MILITARY SPECIFICATION

SEMICONDUCTOR DEVICE, TUNNEL DIODE,

TYPES 1N3713, 1N3715, 1N3717, 1N3719 AND 1N3721

1. SCOPE

1.1 Description.- This specification covers the detail requirements for germanium tunnel diodes and is in accordance with Specification *MIL-S-19500, except as otherwise specified herein.* Characteristics shall be as follows:

	TYPE	I_P	I_V	V_P	V_{FP}	C
		mAdc	mAdc	mVdc	mVdc	pf
MIN	1N3713	0.975	0.075	58	475	
	1N3715	2.15	.165	58	475	
	1N3717	4.58	.350	58	475	
	1N3719	9.75	.750	58	475	
	1N3721	21.5	1.65	58	475	
MAX	1N3713	1.025	.140	72	535	5
	1N3715	2.25	.310	72	535	10
	1N3717	4.82	.600	72	535	25
	1N3719	10.25	1.40	72	535	50
	1N3721	22.5	3.10	72	535	100

1.2 Absolute maximum ratings.-

TYPE	I_R 1/	I_F 1/	T_A (operating)	T_{stg}
	mAdc	mAdc	°C	°C
1N3713	10	5	-55 to +100	-55 to +100
1N3715	20	10		
1N3717	50	25		
1N3719	50	50		
1N3721	50	50		

1/ Derate maximum currents 1%/°C in the range T_A = 25°C to T_A = 100°C.

2. APPLICABLE DOCUMENTS

2.1 The following documents of the issue in effect on the date of invitation for bids or request for proposal, form a part of this specification to the extent specified herein:

SPECIFICATION

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

STANDARD

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

FSC 5960

(Copies of specifications, standards, drawings, and publications required by suppliers in connection with specific procurement functions should be obtained from the procuring activity or as directed by the contracting officer.)

3. REQUIREMENTS

3.1 General.- Diodes shall be in accordance with Specification MIL-S-19500 and as specified herein.

3.2 Abbreviations and symbols.- The abbreviations and symbols used herein are defined in Specification MIL-S-19500 and as follows:

I_P - Peak point current

I_V - Valley point current

V_P - Peak point voltage

V_V - Valley point voltage

V_{FP} - Forward voltage in the injection region corresponding to that point on the forward characteristic where the current is equal to the specified maximum peak point current.

V_{FS} - Forward voltage in the injection region corresponding to that point on the forward characteristic where the current is equal to one-quarter of the nominal peak point current.

C - Valley point terminal capacitance.

R_S - Total series resistance.

-G - Maximum terminal negative conductance.

3.3 Design, construction and physical dimensions.- Diodes shall be of the design, construction and physical dimensions shown on figure 1.

3.4 Performance characteristics.- Performance characteristics shall be as shown in tables I, II and III.

3.5 Marking.- The following marking shall be required:

(a) Type designation.

3.5.1 The following marking specified in Specification MIL-S-19500 may be omitted from the body of the diode:

(a) USN prefix.
(b) Qualification-designation code.
(c) Country of origin.
(d) Acceptance date and inspection lot identification.
(e) Manufacturer's identification.
(f) Color band identification.
(g) Reliability indicator.

3.5.2 All of the above markings shall be placed on the unit package.

3.5.3 Polarity shall be as shown on figure 1.

4. QUALITY ASSURANCE PROVISIONS

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

4.2 Qualification tests.- Qualification tests shall be conducted at a laboratory satisfactory to the Bureau of Ships. Qualification tests shall consist of the tests specified in 4.4, 4.5 and 4.6. (Application for Qualification tests shall be made in accordance with "Provisions Governing Qualification" (see 6.1)).

4.3 Acceptance inspection.- Acceptance inspection shall consist of the examinations and tests specified in 4.4, 4.5, and 4.6.

4.3.1 Acceptance procedure.- When a second sample is chosen, the total sample shall be associated with the minimum rejection numbers shown in tables I, II and III.

4.3.2 Acceptance inspection information.- When specified in the contract or order, one copy of the acceptance inspection data pertinent to the inspection lot shall accompany the shipments.

4.4 Group A inspection.- Group A inspection shall consist of the examinations and tests shown in table I.

4.5 Group B inspection.- Group B inspection shall consist of the examinations and tests shown in table II.

4.6 Group C inspection.- Group C inspection shall consist of the examinations and tests shown in table III.

4.7 Methods of examination and test.- Methods of examination and test shall be as shown in tables I, II, III and as follows:

4.7.1 Peak point current (I_P).- The voltage current characteristic of a tunnel diode is shown on figure 2. The peak point of the tunnel diode is shown at point A on figure 2. Peak point current shall be measured by the method described or equivalent. The diode shall be mounted in a jig with two low inductance resistors, R2 and R3 an integral part of the jig structure (see figure 3). A dc voltage variable from 0 to 500 mv dc with a 5 mv p-p ac component at 1000 cps superimposed on it shall be applied to the jig through a series resistance R1. The ac and dc voltage drop across resistance R3, which is proportional to the dc current and the superimposed ac current of the tunnel diode, is monitored. On increasing the dc voltage from zero volts, the ac fundamental output will null when the peak point is reached. At this point, $V1/_{R3}$ will equal the peak point current of the tunnel diode. The peak point current test shall be calibrated by obtaining a precise measurement of the value of R3 and then reading I_P as $V1/_{R3}$.

4.7.2 Valley point current (I_V).- The valley point of a tunnel diode is shown at point B on figure 2. Valley point current shall be measured by the method described or equivalent. The test shall be performed in the jig used for the peak point current measurements (see figure 3). A dc voltage variable from 0 to 1000 mV dc with an 20 mv p-p ac component at 1000 cps superimposed on it shall be applied to the jig through a series resistance R1. The ac and dc voltage drop across resistance R3, which is proportional to the dc current and the superimposed ac current of the tunnel diode, is monitored. On decreasing the dc voltage from 1.00 volts, the ac fundamental output will null when the valley is reached. At this point $V1/_{R3}$ will equal the valley point current of the tunnel diode. Calibration for the valley point current test may be obtained by obtaining a precise measurement for the value of R3 and then reading I_V as $V1/_{R3}$.

4.7.3 Peak point voltage (V_P).- Peak point voltage shall be measured by the method described or equivalent. Peak point voltage shall be measured in the current shown on figure 3 under the ac null balance conditions of the peak point current test (see 4.7.1). At the point of balance, the dc voltage across the tunnel diode shall be measured, using separate voltage sensing contacts. This voltage is equal to the peak point voltage of the tunnel diode. The calibration procedure for this test consists of verifying the calibration of the dc voltmeter used to measure the peak voltage.

4.7.4 Valley point voltage (V_V).- Valley point voltage shall be measured by the method described or equivalent. Valley point voltage shall be measured in the circuit shown on figure 3 under the ac null balance conditions of the valley point current test (see 4.7.2). At the point of balance, the voltage across the tunnel diode shall be measured, using separate voltage sensing contacts. This voltage shall be equal to the valley point voltage of the tunnel diode. The calibration procedure for this test consists of verifying the calibration of the dc voltmeter used to measure the valley voltage.

4.7.5 Forward voltage point (V_{FP}).- The forward voltage point V_{FP} is shown at point C on figure 2. Forward voltage point shall be measured by the method described or equivalent. The forward voltage of a tunnel diode shall be measured in the circuit shown on figure 4. The diode shall be inserted in the test clips and the current source shall be adjusted to a value of current equal to the specified maximum peak current of the tunnel diode. The reading on voltmeter V1, using separate voltage sensing contacts, is then equal to the V_{FP} of the tunnel diode.

4.7.6 Forward voltage point (V_{FS}).- The forward voltage point V_{FS} is shown at point D on figure 2. Forward voltage point shall be measured by the method described or equivalent. The forward voltage of a tunnel diode shall be measured in the circuit shown on figure 4. The diode shall be inserted in the test clips and the current source shall be adjusted to a value of current, larger than the peak point current, so that the diode will switch to its high voltage state. The current from the current source if then reduced to a value of current equal to 1/4 of the nominal specified peak current of the tunnel diode, the reading on voltmeter V1 is equal to the V_{FS} of the tunnel diode.

4.7.7 Capacitance (C).- Capacitance shall be measured by the method described or equivalent. The test circuit for capacitance measurements shall be as shown on figure 5. A radio frequency bridge calibrated in terms of a shunt resistance - capacitance combination shall be used for the measurement. The problems of internal bridge and connecting lead inductance can be reduced by the use of external standards in the substitution measurement assembly shown on figure 5. C_{ST} is a capacitance standard. The conductance standard, R_r, is a high frequency resistor mounted in a diode encapsulation so as to have a known shunt capacitance and an inductance, L_r, very nearly equal to that of the diode. The bridge is balanced initially with R_r in the circuit. For this initial balance, C_{ST} shall be set to a larger value than the expected diode capacitance. The diode to be measured is then substituted for R_r in the circuit and the conductance made equal to that of R_r by adjusting the bias voltage. A high resolution bias supply is necessary for this adjustment. The bridge is rebalanced by reducing C_{ST} to compensate for the differences between the capacitances of the diode and R_r. This change in capacitance of C_{ST} with the diode inserted in place of the resistance, added to the capacitance of R_r, equals the terminal shunt capacitance of the tunnel diode. The signal level used in the capacitance measurement shall be small enough so that reducing the signal amplitude does not change the accuracy of the measurement within the required limits of accuracy of the test.

4.7.8 Total series resistance (R_S).- Total series resistance shall be measured by the method described or equivalent. Total series resistance R_S shall be measured in the circuit shown on figure 6. The tunnel diode shall be operated in a bridge circuit consisting of two fixed resistances and one variable resistance. The appearance of the trace as a function of the resistance values is also shown on figure 6. The diode in the test shall be operated at a reverse bias of 100 times the nominal peak current of the tunnel diode. At balance, the relation between the resistances of the bridge arms is:

$$R_2 \cdot \frac{R_3}{R_1} = R_S$$

4.7.9 Maximum terminal negative conductance (-G).- Maximum terminal negative conductance shall be measured in the circuit shown on figure 7 or equivalent. The resistance values for various peak current ranges are shown in table III under specific conditions. Resistors R_2 and R_3 shall be of low inductance construction. A decade box with a lowest range of 0.1Ω per step is connected as R_4. As shown on the sketch included in figure 7, when $R_4 = 1/-G$, the middle portion of the scope trace is horizontal.

4.7.10 Risetime (t_r).- Tunnel diode risetime shall be measured in the circuit shown on figure 8 or equivalent. Two small clips shall be used to make contact to the diode and to preserve the impedance match of the socket. The circuit shall be connected to a Tektronix type N sampling plug-in unit or equivalent mounted in a Tektronix 530 or 540 series oscilloscope or equivalent. Risetime shall be measured from the 10 to the 90 percent points on the output voltage waveform. A typical risetime waveform is also shown on figure 8.

5. PREPARATION FOR DELIVERY

5.1 Preparation for delivery shall be in accordance with Specification MIL-S-19500.

6. NOTES

6.1 The activity responsible for the qualified products list is the Bureau of Ships, Department of the Navy, Washington 25, D.C., and information pertaining to qualification of products may be obtained from that activity. Application for qualification tests shall be made in accordance with "Provisions Governing Qualification." (Copies of "Provisions Governing Qualification" may be obtained upon application to Commanding Officer, Naval Supply Depot, 5801 Tabor Avenue, Philadelphia 20, Pa.)

Preparing activity:
Navy - Ships
(Project 5960-N387(NAVY))

Table I - Group A inspection.

Examination or test	Conditions: MIL-STD-750 Method	Conditions: Specific Conditions	LTPD	Min Rej No.	Symbol	Limits: Min.	Limits: Max.	Units
Subgroup 1								
Visual and mechanical examination	2071		10	4				
Subgroup 2								
Peak point current		See 4.7.1 Figure 3 values R1 / R2 / R3			I_P			
1N3713		25 / 25 / 50				0.975	1.025	mAdc
1N3715		10 / 10 / 20				2.15	2.25	mAdc
1N3717		5 / 5 / 10				4.58	4.82	mAdc
1N3719		2 / 2 / 4				9.75	10.25	mAdc
1N3721		1 / 1 / 2				21.5	22.5	mAdc
Valley point current		See 4.7.2 Figure 3 values R1 / R2 / R3			I_V			
1N3713		25 / 25 / 50				.075	.140	mAdc
1N3715		10 / 10 / 20				.185	.310	mAdc
1N3717		5 / 5 / 10	5	5		.350	.600	mAdc
1N3719		2 / 2 / 4				.750	1.40	mAdc
1N3721		1 / 1 / 2				1.65	3.10	mAdc
Peak point voltage		See 4.7.3			V_P	58	72	mVdc
Valley point voltage		See 4.7.4			V_V	315	395	mVdc
Forward voltage point		See 4.7.5			V_{FP}	475	535	mVdc
Capacitance		See 4.7.7			C			
1N3713		C_{ST} = 5pf				---	5	pf
1N3715		C_{ST} = 10pf				---	10	pf
1N3717		C_{ST} = 25pf				---	25	pf
1N3719		C_{ST} = 50pf				---	50	pf
1N3721		C_{ST} = 100pf				---	100	pf
Subgroup 3								
Forward voltage point		See 4.7.6			V_{FS}	410	---	mVdc
Series resistance		See 4.7.8			R_S			
1N3713			10	4		---	4.0	ohms
1N3715						---	3.0	ohms
1N3717						---	2.0	ohms
1N3719						---	1.5	ohms
1N3721						---	1.0	ohms

Table II - Group B inspection.

Examination or test	Conditions		LTPD	Min Rej No.	Symbol	Limits		Units
	MIL-STD-750 Method	Specific Conditions				Min.	Max.	
Subgroup 1								
Physical dimensions	2066		10	4				
Subgroup 2[1/]								
Soldering heat	2031	1 cycle						
Temperature cycling	1051	Cond. A except low temperature -65° ± 3°C	10	4				
Thermal shock	1056	Condition A						
Moisture resistance	1021	Omit initial conditioning						
Subgroup 3[1/]								
Shock	2016	1500 G; 0.5 msec, 5 blows ea 4 planes, total 20 blows. Non operating X_1, Z_1, Y_1, Y_2						
Vibration fatigue	2046	Nonoperating, 20G	10	4				
Vibration variable frequency	2056	Nonoperating, 20G						
Constant acceleration	2006	20,000 G, 4 planes, X_1, Z_1, Y_1 & Y_2						
Subgroup 4[1/]								
Terminal strength (lead fatigue)	2036	Condition E	15	5				
Subgroup 5[1/]								
Salt atmosphere (corrosion)	1041		15	5				
Subgroup 6								
High temperature life (nonoperating)	1031	T_A = 100°C min	λ = 10					

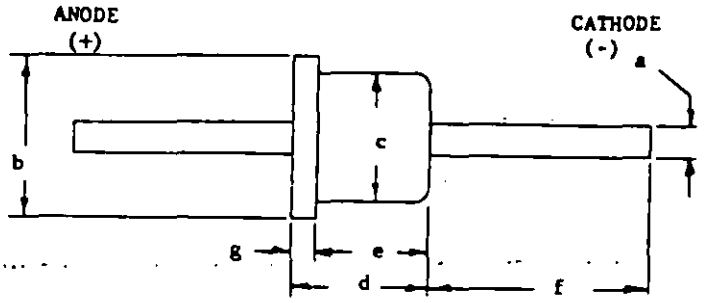
Table II - Group F inspection (cont'd.).

Examination or Test	Conditions				LTPD	Min Rej No.	Symbol	Limits		Units
	MIL-STD-750 Method	Specific conditions						Min.	Max.	
Subgroup 7										
Intermittent operation life	1036	On 50 ± 2 min Off 10 ± 2 min			λ = 10					
1N3713		I_F = 5 mAdc								
1N3715		I_F = 10 mAdc								
1N3717		I_F = 25 mAdc								
1N3719		I_F = 50 mAdc								
1N3721		I_F = 50 mAdc								
End points (for subgroups 2, 3, 5, 6 and 7										
Peak point current		See 4.7.1 Figure 3 values								
		R1	R2	R3						
1N3713		25	25	50			I_P	0.950	1.050	mAdc
1N3715		10	10	20				2.10	2.30	mAdc
1N3717		5	5	10				4.46	4.94	mAdc
1N3719		2	2	4				9.50	10.50	mAdc
1N3721		1	1	2				21.0	23.0	mAdc
Valley point current		See 4.7.2					I_V	---	+20%	
Peak point voltage		See 4.7.3					V_P	55	75	mv
Forward voltage point		See 4.7.5					V_{FP}	470	540	mv

1/ Tests listed in these subgroups are destructive tests.

Table III - Group C inspection.
(Test period = 6 months)

Examination or Test	Conditions				LTPD	Min Rej No.	Symbol	Limits		Units
	MIL-STD-750 Method	Specific Conditions						Min.	Max.	
Negative conductance		See 4.7.9 Figure 7 values			10	4	-G			
		R1	R2	R3						
1N3713		25	25	50				7.5	9.5	mmho
1N3715		10	10	50				16	22	
1N3717		5	5	10				36	46	
1N3719		2	2	4				75	95	
1N3721		1	1	2				160	220	
Rise time		See 4.7.10 Figure 8 values			10	4	t_r			
		R1								
1N3713		4.7K						10	---	nsec
1N3715		470Ω						8	---	nsec
1N3717		470Ω						6	---	nsec
1N3719		470Ω						5	---	nsec
1N3721		270Ω						4	---	nsec



Symbol	Inches		Millimeters		Notes
	Min.	Max.	Min.	Max.	
a	0.018	0.022	0.46	0.56	1
b	.095	.110	2.42	2.80	
c	.070	.090	1.78	2.29	
d	.085	.110	2.16	2.80	
e	.055		1.40		
f	1.000		25.4		1
g	.003		.08		

Note 1: Two leads.

Figure 1 - Design, construction and physical dimensions.

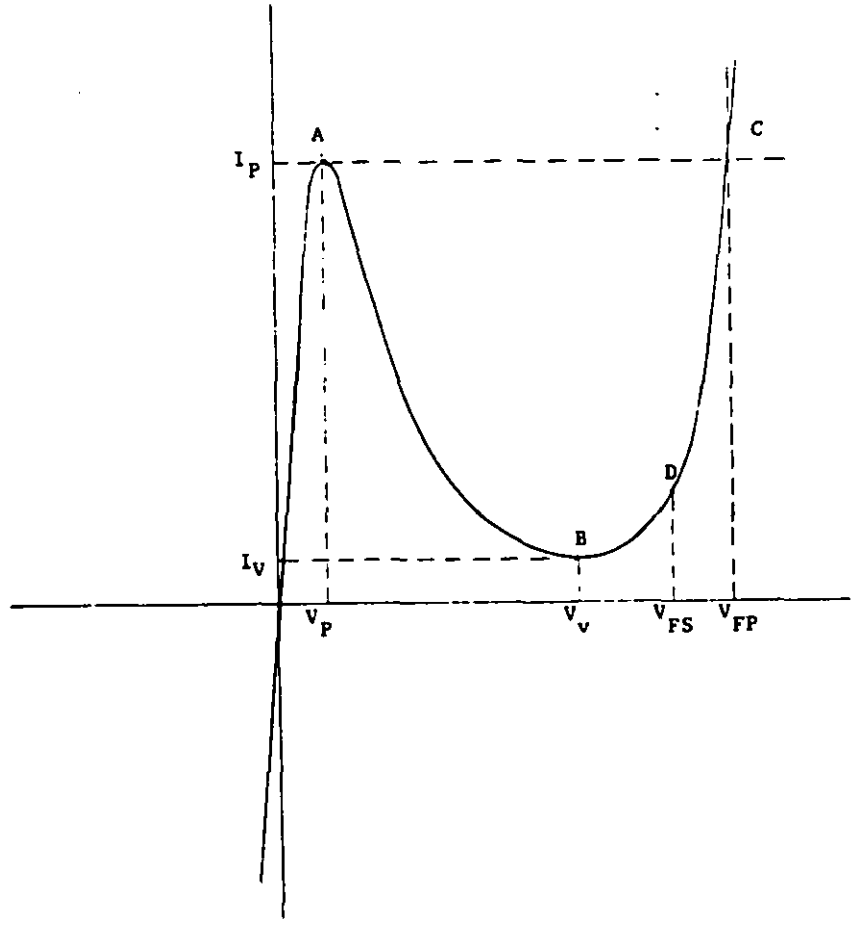


Figure 2 - Tunnel diode voltage-current characteristic.

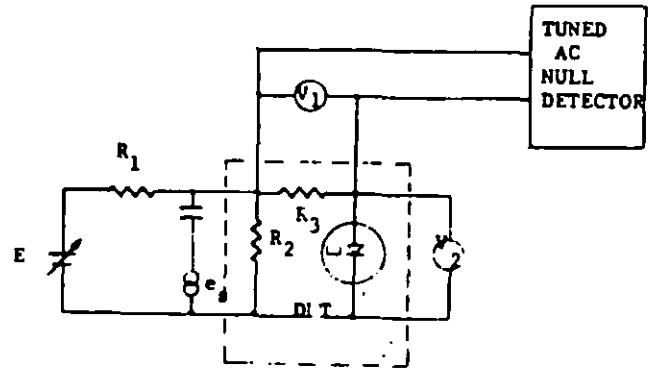


Figure 3 - List circuit for I_P, I_V, V_P and V_V.

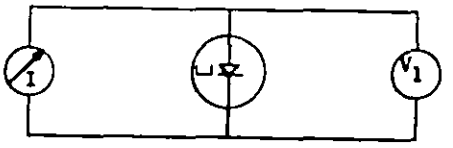


Figure 4 - List circuit for V_{FP} and V_{FS}.

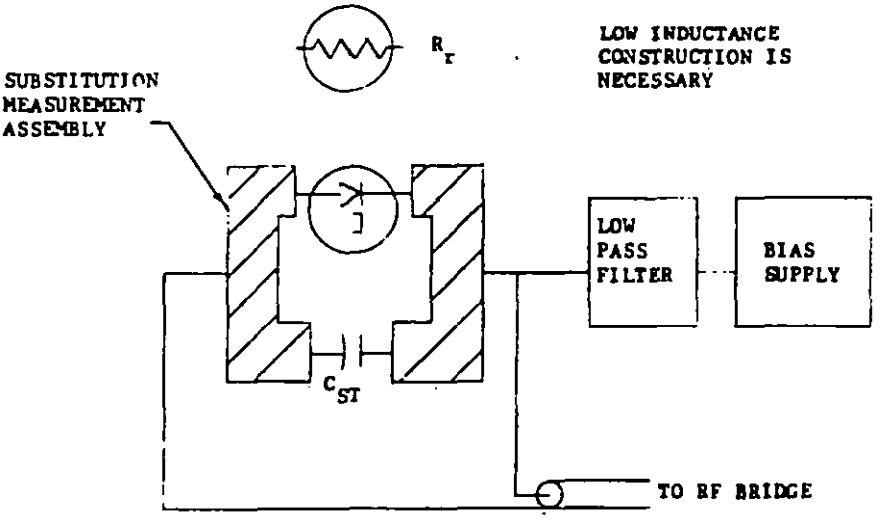
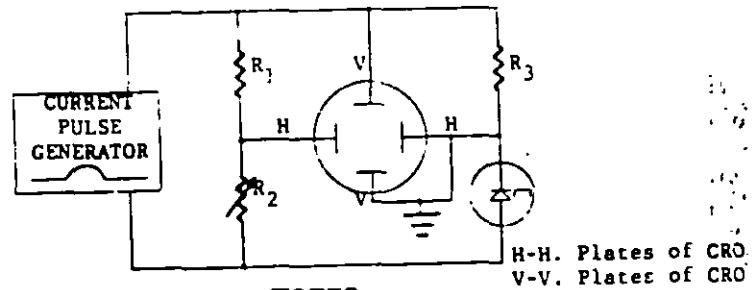
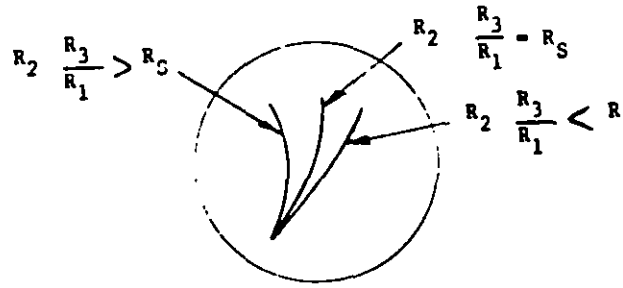


Figure 5 - Diode capacitance measurement for $V \geq V_V$.

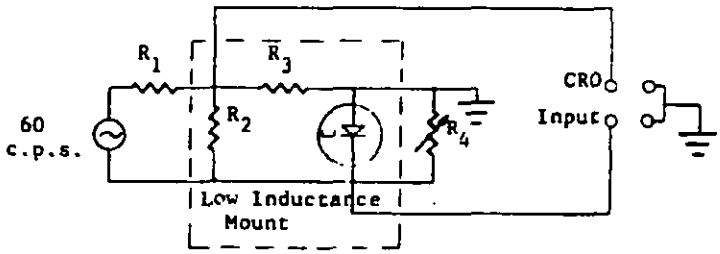


CIRCUIT

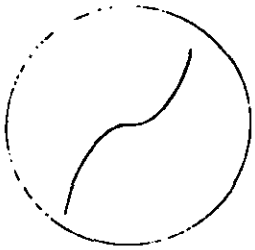


CRO DISPLAY

Figure 6 - R_S measurement circuit.

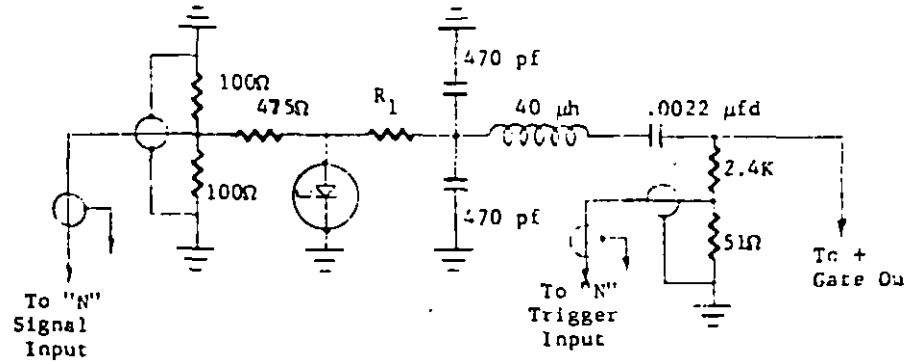


CIRCUIT



CRO DISPLAY

Figure 7 - -G measurement circuit.



TEKTRONIX PART 013-029 OR EQUIVALENT

TYPICAL WAVEFORM

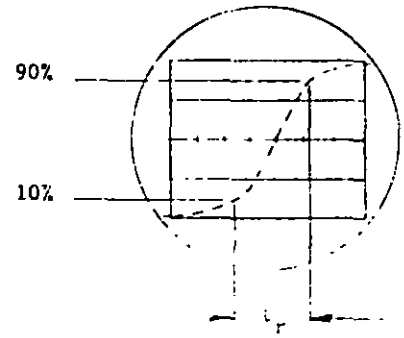


Figure 8 - t_r measurement circuit.