# DMR Technical Explanation

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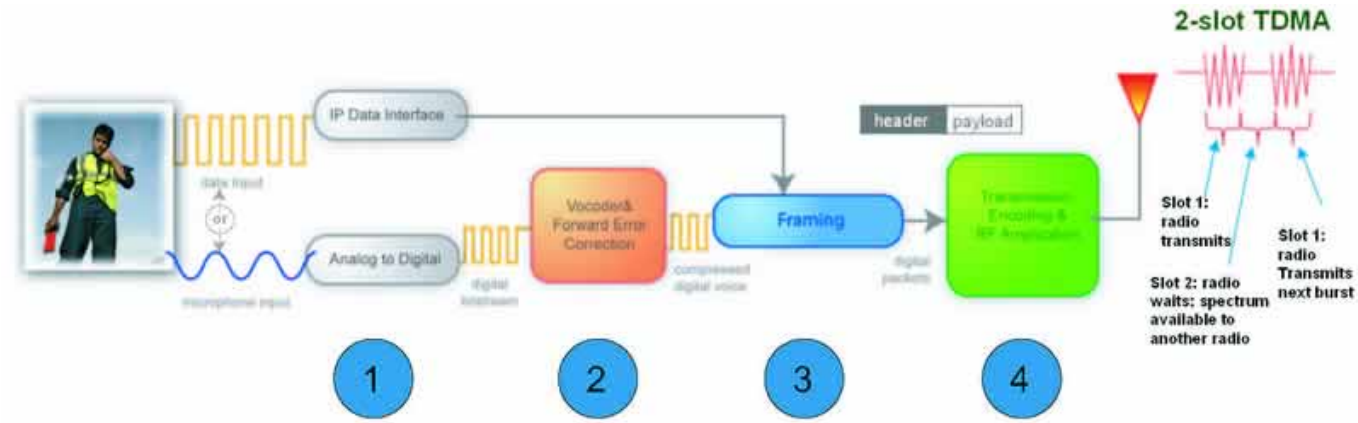
The digital radio technologies employed by MOTOTRBO can be summarized as follows:



**MOTOTRBO Digital Radio Technology" is broken down into four parts which are described in the following subsections.**

**Part One: The Analog to Digital Conversion**

When a radio user presses the Push-To-Talk (PTT) button and begins speaking, his voice is received by the radio microphone and converted from an acoustic waveform to an analog electrical waveform. This voice waveform is then sampled by an analog to digital converter. In typical radio applications, a 16-bit sample is taken every 8kHz, this produces a 128,000bps (bits per second) digital bitstream, which contains far too much information to send over a 12.5kHz or 25kHz radio channel. Therefore some form of compression is required.

**Part Two: The Vocoder and Forward Error Correction (FEC)**

Vocoding (Voice encoding) compresses speech by breaking it into its most important parts and encoding them with a small number of bits, while greatly reducing background noise. Vocoding compresses the voice bitstream to fit the narrow (for MOTOTRBO) 6.25kHz equivalent radio channel. The MOTOTRBO vocoder is AMBE+2TM which was developed by Digital Voice System, Inc. (DVSI), a leader in the vocoding industry. This particular vocoder works by dividing speech into short segments, typically 20 to 30 milliseconds in length. Each segment of speech is analyzed, and the important parameters such as pitch, level, and frequency response are extracted. These parameters are then encoded using a small number of digital bits. The AMBE+2TM vocoder is the first to demonstrate very low bit rates while producing toll-quality speech such as traditionally associated with wireline telephone systems.

**Part Three: Framing**

In framing, the vocoded speech is formatted for transmission. This includes organizing the voice and any embedded signaling information (such as color code, group ID, PTT ID, call type, etc.) into packets. These packets form a header and payload type of structure – the header contains the call control and ID information, and the payload contains the vocoded speech. This same structure can also relay Internet Protocol (IP) data packets – the IP packets are simply an alternative form of payload to the MOTOTRBO radio. The header information is repeated periodically throughout the transmission, thereby improving the reliability of the signaling information as well as enabling a receiving radio to join a call that may already be in progress – we refer to this condition as "late entry".

**Part Four: TDMA Transmission**

Finally, the signal is encoded for a Frequency Modulation (FM) transmission. The bits contained in the digital packets are encoded as symbols representing the amplitude and phase of the modulated carrier frequency, amplified, and then transmitted. TDMA (Time Division Multiple Access) organizes a channel into 2 time slots: a given radio's transmitter is active only for short

bursts, which provides longer battery life. By transmitting only on their alternating time slots, two calls can share the same channel at the same time without interfering with one another, thereby doubling spectrum efficiency. Using TDMA, a radio transmits only during its time slot (i.e. it transmits a burst of information, then waits, then transmits the next burst of information).