CA3096, CA3096A, CA3096C

December 1997

NPN/PNP Transistor Arrays

Applications

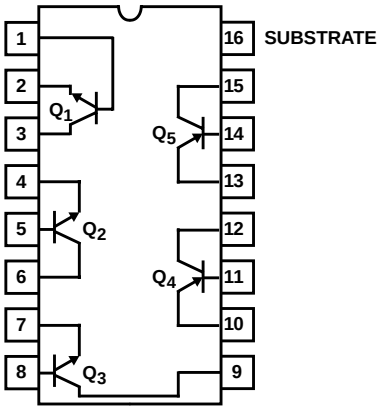
- **Five-Independent Transistors**
  - **Three NPN and**
  - **Two PNP**
- **Differential Amplifiers**
- **DC Amplifiers**
- **Sense Amplifiers**
- **Level Shifters**
- **Timers**
- **Lamp and Relay Drivers**
- **Thyristor Firing Circuits**
- **Temperature Compensated Amplifiers**
- **Operational Amplifiers**

Ordering Information

PART NUMBER (BRAND)	TEMP. RANGE (^{O}C)	PACKAGE	PKG. NO.
CA3096AE	-55 to 125	16 Ld PDIP	E16.3
CA3096AM (3096A)	-55 to 125	16 Ld SOIC	M16.15
CA3096AM96 (3096A)	-55 to 125	16 Ld SOIC Tape and Reel	M16.15
CA3096CE	-55 to 125	16 Ld PDIP	E16.3
CA3096E	-55 to 125	16 Ld PDIP	E16.3
CA3096M (3096)	-55 to 125	16 Ld SOIC	M16.15
CA3096M96 (3096)	-55 to 125	16 Ld SOIC Tape and Reel	M16.15

Pinout

CA3096, CA3096A, CA3096C
(PDIP, SOIC)
TOP VIEW



Description

The CA3096C, CA3096, and CA3096A are general purpose high voltage silicon transistor arrays. Each array consists of five independent transistors (two PNP and three NPN types) on a common substrate, which has a separate connection. Independent connections for each transistor permit maximum flexibility in circuit design.

Types CA3096A, CA3096, and CA3096C are identical, except that the CA3096A specifications include parameter matching and greater stringency in I_{CBO}, I_{CEO}, and V_{CE}(SAT). The CA3096C is a relaxed version of the CA3096.

CA3096, CA3096A, CA3096C Essential Differences

CHARACTERISTIC		CA3096A	CA3096	CA3096C
$V_{(BR)CEO}$ (V) (Min)				
	NPN	35	35	24
	PNP	-40	-40	-24
$V_{(BR)CBO}$ (V) (Min)				
	NPN	45	45	30
	PNP	-40	-40	-24
h_{FE} at 1mA				
	NPN	150-500	150-500	100-670
	PNP	20-200	20-200	15-200
h_{FE} at 100µA				
	PNP	40-250	40-250	30-300
I_{CBO} (nA) (Max)				
	NPN	40	100	100
	PNP	-40	-100	-100
I_{CEO} (nA) (Max)				
	NPN	100	1000	1000
	PNP	-100	-1000	-1000
$V_{CE\ SAT}$ (V) (Max)				
	NPN	0.5	0.7	0.7
$\|V_{IO}\|$ (mV) (Max)				
	NPN	5	-	-
	PNP	5	-	-
$\|I_{IO}\|$ (µA) (Max)				
	NPN	0.6	-	-
	PNP	0.25	-	-

CAUTION: These devices are sensitive to electrostatic discharge; follow proper IC Handling Procedures.
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Absolute Maximum Ratings

	NPN	PNP
Collector-to-Emitter Voltage, V_{CEO}		
CA3096, CA3096A	35V	-40V
CA3096C	24V	-24V
Collector-to-Base Voltage, V_{CBO}		
CA3096, CA3096A	45V	-40V
CA3096C	30V	-24V
Collector-to-Substrate Voltage, V_{CIO} (Note 1)		
CA3096, CA3096A	45V	-
CA3096C	30V	-
Emitter-to-Substrate Voltage, V_{EIO}		
CA3096, CA3096A	-	-40V
CA3096C	-	-24V
Emitter-to-Base Voltage, V_{EBO}		
CA3096, CA3096A	6V	-40V
CA3096C	6V	-24V
Collector Current, I_C (All Types)	50mA	-10mA

Operating Conditions

Temperature Range . . . . . -55^{o}C to 125^{o}C

Thermal Information

Thermal Resistance (Typical, Note 2)	θ_{JA} (^{o}C/W)
PDIP Package	90
SOIC Package	125

Maximum Power Dissipation (Each Transistor, Note 3) 200mW
Maximum Junction Temperature (Plastic Package) . . . . . 150^{o}C
Maximum Storage Temperature Range . . . . . -65^{o}C to 150^{o}C
Maximum Lead Temperature (Soldering 10s) . . . . . 300^{o}C
(SOIC - Lead Tips Only)

CAUTION: Stresses above those listed in "Absolute Maximum Ratings" may cause permanent damage to the device. This is a stress only rating and operation of the device at these or any other conditions above those indicated in the operational sections of this specification is not implied.

NOTES:

1. The collector of each transistor of the CA3096 is isolated from the substrate by an integral diode. The substrate (Terminal 16) must be connected to the most negative point in the external circuit to maintain isolation between transistors and to provide for normal transistor action.
2. θ_{JA} is measured with the component mounted on an evaluation PC board in free air.
3. Care must be taken to avoid exceeding the maximum junction temperature. Use the total power dissipation (all transistors) and thermal resistances to calculate the junction temperature.

Electrical Specifications For Equipment Design, At T_A = 25^{o}C

PARAMETER	TEST CONDITIONS	CA3096			CA3096A			CA3096C			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	
DC CHARACTERISTICS FOR EACH NPN TRANSISTOR											
I_{CBO}	V_{CB} = 10V, I_E = 0	-	0.001	100	-	0.001	40	-	0.001	100	nA
I_{CEO}	V_{CE} = 10V, I_B = 0	-	0.006	1000	-	0.006	100	-	0.006	1000	nA
$V_{(BR)CEO}$	I_C = 1mA, I_B = 0	35	50	-	35	50	-	24	35	-	V
$V_{(BR)CBO}$	I_C = 10µA, I_E = 0	45	100	-	45	100	-	30	80	-	V
$V_{(BR)CIO}$	I_{CI} = 10µA, $I_B = I_E$ = 0	45	100	-	45	100	-	30	80	-	V
$V_{(BR)EBO}$	I_E = 10µA, I_C = 0	6	8	-	6	8	-	6	8	-	V
V_Z	I_Z = 10µA	6	7.9	9.8	6	7.9	9.8	6	7.9	9.8	V
$V_{CE\ SAT}$	I_C = 10mA, I_B = 1mA	-	0.24	0.7	-	0.24	0.5	-	0.24	0.7	V
V_{BE} (Note 4)	I_C = 1mA, V_{CE} = 5V	0.6	0.69	0.78	0.6	0.69	0.78	0.6	0.69	0.78	V
h_{FE} (Note 4)		150	390	500	150	390	500	100	390	670	
$\lvert\Delta V_{BE}/\Delta T\rvert$ (Note 4)	I_C = 1mA, V_{CE} = 5V	-	1.9	-	-	1.9	-	-	1.9	-	mV/^{o}C
DC CHARACTERISTICS FOR EACH PNP TRANSISTOR											
I_{CBO}	V_{CB} = -10V, I_E = 0	-	-0.06	-100	-	-0.006	-40	-	-0.06	-100	nA

Electrical Specifications For Equipment Design, At $T_A = 25^oC$ **(Continued)**

PARAMETER	TEST CONDITIONS	CA3096			CA3096A			CA3096C			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	
I_{CEO}	V_{CE} = -10V, I_B = 0	-	-0.12	-1000	-	-0.12	-100	-	-0.12	-1000	nA
$V_{(BR)CEO}$	I_C = -100µA, I_B = 0	-40	-75	-	-40	-75	-	-24	-30	-	V
$V_{(BR)CBO}$	I_C = -10µA, I_E = 0	-40	-80	-	-40	-80	-	-24	-60	-	V
$V_{(BR)EBO}$	I_E = -10µA, I_C = 0	-40	-100	-	-40	-100	-	-24	-80	-	V
$V_{(BR)EIO}$	I_{EI} = 10µA, $I_B = I_C$ = 0	40	100	-	40	100	-	24	80	-	V
$V_{CE\ SAT}$	I_C = -1mA, I_B = -100µA	-	-0.16	-0.4	-	-0.16	-0.4	-	-0.16	-0.4	V
V_{BE} (Note 4)	I_C = -100µA, V_{CE} = -5V	-0.5	-0.6	-0.7	-0.5	-0.6	-0.7	-0.5	-0.6	-0.7	V
h_{FE} (Note 4)	I_C = -100µA, V_{CE} = -5V	40	85	250	40	85	250	30	85	300	
	I_C = -1mA, V_{CE} = -5V	20	47	200	20	47	200	15	47	200	
$\|\Delta V_{BE}/\Delta T\|$ (Note 4)	I_C = -100µA, V_{CE} = -5V	-	2.2	-	-	2.2	-	-	2.2	-	$mV/^oC$

I_{CBO} Collector-Cutoff Current

I_{CEO} Collector-Cutoff Current

$V_{(BR)CEO}$ Collector-to-Emitter Breakdown Voltage

$V_{(BR)CBO}$ Collector-to-Base Breakdown Voltage

$V_{(BR)CIO}$ Collector-to-Substrate Breakdown Voltage

$V_{(BR)EBO}$ Emitter-to-Base Breakdown Voltage

V_Z Emitter-to-Base Zener Voltage

$V_{CE\ SAT}$ Collector-to-Emitter Saturation Voltage

V_{BE} Base-to-Emitter Voltage

h_{FE} DC Forward-Current Transfer Ratio

$|\Delta V_{BE}/\Delta T|$ Magnitude of Temperature Coefficient: (for each transistor)

NOTE:

4. Actual forcing current is via the emitter for this test.

Electrical Specifications For Equipment Design At $T_A = 25^oC$ (CA3096A Only)

PARAMETER	SYMBOL	TEST CONDITIONS	CA3096A			UNITS
			MIN	TYP	MAX	
FOR TRANSISTORS Q_1 AND Q_2 (AS A DIFFERENTIAL AMPLIFIER)						
Absolute Input Offset Voltage	$\|V_{IO}\|$	V_{CE} = 5V, I_C = 1mA	-	0.3	5	mV
Absolute Input Offset Current	$\|I_{IO}\|$		-	0.07	0.6	µA
Absolute Input Offset Voltage Temperature Coefficient	$\frac{\|\Delta V_{IO}\|}{\Delta T}$		-	1.1	-	$\mu V/^oC$
FOR TRANSISTORS Q_4 AND Q_5 (AS A DIFFERENTIAL AMPLIFIER)						
Absolute Input Offset Voltage	$\|V_{IO}\|$	V_{CE} = -5V, I_C = -100µA R_S = 0	-	0.15	5	mV
Absolute Input Offset Current	$\|I_{IO}\|$		-	2	250	nA
Absolute Input Offset Voltage Temperature Coefficient	$\frac{\|\Delta V_{IO}\|}{\Delta T}$		-	0.54	-	$\mu V/^oC$

Electrical Specifications

Typical Values Intended Only for Design Guidance At $T_A = 25^oC$

PARAMETER	SYMBOL	TEST CONDITIONS	TYPICAL VALUES	UNITS
DYNAMIC CHARACTERISTICS FOR EACH NPN TRANSISTOR				
Noise Figure (Low Frequency)	NF	f = 1kHz, V_{CE} = 5V, I_C = 1mA, R_S = 1kΩ	2.2	dB
Low-Frequency, Input Resistance	R_I	f = 1.0kHz, V_{CE} = 5V I_C = 1 mA	10	kΩ
Low-Frequency Output Resistance	R_O	f = 1.0kHz, V_{CE} = 5V I_C = 1 mA	80	kΩ
Admittance Characteristics				
Forward Transfer Admittance	y_{FE} g_{FE}	f = 1MHz, V_{CE} = 5V, I_C = 1mA	7.5	mS
	b_{FE}	f = 1MHz, V_{CE} = 5V, I_C = 1mA	-j13	mS
Input Admittance	y_{IE} g_{IE}	f = 1MHz, V_{CE} = 5V, I_C = 1mA	2.2	mS
	b_{IE}	f = 1MHz, V_{CE} = 5V, I_C = 1mA	j3.1	mS
Output Admittance	y_{OE} g_{OE}	f = 1MHz, V_{CE} = 5V, I_C = 1mA	0.76	mS
	b_{OE}	f = 1MHz, V_{CE} = 5V, I_C = 1mA	j2.4	mS
Gain-Bandwidth Product	f_T	V_{CE} = 5V, I_C = 1.0mA	280	MHz
		V_{CE} = 5V, I_C = 5mA	335	MHz
Emitter-To-Base Capacitance	C_{EB}	V_{EB} = 3V	0.75	pF
Collector-To-Base Capacitance	C_{CB}	V_{CB} = 3V	0.46	pF
Collector-To-Substrate Capacitance	C_{CI}	V_{CI} = 3V	3.2	pF
DYNAMIC CHARACTERISTICS FOR EACH PNP TRANSISTOR				
Noise Figure (Low Frequency)	NF	f = 1kHz, I_C = 100µA, R_S = 1kΩ	3	dB
Low-Frequency Input Resistance	R_I	f = 1kHz, V_{CE} = 5V, I_C = 100µA	27	kΩ
Low-Frequency Output Resistance	R_O	f = 1kHz, V_{CE} = 5V, I_C = 100µA	680	kΩ
Gain-Bandwidth Product	f_T	V_{CE} = 5V, I_C = 100µA	6.8	MHz
Emitter-To-Base Capacitance	C_{EB}	V_{EB} = -3V	0.85	pF
Collector-To-Base Capacitance	C_{CB}	V_{CB} = -3V	2.25	pF
Base-To-Substrate Capacitance	C_{BI}	V_{BI} = 3V	3.05	pF

Typical Applications

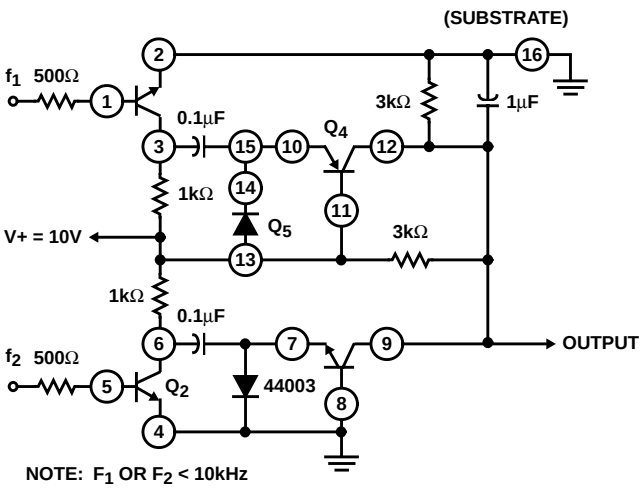


FIGURE 1. FREQUENCY COMPARATOR USING CA3096

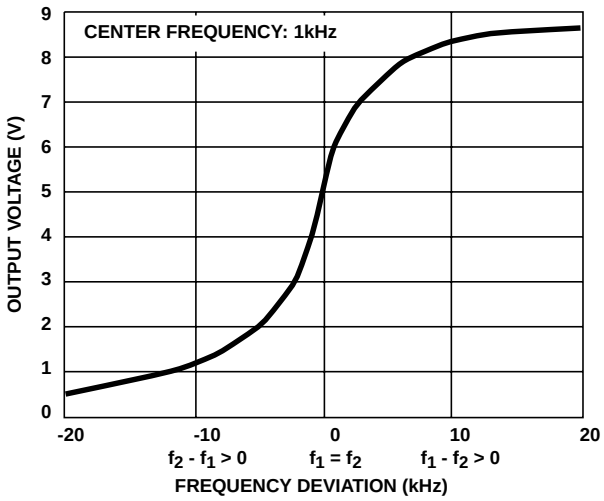


FIGURE 2. FREQUENCY COMPARATOR CHARACTERISTICS

Typical Applications (Continued)

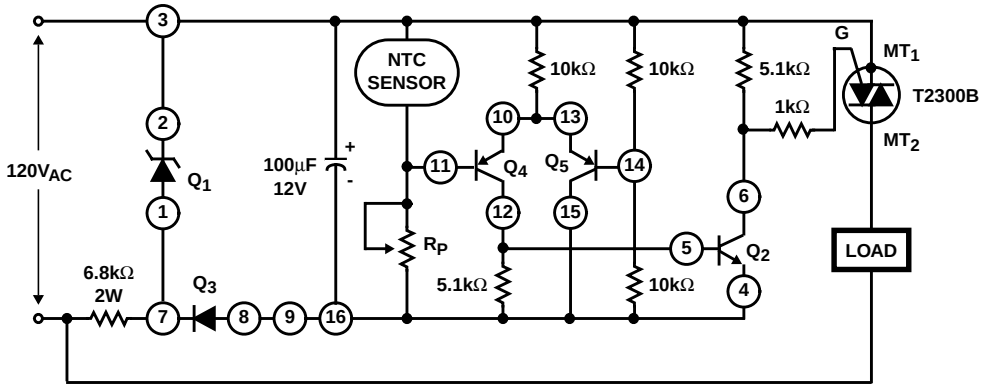


FIGURE 3. LINE-OPERATED LEVEL SWITCH USING CA3096A OR CA3096

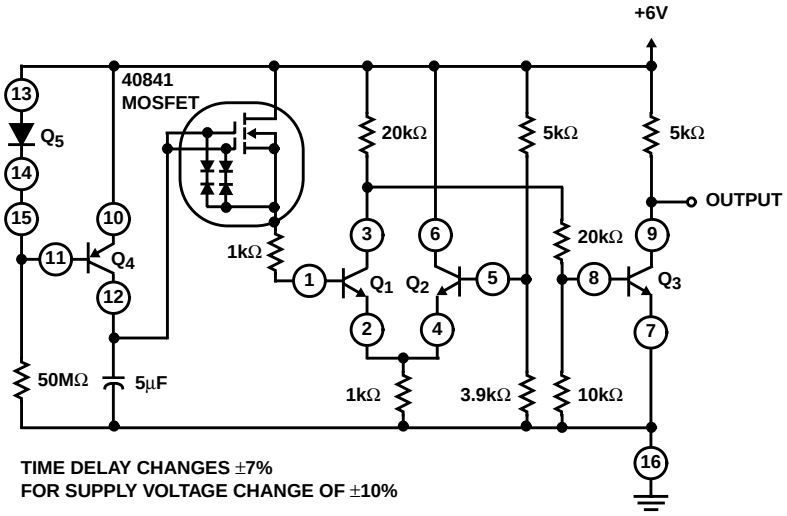
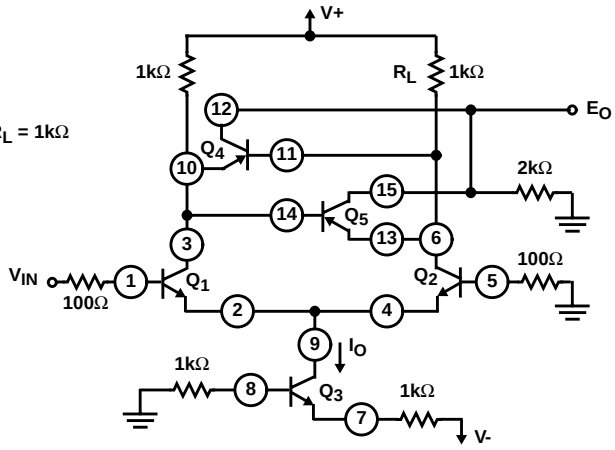


FIGURE 4. ONE-MINUTE TIMER USING CA3096A AND A MOSFET

$$V_T = \pm \frac{36}{I_O R_L}$$

IF I_O = 1mA AND R_L = 1kΩ
V_T = ± 36mV



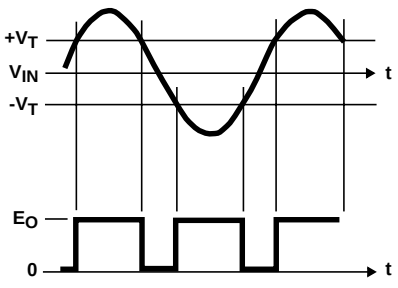


FIGURE 5. CA3096A SMALL-SIGNAL ZERO VOLTAGE DETECTOR HAVING NOISE IMMUNITY

Typical Applications (Continued)

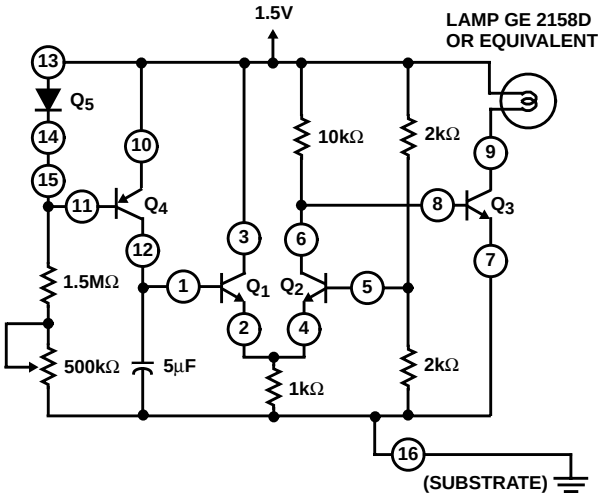
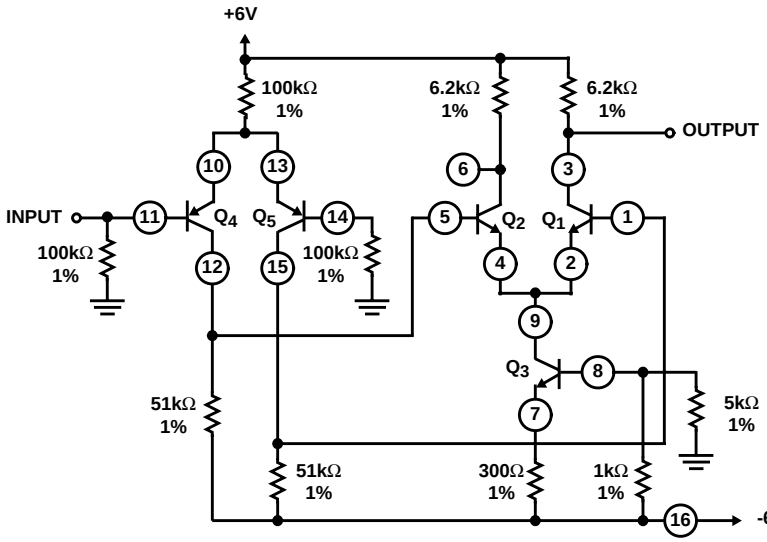


FIGURE 6. TEN-SECOND TIMER OPERATED FROM 1.5V SUPPLY USING CA3096



NOTES:

5. Can be operated with either dual supply or single supply.
6. Wide-input common mode range +5V to -5V.
7. Low bias current: <1μA.

FIGURE 7. CASCADE OF DIFFERENTIAL AMPLIFIERS USING CA3096A

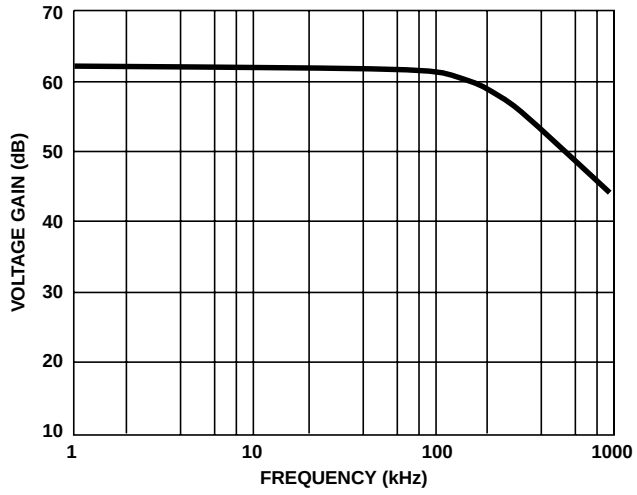


FIGURE 8. FREQUENCY RESPONSE

Typical Performance Curves

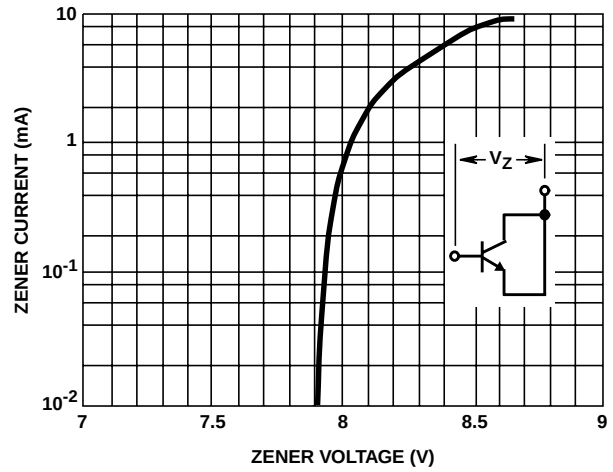


FIGURE 9. BASE-TO-EMITTER ZENER CHARACTERISTIC (NPN)

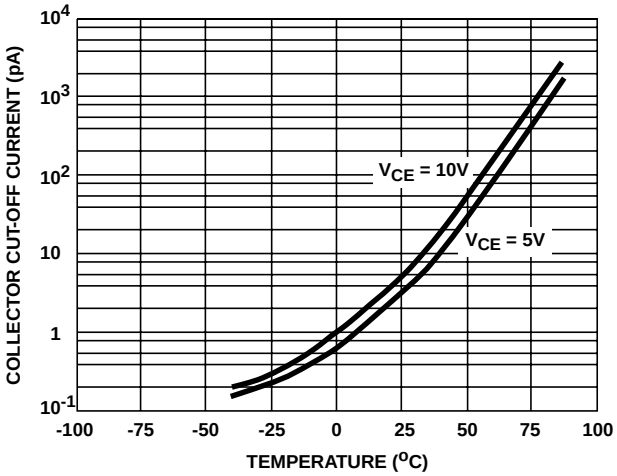


FIGURE 10. COLLECTOR CUT-OFF CURRENT (I_{CEO}) vs TEMPERATURE (NPN)

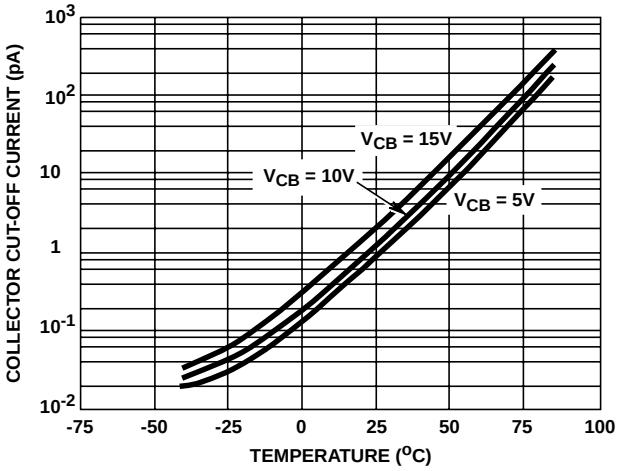


FIGURE 11. COLLECTOR CUT-OFF CURRENT (I_{CBO}) vs TEMPERATURE (NPN)

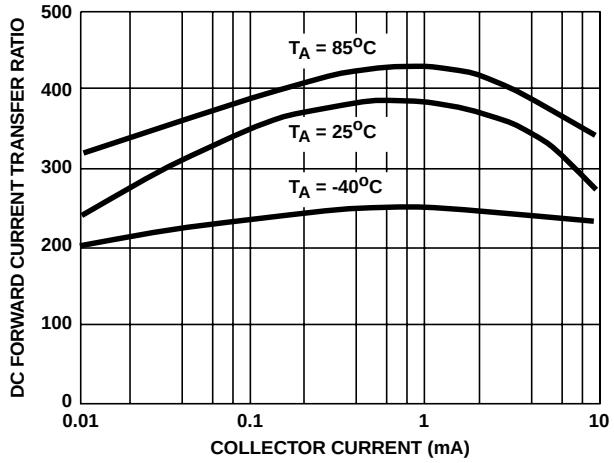


FIGURE 12. TRANSISTOR (NPN) h_{FE} vs COLLECTOR CURRENT

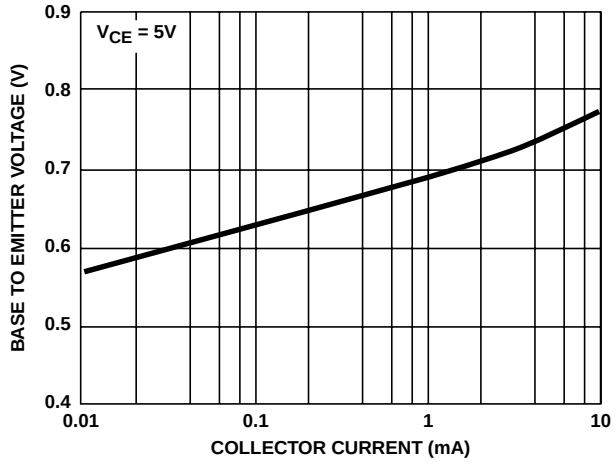


FIGURE 13. V_{BE} (NPN) vs COLLECTOR CURRENT

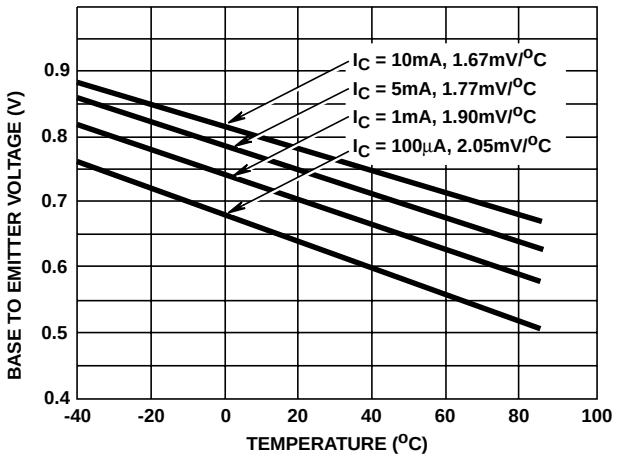


FIGURE 14. V_{BE} (NPN) vs TEMPERATURE

Typical Performance Curves (Continued)

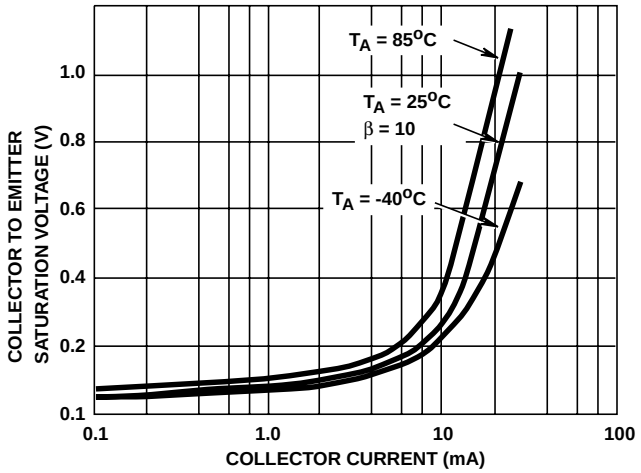


FIGURE 15. $V_{CE\ SAT}$ (NPN) vs COLLECTOR CURRENT

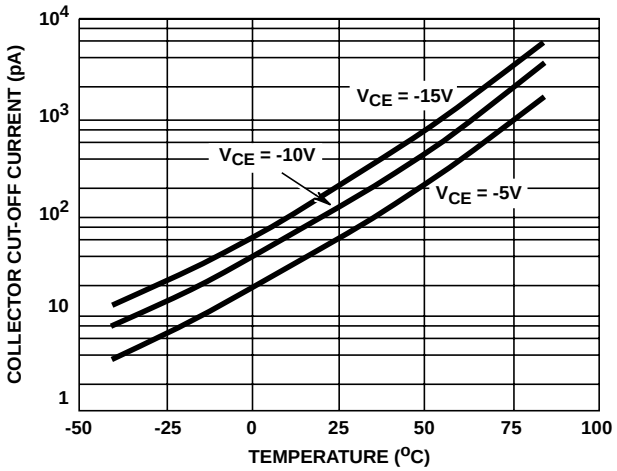


FIGURE 16. COLLECTOR CUT-OFF CURRENT (I_{CEO}) vs TEMPERATURE (PNP)

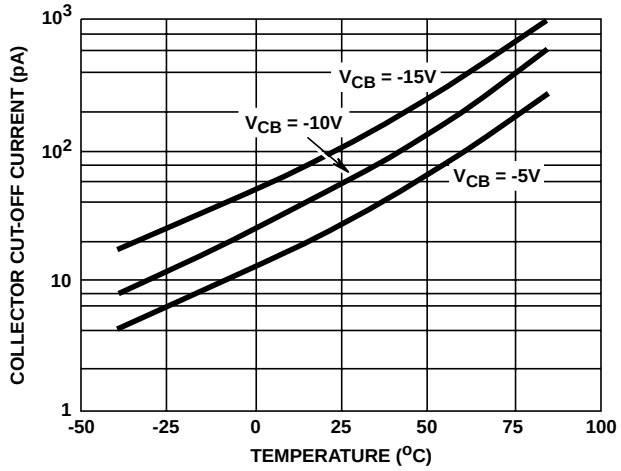


FIGURE 17. COLLECTOR CUT-OFF CURRENT (I_{CBO}) vs TEMPERATURE (PNP)

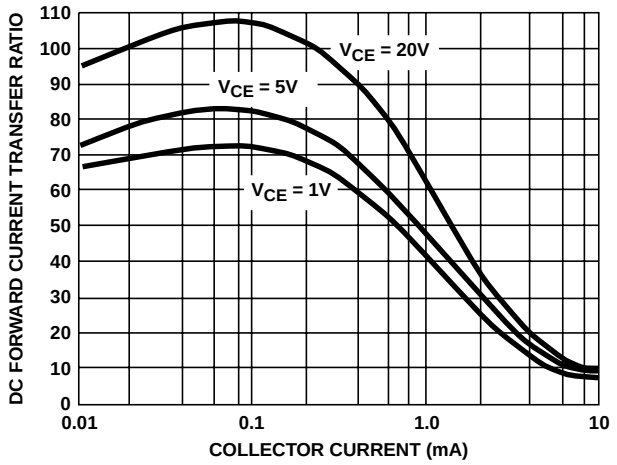


FIGURE 18. TRANSISTOR (PNP) h_{FE} vs COLLECTOR CURRENT

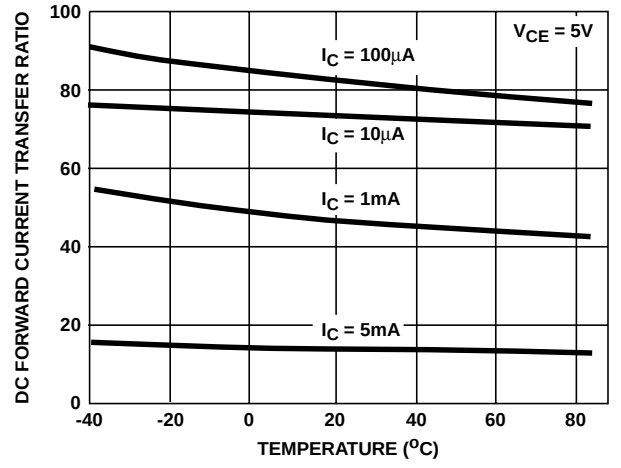


FIGURE 19. TRANSISTOR (PNP) h_{FE} vs TEMPERATURE

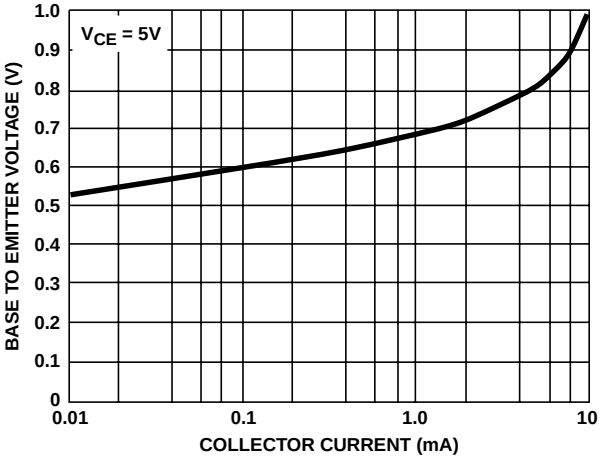


FIGURE 20. V_{BE} (PNP) vs COLLECTOR CURRENT

Typical Performance Curves (Continued)

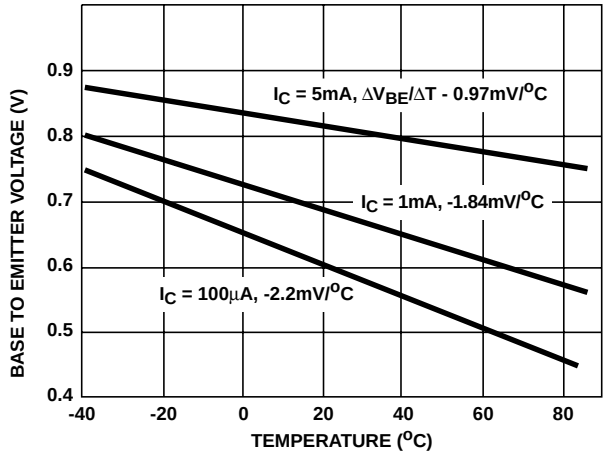


FIGURE 21. V_{BE} (PNP) vs TEMPERATURE

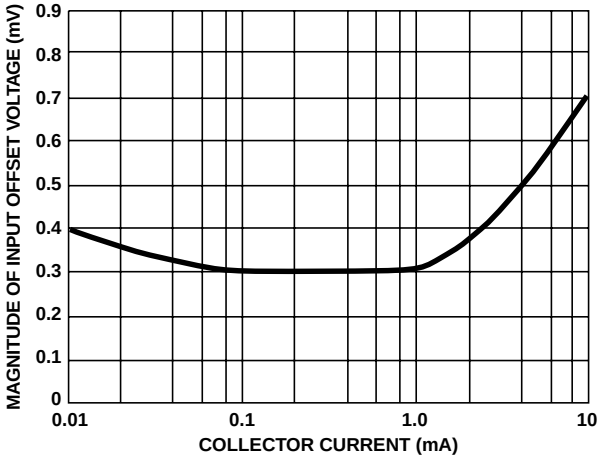


FIGURE 22. MAGNITUDE OF INPUT OFFSET VOLTAGE $|V_{IO}|$ vs COLLECTOR CURRENT FOR NPN TRANSISTOR Q_1 - Q_2

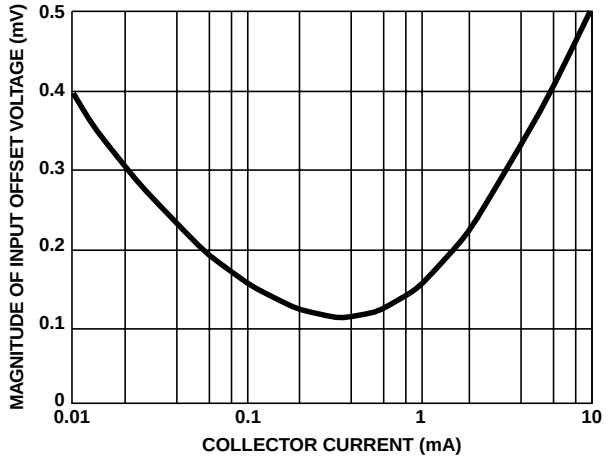


FIGURE 23. MAGNITUDE OF INPUT OFFSET VOLTAGE $|V_{IO}|$ vs COLLECTOR CURRENT FOR PNP TRANSISTOR Q_4 - Q_5

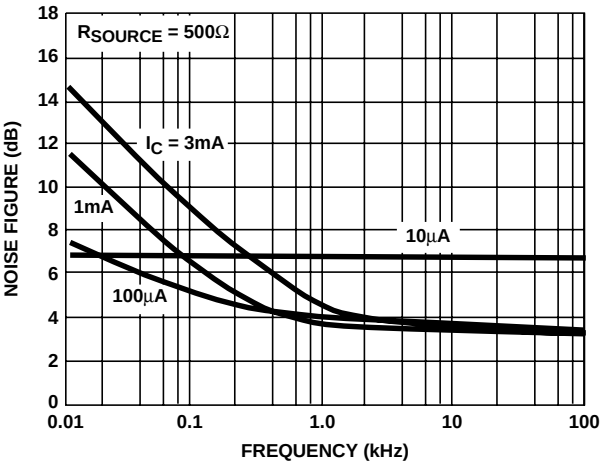


FIGURE 24. NOISE FIGURE vs FREQUENCY FOR NPN TRANSISTORS

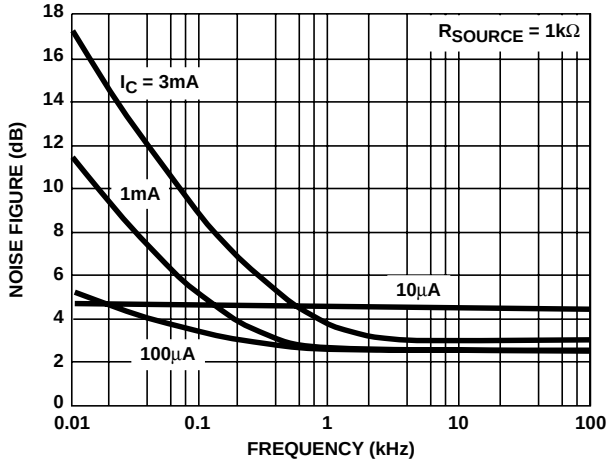


FIGURE 25. NOISE FIGURE vs FREQUENCY FOR NPN TRANSISTORS

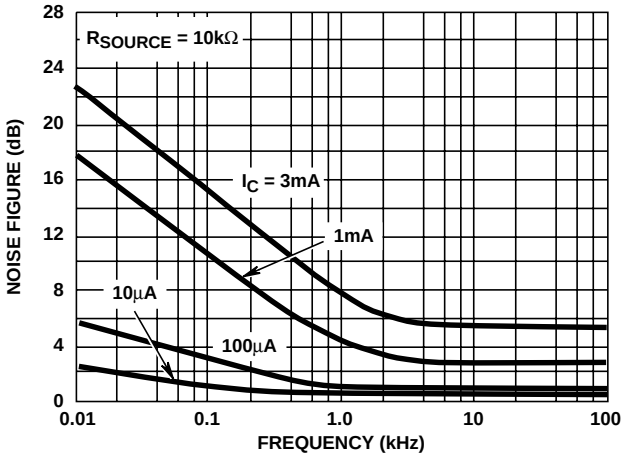


FIGURE 26. NOISE FIGURE vs FREQUENCY FOR NPN TRANSISTORS

Typical Performance Curves (Continued)

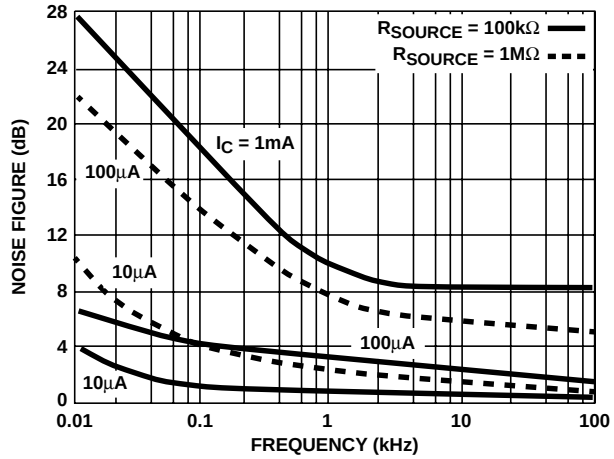


FIGURE 27. NOISE FIGURE vs FREQUENCY FOR NPN TRANSISTORS

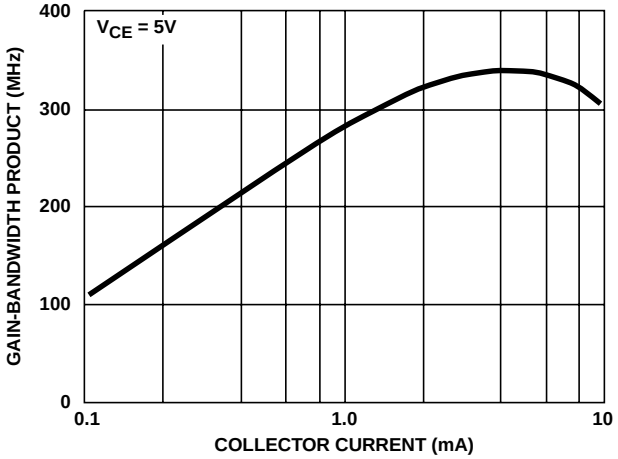


FIGURE 28. GAIN-BANDWIDTH PRODUCT vs COLLECTOR CURRENT (NPN)

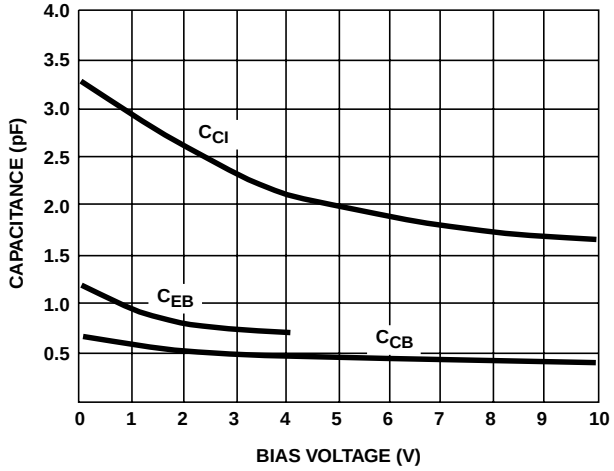


FIGURE 29. CAPACITANCE vs BIAS VOLTAGE (NPN)

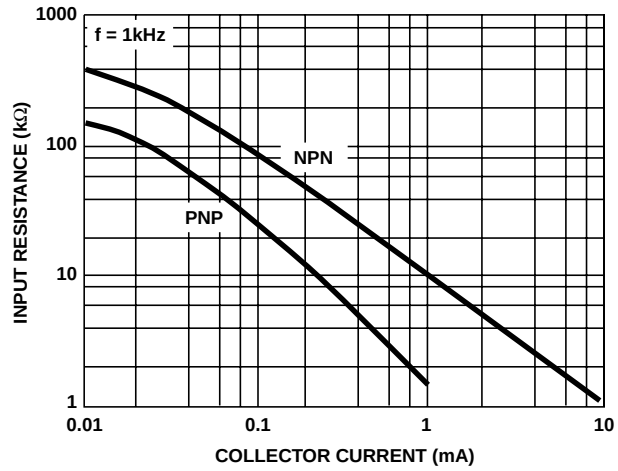


FIGURE 30. INPUT RESISTANCE vs COLLECTOR CURRENT

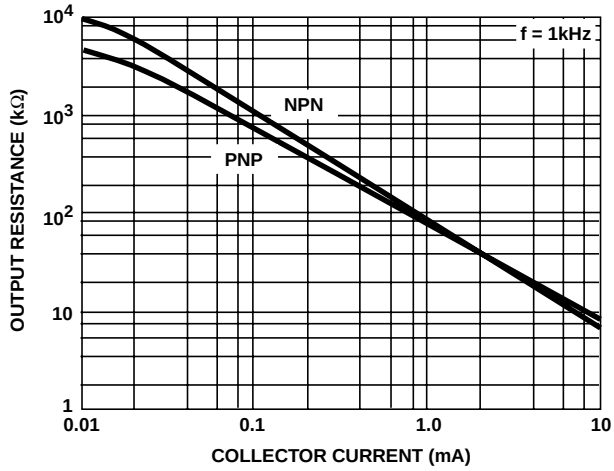


FIGURE 31. OUTPUT RESISTANCE vs COLLECTOR CURRENT

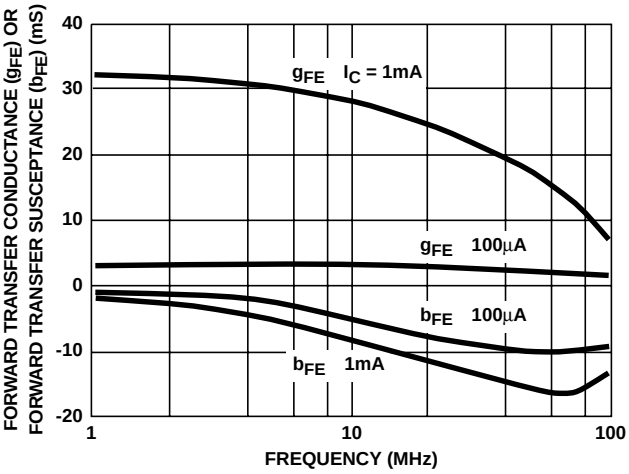


FIGURE 32. FORWARD TRANSCONDUCTANCE vs FREQUENCY

Typical Performance Curves (Continued)

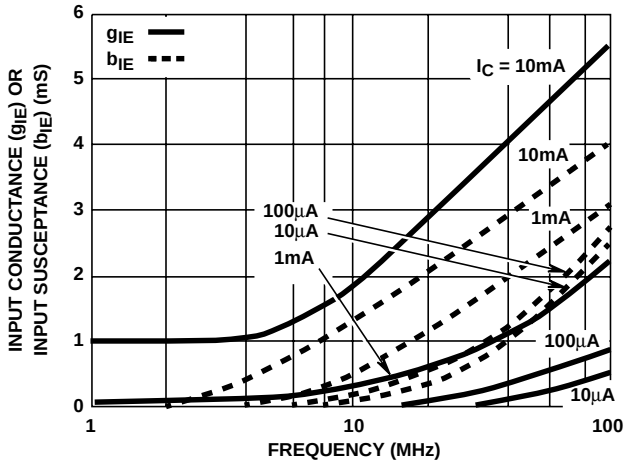


FIGURE 33. INPUT ADMITTANCE vs FREQUENCY

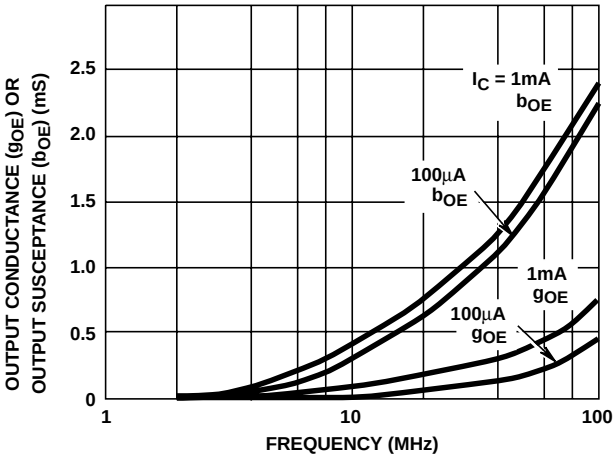


FIGURE 34. OUTPUT ADMITTANCE vs FREQUENCY

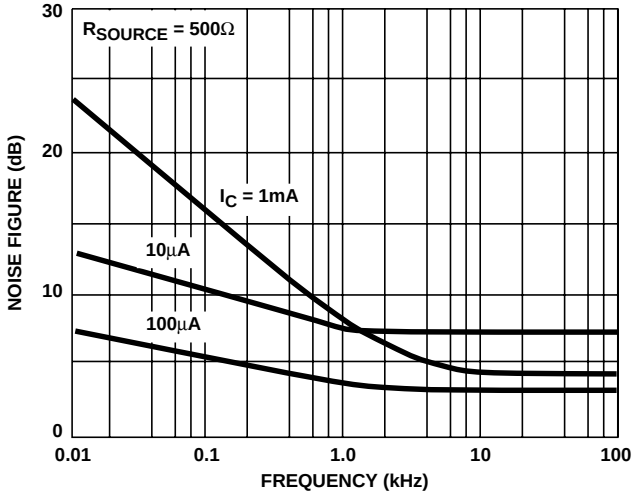


FIGURE 35. NOISE FIGURE vs FREQUENCY (PNP)

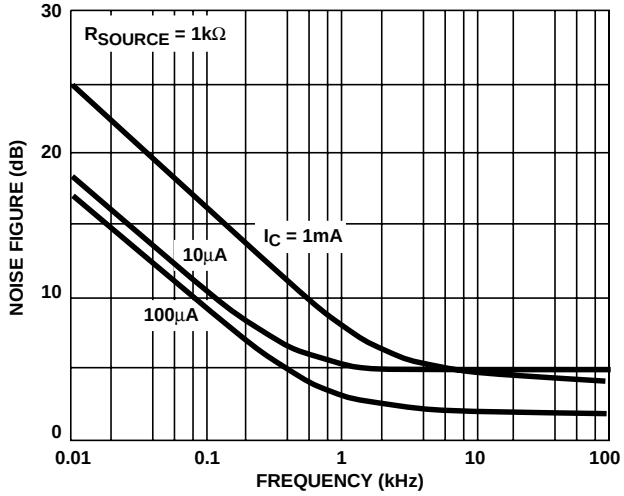


FIGURE 36. NOISE FIGURE vs FREQUENCY (PNP)

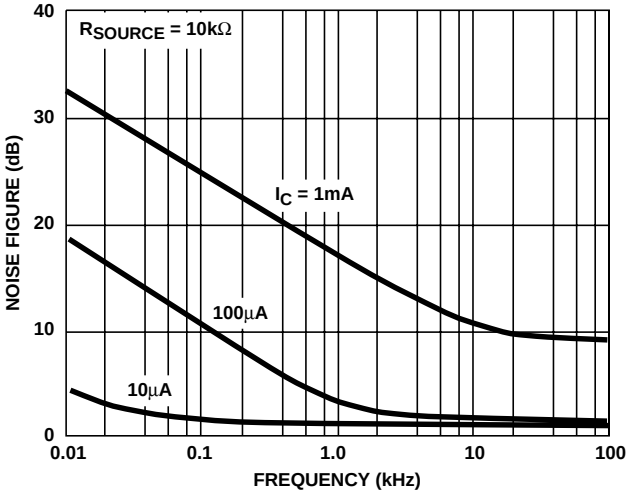


FIGURE 37. NOISE FIGURE vs FREQUENCY (PNP)

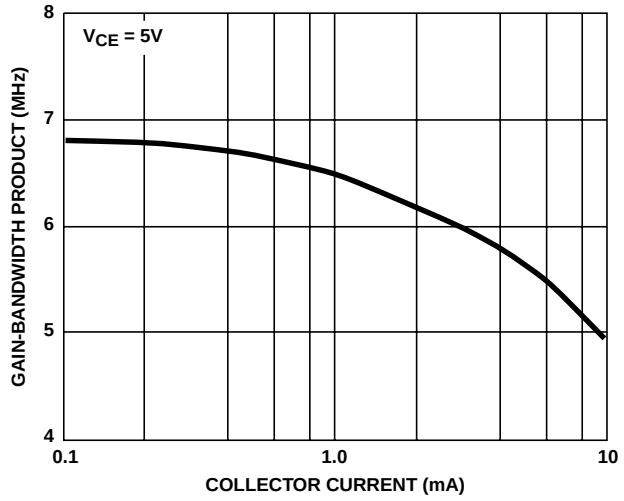


FIGURE 38. GAIN-BANDWIDTH PRODUCT vs COLLECTOR CURRENT (PNP)

Typical Performance Curves (Continued)

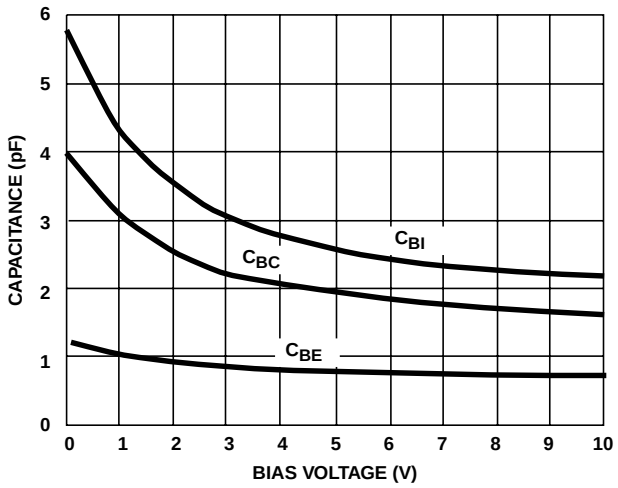
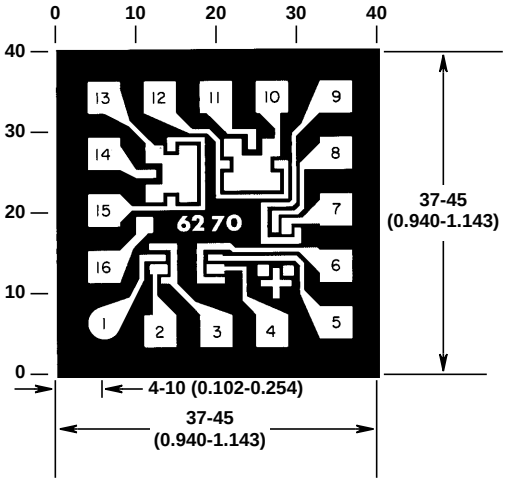


FIGURE 39. CAPACITANCE vs BIAS VOLTAGE (PNP)

Metallization Mask Layout

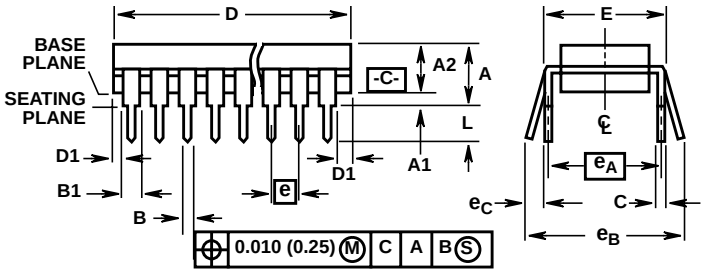
CA3096H



Dimensions in parentheses are in millimeters and are derived from the basic inch dimensions as indicated. Grid graduations are in mils (10^{-3} inch).

The photographs and dimensions represent a chip when it is part of the wafer. When the wafer is cut into chips, the cleavage angles are 57 degrees instead of 90 degrees with respect to the face of the chip. Therefore, the isolated chip is actually 7mils (0.17mm) larger in both dimensions.

Dual-In-Line Plastic Packages (PDIP)



NOTES:

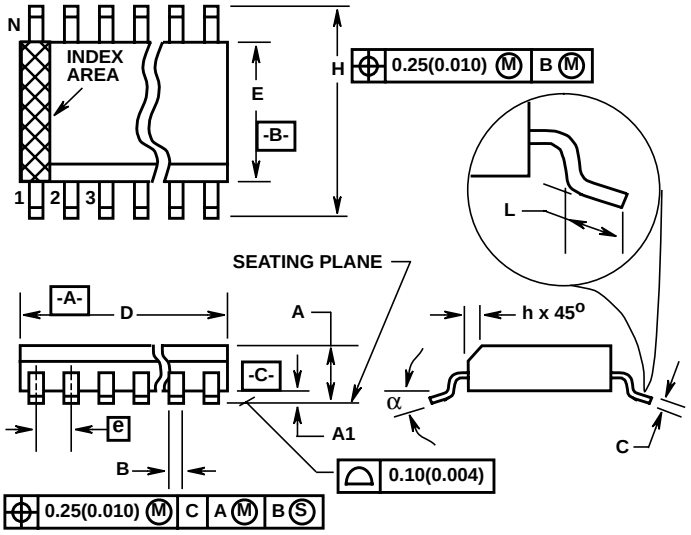
1. Controlling Dimensions: INCH. In case of conflict between English and Metric dimensions, the inch dimensions control.
2. Dimensioning and tolerancing per ANSI Y14.5M-1982.
3. Symbols are defined in the “MO Series Symbol List” in Section 2.2 of Publication No. 95.
4. Dimensions A, A1 and L are measured with the package seated in JEDEC seating plane gauge GS-3.
5. D, D1, and E1 dimensions do not include mold flash or protrusions. Mold flash or protrusions shall not exceed 0.010 inch (0.25mm).
6. E and e_A are measured with the leads constrained to be perpendicular to datum -C-.
7. e_B and e_C are measured at the lead tips with the leads unconstrained. e_C must be zero or greater.
8. B1 maximum dimensions do not include dambar protrusions. Dambar protrusions shall not exceed 0.010 inch (0.25mm).
9. N is the maximum number of terminal positions.
10. Corner leads (1, N, N/2 and N/2 + 1) for E8.3, E16.3, E18.3, E28.3, E42.6 will have a B1 dimension of 0.030 - 0.045 inch (0.76 - 1.14mm).

E16.3 (JEDEC MS-001-BB ISSUE D)
16 LEAD DUAL-IN-LINE PLASTIC PACKAGE

SYMBOL	INCHES		MILLIMETERS		NOTES
	MIN	MAX	MIN	MAX	
A	-	0.210	-	5.33	4
A1	0.015	-	0.39	-	4
A2	0.115	0.195	2.93	4.95	-
B	0.014	0.022	0.356	0.558	-
B1	0.045	0.070	1.15	1.77	8, 10
C	0.008	0.014	0.204	0.355	-
D	0.735	0.775	18.66	19.68	5
D1	0.005	-	0.13	-	5
E	0.300	0.325	7.62	8.25	6
E1	0.240	0.280	6.10	7.11	5
e	0.100 BSC		2.54 BSC		-
e_A	0.300 BSC		7.62 BSC		6
e_B	-	0.430	-	10.92	7
L	0.115	0.150	2.93	3.81	4
N	16		16		9

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Small Outline Plastic Packages (SOIC)



M16.15 (JEDEC MS-012-AC ISSUE C)
16 LEAD NARROW BODY SMALL OUTLINE PLASTIC PACKAGE

SYMBOL	INCHES		MILLIMETERS		NOTES
	MIN	MAX	MIN	MAX	
A	0.0532	0.0688	1.35	1.75	-
A1	0.0040	0.0098	0.10	0.25	-
B	0.013	0.020	0.33	0.51	9
C	0.0075	0.0098	0.19	0.25	-
D	0.3859	0.3937	9.80	10.00	3
E	0.1497	0.1574	3.80	4.00	4
e	0.050 BSC		1.27 BSC		-
H	0.2284	0.2440	5.80	6.20	-
h	0.0099	0.0196	0.25	0.50	5
L	0.016	0.050	0.40	1.27	6
N	16		16		7
α	0^o	8^o	0^o	8^o	-

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NOTES:

1. Symbols are defined in the “MO Series Symbol List” in Section 2.2 of Publication Number 95.
2. Dimensioning and tolerancing per ANSI Y14.5M-1982.
3. Dimension “D” does not include mold flash, protrusions or gate burrs. Mold flash, protrusion and gate burrs shall not exceed 0.15mm (0.006 inch) per side.
4. Dimension “E” does not include interlead flash or protrusions. Interlead flash and protrusions shall not exceed 0.25mm (0.010 inch) per side.
5. The chamfer on the body is optional. If it is not present, a visual index feature must be located within the crosshatched area.
6. “L” is the length of terminal for soldering to a substrate.
7. “N” is the number of terminal positions.
8. Terminal numbers are shown for reference only.
9. The lead width “B”, as measured 0.36mm (0.014 inch) or greater above the seating plane, shall not exceed a maximum value of 0.61mm (0.024 inch).
10. Controlling dimension: MILLIMETER. Converted inch dimensions are not necessarily exact.

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