# Digital Voice-Band Coding
## RALCWI Vocoder and CVSD Codec ICs

**CML Microcircuits**
COMMUNICATION SEMICONDUCTORS

Low Bit Rate VOCODER

## CML's Digital Voice Coding ICs

Products from CML's unique range of flexible voice-data ICs are used globally in wireline, wireless and general purpose audio applications.

As well as use in such active applications as radio and telephone systems, these products, with their highly versatile and efficient data-rate formats and bandwidth requirements, are ideal for voice storage environments like: answering machines, annunciators, voice-repeaters, voice-command and voice scramblers.

CML's voice data products are currently available in two ranges:

- Low Bit-rate (RALCWI) Vocoders
- Continuously Variable Slope Delta (CVSD) modulation type codecs

This document, whilst focusing on the RALCWI Vocoder products, also details the major points of the CML CVSD Codec range of ICs.

- CMX608     RALCWI Vocoder
- CMX618     RALCWI Vocoder with Integral Audio Codec

- CMX639     CVSD Voice Codec
- CMX649     Adaptive Delta Modulation (ADM) Voice Codec
- FX/MX619 and MX629     Military Delta Modulation Codecs

## Vocoder Digital Communications Applications

DMR - dPMR - PMR - LMR - Trunked Radio - TDMA and FDMA Systems - Voice Scrambling and Encryption - Wireless Local Loop Voice Storage, Delay and Playback - Messaging Voice-over-Packet Paging - Digital Radio Repeaters - Annunciators - Multiplexers -

**Robust Advanced Low Complexity Waveform Interpolation**     **Continuously Variable Slope Delta Modulation**     **Adaptive Delta Modulation**
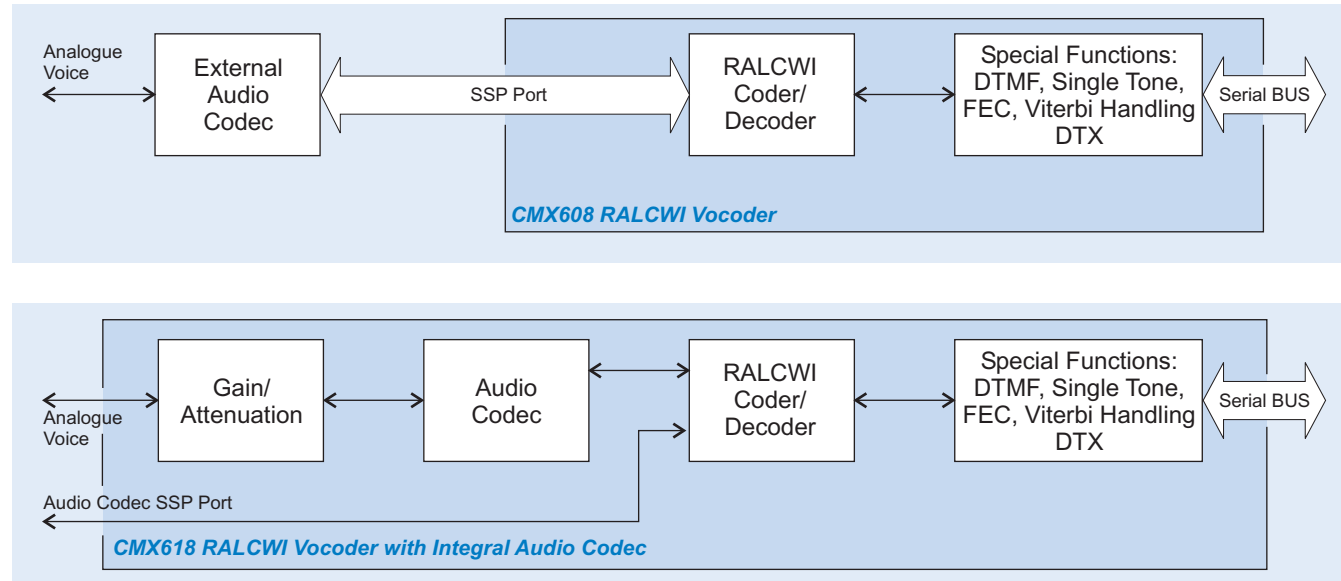
# RALCWI - CVSD - ADM

# CMX608 and CMX618 Flexible Low Bit-Rate RALCWI Vocoders

**CMX608**   Low Bit-rate RALCWI Vocoder IC

**CMX618**   Low Bit-rate RALCWI Vocoder IC with Integral Audio Codec



*CMX608 RALCWI Vocoder*
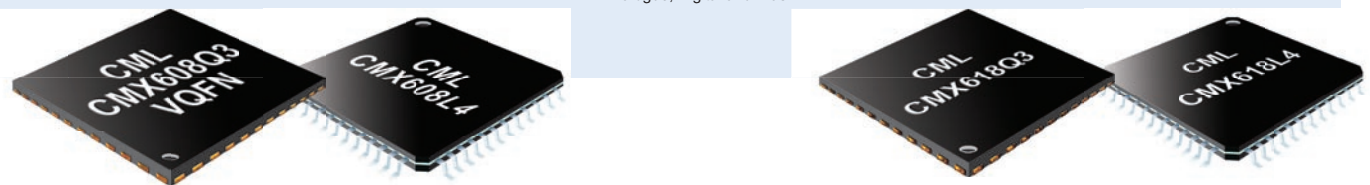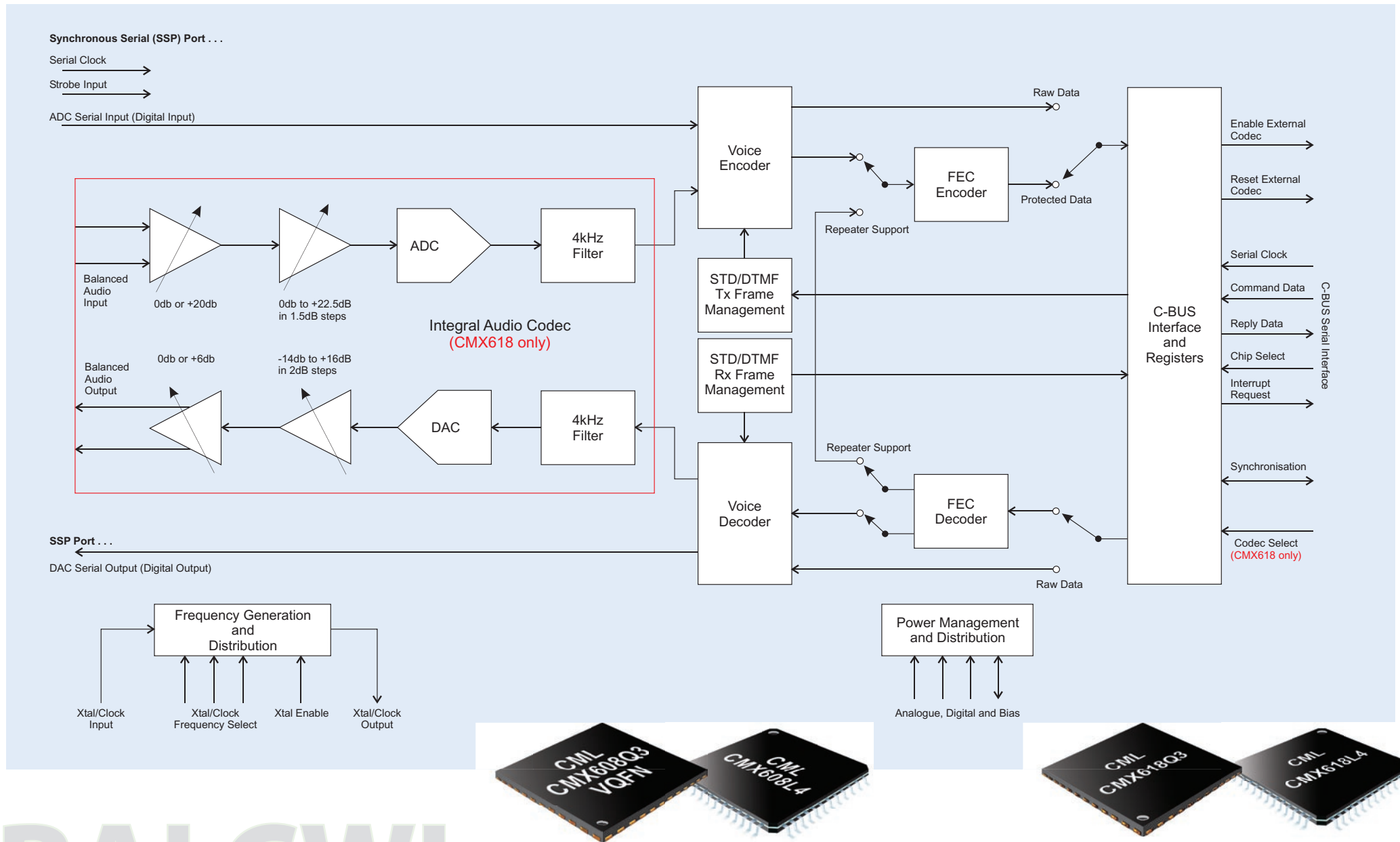


*CMX618 RALCWI Vocoder with Integral Audio Codec*

## Features

- Near Toll-quality RALCWI Coding Algorithm
- Half-duplex Operation
- Multiple Bit-rate Modes
  - 2050, 2400 or 2750 bps
  - 3600bps with FEC Enabled
- 20ms Voice Frames
  - 20, 40, 60 and 80 ms Packet Lengths
  - 60 or 80 ms (with FEC) Packet Lengths
- Compatible with DMR and dPMR Frame (Slot) Parameters
- CMX618 Only
  - Integrated Audio Codec
  - Integrated Input and Output Digital Channel Filters
- Compatible with Many Industry Standard Audio Codecs
- Flexible FEC Operations
- Handles 4-bit Viterbi 'Soft-Decision' Decoding
- FEC 'Loop-through' Mode Supports Digital Repeater Operations
- Ancillary Audio Functions
  - Voice Activity Dectector
  - Comfort Noise Generator
  - DTMF and Single-Tone Transport
- Licence and Royalty Free
- Supported by EV6180 EvKit
- Good PESQ MOS Performance Test Results
- Low Pin Count with Small PCB Footprint
- Small Profile 48-pin (L4) LQFP and (Q3) VQFN Packages
- Supply Requirement Range:
  - 1.8V with 3.3V I/O Tolerance

Two flexible, high performance half-duplex RALCWI Vocoders for use in many wireless and wireline voice applications. With selectable bit rate modes and an FEC function, both ICs offer near toll-quality voice (Mean Opinion Score (MOS) is 3.5 - 3.6) at extremely low bit rates.

RALCWI technology uses proprietary signal decomposition and parameter encoding methods which ensure optimum recovered speech quality at high compression and low bit rates.

Both products, with their low-power requirements, offer versatile encode and decode facilities with the ability to operate to externally generated 'soft-decision' FEC inputs. Added to this is a range of auxiliary functions: Voice Activity Detection, Comfort Noise Generation and DTMF and single-tone detect and regeneration. Provision is made for operation in digital radio repeaters by using the extracted Rx FEC at the repeater to correct any errors in the voice-data before retransmitting (repeating) with a new FEC.

The CMX618's integral audio codec removes the need for an external voice codec whilst providing variable gain earphone and loudspeaker interfaces, ADC and DAC voice-data and data-voice converters with high-order 4kHz channel input and output digital filters.

Both the CMX608 and the CMX618 are free from any licence and royalty costs and both ICs comfortably meet the requirements of many high-performance audio applications.

## Package Styles

| | |
|---|---|
| CMX608L4 | 48-pin LQFP |
| CMX608Q3 | 48-no leads VQFM |
| CMX618L4 | 48-pin LQFP |
| CMX618Q3 | 48-no leads VQFM |

# . . . for Wireless and Wireline Voice Applications

Serial Clock

Strobe Input

ADC Serial Input (Digital Input)

Raw Data

Enable External Codec

Reset External Codec

Voice Encoder

FEC Encoder

Protected Data

Repeater Support

Serial Clock

Command Data

Reply Data

Chip Select

Interrupt Request

C-BUS Serial Interface

STD/DTMF Tx Frame Management

STD/DTMF Rx Frame Management

C-BUS Interface and Registers

ADC

4kHz Filter

Balanced Audio Input

0db or +20db

0db to +22.5dB in 1.5dB steps

Integral Audio Codec
(CMX618 only)

Balanced Audio Output

0db or +6db

-14db to +16dB in 2dB steps

DAC

4kHz Filter

Synchronisation

Repeater Support

Voice Decoder

FEC Decoder

Codec Select
(CMX618 only)

**SSP Port . . .**

DAC Serial Output (Digital Output)

Raw Data

Frequency Generation and Distribution

Power Management and Distribution

Xtal/Clock Input

Xtal/Clock Frequency Select

Xtal Enable

Xtal/Clock Output

Analogue, Digital and Bias

CML CMX608Q3 VQFN

CML CMX608L4

CML CMX618Q3

CML CMX618L4

# RALCWI

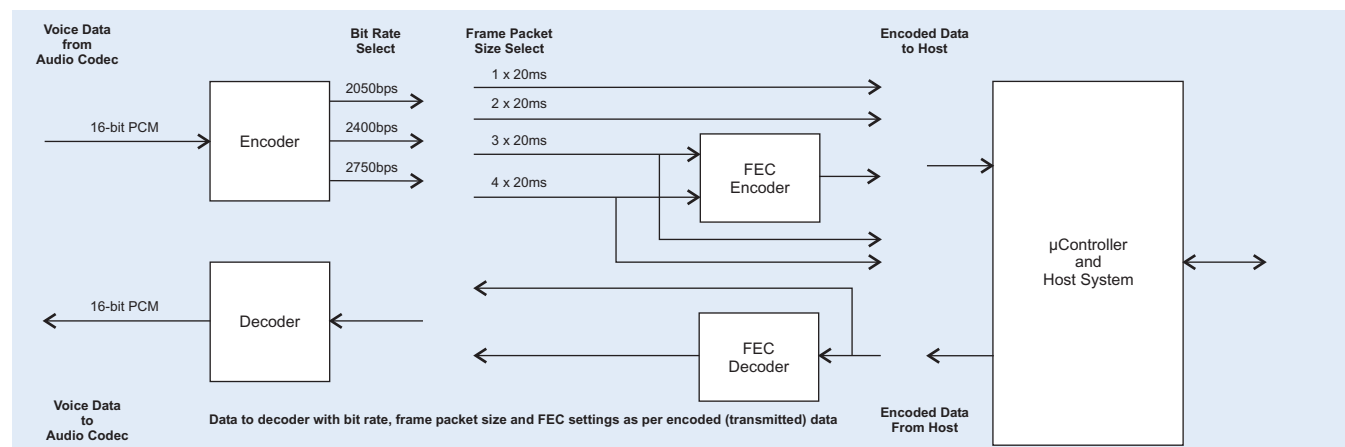**R**obust **A**dvanced **L**ow **C**omplexity **W**aveform **I**nterpolation

# CMX608 and CMX618 Low Bit-Rate RALCWI Vocoders

## The Encoder

The encoder deals with a basic frame size of 20ms: 160 samples of audio. One, two, three or four frames may be collected together and supplied to the host or modulator, via C-BUS, as a single packet. In the case of the three and four frame packets, error protection may be added via the FEC option.

The encoder can also detect single tones (STD) and/or DTMF in the audio stream. If detected, special frames are produced by the encoder which the decoder will recognise and deal with accordingly. Alternatively, dual tone (DTMF) information can be entered via the C-BUS interface as a 4-bit code formatted as required.

## Features

- Basic Individual Frame Size 20ms
- One, Two, Three or Four Frame Packets
- Error Protection via FEC and Interleaving Options
- Audio (Single or Dual) Tone Handling
- Special DTMF and Tone Frames Generated for Encoding
- Special FEC Configuration for Radio Repeater Operations
- Integral Audio Codec (CMX618)
- System Control via C-BUS Serial Interface
- Syncronous Serial Port (SSP) for External Audio Codec
- Flexible Host/Vocoder Synchronisation
- Efficient Power Usage



*Data Flow Settings Throughout Vocoder*

## The Decoder

The decoder deals with a basic frame size of 20ms: 160 samples of audio. One, two, three or four frames may be collected together and supplied by the host as a single packet. In the case of data from the encoder (via a transmission medium), the frame configuration loaded to the FEC decoder/voice decoder will be the configuration as output from the encodiing system.

FEC protected packets may contain either soft bits or hard bits - a soft-bit packet (from the demodulation process) is four times the size of a hard-bit packet, as each soft-bit is represented by four bits.

The decoder can detect the special STD and DTMF frames and reproduce these as tones in the recovered audio stream.

## Forward Error Correction (FEC)

Voice parameters are initially coded by the encoder. Sensitivity to errors has been categorised for each output bit as either *'less sensitve'* or *'more sensitive'*. To protect voice parameters against channel errors without reducing voice quality, the *'more sensitive'* bits are protected. This protection is provided by the FEC system. Three and four frame (60ms and 80ms) packets only may be protected in this way.

The IC's FEC decoding function can be selected to operate to either the basic input FEC data, or to use its integral Viterbi decoder on externally generated 4-bit *'soft-decision'* data. Data interleaving is carried out to optimise performance over a channel prone to burst errors.
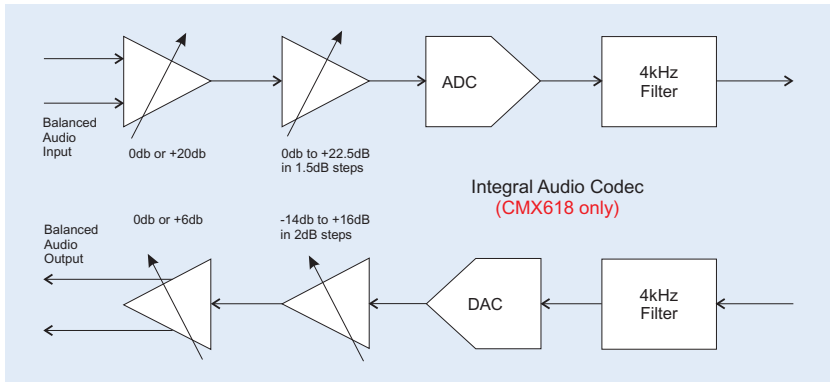
### FEC Support for Radio Repeaters

In applications such as radio repeaters, FEC Rx data can be extracted, the voice data error-corrected, protected and retransmitted.
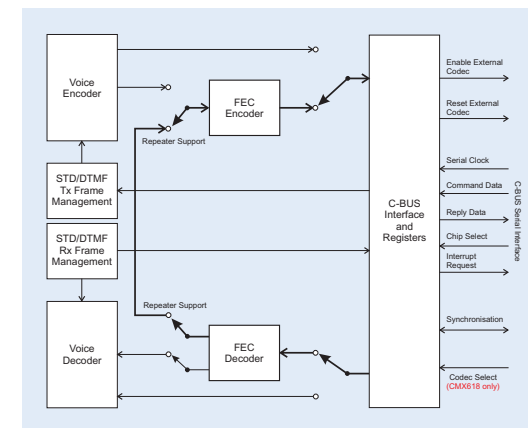


*FEC Configuration for Radio Repeater Operation*

RALCWI

The CMX618's Integral Audio Codec

Balanced Audio Input

0db or +20db

0db to +22.5dB in 1.5dB steps

ADC

4kHz Filter

Integral Audio Codec (CMX618 only)

0db or +6db

-14db to +16dB in 2dB steps

Balanced Audio Output

DAC

4kHz Filter

## Audio Codecs

Samples of audio for encoding are required from an audio codec source. Likewise, an audio codec is required to convert the decoded data back into (analogue) voice audio.

The CMX608 has no audio codec and therefore needs to work with an external codec; the CMX618 has an integral codec but can be set to operate with an external codec.

### External Audio Codec Support

An external codec can be supported, on either product, using the chip's 4-wire Synchronous Serial Port (SSP). The SSP is flexible enough to drive a range of codec devices, and both ICs are pre-configured with parameters for both a general purpose configuration and the Burr-Brown (TI) PCM3500 single channel codec.

### The CMX618 Integral Audio Codec

The encode stage of the integral audio codec consists of a microphone input through variable gain stages to an analogue-to-digital converter (ADC). The decode section operates in reverse. Both input and output analogue interfaces can be used in single or differential configuration with both sections including a high order (4kHz) digital channel filter.

## System Control/Communication

The basic means of communication with the vocoder is via CML's C-BUS serial data interface. C-BUS is a 4-line interrupt-driven serial system for the transfer of control and data information between the host, peripheral devices and the IC's internal registers. The CMX608 and CMX618 C-BUS interfaces offer increased transfer rates by the use of 'data streaming': a method of transferring multiple data bytes with only one address/command.

## Auxiliary Functions

- DTMF Transmit and Receive Coding
- Single Tone Transmit and Receive Coding
- Discontinuous Transmission (DTX) Features
  - Voice Activity Detector
  - Comfort Noise Generation
  - Silence Insertion Description



Chip Select

Serial Clock

Command Data

7 6 5 4 3 2 1 0 7 6 5 4 3 2 1 0 7 6 5 4 3 2 1 0    7 6 5 4 3 2 1 0

Address    First byte    Second byte    …    Last byte

Receive Data    Hi-Z

**Write**

7 6 5 4 3 2 1 0

Address

**Read**

7 6 5 4 3 2 1 0 7 6 5 4 3 2 1 0    7 6 5 4 3 2 1 0

First byte    Second byte    …    Last byte

C-BUS Data Streaming

### Synchronous Serial Port (SSP)

As a control, command and data transfer feature for use in support of an external audio codec source, the product offers a Synchronous Serial Port (SSP).

### Synchronisation

The vocoder/host synchronisation is available via either a logic (pin) input or by a C-BUS command. Likewise, the vocoder can produce sync. pulses for external devices.

## Power Requirements and Optimisation

Both vocoder ICs operate from a very low current (1.8 volts) power supply with 3.3 volt tolerance I/O requirement.

Codec encoder and decoder sections (CMX618) can be individually set to powersave when not operating, and as an added powersaving facility, the vocoder internal clock may be 'throttled' to a quarter of its normal speed.

RALCWI

# CVSD and ADM IC Products

| | |
|---|---|
| **FX/MX619** | 'Eurocom' Delta Codec |
| **MX629** | 'Military' Delta Modulation Codec |
| **CMX639** | CVSD Voice Codec |

## Features
- Full Duplex CVSD Codecs
- Separate Rx and Tx Paths
- 3 or 4-bit Compand Algorithm
- Programmable Sample Rates
  - FX/MX619: 8 to 64 kbps
  - MX629: 8 to 64 kbps
  - CMX638:  8 to 128 kbps
- Encoder and Decoder Force Idle
- Anti-alias Voice Filters
- Data Clock Recovery
- Supply Requirement Ranges:
  - FX/MX619 and MX629: 4.5 to 5.5 V
  - CMX639: 2.7 to 5.5 V

## Package Styles
- FX619J     22-pin cerdip DIL
- MX619J     22-pin cerdip DIL
- FX619L1     24-pin PLCC
- FX619L2     24-lead PLCC
- MX619LH     24-pin PLCC
- FX619M1     28-lead CLCC
- MX619P     22-pin plastic DIL

- MX629J     22-pin cerdip DIL
- MX629LH     24-pin PLCC
- MX629P     22-pin plastic DIL

- CMX639E2     24-plastic TSSOP
- CMX639D4     16-pin plastic SOIC
- CMX639P6     22-pin plastic DIL

## FX/MX619, MX629 and CMX639

CML's full duplex CVSD ICs serve a variety of application fields including DECT, Eurocom and many military and general-purpose voice applications.

With separate Rx and Tx paths, encode and decode output filters are incorporated on-chip.

Sampling clocks, working with a 3- or 4-bit compand algorithm, can operate at internally or externally generated rates of between 8kbps and 64kbps (with the CMX639 increasing the range up to 128kbps). The sampling clock frequency is also available as an output for the synchronisation of external circuits.

With simple pin-selected control functions, the IC provides: CVSD encoder and decoder both with force idle facilities, and a data-enable selector at the encode output to allow the use of the codec IC in multilplex and time domain environments.
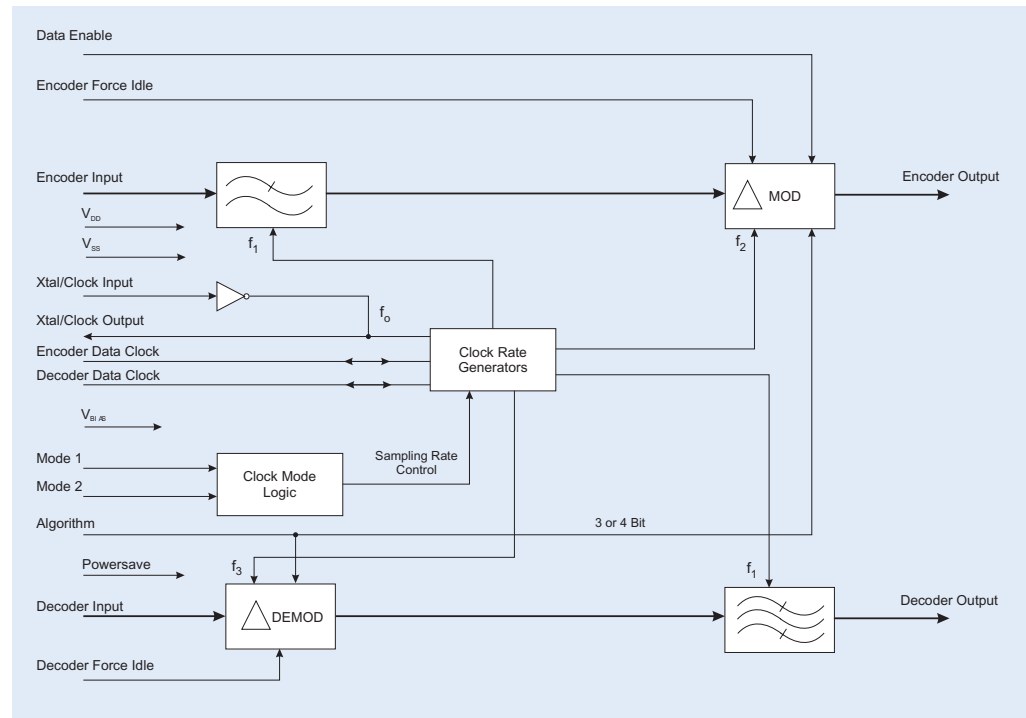


*CVSD Codec*

## CVSD and ADM

*Continuously Variable Slope Delta Modulation and Adaptive Delta Modulation*

## CMX649 Adaptive Delta Modulation (ADM) Voice Codec

As an advance on CML's full duplex CVSD ICs this ADM voice codec offers full duplex ADM, μ-law, A-law and linear PCM codec and transcoder functions for wireless, wireline telephony and general purpose 'voice' applications.

Control, communications and data setting is via CML's C-BUS serial interface.
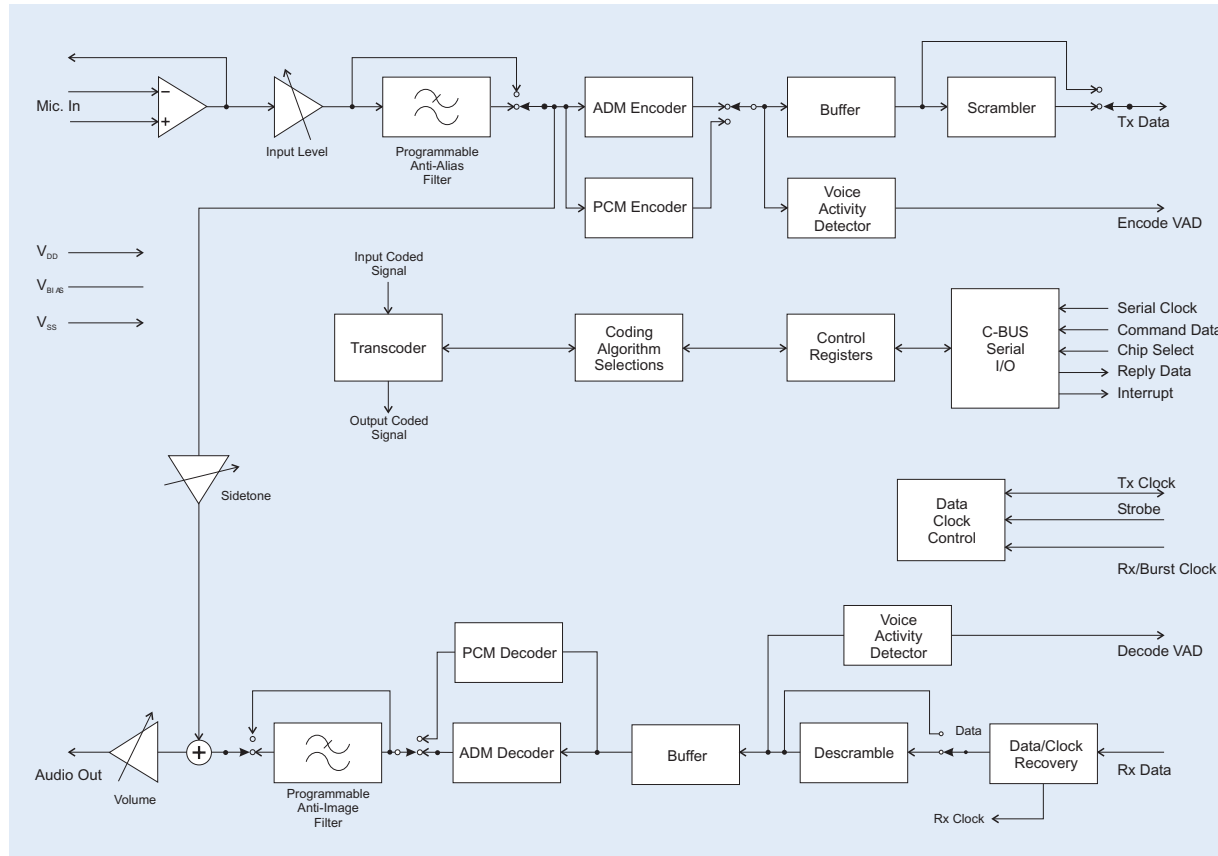


*CMX649 ADM Codec*

### CMX649 Features

- ■ Multiple Codec Modes: 16 to 128 kbps
  - ADM and CVSD
  - PCM: μ-law, A-law and 13-bit Linear
- ■ Flexible Data Interfaces
  - 8 and 16-bit Burst Data with Sync Strobe
  - 1-bit Serial Data with Clock
  - Host Serial Control and Data
- ■ Dual Channel Transcode/Decode Functions
- ■ Versatile Programmable Functions:
  - Input and Output Gains
  - Anti-alias Voice Filters
  - Digital Scrambling
  - Rx and Tx Voice Activity Detectors (VAD)
- ■ Data Clock Recovery
- ■ Control and Communications via C-BUS Serial Interface
- ■ Supported by DE6491 DemoKit
- ■ Supply Requirement Range: 2.7 to 5.5 V

### Package Styles

- ■ CMX649D3      20-pin plastic SOIC
- ■ CMX649E3      20-pin plastic TSSOP

CVSD and ADM

# The EV6180 IC Evaluation Platform

- For CMX608 and CMX618 Evaluation, Demonstration and Investigation
- Operation with Integral (CMX618) or External Audio Codec
- End-to-End Audio Vocoding Demonstration Mode
- Header Connections to SSP and C-BUS Interfaces
- Test Points and Jumpers Provide Access to Signals and Levels
- Single-ended or Differential Audio Codec Input Configuration
- PC Software Available for Performance Demonstration
- Works with PE0001 EvKit Evaluation Card (or Custom Interface) for PC-Based Demonstration
- Circuit Schematics and Board Layouts Available
- Interfaces to PE0001 Evaluation Card Interface
- Mic. and Speaker Jack-sockets On-board
- Single, External DC Power Requirement:
  On-board Regulators Provide Analogue and Digital Supplies
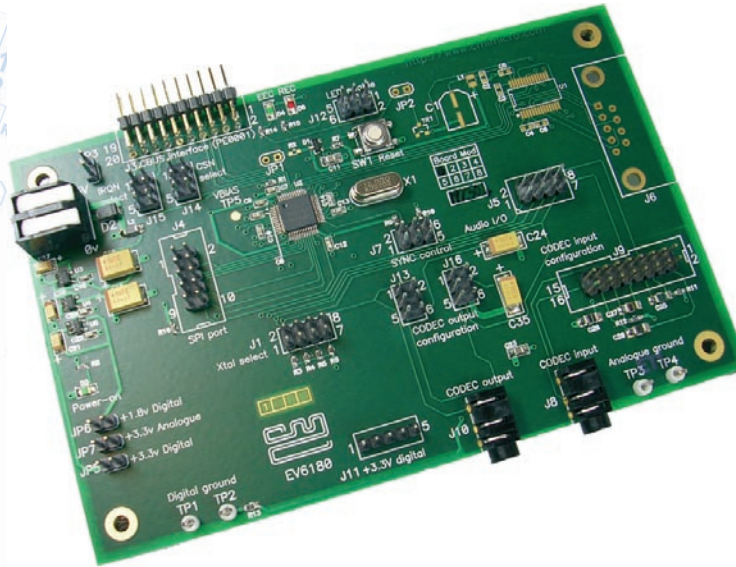
The EV6180 provides the means to demonstrate and evaluate the operation of a CMX608 or a CMX618 half-duplex RALCWI vocoder IC.

The EvKit allows the operation/evaluation of both the CMX608 and the CMX618 at all specified data rates and frame lengths via an external (3rd party) audio codec, or the CMX618 using its integral audio codec.

A PC software application is available which demonstrates the kit running in a special 'end-to-end' audio-loopback mode.

Signal, supply and control monitor points are available, via headers, connectors and test-points, providing access to all of the CMX IC's interfaces and operations.

# The DE6491 Wireless Voice Link Demonstration Kit
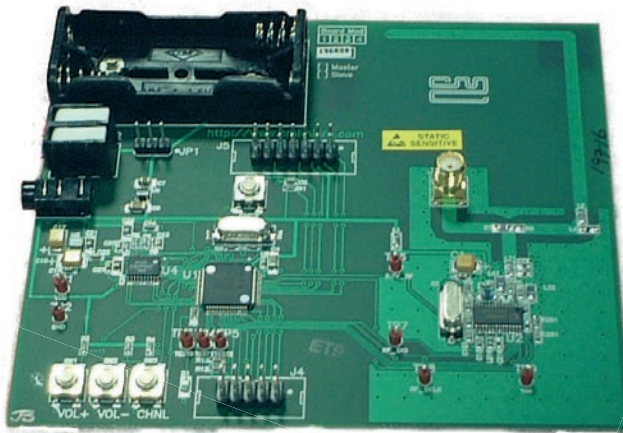
- For CMX649 Demonstration
- Operates in the 863 - 865 MHz European Licence Free Band
- 20m Range - Line of Sight
- Privacy via CMX649 Digital Scrambler
- On/Off, Volume and RF Channel Pushbutton Controls
- Phone Quality Voice Transmission using TDD Airlink Protocol
- Selectable RF Power

A CMX649-based wireless voice link demonstration kit that demonstrates CMX649 ADM Codec IC operation in a low-power, cordless headset application.

## Design Resources

Design and application support available:
- CML website: www.cmlmicro.com/

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