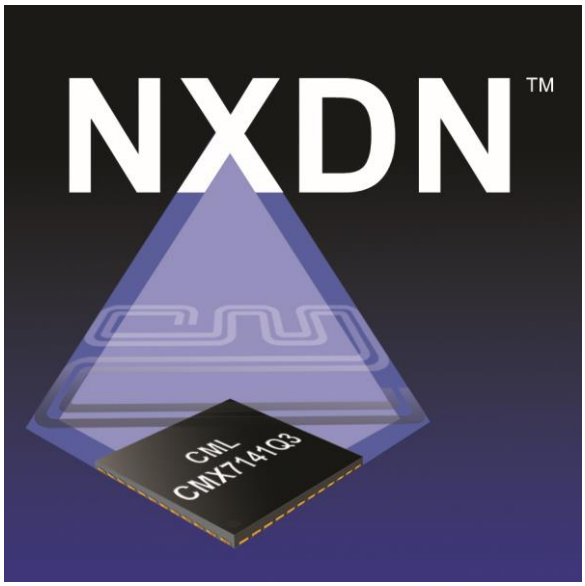
CML Microcircuits
COMMUNICATION SEMICONDUCTORS

White Paper

A Knowledge Base document from CML Microcircuits

NXDN™

High Integration SDR Approach



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1 INTRODUCTION

NXDN™ is an established, open standard, digital Land Mobile Radio (LMR) / Private Mobile Radio (PMR) protocol. Originally developed by ICOM Incorporated and JVC Kenwood Corporation to address the needs of the LMR market being driven towards narrow-banding and digital technology, it has become a strong contender to lead the global digital LMR market.

Based on FDMA technology, the NXDN™ hardware platform can utilise the same basic architecture as analogue FM radio designs, therefore ensuring low complexity and cost; clear drivers throughout the standard's development. NXDN™ addresses all aspects of the LMR market from basic peer-to-peer and repeater operation through to all-encompassing trunking systems. The broad spectrum of functions provide flexibility and adaptation, for the deployment of real life LMR systems and networks.

NXDN™ is supported by a group of leading international radio manufacturers and organisations that form the NXDN™ forum (www.nxdn-forum.com). These companies work together to maintain the standard and support the market place with a range of interoperable radio equipment. At the time of printing of this document there were 32 active members in the NXDN™ Forum:

- Aeroflex - Radio test sets
- ALTONIKA Ltd. - Radio manufacturer
- Arinc - Radio systems management and test house
- Anritsu Company - Radio test sets
- Avtec Inc. - Dispatch consoles and applications
- Catalyst Communications Technologies, Inc. - Dispatch consoles and applications
- CML Microcircuits - Silicon baseband ICs
- Connect Systems Inc. - Radio manufacturer
- CVDS - Recorder Logging Applications
- Daniels Electronics Ltd. - Infrastructure manufacturer
- Etherstack - Protocol stack supplier
- Eventide - Recorder Logging Applications
- EXACOM, Inc. - Logging recording products
- General Dynamics SATCOM Technologies - Radio test sets
- GME/Standard Communications Pty Ltd. - Radio manufacturer
- HigherGround Inc. - Recorder Logging Applications
- Hoag Electronics Inc. - Radio plug-in module manufacturer
- Hytera Communications Corp., Ltd. - Radio manufacturer
- Icom Incorporated - Radio manufacturer
- JVC KENWOOD Corporation - Radio manufacturer
- RF Technology Pty Ltd. - Infrastructure manufacturer
- Raven Electronics Corporation - Manufacturer and applications
- Ritron Inc. - Radio manufacturer
- Swissphone Telecom AG - Manufacturer and applications
- Telex Radio Dispatch Group - Dispatch consoles and applications
- Timco Engineering - Test House/IOP Testing
- Trident Micro Systems - System controllers
- Twisted Pair Solutions - Dispatch consoles and applications
- UL LLC - Test House/IOP Testing
- Ultratech - Test House/IOP Testing
- WAVECOM ELEKTRONIK AG - Decoder software solutions
- Zetron, Inc. - Dispatch consoles and applications

1.1 Other FDMA standards

There are a number of other two-way radio standards supporting the FDMA technology approach to digital LMR/PMR. These together with NXDN™, address the needs of existing and developing digital LMR/PMR markets world-wide. There are similarities between all these systems allowing the radio designer to address the whole market with a single radio platform. The core FDMA based technologies are as follows:

- NXDN™
- dPMR™
- ARIB STD-T98
- ARIB STD-T102

2 SYSTEM CONSIDERATIONS

A digital two-way radio comprises a number of fixed function blocks, these being common across many digital radio systems.

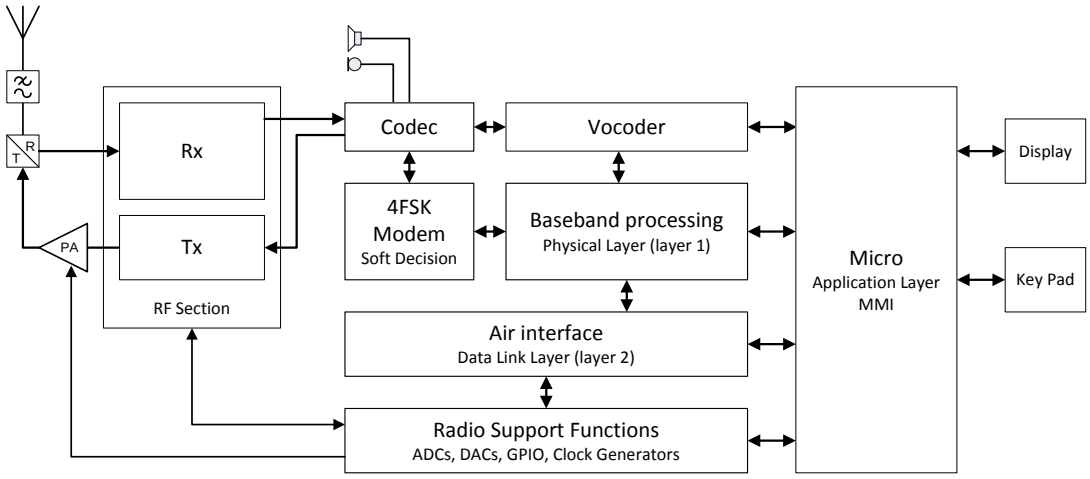

Figure 1: Typical Digital Radio Function Block Diagram

Key factors in the selection of suitable components for a new design include: overall size, BOM cost, flexibility to accommodate multiple radio standards, low power operation, legacy analogue backward compatibility, component longevity, RF to baseband optimisation and time to market.

2.1 RF Architecture

Traditional RF receivers use the superheterodyne approach that has dominated radio receiver (Rx) architecture since the 1930s. Today this traditional RF approach has advantages when there is need to address multiple systems and standards with different operating frequencies, sensitivity, intermodulation and interference rejection requirements. In such multi-mode systems, the superhet becomes complex and costly to manufacture.

Direct Conversion is often considered to be the Holy Grail for an RF receiver and viewed as the ultimate RF solution, due to its small size, flexibility and minimal cost when addressing a multitude of differing system requirements. There are a number of challenges with direct conversion however, these have been addressed in the CMX994 Direct Conversion Receiver IC from CML Microcircuits.

On the transmit (Tx) side, the basic VCO based two-point modulation approach is still considered to be the most cost effective solution, for constant envelope modulations.

2.2 Baseband Operations

At first sight, an off the shelf Digital Signal Processor (DSP) is ideally suited to covering the needs of the baseband signal processing and air interface protocol. There are however, a number of considerations to be taken into account prior to going down this route. This is not a single-chip solution therefore size and power consumption, may be quite large. Also, code development time is a lengthy process with complex signal processing algorithms and communication protocols for multiple systems can become very costly.

On top of all this, the overhead of regression testing should not be underestimated. Code changes as a consequence of field testing, function enhancements, changes in the radio standard must all be regression tested. These tests can all consume a significant amount of development time and therefore the overall costs can escalate.

Using a Commercial Off-The-Shelf (COTS) product such as a *FirmASIC*® from CML Microcircuits, addresses all these issues. It can provide an all-encompassing solution, fully meeting multiple radio system specifications, in the smallest package. The CMX7141 Multi-standard FDMA digital/analogue PMR/LMR processor, is such a device.

3 HIGH INTEGRATION SDR APPROACH

The CMX7141 digital/analogue PMR/LMR Processor combined with the CMX994 Direct Conversion Receiver IC, provides a unique, low risk, high integration solution for NXDN™ and forms the basis of a multi-standard radio platform to address the whole digital FDMA PMR/LMR market.

3.1 Multi-standard FDMA Digital/Analogue PMR Processor Platform

The CMX7141 Digital/Analogue PMR processor fully meets the specific requirements of both new and emerging FDMA digital PMR radio systems and dual-mode digital/analogue two-way radio platforms. The CMX7141 is an enabler for the radio platform concept, allowing a single radio platform to encompass multiple digital PMR standards, all with backward compatibility to legacy analogue PMR.

Built on CML's proprietary *FirmASIC*® technology, the CMX7141 encompasses the elements required for the implementation of a digital radio's air interface physical and data link layers. Proven and field tested high performance is assured, with support for digital radio systems including legacy analogue

operation by Function Image™ upload. The table below provides a list of the Function Images available including the new NXDN™ Function Image™.

Function Image™	System	Standard	Direct Connection to CMX994 DCRx IC
7131/7141FI-1.x	dPMR446 (Mode 1/2)	TS 102 490	-
7131/7141FI-2.x	Digital Convenience Radio (DCR)	ARIB STD-T98	Yes
7131/7141FI-3.x	**NXDN™ (Air Interface)**	**NXDN-TS 1/2**	**Yes**
7131/7141FI-5.x	dPMR (Mode 1/2) Analogue PMR (Audio + Sub Audio Signalling)	TS 102 490 EN 300 086/TIA 603C	-
7131/7141FI-6.x	ARIB STD-T102 (Part 2)	ARIB STD-T102	Yes
7131/7141FI-7.x	dPMR (Mode 1/2/3)	TS 102 658	Yes
7131/7141FI-8.x	Analogue PMR (Multi-function)	EN 300 086/TIA 603C	Yes
7031/7041FI-1.x	Multi-function Analogue PMR (Operation as defined in the CMX7031/7041 Datasheet)	EN 300 086/TIA 603C	-

Table 1: CMX7141 suite of Function Images

3.2 NXDN™ Air Interface Function Image™

A new NXDN™ Function Image™ release brings a new level of functionality, embedding much of the NXDN™ Air Interface Protocol (AI), enabling an NXDN™ radio to be developed quickly with a smooth transition through to production. The list below summarises the embedded operations:

Air Interface Physical Layer 1

- 4-FSK modulation and demodulation
- Bit and symbol definition
- Frequency and symbol synchronisation
- Transmission burst building and splitting

Air Interface – Data Link Layer 2

- Channel coding (FEC, CRC)
- Interleaving, de-interleaving and bit ordering
- Frame building and synchronising
- Burst and parameter definition
- Interfacing of voice applications (voice data) with the Physical Layer
- Data bearer services
- Exchanging signalling and/or user data with the Call Control Layer
- Automatic RAN detection

Advanced Functions

- Rx I/Q interface for direct connection to the CMX994 DCRx IC
- Tx conventional output suitable for 2-point modulation or for an I/Q interface
- Flexible power control facility allowing the device to be placed in its optimum powersave mode when not actively processing signals
- Crystal clock generator, with buffered output, to provide a common system clock
- Automatic Tx sequencer simplifies host control
- RAMDAC ramping operation
- Tx and Rx Enable hardware signals

3.3 Direct Conversion Receiver

The CMX994 DCRx is the ultimate PMR/LMR radio RF front end, providing a small high integration RF solution with optimal performance. It includes a broadband LNA with gain control followed by a high

dynamic range I/Q demodulator. The receiver baseband section includes amplifiers and precise baseband filter stages. LO generation can be provided by an integer-N PLL and a VCO negative resistance amplifier or an external LO may used. LO dividers are provided for flexible multi-band operation.

The CMX994 requires minimal external components and setup. When used in conjunction with the CMX7141 the majority of system-related setup and trimming is managed within the CMX7141's appropriate Function Image™. This minimises setup and trimming required during radio manufacture on the production line.

The CMX7141 and CMX994 together provide the answer to the market requirements for: Low power operation, small size, low cost, low risk, flexibility, high performance, longevity, RF to baseband optimisation.

Considering the typical digital radio function block diagram shown in Fig. 1, the combination of CMX7141 and CMX994 consumes a large portion of the functionality, as shown in Fig. 2 below.

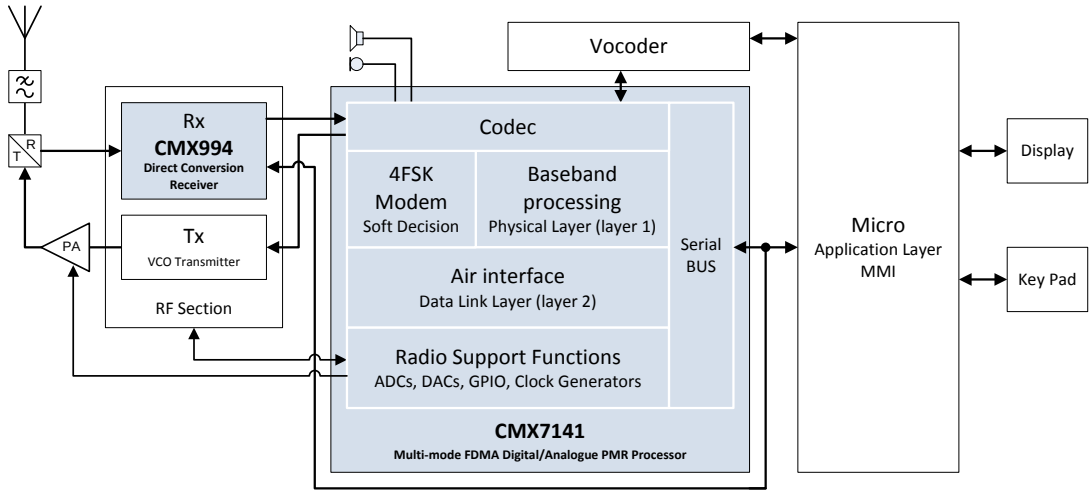

Figure 2: CMX7141 and CMX994 - The Ultimate FDMA Digital/Analogue Radio Chipset

4 GETTING TO MARKET FAST

Evaluating complex devices can be very time consuming and fraught with obstacles without good technical support and assistance from the component manufacturer. To overcome these obstacles and jump start a new design, CML Microcircuits has released the DE9944 SDR Demonstrator for FDMA radio systems. The board allows a fully working radio to be established in the shortest period of time. The DE9944 is based around the CMX7141/CMX994 chip-set combo that includes keyboard, speaker and host processor to demonstrate peer-to-peer digital and analogue PMR, out-of-the-box.

Figure 3: DE9944 SDR FDMA Radio demonstrator

5 CONCLUSIONS

Developing a feature-rich NXDN™ digital LMR radio has never been easier. The CMX7141 and CMX994 chip combination simplifies the design and development process through to production. Utilising the available suite of CMX7141 Function Images, the same radio platform can be used to realise a number of digital and analogue PMR/LMR standards including: NXDN™, dPMR™, ARIB STD-T98, ARIB STD-T102 and conventional analogue PMR.

References

- CMX7131/7141 Multi-standard Digital/Analogue PMR/LMR processor
  www.cmlmicro.com/products/CMX7131_CMX7141_Digital_PMR_Processors/
- CMX994 Direct Conversion Receiver IC
  www.cmlmicro.com/products/CMX_994_RF_Direct_Conversion_Receiver/
- DE9944 SDR Demonstrator for FDMA Radio
  www.cmlmicro.com/products/DE9944_Demonstration_Kit/