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CONTRACT NO. JPL-952309

DESIGN AND DEVELOPMENT OF A HIGH POWER, LOW SATURATION VOLTAGE, MULTI-CHIP SILICON SWITCHING TRANSISTOR

Final Progress Report

For Period Ending February 19, 1970

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INTRODUCTION

Westinghouse Electric Corporation, under Jet Propulsion Laboratory Contract JPL-952309, has made 35 unusually low saturation voltage silicon power transistors. The prime goal was a tight grouping at 100°C of $V_{CE(sat)}$ about 0.100 volts. This goal has been met. In addition to the development work in silicon processing needed to achieve this goal, a considerable mechanical redesign was also done to eliminate an instability in saturation voltage. This was caused by the cracking of a silver plated contact within the hermetic seal of the devices themselves. The plating has been eliminated and the units are now completely stable. In this report, test data is presented and discussed as well as factors leading to the final design and assembly of the units provided.

I. MECHANICAL DESIGN MODIFICATIONS

A. PROBLEMS DISCOVERED

Initially it was assumed that the transistor Pow-R-Disc$^{(T)}$ design and the dual transistor assembly could be used as shown in Figs. 1 and 3 of the final report, May 1969, for Contract No. JPL-952309. It was known that increases in $V_{CE(sat)}$ had been noted when assemblies were stored at 145°C; however, it appeared that this might be due to simple relaxation of the contact force which could be corrected either by retightening or by modifying the assembly procedure.

More detailed investigation revealed that there was bending in the heat sink contact area and there was a situation of double and conflicting constraint in the alignment of the top bus bar contacts. After correcting these items, the $V_{CE(sat)}$ was improved, but an increase was still noted after storing at 145°C. On cutting open Pow-R-Disc packages, it was found that the thinner contact discs (10-mil Teflon) were cracking the silver plating at the edge of the disc. This problem was solved by using a contact design similar to that used on stud-mounted production units. An even lower $V_{CE(sat)}$ was the result and no rise due to 145° storage was noted.

B. ASSEMBLY MODIFICATIONS

The prior design is shown in Fig. 1 from Contract JPL-952309. Referring to this sketch, the alignment grooves in Item 4, the top compression bar, served two purposes. They decreased the assembly thickness by the depth of the groove and they determined the lateral location of the dowel pins. However, the grooves in (2), the emitter contact

bar, cannot be spaced exactly the same as those in (4), especially since the spacing changes very slightly as (4) bends with loading. Since the grooves in (4) were deeper and held the dowel pin firmly, this resulted in the pin contacting (2) only on the side of at least one groove causing a very unbalanced situation.

The grooves in (2) could serve the more important function in distributing the force to the soft copper bar to avoid indentation and bending. Lateral location of the dowel pins could be accomplished by care during assembly. With the upper grooves eliminated, the dowel pins became free to align themselves in the grooves of (2). This change assured more uniform application of force to the emitters, thus obtaining more uniform contact and lower $V_{CE(sat)}$.

It was desirable to determine the actual contact force being applied in the assemblies. This was made possible by calibrating Item 4 with a force gauge. Using the resulting force vs. deflection data, it was possible to determine the contact force in an assembly. It was found that the force determined in this manner varied as much as 30% and using the specified torque and the contact force tended to be considerably more than predicted.

Even allowing for the increased mounting force, it was noted that (10), the support plate, was also deflecting more than originally predicted. This meant that the force was not uniformly distributed on the collector side of the devices because of bending in the heat sink (9) and the collector contact bar (6) as well as (10). Doubling the thickness of (10) could reduce the stress to about one fourth of the previous value and the deflection should be even less proportionately than this since relaxation (a form of creep) should no longer occur at the lower stress.

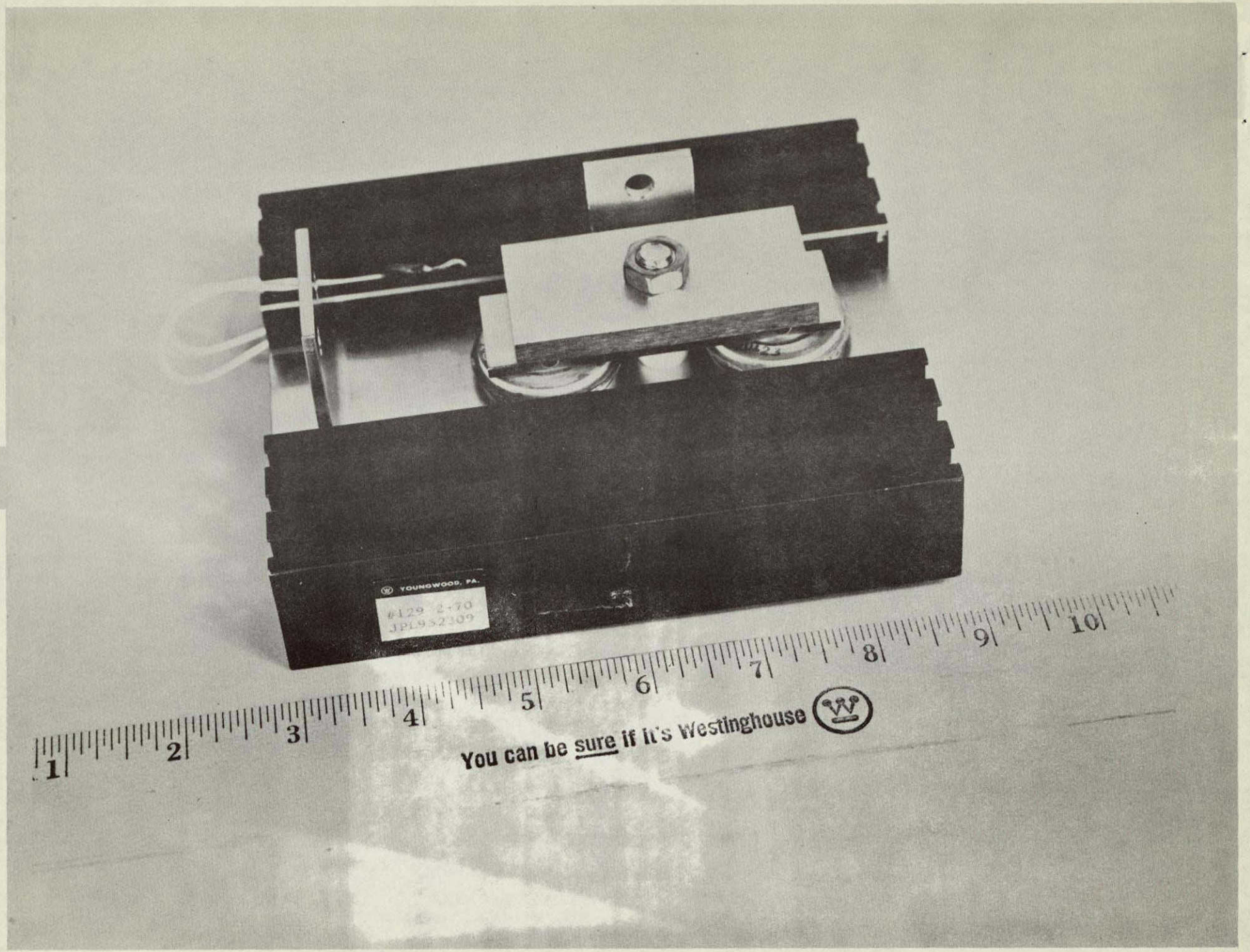
The special bolt (15) and nut (16) in Sketch A335616 seemed to fit too tightly with other parts during assembly, and it was feared that the resultant friction was causing inaccuracy in determining the loading force. It appeared the fits could be less tight with no detriment to the assembly and a standard bolt, nut, and washer could be used. At the same time, the insulator (13) could be improved by lengthening it to cover more of the bolt between the flanges of the flat packages. Also, this insulator made of PTFE Teflon(R) can now serve to align the springs (14), washer (12), and mica (11).

The new arrangement is shown in Fig. 2, Sketch A335291, attached. The bolt is shown 2 1/4" long, but it is apparent that it could be shortened. The previous bolt was 1 7/8" long. A bolt length of 2.0" was tried and found to be just right.

Other changes included going to high quality nickel plating on contacts instead of gold plating since recent experience indicated that gold plating was porous, and some evidence of subsurface corrosion was observed in parts which were gold plated.

A common thermal compound was tried on some of the first assemblies prepared according to the final design. It was found to be sufficiently viscous that a notable change in contact force was observed due to the grease flowing for a considerable time after assembly. Since heat transfer was not a significant problem in this assembly, the thermal grease was omitted in the rest of the assemblies.

The final assembly appears to be adequately stable mechanically, and the electrical data shows that it is also stable electrically.


YOUNGWOOD, PA.
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JPL952309
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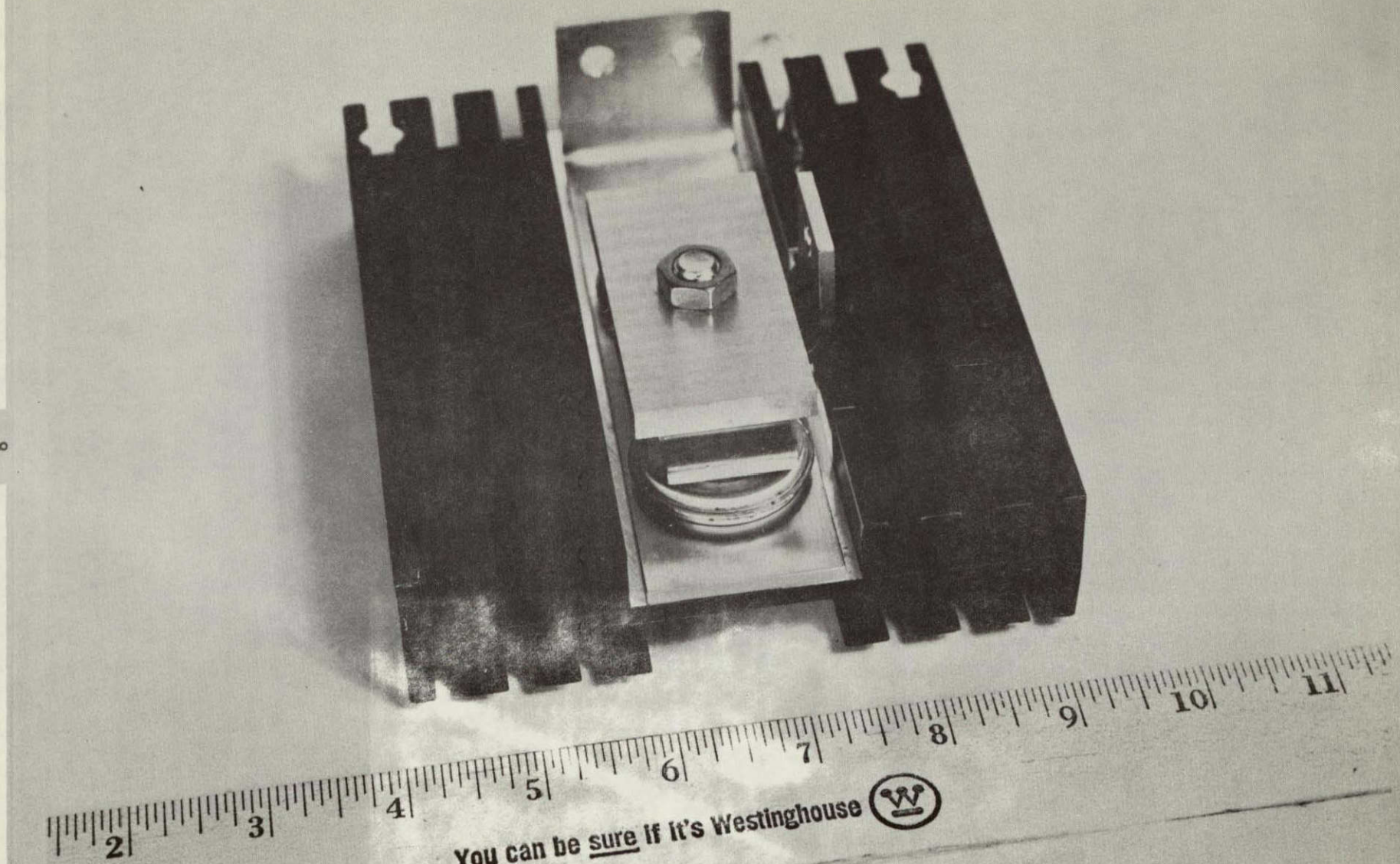
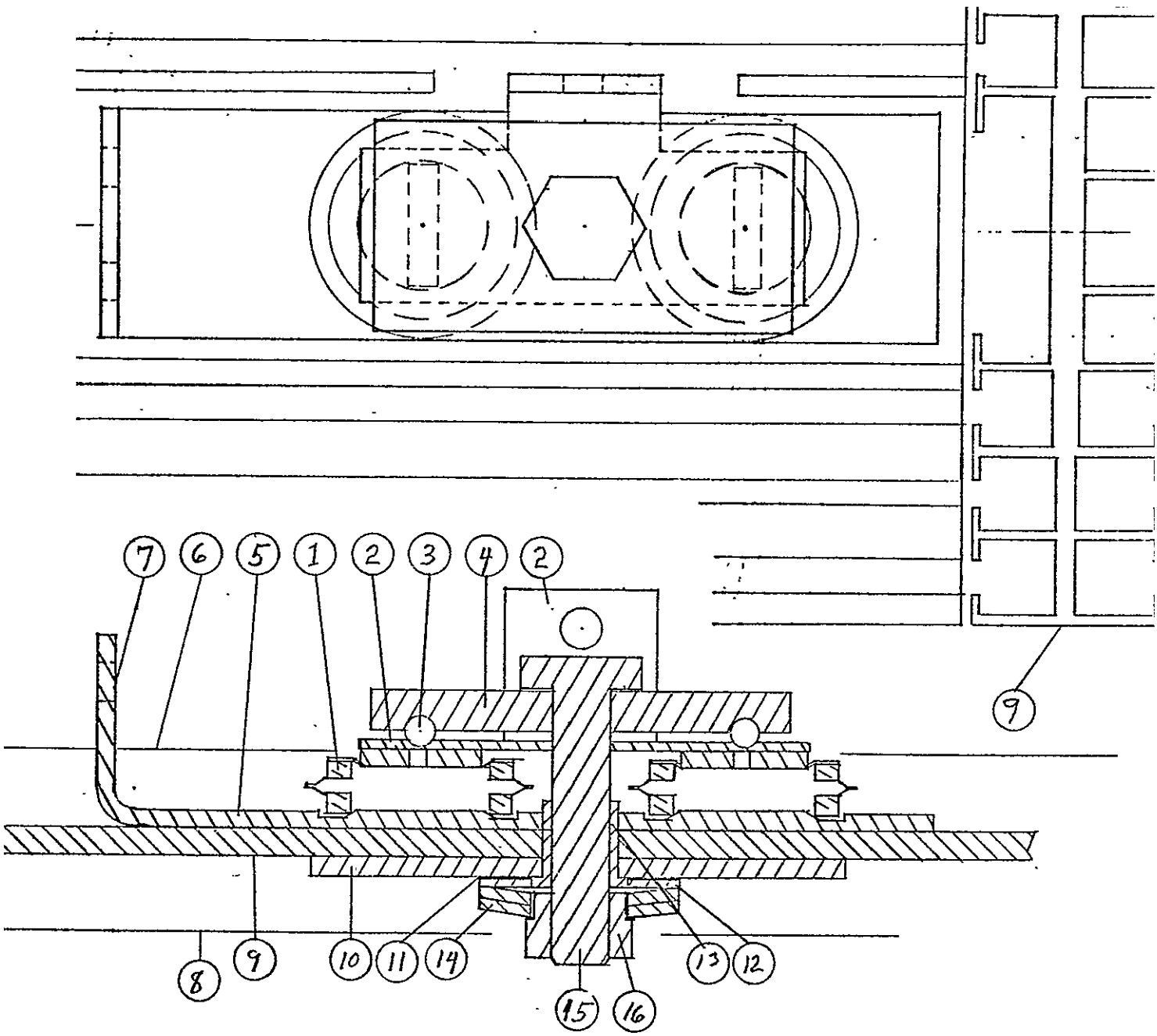
You can be sure if it's Westinghouse



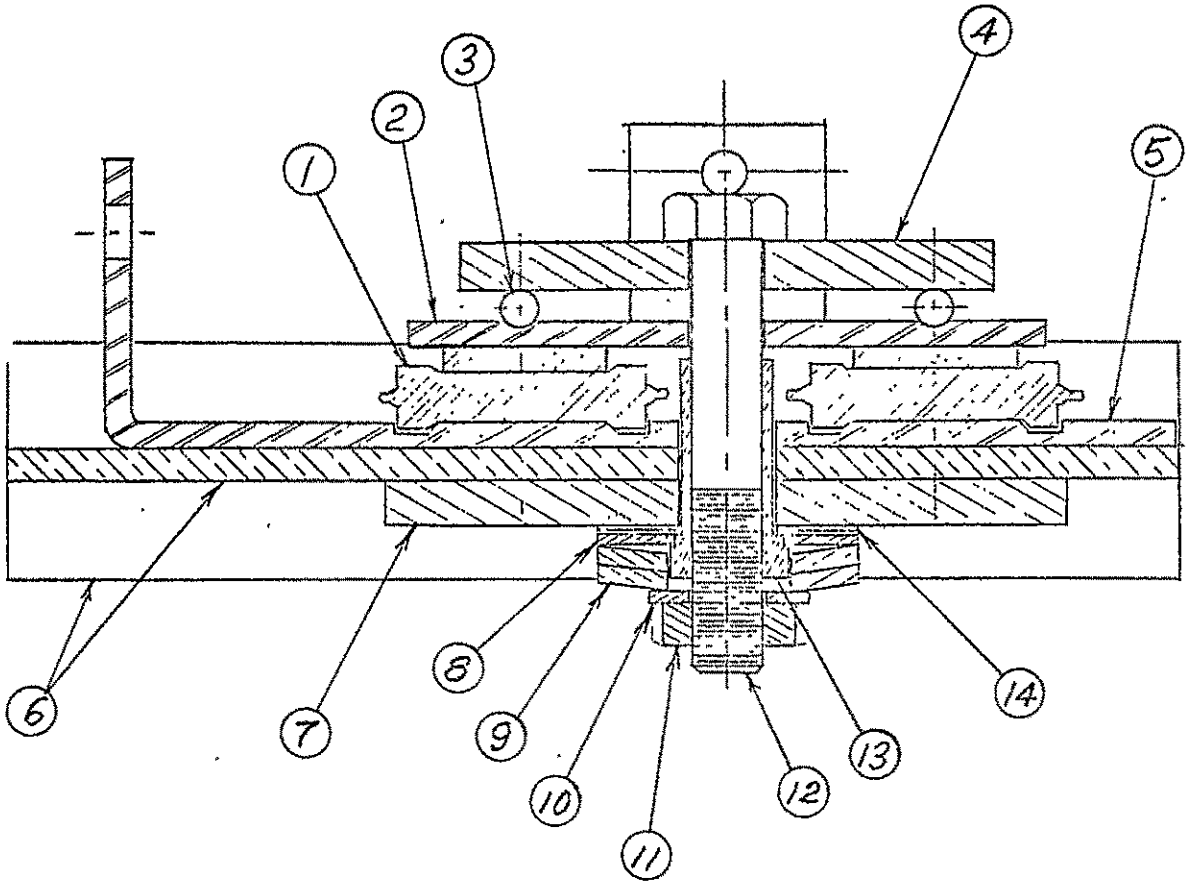
Typical Flat Pack Assembly:
Two Paralleled Low Saturation
Voltage Transistors



(1) Flat Package 1401
(2) Emitter Contact Bar
(3) Dowel Pin Aligner
(4) Top Compression Bar
(5) Collector Contact Bar
(6) Top Fin Limit
(7) Collector Contact Are
(8) Bottom Fin Limit
(9) Heat Sink
(10) Support Plate
(11) Mica Insulation
(12) Compression Washer
(13) Insulator
(14) Belleville Springs
(15) Compression Bolt
(16) Compression Nut

JPL 952309 Assembly

EDSK-A-335616



(1) Type 1402 Flat Package Transistor
(2) Emitter Contact Bus
(3) Dowel Pin
(4) Top Beam
(5) Collector Contact Bus
(6) Aluminum Heat Sink
(7) Lower Beam
(8) Thrust Washer
(9) Belleville Springs
(10) Washer
(11) 3/8 - 24 SST Nut
(12) Bolt
(13) Insulating Locator
(14) Mica Washers

LAYOUT OF JPL ASM., CONT. 952309	
H. E. Ferree 1-16-70	E.D. SK# A335291
FULL SCALE	

II. PROCESSING

The transistor chips were fabricated by the single-diffused process similar to that developed on Contract No. JPL-951303. This process was developed to minimize the saturation voltage while maintaining other characteristics within contract specifications where at all possible. When limitations of the present state-of-the-art presented any conflicts, the goal of low saturation voltage was the primary consideration.

A number of improvements to normal single-diffused processing were made in order to meet contract requirements. These include special rinses, improved gas flow in the diffusion furnace, an additional photomasking step, and improved mounting techniques.

A change in the emitter contact design was necessary due to the difficulty experienced with cracking of the silver plated onto the Teflon emitter contact disc. A contact similar to the type used in our stud-mounted devices was used with improvement of the stability of saturation voltage with temperature cycling. Other factors affecting this saturation voltage stability are discussed in the section of this report on mechanical assembly.

Due to the above change in the emitter contact within the welded Pow-R-Disc, a number of these assembled discs had to be machined open and the old style emitter contacts replaced. This resulted in the necessity of rewelding some seals with corresponding problems of leakage of some of the rewelded seals. This difficulty was the main contributing factor delaying shipping of the assemblies and also made selection of the best devices more difficult.

III. TEST RESULTS

Individual test data sheets are provided for each assembly. A total of 36 units were shipped and a data sheet is given for each assembly. However, unit #135 is considered an extra assembly and is not included in further discussion of data or presentation of average or extreme values. Unit #131 was tested for power rating and the thermocouples were left on for possible additional testing if so desired. The power test data is presented in two curves, one for the actual assembly tested and a second curve for a probable worst-case.

In addition to the test data sheets for each assembly, additional sheets give the average value and the range of test results for various characteristics. Graphs are also presented showing the distribution of each important parameter over its range of values, and the cumulative distribution of the number of assemblies with parameter values above or below any selected value. In these graphs, any units having values above the upper end of the scale are included in the last grouping. Thus, for example, the breakdown voltage grouping corresponding to 95-100 volts includes all units having breakdown voltages in excess of 100 volts. When the value of a parameter equals the value separating two groupings, the unit was counted as falling in the more favorable grouping.

With the exception of unit #102, all units met or exceeded the specifications for breakdown voltages and leakage currents. The test conditions for these parameters are indicated on the test data sheets for each assembly.

Due to the particular circuitry of the pulse gain tester used, it was impossible to check gain at 75 amps collector current and 1 volt V_{CE}.

At high currents and low voltage, the tester becomes unstable and the resultant "hunting" makes it impossible to take meaningful measurements. In a few cases this difficulty was also present at 2 volts. Gain measurements were made at collector-emitter voltages of 4, 3, and 2 volts and did not change appreciably over this range. Since the change with voltage is small and the gains measured at higher voltage are well above the specified value, there is no doubt whatsoever that all units would meet gain requirements at the specified collector-emitter voltage of 1 volt. The emitter-base voltages at these conditions were quite stable as indicated on the test data sheet showing the range of values.

The saturation voltages were measured under specified test conditions. Measurements at 100°C and at room temperature are shown. The distribution graphs show a very tight grouping of $V_{BE(sat)}$ values well below the specified maximum at 100°C. The collector-emitter saturation voltage ranged from 0.062 to 0.106 volts at room temperature and 0.074 to 0.156 volts at 100°C. At the higher temperature, 17 units had values of 0.100 or less, 25 units had values of 0.120 or less, and 29 units had values of 0.140 volts or less. The difficulty with rewelding seals that had been opened, as described earlier, was a factor in not having more units with lower values.

It was not possible to make the switching time measurements at exactly the specified conditions of base current and temperature due to equipment limitations. Six units were used for evaluation of switching time and these six agreed well enough that it was felt unnecessary to test all units. One unit was tested at both room temperature and 100°C and data from this were used to calculate temperature correction factors. Correction factors for base current drive were calculated using equations from Phillips - "Transistor Engineering." The corrected

values are shown on the test data sheets for the assemblies measured. The range of total switching time for these units was 10.7 to 14.2 microseconds, with values for four of the six units falling between 11.4 and 11.8 microseconds. The average value was 11.9 microseconds. While it was expected to perform better in this area, the long switching times are a natural trade-off in the attempt to obtain low values of $V_{CE(sat)}$. There exists a direct relationship between gain and $V_{CE(sat)}$ with higher gain resulting in lower saturation voltage. There is also a relationship between gain and switching time and the decision to do both processing and selection of units to achieve high gain in order to lower the saturation voltage resulted in a less favorable switching time performance.

Final Caution

Low values of saturation voltage depend critically upon the residual resistances external to the silicon wafer as well as on the wafer itself. Those residual resistances are determined by the mechanical assembly. Do not attempt to disassemble the unit or to change the bolt torque. Minor changes in part strains and in seatings will cause $V_{CE(sat)}$ to rise.

HIGH POWER, LOW SATURATION VOLTAGE

SILICON SWITCHING TRANSISTOR

PER: JET PROPULSION LABORATORY
ENGINEERING NOTE NO. 342-015

AVERAGE VALUES

$V_{CE(sat)}$ and Gain Measurements at 25°C ± 5°C

$V_{CE(sat)}$ = .085 V (I_B = 5A, I_C = 75A)
$V_{BE(sat)}$ = .847 V (I_B = 5A, I_C = 75A)
Gain 175, 168, 170 (I_C = 75A, V_{CE} = 4,3,2V)
V_{BE} = .730 V, .732 V, .736 V (I_C = 75A, V_{CE} = 4,3,2V)

$V_{CE(sat)}$ and Gain Measurements at 100°C ± 5°C

$V_{CE(sat)}$ = .108 V (I_B = 5A, I_C = 75A)
$V_{BE(sat)}$ = .768 V (I_B = 5A, I_C = 75A)
Gain = 183, 178, 164 (I_C = 75A, V_{CE} = 4,3,2V)
V_{BE} = .634 V, .631 V, .634 V (I_C = 75A, V_{CE} = 4,3,2V)

Breakdown Voltages	Excluding Assembly 102
BV_{EBO} = 10.3 V @ I_{EBO} = 10 mA	10.49 V
BV_{CBO} = 63.5 V @ I_{CBO} = 10 mA	64.9 V
BV_{CEO} = 50.0 V @ I_{CEO} = 10 mA	49.9 V
BV_{CES} = 52.8 V @ I_{CES} = 10 mA	54.1 V

Leakage Currents	Excluding Assembly 102
I_{EBO} = 1.79 mA @ V_{EBO} = 4V	1.48 mA
I_{CBO} = 0.67 mA @ V_{CBO} = 20V	0.34 mA
I_{CEO} = 2.14 mA @ V_{CEO} = 20V	1.62 mA
I_{CES} = 1.79 mA @ V_{CES} = 20V	1.26 mA

Switching Time

$t_d + t_r$ = ____ µs, t_s = ____ µs, t_f = ____ µs
Total Switching Time = ____ µs (I_C = 75A, I_B = 5A, V_{BE} = -1.5V on turn-off)

HIGH POWER, LOW SATURATION VOLTAGE

SILICON SWITCHING TRANSISTOR

PER: JET PROPULSION LABORATORY
ENGINEERING NOTE NO. 342-015

RANGE OF VALUES

$V_{CE(sat)}$ and Gain Measurements at 25°C ± 5°C

$V_{CE(sat)}$ = .062/.106 V (I_B = 5A, I_C = 75A)
$V_{BE(sat)}$ = .79/1.46 V (I_B = 5A, I_C = 75A)
Gain 62/417, 65/395, 68/417 (I_C = 75A, V_{CE} = 4,3,2V)
V_{BE} = .70/.79 V, .69/.78 V, .68/.76 V (I_C = 75A, V_{CE} = 4,3,2V)

$V_{CE(sat)}$ and Gain Measurements at 100°C ± 5°C

$V_{CE(sat)}$ = .074/.156 V (I_B = 5A, I_C = 75A)
$V_{BE(sat)}$ = .71/1.16 V (I_B = 5A, I_C = 75A)
Gain = 57/441, 55/469, 53/417 (I_C = 75A, V_{CE} = 4,3,2V)
V_{BE} = .60/.76 V, .60/.74 V, .60/.74 V (I_C = 75A, V_{CE} = 4,3,2V)

Breakdown Voltages — Excluding Assembly 102

BV_{EBO} = 9.9/14 V @ I_{EBO} = 10 mA	4.5/14
BV_{CBO} = 15/>100 V @ I_{CBO} = 10 mA	8/>100
BV_{CEO} = 7/>100 V @ I_{CEO} = 10 mA	<1/>100
BV_{CES} = 7/>100 V @ I_{CES} = 10 mA	21/>100

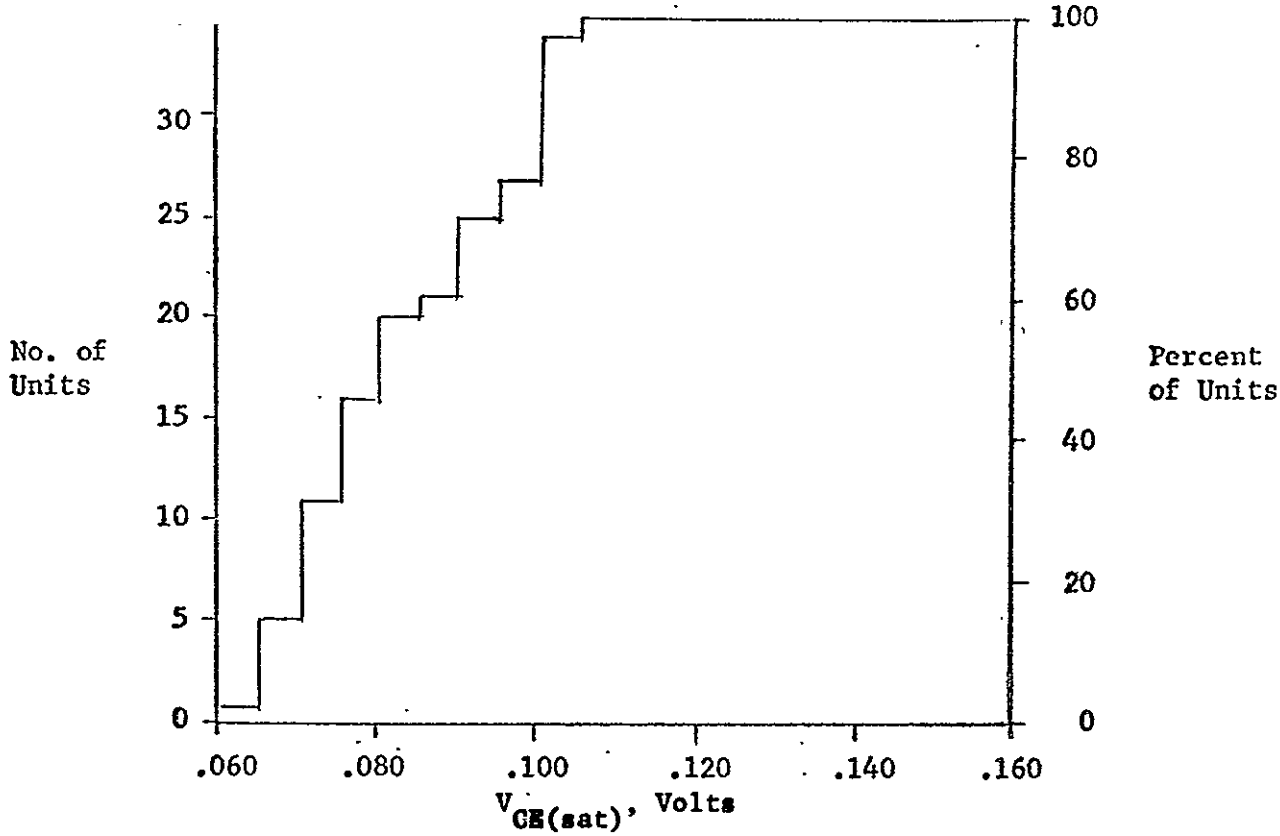
Leakage Currents — Excluding Assembly 102

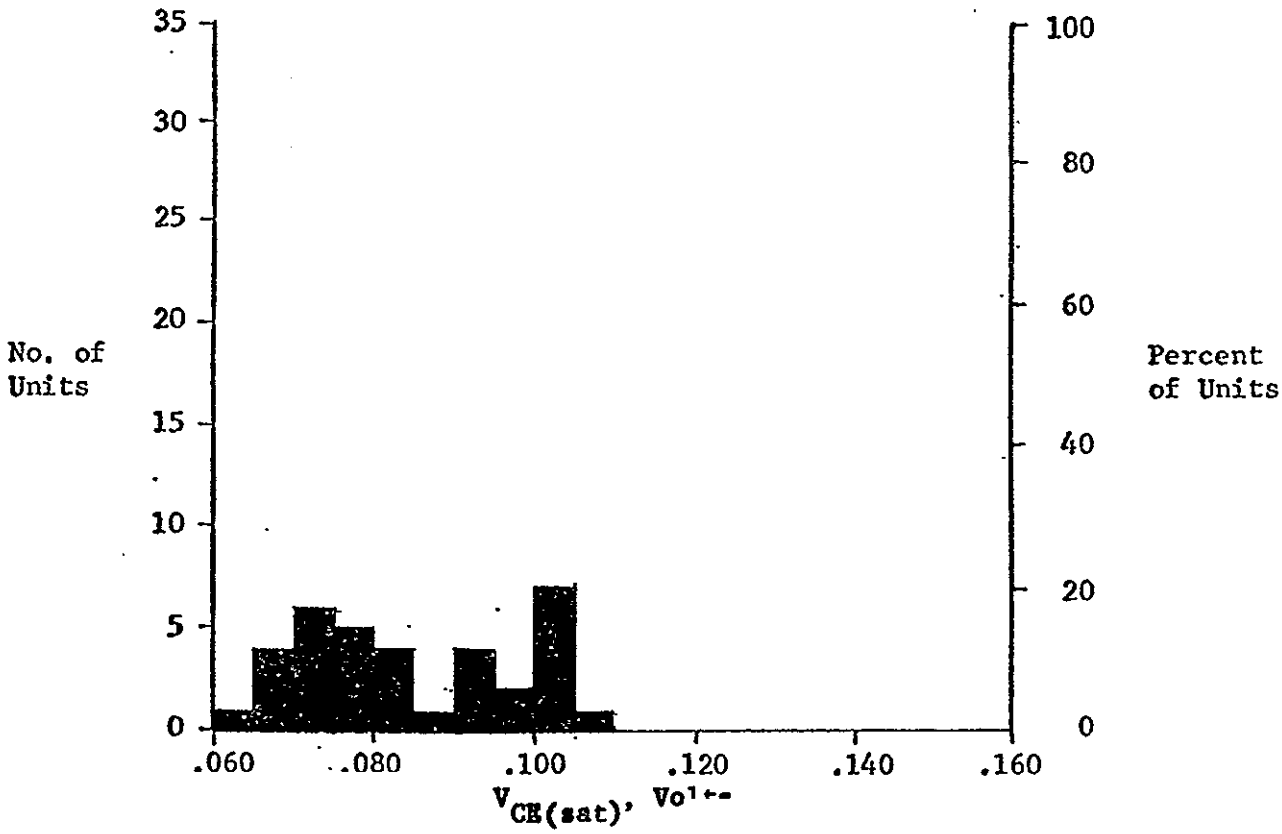
I_{EBO} = <0.1/45 mA @ V_{EBO} = 4V	<0.1/8
I_{CBO} = <0.1/12 mA @ V_{CBO} = 20V	<0.1/2
I_{CEO} = <0.1/20 mA @ V_{CEO} = 20V	<0.1/9
I_{CES} = <0.1/20 mA @ V_{CES} = 20V	<0.1/9

Switching Time

$t_d + t_r$ = ____ µs, t_s = ____ µs, t_f = ____ µs
Total Switching Time = ____ µs (I_C = 75A, I_B = 5A,
V_{BE} = -1.5V on turn-off)

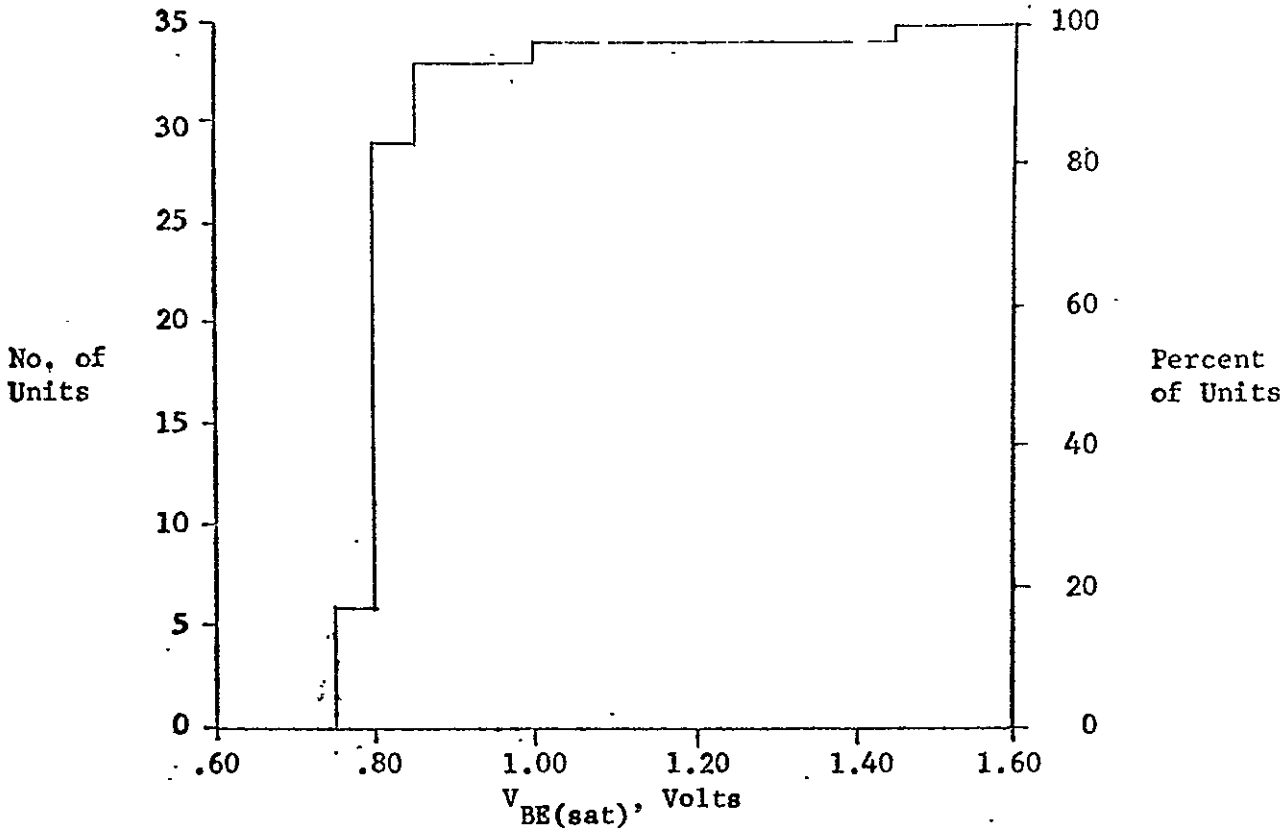
Parameter $\frac{V_{CE(sat)}}{R.T.}$ Units Volts

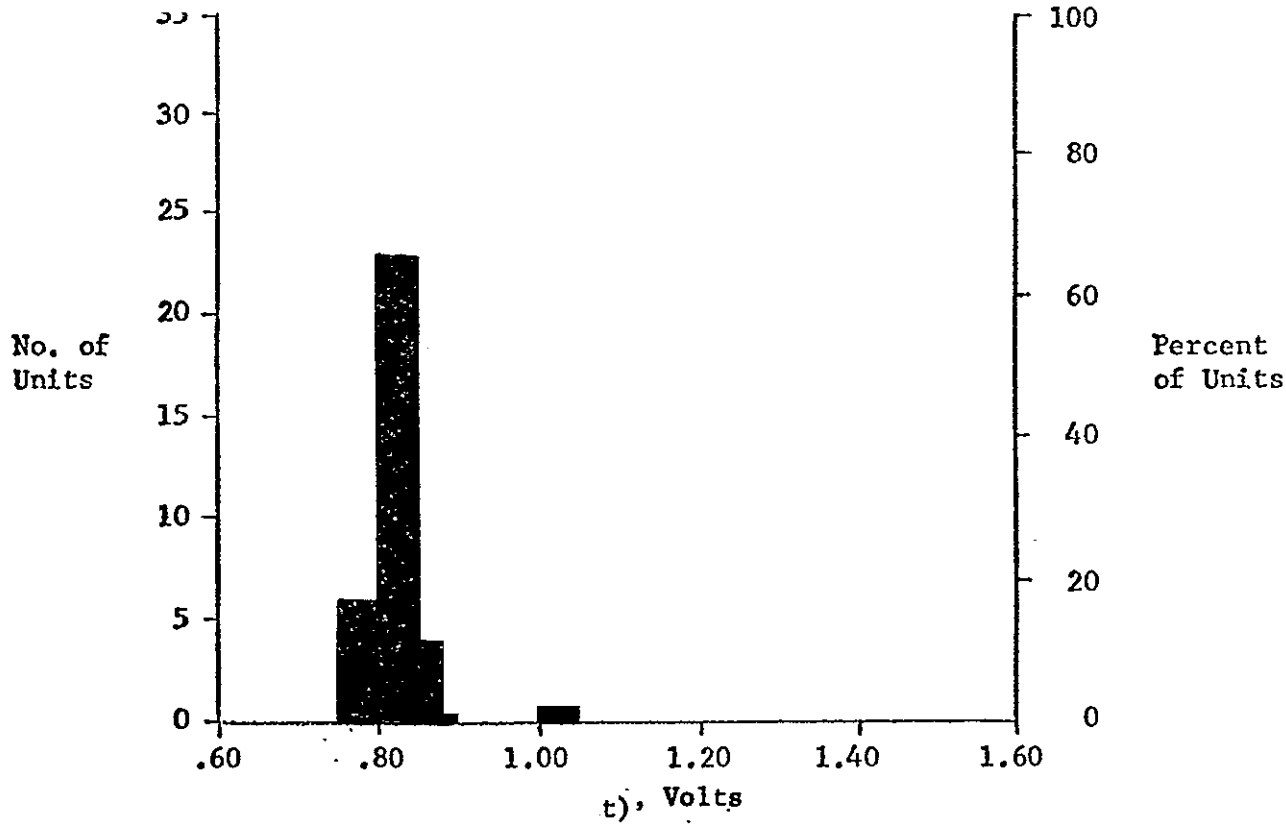




Parameter $V_{BE(sat)}$ Units Volts

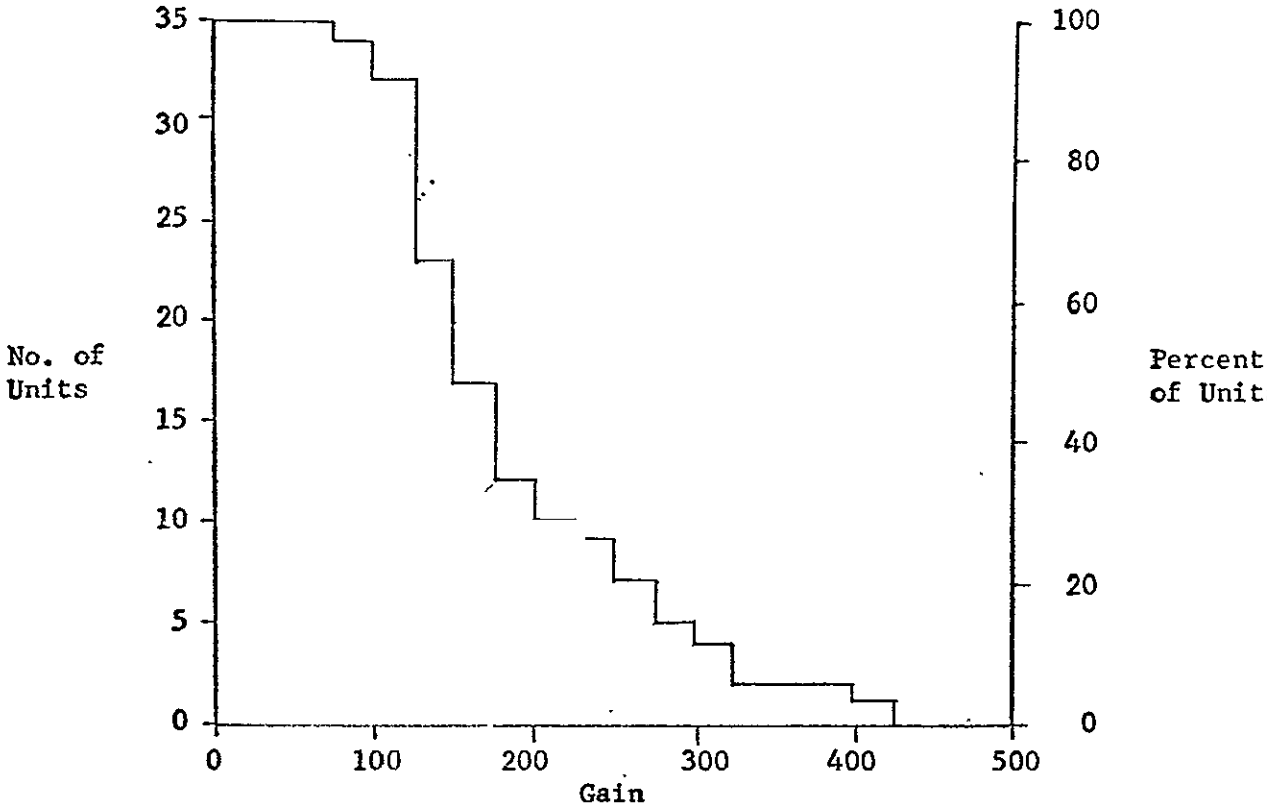
R.T.

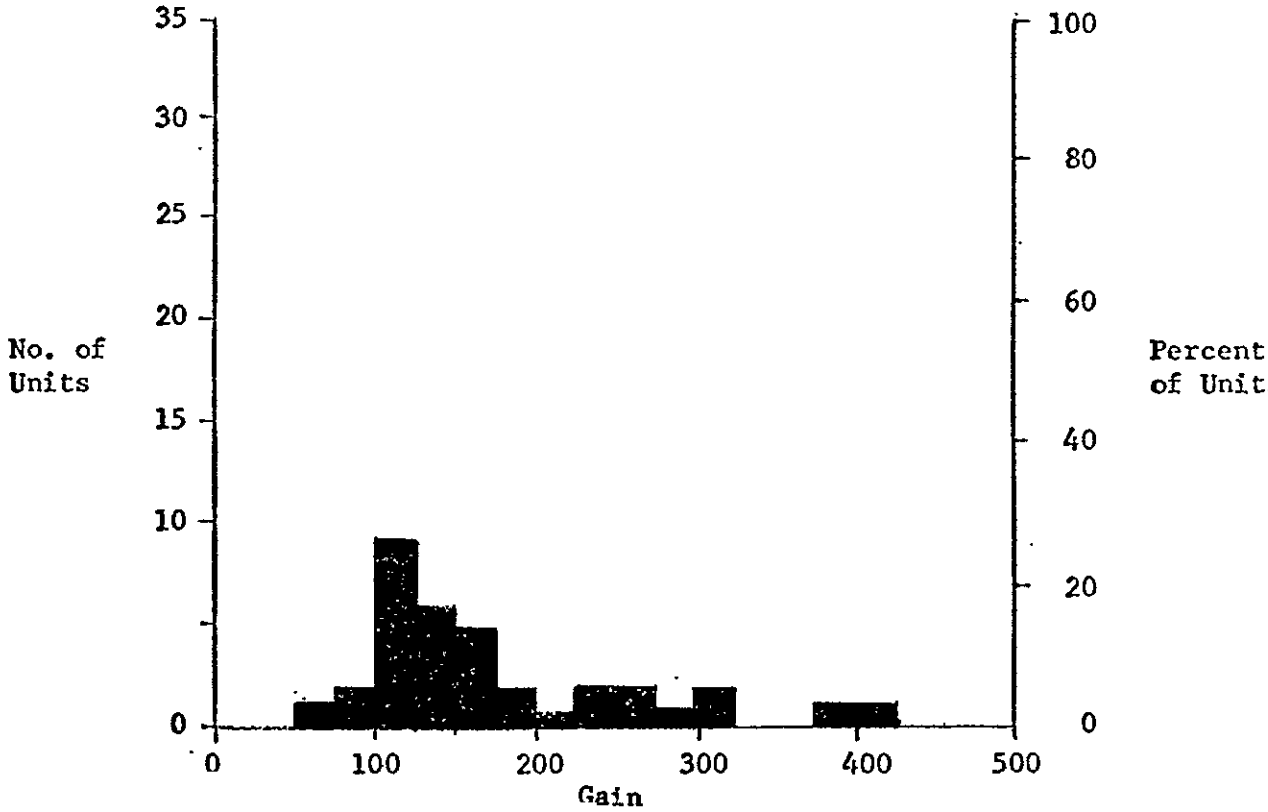




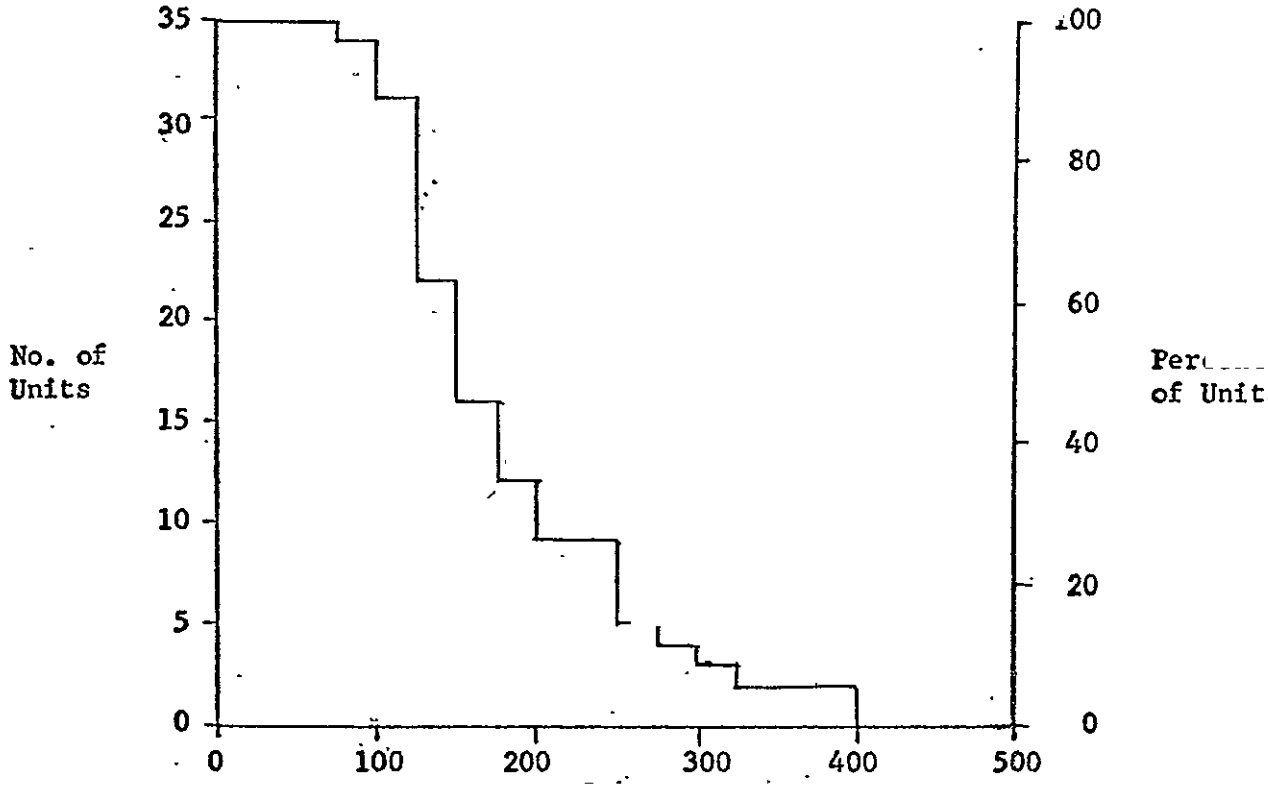
Parameter Gain @ 4V Units ____

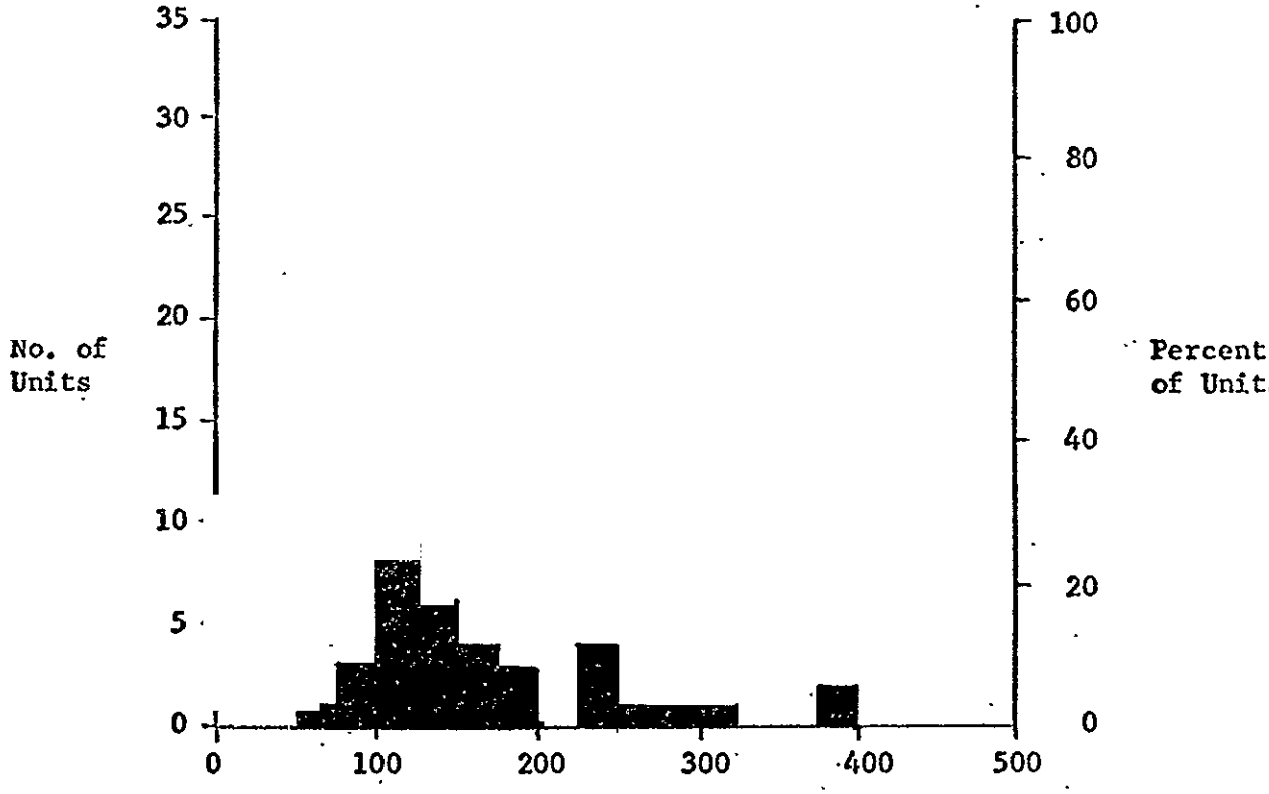
R.T.



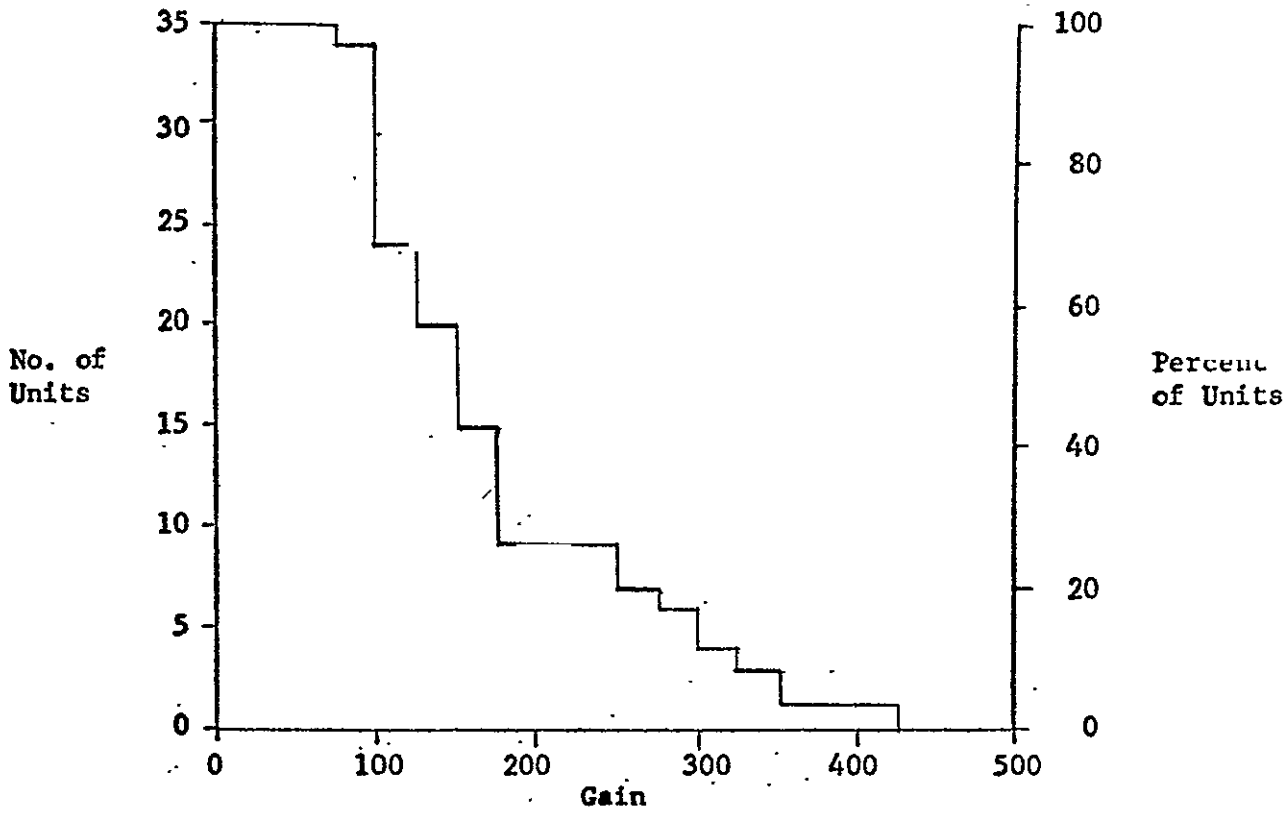


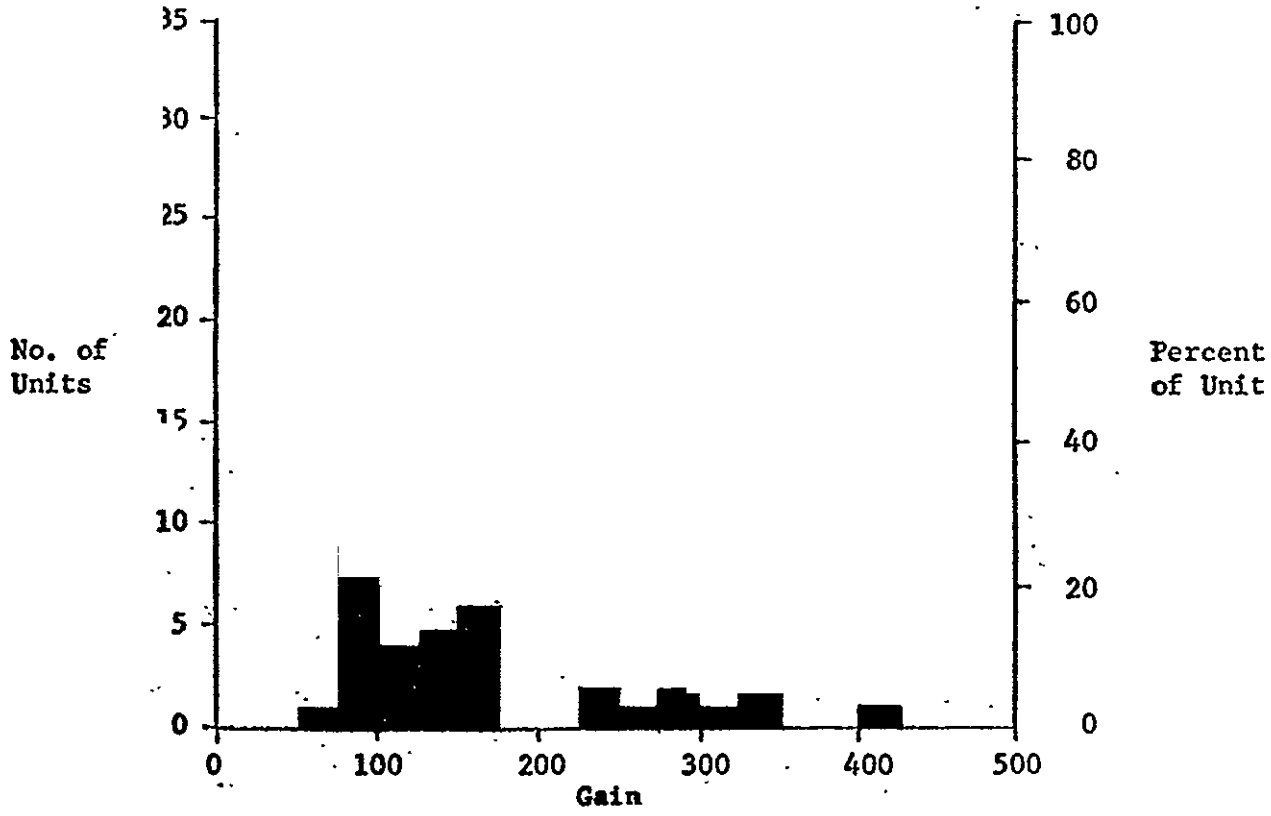
Parameter Gain @ 3V Units ____
R.T.



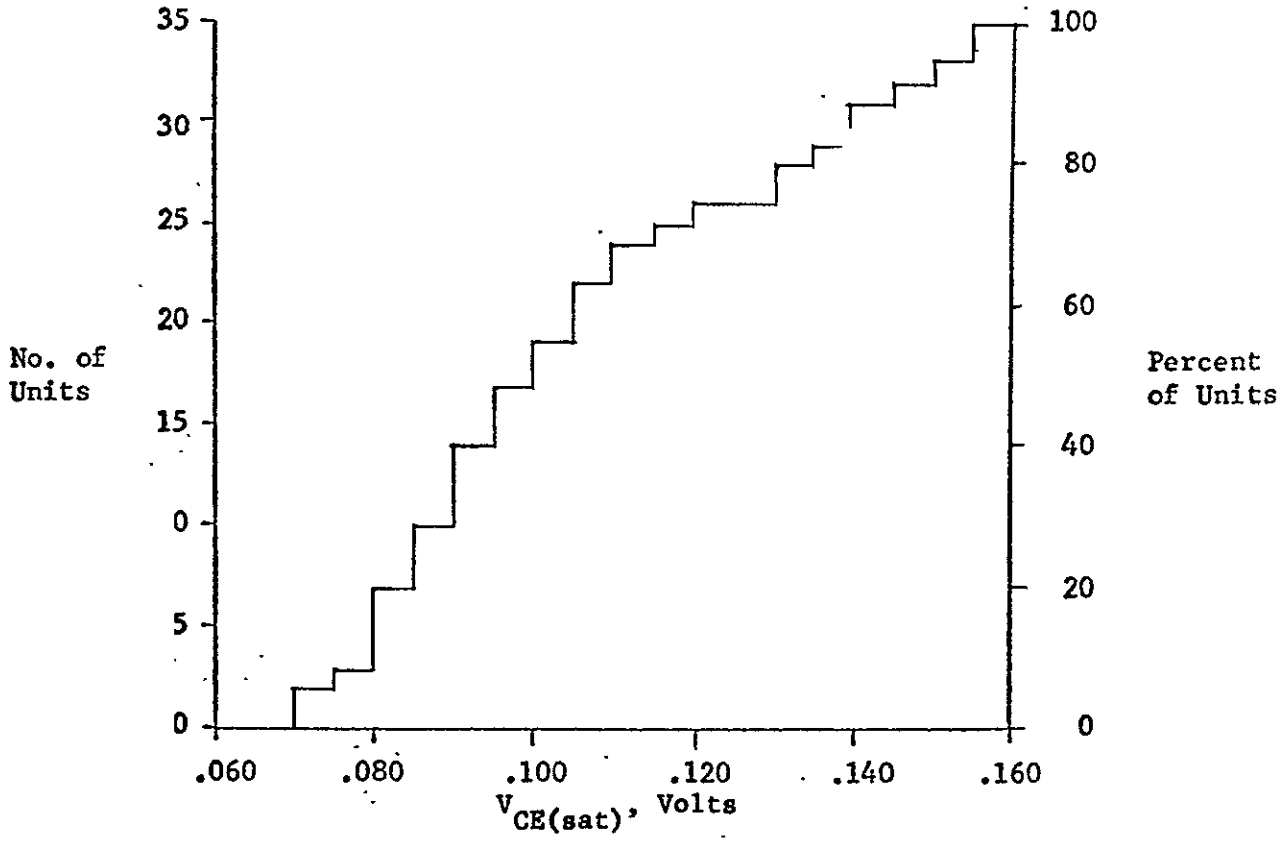


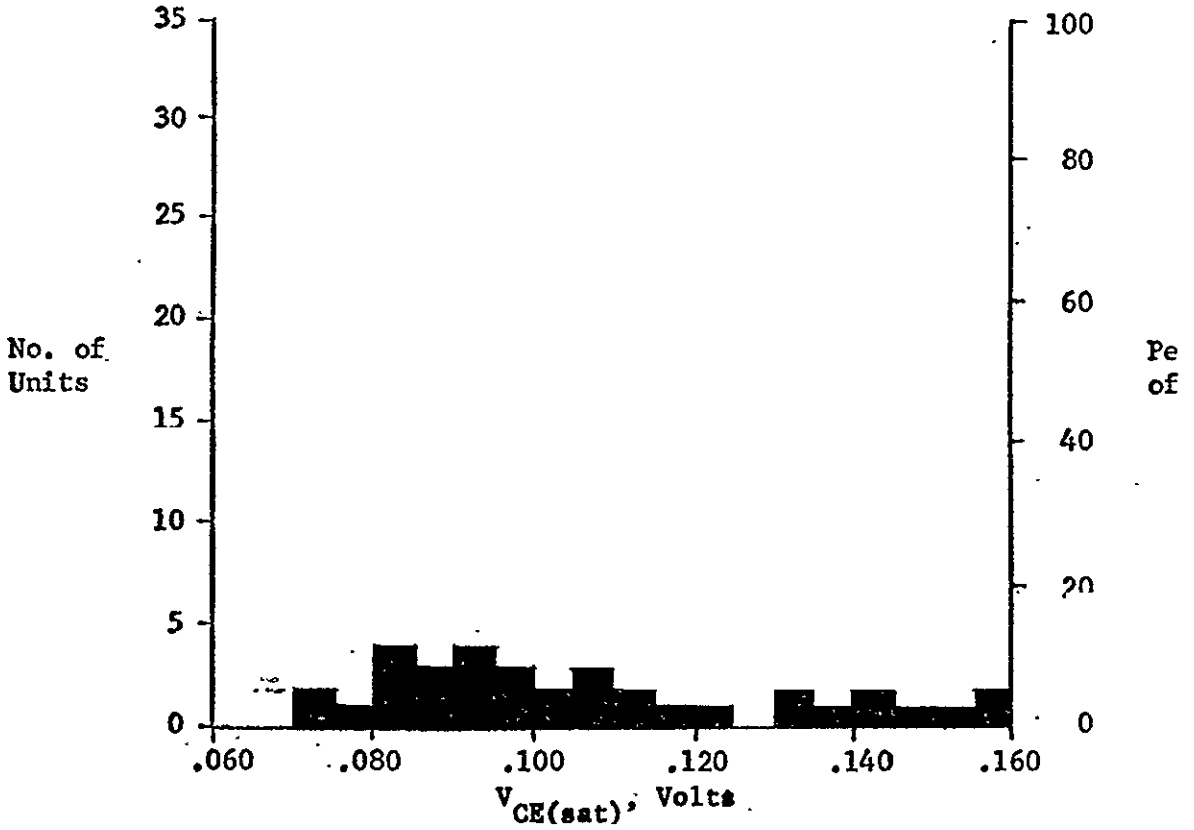
Parameter Gain @ 2V Units
R.T.



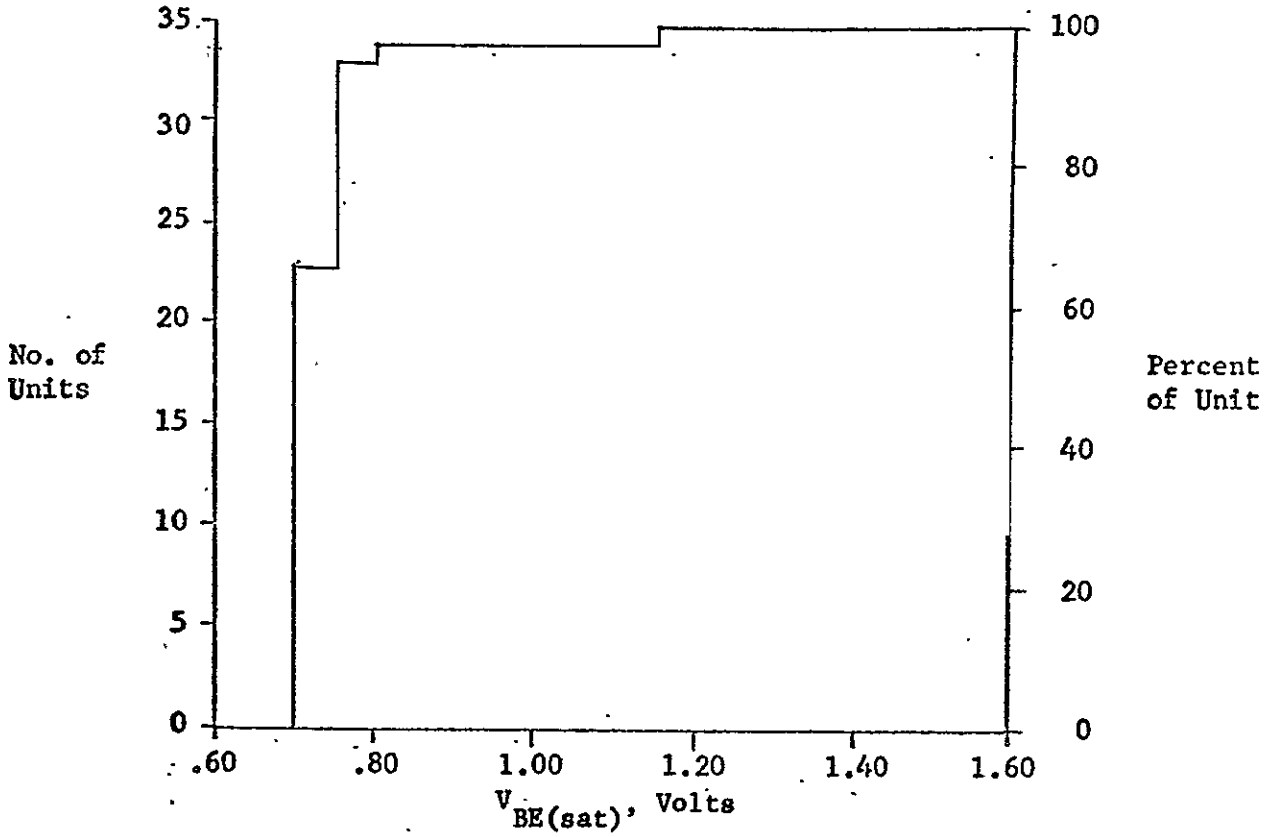


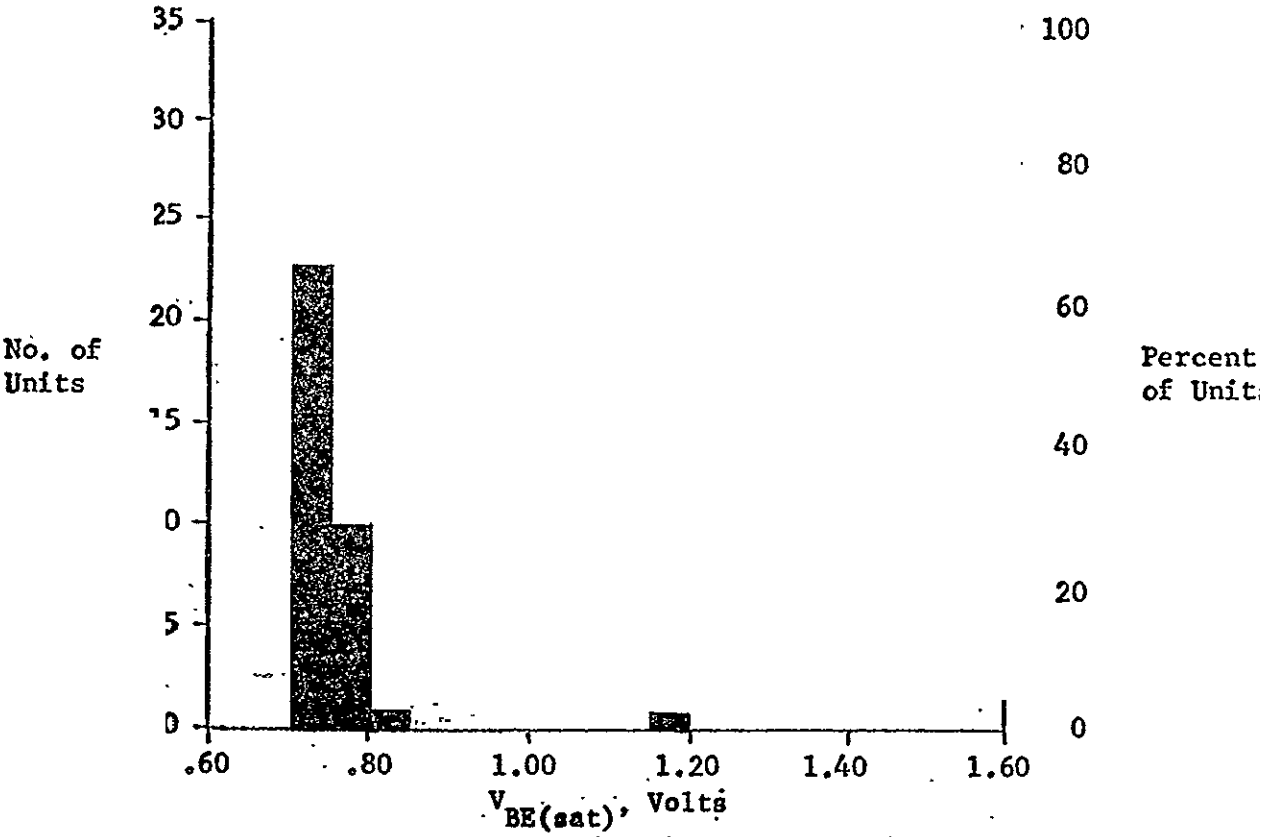
:ameter $\frac{V_{CE(sat)}}{100°C}$ Units Volts





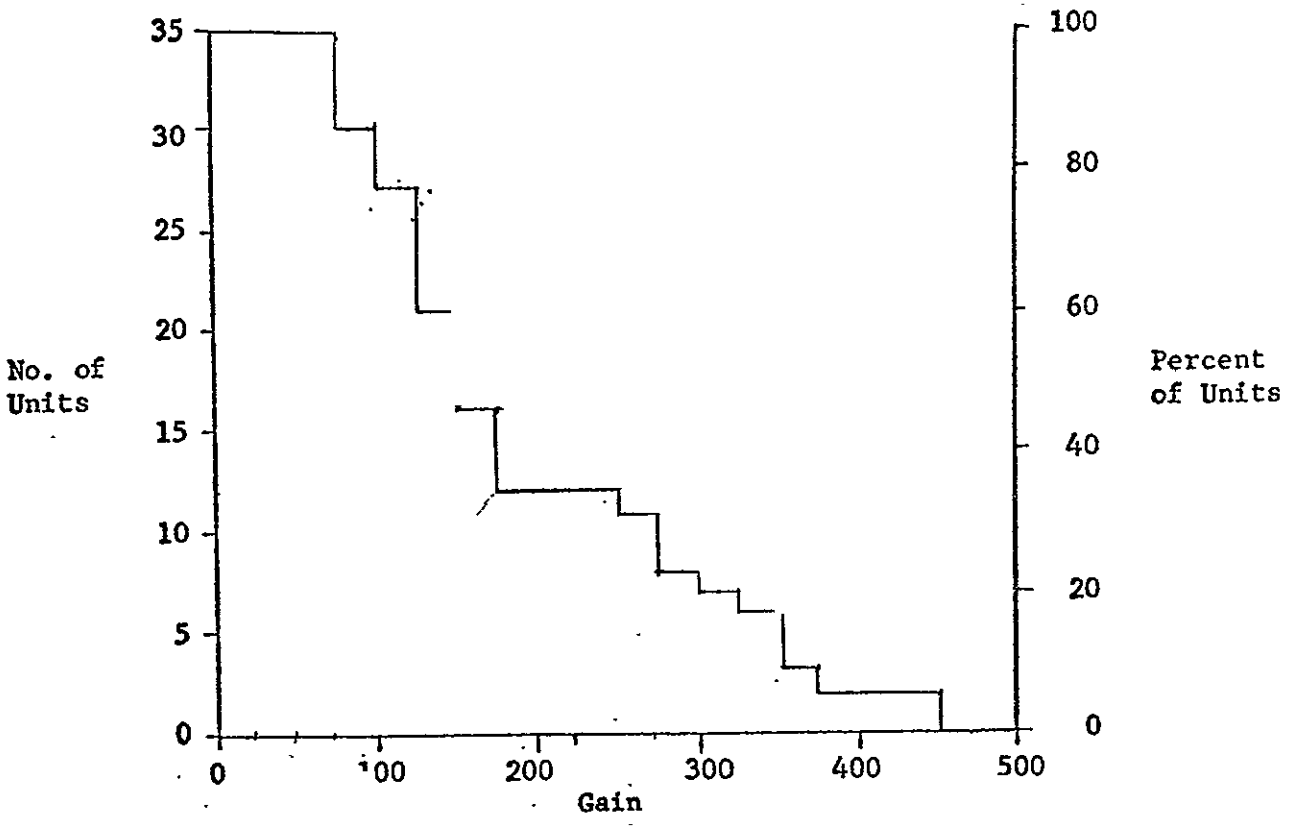
Parameter $\frac{V_{BE(sat)}}{100°C}$ Units Volts

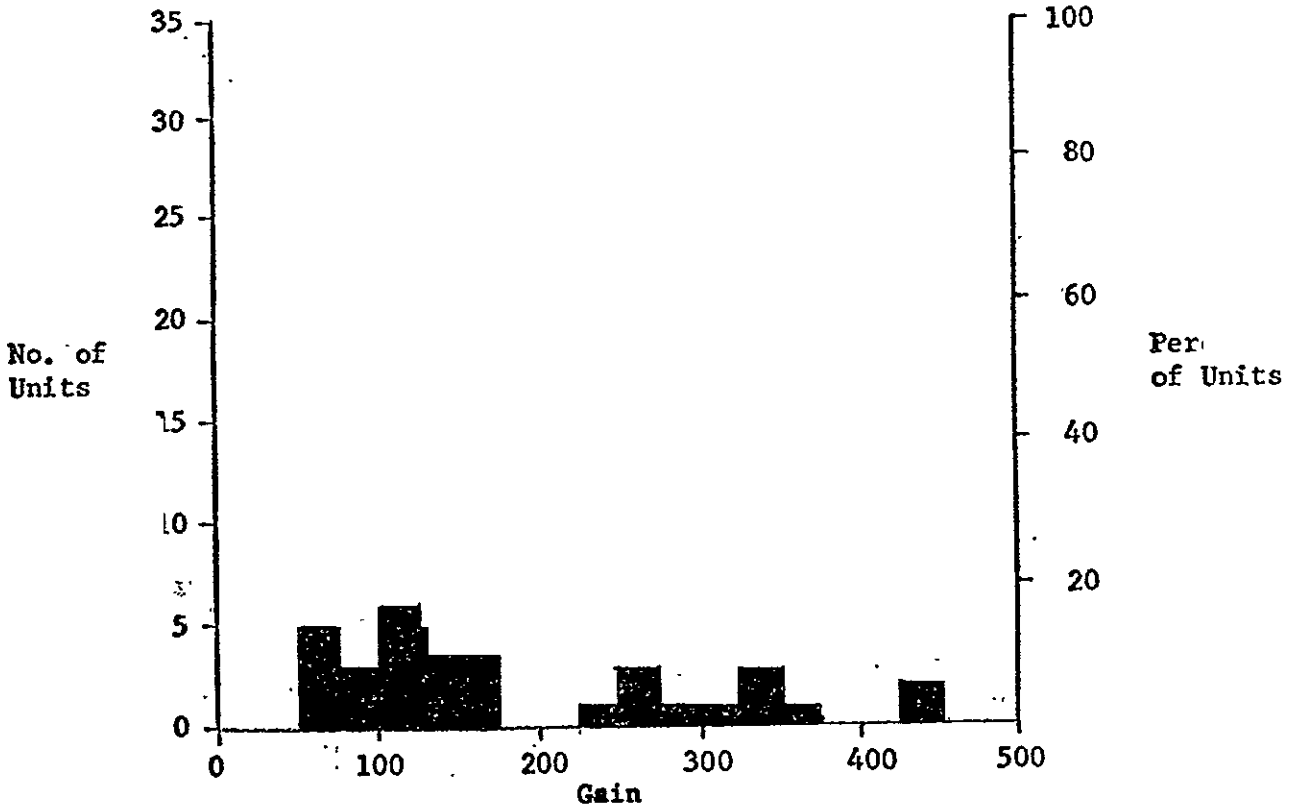




Parameter Gain @ 4V. Units ____

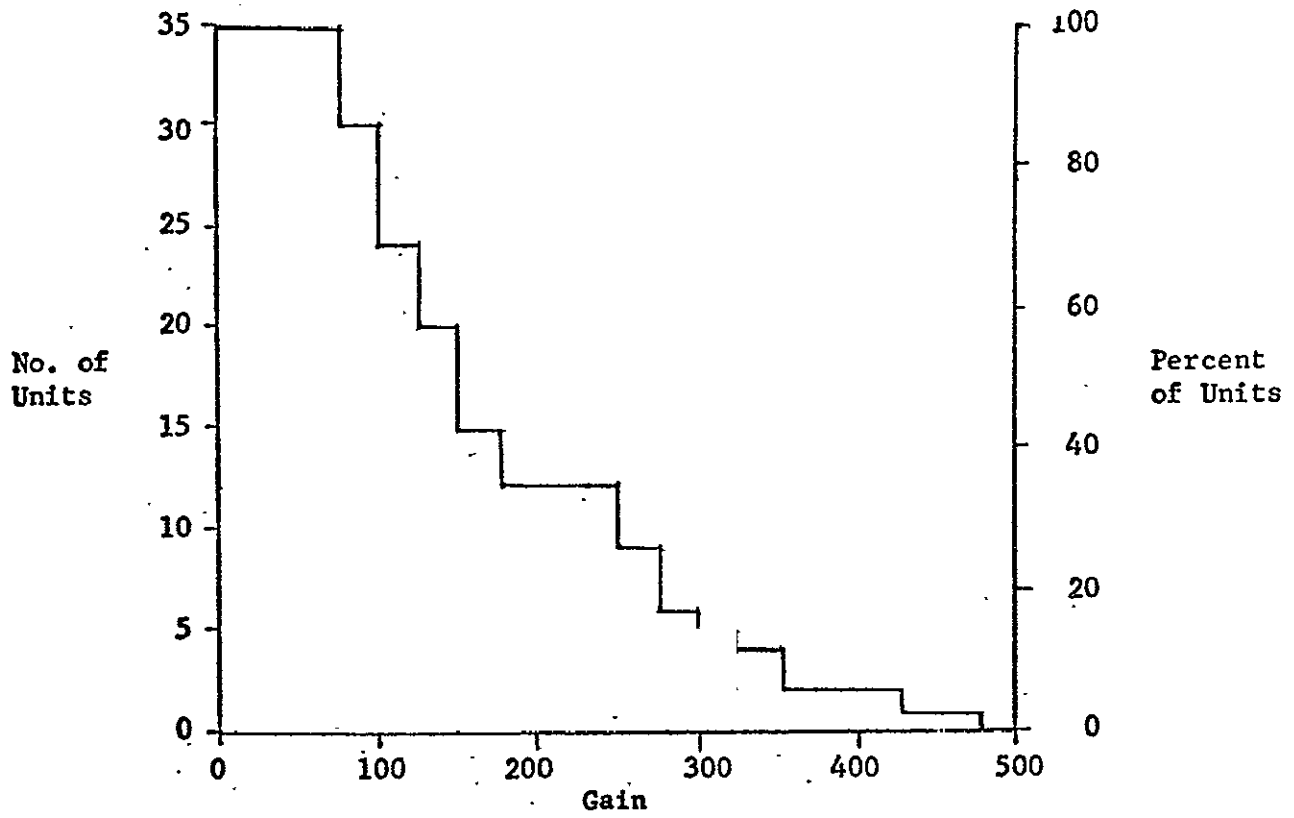
100°C

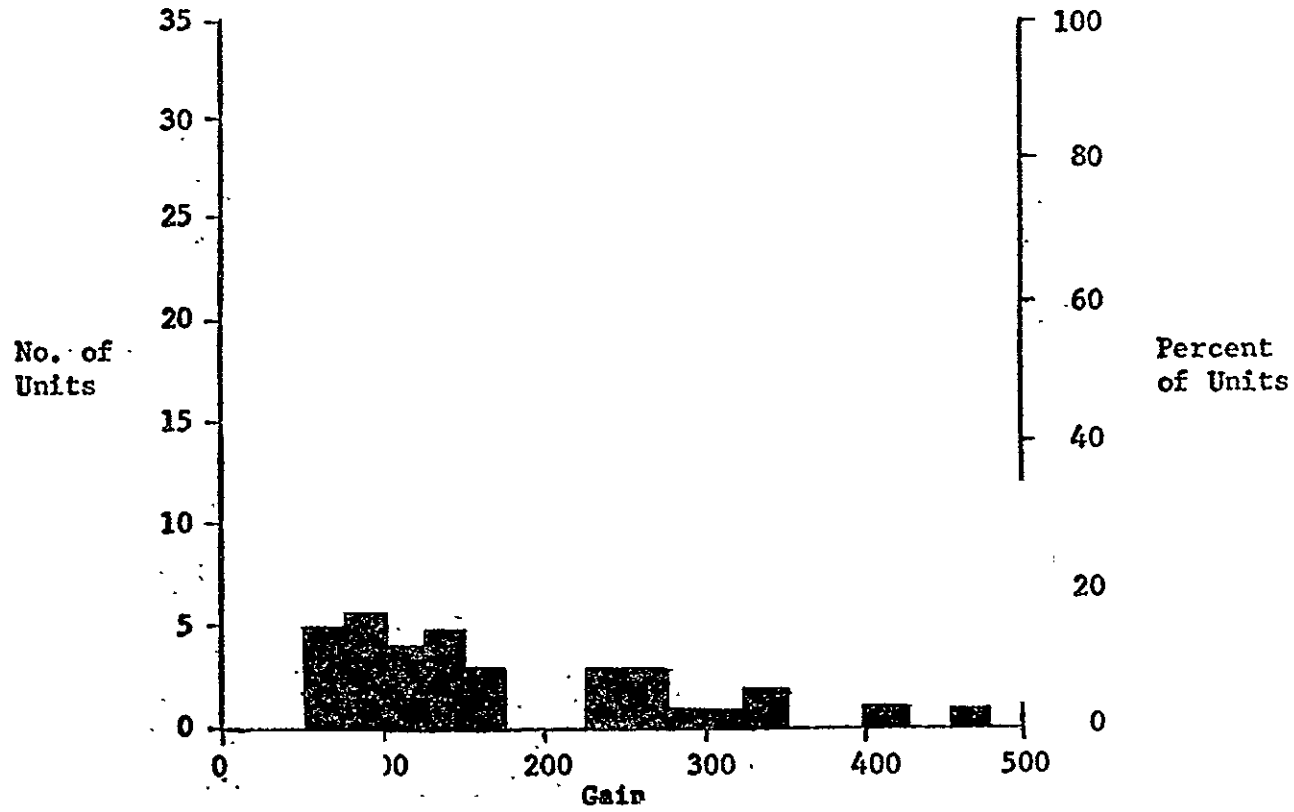




Parameter Gain @ 3V Units ____

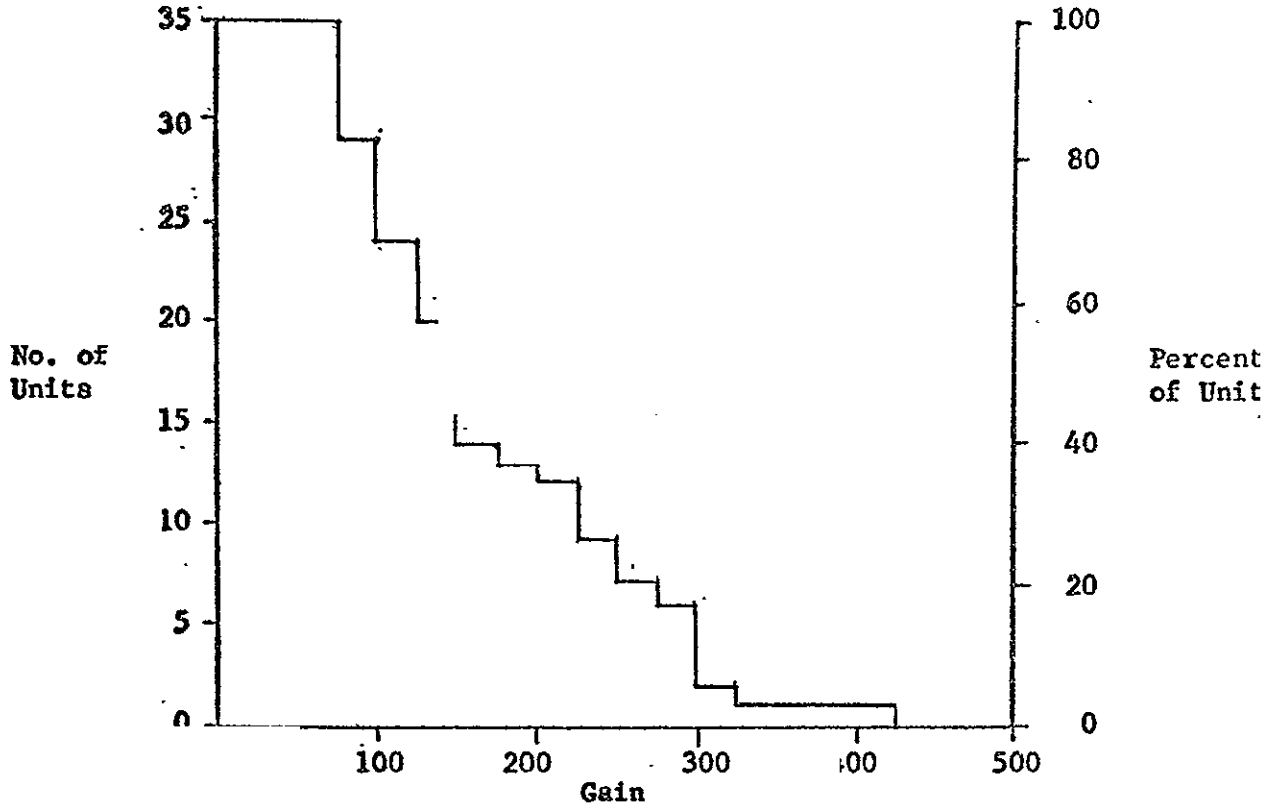
100°C

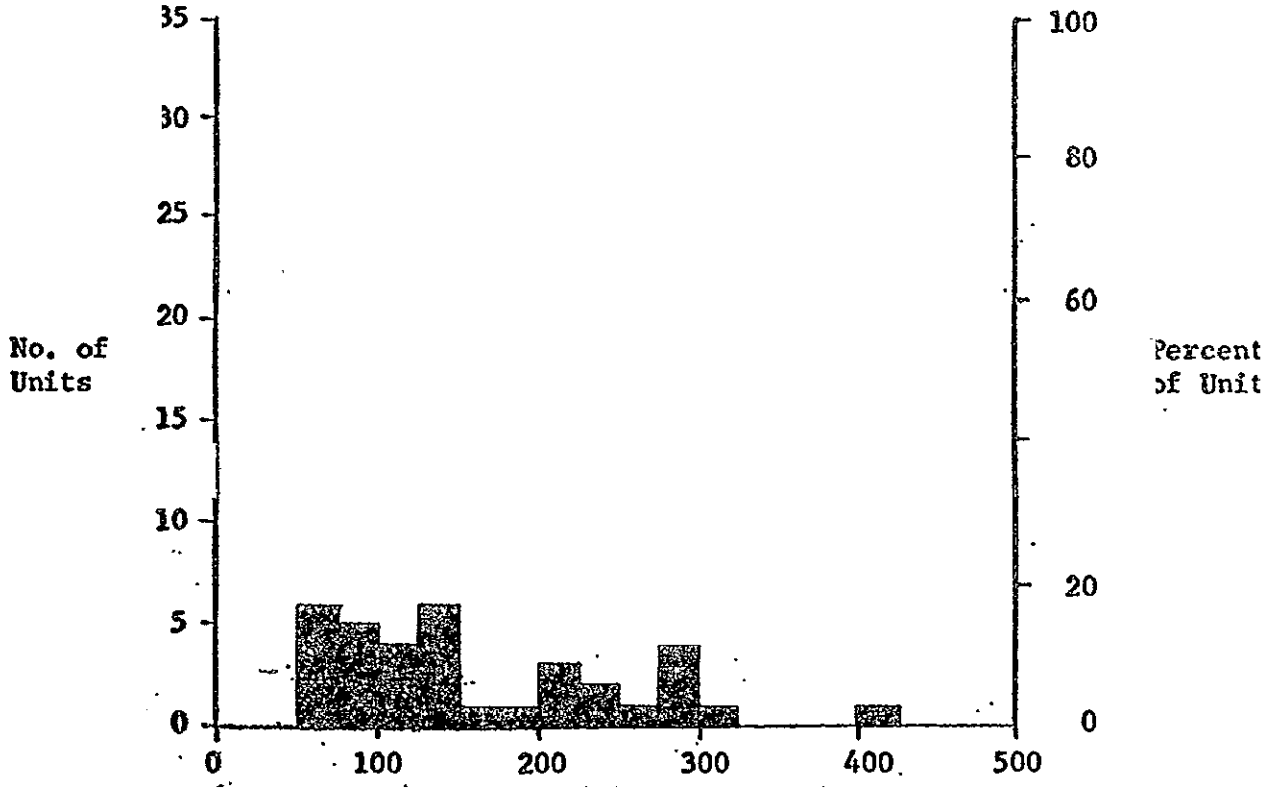




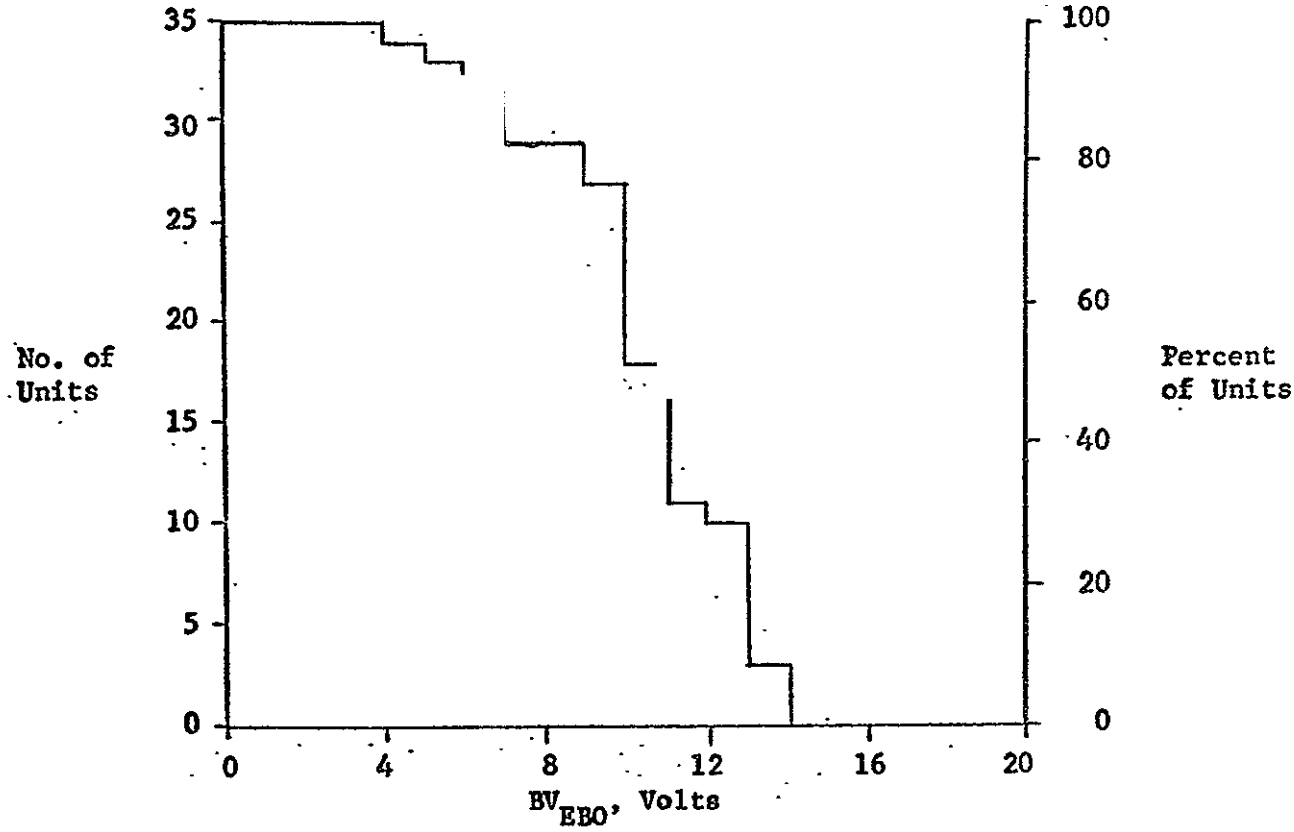
Parameter Gain @ 2V Units ____

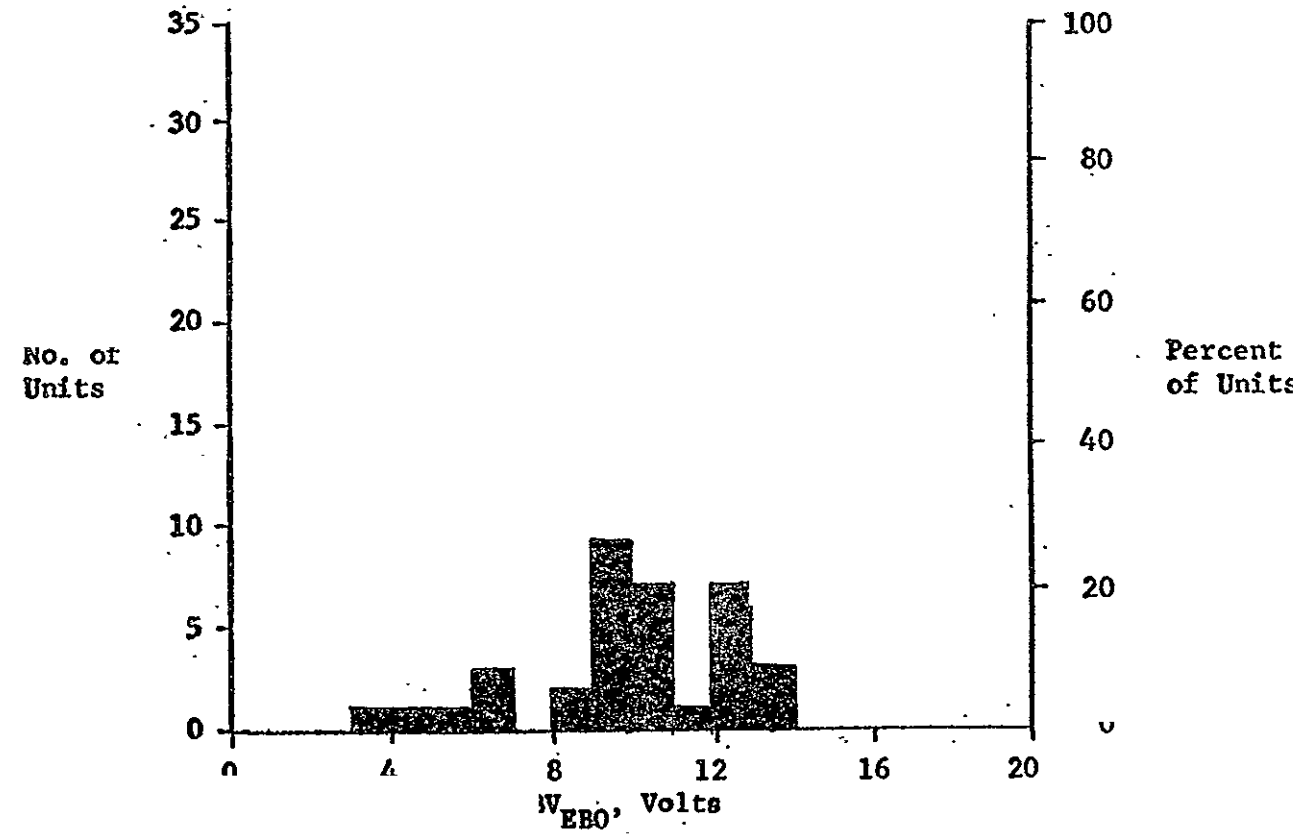
100°C



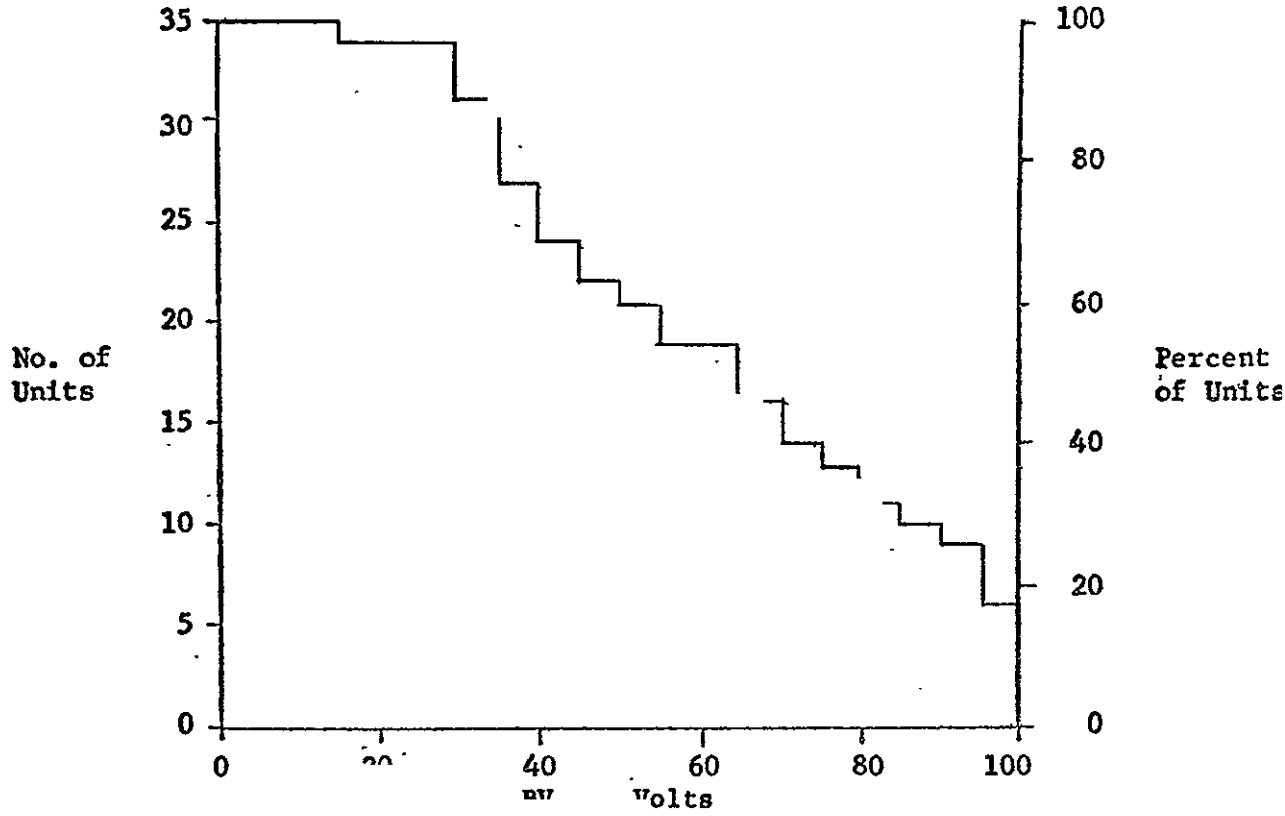


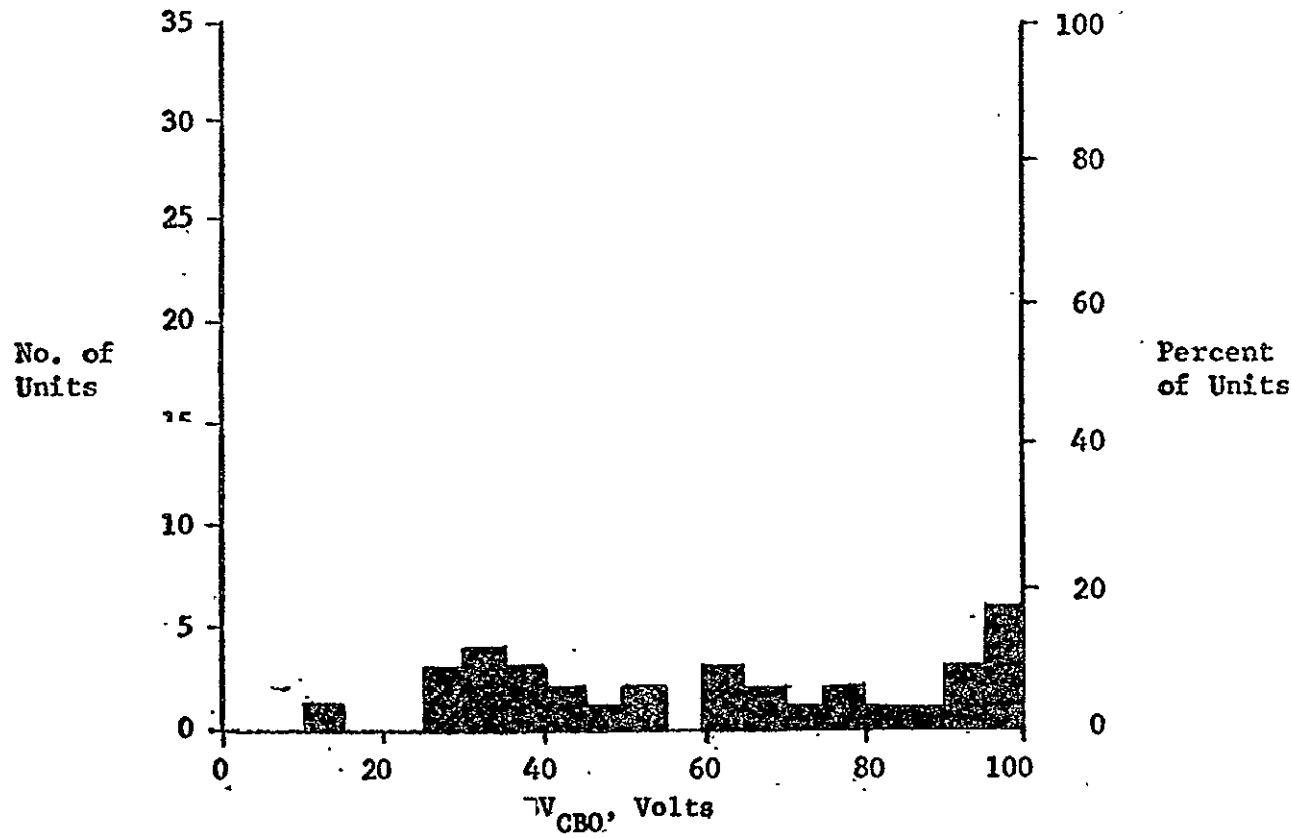
Parameter BV_{EBO} Units Volts



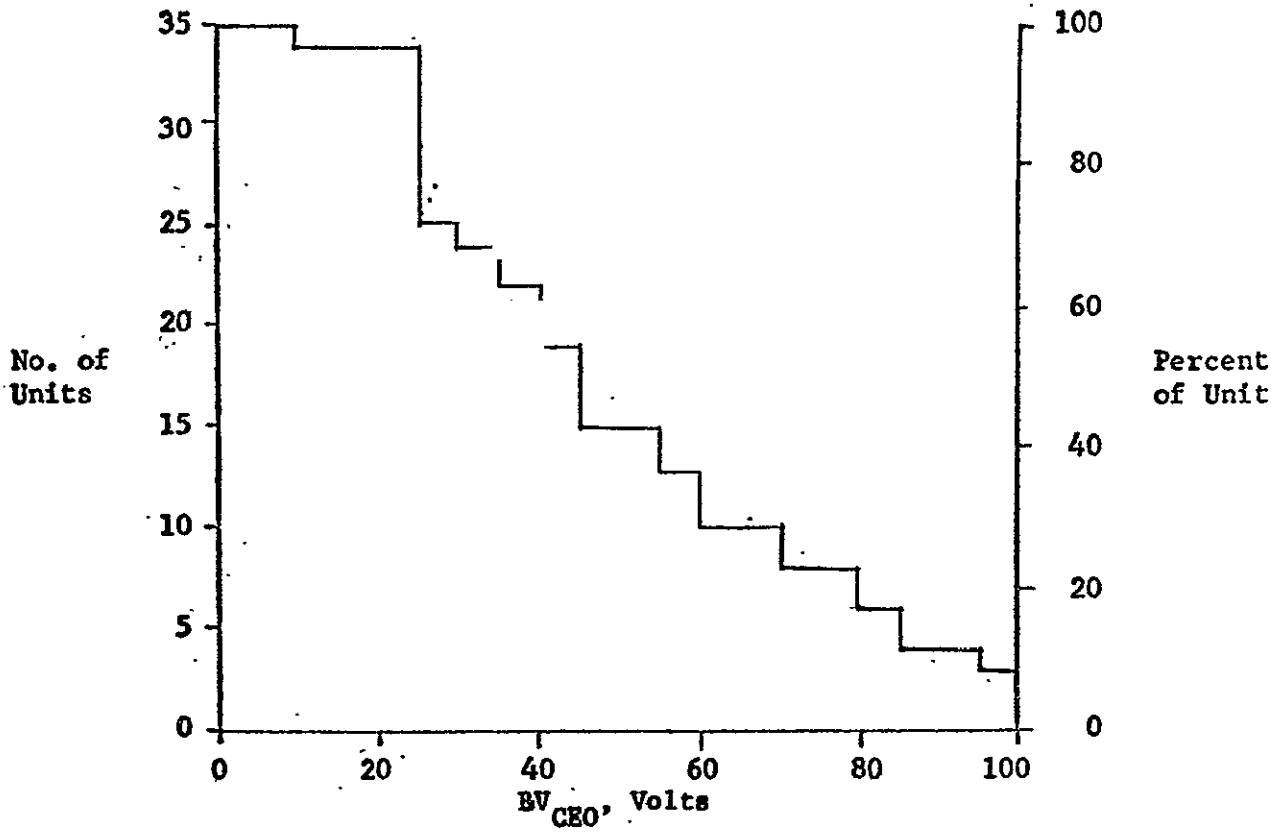


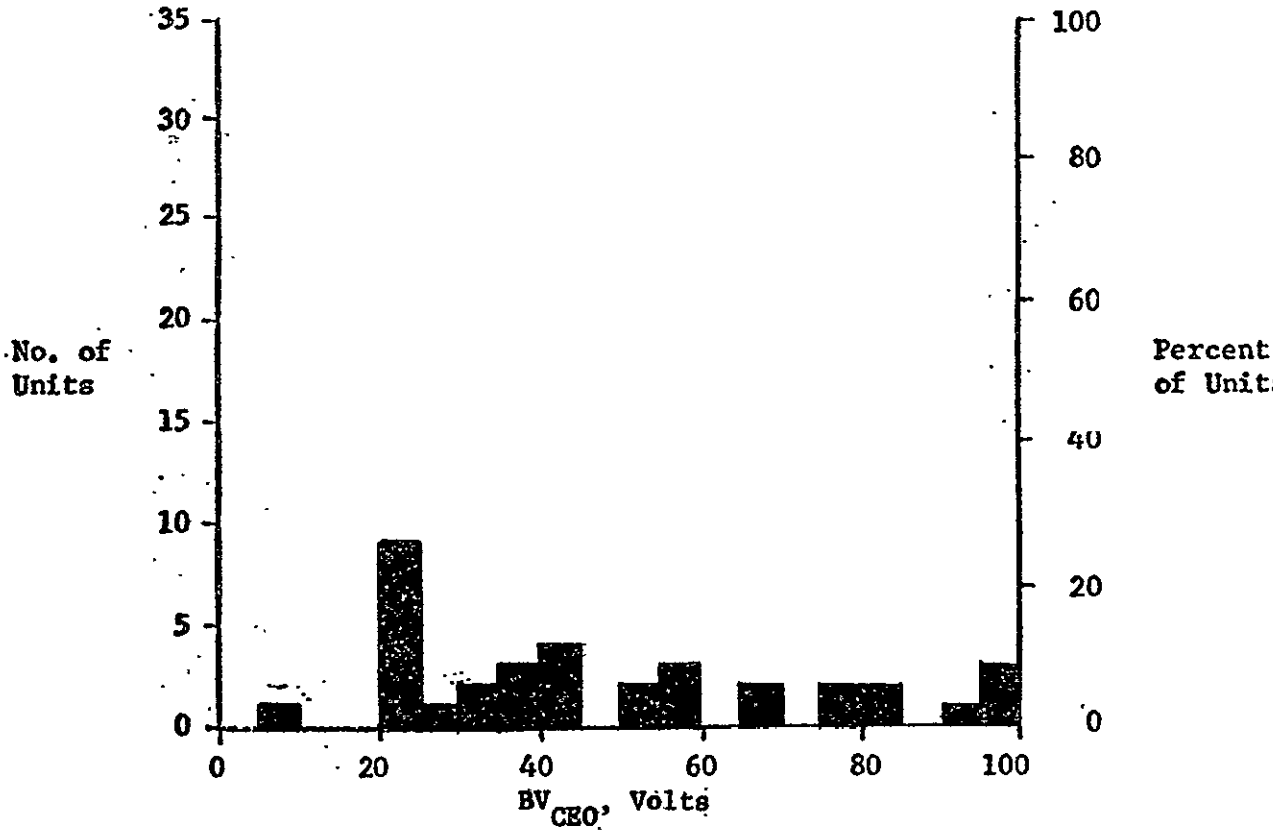
Parameter BV_{CBO} Units Volts



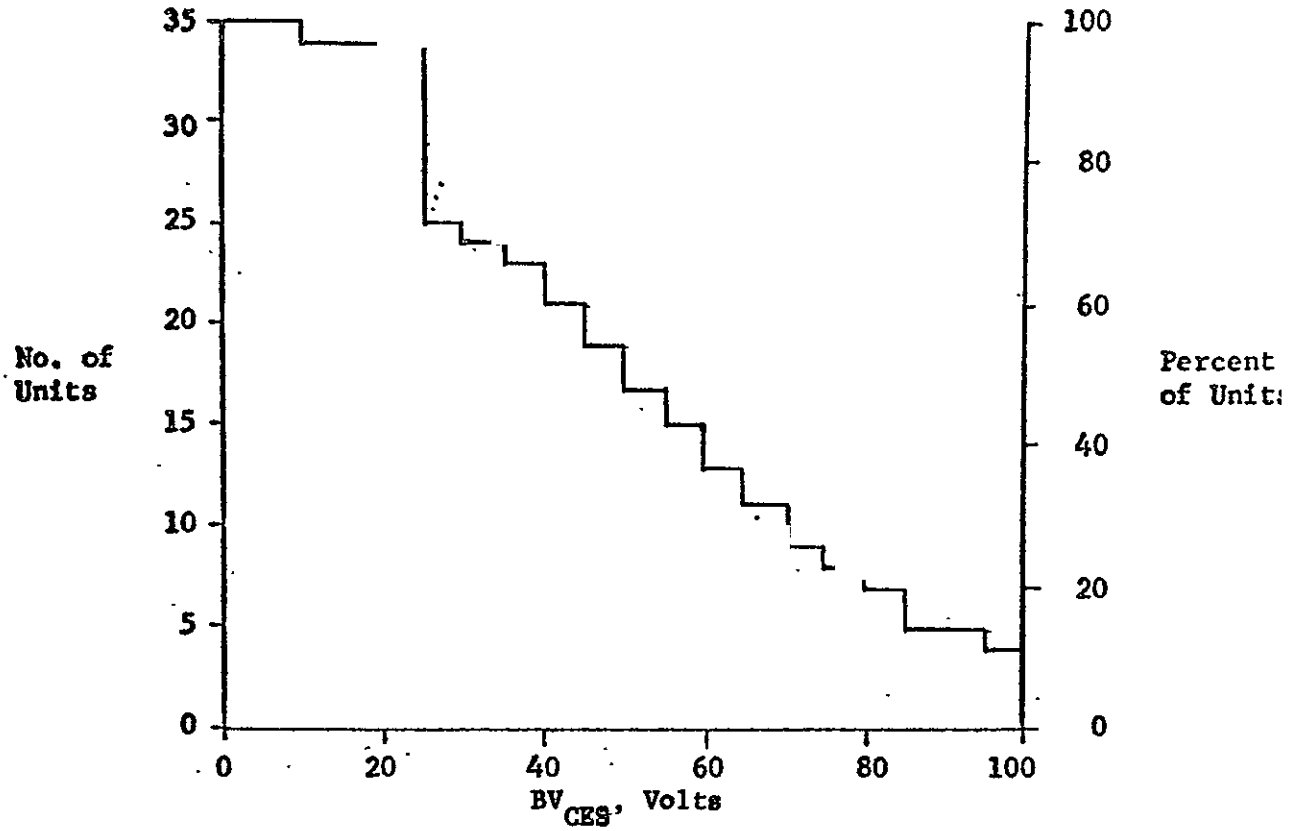


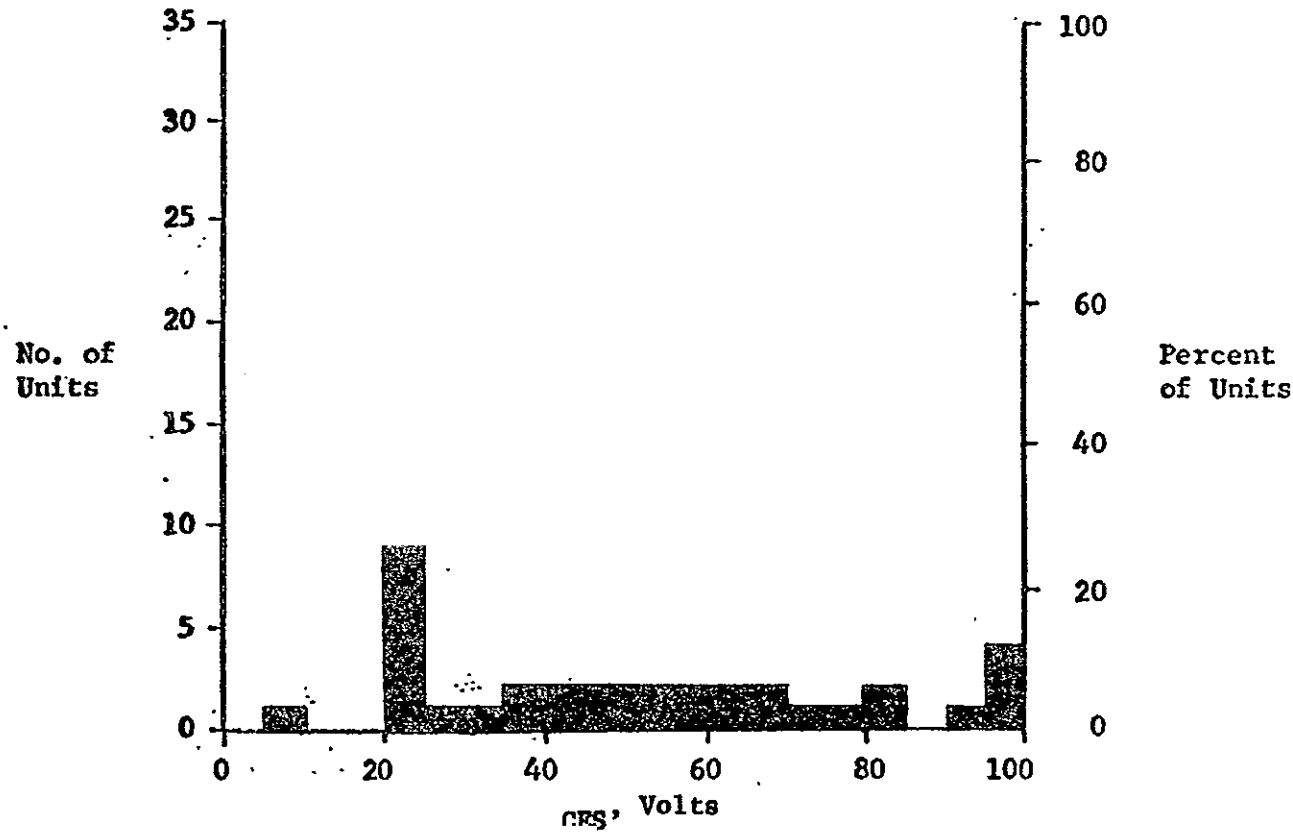
Parameter BV_{CEO} Units Volts



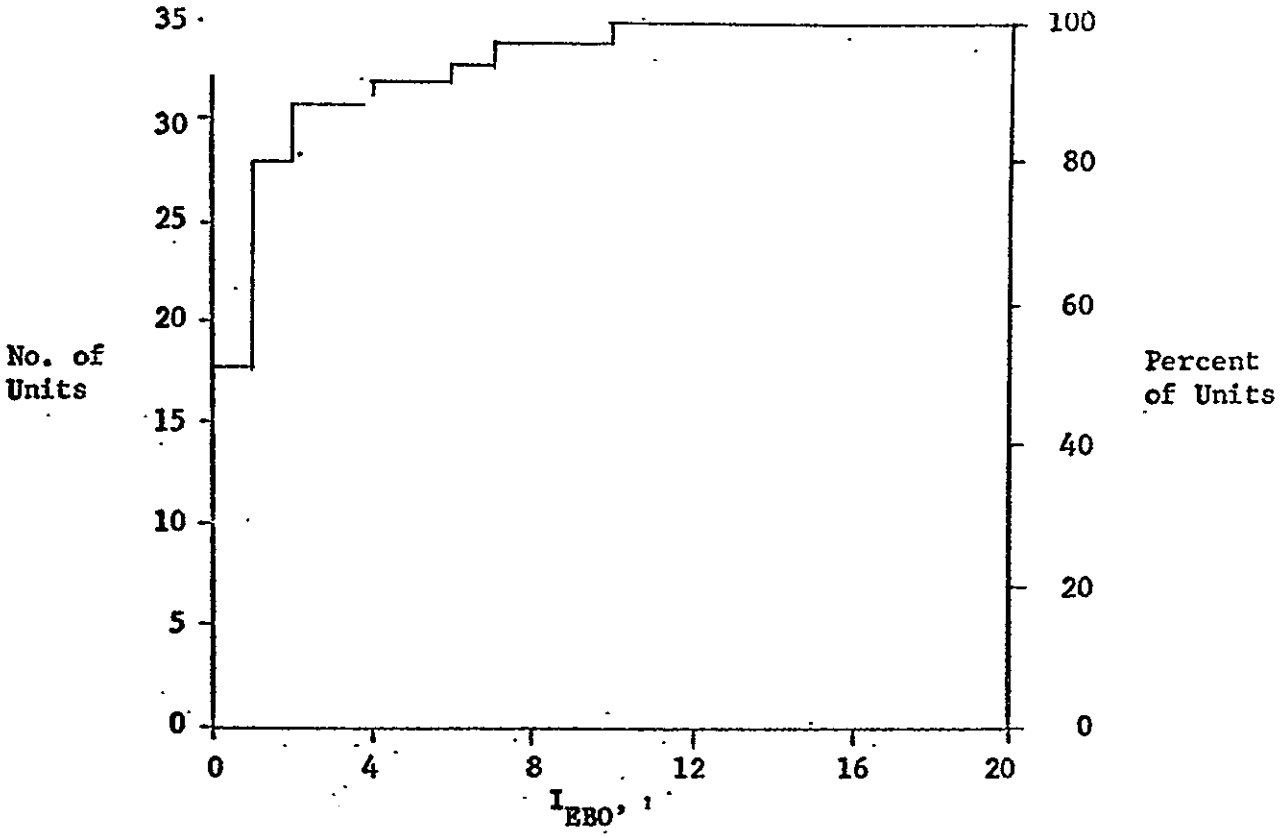


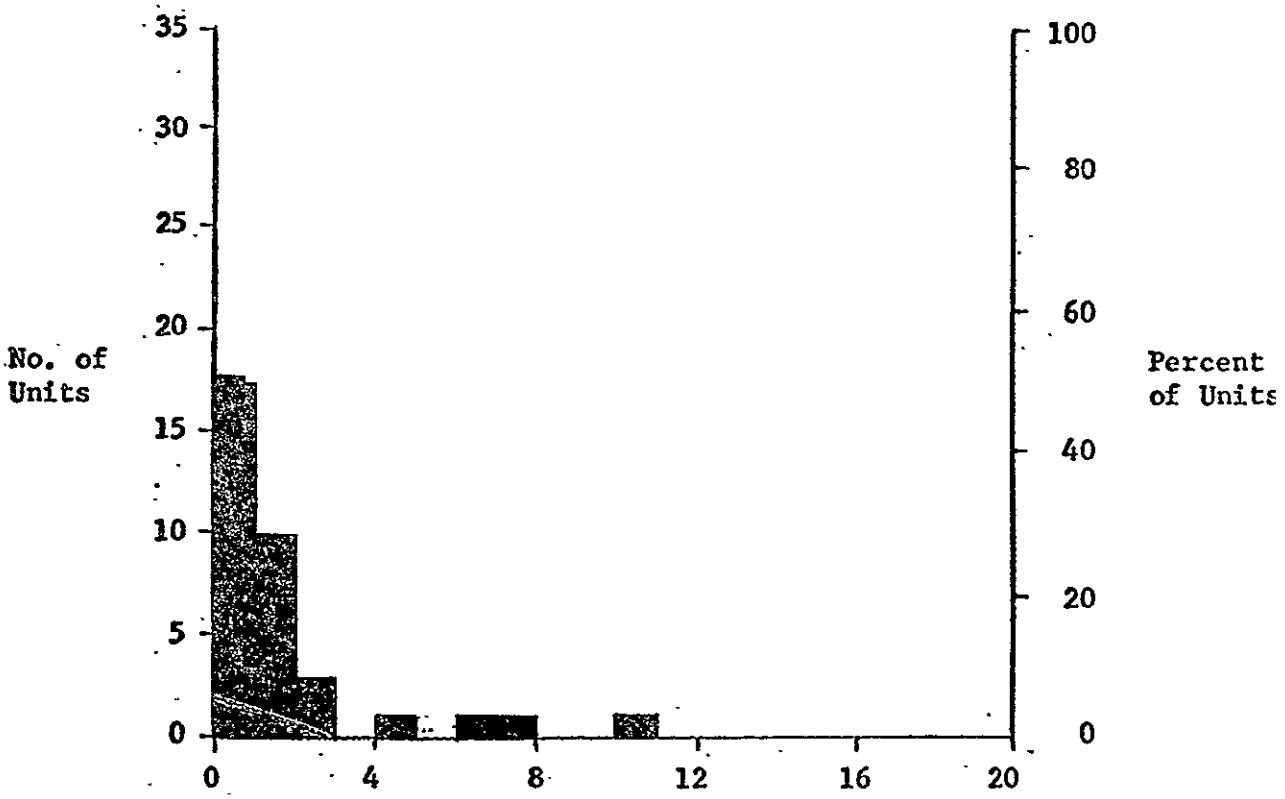
Parameter BV_{CES} Units Volts



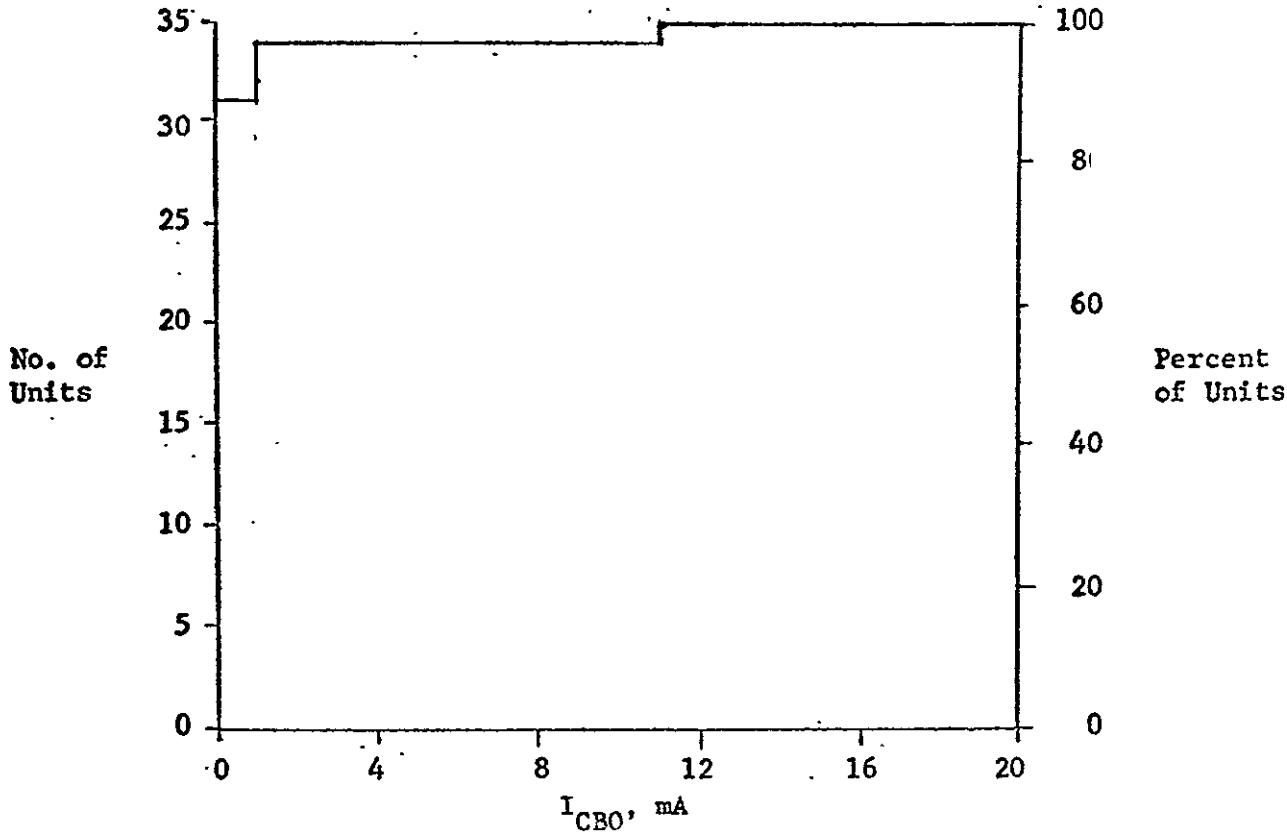


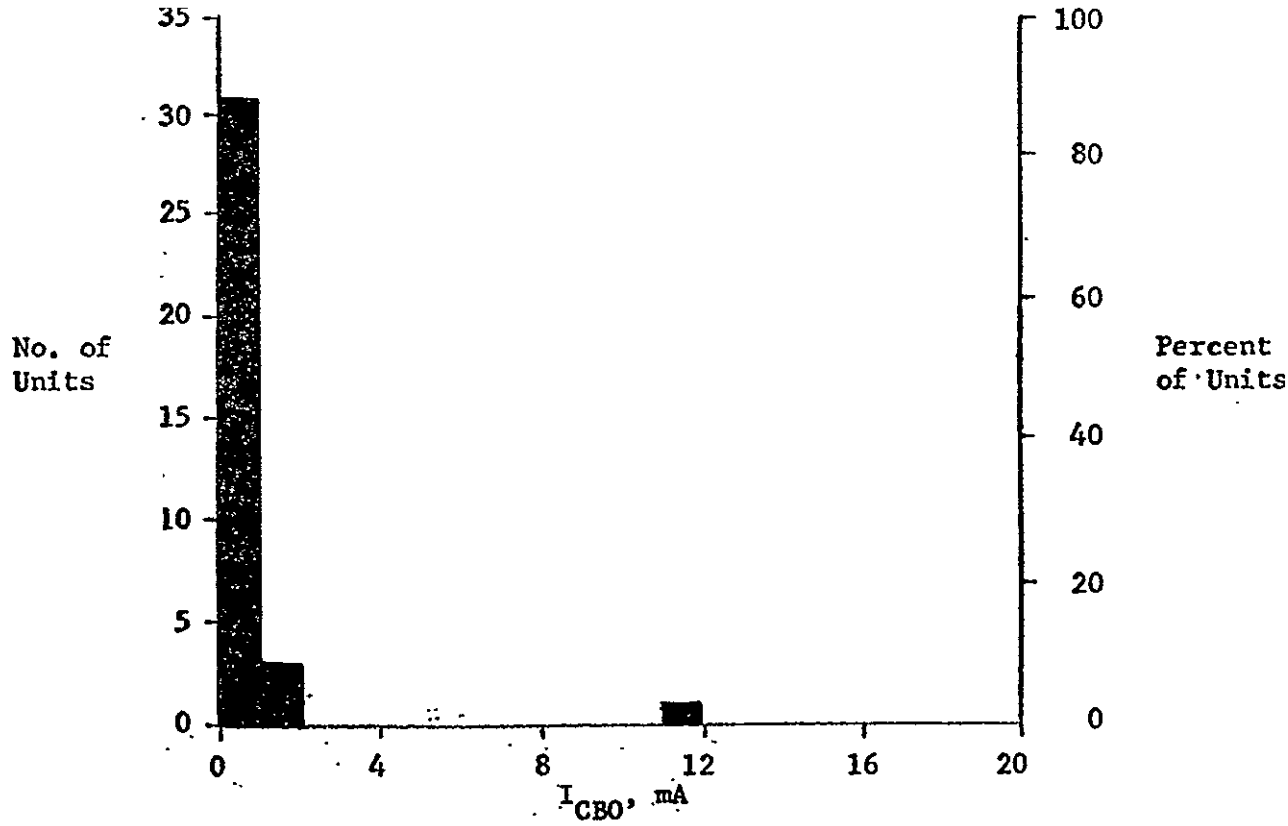
Parameter I_{EBO} Units mA



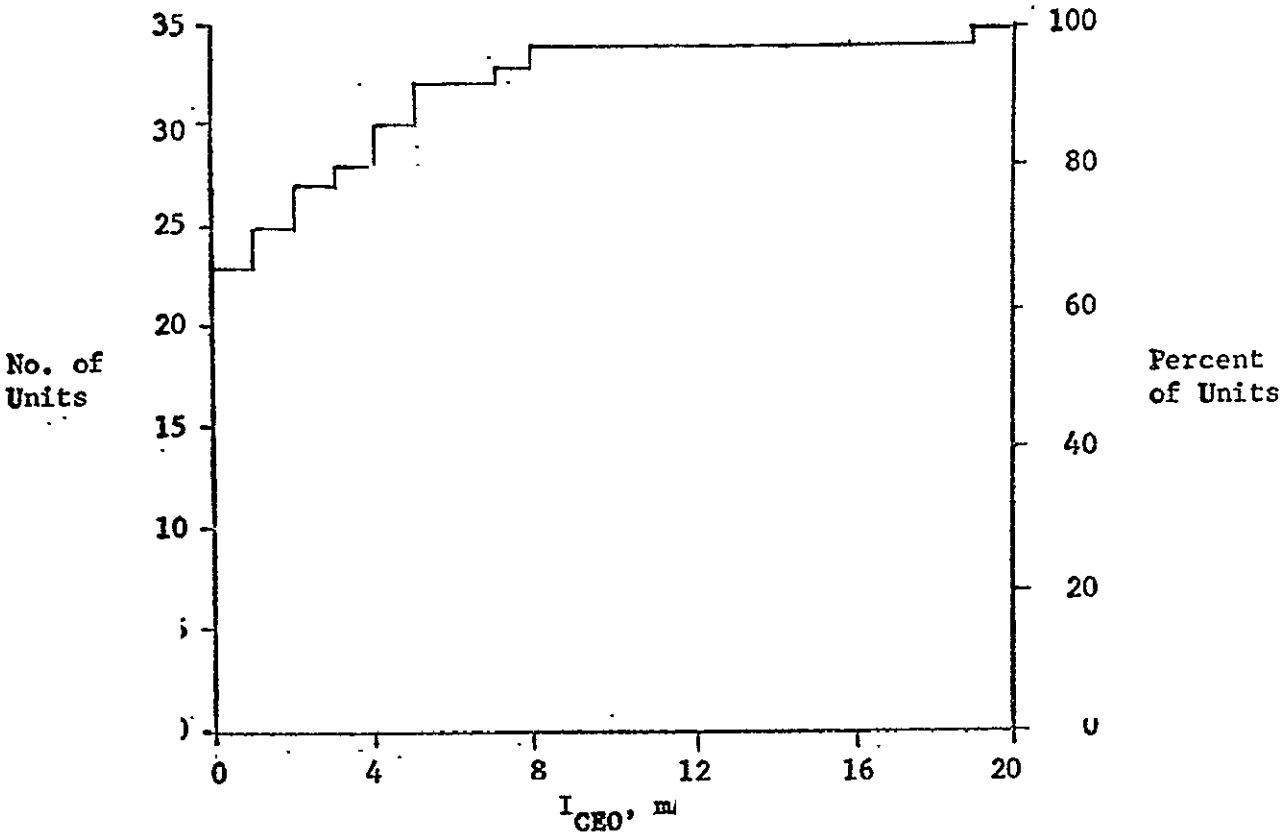


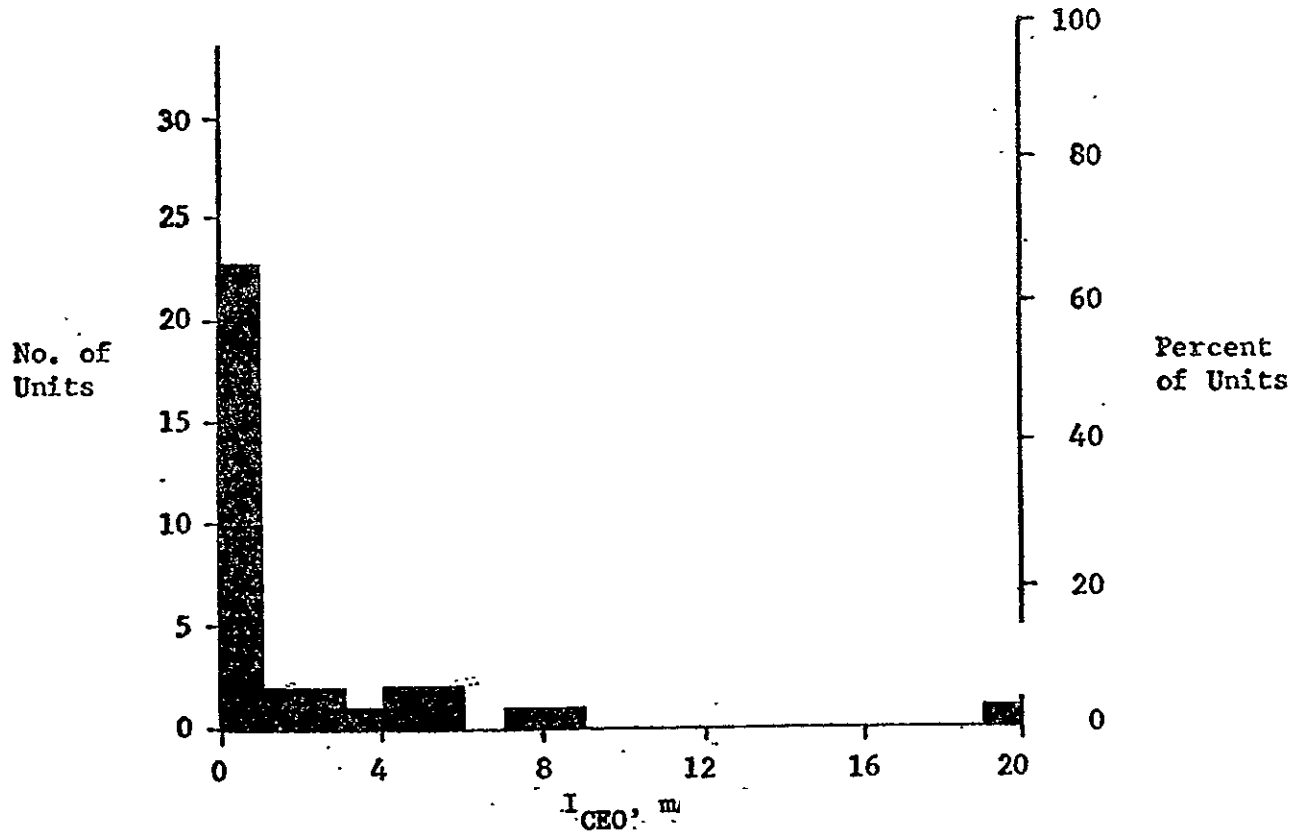
Parameter I_{CBO} Units mA



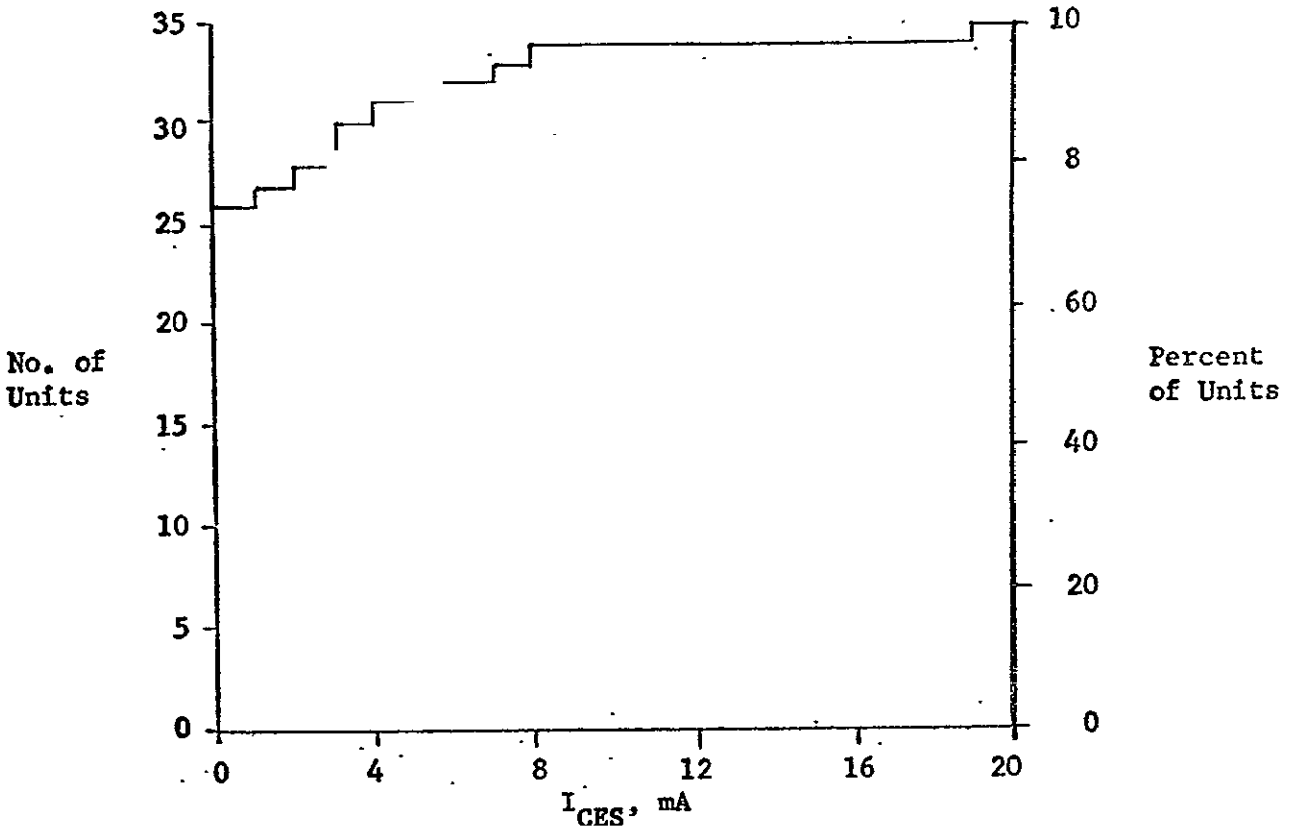


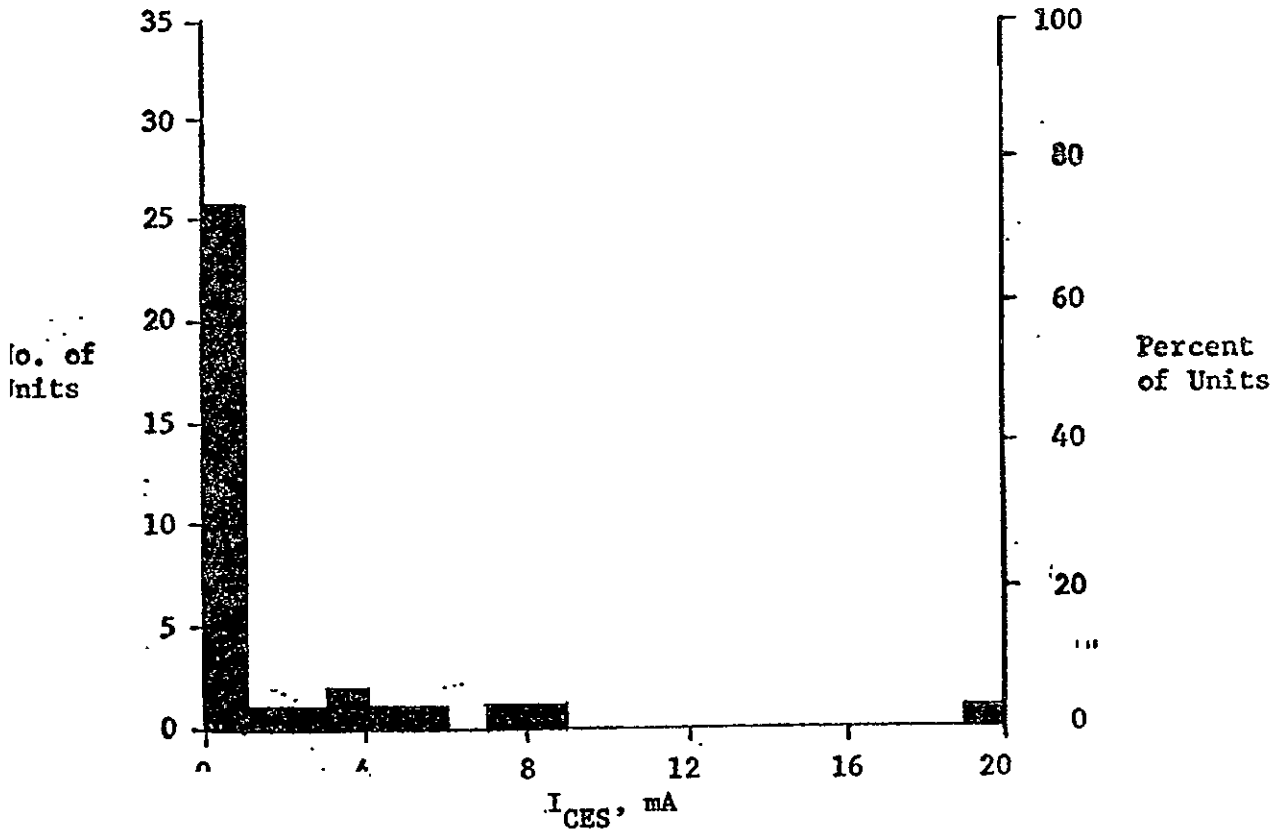
Parameter I_{CEO} Units mA



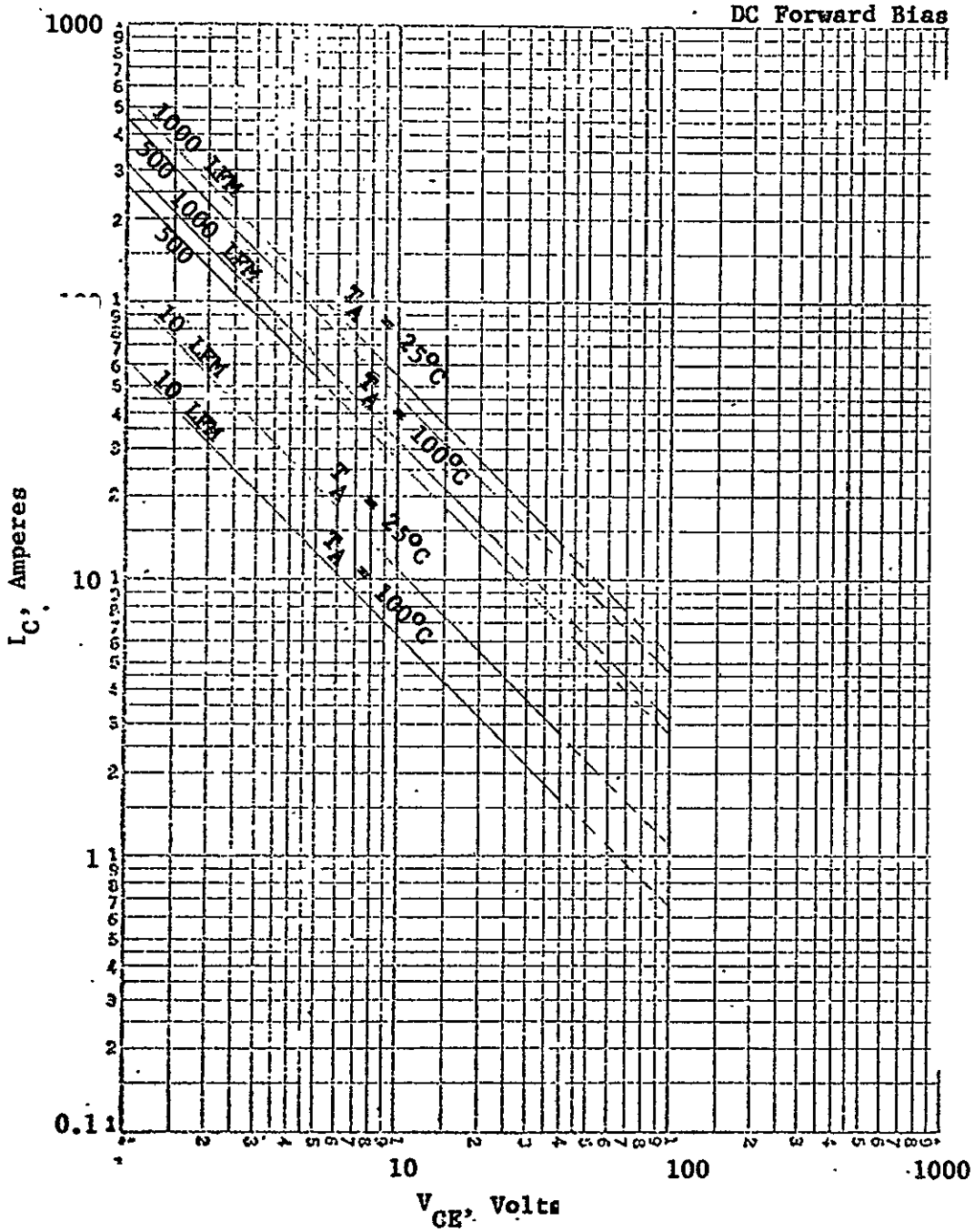


Parameter I_{CES} Units mA



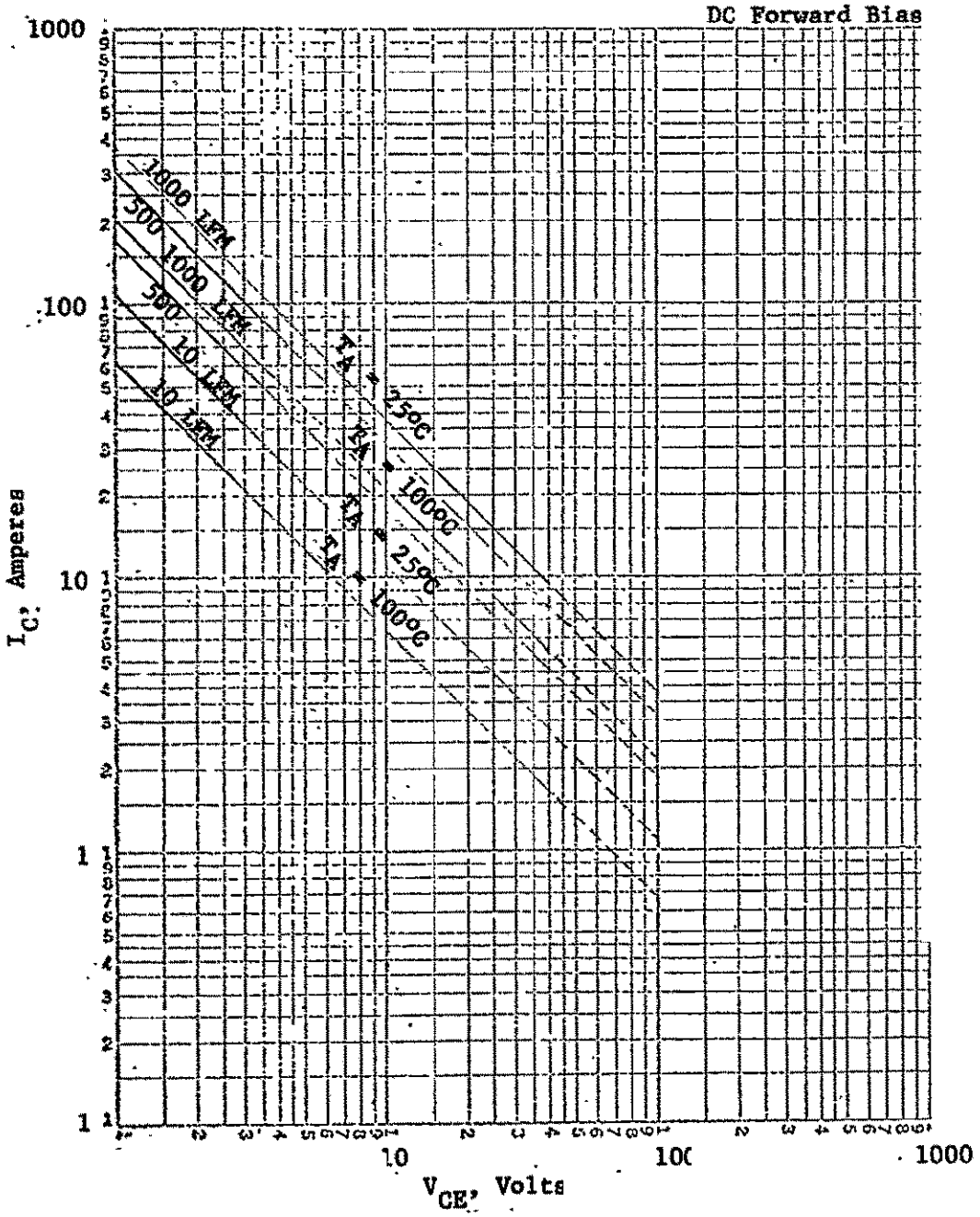


DATA ON UNIT #131



Second Breakdown
Area Not Evaluated

WORST CASE PROJECTED
FROM DATA ON ONE UNIT
USING DATA ON UNIT #131



Second Breakdown
Area Not Evaluated

A P P E N D I X

DATA SHEETS ON INDIVIDUAL ASSEMBLIES

HIGH POWER, LOW SATURATION VOLTAGE

SILICON SWITCHING TRANSISTOR

PER: JET PROPULSION LABORATORY
ENGINEERING NOTE NO. 342-015

DATA ON ASSEMBLY NO. 101

$V_{CE(sat)}$ and Gain Measurements at 25°C ± 5°C

$V_{CE(sat)}$ = .098 V (I_B = 5A, I_C = 75A)
$V_{BE(sat)}$ = .80 V (I_B = 5A, I_C = 75A)
Gain 103, 100, 99 (I_C = 75A, V_{CE} = 4,3,2V)
V_{BE} = .72 V, .72 V, .76 V (I_C = 75A, V_{CE} = 4,3,2V)

$V_{CE(sat)}$ and Gain Measurements at 100°C ± 5°C

$V_{CE(sat)}$ = .114 V (I_B = 5A, I_C = 75A)
$V_{BE(sat)}$ = .77 V (I_B = 5A, I_C = 75A)
Gain = 100, 96, 95 (I_C = 75A, V_{CE} = 4,3,2V)
V_{BE} = .62 V, .62 V, .64 V (I_C = 75A, V_{CE} = 4,3,2V)

Breakdown Voltages

BV_{EBO} = 9.5 V @ I_{EBO} = 10 mA
BV_{CBO} = 95 V @ I_{CBO} = 10 mA
BV_{CEO} = 85 V @ I_{CEO} = 10 mA
BV_{CES} = 85 V @ I_{CES} = 10 mA

Leakage Currents

I_{EBO} = 1.4 mA @ V_{EBO} = 4V
I_{CBO} = <0.1 mA @ V_{CBO} = 20V
I_{CEO} = <0.1 mA @ V_{CEO} = 20V
I_{CES} = <0.1 mA @ V_{CES} = 20V

Switching Time

$t_d + t_r$ = 4.3 µs, t_s = 2.5 µs, t_f = ... µs
Total Switching Time = 14.2 µs (I_C = 75A, I_B = 5A, V_{BE} = -1.5V on turn-off)

HIGH POWER, LOW SATURATION VOLTAGE

SILICON SWITCHING TRANSISTOR

PER: JET PROPULSION LABORATORY
ENGINEERING NOTE NO. 342-015

DATA ON ASSEMBLY NO. 102

$V_{CE(sat)}$ and Gain Measurements at 25°C ± 5°C

$V_{CE(sat)}$ = .080 V (I_B = 5A, I_C = 75A)
$V_{BE(sat)}$ = .84 V (I_B = 5A, I_C = 75A)
Gain 121, 123, 123 (I_C = 75A, V_{CE} = 4,3,2V)
V_{BE} = .74 V, .74 V, .74 V (I_C = 75A, V_{CE} = 4,3,2V)

$V_{CE(sat)}$ and Gain Measurements at 100°C ± 5°C

$V_{CE(sat)}$ = .085 V (I_B = 5A, I_C = 75A)
$V_{BE(sat)}$ = .71 V (I_B = 5A, I_C = 75A)
Gain = 326, 312, 312 (I_C = 75A, V_{CE} = 4,3,2V)
V_{BE} = .60 V, .60 V, .60 V (I_C = 75A, V_{CE} = 4,3,2V)

Breakdown Voltages

BV_{EBO} = 3.9 V @ I_{EBO} = 10 mA
BV_{CBO} = 15 V @ I_{CBO} = 10 mA
BV_{CEO} = 7 V @ I_{CEO} = 10 mA
BV_{CES} = 7 V @ I_{CES} = 10 mA

Leakage Currents

I_{EBO} = 10.5 mA @ V_{EBO} = 4V
I_{CBO} = 12 mA @ V_{CBO} = 20V
I_{CEO} = 20 mA @ V_{CEO} = 20V
I_{CES} = 20 mA @ V_{CES} = 20V

Switching Time

$t_d + t_r$ = ____ µs, t_s = ____ µs, t_f = ____ µs
Total Switching Time = ____ µs (I_C = 75A, I_B = 5A, V_{BE} = -1.5V on turn-off)

HIGH POWER, LOW SATURATION VOLTAGE

SILICON SWITCHING TRANSISTOR

PER: JET PROPULSION LABORATORY
ENGINEERING NOTE NO. 342-015

DATA ON ASSEMBLY NO. 103

$V_{CE(sat)}$ and Gain Measurements at 25°C ± 5°C

$V_{CE(sat)}$ = .095 V (I_B = 5A, I_C = 75A)
$V_{BE(sat)}$ = .89 V (I_B = 5A, I_C = 75A)
Gain 129, 125, 119 (I_C = 75A, V_{CE} = 4,3,2V)
V_{BE} = .74 V, .75 V, .75 V (I_C = 75A, V_{CE} = 4,3,2V)

$V_{CE(sat)}$ and Gain Measurements at 100°C ± 5°C

$V_{CE(sat)}$ = .152 V (I_B = 5A, I_C = 75A)
$V_{BE(sat)}$ = .75 V (I_B = 5A, I_C = 75A)
Gain = 125, 121, 117 (I_C = 75A, V_{CE} = 4,3,2V)
V_{BE} = .64 V, .65 V, .64 V (I_C = 75A, V_{CE} = 4,3,2V)

Breakdown Voltages

BV_{EBO} = 11 V @ I_{EBO} = 10 mA
BV_{CBO} = 73 V @ I_{CBO} = 10 mA
BV_{CEO} = 60 V @ I_{CEO} = 10 mA
BV_{CES} = 61 V @ I_{CES} = 10 mA

Leakage Currents

I_{EBO} = 1.5 mA @ V_{EBO} = 4V
I_{CBO} = 0.1 mA @ V_{CBO} = 20V
I_{CEO} = 0.1 mA @ V_{CEO} = 20V
I_{CES} = 0.2 mA @ V_{CES} = 20V

Switching Time

$t_d + t_r$ = ____ µs, t_s = ____ µs, t_f = ____ µs
Total Switching Time = ____ µs (I_C = 75A, I_B = 5A,
V_{BE} = -1.5V on turn-off)

HIGH POWER, LOW SATURATION VOLTAGE

SILICON SWITCHING TRANSISTOR

PER: JET PROPULSION LABORATORY
ENGINEERING NOTE NO. 342-015

DATA ON ASSEMBLY NO. 104

$V_{CE(sat)}$ and Gain Measurements at 25°C ± 5°C

$V_{CE(sat)}$ = .074 V (I_B = 5A, I_C = 75A)
$V_{BE(sat)}$ = .85 V (I_B = 5A, I_C = 75A)
Gain 153, 147, 144 (I_C = 75A, V_{CE} = 4,3,2V)
V_{BE} = .72 V, .73 V, .73 V (I_C = 75A, V_{CE} = 4,3,2V)

$V_{CE(sat)}$ and Gain Measurements at 100°C ± 5°C

$V_{CE(sat)}$ = .099 V (I_B = 5A, I_C = 75A)
$V_{BE(sat)}$ = .72 V (I_B = 5A, I_C = 75A)
Gain = 131, 129, 127 (I_C = 75A, V_{CE} = 4,3,2V)
V_{BE} = .62 V, .62 V, .63 V (I_C = 75A, V_{CE} = 4,3,2V)

Breakdown Voltages

BV_{EBO} = 90 V @ I_{EBO} = 10 mA
BV_{CBO} = 33 V @ I_{CBO} = 10 mA
BV_{CEO} = 22 V @ I_{CEO} = 10 mA
BV_{CES} = 25 V @ I_{CES} = 10 mA

Leakage Currents

I_{EBO} = 24 mA @ V_{EBO} = 4V
I_{CBO} = 0.9 mA @ V_{CBO} = 20V
I_{CEO} = 6.0 mA @ V_{CEO} = 20V
I_{CES} = 3.2 mA @ V_{CES} = 20V

Switching Time

$t_d + t_r$ = ____ µs, t_s = ____ µs, t_f = ____ µs
Total Switching Time = ____ µs (I_C = 75A, I_B = 5,
V_{BE} = -1.5V on turn-off)

HIGH POWER, LOW SATURATION VOLTAGE
SILICON SWITCHING TRANSISTOR

PER: JET PROPULSION LABORATORY
ENGINEERING NOTE NO. 342-015

DATA ON ASSEMBLY NO. 105

$V_{CE(sat)}$ and Gain Measurements at 25°C ± 5°C

$V_{CE(sat)}$ = .185 V (I_B = 5A, I_C = 75A)
$V_{BE(sat)}$ = .86 V (I_B = 5A, I_C = 75A)
Gain 147, 142, 139 (I_C = 75A, V_{CE} = 4,3,2V)
V_{BE} = .75 V, .75 V, .75 V (I_C = 75A, V_{CE} = 4,3,2V)

$V_{CE(sat)}$ and Gain Measurements at 100°C ± 5°C

$V_{CE(sat)}$ = .109 V (I_B = 5A, I_C = 75A)
$V_{BE(sat)}$ = .78 V (I_B = 5A, I_C = 75A)
Gain = 123, 121, 115 (I_C = 75A, V_{CE} = 4,3,2V)
V_{BE} = .65 V, .65 V, .66 V (I_C = 75A, V_{CE} = 4,3,2V)

Breakdown Voltages

BV_{EBO} = 13 V @ I_{EBO} = 10 mA
BV_{CBO} = >100 V @ I_{CBO} = 10 mA
BV_{CEO} = >100 V @ I_{CEO} = 10 mA
BV_{CES} = >100 V @ I_{CES} = 10 mA

Leakage Currents

I_{EBO} = .1 mA @ V_{EBO} = 4V
I_{CBO} = <0.1 mA @ V_{CBO} = 20V
I_{CEO} = <0.1 mA @ V_{CEO} = 20V
I_{CES} = <0.1 mA @ V_{CES} = 20V

Switching Time

$t_d + t_r$ = ____ µs, t_s = ____ µs, t_f = ____ µs
Total Switching Time = ____ µs (I_C = 75A, I_B = 5A,
V_{BE} = -1.5V on turn-off)

HIGH POWER, LOW SATURATION VOLTAGE

SILICON SWITCHING TRANSISTOR

PER: JET PROPULSION LABORATORY
ENGINEERING NOTE NO. 342-015

DATA ON ASSEMBLY NO. 106

$V_{CE(sat)}$ and Gain Measurements at 25°C ± 5°C

$V_{CE(sat)}$ = .106 V (I_B = 5A, I_C = 75A)
$V_{BE(sat)}$ = .82 V (I_B = 5A, I_C = 75A)
Gain 100, 106, 77 (I_C = 75A, V_{CE} = 4,3,2V)
V_{BE} = .76 V, .75 V, .75 V (I_C = 75A, V_{CE} = 4,3,2V)

$V_{CE(sat)}$ and Gain Measurements at 100°C ± 5°C

$V_{CE(sat)}$ = .156 V (I_B = 5A, I_C = 75A)
$V_{BE(sat)}$ = .75 V (I_B = 5A, I_C = 75A)
Gain = 70, 68, 68 (I_C = 75A, V_{CE} = 4,3,2V)
V_{BE} = .65 V, .65 V, .65 V (I_C = 75A, V_{CE} = 4,3,2V)

Breakdown Voltages

BV_{EBO} = 9.5 V @ I_{EBO} = 10 mA
BV_{CBO} = 92 V @ I_{CBO} = 10 mA
BV_{CEO} = 83 V @ I_{CEO} = 10 mA
BV_{CES} = 83 V @ I_{CES} = 10 mA

Leakage Currents

I_{EBO} = 0.4 mA @ V_{EBO} = 4V
I_{CBO} = <0.1 mA @ V_{CBO} = 20V
I_{CEO} = 0.2 mA @ V_{CEO} = 20V
I_{CES} = <0.1 mA @ V_{CES} = 20V

Switching Time

$t_d + t_r$ = 4.1 µs, t_s = 1.9 µs, t_f = 5.8 µs
Total Switching Time = 11.8 µs (I_C = 75A, I_B = 5A, V_{BE} = -1.5V on turn-off)

HIGH POWER, LOW SATURATION VOLTAGE

SILICON SWITCHING TRANSISTOR

PER: JET PROPULSION LABORATORY
ENGINEERING NOTE NO. 342-015

DATA ON ASSEMBLY NO. 107

$V_{CE(sat)}$ and Gain Measurements at 25°C ± 5°C

$V_{CE(sat)}$ = .092 V (I_B = 5A, I_C = 75A)
$V_{BE(sat)}$ = .82 V (I_B = 5A, I_C = 75A)
Gain 101, 100, 97 (I_C = 75A, V_{CE} = 4,3,2V)
V_{BE} = .75 V, .75 V, .75 V (I_C = 75A, V_{CE} = 4,3,2V)

$V_{CE(sat)}$ and Gain Measurements at 100°C ± 5°C

$V_{CE(sat)}$ = .140 V (I_B = 5A, I_C = 75A)
$V_{BE(sat)}$ = .74 V (I_B = 5A, I_C = 75A)
Gain = 62, 71, 69 (I_C = 75A, V_{CE} = 4,3,2V)
V_{BE} = .76 V, .64 V, .64 V (I_C = 75A, V_{CE} = 4,3,2V)

Breakdown Voltages

BV_{EBO} = 6.5 V @ I_{EBO} = 10 mA
BV_{CBO} = 54 V @ I_{CBO} = 10 mA
BV_{CEO} = 45 V @ I_{CEO} = 10 mA
BV_{CES} = 47 V @ I_{CES} = 10 mA

Leakage Currents

I_{EBO} = 4.6 mA @ V_{EBO} = 4V
I_{CBO} = 40.1 mA @ V_{CBO} = 20V
I_{CEO} = 0.1 mA @ V_{CEO} = 20V
I_{CES} = 0.1 mA @ V_{CES} = 20V

Switching Time

$t_d + t_r$ = 4.3 µs, t_s = 1.7 µs, t_f = 5.6 µs
Total Switching Time = 11.6 µs (I_C = 75A, I_B = 5A, V_{BE} = -1.5V on turn-off)

HIGH POWER, LOW SATURATION VOLTAGE

SILICON SWITCHING TRANSISTOR

PER: JET PROPULSION LABORATORY
ENGINEERING NOTE NO. 342-015

DATA ON ASSEMBLY NO. 108

$V_{CE(sat)}$ and Gain Measurements at 25°C ± 5°C

$V_{CE(sat)}$ = .103 V (I_B = 5A, I_C = 75A)
$V_{BE(sat)}$ = .81 V (I_B = 5A, I_C = 75A)
Gain 62, 65, 68 (I_C = 75A, V_{CE} = 4,3,2V)
V_{BE} = .75 V, .25 V, .75 V (I_C = 75A, V_{CE} = 4,3,2V)

$V_{CE(sat)}$ and Gain Measurements at 100°C ± 5°C

$V_{CE(sat)}$ = .146 V (I_B = 5A, I_C = 75A)
$V_{BE(sat)}$ = .83 V (I_B = 5A, I_C = 75A)
Gain = 57, 55, 53 (I_C = 75A, V_{CE} = 4,3,2V)
V_{BE} = .61 V, .67 V, .68 V (I_C = 75A, V_{CE} = 4,3,2V)

Breakdown Voltages

BV_{EBO} = 4.5 V @ I_{EBO} = 10 mA
BV_{CBO} = 65 V @ I_{CBO} = 10 mA
BV_{CEO} = 45 V @ I_{CEO} = 10 mA
BV_{CES} = 50 V @ I_{CES} = 10 mA

Leakage Currents

I_{EBO} = 8.0 mA @ V_{EBO} = 4V
I_{CBO} = 0.2 mA @ V_{CBO} = 20V
I_{CEO} = 0.3 mA @ V_{CEO} = 20V
I_{CES} = 0.2 mA @ V_{CES} = 20V

Switching Time

$t_d + t_r$ = ____ µs, t_s = ____ µs, t_f = ____ µs
Total Switching Time = ____ µs (I_C = 75A, I_B = 5A, V_{BE} = -1.5V on turn-off)

HIGH POWER, LOW SATURATION VOLTAGE

SILICON SWITCHING TRANSISTOR

PER: JET PROPULSION LABORATORY
ENGINEERING NOTE NO. 342-015

DATA ON ASSEMBLY NO. 109

$V_{CE(sat)}$ and Gain Measurements at 25°C ± 5°C

$V_{CE(sat)}$ = .095 V (I_B = 5A, I_C = 75A)
$V_{BE(sat)}$ = .82 V (I_B = 5A, I_C = 75A)
Gain 101, 103, 79 (I_C = 75A, V_{CE} = 4,3,2V)
V_{BE} = .75 V, .75 V, .76 V (I_C = 75A, V_{CE} = 4,3,2V)

$V_{CE(sat)}$ and Gain Measurements at 100°C ± 5°C

$V_{CE(sat)}$ = .135 V (I_B = 5A, I_C = 75A)
$V_{BE(sat)}$ = .74 V (I_B = 5A, I_C = 75A)
Gain = 76, 76, 74 (I_C = 75A, V_{CE} = 4,3,2V)
V_{BE} = .63 V, .63 V, .63 V (I_C = 75A, V_{CE} = 4,3,2V)

Breakdown Voltages

BV_{EBO} = 6.5 V @ I_{EBO} = 10 mA
BV_{CBO} = 28 V @ I_{CBO} = 10 mA
BV_{CEO} = 21 V @ I_{CEO} = 10 mA
BV_{CES} = 21 V @ I_{CES} = 10 mA

Leakage Currents

I_{EBO} = 0.6 mA @ V_{EBO} = 4V
I_{CBO} = 0.5 mA @ V_{CBO} = 20V
I_{CEO} = 9.0 mA @ V_{CEO} = 20V
I_{CES} = 9.0 mA @ V_{CES} = 20V

Switching Time

$t_d + t_r$ = ____ µs, t_s = ____ µs, t_f = ____ µs
Total Switching Time = ____ µs (I_C = 75A, I_B = 5A, V_{BE} = -1.5V on turn-off)

HIGH POWER, LOW SATURATION VOLTAGE
SILICON SWITCHING TRANSISTOR

PER: JET PROPULSION LABORATORY
ENGINEERING NOTE NO. 342-015

DATA ON ASSEMBLY NO. 110

$V_{CE(sat)}$ and Gain Measurements at 25°C ± 5°C

$V_{CE(sat)}$ = .089 V (I_B = 5A, I_C = 75A)
$V_{BE(sat)}$ = .81 V (I_B = 5A, I_C = 75A)
Gain 174, 170, — (I_C = 75A, V_{CE} = 4,3,2V)
V_{BE} = .72 V, .72 V, — V (I_C = 75A, V_{CE} = 4,3,2V)

$V_{CE(sat)}$ and Gain Measurements at 100°C ± 5°C

$V_{CE(sat)}$ = .111 V (I_B = 5A, I_C = 75A)
$V_{BE(sat)}$ = .73 V (I_B = 5A, I_C = 75A)
Gain = 144, 136, 134 (I_C = 75A, V_{CE} = 4,3,2V)
V_{BE} = .62 V, .62 V, .62 V (I_C = 75A, V_{CE} = 4,3,2V)

Breakdown Voltages

BV_{EBO} = 12.5 V @ I_{EBO} = 10 mA
BV_{CBO} = 37 V @ I_{CBO} = 10 mA
BV_{CEO} = 24 V @ I_{CEO} = 10 mA
BV_{CES} = 24 V @ I_{CES} = 10 mA

Leakage Currents

I_{EBO} = 1.0 mA @ V_{EBO} = 4V
I_{CBO} = 0.4 mA @ V_{CBO} = 20V
I_{CEO} = 3.0 mA @ V_{CEO} = 20V
I_{CES} = 3.0 mA @ V_{CES} = 20V

Switching Time

$t_d + t_r$ = ____ µs, t_s = ____ µs, t_f = ____ µs
Total Switching Time = ____ µs (I_C = 75A, I_B = 5A, V_{BE} = -1.5V on turn-off)

HIGH POWER, LOW SATURATION VOLTAGE

SILICON SWITCHING TRANSISTOR

PER: JET PROPULSION LABORATORY
ENGINEERING NOTE NO. 342-015

DATA ON ASSEMBLY NO. 111

$V_{CE(sat)}$ and Gain Measurements at 25°C ± 5°C

$V_{CE(sat)}$ = .078 V (I_B = 5A, I_C = 75A)
$V_{BE(sat)}$ = 1.01 V (I_B = 5A, I_C = 75A)
Gain 300, 288, 278 (I_C = 75A, V_{CE} = 4,3,2V
V_{BE} = .73 V, .73 V, .73 V (I_C = 75A, V_{CE} = 4,3,2V)

$V_{CE(sat)}$ and Gain Measurements at 100°C ± 5°C

$V_{CE(sat)}$ = .084 V (I_B = 5A, I_C = 75A)
$V_{BE(sat)}$ = .74 V (I_B = 5A, I_C = 75A)
Gain = 268, 268, 278 (I_C = 75A, V_{CE} = 4,3,2V)
V_{BE} = .61 V, .61 V, .62 V (I_C = 75A, V_{CE} = 4,3,2V)

Breakdown Voltages

BV_{EBO} = 13 V @ I_{EBO} = 10 mA
BV_{CBO} = 42 V @ I_{CBO} = 10 mA
BV_{CEO} = 30 V @ I_{CEO} = 10 mA
BV_{CES} = 30 V @ I_{CES} = 10 mA

Leakage Currents

I_{EBO} = 1.0 mA @ V_{EBO} = 4V
I_{CBO} = 0.2 mA @ V_{CBO} = 20V
I_{CEO} = 0.3 mA @ V_{CEO} = 20V
I_{CES} = 0.2 mA @ V_{CES} = 20V

Switching Time

$t_d + t_r$ = ____ µs, t_s = ____ µs, t_f = ____ µs
Total Switching Time = ____ µs (I_C = 75A, I_B = 5A,
V_{BE} = -1.5V on turn-off)

HIGH POWER, LOW SATURATION VOLTAGE
SILICON SWITCHING TRANSISTOR

PER: JET PROPULSION LABORATORY
ENGINEERING NOTE NO. 342-015

DATA ON ASSEMBLY NO. 112

$V_{CE(sat)}$ and Gain Measurements at 25°C ± 5°C

$V_{CE(sat)}$ = .068 V (I_B = 5A, I_C = 75A)
$V_{BE(sat)}$ = 1.46 V (I_B = 5A, I_C = 75A)
Gain 395, 375, 341 (I_C = 75A, V_{CE} = 4,3,2V)
V_{BE} = .72 V, .72 V, .72 V (I_C = 75A, V_{CE} = 4,3,

$V_{CE(sat)}$ and Gain Measurements at 100°C ± 5°C

$V_{CE(sat)}$ = .078 V (I_B = 5A, I_C = 75A)
$V_{BE(sat)}$ = .75 V (I_B = 5A, I_C = 75A)
Gain = 341, 341, 250 (I_C = 75A, V_{CE} = 4,3,2V)
V_{BE} = .61 V, .61 V, .61 V (I_C = 75A, V_{CE} = 4,3,2V)

Breakdown Voltages

BV_{EBO} = 13.5 V @ I_{EBO} = 10 mA
BV_{CBO} = 78 V @ I_{CBO} = 10 mA
BV_{CEO} = 60 V @ I_{CEO} = 10 mA
BV_{CES} = 64 V @ I_{CES} = 10 mA

Leakage Currents

I_{EBO} = 0.2 mA @ V_{EBO} = 4V
I_{CBO} = <0.1 mA @ V_{CBO} = 20V
I_{CEO} = 2.2 mA @ V_{CEO} = 20V
I_{CES} = <0.1 mA @ V_{CES} = 20V

Switching Time

$t_d + t_r$ = ____ µs, t_s = ____ µs, t_f = ____ µs
Total Switching Time = ____ µs (I_C = 75A, I_B = 5A,
V_{BE} = -1.5V on turn-off)

HIGH POWER, LOW SATURATION VOLTAGE

SILICON SWITCHING TRANSISTOR

PER: JET PROPULSION LABORATORY
ENGINEERING NOTE NO. 342-015

DATA ON ASSEMBLY NO. 113

$V_{CE(sat)}$ and Gain Measurements at 25°C ± 5°C

$V_{CE(sat)}$ = .084 V (I_B = 5A, I_C = 75A)
$V_{BE(sat)}$ = .84 V (I_B = 5A, I_C = 75A)
Gain 139, 134, 129 (I_C = 75A, V_{CE} = 4,3,2V)
V_{BE} = .75 V, .75 V, .75 V (I_C = 75A, V_{CE} = 4,3,2V)

$V_{CE(sat)}$ and Gain Measurements at 100°C ± 5°C

$V_{CE(sat)}$ = .104 V (I_B = 5A, I_C = 75A)
$V_{BE(sat)}$ = .76 V (I_B = 5A, I_C = 75A)
Gain = 109, —, — (I_C = 75A, V_{CE} = 4,3,2V)
V_{BE} = .64 V, — V, — V (I_C = 75A, V_{CE} = 4,3,2V)

Breakdown Voltages

BV_{EBO} = 13 V @ I_{EBO} = 10 mA
BV_{CBO} = >100 V @ I_{CBO} = 10 mA
BV_{CEO} = >100 V @ I_{CEO} = 10 mA
BV_{CES} = >100 V @ I_{CES} = 10 mA

Leakage Currents

I_{EBO} = <0.1 mA @ V_{EBO} = 4V
I_{CBO} = <0.1 mA @ V_{CBO} = 20V
I_{CEO} = <0.1 mA @ V_{CEO} = 20V
I_{CES} = <0.1 mA @ V_{CES} = 20V

Switching Time

$t_d + t_r$ = ____ µs, t_s = ____ µs, t_f = ____ µs
Total Switching Time = ____ µs (I_C = 75A, I_B = 5A,
V_{BE} = -1.5V on turn-off)

HIGH POWER, LOW SATURATION VOLTAGE

SILICON SWITCHING TRANSISTOR

PER: JET PROPULSION LABORATORY
ENGINEERING NOTE NO. 342-015

DATA ON ASSEMBLY NO. 114

$V_{CE(sat)}$ and Gain Measurements at 25°C ± 5°C

$V_{CE(sat)}$ = .082 V (I_B = 5A, I_C = 75A)
$V_{BE(sat)}$ = .80 V (I_B = 5A, I_C = 75A)
Gain 178, 183, 170 (I_C = 75A, V_{CE} = 4,3,2V)
V_{BE} = .72 V, .72 V, .73 V (I_C = 75A, V_{CE} = 4,3,2V)

$V_{CE(sat)}$ and Gain Measurements at 100°C ± 5°C

$V_{CE(sat)}$ = .107 V (I_B = 5A, I_C = 75A)
$V_{BE(sat)}$ = .76 V (I_B = 5A, I_C = 75A)
Gain = 174, 150, 178 (I_C = 75A, V_{CE} = 4,3,2V)
V_{BE} = .64 V, .64 V, .64 V (I_C = 75A, V_{CE} = 4,3,2V)

Breakdown Voltages

BV_{EBO} = 5.1 V @ I_{EBO} = 10 mA
BV_{CBO} = 31 V @ I_{CBO} = 10 mA
BV_{CEO} = 24 V @ I_{CEO} = 10 mA
BV_{CES} = 24 V @ I_{CES} = 10 mA

Leakage Currents

I_{EBO} = 7.0 mA @ V_{EBO} = 4V
I_{CBO} = 2.0 mA @ V_{CBO} = 20V
I_{CEO} = 2.0 mA @ V_{CEO} = 20V
I_{CES} = 2.0 mA @ V_{CES} = 20V

Switching Time

$t_d + t_r$ = ____ µs, t_s = ____ µs, t_f = ____ µs
Total Switching Time = ____ µs (I_C = 75A, I_B = 5A,
V_{BE} = -1.5V on turn-off)

HIGH POWER, LOW SATURATION VOLTAGE

SILICON SWITCHING TRANSISTOR

PER: JET PROPULSION LABORATORY
ENGINEERING NOTE NO. 342-015

DATA ON ASSEMBLY NO. 115

$V_{CE(sat)}$ and Gain Measurements at 25°C ± 5°C

$V_{CE(sat)}$ = .069 V (I_B = 5A, I_C = 75A)
$V_{BE(sat)}$ = .79 V (I_B = 5A, I_C = 75A)
Gain 234, 234, 300 (I_C = 75A, V_{CE} = 4,3,2V)
V_{BE} = .70 V, .69 V, .68 V (I_C = 75A, V_{CE} = 4,3,2V)

$V_{CE(sat)}$ and Gain Measurements at 100°C ± 5°C

$V_{CE(sat)}$ = .093 V (I_B = 5A, I_C = 75A)
$V_{BE(sat)}$ = .74 V (I_B = 5A, I_C = 75A)
Gain = 250, 242, 220 (I_C = 75A, V_{CE} = 4,3,2V)
V_{BE} = .62 V, .62 V, .61 V (I_C = 75A, V_{CE} = 4,3,2V)

Breakdown Voltages

BV_{EBO} = 10 V @ I_{EBO} = 10 mA
BV_{CBO} = 47 V @ I_{CBO} = 10 mA
BV_{CEO} = 38 V @ I_{CEO} = 10 mA
BV_{CES} = 38 V @ I_{CES} = 10 mA

Leakage Currents

I_{EBO} = 3.0 mA @ V_{EBO} = 4V
I_{CBO} = 0.2 mA @ V_{CBO} = 20V
I_{CEO} = 0.5 mA @ V_{CEO} = 20V
I_{CES} = 0.4 mA @ V_{CES} = 20V

Switching Time

$t_d + t_r$ = ____ µs, t_s = ____ µs, t_f = ____ µs
Total Switching Time = ____ µs (I_C = 75A, I_B = 5A,
V_{BE} = -1.5V on turn-off)

HIGH POWER, LOW SATURATION VOLTAGE

SILICON SWITCHING TRANSISTOR

PER: JET PROPULSION LABORATORY
ENGINEERING NOTE NO. 342-015

DATA ON ASSEMELY NO. 116

$V_{CE(sat)}$ and Gain Measurements at 25°C ± 5°C

$V_{CE(sat)}$ = .066 V (I_B = 5A, I_C = 75A)
$V_{BE(sat)}$ = .83 V (I_B = 5A, I_C = 75A)
Gain 417, 395, 417 (I_C = 75A, V_{CE} = 4,3,2V)
V_{BE} = .71 V, .71 V, .73 V (I_C = 75A, V_{CE} = 4,3,2V)

$V_{CE(sat)}$ and Gain Measurements at 100°C ± 5°C

$V_{CE(sat)}$ = .074 V (I_B = 5A, I_C = 75A)
$V_{BE(sat)}$ = .75 V (I_B = 5A, I_C = 75A)
Gain = 441, 469, 417 (I_C = 75A, V_{CE} = 4,3,2V)
V_{BE} = .60 V, .61 V, .61 V (I_C = 75A, V_{CE} = 4,3,2V)

Breakdown Voltages

BV_{EBO} = 13 V @ I_{EBO} = 10 mA
BV_{CBO} = 61 V @ I_{CBO} = 10 mA
BV_{CEO} = 40 V @ I_{CEO} = 10 mA
BV_{CES} = 45 V @ I_{CES} = 10 mA

Leakage Currents

I_{EBO} = <0.1 mA @ V_{EBO} = 4V
I_{CBO} = <0.1 mA @ V_{CBO} = 20V
I_{CEO} = <0.1 mA @ V_{CEO} = 20V
I_{CES} = <0.1 mA @ V_{CES} = 20V

Switching Time

$t_d + t_r$ = ____ µs, t_s = ____ µs, t_f = ____ µs
Total Switching Time = ____ µs (I_C = 75A, I_B = 5A, V_{BE} = -1.5V on turn-off)

HIGH POWER, LOW SATURATION VOLTAGE

SILICON SWITCHING TRANSISTOR

PER: JET PROPULSION LABORATORY
ENGINEERING NOTE NO. 342-015

DATA ON ASSEMBLY NO. 117

$V_{CE(sat)}$ and Gain Measurements at 25°C ± 5°C

$V_{CE(sat)}$ = .077 V (I_B = 5A, I_C = 75A)
$V_{BE(sat)}$ = .85 V (I_B = 5A, I_C = 75A)
Gain 242, 242, 227 (I_C = 75A, V_{CE} = 4,3,2V)
V_{BE} = .71 V, .71 V, .72 V (I_C = 75A, V_{CE} = 4,3,2V)

$V_{CE(sat)}$ and Gain Measurements at 100°C ± 5°C

$V_{CE(sat)}$ = .089 V (I_B = 5A, I_C = 75A)
$V_{BE(sat)}$ = .75 V (I_B = 5A, I_C = 75A)
Gain = 278, 259, 234 (I_C = 75A, V_{CE} = 4,3,2V)
V_{BE} = .61 V, .61 V, .61 V (I_C = 75A, V_{CE} = 4,3,2V)

Breakdown Voltages

BV_{EBO} = 9.5 V @ I_{EBO} = 10 mA
BV_{CBO} = 30 V @ I_{CBO} = 10 mA
BV_{CEO} = 21 V @ I_{CEO} = 10 mA
BV_{CES} = 21 V @ I_{CES} = 10 mA

Leakage Currents

I_{EBO} = 1.2 mA @ V_{EBO} = 4V
I_{CBO} = 0.7 mA @ V_{CBO} = 20V
I_{CEO} = 8.0 mA @ V_{CEO} = 20V
I_{CES} = 7.5 mA @ V_{CES} = 20V

Switching Time

$t_d + t_r$ = ____ µs, t_s = ____ µs, t_f = ____ µs
Total Switching Time = ____ µs (I_C = 75A, I_B = 5A,
V_{BE} = -1.5V on turn-c__,

HIGH POWER, LOW SATURATION VOLTAGE

SILICON SWITCHING TRANSISTOR

PER: JET PROPULSION LABORATORY
ENGINEERING NOTE NO. 342-015

DATA ON ASSEMBLY NO. 118

$V_{CE(sat)}$ and Gain Measurements at 25°C ± 5°C

$V_{CE(sat)}$ = .073 V (I_B = 5A, I_C = 75A)
$V_{BE(sat)}$ = .86 V (I_B = 5A, I_C = 75A)
Gain 288, 234, 312 (I_C = 75A, V_{CE} = 4,3,2V)
V_{BE} = .71 V, .71 V, .73 V (I_C = 75A, V_{CE} = 4,3,2V)

$V_{CE(sat)}$ and Gain Measurements at 100°C ± 5°C

$V_{CE(sat)}$ = .087 V (I_B = 5A, I_C = 75A)
$V_{BE(sat)}$ = .76 V (I_B = 5A, I_C = 75A)
Gain = 312, 326, 288 (I_C = 75A, V_{CE} = 4,3,2V)
V_{BE} = .61 V, .62 V, .62 V (I_C = 75A, V_{CE} = 4,3,2V)

Breakdown Voltages

BV_{EBO} = 13 V @ I_{EBO} = 10 mA
BV_{CBO} = 36 V @ I_{CBO} = 10 mA
BV_{CEO} = 23 V @ I_{CEO} = 10 mA
BV_{CES} = 22 V @ I_{CES} = 10 mA

Leakage Currents

I_{EBO} = 1.3 mA @ V_{EBO} = 4V
I_{CBO} = 0.5 mA @ V_{CBO} = 20V
I_{CEO} = 3.2 mA @ V_{CEO} = 20V
I_{CES} = 3.2 mA @ V_{CES} = 20V

Switching Time

$t_d + t_r$ = ____ µs, t_s = ____ µs, t_f = ____ µs
Total Switching Time = ____ µs (I_C = 75A, I_B = 5A,
V_{BE} = -1.5V on turn-off)

HIGH POWER, LOW SATURATION VOLTAGE

SILICON SWITCHING TRANSISTOR

PER: JET PROPULSION LABORATORY
ENGINEERING NOTE NO. 342-015

DATA ON ASSEMBLY NO. 119

$V_{CE(sat)}$ and Gain Measurements at 25°C ± 5°C

$V_{CE(sat)}$ = .071 V (I_B = 5A, I_C = 75A)
$V_{BE(sat)}$ = .90 V (I_B = 5A, I_C = 75A)
Gain 312, 300, 326 (I_C = 75A, V_{CE} = 4,3,2V)
V_{BE} = .70 V, .72 V, .72 V (I_C = 75A, V_{CE} = 4,3,2V)

$V_{CE(sat)}$ and Gain Measurements at 100°C ± 5°C

$V_{CE(sat)}$ = .081 V (I_B = 5A, I_C = 75A)
$V_{BE(sat)}$ = .80 V (I_B = 5A, I_C = 75A)
Gain = 441, 417, 292 (I_C = 75A, V_{CE} = 4,3,2V)
V_{BE} = .60 V, .61 V, .60 V (I_C = 75A, V_{CE} = 4,3,2V,

Breakdown Voltages

BV_{EBO} = 11 V @ I_{EBO} = 10 mA
BV_{CBO} = 34 V @ I_{CBO} = 10 mA
BV_{CEO} = 22 V @ I_{CEO} = 10 mA
BV_{CES} = 23 V @ I_{CES} = 10 mA

Leakage Currents

I_{EBO} = 0.7 mA @ V_{EBO} = 4V
I_{CBO} = 1.2 mA @ V_{CBO} = 20V
I_{CEO} = 5.0 mA @ V_{CEO} = 20V
I_{CES} = 5.0 mA @ V_{CES} = 20V

Switching Time

$t_d + t_r$ = ____ µs, t_s = ____ µs, t_f = ____ µs
Total Switching Time = ____ µs (I_C = 75A, I_B = 5A,
V_{BE} = -1.5V on turn-off)

HIGH POWER, LOW SATURATION VOLTAGE

SILICON SWITCHING TRANSISTOR

PER: JET PROPULSION LABORATORY
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DATA ON ASSEMELY NO. 120

$V_{CE(sat)}$ and Gain Measurements at 25°C ± 5°C

$V_{CE(sat)}$ = .072 V (I_B = 5A, I_C = 75A)
$V_{BE(sat)}$ = .82 V (I_B = 5A, I_C = 75A)
Gain 259, 259, 259 (I_C = 75A, V_{CE} = 4,3,2V)
V_{BE} = .71 V, .71 V, .71 V (I_C = 75A, V_{CE} = 4,3,2V)

$V_{CE(sat)}$ and Gain Measurements at 100°C ± 5°C

$V_{CE(sat)}$ = .074 V (I_B = 5A, I_C = 75A)
$V_{BE(sat)}$ = .73 V (I_B = 5A, I_C = 75A)
Gain = 326, 288, 288 (I_C = 75A, V_{CE} = 4,3,2V)
V_{BE} = .61 V, .61 V, .62 V (I_C = 75A, V_{CE} = 4,3,2V)

Breakdown Voltages

BV_{EBO} = 14 V @ I_{EBO} = 10 mA
BV_{CBO} = 7100 V @ I_{CBO} = 10 mA
BV_{CEO} = 80 V @ I_{CEO} = 10 mA
BV_{CES} = 94 V @ I_{CES} = 10 mA

Leakage Currents

I_{EBO} = <0.1 mA @ V_{EBO} = 4V
I_{CBO} = <0.1 mA @ V_{CBO} = 20V
I_{CEO} = <0.1 mA @ V_{CEO} = 20V
I_{CES} = <0.1 mA @ V_{CES} = 20V

Switching Time

$t_d + t_r$ = ____ µs, t_s = ____ µs, t_f = ____ µs
Total Switching Time = ____ µs (I_C = 75A, I_B = 5A
V_{BE} = -1.5V on turn-off)

HIGH POWER, LOW SATURATION VOLTAGE

SILICON SWITCHING TRANSISTOR

PER: JET PROPULSION LABORATORY
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DATA ON ASSEMBLY NO. 121

$V_{CE(sat)}$ and Gain Measurements at 25°C ± 5°C

$V_{CE(sat)}$ = .060 V (I_B = 5A, I_C = 75A)
$V_{BE(sat)}$ = .81 V (I_B = 5A, I_C = 75A)
Gain 250, 242, 242 (I_C = 75A, V_{CE} = 4,3,2V)
V_{BE} = .72 V, .72 V, .72 V (I_C = 75A, V_{CE} = 4,3,2V)

$V_{CE(sat)}$ and Gain Measurements at 100°C ± 5°C

$V_{CE(sat)}$ = .081 V (I_B = 5A, I_C = 75A)
$V_{BE(sat)}$ = .74 V (I_B = 5A, I_C = 75A)
Gain = 250, 242, 242 (I_C = 75A, V_{CE} = 4,3,2V)
V_{BE} = .61 V, .61 V, .62 V (I_C = 75A, V_{CE} = 4,3,2V)

Breakdown Voltages

BV_{EBO} = 12.5 V @ I_{EBO} = 10 mA
BV_{CBO} = 100 V @ I_{CBO} = 10 mA
BV_{CEO} = 42 V @ I_{CEO} = 10 mA
BV_{CES} = 55 V @ I_{CES} = 10 mA

Leakage Currents

I_{EBO} = 0.1 mA @ V_{EBO} = 4V
I_{CBO} = 0.2 mA @ V_{CBO} = 20V
I_{CEO} = 0.2 mA @ V_{CEO} = 20V
I_{CES} = 0.2 mA @ V_{CES} = 20V

Switching Time

$t_d + t_r$ = ____ µs, t_s = ____ µs, t_f = ____ µs
Total Switching Time = ____ µs (I_C = 75A, I_B = 5A, V_{BE} = -1.5V on turn-off)

HIGH POWER, LOW SATURATION VOLTAGE

SILICON SWITCHING TRANSISTOR

PER: JET PROPULSION LABORATORY
ENGINEERING NOTE NO. 342-015

DATA ON ASSEMBLY NO. 122

$V_{CE(sat)}$ and Gain Measurements at 25°C ± 5°C

$V_{CE(sat)}$ = .069 V (I_B = 5A, I_C = 75A)
$V_{BE(sat)}$ = .81 V (I_B = 5A, I_C = 75A)
Gain 163, 160, 150 (I_C = 75A, V_{CE} = 4,3,2V)
V_{BE} = .73 V, .74 V, .74 V (I_C = 75A, V_{CE} = 4,3,2

$V_{CE(sat)}$ and Gain Measurements at 100°C ± 5°C

$V_{CE(sat)}$ = .094 V (I_B = 5A, I_C = 75A)
$V_{BE(sat)}$ = .73 V (I_B = 5A, I_C = 75A)
Gain = 160, 153, 150 (I_C = 75A, V_{CE} = 4,3,2V)
V_{BE} = .64 V, .64 V, .64 V (I_C = 75A, V_{CE} = 4,3,2V)

Breakdown Voltages

BV_{EBO} = 12 V @ I_{EBO} = 10 mA
BV_{CBO} = 110 V @ I_{CBO} = 10 mA
BV_{CEO} = 95 V @ I_{CEO} = 10 mA
BV_{CES} = 97 V @ I_{CES} = 10 mA

Leakage Currents

I_{EBO} = 04 mA @ V_{EBO} = 4V
I_{CBO} = <0.1 mA @ V_{CBO} = 20V
I_{CEO} = 0.7 mA @ V_{CEO} = 20V
I_{CES} = <0.1 mA @ V_{CES} = 20V

Switching Time

$t_d + t_r$ = ____ µs, t_s = ____ µs, t_f = ____ µs
Total Switching Time = ____ µs (I_C = 75A, I_B = 5A,
V_{BE} = -1.5V on turn-off)

HIGH POWER, LOW SATURATION VOLTAGE

SILICON SWITCHING TRANSISTOR

PER: JET PROPULSION LABORATORY
ENGINEERING NOTE NO. 342-015

DATA ON ASSEMBLY NO. 123

$V_{CE(sat)}$ and Gain Measurements at 25°C ± 5°C

$V_{CE(sat)}$ = .073 V (I_B = 5A, I_C = 75A)
$V_{BE(sat)}$ = .81 V (I_B = 5A, I_C = 75A)
Gain 183, 178, 167 (I_C = 75A, V_{CE} = 4,3,2V)
V_{BE} = .73 V, .73 V, .73 V (I_C = 75A, V_{CE} = 4,3,2V)

$V_{CE(sat)}$ and Gain Measurements at 100°C ± 5°C

$V_{CE(sat)}$ = .095 V (I_B = 5A, I_C = 75A)
$V_{BE(sat)}$ = .75 V (I_B = 5A, I_C = 75A)
Gain = 153, 147, 147 (I_C = 75A, V_{CE} = 4,3,2V)
V_{BE} = .63 V, .63 V, .64 V (I_C = 75A, V_{CE} = 4,3,2V)

Breakdown Voltages

BV_{EBO} = 10 V @ I_{EBO} = 10 mA
BV_{CBO} = 70 V @ I_{CBO} = 10 mA
BV_{CEO} = 60 V @ I_{CEO} = 10 mA
BV_{CES} = 60 V @ I_{CES} = 10 mA

Leakage Currents

I_{EBO} = 0.5 mA @ V_{EBO} = 4V
I_{CBO} = <0.1 mA @ V_{CBO} = 20V
I_{CEO} = 0.2 mA @ V_{CEO} = 20V
I_{CES} = <0.1 mA @ V_{CES} = 20V

Switching Time

$t_d + t_r$ = ____ µs, t_s = ____ µs, t_f ____
Total Switching Time = ____ µs (I_C = 75A, I_B = 5A, V_{BE} = -1.5V on turn-off)

HIGH POWER, LOW SATURATION VOLTAGE

SILICON SWITCHING TRANSISTOR

PER: JET PROPULSION LABORATORY
ENGINEERING NOTE NO. 342-015

DATA ON ASSEMBLY NO. 124

$V_{CE(sat)}$ and Gain Measurements at 25°C ± 5°C

$V_{CE(sat)}$ = .074 V (I_B = 5A, I_C = 75A)
$V_{BE(sat)}$ = .81 V (I_B = 5A, I_C = 75A)
Gain 142, 136, 134 (I_C = 75A, V_{CE} = 4,3,2V)
V_{BE} = .73 V, .73 V, .73 V (I_C = 75A, V_{CE} = 4,3,2V)

$V_{CE(sat)}$ and Gain Measurements at 100°C ± 5°C

$V_{CE(sat)}$ = .089 V (I_B = 5A, I_C = 75A)
$V_{BE(sat)}$ = .75 V (I_B = 5A, I_C = 75A)
Gain = 136, 132, 127 (I_C = 75A, V_{CE} = 4,3,2V)
V_{BE} = .63 V, .63 V, .63 V (I_C = 75A, V_{CE} = 4,3,2V,

Breakdown Voltages

BV_{EBO} = 10 V @ I_{EBO} = 10 mA
BV_{CBO} = 95 V @ I_{CBO} = 10 mA
BV_{CEO} = 80 V @ I_{CEO} = 10 mA
BV_{CES} = 80 V @ I_{CES} = 10 mA

Leakage Currents

I_{EBO} = 2.0 mA @ V_{EBO} = 4V
I_{CBO} = 0.2 mA @ V_{CBO} = 20V
I_{CEO} = 0.2 mA @ V_{CEO} = 20V
I_{CES} = 0.3 mA @ V_{CES} = 20V

Switching Time

$t_d + t_r$ = ____ µs, t_s = ____ µs, t_x ____
Total Switching Time = ____ µs (I_C = 75A, I_B = 5A,
V_{BE} = -1.5V on turn-off)

HIGH POWER, LOW SATURATION VOLTAGE

SILICON SWITCHING TRANSISTOR

PER: JET PROPULSION LABORATORY
ENGINEERING NOTE NO. 342-015

DATA ON ASSEMBLY NO. 125

$V_{CE(sat)}$ and Gain Measurements at 25°C ± 5°C

$V_{CE(sat)}$ = .091 V (I_B = 5A, I_C = 75A)
$V_{BE(sat)}$ = .82 V (I_B = 5A, I_C = 75A)
Gain 132, 127, 125 (I_C = 75A, V_{CE} = 4,3,2V)
V_{BE} = .75 V, .75 V, .75 V (I_C = 75A, V_{CE} = 4,3,2V)

$V_{CE(sat)}$ and Gain Measurements at 100°C ± 5°C

$V_{CE(sat)}$ = .125 V (I_B = 5A, I_C = 75A)
$V_{BE(sat)}$ = .76 V (I_B = 5A, I_C = 75A)
Gain = 110, 106, 101 (I_C = 75A, V_{CE} = 4,3,2V)
V_{BE} = .66 V, .66 V, .66 V (I_C = 75A, V_{CE} = 4,3,2V)

Breakdown Voltages

BV_{EBO} = 9 V @ I_{EBO} = 10 mA
BV_{CBO} = 120 V @ I_{CBO} = 10 mA
BV_{CEO} = 110 V @ I_{CEO} = 10 mA
BV_{CES} = 110 V @ I_{CES} = 10 mA

Leakage Currents

I_{EBO} = 0.5 mA @ V_{EBO} = 4V
I_{CBO} = 0.2 mA @ V_{CBO} = 20V
I_{CEO} = 1.5 mA @ V_{CEO} = 20V
I_{CES} = 0.3 mA @ V_{CES} = 20V

Switching Time

$t_d + t_r$ = ____ µs, t_s = ____ µs, t_f = ____ µs
Total Switching Time = ____ µs (I_C = 75A, I_B = 5A, V_{BE} = -1.5V on turn-off)

HIGH POWER, LOW SATURATION VOLTAGE

SILICON SWITCHING TRANSISTOR

PER: JET PROPULSION LABORATORY
ENGINEERING NOTE NO. 342-015

DATA ON ASSEMBLY NO. 126

$V_{CE(sat)}$ and Gain Measurements at 25°C ± 5°C

$V_{CE(sat)}$ = .104 V (I_B = 5A, I_C = 75A)
$V_{BE(sat)}$ = .81 V (I_B = 5A, I_C = 75A)
Gain 163, 160, 156 (I_C = 75A, V_{CE} = 4,3,2V)
V_{BE} = .72 V, .73 V, .73 V (I_C = 75A, V_{CE} = 4,3,2V)

$V_{CE(sat)}$ and Gain Measurements at 100°C ± 5°C

$V_{CE(sat)}$ = .117 V (I_B = 5A, I_C = 75A)
$V_{BE(sat)}$ = .76 V (I_B = 5A, I_C = 75A)
Gain = 357, 268, 220 (I_C = 75A, V_{CE} = 4,3,2V)
V_{BE} = .62 V, .63 V, .63 V (I_C = 75A, V_{CE} = 4,3,2V)

Breakdown Voltages

BV_{EBO} = 6.8 V @ I_{EBO} = 10 mA
BV_{CBO} = 43 V @ I_{CBO} = 10 mA
BV_{CEO} = 38 V @ I_{CEO} = 10 mA
BV_{CES} = 38 V @ I_{CES} = 10 mA

Leakage Currents

I_{EBO} = 2.0 mA @ V_{EBO} = 4v
I_{CBO} = <0.1 mA @ V_{CBO} = 20V
I_{CEO} = <0.1 mA @ V_{CEO} = 20V
I_{CES} = <0.1 mA @ V_{CES} = 20V

Switching Time

$t_d + t_r$ = 3.9 µs, t_s = 1.8 µs, t_f = 5.7 µs
Total Switching Time = 11.4 µs (I_C = 75A, I_B = 5A, V_{BE} = -1.5V on turn-off)

HIGH POWER, LOW SATURATION VOLTAGE

SILICON SWITCHING TRANSISTOR

PER: JET PROPULSION LABORATORY
ENGINEERING NOTE NO. 342-015

DATA ON ASSEMBLY NO. 127

$V_{CE(sat)}$ and Gain Measurements at 25°C ± 5°C

$V_{CE(sat)}$ = .105 V (I_B = 5A, I_C = 75A)
$V_{BE(sat)}$ = .83 V (I_B = 5A, I_C = 75A)
Gain 96, 92, 96 (I_C = 75A, V_{CE} = 4,3,2V)
V_{BE} = .76 V, .76 V, .76 V (I_C = 75A, V_{CE} = 4,3,2V)

$V_{CE(sat)}$ and Gain Measurements at 100°C ± 5°C

$V_{CE(sat)}$ = .156 V (I_B = 5A, I_C = 75A)
$V_{BE(sat)}$ = 1.16 V (I_B = 5A, I_C = 75A)
Gain = 76, 72, 68 (I_C = 75A, V_{CE} = 4,3,2V)
V_{BE} = .76 V, .65 V, .66 V (I_C = 75A, V_{CE} = 4,3,2V)

Breakdown Voltages

BV_{EBO} = 11 V @ I_{EBO} = 10 mA
BV_{CBO} = 82 V @ I_{CBO} = 10 mA
BV_{CEO} = 66 V @ I_{CEO} = 10 mA
BV_{CES} = 70 V @ I_{CES} = 10 mA

Leakage Currents

I_{EBO} = 0.3 mA @ V_{EBO} = 4V
I_{CBO} = <0.1 mA @ V_{CBO} = 20V
I_{CEO} = <0.1 mA @ V_{CEO} = 20V
I_{CES} = <0.1 mA @ V_{CES} = 20V

Switching Time

$t_d + t_r$ = 3.9 µs, t_s = 1.6 µs, t_f = 5.2 µs
Total Switching Time = 10.7 µs (I_C = 75A, I_B = 5A, V_{BE} = -1.5V on turn-off)

HIGH POWER, LOW SATURATION VOLTAGE

SILICON SWITCHING TRANSISTOR

PER: JET PROPULSION LABORATORY
ENGINEERING NOTE NO. 342-015

DATA ON ASSEMBLY NO. 128

$V_{CE(sat)}$ and Gain Measurements at 25°C ± 5°C

$V_{CE(sat)}$ = .093 V (I_B = 5A, I_C = 75A)
$V_{BE(sat)}$ = .81 V (I_B = 5A, I_C = 75A)
Gain 95, 91, 90 (I_C = 75A, V_{CE} = 4,3,2V)
V_{BE} = .74 V, .75 V, .75 V (I_C = 75A, V_{CE} = 4,3,2V)

$V_{CE(sat)}$ and Gain Measurements at 100°C ± 5°C

$V_{CE(sat)}$ = .134 V (I_B = 5A, I_C = 75A)
$V_{BE(sat)}$ = .75 V (I_B = 5A, I_C = 75A)
Gain = 77, 74, 73 (I_C = 75A, V_{CE} = 4,3,2V)
V_{BE} = .63 V, .63 V, .63 V (I_C = 75A, V_{CE} = 4,3,2V)

Breakdown Voltages

BV_{EBO} = 9.8 V @ I_{EBO} = 10 mA
BV_{CBO} = 35 V @ I_{CBO} = 10 mA
BV_{CEO} = 32 V @ I_{CEO} = 10 mA
BV_{CES} = 32 V @ I_{CES} = 10 mA

Leakage Currents

I_{EBO} = 1.4 mA @ V_{EBO} = 4V
I_{CBO} = <0.1 mA @ V_{CBO} = 20V
I_{CEO} = <0.1 mA @ V_{CEO} = 20V
I_{CES} = <0.1 mA @ V_{CES} = 20V

Switching Time

$t_d + t_r$ = 3.9 µs, t_s = 2.1 µs, t_f = 5.8 µs
Total Switching Time = 11.8 µs (I_C = 75A, I_B = 5A, V_{BE} = -1.5V on turn-off)

HIGH POWER, LOW SATURATION VOLTAGE

SILICON SWITCHING TRANSISTOR

PER: JET PROPULSION LABORATORY
ENGINEERING NOTE NO. 342-015

DATA ON ASSEMBLY NO. 129

$V_{CE(sat)}$ and Gain Measurements at 25°C ± 5°C

$V_{CE(sat)}$ = .101 V (I_B = 5A, I_C = 75A)
$V_{BE(sat)}$ = .82 V (I_B = 5A, I_C = 75A)
Gain 100, 97, 95 (I_C = 75A, V_{CE} = 4,3,2V)
V_{BE} = .75 V, .75 V, .76 V (I_C = 75A, V_{CE} = 4,3,2V)

$V_{CE(sat)}$ and Gain Measurements at 100°C ± 5°C

$V_{CE(sat)}$ = .098 V (I_B = 5A, I_C = 75A)
$V_{BE(sat)}$ = .79 V (I_B = 5A, I_C = 75A)
Gain = 234, 227, 203 (I_C = 75A, V_{CE} = 4,3,2V)
V_{BE} = .61 V, .60 V, .60 V (I_C = 75A, V_{CE} = 4,3,2V)

Breakdown Voltages

BV_{EBO} = 9.5 V @ I_{EBO} = 10 mA
BV_{CBO} = 38 V @ I_{CBO} = 10 mA
BV_{CEO} = 25 V @ I_{CEO} = 10 mA
BV_{CES} = 25 V @ I_{CES} = 10 mA

Leakage Currents

I_{EBO} = 1.6 mA @ V_{EBO} = 4V
I_{CBO} = 2.0 mA @ V_{CBO} = 20V
I_{CEO} = 6.0 mA @ V_{CEO} = 20V
I_{CES} = 6.0 mA @ V_{CES} = 20V

Switching Time

$t_d + t_r$ = ____ µs, t_s = ____ µs, t_f = ____ µs
Total Switching Time = ____ µs (I_C = 75A, I_B = 5A,
V_{BE} = -1.5V on turn-off)

HIGH POWER, LOW SATURATION VOLTAGE

SILICON SWITCHING TRANSISTOR

PER: JET PROPULSION LABORATORY
ENGINEERING NOTE NO. 342-015

DATA ON ASSEMBLY NO. 130

$V_{CE(sat)}$ and Gain Measurements at 25°C ± 5°C

$V_{CE(sat)}$ = .077 V (I_B = 5A, I_C = 75A)
$V_{BE(sat)}$ = .79 V (I_B = 5A, I_C = 75A)
Gain 214, 187, — (I_C = 75A, V_{CE} = 4,3,2V)
V_{BE} = .70 V, .70 V, — V (I_C = 75A, V_{CE} = 4,3,2V)

$V_{CE(sat)}$ and Gain Measurements at 100°C ± 5°C

$V_{CE(sat)}$ = .099 V (I_B = 5A, I_C = 75A)
$V_{BE(sat)}$ = .74 V (I_B = 5A, I_C = 75A)
Gain = 147, 144, 147 (I_C = 75A, V_{CE} = 4,3,2V)
V_{BE} = .61 V, .61 V, .62 V (I_C = 75A, V_{CE} = 4,3,2V)

Breakdown Voltages

BV_{EBO} = 12 V @ I_{EBO} = 10 mA
BV_{CBO} = 55 V @ I_{CBO} = 10 mA
BV_{CEO} = 42 V @ I_{CEO} = 10 mA
BV_{CES} = 42 V @ I_{CES} = 10 mA

Leakage Currents

I_{EBO} = 0.6 mA @ V_{EBO} = 4V
I_{CBO} = <0.1 mA @ V_{CBO} = 20V
I_{CEO} = <0.1 mA @ V_{CEO} = 20V
I_{CES} = <0.1 mA @ V_{CES} = 20V

Switching Time

$t_d + t_r$ = ____ µs, t_s = ____ µs, t_f = ____ µs
Total Switching Time = ____ µs (I_C = 75A, I_B = 5A,
V_{BE} = -1.5V on turn-off)

HIGH POWER, LOW SATURATION VOLTAGE

SILICON SWITCHING TRANSISTOR

PER: JET PROPULSION LABORATORY
ENGINEERING NOTE NO. 342-015

DATA ON ASSEMBLY NO. 131

$V_{CE(sat)}$ and Gain Measurements at 25°C ± 5°C

$V_{CE(sat)}$ = .078 V (I_B = 5A, I_C = 75A)
$V_{BE(sat)}$ = .81 V (I_B = 5A, I_C = 75A)
Gain 110, 107, 104 (I_C = 75A, V_{CE} = 4,3,2V)
V_{BE} = .73 V, .74 V, .73 V (I_C = 75A, V_{CE} = 4,3,2V)

$V_{CE(sat)}$ and Gain Measurements at 100°C ± 5°C

$V_{CE(sat)}$ = .110 V (I_B = 5A, I_C = 75A)
$V_{BE(sat)}$ = .72 V (I_B = 5A, I_C = 75A)
Gain = 94, 94, 94 (I_C = 75A, V_{CE} = 4,3,2V)
V_{BE} = .60 V, .60 V, .61 V (I_C = 75A, V_{CE} = 4,3,2V)

Breakdown Voltages

BV_{EBO} = 10 V @ I_{EBO} = 10 mA
BV_{CBO} = 65 V @ I_{CBO} = 10 mA
BV_{CEO} = 54 V @ I_{CEO} = 10 mA
BV_{CES} = 54 V @ I_{CES} = 10 mA

Leakage Currents

I_{EBO} = 2.0 mA @ V_{EBO} = 4V
I_{CBO} = <0.1 mA @ V_{CBO} = 20V
I_{CEO} = <0.1 mA @ V_{CEO} = 20V
I_{CES} = <0.1 mA @ V_{CES} = 20V

Switching Time

$t_d + t_r$ = ____ µs, t_s = ____ µs, t_f = ____ µs
Total Switching Time = ____ µs (I_C = 75A, I_B = 5A, V_{BE} = -1.5V on turn-off)

HIGH POWER, LOW SATURATION VOLTAGE

SILICON SWITCHING TRANSISTOR

PER: JET PROPULSION LABORATORY
ENGINEERING NOTE NO. 342-015

DATA ON ASSEMBLY NO. 132

$V_{CE(sat)}$ and Gain Measurements at 25°C ± 5°C

$V_{CE(sat)}$ = .085 V (I_B = 5A, I_C = 75A)
$V_{BE(sat)}$ = .80 V (I_B = 5A, I_C = 75A)
Gain 167, 163, — (I_C = 75A, V_{CE} = 4,3,2V)
V_{BE} = .72 V, .72 V, — V (I_C = 75A, V_{CE} = 4,3,2V)

$V_{CE(sat)}$ and Gain Measurements at 100°C ± 5°C

$V_{CE(sat)}$ = .093 V (I_B = 5A, I_C = 75A)
$V_{BE(sat)}$ = .75 V (I_B = 5A, I_C = 75A)
Gain = 167, 163, 147 (I_C = 75A, V_{CE} = 4,3,2V)
V_{BE} = .62 V, .62 V, .63 V (I_C = 75A, V_{CE} = 4,3,2V)

Breakdown Voltages

BV_{EBO} = 11 V @ I_{EBO} = 10 mA
BV_{CBO} = 77 V @ I_{CBO} = 10 mA
BV_{CEO} = 66 V @ I_{CEO} = 10 mA
BV_{CES} = 66 V @ I_{CES} = 10 mA

Leakage Currents

I_{EBO} = 0.6 mA @ V_{EBO} = 4V
I_{CBO} = <0.1 mA @ V_{CBO} = 20V
I_{CEO} = <0.1 mA @ V_{CEO} = 20V
I_{CES} = <0.1 mA @ V_{CES} = 20V

Switching Time

$t_d + t_r$ = ____ µs, t_s = ____ µs, t_f = ____ µs
Total Switching Time = ____ µs (I_C = 75A, I_B = 5A, V_{BE} = -1.5V on turn-off)

HIGH POWER, LOW SATURATION VOLTAGE

SILICON SWITCHING TRANSISTOR

PER: JET PROPULSION LABORATORY
ENGINEERING NOTE NO. 342-015

DATA ON ASSEMBLY NO. 133

$V_{CE(sat)}$ and Gain Measurements at 25°C ± 5°C

$V_{CE(sat)}$ = .104 V (I_B = 5A, I_C = 75A)
$V_{BE(sat)}$ = .79 V (I_B = 5A, I_C = 75A)
Gain 104, 100, 96 (I_C = 75A, V_{CE} = 4,3,2V)
V_{BE} = .72 V, .72 V, .72 V (I_C = 75A, V_{CE} = 4,3,2V)

$V_{CE(sat)}$ and Gain Measurements at 100°C ± 5°C

$V_{CE(sat)}$ = .102 V (I_B = 5A, I_C = 75A)
$V_{BE(sat)}$ = .71 V (I_B = 5A, I_C = 75A)
Gain = 103, 97, 94 (I_C = 75A, V_{CE} = 4,3,2V)
V_{BE} = .60 V, .62 V, .63 V (I_C = 75A, V_{CE} = 4,3,2V)

Breakdown Voltages

BV_{EBO} = 11 V @ I_{EBO} = 10 mA
BV_{CBO} = 26 V @ I_{CBO} = 10 mA
BV_{CEO} = 23 V @ I_{CEO} = 10 mA
BV_{CES} = 25 V @ I_{CES} = 10 mA

Leakage Currents

I_{EBO} = <0.1 mA @ V_{EBO} = 4V
I_{CBO} = 0.2 mA @ V_{CBO} = 20V
I_{CEO} = 5.0 mA @ V_{CEO} = 20V
I_{CES} = 0.2 mA @ V_{CES} = 20V

Switching Time

$t_d + t_r$ = ____ µs, t_s = ____ µs, t_f = ____ µs
Total Switching Time = ____ µs (I_C = 75A, I_B = 5A,
$_{BE}$ = -1.5V on turn-off)

HIGH POWER, LOW SATURATION VOLTAGE
SILICON SWITCHING TRANSISTOR

PER: JET PROPULSION LABORATORY
ENGINEERING NOTE NO. 342-015

DATA ON ASSEMBLY NO. 134

$V_{CE(sat)}$ and Gain Measurements at 25°C ± 5°C

$V_{CE(sat)}$ = .102 V (I_B = 5A, I_C = 75A)
$V_{BE(sat)}$ = .81 V (I_B = 5A, I_C = 75A)
Gain 115, 110, 97 (I_C = 75A, V_{CE} = 4,3,2V)
V_{BE} = .74 V, .75 V, .75 V (I_C = 75A, V_{CE} = 4,3,2V)

$V_{CE(sat)}$ and Gain Measurements at 100°C ± 5°C

$V_{CE(sat)}$ = .141 V (I_B = 5A, I_C = 75A)
$V_{BE(sat)}$ = .75 V (I_B = 5A, I_C = 75A)
Gain = 88, 86, 84 (I_C = 75A, V_{CE} = 4,3,2V)
V_{BE} = .64 V, .64 V, .65 V (I_C = 75A, V_{CE} = 4,3,2V)

Breakdown Voltages

BV_{EBO} = 14 V @ I_{EBO} = 10 mA
BV_{CBO} = 88 V @ I_{CBO} = 10 mA
BV_{CEO} = 55 V @ I_{CEO} = 10 mA
BV_{CES} = 74 V @ I_{CES} = 10 mA

Leakage Currents

I_{EBO} = 24 mA @ V_{EBO} = 4V
I_{CBO} = <0.1 mA @ V_{CBO} = 20V
I_{CEO} = <0.1 mA @ V_{CEO} = 20V
I_{CES} = <0.1 mA @ V_{CES} = 20V

Switching Time

$t_d + t_r$ = ____ µs, t_s = ____ µs, t_f = ____ µs
Total Switching Time = ____ µs (I_C = 75A, I_B = 5A, V_{BE} = -1.5V on turn-off)

HIGH POWER, LOW SATURATION VOLTAGE

SILICON SWITCHING TRANSISTOR

PER: JET PROPULSION LABORATORY
ENGINEERING NOTE NO. 342-015

DATA ON ASSEMBLY NO. 135

$V_{CE(sat)}$ and Gain Measurements at 25°C ± 5°C

$V_{CE(sat)}$ = .125 V (I_B = 5A, I_C = 75A)
$V_{BE(sat)}$ = .86 V (I_B = 5A, I_C = 75A)
Gain 110, 86, — (I_C = 75A, V_{CE} = 4,3,2V)
V_{BE} = .79 V, .78 V, — V (I_C = 75A, V_{CE} = 4,3,2V)

$V_{CE(sat)}$ and Gain Measurements at 100°C ± 5°C

$V_{CE(sat)}$ = .195 V (I_B = 5A, I_C = 75A)
$V_{BE(sat)}$ = .84 V (I_B = 5A, I_C = 75A)
Gain = 78, 76, 71 (I_C = 75A, V_{CE} = 4,3,2V)
V_{BE} = .71 V, .70 V, .70 V (I_C = 75A, V_{CE} = 4,3,2V)

Breakdown Voltages

BV_{EBO} = 11 V @ I_{EBO} = 10 mA
BV_{CBO} = 44 V @ I_{CBO} = 10 mA
BV_{CEO} = 33 V @ I_{CEO} = 10 mA
BV_{CES} = 32 V @ I_{CES} = 10 mA

Leakage Currents

I_{EBO} = 0.2 mA @ V_{EBO} = 4V
I_{CBO} = 0.5 mA @ V_{CBO} = 20V
I_{CEO} = 3.0 mA @ V_{CEO} = 20V
I_{CES} = 2.8 mA @ V_{CES} = 20V

Switching Time

$t_d + t_r$ = ____ µs, t_s = ____ µs, t_f = ____ µs
Total Switching Time = ____ µs (I_C = 75A, I_B = 5A, V_{BE} = -1.5V on turn-off)

HIGH POWER, LOW SATURATION VOLTAGE

SILICON SWITCHING TRANSISTOR

PER: JET PROPULSION LABORATORY
ENGINEERING NOTE NO. 342-015

DATA ON ASSEMBLY NO. 136

$V_{CE(sat)}$ and Gain Measurements at 25°C ± 5°C

$V_{CE(sat)}$ = .102 V (I_B = 5A, I_C = 75A)
$V_{BE(sat)}$ = .83 V (I_B = 5A, I_C = 75A)
Gain 129, 110, — (I_C = 75A, V_{CE} = 4,3,2V)
V_{BE} = .76 V, .75 V, — V (I_C = 75A, V_{CE} = 4,3,2V)

$V_{CE(sat)}$ and Gain Measurements at 100°C ± 5°C

$V_{CE(sat)}$ = .139 V (I_B = 5A, I_C = 75A)
$V_{BE(sat)}$ = .79 V (I_B = 5A, I_C = 75A)
Gain = 100, 91, 83 (I_C = 75A, V_{CE} = 4,3,2V)
V_{BE} = .65 V, .65 V, .64 V (I_C = 75A, V_{CE} = 4,3,2V)

Breakdown Voltages

BV_{EBO} = 11 V @ I_{EBO} = 10 mA
BV_{CBO} = 67 V @ I_{CBO} = 10 mA
BV_{CEO} = 35 V @ I_{CEO} = 10 mA
BV_{CES} = 56 V @ I_{CES} = 10 mA

Leakage Currents

I_{EBO} = <0.1 mA @ V_{EBO} = 4V
I_{CBO} = <0.1 mA @ V_{CBO} = 20V
I_{CEO} = <0.1 mA @ V_{CEO} = 20V
I_{CES} = <0.1 mA @ V_{CES} = 20V

Switching Time

$t_d + t_r$ = ____ µs, t_s = ____ µs, t_f = ____ µs
Total Switching Time = ____ µs (I_C = 75A, I_B = 5A,
V_{BE} = -1.5V on turn-off)