DMR - Digital Mobile Radio

Advanced Protocols

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DMR Overview

In the ever ongoing effort to squeeze more capacity out of a finite resource, the electro-magnetic spectrum, a new digital standard — Digital Mobile radio (DMR) is becoming more and more popular. Whereas the older analogue PMR (Private Mobile Radio) requires 25 kHz channels or for newer systems 12.5 kHz, DMR offers two channels within 12.5 kHz. DMR offers both voice and data communications and interfacing to external networks. Voice communications offer features as call alert, emergency call, remote monitoring, silent worker, Push-to-Talk ID, radio check, all call, stunning etc.
DMR has been standardized by ETSI. The standard describes three tiers of DMR services:
Tier I: Direct mode communication without infrastructure
Tier II: Direct mode (unit-to-unit) or using a base station (BS) for repeating
Tier III: Trunking protocol with a controller managing communications, including simulcast and multicast
To distinguish between adjacent and repeater stations with overlapping coverage, DMR introduces the concept of Color Code. Interlinking of repeaters or base stations is outside the scope of the ETSI standard, but Motorola's implementation of DMR called Mototrbo allows this feature using an ordinary IP connection.

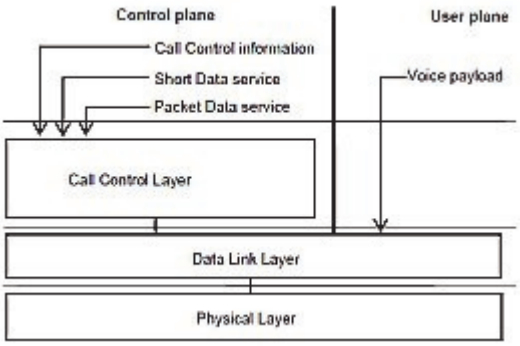

Fig. 1 DMR protocol stack

DMR uses 4FSK modulation at 4800 symbols/second with the dibits mapped to +1944 Hz, +648 Hz, -648 Hz and -1944 Hz in relation to the center frequency.

DMR Protocol Stack

The air interface physical layer is responsible for

- modulation and demodulation
- transmitter and receiver switching
- HF characteristics
- bits and symbol definition
- frequency and symbol synchronization
- burst building

The data link layer main functions are

- channel coding
- media access control
- link addressing
- interfacing of voice
- data bearer services
- acknowledgement mechanisms
- interleaving

The third layer is the call control layer in the control plane which provides

- base station activation and deactivation
- call setup, maintenance and tear-down
- destination addressing
- built-in services
- data call control
- announcement signaling

DMR Air Interface

DMR supports 2-channel TDMA (Time Division Multiple Access). In fig. 2 below the outbound (from a base station) is labeled “BS TX” and the inbound (from a mobile station) “MS TX”. Each burst is 30 ms long. Two bursts constitute a frame and 6 frames constitute a super frame used for voice transmissions.

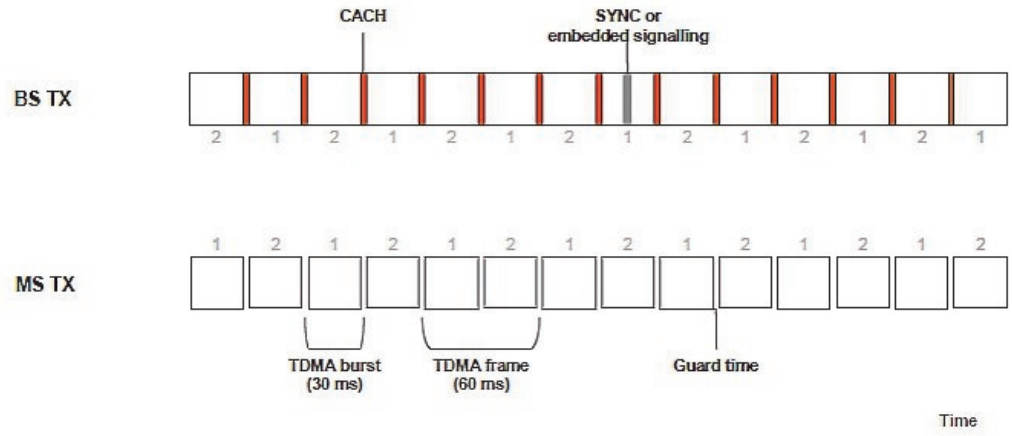

Fig. 2 Two-frequency TDMA timing

The outbound channel is continuously transmitted when the BS (Base Station) is active, whereas the MS (Mobile Station) will stop transmission when it has no more traffic to transmit.
The outbound channel contains a Common Announcement Channel (CACH), between individual bursts, used for traffic channel management and signaling. The inbound channel has an empty guard time between the bursts to allow for propagation delays.
Finally a synchronization or signaling field is embedded in the centre of the burst.
The BS and MS burst and frame structures are shown in fig. 3, fig. 4 and fig. 5.

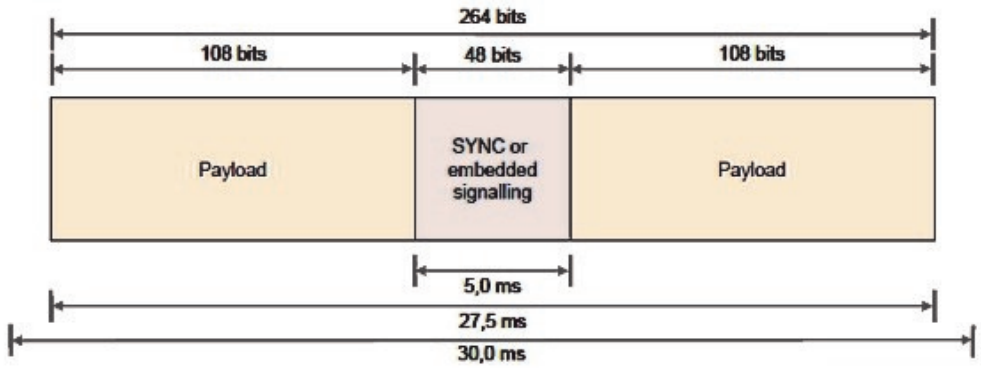

Fig. 3 DMR frame structure

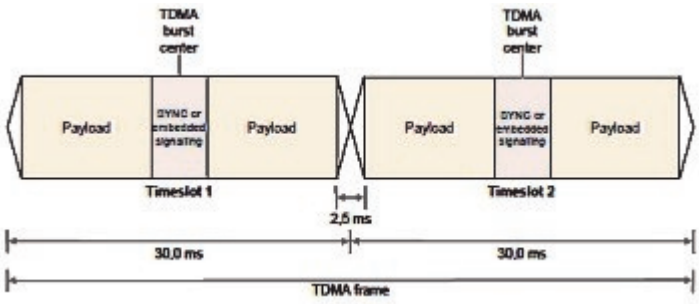

Fig. 4 MS bursts

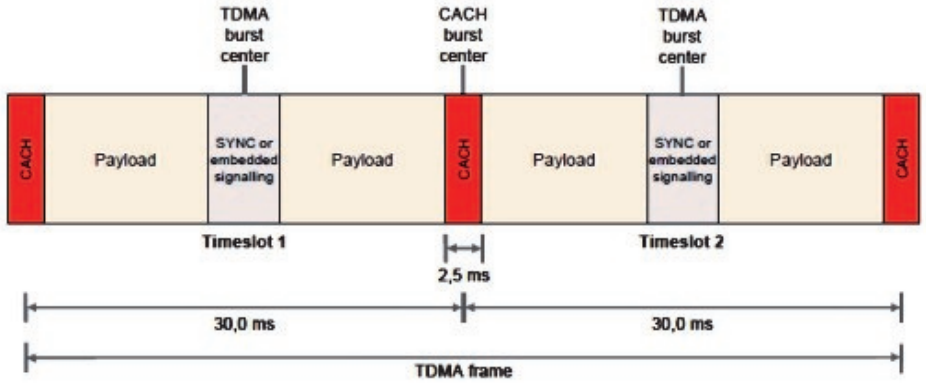

Fig. 5 BS frame structure

DMR also supports a Reverse Channel (RC) which is used for signaling. In the outbound direction the RC replaces the burst center sync field, whereas in the inbound direction a special short burst is used, see fig. 6.

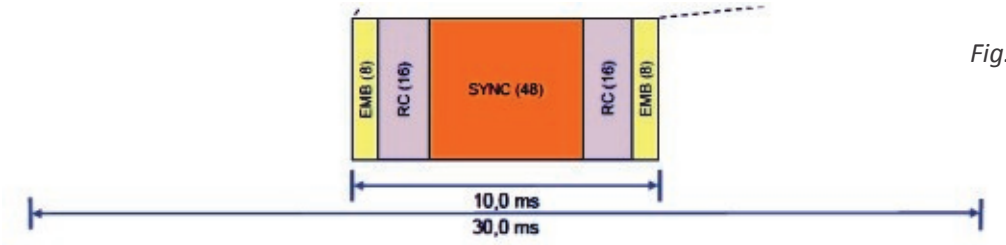

Fig. 6 RC burst structure

For voice transmissions a super frame of use several burst and timeslots, see fig. 7. The individual voice bursts are labeled from A to F.

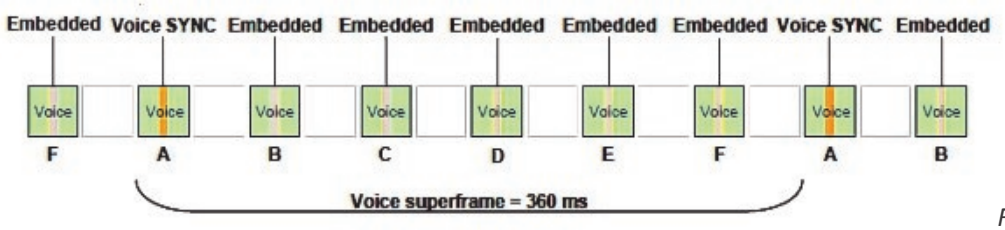

Fig. 7 Voice format

DMR also has the ability for text messaging using either the Short Data Service, a SMS-like function or IP datagram's, see fig. 8. The ability to use IP facilitates the integration with other IP networks. A DMR terminal has its own IP address and contains a DHCP server, which allocates IP addresses to peripheral devices. These devices often connect physically via a USB connector.

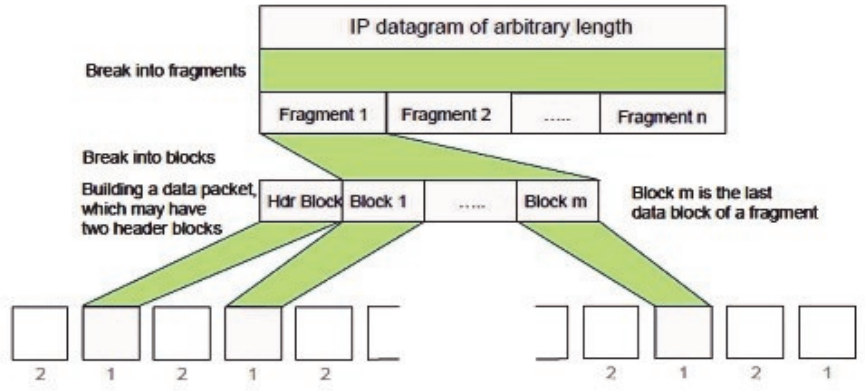

Fig. 8 Fragmentation of IP datagram

Wavecom DMR Decoder

Wavecom DMR decoder works with all equipments compatible to the ETSI standard, e.g., MOTOTRBO series from Motorola and Hytera DMR devices.
The current implementation complies with the ETSI DMR standard series:

- ETSI TS 102 361-1 V2.3.1 (2013-7)
- ETSI TS 102 361-2 V2.2.1 (2013-7)
- ETSI TS 102 361-3 V1.2.1 (2013-7) and
- ETSI TS 102 361-4 V1.6.1 (2014-6).

It covers all three layers of the DMR protocol stack:

- Layer 1: Air interface physical layer
- Layer 2: Air interface data link layer and
- Layer 3: Air interface call control layer.

Wavecom DMR mode covers all three tier services (Tier I: direct mode; Tier II: direct mode and base station communication; Tier III: trunking protocol). It decodes text, voice and service messages. Each data frame is output together with a time-stamp in a resolution of one millisecond, showing the time of receiving resp. decoding. In this way it is easy to verify if the decoder works correctly in real-time and no frame is missing in a long run.
All voice frames are decoded and assembled according to the vocoder standard. Audible voice is smoothly output to the speaker for live monitoring. At the same time all voice sessions are saved in WAV files. The two TDMA slots are sorted in two separate windows for clear display.
The following W-CODE screenshot shows a DMR data and voice decoding with the millisecond time-stamp in real-time communication.

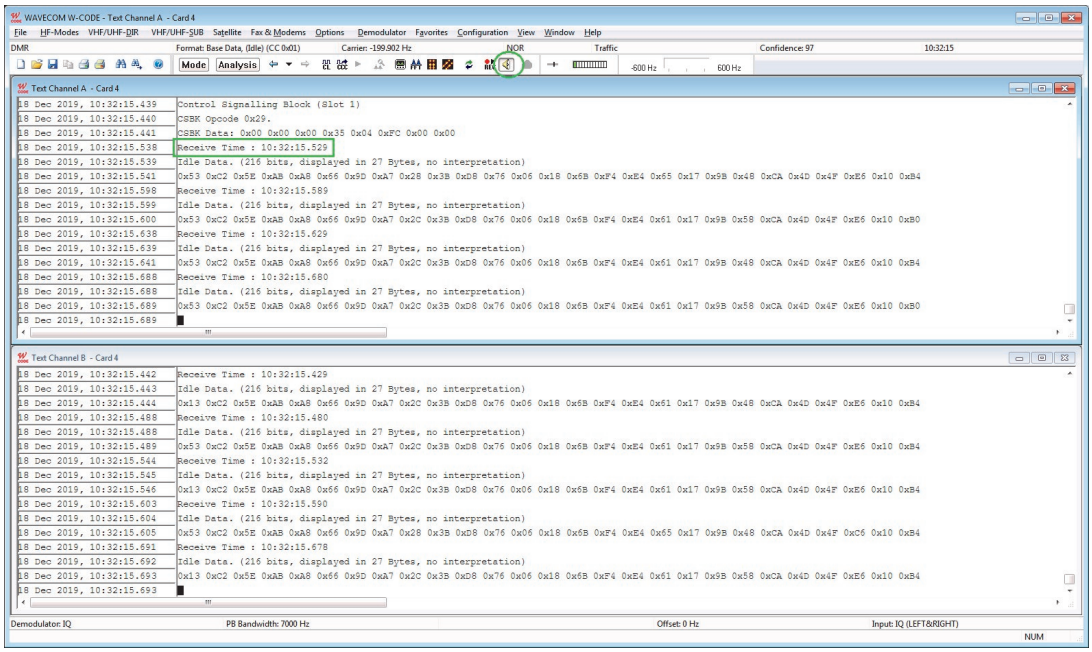

Fig. 9 W-CODE DMR decoding output with real time-stamp

Wavecom DMR End-to-End Decryption Functionality

Wavecom DMR decoder decrypts secured text and voice transmission of Motorola MOTOTRBO series with the license of Motorola Solutions®. There are two kinds of encryption mode: *Basic* mode and *Enhanced* mode, covering ARC-4 and AES-256 encryption algorithms.

For basic mode the encryption is done by a scrambler. The decoder needs to use the same key ID (between 1 and 255) as the sender. The scrambler value to each key ID is predefined (hardcoded) by Motorola and is not sent over the air (OTA) for security reason.

The enhanced mode includes the Motorola proprietary ARC-4 algorithm with a 40-bit key and the Advanced Encryption Standard (AES) with a 256-bit key. Unlike the basic mode, the enhanced key list contains 255 editable keys for both ARC-4 and AES-256 encryptions with the key ID from 1 to 255. (Key ID = 0 is not used.) Each enhanced key is 40-bit (5 bytes) for ARC-4 or 256-bit (32 bytes) long for AES.

The decoder must use the same key list as the sending device. It reads (decodes) the key ID sent by the encrypting device over the air and use the corresponding key value for decryption. The 40-bit or 256-bit key value itself is not sent over the air for security reason.

Wavecom DMR Decryption Functionality

The decoder key list can be edited via a Graphic Useer Interface (GUI).

When the key ID for the basic mode or the key list for the enhanced mode matches to the one used by the sender, a secured text or voice transmission can be decoded to clear text or voice. Otherwise the text is unreadable and the voice is unaudible.

Wavecom DMR decryption function has a “late-entry” feature: the user can enter the correct key ID or edit the key value during the decoding / decryption session and the output text or voice will get to be clear immediately.

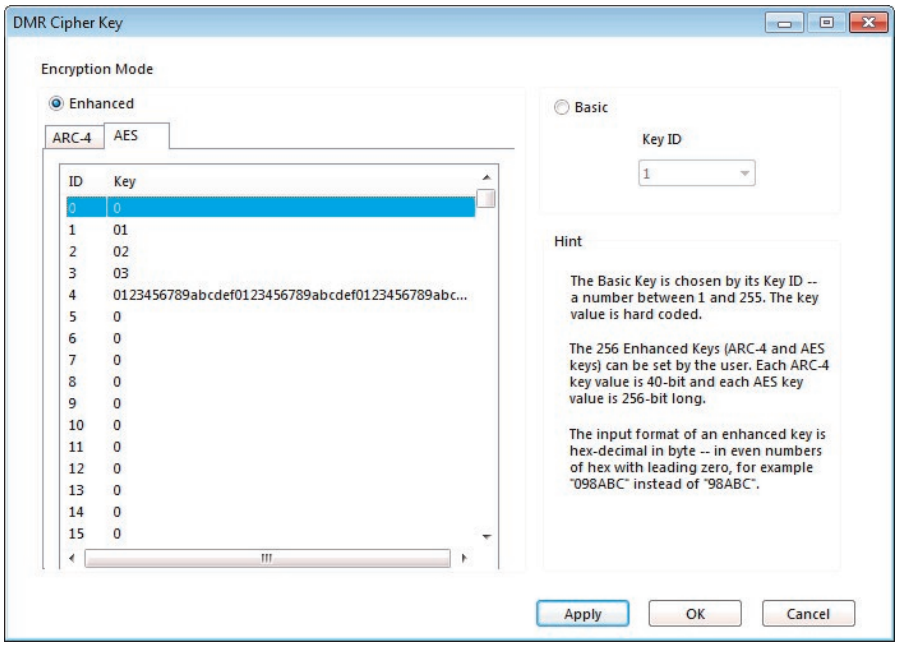

Fig. 10 DMR decryption cipher key editor

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Since more than thirty years Wavecom Elektronik AG has developed, manufactured and distributed high quality devices and software for the decoding and retrieval of information from wireless data communication in all frequency bands. The nature of the data communication may be arbitrary, but commonly contains text, images and voice. The company is internationally established within this industry and maintains a longstanding, world-wide network of distributors and business partners.

Product Information

Products	http://www.wavecom.ch/product-summary.php
Datasheets	http://www.wavecom.ch/brochures.php
Specifications	http://www.wavecom.ch/product-specifications.php
Documentation	http://www.wavecom.ch/manuals.php
Online help	http://www.wavecom.ch/content/ext/DecoderOnlineHelp/default.htm
Software warranty	One year free releases and bug fixes, update by DVD
Hardware warranty	Two years hardware warranty
Prices	http://www.wavecom.ch/contact-us.php

System Requirements

	Minimum	*Recommended*
CPU	P4 Dual-Core 2.4 GHz	Core i5 or Core i7 2.8 GHz
Memory	2 GB RAM	4 - 8 GB RAM
OS	Windows XP	Windows 7 32-bit or Windows 7 64-bit

Distributors and Regional Contacts

You will find a list of distributors and regional contacts at http://www.wavecom.ch/distributors.php

WAVECOM NACHRICHTENTECHNIK

WAVECOM ELEKTRONIK AG
8090 Zurich, Switzerland
E-Mail: sales@wavecom.ch
Internet: www.wavecom.ch