**CML Microcircuits**
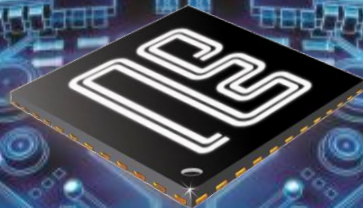*COMMUNICATION SEMICONDUCTORS*

# CMX7164
# Wireless Data Modem

FFSK/MSK · GMSK/GFSK · 2/4/8/16-FSK · 4/16/32/64-QAM · V.23
Adaptive Coded Modulation (ACM) features now available in the QAM Function Image™

Product Presentation

March 2016

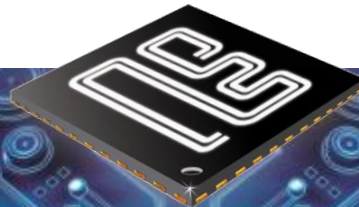CMX7164 Multi-mode Wireless Data Modem
# Applications

- High performance narrowband wireless data systems

- Legacy systems using popular CMX7143, CMX909B and CMX919B devices

- M2M systems over dedicated channels
  - High quality of service; long range and no unlicensed channel congestion
  - Point-to-point, multipoint, multicast, broadcast, and mesh network systems
  - Wireless data concentrator hubs and their backbones e.g. smart grid

- SCADA systems

- Mobile data systems - AVL vehicle location and tracking

- FCC part 90 business and industry spectral efficiency system requirements

- Digital SDR (Software Defined Radio) systems
  - Flexible 6.25kHz to 25kHz RF channel spacing fits changing conditions

- General high speed, high efficiency wireless data telemetry

- Digital WLL - wireless telephone links

- Miniature, battery powered, portable, wireless data terminals
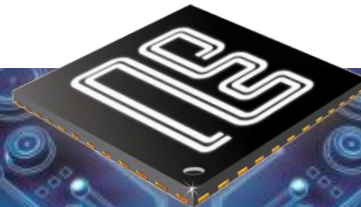
# Systems and standards

- Meets the essential parameters of various global regulatory standards

- ETSI EN 300 113

- ETSI EN 301 166

- ETSI EN 300 220

- Various FCC rule parts including Part 90

- ARIB STD-T67

- RCR STD-30

- Different modes support regulations for 5kHz, 6.25kHz, 7.5kHz, 12.5kHz, 15kHz, 20kHz, 25kHz, and other user-selectable channel spacings
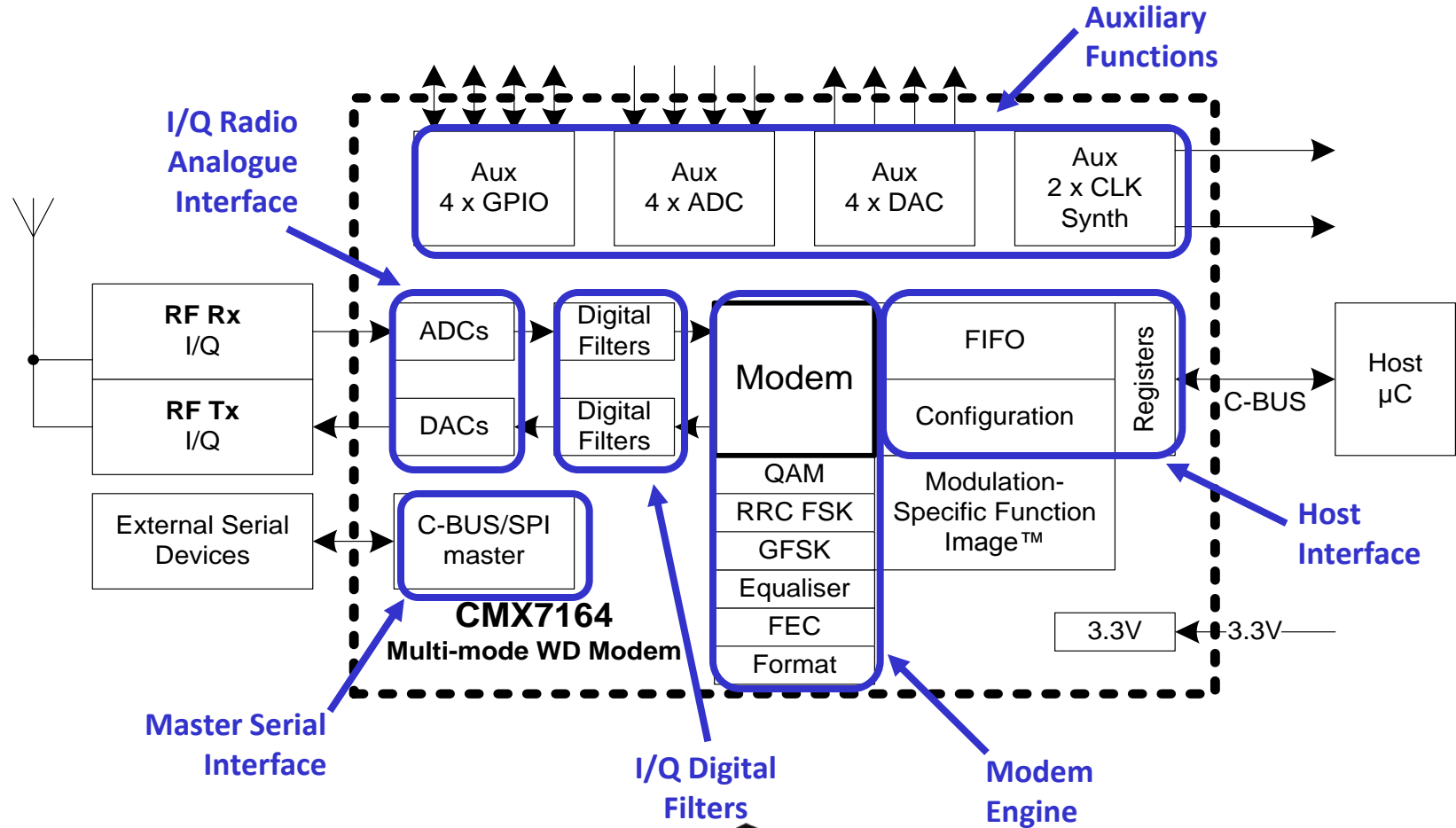
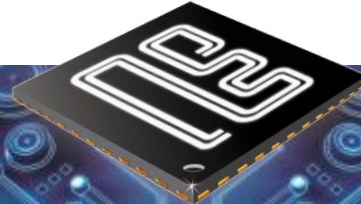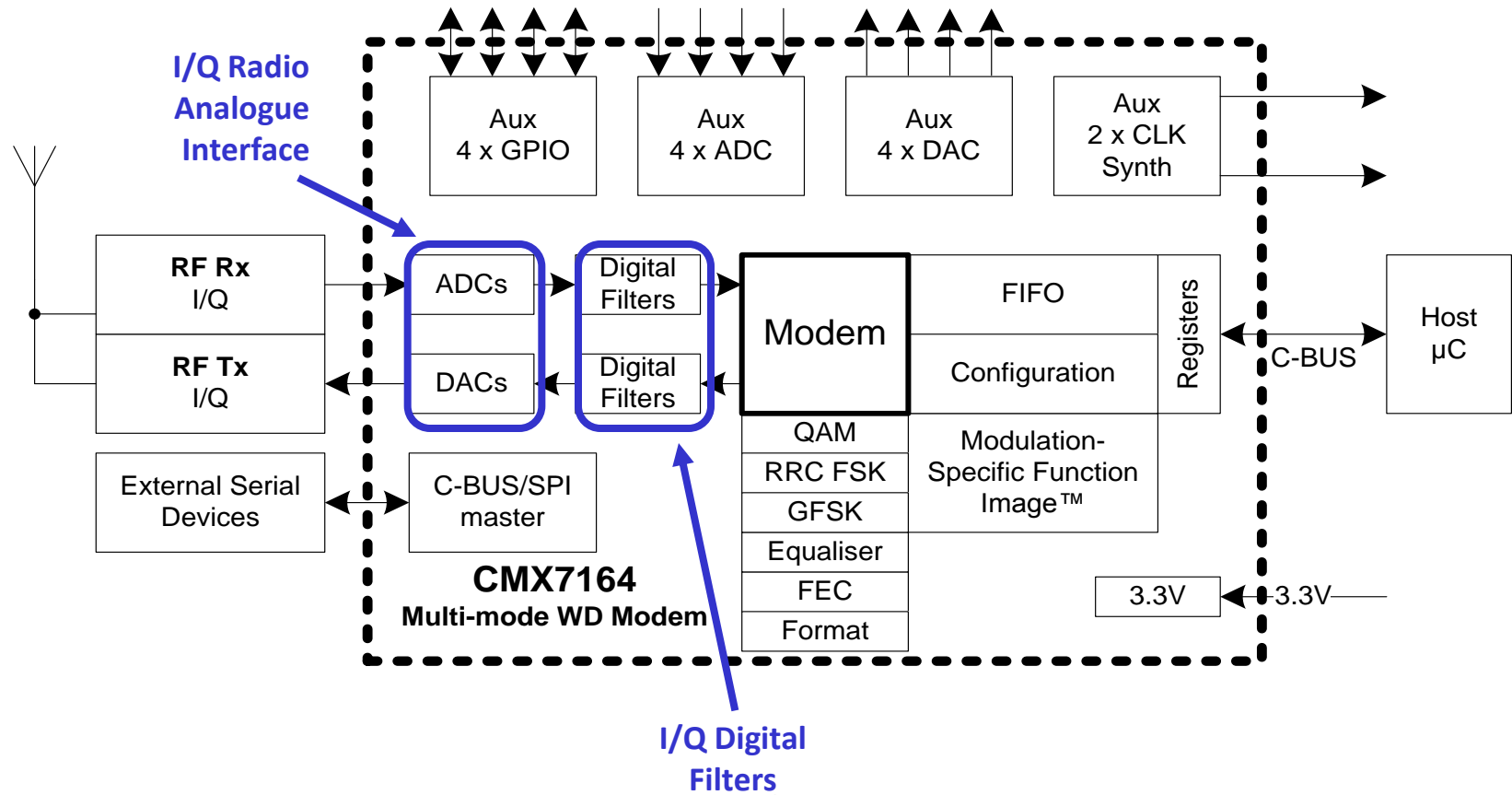**CML Microcircuits**
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# Key features

| Solution Technology | CMX7164 Detail |
|---|---|
| Linear modulation | • Supports spectrally efficient QAM |
| FM (constant envelope) modulation | • Supports root raised cosine 2-FSK, 4-FSK, 8-FSK and 16-FSK<br>• Supports GMSK/GFSK<br>• V.23 Modem |
| I/Q radio architecture | • Direct connects to I/Q zero IF radio transceivers<br>• Integrated radio interface codecs (ADC/DAC)<br>• Integrated digital IF filters scale BW with selected data rate |
| Equalisation and enhanced FEC | • Dynamic equaliser compensates channel response changes<br>• Robust error correcting code supports realistic conditions<br>• Multiple code rates to choose robustness vs. net throughput |
| Multiple modulation choices Function Images | • 7164FI-1.x - GMSK/GFSK<br>• 7164FI-2.x – 2/4/8/16-FSK<br>• 7164FI-4.x (7163FI-4.x) – 4/16/32/64-QAM<br>• Selectable data rates up to ~96kbps<br>• Data rate selection sets bandwidth to suit requirements |

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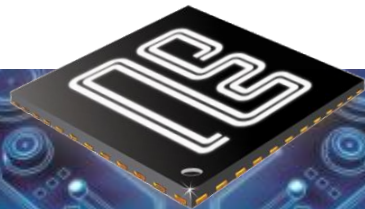
# Section overview

# I/Q Radio interface and digital filters

**I/Q Radio Analogue Interface**

**I/Q Digital Filters**

| Block | Contents |
|---|---|
| Aux 4 x GPIO | |
| Aux 4 x ADC | |
| Aux 4 x DAC | |
| Aux 2 x CLK Synth | |

RF Rx I/Q

RF Tx I/Q

External Serial Devices

ADCs

DACs

Digital Filters

Digital Filters

C-BUS/SPI master

**CMX7164**
**Multi-mode WD Modem**

Modem

FIFO

Configuration

Registers

QAM
RRC FSK
GFSK
Equaliser
FEC
Format

Modulation-Specific Function Image™

C-BUS

Host µC

3.3V     3.3V

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# I/Q Radio interface and digital filters

- Integrated I/Q ADCs and I/Q DACs provide analogue radio interface that can directly connect to zero IF I/Q radio transceivers

- No external ADCs or DACs required

- I/Q ADCs are high dynamic range to support Rx digital IF filter

- Rx (ADC) digital I/Q IF filters provide significant adjacent channel rejection
  - Filter response shape automatically matches selected modulation
  - Linear phase response for negligible group delay distortion
  - I and Q filter path responses are precisely matched
  - Filter bandwidth automatically scales with selected symbol rate
  - Adjacent channel rejection of >58dB may eliminate the need to switch between multiple discrete 2nd IF filters to reduce total BOM cost and size

- Tx DAC path dc offset and gain controls to trim I/Q modulator

- Tx DAC auto-calibrate external CMX998 modulator dc offset (LO suppression)
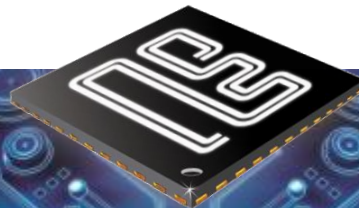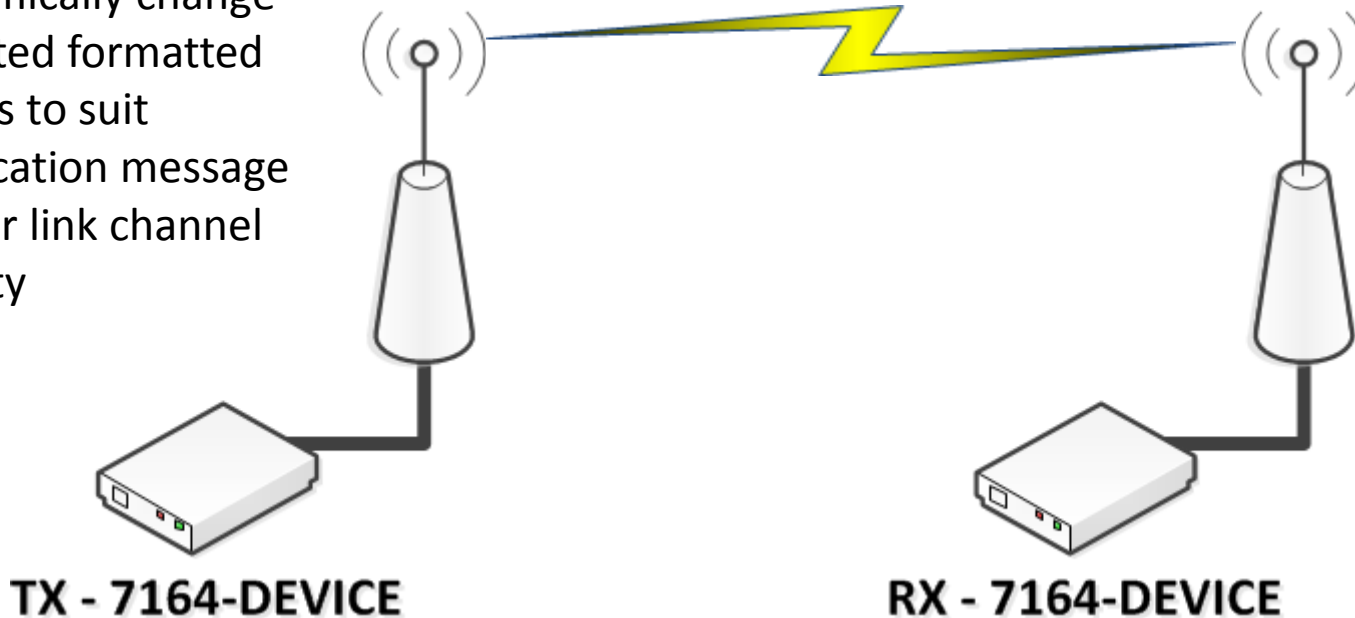
# New QAM features

- QAM Function Image™ only – 7163/7164FI-4.1.x.x

- 32-QAM modulation

- ACM (Adaptive Coded Modulation) features
  - Command to dynamically change modulation type on a per burst basis
  - User defined formatted blocks: data field size, channel coding and CRC sizes
  - Over-air commands

- Iterative channel coding makes short messages more robust

- User defined CRC polynomials

- Serial port interface (SPI) macros speed external slave device setup

- RSSI and Error Magnitude reporting modes provide better guidance to host ACM decisions

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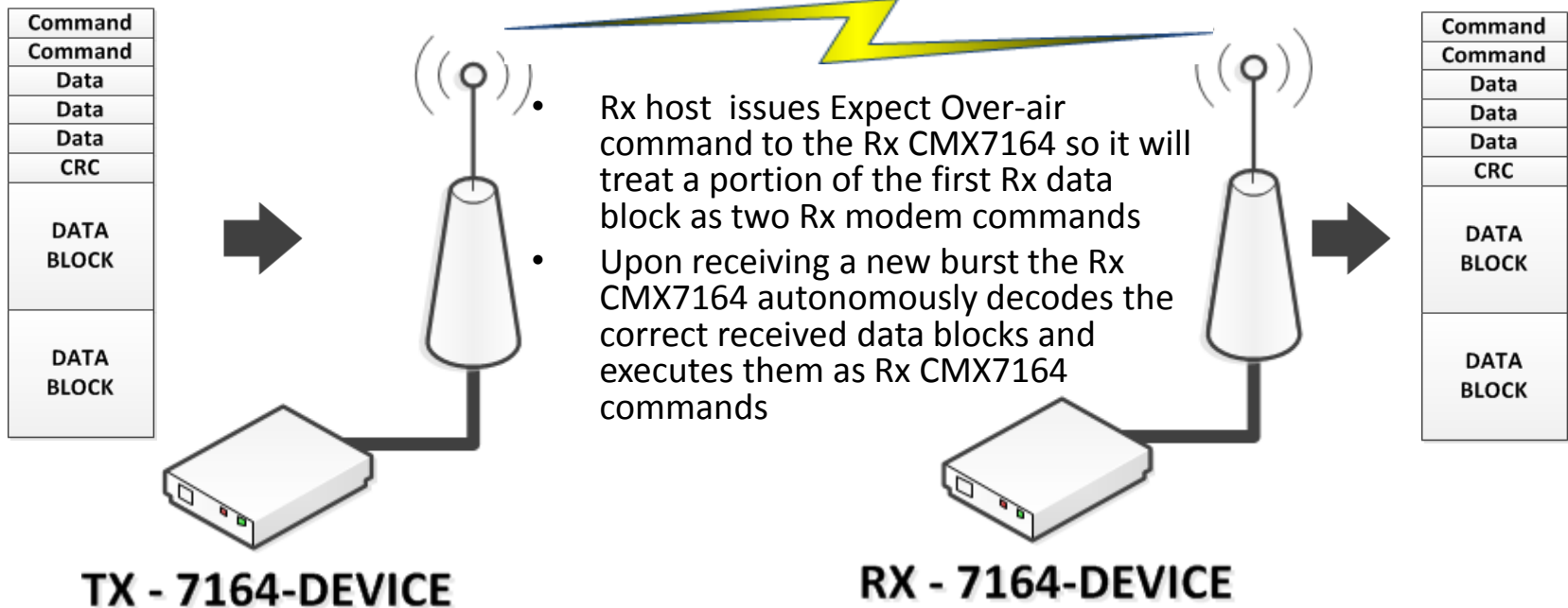COMMUNICATION SEMICONDUCTORS
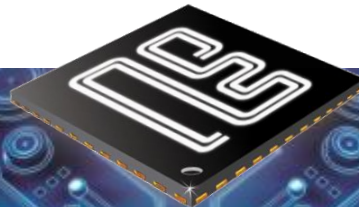
# 'Over-air' commands scenario

Rx host doesn't know what block format will arrive but must in order to issue the correctly corresponding Rx commands to the CMX7164

Tx host wants to dynamically change selected formatted blocks to suit application message size or link channel quality

**TX - 7164-DEVICE**

**RX - 7164-DEVICE**

CMX7164 Multi-mode Wireless Data Modem
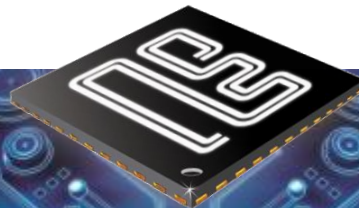# 'Over-air' commands solution

- **Solution**: Tx host inserts Rx modem command data into first data block

- Rx host commands the CMX7164 to treat a selected portion of the first Rx data block as Rx commands



| Command |
| Command |
| Data |
| Data |
| Data |
| CRC |
| DATA BLOCK |
| DATA BLOCK |

- Rx host issues Expect Over-air command to the Rx CMX7164 so it will treat a portion of the first Rx data block as two Rx modem commands
- Upon receiving a new burst the Rx CMX7164 autonomously decodes the correct received data blocks and executes them as Rx CMX7164 commands

| Command |
| Command |
| Data |
| Data |
| Data |
| CRC |
| DATA BLOCK |
| DATA BLOCK |

**TX - 7164-DEVICE**

**RX - 7164-DEVICE**

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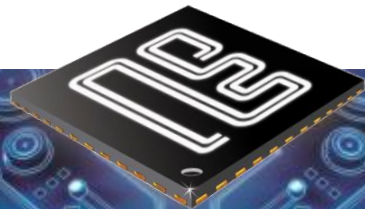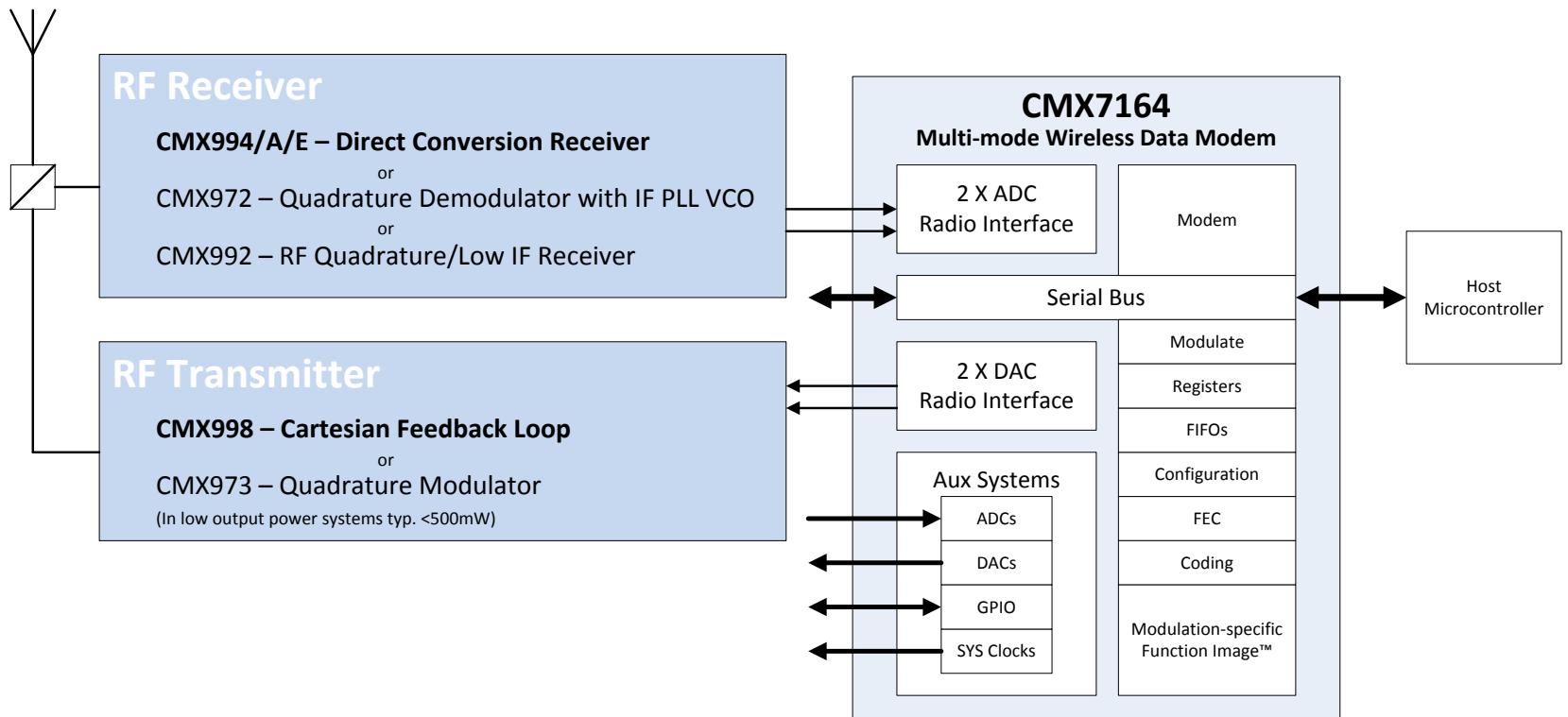COMMUNICATION SEMICONDUCTORS

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# New QAM feature benefits

- ACM (Adaptive Coded Modulation) involves dynamically changing Tx burst in response to Tx host's application message size and the link's channel quality. This technique optimizes network performance.

  – Change modulation type on the fly to suit message size and link channel quality. **New Change M-QAM Modulation command** enables quickly changing to any QAM type on a per burst basis.

  – Change block format: Rx must learn the Tx block formats in time to task the Rx CMX7164 to process them correctly. This would require the Rx host to quickly parse and act upon control data in a burst header. **New Rx Expect Over the Air command** enables the Tx host to autonomously control initial Rx CMX7164 commands *without quick initial Rx parsing by the Rx host*

  – Resolving link channel quality uses Rx CMX7164 RSSI and Error Magnitude metrics. **New, configurable RSSI and EM modes** support developing a more accurate and or timely host view of channel quality.

  – **New user defined formatted blocks (up to 48)** allow the user to tune CMX7164 formatted block 'vocabulary' to best suit his application's message size, robustness, error checking and error correction

  – **New 32-QAM modulation** is an attractive data rate vs. link robustness choice between 16-QAM and 64-QAM

- New iterative channel coding type provides the ability to robustly transport short messages e.g. application control information

- SPI Thru-port macros speed setup and configuration of external C-BUS devices to reduce transition time between Tx and Rx modes
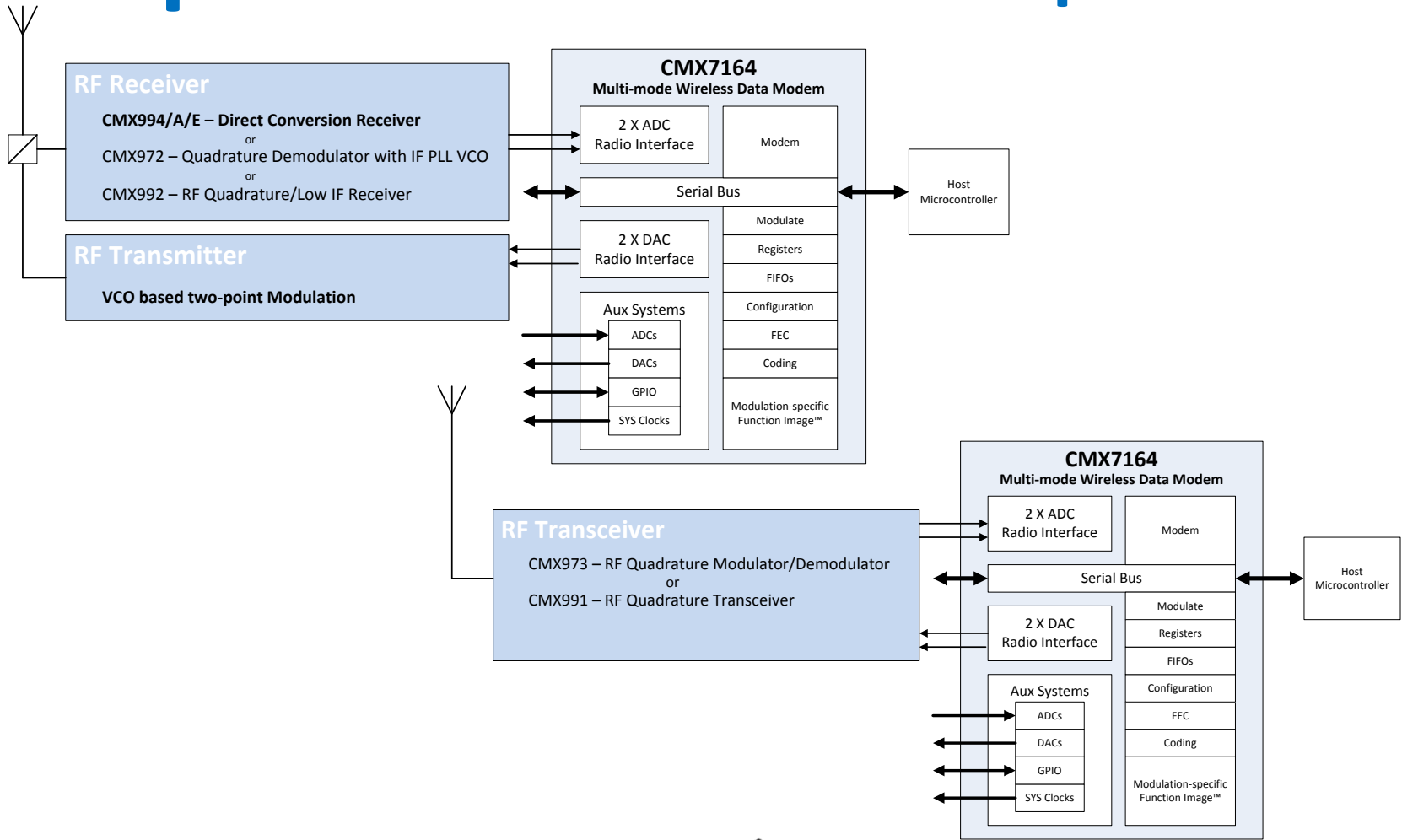
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# Chip-sets - Linear modulation

**RF Receiver**

**CMX994/A/E – Direct Conversion Receiver**

or

CMX972 – Quadrature Demodulator with IF PLL VCO

or

CMX992 – RF Quadrature/Low IF Receiver

**RF Transmitter**

**CMX998 – Cartesian Feedback Loop**

or

CMX973 – Quadrature Modulator

(In low output power systems typ. <500mW)

**CMX7164**

**Multi-mode Wireless Data Modem**

2 X ADC Radio Interface

Modem

Serial Bus

2 X DAC Radio Interface

Modulate

Registers

FIFOs

Aux Systems

ADCs

DACs

GPIO

SYS Clocks

Configuration

FEC

Coding

Modulation-specific Function Image™

Host Microcontroller

# CMX7164 Multi-mode Wireless Data Modem
# Chip-sets - Constant envelope modulation

**RF Receiver**

**CMX994/A/E – Direct Conversion Receiver**
or
CMX972 – Quadrature Demodulator with IF PLL VCO
or
CMX992 – RF Quadrature/Low IF Receiver

**RF Transmitter**

**VCO based two-point Modulation**

**CMX7164**
**Multi-mode Wireless Data Modem**

2 X ADC
Radio Interface

Modem

Serial Bus

2 X DAC
Radio Interface

Modulate

Registers

FIFOs

Aux Systems

Configuration

ADCs

FEC

DACs

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GPIO

Modulation-specific
Function Image™

SYS Clocks

Host
Microcontroller

**RF Transceiver**

CMX973 – RF Quadrature Modulator/Demodulator
or
CMX991 – RF Quadrature Transceiver

**CMX7164**
**Multi-mode Wireless Data Modem**

2 X ADC
Radio Interface

Modem

Serial Bus

2 X DAC
Radio Interface

Modulate

Registers

FIFOs

Aux Systems

Configuration

ADCs

FEC

DACs

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GPIO

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Function Image™

SYS Clocks

Host
Microcontroller

# I/Q Radio – CMX992, CMX998

# I/Q Radio – CMX994/A/E, CMX998
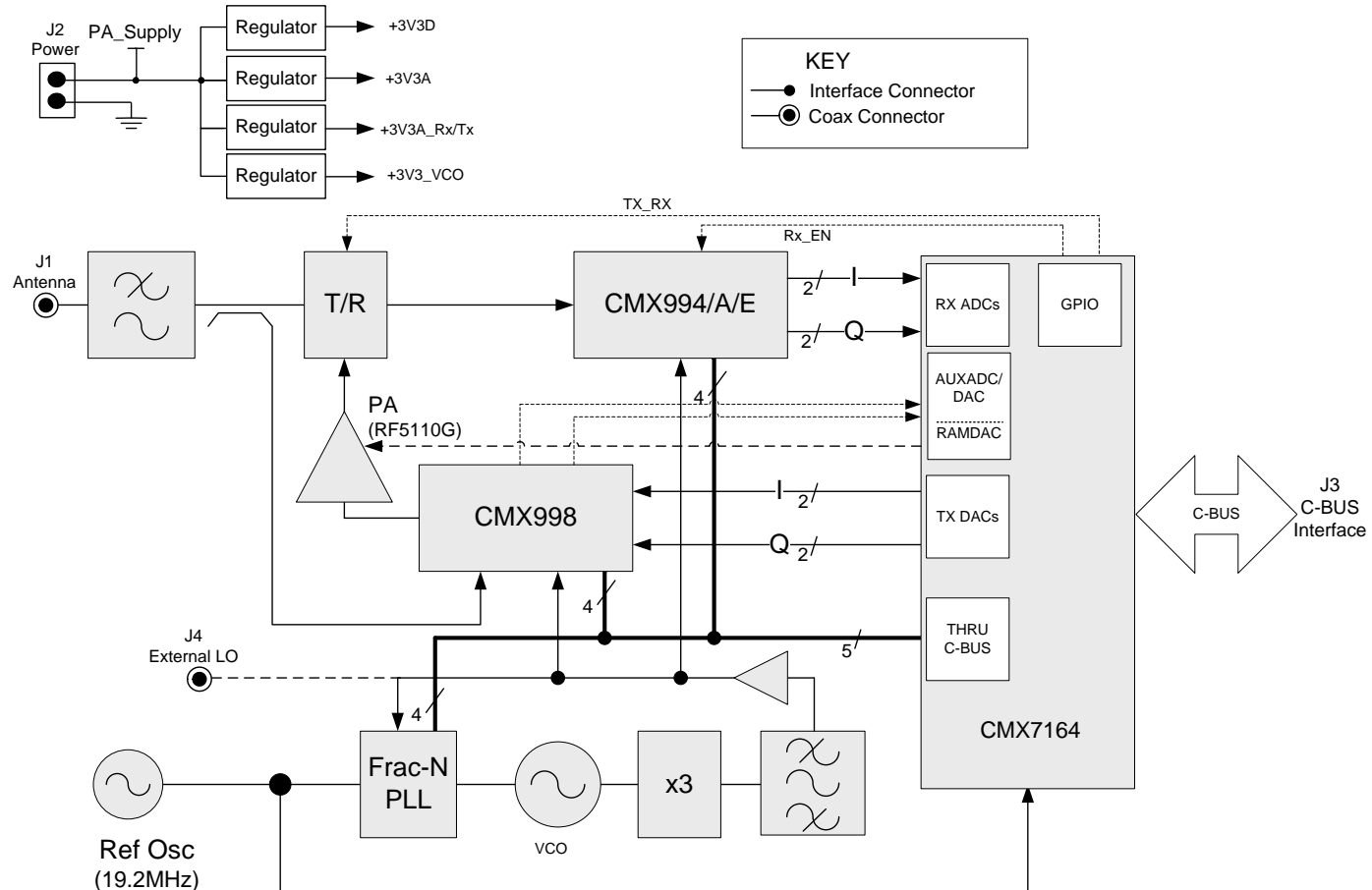
# Auxiliary functions



Auxiliary Functions

Aux 4 x GPIO

Aux 4 x ADC

Aux 4 x DAC

Aux 2 x CLK Synth

RF Rx I/Q

RF Tx I/Q

ADCs

Digital Filters

DACs

Digital Filters

Modem

FIFO

Configuration

Registers

C-BUS

Host µC

QAM

RRC FSK

GFSK

Equaliser

FEC

Format

Modulation-Specific Function Image™

3.3V

3.3V

External Serial Devices

C-BUS/SPI master

**CMX7164**
**Multi-mode WD Modem**

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# Auxiliary functions

- End products require auxiliary ADC, DAC and digital I/O functions

- CMX7164 integrates a full suite that minimises total BOM cost and size

- Four Aux 10-bit DACs
  - Autonomous and configurable RAMDAC function develops an attack/decay PA power control signal for 'smooth' PA on/off transitions

- Four Aux 10-bit ADCs
  - Configurable averaging and IRQ on configured high/low voltage threshold
  - 6:4 input mux
  - Useful for sampling common external signals e.g. RF detector, temperature sensor, Rx signal level, supply voltage, etc.

- Four GPIO
  - Expands GPIO of host µC
  - CMX7164 sequencing for connected RF circuits e.g. transceiver Tx/Rx switch

- Two system clock generators
  - PLLs develop digital clocks of configurable frequency up to 20MHz
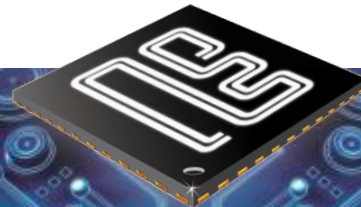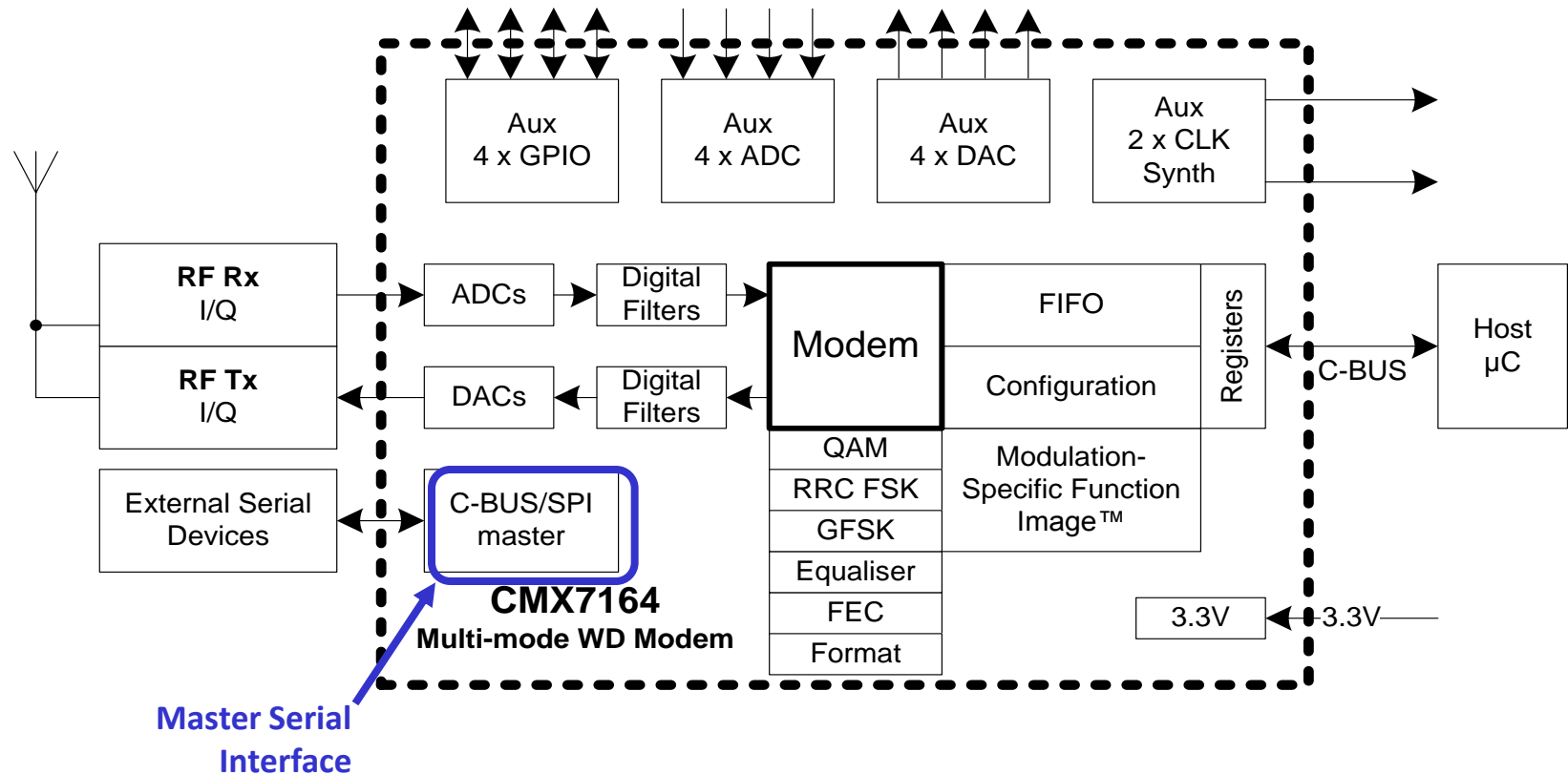
# Host interface
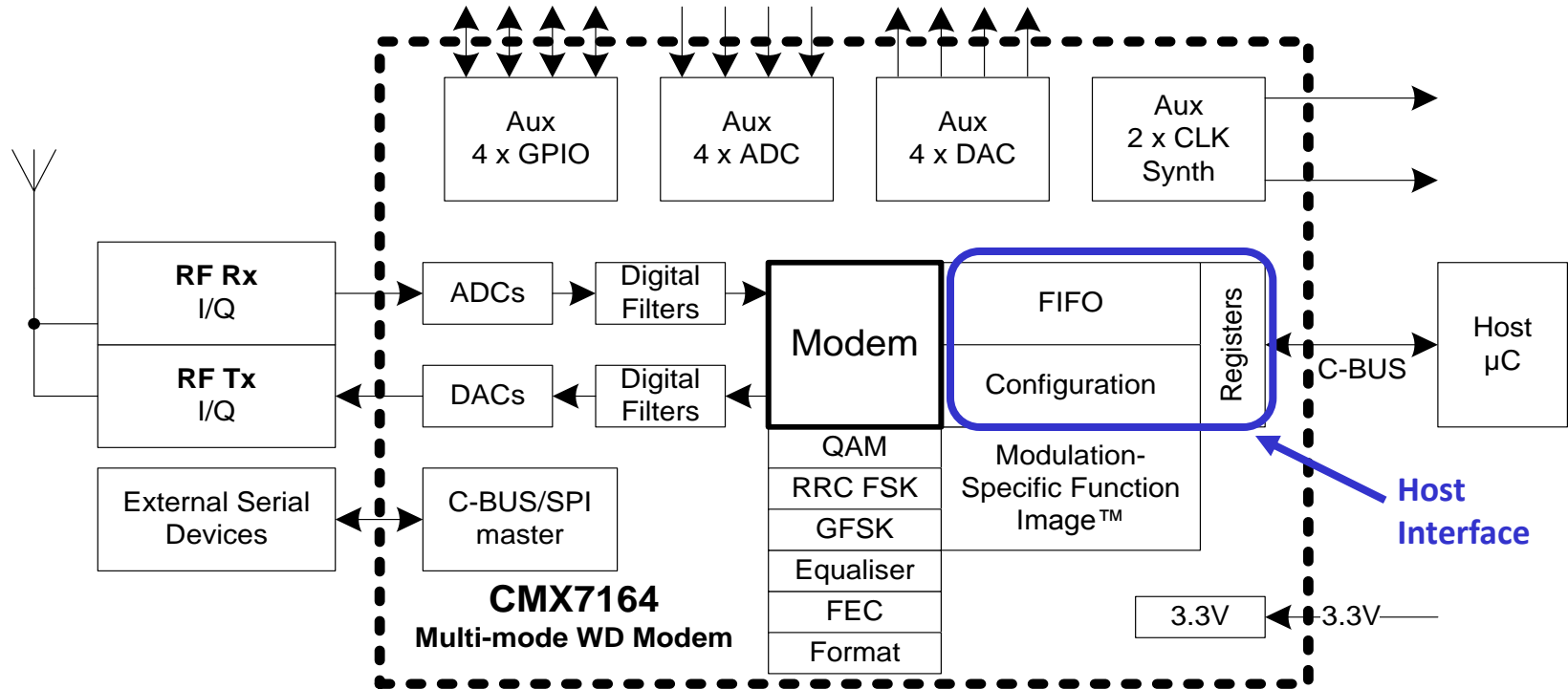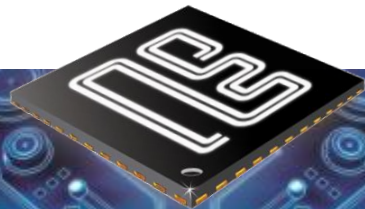
# Host interface

- C-BUS serial control interface
  - SPI-like with register addressing
  - For each bus transaction the first 'Master Out Slave In' field is a C-BUS command that selects the CMX7164 internal register to be operated upon
  - Small pin count: clock, command data, read data, chip select, IRQ
  - 10MHz clock rate comfortably supports data streams to/from host

- FIFOs
  - Relax host μC interrupt service latency requirements by extending time between host data transfers
  - Reduce host μC interrupt rate by supporting fewer, larger, transfers with host
  - 128 bytes deep on both Tx and Rx

- Streaming C-BUS
  - FIFO registers support multiple reads or writes without repeating C-BUS command
  - Concatenate C-BUS read/write operations without releasing CMX7164 chip select
  - Very efficient FIFO data transfers via low C-BUS transaction overhead

- CMX7164 logical interface provides addressable configuration parameters that ease host driver development

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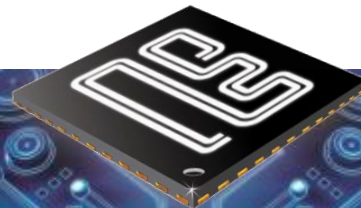
# Master serial interface

# Master serial interface

- End products include external RF circuits that work closely with the modem
  - e.g. RF transmitter, RF receiver, LO synthesisers, RF PA, etc.

- C-BUS/SPI Thru port is a master serial interface to efficiently manage connected slaves

- C-BUS/SPI Thru port Talk-through
  - Enables a single host μC serial interface to command both the CMX7164 and external C-BUS/SPI slave devices attached to CMX7164
  - Reduces number of serial interfaces required on host μC

- External RF receiver AGC control
  - I/Q receivers often feature a digitally controlled VGA that must be dynamically managed by the Modem Engine because it directly 'sees' Rx input signal level
  - When so configured, the CMX7164 can autonomously issue C-BUS/SPI commands to adjust external receiver gain according to received signal level

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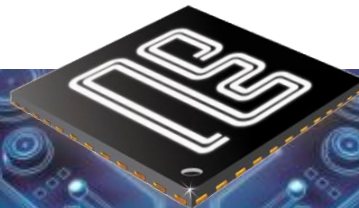
# Modem engine – data pump

- Supports
  - Root raised cosine (RRC) filtered 2/4/8/16-FSK with alpha = 0.2 (can accept custom filter parameters)
  - Gaussian filtered FSK (GFSK and GMSK) with BT = 0.25, 0.27, 0.3 and 0.5 (can accept custom filter parameters)
  - 4/16/32/64-QAM, with RRC filter with alpha=0.2 and 0.35
- Popular legacy narrowband modulations
  - RRC FSK and GFSK/GMSK modulations are established and have been used in a wide range of systems, worldwide
  - New terminal designs require support for both legacy modulations and newer, more spectrally efficient ones
- CMX7164 supports both QAM (higher speed) and legacy modulations
  - Change modulation 'family' by swapping Function Image™ in <0.5s
  - Smooth terminal design migration by supporting new and legacy modulations in a single design
- No external deviation trims required

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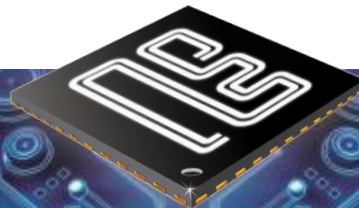
# Modem engine – data pump

- Over air signals are a sequence of specific analogue symbols i.e. waveform segments specific to a configured modulation type

- Tx data pump converts binary input data to 'I/Q form' symbols and Rx data pump recovers binary data from 'I/Q form' symbols

- GMSK/GFSK 2FSK and RRC (root raised cosine) 2/4/8/16-FSK are constant envelope so every symbol is transmitted at same RF power

- Different modulation types carry different numbers of bits per symbol (sym)
  - GFSK/GMSK = 1 bit/sym
  - Multi-level FSK
    - 2-FSK = 1 bits/sym
    - 4-FSK = 2 bits/sym
    - 8-FSK = 3 bits/sym
    - 16-FSK = 4 bits/sym
  - QAM
    - 4-QAM = 2 bits/sym
    - 16-QAM = 4 bits/sym
    - 32-QAM = 5 bits/sym
    - 64-QAM = 6 bits/sym

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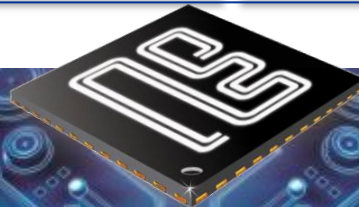COMMUNICATION SEMICONDUCTORS
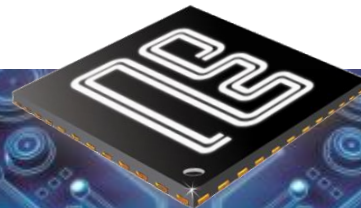
# Unique selling points

- Complete modem baseband system in a small VQFN/LQFP package

- Multiple modulation suites deliver QAM speed and legacy backward compatibility
  - High performance, high spectral efficiency 4/16/32/64-QAM
  - High performance, Constant envelope modulation 2/4/8/16-FSK
  - Gaussian filtered FSK (e.g. GMSK) modulations
  - Telecom modem interconnect V.23

- Small wireless data modem size
  I/Q RF transceiver + CMX7164 + host μC = core of end product

- DSP-free and codec-free design path
  - Single chip baseband modem
  - Soft selectable modulation, symbol rate and FEC suite
  - Software defined radio benefits without the DIY hassle
  - Short time to market
  - Low risk
  - Low cost solution
  - Low power consumption

- *FirmASIC* ® technology enables modulation type swapping and feature evolution

- Combine with high performance CML I/Q RF transmitter, receiver and transceiver devices for smallest, most cost effective total design
  - CMX998 CFBL I/Q modulator linearises external RF PA with high power efficiency
  - CMX994/A/E Direct Conversion Receivers (DCRx ICs) or CMX992/CMX972 dual superhet I/Q RF receive2

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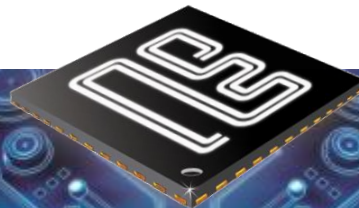
# CMX7164 Multi-mode Wireless Data modem
# Function Image™ availability

| | GMSK/GFSK Packet Data Modem | QAM Packet Data modem | Multi-level FSK Packet Data modem | V.23 Modem | |
|---|---|---|---|---|---|
| **Function Image™** | 7164FI-1.x.x.x | 7164FI-4.x.x.x | 7164FI-2.x.x.x | 7164FI-6.x.x.x | |
| **Basic Configuration** | Half duplex operation / *Differential analogue input and output drivers* | | | | |
| **Modulation Schemes** | GMSK/GFSK 2,000 to 20,000 symbols/s | 4/16/32/64-QAM 2, 4 and 6 symbols 2,000 to 20,000 symbols/s | 2/4/8/16-FSK 1, 2, 4 and 6 symbols 2,000 to 10,000 symbols/s | V.23 1200bp**s** | **Custom Function Images** |
| **Core Systems** | • Up to 16kbps in 25KHz<br>• BT=0.5, 0.3, 0.27 or 0.25<br>• Flexible packet data protocol<br>• Over-air compatible with FX/MX909B and CMX7143FI-1.x<br>• Two frame sync detectors<br>• Automatic frame sync detect<br>• Rx carrier frequency correction<br>• Receive signal quality metrics | • Up to ~96kbps in 25kHz<br>• ACM features<br>• Flexible packet data protocol<br>• Rate, and robust FEC choices<br>• Channel equalisation<br>• Two frame sync detectors<br>• Automatic frame sync detect<br>• Rx carrier frequency and phase correction<br>• Receive signal quality metrics | • Up to 40kbps in 25 kHz<br>• Flexible packet data protocol<br>• Over-air compatibility with CMX969 for RD-LAP, CMX7143, FX/MX919B 4-FSK (not 2-FSK)<br>• Two frame sync detectors<br>• Automatic frame sync detect<br>• Rx carrier frequency correction<br>• Receive signal quality metrics | • 1200bps<br>• V.23 modulation<br>• Two frame sync detectors<br>• Automatic frame sync detection<br>• Rx carrier frequency detection | |
| **ACM** Adaptive Coded Modulation | Yes | | | | |
| **Interface** | C-BUS serial interface to host microcontroller, SPI master serial interface for external device support | | | | |
| **Auxiliary Systems** | Four input 10-bit ADC, Four 10-bit DACs, Master clock PLL, Two system clock outputs, Four GPIO | | | | |

# Evaluation resources

- Ordering information
  - Product
    - CMX7164Q1, CMX7164L9
    - CMX7163Q1, CMX7163L9
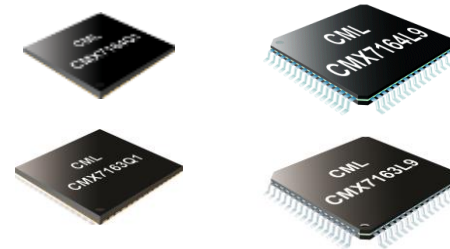
  - Evaluation support
    - PE0601-7164 – CMX7164 EvKit
    - PE0601-7163 – CMX7163 EvKit
    - DE9941 – SDR Demonstrator for Linear Radio Systems
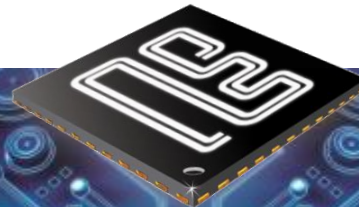    - PE0003 – Universal interface board

PE0003
Universal Interface Board

DE9941
SDR Demonstrator

PE0601-7164
CMX7164 Evaluation Kit

CMX7164 Multi-mode Wireless Data Modem
# Information resources

- CML website www.cmlmicro.com
  - Product Overview
  - Product Datasheet
  - Evaluation kit user manual
    PE0601-7164 (PE0601-7163) and DE9941 SDR WD Modem Demonstrator
  - Application notes and scripts for the PE0002

- CML Technical Portal http://www.cmlmicro.com/TechnicalPortalLink.aspx
  (Registration and product specific authorisation required)
  - Complete product datasheet and user manual
  - Function Images
    7164FI-4.x(4/16/32/64-QAM), 7164FI-2.x(2/4/8/16-FSK), 7164FI-1.x(GMSK/GFSK) and 7164FI-6.x(V.23)

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