Today's plan:

- Announcements
- Sensors – continuation
- Motors, Servos, etc
- Serial communication
- Controlling things with the microcontroller

Lecture test
during the first lecture after the midterm break

I will bring to class a MSP430 based system doing something. It will only use hardware covered in the manual. You will have to specify all the connections and write a program in C which will run this system as shown. List of connections or photographed sketch on paper are both acceptable.

You will be using your computer with all the programs you have written or tested as well as any notes or texts and the lab manual and lectures. You will submit your program as a file – just email it to me when the time is up (no later). 10% penalty per minute!

Its all on the honor system, you will be expected to switch off any communication programs including email, texting and so on, on your computer and not to communicate with anybody or AI.

No labs or lectures next week

Test on Tuesday Feb 28th, 2024. Make sure that you have all you might need on your computer.

Before the next labs (week of February 26) please make sure to submit the plan for your project. We can discuss it during labs.

Magnetic Field Sensors:

- Hall effect

on-off vs field measurement

- magneto-resistive
- magneto-inductive
- Compass modules

eg: Devantech CMPS03 compass module

Position Sensor:

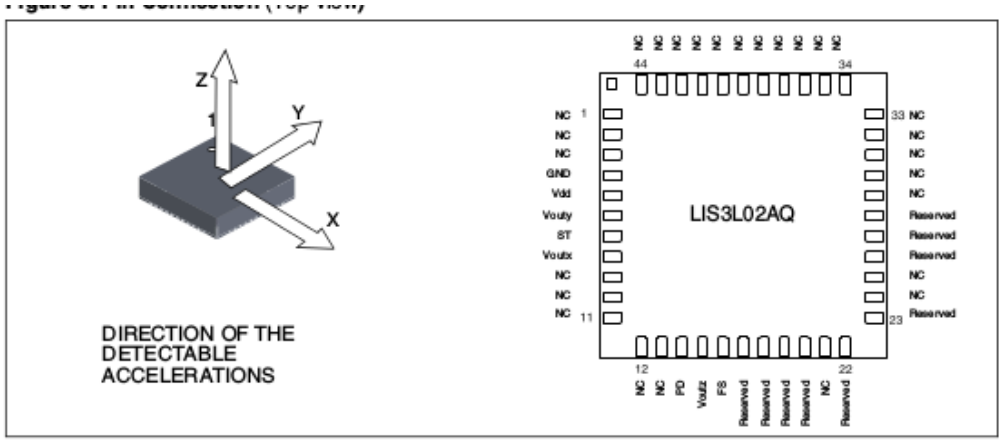
- Potentiometers (3/4 turn, 10 turn)
- Rotation sensor (unlimited turns)
- Linear potentiometers

Accelerometers, Gyroscopes:

- 1 axis, 2 axis, 3 axis

EG: MPU9150: 3 axis gyroscope,
3 axis accelerometer+ 3 axis magnetic field
I^2C interface for ~$10.

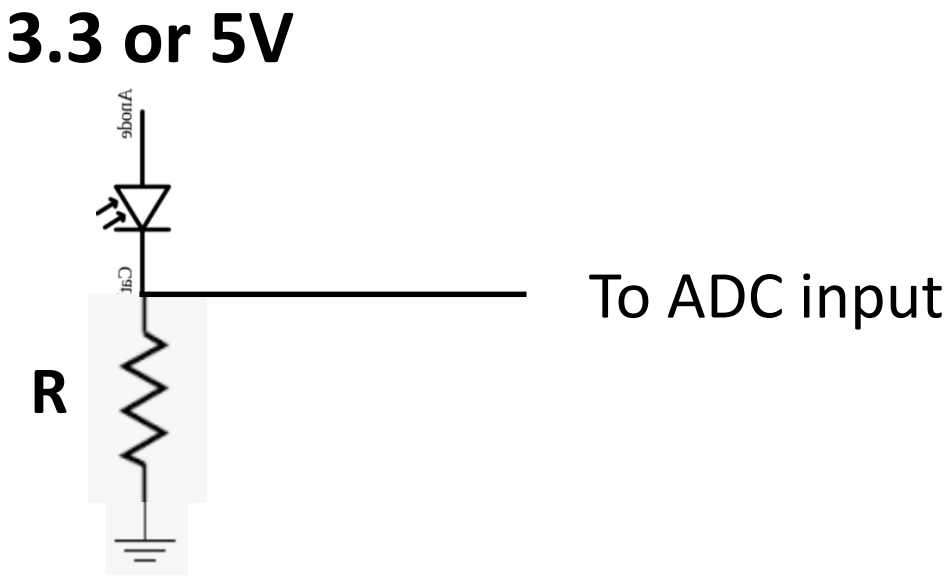
EG: LIS3L02AQ – 3 axis accelerometer with analog outputs.



Pressure Sensors

- Gas or liquid (MPX5100)
- Mechanical (IESF-R-5L)

Connecting resistive or current sensors



R the same order of magnitude
As the resistance range of the sensor

Heart Beat Monitor and Blood Oxygenation Sensor **MAX30102**

- The module is in your kit. You will work with it in the lab (part 9 in the manual).
- It can work as a Heart Beat monitor and Blood Oxygenation sensor.

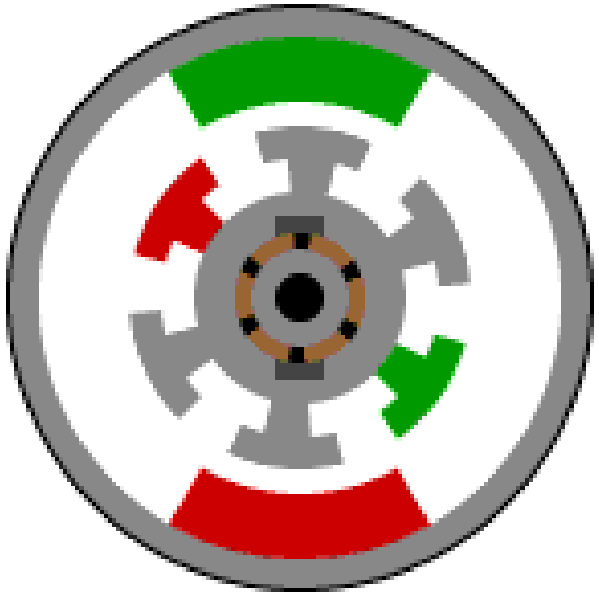
Addresable light strips

- https://www.adafruit.com/product/2842?length=1

Motors, Servos, etc

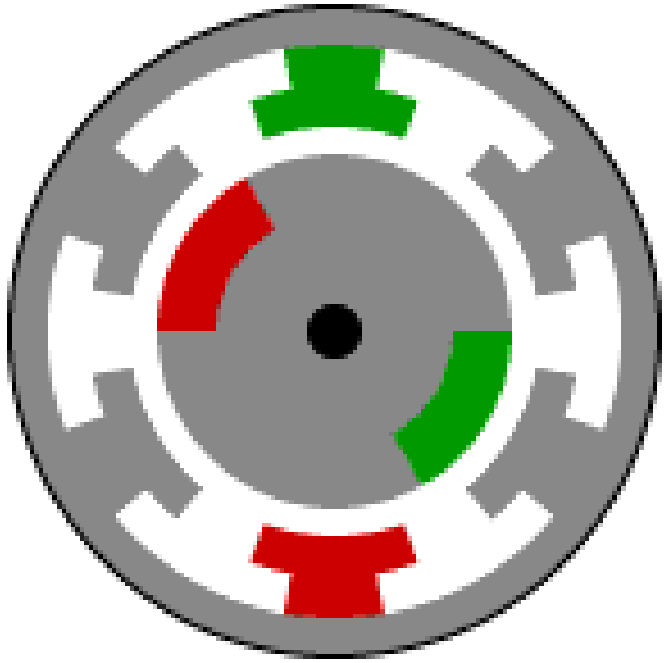
- AC and DC motors
- Stepper motors
- Servo motors
- Solenoids
- Relays
- Solid-state relays

Motors: DC motors



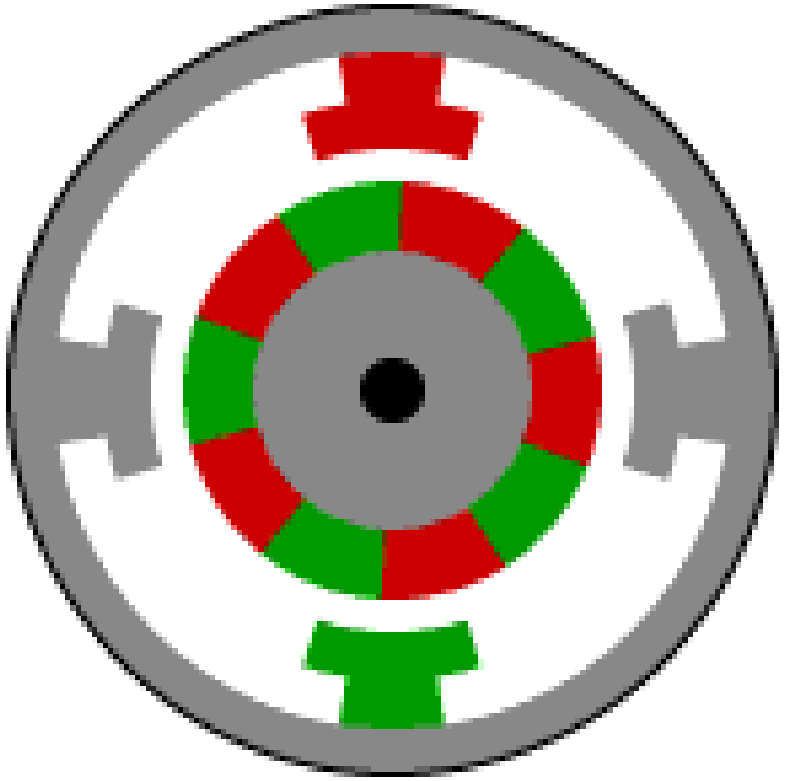
http://www.freescale.com/webapp/sps/site/overview.jsp?code=WBT_MOTORDCTUT_WP

Motors: Brushless DC motors



http://www.freescale.com/webapp/sps/site/overview.jsp?code=WBT_MOTORBLDCTUT_WP

Motors: Stepper motors



Fixed step size, often 200 steps per revolution.

http://www.freescale.com/webapp/sps/site/overview.jsp?code=WBT_MOTORSTEPTUT_WP

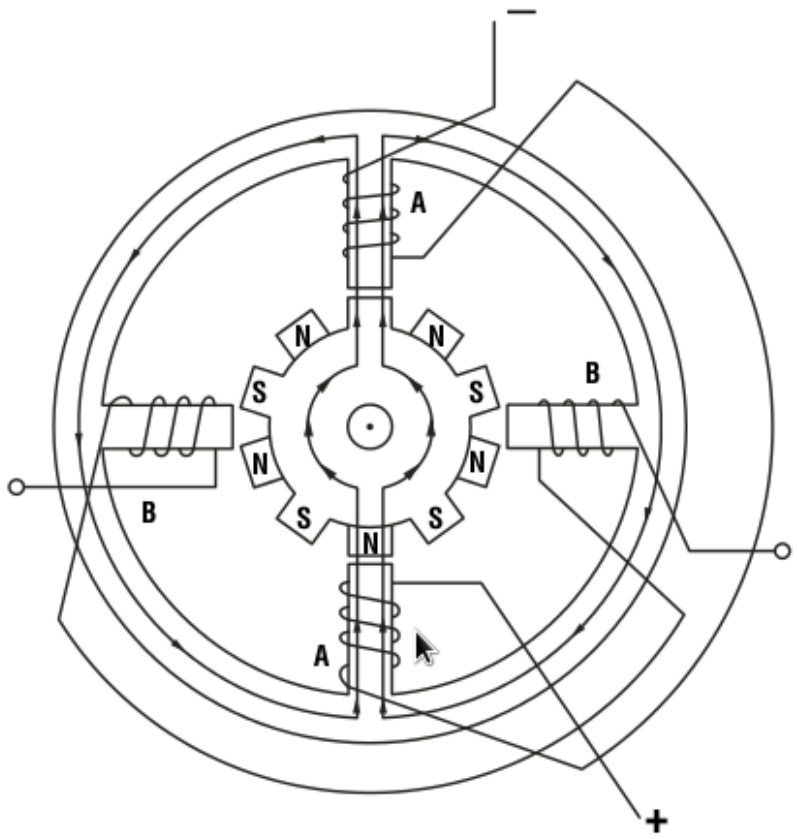
Motors: Servos

photo from Hobby Servo Fundamentals by Darren Sawicz

- precise position control
- One needs a PWM signal to specify position
- typical range of 0-180 degrees

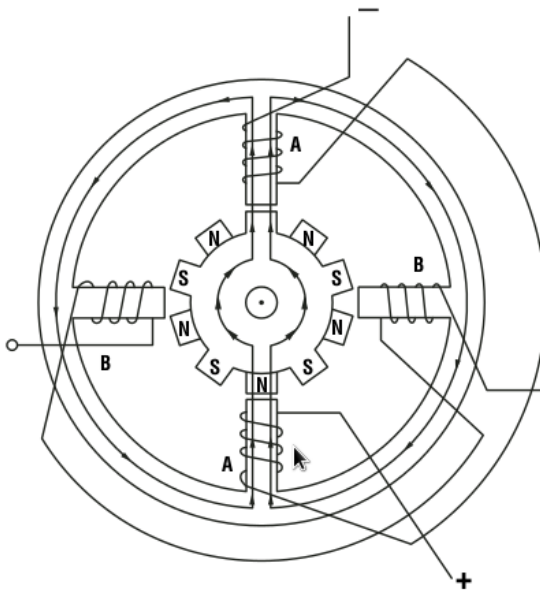
- contains a DC motor, gearing, a potentiometer, control electronics.
- The average PWM voltage is compared to the position, as measured by the potentiometer. The control electronics then drive the motor forward or backward to set the angle as requested.
- Typical PWM period of 20 ms with on time of ~1 – ~2 ms (1.5 ms is 'center'). Wire colours often: red = +5 V, black = ground, white = PWM control.
- Position depends on length of on-pulse.

Motors: Stepper motors

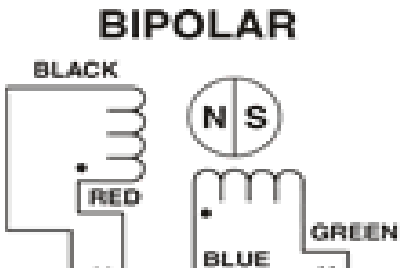


From: Introduction to Step Motors, Applied Motion Products. http://www.omega.ca/auto/pdf/REF_IntroStepMotors.pdf

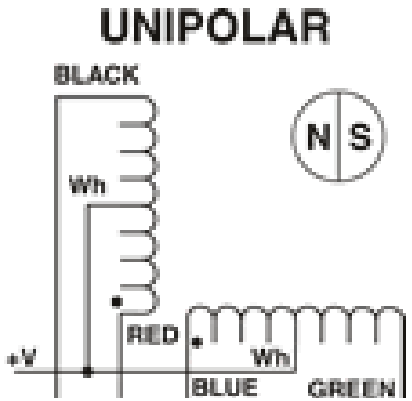
Motors: Stepper motors



Unipolar vs bipolar windings:



4 wires (usually)

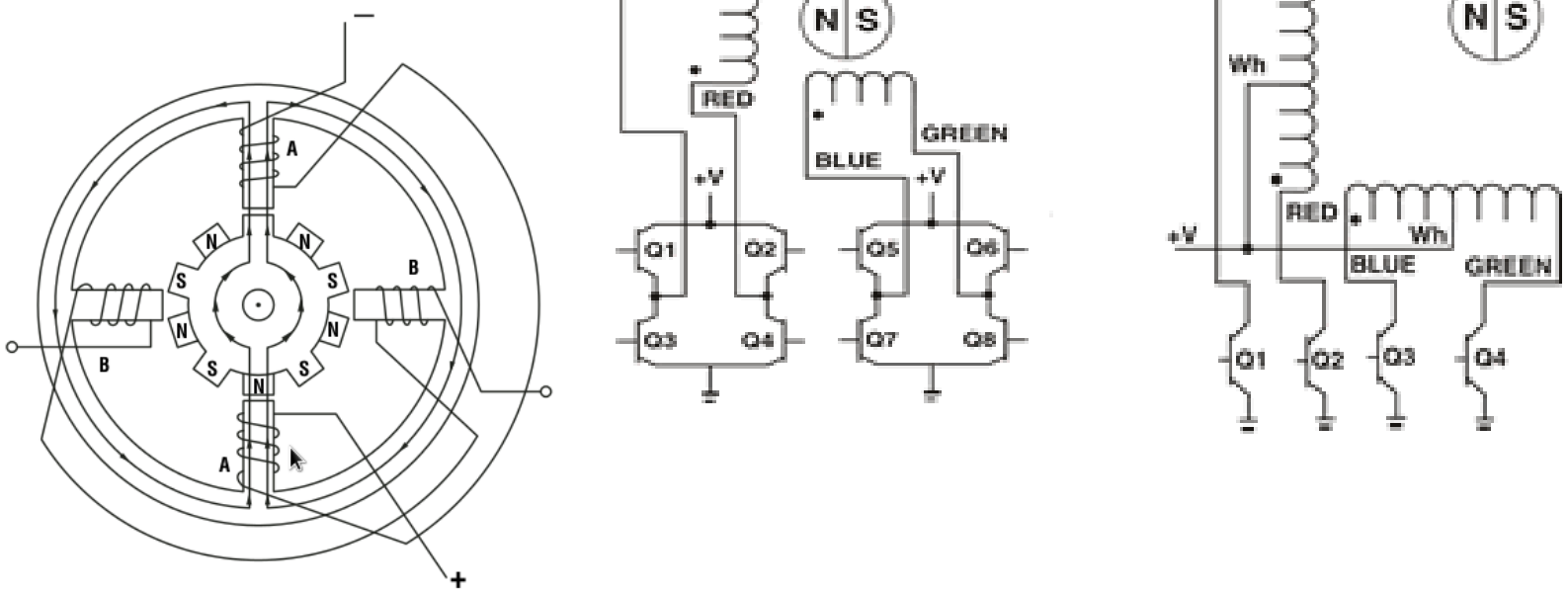


Unipolar stepper (5, 6 or 8 wires)

http://www.haydonkerk.com/Resources/StepperMotorTheory/tabid/192/Default.aspx

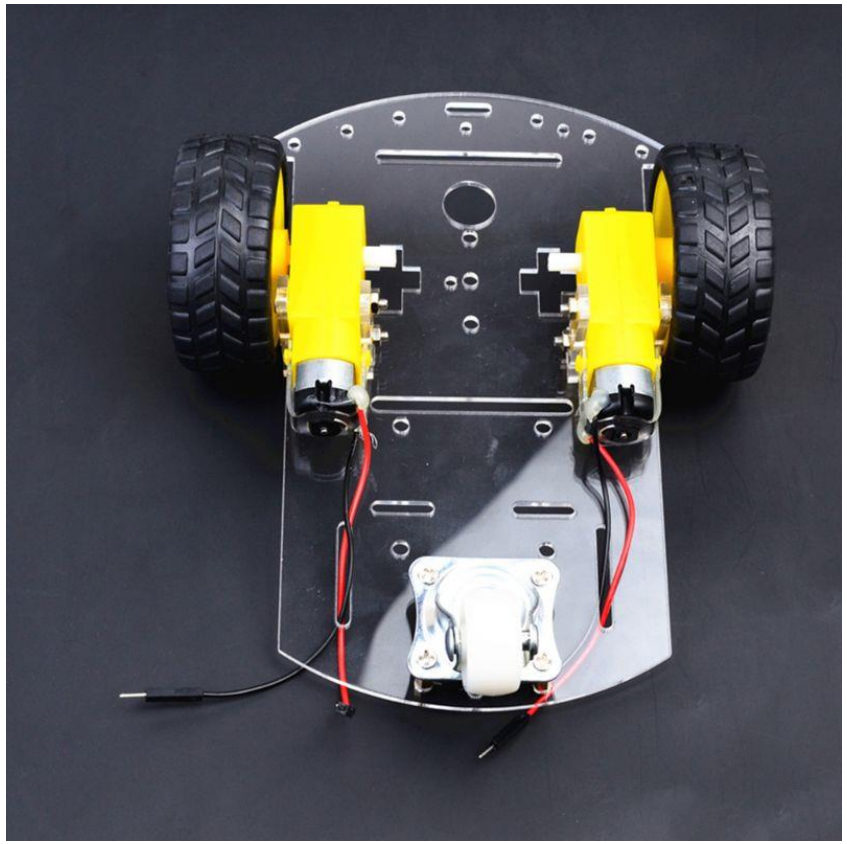
Motors: Stepper motors

Unipolar vs bipolar windings:



http://www.haydonkerk.com/Resources/StepperMotorTheory/tabid/192/Default.aspx

“Robot” platforms

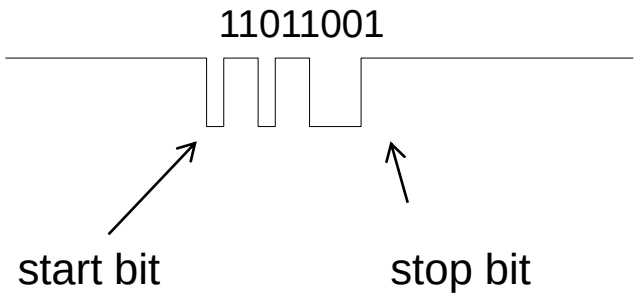


Serial interfaces

Many sensors use standard protocols such as I^2C (inter-integrated circuit), SPI (serial peripheral interface) or UART (Universal Asynchronous Receiver/Transmitter) to talk to the microcontroller.

The MSP430 has a module USCI (Universal Serial Communication Interface) that can be configured for using these protocols.

UART: Universal Asynchronous Receiver/Transmitter



- 3 lines for bi-directional communication: ground, transmit, receive
- start bit is always low, stop bit is always high.
- usually have 8 data bits in between, (but sometimes 5 or 6 or 7)
- least significant bit first, most significant bit last
- sometimes there is parity bit after the data

The USCI can output bytes and decode incoming bytes.

- to transmit a byte, just write it to UCA0TXBUF = byte;
- to receive a byte, set up interrupt to trigger when byte received, then read from receive buffer: byte = UCA0RXBUF;

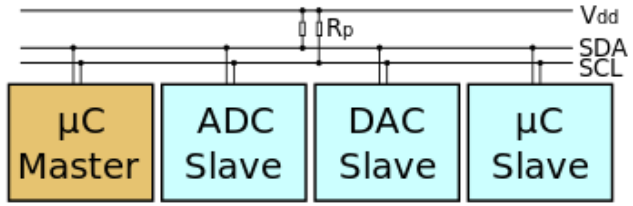
SPI: Serial Peripheral Interface

SCLK: clock from master
MOSI: Master out, slave in
MISO: Master in, slave out.
Slave Select

On every toggle of the clock, bits are transmitted in both directions, though not always useful. Communications controlled completely by the master.

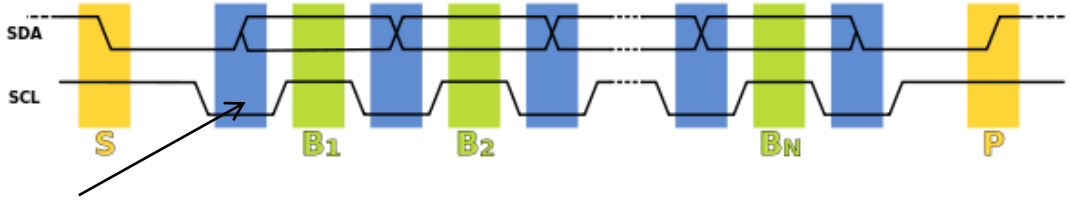
point-to-point, one master, one slave.

I2C: Inter-integrated Circuit



SDA – serial data
SCL – serial clock

Both lines are open-drain, pulled up with pull-up resistors



data line changes when clock is held low.

I2C is a bus: can be multiple masters, multiple slaves on the bus.

Controlling things with the microcontroller

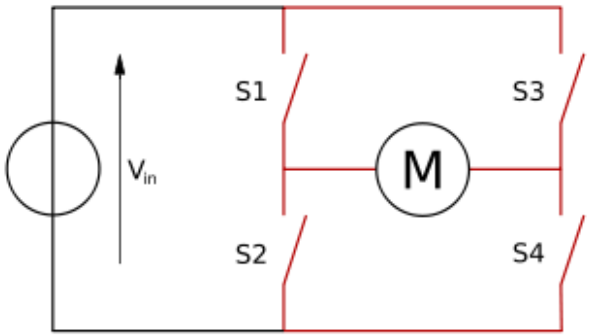
MSP430 P1.x maximum output current: +/- 6 mA (x 3.3V = 20mW)
To drive external loads that are more demanding than logic chips, the MSP430 needs some help.
Some possibilities:

- op-amps
- Buffer/driver
- Transistor (bipolar or MOSFET)
- opto-isolators
- Relay
- Solid-state relay
- H Bridge chip (eg for bi-directional motors)

REFERENCE: The Art of Electronics (Horowitz and Hill)

Driving Motors: H-bridge

To drive a dc motor in either direction with a single power supply, close S1 and S4 OR S2 and S3.



http://en.wikipedia.org/wiki/File:H_bridge.svg

The switches are often transistors: bipolar or MOSFETs

Driving Motors: H-bridge

SN754410
QUADRUPLE HALF-H DRIVER

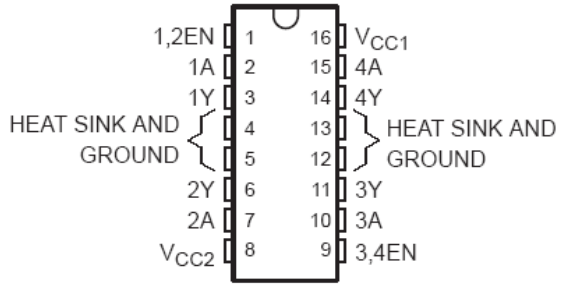
SLRS007B – NOVEMBER 1986 – REVISED NOVEMBER 1995

- **1-A Output-Current Capability Per Driver**
- **Applications Include Half-H and Full-H Solenoid Drivers and Motor Drivers**
- **Designed for Positive-Supply Applications**
- **Wide Supply-Voltage Range of 4.5 V to 36 V**
- **TTL- and CMOS-Compatible High-Impedance Diode-Clamped Inputs**
- **Separate Input-Logic Supply**
- **Thermal Shutdown**
- **Internal ESD Protection**
- **Input Hysteresis Improves Noise Immunity**
- **3-State Outputs**
- **Minimized Power Dissipation**
- **Sink/Source Interlock Circuitry Prevents Simultaneous Conduction**
- **No Output Glitch During Power Up or Power Down**
- **Improved Functional Replacement for the SGS L293**

description

The SN754410 is a quadruple high-current half-H driver designed to provide bidirectional drive currents up to 1 A at voltages from 4.5 V to 36 V. The device is 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.

NE PACKAGE
(TOP VIEW)



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 a high-impedance state regardless of the input levels.

Driving DC Motors: H-bridge

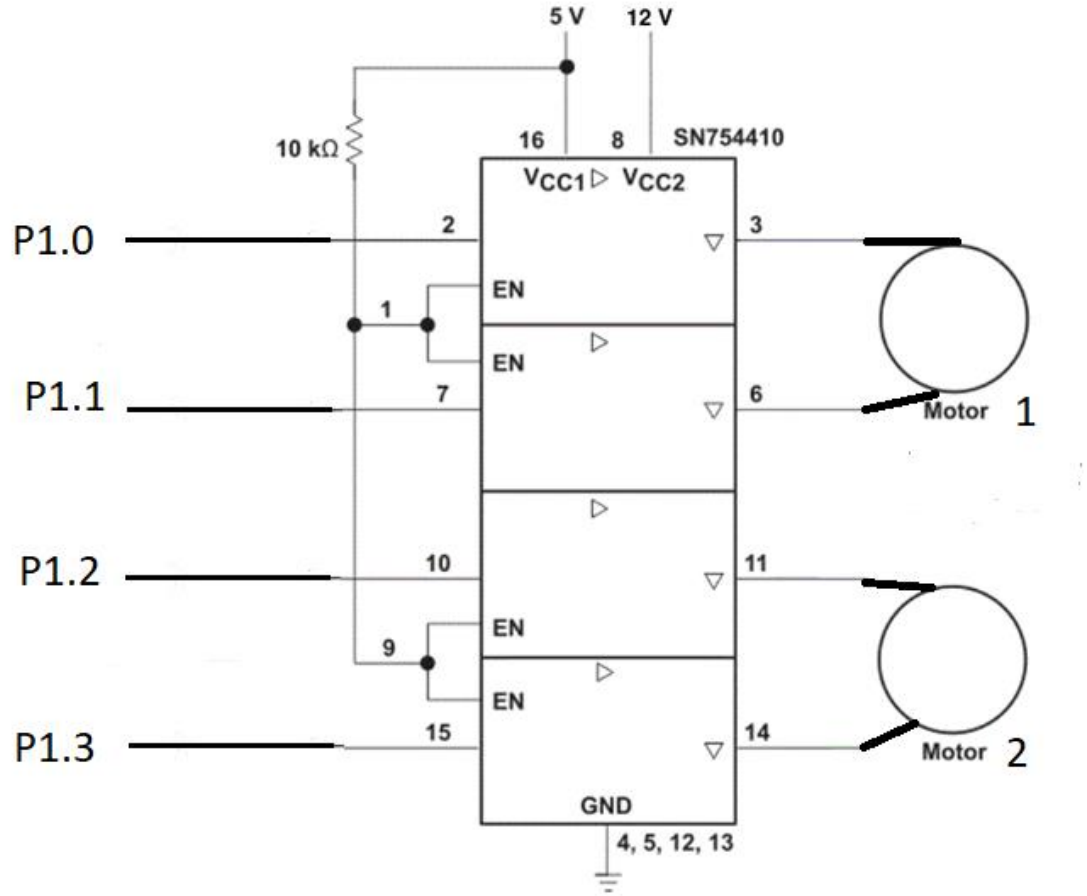
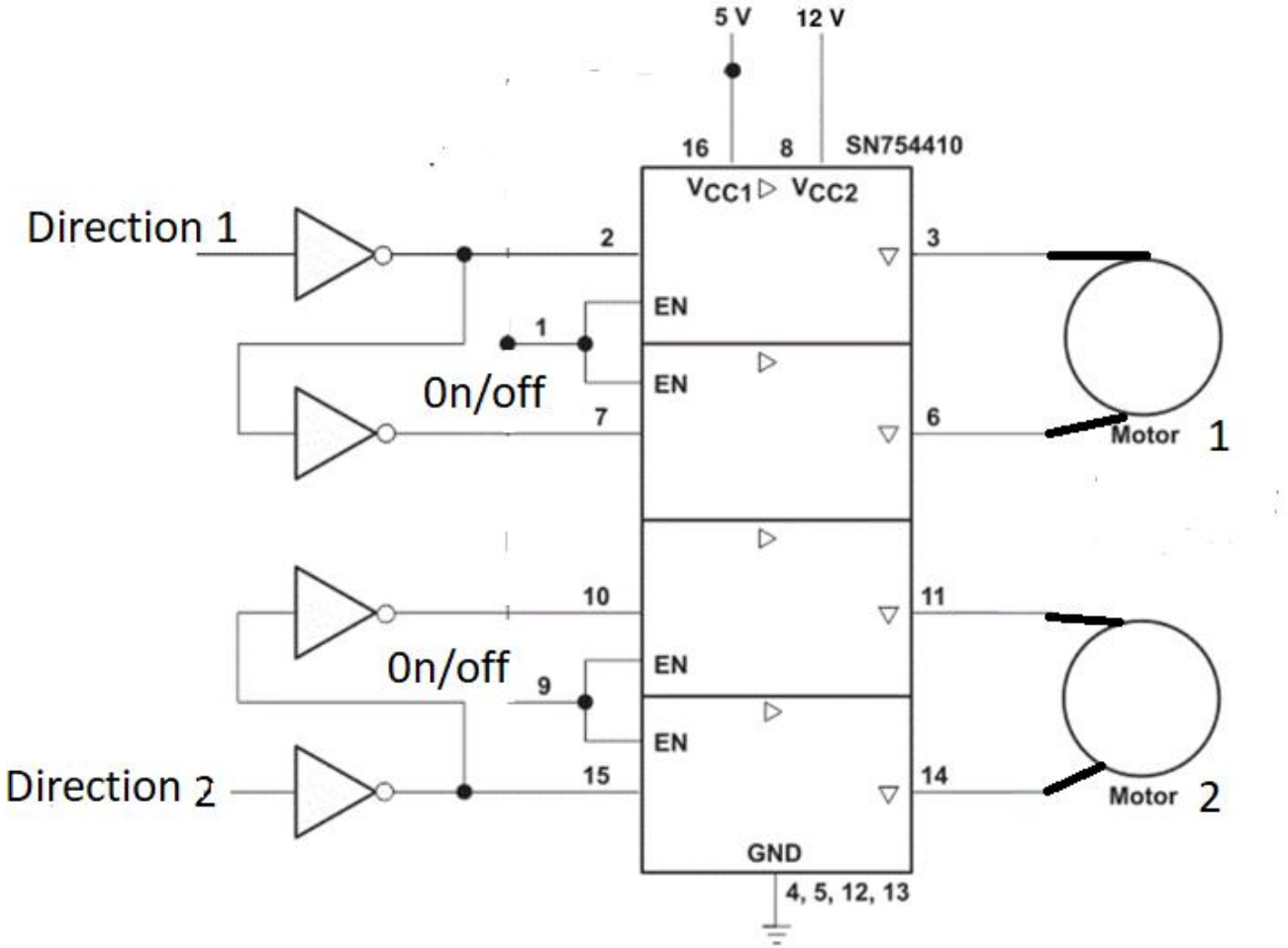


Figure 7. Typical Application Schematic

This is for 2 DC motors

Driving DC Motors: H-bridge



This is for 2 DC motors

Driving Step Motors: H-bridge

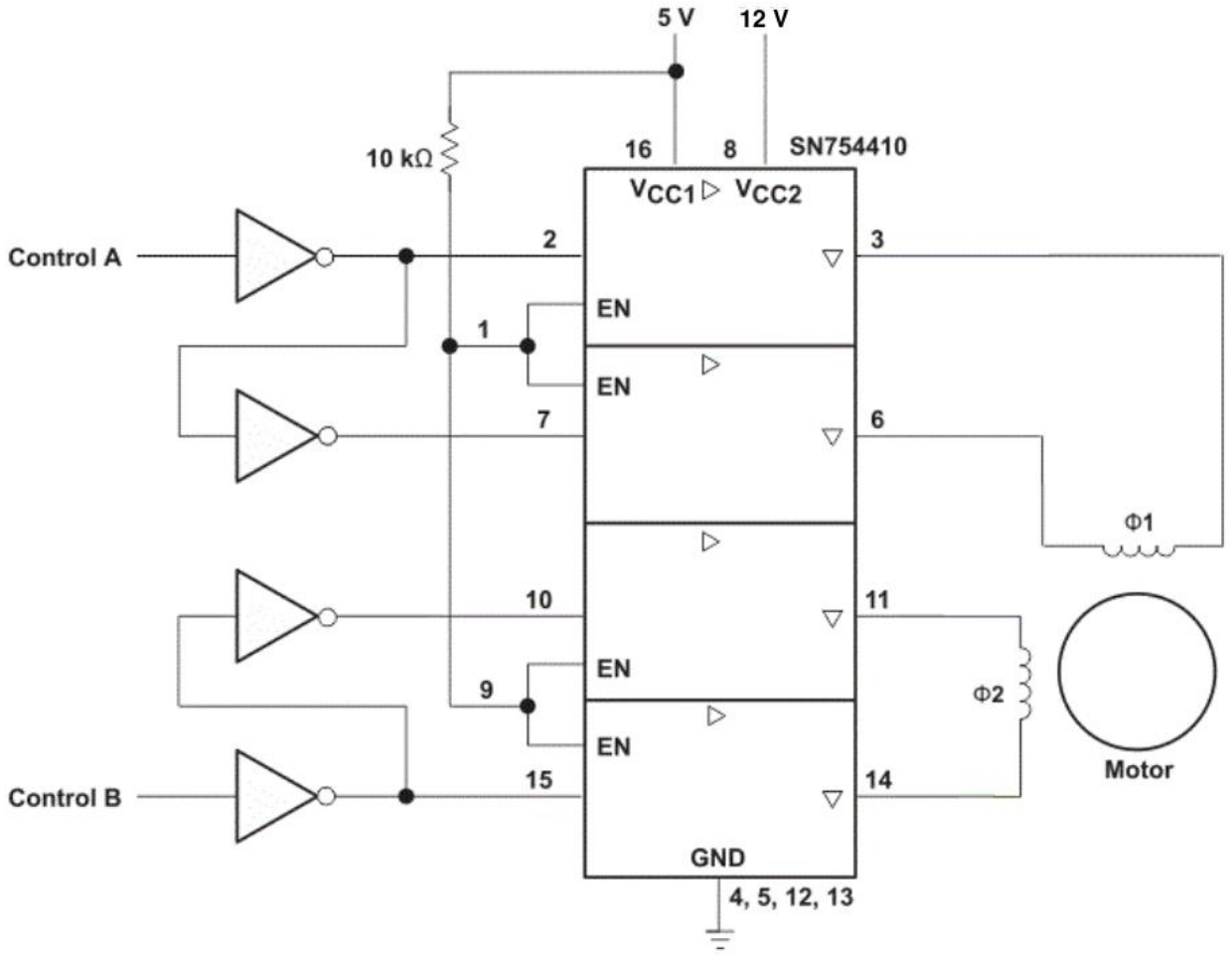


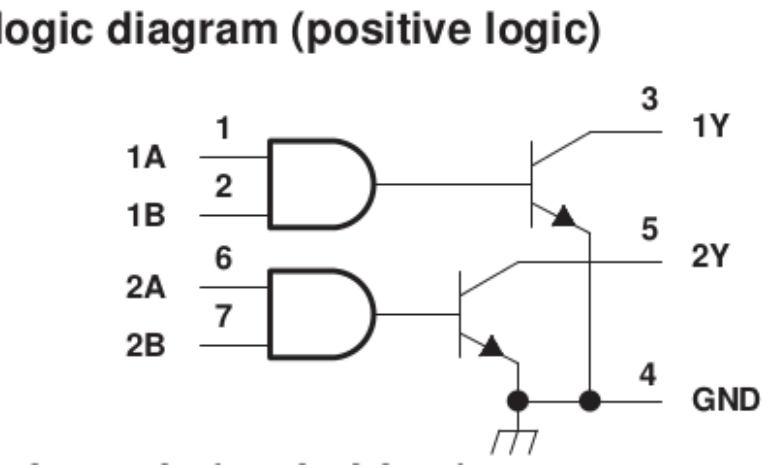
Figure 7. Typical Application Schematic

This is for a bipolar stepper motor (or a unipolar stepper ignoring the center taps)

Controlling things with the microcontroller

Driver eg SN75451

up to 300 mA



usage: