Ensuring Successful Operation Of RFID Tags In High-Value Asset Tracking

Introduction

Radio Frequency Identification (RFID) is not a new technology, with the initial application being IFF (Identification Friend or Foe) used by aircraft during World War 2. Since that time it has found a variety of uses including key fobs, contactless payment, proximity cards for building security, and toll collection. These days, thanks to increases in RFID performance and standards like EPC Class 1 Generation (Gen) 2, RFID readers and tags are finding new life in applications like defense logistics, healthcare and the enterprise as well. According to one estimate alone, the RFID market is poised to surge from millions to tens of billions of tags over the next five years. While this growth bodes well for RFID reader and tag manufacturers alike, it also creates a number of interesting challenges, not the least of which is how to ensure tag operation on metal. This problem is especially troublesome in the high-value asset tracking arena, such as with military supplies featuring metal casings and components (see Figure 1). A new patent-pending, high dielectric material with high magnetic permeability can offer manufacturers an ideal solution for ensuring RFID tags will operate as expected on metal products.

Figure 1. The United States Marines currently use RFID tags to provide information about the contents of shipping containers.

An Emerging Challenge

RFID systems consist of a tag, or transponder, and a reader, also known as an interrogator. The RFID tag is comprised of a small silicon microchip attached to an antenna and is capable of transmitting unique information at a distance of up to several meters in response to a query from a reading device (see Figure 2).

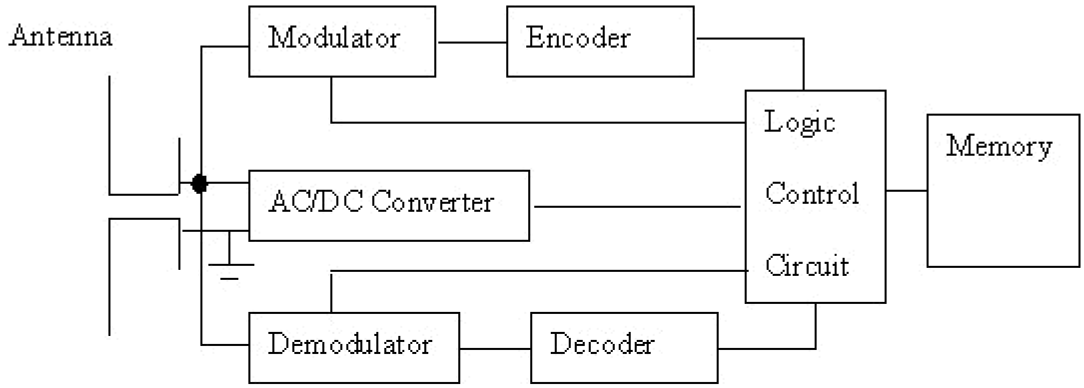

Figure 2. Various components of the tag are shown here. Normally, the antenna is external to the tag chip and large in size.

During operation, the reader sends out electromagnetic waves. The tag antenna, which is attached to an object, is tuned to receive these waves. The tag – for the purpose of this discussion, a passive tag - will identify itself when it detects a signal from a reader that emits a radio frequency transmission. Each RFID tag carries information on it such as a serial number, model number, color, place of assembly, or some other type of data. When these tags pass through a field generated by a compatible reader, they transmit this information back to the reader, thereby identifying the object.

Essentially what is happening is that the RFID reader continuously emits RF carrier signals, and keeps observing the received RF signals for data. The presence of a tag modulates the RF field, and the same is detected by the reader. The tag then absorbs a small portion of the energy emitted by the reader, and starts sending modulated information when sufficient energy is acquired from the RF field generated by the reader. In this case, the data modulation can be accomplished by either direct modulation or FSK or Phase modulation. The reader demodulates the signals received from the tag antenna, and decodes the same for further processing.

While RFID systems have become quite common in everyday life, metal poses a unique challenge to their effective operation. RFID tags are designed to efficiently receive energy transmitted from the reader. Since a passive RFID tag has no power source, it must derive all its power from the incoming wave. If this energy is not transferred to the chip efficiently, the chip will not power up and the tag won't be read. A well designed RFID tag antenna is said to be 'tuned' to the reader frequency and presents a good 'match' to the incoming energy. In proximity to metal, the tag antenna becomes detuned - creating a mismatch. As a result, the tag can no longer efficiently transfer power to the chip at the reader frequency. Greater transmit power therefore is necessary to read the tag, deteriorating the read range. Put simply, the metal interferes with the signals sent between the RFID tag and the reader, causing signal reflection, detuning and grounding which may reduce, or even negate RFID's effectiveness.

Using an RFID tag on a metal object is especially problematic with ultra high frequency (UHF) RFID (tags) systems. While these systems offer a greater read/write range, they are less able to penetrate obstacles such as metal. Higher frequency radio waves tend to bounce off of metal objects.

This challenge is exacerbated by the fact that as of 2004, the United States military has required that all equipment worth over $5,000 be tagged with RFID. That accounts for a large number of products – many of which contain metal. A military laptop computer is a prime example of just such a product. If the tag is placed directly on the computer, than metal interferes with the tags' operation and the tag can not be read.

The conventional way of dealing with this problem today is to employ a dielectric material like foam to offset the tag from the computer. This foam is typically ¼ to ¾ of an inch thick. Here, the further the tag is away from the metal the better its range. But what happens if a situation arises in which there is a restriction on the thickness of the foam? Consider, for example, that a tagged laptop computer must fit into a docking station and therefore the foam isolator used must be extremely thin – much more so than the nominal ½ to ¾ of an inch. And what about situations where the esthetics of the overall product is crucial? In these cases, the foam offset tag simply falls short.

Granted a foam offset tag does have the benefit of being inexpensive, but at the same time, its performance is not always guaranteed. In military applications and others that require high-value asset tracking, a higher performance, ultra-thin, more esthetically pleasing alternative is often required.

Read on Metal Solutions

In order to address the problem of read on metal RFID, many companies have devised a range of solution types. The simplest is the offset method mentioned above which merely lifts the tag off the metal using an inexpensive foam spacer material. Where feasible, the RFID tag could be constructed to hang off the object to be tagged so that it is not in contact with metal. Another solution would be a material with custom electromagnetic properties which when placed between the tag and metal would retune the tag antenna to the proper frequency. Emerson & Cuming Microwave Products offers a patent-pending, thin elastomer which when placed between an RFID tag and metal will allow the tag to be read. Known as ECCOPAD®, this isolator material is substantially thinner than the usual foam spacers, enabling the RFID tag to be read on metal while maintaining a low profile (see Figure 3). It can be used to separate RFID tags from metal by a mere 1/10th of an inch.

Figure 3 Emerson & Cuming Microwave Products ECCOPAD® isolators enable the use of RFID tags on or near metallic surfaces. Isolators are available for use at HF (13.56 MHz) and UHF (915 MHz).

Featuring a unique two layer design, ECCOPAD® is comprised of a back layer which is placed next to the metal and a front layer which sits next to the tag (see Figure 4). The back layer is made of a material with high magnetic permeability. This is essential for retuning the antenna in a reasonably thin layer. In contrast, the front layer consists of a pure dielectric material that fine tunes the performance of the tag antenna.

Figure 4. ECCOPAD® isolators are utilized in a range of applications, such as pictured here in grey.

The drawback of this type of solution is that since the electromagnetic properties of each RFID tag type is different, the ideal ECCOPAD® material will differ for each tag i.e. there is no universal isolator solution. The correct isolator material must be matched to the correct tag. Another drawback is that the full open air read range of the tag will not be achieved on metal. Depending on the tag and the isolator 6'-10' of read range can be achieved.

Conclusion

High-value asset tracking applications, such as with military supplies featuring metal casings and components, are especially prone to the problem of RFID read on metal. Several solutions are available, all with advantages and drawbacks. Key considerations are read range on metal, thickness and of course, price.