INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH & DEVELOPMENT

ISSN: 2278 – 0211 (Online)

Application of RFID Based Inventory Management System in Power Project Sites

K V VRaju
SeniorManager, Technology Development Lab, BHEL Corporate R &D, Hyderabad , INDIA
Deepak Sachan
Engineer, Technology Development Lab, BHEL Corporate R & D, Hyderabad, INDIA
Subrata Biswas
General Manager, Technology Development Lab, BHEL Corporate R & D, Hyderabad, INDIA

Abstract:

RFID (Radio Frequency Identification Device) is a modern method to track different items and control the inventory. Now a days, many companies are using this technology to enhance their material management. Using this technology, the human effort to manage the stores and time taken to search any particular material can be reduced and the efficiency of the whole process can be increased to a satisfactory level.

Hitherto application of RFID is confined to closed stores and non metallic environment, but what about open yards and metal intensive environment? Hence a reliable, satisfactory and authenticated solution is needed to track different type materials in dense metal intensive environment under all-weather conditions with less human effort and minimal search time. This paper illustrates about the technology developed by BHEL R&D to accomplish the task of implementing RFID based inventory management system in closed stores and in open yards at power project sites in a highly metallic environment.

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

1.Introduction

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 and data transfer between a RFID transponder, a microchip fitted inside the RFID Tag and RF antenna. A basic RFID system consists of three components:

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

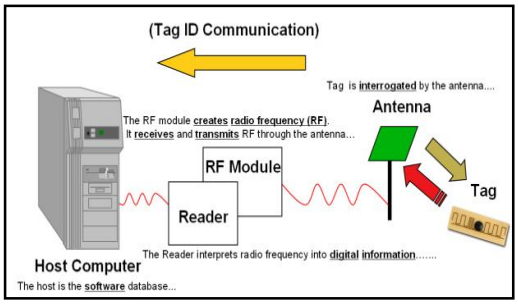

Figure 1: Working principle of RFID System

The antenna emits radio signals to activate the tag and read and write data into it. The RF antenna is connected to a RFID reader, which controls the communication & data transfer functions (Fig 1). 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 and read up to 100,000 times. RFID systems aredistinguished mainly by their frequency ranges. Low-frequency (30 kHz to 500 kHz) systems have short reading ranges and lower system costs. They are most commonly used in security access, asset tracking and animal identification applications. High-frequency (13.56 MHz) systems, offer higher read ranges as compared to LF(Low Frequency) systems (greater then 3 feet) and better reading speeds, and are used for such applications as railroad car tracking and automated toll collection. UHF system (850 MHz to 950 MHz) 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 and 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 a provision to replace the batteries if the life of the battery is over.

In our system we have used two different frequencies: 850MHz (UHF) and 2.4GHz (Microwave) because, these two frequencies are licence free in India.

2.Components of RFID

- RFID Tags
- RFID Reader
- Application Software

2.1.RFID Tag:

RFID tags come in three general varieties: passive, active or 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.

2.2.Passive-tags

Passive RFID tags have no internal power supply. The minute electrical current induced in the antenna by the incoming radio frequency signal provides just enough power for the complementary metal-oxide-semiconductor (CMOS) integrated circuit in the tag to power up and transmit 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.

2.3.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.

2.4.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.

2.5.Tag used by BHEL

BHEL has designed unique tags for both 865 MHz and 2.4 GHz System. These tags are basically semi active tags. These tags basically contains one RF Transceiver chip, antenna, LED alarm, battery etc.

These tags also have a memory capacity of 128 bytes. It means that you can store almost all the relevant information of the tagged material into the tag itself. As soon as any particular tag has been read by the reader it will give both visual and audible signals e.g.; LED and alarm to make the search process easy. The read range for 865 MHz and 2.4 GHz tags under complete metallic environment are 10 mtrs and 25 mtrs respectively. These tags also come with IP65 casing to withstand all weather conditions 24X7.

The specification of the tags are shown in Table 1

2.Rfid Reader

An RFID reader isa device that is used to interrogate with an RFID tag. The reader has an antenna that emits radio waves and 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 tagsmake 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 specifications of the reader are shown in Table-2.

S No	Specification of Reader	Requirement
1	Physical dimensions	300LX130WX220H (mm) or less
2	Weight	2 (Kg) or less
3	Monitor (Type)	Touch screen with keypad
4	Display	Min 320X240 pixel VGA color
5	Read range	10 mtrs for 865 MHZ and 25 mtrs for 2.4 GHz
6	Operating System	Windows Mobile 5.0 or above
7	Wireless Communications	802.11 b/g W LAN with integrated blue tooth
8	Frequency	865 -867 MHz / 2.4 GHZ
9	Memory	Min 128 MB RAM and 256 MB flash
10	Battery	Re-chargeable With 230 V AC adaptor, with Low power indication facility
11	Encasing	IP 65 or Above
12	External connectors	RS 232 C and USB
13	Other features	Memory slot for additional storage
14	Indication of tag reading	When the reader starts reading a tag, an indication should be made available in steps while moving closer to the defined tag.

Table 2-Specifications of RFID Readers

Table 2: Specifications Of RFID Readers

3.APPLICATION SOFTWARE:

We have developed two different application softwares for both 865 MHz and 2.4 GHz system. These application software meets requirements of the BHEL PSSR NCTPS site stores, at Chennai.

The software has a facility to store the data in an MS Access database.

Search facility to display the required component with minimum effort and in lesser time. It contains almost all the search fields which can be required to search any particular material like: Tag ID, Material Description, Product group No., Material received reference No., Part No., Date of Receipt, Dateof Issue, approximate location, Request issue voucher No.

Upon connecting the reader to the system (Host PC) it will automatically update the inventory table.

We can generate reports of the issue and receipt details in Excel and PDF formats and print them.

The Software itself maintains the master database of all the materials in the store with full detail.

S No	Specification of Tag	Requirement
1	Read Range	20 mtrs for 2.4 GHZ and 10 mtrs for 865 MHz
2	Type	battery assisted with read,write and re-writable
3	Size	110X100X15 (mm) or less(Volume of tag)
4	Encasement	IP 65 or above
5	Frequency range	2.4 GHz and 865 MHz
6	User Memory	128 Bytes minimum totally available for the user
7	Operating Temperature	0 to 70 degree celcius
8	Mounting Method	Provision for both screw mounting & tagging by wire/string(Atleast one)
9	Battery Life	1.5 - 2 years with a ficility for indication of low battery while being read
10	Indication of successful read	LED and Alarm indication on being read.

Table 1: Specifications of Tags

Reader Distance From Tag	**TAG NOS.**				**Facility**				**Identification of Specific tag by LED/Alarm on being read**	**Remarks**
	1(--)	2(|)	3(/)	4(||)	Write	Read	Re-Write	Read		
1m	√	√	√	√	√	√	√	√	Yes	
2m	√	√	√	√	√	√	√	√	Yes	
3m	√	√	√	√	√	√	√	√	Yes	
4m	√	√	√	√	√	√	√	√	Yes	
5m	√	√	√	√	√	√	√	√	Yes	
6m	√	√	√	√	√	√	√	√	Yes	
7m	√	√	√	√	√	√	√	√	Yes	
8m	√	√	√	√	√	√	√	√	Yes	

Table 3: Summary of Test Results with 865 MHz RFID System

4.Trials And Simulation Of The System

Prior of implementing the whole system at actual site, we took up the field trials of different types of tags and readers at BHEL R&D Scrap Yard and finalised the following specifications for tags and readers:

Make of the equipment: 865 MHz RFID equipment

4.1.Detailsof tag

Memory : 256 bytes

Frequency : 865 MHz

Range : 0 to 10 meters

Operating Temp : 0 to 70 degree Celsius

Storage Temp : 20 to 65 degree C

Physical dimensions :50X35X15(mm)

Memory : 256 MB RAM, 2 GB Flash

4.2.Details Of Handheld Reader

Frequency : 865 MHz

Range : 6 to 10 meters.

External mounting facility: Yes

Display type : Touch screen

Backlight for display : 800X480 WVGA

Battery: Rechargeable Li-ion with charger and low Power indication

We have conducted various tests of the RFID system after development as a part of field trials to ensure reading, writing and re-writing of the data into the tags and also measured read/write distances keeping the orientation of the tags in horizontal (--), vertical (|), inclined (/) and two tags side-by-side (||) for various distances in a highly metallic environment.

The summery of our experience while testing the 865 MHz RFID system is shown in Table-3.

5.Implementation of the system at BHEL PSSR NCTPS SITE:

Most of BHEL power plant sites have two types of stores:

- Closed Stores
- Open Yard

As already mentioned BHEL have chosen two different frequencies for implementing in the Site. Lower frequency (865 MHz) system was implemented at closed store because of its low read range and higher frequency system (2.4 GHz) was implemented at open Yard because of its higher read range.

We have implemented the whole system in two different phases:

5.1.Phase 1: Implementation of 865 MHz System

At stores various different types of material were kept at different locations (Fig 2). Every day the stores will receive and issue certain items from the stores based on the

erection team's requirement. So starting from the receipt of the material, tracing/locating the material and issue that item to the user i.e. the complete process has been automated by using this RFID based inventory management system.

Reader Distance From Tag	**TAG NOS.**				**Facility**				**Identification of Specific tag by LED/Alarm on being read**	**Remarks**
	1(--)	2(|)	3(/)	4(||)	Write	Read	Re-Write	Read		
5m	√	√	√	√	√	√	√	√	Yes	
10m	√	√	√	√	√	√	√	√	Yes	
15m	√	√	√	√	√	√	√	√	Yes	
20m	√	√	√	√	√	√	√	√	Yes	
25m	√	√	√	√	√	√	√	√	Yes	
30m	√	√	√	√	√	√	√	√	Yes	
35m	√	√	√	√	√	√	√	√	Yes	
40m	√	√	√	√	√	√	√	√	Yes	

Table 4: Summary of Test Results with 2.4 GHz RFID system

Figure 2: Closed Store at NCTPS

The process starts with tagging/assigning the RFID tag to any existing or newly arrived material with a unique Tag ID (Fig 3) and enter all the information of that material into the tag like Material description, PGMA No, DU No., DBR No., Receipt Date, approximate Location, etc. through the hand held reader.

As soon as we click the write button on the reader, the whole data will be written on the in-built memory of the tag.

Figure 3: Tagging a Material in Closed Store at NCTPS(865 MHz)

Once assigning the tags to identified material is complete, the data of transactions already made through the handheld reader have to be transferred to the host PC using a USB data cable to update the master database in the host PC. Synchronization of the reader and the application software takes place on just clicking the Sync button on application software.

The data transfer mechanism is designed to have a two way synchronisation i.e. from reader to the host PC and vice-versa.

Extensive features were provided in the application software of both the reader and the host PC to search and issue any particular material by using any available information of material like: Tag ID,Material description, PGMA No, DU No., DBR No., Receipt Date etc.., The user need to enter relevant information in the respective search field of reader or desktop and search for its location. It will fetch the approximate location of that particular material from the database within 5 meter of radius then the user need to go to that location with the reader and trigger that particular tag. The required RFID tag will respond by blinking the LED and alarm (Fig 4).The read range of these tags under highly metallic environment was found at 8 to 10 meters with an obstruction between the reader and the tag.

Figure 4: Searching a material Closed Store at NCTP (865 MHz)

Once the component is identified, the user can issue all or some part of the material directly from the reader itself at site by adding required data like RIV No, quantity issued and date of issue etc..The reader has again be synchronised with the host PC for updating the master database. There is no need to synchronise the reader with the host PC for every transaction because the hand-held reader was also designed to have sufficient memory to retain all transactions and synchronisation of the reader with the host PC once at the end of the day is enough for updating all the transactions of the day.

5.2.Phase 2: Implementation Of 2.4 Ghz System

The 2.4 GHz RFID system was implemented at open yard in which large components are stacked which are exposed to all weather conditions. (Fig 5)

Figure 5: Open Yard at NCTPS

The method of assigning the tags like wring material data into the tags, reading the tags and re-writing the tags is same as that of the 865 MHz system except the read range of the 2.4 GHz system is about 30-35 meters (Fig 6).

Figure 6: Tagging a Material Open Yard at NCTPS (2.4 GHz)

Receipts of material, searching and issue of material can be controlled same as in the case of 865 MHz system (Fig 7). Since the read range of these tags is large, audibility of the alarm may not be intense hence, it is necessary to go close to the location of the material being searched for better audibility of alarm and visualisation of the LED.

Figure 7: Searching a material Open Yard at NCTPS (2.4 GHz)

Thus we can receive, retrieve and issue any material at any point of time with much less human intervention and in a very short time by using both the systems.

The following table-5 shows the end effect observed after implementing the RFID based inventory management system.

S / No	Criterion	Definition of Criterion	Existing	With RFID	Remarks
1	Time to service	The time from submission of request to delivery of material	60 Min	30 Min	30 Min. saved
2	Process time	The time from material receipt to database updation	120 Min	80 Min	40 min. saved
3	Saving Human Effort	The No. of personnel engaged in search and issue of materials	3 people	1 person	2 persons' work saved
4	Overall Saving	Time saved in receipt and issue of materials in a complete day on an average	6 Hours	4 Hours	2 Hours saved in a complete day

Table 5

6.Limitation Of The System

The system is an exact replica of the stores management database but it still has some limitations:

Tracking of physical theft of the tag or the material itself is beyond the system capacity

If the tagged material has been relocated from its original location to another place, it is necessary to update the old location name by the new location for easy identification of the relocated material.

7.Discussion

The RFID Based inventory management system is basically developed for sites for better management of stores particularly for BHEL sites where the components are stacked for years from starting of the site to the commissioning of the site.

On implementation of this RFID system, it is observed that the performance of semi-active and active RFID tags in a highly metallic environment is satisfactory and it can very well be implemented to the green field projects coming up in near future for better utilisation of in-house developed RFID inventory management system.

8.References

1. Prothro, JOdel T.; Durgine Gregory D. & Griffin Joshua D (2006). The effect of a metal ground plane on RFID tag antennas, Available from: http://www.propagation.gatech.edu/Archive/PG_CP_060710_JTP/PG_CP_060710_JTP.pdf Accessed: 2006-06-09.
2. Sareen B. (2005). Asia: Billion awaken to RFID, in: RFID: Applications, Security & Privacy, Garfinkle S, 2005, 451-466, Addison Wesley, ISBN 0-321-29096-8, USA.
3. Texas instruments (1999). Tag-it Environmental effect on transponder inlays, Available from: http://www.ti.com/rfid/docs/manuals/appNotes/tagenv.pdf Accessed: 2006-01-19
4. Woods. J.; Martin piszczalski et al. (2005). Hype cycle for radio frequency identification, 2005.Gartner Research, 14 July, 2005 ID Number Goo129258.
5. Woods, J. (2005). Positions 2005: RFID is set to define industry processes. Gartner Research, 19 Oct, 2005 ID Number G00130292.
6. How does RFID tag technology works. Science Prog.http://www.scienceprog.com/how-does-rfid-tagtechnology-works/
7. S. Liu. (2007) Extended memory RFID tags provide immediate access to data anywhere, anytime. Industrial Embedded Systems. http://www.industrialembedded.
   Com/article/id/?223.