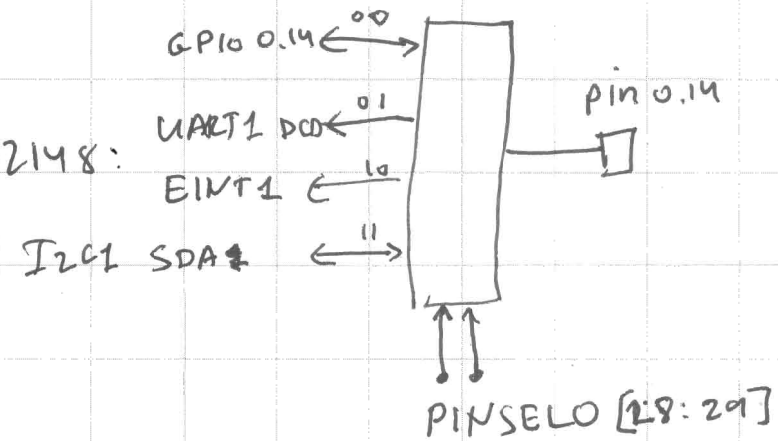
Pin Selection

Pins are a precious resource: there are usually not enough pins for all the functions of all the peripherals.

- E.g. pin 0.14 on LPC2148:

  4 functions for all pins of port 0, but only 2 functions for pins of port 1



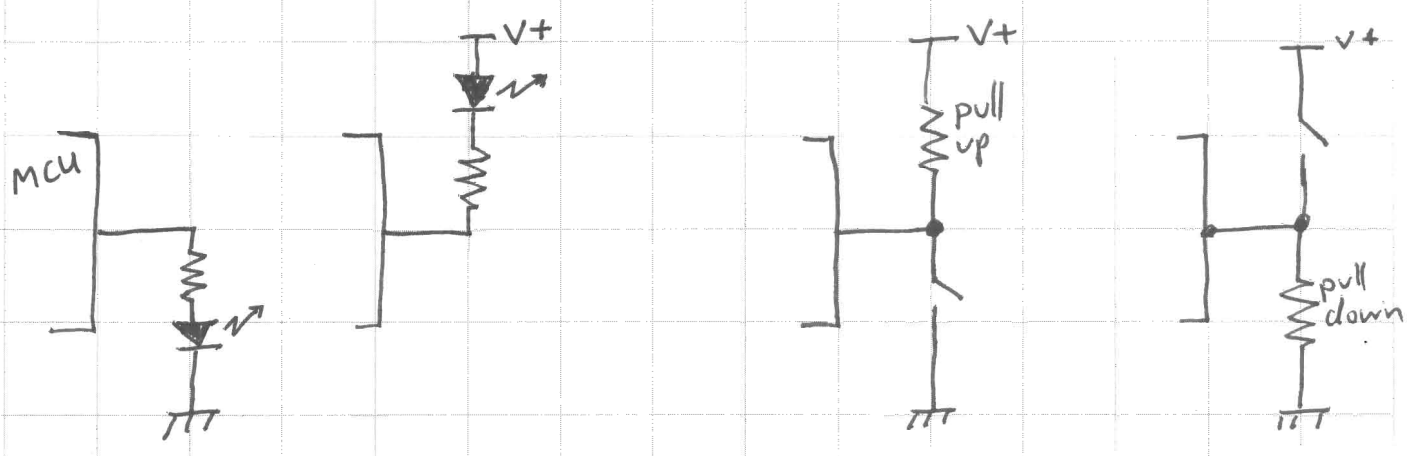
- On MSP430, two functions for each pin (one is always GPIO), using PxSEL
- But: Enabling the DAC (digital-to-Analog converter) connects it to the pin, independently of P6SEL (on MSP430F1611)

  Not uncommon to have such irregularites, especially for analog peripherals.

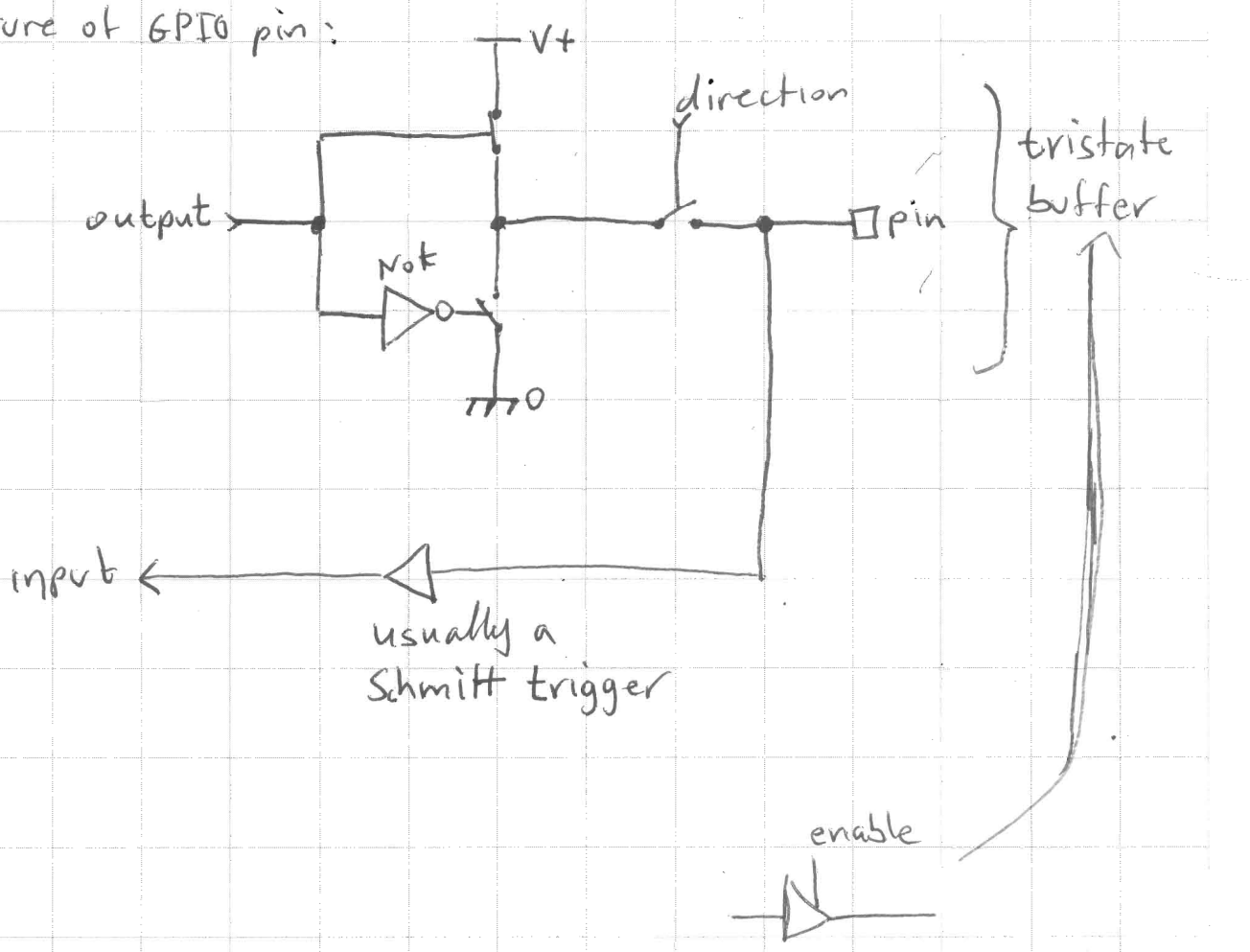
- Sometimes correct peripheral behavior depends on correct direction setting (input or output), sometimes this is automatic.

Advanced Digital I/O (GPIO)

review of simple GPIO applications:

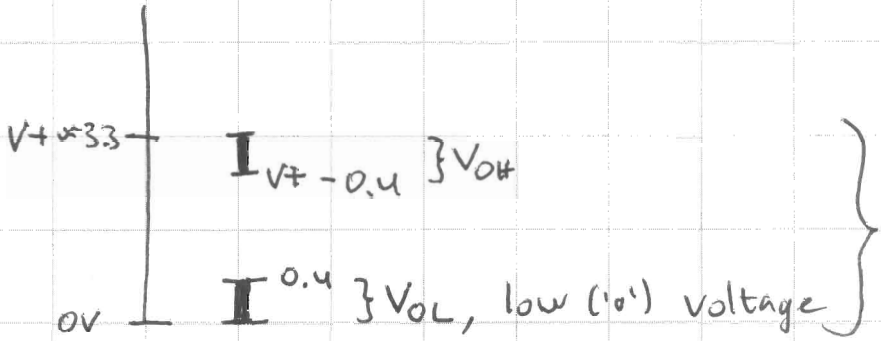


Structure of GPIO pin:

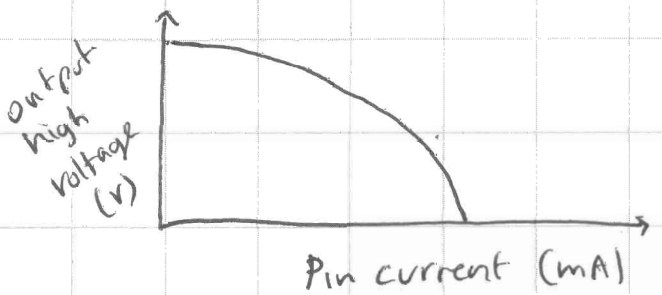


states: high (H, V+, '1')
low (L, 0V, '0')
high-Z (disconnected)

Output characteristics of LPC 2148

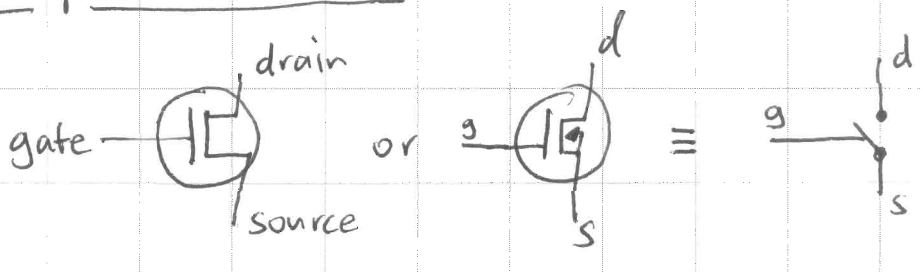


When the pin sources (or sinks) more ~~~~ current, output voltage drops (rises):



⇒ if a load (like an LED, a motor, etc) requires a lot of current or ~~~~ runs on voltage > V+, we need an off-chip switch (amplifier).

Output Switches

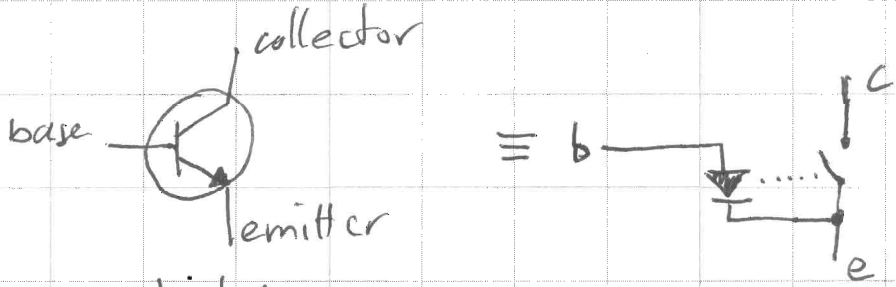


N-channel mosfet. Rule: $V_g > V_s + threshold_{on}$ ⇒ closed

$V_g \leq V_s$ ⇒ open

$V_d - V_s$ can be much higher than threshold.

Can also be used in linear mode, not just as a switch



NPN bipolar transistor. Rule $I_{be} >$ threshold ⇒ closed

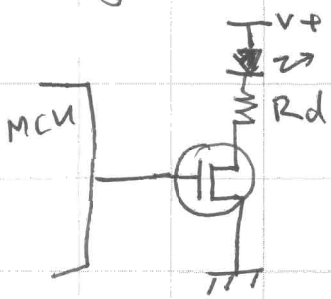
$I_{be} \simeq 0$ ⇒ open

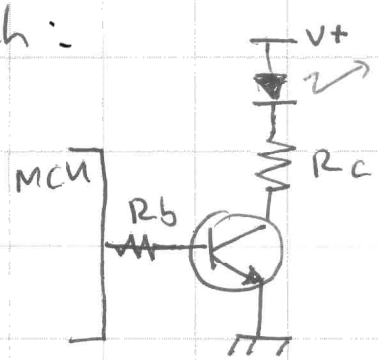
Again V_c can be very high.

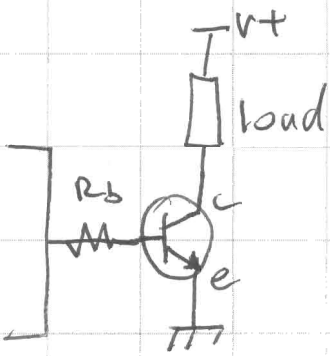
Can also be used as a linear amplifier.

Because B-E junction is a diode $V_{be} \simeq 0.7v$

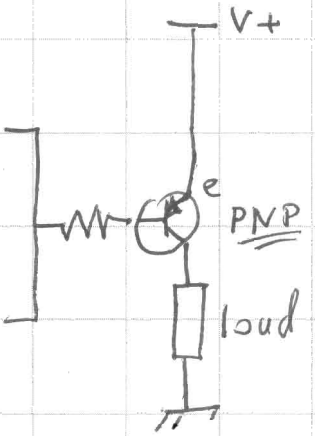
Using an off-chip switch:



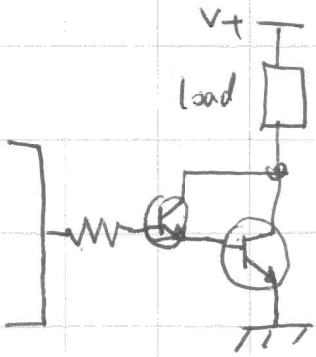




floating load

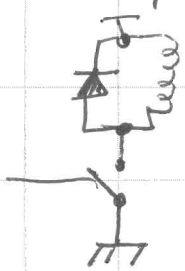


grounded load,
(more difficult
~~[illegible]~~ V+
is high)

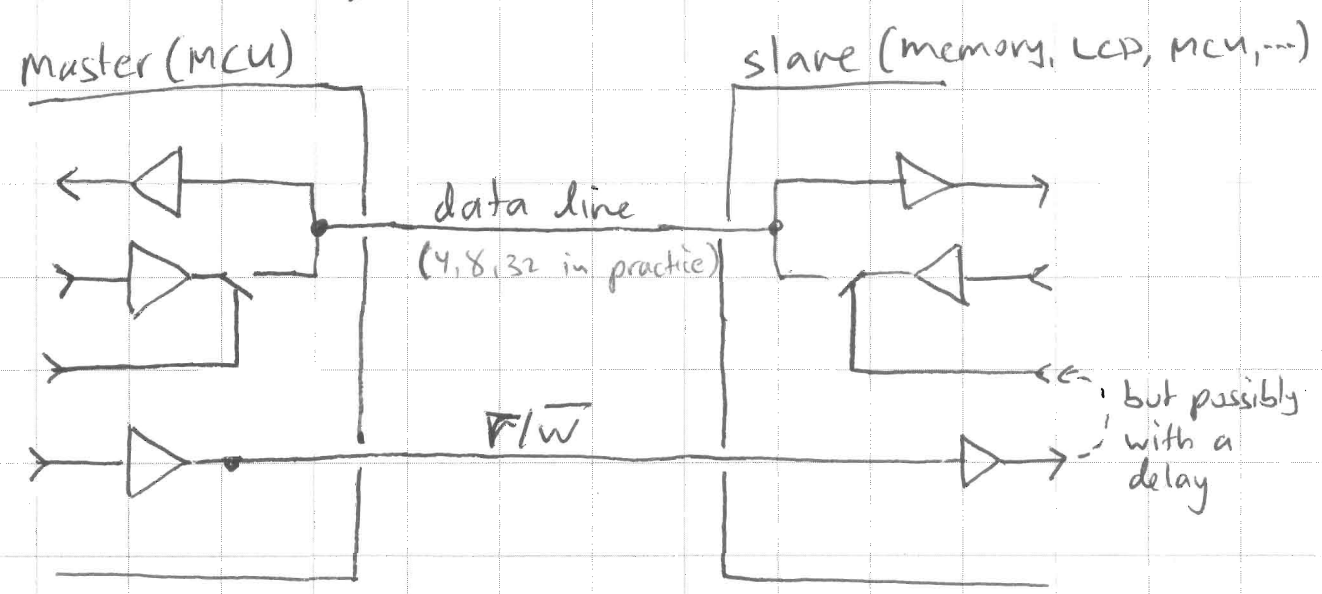


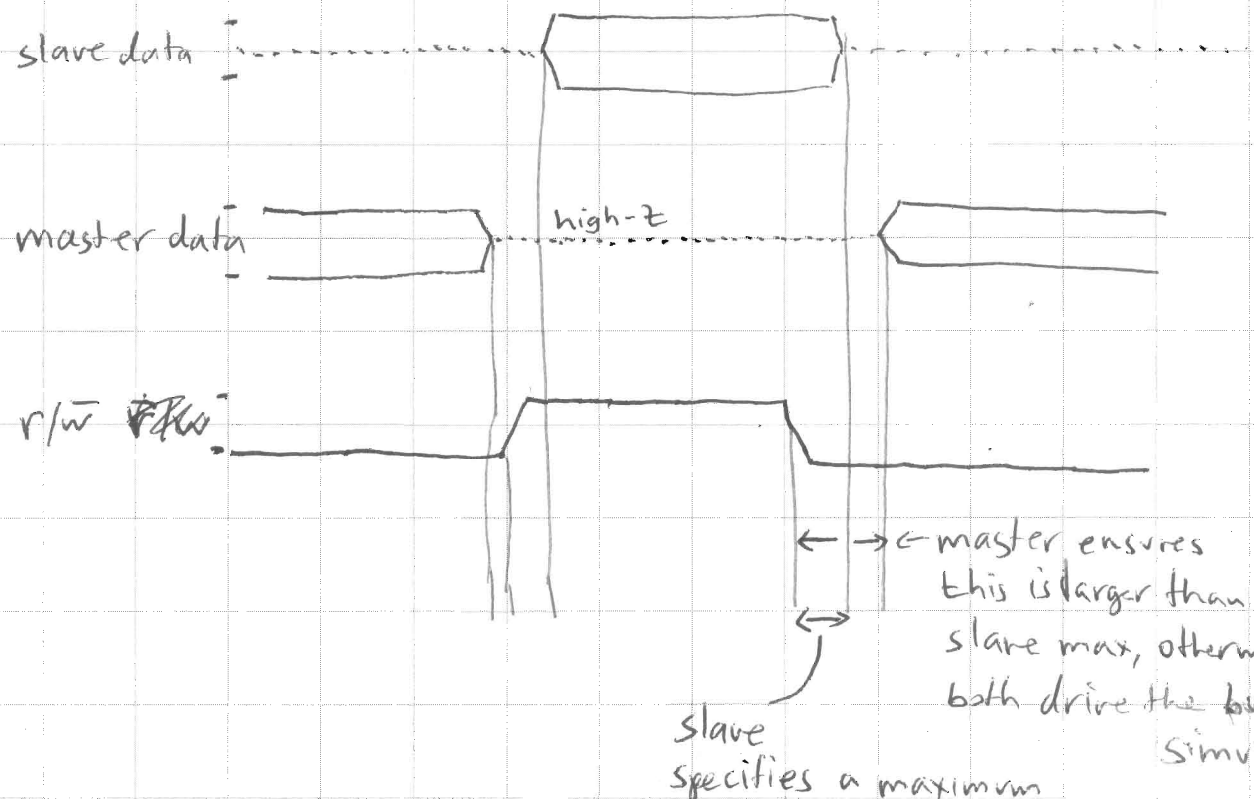
Darlington
(higher load
current at
lower pin
current;
our rule hid
some
details...)

Inductive loads (relays, motors) require a flyback diode, otherwise a high voltage develops ~~across~~ across the switch when the switch opens

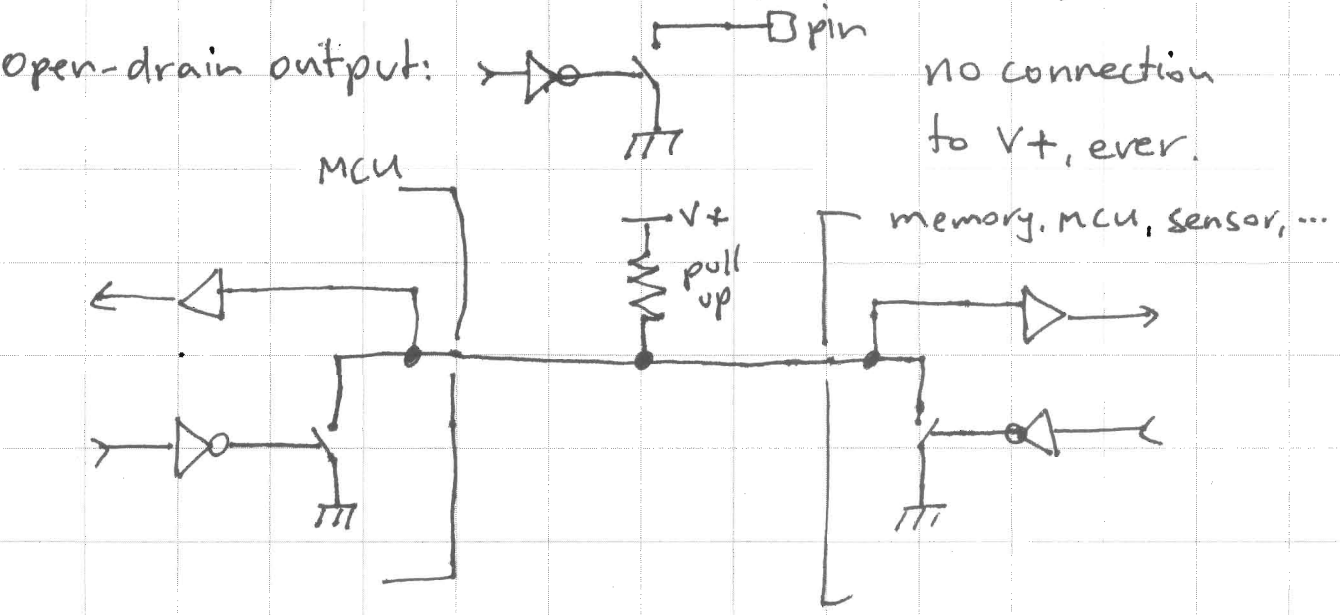


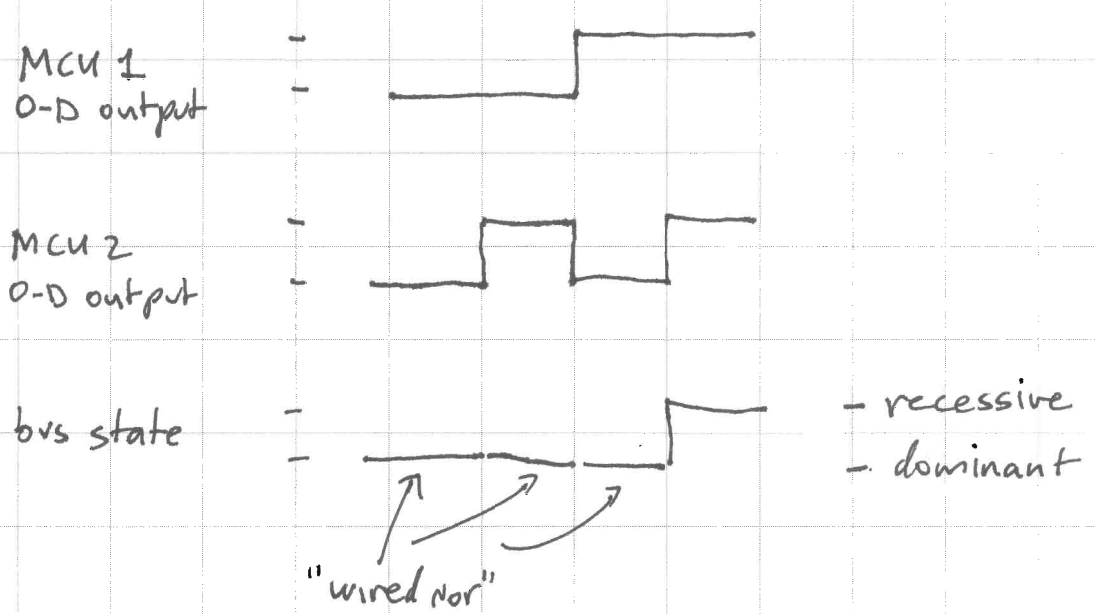
Master-Slave bus with tristate outputs:





Recessive-Dominant bus with open-drain outputs:



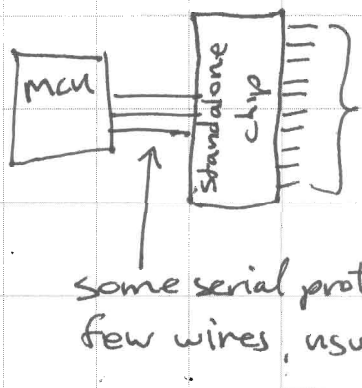


- Slower & shorter distances than tristate buses
- Other recessive-dominant signaling (e.g. differential in CAN)
- read while you write (read a dominant when transmitting recessive ~~can be~~ used for arbitration in I^2C, CAN)
- can sometimes simulate with tristate by switching enabled-low high-Z

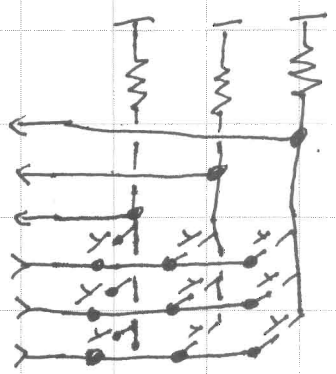
Other advanced digital I/O behaviors

- External interrupts (edge or level)
- Internal pull-ups / pull-downs (newer MSP430s)
- ~~switching~~ configurable as open-drain or tristate
  (on LPC2148, I^2C pins are opendrain, M. others tristate)
-

- GPIO expanders:

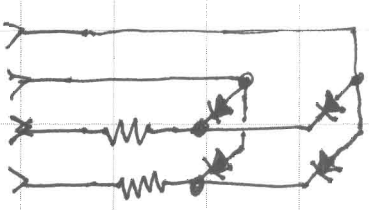


- keyboard scanning



- output scanning

colums may sink a lot of current, may require a transistor ~~switch~~ switch.



make sure 1 ~~resistor~~ LED per resistor, for consistent illumination