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Study of Integration 2.4GHz and 5.8GHz in RFID Tag

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***Abstract*- The most common, though not the only frequencies generally available for RFID use are LF (nominally 132 kHz), HF (13.56 MHz), UHF (860 - 960 MHz) and microwave (2.45 GHz and 5.8 GHz). Wireless LAN systems based on the spread spectrum in the 2.4GHz band and 5.8GHz band are widely used throughout the world. In this study, the consideration is about integrating two RFID spectrums together which is 2.4GHz and 5.8GHz in one active tag. The need of using two spectrums is to get the best RTLS.**

I. Introduction

A. 2.4GHz spectrum

Wireless networking using the unlicensed 2.4-2.5GHz frequency band is the most popular form of radio based networking. Due to the fact that 2.4GHz wireless networking was the first mass-market radio networking and has been around the longest equipment tends to be very wide ranging and relatively low cost. It is therefore often the preferred system for the home and small to medium size enterprise. This is why 2.4GHz networking is the preferred system for both private (home networks) and also for long range bridging.

B. 5.8 GHz spectrum

The use of higher frequencies for location-based applications such as people and equipment tracking presents multiple advantages compared to other frequencies. Location systems built on higher frequencies provide lower costs per device, high data rate transfers between badges/tags and receivers. As well, they offer the best compromise between communication range and shorter signal wavelengths to improve the ability to pass through narrow spaces in harsh environments. By way of signal leakage, they can easily find their way through dense metallic environments. They offer small device sizes with unmatched efficiency for Real-Time Location Systems (RTLS) and active RFID. The physics of wireless technology shows 4 main factors affecting communication quality and system performance; traffic in the band, propagation issues or how the frequency handles obstructions and distances, frequency efficiency and device efficiency.

II. Consideration

A. Traffic In The Band

There are some advantages to moving into higher frequencies. The 433 MHz has been used for decades for short-range communications. The 433 MHz, 900 MHz and 2.4 GHz bands are used largely for consumer devices, such as baby monitors, microwave ovens, Bluetooth interdevice communications and wireless LAN for the 2.4 GHz band. Thus, it is likely that RFID networks will suffer from interferences by the signals bring broadcasted by those devices. The 5.8 GHz band, however, is less crowded.

The higher the traffic is in the band, the more complex the transmitter and receiver have to be in order to pierce through the interference and maintain signal quality. The result is an increase in the complexity and price and complexity of the device. It is therefore more interesting to use a non-crowded band, for instance the 5.8 GHz, to better handle large-capacity tracking systems.

B. Propagation Issue

Most short-range communications occur around human-made constructions, such as vehicles and buildings. For mid-range communications of distances between 0 km to 1 km and for the same transmitted power level, 5.8 GHz offers almost the same communication range than 433 MHz.

5.8 GHz offers the smallest Fresnel diffraction zone compared to 433 MHz, 900 MHz and 2.4 GHz. Due to its shorter wavelength, 5.8 GHz can pass through very narrow spaces. At the same time, it maintains similar penetration capabilities through materials as the 433 MHz band. Therefore, where 433 MHz is blocked or diffracted by obstacles because of its longer signal wavelength of 70 cm, 5.8 GHz can easily pass through unhindered due to its very short 5.17cm wavelength.

Signal Wavelength impacting device size and performance. This is why, in general, products operating on higher frequencies are more compact.

TABLE I

Frequency	Wavelength
5.8 GHz	5.17 cm
2.4 GHz	12.5 cm
900 MHz	32.68 cm
433 MHz	69.28 cm

TABLE 2

Frequency	Distance
5.8 GHz with spread spectrum	300 - 2000 ft
2.4 GHz with spread spectrum	300 - 2000 ft
900 MHz with spread spectrum	300 - 1500 ft
433 MHz	75 - 400 ft

Table 1 show the signal wavelength of the frequency. Since 5.8 GHz has a short wavelength, antennas are smaller and penetration and signal leakage is better. Moreover, the components used in a 5.8 GHz badge or tag are smaller and more energy-efficient.

The characteristics of signal propagation at of 433 MHz, 900 MHz, 2.4GHz and 5.8 GHz in free space and the atmosphere are similar regarding different levels of rain like in Table 2. This issue is important to consider in tropical and continental climates, for outdoor applications. The figure below shows how the long-range propagation for almost all frequencies below 10 GHz is affected in the same way under different types of rain. Under heavy rain, all frequencies below 10 GHz suffer almost 0.1 dB attenuation per kilometer of propagation. Real-time location systems are generally built with tag/receiver communication ranges of less than 500 m. Therefore, one should consider frequency efficiency, noise in the communication band and interferences in order to select the best frequency for your location-aware applications or active RFID application.

In Fig. 1 shows the 5.8 GHz band offers a similar communication range (0 km to 1 km) as other crowded, low-frequency bands. However, at 5.8 GHz, bit error rate (BER) is much better because of a less crowded bandwidth. The ISM band at 5.8 GHz offers 75 MHz of communication bandwidth. This is almost twice as much more bandwidth that the 2.4 GHz band. This means more energy-efficient products with higher data-throughput capacity.

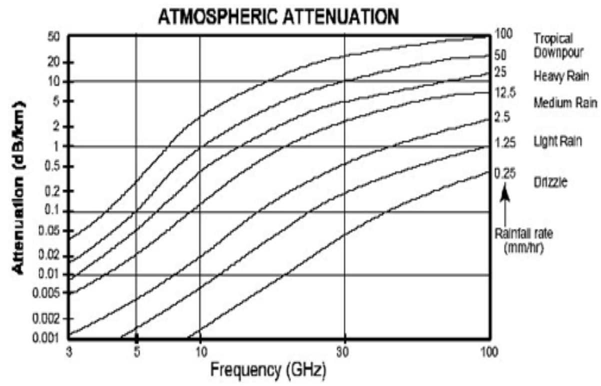

Fig. 1. Propagation of RF signals and atmospheric attenuation for different frequency band

C. Frequency Efficiency

The data transfer rate is higher at 5.8 GHz because the frequency is higher. This is very important when it comes to tracking, locating or communicating with hundreds of moving objects, such as people, equipments, vehicles or containers. Using a Purelink nanoEdge Tracking System, it can track a vehicle travelling at a speed in excess of 200 km/h without any misreading between tags and receiver at 200 meters from the roadside. At this speed, a vehicle moves by 27.77 meters per second. The Doppler Effect can be significant in poor, low-frequency modulation systems, such as 433 MHz. 5.8 GHz tags can be read at speeds of up to 250 km/h without any misreading, even if the wireless tag is hidden in the trunk of the vehicle.

5.8 GHz offers better data rates from 2 MB/s to 100 MB/s. High data rate modulation is important for true real-time location systems. When commercial, safety or security applications are required to locate large quantities of badges and tags with high precision and fine time-granularity, data modulation efficiency is critical.

Data modulation allows large quantities of data to be sent between tags and receivers in a very short time. In many industrial applications, a true real-time location system is required in order to process the location of thousands of workers with accuracy between 1 and 3 meters, every second. Without a dedicated hardware layer, designed especially to deliver consistent RTLS data with high accuracy and integrity, these critical applications can be hard to implement. Real-time location systems based on 433 MHz, 900 MHz and 2.4 GHz can not handle large data rate modulation nor can they deliver, with any consistency, accurate locations for thousands of workers every second, with a precisions between 1 and 3 meters.

D. Device Efficiency

1. Better Electronic Designs at 5.8 GHz

At 5.8 GHz, the capacity to use transmission lines for antenna designs leads to cheaper solutions with smaller printed circuit boards. The result is a very compact tag, at lower cost and with better energy efficiency. Using 5.8 GHz gives the ability to make a tag in one single chipset. This results in lower production costs, smaller and lighter devices and significantly increases the device's power efficiency. At 5.8 GHz, the antennas have a smaller size and can be made in a variety of shapes.

2. 5.8 GHz tags are compatible with CMOS technology

CMOS technology presents multiple advantages:

1) Low-cost and mature technology
2) Low-bias voltage (< 3V, even below 1V for SOI MOS)
3) Low power consumption (portable applications)
4) Mixed analog-digital circuits (one-chip) can be built
5) High levels of integration can be reached
6) Compatible with micromachining techniques (MEMs)

Frequency	Advantage	Disadvantage	Crowded Band
303.8 MHz 418 MHz 433 MHz 868 MHz 915 MHz	Good distance Low data rate	Poor water/tissue penetration 915 MHz crowded Regulatory issues in a lot of countries	Yes
2.45 GHz	Small tag/antenna size Good range High data rate	More susceptible to noise Requires sensitive receivers Consumes a lot of energy Requires frequent battery changes Expensive Cannot be built into a single chip	Yes
5.8 GHz	Very small tag/antenna size Very small device size High energy efficiency Very good communication range High data rate and modulation Can be built into one single CMOS to achieve very low costs	Requires sensitive receivers Requires advanced system designs	No

III. DISCUSSION

Tag collision in RFID systems happens when multiple tags are energized by the RFID tag reader simultaneously, and reflect their respective signals back to the reader at the same time. This problem is often seen whenever a large volume of tags must be read together in the same RF field. The reader is unable to differentiate these signals; tag collision confuses the reader.

Different systems have been invented to isolate individual tags; the system used may vary by vendor. For example, when the reader recognizes that tag collision has taken place, it sends a special signal (a "gap pulse"). Upon receiving this signal, each tag consults a random number counter to determine the interval to wait before sending its data. Since each tag gets a unique number interval, the tags send their data at different times.

IV. CONCLUSION

Reader collision occurs in RFID systems when the coverage area of one RFID reader overlaps with that of another reader. This causes two different problems:

1. Signal interference :
   The RF fields of two or more readers may overlap and interfere. This can be solved by having the readers programmed to read at fractionally different times. This technique (called time division multiple access - TDMA) can still result in the same tag being read twice.
2. Multiple reads of the same tag:
   The problem here is that the same tag is read one time by each of the overlapping readers. The only solution is to program the RFID system to make sure that a given tag (with its unique ID number) is read only once in a session.

The main objective of this paper is use to eliminate some problem that faced by recently tag in the market. This new combination spectrum will give the highest efficiency of the active tag.

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