POWER EFFICIENT SYSTEM FOR AUTONOMOUS TRAM

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Abstract:
The concept of Autonomous tram is designed as automaticand self-sufficient system in energy production. This proposed system holds great potential for addressing transportation challenges in metropolitan cities. The system is specifically designed to operate automatically, eliminating the need for manual intervention. It harnesses solar energy as a free and renewable power source, utilizing solar panels to charge a rechargeable battery. This eco-friendly mode of transportation helps alleviate infrastructure congestion while minimizing environmental impact. The tram's destination is determined through sensor technology, enabling precise halts at designated points.End points are designed with tiny platforms, such that coach is accessible to the passengers. Control circuit is designed with 89c51 controller and it is programmed to run the time automatically when the bus is halted at platform
Key words: 89CC52 Micro-controller, 74573 Latch IC, Limit Switches, DC Motor, Rechargeable battery, IC 567

I. INTRODUCTION

A tram is a rail vehicle that travels on a tramway track on public roads in major cities. The tram lines operated as public transport are called tram ways and, in some places, it is also called as street cars. These are the light rail vehicles which run over a side of main roads and the same space can be utilized for normal traffic. In Calcutta (west Bengal) almost all main roads are equipped with these tram lines and they travel along with normal traffic. Tram vehicles are usually lighter and shorter than rapid transit trains or metro rails. These trams use electric power usually fed by a pantograph on overhead line. These trams can be used for transporting the goods also, but in general trams are used for public transportation.
Driverless systems applied to public transport may improve capacity, efficiency, safety and decrease the operational costs (lower operation personnel cost) and the road congestion. In particular, the autonomous buses and autonomous-rail rapid trams could be characterized by demand-driven schedules and therefore could potentially dynamically regulate their trajectory, capacity and stopping in accordance with user's demand. Several researches have shown positive feedback from passengers towards autonomous buses.
Lot of care must be taken while implementing it practically to avoid accidents. Many advanced economies all over the world implemented this type of automated transport systems to carry the passengers from airport to the central city, for this purpose separate tracks are laid over a side of road, these are called tram lines. In this regard to study the technology of automated transport systems and prove the concept practically, we decided to design a basic module of driverless tram which runs between the two reference points. The main intention of this project work is to run the tram without a human driver, to control the door automatically and to stop the tram automatically at stations, interrupt signals are generated through limit switches for the auto door mechanism and magnetic switches for the tram.

II. LITERATURE REVIEW

In the paper titled "Driver Assistance System for Trams: Smart Tram in Smart Cities " it is understood that mobility in smart cities is becoming smart, promoting on the one hand transport modes based on zero emission electrical technologies and on the other providing vehicles with technological solutions that support the drivers in driving operations. In the cities, more and more cars today are equipped with autonomous driving systems, based on Sensor Fusion Perception platforms, which aim to improve road safety and reduce accidents, to halve accidents in the shortest possible time. On the other hand, sustainability objectives also involve a shift towards the increasingly intensive use of zero-emission public transport, such as trams. Trams, unlike the other rail transport systems, use the same road infrastructure as cars, motorbikes, bikes, and pedestrians and will soon find themselves interacting with vehicles with increasingly higher autonomous driving levels. It is clear, therefore, that even for trams, the time is ripe to accommodate driving support systems. In this document, an overview is provided of the potential for the diffusion of advanced driver assistance systems by the automotive sector, in order to then evaluate their porting to trams, with the goal of increasing their level of safety and automation.

In the paper titled "Utilization of modern sensors in autonomous vehicles" states that the most significant goal for the entire society is the decrease the accident frequency and severity. According to predictions, traffic accidents would overtake all other causes of death to become the second leading cause of death in near future. As a result, enhancing road safety is must in metropolitan cities. Environmental sensors have the responsibility of giving detailed information about everything around the vehicle. The detecting angle, and the greatest distance of the detected object account for the different locations of environmental sensors. Radars used in Trams are responsible for detecting objects around the vehicle and also serve to detect dangerous situations. Object detection and detection of hazardous situations to alert or warn the driver can be used. If the Tram is at a higher level of autonomous control, it can interfere with the braking system or vehicle control. Radar systems are capable of detecting obstacles around the vehicle and their relative speed.

Problem Statement

In the next few decades, freight and passenger global mobility demand will grow mainly in urban areas. The main pressure is expected in the large metropolitan cities in countries, such as India, China, and America, causing a high impact both in terms of population and congestion. It also plays an important role in environmental damage as combustion vehicles tend to release unwanted gases. Thus, seeking a change in the transportation system.

Proposed Solution

A public transport network based on the electric carrier is undoubtedly the sustainable solution to which governments tend to use. In this paper we are suggesting a prototype with solar panels as energy source and is autonomous in nature to avoid the human intervention in the operation of the vehicle, as it is sustained to move in a predetermined track i.e., in a fixed path.

III. DESIGN AND WORKING METHODOLOGY

In this project work a motorized trolley type vehicle is constructed to simulate the tram and it runs over a little length of metal track laid over a wooden plank. DC motor accompanied with spur gear mechanism is used to run the simulated tram automatically according to the data acquired from the sensors. This trolley is having specially designed grooved metal wheels such that it will not deviate from the track. As described in the abstract, to identify the station, Hall Effect sensors are used and are attached to the moving mechanism chassis at its bottom side. The magnets must be arranged between the tracks at both ends of the destination points. Since it is a prototype model, small size magnets are used and are exposed for demo purpose, but for real time applications heavy magnets can be used and they can be buried under the ground to avoid human manipulation. Whenever the tram came to its destination point, the Hall Effect sensor arranged below the chassis of moving mechanism will be parallel to magnet by which it will be activated and the tram will be stopped at that point.

The entire system is designed to utilize free power source of solar energy, for this purpose 12v – 10W solar panel is used and it is arranged over the metal structure of moving mechanism. The solar panel used in the project work can deliver a maximum current of 0.8 amps under the bright Sun & this energy is used for charging the battery. For this purpose, high power rechargeable battery is used as source, which the system uses to drive the tram. One of the ways to utilize the solar energy is by generating electricity directly from the sunlight using photovoltaic conversion. Since photovoltaic modules have now become extensively available in the country. Solar energy has been regarded as an ideal energy source. The advancement in science and technology brought out by mankind had led to developments like the photovoltaic cell. Solar panels consist of several such P V Cells. The output of the Solar Panel is directly proportional to the intensity of incident radiation from the sun.

For demo purpose, small length of metal track will be laid over a wooden plank and 2 halting points are considered such that the tram moves between these two points continuously in shuttling manner. To prove this electrical, electronic, and mechanical component are used to construct the prototype and hence this subject is focused on the Mechatronics. The body of the tram is constructed with electro mechanical components and it is attached with four grooved metal wheels which are aligned with the track. Since it is a prototype module, the length of track is restricted to 3 feet. µC unit designed as central processing unit to control the tram movements over the track between two reference points. To simulate the tram, a small coach type body with automated gate is constructed and over which solar panel will be arranged as a roof top of moving mechanism. When the start button is activated, the coach moves further and reach one destination point and it will be stopped there automatically and door will be opened. Once the door is opened it remains in open condition for 30 seconds and after that gate will be closed automatically and travels in reverse direction to reach another reference point. Magnetic switches are used to detect the destination (where the tram must be stopped) points, for this purpose permanent magnets are used and are arranged at reference points.

The control circuit is designed with 89c51, since it is a self-controlled (Autonomous) tram it moves between two fixed reference points and at the reference point's permanent magnets are arranged. Whenever the tram reaches to the reference point, the magnetic switch (Hall Effect sensor) will be activated and based on this signal the controller stops the tram by disconnecting the supply to the motor through its drive circuit built with L293D motor driving IC. When the tram is halted at the reference point, automatically coach door will be opened through DC motor driven through H Bridge IC. To drive two motors independently, L293D chip is used. When the tram is halted at one reference point door will be opened and halting time will be displayed, as this time is specified as 30 seconds the display starts counting time in decrement mode and after 30 seconds the door will be closed and the tram travels in reverse direction to reach the other station. The process is repeated continuously until the power on switch is turned off or stop button is activated. During the waiting time at the reference point for acquiring passengers, alarm will be energized for alerting the passengers. Heavy-duty re-chargeable battery is used to provide supply to the entire system. The DC motors used to drive the door and tram is having built in type reduction gear mechanism and is driven by H – Bridge driver IC.

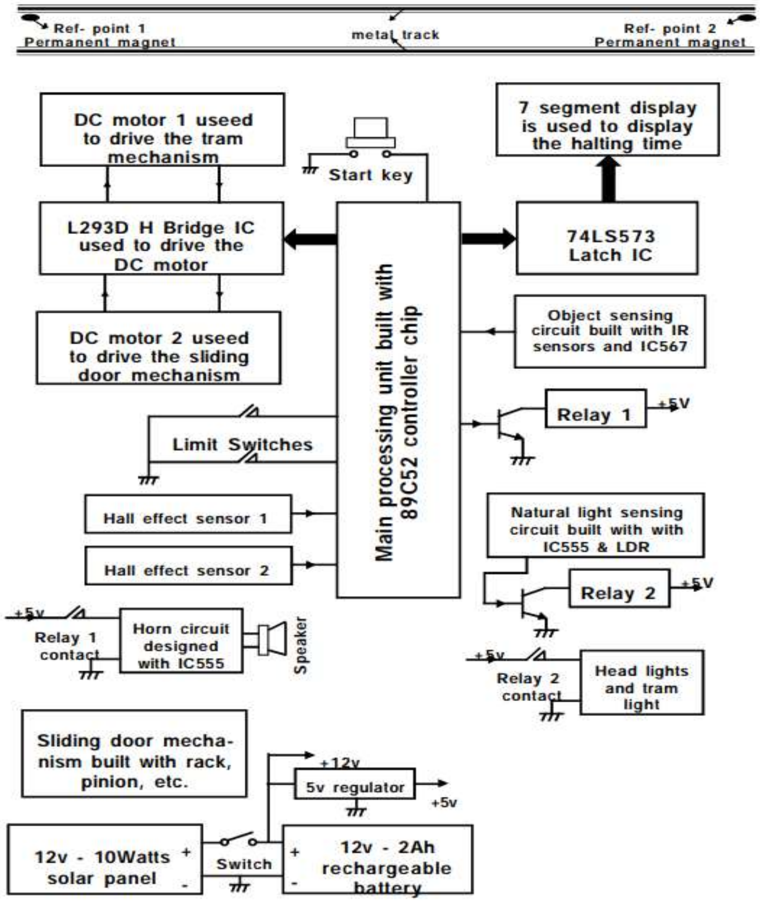

Fig 1. Block Diagram of Model

The controller used in the present project is ATMEL 89C51/52, and it is a 40-pin IC having 32 I/O lines. The ATMEL AT89C51 is a low power, higher performance CMOS 8-bit microcomputer which consists of 4K bytes of flash programmable and erasable read only memory (PEROM). Its high-density non-volatile memory compatible with standard MCS-51 instruction set makes it a powerful controller that provides highly flexible and cost-effective solution to control applications. Micro-controller works according to the program written in it.

The program is written in such a way, so that the Micro controller can read and it can store the information received from the sensing circuits. According to the received information, the Micro controller energizes the DC motors accordingly. Micro controller might consume 50 milli watts. A micro-controller has a dedicated input device and often (but not always) has a control data or LCD display for output. A micro-controller also takes input from the device it is controlling and controls the device by sending signals to different components in the device.

LDR and its Trigger Circuit Analysis

In the field of automation, particularly to control outdoor lights, street lights, head lights, etc, autonomously, natural light sensors are playing key roll to control these lights effectively. As described in the abstract LDR is used for detecting the Natural light intensity. Generally, for measuring the light intensity LDR's are preferred because of their wide variation in the resistance. In General, the light intensity is measured in Lux or Lumens, in some places it is measured in Foot candles too, Lux is the popularly known unit, and therefore the light measuring instrument is known as "LUX METER"

The LDR used in this project work is a very sensitive device, which converts the light energy into variable resistance, and the resistance of this LDR will vary according to the light intensity. As the light intensity increases thus making the resistance decrease. The amount of light falling on the surface of the light sensing device is to be converted into the proportionate DC level. A 10k resistor is connected in series with the LDR to form a potential dividing network. The output is taken from the midpoint, which is called as reference voltage and this voltage varies according to the light intensity. One end of the resistor is connected to the constant +5V DC source, the other end is connected to the LDR, from this point reference voltage is taken out. The other end of the LDR is connected to the ground. The output of the potential dividing network is fed to the 555 timer IC, which is configured in "MONOSTABLE" mode of operation.
In this circuit IC555 timer is used as Schmitt trigger mode of configuration. The resistance of the LDR will vary from minimum to maximum according to the natural light fallen on it. The dark resistance of the LDR will be more than 100KΩ and the light resistance will be less than 1KΩ. Hence, whenever light falls on the LDR, the resistance will come down and this makes a trigger signal to the IC 555 timer. Thereby the output of the timer becomes high and energizes the relay. During the night the resistance of the LDR will be very high by which the output of the timer remains in zero state, in turn de-energize the relay. At this condition by using normally closed contact of the relay streetlights are energized automatically.
This LDR is designed in association with IC 555 timer configured as 'SCHMITT TRIGGER' mode, sometimes it is called mono-stable mode. The IC 555 timer is a versatile IC, consists of two built in comparators, threshold at 1/3Vcc and 2/3Vcc. The 1/3 Vcc comparator is monitored at Pin No.2. The 2/3 Vcc comparator is monitored at pin.6. These pins are shorted and connected to the ground through the LDR. Thus, if pin no.2 voltage is less than 1/3Vcc, output of the IC becomes high, similarly, if the voltage is more than 2/3Vcc, output of the IC becomes zero i.e., whenever the natural light falls on the LDR, the resistance of the LDR will become less than 1K□ and makes the voltage at Pin no. 2 or 6 less than 1/3 Vcc, which in turn triggers the IC and energizes the relay. This relay contact is used to provide supply to the street lights. Once the LDR resistance becomes less than 1K, this in turn changes the state of internal comparator of 555 timer IC and the output of the IC to become high. This high output energizes the output transistor, which in turn energizes the relay. This relay contact is used in series with the street lights. When the relay remains in energized condition, due to the supply is provided through normally closed contact, and this contact gets opened automatically if the relay is energized, there by supply is disconnected.

Object Sensing with IR and IC567 Circuit Analysis

The next important circuit used in the project work is to detect the object present over the track, for this purpose IR sensors are used and are interfaced with IC567. This sensing circuit is installed at front side of the tram by which whenever the sensor is interrupted by the object, the tram will be stopped and siren will be energized automatically. Initially the process begins with IR (infrared) sensors and this circuit is constructed with IR signal transmitting (Tx) LED and IR signal detecting LED. The IR signal or IR energy radiated from the IR Tx LED will be transmitted in uni direction up to certain distance in the air. How long the IR energy can be transmitted is depends up on its energy transmitting power of IR led which can be measured in mill watts, means the voltage applied to the LED and its current consumption. Since it is a prototype module, low power IR LED is used for demonstration purpose. For real time applications high power LED's or laser guns can be used to detect the objects from long distance. Whenever the IR energy hits an object, some of the energy will be reflected, this reflected energy will be detected by IR sensor. The same principle is used here, whenever the IR energy hits a target, the IR beam will be interrupted, by which a logic low signal will be generated from the trigger circuit output. Based on this signal, the microcontroller unit built with 89C52 microcontroller chip energizes the relay and this relay contact is used to energize the siren or hooter circuit. The following is the circuit description.

The LM567 IC is a general-purpose tone decoder designed to provide a switch using saturated transistor to ground when an input signal is present within the pass band. The circuit consists of two-phase detectors i.e., Q and I detector that are driven by a oscillator which is voltage-controlled, which determines the centre frequency of the decoder.

As the IC is configured with a VCO internally, it will be generating the frequency which is depended on the R and C values that are connected to the fifth and sixth pins of the 567-tone decoder IC. Fifth pin is called as the timing resistor (RT) and sixth pin is called as the timing capacitor (CT). As the frequency is inversely proportional to R and C , by defining the RC network at the IC; the VCO (Voltage Controlled Oscillator) along with the Q-phase detector will be generating a particular frequency which will be coming out from the fifth pin of the tone decoder IC. The I-phase detector is used to decode or compare the received frequency with the generated frequency. The frequency produced by the tone decoder IC can be formulated as:

$$F=[1/(2\Pi RC)]$$

Looking at the pin configuration in the circuit diagram of the 567-tone decoder, third pin of the IC is connected to the IR receiver and fifth pin to the IR transmitter by using a transistor. In simple words it can be explained like, as the signal (frequency) generated by the IC will not be having good strength, the transistor is used for amplifying the signal and the amplified signal is fed to IR transmitting LED and in order to limit the current a 460 ohms resistor is connected. The IR is having features of a laser i.e., it almost travels in a straight line with minimum expansion and like laser light it is also a monochromatic light. Another important character of IR is that while the transmission is being done the IR transmitter and the IR receiver both should be in line of sight. The IR receiver is connected to the third pin, which is input pin of the IC. As the IR signal is transmitted into the free space and the IR receiver detects the signal. In the free space as lot of noise signals are present and the IR signal will be received with some noise signals. So, in order to eliminate the noise signals a capacitor is connected in between the third pin of the 567-tone decoder IC and IR receiver. And thus, the IR received signal is sent to the IC, which will compare the received frequency signal with generated frequency. The I-phase detector does the comparison and the output will be enabled when both the frequencies match i.e., transmitted frequency is equal to the received frequency. And if they do not match the output will not be enabled

IV. RESULTS

A. Object Detection

The below figure depicts Object detection using the Tone Decoder circuit

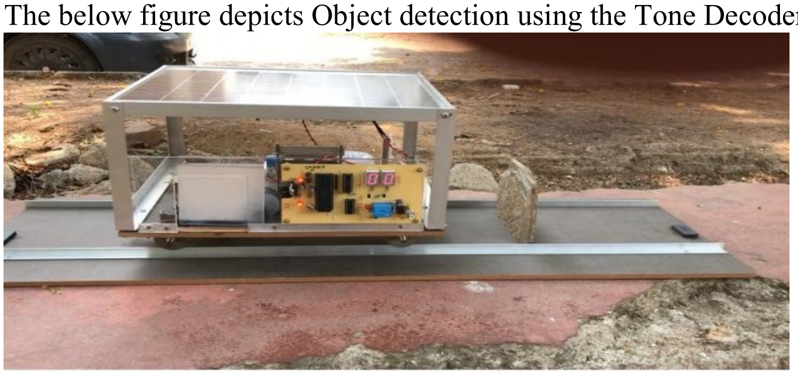

Fig 2. Tram stops as it identifies an object in its path.

B. End station detection using Hall Sensor

Detection of the end station is done based on the Hall sensor signal we tried to illustrate the departure and arrival of the tram across the track.

ISSN: 2278-4632
Vol-13, Issue-06, No.01,June : 2023

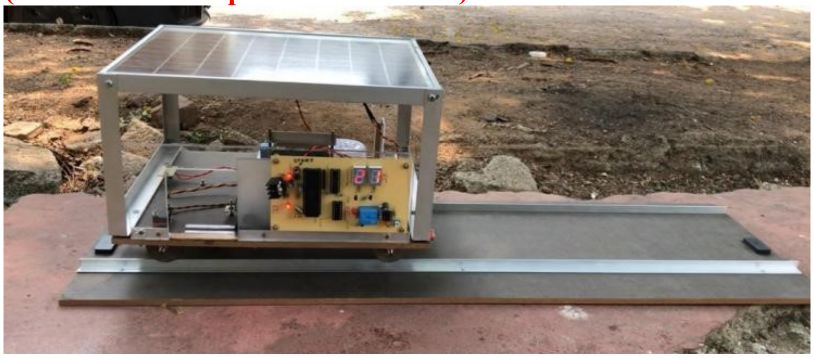

Fig 3. Tram starts its journey after 30s boarding time.

Fig 4. Tram automatically stops at the next station.

C. Light Detection Using LDR

The below image is used to demonstrate the LRD circuit working for automatically switching the light system in case of low light situations

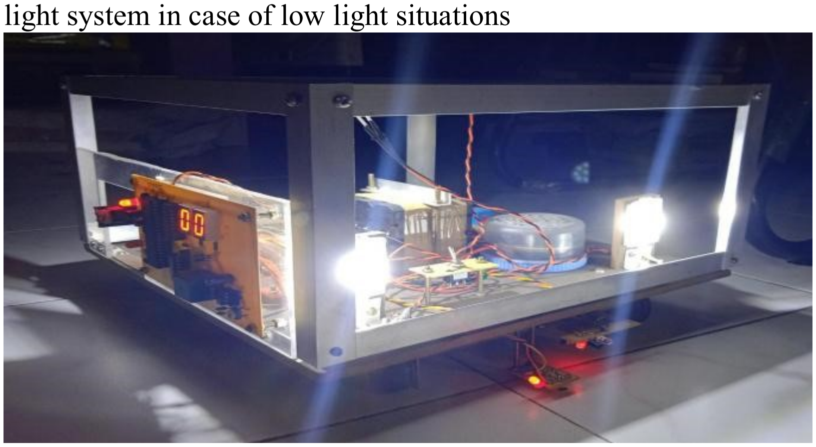

Fig 5. Low light levels trigger the activation of headlights

V. CONCLUSION

Smart trams have the potential to become an essential component of smart cities. With solar panels installed on the roofs of trams, energy can be harnessed from the sun to power the tram's electric motor, reducing reliance on non-renewable energy sources. The potential benefits of solar-powered trams include reduced carbon emissions, improved air quality, and cost savings from lower operating expenses. Special features like object sensing, auto stop, delivering horn sound automatically by sensing the objects, auto control of tram head lights, etc, are incorporated in the system to make it suitable for smart cities.

The proposed model is to run the tram between two points only, but by enhancing and implementing sophisticated technology, the system can be designed for multiple halts. Trams can also be equipped with sensors and communication technologies that allow them to interact with other vehicles and infrastructure, such as traffic signals, to optimize their routes and minimize congestion.

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