Today's plan:

Reminder: Marking

Announcements: status report

Final presentations and reports

Motor drivers

Op-Amp

Powering your project

Analog outputs

Reminder - Marking:

To pass the course you have to:

1. Submit all three reports and check all the required parts (show them working to the TAs or instructor)

2. Present the final project and submit the final report.

If any of these elements above are missing, your grade will be lower of 45% or total of the points.

Marking:

A Lecture test 20%

Activities 5%

Programs and lab reports in first 6 weeks 20%

Project proposal 3%

Status report 2%

Project quality and functionality 20%

Presentation 10%

Final report 20%

Late report submissions - 10% of the grade will be subtracted per day down to 50%. We wave it for good reasons

Announcements: Status Report

I would like a short written status report from everyone turned in at start of the lab during the week of March 24th.

The report should discuss your progress so far: what has been accomplished, what remains to be done. If you have encountered problems, discuss them, and your plans to move forward. If you need help to make progress, please mention it.

These reports need not be long, just a few sentences or points are fine.

Announcements: Final Reports and presentations

- At the end of the course you'll present your project in two ways:

1) Oral presentation in class. These will happen on Tuesday April 1, Wednesday April 2 and Thursday April 3. These are reasonably informal. We will all look at the presentation, with slides if any, and the working project.

2) Formal written report, due April 11, 10PM.

Unfortunately no extensions!

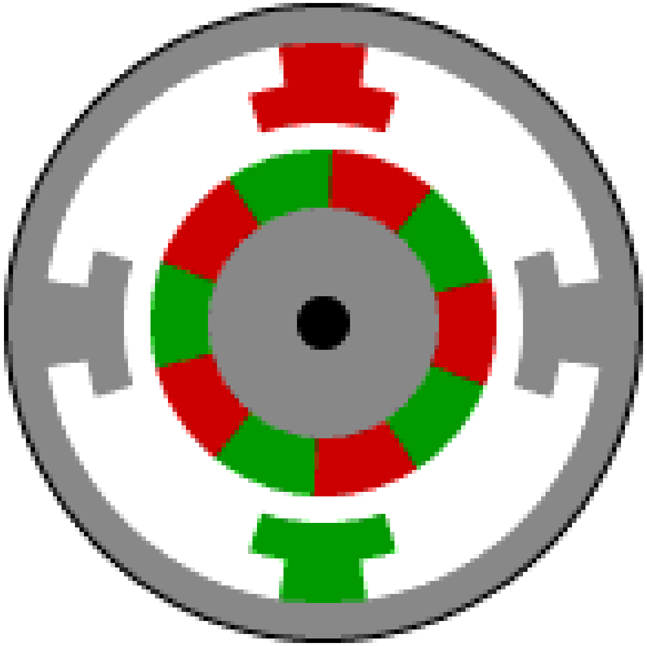
Lecture test

Connections 3 points (2 if 1-2 missing, 1 if 3-5 missing). There were 14 connections in my model.

Distance in cm measurements 7 points. 2 points subtracted for any command which is missing or has to be changed to have it working.

Display distance on 7 segment 10 points. 2 points subtracted for any command which is missing or has to be changed to have it working as planned.

Motors: Stepper motors



Fixed step size, often 200 steps per revolution.

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

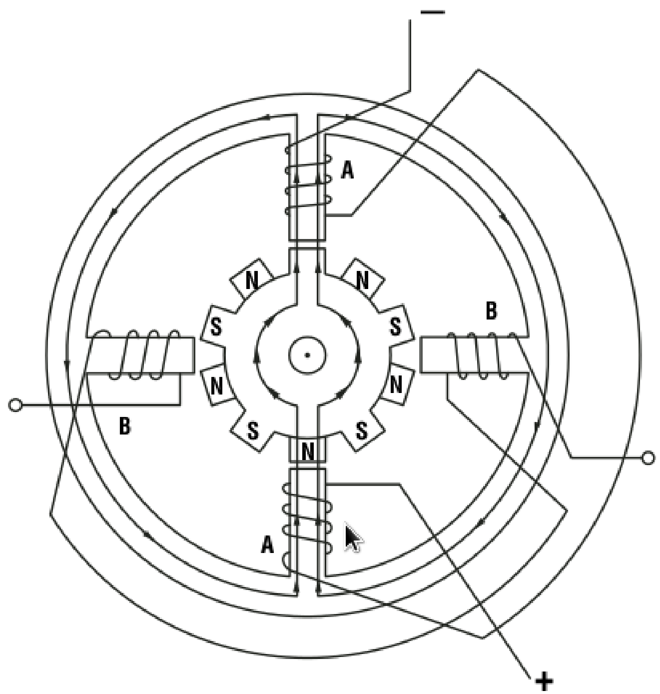
Motors: Servos

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

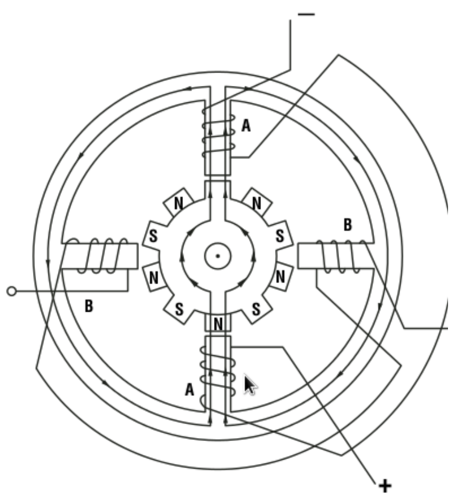
- contains a DC motor, gearing, a potentiometer, control electronics.
- The average PWM voltage is compared to the position, as measured by the potentiometer. The control electronics then drive the motor forward or backward to set the angle as requested.
- Typical PWM period of 20 ms with on time of ~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

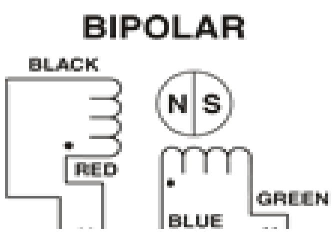


From: Introduction to Step Motors, Applied Motion Products. http://www.omega.ca/auto/pdf/REF_IntroStepMotors.pdf

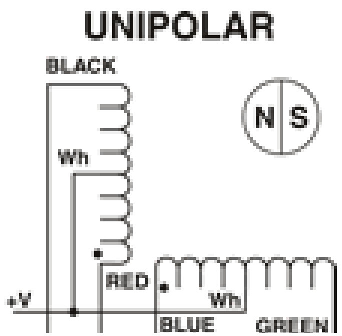
Motors: Stepper motors



Unipolar vs bipolar windings:



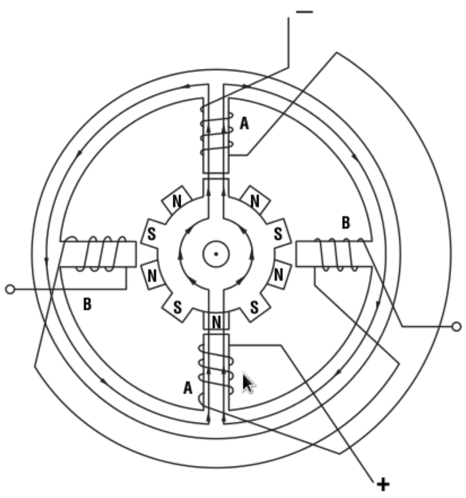
4 wires (usually)



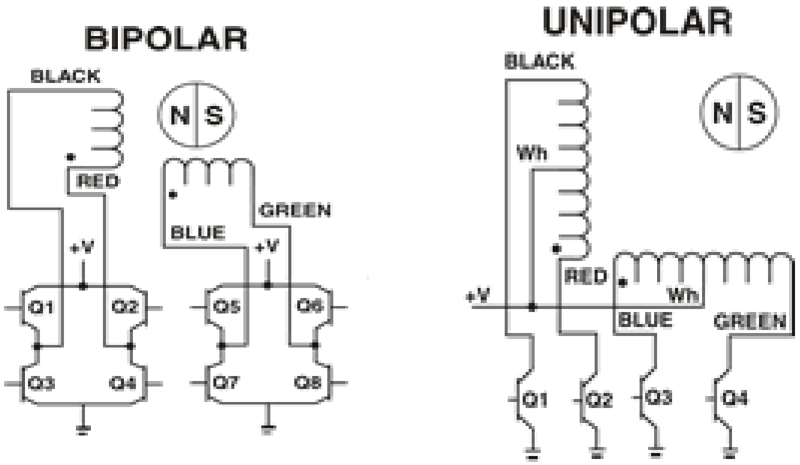
Unipolar stepper (5, 6 or 8 wires)

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

Motors: Stepper motors

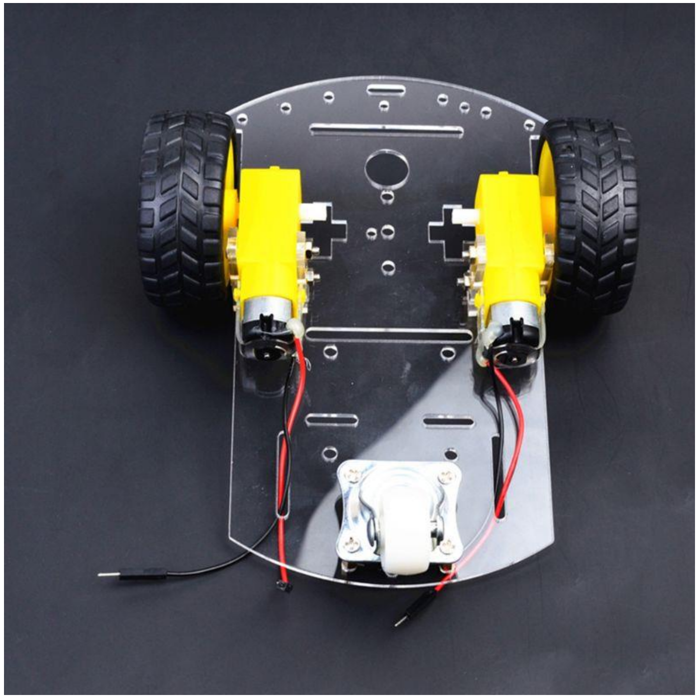


Unipolar vs bipolar windings:



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

“Robot” platforms



Controlling things with the microcontroller

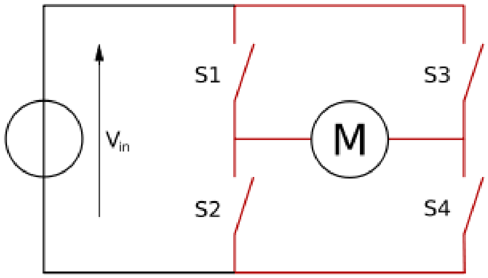
MSP430 P1.x maximum output current: +/- 6 mA (x 3.3V = 20mW)
To drive external loads that are more demanding than logic chips, the MSP430 needs some help.
Some possibilities:

- 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

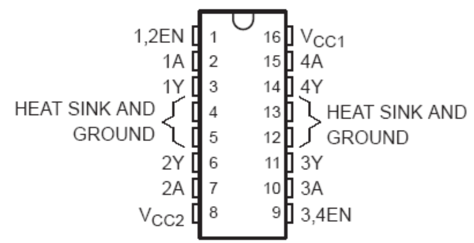
Driving Motors: H-bridge

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**

NE PACKAGE
(TOP VIEW)



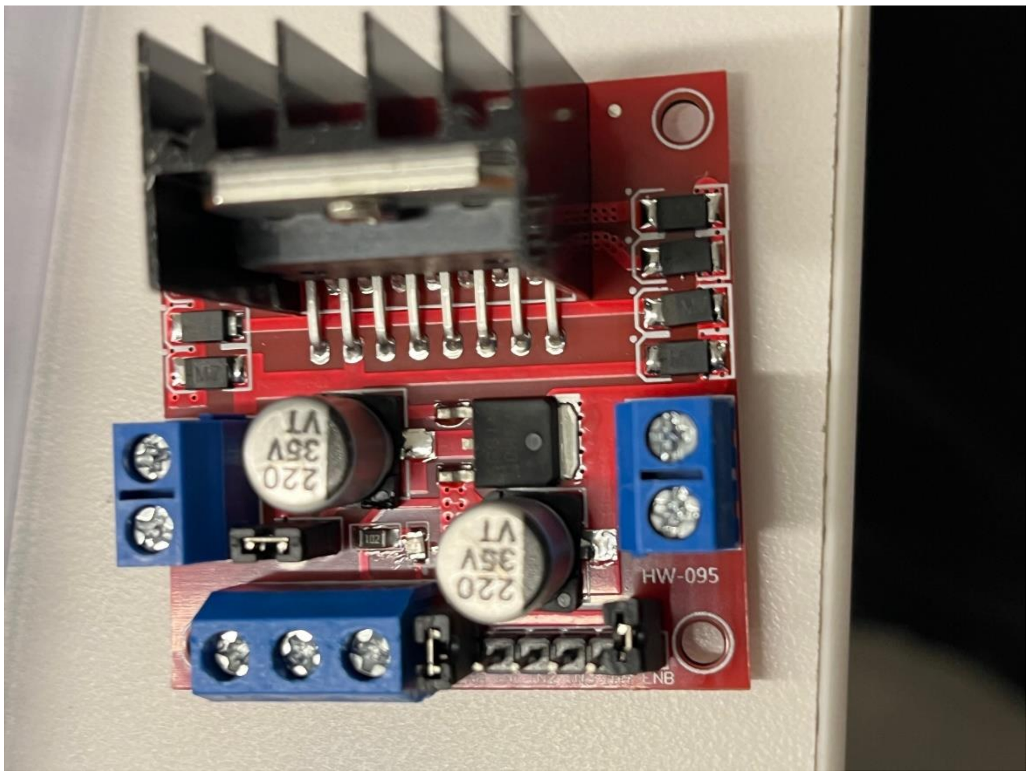
FUNCTION TABLE
(each driver)

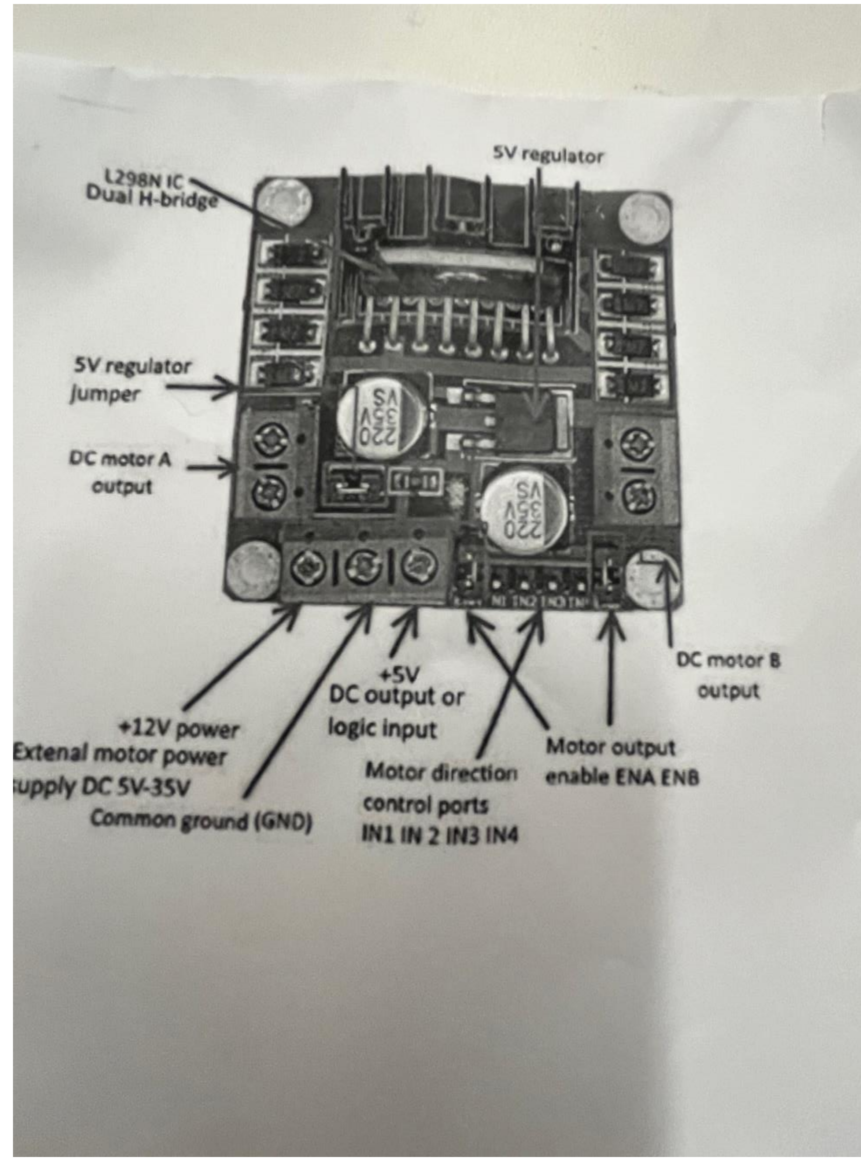
INPUTS†		OUTPUT
A	**EN**	**Y**
H	H	H
L	H	L
X	L	Z

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.

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.


HW-095
220
35V
VT
ENB


5V regulator
L298N IC
Dual H-bridge
5V regulator
jumper
DC motor A
output
DC motor B
output
+5V
DC output or
logic input
+12V power
Extenal motor power
supply DC 5V-35V
Common ground (GND)
Motor direction
control ports
IN1 IN 2 IN3 IN4
Motor output
enable ENA ENB

Driving DC Motors: H-bridge

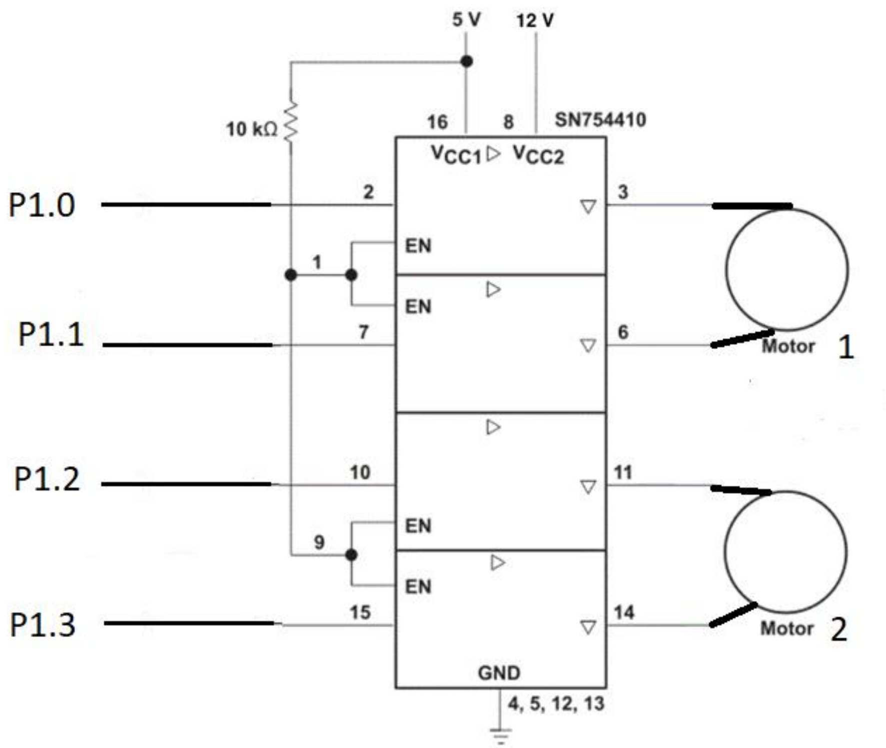


Figure 7. Typical Application Schematic

This is for 2 DC motors

Driving Step Motors: H-bridge

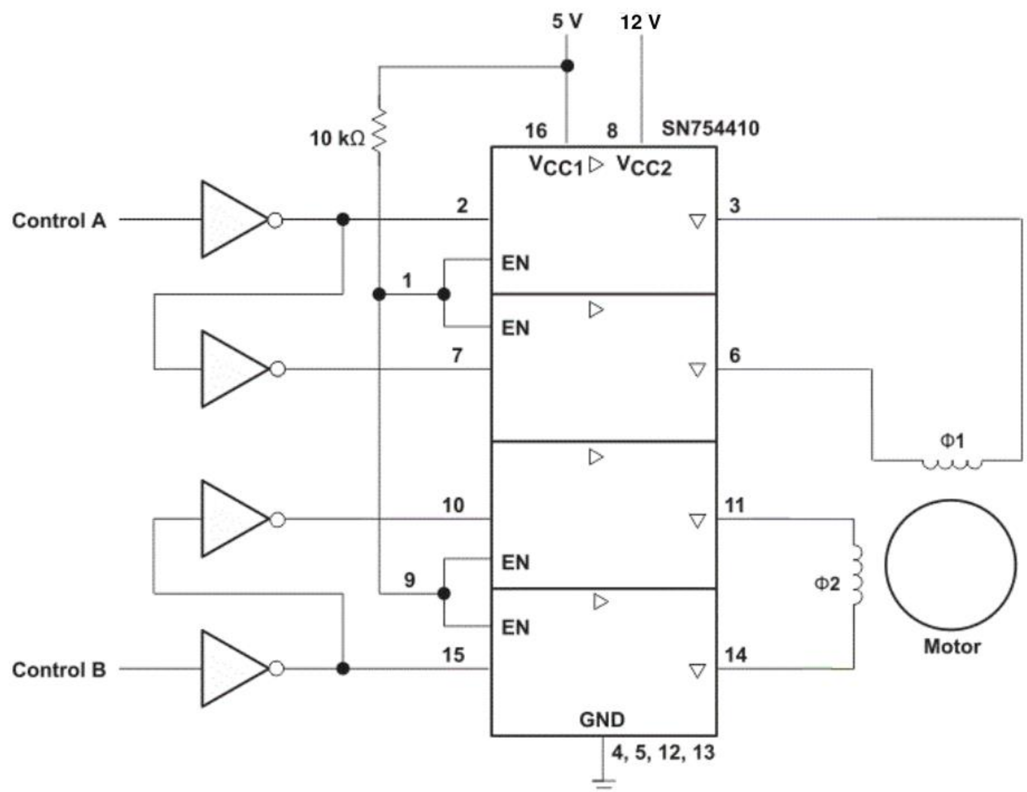


Figure 7. Typical Application Schematic

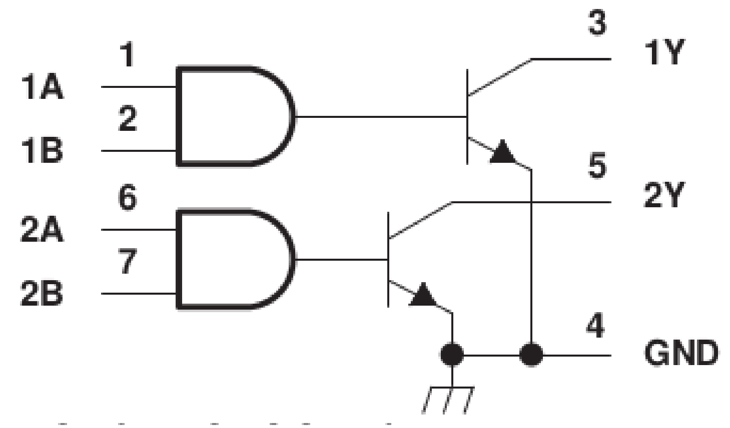
This is for a bipolar stepper motor (or a unipolar stepper ignoring the center taps)

Controlling things with the microcontroller

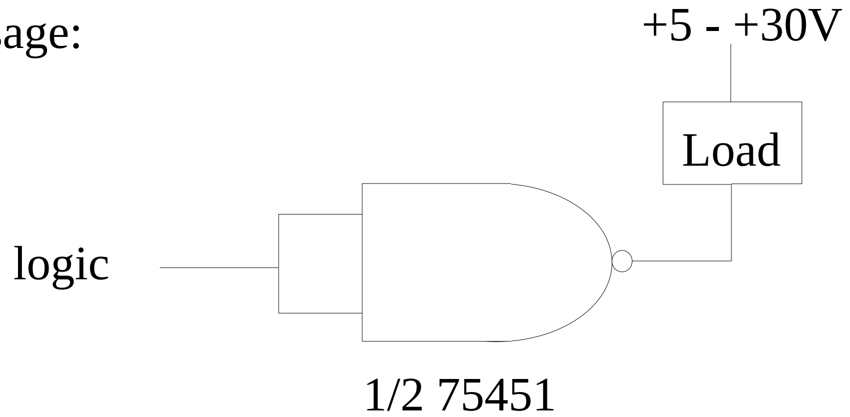
Driver eg SN75451

up to 300 mA

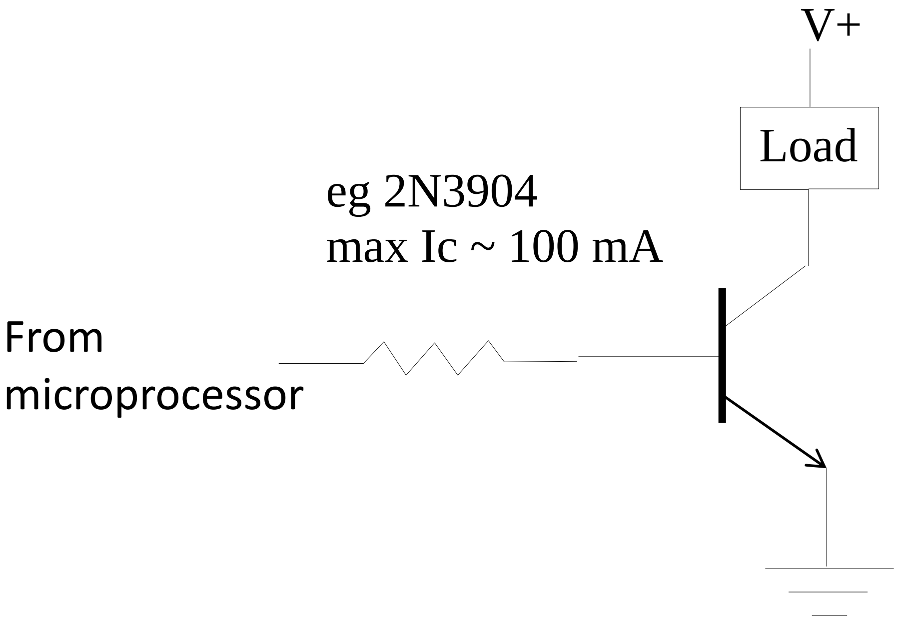
logic diagram (positive logic)



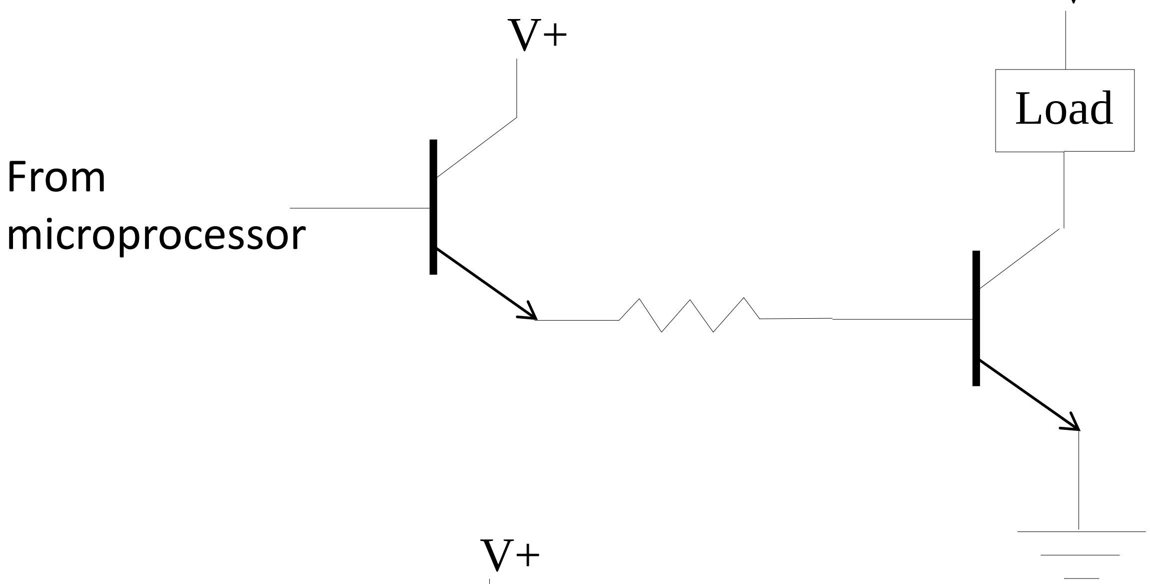
usage:

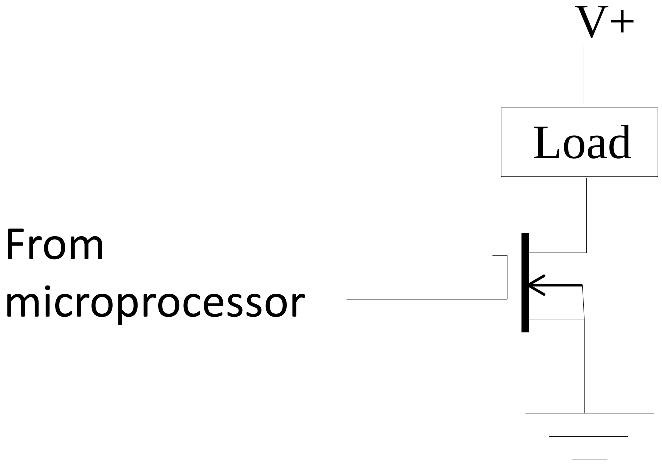


Driving loads: Transistors



A bit more current



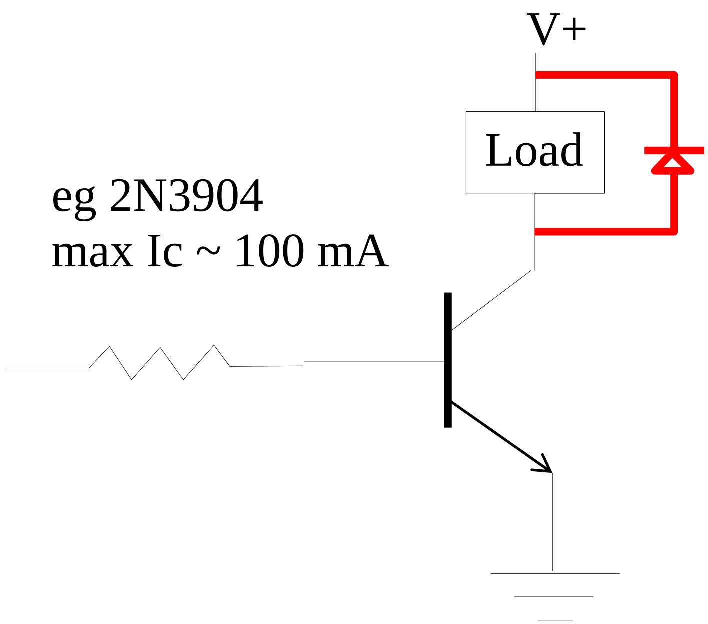


maximum current:
how much do you want?

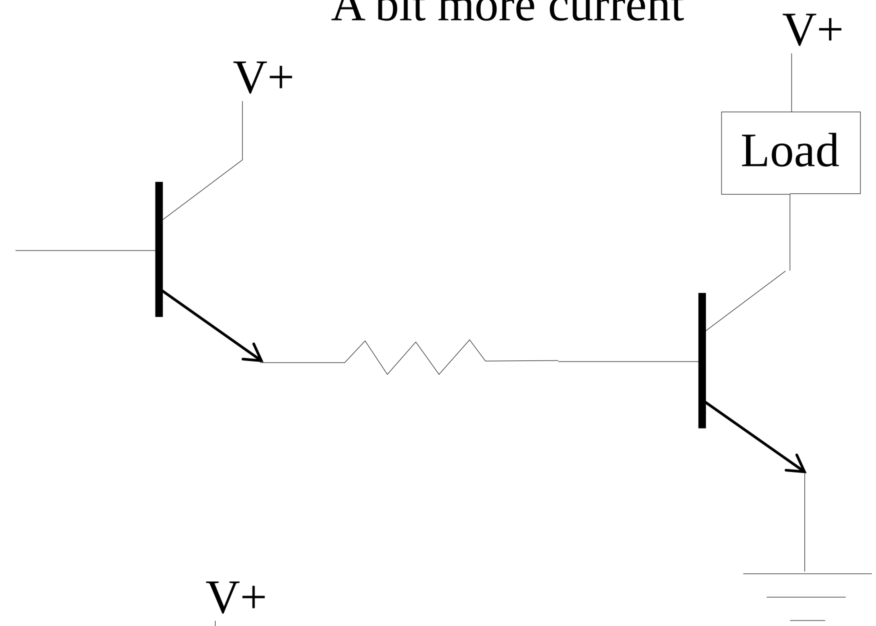
N-channel mosfet

Driving loads: Transistors

eg 2N3904
max Ic ~ 100 mA

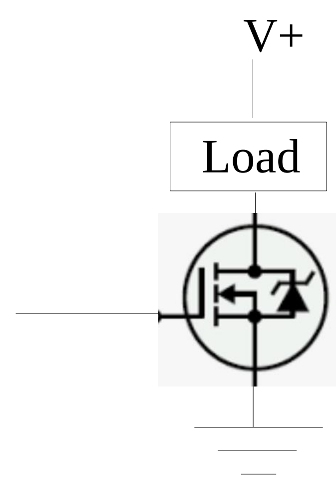


A bit more current



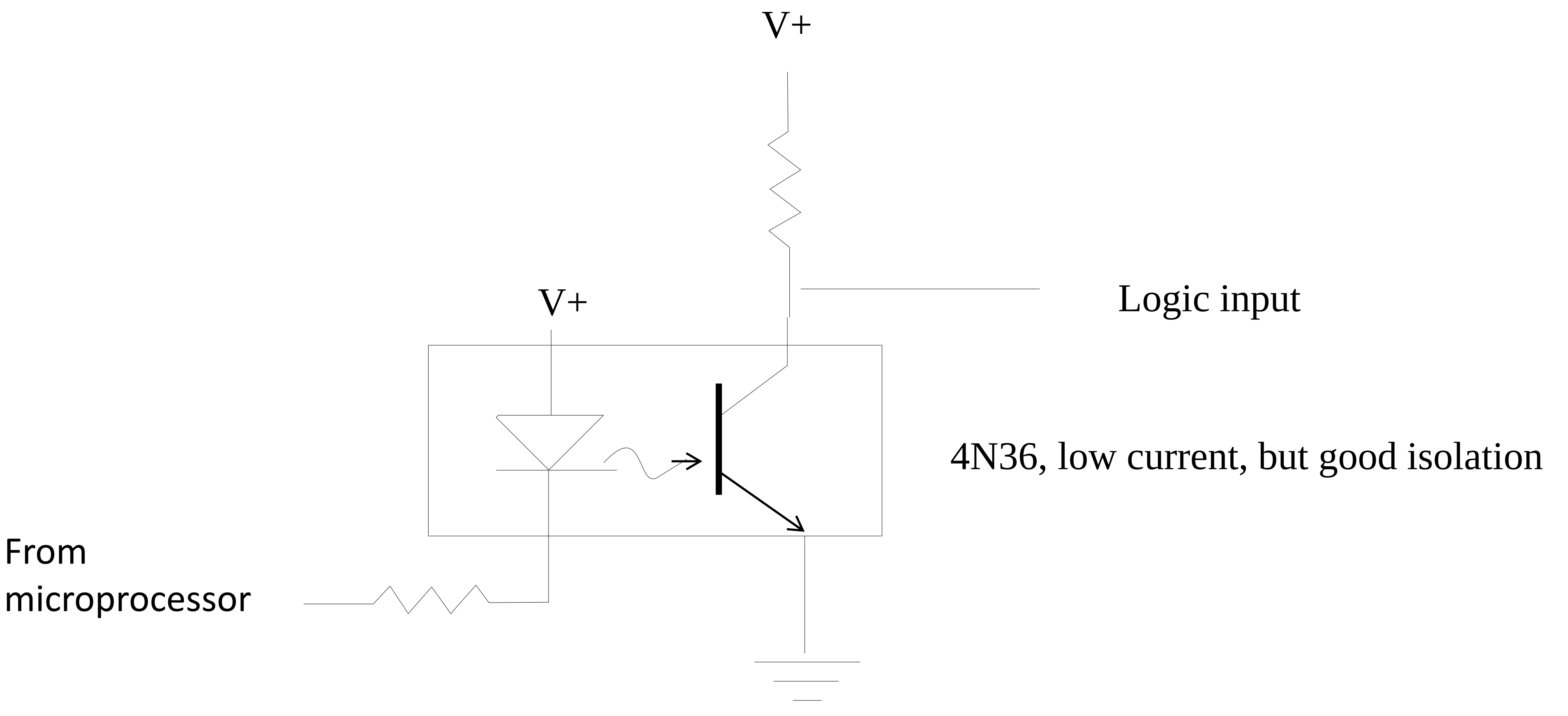
Inductive loads require that
you protect the transistor with a diode!

Many FETs have a diode
build in

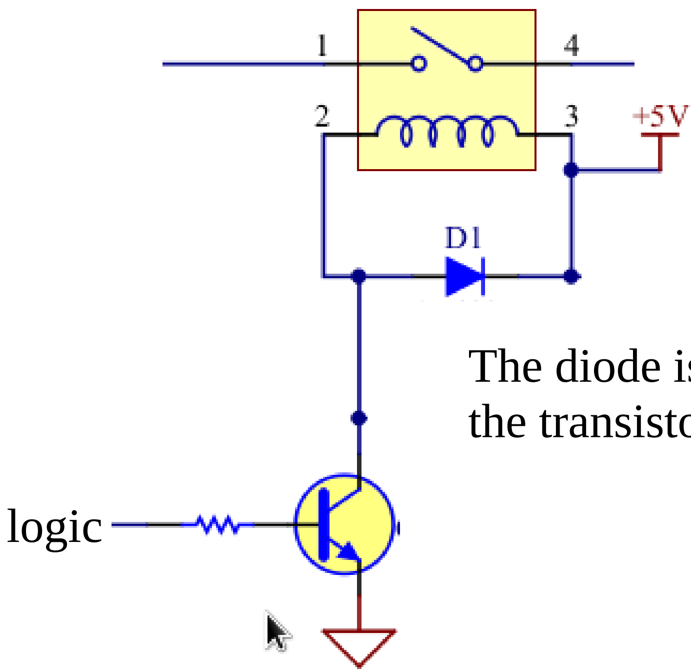


N-channel mosfet

Driving loads: Optoisolators



Driving loads: Relays



The diode is essential to prevent destroying
the transistor on turn-off!

There are some small low-current relays that can be driven directly by logic chips,
again, a diode is essential to protect the logic circuit from the inductive spike on turn-off!

Driving loads: Solid-state Relays

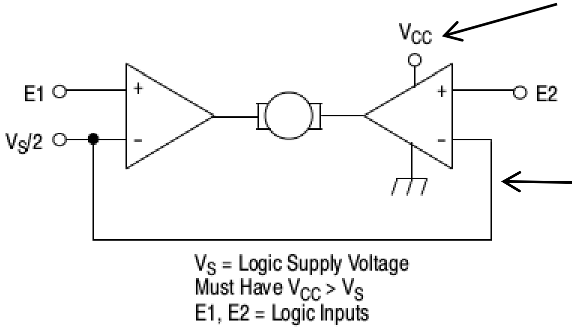
good for AC, large loads, fast, repeated switching
(expensive, may need a heat sink), Often will synchronize to line voltage.

eg Crydom D2425: 280VAC, 25A !

Driving Motors: high current op-amp

dual op-amp with 1A output current
and thermal protection: TCA0372

eg 6V, 12V, 15V for motor

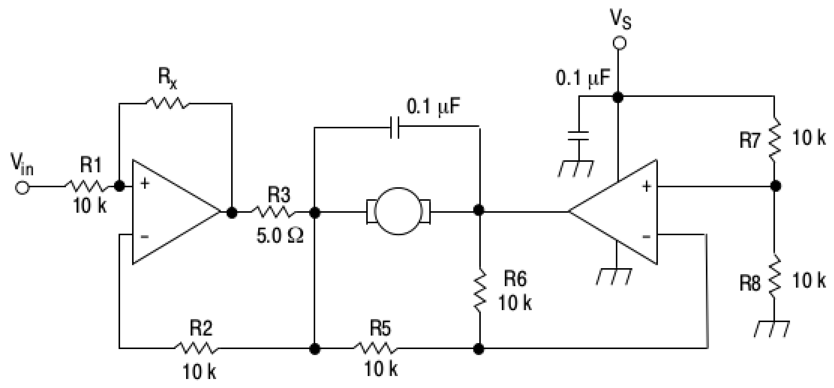


logic threshold

Figure 9. Bidirectional DC Motor Control with Microprocessor–Compatible Inputs

Driving Motors: high current op-amp

dual op-amp with 1A output current
and thermal protection: TCA0372



For circuit stability, ensure that $R_x > \frac{2R3 \cdot R1}{R_M}$ where, R_M = internal resistance of motor.

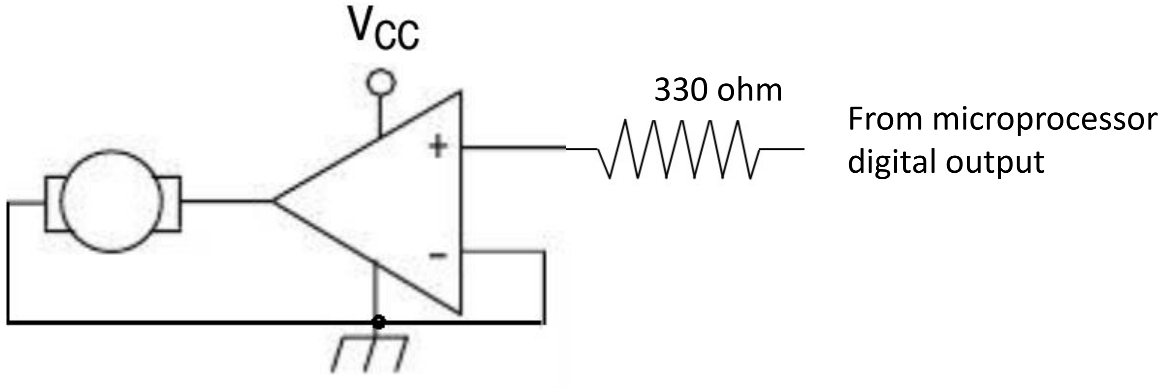
The voltage available at the terminals of the motor is: $V_M = 2\left(V_1 - \frac{V_S}{2}\right) + |R_o| \cdot I_M$

where, $|R_o| = \frac{2R3 \cdot R1}{R_X}$ and I_M is the motor current.

Figure 10. Bidirectional Speed Control of DC Motors

Driving Motors: high current op-amp

Single direction on/off

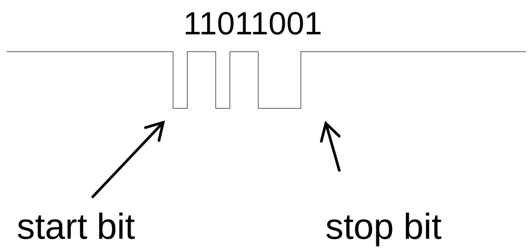


Serial interfaces

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;

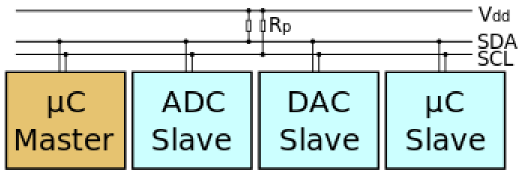
SPI: Serial Peripheral Interface

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.

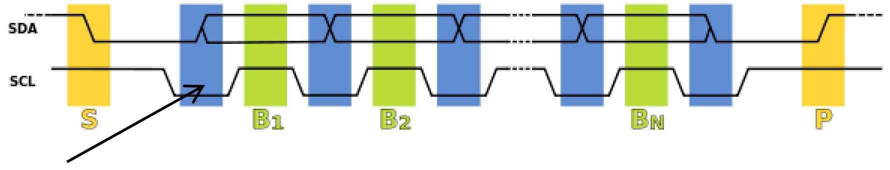
point-to-point, one master, one slave.

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.