MX·COM, INC.

Preliminary Information

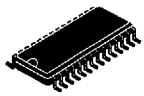
MX836

C-BUS COMPATIBLE

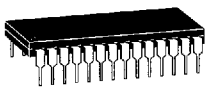
RADIOCOM 2000 SYSTEM AUDIO PROCESSOR

Features

- **Full-Duplex Audio Processing for R2000 Cellular System**
- **On-Chip Speech and Data Facilities**
  - ***TX/RX/Data Filtering & Gain***
  - ***Pre-/De-Emphasis – Deviation Limiter***
- **Serial µProcessor Interface**
- **TX and RX LF-Data Paths**
- **MSK and (50 Baud) LF-Data Facilities**
- **Hands-Free Compatibility**
- **Powersave (Low-Current) Settings**
- **Access to External Processes**
  - ***Compression – Expansion***
  - ***Signaling/Data Mixing***
  - ***VSR Codec (Store/Play)***



MX836DW
28-pin SOIC



MX836J
28-pin CDIP

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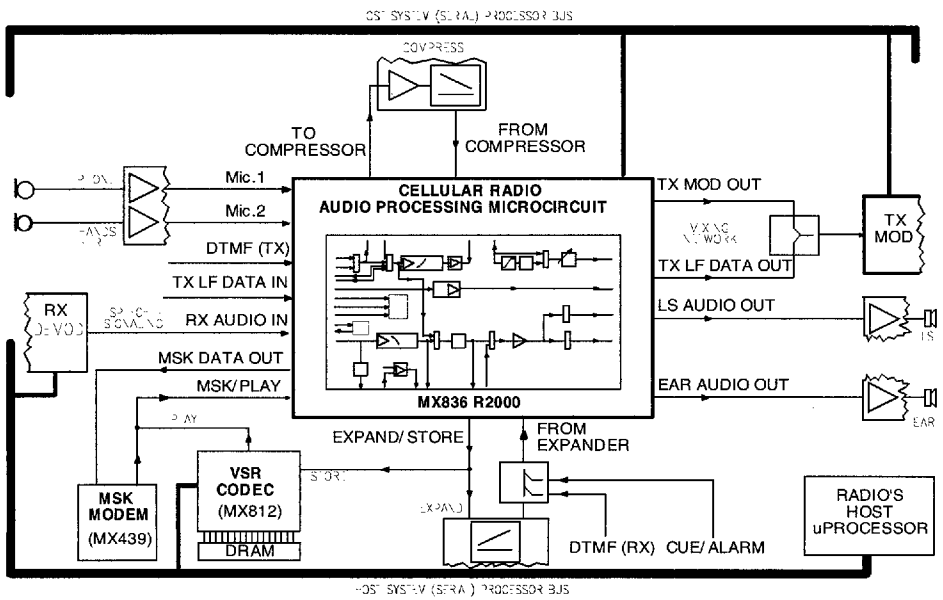

Figure 1 - The MX836 R2000 Audio Processor within a Cellular System

Description

The MX836 is a µProcessor-controlled full-duplex audio processor on a single-chip with separate TX, RX and LF (50 baud) data paths to provide all the filter/gain/limiting functions necessary to pre-process audio, data and signaling in the Radiocom 2000 (R2000) Cellular communications system.

Selectable inputs available for transmission include a choice of two microphones, DTMF/signaling or MSK/data, with access, in this path, to external voice compression circuitry. Operationally the TX path provides input gain/filtering, pre-emphasis, a deviation limiter and TX Modulation Drive controls. Available to the transmit function is a separate path to process LF system control data for amalgamation externally with TX voiceband audio.

The RX path consists of an input gain/de-emphasis/filter block for voice and data, inputs from an external audio expansion system and output gain controls driving loudspeaker and earpiece circuitry.

In the RX path LF data signals are separated from the incoming audio via an LF filter and made available at a separate pin for use by the system µProcessor

Unique to the MX816/826/836 cellular audio processors is the ability to route audio (TX or RX) to an external Voice Store and Retrieve (VSR) device such as the MX802 or MX812, thus providing the radio system with a voice answering and announcement facility using external DRAM.

The MX836, a low-power CMOS device, which reduces the amount of microcircuits and components required in a cellular audio system by providing more functions on a single chip, is available in 28-pin plastic small outline (S.O.I.C.) surface mount and cerdip DIL packages.

Pin	Function
1	**$\overline{\text{Xtal}}$:** The output of the on-chip clock oscillator.
2	**Xtal/Clock:** The input to the on-chip clock oscillator. A Xtal or externally derived clock (f_{XTAL}) should be connected here. Note that operation of the MX836 without a suitable Xtal or clock input may cause device damage. See Figure 2 (notes).
3	**Serial Clock:** The "C-BUS" serial data clock input. This clock, produced by the µController, is used for transfer timing of commands and data to the MX836. See Timing Diagrams.
4	**Command Data:** The "C-BUS" serial data input from the µController. Data is loaded to the MX836 in 8-bit bytes, MSB (B7) first, and LSB (B0) last, synchronized to the Serial Clock. See Timing Diagrams.
5	**Chip Select ($\overline{\text{CS}}$):** The "C-BUS" data loading control function. This input is provided by the µController. Data transfer sequences are initiated, completed or aborted by the $\overline{\text{CS}}$ signal. See Timing Diagrams.
6	**V_{BIAS}:** The internal circuitry bias line, held at $V_{DD}/2$ this pin must be decoupled to V_{SS}. See Figure 2.
7	**RX Audio In:** Normally taken from the radio's discriminator output. This input has a 1MΩ internal resistor to V_{BIAS} and requires connecting via a capacitor.
8	**Expand/Store:** A common output that can be used as either an input to an external audio expandor or the input to a voice storage medium such as the MX812. Components relevant to the external device requirements should be used at this output. See Figures 2 and 4.
9	**(Expanded) Audio In:** The audio input, via SW5, from an external expander or audio mixing function. This input has a 1MΩ internal resistor to V_{BIAS} and requires connecting via a capacitor. See Figures 2 and 4.
10	**TX Mod Out:** The composite TX audio output to the transmitter modulator from a variable attenuation stage (11_H). This output is set to V_{BIAS} via an internal 1MΩ resistor when set to Powersave or OFF.
11	**LS Audio Out:** An audio output of the RX Path (or audio selected by SW2 and SW4 Figure 4) for a loudspeaker system. Available for handsfree operation this output is controlled by the RX Gain and LS Volume Command (12_H) and is internally connected to V_{BIAS} when not required. A driver amplifier may be required at this output.

Note: *To minimize aliasing effects, lowpass filtering may be required at the inputs to this device (especially those supplied from switched-capacitor-type devices) to ensure the input spectrum is kept below 63kHz.*

Pin	Function
12	**Ear Audio Out:** An audio output of the RX Path (or audio selected by SW2 and SW4–Figure 4), available as an output for a handset earpiece. Separate from the LS Audio Out function, this output is controlled by the LF Data Gain and Ear Volume Command (13_H) and is internally connected to V_{BIAS} when not required. A driver amplifier may be required at this output.
13	**TX LF Data Out:** The output, if required, to the TX Modulator, of LF (50 baud) filtered and level-adjusted digital data.
14	**V_{SS}:** Negative supply. Signal ground.
15	**TX LF Data In:** The input of LF (50 baud) digital data for transmission, from an external modem. This input has an internal 1MΩ resistor to V_{BIAS} and should be connected via a capacitor.
16	**RX LF Data Out:** The output, to a 50 baud modem, of the received, filtered, LF data. This pin is used with the 50 Baud Data, Slicer In pins and external components to filter and limit the received LF data. See Figure 4.
17	**Slicer In:** The input to the data slicer. Employed as shown in Figure 4 to filter and limit the received LF data.
18	**RX 50 Baud Data Out:** The output of the received 50 baud data. See Figures 2 and 4.
19	**MSK Out:** The de-emphasized RX audio output available for access to the received MSK data. This output could be directed to an MSK Modem such as the MX439.
20	**Deviation Limiter In:** Input to the on-chip deviation Limiter. This input should be a.c. coupled to the Pre-Emphasis Out pin. The a.c. coupling is required to achieve the best possible symmetry of limiting as this input has a 1MΩ internal resistor to V_{BIAS}. See Figure 2.
21	**Pre-Emphasis Out:** Audio output from the TX Input Gain/Pre-Emphasis function. This output should be a.c. coupled to the Deviation Limiter In pin. See Figures 2 and 4.
22	**DTMF In:** To introduce DTMF type audio, at a suitable level for transmission, to the TX Path, controlled by SW2 (Configuration Command (10_H)). This input has an internal 1MΩ resistor to V_{BIAS} and should be connected via a capacitor.
23	**Compression In:** The audio input from an external compression system. This input has an internal 1MΩ resistor to V_{BIAS} and should be connected via a capacitor.
24	**Compression:** The output to an external audio compression system. Currently available compressor/expanders have Op-Amps incorporated. The compressor can be bypassed by SW2.
25	**Mic.2 In:** TX voice (Mic.) inputs, selectable by SW1 available for handsfree mic./handset mic. or any TX audio input. Pre-amplification may be required prior to these inputs. Each
26	**Mic.1 In:** input has an internal 1MΩ resistor to V_{BIAS} and should be connected via a capacitor.
27	**MSK/Play In:** The TX MSK data input via SW2. This can also be used to input (replay) from a voice storage device such as the MX812. This "replayed" audio can be sent to RX or TX paths allowing a Messaging/Voice Notepad/Answering facility. Both MX439 MSK Modem and MX812 VSR Codec outputs can be wired together at this pin (OR'd) if the functions are activated one-at-a-time. This input has an internal 1MΩ resistor to V_{BIAS} and should be connected via a capacitor.
28	**V_{DD}:** Positive supply. A single +5 volt power supply is required. Levels and voltages within this audio processor are dependent upon this supply.

***C-BUS** is MX-COM's proprietary standard for the transmission of commands and data between a µController and the relevant Cellular IC's. It may be used with any µController, and can, if desired, take advantage of the hardware serial I/O functions embodied into many types ofµµController. The "C-BUS" data rate is determined solely by the µController. For further details refer to the DBS 800 System Information Document.*

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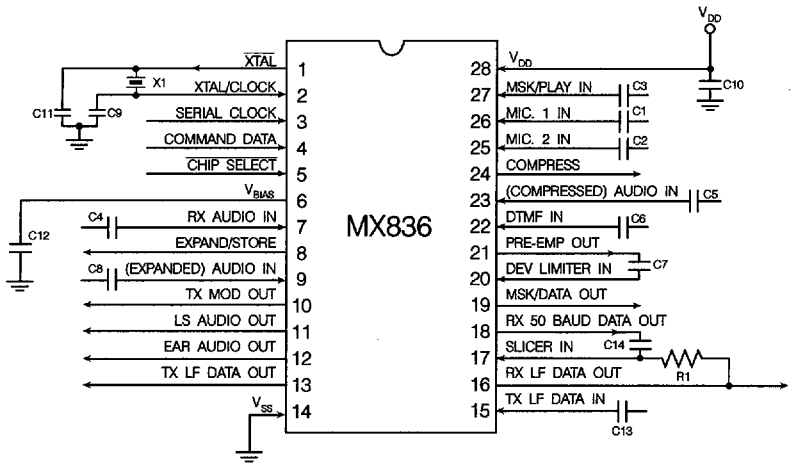
Application Information



R_1	=	1.0MΩ	C_4	=	0.1µF	C_8	=	0.1µF	C_{12}	=	1.0µF
C_1		0.1µF	C_5		0.1µF	C_9		33pF	C_{13}		0.1µF
C_2		0.1µF	C_6		0.1µF	C_{10}		0.1µF	C_{14}		0.1µF
C_3		0.1µF	C_7		0.1µF	C_{11}		33pF	X_1		4.032MHz

Tolerances – Resistors ±10% Capacitors ±20%

Figure 2 - Recommended External Components

1. Xtal/clock operation

Operation of any MX-COM IC without a Xtal or clock input may cause device damage. To minimize damage in the event of a Xtal/drive failure, it is recommended that a current limiting device (resistor or fast-reaction fuse) is installed on the power supply (V_{DD}).

2. MSK Modem

The MX439, a general purpose MSK Modem, could be used with this R2000 system Audio Processor. The MX439 is a non-formatted modem, which, with regard to Xtal/clock frequencies and µProcessor interface, is compatible with both Mobile/Portable and Base Station applications.

Reference Signal Levels

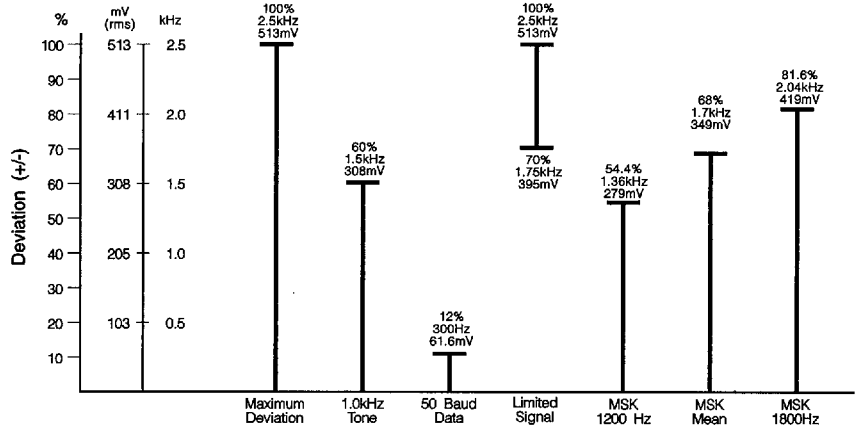


*Figure 3 - R2000 Signal Deviation Levels and corresponding **TX Mod Outputs** with the Mod Level set to 0dB*

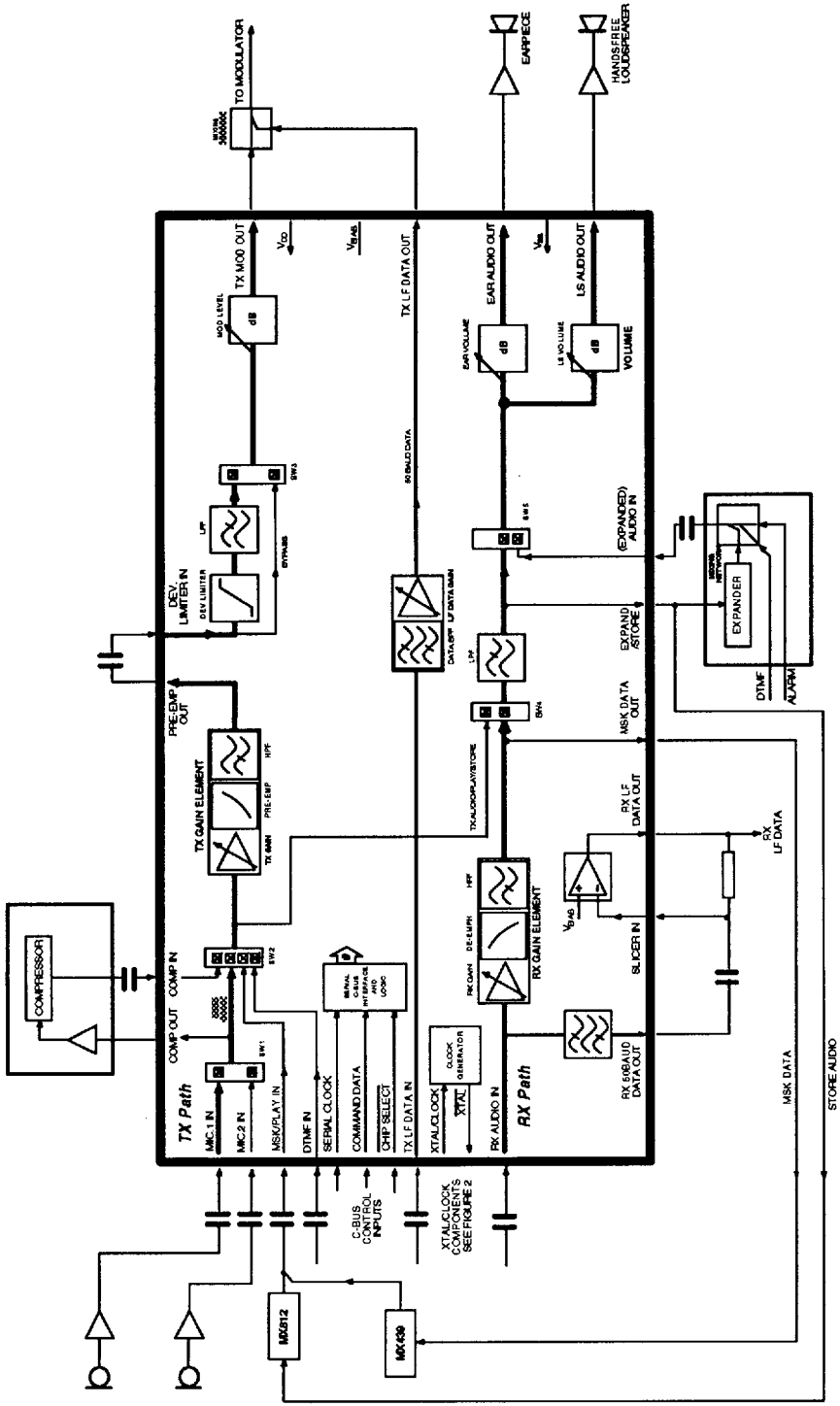


Figure 4 . The MX836 Within an R2000 Cellular System

The Controlling System

C-BUS is designed for low IC pin-count, flexibility in handling variable amounts of data, and simplicity of system design and µController software. It may be used with any µController, and can, if desired, take advantage of the hardware and serial I/O functions built into many types of µController. Because of this flexibility and because the BUS data rate is determined solely by the µController, the system designer has complete freedom to choose a µController appropriate to the overall system processing requirements.

Control of the functions and levels within the MX836 R2000 Audio Processor is by a group of Address/Commands and appended data instructions from the system microcontroller. The use of these instructions is detailed in the following paragraphs and tables.

Command Assignment	Hex.	Address/Command Binary MSB LSB		Command Data	Table
General Reset	01	0 0 0 0 0 0 0 1			
Configuration Command	10	0 0 0 1 0 0 0 0	+	1 byte	2
TX Gain & Mod. Command	11	0 0 0 1 0 0 0 1	+	1 byte	3
RX Gain & LS Vol.	12	0 0 0 1 0 0 1 0	+	1 byte	4
LF Data Gain & Ear Vol.	13	0 0 0 1 0 0 1 1	+	1 byte	5

Table 1 - C-BUS Address/Commands

In C-BUS protocol the MX836 is allocated Address/Command values 10_H to 13_H. Configuration, TX/RX Gains, and SAT/Powersave assignments and data requirements are given in Table 1.

Each instruction consists of an Address/Command (A/C) byte followed by a data instruction formulated from the following tables.

Commands and Data are only to be loaded in the group configurations detailed, as the C-BUS interface recognized the first byte after $\overline{\text{Chip Select}}$ (logic 0) as an Address/Command. Function or Level control data, which is detailed in Tables 2, 3, 4, and 5, is acted upon at the end of the loaded instruction. See Timing Diagrams, Figures 5 and 6.

Upon power-up the value of the "bits" in this device will be random (either "0" or "1"). A General Reset Command (01_H) is required to set all MX816 registers to 00_H.

Configuration Command *(Preceded by A/C 10_H)*

Setting	Control Bits
(MSB) Bit 7	*Transmitted First* **RX Gain Element**
0	Powersave
1	Enable
6	**All Functions** (except RX Gain Element)
0	Powersave
1	Enable
5	**SW5 Expander**
0	Expander Bypass
1	Expander Route
4	**SW4 TX/RX Audio**
0	TX Store/Audio
1	RX Store/Audio
3	**SW3 Dev. Limiter**
0	Dev. Limiter Bypass
1	Dev. Limiter Route
2	**SW1 Mic. Inputs**
0	Mic. 1 Input
1	Mic. 2 Input
1 0	**SW2 TX Function**
0 0	DTMF In
0 1	Compressor In
1 0	Compressor Bypass
1 1	MSK/Play In

Table 2 - Configuration Commands

TX Gain & Mod. Command *(Preceded by A/C 11_H)*

Setting	Gain (dB)
(MSB) 7 6 5 4	*Transmitted First* **TX Mod. Level**
0 0 0 0	OFF (Low Z to V_{BIAS})
0 0 0 1	-5.6dB
0 0 1 0	-5.2dB
0 0 1 1	-4.8dB
0 1 0 0	-4.4dB
0 1 0 1	-4.0dB
0 1 1 0	-3.6dB
0 1 1 1	-3.2dB
1 0 0 0	-2.8dB
1 0 0 1	-2.4dB
1 0 1 0	-2.0dB
1 0 1 1	-1.6dB
1 1 0 0	-1.2dB
1 1 0 1	-0.8dB
1 1 1 0	-0.4dB
1 1 1 1	0dB
3 2 1 0	**TX Input Gain**
0 0 0 0	-2.65dB
0 0 0 1	-2.05dB
0 0 1 0	-1.50dB
0 0 1 1	-0.95dB
0 1 0 0	-0.45dB
0 1 0 1	0dB
0 1 1 0	0.45dB
0 1 1 1	0.85dB
1 0 0 0	1.25dB
1 0 0 1	1.65dB
1 0 1 0	2.05dB
1 0 1 1	2.40dB
1 1 0 0	2.70dB
1 1 0 1	3.05dB
1 1 1 0	3.35dB
1 1 1 1	3.65dB

Table 3 - TX Gain & Mod. Commands

The Controlling System

RX Gain & LS Vol. *(Preceded by A/C 12$_H$)*

Setting				Gain (dB)
(MSB)				*Transmitted First*
7	*6*	*5*	*4*	**RX LS Volume**
0	0	0	0	OFF (Low Z to V_{BIAS})
0	0	0	1	-28.0dB
0	0	1	0	-26.0dB
0	0	1	1	-24.0dB
0	1	0	0	-22.0dB
0	1	0	1	-20.0dB
0	1	1	0	-18.0dB
0	1	1	1	-16.0dB
1	0	0	0	-14.0dB
1	0	0	1	-12.0dB
1	0	1	0	-10.0dB
1	0	1	1	-8.0dB
1	1	0	0	-6.0dB
1	1	0	1	-4.0dB
1	1	1	0	-2.0dB
1	1	1	1	0dB
3	*2*	*1*	*0*	**RX Input Gain**
0	0	0	0	3.75dB
0	0	0	1	4.30dB
0	0	1	0	4.80dB
0	0	1	1	5.30dB
0	1	0	0	5.80dB
0	1	0	1	6.20dB
0	1	1	0	6.55dB
0	1	1	1	7.05dB
1	0	0	0	7.40dB
1	0	0	1	7.80dB
1	0	1	0	8.15dB
1	0	1	1	8.50dB
1	1	0	0	8.80dB
1	1	0	1	9.10dB
1	1	1	0	9.40dB
1	1	1	1	9.70dB

Table 4 - RX Gain and Volume Commands

LF Data Gain & Ear Vol. *(Preceded by A/C 13$_H$)*

Setting				Gain (dB)
MSB				*Transmitted First*
7	*6*	*5*	*4*	**RX Ear Volume**
0	0	0	0	OFF (Low Z to V_{BIAS})
0	0	0	1	-28.0
0	0	1	0	-26.0
0	0	1	1	-24.0
0	1	0	0	-22.0
0	1	0	1	-20.0
0	1	1	0	-18.0
0	1	1	1	-16.0
1	0	0	0	-14.0
1	0	0	1	-12.0
1	0	1	0	-10.0
1	0	1	1	-8.0
1	1	0	0	-6.0
1	1	0	1	-4.0
1	1	1	0	-2.0
1	1	1	1	0
3	*2*	*1*	*0*	**LF** (50 Baud) **Data Gain**
0	0	0	0	OFF (Low Z to V_{BIAS})
0	0	0	1	-2.60
0	0	1	0	-2.20
0	0	1	1	-1.80
0	1	0	0	-1.40
0	1	0	1	-1.00
0	1	1	0	-0.70
0	1	1	1	-0.35
1	0	0	0	0
1	0	0	1	0.30
1	0	1	0	0.60
1	0	1	1	0.90
1	1	0	0	1.20
1	1	0	1	1.50
1	1	1	0	1.75
1	1	1	1	2.00

Table 5 - LF Data Gain and RX Ear Vol. Command

System Performance

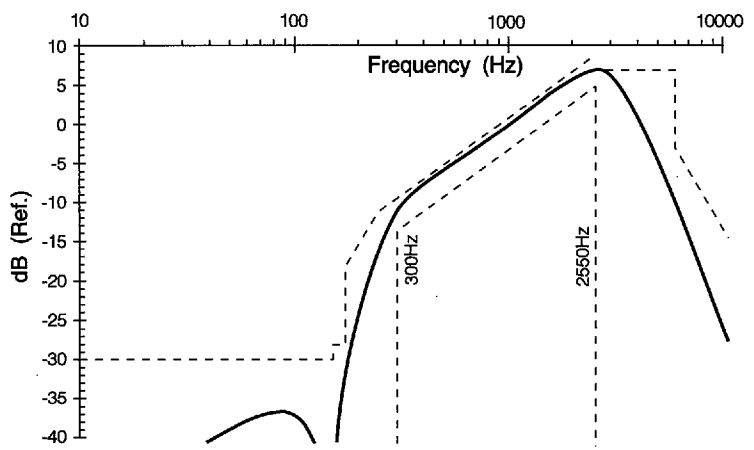
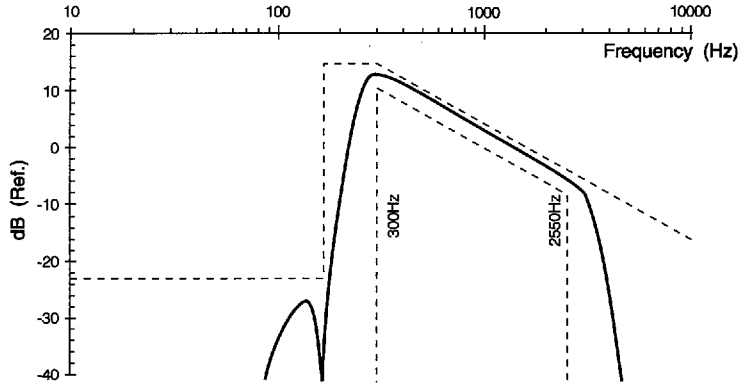


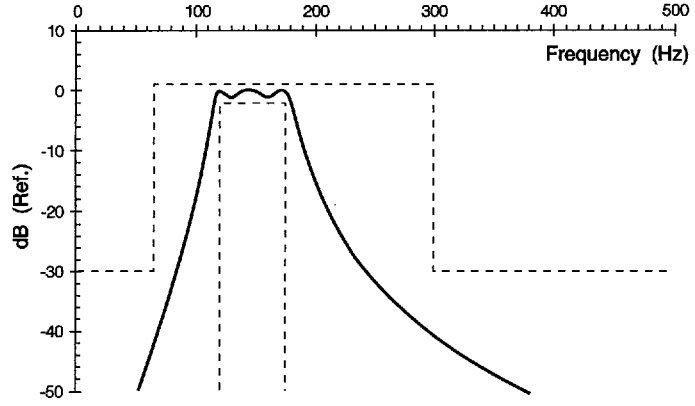
Figure 5 - TX Voiceband Frequency Response

System Performance .....



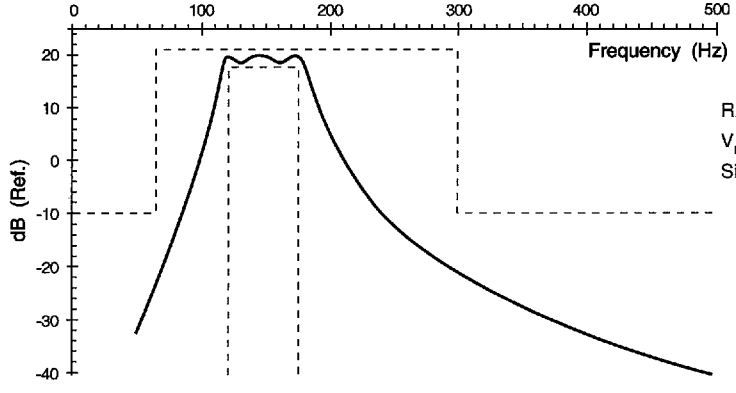
RX Audio In to LS/Ear Audio Out
V_{DD} = 5.0V
Signal Input Level = 68mVrms
RX Gain set to 3.75dB
LS/Ear Volume set to 0dB

Figure 6 - RX Voiceband Frequency Response



TX LF Data In to TX LF Data Out
V_{DD} = 5.0V
Signal Input Level = 55mVrms
LF Data Gain set to 0dB

Figure 7 - TX LF Channel Frequency Response



RX Audio In to RX 50 Baud Data Out
V_{DD} = 5.0V
Signal Input Level = 55mVrms

Figure 8 - RX 50-Baud Data Path Frequency Response

Timing Information

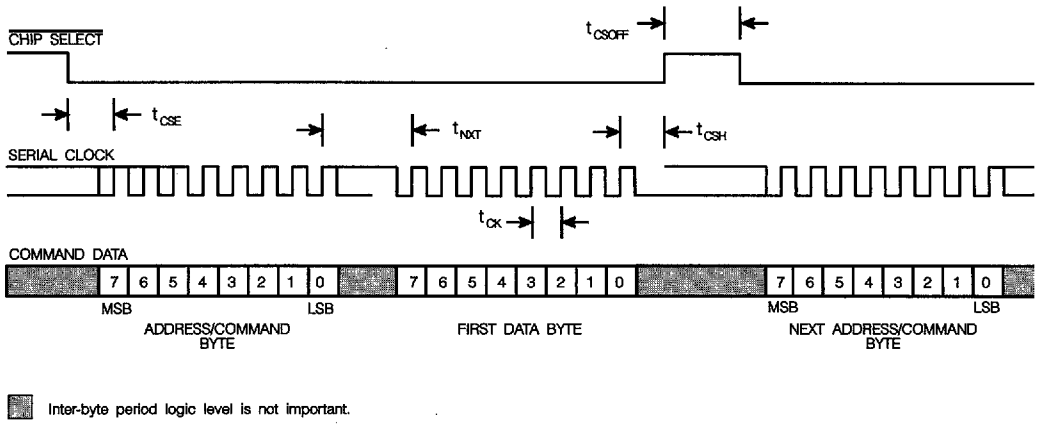


Figure 9 - Control Timing Information

Parameter		See Note	Min.	Typ.	Max.	Unit
"$\overline{CS}$ Enable" to "clock high"	t_{CSE}	1	2.0	-	-	µs
Last "clock high" to "CS high"	t_{CSH}	1	4.0	-	-	µs
"$\overline{CS}$ high" time between transactions	t_{CSOFF}	1,2	2.0	-	-	µs
Clock Cycle Time	t_{CK}	1	2.0	-	-	µs
Inter byte time	t_{NXT}	1	4.0	-	-	µs
Serial Clock-High Period	t_{CH}		500	-	-	ns
Serial Clock-Low Period	t_{CL}		500	-	-	ns
Command Data Set-up Time	t_{CDS}		250	-	-	ns
Command Data Hold Time	t_{CDH}		0	-	-	ns

Notes

1. These minimum timing values are altered during operation of the MX812 VSR Codec.
2. Chip Select must be taken to a logic "1" between each individual transaction.

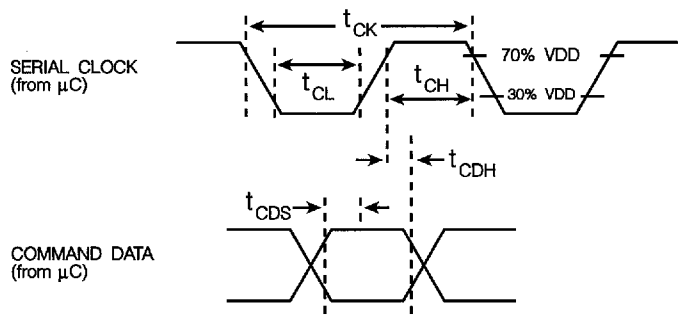


Figure 10 - Control Timing Relationships

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 7.0 V
Input Voltage at any pin (ref V_{SS} = 0V)		-0.3 to (V_{DD}+0.3V)
Sink/source current	(supply pins)	±30mA
	(other pins)	±20mA
Total device dissipation @ T_{AMB} 25°C		800mW Max.
Derating		10mW/°C
Operating Temperature		-40°C to +85°C
Storage Temperature		-55°C to +125°C

Operating Limits

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

V_{DD} = 5.0V

T_{AMB} = 25°C

Xtal/Clock f_0 = 4.032MHz

Audio Level 0dB ref = 308mVrms @ 1kHz

Characteristics	See Note	Min.	Typ.	Max.	Unit
Static Values					
Supply Voltage		4.5	5.0	5.5	V
Supply Current - All Operating		–	10.0	–	mA
- RX Data Mode	1	–	2.5	–	mA
- Powersave All		–	0.6	–	mA
Alias Frequency		–	63.0	–	kHz
On-Chip Xtal Oscillator					
R_{IN}		10.0	–	–	MΩ
R_{OUT}		–	10.0	–	kΩ
Inverter Gain		–	10.0	–	V/V
Gain/Bandwidth Product		–	10.0	–	MHz
Analog Input Impedances					
Mic.1 & 2, MSK/Play, Comp. In, DTMF In, TX LF Data In		–	500	–	kΩ
Dev. Limiter In, RX Audio In		–	100	–	kΩ
(Expanded) Audio In		–	47.0	–	kΩ
Slicer In		10.0	–	–	MΩ
Analog Output Impedances					
Pre-Emp Out, TX Mod. Out, Expand/Store, MSK Data Out, TX 50 Baud Data Out		–	600	–	Ω
LS and Ear Audio		–	1.0	–	kΩ
RX LF Data Out		–	2.0	–	kΩ
Switches – ON		–	1.0	–	kΩ
– OFF		10.0	–	–	MΩ
Input Logic "1" Level	2	3.5	–	–	V
Input Logic "0" Level	2	–	–	1.5	V
I_{IN} (Logic "1" or "0")	2	-1.0	–	1.0	µA
Input Capacitance	2	–	–	7.5	pF
TX Signal Path					
Analog Signal Input Levels					
Mic. 1 and 2, MSK/Play, DTMF, Comp. In	3	–	0	–	dB
TX LF Data In		–	0	–	dB
Analog Signal Output Levels					
Pre-Emp Out, TX Mod Out	3	–	0	–	dB
Tx LF Data Out		–	0	–	dB
Path Gains/Levels					
TX Gain – 11_H					
Nominal Adjustment Range		-2.65		3.65	dB
Error of any Setting		-0.2	–	0.2	dB
Dev Limiter					
Threshold		–	1375	–	mVp-p
Symmetry		–	7.0	–	%
Mod Level Attenuation – 11_H					
Nominal Adjustment Range		-5.6		0	dB
Step Size		0.2	0.4	0.6	dB
Error of any Setting		-1.0	–	1.0	dB

Characteristics	See Note	Min.	Typ.	Max.	Unit
TX LF Data Signal Path					
Bandpass Filter					
Passband		120		175	Hz
Gain		–	0	–	dB
LF Data Gain Level – 13_H					
Nominal Adjustment Range		-2.6		2.0	dB
Error of any Setting		-0.2	–	0.2	dB
Overall					
TX Distortion		–	-40.0	-32.0	dBp
TX Hum and Noise		–	-40.0	-20.0	dB
RX Signal Path					
RX Audio Input Level	3	–	-7.0	–	dB
LS/Ear Audio Output Level	3	–	0	–	dB
Path Gains/Levels					
RX Gain – 12_H					
Nominal Adjustment Range		3.75		9.70	dB
Error of any Setting		-0.2	–	0.2	dB
De-Emphasis					
Frequency Range		900	–	2100	Hz
Gain at 1kHz		-1.0	0	1.0	dB
Response		–	-6.0	–	dB/oct
LS/Ear Volume – $12_H/13_H$					
Nominal Adjustment Range		-28.0		0	dB
Step Size		1.5	2.0	2.5	dB
Error of any Setting		-1.0	–	1.0	dB
Overall					
RX Distortion		–	-40.0	-32.0	dBp
RX Hum and Noise		–	-40.0	-34.0	dB
RX 50 Baud AudioPath					
Bandpass Filter					
Passband		120		175	Hz
Gain		19.0	20.0	21.0	dB

Notes

1. With reference to the Configuration Command and Figure 3, all functions with the exception of the RX Gain Element may be powersaved. This will still allow signaling data through the MX836 to activate the system via the µProcessor.
2. Serial Clock, Command Data and Chip Select inputs.
3. Levels equivalent to ±1.5kHz deviation with the settings below:

   TX Gain = 0dB *Mod Level = 0dB*
   RX Gain = 7.05dB *LS/Ear Volume = 0dB*

   Other levels can be achieved by adjusting the above variable gain blocks in accordance with Tables 1 to 5.