NXDN™

Next Generation Digital LMR Technology.

NXDN™ WHITE PAPER

4 Level FSK/FDMA 6.25 kHz Technology

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NXDN™ Land Mobile Radio 6.25 kHz Technology

Since the beginning of Land Mobile Radio (LMR), there has been a constant juggling act between available spectrum and channel size. As filter and modulation technology has advanced the channel size has progressively reduced, 100 kHz, then 50, followed by 25 and then the 12.5 kHz we have known for the last twenty or so years. Add to that the current policy of spectrum pricing and the FCC narrowbanding mandate, and it becomes clear that a new advance was needed to make the most efficient and economical use of this scarce resource.

Traditionally LMR has always operated with FDMA (Frequency Divided Multiple Access) technology as that has offered the best flexibility to users. TDMA (Time Divided Multiple Access) technology was and has been one solution offered as a method for improved spectrum efficiency. Several of the major LMR players have proffered that 6.25 kHz FDMA was simply not possible. Research by Icom and JVC KENWOOD however showed that 6.25 kHz FDMA was a practical proposition and they entered into a joint agreement to develop the technology further.

In Europe for example, this new digital 6.25 kHz FDMA idea was taken up by ETSI (the European Telecommunications Standards Institute) and developed into a European Standard called dPMR™.

For the North American LMR market in particular, the NXDN™ protocol was developed.

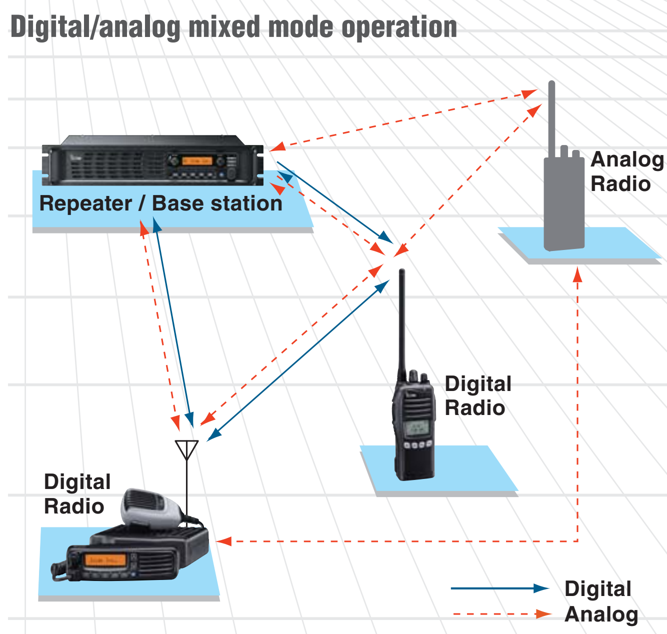
History

Achieving 6.25 kHz channeling was impossible to do using analog technology, so it became necessary to develop a new digital protocol. Availability of high quality low bit rate voice codecs meant that 6.25 kHz was a practical plan if a suitable modulation scheme could be identified. Several methods were considered, including ACSB and the proposed APCO Project 25 Phase II CQPSK. However, both required a more expensive linear amplifier in the transmitter and neither is compatible with existing analog FM hardware.

Instead, 4-Level FSK (4FSK) modulation was selected using FDMA for the access method. This method has a number of advantages:

- Better communication range
- Simpler design
- Easy to maintain and service
- Lower cost for business and industry customers
- Compatible with existing FM radio hardware

The first 6.25 kHz capable radios were introduced to the market in 2006. Icom, JVC KENWOOD and Ritron have NXDN™ products (portables, mobiles and/or repeaters), and measuring equipment manufacturers like Aeroflex, Anritsu and General Dynamics have equipment compatible with NXDN™. Other manufacturers will continue to develop/release products. These new products operate in both digital conventional and digital trunking modes. To enable backwards compatibility, they also operate in 25 kHz* and 12.5 kHz channel bandwidths.



* 25 kHz operation will not be allowed in USA from Jan. 1st, 2013

Backwards compatibility to analog only radios enables a planned migration path to "digital" with existing radios operating analog only and new radios operating analog and digital.

How the Technology Works

General specifications:

Access Method	FDMA
Transmission Rate	4800 bps
Modulation	4-level FSK
Vocoder	AMBE+2™
Codec Rate	3,600 bps (Voice 2,450 + Error Correction 1,150 bps)

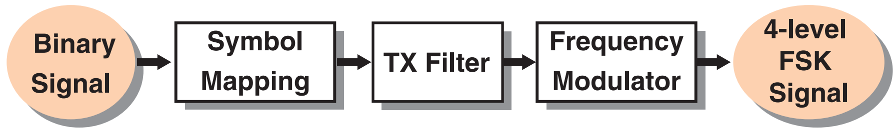
For 6.25kHz only.

Modulation with 4FSK uses a symbol mapping scheme. When the radio receives a binary number, that number is mapped to a symbol, which is interpreted as a 1050Hz frequency deviation.

Information	Symbol	Deviation
01	+3	+1050kHz
00	+1	+350kHz
10	–1	–350kHz
11	–3	–1050kHz

During demodulation, that deviation is detected, filtered and "un-mapped" as a binary signal for transmission.

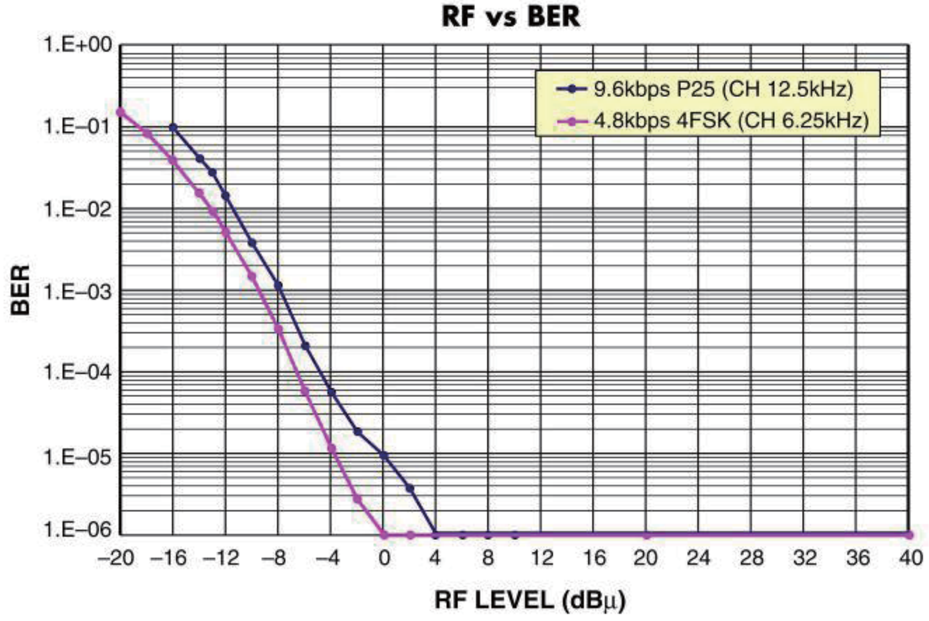
Modulator Diagram



Demodulator Diagram

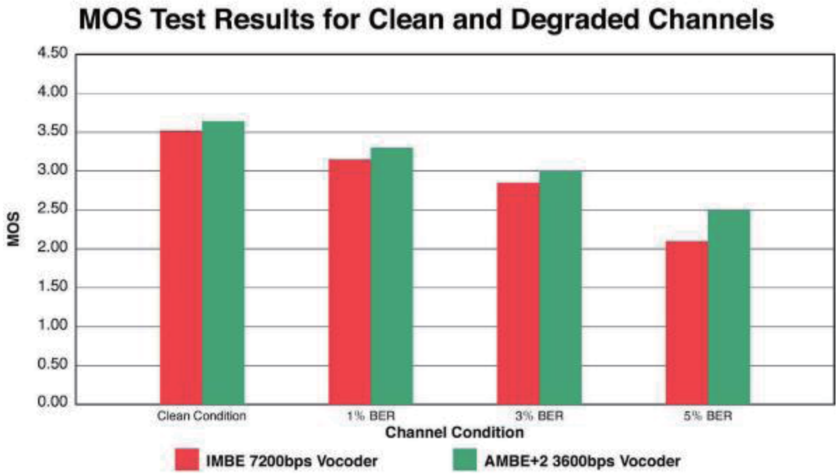
Signal Quality

The FDMA signal BER performance exceeds that of APCO Project 25 Phase 1 radios, which have already been accepted by the market as quality digital radios.



Audio Quality

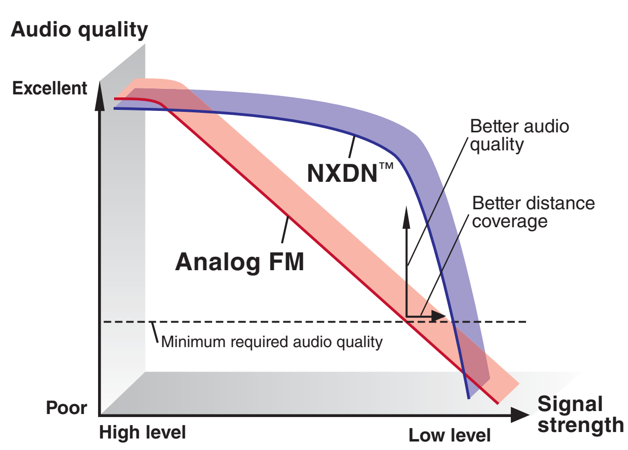
The 6.25 kHz NXDN™ technology also offers improved audio quality compared to P25 audio. Test engineers using a Mean Opinion Sample (MOS) found the audio quality was uniformly better, ranging from clean conditions to 5% BER. Using the AMBE+2™ vocoder makes this possible.



Range

Audio quality over distance is also greatly improved with 6.25 kHz NXDN™ technology. Instead of the early degradation of audio that you see in an analog signal, the 6.25 kHz NXDN™ digital audio quality remains higher over a comparable distance. This has been seconded in real life use from end users.

Analog vs Digital Coverage



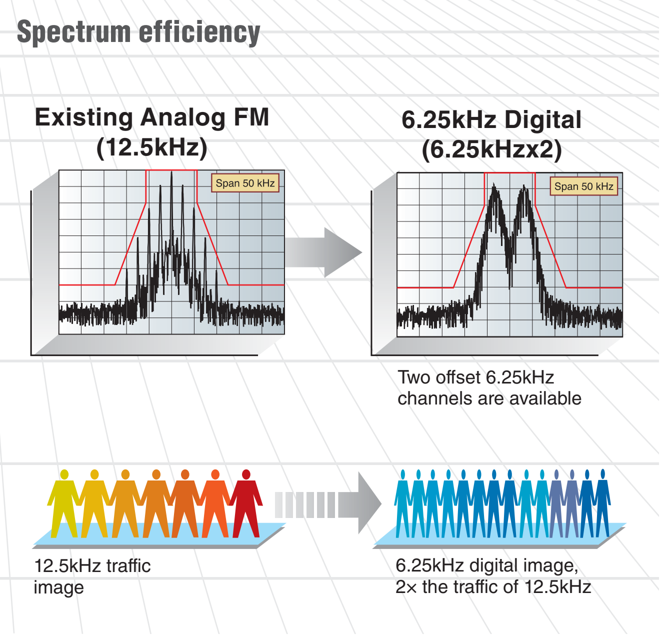
Spectrum Efficiency

A channel is defined by the deviation either side of the carrier frequency. Migrating from a 25 kHz channel to a 12.5 kHz channel on the same carrier frequency is a 1-for-1 move. There is no increase in the capacity to load radio users.

Some administrations have allocated 6.25 kHz frequencies/channels in their band plans, but most went unused because no 6.25 kHz radios were available. With NXDN™ FDMA technology, spectrum coordinators have total flexibility to either assign one 6.25 kHz channel within an existing 25 kHz or 12.5 kHz channel or as a stand-alone frequency somewhere else on the band.

The emission mask above left is established for 12.5 kHz channels. The signal must operate within the mask.

The emission mask on the right shows that the NXDN™ FDMA signal clearly operates within the mask (In this case 2 x 6.25 kHz signals in a 12.5 kHz channel). Accordingly, administrations around the world are certifying 6.25 kHz capable radios for use.



Channeling Considerations

A number of frequency allocation options for 6.25 kHz are available for each country. It is advised that you check with your local authority or frequency coordinator on the conditions for licensing and use of 6.25 kHz FDMA equipment, as not all regulations are uniform at this point.

Expand an Existing System

In most cases spectrum license holders or site owners/operators will have licenses to use 12.5 kHz channels. While it is recommended that consultation with authorities on how you can use/apply 6.25 kHz equipment in your system, current 6.25 kHz FDMA systems offered in the market can already be used ‘as is’, and thus let you begin the migration to a digital system now. As the basic architecture of the equipment is based on existing FM hardware, assimilating components into an existing analogue system is relatively easy. The same antennas, power supplies, duplexors, isolators and combiners etc. can be used, so only the cost of adding a digital channel (s) with the accompanying terminals is required upfront. This is not much different to replacing old analog equipment.

Depending on local regulations, it may also be possible to increase the capacity of the system because of the narrower channel spacing of NXDN™. Applications for new additional 6.25 kHz channels and combine them with their current 25 or 12.5 kHz channels, or new frequencies could occupy the existing 25 kHz or 12.5 kHz bandwidth. Additional stand-alone 6.25 kHz channels could also be used.

Split a 25 kHz or 12.5 kHz Shared or Exclusive Channel

Because the emission mask is so tight, two 6.25 kHz NXDN™ signals can be used next to each other within a 12.5 kHz channel without causing interference to each other or adjacent channels. System interference contour recommendations made by frequency coordinators is one measure of guarantee that interference issues are no different than at 12.5 kHz or 25 kHz.

2-for-1 efficiencies may be realized by splitting existing 12.5 kHz channels. Using 6.25 kHz channels offset from the carrier frequency of a 25 kHz channel, it is possible to fit two 6.25 kHz channels into the 12.5 kHz bandwidth.

Again, we recommend that you contact the spectrum managenment service of your authority for details on how to modify your shared or exclusive 12.5 kHz license for operation of two 6.25 kHz signals.

As a recent new development in the U.S.A., the FCC recently announced a new ruling allowing 2 x 6.25 kHz channels in a 12.5 kHz channel for the UHF land mobile radio band under certain conditions.

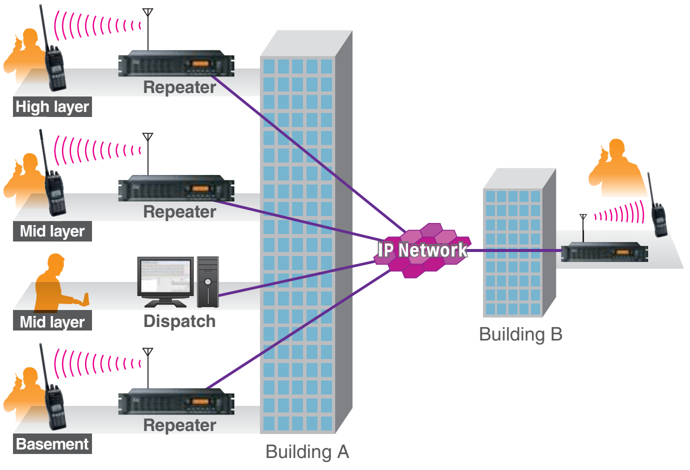
See for **http://www.fcc.gov/document/non-standard-frequency-pairs-450-470-mhz-band** for details.

Current and Future Applications for 6.25 Technology

The new digital land mobile technology can be a platform for future integration of IT and IP technologies. To this end, NXDN™ manufacturers are developing a new generation of digital networking systems. The goal is to allow seamless migration from analog systems to new digital technologies.

Multi-site IP Networks

In-building and Intra-building Networks



Trunking Networks

Handheld battery operated equipment

As already explained, NXDN™ technology offers better audio quality at the extreme fringes of radio coverage. In addition to this, the fact of using narrower 6.25 kHz channels means that receiver filters are narrower too and that the RF sensitivity can be increased. This allows users the choice of reducing the RF power used to extend the possible battery life.

Whilst this is possible, is it actually what is needed in real life?

Handheld radios usually are employed in two scenarios:

• Integrated into a mobile network

• In a dedicated portable only network

Using handhelds in a network that is designed around mobile operation demands that the handhelds are operated for maximum possible range so that they come somewhere near the performance of the mobile units. In these cases the RF power is the first concern not the battery life.

When the handheld application is a portable only type of system, ie in-house or localised area, the typical requirements for coverage normally mean that the radios are operated at reduced power anyway. In such cases the battery life considerably exceeds the operational requirements.

NXDN™ offers a third option to add to these typical scenarios by integrating the localized area system into the full mobile network by means of a local repeater connected to the main network via an internet gateway.

By exploiting the full flexibility of the NXDN™ protocol, system planners can ensure the maximum potential of such mixed systems.

6.25 kHz and ‘equivalence’

Many published comments and adverts use the term ‘6.25 kHz equivalent’. This is simply down to offering 2 voice channels in a 12.5 kHz bandwidth and thereby permits two separate radio systems.

NXDN™ being based on a 6.25 kHz FDMA format is by definition, always 6.25 kHz. There is no need to hedge the definition with - quote equivalent unquote.

Where 6.25 kHz ‘equivalence’ is achieved by other means, such as a TDMA solution we can see why the definition ceases to be black and white.

The very nature of TDMA 'equivalence' is such that the advantages offered leads to compromises in other areas. A TDMA repeater may well offer a lower installation cost as a single repeater may not require a combiner/duplexer. But where the common requirement of direct mode operations is added we see that the operation reverts to 12.5 kHz FDMA and any idea of 6.25 kHz 'equivalence' is lost.

Similarly, the TDMA solution can offer the possibility of emergency break-in where another user can pre-empt a call in progress. However, this requires the use of two time slots to achieve, so again the possibility of two separate systems in 12.5 kHz has been lost.

With NXDN™ the fundamental issue of true 6.25 kHz operation is never compromised. It can also be said that when the day comes where 12.5 kHz spectrum is full, an NXDN™ system will still be a viable solution, thus potentially a longer-term, future proof technology and investment.

As a final note, despite the expected "battle" between TDMA and FDMA advocates that has been underway for a number of years now, in the US market where the narrowbanding mandate is most immediate, the number of licenses allocated for the competing TDMA technology and NXDN™ are practically identical, indicating that the market accepts both equally.

Disclaimer

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