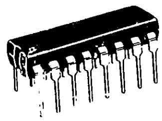
MX·COM, INC.

MX105

TONE DETECTOR



MX105J (CDIP)
MX105P (PDIP)
16 pins

FEATURES:

- Operates in High Noise Conditions
- ≥40dB Signal Input Range
- Simultaneous Tone Detection
- Adjustable Bandwidth
- Hermetically Sealed Ceramic Package
- Wide Frequency Range

APPLICATIONS:

- Tone Decoding in Single and Multitone Signaling Systems
- Decoding of Sequential or Simultaneous Tone Signaling Systems

DESCRIPTION

The MX105 is a monolithic PMOS tone operated switch, designed for tone decoding in single and multitone signaling systems.

The device employs decoding techniques which allow tones to be recognized in the presence of high noise levels or strong adjacent channel tones.

Tone channel center frequency and channel bandwidth can each be adjusted independently. The circuit has a high noise immunity against harmonic and sub-harmonic responses and is able to maintain a constant bandwidth and high noise immunity over a wide range of input signal levels.

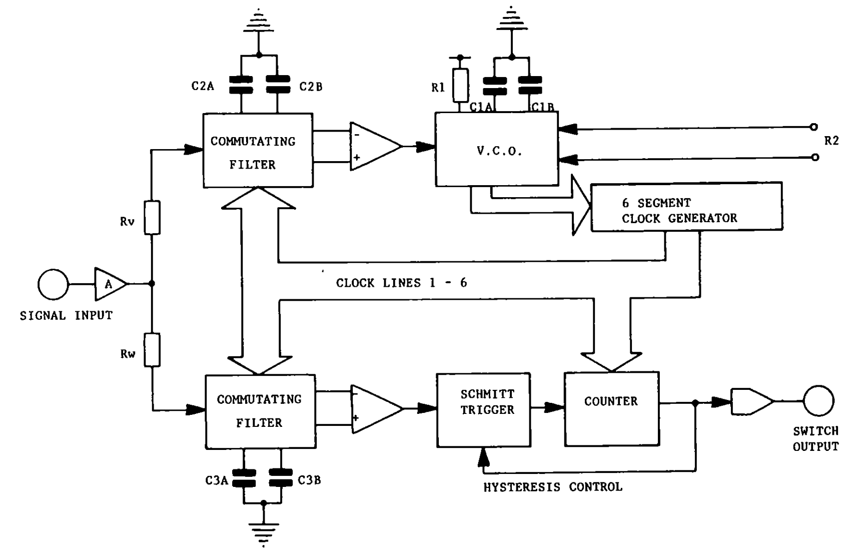
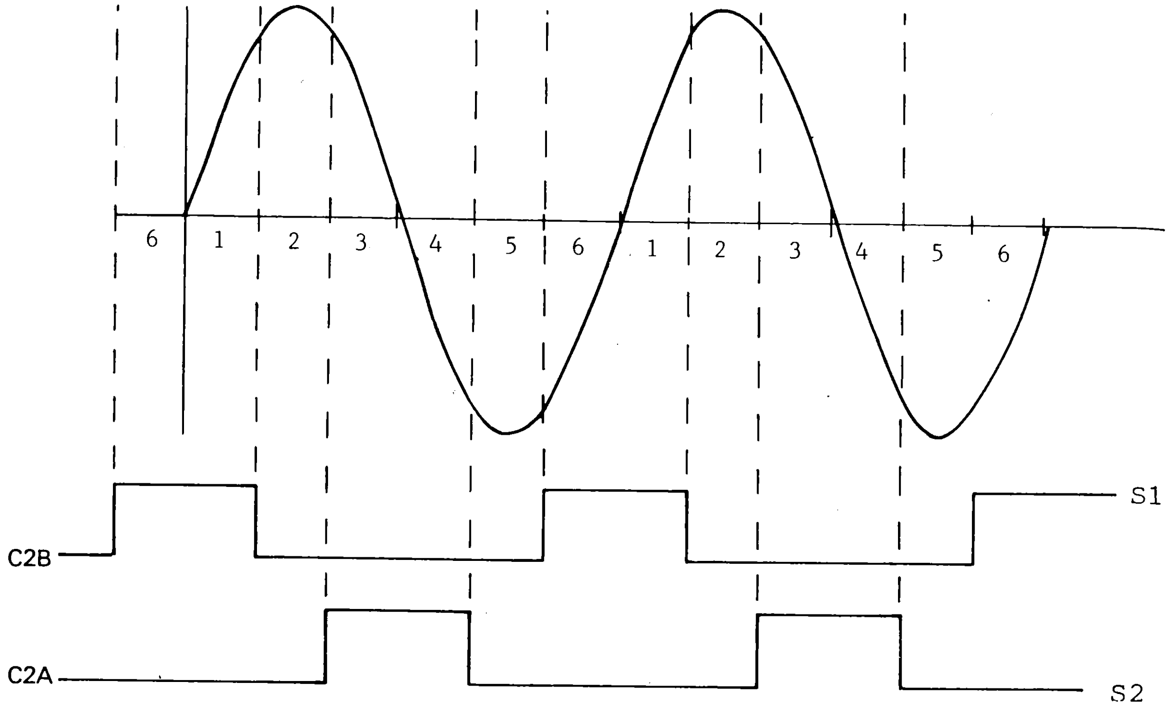


FIG. 1: MX105 INTERNAL BLOCK DIAGRAM

FIG. 2: V.C.O. SAMPLING WAVEFORMS



DEVICE OPERATION

Input signals are A.C. coupled to the buffer input, which is internally biased at 50% of supply voltage. The signal appears at the output of the buffer as an A.C. voltage superimposed on the D.C. bias level. The signal is then coupled via RV and RW to the voltage controlled oscillator and word sampling switches, which sequentially connect C2 and C3 into circuit to form four sample and hold RC integrators.

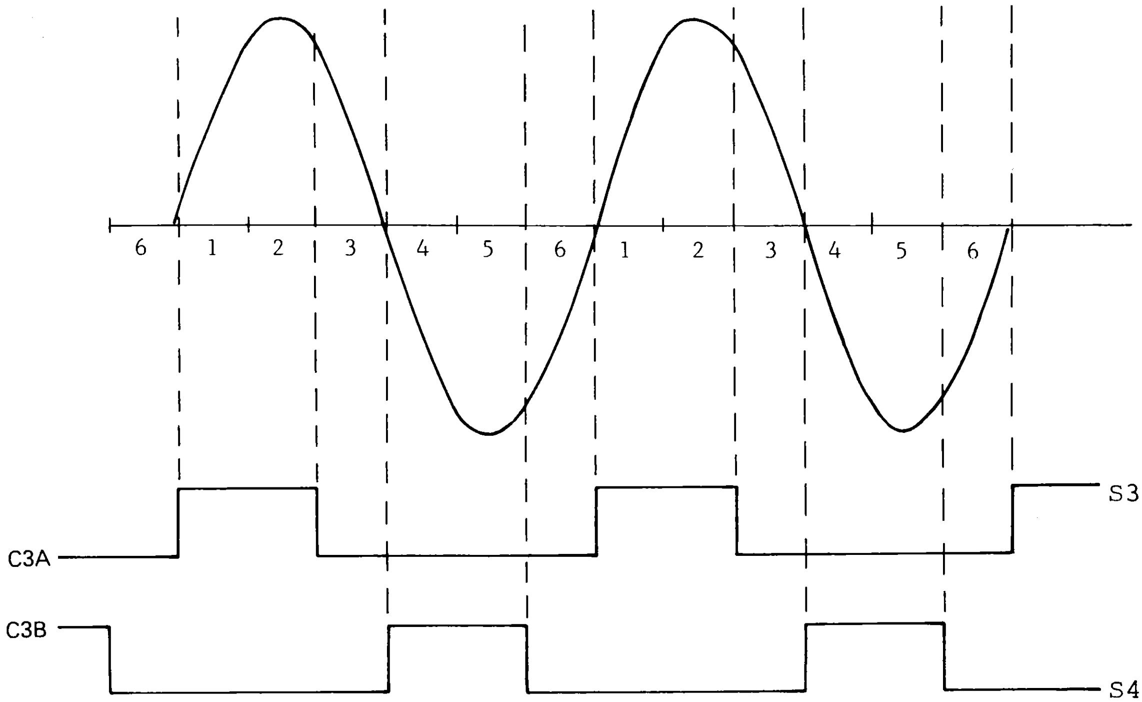
With no input signal, each capacitor charges to the D.C. bias level and differential voltages are zero. When an input signal is applied, each capacitor receives an additional charge. This charge is determined by the integrated average of the signal waveform during the interval the capacitor is switched into circuit.

Figure 2 shows the operating sequence of the V.C.O. sampling switches and their phase relationship to a locked-on inband signal. As can be seen, C2A and C2B should not receive any additional charge, since they always sample the input as it crosses the D.C. bias level. Should the signal not be locked to the V.C.O., then a positive or negative charge voltage will appear on C2A or C2B. This voltage, when differentially amplified, is applied to the V.C.O. as an error correcting signal to enable V.C.O. "lock."

Figure 3 shows the operating sequence of the 'Word' sampling switches and their relationship to a locked-on inband signal. As can be seen, the charge being applied to C3A should always be positive and the charge applied to C3B should always be negative (with respect to the common bias level).

These capacitor potentials are differentially amplified and applied to a D.C. comparator, which switches at a pre-determined threshold voltage. The comparator output is a logic signal used to control a counter. This counter switches the MX105 output ON when the comparator output is maintained in the 'Word Present' state for a minimum number of consecutive signal samples. The activated output switch reduces the comparator threshold by 50%, introducing threshold hysteresis. Output chatter with marginal input signal amplitudes is minimized.

FIG. 3: WORD SAMPLING WAVEFORMS

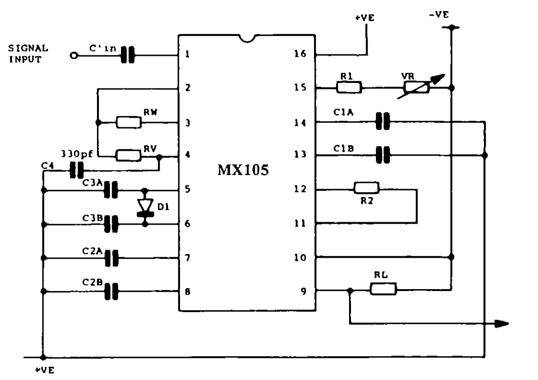


METHOD FOR CALCULATING EXTERNAL COMPONENT VALUES

The external components shown in Figure 4 are used to adjust the various performance parameters of the MX105. The signal to noise performance, turn on delay and signal bandwidth are all interrelated factors which should be optimized to meet the requirements of the application.

By selecting component values in accordance with the following graphs, nominally optimum circuit performance is obtained for any given application.

FIG. 4: EXTERNAL COMPONENT CONNECTIONS



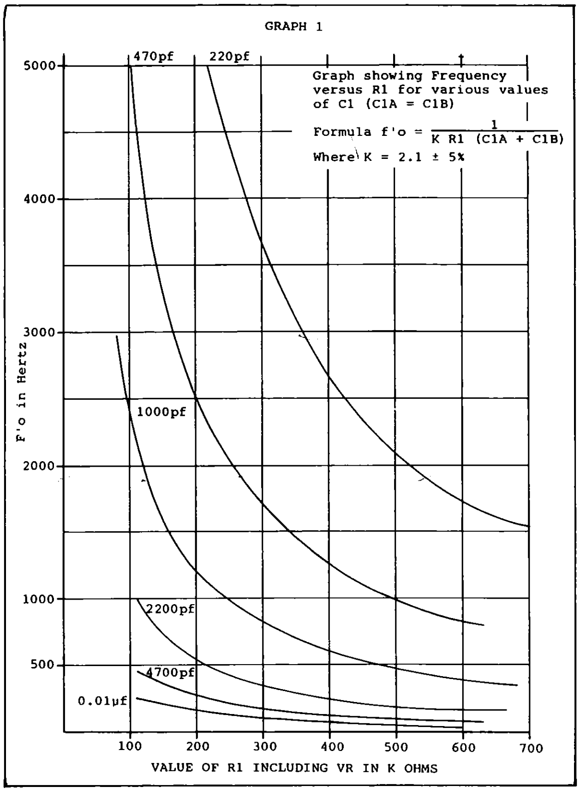
The user should first define the following application parameters:

A. The center frequency to be detected (f'o).
B. The MX105 Minimum Usable Bandwidth (MUBW). This is obtained by taking into account the worst case tolerances on the input tone frequency and variations in the MX105 f'o due to supply voltage (0.07%/%) and ambient temperature (0.02%/°C) changes.
C. The maximum permissible MX105 response time.
D. The minimum input signal amplitude.

Using this information, the appropriate component values can be calculated, and the signal to noise performance can be read from a chart.

Using graphs 1-10, the following example is used to demonstrate the calculation of component values for any given application.

A. MX105 centre band frequency (f'o) = 2800Hz.
B. MX105 bandwidth = 6%.
C. MX105 maximum response time = 50ms.
D. Minimum input signal amplitude = 200mVrms.



R1 C1A C1B

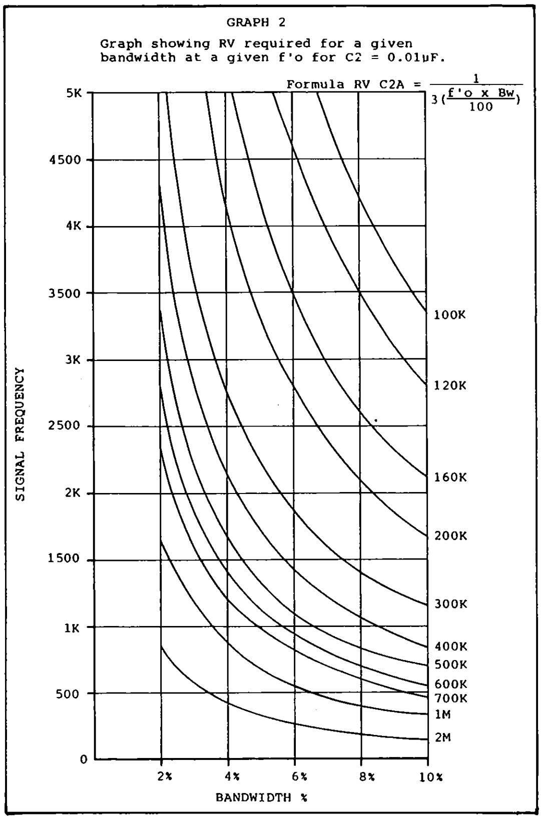
These components set the free running frequency of the V.C.O. and thereby the center band frequency of the MX105.

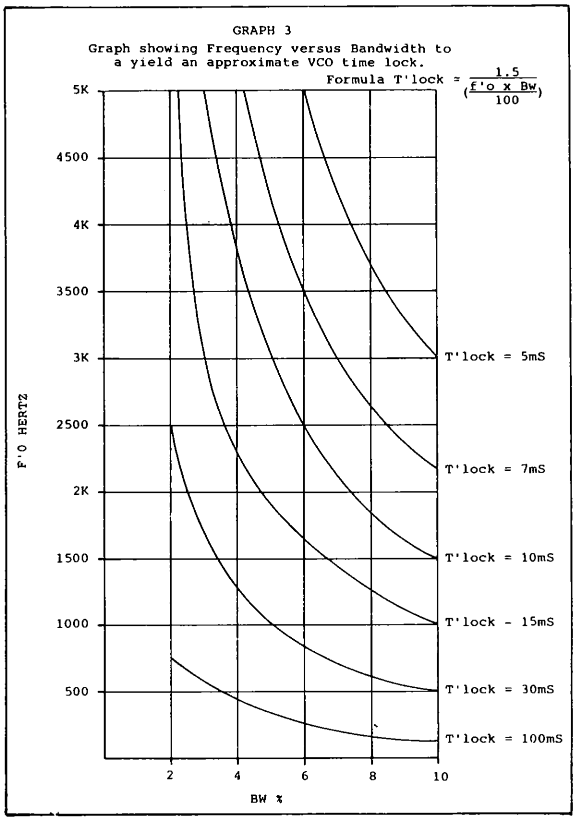
By using graph number 1, the frequency 2800Hz can be seen to correspond to a capacitor value of 220 picofarads and a resistor value of 385k ohms. This resistance can be achieved with a 300k ohm fixed resistor for R1 and a 100k ohm potentiometer.

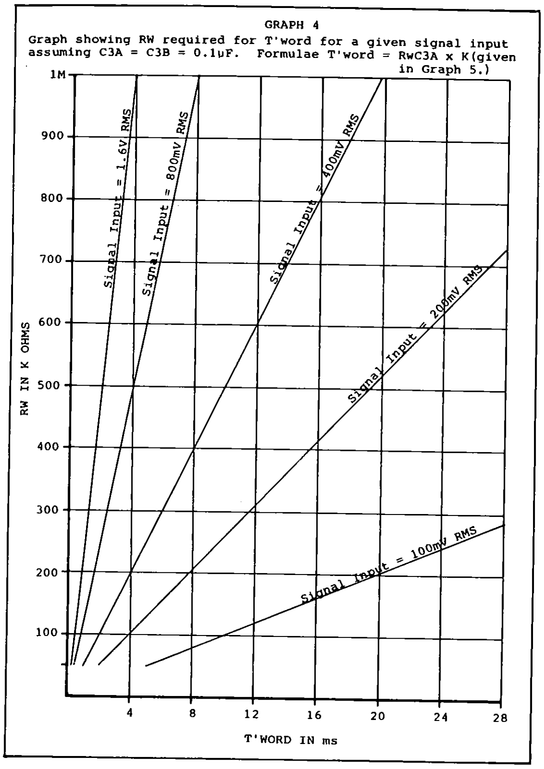
Graph number 2 shows that for a frequency of 2800Hz and a bandwidth of 6%, a resistor RV of 200k ohms and a capacitance for C2A and C2B of 0.01 microfarads will be required.

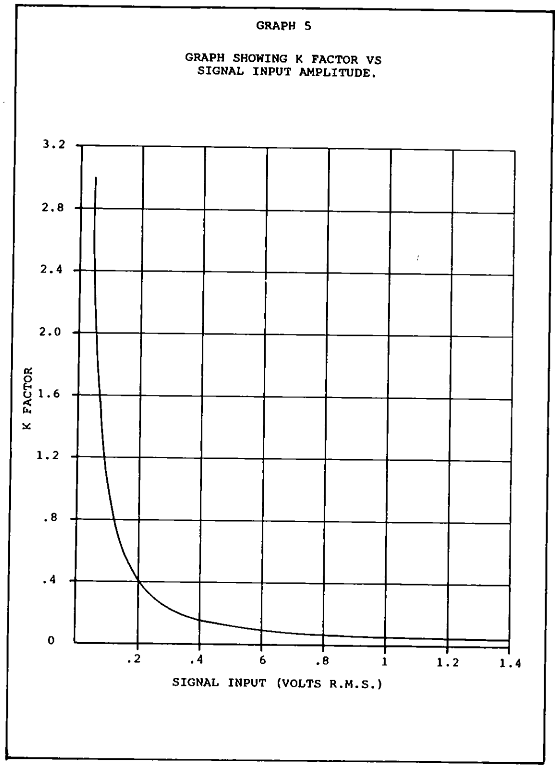
The response time of the MX105 is the sum of the V.C.O. 'Lock' time (T'lock) and the 'Word' integration time (T'word).

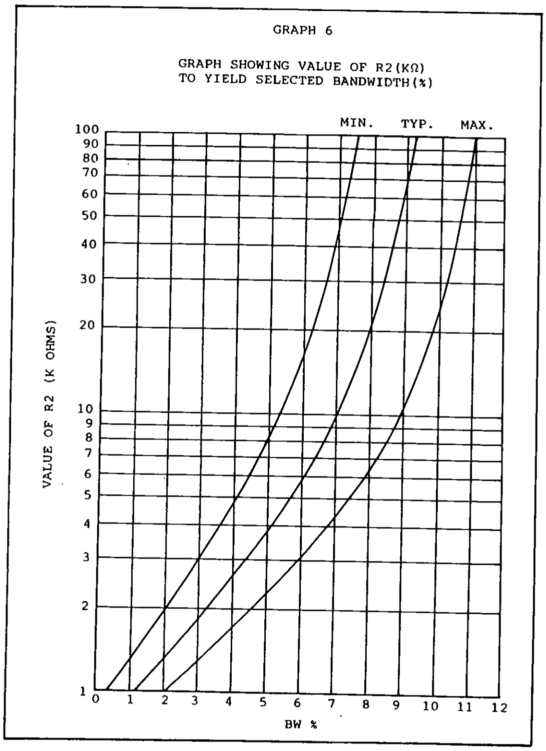
Graph number 3 shows that for a frequency of 2800Hz and a bandwidth of 6% the approximate 'Lock' time will be 9 milliseconds. Since the maximum response time is 50 milliseconds, a 'Word' time of 41 milliseconds is allowed.

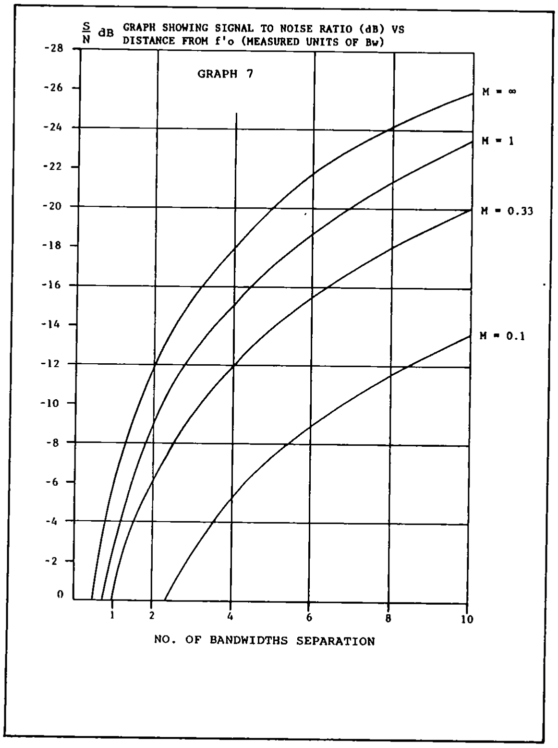





GRAPH 4
Graph showing RW required for T'word for a given signal input assuming C3A = C3B = 0.1µF. Formulae T'word = RwC3A x K(given in Graph 5.)
1M
900
800
700
600
500
400
300
200
100
RW IN K OHMS
Signal Input = 1.6V RMS
Signal Input = 800mV RMS
Signal Input = 400mV RMS
Signal Input = 200mV RMS
Signal Input = 100mV RMS
4
8
12
16
20
24
28
T'WORD IN ms


GRAPH 5
GRAPH SHOWING K FACTOR VS SIGNAL INPUT AMPLITUDE.
3.2
2.8
2.4
2.0
1.6
1.2
.8
.4
0
K FACTOR
.2
.4
6
.8
1
1.2
1.4
SIGNAL INPUT (VOLTS R.M.S.)


GRAPH 6
GRAPH SHOWING VALUE OF R2(KΩ) TO YIELD SELECTED BANDWIDTH(%)
MIN.
TYP.
MAX.
100
90
80
70
60
50
40
30
20
10
9
8
7
6
5
4
3
2
1
VALUE OF R2 (K OHMS)
0
1
2
3
4
5
6
7
8
9
10
11
12
BW %


S/N dB
GRAPH SHOWING SIGNAL TO NOISE RATIO (dB) VS DISTANCE FROM f'o (MEASURED UNITS OF Bw)
GRAPH 7
-28
-26
-24
-22
-20
-18
-16
-14
-12
-10
-8
-6
-4
-2
0
M = ∞
M = 1
M = 0.33
M = 0.1
1
2
4
6
8
10
NO. OF BANDWIDTHS SEPARATION

Graph number 4 shows that for a signal amplitude of 200mVolts, a resistor value RW of 510k ohms with a 0.1 microfarad capacitor for C3A and C3B will yield a 'Word' time of 20ms. This in turn yields a response time of 9ms + 20ms = 29ms.

Graph 6 shows the range of values for R2 to yield a given bandwidth. The exact bandwidth given by any value of R2 will vary with differing production batches. Therefore, in applications where an exact bandwidth is required, R2 should be a variable resistor which is adjusted on test.

- Worst-case signal to noise calculations depend on calculation of an "M" value using the following formula:

$$M = \frac{f'o \times Bw}{100} \times (Rw \cdot C3A)$$

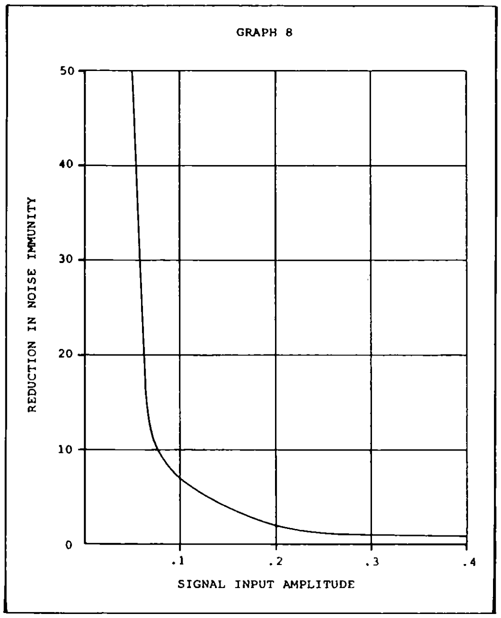
- substituting our example values:

$$\therefore M = \frac{2800 \times 6}{100} \times (0.51 m\Omega \times 0.1 \mu F)$$

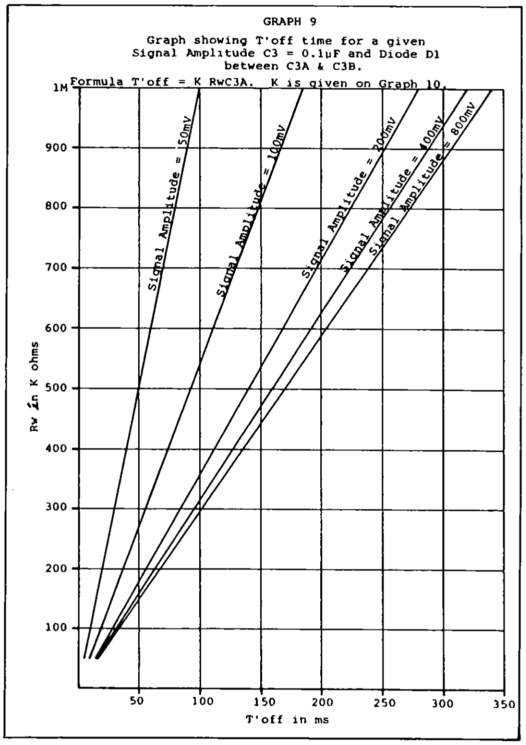
$$\therefore M = 168 \times 0.051$$

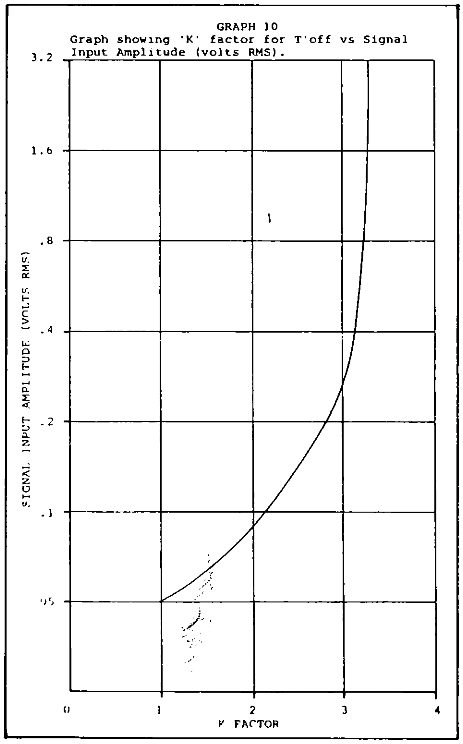
$$\therefore M \simeq 8.57$$

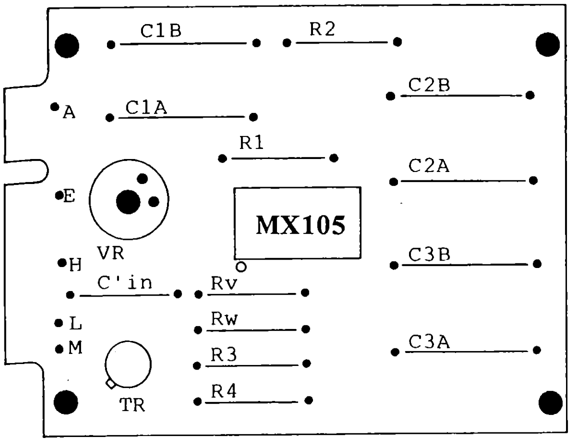
By substituting the value for M of 8.57 in graph number 7, the signal to noise ratio of an adjacent tone can be found. This then has to be decreased depending upon the tone amplitude. The figure to decrease SNR by is calculated from graph 8.



Graphs 9 and 10 show the approximate time the MX105 will take to turn off after an inband signal has been removed. The turn-off time is calculated with a diode (1N914 or similar) between pins 5 and 6, as shown in Figure 4. The effect of this diode is to greatly reduce the turn-off time with signal input amplitudes greater than 300mV R.M.S.





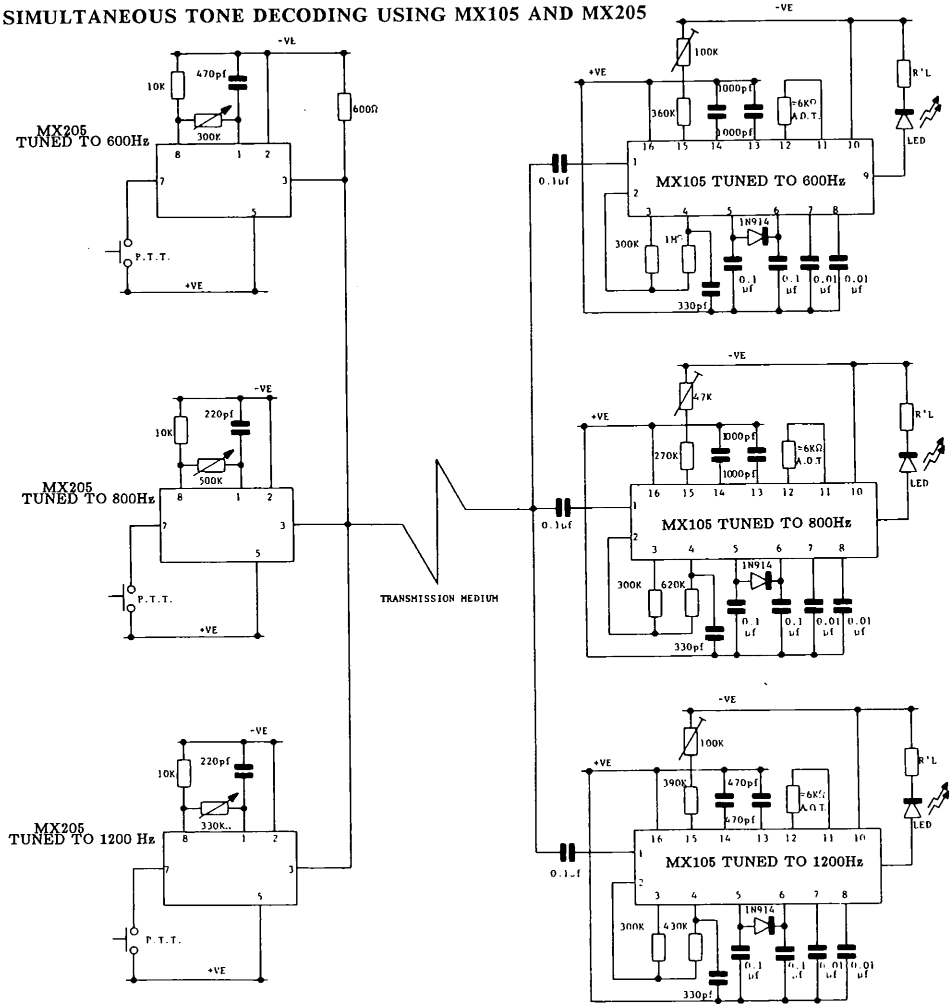


EDGE CONNECTIONS.
A = +ve
E = -ve
H = Signal Input
L = Switch Output
M = Buffer Output

To assist engineers in designing systems utilizing the MX105, MX-COM has produced a printed circuit board with the necessary external component outlines (see Fig. 5), that demonstrates a full working system. Please note there is no provision on the P.C.B. for capacitor C4 or diode D1 and it is recommended that these components are added for improved system operation.

Due to the MX105's ability to decode tones in the presence of adjacent channel tones or noise, the device is ideally suited to applications where a number of tones are sequentially or simultaneously transmitted over a common link. In the example shown in Figure 6, a number of single tone transmitters (MX205) are transmitting over a common link such as cable, radio, optical, etc., to a number of receivers (MX105). The transmitters may transmit either individually or simultaneously to the MX105s without the possibility of missing a call or receiving a false call.

FIG. 6: SIMULTANEOUS TONE DECODING USING MX105 AND MX205



MX105 ELECTRICAL SPECIFICATION

MAX. RATINGS Failure to observe may result in device damage.

MAX. VOLTAGE BETWEEN ANY PIN AND +VE SUPPLY (pin 16) .... −20V and +0.3V
OPERATING TEMPERATURE RANGE .... −30°C to +85°C
STORAGE TEMPERATURE RANGE .... −55°C to +125°C
DEVICE DISSIPATION (at 20°C ambient temperature) 400mW
MAX. OUTPUT SWITCH LOAD CURRENT 10mA

CHARACTERISTICS

Note: Due to A.C. signal coupling either supply polarity may be 'ground.'

SYMBOL	PARAMETER	NOTES	MIN.	TYP.	MAX.	UNITS
V_s	Supply voltage	Operating range	10	12	15	Volts
I_s	Supply current	Total, excluding loads		5		mA
	Signal input	Signal + noise range	0.055		5[1]	Volts R.M.S.
F'o	Channel Frequency		0.04		5	kHz
Bw	Bandwidth		2%		10%	
	O/P switch load current				10	mA
Z_{in}	Input impedance			200		k ohm
	Frequency Stability	vs T'AMB		0.02%/°C		
	Frequency Stability	Per 1% change in supply volts		0.07%		

NOTE
1. For input voltages greater than VDD × 0.143, pins 1 and 2 should be open circuit and the signal applied via C'in to the junction of RV and RW.