NXDN™-Forum

Information Paper

FDMA and TDMA Narrowband Digital Systems

Disclaimer

The information presented here is intended to be for clarification and/or information purposes only, and care has been taken to keep the content as neutral and accurate as possible.

It is assumed that the reader of this paper knows what FDMA and TDMA digital narrowband radio systems are currently available in the Land Mobile Radio (LMR) market, and as a result, no direct reference to competing system names or manufacturer names is used here.

The NXDN™ Forum does not represent that the content of this paper is a detailed comparison of each system, or that the content should be relied upon for comparison purposes.

While care has been taken to ensure the content of this paper is correct and accurate, the NXDN™ Forum assumes no responsibility for any mistakes or inaccuracies. The NXDN™ Forum reserves the right to amend any part of this paper at any time without notice or obligation.

Introduction:

At this time, three business and industry orientated narrowband digital systems are available. Two of them are based on 6.25kHz FDMA technology and one system is based on a 2-slot TDMA modulation scheme operating in a 12.5kHz channel bandwidth.
The debate over the merits and demerits of each system have arisen, but the following are some thoughts on the matter, and to clarify certain issues heard to date.

Initial Conclusion: Which System is Better?

This cannot be answered as each system has its merits and demerits. We leave it up to the reader to make any necessary comparisons of each system separately based on publically available information, to make their own decision as to which system best suits their needs.

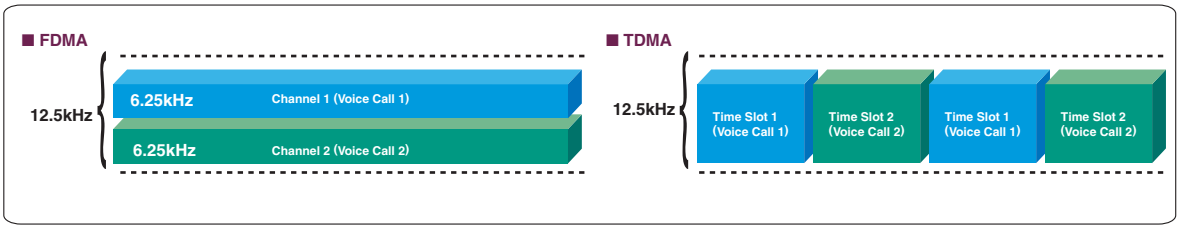
Clarifying the Facts from the Fiction:

The following is an attempt to give a non-biased explanation about these 6.25kHz FDMA and 12.5kHz TDMA systems. Many of the explanations listed below are clarifications of items relating to the three systems that have appeared in the public domain to date.

The Technology:

Without getting too technical, the basic difference between FDMA (Frequency Divided Multiple Access) and TDMA (Time Divided Multiple Access) is the definition of a channel and how it is used (accessed). In FDMA a particular bandwidth (E.g. 6.25kHz) at a particular frequency (E.g. 150.000MHz) is used to define a channel. Basically, the way channels have been allocated for decades.

In TDMA, the same principle applies regarding bandwidth and frequency, but the signal is divided into time slots that allow the channel to have 'extra' capacity in the same bandwidth E.g. Two 6.25kHz 'equivalent' channels in a 12.5kHz channel. See the diagram below for a graphical explanation.



Until now, TDMA was more spectrum efficient at wider channel spacing's like 25kHz, as for example, two or three users could access the same bandwidth as one FDMA channel user. However, in the case of the newly developed narrowband 6.25kHz FDMA technology like NXDN™, both this and 2-slot 12.5kHz TDMA technology achieve the same result as far as spectrum efficiency is concerned.

Proprietary or Open Protocols:

The TDMA system protocol is compliant to the open European Telecommunications Standards Institute (ETSI) technical standard TS102 361, commonly known as DMR (Digital Mobile Radio). A license and royalties to use the protocol in product development is required, but in essence, any manufacturer can develop DMR compliant products.

Outside of Europe, to date the TDMA system has been a single vendor protocol, and as of the writing of this paper, while it is known about the intention of other manufacturers being able to develop or supply product based on this protocol, it is still a single vendor supplying products.

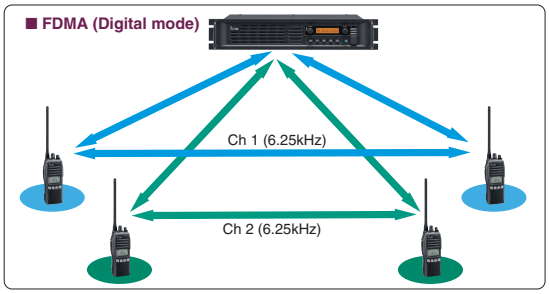
Products compliant to the NXDN™ protocol are currently offered by three manufacturers. It is expected even more manufacturers will eventually offer products based on this protocol as forum membership increases.

Therefore, the answer as to whether either technology is open or proprietary is a mixed one, but in the case of Europe they are essentially open. The NXDN™ protocol itself is considered an “open-proprietary” protocol. This means that it is not an official TIA or ETSI standard, but it is open to the members of the NXDN™ Forum.

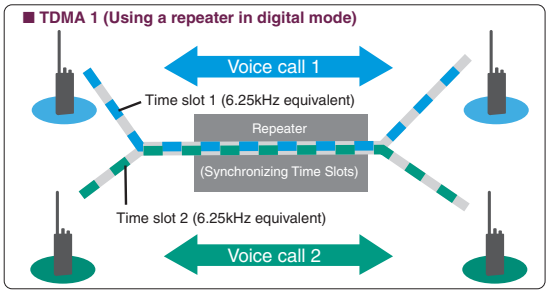
Spectrum Efficiency and "Double Capacity":

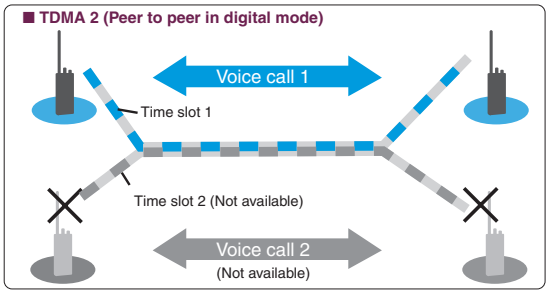
As explained above, both technologies achieve the same 6.25kHz narrowband capability via different methods. The difference is that the FDMA system is a 'true' 6.25kHz channel and the TDMA system provides 6.25kHz channel 'equivalence' via the time slots in 12.5kHz bandwidth. From the perspective that 12.5kHz is considered the current narrowband standard channel spacing, then both systems achieve so called "double capacity". The difference is that the FDMA system is ALWAYS double capacity whether it is used with or without infrastructure. For TDMA, double capacity is ONLY achieved when a repeater is synchronizing the time slots, and that two users are in the same geographical area, accessing the same repeater at the same time. See the diagram below.

Therefore, the answer as to whether either technology is open or proprietary is a mixed one, but in the case of Europe they are essentially open.



• The FDMA is always double capacity, whether in peer to peer or via a repeater.





• Voice call 1 (Time slot 1) occupies whole channel, so time slot 2 stations cannot communicate.

While it is unclear if the TDMA system will provide a solution to utilize both time-slots in peer to peer mode, we are aware that such as solution is being considered for APCO P25 Phase 2. Therefore it may also eventually be available in the TDMA system discussed here.

Audio Quality:

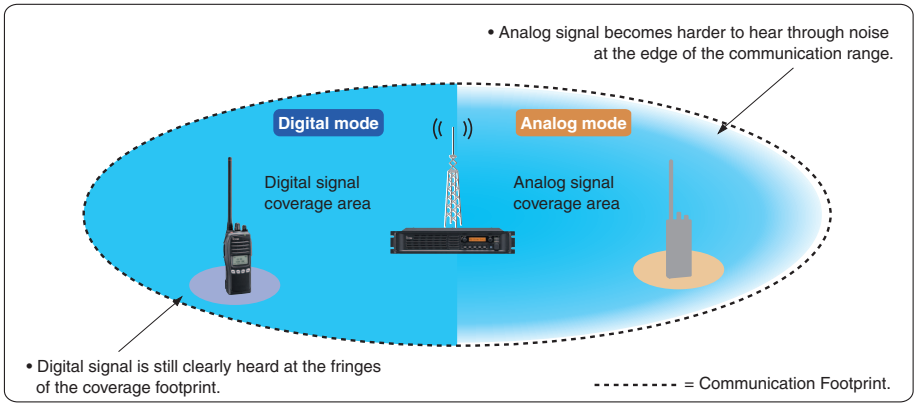
Much has been said about the improvements in audio quality of digital LMR radios compared to analog FM. Currently, both the FDMA and TDMA systems are utilizing the same vocoder, so apart from any differences in the speaker design or output; both systems' audio quality would be of a similar level.

Coverage:

In theory, in identical conditions, the narrower channel width of the FDMA system would allow the signal to achieve better coverage than the 12.5kHz TDMA (or FDMA) system when transmitted at the same output power. This is because the noise floor of any receiver is proportional to the filter bandwidth, therefore the smaller the bandwidth the smaller the signals that can be received.

In real world use, various factors such as topography, antenna height of base stations and surrounding buildings etc. all affect coverage, so without specific comparison tests, either system cannot claim to be better than the other.

What can be said is that when compared to an analog FM signal, digital easily out-performs analog at the fringes of the communication range, thus providing more reliable audio over a greater total area, even if the coverage footprint is the same as analog FM. See the diagram below for an image.



Battery Life:

The manufacturer of the TDMA system claims 40% improved battery life in digital mode as the radio is transmitting only half the time (I.e. one time slot). While only market feedback will prove this true or false, to date, figures on actual transmit power consumption in public literature has been limited to make any accurate judgments on this claim.

As explained in “Coverage”, in the FDMA system, reduced noise components with the narrower channel bandwidth improves receiver sensitivity. Therefore, it could be possible to transmit at reduced power, which in turn conserves battery life and thus can prolong radio use time.

System Costs:

It has been said that the FDMA system is potentially more expensive for licensing costs, and system set up costs (As for example, 'expensive combining equipment' or more repeaters are required). Licensing regulations differ between countries and authorities, so it is completely plausible that the two time slots of the TDMA system could be considered 'individual channels', and thus the same licensing cost issues would apply. In the end individual user needs and market trends will determine the outcome of system costs, and in many cases use of existing site equipment like combiners is possible.

Interference Issues:

Due to the narrower bandwidth, concerns about adjacent channel interference have been raised regarding 6.25kHz FDMA early on. Testing has been done for U.S. frequency coordinating authorities to show that interference issues are not an issue. The result has been the granting of licenses for 6.25kHz channel use. FDMA products are also compliant with the European ETSI standard EN301 166 for analog/digital narrowband communications, at the more difficult to comply with 6.25kHz bandwidth, so for now interference for narrow band digital protocols is no different than for existing analog systems.

Digital Functions:

Both the FDMA and TDMA systems offer a number of functions in both analog and digital modes. A separate comparison of each system by the reader is recommended to obtain better knowledge of which system may suit your requirements, but we will list up what we see as common to both systems for digital features.

- Dual mode capability
  Both systems have analog and digital 'dual mode' capability, and compatibility with existing analog FM systems.
- Peer to peer communication
  Both systems can communicate peer to peer in digital mode. However, as explained, the 6.25kHz FDMA system will always use only 6.25kHz of bandwidth per channel in digital mode. As explained in “Spectrum Efficiency and Double Capacity”, the TDMA system will occupy 12.5kHz of bandwidth, but only use half of the channel (I.e. one time slot). From a spectrum efficiency point of view, FDMA has an advantage in peer to peer communication mode as far as we know at this stage.
- Signaling and Call type features
  Although the naming may differ between systems, the digital equivalent of individual call, group call, selective call, data calls, status messages etc. exist in both systems to one extent or another.
- Digital trunking
  Each manufacturer has a digital trunking feature available now in one form or another.
- Network interfacing
  Both systems have the capability for networking and/or IP capability, and manufactures are offering this functionality now.
- Applications
  Each system has or will offer third party application programs to add to and enhance the system and its features.

Interoperability:

The minimum requirement for interoperability is the following:

* More than one manufacturer offering a product utilizing a common protocol.

* All manufacturers of such a protocol being compliant with the minimum feature set.

The NXDN™ interoperability and conformance test suites exist so that any manufacturer developing a product correctly based on the respective standard, can be interoperable with another manufacturer's radio. It is our understanding that the same exists for the TDMA system in the European standards, but we are unsure if they are being utilized (Due to only one vendor at the moment).

To End:

As shown in this paper, both FDMA and TDMA offer similar advantages and features. We hope that the information provided here has helped clarify some questions you may have had, or given you some new information to reference. It is certainly an exciting time for both manufacturers and users regarding the potential of narrowband digital LMR radio in non-public safety markets around the world.

Please Remember:
If you are a radio user, the following applies to you!

1/1/2011 Applications for new systems using 25 kHz channels, or modification applications that expand the authorized contour of an existing 25 kHz station, will not be accepted.

1/1/2013 Radio systems must operate in 12.5kHz or narrow channels.