Confined Space Trolley With Digital Safety Notification System

G.Narayanasamy[1], R.Boopathi[2]
[1]Dept of Mechanical Engineering
[2]Dept of Industrial Safety Engineering
[1, 2] Sri Shanmugha College of Engineering and Technology, Salem-637 301,Tamilnadu,India

Abstract- *Radio Frequency Identification (RFID) technology already plays a major role in many areas. One of the applications is for object detection. RFID is used for effective object's identification. A good example is object detection at storage management system. It is applicable to the environment where people easily forget the places of the stored object. In the other hand, the automatic object detection will be useful for people like store maintenance person and consumer such that they need information before pick up and store object while doing their daily life activities. The proposed Confined Space Trolley with a Digital Safety Notification System, leveraging RFID technology, focuses on its innovative features related to tool monitoring, tool tracking, and emergency response capabilities. The system employs RFID tags to monitor tools, providing real-time data on their presence or absence on the trolley. Additionally, RFID facilitates precise tracking of the tools' entry and exit times, ensuring a comprehensive record of their usage. The integration of an emergency button further enhances safety by allowing immediate alerts to be triggered in critical situations. This abstract highlights the system's capacity to streamline tool management, minimize the risk of missing tools, and precisely record tool-related activities. Overall, the proposed solution not only prioritizes personnel safety within confined spaces but also introduces efficiency in tool monitoring and emergency responsiveness, making it a holistic and valuable addition to confined space operations.*

Keywords- RFID, Confined space, Efficiency.

I. INTRODUCTION

A confined space trolley focuses on elucidating the critical role that these specialized devices play in ensuring safety and efficiency in confined spaces. Confined spaces pose unique challenges due to limited access points, restricted ventilation, and potential hazards such as poor air quality or limited visibility.

A confined space trolley is specifically designed to navigate these challenging environments, providing a secure and controlled means of transporting personnel and equipment. This introductory paragraph aims to underscore the importance of addressing safety concerns within confined spaces and highlights how a confined space trolley serves as an indispensable tool in mitigating risks and facilitating essential operations in such environments. It sets the stage for a detailed exploration of the features, functions, and safety aspects associated with confined space trolleys.

Fig 1.1 Confined space trolley

1.1 RFID

The integration of Radio-Frequency Identification (RFID) technology into confined space trolleys represents a significant advancement in enhancing safety and operational efficiency. RFID utilizes radio waves to wirelessly transmit data between an RFID tag and a reader device, facilitating seamless identification and tracking. In the context of confined space trolleys, RFID technology can be employed to monitor and manage access, ensuring that only authorized personnel are allowed entry. Each individual entering a confined space can be equipped with an RFID tag, and the trolley can be fitted with an RFID reader. This system enables real-time tracking of personnel movement, enhancing accountability and emergency response capabilities. Additionally, RFID can be utilized for inventory management of equipment and tools carried on the trolley, streamlining the process of ensuring that all necessary items are present and accounted for. The implementation of RFID in confined space trolleys thus contributes to a safer and more organized operational environment by leveraging technology to monitor and control

access while optimizing logistical processes within confined spaces.

Fig 1.2 RFID

1.1.1 EMBEDDED SYSTEMS

An Embedded System is simply a combination of computer hardware and software, either fixed in operability or programmable, which is designed to perform a specific function. It is called an embedded system because it is embedded in a much complex device to control, enhance or assist the operation of that device. Take, for example, any latest car. The automatic transmission, GPS navigation, sunroof, radio, anti-lock brakes inside the car are all embedded systems. Although embedded systems have the potential to perform a number of functions, they serve the best when used to perform a single key function. Engineers who specialize in developing embedded systems have strong knowledge of programming and electronics. Read on to know the characteristics of embedded systems and eligibility, skills set & career prospects for embedded systems.

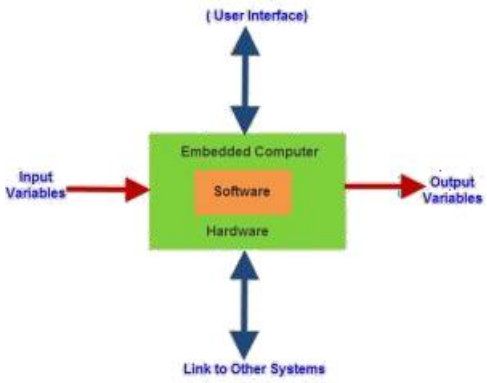

Fig 1.3 Embedded Computer

1.1.2 MAJOR CHARACTERISTICS OF EMBEDDED SYSTEMS

1.Single Key function: Unlike software like Microsoft Word & Excel or a database, an embedded system runs a single programrepeatedly.

2.Direct interaction with the real world: Embedded systems usually communicate with the real world environment through sensors and user interfaces. The users of embedded systems can directly control or modify their attributes when needed.

3.Operate under tight boundaries: Embedded systems have restricted resources in terms power consumption, memory and interfaces for connecting with other systems.

4.Developed on "reactive" principles: Since embedded systems are developed to serve a dedicated function, they are generally built using reactive principles such that their operation is stimulated by an external action.

5.High reliability: Embedded systems are integrated in machines and are expected to work continuously for years without issues and in some cases even recover on their own.

1.2 OBJECTIVE OF THE PROJECT

The primary objective of incorporating a Confined Space Trolley with a Digital Safety Notification System is to enhance overall safety, communication, and emergency response capabilities within confined spaces. The integration of a digital safety notification system into the confined space trolley aims to provide real-time monitoring and communication, ensuring the well-being of personnel working in challenging environments.

Enable instant and automated alerts in the event of any potential hazards or emergencies within the confined space.

II.LITERATURE SURVEY

2.1 Smart LPG Level Monitoring and Automatic Booking system Integrated with trolley Author : Hrushikesh Vijay Parjane; Vaibhav Sanjay Andhale Year:2023 Description Nowadays LPG Gas cylinder has become the most preferred fuel for cooking purposes. With the help of Pradhan Mantri Ujjwala Yojana Government of India has provided 50 million new connections to womens below poverty line since 2016. Replacing the old convenient way of cooking the LPG emits low carbon footprints. LPG is a mixture of propane, butane, propylene, butylene and isobutane. According to the survey of the Ministry of Petroleum and Natural Gas nearly LPG coverage in India is 99.8% in 2021-22. These systems are prepared to reduce the downtime in cooking and to make the LPG Gas cylinder booking free from human interface. It is also used to detect the gas leakage in the environment via.MQ2 sensor. It also increases productivity and helps to reduce the time for cooksing.

2.2 IoT-Based Digital LPG Gas Cylinder Trolley to Prevent Hazards with Voice-Controlled Features Author:SachinChawla;HunnyChawla Year:2023 Description Our kitchen has an LPG gas cylinder, an essential home part. This Gas cylinder helps to cook food sometimes it is very life-threatening and dangerous. It should operate under

constant surveillance to decrease the life risk. This paper consists of a solution to the above mention risk and to create a safety-oriented system with some innovative features such as gas leakage detection, Fire detection and weight of gas in the cylinder, and easy movement of the gas trolley, the gas regulator will off automatically as it finds the threat of gas leakage. A new voice-controlled feature added to the system through which we can turn on and off the regulator with single voice command. These advanced alerts may reduce the risk of any life- threatening conditions. This system includes the load sensor used to monitor the continuous weight of cylinder the and directly update it on the mobile app and web server. This also prevents the gas weight scam done by the gas agency. It sends an alert to the customer when the gas level is below the critical level and provides the option for the automatic booking of gas. Overall, this trolley is smart and intelligent and can perform actions in critical conditions and take decisions when necessary.

2.3 Smart Trolley and Predictive Stock Monitoring using Machine Learning Author : T. Rajasekar; S Y Ritika; G Ruthra Year:2022 Description Retailers and shopkeepers have struggled with stock prediction because it needs a lot of physical labour and time. It's a challenging job for retailers because it can lead to miscalculations and incorrect forecasting. As a result, there is a demand in the market for stock prediction, which can be accomplished using a machine learning system. But there is no proper machine learning algorithm for stock prediction. Study of different machine learning algorithms such as Decision Tree, Logistic Regression and Naïve Bayes is done, to find out which algorithm is best suited for the prediction of stocks, and stock prediction is done using the best algorithm obtained from the analysis. In this process, the input is taken from the input dataset It contains the stock name, total number of stocks, number of stocks left and number of days the stock will be there. The average person's daily life has become significantly frantic, and most people don't have time to go shopping, which is an inescapable occurrence. As a result, there is a need to develop an effective billing system that meets the needs of the consumers. The newly designed smart trolley consists of a Raspberry Pi, an RD reader, and a tag which does automatic bill generation. Moreover, a user friendly android application is also built for the benefit of customers and retailers.

III.SYSTEM ANALYSIS

3.1 EXISTING SYSTEM

Study on IoT applications is a popular topic in recent years, but smart shopping systems have not been well-investigated. There are some research works being published in recent years regarding improving customers' shopping experience. In 2011, Klabjan et al. proposed the idea of tracking a customer in the store and discovering customers' interests in order to offer personalized coupons. The idea of smart shelves and smart cards were also discussed in their work. Smart cards can be tracked using RFID technology and smart shelves can monitor the location and statuses of the items.

DISADVANTAGE

•No proper security method is applied.
•Security and privacy issues related to smart shopping systems

3.1.1 PROPOSED SYSTEM

Confined Space Trolley with a Digital Safety Notification System aims to revolutionize safety protocols within confined spaces by integrating advanced RFID technology. The system is designed to prioritize real-time safety monitoring, communication, and response capabilities. By incorporating RFID tags for personnel and equipment, the trolley ensures precise tracking of individuals within the confined space. In this system Identified missing tools,Monitoring tool det in/out timing and the emergency for Digital Safety Notification System leverages RFID data to trigger immediate alerts, notifying both on-site and remote personnel. This seamless communication is facilitated through a two-way communication system, allowing for instant coordination and guidance. The RFID technology not only enhances personnel accountability but also enables automated access control, ensuring that only authorized individuals enter the confined space. Environmental sensors integrated into the system continuously monitor conditions, triggering alerts if air quality or temperature deviates from predetermined safety thresholds. Furthermore, the proposed trolley includes data logging capabilities, allowing for thorough post-incident analysis and continuous improvement of safety protocols. By combining RFID technology with a comprehensive safety notification system, the proposed Confined Space Trolley enhances safety, communication, and overall operational efficiency in confined environments.

3.1.2 PROPOSED BLOCK DIAGRAM

The smart rack is able to automatically read the items put into a rack via the RFID reader. A micro controller is installed on the rack for data processing and a LCD screen is equipped as the user interface. In order for the smart rack to communicate with the server, we have chosen Zig-Bee technology as it is low- power and inexpensive. We also have a weight scanner installed on the smart rack for weighting

items. The force sensor can also help do a security check, for example, if a malicious user peels off one item's RFID tag and puts it into the rack, extra unaccounted weight will be added. When a customer finishes shopping, they pay at the checkout point using the generated billing information on the smart rack. We also set a RFID reader before the exit door to check that all the items in the rack have been paid for.

3.1.1.1 TRANSMITTER

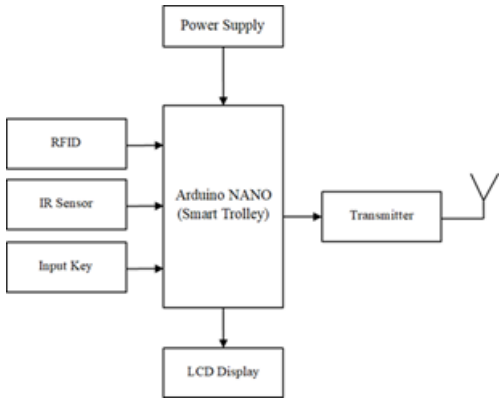

Fig 3.1 TRANSMITTER

3.1.1.2RECEIVER

We have built a prototype to test the functions of the smart rack. We have also closely monitored the reading range to guarantee only the items put into a smart rack can be read. We test the placement of the RFID reader in the smart rack and of the reader at the checkout point. We also give a security analysis and performance evaluation to prove this system is practical.

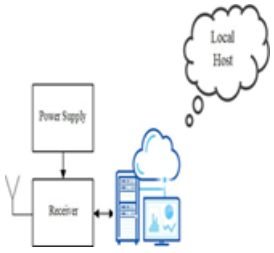

Fig 3.2 RECEIVER

Our proposed smart shopping system should achieve the following major goals:

- **Item reading:** The smart rack should be able to accurately read items put into or removed from the rack. An item put into one rack should not be able to be read by another rack nearby.
- **Items tracking:** The server should maintain the state of items in the store. With RFID readers installed on the rack, the items can be monitored and the item stock can be updated to the server.

Our proposed smart shopping system consists of the following components:

- **Server:** All items are registered to the server before moved to the shelves. The server stores all items' information, such as location and price, in a database. The server communicates with all the other entities in the smart shopping system through Zig-Bee.
- **Smart Rack:** As shown in Fig. the following components are equipped on the smart rack.
- **Microcontroller:** Coordinates with the RFID reader, Zig-Bee adapter and LCD touch screen to perform computing functions.
- **Zig-Bee Adapter:** Zig-Bee is a low-cost and low power protocol that costs much less energy than WiFi.
- **Force Sensor:** The weight sensor can weigh items that are put in the rack to ensure the tag corresponds to the correct item. It can also help with a security check: if a malicious user peels off the RFID tags before putting it into the rack, the rack can detect it as no weight is sensed.
- **RFID reader:** We use a low frequency (LF) RFID reader which allows a reading range up to 2 centimetre meters. By tuning the transmission power of the reader, we can control its reading range.
- **User Interface (LCD display):** Displays product information, possible navigation choices,billing,information,coupons etc.

IV. IMPLEMENTATION DETAILS

4.1 HARDWARE REQUIREMENT

- Microcontroller
- RFID LF 127KHz
- LCD display
- Power Supply

4.2 SOFTWARE REQUIREMENTS

- Arduino IDE

4.3 HARDWARE SPECIFICATION

4.3.1 Power Supplies

A power supply (sometimes known as a power supply unit or PSU) is a device or system that supplies electrical or other types of energy to an output load or group of loads. The term is most commonly applied to electrical energy supplies, less often to mechanical ones, and rarely to

others.This circuit is a small +5V power supply, which is useful when experimenting with digital electronics. Small inexpensive wall transformers with variable output voltage are available from any electronics shop and supermarket. Those transformers are easily available, but usually their voltage regulation is very poor, which makes then not very usable for digital circuit experimenter unless a better regulation can be achieved in some way. The following circuit is the answer to the problem.

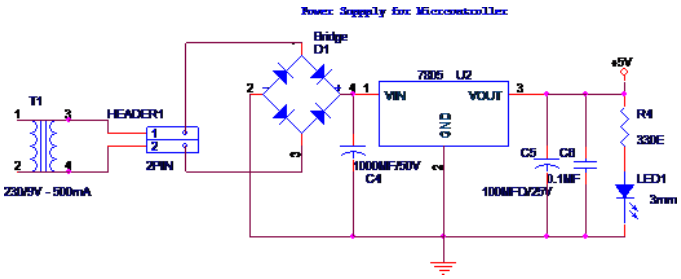

Fig 4.3.1 Block diagram of power supply

Transformer

A transformer is a device that transfers electrical energy from one circuit to another through inductively coupled wires. A changing current in the first circuit (the primary) creates a changing magnetic field; in turn, this magnetic field induces a changing voltage in the second circuit (the secondary). By adding a load to the secondary circuit, one can make current flow in the transformer, thus transferring energy from one circuit to the other. The secondary induced voltage V_S is scaled from the primary V_P by a factor ideally equal to the ratio of the number of turns of wire in their respective windings:

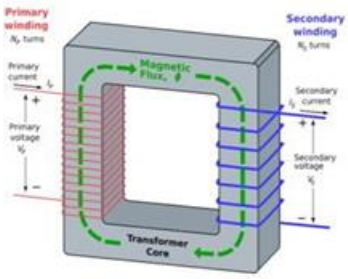

Fig 4.3.2 An ideal step-down transformer

Rectifier

A rectifier is an electrical device that converts alternating current (AC), which periodically reverses direction, to direct current (DC), which flows in only one direction. The process is known as rectification. Rectifiers are used as components of power supplies and as detectors of radio signals. Mainly there are three types of rectifier i.e. half wave rectifier, full wave rectifier and Bridge Rectifier.

Half-wave rectifier

In half-wave rectification of a single-phase supply, either the positive or negative half of the AC wave is passed, while the other half is blocked. Because only one half of the input waveform reaches the output, mean voltage is lower. Half-wave rectification requires a single diode in a single-phase supply, or three in a three-phase supply. Rectifiers yield a unidirectional but pulsating direct current; half-wave rectifiers produce far more ripple than full-wave rectifiers, and much more filtering is needed to eliminate harmonics of the AC frequency from the output.

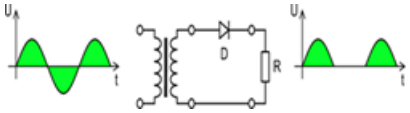

Fig 4.3.3 Half Wave Rectifier

Full-wave rectifier

A full-wave rectifier converts the whole of the input waveform to one of constant polarity (positive or negative) at its output. Full-wave rectification converts both polarities of the input waveform to pulsating DC (direct current), and yields a higher average output voltage. Two diodes and a center tapped transformer are needed.

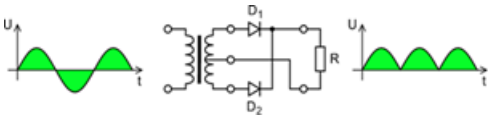

Fig 4.3.4 Full-Wave Rectifier

Bridge Rectifier

A diode bridge is an arrangement of four (or more) diodes in a bridge circuit configuration that provides the same polarity of output for either polarity of input. When used in its most common application, for conversion of an alternating current (AC) input into a direct current (DC) output, it is known as a bridge rectifier. A bridge rectifier provides full-wave rectification from a two-wire AC input, resulting in lower cost and weight as compared to a rectifier with a 3-wire input from a transformer with a center-tapped secondary winding. The essential feature of a diode bridge is that the polarity of the output is the same regardless of the polarity at the input.

Basic operation

According to the conventional model of current flow, current is defined to be positive when it flows through electrical conductors from the positive to the negative pole. In actuality, free electrons in a conductor nearly always flow from the negative to the positive pole.

In the vast majority of applications, however, the actual direction of current flow is irrelevant. Therefore, in the discussion below the conventional model is retained.

In the diagrams below, when the input connected to the left corner of the diamond is positive, and the input connected to the right corner is negative, current flows from the upper supply terminal to the right along the red (positive) path to the output, and returns to the lower supply terminal via the blue (negative) path.

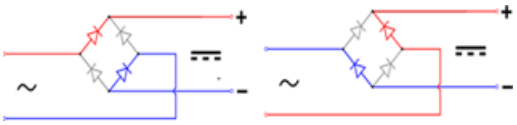

Fig 4.3.5 Operation of bridge rectifier

IC Voltage Regulators

Voltage regulators comprise a class of widely used ICs. Regulator IC units contain the circuitry for reference source, comparator amplifier, control device, and overload protection all in a single IC.

Three-Terminal Voltage Regulators

Figure shows the basic connection of a three-terminal voltage regulator IC to a load.

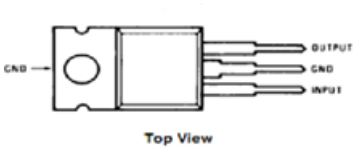

Fig 4.3.6 Three-Terminal Voltage Regulators

78xx series

There are common configurations for 78xx ICs, including 7805 (5 V), 7806 (6 V), 7808 (8 V), 7809 (9 V), 7810 (10 V), 7812 (12 V), 7815 (15 V), 7818 (18 V), and 7824 (24 V) versions. The 7805 is the most common, as its regulated 5- volt supply provides a convenient power source for most TTL components. Less common are lower-power versions such as the LM78Mxx series (500 mA) and LM78Lxx series (100 mA) from National Semiconductor.

Positive Voltage Regulators in 7800 series

IC Part	Output Vi (V)	Voltage(V)
7805	+5	7.3
7806	+6	8.3
7808	+8	10.5
7810	+10	12.5
7812	+12	13.6
7815	+15	17.7
7818	+18	21.0
7824	+24	27.1

79xx series

The 79xx devices have a similar "part number" to "voltage output" scheme, but their outputs are negative voltage, for example 7905 is -5 V and 7912 is -12 V. The 7912 has been a popular component in ATX power supplies, and 7905 was popular component in ATX before -5 V was removed from the ATX specification.

THE MICROCONTROLLER

The Arduino R3 comes with an ATmega 328 Microcontroller with an Arduino Uno Bootloader. The Bootloader facilitates the Programming of the IC from within the Arduino IDE.

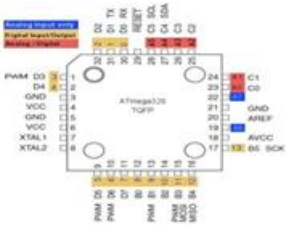

Fig 4.3.7 Microcontroller AT328-Pin Diagram

4.1 SOFTWARE DESCRIPTION

4.1.1 ARDUINO SOFTWARE (IDE)

The Arduino Integrated Development Environment - or Arduino Software (IDE) - contains a text editor for writing code, a message area, a text console, a toolbar with buttons for common functions and a series of menus. It connects to the Arduino hardware to upload programs and communicate with them.

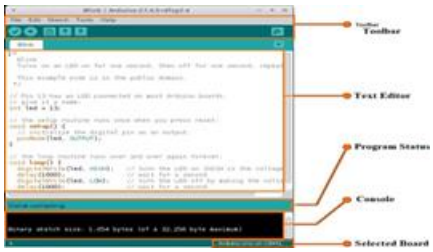

Fig 4.3.11 Arduino IDE

File

- New Creates a new instance of the editor, with the bare minimum structure of a sketch already in place.
- Open Allows to load a sketch file browsing through the computer drives and folders.
- Open Recent Provides a short list of the most recent sketches, ready to be opened.
- Sketchbook Shows the current sketches within the sketchbook folder structure; clicking on any name opens the corresponding sketch in a new editor instance.

Examples Any example provided by the Arduino Software (IDE) or library shows up in this menu item. All the examples are structured in a tree that

- allows easy access by topic or library.
- Close Closes the instance of the Arduino Software from which it is clicked.
- Save Saves the sketch with the current name. If the file hasn't been named before, a name will be provided in a "Save as.." window.
- Save as... Allows to save the current sketch with a different name.
- Page Setup It shows the Page Setup window for printing.
- Print Sends the current sketch to the printer according to the settings defined in Page Setup.
- Preferences Opens the Preferences window where some settings of the IDE may be customized, as the language of the IDE interface.
- Quit Closes all IDE windows. The same sketches open when Quit was chosen will be automatically reopened the next time you start the IDE.

Edit

- Undo/Redo Goes back of one or more steps you did while editing; when you go back, you may go forward with Redo.
- Cut Removes the selected text from the editor and places it into the clipboard.
- Copy Duplicates the selected text in the editor and places it into the clipboard.
- Copy for Forum Copies the code of your sketch to the clipboard in a form suitable for posting to the forum, complete with syntax coloring.
- Copy as HTML Copies the code of your sketch to the clipboard as HTML, suitable for embedding in web pages.
- Paste Puts the contents of the clipboard at the cursor position, in the editor.
- Select All Selects and highlights the whole content of the editor.
- Comment/Uncomment Puts or removes the // comment marker at the beginning of each selected line.
- Increase/Decrease Indent Adds or subtracts a space at the beginning of each selected line, moving the text one space on the right or eliminating a space at the beginning.
- Find Opens the Find and Replace window where you can specify text to search inside the current sketch according to several options.
- Find Next Highlights the next occurrence - if any - of the string specified as the search item in the Find window, relative to the cursor position.
- Find Previous Highlights the previous occurrence - if any - of the string specified as the search item in the Find window relative to the cursor position.
- Verify/Compile Checks your sketch for errors compiling it; it will report memory usage for code and variables in the console area
- Upload Compiles and loads the binary file onto the configured board through the configured Port.
- Upload Using Programmer This will overwrite the bootloader on the board; you will need to use Tools > Burn Bootloader to restore it and be able to Upload to USB serial port again. However, it allows you to use the full capacity of the Flash memory for your sketch. Please note that this command will NOT burn the fuses. To do so a Tools -> Burn Bootloader command must be executed.
- Export Compiled Binary Saves a .hex file that may be kept as archive or sent to the board using other tools.
- Show Sketch Folder Opens the current sketch folder.
- Include Library Adds a library to your sketch by inserting #include statements at the start of your code. For more details, see libraries below. Additionally, from this menu item you can access the

Library Manager and import new libraries from .zip files.

Add File... Adds a source file to the sketch (it will be copied from its current location). The new file appears in a new tab in the sketch window. Files can be removed from the sketch using the tab menu accessible clicking on the small triangle icon below the serial monitor one on the right side of the toolbar.

Tools

- Auto Format This formats your code nicely: i.e. indents it so that opening and closing curly braces line up, and that the statements inside curly braces are indented more.
- Archive Sketch Archives a copy of the current sketch in .zip format. The archive is placed in the same directory as the sketch.
- Fix Encoding & Reload Fixes possible discrepancies between the editor char map encoding and other operating systems char maps.
- Serial Monitor Opens the serial monitor window and initiates the exchange of data with any connected board on the currently selected Port. This usually resets the board, if the board supports Reset over serial port opening.
- Board Select the board that you're using. See below for descriptions of the various boards.
- Port This menu contains all the serial devices (real or virtual) on your machine. It should automatically refresh every time you open the top-level tools menu.
- Programmer For selecting a hardware programmer when programming a board or chip and not using the onboard USB-serial connection. Normally you won't need this, but if you're burning a bootloader to a new microcontroller, you will use this.
- Burn Bootloader The items in this menu allow you to burn a bootloader onto the microcontroller on an Arduino board. This is not required for normal use of an Arduino board but is useful if you purchase a new ATmega microcontroller (which normally comes without a bootloader). Ensure that you've selected the correct board from the Boards menu before burning the bootloader on the target board. This command also set the right fuses.

Help

- Here you find easy access to a number of documents that come with the Arduino Software (IDE). You have access to **Getting Started, Reference**, this guide to the IDE and other documents locally, without an internet connection. The documents are a local copy of the online ones and may link back to our online website.
- Find in Reference This is the only interactive function of the Help menu: it directly selects the relevant page in the local copy of the Reference for the function or command under the cursor.

Fig 4.3.12 NANO Interfacing USB Types of Port

Open your first sketch

- Open the LED blink example sketch: File > Examples > 01.Basics > Blink.

Select your board type and port

- Select Tools > Board > Arduino AVR Boards > Arduino Nano.

V. PERFORMANCE EVALUATION

We test the robustness of the system with our prototype, and we find that the RFID reading is accurate and precise. According to our tests, the metal of the rack blocks the signal to a large extent and an item outside the rack can not be read by the reader inside the rack. When a new item is put into the smart rack, it will be automatically read by the reader, which is continually scanning items within its range. After a product is read, its ID will be checked to see if it is a newly added item. If so, its information will be listed on the user interface. On the other hand, when an item is removed from the smart rack, the reader will no longer be able to scan its information.We now evaluate the computational and communication overhead of our proposed protocol. We focus only on the communications between the server and the smart rack, as the communication patterns between the checkout point and the server are the same.

ADVANTAGES

- It becomes easy for the store to do inventory management as all items can be automatically read and easily logged.

- As an IOT application, the power consumption must be low.
- Computational overhead at the smart rack side for higher efficiency.

APPLICATION

- Smart homes, e-health systems, wearable devices
- Smart Shopping in Shopping Mall
- Library Management

VI. CONCLUSION

In this project, we propose a secure Confined space trolley monitoring system utilizing RFID technology. This is the first time that LF RFID is employed in enhancing Identifying tools and security issues are discussed in the context of a confined space trolley with digital safety notification system the integration of a Confined Space Trolley with a Digital Safety Notification System, incorporating RFID technology, represents a paramount advancement in ensuring the utmost safety and efficiency within confined spaces. The RFID-enabled system provides an unparalleled level of real-time monitoring, personnel tracking, and hazard notification, contributing to a proactive and responsive safety infrastructure. By leveraging RFID tags for personnel and equipment, the trolley ensures precise location tracking, fostering accountability and facilitating swift emergency responses. The two-way communication system enhances coordination and guidance, fostering a safer working environment. The automated access control features further mitigate risks by allowing only authorized personnel entry. Environmental sensors add an additional layer of safety, monitoring conditions to preemptively address potential hazards. The data logging capabilities offer valuable insights for post-incident analysis and continuous safety improvement. In essence, the proposed Confined Space Trolley with a Digital Safety Notification System using RFID stands as a comprehensive solution, redefining safety standards within confined spaces and ensuring the well-being of personnel while optimizing operational efficiency.

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