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Driverless Metro Train Shuttle between the Stations using LabVIEW

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ABSTRACT

The aim of this paper is to illustrate an improvement in the existing technology used in metro train movements. This train is equipped with a controller and an IR Object sensor that enables the automatic stopping of the train from one station to another station. This paper presents the development process of a prototype for a driverless train implemented using a RASPBERRY PI controller. Simulation for the system's circuits is done with LabVIEW software. The hardware circuit is interfaced with actuators and sensors for automation purposes using LabVIEW. A hardware comprised of IR sensor, RASPBERRI PI are assembled in a prototype train. A LabVIEW CODE is used for programming the controller. A Smoke sensor is also interfaced to detect any smoke or gas present in the train.

Keywords: *IR sensor, Raspberry PI, MPU_6050, Metro train.*

I. INTRODUCTION*:*

A lot of advancement has been made in Railroad transport. A huge transformation has occurred starting with the early steam operated engines to the most recent bullet train. Many developments in railroad transport has utilized the existing infrastructure, where the existing metro system is being modernized and equipped with automatic train control and safety system in order to make them more efficient. Driverless automated concepts have been adopted, and the first recorded implementation was the London underground Victoria line, opened in 1967. The Unmanned Train Operation (UTO), which is featured by the highest degree of automation, is not a very recent development with the first UTO lines date from 1981. However a fully driverless system was only implemented in 2003 in Singapore, while the 75 Km Dubai line is the longest metro line in the world. There has been a continuous research intended to enhance the overall automation system functions and performance of the Metro trains. In modern days metro train transportation has become the most economical and safe way of public transportation system. It helps to connect two major cities and provides a high speed transportation services to the public. The unmanned metro train (Driverless) allows a highly secure and high performance means of transportation. The prototype makes use of microcontroller to control the train movements. It also controls passenger counting and generates a warning signal including automatic opening and closing of doors. The train runs between two predefined stations. It also provides a facility of collision avoidance in case of two trains being on the same track. The distance between two stations is also predefined. The train runs between two stations without human intervention. It provides a reset switch to the passenger which acts as an emergency braking system to stop the train in case of emergency. The main idea of the approach is to allow automatic metro train system which is completely unmanned and is precise and errorless in its operation. Counting of passengers happens by using bidirectional detection by IR and photo diode arrangement.

Now-a-days driverless metro trains which are used in most of the developed countries like Germany, France, and Japan etc. These trains are equipped with the CPU which controls the train. The train is programmed for a specific path. Every station on the path is defined and also the stoppage timing of the train and distance between the two stations is predefined. Modern technologies are being integrated in almost all aspects of our life including transportation, where a lot of advancement has been made. Railroad transport, for instance, has undergone a huge transformation, starting with the early steam operated engines to the most recent bullet train.

In the proposed system, the train is equipped with a controller and a IR Object sensor that enables the automatic stopping of the train from one station to another station. The hardware circuit is interfaced with actuators and sensors for automation purposes using LabVIEW. The hardware is assembled in a prototype train. The LabVIEW CODE is used for programming the controller. A Smoke sensor is also interfaced to detect any smoke or gas in the train to avoid unnecessary accidents. The speed of the train is controlled by applying PID Controller using arduino Uno and LabVIEW with the sensor accelerometer as a feedback.

II. METHODOLOGY

The proposed system includes DC Motors, Stepper motor, various sensors like IR sensor and smoke sensor, Raspberry Pi controller, Buzzer and seven segment display. In the proposed system speed control is automated using PID controller and LabVIEW. The presence of smoke (if any) is detected by the smoke sensor and an alert is given by a Buzzer. The station or obstacle is recognised by IR object sensor and the train is stopped An alert is made for three times before the door opens, the door remains open for 20 seconds and then the alert is made for three times and the door closes.

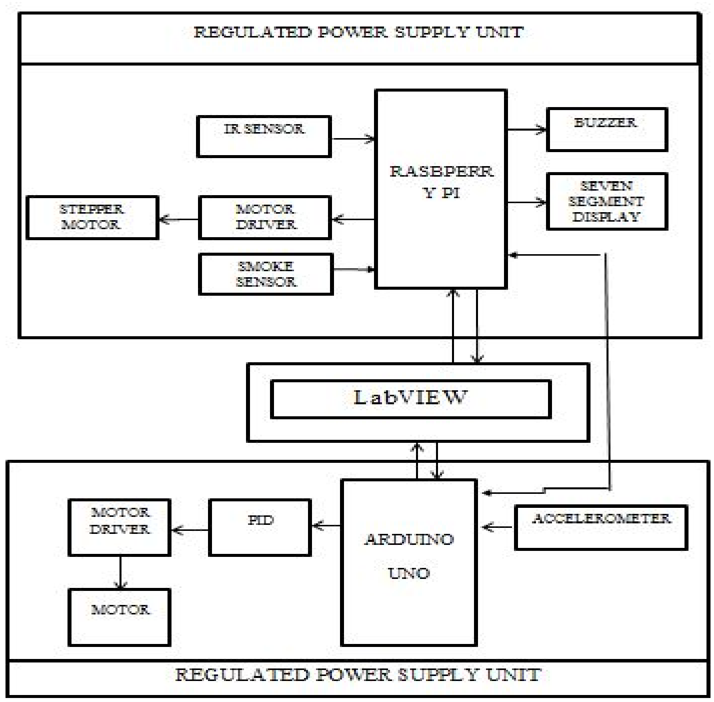

Figure 1: Block diagram

1. HARDWARE REQUIREMENTS

A. RASPERRY PI:

The Raspberry Pi 3 Model B is the third generation Raspberry Pi. This powerful credit-card sized single board computer can be used for many applications and supersedes the original Raspberry Pi Model B+ and Raspberry Pi 2 Model B.

Here, Raspberry Pi is used as a controller, using this various sensors, motors, buzzer and seven segment display are interfaced using LabVIEW.

B. Seven segment display:

Here seven segment display is used to display the time in seconds from 19 to 0 meanwhile the doors remain open till the count become zero.

C. Buzzer:

A buzzer or beeper is an audio signalling device, which may be mechanical, electromechanical, or piezoelectric. Typical uses of buzzers and beepers include alarm devices, timers and confirmation of user input such as a mouse click or keystroke.

Here Buzzer is used to make sound before opening and closing the door. The buzzer will alarms three times as programmed.

D. Stepper Motor:

Stepper motor is a special type of electric motor that moves in precisely defined increments of rotor position (Steps). The size of the increment is measured in degrees and can vary depending on the application. Due to precise control, stepper motors are commonly used in medical, satellites, robotic and control applications.

Here, Stepper motor is used for opening and closing the doors.

E. DC Motor:

A DC motor is a class of rotary electrical machines that converts direct current electrical energy into mechanical energy. Nearly all types of DC motors have some internal mechanism, either electromechanical or electronic; to periodically change the direction of current flow in part of the motor.

F. IR Object Sensor:

This Medium Range Infrared sensor offers simple, user friendly and fast obstacle detection using infrared; it is non-contact detection. The implementations of modulated IR signal immune the sensor to the interferences caused by the normal light of a light bulb or the sun light. The sensing distance can be adjusted manually.

IR Object Sensor is used for automatic stopping of the train in this project.

G. L293D Motor Driver Circuit:

L293D is a typical Motor driver or Motor Driver IC which allows DC motor to drive on either direction. L293D is a 16-pin IC which can control a set of two DC motors simultaneously in any direction. It means that you can control two DC motor with a single L293D IC. It works on the concept of H-bridge. H-bridge is a circuit which allows the voltage to be flown in either direction.

H. MPU-6050 Motion Tracking:

The MPU-6050 sensor contains a MEMS accelerometer and a MEMS gyro in a single chip. It is very accurate, as it contains 16-bits analog to digital conversion hardware for each channel. Therefore it captures the x, y, and z channel at the same time.

The sensor uses the I2C-bus to interface with the Arduino. Accelerometer function is to measure the tilt angle of x, y, z axis. The difference between actual tilt with reference is the error given to the input of PID controller, the output of the PID controller is scaled to PWM input ranging from 0 to 1 for controlling the motors.

I. Smoke Sensor:

A smoke sensor is a device that senses smoke, typically as an indicator of fire. as part of a fire alarm system, while household detectors, known as smoke alarms. The smoke sensor is sensitive to smoke and to the flammable gases LPG, Butane, Propane, Methane, Alcohol and Hydrogen.

2. SOFTWARE REQUIREMENTS

LabVIEW

LabVIEW programs are called virtual instruments, or VIs, because their appearance and operation imitate physical instruments, such as oscilloscopes and millimetres. LabVIEW contains a comprehensive set of tools for acquiring, analysing, displaying, and storing data. In LabVIEW, you build a user interface, or front panel, with controls and indicators. Controls are knobs, push buttons, dials, and other input mechanisms. Indicators are graphs, LEDs, and other output displays. We can use LabVIEW to communicate with hardware such as data acquisition, vision, and motion control devices, as well as GPIB, PXI, VXI, RS232, and RS485 instruments

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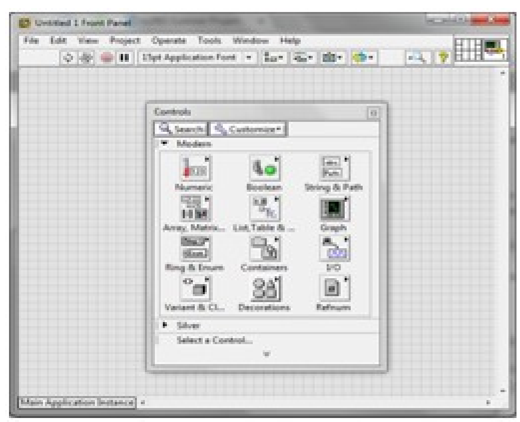

Figure 2: LabVIEW Front Panel

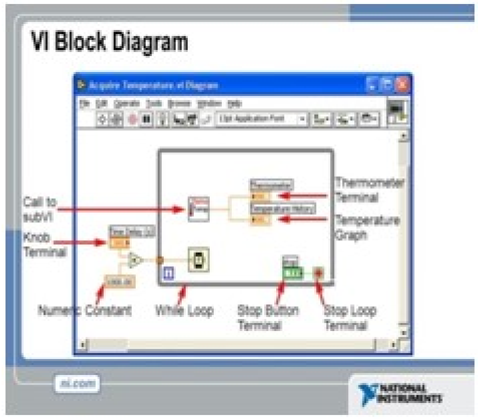

Figure 3: LabVIEW Block diagram

III. IMPLEMENTATION

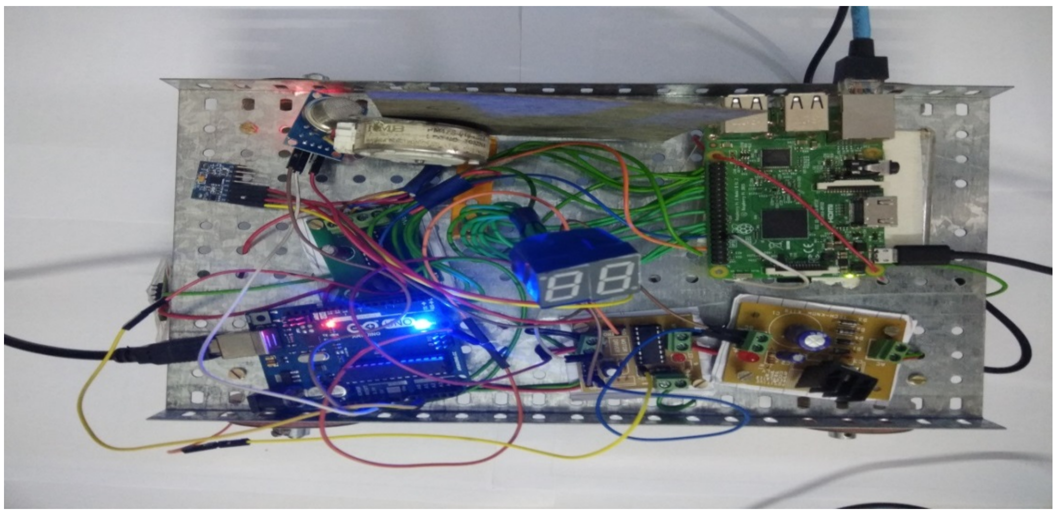

Figure 4: Hardware Model

The proposed system includes DC Motors, Stepper motor, various sensors, Raspberry Pi controller, Buzzer, seven segment display. In the proposed system speed control is automated using PID controller. The Arduino Uno and MPU 6050 is used along with LabVIEW blocks are used for applying the PID controller for accleration of the train. The raspberry pi is connected to the PC through an Ethernet Cable. Platform used in this research is a Wild thumper, The four wheels of diameter 10cm, two of four on either side and is used to build the vehicle platform. The vehicle dimensions are 17 inches 12 inches 6.5 inches as shown in the Fig 7.1 Platform has four wheels four motors with steel gear boxes integrated inside the motors itself . The chassis top has 4 mm holes punched every 10 mm far throughout the chassis for mounting sensors modules and other hardware. The power supply to Arduino is given from PC .The DC 5V regulated power supply to the rasppberry pi and 12V to motors are given. Seven segment display is used to display the time in seconds from19 to 0 meanwhile the doors remain open till the count become zero. Buzzer is used to make sound before opening and closing the door. The buzzer will alarms three times as programmed. And when the smoke is detected the buzzer should give an alert. Stepper motor is used for opening and closing the doors.IR Object Sensor is used for automatic stopping of the train in this project.L293D is a typical Motor driver or Motor Driver IC which allows DC motor to drive on either direction. Accelerometer function is to measure the tilt angle of x, y, z axis. The difference between actual tilt with reference is the error given to the input of PID controller, the output of the PID controller is scaled to PWM input ranging from 0 to 1 for controlling the motors. A smoke sensor is a device that senses smoke, typically as an indicator of fire. As part of a fire alarm system, while household detectors, known as smoke alarms. The smoke sensor is sensitive to smoke and to the flammable gases LPG, Butane, Propane, Methane, Alcohol and Hydrogen. *LabVIEW* programs are called virtual instruments, or VIs, because their appearance and operation imitate physical instruments, such as oscilloscopes and millimetres. LabVIEW contains a comprehensive set of tools for acquiring, analysing, displaying, and storing data.

LabVIEW code for PID Control

The VI Block diagram for PID controller is as shown in figure 5

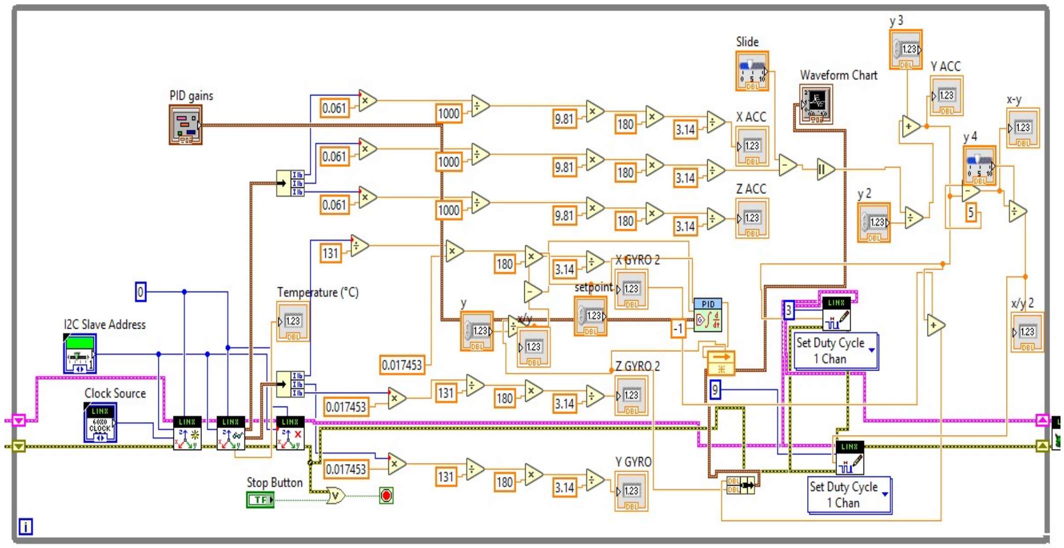

Figure 5: VI Block Diagram for PID controller

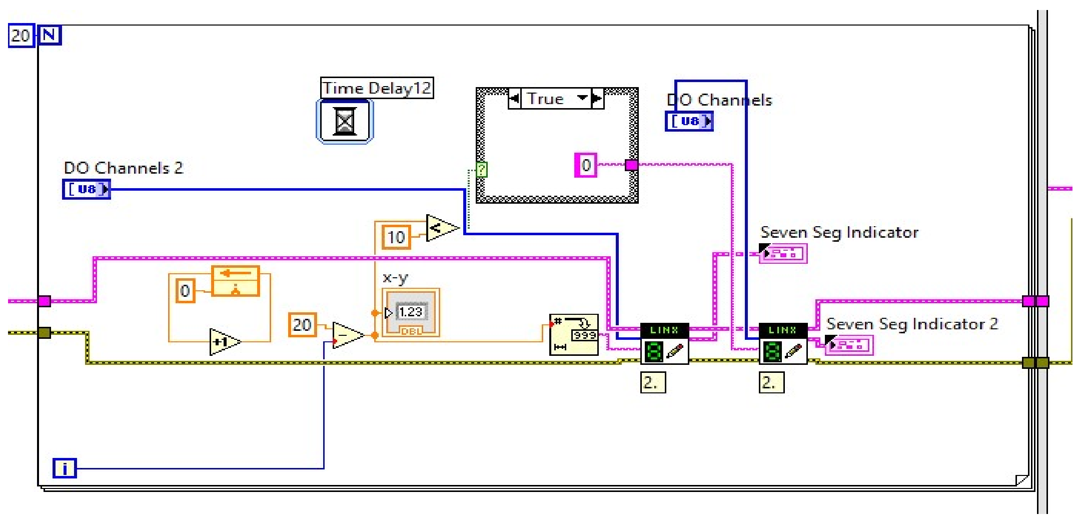

Figure 6: VI Block diagram for seven segment display.

The VI Block diagram for Seven Segment display is as shown in figure 6. The seven segment code designed to count for 20 seconds. After opening the doors the seven segment display starts the count from 19 to 0.

When the counter reaches zero the code for alarm will be enabled and the buzzer alarms for three times .The code for stepper motor makes the door close after three alarms.

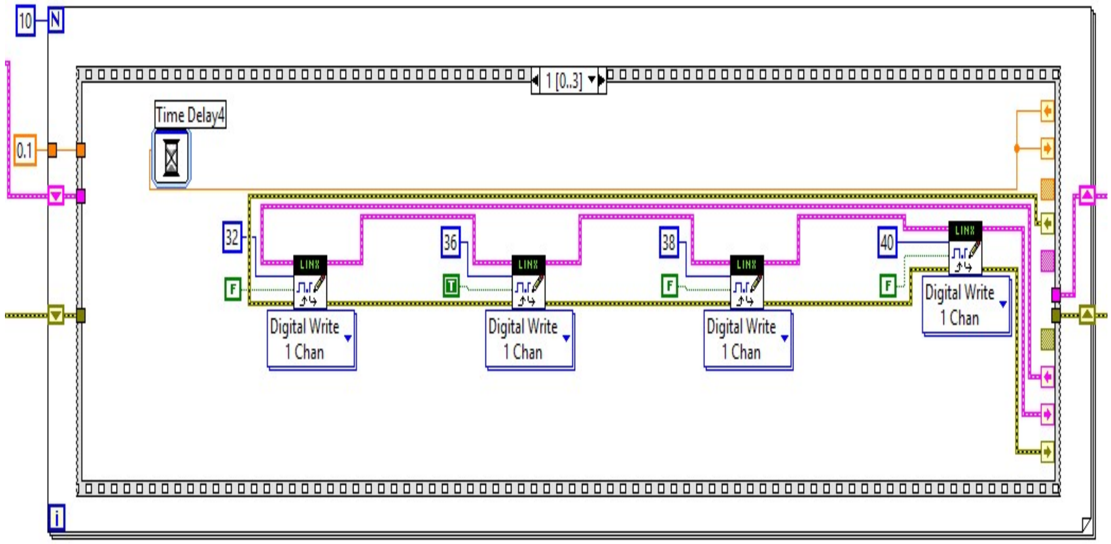

Figure 7: VI Block diagram for stepper motor

The VI Block diagram for stepper motor is as shown in figure 7. The stepper makes clockwise rotation for 10 steps in the clockwise direction and doors are closed. After when the conditions are satisfied the stepper motor will make 10 steps to close the door.

IV. RESULTS AND DISCUSSION

IR Sensor

IR Sensor	Station	Status of Train
OFF	Not Arrived	Running
ON	Arrived at Station 1	Stop
OFF	Not Arrived	Running
ON	Arrived at Station 2	Stop

Table 1: IR sensor Results

The IR Sensor is fixed at the front face of the train. The train keeps running towards the station in its path. IR sensor goes high once the station is detected, this high signal is processed and the train gets stopped in the station.

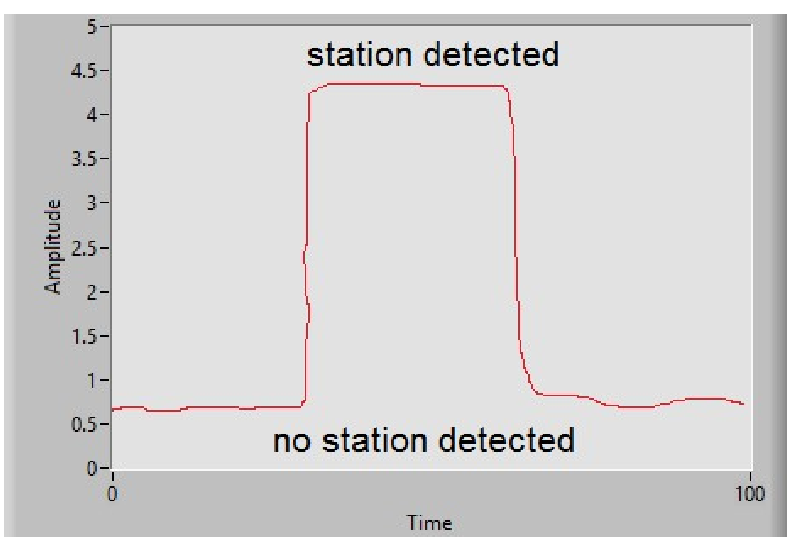

Figure 8: IR sensor output

The IR sensor will be triggered on as soon as it detects the black colour.

Smoke sensor response

The below figure shows the output response of the smoke sensor it slowly increases in presence of smoke from 0.5v to nearly 4.5v and it also shows the level of the smoke in terms of voltage in the front panel

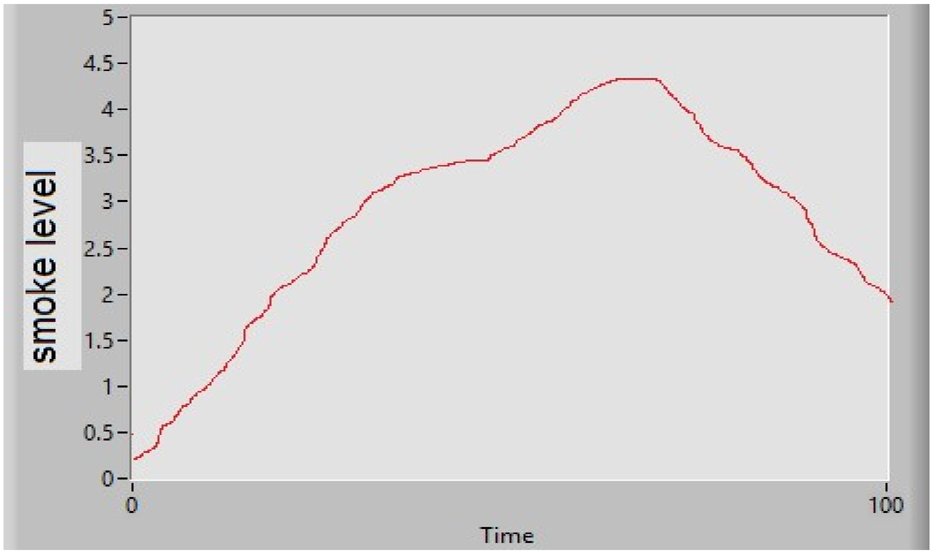

Figure 9: Smoke sensor response

Scenario	Status of Smoke sensor	Buzzer	LabVIEW Display
No Smoke	OFF	OFF	No Smoke
Smoke	Beyond threshold – ON	ON	Smoke Detected

Table 2: Smoke Sensor Results

A smoke sensor is placed inside the train compartment. Whenever it detects smoke, the sensor will output high, the buzzer beeps and the Front Panel of LabVIEW displays "Smoke level" and the doors open. The status and response of smoke sensor is verified in the above table.

Sequence of operation on metro train

Status of Train	Buzzer	Stepper motor	Door Status	Seven Segment Display	Buzzer	Stepper motor	Door Status
Running	OFF	OFF	Closed	OFF	OFF	OFF	Closed
Stop	Turns on (beeps for 3 times)	ON	Opened for 20 seconds	ON (Counts from 19 to 0)	Turns on (beeps for 3 times)	ON	Closed

Table 3: Opening and Closing of Doors

When the train is running Buzzer, stepper motor, seven segment display will be in the OFF condition and doors are closed. When the train stops the buzzer beeps for three times, the doors are opened and it will remain for 20 seconds. The count is displayed on the seven segment display. After 20 seconds buzzer beeps for three times and then doors are closed. The train starts moving towards the next station. The process will be repeated for the next stations.

Front panel PID response of real time model

The below figure shows the PID response for real time implementation. The response for tuning is shown in the below figure. Also the speed of the train is displayed in analog meter on the front panel.

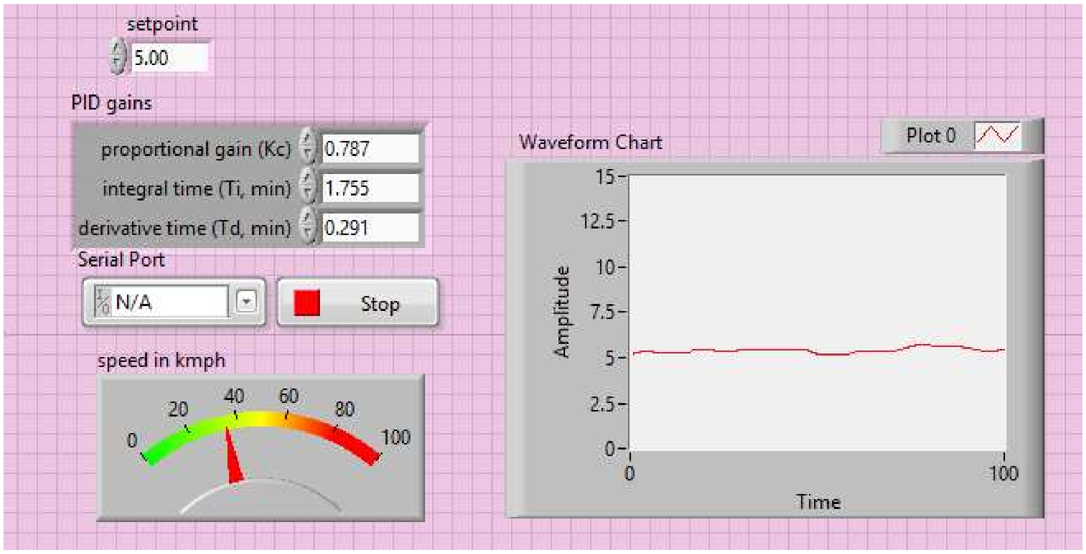

Figure 8.3 Front panel of PID response and the speed of vehicle.

V. CONCLUSION AND FUTURE SCOPE

In the present project, Driverless Metro Train Shuttle between two station using LabVIEW has been successfully implemented. Real time monitoring and controlling of the proposed model is successfully done as expected. With the help of MPU6050 accelerometer, the speed of the metro train is modulated using PID and Station detection between shuttles is achieved with the help of IR Sensor automatically without presence of driver. If smoke is detected by the Smoke sensor (MQ2), then the train stops and the doors will open automatically along with alarm sound as an alert for the passengers.

In future, new features like seats not occupied information can be displayed or announcement is made to the passengers in the train. In case if any failure in the automatic system then with the help of Team Viewer the operator at the station can access the control of the system manually.

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