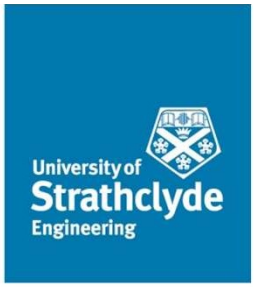
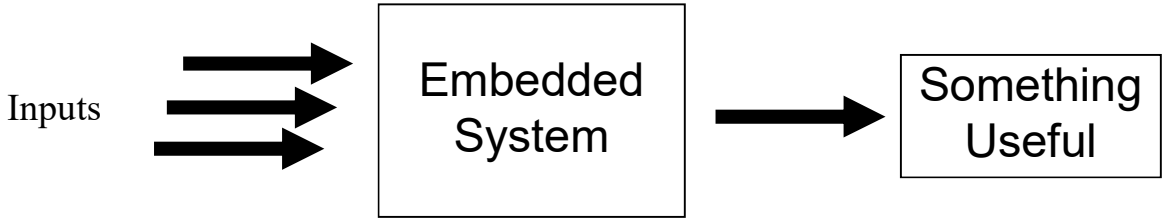


Week 6:
Advanced Interfacing

James Irvine

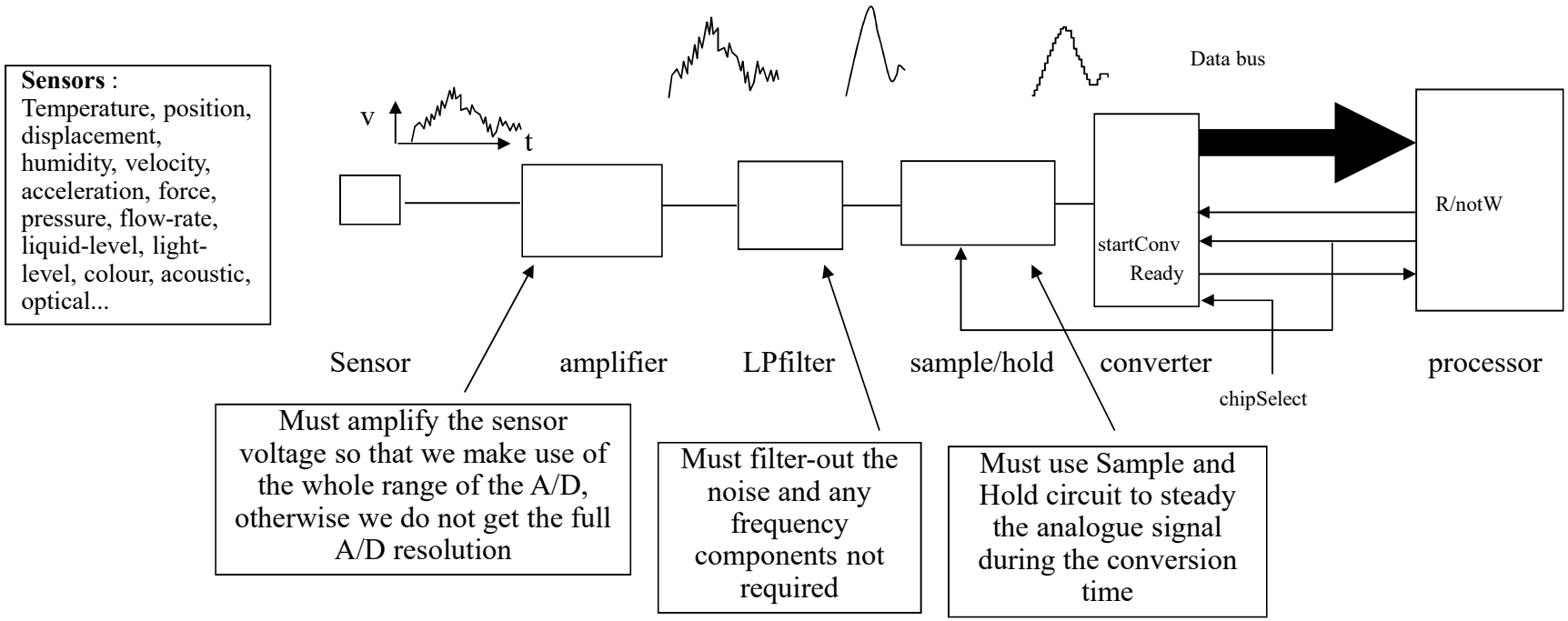
DEPARTMENT OF ELECTRONIC & ELECTRICAL ENGINEERING

Basic Embedded System



- Inputs
  - Can be real world sensors or another system
- Outputs
  - Pretty pointless without some output!
  - Can be divided between
    - Signal and power
    - Analogue and digital

Typical Signal Conditioning Chain



Inputs from other systems

- Generally easy
- Ensure some verification is available
  - ACK, ARQ, etc
- Serial communications saves I/O lines, but watch bandwidth and processing

Real World Inputs

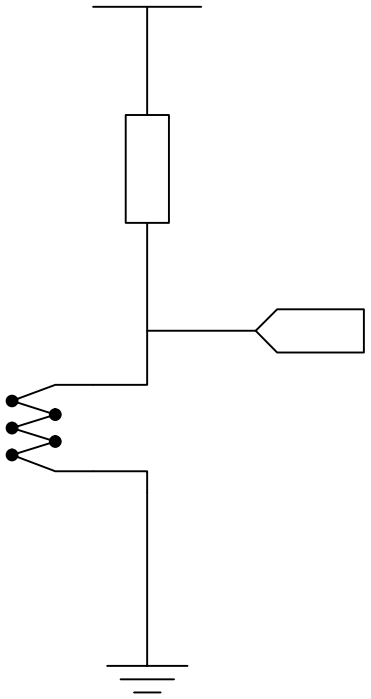
- Digital inputs include
  - mechanical switch
    - requires debouncing
  - reed switch
    - as above, but environmentally sealed
  - optical sensor
    - probably requires threshold detector
  - hall effect sensor
    - probably requires threshold detector
  - thermistor
    - will require threshold detector
  - strain gauge
    - will require threshold detector & perhaps amplification

Beware!

- If something is important enough to get, it is important enough to check
- Switches get dirty
- Optical sensors can be swamped by ambient light
- Everything can break (open circuit) or short (close circuit)

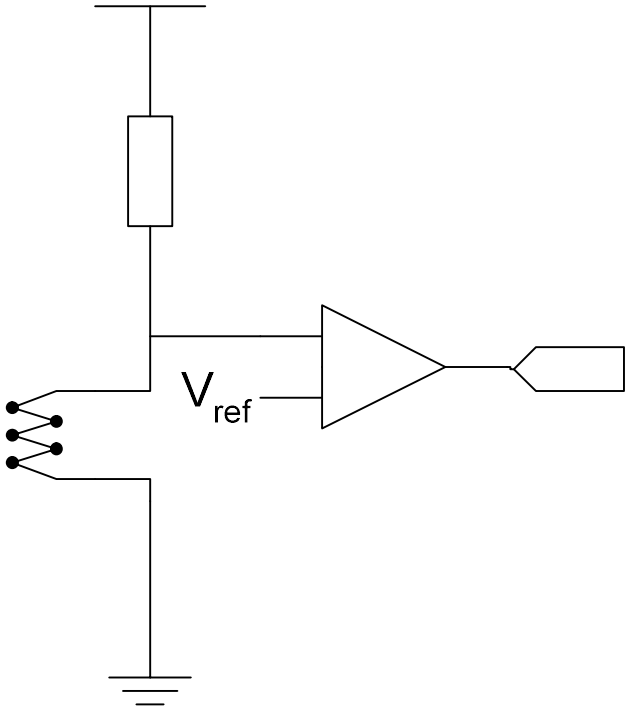
Basic Sensor

- Only works if sensor causes a logic voltage change



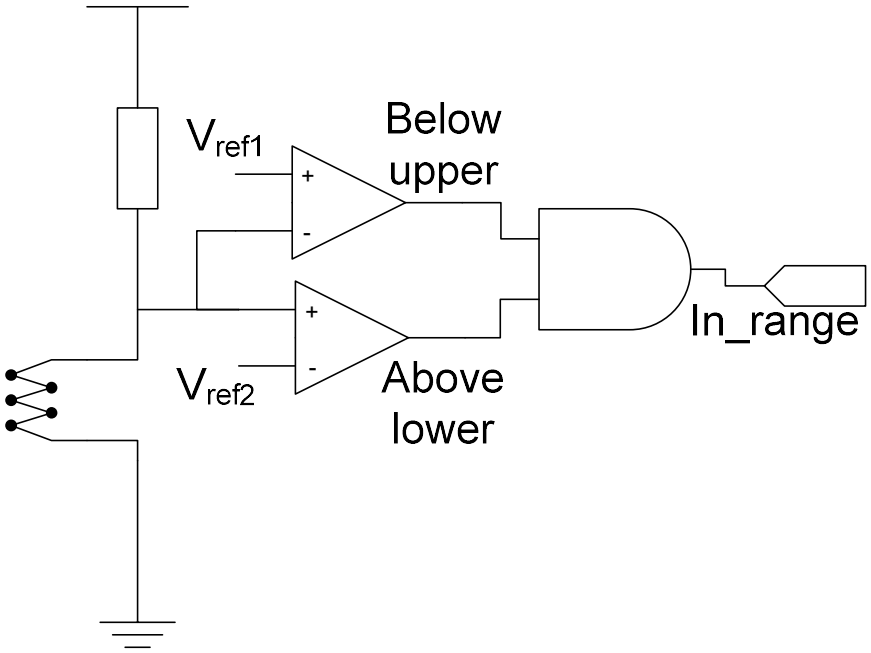
Improved Sensor

- Can cope with non-logic voltages



Better Sensor

- Copes with failures if correctly designed
- In_range = 1 if input >V_{ref2} & <V_{rev1}

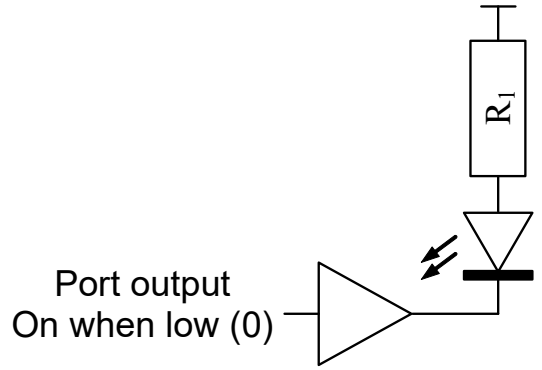


Outputs

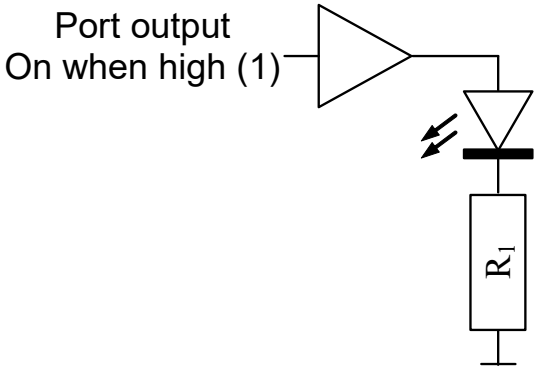
- Signal outputs
  - Other embedded systems
  - Communication devices
  - Intelligent displays
  - Some dumb displays (LCD, etc)
- Power outputs
  - Almost everything else…
  - Requires
    - Power amplification
    - Protection
    - May require isolation

Signal Power Connectors

- Sometimes you can get just enough power…
- Most micros can directly drive an LED
- Most common arrangement
  - Micros can often sink more current than they can source
  - Negative logic (0 for on)

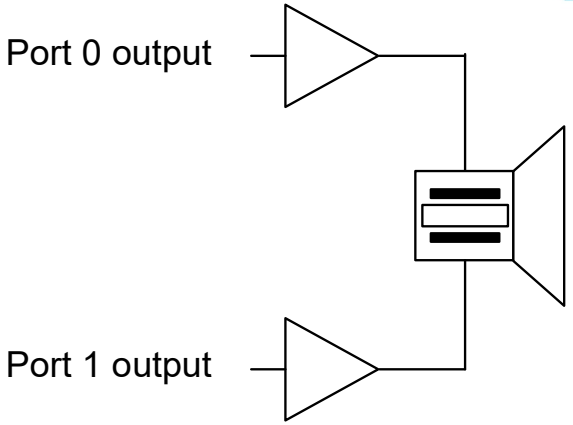


- Positive logic
  - 0 for off
  - More intuitive, but less common

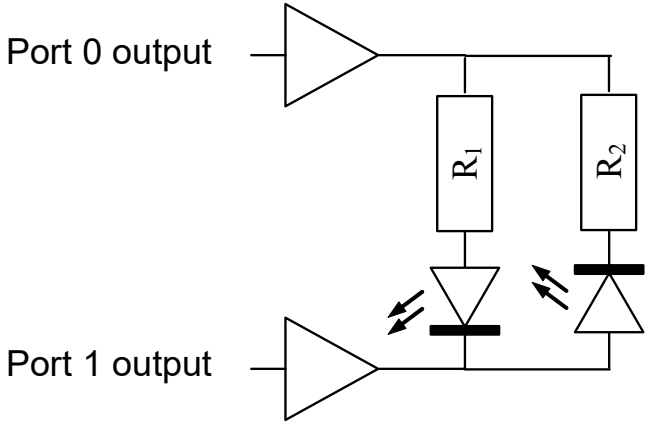


Push/pull (bridged) arrangement

- Doubles effective voltage swing
  - Very useful for piezo transducers



- Also allows bidirectional current
  - Useful for bicolour LEDs with less wiring

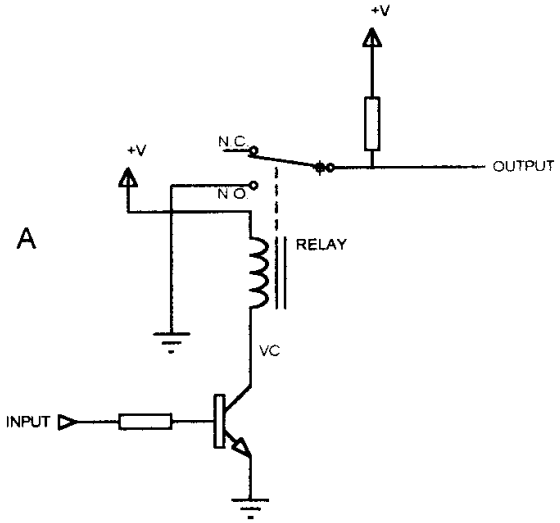


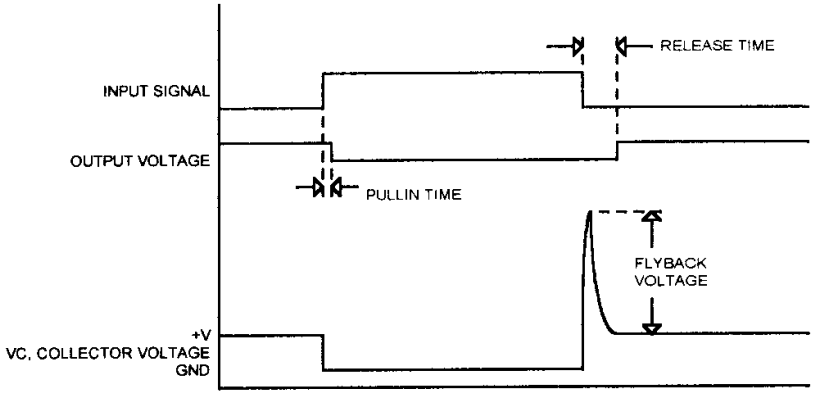
Relays

- Power amplification and isolation in one package
- May be mechanical or solid state
- Pros
  - Excellent isolation
  - Excellent amplification
  - Easy to design and maintain
  - Low on resistance
  - Work for AC or DC
- Cons
  - Mechanical, so reliability concerns
  - Switch contacts may degrade
  - Slow operation & debouncing issues
  - Relatively high power requirements for low loads
  - Inductive pulses & electromagnetic noise
  - Sparks

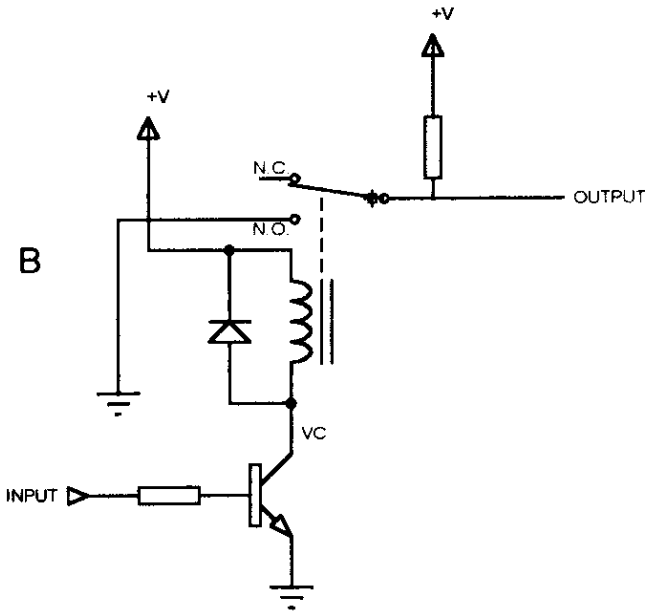
Flyback Voltage

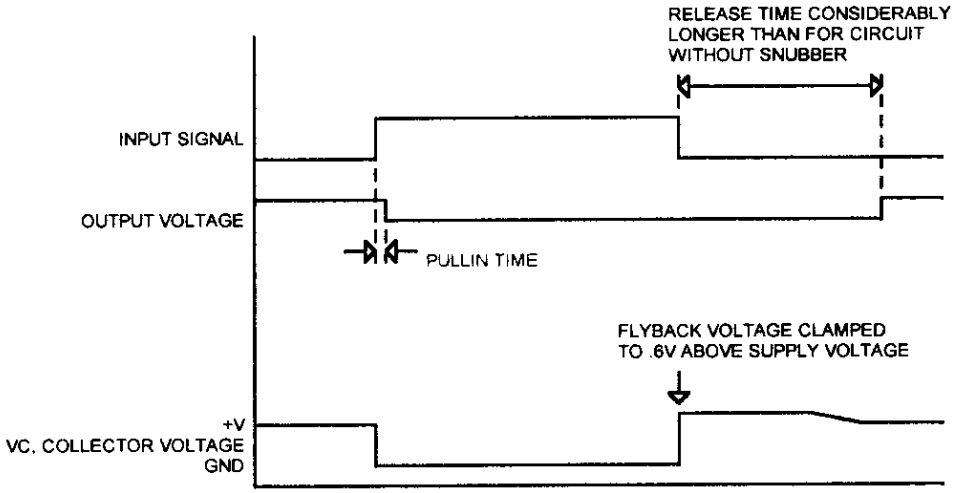
- Relay coil continues to conduct when it is switched off
- Very destructive ‘flyback’ voltage
  - Current remains constant in the very short term, but high resistance = high voltage = fried semiconductors





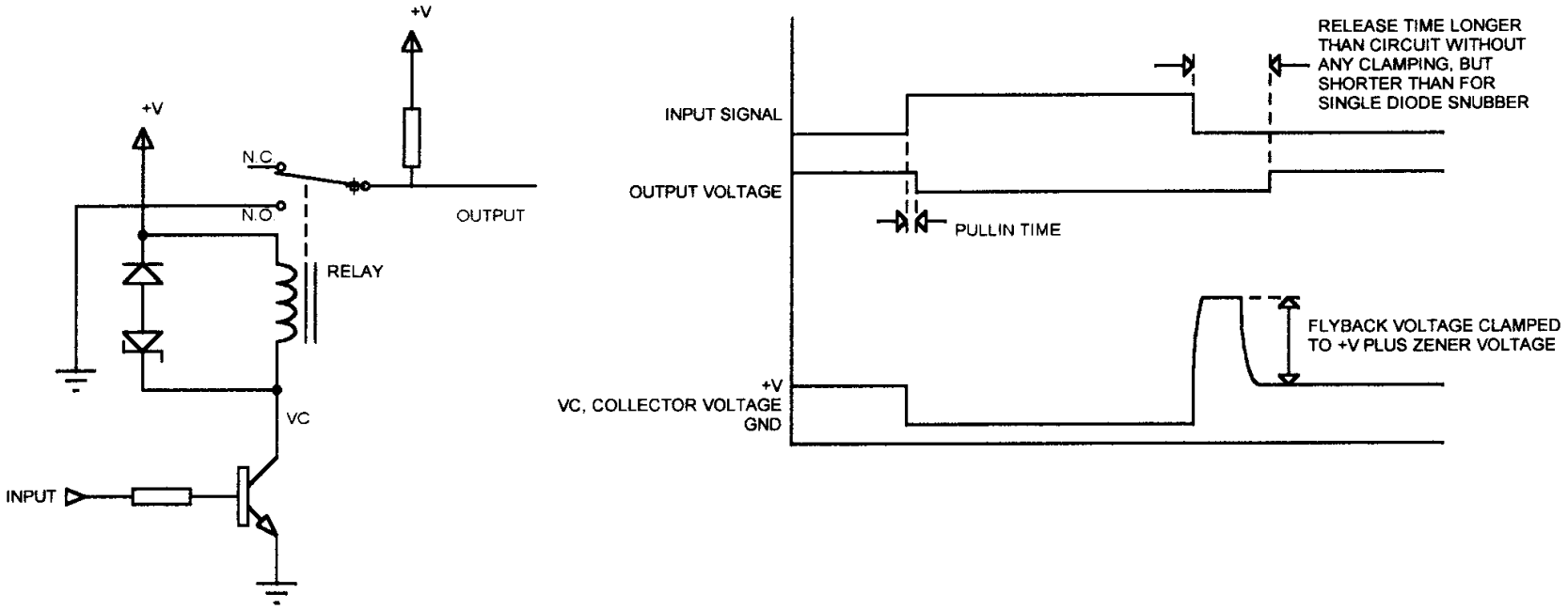
Diode to short flyback





- Kills flyback, but lengthens release time

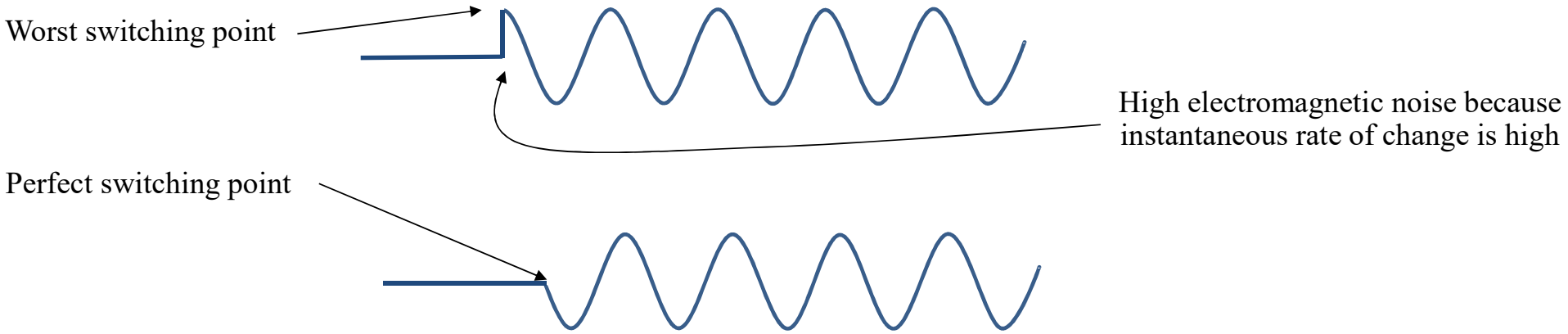
Zener to improve release times



- Compromise - keeps flyback within safe limits but shortens release time

Switching AC Power

- Switching 240V AC at 10's of Amps can create high contact noise - depending on which part of the phase the switching takes place



Solid-state Relay

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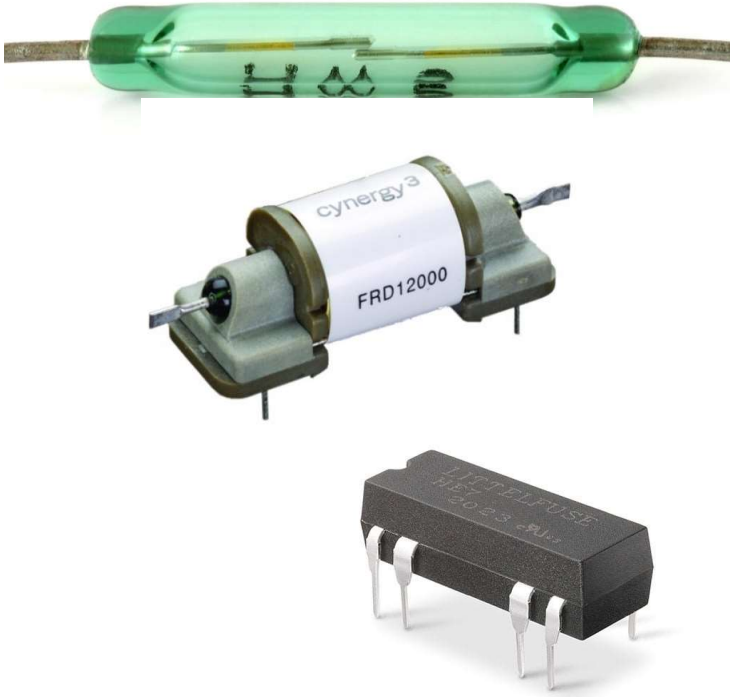
- Solid state package which acts as a relay but is totally semiconductor based
- Has high isolation (usually through optoisolators)
- AC and DC versions are available
  - AC versions use a zero crossing circuit to switch on the zero crossing point to avoid switching noise

Reed Relay

- A mechanical relay which uses a reed switch as the switch element
- Lower power
- Environmentally sealed (no sparks)
- Much less contact degradation
- Can’t switch high currents



Transistor Switches

- Bipolar transistors are cheap and simple to use, but
  - Watch the gain - the base current may be significant for high current applications
  - Can use a Darlington but the collector/emitter voltage drop rises
  - Can get it as low as 0.1V for a single stage
  - Watch the maximum voltages between pins

MOSFETs

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- High current capability
- Low voltage drop for large devices (as low as 0.025R)
- Voltage rather than current controlled, so ideal as a switch from an embedded system
  - Not all switch on 3.3v though – check the data sheet!
- Can drive high voltage devices directly, **but**
  - that means you have high voltages floating about your circuit board
- Big con - no isolation

Switching Options (Low volt load)

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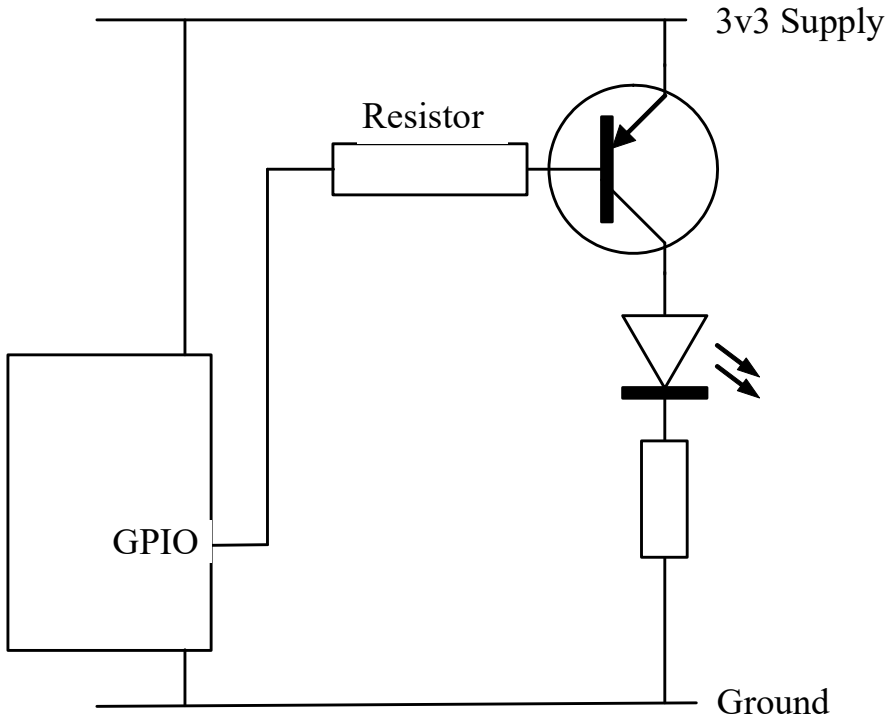
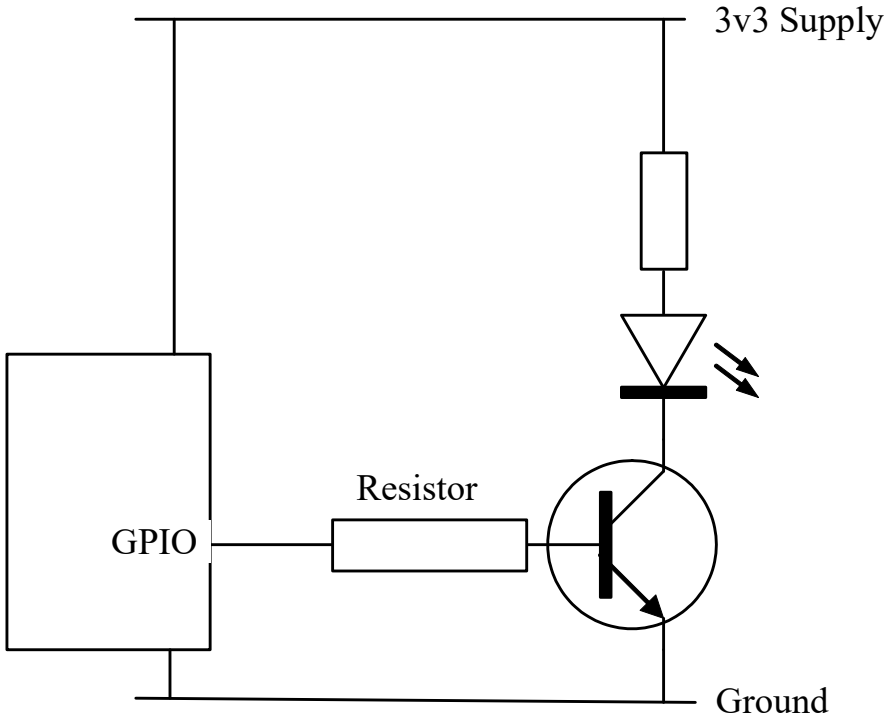
High side switching



Low side switching

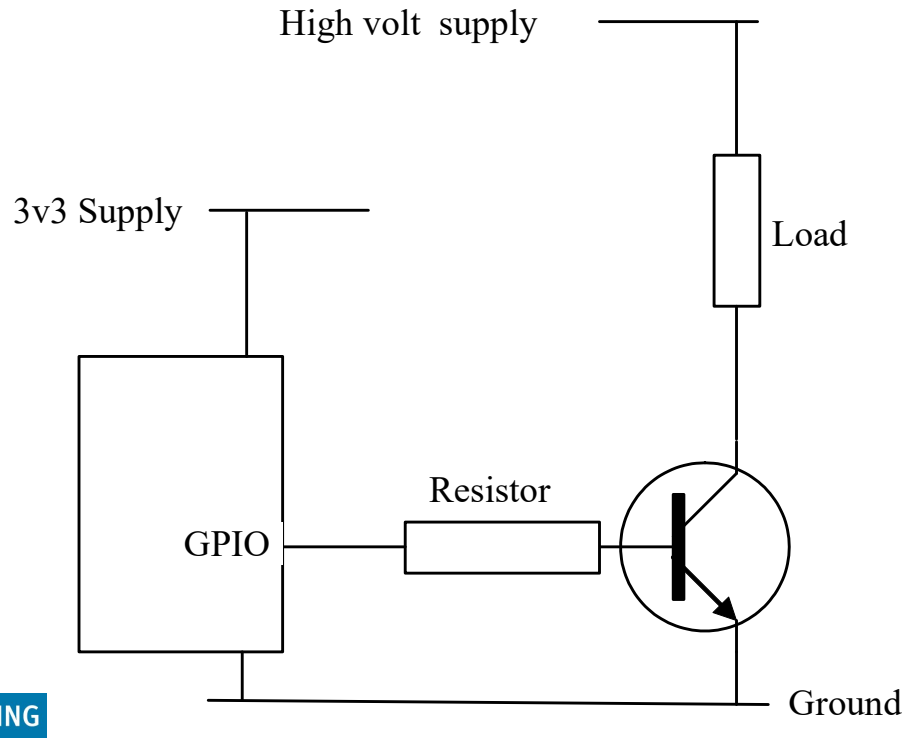


Switching Options (Low volt load)

- High side switching
  - PNP transistor between supply and load
  - Load is grounded
  - **Logic high switches load off, logic low switches on**
  - Resistor sized so transistor saturates
- Low side switching
  - NPN transistor between supply and ground
  - **Load floats high when off**
  - Logic high switches load on, logic low switches off
  - **Some uC can't source much current, so take care**
  - Resistor sized so transistor saturates

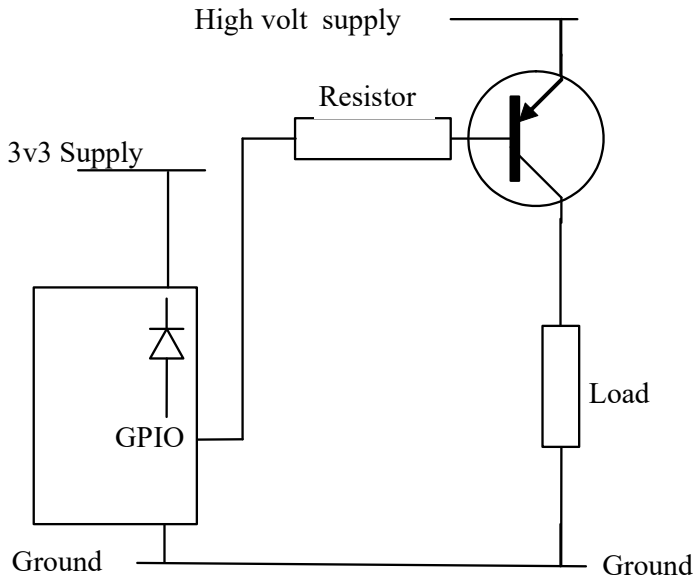
Low Side Switching (High volt load)

- Watch out for max collector-emitter voltage
  - High voltage supply will be seen across transistor when off



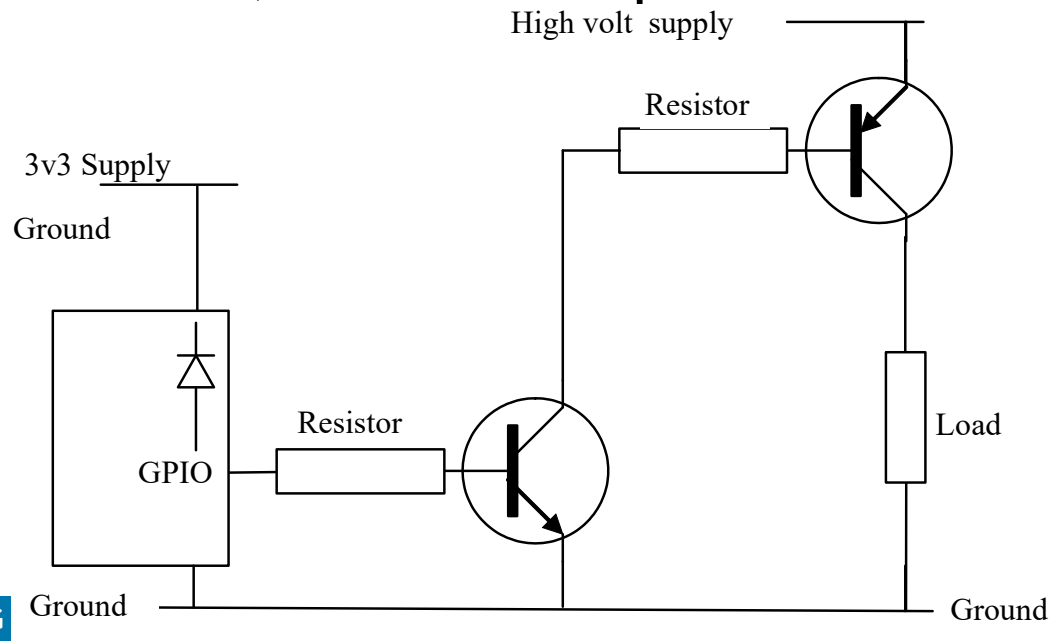
High Side Switching (High volt load)

- uC protection diode stops this working
- Current will flow from transistor to 3v3 supply!
  - Load always on and you will probably kill the micro



High Side Switching (High volt load)

- Solution – buffer with an NPN
- Watch the maximum collector-emitter voltage
  - A MOSFET may be better, but more expensive



Switching LEDs with bipolar transistors

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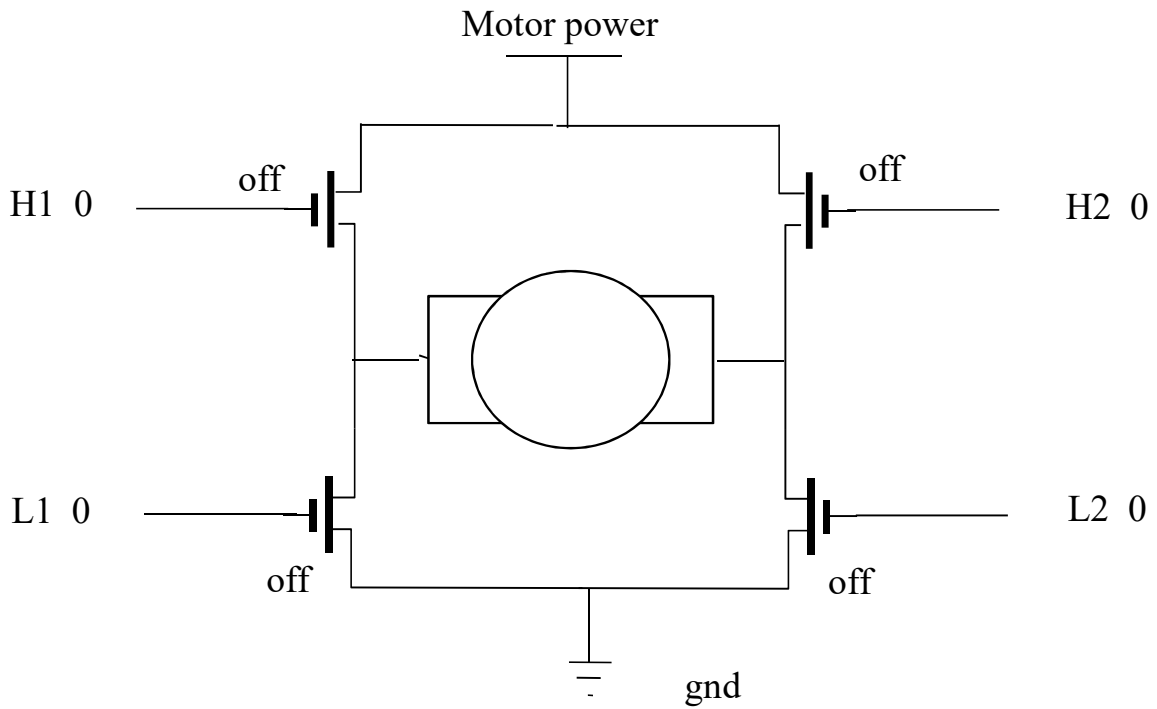
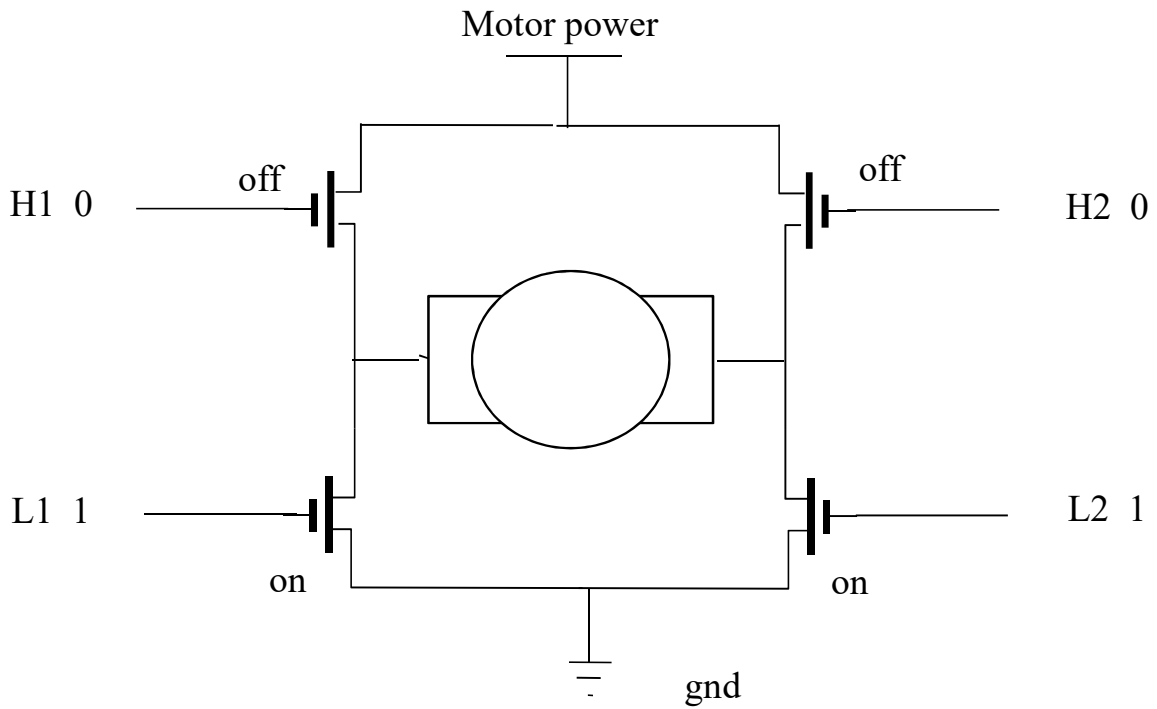
- Bipolar transistors have a small leakage current
  - 10uA is not uncommon
- LEDs will glow (very) dimly with that current

- Either
  - Use a MOSFET – no leakage
  - Best solution in a battery circuit but they cost much more
- or
  - Add a resistor in parallel with LED (47k would work well – 0.47v)

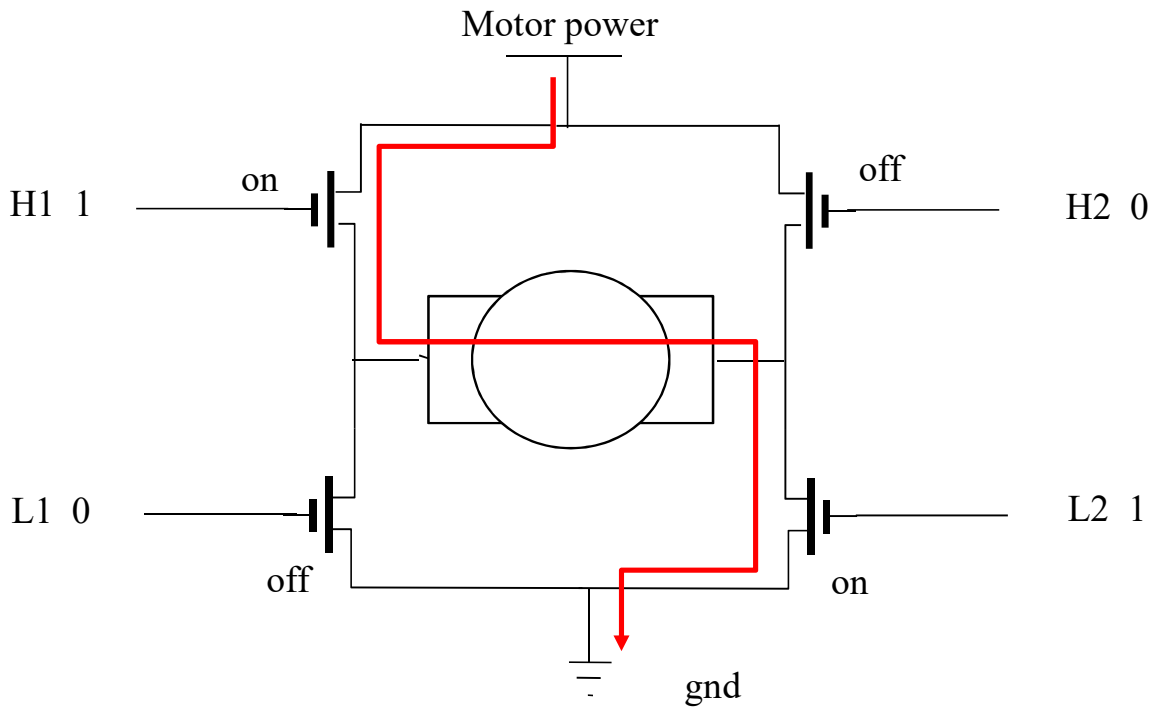
H-Bridge Motor Control



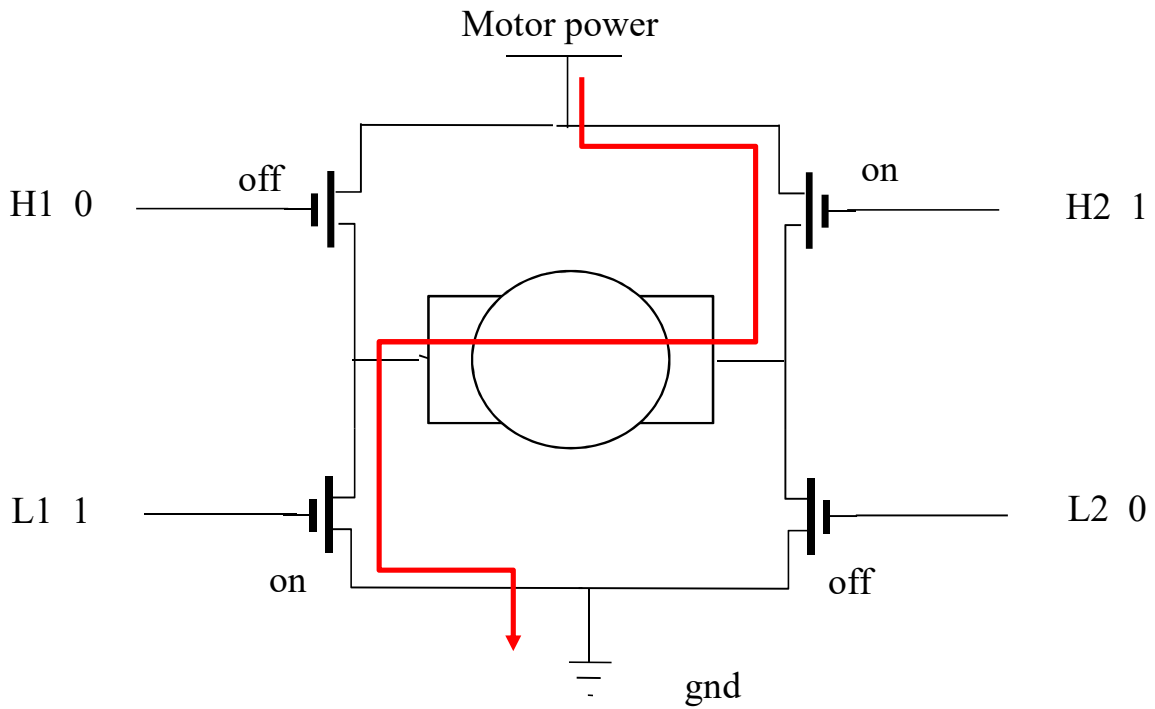
H-Bridge Motor Control: brake



H-Bridge Motor Control: forward



H-Bridge Motor Control: backward

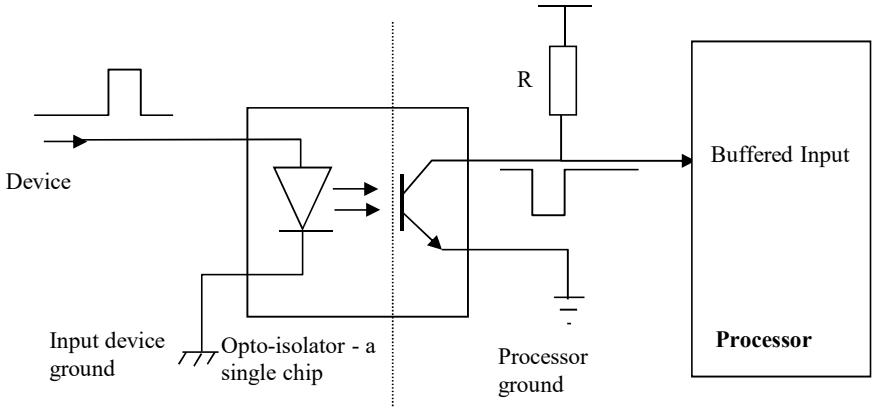


H-Bridge Motor Control

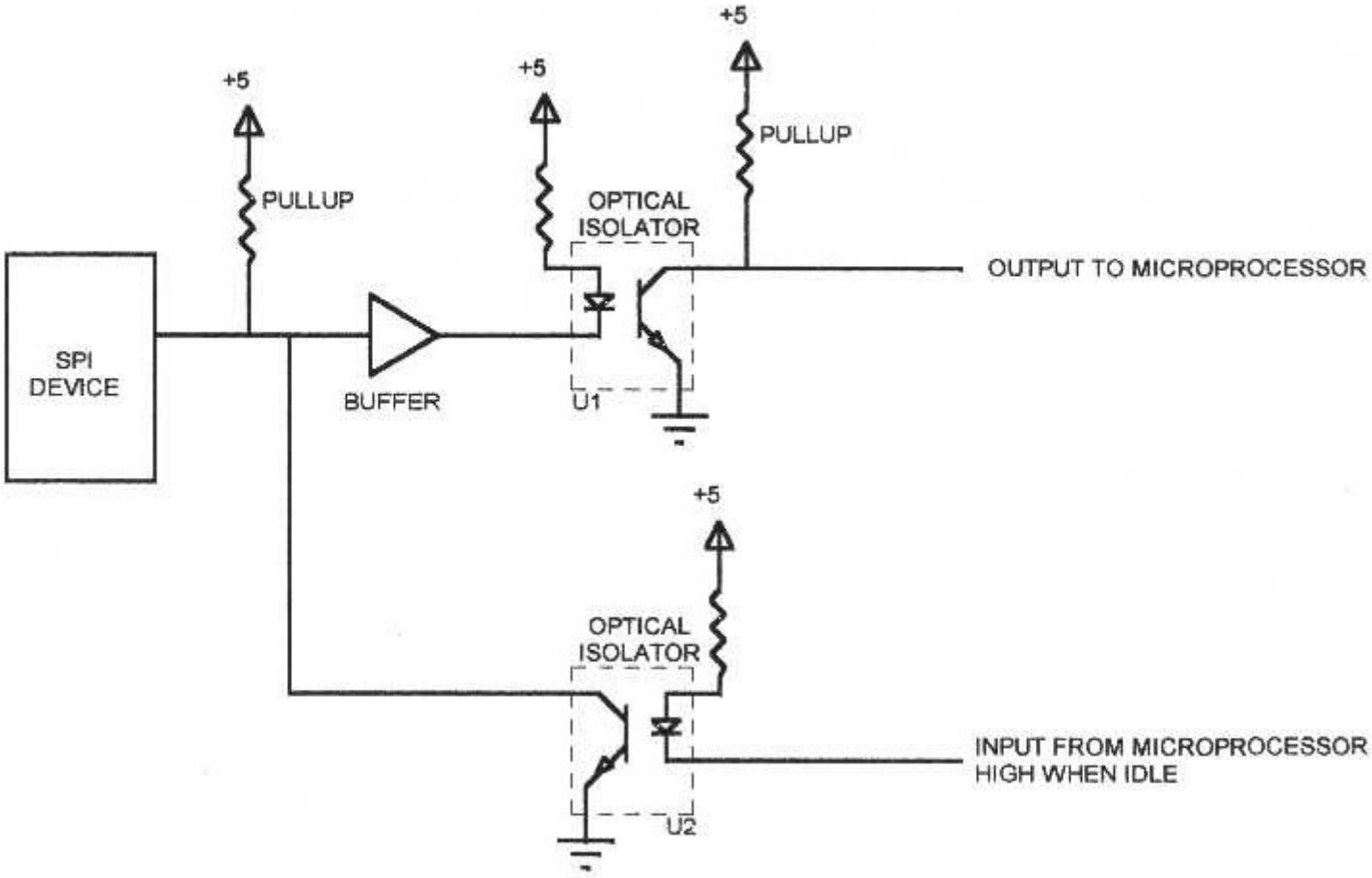
- In summary,
  - Both Low on, both High off = braking
  - One high on, opposite low on = movement
  - Neither switch both H1/L1 or H2/L2 on at once = short
  - If using PWM, pulse only one end, leave other on constantly
- **NEVER switch 10 to 01;** causes shoot through (all transistors on giving a short)
  - Doesn't do the motor much good mechanically either!
  - Also means never tie the two inputs together through an inverter
  - Propagation delay through invertor will cause 00 or 11 for a short time

Optoisolators

- Signal sent between devices optically
- Complete electrical isolation
- Allows separate grounds



Optoisolators



Challenge 3 (Week 7)

- Write a program to output a two klaxon using the piezo buzzer, which should sound like the alarm at a level crossing.
- The frequency of the klaxon should be able to be tuned using the potentiometer, and whether it is the upper or lower frequency that is being changed should be changed by pressing the switch.

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