ANTENNA ROTATOR DESIGN AND CONTROL

by

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14302

Dissertation submitted in partial fulfilment of

the requirement for the

Bachelor of Engineering (Hons)

(Electrical & Electronics Engineering)

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CERTIFICATION OF APPROVAL

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A project dissertation submitted to the
Electrical & Electronics Engineering Programme
Universiti Teknologi PETRONAS
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Approved by,

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UNIVERSITI TEKNOLOGI PETRONAS
TRONOH, PERAK
September 2014

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

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MUHAMMAD RUSYDI BIN BUCHEK

ABSTRACT

This paper consists of design and development of rotator for antenna positioning according to the desired azimuth and elevation. The rotator is to have the capability to be manually controlled (press button switch) or software driven. It should incorporate safety stop switches as well as position and speed sensors in order to achieve smooth movement and correct stopping position.

The basic principle needs to be studies are speed control using the microcontroller, exact angle of position movement, and stoppable motor can be done in time due to emergency cases. As larger load is applied to the device, the large inertia will need to be compensated to achieve a good dynamic. For position and speed regulation in antenna system, a DC motor will need to be used as the primary driver along with the appropriate in mechanical coupling. The appropriate and suitable rotator need to be chosen for better result in speed and position.

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CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

An antenna or can be called as aerial is the electrical power to radio waves conversion device and radio waves to electrical power [1]. The antenna communications need transmitter and receiver. The transmitter used is radio transmitter and the receiver used is radio receiver. The radiation pattern plays the important roles as characteristics of antenna [2]. It can determine where the concentrated radiation been directed. The best radiation pattern is the one that has the ability to increase the signal-to-noise ratio (SNR).

It will be better if the orientation of the antenna can be control by some device such as antenna rotator. The antenna is connected near to the controller and the rotator mounted below the antenna [3]. Rotator widely used as communication installation for military and radio. It can help the antenna to receive better signal from different direction without more forces.

The Antenna Rotator Design and Control project is all about design and development of rotator to position antenna according to the desired azimuth and elevation [3]. The rotator need to have the capability to be manually controlled by using button switch or software driven. It should incorporate safety stop switches as well as position and speed sensors in order to achieve smooth movement and correct stopping position.

The basic rotator that have been assemble consists of gearbox, motor, an encoder and rotary joint as illustrated below.

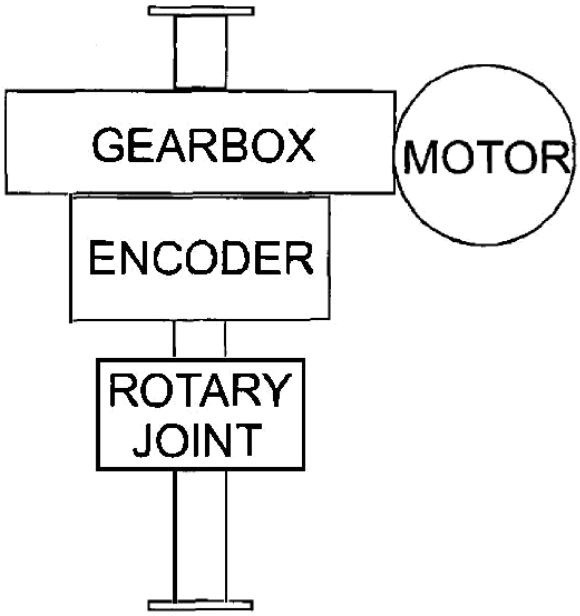

FIGURE 1: The Basic Rotator Assembly

1.2 PROBLEM STATEMENT

The basis of all rotation devices is speed control and position. As larger load is applied to the device, the large inertia will need to be compensated to achieve a good dynamic [4]. For position and speed regulation in antenna system, a DC motor will need to be used as the primary driver along with the appropriate in mechanical coupling. The appropriate and suitable rotator need to be chosen for better result in speed and position.

In order to regulate the position and speed, control signal need to be issued by a microcontroller to be used to move the motor and stop in time. To achieve better respond, proper control algorithm need to developed and implement on a microcontroller to provide the position control command.

Therefore, the best antenna rotator is the rotator that can be control in speed and move towards desired angle and position. The rotator device, circuit interface and controller need to be designed properly and follow the antenna's standard.

1.3 OBJECTIVES

The project needs to be done to design suitable rotation device with two depth of field (DOF) for azimuth and elevation control, design the interfacing circuit between the motor and the microcontroller. The project also needs to program and implement microcontroller based control strategy for motion control.

1.4 SCOPE OF STUDY

The study will involve in design the suitable rotating device using the chosen rotator, DC motor and Arduino board. The element needs to be taken in consideration before design the device are:

1. Speed control using the microcontroller
2. Exact angle of position movement
3. Motor can be stopped in time
4. Easy to handle and movable device

CHAPTER 2

LITERATURE REVIEW

Antenna can be described as the passive linear reciprocal device. It needs to be combined with active, nonlinear and nonreciprocal circuit element to make it as transmitting device [5]. The frequency of the antenna must be specified in term of quantitative. Antenna can be both transmitter and receiver. For transmitter, the radio transmitter will converts electrical energy to radio energy and transmit is to the antenna's terminals. The antenna's terminals that receive the radio signal will act as the antenna receiver and convert the radio energy to electrical energy signal.

The working principle of antenna is the important theory for design the antenna rotator. The transmitting antenna will radiate the radio signals that have been generated in transmitter to a receiver. The receiving antenna will pick up the radio signals that have been transmit by transmitter antenna in the space. The medium for the transmission is air in space. The transmitted signal in the space is in the electromagnetic form. The antenna system needs to be designed properly so that it will be able to radiate efficiently to avoid wasted power supply.

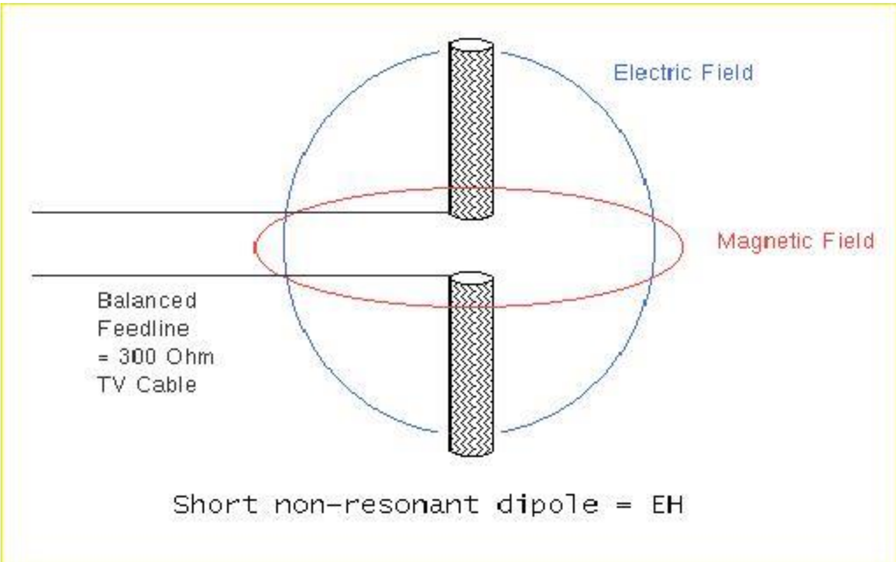

FIGURE 2: Antenna Working Principle

Sometimes, the antenna needs to be moved to get the better radiation pattern. Therefore, the orientation of directional antenna can be change by using the antenna rotator device. It is consists of controller and rotator.

Rotator can be described as device that can course something to rotate. In the antenna rotator project, rotator plays the important roles and need to be constructed perfectly for better movement and rotation. Basic motor consists of gearbox and motor (geared motor), encoder for azimuth angle and rotary joint [6].

From the study of the past researched, the rotator has been designed based on the millimetre-wave rotator assembly. The design was specific on the coax rotary joints and coaxial cable. The rotator used was millimetre-wave rotator. The rotator bearing layout was shown as below.

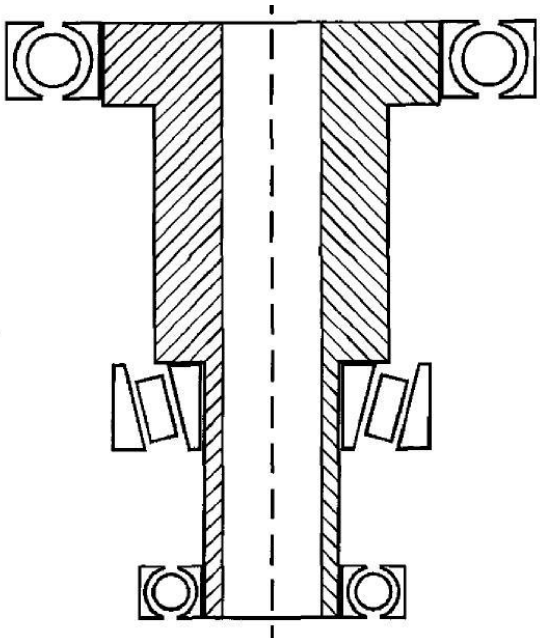

FIGURE 3: The Rotator Bearing Layout

The upper and lower bearings take the radial loads and the middle bearing provides axial support. Some of the antenna rotator project used the rotating table as the supporter for the rotation. It is called "lazy-Susan" turntable. The rotating table will support the shaft of the motor while rotate [6].

Servo and Position Control for Rotating Antenna

The motor can spin continuously with continues current. But the motor will not stop or move to the exact position. Therefore, the servo takes place to make sure the motor move in the right position, direction and angle. The main part of the basic servo motor is DC motor, sensor for position, gear box system, and control electronics. The main part of the motor can be seen as figure below:

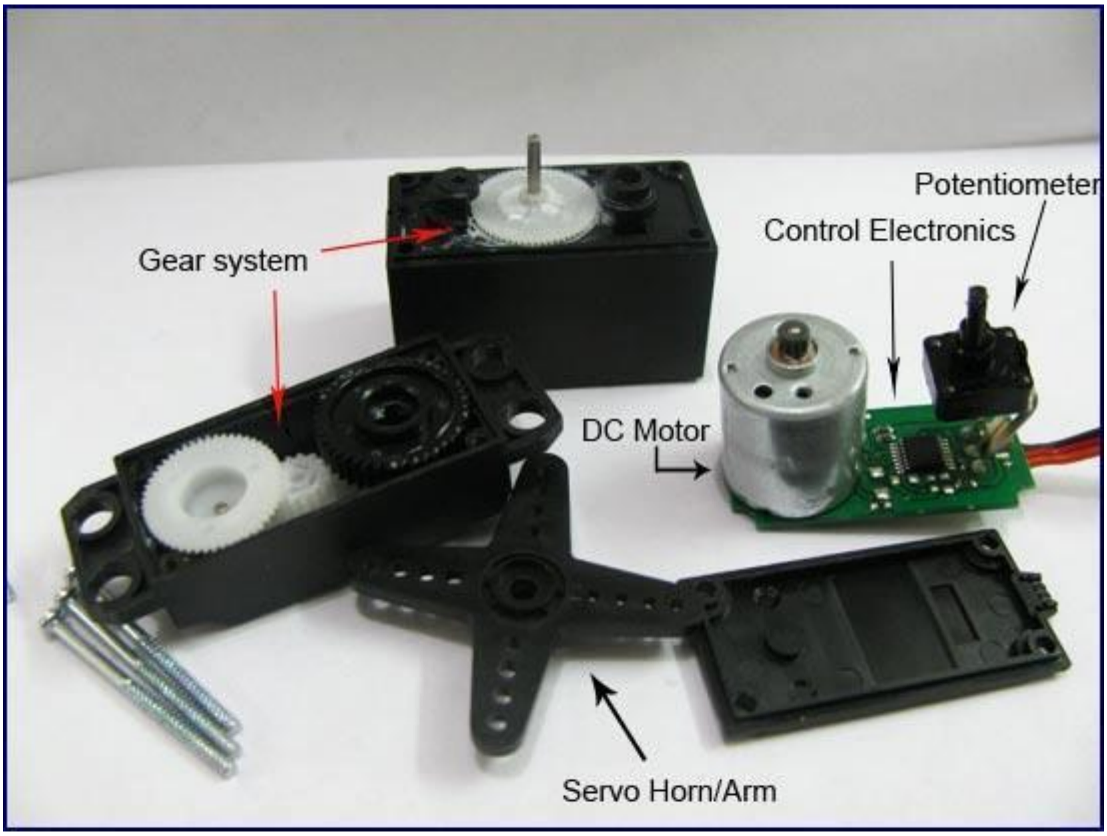

FIGURE 4: Main Part of Servo Motor

The gear mechanism is connected to the DC motor. This will provide the feedback to position sensor. The servo horn will be connected to the motor output with servo spline as the medium from the gear box. The position sensor will be react and respond to the current position of the DC motor. Therefore, the resistance changes will be affected to the voltage from the position sensor. The signal from the pulse width modulation will be inserted to the control wire. The signal is then been converted to the equivalent voltage and been compared with the position sensor via error amplifier.

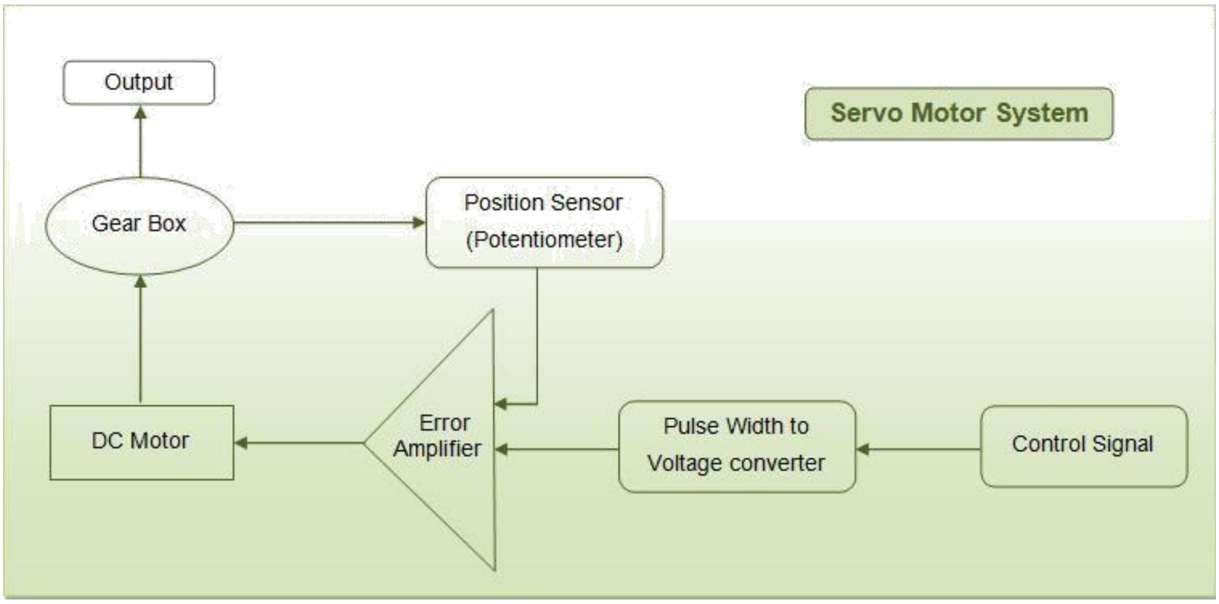

FIGURE 5: The Servo Motor System

The error amplified signal will be provided to the DC motor and been used by the DC motor as the desired position. The desired position and current position will be compared. When the difference is large the motor will rotates fast and when the difference is low, the motor will rotates in slow mode.

CHAPTER 3

METHODOLOGY

The important aspect need to be included while design the project understands of the tools and software used. For the rotating device, the main tools and software that need to be study are:

1. DC Motor

   It will be used as the primary driver to support the mechanical coupling.the authorneed to study the chosen DC Motor datasheet for references.

2. Arduino Board

   It is the electronics platform for controlling the motor and sensor.the authorneed to be familiar with arduino software and C / C++ coding to design the controller.

3. Rotator and Gear

   For rotator and gear the standard need to be follow. The best and suitable rotator and gear need to be studied and compared.

3.1 PROJECT FLOW CHART

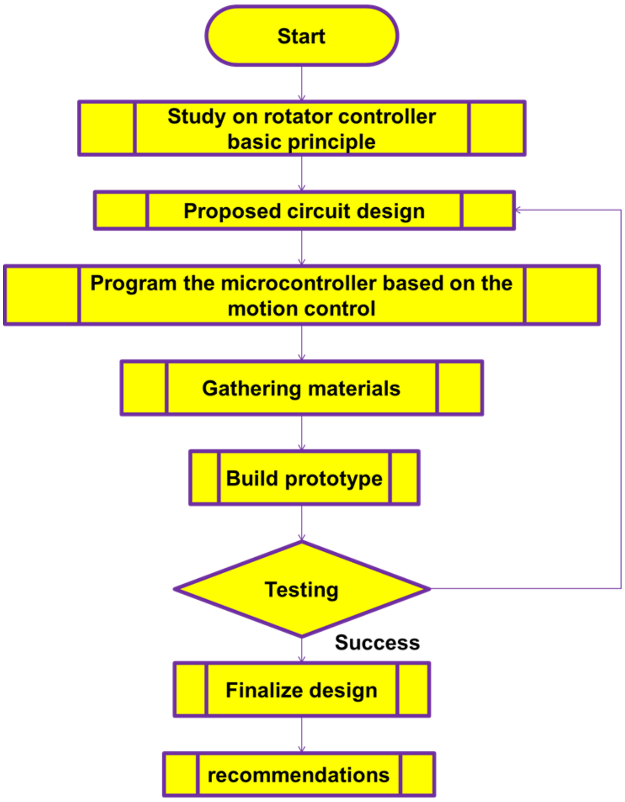

FIGURE 6: Methodology Flow Chart

3.1.1 Rotator Basic Principle and Proposed Circuit Design

The rotator basic principle need to include the human operator, comparator and desired angle. The human operator will give the input to the microcontroller to decide the desired angle. In the other hand, the comparator used to tally current angle with the desired angle. It will help to make sure the rotator stop in the right position. The encoder can be used as comparator. The block diagram can be illustrated as below:

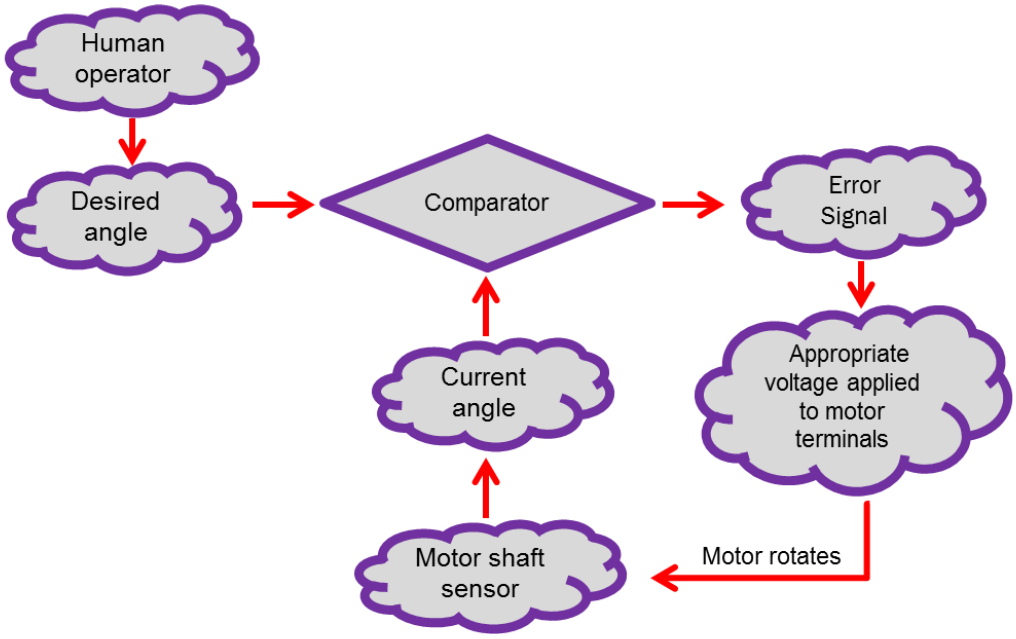

FIGURE 7: Rotator's Block Diagram

For the circuit design, the basic principle need to be considered for better output. The initial design planned as below:

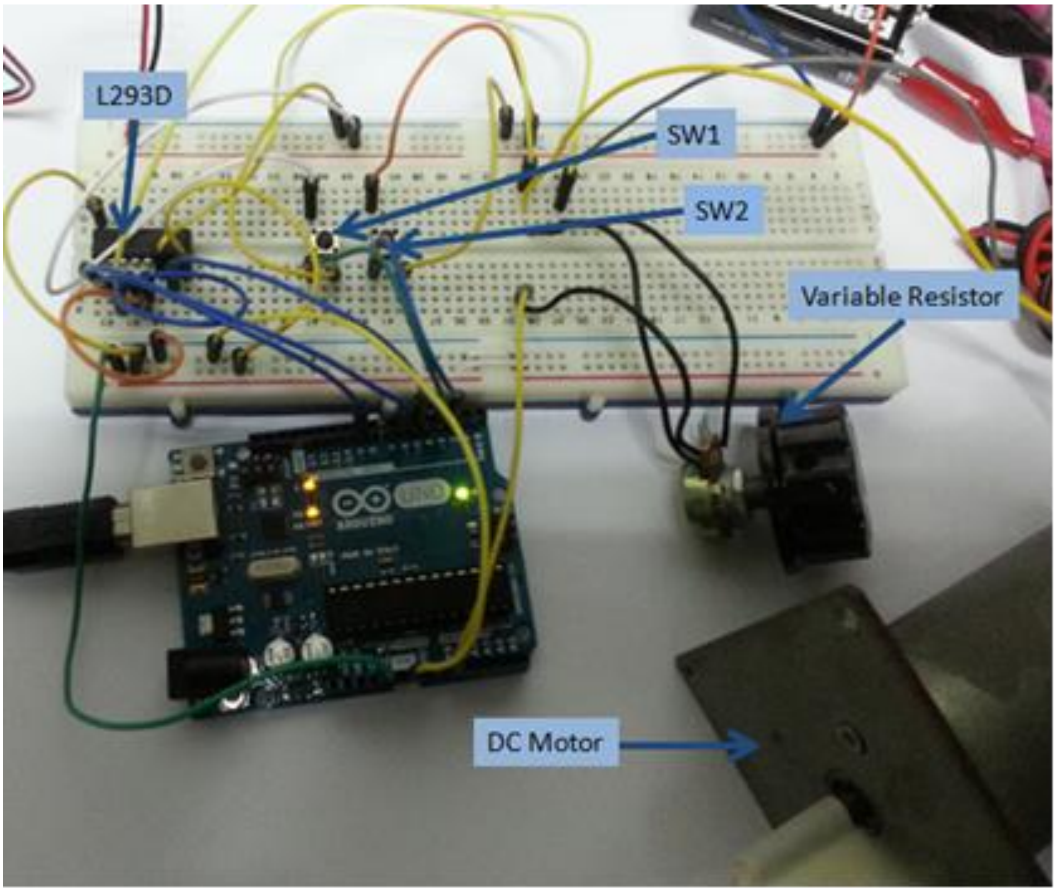

FIGURE 8: Initial Design Concept

Where switch 1 and switch 2 used to move the motor in clockwise and counter clockwise direction. Variable resistor used to control the speed and L293D chip is a motor driver.

The design then be changed by using toggle switch to change the rotation direction and push button to start the rotation. More details will be explain on the result and discussion.

3.1.2 Tools and materials

For the controller, materials used are:

- Arduino UNO
- L293D motor driver
- Push Button
- Toggle switch
- Potentiometer (10k Ohm)
- Resistor (10k Ohm and 4.7k Ohm)
- Capacitor (1000uF)
- LCD Display 16 X 2

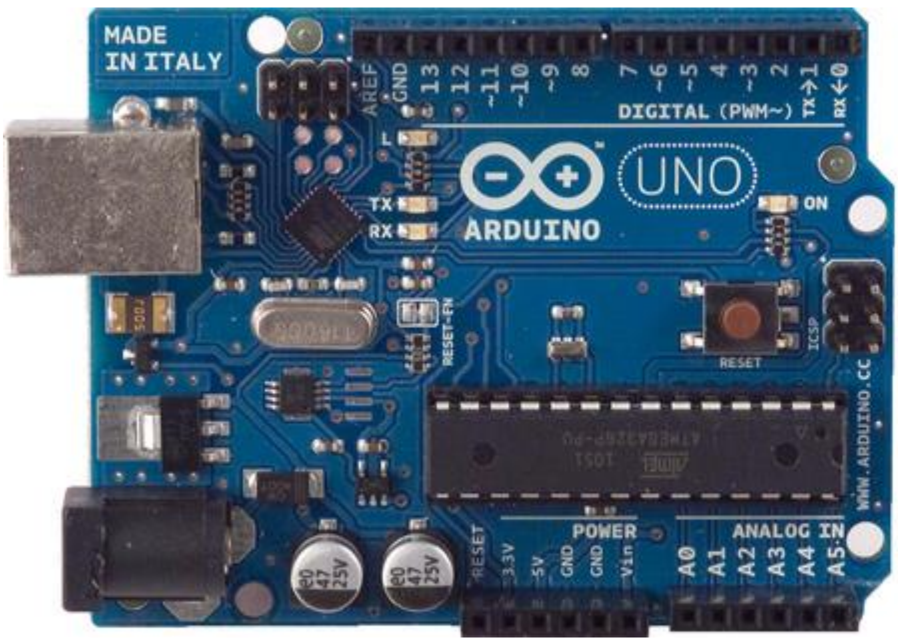

FIGURE 9: Arduino UNO

Arduino UNO function as microcontroller to control the motor rotation and speed. The specification as below:

Microcontroller	Arduino UNO
Operating Voltage	5V
Input Voltage (recommended)	7-12V
Input Voltage (limits)	6-20V
Digital I/O Pins	14 (of which 6 provide PWM output)
Analog Input Pins	6
DC Current per I/O Pin	40 mA
DC Current for 3.3V Pin	50 mA
Flash Memory	32 KB (ATmega328) of which 0.5 KB used by bootloader
SRAM	2 KB (ATmega328)
EEPROM	1 KB (ATmega328)
Clock Speed	16 MHz
Length	68.6 mm
Width	53.4 mm
Weight	25 g

L293D used to drive the motor. The chip can control 2 motor each but for this project, the author only used 1 motor. Using the chip is simpler because it is time-consuming for servo drive tuning.

This chip will connect the gear motor with LiPo battery and Arduino boards. For the rotator, motor used is DC Geared Motor. It can handle the current up to 2.2A in 12V.

FIGURE10: L293D Motor Driver

FIGURE 11: DC Geared Motor

- DC12V
- Output Power: 3.4 Watt
- Rated Speed: 170RPM
- Rated Current: 0.9A
- Rated Torque: 196mN.m

3.1.3 Programmed the Microcontroller and Testing Method

For the project works section, the procedure of the works and experiments will be explained briefly. The latest progress that has been done is to control the rotation of the motor clockwise and anti-clockwise by using push button and the speed can be adjusted by using potentiometer. The methodology to achieve this result as mention below:

1. The DC motor will be moving with help of H-bridge chip called L293D and will be controlled by Arduino controller.

2. The DC motor will be tested by using basic coding from Arduino to run clockwise and anti-clockwise. Then, the toggle switch will be used to indicate the rotation direction. Where push button will be used to start the rotation.

3. Therefore, the variable resistor will be used as potentiometer to control the speed of the motor to desired speed. The analogue input need to be added into the coding for potentiometer input. The simulation of the circuit diagram by using Virtual Bread Board (VBB) as below:

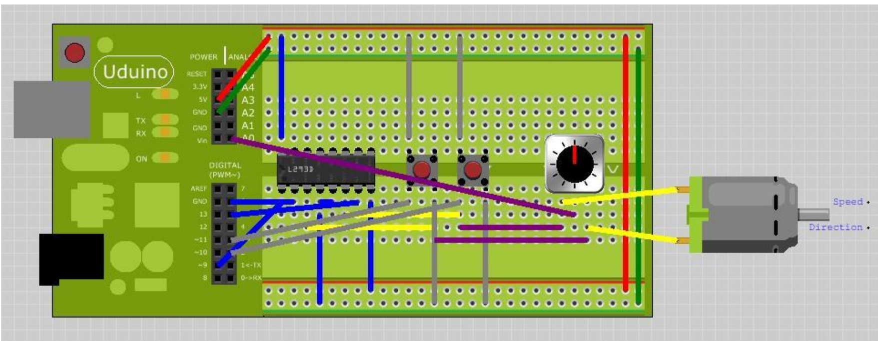

FIGURE 12: Project Current Design Using VBB

4. The value of the minimum and maximum of variable resistor been observed by using Serial Monitor. Then, the value will be used to control the speed of the motor from 0 to 255 binary numbers.

5. After all the method has been done, the data will be tested and analyzed.

3.2 GANT CHART AND KEY MILESTONE

The project will be carried out methodically based on the following timeline:

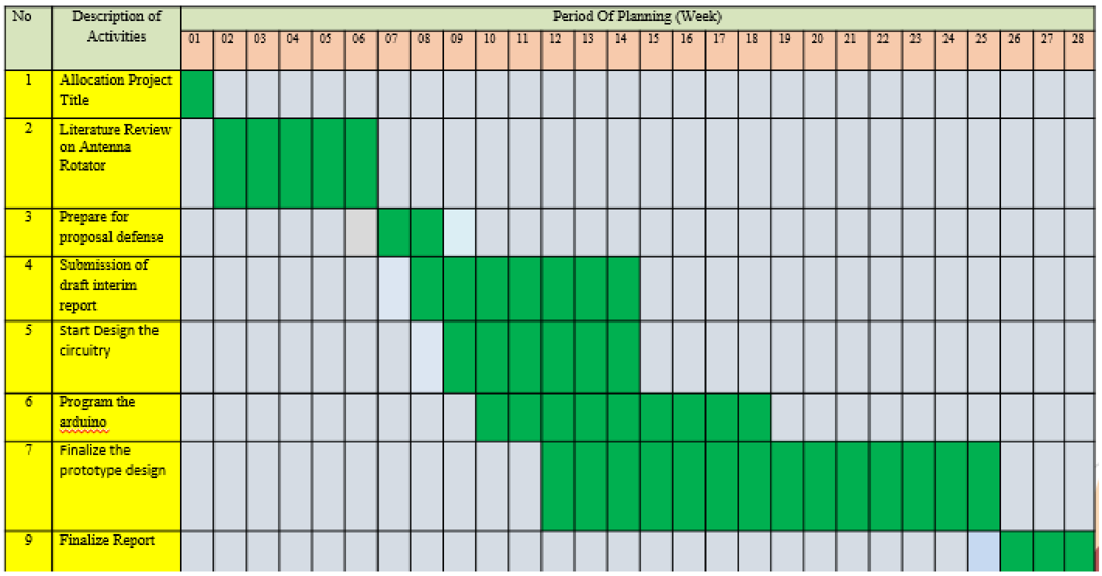

FIGURE 13: Project Gant Chart

CHAPTER 4

RESULT AND DISSCUSION

This chapter will discuss about the testing method and the preliminary design of the antenna rotator design and control. The most importance aspect that needs to be understood and tested is motor for position control. The basic block diagram for this project as shown in figure below:

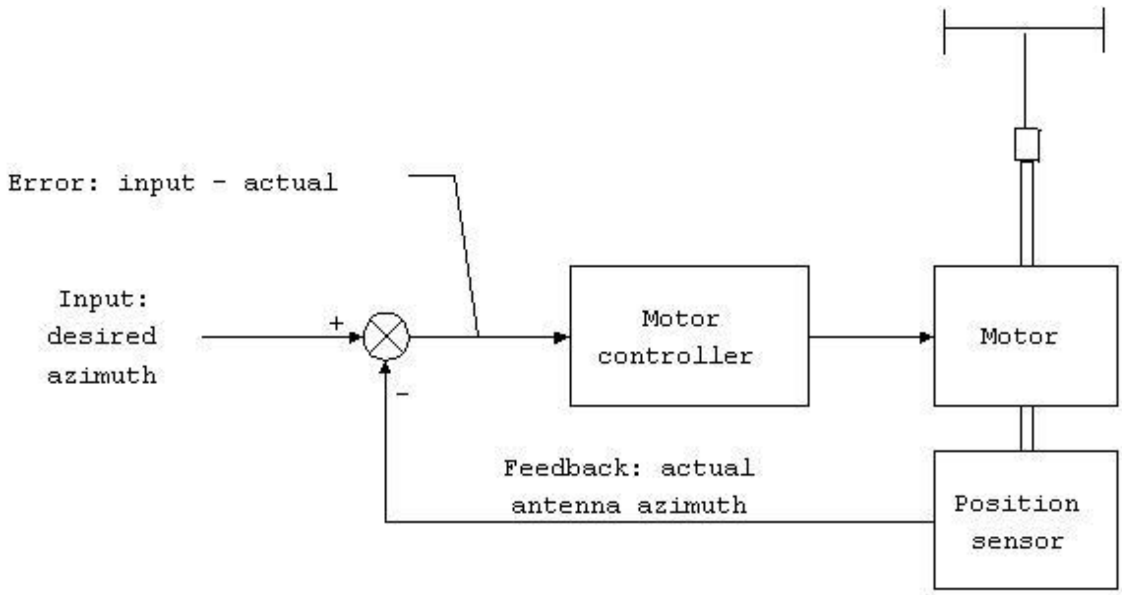

FIGURE 14: Serco Mechanism Block Diagram

The desired command of input antenna is the azimuth position of the antenna. The signal of error will drives the motor to move the antenna and will be stopped when the position feedback stated the antenna in a right desired azimuth.

The basic idea for antenna rotator is using microcontroller Arduino, AC power supply, motor, gearbox for gear step up and step down, rotator and position display. The figure of the design can be seen as below:

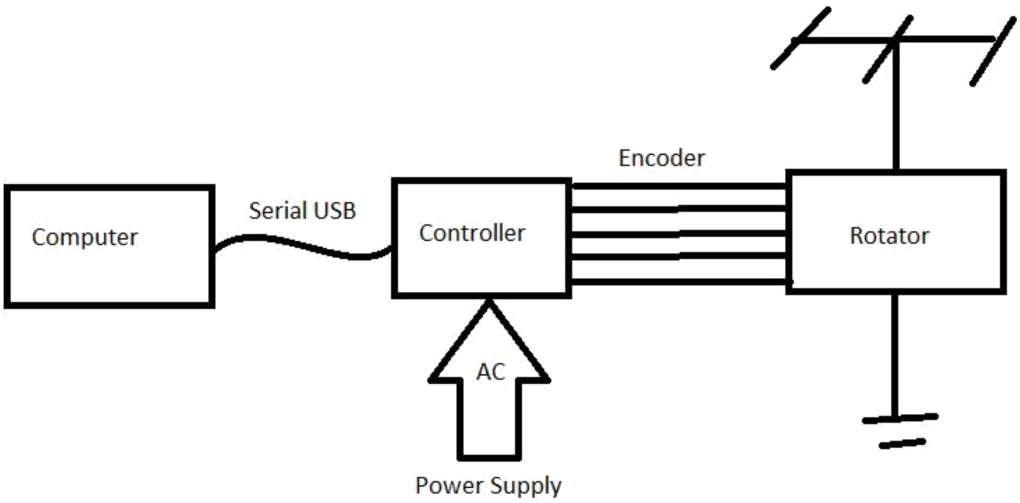

FIGURE 15: Antenna Rotator

The motor has been tested using Arduino for checking the basic principle of clockwise and anti-clockwise motor. The overall circuit diagram as below:

FIGURE 16: Project Final Design Concept

The motor is being drive by L293D chip. The chip has been powered by Arduino (5V) and supply approximately 5V to the motor + and motor – depending on the rotation direction. The speed of the rotation of the motor will be controlled by variable resistor. When the variable resistor is rotated to the clockwise, the speed of the motor will be decreased and to increase the speed, rotate the variable resistor anti-clockwise. The figure below shows the serial monitor displayed the speed of the motor by turning the variable resistor.

```
potentiometer = 434      motor = 91
potentiometer = 437      motor = 90
potentiometer = 442      motor = 91
potentiometer = 449      motor = 94
potentiometer = 455      motor = 97
potentiometer = 469      motor = 99
potentiometer = 483      motor = 105
potentiometer = 499      motor = 112
potentiometer = 509      motor = 119
potentiometer = 520      motor = 123
potentiometer = 530      motor = 128
potentiometer = 537      motor = 133
potentiometer = 539      motor = 136
potentiometer = 542      motor = 137
potentiometer = 543      motor = 138
potentiometer = 543      motor = 138
```

FIGURE 17: Serial Monitor from Arduino

The value of the potentiometer was set to be 230 to 800 where 230 is the minimum resistance and 800 reflected the maximum resistance of the variable resistor. It have been coded to control the motor speed from 0 to 255.

In order to control the rotation direction of the motor, a pair of push button switch has been used. The switches have being labelled as SW1 for clockwise rotation and SW2 for anti-clockwise rotation. Therefore, the position of the antenna can be controlled by pushing the SW1 of SW2 and stop when the motor have positioned in the right position.

The basic Arduino programming code:

```
int switchPin1 = 2;// switch input anticlockwise
int switchPin2 = 3; //switch input clockwise
int potPin = A0;
int motorPin1 = 5;    // pin 2 on L293D
int motorPin2 = 6;    // pin 7 on L293D
int enablePin = 9;    // pin 1 on L293D
int potValue = 0;
int motorValue = 0;


void setup() {
  // set the switch as an input:
  pinMode(switchPin1, INPUT);
  pinMode(switchPin2, INPUT);

  // set all the other pins you're using as outputs:
  pinMode(motorPin1, OUTPUT);
  pinMode(motorPin2, OUTPUT);
  pinMode(enablePin, OUTPUT);

  // set enablePin high so that motor can turn on:
  digitalWrite(enablePin, HIGH);

  Serial.begin(9600);
  }


void loop() {
  // if the switch is high, motor will turn on one direction:
  int f = digitalRead(switchPin1);
  int r = digitalRead(switchPin2);

  potValue = analogRead(potPin);

  Serial.print("potentiometer = " );
  Serial.print(potValue);
  Serial.print("\t motor = ");
  Serial.println(motorValue);
  delay(2);

  if (f == LOW && r == HIGH) {

    motorValue = map(potValue, 230, 805, 0, 255);
    digitalWrite(motorPin1, LOW);   // set pin 2 on L293D low
    digitalWrite(motorPin2, HIGH);  // set pin 7 on L293D high

  }
  // if the switch is low, motor will turn in the opposite direction:
  else if (r == LOW && f == HIGH) {

    motorValue = map(potValue, 805, 230, 0, 255);
    digitalWrite(motorPin1, HIGH);  // set pin 2 on L293D high
    digitalWrite(motorPin2, LOW);   // set pin 7 on L293D low

  }


  else {
    digitalWrite(motorPin1, LOW);  // set pin 2 on L293D low
    digitalWrite(motorPin2, LOW);   // set pin 7 on L293D low
  }

}
```

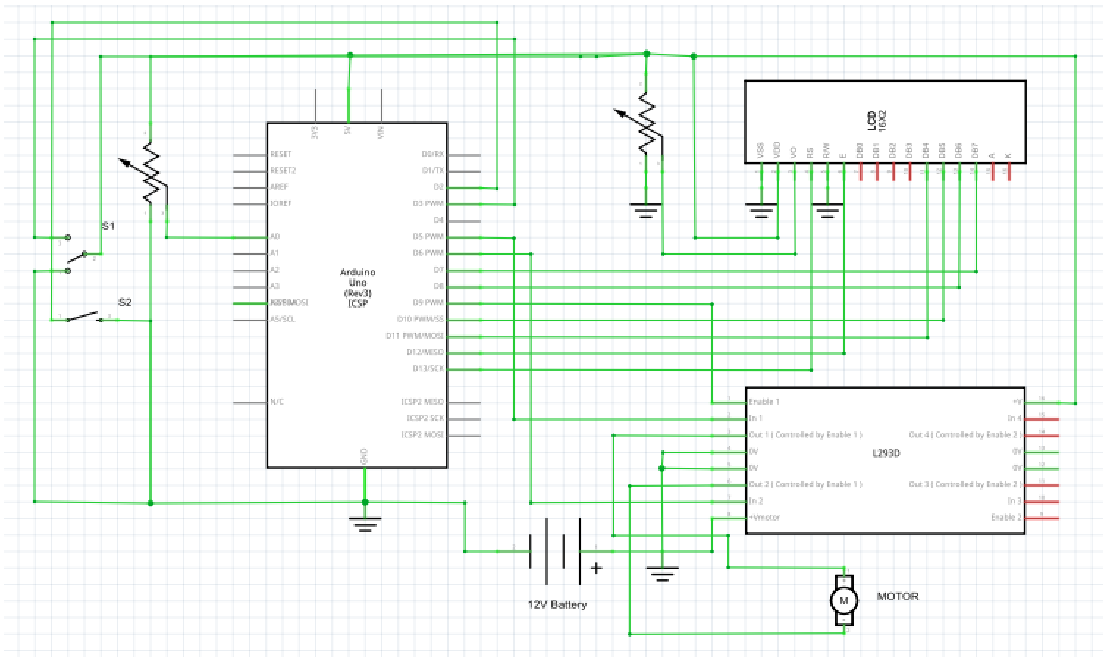

FIGURE 18: Schematics Diagram using Fritzing

The schematic diagram has been designed using Fritzing software. All the component used for the controller has been assigned as above:

From the schematic diagram above, we can clearly indicated the connection between the Arduino UNO, L293D and LCD with the switch and battery.
The controller then been placed in the black box for safety and tidiness of the prototype. The designed been shown below:

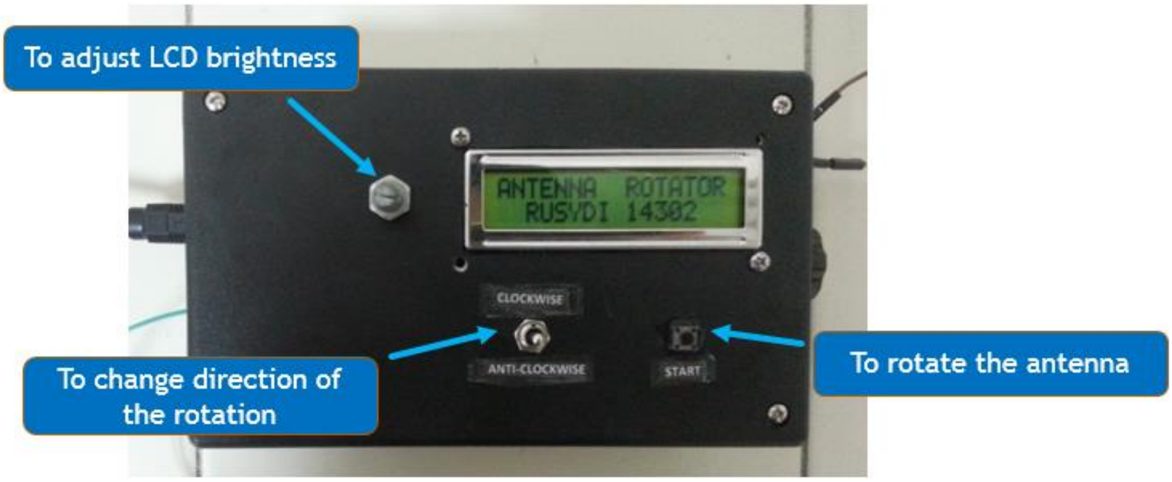

FIGURE 19: Front View of the Controller

FIGURE 20: Right Side of the Controller

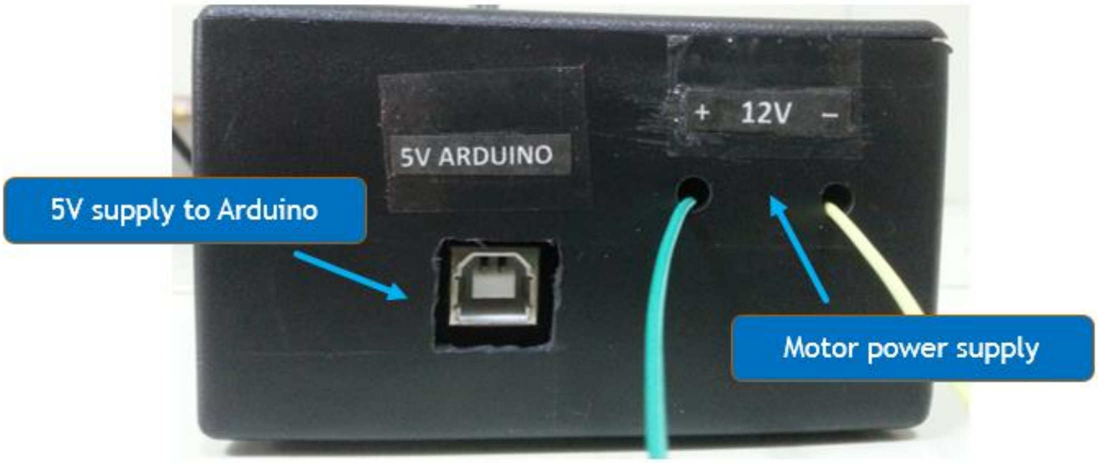

FIGURE 21: Left Side of the Controller

CHAPTER 5

CONCLUSION

The antenna rotator is the automation and control system project. It is required hardware and software knowledge in Arduino board and Dc motor as well as rotator. The design of the rotator effects on the azimuth angle and position of the antenna. The outcome of the project need to fulfil the working prototype for antenna rotator complete with rotating device, circuit interface and controller. The objectives that need to be achieved are the project needs to be done to design suitable rotation device with two depth of field (DOF) for azimuth and elevation control, design the interfacing circuit between the motor and the microcontroller. The project also needs to program and implement microcontroller based control strategy for motion control.

For recommendation, it is better to use wireless connection between the rotator and controller. It is also more applicable to use the higher motor rating to run the rotator with larger antenna. Last but not least, the antenna rotator can be upgrade to detect the signal and stop at the position where the desired signal been detected.

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APPENDICES

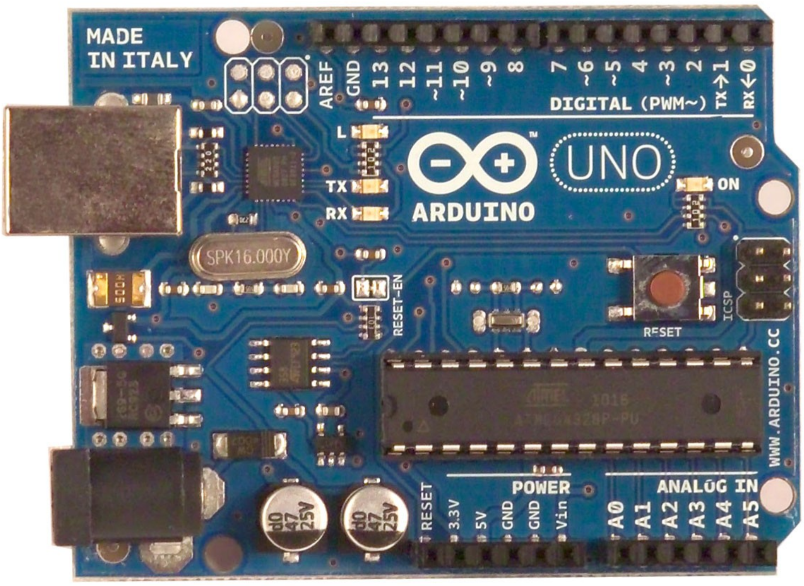
APPENDIX I

```
#include <LiquidCrystal.h>

LiquidCrystal lcd(13, 12, 11, 10, 8, 7);

int switchPin1 = 2;// switch to move the motor
int switchPin2 = 3; // switch to change direction
int motorPin1 = 5;    // pin 2 on L293D
int motorPin2 = 6;    // pin 7 on L293D
int enablePin = 9;    // pin 1 on L293D
int potPin = 0;

void setup() {
  // set the switch as an input:
  pinMode(switchPin1, INPUT_PULLUP);
  pinMode(switchPin2, INPUT);

  // set all the other pins you're using as outputs:
  pinMode(motorPin1, OUTPUT);
  pinMode(motorPin2, OUTPUT);
  pinMode(enablePin, OUTPUT);

  // set enablePin high so that motor can turn on:
  digitalWrite(enablePin, HIGH);

  lcd.begin(16, 2);
  lcd.setCursor(0, 0);
  lcd.print("ANTENNA  ROTATOR");
  lcd.setCursor(2, 1);
  lcd.print("RUSYDI 14302");
}

void loop() {

  int speed = analogRead(potPin) / 4;
  boolean reverse = digitalRead(switchPin1);
  setMotor(speed, reverse);
```

```
 // if the switch is high, motor will turn on one direction:
 if (digitalRead(switchPin1) == LOW) {

   if (digitalRead(switchPin2) == HIGH) {
     digitalWrite(motorPin1, HIGH);  // set pin 2 on L293D low
     digitalWrite(motorPin2, LOW);   // set pin 7 on L293D low
     lcd.begin(16, 2);
     lcd.setCursor(3, 0);
     lcd.print("Clockwise");
   }

   else if (digitalRead(switchPin2) == LOW) {
     digitalWrite(motorPin1, LOW);  // set pin 2 on L293D low
     digitalWrite(motorPin2, HIGH);   // set pin 7 on L293D low
     lcd.begin(16, 2);
     lcd.setCursor(1, 0);
     lcd.print("Anti-clockwise");
   }
 }

 else {
   digitalWrite(motorPin1, LOW);  // set pin 2 on L293D low
   digitalWrite(motorPin2, LOW);   // set pin 7 on L293D low
 }
}

 void setMotor(int speed, boolean reverse)
{
 analogWrite(enablePin, speed);
 digitalWrite(motorPin1, reverse);
 digitalWrite(motorPin2, reverse);
}
```

APPENDIX II

Arduino UNO



Product Overview

The Arduino Uno is a microcontroller board based on the ATmega328 (datasheet). It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started. The Uno differs from all preceding boards in that it does not use the FTDI USB-to-serial driver chip. Instead, it features the Atmega8U2 programmed as a USB-to-serial converter.

"Uno" means one in Italian and is named to mark the upcoming release of Arduino 1.0. The Uno and version 1.0 will be the reference versions of Arduno, moving forward. The Uno is the latest in a series of USB Arduino boards, and the reference model for the Arduino platform; for a comparison with previous versions, see the index of Arduino boards.

Index

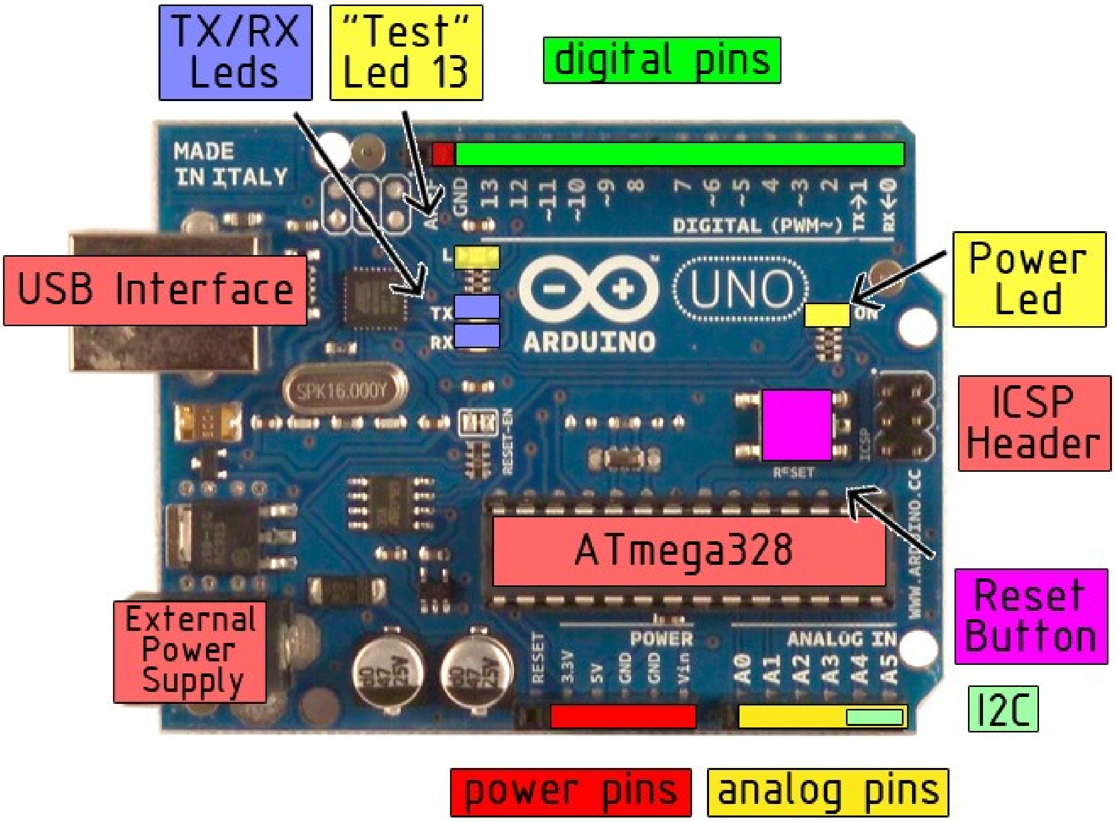
Technical Specification

EAGLE files: arduino-duemilanove-uno-design.zip Schematic: arduino-uno-schematic.pdf

Summary

Microcontroller	ATmega328
Operating Voltage	5V
Input Voltage (recommended)	7-12V
Input Voltage (limits)	6-20V
Digital I/O Pins	14 (of which 6 provide PWM output)
Analog Input Pins	6
DC Current per I/O Pin	40 mA
DC Current for 3.3V Pin	50 mA
Flash Memory	32 KB of which 0.5 KB used by bootloader
SRAM	2 KB
EEPROM	1 KB
Clock Speed	16 MHz

the board



Power

The Arduino Uno can be powered via the USB connection or with an external power supply. The power source is selected automatically.

External (non-USB) power can come either from an AC-to-DC adapter (wall-wart) or battery. The adapter can be connected by plugging a 2.1mm center-positive plug into the board's power jack. Leads from a battery can be inserted in the Gnd and Vin pin headers of the POWER connector.

The board can operate on an external supply of 6 to 20 volts. If supplied with less than 7V, however, the 5V pin may supply less than five volts and the board may be unstable. If using more than 12V, the voltage regulator may overheat and damage the board. The recommended range is 7 to 12 volts.

The power pins are as follows:

- **VIN.** The input voltage to the Arduino board when it's using an external power source (as opposed to 5 volts from the USB connection or other regulated power source). You can supply voltage through this pin, or, if supplying voltage via the power jack, access it through this pin.
- **5V.** The regulated power supply used to power the microcontroller and other components on the board. This can come either from VIN via an on-board regulator, or be supplied by USB or another regulated 5V supply.
- **3V3.** A 3.3 volt supply generated by the on-board regulator. Maximum current draw is 50 mA.
- **GND.** Ground pins.

Memory

The Atmega328 has 32 KB of flash memory for storing code (of which 0,5 KB is used for the bootloader); It has also 2 KB of SRAM and 1 KB of EEPROM (which can be read and written with the EEPROM library).

Input and Output

Each of the 14 digital pins on the Uno can be used as an input or output, using pinMode(), digitalWrite(), and digitalRead() functions. They operate at 5 volts. Each pin can provide or receive a maximum of 40 mA and has an internal pull-up resistor (disconnected by default) of 20-50 kOhms. In addition, some pins have specialized functions:

- **Serial: 0 (RX) and 1 (TX).** Used to receive (RX) and transmit (TX) TTL serial data. TThese pins are connected to the corresponding pins of the ATmega8U2 USB-to-TTL Serial chip .
- **External Interrupts: 2 and 3.** These pins can be configured to trigger an interrupt on a low value, a rising or falling edge, or a change in value. See the attachInterrupt() function for details.
- **PWM: 3, 5, 6, 9, 10, and 11.** Provide 8-bit PWM output with the analogWrite() function.
- **SPI: 10 (SS), 11 (MOSI), 12 (MISO), 13 (SCK).** These pins support SPI communication, which, although provided by the underlying hardware, is not currently included in the Arduino language.

- **LED: 13.** There is a built-in LED connected to digital pin 13. When the pin is HIGH value, the LED is on, when the pin is LOW, it's off.

The Uno has 6 analog inputs, each of which provide 10 bits of resolution (i.e. 1024 different values). By default they measure from ground to 5 volts, though is it possible to change the upper end of their range using the AREF pin and the analogReference() function. Additionally, some pins have specialized functionality:

- **I^2C: 4 (SDA) and 5 (SCL).** Support I^2C (TWI) communication using the Wire library.

There are a couple of other pins on the board:

- **AREF.** Reference voltage for the analog inputs. Used with analogReference().
- **Reset.** Bring this line LOW to reset the microcontroller. Typically used to add a reset button to shields which block the one on the board.

See also the mapping between Arduino pins and Atmega328 ports.

Communication

The Arduino Uno has a number of facilities for communicating with a computer, another Arduino, or other microcontrollers. The ATmega328 provides UART TTL (5V) serial communication, which is available on digital pins 0 (RX) and 1 (TX). An ATmega8U2 on the board channels this serial communication over USB and appears as a virtual com port to software on the computer. The '8U2 firmware uses the standard USB COM drivers, and no external driver is needed. However, on Windows, an *.inf file is required..

The Arduino software includes a serial monitor which allows simple textual data to be sent to and from the Arduino board. The RX and TX LEDs on the board will flash when data is being transmitted via the USB-to-serial chip and USB connection to the computer (but not for serial communication on pins 0 and 1).

A SoftwareSerial library allows for serial communication on any of the Uno's digital pins.

The ATmega328 also support I2C (TWI) and SPI communication. The Arduino software includes a Wire library to simplify use of the I2C bus; see the documentation for details. To use the SPI communication, please see the ATmega328 datasheet.

Programming

The Arduino Uno can be programmed with the Arduino software (download). Select "Arduino Uno w/ ATmega328" from the **Tools > Board** menu (according to the microcontroller on your board). For details, see the reference and tutorials.

The ATmega328 on the Arduino Uno comes preburned with a bootloader that allows you to upload new code to it without the use of an external hardware programmer. It communicates using the original STK500 protocol (reference, C header files).

You can also bypass the bootloader and program the microcontroller through the ICSP (In-Circuit Serial Programming) header; see these instructions for details.

The ATmega8U2 firmware source code is available . The ATmega8U2 is loaded with a DFU bootloader, which can be activated by connecting the solder jumper on the back of the board (near the map of Italy) and then resetting the 8U2. You can then use Atmel's FLIP software (Windows) or the DFU programmer (Mac OS X and Linux) to load a new firmware. Or you can use the ISP header with an external programmer (overwriting the DFU bootloader).

Automatic (Software) Reset

Rather than requiring a physical press of the reset button before an upload, the Arduino Uno is designed in a way that allows it to be reset by software running on a connected computer. One of the hardware flow control lines (DTR) of the ATmega8U2 is connected to the reset line of the ATmega328 via a 100 nanofarad capacitor. When this line is asserted (taken low), the reset line drops long enough to reset the chip. The Arduino software uses this capability to allow you to upload code by simply pressing the upload button in the Arduino environment. This means that the bootloader can have a shorter timeout, as the lowering of DTR can be well-coordinated with the start of the upload.

This setup has other implications. When the Uno is connected to either a computer running Mac OS X or Linux, it resets each time a connection is made to it from software (via USB). For the following half-second or so, the bootloader is running on the Uno. While it is programmed to ignore malformed data (i.e. anything besides an upload of new code), it will intercept the first few bytes of data sent to the board after a connection is opened. If a sketch running on the board receives one-time configuration or other data when it first starts, make sure that the software with which it communicates waits a second after opening the connection and before sending this data.

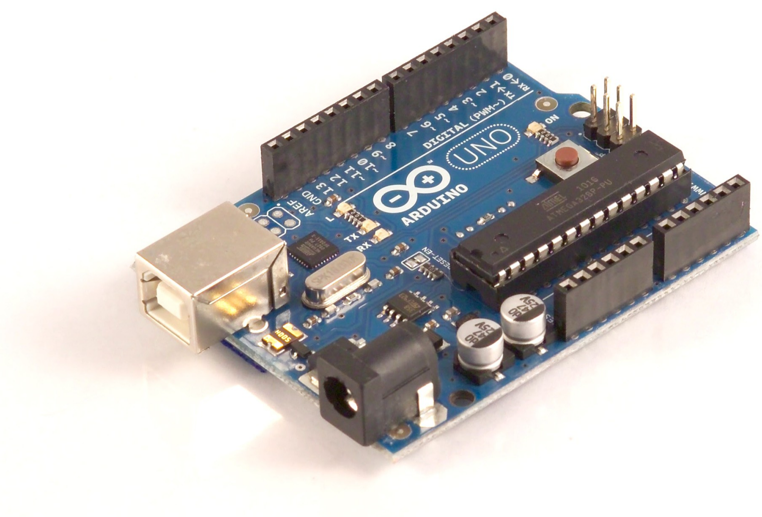
The Uno contains a trace that can be cut to disable the auto-reset. The pads on either side of the trace can be soldered together to re-enable it. It's labeled "RESET-EN". You may also be able to disable the auto-reset by connecting a 110 ohm resistor from 5V to the reset line; see this forum thread for details.

USB Overcurrent Protection

The Arduino Uno has a resettable polyfuse that protects your computer's USB ports from shorts and overcurrent. Although most computers provide their own internal protection, the fuse provides an extra layer of protection. If more than 500 mA is applied to the USB port, the fuse will automatically break the connection until the short or overload is removed.

Physical Characteristics

The maximum length and width of the Uno PCB are 2.7 and 2.1 inches respectively, with the USB connector and power jack extending beyond the former dimension. Three screw holes allow the board to be attached to a surface or case. Note that the distance between digital pins 7 and 8 is 160 mil (0.16"), not an even multiple of the 100 mil spacing of the other pins.



How to use Arduino

Arduino can sense the environment by receiving input from a variety of sensors and can affect its surroundings by controlling lights, motors, and other actuators. The microcontroller on the board is programmed using the Arduino programming language (based on Wiring) and the Arduino development environment (based on Processing). Arduino projects can be stand-alone or they can communicate with software on running on a computer (e.g. Flash, Processing, MaxMSP).

Arduino is a cross-platoform program. You'll have to follow different instructions for your personal OS. Check on the Arduino site for the latest instructions. *http://arduino.cc/en/Guide/HomePage*

Linux Install

Windows Install

Mac Install

Once you have downloaded/unzipped the arduino IDE, you can Plug the Arduino to your PC via USB cable.

Blink led

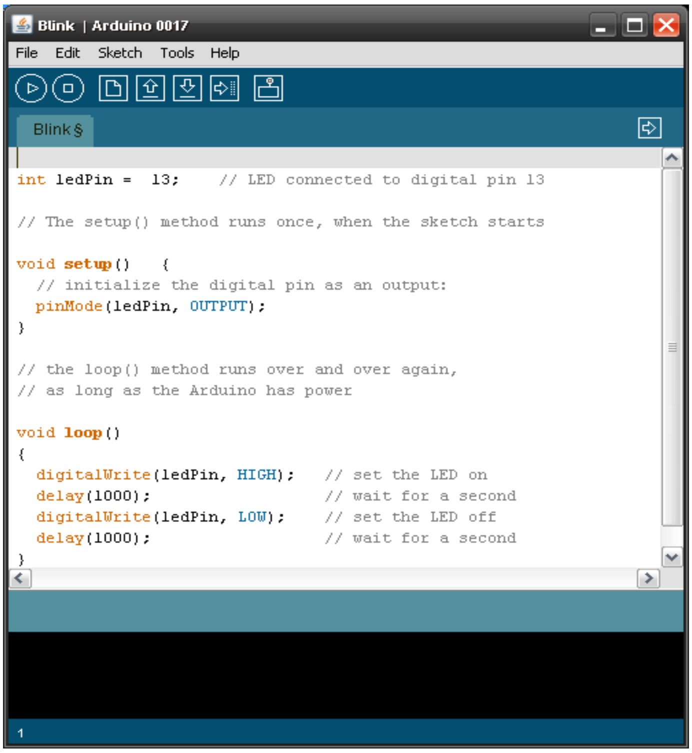
Now you're actually ready to "burn" your first program on the arduino board. To select "blink led", the physical translation of the well known programming "hello world", select

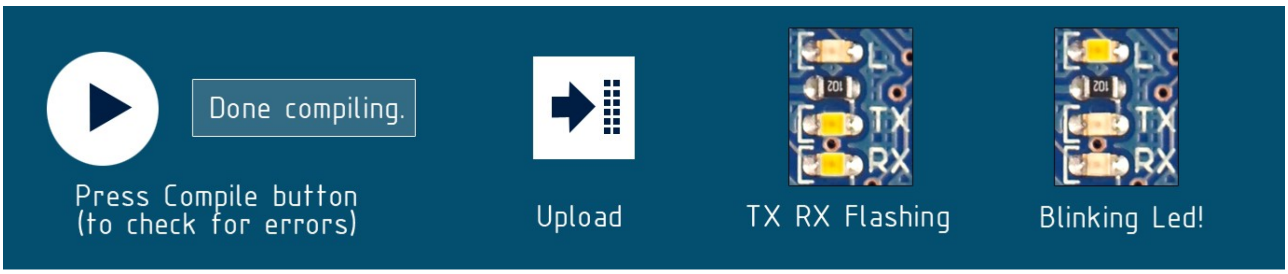
**File>Sketchbook>
Arduino-0017>Examples>
Digital>Blink**

Once you have your skecth you'll see something very close to the screenshot on the right.

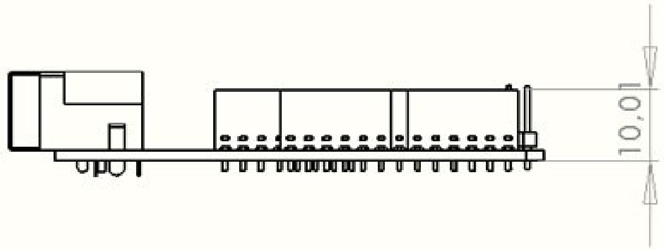
In **Tools>Board** select

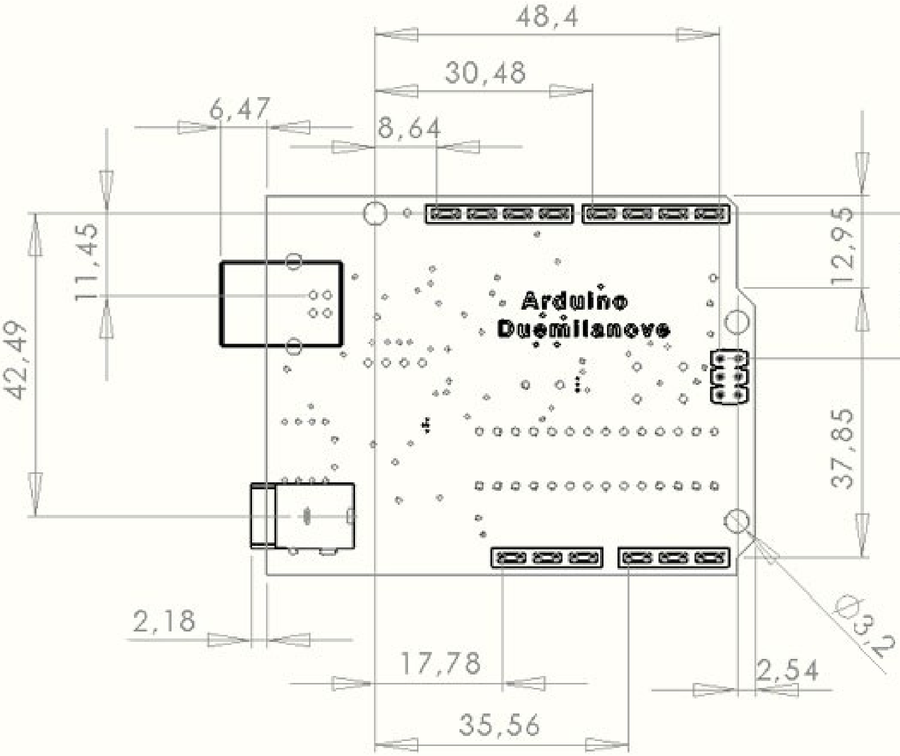
Now you have to go to
Tools>SerialPort
and select the right serial port, the one arduino is attached to.

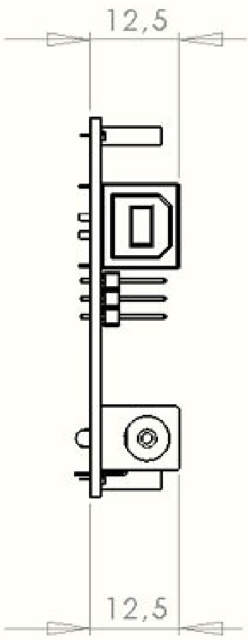


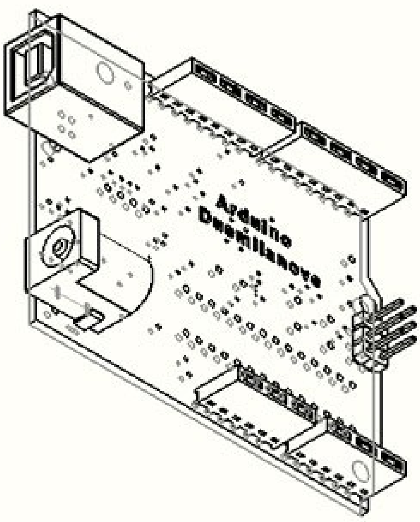


Dimensioned Drawing









Terms & Conditions

1. Warranties

1.1 The producer warrants that its products will conform to the Specifications. This warranty lasts for one (1) years from the date of the sale. The producer shall not be liable for any defects that are caused by neglect, misuse or mistreatment by the Customer, including improper installation or testing, or for any products that have been altered or modified in any way by a Customer. Moreover, The producer shall not be liable for any defects that result from Customer's design, specifications or instructions for such products. Testing and other quality control techniques are used to the extent the producer deems necessary.

1.2 If any products fail to conform to the warranty set forth above, the producer's sole liability shall be to replace such products. The producer's liability shall be limited to products that are determined by the producer not to conform to such warranty. If the producer elects to replace such products, the producer shall have a reasonable time to replacements. Replaced products shall be warranted for a new full warranty period.

1.3 EXCEPT AS SET FORTH ABOVE, PRODUCTS ARE PROVIDED "AS IS" AND "WITH ALL FAULTS." THE PRODUCER DISCLAIMS ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, REGARDING PRODUCTS, INCLUDING BUT NOT LIMITED TO, ANY IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE

1.4 Customer agrees that prior to using any systems that include the producer products, Customer will test such systems and the functionality of the products as used in such systems. The producer may provide technical, applications or design advice, quality characterization, reliability data or other services. Customer acknowledges and agrees that providing these services shall not expand or otherwise alter the producer's warranties, as set forth above, and no additional obligations or liabilities shall arise from the producer providing such services.

1.5 The Arduino™ products are not authorized for use in safety-critical applications where a failure of the product would reasonably be expected to cause severe personal injury or death. Safety-Critical Applications include, without limitation, life support devices and systems, equipment or systems for the operation of nuclear facilities and weapons systems. Arduino™ products are neither designed nor intended for use in military or aerospace applications or environments and for automotive applications or environment. Customer acknowledges and agrees that any such use of Arduino™ products which is solely at the Customer's risk, and that Customer is solely responsible for compliance with all legal and regulatory requirements in connection with such use.

1.6 Customer acknowledges and agrees that it is solely responsible for compliance with all legal, regulatory and safety-related requirements concerning its products and any use of Arduino™ products in Customer's applications, notwithstanding any applications-related information or support that may be provided by the producer.

2. Indemnification

The Customer acknowledges and agrees to defend, indemnify and hold harmless the producer from and against any and all third-party losses, damages, liabilities and expenses it incurs to the extent directly caused by: (i) an actual breach by a Customer of the representation and warranties made under this terms and conditions or (ii) the gross negligence or willful misconduct by the Customer.

3. Consequential Damages Waiver

In no event the producer shall be liable to the Customer or any third parties for any special, collateral, indirect, punitive, incidental, consequential or exemplary damages in connection with or arising out of the products provided hereunder, regardless of whether the producer has been advised of the possibility of such damages. This section will survive the termination of the warranty period.

4. Changes to specifications

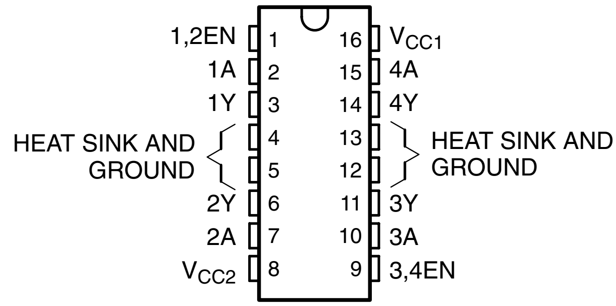
The producer may make changes to specifications and product descriptions at any time, without notice. The Customer must not rely on the absence or characteristics of any features or instructions marked "reserved" or "undefined." The producer reserves these for future definition and shall have no responsibility whatsoever for conflicts or incompatibilities arising from future changes to them. The product information on the Web Site or Materials is subject to change without notice. Do not finalize a design with this information.

Enviromental Policies

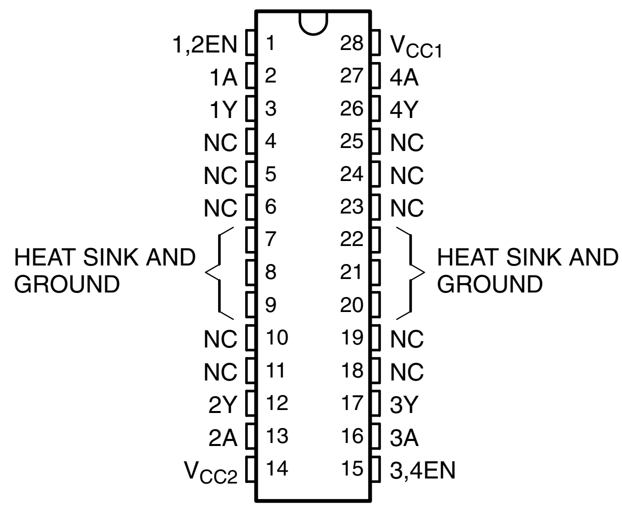
The producer of Arduino™ has joined the Impatto Zero® policy of LifeGate.it. For each Arduino board produced is created / looked after half squared Km of Costa Rica's forest's.

- **Featuring Unitrode L293 and L293D Products Now From Texas Instruments**
- **Wide Supply-Voltage Range: 4.5 V to 36 V**
- **Separate Input-Logic Supply**
- **Internal ESD Protection**
- **Thermal Shutdown**
- **High-Noise-Immunity Inputs**
- **Functionally Similar to SGS L293 and SGS L293D**
- **Output Current 1 A Per Channel (600 mA for L293D)**
- **Peak Output Current 2 A Per Channel (1.2 A for L293D)**
- **Output Clamp Diodes for Inductive Transient Suppression (L293D)**

L293 . . . N OR NE PACKAGE
L293D . . . NE PACKAGE
(TOP VIEW)



L293 . . . DWP PACKAGE
(TOP VIEW)



description/ordering information

The L293 and L293D are quadruple high-current half-H drivers. The L293 is designed to provide bidirectional drive currents of up to 1 A at voltages from 4.5 V to 36 V. The L293D is designed to provide bidirectional drive currents of up to 600-mA at voltages from 4.5 V to 36 V. Both devices are designed to drive inductive loads such as relays, solenoids, dc and bipolar stepping motors, as well as other high-current/high-voltage loads in positive-supply applications.

All inputs are TTL compatible. Each output is a complete totem-pole drive circuit, with a Darlington transistor sink and a pseudo-Darlington source. Drivers are enabled in pairs, with drivers 1 and 2 enabled by 1,2EN and drivers 3 and 4 enabled by 3,4EN. When an enable input is high, the associated drivers are enabled, and their outputs are active and in phase with their inputs. When the enable input is low, those drivers are disabled, and their outputs are off and in the high-impedance state. With the proper data inputs, each pair of drivers forms a full-H (or bridge) reversible drive suitable for solenoid or motor applications.

ORDERING INFORMATION

T_A	PACKAGE†		ORDERABLE PART NUMBER	TOP-SIDE MARKING
0°C to 70°C	HSOP (DWP)	Tube of 20	L293DWP	L293DWP
	PDIP (N)	Tube of 25	L293N	L293N
	PDIP (NE)	Tube of 25	L293NE	L293NE
		Tube of 25	L293DNE	L293DNE

† Package drawings, standard packing quantities, thermal data, symbolization, and PCB design guidelines are available at www.ti.com/sc/package.

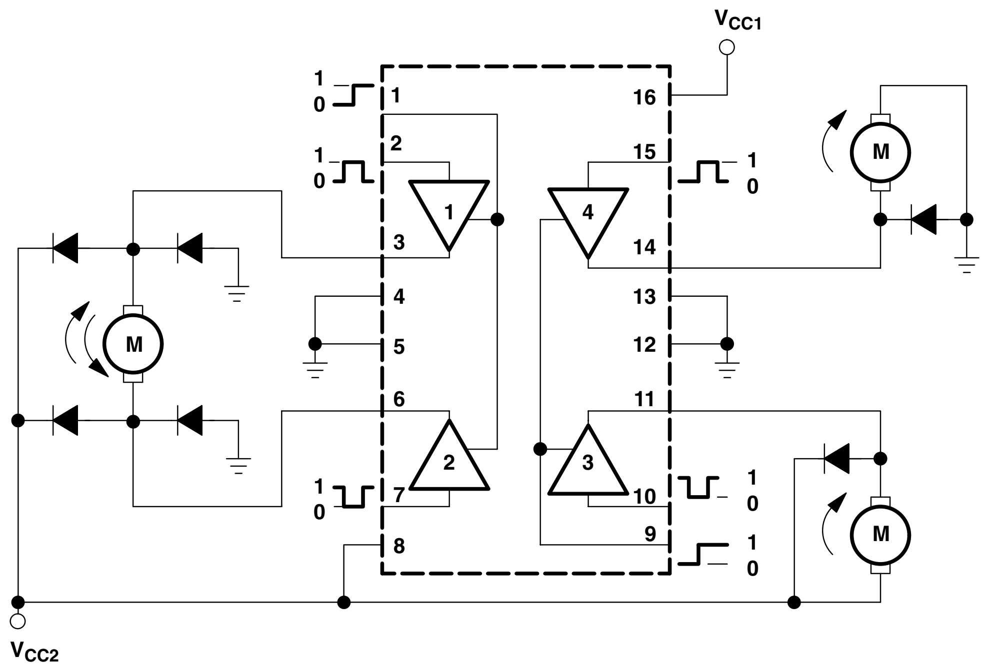
description/ordering information (continued)

On the L293, external high-speed output clamp diodes should be used for inductive transient suppression.

A V_{CC1} terminal, separate from V_{CC2}, is provided for the logic inputs to minimize device power dissipation.

The L293and L293D are characterized for operation from 0°C to 70°C.

block diagram



NOTE: Output diodes are internal in L293D.

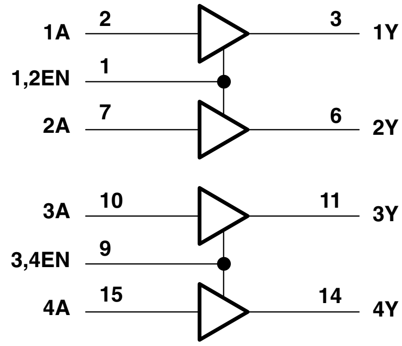
FUNCTION TABLE
(each driver)

INPUTS†		OUTPUT
A	EN	Y
H	H	H
L	H	L
X	L	Z

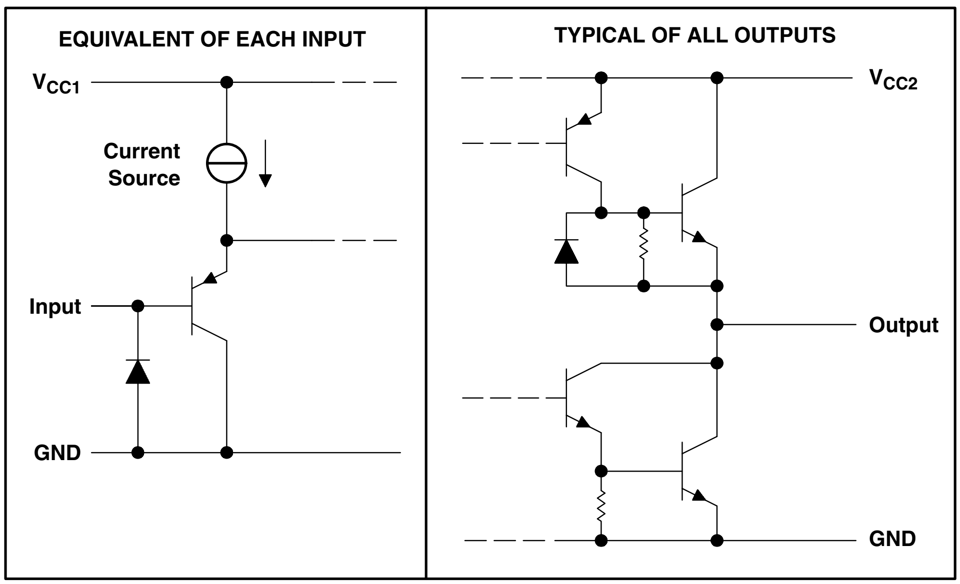
H = high level, L = low level, X = irrelevant,
Z = high impedance (off)

† In the thermal shutdown mode, the output is in the high-impedance state, regardless of the input levels.

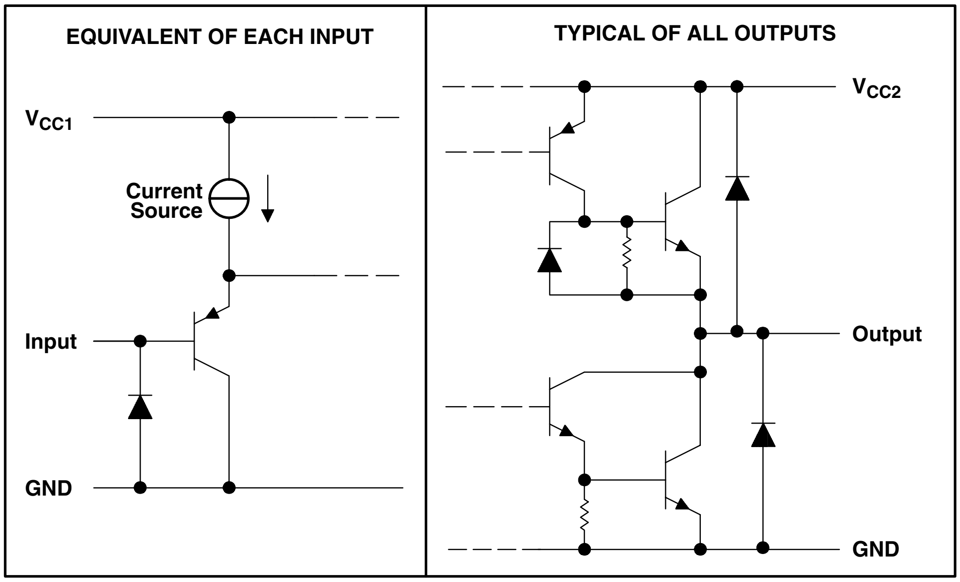
logic diagram



schematics of inputs and outputs (L293)



schematics of inputs and outputs (L293D)



absolute maximum ratings over operating free-air temperature range (unless otherwise noted)†

Supply voltage, V_{CC1} (see Note 1)		36 V
Output supply voltage, V_{CC2}		36 V
Input voltage, V_I		7 V
Output voltage range, V_O		–3 V to V_{CC2} + 3 V
Peak output current, I_O (nonrepetitive, $t \leq 5$ ms): L293		±2 A
Peak output current, I_O (nonrepetitive, $t \leq 100$ µs): L293D		±1.2 A
Continuous output current, I_O: L293		±1 A
Continuous output current, I_O: L293D		±600 mA
Package thermal impedance, θ_{JA} (see Notes 2 and 3):	DWP package	TBD°C/W
	N package	67°C/W
	NE package	TBD°C/W
Maximum junction temperature, T_J		150°C
Storage temperature range, T_{stg}		–65°C to 150°C

† Stresses beyond those listed under "absolute maximum ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under "recommended operating conditions" is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

NOTES: 1. All voltage values are with respect to the network ground terminal.
2. Maximum power dissipation is a function of T_J(max), θ_{JA}, and T_A. The maximum allowable power dissipation at any allowable ambient temperature is $P_D = (T_J(max) – T_A)/\theta_{JA}$. Operating at the absolute maximum T_J of 150°C can affect reliability.
3. The package thermal impedance is calculated in accordance with JESD 51-7.

recommended operating conditions

			MIN	MAX	UNIT
	Supply voltage	V_{CC1}	4.5	7	V
		V_{CC2}	V_{CC1}	36	
V_{IH}	High-level input voltage	$V_{CC1} \leq 7$ V	2.3	V_{CC1}	V
		$V_{CC1} \geq 7$ V	2.3	7	V
V_{IL}	Low-level output voltage		–0.3†	1.5	V
T_A	Operating free-air temperature		0	70	°C

† The algebraic convention, in which the least positive (most negative) designated minimum, is used in this data sheet for logic voltage levels.

electrical characteristics, V_{CC1} = 5 V, V_{CC2} = 24 V, T_A = 25°C

PARAMETER			TEST CONDITIONS		MIN	TYP	MAX	UNIT
V_{OH}	High-level output voltage		L293: I_{OH} = –1 A L293D: I_{OH} = –0.6 A		V_{CC2} – 1.8	V_{CC2} – 1.4		V
V_{OL}	Low-level output voltage		L293: I_{OL} = 1 A L293D: I_{OL} = 0.6 A			1.2	1.8	V
V_{OKH}	High-level output clamp voltage		L293D: I_{OK} = –0.6 A			V_{CC2} + 1.3		V
V_{OKL}	Low-level output clamp voltage		L293D: I_{OK} = 0.6 A			1.3		V
I_{IH}	High-level input current	A	V_I = 7 V			0.2	100	μA
		EN				0.2	10	
I_{IL}	Low-level input current	A	V_I = 0			–3	–10	μA
		EN				–2	–100	
I_{CC1}	Logic supply current		I_O = 0	All outputs at high level		13	22	mA
				All outputs at low level		35	60	
				All outputs at high impedance		8	24	
I_{CC2}	Output supply current		I_O = 0	All outputs at high level		14	24	mA
				All outputs at low level		2	6	
				All outputs at high impedance		2	4	

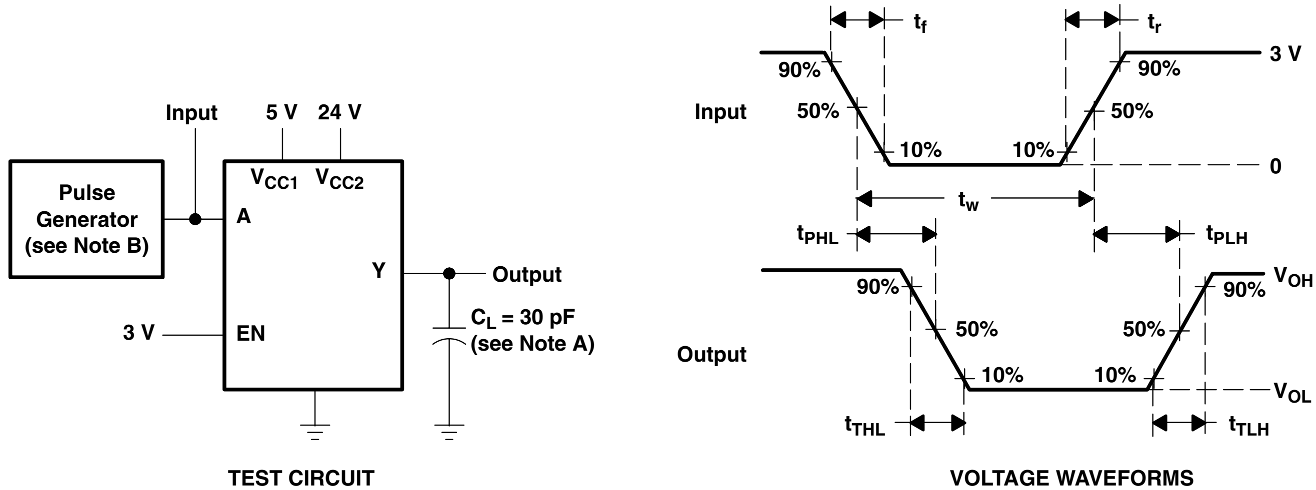
switching characteristics, V_{CC1} = 5 V, V_{CC2} = 24 V, T_A = 25°C

PARAMETER		TEST CONDITIONS	L293NE, L293DNE			UNIT
			MIN	TYP	MAX	
t_{PLH}	Propagation delay time, low-to-high-level output from A input	C_L = 30 pF, See Figure 1		800		ns
t_{PHL}	Propagation delay time, high-to-low-level output from A input			400		ns
t_{TLH}	Transition time, low-to-high-level output			300		ns
t_{THL}	Transition time, high-to-low-level output			300		ns

switching characteristics, V_{CC1} = 5 V, V_{CC2} = 24 V, T_A = 25°C

PARAMETER		TEST CONDITIONS	L293DWP, L293N L293DN			UNIT
			MIN	TYP	MAX	
t_{PLH}	Propagation delay time, low-to-high-level output from A input	C_L = 30 pF, See Figure 1		750		ns
t_{PHL}	Propagation delay time, high-to-low-level output from A input			200		ns
t_{TLH}	Transition time, low-to-high-level output			100		ns
t_{THL}	Transition time, high-to-low-level output			350		ns

PARAMETER MEASUREMENT INFORMATION



NOTES: A. C_L includes probe and jig capacitance.
B. The pulse generator has the following characteristics: $t_r \leq 10$ ns, $t_f \leq 10$ ns, $t_w = 10$ µs, PRR = 5 kHz, $Z_O = 50\ \Omega$.

Figure 1. Test Circuit and Voltage Waveforms

APPLICATION INFORMATION

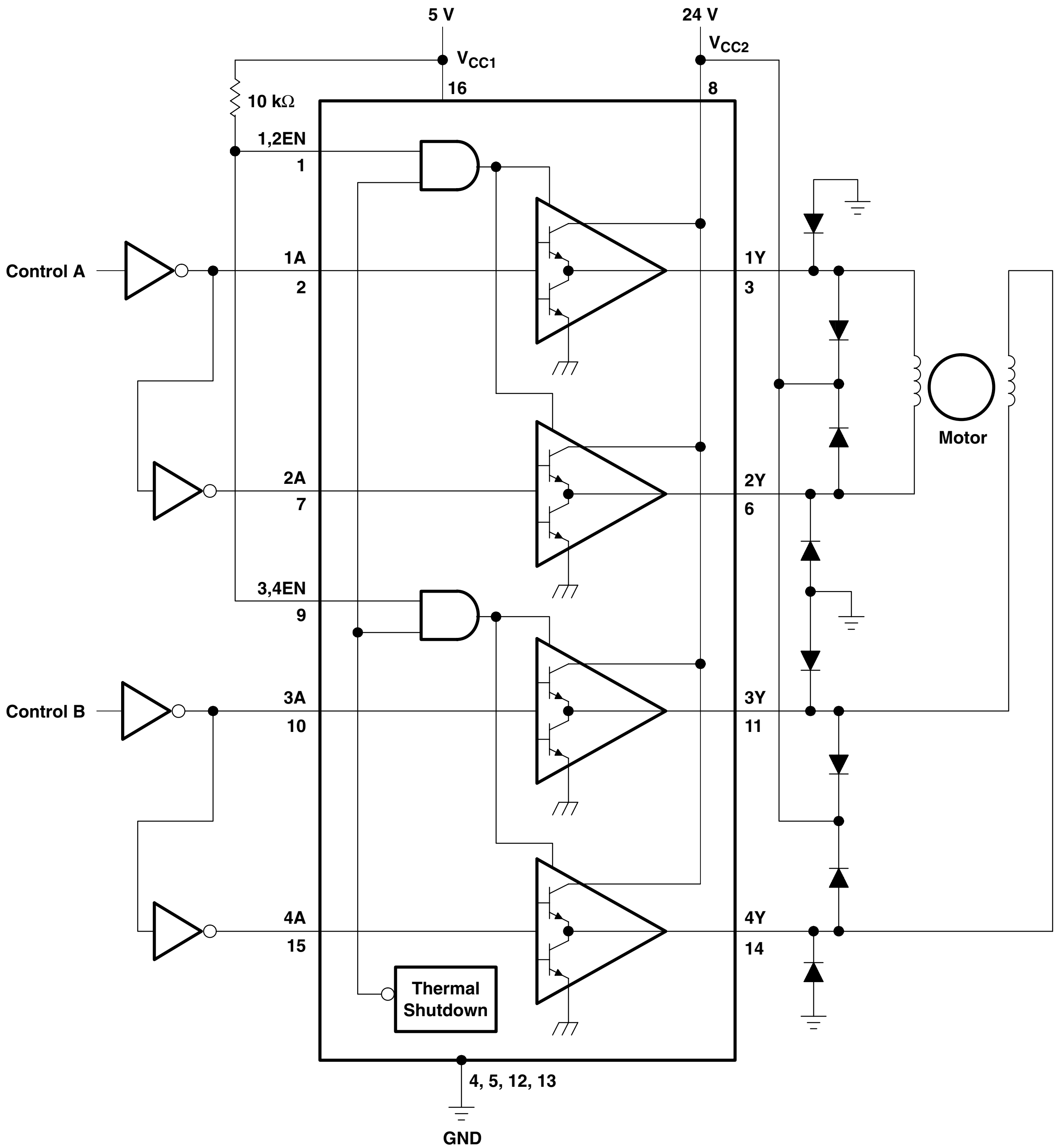


Figure 2. Two-Phase Motor Driver (L293)

APPLICATION INFORMATION

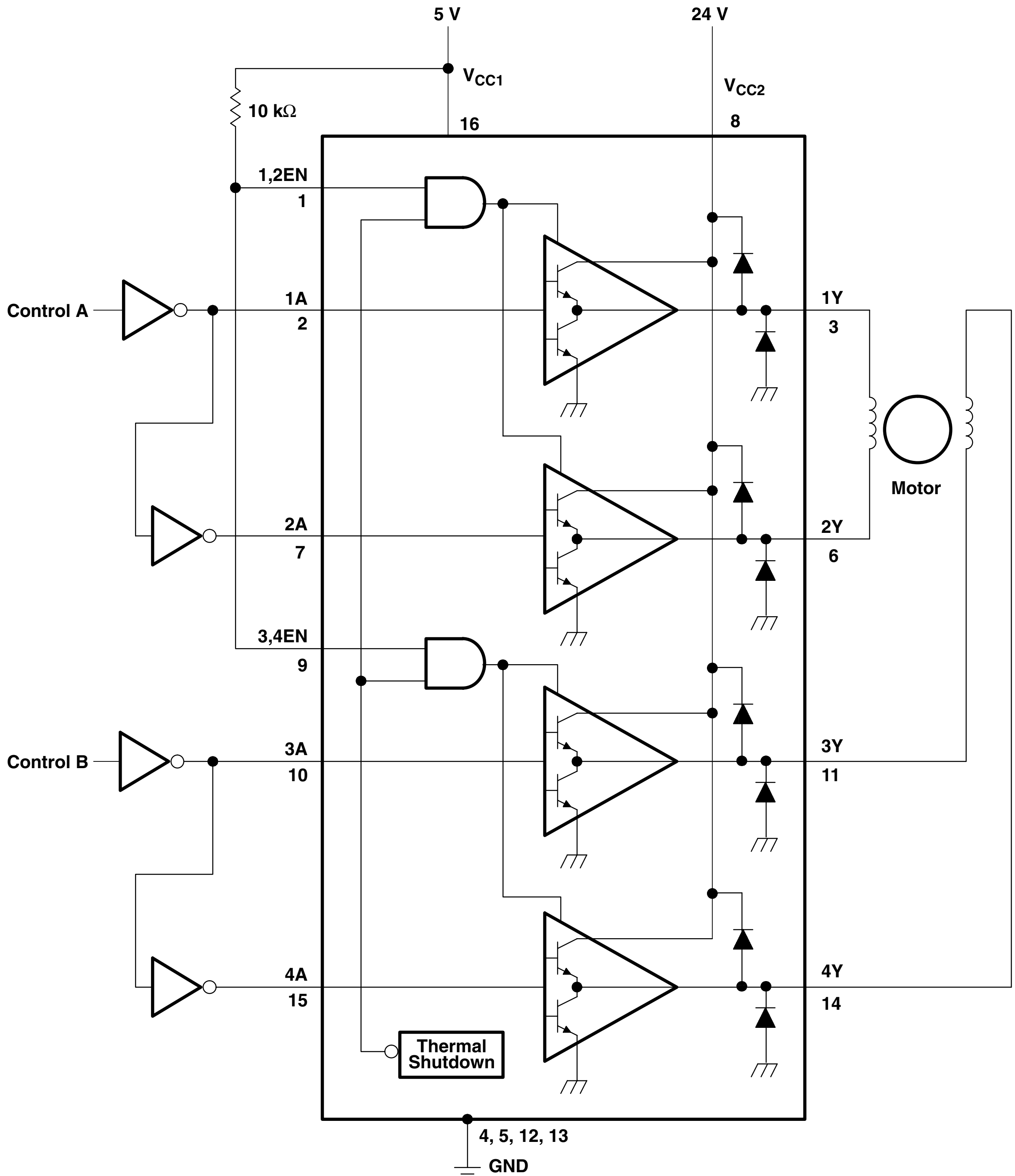
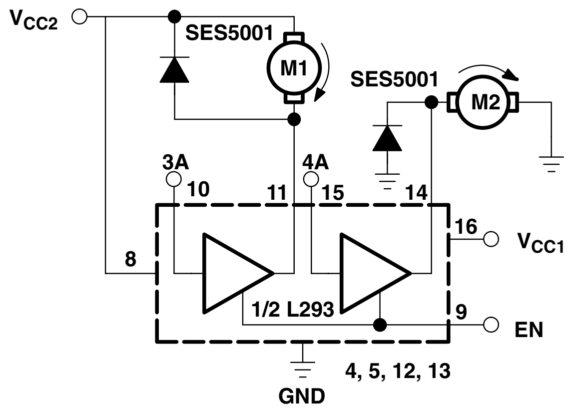


Figure 3. Two-Phase Motor Driver (L293D)

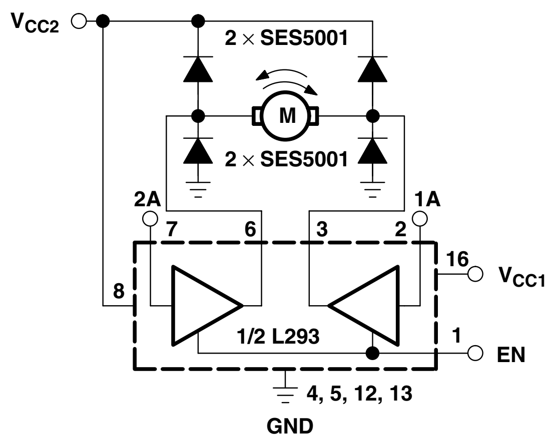
APPLICATION INFORMATION



EN	3A	M1	4A	M2
H	H	Fast motor stop	H	Run
H	L	Run	L	Fast motor stop
L	X	Free-running motor stop	X	Free-running motor stop

L = low, H = high, X = don’t care

Figure 4. DC Motor Controls (connections to ground and to supply voltage)



EN	1A	2A	FUNCTION
H	L	H	Turn right
H	H	L	Turn left
H	L	L	Fast motor stop
H	H	H	Fast motor stop
L	X	X	Fast motor stop

L = low, H = high, X = don’t care

Figure 5. Bidirectional DC Motor Control

APPLICATION INFORMATION

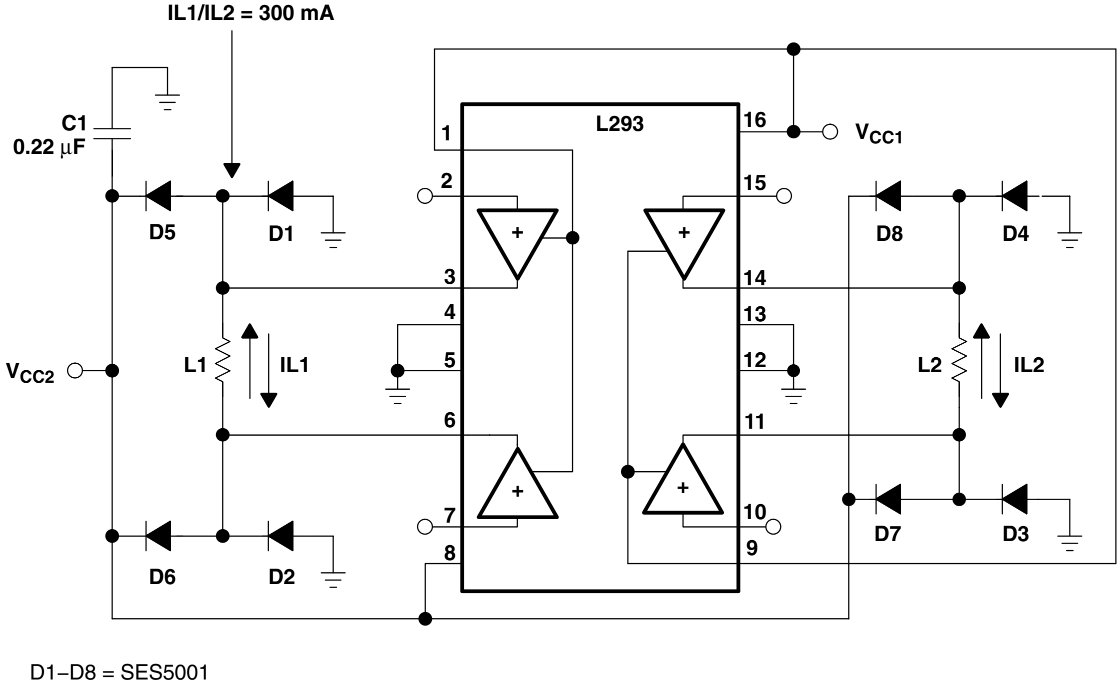


Figure 6. Bipolar Stepping-Motor Control

mounting instructions

The Rthj-amp of the L293 can be reduced by soldering the GND pins to a suitable copper area of the printed circuit board or to an external heat sink.

Figure 9 shows the maximum package power P_{TOT} and the θ_{JA} as a function of the side ℓ of two equal square copper areas having a thickness of 35 μm (see Figure 7). In addition, an external heat sink can be used (see Figure 8).

During soldering, the pin temperature must not exceed 260°C, and the soldering time must not exceed 12 seconds.

The external heatsink or printed circuit copper area must be connected to electrical ground.

APPLICATION INFORMATION

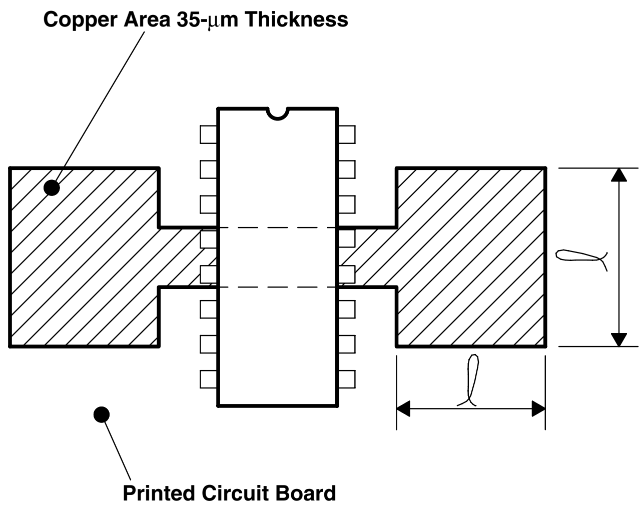


Figure 7. Example of Printed Circuit Board Copper Area (used as heat sink)

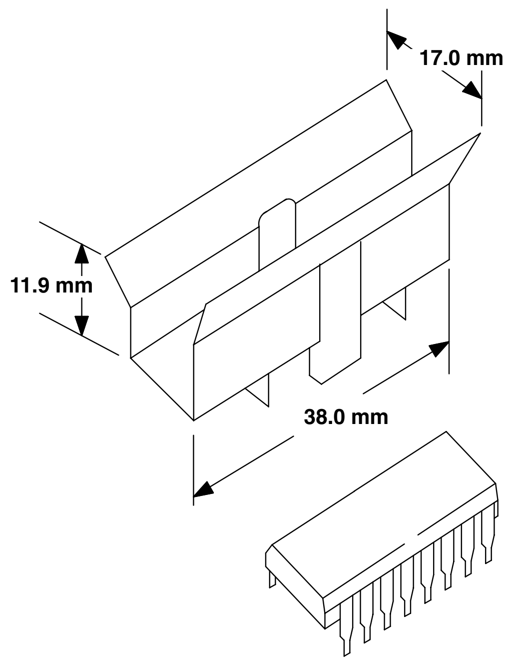


Figure 8. External Heat Sink Mounting Example (θ_{JA} = 25°C/W)

APPLICATION INFORMATION

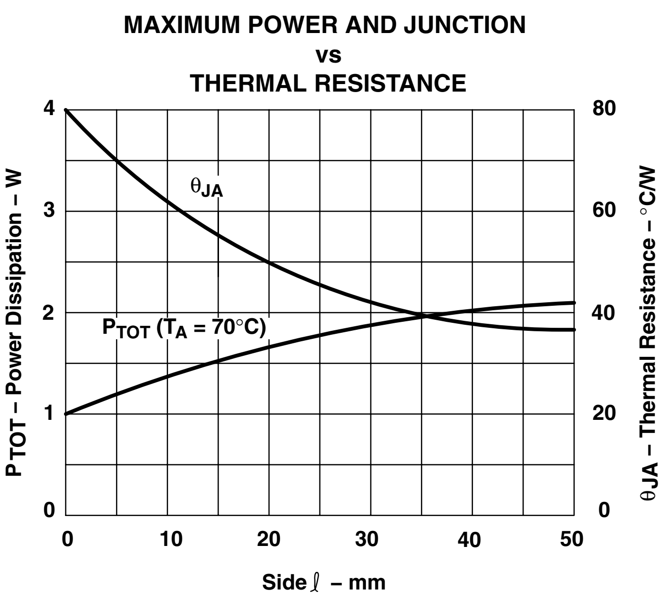


Figure 9

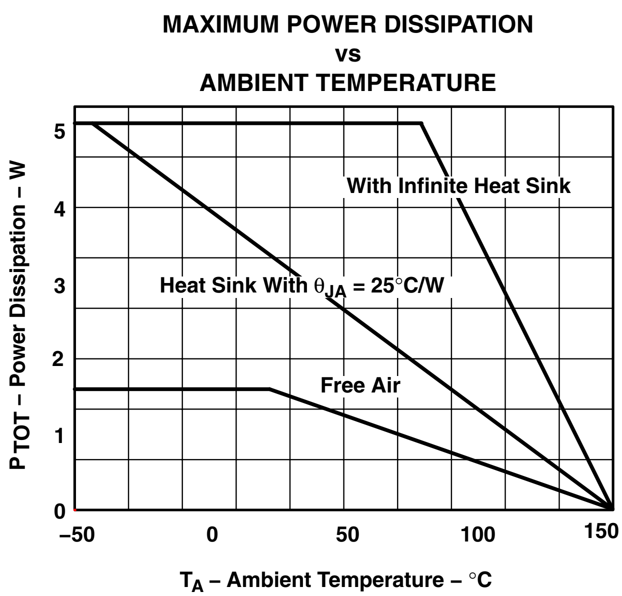


Figure 10

PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
L293DNE	ACTIVE	PDIP	NE	16	25	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type	0 to 70	L293DNE	Samples
L293DNEE4	ACTIVE	PDIP	NE	16	25	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type	0 to 70	L293DNE	Samples
L293DWP	OBSOLETE	SOIC	DW	28		TBD	Call TI	Call TI	0 to 70	L293DWP	
L293DWPG4	OBSOLETE	SOIC	DW	28		TBD	Call TI	Call TI	0 to 70		
L293DWPTR	OBSOLETE	SO PowerPAD	DWP	28		TBD	Call TI	Call TI	0 to 70		
L293N	OBSOLETE	PDIP	N	16		TBD	Call TI	Call TI	0 to 70	L293N	
L293NE	ACTIVE	PDIP	NE	16	25	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type	0 to 70	L293NE	Samples
L293NEE4	ACTIVE	PDIP	NE	16	25	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type	0 to 70	L293NE	Samples
L293NG4	OBSOLETE	PDIP	N	16		TBD	Call TI	Call TI	0 to 70		

(1) The marketing status values are defined as follows:
ACTIVE: Product device recommended for new designs.
LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.
NRND: Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.
PREVIEW: Device has been announced but is not in production. Samples may or may not be available.
OBSOLETE: TI has discontinued the production of the device.

(2) Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check http://www.ti.com/productcontent for the latest availability information and additional product content details.
TBD: The Pb-Free/Green conversion plan has not been defined.
Pb-Free (RoHS): TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.
Pb-Free (RoHS Exempt): This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.
Green (RoHS & no Sb/Br): TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

(3) MSL, Peak Temp. - The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

(5) Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

(6) Lead/Ball Finish - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead/Ball Finish values may wrap to two lines if the finish value exceeds the maximum column width.

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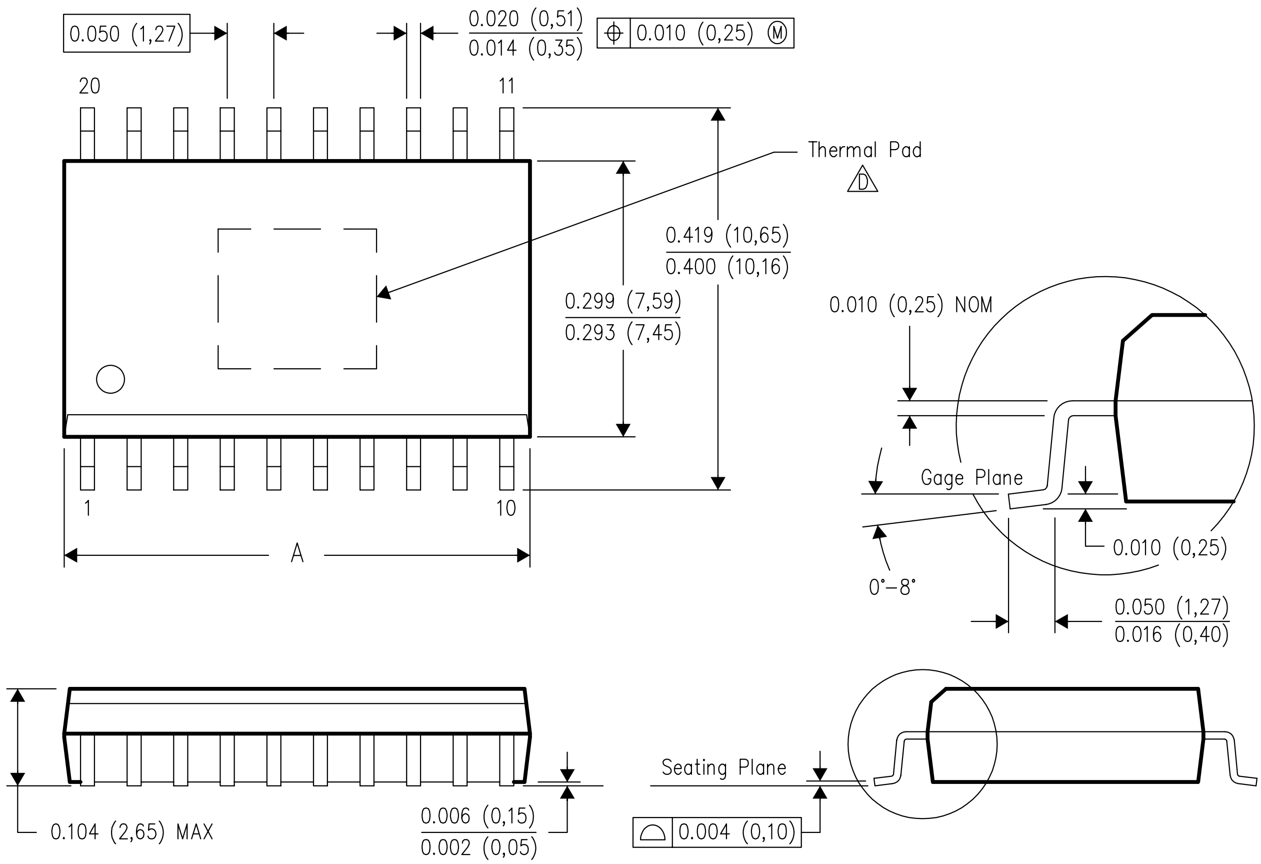
DWP (R-PDSO-G**) PowerPAD™ PLASTIC SMALL-OUTLINE PACKAGE

20 PINS SHOWN

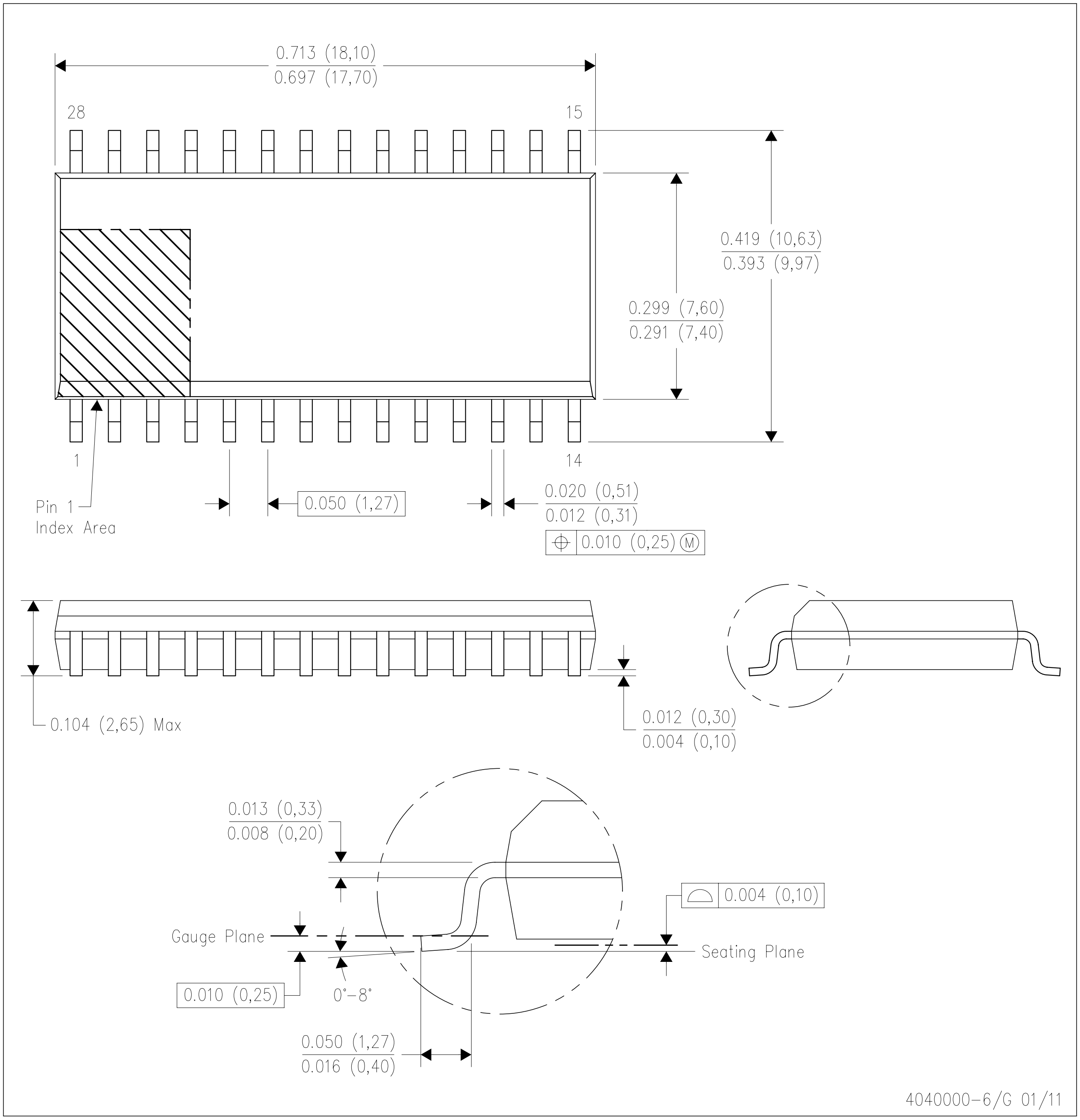


DIM \ PINS **	16	20	24	28
A MAX	0.410 (10,41)	0.510 (12,95)	0.610 (15,49)	0.710 (18,03)
A MIN	0.400 (10,16)	0.500 (12,70)	0.600 (15,24)	0.700 (17,78)

4147575/C 02/05

NOTES:
- A. All linear dimensions are in inches (millimeters).
- B. This drawing is subject to change without notice.
- C. Body dimensions do not include mold flash or protrusion not to exceed 0.006 (0,15).
- D. This package is designed to be soldered to a thermal pad on the board. Refer to Technical Brief, PowerPad Thermally Enhanced Package, Texas Instruments Literature No. SLMA002 for information regarding recommended board layout. This document is available at www.ti.com <http: //www.ti.com>. See the product data sheet for details regarding the exposed thermal pad dimensions.

DW (R–PDSO–G28) PLASTIC SMALL OUTLINE



NOTES:
- A. All linear dimensions are in inches (millimeters). Dimensioning and tolerancing per ASME Y14.5M–1994.
- B. This drawing is subject to change without notice.
- C. Body dimensions do not include mold flash or protrusion not to exceed 0.006 (0,15).
- D. Falls within JEDEC MS–013 variation AE.

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