Current trends in transponder systems

Major successes using RFID technologies in use today are:

Electronic Article Surveillance (EAS)

Market penetration of this technology is already reportedly reaching 6 000 million units per year and growing strongly. However there is still lack of standardisation between the different manufacturers, which causes confusion with the end users.

Shipping Container and railcar tracking

One of the early success of transponder technology and fast becoming a global system. Based around electric coupled transponders that are attached to each container and railcar, being read at speed by readers alongside the rail track. One manufacturer claims to have already labelled 4 million rolling stock items using this technology.

Animal tracking

Originally a series of magnetic implantable transponders were developed for tracking slaughter animals. Unfortunately success in this application has been poor mainly due to lack of acceptance by the relevant authorities.

The labelling of pets so that they can be identified and returned to the owners has become a major consumer of RFID systems. Some municipalites require all pet dogs withing their jurisdiction to be identifyable via an embedded transponder that is injected under the skin. Small RFID transponders, 8mm long and less than 1 mm in diameter, have been developed that are suitable for injecting under the skin of the pet. The data within the transponder can be read using a scanner a couple of inches from the animal.

Implantable and external transponders are being successfully applied in the research of the habits of wildlife, both fish and animals.

Prior to 1997, cows had usually been labelled by ear tags that combined a visual reference with an RFID transponder. A new series of RFID tags have recently been developed called Ruminary tags, tags that are encased in a tough plastic case which can be fed to the cow with its food, and will reside in the stomach of the cow for the life of the animal. These tags are resistant to attack by the acids in the stomach and operate using magnetic coupling techniques with readers outside the animal.

Vehicle access and control

Electric field coupled transponders have been used for many years to allow vehicle access to garages in buildings. Generally these transponders are relatively expensive but as they are reuseable, and are attached to expensive cars, their use is cost effective.

Personnel access

Personnel access has long been facilitated by RF transponder technologies. This solution has not been widely accepted, mainly due to the limited reading range, relatively expensive technology, and the success of the magswipe cards as a viable alternative.

Production control

Most probably led by the automobile industry, many factories use transponders to identify and trace their goods during the manufacture process. These transponders are generally sophisticated, including read write features, and are reused once the manufacturing process has been completed.

Ski passes

For many years magnetic based transponder technology has been used in ski passes, allowing its identity to be read through ski clothing at access points to ski lifts, etc

Sports Timing

Particularly for long distance racing and for marathon racing, the use of transpoinders for timing is becoming more common place. Currently the preferred technology is to use a small 125kHz transponder attached to the shoe of the athlete which is read by the athlete tramping on one or more sensor mats across the timing line. The technology records the presence of the athlete but is not suitable for accurate timing as it can only sense the time when the athletes foot touches one of a number of mats. 900 Mhz technology has been recently used in South Africa and this might be very promising in such applications, as besides having 4 to 6 meter reading ranges allowing overhead antennas to sense the athletes, timing accuracies better than 2 tenths of a second seem possible

Document authentication

A system of providing a radio frequency "signature" for documents is becoming commercially available. The system comprises printed radio frequency antennas attached to precut crystal resonators. The interrogating frequency of the reader sweeps through the reading frequency band, causing the crystal resonators to resonate when excited at the correct frequency. By choosing frequencies to indicate specific data, documents can be given a radio signature that can be used for verification of documents. Novel applications include the enabling or preventing of photocopying of certain documents depending on their signature.

The matrix comprising the antenna and crystals can have a footprint as small as a postage stamp and is available even in a thin layered paste. Currently the developers claim 400 million such radio frequency signature transponders are now in circulation.

Dairy tagging

This technology is widely accepted throughoutthe world, particularly for identifying cows in a dairy. By using eartags a computer system is able to identify the cow when close to the reader. This identification allows a computer to record the milk output of the cow and also allows it to provide the correct feed mixture to the particular cow while it is being milked. These feature allows a few staff to manage a large herd and also to change the diet of the cow through different phases of its milking cycle. Recently an Australian State has called for a marking system to be applied to all herd animals in the region.

Petrol and chemical dispensing

Companies conveying different chemicals in road and rail tankers are seeking technologies to allow computer verification that the tanker is only filled from the correct nozzle in order to prevent contamination of product. This has resulted in developments of transponder systems suitable for attaching to the filling nozzles and computer compatible reading equipment to verify the identification of the nozzle and the tanker before allowing loading. A recent patent proposes extending this principle to petrol stations. By placing a small transponder alongside the filler cap of motor vehicle's fuel tank, whereby the pump can sense the users requirements automatically to dispense the correct fuel grade as well as authenticate the accounting systems. For identifying customers and debiting their credit cards with the appropriate charges, two major petrol companies are trying out transponder systems. Mobil is using Speedpass and Shell is calling its system EasyPay. Transponders are either windscreen mounted, operating at the 900 or 2.45GHz band which communicate with reading equipment situated in the pump alongside which the motorist pulls up, or they are 125Khz magnetic coupled versions in a key ring holder, where the motorist swipes the transponder over a reader at the pump to provide identity details. TIRIS have aligned with a pump manufacturer to provide systems complete with pumps.

Enviromental monitoring of transport environment

A company in Canada has recently developed an active tag with a large memory, programmable microprocessor, sensors and RFID communications interfaces that allow the tag to monitor at regular intervals the enviromental conditions experienced by the tag and its labelled cargo while in transit. This could have application in the shipping of for example frozen goods allowing the recipient to verify that their shipping requirements were adhered to.

In addition there are many different successful applications of the technology, but most probably not yet at the level of being a "trend".

Future trends in transponder systems

Before looking at applications, there are some industry driving issues that will steer the future of these technologies:

Manufacturing methods

Tags consist of antennas, electronic circuitry, and energy sources. Passive tags, that is those that receive their energy from the energising field, can dispense with the need for energy sources. Electronic circuitry has already advanced to the stage where the electronic circuitry is implimented on a single circuit. The last major manufacturing hurdles are the antenna system and the packaging.

Technological design

Whereas initially RFID tags were based on magnetic coupling techniques, assisted by the then limitations in semiconductor design methods, and the desire to operate at frequencies below the minimum licensing frequency (135KHz), resulting in tags that could only be read single and over short distances, requirements for distance are resulting in new technologies coming to the fore.

Major applications are starting to appear in the 433MHz band, the 915MHz band and soon in the 2.45GHz and 5.6GHz band. The latter two bands are still technically challenging for the semiconductor industry. With increasing range, it is necessary to be able to read many transponders at the same time, as the chances of finding a volume in which only one transponder will be present is ever reducing.

Transponder price

Due to current manufacturing techniques, pricing in the different RFID technologies seems to have reached a plateau. Current developments that will see the light of day in the next few years, are likely to to drastically reduce the production price, allowing far greater commercial penetration of RFID technology. This reduction will allow EAS and identification features to be merged into a single product suitable for the retail labelling market.

Spectrum allocation

When deciding to operate above 135KHz, it is necessary to acquire an operating frequency allocation from the regulatory bodies. As RFID becomes more popular, this allocation will become a valuable asset. Applications that are driving the developments of RFID Technologies are among others:

EAS security applications

In the next few years there will be rapid expansion of the EAS market penetration. Particularly in the Western World, shoplifting has become a major problem and has created a massive need for low cost anti-shoplifting solutions. At present there are a variety of technologies ranging from amorphous magnetic strips, to destructible tuned circuits. The primary issue is to develop very low cost techniques in view of a transponder being needed on every item.

Electronic car security

Major developments are happening particularly in Europe, where short reading range transponders (magnetic coupling) are being included in motorcar keys, allowing the onboard management computer to verify the authenticity of the key to try to reduce motor car theft. The advantage of this method is that since the management system controls the fuel injection, timing and performance of the engine, an invalid identity allows the management system to completely close down the motor vehicle engine. Communication between the sensor of the key and the engine management system is accomplished by a system of codes dependent on the value of the ID transponder so that thieves cannot simply cut appropriate wires and bypass the communication system.

Toll roads

With more local authorities funding their motorway development by taxing users, toll booths have been established on many of the countries highways. Unfortunately a motorway is there to move traffic relatively quickly between points, and slowing the traffic down at paypoints to collect funds is very disruptive. Major attention is being focussed on trying to use RFID techniques to recognise and automatically charge the drivers of the vehicles at pay booths without requiring them to slow down. Unfortunately these efforts are fragmented and few global standards are in place. One light of hope at the end of this lack of standards tunnel, is that in April 1993, Lawrence Livermore National Laboratory published a report on their proposed solution and the results from their demonstration model, of a system that they had developed for the California Depertment of Transport (CalTrans). This development was funded by the US Dept of Energy. This system allowed car mounted tranponders to be read up to 5 times during the period they travelled only 1 meter even at speeds as high as 160kph (100mph) on a five line highway. Frequency allocations are generally at 915 MHz (Caltrans/Sidney) but more recently allocations are being used at 5.8GHz (Melbourne). The later frequencies require active tags and state of the art manufacturing technologies. Up to April 1997 there were already a reported 1.8million transponder tags for toll roads in use.

On the 1 April 1998 Singapore turned on the S$197 million Electronic Road Pricing (ERP} system. With ERP in place, Singapore is the first country in the world to use ERP for traffic management. Transponders are window mounted and cost about $150 each.

Postal systems efficiency

Governements are keen to monitor automatically the efficiency of their postal systems. Companies are developing transponder systems that can be incorporated into dummy letters and pass through the postal system being monitored by readers remotely to estimate actual system efficiency.

Postage stamp replacement

Developments are taking place and patents being granted for systems where the postage stamp will contain a transponder that can be used by the postal authorities for routing, and for cancelling the stamp after use. No cost effective system yet seems to be in place.

Golf balls

A recently granted patent finally shows an effective method of finding lost golf balls on a golf course. For conventional transponders, the antenna placement and orientation with regard to the reader has always been a problem. The new system proposes fitting a radar corner reflector in the golf ball and using a search beam which can detect the reflection of the radiation beam over a short distance.

Gaming chips

Developments are happening in the gaming industry to incorporate transponders in gaming chips, thereby allowing slot machines to play with "coins" of a larger value than that of the highest coin value of the countries currency, to limit counterfeiting, and to allow machines to accurately "read" the value of the chip.

Criminal penal monitoring

Recently systems are being tried out to monitor the presence of a convicted criminal within a zone. The system would be used to impose and monitor house arrest imposed by the courts, rather than sending the criminal to prison. One system under test, involves a transponder in a band attached to the person's ankle, and an associated receiver in the house which monitors the presence continually.

Smart appliances

Recent developments and published patents detail improvements in home appliances using RFID technology. In one case a company has developed an intelligent fridge which uses transponders attached to the bottles to detail the contents of the fridge on a TV screen or PC. Such developments would have application in situations such as bar fridges in hotel rooms.

A recent patent details the concept of embedding transponders into clothing and encoding the transponders with washing, folding and ironing information. Appliances can then interrogate the garment and set up the correct washing cycle, water temperature and spin cycles for the garments. A feature is to write back to the transponder the number of washing cycles the garment has been exposed to to compensate for the age of the garment.

Remote controlled computer access

An interesting development recently from the US is the concept of adding a transponder to the clothes of the operators of a PC, which presence is sensed by a reader in the PC allowing the PC to lock up the computer system and unlock the computer system whenever the operator leaves or approaches his workstation. This system prevents others tampering with the computer and data providing RF controlled security.

Airline baggage

With the suitablility for automatic sorting and routing of luggage within the air terminals, the tagging of airline luggage using RFID transponders is an ideal application. As the luggage can be tagged when it is accepted and its details linked to a datafile in a computer system, it is then viable for the luggage to be routed to the correct aircraft luggage loading bay, and for the progress of the luggage through the transport system to be monitored for later quering if it is necessary.

A complication for RFID tagging in this application, is that the RF field used for reading the RF tags, will also penetrate the luggage and would read any tags contained in the luggage. These other tags will provide confusing signals, or even provide interferring signals that might jam the reader system for the luggage tags. To minimise these effects, tag systems that are able to read multiple tags at a time might be used together with an organised numbering system so that the luggage tags might be differentiated from any goods that are tagged.

In 1998 tests are reported to be starting to evaluate different RFID tags.

Warehousing control
Manufacturing methods
Logistic measurements
Parcel routing
Libraries
Postage stamps
Battery developments

Can RFID tags replace barcodes cost-effectively?

Recently two statements have been published suggesting that because the price of a barcode is so low, it is unlikely that RFID would be a viable replacement

In the one case the statement was:

"I see RFID tags replacing bar codes in [more expensive] garments, for instance. But I don't see it happening in the supermarket. People have talked about replacing U.P.C. code with RFID, but I don't think it will ever happen. Because nothing's cheaper than zero. And it literally costs nothing to put a U.P.C. code on a package. You just integrate a bar code into your artwork and print it; it doesn't cost anything. And they're never going to bring an RFID tag down to a hundredth of a cent, or even less. Anything that it costs is going to cost more than zero."

while the other read::

"Its highly unlikely that the technology will ultimately replace bar code- even with the inevitable reduction in raw material costs coupled with the economies of scale, the integrated circuit in the RF tag will never be as cheap as a barcode label."

Both of these commentaries seem to be based on the premise that because a barcode label is integrated into the display packaging of the product, it is very cheap.Surely the real issue is what are the productivity benefits by using an RFID tag, *versus* a barcode, *versus* a numeric number? Barcodes have made their presence felt in society almost solely around potential productivity benefits they could offer. Surely at their inception, nobody would every believe that technology was advancing in a cost effective manner by adding some squiggly lines to a package that nobody could interpret without first purchasing some very expensive and then crude scanning equipment, compared to the then product identification methods in place. That barcodes have existed is in the belief that oneday it would be such a widespread system and scanners would be so cheap that by providing machine readable tags productivity benefits over the manual systems would be realised.

Barcodes are now widely accepted, particularly with the order that the UCC and EAN have brought to product labelling, as well as advances in computer systems allowing the data in the barcode label to act as a pointer to the appropriate description and pricing information. However barcodes do not cost only the cost of the ink on the packaging. The user needs to buy sophisticated scanning equipment, information systems, communication systems and manage databases just to be part of the user group for benefiting from machine readable labels. Simultaneous with the wide spread recent acceptance of barcode scanning by retailers and manufacturers, has been the growth of the EAS (Electronic Article Surveillance) industry. For some reason, maybe either for kicks or because of the chosen methods of selling goods, first world countries such as the USA and Europe suffer from a shoplifting disease that does not seem to be as widespread in developing countries. This disease has led to the growth of an EAS industry, to combat the shoplifting shrinkage which has been reported as high as 12% of turnover in some industries. The solution to the problemhas been to mark goods with a RF tag (one bit) which triggers an alarm if not deactivated before passing through a sensor's field at the exit to the shop. More than 6 billion such tags are reported as being sold in Europe alone, at prices as high as US$0-06 each. Recent documents from the US indicate that the estimated shoplifting per annum is in excess of $12billion and that the EAS industry in addition supply $10billion worth of equipment.

The RFID tag to replace barcodes is about to arrive from a number of different suppliers who are all working towards this goal. At the end of the day, all the tags offered will comprise of a small integrated circuit and an antenna in some form. With the departure from the 125KHz frequency range by manufacturers targeting this market, the need for expensive 1000 turn coils is gone drastically reducing the delivered price of the new technologies. While features may vary from supplier to supplier (e.g one claims it can read 1000 items at a time at 4 meter range with 3D orientation) almost all the new generation suppliers have included EAS features as standard, meaning that besides offering fast computer scanning, high accuracy, long range reading distances, and reading signals that penetrate packaging, besides other features, the EAS virtually comes for free. In addition the cost of an RFID scanner is generally very low, as it uses simple well established simple technology in simple packaging.

RFID can also benefit not just the retailer, but all parties from the manufacturer, distributor, logistics operator, retailer and the user. For example, in a recent patent application a washing machine with an inbuilt RF scanner and RFID tags in the clothing, automatically senses the requirements of the clothes being loaded to be washed and adjusts its program accordingly. For productivity from Australia comes a trolley scanning design for a checkout aisle which by combining an RFID scanner, an EAS scanner and credit card processing features, an unmanned self service checkout with full EAS features can be offered.

Of course the arrival of RFID is not going to remove the need for barcode labels on goods, as there are always going to be those users that have existing equipment, or purchase second hand equipment for low levels of machine readable tagging, or just want to operate a generation behind. The rollout of RFID as a viable replacement is not without its hurdles, particularly the size of the project that will require many players involvement and initially only allow leading/forward-looking retailers to be involved. The reality of the situation is that RFID is going to win its major position in these applications through real productivity enhancements and benefits for the users, which will completely outweigh that it might cost more than the price of the ink on the barcode label.

In February 2001, three major RFID producers, two from Europe and one from the USA, announced that they were submitting a combined proposal for RFID for retail applications to the EAN/UCC, the global bodies that allocate numbering systems (commonly implimented in barcode form) for manufacturers of products that are sold through retail stores. The EAN/UUCC have been an active driver of this process of integrating RFID into retail having full time staff allocated to the project and having received a number of proposals todate. The standard is to be known as GTAG (or ISO18000) although at present it is just a broad framework without being very specific.

In 2001 Ford Motor company specify that all tyres provided in future vehicles are to contain a UHF transponder to allow speedy identification. This is a major position change from the opening statements of this editorial, all achieved in only 3 years. Funded by sponsors such as Proctor Gamble, the Auto ID Centre was formed with a view to developing a low cost RFID tag suitable for retail applications. This event did not realise a single universal design, but focused the interests of many suppliers on the problem. November 2002 saw the announcement by Gillette that it was not waiting for the development of any standard and would be ordering 500 million UHF transponders in March 2003. 2003 sees the start of the realisation that replacing barcodes with RFID systems unleasehes many productivity enhancements.

Editor

What are TRANSPONDERS

Transponders were originally electronic circuits that were attached to some item whose position or presence was to be determined. The Transponder functioned by replying to an interrogation request received from an interrogator, either by returning some data from the transponder such as an identity code or the value of a measurement, or returning the original properties of the signal received from the interrogator with virtually zero time delay, thereby allowing ranging measurements based on time of flight. As the interrogation signal is generally very powerful, and the returned signal is relatively weak, the returned signal would be swamped in the presence of the interrogation signal. The functioning of the Transponder was therefore to move some property of the returned signal from that of the interrogation signal so that both could be detected simultaneously without the one swamping the other. The most common property to change is the transmission frequency meaning that the transponder might receive the interrogation frequency at one frequency, and respond on another frequency that is seperated sufficiently with regard to frequency so that both may be detected simultaneously.

Transponders were initially used in World War 2 on aircraft to identify the aircraft using IFF (Identify Friend or Foe), where friendly aircraft would respond to secret preprogrammed interrogation codes and indicate to the radar operators that they were friendly aircraft. Today Transponders are still used extensively on commercial aircraft to relay to the radar operators the height and identity of the aircraft on their radar displays. Another important use for transponders has been in the measurement of distance. Here the interrogator sends a signal to the transponder, which immediately responds on another frequency. By measuring the time from the sending of the initial signal by the interrogator, to the receipt of the signal from the transponder, and calculating the effective double path travelled using the speed of light, the distance between the transponder and the interrogator can be determined. The accuracy of such systems is limited to fractions of a meter using electromagnetic propogation systems due to the limits in determining the transmission times with sufficient accuracy. (A system called Tellurometer invented in the 1960's improved this resolution over distances of 100's of kilometers to a few centimeters, but although this still used transponders, it was not based on the principle of time of flight).

Another major category of Transponders which is not the subject of this newspaper, is the use of transponders in radio relay systems such as fixed/mobile radio networks and satellite transmissions. The same principle applies in that the data is transmitted on a carrier frequency at one frequency, and rebroadcast on a carrier of another frequency, allowing the strong and weak signals to co-exist.

Transponder systems have recently started to become major players in the field of electronic identification. Within this application, it is necessary to make the transponders as cheap as possible, and to rather build the sophistication into the readers. This lack of sophistication generally means that changing the transmission frequency is no longer an option, as the frequency translation needs expensive and complex tuned circuitry. Instead the transponders have given up the ranging ability and rather time slice the communications channel with the interrogator. Here the interrogator (called a reader) sends an interrogation signal for a limited time. The transponder receives the signal and waits for its completion, and then responds on the same frequency with its identity and data code. (There are more complex methods but this covers the basics.) The devices are sometimes called transponders and are also sometimes called *tags*, most probably because their end application eventually will be the tagging of goods. Transponders vary in selling prices from $1000 US down to $0-20, depending on application and features.

What are RFID systems

RFID stands for *radio frequency identification*. It is a widely varied collection of technologies for various applications, ranging from the high speed reading of railway containers to applications in retail that can be regarded as a potential successor to the barcoding technologies in use today. RFID is based around radio or electromagnetic propogation. This has the ability to allow energy to penetrate certain goods and read a tag that is not visible thereby to identify those goods remotely, either in the form of an identity code or more simply that something is present (EAS). Different frequencies of the radio system result in different reading ranges and properties of the system.

Commonly available tags have an operating frequency in the range from 60kHz to 5.8GHz depending on application.

In operation one can generally say that there are three different types of technologies being implimented. They are:

- Magnetic based RFID technologies
- EAS based technologies
- Electric field based RFID technologies

EAS systems

EAS stands for Electronic Article Surveillance. Becoming more common in the retail industry nowadays, the EAS systems are used to electronically detect goods that have not been authorised when they are removed from a retailer. The systems comprise a tag attached to the goods and a sensor mechanism. The tag can be neutralised by the retailer when he wishes to authorise the removal of the goods, for example when the items have been legitimately purchased. In effect, EAS systems are single bit RFID systems, able to convey their presence, but not having sufficient data capabilities to convey an identity.

Presently there are four major technologies used for EAS systems. They are:

- Microwave
- Magnetic
- Acousto-Magnetic
- Radio Frequency

Market penetration is currently estimated at 6 000 million tags per annum at $0.12 each

The different EAS technologies have widely differing performance in the issues of price, reading range and reliability. The Magnetic and radio-frequency versions are very cheap and are generally attached permanently to the goods or their packaging, while the microwave tags are expensive and are removed by the store personnel when the item is paid for using a special removal tool.

Markers that are left on the goods and neutralised by the sales staff are called deactivatable.

One type of deactivateable marker is in the form of an electronic circuit comprising inductance and capacitance elements which resonate at radio frequencies. Another type of marker - a magnetic marker - comprises a strip of soft magnetic material which interacts with a ferromagnetic element made of a hard magnetic material which can be magnetised or demagnetised. The soft magnetic strip resonates and generates harmonics in the presence of a magnetic field having a certain frequency. This allows the marker to be identified. The hard ferromagnetic element can be magnetised or demagnetised thereby deactivating or activating the marker.

Another type of marker is the acouto-magnetic or magneto-mechanical marker. This type of marker comprises a strip of magnetostrictive material and a strip of magnetic material of high coercivity. The magnetostrictive material resonates mechanically in the presence of a magnetic field of a particular frequency. This resonance can be detected by a receiver sensitive to the magnetic field created by the mechanical resonating magnetostrictive material. The marker is ordinarily deactivated by modifying the magnetic bias of the strip of magnetic material. The above systems are commercially available from many competing suppliers.

EAS is a simple addition to electronic RFID systems whose developments have been announced but are as yet still not commercially available. The advantage of such systems with regard to EAS, is that

- they would broadcast not just the presence of the item triggering the alarm system, but the actual identity of the product
- they would be turned on and turned off by command allowing the same tagging system to have application at all stations from the manufacturer, through the distribution channels, to the retailer
- controlling the tag would not be conspicuous, being incorporated into the reading protocol, rather than the terrible magnetic pads currently used by some retailers that wipes the information from wayward credit cards.
- as the system uses radio communications, the tags can be packaged inside the goods preventing the goods being removed while the boxes with the conventional EAS tags remain behind in the store.
- the EAS features are incorporated in the identification and tracking system for virtually no additional cost.

These systems are still in their infancy and have a long development path ahead.

Multibit EAS tags

The following article explains some experimental concepts in achieving multibit or multi-status from a modification of standard EAS techniques. Generally EAS tags are single bit devices and are not switchable in both the on and off direction using a programming signal.

A resonant circuit is one in which the values of circuit resistance, R, capacitance, C, and inductance, L, are chosen such that the reactance of the resonant circuit is a minimum at a resonant frequency.

One method that is used is for a resonant circuit to be disposed on a thin insulating dielectric substrate to form a tag for use in electronic article detection (EAS) schemes. Generally, the coil of the resonant circuit consists of a closed loop of a conducting element which has a certain value of resistance and inductance. A capacitive element which forms part of this closed loop consists of two separate areas of thin metal conducting film disposed on opposite sides of the dielectric. The tag is attached to articles to be protected from theft. An RF signal at or near the resonant frequency of the resonant circuit is emitted from a base station. When the tag is in the RF field, the tag's absorption can lead to a change in the tank circuit current of the base station and a power dip in a receiving coil. Either one of these two effects can be used to sense the presence of the tag and hence the item to which it is attached. Thus, an alarm can be made to sound when either of these effects are sensed by a pickup coil or by an amplifier, indicating improper removal of an item. To deactivate the tag, a relatively high RF power pulse can be applied at the counter at which the point-of-sale of the item takes place. This high power acts to short the capacitor or burn out a weak portion of the coil. In either case, the circuit is no longer resonant and will not respond to the RF interrogation from the base station. Therefore, the customer who has made a legitimate purchase at the point-of-sale counter can pass through the interrogation-sensing gate without setting off an alarm.

It is clear from this description that these tags, once deactivated, are not reusable. In addition, in the configuration just described, the tags are capable of only conveying one bit of information. Thus, they cannot give any information regarding the item's identification and are useful only for anti-theft applications. This kind of tag is normally classified as a single bit tag.

Some RF tags consist of a resonant coil or a double sided coil containing two thin film capacitors with the plate of each capacitor on opposite sides of the dielectric. Such tags can be used for source tagging and have an initial frequency that is different from the frequency used at the retail establishment for theft protection. For example the tag is designated as being in a deactivated state until the first capacitor is shorted by means of a high power RF pulse at the then resonant frequency. Disabling the capacitor shifts the resonant frequency of the RF circuit to the store interrogation frequency. A second deactivation pulse is used to disable the second capacitor at the point-of-sale when payment is received for the item to which the tag is attached. At this stage, the tag is no longer usable and has been permanently destroyed.

Some other systems have been proposed where two or more frequencies can be obtained on a RF coil tag by altering the capacitance of the circuit. In one case, a strong DC electric field is applied to change the effective dielectric constant of the capacitor. Thus, the circuit has two resonant frequencies depending on the value of the applied electric field. Due to the ferroelectric hysteresis, the tag can be deactivated by the application of a DC field. However, it can also be reactivated and hence re-used by applying a DC field of opposite polarity. In another version, a set of capacitors connected in parallel attached to an inductance have been described in which each dielectric of the set of capacitors varies in thickness. In this manner, a series of resonant frequencies can be obtained by applying different voltages (electric fields). Each of the capacitors then changes capacitance at a different electric field (voltage) levels depending on the thickness of the dielectric.

Another concept consists of an array of series capacitors connected in parallel with an inductor. Here, the resonance can be altered by selectively shorting one or more of the capacitors, thereby changing the resonant frequency of the resulting circuit. A frequency code can thereby be established by disabling or burning out selective capacitors at the time of interrogation, those capacitors becoming disabled which at the time of manufacture of the tag were "edimpled"u. The tag is not reusable once scanned since the code relies on burning out a capacitor during the scan cycle and observing the change in frequency. Thus, once the tag has been queried its capacitive elements become irreversibly shorted and hence the tag cannot be scanned again.

An idea for a reusable tag comprises of two ferromagnetic elements, one soft (low coercivity) and one hard (high coercivity) both physically covering a portion of an R.F. coil. The ferromagnetic element with high coercivity can be magnetized to apply a bias field to the soft material to put the latter into saturation. In that state, the R.F. field generates very small hysteresis losses leading to a relatively high Q of the tag circuit. On the other hand, when the hard magnet is demagnetized, the RF field results in hysteresis losses in the soft material which lowers the Q of the circuit. This change in Q can be used to determine whether a tag is active or has been deactivated.

A reader apparatus for interrogating and sensing the presence of a RF resonant tag is realised where the interrogating frequency is swept around a center frequency. In general, there is very little radiation emitted except when the tag is present in the field of the emitter. Thus, when there is no tag in the antenna field, very little energy is lost from the antenna circuit. When the swept frequency coincides with the resonant frequency of an active tag, energy is absorbed and a sensing circuit detects a drop in voltage level in the interrogating antenna oscillator circuit. The tag absorption occurs twice with every complete sweep cycle resulting in a negative dip in the oscillator circuit. The negative dip causes pulse modulation which is filtered, demodulated and amplified to cause an alarm to be activated, indicating theft of an item. Thus, the basic detection is achieved by varying the interrogation carrier frequency to match the resonance of a tag whose center frequencies span a range depending on the type or make of tag.

Using wires for identification

The following is an extract from US Patent 5729201 invented by Jahnes, Christopher; Gambino, Richard;Paunovic, Milan ;Schrott, Alejandro; and von Gutfeld, Robert where there is a description of prior art that describes the operation of the magnetic based technologies physics which are relevant to many EAS systems

Retail tagging, tagging used in the road/air-freight package industry, personnel identification tagging, pallet tagging in manufacturing processes, etc., requires a tag for identifying a product, article or person in detail. With a sufficient number of bits, the tag can be interrogated to yield useful information such as what the product is, its date of manufacture, its price, whether the product, article or person has been properly passed through a check-out counter or kiosk, etc. Further, identifying a large number of products via tags can lead to a new type of check-out system for the retail industry giving rise to the much hoped for "no-wait check-out". Conventional tags and tag systems have had a number of problems including: 1) having only one bit, typical of anti-theft tags, or 2) requiring a large amount of power to read the tag, thus requiring a tag battery (or other suitable power source), or 3) being relatively easy to defeat by tampering.

Multibit, remotely-sensed tags are needed for retailing, inventory control and many other purposes. For many applications, the cost must be low and the tags must be able to be individually encoded. Further, when the tag is interrogated it must produce a distinctive signal to reliably identify the article to which the tag is attached or coupled. Some conventional tags have employed the Barkhausen jump effect. Generally, the Barkhausen effect is characterized by a tendency for magnetization to occur in discrete steps rather than by continuous change, thereby giving rise to a large temporal flux change, d.phi./dt, which is key for inducing a sizable voltage in a sensing or pickup cot.

For example, U.S. Pat. No. 5,181,020 describes a thin-film magnetic tag having a magnetic thin film formed on a polymer substrate and a method for producing the same. The thin film exhibits a large Barkhausen discontinuity without intentional application of external torsional or tensile stress on use. A particular disclosed use is as a marker or tag for use in an article surveillance system wherein articles may be identified by interrogating the tagged article in a cyclic magnetic field of a predetermined frequency in a surveillance area and detecting a harmonic wave of the magnetic field generated by the tag in the surveillance area. This conventional system is only a single bit element using a single Barkhausen layer with no ability to develop a code to distinguish items.

U.S. Pat. No. 5,313,192 describes another single bit tag which relies on the Barkhausen effect. The tag of this invention is selected to include a first component comprised of a soft magnetic material which constitutes the bulk of the tag. A second component comprised of a semi-hard or hard magnetic material is integral with the first component. The tag is conditioned such that the second component has activating and deactivating states for placing the tag in active and deactivated states, respectively. Such conditioning includes subjecting the composite tag to predetermined magnetic fields during thermal processing stages.

By switching the second component between its activating and deactivating states the tag can be switched between its active and deactived states. A reusable tag with desired step changes in flux which is capable of deactivation and reactivation is thereby realized.

U.S. Pat. No. 4,980,670 describes a one bit magnetic tag formed from a magnetic material having domains with a pinned wall configuration. The resulting hysteresis characteristic for that material is such that upon subjecting the material to an applied alternating magnetic field, the magnetic flux of the material undergoes a regenerative step change in flux (Barkhausen jump) at a threshold value when the field increases to the threshold value from substantially zero and undergoes a gradual change in flux when the field decreases from the threshold value to substantially zero. For increasing values of applied field below the threshold, there is substantially no change in the magnetic flux of the material. The tag may be deactivated by preventing the domain walls from returning to their pinned condition by, for example, application of a field of sufficiently high frequency and/or amplitude.

U.S. Pat. No. 4,940,966 describes the use of a plurality of magnetic elements in predetermined associations (e.g. with predetermined numbers of magnetic elements and with predetermined spacings between said elements), for identifying or locating preselected categories of articles. When the articles are caused to move relative to a predetermined interrogating magnetic field, each particular association of magnetic elements gives rise to a magnetic signature whereby the article or category of article carrying each of the predetermined associations can be recognized and/or located.

U.S. Pat. No. 4,660,025 describes a marker for use in an electronic surveillance system. The marker, which can be in the form of a wire or strip of magnetic amorphous metal, is characterized by having retained stress and a magnetic hysteresis loop with a large Barkhausen discontinuity. When the marker is exposed to an external magnetic field whose field strength, in the direction opposing the instantaneous magnetic polarization of the marker, exceeds a predetermined threshold value, a regenerative reversal of the magnetic polarization of the marker occurs and results in the generation of a harmonically rich pulse that is readily detected and easily distinguished.

U.S. Pat. No. 5,175,419 describes a method for interrogating an identification tag comprised of a plurality of magnetic, thin wires or thin bands which have highly rectangular hysteresis curves and different coercive forces. The wires or bands are preferably of amorphous material, but means for obtaining the highly rectangular hysteresis curves and different coercive forces are not taught; nor is the concept taught of using a time varying magnetic field superimposed on a ramp field for interrogation.

Their invention is An inexpensive multibit magnetic tag is described which uses an array of amorphous wires in conjunction with a magnetic bias field. The tag is interrogated by the use of a ramped field or an ac field or a combination of the two. The magnetic bias is supplied either by coating each wire with a hard magnetic material which is magnetized or by using magnetized hard magnetic wires or foil strips in proximity to the amorphous wires. Each wire switches at a different value of the external interrogation field due to the differences in the magnetic bias field acting on each wire.

Magnetic coupled transponder systems

These are the most common transponders available today, manufactured by a wide range of suppliers.

Generally operating at frequencies typically in the order of 125KHz, the tags are characterised by antenna systems that comprise of numerous turns of a fine wire around a coil former to collect energy from a reader's magnetic field. Due to the magnetic method of coupling, range is limited generally to a number of inches, being determined by the fields generated between the effective North and South pole of the reader. Magnetic Tags are manufactured by many suppliers and find application in tagging animals, labelling gas bottles, electronic automobile key identification, and factory automation.

Different forms of communication are used by the different manufacturers. Typical methods are to use the energising signal at a frequency of 125 kHz and to receive data back from the transponder by

- receiving data back from the transponder at half the frequency of the transmitter link while the transmitter operates in a CW mode.
- using the transmitter in pulse mode, and to transmit the data back immediately the transmitter signal stops, namely on the flyback while the tag energy is decaying when the energy is removed
- by letting the tag load the energising field, with this fluctuating load being sensed by the changes occuring on the energising field

Issues around magnetic coupling are that the frequency is low, the energising field is very much stronger than the returned data field strength, that it is difficult to create filters with sufficient tuning to separate the transmit and received signal while both are present, that the tags have very limited energy storage capability, meaning that the energising field needs to be applied in a uniform continuous manner, or data can be received back in that short period of time after the energising field is removed (flyback)

Since 1998 a new series of tags that are actually magnetic coupled, but which operate on similar principles to their electric field coupled counterparts are becoming available. The tags comprise of a small coil of a few turns, often etched on a flexible printed circuit substrate, and to which a single chip is bonded. These transponders might be as small as 1.5cm by 1.5cm in area and couple their energy to the reader via magnetic propogation. By the reader continuously providing an energising field, which can be modulated, the tags can extract energy and data from the reader and communicate back to the reader. Such tags often have read/write capabilities and often anti-collision properties to allow for many tags to be in the reader beam at the same time. The reading and writing distance of such tags is limited by the magnetic means of propogation to typically 18cms, but some manufacturers claim 1 meter operating range. These tags seem to be positioning to replace the more difficult to produce 125KHz tags which required coil winding facilities. Almost all magnetic based transponder systems are passive, that is they get their energy from the reader's energising field. Transponder systems operating on magnetic coupling principles operate at frequencies as high as 29MHz.

Electric coupled transponder systems

Electric field coupled transponders generally provide vastly increased ranges over their magnetic counterparts. Rather than being limited to the ranges of the lines of force emitting from a magnetic field generator, they use the electric field propogation properties of radio communication to convey energy and data from the reader to the transponder and data from the transponder to the reader.

Electric field propogation requires antenna systems that are typically half a wavelength of the operating frequency in size.(150cm at 100MHz,15 cm at 1GHz, 5 cm at 2.5Ghz and 2.5cm at 5.8Ghz). This causes practical limits to how low a frequency to start using Efield propogation methods due to the size of the antenna.

Higher operating frequencies require more expensive components and loose the ability to transfer energy at a rate of the inverse of the wavelength squared.

In addition the energy density of a signal radiated using electric field coupling, decreases as the inverse of the distance squared between the source and the transponder. Whereas sensitive receivers can compensate for this loss of energy for the data communications over long distances, passive transponders which use the reader's energising field as a source of power are practically limited to maybe ten meters (say at 400 MHz). Beyond that distance (which reduces drastically with increased frequency to less than 1 meter at 2.5GHz) it is necessary for the tags to use an external battery as a source of power.

Electric field tags are available in many different configurations and price ranges, particularly dependant on the complexity of the transponder. If the transponder is a read/write transponder and is required to operate beyond the range of passive transponders, the receiver circuitry onboard can be expensive and difficult to construct particularly if frequency stability is needed with temperature.

However the invention of the backscatter modulation principle at Lawrence Livermore Laboratories in the 1960s and the skills of semiconductor designers to shrink all features into cheap integrated circuits, has meant that electric field type tags in a read only mode can be made extremely cheaply, most probably for less than 10 US cents in high volume. Such a tag would be passive, have no onboard tuned circuits, be read only, consist of a single integrated circuit and a simple antenna, would operate at any of a range of frequencies, be temperature insensitive, and would broadcast a large data value when illuminated by a reader's energising field. In such a system the reader is complex because it provides the frequency stability, the energy of the system, and the receiver selectivity to receive the weak return communications, but the tags are very cheap. This is ideal for the situations where there is one reader and many tags.

Electric field tags need to operate in an ordered spectrum management system as their radiated energy (particularly from the reader) can be detected by other sensitive receivers far away and cause possible interference.

Recent developments in passive tag technology see the amount of power needed to power up the tag dropping dramatically. The reader radiates energy from its transmit antenna, some of which is collected by the tag in an area around its antenna called the "antenna's aperture". The size of this area is dependant upon the characteristics of the tag antenna and the operating frequency of the system, (e.g a 915MHz dipole has a 134cm^2 aperture). Traditionally a 5 volt logic circuit in a transponder would need 55 milliwatts of RF energy to operate while recent developments see this amount of power dropping to less than 1 milliwatt, thereby dramatically reducing the power needed by the reader and increasing the range over which passive transponders can operate effectively. Recent developments with electric field tags relate to the development of transponder/smart card systems for toll road applications. Here the tags are active (that is they have a battery) but only consume battery power after the tag is "activated" by passing through a high energy activation field. Thereafter the tag can send/receive data with an overhead reader and can adjust the data representing the balance remaining in the smart card after the toll fees are deducted. Such applications are proposed in the 2.45GHz frequency band and more recently in the 5.8GHz band.

A seperate category also exists of "active" tags (battery powered). These tags are "beacon" tags, that is they are not interrogated by a reader, but wake themselves up from a low power "sleep mode" periodically and broadcast their identity before returning to "sleep mode". By broadcasting on a fixed frequency, a sensitive receiver tuned to that frequency and within close proximity to the tag will receive the identity message. This type of transponder offers ranges up to hundreds of meters, but is not suited for situations where the location of a tag is being determined to a couple of meters range, or where very many tags are present in the reader zone. Encryption technology has also been added to these systems to stop unwanted tags being accepted as valid codes by the reader. Despite the hurdles, the greater range, higher data rates and new technologies make these transponders suitable for a great number of applications.

Multiple article scanning

As the distance over which one needs to read the identity of transponders is increased, so the importance of the reader to handle the multiple article scanning increases. This is primarily as it becomes less likely that with increased range only one transponder will be in the reading zone at the reading instant.

To detect the presence of multiple articles using RFID techniques actually is not simple and introduces many complexities. The central issue is that generally there is only one communications channel between all the transponders and the reader. As the transponders are not able to detect the transmissions from other transponders in the same reader area, often more that one transponder is transmitting at the same time causing a confused message to be received by the reader. A model of this situation would be for a room filled with deaf and blind people, where each calls out its identity number (transponder) while on the stage there is a blind person who has to identify all the people in the room (reader). Generally if the transponders in the reading zone are few in number, then by getting them to transmit at random times, occasionally a transponders transmission will not be interfered with by another transmission from some other transponder and its identity can be determined.

EAS tags handle the need for multiple identification by operating on the principle that tags are disabled when the goods to which they are attached are paid for, thereby meaning that if the receiver detects no transmissions, then no stolen goods are being removed. The procedure is the same as followed by the security personel whether there is one transponder detected or many transponders detected.

Few magnetic transponder systems can handle multiple tag situations. This is generally not serious as the reading range of the reader is short, say typically a few inches, and it is not too difficult to arrange the reading situation so that only one transponder is in the reading zone at one time. The reason for the problems with multiple transponders in the magnetic situation is that the protocol generally lacks a freedom of time dimension. The transponders are energised with a relatively strong field which transfers energy from the reader to the transponder for operating its logic, and the transponder replies immediately the energising pulse is removed, that is before it loses its onboard energy and without the energising field interfering with the weak return (this period is often called the flyback period). As all the transponders respond at exactly the same time, they all interfere with each other causing confused transmissions. The developments from 1998 onwards of the 13.56MHz frequency range magnetic transponders by a number of manufacturers starts to change this situation as almost all manufacturers have realised the importance of multiple tags and have started providing proprietary anit-collision protocols in this product range. These tags operate similarly to Electric Field tags even though they are in fact magnetic coupled tags by virtue of their simple coil antennas. By having a continuous energising field applied by the reader during the scanning which is used to power the tags, the tags can use time for seperating replies as well as use onboard receivers on the tags for addressing specific tags. These tags generally are read/write and have two way communications between the tags and the reader, although their operating ranges are limited to approximately one meter.

For electric transponders, reception from multiple transponders is possible with increased transponder complexity, generally by using the time domain. As the energising field can be present at the same time as the reader is receiving the transponders transmissions. (Primarily because the energising frequency is slightly different from the reading frequency), this allows the transponder to emit transmissions at random times repeatedly over a long time period, increasing the probability that their transmission will be heard. If the design can afford the additional cost of onboard receivers and does not need frequency agility, another protocol allows for communication between the reader and the transponders whereby each transponder can be individually addressed using unique identities, and the transponders individually polled. There are a number of similar protocols that can be implimented as soon as the transponder complexity can be increased.

A significant development in this regard happened in South Africa in 1994 when a demonstration of a supermarket trolley being scanned in a couple of seconds was shown to the world press. The significance of this development was that the transponders did not have the additional on board receivers, and in fact did not need unique identity numbers, features that were key to multiple transponder situations for electric coupled tags previously. This technology has yet to appear commercially and should cause dramatic reductions in the price of electric transponders when available. In March 1998 the scanning trolley came a few leaps closer. The South African company Trolley Scan filed a series of provisional patents that focussed on replacing barcoded identification systems with RFID transponders. Having simplified the design of a transponder down to a very small silicon circuit comprising only a few tens of equivalent gates, a simple antenna system and simple packaging, the manufactured price of transponders has been decreased to levels where such an application is starting to be viable. Trolley Scan have as a demonstration of the robustness of their multiple article protocol provided details of 1000 tags being scanned simultaneously in one operation even with the tags having random geometric orientations.

Single bit/read only/ read-write,smartcards and RFDC

A brief description of the different technology issues.

Single bit

Single bit transponders are used generally in Electronic Article Surveillance (EAS) systems. The single bit status conveys an ON or an OFF status to a reader, being suitable for use in anti-shoplifting systems. Often this tag comprises a strip of magnetised material. or alternatively a tuned circuit which is destroyed to switch to the off state. The magnetic versions state is changed using magnetic fields, and can be switched either on or off according to the magnetic orientation of the particles.

Read only transponders (tags)

This is the most basic form of transponder. In its most simple form, it could comprise of some read only memory, a power rectifying circuit, an onboard oscillator,a variable antenna loading circuit (for backscatter modulation) and driving logic. As the memory is often permanent, the tags do not need power to retain their identity and often would be passive in nature (that is no battery). Transponders in this form can be made very cheaply, often comprising only a single integrated circuit which is attached to an antenna. EAS features can be added to the circuitry. The read-only transponders are effective where the identity of an object is required, or can be used with a computer network for situations where the transponder provides a reference to a database and the database contains the variable information. The permanent memory of read only tags can be programmed by the factory and in some cases by the users.

Read-write transponders

Read-write requirements introduce many new levels of complexity over the read only transponders. Read-write transponders find application in situations where the information to be carried by the transponder is variable, and might be altered along the route. For a tag to be suitable for use in read-write situations, it must have some form of static memory, and a method of retaining that state when not in the interrogation field. Such memory might be battery backed up memory, or alternatively magnetic based memory that will retain its magnetic status when not powered. A read-write tag needs some form of receiver on board to receive communications from the reader that contains the data to be stored. This introduces new complexities and might mean that the tag loses its frequency agility. The tag will also need some means of unique identity to ensure that the correct data is written to the correct tag in situations where many tags are present in the reading field. The next major complication is catering for variations between the clock rate of the transponder and the reader. As the data is likely to be a serial data stream, there being only one data communication channel often between the reader and the transponder, it is necessary to synchronise the data rate so that the correct data is stored and interpretted by the transponder. This might be achieved by using a manchester encoded type format, crystal controlled clocks in both the transponder and the reader, or some method of calibrating the transponder relative to the reader which often involves additional tuned circuits, logic and even microprocessors on the tags. Read-wrtite transponders find application particularly in the more expensive transponder market, such as with toll roads where developments are leading to their integration with smart cards for the financial transactions.

The more expensive read-write transponders are also to be found using spread spectrum communication for the datalinks rather than using tuned receivers. Read-write transponders due to their complexity can cost many tens of dollars each versus the sub- dollar read only possibilities.

Smartcards

Smartcards are in reality a merging of microprocessor technology, memory technology and packaging. Often the connections to the smartcard are via direct contacts or lately via short range magnetic coupling. The later being called contactless smartcards. The benefits of the intelligence in the smartcard is that it can execute specific programs allowing high levels of security where the answer supplied by the application matches some algorithm computed in the card. More recently banks have started to use smartcards as cashcards, where electronic money is in effect carried in the card securely as the contents are encrypted. The cards are recharged by means of automatic teller machines. Smartcards are a distant technology from transponders, and are mentioned here merely to place their technology in perspective.

RFDC

This technology is often associated with identification systems such as barcoding but it has little to do with the identification technology. RFDC is a communication system utilising radio techniques that allows a terminal/scanner/display or any computer device, to be linked to a computer sysetem in situations where a direct wire between the device and the computer network is not viable. The RFDC protocol allows many devices to share the radio communication system at the same time. In an identification scenario, a communications hub might be attached to the roof of the warehouse or store, and operators with hand scanners fitted with RFDC could roam the floor passing data via the RFDC link to the computer system. RFDC systems typically operate at about 2.5GHz and by using spread spectrum or frequency hopping techniques, allow many devices to operate at the same time without interferring with each other and without requiring specialist operators to manage instalation or the provision of complex frequency management systems.

Unusual applications

Monitoring efficiency of postal systems

Kasten Chase Applied Research have recently been awarded contracts by various postal authorities to supply systems to evaluate the efficiency of the postal services. In one application the system comprises of 100 000 transponders that are placed in test letters and posted from a variety of different locations to different destinations, with their progress being monitored by readers in 185 locations. The readers are capable of identifying the letters at a distance while still in the mail bags. Using such systems the performance of postal systems across international boundaries can be evaluated.

Kasten Chase Applied Research

Studies of fish migration

PTAGIS: Passive Integrated Transponder (PIT) Tag Information System http://www.psmfc.org/pittag

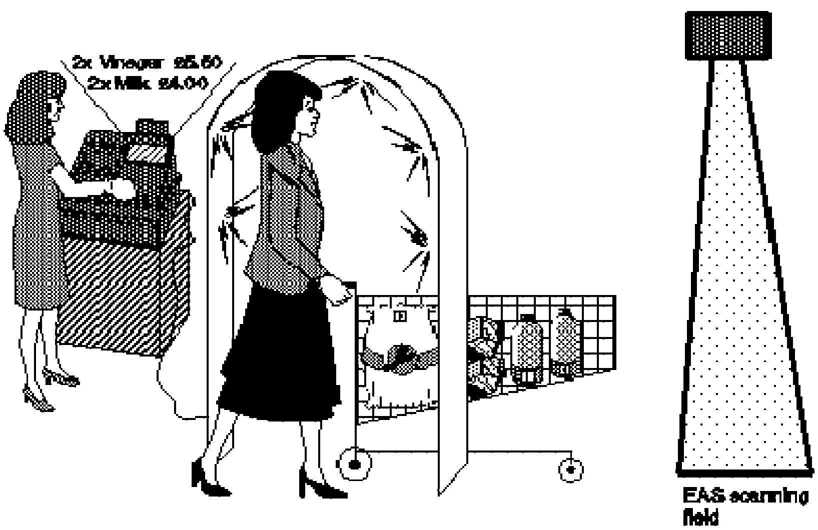
What is PTAGIS?

Since 1985, researchers have employed electronic identification (EID) in studies to learn about migration characteristics of juvenile salmonid in the Snake and Columbia river drainages. A Passive Integrated Transponder is implanted in juvenile fish. A network of interrogation systems located at hydro-electric projects and other interrogation systems located at juvenile fish traps passively collects information about individual fish as they migrate down river.

The PTAGIS project is a data managment project. Our mission is the collection and distribution of PIT Tags and PIT Tag data for the Columbia River Basin. Included in our data management responsibilities are data verification and data integrity, interrogation hardware and software maintenance and operations, and development and maintenance of various other software and PIT Tag related processes.

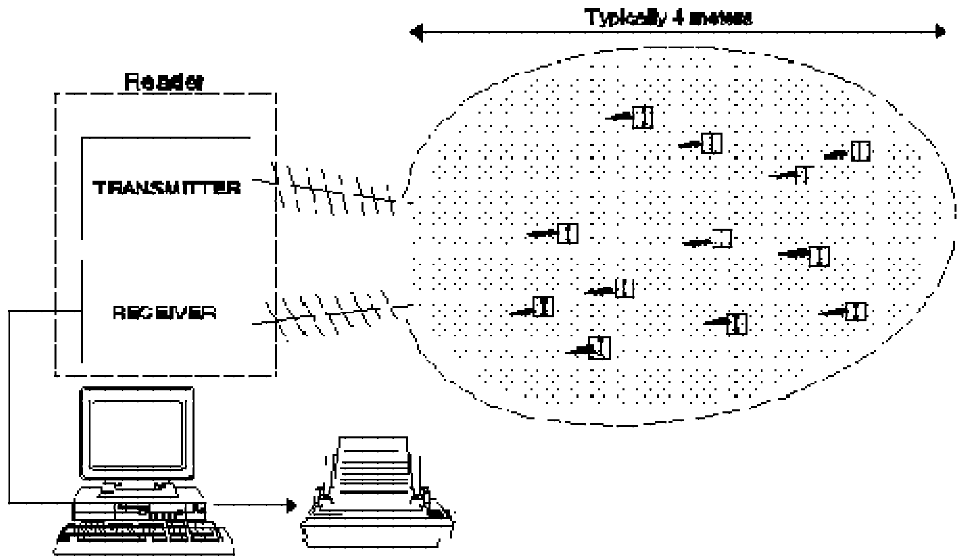
How RFID systems work

A brief introduction to some of the systems available



Electronic Article Surveillance (EAS)

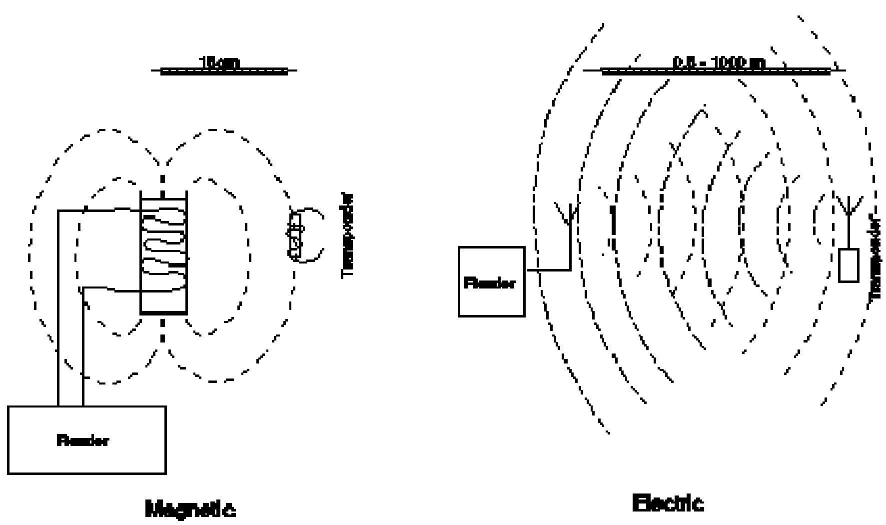
A radio transponder system uses radio energy to provide an energising field, which powers up the transponders in the field and enables then to return their identity back to the reader. The transponders can be attached to goods and the radio energy can penetrate many types of packaging, allowing a system to for example scan the contents of a supermarket trolley, a pile of books, goods in a warehouse, etc. It is actually not as simple as this but we will attempt to provide further information in this document to highlight some of the issues. An Electronic Article Surveillance system (EAS) is used to detect the presence of operating tags that pass through its energising field. It could be used for instance in a retail outlet to detect tags that have not been neutralised at a point of sale terminal, therefore acting as an effective anti-shoplifting system.



Components of an RFID system

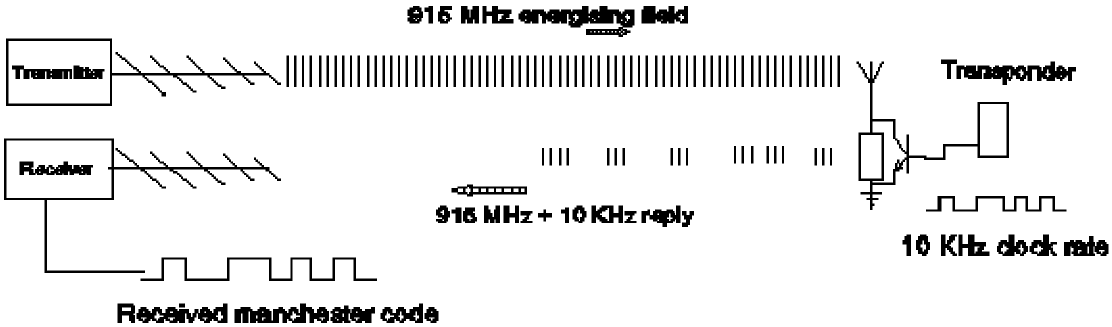
The components of a tagging system are the transponders, a transmitter to provide energy to the tags, and a reader to receive the identities of the tags, and a computer system to process the information. In order to receive the identities of many tags in a field at the same time, a protocol is needed. By using electric field propogation systems, typical reading ranges of 4 meteres are easily achievable.

How it works (Part 2)



Different types of coupling for RFID systems

There are two major propogation methods which have an influence over the range of detection of the transponders from the readers. In magnetic systems, the energising field is similar to that shown at school between the poles of a permanent magnet shown with iron filings. To increase the range the poles of the magnet need to be seperated (increase the size of the reader) or increase the power of the field (not very effective). Coupling is by the means of coils for the antennas, and typically the energising frequency could be 130KHz. Receiving antenna could have 1000 turns on the antenna. The electric field coupling uses antennas to propogate the energy from the transmitter to the transponder. The antennas size is dependent on the frequency of operation (typically 400 MHz to 2.5 GHz) and the energising field typically drops off as the inverse of the square of the distance between the transmitter and the transponder. Using this method, ranges of 4 meters are achievable.



Backscatter modulation frequency shift

Some transponder systems can use a principle called *backscatter modulation* to communicate the data from the transponder to the reader, when in the presence of an energising field. The energising field is emitted from the transmitter in the form of a carrier wave signal at a fixed frequency (in the example this is 915MHz). This energy from the transmitter is collected by the transponder antenna, rectified and used to power the transponder. The transponder generates a data stream comprising a clock signal and the data to be communicated, is a form of a modified manchester code. Typically the clock rate of the transponder might be at 10KHz. The data from the transponder is used to drive a shorting transisitor across the antenna, which has the effect of changing the reflectivity of the transponder antenna and causing some of the received energy from the transmitter to be reflected back towards the receiver. This reflected energy has the form of packets of energy at a frequency that is shifted from the original transmitter carrier by the clockrate of the transponder. A simple receiver using the transmitter signal as a local oscillator can decode the received energy and extract the modified manchester code.