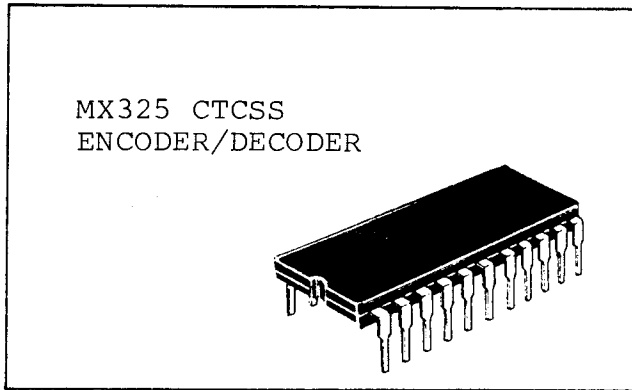


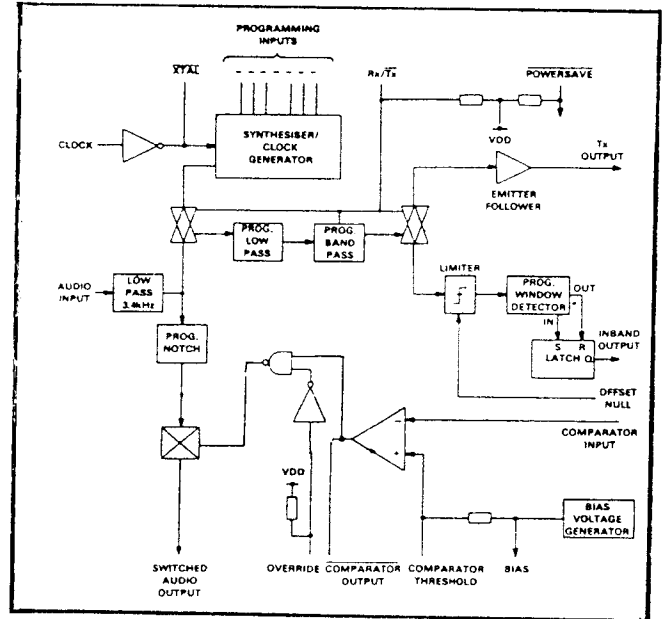
MX325
Preliminary
March 1983

CTCSS ENCODER/DECODER



Features:

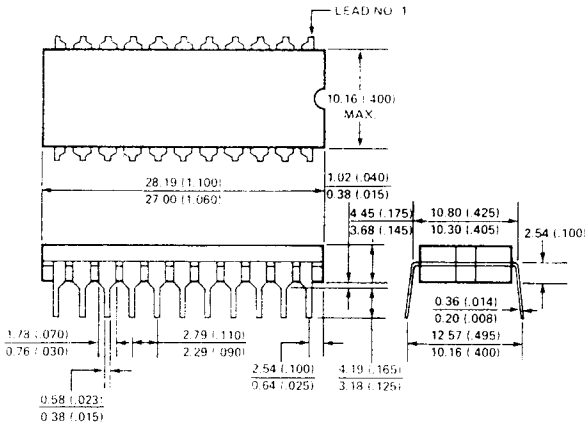
- *Low Cost
- *37 Programmable Frequencies
- *Meets or Exceeds EIA RS220A
- *Low Power CMOS
- *Less Than 2% Distortion Tx
- *Decoder Includes Programmable Notch & Band Pass Filter



The MX325 Encoder/Decoder alternately transmits or receives the standard CTCSS frequencies to effect a tone selective squelch function in 2-way radio services according to the EIA RS220-A standard. Programming the transmit tone also programs the receive tone to be detected and a notch filter that reduces the control tone's level in the speech output to the radio's audio amplifier. The audio output to the radio is internally switched by the detection of the control tone. External R C values integrate the detected tone, while others set the desired bias, sensitivity and attack/decay times. The audio switch may be overridden by a control line normally grounded through the microphone hanger, permitting the radio channel to be monitored prior to initiating a call. Another control is connected to the radio's carrier squelch. This both reduces standby power and protects the MX325 from the high level Gaussian noise associated with some unquieted FM receivers.

Physical Dimensions
22 Pin Cerdip Package

Pinout Diagram



CLOCK	1	22	Vdd
$\overline{\text{XTAL}}$	2	21	AUDIO INPUT
$\overline{\text{POWERSAVE}}$	3	20	SWITCHED AUDIO OUT
$\overline{\text{y}}$	4	19	BIAS
$\overline{\text{x}}$	5	18	OVERRIDE
$\overline{\text{8}}$	6	17	Rx/ $\overline{\text{Tx}}$
$\overline{\text{4}}$	7	16	Tx OUTPUT
$\overline{\text{2}}$	8	15	INBAND OUTPUT
$\overline{\text{1}}$	9	14	OFFSET NULL
Vss	10	13	COMPARATOR INPUT
COMP.THRESH.	11	12	COMPARATOR OUTPUT

MX325 ENCODER/DECODER: (Refer to Test Circuit, Fig. 1)

Pin Function

1,2 CLOCK, $\overline{\text{XTAL}}$: Connect to a 1MHz crystal in parallel with a 15 megohm resistor keeping leads as short as possible. As an alternative a parallel 1 megohm resistor may be used with a 33 pfd capacitor to ground from the $\overline{\text{XTAL}}$ line. In the event multiple 325's are to be operated from a common crystal connect, the subordinate devices' clock lines to the master $\overline{\text{XTAL}}$ output, reducing the value of the capacitor by 5 pfd for each subordinate unit added. If circuit traces get overly long insert a CMOS gate in the $\overline{\text{XTAL}}$ output line.

The following specifications are for typical crystals:

	AT-CUT	DT-BAR	SL-CUT
Oscillation Mode	parallel	parallel	parallel
Frequency, Nominal	1 MHz	1 MHz	1 MHz
RS	540 ohm	2000 ohm	3000 ohm
CO	7 pf	1.3 pf	3 pf
Temp Range °C	-30+85	-40+70	-30+80
Case Size	HC-18/U	HC-45/U	HC-45/U

The inherent maximum Tx error of the MX325 is 0.31%. Thus to comply with the EIA RS220A transmit tone tolerance of $\pm 0.5\%$ a worst case crystal tolerance (combining initial accuracy, temperature and aging effects) of $\pm 0.19\%$ is allowed.

- 3 $\overline{\text{POWERSAVE}}$: An input that sets the decoder into a standby condition when held lo. This disables decoding, but is automatically overridden by a transmit or manual override command. $\overline{\text{POWERSAVE}}$ is held hi or open circuit to enable decoding and is normally connected to the radio receiver's carrier squelch. Installation that exposes the MX325's input to ≥ 3 VP-P of Gaussian noise (usually only when the radio is unquieted) should use carrier detector control of the $\overline{\text{POWERSAVE}}$ to prevent falsing.
- 4-9 $\overline{\text{x,y,8,4,2,1}}$: Programming lines, all with internal 500Kohm typical pull-ups to Vdd. An all lines hi (open circuit) selects 67 Hz, an all lo 250.3 Hz. See Program Truth Table. Invalid programs produce a 4083 Hz output.
- 10 Vss

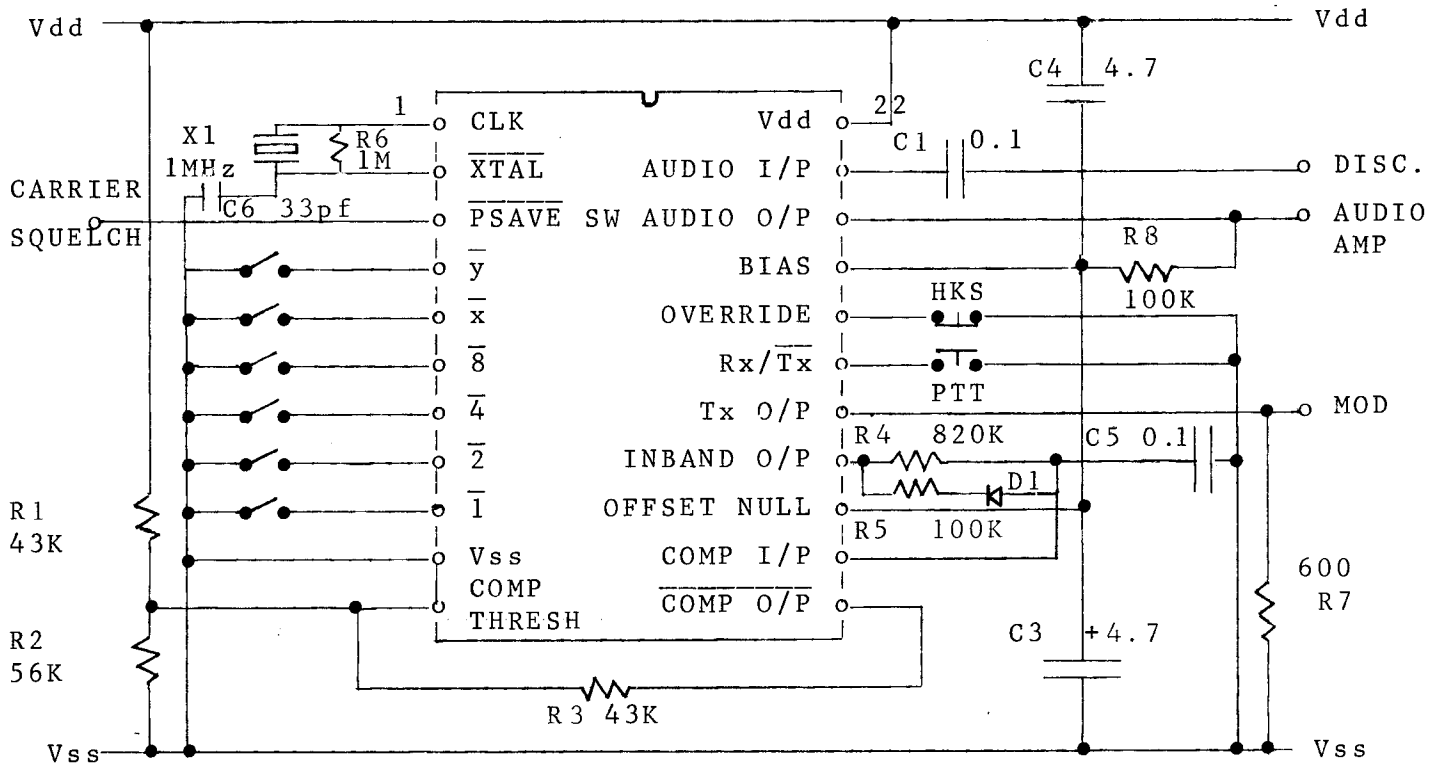
MX325 ENCODER/DECODER (CONT.):

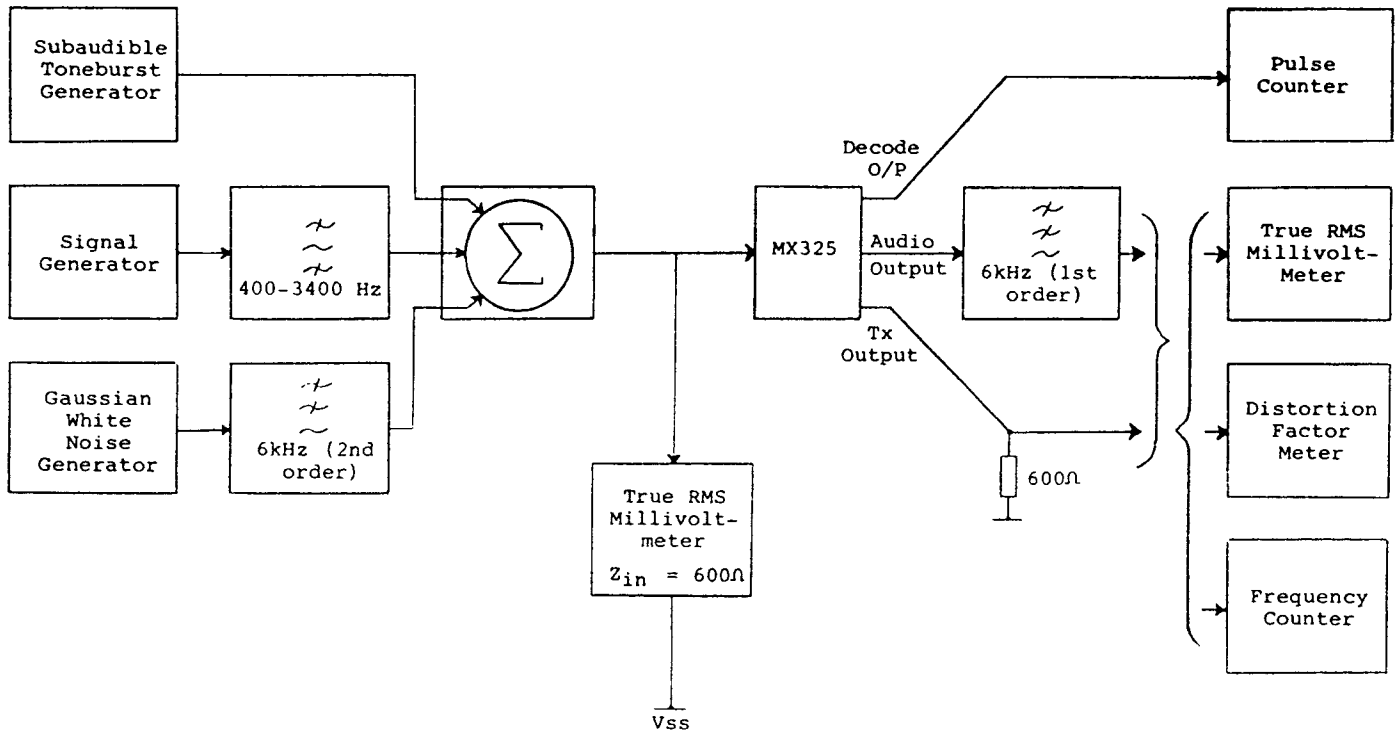
Pin	Function
11	COMPARATOR THRESHOLD: The threshold voltage at pin 11 defines the signal level needed on pin 13, the <u>COMPARATOR INPUT</u> , to activate the <u>SWITCHED AUDIO OUTPUT</u> , pin 20, and <u>COMPARATOR OUTPUT</u> , pin 12. A voltage divider formed by R1 and R2 in figure 1 sets the desired level to typically 57% of supply (without the hysteresis effect of R3 discussed below).
12	<u>COMPARATOR OUTPUT</u> : Normally hi, switches lo on detection of a CTCSS tone. A resistor, R3, is connected from pin 12 to pin 11, R1 and R2. As R3 parallels R2 when pin 12 is hi and R2 when pin 12 is lo the <u>COMPARATOR THRESHOLD</u> is being increased when no CTCSS tone is present and decreased once a tone has been detected. This hysteresis effect provides a more positive audio switching action. With no tone present the threshold voltage will be given by the ratio of: $R2: \frac{R1.R3}{R2+R3}$ (i.e. R1 parallel to R3) When a tone has been detected the ratio becomes: $\frac{R2.R3}{R2+R3}:R1$ (i.e. R2 parallel to R3) The values shown in figure 1 for R1, R2, R3 therefore yield a comparator threshold at 75% of supply before tone detection and 36% after. The <u>COMPARATOR OUTPUT</u> , pin 12 may also be used to switch external audio amplifiers or related circuits through a buffer transistor.
13	<u>COMPARATOR INPUT</u> : Requires a level derived from the <u>INBAND OUTPUT</u> (pin 15) equal to or above the threshold value established on pin 11 to cause the <u>SWITCHED AUDIO OUTPUT</u> (pin 20) and <u>COMPARATOR OUTPUT</u> (pin 12) to switch. As the <u>INBAND OUTPUT</u> (pin 15) changes rapidly this signal is integrated through R4 and C5. Deresponse is improved by discharging C5 through Diode D1 and R5.
14	<u>OFFSET NULL</u> : Sets the limiter threshold of the programmable window detector, connects directly to pin 19, bias.
15	<u>INBAND OUTPUT</u> : Is set hi if an individual period at the limiter output falls within the design bandwidth "window". The data is refreshed at the end of each period but can change rapidly due to the effects of dither created by interfering signals (voice). These logic levels are therefore integrated by R4 and C5 establishing a minimum validity period. Figure 1 shows the <u>INBAND OUTPUT</u> applied to R4 and C5 and the integral voltage taken to pin 13, the <u>COMPARATOR INPUT</u> . R5 and Diode D1 improve the deresponse performance.
16	<u>TX OUTPUT</u> : Figure 3 is representative of the Tx <u>OUTPUT</u> stage. The emitter follower can source large currents but the 10K ohm emitter resistor cannot sink large currents. Therefore, to drive a low impedance, DC couple and connect the load between this output and ground.
17	<u>Rx/Tx</u> : An input that includes a pull-up resistor establishing the receive mode, subject to the state of <u>POWERSAVE</u> input. Hold lo to <u>transmit</u> the programmed tone. Transmission forces the <u>COMPARATOR OUTPUT</u> hi and the <u>INBAND OUTPUT</u> lo to squelch the receiver and reinitialize the integration R C components.
18	<u>MANUAL OVERRIDE</u> : An input usually held lo by an external switch or microphone hanger. Opening the switch activates the <u>SWITCHED AUDIO OUTPUT</u> regardless of the <u>POWERSAVE</u> state to permit channel monitoring before calling.

MX 325 ENCODER/DECODER (CONT.):

Pin	Function
19	BIAS: Capacitor C3 to ground and C4 to VDD decouples noise from internally generated bias voltage.
20	SWITCHED AUDIO OUTPUT: The output to the audio amplifier and speaker but with the control tone attenuated, switched by the detection of tone and/or operation of the MANUAL OVERRIDE line. R8 loads this output to reduce noise pick-up when the output is high impedance. Also a 1000 pfd capacitor to ground (not shown) may be applied to help reduce any high frequency switching noise that may be present.
21	AUDIO INPUT: Normally sourced by an FM radio's discriminator, the bandwidth should be limited to less than 6 kHz and peak levels should be kept at or below 3 VP-P to prevent clipping. Capacitor C1 provides AC coupling into a 3 megohm typical input impedance. Voice signals passed through the MX325 will be attenuated 3 to 6 dB when the output is switched on, 40 dB when switched off.
22	Vdd: +4.5 to 5.5 Volts.

Figure 1. MX325 External Connections





ELECTRICAL SPECIFICATIONS

MAXIMUM RATINGS. Exceeding maximum ratings may result in device damage.						
Maximum Voltage between any pin and -ve supply:		-0.3V to 7.0V CERDIP				
Operating Temperature Range:		-30°C to +85°C				
Storage Temperature Range:		-55°C to +125°C				
Device Dissipation at 85°C:		100 mW				
ELECTRICAL CHARACTERISTICS (Vdd = 5V, T'A = 25°C, $\phi = 1$ MHz, $\Delta fo = 0$)						
Symbol	Static Characteristics	Min	Typ	Max	Units	Conditions
Vdd	Supply Voltage	4.5	5.0	5.5	Volts	Vss = 0V
Idd	Supply Current Tx		3.5		mA	Excludes output current
	Rx		2.5		mA	
	Stby		0.6		mA	
Voh	Logic output "1"	4.0			Volts	I source 100 μ A
Vol	Logic output "0"			1.0	Volts	I sink 100 μ A
Vih	Logic input "1"	3.5			Volts	
Vil	Logic input "0"			1.5	Volts	
Rp	Internal pull-up		500		< ohms	

ELECTRICAL SPECIFICATIONS

Symbol	Encoder Characteristics	Min	Typ	Max	Units	Conditions
Vout	Tx Output	-3	0		dBm	RL = 600 Ω, CL = 15pf
Iout	Load Current			5	mA	
Thdtx	Tx distortion		2	5	%	RL = 600 Ω, CL = 15pf
Tr	Tx rise fo>100Hz To 90% fo<100Hz		15 45		ms ms	RL = 600 Ω, CL = 15pf
Vout Δ	Tone/Tone Lev.Var		0.1		dB	RL = 600 Ω, CL = 15pf

Decoder Characteristics (Prob.= 0.98 for 100Hz > fo > 67Hz, T = 100 + fo(1+z) x 250 MS)

Bw	Tone Decoder bandwidth	±0.3		±3	% fo	Any programmed tone
Vsig min				40	mVRMS	1kHz present @ 320 mV
Tr	Response fo>100Hz Time fo = 67Hz			250 373	ms ms	1kHz present @ 320 mV CTCSS Tone @ 80 mV
Td	Deresponse Time fo > 100Hz fo = 67Hz			250 373	ms ms	1kHz present @ 320 mV CTCSS Tone @ 80 mV

Symbol	Audio Path Characteristics	Min	Typ	Max	Units	Conditions
Zin	Input Impedance		3		M ohm	
Zout	Output Impedance		3		K ohm	
Thdrx	Speech Path Distortion		2	5	%	300-3400 Hz Range 387.5 mV < Vin < 1550 mV
Tone In:Out	Notch Filter Attenuation	-18	-23		dB	0 to 250.3 Hz @ -6dBm
N Open	Hum & Noise w/Audio unmuted		4	8	mV	Signal Input A.C. Coupled to Ground
N Mute	Hum & Noise w/Audio muted			1.5	mV	1kHz Vin Present at 387.5 mV

NOTE: All AC levels true RMS, 0 dBm = 775 mV into 600 ohms, all AC measurements in 0 to 6 kHz bandwidth.

PROGRAM TRUTH TABLE

Logic 1 = Vdd, Logic 0 = Vss
 Programming inputs are internally pulled to Vdd
 XTAL=1MHz

#	EIA Specification		MX325 Output Frequency	MX325 Δ %	-	-	-	-	-	-
	Group	Hz			x	y	1	2	4	8
1	A	67.0	67.05	+0.075	1	1	1	1	1	1
2	B	71.9	71.90	-	1	0	1	1	1	1
3	C	74.4	74.35	-.072	1	1	0	1	1	1
4	A	77.0	76.96	-.047	0	0	1	1	1	1
5	C	79.7	79.77	+0.092	1	1	1	0	1	1
6	B	82.5	82.59	+0.104	1	0	0	1	1	1
7	C	85.4	85.38	-.021	1	1	0	0	1	1
8	A	88.5	88.61	+0.127	0	0	0	1	1	1
9	C	91.5	91.58	+0.091	1	1	1	1	0	1
10	B	94.8	94.76	-.043	1	0	1	0	1	1
11	A	100.0	99.96	-.040	0	0	1	0	1	1
12	B	103.5	103.43	-.069	1	0	0	0	1	1
13	A	107.2	107.15	-.050	0	0	0	0	1	1
14	B	110.9	110.77	-.121	1	0	1	1	0	1
15	A	114.8	114.64	-.140	0	0	1	1	0	1
16	B	118.8	118.80	-	1	0	0	1	0	1
17	A	123.0	122.80	-.165	0	0	0	1	0	1
18	B	127.3	127.08	-.173	1	0	1	0	0	1
19	A	131.8	131.67	-.096	0	0	1	0	0	1
20	B	136.5	136.61	+0.082	1	0	0	0	0	1
21	A	141.3	141.32	+0.016	0	0	0	0	0	1
22	B	146.2	146.37	+0.116	1	0	1	1	1	0
23	A	151.4	151.09	-.204	0	0	1	1	1	0
24	B	156.7	156.88	-.111	1	0	0	1	1	0
25	A	162.2	162.31	+0.068	0	0	0	1	1	0
26	B	167.9	168.14	+0.141	1	0	1	0	1	0
27	A	173.8	173.48	-.187	0	0	1	0	1	0
28	B	179.9	180.15	+0.137	1	0	0	0	1	0
29	A	186.2	186.29	+0.047	0	0	0	0	1	0
30	B	192.8	192.86	+0.033	1	0	1	1	0	0
31	A	203.5	203.65	+0.071	0	0	1	1	0	0
32	B	210.7	210.17	-.251	1	0	0	1	0	0
33	A	218.1	218.58	+0.219	0	0	0	1	0	0
34	B	225.7	226.12	+0.184	1	0	1	0	0	0
35	A	233.6	234.19	+0.253	0	0	1	0	0	0
36	B	241.8	241.08	-.298	1	0	0	0	0	0
37	A	250.3	250.28	-.007	0	0	0	0	0	0

Specifications Subject to change.