MV SERIES

COMPONENT PERFORMANCE

TRANSISTOR PERFORMANCE

Parameter	Small NPN, 1X	Medium NPN	Large NPN
Useful Current Range	10nA-10mA	100nA-30mA	100nA-90mA
Current Gain, h_{FE}	80-400	80-400	80-400
Matching of h_{FE}	±10%	±10%	±10%
Matching of V_{BE}	±5mV maximum	±4mV maximum	±3mV maximum
Collector Breakdown Voltage, LV_{CEO}	40V minimum	40V minimum	40V minimum
Collector-Base Leakage	5pA typical	2pA typical	10pA typical
Base-Emitter Breakdown, BV_{EBO}	7.3V typical	7.3V typical	7.3V typical
Cutoff Frequency, fT	450MHz typical	450MHz typical	450MHz typical
Saturation Resistance	10-30 ohms	5-20 ohms	3-8 ohms

Parameter	Lateral PNP	Vertical PNP
Useful Current Range	10nA-1mA	10nA-5mA
Current Gain, h_{FE}	30-250	75-250
Matching of h_{FE}	±10%	±10%
Matching of V_{BE}	±5mV maximum	±5mV maximum
Collector Breakdown Voltage, LV_{CEO}	50V minimum	50V minimum
Collector Base Leakage	7pA typical	7pA typical
Base-Emitter Breakdown, BV_{EBO}	40V minimum	7.3V typical
Cutoff Frequency, fT	4.5MHz typical	13MHz typical
Saturation Resistance	300-900 ohms	10-40 ohms

PASSIVE COMPONENT PERFORMANCE

Diffused Resistor Performance

P Base Diffused Resistors

Resistor Values	300 ohms 900 ohms 1.8K ohms
Resistor Tolerance	±25%
Temperature Coefficient	+0.2%/°C typ.
Matching	
Equal (1:1) Ratio	±2%
Non-Equal Ratio	±6%

N+ Emitter Diffused Resistors

Resistor Values	15, 20, 25 ohms
Resistor Tolerance	±25%
Temperature Coefficient	+0.13%/°C typ.

Implanted Resistor Performance

Resistor values	10K, 50K ohms typ.
Resistor Tolerance	±25%
Temperature Coefficient	0.33%/°C typ.
Breakdown Voltage	40V min.

Capacitor Performance

Capacitor Value	5pF typ.
Capacitor Tolerance	±25%

Diode Performance

Forward Voltage	0.7V typ.
Forward Voltage Matching	±5mV max.
Temperature Coefficient, Forward	-1.8V/°C typ.
Reverse Breakdown Voltage	
Emitter-Base (NPN)	7.3V typ.
Temp. Coeff., Reverse	+2.9V/°C typ.
Emitter-Base (PNP)	40V min.

MACROCHIP MV FAMILY COMPONENT CHART						
	Cell	MVA	MVC	MVE	MVG	MVJ
Array Cell	1	4	6	9	12	20
NPN-2X	4	22	30	42	54	86
NPN-medium	-	2	3	3	4	5
NPN-large	-	2	3	3	4	5
NPN-pad 2X	-	8	8	12	12	16
NPN (Resistor Pocket)	-	4	4	6	6	8
PNP/NPN (Monistor)	4	22	30	44	56	88
Substrate PNP	-	2	3	3	4	5
Base Resistance:						
900 ohms	16	100	138	206	263	428
1800 ohms	16	98	136	236	303	476
300 ohms	4	16	24	36	48	80
400 ohms	-	4	4	6	6	8
Total Base Res.	44.4K	272.8K	377.8K	623.4K	798.9K	1269.2K
Implant Resistance						
10K ohms	12	68	92	138	174	280
50K ohms	-	4	4	6	6	8
Total Impl. Res.	120K	880K	1120K	1680K	2040K	3200K
Total Resistance	164.4K	1152.8K	1497.8K	2303.4K	2838.9K	4469.2K
Capacitors (5PF)						
(Or use as pads)	-	4	4	6	6	8
Pads	-	16	20	24	28	36
Size (Mils)	-	93x79	93x101	132x101	132x123	164x145

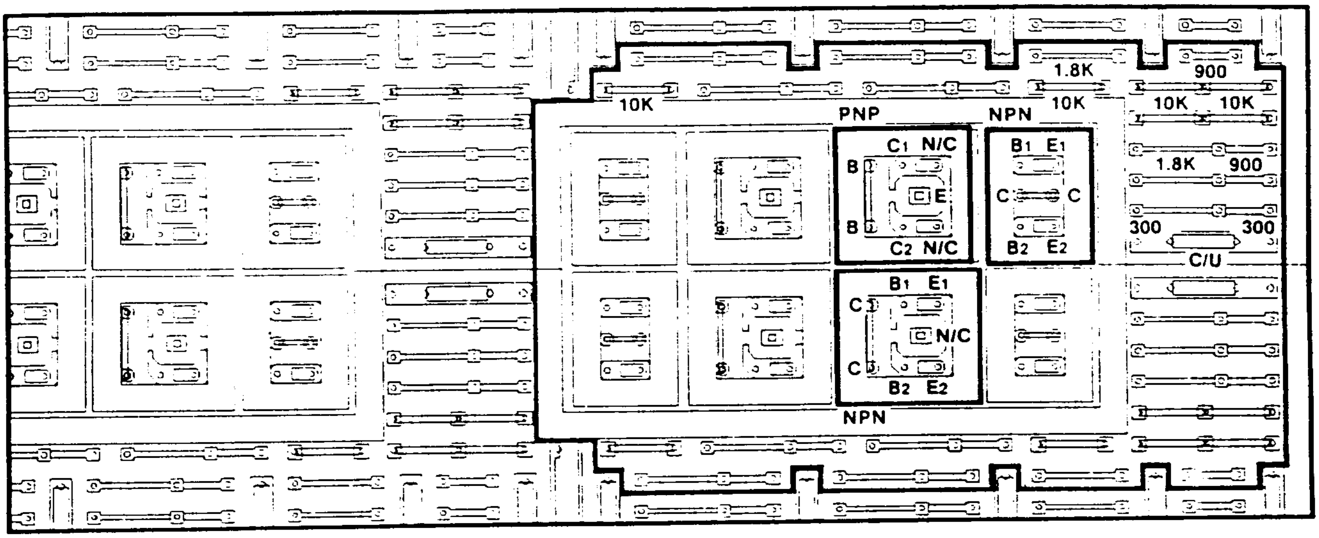
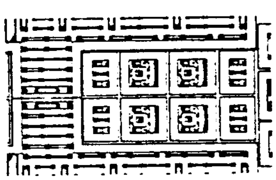


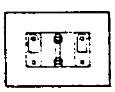
Figure 3-8. Basic Array Cell with Components outlined.

THE MV SERIES MACROCHIP



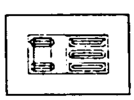
MV Series Macrochip Array Cell

All MV Series Macrochips feature identical array cells which contain dedicated NPN transistors, monistors for use as either NPN or lateral PNP transistors, diffused resistors with basic values of 300 ohms, 900 ohms and 1800 ohms, and ion-implanted resistors equal to 10K ohms. These array cells are the basic design blocks used in the library of macro designs made available for circuit designers.



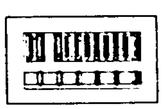
Small NPN Transistor (2X)

All array cells use common-collector dual NPN transistors as primary gain elements. The independent base and emitter areas allow 2:1 area matching to be achieved as well as providing a more efficient use of the basic silicon area. The double collector contacts the low impedance N+ region to be used as a crossunder resistor.



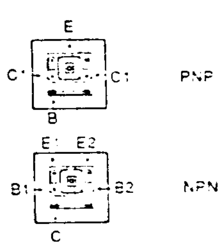
Medium NPN Transistor

The medium NPN transistor is a peripheral component with lengthened rectangular emitters to provide increased current capability. The double collector contacts allow the low impedance N+ region to be used as a crossunder resistor.



Large NPN Transistor

The large NPN transistor is a peripheral component with additional long rectangular emitters designed to provide high current capability. This is a common-collector dual NPN transistor with a 5:1 emitter area ratio. The six collector contacts allow the low impedance N+ region to be used as a crossunder resistor.

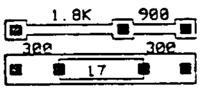


Monistor (PNP/NPN)

For increased versatility, each array cell contains monistors instead of dedicated lateral PNP transistors. The monistor is a multi-purpose device which may be connected to function as either a lateral PNP transistor or an NPN transistor. When connected as a lateral PNP transistor, the monistor has two collectors. The two base contacts allow the low impedance N+ region to be used as a crossunder resistor. When connected as an NPN transistor, the monistor is a common-collector dual NPN transistor with emitter areas equal to those of the dedicated small NPN transistor. The dual collector allows the low impedance N+ region to be used as a crossunder resistor.

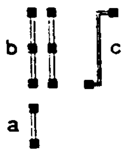
Vertical PNP Transistor

The vertical PNP transistor, or the "substrate PNP", is a peripheral component providing gain at higher current levels. Because the substrate serves as the collector of this device, its use is limited to situations in which the collector is connected to the negative power supply.



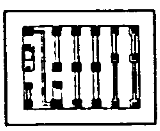
Diffused Resistors

Each array cell and the peripheral and bus areas contain base diffused resistors with three basic values of 300 ohms, 900 ohms, and 1800 ohms. The resistors are designed to provide closely matched values which can be connected in parallel or series as desired. Note that two resistor strings, each containing one 900 ohm and one 1800 ohm resistor, can be used to create eighteen different-value resistors.



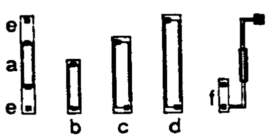
Ion-Implanted Resistors

Each array cell and each peripheral resistor pocket contains ion-implanted resistors designed to provide 10K ohms each. These appear both individually (a), and in resistor strings of two (b). Each peripheral resistor pocket contains a 50K ohm ion-implanted resistor (c) in addition to the 10K ohm resistors. All resistors on the MV Macrochip are useful up to the rated 40 volts.



Peripheral Resistor Pocket

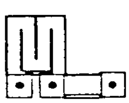
Each MV Macrochip has at least four individual resistor pockets in the peripheral area. These pockets may be biased at voltages different from the main positive power supply for added versatility. Each pocket contains diffused resistors, ion-implanted resistors, and an NPN transistor of which the collector is the N-type epi resistor pocket itself. This peripheral resistor pocket NPN has an emitter area equal to that of a single emitter of the dedicated small NPN transistor.



Crossunders

There are four different N+ crossunders and two P crossunders, each of which provides a low impedence:

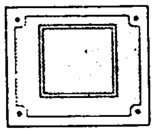
- (a) Cell crossunder (N+)
- (b) Small bus crossunder (N+)
- (c) Medium bus crossunder (N+)
- (d) Large bus crossunder (N+)
- (e) Cell base diffused resistor (P)
- (f) Peripheral resistor pocket base diffused resistor (P)



Epi-Pinch Resistor

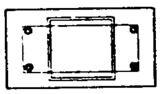
Each MV Macrochip contains one Epi-pinch resistor using the epitaxial layer as the resistance. This provides a high value resistor which is useful to the rated 40 volts.

Capacitor



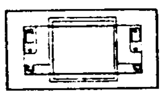
Each MV Macrochip contains at least four oxide capacitors which provide 5pF of capacitance each, constant up to the rated 40 volts. These capacitors are particularly useful as on-chip compensation capacitors to provide stable operation of amplifier circuits, reducing the need for external components. When not used as capacitors, these structures may be used as bonding pads.

Bonding Pads and Grid Structure



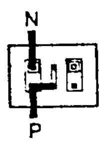
All MV Macrochips include dedicated bonding pad locations which allow electrical connections of the circuit to the outside world. All dedicated bonding pads have crossunders positioned underneath them. The layout also contains a grid structure which indicates where metal traces can be run on the IC to avoid violation of design rules.

Bonding Pad NPN Transistor



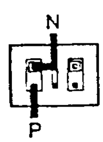
Every MV Macrochip has at least eight bonding pad NPN transistors, which are common-collector dual NPN transistors with emitter areas equal to those of the dedicated small NPN transistor. These devices also serve as isolated bonding pads.

Diodes



Diodes, as a seperate circuit element, are not included on the MV Macrochips. However, any transistor or monistor can be used as a circuit diode. The preferred circuit connection is to short the transistor controller and base. The resultant diode will thus have the forward and reverse characteristics of the transistor emitter-base junction.

Zener Diodes



Zener diodes can be formed by using any transistor or monistor. The NPN emitter-base junction, when used in reverse bias, has a breakdown voltage of approximately 7 volts. Such zener structures offer a low temperature coefficient and good matching on the same chip. The preferred circuit connection is short the transistor collector and emitter.

P-DIFFUSED RESISTORS

Each array cell and the peripheral and bus areas contain base diffused resistors with three basic values of 300 ohms, 900 ohms and 1800 ohms. The resistors are designed to provide closely matched values which can be connected in parallel or series as desired. Note that two resistor strings, each containing one 900 ohm and one 1800 ohm resistor, can be used to create eighteen different-value resistors.

Tolerances and Temperature Coefficients

Since none of these resistors can be pretested, trimmed, or selected, their variation is necessarily larger compared to that of a discrete resistor. Also, the material from which these resistors are made, diffused silicon, is not optimal for this purpose, resulting in a larger temperature coefficient compared to both thin film and carbon resistors.

On the other hand, all resistors on a chip are made within the same block of material and are in close proximity, thus, the ratios between the various resistors tend to be very close and stable with temperature.

Isolation

All resistors are in a common epitaxial N-type island. To keep each resistor electrically isolated, the N-island must be connected to a voltage equal to or more positive than the highest resistor voltage. Normally, this condition is achieved by connecting the N-island to the most positive supply voltage. Each MV chip has at least one main N-island and at least four peripheral N-islands to allow resistors in them ot be operated at voltages greater than V+. For this case, the connection between the islands has to be severed and the V+ contact of each island has to be tied to a voltage equal or higher than the highest voltage on any resistor within.

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
P Base Diffused Resistor					
900 ohms	VBIAS = 10V	675		1125	Ω
1800 ohms	VBIAS = 10V	1350		2250	Ω
300 ohms	VBIAS = 10V	225		375	Ω
.9K/.9K% Matching	(VBIAS = Voltage			2	%
.9K/1.8K% Matching	across the resistor)			3	%
.9K/3K% Matching				12	%
1.8K/.3K% Matching				12	%

ELECTRICAL CHARACTERISTICS (TA = +25°C)

Change of Ratio Accuracy from Wafer to Wafer..........................2%
Temperature Coefficient..+0.2%/°C
Variation in Resistor Ratio with Temperature.....................±0.01%/°C
Variation in Resistor Ratio with Voltage...........................+0.01%/V

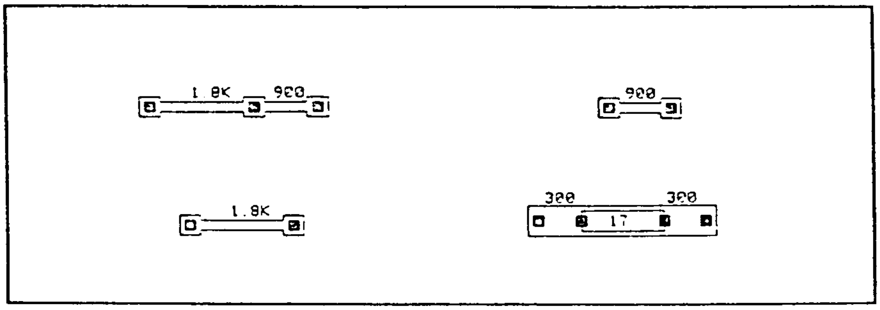
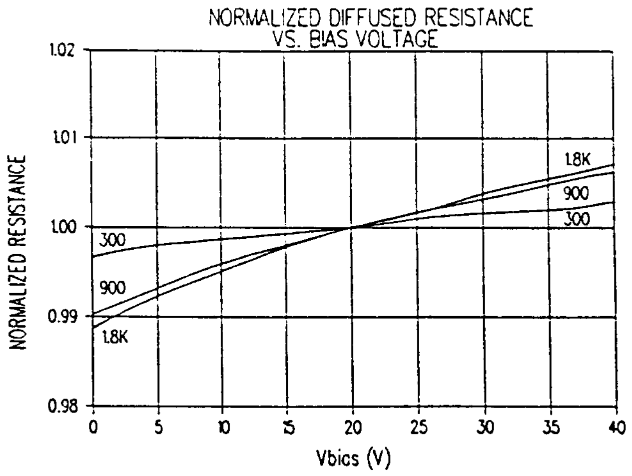
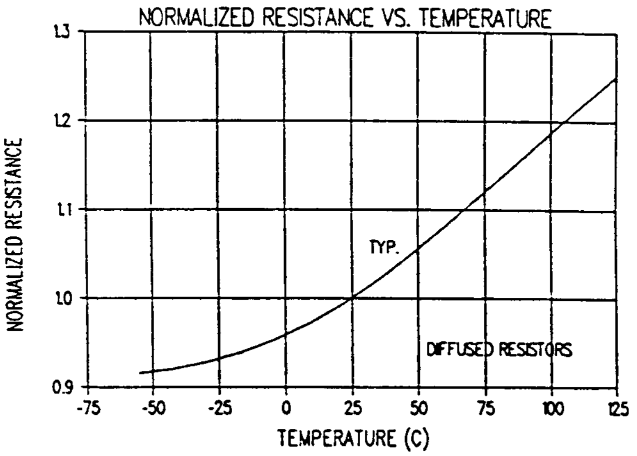


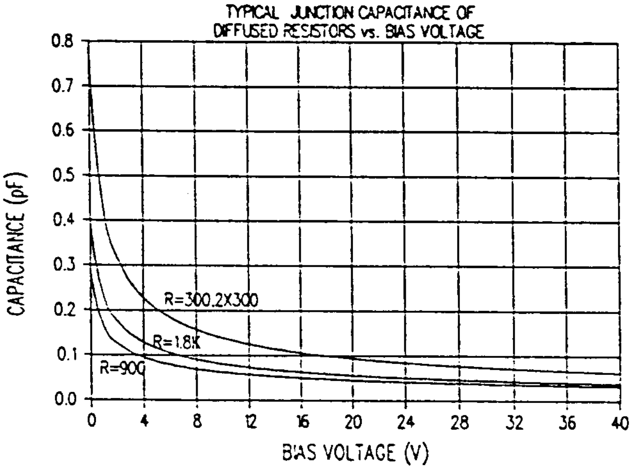
Figure 3-9. Diffused Resistors.



NORMALIZED DIFFUSED RESISTANCE
VS. BIAS VOLTAGE
NORMALIZED RESISTANCE
1.02
1.01
1.00
0.99
0.98
1.8K
900
300
300
900
1.8K
0
5
10
15
20
25
30
35
40
Vbias (V)



NORMALIZED RESISTANCE VS. TEMPERATURE
NORMALIZED RESISTANCE
1.3
1.2
1.1
1.0
0.9
TYP.
DIFFUSED RESISTORS
-75
-50
-25
0
25
50
75
100
125
TEMPERATURE (C)



TYPICAL JUNCTION CAPACITANCE OF
DIFFUSED RESISTORS vs. BIAS VOLTAGE
CAPACITANCE (pF)
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
R=300.2X300
R=1.8K
R=900
0
4
8
12
16
20
24
28
32
36
40
BIAS VOLTAGE (V)

ION-IMPLANTED RESISTORS

Ion-Implanted Resistors

Each array cell and each peripheral resistor pocket contains ion-implanted resistors designed to provide 10K ohms each. These appear both individually (a), and in resistor strings of two (b). Each peripheral resistor pocket contains a 50K ohm ion-implanted resistor (c) in addition to the 10K ohm resistors. All resistors on the MV Macrochip are useful up to the rated 40 volts.

Bias Voltage Effect on Ion-Implanted Resistors

The effect of bias voltage on the value of the ion-implanted resistors is significantly greater than it is with the diffused resistors. While this effect over the entire 40 volt range is typically about 2% for diffused resistors, it amounts to more than 12% for ion-implanted resistors. Consult the graphs for specific design data.

MOS Effect on Ion-Implanted Resistors

A metal trace crossing the bulk of the implanted resistor will increase its value depending on the area covered and the voltage between the metal and the underlying resistor portion. This effect occurs in addition to and effectively independent of the other effects described in the graphs.

In the graphs the curve for 1 standard stripe gives the increase for a metal trace 10 microns wide. The line labeled "MAX.COVERAGE" shows the effect when the whole resistor bar is covered by continuous metal, except for the minimum spaces necessary for resistor contacts not to be connected to this metal. The horizontal axis scale is the voltage difference between the metal and the low voltage end of the resistor.

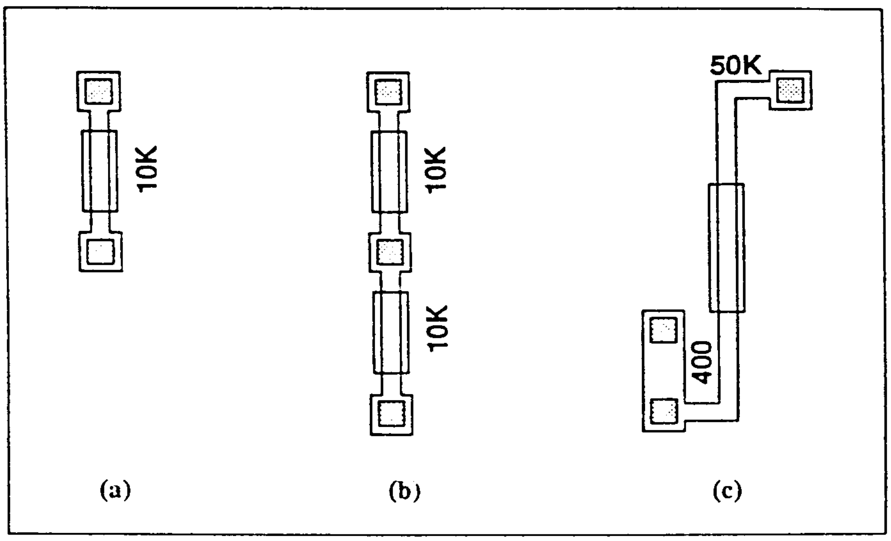
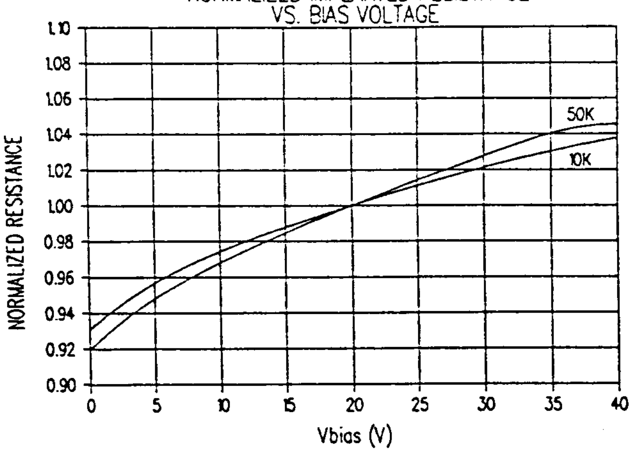
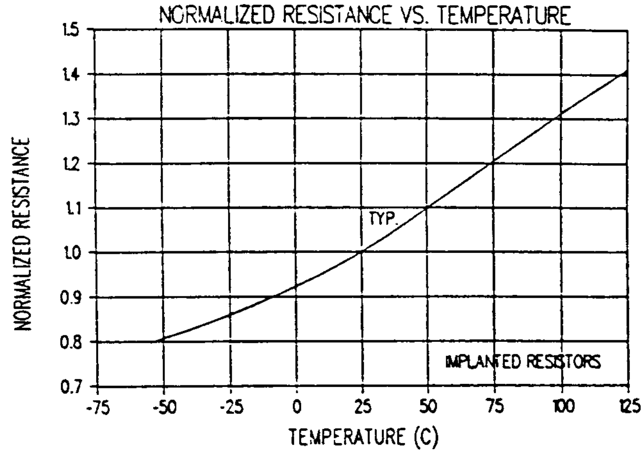


Figure 3-10. Ion-Implanted Resistors.

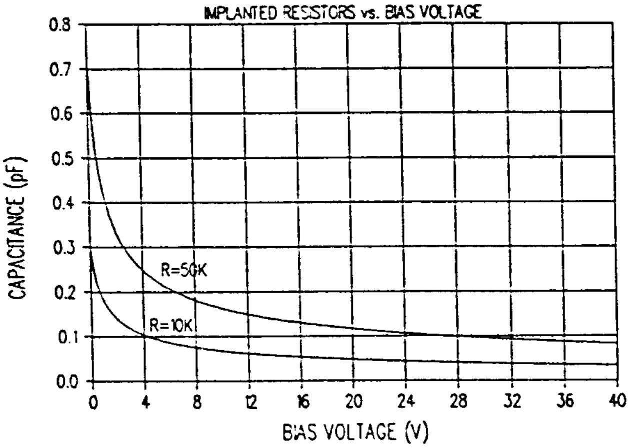
NORMALIZED IMPLANTED RESISTANCE
VS. BIAS VOLTAGE



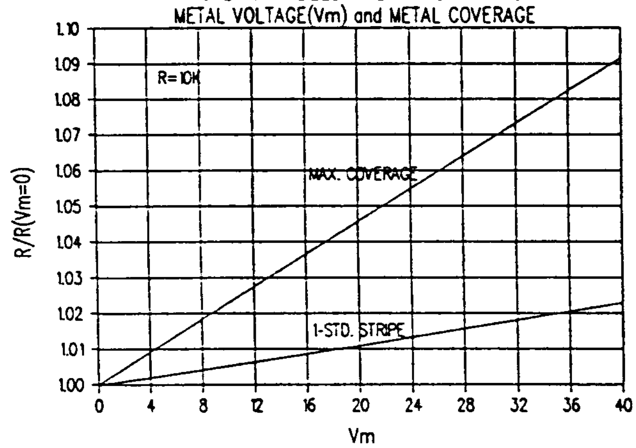
NORMALIZED RESISTANCE VS. TEMPERATURE



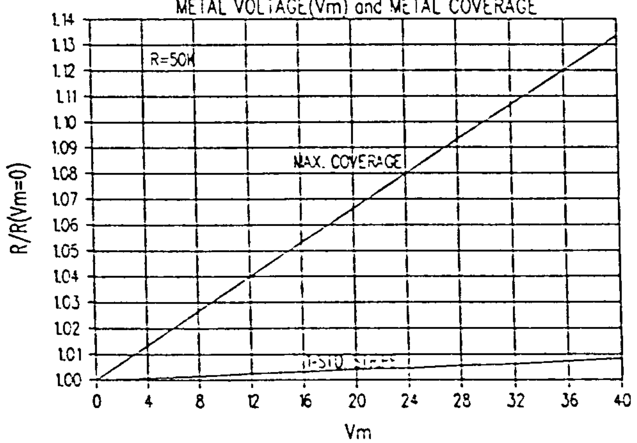
TYPICAL JUNCTION CAPACITANCE OF
IMPLANTED RESISTORS vs. BIAS VOLTAGE



TYPICAL NORMALIZED IMPLANT RESISTANCE vs.
METAL VOLTAGE(Vm) and METAL COVERAGE



TYPICAL NORMALIZED IMPLANT RESISTANCE vs.
METAL VOLTAGE(Vm) and METAL COVERAGE



EPI-PINCH RESISTOR

Epi-Pinch Resistor

Each MV Macrochip contains one Epi-pinch resistor. This provides a high value resistor which is useful up to the rated 40 volts. This structure is actually two resistors in series. It uses the high resistivity of the expitaxial layer and is formed by placing a P-base layer completely over a strip of epi-material bordered by the isolation diffusion. The resistor is formed by the N-epi material, reduced in its crossection by the surrounding P-material. All points of this resistor should always be biased positive with respect to the substrate. Careful attention should be given to the design data provided in this section, in order to avoid accidently turning this device off.

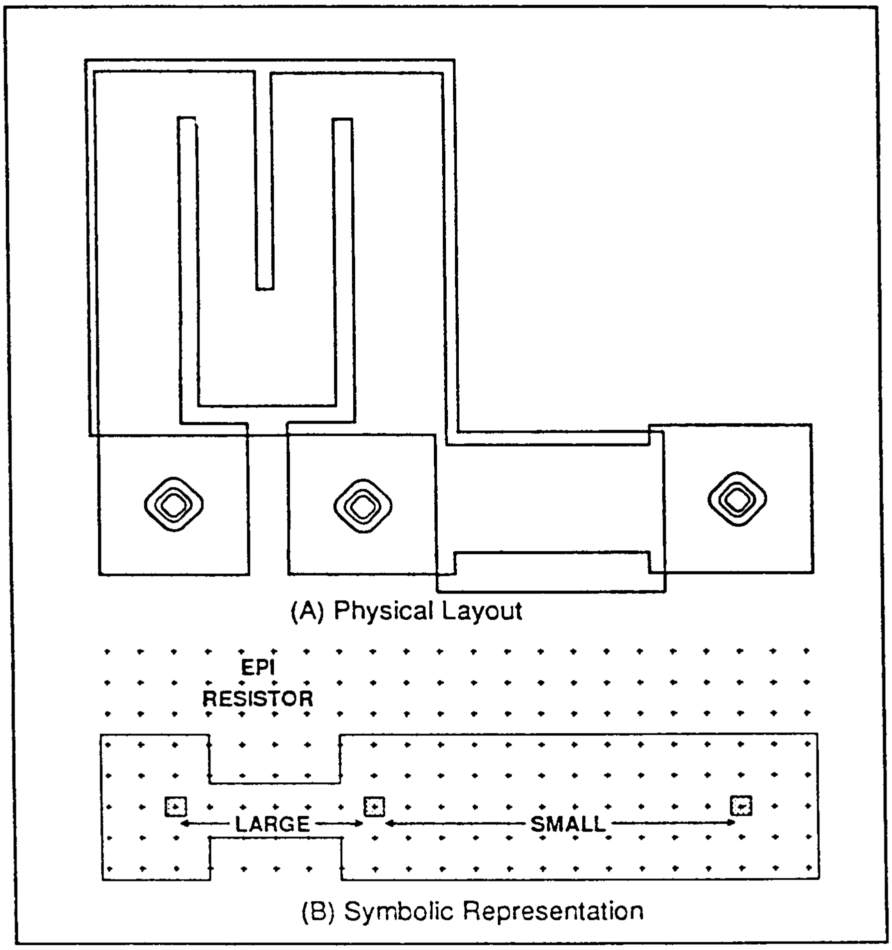


Figure 3-11. Epi Pinch Resistor.

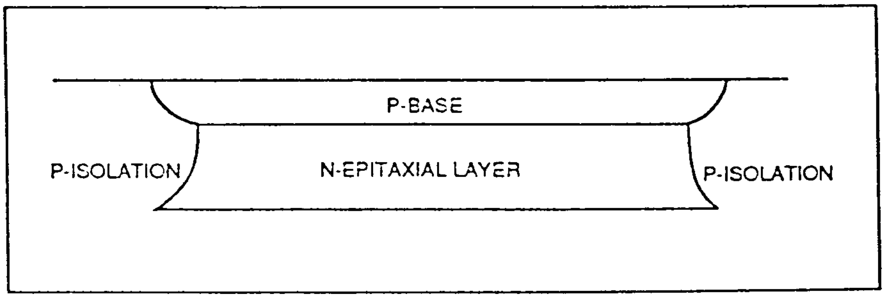
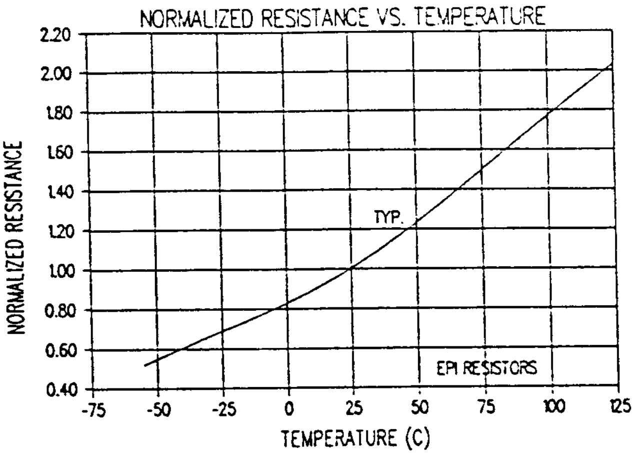
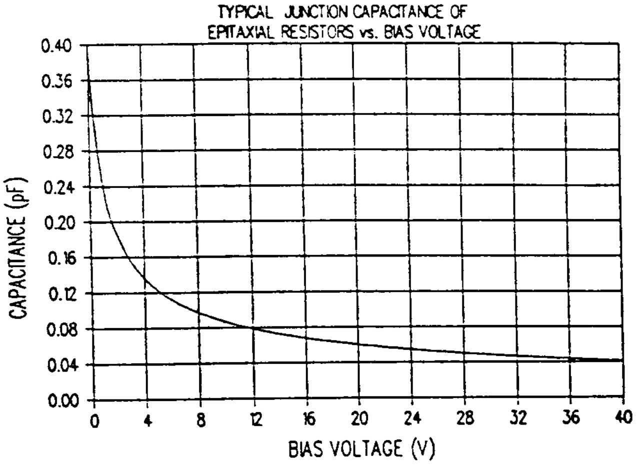
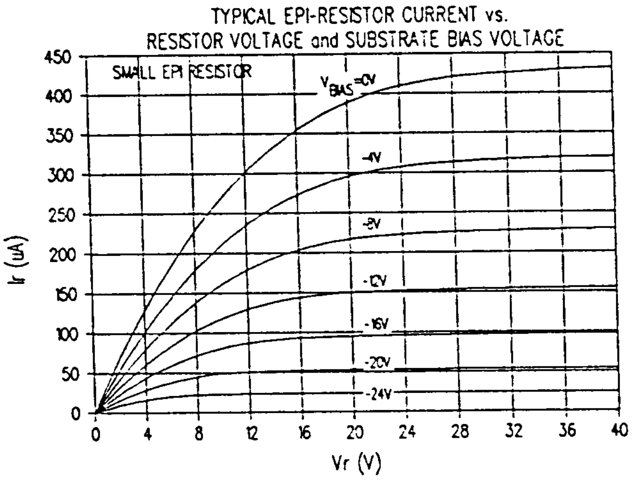
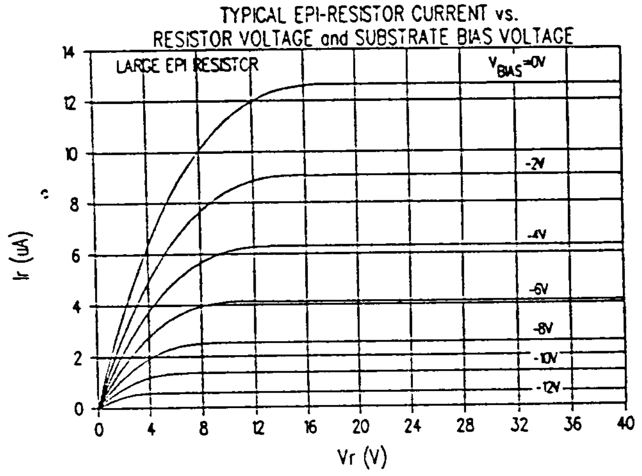


Figure 3-12. Cross Section of the Epi Pinch Resistor.


NORMALIZED RESISTANCE VS. TEMPERATURE
NORMALIZED RESISTANCE
TEMPERATURE (C)
TYP.
EPI RESISTORS


TYPICAL JUNCTION CAPACITANCE OF
EPITAXIAL RESISTORS vs. BIAS VOLTAGE
CAPACITANCE (pF)
BIAS VOLTAGE (V)


TYPICAL EPI-RESISTOR CURRENT vs.
RESISTOR VOLTAGE and SUBSTRATE BIAS VOLTAGE
SMALL EPI RESISTOR
Ir (uA)
Vr (V)


TYPICAL EPI-RESISTOR CURRENT vs.
RESISTOR VOLTAGE and SUBSTRATE BIAS VOLTAGE
LARGE EPI RESISTOR
Ir (uA)
Vr (V)

CAPACITOR ("CAPAD")

The oxide capacitors which are present on all MV Macrochips provide 5 pF of capacitance each, constant up to the rated 40 volts. The metal which forms the top plate of the capacitor is the same metal layer which is patterned to interconnect the various components on the chip. Thus, the standard metal mask may be used to customize the area of the capacitor metal to obtain values of capacitance lower than the nominal 5pF.

If none of the CAPADs on a chip are used as capacitors, then all of them are available for use as bonding pads. When used as bonding pads, the CAPADs are cut down to standard bonding pad size. Metal traces which are routed over the thin oxide of the capacitor will have some capacitance with respect to the capacitor N+, as will the pad itself. This capacitance will be quite small, and may be estimated by comparing the area of such metal to the total area of a standard 5pF capacitor.

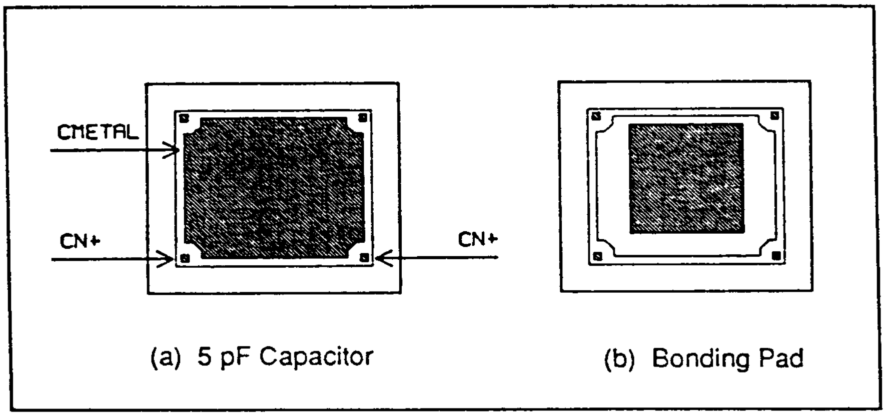


Figure 3-13. MV CAPAD USES.

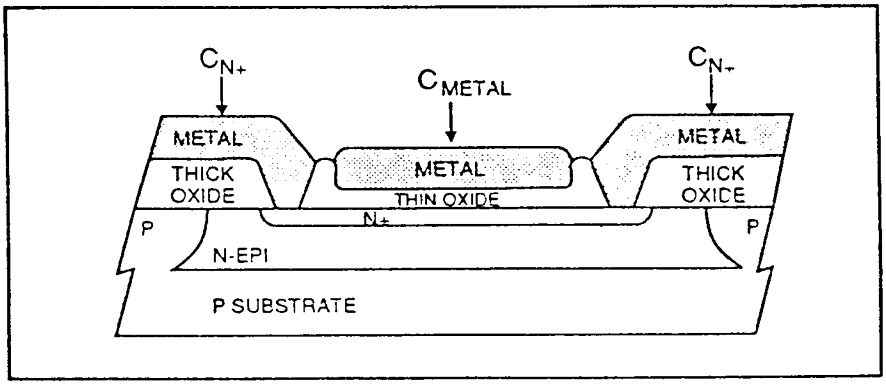
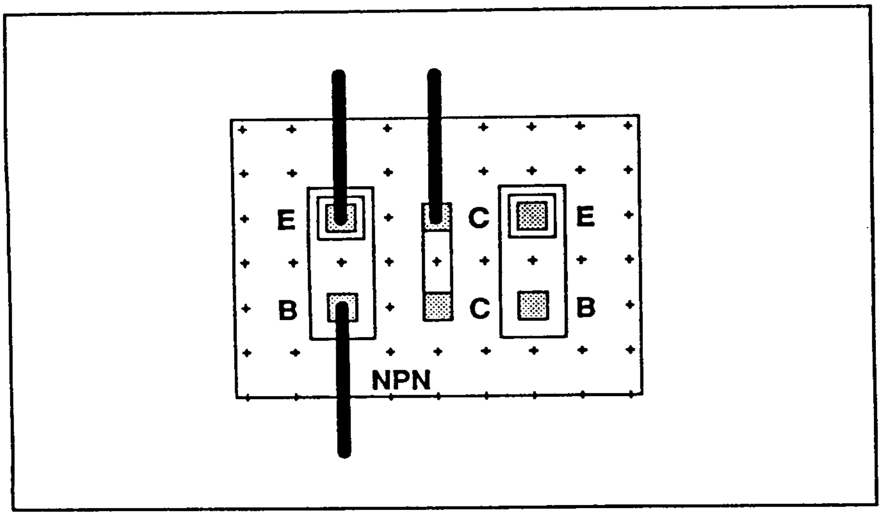


Figure 3-14. The MV CAPAD Cross-Section.

The MV 1X NPN TRANSISTOR ("1X NPN")

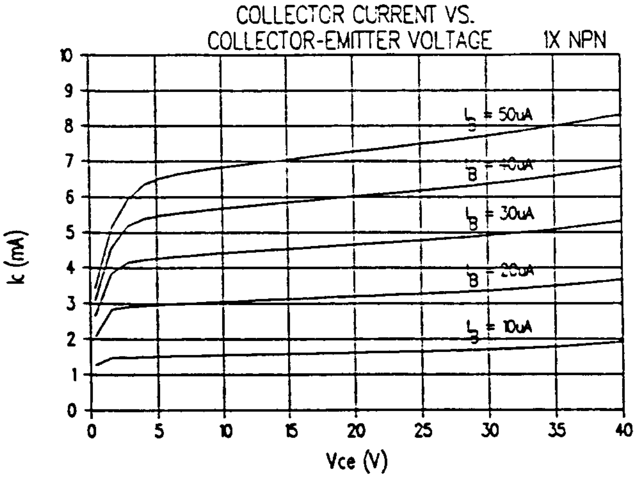
The MV 1X NPN transistor is actually just a 1X connection of a 2X NPN transistor. It is convenient to have data available for this 1X connection, and to refer to it as a "1X NPN". This data is useful for the NPN transistor in the peripheral resistor pocket, and for the 1X connections of the Monistors and bonding pad NPN transistors as well.

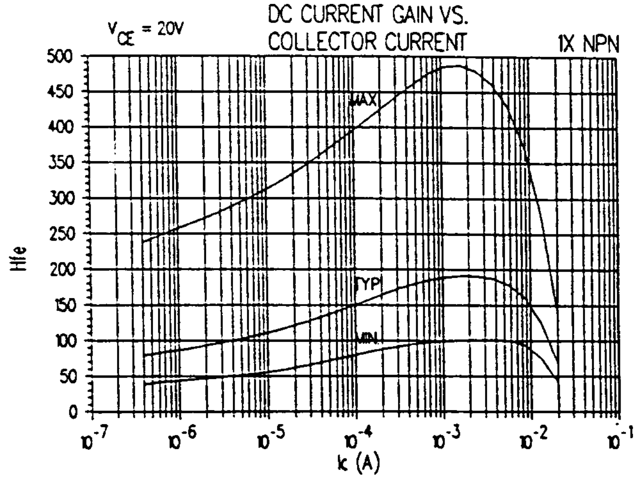


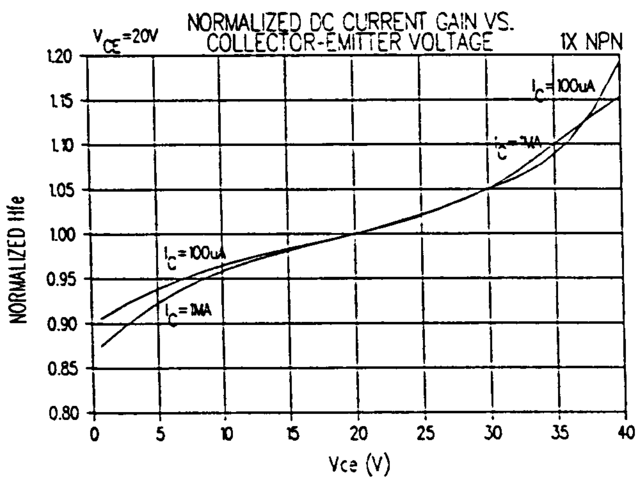
THE MV NPN TRANSISTOR - 1X CONNECTION

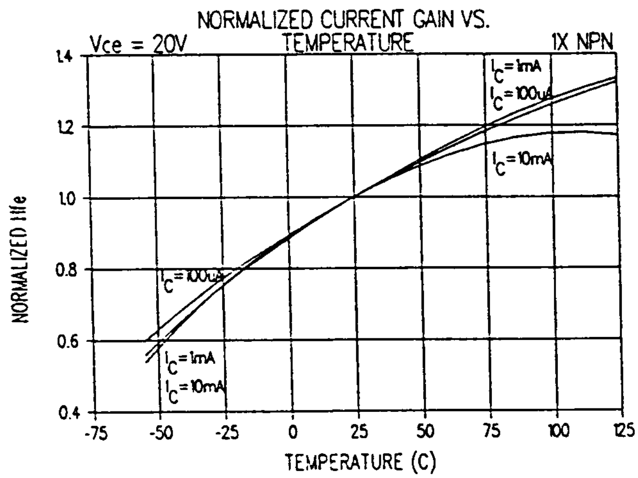
ELECTRICAL CHARACTERISTICS (T_A = +25°C) 1X NPN

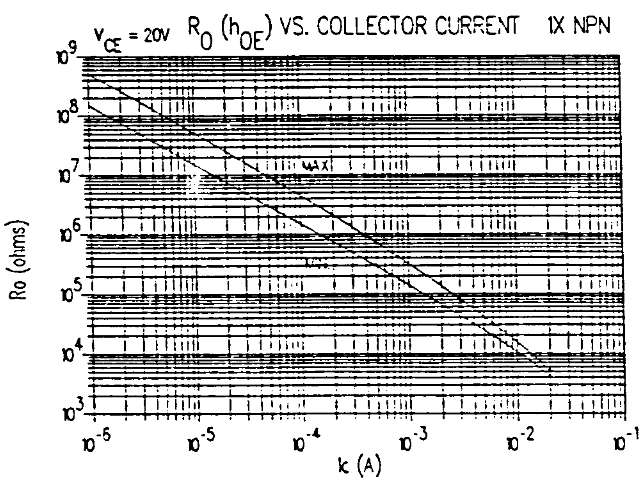
PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNITS
Forward Current Gain	ßF	VCE=20V, IC=100µA	80		400	
Reverse Current Gain	ßR	VCE=-5V, IC=100µA		0.7		
Reverse Saturation Current	IS			3.3×10^{-16}		A
Base Emitter Voltage	VBE	VCE=20V, IE=100µA	0.61			V
Collector-Emitter Saturation Voltage	VCE(SAT)	IC=1mA, IB=0.1mA			0.73	V
Emitter-Base Breakdown Voltage	BVEBO	IE=10µA	6.7			V
Collector-Emitter Breakdown Voltage	BVCEO	IC=100µA	40		0.2	V
Collector-Base Breakdown Voltage	BVCBO	IC=100µA	60		7.7	V
Collector-Emitter Leakage Current	ICEO	VCE=40V		50		pA
Collector-Base Leakage Current	ICBO	VCB=40V		5		pA
Emitter-Base Leakage Current	IEBO	VEB=4V		25		pA
Collector Resistance	RC	IC=1mA, IB=2mA		26		Ω
Emitter Resistance	RE	IE=5mA		4		Ω
Base Resistance	RB	IC=10mA		200		Ω
Early Voltage	VA	VCE=20V, IC=100µA		120		V
Current Gain Bandwidth Product	fT	VCE=20V, IC=1mA		450		MHz
Forward Transit Time	TF	VCE=20V, IC=1mA		0.35		nSec
Base Emitter Capacitance	CBEO	VBIAS=0V		0.45		pF
Collector-Base Capacitance	CCBO	VBIAS=0V		0.25		pF
Collector-Substrate Capacitance	CCSO	VBIAS=0V		2		pF

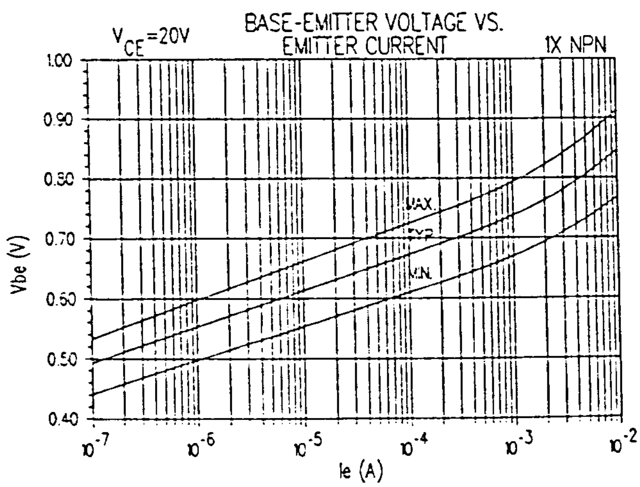

COLLECTOR CURRENT VS.
COLLECTOR-EMITTER VOLTAGE
1X NPN
Ic (mA)
Vce (V)
IB = 50uA
IB = 40uA
IB = 30uA
IB = 20uA
IB = 10uA

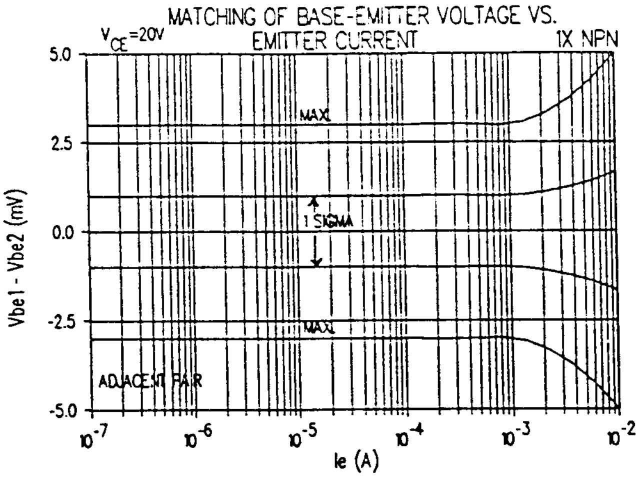

VCE = 20V
DC CURRENT GAIN VS.
COLLECTOR CURRENT
1X NPN
Hfe
Ic (A)
MAX
TYP
MIN

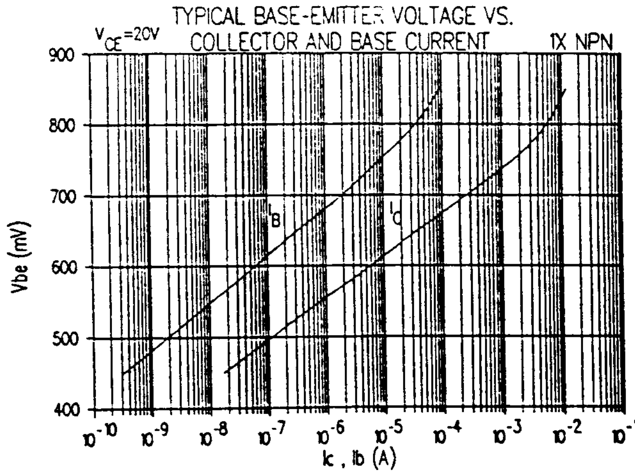

VCE=20V
NORMALIZED DC CURRENT GAIN VS.
COLLECTOR-EMITTER VOLTAGE
1X NPN
NORMALIZED Hfe
Vce (V)
IC=100uA
IC=1MA

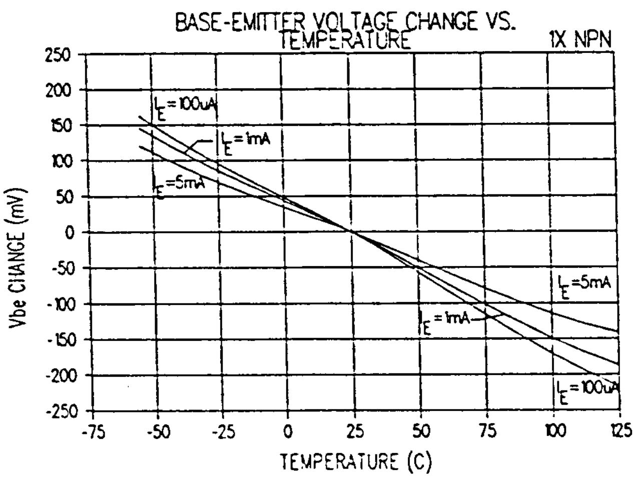

NORMALIZED CURRENT GAIN VS.
TEMPERATURE
Vce = 20V
1X NPN
NORMALIZED Hfe
TEMPERATURE (C)
IC=1mA
IC=100uA
IC=10mA

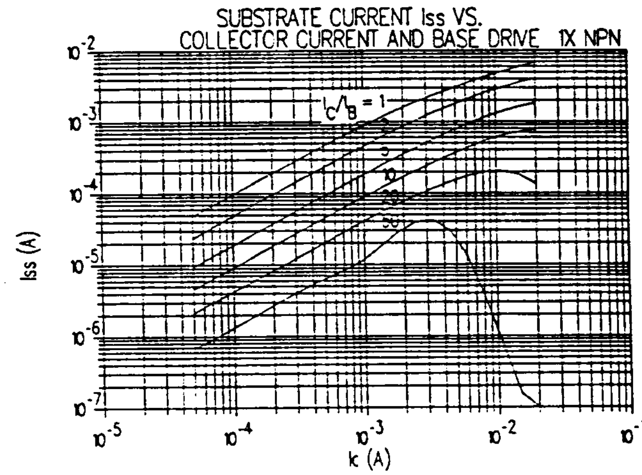

VCE = 20V
RO (hOE) VS. COLLECTOR CURRENT
1X NPN
Ro (ohms)
Ic (A)
MAX

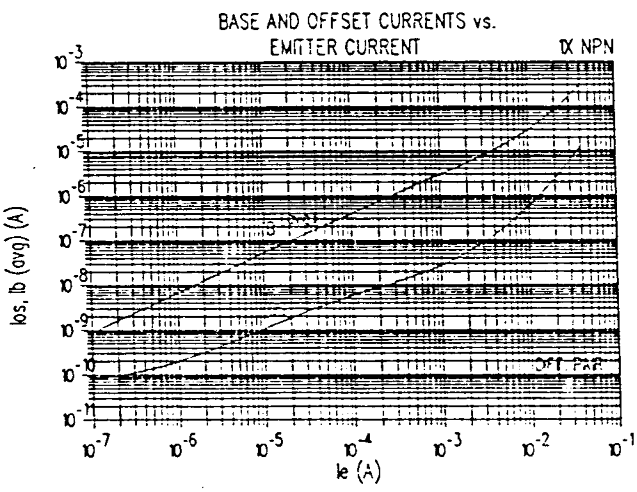

VCE=20V
BASE-EMITTER VOLTAGE VS.
EMITTER CURRENT
1X NPN
Vbe (V)
Ie (A)
MAX
TYP
MIN

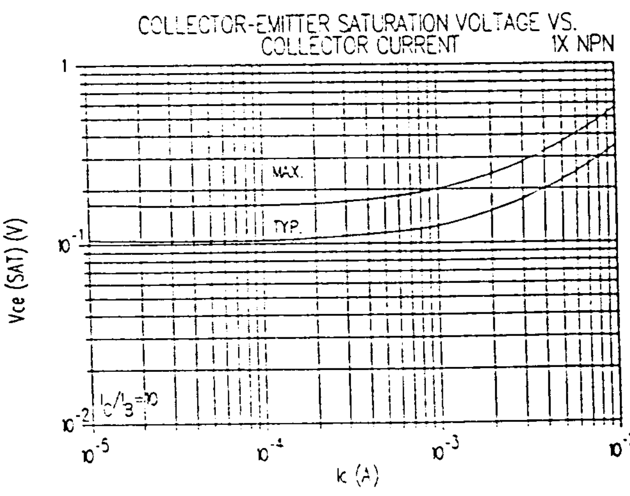

MATCHING OF BASE-EMITTER VOLTAGE VS.
EMITTER CURRENT
V_{CE}=20V
1X NPN
MAX.
1 SIGMA
MAX.
ADJACENT PAIR
Vbe1 - Vbe2 (mV)
5.0
2.5
0.0
-2.5
-5.0
Ie (A)

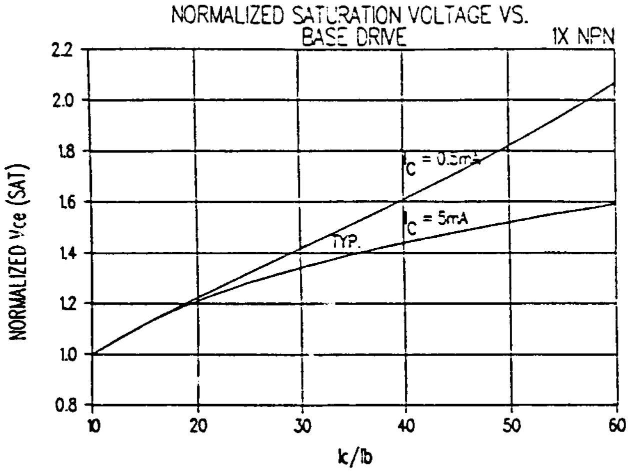

TYPICAL BASE-EMITTER VOLTAGE VS.
COLLECTOR AND BASE CURRENT
V_{CE}=20V
1X NPN
I_B
I_C
Vbe (mV)
900
800
700
600
500
400
Ic , Ib (A)

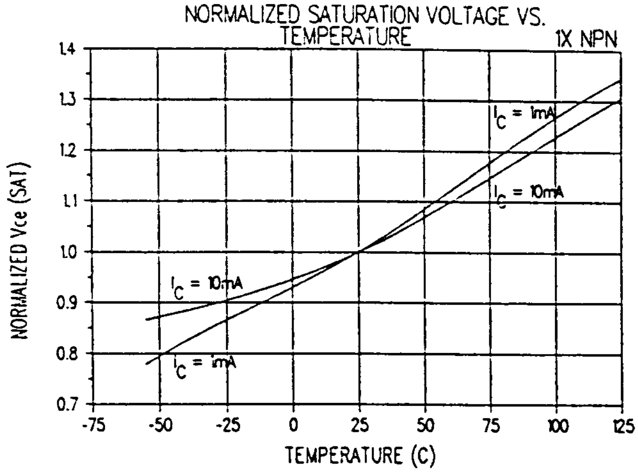

BASE-EMITTER VOLTAGE CHANGE VS.
TEMPERATURE
1X NPN
I_E=100uA
I_E=1mA
I_E=5mA
Vbe CHANGE (mV)
TEMPERATURE (C)

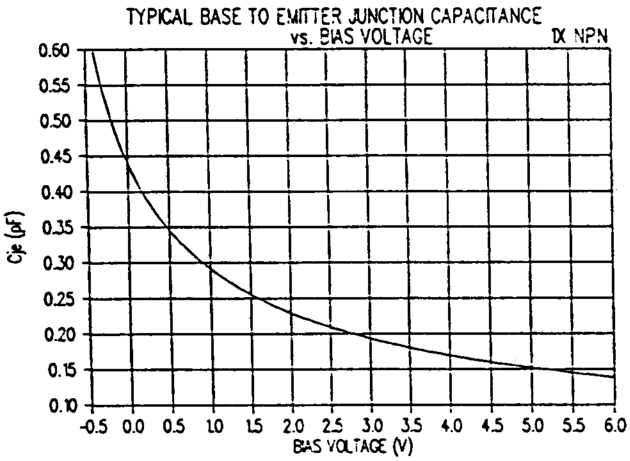

SUBSTRATE CURRENT Iss VS.
COLLECTOR CURRENT AND BASE DRIVE
1X NPN
I_C/I_B = 1
Iss (A)
Ic (A)

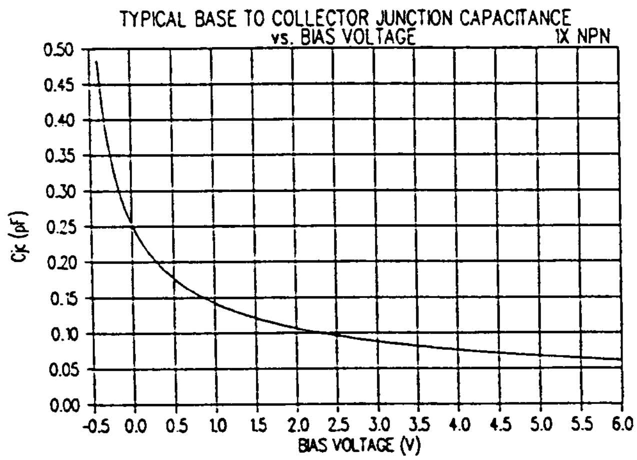

BASE AND OFFSET CURRENTS vs.
EMITTER CURRENT
1X NPN
Ios, Ib (avg) (A)
Ie (A)

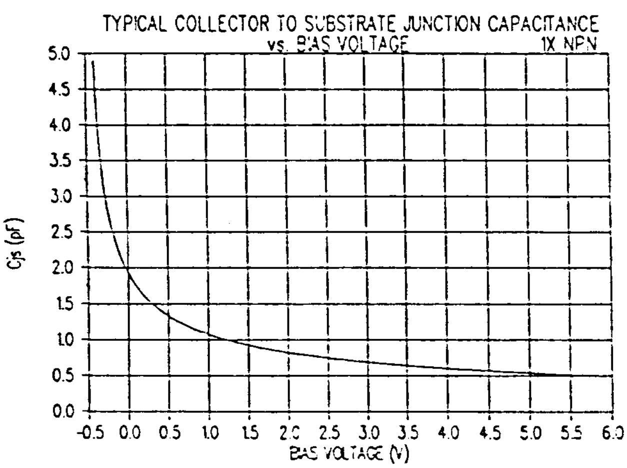

COLLECTOR-EMITTER SATURATION VOLTAGE VS.
COLLECTOR CURRENT
1X NPN
MAX.
TYP.
I_C/I_B=10
Vce (SAT) (V)
Ic (A)

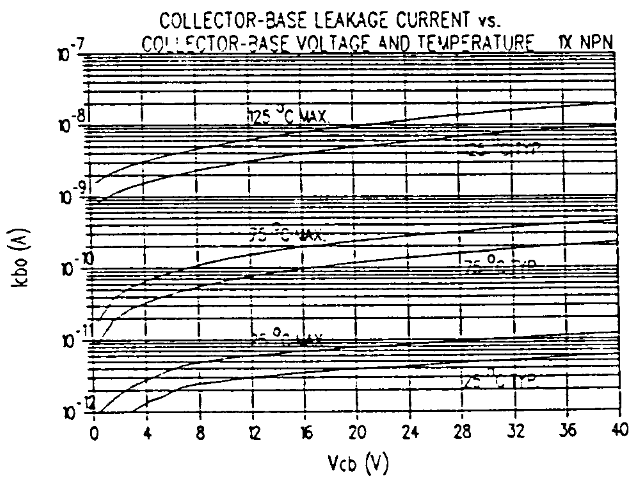

NORMALIZED SATURATION VOLTAGE VS.
BASE DRIVE
1X NPN
NORMALIZED Vce (SAT)
Ic/Ib
I_C = 0.5mA
I_C = 5mA
TYP.

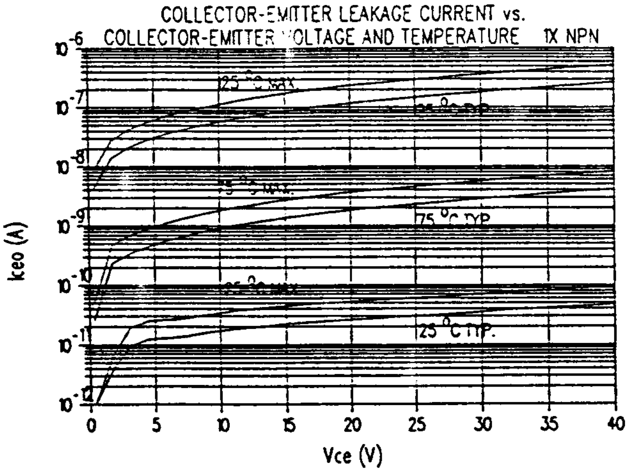

NORMALIZED SATURATION VOLTAGE VS.
TEMPERATURE
1X NPN
NORMALIZED Vce (SAT)
TEMPERATURE (C)
I_C = 1mA
I_C = 10mA


TYPICAL BASE TO EMITTER JUNCTION CAPACITANCE
vs. BIAS VOLTAGE
1X NPN
Cje (pF)
BIAS VOLTAGE (V)

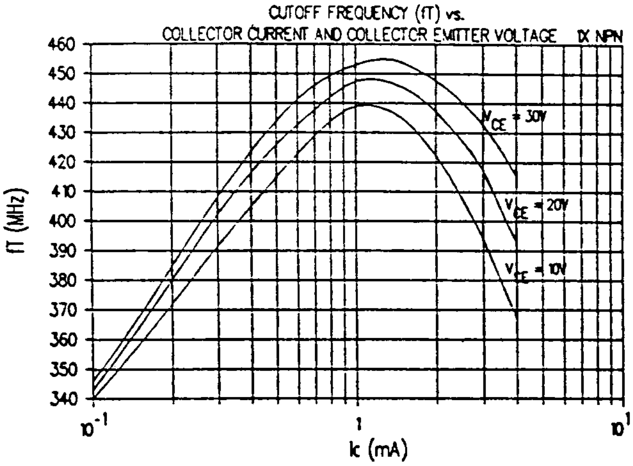

TYPICAL BASE TO COLLECTOR JUNCTION CAPACITANCE
vs. BIAS VOLTAGE
1X NPN
Cjc (pF)
BIAS VOLTAGE (V)


TYPICAL COLLECTOR TO SUBSTRATE JUNCTION CAPACITANCE
vs. BIAS VOLTAGE
1X NPN
Cjs (pF)
BIAS VOLTAGE (V)

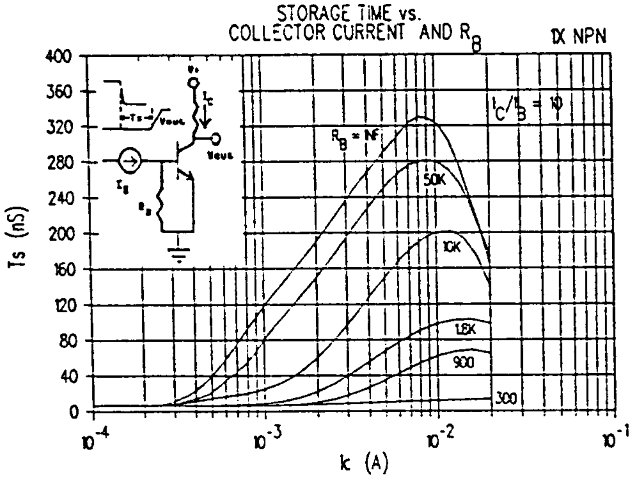

COLLECTOR-BASE LEAKAGE CURRENT vs.
COLLECTOR-BASE VOLTAGE AND TEMPERATURE
1X NPN
Icbo (A)
Vcb (V)
125 °C MAX.
75 °C MAX.



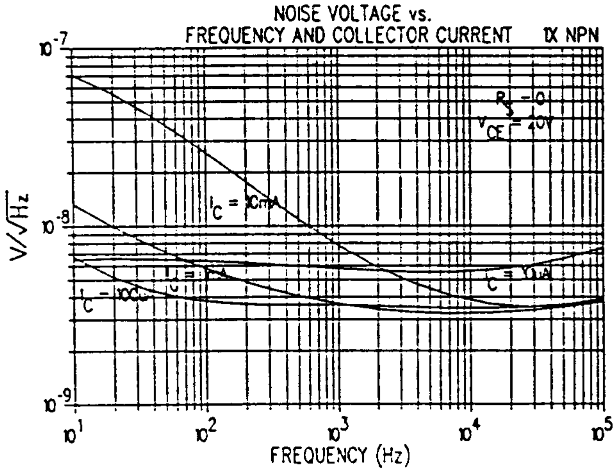
COLLECTOR-EMITTER LEAKAGE CURRENT vs.
COLLECTOR-EMITTER VOLTAGE AND TEMPERATURE
1X NPN
Iceo (A)
Vce (V)
125 °C MAX
125 °C TYP
75 °C TYP
25 °C TYP.



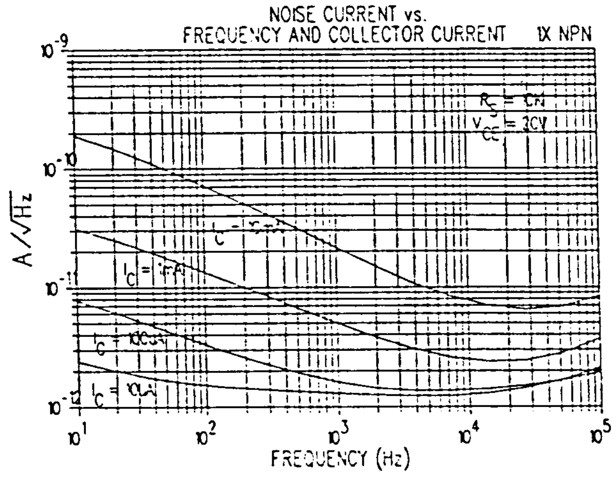
CUTOFF FREQUENCY (fT) vs.
COLLECTOR CURRENT AND COLLECTOR EMITTER VOLTAGE
1X NPN
fT (MHz)
Ic (mA)
VCE = 30V
VCE = 20V
VCE = 10V



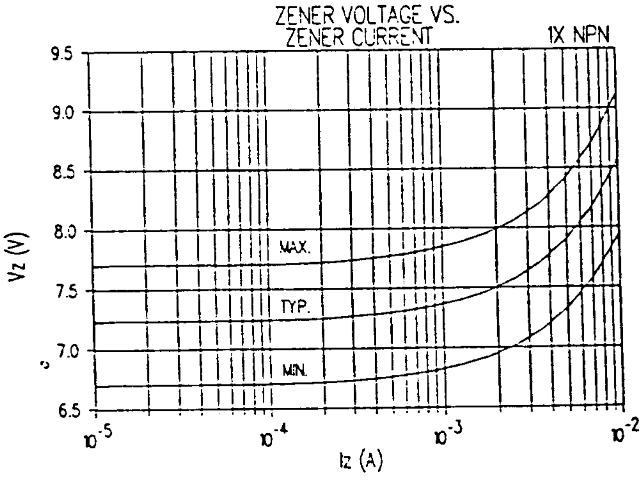
STORAGE TIME vs.
COLLECTOR CURRENT AND RB
1X NPN
Ts (nS)
Ic (A)
IC/IB = 10
RB = INF
50K
10K
1.8K
900
300



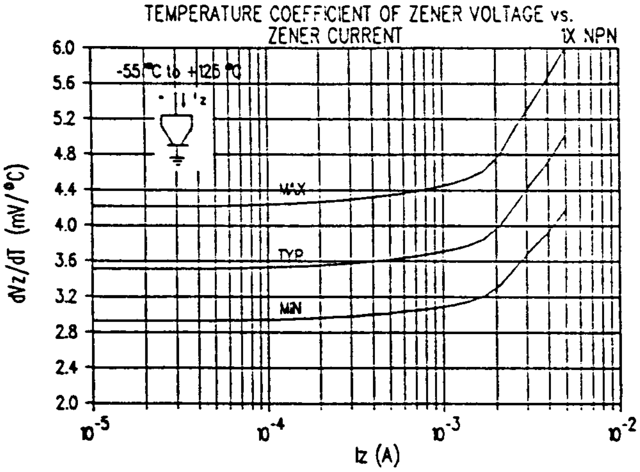
NOISE VOLTAGE vs.
FREQUENCY AND COLLECTOR CURRENT
1X NPN
V/√Hz
FREQUENCY (Hz)
VCE = 40V
IC = 10mA



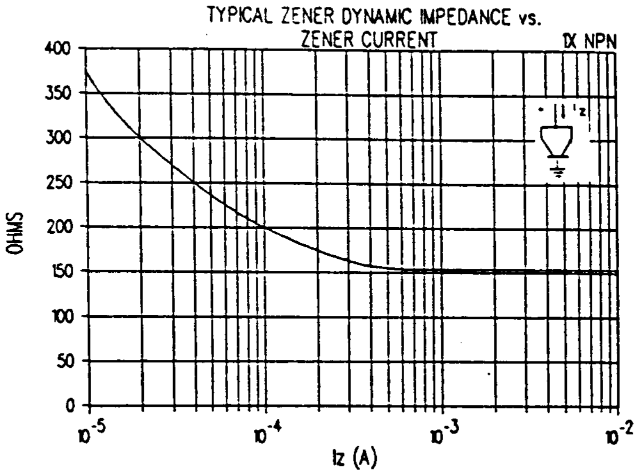
NOISE CURRENT vs.
FREQUENCY AND COLLECTOR CURRENT
1X NPN
A/√Hz
FREQUENCY (Hz)
VCE = 20V
IC = 1mA
IC = 10uA



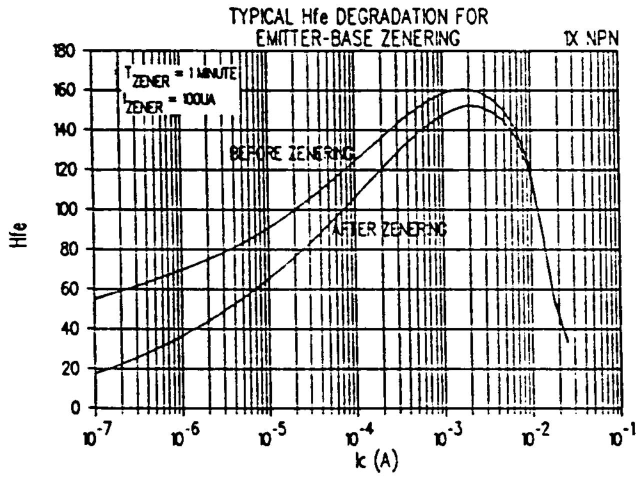
ZENER VOLTAGE VS.
ZENER CURRENT
1X NPN
Vz (V)
Iz (A)
MAX.
TYP.
MIN.



TEMPERATURE COEFFICIENT OF ZENER VOLTAGE vs.
ZENER CURRENT
1X NPN
-55°C to +125°C
MAX
TYP
MIN
dVz/dT (mV/°C)
Iz (A)



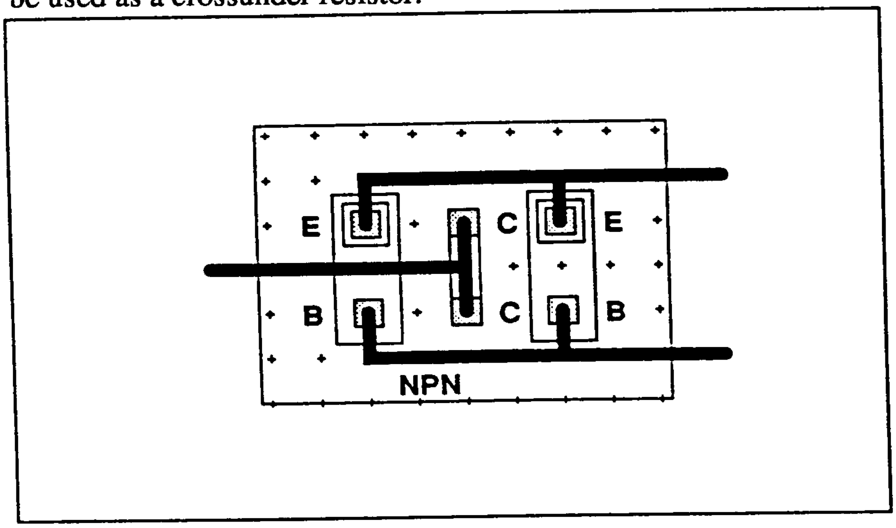
TYPICAL ZENER DYNAMIC IMPEDANCE vs.
ZENER CURRENT
1X NPN
OHMS
Iz (A)



TYPICAL Hfe DEGRADATION FOR
EMITTER-BASE ZENERING
1X NPN
BEFORE ZENERING
AFTER ZENERING
Hfe

THE MV 2X NPN TRANSISTOR ("2X NPN")

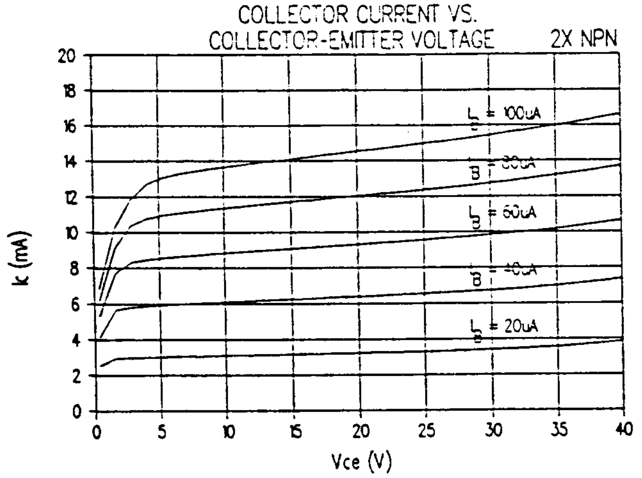
All array cells are common-collector dual NPN transistors as primary gain elements. The independent base and emitter areas allow 2:1 area matching to be achieved as well as providing a more efficient use of the basic silicon area. The double collector contacts allow the low impedance N+ region to be used as a crossunder resistor.

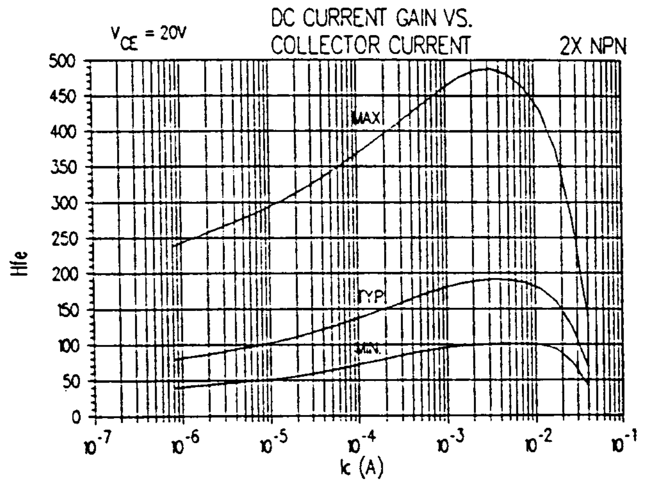


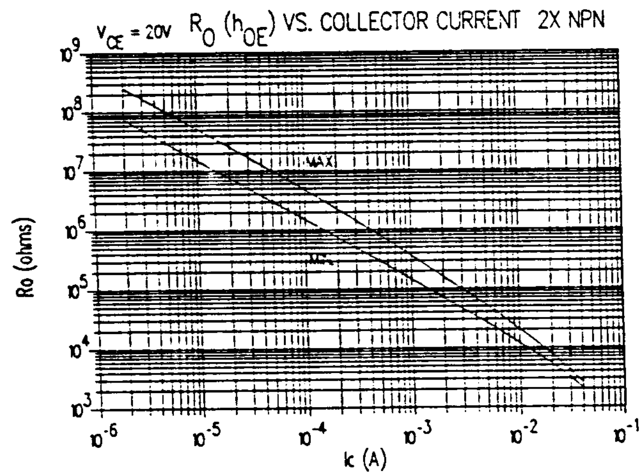
THE MV NPN TRANSISTOR - 2X CONNECTION

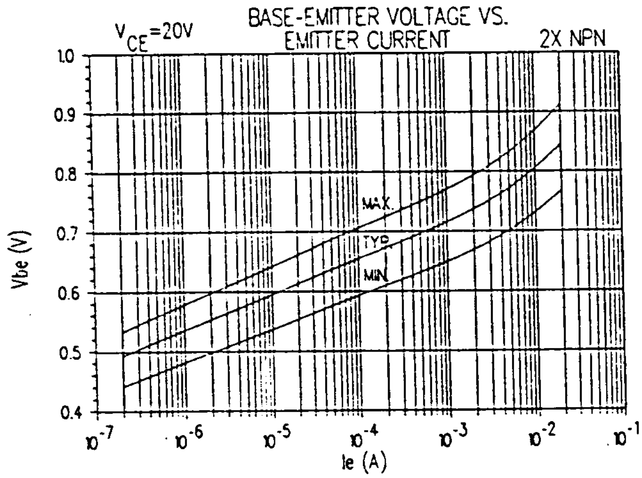
ELECTRICAL CHARACTERISTICS (TA=+25°C) 2X NPN

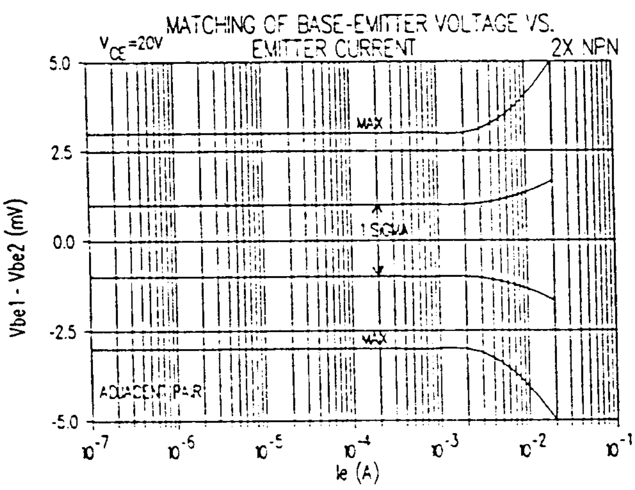
PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNITS
Forward Current Gain	ßF	VCE=20V, IC=200µA	80		400	
Reverse Current Gain	ßR	VCE=-5V, IC=200µA		0.7		
Reverse Saturation Current	IS			$6.6x10^{-16}$		A
Base Emitter Voltage	VBE	VCE=20V, IE=200µA	0.61			V
Collector-Emitter Saturation Voltage	VCE(SAT)	IC=2mA, IB=0.2mA			0.73	V
Emitter-Base Breakdown Voltage	BVEBO	IE=20µA	6.7			V
Collector-Emitter Breakdown Voltage	BVCEO	IC=200µA	40		0.2	V
Collector-Base Breakdown Voltage	BVCBO	IC=200µA	60		7.7	V
Collector-Emitter Leakage Current	ICEO	VCE=40V		100		pA
Collector-Base Leakage Current	ICBO	VCB=40V		10		pA
Emitter-Base Leakage Current	IEBO	VEB=4V		50		pA
Collector Resistance	RC	IC=2mA, IB=4mA		13		Ω
Emitter Resistance	RE	IE=10mA		2		Ω
Base Resistance	RB	IC=20mA		100		Ω
Early Voltage	VA	VCE=20V, IC=200µA		120		V
Current Gain Bandwidth Product	fT	VCE=20V, IC=2mA		450		MHz
Forward Transit Time	TF	VCE=20V, IC=2mA		0.35		nSec
Base Emitter Capacitance	CBEO	VBIAS=0V		0.45		pF
Collector-Base Capacitance	CCBO	VBIAS=0V		0.25		pF
Collector-Substrate Capacitance	CCSO	VBIAS=0V		2		pF

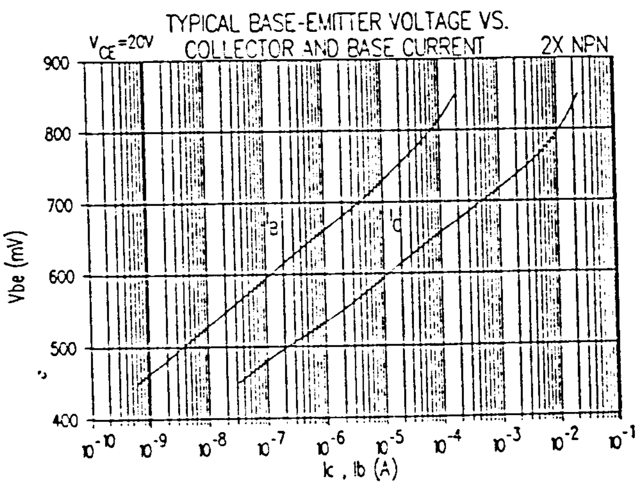

COLLECTOR CURRENT VS.
COLLECTOR-EMITTER VOLTAGE
2X NPN
Ic (mA)
Vce (V)
IB = 100uA
IB = 80uA
IB = 60uA
IB = 40uA
IB = 20uA

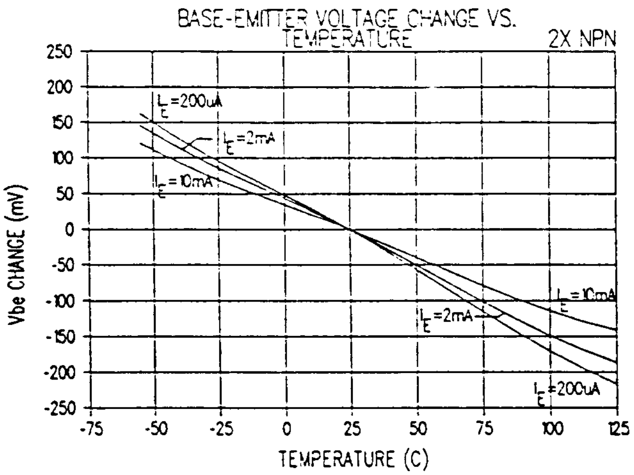

DC CURRENT GAIN VS.
COLLECTOR CURRENT
2X NPN
VCE = 20V
Hfe
MAX
TYP
MIN
Ic (A)

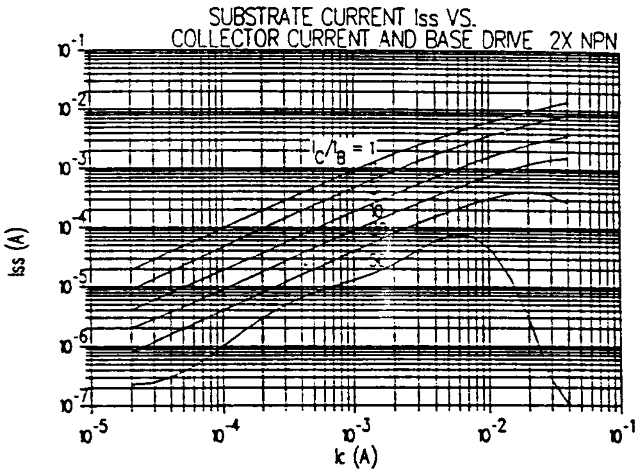

VCE = 20V
RO (hOE) VS. COLLECTOR CURRENT
2X NPN
Ro (ohms)
MAX
MIN
Ic (A)

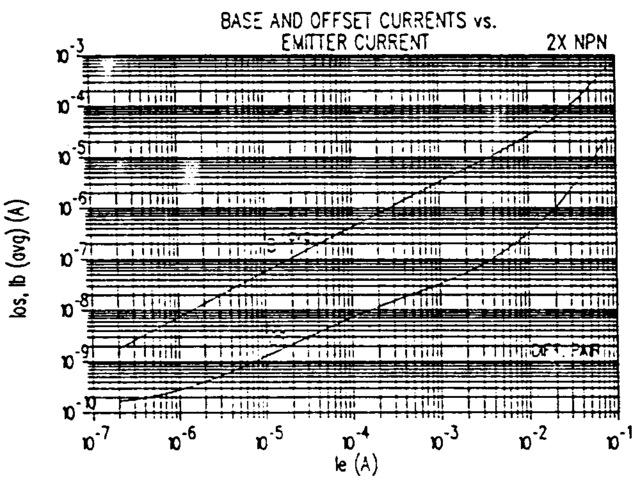

BASE-EMITTER VOLTAGE VS.
EMITTER CURRENT
2X NPN
VCE=20V
Vbe (V)
MAX
TYP
MIN
Ie (A)

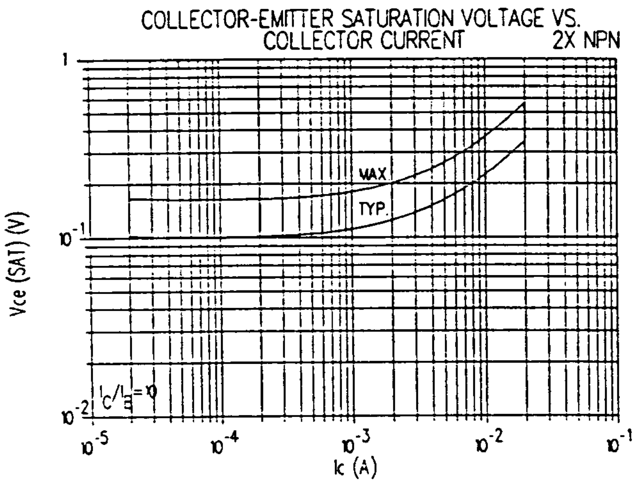

MATCHING OF BASE-EMITTER VOLTAGE VS.
EMITTER CURRENT
2X NPN
VCE=20V
Vbe1 - Vbe2 (mV)
MAX
1 SIGMA
ADJACENT PAIR
Ie (A)

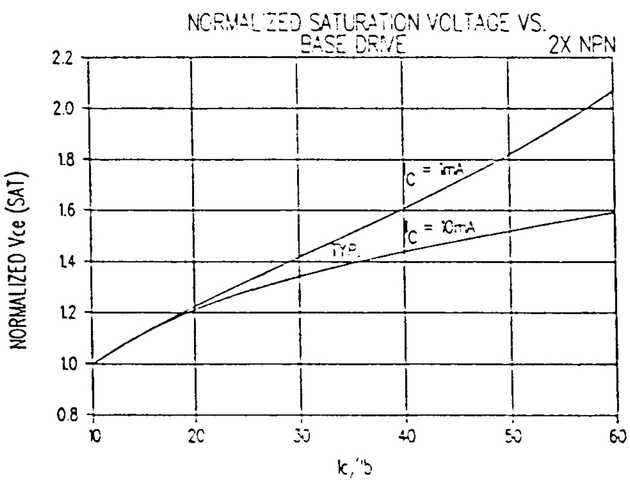

TYPICAL BASE-EMITTER VOLTAGE VS.
COLLECTOR AND BASE CURRENT
2X NPN
VCE=20V
Vbe (mV)
Ic , Ib (A)

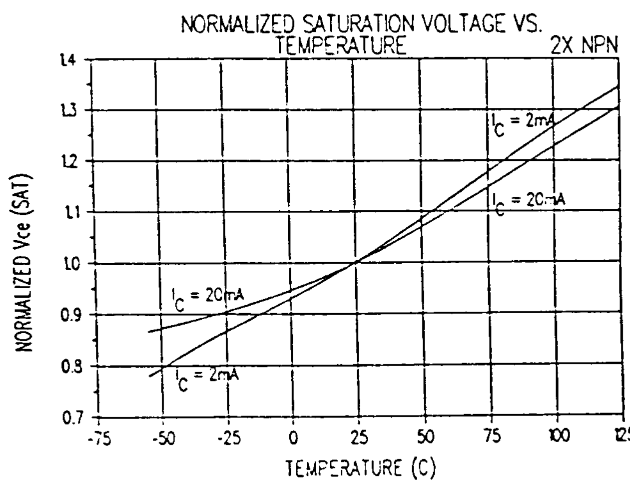

BASE-EMITTER VOLTAGE CHANGE VS.
TEMPERATURE
2X NPN
Vbe CHANGE (mV)
TEMPERATURE (C)
IE=200uA
IE=2mA
IE=10mA


SUBSTRATE CURRENT Iss VS.
COLLECTOR CURRENT AND BASE DRIVE
2X NPN
Iss (A)
Ic (A)
IC/IB = 1

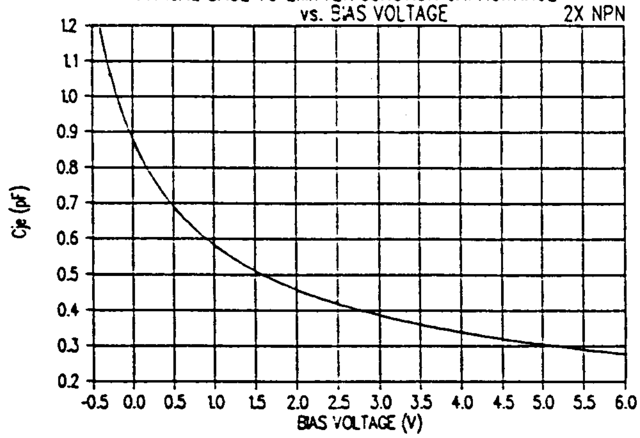

BASE AND OFFSET CURRENTS vs.
EMITTER CURRENT
2X NPN
Ios, Ib (avg) (A)
Ie (A)


COLLECTOR-EMITTER SATURATION VOLTAGE VS.
COLLECTOR CURRENT
2X NPN
Vce (SAT) (V)
Ic (A)
MAX
TYP.
IC/IB=10

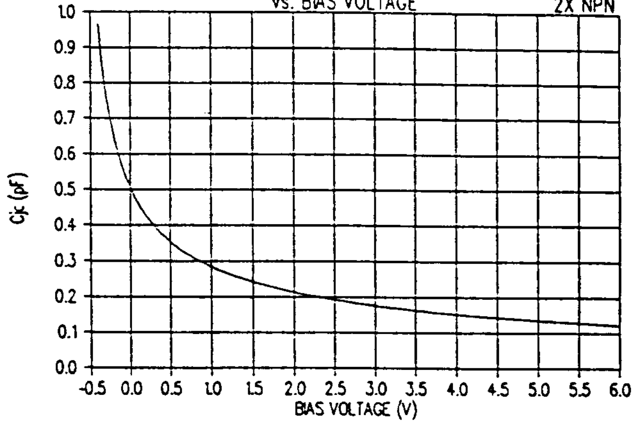

NORMALIZED SATURATION VOLTAGE VS.
BASE DRIVE
2X NPN
NORMALIZED Vce (SAT)
TYP.
IC = 10mA


NORMALIZED SATURATION VOLTAGE VS.
TEMPERATURE
2X NPN
NORMALIZED Vce (SAT)
TEMPERATURE (C)
IC = 2mA
IC = 20mA

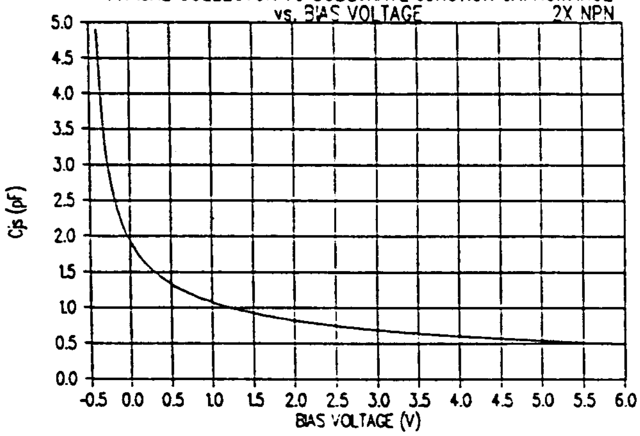
TYPICAL BASE TO EMITTER JUNCTION CAPACITANCE vs. BIAS VOLTAGE 2X NPN



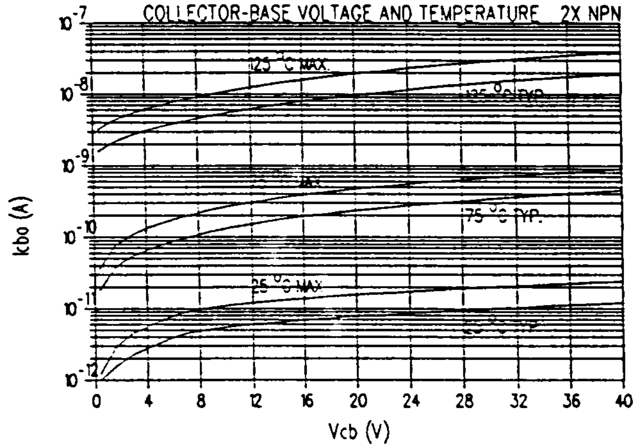
TYPICAL BASE TO COLLECTOR JUNCTION CAPACITANCE vs. BIAS VOLTAGE 2X NPN



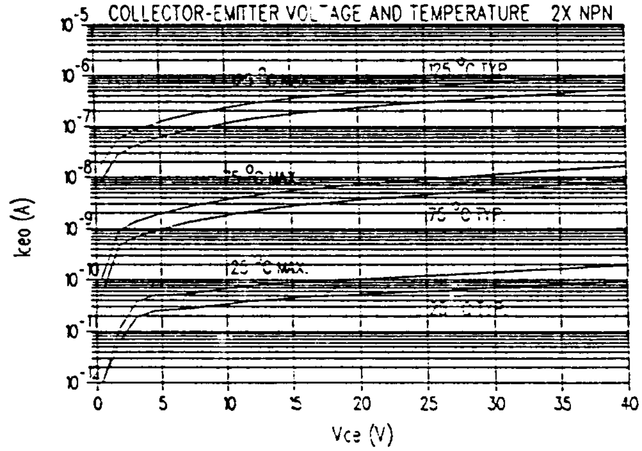
TYPICAL COLLECTOR TO SUBSTRATE JUNCTION CAPACITANCE vs. BIAS VOLTAGE 2X NPN



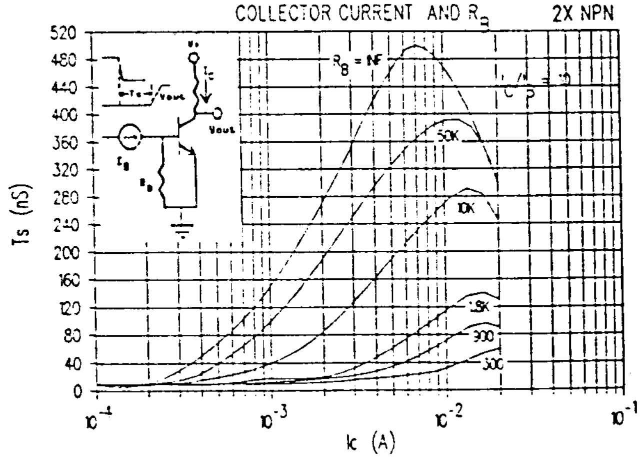
COLLECTOR-BASE LEAKAGE CURRENT vs. COLLECTOR-BASE VOLTAGE AND TEMPERATURE 2X NPN

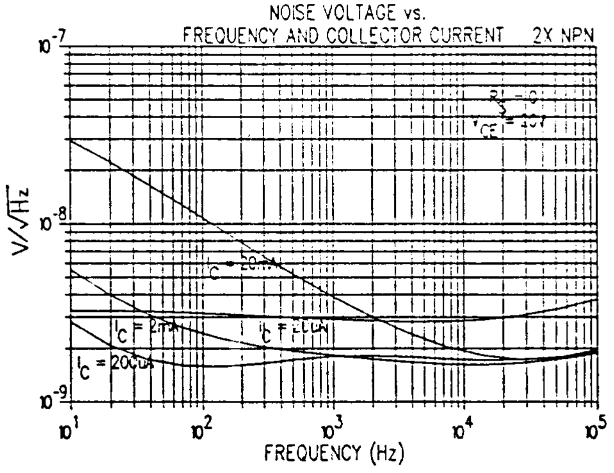


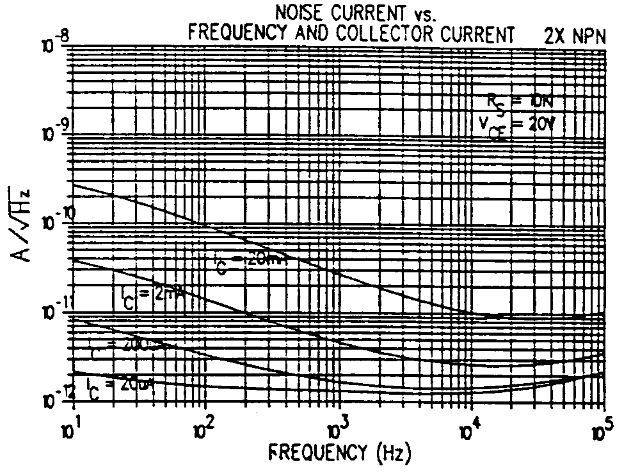
COLLECTOR-EMITTER LEAKAGE CURRENT vs. COLLECTOR-EMITTER VOLTAGE AND TEMPERATURE 2X NPN

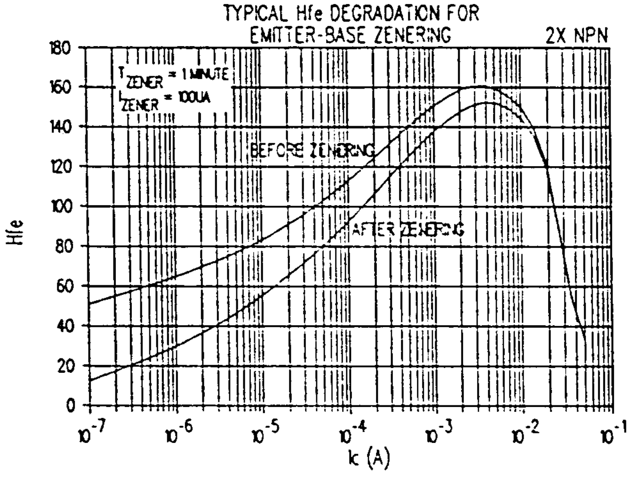


STORAGE TIME vs. COLLECTOR CURRENT AND R_B 2X NPN



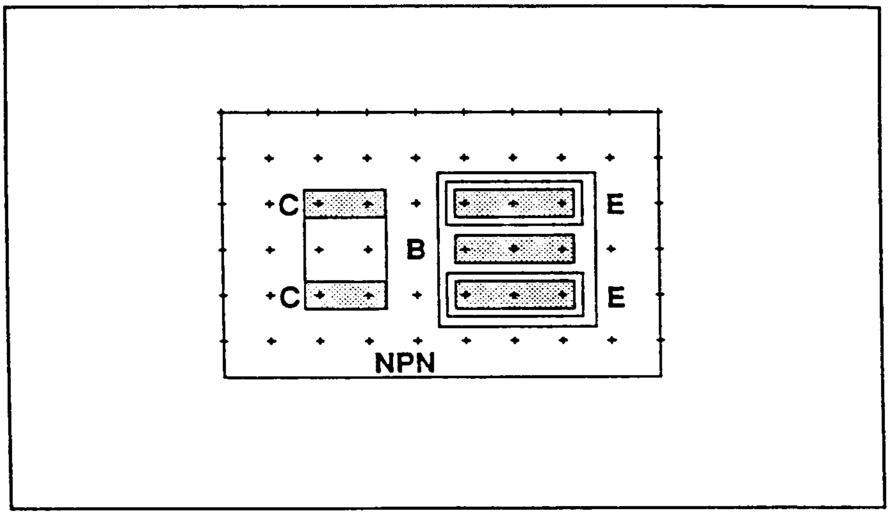

NOISE VOLTAGE vs.
FREQUENCY AND COLLECTOR CURRENT 2X NPN
V/√Hz
FREQUENCY (Hz)


NOISE CURRENT vs.
FREQUENCY AND COLLECTOR CURRENT 2X NPN
RS = 10K
VCE = 20V
A/√Hz
FREQUENCY (Hz)


TYPICAL Hfe DEGRADATION FOR
EMITTER-BASE ZENERING 2X NPN
BEFORE ZENERING
AFTER ZENERING
Hfe

THE MV MEDIUM NPN TRANSISTOR ("MD NPN")

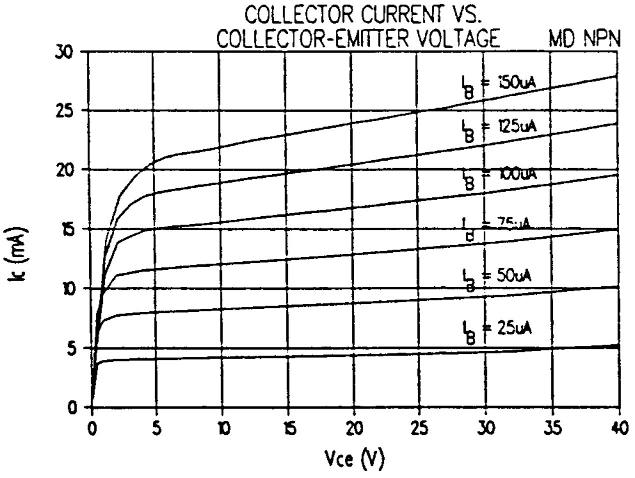
The medium NPN transistor is a peripheral component with lengthened rectangle emitters to provide increased current capability. The double collector contacts allow the low impedance N+ region to be used as a crossunder resistor.

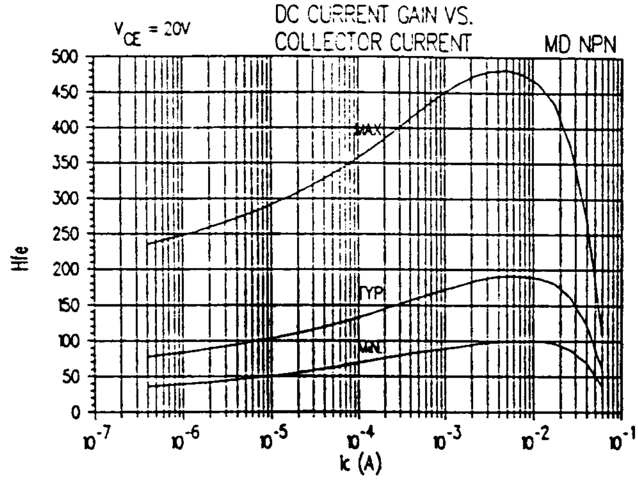


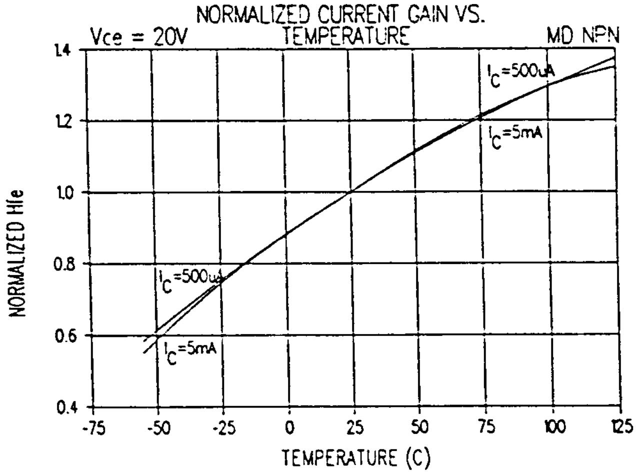
THE MV MEDIUM NPN TRANSISTOR - ("MD NPN")

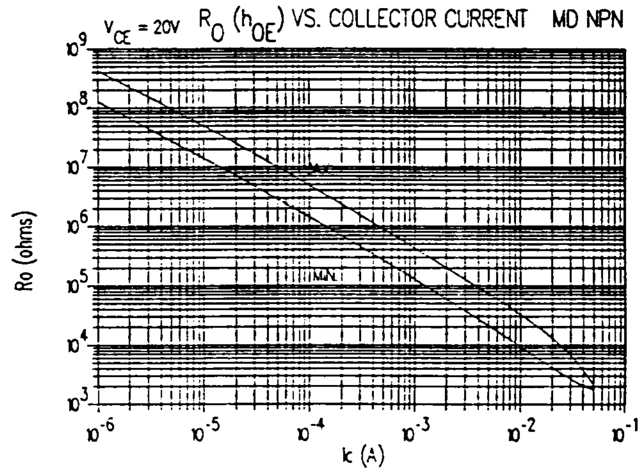
ELECTRICAL CHARACTERISTICS (T_A = +25°C) MEDIUM NPN

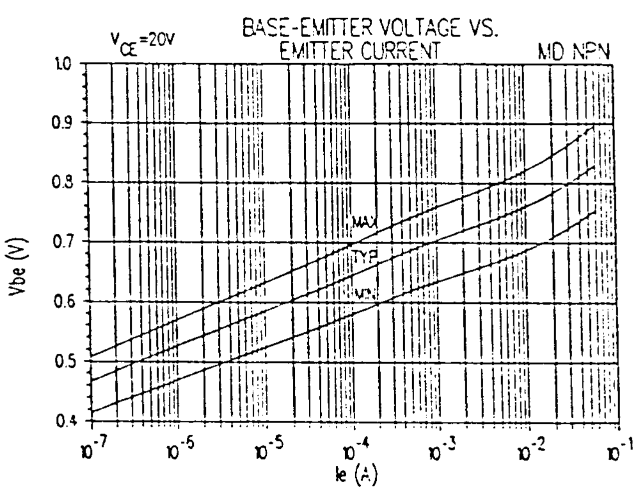
PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNITS
Forward Current Gain	ßF	VCE=20V, IC=300µA	80		400	
Reverse Current Gain	ßR	VCE=-5V, IC=-300µA		2.8		
Reverse Saturation Current	IS			1.0×10^{-15}		A
Base Emitter Voltage	VBE	VCE=20V, IE=300µA	0.61			V
Collector-Emitter Saturation Voltage	VCE(SAT)	IC=3mA, IB=300µA			0.73	V
Emitter-Base Breakdown Voltage	BVEBO	IE=30µA	6.7			V
Collector-Emitter Breakdown Voltage	BVCEO	IC=300µA	40		0.2	V
Collector-Base Breakdown Voltage	BVCBO	IC=300µA	60		7.7	V
Collector-Emitter Leakage Current	ICEO	VCE=40V		60		pA
Collector-Base Leakage Current	ICBO	VCB=40V		2		pA
Emitter-Base Leakage Current	IEBO	VEB=4V		30		pA
Collector Resistance	RC	IC=3mA, IB=6mA		12		Ω
Emitter Resistance	RE	IE=15mA		1		Ω
Base Resistance	RB	IC=30mA		30		Ω
Early Voltage	VA	VCE=20V, IC=300µA		125		V
Current Gain Bandwidth Product	fT	VCE=20V, IC=3mA		450		MHz
Forward Transit Time	TF	VCE=20V, IC=3mA		0.31		nSec
Base Emitter Capacitance	CBEO	VBIAS=0V		1.35		pF
Collector-Base Capacitance	CCBO	VBIAS=0V		0.5		pF
Collector-Substrate Capacitance	CCSO	VBIAS=0V		2		pF

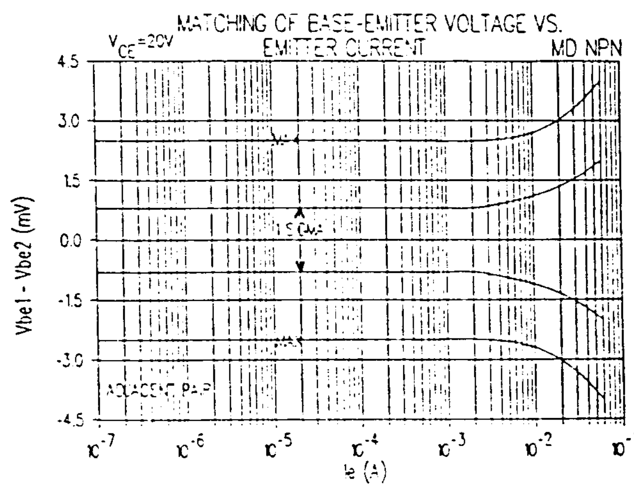

COLLECTOR CURRENT VS.
COLLECTOR-EMITTER VOLTAGE
MD NPN
I_B = 150uA
I_B = 125uA
I_B = 100uA
I_B = 75uA
I_B = 50uA
I_B = 25uA
Ic (mA)
Vce (V)

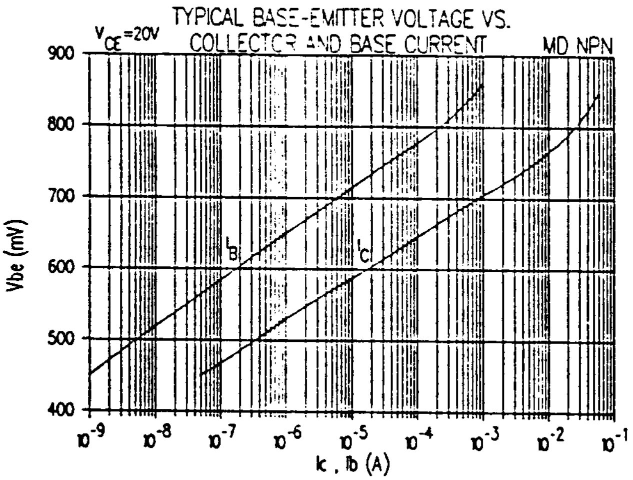

V_{CE} = 20V
DC CURRENT GAIN VS.
COLLECTOR CURRENT
MD NPN
MAX
TYP
MIN
Hfe
Ic (A)

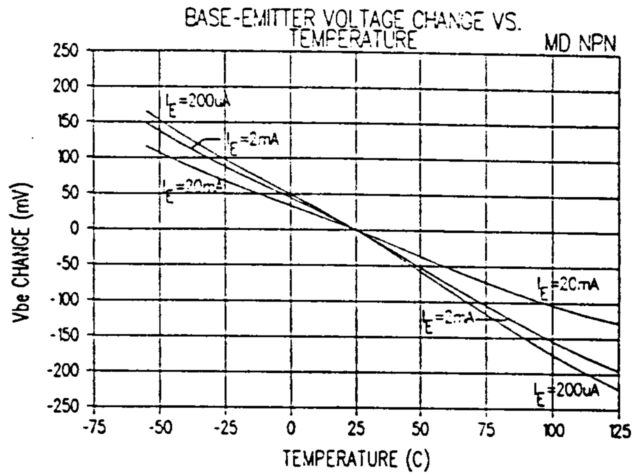

NORMALIZED CURRENT GAIN VS.
TEMPERATURE
Vce = 20V
MD NPN
I_C=500uA
I_C=5mA
I_C=500uA
I_C=5mA
NORMALIZED Hfe
TEMPERATURE (C)

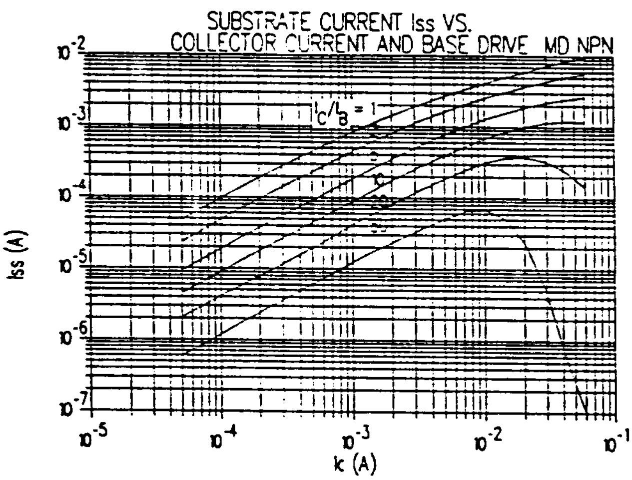

V_{CE} = 20V
R_O (h_{OE}) VS. COLLECTOR CURRENT
MD NPN
Ro (ohms)
Ic (A)

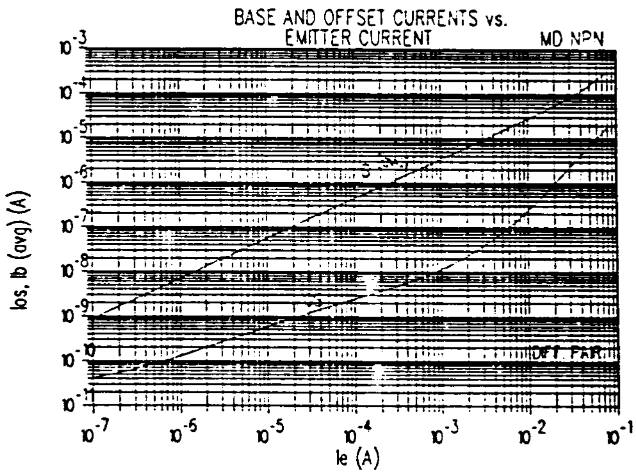

V_{CE}=20V
BASE-EMITTER VOLTAGE VS.
EMITTER CURRENT
MD NPN
MAX
TYP
Vbe (V)
Ie (A)

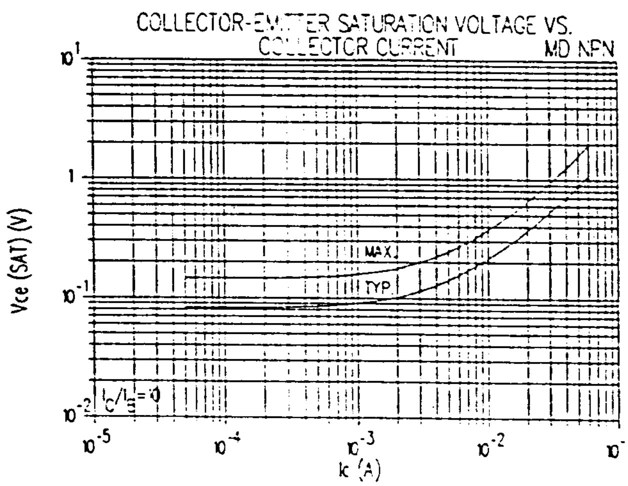

V_{CE}=20V
MATCHING OF BASE-EMITTER VOLTAGE VS.
EMITTER CURRENT
MD NPN
Vbe1 - Vbe2 (mV)
Ie (A)

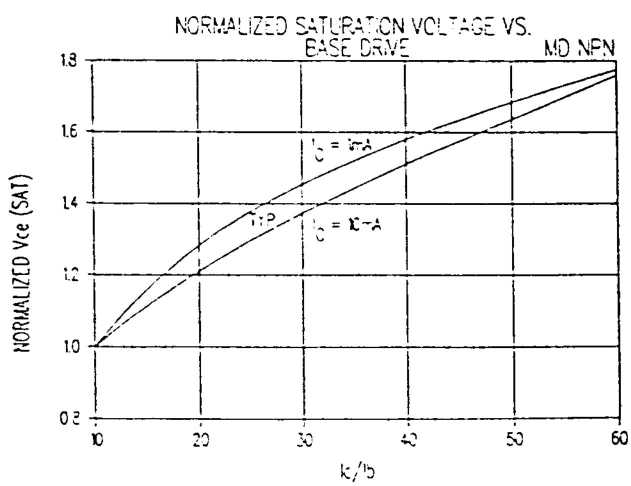

TYPICAL BASE-EMITTER VOLTAGE VS.
COLLECTOR AND BASE CURRENT
V_{CE}=20V
MD NPN
Vbe (mV)
900
800
700
600
500
400
I_B
I_C
10^{-9} 10^{-8} 10^{-7} 10^{-6} 10^{-5} 10^{-4} 10^{-3} 10^{-2} 10^{-1}
Ic , Ib (A)

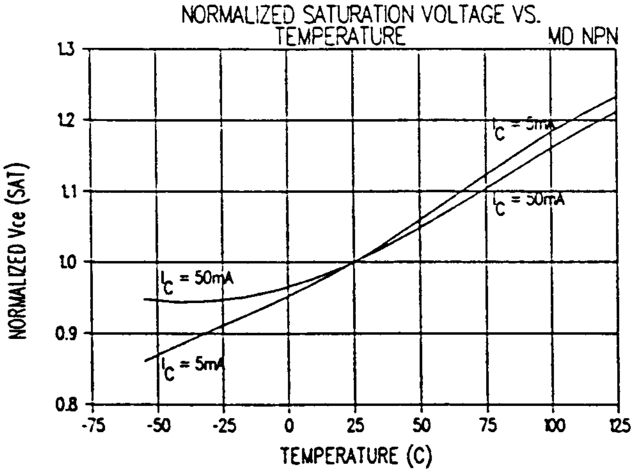

BASE-EMITTER VOLTAGE CHANGE VS.
TEMPERATURE
MD NPN
Vbe CHANGE (mV)
250
200
150
100
50
0
-50
-100
-150
-200
-250
I_E=200uA
I_E=2mA
I_E=20mA
I_E=20mA
I_E=2mA
I_E=200uA
-75 -50 -25 0 25 50 75 100 125
TEMPERATURE (C)

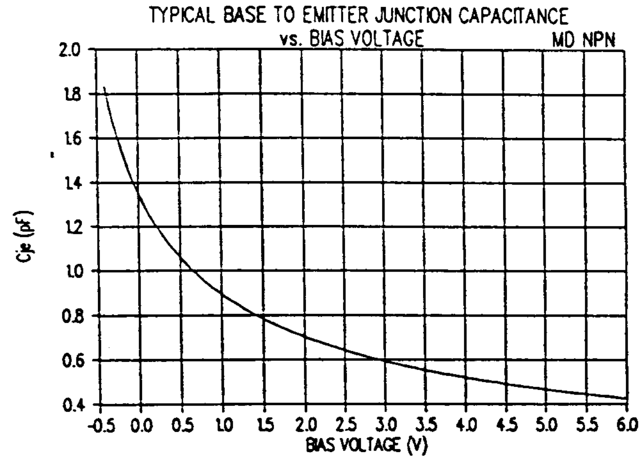

SUBSTRATE CURRENT Iss VS.
COLLECTOR CURRENT AND BASE DRIVE
MD NPN
Iss (A)
10^{-2}
10^{-3}
10^{-4}
10^{-5}
10^{-6}
10^{-7}
I_C/I_B = 1
10^{-5} 10^{-4} 10^{-3} 10^{-2} 10^{-1}
Ic (A)

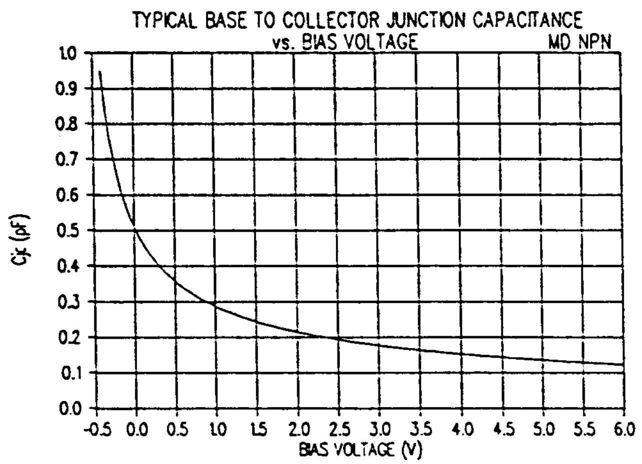

BASE AND OFFSET CURRENTS vs.
EMITTER CURRENT
MD NPN
Ios, Ib (avg) (A)
10^{-3}
10^{-4}
10^{-5}
10^{-6}
10^{-7}
10^{-8}
10^{-9}
10^{-10}
10^{-11}
DIFF. PAIR
10^{-7} 10^{-6} 10^{-5} 10^{-4} 10^{-3} 10^{-2} 10^{-1}
Ie (A)

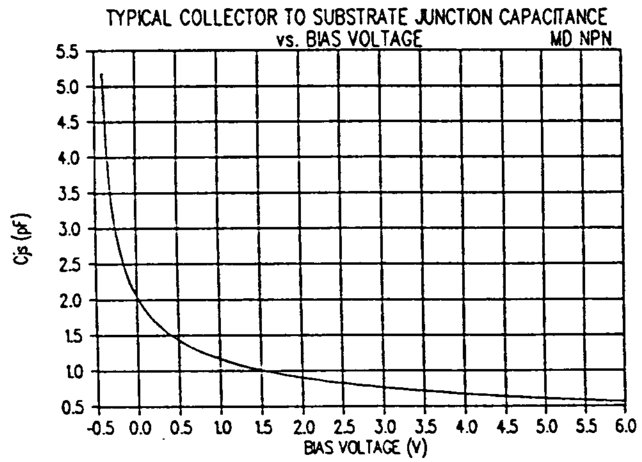

COLLECTOR-EMITTER SATURATION VOLTAGE VS.
COLLECTOR CURRENT
MD NPN
Vce (SAT) (V)
10^{1}
1
10^{-1}
10^{-2}
MAX.
TYP.
I_C/I_B=10
10^{-5} 10^{-4} 10^{-3} 10^{-2} 10^{-1}
Ic (A)

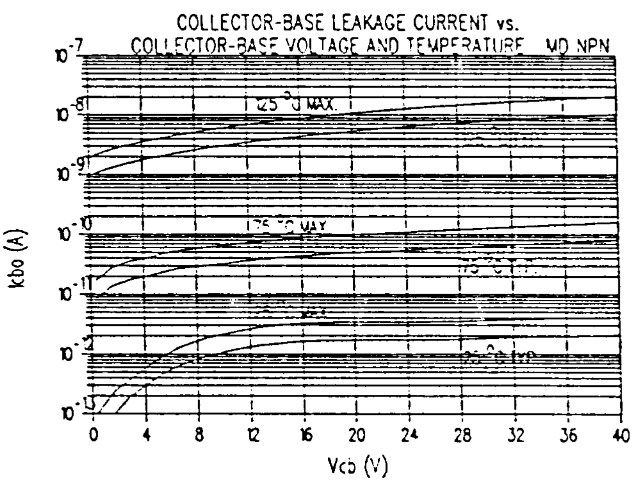

NORMALIZED SATURATION VOLTAGE VS.
BASE DRIVE
MD NPN
NORMALIZED Vce (SAT)
1.8
1.6
1.4
1.2
1.0
0.8
I_C = 1mA
TYP.
I_C = 10mA
10 20 30 40 50 60
Ic/Ib

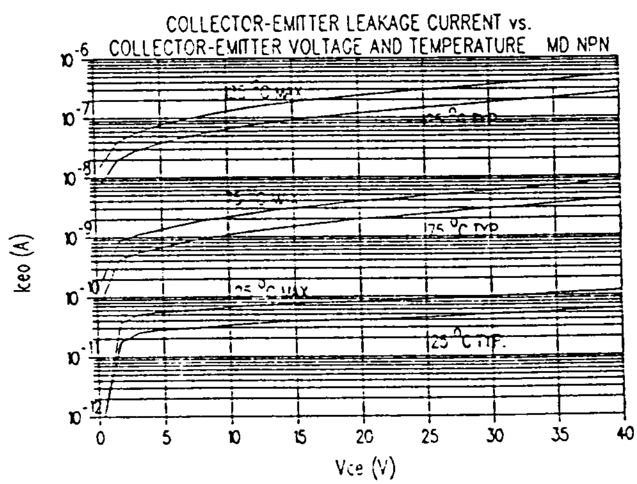

NORMALIZED SATURATION VOLTAGE VS. TEMPERATURE
MD NPN
NORMALIZED Vce (SAT)
TEMPERATURE (C)
I_C = 5mA
I_C = 50mA
I_C = 50mA
I_C = 5mA
1.3
1.2
1.1
1.0
0.9
0.8
-75 -50 -25 0 25 50 75 100 125

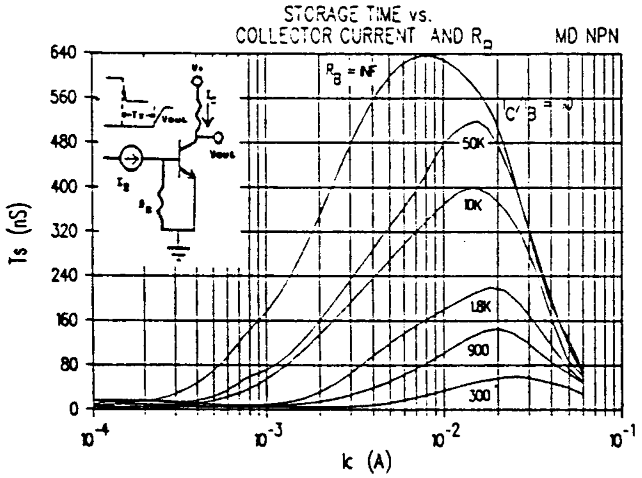

TYPICAL BASE TO EMITTER JUNCTION CAPACITANCE vs. BIAS VOLTAGE
MD NPN
Cje (pF)
BIAS VOLTAGE (V)
2.0 1.8 1.6 1.4 1.2 1.0 0.8 0.6 0.4
-0.5 0.0 0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0 5.5 6.0

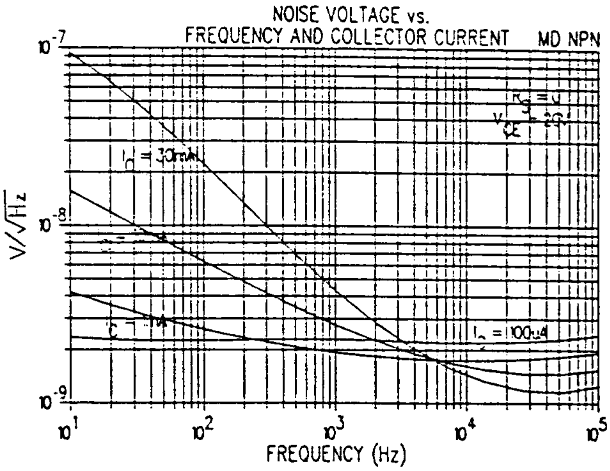

TYPICAL BASE TO COLLECTOR JUNCTION CAPACITANCE vs. BIAS VOLTAGE
MD NPN
Cjc (pF)
BIAS VOLTAGE (V)
1.0 0.9 0.8 0.7 0.6 0.5 0.4 0.3 0.2 0.1 0.0
-0.5 0.0 0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0 5.5 6.0

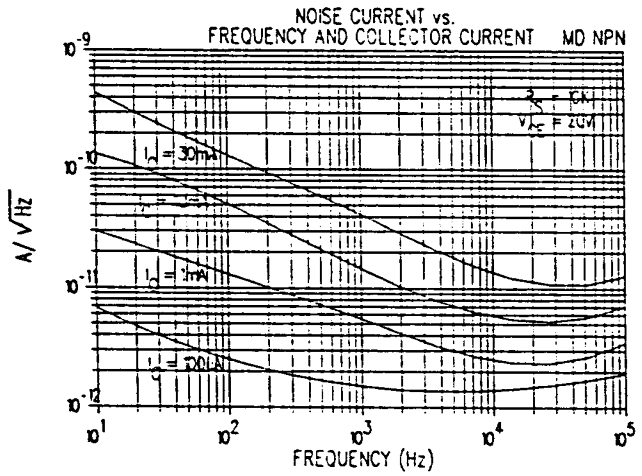

TYPICAL COLLECTOR TO SUBSTRATE JUNCTION CAPACITANCE vs. BIAS VOLTAGE
MD NPN
Cjs (pF)
BIAS VOLTAGE (V)
5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5
-0.5 0.0 0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0 5.5 6.0

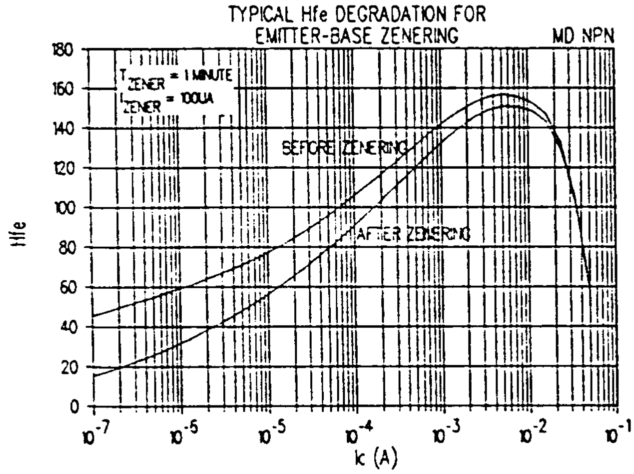

COLLECTOR-BASE LEAKAGE CURRENT vs. COLLECTOR-BASE VOLTAGE AND TEMPERATURE
MD NPN
Icbo (A)
Vcb (V)
10^{-7} 10^{-8} 10^{-9} 10^{-10} 10^{-11} 10^{-12} 10^{-13}
0 4 8 12 16 20 24 28 32 36 40


COLLECTOR-EMITTER LEAKAGE CURRENT vs. COLLECTOR-EMITTER VOLTAGE AND TEMPERATURE
MD NPN
Iceo (A)
Vce (V)
175 °C TYP.
125 °C MAX.
125 °C TYP.
10^{-6} 10^{-7} 10^{-8} 10^{-9} 10^{-10} 10^{-11} 10^{-12}
0 5 10 15 20 25 30 35 40


STORAGE TIME vs.
COLLECTOR CURRENT AND R_B
MD NPN
Ts (nS)
Ic (A)
50K
10K
1.8K
900
300

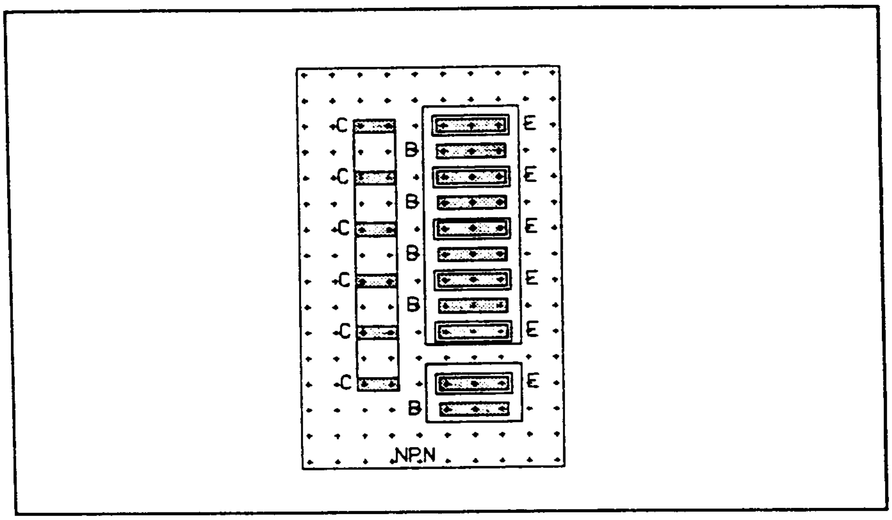

NOISE VOLTAGE vs.
FREQUENCY AND COLLECTOR CURRENT
MD NPN
V/√Hz
FREQUENCY (Hz)


NOISE CURRENT vs.
FREQUENCY AND COLLECTOR CURRENT
MD NPN
A/√Hz
FREQUENCY (Hz)


TYPICAL Hfe DEGRADATION FOR
EMITTER-BASE ZENERING
MD NPN
Hfe
Ic (A)
BEFORE ZENERING
AFTER ZENERING

THE MV LARGE NPN TRANSISTOR ("LG NPN")

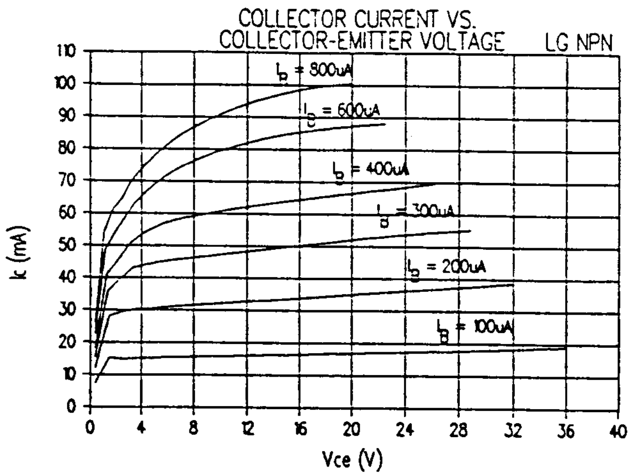
The large NPN transistor is a peripheral component with additional long rectangular emitters designed to provide high current capability. This is a common-collector dual NPN transistor with a 5:1 emitter area ratio. The six collector contacts allow the low impedance N+ region to be used as a crossunder resistor.

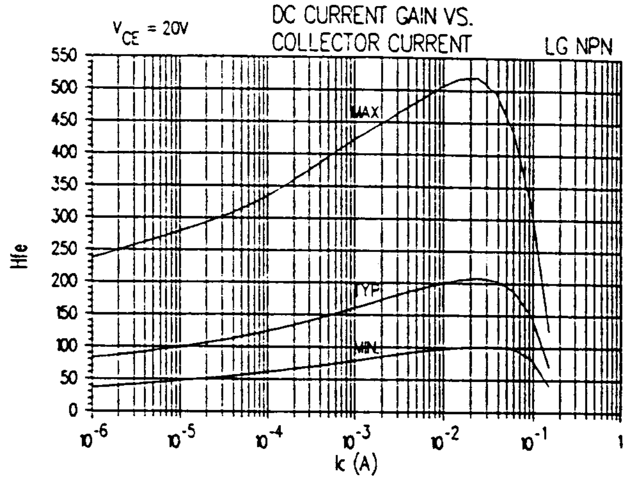


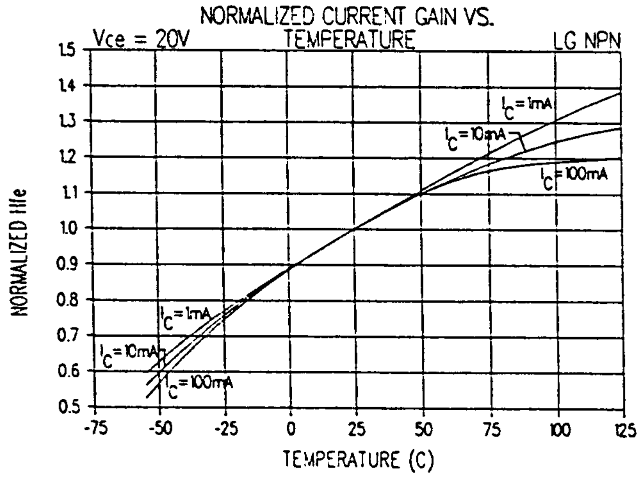
THE MV LARGE NPN TRANSISTOR - ("LG NPN")

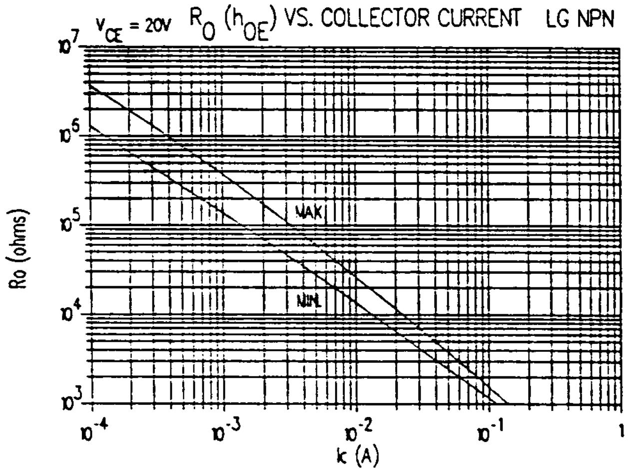
ELECTRICAL CHARACTERISTICS (T_A = +25°C) LARGE NPN

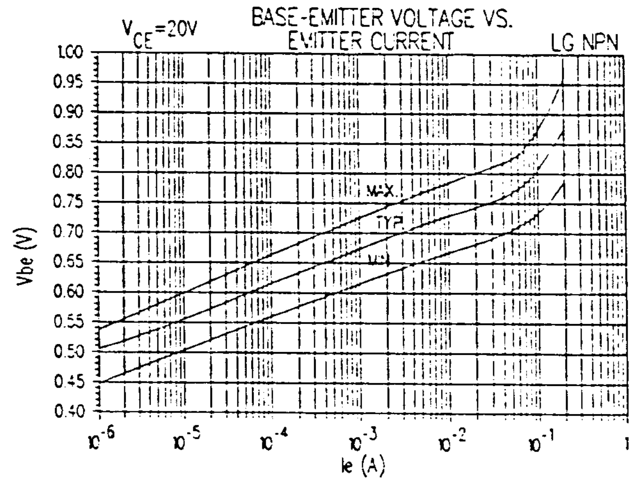
PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNITS
Forward Current Gain	ßF	VCE=20V, IC=1mA	80		425	
Reverse Current Gain	ßR	VCE=-5V, IC=-1mA		4		
Reverse Saturation Current	IS			2.9×10^{-15}		A
Base Emitter Voltage	VBE	VCE=20V, IE=1mA	0.61			V
Collector-Emitter Saturation Voltage	VCE(SAT)	IC=10mA, IB=1mA			0.73	V
Emitter-Base Breakdown Voltage	BVEBO	IE=100µA	6.7			V
Collector-Emitter Breakdown Voltage	BVCEO	IC=1mA	40		0.2	V
Collector-Base Breakdown Voltage	BVCBO	IC=1mA	60		7.7	V
Collector-Emitter Leakage Current	ICEO	VCE=40V		100		pA
Collector-Base Leakage Current	ICBO	VCB=40V		10		pA
Emitter-Base Leakage Current	IEBO	VEB=4V		50		pA
Collector Resistance	RC	IC=10mA, IB=20mA		4		Ω
Emitter Resistance	RE	IE=50mA		0.3		Ω
Base Resistance	RB	IC=100mA		10		Ω
Early Voltage	VA	VCE=20V, IC=1mA		133		V
Current Gain Bandwidth Product	fT	VCE=20V, IC=10mA		450		MHz
Forward Transit Time	TF	VCE=20V, IC=10mA		0.3		nSec
Base Emitter Capacitance	CBEO	VBIAS=0V		4		pF
Collector-Base Capacitance	CCBO	VBIAS=0V		1.7		pF
Collector-Substrate Capacitance	CCSO	VBIAS=0V		5.3		pF

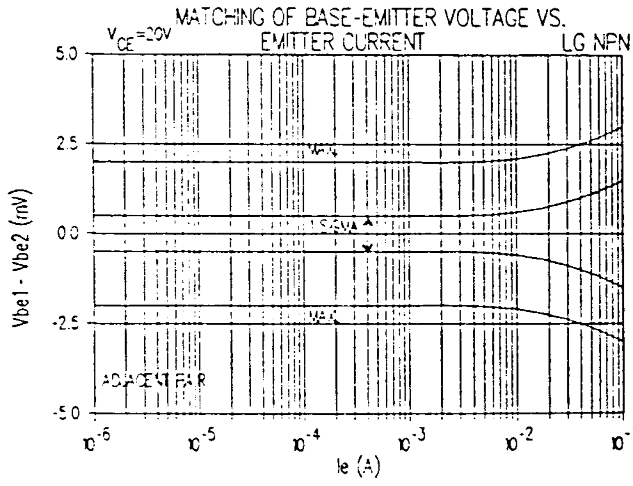

COLLECTOR CURRENT VS. COLLECTOR-EMITTER VOLTAGE
LG NPN
Ic (mA)
Vce (V)
Ib = 800uA
Ib = 600uA
Ib = 400uA
Ib = 300uA
Ib = 200uA
Ib = 100uA

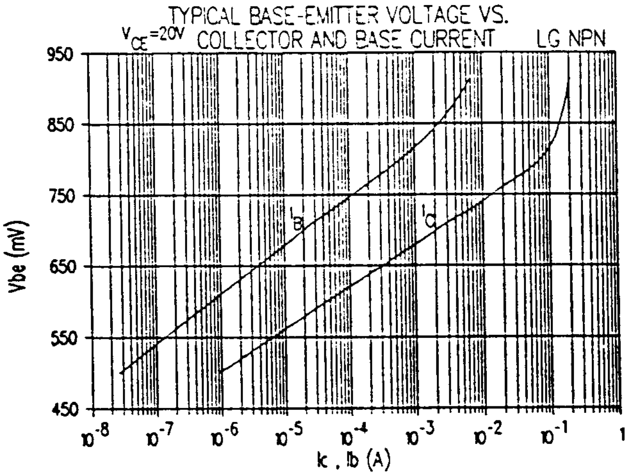

DC CURRENT GAIN VS. COLLECTOR CURRENT
VCE = 20V
LG NPN
Hfe
Ic (A)
MAX
TYP
MIN

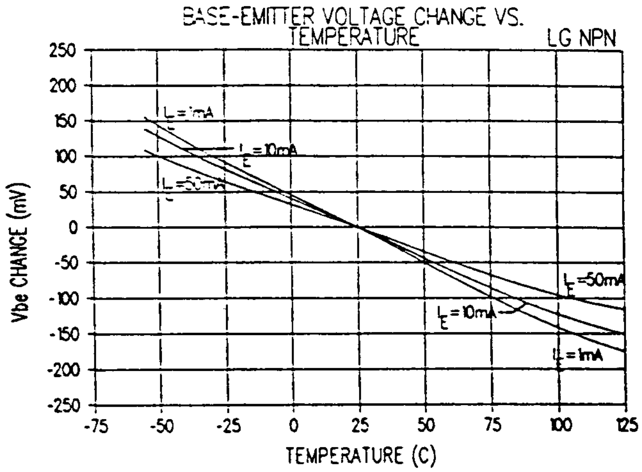

NORMALIZED CURRENT GAIN VS. TEMPERATURE
Vce = 20V
LG NPN
NORMALIZED Hfe
TEMPERATURE (C)
IC = 1mA
IC = 10mA
IC = 100mA

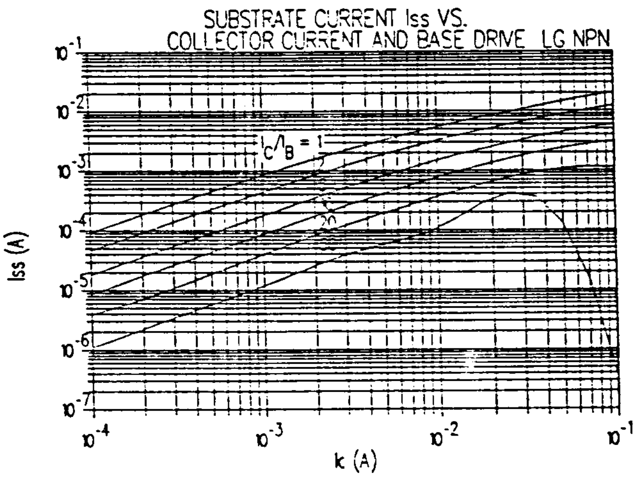

VCE = 20V
RO (hOE) VS. COLLECTOR CURRENT
LG NPN
Ro (ohms)
Ic (A)
MAX
MIN

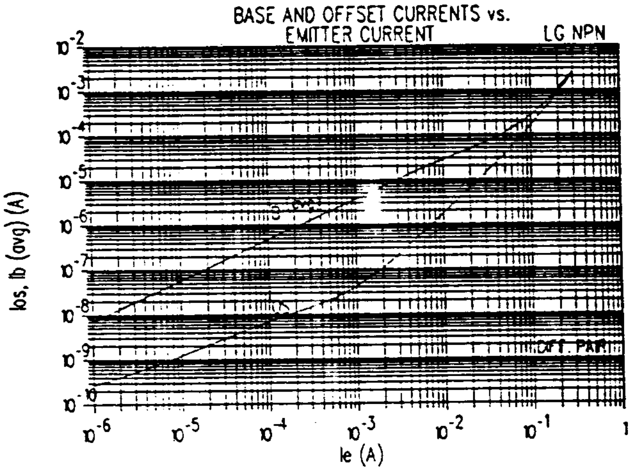

BASE-EMITTER VOLTAGE VS. EMITTER CURRENT
VCE=20V
LG NPN
Vbe (V)
Ie (A)
MAX
TYP

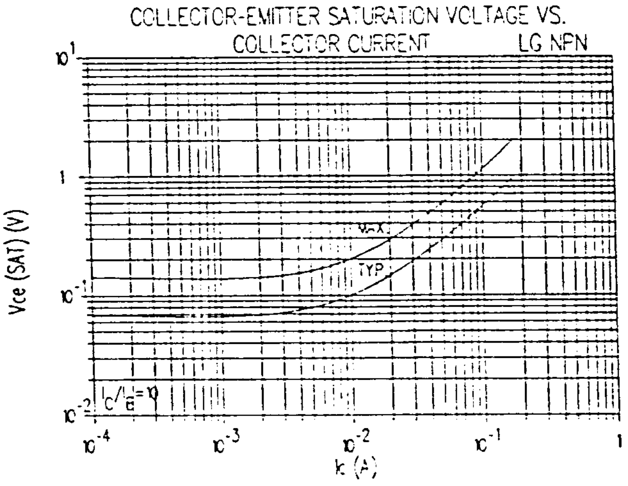

MATCHING OF BASE-EMITTER VOLTAGE VS. EMITTER CURRENT
VCE=20V
LG NPN
Vbe1 - Vbe2 (mV)
Ie (A)
ADJACENT PAIR

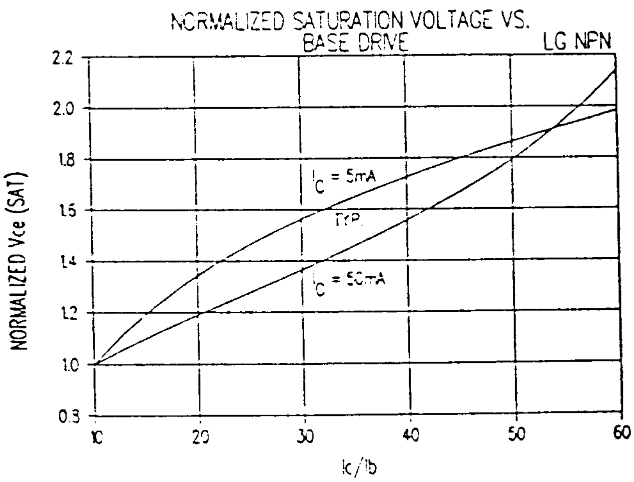

TYPICAL BASE-EMITTER VOLTAGE VS.
V_{CE}=20V COLLECTOR AND BASE CURRENT
LG NPN
Vbe (mV)
Ic , Ib (A)


BASE-EMITTER VOLTAGE CHANGE VS. TEMPERATURE
LG NPN
Vbe CHANGE (mV)
TEMPERATURE (C)

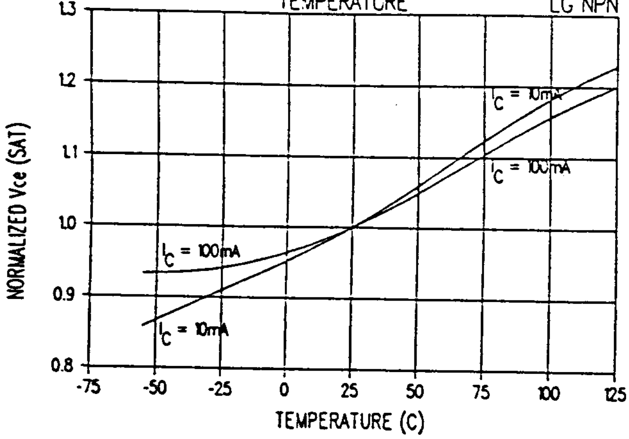

SUBSTRATE CURRENT Iss VS.
COLLECTOR CURRENT AND BASE DRIVE
LG NPN
Iss (A)
Ic (A)


BASE AND OFFSET CURRENTS vs.
EMITTER CURRENT
LG NPN
Ios, Ib (avg) (A)
Ie (A)

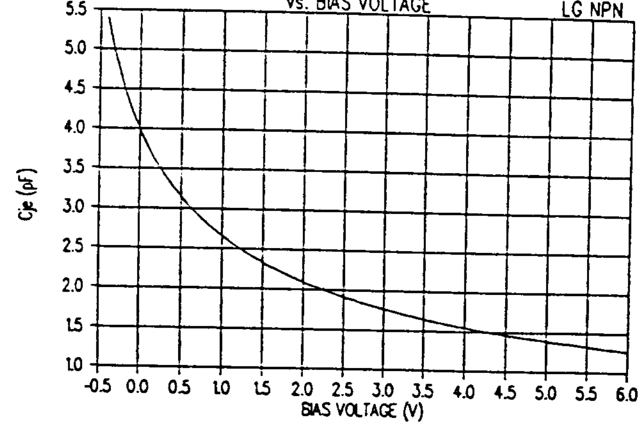

COLLECTOR-EMITTER SATURATION VOLTAGE VS.
COLLECTOR CURRENT
LG NPN
MAX
TYP
Vce (SAT) (V)
Ic (A)


NORMALIZED SATURATION VOLTAGE VS.
BASE DRIVE
LG NPN
TYP.
NORMALIZED Vce (SAT)
Ic/Ib

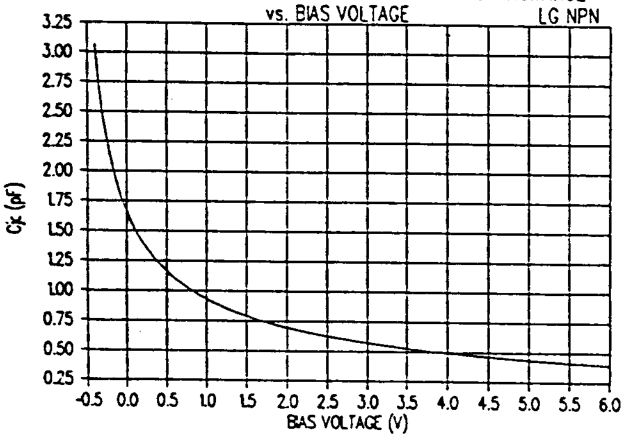
NORMALIZED SATURATION VOLTAGE VS. TEMPERATURE LG NPN



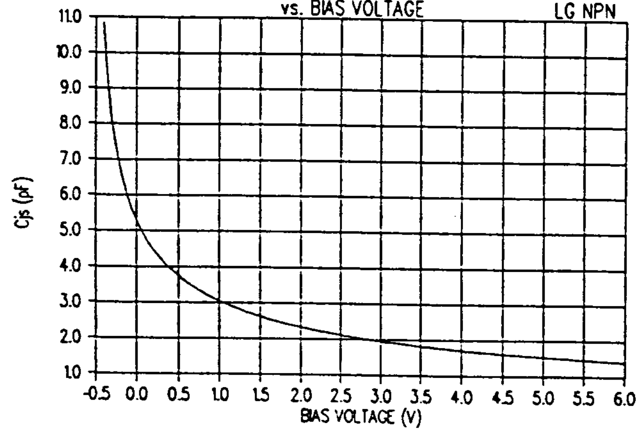
TYPICAL BASE TO EMITTER JUNCTION CAPACITANCE vs. BIAS VOLTAGE LG NPN



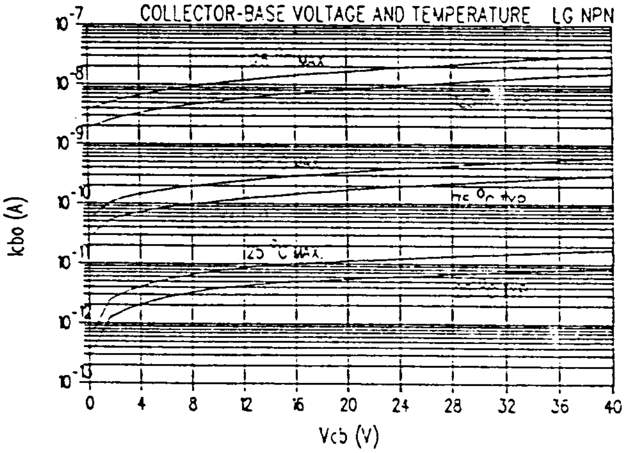
TYPICAL BASE TO COLLECTOR JUNCTION CAPACITANCE vs. BIAS VOLTAGE LG NPN



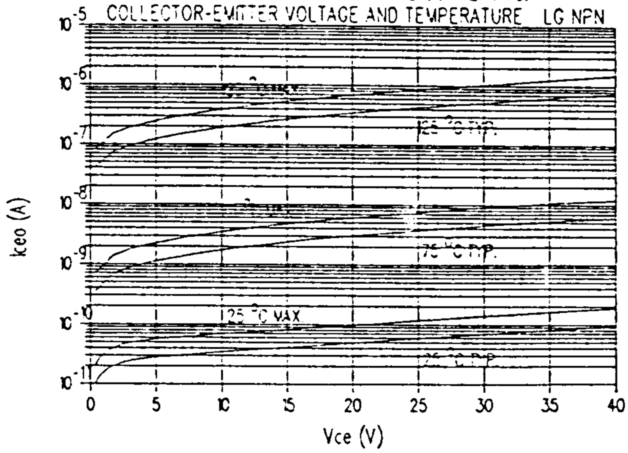
TYPICAL COLLECTOR TO SUBSTRATE JUNCTION CAPACITANCE vs. BIAS VOLTAGE LG NPN

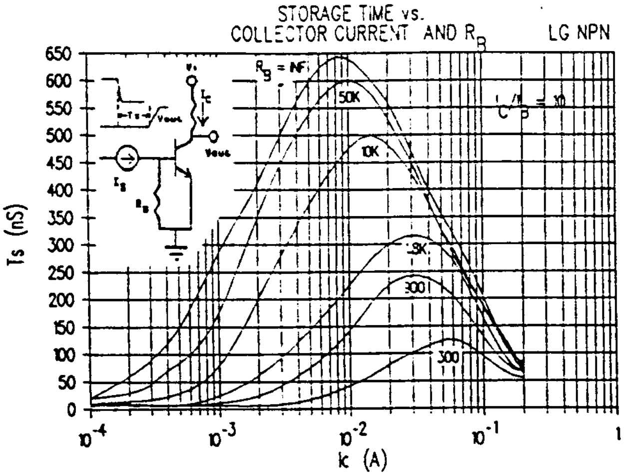


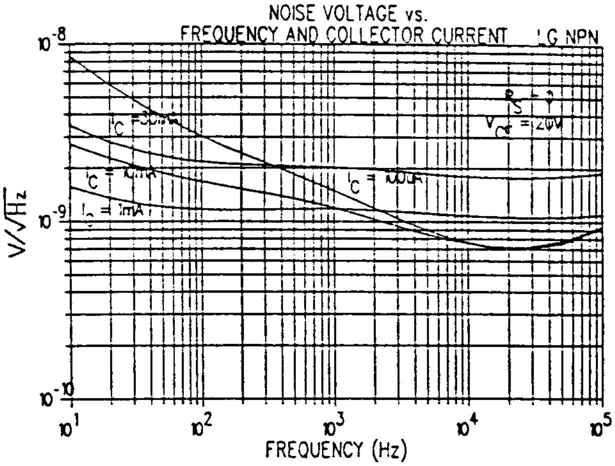
COLLECTOR-BASE LEAKAGE CURRENT vs. COLLECTOR-BASE VOLTAGE AND TEMPERATURE LG NPN

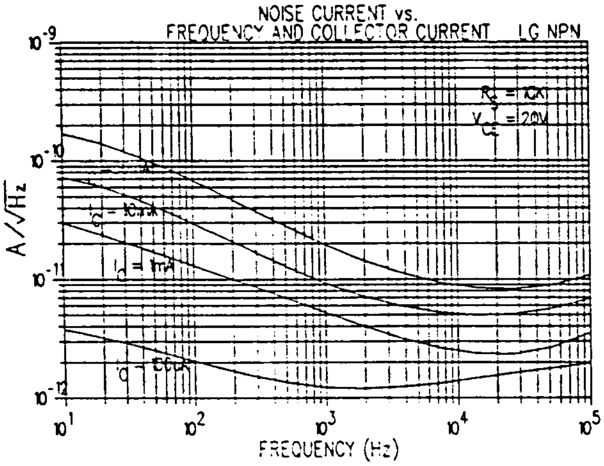


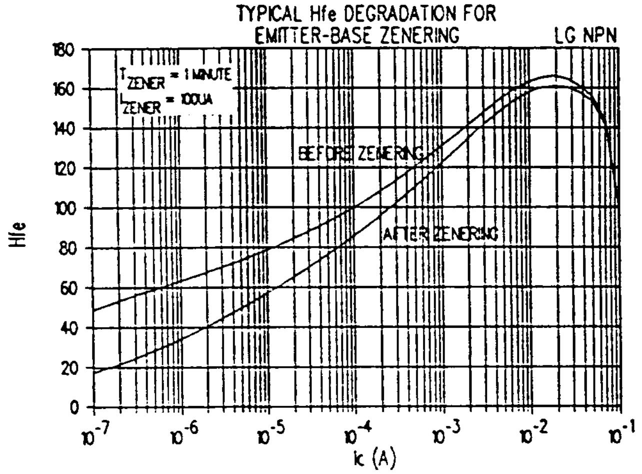
COLLECTOR-EMITTER LEAKAGE CURRENT vs. COLLECTOR-EMITTER VOLTAGE AND TEMPERATURE LG NPN




STORAGE TIME vs.
COLLECTOR CURRENT AND R_B
LG NPN
Ts (nS)
Ic (A)

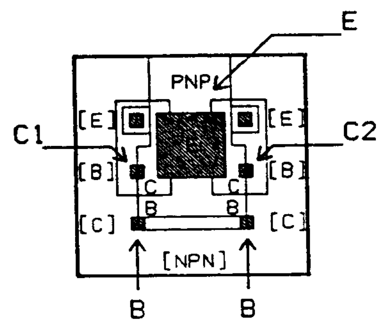

NOISE VOLTAGE vs.
FREQUENCY AND COLLECTOR CURRENT
LG NPN
V/√Hz
FREQUENCY (Hz)


NOISE CURRENT vs.
FREQUENCY AND COLLECTOR CURRENT
LG NPN
A/√Hz
FREQUENCY (Hz)


TYPICAL Hfe DEGRADATION FOR
EMITTER-BASE ZENERING
LG NPN
Hfe
BEFORE ZENERING
AFTER ZENERING
Ic (A)

THE MV MONISTOR (PNP/NPN)

For increased versatility, each array cell contains monistors instead of dedicated lateral PNP transistors. The monistor is a multi-purpose device which may be connected to function as either a lateral PNP transistor or an NPN transistor. When connected as a lateral PNP transistor, the monistor has two collectors. The two base contacts allow the low impedance N+ region to be used as a crossunder resistor. When connected as an NPN transistor, the monistor is a common-collector dual NPN transistor with emitter areas equal to those of the dedicated small NPN transistor. The dual collector contacts allow the low impedance N+ region to be used as a crossunder resistor. For design data on NPN operation, see the 2X NPN design data.



THE MV MONISTOR - LATERAL PNP CONNECTION ("MN PNP")

USING THE MONISTOR AS A LATERAL PNP TRANSISTOR ("MN PNP")

When using the Monistor as a lateral PNP transistor, connect it as shown here. The monistor will behave as a lateral PNP transistor, with all of the advantages and disadvantages associated with any lateral PNP transistor.

The lateral PNP transistor is a compromise device designed in such a way as not to add any processing steps. Although this results in a low gain and frequency response, the lateral PNP transistor is nevertheless a highly useful device.

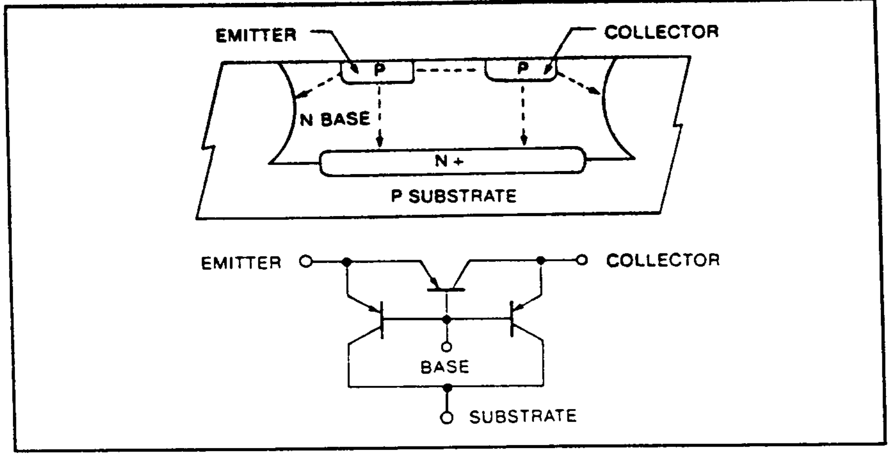
This structure utilizes the NPN transistor base diffusion to form concentric emitter and collector regions. The epitaxial region acts as the base. Thus the current flows laterally, along the surface, between emitter and collector. The PNP transistors have two collectors which can be used as two independent transistors, with base and emitter tied together. Both collectors must be used. They may be tied together, or an unused collector may be tied to the substrate or any place in the circuit where the transistor will not saturate. If one collector is left open or allowed to saturate, the apparent beta of the other transistor will drop by as much as a factor of five and it will conduct 70% of the emitter current. The currents in the two collectors will be substantially equal for equal collector voltages (matched with ±1%). Variation of collector due to Early Effect and due to electrical crossfields will cause additional mismatch if the collector voltages are not equal.

There are two stray effects which must be kept in mind when using any lateral PNP transistor. Both are created by the fact that in addition to the

PNP structure near the surface, there is also a second PNP transistor formed by the emitter and base of the lateral device and the substrate acting as collector.

When the lateral PNP transistor is in its normal active region (not saturated), the substrate collector received only a small fraction of the lateral collector current. Thus, unless your application requires high precision, this fraction of the collector current lost to the substrate can generally be ignored.

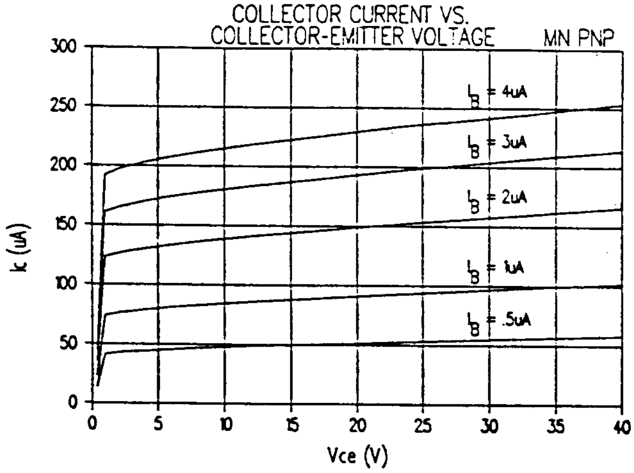
The second stray effect, however, can be more serious. If a lateral PNP transistor is allowed to saturate, the substrate PNP transistor becomes heavily active. The substrate current can be figured from the graph of substrate current versus collector current. Too much substrate current can cause problems.

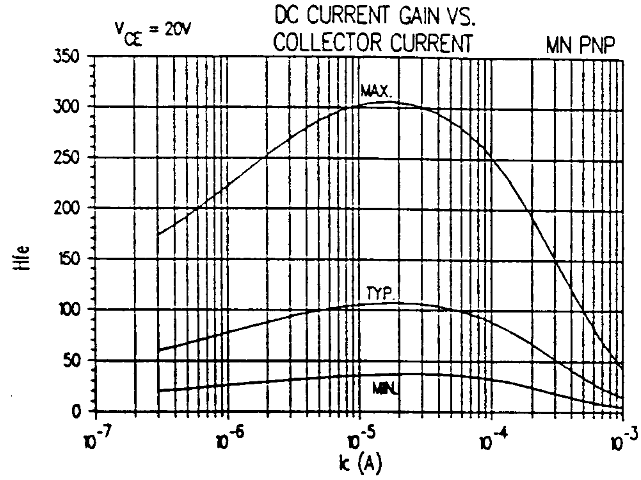


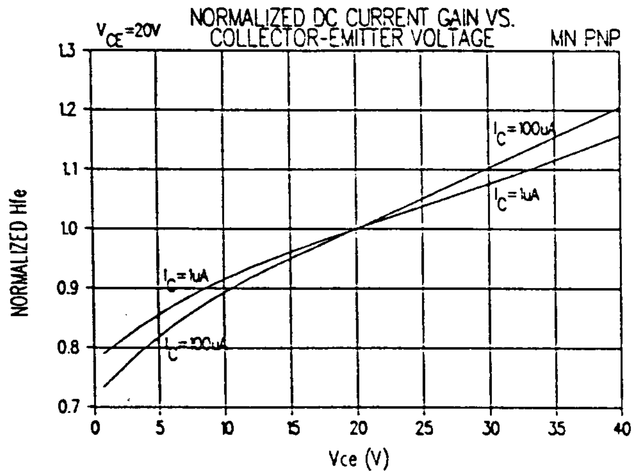
LATERAL PNP TRANSISTOR BEHAVIOR

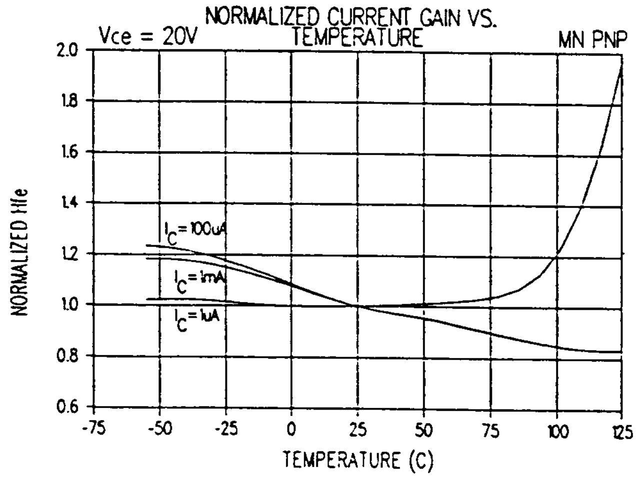
ELECTRICAL CHARACTERISTICS (T_A = +25°C) MONISTOR PNP ("MN PNP")

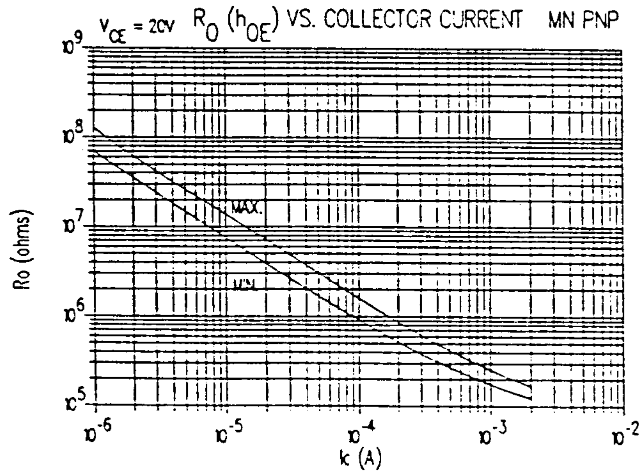
PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNITS
Forward Current Gain	ßF	VCE=-20V, IC=-100µA	30		250	
Reverse Current Gain	ßR	VCE=20V, IC=100µA		20		
Reverse Saturation Current	IS			$2.7x10^{-15}$		A
Base Emitter Voltage	VBE	VCE=20V, IE=100µA	0.62		.74	V
Collector-Emitter Saturation Voltage	VCE(SAT)	IC=100µA, IB=100µA			0.2	V
Emitter-Base Breakdown Voltage	BVEBO	IE=10µA	40			V
Collector-Emitter Breakdown Voltage	BVCEO	IC=100µA	50			V
Collector-Base Breakdown Voltage	BVCBO	IC=10µA	60			V
Collector-Emitter Leakage Current	ICEO	VCE=40V		100		pA
Collector-Base Leakage Current	ICBO	VCB=40V		7		pA
Collector Resistance	RC	IC=0.2mA, IB=1mA		50		Ω
Emitter Resistance	RE	IE=5mA		15		Ω
Base Resistance	RB	IC=1mA		150		Ω
Early Voltage	VA	VCE=20V, IC=10µA		60		V
Current Gain Bandwidth Product	fT	VCE=20V, IC=200µA		4.5		MHz
Forward Transit Time	TF	VCE=20V, IC=200µA		35		nSec
Base Emitter Capacitance	CBEO	VBIAS=0V		0.13		pF
Collector-Base Capacitance	CCBO	VBIAS=0V		0.65		pF
Collector-Substrate Capacitance	CCSO	VBIAS=0V		2.8		pF

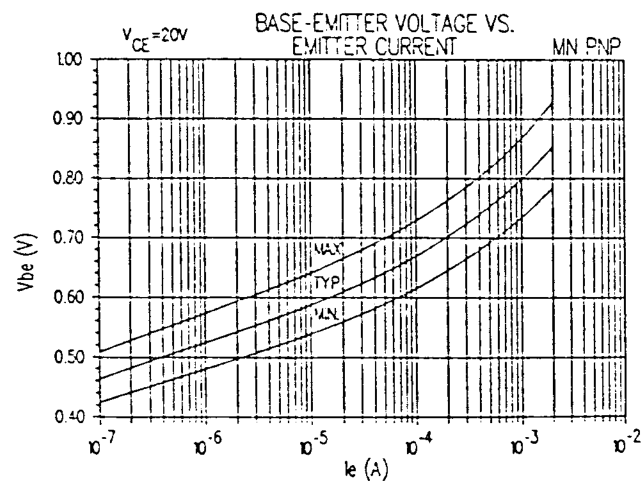

COLLECTOR CURRENT VS.
COLLECTOR-EMITTER VOLTAGE
MN PNP
Ic (uA)
Vce (V)
IB = 4uA
IB = 3uA
IB = 2uA
IB = 1uA
IB = .5uA

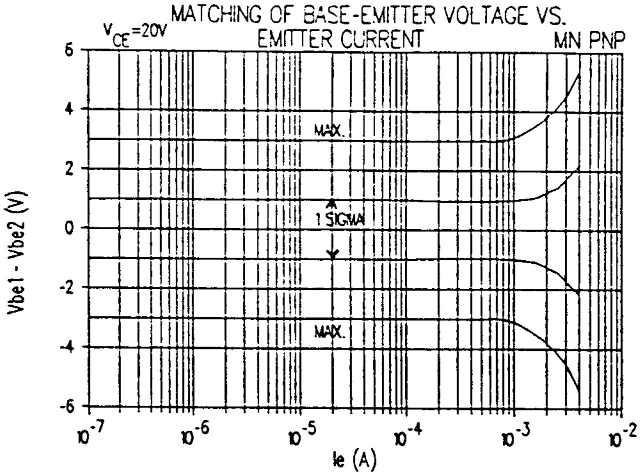

DC CURRENT GAIN VS.
COLLECTOR CURRENT
MN PNP
VCE = 20V
Hfe
Ic (A)
MAX.
TYP.
MIN.

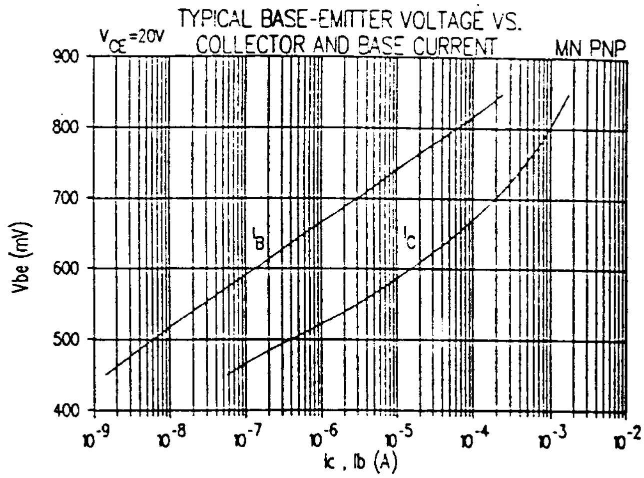

NORMALIZED DC CURRENT GAIN VS.
COLLECTOR-EMITTER VOLTAGE
MN PNP
VCE=20V
NORMALIZED Hfe
Vce (V)
IC = 100uA
IC = 1uA

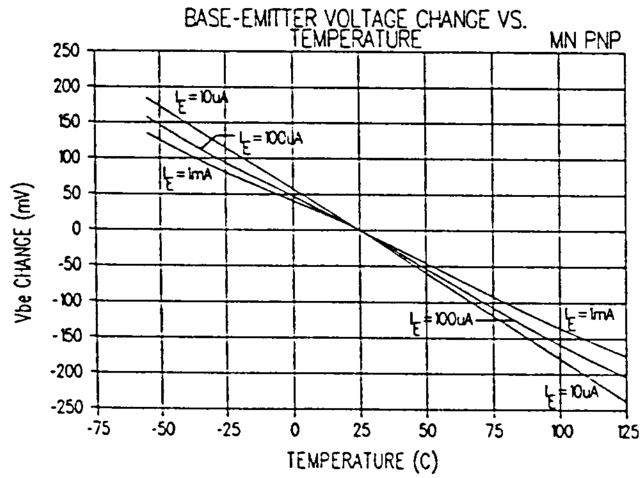

NORMALIZED CURRENT GAIN VS.
TEMPERATURE
MN PNP
Vce = 20V
NORMALIZED Hfe
TEMPERATURE (C)
IC = 100uA
IC = 1mA
IC = 1uA

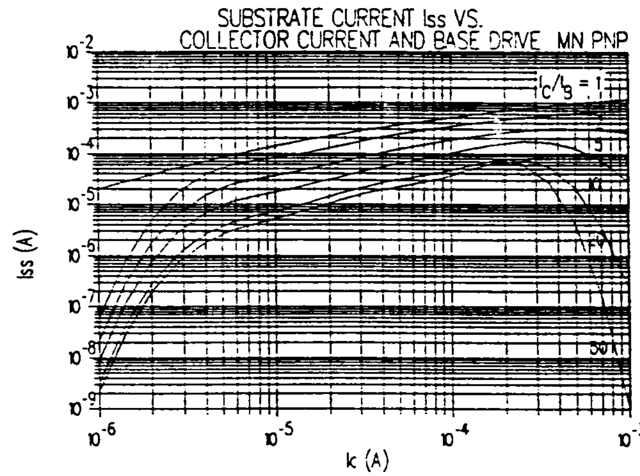

VCE = 20V
RO (hOE) VS. COLLECTOR CURRENT
MN PNP
Ro (ohms)
Ic (A)
MAX.
MIN.

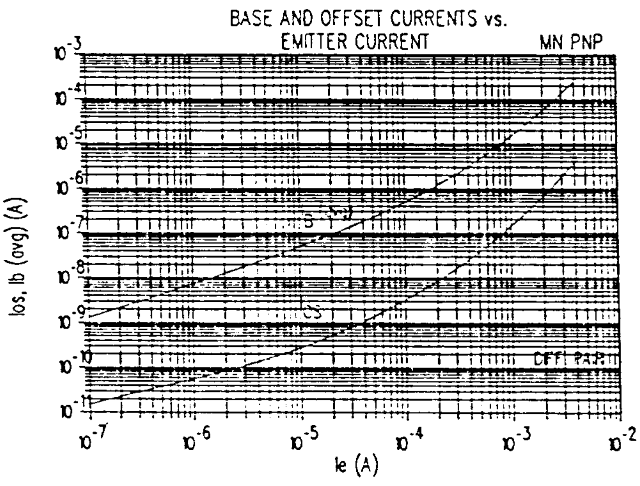

BASE-EMITTER VOLTAGE VS.
EMITTER CURRENT
MN PNP
VCE=20V
Vbe (V)
Ie (A)
MAX.
TYP.
MIN.

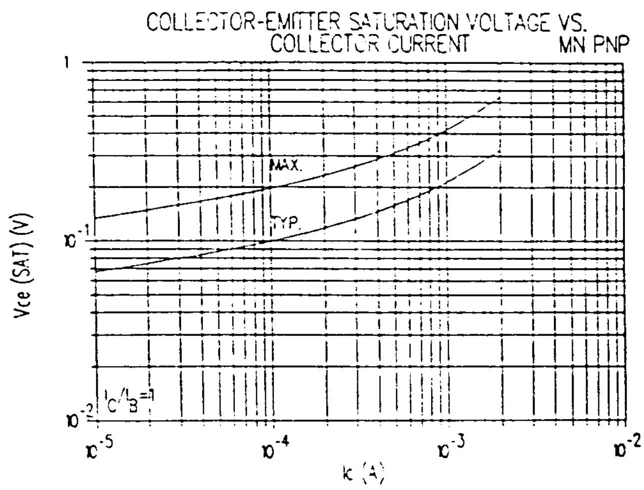

MATCHING OF BASE-EMITTER VOLTAGE VS.
EMITTER CURRENT
V_{CE}=20V
MN PNP
MAX.
1 SIGMA
MAX.
Vbe1 - Vbe2 (V)
Ie (A)

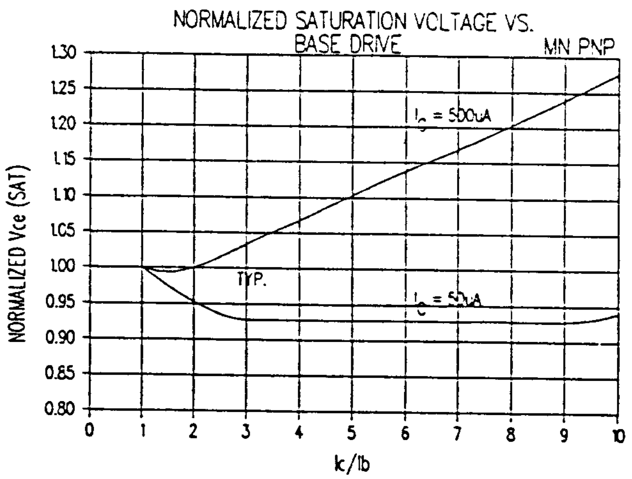

TYPICAL BASE-EMITTER VOLTAGE VS.
COLLECTOR AND BASE CURRENT
V_{CE}=20V
MN PNP
I_B
I_C
Vbe (mV)
Ic , Ib (A)

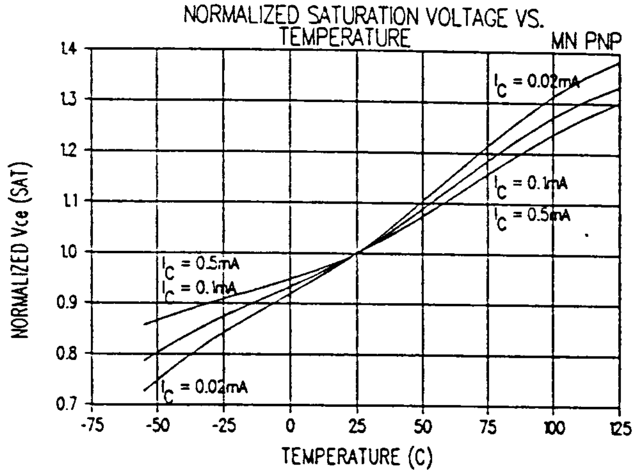

BASE-EMITTER VOLTAGE CHANGE VS.
TEMPERATURE
MN PNP
I_E=10uA
I_E=100uA
I_E=1mA
Vbe CHANGE (mV)
TEMPERATURE (C)

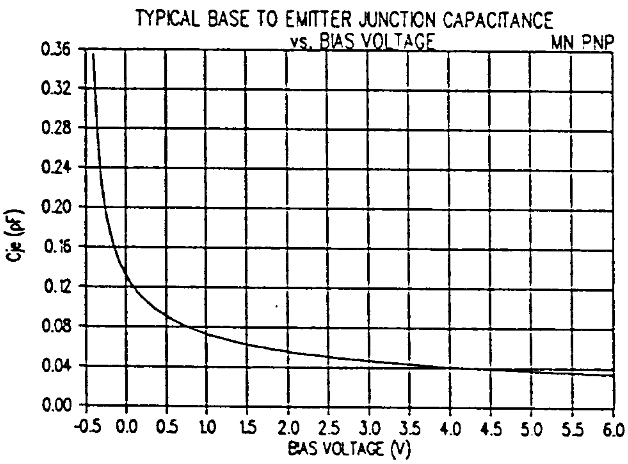

SUBSTRATE CURRENT Iss VS.
COLLECTOR CURRENT AND BASE DRIVE
MN PNP
I_C/I_B = 1
Iss (A)
Ic (A)

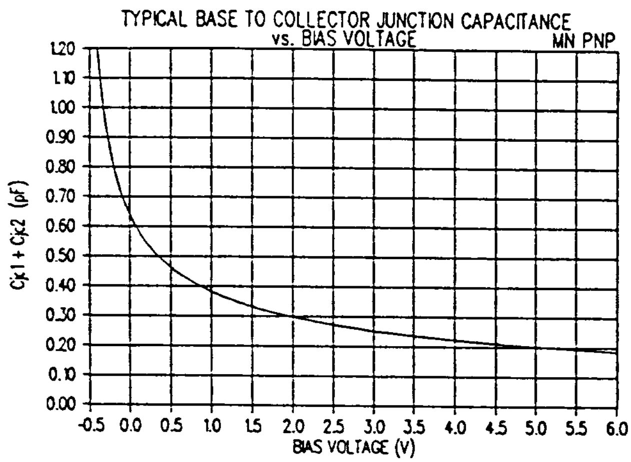

BASE AND OFFSET CURRENTS vs.
EMITTER CURRENT
MN PNP
I_{OS}
DIFF PAIR
Ios, Ib (avg) (A)
Ie (A)

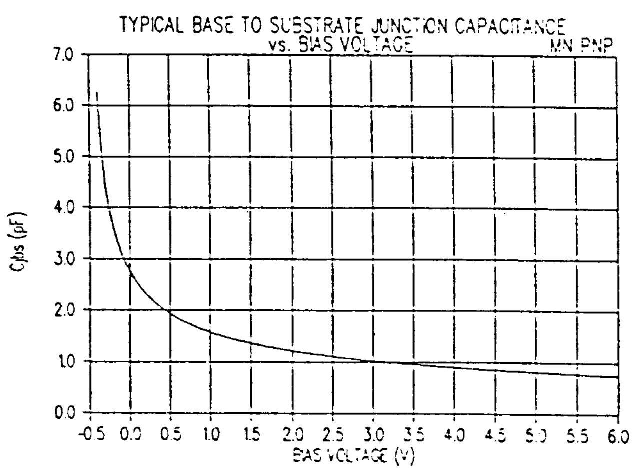

COLLECTOR-EMITTER SATURATION VOLTAGE VS.
COLLECTOR CURRENT
MN PNP
MAX.
TYP.
I_C/I_B=1
Vce (SAT) (V)
Ic (A)

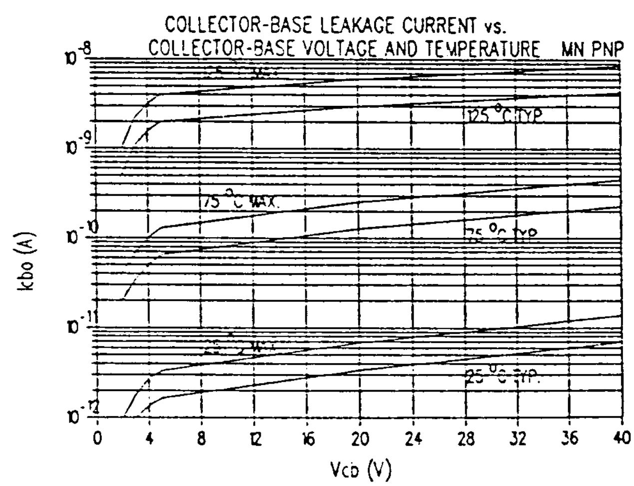

NORMALIZED SATURATION VOLTAGE VS.
BASE DRIVE
MN PNP
NORMALIZED Vce (SAT)
Ic = 500uA
TYP.
Ic = 50uA
Ic/Ib

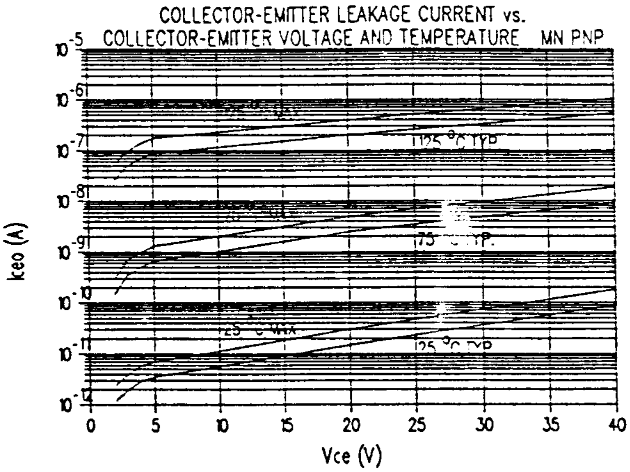

NORMALIZED SATURATION VOLTAGE VS.
TEMPERATURE
MN PNP
NORMALIZED Vce (SAT)
Ic = 0.02mA
Ic = 0.1mA
Ic = 0.5mA
Ic = 0.5mA
Ic = 0.1mA
Ic = 0.02mA
TEMPERATURE (C)

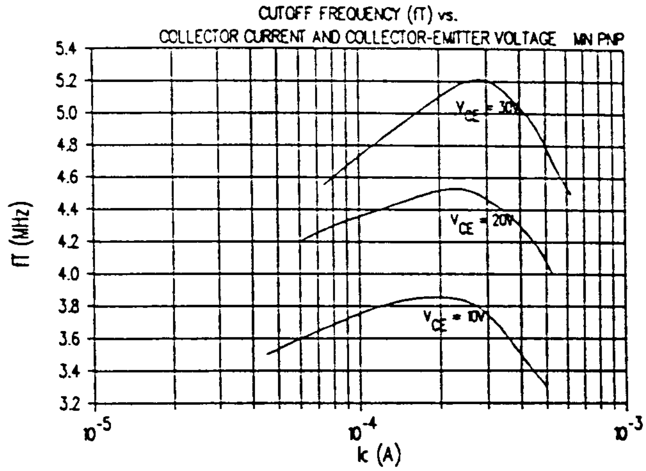

TYPICAL BASE TO EMITTER JUNCTION CAPACITANCE
vs. BIAS VOLTAGE
MN PNP
Cje (pF)
BIAS VOLTAGE (V)

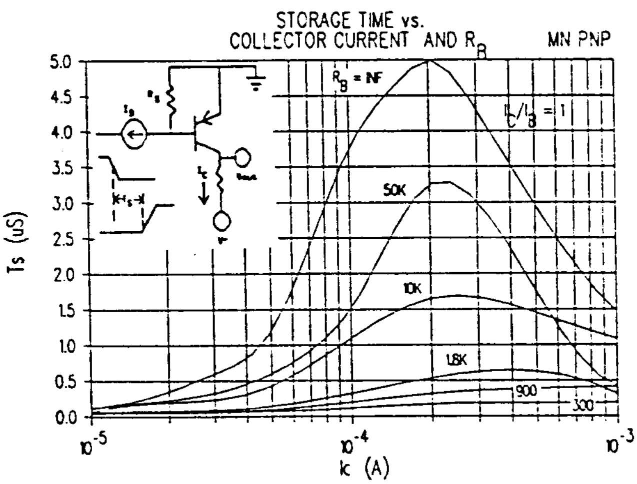

TYPICAL BASE TO COLLECTOR JUNCTION CAPACITANCE
vs. BIAS VOLTAGE
MN PNP
Cjc1 + Cjc2 (pF)
BIAS VOLTAGE (V)

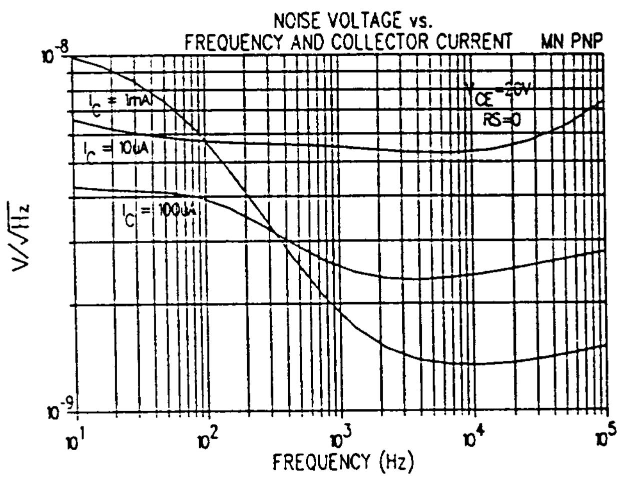

TYPICAL BASE TO SUBSTRATE JUNCTION CAPACITANCE
vs. BIAS VOLTAGE
MN PNP
Cjbs (pF)
BIAS VOLTAGE (V)

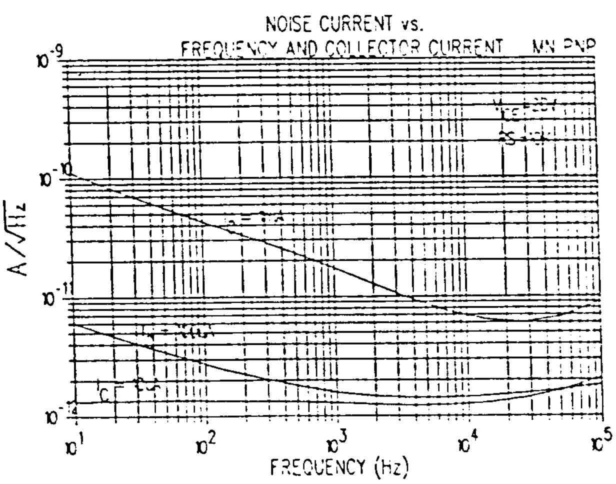

COLLECTOR-BASE LEAKAGE CURRENT vs.
COLLECTOR-BASE VOLTAGE AND TEMPERATURE MN PNP
125 °C TYP.
75 °C MAX.
Icbo (A)
Vcb (V)

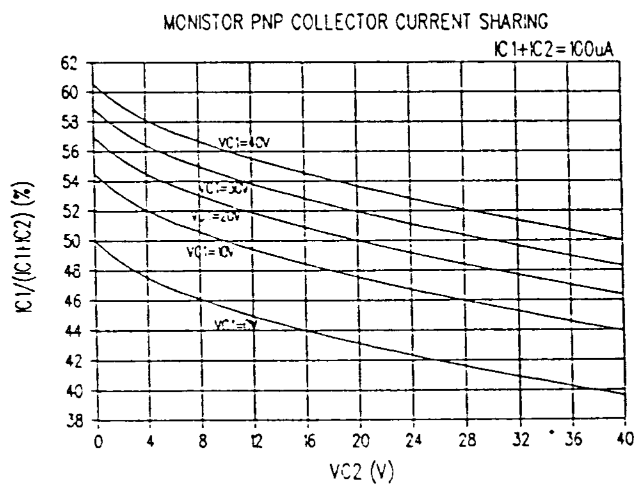

COLLECTOR-EMITTER LEAKAGE CURRENT vs.
COLLECTOR-EMITTER VOLTAGE AND TEMPERATURE MN PNP
125 °C TYP.
75 °C TYP.
25 °C MAX
125 °C TYP.
Iceo (A)
Vce (V)
0
5
10
15
20
25
30
35
40


CUTOFF FREQUENCY (fT) vs.
COLLECTOR CURRENT AND COLLECTOR-EMITTER VOLTAGE MN PNP
VCE = 30V
VCE = 20V
VCE = 10V
fT (MHz)
Ic (A)


STORAGE TIME vs.
COLLECTOR CURRENT AND RB MN PNP
RB = INF
IC/IB = 1
50K
10K
1.5K
900
300
Ts (uS)
Ic (A)

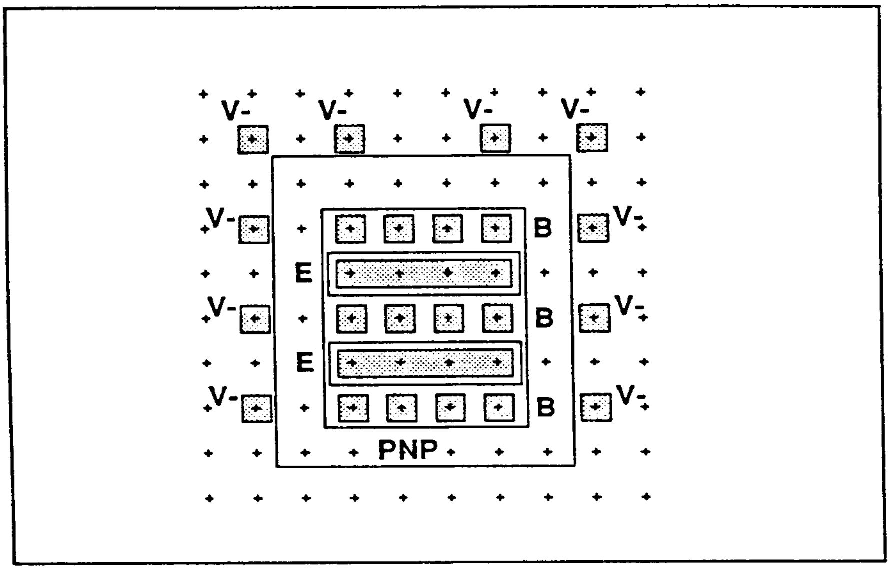

NOISE VOLTAGE vs.
FREQUENCY AND COLLECTOR CURRENT MN PNP
VCE = 20V
RS=0
IC = 1mA
IC = 10uA
IC = 100uA
V/√Hz
FREQUENCY (Hz)


NOISE CURRENT vs.
FREQUENCY AND COLLECTOR CURRENT MN PNP
A/√Hz
FREQUENCY (Hz)

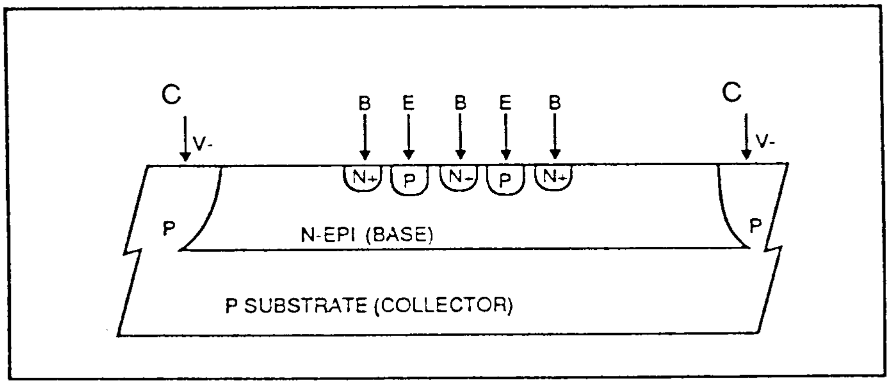

MONISTOR PNP COLLECTOR CURRENT SHARING
IC1+IC2=100uA
VC1=40V
VC1=30V
VC1=20V
VC1=10V
VC1=1V
IC1/(IC1+IC2) (%)
VC2 (V)

THE MV VERTICAL

The vertical PNP transistor, or "substrate PNP", is a peripheral component providing gain at higher current levels. Because the substrate serves as the collector of this device, its use is limited to situations in which the collector is connected to the negative-most power supply voltage (V-). Contact to the substrate collector is made through the "V-" contacts which surround the vertical PNP. There are two emitters, and one base region with multiple contacts. The emitter-base breakdown voltage is comparable to that of the NPN transistors, between 6.7 and 7.7 volts.



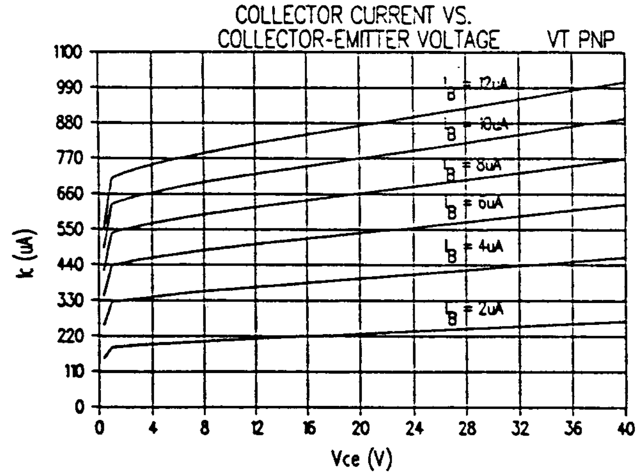
MV VERTICAL PNP TRANSISTOR ("VT PNP")

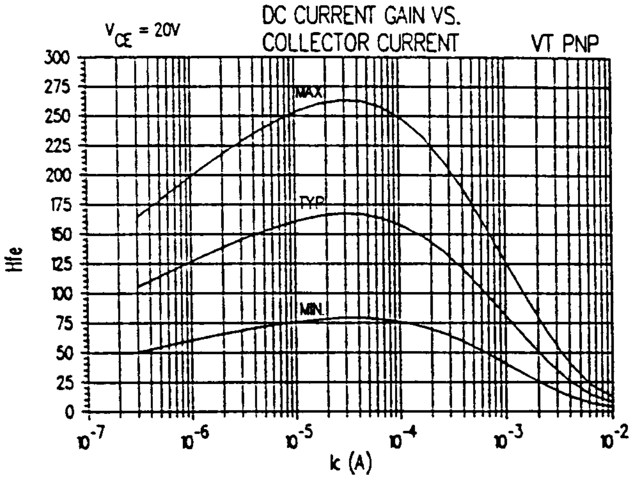


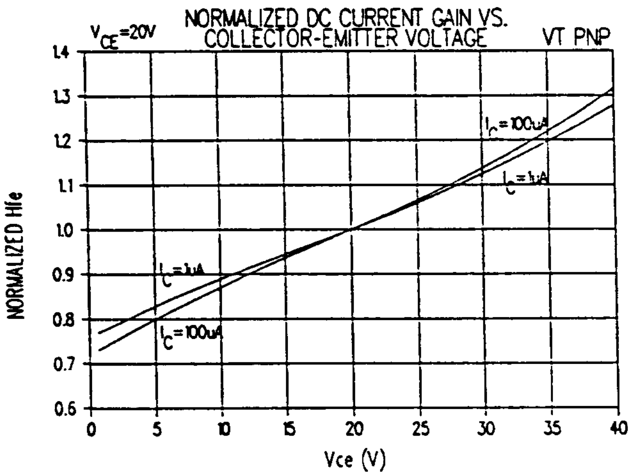
MV VERTICAL PNP TRANSISTOR CROSS SECTION

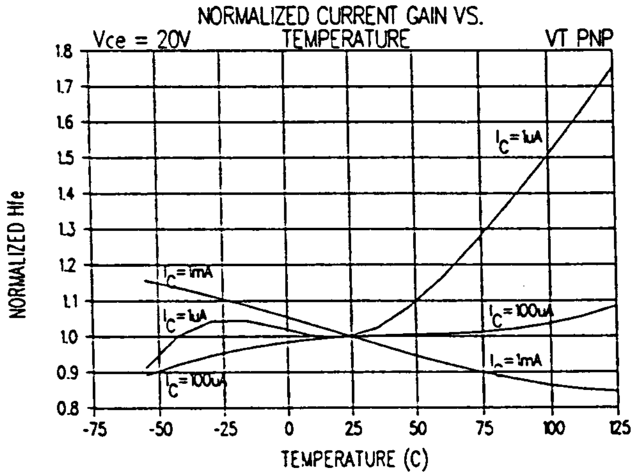
ELECTRICAL CHARACTERISTICS (T_A = +25°C) 1X NPN

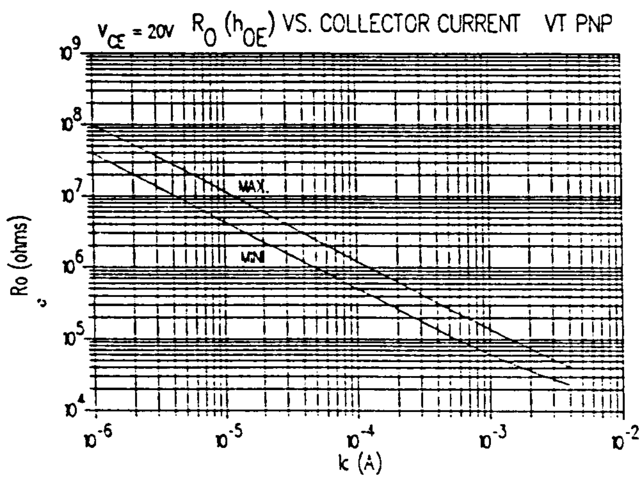
PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNITS
Forward Current Gain	ßF	VCE=-20V, IC=-100µA	75		400	
Reverse Saturation Current	IS			2.8×10^{-14}		A
Base Emitter Voltage	VBE	VCE=20V, IE=100µA	0.55			V
Collector-Emitter Saturation Voltage	VCE(SAT)	IC=1mA, IB=1µA				V
Emitter-Base Breakdown Voltage	BVEBO	IE=50µA	6.7		0.73	V
Collector-Emitter Breakdown Voltage	BVCEO	IC=10µA	50			V
Collector-Base Breakdown Voltage	BVCBO	IC=100µA	80		0.2	V
Collector-Emitter Leakage Current	ICEO	VCE=40V		70	7.7	pA
Collector-Base Leakage Current	ICBO	VCB=40V		7		pA
Collector Resistance	RC	IC=0.2mA, IB=1mA		15		Ω
Emitter Resistance	RE	IE=5mA		8		Ω
Base Resistance	RB	IC=1mA		100		Ω
Early Voltage	VA	VCE=20V, IC=100µA		70		V
Current Gain Bandwidth Product	fT	VCE=20V, IC=1mA		13		MHz
Forward Transit Time	TF	VCE=20V, IC=1mA		17		nSec
Base Emitter Capacitance	CBEO	VBIAS=0V		1.2		pF
Collector-Base Capacitance	CCBO	VBIAS=0V		1.1		pF

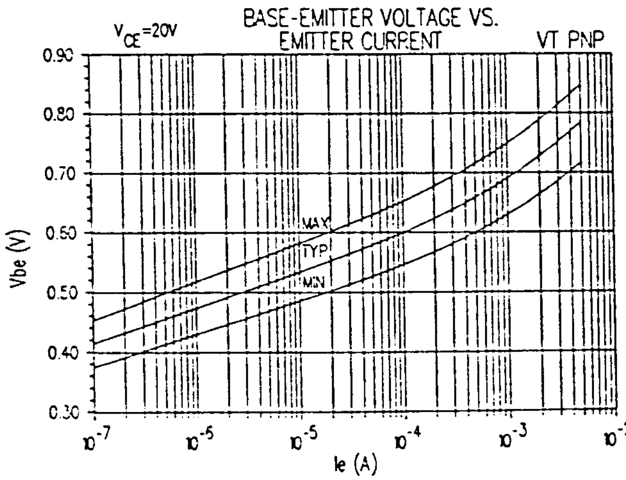

COLLECTOR CURRENT VS.
COLLECTOR-EMITTER VOLTAGE
VT PNP
Ic (uA)
Vce (V)
IB = 12uA
IB = 10uA
IB = 8uA
IB = 6uA
IB = 4uA
IB = 2uA

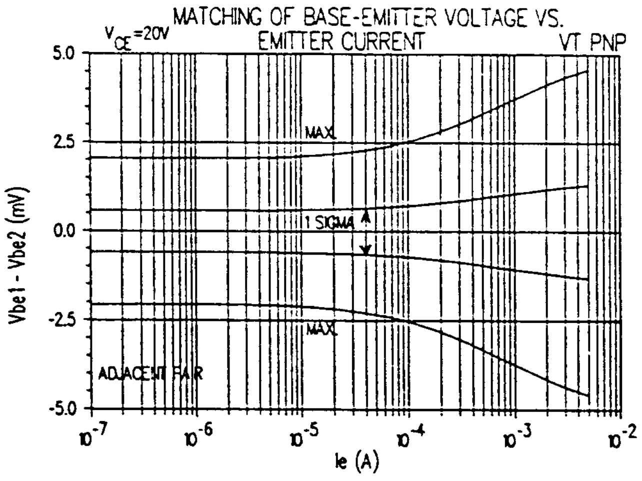

VCE = 20V
DC CURRENT GAIN VS.
COLLECTOR CURRENT
VT PNP
Hfe
Ic (A)
MAX
TYP
MIN

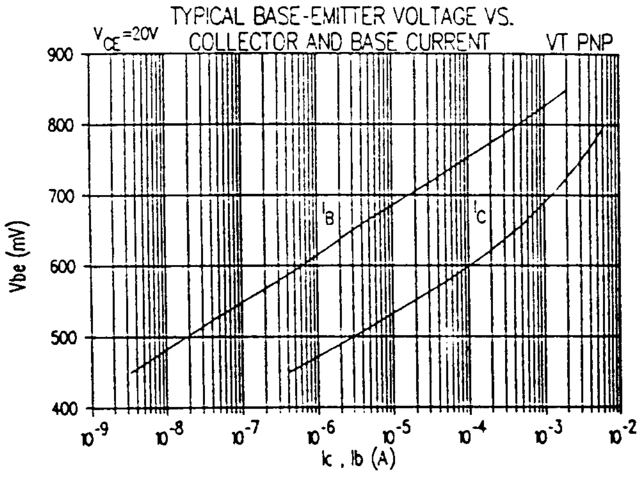

VCE=20V
NORMALIZED DC CURRENT GAIN VS.
COLLECTOR-EMITTER VOLTAGE
VT PNP
NORMALIZED Hfe
Vce (V)
IC=100uA
IC=1uA

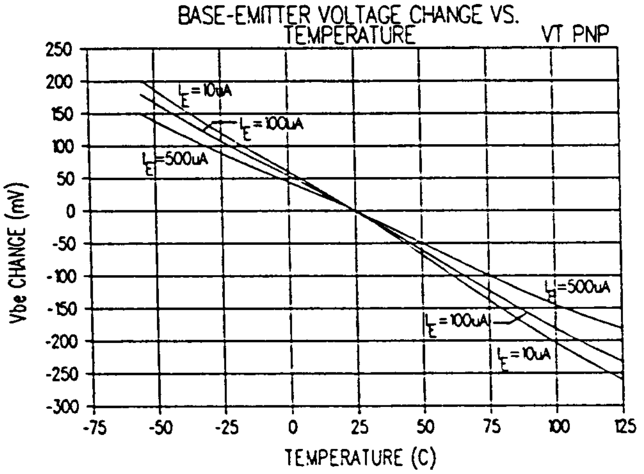

Vce = 20V
NORMALIZED CURRENT GAIN VS.
TEMPERATURE
VT PNP
NORMALIZED Hfe
TEMPERATURE (C)
IC=1uA
IC=1mA
IC=100uA

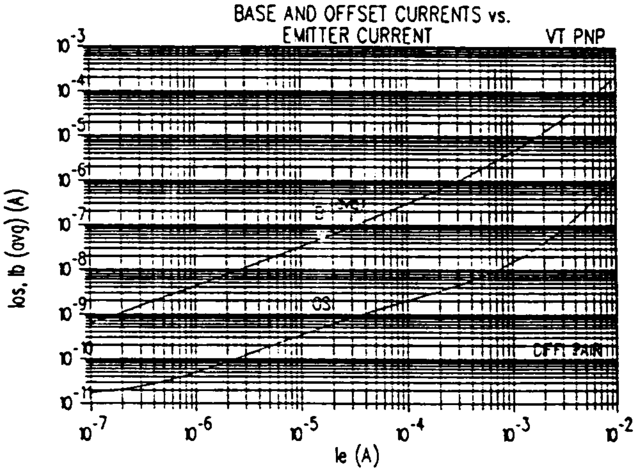

VCE = 20V
RO (hOE) VS. COLLECTOR CURRENT
VT PNP
Ro (ohms)
Ic (A)
MAX.
MIN

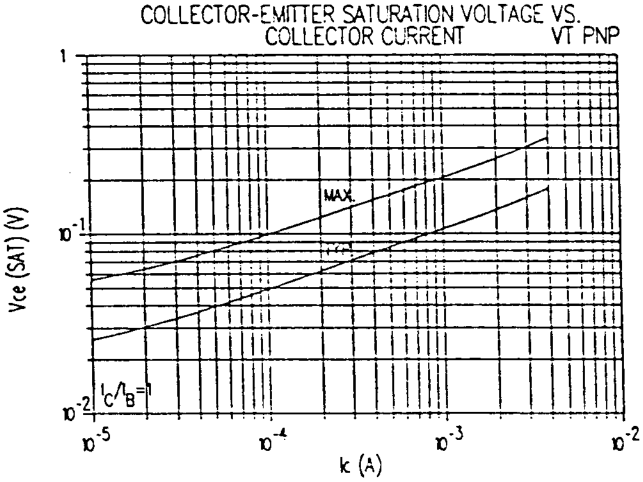

VCE=20V
BASE-EMITTER VOLTAGE VS.
EMITTER CURRENT
VT PNP
Vbe (V)
Ie (A)
MAX
TYP
MIN

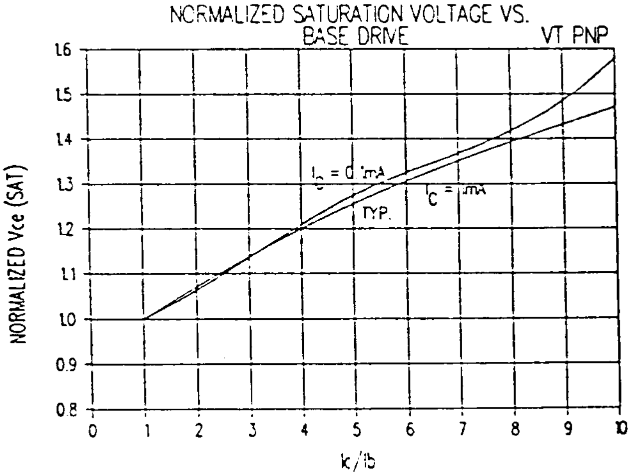

MATCHING OF BASE-EMITTER VOLTAGE VS. EMITTER CURRENT
VT PNP
V_CE=20V
MAX
1 SIGMA
MAX
ADJACENT PAIR
Vbe1 - Vbe2 (mV)
Ie (A)

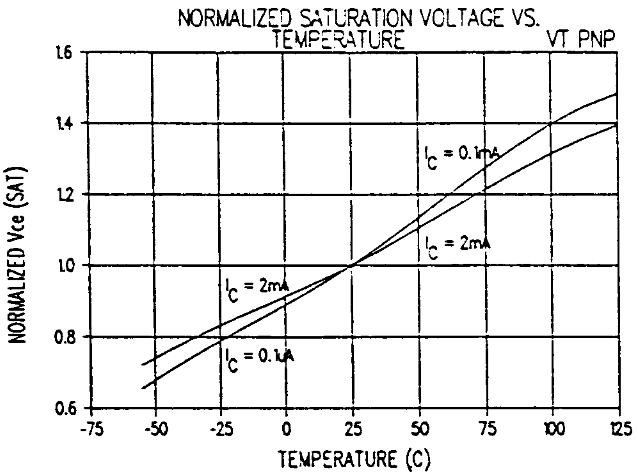

TYPICAL BASE-EMITTER VOLTAGE VS. COLLECTOR AND BASE CURRENT
VT PNP
V_CE=20V
Vbe (mV)
Ic , Ib (A)

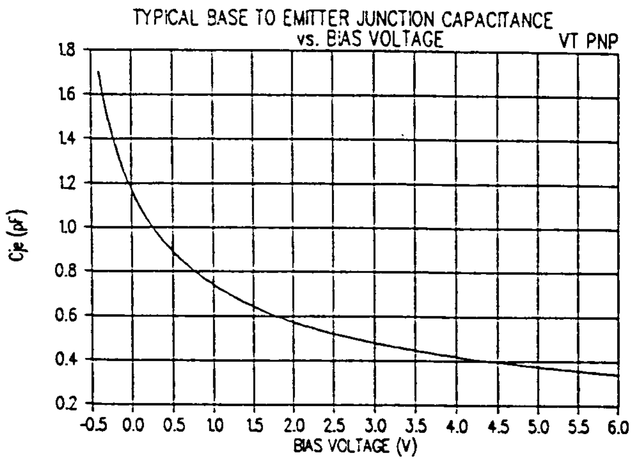

BASE-EMITTER VOLTAGE CHANGE VS. TEMPERATURE
VT PNP
I_E=10uA
I_E=100uA
I_E=500uA
Vbe CHANGE (mV)
TEMPERATURE (C)

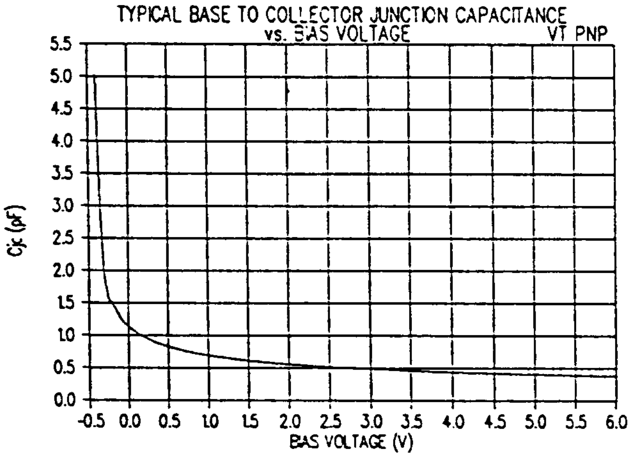

BASE AND OFFSET CURRENTS vs. EMITTER CURRENT
VT PNP
OSI
DIFF PAIR
Ios, Ib (avg) (A)
Ie (A)

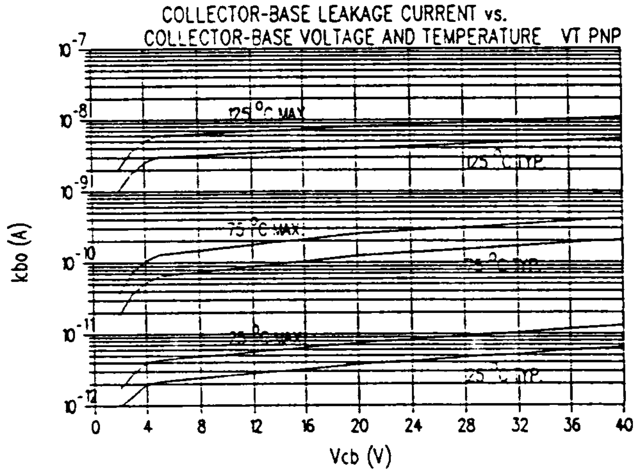

COLLECTOR-EMITTER SATURATION VOLTAGE VS. COLLECTOR CURRENT
VT PNP
MAX.
I_C/I_B=1
Vce (SAT) (V)
Ic (A)

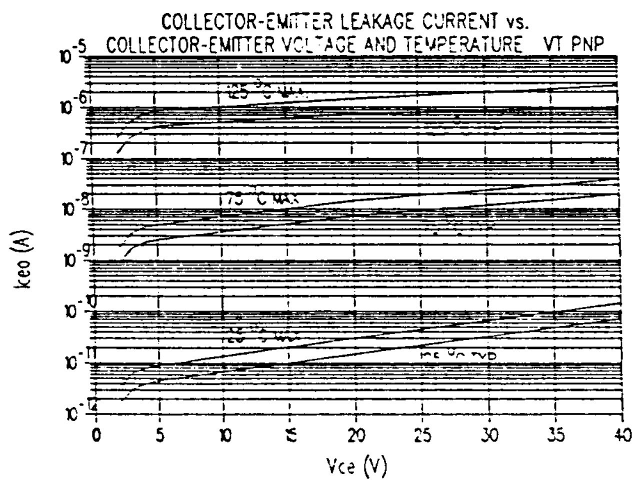

NORMALIZED SATURATION VOLTAGE VS. BASE DRIVE
VT PNP
TYP.
NORMALIZED Vce (SAT)
Ic/Ib

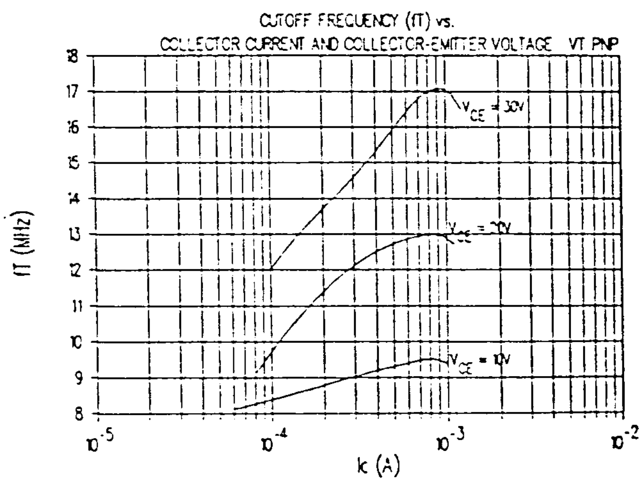

NORMALIZED SATURATION VOLTAGE VS. TEMPERATURE
VT PNP
NORMALIZED Vce (SAT)
TEMPERATURE (C)

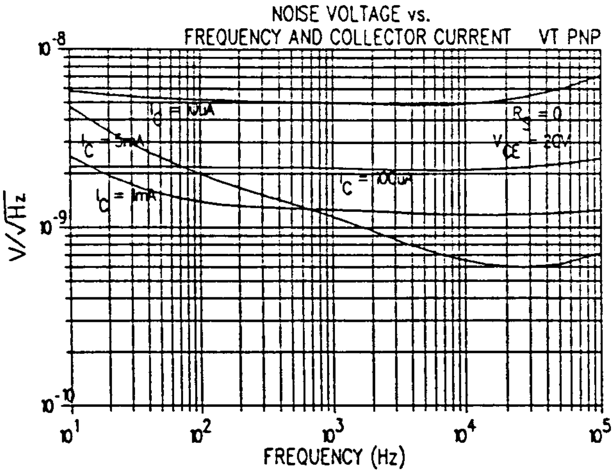

TYPICAL BASE TO EMITTER JUNCTION CAPACITANCE vs. BIAS VOLTAGE
VT PNP
Cje (pF)
BIAS VOLTAGE (V)

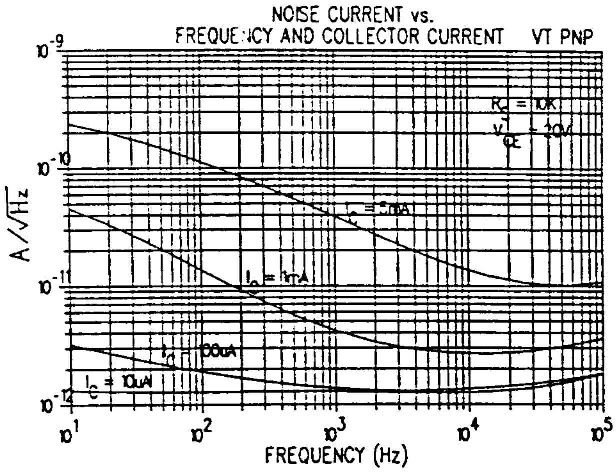

TYPICAL BASE TO COLLECTOR JUNCTION CAPACITANCE vs. BIAS VOLTAGE
VT PNP
Cjc (pF)
BIAS VOLTAGE (V)


COLLECTOR-BASE LEAKAGE CURRENT vs. COLLECTOR-BASE VOLTAGE AND TEMPERATURE
VT PNP
Icbo (A)
Vcb (V)


COLLECTOR-EMITTER LEAKAGE CURRENT vs. COLLECTOR-EMITTER VOLTAGE AND TEMPERATURE
VT PNP
Iceo (A)
Vce (V)


CUTOFF FREQUENCY (fT) vs. COLLECTOR CURRENT AND COLLECTOR-EMITTER VOLTAGE
VT PNP
fT (MHz)
Ic (A)


NOISE VOLTAGE vs.
FREQUENCY AND COLLECTOR CURRENT VT PNP
V/√Hz
FREQUENCY (Hz)
R_S = 0
V_CE = 20V
I_C = 5mA
I_C = 1mA
I_C = 100uA


NOISE CURRENT vs.
FREQUENCY AND COLLECTOR CURRENT VT PNP
A/√Hz
FREQUENCY (Hz)
R_S = 10K
V_CE = 20V
I_C = 5mA
I_C = 1mA
I_C = 100uA
I_C = 10uA