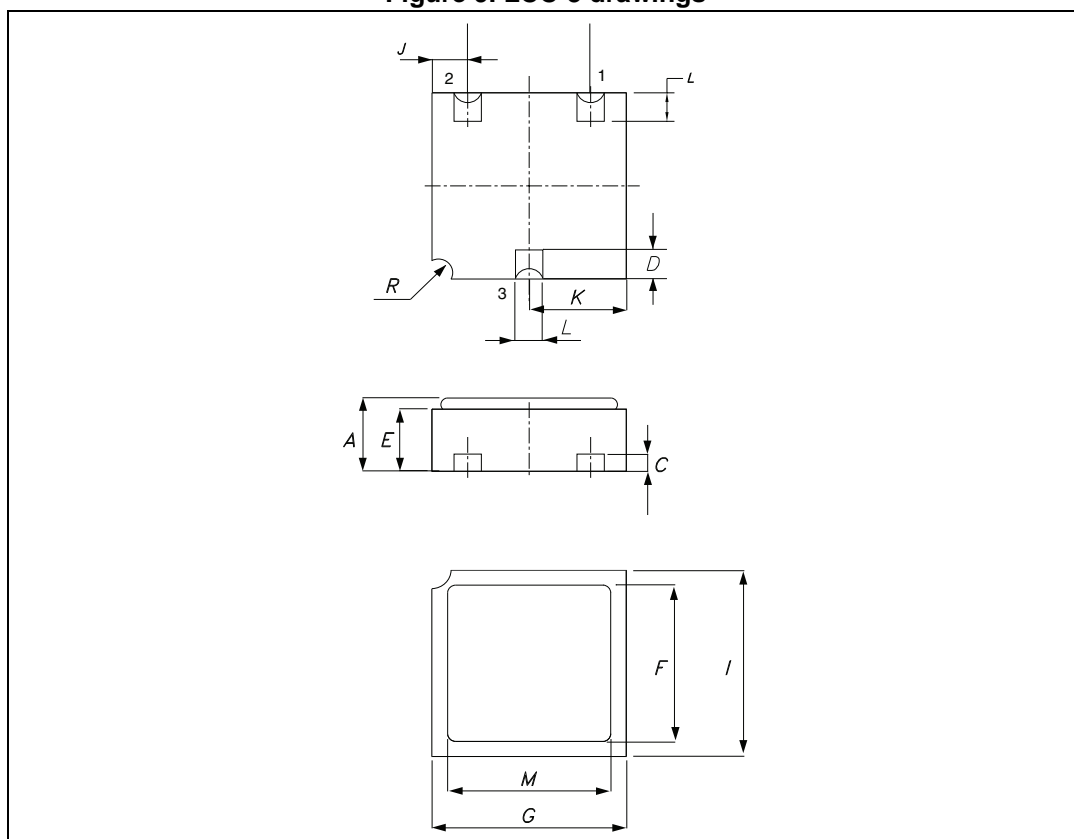
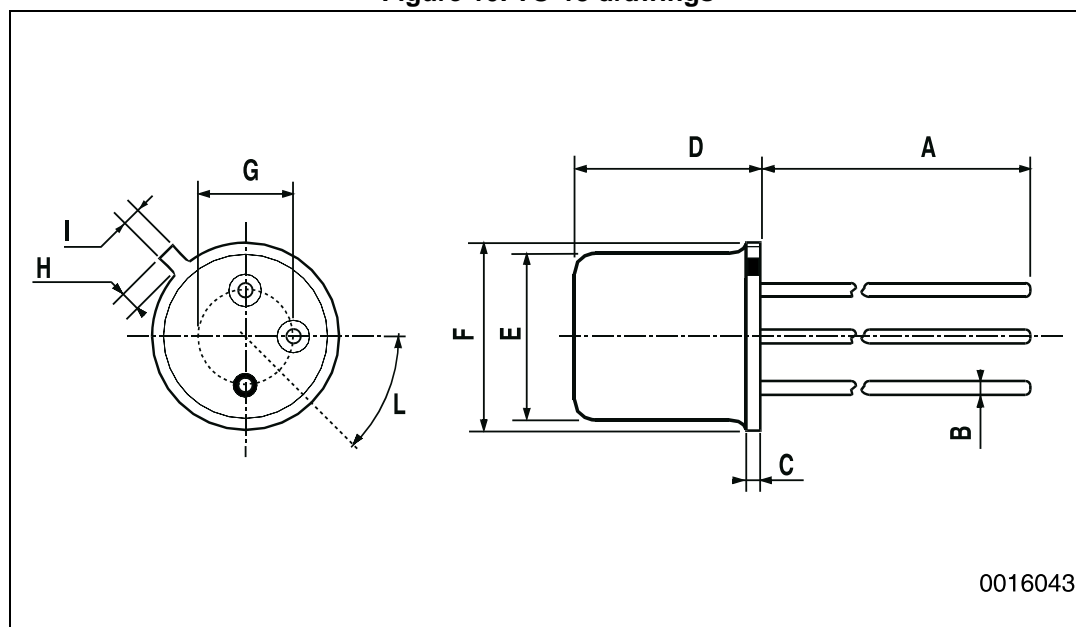


Table 12. TO-18 mechanical data

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 13. Ordering information

Part number	Agency specification	EPPL	Quality level	Radiation level	Package	Lead finish	Marking ⁽¹⁾	Packing
2N2222AUB1	-	-	Engineering model ESCC	-	LCC-3UB	Gold	U20	Waffle pack
J2N2222AUB1		-	Engineering model JANS		LCC-3UB	Gold	J2N2222A	Waffle pack
SOC2222A	-	-	Engineering model ESCC	-	LCC-3	Gold	N20	Waffle pack
JANS2N2222AUBG	MIL-PRF-19500/255	-	JANS flight	-	LCC-3UB	Gold	JS2222	Waffle pack
JANS2N2222AUBT	MIL-PRF-19500/255	-	JANS flight	-	LCC-3UB	Solder dip	JS2222	Waffle pack
JANSR2N2222AUBG	MIL-PRF-19500/255	-	JANS flight	100 krad	LCC-3UB	Gold	JSR2222	Waffle pack
JANSR2N2222AUBT	MIL-PRF-19500/255	-	JANS flight	100 krad	LCC-3UB	Solder dip	JSR2222	Waffle pack
2N2222ARUBG	5201/002/11R	Target	ESCC flight	100 krad	LCC-3UB	Gold	520100211R	Waffle pack
2N2222ARUBT	5201/002/12R	Target	ESCC flight	100 krad	LCC-3UB	Solder dip	520100212R	Waffle pack
2N2222AUB11SW ⁽²⁾	5201/002/11	Yes	ESCC flight	100 krad	LCC-3UB	Gold	520100211	Waffle pack
2N2222AUB12SW ⁽²⁾	5201/002/12	Yes	ESCC flight	100 krad	LCC-3UB	Solder dip	520100212	Waffle pack
2N2222AUB11	5201/002/11	-	ESCC flight	-	LCC-3UB	Gold	520100211	Waffle pack
2N2222AUB12	5201/002/12	-	ESCC flight	-	LCC-3UB	Solder dip	520100212	Waffle pack
SOC2222ARHRG	5201/002/04R	Target	ESCC flight	100 krad	LCC-3	Gold	520100204R	Waffle pack
SOC2222ARHRT	5201/002/05R	Target	ESCC flight	100 krad	LCC-3	Solder dip	520100205R	Waffle pack
SOC2222ASW ⁽²⁾	5201/002/04 or 05 ⁽³⁾	Yes	ESCC flight	100 krad	LCC-3	Gold or solder dip ⁽¹⁾	520100204 or 05 ⁽³⁾	Waffle pack
SOC2222AHRB	5201/002/04 or 05 ⁽³⁾	Yes	ESCC flight	-	LCC-3	Gold or solder dip ⁽¹⁾	520100204 or 05 ⁽³⁾	Waffle pack
2N2222AHR	5201/002/01 or 02 ⁽³⁾	-	ESCC flight	-	TO-18	Gold or solder dip ⁽¹⁾	520100201 or 02 ⁽³⁾	Strip 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

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

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

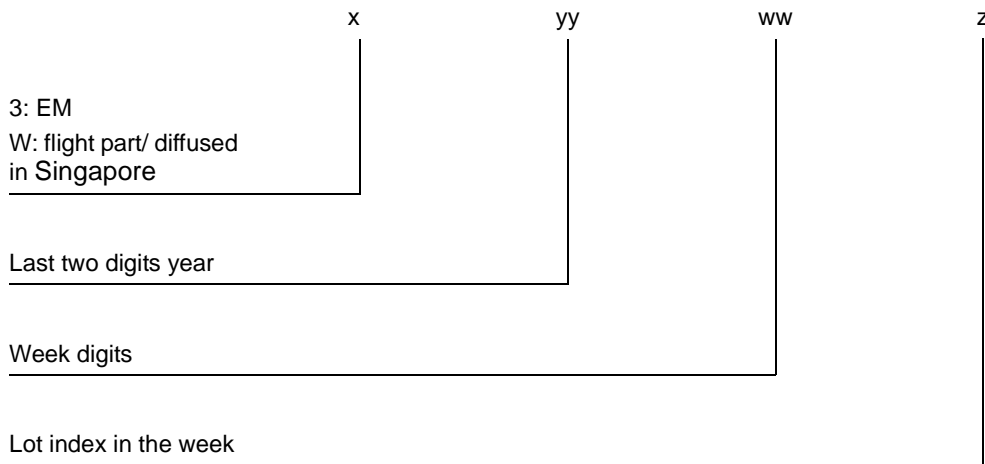
6 Shipping details

6.1 Data code

Data code is structured as described below:

- EM (ESCC and JANS) xyywwz
- ESCC Flight yywwz
- JANS Flight xyywwz

where:



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
04-Jan-2010	1	Initial release
16-Apr-2010	2	Added Table 1 on page 1
09-Jul-2010	3	Modified: Table 1 on page 1 and Table 12 on page 15
30-Nov-2011	4	<ul style="list-style-type: none"> – Modified: Table 5 on page 5 – Added: Section 2.3: Electrical characteristics (curves) – Modified: Table 1 and 2 – Added: Table 2, 11, 12 – Minor text changes in the document title and description on the cover page.
12-Dec-2011	5	Minor text changes to improve readability
17-Apr-2012	6	<p>Updated:</p> <ul style="list-style-type: none"> – Title and description in cover page. – P_{TOT} in Table 2: Absolute maximum ratings. – The entire Section 2: Electrical characteristics. – Table 13: Ordering information. <p>Added:</p> <ul style="list-style-type: none"> – Table 3: Thermal data, Section 3: Radiation hardness assurance and Table 13: Ordering information. – Figure 5: JANS saturated turn-on switching time test circuit and Figure 6: JANS saturated turn-off switching time test circuit. – Section 6: Shipping details.
19-Apr-2012	7	Updated titles in Figure 5: JANS saturated turn-on switching time test circuit and Figure 6: JANS saturated turn-off switching time test circuit .
24-Apr-2012	8	Updated R_{thJA} value in Table 3: Thermal data .
14-May-2012	9	Updated Table 13: Ordering information .
21-Feb-2013	10	<p>Table 1: Devices summary and Table 13: Ordering information have been updated.</p> <p>Updated text in Section 3: Radiation hardness assurance.</p>
04-Apr-2013	11	Inserted Table 7: Radiation summary

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