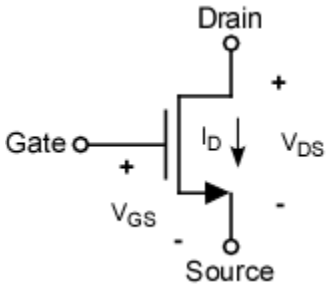
Minutes:

Recap Last week: Kicker/ Aus

Kicker board – charges caps and sends energy to solenoid (kicker)

Auxiliary kicker – a control board that tells the kicker when to kick, when to charge

MOSFET – component used in aux; we use nmos (rather than pmos)



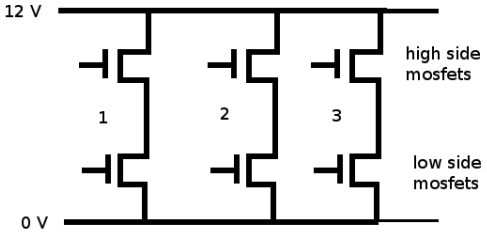
- **gate** – when voltage between gate and source large enough, current flows from drain to source
- **drain**
- **source**
- further reading: http://en.wikipedia.org/wiki/MOSFET#Modes_of_operation

This week: Brushless
Next Week: firmware

DRC check for eagle tutorial – errors are ok, you'll notice if it is a glaring mistake
ERC – checks schematic versus layout – try to get no errors, which mean that things are not connected; warnings are ok

Brushless board:

- 4 boards on each robot
- each board controls 1 wheel
- communicates with computer to drive wheel
- 3 pairs of mosfets
  - high side mosfet
  - low side mosfet
- can never turn high side and low side mosfet on for the same totem pole
- energizing any pair can get a certain phase



Motor:

- we use brushless motors
- magnet and set of coils
- when a certain set of coils are energized, they induce magnet to go in certain direction
  - paste link here for more info
- 3 phases
- hall sensors in motor detect when motor has reached a certain position; will signal that next phase need to be energized

Controlling speed

- You can consider: a variable power source; however, that's difficult to make
- Alternatively: use a 12 volt source, but use a switch to apply the 12 volts for a percentage of the time
- Duty Cycle: the percentage of time the voltage is applied (50% duty cycle for a 12 volt source is equivalent to applying a 6 volt source)

- We keep frequency constant

Oscilloscope Demonstration:
- as the pwm increases, the length of time that the signal is on is longer, also the speed is increased
- note that there are some vias on the board that exist purely as useful probing spots for the oscilloscope probe

Schematic of Brushless Board
- Leftmost panel of schematic shows header pins
  - pin2 = 5V
  - pin 3, pin4 = QEB, QEA = encoder signals → let us calculate how quickly the motor is going
  - BBID0, BBID1 – tells brushless board 1 to do what, tells brushless board 2 what to do; because same signal gets sent to all board (multiplexed), so we need a way to separate the commands
  - Hall3, Hall1, Hall2 – hall effect sensors are built into motor; depending on which signal is high, we know which position the motor is in; firmware reads this, and then instructs the mosfets (from the brushless board) to change phase, so that the wheel will turn to another position

Hold on: Hall effect sensor tells us the position information. Encoder also tells us position information. Why both?
Hall effect is very precise – so we use it to tell when to change phases; reducese jittery
Encoder – used to estimate speed and high speed information; in our control loop, we use the encoder to control the speed of the motor

- BOTID0, BITID1, BOTID2, BOTID3 – robot ID;
  - question, why do we use 4 ID's?
  - For future expansion, so we can suport up to 16 robots. Also, if we ever get 10 robots and want to play them against each other, we can have a unique ID for all of them
- TX, RX – singals, from/to antennae and transmitter
  - are signals incripted?
  - No, but they are modulated on to carrier frequency
- PH3, PH2, PH1 -
- pin 1, quiet ground – for things that draw small current like microcontroller;
- pin 24, 25 – PE = power ground; draws large current
  - if microcontroller is connected to power ground -

Bypass capacitors – supply is noisy; to reduce noise, we add capacitors across ground to act like a low pass filter

Low pass filter:
- http://en.wikipedia.org/wiki/Low-pass_filter#Passive_electronic_realization
- various values: 100 mF and .1 mF in parallel – why?
  - B/c 100 mF has bad frequency response (no longer looks like 100 mF at high frequencies, will look like an inductor instead)
  - putting 0.1 mF in parallel reduce

Middle Pane:

- microcontroller --- let's ignore this for not

Right pane

- driver – acts as voltage commander
- pins on left receive commands from microcontroller (0-5V)
- pins on right are same signals as commands from microcontroller, but get sent out at 0-12 V
- add link to datasheet

Questions

- What are diode and capacitro for
  - they are part of a “bootstrap circuit” which help us to get the 12 V exactly
- what are resistors between 12V gate and gate of mosfet for
  - limit the current to mosfet; we want to do this b/c the mosfet has a parasitic capacitance in it;
- sense resistor
  - monitor current by monitoring voltage across here;

Projects

- Kicker – Erwin, Ben, Manny
- Dribbler – David G, David K, Markus
- Acceleration – Manny, Erwin
- Debugging – Erwin, Markus, Manny, Ben

Timeline

- feb, so that CS has time to implement