Technology Brief 13: RFID Systems

In 1973, two separate patents were issued in the United States for Radio Frequency Identification (RFID) concepts. The first, granted to Mario Cardullo, was for an ***active RFID tag*** with rewritable memory. An active tag has a power source (such as a battery) of its own, whereas a ***passive RFID tag*** does not. The second patent was granted to Charles Walton who proposed the use of a passive tag for keyless entry (unlocking a door without a key). Shortly thereafter a passive RFID tag was developed for tracking cattle (Fig. T13-1), and then the technology rapidly expanded into many commercial enterprises, from tracking vehicles and consumer products to supply chain management and automobile anti-theft systems.

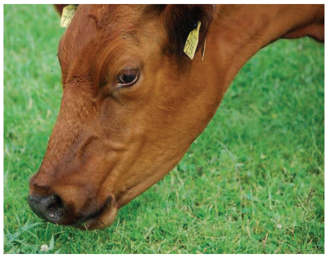

Figure TF13-1: Passive RFID tags were developed in the 1970s for tracking cows.

RFID System Overview

In an RFID system, communication occurs between a ***reader***—which actually is a ***transceiver***—and a ***tag*** (Fig. T13-2). When *interrogated* by the reader, a tag responds with information about its identity, as well as other relevant information depending on the specific application. The tag is, in essence, a ***transponder*** commanded by the reader. The functionality and associated capabilities of the RFID tag depend on two important attributes: (a) whether the tag is of the active or passive type, and (b) the tag's operating frequency. Usually the RFID tag remains dormant (*asleep*) until activated by an electromagnetic signal radiated by the reader's antenna. The magnetic field of the EM signal induces a current in the coil contained in the tag's circuit (Fig. T13-3). For a passive tag, the induced current has to be sufficient to generate the power necessary to activate the chip as well as to transmit the response to the reader. Consequently, passive RFID systems are limited to short ***read ranges*** (between reader and tag) on the order of 30 cm to 3 m, depending on the system's frequency band (as discussed later). The obvious advantage of active RFID systems is that they can operate over greater distances and do not require reception of a signal from the reader's antenna to get activated. However, active tags are significantly more expensive to fabricate than their passive cousins.

RFID Frequency Bands

Table T13-1 provides a comparison among the four frequency bands commonly used for RFID systems. Generally speaking, the higher-frequency tags can operate over longer read ranges and can carry higher data rates, but they are more expensive to fabricate.

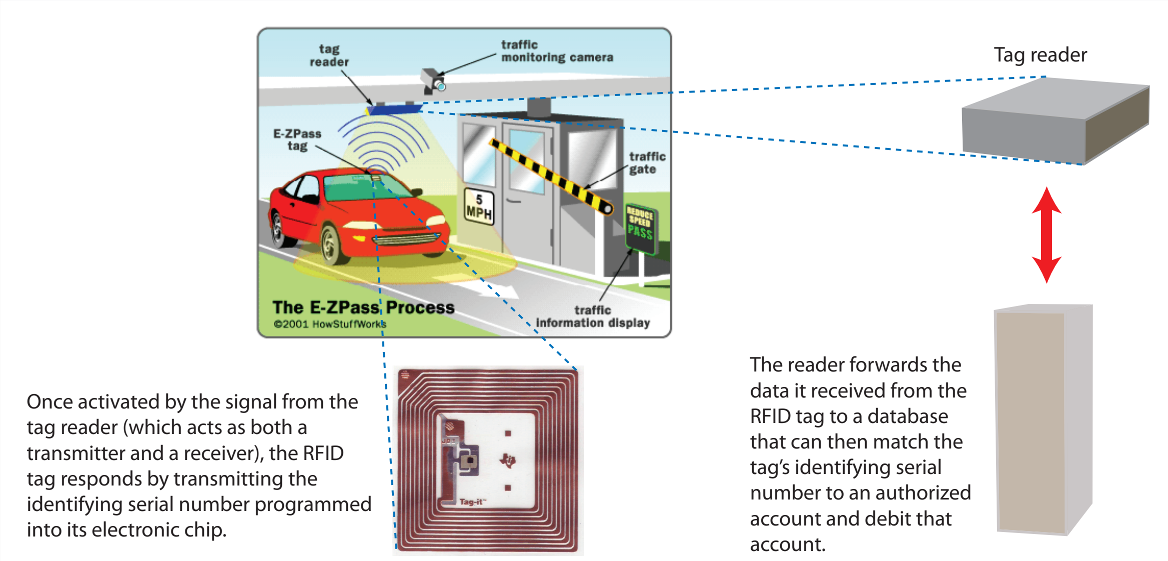

Figure TF13-2: How an RFID system works is illustrated through this EZ-Pass example.

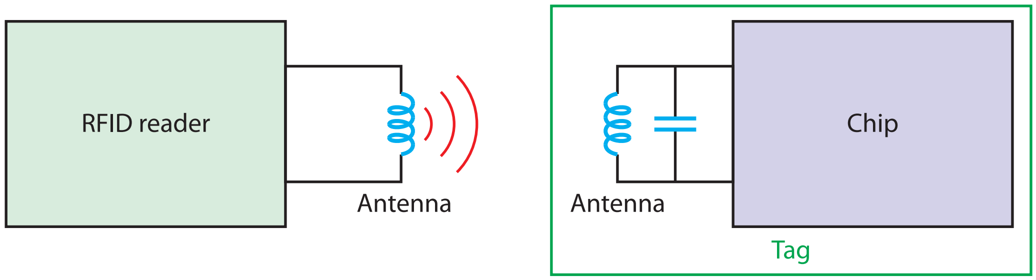

Figure TF13-3: Simplified diagram for how the RFID reader communicates with the tag. At the two lower carrier frequencies commonly used for RFID communication, namely 125 kHz and 13.56 MHz, coil inductors act as magnetic antennas. In systems designed to operate at higher frequencies (900 MHz and 2.54 GHz), dipole antennas are used instead.

Table 0-2: Comparison of RFID frequency bands.

Band	LF	HF	UHF	Microwave
RFID frequency	125–134 kHz	13.56 MHz	865–956 MHz	2.45 GHz
Read range	$\leq$ 0.5 m	$\leq$ 1.5 m	$\leq$ 5 m	$\leq$ 10 m
Data rate	1 kbit/s	25 kbit/s	30 kbit/s	100 kbit/s
Typical applications	• Animal ID • Automobile key/antitheft • Access control	• Smart cards • Article surveillance • Airline baggage tracking • Library book tracking	• Supply chain management • Logistics	• Vehicle toll collection • Railroad car monitoring