White Paper: The 450 MHz Band: Security, Reach, and Reliability For Smart Water Metering

Introduction

Since the early 1980s, the 900 MHz frequency band has been widely used for wireless communications in consumer, business, and municipal applications. From cordless phones and baby monitors to radio modems and automated meter reading (AMR) solutions, the proliferation of devices operating in this unlicensed frequency range has led to problems with overcrowding and interference. By 2009, hundreds of millions of devices operated in the 900 MHz band, making it a less-than-ideal communication environment for critical networks such as public water systems.[1]

Today, as utility operators strive to deploy more efficient and reliable advanced metering infrastructure (AMI) networks and connect water metering with the smart grid, manufacturers have looked outside the 900 MHz band to build communication systems that provide better range, security, and availability from end to end.

450 MHz: A Perfect Fit for AMI

The solution to the shortcomings and security risks of 900 MHz lies further down the radio spectrum. The Ultra High frequency (UHF) 450 to 470 MHz band is a licensed frequency range ideally suited to the demands of advanced water metering, as well as smart metering applications for the energy grid.

While 900 MHz and other higher frequency bands offer more capacity to serve mass market demands, the data rates offered by the 450 MHz band are more than sufficient to meet the small packet requirements of machine-to-machine (M2M) communications such as those between radio frequency (RF) endpoints and base stations in an AMI network. Unlike consumer wireless systems that seek to achieve the highest possible data capacity for talk, text, video, and other human-to-human or human-to-computer interactions, the devices linked together in the Internet of Things (IoT) can send meter readings, report leaks, or transmit other useful data with just a few bits.

[1] *Utilities Telecom Council, "The Utility Spectrum Crisis: A Critical Need to Enable Smart Grids," January 2009.*

In an advanced smart metering system, the flow of data communication begins with a fixed RF endpoint connected to a water meter. The endpoint takes reads on a regular basis, typically hourly, and transmits that usage information on a preset transmission schedule, transmitting a set of 12 readings once every 12 hours, for example. The endpoint turns on for just a few seconds at a time, and the application requires very little bandwidth — in the neighborhood of a couple kilohertz (KHz) per transmission.

Better Propagation, Lower Network Costs

Each of the RF endpoints described above transmits its usage data to a dedicated base station. While every system infrastructure is slightly different, the larger the signal range and the more endpoints served by a single base station, the lower the overall cost. Here, the lower frequency of the 450 MHz band offers two distinct advantages for smart water metering. The first is that radio waves at lower frequencies propagate further than radio waves at higher frequencies, with reduced signal path loss.

Distance in Km	450 MHz	900 MHz
1	85.486 dB	91.507 dB
2	91.507 dB	97.527 dB
3	95.029 dB	101.049 dB
4	97.527 dB	103.548 dB
5	99.465 dB	105.486 dB

Table 1: Loss of power over distance for 450 vs 900 MHz, assuming direct line-of-sight with no physical obstructions.

The 450 MHz frequency range provides a significantly larger cell size than the 900 MHz band, meaning that steady, reliable coverage can be achieved with far fewer base stations, particularly in rural service areas. As a general rule, doubling the frequency (halving the wavelength) quadruples the number of base stations required, so for a given coverage area, a 900 MHz system would require four base stations to achieve the same range as one base station in the 450 MHz band.[2] Because base stations represent the greatest cost associated with installing and maintaining a wireless communication network, the reduction in infrastructure from a 900 MHz network to a 450 MHz network results in faster

[2] *S. Nedevschi, S. Surana, B. Du, R. Patra, E. Brewer, V. Stan, "Potential of CDMA450 for Rural Network Connectivity", IEEE Communications Magazine, January 2007.*

deployment, lower upfront costs, fewer long-term operating costs, and a reduced total cost of ownership (TCO).[3]

In addition to larger cell size, 450 MHz offers superior propagation in and around structures. Building penetration improves as frequency decreases.[4] Accordingly, the lower frequency 450 to 470 MHz channel provides better in-building penetration than devices operating in the higher 890 MHz and 902 to 930 MH bands, giving 450 MHz the advantage over 900 MHz in houses and buildings where smart meters are installed.[5]

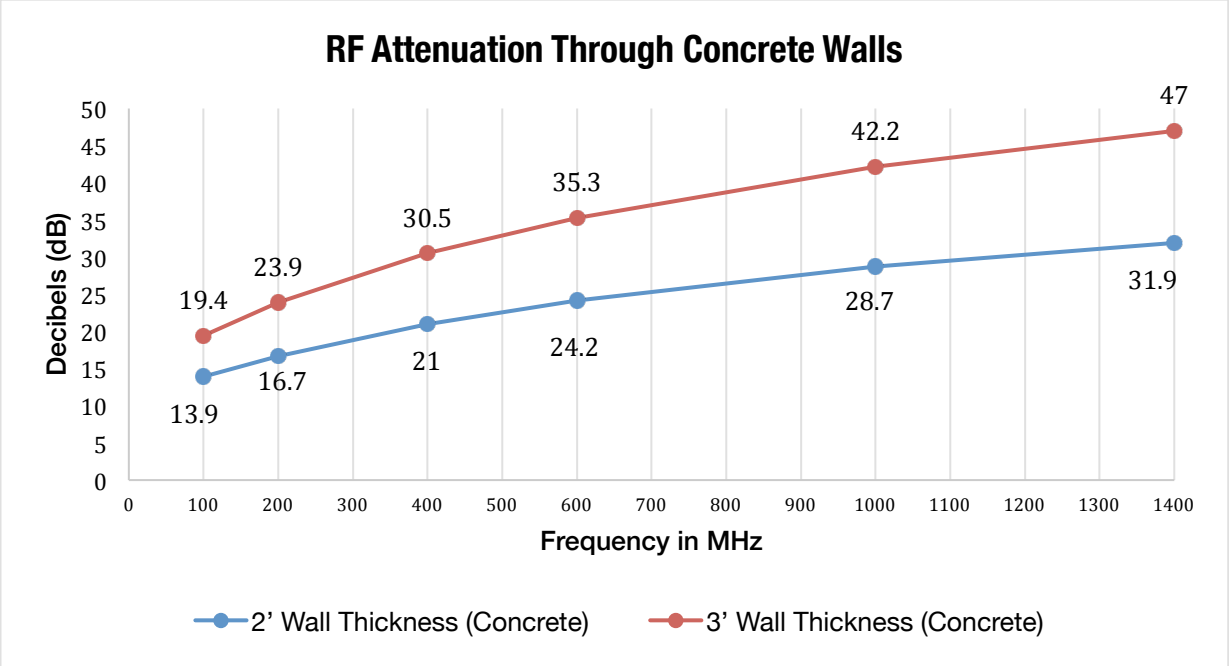

Figure 1: *RF attenuation through concrete walls (adapted from Phillips Laboratories "Measurement of RF Propagation into Concrete Structures over the Frequency Range 100 MHz to 3 GHz")*

While all frequencies experience some degree of signal loss through and around

[3] *450 MHz Alliance, "The Economics of 450 MHz Band for the Smart Grid and Smart Metering."*

[4] *Phillips Laboratories, "Measurement of RF Propagation into Concrete Structures over the Frequency Range 100 MHz to 3 GHz."*

[5] *450 MHz Alliance, "The 450 MHz Band for the Smart Grid and Smart Metering."*

windows, walls, and doors, better in-building penetration at the lower frequency means improved reliability and fewer repeaters needed to support pockets of lost coverage.

Secure, Reliable Communications Unlike 900 MHz, the 450 MHz band is a licensed frequency, making it illegal for anyone other than the licensee to transmit data over the frequency. The benefits of operating on a licensed channel include both security and reduced noise, two key requirements for any advanced metering system, particularly a smart-grid-connected AMI network. Water meters and first-generation automated metering systems have been identified as potential security holes in a critical public infrastructure, and inaccurate water usage data — whether the result of deliberate meter tampering or missed and incomplete reads — is estimated to cost water utilities and their customers millions of dollars each year.

Consider an AMI network that operates on a two-way synchronous RF transmission. The base station communicates to each RF endpoint a time that it needs to turn on and respond to a request from the base station. The RF endpoint turns on for just a couple milliseconds, then shuts off again until its next scheduled transmission. From the base station, the customer's water usage data travels to a cellular backbone, then up to the cloud. To protect the integrity of the data transmissions in both directions, the wireless network must be both reliable and secure at every communication point.

Anyone has the ability to purchase one of the many readily available consumer electronic products in the 900 MHz band, remove its transmitter, and connect to a water utility's frequency. In the 450 to 470 MHz range, licensing acts as an intrinsic security feature. While licensing alone does not address all the requirements of a secure connected AMI network, it adds an important first-level barrier, making it difficult for an unlicensed operator to purchase an RF transmitter on the 450 MHz frequency or subsequently use that transmitter to tamper with a customer meter or access a municipal network.

With far fewer devices operating in the 450 MHz frequency than on 900 MHz, the 450 MHz band also offers reduced noise and a higher reliability of connectivity. Compared with the 900 MHz range, 450 MHz provides fewer missed reads and fewer missed or

incomplete transmissions, resulting in more accurate usage data and lower costs.

Key Characteristics of 450MHz and 900MHz

Feature	450 MHz	900 MHz
Propagation Characteristics	Strong	Weak
• **Range**	Cell radius 48.9 km[6]	Cell radius 26.8 km[7]
• **In-building penetration**	Good	Fair
Security	Licensed, restricted grid	None, public grid
Interference / Noise	No	Possible
Infrastructure Costs	Lower	Higher
Optimized for M2M Applications?	Yes	No
Data Rates	Sufficient	Inefficient

Table 2: *Comparison of 450 MHz and 900 MHz frequency ranges for advanced metering applications (adapted from "Communication Technologies and Networks for Smart Grid and Smart Metering" by the 450 MHz Alliance)*

Conclusions

Secure, reliable, and efficient two-way telecommunication is perhaps the most critical component of any intelligent and effective AMI network. As advanced water metering becomes increasingly tied into the smart energy grid and linked to other intelligent devices in the IoT, utility managers and water system operators will require accurate, cost-effective, and easily manageable solutions.

With its wide reach, superior penetration, and low network cost, the 450 MHz frequency band is ideally suited to the communication needs of automated and advanced water metering applications.

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[6] *450 MHz Alliance, "450 MHz Band for Smart Energy," 2014.*
[7] *450 MHz Alliance, "450 MHz Band for Smart Energy," 2014.*

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