Working and Analysis of the H – Bridge Motor Driver Circuit Designed for Wheeled Mobile Robots

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***Abstract* - Wheeled mobile robots (WMR's) are built with their wheel's drive machine, motors. Depend upon their desire design of WMR, technicians made use of DC motor for motion. As a driving system of DC motor, a Peripheral Interface Controller PIC 16F877A based control system is designed with H- bridge motor driver circuit. The driving system is used to drive two DC gear motors which are used to control motion of WMR.The outputs of PIC are used to drive the H - bridge motor driver circuit which makes the movement of the motor. In this article three circuits of H – bridge have been explained. The first circuit explains the motion of the motor and the concept of differential drive which technicians have been using. The second circuit lays emphasis on the proper triggering of transistors thereby improving the earlier circuit. The third concept is the H – bridge motor driver circuit at heavy load conditions. The whole paper is made on the basic research in order to make an efficient driving system under any conditions.**

I. INTRODUCTION

Control system designed and analysis technology are widely spread and very useful in real time applications. Some can be solved by hardware technology and by the advance use of software, control systems are analyzed easily and in detail.

As an application of Wheeled Mobile Robots (WMR), DC motors can be used as wheel drive machines and by using a simple microcontroller PIC 16F877A or 8051/8052 series, the rotation of motors or motion of the robots can be controlled easily.

The motion of WMR is based on the concept of differential mechanism. Taking into consideration two wheel drives, the left and the right wheels are driven with a DC geared motor, such that each motor movement controls the motion of Robot.

TABLE I

DIFFERENTIAL MECHANISM FOR TWO WHEEL DRIVE SYSTEM

Left Motor	**Right Motor**	**Motion**
Clockwise	Clockwise	Forward
Clockwise	stop	Right
stop	Clockwise	Left
Anticlockwise	Anticlockwise	backward

A. DC Motor driver circuit for Differential Mechanism

For controlling the drive system of the DC geared motor for Differential WMR, the H-bridge motor driver circuit (Fig.1) is used [1]. The circuit used is:

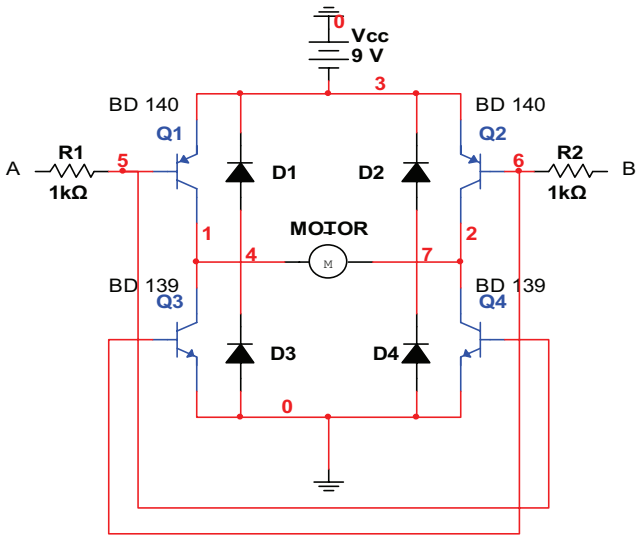

Fig.1 H- Bridge Motor Driver Circuit [8]

The DC geared motor will work in two directions (Clockwise or anticlockwise) depending upon the direction of flow of current from it. The Inputs A and B will be fed from the microcontroller PIC 16F 877A [2]. Transistors Q1 and Q4 and transistors Q2 and Q3 are given the same input.

When A is HIGH, while B is LOW, transistors Q2 and Q3 triggers making the movement of the motors in one direction. Similarly when A is LOW, while B is HIGH, transistors Q1 and Q4 triggers making the direction of the motor opposite. The logic table is as follows:

TABLE II

LOGIC TABLE FOR H – BRIDGE CIRCUIT FROM PIC

A	**B**	**Motion**
0	0	Stop

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0	1	Clockwise
1	0	Anticlockwise

The transistors used are BD 139(NPN) and BD 140(PNP).

These are power transistors which are able to withstand the high starting current of the motors due to starting torque from the gears, unlike simple BJT's.

TABLE IV

CHARACTERISTICS OF BD 139 AND BD 140 [3]

Symbol	Parameter	Max.	Unit
VCBO	collector-base voltage	100	V
VCEO	collector-emitter voltage	80	V
IC	collector current (DC)	1.5	A
Ptot	total power dissipation	8	W
hFE	DC current gain IC = 150 mA; VCE = 2 V;	250	V

Since the maximum value of I_C is 1.5A, these can easily withstand the current required by the motors.

There are four protective diodes used (Fig.4) in order to prevent the high value of current from the motor to go inside the emitter junction and damage it, when the motor reverses its direction.

II. IMPROVEMENT IN THE H – BRIDGE MOTOR DRIVER CIRCUIT

A. Use of high current gain transistor QN2222 for proper triggering of power transistors (Fig.2).

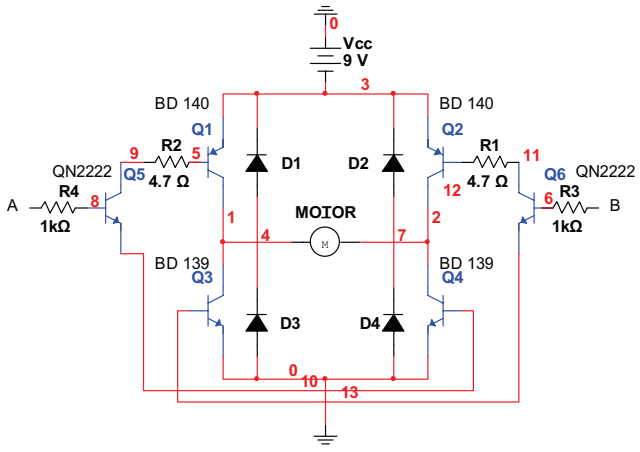

Fig.2 H- Bridge Motor Driver Circuit with high current gain transistors [9]

Taking into account the earlier H-bridge circuit, there was no proper triggering of the power transistors. The 5V from the microcontroller after 1K drop from the resistor is fed to the base of the transistor, but the value of I_B current was not appreciable [4], so the collector and the emitter junction were not short circuit in a proper manner i.e. not all the conduction electrons are able to cross the junction. So less value of current to that expected is delivered to the DC geared motor. In other terms, whenever I_B current is fed to the base of a transistor the base drive of the transistor increases i.e. the barrier voltage (Fig.3) between emitter and the collector decreases [7] allowing the conduction electrons to flow. More the value of I_B more the base drive and more is the current flow.

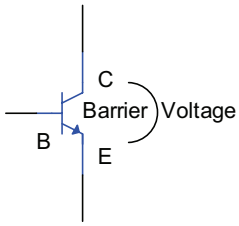

Fig.3 NPN Transistor depicting the barrier voltage [7]

To increase the base drive we use high current gain transistors i.e. QN2222 is used in order to provide good value of base current.

The HIGH pulse from the controller triggers Q_5 and Q_6 thereby triggering the power transistors also.

Since the value of I_C is approximately equal to I_E transistors Q_1 and Q_4 are simultaneously triggered with equal amount of current.

B. Use of Darlington power transistors TP122 (NPN) and TP 127 (PNP) (Fig.4) for high current gain in case of heavy load conditions.

The Darlington pair of transistors is an arrangement of transistors so as to provide a high current gain.

Fig.4 Darlington power transistors TP122 (NPN) and TP 127 (PNP)

$$I_C = \beta I_B, \quad (1)$$

I_C – Collector Current, I_E – Emitter Current

Where $\beta = \beta_1 . \beta_2$ where β_1 and β_2 are the current gain for two transistors in Darlington pair. The collectors of both transistors in the pair are connected while the emitter of the

one is connected to the base of another thereby increasing the current gain appreciably.

The transistors used are TP122 (NPN) and TP 127 (PNP).

TABLE IV

CHARACTERISTICS OF TP 122 AND TP 127[5]

Rating	Symbol	Value	Unit
Collector –emitter voltage	V_{CEO}	100	V_{dc}
Collector Current – Continuous Peak	I_C	8	A
Power Dissipation	P_D	65	W
Current Gain	h_{fe}	2500	

Here value of collector current is 8A which is 5 times the value of collector current in simple power BJT.

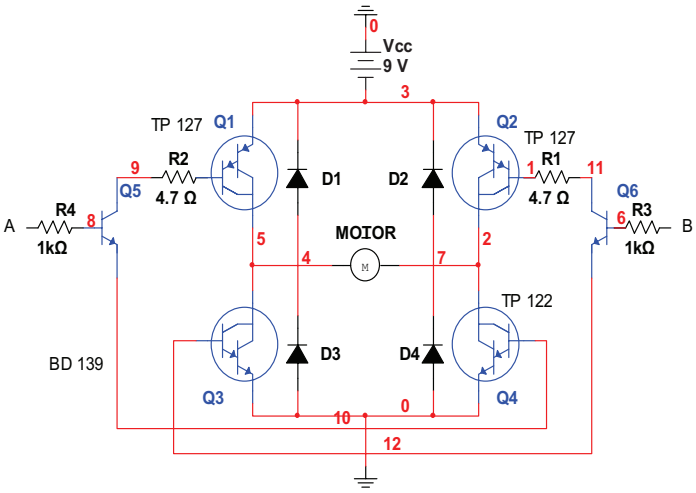

Fig.5 H- Bridge Motor Driver Circuit with Darlington pair of transistors [10]

This circuit (Fig.5) can be used in case of heavy load conditions. At heavy load conditions the amount of current in the DC motor is very high hence the current carrying capacity of the power transistors should be increased. The value of the starting current is 5 – 10 times the rated current [6] and this current may be up to 4A at 60V. So in this situation the power BJT's may get damage. So to overcome this situation we use Darlington pair of power transistors.

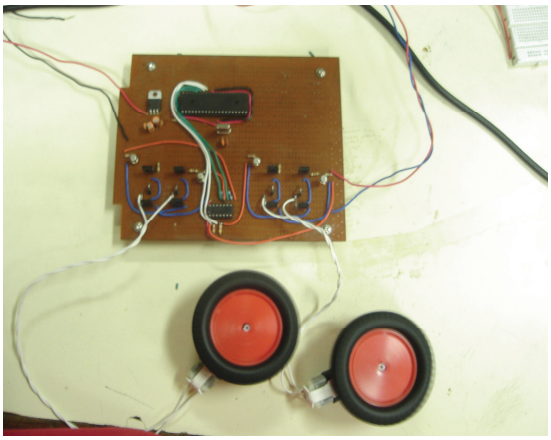

Fig.6 Circuit construction of H – Bridge and testing photos

III. RESULT

The experiment done is for two wheel drive system using DC geared motor for motion. The motor has an RPM of 250 under no load conditions. The RPM is reduced to 100 when wheels were mounted on it. Taking into consideration Fig.6 two H- Bridge circuits (Fig.2) are used for two drives. The logic to the H- Bridge circuits is given by PIC microcontroller of 16F 877A series.

1. The starting current is 0.4A for both drives and is reduced to 0.2A under constant motion. The wheels are made to stop by force and the current increases to 2A at full load damaging the power transistors. As a rectification Darlington pair of power transistors is used, this increases the current capability by 5 times i.e.8A. Thus this system works at full load using Darlington pair.

2. The value of V_{CE} i.e. barrier voltage is noted in case of Fig.1 and Fig.2.

It is found that V_{CE} for Fig.1 is more than V_{CE} for fig2.

This ensures better triggering of transistors.

IV. CONCLUSION

A drive system for the wheeled mobile robots should be efficient enough to provide good movement to the robot. The capability of any drive is the measure of load it can withheld. In order to carry load the current required is also large. The circuits explained above will help to make the drive system efficient and is able to work at heavy load conditions with proper switching.

These circuits will help to make the WMR versatile and will work under any conditions of the proposed problem statement.

V. FUTURE SCOPE

Designing of an automated system for load placement where the value of load is unpredictable. This system can work in mining and household areas.

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