

# FX802 DVSR CODEC



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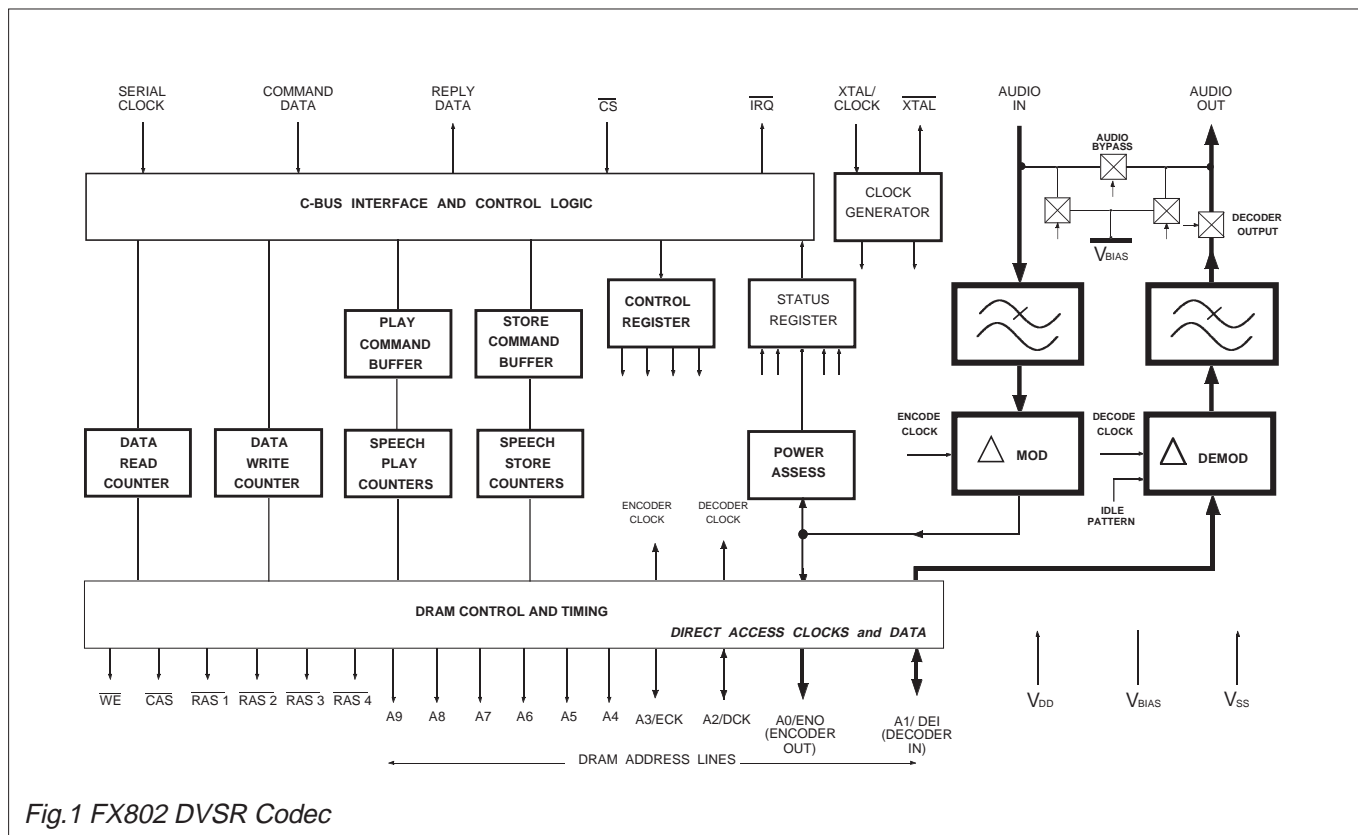


Fig.1 FX802 DVSR Codec

## Brief Description

The FX802 DVSR Codec contains:

A Continuously Variable Slope Delta Modulation (CVSD) encoder and decoder.

Control and timing circuitry for up to 4Mbits of external Dynamic Random Access Memory (DRAM).

"C-BUS"  $\mu$ Processor interface and control logic.

When used with external DRAM, the FX802 has four primary functions:

### ● Speech Storage

Speech signals present at the Audio Input may be digitized by the CVSD encoder, and the resulting bit stream stored in DRAM. This process also provides readings of input power level for use by the system  $\mu$ Controller.

### ● Speech Playback

Previously digitized speech data may be read from DRAM and converted back into analogue form by the CVSD decoder.

### ● Data Storage

Digital data sent over the "C-BUS" from the system  $\mu$ Controller may be stored in DRAM.

### ● Data Retrieval

Digital data may be read from DRAM and sent over "C-BUS" to the system  $\mu$ Controller.

Speech storage and playback may be performed concurrently with data storage or retrieval.

The FX802 may also be used without DRAM (as a "stand-alone" CVSD Codec), in which case direct access is provided to the CVSD Codec digital data and clock signals.

All functions are controlled by "C-BUS" commands from the system  $\mu$ Controller.

The Storage, Recovery and Replay functions of the FX802 can be used for:

- Answering Machine applications, where an incoming speech message is stored for later recall.
- Busy Buffering, an outgoing speech message is stored temporarily until the transmit channel becomes free.
- Automatic transmission of pre-recorded 'Alarm' or status announcements.
- Time Domain Scrambling of speech messages.
- VOX control of transmitter functions.
- Temporary Data Storage applications, such as buffering of over-air data transmissions.

On-chip the Delta Codec is supported by input and output analogue switched-capacitor filters and audio output switching circuitry. The DRAM control and timing circuitry provides all the necessary address, control and refresh signals to interface to external DRAM.

The FX802 DVSR Codec is a low-power 5-volt CMOS LSI device.

## Pin Number Function

| FX802<br>J | FX802<br>LG/LS |   |
|------------|----------------|---|
| 1          |                | <b>Row Address Strobe 2 (RAS2):</b> Should be connected to the Row Address Strobe input of the second 1Mbit DRAM chip (if fitted).  |
| 2          | 1              | <b>Row Address Strobe 1 (RAS1):</b> Should be connected to the Row Address Strobe input of the first DRAM chip.   |
| 3          | 2              | <b>Write Enable (WE):</b> The DRAM Read/Write control pin.  |
| 4          |                | <b>Xtal:</b> The output of the on-chip clock oscillator. External components are required at this output when a Xtal is employed. A Xtal cannot be used with the 24-pin version.  |
| 5          | 3              | <b>Xtal/Clock:</b> The input to the on-chip clock oscillator inverter. A 4.0MHz Xtal or externally derived clock should be connected here, see Figure 2. This clock provides timing for on-chip elements, filters etc. A Xtal cannot be used with the 24-pin version. Various Xtal frequencies can be used with this device, see Table 3 for the sampling clock rate variations.  |
| 6          | 4              | <b>Interrupt Request (IRQ):</b> The output of this pin indicates an interrupt condition to the $\mu$ Controller, by going to a logic "0." This is a "wire-or able" output, enabling the connection of up to 8 peripherals to 1 interrupt port on the $\mu$ Controller. The pin has a low-impedance pulldown to logic "0" when active and a high impedance when inactive.<br>Conditions indicated by this function are:<br>Power Reading Ready, Play Command Complete, Store Command Complete. |
| 7          | 5              | <b>Serial Clock:</b> The "C-BUS," serial clock input. This clock, produced by the $\mu$ Controller, is used for transfer timing of commands and data to and from the DVSR Codec. See Timing Diagrams and System Support Document, Document 2. The clock-rate requirements vary for differing FX802 functions.   |
| 8          | 6              | <b>Command Data:</b> The "C-BUS," serial data input from the $\mu$ Controller. Data is loaded to this device in 8-bit bytes, MSB (B7) first, and LSB (B0) last, synchronized to the Serial Clock. See Timing Diagrams and System Support Document, Document 2.  |
| 9          | 7              | <b>Chip Select (CS):</b> The "C-BUS", data transfer control function, this input is provided by the $\mu$ Controller. Command Data transfer sequences are initiated, completed or aborted by the CS signal. See Timing Diagrams and System Support Document, Document 2.  |
| 10         | 8              | <b>Reply Data:</b> The "C-BUS," serial data output to the $\mu$ Controller. The transmission of Reply Data bytes is synchronized to the Serial Data Clock under the control of the Chip Select input. This 3-state output is held at high impedance when not sending data to the $\mu$ Controller. See Timing Diagrams and System Support Document, Document 2.   |
| 11         | 9              | <b>V<sub>BIAS</sub>:</b> The output of the on-chip analogue circuitry bias system, held internally at $V_{DD}/2$ . This pin should be decoupled to $V_{SS}$ by a capacitor $C_1$ , See Figure 2.  |
| 12         | 10             | <b>Audio Out:</b> The analogue signal output.   |
| 13         | 11             | <b>Audio In:</b> The audio (speech) input. The signal to this pin must be a.c. coupled by a capacitor $C_4$ and decoupled to $V_{SS}$ by an HF bypass capacitor $C_6$ . For optimum noise performance this input should be driven from a source impedance of less than 100 $\Omega$ .   |
| 14         | 12             | <b>V<sub>SS</sub>:</b> Negative supply rail (GND).  |

## Pin Number Function

| FX802<br>J | FX802<br>LG/LS |   |
|------------|----------------|---|
| 15         | 13             | <b>DRAM Data In/A0/ (Direct Access – Encoder Out (ENO)):</b> Connected to the DRAM data input and address line A0. With no DRAM employed this output is available (in Direct Access mode) as the Delta Encoder digital data output. Direct Access control is achieved by Control Register byte 1 – bit 6. |
| 16         | 14             | <b>DRAM Data Out/ A1/ (Direct Access – Decoder In (DEI)):</b> Connected to the DRAM data output and address line A1. With no DRAM employed this pin is available (in Direct Access mode) as the Delta Decoder digital data input. Direct Access control is achieved by Control Register byte 1 – bit 6.   |
| 17         | 15             | <b>DRAM A2/ (Direct Access – Decoder Clock (DCK)):</b> DRAM address line A2. With no DRAM employed this pin is available (in Direct Access mode) as the Delta Decoder Clock input. Direct Access control is achieved by Control Register byte 1 – bit 6.  |
| 18         | 16             | <b>DRAM A3/ (Direct Access – Encoder Clock (ECK)):</b> DRAM address line A3. With no DRAM employed this pin is available (in Direct Access mode) as the Delta Encoder Clock output. Direct Access control is achieved by Control Register byte 1 – bit 6.   |
| 19         | 17             | <b>DRAM A4:</b> DRAM address line A4.   |
| 20         | 18             | <b>DRAM A5:</b> DRAM address line A5.   |
| 21         | 19             | <b>DRAM A6:</b> DRAM address line A6.   |
| 22         | 20             | <b>DRAM A7:</b> DRAM address line A7.   |
| 23         | 21             | <b>DRAM A8:</b> DRAM address line A8.   |
| 24         |                | <b>Row Address Strobe 4 (RAS4):</b> Should be connected to the Row Address Strobe input of the fourth 1Mbit DRAM chip (if fitted).  |
| 25         |                | <b>Row Address Strobe 3 (RAS3):</b> Should be connected to the Row Address Strobe input of the third 1Mbit DRAM chip (if fitted).   |
| 26         | 22             | <b>DRAM A9:</b> DRAM address line A9. This pin is not connected when a 256kbit DRAM is employed.<br><b>Note:</b> To simplify PCB layout, the DRAM address inputs A0 – A8 may be connected in any physical order to the DVSR Codec output pins A0 – A8.  |
| 27         | 23             | <b>Column Address Strobe (CAS):</b> The DRAM Column Address Strobe pin. Should be connected to the CAS pins of all DRAM chips.  |
| 28         | 24             | <b>V<sub>DD</sub>:</b> Positive supply rail. A single, stable +5-volt supply is required. Levels and voltages within the DVSR Codec are dependant upon this supply.   |

# External Components

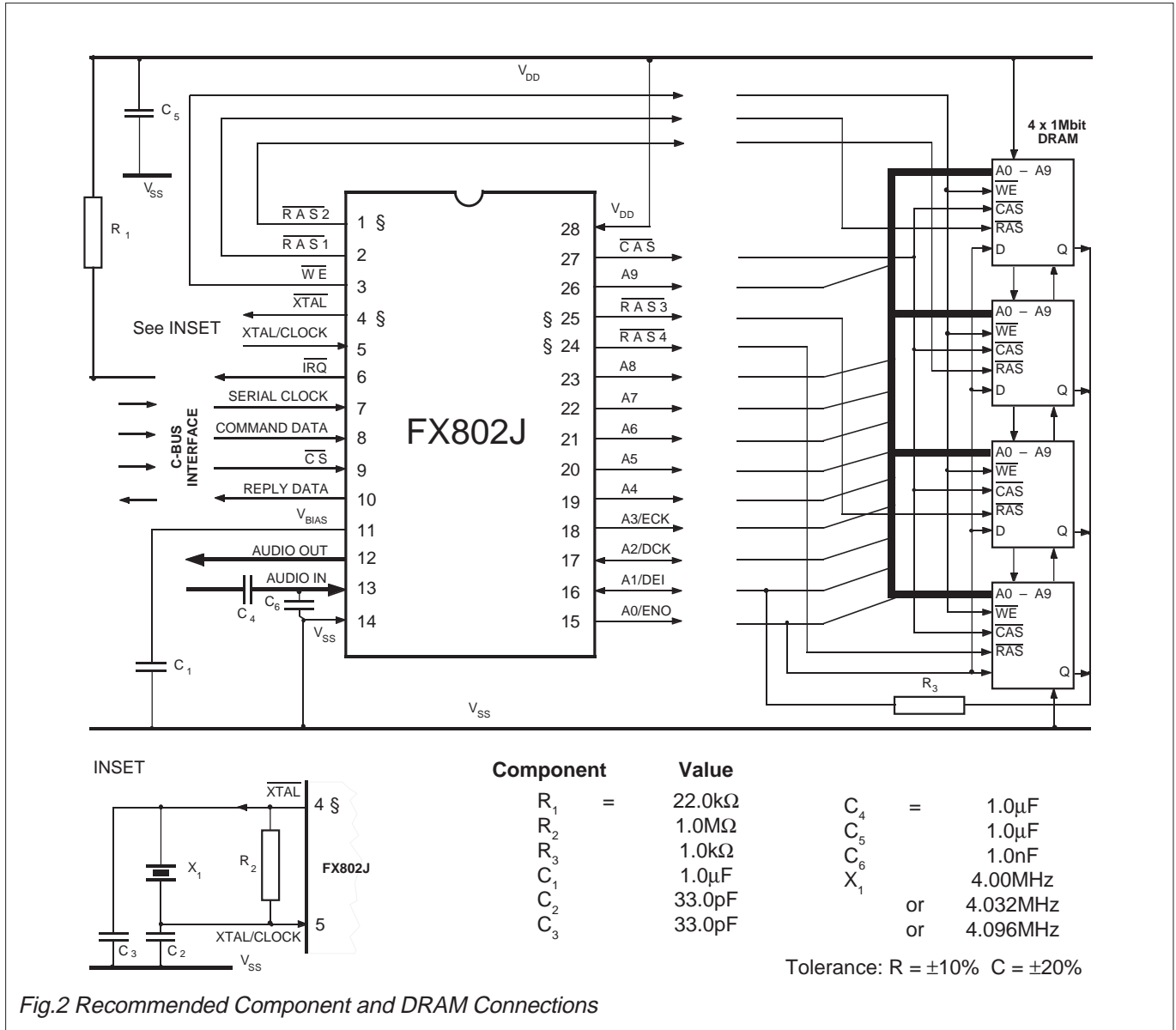


Fig.2 Recommended Component and DRAM Connections

## Notes

- Xtal circuitry shown INSET is in accordance with CML Application Note D/XT/2 December 1991.
- External Xtal circuitry is not applicable to the 24-pin/lead versions of this device, only a clock pulse input can be used.
- Functions whose pins are marked § above are not available on the 24-pin/lead versions of this device. Pin numbers illustrated are for 28-pin versions.
- Table 3 details the actual encoder/decoder sample rates available using the Xtal frequencies recommended above.
- R<sub>1</sub> is used as the DBS 800 system common-pullup for the "C-BUS" Interrupt Request (IRQ) line, the optimum value will depend upon the circuitry connected to the IRQ line. Up to 8 peripherals may be connected to this line.
- Recommended DRAM Parameters:  
256kbit x 1 or 1Mbit x 1 Dynamic Random Access Memory with 'CAS before RAS' refresh mode, maximum Row Address Access time = 200nsec.  
Example DRAM types:  
256kbit (262,144bits)  
Texas Instruments TMS4256-20  
Hitachi HM51256-15  
1Mbit (1,048,576bits)  
Texas Instruments TMX4C1024-15  
Hitachi HM511000-15
- Figure 2 (above) shows connections to 4 x 1Mbit sections of DRAM. If desired, to simplify PCB layout, the DRAM inputs A0 to A8 may be connected in any order to the FX802 DVSR Codec output pins A0 to A8. Connections to 256kbit DRAM are similar, but A9 unconnected.
- When using the FX802 "stand-alone (Direct Access)," no DRAM should be connected.

# Controlling Protocol

Control of the functions of the FX802 DVSR Codec is by a group of Address/Commands (A/Cs) and appended instructions or data to and from the system  $\mu$ Controller (see Figure 5). The use and content of these instructions is detailed in the following paragraphs and tables.

| Command Assignment              | Address/Command (A/C) Byte |        |   |     | + | Data Byte/s |   |   |  |
|---------------------------------|----------------------------|--------|---|-----|---|-------------|---|---|--|
|                                 | Hex.                       | Binary |   | LSB |   |             |   |   |  |
|                                 |                            | MSB    |   |     |   |             |   |   |  |
| General Reset                   | 01                         | 0      | 0 | 0   | 0 | 1           |   |   |  |
| Write to Control Register       | 60                         | 0      | 1 | 1   | 0 | 0           | 0 | + | 2 byte Instruction to Control Register |
| Read Status Register            | 61                         | 0      | 1 | 1   | 0 | 0           | 0 | + | 1 byte Reply from Status Register      |
| Store 'N' pages. Start page 'X' | 62                         | 0      | 1 | 1   | 0 | 0           | 0 | + | 2 bytes Command – Immediate            |
| Store 'N' pages. Start page 'X' | 63                         | 0      | 1 | 1   | 0 | 0           | 0 | + | 2 bytes Command – Buffered             |
| Play 'N' pages. Start page 'X'  | 64                         | 0      | 1 | 1   | 0 | 0           | 1 | + | 2 bytes Command – Immediate            |
| Play 'N' pages. Start page 'X'  | 65                         | 0      | 1 | 1   | 0 | 0           | 1 | + | 2 bytes Command – Buffered             |
| Write Data. Start page 'P'      | 66                         | 0      | 1 | 1   | 0 | 0           | 1 | + | 2 bytes 'P' + Write data               |
| Read Data. Start page 'P'       | 67                         | 0      | 1 | 1   | 0 | 0           | 1 | + | 2 bytes 'P' + Read data                |
| Write Data – Continue           | 68                         | 0      | 1 | 1   | 0 | 1           | 0 | + | Write data                             |
| Read Data – Continue            | 69                         | 0      | 1 | 1   | 0 | 1           | 0 | + | Read data                              |

*Table 1 "C-BUS" Address/Commands*

## Address/Commands

Instruction and data transactions to and from this device consist of an Address/Command (A/C) byte followed by either:

- (i) a further instruction or data, or
- (ii) a Status or data Reply.

Control and configuration is by writing instructions from the  $\mu$ Controller to the Control Register (60<sub>H</sub>). Reporting of FX802 configurations is by reading the Status Register (61<sub>H</sub>). Instructions and data are transferred, via "C-BUS," in accordance with the timing information given in Figures 5 and 6.

A complete list of DBS 800 "C-BUS" Address locations is published in the System Support Document.

## Speech

The delta encoder and decoder sampling rates are independently set, via the Control Register (Table 4), to (nominally) 16, 25, 32, 50 or 64kbits/s (see Tables 2 and 3), allowing the user to choose between speech-quality and storage-time, whilst providing for time-compression or expansion of the speech signals.

The DVSR Codec can handle from 256kbits to 4Mbits of DRAM, giving, in the case of 32kbit/s sampling rate, from 8 to 131 seconds of speech storage.

For speech storage purposes, the memory is divided into 'pages' of 1024 bits each, corresponding to 32ms at a 32kbit/s sampling rate.

|                         |             |
|-------------------------|-------------|
| A 256kbit DRAM contains | 256 pages.  |
| A 1Mbit DRAM contains   | 1024 pages. |
| 4Mbit of DRAM contains  | 4096 pages. |

The Delta Codec may be used without DRAM, when the decoder sampling rate (8 to 64 kbits/s) is determined by an external clock source applied to the Decoder Clock pin.

## Operation with DRAM

The FX802 can operate with up to 4Mbits of DRAM. When used with DRAM the DVSR Codec performs four main functions under the control of commands received over the "C-BUS" interface from the  $\mu$ Controller:

**Stores Speech** by digitally encoding the analogue input signal and writing the resulting digital data into the associated Dynamic RAM (DRAM).

**Plays** stored speech by reading the digital data stored in the DRAM and decoding it to provide an analogue output signal.

**Writes** data sent over the "C-BUS" from the  $\mu$ Controller to DRAM.

**Reads** data from DRAM, sending it to the  $\mu$ C over the "C-BUS".

'Data' is directed to and from DRAM by the on-chip DRAM Controller.

## Store and Play Speech Commands

Speech storage and playback may take place simultaneously.

These commands are transmitted, via "C-BUS," to the FX802, in the form:

**STORE or PLAY 'N' (1024-bit) pages (of encoded speech data) starting at page 'X.'**

'N' is any number from 1 to 16 (pages) and 'X' from (page) 0 to 4095 (4Mbit DRAM), as illustrated below.

Preceded by the A/C, this command writes 16-bits (byte 1 (first) and byte 0) of data from the  $\mu$ C to the FX802 Store or Play Command Buffer.

| MSB |    |    |    |    |    |   |   | Byte 1 |   |   |   |   |   |   |   | Byte 0 |   |   |   |   |   |   |   | LSB |   |   |   |   |   |   |   |
|-----|----|----|----|----|----|---|---|--------|---|---|---|---|---|---|---|--------|---|---|---|---|---|---|---|-----|---|---|---|---|---|---|---|
| 15  | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7      | 6 | 5 | 4 | 3 | 2 | 1 | 0 | 7      | 6 | 5 | 4 | 3 | 2 | 1 | 0 | 7   | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| 'N' |    |    |    |    |    |   |   | 'X'    |   |   |   |   |   |   |   |        |   |   |   |   |   |   |   |     |   |   |   |   |   |   |   |

# Controlling Protocol .....

## Store and Play Speech

### Speech Store Commands

- 62<sub>H</sub> STORE 'N' PAGES – START PAGE 'X' (immediate).
- 63<sub>H</sub> STORE 'N' PAGES – START PAGE 'X' (buffered).

The digitised speech from the Delta Encoder is stored in consecutive DRAM locations with the Speech Store Counters sequencing through the DRAM addresses and counting the number of complete 'pages' stored since the start of execution of the command.

As soon as the command has terminated the following events take place:

- (1) The "Store Command Complete" bit in the Status Register (Table 6) is set.
- (2) An "Interrupt Request" ( $\overline{IRQ}$ ) is sent (if enabled) to the  $\mu$ C.
- (3) The next Speech Store command (if present) is immediately taken from the Store Command Buffer and execution of the new command commences.

**Speech Playback** is controlled by similar commands:

- 64<sub>H</sub> PLAY 'N' PAGES – START PAGE 'X' (immediate).
- 65<sub>H</sub> PLAY 'N' PAGES – START PAGE 'X' (buffered).

using the Speech Play Counters and Play Command Buffer.

As soon as the Play Command has completed, the "Play Command Complete" bit in the Status Register is set and an Interrupt Request generated (if enabled).

If no 'next' command is waiting in the Play Command Buffer when a speech Play command finishes, a continuous idle code (0101.....0101) will be fed to the Delta Decoder.

Speech "data" is stored or recovered at the selected Encode or Decode sample rate (Table 3). Store or Play Command Complete bits in the Status Register are cleared by the next Store or Play command received from the  $\mu$ C, or by a General Reset command.

The  $\overline{IRQ}$  output is cleared by reading the Status Register.

- 61<sub>H</sub> READ STATUS REGISTER (Table 6).

To provide continuity of speech commands, both Store and Play commands can be presented to the FX802 in one of two formats; *Immediate or Buffered*.

An *Immediate* command will be started on completion of its loading, irrespective of the condition of the current command.

A *Buffered* command will be acted upon on the completion of the current Store or Play command, unless Speech Synchronization Bits (Control Register) are set.

Buffering of commands lets the DVSR Codec execute a series of commands without intervening gaps, even though the  $\mu$ Controller may take several milliseconds to respond to each "Command Complete" Interrupt Request.

In either case, the Store or Play Command Complete bit of the Status Register will be cleared.

### Store/Play Speech Synchronization – (Table 4)

This facility is provided, primarily, for Time Domain Scrambling applications.

Speech Synchronization bits in the Control Register will produce the effects described below:

**No Speech Sync Set;** Store and Play operations may take place completely independently.

**Store after Play;** The next "buffered" Store command will start *on completion of a Play operation*, whilst the next Play command (if any) sequence continues normally.

**Play after Store;** The next "buffered" Play command will start *on completion of a Store operation*, whilst the next Store command (if any) sequence continues normally.

These actions will continue whilst 'Speech Sync' bits remain set.

## DRAM Speech Capacity

28-pin/lead versions of the FX802 may be used with a single 256kbit DRAM or with up to 4 x 1Mbit DRAM. 24-pin/lead versions may only be used with a single 256kbit or 1Mbit DRAM. The different Encode and Decode sampling clock rates available enable the user to set voice store and play times against recovered speech quality. Table 2 gives information on storage capacity and Store/Playback times. Speech data can be replayed at a different sample rate or in a reverse sequence, see Control Register for details.

| DRAM Size | Available Bits | "Speech Pages" | Nominal Sample Rates (kbits/s) |       |       |      |      |
|-----------|----------------|----------------|--------------------------------|-------|-------|------|------|
|           |                |                | 16                             | 25    | 32    | 50   | 64   |
| 256kbits  | 262144         | 256            | 16.0                           | 10.0  | 8.0   | 5.0  | 4.0  |
| 1024k     | 1048576        | 1024           | 65.0                           | 42.0  | 32.0  | 20.0 | 16.0 |
| 2Mbits    | 2097152        | 2048           | 131.0                          | 84.0  | 65.0  | 42.0 | 32.0 |
| 3M        | 3145728        | 3072           | 196.0                          | 126.0 | 98.0  | 63.0 | 49.0 |
| 4M        | 4194304        | 4096           | 262.0                          | 168.0 | 131.0 | 84.0 | 65.5 |

**Store and Play Times (seconds)**

Table 2 Sampling Clock Rates vs Speech Storage/Playback Times

# Controlling Protocol .....

## Data Operations

### Data Storage and Recovery

For the purpose of storing data sent via "C-BUS" from the  $\mu$ C, the memory (DRAM) is divided into 'data-pages' of 64-bits (8-bytes).

- A single 256kbit DRAM contains 4096 data-pages.
- A single 1Mbit DRAM contains 16384 data-pages.
- 4Mbit DRAM contains 65536 data-pages.

In accordance with "C-BUS" timing specifications, data is handled 8-bits (1-byte) at a time although any number of 8-bit blocks of data may be written-to or read-from the DRAM by a single command.

The data transfer action is terminated by the Chip Select line being taken to a logic "1".

### "C-BUS" Data Transfer Limitations

For those commands which transfer data over the "C-BUS" between DRAM and the  $\mu$ Controller (Write and Read Data) the "C-BUS" Serial Clock rate is limited to a maximum of:

- 125kHz if the VSR Codec is executing Store and Play commands.
- 250kHz if no speech Store or Play commands are active.

All other commands and replies (Control, Status, General Reset) may use a maximum clock rate of 500kHz. See Figure 5.

Read and Write Data actions are explained below

#### Read Data

67<sub>H</sub> READ DATA – START PAGE "P"

Sets the Data Read Counter to "P" page and then reads data bytes from successive DRAM locations, sending them to the  $\mu$ C as Reply Data bytes incrementing the Data Read Counter by 1 for each bit read.

69<sub>H</sub> READ DATA – CONTINUE

Reads data bytes from successive DRAM locations determined by the Data Read Counter incrementing the counter by 1 for each bit read.

#### Write Data

66<sub>H</sub> WRITE DATA – START PAGE "P"

Sets the Data Write Counter to "P" page and then writes data bytes to successive DRAM locations, incrementing the Data Write Counter by 1 for each bit received via the "C-BUS."

The Start Page "P," is indicated by loading a 2-byte word after the relevant Address/Command byte. This 16-bit word allows data-page addresses from 0 to 65535 (4Mbits DRAM).

68<sub>H</sub> WRITE DATA – CONTINUE

Writes data bytes to successive DRAM locations determined by the Data Write Counter, incrementing the counter by 1 for each bit received over the "C-BUS."

## Encoder and Decoder Sampling Clocks

Encoder and decoder sampling clock rates are programmable via the Control Register. Table 3 shows the range of sampling rates available for differing Xtal/clock input frequencies, and the counter ratios used to produce them. If different "Store and Play" sampling rates are used in a single operation, only combinations of 25kb/s with 32kb/s or 50kb/s with 64kb/s will give correct output levels in accordance with current specifications. Consideration should be given to the effect of differing Xtal/clock frequencies upon the audio frequency performance of the device.

|                  |   |   |           | Xtal/clock Frequency (MHz)      |                         |       |
|------------------|---|---|-----------|---------------------------------|-------------------------|-------|
| Control Register |   |   |           | 4.0                             | 4.032                   | 4.096 |
| Byte 0, Bits     |   |   |           | Internal Counter Division Ratio | Sampling Rate (kbits/s) |       |
| 5                | 4 | 3 | Dec. Enc. |                                 |                         |       |
| 2                | 1 | 0 | 0         | 256                             | 15.625                  | 15.75 |
| 0                | 1 | 1 | 0         | 160                             | 25.0                    | 25.20 |
| 1                | 0 | 1 | 1         | 128                             | 31.25                   | 31.50 |
| 1                | 1 | 0 | 0         | 80                              | 50.0                    | 50.4  |
| 1                | 1 | 1 | 1         | 64                              | 62.50                   | 63.0  |
| 1                | 1 | 1 | 0         |                                 |                         | 16.0  |
|                  |   |   |           |                                 |                         | 25.60 |
|                  |   |   |           |                                 |                         | 32.0  |
|                  |   |   |           |                                 |                         | 51.20 |
|                  |   |   |           |                                 |                         | 64.0  |

Table 3 Sampling Clock Rates Available

With respect to using a single Xtal/clock frequency for all DBS 800 devices in use it should be noted that:

- (a) a 4.032MHz Xtal/clock input will produce an accurate 1200 baud rate for the FX809 FFSK Modem
- (b) a 4.096MHz Xtal/clock input will generate exactly 16kb/s and 32kb/s Codec sampling clock rates.

**“Write to Control Register”** — Address/Command 60<sub>H</sub>, followed by 2 bytes of Command Data

| Setting       |          | Function   |  |
|---------------|----------|--|--|
| <b>Byte 1</b> |          | <b>First Byte for Transmission</b>                   |  |
| <b>(MSB)</b>  |          |  |  |
| <b>Bit 7</b>  |          | Not used – Set to “0”                                |  |
| <b>6</b>      |          | <b>Direct Access</b>                                 |  |
| 1             |          | – Encoder Data Out to A0/ENO                         |  |
|               |          | – Encoder Clock to A3/ECK                            |  |
|               |          | – Decoder Input from A1/DEI                          |  |
| 0             |          | – Decoder Clock from A2/DCK<br>Normal DVSR Operation |  |
| <b>5</b>      |          | <b>Play Counter</b>                                  |  |
| 1             |          | Decrement  |  |
| 0             |          | Increment  |  |
| <b>4</b>      |          | <b>DRAM Control</b>                                  |  |
| 1             |          | Disable DRAM   |  |
| 0             |          | Enable DRAM  |  |
| <b>3</b>      |          | <b>Codec Powersave</b>                               |  |
| 1             |          | Powersave Delta Codec                                |  |
| 0             |          | Enable Delta Codec                                   |  |
| <b>2</b>      |          | <b>Store Command Interrupt</b>                       |  |
| 1             |          | Enable Interrupt                                     |  |
| 0             |          | Disable  |  |
| <b>1</b>      |          | <b>Play Command Interrupt</b>                        |  |
| 1             |          | Enable Interrupt                                     |  |
| 0             |          | Disable  |  |
| <b>0</b>      |          | <b>Power Reading Interrupt</b>                       |  |
| 1             |          | Enable Interrupt                                     |  |
| 0             |          | Disable  |  |
| <b>Byte 0</b> |          | <b>Last Byte for Transmission</b>                    |  |
| <b>(MSB)</b>  |          |  |  |
| <b>7</b>      | <b>6</b> | <b>Store/Play Speech Sync</b>                        |  |
| 0             | 0        | No Sync  |  |
| 0             | 1        | No Sync  |  |
| 1             | 0        | Sync – Play after Store                              |  |
| 1             | 1        | Sync – Store after Play                              |  |
| <b>5</b>      | <b>4</b> | <b>3</b>   | <b>Decoder Control</b>                       |
| 0             | 0        | 0  | Idle (32kbit/s); Aud O/P via L.P.F.          |
| 0             | 0        | 1  | Idle (32kbit/s); Aud By-Pass                 |
| 0             | 1        | 0  | Idle (32kbit/s); Aud O/P at High Z           |
| 0             | 1        | 1  | On – Sampling Rate 16kbit/s                  |
| 1             | 0        | 0  | On – " 25kbit/s                              |
| 1             | 0        | 1  | On – " 32kbit/s                              |
| 1             | 1        | 0  | On – " 50kbit/s                              |
| 1             | 1        | 1  | On – " 64kbit/s                              |
| <b>2</b>      | <b>1</b> | <b>0</b>   | <b>Encoder Control</b>                       |
| 0             | 0        | 0  | I/P at V <sub>BIAS</sub> – F/Idle (32kbit/s) |
| 0             | 0        | 1  | I/P at High Z – F/Idle (32kbit/s)            |
| 0             | 1        | 0  | I/P at High Z – F/Idle (32kbit/s)            |
| 0             | 1        | 1  | On – Sampling Rate 16kbit/s                  |
| 1             | 0        | 0  | On – " 25kbit/s                              |
| 1             | 0        | 1  | On – " 32kbit/s                              |
| 1             | 1        | 0  | On – " 50kbit/s                              |
| 1             | 1        | 1  | On – " 64kbit/s                              |

Table 4 Control Register

**General Reset**

Upon Power-Up the “bits” in the FX802 registers will be random (either “0” or “1”). A General Reset command (01<sub>H</sub>) will be required to “reset” all microcircuits on the “C-BUS,” and has the following effect upon the FX802:

|                                      |                        |
|--------------------------------------|------------------------|
| Control Register                     | Set as 00 <sub>H</sub> |
| Status Register                      | Set as 00 <sub>H</sub> |
| Clear Store and Play Command Buffers |                        |

**Direct Access**

Allows external circuitry “Direct Access” to the Delta Codec data and sampling clocks, disabling the DRAM timing circuitry. This permits the Delta Codec section of the FX802 to be used as a “stand-alone” delta modulation voice encoder and decoder.

Input Audio is encoded and made available at the Encoder Out (ENO) pin. Speech data input to the Decoder In (DEI) pin is decoded to give voice-band audio at the Audio Output.

The following points, with respect to Control Register settings, should be considered. Analogue output switching remains under the control of the Control Register, but the Decoder sampling clock rate (8kbit/s to 64kbit/s) must be provided from an external source to the Decoder Clock (DCK) pin. To ensure correct filter setting, Decoder Control bits (Byte 0, Bits 5, 4, 3) should be set to (binary) 1, 1, 1, where the required rate approximates to a multiple of 16kb/s, or (binary) 1, 1, 0, where the required rate approximates to a multiple of 25kb/s.

Both the Encoder internal sampling clock rate and input switching (Table 5) remain under the control of the Control Register. The sampling clock rate is available to external circuitry at the Encoder Clock Out (ECK) pin.

**Play Counter**

The Play Counter direction may be set to run backwards as well as forwards. This can be used in a scrambling system by replaying speech data in reverse order.

**DRAM Control**

A logic “1” will disable the DRAM Control timing circuits and associated counters. The “C-BUS” Interface, Clock Generator, Delta Codec and filters remain active. This bit should be set to logic “1” when the FX802 is used in the Direct Access mode.

Minimum DVSR Codec power consumption is achieved by setting both DRAM Control and Powersave bits to a logic “1.”

**Codec Powersave**

A logic “1” puts the Delta Codec and filters into a Powersave mode, with V<sub>BIAS</sub> maintained.

The Clock Generator, “C-BUS” Interface and DRAM Control and Timing remain active.

**Command Interrupt Enable**

A logic “1” set at the relevant bit will enable Interrupt Requests to the µController when that command operation is complete.

**Store and Play Speech Synchronization**

Intended, primarily, for Time Domain Scrambling.

**Decoder and Encoder Control**

Sets individually, decoder and encoder sampling clock rates and the source of the Audio Output.



# Encoder and Decoder Control

## Analogue Input and Output Switching

The Control Register, Byte 0 – bits 0 to 5, are used, in conjunction with the codec Powersave Bit (Byte 1 – bit 3) to control codec input/output conditions and sample rates. Figure 3 shows the codec functional situation.

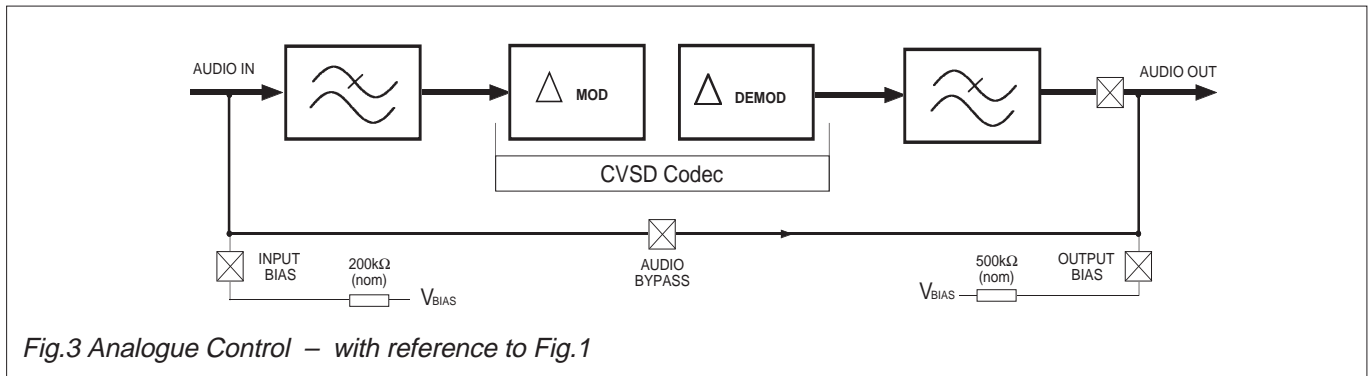


Fig.3 Analogue Control – with reference to Fig.1

| Control Register    |                 |     |     | Circuit Switches |           |             | OFF = Switch Open<br>ON = Switch Closed                     | Note |
|---------------------|-----------------|-----|-----|------------------|-----------|-------------|---|------|
| Codec Powersave Bit | Decoder Control |     |     | Audio By-Pass    | Audio Out | Output Bias |   |      |
|                     | "5"             | "4" | "3" |                  |           |             |   |      |
| 0                   | 0               | 0   | 0   | OFF              | ON        | OFF         | Decoder 'idling' fed with "1010101 ...." pattern at 32kb/s. | 1    |
| 0                   | 0               | 0   | 1   | ON               | OFF       | OFF         |   |      |
| 0                   | 0               | 1   | 0   | OFF              | OFF       | OFF         |   |      |
| 0                   | 0               | 1   | 1   | OFF              | ON        | OFF         | Decoder running at the selected sampling rate.              | 1    |
| –                   | –               | –   | –   | –                | –         | –           |   |      |
| 0                   | 1               | 1   | 1   | OFF              | ON        | OFF         | Decoder circuits Powersaved                                 |      |
| 1                   | 0               | 0   | 0   | OFF              | OFF       | ON          |   |      |
| 1                   | 0               | 0   | 1   | ON               | OFF       | OFF         |   |      |
| 1                   | 0               | 1   | 0   | OFF              | OFF       | ON          |   |      |
| 1                   | 0               | 1   | 1   | OFF              | OFF       | ON          |   |      |
| –                   | –               | –   | –   | –                | –         | –           |   |      |
| 1                   | 1               | 1   | 1   | OFF              | OFF       | ON          | Encoder circuits Powersaved                                 | 2    |
| Encoder Control     |                 |     |     | Input Bias       |           |             |   |      |
|                     | "2"             | "1" | "0" |                  |           |             |   |      |
| 0                   | 0               | 0   | 0   | ON               |           |             |   |      |
| 0                   | 0               | 0   | 1   | OFF              |           |             |   |      |
| 0                   | 0               | 1   | 0   | OFF              |           |             |   |      |
| 0                   | 0               | 1   | 1   | OFF              |           |             | Encoder running at selected Sampling Rate                   |      |
| –                   | –               | –   | –   | –                |           |             |   |      |
| 0                   | 1               | 1   | 1   | OFF              |           |             | Encoder circuits Powersaved                                 |      |
| 1                   | 0               | 0   | 0   | ON               |           |             |   |      |
| –                   | –               | –   | –   | –                |           |             |   |      |
| 1                   | 1               | 1   | 1   | ON               |           |             |   |      |

Table 5 Analogue Control – with reference to Fig.3

### Notes

- If the Delta Codec is in the Direct Access mode, these sampling rates will be as provided by the externally applied clock.
- The Input Bias switch is operated by the Control Register Codec Powersave' and 'Encoder Control' bits to provide a

relatively low impedance path for  $V_{BIAS}$  to charge the input coupling capacitor whenever the codec is powersaved, or the Encoder control bits are set to "0," so that input bias can be established quickly prior to operation.

## Time Compression of Speech

The 25kb/s and 50kb/s sampling rate options are provided for time compression (and subsequent expansion) of speech signals.

For example, 1.0 second of speech stored at 50kb/s may be transmitted in 0.8 seconds if played out at 64kb/s, and finally restored to its original speed at the receiver by storing

at 64kb/s and playing out at 50kb/s. A similar result (with a degraded SINAD) may be achieved by using 25kb/s and 32kb/s sampling rates.

However, the speech frequencies are raised by time compression, and since the signal transmitted to air must be band limited to 3400Hz, the effective end-to-end bandwidth is  $0.8 \times 3400\text{Hz}$ , which is approximately 2700Hz.

**“Read Status Register”** – Address/Command, 61<sub>H</sub>, followed by 1 byte of Reply Data.

| Reading          |          |          |          |          | Function                      |                          |
|------------------|----------|----------|----------|----------|-------------------------------|--------------------------|
| <b>MSB Bit 7</b> |          |          |          |          |                               |                          |
| 1                |          |          |          |          | <b>Power Reading Ready</b>    |                          |
| 6                |          |          |          |          | <b>Store Command Complete</b> |                          |
| 5                |          |          |          |          | <b>Play Command Complete</b>  |                          |
|                  |          |          |          |          | <b>Power Register</b>         |                          |
| <b>4</b>         | <b>3</b> | <b>2</b> | <b>1</b> | <b>0</b> | <b>Pwr</b>                    | <b>Compand Bits/page</b> |
| 0                | 0        | 0        | 0        | 0        |                               | 0                        |
| 0                | 0        | 0        | 0        | 1        |                               | 1                        |
| 0                | 0        | 0        | 1        | 0        |                               | 2                        |
| 0                | 0        | 0        | 1        | 1        |                               | 3                        |
| 0                | 0        | 1        | 0        | 0        |                               | 4                        |
| 0                | 0        | 1        | 0        | 1        |                               | 5                        |
| 0                | 0        | 1        | 1        | 0        |                               | 6                        |
| 0                | 0        | 1        | 1        | 1        |                               | 7                        |
| 0                | 1        | 0        | 0        | 0        | -39.0 dB                      | 8                        |
| 0                | 1        | 0        | 0        | 1        |                               | 10                       |
| 0                | 1        | 0        | 1        | 0        | -36.0                         | 12                       |
| 0                | 1        | 0        | 1        | 1        |                               | 14                       |
| 0                | 1        | 1        | 0        | 0        | -33.5                         | 16                       |
| 0                | 1        | 1        | 0        | 1        |                               | 18                       |
| 0                | 1        | 1        | 1        | 0        | -30.0                         | 20                       |
| 0                | 1        | 1        | 1        | 1        |                               | 22                       |
| 1                | 0        | 0        | 0        | 0        | -28.0                         | 24                       |
| 1                | 0        | 0        | 0        | 1        |                               | 32                       |
| 1                | 0        | 0        | 1        | 0        | -25.0                         | 40                       |
| 1                | 0        | 0        | 1        | 1        |                               | 48                       |
| 1                | 0        | 1        | 0        | 0        | -22.0                         | 56                       |
| 1                | 0        | 1        | 0        | 1        |                               | 64                       |
| 1                | 0        | 1        | 1        | 0        | -19.0                         | 72                       |
| 1                | 0        | 1        | 1        | 1        |                               | 80                       |
| 1                | 1        | 0        | 0        | 0        | -16.0                         | 88                       |
| 1                | 1        | 0        | 0        | 1        |                               | 128                      |
| 1                | 1        | 0        | 1        | 0        | -10.0                         | 192                      |
| 1                | 1        | 0        | 1        | 1        |                               | 256                      |
| 1                | 1        | 1        | 0        | 0        | -6.0                          | 320                      |
| 1                | 1        | 1        | 0        | 1        |                               | 384                      |
| 1                | 1        | 1        | 1        | 0        | 0dB                           | 448                      |
| 1                | 1        | 1        | 1        | 1        |                               | 512                      |

Table 6 Status Register

**Interrupts**

An Interrupt Request (IRQ), (if enabled by the Control Register) is produced by the FX802 to report the following actions:

- Power Reading Ready
- Store Command Complete
- Play Command Complete.

When an Interrupt Request is produced the Status Register must be read to ascertain the source of the interrupt. This action will clear the IRQ output.

**Store Command Complete bit**

(and an interrupt) is set on completion of a Store command. This bit is cleared by loading the next Store command, or by a General Reset command (01<sub>H</sub>).

**Play Command Complete bit**

(and an interrupt) is set on completion of a Play command. This bit is cleared by loading the next Play command, or by a General Reset command (01<sub>H</sub>).

**Power Reading Ready bit**

(and an interrupt) is set for every 1024 (1 page) voice-data bits from the Encoder. This bit is cleared after reading the Status Register, or by a General Reset command (01<sub>H</sub>).

**Power Register**

The power assessment element shown in Figure 1 assesses the input signal power for each encoded 'page' (every 1024 encoder output bits) by counting the number of 'compand bits' (000 or 111 sequences in the output bit-stream) produced during that 'page,' shown in Table 6, with typical encoder input power levels (dB).

Power Reading measurements (Bits 0 – 4) are produced under the same conditions as in Figure 4.

At the end of each 'page' the "Power Reading Ready" bit of the Status Register is set, an Interrupt Request is generated (if enabled) and the resulting count converted to a 5-bit quasi-logarithmic form.

The Power Register reading is interpreted as below.

- 00000 represents 0 compand bits
- 00001 represents 1 compand bit
- 11111 represents 512 compand bits – the maximum.

This "Power" reading is placed in the Status Register where it can be read by the μC.

Figure 4 shows this output in graphical form, indicating the typical Input Power Level.

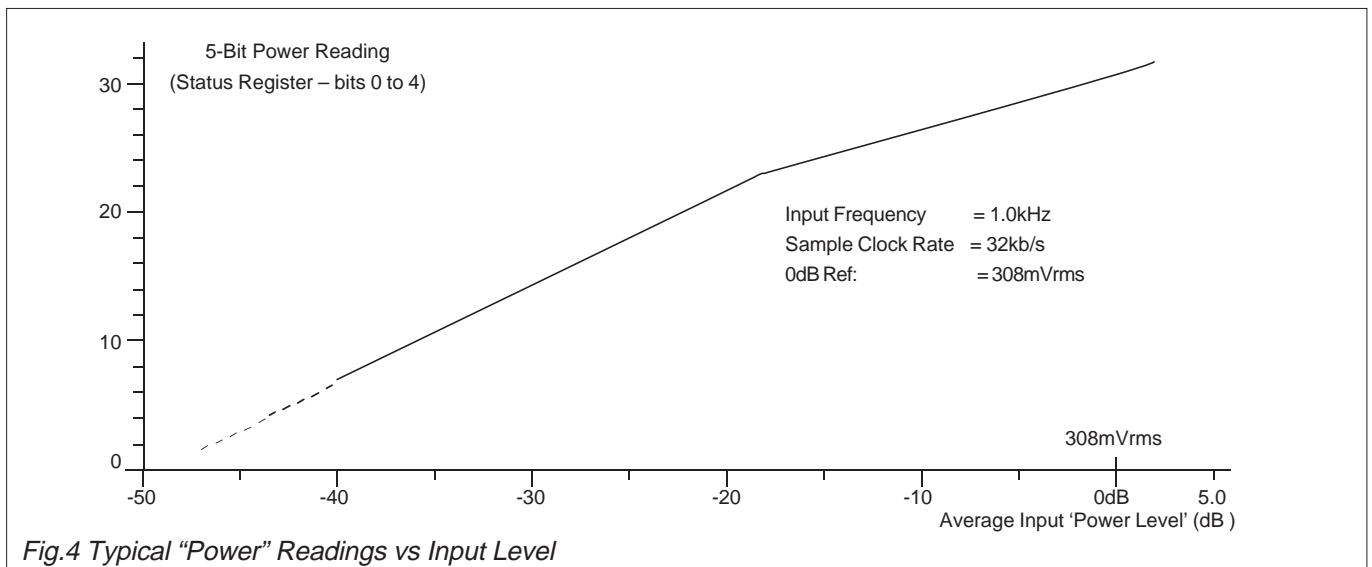


Fig.4 Typical "Power" Readings vs Input Level

# Timing Information

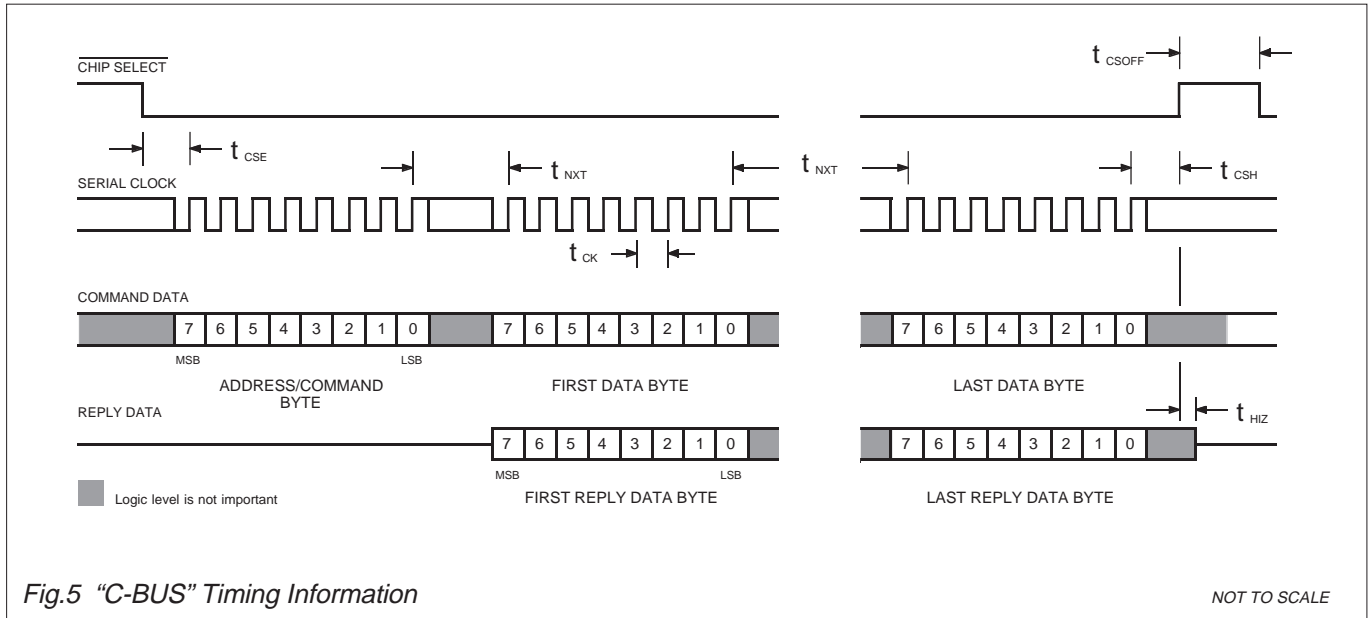


Fig.5 "C-BUS" Timing Information

NOT TO SCALE

"C-BUS" Timing – Figure 5

| Parameter   | Min.     | Max.     | Unit     |                   |
|-------------|----------|----------|----------|-------------------|
|             | <b>a</b> | <b>b</b> | <b>c</b> |                   |
| $t_{CSE}$   | 2.0      | 4.0      | 8.0      | – $\mu\text{s}$   |
| $t_{CSH}$   | 4.0      | 4.0      | 8.0      | – $\mu\text{s}$   |
| $t_{HIZ}$   | –        | –        | –        | 2.0 $\mu\text{s}$ |
| $t_{CSOFF}$ | 2.0      | 4.0      | 8.0      | – $\mu\text{s}$   |
| $t_{NXT}$   | 4.0      | 8.0      | 16.0     | – $\mu\text{s}$   |
| $t_{CK}$    | 2.0      | 4.0      | 8.0      | – $\mu\text{s}$   |

Direct Access Timing – Figure 6

| Parameter                              | Min. | Typ | Max. | Unit          |
|--|------|-----|------|---------------|
| $t_{CH}$                               | 1.0  | –   | –    | $\mu\text{s}$ |
| $t_{CL}$                               | 1.0  | –   | –    | $\mu\text{s}$ |
| $t_{SU}$                               | 450  | –   | –    | ns            |
| $t_H$                                  | 600  | –   | –    | ns            |
| $t_{PCO}$                              | –    | –   | 750  | ns            |
| $t_{SU} + t_H = \text{Data True Time}$ |      |     |      |               |

## Notes

- Minimum Timing Values**
  - For all commands except "Read Data" and "Write Data" commands.
  - For "Read Data" and "Write Data" commands when no "Speech Store" or "Speech Play" commands are active.
  - For "Read Data" and "Write Data" commands when "Speech Store" or "Speech Play" commands are active.
- Depending on the command, 1 or 2 bytes of Command Data are transmitted to the peripheral MSB (bit7) first, LSB (bit0) last. Reply Data is read from the peripheral MSB (bit7) first, LSB (bit0) last.
- To allow for differing  $\mu\text{Controller}$  serial interface formats "C-BUS" compatible ICs are able to work with either polarity Serial Clock pulses.
- Data sent from the  $\mu\text{Controller}$  is clocked into the FX802 on the rising edge of the Serial Clock pulses. Reply Data sent from the FX802 to the  $\mu\text{Controller}$  is clocked into the  $\mu\text{Controller}$  when the Serial Clock is "high."
- Loaded commands are acted upon at the end of each command.

## Direct Access

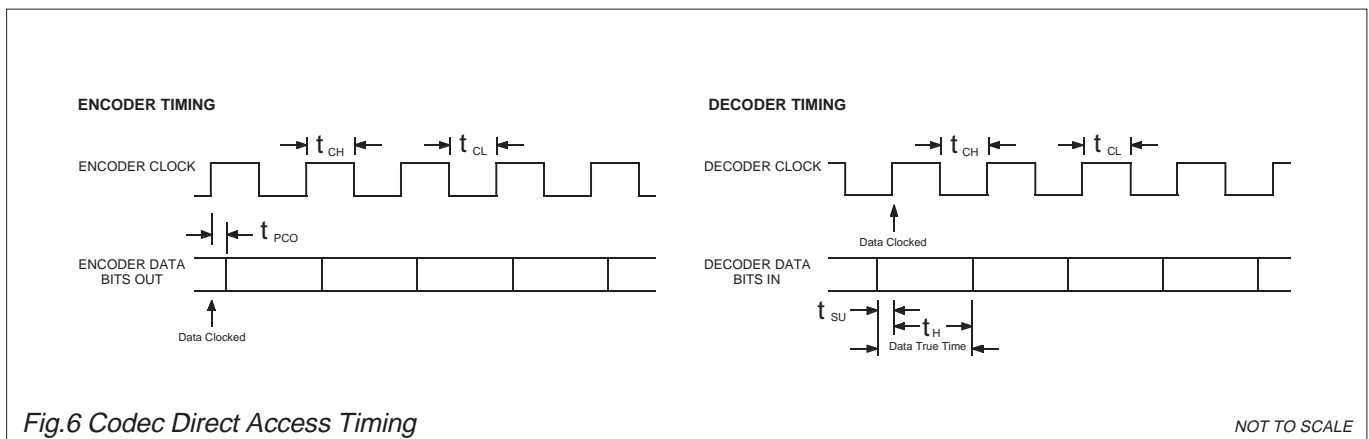


Fig.6 Codec Direct Access Timing

NOT TO SCALE

# 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 @ $T_{AMB} = 25^{\circ}C$ |                   | 800mW Max.                                   |
| Derating   |                   | 10mW/ $^{\circ}C$                            |
| Operating temperature range:                       | <b>FX802J</b>     | -40 $^{\circ}C$ to +85 $^{\circ}C$ (cerdip)  |
|  | <b>FX802LG/LS</b> | -40 $^{\circ}C$ to +85 $^{\circ}C$ (plastic) |
| Storage temperature range:                         | <b>FX802J</b>     | -55 $^{\circ}C$ to +125 $^{\circ}C$ (cerdip) |
|  | <b>FX802LG/LS</b> | -40 $^{\circ}C$ to +85 $^{\circ}C$ (plastic) |

## Operating Limits

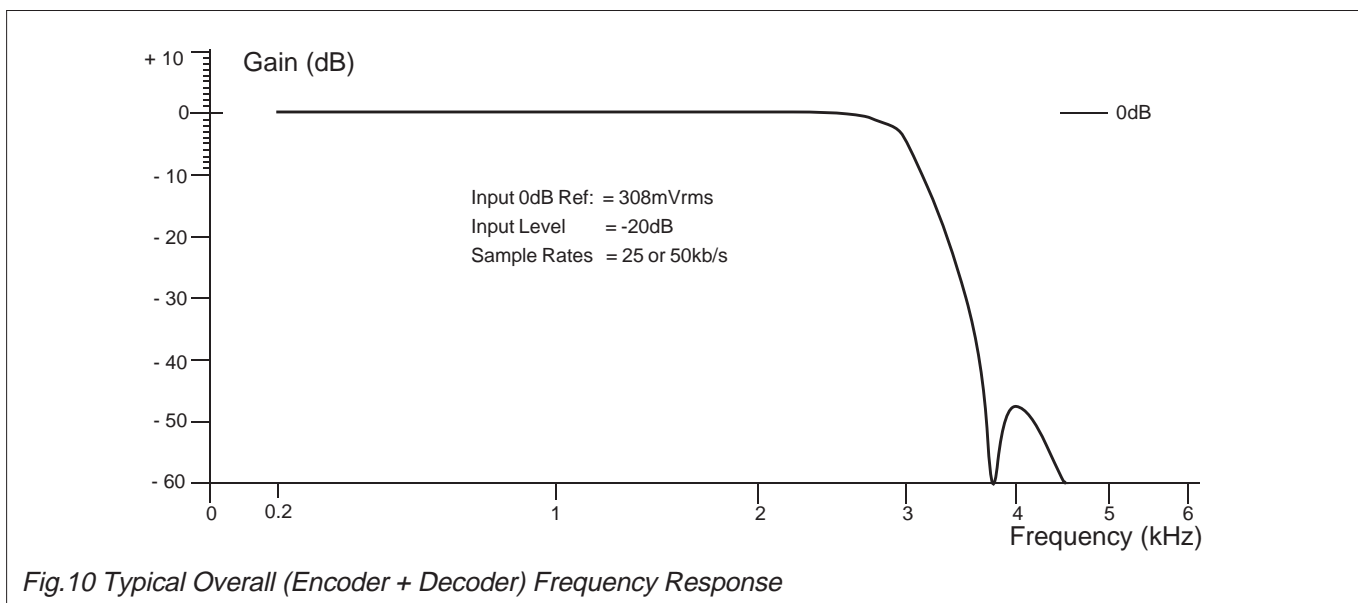
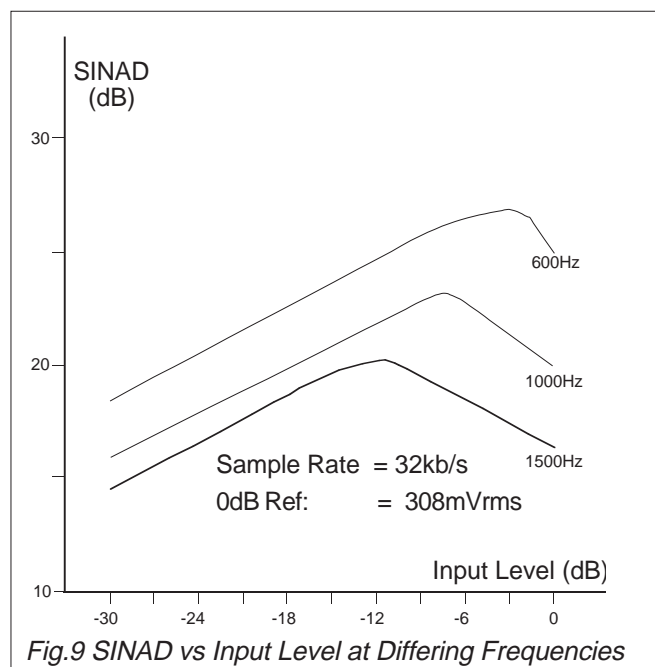
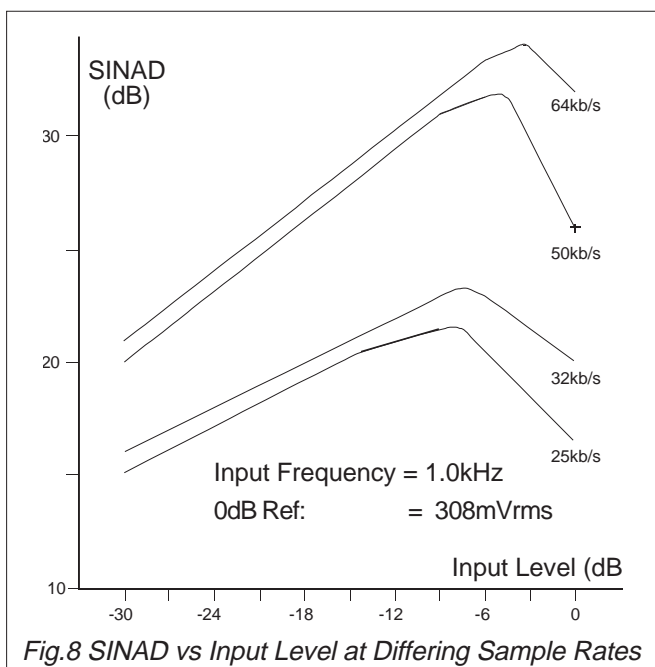
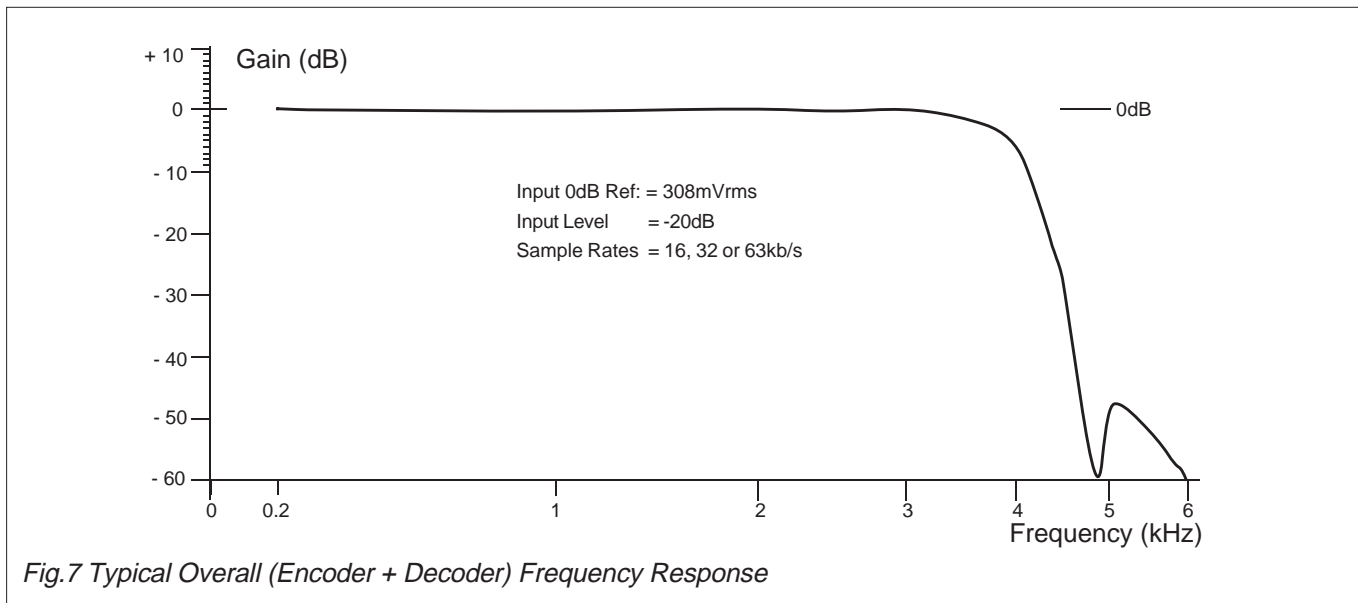
All device characteristics are measured under the following conditions unless otherwise specified:

$V_{DD} = 5.0V$ .  $T_{AMB} = 25^{\circ}C$ . Xtal/Clock  $f_0 = 4.0MHz$ . Standard Test Signal  $f_0 = 1.0kHz$ . Sample Rate = 31.25kbits/s  
Audio Level 0dB ref: = 308mVrms .

| Characteristics   | See Note | Min.  | Typ. | Max. | Unit       |
|---|----------|-------|------|------|------------|
| <b>Static Values</b>                                    |          |       |      |      |            |
| Supply Voltage ( $V_{DD}$ )                             |          | 4.5   | 5.0  | 5.5  | V          |
| Supply Current (enabled)                                | 1        | –     | 7.0  | –    | mA         |
| Supply Current (all powersaved)                         | 1        | –     | 1.0  | –    | mA         |
| <b>Digital Interface</b>                                |          |       |      |      |            |
| Input Logic "1"   | 2, 4     | 3.5   | –    | –    | V          |
| Input Logic "0"   | 2, 4     | –     | –    | 1.5  | V          |
| Output Logic "1"  |          |       |      |      |            |
| at IOH = -120 $\mu A$                                   | 8, 4     | 4.6   | –    | –    | V          |
| at IOH = -50 $\mu A$                                    | 3, 4     | 4.6   | –    | –    | V          |
| at IOH = 20 $\mu A$                                     | 4, 10    | 4.6   | –    | –    | V          |
| Output Logic "0"  |          |       |      |      |            |
| at IOL = 20 $\mu A$                                     | 4, 10    | –     | –    | 0.4  | V          |
| at IOL = 100 $\mu A$                                    | 3, 4     | –     | –    | 0.4  | V          |
| at IOL = 360 $\mu A$                                    | 4, 8, 9  | –     | –    | 0.4  | V          |
| Digital Input Current<br>( $V_{IN} =$ Logic "1" or "0") | 2        | –     | –    | 1.0  | $\mu A$    |
| Leakage Current into <u>IRQ</u> "OFF" Output            | 5        | –     | –    | 4.0  | $\mu A$    |
| Digital Input Capacitance                               | 2        | –     | –    | 7.5  | pF         |
| <b>Analogue Impedance</b>                               |          |       |      |      |            |
| Input Impedance   | 13       | –     | 500  | –    | k $\Omega$ |
| Output Impedance  |          | –     | 1.5  | –    | k $\Omega$ |
| <b>Dynamic Values</b>                                   |          |       |      |      |            |
| <b>Encoder</b>  |          |       |      |      |            |
| Analogue Signal Input Levels                            | 6        | -24.0 | –    | 4.0  | dB         |
| Passband  | 11, 12   | –     | 3400 | –    | Hz         |
| <b>Decoder</b>  |          |       |      |      |            |
| Analogue Signal Output Levels                           | 6        | -24.0 | –    | 4.0  | dB         |
| Passband  | 11, 12   | 300   | –    | 3400 | Hz         |
| <b>Encoder/Decoder (Full Codec)</b>                     |          |       |      |      |            |
| Passband  | 11, 12   | 300   | –    | 3400 | Hz         |
| Passband Gain   | 12       | –     | 0    | –    | dB         |
| Passband Ripple   | 12       | -3.0  | –    | 3.0  | dB         |
| Stopband  |          | 6.0   | –    | 10   | kHz        |
| Stopband Attenuation                                    |          | –     | 50.0 | –    | dB         |
| SINAD Level (-6dB)                                      |          | –     | 23.0 | –    | dB         |
| Output Noise (Input short circuit)                      |          | –     | -50  | –    | dBp        |
| Idle Channel Noise (Forced )                            |          | –     | -55  | –    | dBp        |
| Xtal/clock Frequency                                    | 7        | –     | 4.0  | –    | MHz        |

- Notes**
- Does not include current drawn by any attached DRAM.
  - Serial Clock, Command Data, CS, A1/DE1 and A2/DCK inputs.
  - CAS, WE and A0 to A9 outputs.
  - All measurements are made at 5.0 volts  $V_{DD}$ , any variations may alter parameters accordingly.
  - When the IRQ Output is at  $V_{DD}$ .
  - The optimum range of levels for a good Signal-to-Noise Ratio.
  - Audio frequency responses will vary with respect to Xtal/clock frequency.
  - Reply Data output.
  - IRQ output.
  - RAS Outputs.
  - Passband is reduced to (typically) 2700Hz when a sample rate of 25kb/s or 50kb/s is employed.
  - Measured with a -20dB input level to avoid codec slope-overload.
  - For optimum noise performance this input should be driven from a source impedance of less than 100 $\Omega$ .

# Codec Performance



## Package Outlines

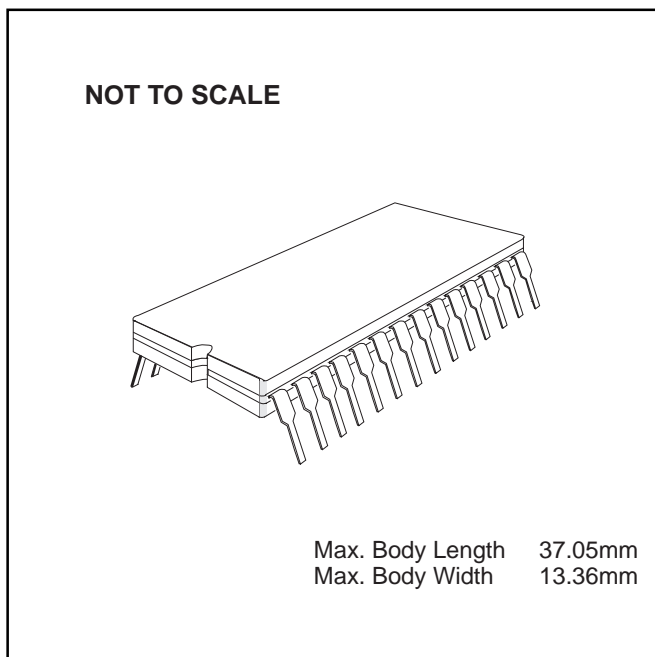
The FX802 is available in the package styles outlined below. Mechanical package diagrams and specifications are detailed in Section 10 of this document.

Pin 1 identification marking is shown on the relevant diagram and pins on all package styles number anti-clockwise when viewed from the top.

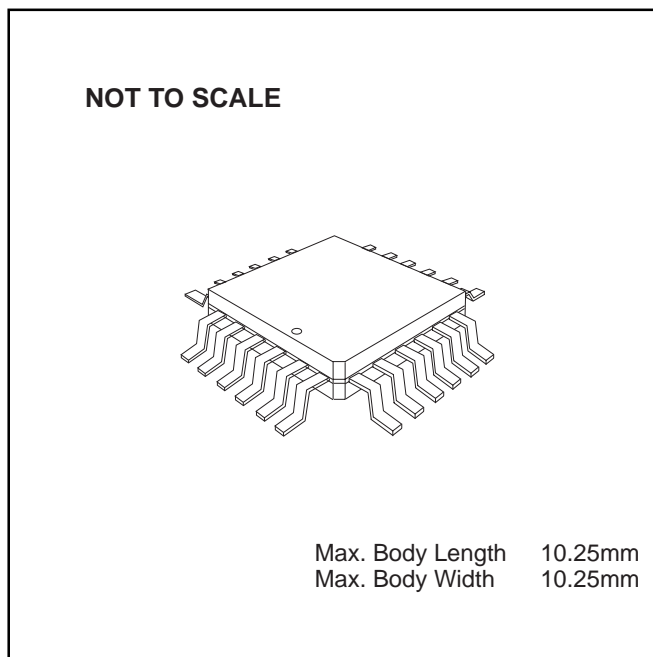
## Handling Precautions

The FX802 is a CMOS LSI circuit which includes input protection. However precautions should be taken to prevent static discharges which may cause damage.

**FX802J** 28-pin cerdip DIL (J5)



**FX802LG** 24-pin quad plastic encapsulated bent and cropped (L1)



## Ordering Information

**FX802J** 28-pin cerdip DIL (J5)

**FX802LG** 24-pin encapsulated bent and cropped (L1)

**FX802LS** 24-lead plastic leaded chip carrier (L2)

**FX802LS** 24-lead plastic leaded chip carrier (L2)

