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DESIGN OF A MICROCONTROLLER BASED ECONOMIC MAGLEV GUIDEWAY SYSTEM

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Abstract: *Magnetic Levitation (Maglev) trains work in one of the two ways; both methods are based on same notion but involve different approaches. The first one, Electro Dynamic Suspension (EDS) technology uses inductrack. In this technology there are two active parts. One is the vehicle or compartments of a train; another is the stationery one or the guideway (Train path) of the vehicle. The main advantage of those two parts does not touch each other as magnetic force implies here. To establish this condition, power is needed to energize the vehicle and guideway. However, it is not possible to supply energy for huge length of guideway at a time as well as not economic. Thus a controlling of the energy supply to the guideway is needed without hampering the total Maglev system. So the power should be supplied where it is needed and it should be sensible to the movement of the vehicle. In this research, we have designed a power economic maglev guideway that focuses on power flow with a new position sensor which responses with the motion of the vehicle of Maglev.*

Keywords: Maglev Train, EMS, Inductrack, guideway;

1. INTRODUCTION

In our age of advanced materials and low-cost, high-speed computing, we have the ability to make magnetic levitation integral part of life. Magnetic actuation has the potential for numerous other applications. In addition to supporting loads or levitation, it can apply precision force, and move objects at precise distances without any contact between surfaces and essentially with no friction. This type of actuation can be used in harsh environments (corrosive, vacuum, etc.) where traditional mechanical or hydraulic actuators might not survive. A magnetic actuator can operate in ultra clean environments without the hazard of producing contaminants from its use. The main hindrance to the widespread application of magnetic levitation and other magnetically actuated systems is the complexity of the involved physics and the need for low-cost and effective control systems to operate the system and maintain stability.

The function of the magnetic levitation (Maglev) guideway is to transmit actions due to operation, environment influences and its own load into the subsoil. It supports the vehicles which are suspended on the guideway without contact. Functional components that enable the impelling, levitation and guidance with magnetic force are installed. Being controlled electronically, the levitation magnets, which are installed on both sides along the total vehicle, will keep the vehicle on the desired vertical distance over magnetic attractive forces. Guidance magnets will keep the vehicle horizontally non-contact with the guidance rails. The driving component is installed on the guideway in form of stator packs. This circumstance distinguishes the maglev guideway from those of all other traffic systems. Magnetism is a phenomenon that occurs when a moving charge exerts a force on other moving charges. The magnetic force caused by these moving charges sets up a field which in turn exerts a force on other moving charges. This magnetic field is found to be perpendicular to the velocity vector of the current. The force of the field diminishes with distance from the charge. There are different types of magnetism. Steel and iron are considered as magnetic material though all substances are affected by magnetism.

A problem arises when the track is too large, for example 200 km. In that case, it is not possible to supply power to the whole track. Even it is not efficient enough as the total track, especially the electrical section, constructed with solenoid or coil. This coil section is the main part of the guideway, though a control circuit is implement there to ensure and control various data upon which levitation react later. This control of power flow can be done by two ways-either active or passive. Active device will employed within the track along with stator coil. This active device may be composed of several sensing devices acting interactively to control the levitation. Another way is passive mode which involves several sensing device at outpost and communicate with some other communication medium (currently in TRANSPAID Railway System).

This paper focuses on the electrical section in the guideway of maglev system transportation. Total maglev system is similar to linear motor. So like linear motor it involves two main parts- one is stator and another is rotor. In maglev, the guideway is a stationary part. Thus electric power supply is needed to make this part turn into electromagnet. Unlike linear motor, guideway is not limited into little lengths i.e. few meters, rather it is theoretically expandable into any lengths. Maglev need electric power as electromagnet implies here instead of permanent magnet. But the major problem is enough power cannot be supplied to turn the electromagnet ON, if it concern with a long distance of length. So power should be supplied where it needs to turn the EM ON with necessary way. Thus a control system is needed to control the flow of power in the maglev guideway.

The rest of this paper is organized as follows. In section 2 we have presented selected literature reviews on magnetic levitation techniques. Section 3 and 4 describes Maglev guideway power flow mechanism and control unit respectively. Power calculation is presented in Section 5. Finally Section 6 concludes the paper.

2. LITERATURE REVIEW

Many research works are found which analyze the prospect and constraints of Maglev. General relations and limitations, pertinent to the design of an inductive magnetic suspension system are derived in [1]. M.L.Nagurka presents a summary of research designed to formulate analytical models of an electromagnetic suspension (EMS) maglev system to conduct computer simulation studies [2]. The authors in [3] say that, the maglev project is a study on the real world and train transportation system because many countries tag it as “greener”. There is a question about energy consumption. It uses superconductors. Once a superconductor is lowered to its critical temperature the point at which the material expel magnetic flux line and move round the conductor which is main reason of floating. The main remedies are superconductor is expensive as well as it has to be cooled for long time. In [4], design of dc servo motor position control system was developed based on the virtual instrument technology. The research objective was focused on the system configuration, PID controller, data acquisition and real time control procedures. The system was friendly, high precision and reliable.

Reference [5] described the analysis, design procedure and real time control of a maglev system. The main motive was to suspend a ball. A proportional derivative controller combined to a nonlinear controller is used. The author claimed that it makes the maglev system stable. Hyung-Woo Lee et al. reviewed and summarized Maglev train technologies from an electrical engineering point of view and incorporated the results of works over the past three decades carried out all over the world [6]. Maglev project of Dutch Government is described in details in [7] where guideway design was the main factor. It discusses the problem associated with guideway design and modeling of vehicle and guideway interactions. A preliminary study on effects on stability by relative position between the maglev vehicle and the guideway was made in [8] on the condition that the guideway was a single-span guideway. In that research, a vehicle-guideway-coupled model for double suspension magnets was introduced, and root locus analysis method was used to analyze the influence of the relative position between the maglev vehicle and the guideway. Feedback controller and a linear observer based levitation control design for super-speed magnetic levitation trains is presented in [9]. The configuration of the control system is presented, and its characteristics are analyzed theoretically and numerically.

3. MAGLEV GUIDEWAY POWER FLOW

This is a simple setup, illustrated in Fig. 1, in which Electromagnet (EM) core is placed with a simple IR sensor one after one. Each EM is connected with bus bar through a control unit and IR sensor connected with Control Unit (CU) to control the power flow to EM core. The guideway is the stationary part and the moving part of the vehicle is arranged with permanent magnet at the bottom. When a vehicle passes over the IR sensor, an electric signal is generated which makes the CU to activate the next EM core. After feeding the signal, the CU makes clearance to flow power to EM core. It is shown in Fig. 2. These processes happen sequentially.

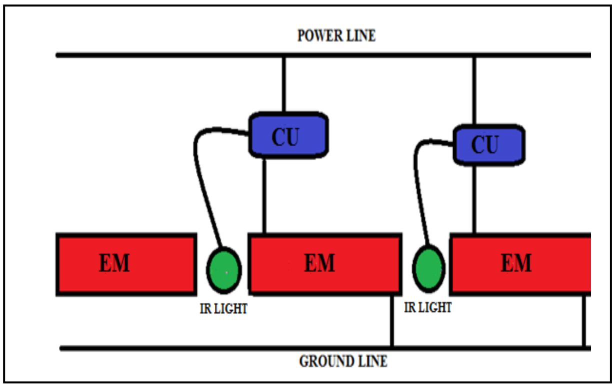

Fig 1: Sectional view of controlling mechanism

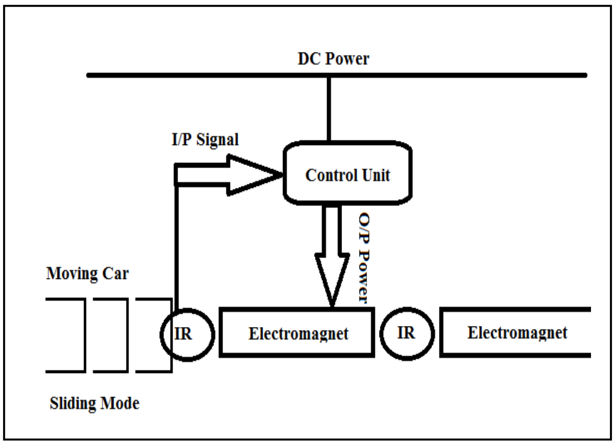

Fig 2: Block diagram of the system

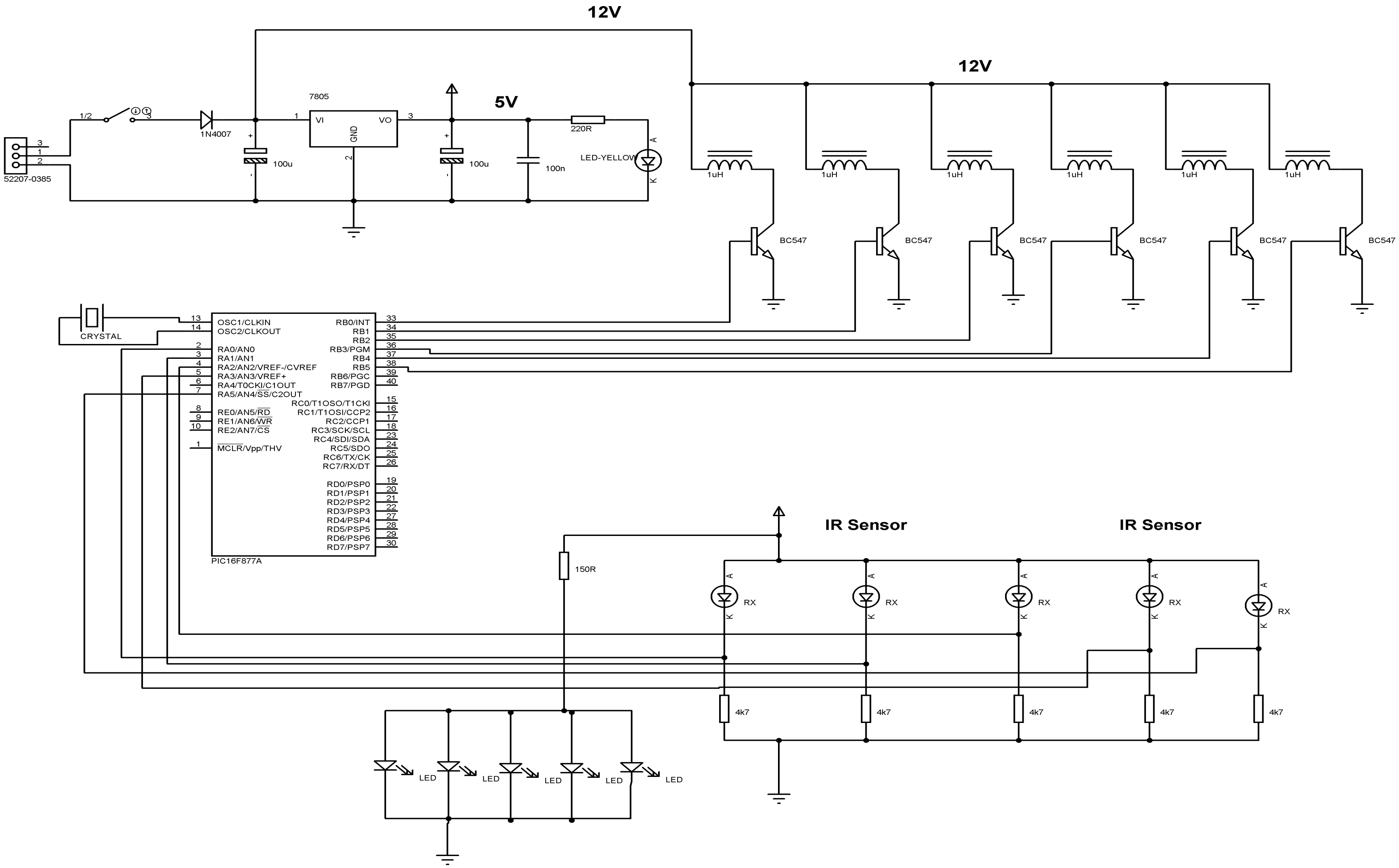

Fig 3: Circuit diagram of control unit

4. CIRCUIT FOR CONTROLLING

Control unit (Fig. 3) works based on discreet signal comes to microcontroller. When a mono signal generated from infrared light occurs, microcontroller gives another signal to the transistor for switching the circuit. Thus dc power flows through the electromagnet coil feeding from a 12volt dc source and creates strong magnetic field around the wire. Wire is wound around an electromagnet core (ferromagnetic material) to form strong magnetic field.

The circuit diagram is combination of three sections, namely Input or signal generation, Signal processing and Output section.

Input or signal generation-The main component of this section is Infrared light (IR) sensor. When vehicle move through, there is interruption occur between IR transmitter and IR received. Due to this interruption a mono signal generate and work as input signal to signal processing zone. Signal processing-PIC16F877A is a microcontroller, here working as signal processing zone. In this circuit microcontroller generate an output signal to a specific port (specific port is defined by microcontroller, programming) according to this signal. Output section-From output we have obtained necessary magnetic field from electromagnetic core. In normal condition EM core is connected with a 12 volt dc source via a npn transistor, but current does not follow because of incomplete circuit. When microcontroller feed a signal in it, it creates specific port signal. This output signal is the biasing voltage to the transistor connected with that port and thus transistor work as switch. So when signal generates transistor trip and complete the circuit of that port, resulting current follow through the EM core and we have obtained necessary magnetic field.

There are three types of bus as illustrated in Fig. 4

1. Signal bus (blue line)
2. Live bus (red line)
3. Ground (black line)

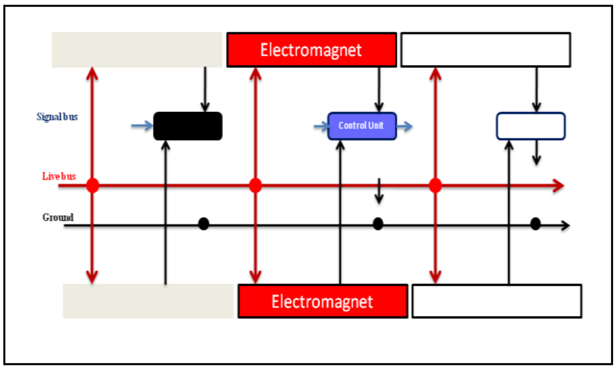

Fig 4: Diagram of Track controlling mechanism

Signal bus is used for controlling the track to energized simultaneously one after one without any manual control. control unit are connected between EM and ground thus it complete the circuit to follow current for establishing EM Same time it send a signal to another CU when next CU active to create EM ,previous section will inactive. A power source is provided to establish EM and for other necessary power requirement. Ground line is provided to complete the circuit.

5. POWER REQUIREMENT CALCULATION

From power equation,

$P = VI$

In our prototype design we have used the following values

$V_L = 12V$, $R = 387.5$ ohm, $L = 1u\ H = 10^{-6}$ H

$$V_L = L\left(\frac{di}{dt}\right),$$

$$I_L = \frac{V_L}{L} \int_{T0}^{T} dt$$

$$T_0 = 0$$

$$T = \frac{L}{R} = 10^{-6}/387.5$$

$$= 2.6x10^{-9}\ s$$

$$I_L = \frac{12}{10^{\wedge}-6} \int_0^{2.6x10^{\wedge}-9} dt \quad = \frac{12}{10^{\wedge}-6}\ [t]$$

$$= \frac{12}{10^{\wedge}-6}\ [T-T_0] = \frac{12}{10^{\wedge}-6} [2.6x10^{-9} - 0]$$

$$= 0.0312$$

Now $P = V_L I_L$ = 12* 0.0312= 0.3744 w.

Then

For our 1 feet track

power requirement is 6*0.3744 w =2.2464 w

Distance between Dhaka and Chittagong through railway is 258 kilometers.

So total power = 258000*3.28*2.2464 w

= 1900993.54 w

= 1900.9935 kW

So, power requirement is, 1900.9935 kW.

6. CONCLUSIONS

Magnetic levitation is very much demanding technology because Maglev is not only useful for railway transportation but also important in many other research areas such as rocket and missile propulsion. In this research we have worked with Maglev guideway system especially on electrical system in the guideway. In our approach instead of energize the whole guideway, power is provided to the selected portion of the guideway where it is needed. So the system is much more power saver. We have developed a microcontroller based control system and a position sensor to deliver the power to specific portion of the guideway. An estimate calculation of power requirement to energize Dhaka-Chittagong Railway track is also provided.

7. REFERENCES

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