MX275

Preliminary Information

January 1994

MX·COM, INC.

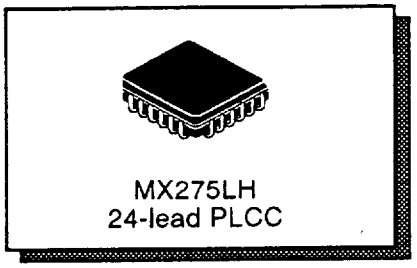
DATA BULLETIN

Low Voltage *Pvt* SQUELCH™ CTCSS Encoder/Decoder

SIX SIGMA BASED

Features

- MX•COM MiXed SIGNAL CMOS
- PRIVATE/CLEAR CAPABILITY
- ON-CHIP TX AUDIO PRE-/DE-EMPHASIS
- POWERSAVE OPTION
- ALTERNATIVE TO STANDARD CTCSS "PARTY LINE"
- LOW VOLTAGE
- MEETS TIA/EIA-603 LAND MOBILE RADIO STANDARD



MX275LH
24-lead PLCC

Applications

- MOBILE RADIOS
- COMMUNITY REPEATERS
- TELEPHONE/RADIO INTERCONNECT SYSTEMS
- SPORT RADIOS
- SERVES 2-CELL APPLICATIONS

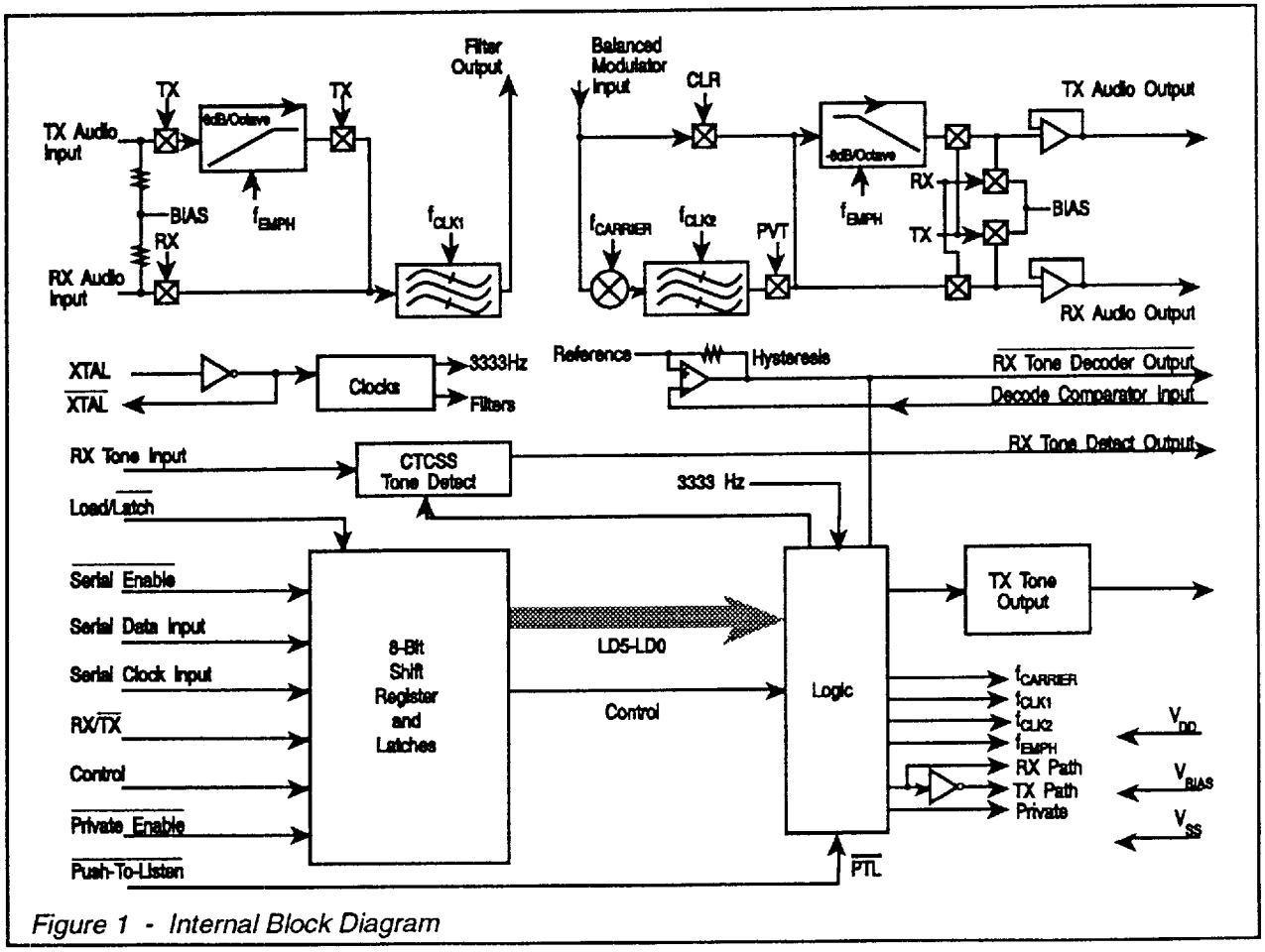


Figure 1 - Internal Block Diagram

Description

The MX275 is a CMOS LSI microcircuit which combines CTCSS Encode/Decode operation with voice band frequency inversion. Frequency inversion is achieved by modulating the input audio with a 3333 Hz carrier frequency. Higher voice band frequencies are translated downward, and lower frequencies upward, resulting in a "mirror image" voice transmission.

The MX275 features:

1) Serial tone programming capability,
2) The ability to operate under NOTONE conditions,
3) On-chip TX and RX audio filtering,
4) Pin-selectable Private/Clear operation, and
5) Pre-/de-emphasis filters in the TX path, for optimal recovered audio quality.

The MX275 is fabricated using a special low-voltage CMOS process. It is offered in a 24-pin PLCC package and requires a minimum of external support components.

What is *Pvt* SQUELCH ?

Pvt SQUELCH™ combines CTCSS with inverted speech to prevent users from understanding each other's communications unless the transmissions are accompanied by the group's assigned tone. Its net effect is to eliminate casual eavesdropping and give mobile radio users a certain degree of privacy at a minimal price. Up to 38 *Pvt* SQUELCH user groups (one per CTCSS tone) can share a single radio channel. With *Pvt* SQUELCH, competing businesses can share a radio channel without compromising communications security.

Application Notes

Pre- and de-emphasis (6dB/octave) filters are included on-chip in the transmit path, so that the use of this device will produce natural sounding audio (clear or private modes) when installed in modern radio communication transceivers, with or without existing audio processing circuitry. The recommended layout is shown in block form below.

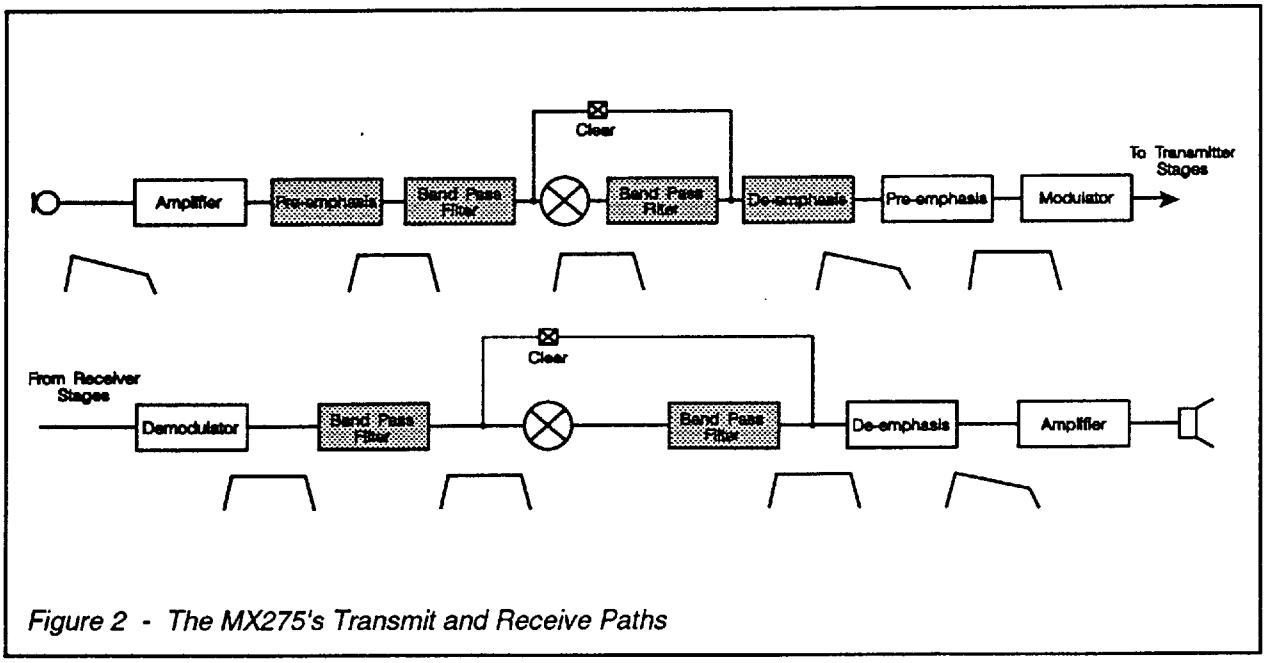


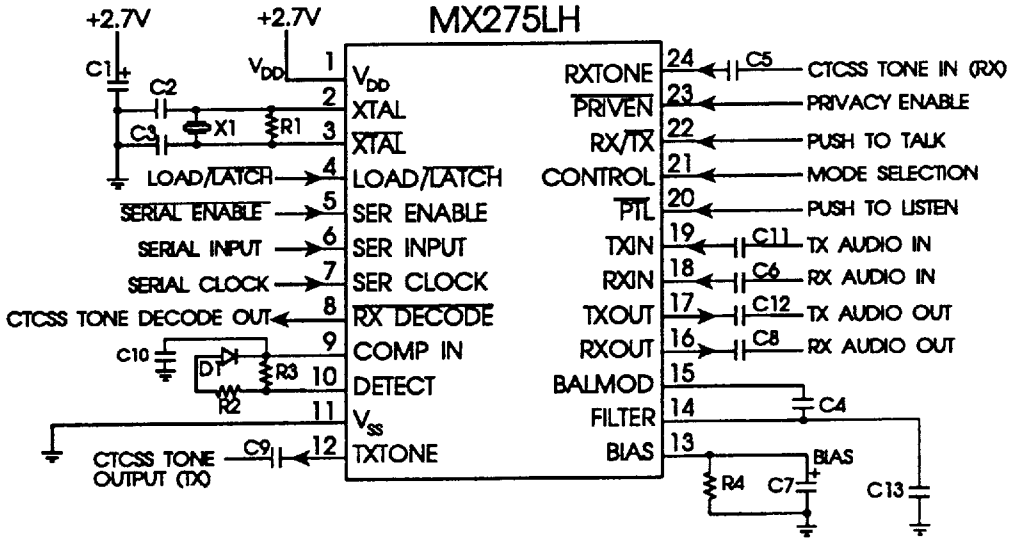
Figure 2 - The MX275's Transmit and Receive Paths

Pin Function Chart

Pin	Function
1	V_{DD}: The positive 2.7V supply pin.
2	**XTAL/CLOCK**: This is the input to the clock oscillator inverter. An external 4 MHz xtal or clock input should be applied to this pin.
3	**$\overline{\text{XTAL}}$**: This is the 4 MHz output of the clock oscillator inverter.
4	**LOAD/$\overline{\text{LATCH}}$**: This input controls the eight input latches: RX/$\overline{\text{TX}}$, $\overline{\text{Private Enable}}$, and D0-D5, as detailed in Table 2(a). Alternatively, the RX/$\overline{\text{TX}}$ and $\overline{\text{Private Enable}}$ inputs can be addressed separately by setting the Load/$\overline{\text{Latch}}$ and Control inputs as shown in Table 2(b). 1 MΩ pullup.
5-7	**Programming Inputs**: These are the RX/$\overline{\text{TX}}$ tone programming and function inputs which enable the serial programming mode. With Load/$\overline{\text{Latch}}$ at logic "0" data is loaded in the following sequence: D5, D4, D3, D2, D1, D0, RX/$\overline{\text{TX}}$, $\overline{\text{Private Enable}}$. When these 8 bits have been clocked in on the rising clock edge, data is latched by strobing the Load/$\overline{\text{Latch}}$ input "0 - 1 - 0" (See Figure 4). Pin 5 = $\overline{\text{Serial Enable}}$ Pin 6 = Serial Data Input Pin 7 = Serial Clock Input
8	**$\overline{\text{RX TONE DECODE}}$**: The gated output of the decode comparator. In RX, a logic "0" indicates a valid CTCSS tone decode condition, or the presence of NOTONE programming. A logic "0" enables the RX audio path. In TX this output is held at logic "1."
9	**DECODE COMPARATOR**: The voltage level at this pin is compared internally with a fixed reference level. A greater input level compared to the reference will result in a logic "0" at the RX Tone Decode output. This input should be externally connected to the RX Tone Detect output via external integration components C_7, R_2, R_3, and D_1 (see Figure 3).
10	**RX TONE DETECT**: In RX, this pin outputs a logical "1" when a valid programmed CTCSS tone is received at the RX TONE INPUT. This input should be externally connected to the Decode Comparator input via external integration components C_{10}, R_2, R_3, and D_1 (see Figure 3).
11	V_{SS}: The negative supply pin (ground).
12	**TX TONE OUTPUT**: The buffered CTCSS sinewave tone output appears on this pin. In TX mode, the tone frequency is selected by program code (see Table 1); if NOTONE is programmed, the output is at V_{BIAS}-0.7V. In RX mode, the output goes open circuit. This is an emitter follower output with an internal 10 kΩ load.
13	**BIAS**: This pin is set internally to approximately $V_{DD}/2$. It must be externally decoupled using a capacitor (C_7) to V_{SS}. See Figure 3.
14	**FILTER OUTPUT**: This is the output of the Input Audio Bandpass Filter. It must be A.C. coupled to the Balanced Modulator Input via capacitor C_4. See Figure 3.
15	**BALANCED MODULATOR INPUT**: This is the input to the balanced modulator. It must be A.C. coupled to the Filter Output via capacitor C_4. See Figure 3.

Pin Function Chart

Pin	Function
16	**RX AUDIO OUTPUT:** Outputs the received audio from a buffered output stage and is held at V_{BIAS} when in TX.
17	**TX AUDIO OUTPUT:** Outputs the transmitted audio in TX. In RX, this pin is held at V_{BIAS}.
18	**RX AUDIO INPUT**: The audio input for the RX mode. Input signals should be AC coupled via external capacitor C_6. See Figure 3.
19	**TX AUDIO INPUT:** This is the TX Audio voice input. Signals should be AC coupled via external capacitor C_{11}. See Figure 3.
20	**$\overline{\text{PTL}}$**: The "press to listen" function input. In RX mode, a logic "0" enables the RX Audio Output directly, overriding tone squelch but not intercepting a private conversation; in TX mode, a logic "0" reverses the phase of the TX Tone Output for "squelch tail" reduction (see Table 2).
21	**CONTROL:** This input, together with Load/$\overline{\text{Latch}}$, selects the operational mode of the RX/$\overline{\text{TX}}$ and $\overline{\text{Private Enable}}$ functions. See Table 2(b).
22	**RX/$\overline{\text{TX}}$**: This input selects the RX or TX mode (RX = 1, TX = 0). See Table 2.
23	**$\overline{\text{PRIVATE ENABLE}}$**: This input selects either Private or Clear mode (Clear = 1, Private = 0), and is loaded as described in Table 2. This input has an internal 1 MΩ pullup resistor.
24	**RX TONE INPUT**: This is the received audio input to the on-chip CTCSS tone decoder. It should be A.C. coupled via capacitor C_5.



COMPONENT VALUES

R1 = 1MΩ	C1 = 1µF	C6 = 0.1µF	C11 = 0.1µF
R2 = 560kΩ	C2 = 33pF	C7 = 1µF	C12 = 0.1µF
R3 = 820kΩ	C3 = 33pF	C8 = 0.1µF	C13 = 0.001µF
R4 = 560kΩ	C4 = 0.1µF	C9 = 0.1µF	D1 = small signal
X1 = 4MHz	C5 = 0.1µF	C10 = 0.1µF	

Tolerances: Resistors: ±10% Capacitors: ±20%

XTAL: At cut, fundamental, parallel resonant 20pF load capacitance, 0.05% tolerance

Figure 3 - External Component Connections

CTCSS PROGRAMMING TABLE

TIA/EIA-603 Nominal Frequency(Hz)	Frequency (Hz)	Δ f_o (%)	Programming Inputs D5	D4	D3	D2	D1	D0	HEX
67.0	67.05	+0.07	1	1	1	1	1	1	3F
71.9	71.9	0	0	1	1	1	1	1	1F
74.4	74.35	-0.07	1	1	1	1	1	0	3E
77.0	76.96	-0.5	0	0	1	1	1	1	0F
79.7	79.77	+0.09	1	1	1	1	0	1	3D
82.5	82.59	+0.1	0	1	1	1	1	0	1E
85.4	85.38	-0.2	1	1	1	1	0	0	3C
88.5	88.61	+0.13	0	0	1	1	1	0	0E
91.5	91.58	+0.09	1	1	1	0	1	1	3B
94.8	94.76	-0.04	0	1	1	1	0	1	1D
97.4	97.29	-0.11	1	1	1	0	1	0	3A
100.0	99.96	-0.04	0	0	1	1	0	1	0D
103.5	103.43	-0.07	0	1	1	1	0	0	1C
107.2	107.15	-0.05	0	0	1	1	0	0	0C
110.9	110.77	-0.12	0	1	1	0	1	1	1B
114.8	114.64	-0.14	0	0	1	0	1	1	0B
118.8	118.8	0	0	1	1	0	1	0	1A
123.0	122.8	-0.17	0	0	1	0	1	0	0A
127.3	127.08	-0.17	0	1	1	0	0	1	19
131.8	131.67	-0.10	0	0	1	0	0	1	09
136.5	136.61	+0.08	0	1	1	0	0	0	18
141.3	141.32	+0.02	0	0	1	0	0	0	08
146.2	146.37	+0.12	0	1	0	1	1	1	17
151.4	151.09	-0.2	0	0	0	1	1	1	07
156.7	156.88	+0.11	0	1	0	1	1	0	16
162.2	162.31	+0.07	0	0	0	1	1	0	06
167.9	168.14	+0.14	0	1	0	1	0	1	15
173.8	173.48	-0.19	0	0	0	1	0	1	05
179.9	180.15	+0.14	0	1	0	1	0	0	14
186.2	186.29	+0.05	0	0	0	1	0	0	04
192.8	192.86	+0.03	0	1	0	0	1	1	13
203.5	203.65	+0.07	0	0	0	0	1	1	03
210.7	210.17	-0.25	0	1	0	0	1	0	12
218.1	218.58	+0.22	0	0	0	0	1	0	02
225.7	226.12	+0.18	0	1	0	0	0	1	11
233.6	234.19	+0.25	0	0	0	0	0	1	01
241.8	241.08	-0.30	0	1	0	0	0	0	10
250.3	250.28	-0.01	0	0	0	0	0	0	00
Notone			1	1	0	0	0	0	30

Table 1 - CTCSS Programming Chart

(A)Explanation of Load/Latch function

Load Configuration	Load/$\overline{\text{Latch}}$	Result
Data loading	0	No change while serial data train is loaded
Data loaded	0 - 1 - 0	Loaded serial data is latched

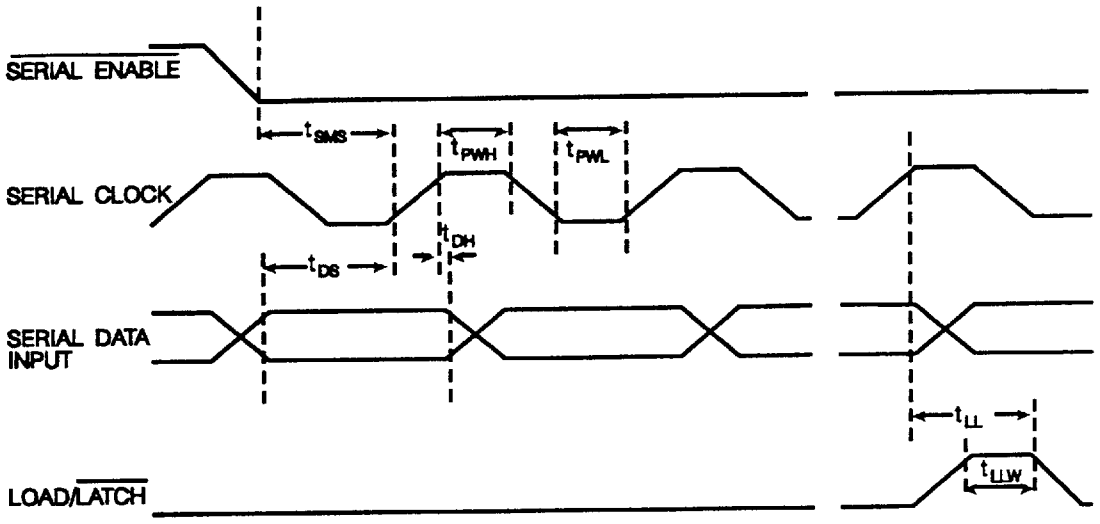
(B) Explanation of Control Input

Load Configuration	Load/$\overline{\text{Latch}}$	Control	RX/$\overline{\text{TX}}$, $\overline{\text{Private Enable}}$
Serial Control Input	0 - 1 - 0	0	Serial Load
Serial Control Input	X	1	Transparent

Notes: "0 - 1 - 0" is a strobe pulse as shown in Figures 4 and 5 (Timing).
"X" denotes any logical state.

Table 2 - Load/$\overline{\text{Latch}}$ and Control Functions

Control instructions are input to the MX275 by serial means, using Data Inputs and Load/Latch as shown below.



	Min.	Typ.	Max.	Unit
Serial Mode Enable Set Up Time (t_{SMS})	250	-	-	ns
Clock "High" Pulse Width (t_{PWH})	250	-	-	ns
Clock "Low" Pulse Width (t_{PWL})	250	-	-	ns
Data Set Up Time (t_{DS})	150	-	-	ns
Data Hold Time (t_{DH})	50	-	-	ns
Load/Latch Set Up Time (t_{LL})	250	-	-	ns
Load/Latch Pulse Width (t_{LLW})	150	-	-	ns

Figure 4 - Serial Load Timing

D0-D5	NOTONE	RX/TX	PRIVATE ENABLE	PTL	RXTONE DETECT	RXTONE DECODER	TONE OUTPUT	TONE PHASE	TX PATH	RX PATH	PATH STATE	TONE
TONE	1	0	0	1	0	1	YES	0°	OPEN	BIAS	INV	TX, TONE
TONE	1	0	0	0	0	1	YES	180°	OPEN	BIAS	INV	TX, TONE REV
NOTONE	0	0	0	X	0	1	BIAS	X	OPEN	BIAS	CLR	TX, NOTONE
TONE	1	1	0	1	0	1	BIAS	X	BIAS	BIAS	X	INCOMPATIBLE
TONE	1	1	0	0	0	1	BIAS	X	BIAS	OPEN	CLR	INCOMPATIBLE
TONE	1	1	0	X	1	0	BIAS	X	BIAS	OPEN	INV	COMPATIBLE
NOTONE	0	1	0	X	X	0	BIAS	X	BIAS	OPEN	CLR	RX, NOTONE
TONE	1	0	1	1	0	1	YES	0°	OPEN	BIAS	CLR	TX, TONE
TONE	1	0	1	0	0	1	YES	180°	OPEN	BIAS	CLR	TX, TONE REV
NOTONE	0	0	1	X	0	1	BIAS	X	OPEN	BIAS	CLR	TX, NOTONE
TONE	1	1	1	1	0	1	BIAS	X	BIAS	BIAS	X	INCOMPATIBLE
TONE	1	1	1	0	0	1	BIAS	X	BIAS	OPEN	CLR	INCOMPATIBLE
TONE	1	1	1	X	1	0	BIAS	X	BIAS	OPEN	CLR	COMPATIBLE
NOTONE	0	1	1	X	X	0	BIAS	X	BIAS	OPEN	CLR	RX, NOTONE

ALGEBRAIC FUNCTIONS:
RX PATH ON = RX* (PTL + RX TONE DECODER)
CLEAR PATH = NOTONE + PRIVATE ENABLE + (PTL RX TONE DECODER)
NOTONE (D0-D5) = 000011
CARRIER FREQUENCY = 3333Hz DURING INVERTED PATH(TX or RX)

NOTES: 1. The Pre- and De-emphasis circuits remain in the transmit path in both Clear and Invert modes.
2. Power remains applied to the CTCSS tone decoder at all times.
3. During Clear operation the carrier frequency is turned off to reduce spurious emissions.

Table 4 - Functions and Outputs

Audio Passband Characteristics

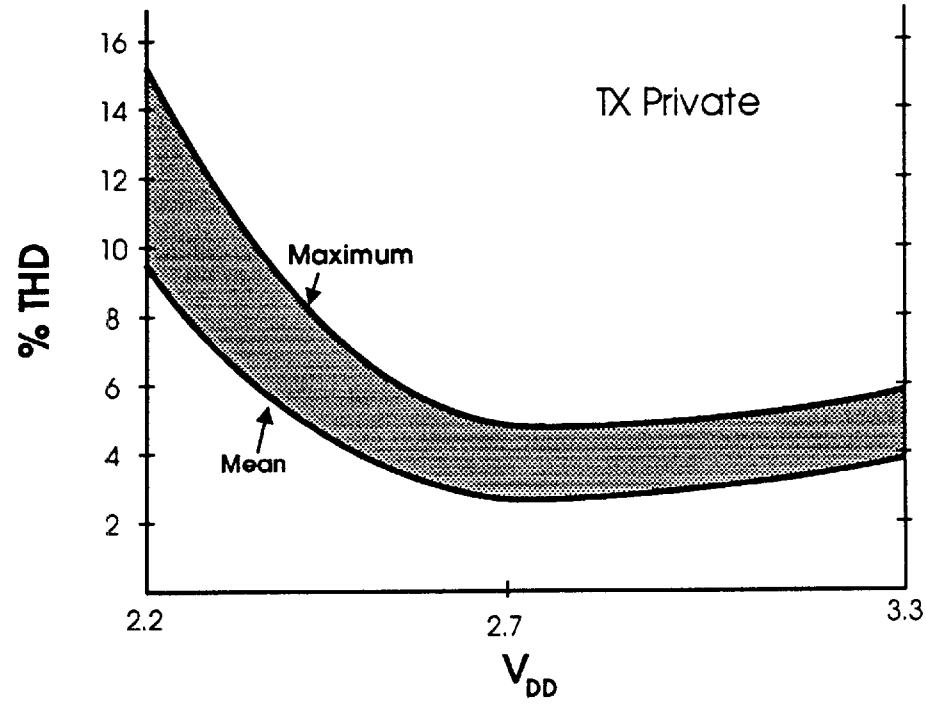


Figure 5 - %THD vs. V_{DD} when Transmitting Inverted Audio

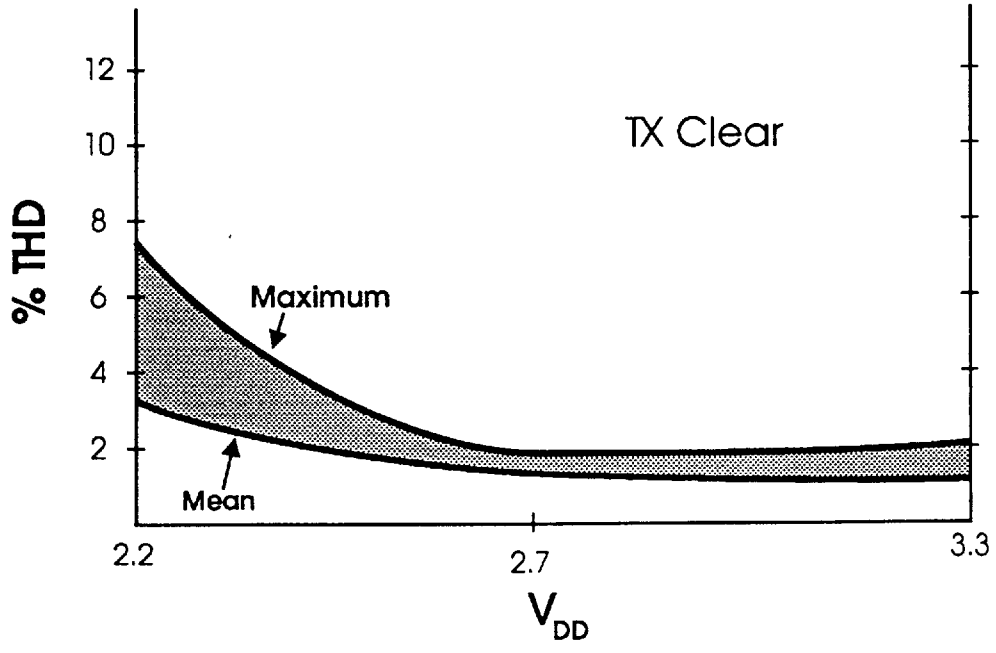


Figure 6 - %THD vs. V_{DD} when Transmitting Clear Audio

Audio Passband Characteristics

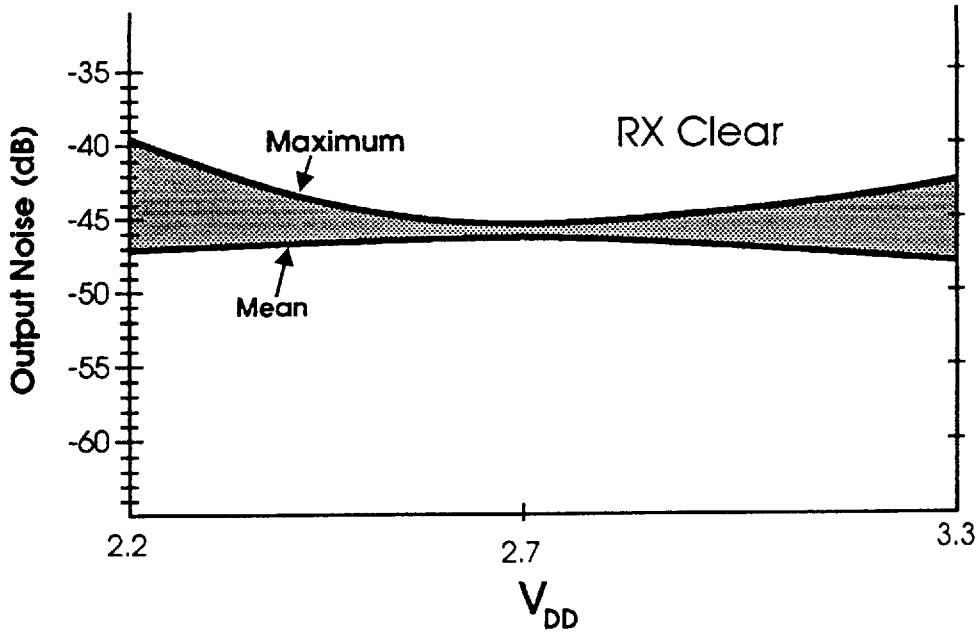


Figure 7 - Output Noise vs. V_{DD} when Receiving Clear Audio

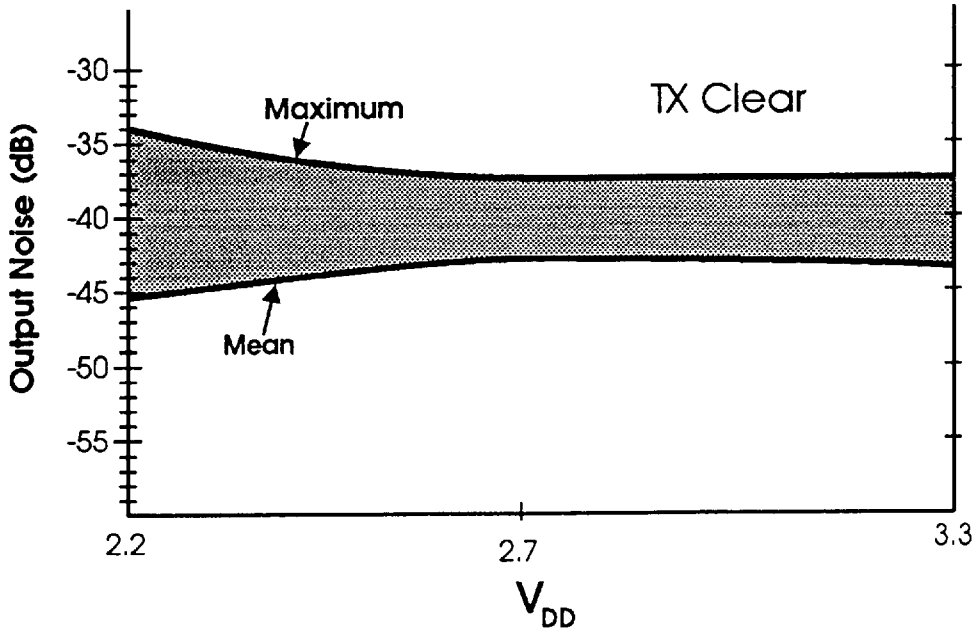


Figure 8 - Output Noise vs. V_{DD} when Transmitting Clear Audio

Specifications

Absolute Maximum Ratings

Exceeding the maximum rating can result in device damage. Operation of the device outside the operating limits is not suggested.

Supply Voltage	-0.3 to 4.0 V
Input Voltage at any pin	-0.3V to (V_{DD} + 0.3 V)
Sink/Source Current	
(Supply pins)	±30 mA
(Other pins)	±20 mA
Total Device Dissipation @ T_{AMB} 25°C	800 mW max.
Derating	10 mW/°C
Operating Temperature	-15°C to +60°C
Storage Temperature	-55°C to +125°C

Operating Limits

All devices were measured under the following conditions unless otherwise noted.

V_{DD}	2.7V
T_{AMB}	25°C
Xtal/Clock f_0	4.0 MHz
Audio level 0dB ref	250 mVrms

Composite input signal = 300 mVrms, 1 kHz tone in, 75 mVrms (6 kHz band limited) gaussian noise, and a 30 mVrms CTCSS tone.

Characteristics	Note	Min.	Typ.	Max.	TIA/EIA -603	Unit
Static Values						
Supply Voltage		2.2	2.7	3.2	-	V
Supply Current						
TX (Operating)		-	5.0	10.0	-	mA
RX (Operating)		-	2.3	4.6	-	mA
RX Standby (No Decode)		-	1.5	4.0	-	mA
Analog Input Impedance			175	-	-	kΩ
Analog Output Impedance		-	0.75	-	-	kΩ
Tone Input Impedance		-	0.6	-	-	MΩ
Tone Output Impedance	2	-	1.50	-	-	kΩ
Input Logic "1"		70% V_{DD}	-	-	-	V
Input Logic "0"		-	-	30%V_{DD}	-	V
Output Logic "1" (I=-0.1mA)		80%V_{DD}	-	-	-	V
Output Logic "0" (I=-0.1mA)		-	-	20%V_{DD}	-	V
Dynamic Values						
Decoder						
Input Signal Level	1,4	30	-	-	-	mVrms
Response Time	1,4,5	-	-	250	250	ms
Deresponse Time	1,4,5	-	-	250	250	ms
Selectivity	12	±0.5	-	-	±0.5	%f_0
Encoder						
Tone Output Level (at V_{DD}=2.7V)	10	325	400	-	-	mVrms
Tone Output Level (over total V_{DD} range)	9,10	140	400	-	-	mVrms
Tone Frequency Accuracy		-0.3	-	+0.3	-	%f_0
Tone Harmonic Distortion	11	-	2.7	8	-	%
Output Level Variation between Tones	8	-1.0	-	1.0	-	dB
Risetime (to 90% nominal level)						
(f_0>100 Hz)		-	15	-	150	ms
(f_0<100 Hz)		-	45	-	150	ms
RX Clear						
Total Harmonic Distortion	3	-	4	8	-	%
AC Short Circuit Output Noise Level	6	-	2.5	-	-	mVrms
Passband		300	-	3000	-	Hz
Passband Gain	3	-1.5	0	+0.5	-	dB
Passband Ripple (500-2500Hz)	13	-	-	3	-	dB
Audio Stopband Attenuation						
(f_{in}>3333Hz)		-	-20	-	-	dB
(f_{in}>3633Hz)		-	-45	-	-	dB
(f_{in}<250Hz)		-	-42	-	-	dB

Characteristics	Note	Min.	Typ.	Max.	TIA/EIA -603	Unit
RX Private						
Total Harmonic Distortion	3,7	-	8	12	-	%
Baseband Breakthrough	3		-38	-	-	dB
Carrier Breakthrough	3	-	-44	-	-	dB
AC Short Circuit Output Noise Level	6,7	-	2.5	-	-	mVrms
Passband Ripple (500-2500Hz)	3	-	+1/-2	-	-	dB
Audio Stopband Attenuation						
(f_{in}>3333Hz)	7	-	-50	-	-	dB
(f_{in}>3633Hz)	7	-	-60	-	-	dB
(f_{in}<250Hz)	7	-	-60	-	-	dB
TX Clear						
Total Harmonic Distortion	3	-	5	10	-	%
AC Short Circuit Output Noise Level	6	-	4.5	-	-	mVrms
Passband	3	300	-	3000	-	Hz
Passband Gain	3	-1	-	+1	-	dB
Passband Ripple (500-2500Hz)	3,13	-3	-	+1	-	dB
Audio Stopband Attenuation						
(f_{in}>3333Hz)		-	-20	-	-	dB
(f_{in}>3633Hz)		-	-45	-	-	dB
(f_{in}<250Hz)		-	-42	-	-	dB
TX Private						
Total Harmonic Distortion	3,7	-	8	12	-	%
Baseband Breakthrough	3		-38	-	-	dB
Carrier Breakthrough	3	-	-54	-	-	dB
AC Short Circuit Output Noise Level	6,7	-	4.5	-	-	mVrms
Passband Ripple (500-2500Hz)	3	-	+1/-2	-	-	dB
Audio Stopband Attenuation						
(f_{in}>3333Hz)	7	-	-50	-	-	dB
(f_{in}>3633Hz)	7	-	-60	-	-	dB
(f_{in}<250Hz)	7	-	-60	-	-	dB

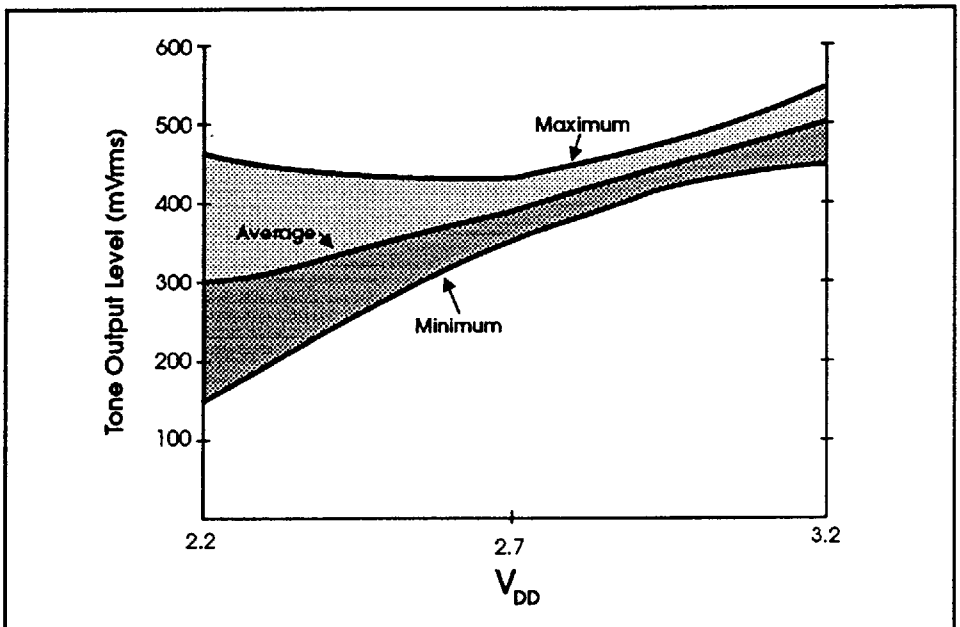


Figure 9 - Tone Output Level vs. Supply Voltage

NOTES:

1. These values are obtained using the external integrating components given in Figure 3.
2. An emitter follower output
3. With an input signal of 1 kHz @ 0dB.
4. Under Composite Signal test conditions.
5. f_o > 100 Hz, (for 100Hz > f_o > 67Hz: t = [100/f_o(Hz)] x 250ms).
6. Input ac short-circuit, audio path enabled.
7. Due to frequency inversion, these figures reflect the sum of the attenuation due to the filter rolloff and the baseband suppression.
8. Reference 127.08 Hz.
9. The tone output level varies with V_{DD}, ie. when V_{DD} is 2.2V the tone output level will be lower than when V_{DD} is 3.2V.
10. See Figure 9.
11. See Figure 10.
12. Complies with TIA/EIA-603 -- must not decode adjacent f_o ±0.5%.
13. <6dB roll-off per octave, less than 500 Hz and greater than 2500 Hz per TIA/EIA-603

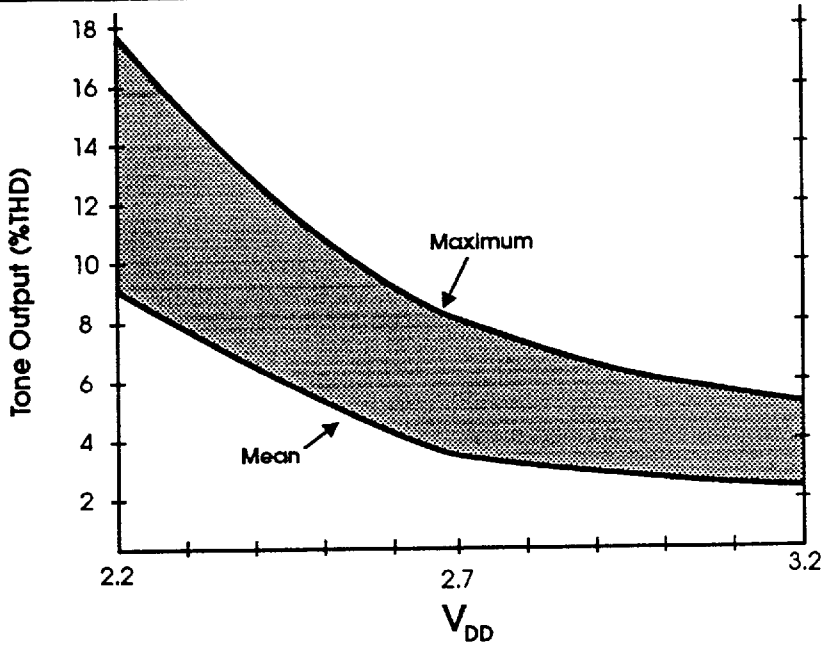
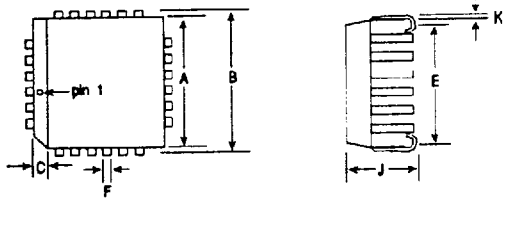


Figure 10 - Tone Output % Total Harmonic Distortion vs. Supply Voltage

Package Information

The MX275 24-lead Plastic Leaded Chip Carrier package is shown in Figure 11. For identification purposes it has an ident spot adjacent to pin 1 and a chamfered corner between pins 3 & 4.

Figure 11 - MX275LH PLCC-24



Package Tolerances

Dimension in.(mm)	Min.	Max.
A	.382 (9.70)	.410 (10.40)
B	.417 (10.60)	.435 (11.05)
C	.045 (1.15)x45°	typical
D	.050 (1.27)	typical
E	.366 (9.30)	typical
F	.018 (0.45)	.022 (0.55)
H	.250 (6.35)	typical
J	.128 (3.25)	.146 (3.70)
K	.007 (0.17)	.011 (0.27)

Handling Precautions

The MX275 is a CMOS LSI circuit which includes input protection. However, precautions should be taken to prevent static discharges which may cause damage.