

CMX981

Advanced Digital-Radio Baseband Processor

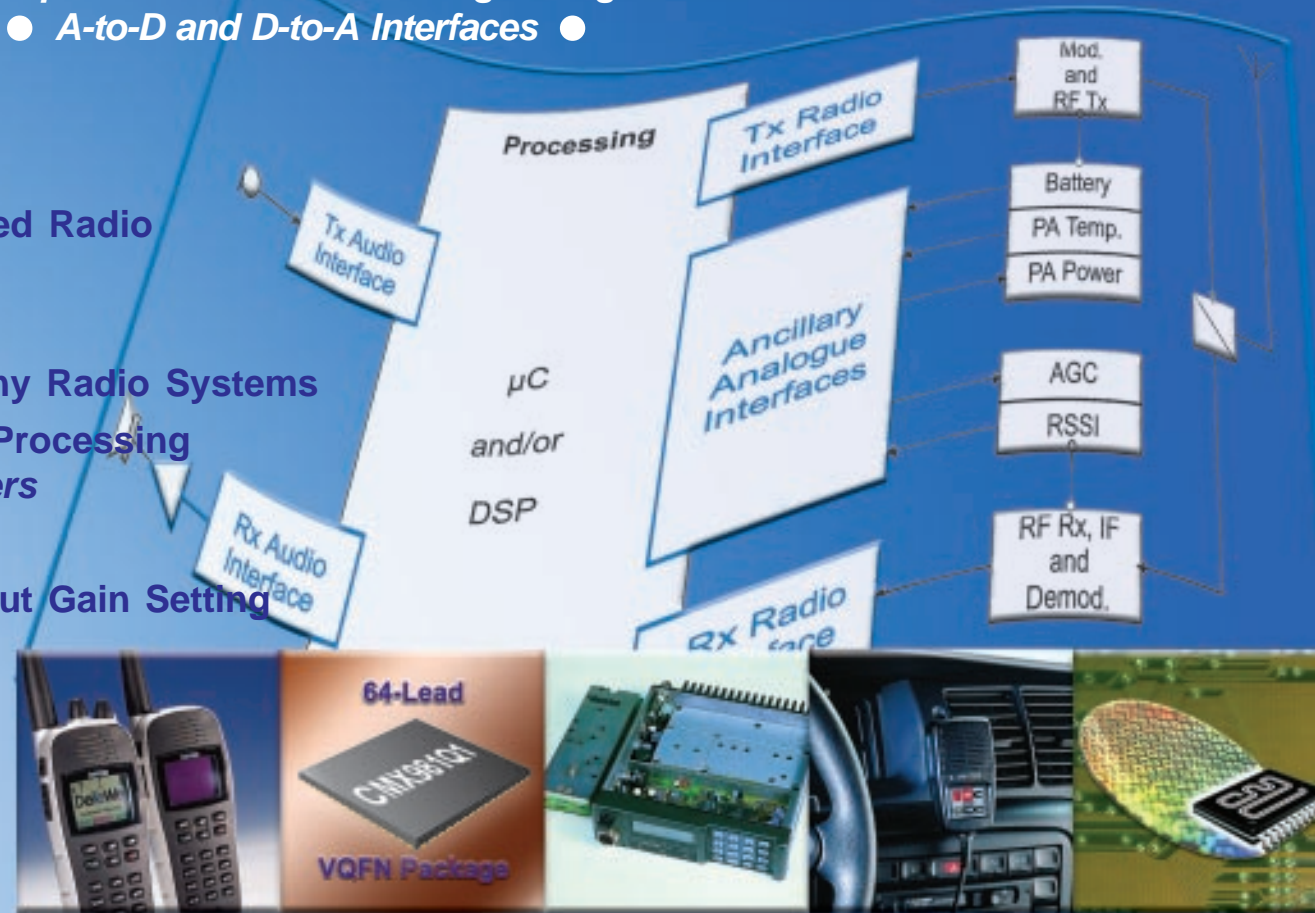
A Software-Defined Radio Baseband Processor IC

INNOVATIONS
INV/TwoWay/981/1 March 2004



- Combination Full-Duplex Voice-Codec and Digital Signal Processor IC ●
- A-to-D and D-to-A Interfaces ●

- Software-Defined Radio (SDR) Processor IC
- Multi-Mode Digital/Analogue PMR and Trunked Radio
- High Integration Saves Cost, Space, Power and Design Time
- Programmable Flexibility Enables Use in Many Radio Systems
- Transmit and Receive Analogue and Digital Processing
- Tx and Rx programmable multi-tap FIR filters
- Exceptional Rx SINAD Performance
- Full-Duplex Voice Codec with Input and Output Gain Setting and Speaker/Earpiece Power Amplifiers
- Flexible Serial Interfaces for Multi-Processor Operation
- Auxiliary ADCs and DACs for Ancillary Radio Functions
- Autonomously Performs Many Critical DSP Intensive Functions
- Low-Power 2.5V Operation
- EV9810 EvKit Available



SUITABLE APPLICATIONS

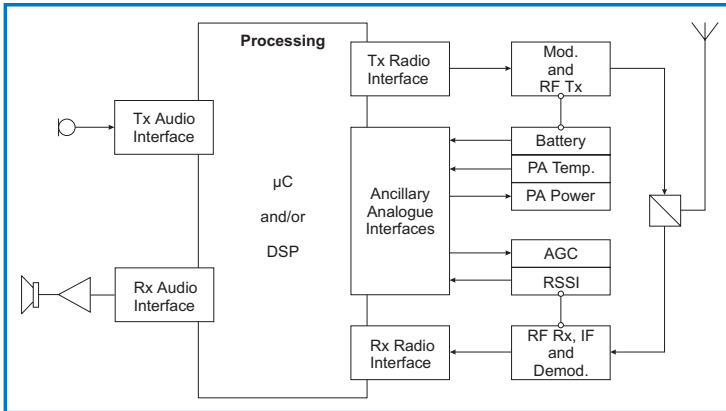
TETRA - APCO25 - Tetrapol - RCR STD-39 - ARIB STD-T61 - ARIB STD-T85

... and many other digital radio systems

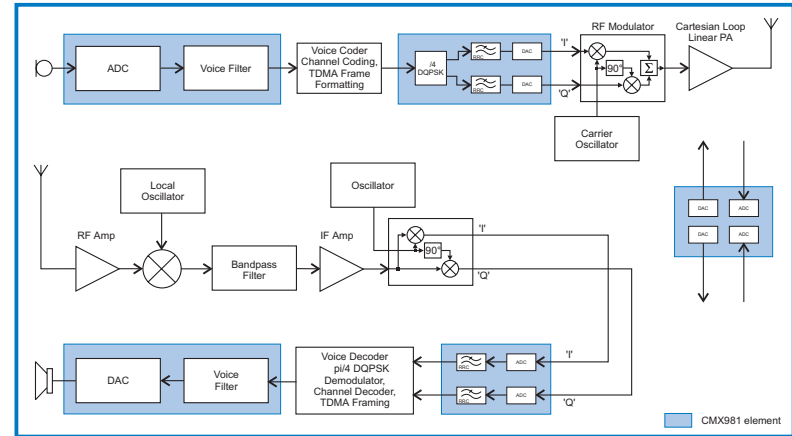
Digital Radio*

Narrowband digital radio systems provide many advantages over traditional analogue FM approaches. By implementing error correction, a digital system can consistently maintain a respectable operating range even in the presence of significant interference. The majority of current PMR and trunked digital radio systems deal not only in voice transactions, but also in data, video and still graphics; all within a fixed bandwidth.

In the case of voice transactions over a digital system, the digital radio system can provide high-quality voice output, even in high noise environments.



A theoretical narrowband digital radio implementation



CMX981 within a typical (TETRA) digital radio - the CMX981 performs the majority of baseband processes

High Performance Digital Radio voice designs rely on a DSP to perform many of the signal control, encoding, interfacing, routing, level and shaping tasks.

The **CMX981** is a truly universal in-phase and quadrature (I and Q) compatible digital radio baseband processor and voice-codec that can be used with many types of analogue and digital modulation schemes. With its flexibility, via software definition, the **CMX981** can be used in many types of system, including those operating in: AM and FM modes, and using QAM, BPSK, QPSK, $\pi/4$ DQPSK and FSK modulation schemes.

The **CMX981** goes many steps further in the provision, on chip, of the majority of baseband and system interfacing: voiceband digital-to-analogue and analogue-to-digital conversion, Rx and Tx signal shaping via multi-tap digital FIR filters and $\pi/4$ DQPSK modulation. Included on chip is a voice-codec section with gain control and loudspeaker and earphone amplifiers. In addition to baseband signal path processing, the **CMX981** offers auxiliary D-to-A and A-to-D functions for the interfacing of other radio operations.

The **integration** of signal processing functions digitally within the **CMX981** reduces the load requirements on the host DSP and μ C, thus allowing the selection of a lower cost, lower speed and lower powered DSP/ μ C, and releasing the host controller's time and power for other tasks.

The **CMX981's** default filter co-efficients are aimed at the TETRA standard, but this versatile baseband IC can be programmed to operate in many other radio voice and high-speed data systems. Direct access is available for writing to the I and Q Tx filters; additionally, the $\pi/4$ DQPSK modulator can be bypassed to allow formatted data to be written directly to the signal path.

Flexible clock dividers allow different voice codec and signal codec rates to be accommodated.

*For the purposes of this Innovations document, discussions centre around narrowband public and private mobile and trunked radio systems. Other radio systems can employ the CMX981.

Narrowband Digital Radio Standards

TETRA: Terrestrial **T**runked **R**adio is an open digital trunked radio standard defined by the European Telecommunications Standardisation Institute (ETSI) to meet the needs of digital, cellular, trunked radio networks. TETRA systems have been, to-date, designed and developed notably as a mobile system for handling emergency and safety tasks and is widely established in over 55 countries.

APCO 25 (P25) is an open digital radio standard suite specified for high-performance public safety radio applications in North America. Supporting both voice and data services the suite includes several American National Standards Institute (ANSI) approved technical standards developed by the TIA TR-8 Committee and its subcommittees.

P25 Phase 1 radios support both digital and analog FM modulation so they interoperate with legacy analog FM equipment. Spectral efficiency is 1 voice per 12.5kHz RF bandwidth. P25 Phase 2 radios provide 1 voice per 6.25kHz RF bandwidth.

In certain public safety bands, FCC rules now require that radios support P25 interoperability mode.

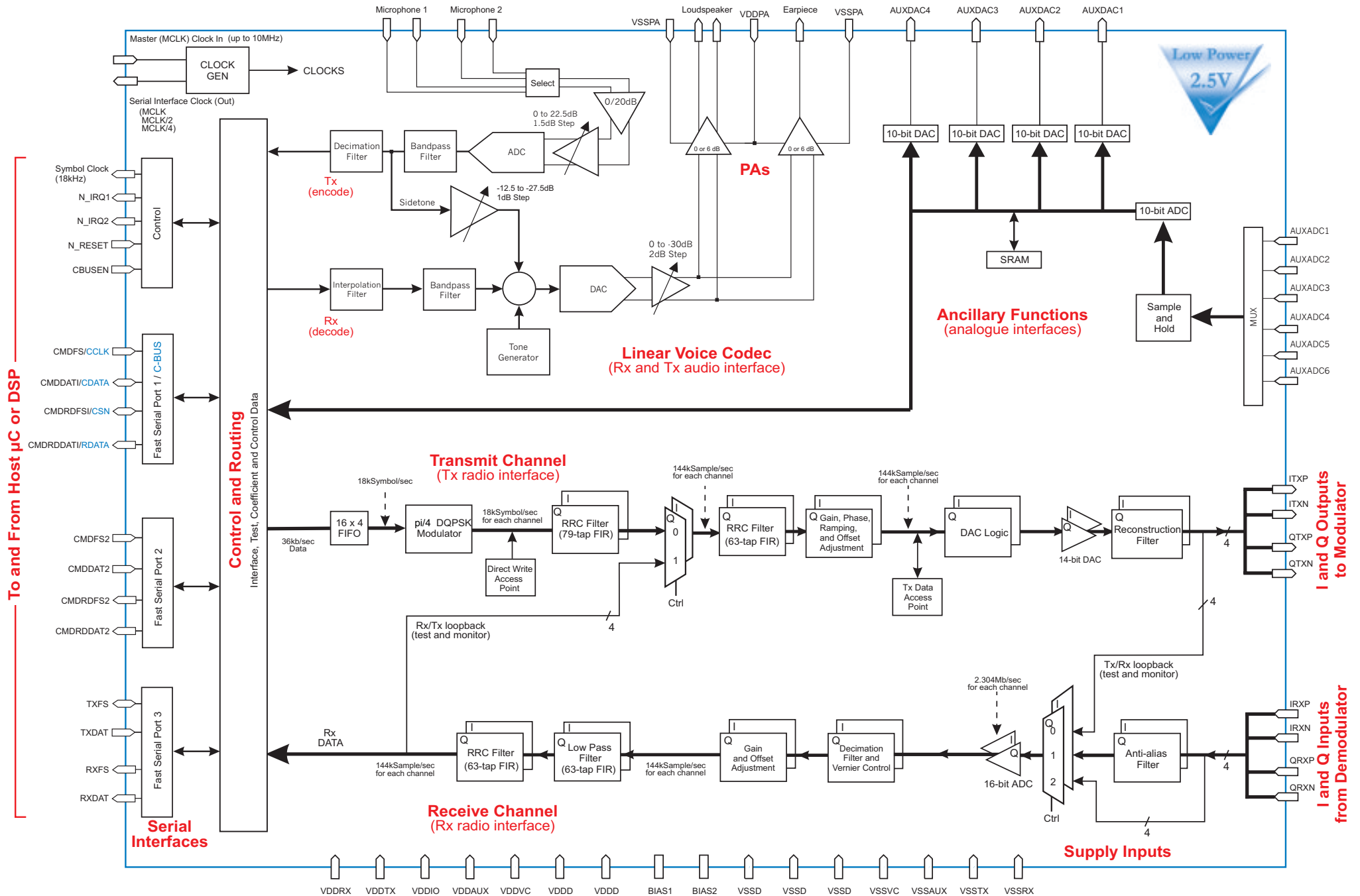
Tetrapol is a digital trunked radio system based on FDMA access and GMSK modulation. Like its competitor, TETRA, Tetrapol is widely used in a large number of countries, predominately in Europe.

RCR STD-39 is the standard for 400MHz professional digital mobile communication systems including TDMA public radio in Japan.

ARIB STD-T61 is the standard for 800MHz digital MCA systems in Japan using $\pi/4$ shift QPSK for land vehicles such as taxis.

ARIB STD-T85 is the standard for 400MHz and 150MHz Japanese professional digital mobile communication systems, including SCPC public radio.

Operational Functions

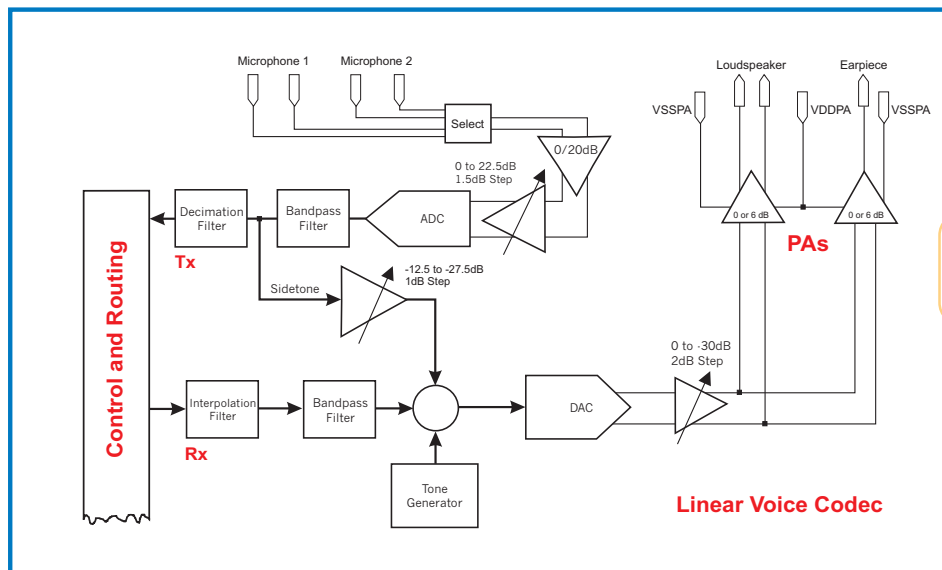


- Give us the signal - Let us do the rest -

Voice Codec



- Encode (Tx) analogue-to-digital conversion with coarse and fine level control
- Decode (Rx) digital-to-analogue conversion with level control *plus* earpiece and loudspeaker PAs
- Sidetone facility with level adjust
- Call/user tones available to Rx path
- Selectable clock/sample rates



Encode (Tx) Path

- Dual selectable differential microphone sources
- Input amp with selectable gain: 0db, 20dB and mute
- Fine gain control with 22.5dB range
- 14-bit Sigma-Delta analogue-to-digital conversion
- Digital encode bandpass filter conforms to CCITT G.712 standard; with selectable highpass section
- Decimation filter provides (8kHz) data suitable for radio system signal formatting process

Separate Rx and Tx Paths

- Controlled by host via internal registers
- Configurable to full-duplex operation

Decode (Rx) Path

- Data written via serial interface interpolated to 32kHz
- Digital decode bandpass filter conforms to CCITT G.712 standard; with selectable highpass section
- Level and period adjustable ring-tone generator (0 to 4 kHz) and programmable sidetone path available
- 14-bit Sigma-Delta digital-to-analogue conversion
- Fine gain control with 0 to -30 dB range
- Two selectable output driver (0 or 6 dB) amps:
 - Differential speaker (130mW into 8 Ω)
 - Single-ended earpiece (16.5mW into 32 Ω)

The digitizing voice codec of the CMX981 converts voice signals to and from digital form and can be configured to apply a digital voice filter to meet the G.712 standard.

The encode path (Tx) accepts a differential analogue audio input signal, converts it into digital form and then applies digital filtering to produce a processed data stream.

The decode path (Rx) accepts a digital stream written to the serial interface, applies digital filtering, converts the result to an analogue signal, and presents the audio at either differential speaker or single-ended earphone driver outputs. Additionally a sidetone path and audio tones can be programmed.

The inclusion of this audio/digital interface facility on-chip minimizes the need for additional areas of PCB and the attendant external components; on chip processing in this section reduces the host μ C/DSP hardware, software, capacity and power requirements.



Transmit Section



- **pi/4 DQPSK modulation**
- **Accurate controllable filtering**
- **Channel gain, phase and offset manipulation**
- **Analogue reconstruction**
- **Transmit data access**
- **Programmable clock/sample rates**
- **Programmable output signal ramping**

The transmit section of the CMX981 accepts the data stream from the host processor, via the serial interface, and passes it through the pi/4 DQPSK modulator. I and Q data streams from the modulator are applied to the relevant channel multi-tap digital filter to provide shaping in accordance with the RF channel requirements. The availability of gain, phase and offset adjustments allow the dynamic compensation of RF hardware and transmission channel anomalies. To minimise the generation of spurious at Tx 'on' and 'off', the signal level of each channel can be ramped up (and down) at a programmed rate. Both channel signals are reconstructed via digital-to-analogue converters and lowpass filters before being made available as differential analogue outputs to the RF modulator.

Provision is made, to each digital channel, to allow the input of data streams after the pi/4 DQPSK modulator for use with systems using alternative modulation schemes. As a system check, Tx and Rx loopback test and monitor paths are available.

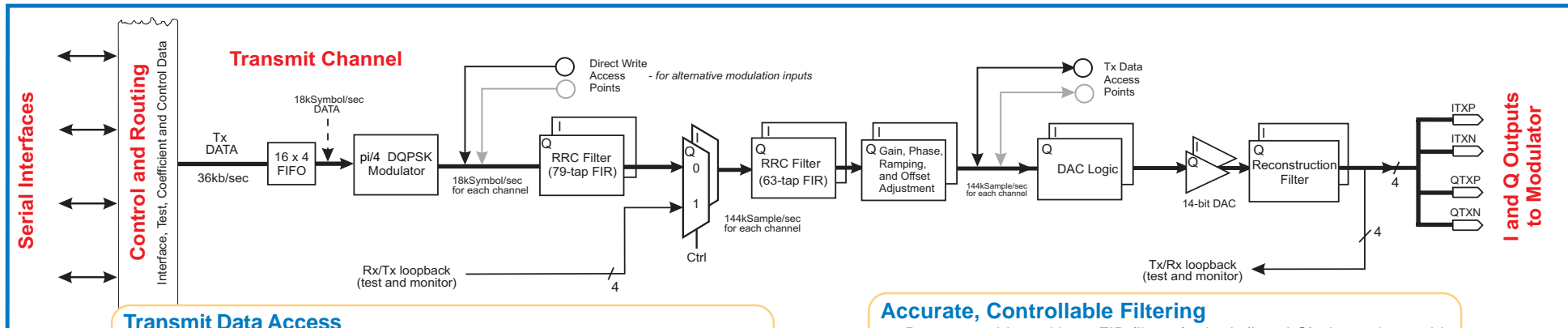
Note that the 18ksymbols/sec rate is suitable for TETRA use. Other rates may be programmed for use in other systems.

Channel Gain, Phase and Offset Adjust

- Independent (I and Q) channel attenuation is programmable
 - channel phase inversion is facilitated
- Phase pre-distortion provides compensation for non-orthogonal carrier-phase in the RF modulator
- Independent I and Q digital offset correction for analogue Tx path offsets
 - I or Q advance or retard

pi/4 DQPSK Modulation

- Symbol data from external processes via serial port
- 4-word deep FIFO
- Bypassable pi/4 DQPSK modulator provides encoded I and Q values for each input phase



Transmit Data Access

- Read and write functions
 - Read the I or Q signal value at that point
 - Write data directly into the Sigma-Delta DAC for other modulation schemes
- Direct write access to the I or Q inputs of the FIR filters for the insertion of data

Accurate, Controllable Filtering

- Programmable multi-tap FIR filters for both (I and Q) channels provide stopband rejection and Root Raised Cosine (RRC) shaping
- Alternative FIR coefficients can be programmed via serial interface

Programmable Output Ramping

- Two modes of Tx output signal-ramping are available:
 - Linear or Sigmoidal
- Both amplitude ramp-up and ramp-down actions are programmable

Analogue Reconstruction

- Low distortion 14-bit Sigma-Delta digital-to-analogue conversion
- Switched capacitor lowpass filters shape I and Q outputs to RF modulator
- Tx/Rx and Rx/Tx loopback facilities for test and monitoring



Receive Section



- Analogue-to-digital conversion
- Exceptional SINAD performance
- Dynamic signal manipulation
- Digital processing
- Programmable clock dividers

The **receive section** of the **CMX981** accepts the demodulated I and Q output signal from the 'radio' section via differential channel inputs. In-band pick-up is minimized using this input method. Sampling frequency rejection is carried out by the bypassable anti-alias filter. The following Sigma-Delta analogue-to-digital converter displays extremely low distortion and a dynamic range in excess of 90dB.

Gain and offset adjustment is available, to each channel, to set the dynamic range of data within the channel and to remove system generated offsets; phase inversion is available. The two channels are independently programmable thus allowing differential gain corrections within the digital domain.

Digital filtering is applied to the data by two cascaded multi-tap FIR filters which enhance stopband rejection and provide a programmed shape (the default is an RRC response) and reduce the reliance on analogue components.

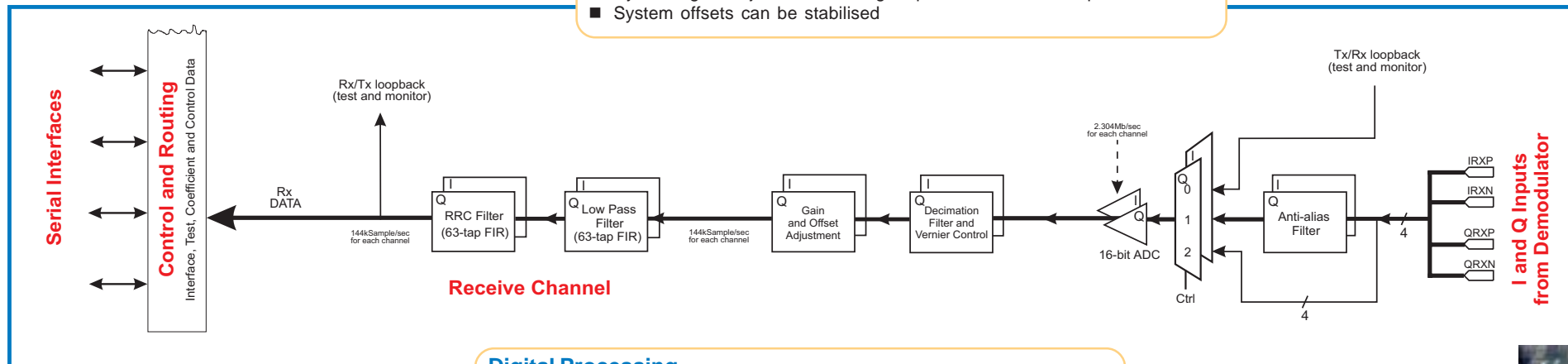
The **CMX981** processed Rx data is then available to the system processor/s; demodulation, would typically be performed by an external DSP.

Analogue-to-Digital

- Differential analogue I and Q inputs
- Selectable anti-alias filters exhibit high sampling frequency rejection
- Wide range, low-distortion Sigma-Delta analogue-to-digital conversion provides I and Q 'single bits' for processing

Dynamic Signal Manipulation

- Dynamic gain adjustment with signal phase inversion if required
- System offsets can be stabilised

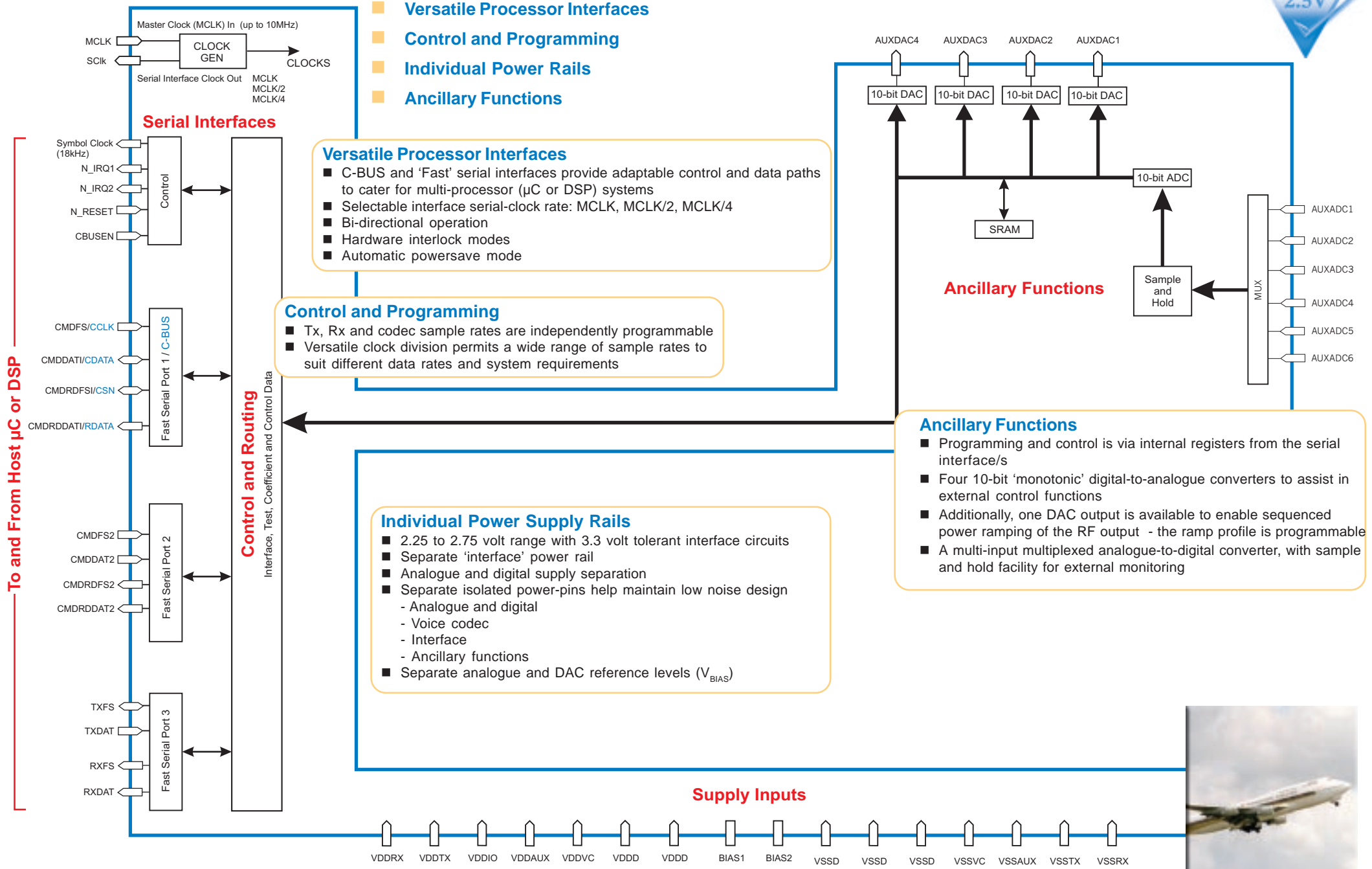


Digital Processing

- Programmable multi-tap low-pass and RRC FIR decimation filters provide pre-process shaping
- I and Q channels are independently programmable
- Rx/Tx and Tx/Rx loopback facilities for test and monitoring



Control; Power; Interface



- Versatile Processor Interfaces
- Control and Programming
- Individual Power Rails
- Ancillary Functions

Versatile Processor Interfaces

- C-BUS and 'Fast' serial interfaces provide adaptable control and data paths to cater for multi-processor (μ C or DSP) systems
- Selectable interface serial-clock rate: MCLK, MCLK/2, MCLK/4
- Bi-directional operation
- Hardware interlock modes
- Automatic powersave mode

Control and Programming

- Tx, Rx and codec sample rates are independently programmable
- Versatile clock division permits a wide range of sample rates to suit different data rates and system requirements

Individual Power Supply Rails

- 2.25 to 2.75 volt range with 3.3 volt tolerant interface circuits
- Separate 'interface' power rail
- Analogue and digital supply separation
 - Analogue and digital
 - Voice codec
 - Interface
 - Ancillary functions
- Separate analogue and DAC reference levels (V_{BIAS})

Ancillary Functions

- Programming and control is via internal registers from the serial interface/s
- Four 10-bit 'monotonic' digital-to-analogue converters to assist in external control functions
- Additionally, one DAC output is available to enable sequenced power ramping of the RF output - the ramp profile is programmable
- A multi-input multiplexed analogue-to-digital converter, with sample and hold facility for external monitoring

To and From Host μ C or DSP



Recent Two-Way Radio IC Products From CML

- CMX649** Adaptive Delta Modulation (ADM) Codec
- CMX838** FRS/PMR446/GMRS 'Family Radio' Processor
- CMX823** Multi-Standard Analogue Paging-Tone Decoder
- CMX881** Baseband Processor for PMR and Trunked Radios
- CMX882** Baseband Processor with Data for Leisure Radios
- CMX883** Baseband Processor for Leisure Radios

CML's full range of products for Two-Way Radio, Wireline Telecom and Wireless Data environments can be viewed on www.cmlmicro.com

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EV9810 Evaluation Kit for the CMX981

The **EV9810** evaluation kit is intended to allow investigation, demonstration and evaluation of the **CMX981** IC. This PCB-based EvKit provides a hardware and interface platform for both hardware and software designers to develop, test and interface prototype equipments.

- Analogue PCB with Low Noise-Floor Design
- Buffered Serial Interface Ports with Signal Shifting
- Differential or Single-ended Baseband Signal I/O
- Dual (+ and -) 8 Volt Supply Requirement
- On-board Regulators for All Power Rails
- Separate 5-Volt Power Rail for Analogue Interfaces
- Auxiliary ADC and DAC Connections Available
- Microphone Inputs and Speaker/Earpiece Outputs via 3.5mm Mono Jack Sockets
- Signal and Power Test Access
- Access to All **CMX981** Functions
- **CMX981** Q1 Device Supplied In-Situ
- Separate Digital and Analogue Ground Planes
- User Manual and Circuit and EvKit Layout Diagrams Provided
- CML Help Desk: techsupport@cmlmicro.com



Information - www.cmlmicro.com
www.cmlmicro.com/products/twoway/CMX981.htm



| | |
|-----------------|---------------|
| Packages | -40° to +85°C |
| CMX981Q1 | 64-lead VQFM |

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