Today's plan:

Reminder: Marking

Announcements: status report

Final presentations and reports

Connecting resistive or current sensors

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 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 25.

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

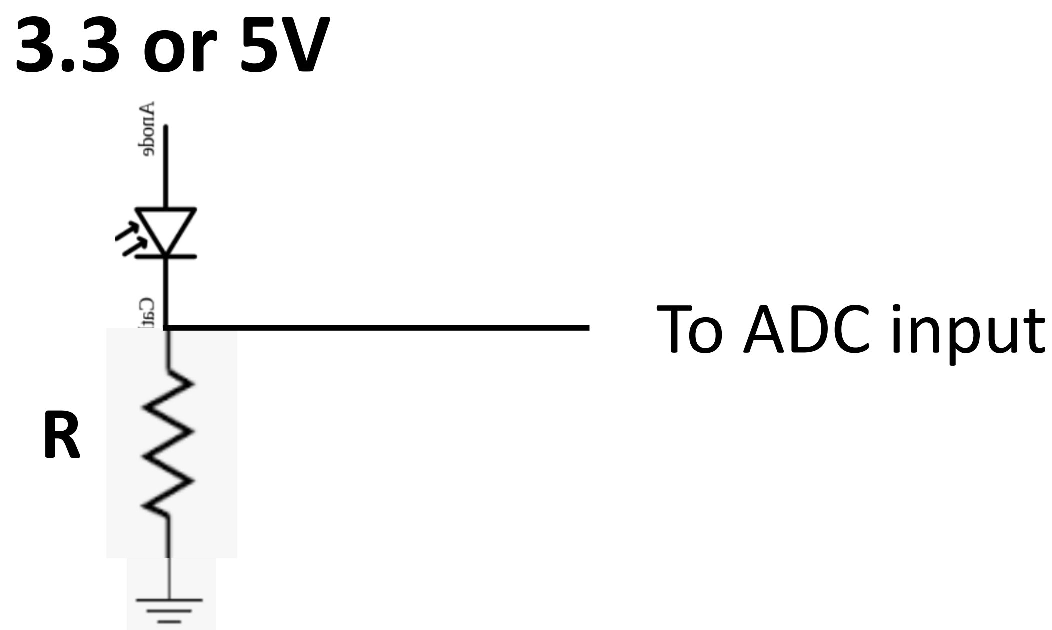
- At the end of the course you'll present your project in two ways:

1) Oral presentation in class. These will happen on Tuesday April 9, Wednesday April 10 and Thursday April 11. 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 15, 10PM.

Unfortunately no extensions!

Connecting resistive or current sensors



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

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

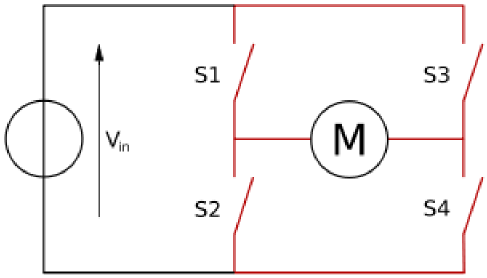
Some possibilities:

- 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)

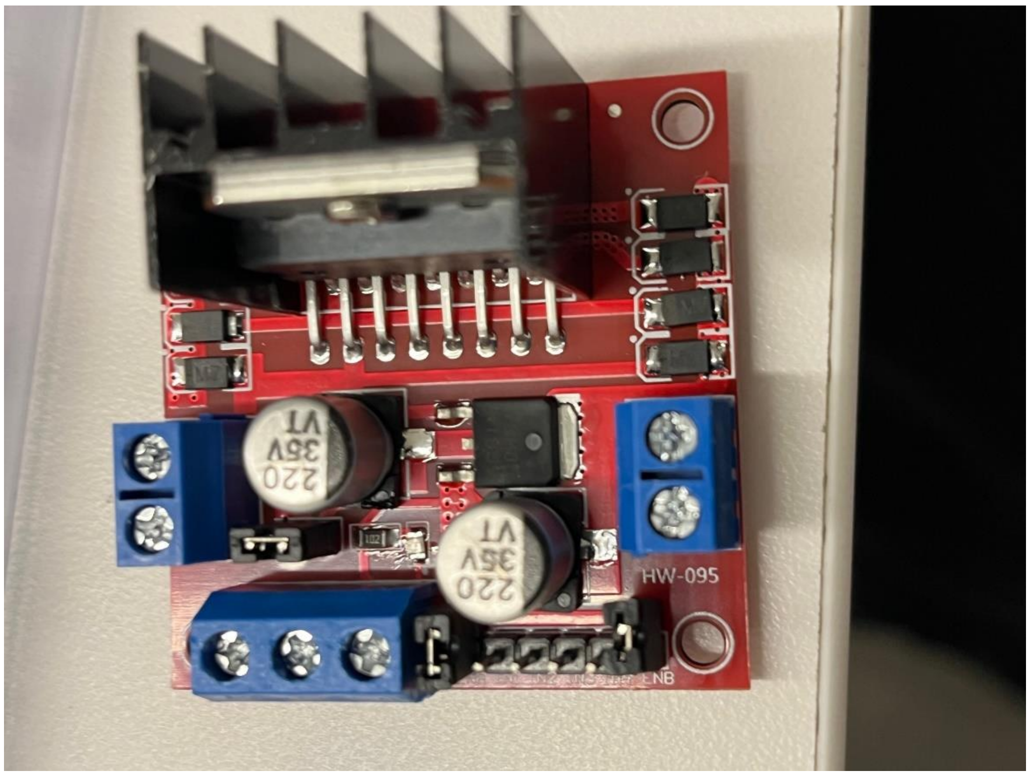
Driving Motors: H-bridge

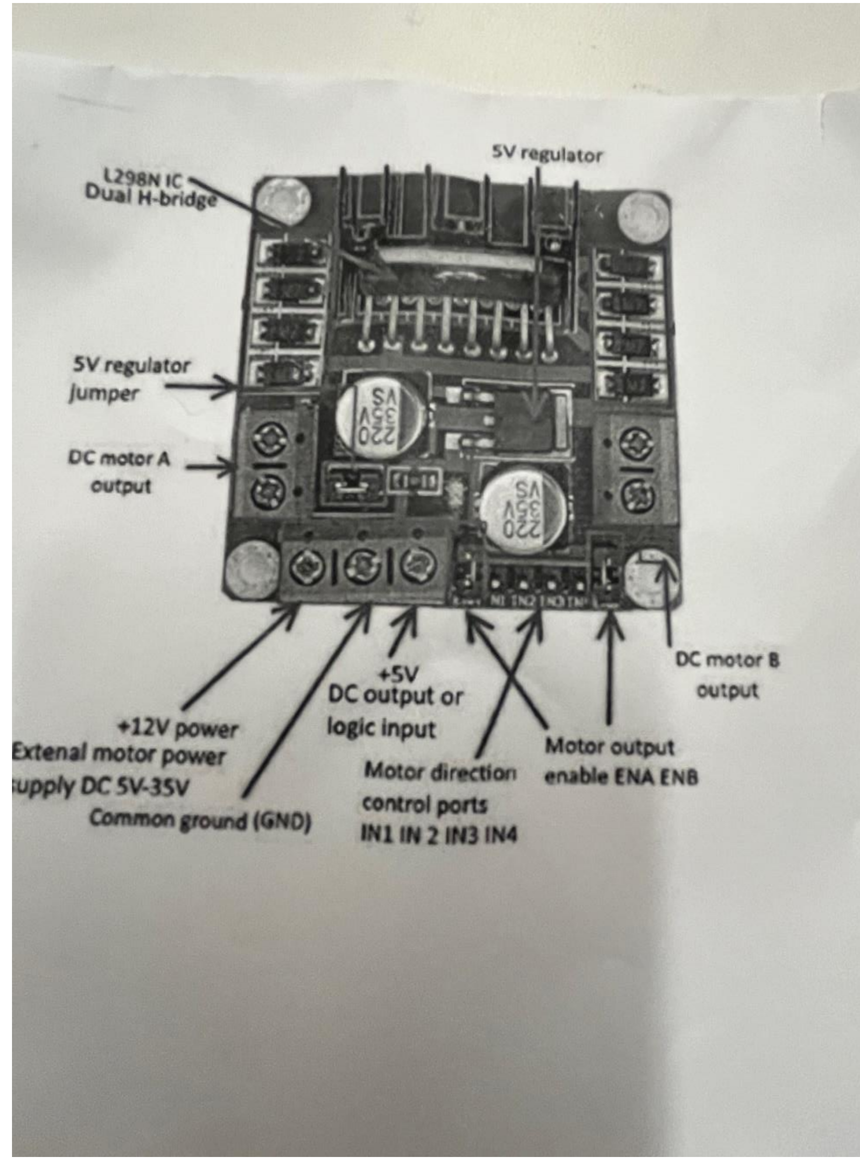
To drive a dc motor in either direction with a single power supply, close S1 and S4 OR S2 and S3.



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

The switches are often transistors: bipolar or MOSFETs


HW-095
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

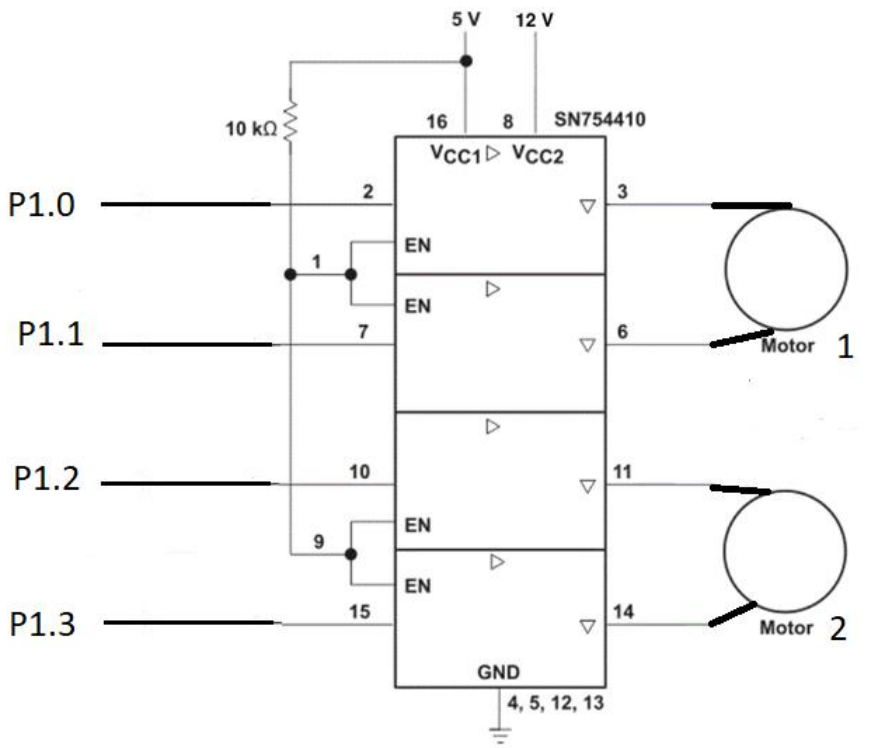


Figure 7. Typical Application Schematic

This is for 2 DC motors

Driving Step Motors: H-bridge

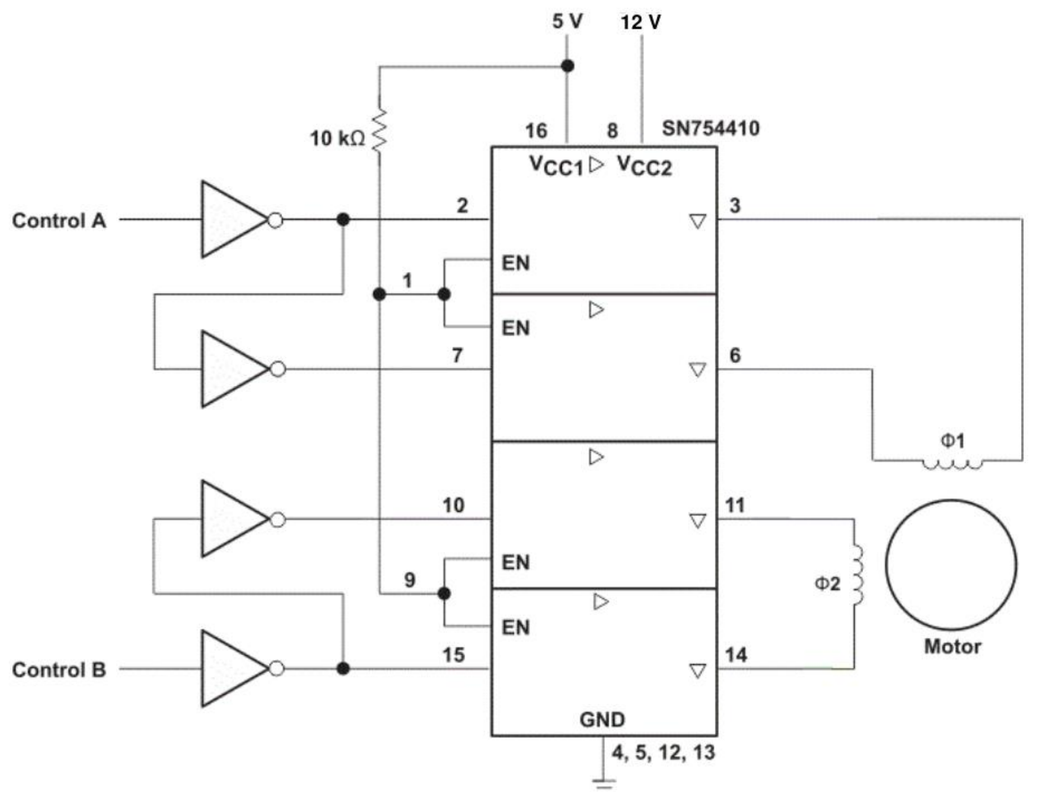


Figure 7. Typical Application Schematic

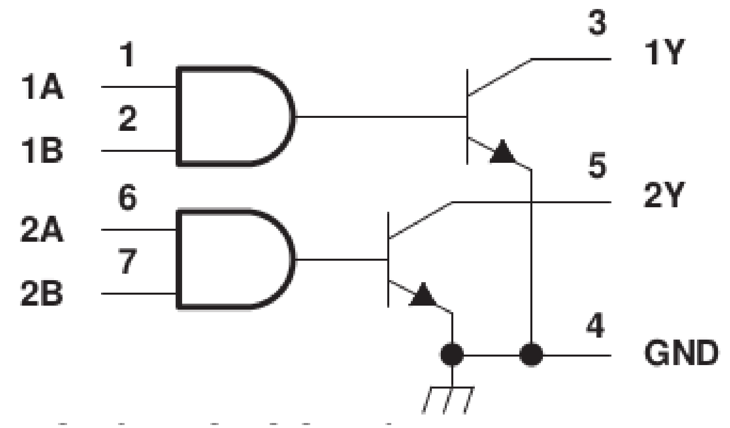
This is for a bipolar stepper motor (or a unipolar stepper ignoring the center taps)

Controlling things with the microcontroller

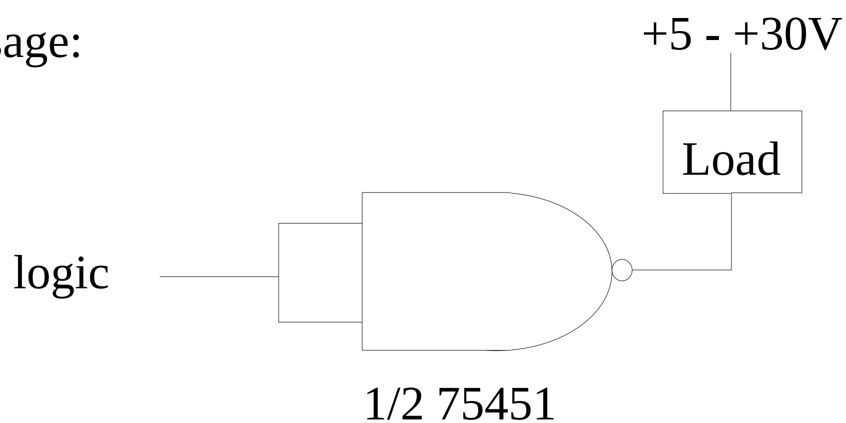
Driver eg SN75451

up to 300 mA

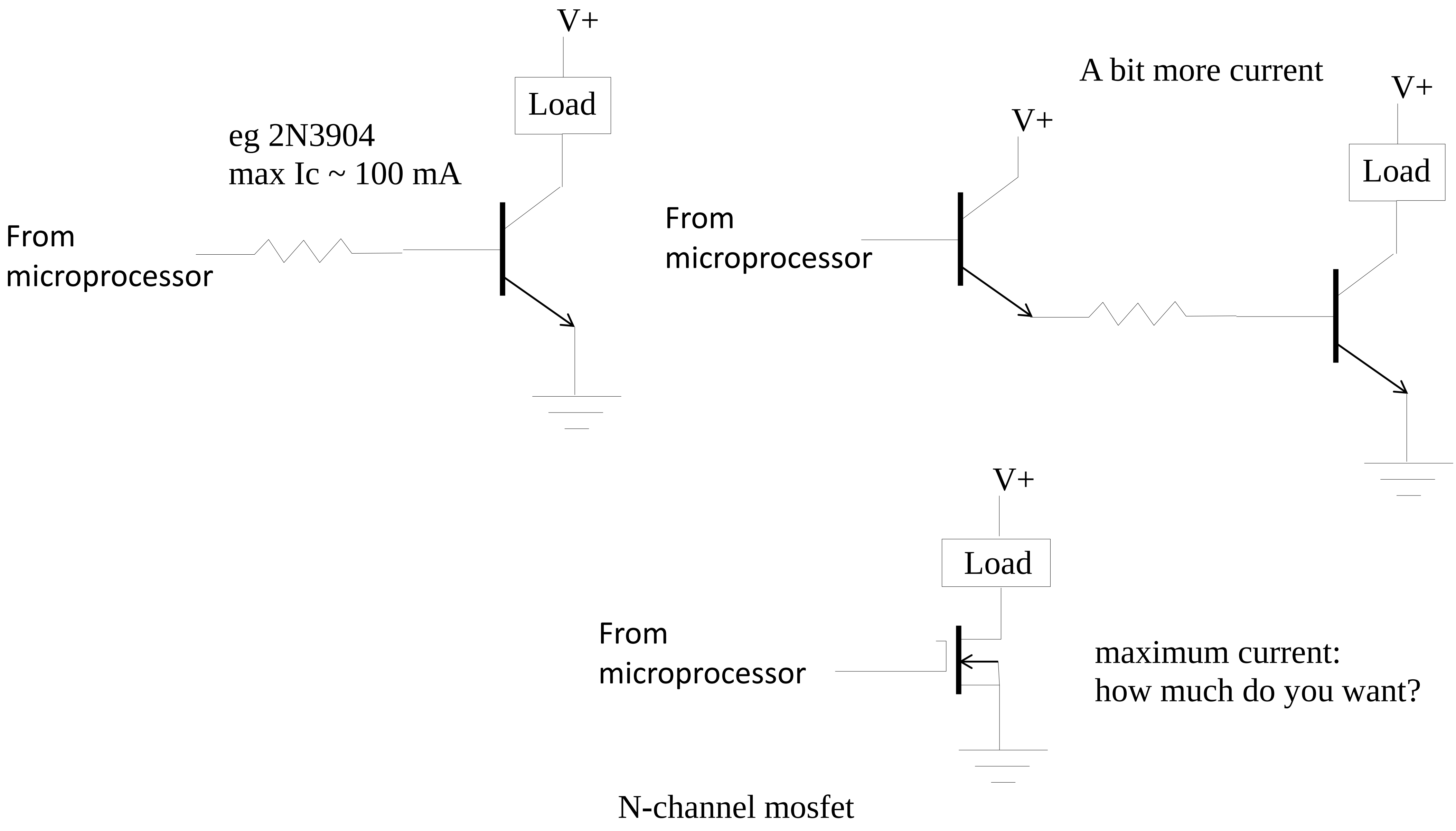
logic diagram (positive logic)



usage:

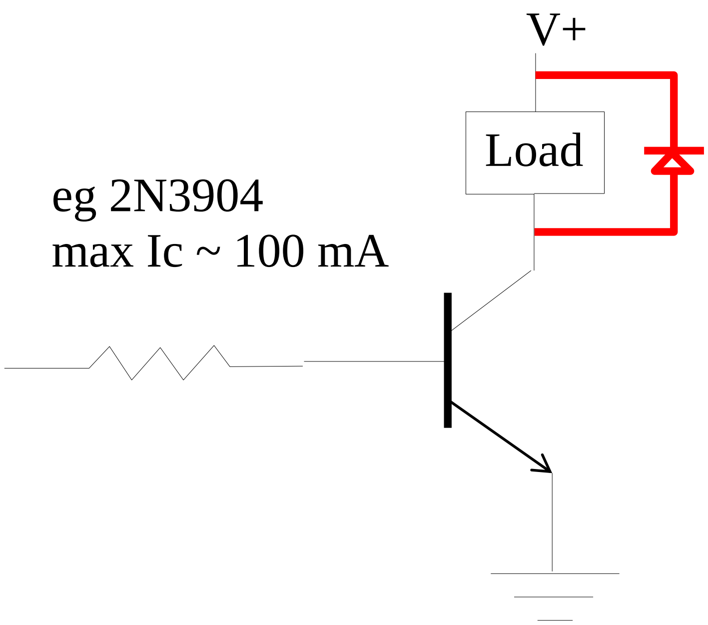


Driving loads: Transistors

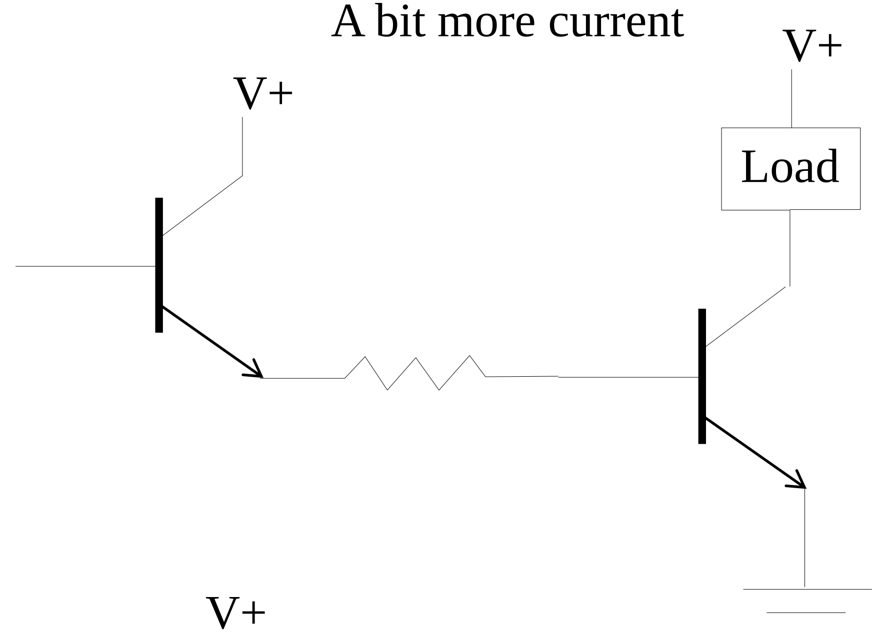


Driving loads: Transistors

eg 2N3904
max Ic ~ 100 mA

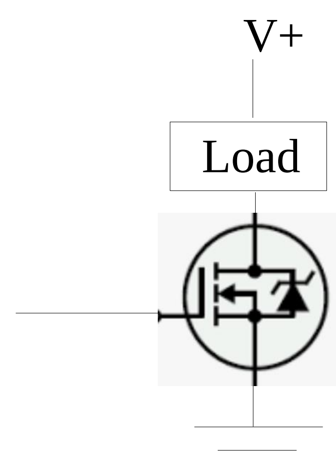


A bit more current



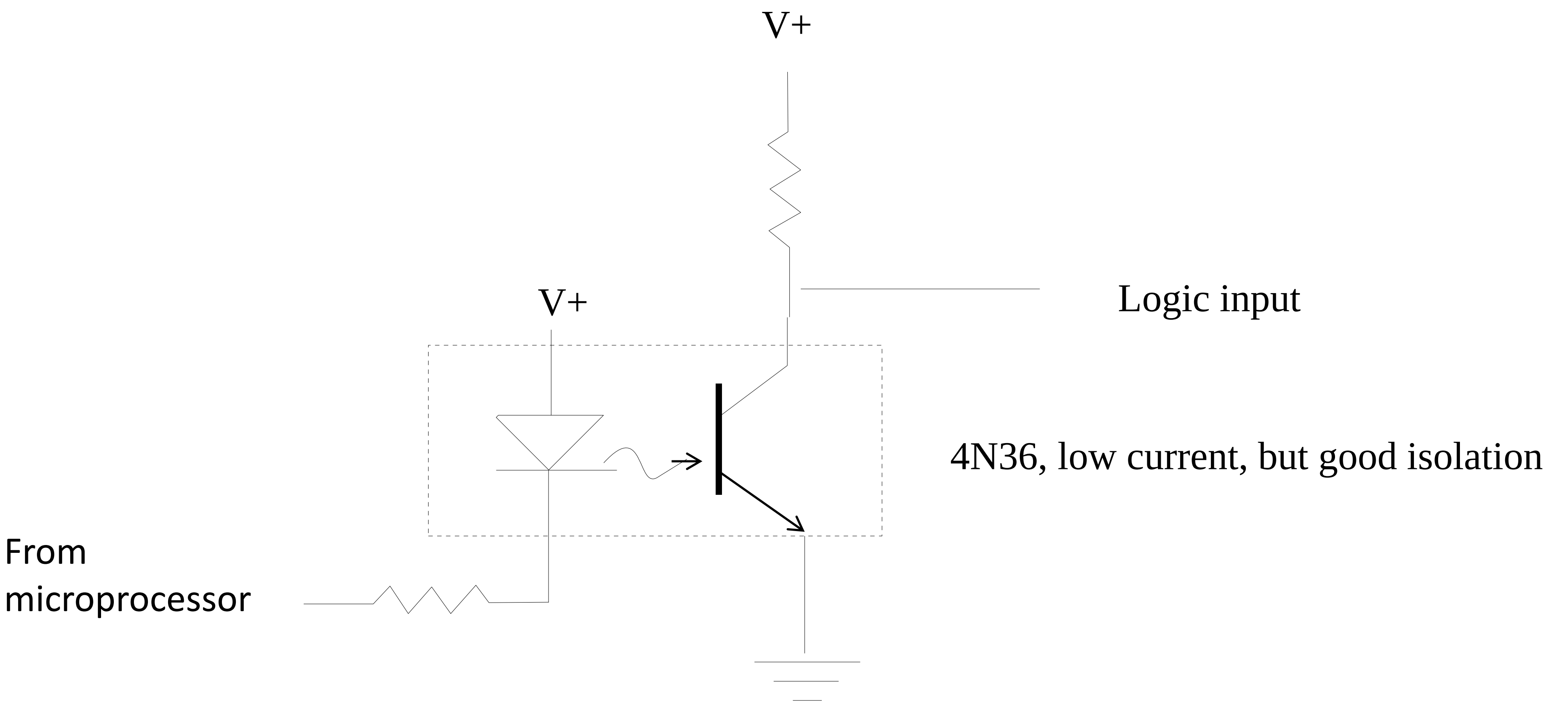
Inductive loads require that
you protect the transistor with a diode!

Many FETs have a diode
build in

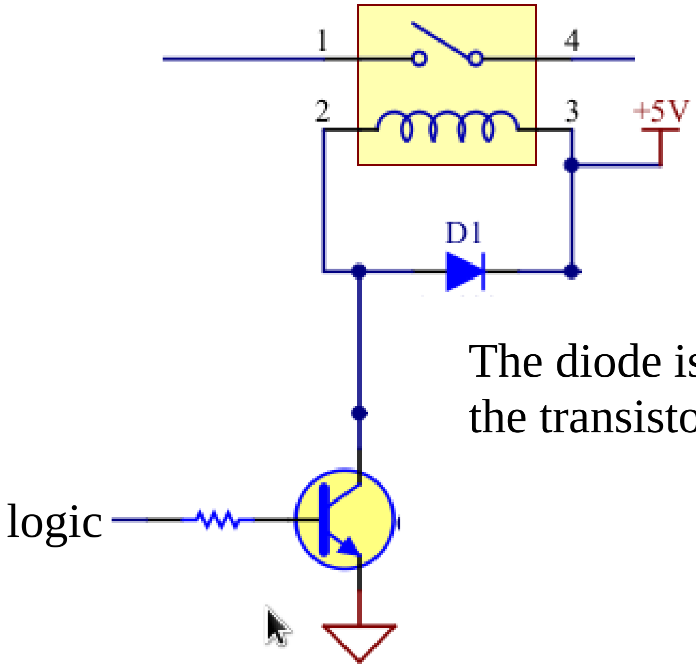


N-channel mosfet

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

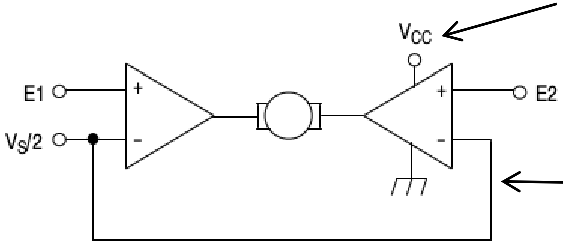
good for AC, large loads, fast, repeated switching
(expensive, may need a heat sink), Often will synchronize to line voltage.

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



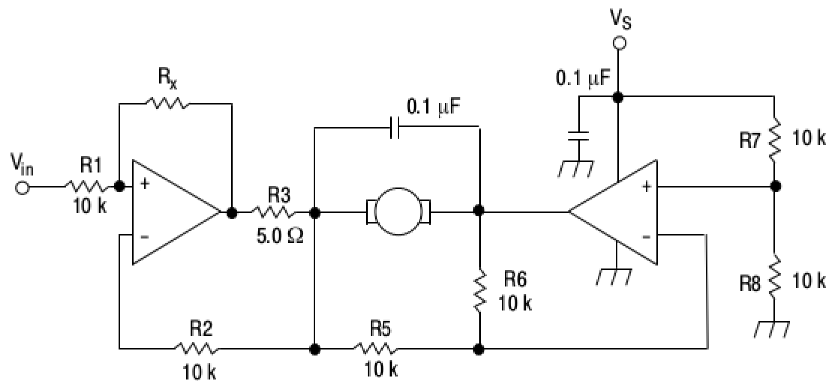
logic threshold

V_S = Logic Supply Voltage
Must Have $V_{CC} > V_S$
E1, E2 = Logic Inputs

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.

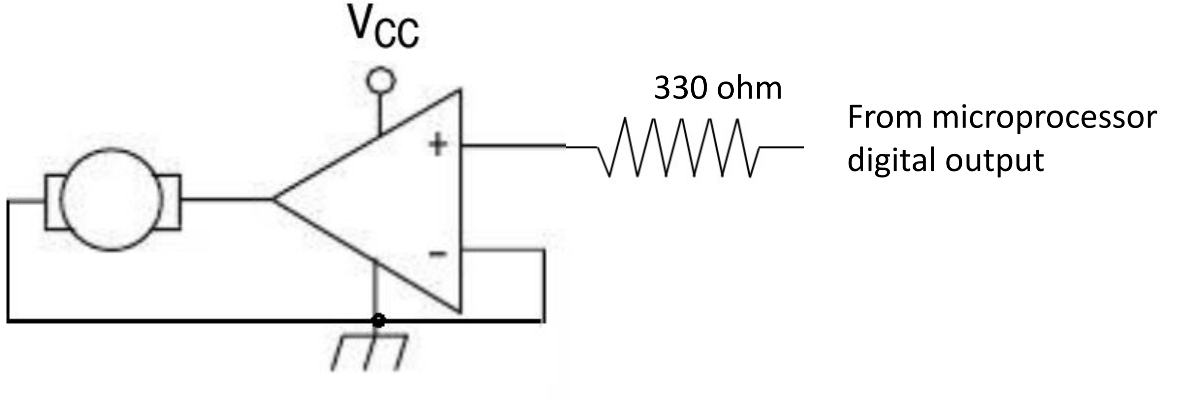
The voltage available at the terminals of the motor is: $V_M = 2\left(V_1 - \frac{V_S}{2}\right) + |R_o| \cdot I_M$

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

Figure 10. Bidirectional Speed Control of DC Motors

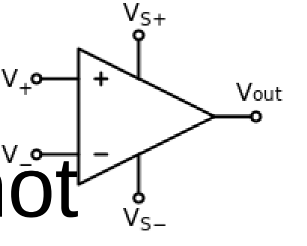
Driving Motors: high current op-amp

Single direction on/off

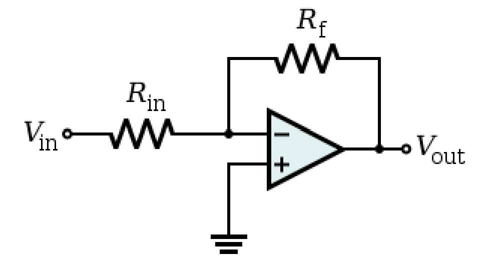


Op-amps

- Vout = A (V_+-V_-), where A is a large number (10^4-10^6)
- Exact value of A is usually not very important.
- (Almost) always use in a circuit with feedback.
- Needs power supplies, often not shown on circuit diagrams. Typical supplies are +/- 15V, but can vary.



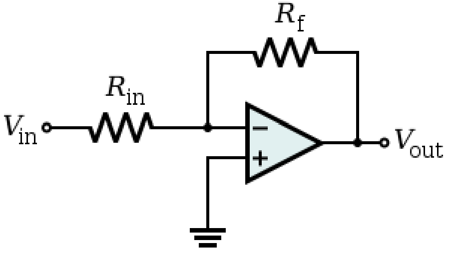
Golden Rules



- (1) The output attempts to do whatever is necessary to make the voltage difference between the inputs zero.
- (2) The inputs draw no current.
- Both rules are approximations! Rule (1) is only obeyed in a circuit with negative feedback, and the difference is usually not quite 0. The inputs draw a tiny amount of current.

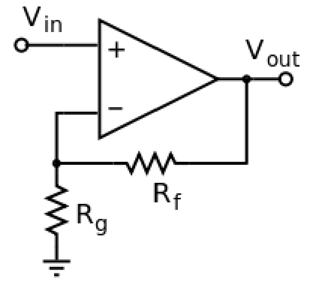
Inverting amplifier

- $V_{out} = -V_{in}\, R_f/R_{in}$
- Often the preferred topology, except:
- Low-ish input impedance (R_{in})



Non-inverting amplifier

- $V_{out} = V_{in} (1+ R_f/R_g)$
- input impedance limited by the op-amp itself (usually very high!)



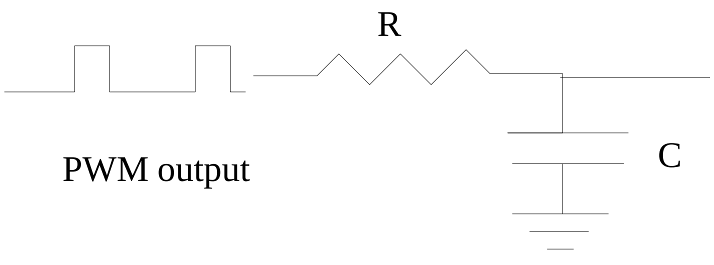
Imperfections

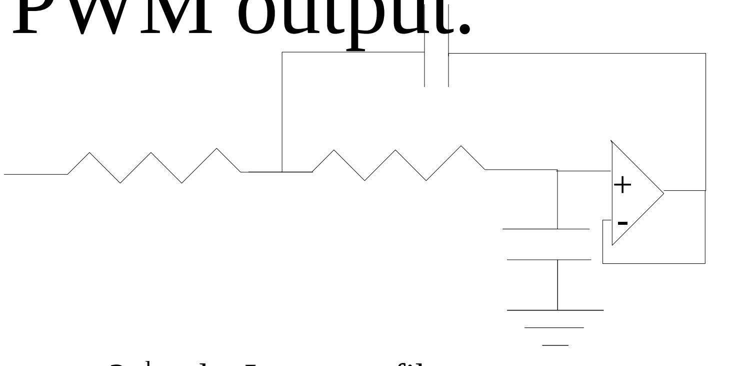
- Gain, A, is not frequency independent. The op-amp gain will roll off at high frequency (design choice for stability).
- inputs do draw some current (input bias current) – must provide a dc current path!
- Output cannot swing beyond (or in some cases even too close to) the power supply rails.

Analog Output:

The MSP430F5529 doesn't have a DAC. If you want an adjustable analog output, there are a couple of options:

- Add an external DAC (serial or parallel)
- low-pass filter and PWM output.

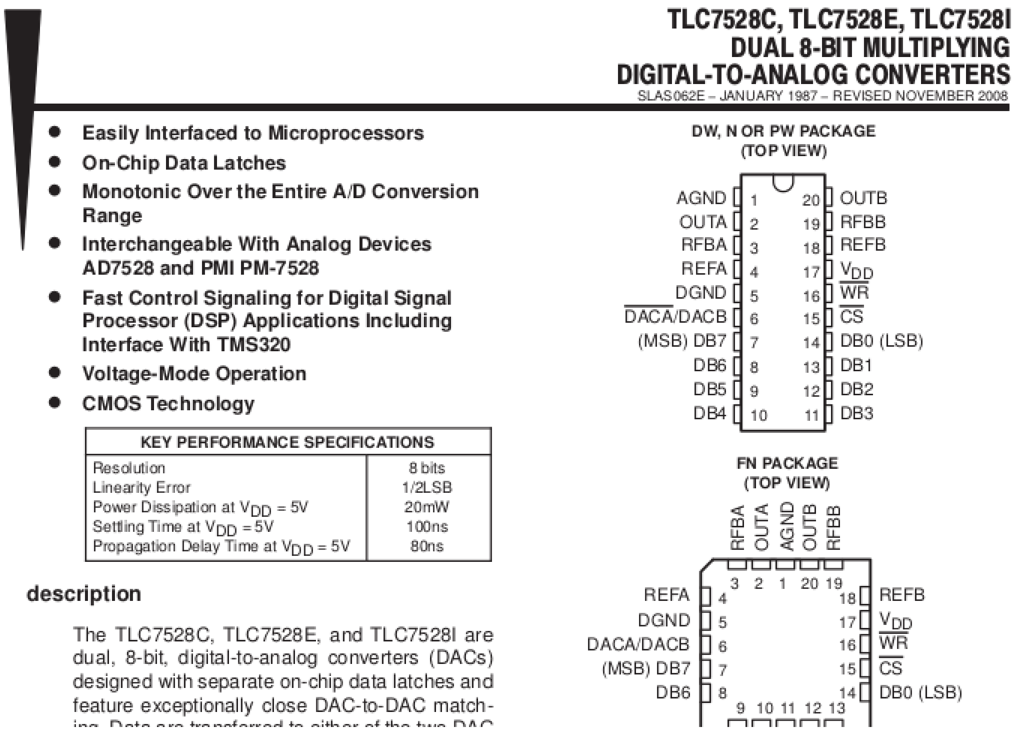




2nd order Low-pass filter

Analog Output:

Parallel DAC: eg TLC7528, Dual 8bit multiplying digital to analog converter.



TLC7528C, TLC7528E, TLC7528I
DUAL 8-BIT MULTIPLYING
DIGITAL-TO-ANALOG CONVERTERS
SLAS062E – JANUARY 1987 – REVISED NOVEMBER 2008

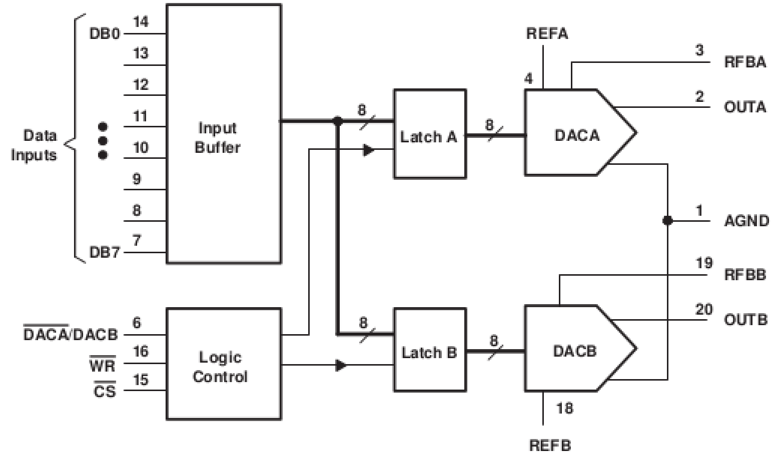
- **Easily Interfaced to Microprocessors**
- **On-Chip Data Latches**
- **Monotonic Over the Entire A/D Conversion Range**
- **Interchangeable With Analog Devices AD7528 and PMI PM-7528**
- **Fast Control Signaling for Digital Signal Processor (DSP) Applications Including Interface With TMS320**
- **Voltage-Mode Operation**
- **CMOS Technology**

KEY PERFORMANCE SPECIFICATIONS	
Resolution	8 bits
Linearity Error	1/2LSB
Power Dissipation at V_{DD} = 5V	20mW
Settling Time at V_{DD} = 5V	100ns
Propagation Delay Time at V_{DD} = 5V	80ns

description

The TLC7528C, TLC7528E, and TLC7528I are dual, 8-bit, digital-to-analog converters (DACs) designed with separate on-chip data latches and feature exceptionally close DAC-to-DAC matching. Data are transferred to either of the two DAC

DAC: TLC7528



operating sequence