



SWAYAM NPTEL COURSE ON MINE AUTOMATION AND DATA ANALYTICS

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Module 04:
Advanced system in Mining Industry

Lecture 09 B:
RFID in Mining Engineering

CONCEPTS COVERED

- Introduction to RFID technology
- How does RFID work?
- How Smart Haulage works
- RFID basics
- Working principle
- Main benefits of RFID
- Why RFID in mining
- RFID Applications in Mining Industry
- RFID in mining : Use Cases
- Case study on RFID



Introduction to RFID technology

- It is a wireless technology that uses radio waves to identify and track objects by placing an RFID tag or transponder on them. The tag contains a microchip and an antenna that transmits a unique identifier to a reader device when prompted by the reader's radio signal.
- This technology allows for non-contact, non-line-of-sight identification and tracking of items, which is beneficial for many businesses, including those involved in supply chain management, retail, logistics, and asset management.
- Combining RFID with IoT solutions allows for gathering and analyzing massive amounts of information to optimize and improve business processes and decision-making.



How does RFID work?

- When an RFID reader is activated, it transmits a radio frequency signal to the antenna, which then broadcasts the signal to the surrounding area.
- If an RFID tag is within range of the reader, the radio frequency energy from the reader's signal is absorbed by the tag's antenna, which powers up the microchip on the tag.
- The microchip then uses this energy to transmit the data stored on the tag back to the reader. Each tag responds with a unique number.

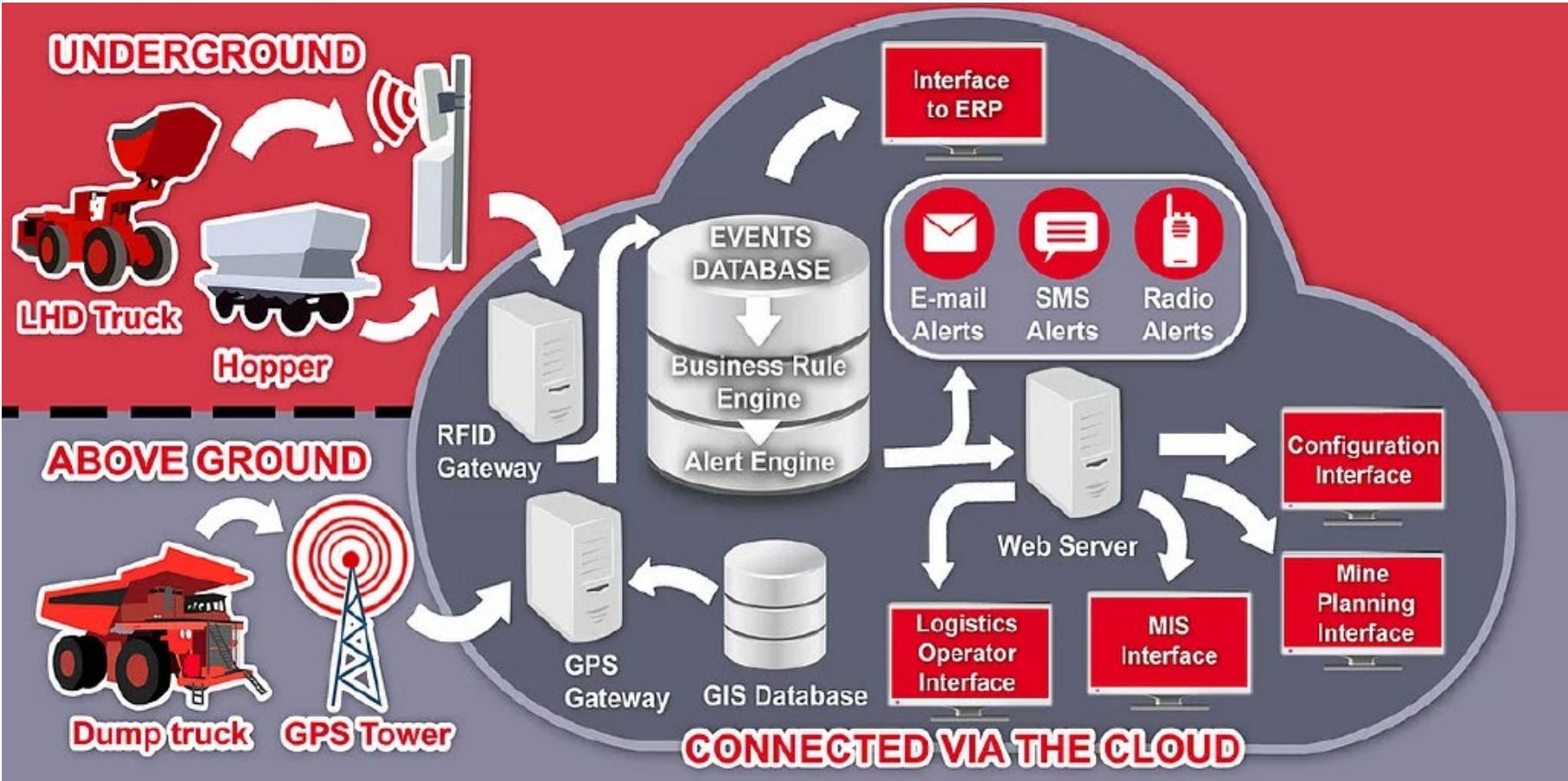


How does RFID work?

- The data transmission from the tag to the reader is a one-way communication. The reader receives the data from the tag and decodes it, typically using a microprocessor. The data from the tag is then processed and sent to the host system, which can be a computer, a mobile device, or another type of system.
- There are two main types of RFID tags: passive and active. The passive tag does not have its own power source, and it relies on the energy transmitted from the reader to activate and transmit its data. The active tag has its own power source, typically a battery, and it can transmit data continuously, even when it is not in close proximity to the reader.



How does RFID work?



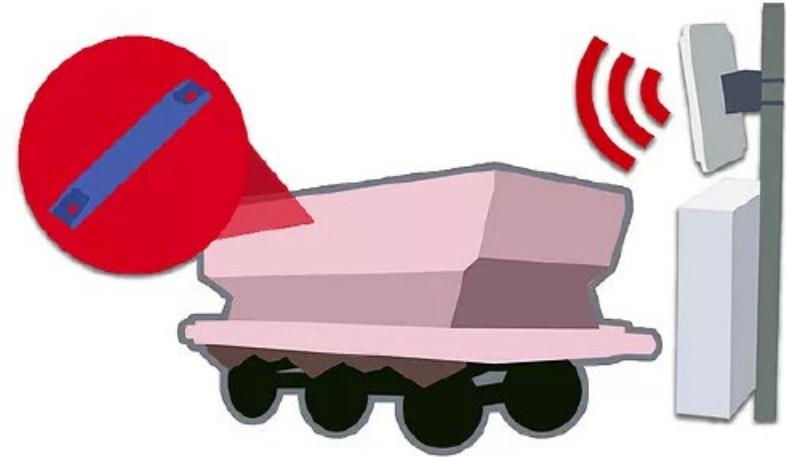
Schematic of RFID system for underground and surface mine machinery control

How Smart Haulage works:

- The hoppers, LHD trucks and dump trucks are tagged with rugged RFID tags.
- Fixed RFID readers are installed at key points. Movement of haulage equipment is detected by RFID readers and GPS is used to measure the productivity of each vehicle on a second by second basis. This data is sent to the Events Database.
- Smart Haulage will then compare the event data with the rules in the Business Rule Engine. Business rules are initially configured for each mining area as it is specific to the layout of each mine and its operations. The following exceptions can be set to trigger alarms: routes not allowed, min/max travel time between points, min/max waiting time per point, min/max number of visits per shift per point, etc.



How Smart Haulage works



Smart Haulage working systems

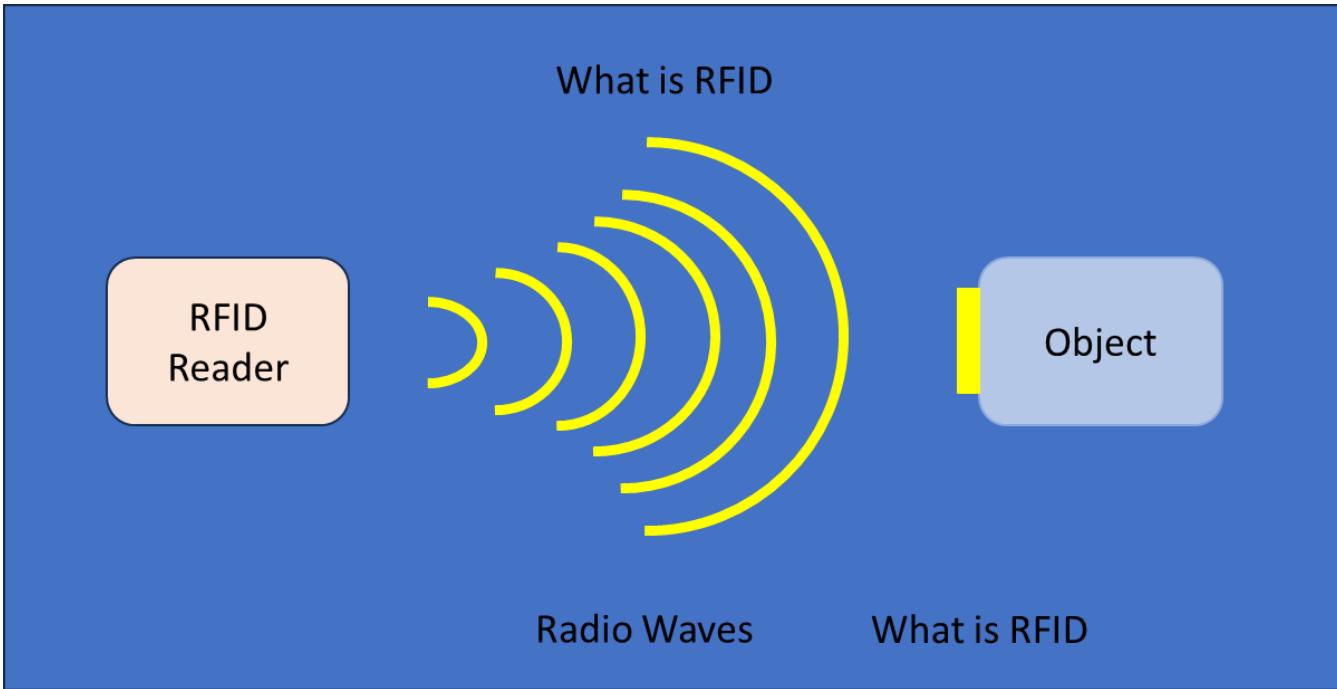


How Smart Haulage works

- When vehicle movement exceeds the parameters set by the Business Rules, alarms are generated on the screen of the Logistics Operator Interface and can also be sent via email, SMS or radio. The control center can then contact the driver and advise the most appropriate action.
- The MIS Interface allows for comprehensive reporting per vehicle per shift with data such as: ROM tonnage moved, ROM tonnage output, ROM cycles completed, % process uptime, % process downtime scheduled, % process downtime unscheduled, % equipment downtime scheduled, and more.
- All data captured and produced by the system will be synchronized and uploaded to the Cloud in real time, where authorized employees can log in to their SmartHaulage accounts at any time to access it.

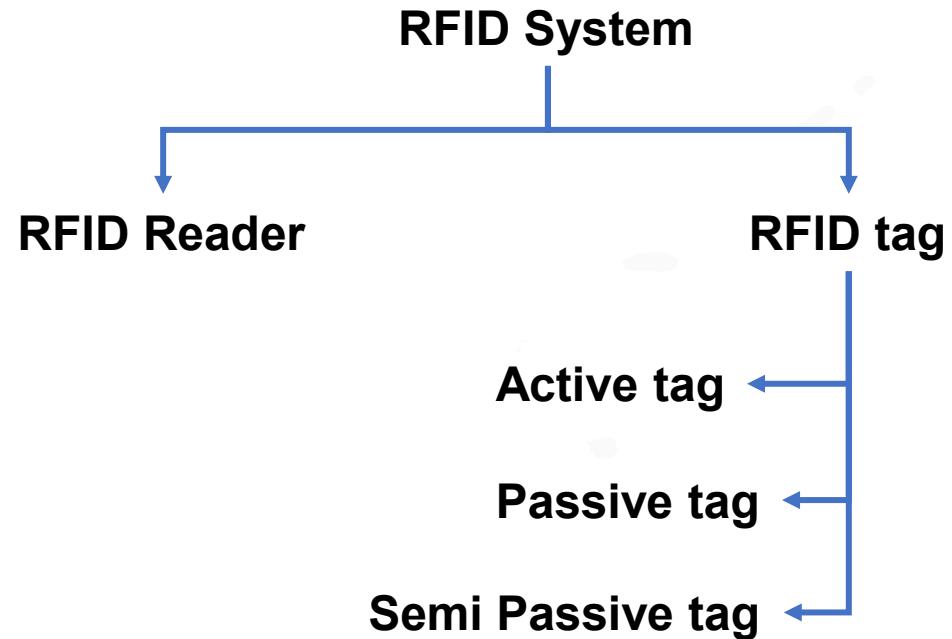


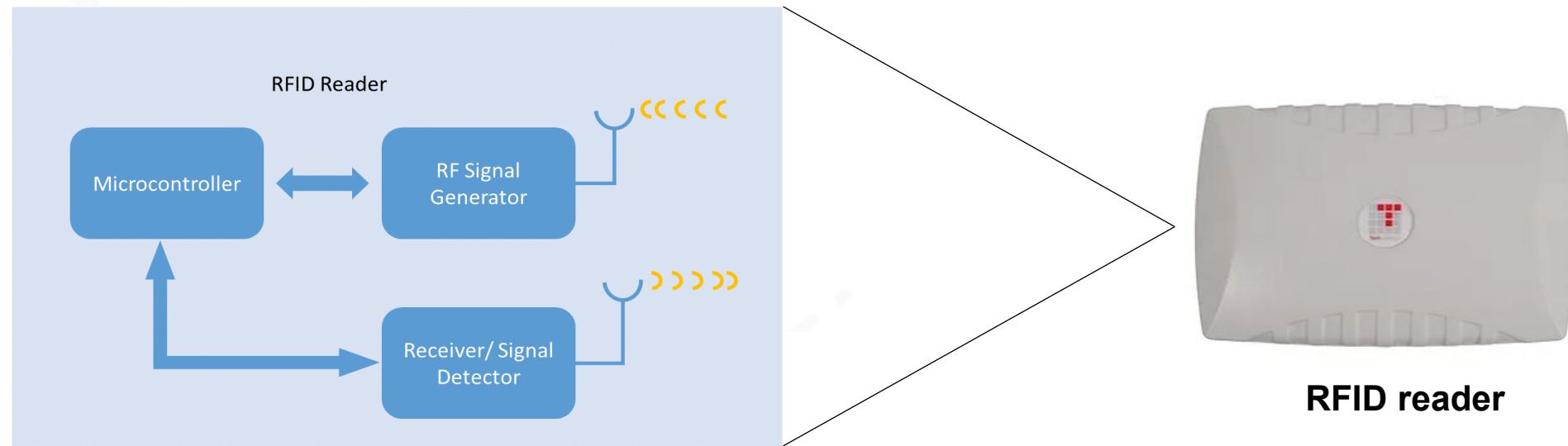
RFID basic



Schematic diagram of RFID System

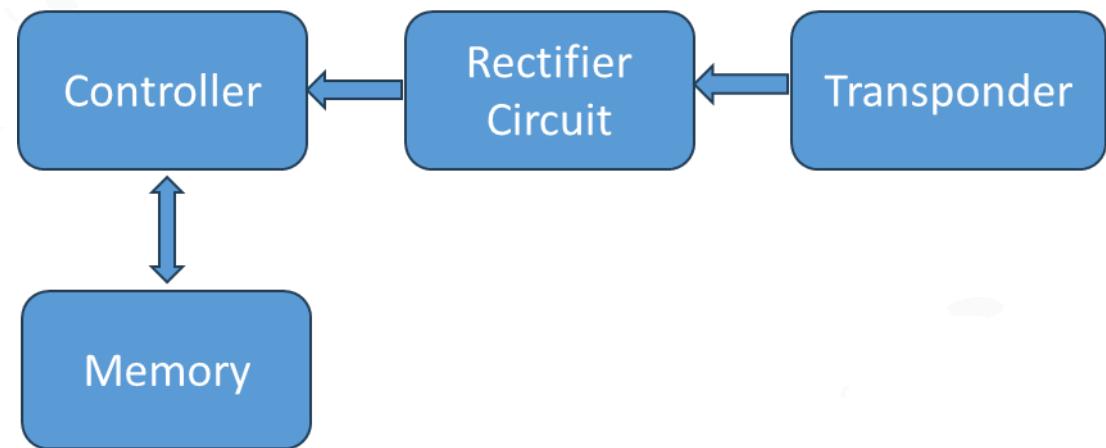
RFID basic





- The LR100 is a rugged long range UHF reader for outdoor applications with integrated Dual Linear Polarized antenna. This is a high performance industrial-class reader and achieves a read range in excess of 30m.
- The LR100 is used for tracking in mining, warehousing, tolling, parking and access control, weigh bridge automation, and more. It also supports the various Cloud Platforms provided by Techsolutions including RFID-Access, SmartAsset, SmartInventory, eFreight, etc.

RFID Tag



P-Apex Tag for Metal Assets

- P-Apex is a tough and rugged waterproof UHF tag for tracking metal items, assets and equipment such as machinery, parts, containers, railway cars, trolleys, trailers, etc.

Dimensions: 150 x 25 x 12mm. It has a read range of up to 9m

Frequency of Operation

LF
(Low frequency)
125 kHz or 134 kHz

Range: up to 10 cm

HF
(High frequency)
13.56 MHz

Range: up to 1 m

UHF
(Ultra High frequency)
860 - 960 MHz

Range: 10 to 15 m



Working principle

LF and HF RFID Tags: Inductive Coupling (near Field Coupling)

UHF RFID Tags: Electromagnetic Coupling (Far Field Coupling)

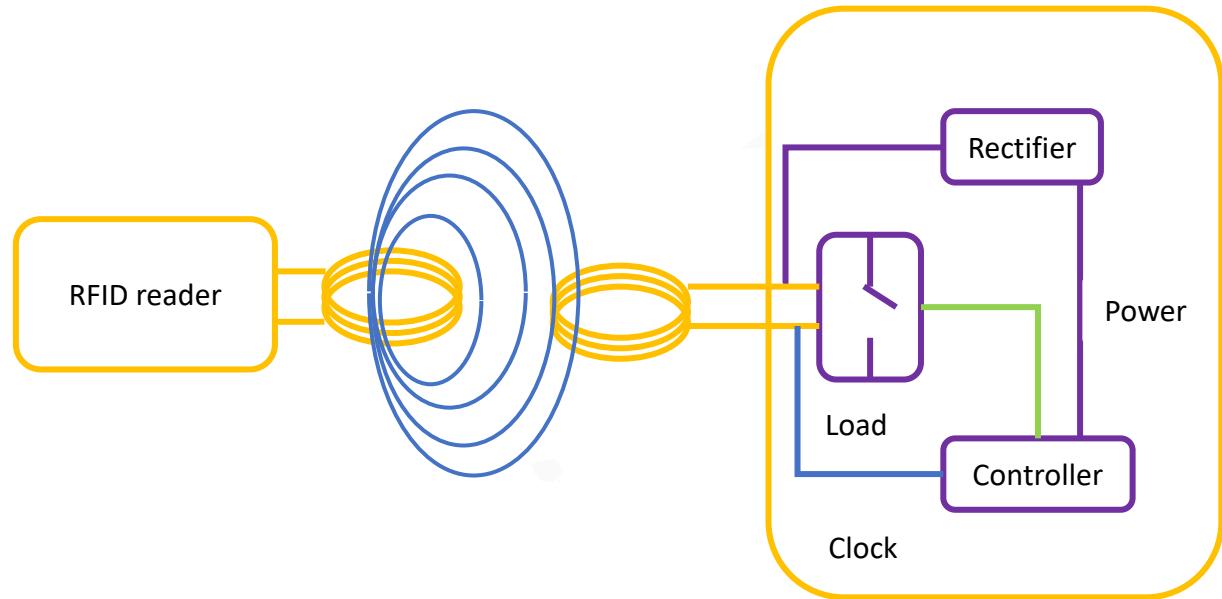
Inductive Coupling (near field coupling)

RFID reader

- Induce enough power into tag
- Synchronization clock to tag
- Acts as a carrier for return data From tag

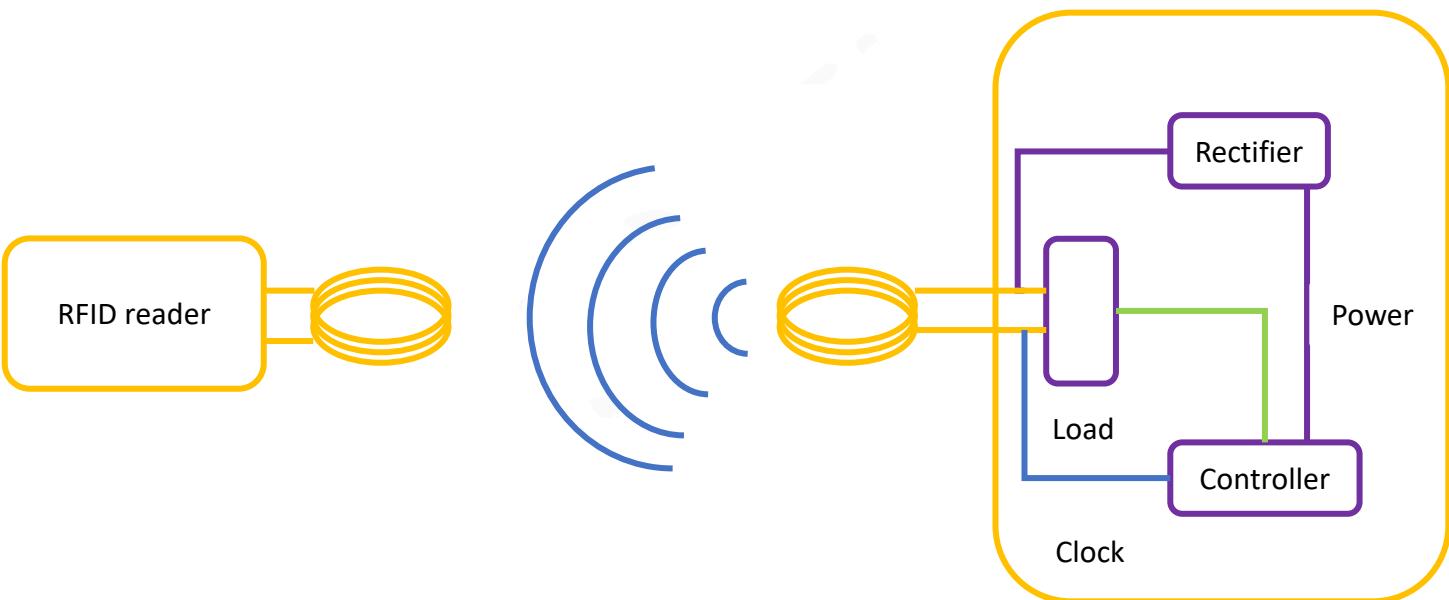


Inductive Coupling (Near field coupling)



LOAD MODULATION

Far field coupling



BACK SCATTER MODULATION

RFID Technology

- **Overview of RFID:**

RFID technology relies on radio frequency range and it work on it.

- **Types of RFID Tags:**

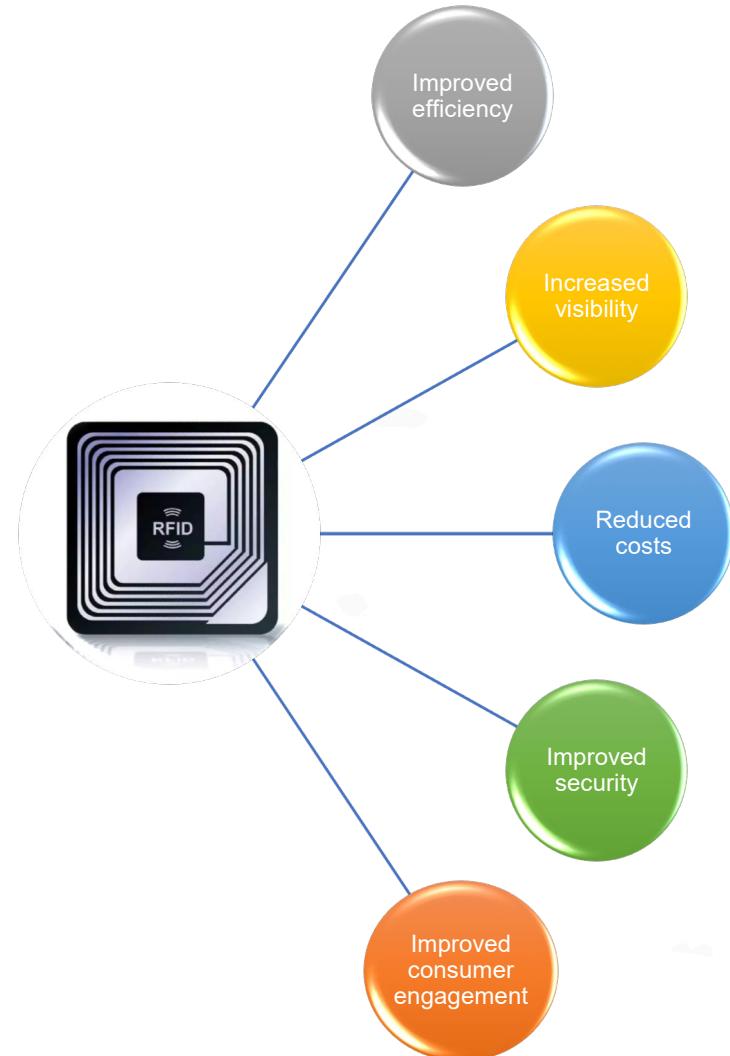
Active and passive RFID tags used in mining applications.

- **RFID Frequencies:**

Various RFID frequencies are used based on different mining scenarios.



Main benefits of RFID



Main benefits of RFID

Improved efficiency

RFID technology enables fast and efficient data exchange between an RFID reader and an RFID tag, which can result in improved efficiency and accuracy in various applications, such as inventory management, supply chain management, and asset tracking.

Increased visibility

RFID technology provides real-time data and increased visibility into the movement of goods and assets, enabling organizations to make more informed decisions and respond quickly to changes in demand or other conditions.



Main benefits of RFID

Reduced costs

By automating processes and reducing manual labor, RFID technology can help organizations to reduce costs and improve their bottom line. For example, RFID can help reduce inventory shrinkage and improve asset utilization, both of which can lead to significant cost savings.



Main benefits of RFID

Improved security

RFID technology can be used to enhance security by controlling access to secure areas and facilities and by helping to prevent theft and shrinkage.

Improved consumer engagement

RFID technology can also be applied to create an engaging shopping experience for consumers by providing personalized recommendations, real-time product information, and location-based marketing.



Why RFID in Mining

- The mining industry is one of the most dangerous industries to work in. There are many hazards that workers face on a daily basis, including exposure to toxic chemicals, heavy machinery, and falling debris. In recent years, the industry has been looking for ways to improve safety for workers. One way that mining companies are doing this is by implementing RFID technology.
- RFID stands for "radio frequency identification." This technology uses radio waves to identify and track objects. RFID tags can be attached to equipment, vehicles, or even people. When an RFID reader scans the tag, it can collect information about the object that it is attached.



Why RFID in Mining

- Mining companies are using RFID tags to track equipment and vehicles. This helps them to keep track of where their assets are, and it also helps them to prevent theft. In addition, RFID tags can be used to monitor equipment maintenance. By tracking when equipment is due for servicing, mining companies can minimize downtime and keep their operations running smoothly.
- RFID technology is still relatively new but has already proven valuable for the mining industry. As this technology continues to evolve, even more uses will likely be found in the mining industry.



RFID Applications in Mining Industry

In the mining industry, the effective management and control of assets, personnel, and resources are paramount for ensuring both efficiency and safety. Radio Frequency Identification (RFID) technology has emerged as a powerful tool to address these challenges.



Asset Tracking and Management

- **Asset Identification:**

How RFID is used to uniquely identify and track mining equipment, vehicles, and materials.

- **Real-Time Location Systems (RTLS):**

The implementation of RTLS using RFID for accurate asset location and monitoring.

- **Maintenance and Inventory Control:**

Using RFID for maintenance scheduling, inventory management, and reducing downtime.



Personnel Safety and Monitoring

- **RFID-Based Access Control:**

How RFID enhances security and access control in mining facilities.

- **Personnel Tracking:**

Using RFID for real-time monitoring of personnel, ensuring their safety and compliance.

- **Emergency Response:**

Discussing RFID's role in efficient emergency response and evacuations.



RFID can be more costly

- Whether it be software or hardware, RFID requires more costly equipment that needs to be maintained through the life of the solution.
- Additionally, tags, whether they be Active, Passive or Semi-Passive, can set a business back a ways.
- Although prices have fallen with RFID upgrades since the 1970s, businesses are still taking a pass because of the steep prices.



Trouble with metals and liquids

- RFID has long had a difficult relationship working among liquids and metals, as both make it harder to get proper reads on assets.
- With metal, the problem stems from the radio waves bouncing all over the place.
- Liquids play havoc with RFID in that it can absorb signals sent from a tag.



The RFID collision course:

- In dealing with RFID technology, workers come across reader and tag collisions.
- With reader collision, a worker might come across interference from another reader in the field.
- Tag collision is a little different, in that workers with readers face issues in reading an abundance of tags at one time.
- It happens when more than one tag reflects a signal, and it confuses the reader.



The RFID systems can be easily disrupted

- RFID systems that use the electromagnetic spectrum (Wi-Fi networks as well as cell phones), leading to a collision when you are working on the same frequency and to a lot of delays and inconvenience to consumers who want to Pay and get out of the store.
- In addition to the cards that contain the effective battery that will be questioned continuously at a low level of the battery if no answer.



RFID in Mining: Use Cases

Controlling access to mine sites

RFID can control access to mine sites. By tagging employees' ID badges with RFID tags, companies can track which employees are entering and exiting the site. This information can be used to improve safety by ensuring that only authorized personnel are on site.

Logistic distribution of supplies

RFID tags have many benefits over other tracking methods, such as barcodes. For example, they are more durable, can withstand harsh conditions, do not require a line of sight to be read, and can store more data than barcodes. This makes them ideal for tracking products in the mining industry.

RFID in Mining: Use Cases

RFID tags can provide a wide range of information about the products they are affixed to, making them ideal for tracking in the mining industry. There are two main ways that RFID tags are being used in mining operations:

Open circuit

The same RFID tag that the supplier uses is reused by the mining operation to track the products inside the mine.

Closed circuit

The mining company puts new RFID tags on the products distributed in the mine environment. This allows them to track the products easily and prevents mix-ups.



RFID in Mining: Use Cases

Tracking personnel

RFID tags are used in the mining industry for people localization, as each worker is given an RFID tag. The RFID readers are located at strategic points throughout the mine, such as the main entrance and level entrances. In drifts or ramps of an underground mine, the antennas are located based on readers' range and spacing. The goal is to decrease the personal location uncertainty areas. This allows the rescue and first aid teams to know exactly where everyone is in case of an emergency.



RFID in Mining: Use Cases

Evacuation and rescue

- Safety is of the utmost importance in underground mining. Radio frequency identification (RFID) technology plays an increasingly important role in helping to keep miners safe. It is vital monitoring miners to know each worker's exact location and where the rescue and first aid teams are.
- In an accident, RFID can help first responders locate individuals who may be trapped. It is possible to activate alarms immediately and implement evacuation protocols, monitor and guide rescue teams, do the same with workers and conduct them to safe places or operating lifts, stop truck traffic and stop works affected directly or indirectly by accident.



RFID in Mining: Use Cases

Managing explosives

RFID can also be used to track the location of explosives in a mine. This information can improve safety by ensuring that explosives are only used when and where they are supposed to be.

RFID in Mining: Use Cases

Detection areas

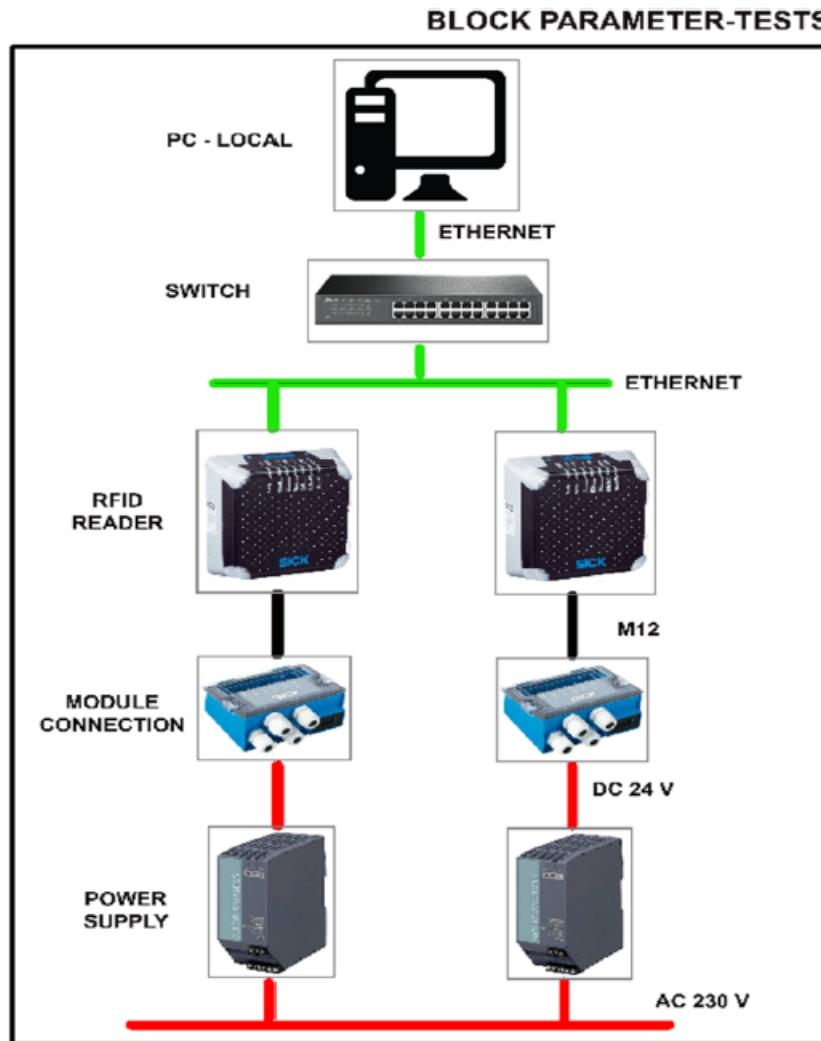
RFID is used in the mining industry for proximity warning systems. These systems use RFID tags to track the location of workers and equipment and then warn the vehicle driver if someone or something is in his proximity. This helps prevent accidents by ensuring the driver is aware of his surroundings. These systems can also be used to track the location of assets and inventory, which can help improve efficiency and productivity in the mining industry.

Case Study



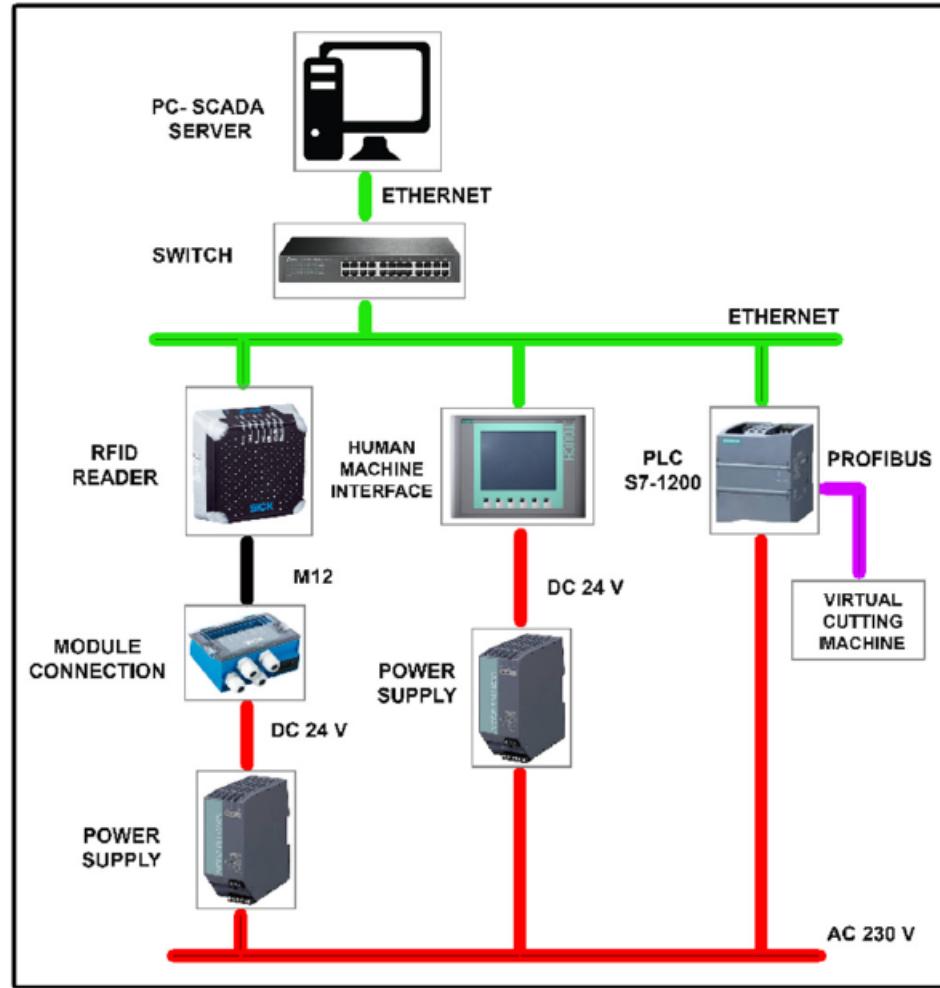
Block-Parameter Tests: Experimental Implementation at University of Evora: 1 = RFID Read/write Sensor and Antenna (SICK RFU620-10100), 2 = Data Acquisition system (NI DAQ-6009), 3 = Passive RFID-tag (Alien H3 EPC Global Gen 2), 4 = Current Source (Keithley 228A) and Digital Multimeter (Agillient 34410A).

Case Study



Schematic layout of RFID-System used in the Block-Parameter Tests.

Case Study



Schematic layout of RFID-System used in the Block-Production Tests.



REFERENCES

- Andrade, L.; Figueiredo, J.; Tlemçani, M. A New RFID-Identification Strategy Applied to the Marble Extraction Industry. *Electronics* 2021, 10, 491. <https://doi.org/10.3390/electronics10040491>
- <https://www.techsolutions.co.za/rfid-haulage-vehicle-tracking>
- <https://www.identecsolutions.com/news/rfid-in-mining>
- <https://iopscience.iop.org/article/10.1088/1757-899X/133/1/012050/pdf>



CONCLUSION

- Provided an overview of Radio-Frequency Identification (RFID) technology.
- Explored the operational principles behind RFID technology.
- Examined the application of RFID in the context of smart haulage systems.
- Introduced fundamental concepts and explained the working principle of RFID.
- Discussed the key advantages associated with the use of RFID technology.
- Explored the specific reasons for implementing RFID technology in the mining industry.



CONCLUSION

- Examined diverse applications of RFID technology within mining operations.
- Discussed practical use cases showcasing the application of RFID technology in mining.
- Examined a real-world case study illustrating the implementation and outcomes of RFID technology.





THANK YOU



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