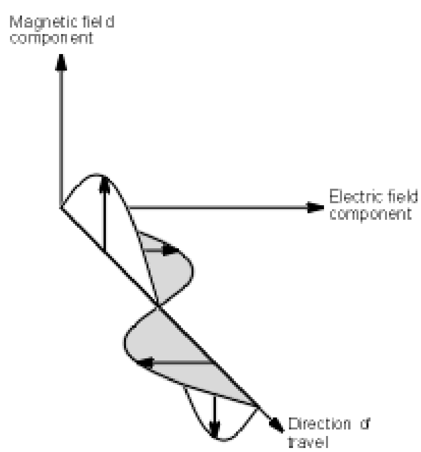
FreeLinc Near-Field Magnetic Induction Technology

NEAR FIELD MAGNETIC INDUCTION

Far-Field

FreeLinc is the leader in wireless accessories for two-way radio communication systems in the public safety market. Currently, all FreeLinc products are based on patented Near Field Magnetic Induction technology.

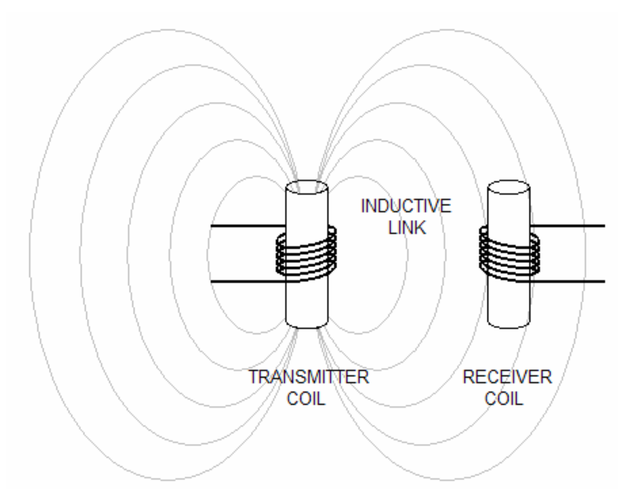
FreeLinc's Near-Field Magnetic Induction (NFMI) systems differ from other wireless communication systems in that most conventional wireless RF systems use an antenna to generate and transmit a propagated electromagnetic wave. In these types of systems all of the transmission energy is designed to radiate into free space. This type of transmission is referred to as "far-field."



According to Maxwell's equation for a radiating wire, the power density of far-field transmissions attenuates or rolls off at a rate proportional to the inverse of the range to the second power ($1/range^2$) or -20dB per decade. This slow attenuation over distance allows far-field transmissions to communicate effectively over a long range. The properties that make long range communication possible are a disadvantage for short range communication systems.

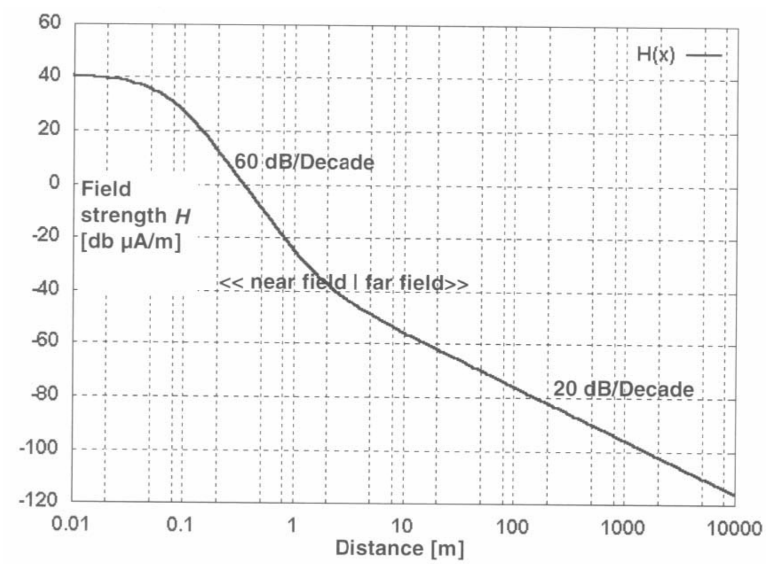
Near-Field

FreeLinc's near field magnetic induction system is a short range wireless physical layer that communicates by coupling a tight, low-power, non-propagating magnetic field between devices. The concept is for a transmitter coil in one device to modulate a magnetic field which is measured by means of a receiver coil in another device.



The standard modulation schemes used in typical RF communications (amplitude modulation, phase modulation, and frequency modulation) can be used in near-field magnetic induction systems.

FreeLinc's NFMI systems are designed to contain transmission energy within the localized magnetic field. This magnetic field energy resonates around the communication system, but does not radiate into free space. This type of transmission is referred to as "near-field." As shown in the graph below, the power density of near-field transmissions attenuates or rolls off at a rate proportional to the inverse of the range to the sixth power ($1/range^6$) or -60dB per decade.



In the example above, the carrier frequency is 13.56MHz and has a wavelength (λ) of 22 meters. The crossover point between near-field and far-field occurs at approximately $\lambda/2\pi$. At this frequency the crossover occurs at 3.52 meters, at which point the propagating energy from the NFMI system conforms to the same propagation rules as any far-field system; rolling off at -20dB per decade. At this distance the propagated energy levels are -40dB to -60dB (10,000 to 1,000,000 times) lower than an equivalent intentional far-field system.

CURRENT WIRELESS COMMUNICATION SYSTEMS

The majority of wireless communications systems use traditional far field RF communication topologies that rely on transmitting a propagating electromagnetic wave through free space. While this method is ideal for long range communication (several miles or more) it is not the ideal medium for short range, high density, squad level communication systems.

Spectrum Contention

A primary concern in military communications is the assignment and control of the RF frequency spectrum. As more and more infantry and vehicle mounted radios are issued, the demand for available frequencies and clear channels becomes greater. Because all current wireless communication systems rely on a far-field RF physical layer, which can cause interference at great distances, these systems must be designed to share much of the same frequency spectrum. This requires the implementation of complex time and frequency allocation algorithms. However, even with these work-around allocation schemes, the RF spectrum is still becoming increasingly crowded. The result is steadily worsening interference and interoperability problems that simply cannot be overcome by transmitting with more power or moving to more complex and power-intensive frequency-management schemes.

The spectrum contention problem is amplified in urban environments where soldiers must compete with consumer devices for frequency allocation. Currently, many of the personal role radio systems available use the unlicensed ISM band at 2.4GHz. This frequency has become a standard for WiFi, Bluetooth, and multiple other wireless communication protocols. This is a serious issue, when a squad is trained to rely on their communication system and find themselves in an urban environment where the over used frequencies can cause unexpected communication failures.

In addition, it is critical to keep the frequency spectrum clear for squad-to-command transmissions that must use far-field communication methods for long range communications, and not allow short range squad level communication systems to compete with the frequency spectrum required for these long range communications.

Signal Quality

In practice, the far-field RF signals used in existing communication systems can be unpredictable, especially in urban environments, where frequency spectrum contention and fades, reflections, and blocking due to interfering obstacles such as buildings, vehicles, and industrial equipment can significantly reduce the effectiveness of current far-field RF technology based systems.

The signal loss due to these combined effects creates poor signal quality and unreliable communication between devices. This compromised signal quality must be restored by transmitting with higher power levels. However, transmitting with higher power levels causes more inter-system frequency contention.

Power Consumption

Another disadvantage in increasing transmit power to ensure good signal quality is the increased power consumption required to sustain higher power transmissions. Higher power transmissions will greatly reduce the battery life of the portable radio systems which forces the user to carry additional batteries or be compromised with loss of communications.

The fundamental nature of far-field RF communication is to generate a signal and transmit this signal into free space. By design, all of the energy is transmitted into free space with no re-use of transmit power. This is very inefficient from a power usage perspective.

Security

Increased power extends the communication's range and improves the signal quality but it also poses a security risk as the far reaching propagation of EM waves in a far-field system can travel miles before attenuating below ambient noise floor levels, where the risk of interception becomes improbable.

This increased risk of security requires the communication transmissions to be encrypted. In systems such as on-the-body wireless networks, where ideally every soldier is outfitted with their own equipment, the process of loading encryption keys can be very time consuming and logistically complex.

RF Jamming Compatibility

A major weakness with all current short range communication systems is interoperability in an RF jammed environment. Current jamming devices are designed to prevent communication by RF far-field transmission. Such jamming is used to prevent the enemy from communicating or triggering remote detonated explosive devices such as IED's. When these jamming devices are enabled, current communication systems are disrupted and communication is lost, leaving the squad in a compromised situation.

FREELINC SOLUTION

FreeLinc's near field magnetic induction based communication systems suffer from virtually none of these problems. The benefits of NFMI based systems include the following:

Reliable Signal Quality

FreeLinc's NFMI energy is contained in a magnetic field, forming a tight communication "bubble" which provides a high signal-to-noise ratio between devices. These magnetic fields are highly predictable and less susceptible to fading, reflection, and environmental conditions than RF electromagnetic waves used in most communication systems.

Lower Power Consumption

FreeLinc's NFMI systems use substantially less power than far-field RF communication systems. It requires less power to sustain a non-propagating magnetic field compared to typical radio systems which must continually generate and propagate an electromagnetic wave into free space. In theory a resonating field will consume no additional energy once the field is established.

Reduced Frequency Contention

Most far-field RF systems must share their bandwidth using time or frequency allocation due to the long range of RF signal propagation. The well defined communication bubble of magnetic-field energy allows for a large number of FreeLinc NFMI systems to be co-located while operating on the same frequency. Simultaneous access to a defined frequency spectrum is accomplished by localizing the communication region or spatial allocation – not by the allocation of frequencies or time division.

A near field magnetic induction short range radio system will reduce spectrum contention and leave bandwidth clear and available when critical long range communication is required.

Improved Security

FreeLinc's NFMI systems are designed to work in the near-field. Therefore, the far-field power density of these systems is up to -60dB less than an equivalent far-field RF device, which is designed to intentionally emit far-field electromagnetic waves. As the distance from an NFMI system increases the emission levels rapidly attenuate below ambient noise floors making detection extremely difficult.

In addition to emitting lower RF power levels, FreeLinc has pending patent applications allowing for artificial far-field RF noise floors in a near field magnetic induction based communication system. This combined system dramatically reduces the threat of detection from outside the near-field range.

The concept is to communicate using magnetic induction which does not rely on far-field, far-reaching, electromagnetic radiation or propagated waves. However such far-field waves typically do exist in any wireless electronic system due to the spurious or unwanted emissions generated by the transmitter and supporting circuitry.
By intentionally generating and emitting an artificial noise floor these spurious emissions can be masked, destroyed, or made undetectable. This allows for short range communications to occur at the squad level with a significantly reduced threat of interception and demodulation.

In secure situations due to the long distance range of far-field RF systems high levels of encryption are necessary to ensure protection as the propagated signal can be intercepted several miles from the transmission source.

Due to the large number of squad level devices, the process of changing and loading encryption keys becomes logistically complicated and prohibitively time consuming.

RF Jamming Compatibility

FreeLinc's near field magnetic induction systems do not rely on propagated EM waves to communicate. Therefore it may be possible to shield the NFMI antenna arrays from EM waves while allowing the quasi-static magnetic fields to penetrate the localized area around the user. This type of NFMI system will allow for an environment to be saturated with RF jamming signals at the same frequency as the NFMI communication system, while still allowing for short range communication.