Magnetic induction: A low-power wireless alternative

Magnetic induction makes for an interesting alternative to today's high-profile, highly political unlicensed wireless communications systems.

By Chris Bunszel

Using a modulated magnetic field to transmit a signal across the air interface is an eyebrow-raising, yet viable option for an alternative low-power, low-cost communications system.

Let's talk interference

With magnetics, many of the drawbacks of traditional RF systems can be overcome. Some of these drawbacks are nulls, scattering, multipath fading, Federal Communications Commission (FCC) limits, security concerns and interference. Unlicensed RF systems such as Bluetooth and 802.11x fall in the same band. Presently, there are significant interference issues plaguing these systems because of their locations within the frequency band.

This isn't a problem in magnetic induction systems (MI) because the e-field is near-absent. MI systems are typically low power, so they can be used in most frequency bands with little interference. This has several advantages. Most notably is the ability to meet FCC limitations, particularly for short-range devices, and the ability to reuse frequencies in close proximity. For example, magnetic induction (MI) is ideal for wireless personal area network (WPAN) applications under 3 meters.

Lower power

MI is a low-power technology for several reasons. It is a combination of the ability to use a lower frequency, the processing power required, design techniques, process, and transmit characteristics. A typical magnetic induction chipset may draw as little as 7 mA to transmit voice or data across a 1-meter link. RF systems would require 10 times this amount.

The ability of a magnetic communications system to operate on a carrier of 11 to 15 MHz offers tremendous advantages over a 2.4 GHz system. For instance, setting up the IF frequencies for the receiver or transmitter, or running the amplifiers requires more current at the higher frequency. An on-chip amplifier running at 2.4 GHz requires several mA of current, while an 11.5 MHz amplifier requires only a few hundred microamps. Similar current savings are typical of every block of MI systems.

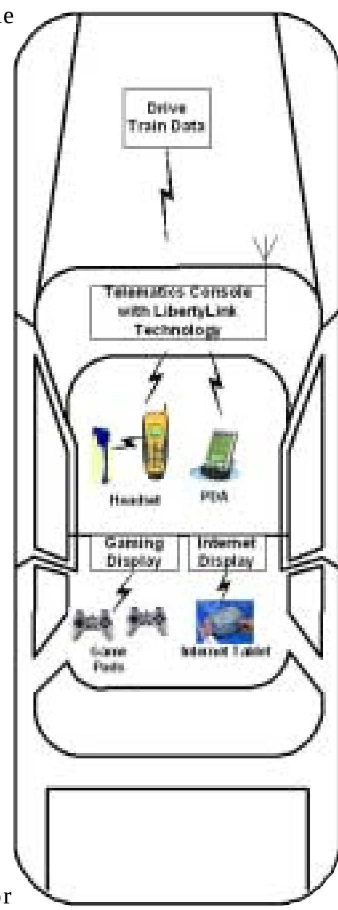

Figure 1. An automobile with a magnetic induction telematics system.

System complexities

The RF systems being built today are complex compared to magnetic systems. Nearly all aspects, from digitizing the receiver to channel and frequency allocation, require more processing power. This complexity requires using more complex and power-hungry processors.

Magnetic systems use design techniques that cannot be used at 2.4 GHz, resulting in less power consumption through the chain and a smaller component count.

Finally, many higher-frequency RF systems, particularly the 2.4 GHz products, require the use of more exotic semiconductor processes. The magnetic induction chipset needs only a standard (and stable) .25 µm CMOS technology. On the other hand, state-of-the-art RF companies are using silicon germanium(SiGe), BiCMOS or 0.18um CMOS processes. These exotic processes are more expensive and consume more power.

Each of these advantages adds to the incremental power savings in a magnetic induction system. Because only a few commercial RF applications require 3-meter operations (most are 10 meters or more), it is difficult to compare a 3-meter RF to a 3-meter magnetic system. For these close-proximity applications, the specification (Bluetooth for instance) still requires a minimal 10-meter operation. The RF systems designed to the 10-meter specification will draw 10-30 times more current than the magnetic system.

Lower cost

For devices in a personal-area network, particularly for consumer devices, price is always a tantamount concern. Consumers are usually unaware of, or apathetic about, which technology they use. They just want it to work and be affordable. It can be hard to compare cost for different technologies, unless the total solution is considered. Discussing 'chip price' is useless if this is only a fraction of the overall cost of building a system. For instance, Bluetooth has continuously quoted the $5 solution. However, when all is said and done, and the cost of the additional components in considered, the end cost is well above this.

Industry analysts recently cited that the cost of a two-node wireless link, using Bluetooth, is $43.24 (in 2001). The apples-to-apples cost of a magnetic system is considerably less. In medium volumes, the magnetic system requires only about 15% of the total cost for off-chip components. Therefore, this system offers chipsets at a price on the same order of magnitude of Bluetooth, while having an overall system cost well below that of the RF system's.

Furthermore, the above cost does not include manufacturing, plastic housings or batteries. It can be assumed that the manufacturing and plastics cost will be about the same regardless of technology. The battery cost, however, will vary.

Minimum power, maximum gain

For consumer mobile products, it is not unreasonable to expect to get one day's worth of charge from the product. For the low-power magnetic system, this can be accomplished with two NiMH, 40 mAh batteries. In reasonable quantities, such a battery pack currently costs about $0.45. For the high-power RF system, which draws 50 to 150 mA, this would require a 400 to 1200 mAh lithium battery. These battery packs cost in the $5 to $11 range and require safety monitoring circuitry. The RF battery is 2.73 cm^3. The batteries for the magnetic system take up 1.54 cm^3. Consequently, the RF power packs up the ante in all directions: cost, size and weight. The MI pack offers a 45% volume savings. This becomes significant in wearable mobile devices such as a headset.

Current estimates of an OEM's total cost for a magnetic induction headset product is around $22 for two nodes, while the RF solution is between $48 - $54, or about 2.5 times higher. Using a conservative retail multiple of four, this puts the products on the shelf at $88 for the magnetic headset and $199-plus for the RF solution.

No more signal loss

One of the biggest problems plaguing RF solutions is the effect the environment has on the signal. Any time someone walks around using an RF product (cordless or cell phone for instance), the call clarity changes with location. These 'drop-outs' can be attributed to antenna pattern nulls, scattering effects or one of several fading problems. RF solutions do not radiate in concentric circles like a magnetic system; instead, they favor a particular direction or pattern. While these patterns can be optimized, they are also subject to nulls.

The magnetic induction system is constant power at a given distance to the transmitter and is not generally affected by environment. For instance, if the magnetic induction system is used for a headset and worn on the body, there are no interference concerns.

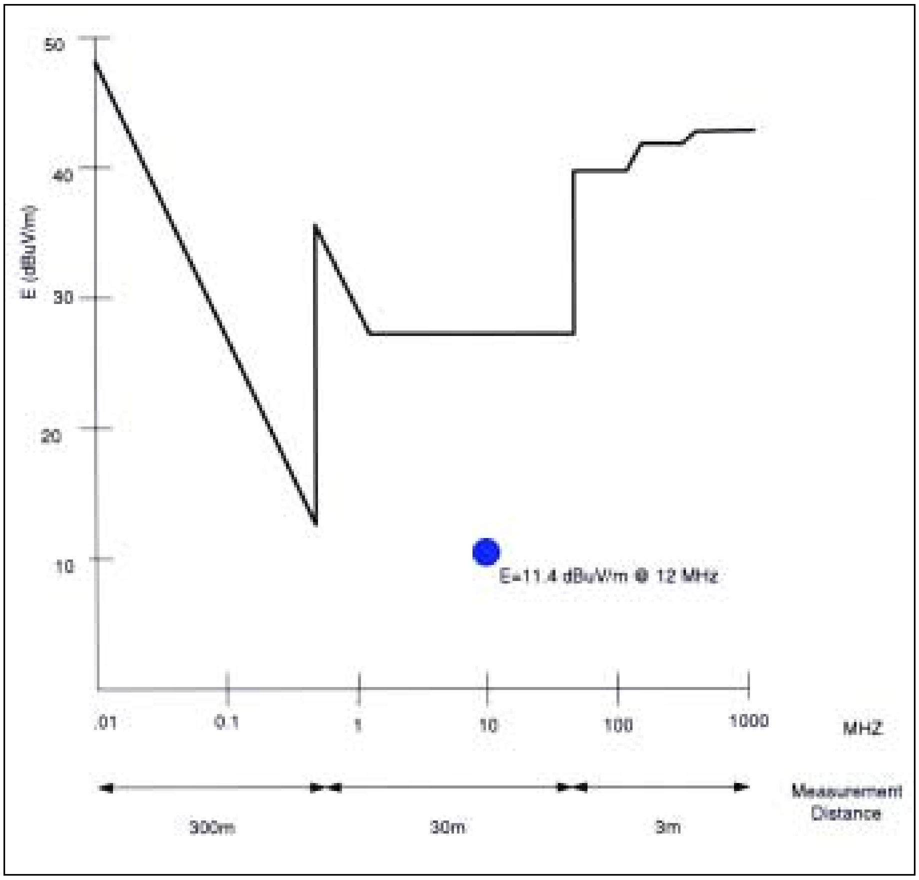

Figure 2. Typical FCC power levels with an MI system superimposed. The blue dot represents the frequency and e-field used by the MI system.

And finally, security

Security is always an issue in any wireless system. The security issue becomes more acute as the power and distance increase. In a system in which the signal only goes a couple of meters, an eavesdropper would need to be standing within 2 meters to listen to the conversation. With an RF system that propagates 10, 100, or more meters, much more opportunity exists to eavesdrop. None-the-less, the same type of security and encryption can be implemented in a magnetic system if necessary.

Consortiums – the real power

Finally, one factor with pros and cons is the industry backing. A consortium has the power and money to market and hype a technology until it is a household name. Bluetooth has mastered this approach. Bluetooth's hype has had a significant effect on other competitive technologies. Unfortunately, this has the effect of pushing lesser-known technologies into the shadows so they are often overlooked or dismissed. To that end, creating a large consortium or special interest group (SIG) seems like the best way to promote technology.

However, consortiums have downsides. First, hundreds or thousands of companies, each with its own agenda, are working toward a common specification. This creates a specification with tremendous overhead for companies wanting a simple solution. This overhead increases complexity, cost, size and development time.

It also tips a hand to competitors. In many cases, to get something into the specification that benefits a company's products, the company can lose some competitive advantage. Any innovative idea may need to be disclosed either at the specification or qualification stage, allowing competitors to copy it.

Summary

While the magnetic technology has clear advantages over RF in terms of cost, power consumption, interference and security, it only works in the close proximity. Magnetic solutions are about 1/3 the cost of the RF solution and require about 10 to 30 times less power. They are also less prone to interference and eavesdropping. However, it will not drive a wireless LAN or other 100-meter applications.

By the end of this year, several RF and magnetic induction solutions will be available for wireless voice and data networks within the 100-meter space. These include Bluetooth, HomeRF, "Wi-Fi", and MI technology. Each is poised to dominate a niche in the market. Bluetooth will enable less cost-sensitive, high-data-rate electronic devices. HomeRF will capture the in-home and small office/home office (SOHO) market. Wi-Fi, or 802.11, will enable high-speed LANs. MI is poised to be the backbone for close-proximity, low-power, low-cost, wireless devices.

RF

About the author

Chris Bunszel is the Marketing Manager for Aura Communications. He can be reached at 978.988.0088, ext. 114 or chrisb@auracomm.com. The company's Web site address is www.auracomm.com. Physical address is 187 Ballardvale St., Wilmington, MA 01887