CML Semiconductor Products
PRODUCT INFORMATION

FX836 Radiocom 2000 System Audio Processor

Publication D/836/3 July 1994
Provisional Issue

Features/Applications

- **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**
- **FFSK and (50 Baud) LF-Data Facilities**
- **Hands-Free Compatibility**
- **Access to External Processes**
  - ***Compression – Expansion***
  - ***Signalling/Data Mixing***
  - ***VSR Codec (Store/Play)***
- **Powersave (Low-Current) Settings**

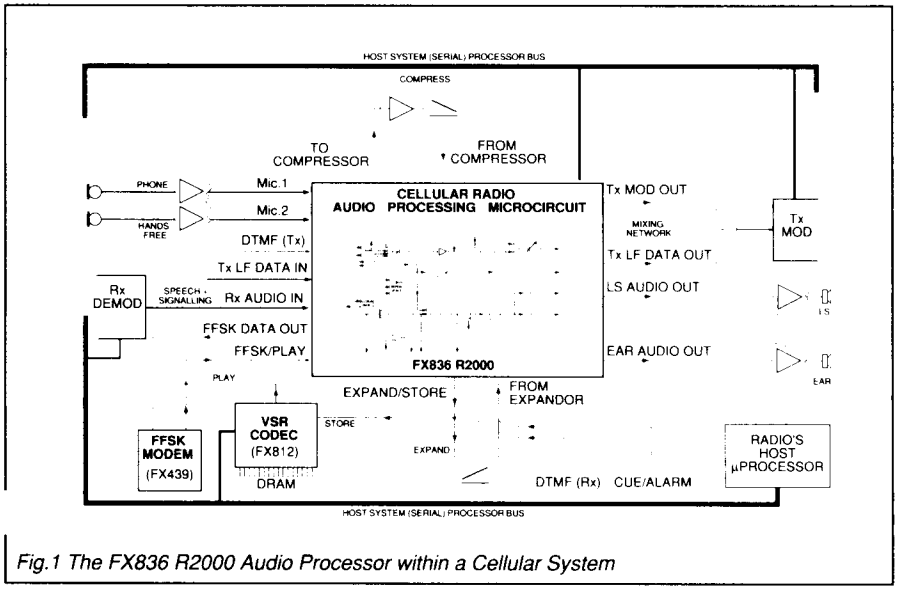


Fig.1 The FX836 R2000 Audio Processor within a Cellular System

FX836

Brief Description

The FX836 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 signalling in the Radiocom 2000 (R2000) Cellular communications system.

Selectable inputs available for transmission are: a choice of two microphones, DTMF/signalling or FFSK/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

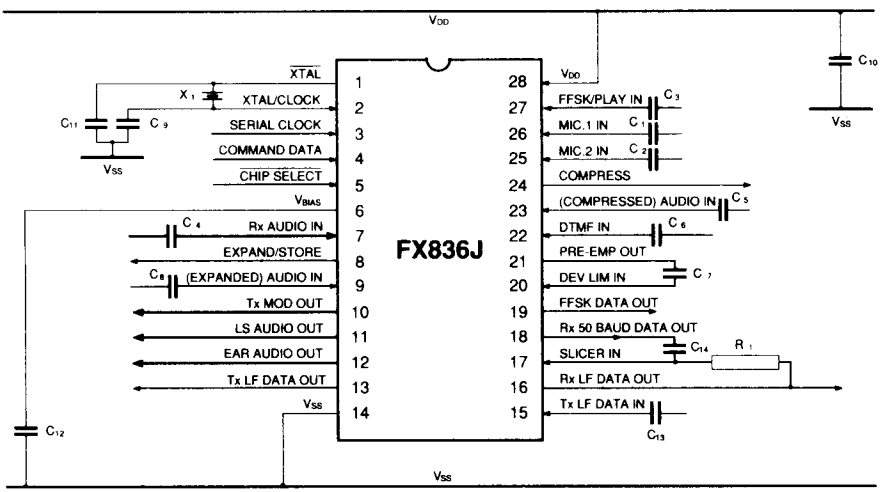
Unique to the FX816/826/836 cellular audio processors is the ability to route audio (Tx or Rx) to an external Voice Store and Retrieve (VSR) device such as the FX802 or FX812 thus providing the radio system with a voice answering and announcement facility using external DRAM.

The FX836, 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 Number FX836DW FX836J	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 FX836 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 FX836. See Timing Diagrams.
4	**Command Data:** The "C-BUS" serial data input from the µController. Data is loaded to the FX836 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 to be connected 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 FX812. 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 expandor or audio mixing function. This input has a 1MΩ internal resistor to V_{BIAS} and requires to be connected 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.
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 rail. Signal ground.
	Notes on Inputs: *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 Number FX836DW FX836J	Function
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	**FFSK Out:** The de-emphasized Rx audio output available for access to the received FFSK data. This output could be directed to an FFSK Modem such as the FX439.
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/ expandors have Op-Amps incorporated. The compressor can be by-passed 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 input has an internal
26	**Mic.1 In:** 1MΩ resistor to V_{BIAS} and should be connected via a capacitor.
27	**FFSK/Play In:** The Tx FFSK data input via SW2. This can also be used to input (replay) from a voice storage device such as the FX812. This "replayed" audio can be sent to Rx or Tx paths allowing a Messaging/Voice Notepad/Answering facility. Both FX439 FFSK Modem and FX812 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 rail. A single +5 volt power supply is required. Levels and voltages within this audio processor are dependent upon this supply. *"C-BUS" is CML's proprietary standard for the transmission of commands and data between a µController and the relevant Cellular microcircuits. It may be used with any µController, and can, if desired, take advantage of the hardware serial I/O functions embodied into many types of µController. The "C-BUS" data rate is determined solely by the µController.* *For further details refer to CML Publication No. D/µINT/1 June 1991 or DBS 800 System Information Document.*

Application Information



R_1	=	1.0MΩ	C_4	=	100nF	C_8	=	100nF	C_{12}	=	1.0µF
C_1		100nF	C_5		100nF	C_9		33pF	C_{13}		100nF
C_2		100nF	C_6		100nF	C_{10}		100nF	C_{14}		100nF
C_3		100nF	C_7		100nF	C_{11}		33pF	X_1		4.032MHz

Tolerances – Resistors ±10% Capacitors ±20%

Fig.2 Recommended External Components

1. **Xtal/clock operation**
Operation of any CML microcircuit without a Xtal or clock input may cause device damage.
To minimise damage in the event of a Xtal/drive failure, it is recommended that the power rail (V_{DD}) is fitted with a current limiting device (resistor or fast-reaction fuse).

2. **FFSK Modem**
The FX469, a general purpose FFSK Modem could be employed with this NMT system Audio Processor. The FX469 is a non-formatted modem, which with due regard to Xtal/clock frequencies and µProcessor interface, is compatible with both Mobile/Portable and Base Station applications.

Reference Signal Levels

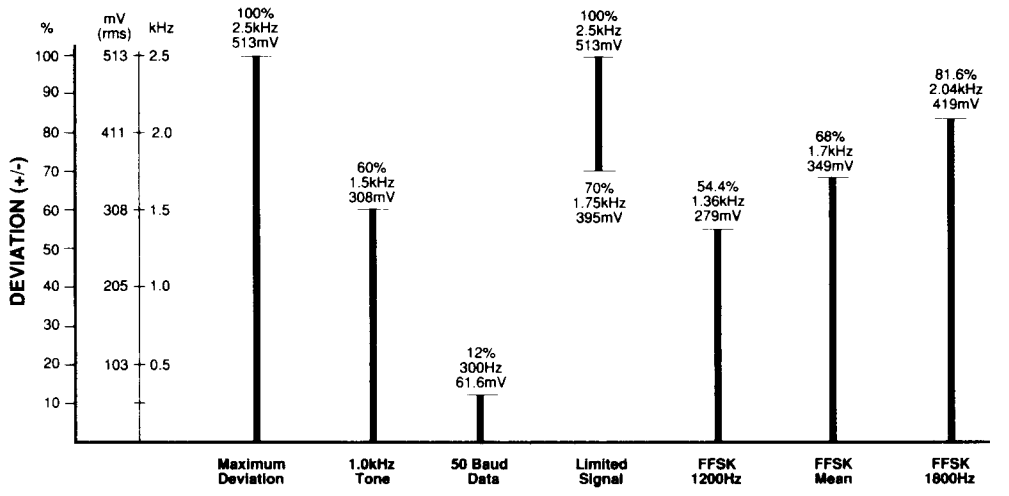


*Fig.3 R2000 Signal Deviation Levels and corresponding **Tx Mod Outputs** with the Mod Level set to 0dB*

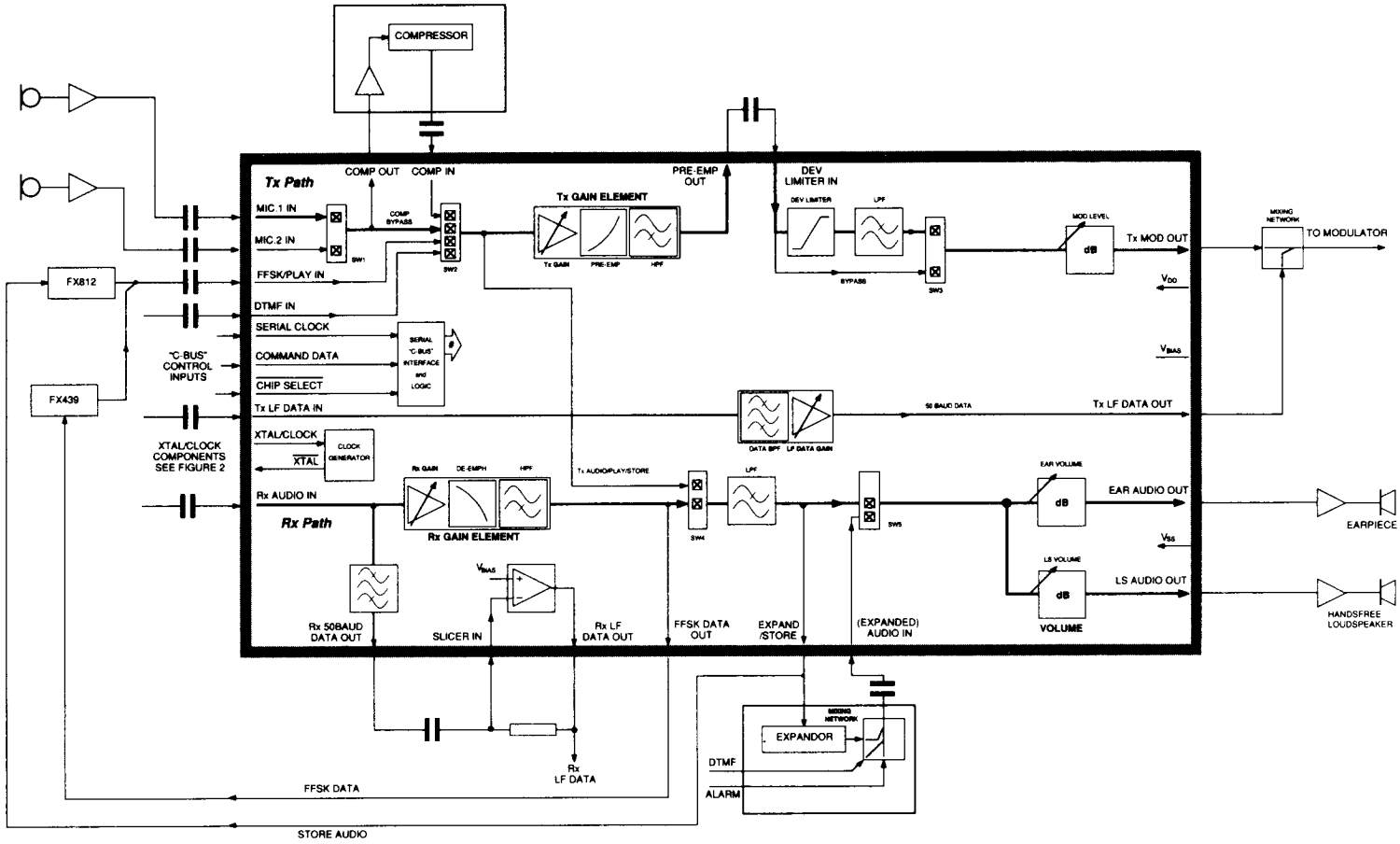


Fig.4 The FX836 within an R2000 Cellular Radio System

The Controlling System

"C-BUS" Hardware Interface

"C-BUS" is CML's proprietary standard for the transmission of commands and data between a µController and CML's New Generation microcircuits.

"C-BUS" has been designed for a 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 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 FX836 R2000 Audio Processor is by a group of Address/Commands and appended data instructions from the system µController to set/adjust the functions and elements of the device. The use of these instructions is detailed in the following paragraphs and tables.

Command Assignment	Address/Command (A/C) Byte Hex	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. Level	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 audio processor is allocated Address/Command (A/C) 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 recognises the first byte after 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.

Upon Power-Up the value of the "bits" in this device will be random (either "0" or "1"). Therefore a **General Reset Command (01_H)** will be required initially to set all FX836 registers to 00_H.

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

Setting	*Control Bits*
MSB	***Transmitted First***
Bit 7	**Rx Gain Element**
0	Powersave
1	Enable
6	**All Functions** (except Rx Gain Element)
0	Powersave
1	Enable
5	**Sw5 Expandor**
0	Expandor By-Pass
1	Expandor Route
4	**Sw4 Tx/Rx Audio**
0	Tx Store/Audio
1	Rx Store/Audio
3	**Sw3 Dev. Limiter**
0	Dev. Limiter By-Pass
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 By-Pass
1 1	FFSK/Play In

Note that Bits 6 and 7 can be configured to allow the Rx to "listen for data" whilst powersaved. See Figure 4.

Table 2 Configuration Commands

Tx Gain & Mod. Level *(Preceded by A/C 11_H)*

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

Table 3 Tx Gain & Mod. Commands

The Controlling System .....

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

Setting				Gain (dBs)
MSB				***Transmitted First***
7	***6***	***5***	***4***	**Rx LS Volume**
0	0	0	0	OFF (Low Z to V_{BIAS})
0	0	0	1	-28.0
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***	**Rx Input Gain**
0	0	0	0	3.75
0	0	0	1	4.30
0	0	1	0	4.80
0	0	1	1	5.30
0	1	0	0	5.80
0	1	0	1	6.20
0	1	1	0	6.65
0	1	1	1	7.05
1	0	0	0	7.40
1	0	0	1	7.80
1	0	1	0	8.15
1	0	1	1	8.50
1	1	0	0	8.80
1	1	0	1	9.10
1	1	1	0	9.40
1	1	1	1	9.70

Table 4 Rx Gain and LS Vol. Command

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

Setting				Gain (dBs)
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 Volume Command

System Performance

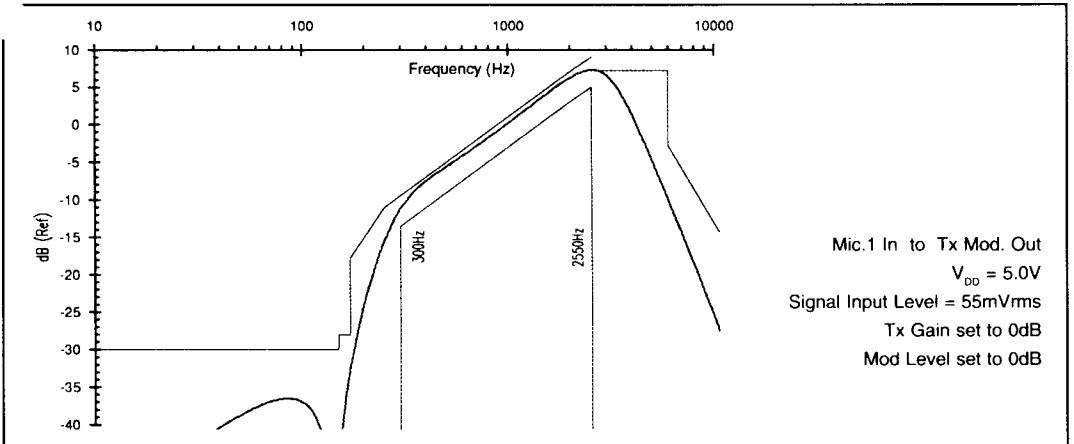


Fig.5 Tx Voiceband Frequency Response

System Performance .....

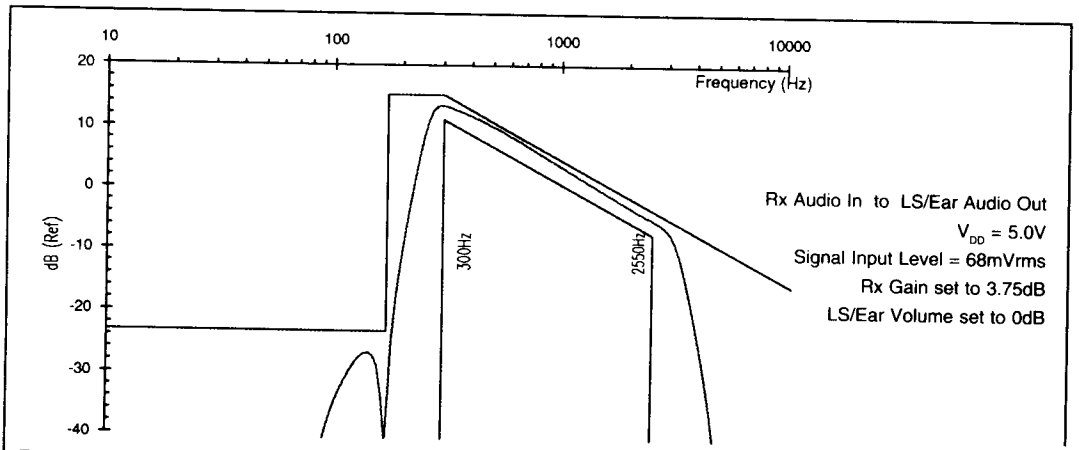


Fig.6 Rx Voiceband Frequency Response

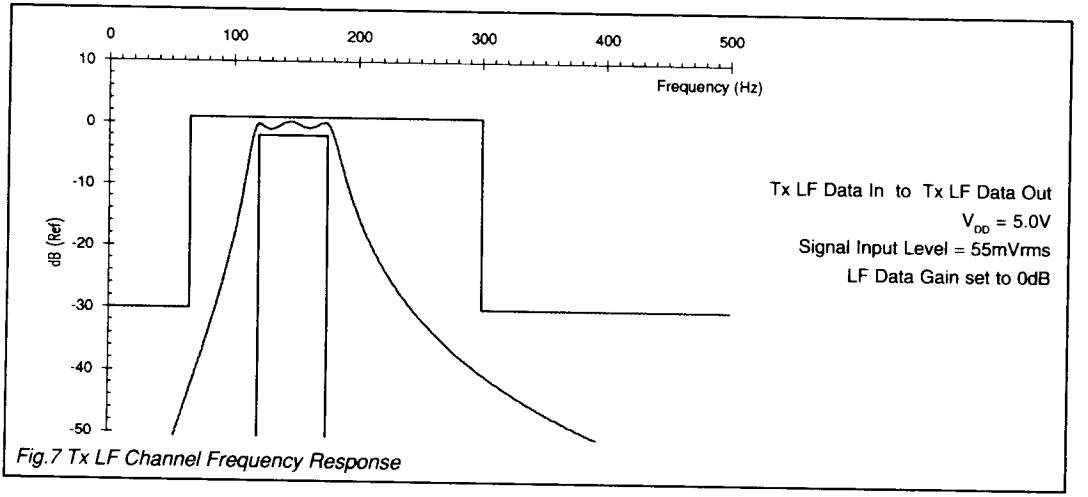


Fig.7 Tx LF Channel Frequency Response

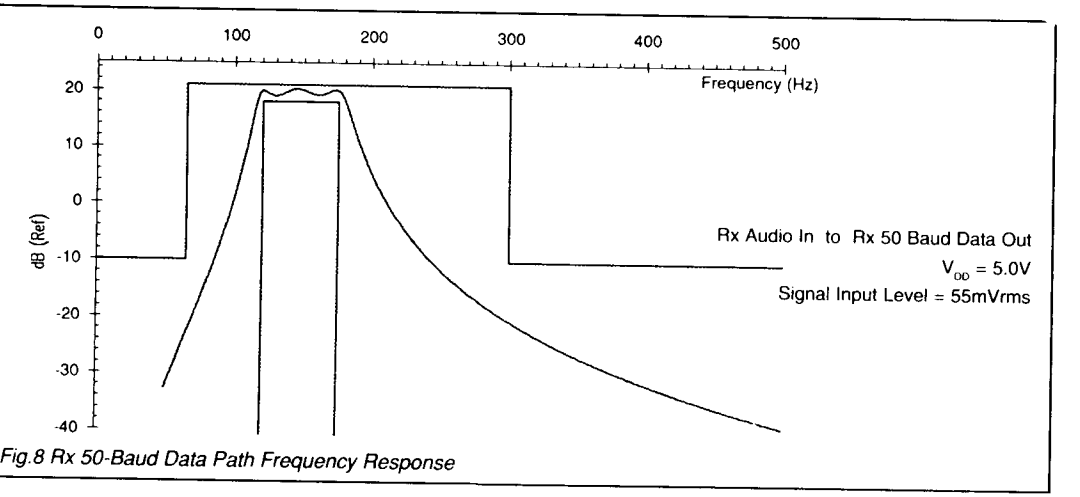


Fig.8 Rx 50-Baud Data Path Frequency Response

Control Timing Information

Timing Specification – Figures 9 and 10

Characteristics		See Note	Min.	Typ.	Max.	Unit
t_{CSE}	"CS-Enable to Clock-High"	1	2.0	–	–	µs
t_{CSH}	Last "Clock-High to CS-High"	1	4.0	–	–	µs
t_{CSOFF}	"CS-High" Time between transactions	1, 2	2.0	–	–	µs
t_{CK}	"Clock-Cycle" Time	1	2.0	–	–	µs
t_{NXT}	"Inter-Byte" Time	1	4.0	–	–	µs
t_{CH}	"Serial Clock-High" Period		500	–	–	ns
t_{CL}	"Serial Clock-Low" Period		500	–	–	ns
t_{CDS}	"Command Data Set-Up" Time		250	–	–	ns
t_{CDH}	"Command Data Hold" Time		0	–	–	ns

Notes

1. These Minimum Timing values are altered during operation of the FX812 VSR Codec.
2. Chip Select must be taken to a logic "1" between each individual transaction.

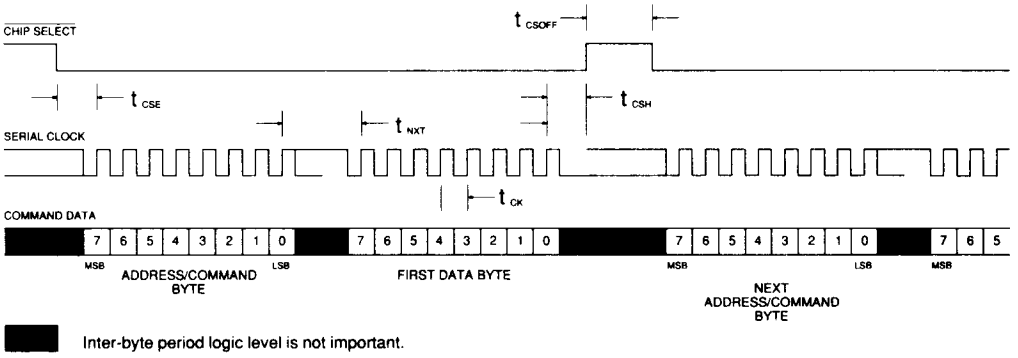


Fig.9 Control Timing Information

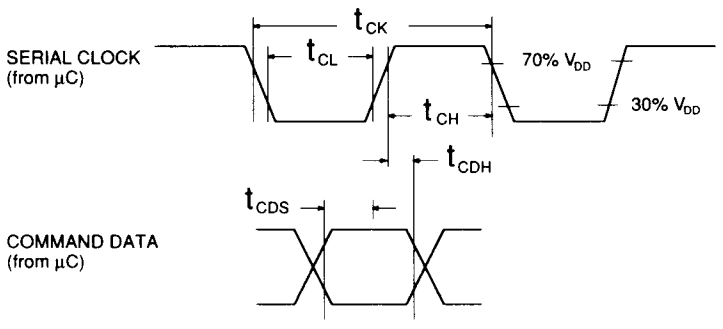


Fig.10 Control Timing Relationships

Specification

Absolute Maximum Ratings

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

Supply voltage		-0.3 to 7.0V
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 range:	**FX836DW**	-40°C to +85°C (plastic)
	FX836J	-40°C to +85°C (cerdip)
Storage temperature range:	**FX836DW**	-40°C to +85°C (plastic)
	FX836J	-55°C to +125°C (cerdip)

Operating Limits

All device characteristics are measured under the following conditions unless otherwise specified:

V_{DD} = 5.0V. T_{AMB} = 25°C. Xtal/Clock f_0 = 4.032MHz. Audio level 0dB ref. = 308mV rms @ 1.0kHz.

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
Analogue Input Impedances					
Mic.1 & 2		–	500	–	kΩ
FFSK/Play		–	500	–	kΩ
Comp In		–	500	–	kΩ
DTMF In		–	500	–	kΩ
Dev. Limiter In		–	100	–	kΩ
(Expanded) Audio In		–	47.0	–	kΩ
Tx LF Data In		–	500	–	kΩ
Slicer In		10.0	–	–	MΩ
Rx Audio In		–	100	–	kΩ
Analogue Output Impedances					
Pre-Emp Out		–	600	–	Ω
Tx Mod Out		–	600	–	Ω
Expand/Store		–	600	–	Ω
LS and Ear Audio		–	1.0	–	kΩ
FFSK Data Out		–	600	–	Ω
Rx LF Data Out		–	2.0	–	kΩ
Tx 50 Baud Data Out		–	600	–	Ω
Switches – ON		–	1.0	–	kΩ
– OFF		10.0	–	–	MΩ
Control Interface Parameters					
Input Logic Levels					
Logic "1"	2	3.5	–	–	V
Logic "0"	2	–	–	1.5	V
I_{IN} (logic "1" or "0")	2	-1.0	–	1.0	µA
Input Capacitance	2	–	–	7.5	pF
Channel Performances					
Tx Path					
Analogue Signal Input Levels					
Mic. 1 and 2	3	–	0	–	dB
FFSK/Play	3	–	0	–	dB
DTMF	3	–	0	–	dB
Comp. In	3	–	0	–	dB
Tx LF Data In		–	0	–	dB

Specification .....

Characteristics	See Note	Min.	Typ.	Max.	Unit
Analogue Signal Output Levels					
Pre-Emp Out	3	–	0	–	dB
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
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
.x 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 signalling data through the FX836 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.

Package Outlines

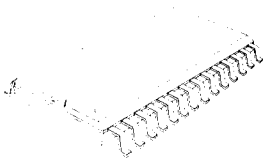
The FX836 is available in the package styles outlined below. Mechanical package diagrams and specifications are detailed in Section 10 of this document.
Pin 1 identification marking is shown on the relevant diagram and pins on all package styles number anti-clockwise when viewed from the top.

Handling Precautions

The FX836 is a CMOS LSI circuit which includes input protection. However precautions should be taken to prevent static discharges which may cause damage.

FX836DW 28-pin plastic S.O.I.C. (D1)

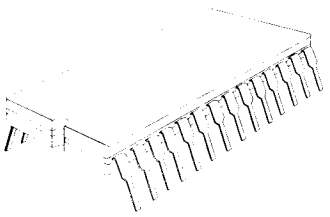
NOT TO SCALE



Max. Body Length 18.05mm
Max. Body Width 7.65mm

FX836J 28-pin cerdip DIL (J5)

NOT TO SCALE



Max. Body Length 37.05mm
Max. Body Width 13.36mm

Ordering Information

FX836DW 28-pin plastic S.O.I.C. (D1)

FX836J 28-pin cerdip DIL (J5)