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TEXAS INSTRUMENTS INCORPORATED
Semiconductor/Components Division
Dallas, Texas

SIGNAL CORPS SELECTED FUNCTIONAL ELECTRONIC BLOCKS

Contract Item 2C

Contract
~~Report~~ No. DA 36-039 SC78322

US Army Signal Research and Development Laboratory
Fort Monmouth, New Jersey

TEXAS INSTRUMENTS INCORPORATED
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ABSTRACT

This report describes the fabrication and testing of a set of functional digital circuits in semiconductor network form which would be operationally equivalent to circuits used in Signal Corps equipment. The circuit required both PNP and NPN transistor structures and include both resistor-diode gates, inverters, flip-flops and an exclusive-OR logic circuit.

The semiconductor networks were formed by diffusing element paths into silicon material, using both mesa and planar configurations.

Circuit test procedures are outlined and performance data is tabulated.

SIGNAL CORPS SELECTED FUNCTIONAL ELECTRONIC BLOCKS

I. INTRODUCTION

This report summarizes the fabrication and performance of all semiconductor networks delivered under Phase I of Signal Corps Contract DA 36-039SC-78322. The contract provided for Texas Instruments Incorporated to design and fabricate a set of functional digital circuits in semiconductor network form which would replace circuits already in Signal Corps equipment.

Each network demonstrates state-of-the-art techniques for semiconductor networks at the time of its design. While manufacturing processes progressed from mesa to surface-passivating planar techniques, circuit complexity increased from simple diode-resistor gates to the fully integrated 19-component parity logic circuit. Table I lists the networks in the order they were designed and illustrate the advance technology of the area.

In the following sections, each type of unit will be discussed concerning its fabrication and functional performance.

II. SN-205 AND SN-206

A. Introduction

The SN-205 is a six-input negative AND diode gate with a 2 K-resistor. The SN-206 consists of six diodes (Figure 1). Figure 2 shows the semiconductor network package containing the simple bar which is used for either circuit.

B. Fabrication

A single P-type diffusion over the surface of an N-type bar provides all the necessary junctions. The surface is etched away from all except the diode and resistor areas. Aluminum contacts are made to the anodes of the diode and to each end of the resistor. Resistivity of the diffused layer was chosen to give a resistor with a low temperature coefficient. The resistor-substrate junction is always reverse biased in circuit operation, except at the end which is connected to the diode cathodes, providing electrical isolation. Thermally bonded gold wires connect circuit components to package leads. The substrate is electrically connected to pins 4 and 9 (Figure 2) by alloying. Pins 9 and 10 of the SN-206 have been shorted with an internal jumper wire giving an extra output terminal for convenience in wiring. The units are identified by color stripes on one end.

Table I. Order of Network Design

Unit No.	Processes Used	No. of Chips	No. of Components
SN-205	Mesa diodes	1	6 diodes
	Mesa resistor		1 resistor
SN-206	Mesa diodes	1	6 diodes
SN-207	Planar diodes	2	4 diodes
	Mesa resistors		4 resistors
SN-208	Planar Diodes	1	4 diodes
SN-203	Mesa transistors	1	2 transistors
	Mesa resistors		2 resistors
SN-204	Mesa transistor	3	1 transistor
	Planar resistors		3 resistors
	Planar diodes		2 diodes
	Capacitors		1 capacitor
SN-204A	Same as SN-204	3	Same as SN-204
SN-202	Mesa transistors	7	2 transistors
	Planar resistors		6 resistors
	Planar diodes		7 diodes
	Capacitors		4 capacitors
	Evaporated Aluminum Interconnections		
SN-218	Everything planar	1	6 transistors
	Evaporated Aluminum Interconnections		7 resistors
			1 diode
			5 capacitors

C. Testing

No performance test requirements were given by the Signal Corps. Texas Instruments Incorporated provided for the following tests: resistor values, diode forward voltages at 1 ma and 6 ma, and diode reverse leakages. The statistical mean and the upper and lower 3σ values are listed in Table II for these parameters. Over 99 percent of the parameters measured fall

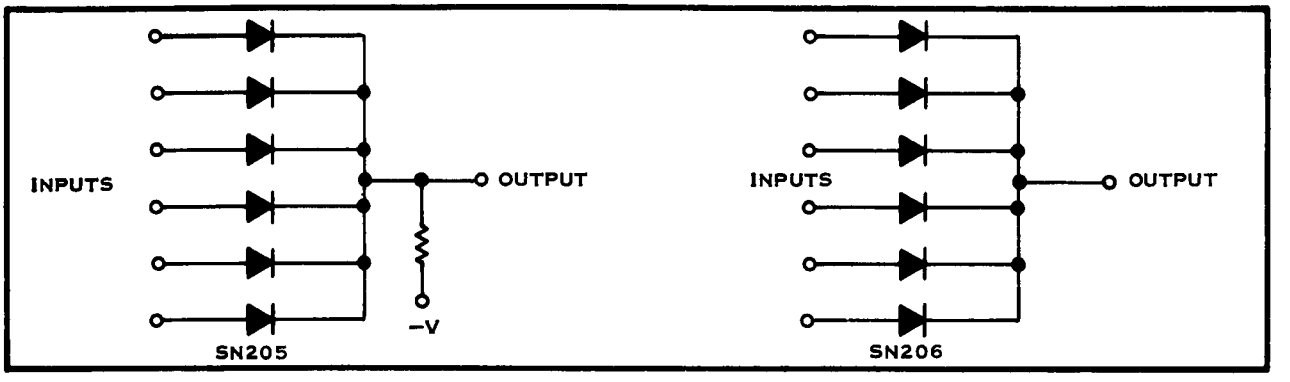

Figure 1. Schematic of SN-205 and SN-206

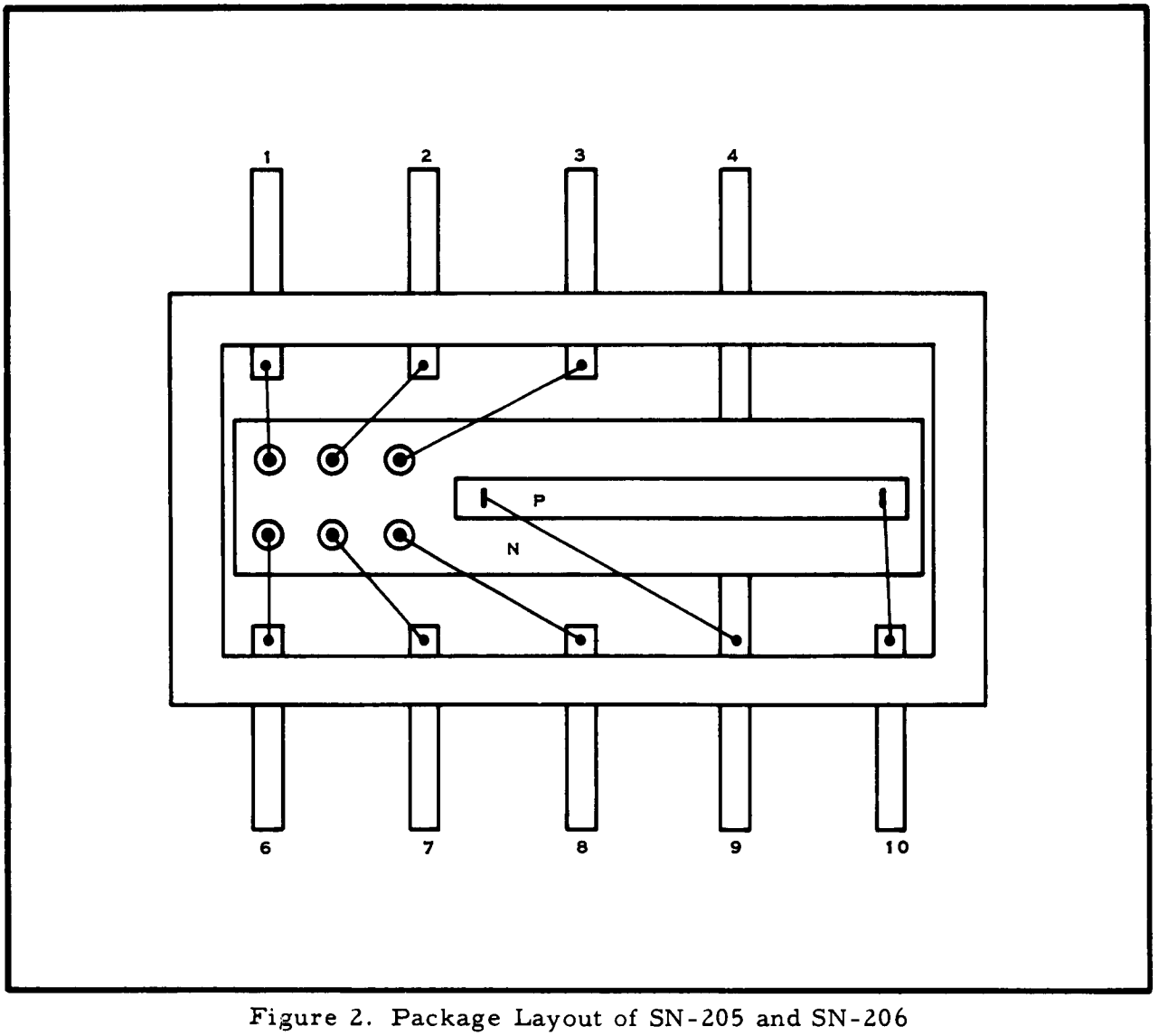

Figure 2. Package Layout of SN-205 and SN-206

Table II. Parameter Limits and Mean Values for SN-205 and SN-206

	Temp.	Mean	Upper 3σ	Lower 3σ
Resistor Values	−40°C	1.980K	2.068K	1.892K
	+25°C	2.005K	2.095K	1.915K
	+80°C	2.144K	2.275K	2.013K
Diode Drop (volts) at I_F = 1 ma	−40°C	0.787	0.897	0.677
	+25°C	0.677	0.776	0.558
	+80°C	0.568	0.676	0.460
Diode Drop (volts) at I_F = 6 ma	−40°C	1.057	1.450	0.664
	+25°C	0.992	1.367	0.617
	+80°C	0.925	1.348	0.502

below the upper 3σ or above the lower 3σ values. Tests were performed at −40°C, +25°C, and +80°C. Initial values of resistors are within ±5 percent of the nominal 2 K value. Reverse leakage across the diodes was measured at V_R = 13 volts and the worst-case temperature +80°C. The upper 3σ limit is 15 microamperes.

All units were subjected to 10-day humidity cycles prior to final test. Measurements made just before cycling showed the units unaffected by this environment. Twenty-five units of each type were delivered.

III. SN-207 AND SN-208

A. Introduction

Figure 3 shows the circuit diagram and network pin connection of the SN-207 and SN-208. The SN-207 is a four-input diode-resistor logic circuit consisting of four diodes and four resistors. The SN-208 is a diode network and is the same as the diode portion of the SN-207.

B. Fabrication

The diodes are planar devices formed on a single P-type silicon wafer by a selective N-type diffusion. The surface is protected by an oxide layer. The following steps are followed throughout the process.

1. 0.5 ohm-cm P-type silicon wafers are oxidized.
2. The oxide is removed in areas where the oxide is to be formed. N-type impurities are diffused through the windows in the oxide to a depth of 0.0003 inch with

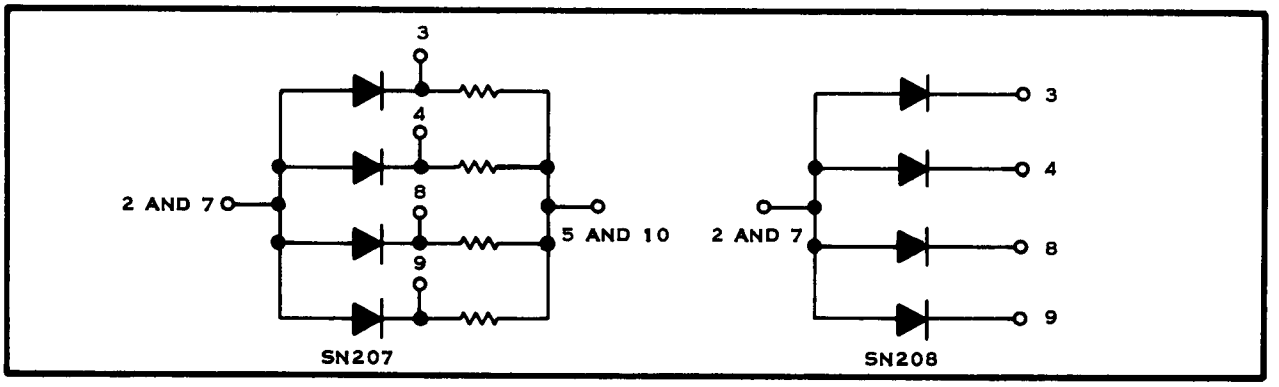

Figure 3. Schematic of SN-207 and SN-208 with Network Pin Numbers

a surface concentration of 10^{19} atoms per cubic centimeter. A new layer of oxide is grown in these windows.

3. Oxide is removed in small areas over the previous diffusion. Aluminum is evaporated on the wafer and selectively removed, leaving metal in areas where contact is to be made.

4. The aluminum contacts are alloyed.

5. Gold is then evaporated over the back of the wafer and alloyed, forming contact to the substrate.

Resistors are constructed on a separate N-type substrate by diffusing P-type impurities over the entire wafer and mesa etching for isolation. Two-piece design was utilized for this network to obtain diodes with the proper breakdown voltage and resistors with the desired temperature coefficients. Electrical terminals are provided at various places on the resistors to allow greater flexibility in obtaining the desired initial resistance.

Figure 4 is a top view of the finished network, excluding the cap.

C. Testing

No electrical specifications were given on the diodes. The following tests were performed for both types of networks.

$$V_F \text{ at } I_F = 6 \text{ ma at } T = -40°C, +25°C, \text{ and } +85°C.$$

$$I_R \text{ at } V_R = 14 \text{ volts at } +85°C.$$

Diode breakdown voltages were greater than 25 volts. Resistors on the SN-207 were measured at the three temperatures. Tables III, IV, and V show data on forward diode drop, reverse leakage and resistor sizes.

All units were subjected to a 10-day humidity cycle prior to final test. Twenty-five units were delivered.

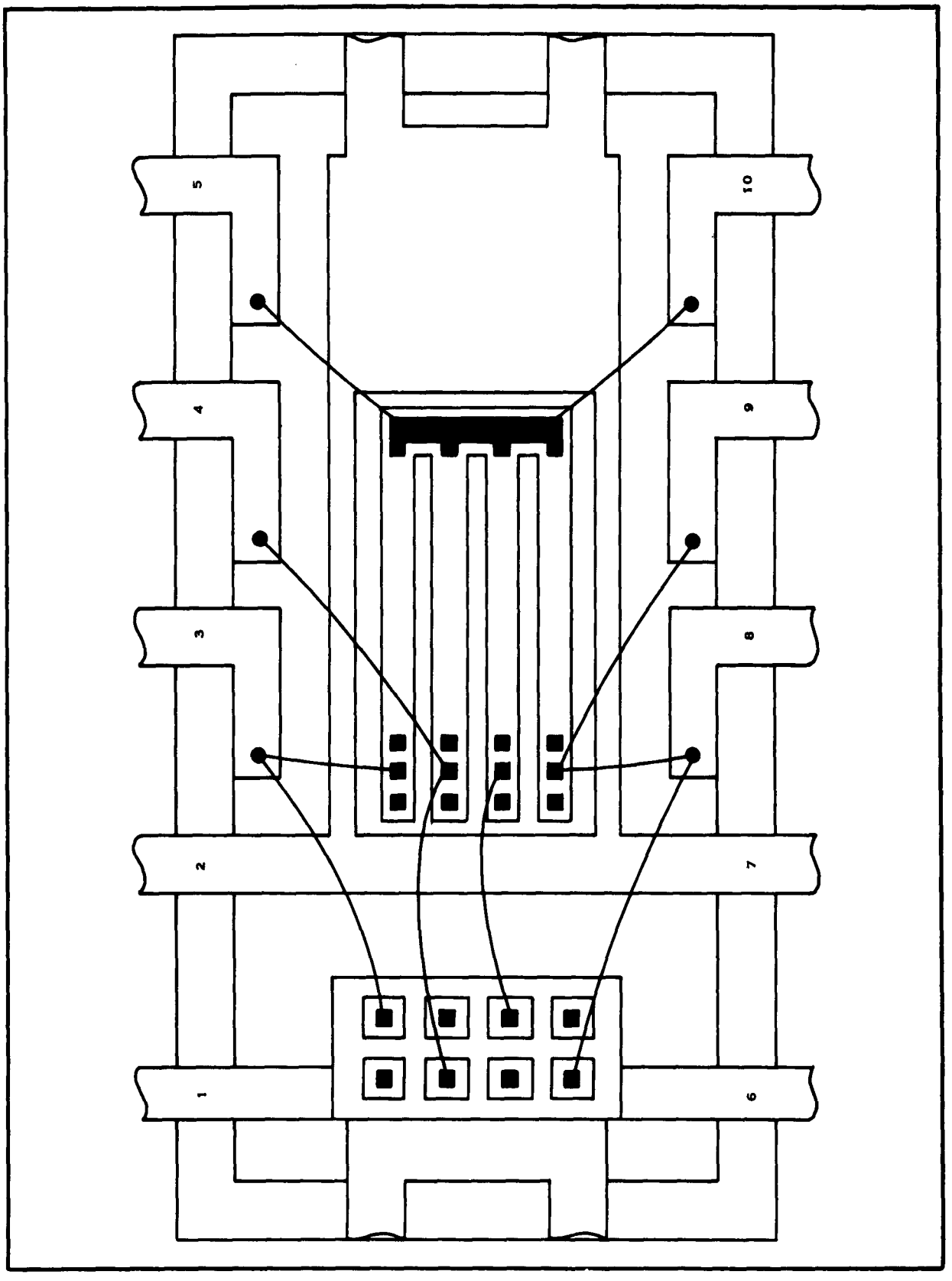

Figure 4. Package Layout of SN-207

Table III. SN-207 and SN-208 Forward Diode Voltages at I_F = 6ma

V_F (volts)	Number of Units SN-207 Temperature °C −40°	+25°	+85°	SN-208 Temperature °C −40°	+25°	+85°
0.56						3
0.57						1
0.58						
0.59						
0.60						
0.61						
0.62						
0.63						1
0.64			4			1
0.65			11			27
0.66			31			33
0.67			37		1	8
0.68			5		3	8
0.69			4			4
0.70						3
0.71			1			4
0.72		1	1			3
0.73		2			4	
0.74		16	1		37	1
0.75		24	2		21	
0.76		35	1		8	1
0.77		14			7	
0.78		1			4	1
0.79		1			8	
0.80				2		
0.81		2		1		
0.82				1	3	
0.83	1	2		3		
0.84	12			11	1	1
0.85	17		1	33	1	
0.86	15			17		
0.87	18			3	1	
0.88	16			8		
0.89	13		1	6		
0.90	4			2		
0.91		1		4		
0.92	2			2		
0.93		1		2		
0.94				2		
0.95				1	1	
0.96	1					
0.97	1			1		
0.98				1		

Table IV. SN-207 and SN-208 Diode Reverse Leakage (I_R)

Note:
1. Leakages recorded in nanoamps
2. Leakages measured between Pin No. 1 and Pins indicated on data
3. VR = 14 volts and T = 84°C.

SN-207					SN-208				
Unit No.	Pin No. 3	Pin No. 4	Pin No. 9	Pin No. 8	Unit No.	Pin No. 3	Pin No. 4	Pin No. 9	Pin No. 8
47	500	510	520	530	78	124	113	100	106
48	350	350	360	380	79	88	82	90	86
52	400	410	420	390	80	112	100	32	134
54	500	500	450	400	81	114	105	108	100
56	360	380	390	380	82	180	200	160	165
58	380	400	390	390	83	85	87	94	89
59	330	330	330	330	84	93	100	100	100
61	610	610	620	620	85	74	76	120	760
69	450	470	480	490	86	90	93	88	86
71	290	290	290	300	87	100	95	102	105
72	520	510	520	520	89	130	145	140	115
73	360	370	370	390	90	110	100	110	100
75	390	400	400	400	91	100	90	100	95
107	430	420	430	430	93	125	95	97	90
108	440	450	460	450	95	99	105	100	100
109	560	570	570	570	96	105	96	95	125
110	370	370	370	370	97	350	330	340	340
111	380	390	390	400	98	100	120	92	105
113	460	480	490	500	99	110	100	110	150
114	330	340	350	340	100	115	125	115	130
116	510	500	510	500	101	125	125	130	120
119	470	480	490	510	102	100	95	93	90
121	440	460	470	470	103	100	110	89	110
122	480	480	480	490	104	142	110	130	120
124	390	390	400	400	127	115	110	115	117

Table V. SN-207 Resistor Values

Note: Resistances measured in ohms.

	−40°C					+25°C					+85°C			
Unit No.	Pin No. 3	Pin No. 4	Pin No. 9	Pin No. 8	Unit No.	Pin No. 3	Pin No. 4	Pin No. 9	Pin No. 8	Unit No.	Pin No. 3	Pin No. 4	Pin No. 9	Pin No. 8
47	2067	2060	2050	2100	47	2020	2010	2003	2054	47	2137	2114	2107	2174
48	2055	2047	2041	2008	48	2008	2000	1986	1961	48	2136	2124	2103	2086
52	2023	2187	2131	2078	52	2000	2156	2091	2054	52	2138	2297	2222	2194
54	2063	2111	2108	2063	54	2043	2084	2075	2035	54	2156	2180	2174	2158
56	2055	2075	2141	2124	56	1961	1961	2028	2033	56	1824	1708	1775	1897
58	1957	1963	1958	2041	58	1953	1955	1968	2070	58	2069	2064	2023	2167
59	2053	2069	2122	1973	59	2020	2041	2099	1950	59	2154	2179	2245	2083
61	2037	2048	2174	1869	61	1985	1988	2113	1820	61	2099	2099	2238	1938
69	1986	1896	2004	1989	69	1947	1858	1966	1949	69	2072	1984	2093	2078
71	1977	2000	1952	1970	71	1903	1892	1837	1884	71	1902	1800	1717	1836
72	2049	2139	2080	2090	72	1959	1957	1904	1981	72	2012	1919	1856	2008
73	2000	1993	1984	1981	73	1916	1896	1901	1911	73	1966	1912	1941	1990
75	1976	1991	1975	1961	75	1933	1945	1927	1919	75	2025	2018	1994	2008
107	1839	1929	1938	1957	107	1860	1942	1950	1984	107	1964	2018	2055	2128
108	2018	2182	2174	2181	108	1966	2120	2113	2114	108	2083	2250	2240	2251
109	2180	2225	2036	2178	109	2128	2164	1962	2072	109	2254	2280	2153	2217
110	1955	1996	2002	2181	110	2002	2043	2049	2038	110	2206	2252	2257	2245
111	1875	1866	1880	1879	111	1936	1932	1948	1954	111	2150	2152	2167	2178
113	2004	1982	1972	2041	113	2000	1901	1896	2034	113	2128	1971	1944	2130
114	1852	1849	1791	1786	114	1891	1878	1818	1825	114	1989	1955	1929	1954
116	1980	2028	2011	2009	116	2042	2082	2066	2072	116	2207	2196	2192	2247
119	2018	2023	2032	1984	119	2076	2083	2099	2052	119	2275	2260	2285	2257
121	1861	1871	1882	1872	121	1901	1907	1917	1917	121	2087	2079	2095	2111
122	1892	1912	1905	1890	122	1938	1956	1952	1942	122	2123	2114	2114	2129
124	1835	1845	1843	1838	124	1890	1894	1891	1889	124	2081	2088	2072	2077

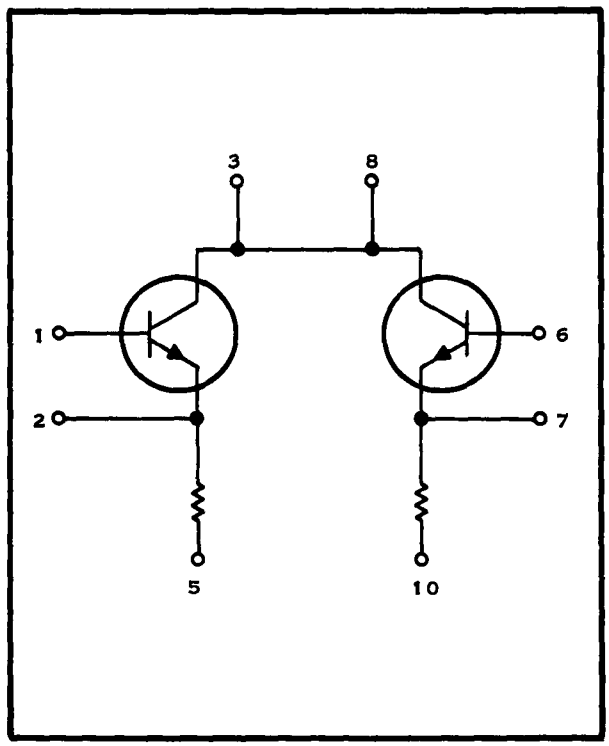

Figure 5. Schematic of SN-203 with Pin Numbers

IV. SN-203

A. Introduction

The SN-203 consists of two emitter followers on a single piece of silicon (Figure 5). The original circuit used alloy transistors and carbon composition resistors. Mesa transistors of the 2N702 type were substituted for compatibility with semiconductor network processes.

B. Fabrication

The transistors were double-diffused and mesa etched for isolation. Substrate material forms the collectors and is common to both transistors. Resistors are P-diffused and utilize the reversed biased PN junction (resistor to substrate) for isolation from transistor collectors. The impurity concentration was chosen to give a low temperature coefficient of resistance. Resistance can be controlled to ±5 percent initially and to ±10 percent over the operating temperature range −40°C to +85°C.

The network bar was processed as follows:

1. 0.8 — 1.2 ohm-cm N-type wafers are oxidized.
2. A P-type diffusion is made over the entire wafer and will serve as the diffused resistor and transistor base.

3. The oxide is removed where the transistor emitters will be. An N-type diffusion is made in these areas and another layer of oxide formed.

4. The wafer is mesa-etched, identifying the transistor and resistor areas.

5. An area surrounding each network bar on the wafer is deep etched to allow for future separation of bars.

6. Oxide is removed on areas where contacts are to be made.

7. Aluminum is selectively evaporated on the contact areas through a metal mask. It is alloyed to make electrical contact.

8. The wafers are lapped from the back until the bars are separated at the deep-etch regions.

9. Gold is evaporated on the back of the bars and alloyed to provide electrical contact to the collectors.

10. The bars are tested, mounted in the semiconductor network package, and bonded.

The package layout of the SN-203 is shown in Figure 6.

C. Testing

The networks meet the required input impedance of 35K (no load, audio frequency). Average current drain at 13.4 volts was 6.1 milliamperes at 25°C. The transistors were subjected to the following tests to determine performance:

h_{FE} (I_C = 5 ma, V_{CE} = 5 V, T = −55°C, +25°C, +85°C)

$V_{CE(sat)}$ (I_C = 5 ma, I_B = 0.3 ma, T = −55°C, +25°C, +85°C)

I_{CBO} (V_{CB} = 13 V, T = 85°C)

I_{CEO} (V_{CE} = 3 V, T = 85°C)

I_{CEO} (V_{CE} = 13 V, T = 85°C)

BV_{EBO} (I_{EBO} = 10 μa, T = 25°C)

BV_{CBO} (I_{CBO} = 10 μa, T = 25°C).

Variations of resistors and input impedance with temperature were also measured. The network performance was equal to the original circuit except for $V_{CE(sat)}$, which was ≤0.5 volt; Tables VI, VII, and VIII contains the data. Figures 7 and 8 show limits on resistors and input impedance versus temperature.

All units were subjected to a 10-day humidity cycle prior to final test. Nineteen units were delivered.

Table VI. h_{FE} and $V_{CE(sat)}$ for SN-203

h_{FE} (I_C = 5ma, V_{CE} = 5V)				$V_{CE(sat)}$ (I_C = 5ma, I_B = 0.3ma)			
Unit. No.	−55°C	+25°C	+85°C	Unit. No.	−55°C	+25°C	+85°C
1	18.9	27.8	30.3	1	0.18	0.22	0.23
	20.8	28.6	32.2		0.20	0.20	0.20
2	21.2	27.8	31.2	2	0.30	0.39	0.51
	25.0	31.2	35.7		0.20	0.24	0.29
3	26.3	38.5	50.0	3	0.15	0.15	0.18
	20.0	27.8	40.0		0.17	0.17	0.18
4	20.8	41.6	69.5	4	0.45	0.44	0.49
	25.0	35.7	61.0		0.45	0.43	0.49
5	33.3	51.0	67.6	5	0.39	0.40	0.48
	27.8	45.4	61.7		0.39	0.39	0.45
6	17.5	25.0	29.4	6	0.24	0.20	0.21
	18.2	25.3	27.8		0.20	0.19	0.22
7	25.0	40.0	55.5	7	0.44	0.44	0.43
	27.0	41.7	55.5		0.44	0.45	0.44
8	27.8	36.8	45.4	8	0.13	0.17	0.18
	26.3	40.3	45.4		0.16	0.19	0.19
9	22.1	37.3	43.8	9	0.36	0.39	0.40
	22.3	33.3	34.7		0.16	0.41	0.41
10	26.3	40.3	48.0	10	0.20	0.22	0.26
	25.0	38.5	45.4		0.20	0.22	0.27
11	25.0	31.2	47.6	11	0.14	0.18	0.18
	22.7	29.4	41.6		0.29	0.30	0.30
12	29.4	36.8	43.9	12	0.20	0.25	0.27
	32.1	48.1	52.1		0.19	0.23	0.25
13	25.0	41.6	50.0	13	0.14	0.20	0.19
	23.6	41.0	47.2		0.16	0.18	0.20
14	13.7	27.8	38.4	14	0.22*	0.36	0.25
	15.4	27.8	35.7		0.22*	0.34	0.24
15	16.6	27.8	31.2	15	0.18*	0.22	0.23
	16.15	26.3	27.8		0.25	0.32	0.38
16	20.0	29.4	31.2	16	0.25	0.30	0.30
	18.2	26.3	29.4		0.25	0.26	0.28
17	20.0	38.5	50.0	17	0.20	0.21	0.21
	25.0	39.7	54.4		0.14	0.16	0.20
18	25.0	35.2	40.3	18	0.12	0.14	0.17
	23.1	39.7	48.0		0.13	0.15	0.17
19	23.1	31.1	35.7	19	0.18	0.20	0.20
	23.1	29.4	33.3		0.12	0.15	0.18

*I_b = 6ma

Table VII. SN-203 Breakdown Voltages and Leakage Currents

	T = 25°C (Volts)			T = 85°C (Volts)		
Unit No.	B_{VEBO} at 10 μa	B_{VCBO} at 10 μa	Unit No.	I_{EBO} at 3V (μa)	I_{CBO} at 13V (μa)	I_{CEO} at 13V (μa)
1	8	85	1	0	2	5
	8	60		0	1	2
2	20	75	2	0	1	1
	20	54		0	1	1
3	8	30	3	0	3	3
	7.5	41		0	0.5	0
4	8	90	4	0	1	1
	5.5	55		0	1.5	4
5	9.4	70	5	0	1	1
	9.0	45		0	2	2
6	8.0	41	6	0	0.5	1
	8.3	10		0	0.5	1
7	8.8	55	7	0	1	1
	8.5	68		0	1	1
8	8.1	36	8	0	0.5	1
	8.1	23		0	0.5	4
9	8.2	88	9	0	1	1
	8.8	50		1	1	1
10	5.0	41	10	2	3	3.5
	8.2	52		0.5	3	4
11	8.1	74	11	0	0.5	1
	8.6	30		0	1	2
12	9.2	80	12	0	0.5	0
	9.0	90		0	0.5	0
13	8.8	88	13	0	1	1.5
	8.5	88		0	0.5	0.5
14	8.6	75	14	1	3	7
	7.6	75		1.5	2	3
15	8.8	38	15	1	1	1
	8.2	50		0	0	0
16	8.8	50	16	0	0.5	0
	8.6	40		0	0.5	0.5
17	8.1	48	17	0	2.5	12
	9.0	65		0	1.5	2
18	8.0	25	18	1	6	16
	8.0	50		1	2	5
19	7.0	35	19	0	1	1
	6.5	40		1	1	1

Table VIII. SN-203 Resistor Values and Input Impedances

Unit No.	Resistance (K) 100°C	75°C	50°C	25°C	0°C	-25°C	-55°C
1	2.20	2.15	2.10	2.05	2.02	2.00	2.14
2	2.27	2.21	2.15	2.10	2.08	2.09	2.19
3	2.29	2.21	2.13	2.07	2.04	2.06	2.15
4	2.22	2.13	2.07	2.02	2.00	2.01	2.13
5	2.28	2.23	2.16	2.12	2.10	2.12	2.23
6	2.22	2.15	2.08	2.04	2.01	2.02	2.13
7	2.35	2.27	2.20	2.15	2.11	2.13	2.23
-	100. C	60°C		25°C	-5°C	-30°C	-55°C
8	2.44	2.33		2.27	2.26	2.30	2.43
9	2.27	2.17		2.09	2.07	2.11	2.22
10	2.39	2.26		2.18	2.16	2.20	2.31
11	2.51	2.37		2.30	2.28	2.33	2.45
12	2.50	2.38		2.31	2.28	2.33	2.45
13	2.27	2.13		2.02	2.00	2.02	2.10
14	2.48	2.35		2.27	2.23	2.25	2.30
15	2.29	2.14		2.06	2.01	2.03	2.12
16	2.25	2.14		2.08	2.06	2.07	2.18
17	2.45	2.30		2.22	2.19	2.19	2.29
18	2.24	2.18		2.11	2.10	2.10	2.17
19	2.34	2.28		2.21	2.19	2.24	2.34

Unit No.	Input Impedance (K) -55°C	+25°C	+85°C
1	46.7	72.6	102.2
	54.2	79.2	110.0
2	53.1	72.5	93.8
	64.5	82.7	106.2
3	70.1	109.1	141.9
	55.4	80.6	112.7
4	76.3	139.3	184.3
	69.4	124.0	170.7
5	90.8	145.7	172.8
	75.8	123.5	163.0
6	45.6	68.7	86.1
	48.3	66.3	79.4
7	70.8	114.5	145.3
	75.6	120.0	149.1
8	78.2	121.0	144.4
	81.9	130.9	147.6
9	64	104.3	143.8
	64	81.9	113.3
10	76.3	133.8	157.9
	73.8	118.2	149.1
11	74.3	92	153.6
	75.6	87	134.7
12	82.4	121.8	152.1
	88.5	117.1	163.2
13	78.5	117.1	162
	73.9	109	147
14	44.3	82.5	117.6
	48.3	85.1	128.6
15	50.2	76.7	92.3
	46	62.4	75.8
16	59.4	82.8	118.9
	51.3	78.6	108.8
17	63.6	100.1	143.8
	76	111.4	155.2
18	67.2	132.5	169
	67.1	129.5	187.3
19	65.0	80.2	118.2
	61.2	75.4	108.0

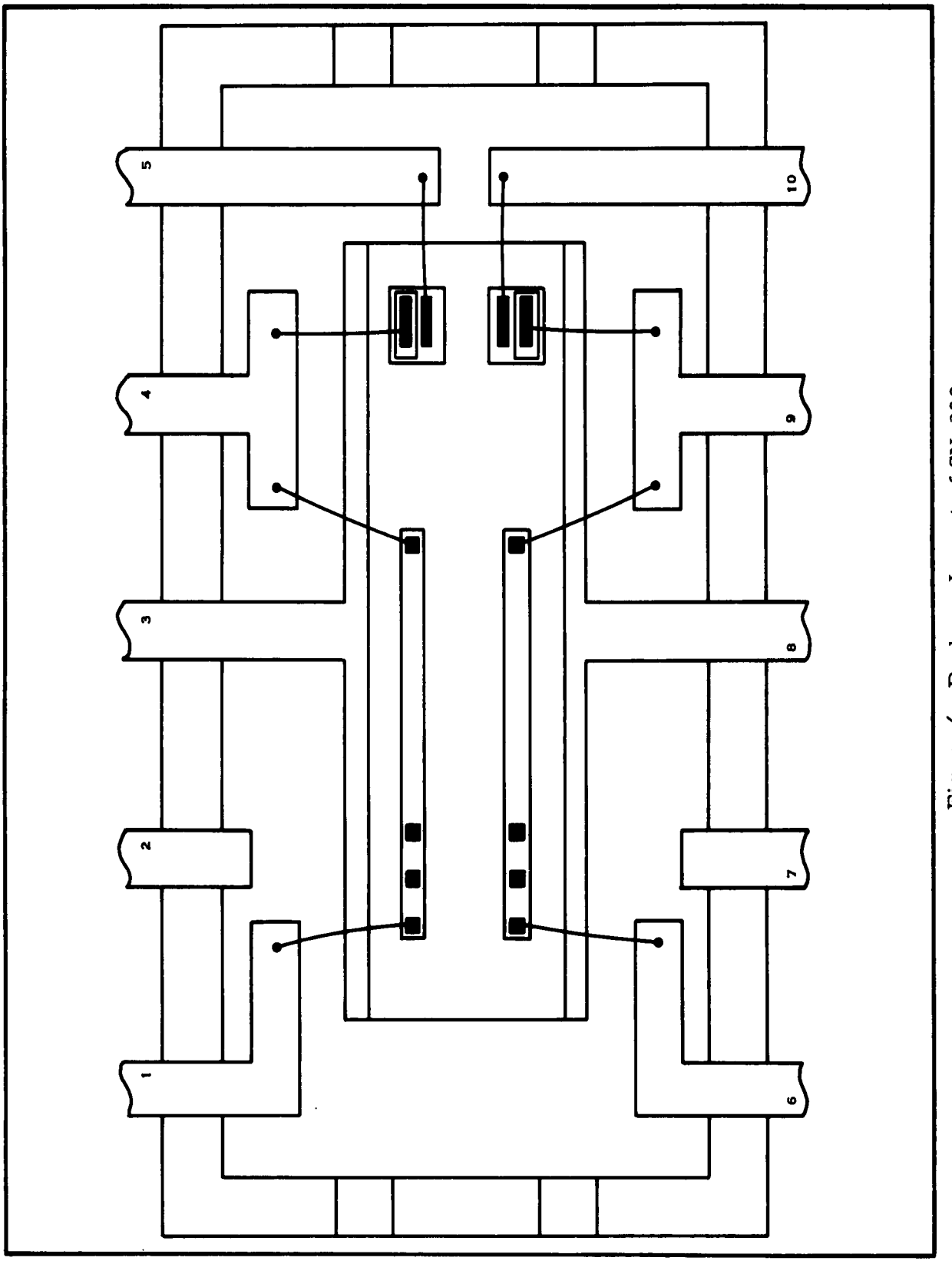

Figure 6. Package Layout of SN-203

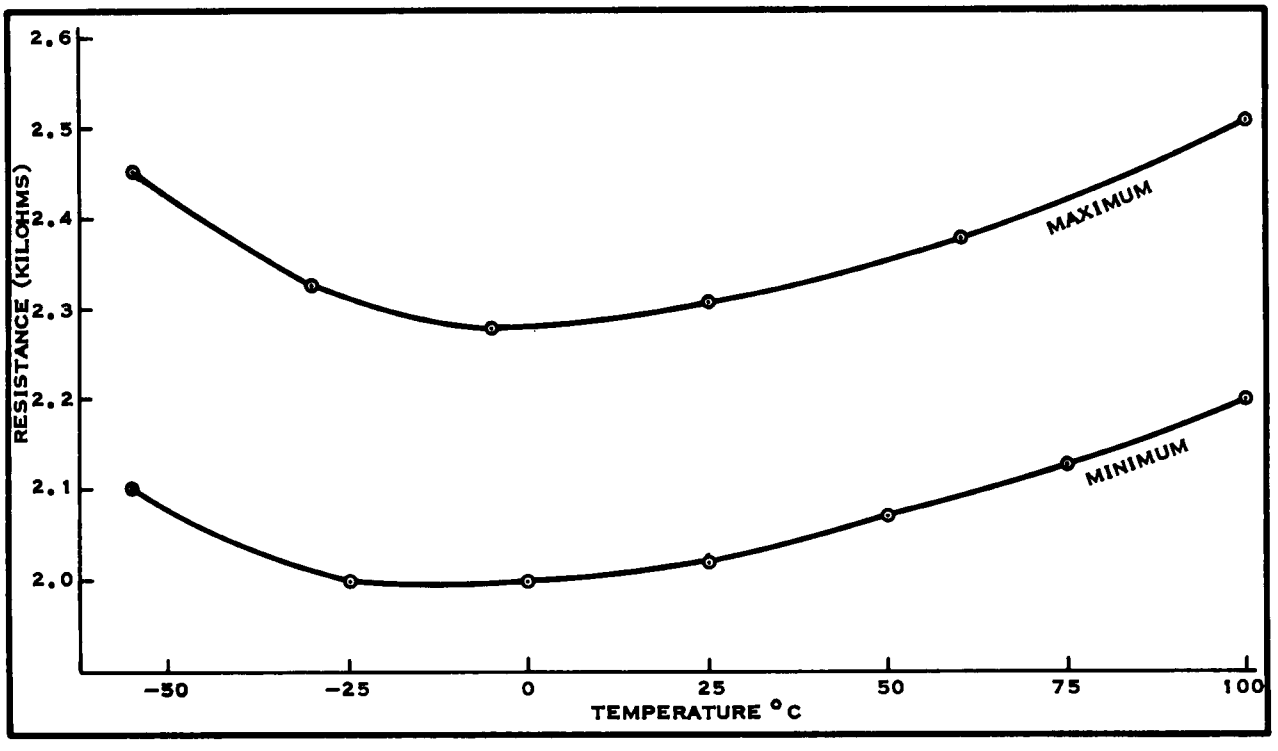

Figure 7. SN-203 Resistor Variations Versus Temperature

V. SN-204 AND SN-204A

A. Introduction

These functional electronic blocks perform the INVERTER logic function. The design goal for the SN-204 and SN-204A was that they provide terminal and transfer characteristics equivalent to those specified on the INVERTER INJ Drawing No. 605304-095 (sheet I-9). This is a Stromberg-Carlson standard circuit drawing provided by the Signal Corps. The equivalent circuit for the semiconductor network inverter and the package terminal identification are shown in Figure 9. Both types of network were mounted in a package which allowed a lid to be welded to the top rim. This network package is constructed differently from the soldered package to accommodate the welding electrodes.

Specifications for each circuit are the same except the SN-204 operating temperature range is -40°C to +85°C, while that of the SN-204A is -40°C to +125°C.

B. Fabrication

The SN-204 and SN-204A were designed to utilize three pieces of silicon per network. All resistors and diodes are diffused in one piece.

The high current levels required a low R_{CS} in the transistor; thus, a separate silicon transistor is employed. The speed-up capacitor was formed on a separate chip because of the large area required.

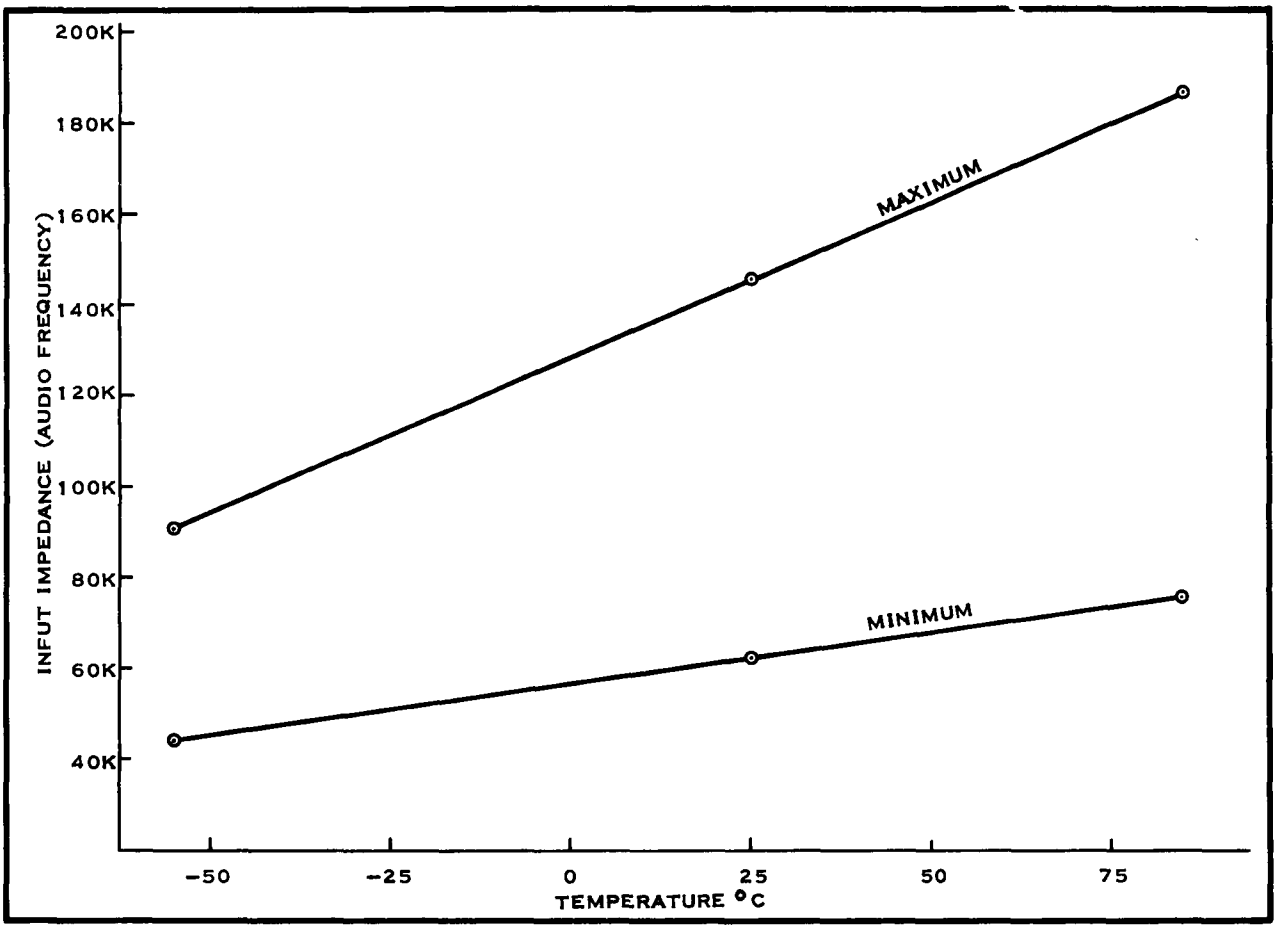

Figure 8. SN-203 Input Impedance Variations Versus Temperature

The resistor-diode bar must go through the following processes:

1. A P-type slice of silicon is polished and oxidized.
2. Certain areas of the oxide are removed and an N-type layer is diffused into these areas to isolate the diodes and substrate. Another oxide is formed over these areas during the diffusion process.
3. A second oxide-removal pattern provides windows through which P-type impurities are diffused for diode anodes. Another oxide is formed over these areas during the diffusion process.

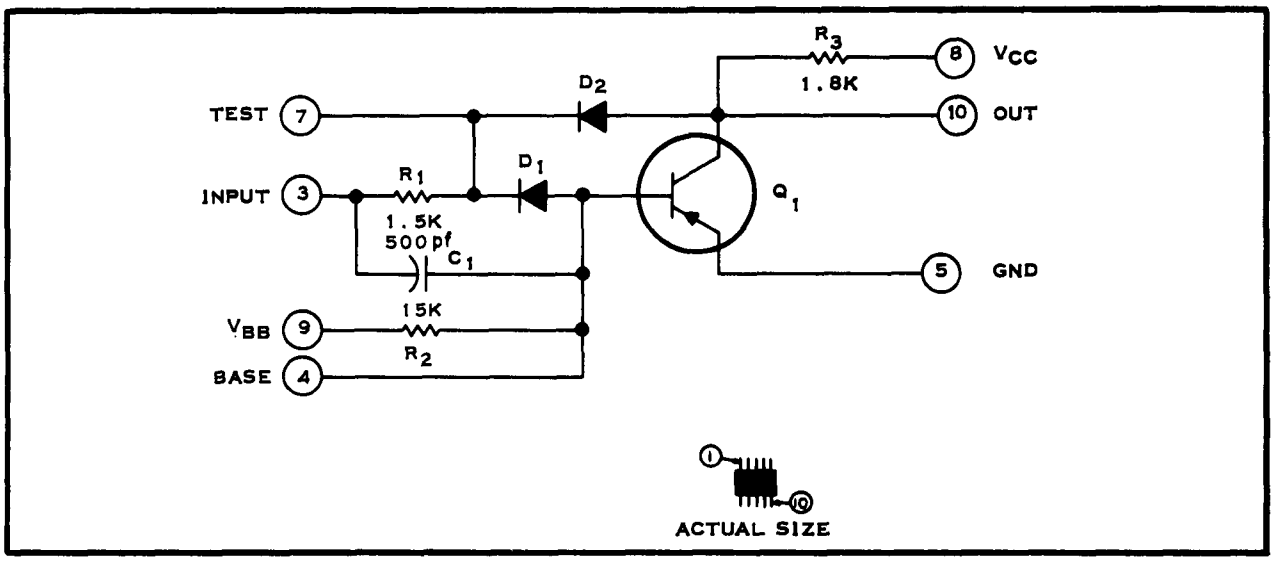

Figure 9. Schematic of SN-204 and SN-204A with Network Pin Numbers

4. Other areas of oxide are then removed and an N-type layer is diffused for the resistors and diode cathodes. Again an oxide is formed in these areas during the diffusion process.

5. Oxide is removed where contacts in the N-type areas are to be. A high-concentration N-type diffusion lowers the resistivity in these areas so that aluminum will make good electrical contact. An oxide is formed in these areas during the diffusion process.

6. Oxide is then removed in the areas where contacts are to be made. No junctions are exposed except those that were designed to be shorted by the contacts.

7. Aluminum is evaporated over the entire surface and removed selectively except where contacts are to be made. The aluminum is then alloyed into the contact areas.

8. The silicon slice is etched from the back until the correct thickness is reached and is then scribed and broken into separate bars.

After all the components have been tested, the networks are assembled in packages as shown in Figure 10.

1. The transistor is alloyed to a metal area in the package, making electrical contact to the collector.

2. A resistor-diode bar is secured in the package with glass.

3. Connections are made with gold wire leads by ball-bonding.

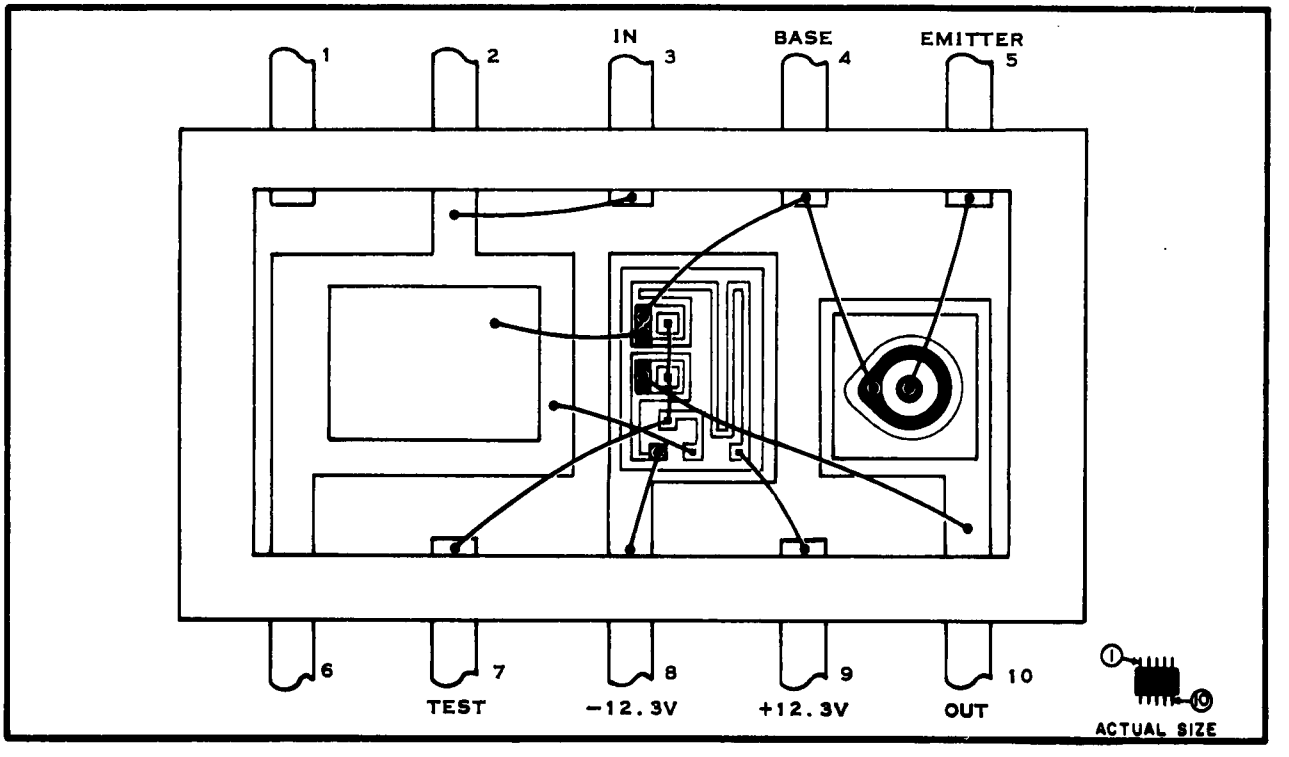

Figure 10. Package Layout of SN-204 and SN-204A

4. The SN-204 capacitor is mounted in the package. A gold wire is attached to the top with gold paste for electrical contact. The capacitor is then physically secured to the lead frame with gold paste, which also provides electrical contact.

   SN-204A contacts on the capacitor are made by ball-bonding a gold wire on each side. The capacitor is then secured to the package with gold paste, and the bottom wire is bonded to the lead frame area on which it rests. This technique ensures a good electrical contact at 125°C.

5. The networks are tested for circuit performance and sealed by welding a lid to the header.

Mechanical data for the network package is given in Figure 11.

C. Testing

Figures 12 and 13 show the final tests performed. Data was taken at ambient temperatures of −40°C, +25°C, and +85°C on the SN-204 and at −40°C, +25°C, and +125°C on the SN-204A. The results are tabulated in Tables IX through XX. Figures 14 through 19 illustrate parameter variations with temperature.

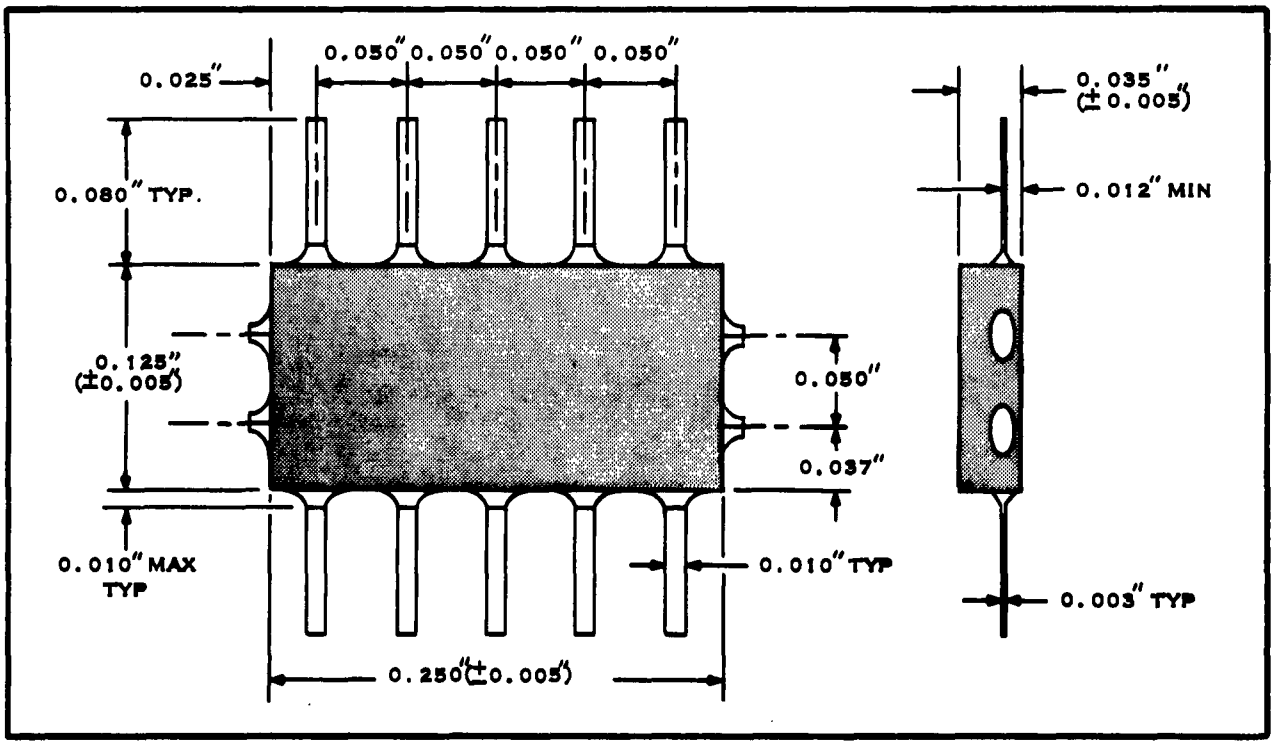

Figure 11. Specifications for Weldable Package (SN-204, SN-204A, SN-202)

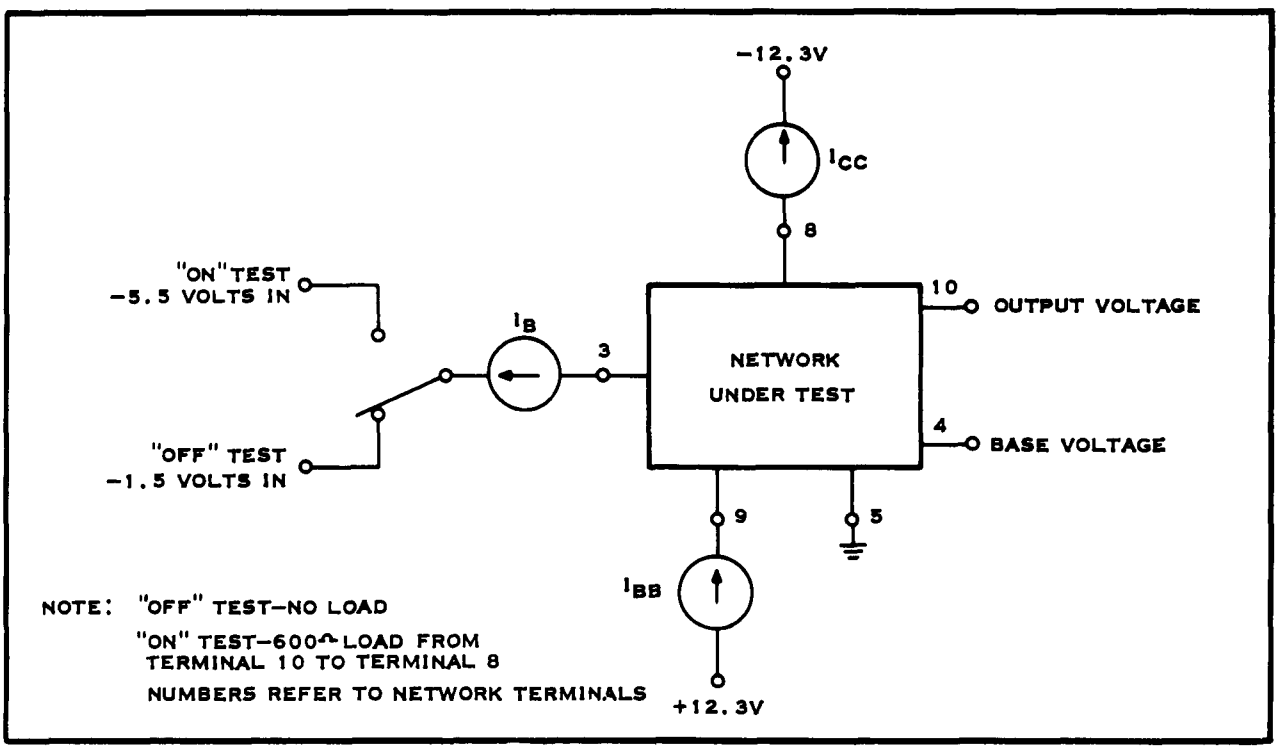

Figure 12. DC Test Circuit for SN-204 and SN-204A

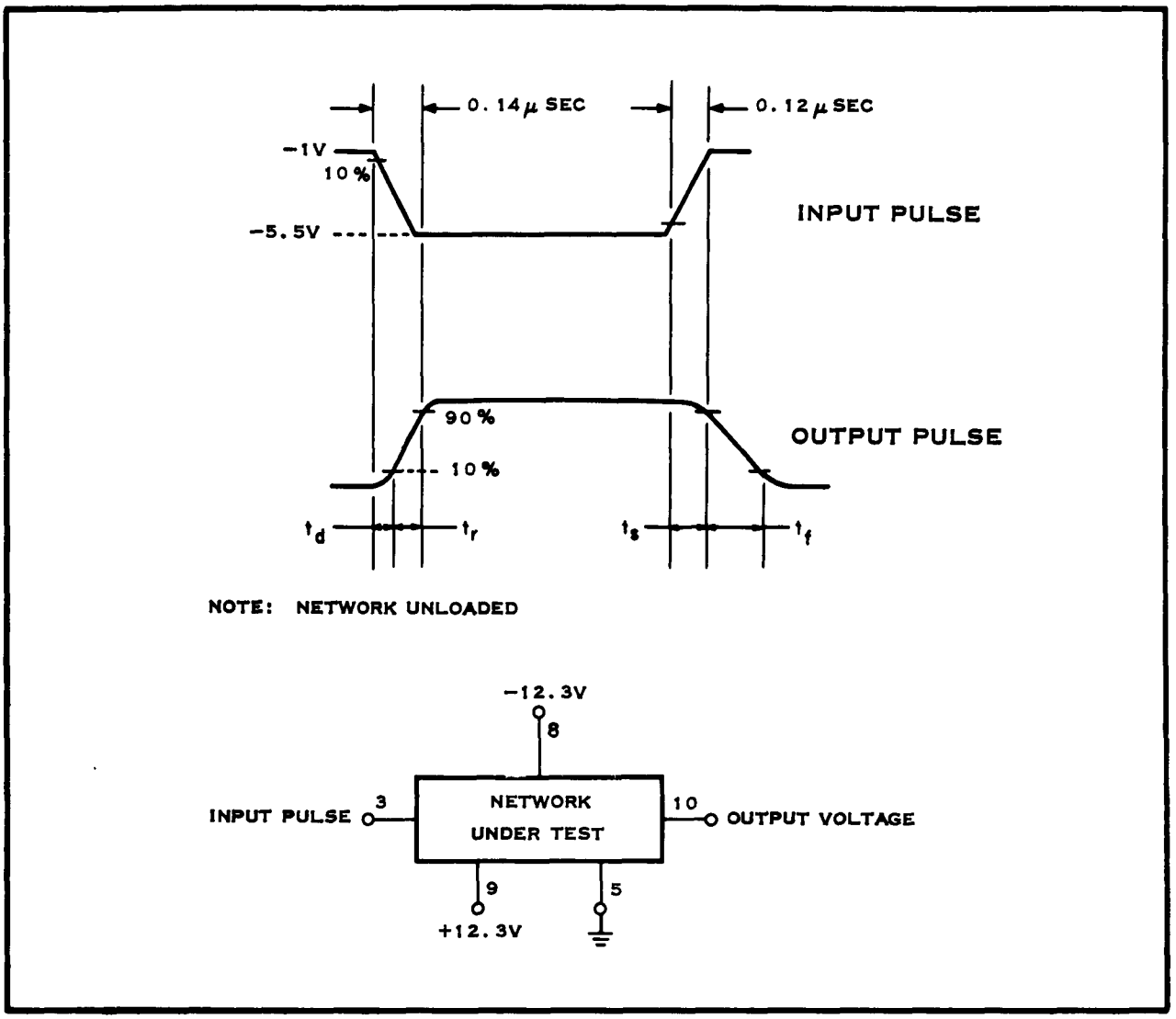

Figure 13. Switching-Time Test Circuit for SN-204 and SN-204A

The value of $I_{CC(OFF)}$ for some units is 0.5 ma or more. This is caused by diode D_1, which is a triple-diffused component. Junctions of D_1 are biased in such a way that transistor action occurs, the substrate material acting as a collector. Some current thus flows into the collector supply. None of this collector supply current passes through the load resistor or transistor. When switching speeds would allow it, D_1 was shorted to avoid this extra current drain, also resulting in a decrease in $V_{CE(ON)}$.

All units were subjected to a ten-day humidity cycle prior to final testing. Fifty inverters of each type were delivered.

Table IX. DC Data for T = −40°C (SN-204)

Unit No.	$I_{B(OFF)}$ (ma)	$I_{BB(OFF)}$ (ma)	$I_{CC(OFF)}$ (ma)	$V_{BE(OFF)}$ (volts)	$V_{CE(OFF)}$ (volts)	$I_{B(ON)}$ (ma)	$I_{BB(ON)}$ (ma)	$I_{CC(ON)}$ (ma)	$V_{BE(ON)}$ (volts)	$V_{CE(ON)}$ (volts)
1	0.54	0.63	90 μa	+0.96	−12.3	1.85	0.73	23.0	−0.81	−0.91
2	0.93	0.95	4.0 μa	+0.83	−12.3	3.5	1.08	26.0	−0.82	−0.96
3	0.60	0.60	1 μa	+1.13	−12.3	1.7	0.70	22.0	−0.83	−0.94
4	0.45	0.59	0.143	+0.71	−12.0	1.9	0.67	22.3	−0.82	−0.91
5	1.03	1.04	1 μa	+1.02	−12.3	3.3	1.2	29.0	−0.81	−0.98
6	0.98	2.0	0.98	+0.77	−12.2	3.8	1.9	27.0	−0.81	−1.0
7	0.35	1.15	0.78	0	−12.1	2.4	1.2	33.0	−0.81	−0.38
8	0.45	1.03	0.57	+0.13	−12.2	2.5	1.08	32.0	−0.81	−0.23
9	0.37	0.75	0.34	+0.025	−12.2	2.2	0.80	29.0	−0.81	−0.21
10	0.46	2.3	1.9	−0.06	−12.3	3.3	2.2	35.0	−0.80	−0.20
11	0.74	1.2	0.47	−0.40	−12.2	2.5	1.3	30.0	−0.80	−0.95
12	0.90	1.0	1 μa	−0.13	−12.3	3.0	1.0	26.0	−0.82	−0.24
13	0.48	1.2	0.65	+0.10	−12.3	2.7	1.3	34.0	−0.80	−0.21
14	0.94	1.4	0.44	+0.42	−12.3	3.4	1.5	33.5	−0.78	−0.42
15	1.6	1.6	1 μa	+1.0	−12.2	2.9	1.8	25.0	−0.83	−0.15
16	0.90	0.99	88 μa	+0.60	−12.3	2.5	1.2	26.0	−0.80	−0.95
17	0.86	1.4	1.2	+0.96	−12.2	4.0	1.5	33.0	−0.77	−0.49
18	0.87	1.4	0.84	+0.70	−12.3	3.0	1.5	31.0	−0.82	−0.55
19	0.80	0.90	20 μa	+0.10	−12.3	2.3	0.90	26.0	−0.84	−0.30
20	0.55	3.5	2.8	+0.36	−12.3	2.2	2.7	32.5	−0.80	−0.40
21	0.31	1.6	1.4	−0.57	−12.2	2.5	1.2	31.5	−0.84	−0.30
22	0.44	0.77	0.65	+0.17	−12.3	2.0	1.0	29.5	−0.78	−0.22
23	0.82	0.90	1 μa	+0.01	−12.2	2.4	0.9	26.0	−0.85	−0.22
24	1.7	1.7	1 μa	+1.1	−12.3	3.0	2.0	27.0	−0.81	−0.16
25	1.3	1.3	15 μa	+0.18	−12.3	3.4	1.5	28.0	−0.89	−0.23
26	0.90	1.0	10 μa	−0.11	−12.3	2.9	1.0	26.0	−0.86	−0.19
27	0.34	0.65	0.31	−0.50	−12.3	1.8	0.71	30.0	−0.83	−0.52
28	0.40	1.0	1.05	+1.2	−12.3	2.2	1.1	30.0	−0.81	−0.36
29	1.4	1.7	0.18	−0.14	−12.3	4.7	1.7	31.0	−0.88	−0.20
30	0.86	1.5	0.87	+0.22	−12.1	3.5	1.5	33.0	−0.83	−0.64
31	0.71	0.73	0.10	+0.59	−12.2	2.0	0.9	23.5	−0.81	−0.90
32	0.39	1.10	0.7	−0.06	−12.2	2.7	1.2	32.0	−0.83	−0.41
33	1.40	1.50	1 μa	−0.05	−12.3	4.2	1.5	29.5	−0.87	−0.18
34	1.80	1.90	1 μa	+0.07	−12.2	5.1	1.9	30.0	−0.87	−0.19
35	0.48	0.58	0.85	+0.18	−12.2	1.9	0.62	27.5	−0.82	−0.79
36	0.40	0.76	0.34	+0.03	−12.3	2.1	0.83	29.5	−0.84	−0.53
37	0.56	0.57	1 μa	+0.53	−12.2	1.7	0.63	22.0	−0.81	−0.87
38	0.52	0.73	10 μa	+0.10	−12.3	2.4	0.80	30.0	−0.82	−0.51
39	0.51	0.66	0.14	+0.22	−12.3	1.9	0.72	26.0	−0.92	−0.86
40	0.68	0.69	1 μa	−0.39	−12.2	2.8	0.73	24.5	−0.88	−0.19
41	0.68	0.70	1 μa	−0.15	−12.2	2.3	0.74	24.0	−0.85	−0.13

Table IX. DC Data for T = −40°C (SN-204) (Continued)

Unit No.	$I_{B(OFF)}$ (ma)	$I_{BB(OFF)}$ (ma)	$I_{CC(OFF)}$ (ma)	$V_{BE(OFF)}$ (volts)	$V_{CE(OFF)}$ (volts)	$I_{B(ON)}$ (ma)	$I_{BB(ON)}$ (ma)	$I_{CC(ON)}$ (ma)	$V_{BE(ON)}$ (volts)	$V_{CE(ON)}$ (volts)
42	0.88	0.89	1 μa	−0.13	−12.2	2.9	0.96	25.0	−0.89	−0.20
43	0.62	0.63	2 μa	−0.33	−12.2	2.4	0.67	23.5	−0.88	−0.19
44	0.66	0.67	1 μa	−0.23	−12.1	2.4	0.72	24.0	−0.87	−0.19
45	0.32	0.60	0.56	+0.13	−12.1	1.5	0.65	26.0	−0.85	−0.45
46	0.70	0.80	10 μa	−0.31	−12.3	2.8	0.9	24.5	−0.87	−0.19
47	0.60	0.70	7.5 μa	−0.59	−12.1	1.7	0.79	23.5	−0.82	−0.79
48	1.0	1.1	3 μa	−0.05	−12.3	3.2	1.2	25.0	−0.87	−0.18
49	1.0	1.1	1 μa	−0.38	−12.3	4.4	1.16	29.5	−0.83	−0.17
50	0.90	0.92	10 μa	−0.24	−12.3	3.8	1.08	28.0	−0.85	−0.15
Σ	38.08	55.08	18.55	+9.72	−612.0	137.6	57.57	1395.0	−41.62	−22.49
Avg.	0.761	1.10	0.37	+0.194	−12.2	2.75	1.15	27.9	−0.832	−0.449
Max.	1.80	3.5	2.80	−0.59	−12.3	5.10	2.70	35.0	−0.92	−1.00
Min.	0.31	0.57	1 μa	+1.2	−12.0	1.50	0.62	22.0	−0.77	−0.13

Table X. DC Data for T = +25°C (SN-204)

Unit No.	$I_{B(OFF)}$ (ma)	$I_{BB(OFF)}$ (ma)	$I_{CC(OFF)}$ (ma)	$V_{BE(OFF)}$ (volts)	$V_{CE(OFF)}$ (volts)	$I_{B(ON)}$ (ma)	$I_{BB(ON)}$ (ma)	$I_{CC(ON)}$ (ma)	$V_{BE(ON)}$ (volts)	$V_{CE(ON)}$ (volts)
1	0.59	0.64	49 μa	+0.94	-12.3	1.9	0.72	23.3	-0.70	-0.75
2	0.94	0.94	< 1.0 μa	+0.75	-12.3	3.5	1.05	27.0	-0.72	-0.80
3	0.62	0.62	2.5 μa	+0.58	-12.3	1.8	0.69	22.7	-0.71	-0.80
4	0.51	0.62	0.115	+0.24	-12.1	2.0	0.68	22.5	-0.72	-0.77
5	1.06	1.08	9.0 μa	+0.46	-12.3	3.3	1.16	29.0	-0.71	-0.80
6	1.07	1.8	0.66	+0.32	-12.2	3.7	1.6	28.0	-0.69	-0.65
7	0.29	1.11	0.80	-0.10	-12.2	2.3	1.11	32.0	-0.70	-0.23
8	0.36	0.99	0.62	-0.01	-12.3	2.3	1.02	31.0	-0.72	-0.25
9	0.28	0.74	0.45	-0.11	-12.2	1.9	0.74	29.0	-0.72	-0.24
10	0.39	2.1	1.6	-0.12	-12.3	3.0	1.9	34.0	-0.71	-0.23
11	0.61	1.17	0.55	+0.36	-12.2	2.4	1.2	30.5	-0.69	-0.46
12	0.86	0.88	< 1.0 μa	-0.13	-12.2	3.0	0.92	26.0	-0.72	-0.24
13	0.39	1.2	0.71	-0.03	-12.3	2.5	1.25	33.0	-0.72	-0.24
14	0.75	1.4	0.60	+0.30	-12.3	3.2	1.5	33.0	-0.71	-0.28
15	1.5	1.5	10 μa	+0.89	-12.3	2.8	1.6	24.5	-0.72	-0.18
16	0.74	0.97	0.22	+0.44	-12.3	2.5	1.1	27.5	-0.70	-0.51
17	0.71	1.4	0.68	+0.22	-12.1	3.7	1.4	34.0	-0.71	-0.24
18	0.73	1.4	0.55	+0.46	-12.2	2.8	1.5	31.5	-0.70	-0.33
19	0.77	0.83	50 μa	+0.07	-12.2	2.3	0.88	26.0	-0.72	-0.20
20	0.45	2.5	2.0	+0.23	-12.3	2.1	2.1	33.0	-0.70	-0.23
21	0.27	1.03	0.75	-0.10	-12.3	2.2	1.2	31.5	-0.72	-0.24
22	0.32	0.85	0.92	-0.10	-12.3	1.8	0.80	29.0	-0.71	-0.22
23	0.77	0.82	40 μa	-0.035	-12.3	2.4	0.88	26.0	-0.75	-0.24
24	1.80	1.60	3 μa	+1.0	-12.3	3.0	1.9	26.0	-0.71	-0.20
25	1.2	1.3	2 μa	+0.18	-12.3	3.4	1.3	27.5	-0.76	-0.24
26	0.88	0.92	50 μa	-0.12	-12.3	2.8	1.0	26.0	-0.75	-0.23
27	0.23	0.67	0.45	-0.29	-12.1	1.9	0.68	30.0	-0.72	-0.25
28	0.30	0.91	0.60	-0.10	-12.3	2.2	0.93	30.0	-0.72	-0.22
29	1.3	1.55	0.20	-0.19	-12.3	4.5	1.4	30.0	-0.77	-0.23
30	0.61	1.3	0.66	+0.03	-12.3	3.2	1.4	34.0	-0.71	-0.33
31	0.58	0.74	0.15	+0.31	-12.3	2.0	0.80	26.0	-0.70	-0.48
32	0.31	1.1	0.76	-0.13	-12.2	2.6	1.2	32.0	-0.72	-0.27
33	1.3	1.4	< 1 μa	-0.055	-12.3	4.0	1.4	29.0	-0.75	-0.20
34	1.7	1.7	5 μa	+0.06	-12.3	4.9	1.8	29.0	-0.75	-0.24
35	0.33	0.56	0.24	-0.17	-12.3	2.0	0.56	29.0	-0.72	-0.25
36	0.28	0.78	0.47	-0.07	-12.3	2.1	0.80	30.5	-0.70	-0.30
37	0.48	0.56	0.62	+0.34	-12.2	1.7	0.60	23.0	-0.70	-0.49
38	0.35	0.75	0.20	-0.24	-12.2	2.3	0.74	31.0	-0.72	-0.27
39	0.37	0.67	0.29	-0.07	-12.3	2.0	0.69	28.0	-0.78	-0.25
40	0.68	0.69	1 μa	-0.36	-12.3	2.8	0.70	24.5	-0.76	-0.21
41	0.68	0.70	1 μa	-0.14	-12.2	2.3	0.72	24.0	-0.74	-0.16

Table X. DC Data for T = +25°C (SN-204) (Continued)

Unit No.	$I_{B(OFF)}$ (ma)	$I_{BB(OFF)}$ (ma)	$I_{CC(OFF)}$ (ma)	$V_{BE(OFF)}$ (volts)	$V_{CE(OFF)}$ (volts)	$I_{B(ON)}$ (ma)	$I_{BB(ON)}$ (ma)	$I_{CC(ON)}$ (ma)	$V_{BE(ON)}$ (volts)	$V_{CE(ON)}$ (volts)
42	0.88	0.89	1 μa	−0.12	−12.1	3.9	0.92	25.0	−0.76	−0.22
43	0.61	0.63	1 μa	−0.31	−12.2	2.4	0.64	23.5	−0.76	−0.22
44	0.66	0.67	1 μa	−0.19	−12.1	2.3	0.69	23.5	−0.75	−0.22
45	0.25	0.59	0.32	−0.05	−12.2	1.4	0.58	26.0	−0.73	−0.26
46	0.72	0.74	1 μa	−0.31	−12.3	4.6	0.76	19.0	−0.77	−0.18
47	0.44	0.71	0.25	+0.23	−12.2	1.7	0.74	26.0	−0.71	−0.37
48	1.02	1.04	2 μa	−0.067	−12.2	3.2	1.09	25.0	−0.74	−0.22
49	1.02	1.09	26 μa	−0.37	−12.3	4.6	1.10	29.0	−0.72	−0.22
50	0.96	0.98	1 μa	−0.012	−12.3	3.7	1.05	27.0	−0.74	−0.19
Σ	34.92	51.83	16.69	+4.31	−612.5	136.9	53.19	1397.0	−36.23	−16.05
Avg.	0.698	1.04	0.334	+0.086	−12.25	2.74	1.06	27.9	−0.724	−0.321
Max.	1.80	2.50	2.00	−0.37	−12.30	4.9	2.1	34.0	−0.78	−0.80
Min.	0.23	0.56	1 μa	+0.94	−12.10	1.4	0.56	22.5	−0.69	−0.18

Table XI. DC Data for T = +85°C (SN-204)

Unit No.	$I_{B(OFF)}$ (ma)	$I_{BB(OFF)}$ (ma)	$I_{CC(OFF)}$ (ma)	$V_{BE(OFF)}$ (volts)	$V_{CE(OFF)}$ (volts)	$I_{B(ON)}$ (ma)	$I_{BB(ON)}$ (ma)	$I_{CC(ON)}$ (ma)	$V_{BE(ON)}$ (volts)	$V_{CE(ON)}$ (volts)
1	0.61	0.61	6 μa	+0.92	-12.3	1.9	0.68	23.5	-0.60	-0.59
2	0.90	0.91	5 μa	+0.66	-12.3	3.4	1.00	27.0	-0.63	-0.45
3	0.61	0.61	5 μa	+0.47	-12.3	1.8	0.66	23.0	-0.62	-0.69
4	0.49	0.72	0.24	+0.13	-12.0	1.9	0.77	23.0	-0.63	-0.68
5	1.00	1.06	50 μa	+0.34	-12.3	3.2	1.12	30.0	-0.62	-0.57
6	1.02	1.5	0.52	+0.27	-12.2	3.6	1.4	28.0	-0.61	-0.42
7	0.24	1.07	0.81	-0.19	-12.2	2.2	1.06	32.0	-0.63	-0.26
8	0.28	0.95	0.66	-0.16	-12.2	2.2	0.96	31.0	-0.65	-0.30
9	0.25	0.71	0.41	-0.24	-12.1	2.0	0.70	29.0	-0.65	-0.26
10	0.32	2.0	1.6	-0.17	-12.2	2.8	1.12	32.0	-0.64	-0.26
11	0.51	1.10	0.60	+0.28	-12.1	2.3	1.16	30.5	-0.62	-0.35
12	0.83	0.85	1 μa	-0.14	-12.2	2.9	1.0	25.0	-0.64	-0.29
13	0.32	1.08	0.75	-0.13	-12.3	2.4	1.2	32.5	-0.65	-0.28
14	0.62	1.4	0.67	+0.22	-12.3	2.8	1.4	32.5	-0.64	-0.30
15	1.4	1.5	10 μa	+0.78	-12.3	2.6	1.8	24.0	-0.64	-0.21
16	0.62	1.1	0.31	+0.37	-12.3	2.4	1.1	28.0	-0.63	-0.32
17	0.60	1.4	0.74	+0.15	-12.1	3.2	1.5	33.5	-0.64	-0.25
18	0.60	1.3	0.60	+0.40	-12.0	2.5	1.4	30.5	-0.63	-0.36
19	0.74	0.79	90 μa	+0.05	-12.2	2.2	0.9	25.0	-0.64	-0.24
20	0.37	2.0	3.3	+0.08	-12.0	2.0	1.8	31.5	-0.64	-0.25
21	0.22	1.0	0.74	-0.19	-12.0	2.0	1.1	30.5	-0.65	-0.27
22	0.26	0.90	0.50	-0.17	-12.3	1.7	0.80	28.5	-0.64	-0.24
23	0.72	0.88	0.25	-0.11	-12.3	2.3	1.0	25.0	-0.66	-0.28
24	1.5	1.6	10 μa	+0.89	-12.2	2.8	1.7	25.5	-0.63	-0.24
25	1.2	1.3	15 μa	+0.16	-12.3	3.3	1.3	27.0	-0.67	-0.28
26	0.84	0.90	0.10	-0.17	-12.3	2.8	1.0	25.0	-0.66	-0.27
27	0.17	0.66	0.60	-0.44	-12.0	1.8	0.66	29.5	-0.65	-0.28
28	0.25	1.0	0.65	-0.25	-12.3	2.0	1.0	29.5	-0.65	-0.25
29	1.1	1.9	0.60	-0.48	-12.0	4.4	2.3	31.0	-0.68	-0.26
30	0.48	1.4	0.75	-0.16	-12.2	3.3	1.3	34.0	-0.63	-0.33
31	0.44	0.72	0.53	+ .075	-12.2	2.0	0.80	26.5	-0.61	-0.31
32	0.26	1.03	0.75	-0.21	-12.2	2.3	1.1	31.5	-0.63	-0.30
33	1.19	1.4	60 μa	- .079	-12.3	3.9	1.4	28.5	-0.65	-0.33
34	1.65	1.70	6 μa	+ .03	-12.3	4.8	1.7	28.5	-0.66	-0.27
35	0.24	0.53	0.29	-0.38	-12.3	1.8	0.52	29.0	-0.65	-0.27
36	0.21	0.76	0.54	-0.38	-12.3	2.0	0.76	30.0	-0.68	-0.31
37	0.38	0.53	0.14	+0.15	-12.2	1.6	0.55	24.0	-0.62	-0.30
38	0.25	0.72	0.95	-0.40	-12.3	2.2	0.69	30.0	-0.66	-0.29
39	0.26	0.65	0.36	-0.27	-12.3	1.8	0.65	28.0	-0.68	-0.25
40	0.64	0.65	10 μa	-0.37	-12.2	2.7	0.66	24.0	-0.68	-0.25
41	0.65	0.66	1 μa	-0.12	-12.2	2.2	0.68	24.0	-0.65	-0.18

Table XI. DC Data for T = +85°C (SN-204) (Continued)

Unit No.	$I_{B(OFF)}$ (ma)	$I_{BB(OFF)}$ (ma)	$I_{CC(OFF)}$ (ma)	$V_{BE(OFF)}$ (volts)	$V_{CE(OFF)}$ (volts)	$I_{B(ON)}$ (ma)	$I_{BB(ON)}$ (ma)	$I_{CC(ON)}$ (ma)	$V_{BE(ON)}$ (volts)	$V_{CE(ON)}$ (volts)
42	0.85	0.86	1 μa	-0.10	-12.2	2.8	0.88	25.0	-0.66	-0.26
43	0.58	0.60	3 μa	-0.33	-12.2	2.2	0.60	23.0	-0.67	-0.25
44	0.62	0.64	1 μa	-0.20	-12.2	2.2	0.65	23.0	-0.67	-0.25
45	0.19	0.53	0.33	-0.13	-12.1	1.3	0.60	25.0	-0.65	-0.29
46	0.69	0.70	1 μa	-0.27	-12.3	2.7	0.80	23.0	-0.67	-0.24
47	0.32	0.68	0.34	+ .03	-12.0	1.6	0.70	26.0	-0.63	-0.30
48	0.97	0.99	5 μa	- .025	-12.2	3.1	1.1	24.0	-0.68	-0.29
49	1.04	1.08	35 μa	-0.37	-12.2	4.8	1.08	29.0	-0.67	-0.25
50	0.95	1.05	40 μa	-0.28	-12.3	3.6	1.06	26.5	-0.66	-0.22
Σ	31.45	50.68	19.40	-0.29	-610.3	128.3	51.87	1386.0	-32.30	-15.44
Avg.	0.629	1.01	0.388	- .0058	-12.20	2.56	1.03	27.7	-0.646	-0.308
Max.	1.65	2.0	3.30	-0.48	-12.30	4.8	2.3	34.0	-0.68	-0.69
Min.	0.21	0.53	1 μa	+0.92	-12.00	1.3	0.52	23.0	-0.60	-0.18

Table XII. Switching-Time Data for T = −40°C (SN-204)

Unit No.	t_d (n sec)	t_r (n sec)	t_s (n sec)	t_f (n sec)	t_{TOTAL} (n sec)	Unit No.	t_d (n sec)	t_r (n sec)	t_s (n sec)	t_f (n sec)	t_{TOTAL} (n sec)
1	40	35	30	350	455	28	20	40	30	300	390
2	40	40	15	220	315	29	20	20	70	160	270
3	60	60	30	400	550	30	20	20	30	180	250
4	40	50	30	400	520	31	20	20	30	320	390
5	40	45	10	180	275	32	20	10	40	200	270
6	40	40	10	220	310	33	20	10	80	220	330
7	30	35	25	230	320	34	20	20	80	200	320
8	38	30	40	250	358	35	20	10	20	300	350
9	30	40	50	320	440	36	20	20	20	280	340
10	40	30	40	220	330	37	20	20	20	420	480
11	40	30	10	180	260	38	20	20	20	280	340
12	20	10	30	220	280	39	20	20	30	320	390
13	20	30	60	200	310	40	20	10	70	330	430
14	30	40	10	150	230	41	20	10	90	380	500
15	50	40	80	300	470	42	20	10	60	290	380
16	40	40	10	200	290	43	20	10	80	360	470
17	30	50	10	210	300	44	20	10	70	360	460
18	50	50	10	270	380	45	40	30	40	380	490
19	20	20	40	260	340	46	20	25	90	350	485
20	30	30	30	200	290	47	40	20	30	380	470
21	30	30	30	240	330	48	25	25	90	310	450
22	30	40	20	300	390	49	20	29	90	270	400
23	20	20	40	240	320	50	20	20	100	280	420
24	30	10	70	230	340	Σ	1413	1325	2120	13, 750	18, 608
25	20	20	40	300	380	Avg.	28. 2	26. 5	42. 4	275	372
26	20	10	50	250	330	Max.	60	60	100	420	550
27	30	30	20	340	420	Min.	20	10	10	150	230

Table XIII. Switching-Time Data for T = +25°C (SN-204)

Unit No.	t_d (n sec)	t_r (n sec)	t_s (n sec)	t_f (n sec)	t_{TOTAL} (n sec)	Unit No.	t_d (n sec)	t_r (n sec)	t_s (n sec)	t_f (n sec)	t_{TOTAL} (n sec)
1	40	30	30	400	500	28	20	30	120	370	540
2	30	30	15	250	325	29	20	10	140	170	340
3	40	30	50	430	550	30	20	10	50	190	270
4	40	30	40	430	540	31	20	20	30	320	390
5	40	30	10	200	280	32	20	10	80	240	350
6	35	30	15	230	310	33	20	10	120	280	430
7	20	20	70	280	390	34	20	10	120	240	390
8	25	25	100	320	470	35	20	10	50	320	400
9	20	30	100	350	500	36	20	20	80	320	440
10	25	20	100	260	405	37	20	20	40	420	500
11	30	20	50	200	300	38	20	20	60	280	380
12	20	10	60	240	330	39	20	20	60	400	500
13	20	30	150	230	430	40	20	20	120	440	590
14	20	30	50	170	270	41	20	10	130	400	560
15	30	30	110	390	560	42	20	10	100	310	440
16	30	30	30	250	340	43	20	10	130	370	530
17	20	40	60	120	240	44	20	10	110	390	530
18	30	30	80	180	320	45	30	20	70	520	640
19	20	10	60	270	360	46	20	30	110	360	520
20	20	30	80	300	430	47	20	20	80	380	500
21	20	20	80	260	380	48	20	20	130	370	540
22	20	20	80	320	440	49	20	20	110	300	450
23	20	10	70	250	350	50	30	20	130	370	550
24	20	10	70	280	380	Σ	1175	1005	3980	15, 370	21, 530
25	20	10	70	230	330	Avg.	23.5	20.1	79.6	307	431
26	20	10	80	270	380	Max.	40	40	150	520	640
27	20	20	100	500	640	Min.	20	10	10	120	240

Table XIV. Switching-Time Data for T = +85°C (SN-204)

Unit No.	t_d (n sec)	t_r (n sec)	t_s (n sec)	t_f (n sec)	t_{TOTAL} (n sec)	Unit No.	t_d (n sec)	t_r (n sec)	t_s (n sec)	t_f (n sec)	t_{TOTAL} (n sec)
1	35	30	35	400	500	28	10	20	160	360	550
2	30	30	40	260	360	29	20	10	360	240	630
3	40	30	40	450	560	30	20	10	140	220	390
4	30	30	50	450	560	31	20	10	70	380	480
5	30	30	30	200	290	32	20	10	140	300	470
6	30	25	50	260	365	33	20	30	150	350	550
7	20	20	130	310	480	34	20	10	190	280	500
8	20	20	160	400	600	35	20	20	110	390	540
9	10	20	150	350	530	36	20	20	140	420	600
10	25	20	150	300	495	37	20	10	100	510	640
11	30	30	90	190	340	38	20	10	130	370	530
12	20	10	60	230	320	39	20	20	120	480	640
13	10	20	180	160	370	40	20	20	150	410	600
14	20	20	100	180	320	41	20	20	160	440	640
15	40	30	110	350	530	42	20	20	140	400	580
16	30	20	50	250	350	43	20	20	180	320	540
17	30	30	80	170	310	44	20	20	150	450	640
18	30	40	100	200	370	45	15	20	10	530	575
19	20	10	100	300	430	46	20	20	150	440	630
20	20	30	90	210	350	47	20	20	70	500	610
21	20	20	110	270	420	48	20	15	140	420	595
22	20	20	100	400	540	49	20	20	160	340	540
23	20	10	140	360	530	50	20	20	160	420	620
24	20	10	140	380	550	Σ	1095	990	6005	17,080	25,170
25	20	10	140	340	510	Avg.	21.9	19.8	120	342	503
26	20	10	160	360	550	Max.	40	40	180	530	640
27	10	20	140	380	550	Min.	10	10	10	160	290

Table XV. DC Data for T = -40°C (SN-204A)

Unit No.	$I_{B(OFF)}$ (ma)	$I_{BB(OFF)}$ (ma)	$I_{CC(OFF)}$ (μa)	$V_{BE(OFF)}$ (volts)	$V_{CE(OFF)}$ (volts)	$I_{B(ON)}$ (ma)	$I_{BB(ON)}$ (ma)	$I_{CC(ON)}$ (ma)	$V_{BE(SAT)}$ (volts)	$V_{CE(SAT)}$ (volts)
51	0.90	0.93	18	-0.20	-12.3	3.2	1.0	27.0	-0.89	-0.20
52	0.79	0.81	5.0	-0.35	-12.3	3.1	0.85	26.5	-0.92	-0.23
53	0.88	0.89	1.0	-0.26	-12.3	3.1	0.95	27.0	-1.00	-0.20
54	0.66	0.68	6.0	+0.65	-12.2	1.8	0.80	22.5	-0.81	-0.97
55	0.90	1.0	1.0	-0.06	-12.3	3.2	1.0	26.0	-0.86	-0.17
56	1.4	1.5	1.0	-0.19	-12.3	5.1	1.5	29.5	-0.88	-0.36
57	0.54	0.60	40	+0.53	-12.3	1.7	0.66	25.0	-0.82	-0.68
58	1.2	1.2	20	-0.28	-12.3	4.2	1.3	30.0	-0.84	-0.17
59	1.5	1.7	50	+0.35	-12.2	3.6	1.8	28.0	-0.82	-0.16
60	1.03	1.05	1.0	-0.15	-12.3	3.6	1.3	26.5	-0.83	-0.18
61	1.4	1.4	1.0	-0.19	-12.3	4.8	1.6	28.0	-0.88	-0.23
62	1.02	1.04	15	-0.34	-12.3	3.9	1.1	29.0	-0.91	-0.18
63	1.15	1.4	210	+0.48	-12.3	3.5	1.5	30.0	-0.80	-0.94
64	0.85	1.6	600	+0.06	-12.3	4.5	1.7	39.0	-0.81	-0.23
65	1.16	1.3	1.0	-0.16	-12.3	4.0	1.3	28.5	-0.87	-0.20
66	0.58	0.64	38	+0.34	-12.2	2.0	0.70	24.0	-0.83	-0.74
67	1.02	1.04	1.0	-0.14	-12.3	3.5	1.2	33.0	-0.88	-0.16
68	1.0	1.0	1.0	-0.17	-12.3	3.5	1.08	27.0	-0.85	-0.16
69	1.02	1.03	1.0	-0.20	-12.3	3.6	1.1	27.0	-0.88	-0.18
70	0.90	0.92	1.0	-0.10	-12.3	3.0	0.98	27.0	-0.85	-0.17
71	1.05	1.15	1.0	+0.04	-12.3	3.0	1.2	26.0	-0.89	-0.24
72	0.94	0.96	1.0	-0.28	-12.3	3.6	1.02	27.0	-0.89	-0.17
73	0.71	0.98	260	+0.30	-12.3	2.7	1.1	30.0	-0.86	-0.55
74	0.71	0.73	1.0	-0.11	-12.3	2.3	0.80	25.0	-0.86	-0.16
75	0.89	0.94	40	-0.16	-12.3	3.0	0.98	26.0	-0.93	-0.25
76	0.88	0.89	1.0	-0.23	-12.3	3.1	0.95	26.5	-0.91	-0.17
77	0.97	0.98	1.0	-0.18	-12.3	3.4	1.1	27.0	-0.83	-0.18
78	0.63	0.73	10	+0.46	-12.3	2.0	0.85	26.0	-0.80	-0.81
79	0.76	0.80	23	-0.08	-12.3	2.5	0.85	25.0	-0.85	-0.21
80	0.90	0.91	1.0	-0.13	-12.3	3.0	0.97	26.0	-0.85	-0.16
81	0.81	0.87	40	+0.46	-12.3	2.7	0.97	28.5	-0.81	-0.65
82	0.78	0.85	57	+0.47	-12.2	2.5	0.95	27.0	-0.82	-0.73
83	1.0	1.02	1.0	-0.25	-12.3	3.6	1.1	28.0	-0.92	-0.17
84	1.02	1.7	550	-0.58	-12.3	5.1	1.6	31.5	-0.95	-0.20
85	0.89	0.90	1.0	+0.02	-12.3	3.0	1.1	26.0	-0.86	-0.17
86	0.73	0.75	1.0	-0.16	-12.3	2.5	0.85	25.0	-0.88	-0.18
87	0.80	0.82	1.0	-0.23	-12.3	3.0	0.95	25.0	-0.84	-0.18
88	1.65	1.75	1.0	-0.14	-12.3	5.5	1.8	30.0	-0.84	-0.19
89	0.90	0.92	5.0	0	-12.3	2.8	1.01	26.0	-0.90	-0.17

Table XV. DC Data for T = -40°C (SN-204A) (Continued)

Unit No.	$I_{B(OFF)}$ (ma)	$I_{BB(OFF)}$ (ma)	$I_{CC(OFF)}$ (μa)	$V_{BE(OFF)}$ (volts)	$V_{CE(OFF)}$ (volts)	$I_{B(ON)}$ (ma)	$I_{BB(ON)}$ (ma)	$I_{CC(ON)}$ (ma)	$V_{BE(SAT)}$ (volts)	$V_{CE(SAT)}$ (volts)
90	0.90	0.91	1.0	-0.18	-12.3	3.2	1.05	27.0	-0.90	-0.19
91	0.75	0.76	14	-0.11	-12.3	2.5	0.82	25.0	-0.84	-0.20
92	0.69	0.71	3.0	-0.14	-12.3	2.4	0.85	24.0	-0.83	-0.18
93	0.96	0.97	1.0	-0.21	-12.3	3.3	1.05	27.0	-0.87	-0.19
94	0.68	0.70	1.0	-0.18	-12.3	2.4	0.80	26.5	-0.82	-0.75
95	1.6	1.65	1.0	+0.11	-12.3	4.3	1.7	28.0	-0.86	-0.19
96	1.0	1.07	1.0	-0.19	-12.3	3.6	1.2	27.0	-0.84	-0.17
97	0.54	0.66	920	+0.47	-12.1	1.8	0.73	25.5	-0.82	-0.79
98	0.96	0.97	1.0	-0.19	-12.3	3.3	1.1	27.5	-0.82	-0.18
99	1.2	1.25	5.0	-0.14	-12.3	3.8	1.3	28.5	-0.86	-0.19
100	1.05	1.15	1.0	-0.15	-12.3	3.5	1.2	32.0	-0.84	-0.17
Σ	47.25	51.18	2957	-2.07	614.4	162.3	55.37	1370.	43.02	15.25
AVG	0.944	1.025	60.6	-0.041	-12.29	3.25	1.108	27.4	-0.86	-0.305
MAX	1.65	1.75	920	-0.58	-12.3	5.5	1.8	39.0	-1.00	-0.97
MIN	0.54	0.60	1.0	+0.65	-12.0	1.7	0.66	22.5	-0.80	-0.16

Table XVI. DC Data for T = +25°C (SN-204A)

Unit No.	$I_{B(OFF)}$ (ma)	$I_{BB(OFF)}$ (ma)	$I_{CC(OFF)}$ (μa)	$V_{BE(OFF)}$ (volts)	$V_{CE(OFF)}$ (volts)	$I_{B(ON)}$ (ma)	$I_{BB(ON)}$ (ma)	$I_{CC(ON)}$ (ma)	$V_{BE(SAT)}$ (volts)	$V_{CE(SAT)}$ (volts)
51	0.92	0.[illegible]	1.0	-0.22	-12.3	2.8	0.95	26.5	-0.75	-0.22
52	0.80	0.82	13	-0.51	-12.3	3.2	0.83	26.0	-0.79	-0.23
53	0.89	0.90	1.0	-0.26	-12.3	3.1	0.73	26.0	-0.81	-0.22
54	0.54	0.70	140	+0.46	-12.2	1.8	0.74	25.0	-0.68	-0.41
55	0.93	0.95	1.0	-0.17	-12.3	3.1	0.97	26.0	-0.74	-0.21
56	1.5	1.6	1.0	-0.40	-12.3	5.0	1.6	29.0	-0.76	-0.29
57	0.40	0.60	180	+0.12	-12.3	1.7	0.62	27.0	-0.72	-0.31
58	1.1	1.1	10	-0.28	-12.3	4.0	1.1	29.5	-0.72	-0.23
59	1.5	1.55	1.0	-0.36	-12.3	3.6	1.6	27.5	-0.72	-0.21
60	1.06	1.06	1.0	-0.15	-12.3	3.6	1.1	26.0	-0.72	-0.20
61	1.5	1.5	1.0	-0.076	-12.3	4.7	1.5	27.0	-0.77	-0.22
62	1.01	1.08	1.0	-0.32	-12.3	3.9	1.04	28.5	-0.78	-0.20
63	0.96	1.5	410	+0.4	-12.1	3.5	1.5	31.0	-0.69	-0.39
64	0.65	1.5	800	-0.084	-12.2	4.0	1.6	38.0	-0.72	-0.28
65	1.17	1.2	1.0	-0.18	-12.3	4.0	1.3	28.0	-0.74	-0.23
66	0.48	0.65	150	+0.15	-12.1	2.1	0.68	25.0	-0.70	-0.33
67	1.05	1.06	1.0	-0.12	-12.3	3.5	1.09	30.0	-0.75	-0.20
68	1.0	1.02	1.0	-0.19	-12.3	3.5	1.05	26.5	-0.74	-0.19
69	1.02	1.04	1.0	-0.19	-12.3	3.6	1.08	26.5	-0.77	-0.21
70	0.90	0.91	1.0	-0.11	-12.3	3.0	0.95	26.5	-0.74	-0.20
71	1.0	1.05	1.0	+0.05	-12.3	3.0	1.1	26.0	-0.76	-0.23
72	0.86	0.87	1.0	-0.28	-12.3	3.6	0.99	27.0	-0.77	-0.20
73	0.53	1.03	480	+0.05	-12.3	2.7	1.08	31.0	-0.75	-0.27
74	0.73	0.74	1.0	-0.07	-12.3	2.4	0.77	24.0	-0.74	-0.19
75	0.89	0.91	2.0	-0.19	-12.3	3.1	0.84	26.0	-0.82	-0.28
76	0.88	0.89	1.0	-0.23	-12.3	3.2	0.92	26.0	-0.80	-0.20
77	0.98	1.0	1.0	-0.18	-12.3	3.5	1.1	26.5	-0.74	-0.19
78	0.46	0.77	300	+0.08	-12.3	2.1	0.81	28.0	-0.74	-0.35
79	0.78	0.80	15	-0.24	-12.3	2.5	0.85	25.0	-0.77	-0.22
80	0.89	0.90	1.0	-0.13	-12.3	3.0	0.94	26.0	-0.75	-0.21
81	0.61	0.88	530	+0.11	-12.3	2.7	0.92	30.0	-0.71	-0.31
82	0.59	0.86	560	+0.15	-12.2	2.5	1.0	29.0	-0.71	-0.28
83	1.05	1.06	1.0	-0.17	-12.3	3.6	1.2	28.0	-0.80	-0.21
84	1.4	1.6	240	-0.35	-12.3	5.1	1.7	31.0	-0.82	-0.24
85	1.0	1.1	1.0	-0.03	-12.3	3.0	1.1	25.5	-0.75	-0.21
86	0.76	0.78	1.0	-0.08	-12.3	2.5	0.90	25.0	-0.76	-0.19
87	0.84	0.85	1.0	-0.15	-12.3	2.9	1.0	25.0	-0.74	-0.20
88	1.4	1.65	150	-0.20	-12.3	5.4	1.7	29.5	-0.74	-0.24
89	0.94	0.96	3.0	+0.05	-12.3	2.8	1.1	25.5	-0.79	-0.30

Table XVI. DC Data for T = +25°C (SN-204A) (Continued)

Unit No.	$I_{B(OFF)}$ (ma)	$I_{BB(OFF)}$ (ma)	$I_{CC(OFF)}$ (μa)	$V_{BE(OFF)}$ (volts)	$V_{CE(OFF)}$ (volts)	$I_{B(ON)}$ (ma)	$I_{BB(ON)}$ (ma)	$I_{CC(ON)}$ (ma)	$V_{BE(SAT)}$ (volts)	$V_{CE(SAT)}$ (volts)
90	0.94	0.96	1.0	-0.13	-12.3	3.2	1.1	26.5	-0.76	-0.22
91	0.78	0.70	1.0	-0.03	-12.3	2.5	1.9	24.5	-0.72	-0.25
92	0.72	0.73	1.0	-0.08	-12.3	2.4	0.80	24.0	-0.73	-0.23
93	1.0	1.01	1.0	-0.12	-12.3	3.3	1.1	26.5	-0.77	-0.26
94	0.71	0.72	4.0	-0.11	-12.3	2.3	0.73	25.0	-0.72	-0.74
95	1.5	1.5	1.0	+0.10	-12.3	4.2	1.6	28.0	-0.75	-0.23
96	1.1	1.11	2.0	-0.08	-12.3	3.6	1.25	27.0	-0.73	-0.21
97	0.37	0.70	640	+0.03	-12.3	1.8	0.60	27.5	-0.71	-0.30
98	1.0	1.01	1.0	-0.11	-12.3	3.2	1.03	27.0	-0.72	-0.23
99	1.1	1.2	3.0	-0.16	-12.3	3.8	1.25	28.0	-0.75	-0.26
100	1.0	1.1	1.0	-0.10	-12.3	3.4	1.1	30.0	-0.73	-0.22
Σ	46.19	51.06	4,662	-5.09	614.3	161.0	54.51	1364	37.36	12.65
AVG	0.923	1.02	93.2	-0.10	-12.28	3.22	1.09	27.2	-0.75	-0.25
MAX	1.5	1.65	800	-0.51	-12.3	5.4	1.9	38.0	-0.82	-0.74
MIN	0.40	0.60	1.0	+0.46	-12.1	1.7	0.60	24.0	-0.68	-0.19

Table XVII. DC Data for T = +125°C (SN-204A)

Unit No.	$I_{B(OFF)}$ (ma)	$I_{BB(OFF)}$ (ma)	$I_{CC(OFF)}$ (μa)	$V_{BE(OFF)}$ (volts	$V_{CE(OFF)}$ (volts)	$I_{B(ON)}$ (ma)	$I_{BB(ON)}$ (ma)	$I_{CC(ON)}$ (ma)	$V_{BE(SAT)}$ (volts)	$V_{CE(SAT)}$ (volts
51	0.83	0.86	10	-0.15	-12.3	3.1	0.86	26.0	-0.61	-0.27
52	0.74	0.75	50	-0.34	-12.3	3.0	0.75	25.0	-0.63	-0.30
53	0.63	0.65	60	-0.07	-12.3	3.0	0.84	25.0	-0.63	-0.28
54	0.34	0.64	280	+0.012	-12.2	1.6	0.64	25.0	-0.55	-0.31
55	0.83	0.85	1.0	-0.08	-12.3	2.9	1.0	24.0	-0.61	-0.28
56	1.3	1.4	7	-0.18	-12.3	4.7	1.4	27.5	-0.63	-0.34
57	0.23	0.55	310	-0.28	-12.2	1.4	0.54	26.5	-0.60	-0.32
58	1.08	1.08	2.0	-0.29	-12.3	3.8	1.08	29.0	-0.61	-0.29
59	1.3	1.5	30	-0.34	-12.3	3.3	1.6	26.5	-0.60	-0.28
60	0.94	0.96	6.0	-0.16	-12.3	3.3	0.97	25.0	-0.59	-0.28
61	1.3	1.3	80	-0.18	-12.3	4.5	1.4	26.5	-0.60	-0.29
62	0.91	0.94	76	-0.34	-12.1	3.7	0.94	27.0	-0.60	-0.25
63	0.68	1.3	570	+0.77	-12.0	3.1	1.4	31.5	-0.56	-0.32
64	0.40	1.4	1000	-0.32	-12.1	3.6	1.4	37.0	-0.61	-0.34
65	1.05	1.08	12	-0.21	-12.3	3.8	1.09	27.0	-0.60	-0.29
66	0.30	0.56	260	-0.17	-12.1	1.7	0.57	25.0	-0.56	-0.36
67	1.0	1.02	10	-0.11	-12.3	3.4	1.2	29.0	-0.59	-0.27
68	0.93	0.93	3.0	-0.12	-12.3	3.3	1.1	26.0	-0.60	-0.25
69	0.96	0.98	7.0	-0.20	-12.3	3.4	1.1	26.0	-0.62	-0.28
70	0.81	0.84	11	-0.09	-12.3	2.8	0.86	25.0	-0.60	-0.27
71	0.90	1.0	15	+0.02	-12.3	2.8	1.05	25.0	-0.61	-0.29
72	0.90	0.90	7.0	-0.28	-12.3	3.4	1.0	26.0	-0.61	-0.26
73	0.33	0.97	620	-0.25	-12.0	2.4	1.1	30.0	-0.60	-0.30
74	0.65	0.67	5.0	-0.11	-12.3	2.2	0.80	24.0	-0.60	-0.25
75	0.81	0.84	20	-0.18	-12.3	2.9	0.85	25.0	-0.63	-0.35
76	0.81	0.83	10	-0.24	-12.3	3.0	0.95	25.5	-0.62	-0.26
77	0.90	0.93	17	-0.18	-12.3	3.2	1.05	26.0	-0.60	-0.25
78	0.26	0.72	480	-0.32	-12.1	1.8	0.80	28.0	-0.60	-0.30
79	0.70	0.74	20	-0.08	-12.3	2.3	0.73	24.0	-0.58	-0.28
80	0.81	0.83	30	-0.12	-12.3	2.8	0.84	25.0	-0.61	-0.29
81	0.80	0.83	770	-0.29	-12.1	2.2	0.83	31.0	-0.60	-0.35
82	0.34	0.82	480	-0.28	-12.1	2.2	0.81	29.0	-0.59	-0.27
83	0.88	0.90	50	-0.30	-12.3	3.5	1.0	27.5	-0.61	-0.26
84	1.3	1.5	18	-0.34	-12.3	4.9	1.3	30.0	-0.63	-0.30
85	0.84	0.85	8.0	-0.11	-12.3	2.9	1.0	25.0	-0.60	-0.26
86	0.63	0.65	8.0	-0.20	-12.3	2.3	0.75	24.0	-0.59	-0.22
87	0.71	0.73	12	-0.27	-12.3	2.7	0.80	25.0	-0.58	-0.24
88	1.45	1.55	30	-0.15	-12.3	5.1	1.6	28.5	-0.60	-0.31
89	0.83	0.85	8.0	-0.005	-12.3	2.6	0.95	25.0	-0.62	-0.23

Table XVII. DC Data for T = +125°C (SN-204A) (Continued)

Unit No.	$I_{B(OFF)}$ (ma)	$I_{BB(OFF)}$ (ma)	$I_{CC(OFF)}$ (μa)	$V_{BE(OFF)}$ (volts)	$V_{CE(OFF)}$ (volts)	$I_{B(ON)}$ (ma)	$I_{BB(ON)}$ (ma)	$I_{CC(ON)}$ (ma)	$V_{BE(SAT)}$ (volts)	$V_{CE(SAT)}$ (volts)
90	0.81	0.83	5.0	-0.25	-12.3	3.0	0.95	26.0	-0.61	-0.27
91	0.68	0.70	4.0	-0.09	-12.3	2.3	0.90	24.0	-0.58	-0.33
92	0.62	0.64	3.0	-0.15	-12.3	2.2	0.80	23.5	-0.59	-0.31
93	0.89	0.92	5.0	-0.18	-12.3	3.2	1.0	26.0	-0.60	-0.32
94	0.61	0.63	9.0	-0.18	-12.3	2.1	0.65	24.0	-0.58	-0.84
95	1.3	1.4	8.0	+0.10	-12.3	4.0	1.45	27.0	-0.61	-0.30
96	0.97	1.03	270	-0.19	-12.2	3.4	1.2	26.0	-0.60	-0.27
97	0.20	0.60	500	-0.38	-12.3	1.4	0.60	27.0	-0.61	-0.35
98	0.88	0.90	6.0	-0.16	-12.3	3.0	0.95	26.0	-0.58	-0.30
99	1.05	1.1	7.0	-0.12	-12.3	3.6	1.2	27.0	-0.61	-0.33
100	0.95	1.0	5.0	-0.13	-12.3	3.2	1.0	28.5	-0.60	-0.28
Σ	43.07	46.45	6215	-8.28	612.9	150.0	49.65	1328	30.05	15.04
AVG	0.86	0.929	124.0	-0.165	-12.25	3.0	0.993	26.5	-0.60	-0.30
MAX	1.45	1.55	1000	-0.38	-12.3	5.1	1.6	37.0	-0.63	-0.84
MIN	0.20	0.55	1.0	+0.77	-12.0	1.4	0.54	23.5	-0.55	-0.22

Table XVIII. Switching-Time Data for T = −40°C (SN-204A)

Unit No.	t_d (nsec)	t_r (nsec)	t_s (nsec)	t_f (nsec)	t_{TOTAL} (nsec)	Unit No.	t_d (nsec)	t_r (nsec)	t_s (nsec)	t_f (nsec)	t_{TOTAL} (nsec)
51	20	10	70	270	370	78	40	40	30	350	460
52	20	10	60	260	350	79	30	30	50	330	440
53	20	20	60	240	340	80	30	30	90	270	420
54	40	30	30	360	460	81	30	30	20	330	410
55	30	25	80	290	425	82	40	30	30	260	360
56	20	20	50	210	300	83	30	30	80	260	400
57	40	50	40	340	470	84	20	30	70	200	320
58	30	20	70	210	330	85	20	30	90	320	460
59	30	20	70	230	350	86	30	40	80	340	490
60	30	30	70	280	410	87	30	30	60	380	500
61	30	50	60	200	340	88	30	30	80	220	360
62	20	30	70	230	350	89	30	40	60	400	530
63	50	60	10	180	300	90	30	30	70	280	410
64	20	30	30	180	260	91	30	30	80	360	500
65	30	30	70	320	450	92	30	30	90	380	530
66	50	50	20	340	460	93	30	30	80	420	560
67	20	20	90	120	250	94	20	40	60	220	340
68	30	30	60	250	370	95	30	30	90	260	410
69	30	30	60	270	390	96	20	30	90	300	440
70	20	20	70	240	350	97	30	30	30	360	450
71	30	30	60	300	420	98	20	30	70	260	380
72	25	30	70	260	385	99	20	30	90	300	440
73	30	30	20	280	360	100	30	30	90	160	310
74	30	30	100	400	560	Σ	1435	1525	3190	14,040	20,190
75	30	30	80	260	400	AVG.	28.7	30.5	63.8	281	404
76	30	30	70	300	430	MAX.	50	60	100	420	560
77	30	30	70	260	390	MIN.	20	10	10	120	250

Table XIX. Switching-Time Data for T = +25°C (SN-204A)

Unit No.	t_d (nsec)	t_r (nsec)	t_s (nsec)	t_f (nsec)	t_{TOTAL} (nsec)	Unit No.	t_d (nsec)	t_r (nsec)	t_s (nsec)	t_f (nsec)	t_{TOTAL} (nsec)
51	20	10	170	440	640	78	20	30	100	450	600
52	20	20	150	450	640	79	30	40	120	440	630
53	20	20	100	310	450	80	20	20	140	460	640
54	20	20	100	430	570	81	10	20	140	320	490
55	20	20	150	450	640	82	20	40	140	400	600
56	15	20	140	430	605	83	20	20	170	400	610
57	30	20	90	470	610	84	20	20	200	240	480
58	20	20	170	330	540	85	20	30	170	430	650
59	30	20	130	370	550	86	20	20	140	460	640
60	20	20	160	400	600	87	20	20	130	460	630
61	20	20	140	280	460	88	20	30	190	390	630
62	20	20	160	410	610	89	20	30	120	380	550
63	30	30	120	220	400	90	20	30	170	400	620
64	10	10	270	200	490	91	20	30	160	340	550
65	20	30	130	310	490	92	20	20	160	440	640
66	20	20	100	410	550	93	20	30	150	420	620
67	20	20	230	320	590	94	30	30	110	340	510
68	20	30	140	360	550	95	20	30	170	370	590
69	20	30	170	410	630	96	20	20	160	440	640
70	20	20	140	430	610	97	20	20	100	500	640
71	20	30	130	440	620	98	20	30	130	330	510
72	20	20	150	410	600	99	20	20	150	400	590
73	20	50	110	370	550	100	20	20	170	340	550
74	20	30	150	450	650	Σ	1145	1275	5220	16,420	24,060
75	20	20	120	380	540	AVG.	22.9	25.5	104	328	481
76	20	30	150	420	620	MAX.	30	50	270	500	650
77	30	30	140	400	600	MIN.	10	10	90	200	400

Table XX. Switching-Time Data for T = +125°C (SN-204A)

Unit No.	t_d (nsec)	t_r (nsec)	t_s (nsec)	t_f (nsec)	t_{TOTAL} (nsec)	Unit No.	t_d (nsec)	t_r (nsec)	t_s (nsec)	t_f (nsec)	t_{TOTAL} (nsec)
51	20	10	110	300	440	78	30	30	30	300	390
52	20	20	120	300	460	79	30	30	80	460	600
53	20	20	80	240	360	80	20	30	120	400	570
54	40	20	40	360	460	81	30	20	30	260	340
55	20	25	110	320	475	82	30	20	40	320	410
56	20	20	120	360	520	83	20	30	120	340	510
57	30	20	30	370	450	84	20	30	120	240	410
58	20	20	120	260	420	85	20	30	130	360	540
59	30	20	90	280	420	86	30	30	100	380	540
60	20	20	90	300	430	87	20	30	80	320	450
61	30	20	80	220	350	88	20	30	140	300	490
62	20	30	100	300	450	89	30	30	90	310	460
63	40	20	30	180	270	90	20	30	110	320	480
64	20	20	100	200	340	91	20	30	130	360	540
65	25	30	70	260	385	92	20	30	100	400	550
66	30	20	50	330	430	93	20	30	110	340	500
67	20	20	160	220	420	94	20	30	70	280	400
68	20	30	90	280	420	95	20	30	120	280	450
69	20	30	110	340	500	96	20	30	120	380	550
70	20	30	110	340	500	97	10	20	50	420	500
71	20	30	90	340	480	98	20	30	90	280	420
72	20	30	110	340	500	99	20	30	110	360	520
73	20	30	60	260	370	100	20	30	130	220	400
74	20	30	120	380	550	Σ	1135	1295	4700	18,700	27,775
75	20	30	100	320	470	AVG.	22.7	25.9	94.0	374	555
76	20	30	110	360	520	MAX.	40	30	160	460	600
77	20	30	80	280	410	MIN.	10	10	30	180	270

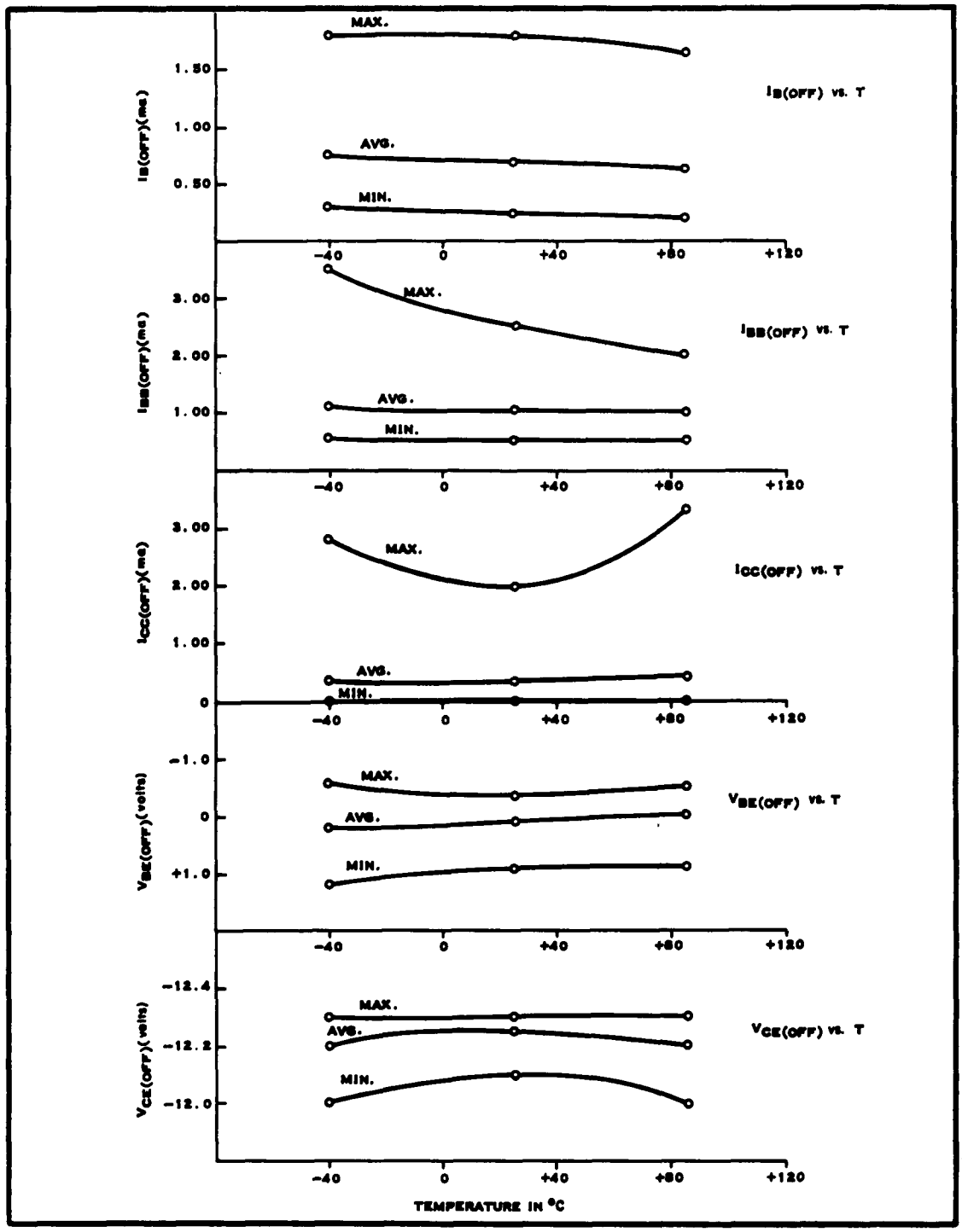

Figure 14. SN-204 Parameter Variation Versus Temperature-Transistor "OFF"

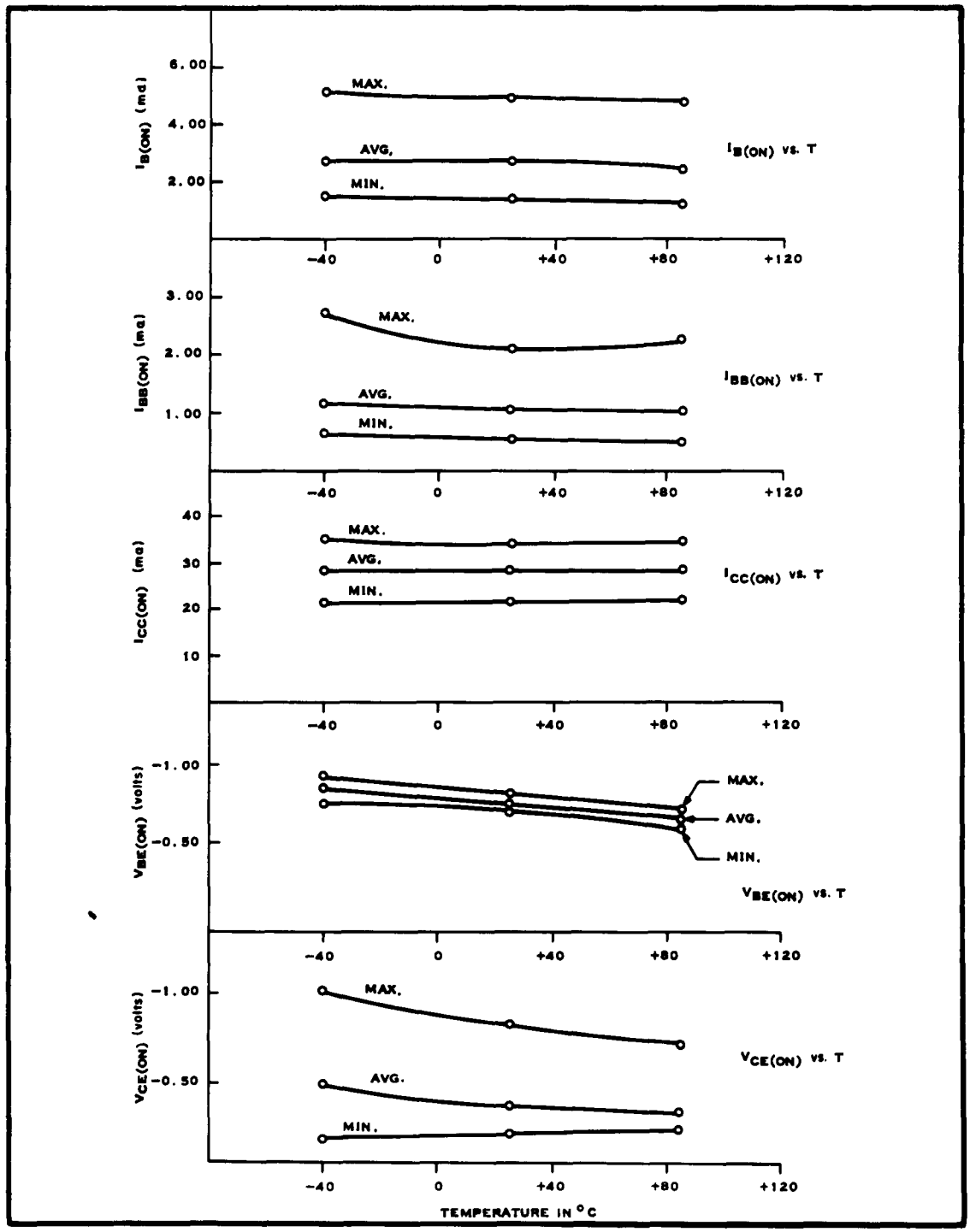

Figure 15. SN-204 Parameter Variation Versus Temperature-Transistor "ON"

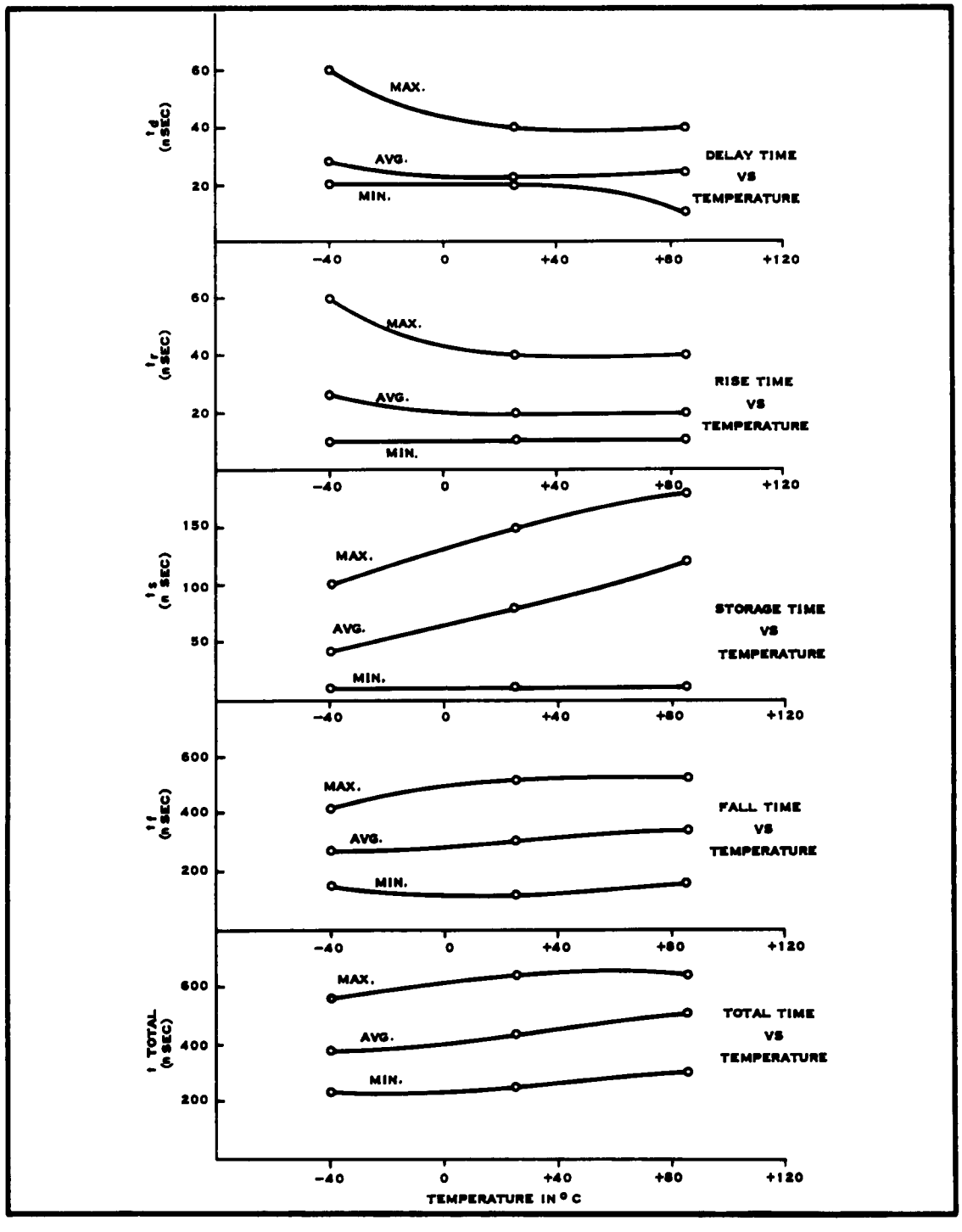

Figure 16. SN-204 Switching Times Versus Temperature

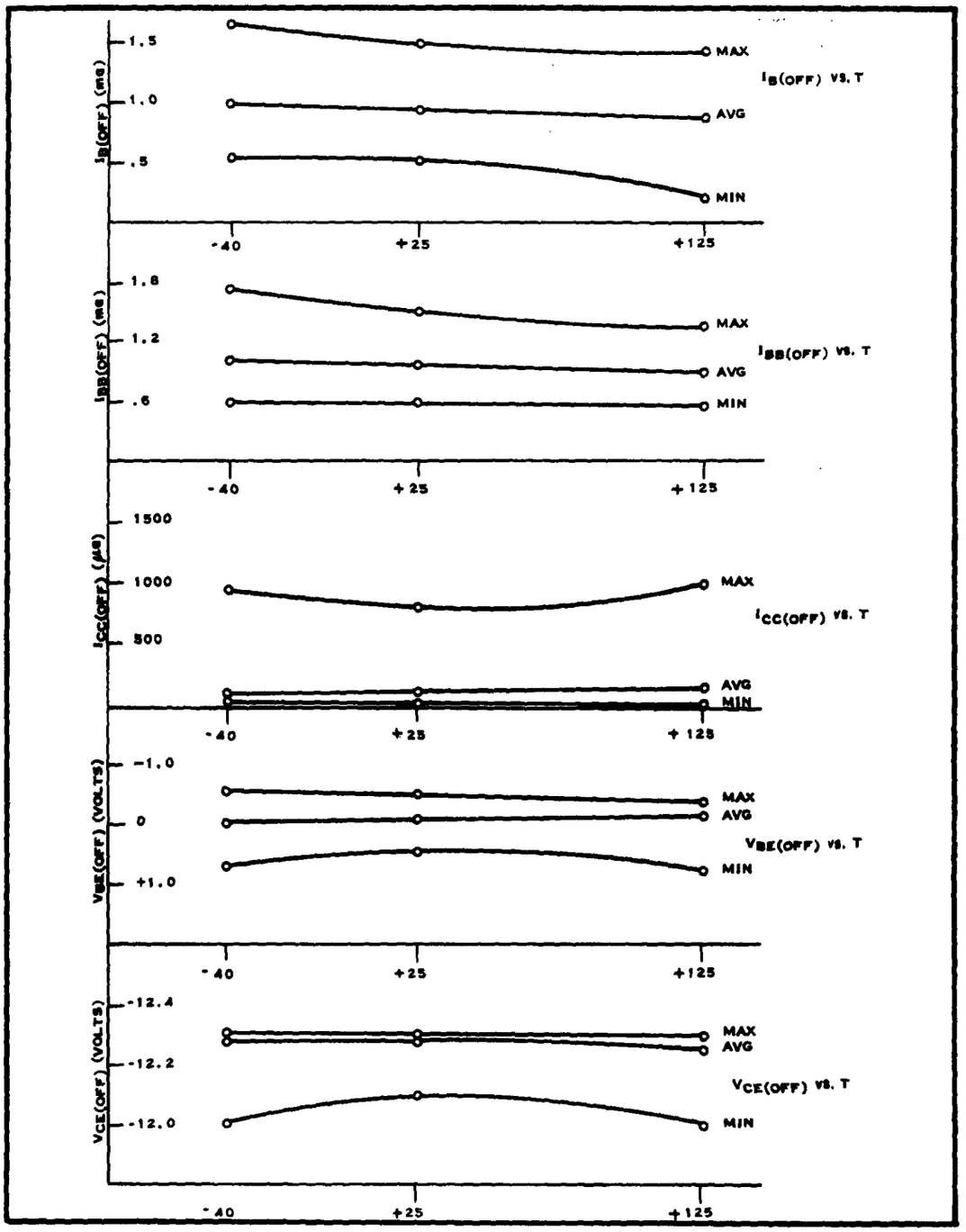

Figure 17. SN-204A Parameter Variation Versus Temperature-Transistor "OFF"

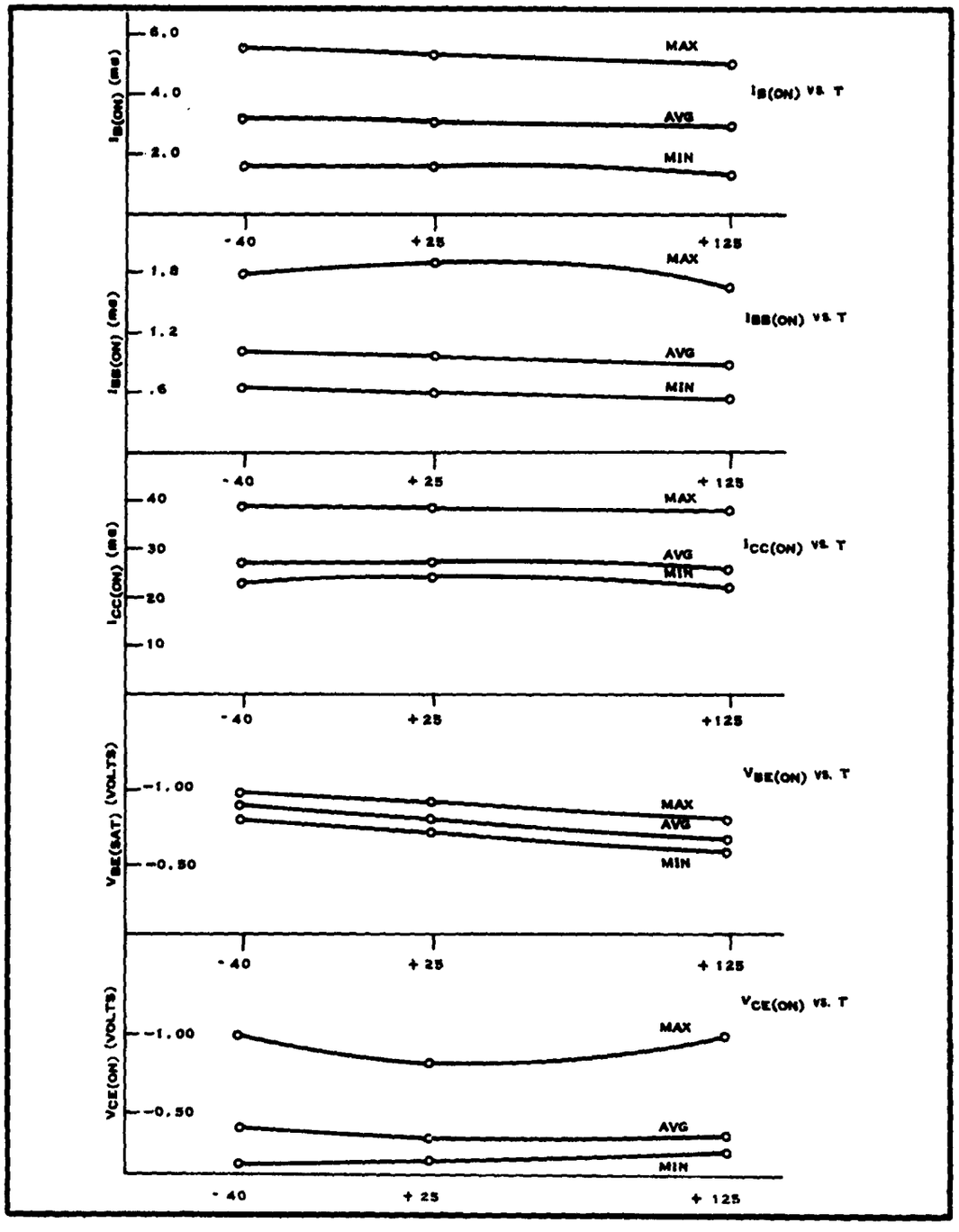

Figure 18. SN-204A Parameter Variation Versus Temperature-Transistor "ON"

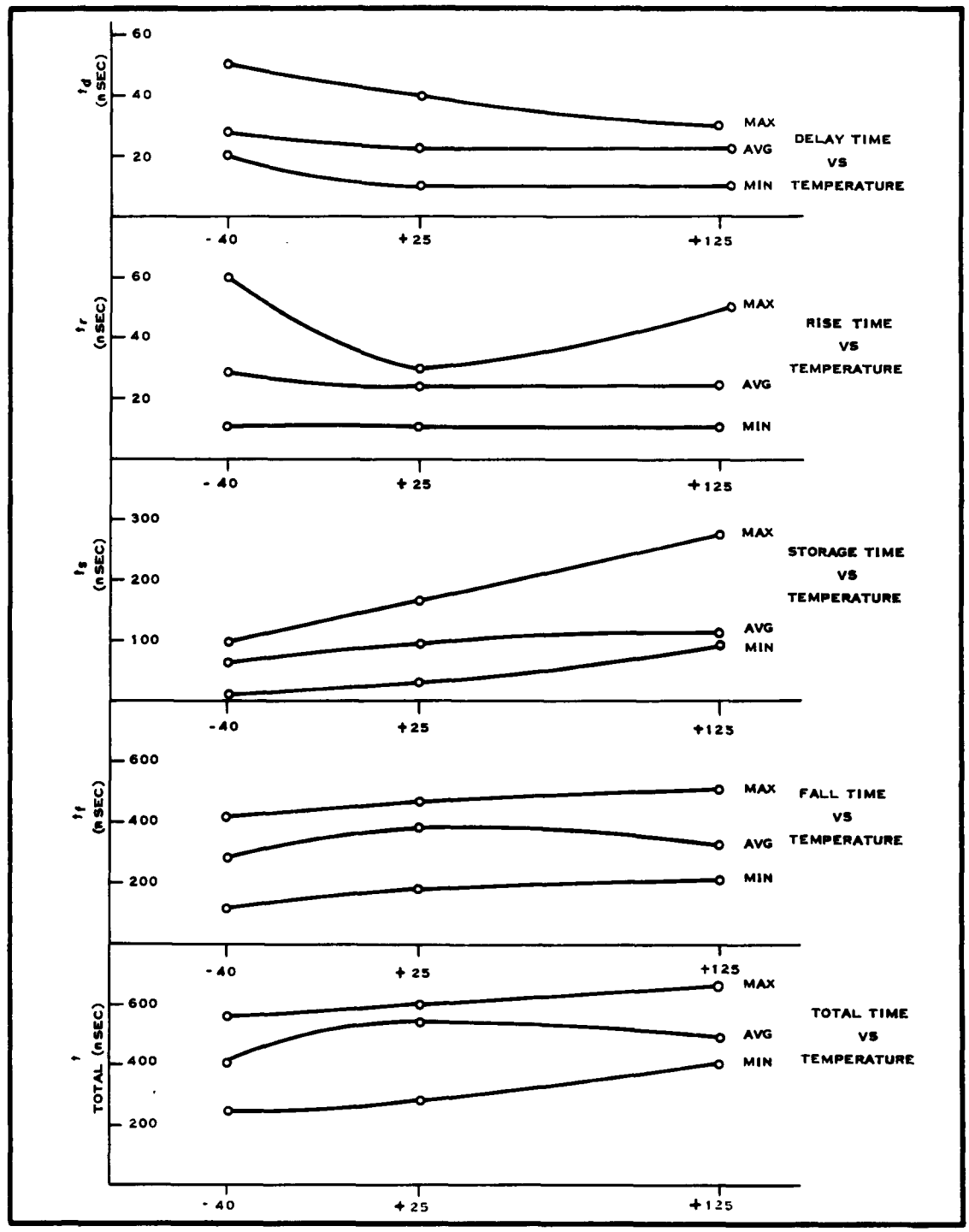

Figure 19. SN-204A Switching Time Versus Temperature

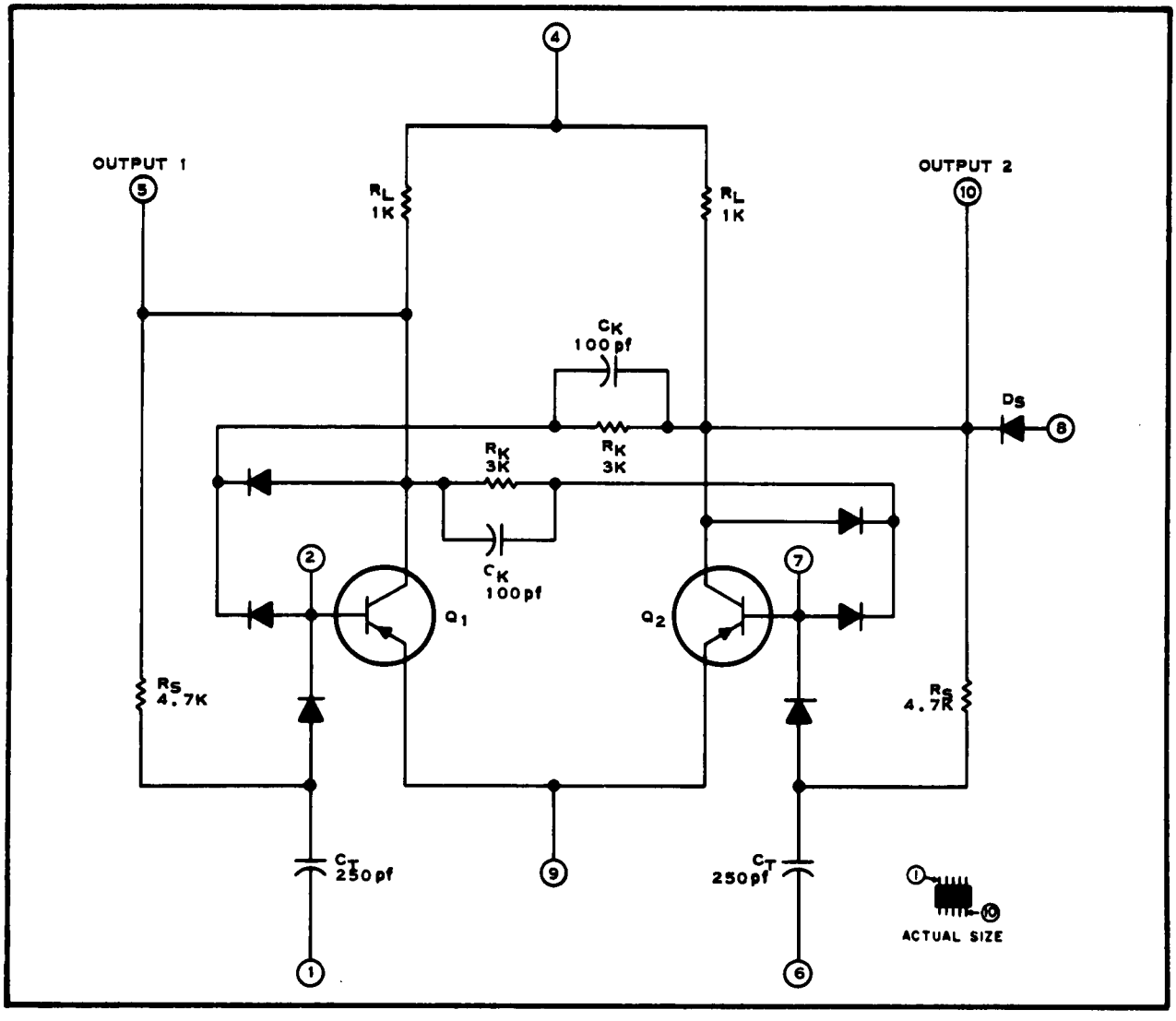

Figure 20. Schematic of SN-202 Flip-Flop with Pin Numbers

VI. SN-202

A. Introduction

The SN-202 is a flip-flop using PNP transistors with the addition of clamp diodes to prevent saturation and a preset diode on one collector. The design goal for the SN-202 was to provide terminal and transfer characteristics equivalent to those specified on the Hi-Speed Flip-Flop FOB Drawing No. 605304-095 (sheet F4). This is a Stromberg-Carlson standard circuit drawing provided by the Signal Corps. The equivalent circuit for the semiconductor network flip-flop and the package terminal identification are shown in Figure 20. Fifty networks were delivered.

B. Fabrication

The SN-202 was designed to utilize three pieces of silicon per network. All diodes and resistors are diffused in one piece. High current levels required a low R_{CS} in the transistor; thus, two separate silicon transistors are employed.

The resistor-diode bar must go through the following processes:

1. An N-type slice of silicon is polished and oxidized.
2. Certain areas of the oxide are removed and a P-type layer is diffused into these areas to isolate the diodes and substrate. Another oxide is formed over these areas during the diffusion process.
3. A second oxide-removal pattern provides windows through which N-type impurities are diffused for diode cathodes. Another oxide is formed over these areas during the diffusion process.
4. Other areas of oxide are then removed and a P-type layer is diffused for the resistors and diode anodes. Again an oxide is formed in these areas during the diffusion process.
5. Oxide is removed where contacts in the N-type areas are to be. A high-concentration N-type diffusion lowers the resistivity in these areas so that aluminum will make good electrical contact. An oxide is formed in these areas during the diffusion process.
6. Oxide is then removed in the areas where contacts are to be made.
7. Aluminum is evaporated over the entire surface and removed selectively except where contacts are to be made. The aluminum is then alloyed into the contact areas.
8. Aluminum is again evaporated on the entire surface for leads between contacts. The aluminum is selectively removed, leaving aluminum strips between contacts which are to be connected.
9. The silicon slice is etched from the back until the correct thickness is reached and is then scribed and broken into separate bars.

After the bars have been tested, the networks are assembled in packages as shown in Figure 21.

1. The transistors are alloyed to metal areas in the package, making electrical contact to the collectors.

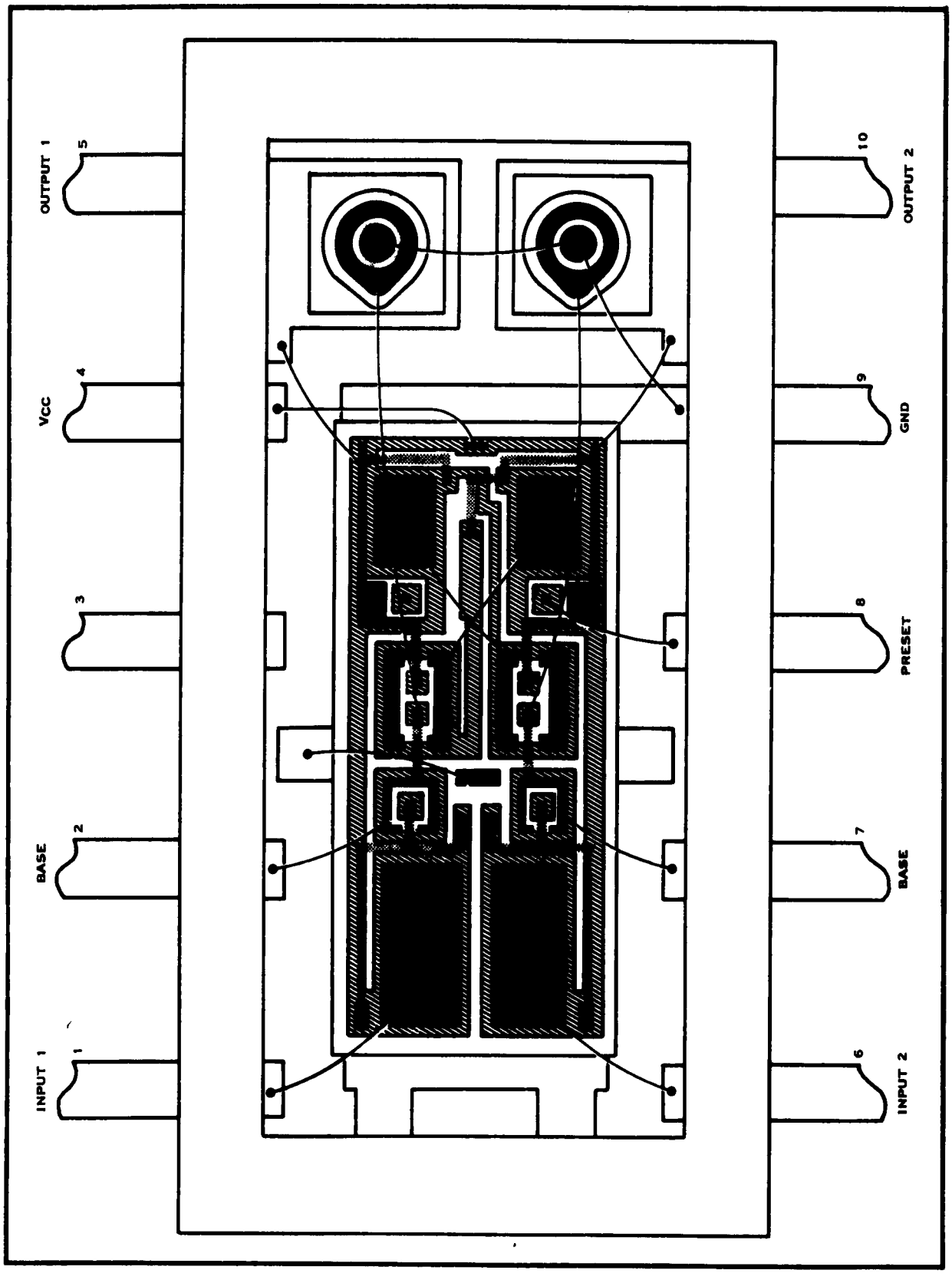

Figure 21. Package Layout of SN-202

PARAMETER	CONDITIONS	MIN	MAX	UNITS
V_T	V_{CC} = −14.5, 220-pf LOAD		5	VOLTS
$V_{CE(OFF)}$	V_{CC} = −10V, NO DC LOAD	−7		VOLTS
$V_{CE(ON)}$	V_{CC} = −10V, NO DC LOAD		−1	VOLT
t_r	V_{CC} = −14.5V, NO LOAD		0.4	μSEC
t_f	MEASURED FROM 10% TO 90%		1.0	μSEC
t_r	V_{CC} = −14.5V 220pf LOAD ON SIDE 2		0.45	μSEC
t_f	t_r MEASURED FROM 10% TO 90% t_f MEASURED FROM 10% TO 80%		1.5	μSEC

Figure 22. Circuit Specifications for SN-202

2. The resistor-diode bar is secured in the package with glass.
3. Connections are made with gold wire leads by ball-bonding.
4. Ceramic-chip capacitors are mounted on the four large contact areas of the resistor-diode bar with Eccobond to ensure electrical contact. Wires are added to make contact to the top plates.
5. The networks are tested for circuit performance, then sealed by welding a lid to the header. All units are given a humidity test for leaks.

Package specifications for the SN-202 are the same as for the SN-204 (Figure 11).

C. Testing

The networks were tested at −1°C, +25°C, and +55°C, as specified on the drawing submitted and referenced in the introduction. Circuit specifications are listed in Figure 22 and test data is presented in Tables XXI through XXVI (units numbered 7 through 56). Rise and fall times were measured at both collectors in the unloaded condition. Rise time was measured between the 10- and 90-percent points of the output waveform, and fall time from 10 to 80 percent of the final level. Switching times were measured with a

Table XXI. DC Data for T = -1°C (SN-202)

Unit No.	V_{CC} = -10V					V_{CC} = -14.5V					
	V_{CE_1} (ON)	V_{CE_2} (ON)	V_{CE_1} (OFF)	V_{CE_2} (OFF)	I_{CC} (ma)	V_{CE_1} (ON)	V_{CE_2} (ON)	V_{CE_1} (OFF)	V_{CE_2} (OFF)	I_{CC} (ma)	$V_{T(MIN)}$
7	-0.64	-0.71	-7.6	-7.5	11.4	-0.59	-0.58	-10.8	-10.5	16.2	3.7
8	-0.71	-0.73	-7.3	-7.3	8.5	-0.69	-0.72	-10.5	-10.4	10.8	2.8
9	-0.71	-0.70	-7.7	-7.5	10.1	-0.64	-0.64	-11.0	-10.7	14.2	2.9
10	-0.67	-0.70	-7.5	-7.4	10.4	-0.61	-0.64	-10.8	-10.8	14.7	4.5
11	-0.66	-0.70	-7.7	-7.5	10.5	-0.61	-0.64	-11.0	-10.7	14.8	3.6
12	-0.65	-0.63	-8.0	-7.7	11.5	-0.53	-0.54	-11.5	-11.1	16.8	3.5
13	-0.60	-0.61	-7.8	-7.7	11.8	-0.48	-0.50	-11.2	-11.1	16.6	3.0
14	-0.61	-0.62	-7.9	-7.9	12.3	-0.52	-0.49	-11.3	-11.0	17.3	2.8
15	-0.63	-0.62	-7.9	-7.5	12.0	-0.51	-0.50	-11.3	-10.8	17.1	2.9
16	-0.62	-0.63	-7.9	-7.7	12.0	-0.50	-0.52	-11.4	-11.1	17.0	3.3
17	-0.64	-0.66	-7.1	-7.3	10.1	-0.58	-0.62	-10.2	-10.3	14.0	3.8
18	-0.66	-0.66	-8.0	-7.9	14.3	-0.63	-0.64	-11.4	-11.2	19.9	3.5
19	-0.64	-0.65	-7.9	-7.7	12.8	-0.56	-0.59	-11.2	-10.9	17.8	3.9
20	-0.66	-0.66	-8.0	-7.5	11.9	-0.60	-0.61	-11.2	-10.6	17.7	3.9
21	-0.66	-0.68	-7.8	-7.6	13.8	-0.62	-0.61	-11.1	-10.8	19.5	4.8
22	-0.65	-0.66	-7.9	-7.6	13.3	-0.58	-0.61	-11.2	-10.8	18.7	3.8
23	-0.65	-0.65	-7.8	-7.6	12.8	-0.59	-0.59	-11.2	-10.9	17.5	3.6
24	-0.64	-0.66	-7.9	-7.7	13.1	-0.57	-0.60	-11.2	-11.1	18.0	3.8
25	-0.61	-0.62	-7.8	-7.6	13.9	-0.54	-0.56	-11.2	-10.8	19.4	3.9
26	-0.67	-0.68	-7.8	-7.6	13.8	-0.59	-0.60	-11.2	-10.8	19.4	3.8
27	-0.64	-0.65	-7.6	-7.4	14.0	-0.57	-0.58	-11.1	-10.9	20.0	3.8

Table XXI. DC Data for T = -1°C (SN-202) (Continued)

Unit No.	V_{CC} = -10V					V_{CC} = -14.5V					$V_{T(MIN)}$
	V_{CE_1} (ON)	V_{CE_2} (ON)	V_{CE_1} (OFF)	V_{CE_2} (OFF)	I_{CC} (ma)	V_{CE_1} (ON)	V_{CE_2} (ON)	V_{CE_1} (OFF)	V_{CE_2} (OFF)	I_{CC} (ma)	
28	-0.63	-0.65	-7.7	-7.4	11.4	-0.56	-0.60	-10.7	-10.9	16.4	4.2
29	-0.60	-0.61	-7.8	-7.5	11.2	-0.51	-0.52	-11.2	-10.7	16.7	3.2
30	-0.64	-0.57	-7.7	-6.9	12.5	-0.55	-0.48	-11.0	- 9.8	18.0	3.4
31	-0.66	-0.66	-7.9	-7.6	11.0	-0.58	-0.59	-10.7	-10.7	17.8	3.3
32	-0.69	-0.67	-7.6	-7.2	8.0	-0.66	-0.67	-10.7	-10.3	12.0	3.8
33	-0.66	-0.62	-7.7	-7.3	13.2	-0.60	-0.56	-11.0	-10.4	18.0	3.4
34	-0.66	-0.67	-7.7	-7.5	11.0	-0.57	-0.59	-10.9	-10.8	16.0	3.2
35	-0.67	-0.67	-7.9	-7.7	15.2	-0.58	-0.56	-11.2	-10.9	21.7	3.8
36	-0.62	-0.64	-8.0	-7.7	14.9	-0.59	-0.60	-11.3	-10.9	20.7	4.0
37	-0.62	-0.62	-7.8	-7.5	13.1	-0.54	-0.55	-11.2	-10.8	18.5	3.2
38	-0.63	-0.65	-7.3	-7.5	13.2	-0.56	-0.60	-10.0	-10.5	18.0	4.4
39	-0.65	-0.64	-7.8	-7.7	12.7	-0.57	-0.57	-11.1	-10.8	18.0	4.2
40	-0.61	-0.62	-7.8	-7.4	14.3	-0.54	-0.57	-10.5	-10.0	20.8	3.2
41	-0.67	-0.66	-7.8	-7.5	13.5	-0.59	-0.59	-11.2	-10.8	19.5	3.4
42	-0.64	-0.65	-7.9	-7.8	14.2	-0.58	-0.59	-11.3	-11.1	20.5	2.7
43	-0.57	-0.57	-7.9	-7.8	14.7	-0.48	-0.49	-11.2	-11.0	21.2	3.8
44	-0.64	-0.66	-7.8	-7.4	12.8	-0.56	-0.57	-11.1	-10.3	18.5	3.6
45	-0.63	-0.64	-7.6	-7.5	13.3	-0.56	-0.57	-11.1	-10.8	19.2	2.7
46	-0.67	-0.69	-7.8	-7.7	11.3	-0.60	-0.63	-11.2	-11.0	16.4	3.8
47	-0.64	-0.66	-7.9	-7.6	13.0	-0.58	-0.59	-11.3	-10.8	19.0	2.8

Table XXI. DC Data for T = -1°C (SN-202) (Continued)

Unit No.	V_{CC} = -10V V_{CE_1} (ON)	V_{CE_2} (ON)	V_{CE_1} (OFF)	V_{CE_2} (OFF)	I_{CC} (ma)	V_{CC} = -14.5V V_{CE_1} (ON)	V_{CE_2} (ON)	V_{CE_1} (OFF)	V_{CE_2} (OFF)	I_{CC} (ma)	$V_{T(MIN)}$
48	-0.64	-0.63	-7.9	-7.7	14.7	-0.50	-0.51	-11.4	-11.0	21.2	4.6
49	-0.50	-0.62	-7.8	-7.7	15.7	-0.50	-0.49	-11.2	-11.0	22.5	3.8
50	-0.69	-0.65	-7.9	-7.8	13.5	-0.63	-0.56	-11.2	-10.9	19.0	2.7
51	-0.65	-0.66	-7.9	-7.8	14.3	-0.51	-0.54	-11.2	-11.1	20.0	3.8
52	-0.64	-0.68	-7.8	-7.6	13.7	-0.54	-0.56	-11.0	-10.8	19.3	3.6
53	-0.66	-0.68	-8.0	-7.8	15.5	-0.65	-0.66	-11.3	-11.1	22.3	2.3
54	-0.65	-0.66	-7.9	-7.6	14.3	-0.56	-0.57	-11.3	-10.9	20.5	3.3
55	-0.69	-0.66	-7.8	-7.6	13.8	-0.59	-0.52	-11.1	-10.7	19.4	3.6
56	-0.63	-0.62	-7.8	-7.6	14.0	-0.53	-0.54	-11.1	-10.8	20.3	3.8
MAX					15.7					22.5	4.8
AVG					12.7					18.2	3.5
MIN					8.0					10.8	2.3

Table XXII. DC Data for T = +25°C (SN-202)

Unit No.	V_{CC} = -10V V_{CE_1} (ON)	V_{CE_2} (ON)	V_{CE_1} (OFF)	V_{CE_2} (OFF)	I_{CC} (ma)	V_{CC} = -14.5V V_{CE_1} (ON)	V_{CE_2} (ON)	V_{CE_1} (OFF)	V_{CE_2} (OFF)	I_{CC} (ma)	$V_{T(MIN)}$
7	-0.57	-0.61	-7.7	-7.8	11.2	-0.43	-0.50	-11.0	-10.8	15.7	3.7
8	-0.63	-0.61	-7.6	-7.2	7.5	-0.57	-0.58	-11.1	-10.6	10.5	2.7
9	-0.60	-0.61	-7.6	-7.5	9.8	-0.49	-0.55	-11.2	-10.9	14.0	2.7
10	-0.58	-0.61	-7.6	-7.5	10.0	-0.53	-0.55	-11.2	-10.9	14.4	3.0
11	-0.57	-0.59	-7.7	-7.5	10.0	-0.52	-0.56	-11.2	-10.9	14.5	3.0
12	-0.51	-0.51	-7.8	-7.6	11.0	-0.41	-0.42	-11.5	-11.0	16.0	3.7
13	-0.51	-0.47	-7.6	-7.6	11.1	-0.40	-0.41	-11.2	-11.1	16.0	2.7
14	-0.49	-0.53	-7.8	-7.6	11.7	-0.40	-0.43	-11.4	-10.9	16.8	3.3
15	-0.50	-0.51	-7.7	-7.6	11.2	-0.38	-0.39	-11.4	-11.1	17.0	3.8
16	-0.53	-0.53	-7.8	-7.6	11.2	-0.45	-0.43	-11.4	-11.0	16.5	3.3
17	-0.55	-0.55	-7.6	-7.4	9.0	-0.48	-0.48	-11.1	-10.8	12.7	2.7
18	-0.58	-0.58	-7.9	-7.7	13.7	-0.55	-0.54	-11.5	-11.3	19.7	3.7
19	-0.54	-0.56	-7.7	-7.5	12.3	-0.46	-0.50	-11.2	-10.9	17.5	4.3
20	-0.54	-0.56	-7.8	-7.3	11.8	-0.48	-0.49	-11.4	-10.8	16.8	3.4
21	-0.56	-0.57	-7.7	-7.5	13.2	-0.52	-0.50	-11.2	-10.9	18.3	4.6
22	-0.54	-0.57	-7.7	-7.4	12.8	-0.49	-0.51	-11.2	-10.8	17.8	3.7
23	-0.56	-0.56	-7.7	-7.5	12.0	-0.49	-0.49	-11.1	-10.8	17.4	3.6
24	-0.55	-0.57	-7.7	-7.5	12.2	-0.48	-0.51	-11.3	-10.9	17.7	3.4
25	-0.55	-0.56	-7.6	-7.4	12.8	-0.45	-0.48	-11.1	-10.7	18.7	3.9

Table XXII. DC Data for T = +25°C (SN-202) (Continued)

Unit No.	V_{CC} = -10V V_{CE_1} (ON)	V_{CE_2} (ON)	V_{CE_1} (OFF)	V_{CE_2} (OFF)	I_{CC} (ma)	V_{CC} = -14.5V V_{CE_1} (ON)	V_{CE_2} (ON)	V_{CE_1} (OFF)	V_{CE_2} (OFF)	I_{CC} (ma)	$V_{T(MIN)}$
26	-0.57	-0.57	-7.6	-7.4	13.3	-0.49	-0.50	-11.0	-10.8	18.7	4.4
27	-0.56	-0.57	-7.6	-7.5	13.7	-0.49	-0.50	-11.0	-10.9	19.5	4.0
28	-0.53	-0.57	-7.7	-7.4	11.1	-0.46	-0.50	-11.2	-10.8	16.1	3.8
29	-0.43	-0.45	-7.8	-7.6	11.2	-0.43	-0.46	-11.3	-11.0	16.0	4.0
30	-0.54	-0.49	-7.7	-7.7	11.7	-0.43	-0.38	-11.0	-11.0	16.3	4.3
31	-0.57	-0.58	-7.7	-7.7	11.2	-0.49	-0.51	-10.4	-11.0	17.5	3.0
32	-0.61	-0.61	-7.7	-7.5	8.0	-0.54	-0.56	-10.9	-10.8	11.0	3.6
33	-0.56	-0.52	-7.8	-7.6	12.5	-0.50	-0.47	-11.1	-10.8	17.7	4.0
34	-0.56	-0.57	-7.8	-7.7	11.0	-0.47	-0.48	-11.1	-10.9	15.3	3.4
35	-0.56	-0.57	-7.8	-7.6	15.2	-0.46	-0.47	-11.2	-10.8	21.2	3.6
36	-0.54	-0.57	-8.0	-7.7	14.8	-0.50	-0.53	-11.4	-11.1	20.7	4.3
37	-0.51	-0.55	-7.9	-8.1	12.6	-0.43	-0.47	-11.3	-11.7	17.8	3.6
38	-0.54	-0.58	-7.2	-7.3	12.8	-0.48	-0.51	-10.0	-10.5	19.0	3.2
39	-0.57	-0.56	-7.9	-7.7	12.3	-0.49	-0.49	-11.2	-10.9	17.4	3.6
40	-0.54	-0.57	-8.0	-7.8	14.0	-0.49	-0.51	-11.4	-11.2	19.8	3.8
41	-0.60	-0.60	-7.8	-7.7	13.5	-0.48	-0.48	-11.2	-11.0	19.2	3.5
42	-0.55	-0.56	-7.9	-7.8	14.0	-0.51	-0.52	-11.3	-11.1	20.0	2.7
43	-0.48	-0.48	-7.9	-7.8	15.3	-0.39	-0.38	-11.2	-11.0	20.7	4.0
44	-0.55	-0.56	-7.8	-7.3	12.6	-0.49	-0.49	-11.2	-10.7	17.3	3.6
45	-0.55	-0.56	-7.9	-7.7	13.0	-0.49	-0.49	-11.3	-10.9	18.5	3.3
46	-0.60	-0.62	-7.8	-7.7	11.5	-0.52	-0.55	-11.1	-10.9	16.0	3.6

Table XXII. DC Data for T = +25°C (SN-202) (Continued)

Unit No.	V_{CC} = −10V V_{CE_1} (ON)	V_{CE_2} (ON)	V_{CE_1} (OFF)	V_{CE_2} (OFF)	I_{CC} (ma)	V_{CC} = −14.5 V_{CE_1} (ON)	V_{CE_2} (ON)	V_{CE_1} (OFF)	V_{CE_2} (OFF)	I_{CC} (ma)	$V_{T(MIN)}$
47	−0.57	−0.57	−7.9	−7.3	13.0	−0.50	−0.50	−11.3	−10.5	19.5	3.2
48	−0.52	−0.52	−7.9	−7.8	14.4	−0.40	−0.41	−11.4	−11.1	20.8	4.0
49	−0.45	−0.51	−7.8	−7.7	15.4	−0.42	−0.39	−11.1	−11.0	21.8	4.6
50	−0.60	−0.56	−7.9	−7.7	13.5	−0.58	−0.48	−11.2	−10.9	19.2	2.2
51	−0.54	−0.56	−7.8	−7.7	14.0	−0.38	−0.41	−11.2	−11.0	19.5	3.6
52	−0.56	−0.59	−7.7	−7.6	13.3	−0.46	−0.46	−11.0	−10.8	18.8	3.3
53	−0.58	−0.60	−7.8	−7.6	15.2	−0.54	−0.56	−11.4	−11.2	22.0	3.6
54	−0.56	−0.57	−7.9	−7.6	14.2	−0.47	−0.49	−11.3	−10.8	20.0	3.6
55	−0.60	−0.55	−7.8	−7.6	13.3	−0.46	−0.38	−11.1	−10.8	19.0	3.6
56	−0.54	−0.53	−7.6	−7.4	13.8	−0.46	−0.45	−11.1	−10.9	20.0	4.0
MAX.					15.4					22.0	4.6
AVG.					12.4					17.1	3.6
MIN.					7.5					10.5	2.2

Table XXIII. DC Data for T = +55°C (SN-202)

Unit No.	V_{CC} = −10V					V_{CC} = −14.5V					
	V_{CE_1} (ON)	V_{CE_2} (ON)	V_{CE_1} (OFF)	V_{CE_2} (OFF)	I_{CC} (ma)	V_{CE_1} (ON)	V_{CE_2} (ON)	V_{CE_1} (OFF)	V_{CE_2} (OFF)	I_{CC} (ma)	$V_{T(MIN)}$
7	−0.47	−0.55	−7.6	−7.6	10.8	−0.38	−0.47	−11.2	−11.0	15.6	3.8
8	−0.55	−0.51	−7.6	−7.2	7.8	−0.45	−0.46	−11.1	−10.5	10.5	2.4
9	−0.60	−0.61	−7.7	−7.5	10.0	−0.50	−0.53	−11.2	−10.9	14.0	2.7
10	−0.58	−0.61	−7.6	−7.5	10.3	−0.53	−0.53	−11.1	−11.0	14.3	2.4
11	−0.58	−0.60	−7.7	−7.5	10.0	−0.49	−0.51	−11.2	−11.0	14.2	2.8
12	−0.48	−0.46	−7.8	−7.1	11.6	−0.47	−0.37	−11.5	− 9.8	17.0	3.3
13	−0.45	−0.45	−7.7	−7.6	11.2	−0.36	−0.38	−11.3	−11.2	15.8	2.7
14	−0.48	−0.46	−7.8	−7.6	11.7	−0.40	−0.40	−11.5	−11.0	16.7	3.0
15	−0.45	−0.45	−7.8	−7.6	10.9	−0.35	−0.35	−11.5	−11.1	16.6	3.1
16	−0.46	−0.48	−7.8	−7.6	11.2	−0.37	−0.38	−11.5	−11.0	16.7	3.6
17	−0.54	−0.56	−7.6	−7.4	8.7	−0.46	−0.49	−11.2	−10.7	12.4	2.6
18	−0.54	−0.54	−7.9	−7.8	13.3	−0.52	−0.52	−11.5	−11.3	18.6	4.0
19	−0.49	−0.52	−7.7	−7.5	11.8	−0.42	−0.45	−11.2	−10.9	16.9	4.2
20	−0.51	−0.51	−7.8	−7.3	11.0	−0.44	−0.45	−11.4	−10.7	16.4	2.8
21	−0.53	−0.52	−7.7	−7.5	12.6	−0.49	−0.48	−11.2	−10.8	18.0	4.6
22	−0.50	−0.53	−7.7	−7.4	13.0	−0.44	−0.47	−11.2	−10.8	18.2	4.2
23	−0.51	−0.51	−7.7	−7.5	11.4	−0.46	−0.46	−11.2	−10.8	16.7	3.8
24	−0.50	−0.53	−7.7	−7.5	12.0	−0.45	−0.48	−11.3	−10.9	17.4	3.3
25	−0.49	−0.51	−7.6	−7.4	12.6	−0.41	−0.43	−11.1	−10.7	18.3	3.9
26	−0.49	−0.50	−7.6	−7.4	13.0	−0.40	−0.43	−10.9	−10.8	18.3	4.8
27	−0.52	−0.52	−7.5	−7.5	13.5	−0.45	−0.46	−10.9	−10.7	19.0	4.0

Table XXIII. DC Data for T = +55°C (SN-202) (Continued)

Unit No.	V_{CC} = -10V					V_{CC} = 14.5V					
	V_{CE_1} (ON)	V_{CE_2} (ON)	V_{CE_1} (OFF)	V_{CE_2} (OFF)	I_{CC} (ma)	V_{CE_1} (ON)	V_{CE_2} (ON)	V_{CE_1} (OFF)	V_{CE_2} (OFF)	I_{CC} (ma)	$V_{T(MIN)}$
28	-0.49	-0.54	-7.1	-7.4	11.2	-0.43	-0.48	-10.4	-10.7	16.0	4.7
29	-0.49	-0.49	-7.9	-7.	11.0	-0.41	-0.40	-11.4	- 9.8	15.5	4.0
30	-0.54	-0.46	-7.7	-6.7	12.2	-0.43	-0.37	-10.3	- 9.6	17.7	4.6
31	-0.53	-0.53	-7.9	-7.7	11.0	-0.45	-0.49	-11.3	-11.0	15.5	3.0
32	-0.55	-0.57	-7.7	-7.5	7.8	-0.49	-0.51	-11.0	-10.9	11.0	4.4
33	-0.52	-0.50	-7.8	-7.6	12.2	-0.47	-0.44	-11.2	-10.7	17.1	3.6
34	-0.56	-0.57	-7.8	-7.7	11.0	-0.47	-0.48	-11.1	-10.9	15.3	3.4
35	-0.51	-0.51	-7.8	-7.6	15.2	-0.43	-0.44	-11.2	-10.8	21.7	4.3
36	-0.50	-0.53	-8.0	-7.7	14.7	-0.46	-0.49	-11.4	-11.1	20.3	4.7
37	-0.46	-0.50	-7.8	-8.1	12.3	-0.40	-0.44	-11.3	-11.6	17.5	4.0
38	-0.49	-0.52	-7.2	-7.4	12.8	-0.43	-0.48	-10.3	-10.6	18.0	4.6
39	-0.51	-0.51	-7.9	-7.8	12.0	-0.45	-0.45	-11.3	-11.1	16.8	3.6
40	-0.48	-0.51	-7.9	-7.5	13.5	-0.44	-0.46	-11.4	-11.0	19.0	3.4
41	-0.54	-0.54	-7.7	-7.6	13.3	-0.41	-0.41	-11.2	-11.0	18.7	3.6
42	-0.51	-0.52	-7.8	-7.6	13.6	-0.49	-0.50	-11.3	-11.1	19.5	2.7
43	-0.43	-0.42	-7.8	-7.6	14.3	-0.37	-0.35	-11.2	-10.5	20.5	3.6
44	-0.50	-0.51	-7.7	-7.5	11.8	-0.43	-0.45	-11.2	-10.5	16.8	3.6
45	-0.49	-0.50	-7.8	-7.6	12.3	-0.44	-0.44	-11.3	-11.0	18.5	3.4
46	-0.54	-0.57	-7.8	-7.7	10.8	-0.47	-0.51	-11.2	-10.9	15.3	3.2
47	-0.52	-0.52	-7.9	-7.5	12.8	-0.47	-0.47	-11.3	-10.8	18.3	3.2
48	-0.47	-0.48	-7.8	-7.6	14.0	-0.37	-0.38	-11.4	-11.2	20.2	4.6

Table XXIII. DC Data for T = +55°C (SN-202) (Continued)

Unit No.	V_{CC} = - 10V V_{CE_1} (ON)	V_{CE_2} (ON)	V_{CE_1} (OFF)	V_{CE_2} (OFF)	I_{CC} (ma)	V_{CC} = 14.5V V_{CE_1} (ON)	V_{CE_2} (ON)	V_{CE_1} (OFF)	V_{CE_2} (OFF)	I_{CC} (ma)	$V_{T(MIN)}$
49	-0.43	-0.46	-7.8	-7.7	15.2	-0.39	-0.35	-11.2	-11.0	21.5	4.95
50	-0.55	-0.50	-7.9	-7.7	13.2	-0.55	-0.44	-11.2	-10.9	18.5	2.8
51	-0.49	-0.51	-7.9	-7.8	14.0	-0.35	-0.38	-11.2	-11.0	19.5	3.8
52	-0.49	-0.51	-7.8	-7.6	13.0	-0.38	-0.40	-11.0	-10.8	18.3	3.4
53	-0.55	-0.56	-8.0	-7.8	15.2	-0.50	-0.52	-11.5	-11.2	21.5	4.0
54	-0.50	-0.52	-7.9	-7.7	14.0	-0.44	-0.46	-11.3	-10.9	19.7	4.0
55	-0.53	-0.48	-7.9	-7.6	13.3	-0.40	-0.32	-11.2	-10.9	18.7	3.4
56	-0.49	-0.48	-7.8	-7.6	13.5	-0.41	-0.42	-11.2	-10.8	19.5	3.6
MAX.					15.2					21.7	4.95
AVG.					12.2					17.5	3.6
MIN.					7.8					10.5	2.4

Table XXIV. Switching-Time Data for T = -1°C (SN-202)

Unit No.	t_{r_1} (μsec)	V_{CC} = -14.5 V No Load t_{r_2} (μsec)	t_{f_1} (μsec)	t_{f_2} (μsec)	V_{CC} = -14.5 V 220-pf load t_{r_2} (μsec)	t_{f_2} (μsec)
7	0.16	0.16	0.58	0.34	0.18	0.70
8	0.25	0.24	0.80	0.65	0.27	1.30
9	0.22	0.22	0.49	0.47	0.24	0.83
10	0.19	0.20	0.54	0.58	0.20	1.00
11	0.21	0.22	0.55	0.50	0.26	0.90
12	0.28	0.24	0.72	0.46	0.27	0.76
13	0.24	0.25	0.56	0.55	0.28	0.89
14	0.23	0.23	0.47	0.43	0.25	0.79
15	0.28	0.23	0.48	0.58	0.25	0.94
16	0.22	0.21	0.67	0.47	0.23	0.82
17	0.17	0.17	0.80	0.62	0.20	1.10
18	0.37	0.38	0.37	0.40	0.42	0.72
19	0.14	0.13	0.54	0.46	0.15	0.82
20	0.19	0.17	0.52	0.50	0.17	0.84
21	0.17	0.12	0.50	0.48	0.14	0.75
22	0.14	0.14	0.48	0.45	0.16	0.79
23	0.15	0.14	0.50	0.46	0.16	0.78
24	0.14	0.16	0.66	0.78	0.18	1.00
25	0.13	0.12	0.55	0.60	0.13	0.88
26	0.13	0.13	0.45	0.48	0.15	0.80
27	0.13	0.13	0.38	0.40	0.15	0.68
28	0.15	0.16	0.45	0.45	0.17	0.85
29	0.25	0.25	0.45	0.38	0.27	0.72
30	0.18	0.17	0.45	0.40	0.20	0.72
31	0.25	0.23	0.40	0.43	0.27	0.75
32	0.34	0.20	0.68	0.60	0.23	1.20
33	0.15	0.12	0.38	0.31	0.13	0.60

Table XXIV. Switching-Time Data for T = −1°C (SN-202) (Continued)

	V_{CC} = −14.5 V No Load				V_{CC} = −14.5 V 220-pf load	
Unit No.	t_{r_1} (μsec)	t_{r_2} (μsec)	t_{f_1} (μsec)	t_{f_2} (μsec)	t_{r_2} (μsec)	t_{f_2} (μsec)
34	0.23	0.21	0.43	0.44	0.25	0.76
35	0.15	0.10	0.32	0.30	0.12	0.56
36	0.16	0.18	0.32	0.32	0.20	0.60
37	0.20	0.18	0.33	0.24	0.21	0.46
38	0.24	0.28	0.40	0.36	0.32	0.72
39	0.25	0.26	0.31	0.31	0.28	0.66
40	0.36	0.40	0.36	0.32	0.43	0.60
41	0.12	0.11	0.40	0.48	0.13	0.80
42	0.34	0.34	0.34	0.36	0.40	0.68
43	0.12	0.20	0.32	0.40	0.21	0.70
44	0.17	0.15	0.40	0.32	0.18	0.62
45	0.24	0.22	0.38	0.34	0.25	0.66
46	0.15	0.18	0.45	0.44	0.21	0.78
47	0.24	0.23	0.44	0.44	0.28	0.76
48	0.22	0.13	0.38	0.30	0.15	0.56
49	0.13	0.11	0.38	0.32	0.12	0.60
50	0.31	0.20	0.46	0.40	0.24	0.75
51	0.12	0.12	0.36	0.36	0.13	0.68
52	0.14	0.13	0.42	0.42	0.17	0.72
53	0.33	0.35	0.32	0.32	0.40	0.60
54	0.17	0.20	0.35	0.35	0.23	0.68
55	0.15	0.12	0.38	0.38	0.13	0.70
56	0.13	0.12	0.39	0.40	0.14	0.70
MAX.		0.40		0.78	0.43	1.30
AVG.		0.20		0.45	0.22	0.77
MIN.		0.10		0.24	0.12	0.46

Table XXV. Switching-Time Data for T = +25°C (SN-202)

		V_{CC} = −14.5 V No Load			V_{CC} = −14.5 V 220-pf load	
Unit No.	t_{r_1} (μsec)	t_{r_2} (μsec)	t_{f_1} (μsec)	t_{f_2} (μsec)	t_{r_2} (μsec)	t_{f_2} (μsec)
7	0.14	0.18	0.50	0.60	0.21	0.80
8	0.29	0.29	0.74	0.64	0.30	1.20
9	0.25	0.23	0.60	0.63	0.25	1.15
10	0.23	0.24	0.60	0.60	0.27	1.00
11	0.26	0.27	0.64	0.56	0.30	1.00
12	0.34	0.25	0.55	0.37	0.37	0.75
13	0.26	0.28	0.70	0.58	0.30	0.95
14	0.25	0.24	0.50	0.48	0.27	0.85
15	0.18	0.25	0.45	0.50	0.26	0.90
16	0.25	0.23	0.65	0.49	0.26	0.87
17	0.18	0.20	0.70	0.78	0.22	1.15
18	0.30	0.34	0.40	0.40	0.36	0.75
19	0.15	0.15	0.50	0.47	0.15	0.69
20	0.18	0.16	0.52	0.46	0.18	0.86
21	0.17	0.13	0.50	0.42	0.13	0.75
22	0.15	0.13	0.53	0.50	0.15	0.85
23	0.15	0.15	0.56	0.46	0.16	0.83
24	0.17	0.16	0.68	0.70	0.17	1.00
25	0.13	0.13	0.45	0.52	0.14	0.85
26	0.13	0.12	0.40	0.32	0.13	0.63
27	0.14	0.14	0.35	0.37	0.14	0.68
28	0.17	0.17	0.45	0.47	0.19	0.80
29	0.25	0.25	0.45	0.38	0.27	0.72
30	0.17	0.18	0.31	0.54	0.20	0.71
31	0.31	0.30	0.56	0.52	0.34	0.90
32	0.32	0.24	0.90	0.60	0.25	1.25

Table XXV. Switching-Time Data for T = +25°C (SN-202) (Continued)

Unit No.	V_{CC} = -14.5 V No Load			V_{CC} = -14.5 V 220-pf load		
	t_{r_1} (μsec)	t_{r_2} (μsec)	t_{f_1} (μsec)	t_{f_2} (μsec)	t_{r_2} (μsec)	t_{f_2} (μsec)
33	0.14	0.13	0.50	0.45	0.14	0.80
34	0.28	0.25	0.52	0.50	0.28	0.90
35	0.16	0.12	0.35	0.32	0.12	0.64
36	0.17	0.16	0.37	0.33	0.18	0.61
37	0.18	0.22	0.44	0.30	0.24	0.55
38	0.24	0.29	0.38	0.38	0.34	0.72
39	0.27	0.30	0.50	0.42	0.32	0.80
40	0.34	0.28	0.42	0.34	0.30	0.67
41	0.17	0.10	0.44	0.50	0.12	0.83
42	0.30	0.34	0.34	0.38	0.40	0.70
43	0.14	0.23	0.31	0.44	0.24	0.72
44	0.20	0.15	0.42	0.28	0.17	0.45
45	0.26	0.23	0.40	0.40	0.25	0.75
46	0.23	0.20	0.56	0.34	0.23	0.70
47	0.27	0.25	0.43	0.50	0.30	0.84
48	0.15	0.16	0.36	0.42	0.20	0.75
49	0.14	0.12	0.40	0.35	0.12	0.66
50	0.32	0.24	0.41	0.38	0.26	0.72
51	0.13	0.13	0.40	0.40	0.14	0.70
52	0.14	0.16	0.44	0.42	0.18	0.80
53	0.24	0.25	0.37	0.35	0.26	0.68
54	0.19	0.22	0.30	0.30	0.25	0.68
55	0.16	0.13	0.44	0.40	0.14	0.74
56	0.14	0.12	0.44	0.40	0.15	0.70
MAX.		0.34	0.90		0.40	1.25
AVG.		0.20	0.47		0.23	0.80
MIN.		0.12	0.30		0.12	0.46

Table XXVI. Switching-Time Data for T = +55°C (SN-202)

		V_{CC} = −14.5 V No Load			V_{CC} = −14.5 V 220-pf load	
Unit No.	t_{r_1} (μsec)	t_{r_2} (μsec)	t_{f_1} (μsec)	t_{f_2} (μsec)	t_{r_2} (μsec)	t_{f_2} (μsec)
7	0.15	0.17	0.55	0.53	0.19	0.95
8	0.34	0.34	0.66	0.67	0.36	1.10
9	0.26	0.25	0.60	0.55	0.27	0.97
10	0.32	0.25	0.59	0.42	0.27	0.85
11	0.27	0.30	0.62	0.52	0.31	0.95
12	0.33	0.37	0.50	0.28	0.37	0.62
13	0.24	0.30	0.68	0.55	0.31	0.98
14	0.27	0.28	0.50	0.46	0.29	0.82
15	0.27	0.27	0.35	0.47	0.28	0.85
16	0.26	0.24	0.65	0.45	0.28	0.72
17	0.19	0.21	0.80	0.80	0.23	1.33
18	0.27	0.30	0.40	0.40	0.33	0.84
19	0.16	0.16	0.46	0.45	0.16	0.80
20	0.18	0.17	0.60	0.50	0.18	0.90
21	0.18	0.13	0.50	0.45	0.14	0.74
22	0.16	0.14	0.57	0.51	0.17	0.80
23	0.15	0.15	0.52	0.50	0.15	0.90
24	0.17	0.17	0.72	0.60	0.18	0.96
25	0.14	0.15	0.50	0.68	0.16	0.94
26	0.13	0.14	0.40	0.43	0.14	0.76
27	0.15	0.14	0.36	0.48	0.15	0.82
28	0.16	0.17	0.45	0.50	0.18	0.90
29	0.25	0.40	0.30	0.45	0.40	0.85
30	0.18	0.18	0.38	0.35	0.32	0.87
31	0.34	0.34	0.60	0.50	0.37	0.90
32	0.30	0.25	0.54	0.64	0.28	1.25

Table XXVI. Switching-Time Data for T = +55°C (SN-202) (Continued)

		V_{CC} = -14.5 V No Load			V_{CC} = -14.5 V 220-pf load	
Unit No.	t_{r_1} (μsec)	t_{r_2} (μsec)	t_{f_1} (μsec)	t_{f_2} (μsec)	t_{r_2} (μsec)	t_{f_2} (μsec)
33	0.14	0.13	0.46	0.46	0.14	0.78
34	0.28	0.25	0.52	0.50	0.28	0.90
35	0.18	0.10	0.34	0.30	0.12	0.60
36	0.17	0.15	0.38	0.35	0.16	0.68
37	0.18	0.22	0.44	0.32	0.24	0.60
38	0.19	0.34	0.35	0.42	0.36	0.74
39	0.30	0.32	0.42	0.50	0.33	0.84
40	0.30	0.24	0.38	0.22	0.27	0.50
41	0.18	0.12	0.44	0.32	0.12	0.64
42	0.31	0.32	0.38	0.38	0.38	0.72
43	0.17	0.25	0.40	0.35	0.28	0.60
44	0.20	0.20	0.40	0.31	0.24	0.56
45	0.26	0.24	0.40	0.35	0.24	0.70
46	0.20	0.22	0.46	0.46	0.26	0.82
47	0.27	0.25	0.40	0.40	0.28	0.72
48	0.16	0.15	0.35	0.28	0.18	0.56
49	0.15	0.12	0.38	0.35	0.13	0.62
50	0.30	0.22	0.44	0.40	0.25	0.76
51	0.12	0.13	0.38	0.38	0.14	0.70
52	0.16	0.16	0.42	0.48	0.19	0.80
53	0.23	0.24	0.35	0.32	0.25	0.65
54	0.20	0.21	0.33	0.36	0.24	0.70
55	0.18	0.13	0.40	0.40	0.15	0.70
56	0.16	0.14	0.40	0.38	0.16	0.70
MAX.	0.40		0.80		0.40	1.33
AVG.	0.22		0.46		0.24	0.80
MIN.	0.10		0.22		0.12	0.50

220-picofarad capacitive load on the side with the preset diode (side 2) and with a 6-volt pulse, 2 microseconds long, with a 0.2-microsecond rise time. Figure 23 shows the measurement method. Parameter variation versus temperature is shown in Figures 24 and 25.

Figure 26 shows the method used to preset the flip-flop. Grounding the base of the emitter-follower drives terminal 8 positive and turns that side of the flip-flop ON.

Output voltage levels in the unloaded condition with transistors both ON and OFF are recorded at supply voltages of -10 and -14.5 volts. A stability test was run with a 1K resistor paralleled with each load resistor to provide a 10-milliampere load. No data was recorded for this test.

VII. SN-218

A. Introduction

These functional electronic blocks, designated SN-218, perform the "exclusive-OR" logic function. The SN-218 was designed to be functionally equivalent to the "parity logic A" circuit shown in Figure 27, except that:

Silicon NPN transistors are used.

The circuit operates at a much lower power level and is therefore somewhat slower.

A single-ended power supply is used because pull-down is not necessary for the silicon transistors.

An emitter-follower output is provided to drive the higher-level original circuit.

These changes are shown in Figure 28. A total of fifty units were delivered.

B. Fabrication

These networks are formed on a single piece of silicon and fabricated as follows:

1. A P-type slice of silicon is polished and oxidized.
2. Certain areas of the oxide are removed and an N-type layer is diffused into these areas to form the resistors, transistor collectors, diode cathodes, and part of the capacitors. Another oxide is formed over these areas during this process (Figure 29).
3. A second oxide-removal pattern provides windows through which P-type impurities are diffused for transistor bases, diode anodes, and part of the capacitors. Another oxide is formed over these areas during the diffusion process (Figure 30).

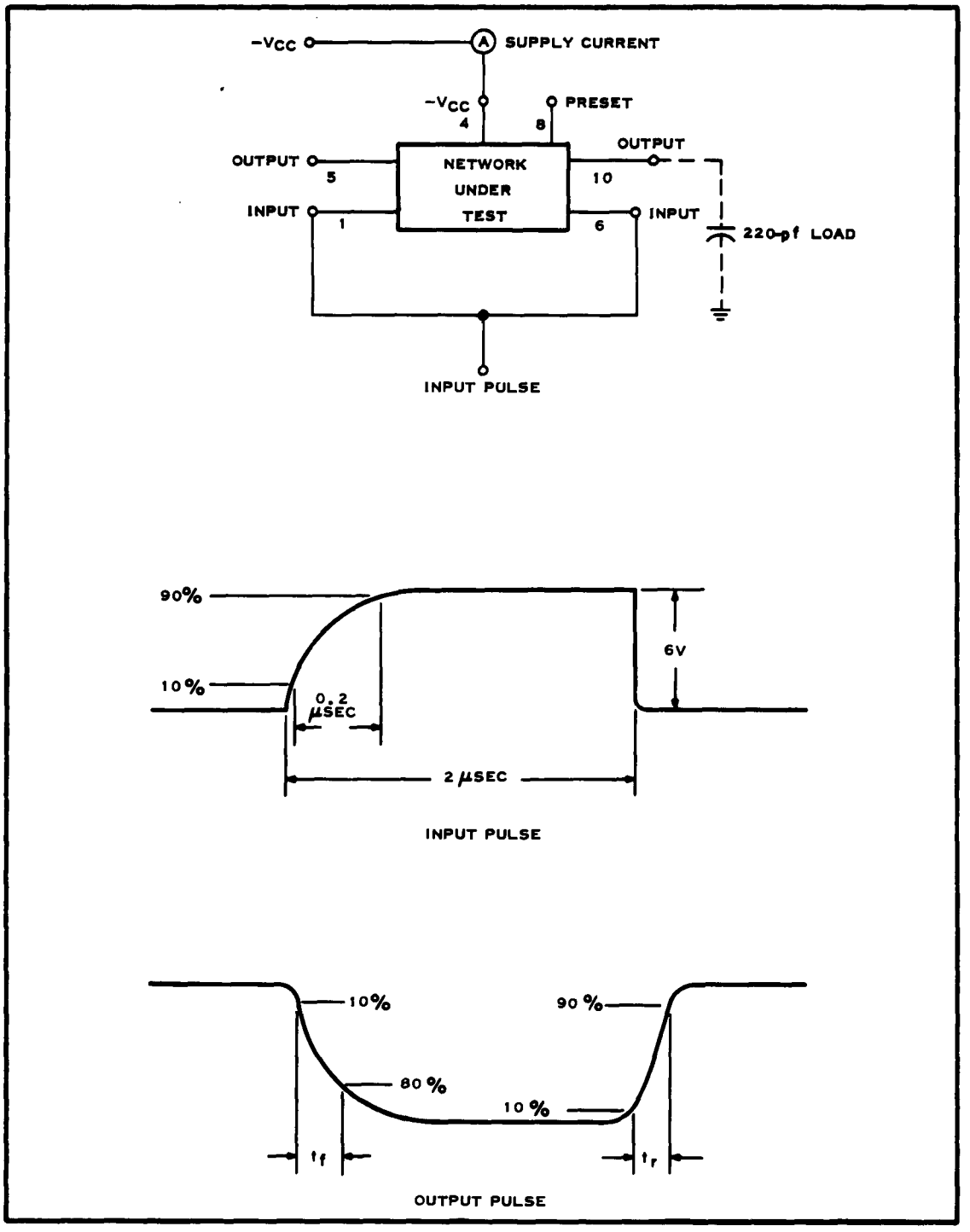

Figure 23. Switching-Time Measurement Technique (SN-202)

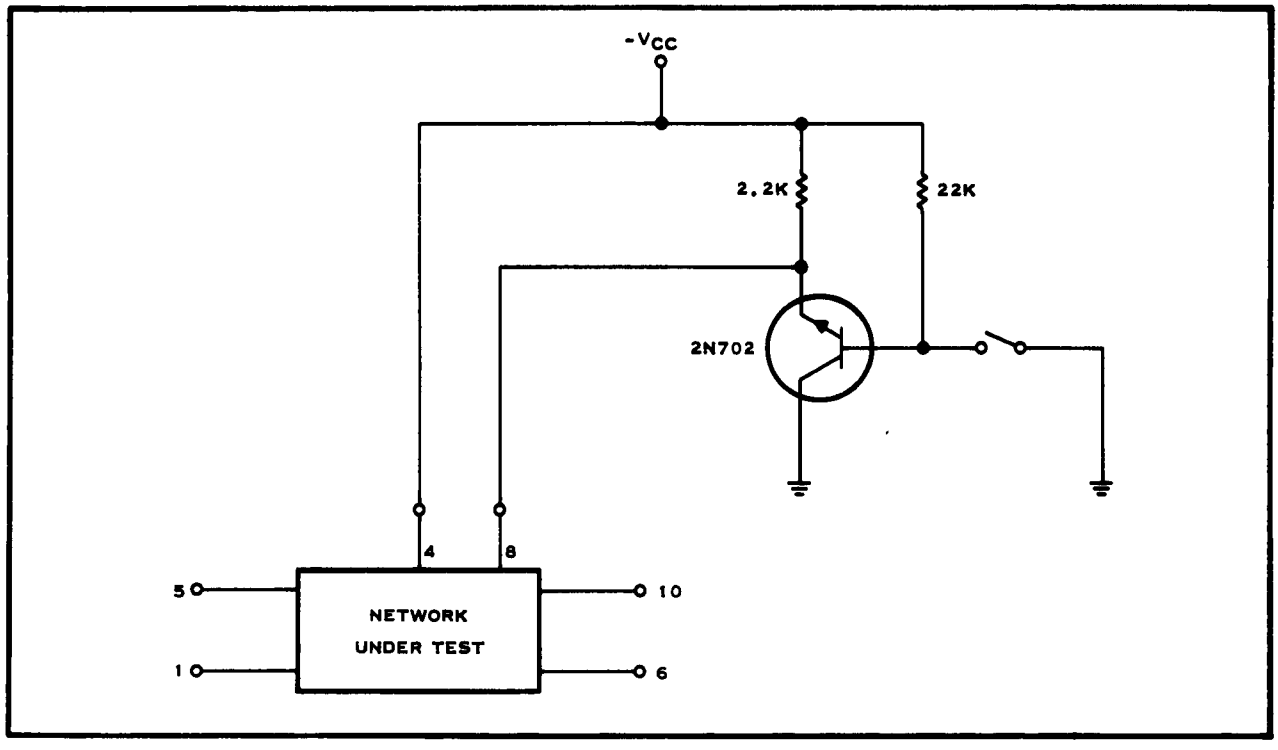

Figure 24. Preset Test Circuit (SN-202)

4. Other areas of oxide are then removed and an N-type layer is diffused for transistor emitters, part of the capacitors, and contact areas. Again an oxide is formed in these areas during the diffusion process (Figure 31).

5. Oxide is then removed in the areas where contact is to be made. No junctions are exposed.

6. Gold is evaporated into the contact areas of the elements that are likely to have excess minority carriers, and this is diffused to reduce minority carrier lifetime in those areas. The purpose of this step is to increase switching speed.

7. Aluminum is evaporated over the entire surface and removed selectively except where contacts are to be made. It is then alloyed in the contact areas (Figure 32).

8. At this point, all components can be tested individually by utilizing test probes attached to micromanipulators.

9. Aluminum is evaporated over the entire surface and removed selectively leaving the elements connected except for two wires as shown in Figure 28.

10. The networks are then separated by etching.

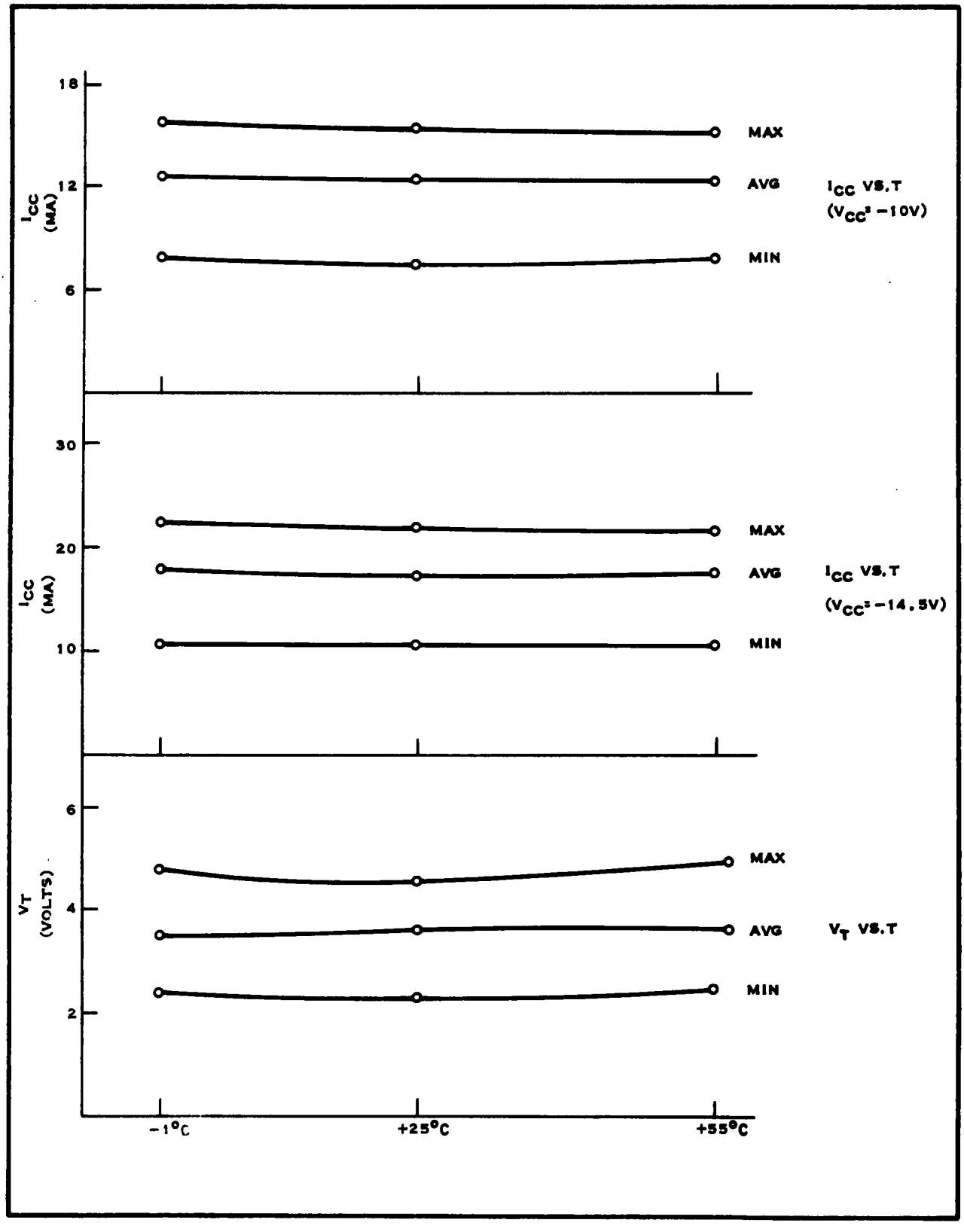

Figure 25. SN-202 Parameter Variation Versus Temperature

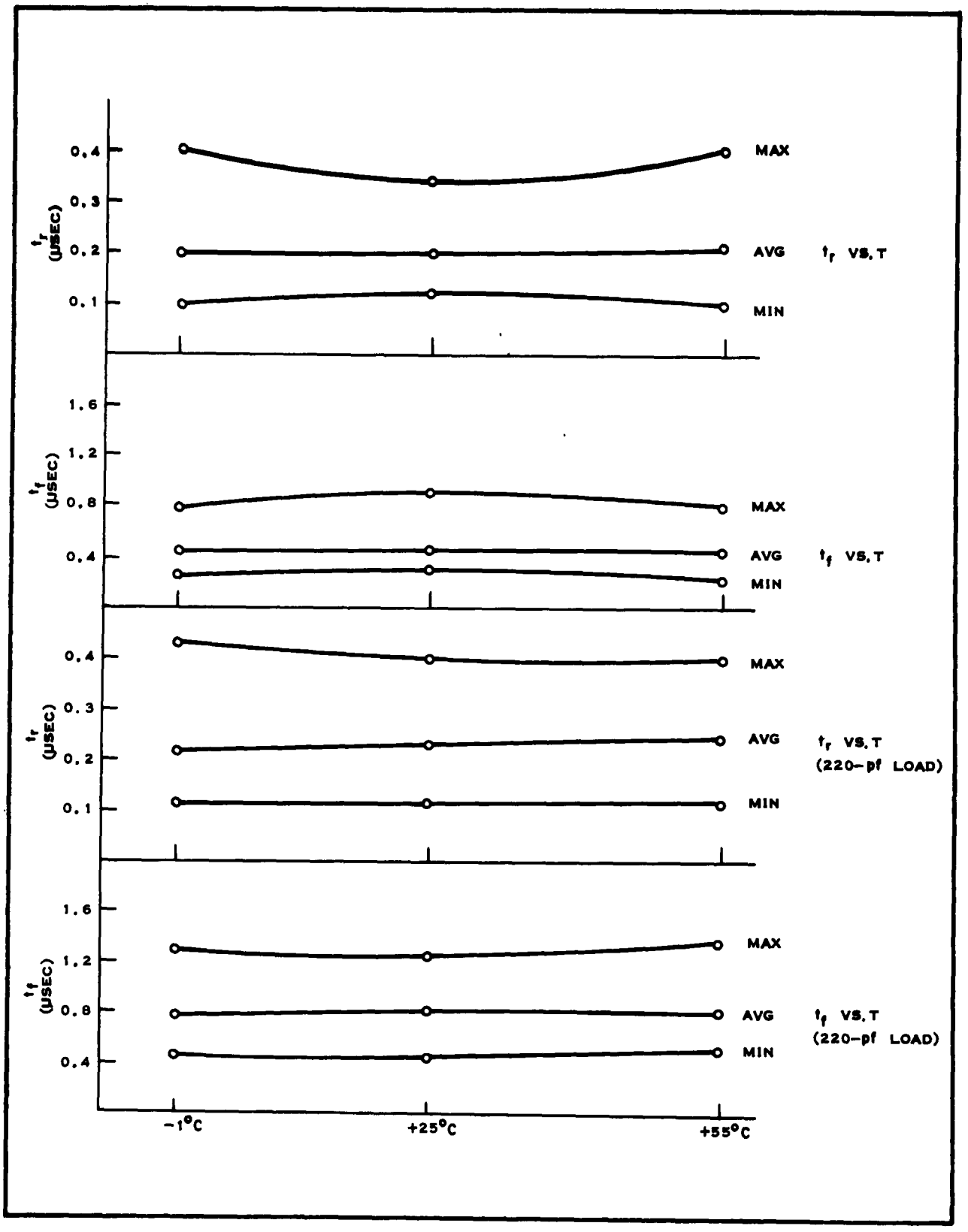

Figure 26. SN-202 Switching Time Versus Temperature

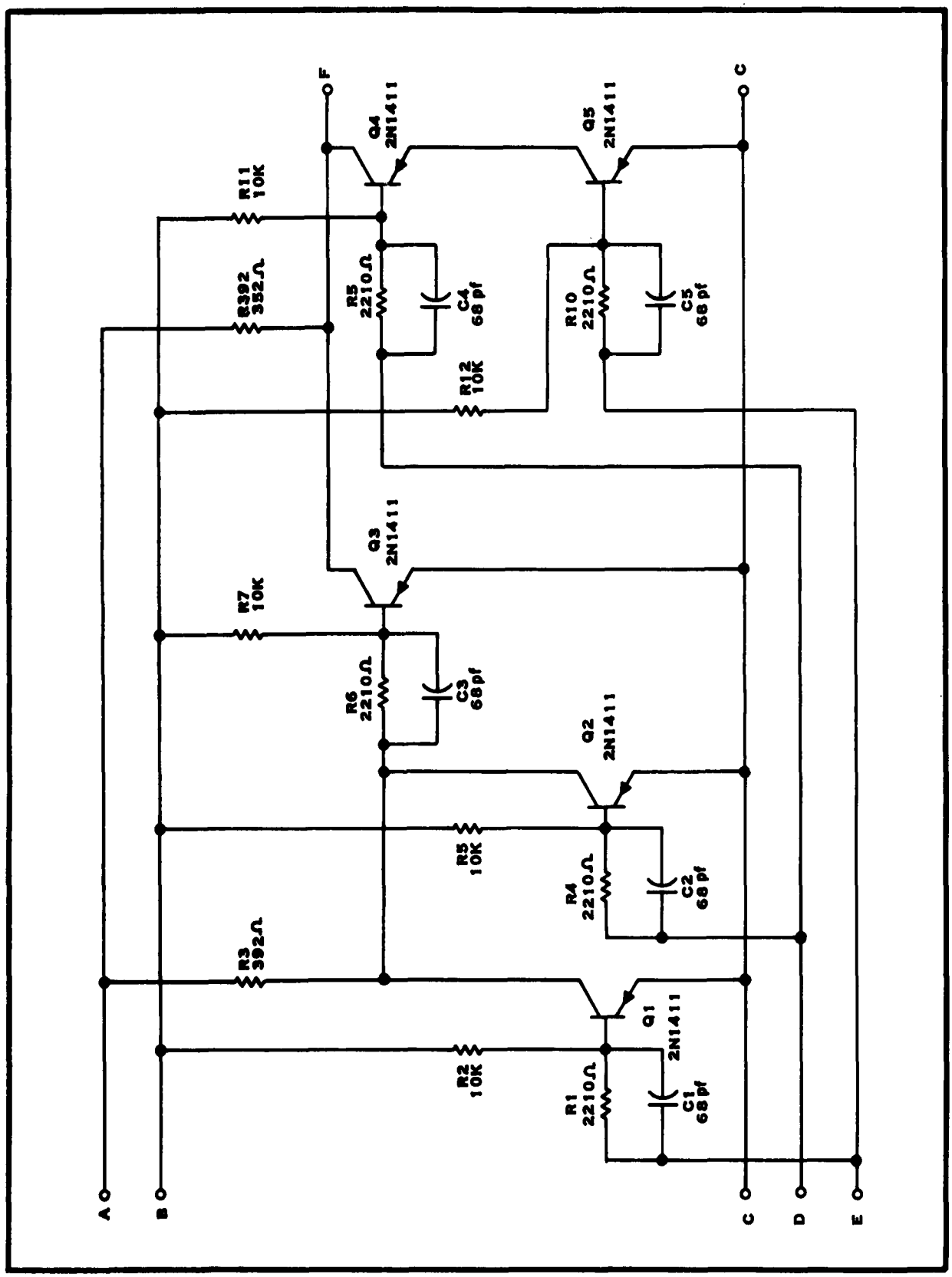

Figure 27. "Parity Logic A" Schematic

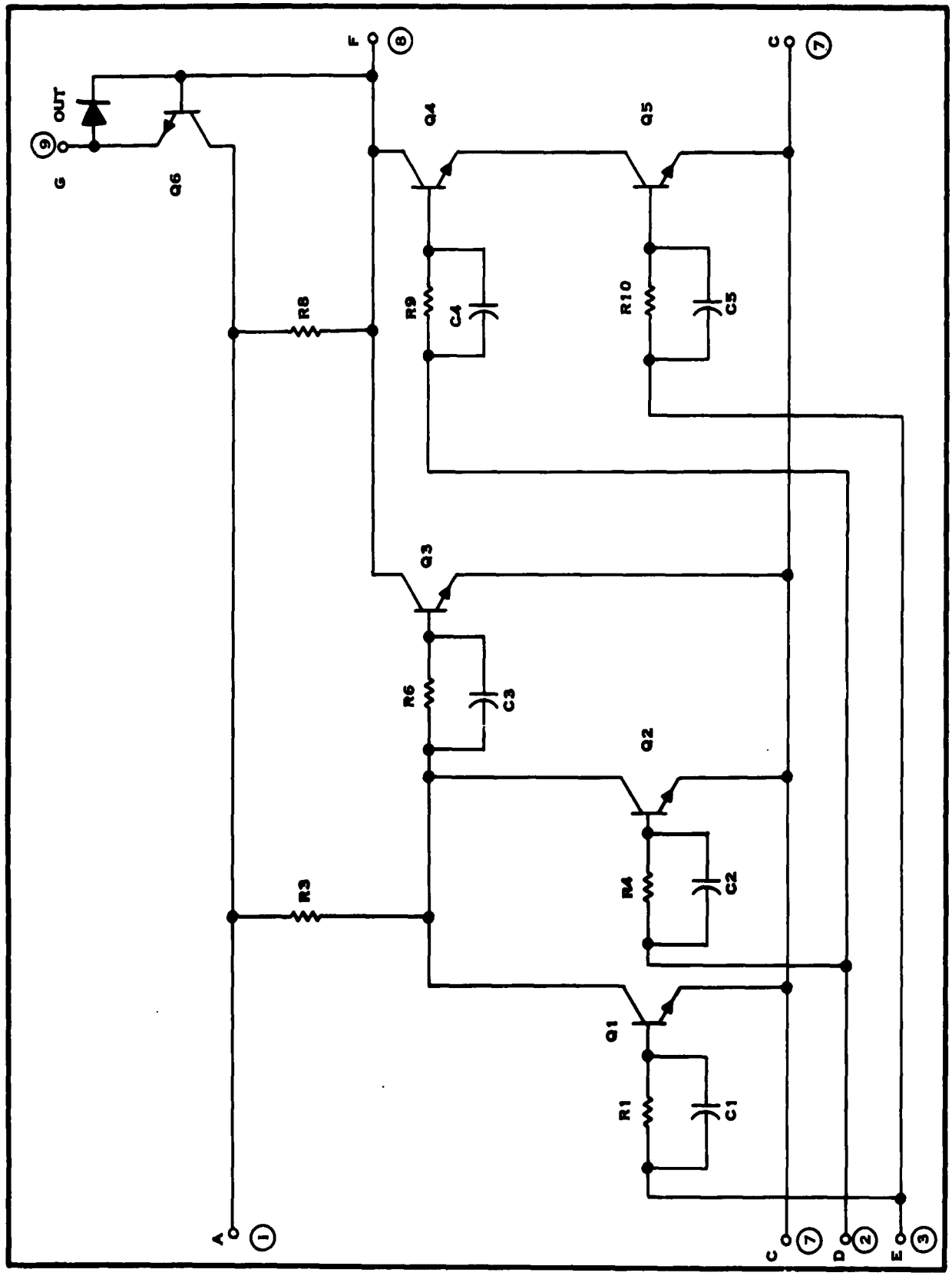

Figure 28. SN-218 Semiconductor Network Parity Logic Schematic

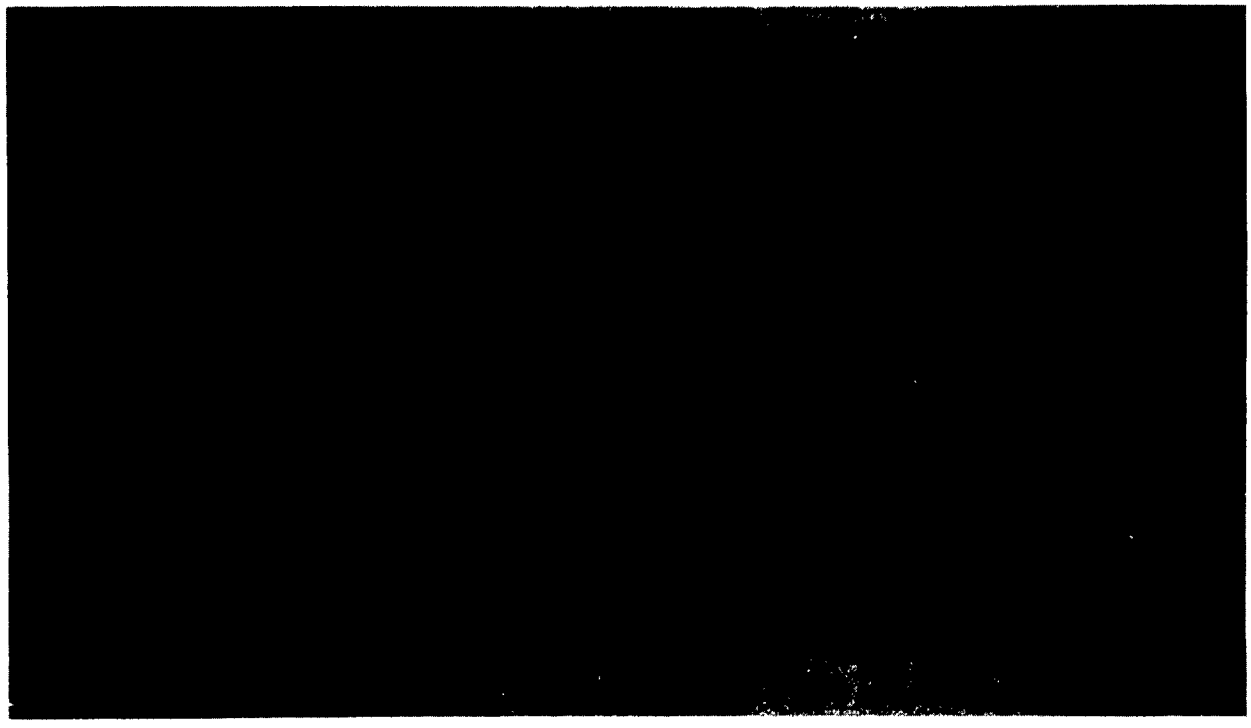

Figure 29. Silicon Slice After "N"-Type First Diffusion (SN-218)

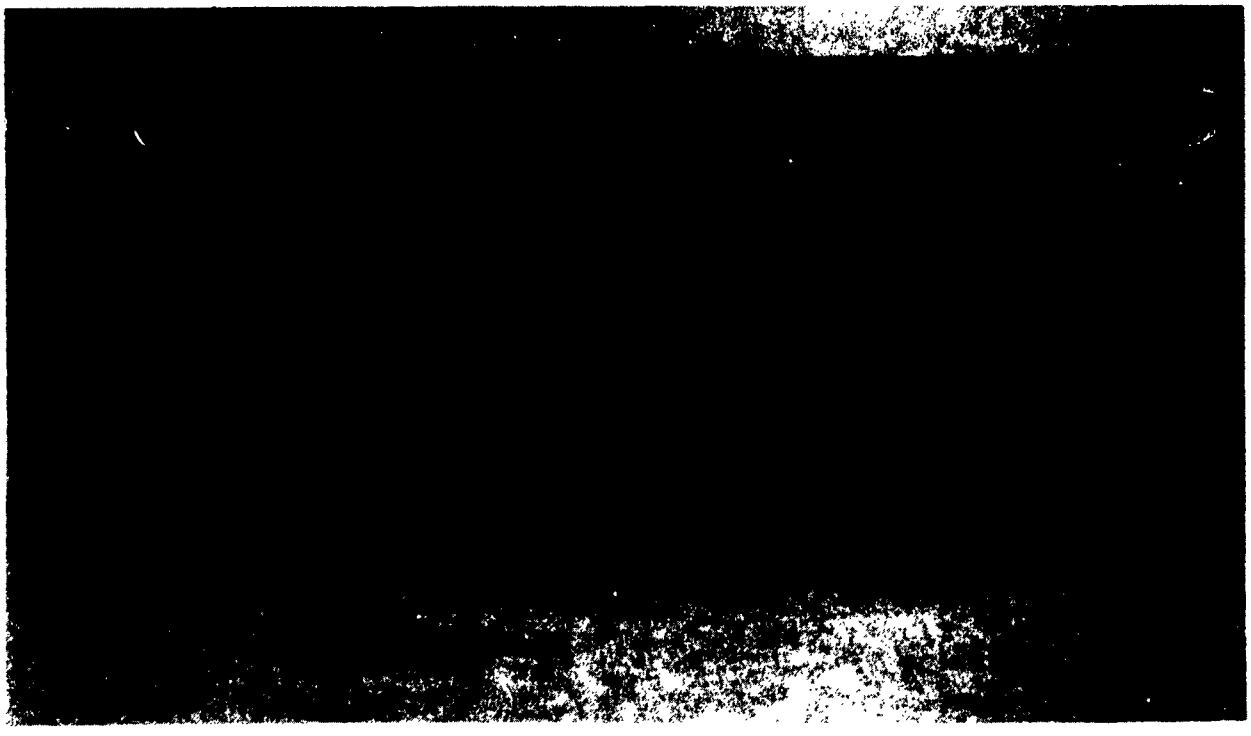

Figure 30. Silicon Slice After "P"-Type Second diffusion (SN-218)

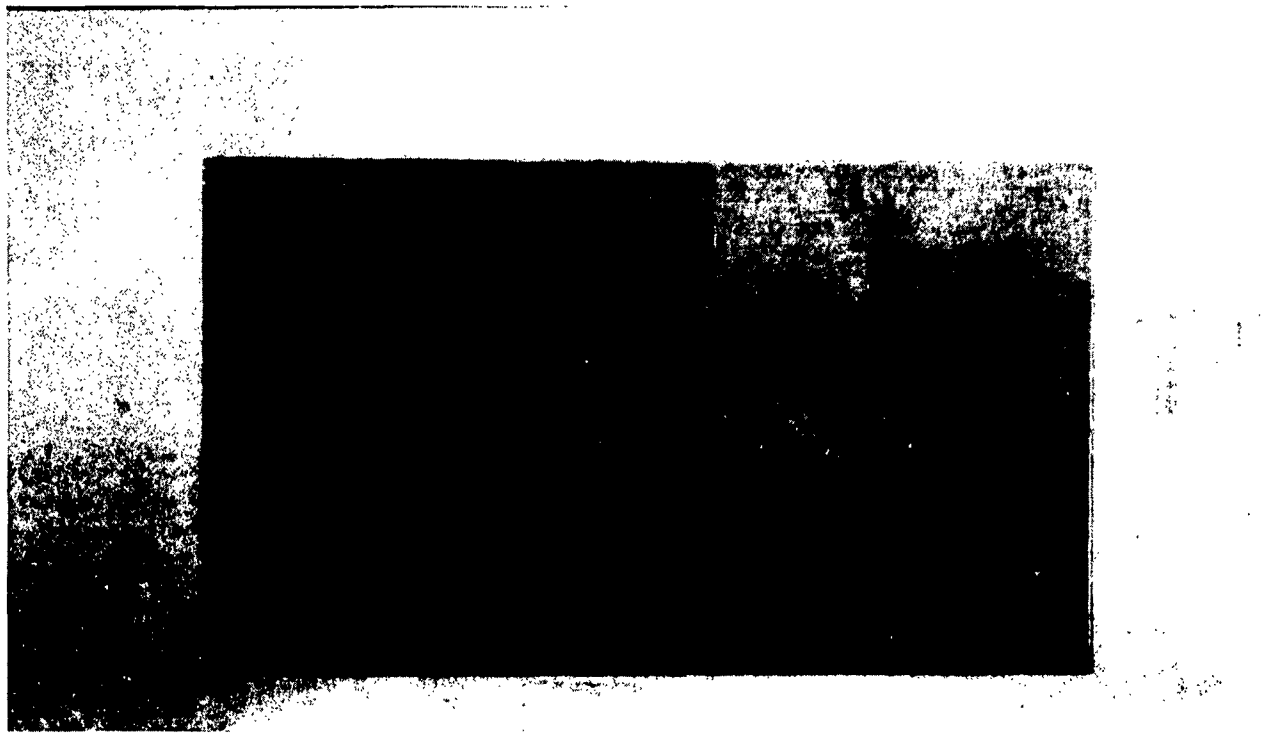

Figure 31. Silicon Slice After "N"-Type Third Diffusion (SN-218)

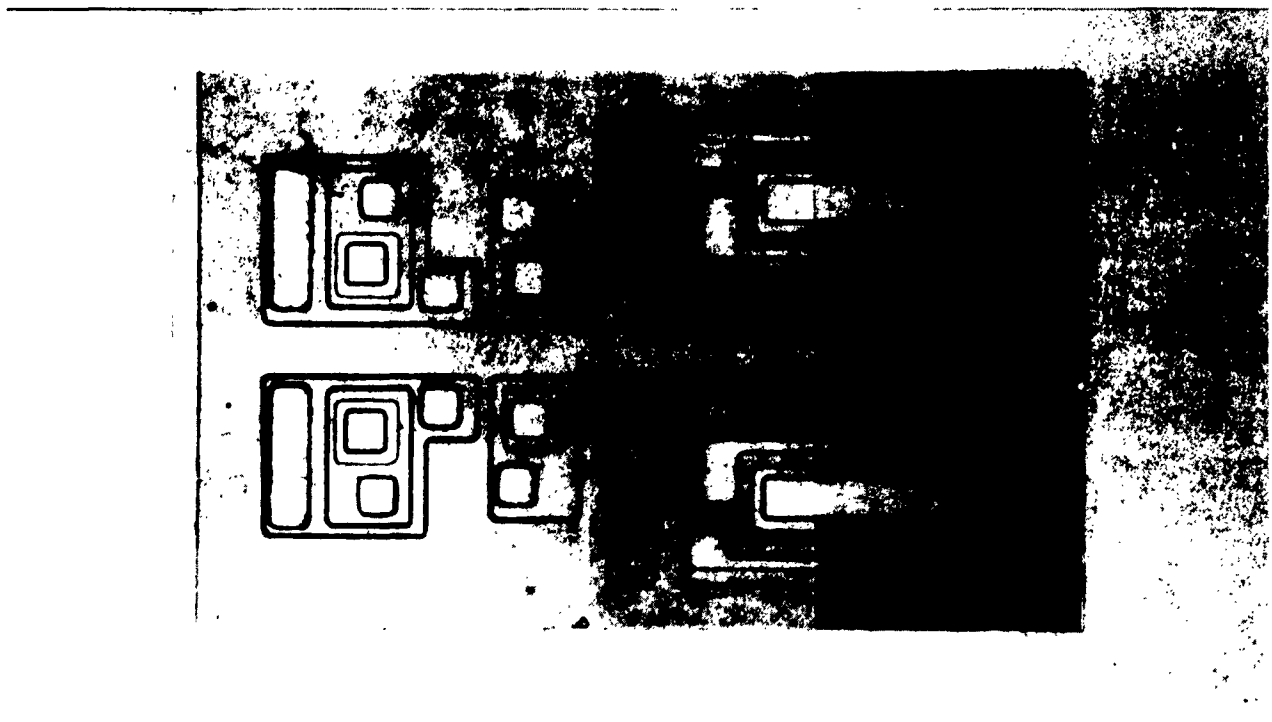

Figure 32. Silicon Slice With Alloyed Contacts (SN-218)

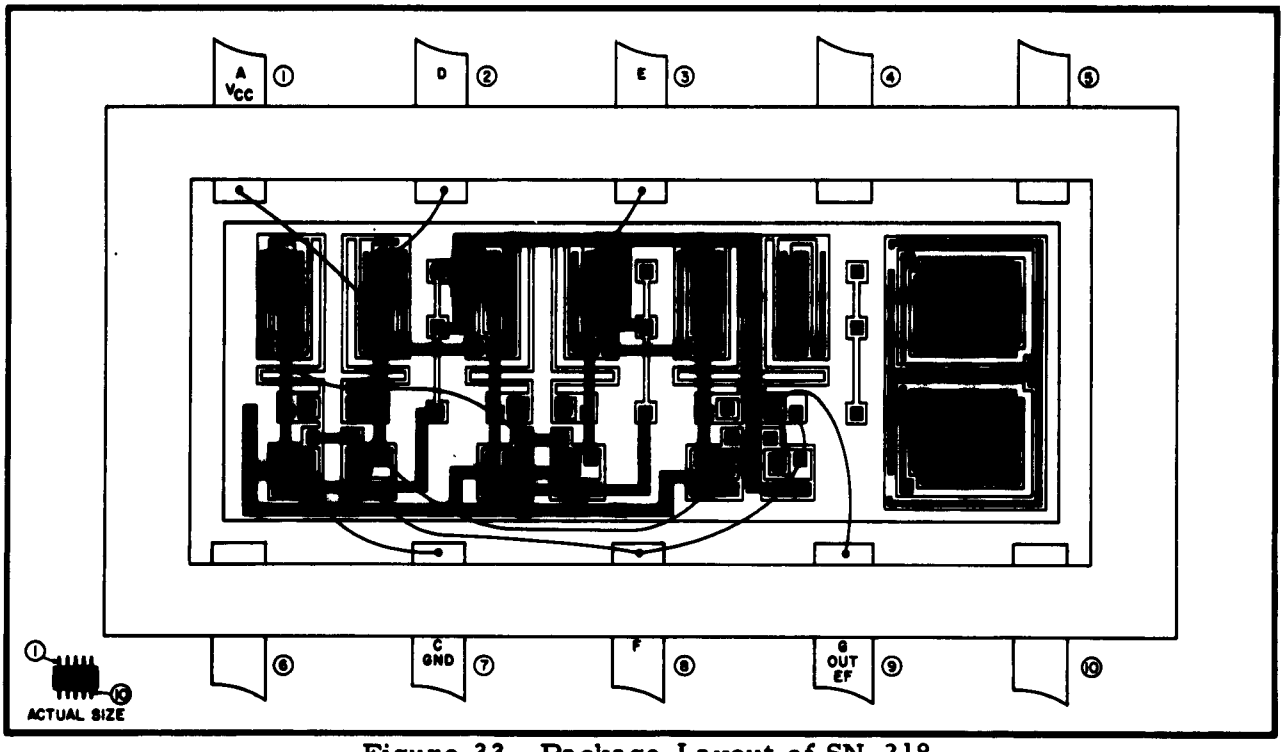

Figure 33. Package Layout of SN-218

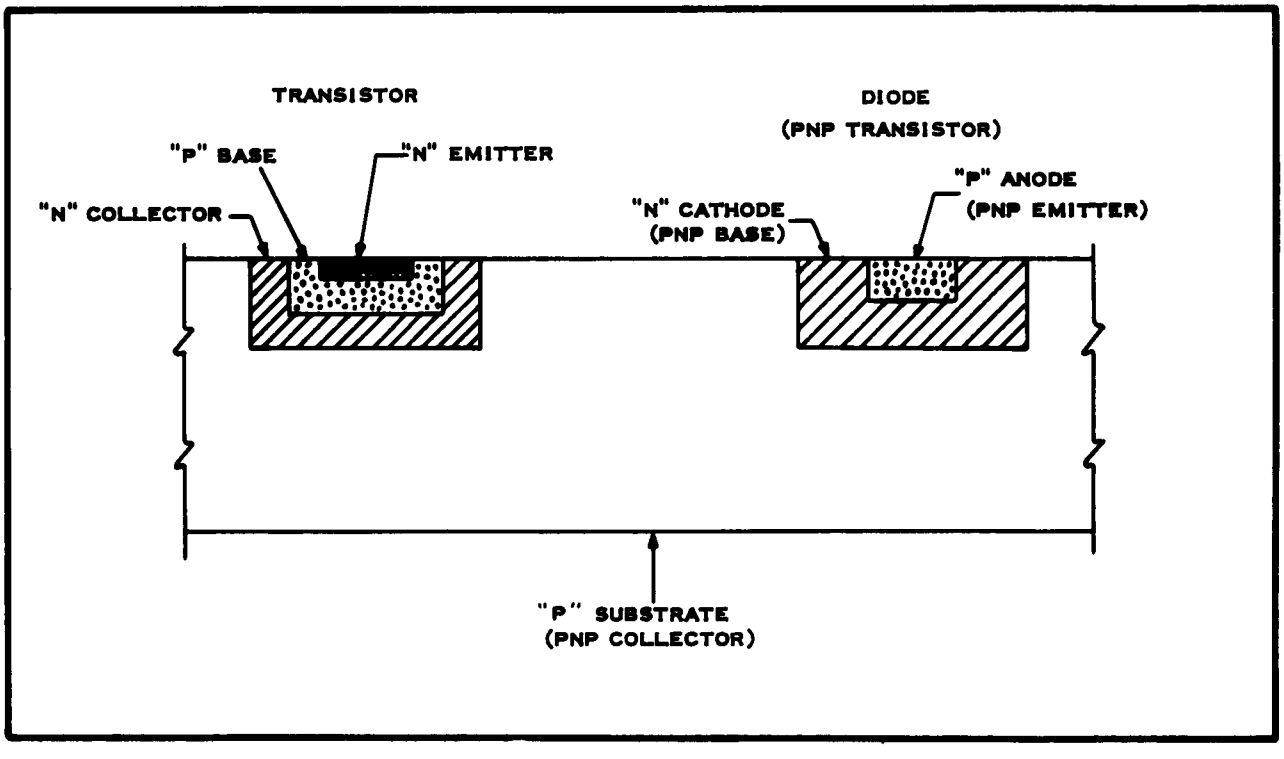

Figure 34. Cross Section View of SN-218 Slice

11. Individual networks are mounted in the header, and the remaining connections are made by ball-bonding gold wire leads (Figure 33).

12. After preliminary tests, the headers are hermetically sealed.

All process steps, including cleaning and inspection, are similar to those employed in transistor manufacturing. The latest planar-transistor fabrication techniques are employed for maximum reliability.

After step No. 8, the network may be used for many applications. The components may be connected for other functions by using a different evaporated lead pattern. This adaptability is easily recognized in Figure 33.

A cross section of a silicon slice, showing the diode and transistor areas, is shown in Figure 34. The diode will actually be a PNP transistor in which the substrate acts as a collector. Therefore, the diode shown in Figure 28 actually has some current gain. By keeping the substrate at ground potential, it is possible to obtain complementary emitter-follower action. The processes are designed to emphasize production of optimum NPN transistors; consequently, PNP characteristics are less than ideal.

C. Testing

All measurements were made with the test circuit shown in Figure 35. The data taken at −40°C, +25°C, and +85°C is tabulated in Tables XXVII through XXIX. The average parameters versus temperature are shown in Figures 36 and 37.

The most significant parameter is probably power dissipation, because it indicates the resistor size variation from unit to unit. This parameter shows there is about a ±30-percent resistor variation. Switching times, which are practically all RC time constants, show a similar spread. The emitter-follower outputs make it unnecessary to hold tight resistor tolerance. However, close distribution of all parameters would result if they were held tighter.

VIII. CONCLUSION

The difficulty in making these semiconductor networks arose largely from the requirement that the original circuits were to be duplicated as nearly as possible in semiconductor network form. The PNP germanium alloy transistors could not be made because of the incompatibility of their manufacturing processes with semiconductor network processes. They were therefore replaced with silicon PNP transistors and the circuit configurations were retained in network form. The transistor parameters required for these circuit configurations made the inclusion of these devices on the network bar impracticable, requiring separate transistor chips.

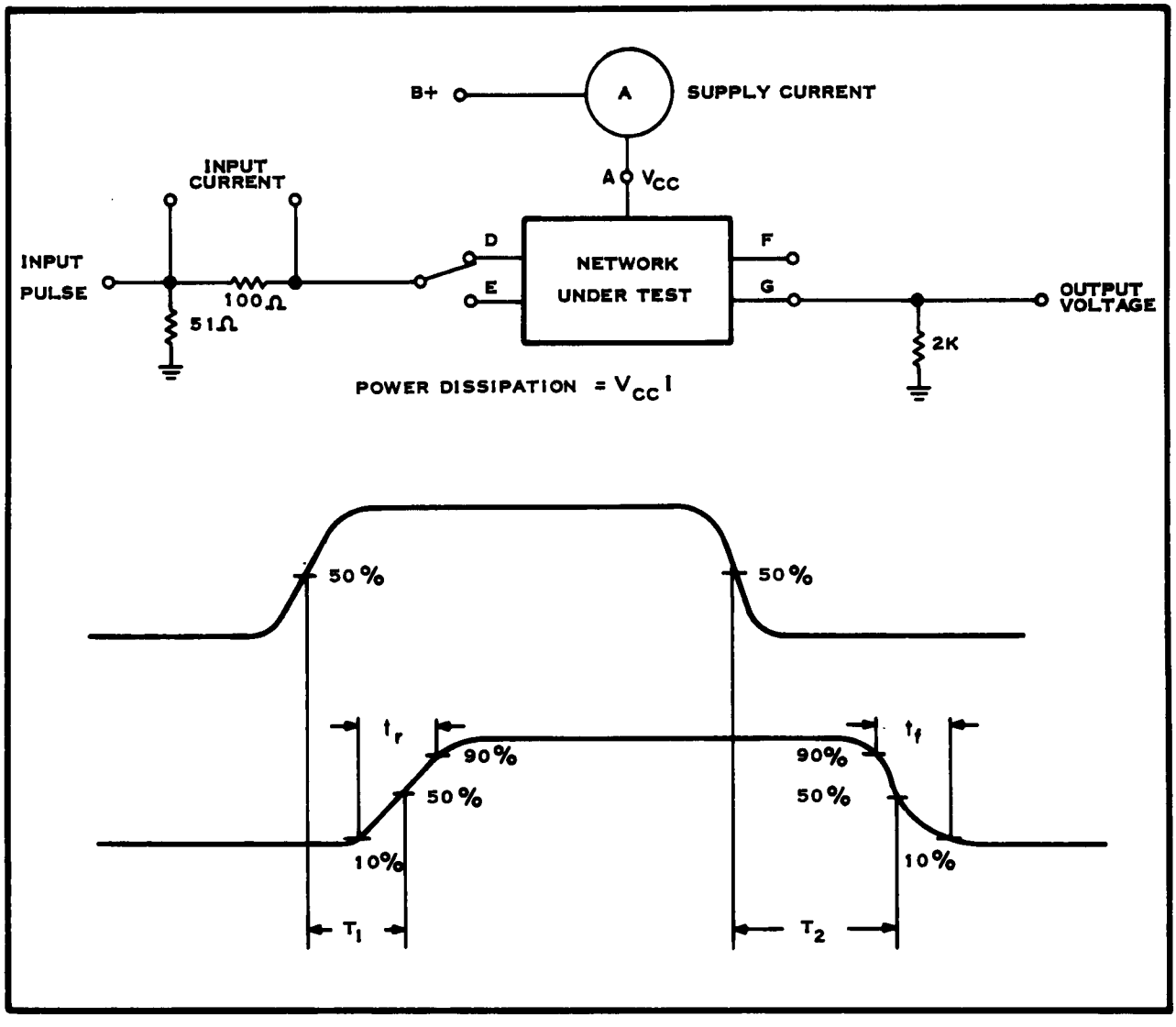

Figure 35. SN-218 Test Circuit

In contrast, the SN-218 is an example of a circuit designed both to realize the required circuit function and take advantage of the best semiconductor network processes. The result is a single-bar planar semiconductor network which is more complex, yet easier to build. This philosophy of approach utilizes the best in semiconductor network technology without sacrifice of circuit performance.

This report has summarized information previously reported as each semiconductor network device type was delivered. Fabrication processes and performance test data have been presented. The networks were discussed in the order in which they were fabricated and thereby illustrate the progress of semiconductor network technology.

Table XXVII. SN-218 Network Parameters for T = -40°C

Unit No.	T_1	T_2	T_r	T_f	Min. Input (volts)	Input Current (ma)	Max. Output (volts)	Power Dissip. (mw)	Min. Output (volts)
1	—	—	0.5	0.2	—	0.1	2.7	4.8	0.01
			0.5	0.2		0.16	2.7	4.8	0.01
2	—	—	0.5	0.1	—	0.10	3.3	6.8	0.01
			0.5	0.1		0.14	3.3	6.8	0.01
3	—	—	0.6	0.1	—	0.10	3.1	5.6	0.01
			0.6	0.1		0.15	3.1	5.6	0.01
4	—	—	0.9	0.18	—	0.11	3.0	4.8	0.01
			0.9	0.18		0.17	3.0	4.8	0.01
5	—	—	0.9	0.15	—	0.11	3.0	5.6	0.01
			0.9	0.15		0.17	3.0	5.6	0.01
6	—	—	0.7	0.2	—	0.11	2.8	5.2	0.01
			0.7	0.2		0.17	2.8	5.2	0.01
7	—	—	1.0	0.10	—	0.17	3.1	3.44	0.01
			1.0	0.10		0.16	3.1	3.44	0.01
8	—	—	0.60	0.10	—	0.10	3.2	5.2	0.01
			0.65	0.10		0.15	3.2	5.2	0.01
9	—	—	0.60	0.15	—	0.12	3.1	5.6	0.01
			0.60	0.15		0.12	2.9	5.6	0.01
10	—	—	0.8	0.2	—	0.08	2.8	3.2	0.01
			0.8	0.2		0.13	2.8	3.2	0.01
11	—	—	0.8	0.1	—	0.08	2.9	5.2	0.01
			0.8	0.1		0.12	2.9	5.2	0.01
12	—	—	1.0	0.2	—	0.07	3.0	4.8	0.01
			1.0	0.2		0.10	3.0	4.8	0.01
13	—	—	0.3	0.1	—	0.10	2.8	12.0	0.01
			0.3	0.1		0.15	2.5	12.0	0.01
14	—	—	0.5	0.1	—	0.11	2.7	5.2	0.01
			0.5	0.1		0.17	2.7	5.2	0.01
15	—	—	0.5	0.1	—	0.08	3.4	6.4	0.01
			0.5	0.1		0.13	3.4	6.4	0.01
16	—	—	0.5	0.2	—	0.08	3.2	5.2	0.01
			0.5	0.2		0.13	3.2	5.2	0.01
17	—	—	0.4	0.2	—	0.07	3.0	5.6	0.04
			0.4	0.2		0.14	3.0	5.6	0.04

Table XXVII. SN-218 Network Parameters for T = -40°C (Continued)

Unit No.	T_1	T_2	T_r	T_f	Min. Input (volts)	Input Current (ma)	Max. Output (volts)	Power Dissip. (mw)	Min. Output (volts)
18	–	–	0.35	0.15	–	0.09	2.8	4.8	0.01
			0.35	0.15		0.15	2.8	4.8	0.01
19	–	–	0.5	0.1	–	0.13	3.1	6.4	0.01
			0.5	0.1		0.18	3.1	6.4	0.01
20	–	–	0.6	0.15	–	0.11	3.2	6.0	0.01
			0.6	0.15		0.22	3.2	6.0	0.01
21	0.25	0.15	0.82	0.20	2.8	0.06	3.0	6.4	0.01
	0.20	0.15	0.82	0.20	1.3	0.10	3.2	6.4	0.01
22	0.25	0.3	0.7	0.38	1.3	0.10	3.3	6.0	0.01
	0.20	0.3	0.7	0.38	0.8	0.11	3.4	6.0	0.01
23	0.25	0.3	0.7	0.2	1.7	0.06	3.2	5.6	0.01
	0.20	0.3	0.7	0.2	0.75	0.10	3.3	5.6	0.01
24	0.20	0.2	0.5	0.1	1.3	0.2	3.4	8.0	0.01
	0.15	0.15	0.5	0.1	0.7	0.12	3.4	8.0	0.01
25	0.25	0.3	0.7	0.2	1.4	0.06	3.4	5.2	0.01
	0.20	0.3	0.7	0.2	0.9	0.10	3.3	5.2	0.01
26	0.3	0.25	1.1	0.1	1.8	0.06	3.2	6.0	0.01
	0.3	0.2	1.1	0.2	1.5	0.08	3.0	6.0	0.01
27	0.2	0.4	0.8	0.64	2.0	0.10	3.0	4.4	0.01
	0.2	0.4	0.8	0.64	1.75	0.10	3.2	4.4	0.01
28	0.30	0.25	0.7	0.2	2.6	0.10	3.2	4.4	0.01
	0.30	0.25	0.7	0.2	1.6	0.10	3.2	4.4	0.01
29	0.25	0.25	0.9	0.2	1.4	0.08	3.2	4.0	0.01
	0.20	0.20	0.9	0.2	1.5	0.10	3.2	4.0	0.01
30	0.2	0.2	0.7	0.2	1.7	0.08	3.2	5.2	0.01
	0.2	0.2	0.7	0.2	1.4	0.10	3.2	5.2	0.01
31	0.3	0.3	0.8	0.2	1.7	0.08	3.2	6.0	0.01
	0.3	0.25	0.8	0.2	1.5	0.10	3.2	6.0	0.01
32	0.3	0.25	0.7	0.2	1.4	0.8	3.1	6.0	0.01
	0.3	0.25	0.7	0.2	1.5	0.12	3.2	6.0	0.01
33	0.2	0.2	0.8	0.1	1.3	0.08	3.2	5.6	0.01
	0.2	0.2	0.8	0.1	1.4	0.10	3.2	5.6	0.01

Table XXVII. SN-218 Network Parameters for T = -40°C (Continued)

Unit No.	T_1	T_2	T_r	T_f	Min. Input (volts)	Input Current (ma)	Max. Output (volts)	Power Dissip. (mw)	Min. Output (volts)
34	0.28	0.2	0.6	0.1	1.6	0.08	2.9	6.8	0.01
	0.26	0.2	0.6	0.1	2.3	0.13	2.9	6.8	0.01
35	0.25	0.30	0.9	0.4	1.7	0.10	2.8	6.4	0.01
	0.25	0.30	0.9	0.4	1.5	0.10	2.8	6.4	0.01
36	0.22	0.2	0.5	0.10	1.7	0.08	2.8	6.4	0.01
	0.22	0.2	0.5	0.10	1.7	0.13	2.8	6.4	0.01
37	0.25	0.2	0.7	0.3	2.0	0.08	2.8	7.2	0.01
	0.25	0.2	0.7	0.3	1.8	0.10	2.8	7.2	0.01
38	0.2	0.25	0.7	0.6	2.0	0.10	2.4	6.4	0.03
	0.2	0.25	0.7	0.6	2.2	0.10	2.3	6.4	0.03
39	0.25	0.2	0.9	0.3	2.2	0.10	3.2	6.4	0.01
	0.20	0.2	0.9	0.3	1.6	0.10	3.0	6.4	0.01
40	0.25	0.25	0.9	0.3	1.7	0.08	3.0	7.2	0.01
	0.25	0.25	0.9	0.3	1.6	0.10	3.0	7.2	0.01
41	0.2	0.2	0.5	0.2	1.4	0.10	3.0	7.2	0.01
	0.2	0.2	0.5	0.2	1.4	0.10	3.0	7.2	0.01
42	0.2	0.16	0.44	0.1	1.6	0.08	2.9	7.2	0.01
	0.2	0.18	0.44	0.1	1.5	0.13	2.9	7.2	0.01
43	0.2	0.2	0.8	0.3	1.4	0.10	3.2	6.8	0.01
	0.2	0.2	0.8	0.3	1.5	0.10	3.2	6.8	0.01
44	0.2	0.2	0.5	0.1	1.8	0.10	2.7	7.6	0.01
	0.2	0.2	0.5	0.1	1.7	0.13	2.7	7.6	0.01
45	0.26	0.26	0.5	0.16	1.7	0.08	2.9	6.8	0.01
	0.26	0.28	0.5	0.16	1.6	0.12	2.9	6.8	0.01
46	0.2	0.2	0.7	0.24	2.4	0.10	3.2	6.8	0.01
	0.2	0.2	0.7	0.24	2.5	0.10	3.2	6.8	0.01
47	0.24	0.3	0.6	0.1	2.4	0.10	3.0	8.0	0.01
	0.20	0.3	0.6	0.1	1.8	0.13	3.0	8.0	0.01
48	0.2	0.2	0.42	0.1	1.6	0.09	3.0	8.0	0.01
	0.2	0.2	0.42	0.1	1.6	0.13	3.0	8.0	0.01
49	0.2	0.24	0.4	0.1	1.5	0.10	3.1	8.0	0.01
	0.2	0.24	0.4	0.1	1.4	0.14	3.1	8.0	0.01

Table XXVII. SN-218 Network Parameters for T = -40°C (Continued)

Unit No.	T_1	T_2	T_r	T_f	Min. Input (volts)	Input Current (ma)	Max. Output (volts)	Power Dissip. (mw)	Min. Output (volts)
50	0.2	0.2	0.7	0.24	1.6	0.10	3.0	8.0	0.01
	0.2	0.2	0.7	0.24	1.5	0.10	3.0	8.0	0.01
Total	13.66	14.06	66.49	19,18	99.60	10.96	303.0	611.68	1.82
Avg.	0.23	0.23	0.66	0.19	1.66	0.11	3.03	6.11	0.018

Table XXVIII. SN-218 Network Parameters for T = 25°C

Unit No.	T_1	T_2	T_r	T_f	Min. Input (volts)	Input Current (ma)	Max. Output (volts)	Power Dissip. (mw)	Min. Output (volts)
1	0.35	0.25	—	—	1.7	—	3.2	—	0.01
	0.30	0.25			2.4		3.2		0.01
2	0.3	0.3	—	—	1.1	—	3.0	—	0.01
	0.3	0.3			1.2		3.2		0.01
3	0.3	0.5	—	—	1.0	—	2.4	—	0.01
	0.3	0.5			1.0		2.2		0. 01
4	0.4	0.4	—	—	1.1	—	3.0	—	0.01
	0.4	0.4			1.1		3.0		0.01
5	0.35	0.35	—	—	0.9	—	3.1	—	0.01
	0.35	0.35			1.0		3.0		0.01
6	0.35	0.4	—	—	1.4	—	3.0	—	0.01
	0.40	0.4			1.4		3.0		0.01
7	0.55	0.40	—	—	1.0	—	3.2	—	0.01
	0.5	0.35			2.4		3.2		0.01
8	0.35	0.4	—	—	1.0	—	3.0	—	0.01
	0.3	0.3			1.0		3.0		0.01
9	0.35	0.35	—	—	1.8	—	3.0	—	0.01
	0.30	0.30			1.4		3.0		0.01
10	0.5	0.6	—	—	1.0	—	3.0	—	0.01
	0.5	0.6			1.2		3.0		0.01
11	0.4	0.4	—	—	1.1	—	3.0	—	0.01
	0.4	0.35			1.2		3.0		0.01
12	0.3	0.5	—	—	1.0	—	3.0	—	0.01
	0.35	0.5			1.1		3.0		0.01
13	0.2	0.1	—	—	1.3	—	3.2	—	0.01
	0.2	0.1			1.4		3.2		0.01
14	0.3	0.25	—	—	1.3	—	3.0	—	0.01
	0.3	0.25			1.4		3.0		0.01
15	0.25	0.30	—	—	1.1	—	3.2	—	0.01
	0.25	0.25			1.0		3.0		0.01
16	0.3	0.3	—	—	1.6	—	3.0	—	0.01
	0.3	0.3			1.8		3.0		0.01
17	0.2	0.4	—	—	1.0	—	2.6	—	0.02
	0.2	0.3			1.2		3.0		0.03

Table XXVIII. SN-218 Network Parameters for T = 25°C (Continued)

Unit No.	T_1	T_2	T_r	T_f	Min. Input (volts)	Input Current (ma)	Max. Output (volts)	Power Dissip. (mw)	Min. Output (volts)
18	0.25	0.35	—	—	1.5	—	3.0	—	0.01
	0.25	0.30			1.7		3.0		0.01
19	0.3	0.25	—	—	1.0	—	3.1	—	0.01
	0.3	0.25			1.0		3.1		0.01
20	0.40	0.30	—	—	1.3	—	3.0	—	0.01
	0.40	0.25			1.2		3.0		0.01
21	0.4	0.25	0.9	0.1	1.8	0.07	3.1	4.8	0.01
	0.35	0.25	0.9	0.1	1.7	0.10	3.4	4.8	0.01
22	0.30	0.4	0.8	0.2	1.1	0.6	3.3	4.8	0.01
	0.35	0.35	1.0	0.2	1.1	0.10	3.3	4.8	0.01
23	0.3	0.4	0.7	0.22	1.3	0.06	3.2	4.4	0.01
	0.3	0.4	0.7	0.22	1.2	0.10	3.2	4.4	0.01
24	0.20	0.25	0.7	0.2	1.1	0.08	3.4	6.0	0.01
	0.20	0.20	0.7	0.2	1.1	0.12	3.2	6.0	0.01
25	0.35	0.40	0.8	0.22	1.2	0.06	3.4	4.4	0.01
	0.30	0.35	0.8	0.22	1.35	0.10	3.2	4.4	0.01
26	0.35	0.35	0.7	0.2	1.7	0.07	3.2	4.8	0.01
	0.35	0.35	0.7	0.2	1.2	0.11		4.8	0.01
27	0.3	0.5	0.95	0.6	1.7	0.08	3.4	4.0	0.01
	0.3	0.5	0.95	0.6	1.4	0.10	3.4	4.0	0.01
28	0.4	0.3	0.7	0.22	1.8	0.06	3.4	3.2	0.01
	0.4	0.3	0.7	0.22	1.0	0.10	3.4	3.2	0.01
29	0.3	0.3	0.9	0.22	1.1	0.06	3.4	3.2	0.01
	0.3	0.3	0.9	0.22	1.0	0.10	3.4	3.2	0.01
30	0.3	0.3	0.7	0.22	1.4	0.08	3.4	4.0	0.01
	0.3	0.3	0.7	0.24	1.0	0.10	3.4	4.0	0.01
31	0.4	0.4	0.9	0.24	1.2	0.7	3.2	4.4	0.01
	0.4	0.4	0.9	0.24	1.1	0.10	3.4	4.4	0.01
32	0.4	0.3	1.0	0.2	1.0	0.08	3.0	4.8	0.01
	0.3	0.3	1.0	0.2	1.0	0.10	3.2	4.8	0.0
33	0.25	0.25	0.7	0.2	1.1	0.08	3.4	4.0	0.01
	0.30	0.30	0.7	0.2	1.1	0.10	3.4	4.0	0.01
34	0.20	0.32	1.0	0.2	1.1	0.07	3.0	5.2	0.01
	0.26	0.34	1.0	0.2	1.6	0.12	3.0	5.2	0.01

Table XXVIII. SN-218 Network Parameters for T = 25°C (Continued)

Unit No.	T_1	T_2	T_r	T_f	Min. Input (volts)	Input Current (ma)	Max. Output (volts)	Power Dissip. (mw)	Min. Output (volts)
35	0.4	0.35	1.02	0.6	1.0	0.08	3.3	5.2	0.01
	0.3	0.30	1.02	0.6	1.0	0.10	3.4	5.2	0.01
36	0.32	0.32	0.7	0.16	1.2	0.07	2.9	4.4	0.01
	0.32	0.32	0.7	0.16	1.2	0.11	2.9	4.4	0.01
37	0.25	0.3	1.0	0.4	1.2	0.08	3.4	5.6	0.01
	0.30	0.25	1.0	0.4	1.7	0.10	3.4	5.6	0.01
38	0.35	0.35	1.2	0.48	1.4	0.06	3.1	3.2	0.01
	0.35	0.35	1.2	0.60	1.6	0.10	3.0	3.2	0.01
39	0.3	0.3	1.2	0.38	1.6	0.06	3.2	3.6	0.01
	0.3	0.3	1.2	0.40	1.3	0.10	3.1	3.6	0.01
40	0.35	0.3	1.02	0.42	1.1	0.08	3.4	5.6	0.01
	0.30	0.3	1.02	0.42	1.3	0.10	3.4	5.6	0.01
41	0.25	0.2	0.9	0.3	1.0	0.10	3.4	6.0	0.01
	0.20	0.2	0.9	1.32	1.0	0.10	3.4	6.0	0.01
42	0.3	0.22	0.7	0.1	1.1	0.08	3.0	5.6	0.01
	0.3	0.26	0.7	0.1	1.1	0.12	3.0	5.6	0.01
43	0.3	0.3	1.0	0.40	1.2	0.08	3.2	3.2	0.01
	0.3	0.3	1.0	0.42	1.2	0.10	3.2	3.2	0.01
44	0.3	0.26	0.7	0.16	1.3	0.08	2.8	6.0	0.01
	0.3	0.28	0.7	0.16	1.6	0.12	2.8	6.0	0.01
45	0.26	0.36	0.9	0.24	1.2	0.07	2.9	5.2	0.01
	0.26	0.40	0.9	0.24	1.3	0.10	2.9	5.2	0.01
46	0.25	0.25	1.0	0.38	1.7	0.06	3.2	3.6	0.01
	0.25	0.25	1.0	0.40	1.8	0.10	3.2	3.6	0.01
47	0.3	0.32	1.0	0.12	2.2	0.08	3.1	6.0	0.01
	0.3	0.32	1.0	0.12	2.8	0.11	3.1	6.0	0.01
48	0.28	0.28	0.6	0.12	1.2	0.08	3.0	6.0	0.01
	0.28	0.28	0.6	0.10	1.2	0.12	3.0	6.0	0.01
49	0.3	0.30	0.9	0.2	2.0	0.08	3.1	6.0	0.01
	0.3	0.28	0.9	0.2	2.3	0.13	3.1	6.0	0.01
50	0.3	0.25	0.9	0.4	1.3	0.08	3.4	6.0	0.01
	0.25	0.25	0.9	0.4	1.3	0.10	3.4	6.0	0.01
Total	31.58	32.34	52.58	16.40	132.05	5.36	312.70	286.40	1.03
Avg.	0.32	0.32	0.88	0.24	1.32	0.09	3.12	4.7	0.01

Table XXIX. SN-218 Network Parameters for T = 85°C

Unit No.	T_1	T_2	T_r	T_f	Min. Input (volts)	Input Current (ma)	Max. Output (volts)	Power Dissip. (mw)	Min. Output (volts)
1	—	—	1.25	0.25	—	0.07	2.7	3.36	0.01
			1.25	0.25		0.10	2.7	3.32	0.01
2	—	—	1.0	0.15	—	0.09	3.3	4.4	0.01
			1.0	0.15		0.18	3.3	4.4	0.01
3	—	—	1.0	0.25	—	0.06	2.9	3.64	0.01
			1.0	0.25		0.14	2.9	3.64	0.01
4	—	—	1.0	0.3	—	0.06	3.1	3.04	0.01
			1.3	0.3		0.10	3.1	3.04	0.01
5	—	—	1.4	0.30	—	0.08	2.8	3.6	0.01
			1.5	0.30		0.14	2.8	3.6	0.01
6	—	—	1.25	0.25	—	0.09	2.5	3.32	0.01
			2.5	0.25		0.17	2.5	3.28	0.01
7	—	—	2.0	0.25	—	0.04	2.3	2.36	0.01
			1.15	0.25		0.10	2.3	2.36	0.01
8	—	—	1.0	0.25	—	0.06	2.6	3.28	0.01
			1.1	0.25		0.12	2.6	3.28	0.01
9	—	—	1.0	0.30	—	0.08	3.2	3.4	0.01
			1.1	0.30		0.14	3.2	3.4	0.01
10	—	—	0.9	0.35	—	0.04	2.0	2.0	0.01
			1.0	0.30		0.08	2.0	2.0	0.01
11	—	—	1.1	0.25	—	0.07	3.1	3.2	0.01
			1.15	0.20		0.12	3.1	3.24	0.01
12	—	—	1.2	0.3	—	0.06	2.7	3.32	0.01
			1.25	0.3		0.12	2.8	3.36	0.01
13	—	—	0.8	0.1	—	0.13	2.5	7.6	0.01
			0.8	0.1		0.24	2.2	7.6	0.01
14	—	—	1.0	0.2	—	0.07	2.5	3.24	0.01
			1.2	0.15		0.14	2.5	3.24	0.01
15	—	—	1.1	0.2	—	0.09	2.8	3.88	0.01
			1.1	0.2		0.16	2.8	3.88	0.01
16	—	—	0.65	0.3	—	0.07	2.6	3.28	0.01
			0.60	0.3		0.15	2.6	3.28	0.01
17	—	—	0.45	0.2	—	0.07	2.4	3.44	0.8
			0.40	0.2		0.23	2.4	3.44	0.8

Table XXIX. SN-218 Network Parameters for T = 85°C (Continued)

Unit No.	T_1	T_2	T_r	T_f	Min. Input (volts)	Input Current (ma)	Max. Output (volts)	Power Dissip. (mw)	Min. Output (volts)
18	—	—	0.5	0.2	—	0.8	2.6	3.36	0.01
			0.5	0.2		0.16	2.6	3.36	0.01
19	—	—	1.0	0.15	—	0.06	3.3	4.68	0.01
			1.1	0.20		0.16	3.3	4.4	0.01
20	—	—	1.25	0.20	—	0.07	2.7	3.42	0.01
			1.25	0.20		0.14	2.7	3.42	0.01
21	0.5	0.25	1.2	0.28	1.5	0.06	3.4	4.0	0.01
	0.4	0.25	1.2	0.28	1.4	0.10	3.4	4.0	0.01
22	0.4	0.5	1.0	0.6	0.9	0.06	3.3	4.0	0.01
	0.35	0.4	0.9	0.64	0.8	0.08	3.3	4.0	0.01
23	0.3	0.5	0.9	0.68	1.1	0.06	3.4	4.0	0.01
	0.4	0.5	0.9	0.68	0.9	0.08	3.2	4.0	0.01
24	0.3	0.3	0.85	0.2	1.0	0.08	3.6	5.2	0.01
	0.3	0.3	0.85	0.2	0.9	0.11	3.4	5.2	0.01
25	0.5	0.5	1.2	0.3	1.0	0.06	3.6	4.0	0.01
	0.4	0.4	1.2	0.3	1.0	0.10	3.4	4.0	0.01
26	0.4	0.4	1.1	0.3	1.9	0.08	3.3	3.6	0.01
	0.4	0.35	1.25	0.3	1.0	0.14	3.2	3.6	0.01
27	0.4	0.5	1.02	0.6	1.4	0.07	3.2	4.0	0.01
	0.35	0.5	1.02	0.62	1.4	0.10	3.2	4.0	0.01
28	0.6	0.4	0.9	0.24	1.4	0.06	3.0	3.6	0.01
	0.5	0.4	0.9	0.24	1.0	0.08	3.0	3.6	0.01
29	0.35	0.5	1.2	0.3	1.0	0.06	3.2	4.0	0.01
	0.40	0.4	1.2	0.3	1.0	0.08	3.2	4.0	0.01
30	0.5	0.3	0.7	0.22	1.2	0.06	3.2	4.0	0.01
	0.35	0.3	0.7	0.24	1.0	0.10	3.4	4.0	0.01
31	0.5	0.5	0.9	0.4	1.1	0.06	3.4	4.0	0.01
	0.5	0.5	0.9	0.4	1.0	0.10	3.4	4.0	0.01
32	0.5	0.4	0.85	0.22	0.9	0.06	3.1	4.0	0.01
	0.4	0.35	0.85	0.24	0.9	0.10	3.4	4.0	0.01
33	0.35	0.35	0.7	0.2	0.8	0.06	3.2	4.4	0.01
	0.30	0.30	0.7	0.2	1.0	0.10	3.0	4.4	0.01
34	0.54	0.4	1.2	0.22	1.6	0.05	3.1	4.4	0.01
	0.48	0.4	1.2	0.22	1.6	0.10	3.1	4.4	0.01

Table XXIX. SN-218 Network Parameters for T = 85°C (Continued)

Unit No.	T_1	T_2	T_r	T_f	Min. Input (volts)	Input Current (ma)	Max. Output (volts)	Power Dissip. (mw)	Min. Output (volts)
35	0.4	0.4	1.02	0.6	0.9	0.06	3.0	4.4	0.01
	0.6	0.5	1.06	0.6	0.9	0.10	3.0	4.4	0.01
36	0.38	0.34	1.0	0.2	1.0	0.06	3.1	4.0	0.01
	0.38	0.40	1.0	0.2	1.0	0.10	3.1	4.0	0.01
37	0.4	0.4	1.01	0.42	1.5	0.06	3.2	4.8	0.01
	0.35	0.4	1.01	0.44	1.2	0.10	3.2	4.8	0.01
38	0.5	0.4	1.2	0.6	1.1	0.08	3.2	4.4	0.01
	0.4	0.4	1.2	0.64	1.2	0.10	3.2	4.4	0.01
39	0.4	0.4	1.1	0.42	1.3	0.08	3.2	4.8	0.01
	0.4	0.35	1.1	0.44	1.0	0.10	3.2	4.8	0.01
40	0.5	0.4	1.02	0.44	1.1	0.06	3.3	4.8	0.01
	0.4	0.4	1.02	0.46	1.1	0.10	3.3	4.8	0.01
41	0.3	0.3	0.9	0.3	0.9	0.08	3.4	5.2	0.01
	0.3	0.25	0.9	0.3	1.0	0.10	3.4	5.2	0.01
42	0.34	0.26	0.9	0.16	1.0	0.06	3.2	5.2	0.01
	0.34	0.32	0.9	0.18	1.0	0.10	3.2	5.2	0.01
43	0.4	0.4	1.02	0.44	1.0	0.08	3.2	4.8	0.01
	0.4	0.35	1.02	0.46	1.0	0.10	3.2	4.8	0.01
44	0.36	0.34	1.2	0.2	1.4	0.07	3.0	5.2	0.01
	0.36	0.36	1.2	0.2	1.4	0.10	3.0	5.2	0.01
45	0.44	0.40	1.25	0.3	1.1	0.05	3.0	4.4	0.01
	0.46	0.46	1.25	0.3	1.2	0.10	3.0	4.4	0.01
46	0.35	0.3	1.02	0.42	1.3	0.08	3.2	4.8	0.01
	0.35	0.3	1.02	0.44	1.4	0.10	3.2	4.8	0.01
47	0.34	0.4	1.0	0.2	1.4	0.07	3.0	6.0	0.01
	0.34	0.4	1.0	0.2	1.2	0.10	3.0	6.0	0.01
48	0.36	0.32	0.9	0.2	1.1	0.07	3.1	5.2	0.01
	0.36	0.36	0.9	0.2	1.1	0.10	3.1	5.2	0.01
49	0.36	0.34	0.9	0.2	1.3	0.08	3.2	6.0	0.4
	0.36	0.38	0.9	0.2	1.3	0.12	3.2	6.0	0.5
50	0.35	0.35	1.0	0.42	1.4	0.08	3.4	5.2	0.01
	0.35	0.35	1.0	0.42	1.1	0.10	3.4	5.2	0.01
Total	24.0	22.88	103.51	30.18	68.60	9.32	302.0	416.16	3.46
Avg.	0.40	0.38	1.035	0.30	1.14	0.09	3.02	4.16	0.035

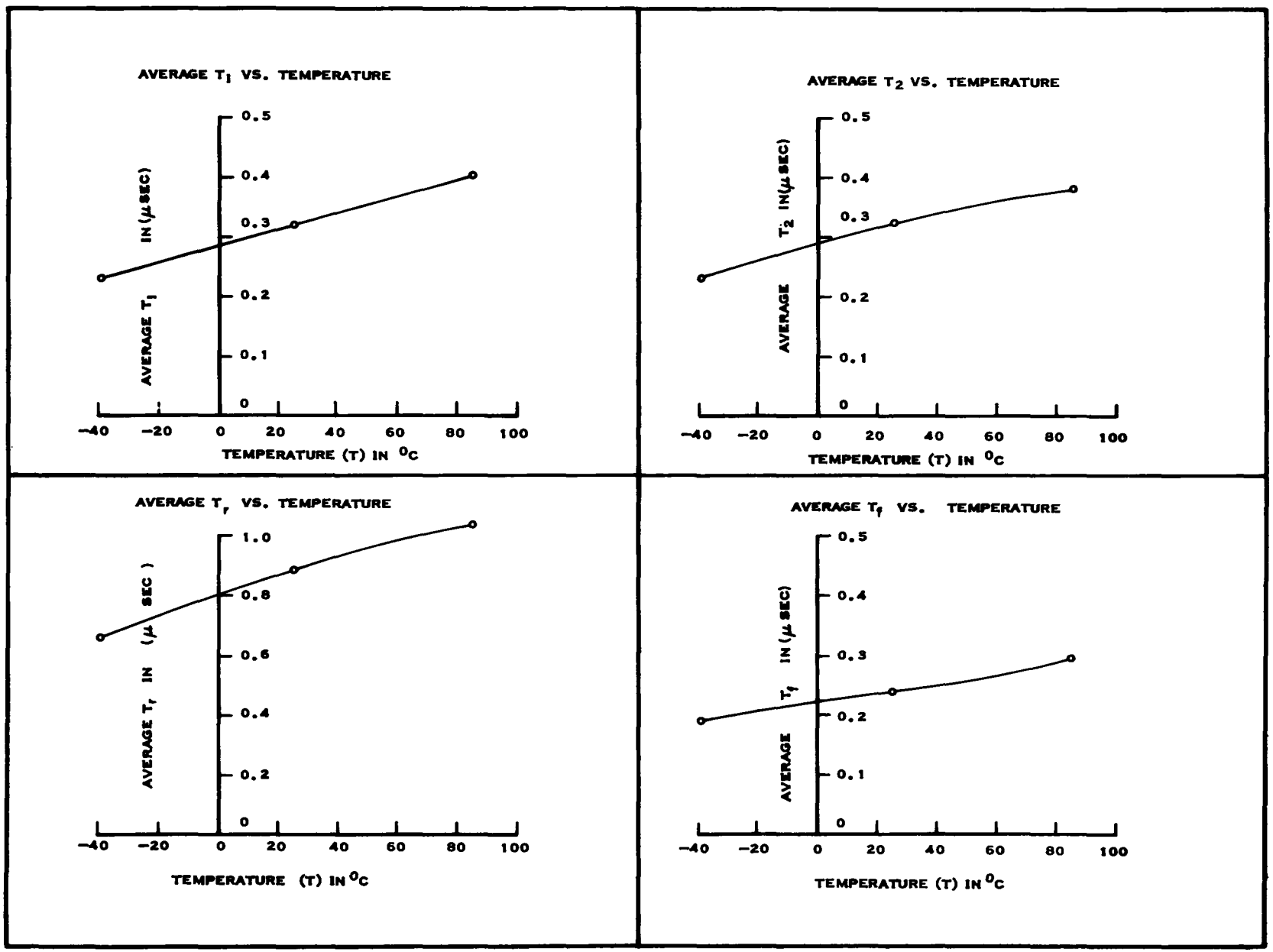

Figure 36. SN-218 Parameter Variation Versus Temperature

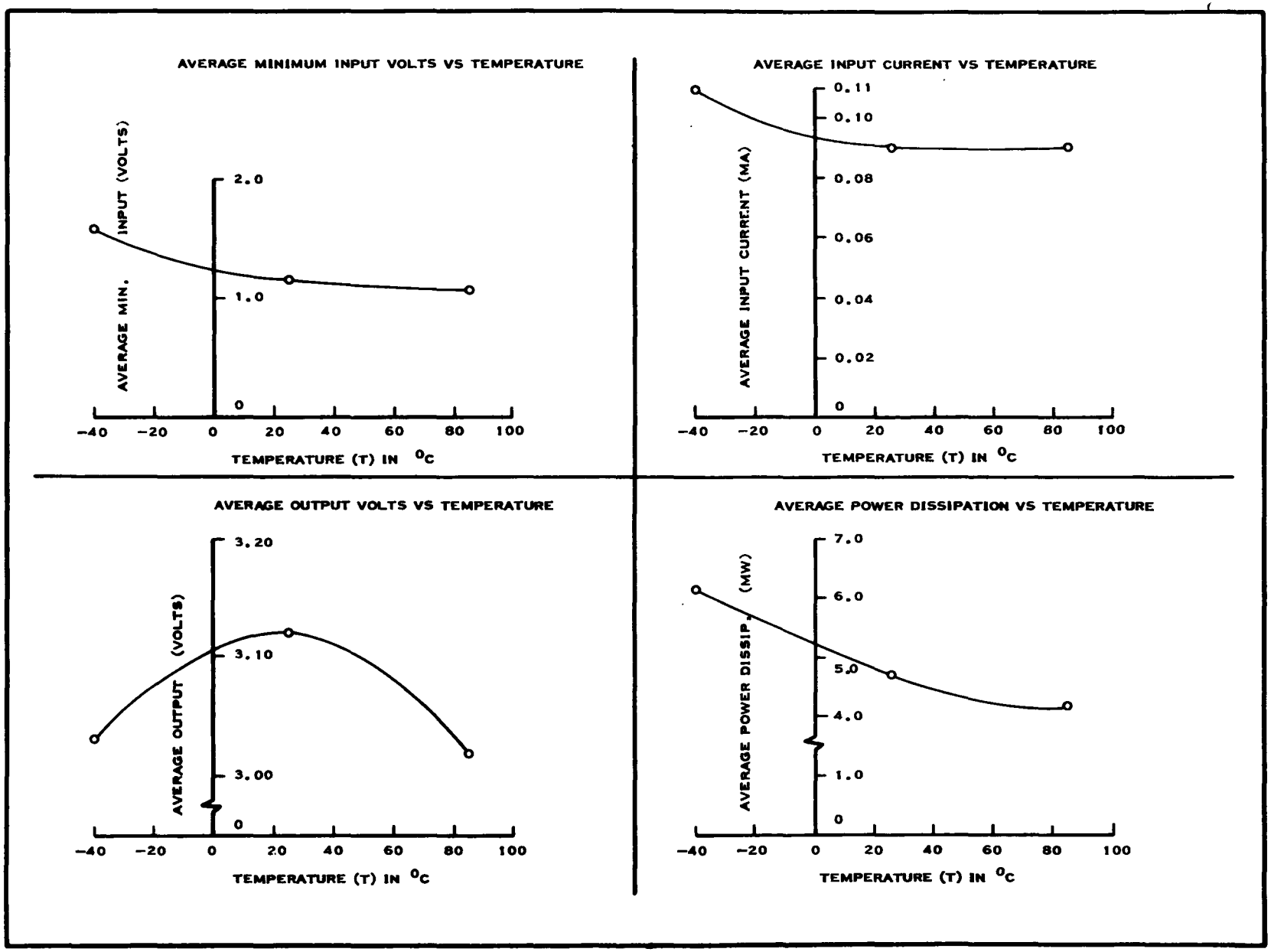

Figure 37. SN-218 Parameter Variation Versus Temperature

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ABSTRACT

This report describes the fabrication and testing of a set of functional digital circuits in semiconductor network form which would be operationally equivalent to circuits used in Signal Corps equipment. The circuit required both PNP and NPN transistor structures and include both resistor-diode gates, inverters, flip-flops and an exclusive-OR logic circuit. The semiconductor networks were formed by diffusing element paths into silicon material, using both mesa and planar configurations. Circuit test procedures are outlined and performance data is tabulated.

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