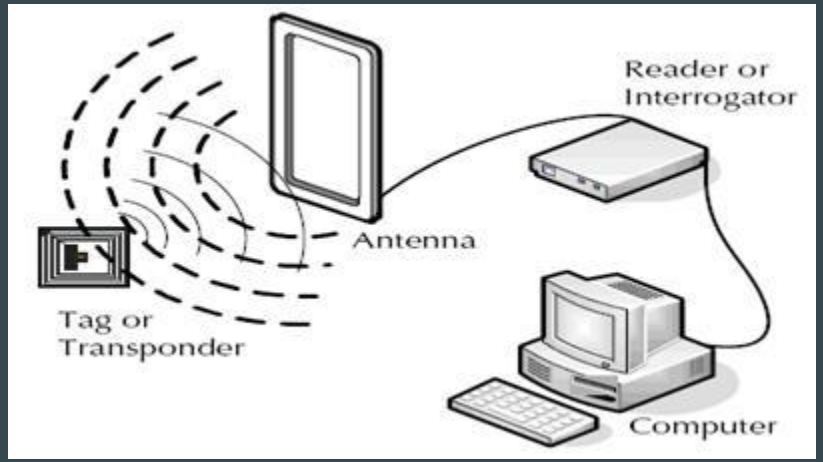
Structural Health Monitoring System using Wireless Passive Sensors

Presented by: Manish Shah (201601041)
Vaibhav Sherekar (201601057)

What is RFID?

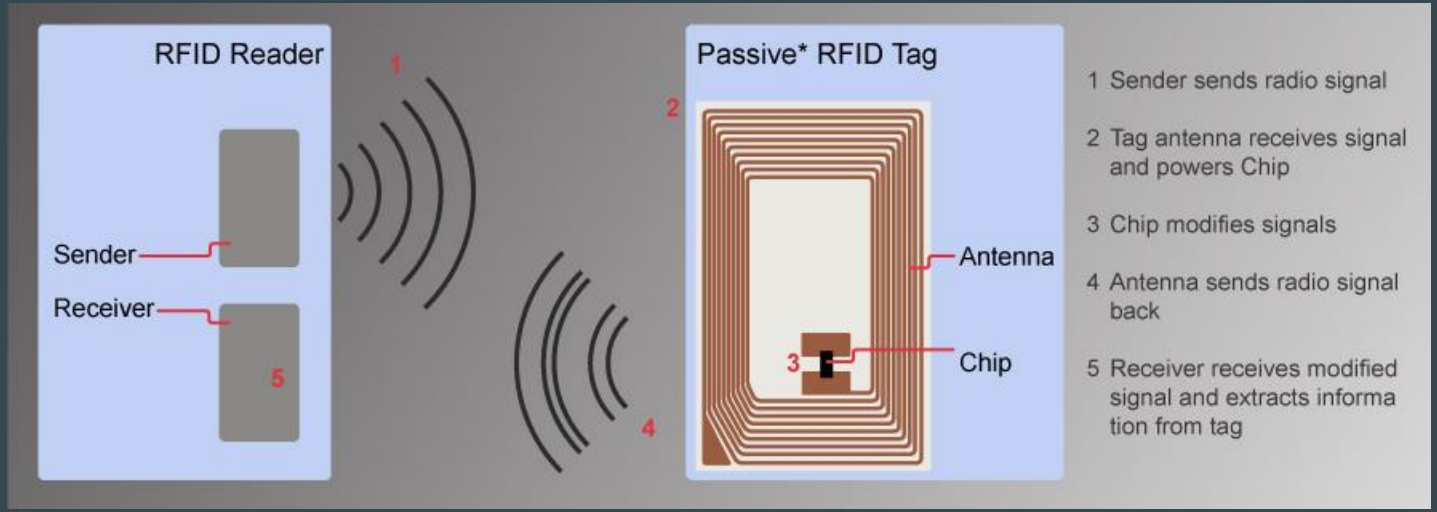
Radio-Frequency Identification (RFID) is the use of radio waves to read and capture information stored on a tag attached to an object. A tag can be read from up to several feet away and does not need to be within direct line-of-sight of the reader to be tracked.



https://www.elprocus.com/wp-content/uploads/2013/09/An-Active-RFID-system.jpg

What is Passive RFID?

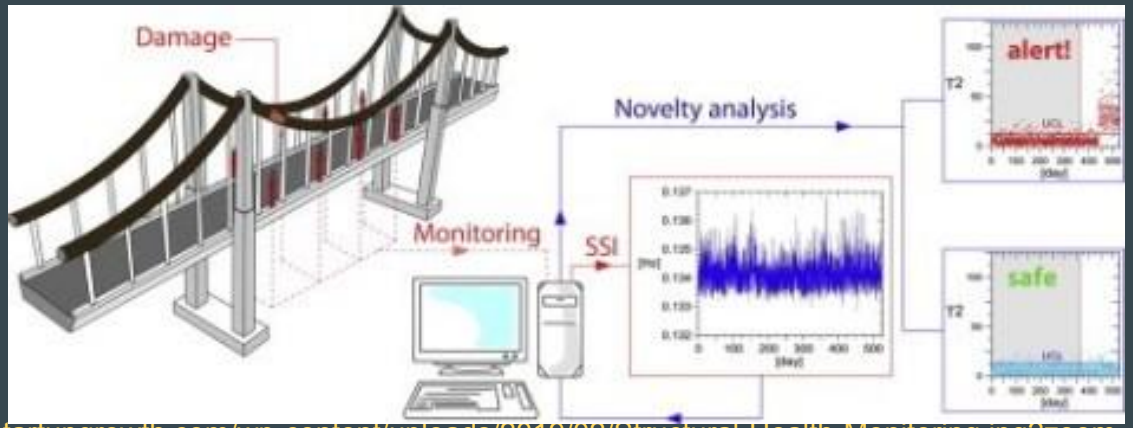
A passive tag is an RFID tag that does not contain a battery; the power is supplied by the reader. When radio waves from the reader are encountered by a passive rfid tag, the coiled antenna within the tag forms a magnetic field. The tag draws power from it, energizing the circuits in the tag. The tag then sends the information encoded in the tag's memory.



https://www.cxjrfidfactory.com/wp-content/uploads/2016/08/passive-RFID-labels-1.jpg

What is Structural Health Monitoring (SHM)?

Structural health monitoring refers to the process of implementing a damage detection and characterization strategy for engineering structures.



https://i0.wp.com/thestartupgrowth.com/wp-content/uploads/2019/02/Structural-Health-Monitoring.jpg?zoom=1.25&fit=500%2C187&ssl=1

Wireless Concrete Mixture Composition Sensor Based on Time-Coded UWB RFID

- Structural health of concrete-based civil structures is a major concern in today's society and a non-destructive technique is desirable for durability and longevity.
- The method implemented here is passive sensor technology. A passive permittivity sensor which uses UHF radio frequency identification (RFID) under some specific frequency is used.
- The main idea on which RFID system works is the ‘Reader - Tag’ system.
- The sensor tag can be seen as an equivalent two - port network (antenna) loaded with an open-ended delay line.

- The reader sends through its transmitting antenna a Gaussian pulse which hits the tag and the tag responds with the corresponding information to the receiving antenna of the reader.
- The tag is passive; which means it doesn’t have its own energy. It obtains energy from the reader; the electromagnetic waves which the reader sends along with the information.
- The delay line is embedded in the concrete and the metal plate is perpendicular to the antenna to provide a strong reference peak.

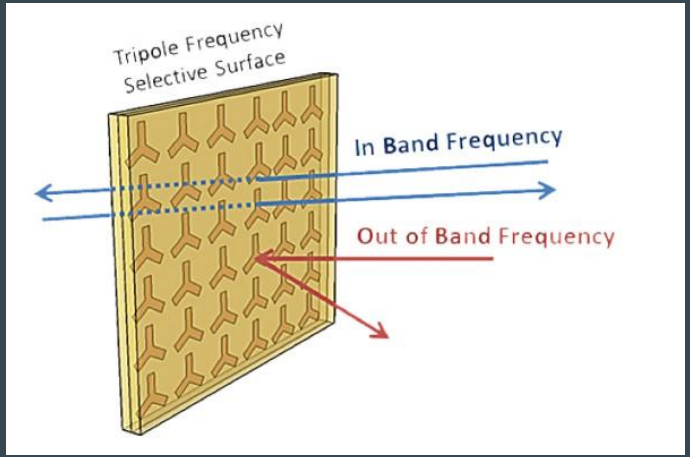
Results of the RFID method for SHM.

- The results showed that more the concentration of concrete than sand, more delay it takes between the tag and the metal plate, and the amplitude of the tag is reduced.
- The results showed that permittivity is concerned directly with the composition.
- It is possible to remotely detect the concrete mixture and sand in a concrete block using UWB technology.

SHM in transportation infrastructure using Frequency Selective Surface (FSS)

What is FSS?

- A frequency-selective surface is any thin, repetitive surface designed to reflect, transmit or absorb electromagnetic fields based on the frequency of the field.



https://www.ccm.udel.edu/wp-content/uploads/2013/06/mccauly2-e1371563801171.jpg

Advantages of FSS

- FSS is completely passive, consisting only of conductive elements.
- Easy to fabricate as it consists of only metal patterns (no dielectrics or semiconductors used).
- The key functionality of an FSS is the ability to control the electromagnetic response (reflection and transmission properties) from a structure.

There are mainly two types of damage detection techniques: Local and Global.

1. **Local-based** techniques detect damage such as cracks, yielding, or delamination by interrogating a structure over a finite area.
2. **Global-based** damage detection refers to instrumenting a structure with a finite number of discrete sensors.

- Designing an FSS as a resonant structure allows us to design one or more sharp changes in the response at a prescribed frequency
- The process for development of FSS includes designing, screen printing and etching and strain testing.

Understanding SHM using various kinds of materials.

Types of materials chosen are:

1. Timber
2. Dielectric
3. Concrete

Major issues with these different materials are:

- Timber gets affected by moisture and humidity very easily.
- Dielectric materials are insulators of electricity; maybe transparent or opaque.

So, basically depending on the type of material the effectiveness of SHM is determined.

Problem Statement

- To design a ‘Reader - Tag’ sensor system and an antenna in CST Microwave Studio to get the status of the structure in real time based on various important parameters of the antenna & tag such as location, position, range, longevity, materials, types, design, method of implementation, protocols, memory, programmable circuits.

References

1. Wireless Concrete Mixture Composition Sensor Based on Time-Coded UWB RFID by Angel Ramos, David Girbau, Antonio Lazaro, and Ramon Villarino.
2. Ultrawideband Chipless RFID by Marco Garbati, Etienne Perret, Romain Siragusa, and Christophe Halopé.
3. Structural Health Monitoring and Remote Sensing of Transportation Infrastructure Using Embedded Frequency Selective Surfaces by PI Edward C. Kinzel1, Co-PI Kristen M. Donnell, Co-PI K. Chandrashekhara
4. An overview of wireless structural health monitoring for civil structures by Jerome Peter Lynch.
5. An introduction to structural health monitoring by Charles R. Farrar and Keith Worden.
6. A Review on Chipless RFID Tag Design by Ali Hashemi, Amir Hossein Sarhaddi, and Hossein Emami
7. A Review of Passive RFID Tag Antenna-Based Sensors and Systems for Structural Health Monitoring Applications by Jun Zhang, Gui Yun Tian, Adi M. J. Marindra, Ali Imam Sunny and Ao Bo Zhao.
8. Implementation of Structural Health Monitoring based on RFID and WSN by SHiva Mirshahi, Aliakbar Akbari and Sener Uysal.
9. Structural Health Monitoring of an innovative Timber Building by Claude Leyder, Eleni Chatzi and Andrea Frangi
10. Passive wireless antenna sensor for strain and crack sensing – electromagnetic modeling, simulation, and testing by Xiaohua Yi, Chunhee Cho, James Cooper, Yang Wang, Manos M. Tentzeris, Roberto T.Leon.

Thank You