The documentation and process conversion measures necessary to comply with this revision shall be completed by 15 Jun 1993

INCH-POUND

MIL-S-19500/301C
15 March 1993
SUPERSEDING
MIL-S-19500/301B
10 July 1980

MILITARY SPECIFICATION

SEMICONDUCTOR DEVICE, TRANSISTOR, NPN SILICON, LOW-POWER
TYPE 2N918
JANS, JANTX, AND JANTXV

This specification is approved for use by all Departments and Agencies of the Department of Defense.

1. SCOPE

1.1 Scope. This specification covers the detail requirements for NPN, silicon, ultra-high frequency transistors. Three levels of product assurance are provided for each device type as specified in MIL-S-19500.

1.2 Physical dimensions. See 3.3.

1.3 Maximum ratings.

Types	P_T 1/ T_A = +25°C	P_T 2/ T_C = +25°C	V_{CBO}	V_{CEO}	V_{EBO}	I_C	T_{STG} and T_J
	mW	mW	V dc	V dc	V dc	mA dc	°C
2N918	200	300	30	15	3.0	50	-65 to +200

1/ Derate linearly, 1.14 mW/°C for T_A > +25°C.
2/ Derate linearly, 1.71 mW/°C for T_C > +25°C.

1.4 Primary electrical characteristics at T_A = +25°C.

Limit	$\|h_{FE}\|$ V_{CE} = 10 V dc I_C = 4 mA dc f = 100 MHz	$r_b' C_c$ V_{CB} = 10 V dc I_E = -4.0 mA dc f = 79.8 MHz	C_{obo2} V_{CB} = 10 V dc I_E = 0 mA dc 100 kHz≤f≤1 MHz	NF V_{CE} = 6 V dc I_C = 1 mA dc f = 60 MHz g_s = 2.5 mmho	G_{pe} V_{CB} = 12 V dc I_C = 6.0 mA dc f = 200 MHz
		ps	pF	dB	dB
Minimum	6.0				15
Maximum	18.0	25	1.7	6.0	

Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: Commander, US Army Research Laboratory, ATTN: AMSRL-EP-RD, Fort Monmouth, NJ 07703-5601, by using the Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

AMSC N/A

FSC 5961

DISTRIBUTION STATEMENT A. Approved for public release, distribution is unlimited.

1.4 Primary electrical characteristics at T_A = 25°C - Continued.

Limit	h_{FE1} V_{CE} = 10 V dc I_C = 500 µA dc	h_{FE2} V_{CE} = 1.0 V dc I_C = 3.0 mA dc	h_{FE3} V_{CB} = 10 V dc I_C = 10 mA dc
Minimum	10	20	20
Maximum		200	

2. APPLICABLE DOCUMENTS

2.1 Government documents.

2.1.1 Specifications, standards, and handbooks. The following specifications, standards, and handbooks form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those listed in the issue of the Department of Defense Index of Specifications and Standards (DODISS) and supplement thereto, cited in the solicitation (see 6.2).

SPECIFICATIONS

MILITARY

MIL-S-19500 - Semiconductor Devices, General Specification for.

STANDARDS

MILITARY

MIL-STD-750 - Test Methods for Semiconductor Devices.

(Unless otherwise indicated, copies of federal and military specifications, standards, and handbooks are available from the Standardization Documents Order Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.)

2.2 Order of precedence. In the event of a conflict between the text of this document and the references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

3. REQUIREMENTS

3.1 Associated detail specification. The individual item requirements shall be in accordance with MIL-S-19500 and as specified herein.

3.2 Abbreviations, symbols, and definitions. The abbreviations, symbols, and definitions used herein are defined in MIL-S-19500.

G_S . . . . . Noise source conductance.

P_O . . . . . Oscillator, power output.

R_{BE} . . . . . External resistance, base to emitter.

3.3 Design, construction, and physical dimensions. The design, construction and physical dimensions shall be as specified in MIL-S-19500, Appendix F, Figure 9.

3.3.1 Lead finish. Lead finish shall be solderable as defined in MIL-S-19500, MIL-STD-750, and herein.

3.4 Marking. Devices shall be marked in accordance with MIL-S-19500. At the option of the manufacturer, the marking of the country of origin may be omitted from the body of the transistor.

4 QUALITY ASSURANCE PROVISIONS

4.1 Sampling and inspection. Sampling and inspection shall be in accordance with MIL-S-19500, and as specified herein.

4.2 Qualification inspection. Qualification inspection shall be in accordance with MIL-S-19500 and as specified herein.

4.3 Screening (JANS, JANTX, AND JANTXV levels only). Screening shall be in accordance with MIL-S-19500 (table II), and as specified herein. The following measurements shall be made in accordance with table I herein. Devices that exceed the limits of table I herein shall not be acceptable.

Screen (see table II of MIL-S-19500)	Measurement	
	JANS level	JANTX and JANTXV levels
9	I_{CBO1} and h_{FE2}	
11	I_{CBO1} and h_{FE2} ΔI_{CBO1} = 100% of initial value or 5 nA dc, whichever is greater; Δh_{FE2} = ±15%.	I_{CBO1} and h_{FE2}
12	See 4.3.1	See 4.3.1
13	Subgroups 2 and 3 of table I herein; ΔI_{CBO1} = 100% of initial value or 5 nA dc, whichever is greater; Δh_{FE2} = ±15 %.	Subgroup 2 of table I herein; ΔI_{CBO1} = 100% of initial value or 5 nA dc, whichever is greater; Δh_{FE2} = ±20%.

4.3.1 Power burn-in conditions. Power burn-in conditions are as follows:

2N918 . . . . . V_{CB} = 10 V dc, P_T = 200 mW at T_A = room ambient as defined in the general requirements of MIL-STD-750, (see 4.5).

NOTE: No heat sink or forced air cooling on the devices shall be permitted.

4.4 Quality conformance inspection. Quality conformance inspection shall be in accordance with MIL-S-19500 and as specified herein. Group A inspection shall be performed on each sublot.

4.4.1 Group A inspection. Group A inspection shall be conducted in accordance with MIL-S-19500 and table I herein.

4.4.2 Group B inspection. Group B inspection shall be conducted in accordance with the conditions specified for subgroup testing in table IVa (JANS) and table IVb (JANTX) of MIL-S-19500. Electrical measurements (end-points) and delta requirements shall be in accordance with the applicable steps of table II herein.

4.4.2.1 Group B inspection, table IVa (JANS) of MIL-S-19500

a. Subgroup 3, condition for bond strength is test condition A. All internal leads for each device shall be pulled separately.

b. Subgroup 4, condition for intermittent operation life are as follows: V_{CB} = 10 V dc; P_T = 200 mW at T_A = room ambient as defined in the general requirements of MIL-STD-750, paragraph 4.5; t_{on} = t_{off} = 3 minutes minimum for 2,000 cycles. No heat sink or forced-air cooling on devices shall be permitted.

c. Subgroup 5, condition for steady-state operation life (accelerated) are as follows: V_{CB} = 10 V dc; T_A = 125°C ± 25°C for 96 hours, P_T = 200 mW at T_A = 100°C or adjusted as required according to the chosen T_A to give an average T_J = 275°C

4.4.2.2 Group B inspection, table IVb (JANTX and JANTXV) of MIL-S-19500.

a. Subgroup 3, condition for steady-state operation life are as follows: V_{CB} = 10 V dc; P_T = 200 mW at T_A = room ambient as defined in the general requirements of MIL-STD-750, (see 4.5). No heat sink or forced-air cooling on devices shall be permitted.

b. Subgroup 3, condition for bond strength is test condition A. All internal leads for each device shall be pulled separately.

4.4.3 Group C inspection. Group C inspection shall be conducted in accordance with the conditions specified for subgroup testing in table V of MIL-S-19500. Electrical measurements (end-points) and delta requirements shall be in accordance with the applicable steps of table II herein.

4.4.3.1 Group C inspection, table V of MIL-S-19500.

a. Subgroup 2, condition for terminal strength is test condition E.

b. Subgroup 6, condition for Steady-state operation life (accelerated) are as follows: V_{CB} = 10 V dc, P_T = 200 mW at T_A = room ambient as defined in the general requirements of MIL-STD-750, (see 4.5). No heat sink or forced air cooling on the devices shall be permitted.

4.5 Methods of inspection. Methods of inspection shall be as specified in the appropriate tables and as follows.

4.5.1 Input capacitance. This test shall be conducted in accordance with method 3240 of MIL-STD-750 except that the output capacitor shall be omitted.

4.5.2 Disposition of case lead during electrical measurements. All electrical measurements and operating life test shall be performed with the case lead connected to the source.

4.5.3 Noise figure. The noise figure shall be measured using commercially available test equipment and its associated standard test procedures (see figure 1).

4.5.4 Collector-base time constant. 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 (V_{eb}) 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:

$$r_{b'}C_c \text{ (psec)} = 2 \times V_{eb} \text{ (millivolts)}$$

TABLE I. Group A inspection.

Inspection 1/	MIL-STD-750		Symbol	Limits		Unit
	Method	Conditions		Min	Max	
Subgroup 1						
Visual and mechanical examination	2071					
Subgroup 2						
Breakdown voltage, collector to base	3001	Bias Condition D, I_C = 1.0 µA dc	$V_{(BR)CBO}$	30		V dc
Breakdown voltage, collector to emitter	3011	Bias Condition D, I_C = 3.0 mA dc	$V_{(BR)CEO}$	15		V dc
Breakdown voltage, emitter to base	3026	Bias Condition D, I_E = 10 µA dc	$V_{(BR)EBO}$	3		V dc
Collector to base cutoff current	3036	Bias Condition D, V_{CB} = 25 V dc	I_{CBO1}		10	nA dc
Emitter to base cutoff current	3061	Bias Condition D, V_{EB} = 2.5 V dc	I_{EBO}		10	nA dc
Forward-current transfer ratio	3076	V_{CE} = 10 V dc; I_C = 500 µA dc;	h_{FE1}	10		
Forward-current transfer ratio	3076	V_{CE} = 1.0 V dc; I_C = 3.0 mA dc;	h_{FE2}	20	200	
Forward-current transfer ratio	3076	V_{CE} = 10 V dc; I_C = 10 mA dc;	h_{FE3}	20		
Collector to emitter voltage (saturated)	3071	I_C = 10 mA dc; I_B = 1.0 mA dc;	$V_{CE(sat)}$		0.4	V dc
Base to emitter voltage (saturated)	3066	Test condition A; I_C = 10 mA dc; I_B = 1.0 mA dc	$V_{BE(sat)}$		1.0	V dc
Subgroup 3						
High temperature operation		T_A = +150°C				
Collector to base cutoff current	3036	Bias Condition D, V_{CB} = 25 V dc	I_{CBO2}		1.0	µA dc
Low-temperature operation		T_A = -55°C				
Forward-current transfer ratio	3076	V_{CE} = 1.0 V dc; I_C = 3.0 mA dc	h_{FE4}	10		

See footnotes at end of table.

TABLE I. Group A inspection - Continued.

Inspection 1/	MIL-STD-750		Symbol	Limits		Unit
	Method	Conditions		Min	Max	
Subgroup 4						
Open circuit output capacitance	3236	V_{CB} = 10 V dc; I_E = 0; 100 kHz ≤ f ≤ 1 MHz	C_{obo1}		5.0	pF
Open circuit output capacitance	3236	V_{CB} = 10 V dc; I_E = 0; 100 kHz ≤ f ≤ 1 MHz	C_{obo2}		1.7	pF
Input capacitance (output open-circuited)	3240	V_{EB} = 0.5 V dc, I_C = 0; 100 kHz ≤ f ≤ 1 MHz	C_{ibo}		2.0	pF
Magnitude of common emitter, small-signal short-circuit forward current transfer ratio	3306	V_{CE} = 10 V dc; I_C = 4.0 mA dc; f = 100 MHz	$\lvert h_{FE} \rvert$	6.0	18	
Noise figure		V_{CE} = 6 V dc; I_C = 1.0 mA dc; f = 60 MHz; g_s = 2.5 mmho (see 4.5.2, 4.5.3, and figure 1)	NF		6.0	dB
Small-signal power gain	3256	V_{CB} = 12 V dc; I_C = 6.0 mA dc; f = 200 MHz; (see 4.5.2 and figure 2)	G_{pe}	15		dB
Collector-base time constant		V_{CB} = 10 V dc; I_E = -4.0 mA dc; f = 79.8 MHz (see 4.5.2 and 4.5.4)	$r_b' C_c$		25	ps
Oscillator power output		V_{CB} = 15 V dc; I_C = 8.0 mA dc; f ≥ 500 MHz (see figure 3)	P_o		30	mW
Collector efficiency		V_{CE} = 15 V dc; I_C = 8.0 mA dc; f ≥ 500 MHz (see figure 3)	η		25	%
Subgroup 5						
Not applicable						

1/ For sampling plans, see MIL-S-19500.

TABLE II. Group E and J electrical measurements. 1/ 2/ 3/

Step	Inspection	MIL-STD-750		Symbol	Limits		Unit
		Method	Conditions		Min	Max	
1	Collector to base cutoff current	3036	Bias condition D; V_{CB} = 25 V dc	I_{CBO1}		10	nA dc
2	Collector to base cutoff current	3036	Bias condition D; V_{CE} = 25 V dc	I_{CBO2}		20	nA dc
3	Emitter-base cutoff current	3061	Bias condition D; V_{CB} = 2.5 V dc	I_{EBO}		10	nA dc
4	Collector to emitter voltage (saturated)	3071	I_C = 10 mA dc; I_B = 1.0 mA dc	$V_{CE(sat)}$		0.4	V dc
5	Base emitter voltage (saturated)	3066	Test condition A; I_C = 10 mA dc; I_B = 1.0 mA dc	$V_{BE(sat)}$		1.0	V dc
6	Forward-current transfer ratio	3076	V_{CE} = 1.0 V dc; I_C = 3.0 mA dc	h_{FE2}	20	200	
7	Forward-current transfer ratio	3076	V_{CE} = 10 V dc; I_C = 10 mA dc	h_{FE3}	20		
8	Collector-base cutoff current	3036	Bias condition D; V_{CB} = 25 V dc	ΔI_{CBO1} 4/	100 percent of initial value or 5 nA dc, whichever is greater.		
9	Forward-current transfer ratio	3076	V_{CE} = 1.0 V dc; I_C = 3.0 mA dc	Δh_{FE2} 4/	±25 percent change from initial reading		
10	Collector-emitter voltage (saturated)	3071	I_C = 10 mA dc; I_B = 1.0 mA dc	$\Delta V_{CE(sat)}$ 4/	±50 mV dc change from previously measured value.		

1/ The electrical measurements for table IVa (JANS) of MIL-S-19500 are as follows:

a. Subgroup 3, see table II herein, steps 1, 3, 4, 5, and 6.
b. Subgroup 4, see table II herein, steps 1, 3, 4, 5, 6, and 10.
c. Subgroup 5, see table II herein, steps 1, 3, 4, 5, 6, 8, 9, and 10.

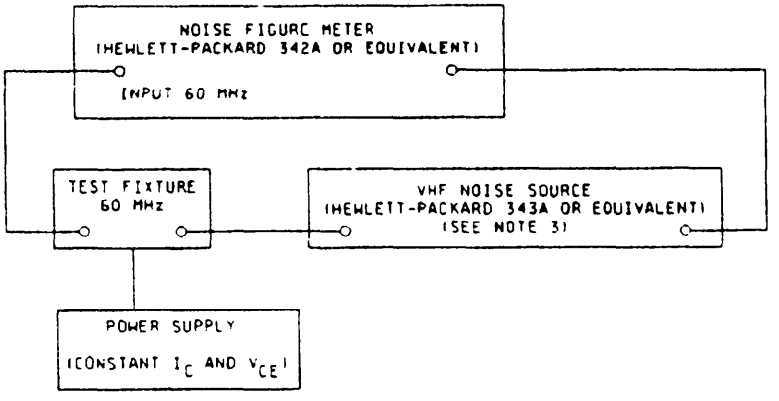
2/ The electrical measurements for table IVb (JANTX and JANTXV) of MIL-S-19500 are as follows:

a. Subgroup 2, see table II herein, steps 1, 4, and 6.
b. Subgroups 3 and 6, see table II herein, steps 2, 6, and 9.

3/ The electrical measurements for table V of MIL-S-19500 are as follows:

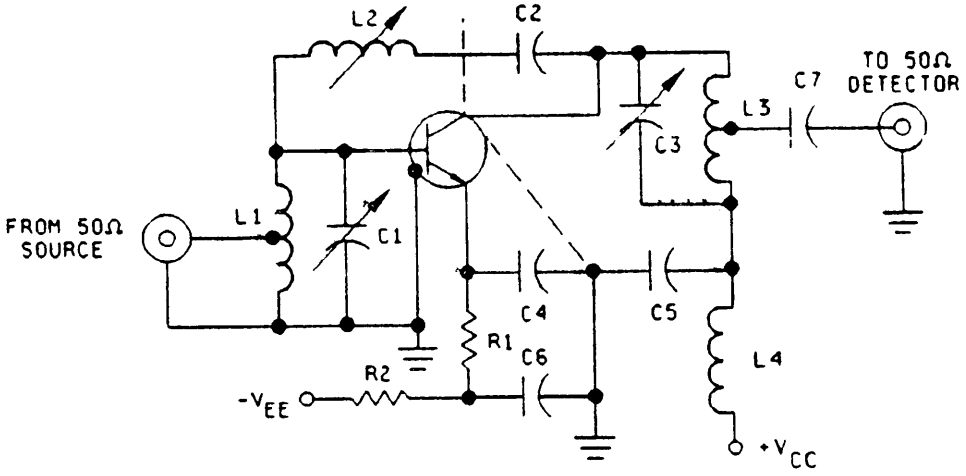
a. Subgroups 2 and 3, see table II herein, steps 1, 3, 4, 5, 6, and 7 for JANS level and steps 1, 4, and 7 for JAN, JANTX, and JANTXV levels.
b. Subgroup 6, see table II herein, steps 1, 3, 4, 5, 6, 7, 8, 9, and 10 for JANS level and steps 2, 6, and 9 for JAN, JANTX, and JANTXV levels.

4/ Devices which exceed the group A limits for this test shall not be acceptable



NOTES:
1. The test fixture shall consist of a 60 MHz tuned amplifier and suitable biasing circuits. It should be constructed utilizing very high-frequency design techniques.
2. The effective source susceptance should be tuned for each device being tested to obtain minimum noise figure.
3. The HP-343A has a 50-ohm output resistance, therefore a suitable impedance transformer must be used to obtain an effective source conductance of 2.5 mmho at the transistor with minimum losses.

FIGURE 1. Block diagram for noise-figure test.



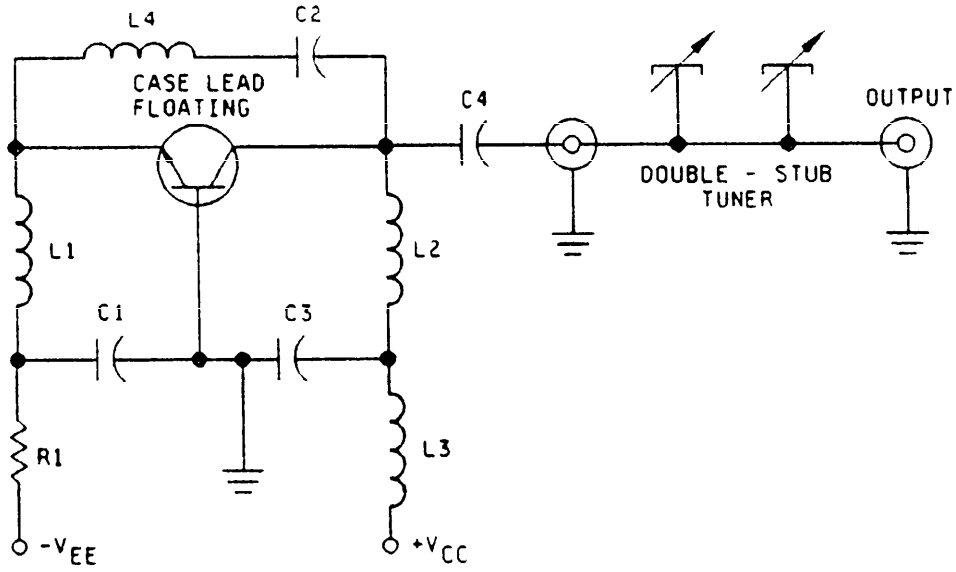
NEUTRALIZATION PROCEDURE:

a. Connect a 200 MHz signal generator (with a 50 ohm output impedance) to the input terminals of the amplifier, and connect a 50 ohm rf voltmeter to the output terminals of the amplifier.
b. Apply V_{EE} and V_{CC} to obtain the specified test conditions.
c. Adjust the output of the signal generator to approximately 10 millivolts and tune C_1 and C_3 for maximum output.
d. Interchange the connections to the signal generator and rf voltmeter and with sufficient signal applied at the output terminals, tune L_2 for a minimum indication on the rf voltmeter.
e. Repeat this sequence until optimum settings are obtained for all variables.

CIRCUIT-COMPONENT INFORMATION:

C1:	3-12 pF
C2 and C7:	1000 pF
C3:	1.5 - 7.5 pF
C4 and C5:	0.01 µF
C6:	0.05 µF
L1:	3½ T No. 16 AWG 5/16" ID, 7/16" length, Turns ratio ≅ 2 to 1
L2:	0.4 - 0.65 µh, Miller No. 4303 (or equal)
L3:	8 T No. 16 AWG, ⅜" ID, ⅜" length, Turns ratio ≅ 8 to 1
L4:	200 MHz RFC
R1:	100Ω
R2:	1 kΩ

FIGURE 2. Small-signal power gain.



OSCILLATOR ADJUSTMENT PROCEDURE:

Measurement of P_o shall be made in this circuit or a suitable equivalent. The circuit adjustment procedure is as follows:

a. Set V_{CC} and V_{EE} to obtain the specified test conditions.
b. Adjust the stub tuner to obtain the maximum output at the specified frequency of oscillation.
c. Check I_C and reset if necessary.
d. Read P_o.

Note 1. Collector efficiency ( ), may be determined as follows:

$$\eta \text{ in } \% \frac{P_o}{120} \times 100 \qquad \text{Where } P_o \text{ is in milliwatts}$$

CIRCUIT-COMPONENT INFORMATION:

C1 and C3:	1000 pF
C2:	50 pF
C4:	75 pF
R1:	2.2 kΩ
L1 and L3:	500 mC RFC
L2:	2 turns No. 16 AWG, ¼" OD, 1½" length
L4:	9 turns No. 22 AWG, 3/16" OD, ½" length

Double-stub tuner consists of the following commercially available components:

2 GR Type 874 TEE (or equivalent)
1 GR Type 874-D20 Adjustable Stub (or equivalent)
1 GR Type 874-LA Adjustable Line (or equivalent)
1 GR Type 874-WN3 Short-Circuit Termination (or equivalent)

FIGURE 3. Oscillator power output

5. PACKAGING

5.1 Packaging requirements. The requirements for packaging shall be in accordance with MIL-S-19500.

6. NOTES

(This section contains information of a general or explanatory nature that may be helpful, but is not mandatory.)

6.1 Notes. The notes specified in MIL-S-19500 are applicable to this specification.

6.2 Acquisition requirements. Acquisition documents should specify the following:

a. Issue of DODISS to be cited in the solicitation.

b. Lead finish as specified (see 3.3.1).

c. Product assurance level and type designation.

6.4 Changes from previous issue. Marginal notations are not used in this revision to identify changes with respect to the previous issue, due to the extensiveness of the changes.

CONCLUDING MATERIAL

Custodians:
Army - ER
Navy - EC
Air Force - 17
NASA - NA

Review activities:
Army - AR, MI
Air Force - 19, 85, 99
DLA - ES

User activities:
Navy - AS, CG, MC, SH
Air Force - 15

Preparing activity:
Army - ER

Agent:
DLA - ES

(Project 5961-1416)