MH88305
Hybrid DTMF Receiver System

February 1985

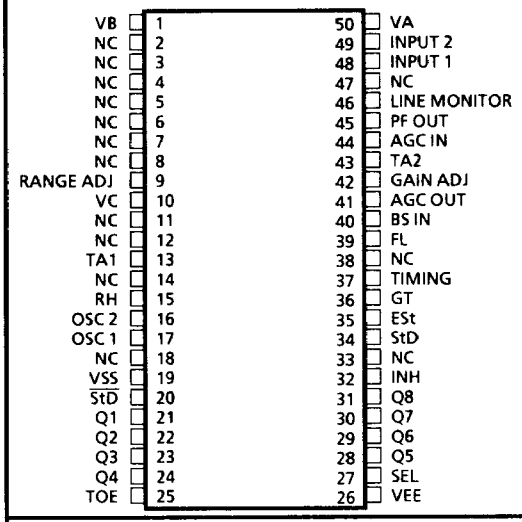
Features

- Up to 55 dB Dynamic Range.
- AGC for precise twist adjustment.
- No exernal components needed.
- Direct connection to telephone lines.
- Exceptional talk off.
- 14 dB acceptable signal to noise ratio.
- Acquisition time adjustable down to 10 ms.
- Major parameters externally adjustable.
- 5 V and 8 V to 12 V operation.

Applications

- End to end signalling.
- Control systems.
- Mobile radio.
- Central office.
- PABX.
- Key systems.

Pin Connections



Ordering Information −40°C to +85°C
MH88305 50 Pin

Description

The Mitel MH88305 Hybrid TOUCH-TONE® Receiver is a high performance, high quality unit, packaged in a dual-in-line hybrid measuring 2.5"x1.5"x0.25" and requires no external components for normal operation. The unit features exceptional dynamic range and precise twist performance, both adjustable to meet the exacting demands of end to end signalling applications as well as providing a unit of excellent central office quality. The MH88305 utilizes a digital detection algorithm which provides the unit with excellent talk-off immunity and signal to noise performance. Bandsplit filtering is achieved using the Mitel ISO²-CMOS™ MT8865 DTMF filter.

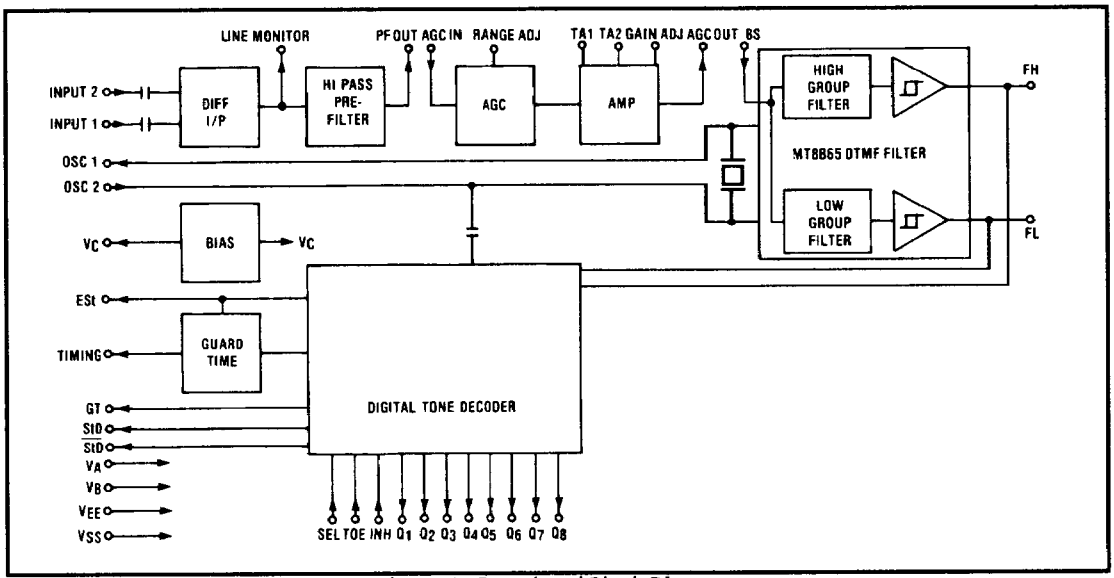


Figure 1 - Functional Block Diagram

Absolute Maximum Ratings*

	Parameter	Symbol	Min	Max	Units
1	Supply voltage	$V_A - V_{EE}$		15	V
		$V_A - V_B$		15	V
	$V_{SS} = V_{EE}$ 5 V Operation	$V_A - V_{SS}$		5.5	V
2	Input Current on any logic pin	I_{IN}		10	mA
3	Voltage on any logic pin	V_{IN}	V_{EE} - 0.3	V_A + 0.3	V
4	Operating Temperature Range	T_A	- 40	+ 85	°C
5	Storage Temperature Range	T_{STG}	- 55	+ 100	°C

*Exceeding these values may cause permanent damage. Functional operation under these conditions is not implied.

DC Electrical Characteristics - See Note 1.

		Characteristics	Sym	Min	Typ	Max	Units	Test Conditions
1		Analog Operating Voltage	V_A-V_B	4.75			V	V_A = 5V
		Ref. to V_B	V_A-V_B			13	V	V_A = 12V
2		Digital Operating Voltage	V_A-V_{EE}	4.75			V	V_A = 5V
			V_A-V_{EE}			13	V	V_A = 12V
3		Internal Logic Ground Voltage	V_A-V_{SS}	4.75		5.25	V	V_A = 5V
		Ref. to V_{SS}	V_A-V_{SS}	6.0	6.5	7.5	V	V_A = 12V
4		Operating Supply Current	I_A		10		mA	V_A = 5V
			I_A		15		mA	V_A = 12V
5		High Level Input Voltage	V_{IH}	3.5			V	V_A = 5V
			V_{IH}	8.5			V	V_A = 12V
6		Low Level Input Voltage	V_{IL}			1.5	V	V_A = 5V
			V_{IL}			3.5	V	V_A = 12V
7		Pull Down Sink Current	I_{SI}	10	25	75	µA	V_A = 5V, V_{IH} = V_A
		(INH/SEL)	I_{SI}	10	200	400	µA	V_A = 12V, V_{IH} = V_A
8		Pull Up Source Current	I_{SO}	2	7	45	µA	V_A = 5V, V_{IL} = V_{EE}
		(TOE)	I_{SO}	2	7	45	µA	V_A = 12V, V_{IL} = V_{EE}
9		Input High Leakage Current	I_{IH}		0.1	1.5	µA	V_A = 5V, V_{IH} = V_A
			I_{IH}		0.1	1.5	µA	V_A = 12V, V_{IH} = V_A
10		Input Low Leakage Current	I_{IL}		0.1	1.5	µA	V_A = 5V, V_{IL} = V_{EE}
			I_{IL}		0.1	1.5	µA	V_A = 12V, V_{IL} = V_{EE}
11		Output Drive Current	I_{OL}	0.8	1.2		mA	V_A = 5V, Note 2
		(Except StD) Sink	I_{OL}	1	1.6		mA	V_A = 12V, Note 2
12		Output Drive Current	I_{OH}	0.4	0.6		mA	V_A = 5V, Note 3
		(Except StD) Source	I_{OH}	0.5	0.8		mA	V_A = 12V, Note 3
13		Tristate Output Leakage	I_{OZ}		0.1	1.5	µA	V_A = 5V, Note 4
		Current	I_{OZ}		0.3	1.5	µA	V_A = 12V, Note 4
14		StD Output Sink Current	I_{OLS}	35.0			µA	V_A = 5V, V_{OL} = 0.5V
			I_{OLS}	45			µA	V_A = 12V, V_{OL} = 0.5V
15		StD Output Source Current	I_{OHS}	35.0	1.2		µA	V_A = 5V, V_{OH} = V_A-0.5V
			I_{OHS}	45	1.6		µA	V_A = 12V, V_{OH} = V_A-0.5V
16		High Level Output Voltage	V_{OH}	4.9			V	V_A = 5V Outputs Open
			V_{OH}	11.9			V	V_A = 12V Circuit
17		Low Level Output Voltage	V_{OL}			0.1	V	V_A = 5V Outputs Open
			V_{OL}			0.1	V	V_A = 12V Circuit

Test Condition Notes: ① Unless otherwise noted: T_A = 25C; V_{EE} = V_B = 0.V. All voltages referenced to V_{EE}.
②V_{OL} = 0.4V(V_A = 5V), V_{OL} = 0.5V(V_A = 12) ③ V_{OH} = 4.6V(V_A = 5V), V_{OH} = 11.5V(V_A = 12V) ④V_{OH} = V_A, V_{OL} = V_{EE}

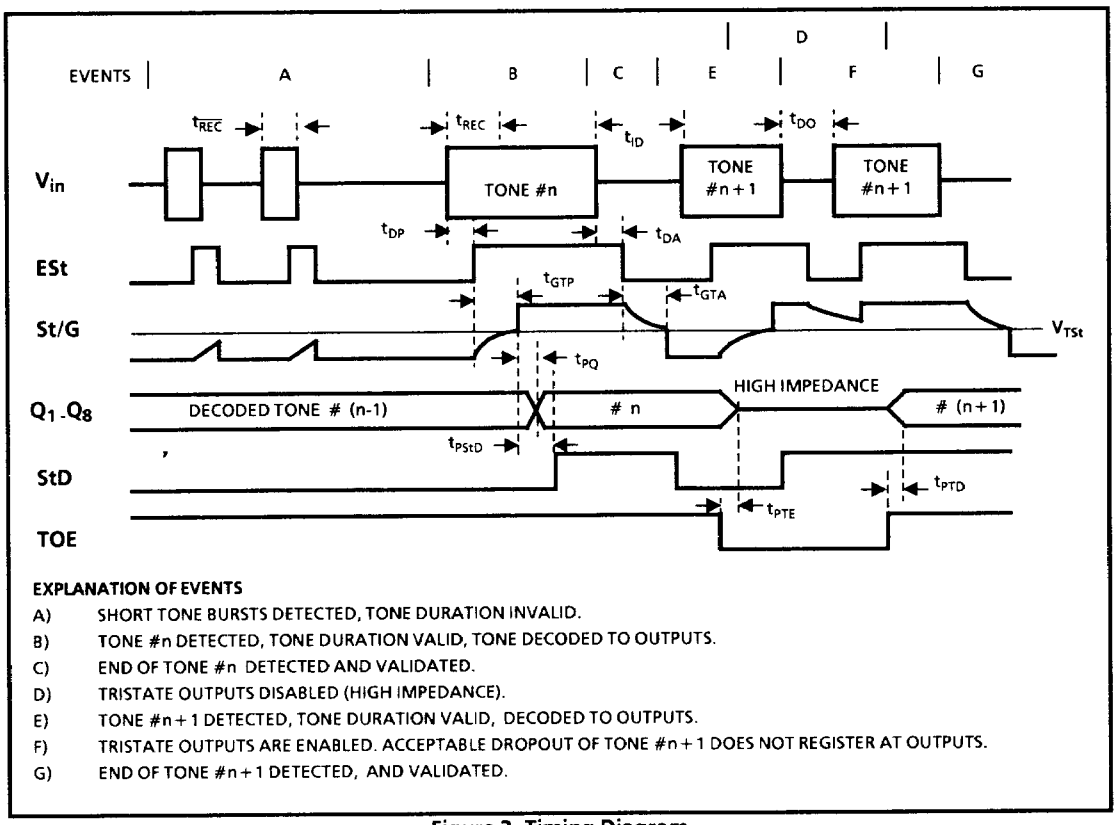
AC Electrical Characteristics - See Note 1.

	Characteristics	Sym	Min	Typ	Max	Units	Test Conditions
1	Maximum Valid Input Signal (Each tone of composite signal)		+3 +3			dBm dBm	$V_A = 5V$ $V_A = 12V$
2	Minimum Valid Input Signal (Each tone of composite signal)		-26 -46		-20 -40	dBm dBm	Normal Extended RRD = 2kΩ. Note 5
3	Accept. Signal to Noise Ratio		14			dB	Note 2
4	Maximum Twist Acceptance		±6	+9		dB	
5	Frequency Detect Bandwidth	Δf_A	±1.8		±3.5	%Nom	
6	Differential Input Impedance		360	400		kΩ	f = 1 kHz
7	DC Common ModeTolerance		±200			V	
8	AC Common Mode Tolerance		70			Vrms	15-60 Hz
9	Dial Tone Tolerance		30			dB	Note 3
10	Tone Present Detection Time	t_{DP}	6		10	ms	
11	Tone Absent Detection Time	t_{DA}	0.6		6	ms	
12	Tone Present Guard Time	t_{GTP}		25		ms	Note 4
13	Tone Absent Guard Time	t_{GTA}		35		ms	Note 4
14	Minimum Tone Duration	t_{REC}			40	ms	Note 4
15	Max. Invalid Tone Duration	$t_{\overline{REC}}$	20			ms	Note 4
16	Minimum Interdigit Pause	t_{ID}			40	ms	Note 4
17	Maximum Intradigit Dropout	t_{DO}	20			ms	Note 4
18	Data Valid to StD Delay	t_{PStD}	6		10	µs	

Notes:
1. Unless otherwise noted: $T_A = 25°C$; $V_A = 5V$ or 12V; normal mode; no external adjustment.
2. Band-limited white noise, 300 Hz-3400 Hz. 50 ms on/50 ms off. Error Rate < 1 in 10,000.
3. Relative to minimum valid input signal level (A).
4. No external guard-time components; $V_A = 12V$.
5. No external twist adjustment. Typically up to a further 6 dB of sensitivity is available by insertion of R_{TI} (Fig. 10), see text.

	SEL = H (2-of-8 Code)								SEL = L (Two 4-Bit Binary Codes)							
	Q_1	Q_2	Q_3	Q_4	Q_1	Q_2	Q_3	Q_4	Q_1	Q_2	Q_3	Q_4	Q_1	Q_2	Q_3	Q_4
1	H	L	L	L	H	L	L	L	H	L	L	L	L	L	L	L
2	H	L	L	L	L	H	L	L	L	H	L	L	L	H	L	L
3	H	L	L	L	L	L	H	L	H	H	L	L	L	L	H	L
4	L	H	L	L	H	L	L	L	L	L	H	L	L	L	L	H
5	L	H	L	L	L	H	L	L	H	L	H	L	L	H	L	H
6	L	H	L	L	L	L	H	L	L	H	H	L	L	L	H	H
7	L	L	H	L	H	L	L	L	H	H	H	L	H	L	L	L
8	L	L	H	L	L	H	L	L	L	L	L	H	H	H	L	L
9	L	L	H	L	L	L	H	L	H	L	L	H	H	L	H	L
0	L	L	L	H	L	H	L	L	L	H	L	H	L	H	H	L
*	L	L	L	H	H	L	L	L	H	H	L	H	H	L	H	H
#	L	L	L	H	L	L	H	L	L	L	H	H	H	L	L	H
A	H	L	L	L	L	L	L	H	H	L	H	H	H	H	H	L
B	L	H	L	L	L	L	L	H	L	H	H	H	H	H	L	H
C	L	L	H	L	L	L	L	H	H	H	H	H	L	H	H	H
D	L	L	L	H	L	L	L	H	L	L	L	L	H	H	H	H

Table 1 - Output Truth Table



EXPLANATION OF EVENTS

A) SHORT TONE BURSTS DETECTED, TONE DURATION INVALID.
B) TONE #n DETECTED, TONE DURATION VALID, TONE DECODED TO OUTPUTS.
C) END OF TONE #n DETECTED AND VALIDATED.
D) TRISTATE OUTPUTS DISABLED (HIGH IMPEDANCE).
E) TONE #n+1 DETECTED, TONE DURATION VALID, DECODED TO OUTPUTS.
F) TRISTATE OUTPUTS ARE ENABLED. ACCEPTABLE DROPOUT OF TONE #n+1 DOES NOT REGISTER AT OUTPUTS.
G) END OF TONE #n+1 DETECTED, AND VALIDATED.

Figure 2- Timing Diagram

Pin Description

Pin #	Name	Description
1	V_B	Negative Analog Power Supply.
2-8	NC	No Connection.
9	RANGE ADJ.	Resistor connected between Pin 9 and V_C (Pin 10) increases input sensitivity.
10	V_C	Internally derived reference voltage output.
11-12	NC	No Connection.
13	TA1	Twist Adjust 1. Resistor connected between Pin 13 and TA2 (Pin 42) increases twist acceptance. See Figs. 9 and 10.
14	NC	No Connection.
15	FH	Test output of High Group Schmitt trigger.
16	OSC 2	Test output of internal oscillator amplifier. 3.579545 MHz.
17	OSC 1	Test input of internal oscillator amplifier.
18	NC	No Connection.
19	V_{SS}	Internal logic ground . Shorted to V_{EE} (Pin 26) for 5V Logic Operation.
20	$\overline{StD}$	Buffered inverted StD.

Pin Description (cont'd.)

Pin #	Name	Description
21 22 23 24	Q_1 Q_2 Q_3 Q_4	Data Outputs 3-state buffered. Provides 4 bit binary word (SEL. LOW) or half of 2 of 8 binary word (SEL. HIGH), corresponding to the tone pair decoded, when enabled by TOE. See Table 1 for state table.
25	TOE	3-State Output Enable logic input. Active HIGH enables Q_1-Q_8 data output. When TOE = LOW; Q_1-Q_8 are high impedance.
26	V_{EE}	Negative Logic Power Supply. Logic ground for output signals.
27	SEL	Output Code Select logic input. HIGH on this input selects 2 of 8 code active HIGH on Q_1-Q_8. LOW selects two 4-bit codes on Q_1-Q_4 and Q_5-Q_8.
28 29 30 31	Q_5 Q_6 Q_7 Q_8	Data outputs 3-state buffered. Provides 4 bit binary word (SEL. LOW) or half of 2 of 8 binary word (SEL. HIGH), corresponding to the tone pair decoded, when enabled by TOE. See Table 1 for state table.
32	INH	Inhibit logic input. Active HIGH disables detection of A, B, C, D, *, #.
33	NC	No Connection.
34	StD	Valid Tone Detect indication, logic output. Active HIGH.
35	ESt	Early Steering Digital Output. Active HIGH indicates digital detection of valid tone pair.
36	GT	Guard Time Output. Normally connected to (Pin 37), TIMING.
37	TIMING	Guard Time Adjust. A capacitor connected between Pin 37 and V_A (Pin 50) increases guard time. A resistor connected between Pin 37 and ESt (Pin 35) decreases guard time.
38	NC	No Connection.
39	FL	Test output of Low Group Schmitt trigger.
40	BS IN	Analog input to the bandsplitting filters. Normally connected to AGC OUT (Pin 41).
41	AGC OUT	Analog output of the AGC circuit. Normally connected to BS IN (Pin 40).
42	GAIN ADJ	Adjusts signal level into MT8865. Shorted to TA2 (Pin 43) for 5V analog operation.
43	TA2	Twist adjust 2. Resistor connected between Pin 43 and AGC output (Pin 41) decreases twist acceptance. See Figs. 9 and 10.
44	AGC IN	Analog input to the AGC circuit. Normally connected to PF OUT (Pin 45).
45	PF OUT	Analog output from Dial Tone Reject Highpass filter. Normally connected to AGC IN (Pin 44).
46	LINE MONITOR	Single-ended test output of the differential line input. Attenuated 6 dB referred to line input signal.
47	NC	No Connection.
48 49	INPUT 1 INPUT 2	Differential line inputs AC coupled. Direct connection to telephone line.
50	V_A	Positive Power Supply.

Functional Description

The Mitel Hybrid DTMF Tone Receiver offers small size (2.5" x 1.5"), exceptional signal detection performance, and high quality through the use of state of the art thick film and CMOS/LSI technology. No external components are needed and the unit can be directly connected to telephone lines. Digital outputs are CMOS and Low Power Schottky TTL compatible (2 loads). The unit is particularly suited to applications where high sensitivity, high twist, and detection in the presence of noise is required, such as end to end signalling, mobile radio, Central Office, PABX and other applications. For maximum flexibility all major functional blocks of the receiver are externally accessible, and the use of an external resistor provides adjustment of input sensitivity, twist accept/reject limits and guard-time decrement while the use of an external capacitor allows an increase of guard-time.

The MH88305 is designed to accept the standard DTMF frequencies as recommended by CCITT normally generated from a push-button TOUCH-TONE telephone set. See Fig. 4.

The input signal is received on INPUT 1 and INPUT 2 which provide an AC-coupled balanced differential input impedance of approximately 400 kΩ. The signal is fed into a high-pass prefilter providing 60 dB dial-tone rejection over the frequency range 0-480 Hz. The use of an AGC circuit provides the unit with up to 55 dB dynamic range, and the AGC output amp has provision for precise adjustment of twist.

The high-and-low-frequency signals are separated by the MT8865 DTMF filter/limiter, the outputs of which are rectangular waves having the same frequency as the incoming high and low tones and appear at FH and FL respectively.

The on-chip digital tone decoder accepts FH and FL and performs a complex proprietary averaging algorithm empirically developed in a practical telecommunications environment. On valid detection of both the high and low tone the early steering output (ESt) goes HIGH. (Refer to Fig. 2.) This activates a simple analog guard-time circuit which operates on tone acquisition and release, preventing multiple digit recognition in the presence of impulse noise, or tone interruption less than the allowable tone drop-out-time, t_{DO}. In the event of a tone drop-out or frequency error prior to elapse of the guard time (t_{GTP}), ESt goes low resetting the analog guard-time circuit and the digital detection algorithm is repeated.

The positive transition of StD indicates that the output latches Q_1-Q_8 have been updated. Three output formats are selectable via SEL, Pin 27. These formats are 2 of 8 active high and two 4-bit codes. The truth table is listed in Table 1. The data in the output latches will remain stable until the valid recognition of the subsequent tone pair. The delayed strobe signal (StD) is available on Pin 34 and this signal remains HIGH for the duration of the detected tone pair and goes low after the release guard time (t_{GTA}) has elapsed. Additionally, a tristate output enable, TOE, (Pin 25) is provided to enable bussing of the data outputs.

The INH pin taken HIGH allows the user to inhibit the decode of tone pairs corresponding to the keypad designations, A, B, C, D, *, #, for security uses or for further reducing susceptibility to "talk-off".

Applications

The typical connection diagram, Fig. 3, illustrates the ease with which the MH88305 may be applied in a system, requiring no extra external components to perform the tone receiving and decoding function, and providing direct connection to 5V CMOS Logic.

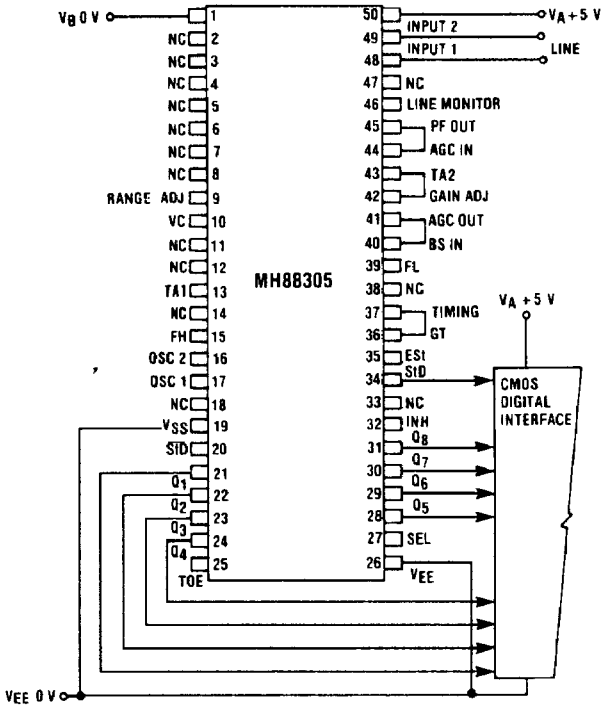
The outputs Q_1-Q_8, and $\overline{StD}$ are directly interfaceable to Low Power Schottky TTL if V_A and V_{EE} are connected to the TTL positive and common rails respectively. However, it is necessary to buffer StD as shown in Fig. 5.

A feature of the MH88305 is the flexibility to adjust tone recognition parameters by the use of single external components. The following parameters are adjustable:

- input sensitivity
- guard time
- twist accept/reject limit.

The methods of increasing or decreasing each one of these parameters are shown in Figs. 7, 8, 9 and 10 respectively. Note that the minimum Valid Input Signal Levels as specified in the AC Electrical Characteristics and Fig. 7 apply when the input signal has no twist.

Adjustment to the twist acceptance level and minimum valid input signal, may be performed as follows: Using Fig. 9 or 10, determine the twist adjust resistor value (R_T) giving the desired twist acceptance level. Subtract 9 dB from this twist acceptance level (in dB) and add this result to the desired minimum valid input signal. With this adjusted signal level, use Fig. 7 to determine the



TYPICAL PERFORMANCE

Dynamic Range	27dB
Twist	±9dB
ACC. S/N Ratio	14 dB
T_{REC}	30ms
Max. Invalid Tone Duration	20ms
Min. Interdigit Pause	30ms
Max. Acceptable Dropout	20ms

Figure 3. Typical Connection Diagram for 5V Operation

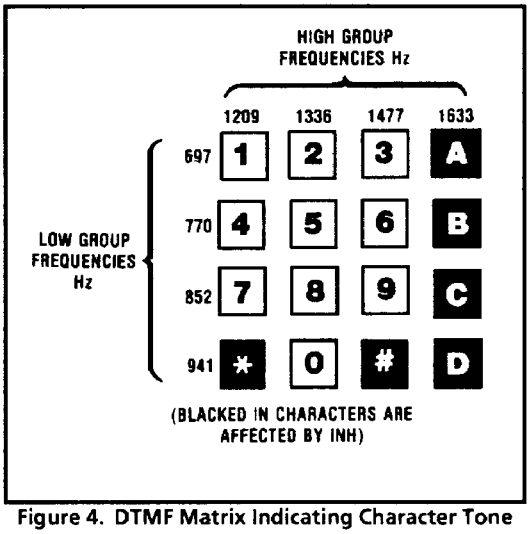


Figure 4. DTMF Matrix Indicating Character Tone Pair Correspondence

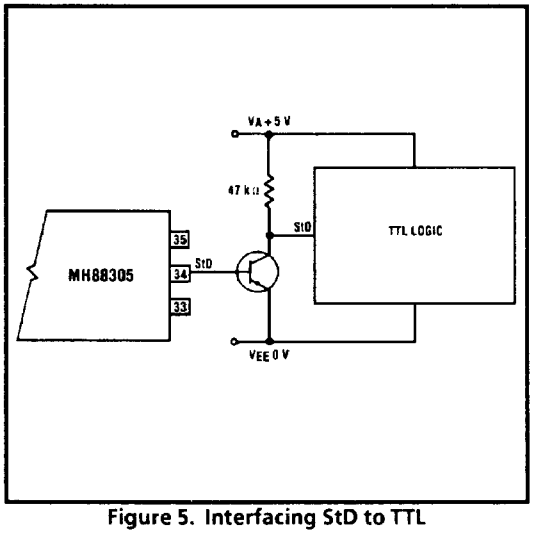


Figure 5. Interfacing StD to TTL

range adjust resistor value (R_R) and connection configuration.

Example:

$V_A = +5V$ $V_{EE} = V_B = 0$
Required Twist Acceptance Level = 18 dB
Required Valid Input Signal Level = −35 dB
Fig. 9, Twist Increment, gives $R_{TI} = 70k\Omega$
Adjusted Signal Level = (18−9) dB + (−35) dBm = −26 dBm
Fig. 7 Valid Input Signal Level
Decrement gives $R_{RD} = 25k\Omega$

To change the minimum Valid Input Signal Level, with a twist level unchanged from the typical value of 9 dB, use Fig. 7 to determine the required range adjust resistor value (R_R) and connection configuration.

Adjustment of Twist Acceptance with a ±V Supply

When using the MH88305 with a split supply ($V_A = 5V$, $V_B = -5V$) the schematic shown in Figure 6 should be referred to for proper connections.

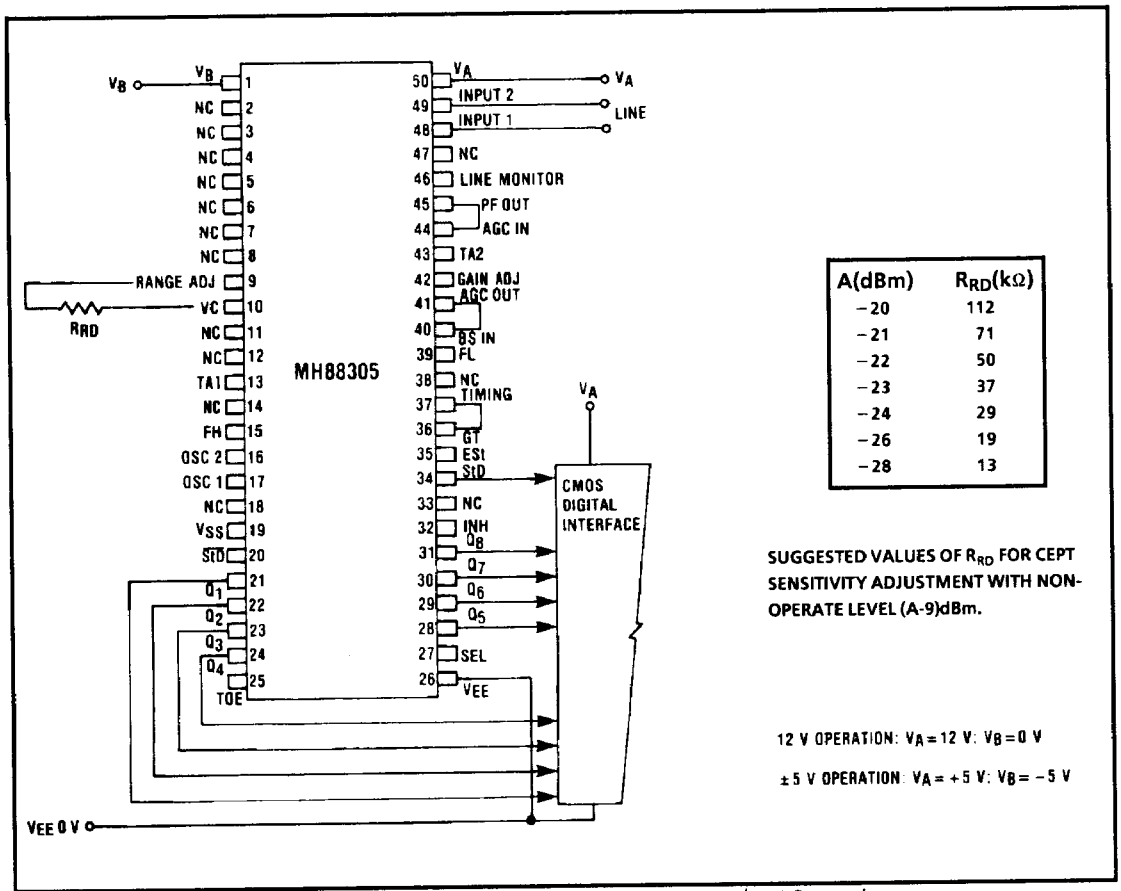
To choose a twist adjust resistor, use the graphs in Figure 10 to obtain the required resistance. These graphs, are in fact, also used for 12 volt operation $V_A = 12$, $V_B = 0$).

The selection of a range adjust resistor, however, is independent of supply voltage. Refer to Fig. 7 for selection of this resistor.

It should be noted that with split supply operation ($V_A = 5$, $V_B = -5$), the digital outputs will toggle from 0V to +5V.

Example:

$V_A = +5V$ $V_B = -5$ $V_{EE} = 0$
Required Twist Acceptance Level = 6 dB
Required Valid Input Signal Level = −30 dB
The corresponding twist adjustment resistor is 82 kΩ (Fig. 10)
The adjusted signal level = (6−12)dB + (−30)dBm = −36 dBm
The corresponding input sensitivity adjust resistor is 5kΩ (Fig. 7).



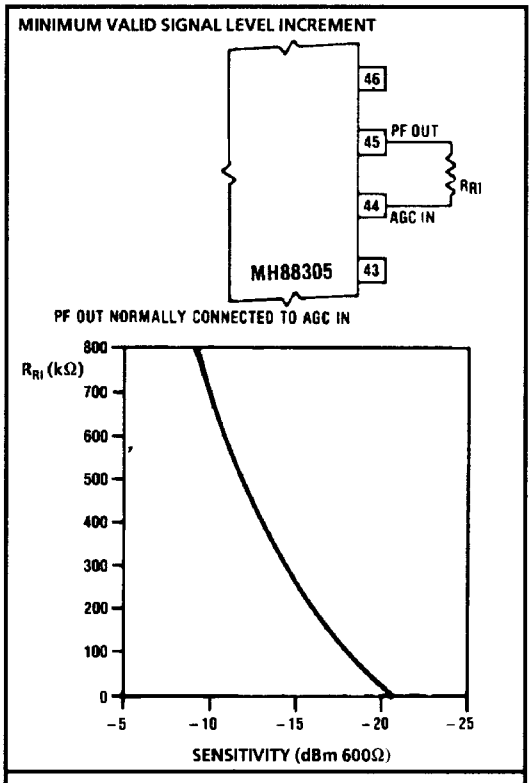
A(dBm)	R_{RD}(kΩ)
−20	112
−21	71
−22	50
−23	37
−24	29
−26	19
−28	13

SUGGESTED VALUES OF R_{RD} FOR CEPT SENSITIVITY ADJUSTMENT WITH NON-OPERATE LEVEL (A-9)dBm.

12 V OPERATION: $V_A = 12$ V; $V_B = 0$ V

±5 V OPERATION: $V_A = +5$ V; $V_B = -5$ V

Figure 6. Typical Connection Diagram for 12V or ±5V Operation



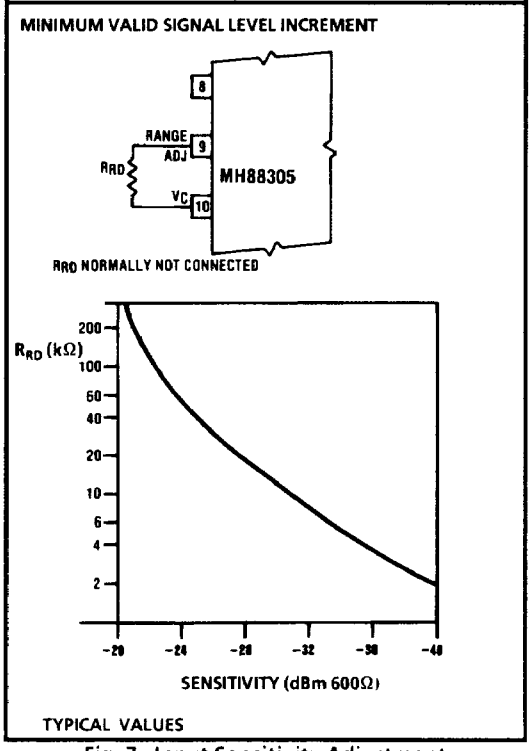
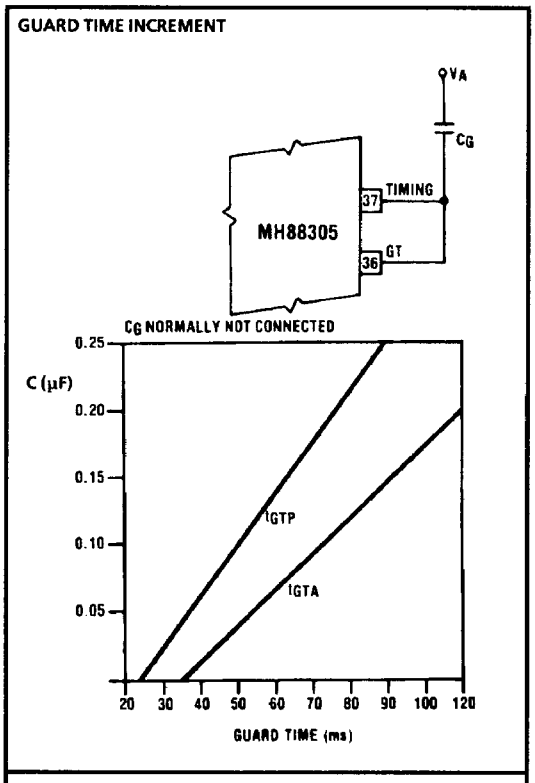


Fig. 7 - Input Sensitivity Adjustment



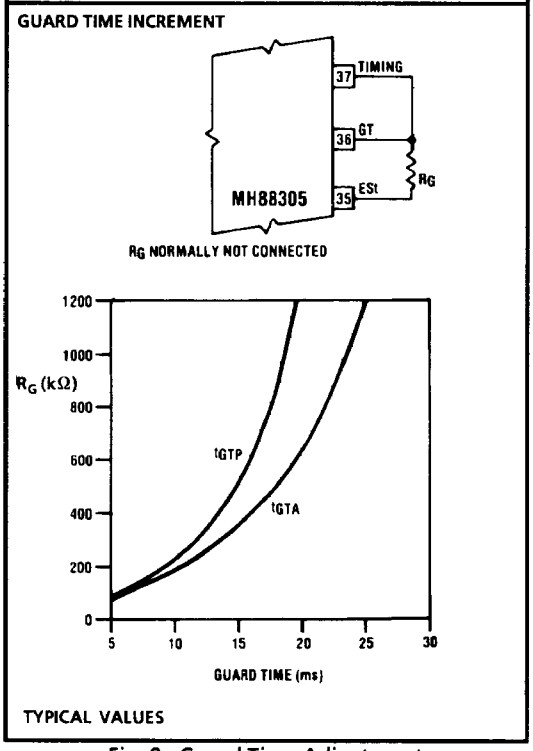


Fig. 8 - Guard Time Adjustment

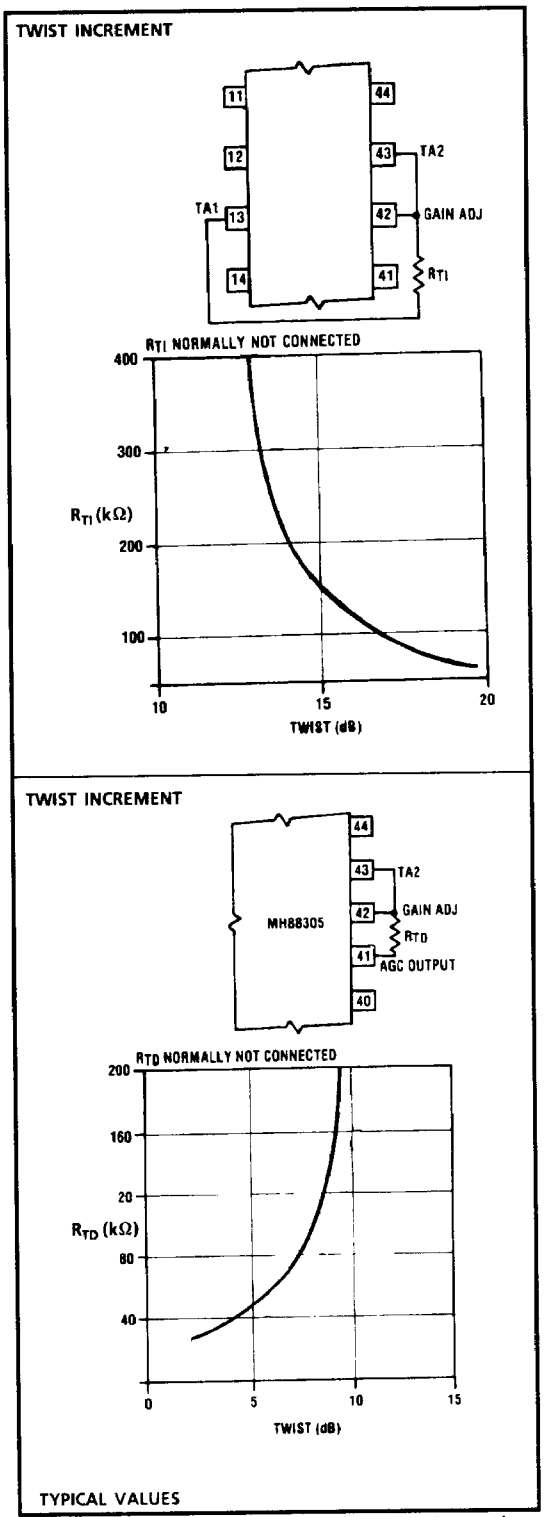


Fig. 9 - Twist Adjustment for 5V Analog Operation

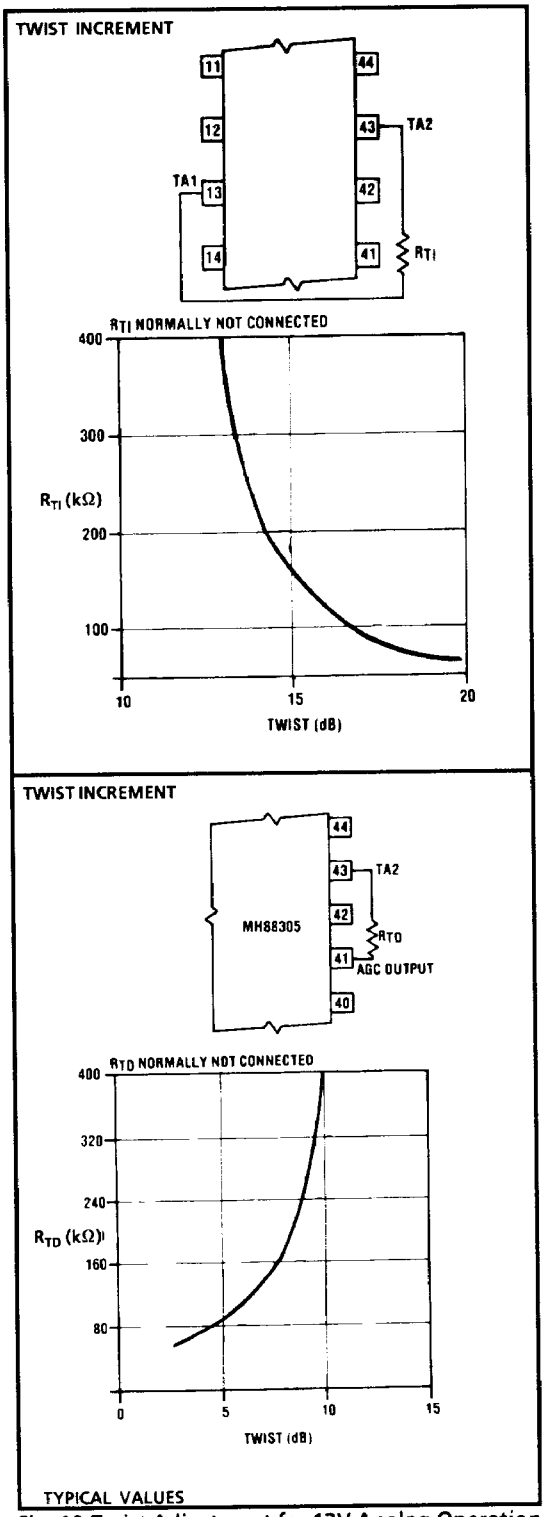


Fig. 10-Twist Adjustment for 12V Analog Operation

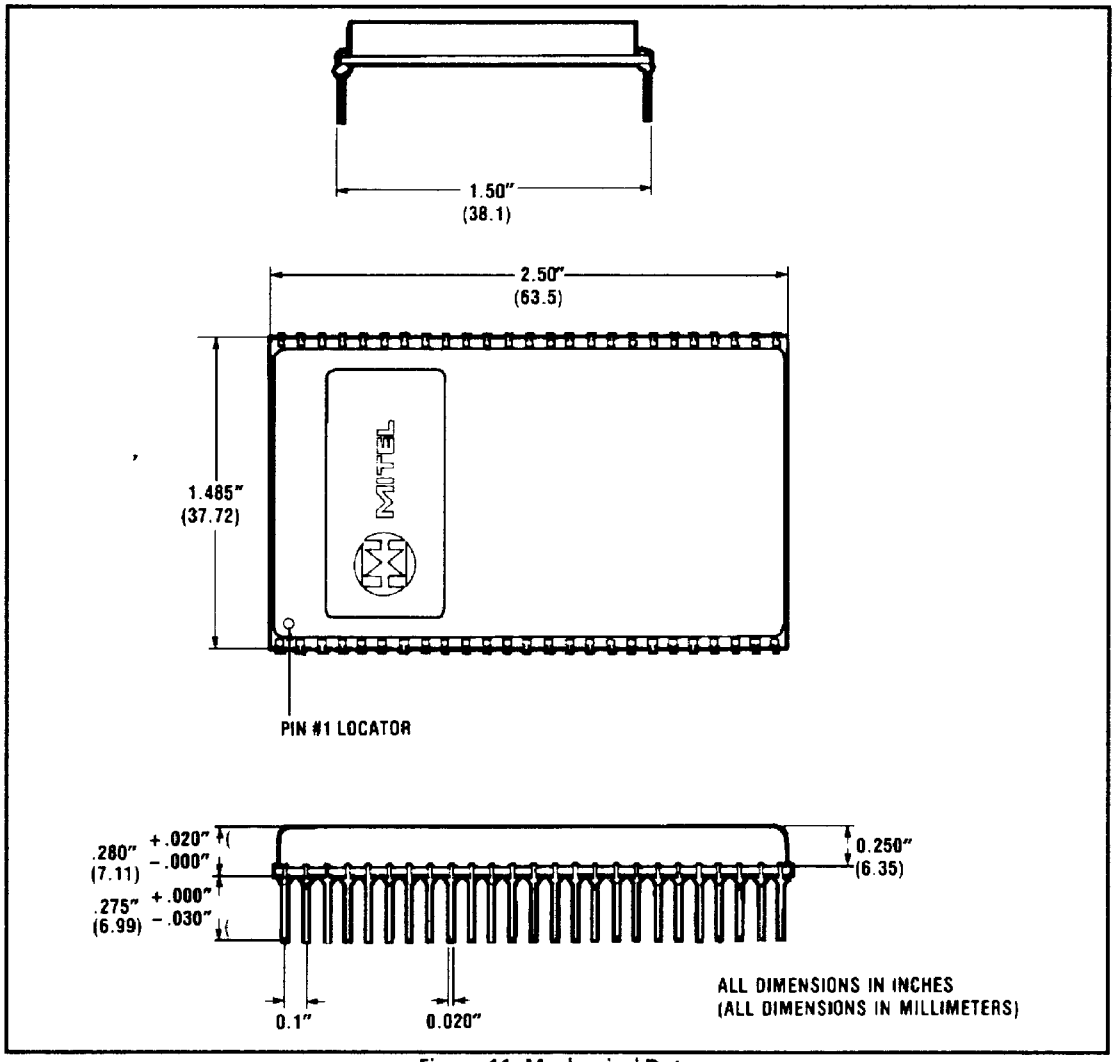
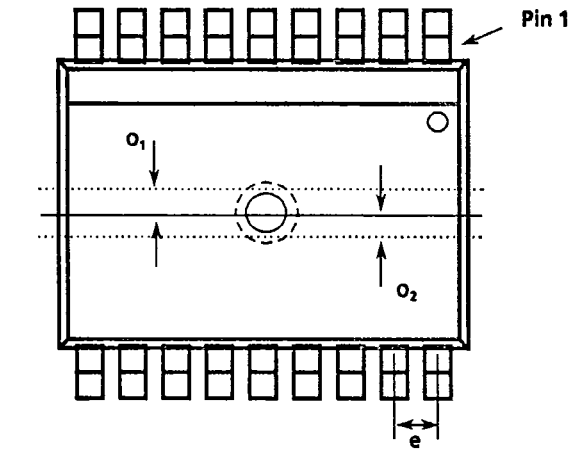


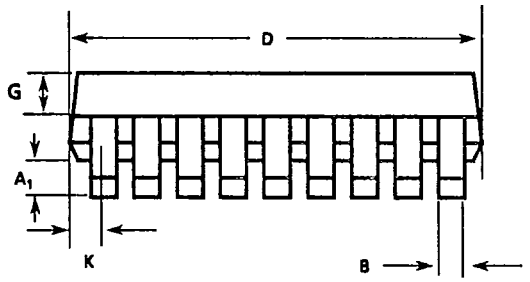
Figure 11- Mechanical Data

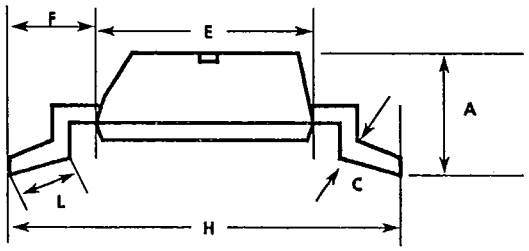
Package Outlines

PACKAGING OUTLINES

T-90-20







DIM	18-Pin SOIC		20-Pin SOIC	
	Min	Max	Min	Max
A	0.093 (2.35)	0.104 (2.65)	0.093 (2.35)	0.104 (2.65)
A_1	0.004 (0.10)	0.012 (0.30)	0.004 (0.10)	0.012 (0.30)
B	0.014 (0.351)	0.019 (0.488)	0.014 (0.351)	0.019 (0.488)
C	0.009 (0.231)	0.013 (0.318)	0.009 (0.231)	0.013 (0.318)
D	0.447 (11.35)	0.469 (11.90)	0.496 (12.60)	0.518 (13.00)
E	0.291 (7.40)	0.305 (7.75)	0.291 (7.40)	0.305 (7.75)
e	0.050 BSC (1.27 BSC)		0.050 BSC (1.27 BSC)	
F	0.044 (1.125)	0.064 (1.625)	0.044 (1.125)	0.064 (1.625)
G	0.040 (1.016)	0.050 (1.270)	0.040 (1.016)	0.050 (1.270)
H	0.394 (10.00)	0.419 (10.65)	0.394 (10.00)	0.419 (10.65)
K	0.035 (0.889)	0.045 (1.143)	0.035 (0.889)	0.045 (1.143)
L	0.016 (0.40)	0.050 (1.27)	0.016 (0.40)	0.050 (1.27)
O_1	-	0.005 (0.13)	-	0.005 (0.13)
O_2	-	0.005 (0.13)	-	0.005 (0.13)

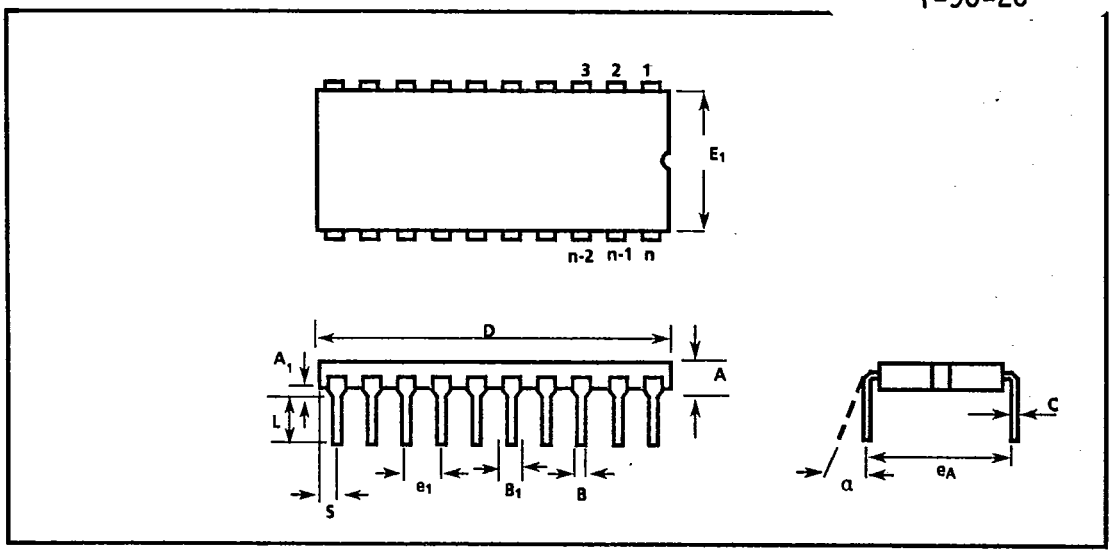
NOTE: ( ) millimeters

NOTES:
1) A & B Maximum dimensions include allowable mold flash.
2) O_1 & O_2 are SYMMETRY dimensions.

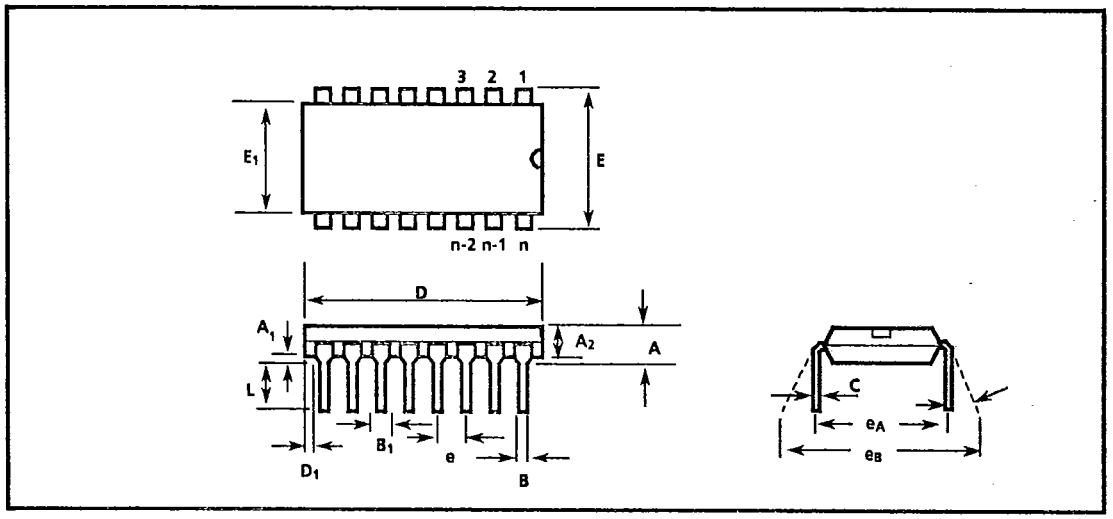
Lead SOIC Package (S Suffix)

Package Outlines

T-90-20



Ceramic Dual-In-Line Packages (CDIP) - C Suffix



Plastic Dual-In-Line Packages (PDIP) - E Suffix

Package Outlines

T-90-20

DIM	8-Pin				16-Pin				18-Pin				20-Pin			
	Plastic		Ceramic		Plastic		Ceramic		Plastic		Ceramic		Plastic		Ceramic	
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
A		0.210 (5.33)	0.105 (2.67)	0.200 (5.08)		0.210 (5.33)	0.105 (2.67)	0.200 (5.08)		0.210 (5.33)	0.105 (2.67)	0.200 (5.08)		0.210 (5.33)	0.105 (2.67)	0.200 (5.08)
A_1			0.025 (0.64)	0.055 (1.39)			0.025 (0.64)	0.055 (1.39)			0.025 (0.64)	0.055 (1.39)			0.025 (0.64)	0.055 (1.39)
A_2	0.115 (2.93)	0.195 (4.95)			0.115 (2.93)	0.195 (4.95)			0.115 (2.93)	0.195 (4.95)			0.115 (2.93)	0.195 (4.95)		
B	0.014 (0.356)	0.022 (0.558)	0.015 (0.381)	0.021 (0.533)	0.014 (0.356)	0.022 (0.558)	0.015 (0.381)	0.021 (0.533)	0.014 (0.356)	0.022 (0.558)	0.015 (0.381)	0.021 (0.533)	0.014 (0.356)	0.022 (0.558)	0.015 (0.381)	0.021 (0.533)
B_1	0.045 (1.15)	0.070 (1.77)	0.035 (0.89)	0.060 (1.52)	0.045 (1.15)	0.070 (1.77)	0.035 (0.89)	0.060 (1.52)	0.045 (1.15)	0.070 (1.77)	0.035 (0.89)	0.060 (1.52)	0.045 (1.15)	0.070 (1.77)	0.035 (0.89)	0.060 (1.52)
C	0.008 (0.204)	0.015 (0.381)	0.008 (0.204)	0.012 (0.304)	0.008 (0.204)	0.015 (0.381)	0.008 (0.204)	0.012 (0.304)	0.008 (0.204)	0.015 (0.381)	0.008 (0.204)	0.012 (0.304)	0.008 (0.204)	0.015 (0.381)	0.008 (0.204)	0.012 (0.304)
D	0.348 (8.84)	0.430 (10.92)	0.380 (9.7)	0.550 (13.9)	0.745 (18.93)	0.840 (21.33)		0.784 (19.9)	0.845 (21.47)	0.925 (23.49)	0.880 (22.36)	0.930 (23.62)	0.925 (23.49)	1.060 (26.9)		0.996 (25.3)
D_1	0.005 (0.13)				0.005 (0.13)				0.005 (0.13)				0.005 (0.13)			
E	0.290 (7.37)	0.330 (8.38)			0.290 (7.37)	0.330 (8.38)			0.290 (7.37)	0.330 (8.38)			0.290 (7.37)	0.330 (8.38)		
E_1	0.240 (6.10)	0.280 (7.11)	0.280 (7.12)	0.310 (7.87)	0.240 (6.10)	0.280 (7.11)	0.280 (7.12)	0.310 (7.87)	0.240 (6.10)	0.280 (7.11)	0.280 (7.12)	0.310 (7.87)	0.240 (6.10)	0.280 (7.11)	0.280 (7.12)	0.310 (7.87)
e	0.100 BSC (2.54 BSC)				0.100 BSC (2.54 BSC)				0.100 BSC (2.54 BSC)				0.100 BSC (2.54 BSC)			
e_1			0.100 BSC (2.54 BSC)				0.100 BSC (2.54 BSC)				0.100 BSC (2.54 BSC)				0.100 BSC (2.54 BSC)	
e_A	0.300 BSC (7.62 BSC)		0.300 BSC (7.62 BSC)		0.300 BSC (7.62 BSC)		0.300 BSC (7.62 BSC)		0.300 BSC (7.62 BSC)		0.300 BSC (2.54 BSC)		0.300 BSC (7.62 BSC)		0.300 BSC (7,62 BSC)	
e_B		0.430 (10.92)				0.430 (10.92)				0.430 (10.92)				0.430 (10.92)		
L	0.115 (2.93)	0.160 (4.06)	0.125 (3.18)	0.175 (4.44)	0.115 (2.93)	0.160 (4.06)	0.125 (3.18)	0.175 (4.44)	0.115 (2.93)	0.160 (4.06)	0.125 (3.18)	0.175 (4.44)	0.115 (2.93)	0.160 (4.06)	0.125 (3.18)	0.175 (4.44)
S				0.120 (3.04)				0.120 (3.04)				0.120 (3.04)				0.120 (3.04)
α			0°	15°			0°	15°			0°	15°			0°	15°

NOTE: ( ) Millimeters

Package Outlines

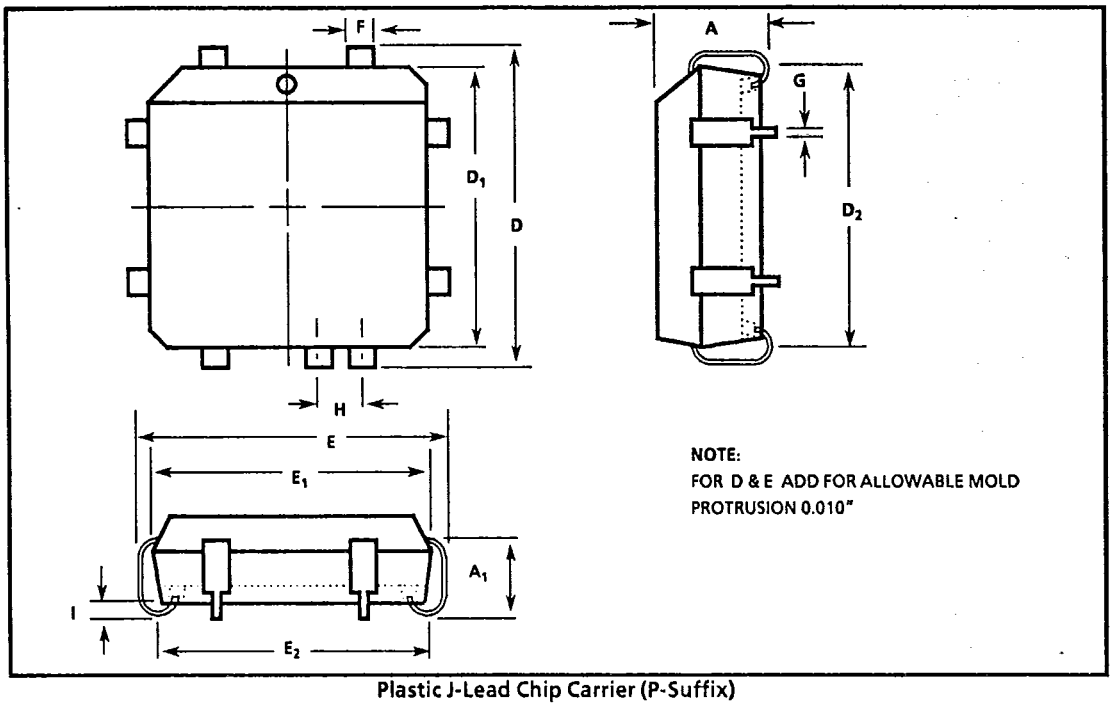
T-90-20

DIM	22-Pin				24-Pin				28-Pin				40-Pin			
	Plastic		Ceramic		Plastic		Ceramic		Plastic		Ceramic		Plastic		Ceramic	
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
A		0.210 (5.33)	0.090 (2.29)	0.225 (5.71)		0.250 (6.35)	0.085 (2.2)	0.190 (4.8)		0.250 (6.35)	0.085 (2.2)	0.190 (4.8)		0.250 (6.35)	0.085 (2.2)	0.190 (4.8)
A_1			0.025 (0.64)	0.055 (1.39)			0.020 (0.51)	0.070 (1.77)			0.020 (0.51)	0.070 (1.77)			0.020 (0.51)	0.070 (1.77)
A_2	0.125 (3.18)	0.195 (4.95)			0.125 (3.18)	0.195 (4.95)			0.125 (3.18)	0.195 (4.95)			0.125 (3.18)	0.195 (4.95)		
B	0.014 (0.356)	0.022 (0.558)	0.015 (0.381)	0.023 (0.584)	0.014 (0.356)	0.022 (0.558)	0.015 (0.381)	0.023 (0.584)	0.014 (0.356)	0.022 (0.558)	0.015 (0.381)	0.023 (0.584)	0.014 (0.356)	0.022 (0.558)	0.015 (0.381)	0.023 (0.584)
B_1	0.045 (1.15)	0.070 (1.77)	0.028 (0.71)	0.060 (1.52)	0.030 (0.77)	0.070 (1.77)	0.028 (0.71)	0.060 (1.52)	0.030 (0.77)	0.070 (1.77)	0.028 (0.71)	0.060 (1.52)	0.030 (0.77)	0.070 (1.77)	0.028 (0.71)	0.060 (1.52)
C	0.008 (0.204)	0.015 (0.381)	0.008 (0.204)	0.012 (0.304)	0.008 (0.204)	0.015 (0.381)	0.008 (0.204)	0.012 (0.304)	0.008 (0.204)	0.015 (0.381)	0.008 (0.204)	0.012 (0.304)	0.008 (0.204)	0.015 (0.381)	0.008 (0.204)	0.012 (0.304)
D	1.050 (26.67)	1.120 (28.44)	1.040 (26.42)	1.260 (32.0)	1.150 (29.3)	1.290 (32.7)	1.180 (29.88)	1.291 (32.80)	1.380 (35.1)	1.565 (39.7)	1.380 (35.06)	1.520 (38.61)	1.980 (50.3)	2.095 (53.2)	1.980 (50.30)	2.110 (53.60)
D_1	0.005 (0.13)				0.005 (0.13)				0.005 (0.13)				0.005 (0.13)			
E	0.390 (9.91)	0.430 (10.92)			0.600 (15.24)	0.670 (17.02)			0.600 (15.24)	0.670 (17.02)			0.600 (15.24)	0.670 (17.02)		
E_1	0.330 (8.39)	0.380 (9.65)	0.350 (8.89)	0.410 (10.41)	0.485 (12.32)	0.580 (14.73)	0.516 (13.11)	0.610 (15.49)	0.485 (12.32)	0.580 (14.73)	0.480 (12.19)	0.610 (15.49)	0.485 (12.32)	0.580 (14.73)	0.480 (12.19)	0.618 (15.70)
e	0.100 BSC (2.54 BSC)				0.100 BSC (2.54 BSC)				0.100 BSC (2.54 BSC)				0.100 BSC (2.54 BSC)			
e_1			0.100 BSC (2.54 BSC)				0.100 BSC (2.54 BSC)				0.100 BSC (2.54 BSC)				0.100 BSC (2.54 BSC)	
e_A	0.400 BSC (10.16 BSC)		0.400 BSC (10 .16 BSC)		0.600 BSC (15.24 BSC)		0.600 BSC (15.24 BSC)		0.600 BSC (15.24 BSC)		0.600 BSC (15.24 BSC)		0.600 BSC (15.24 BSC)		0.600 BSC (15.24 BSC)	
e_B		0.500 (12.70)				0.700 (17.78)				0.700 (17.78)				0.700 (17.78)		
L	0.115 (2.93)	0.160 (4.06)	0.125 (3.18)	0.175 (4.44)	0.115 (2.93)	0.200 (5.08)	0.125 (3.18)	0.175 (4.44)	0.115 (2.93)	0.200 (5.08)	0.125 (3.18)	0.175 (4.44)	0.115 (2.93)	0.200 (5.08)	0.125 (3.18)	0.175 (4.44)
S				0.120 (3.04)				0.100 (2.54)				0.800 (2.05)				0.800 (2.05)
α			0°	15°			0°	15°			0°	15°			0°	15°

NOTE: ( ) Millimeters

Package Outlines

T-90-20



Plastic J-Lead Chip Carrier (P-Suffix)

T-90-20

DIM	20-Pin PLCC		28-Pin PLCC		44-Pin PLCC		68-Pin PLCC		84-Pin PLCC	
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
A	0.165 (4.20)	0.180 (4.57)	0.165 (4.20)	0.180 (4.57)	0.165 (4.20)	0.180 (4.57)	0.165 (4.20)	0.200 (5.08)	0.165 (4.20)	0.200 (5.08)
A_1	0.090 (2.29)	0.120 (3.04)	0.090 (2.29)	0.120 (3.04)	0.090 (2.29)	0.120 (3.04)	0.090 (2.29)	0.130 (3.30)	0.090 (2.29)	0.130 (3.30)
B			0.020 TP (0.511 TP)							
B_1										
B_2										
D/E	0.385 (9.78)	0.395 (10.03)	0.485 (12.32)	0.495 (12.57)	0.685 (17.40)	0.695 (17.65)	0.985 (25.02)	0.995 (25.27)	0.185 (30.10)	1.195 (30.35)
D_1/E_1	0.350 (8.890)	0.356 (9.042)	0.450 (11.430)	0.456 (11.582)	0.650 (16.510)	0.656 (16.662)	0.950 (24.130)	0.958 (24.333)	1.150 (29.210)	1.158 (29.413)
D_2/E_2	0.290 (7.37)	0.330 (8.38)	0.390 (9.91)	0.430 (10.92)	0.590 (14.99)	0.630 (16.00)	0.890 (22.61)	0.930 (23.62)	1.090 (27.69)	1.130 (28.70)
D_4/E_4										
e			0.050 BSC (1.27 BSC)							
F	0.026 (0.661)	0.032 (0.812)	0.026 (0.661)	0.032 (0.812)	0.026 (0.661)	0.032 (0.812)	0.026 (0.661)	0.032 (0.812)	0.026 (0.661)	0.032 (0.812)
G	0.013 (0.331)	0.021 (0.533)	0.013 (0.331)	0.021 (0.533)	0.013 (0.331)	0.021 (0.533)	0.013 (0.331)	0.021 (0.533)	0.013 (0.331)	0.021 (0.533)
H	0.050 BSC (1.27 BSC)				0.050 BSC (1.27 BSC)		0.050 BSC (1.27 BSC)		0.050 BSC (1.27 BSC)	
h			0.040 BSC (1.02 BSC)							
h_1										
I	0.020 (0.51)		0.020 (0.51)		0.020 (0.51)		0.020 (0.51)		0.020 (0.51)	
L										
L_1										
R_1										

NOTE: ( ) Millimeters