RF Products (CMX994)
CML's Flexible Family of RF IC Products

www.cmlmicro.com

INV/RF99x/10 June 2014

Transmit

Receive

Linear

Modulation Schemes

CML CMX994Q4

CML CMX998Q1

CML CMX992Q3

CML CMX991Q3

CML CMX993WQ3

Non-linear
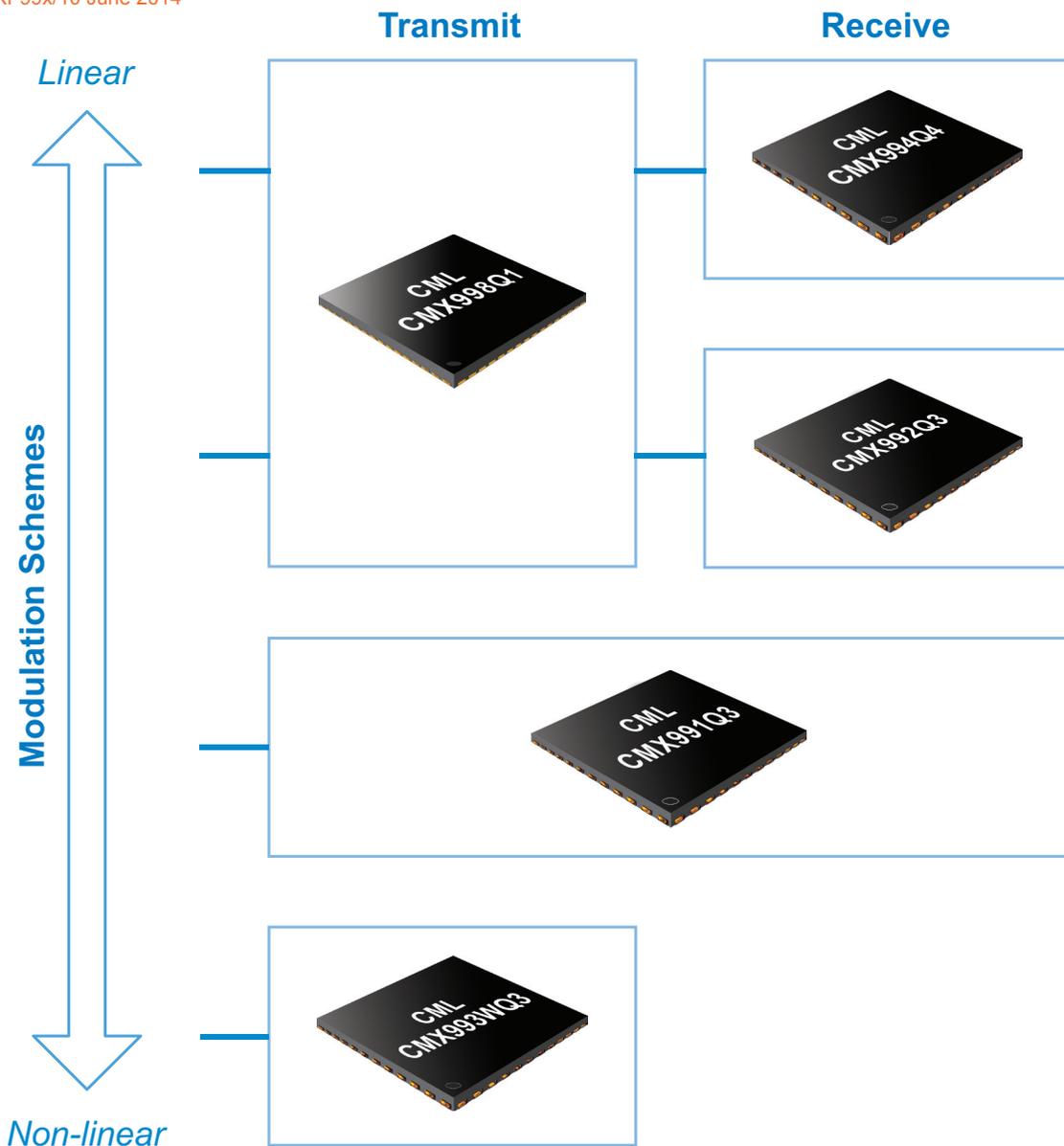
CMX991	Quadrature Transceiver
CMX992	Quadrature Receiver
CMX993/W	Quadrature Modulator
CMX994	Direct Conversion Receiver
CMX998	Cartesian Feedback Loop Transmitter

A family of highly flexible ICs working in the RF frequency range of 100MHz to 1GHz, with the CMX993/W and CMX998 operating down to 30MHz. These ICs, singularly or in combination, address the needs of many over-air formats for data and encoded-voice operation in both constant-envelope and linear modulation systems.

To reduce savings in the printed circuit board requirement, these low-power products require a basic minimum in the way of external circuitry and control and are available in compact VQFN packages.

To enable the shortest design-in time, these RF products are well supported, from a customer's project inception through to final shipping, by ready-to-use evaluation and demonstration aids in the form of populated pcbs accompanied by circuit diagrams, pcb layout masks, bill-of-material information and example scripts.

CML's website (www.cmlmicro.com) provides datasheets/user manuals, material updates, FAQs and application notes.

Introduction

CML's Growing RF Product Family

This document introduces and describes CML's expanding family of RF oriented IC products for data and encoded voice operations.

Direct digital modulation is ideally suited to wireless data applications for higher speed data systems and wider channel bandwidth requirements. To pass more data over the same channel requires accurate phase modulation and introduces the need for systems working to I/Q quadrature modulation.

CML's very flexible family of low-power radio frequency ICs supports many different signal formats. These solutions offer a range of RF design approaches to suit different systems and applications. The support products, in the form of evaluation kits, allow rapid development resulting in shortened project design times.

CML's RF IC Products								
Product	**Description**	**RF Rx**	**RF Tx**	**Operating Frequency Range**	**Modulation Type**	**Stages**	**Package/s**	**Notes**
CMX991	RF Quadrature Transceiver	✓	✓	100MHz to 1GHz	Constant Envelope and 'Slightly' Linear	• Rx RF Mixer • Selectable Rx IF • Rx I/Q Demodulator • Rx I/Q Output Amps • Tx I/Q Modulator to IF • Up-converter • IF and RF Outputs	48-pin VQFN	EvKit: EV9910B
CMX992	RF Quadrature/Low IF Receiver	✓		100MHz to 1GHz	Constant Envelope and Linear	• Rx RF Mixer • Selectable Rx IFs • Rx I/Q Demodulator • Rx I/Q Output Amps	48-pin VQFN	EvKit: EV9920B
CMX993 CMX993W	Quadrature Modulator		✓	30MHz to 1GHz	Constant Envelope and 'Slightly' Linear	• Input Amps • Filter/Interface Amps • I/Q Mixer	48-pin VQFN	EvKit/s: EV9930 and EV9930W
CMX994	Direct Conversion Receiver	✓		50MHz to 940MHz	Constant Envelope and Linear	• On-chip LNA • I/Q Demodulators • Local Oscillator • I and Q Filters with Gain Control	40-pin VQFN	EvKit: EV9942
CMX998	Cartesian Feedback Loop Transmitter		✓	30MHz to 1GHz	Linear	• Input Amps • Up-converter • Down-converter • Local Oscillator • Instability Detector • RF Power Detector	64-pin VQFN	EvKit: EV9980
Please note that the majority of interface function examples shown on the following diagrams are available on the CMX981 Advanced Digital Radio Baseband Processor IC								

Table of Contents

Example Combination Paths

Quadrature Modulator
CMX993/W

Cartesian Feedback Loop Transmitter
CMX998

AND

Quadrature Transceiver
CMX991

OR

Quadrature Receiver
CMX992

Direct Conversion Receiver
CMX994

PA

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R

The Flexibility of CML's RF IC Products

CMX991 Quadrature Transceiver

Core RF functions for a full-feature transmitter and receiver

A high performance RF quadrature transceiver IC that provides the core baseband, IF and RF functions required to implement a full-featured radio transceiver. Operating in the range 100MHz to 1GHz, its I/Q architecture supports the inclusion of multiple modulation types and bandwidths within a single radio design.

The half duplex CMX991 integrates Tx modulator, Rx demodulator and IF PLL and VCO sub-systems to minimise the external circuits required to implement the complete transceiver unit. User-selected modes suit different application requirements.

The Tx path includes an I/Q modulator (up-converter) to accurately generate modulation to the IF frequency, which may then be translated to the final RF frequency by an integrated image-reject up-converter system. The I/Q modulated IF output is also made available separately for conversion to RF via other external circuits, if desired.

The superheterodyne Rx path includes an integrated 1st RF mixer, with a diferential input, having two separate switched outputs supporting one of two possible external 1st IF filter choices, an integrated 2-to-1 input mux with a variable gain amplifier and wideband signal level measurement (signal level indication) functions, to support AGC implementation. The 1st IF signal is then either I/Q demodulated to zero-IF or mixed to a low IF output. The Rx output path includes uncommitted differential amplifiers for flexible output signal conditioning, including differential to single-ended conversion.
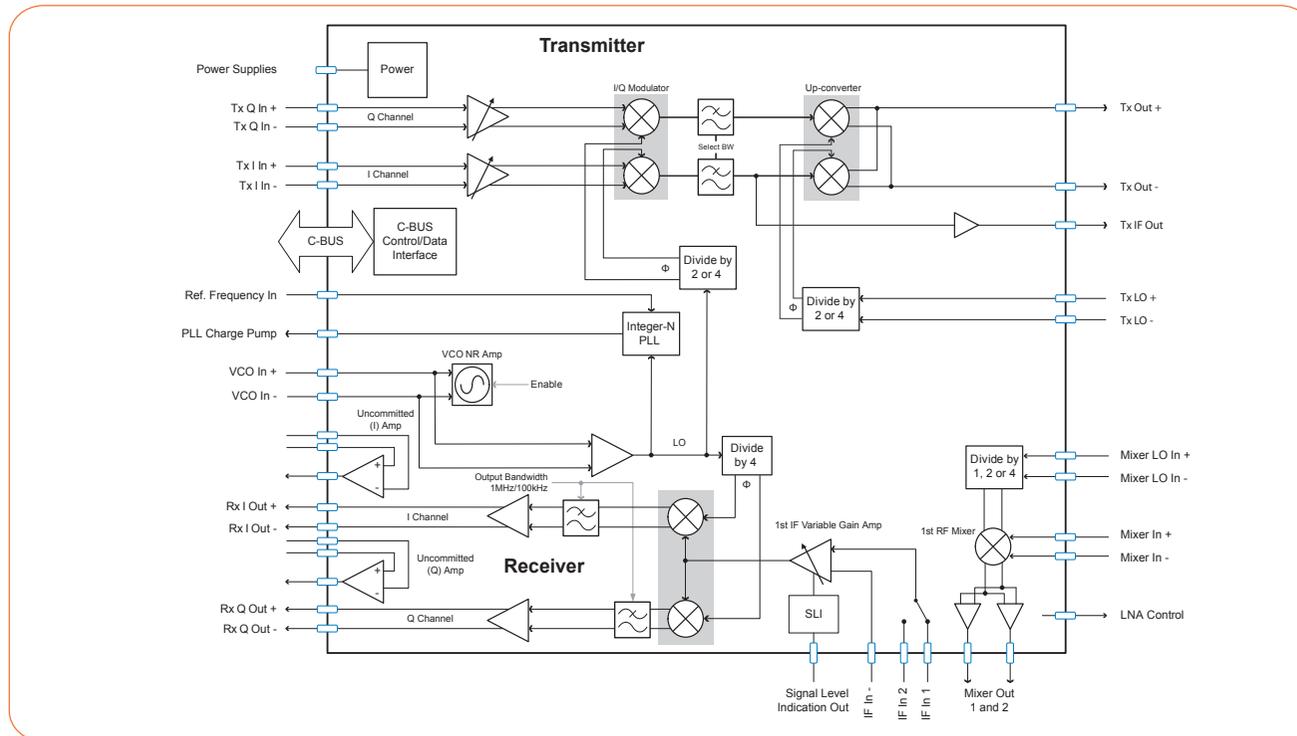
Features
- Operating Frequency: 100MHz to 1GHz
- Receiver
  - Differential or Single-ended Input/s
  - RF Mixer with Output Select
  - 1st IF Input Select
  - Two Selectable Low IF Output Paths
  - 1st IF Variable Gain Amplifier
  - 1st IF Signal Level Indicator (SLI)
  - Two Mode Down-converter: I/Q or Low IF
  - Low Noise Amplifier (LNA) Control Feature
- Transmitter
  - I/Q Modulator to IF
  - Image-reject Up-converter
  - IF and RF Outputs
  - Post Modulator Filter with Selectable Bandwidths
- Local Oscillator
  - IF LO Synthesiser
  - IF Negative Resistance Amplifier

Packages
- CMX991Q3: 48-pin VQFN

Supply Voltage
- 3.0 to 3.6 V

Applications
- Analogue/Digital Multimode Radio
- Software Defined Radio
- Data Telemetry Modems
- ETSI: EN 300 113, EN 301 166, EN 302 561, EN 300 220, TS 102 361 (DMR)
- Automatic Identification System (AIS) Transponders
- Constant Envelope and Linear Modulation
- Narrowband: 25kHz, 12.5kHz and 6.25kHz
- Wideband: up to 2MHz
- APCO Project 25 (P25) Phase 1 and Phase 2 TDMA: TIA-102.CAAB
- Police Digital Trunking (PDT - China) Equipment
- Satellite Communications

CMX991 Example
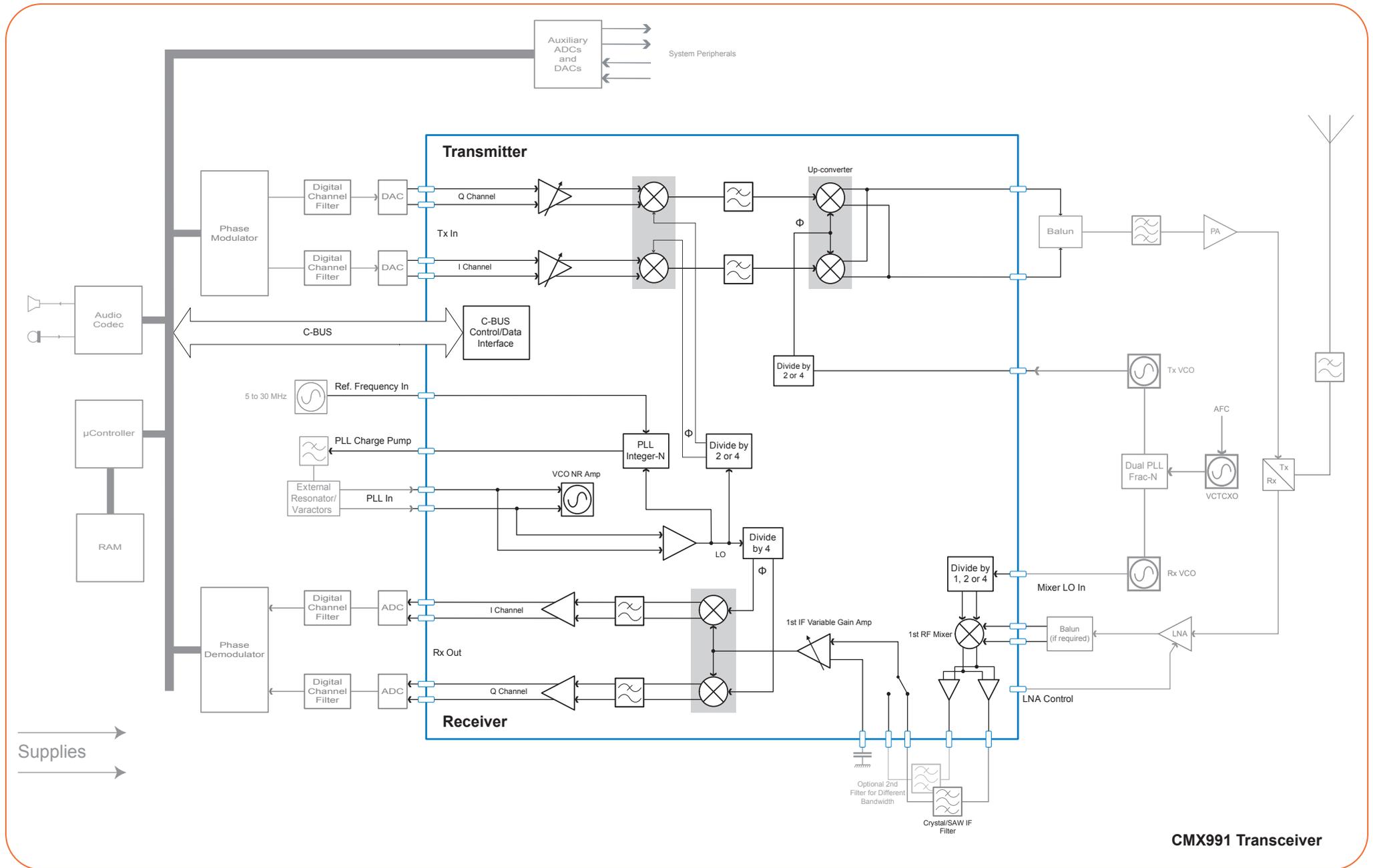
CMX991 Transceiver

CMX992 Quadrature/Low IF Receiver

Core RF functions for a full-feature receiver

The CMX992 is a single-chip, high performance, RF superheterodyne receiver IC for analogue and digital radio systems; it employs the receiver section circuitry of the CMX991 Transceiver. It operates in the RF range 100MHz to 1GHz and its I/Q architecture supports multiple modulation types and bandwidths with a single radio design.

The CMX992, which includes the core RF and IF functions of a high performance receiver, can be used in a wide range of narrowband and wideband wireless products including multi-mode analogue/digital terminals.

The CMX992 integrates 1st RF mixer, Rx demodulators and IF PLL and VCO sub-systems that minimise the external circuits needed to implement a complete receiver. User-selectable modes suit different application requirements.

The Rx path includes an integrated 1st RF mixer having two IF outputs to support two external 1st IF filter choices, then an integrated 2-to-1 input mux integrated with a Variable Gain Amplifier (VGA) and wideband signal level measurement (SLI) functions to support AGC implementation. The 1st IF signal is then either I/Q demodulated to zero IF or mixed to a low IF output.

The CMX992 provides differential and single-ended Rx output options and stand-alone on-chip differential amplifiers for flexible baseband output signal conditioning.

The CMX992 can be used where highly linear modulations are being used, for instance, in applications such as TETRA, where a typical transmitter line-up could include the CMX998 Cartesian Feedback Transmitter.

Features
- Operating Frequency: 100MHz to 1GHz
- Receiver
  - Differential or Single-ended Input/s
  - RF Mixer with Output Select
  - 1st IF Input Select
  - Two Selectable Low IF Output Paths
  - 1st IF Variable Gain Amplifier
  - 1st IF Signal Level Indicator
  - Two Mode Down-converter: I/Q or Low IF
  - Low Noise Amplifier (LNA) Control Feature
- Local Oscillator
  - IF LO Synthesiser
  - IF Negative Resistance Amplifier
- C-BUS Serial/Control (SPI Compatible) Interface

Packages
- CMX992Q3: 48-pin VQFN

Supply Voltage
- 3.0 to 3.6 V

Applications
- Analogue/Digital Multimode Radio
- Software Defined Radio
- Data Telemetry Modems
- ETSI: EN 300 113, EN 301 166, EN 302 561, EN 300 220, TS 102 361 (DMR)
- Automatic Identification System (AIS) Transponders
- Constant Envelope and Linear Modulation
- Narrowband: 25kHz, 12.5kHz and 6.25kHz
- Wideband: up to 2MHz
- APCO Project 25 (P25) Phase 1 and Phase 2 TDMA: TIA-102.CAAB
- TETRA Systems
- Police Digital Trunking (PDT - China) Equipment
- Satellite Communications
- Compatible with CMX998
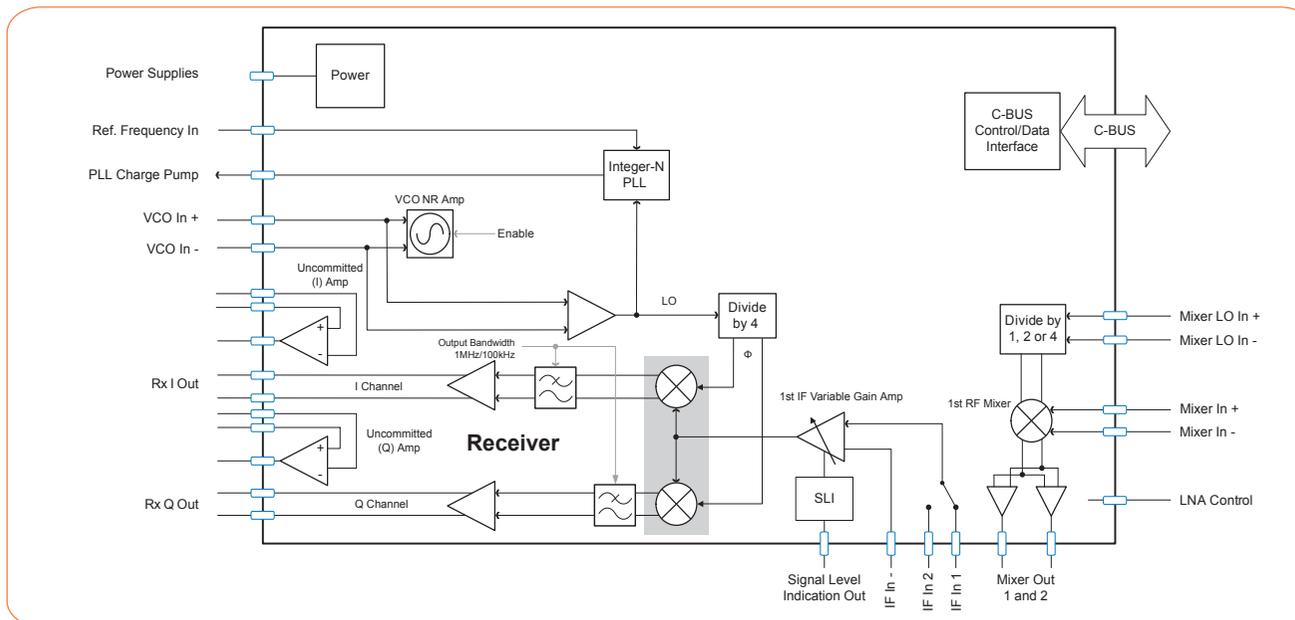
CMX992 and CMX998 Example

CMX998 CFBL Transmitter

CMX992 Receiver

- For ease of addressing when using the CMX998 with the CMX992 or CMX994, the C-BUS addresses of the CMX992 or CMX994 are different, arranged not to overlap and to allow common C-BUS connections

- Note that the CMX994 Direct Conversion Receiver could be used in place of the CMX992
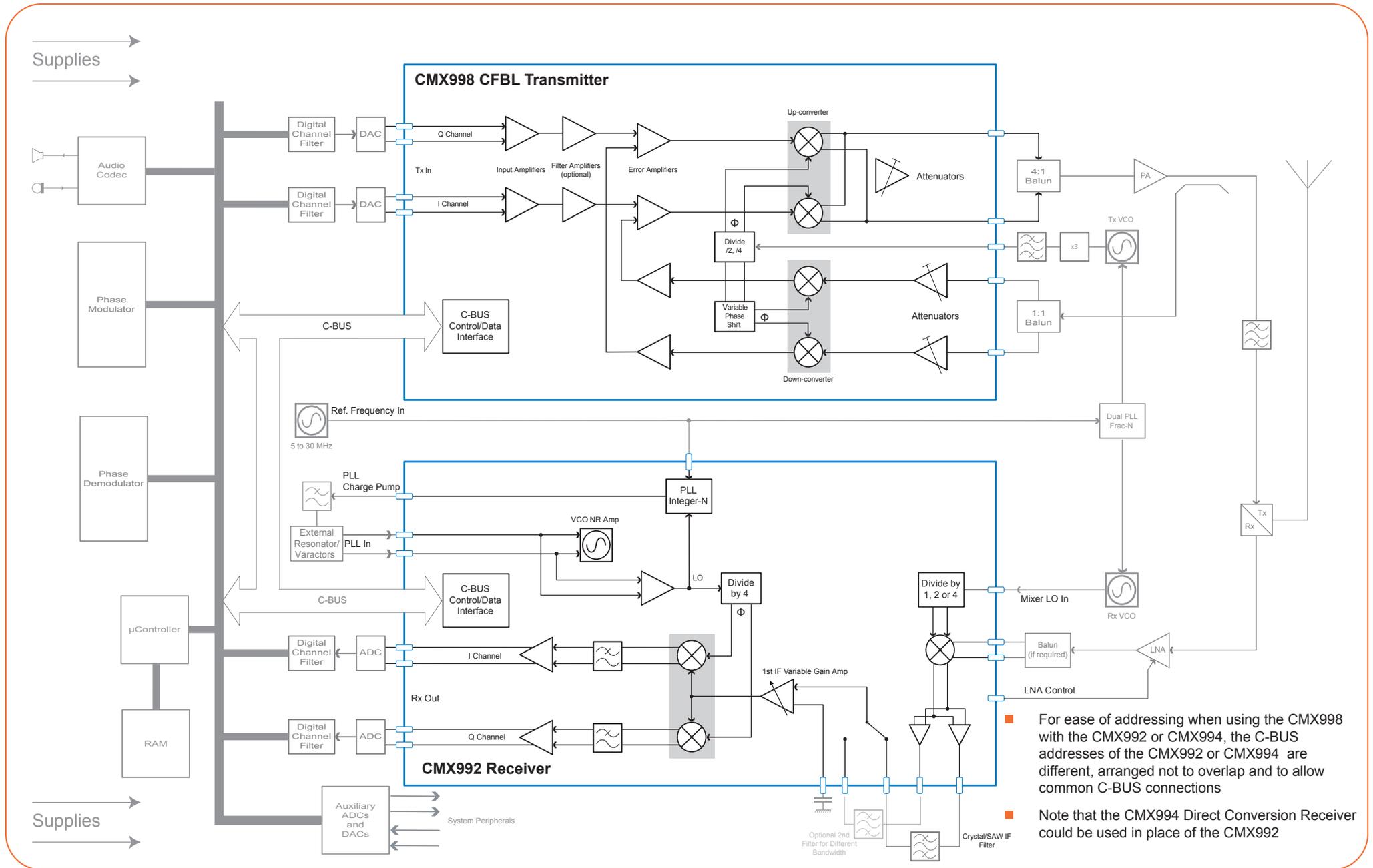
CMX993 and CMX993W Quadrature Modulators

Translation from baseband I and Q up to a modulated RF signal

These integrated, low voltage quadrature (I/Q) modulator ICs provide translation from baseband I and Q signals to a modulated RF signal. Both ICs, which each integrate two matched double balanced mixers driven from a buffered and quadrature split local oscillator, are suitable for use in applications operating from 30MHz to 1GHz.

The LO frequency is divided by a factor of either two or four. The mixers form an I/Q vector modulator with programmable gain stages offering up to 30dB of gain, controlled in 2.5dB steps.

Uncommitted low frequency differential amplifiers are provided for users to implement such functions as filtering, differential-to single-ended signal conversion and level shifting.

The CMX993W product variant offers wide-bandwidth operation. Integrating differential wideband filter/interface amplifiers the CMX993W can be utilised in systems with modulation bandwidths up to 100MHz.

A digital control interface, C-BUS, (an SPI compatible interface) allows gain control as well as power management of individual internal blocks to optimise system performance. The C-BUS SPI compatible serial control/data interface operates from its own independent supply enabling the device to be interfaced to different voltage baseband devices.

Quadrature modulation is ideally suited to wireless data applications for higher speed data systems including wide channel bandwidths. The CMX993 I/Q quadrature modulator offers accurate phase modulation and provides a high degree of system/ implementation flexibility.

Features
- Operating Frequency: 30MHz to 1GHz
- Wide Band Noise: -148dBc/Hz
- Noise Floor: -155dBm/Hz
- Programmable Output Attenuation Range
  - 0dB to 30dB
- Output Power: +3dBm (PEP)
- Low Local Oscillator Drive Requirement: -15dBm
- Uncommitted Amplifiers for Filtering and Interfacing
- Individual Bandwidths:
  - CMX993: 10MHz (I/Q)
  - CMX993W: >50MHz (I/Q)
- C-BUS Serial/Control (SPI Compatible) Interface with Separate Supply Domain
- On-chip Bandgap Reference

Packages
- CMX993Q3: 48-pin VQFN
- CMX993WQ3: 48-pin VQFN

Supply Voltage
- 3.0 to 3.6 V

Applications
- APCO (P25) Wireless Data
- Digital TV/CATV Modulators
- Wireless LAN and Local Loop
- IF and/or RF Modulators
- AFSK, GMSK, 4FSK, C4FM, QPSK, QAM, SSB OFDM Multi-carrier Systems
- Software Defined Radio (SDR)
- WiMax Systems
- OFDM/COFDM Systems
- Satelite Communications
- Cellular Picocell and Nanocell Systems
- RF Channel Bandwidths up to 100MHz
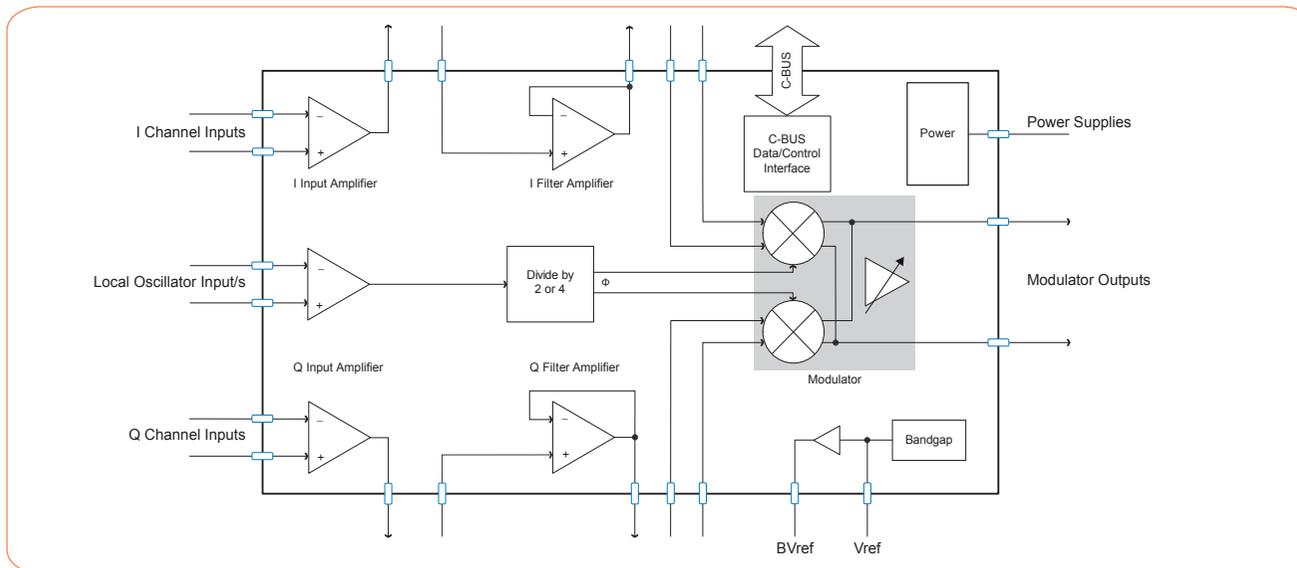
CMX993 and CMX994 Example

Note that the CMX992 Quadrature Receiver could be used in place of the CMX994
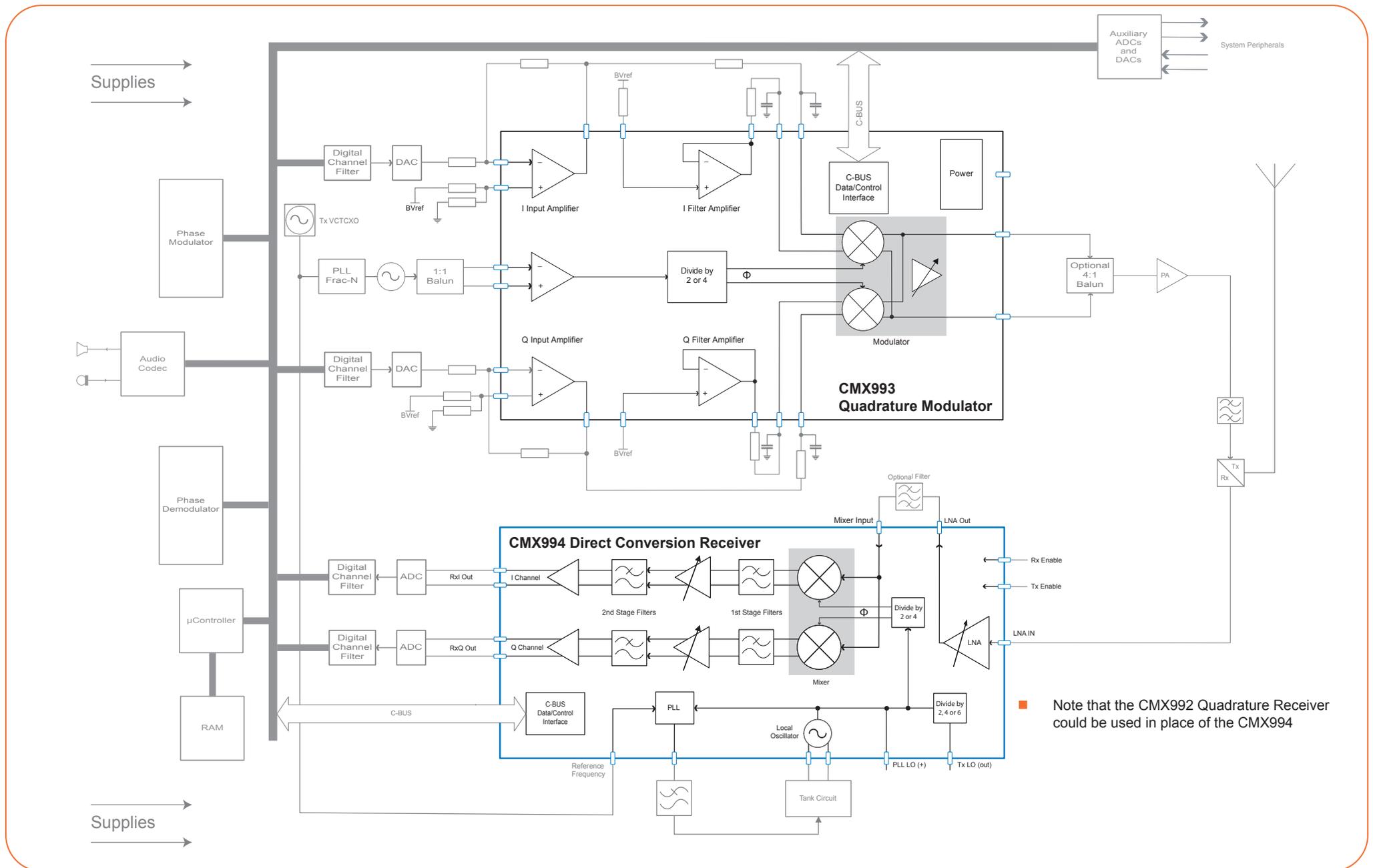
CMX994 Direct Conversion Receiver *(advance information)*

RF, I/Q demodulation and baseband circuits

The CMX994 is a direct conversion receiver IC. The Direct Conversion RF architecture offers the ultimate lowest cost and small size receiver solution. The use of integrated channel filtering removes bulky and expensive external components. This CML approach also minimises local oscillator (LO) requirements.

The receiver is fully integrated with a broadband Low Noise Amplifier (LNA) preceding the down-converter section, a high dynamic-range I/Q demodulator.

The receiver baseband section includes amplifiers and precise baseband filter stages. High-linearity down-converting mixers are immediately followed by a baseband filter stage.

The first stage of filtering is designed to remove off-channel blocking signals prior to baseband amplification. Following the filters, gain is applied via an on-chip variable gain amplifier.

LO generation is provided by an Integer-N PLL and VCO negative-resistance amplifier suitable for VHF operation; an external LO may be used for other bands. Also provided is a divided LO output which can be used in transmitter circuits. The LO divide ratios are ÷1, ÷2, ÷4 or ÷6.

The receiver I/Q chain includes the facility to correct for inherent dc offsets in the hardware. This process is intended to optimise the dynamic range of the system and must be controlled by the microprocessor or DSP that processes the I/Q signals from the IC.

The I and Q baseband filters are internally calibrated to ensure that a precise frequency response is maintained. This allows excellent channel filtering and the addition of digital compensation (if required) in subsequent processing. The CMX994 also provides accurately controlled scaling of filters on a ratio of 1:2:4 making the support of multiple channel bandwidths straightforward, for example: systems support of 6.25kHz, 12.5kHz and 25kHz channel bandwidths are particularly convenient to implement.

Features
- Receiver
  - Operating Frequency: 100MHz to 1GHz
  - Direct Conversion Eliminates Image Responses
  - Low Noise Amplifier (LNA) with Gain Control
  - Precise Filtering with Bandwidth Setting and '1:2:4' Bandwidth Modes
- Local Oscillator
  - LO Synthesiser
  - VCO Negative Resistance Amplifier
  - LO Divide by '2' or '4' Modes
- C-BUS Serial/Control (SPI Compatible) Interface

Packages
- CMX994Q4: 40-pin VQFN

Supply Voltage
- 3.0 to 3.6 V

Applications
- Analogue/Digital Multi-mode Radio
- Software Defined Radio (SDR)
- Data Telemetry Modems
- Satellite Communications
- EN 301 166, EN 300 113 and EN 302 561
- TS 102 361 (DMR), TS 102 490 (dPMR Mode 1) and TS 102 658 (dPMR Mode 2/Mode 3)
- TETRA and TETRA TEDS
- APCO P25 Phase 1 and Phase 2
- ARIB –T96 (DCR) and NXDN
- Police Digital Trunking (PDT - China) Equipment
- Constant Envelope and Linear Rx Modulation
- Rx Function Compatible with CMX998 (Tx)
- Narrowband: 25kHz, 12.5kHz and 6.25kHz
- Wideband: up to 2MHz

CMX994 and VCO Tx Example

Supplies

CMX994 Receiver

Mixer Input / LNA Out

Rx Enable

Tx Enable

Digital Channel Filter — ADC — RxI Out — I Channel

2nd Stage Filters — 1st Stage Filters — Mixer

Divide by 2, 4 or 6

Φ

LNA — LNA IN

Digital Channel Filter — ADC — RxQ Out — Q Channel

Demodulator

Divide by 2 or 4

C-BUS — C-BUS Data/Control Interface

PLL

Local Oscillator

Reference Frequency

Tank Circuit

PLL LO (+) / Tx LO (out)

(Optional Filter)

Audio Codec

µController

PA

Rx / Tx

Below 400MHz (internal VCO)

Above 400MHz (external VCO)

Modulator — DAC

VCTCXO eg. 19.2MHz

DAC — Phase Detector — VCO

Two-point Modulation Signalling
(independent gain adjustment
in DAC, or single DAC with
external gain-adjust)

Auxiliary ADCs and DACs — System Peripherals

- The CML range of RF products can be used quite comfortably alongside discrete or other circuits

CMX998 Cartesian Feedback Loop Transmitter

Efficiency and linearity for non-constant envelope systems

As a flexible state-of-the art design for an integrated Cartesian Feedback Loop (CFBL), the CMX998 improves the efficiency and linearity of transmitters of non-constant envelope modulation.

Consisting of an 'I' and 'Q' up-converter (modulator) in the forward path and 'I' and 'Q' mixers in the feedback path, the CMX998 makes available a complete collection of building-block type circuits on a single integrated circuit that the designer/user can select to perform all of the functions required to produce a clean linear Tx output in a wide-ranging RF spectrum.

Covering a wide RF range, from 30MHz to 1GHz, it is usable with channel bandwidths up to 150kHz.

The CMX998 offers high performance, low wide-band noise and a large degree of linearisation gain: typically 30dB of linearisation improvement is achievable.

This product is an ideal companion to the CMX981 Advanced Digital Radio Baseband Processor IC and the CMX7163 QAM Modem IC in digital radio designs.

Features
- Operating Frequency: 30MHz to 1GHz
- Wideband Noise: -148dBc/Hz
- Gain Control
- Error Amplifiers
- Forward Path Up-converter
- Reverse Path Down-converter for Feedback Linearisation
- 360º Loop Phase-shift Control
- DC Offset Measurement Output
- Selectable Open and Closed Loop Functions
- Instability Detector
- Flexible Digital Interface
- Linearisation Gains of 30dB or More Achievable
- C-BUS Serial/Control (SPI Compatible) Interface

Packages
- CMX998Q1: 64-pin VQFN

Supply Voltage
- 3.0 to 3.6 V

Applications
- TETRA 1 and 2 and APCO Phase 2 Terminals
- Satellite Terminals
- Linear Modulation Schemes:
  QPSK, pi/4DQPSK, 8PSK, QAM, OFDM, F4FM
- Direct Interface to CMX981

CMX998 Performance
Tx output spectrum in open loop and CMX998 closed loop operation
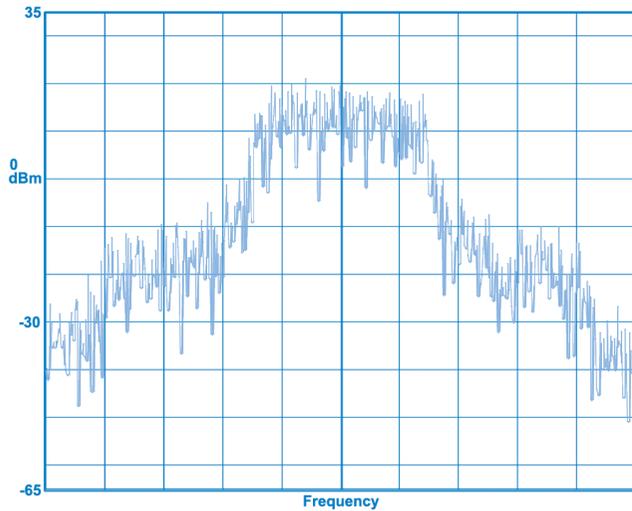
Open loop (no linearisation) gives poor performance
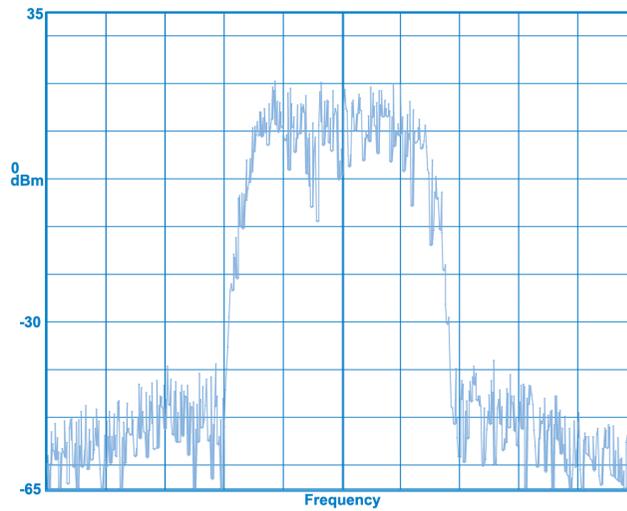
Closed loop (CMX998 linearisation) gives much improved performance

CMX998 Building Blocks
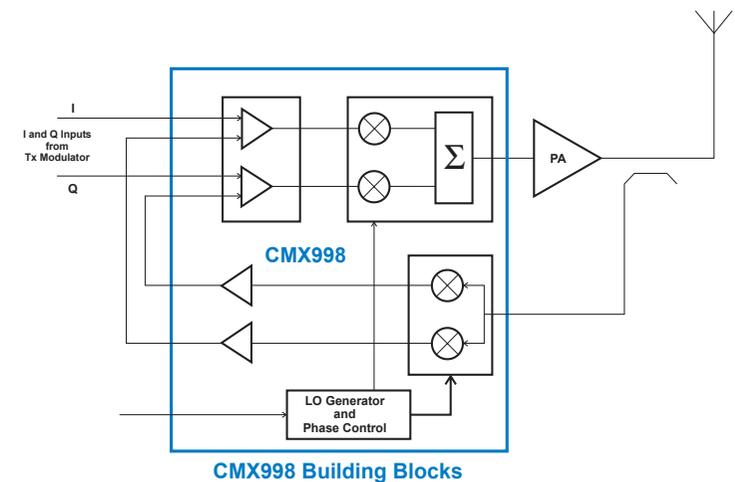
CMX998
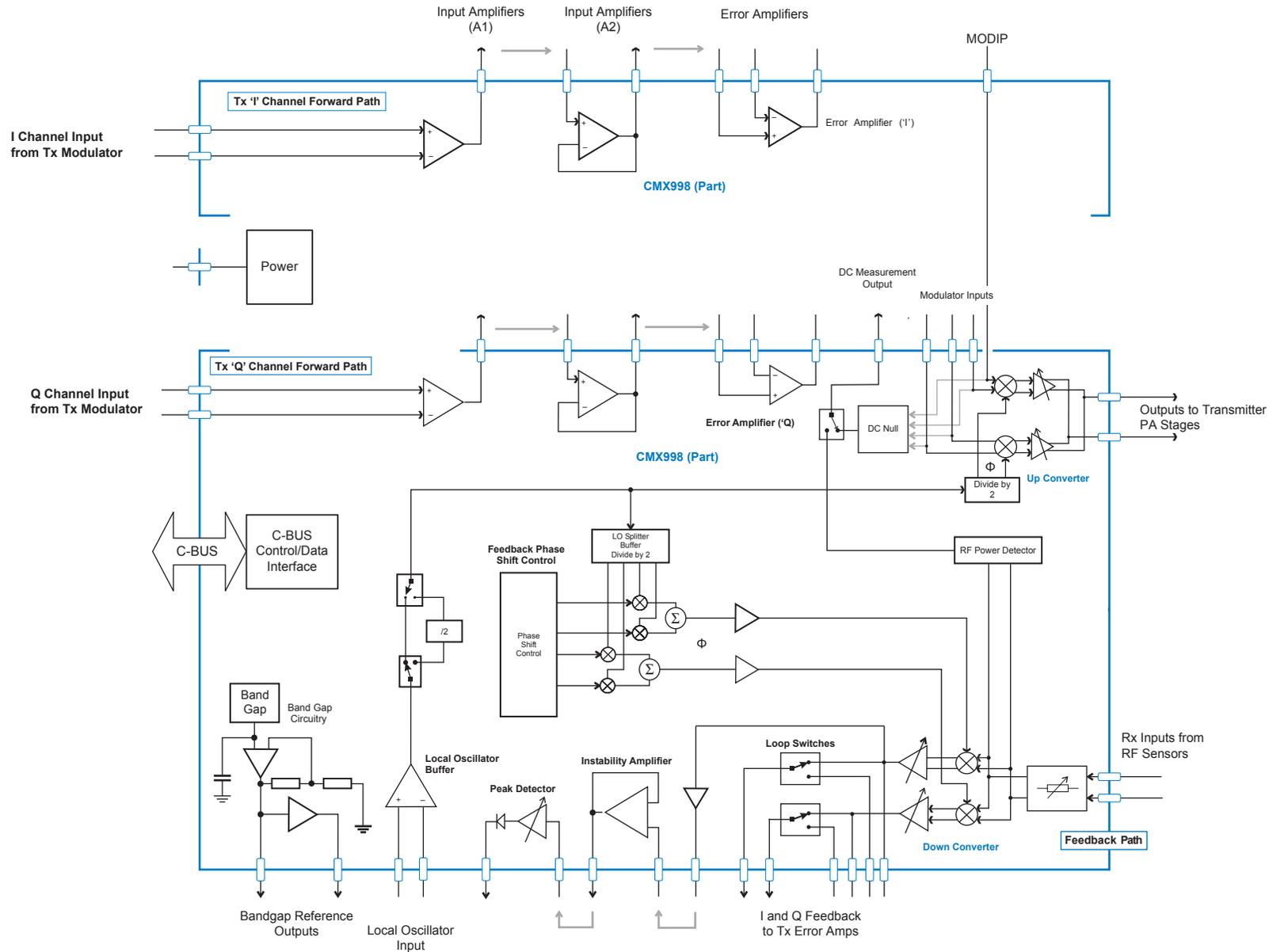
Other Relevant CML IC Products Available

CMX7031/CMX7041 Analogue Two-way Radio Processor	Voice, Data and Signalling + RF Synths
CMX7032 Automatic Identification System (AIS) Processor	AIS and DSC Data + RF Synths
CMX7131/CMX7141 Digital PMR Processor	dPMR, DCR and NXDN™ Data and Analogue Two-way Radio + RF Synths
CMX7163 QAM Modem	4, 16 and 64 (Raw and Packet) QAM, I/Q Interface, Digital IF Filter for Multiple RF Spacings
CMX910 AIS Baseband Processor	Class A and B AIS Processing, Half Duplex GF(M)SK, FSK and DSC, Slot/Sample Counter with UTC Timing Interface
CMX981 Advanced Digital Radio Baseband Processor	Quadrature (I and Q) Rx and Tx Channels + Linear Codec + High Quality Digital Filters + Auxiliary ADCs and DACS
CMX7164 Multi-mode WD Modem	GMSK/GFSK, 2/4/8/16 FSK and 4/16/64 QAM

Demonstrate, Evaluate and Design-in

CML's RF products are well supported in terms of the CML website (www.cmlmicro.com), CML's help desks and evaluation and demonstration kits.

Generally available as pcb-based, these kits provide a target IC and all relevant peripheral circuitry, test points and power distribution.

Additionally available are high resolution circuit diagrams, pcb layout masks and bill-of-material information.

PE0002 EvKit Interface Card: a global control/interface system, via GUI, for use with evaluation kits for CML's new generation ICs, including *FirmASIC*®-based products.

Customers' own interface/control circuitry can be used.

Product	Evaluation and Support Kits	
CMX991 RF Quadrature Transceiver	EV9910B	
CMX992 RF Quadrature Receiver	EV9920B	
CMX993 and **CMX993W** RF Quadrature Modulators	EV9930 EV9930W	PE0002 Evaluation Kit Interface Card
CMX994 Direct Conversion Receiver	EV9942	
CMX998 Cartesian Feedback Loop Transmitter	EV9980	

Member Companies

CML Microcircuits (UK) Ltd

COMMUNICATION SEMICONDUCTORS

Tel: +44 (0)1621 875500   Fax: +44 (0)1621 875600
sales@cmlmicro.com   www.cmlmicro.com

CML Microcircuits (USA) Inc.

COMMUNICATION SEMICONDUCTORS

Tel: +1 336 744 5050 and 800 638 5577   Fax: +1 336 744 5054
us.sales@cmlmicro.com   www.cmlmicro.com

CML Microcircuits (Singapore)Pte Ltd

COMMUNICATION SEMICONDUCTORS

Singapore
Tel: +65 62888129   Fax: +65 62888230
sg.sales@cmlmicro.com   www.cmlmicro.com

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