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Application of RFID based Inventory Management System in Power Project Sites

KVV Raju[1], Deepak Sachan[2],Subrata Biswas[3]

[1]DGM/ Technology Development Lab BHEL R&D Hyderabad, India

[2]Engineer/ Technology Development Lab BHEL R&D Hyderabad, India

[3]Director ERD BHEL Head Quarters, New Delhi

ABSTRACT

Large construction project sites typically require handling thousands of different assets as they are continuously being checked in and out of the yards. Unfortunately yards are also riddled with inefficiencies due to lack of organization and control. Loss, theft, misplacement, and non-identification of material and equipment are common issues that affect many construction projects. Given these challenges, real-time asset visibility and inventory accuracy becomes the ultimate goal of an effective yard management solution. The present paper presents a novel method using RFID technology to manage the materials inside an open yard. The system uses RFID, GPS and GPRS technology.

Key words:- RFID, Inventory Management, metallic environment, Asset Tracking

1. INTRODUCTION

RFID: Radio Frequency Identification or RFID is a non-contact, non-line-of-sight (LOS) type Automatic Identification & Data Capture (AIDC) technology, which uses radio frequency to establish communication & data transfer between a RFID transponder, a microchip fitted inside the RFID Tag and RF antenna Fig 1.[1] A basic RFID system consists of three components:

- A reader (with decoder)
- An Antenna
- A transponder (RFID tag) electronically programmed with unique information

The antenna emits radio signals to activate the tag and read/write data into it. The RF antenna is connected to a RFID reader, which controls the communication & data transfer functions.

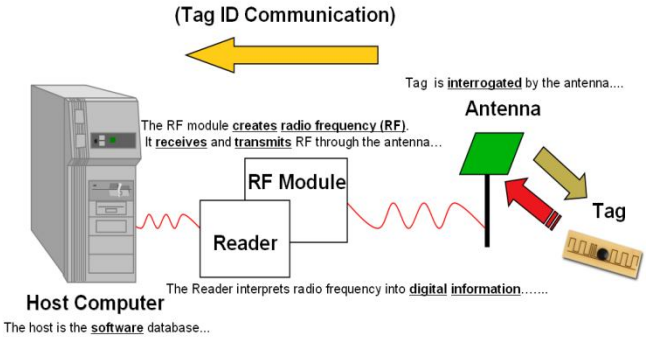

Figure1 Working principle of RFID System

The transponder, generally called as a "Tag", is basically an integrated circuit with miniature RF antenna. The tag has its own memory and depending on its type, data can be written, re-written & read up to 100,000 times. RFID systems are distinguished mainly by their frequency range. LF (Low-frequency) operates at 30 KHz to 500 KHz have short reading ranges and lower system costs.

They are most commonly used in security access, asset tracking and animal identification applications. HF (High-frequency) operates at 13.56 MHz, offer higher read ranges as compared to LF systems (greater then3 feet) and better reading speeds, and are used for such applications as railroad car tracking and automated toll collection. UHF(Ultra High Frequency 850 MHz to 950 MHz) system offer read range in excess of 9 feet with very high read rates. Microwaves (2.4 GHz) gives still better read range. Low and medium frequency devices operate as a rule as passive

devices, taking the energy needed to communicate from the emitting antenna. Semi passive/ semi Active tags operating at UHF & microwave frequencies have their own battery, responds to the antenna as and when query sent by the antenna. Active tag having its own battery always shows its presence by continuously emitting signal irrespective of query sent by antenna. These tags are now coming with dry cell batteries which last for 3-5 years depending on use and has provision to replace the batteries if the life of the battery is over.[2],[3]

GPS (Global Positioning System) is a space-based satellite navigation system that provides location and time information in all weather conditions, anywhere on or near the Earth where there is an unobstructed line of sight to four or more GPS satellites. GPRS (**General packet radio service**) is a packet oriented mobile data service on the 2G and 3Gcellular communication system's global system for mobile communications (GSM).

2. RFID COMPONENTS AND THEIR SPECIFICATIONS

2.1 RFID Tag

RFID tags come in three general varieties: passive, active and semi-passive (also known as battery-assisted). Passive tags require no internal power source (they are only active when a reader is nearby to power them), whereas semi-passive and active tags require a power source, usually a small battery.[4]

2.1.1. Passive-tags

Passive RFID tags have no internal power supply. The minute electrical current induced in the antenna by the incoming radio frequency signal, just enough power for the complementary metal-oxide-semiconductor (CMOS) integrated circuit in the tag to power up and transmits a response. Most passive tags signal by backscattering the carrier wave from the reader. This means that the antenna has to be designed both to collect power from the incoming signal and also to transmit the outbound backscatter signal.

2.1.2 Active-tags

Unlike passive RFID tags, active RFID tags have their own internal power source, which is used to power the integrated circuits and to broadcast the response signal to the reader. Communications from active tags to readers is typically much more reliable (i.e. fewer errors) than from passive tags due to the ability for active tags to conduct a "session" with a reader.

2.1.3 Semi-passive-tags

Semi-passive tags, also called semi-active tags, are similar to active tags in that they have their own power source, but the battery only powers the microchip and does not power the broadcasting of a signal.

2.1.4Tags used by BHEL

BHEL has designed unique tags for 2.4 GHz System. These tags are basically semi active tags. These tags essentially contains one RF Transceiver chip, antenna, LED alarm, battery etc.

These tags also have a memory capacity of 512 bytes. It means that user can store almost all the relevant information of the tagged material into the tag itself. On reading a particular tag by the reader, the respective tag gives both visual and audible signals (LED and alarm) to make the search process easy. These tags also come with IP65 casing to withstand all weather conditions 24X7.

The specification of the tags are shown in Table1

Table 2 Specifications of the tags

Operating Frequency	2.4-2.48GHz
Output Power	-6dBm
Sensitivity	-85dBm
Basic Parameters	
Basic ID	4-byte
Memory	512-byte(16k programmable user memory)
Operating mode	Passive operating mode
Signal Interval	1s/time(can be customized)
Battery Life	3–year life (related operating mode and output power)
Reading Distance	0-50m (active operating mode, test under open environment)
Status Indication	LED, Buzzer
Dimensions	88mm × 42mm × 9mm
Weight	32g
Operating Temperature	-40°C~+60°C
Storage Temperature	-60℃~+80℃
Waterproof	IP67

The normal read range of the tag was tested under open weather condition and the results were found as follows table2, Fig 2.

Table 3 Testing in Open Conditions

Function	**Read range (Meters)**
Reading of Tag	40 (For LED/Alarm function)
Read range of tag memory:	15 (Response from the tag)
Write range:	15
Re-Write range:	15

The tag designed by BHEL has been tested in water Fig 3 and the results were found as follows table 3.

Table 4 Testing in water

Function	**Read range (Meter)**	**Read range (Meter)**
Read range of Reader:	15	8
Read range of tag memory:	5	0.5
Write range:	5	0.5
Re-Write range:	5	0.5

Figure 2: Testing the read range of the tag

Figure3: Tag immersed in water

Tag designed by BHEL has been tested in intense metallic (Tag covered in silver foil) environment (Fig 4) and the results were found as follows table 4.

Table 5 Testing in Metal intensive environment

Function	Little Air Gap Read range (Meter)	No Air Gap Read range (Meter)
Read range of Reader: Read range of tag memory: Write range: Re-Write range	10 Meters 3 Meters 3 Meters 3 Meters	8 Meters 0.5 Meters 0.5 Meters 0.5 Meters

Figure 4: Tag covered in silver foil

2.2 Reader

An RFID reader is a device that is used to interrogate with an RFID tag. The reader has an antenna that emits radio waves & the tag responds by sending back its data. The antenna is a conductive element that permits the tag to exchange data with the reader. Passive RFID tags make use of a coiled antenna that can create a magnetic field using the energy provided by the reader's carrier signal. The reader comes up with application software which can be synchronised with the application software to maintain the master database.The specification of the Hand Held reader is shown in table 5.

Table 6 Specifications of Hand Held Reader [5]

Operating Frequency	2.400-2.48GHz
Receiving Sensitivity	-80dBm
Antenna gain	2dBi
Communication Interfaces	RS232 DB9; USB Host port; USB
Processor	PXA 270 624MHz CPU
Operation System	Win CE 5.0
Scanner	1D/2D Barcode Scanning Engine (Optional)
Wireless Communication	v2.0 + EDR; IrDA;Bluetooth, EDGE/GPRS Module (Optional); WiFi Module (Optional); GPS Module(Optional)
Display	3.5QVGA (backlight), TFT-LCD 256K, four-wire resistance touch screen
Memory System Storage	128MB SDRAM, system flash memory 1GB NAND FLASH
Tag Protocol	Private Protocol
Reading Range	0~50m (depends on tag power output)
Dimensions	223mm×75/100mm×31/42mm;200mm×75/100mm×31/42mm
Weight	400g (including standard battery)
Power Supply	3.7V lithium battery, 4400mAh
Durability	Drop test from 1.5 m height to cement floor. It can resist three times of collision from three directions on six surfaces.
International Protection	IP65, (IEC60529 standard)
Continuous Working	8 hours

Period	
Working Temperature	-20℃~+55℃

GPS accuracy of the reader was found to be very good. At every point of time 11-13 out of 24 GPS satellites are interacting with the reader. Fig 5
GPS Accuracy: 1 Meter
GPRS Function: Available with any network
GSM Function: Available

Figure 5 GPS Function of the reader

3. IMPLEMENTATION OF THE SYSTEM AT VALLUR TPS SITE

BHEL R&D has developed in-house, a system for implementation on a pilot scale using RFID BAP(Battery Assisted Passive) Tags, Hand Held readers with GPS and GPRS facility to prove the RFID capabilities in heavy metal environment.
As part of the POC, 200 RFID Tags have been assigned at various locations at our BHEL, Vallur TPS facility (Fig.6). The assigned tags have been mapped into Satellite maps in the software with the help of GPS and GPRS features available in the hand held reader. BSNL SIM cards have been used in the GPRS module for transferring the data into the host PC server through internet.

Figure 6: Tags Tied to different types materials

Total identified area has been divided in to segments and the list of items available in each segment has been prepared. RFID tags were mounted on the identified components / crates/ boxes/ bunches etc and the item wise data e.g. PGMA, DU, Material description, material serial no, date of receipt etc.. has been written in the RFID tags using the Hand Held Device. The location of a particular item tagged with RFID tag was mapped into Satellite maps using the GPS technology available in the HH Reader.
The complete details of the tagged material with its real time co-ordinates were transferred to the central server installed at BHEL R&D through GPRS technology.The complete list of the material in the desktop application software can be shown as below (Fig 7):

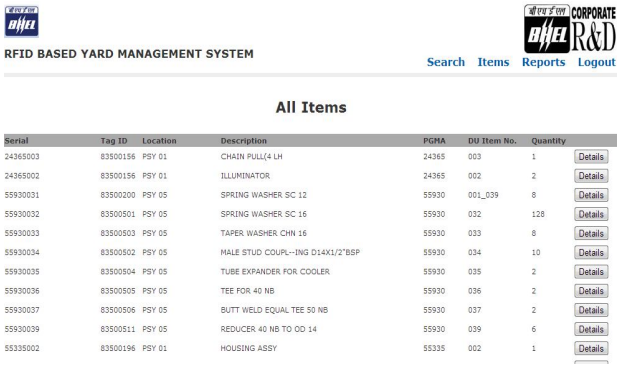

Figure.7 List of all items

Fig 8 shows all the available items in the Google Map.

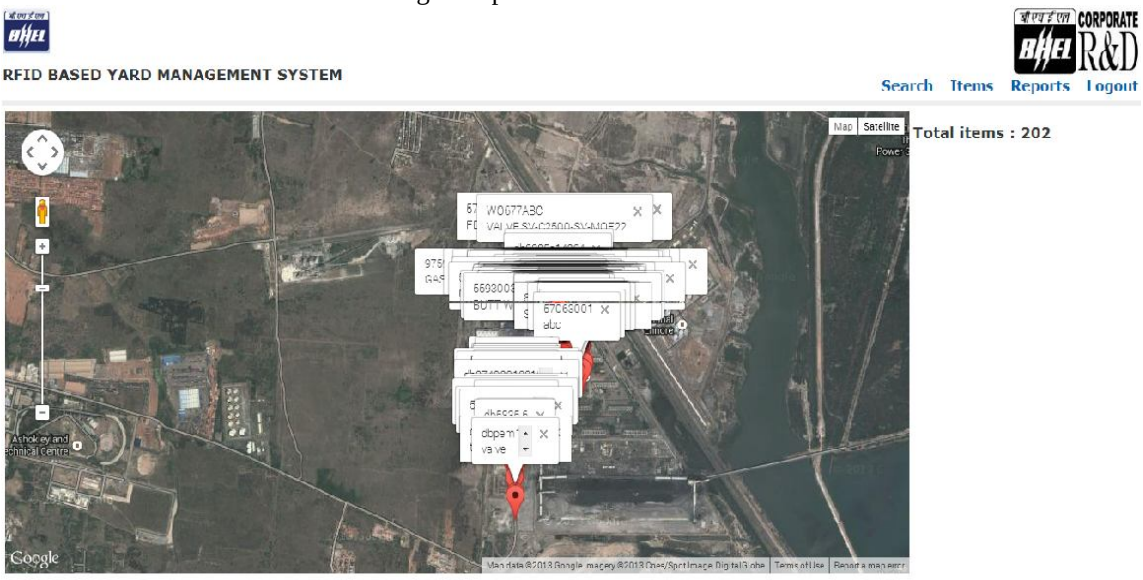

Figure.8 All items in map

While we search for any particular item into the desktop application the complete details of that item with its location on map will be shown in the screen (Fig.9).

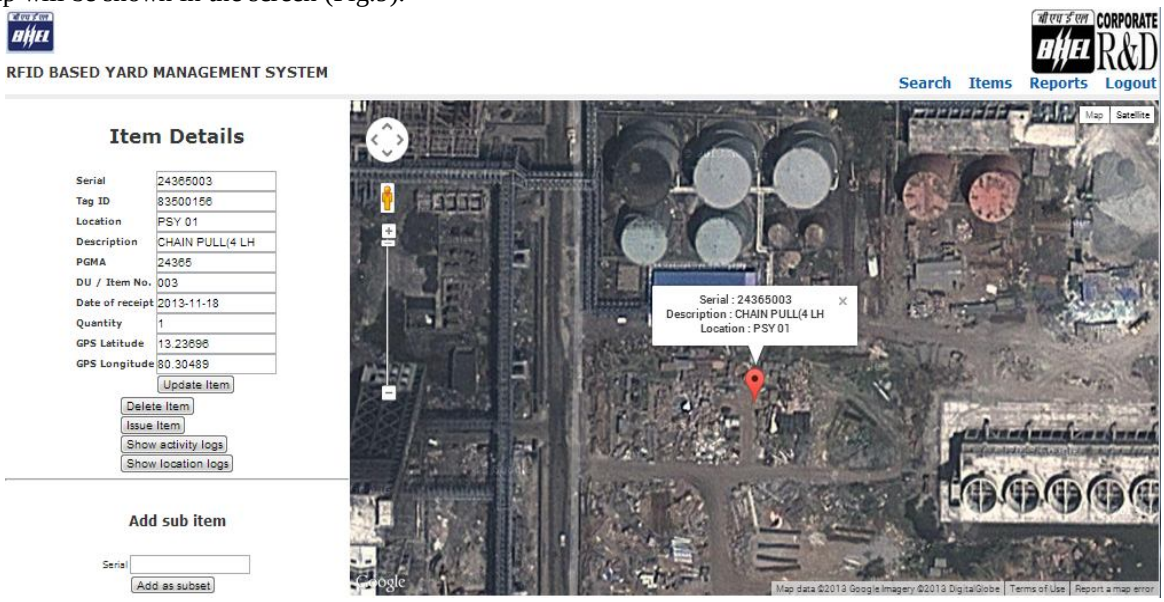

Figure 9 Details of a particular item

The handheld reader can be used for receipt /issue of material at site and the tags can be re-written to update latest data into it.The Hand Held reader is having a facility of periodic scan. So while doing the periodic scan the Hand Held reader will create the exception list of the tags which are either misplaced (50m. away from its original location) or not found in the yard.

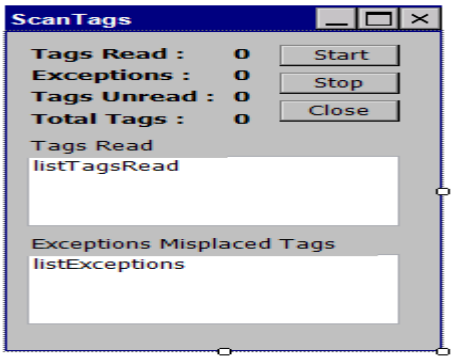

Figure 10. Scan Tags

So the misplaced items can be either placed in their original location or their new co-ordinates can be updated through the Hand Held reader.Any time the user can search for any particular material by entering its unique tag ID/Serial No./PGMA/DU/Date of receipt into the Hand Held Reader and Desktop application as well.If the user wants to search for a particular item in the yard first of all he has to check the location of the tag in the yard through Satellite maps and then go to that area and trigger for that tag using the hand held reader the particular tag will respond in the form of LED and alarm already built into it.

4.BENEFITS OF SYSTEM

- The search time of materials will be reduced.
- By use of Satellite maps it is very easy to locate the position of any particular item in the complete open yard.
- With this system any material in the stores can be correctly located within 2-5 minutes in 1st attempt itself and if it is not found then it will be marked as misplaced/missing in the report.
- Periodic scan helps to find out misplaced items in the yard.
- Easy to use and user friendly.
- Addition of new convenient feature to the conventional inventory management
- Building up of expertise in the area of RF identification system/devices in metallic environment, leading towards further varied application.

5.CONCLUSION

RFID is an emerging and widely spreading technology for non-contact identification combined with GPS and GPRS.. RFID finds its application in many areas e.g materialhandling, inventory management, asset tracking etc. RFID is well established in material and inventory management in closed stores and open yards in non-metallic environment. Hence RFID after being proven suitable for metallic environment can solve many inventory management issues like misplacement of materials, theft etc.. in heavy metallic environment.

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AUTHOR

KVV Rajureceived the B.E degree in Mechanical Engineering and M Tech in thermal Engineering from Andhra University and JUTU respectively. Joined BHEL as an Engineer in 1995 and has experience in project planning, implementation, Design & development, Erection and commissioning of power projects particularly auxiliaries for more than 10 years and later shifted to R&D to utilise his expertise in developing new products like RFID for inventory management , VTS and other manufacturing automation systems.

Deepak Sachanreceived the B.Tech. Hons. degree in Electronics and Communication Engineering from Madam Mohan Malviya Engineering College in 2009. Since 2010 he is working in Research and Development division of Bharat Heavy Electricals Limited, a Maharatna PSU of India. He is working in Technology and Development Lab of BHEL R&D and his main areas of research are Robotic applications, manufacturing automation and various new technologies like 3D printing, RFID, VTS etc.

Subrata Biswas received B.Tech degree in Electronics Engineering from BHU-IT (now IIT-Varanasi), and MBA degree from the Indian Institute of Management, Kolkata. He has also pursued a Fellowship Program from Purdue University, USA. Mr. Biswas has 33 years of diversified and versatile professional experience through working in major R&D segments of BHEL. He has handled a variety of assignments in strategic as well as operational areas in various capacities. He spearheaded the development of products like automated guided vehicle; flexible manufacturing system for automation in production shop floor; automated storage and retrieval system (13 systems installed at major BHEL units and 26 systems at Defence Depot, Kanpur); robotic welding systems for manufacturing of compressor components, RFID and GPS based systems for material tracking at units and sites; tracking system for Solar PV arrays; fuel cells, etc.