Technologies differ widely: How to Decipher Types of RFID Transponders

Think all transponders are alike? In the second of three articles on RFID technology, Robert Stewart discusses the applications, varieties and attributes of the transponder today.

RFID
Since the time that RFID systems were first conceived, technology and innovation have proliferated. This proliferation has resulted in a variety of transponder technologies, each with distinct advantages and capabilities. In this second of three articles on Radio Frequency Identification systems, we review these transponder varieties, their unique attributes and typical applications.

Basic transponder technologies
early RFID systems were comprised of relatively unsophisticated transponders, with capabilities limited to emitting primitive and characteristically simple identification signatures. The most economical RFID systems employed transponders that were passive, low frequency and full-duplex.

A passive transponder does not contain an integral power source, such as a battery; the transponder is instead powered by energy that it absorbs from the reading equipment used to scan its identification code. Low frequency means that the radio frequency (RF) spectrum in which the transponder operates is between 100 kHz and 500 kHz. Full-duplex means that the transponder transmits its identification code information simultaneously with the receipt of the energy from the reading equipment.

In exchange for the relative low cost of RFID systems with these traits, performance is very range limited—usually less than 1 meter of reading distance—and these systems can be susceptible to electrical noise interference that can be generated by a variety of electrical machinery, power distribution systems and other low frequency sources. But a major advantage of transponders of this type is that they can be miniaturized in extremely small packages. For example, small glass pellets measuring 2 mm in diameter and 12 mm in length, or small coin-like disks measuring 12 mm in diameter and 1 mm thick, are commonly available. Such transponders can be installed in many objects, such as automobile keys, without altering the original dimensions of the object, and are quite rugged and long-lasting.

In contrast to full-duplex transponders, the TIRIS™ RFID system by Texas Instruments was developed based on a half-duplex concept. In half-duplex systems, the reading system emits an energy field for a finite length of time—usually between 50 and 100 milliseconds in duration—and within this interval, the transponder absorbs and stores energy in an internal electrical component called a capacitor.

When the energy field ceases, the transponder uses the energy stored in the capacitor to power the transponder and enable it to transmit its identification code, much like a very small rechargeable battery would. This half-duplex system can produce superior read range performance—typically up to 50 percent greater distance for comparably sized transponders. This is a consequence of the transponder's storing of energy and transmitting its ID code information during an interval when there is no interfering energy field generation signal.

An active transponder device contains its own power source, typically a small battery cell that powers the transponder upon receipt of an activation command pulse from the reading system. The advantage of an active transponder is that it can transmit a significantly stronger identification code signal, which is detectable at a much further distance than is possible with a passive transponder. The half-duplex system can be considered a pseudo-active transponder: While it does not contain a power source, it does operate with many of the same advantages of an active transponder, and its cost and size are considerably smaller than a transponder containing an integral battery.

Covering the spectrum

Transponders typically operate within one of three RF spectrums: (a) the aforementioned low frequency spectrum—100 kHz to 500 kHz; (b) intermediate frequency—30 MHz vicinity; and (c) high frequency—0.9 GHz to 2.5 GHz. The lower frequency systems are more economical but offer less performance with respect to several attributes. Intermediate and high frequency systems provide performance advantages, but equipment and transponder costs are typically much higher.

Summarizing the transponder technologies discussed thus far, we can classify them with respect to these three categories:

Transponder Type: active or passive—an active transponder contains an integral power source, while a passive transponder is powered by energy absorption from the reading system.

Duplex Mode: full-duplex (FDX) or half-duplex (HDX)—a full-duplex transponder transmits its identification code information simultaneously with receipt of the reader's energy signal, while a half-duplex transponder absorbs the reader's energy, stores it and transmits its ID code information when the energy signal ceases.

RF Spectrum: low, intermediate or high frequency—the operating frequency is generally proportional to system cost and system performance. Table 1 provides a comparative assessment of RFID system performance as a function of Transponder Type, Duplex Mode and RF Spectrum.

Using the assessments provided in **Table 1**, for example, the maximum performance for read range would be achieved with an RFID system characterized by an active transponder operating in the HDX mode at high frequency. Similarly, a hostile environmental application would be best satisfied with a passive, low frequency transponder operating in either the FDX or HDX Duplex Mode. If electrical noise is another characteristic of such an application, HDX would likely perform in a superior fashion.

	Transponder Type		Duplex Mode		RF Spectrum	
Performance Attribute	**Active**	**Passive**	**FDX**	**HDX**	**Low**	**Intermed and High**
Read Range	+	-	-	+	-	+
ID Code Acquisition Time	0	0	-	+	+	-
Reliability[1]	-	+	0	0	0	0
Transponder Package Size	+	-	-	+	-	+
Complexity & Cost	+	-	-	+	-	+
Data Capacity During Transmission	0	0	0	0	-	+
Error Probability	-	+	+	-	+	-
Electrical Noise Immunity[2]	+	-	-	+	0	0
Environmental Susceptibility[1]	-	+	0	0	+	-

+ Greater
- Lesser
0 Equivalent
Note 1: Relative Reliability and Environmental Susceptibility are limited only by the battery characteristics of the active transponder.
Note 2: Low, intermediate and high frequency RFID systems can be adversely affected by electromagnetic interference occurring within the same spectrum as the RFID system.

Table 1 Comparison of RFID System Performance

Advanced technology transponders

Transponder technology traits discussed thus far apply primarily to the physical considerations of a particular application—that is, what levels of performance are required from the RFID system. Advanced technology transponders that have been recently introduced by several manufacturers build on these basic traits, and offer capabilities that focus on the RFID system application—that is, what information capabilities are required from the RFID system.

Three additional parameters can be used to classify transponders with respect to their information capabilities: (a) transponder data; (b) transponder protocol; and (c) transponder intelligence, or IQ.

Transponder Data—With respect to data capability, a transponder can possess one or more of the following three technologies:

a. Read-only or Read/Write—a read-only transponder has permanently programmed ID code information stored in it, while a read/write transponder can have its code information contents modified by the reading system.

b. Extended Memory—transponder information is typically stored internally in partitioned sections called pages. Each page of memory, comprising 64 to 128 bits of information, for example, can be read sequentially or on a random access basis by the reading system.

c. Data Acquisition—some transponders are equipped with micro-sensors, or transducers, capable of sensing physiological information, such as temperature, for example. The value of the measured characteristic is transmitted within the ID code information when the transponder is interrogated by the reading system.

Transponder Protocol—Most RFID systems cannot read more than one transponder at a time. That is, if two or more transponders are placed within the detection zone of a reading system, the transponders data transmissions collide. The simultaneous receipt of two or more transponder signals by the reading system prevents any of the transponder signals from being properly detected. (Note: in some systems, if there is significant spatial diversity between the transponders, the reading system can detect the one producing the stronger signal; but if the transponders are collocated, detection is generally not possible.)

One of several exceptions to this limitation is the Supertag® system, manufactured by Samsys

Incorporated of Toronto, Canada. The Supertag transponder technology employs a data collision avoidance scheme that prevents transponders from transmitting information simultaneously. The Samsys RFID system permits the simultaneous reading of multiple transponders—up to as many as 50—at distances up to 4 meters.

Transponder intelligence (IQ)—Most RFID transponders are technically “dumb” devices. They contain either certain fixed information that is permanently integral to the transponder, or information which can be altered on user command, or sensed from integral transducer elements. None of these conventional devices, however, have the ability to make decisions on an “if-then-else” basis.

An exception to the conventional transponder device is the MicroStamp® module, manufactured by Micron Communications. As described in an article appearing in Petroleum Equipment & Technology magazine (Sept/Oct 1997, page 24), the MicroStamp® unit includes microprocessor technology within it that enables the unit to be used in a variety of innovative applications where information processing intelligence in the transponder provides an advantage.

Advanced technology transponders that provide enhanced forms of data, protocol and/or intelligence, use one form of each of the three basic characteristics—type, mode and RF spectrum—discussed in the first part of this article.

For example, TIRIS’s transponder technology is based on passive, HDX, low frequency technology. TIRIS™ offers advanced technology transponders with extended memory and read/write capability, for example, that continue to operate with passive, HDX, low frequency characteristics. Micron’s MicroStamp® technology is fundamentally an active, HDX, high frequency system; however, it can be further classified as having intelligence, as well as read/write, extended memory and data acquisition capability.

Table 2 summarizes the characteristics of advanced technology transponders.

In the next issue of PE&T, our third of three articles will review some of the past and current efforts to standardize certain operating characteristics of RFID systems. The goal of this standardization is to allow the combining of transponders and reading systems from various manufacturers within a single user’s system application.

	Transponder Data		**Transponder Protocol**		**Transponder IQ**	
Transponder/System Characteristic	**Read-only**	**R/W, Ext Mem, D/A**	**Single**	**Multiple**	**Intelligent**	**Dumb**
Complexity & Cost	-	+	-	+	+	-
Data Transaction Time[1]	-	+	-	+	+	-
Transponder Package Size	-	+	-	+	+	-
Data/Info Capacity in Device	-	+	0	0	+	-
Application Sophistication	-	+	-	+	+	-

+ Greater
- Lesser
0 Equivalent
Note 1: Transaction time assumes comparable operating frequencies and data transfer rates.

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