

Kaizen

- Took longer than I expected.
- Messed up calendar numbers though rough timing was right.
- Demo of MCP6044 instability worked, but not sure people understood – need to show pot values as scope changed.
- Two people responded with 1's on understanding rules and autonomous behaviors, though most others responded 3's and 4's for those two. Will follow up on 1's

Lecture 20

Game Rules

Sensing for Behaviors

Agenda

- Game Rules
- Q & A
- Beacon Tracking
- Capacitive Touch sensor
- Heat Sinks

Final Project Tentative Schedule

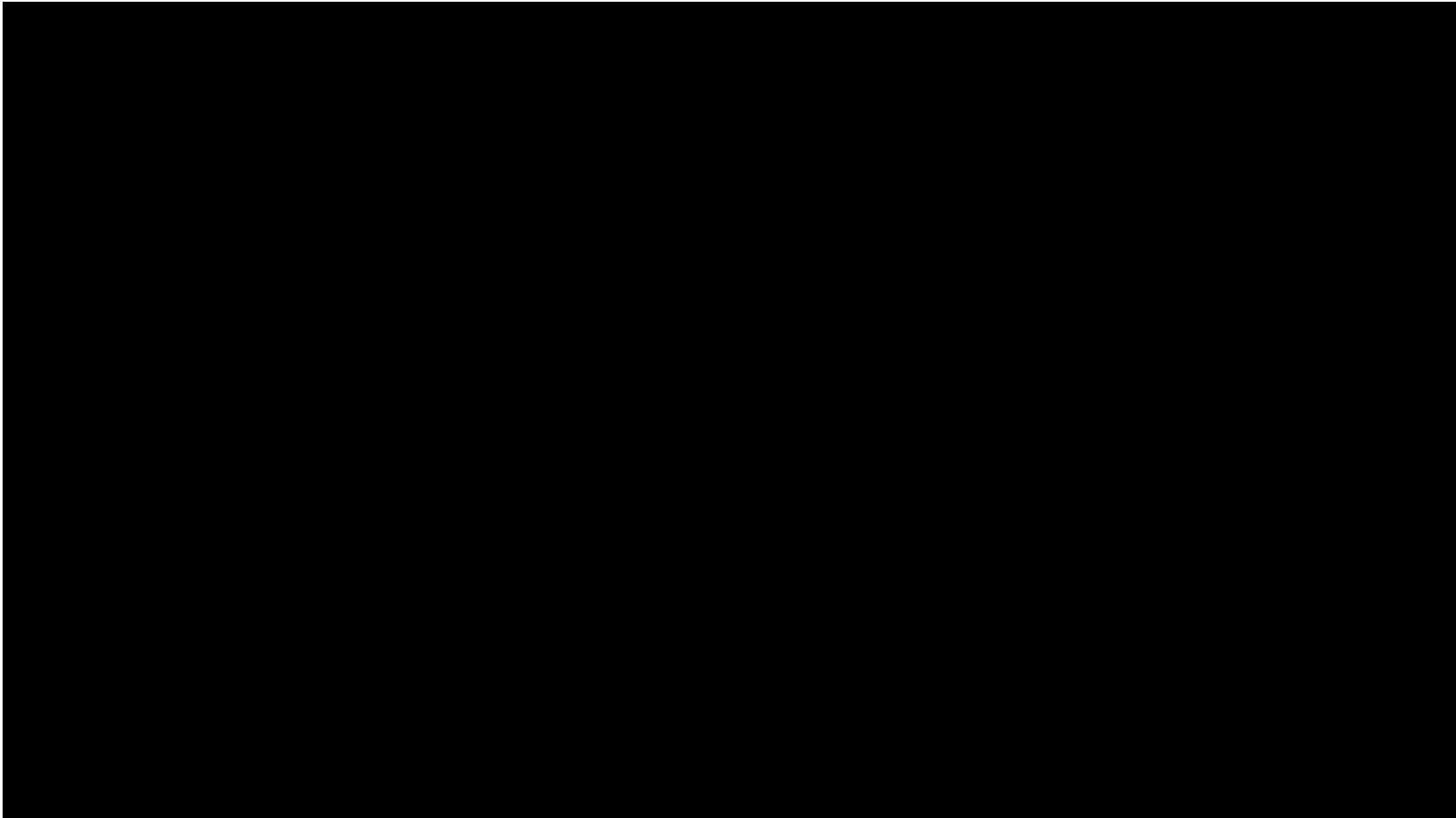
28	29	30	31 Today	Apr 1	2	3
4	5	6	7	8	9 Design Review 1	10
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FIXED DATES

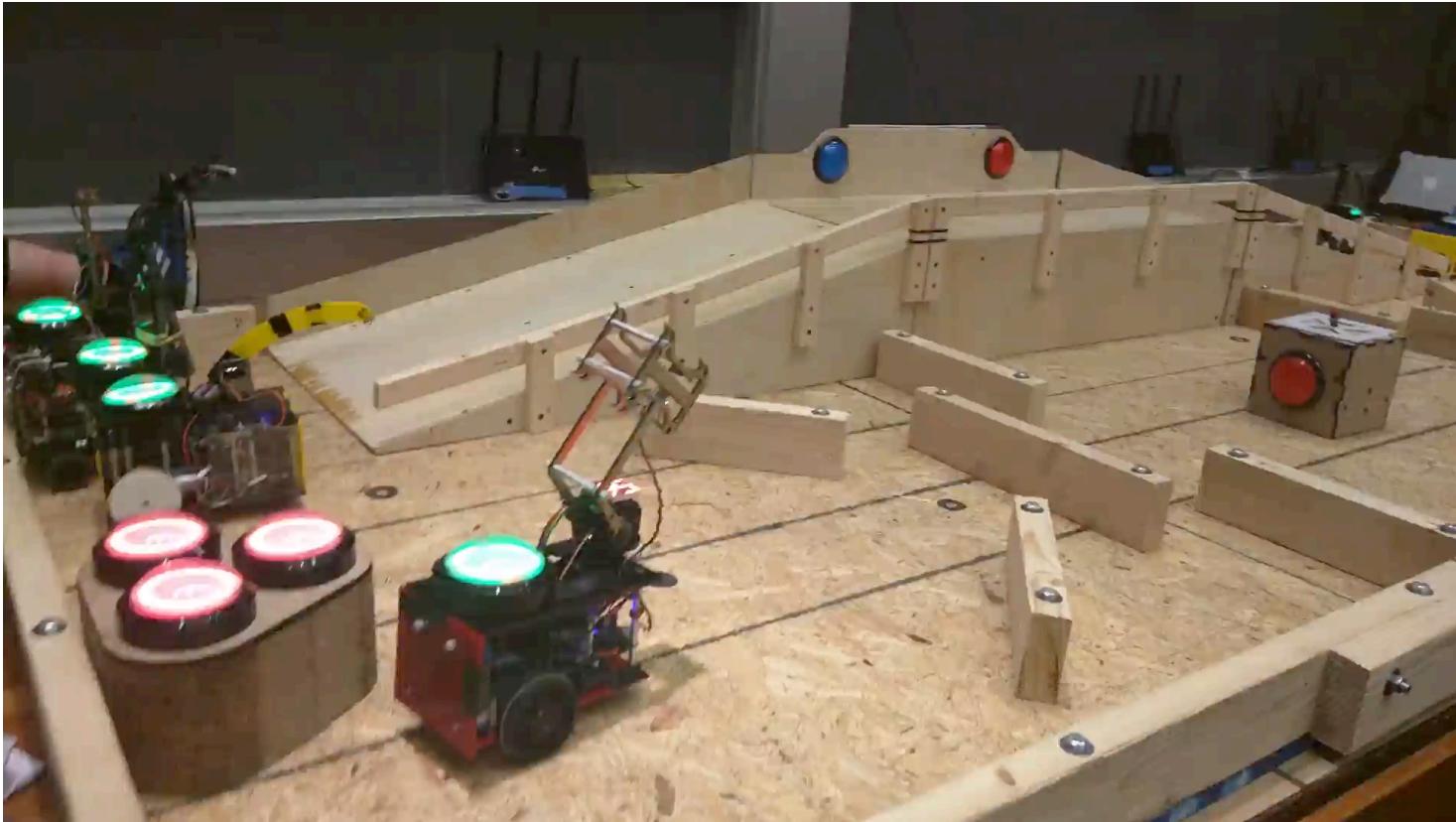
01

Game Rules

MEAM510 - 2017 Game



MEAM510 - 2018 Game

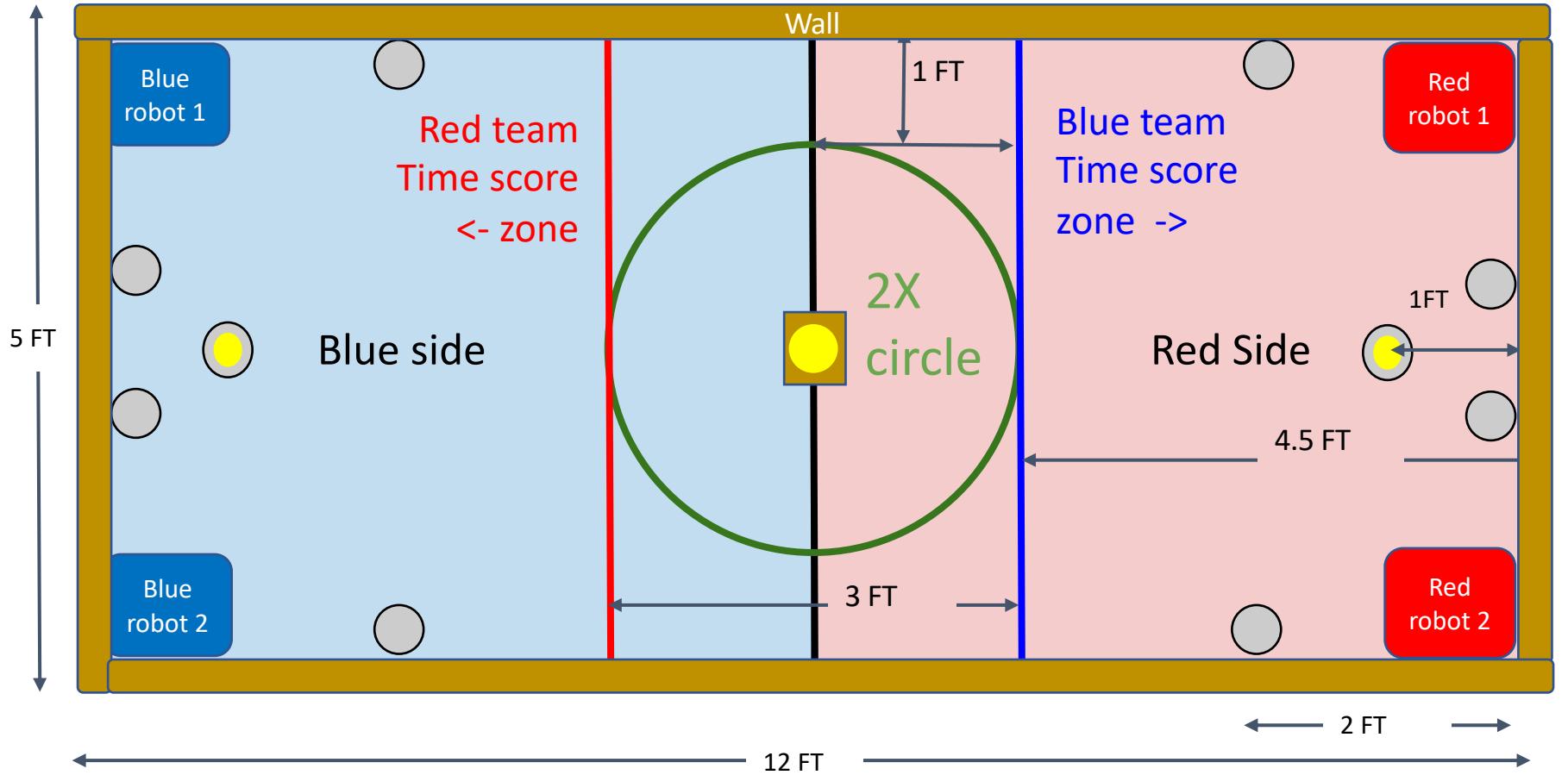


Grand Theft Autonomous 2021

- The goal of this game is to get as many points as you can. Ideally by stealing soda cans from your opponent.
- Game is played head-to-head with teams of two (e.g. 2v2)
- Teams move robots semi-autonomously to move or steal cans from each other to score points. The team with the most points when time expires wins.

Field of play

Approximate dimensions +/- 5%
Drawing not to scale
Field is symmetric vertically and horizontally

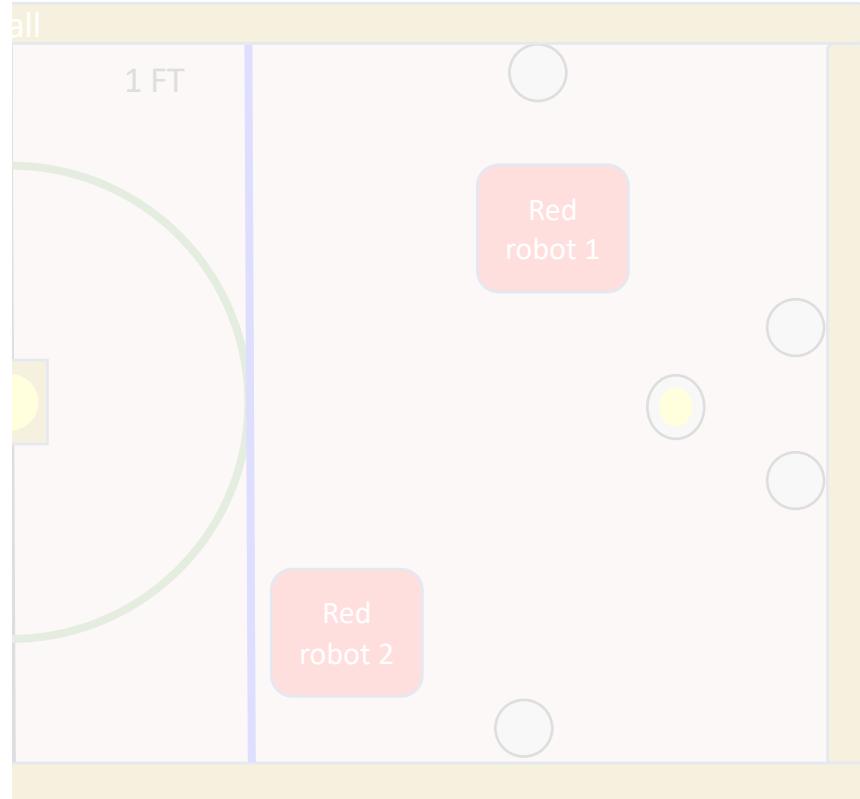


Game Play

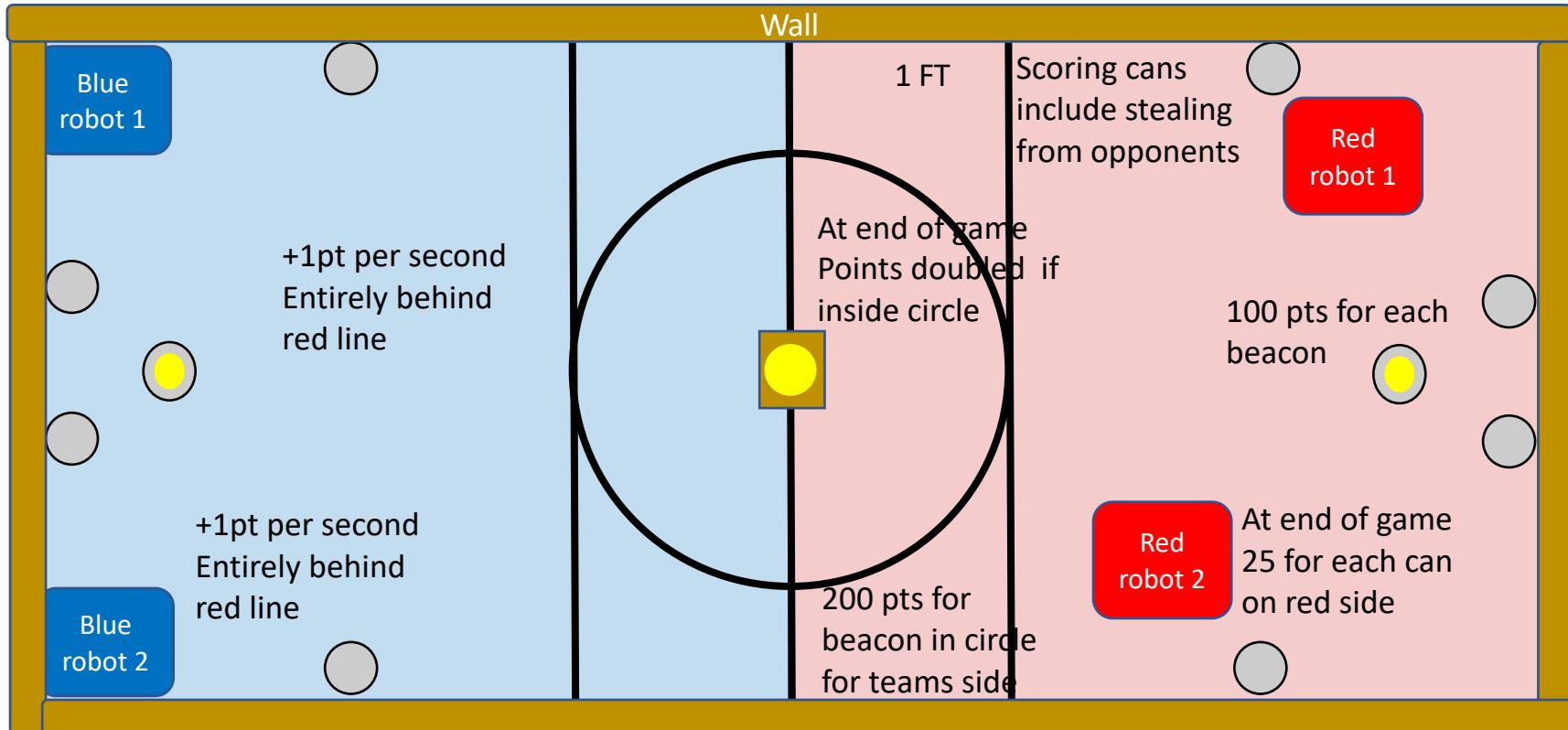
- Each side has their own zoom with view of their own half. Teams can communicate with each other and TA's but not other side.



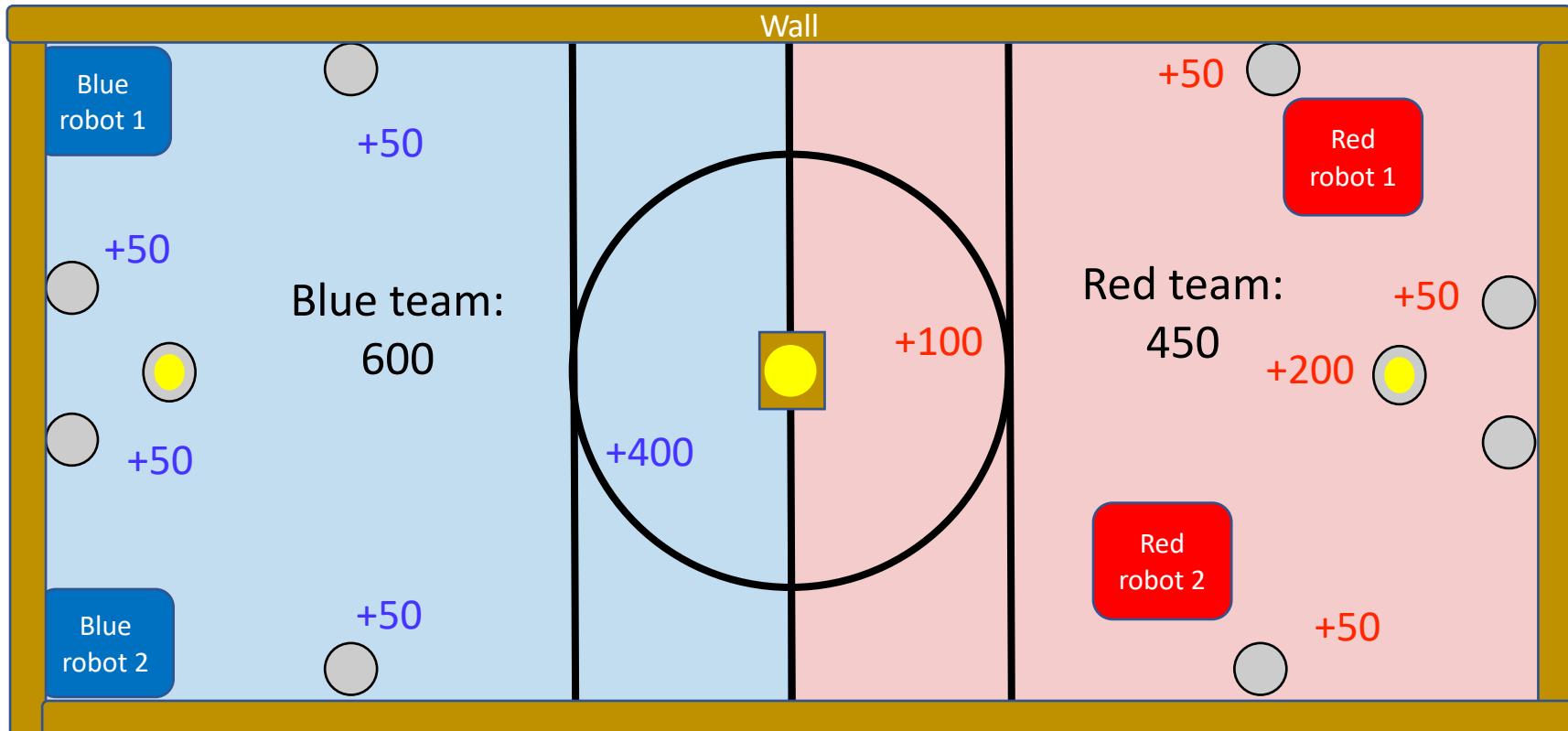
Blue team view Overhead Cam Red team view



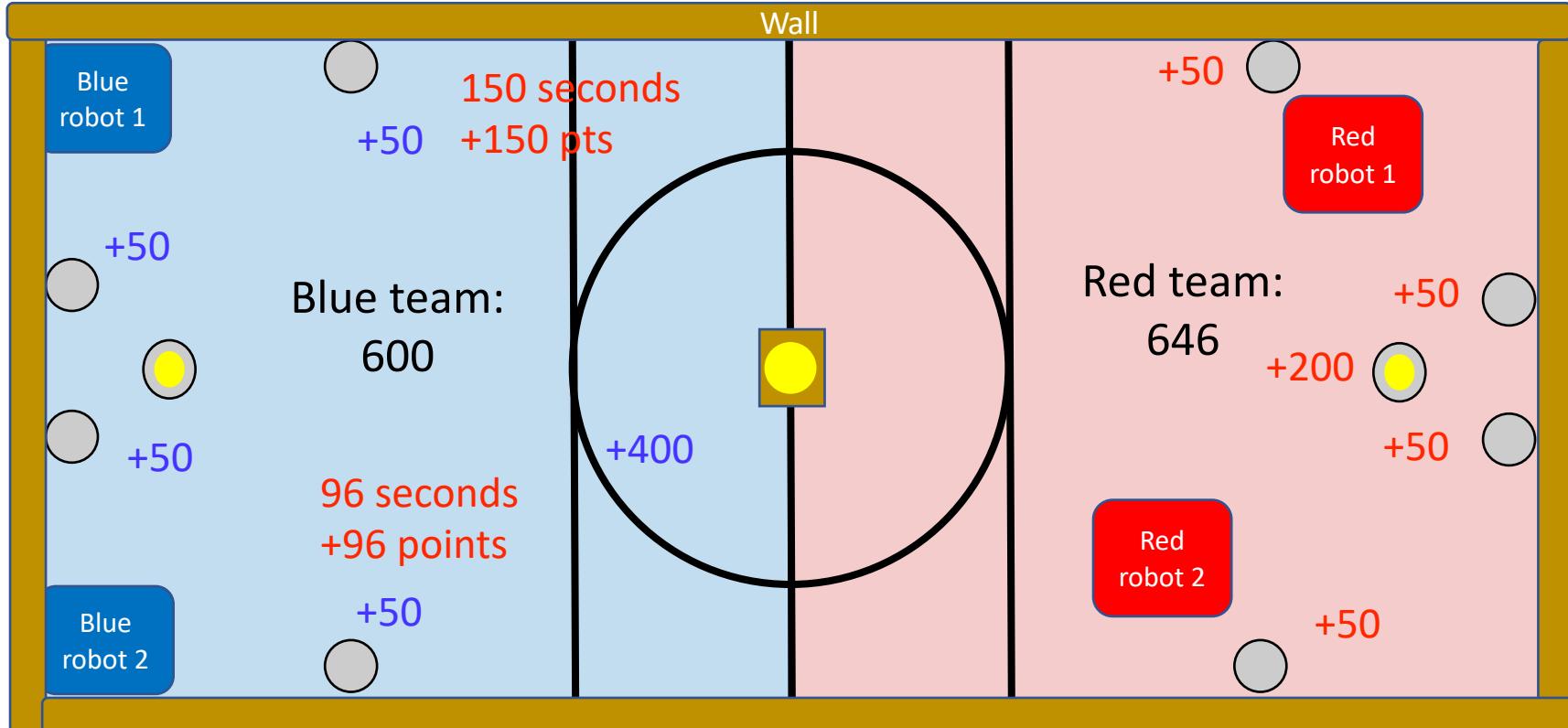
Scoring: Timing points and object points



Score example: no blind excursion, no timing pts



Score example: red team time points



Scoring summary

- Object points starting position: 400pts 400pts
- Object points max none stolen: 800pts 800pts
- Object points max all stolen: 1600pts 0 pts
- Max time points for 3 minutes two robots: 360 pts
- Min total score for both teams combined 800 pts
- Max possible score for one team 1960 pts

Q1: What is the maximum total score for both teams combined?

Robot Constraints

- Robots must fit in 12" x 12" x 12" box to start
- Robots are controlled via internet through one URL via ngrok
- Robots can have a maximum of 10Kbytes/sec data transmission each way
- Robots can't physically damage other robots or field
- Robots may not intentionally disrupt sensing or communication of other robots.

Frequently Asked Unusual Questions

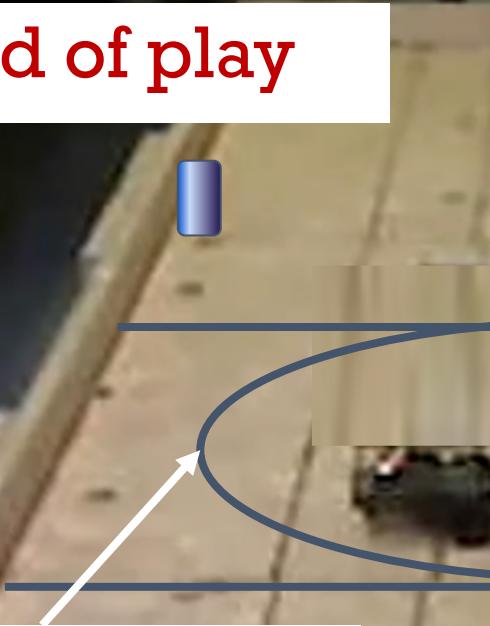
- Can we make something that grabs an opponent?
 - Yes! Something like Blitzcrank would be awesome - but hard...
- Can we make a quadrotor drone?
 - Yes... if you can make one in our budget and control it with 10k byte/sec.
- Can we make a jumping robot?
 - See above
- Can we throw things at opponents or cans or throw cans?
 - Yes as long as it is not dangerous
- Can we make a giant arm?
 - Yes if it starts in the 12"x12"x12" constraint.

Robot Grading: Functional evaluation

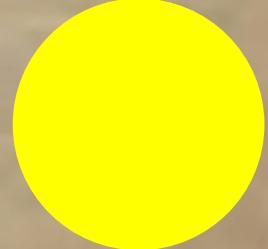
Robots will be placed on field alone (no other robots) and tested for the following: Must be achieved before game time expires.

- For receiving passing grade in this class
 - Must have robot controlled through internet
- For full marks on Final Project
 - Move at least one can to doubling circle.
 - Move at least two cans from opposing side to score on your side.
 - Show at least one autonomous behavior:
 - Wall following, make full circuit
 - Locate and move relative to a beacon or lighthouse

Field of play



- Black electrical tape delimits scoring and doubling zones
- Surrounding wall is approximately 3" from floor. Mostly 2by4 wood except two places
- Plywood board flooring



Lighthouse

- Mounted on top of unmoveable 6x6" base
- Located center of field
- Height 36"
- IR frequency Binks at 500Hz

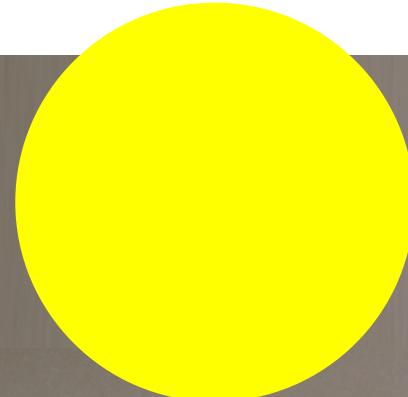
Soda can objects

- Weighted to stay upright (mostly)
- 6 quarters taped to bottom
- 7 quarters taped around bottom edge



Beacon object

- Mounted on top of can
- 12" high IR LEDs
- One side blinks 200Hz
- Other side blinks 300Hz



Q&A on Game Grading or Game Rules?



Purchase recommendations

- Choosing motors (pololu, sparkfun) maybe largest purchase.
- If high current motor is used, may want motor driver - can make things easier than building your own h-bridge.
- Wheels and motor shaft mounts may be a good purchase. Extra batteries are an option.
- Delivery time:
 - McMaster typically 3 business days from order.
 - Digikey typically 3-5 business days from order.
 - All others 5-10 business days from order.
- Don't buy a "robot kit". This is against the rules.

Recommendations

- Robot – robot contact is likely. Strong heavier robots tend to do better in a pushing contest.
- Stealing objects from the other side causes large score swings.
- Doubling circle can lead to easy steals.
- Defense can be important but will not win a game (no points gained).
- Don't try to do too much.
- Develop strategy for doing minimal first adding more functionality as time allows.

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FIXED DATES

Potentially Useful Behaviors/sensing?

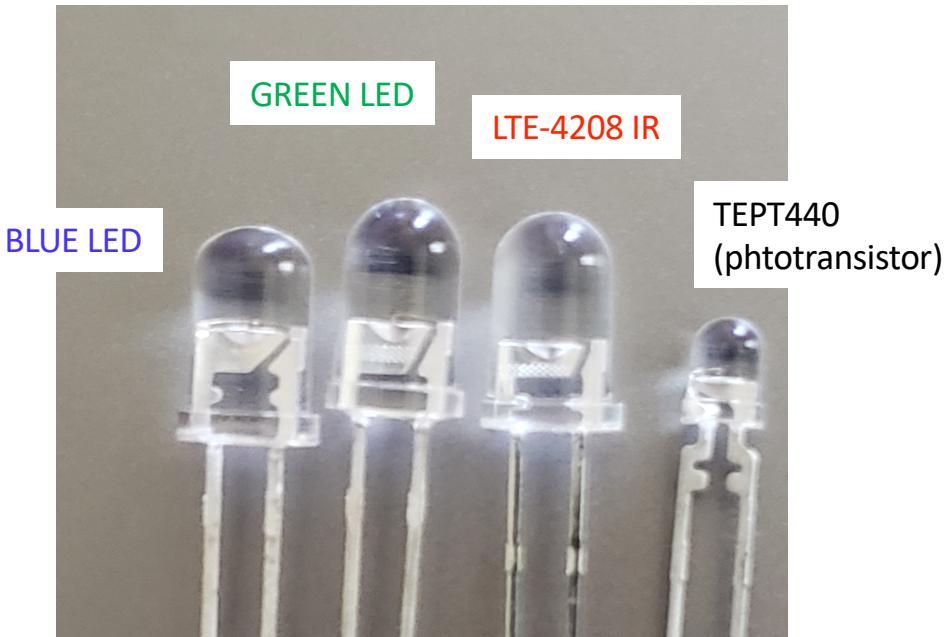
Q2: List 4 different potentially useful behaviors and associated sensing modalities

02 Behaviors

Beacon Tracking

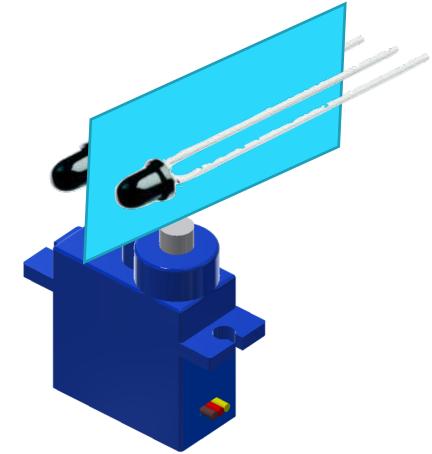
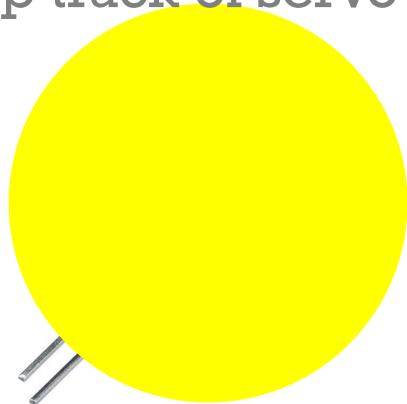
Beacon construction

- Multiple LTE-4208 IR LED's (you have 4 in your kit) will be in each beacon.
- Roughy 40mA current
- Shine off of reflective surface



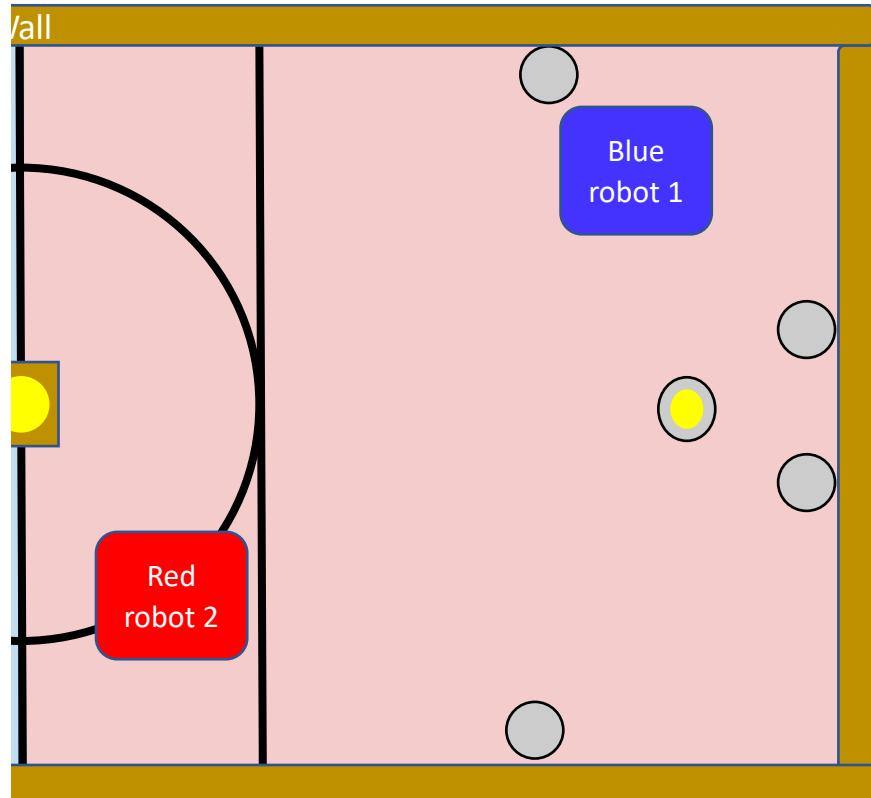
Beacon Tracking Architecture

- Mount two IR phototransistors on a servo with optical separator
- If the left side sees the beacon rotate left
- If the right side sees, then rotate right
- Keep track of servo position to steer robot.

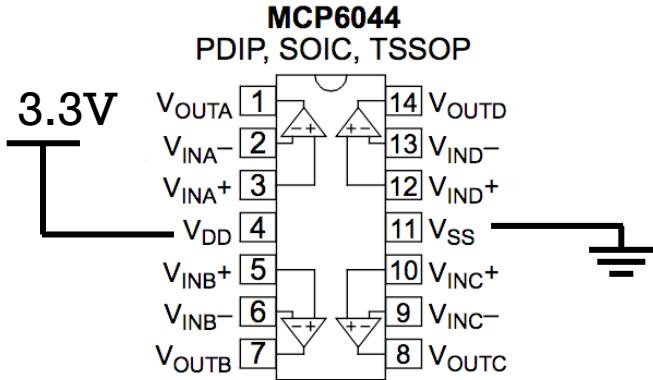
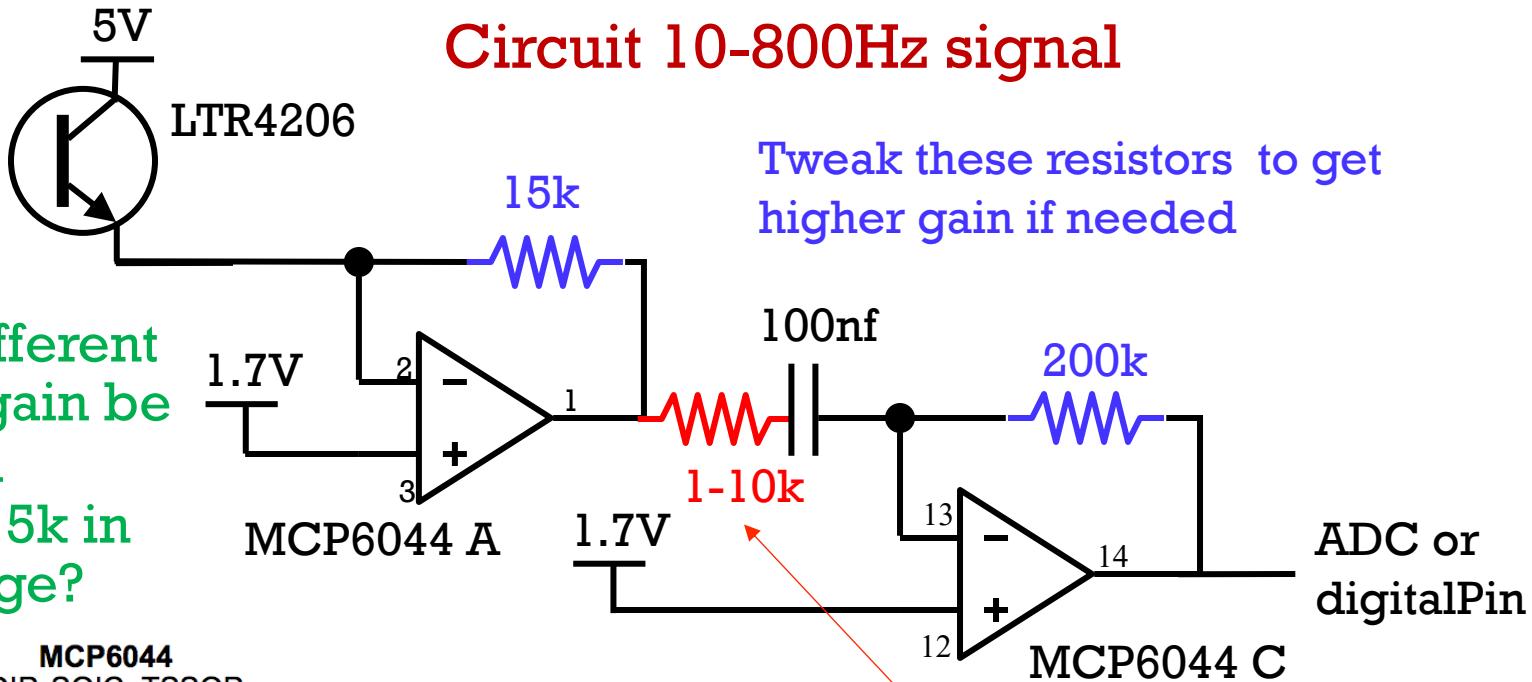


Example behaviors

- Lock on beacon,
 - Align robot with servo.
 - Move forward until contact
-
- Lock on lighthouse
 - Align robot 90 to servo,
 - Move forward while turning to maintain 90 servo angle



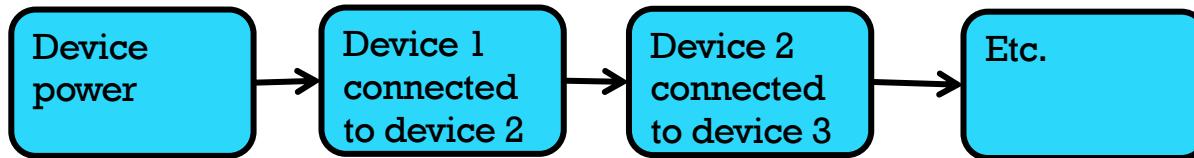
Q3: How different would the gain be if 30k used instead of 15k in the first stage?



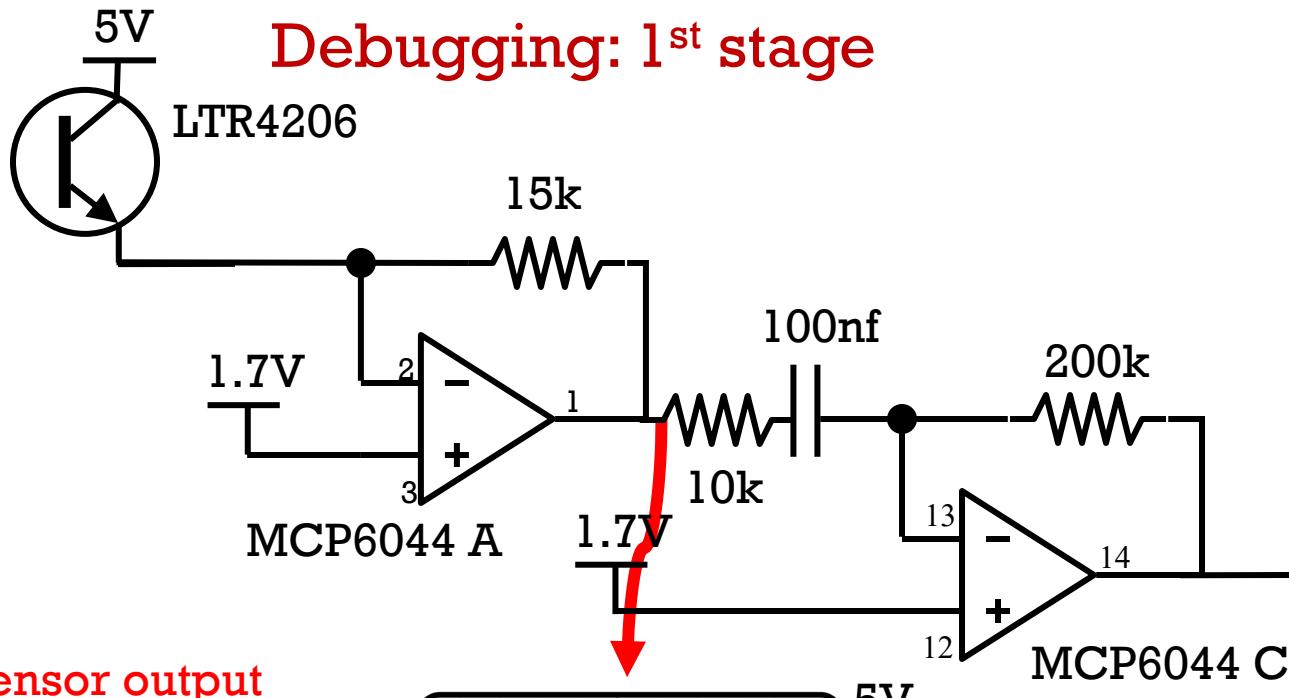
Add this resistor to make the MCP6044 more stable. May get 300-400Hz noise otherwise. Acts as low-pass

Debugging Electronics

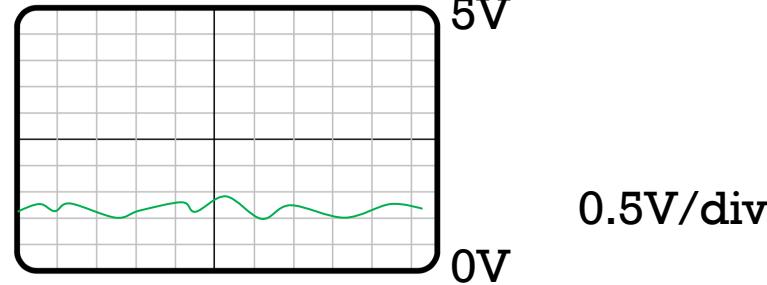
- Hardware and Software piece - need to check both
- Break your system apart into pieces
 - viewed as linked via inputs and outputs
 - Ideally a chain of parts with 1 output from one part going to 1 input in the next part.



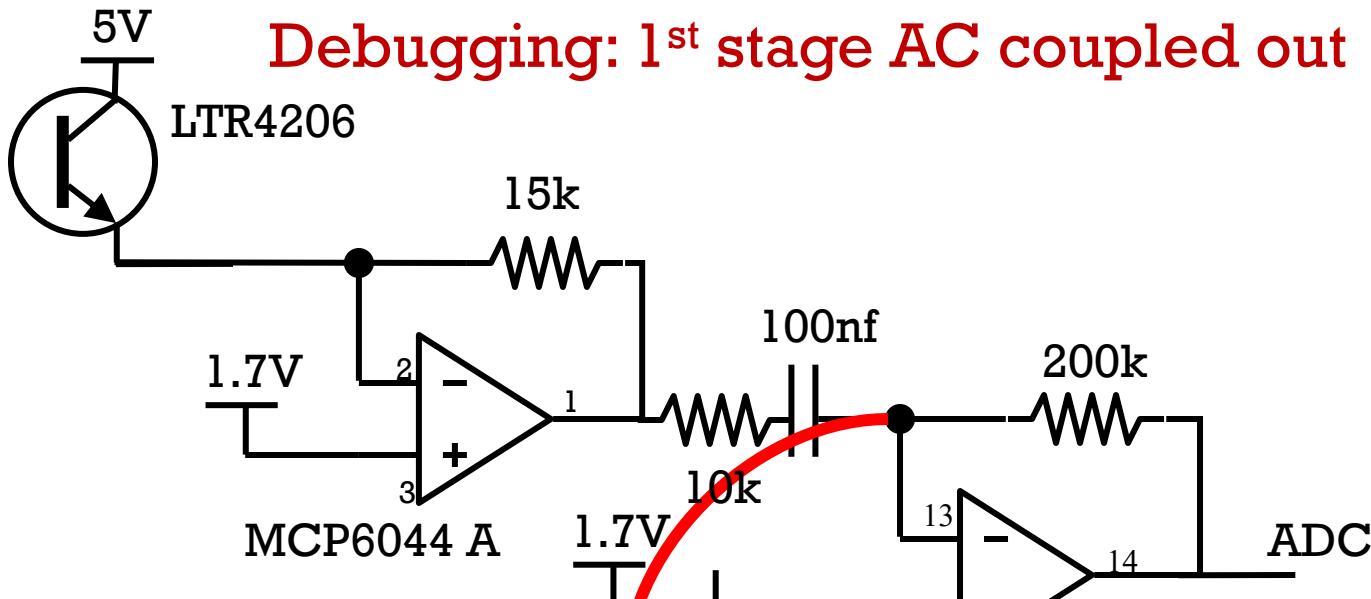
- Check known voltage at each part starting with power and ground.



No light \rightarrow 2.5V
 Should fall with
 incident light (e.g.
 output between 0
 and 2.5V)

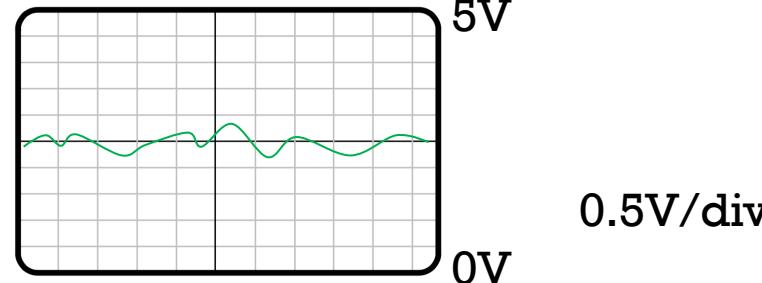


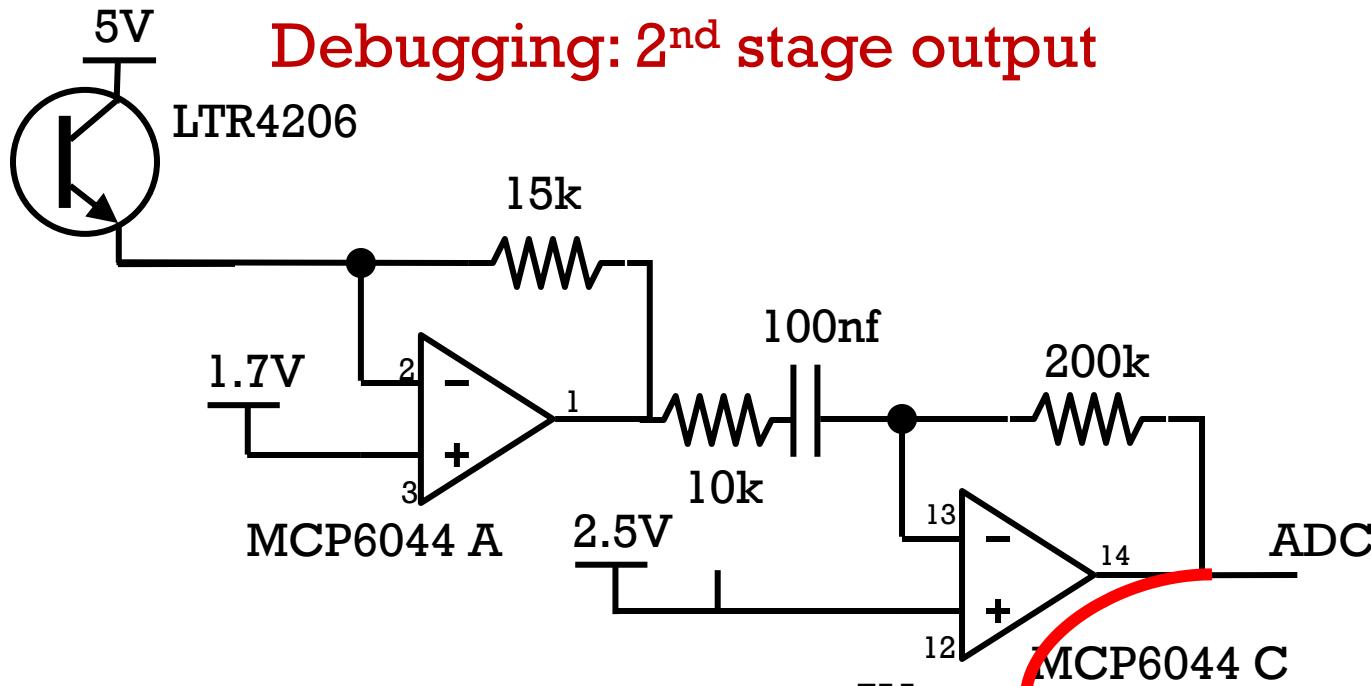
Debugging: 1st stage AC coupled out



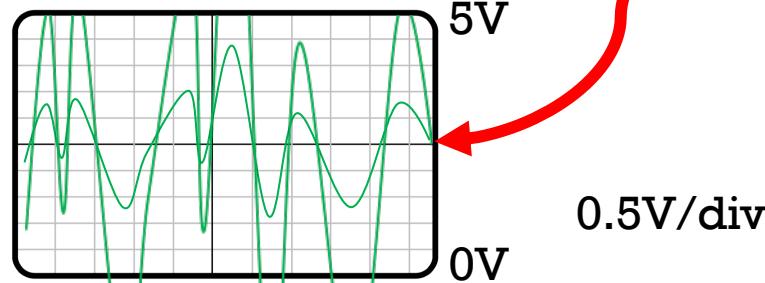
AC coupled
output

Signal centered around
2.5V. Amplitude
should be between 0
and 5V





No signal-> line@2.5V
 Ideally centered at 2.5V
 But large signal may be clipped at 0V or 5V



Code structure example

```
//You need setup() and other
//You need #defines PERIOD, NOISE, RES, SERVOOFF etc.

uint32_t us;
int x;
int pin[] = {PIN1, PIN2};

void checkFreq(int ch) {
    static int oldpin[2];
    static uint32_t oldtime[2];

    if (mydigitalRead(pin[ch]) != oldpin[ch]) {
        int per = us-oldtime[ch];
        if (per>PERIOD-NOISE && per<PERIOD+NOISE) {
            if (ch==0)    x++;
            else x--;
        }
        oldpin[ch] = mydigitalRead(pin[ch]);
        oldtime[ch] = us;
    }
}

void loop()
{
    static uint32_t lastServo = micros();

    us = micros();
    checkFreq(0);
    checkFreq(1);

    // update the servo position
    if (us-lastServo > 1000000/10) {
        Serial.printf("%d servo x=%d \n", x);
        ledcAnalogWrite(0, SERVOOFF+x, RES);
        lastServo = us;
    }

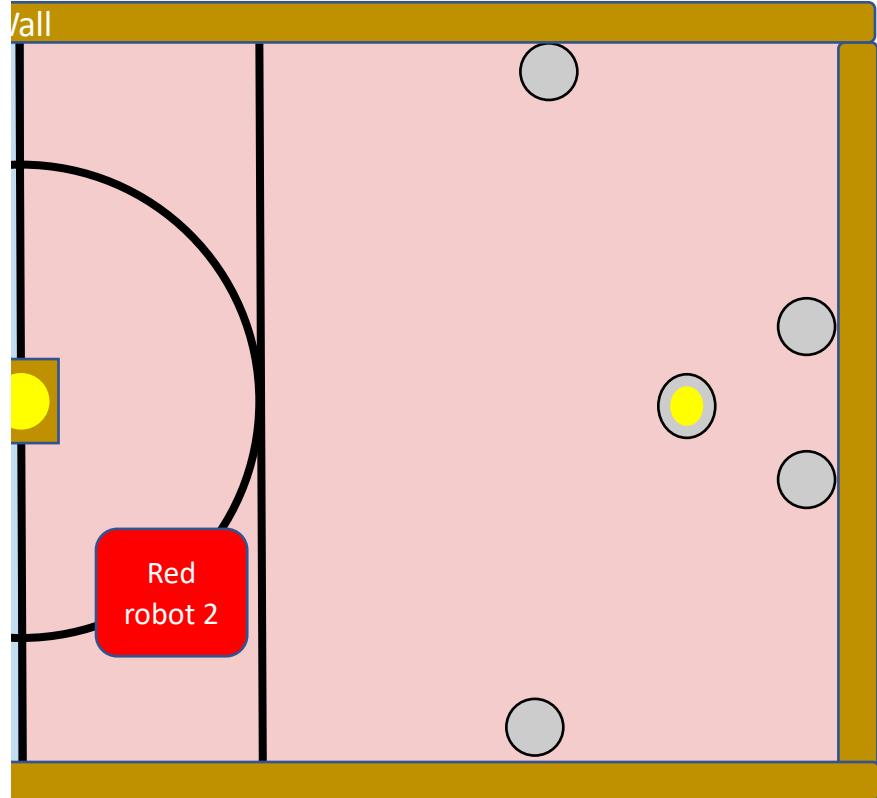
    delayMicroseconds(200);
}
```

02b

Wall Following Behavior

Wall Following

- Behavior could be very useful.
- This will be demonstrated at recitation on Friday.



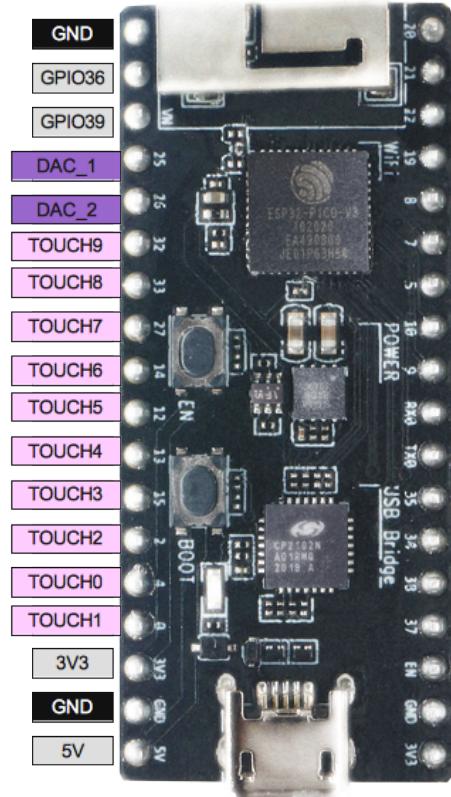
03

ESP32 Capacitive Sensor

Capacitive Touch Sensor

- One wire "circuit."
- Capacitance is measured by generating frequency on output pin then reading voltages with ADC.
- Use Arduino command

```
int touchRead(TouchPIN);
```
- Returns values around 50-100
- Values will drift, but sudden drops in value usually mean contact.



Maybe useful as conductive contact sensor

- Distinguishes between touching can vs anything else
- Feelers can be bare wires.
- For two-wire contact (larger response) need to have mechanism for both wires to contact object but not each other.
 - Ideally compliant wires so if one makes contact it doesn't stop the other from making contact
 - But not so compliant that the two wires touch each other.

04

Heat Sinks

Which electronics get hot?

Power Transistors

- IRLB8721
- TIP32
- TIP102
- **ULN2003***

Power circuits

- LM7805 – 5V Regulator
- **SN754410* – H-Bridge**

* DIP package in ministore

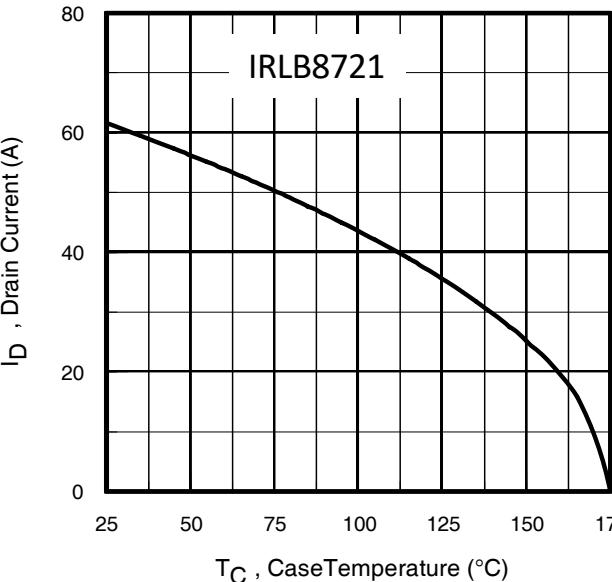


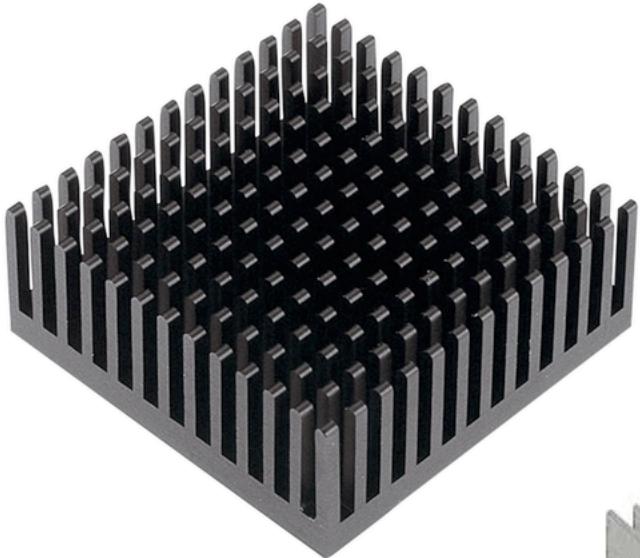
Fig 9. Maximum Drain Current vs. Case Temperature

7.2 Recommended Operating Conditions SN754410

over operating free-air temperature range (unless otherwise noted)

		MIN	MAX	UNIT
V_{CC1}	Logic supply voltage	4.5	5.5	V
V_{CC2}	Output supply voltage	4.5	36	V
V_{IH}	High-level input voltage	2	5.5	V
V_{IL}	Low-level input voltage	-0.3 ⁽¹⁾	0.8	V
T_J	Operating virtual junction temperature	-40	125	°C
T_A	Operating free-air temperature	-40	85	°C

Heat Sinks



CPU heat sink



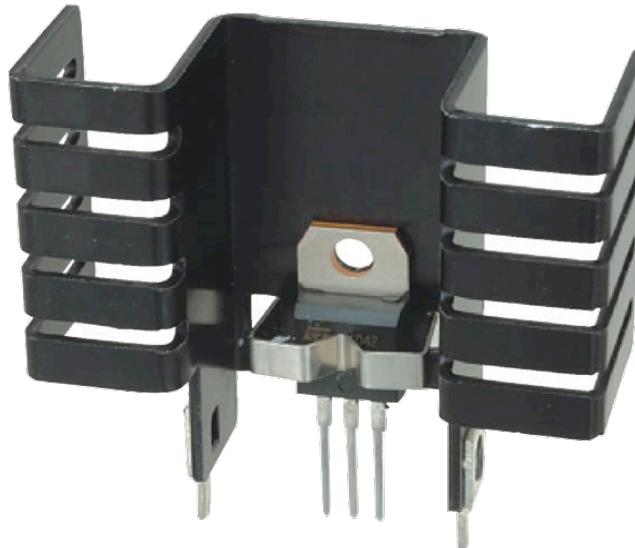
Relay heat sink



Motor heat sink

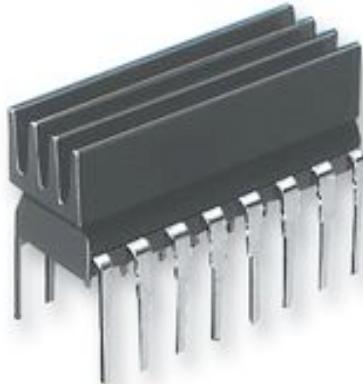
TO-220 Package

- LM7805
- MOSFETS in ministore
- TIP102
- TIP32

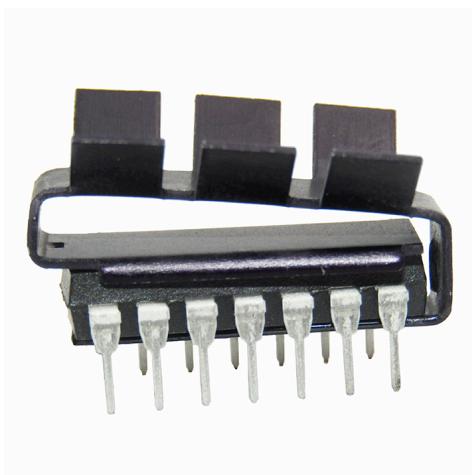


DIP16

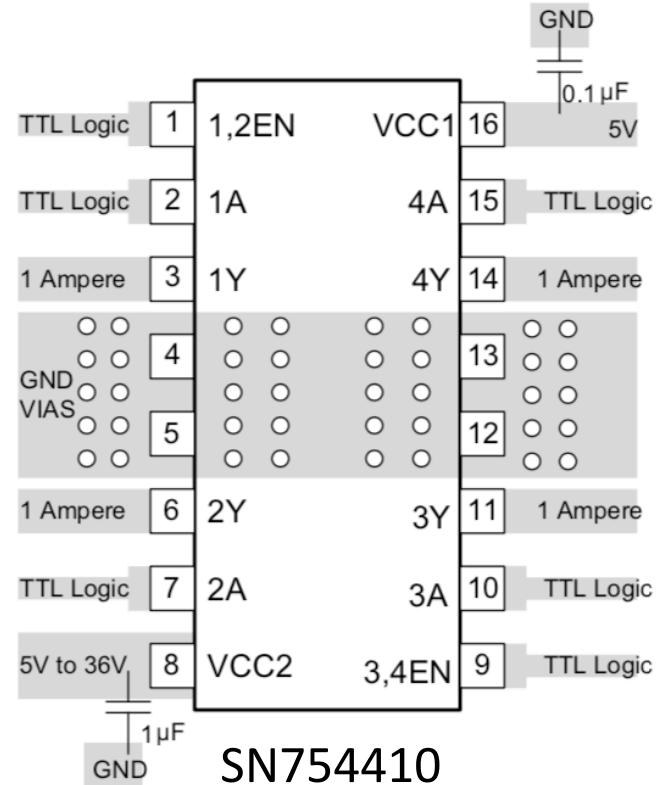
- SN754410 H-Bridge
- FAN8100
- ULN2003 Darlington Pair Drivers



\$0.59 on Digikey



\$1.84 on Digikey

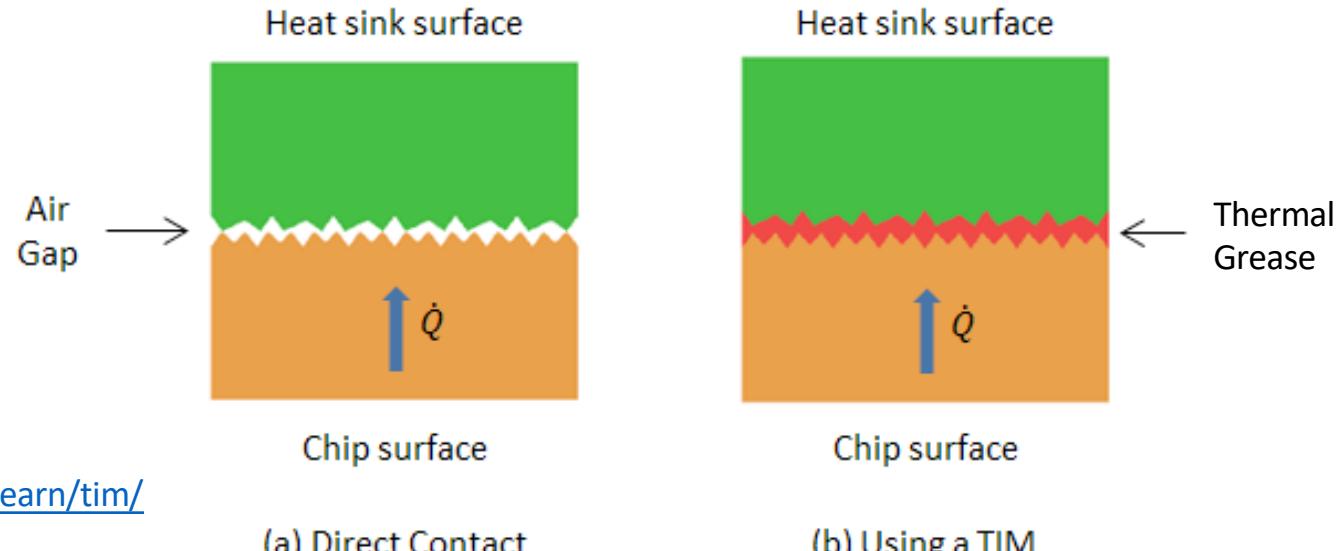


SN754410

Figure 9. Layout Diagram

Thermal grease will make heat sinks work

- A dry interface will not conduct heat very well.
- Thermal grease greatly improves performance.
- Many types of grease work but, thermal grease will tend to last longer and not dry out.



Summary

- The MCP6044 may go unstable with capacitive load – add resistor
- Two low level autonomous behaviors are candidates for the final project: wall-following and beacon tracking
- Capacitive touch sensor is a way to detect cans
- Heat sinks enable help high current devices

Answer in CHAT

Answer how you feel about each topic below with:

1. I don't understand this topic at all
2. I don't know now, but know what to do to get by
3. I understand some, but expect to get the rest later
4. I understand completely already

- A. Using OpAmp Circuit
- B. Rules of the game
- C. Some Autonomous Behaviors