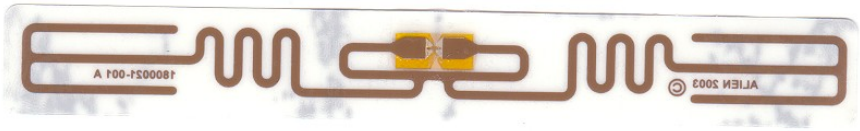
RFID

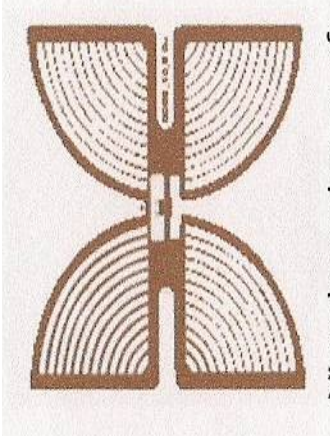


Presented by

BESSER ASSOCIATES

Instructor: Al Scott

COURSE OUTLINE

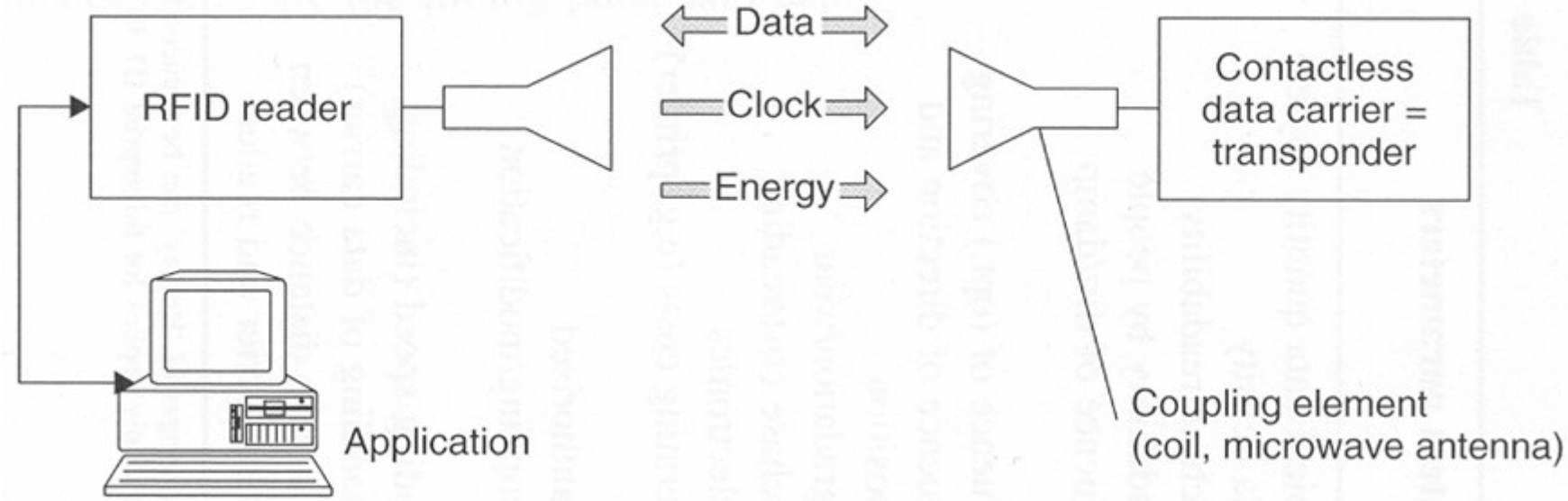


- Uses of RFID
- Basic RFID System
- ISM Frequency Bands
- Walmart Directive
- EPC RFID System
- How RF part of EPC System Works
- RF antennas at 915 MHz
- Transponders
- Test Results
- Effect of Multipath
- The 5 cent Tag
- RFID readers
- What the Tag Bits Represent
- Special Purpose Tags

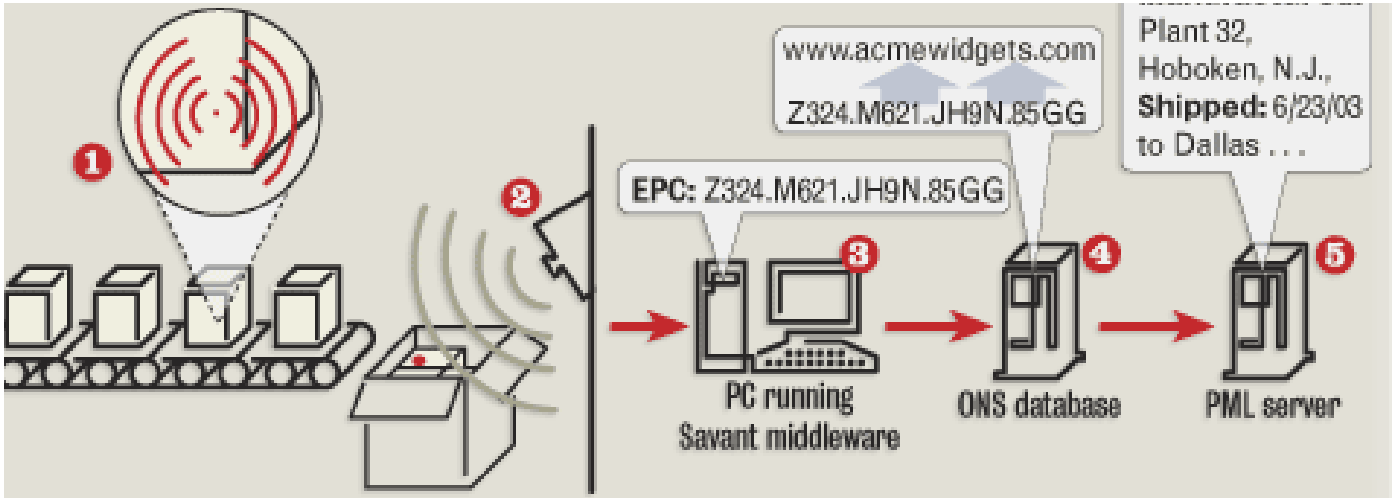
USES OF RFID

- Security/access control
- Asset management
- Transportation
- Supply chain management
- Point of sale
- Rental item tracking
- Toll collection
- Automobile immobilization
- Baggage handling
- Inventory control in manufacturing
- Railroad car tracking
- Animal tracking

BASIC RFID SYSTEM



EPC (Electronic Product Code) RFID SYSTEM



1. An EPC is em-bedded into an RFID tag and attached to an item.
2. RFID readers scan the smart tag and send the data to a computer running middleware.
3. Savant middle-ware queries an object naming service (ONS) database.
4. ONS maps the EPC to a URL where all the item's informa-tion is stored using Physical Markup Language (PML).
5. The PML server contains information about the item, such as when it was manufactured and where it was shipped.

ISM FREQUENCY BANDS

- ISM stands for “Industrial, Scientific, Medical
- Industrial applications are RF and microwave heating and drying, home microwave ovens
- Scientific applications are accelerators for nuclear research
- Medical applications are diathermy and oncology equipment
- For the above uses, the RF power is contained inside an enclosure, so the frequencies can also be used for communication systems outside of the enclosure
- Use of the ISM frequencies for communication is unlicensed
- Power is limited for unlicensed use
  - Low power limits are set for any type of system
  - Higher power limits are allowed if spread spectrum techniques are used (frequency hopping, CDMA, OFDM)

THE WALMART DIRECTIVE

In 2004, Wal-Mart notified its 100 top suppliers that they must provide RF identification of cases at distances up to 30 feet by 2005

Approximately 25 years ago, Wal-Mart issued a similar directive regarding optical bar code identification, which triggered the bar code industry

The Wal-Mart requirement is for passive tags operating in the 902 to 928 MHz range. The tags will carry digitally coded information in an IC chip identifying their contents. The chips may be reprogrammed on the fly to add location information

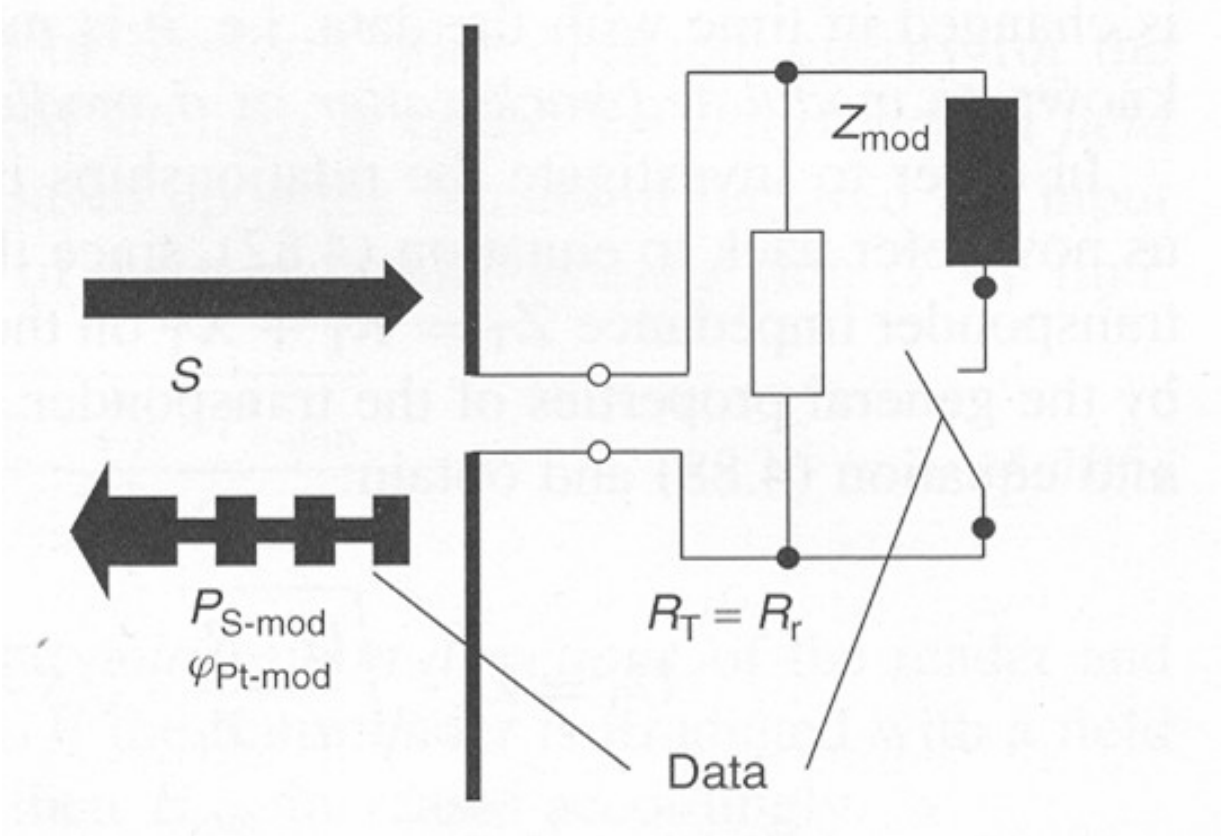
HOW THE RF PART OF THE EPC RFID SYSTEM WORKS

- The “reader” transmits an RF signal modulated with on-off switching to interrogate the tag for about 6 microseconds
- 90% of the power received by a diode in the tag is rectified, and used to power the IC chip
- The remaining 10% of the power is demodulated to provide a digital query signal to the IC chip

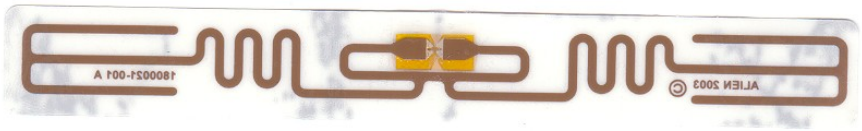
HOW THE RF PART OF THE EPC RFID SYSTEM WORKS (continued)

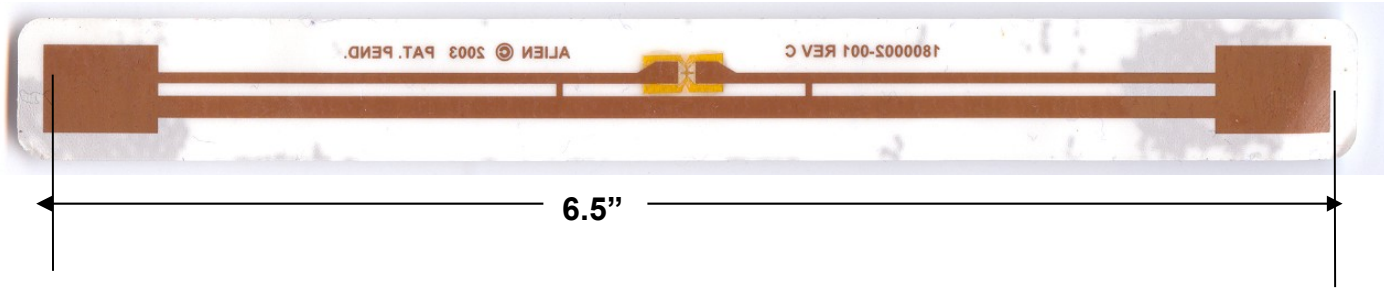
- During the next approximately 6 μs time interval, the IC sends a digital signal to the diode to change its impedance, which changes the impedance of the tag antenna
- The reader sends a non-modulated RF signal during the time that the tag IC is modulating the diode. More or less signal is therefore being reflected back to the reader. This is the information content of the tag
- The weak RF signal received from the tag is amplified by the reader and demodulated, and the resulting digital data is sent to the digital processing equipments

SCHOTTKY DIODE AS A BACKSCATTER MODULATOR



HALF WAVE DIPOLE AT 915 MHz

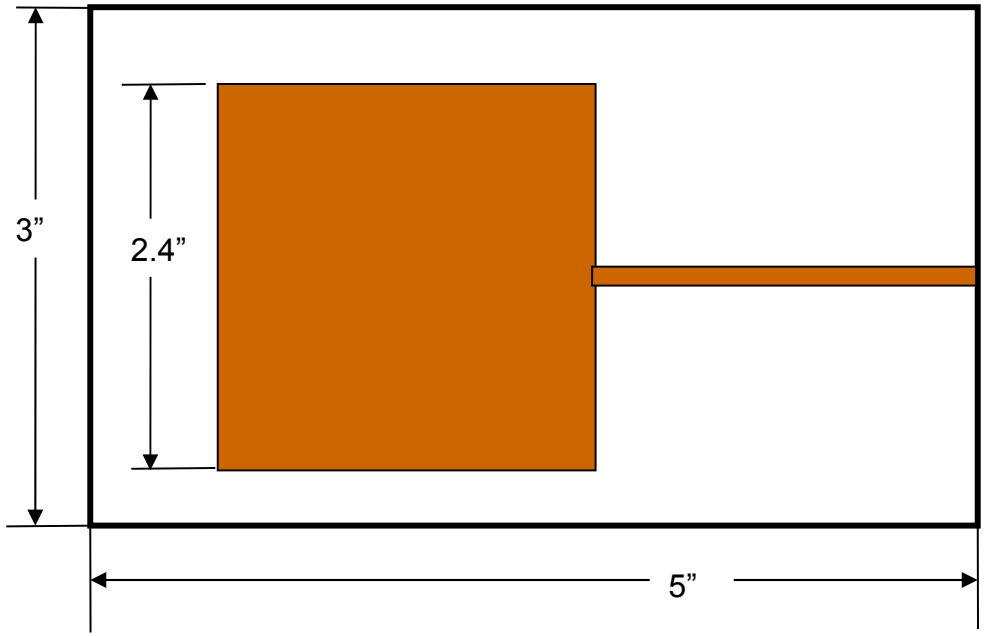




Direction of polarization is along long direction of dipole

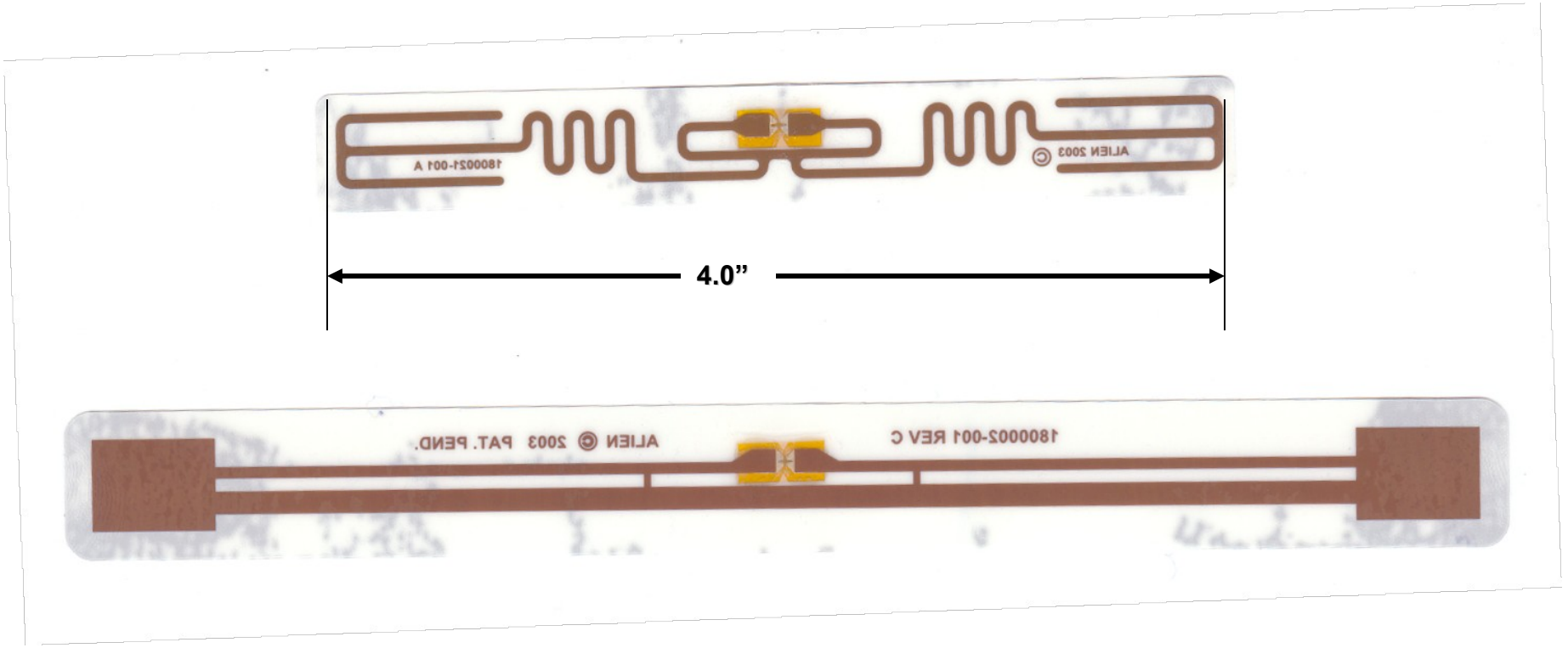
PATCH ANTENNA

Designed for 915 MHz on FR-4 substrate with groundplane

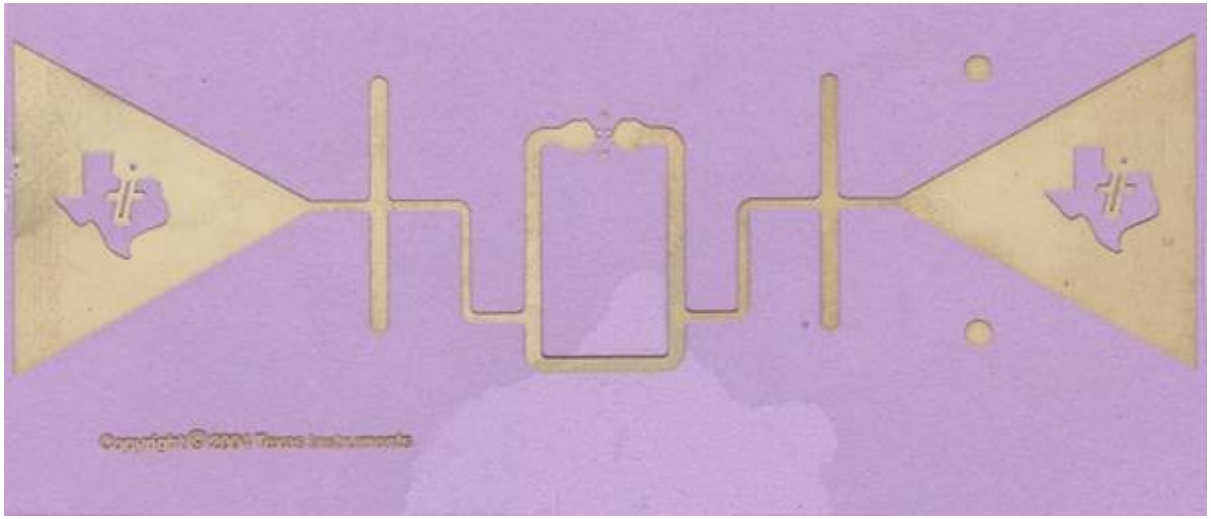


Gain = 4 dBi Linear polarization in horizontal direction

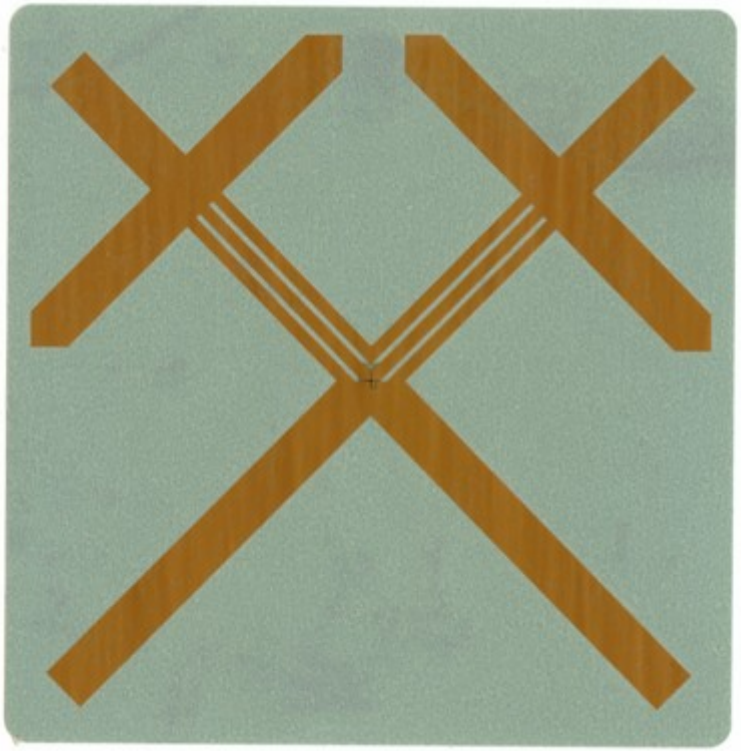
ALIEN RFID TAGS

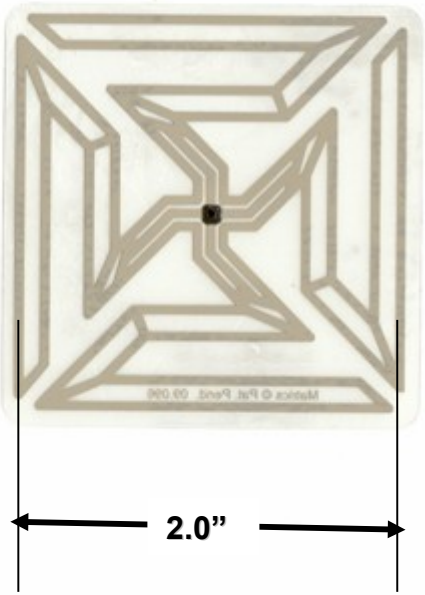


TEXAS INSTRUMENT 915 MHz RFID TAG

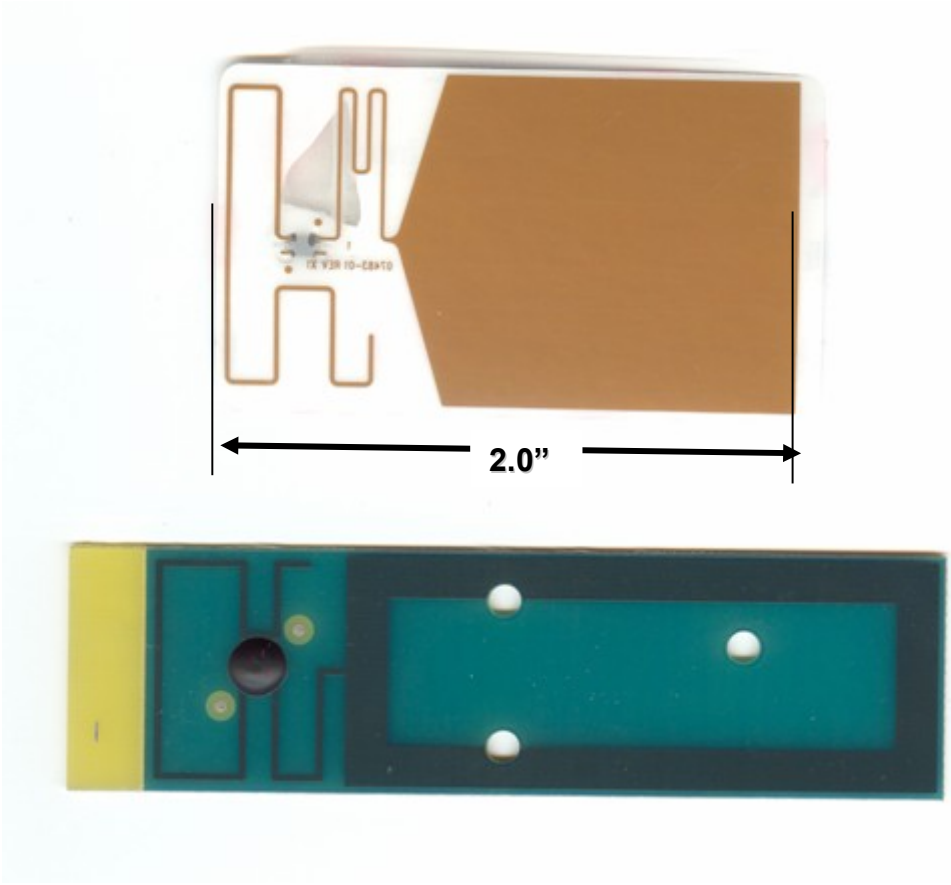


MATRIX RFID TAGS





INTERMEC RFID TAGS



TAG SELECTION CHECK LIST

- Frequency Range
- Read/Write vs. Read Only technology
- Range performance
  (Write range is typically 70% of read range)
- Form factor
- Environmental conditions
- Standards compliance

TAG NOMENCLATURE

Class 0 and Class 1 are passive tags
Class 2 tags have greater features
Class 3 are semi-active and active tags,
and have a battery

Class 0	**Read only – Original standard**
Class 0+	**Read and write – Modified original**
Class 1 Gen 1	**Read and write**
Class 1 Gen 2	**Read and write – Ultimate global**

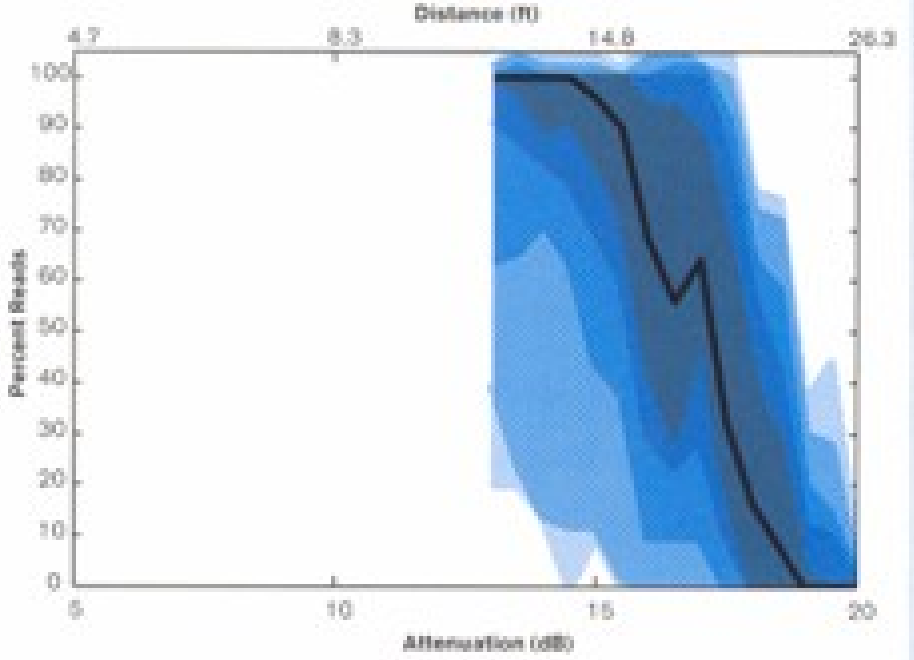
,

ADVANTAGES OF READ/WRITE TAGS COMPARED TO READ ONLY TAGS

- Tag content can be changed by user
- The tag can be reused. This feature provides significant cost savings that offsets the higher cost of the read/write tag
- Location information can be changed as the product is moved
- Tag can be changed to conform to spec modifications
- Obtaining tag data is less dependent on database lookup
- Offers advantages in:
  - Shipping and receiving
  - Distribution
  - Return and recall management
  - Service and warrantee authorization

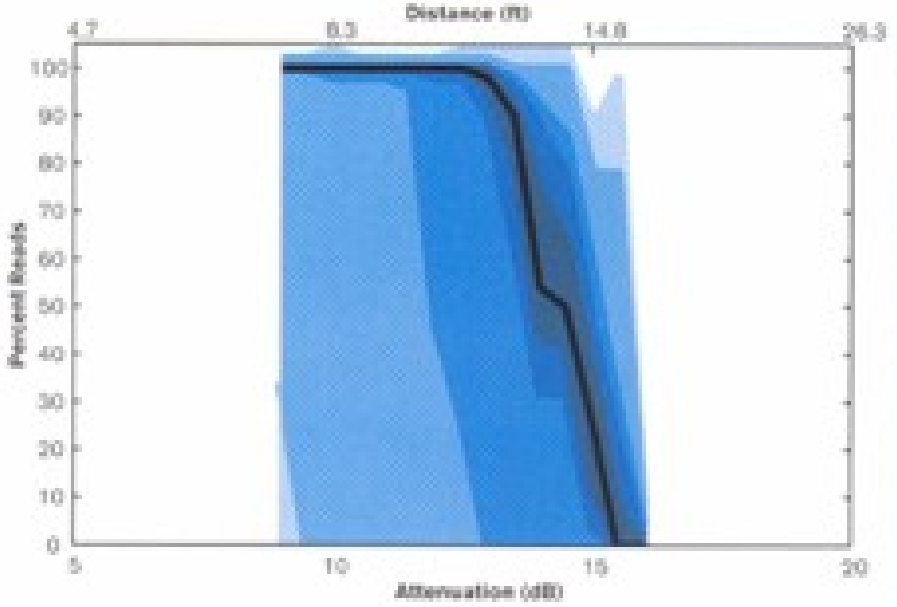
TEST RESULTS
CLASS 0 and 0+ TAGS

Symbol X2040



TEST RESULTS
CLASS 0 and 0+ TAGS

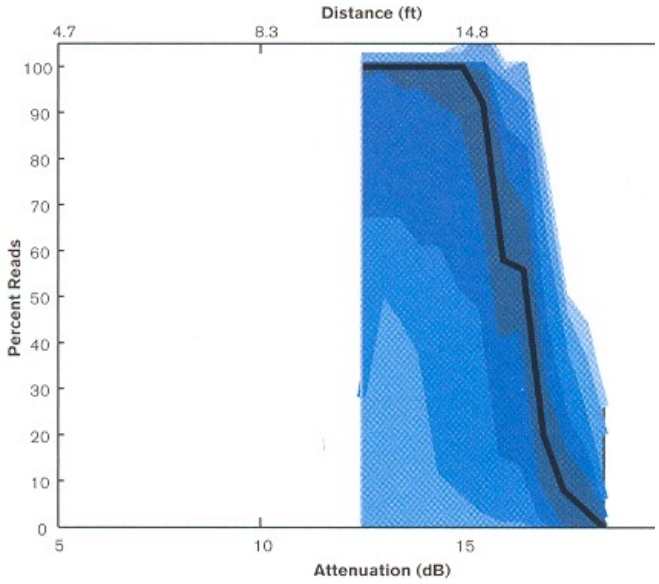
Avery Triflex



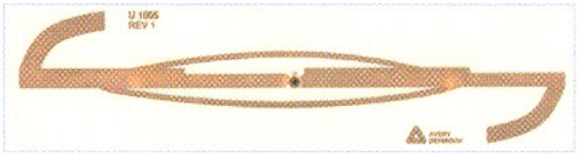
Source: RFID Alliance Lab

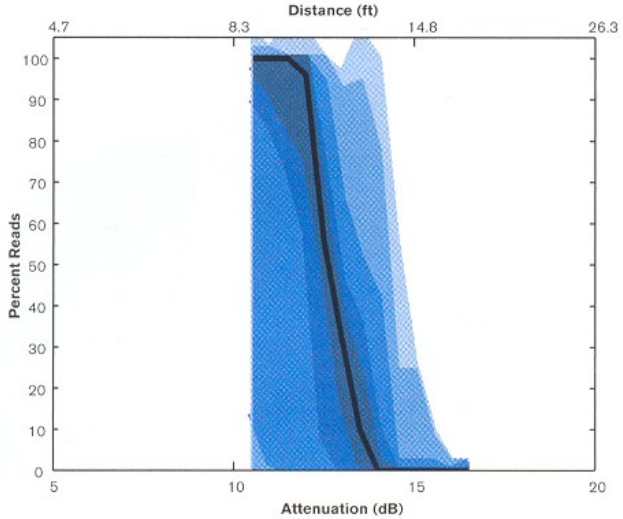
TEST RESULTS
CLASS 0 and 0+ TAGS

Symbol I2010



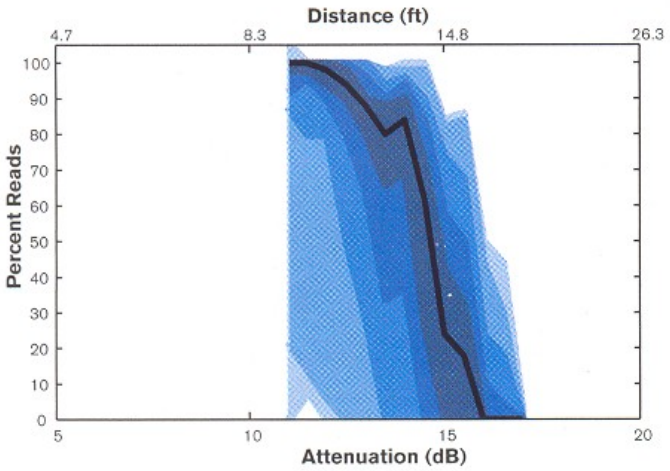
Avery DS1



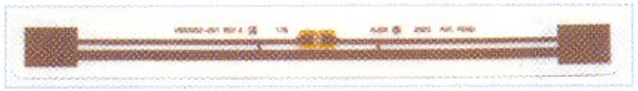


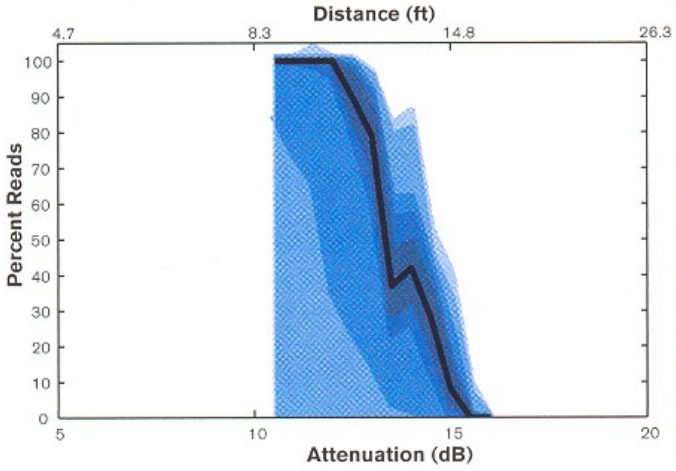
TEST RESULTS
CLASS 1 TAGS

Alien M



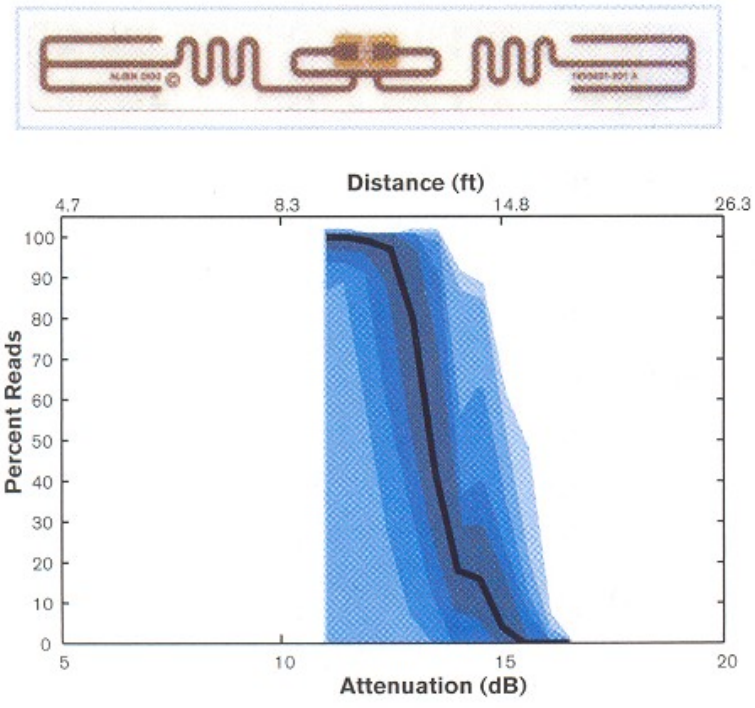
Alien I2



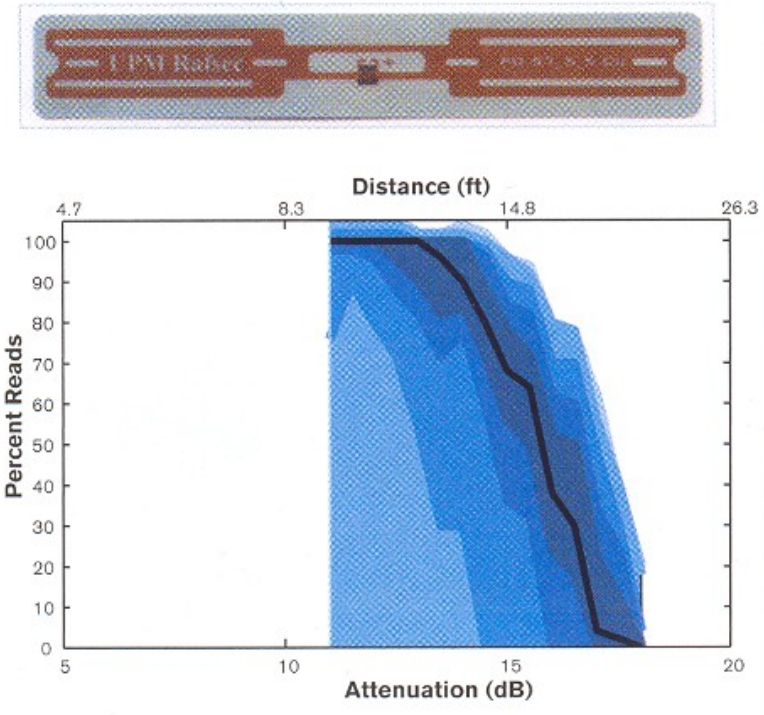


TEST RESULTS
CLASS 1 TAGS

Alien Squiggle

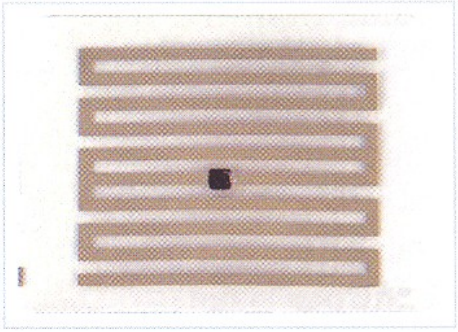


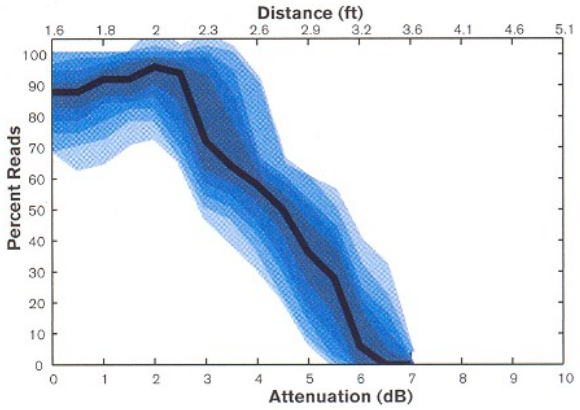
Rafsec 457



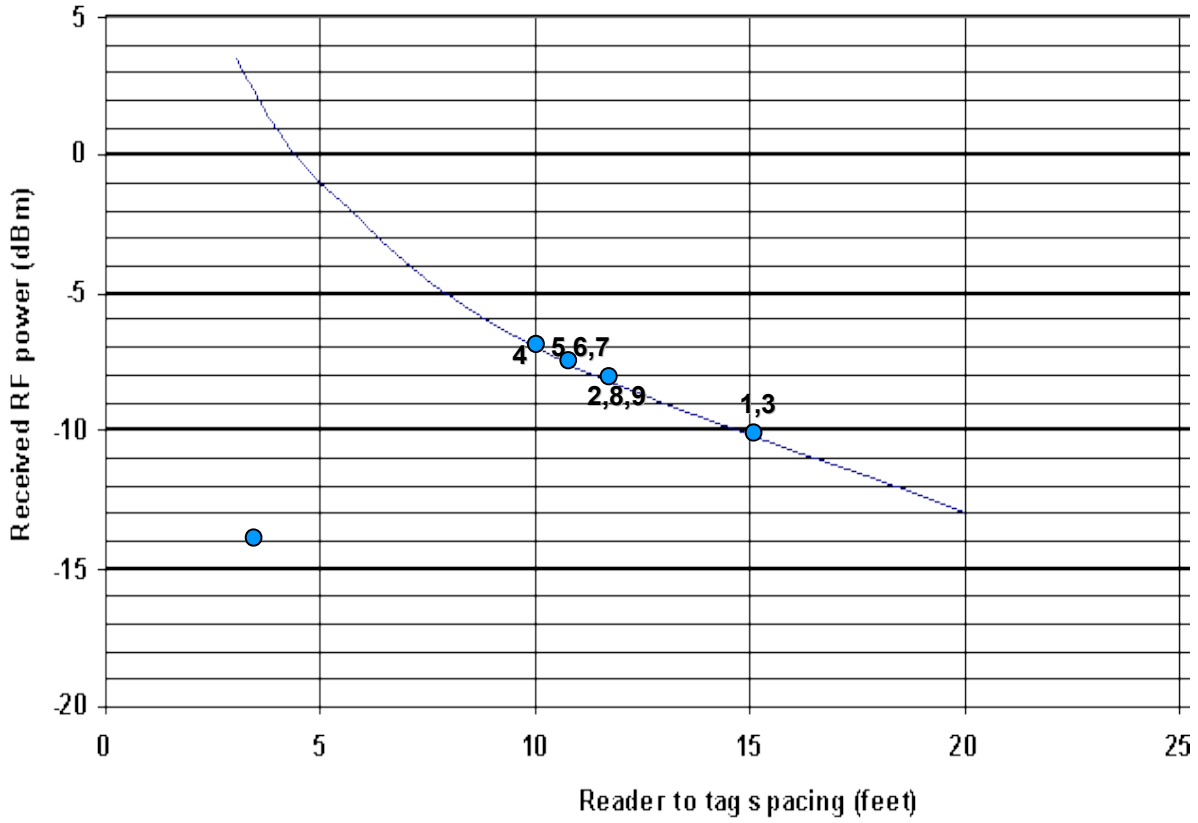
TEST RESULTS
CLASS 1 TAGS

Symbol I1030



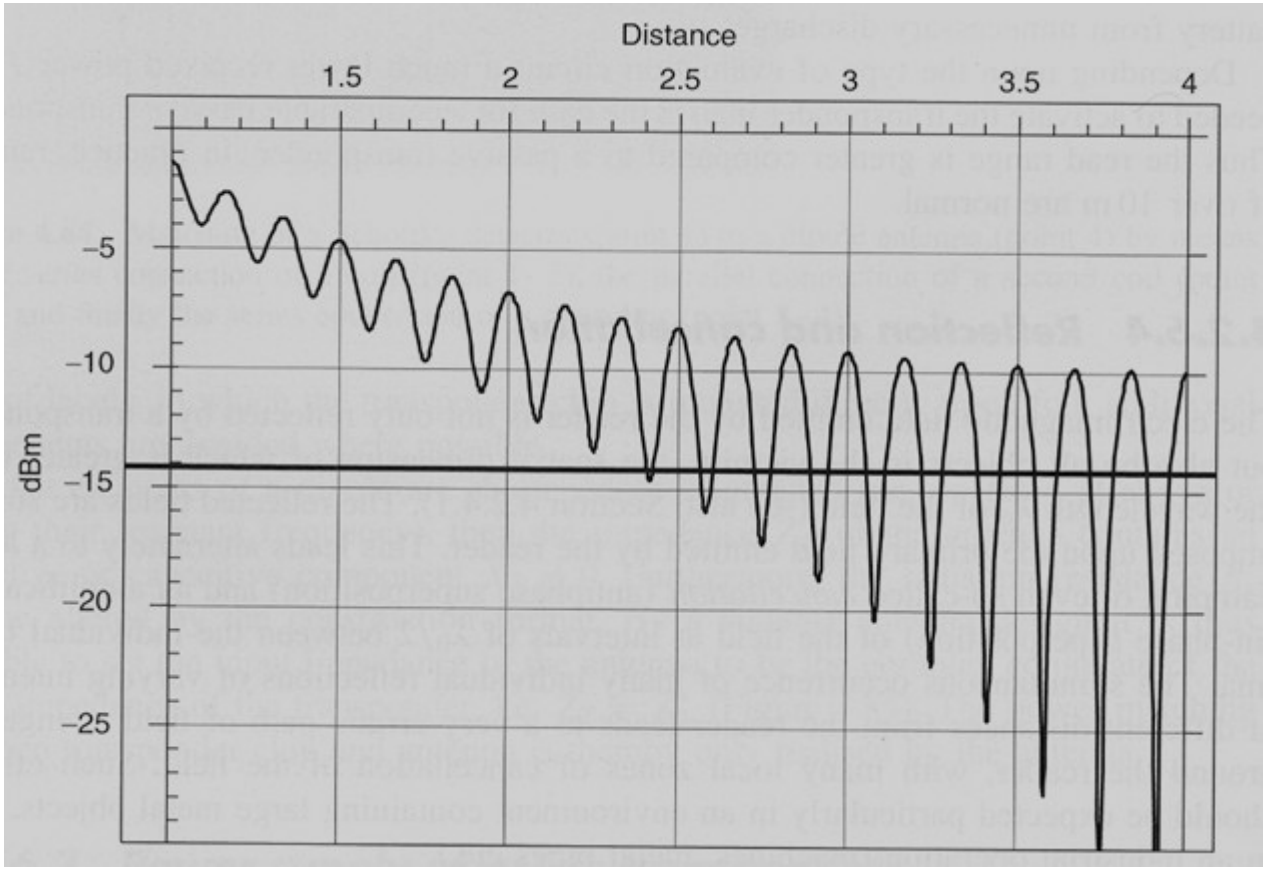


CALCULATED RECEIVED POWER VERSUS MEASURED READ RANGE



1. Symbol X2040 (Matrix 4x4)
2. Avery Triplex
3. Symbol I2010 (Matrix 1x6)
4. Avery DS1
5. Alien M
6. Alien 12
7. Alien Squiggle
8. Rafsec 457
9. Intellitag Free Space

EFFECT OF MULTIPATH REFLECTIONS



THE 5 CENT TAG

- WalMart has mandated that tags cost no more than 5 cents when used at a 30 billion per year rate
- 5 major retailers alone would require 10 billion tags per year
- Suppliers will have to pay for the tags
- Alien was offering their “Squiggle” tag at 12.7 cents each in quantities of 1 million (2006)

FACTORS AFFECTING TAG COSTS

- Cost of antenna, including the substrate
- Cost of electronics chip
- Attaching the electronics chip to the antenna
- Mounting the tag into a label
  - “Smart label”
  - Label has printed description of product on one side, adhesive on the other side, with the tag antenna/chip in between
- Mounting label onto product

AUTO-ID STUDY OF TAG COSTS

- **Auto-ID study estimates at a 30 Billion/year rate, and using antennas with conductive ink, a tag will cost as follows:**

Antenna:	**1.0 cents**
Electronic chip (attached to antenna):	**3.3 cents**
Profit:	**0.7 cents**
	5.0 cents

- **This cost does not include putting tag inside label, or attaching label to merchandise**

REDUCING THE TAG ANTENNA COST

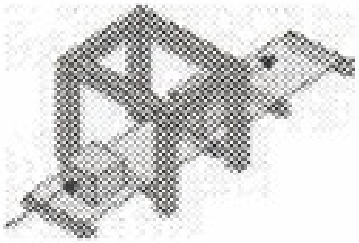
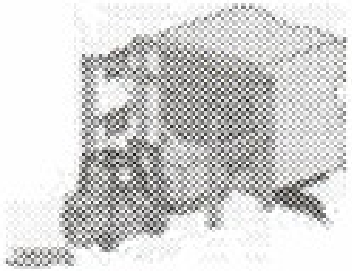
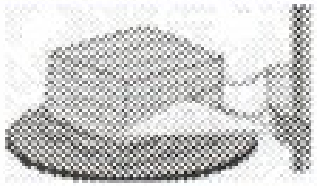
Current antennas are fabricated by photoetching copper clad plastic substrates using RF microstrip techniques. Antennas must be a half wavelength long, which is about 6” long in the 915 MHz range of EPC Global. Antennas made in this conventional way cost several times the 1 cent estimate of the Auto-ID lab report. It is generally believed that the cost of the antenna could come down to 1 cent if it is printed with conductive ink on corrugated cardboard.

PRINTING ALL TAG COMPONENTS

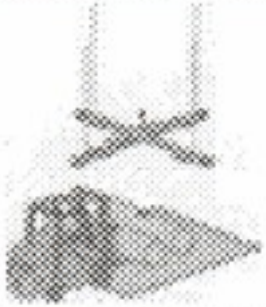
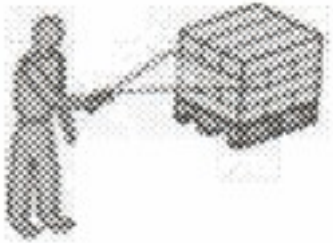
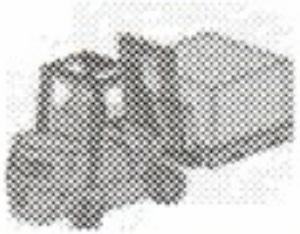
One exciting area of innovation to reduce the cost of the complete RFID tag and label to 2 cents is by “printing” the antenna and the IC on the case.

This process is based on the semiconducting properties of organic materials. Various types of electronic grade inks that have conductive, insulating and semiconducting properties are printed in successive layers to produce an electronic circuit. The printable electronics process is virtually the same as a color printing process. Printable electronics uses multiple print plates, one for each type of semiconductor material. The top print layer is the interconnect layer which includes the antenna. The retail price per printed page in a color magazine is roughly 1.8 cents, and the price for the complete tag/label would be the same.

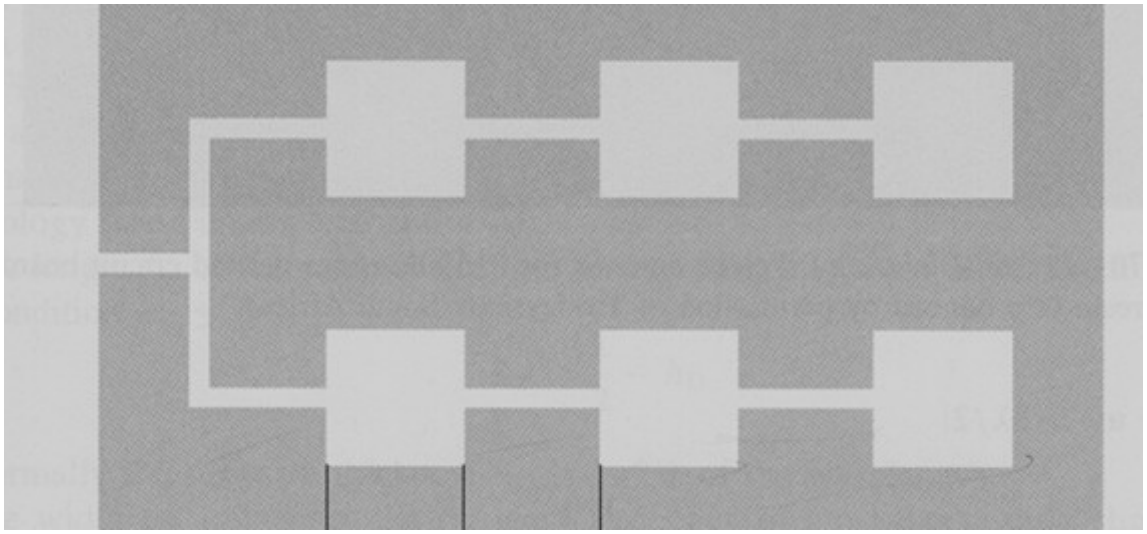
RFID READER OPTIONS BY APPLICATION

Application	Description
Conveyor Reading 	Recommended for case-level and each-level tracking, conveyor reading is best achieved with multiple antennas. Recyclable plastic containers (RPCs) with embedded RFID tags have also proven effective in conveyed reading applications.
Dock Door or Portal Reading 	Ideal for pallet-level reading, portal readers work in conjunction with presence detectors and an RF-reflective surface, such as metal mesh. The metal mesh, which surrounds the doorway, prevents transmissions from adjoining doors being read in error.
Stretch Wrap Station Reading 	The stretch wrap station provides a fixed reader ample time to identify and categorize items on pallets and to associate them with RFID-enabled pallets.

RFID READER OPTIONS BY APPLICATION (continued)

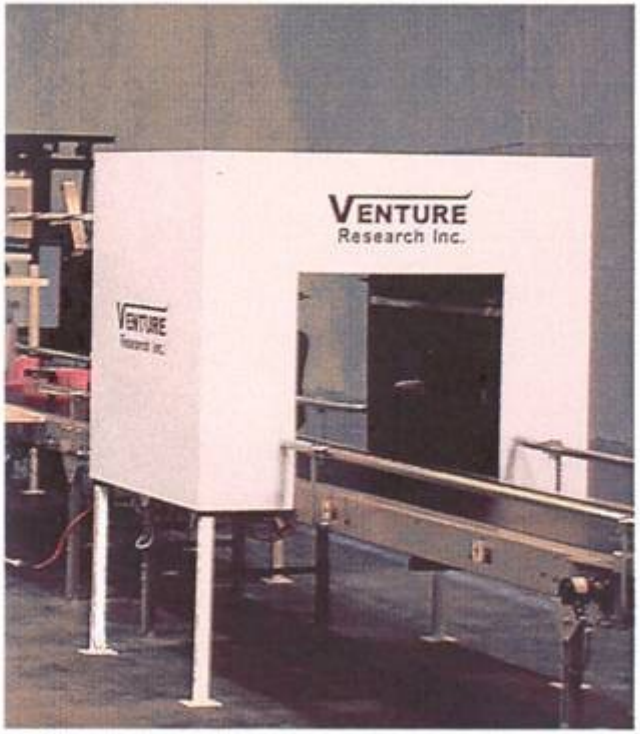
Overhead Reading		Using a fixed reader and a single set of antennas that radiate downward to an RF-reflective surface, bulky single items and pallets, with RFID tags oriented skyward, can easily be read while traveling on a forklift truck.
Handheld Mobile Reading		There is always a need for exception-based scanning. Applications requiring a search for a specific item are made easier by the mobility of a handheld mobile RFID reader because the user can bring them to a specific location to execute a search.
Forklift Reading		The mobility and flexibility offered by an RFID-enabled forklift mounted computer can be a good alternative to portal reading applications. It is especially well-suited for reading pallet-mounted or pallet racking tags.

PATCH ANTENNA ARRAY



Gain = 4 dBi + 8 dB = 12 dBi (8 dB = 6 X) Linear polarization in horizontal direction

RFID CONVEYOR TUNNEL



"Quietized" Fully Enclosed Conveyor Tunnel

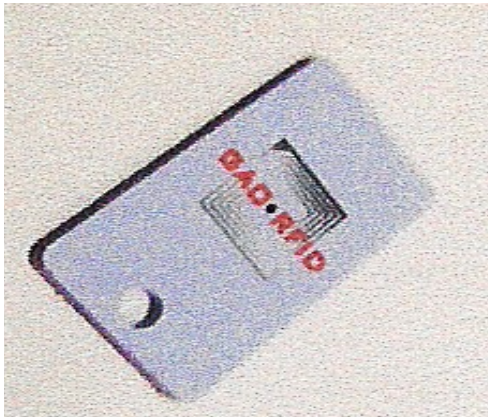
Open Frame Tunnel

WHAT THE TAG BITS REPRESENT

EPC version number
Manufacturer
Product identification (SKU)
Location of manufacturer
Serial number of product item
Location to where product item is being shipped
Error detection
Security codes
Command sets
State diagrams
Arbitration commands
Kill command for consumer protection

SPECIAL PURPOSE TAGS

860-960 MHz, Gen 2, Mini thin card



- Any application where small form factor and longer read rate is needed
- EPC Class 1, Gen 2, 96 bits
- Read range: 3.5 m, Write range: 2.5 m
- Tag size: 37mm x 24mm x 1 mm

860-960 MHz, Gen 2, Windshield Tag

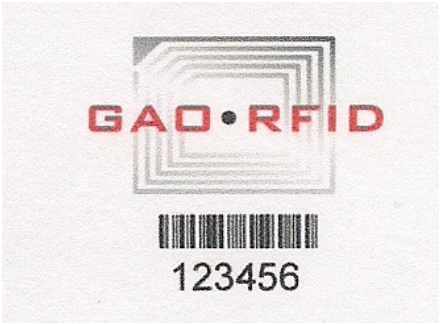
- Allows secure access to parking lots and other gated areas
- EPC Class 1, Gen 2, 96 bits
- Read range: 7 m, Write range: 3.5 m
- Tag size: 82mm x 49mm x 0.4 mm

SPECIAL PURPOSE TAGS

860-960 MHz, Gen 2, Laundry Tag

- 24mm dia x 2.5mm thick
- For laundry application with harsh temperature environments to 110 C
- Read/Write
- EPC Class Gen 2, 96 bits
- Read range: 1.5 m, Write range: 0.5 m
- Waterproof

860-865 MHz, Gen 2, RFID/Bar Code Tag



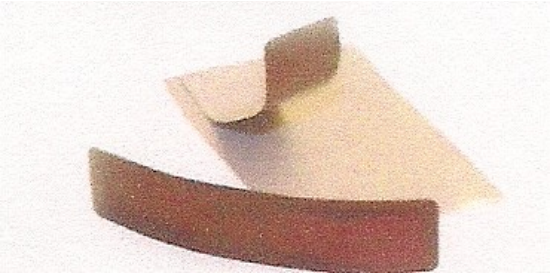
- Contactless Read/Write
- EPC Class 1, Gen 2, 96 bits
- Read range: 7 m, Write range: 3.5 m
- Tag size: 35mm x 35mm x 1 mm
- Waterproof and dustproof

SPECIAL PURPOSE TAGS

860-960 MHz, Gen 2, Fob Tag

- 30mm x 30mm x 14 mm thick
- Passive tag for loop attachment to key rings, hand tools, equipment
- Read/Write on edge
- Battery operated
- 60 kb user rewritable memory
- Waterproof

865-928 MHz, Gen 2, Tire Tag

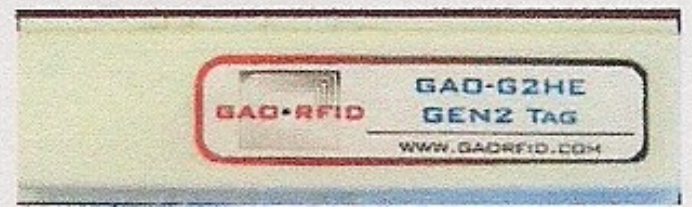


- Vehicle tire identification
- EPC Class 1, Gen 2, 96 bits
- Read range: 3- 4m
- Tag size: 16 mm x 74 mm x 0.4 mm
- Adhesive backing

SPECIAL PURPOSE TAGS

865 MHz, Gen 2,

Harsh Environment RFID Tag



- 180 mm x 40 mm x 15 mm thick
- For harsh environments
- Resistant to immersion in salt water, alcohol, oil
- Waterproof and dustproof
- Operating Temperature: -25 C to 70 C
- Maximum read quantity: 500 tags/sec