Design and Development of Universal Motor Control Unit using MATLAB and Arduino

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Abstract— AC and DC drives play a vital role in each and every industry. This research paper shows the methodology to interface stepper, servo, AC and DC motor on a single platform. GUI is designed in MATLAB to control all motors. Directions and speed of DC motor are controlled by electromechanical relay and H BRIDGE respectively. AC motor is controlled by solid state relay, stepper motor is controlled by ULN2003 current driver and servo motor is controlled by timers of the ATMEL controller. In a nut shell, all the motors are controlled using MATLAB GUI and Arduino controller. This instrument is best for the Power electronics lab for educational purpose.

Key words: AC Motor, DC Motors, MATLAB HMI, ATMEL ATMEGA 328, H Bridge Drive, Stepper Motor, Servo Motor

I. INTRODUCTION

The concept of motion control of motor is easily optimized with the help of electrical drive. In other words, the systems which control the motion of the electrical machines are known as electrical drives. Typical drive system is assembled with an electric motor (may be several) and a sophisticated system that controls the rotation of the motor shaft. Now days, the control can be done easily with the help of software. So, the controlling of motor becomes more and more accurate and this concept of drive also provides the ease of use[1]. The motor requires higher-current control signal which is obtained from low current control signal using a motor driver circuit. When DC motors are used in large applications, the use of drives is very necessary for the smooth running and operation of these motors. The DC motor drives are mainly used for good speed regulation, frequent starting, braking and reversing [2]. This entire task can be performed using L293d H-Bridge motor drive[3].

II. METHODOLOGY

This paper explains how the actual motor drive works. First, the drive components are assembled and programmed through Arduino using algorithm developed. The desired motors are connected; external power supply is required to power the relay cards and also the drive [4][5].

The main unit of this drive is Arduino Board (ATMEL AtMega328). It controls the panel of different motors using MATLAB HMI (Human Machine Interface). A panel is designed in MATLAB which serially communicates with Arduino [6][7].

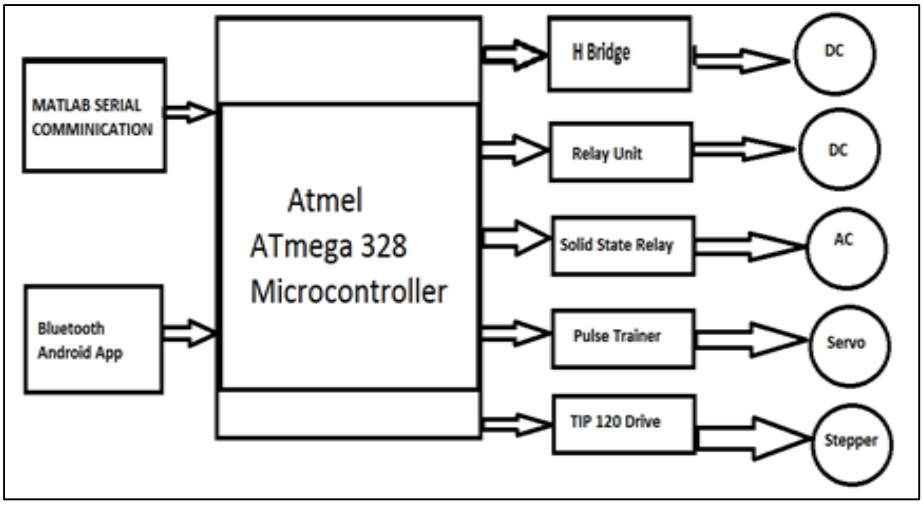

Fig. 1: Block Diagram

Micro-controller controls the drives of different motors. Figure shows the block diagram for universal drive i.e. a drive on single platform that controls all types of motors.

Different types of motor controlled are:

1) 2-DC Motors
2) AC Motor
3) Stepper Motor
4) Servo Motor

III. OBJECTIVES

1) Interfacing H-bridge to vary the speed of DC motor.
2) Interfacing SSR to Control AC motor.
3) Interfacing Pulse trainer to Interface Servo motor.
4) Interfacing TIP120 drive to control stepper motor in bipolar and uni-polar mode.
5) Controlling whole system using MATLAB GUI as well as Android application.
6) Manual control is also possible.

IV. HARDWARE & SOFTWARE

A. Hardware

1) Arduino

This section explains about the heart of the drive. The project contains the microcontroller which is an open source platform called "Arduino" which uses Atmel AtMega328 microcontroller. It connects to a computer via a USB cable, and is programmed using language similar to C++ [8].

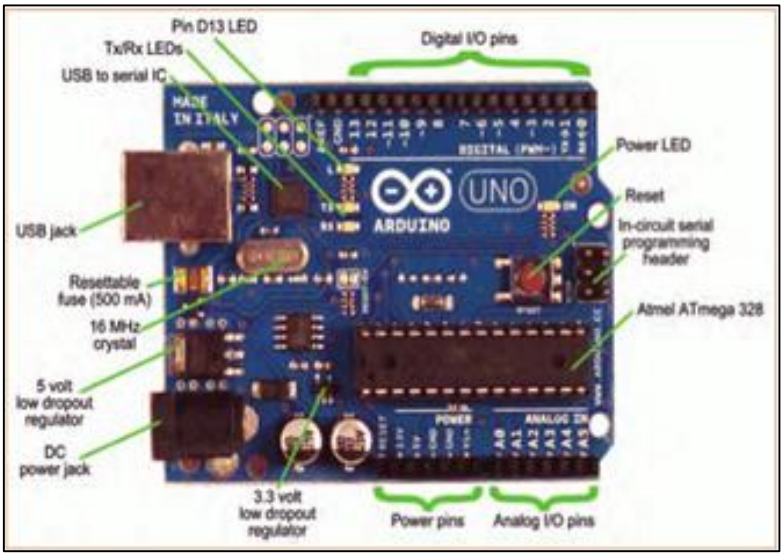

Fig. 2: Arduino Board

The Arduino has a number of output ports that gives control signals to other circuits and drives, input ports which can be used to read input signals.

Microcontroller	ATmega328p
Operating Voltage	5 V
Input Voltage(recommended)	7-12 V
Input Voltage(limit)	6-20 V
Digital I/O Pins	14(including 6 pins as PWM)
PWM Digital I/O Pins	6
Analog Input Pins	6
DC Current per I/O Pin	20 mA
DC Current per 3.3V Pin	50 mA
Flash Memory	32 KB (ATmega328P) of which 0.5KB is used by boot loader
SRAM	2 KB (ATmega328P)
EEPROM	1 KB (ATmega328P)
Clock Speed	16 MHz
Length	68.6 mm
Width	53.4 mm
Weight	25gm

Table 1: Microcontroller

Project uses Arduino as it is commonly used user-friendly platform, which provides lots of inbuilt libraries and sufficient number of digital as well as analog I/O ports as per the requirement.

2) H-Bridge Drive

Generally, an H-bridge is a simple circuit, consisting of four switches, with the load connected at the centre, in an H-shape.

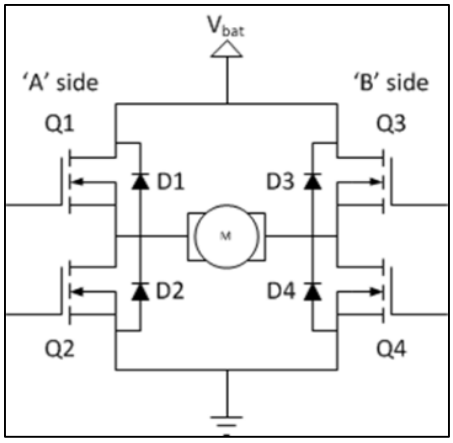

Fig. 3: H-Bridge Diagram

Generally bi-polar or FET transistors(Q1, Q2, Q3 & Q4) are used as the switches. The diodes (D1, D2, D3 & D4) are called catch diodes and are basically of a Schottky type. The top-end and bottom-end of bridge are connected to a power supply and ground respectively. All four switches can be turned on and off independently, inspite of some general restrictions. The load in theory can be anything we want, but by far the most prevalent application H-bridge is used with a brushed DC motor as load [1-4].

3) Relay

A relay is a device that operates on an electro-mechanical principle that controls larger voltages and currents using small electrical voltages and currents.

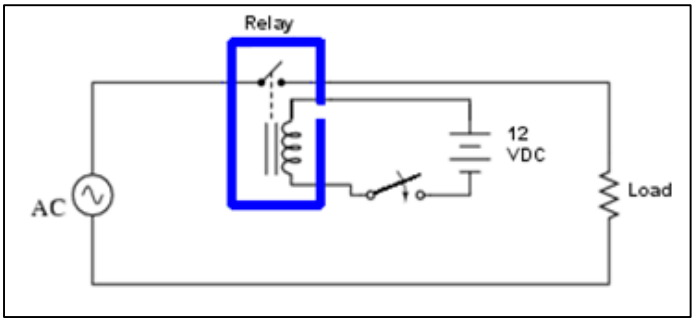

Fig. 4: Relay

B. Software

1) MATLAB GUI

It is high-performance software for technical functioning. It is basically used to integrate, differentiate, compute, visualise, program or transmit control signals on a user friendly platform where solution for any problem can be expressed in known mathematical notation.

GUI (also known as graphical user interfaces or UI) is used as it provides point-and-click control of software applications, eliminating the need to learn a language or type commands in order to run the application. MATLAB apps are self-contained MATLAB programs with GUI front ends that automate a task or calculation. It typically consists of controls such as menus, toolbars, buttons, and sliders. We can create our own custom apps, including their corresponding UIs, for others to use. GUIDE (GUI development environment) provides tools to design user interfaces for custom apps [3-6].

Here, using the GUIDE Layout Editor, we have graphically designed our own UI. It is then modified to program the behaviour of our application. According to application, six panels are created. First panel is for connecting and disconnecting COM port associated with Arduino, all the other panels are associated with respective motors controlling speed, direction and angle as per the requirement.

V. INTERFACING OF DIFFERENT COMPONENTS & MATLAB CONTROL PANEL

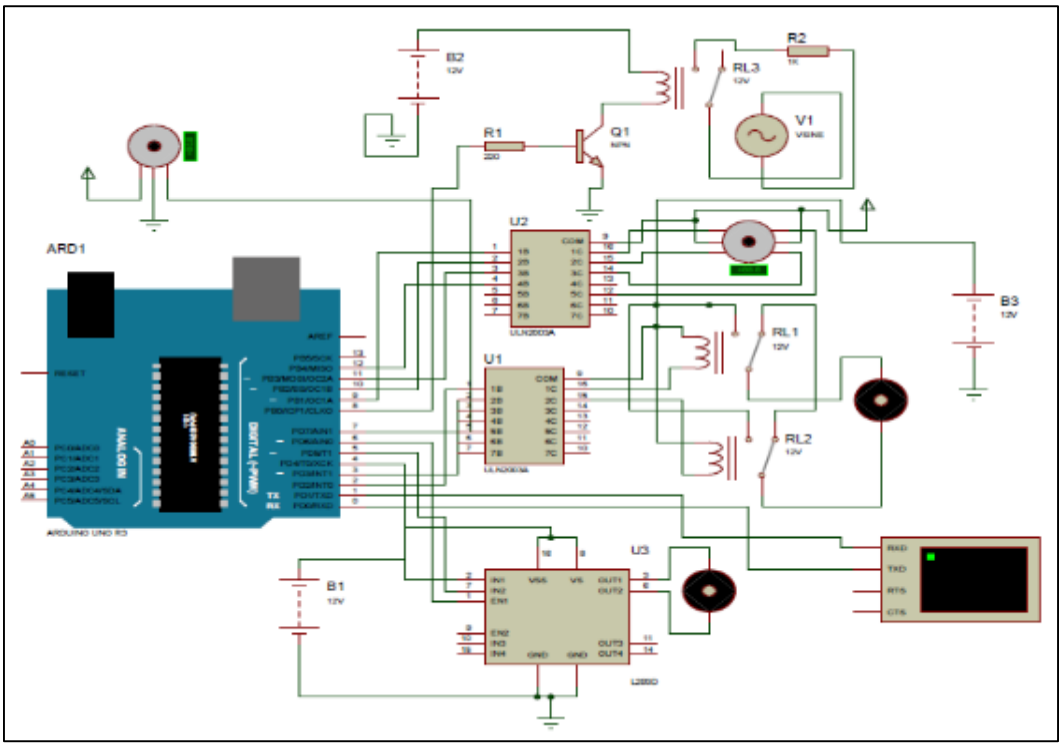

Fig. 5: Interfacing in Proteus

Different types of motors are interfaced with Arduino using Analog and Digital pins which is then controlled by MATLAB GUI. Interfacing is done along with different control ICs and Relays. All this together forms a Relay board and Driver Circuitry. A power supply is also separately provided.

First DC motor is connected to 2 & 3; second DC motor is connected to 4 & 5 number pins of Arduino. The direction of DC motor 1 is controlled by pair of relay. DC motor 2 is controlled by L293d IC whose ENABLE pin is connected to pin 6 of Arduino, it controls the speed of DC motor 2. Pulse to Servo motor is given from pin 7 of Arduino. ON/OFF of AC motor is done using pin 8 and stepper motor utilises 9 10 11 & 12 pin on Arduino Board. Also the controlling of whole application through BT Android App is featured, for this Bluetooth occupies pin number 14 & 15 of Arduino.

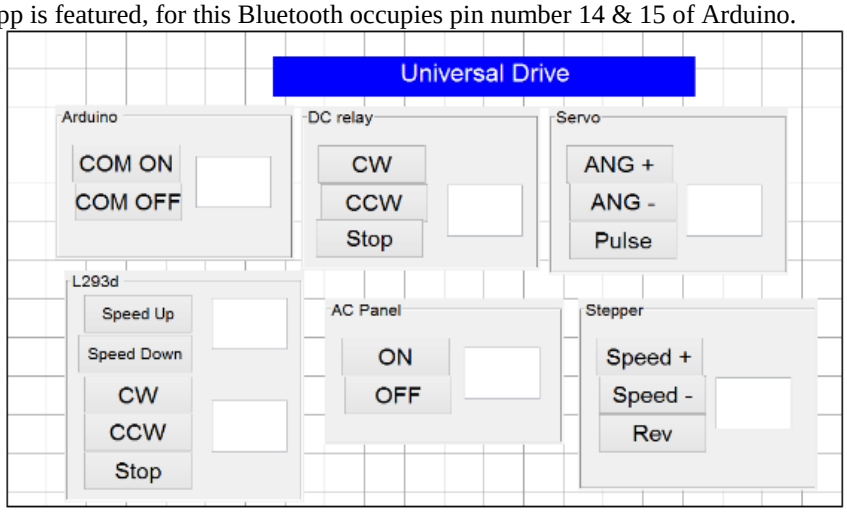

Fig. 6: Control Panel in MATLAB GUI

VI. ADVANTAGES

It readily used for controlling purpose but this is not the only advantage of electrical drives. There are several other advantages which are listed below –

1) This Universal Drive can be used to reduce the hardware cost and space.
2) This drive can provide variation in speed and power.
3) The control characteristics of this drive are flexible.
4) It is adaptable for any type of operating conditions, no matter how much vigorous or rough it is.
5) It does not contaminate the environment.
6) It does not require any refuelling or preheating, it can be initiated instantly and can be loaded immediately.

7) It is powered by electrical energy which is atmosphere friendly and cheap source of power.

VII. APPLICATIONS

The motor drive systems can be widely used in large number of industrial and domestic applications like factories, transportation systems, textile mills, fans, pumps, motors, robots, LED and incandescent displays, Automotive applications, Audiovisual equipment, PC Peripherals, Car audios, Car navigation systems, etc..

Drives are also employed as prime movers for diesel or petrol engines, gas or steam turbines, hydraulic motors and electric motors.

This drive serves the purpose of different motor drivers and thus can be used for multiple applications including educational and laboratory testing.

VIII. CONCLUSION

From the research it can be conclude that this drive can control different motors i.e. two DC motors and an AC motor using the single hardware drive. This drive is actually simple to operate and has different modes of operation. It controls the motors and can be operated manually using MATLAB GUI and wirelessly using Bluetooth on an Android platform. Using Bluetooth for operation is easy for user to understand and provides the most convenient wireless service for the drive. It is power efficient and compatible. It can operate under different atmospheric conditions. It is most useful for low budget starts-ups and serves as reliable equipment to control different sets of motors, their direction and speed at instant.

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