INTERNET OF THINGS (IOT)

RFID TEMPERATURE SMART SENSOR

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Abstract

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Abstract

The main of this project was to build a temperature smart sensor using Internet Of Things (IOT) technology as the base of our application implementation. IOT was implemented by integrating passive RFID technology and smart sensor technology. MEMs sensors which are micro systems and are enough to build a relatively small device were used.

A customized made “G2iL+” chip was used to build the tag and the tag’s antenna was also from a copper PCB board. A passive RFID tag developed after integrating the copper PCB board and the chip was powered by a reader to read the tag’s information. A temperature switch was then connected to enable us measure extreme temperatures.

The device built from this project can be embedded in any surface to collect temperature data from the surroundings and also in an extreme temperature condition.

Keywords

Internet Of Things (IOT),RFID tag, smart sensor, temperature switch

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Tiivistelmä

Tämän työn päämäränä oli rakentaa ”Temperature Smart sensor” käyttäen”Internet OfThings” (IOT)- teknologiaa sovelluksemme toteutuksen perustana. IOT- teknologiaa toteutettiin integroimalla passiivista RFID-teknologiaa sekä älyanturiteknologiaa. Työssä käytettiin myös mikrosysteemejä (MEMs), jotka ovat riittävän pieniä vastaavan pienen laitteen rakentamiseksi.

Mittatilaustyönä tehtyä “G2iL+”- sirua käytettiin tagin rakentamiseksi ja tagin antenni oli myös kuparisesta PCB- taulusta. Passiivinen RFID- tagi kehitettiin kupariseen PCB- tauluun integroimisen jälkeen ja siru sai virtansa lukijasta, joka luki tagin informaatiota. ”temperature switch” yhdistettiin siten mahdollistettaeksi äärimmäisten lämpötilojen mittaaminen.

Tässä projektissa rakennettu laite voidaan sulauttaa mihin tahansa pintaan pintojen lämpötilatietojen keräämiseksi myös äärimmäisissä lämpötiloissa.

Avainsanat
Internet Of Things (IOT),RFID tagi, temperature switch

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Anane Phenehas Fosu
7th December 2012
Kuopo- Finland

Glossary

RFID – Radio Frequency Identification

IBIM – IntelliBus Interface Modules

EPC – Electronic Product Code

ERP -Electronic Road Pricing

ETSI - European Telecommunications Standards Institute

HF – High Frequency

IC – Integrated Circuit

ISO- International Organization for Standardization

kph – Kilometer Per Hour

LF – Low Frequency

mW – Milliwatt

RF600A – Simatic RFID Antenna

RF600R – Simatic RFID Reader

RF-Manager – Simatic RFID Host Application Developer Software

RF – Radio Frequency

TCP – Transmission Control Protocol

IP - Internet Protocol

TR - Receive

TX – Transmit

UHF – Ultra High Frequency

USB – Universal Serial Bus

WR – Read Write (reprogrammable)

IOT – Internet of Things

MEMs – Micro-electromechanical Systems

Table of Contents

1.0 Introduction

Internet of Things (IOT) can be defined as a network infrastructure connecting physical and virtual objects through the exploitation of data capture and communication capabilities. The infrastructure is made up of existing and evolving network and internet development which will offer specific object identification, sensor and connection capability as the basis for the development of independent cooperative services and applications.

The main communication form on the internet today, is human to human but IOT gives objects opportunity to have a unique way of identification and can be addressed so that every object can be connected. This also expands the forms of communication from human- human to human- things. Radio Frequency Identification (RFID) and other related identification is the building blocks of the IOT.

The developing trend of the IOT is made up of three steps. They are embedded intelligence, connectivity and interaction.

The embedded intelligence can perform action automatically. RFID tag is an example of the embedded intelligence with a lot of applications. It is embedded in food to record information about its condition which can be retrieved by RFID reader. The retrieved data can be transmitted remotely by having connectivity through internet. Things can be connected wired or wirelessly. Based on the infrastructure, there are many ways to connect things. These include Zigbee, RFID, WPAN, WSN, DSL, UMTS, WiMax, WiFi, 3G and so on. An interaction platform is then created to process information, self-configure, self-maintain and self-repair, make independent decision and play active role on their own disposal. This can make things to interact and exchange information by themselves.

The IOT brings an era where both physical world and information world are mix together. This will generate a platform on which machines will be communicating to machines on behalf of people. With the help of the IOT the future is certain that ushering into a new communication era between humans and things and between things themselves where new dimension will be added to the world of information and communication technologies.

2.0 RADIO-FREQUENCY IDENTIFICATION (RFID)

Radio-frequency identification is the use of a wireless non-contact radio system to transfer data from a tag attached to an object to identify and track it. RFID provides out of line of sight identification, and at distances much greater than that can be scanned by barcode readers. The main components of RFID system are tags, interrogator or reader and an antenna. Figure 1 below shows the basic building blocks of RFID system.

RFID tags can be classified by their power source into three major categories: *active* tags, *passive* tags, and *semi-passive* (*semi-active*) tags. An active tag possesses both a radio transceiver and a battery that is used to power the transceiver. A passive tag operates without any battery. It reflects the RF signal transmitted to it from a reader (interrogator) or a transceiver and adds information by modulating the reflected signal. The passive tag does not use any battery to elevate the energy of the reflected signal. Similarly, Semi-passive tags use the radio waves of senders as an energy source for their transmissions. A semi-passive tag may also be equipped with batteries to help maintain memory in the tags or power some other additional functions. Active tags are more powerful than passive tags when it comes to their larger range, memory size and ability to perform other functions. Meanwhile, the active tags are more costly than passive tags.

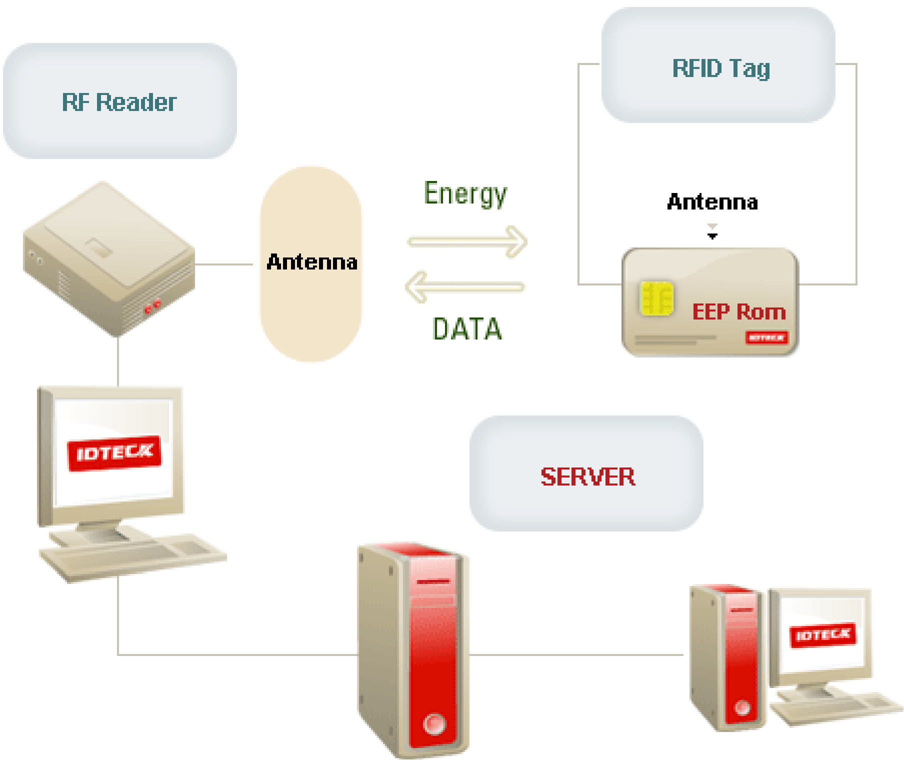


Figure 1.The basic building blocks of RFID system.

2.1 FREQUENCY RANGE OF RFID SYSTEM

RFID systems are distinguished by the frequency of the radio waves they use and by the protocols used to communicate between the tag and reader.

RFID system operates in frequency bands. The exact frequency is controlled by the Radio Regulatory body in each country. The systems are distinguish by the frequency of the radio waves they use, the protocols used to communicate between the tag and the interrogator (reader) and the means to provide power to induce and activate the tag.

The frequency of RFID systems ranges from 125 kHz to over 5GHz. The low frequency (LF) tags operate within 125 kHz and 134 kHz band whilst the high-frequency HF systems operate at range of 10-15 MHz. The RFID systems which operate from 860MHz to 960MHz frequency range are known as ultra-high frequency (UHF) and frequency range around 2.4 to 2.45 GHz frequency band are Microwave RFID systems.

LF tags are less affected by the presence of fluids or metals compared to the higher frequency tags and are fast enough for most applications but have shorter reading ranges. HF tags have higher transmission rates and ranges but are more costly than LF tags. One example is RFID smart cards, working at 13.56MHz.
LF and HF tags are license exempt and can be used worldwide while UHF tags need a permit and are different from country to country.

2.2 DESCRIPTION OF BUILDING BLOCKS OF RFID SYSTEMS

2.2.1 TAG

RFID tags are composed of chip, a built-in antenna for communicating and other component. Each tag has a global unique Electronic Product Code (EPC). The aim of EPC is to provide global unique identifier to each product it is tag to, identifies and finds individual product by the network. This means that individual product information can be tracked with the help EPC's network and RFID systems. Chip tags can be both read-only (programmed during manufacture) and read-write or can be read only. The size of the tag depends on the size of the antenna, which increases with range of tag and decreases with frequency. The chip tags also have memory space for storing the product information.

Figure 2. Various forms of passive tags

2.2.2 Readers and Antennas

RFID reader devices convert radio waves from RFID tags into a form that can be passed to Middleware software. The reader or interrogator uses antennas to communicate with the RFID tag. Most reader requires the use of multiple antennas to make its reading successful.
Handheld readers that act like a handheld bar code scanner and RFID readers embedded into mobile data collection devices are different variety of reading systems and technologies used by the RFID readers (interrogator).

Figure 3. RFID readers (interrogators)

The antenna transmits RF signals between the readers and the tags.

Figure 4. A Different types of RFID external Antennas

2.2.3 Middleware

Middleware software applications are used to manage the flow of data from readers to back-end management systems and vice versa. RFID middleware help with the retrieving data from readers and also filtering data feeds to application software. The middleware also assist in capturing history, monitoring tag and reader network performance, generating inventory movement notifications, analyzing tag-read events for application tuning and optimization.

2.3 BASIC PRINCIPLES OF RFID SYSTEMS

The reader sends a certain RF frequency signals with the help of the antenna. The tag is induced and activated when it falls within or comes into the induced current field of the antenna. The activated tag now sends its own code out through the built-in antenna. The external antenna received the carrier signals sent by the tag and finally send them to the reader. The interrogator (reader) will demodulate and decode the signals .The decoded signals or information is sent to the background of the main systems for storage and other applications.

2.4 INTEGRATION OF RFID AND SENSOR NETWORKS

RFID and sensor networks are both important components of pervasive computing. Sensor network can be used to sense and also monitor physical, chemical, and biological environments. Although any object that is embedded with an RFID tag can be sensed but its application or sensing ability has limitations such as low tolerance to fluid or metal environments. RFID systems can extend the ability of a sensor network by providing sensible property to otherwise insensible objects.

Wireless sensor networks have a number of advantages over traditional RFID implementations. Firstly, sensors are able to give more detail information, such as the measurement of temperature, humidity, pressure, vibration intensity, sound intensity, power-line voltage, chemical concentrations, and pollutant levels and so on. Secondly, incorporation with sensors helps RFID to push logic into nodes to enable RFID readers/tags to have intelligence. This allows for applications, such as real-time warning of proximity to dangerous substances or enforcement of safety rules in the operation of heavy machinery. One example is the RFID sensor developed by Detection & Food Safety Center of Auburn University is able to measure contamination owing to bacterial growth and can operate in an alarm mode with signaling once a problem has been detected. Sensor networks give limitless potentials for RFID. Integration of RFID and sensor networks can give RFID the capacity to work in multi-hop way that potentially extends applications of RFID to operate in a wider area. The figure shows effective role sensors and RFID systems can play in IOT.

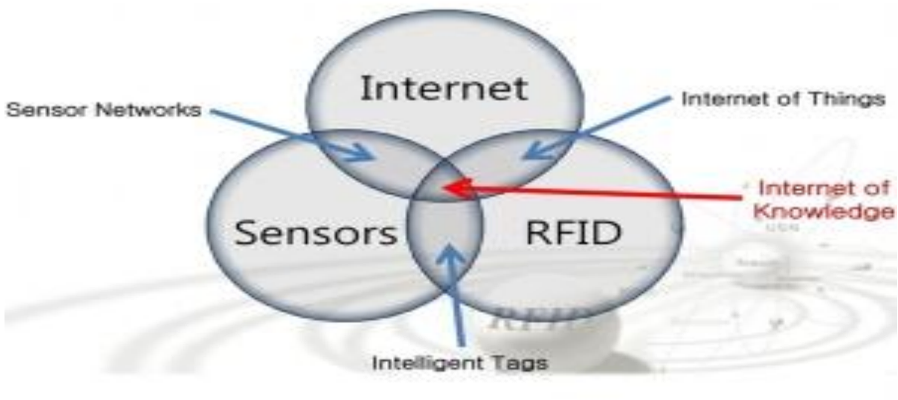


Figure 5 compatibility of sensors and RFID systems

3.0 EPC NETWORK

The process of EPC network is shown in the figure 6 below. The operation is an integration of web application systems and RFID EPC code.

3.1 Description of EPC Network features

3.1.1 Middleware

The Middleware has specific features which meets users demand. One of the most important features is ALE (Application Level Events). ALE helps in transmission of data between RFID reader and back-end systems. It also retrieves real-time data and affairs and transmits them either to the back-end or the reader.

3.1.2 EPC information services (EPC-IS)

The EPC information service (EPC-IS) form part of the framework of the EPC network system and provides an extensible interface for both services and data. The main functions of the EPC-IS is to store data of information handled by Middleware and also query information.

3.1.3 EPC Object Naming System (EPC-ONS)

Another feature of the EPC network is EPC Object Naming System (EPC-ONS) The ONS identify servers that stores data of the middleware. Its work is similar to Domain Name analytic Service (DNS).

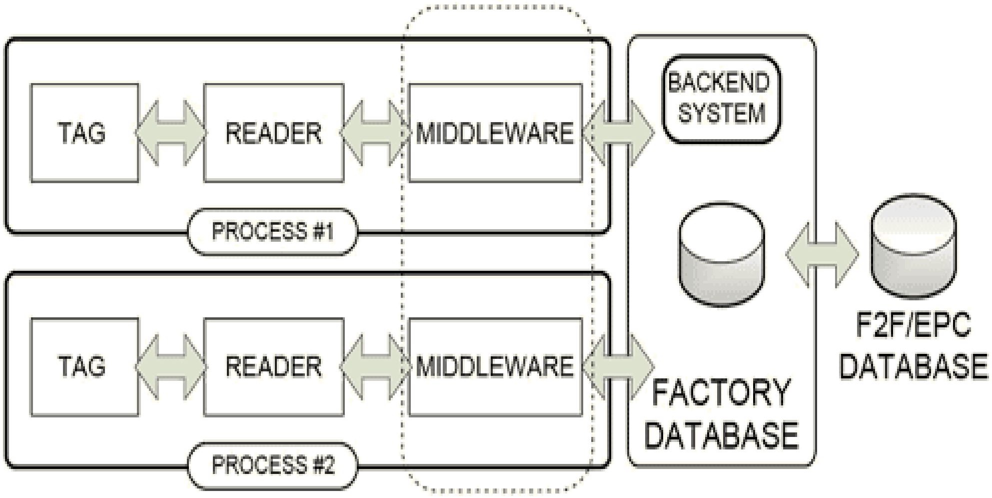


Figure 6. EPC network system

4.0 THE ARCHITECTURE OF THE IOT SYSTEMS

The IOT consist of three main parts. They are the sensing layer (EPC sensor network), the network layer and application layer (information service system). The figure 7 below outlines the various layers of IOT architecture.

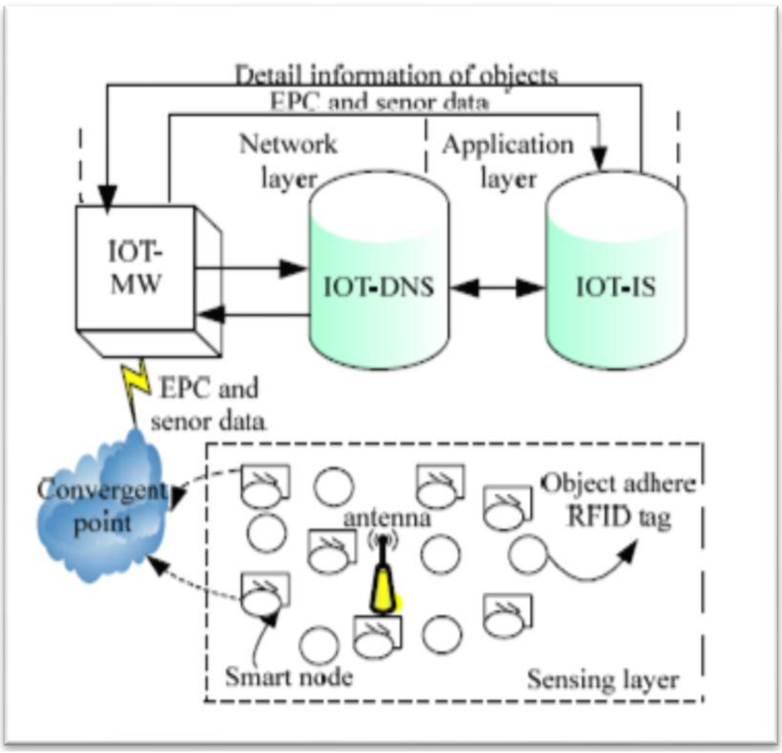


Figure 7. IOT architecture

4.1 Sensing Layer

The sensing Layer is an integration of RFID systems and Wireless Sensing Network (WSN). The fusion of RFID systems and WSN helps to gain object's environment information and distinguish each object precisely. The recognition scope of RFID systems expand as a result of the integration of the smart node, reader and WSN node to gather object environment information precisely and determine the objects exhaustive position. The Sensor technology may enable effective identification to read up to 100m as compel to RFID systems which can read up 10m or less.

4.2 Network Layer

The network layer is made of IOT-DNS (Domain Name System) and IOT WM (Wireless Middleware). The network helps to distinguish each object that is interconnected in the physical world. It makes the object more intelligent product with dynamic information. It also provides a fast and efficient network platform for sharing objects information.
The IOT-DNS serves as a directory which assigns a unique code to each tagged object. This unique code contains all the information of the object which matches with the information server system network localization address of that in store all the necessary information of the object. The IOT-DNS works in the same as the domain name analysis and its main purpose is to locate the tagged object information code to the database server that stores the related information of the tagged object.
The middleware is between the sensing layer and application layer. It provides a series of computation and data processing function.

4.3 Application Layer

The application layer provides information service about the tagged object. It is made up of IOT client side, data storage module and data inquiry module. The IOT-IS (information server) adjust data, balance the different kind of data application demand in both interior and exterior these systems. It also provides require data for each kind of inquiry.

5.0 Applications of IOT

5.1 RFID-Base Mobile Payment to IOT

On-site payment credit card payment is one means of payment using internet of things application. The mobile phone is near to the surface of an intelligent machine or reader using a radio frequency technology for the transaction completion. The on-site payment plays an important role in the business world for the current mobile phone payment field because of its reliability, safety and many other advantages.
On-site mobile phone credit card payment has three different implementations. They are:

- SIM-pass
- RF-SIM
- NFC (Near Field Communication)

5.1.1SIM-pass

SIM pass is also known as dual interface SIM card and has both contact and non-contact working mode. The contact mode is for SIM functions and the non-contact mode for the payment function. Payment is service can be achieve with the help of wireless communication network and corresponding mobile payment service platform. SIM pass works in 13.56MHz frequency range and has strong compatibility. It is compactable with industrial sector both home and abroad.

5.1.2 RF-SIM (Radio Frequency-SIM)

RF-SIM card is integrated with the card system and works in the 2.4GHz frequency band. With such a large frequency antenna integrated in the SIM card, the carrier can penetrate through the batteries and the back cover of the mobile phone, making it communication distance (10-500cm) bit further as compare to that of the SIM-pass.

5.1.3 NFC (Near Field Communication)

NFC (Near Field Communication) is a short range wireless communication technology which integrates non-contact reader, non-contact card and peer-to-peer function into a single chip and loaded into a mobile phone. NFC works in 13.56MHz frequency band at a distance of 10cm and has strong compatibility. With NFC the manufacturers provide the chip and its corresponding interface accessories and sell them to users or service providers.

5.2 Monitoring and anti-counterfeiting of products

Application of RFID and IOT in monitoring and anti-counterfeiting of product
In the supply chain management, monitoring and anti-counterfeiting of product is very essential if enterprise wants to offer consumers a real-time information inquiry platforms on commodity and also to allow them have clear picture of the whole life cycle of a particular product. This gives the customers the opportunity and convenient channel to know and identify the authenticity of a particular product. This whole process can be achieved by taking advantage of RFID and IOT.

5.2.1 The process of anti-counterfeiting for products

In the process of anti-counterfeiting of product, the enterprise will distribute their product information which includes directory and directory service of products, RFID anti-counterfeiting label information and the life cycle of the product to the public platform of the RFID anti-counterfeiting through internet. The consumer with the help of the label code on the product will be able to access to the corporate anti-counterfeiting information service address through RFID-enable mobile phones. It can also be achieved by internet connected computers equipped with read-write application software for the RFID tags. The figure 8 shows the process of identifying if a product is counterfeit or not.

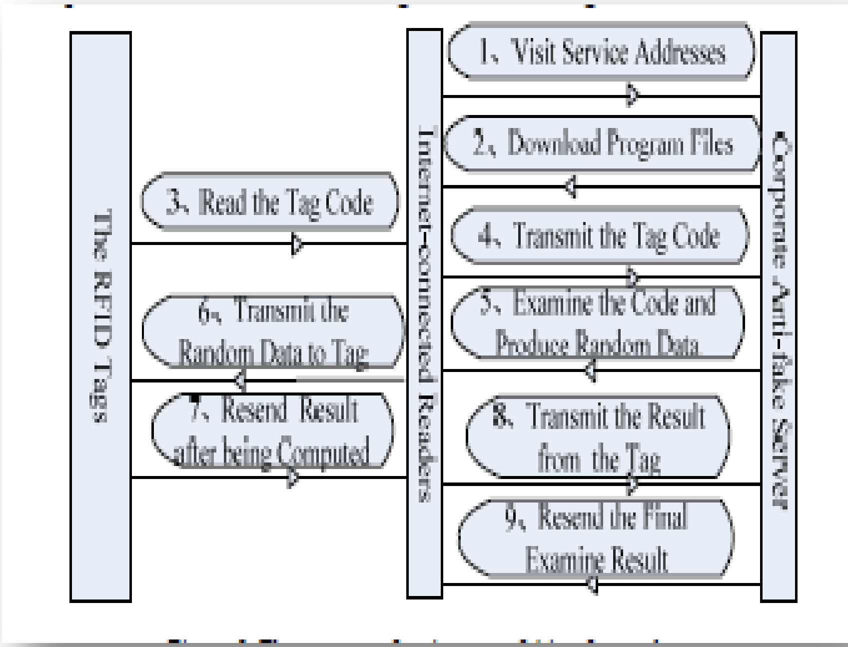


Fig. 8 The process of anti-counterfeiting for products

5.2.2 Description of the various stages

Firstly, the consumer retrieves the corporate anti-counterfeiting server address from either product description or other identification directly. When products with RFID labels are received by the consumer, the consumer uses the RFID-enabled phone to go to the web address and download program files that interact with the server. The figure 9 shows client phone connecting to the server.

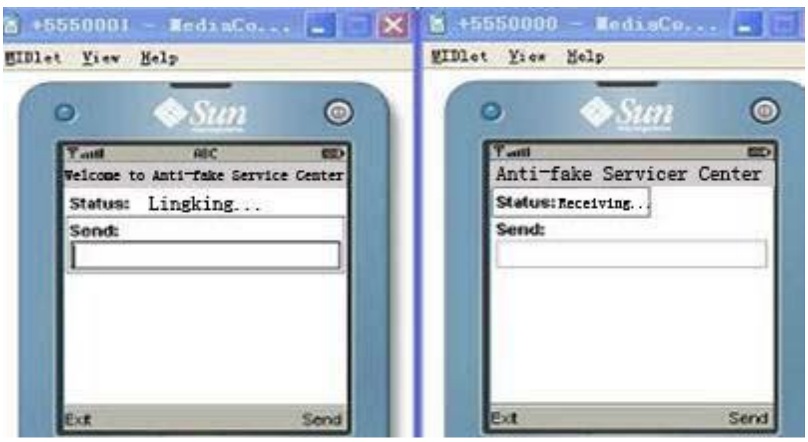


Fig. 9 The client phone is connecting to the server

In the second stage the consumer now uses the mobile phone to read the label of the product to capture a set of numbers and letters for the label and forward it the anti-counterfeit server. This set of numbers and figures is also known as the product's RFID code. If the code meets with the RFID coding standard of the corporate product, then the server queries by producing a random data that is pass to the client. Figure 10 displays how the phone passes the information to the server after receiving the query from the server.

Fig. 10. The phone passes the information to the server

Finally, the client phone in turns sends the random data to the tag or the product label after it has received it from the server. The tag's internal calculated result is forward back to the server for a check. After the server has check the calculated result it then send information back to confirms the product authenticity either genuine or not. The figures 11 and 12 shows the mobile phone receiving random numbers from the server and the sending of the inspection results that the product is genuine respectively.

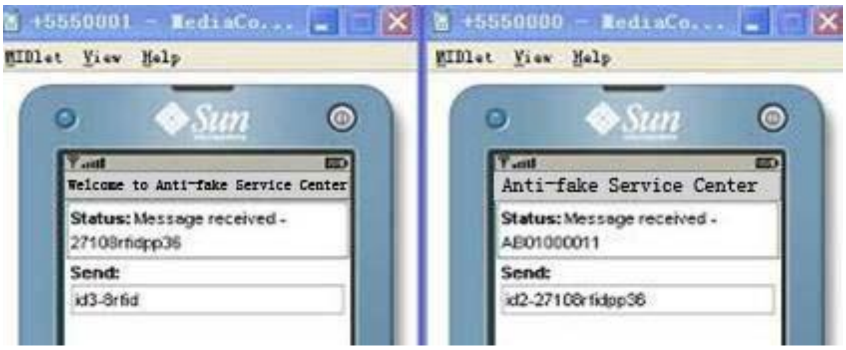


Figure 11. The server sends random number to mobile phone

Figure 12. The service sends the inspection results that the product is genuine

5.3 SOME OTHER APPLICATIONS OF IOT

- Oxygen cylinder management architecture.
- Logistic Unified information system warehouse design.
- Automotive recycling information management based.

6.0 Smart Sensors

Smart sensors devices are embedded with more features as compare to ordinary sensors. These sensors detect and report data in both unusual and extreme situations and transmit the collected information to the end user. The sensors consume less power, cost effective, small in size and can share information among neighbours with over lapping sensing areas. The embedded features, signalling conditioning and other properties makes the sensors more adopted in the market and the trend toward pervasive sensors.

6.1 Types of smart sensors

Smart sensors are mostly of MEMs systems and have many application including biomedical, control systems, security systems, metrological service, aviation and so on. Different types of smart sensors include:

- Temperature sensors

- ❖ Pressures sensors
- ❖ Humidity sensors
- ❖ Accelerometer sensors
- ❖ Optical sensors
- ❖ Gas sensors
- ❖ Biosensor sensors
- ❖ Chemical sensors

Figure 13 shows examples of temperature smart sensors.

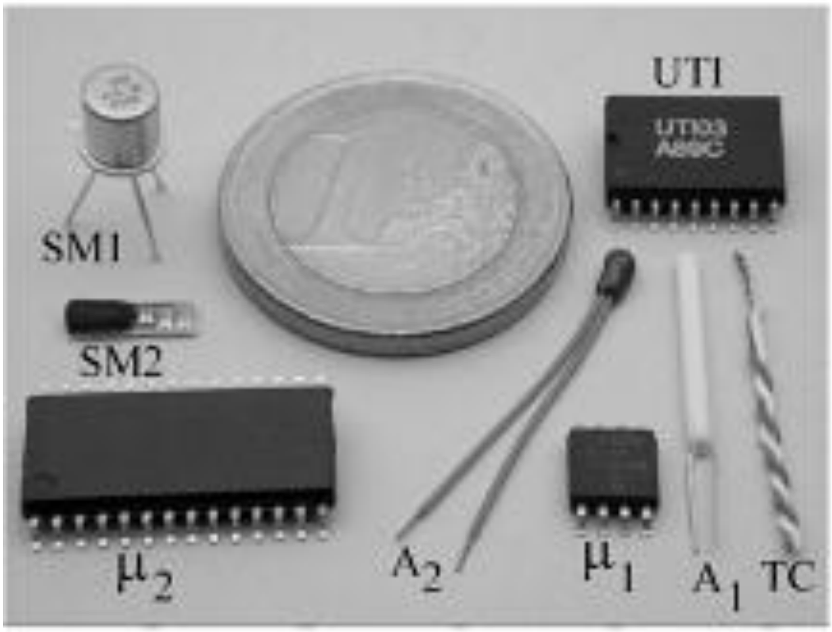


Figure 13. Temperature smart sensors

6.2 RFID tags and smart sensors

The integration of an RFID tags and smart sensors can lead to formation of a more sophisticated sensors system for collection and transmission of data to the end users in an extreme condition. The RFID smart sensors are versatile and easy to configure to the required specification. The other characteristics include low cost and power consumption, it’s compatibility to any kind of sensor and easy to use in different application domain.

7.0 Smart transducers

Smart transducer is an integration of sensor or actuator, a processing unit and a communication interface. The manufacturing of smart transducers which allow a two level design has reduced the overall complexity of the system by separating issues between designers and manufacturers. The smart transducers are manufactured with their own standards and protocols which allows for simple implementation, real-time communication capabilities and resource-efficient handling of data. The two main standard of transducers are IEEE 1451.2 standard and OMG Smart Transducer Interface standard.
The IEEE 1451.2 keeps the configuration data physically associated to the nodes whilst OMG STI standard keep memory requirements on nodes low and enforces a tight integration of smart transducer systems together with software tools and external description. Figure 14 is a picture of smart transducers and distance sensor application.

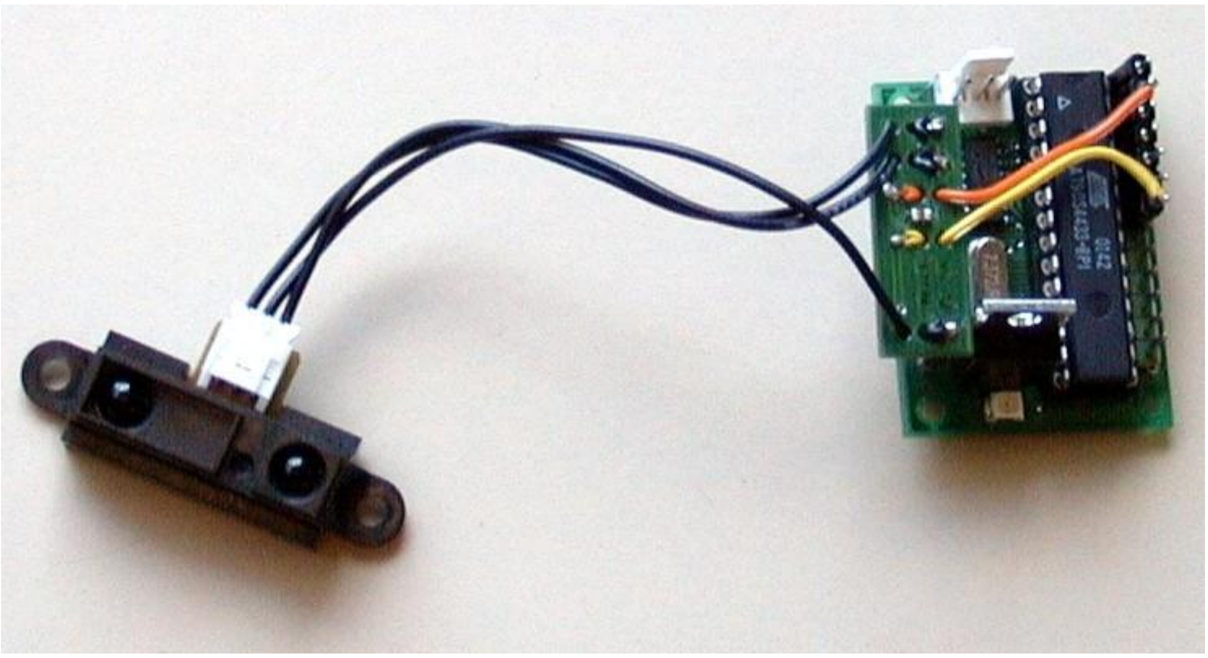


Figure 14.Smart transducers with distance sensor connected to Atmel AVR Microcontroller

7.1 Integration of Smart sensors

The measurement functions which include analog signal conditioning, analog-to-digital conversion, digital signal processing, application algorithm data communication etc. are integrated by smart sensor network systems into a small electronic module that can be inserted into a traditional transducer making it a smart sensor or a module which can interface to existing analog transducers. The integrated transducer will now consist of a multi-drop sensor architecture having a smart digital output sensors interconnected to a network interface controller (NIC) via a common digital transducer bus. This helps to eliminate most interconnecting cables and increasing the system's performance and its reliability. Figure 15 shows the integrated features of the smart transducer.

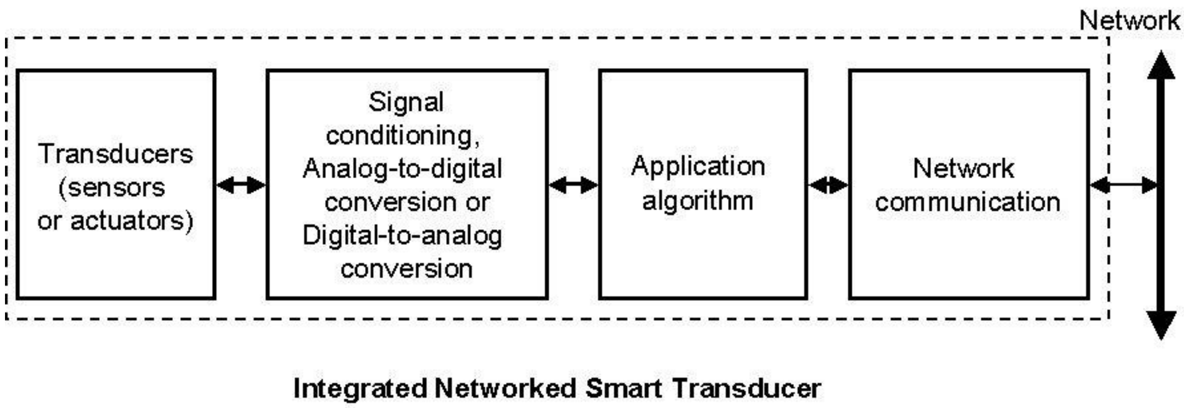


Figure 15. Integrated networked smart transducer

7.2 Advantages of smart sensors and transducers

- **Minimum interconnecting cables**
  Cables and their length used by older star topologies for interconnecting analog transducers to a central signal processing equipment has a great impact on all aspect of the measuring system. These measures have decreased system performance, increase system operation and decrease system the accuracy and reliability of measurements.
  The sensor network architecture has minimized the interconnecting cables by interconnecting all of the transducers through a common

digital bus cable. Miniature modules which strategically distribute the setup have replaced the centralized bulky electronic boxes of traditional measurement systems.

- **High Performance**
  Higher accurate measurements can now be obtained by digital correction over both analog signal conditioning instrumentation and transducers sensitivity.
  Other problems which retarded the performance of sensors and transducers were large numbers of analog transducers resulting in difficult-to-manage situation and large and long bundles of cables carrying analog signal which were susceptible to corruption by EMI/RFI noise. These problems are now immune by cable carrying digital signals and are easier to interface as compare to cable carrying analog signals.

- **High reliability**
  High Reliability can now be achieved by minimizing the total number of interconnecting cables and adding Built-in-Test (BIT) features. The self-test builds in a higher level of confidence that a given measurement channel is alive and working properly.

- **Minimum cost**
  The implementation of smart sensors and transducers has reduced the design, operation and maintenance cost. The standard hardware and software interfaces proposed for all transducer types have reduced the capital equipment cost.

- **Small Rugged packaging**
  The measurement system components are lightweight, small and package to work under a higher demanding environmental conditions typical of aerospace applications which include high temperature, high vibration, high pressure, humidity, etc.

- **Scalable-Flexible System**
  The new sensor network measurement system accepts both traditional analog type of transducers and new smart sensors. It also gives way for easy expansion or reduction in the number measurement channels.

7.3 System Description Smart Sensor Network System

Smart Sensor Network System can be defined as a distributed sensor instrumentation system with synchronous sampling which is made of smart digital output sensors and transducer modules interconnected to a Network Interface Controller (NIC) via a multi-drop digital serial bus (IntelliBus). The IntelliBus Interface Modules serve as an interface for any traditional analog transducer to the bi-directional digital bus.

7.3.1 Smart Networked Sensors

The smart Networked sensors is made of sensor element, signal conditioning, analog-to-digital conversion and digital signal processing and communications function in one mechanical package and communicate directly to the transducer bus. The figures 16 and 17 show description of the smart network sensors.

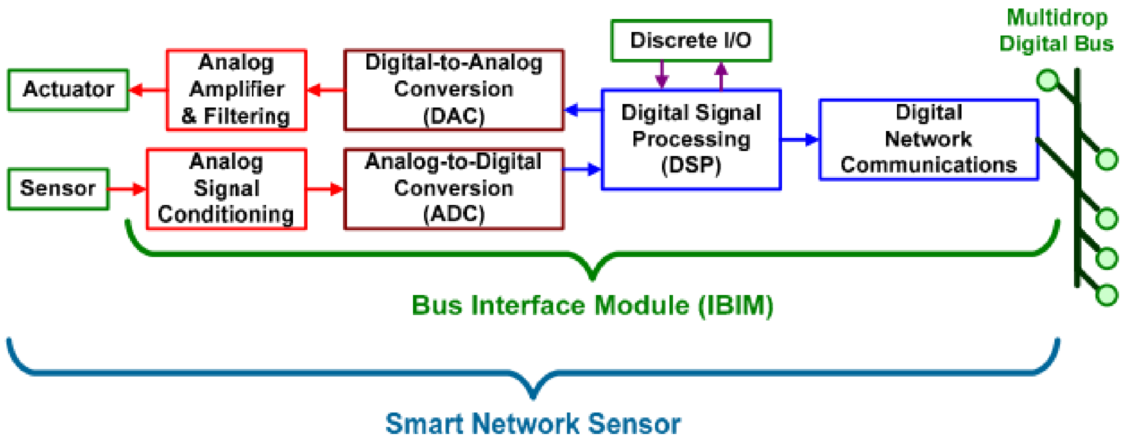


Figure 16 Smart Networked Sensor

7.3.2 IntelliBus Interface Modules (IBIM's)

The IntelliBus Interface Modules have in them all the function of a measurement system with exception of the sensor element. The IBIM's improves the smartness of analog transducer so that they can interface to the digital transducer bus as shown in figure 16.

7.3.3 Network Interface Controller (NIC)

The NIC serves as a gateway between the Intellibus and an on-board computer or with a downstream wired Ethernet port depending on the configuration or telemetry system. NIC communicate digitally through a standard digital transducer bus with IBIM.

The NIC serves as a master of the digital network and also provide power and simultaneous signal to achieve synchronize data sampling among all sensors and IBIM's on the transducer bus.
The IBIM's are designed as stand-alone, distributed sensor and control nodes. They have in them software algorithms implementation in their internal microprocessor to sense, process the sense signals to control the actuators and switches. Figure 17 shows the work of NIC in a smart sensor network system concept.

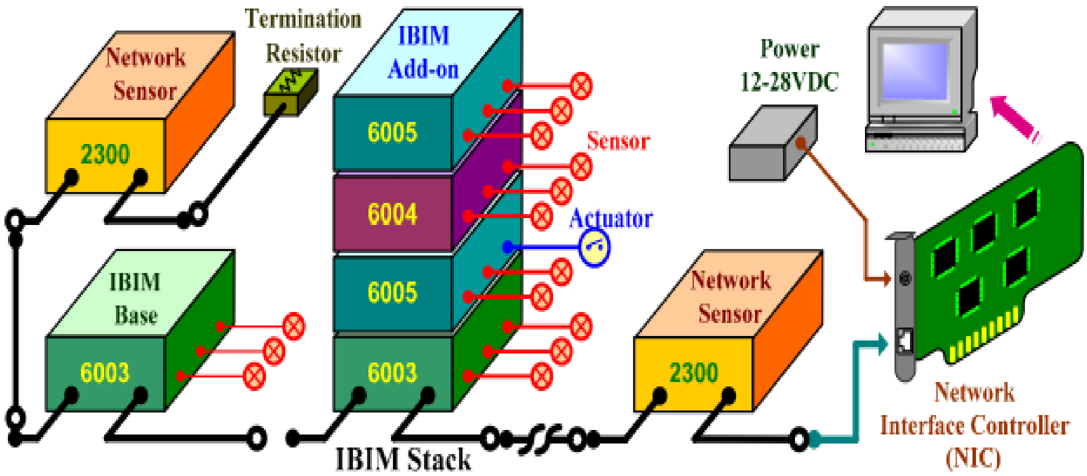


Figure. 17 Smart Sensor Network System Concept

7.3.4 Plug and Play

Plug and Play is another useful feature of the new network system. It makes replacement of units that are not working properly and changes in configuration easier since each device in the transducer bus has a TEDS saved in its non-volatile memory, the NIC is able to find what devices are the bus and examine their configuration settings, status and other features. This new feature has made increasing or decreasing the number measurement channels becomes an easy task.

7.3.5 IntelliBus

IntellliBus is defined as isochronous, half-duplex, multipoint serial bus running at 15Mbps and serves as the transducer network bus protocol used in VIP sensors. The physical layer of intellibus is made up of double wire shared-twisted-pair (RS-485) including power and ground wires.
NIC can address up to 510 smart sensors and / or IBIM's nodes but the number of IBIM's that can connect to a NIC depends on the bus speed, power

consumption, sampling rate, length of cable and the number of channels in each IBIM nodes. The new design is limited to 15Mbps bus speed a 7A of DC supply.
One application of this Intellibus is its deployment in the aerospace programs and it has worked successfully especially for Boeing aircraft.

7.4 Smart transducer interface

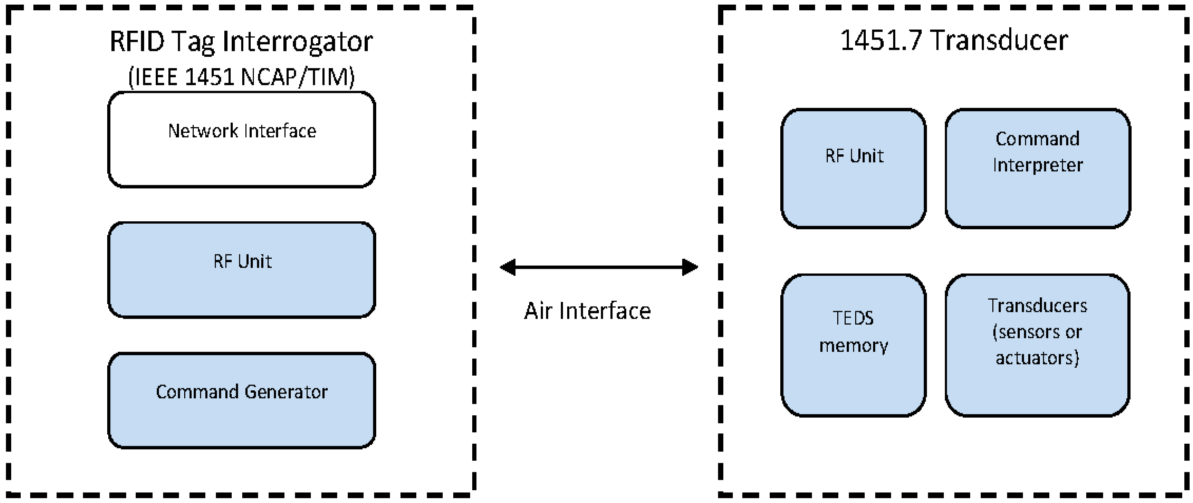


Figure 16. A Smart transducer interface with RFID systems

Transducer interface for sensors are standards that define a set of elements which enable the smart transducer to communicate with the outside world. These set of elements employed in RFID systems help to allow for easy communication between the interfaces. IEEE 1451 are standard specify for sensors and actuators. It is made of seven document standard. They are;

- IEEE P1451.0; Common Functions, Communication Protocols, and Transducer Electronic Data Sheet (TEDS).
- IEE std 1451.1; Network Capabilities Application Processor (NCAP) information Model for Transducers.

- IEEE std 1451.2; Transducer, Microprocessor Communication Protocols and Transducer Electronic Data sheet (TEDS) format.

  IEEE P1451.3; Digital Communication and Transducer Electronic Data Sheet (TEDS) Formats made for Distribution Multi-drop Systems.

- IEEE P1451.4; Mixed-mode Communication protocols and Transducer Electronic Data Sheet (TEDS) formats.

- IEEE P1451.5; Wireless Communication and Transducer Electronic Data sheet (TEDS) formats.
- IEEE 1451.7 released in 2010; Transducers to Radio Frequency Identification (RFID) Systems communication protocols and Transducers Electronic Data Sheet (TEDS) format.

The figure 16 shows a transducer interface interacting with an RFID system.

7.4.1 Transducer electronic data sheet (TEDS)

Transducer electronic data sheet is a standardised method of keeping transducer calibration, correction data, identification and manufacturer related information. This electronic data sheet can be implemented as a memory containing information needed by control system to interface with a transducer or a measurement instrument. TEDS can be implemented in two different ways;

- TEDS can be in embedded memory which is typically an EEPROM inside the transducer connected to the measurement instrument or control system.

- TEDS in a virtual form can also exist as data file that be accessed by control system measurement instrument.

7.4.2 IEEE 1451.7 Standards

IEEE 1451.7 standard gives a set of elements which allows the smart transducer to communicate with the world using RFID systems techniques. There are four elements that are embodied in all smart transducers which are conforming to this standard. These essential elements include;

- Communication protocol

- Common structure

- ❖ Transducer electronic data sheet
- ❖ Transducer data

7.4.3 Effects of the four essential elements

- ✓ The communication protocol gives a direct link between the smart transducer and the outside world.
- ✓ The common structure is the language which the action of the transducer is controlled.
- ✓ The transducer data is made up of the results of sensor measurement.
- ✓ TEDS have in store the capability and configuration information.

8.0 UCODE G2IL+ CHIP

UCODE G2iL+ chip is manufactured by NXP semiconductor and is an upgraded version of G2iL chip. This chip was used with a specific antenna design for it to achieve our goals for the project. The chip together with the design antenna forms a passive RFID tag.

Figure 17. G2IL+ chip

8.1 Characteristics of G2iL+ chip

The table 1 below gives detailed characteristics of G2iL+ chip

Table 1 the characteristics of G2IL+ chip

Generation	EPG Gen 2
Memory	128 of EPC memory. 64-bit is the TAG identifier (TID) from the memory which has 32-bit of which is a factory locked with unique serial number.
Memory read protection	The chip has 32-bit killed password for permanent disabling of the tag and 32-bit access password.
Function	The default factory setting is for the chip to act as an identifier but can be set to perform various functions as tamper alarm, digital switch and transfer mode.
Read and Write	The chip is having a read/write function which allows the user to activate different features onto the tag.
Power	The chip is a passive one and is activated when it is in the readers range.
Data memory	It has data memory retention of up to twenty years.

8.2 Operating features of G2iL+

Table 2. Operational characteristics of G2iL+

Operating Frequency	It is operating on an international input frequency of 840MHz and 960 MHz.
Input power	-18dbm
Power Supply	1.8v voltage and 7μA current supply receive by the chip

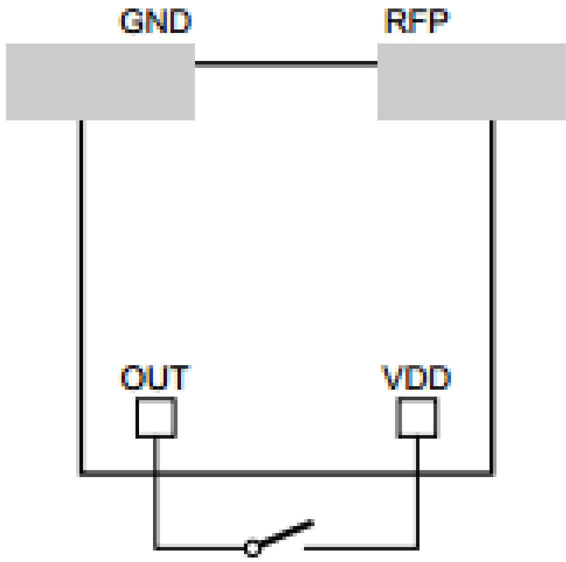


Figure 18 Example of the Chip Function Connection (Tamper alarm) (NXP, 2012)

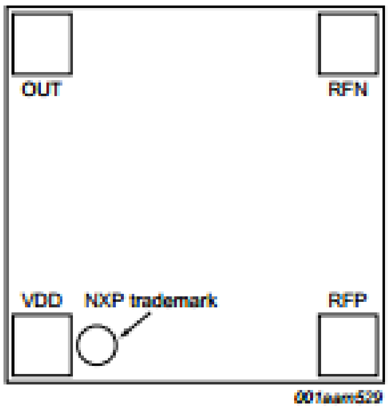


Figure 19 Back View of the Chip (Pin bearing) (NXP 2012).

9.0 Antenna Design

A slot antenna was design in this project to make the entire PCB act as the effective antenna area. A slot is made on the PCB board made of copper metal in specify dimensions shown in the figure 20 below. The length and the width of the created slot determine the inductance impedance of the slot antenna. An effective performance of the PCB antenna depends on how well the PCB antenna impedance is matched with the capacitive impedance of the package IC. The position of the slot calls for effective performance but in a situation where reduced performance is allowed then the slot can be placed asymmetrically on the PCB board with various turn shown in the figure 20.

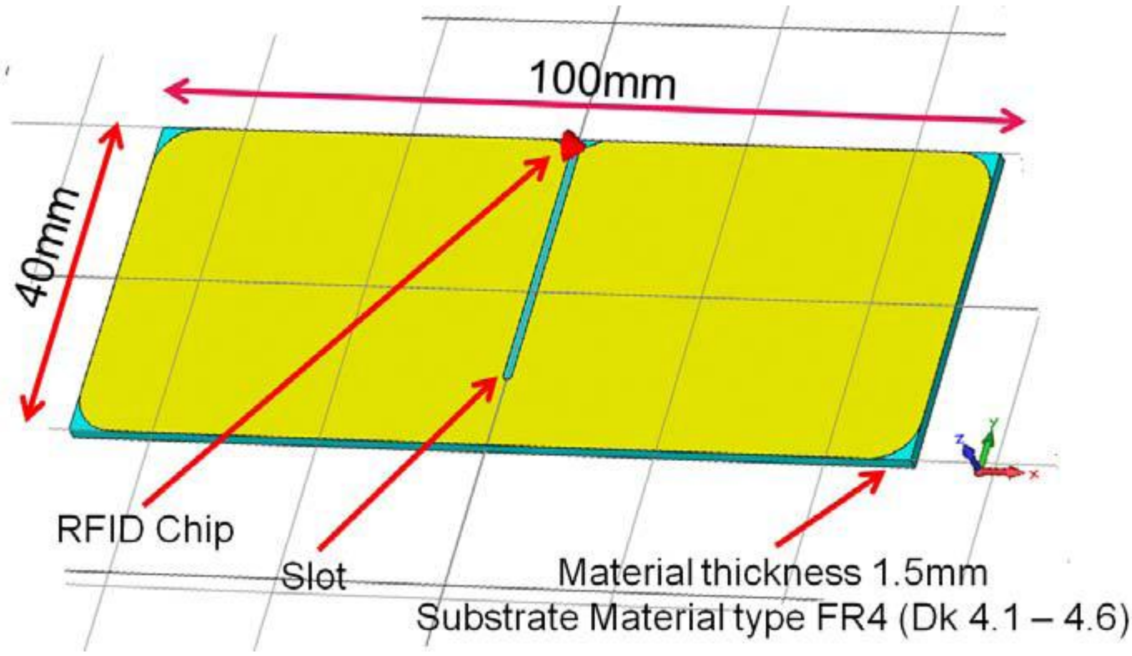


Figure 20 A drawing pattern of a slot antenna design

The figure 21 shows how the end product of the slot antenna with the chip fixed on it looks.

Figure 21 An antenna having G2iL+ chip fixed

The figure 22 shows the picture of the antenna with the chip.

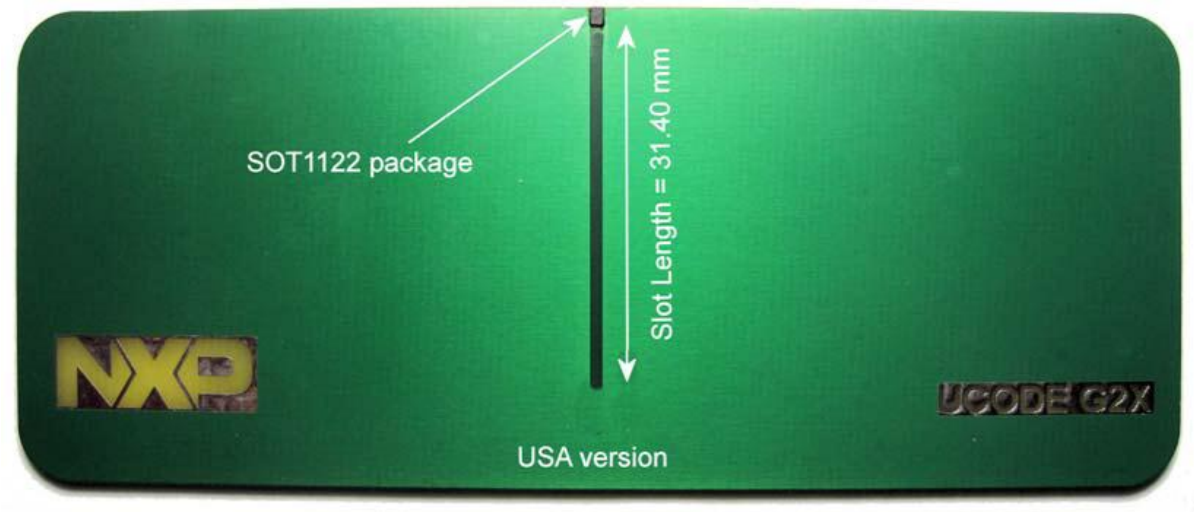
Figure 22 A picture of slot antenna with the G2iL+ chip

9.1 Factors considered before designing the slot antenna on a PCB

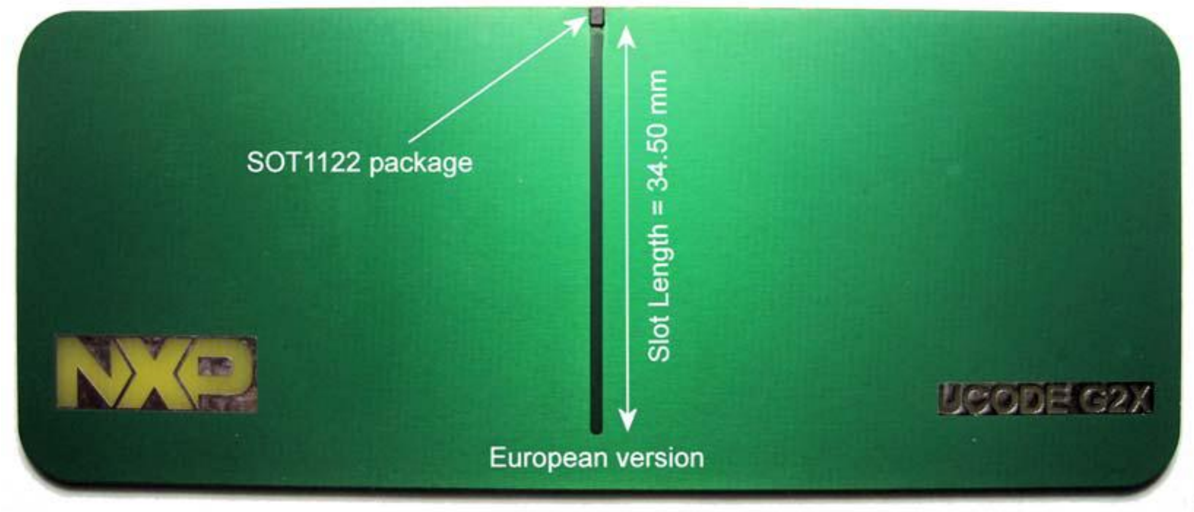
Antenna area requirement: To have an effective working antenna, the size antenna area (copper metal layer) on the PCB was 5 times the slot width (W). This means that each side of the slot had a metallization area of 2*W each.

Width area clearance: There was no component placed in an area surrounding the 2mm slot due to the high density of the magnetic field strength.

Slot dimension: The slot dimension and placement or position is a critical factor in determine the optimum performance. The position of the slot was maintains as shown in the figure 23.



Width W = 1 mm; Length of USA version = 31.40 mm



Width W = 1 mm; Length of European version = 34.50 mm

Figure 23 Prototypes of reference design

The table 3 below shows the properties used in the design of the project antenna.

Table 3. Properties of the design antenna

Layers	Single layer
PCB dimension	100 mm × 40 mm
Slot	34.50 mm
Substrate thickness	1.6 mm
Antenna material	Copper
Antenna material thickness	35 µm

10.0 Testing for the built RFID tag

A Siemens RF660 RFID system was used to test for the built passive tag. The figure 24 below shows the picture of the reading results captured by the interface on a monitor.

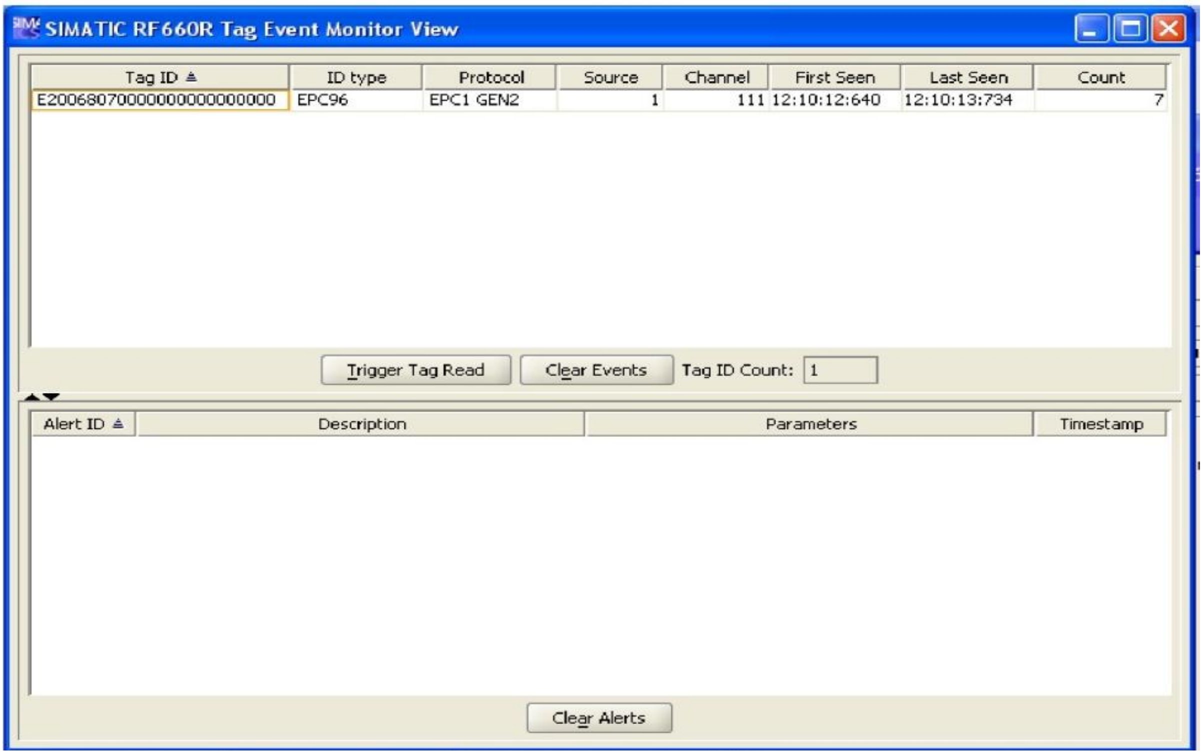


Figure 24 A captured reading by Siemens RF660 software from the tag

11.0 Temperature switch

A temperature switch or a thermos switch is activated in responds to the change in temperature. A temperature switch has a component that responds by opening and closing a switch once the required temperature recognized by the responding component. The temperature sensitive switch is mostly used as a thermal protection to regulate the temperature of a component or a particular location.
The device can be programmed to activate at different temperature thresholds. In order to achieve this, the switch monitors the temperature and maintains control over the amount of power that is used.
In this final work, an ELFA UP62 thermo switch was used with an embedded unit to make the thermo stat works more efficiently. Figure 25 shows the picture of an ELFA UP62 thermo switch.

Figure 25 an ELFA UP62 thermo switch

11.1 How ELFA UP62 thermo switch works

The switch can be fixed with the unprinted side on the surface to be monitored when it is set to be used.
The size of the switch has a greater effect to its responds to temperature changes. The ELFA UP62 switch is small in size and gives a fast reaction to the temperature changes. It works at a fixed temperature of 90 ˚C and when the required temperature is reached, it performs a specific function according to

its implementation. Figure 26 and 27 shows the switch dimension and how it mounting is done respectively.

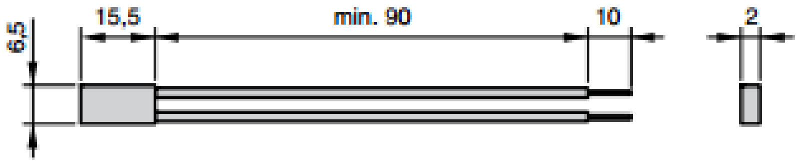


Figure 26 Dimension of ELFA UP62 in mm

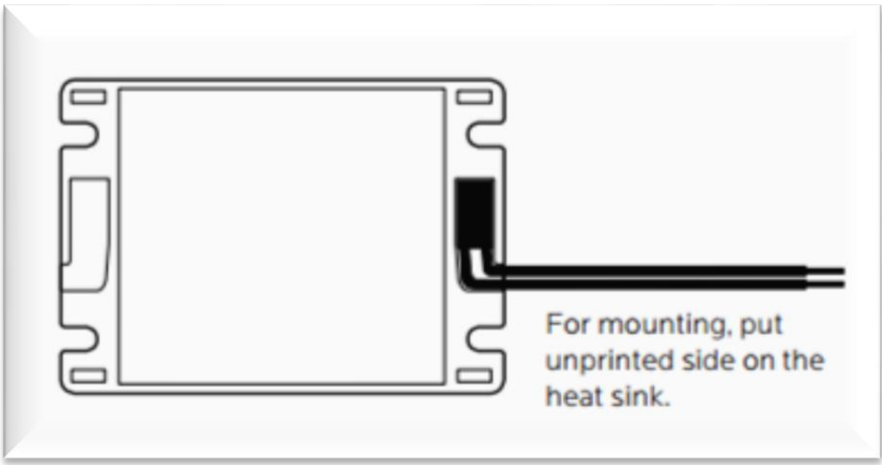


Figure 27Mounting the ELFA UP62 on the heat sink

11.2 RFID Temperature smart sensor

In this project, the development of a new smart temperature sensor adapted to monitoring extreme temperature is presented. The design makes use of RFID technology in order to meet operation specifications which are impossible with other technologies. The information sensed by the temperature sensor is received by the tag, computes it and allows the measurement to be shown and read. The connection of the temperature switch and the constructed RFID tag gave birth to the smart temperature sensor used for the project. Figure 28 shows the picture of the connection.
The idea of this project was to first read the constructed tag. Then with the help of Siemens RF600 system software we will be able to write a temper alarm function on it. This temper alarm will enable the tag to function as a

switch. The thermo switch is then connected to the VDD and OUT pin of the tag. The antenna connected to the ground pin of the chip serves as a ground connection for the whole smart sensor.

Figure 28 A constructed RFID Temperature smart sensor

11.3 Operation of the Constructed temperature smart sensor

The operation of the constructed temperature smart sensor is based on the following characteristics;

Voltage: input voltage was 1.85v

Frequency: 915MHz

Temperature: 90°C

11.4 Application of RFID Temperature smart sensor

It monitors temperature data during the course of transportation. The smart sensor is a passive device based on UHF RFID technology and can be used in air, sea and land transportation without restriction. The figure 29 shows a picture of a smart sensor used to monitor temperature data during transportation.

Figure 29 RFID temperature smart sensor

Another application of RFID temperature smart sensor is at the machine and food processing industries to monitor the temperature. The smart sensors are placed at sensitive and strategic places in the production line to check the temperature not to go over a temperature threshold to bring about serious damage in the production process.

12.0 Humidity Smart Sensor

The Humidity smart sensor can be used in walls where humidity can be monitored from time to time. One example is bathrooms.
As part of the case study an already built kit humidity smart sensor was used to measure amount of water in a particular content. The purpose was of this was to give insight on how the technology of IOT has been in use. The sensor working passively with RFID tag was able to interpret the level of humidity of the measured substance. The figure 30 shows the picture of the humidity smart sensor kit and the materials used for the test.

Figure 30 smart sensor used and a full kit

12.1 Testing

The smart sensor was embedded in a concrete that comes with the kit and its humidity measured after sometime when the concrete is harden.
The reader can take measurement between 65 and 100 RH % (relative humidity). The actual measurements taken by the reader at different time interval were ranging from 95-99%. The figure 31 shows a sample of the measurements taken by the reader.

Figure 31 sample measurement taken by the embedded sensor

13.0 Conclusion

The idea of internet of things has been highlighted and its significant to human daily life has been elaborated in this final project. The IOT which is gaining grounds is bringing new era in which everything can be identified and connected and things can exchange information and make decisions by themselves. This form of communication will bring human and objects and things-things interaction.

The idea of RFID smart sensor has proven to be effective tool and can withstand various conditions that would have been difficult to retrieved necessary information with either rfid tag or sensor alone.

In future more efficient and cost savings RFID smart sensors systems can be built in order to allow things to interact and also lead to less dependency on humans in dealing with things.

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