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School of Engineering and Computer Science

BRAC University

Undergraduate Program

Bachelor of Science in Electrical and Electronic Engineering

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Project Report

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PROJECT TITLE

The PeopleMover Project

TEAM TITLE

The Electronics Group

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OLD DC MOTOR DRIVER

A dc motor driver was developed at the end of the previous semester. That was intended to be integrated with the electronic circuitry provided by **'The Control Systems Group'** which contains a microcontroller. The output of the microcontroller was to be given to the driver as the input. This process faced a problem. The driver takes a variable dc voltage as its input whereas the microcontroller gives a pulse width modulated voltage as its output. So, the integration could not be made. As a result, the driver becomes isolated from the project.

GENERAL DC MOTOR SPEED CONTROLLER (1, 2 and 3)

The diagram of the electronic circuit is shown in figure 1. Figure 1 is generated by a computer software called 'PSpice'. OA1A, OA2A, OA3A and OA4A are opamps. The part identification number of OA1A, OA2A and OA4A is LM324N. That of OA3A is HA17339A. These are actual numbers that may not match with the figure. OA1A and OA2A work as a basic unipolar triangle voltage generator. OA3A works as a comparator. OA4A works as a voltage follower. E_i represents the input of the circuit which is a dc voltage varying from 0V to 9V. V_o represents the output of it which is a pulse width modulated voltage with varying duty cycle. Its maximum value is 5V, minimum value is 0V and frequency is 1kHz. Figure 2 shows V_o theoretically when E_i = 5V. Figure 3 does the same thing when E_i = 7V. Both figures are generated by ‘PSpice’.

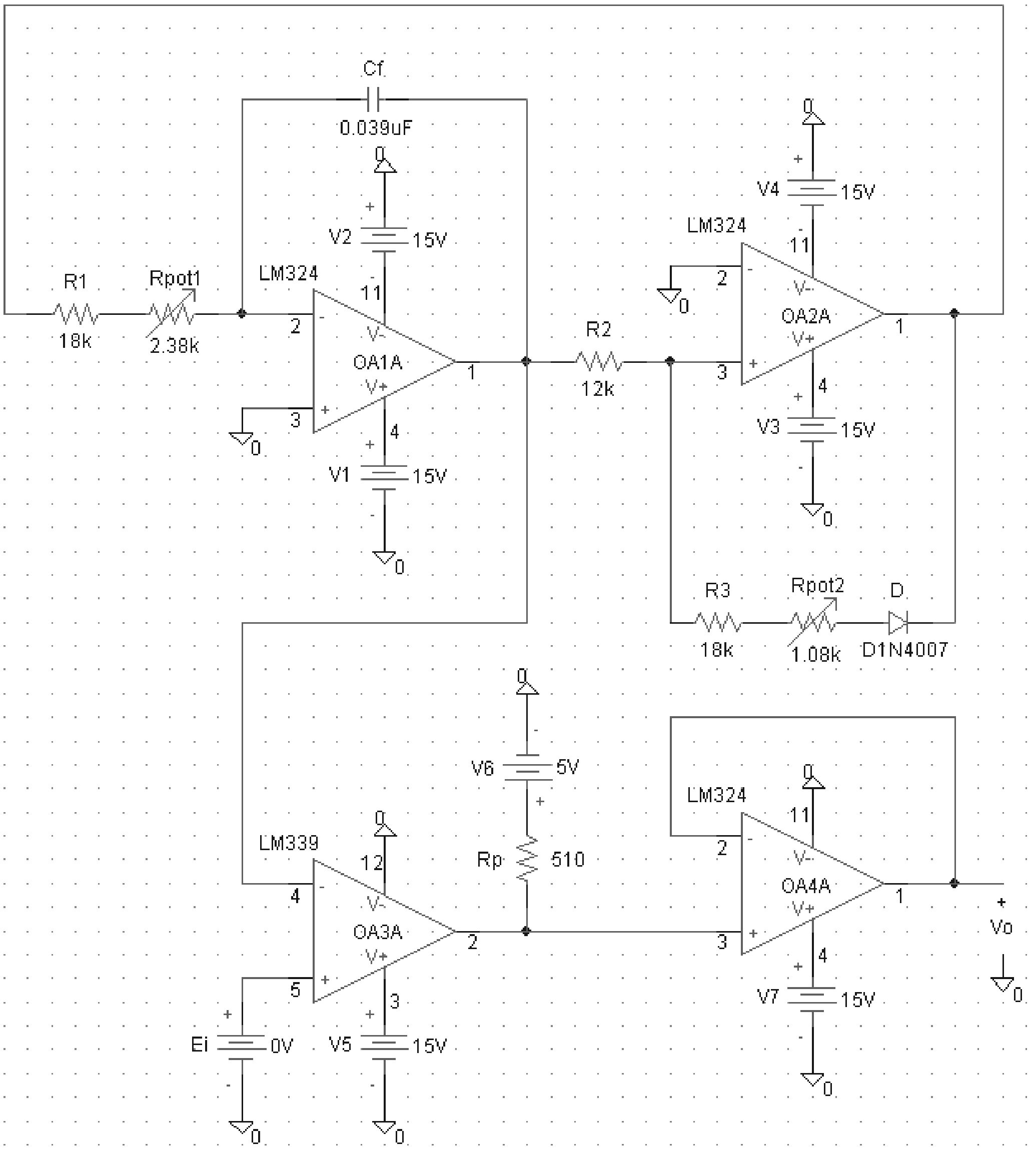


Figure 1

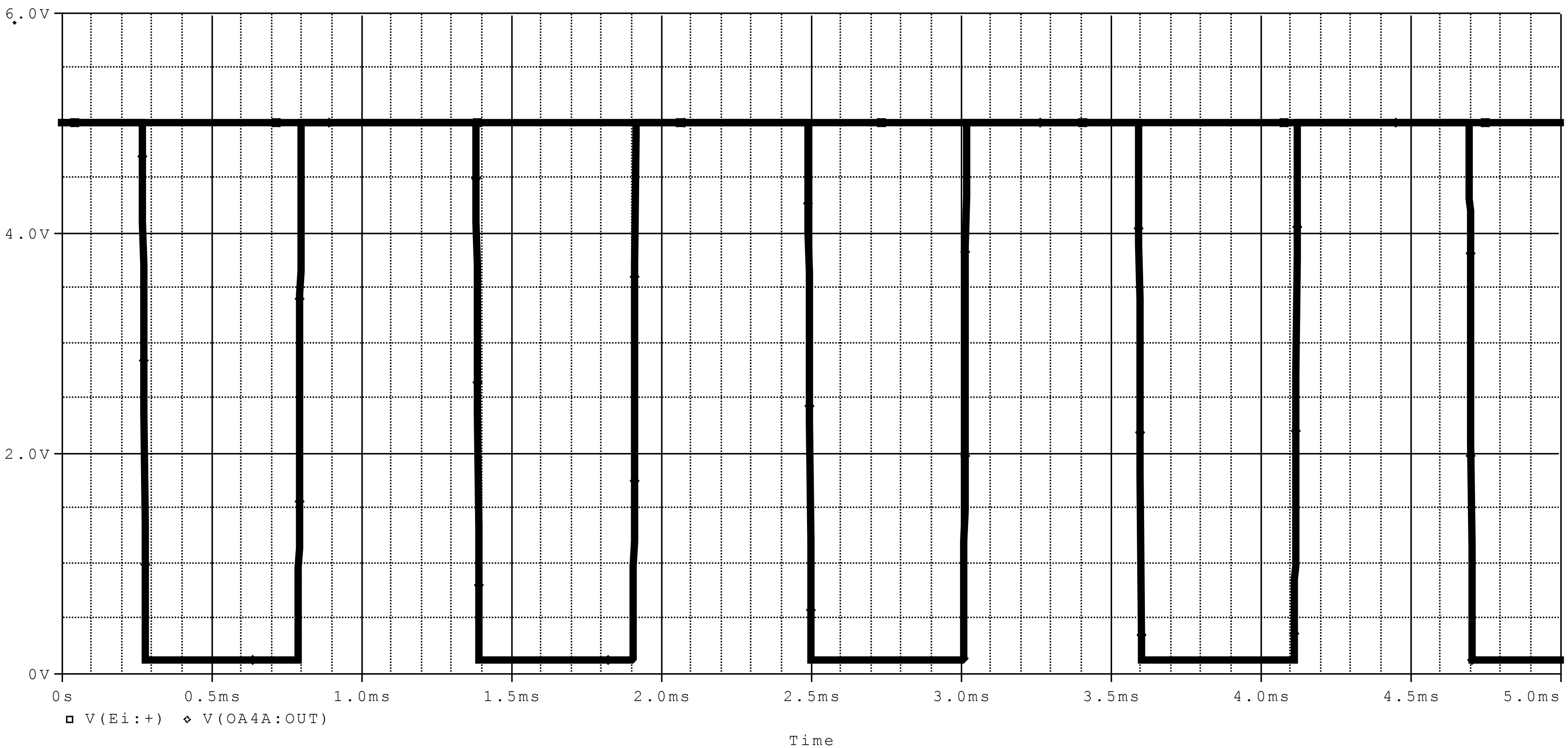

6.0V
4.0V
2.0V
0V
0s
0.5ms
1.0ms
1.5ms
2.0ms
2.5ms
3.0ms
3.5ms
4.0ms
4.5ms
5.0ms
V(Ei:+)
V(OA4A:OUT)
Time

Figure 2

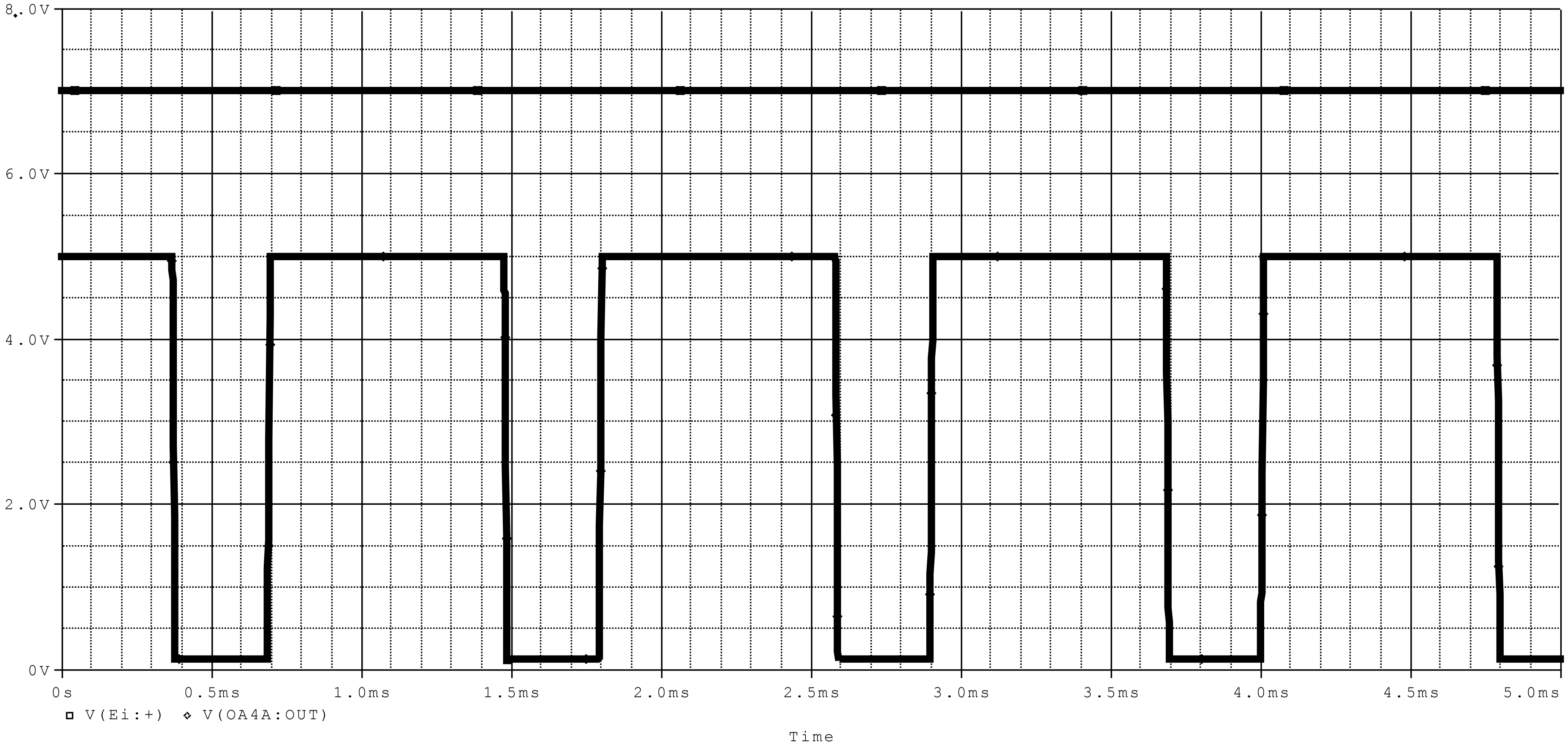

8.0V
6.0V
4.0V
2.0V
0V
0s
0.5ms
1.0ms
1.5ms
2.0ms
2.5ms
3.0ms
3.5ms
4.0ms
4.5ms
5.0ms
V(Ei:+)
V(OA4A:OUT)
Time

Figure 3

5V POWER SUPPLY (4)

The diagram of the electronic circuit is shown in figure 4.

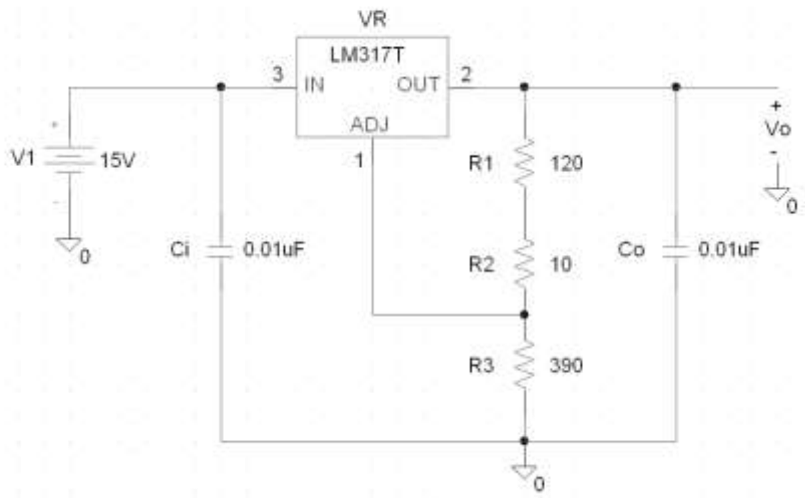


Figure 4

Figure 4 is generated by ‘PSpice’. VR is a voltage regulator. Its part identification number is LM317T. C_i and C_o are ceramic disc capacitors. The input of the circuit is a dc voltage of 15V. Its output is a dc voltage of 5V represented by V_o. Figure 5 shows V_o theoretically. It is generated by ‘PSpice’.

IMPROVED DC MOTOR SPEED CONTROLLER

It is the combination of the general dc motor speed controller and the 5V power supply. The diagram of the electronic circuit is shown in figure 6. Figure 6 is generated by ‘PSpice’. If figure 1 and figure 6 are compared, it will be found that the dc voltage source represented by V_6 in figure 1 is replaced by the 5V power supply in figure 6. Thus, the need for a source is avoided. The function of the two controllers is identical.

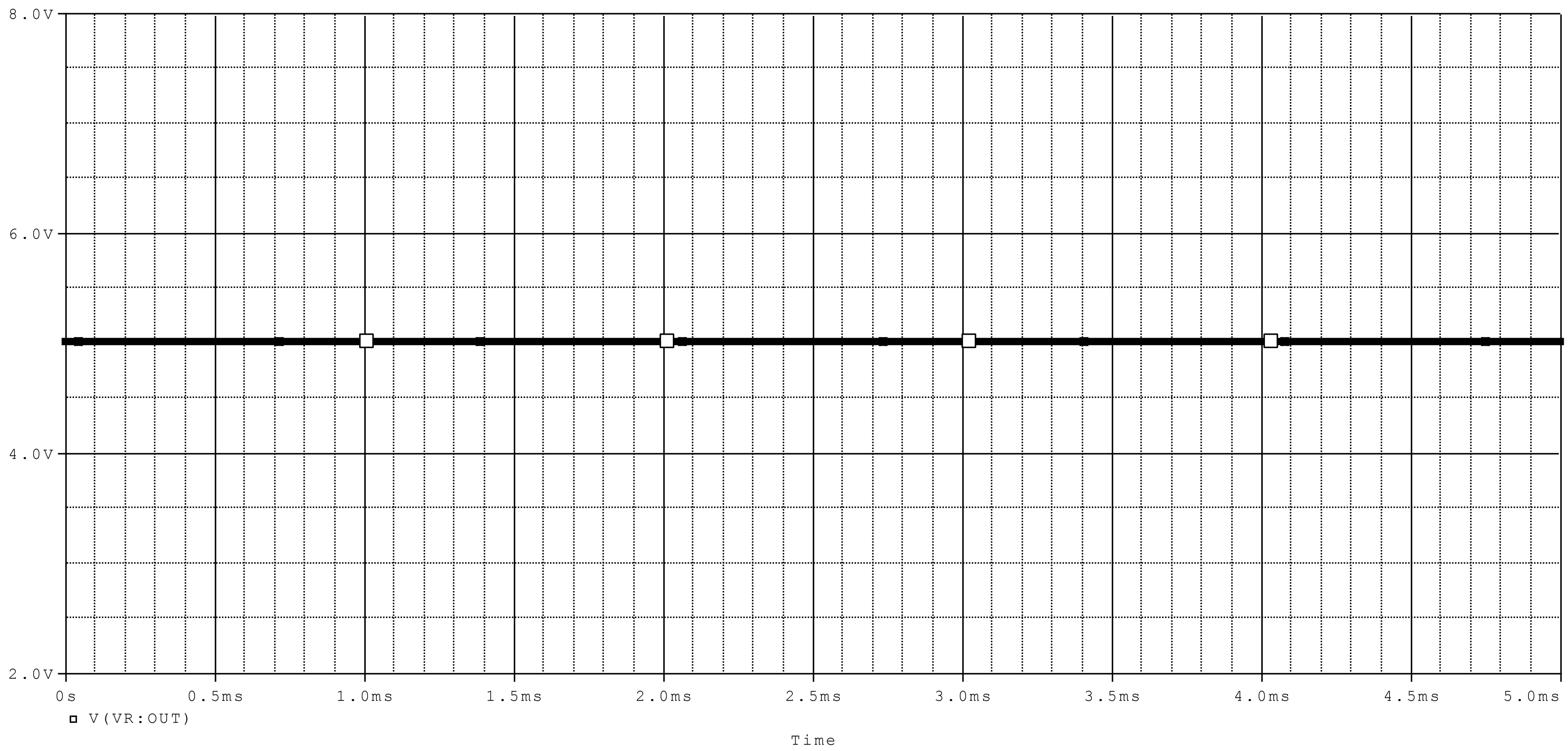

8.0V
6.0V
4.0V
2.0V
0s
0.5ms
1.0ms
1.5ms
2.0ms
2.5ms
3.0ms
3.5ms
4.0ms
4.5ms
5.0ms
V(VR:OUT)
Time

Figure 5

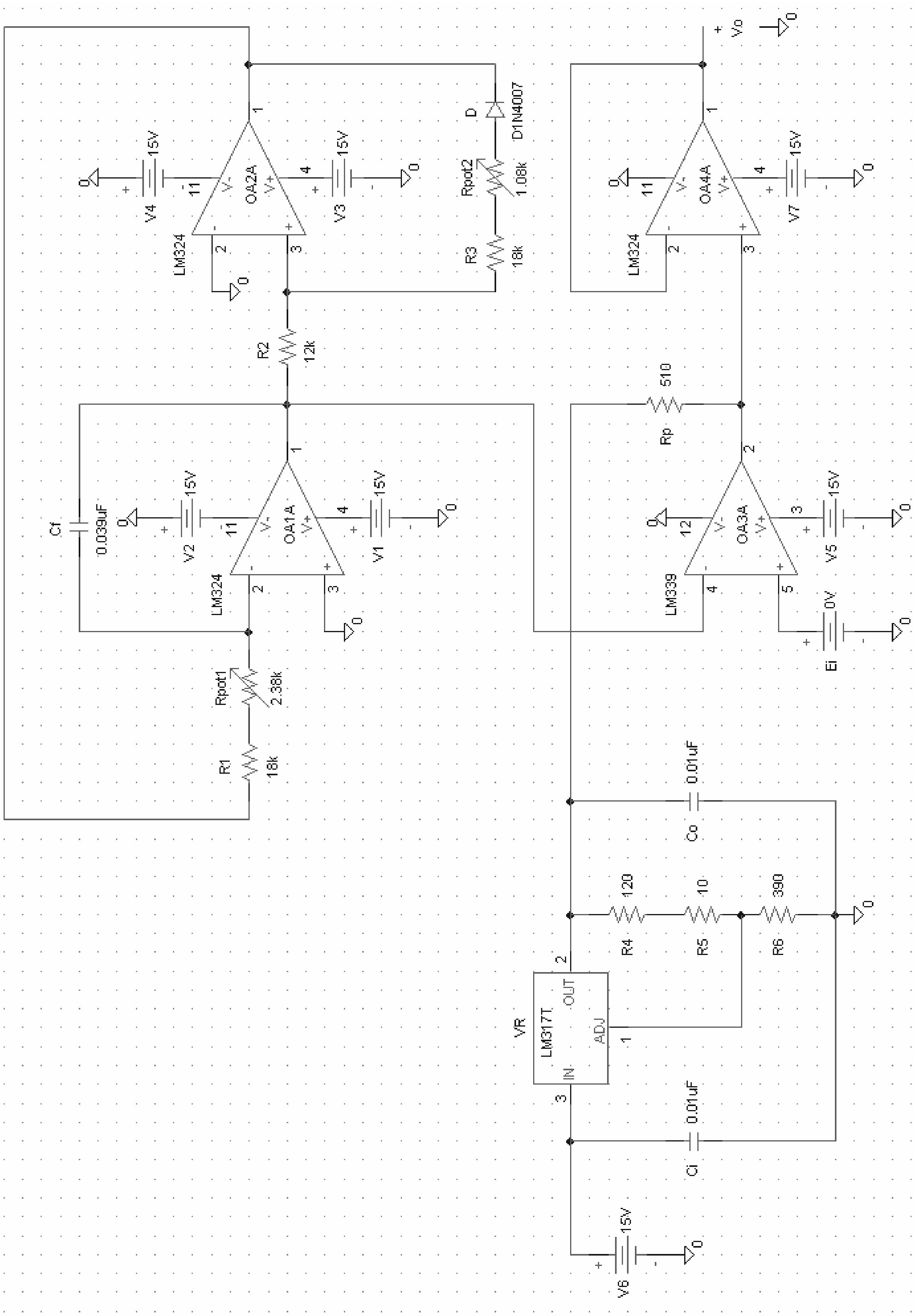

Cf
0.039uF
R1
18k
Rpot1
2.38k
LM324
OA1A
V1
V2
15V
R2
12k
R3
18k
Rpot2
1.08k
D
D1N4007
OA2A
V3
V4
Rp
510
LM339
OA3A
V5
Ei
0V
OA4A
V7
Vo
VR
LM317T
IN
OUT
ADJ
R4
120
R5
10
R6
390
Co
0.01uF
Ci
0.01uF
V6
15V

Figure 6

GENERAL DC MOTOR ROTATION CONTROLLER (2 and 3)

The diagram of the electronic circuit is shown in figure 7.

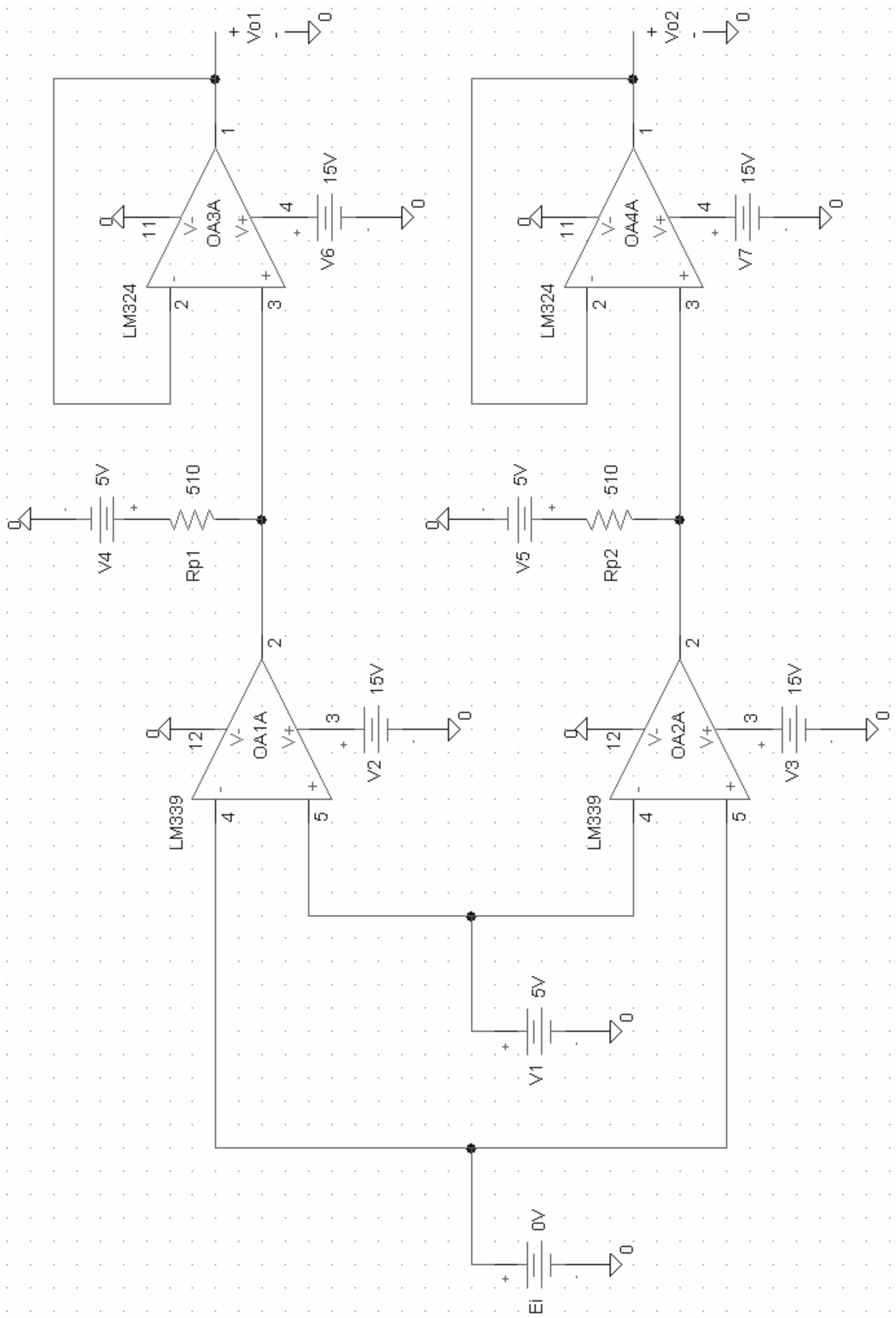


Figure 7

Figure 7 is generated by ‘PSpice’. OA1A, OA2A, OA3A and OA4A are opamps. The part identification number of OA1A and OA2A is HA17339A. That of OA3A and

OA4A is LM324N. These are actual numbers that may not match with the figure. OA1A and OA2A work as comparators. OA3A and OA4A work as voltage followers. E_i represents the input of the circuit which is a variable dc voltage. $V_{o,\,1}$ and $V_{o,\,2}$ represent the outputs of the circuit that are also dc voltages. When $E_i < 5V$, $V_{o,\,1} = 5V$ and $V_{o,\,2} = 0V$. This is shown by figure 8 theoretically where $E_i = 4V$. When $E_i > 5V$, $V_{o,\,1} = 0V$ and $V_{o,\,2} = 5V$. This is shown by figure 9 theoretically where $E_i = 6V$. Both figures are generated by ‘PSpice’.

IMPROVED DC MOTOR ROTATION CONTROLLER

It is the combination of the general dc motor rotation controller and the 5V power supply. The diagram of the electronic circuit is shown in figure 10. Figure 10 is generated by ‘PSpice’. If figure 7 and figure 10 are compared, it will be found that the dc voltage sources represented by V_1, V_4 and V_5 in figure 7 are replaced by the 5V power supply in figure 10. Thus, the need for a source is avoided. The function of the two controllers is identical.

9V POWER SUPPLY (4)

The diagram of the electronic circuit is shown in figure 11. Figure 11 is generated by ‘PSpice’. VR is a voltage regulator. Its part identification number is LM317T. C_i and C_o are ceramic disc capacitors. The input of the circuit is a dc voltage of 15V. Its output is a dc voltage of 9V represented by Vo. Figure 12 shows Vo theoretically. It is generated by ‘PSpice’.

NEW DC MOTOR DRIVER (5)

The block diagram of the electronic circuit is shown in figure 13. Figure 13 is generated by ‘PSpice’. IC is an integrated circuit whose part identification number is L293D. It has 16 pins. The output of the improved dc motor speed controller is

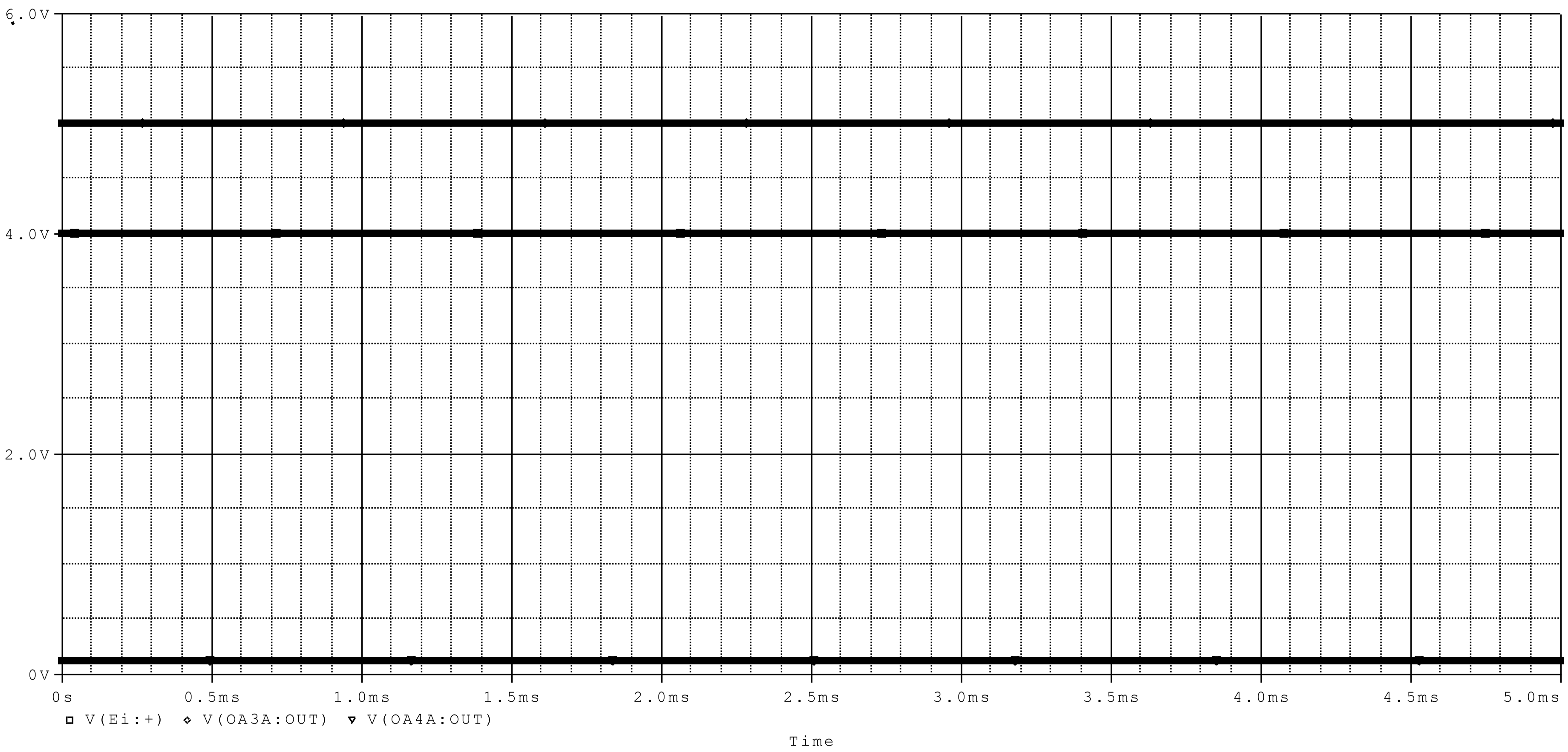

6.0V
4.0V
2.0V
0V
0s
0.5ms
1.0ms
1.5ms
2.0ms
2.5ms
3.0ms
3.5ms
4.0ms
4.5ms
5.0ms
V(Ei:+)
V(OA3A:OUT)
V(OA4A:OUT)
Time

Figure 8

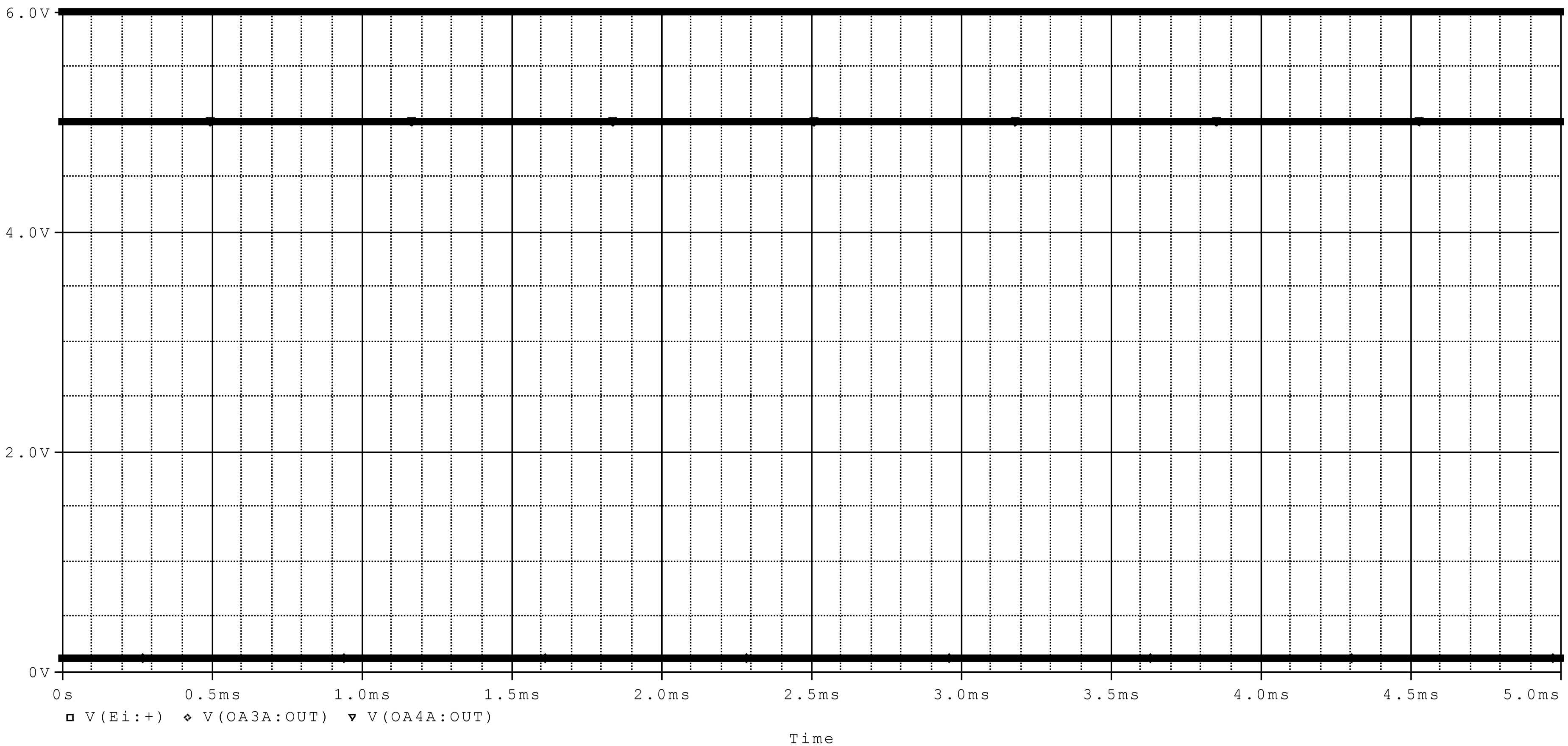
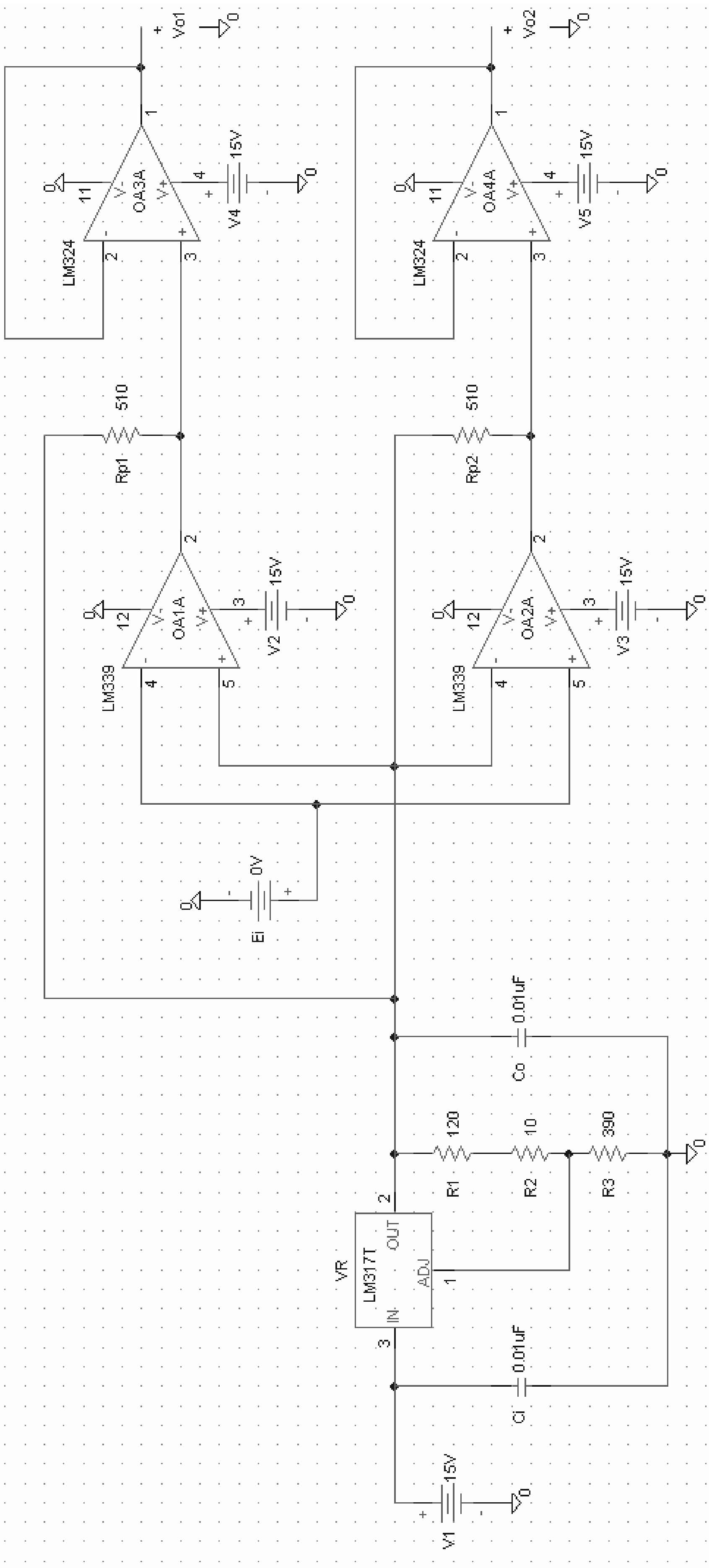

6.0V
4.0V
2.0V
0V
0s
0.5ms
1.0ms
1.5ms
2.0ms
2.5ms
3.0ms
3.5ms
4.0ms
4.5ms
5.0ms
V(Ei:+) V(OA3A:OUT) V(OA4A:OUT)
Time

Figure 9



V1
15V
Ci
0.01uF
VR
LM317T
IN
OUT
ADJ
R1
120
R2
10
R3
390
Co
0.01uF
Ei
0V
LM339
OA1A
OA2A
V2
V3
15V
Rp1
Rp2
510
LM324
OA3A
OA4A
V4
V5
Vo1
Vo2

Figure 10

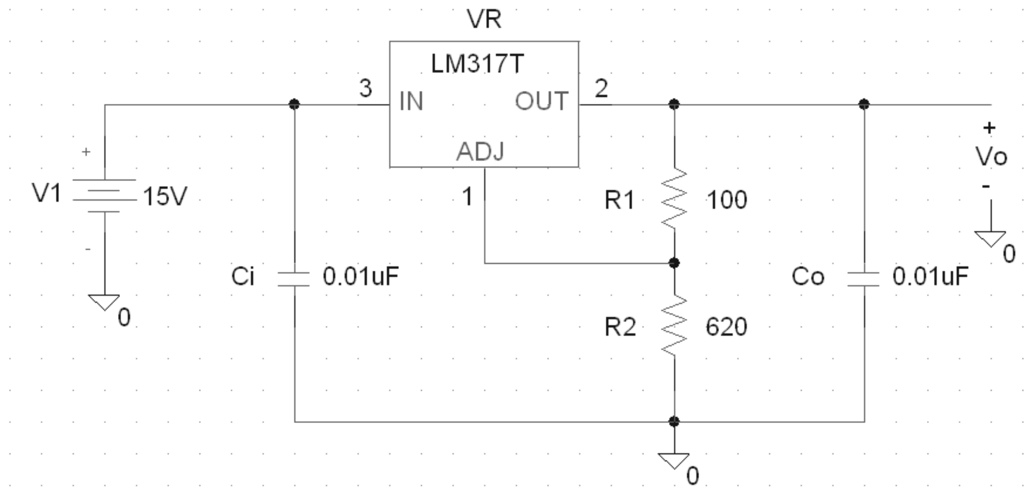
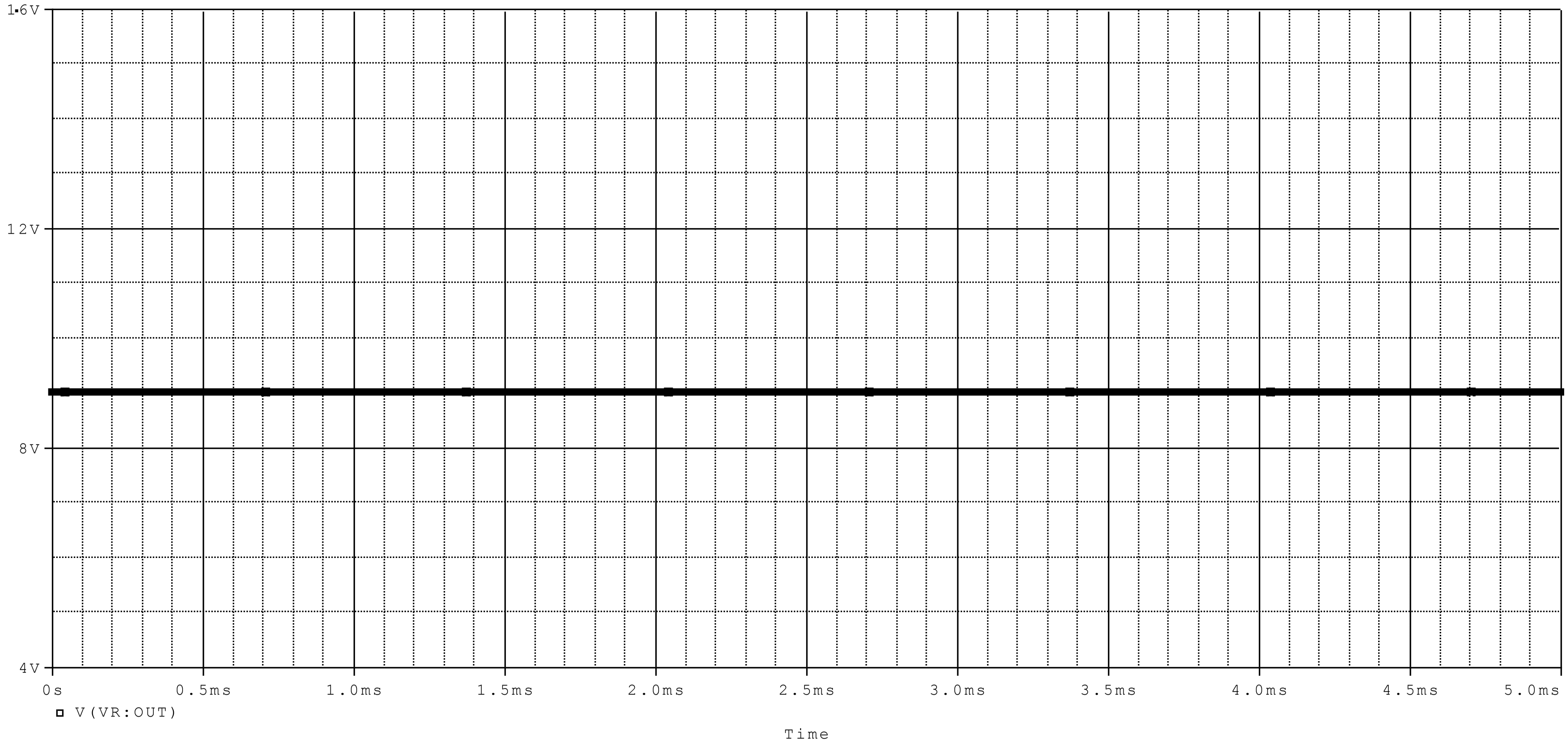


Figure 11

applied to the 1st pin of IC. The outputs of the improved dc motor rotation controller are $V_{o,1}$ and $V_{o,2}$. $V_{o,1}$ is applied to the 2nd pin and $V_{o,2}$ is applied to the 7th pin. The output of the 9V power supply is applied to the 8th pin. That of the 5V power supply is applied to the 16th pin. That of IC is represented by V_o which is a pulse width modulated voltage with varying duty cycle. Its maximum value is 9V, minimum value is 0V and frequency is 1kHz. The dc motor is connected to the 3rd pin and 6th pin of IC. It can tolerate up to a dc voltage of 9V. So, the 9V power supply is connected to IC.

When the input of the speed controller increases, the duty cycle of V_o increases. When it decreases, the duty cycle decreases. The speed of the motor's rotation increases when the duty cycle of V_o increases. It decreases when the duty cycle decreases. Thus, the train moves either fast or slowly. When the input of the rotation controller is less than 5V, V_o is positive. When it is greater than 5V, V_o is negative. The motor rotates in one direction when V_o is positive. It rotates in another direction when V_o is negative. Thus, the train moves either forward or backward.

The practical arrangement of the circuit is partially shown in figure 14. It is taken from a breadboard by a digital camera. Figure 15 and figure 16 show V_o practically when the input of the speed controller is 5V and 7V respectively. The input of the rotation controller is 4V for both cases. Figure 17 and figure 18 show V_o practically when the input of the speed controller is 5V and 7V respectively. The input of the rotation controller is 6V for both cases. The last four figures are taken form an



1•6V
12V
8V
4V
0s
0.5ms
1.0ms
1.5ms
2.0ms
2.5ms
3.0ms
3.5ms
4.0ms
4.5ms
5.0ms
V(VR:OUT)
Time

Figure 12

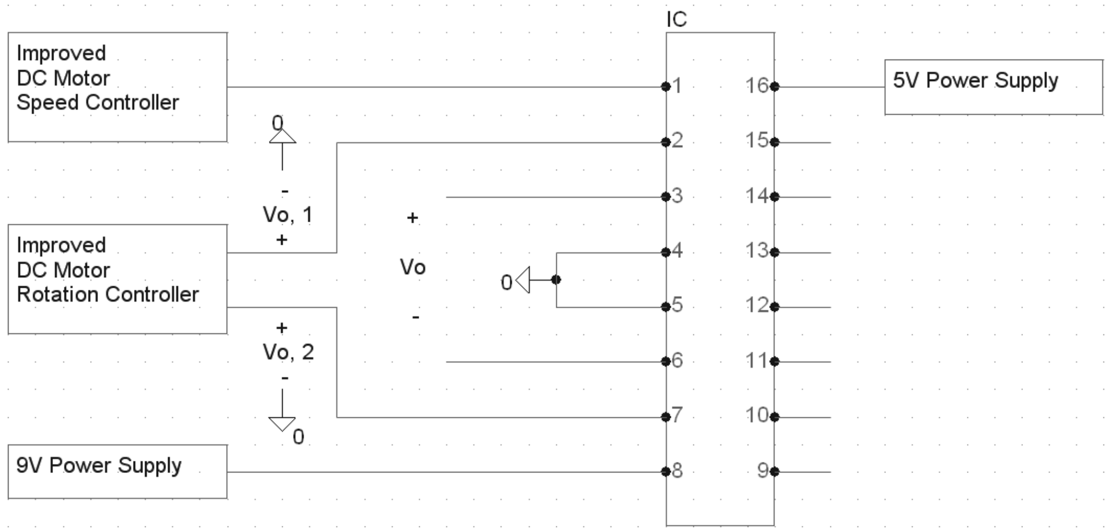


Figure 13

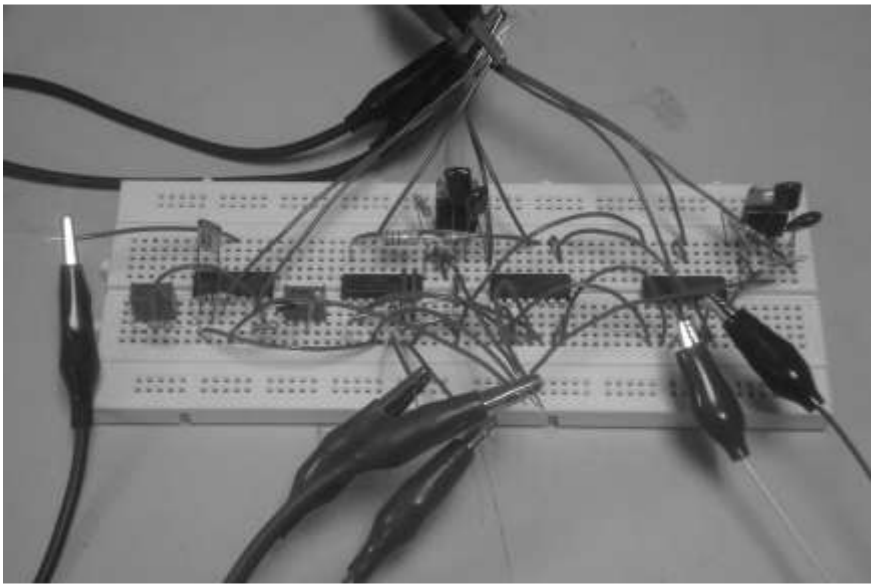


Figure 14

oscilloscope by the digital camera.

Unfortunately, a problem is associated with this driver. It performs well when the motor is not connected with it. When the motor is connected, the motor does not rotate. As a result, the train does not move. It is found that the motor get a very little amount of voltage when it is connected with the driver. The reason behind it may be that the internal resistance of the driver is pretty high. The motor draws dc current. When it does that, most of the voltage gets dropped across that resistance. Due to this difficulty, the driver cannot be used in the project. Besides, similar driver is developed successfully by **'The Control Systems Group'**. Therefore, no further research is done on this matter.

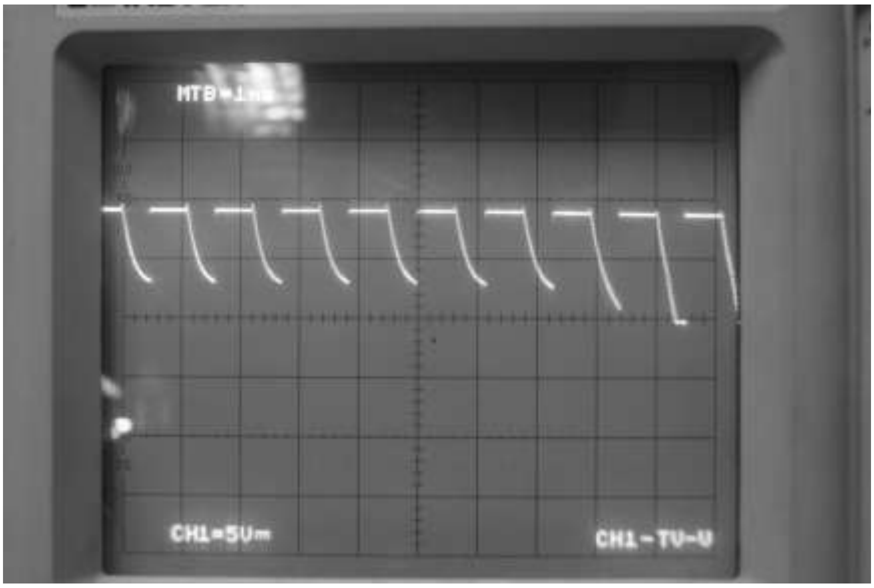


Figure 15

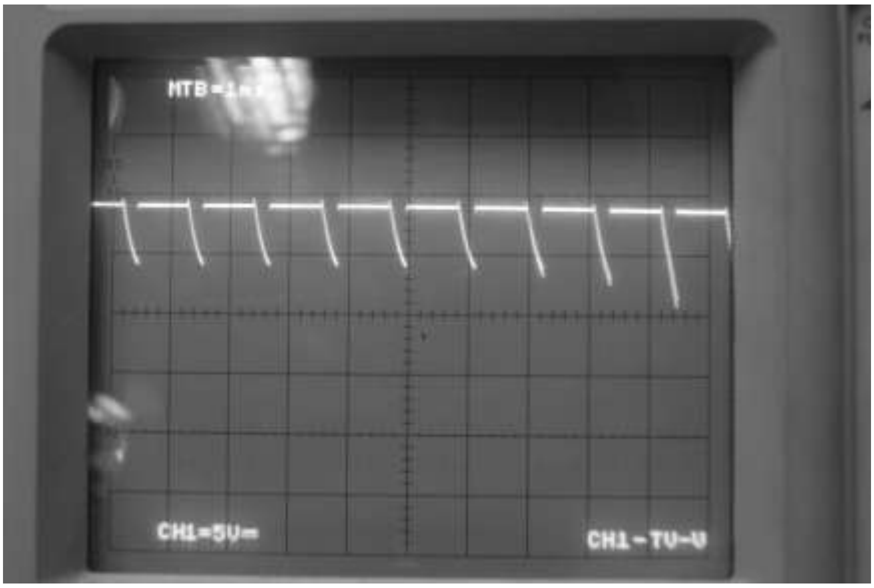


Figure 16

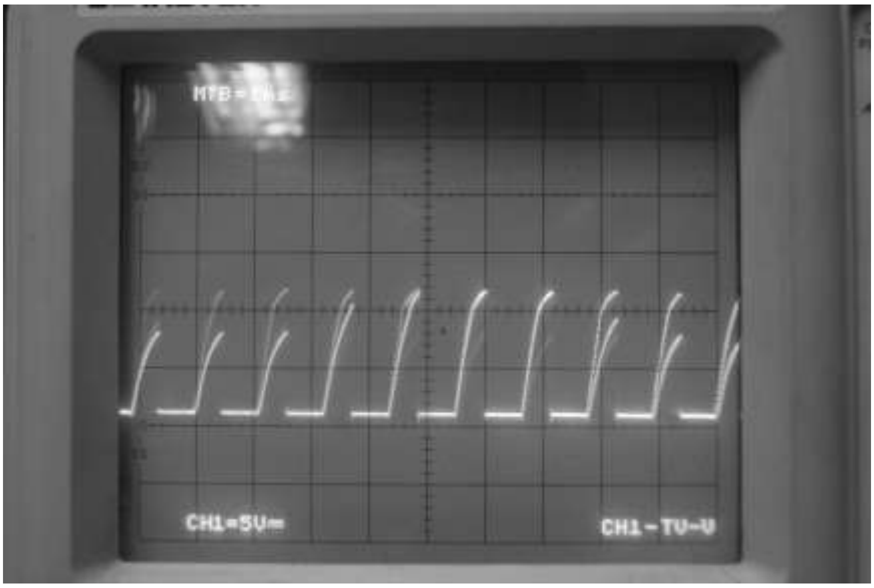


Figure 17

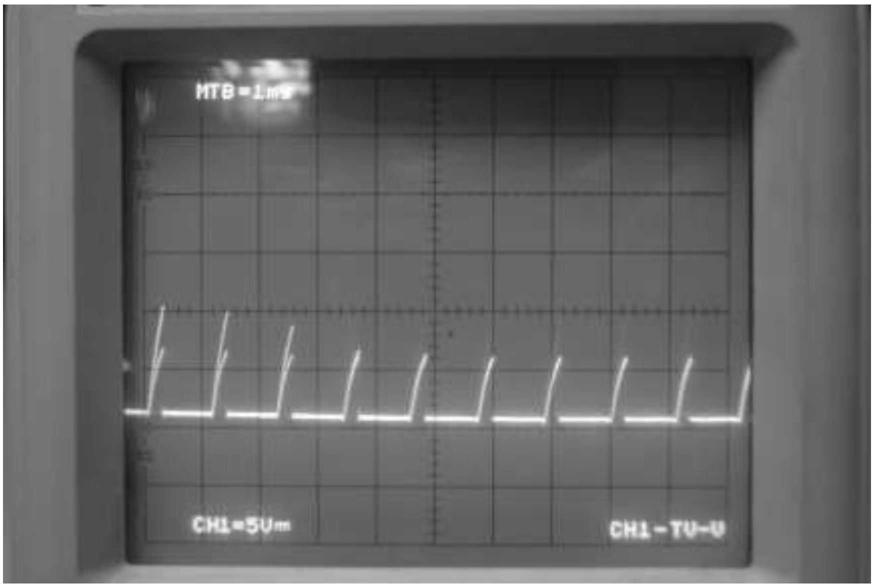


Figure 18

INTERFACE BETWEEN DIFFERENT PARTS OF THE PROJECT

At present, the telecommunications part has two electronic circuits. They are a transmitter and a receiver. The control systems part has a microcontroller and an integrated circuit. The electronics part has one circuit which is a feedback circuit. Here, the receiver, the microcontroller and the integrated circuit are taken into consideration. They work with the dc motor in a way which is shown in figure 19 by a block diagram.

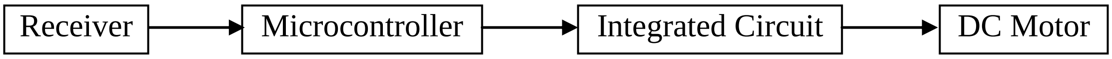


Figure 19

The communication between two blocks is done by a signal. The direction of the signal is represented by an arrow sign. Here, the speed control aspect of the motor is considered only. The term ‘speed’ means rotational speed. The motor should rotate in two speeds called high speed and low speed. For this purpose, the motor should get two dc voltages called high voltage and low voltage. The high voltage corresponds to 7V and it gives rise to the high speed. The low voltage corresponds to 5V and it gives rise to the low speed. The output of the integrated circuit is a pulse width modulated voltage with varying duty cycle. Its maximum value is 9V, minimum value is 0V and frequency is 1kHz. In this case, the motor does not understand that it gets the pulse width modulated voltage. It considers the average value of the voltage as the dc voltage. The output of the microcontroller is another pulse width modulated voltage with varying duty cycle. Its maximum value is 4.70V, minimum value is 0V and frequency is 1kHz. The duty cycles of the two pulse width modulated voltages at a particular moment are the same. The output of the receiver is a dc voltage. It is equal to the average value of the output of the microcontroller.

The average value of any pulse width modulated voltage can be found by the following formula.

$$V_{ave} = V_{max}D$$

Here, the average value is represented by V_{ave}, the maximum value is represented by V_{max} and the duty cycle is represented by D.

The case to be considered next is the one where the motor should rotate in the high speed. So, it should get the high voltage i.e. 7V. Then, the average value of the output of the integrated circuit should be 7V.

Now, $V_{ave} = V_{max}D$

Or, $7 = 9D$

Or, $D = 0.7778$

So, the duty cycle of the output of the microcontroller should be 0.7778.

Now, $V_{ave} = V_{max}D$

$= 4.70 \times 0.7778$

$= 3.66V$

Therefore, the output of the receiver should be 3.66V.

The case to be considered next is the one where the motor should rotate in the low speed. So, it should get the low voltage i.e. 5V. Then, the average value of the output of the integrated circuit should be 5V.

Now, $V_{ave} = V_{max}D$

Or, $5 = 9D$

Or, $D = 0.5556$

So, the duty cycle of the output of the microcontroller should be 0.5556.

Now, $V_{ave} = V_{max}D$

$= 4.70 \times 0.5556$

$= 2.61V$

Therefore, the output of the receiver should be 2.61V.

DIAMETER OF THE PRIMARY PAIR OF WHEELS OF THE TRAIN

The train has three pairs of wheels. One of them is primary and the rest are secondary. Here, the term ‘primary pair of wheels’ means that the pair of wheels is connected to the dc motor by means of a set of gears and the term 'secondary pair of wheels' means that the pair of wheels is free from any connection to the motor. The diameter of the primary pair is determined by a vernier caliper. The two wheels of the pair are very similar. So, their diameters are very close to each other. A total of four readings are taken to calculate the diameter. Among them, two are from one wheel and the remaining two are from the other wheel. A few of the resulting data are mentioned below and the rest are incorporated in table 1. In the table, the reading of main scale is represented by MSR, the number of divisions from the starting mark to a mark on the vernier scale that matches with a mark on the main scale is represented by N, the reading of vernier scale is represented by VSR, the apparent diameter is represented by AD and the actual diameter is represented by D which is the arithmetic mean of the four apparent diameters.

Length of the Smallest Division of Main Scale, L = 1mm

= 0.0010m

Total Number of Divisions of Vernier Scale, T = 20

Vernier Constant, VC = $\frac{L}{T}$

= $\frac{0.0010}{20}$

= 0.00005m

Mechanical Error, ME = 0m

MSR **m**	**N**	**VSR = VC × N** **m**	**AD = MSR + VSR – ME** **m**	**D** **m**
0.0290	19	0.00095	0.02995	0.0301
0.0300	4	0.00020	0.03020	
0.0300	5	0.00025	0.03025	
0.0290	20	0.00100	0.03000	

Table 1

Therefore, the diameter is 0.0301m.

SPEED-VOLTAGE PROFILE OF THE TRAIN

When a certain dc voltage is applied to the dc motor of the train, the primary pair of wheels starts rotating in a specific rotational speed. To measure the speed, a distance is fixed at first. Then, the circumference of the wheels is calculated. After that, the number of rotations needed for the wheels to travel the distance is found out. Next, the train is let to travel the distance and the duration of the journey is taken. Finally, the speed is obtained.

The train runs on tracks. A track can be a straight one or it can be a curved one. For this purpose, straight tracks are used because measuring their length is easy. It can be done with a tape. The distance is marked on the tracks. The duration can be recorded by a stop watch. A few of the resulting data are mentioned below.

Distance, D_1 = 203cm
= 2.0300m

The circumference can be calculated by the following formula.

$C = \pi D_2$

Here, the circumference is represented by C. π represents a constant. Its value is 3.1416 up to four decimal places. The diameter of the wheels is represented by D_2. It is 0.0301m.

Now, $C = \pi D_2$
$= 3.1416 \times 0.0301$
= 0.0946m

Number of Rotations, $N = \frac{D_1}{C}$

$= \frac{2.0300}{0.0946}$

$= 21.4588$

Here, two cases are considered. In one case, the engine is taken alone. In the other case, the engine is taken along with three wagons. In both cases, different voltages are taken. Three readings are taken to measure the speed for each voltage. Data for the first case are incorporated in table 2. Those for the second case are incorporated in table 3. In these tables, the voltage is represented by V_{dc}, the time is represented by T, the apparent speed is represented by ARS and the actual speed is represented by S_r which is the arithmetic mean of three apparent speeds.

V_{dc} V	T s	$ARS = \frac{60N}{T}$ rpm	S_r rpm
2.50	25.458	50.5746	50.4051
	25.435	50.6203	
	25.740	50.0205	
3	21.964	58.6199	59.4767
	21.618	59.5581	
	21.369	60.2521	
3.50	18.276	70.4491	70.5261
	18.480	69.6714	
	18.018	71.4579	
4	15.456	83.3028	82.6947
	15.706	81.9768	
	15.549	82.8046	

Table 2

V_{dc} V	T s	ARS = $\frac{60N}{T}$ rpm	S_r rpm
4.50	14.118	91.1976	90.7938
	14.173	90.8437	
	14.252	90.3402	
5	12.816	100.4625	99.9937
	12.863	100.0955	
	12.950	99.4230	
5.50	11.640	110.6124	110.4098
	11.524	111.7258	
	11.824	108.8911	
6	10.578	121.7175	120.5149
	10.800	119.2156	
	10.675	120.6115	
6.50	9.636	133.6164	131.5495
	9.895	130.1191	
	9.835	130.9129	
7	9.212	139.7664	141.0962
	9.050	142.2683	
	9.115	141.2538	
7.50	8.584	149.9916	147.3027
	8.667	148.5552	
	8.981	143.3613	
8	8.086	159.2293	158.9753
	8.201	156.9965	
	8.012	160.7000	
8.50	7.560	170.3079	171.6884
	7.421	173.4979	
	7.518	171.2594	

Table 2 (Continued)

V_{dc} V	T s	ARS = $\frac{60N}{T}$ rpm	S_r rpm
9	7.089	181.6234	182.5033
	7.070	182.1115	
	7.006	183.7751	

Table 2 (Continued)

V_{dc} V	T s	ARS = $\frac{60N}{T}$ rpm	S_r rpm
2.50	35.007	36.7792	36.3507
	36.863	34.9274	
	34.476	37.3456	
3	26.935	47.8013	47.0321
	27.226	47.2904	
	27.987	46.0045	
3.50	22.449	57.3535	57.7308
	22.320	57.6849	
	22.140	58.1539	
4	18.996	67.7789	68.1605
	18.881	68.1917	
	18.793	68.5110	
4.50	16.661	77.2780	77.7544
	16.403	78.4934	
	16.615	77.4919	
5	14.741	87.3433	87.3232
	14.916	86.3186	
	14.580	88.3078	

Table 3

V_{dc} V	T s	$ARS = \frac{60N}{T}$ rpm	S_r rpm
5.50	13.970	92.1638	92.8198
	13.790	93.3668	
	13.855	92.9288	
6	12.807	100.5331	100.8830
	12.752	100.9668	
	12.729	101.1492	
6.50	11.524	111.7258	111.1616
	11.635	110.6599	
	11.589	111.0991	
7	10.592	121.5566	119.7616
	10.860	118.5569	
	10.804	119.1714	
7.50	9.950	129.3998	132.5476
	9.401	136.9565	
	9.807	131.2866	
8	8.921	144.3255	144.8059
	8.930	144.1801	
	8.824	145.9121	
8.50	8.238	156.2913	155.5091
	8.261	155.8562	
	8.340	154.3799	
9	7.726	166.6487	164.9914
	7.850	164.0163	
	7.836	164.3093	

Table 3 (Continued)

Using the data of table 2 and table 3, two graphs are plotted that are shown in figure 20 and figure 21 respectively. In each graph, the actual curve along with a straight line found by curve fitting method is displayed. Both figures are generated by a

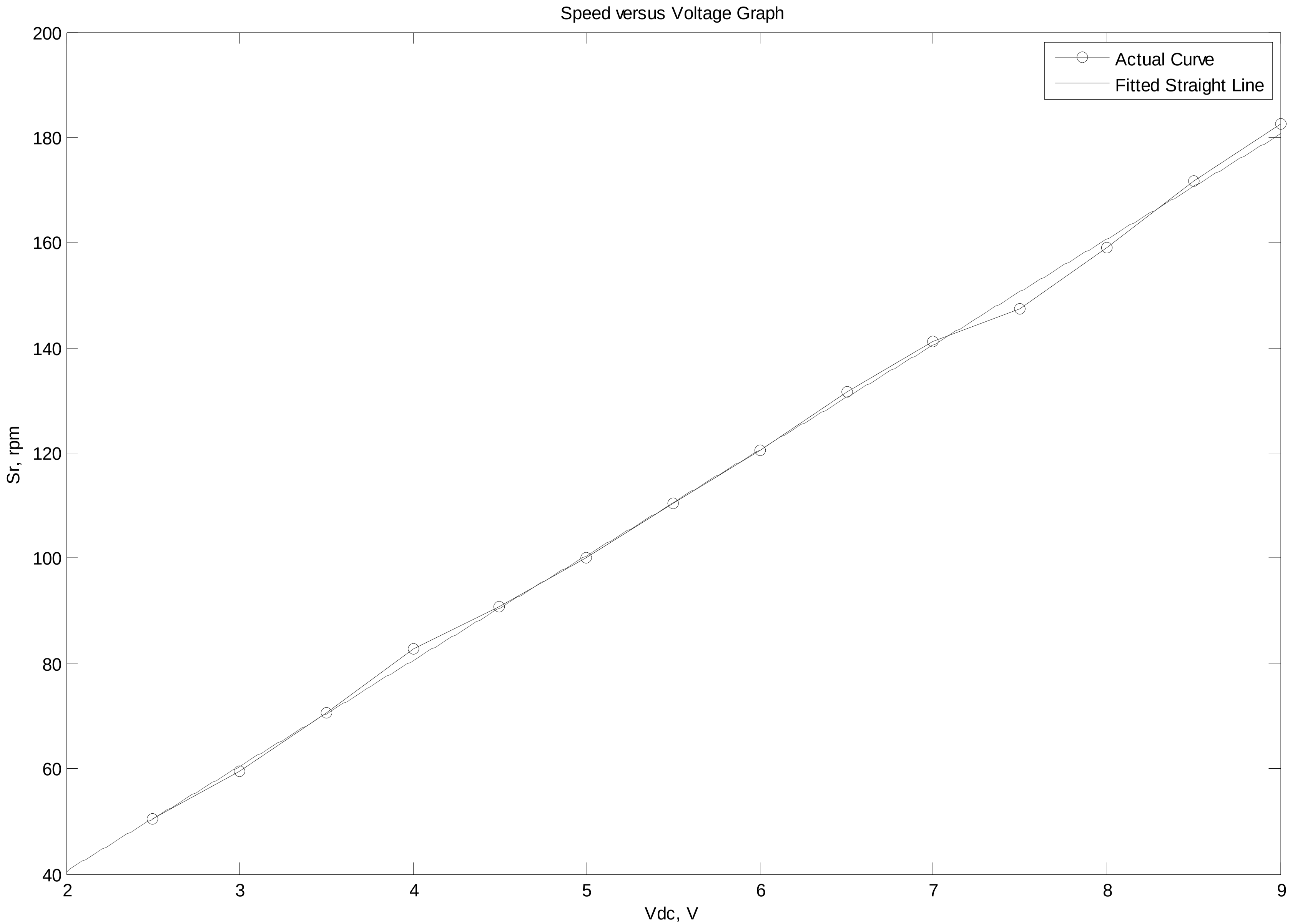

Speed versus Voltage Graph
Actual Curve
Fitted Straight Line
Sr, rpm
200
180
160
140
120
100
80
60
40
2
3
4
5
6
7
8
9
Vdc, V

Figure 20

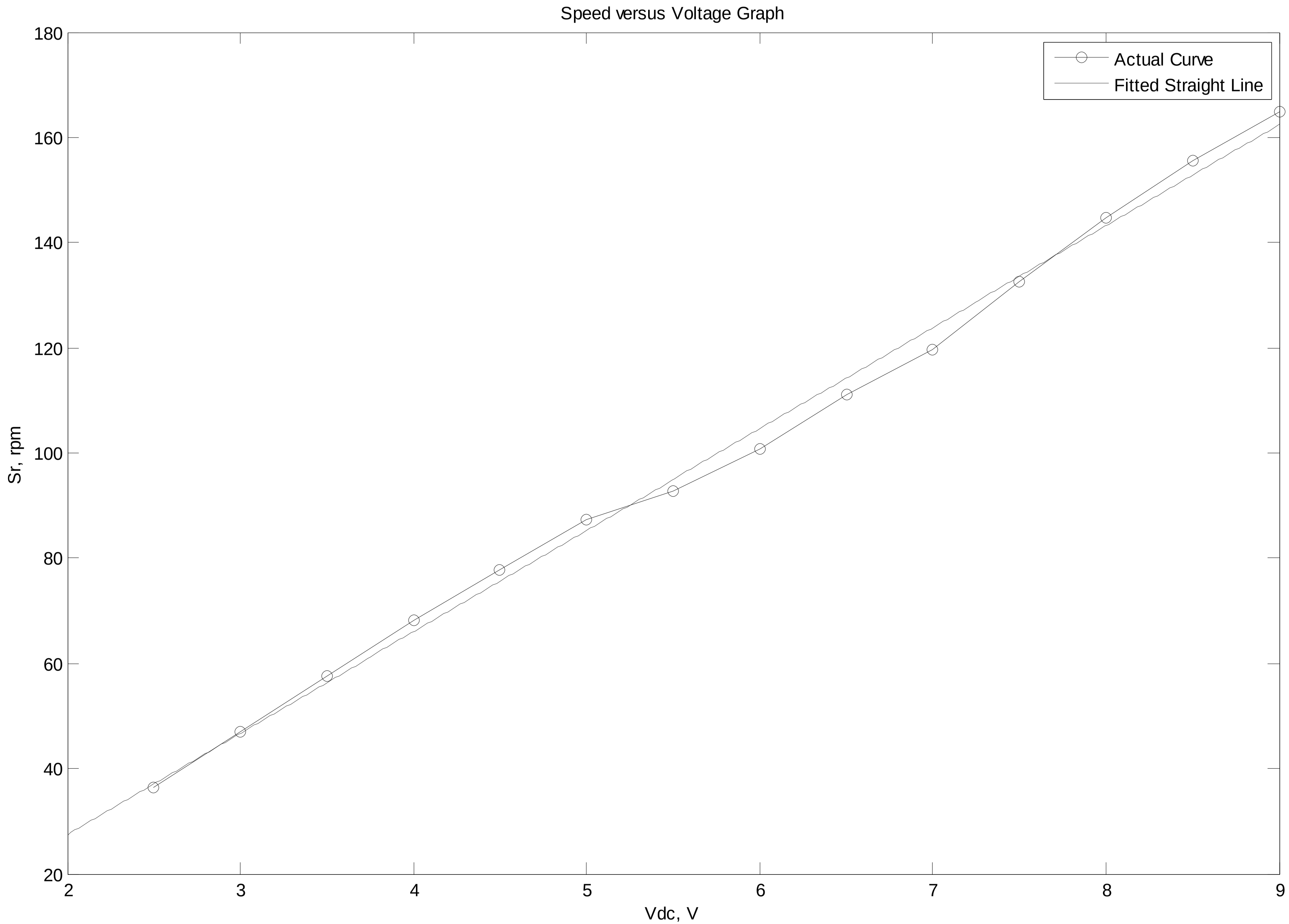

Speed versus Voltage Graph
Actual Curve
Fitted Straight Line
Sr, rpm
Vdc, V
180
160
140
120
100
80
60
40
20
2
3
4
5
6
7
8
9

Figure 21

computer software called ‘MATLAB’.

The equation of the straight line of figure 20 is mentioned below.

$S_r = 20.0270V_{dc} + 0.4100$

Using the values of V_{dc} from table 2, the standard values of S_r can be calculated from the above equation. These data are incorporated in table 4.

V_{dc} V	S_r rpm
2.50	50.4775
3	60.4910
3.50	70.5045
4	80.5180
4.50	90.5315
5	100.5450
5.50	110.5585
6	120.5720
6.50	130.5855
7	140.5990
7.50	150.6125
8	160.6260
8.50	170.6395
9	180.6530

Table 4

The equation of the straight line of figure 21 is mentioned below.

$S_r = 19.2950V_{dc} – 11.1720$

Using the values of V_{dc} from table 3, the standard values of S_r can be calculated from the above equation. These data are incorporated in table 5.

V_{dc} V	S_r rpm
2.50	37.0655
3	46.7130
3.50	56.3605
4	66.0080
4.50	75.6555
5	85.3030
5.50	94.9505
6	104.5980
6.50	114.2455
7	123.8930
7.50	133.5405
8	143.1880
8.50	152.8355
9	162.4830

Table 5

Along with the values incorporated in table 4 and table 5, any other values from 2.50V to 9V can be used for V_{dc} in the equation of each case.

FEEDBACK OF THE TRAIN

The train starts moving in a particular fashion upon the application of a specific amount of dc voltage. The purpose of feedback is to check whether the current fashion corresponds to the applied voltage or not. If it is alright, then nothing is done. Otherwise, corrective measures are taken.

The feedback is delivered to the microcontroller of the control systems part. Previously, the microcontroller was prepared in such a way that it could treat the feedback as a dc voltage. Later, it got changed so that it started considering the feedback as a rotational speed. For this purpose, a pulse wave is sent to the microcontroller. The frequency of the wave depends on the fashion of the train's movement. If the train moves fast, then the frequency is more. If it moves slowly, then the frequency is less. The microcontroller counts a fixed number of pulses. It measures the duration of counting as well. Based on these two pieces of information, it determines the speed. The speed increases with the rise in the wave's frequency. It decreases with the fall in the frequency. The speed is ultimately converted to voltage. For this purpose, the train should be taken with the final characteristics. For example, if the train is to have three wagons along with the engine finally, then it should take those things at this stage. If the train is to bear a certain amount of load upon it finally, then that load should be applied to it in this case. Suitable different voltages should be chosen. The train should move along the tracks. The tracks should be parallel to the ground. Speed for each voltage should be measured by the microcontroller. A graph should be plotted and a straight line should be found out by the curve fitting method. The equation of the line should be able to calculate the corresponding voltage for a speed. The conversion process is done by this equation. In reality, the train was not taken with the final characteristics because a lot of wires were necessary for the connections and maintaining everything properly during the train's movement was very tough. Several trials were made. Some sorts of problem regarding the wires were faced in each case. Therefore, the engine of the train was considered alone in the upside down manner as shown in figure 22. The results found here are not compatible with the train with the final characteristics.

The level of accuracy for feedback is chosen according to necessity. A general rule is that if the feedback voltage is equal to the applied voltage, then nothing is done. Otherwise, corrections are made. This rule ensures a high level of accuracy. It may not be needed everywhere. A specific rule may be that if the difference between the applied voltage and the feedback voltage is less than 0.50V, then nothing is done. Otherwise, corrections are made. This rule introduces a low level of accuracy.

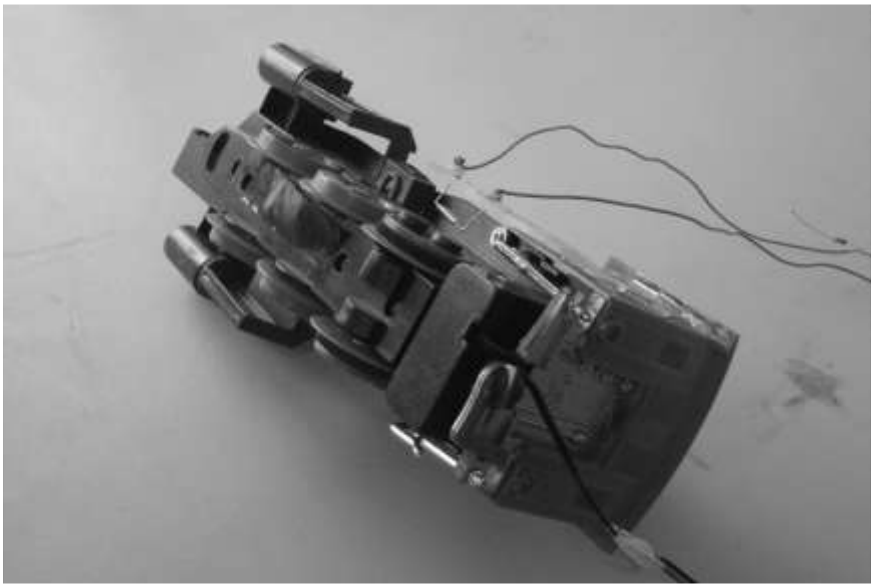


Figure 22

The pulse wave sent to the microcontroller can be generated in two ways. In one way, magnet and magnetic switch are used. In the other way, infrared emitting diode and photodiode are used.

The first way is taken into consideration next. The diagram of the electrical circuit for the magnetic switch is shown in figure 23.

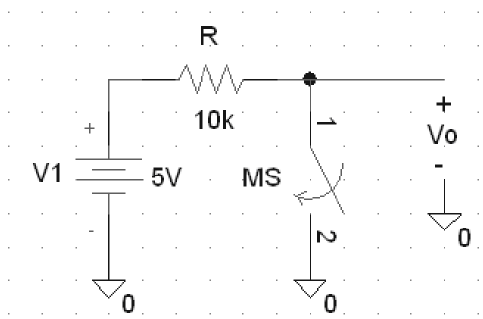


Figure 23

MS is the switch. V_o represents the output of the circuit. When the magnet is very close to MS, it feels the presence of the magnet. Otherwise, it does not do so. MS becomes open when it does not feel the magnet's presence. In this case, V_o = 5V. MS becomes closed when it feels the magnet's presence. In this case, V_o = 0V. The practical arrangement of the circuit is partially shown in figure 24.

Figure 24

Magnet is attached on two places of one wheel of the train's primary pair of wheels. When the pair rotates, V_o becomes a pulse wave. Two pulses are found in one rotation due to the placement of magnet in two positions. The microcontroller divides the number of pulses by two to determine the number of rotations and calculates the speed of the pair.

A problem is associated with this process. The primary pair of wheels does not rotate accurately. So, the speed corresponding to a voltage fluctuates a lot. As a result, the feedback is not obtainable. The relevant data are incorporated in table 6. In the table, the voltage is represented by V_{dc} and the speed is represented by S_r. A duration of two minutes is spent for each voltage to take the reading of the corresponding speeds. Odd speeds are cancelled when found. The remaining ones are mentioned as a range starting with the minimum speed and ending with the maximum one. Only one exception is found where the corresponding speed of a voltage does not fluctuate. The microcontroller counts a total of fifty pulses in this case. So, the number of rotations of the pair is twenty-five.

The second way is taken into consideration next. The diagram of the electrical circuit for the infrared emitting diode is shown in figure 25.

V_{dc} V	S_r rpm
3	5 – 8
4	5 – 7
5	7
6	9 – 13
7	10 – 25
8	13 – 32
9	15 – 47

Table 6

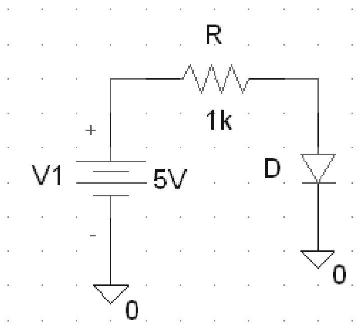


Figure 25

D is the diode. It emits the infrared wave. The diagram of the electrical circuit for the photodiode is shown in figure 26.

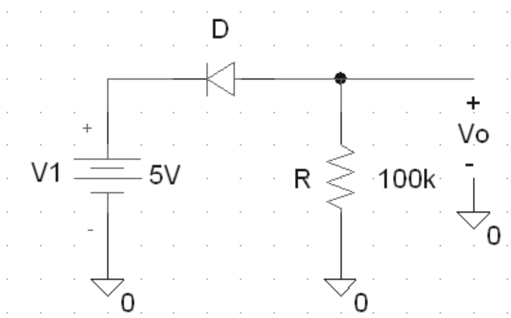


Figure 26

D is the diode. V_o represents the output of the circuit. When D receives the infrared wave, V_o = 5V. When it does not do that, V_o = 0V. These circuits are installed in the engine of the train. The engine has a small box that contains the dc motor and gears. The box is shown in figure 27. It can be identified by the fact that it has wheels on two sides.

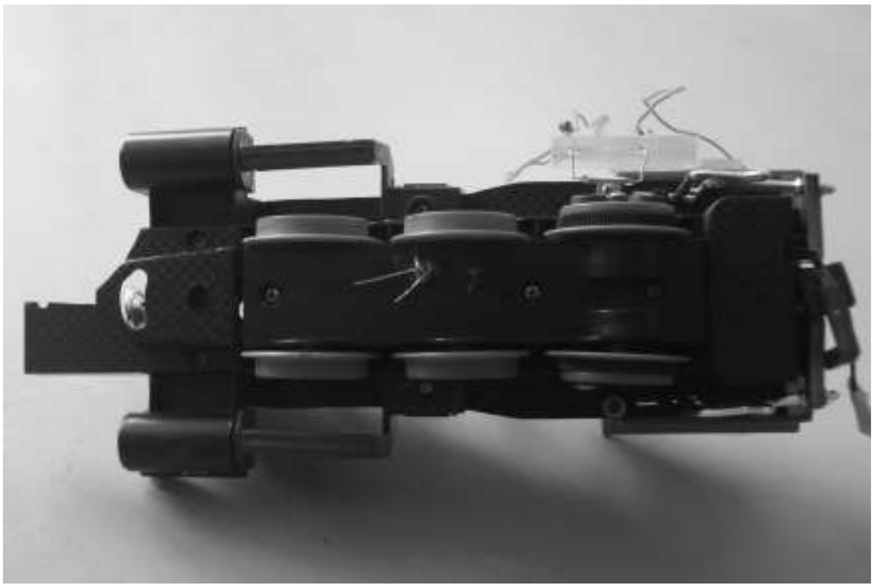


Figure 27

A suitable gear is chosen. A number of small holes are made on the surface of the gear radially. The holes are approximately at the same distance from the center of the gear's surface. The distance between any two holes is approximately the same as well. The infrared emitting diode is placed on one side of the gear by making a hole on the surface of the box. The photodiode is placed on the other side of the gear by making another hole on the surface of the box. It has two pins that are visible upon the surface in figure 27. The diodes are positioned in such a way that when a hole comes between them, the infrared wave is passed from the infrared emitting diode to the photodiode and V_o = 5V. When no holes exist between them, the wave should not pass and V_o should be equal to 0V. When the gear rotates, V_o should be a pulse wave. The number of pulses found in one rotation should be equal to the number of holes. The microcontroller should divide the number of pulses by the number of holes to determine the number of rotations and should calculate the speed of the gear.

A problem is associated with this process. When no holes are between the diodes, $V_o \neq 0V$. The problem may be that the gear is thin and a little transparent. So, the infrared wave is passed in some extents from the infrared emitting diode to the photodiode.

One surface of the gear was colored black to solve the problem but it was not successful. The problem may also be that the photodiode is damaged as it is bent much during the installing process. The photodiode could not be replaced by another one as it was made fixed to the box. So, the pulse wave is not generated. As a result, the feedback is not obtainable.

Therefore, it is the structure of the train which is mainly responsible for all the problems occurred regarding the feedback. The train was not constructed in such a way that can have the necessary arrangement for feedback. So, the feedback cannot be ensured.

FUTURE OBJECTIVES

Some important features can be introduced in the train in future. They are mentioned below.

- The train can be made to take power directly from the tracks.
- The train can have a log control unit that will record its past course of actions. Then, proper reasons of a fault can be checked upon the occurrence of it.
- There can be a light control unit in the train. It will make sure that the lights of the train are illuminated only when they are necessary.
- A collision control unit can be installed in the train so that it can be stopped before a collision can take place.

PROJECT EXPENSES

The budget of the project for this team is BDT 5,000 i.e. five thousand taka only. Total expense of this semester i.e. the third semester is BDT 1,571 i.e. one thousand five hundred and seventy-one taka only. That of the second semester is BDT 1,590 i.e. one thousand five hundred and ninety taka only. No expense is incurred in the first semester. Altogether BDT 3,161 i.e. three thousand one hundred and sixty-one taka is expensed only.

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3. Operational Amplifiers and Linear Integrated Circuits; Robert F. Coughlin and Frederick F. Driscoll; Sixth Edition; Prentice-Hall of India Private Limited; Section 3-6

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5. http://students.iitk.ac.in/roboclub/tutorials/Motor%20Driver.pdf

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