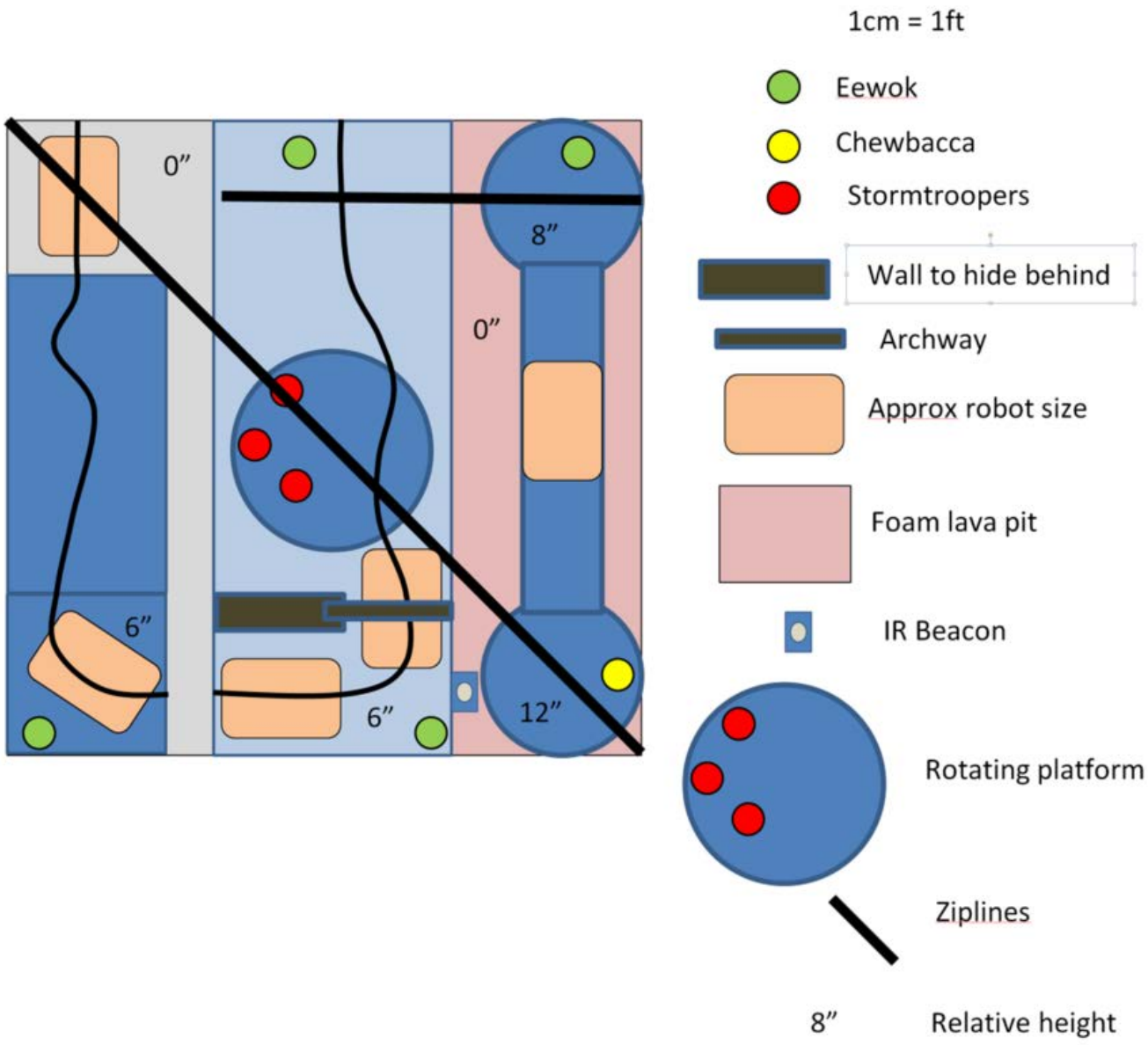
ENPH 253 – Introduction to Instrument Design - Summer 2018

DRAFT Competition Rules – April 3, 2018

Eewok Rescue: A Star Warz Story

Chewebacca and the Ewoks have been trapped inside an Empire stronghold! When you last saw them they worshipped you as a God - now it's your turn to help them.

Figure 1 – Competition Surface



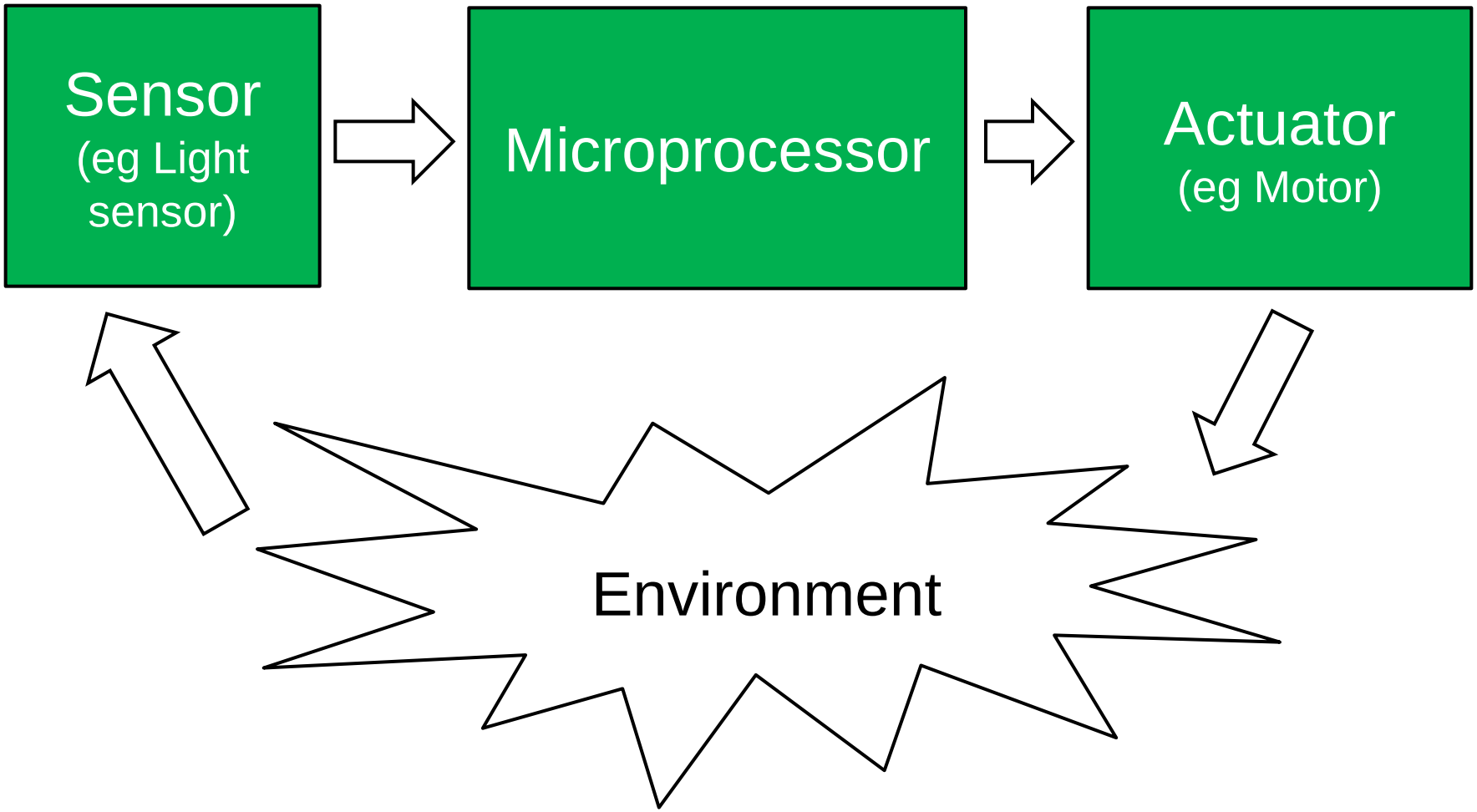
“Smart” instruments

The use of microprocessors to replace mechanical systems leads to

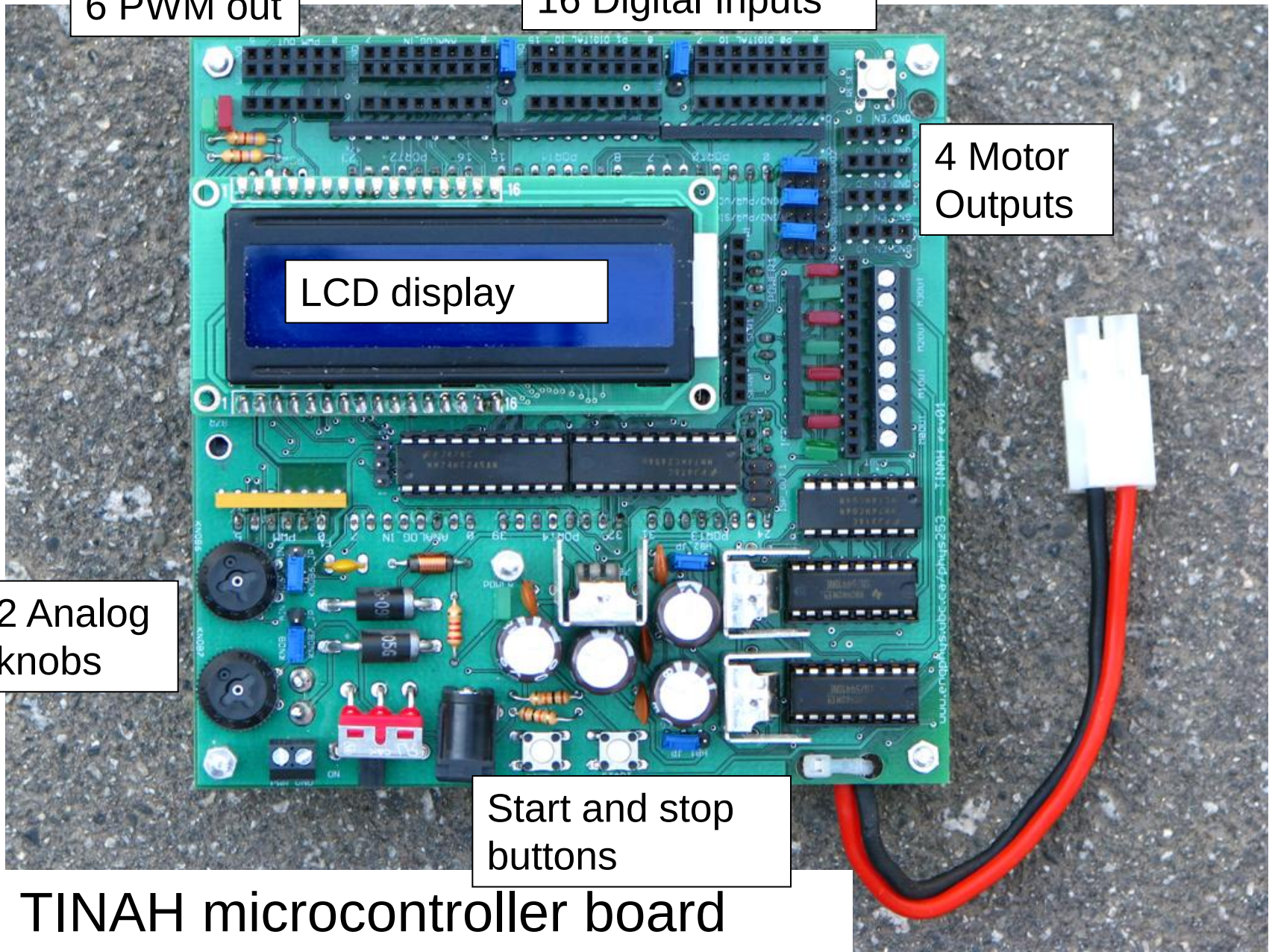
- better performance
- higher reliability
- more complex behavior with a mechanically simpler instrument
- often lower total cost of instrument

Eg #1: mechanical vs. electronic thermostats

“Smart” instruments



Rescue bot video



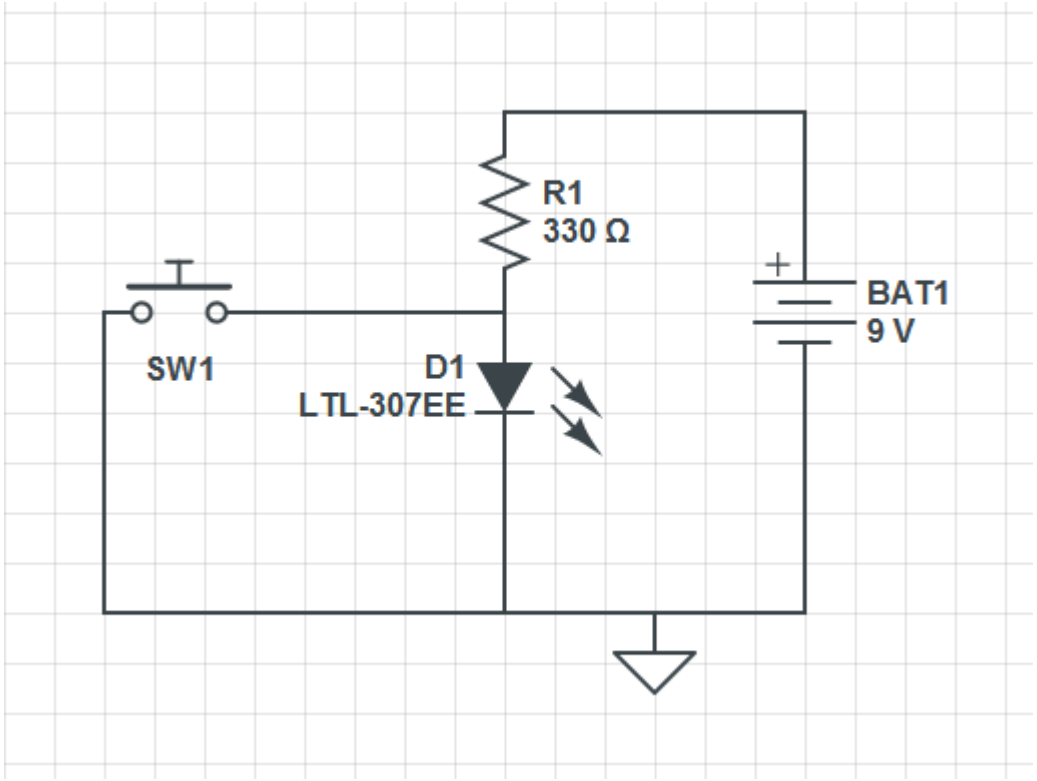
TINAH microcontroller board

Step 1 – Getting your robot to detect its environment

Digital Inputs – Touch sensor

Build this circuit:

- LED is normally lit
- While the switch is pressed, the LED goes off



- Why do you need the 330R resistor?
- What happens if you remove it? (don’t)

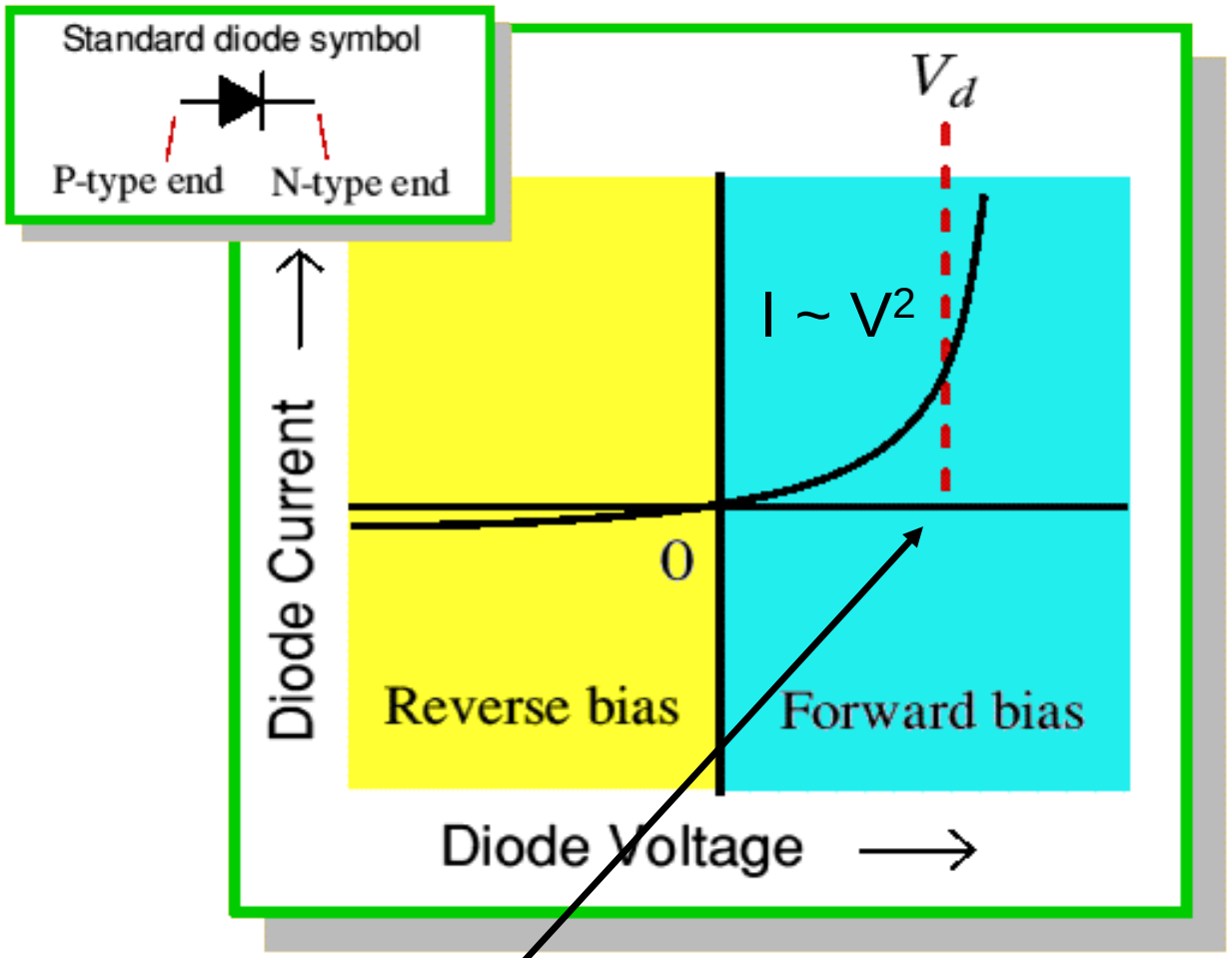
Discrete devices: diodes

$\Delta V = 0.7$ V

Treat as conductor

I = 0 A

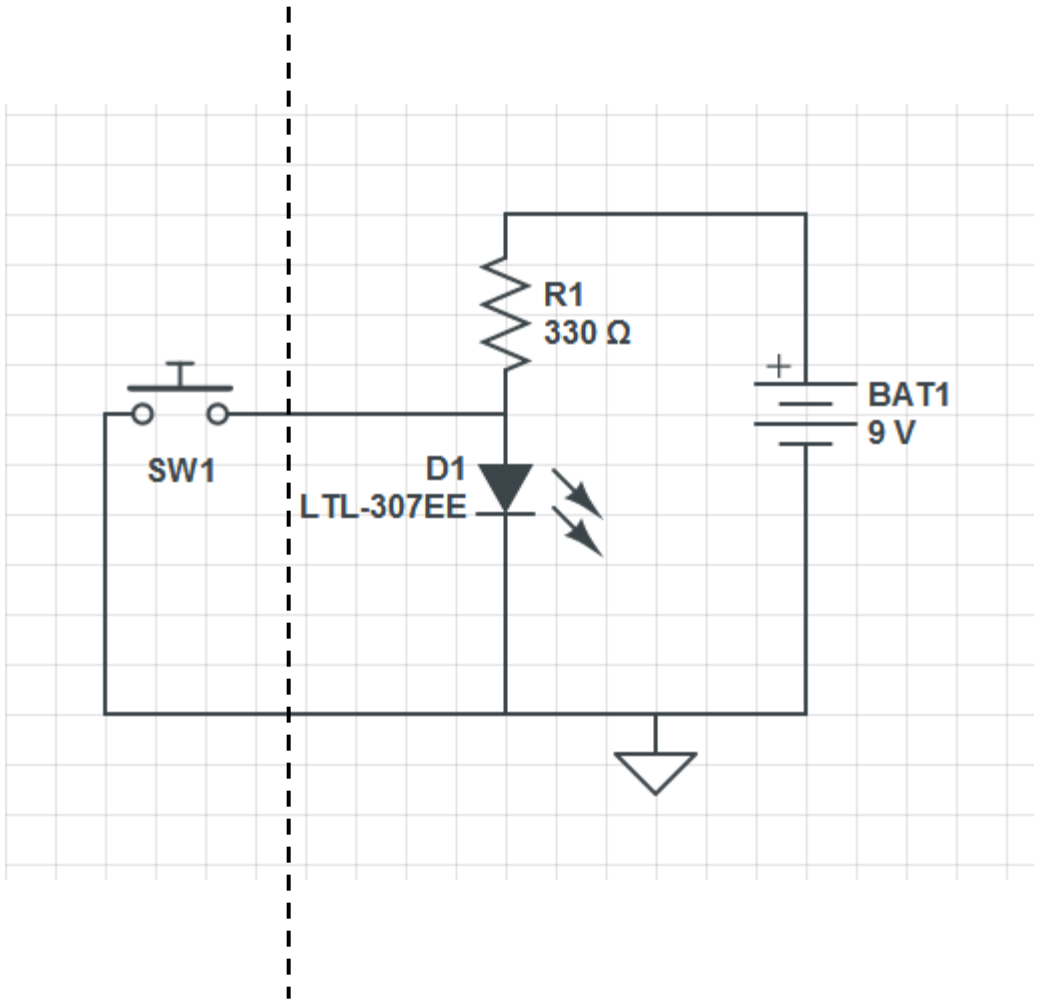
Treat as open circuit



Typical ~ 0.7 V

Diagrams courtesy of: University of St. Andrews, St Andrews, Fife KY16 9SS, Scotland

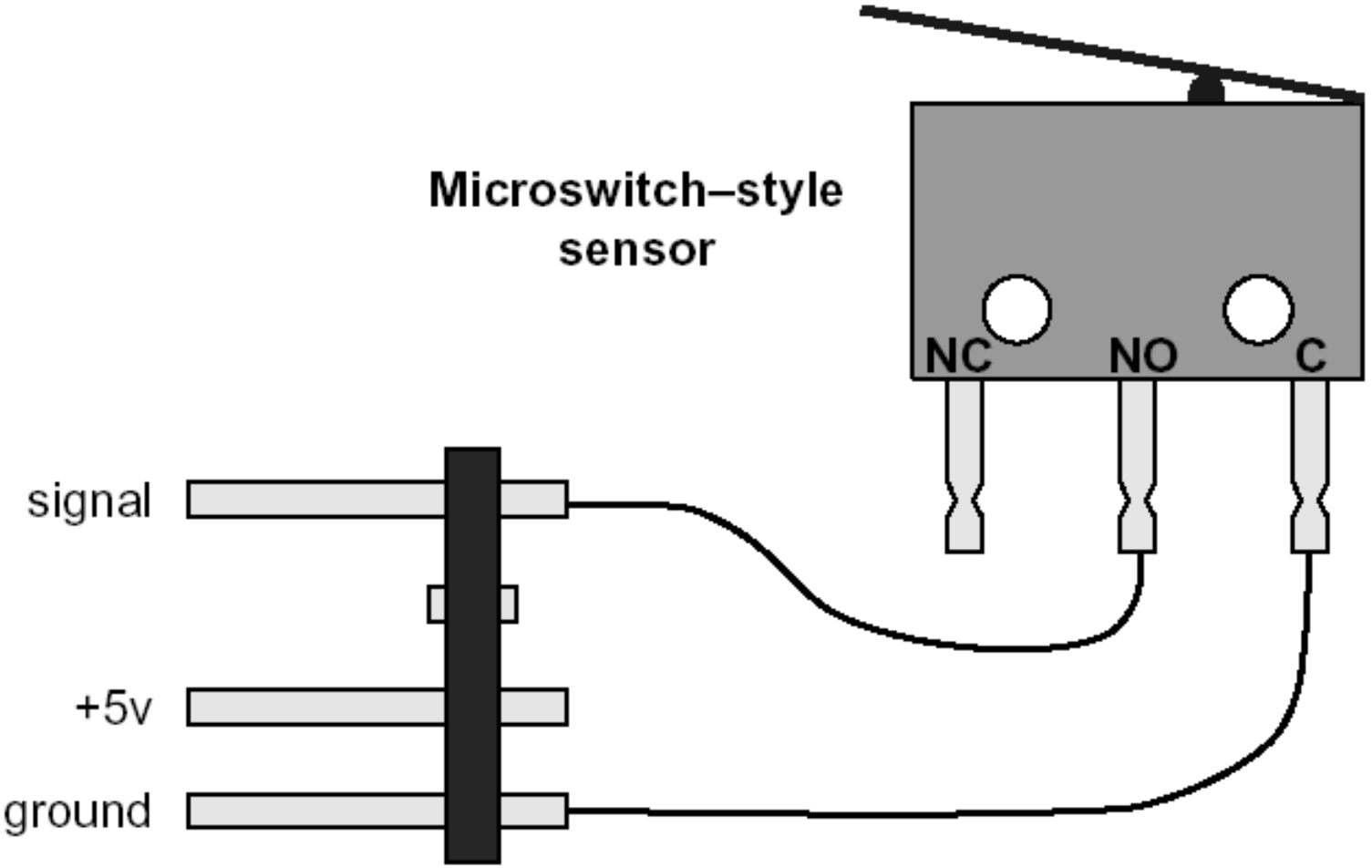
Digital Inputs – Touch sensor



Digital Inputs – Getting information INTO your microprocessor

Digital Inputs – Touch sensor

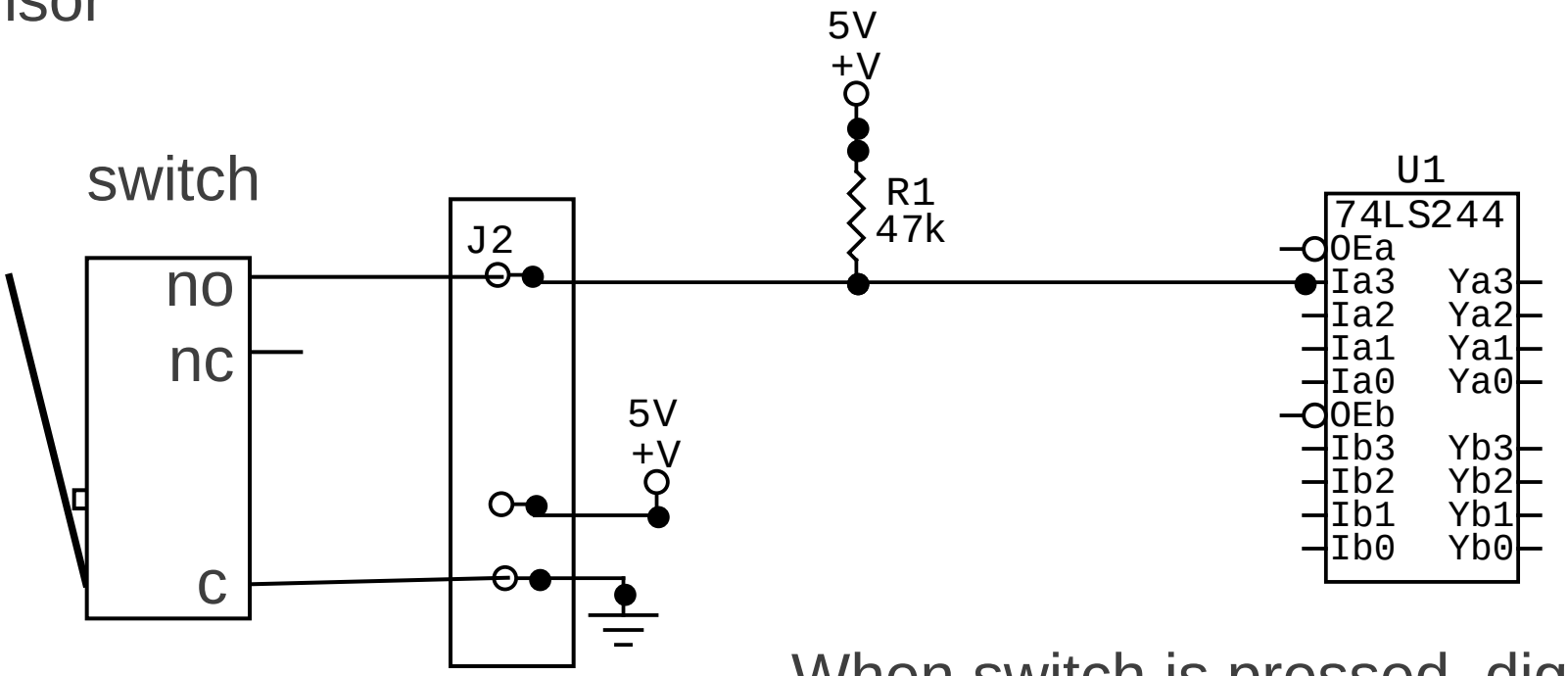
6.3.2 Switch Sensor



Wire to switch terminals labelled **C** (common) and **NO** (normally open)

Digital Inputs – Touch sensor

• A simple mechanical switch can be used as a collision or touch sensor




```
if (digitalRead(0))
  {    LCD.print("switch NOT pressed");   }
 else
  {   LCD.print("Collision!!");   }
```

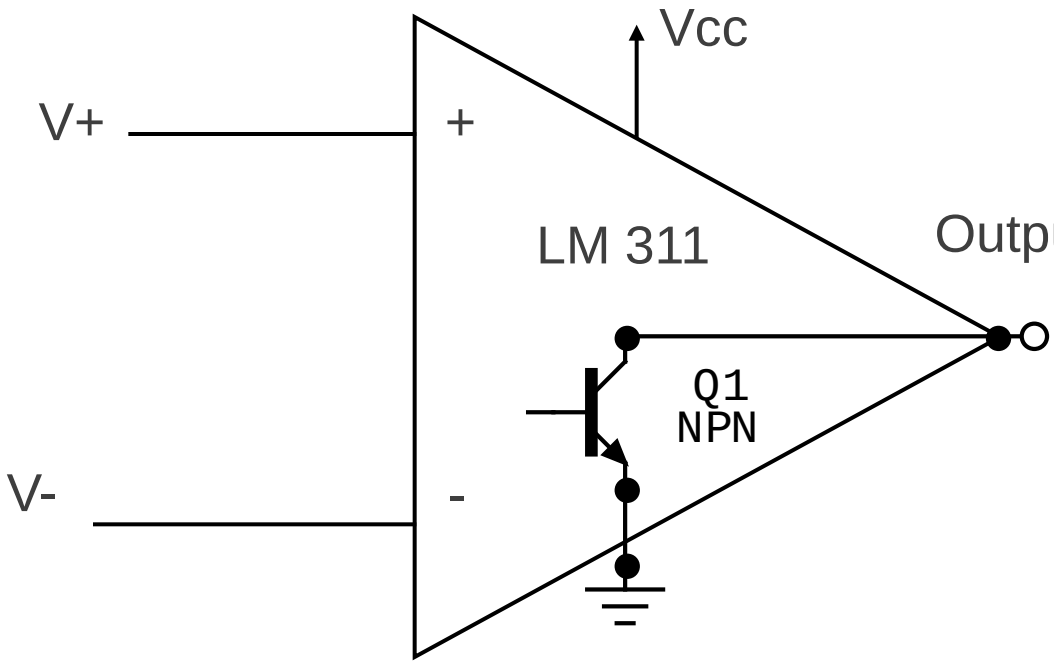
When switch is pressed, digital input is pulled low (0 V) by the switch.

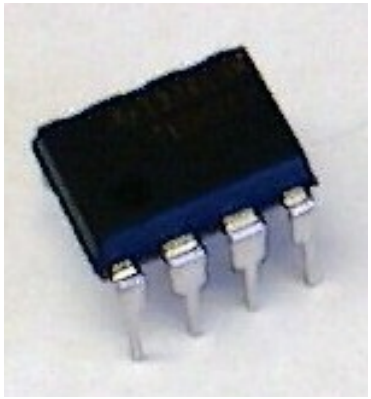
When not pressed it is pulled high (5V) by the resistors

Step 1b – What if a sensor is not ON/OFF?

LM311 comparator – open collector output

• Comparators and other chips are sometimes provided with **Open Collector outputs** for easy interfacing to digital inputs.





When V+ < V- , Q1 is turned on (conducting). Output pin is grounded through Q1. When V+ >V- , Q1 is off, and output pin floats unless externally pulled up!!!. (but Q1 cannot sink any current to ground).

Remember: it takes very little charge to change the voltage of a disconnected wire!

LM311 comparator – Example of a data sheet

5.0 Absolute Maximum Ratings for the LM311 (Note 12)

If Military/Aerospace specified devices are required, please contact the National Semiconductor Sales Office/ Distributors for availability and specifications.

Total Supply Voltage (V_{84})	36V
Output to Negative Supply Voltage (V_{74})	40V
Ground to Negative Supply Voltage (V_{14})	30V
Differential Input Voltage	±30V
Input Voltage (Note 13)	±15V
Power Dissipation (Note 14)	500 mW
ESD Rating (Note 19)	300V
Output Short Circuit Duration	10 sec
Operating Temperature Range	0° to 70°C
Storage Temperature Range	−65°C to 150°C
Lead Temperature (soldering, 10 sec)	260°C
Voltage at Strobe Pin	V^+−5V
Soldering Information	
Dual-In-Line Package	
Soldering (10 seconds)	260°C
Small Outline Package	
Vapor Phase (60 seconds)	215°C
Infrared (15 seconds)	220°C

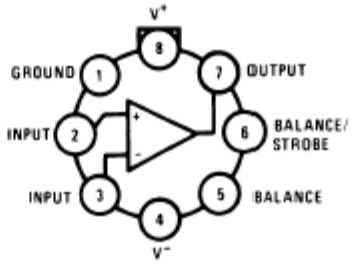
See AN-450 "Surface Mounting Methods and Their Effect on Product Reliability" for other methods of soldering surface mount devices.

DANGER LEVELS: Exceeding these voltages / currents will blow up the chip.

LM311 comparator – Example of a data sheet

11.0 Connection Diagrams

Metal Can Package

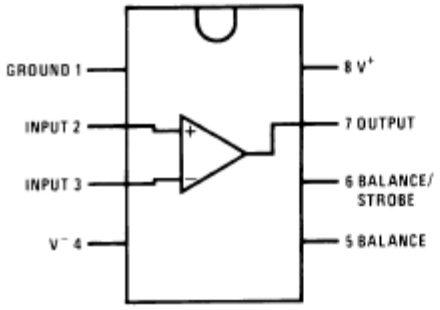


DS005704-6

Note: Pin 4 connected to case

Top View
Order Number LM111H, LM111H/883(Note 21) , LM211H or LM311H
See NS Package Number H08C

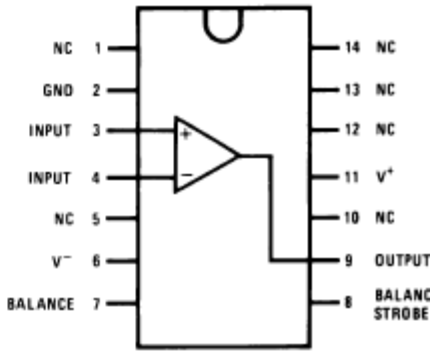
Dual-In-Line Package



DS005704-34

Top View
Order Number LM111J-8, LM111J-8/883(Note 21),
LM311M, LM311MX or LM311N

Dual-In-Line Package



DS005704

Top View

The most often used page – how to hook up the chip.

LM311 comparator – Example of a data sheet

Electrical Characteristics (Note 15)
for the LM311

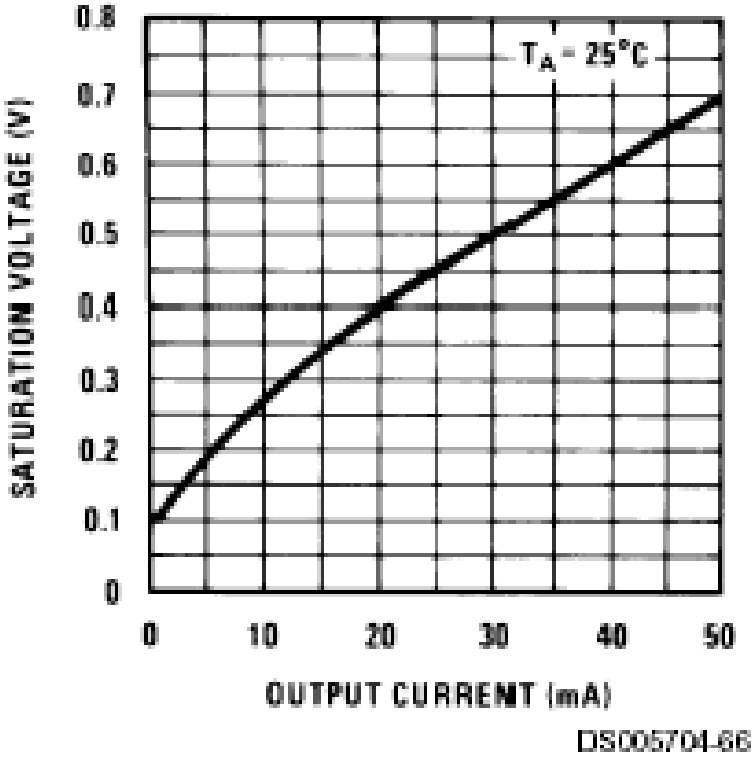
Parameter	Conditions	Min	Typ	Max	Units
Input Offset Voltage (Note 16)	T_A=25°C, R_S≤50k		2.0	7.5	mV
Input Offset Current(Note 16)	T_A=25°C		6.0	50	nA
Input Bias Current	T_A=25°C		100	250	nA
Voltage Gain	T_A=25°C	40	200		V/mV
Response Time (Note 17)	T_A=25°C		200		ns
Saturation Voltage	V_{IN}≤−10 mV, I_{OUT}=50 mA T_A=25°C		0.75	1.5	V
Strobe ON Current (Note 18)	T_A=25°C		2.0	5.0	mA
Output Leakage Current	V_{IN}≥10 mV, V_{OUT}=35V T_A=25°C, I_{STROBE}=3 mA V^- = Pin 1 = −5V		0.2	50	nA
Input Offset Voltage (Note 16)	R_S≤50K			10	mV
Input Offset Current (Note 16)				70	nA
Input Bias Current				300	nA
Input Voltage Range		−14.5	13.8,−14.7	13.0	V
Saturation Voltage	V^+≥4.5V, V^-=0 V_{IN}≤−10 mV, I_{OUT}≤8 mA		0.23	0.4	V
Positive Supply Current	T_A=25°C		5.1	7.5	mA
Negative Supply Current	T_A=25°C		4.1	5.0	mA

Important operating characteristics: these numbers will tell you how the chip will behave.

LM311 comparator – Example of a data sheet

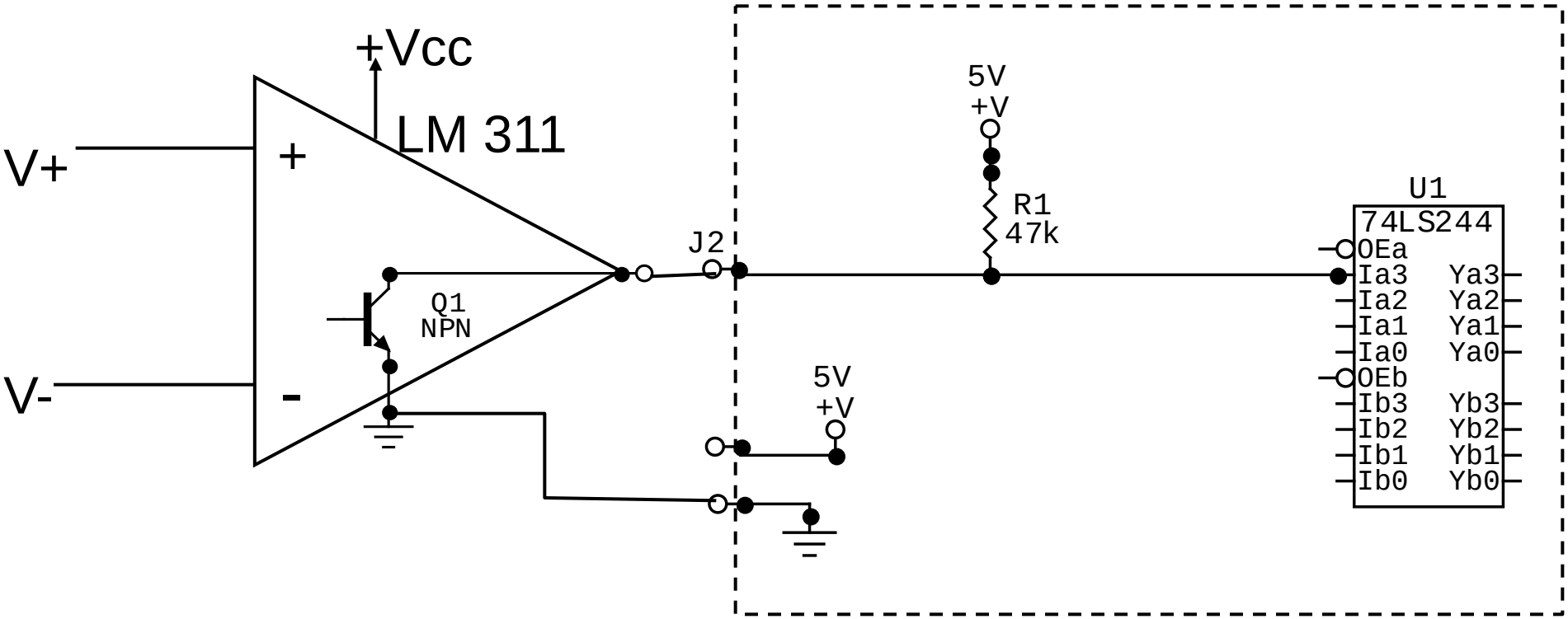
7.0 LM311 Typical Performance Characteristics

Output Saturation Voltage



LM 311 can only sink a limited amount of current

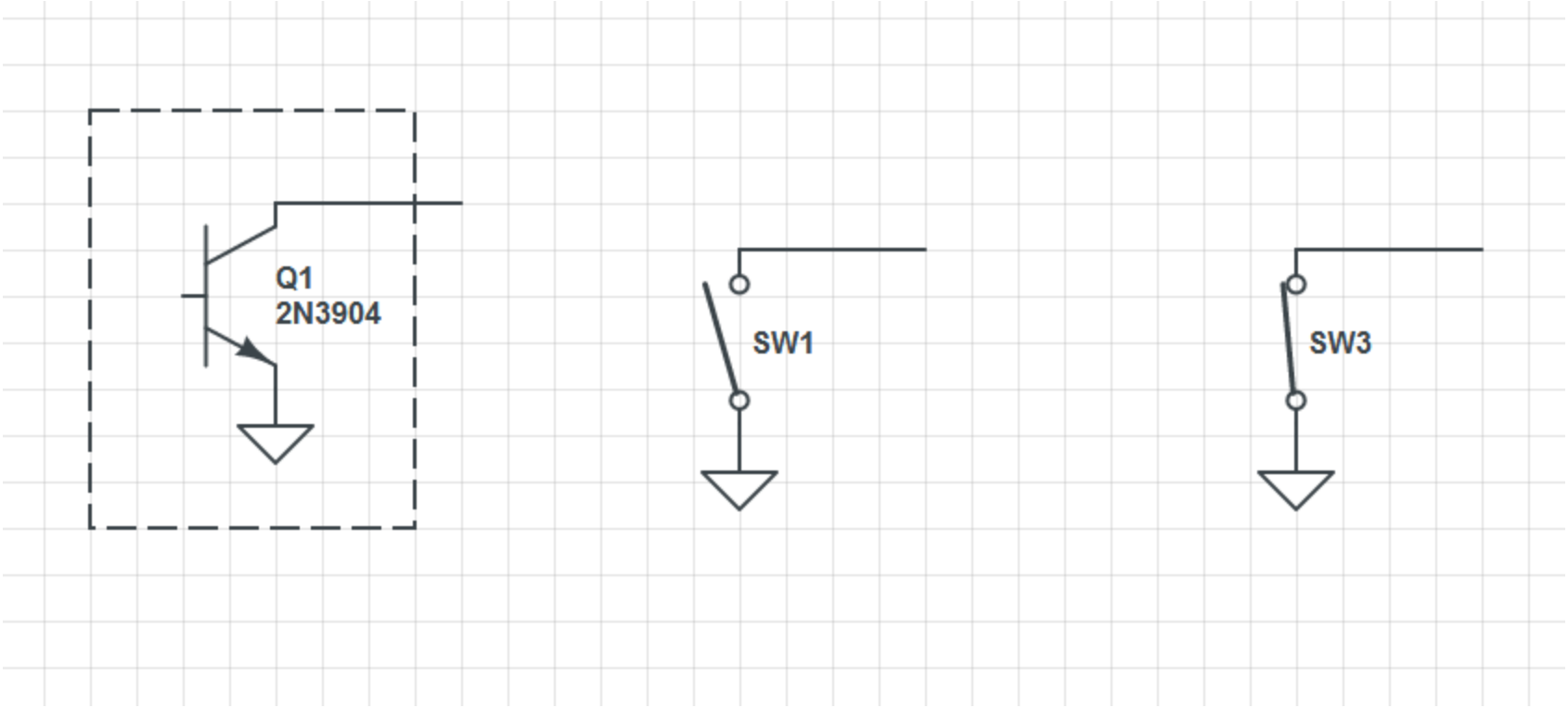
LM311 comparator – open collector output



Unlike an OP-amp, the 311 is NOT a source of power! You cannot drive a load with the output pin.

Now, when Q1 is off, digital input J2 is pulled high by R1. When Q1 is on, J2 is pulled low (~ 0.1 or 0.2 V) by Q1. Note that the LM311 and the TINAH **must share ground** for this to work, but DO NOT NEED TO SHARE POWER RAILS.

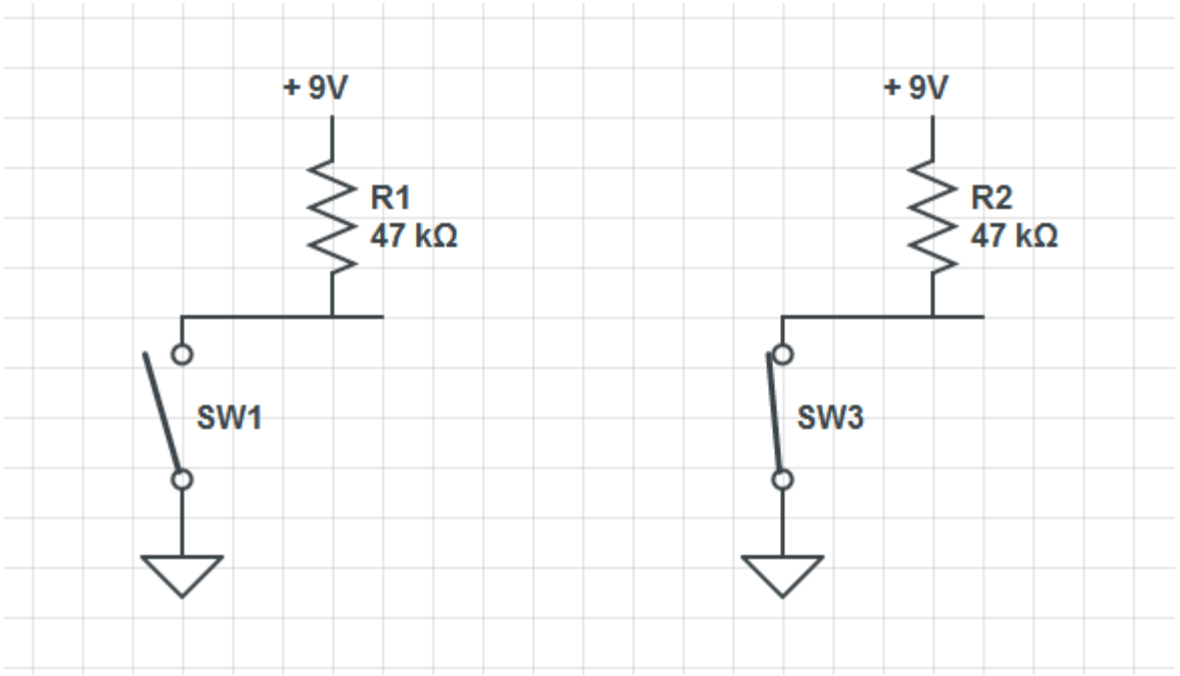
LM311 comparator – open collector output



ON

OFF

LM311 comparator – open collector output

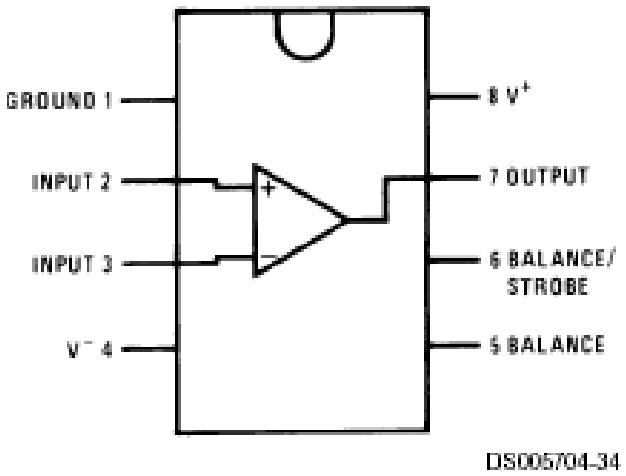


ON

OFF

LM311 comparator – open collector output

Dual-In-Line Package



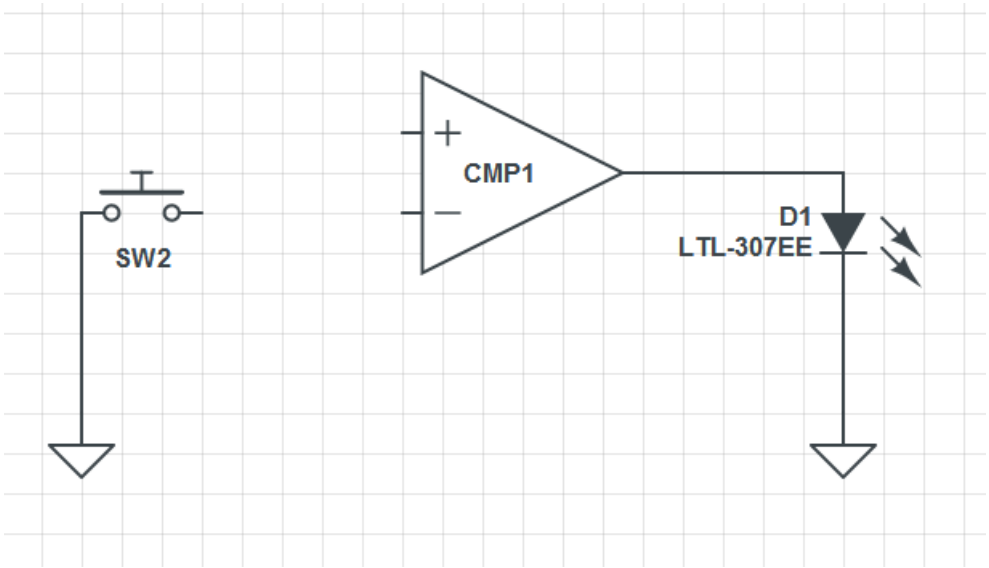
Top View
Order Number LM111J-8, LM111J-8/883(Note 21), LM311M, LM311MX or LM311N

- You must ground Pin 1 for the comparator to work!
- Pin 7 (Output) must be “pulled up”!

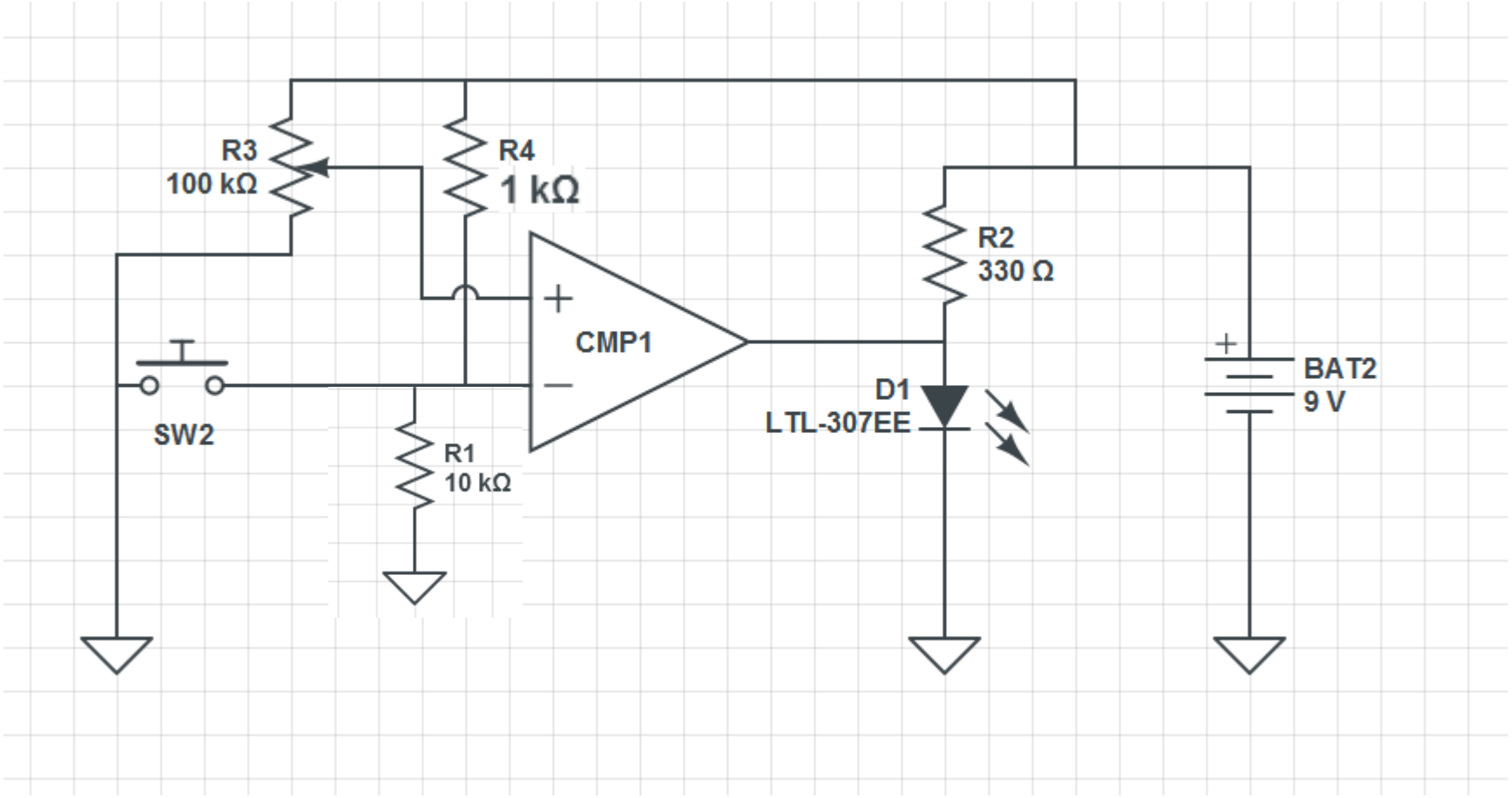
LM311 comparator – open collector output

Build a circuit that has:

- An LED that is normally lit
- While a switch is pressed, the LED goes off
- The LED is connected to switch through a 311
- Start with this and add elements:



LM311 comparator – open collector output

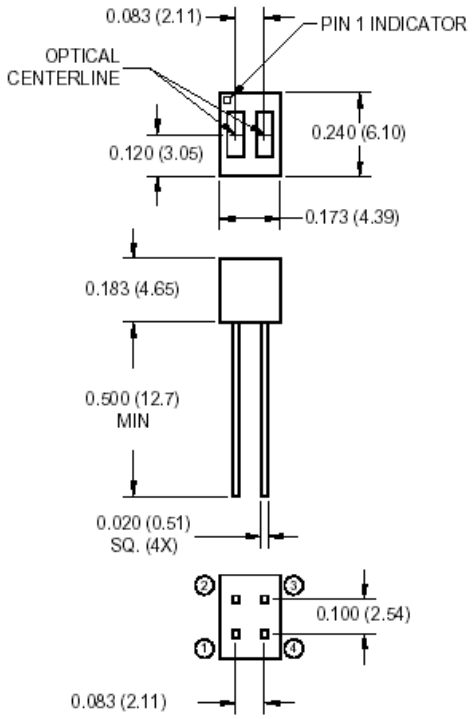


Example: QRD1114 reflectance sensor

QT OPTOELECTRONICS

QRD1113/1114
REFLECTIVE OBJECT SENSOR

PACKAGE DIMENSIONS



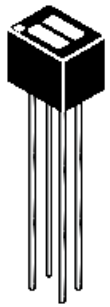
PIN 1 COLLECTOR — PIN 3 ANODE
PIN 2 EMITTER — PIN 4 CATHODE

NOTES:

1. Dimensions for all drawings are in inches (millimeters).
2. Tolerance of ± .010 (.25) on all non-nominal dimensions unless otherwise specified.
3. Pins 2 and 4 typically .050" shorter than pins 1 and 3.
4. Dimensions controlled at housing surface.

FEATURES

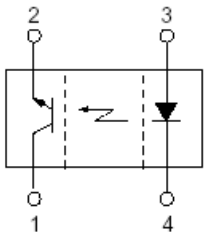
- Phototransistor Output
- No contact surface sensing
- Unfocused for sensing diffused surfaces
- Compact Package
- Daylight filter on sensor



NOTES (Applies to Max Ratings and Characteristics Tables.)

1. Derate power dissipation linearly 1.33 mW/°C above 25°C.
2. RMA flux is recommended.
3. Methanol or isopropyl alcohols are recommended as cleaning agents.
4. Soldering iron 1/16" (1.6mm) from housing.
5. As long as leads are not under any spring tension.
6. D is the distance from the sensor face to the reflective surface.
7. Cross talk (I_{CX}) is the collector current measured with the indicator current on the input diode and with no reflective surface.
8. Measured using an Eastman Kodak neutral white test card with 90% diffused reflecting as a reflective surface.

SCHEMATIC



QRD1114 reflectance sensor

QRD1113/1114

ΓIVE OBJECT SENSOR

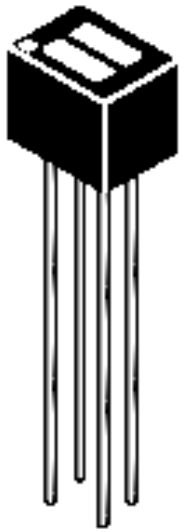
Output

ıce sensing

ensing diffused surfaces

ge

sensor

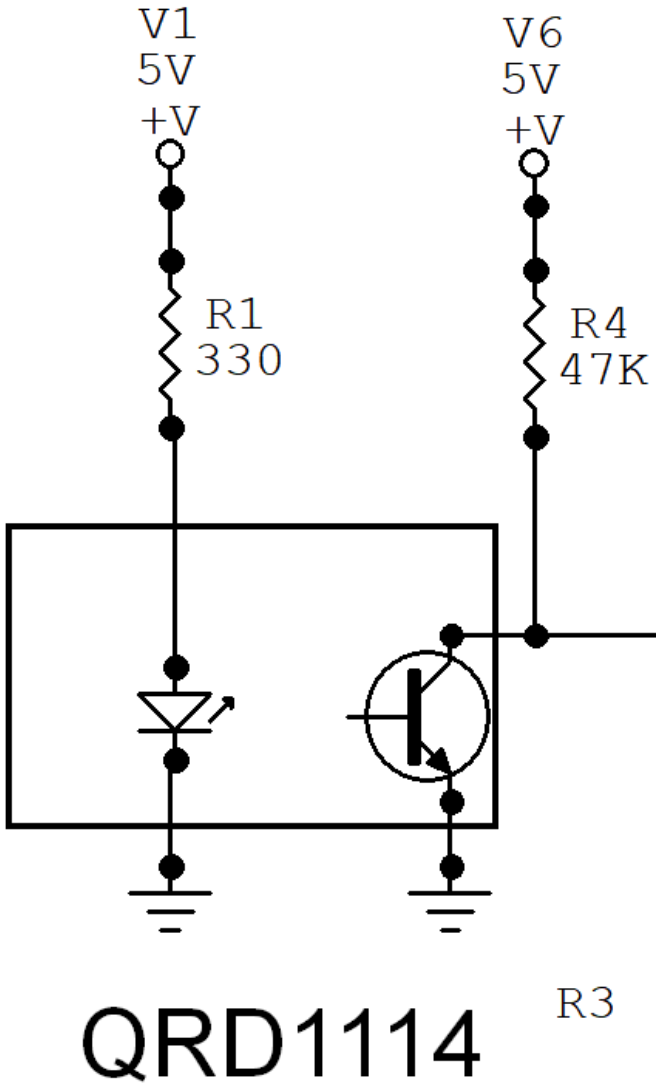


Watch for direct cross-talk: diode and transistor can come out of the housing.

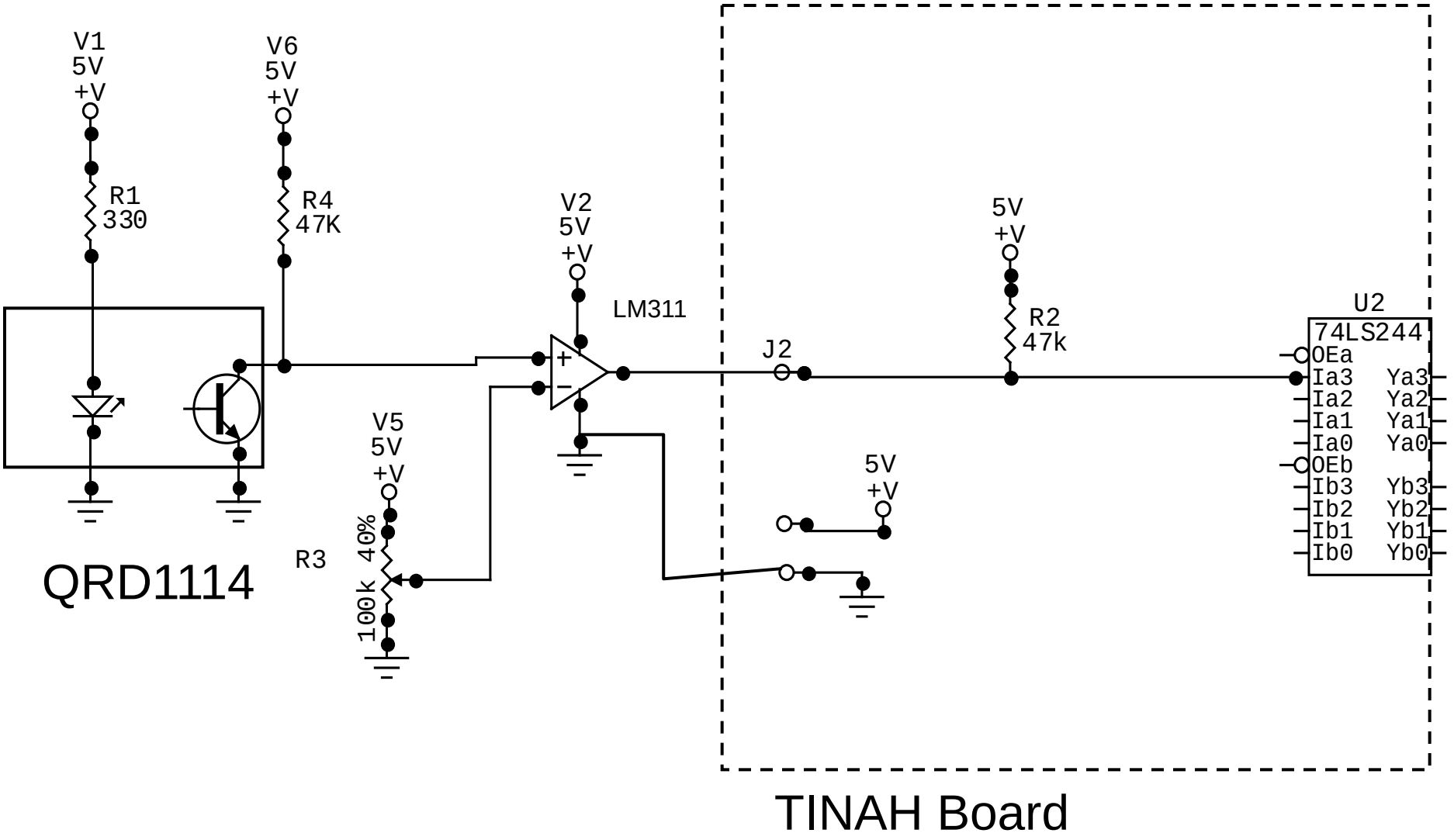
QRD 1114 – reflectance sensor

Build a circuit to test a QRD sensor:

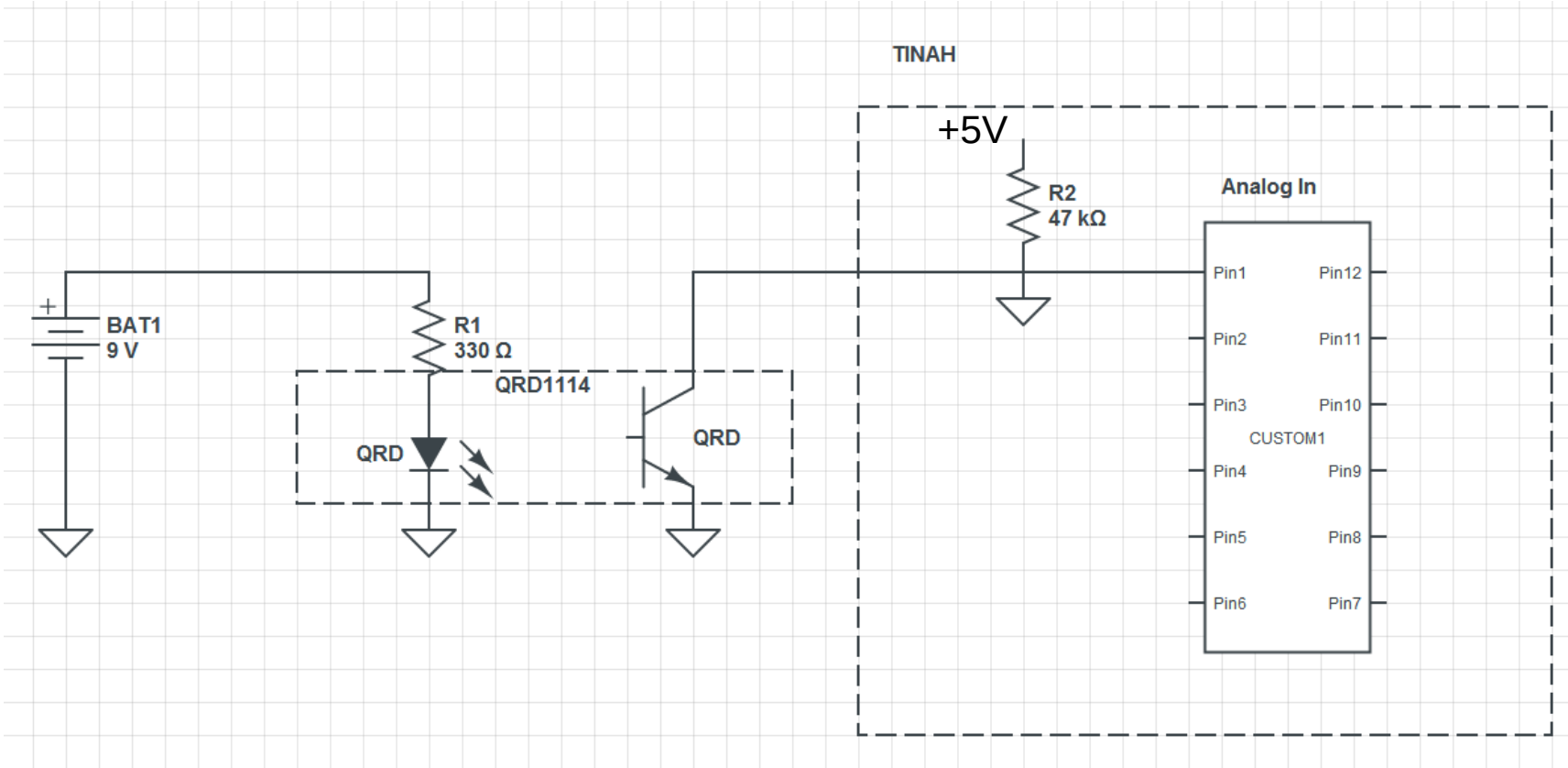
- Use the voltmeter to test that the QRD output responds to light
- See if you or your teammates have a cell phone camera that can see if the QRD is on.
- Add a comparator to this circuit to give you a digital output.



Example: QRD1114 reflectance sensor



QRD1114 simple analog connection



Digital Inputs – QRD sensor - analog

```
while (!startbutton())
{
  LCD.clear();  LCD.home();
  if (analogRead(0)>knob(7))
  {    LCD.print("object NOT detected."); }
  else
  {    LCD.print("object nearby!!");   }
  delay(100) ;
}
}
```

Things to keep in mind for Lab 1

- Bring a Lab Notebook!

Common problems:

- Circuit (LM311) and TINAH are not connected to a common ground. YOU NEED TO CONNECT THEM.
- The LM311 comparator output pin is not pulled up.
- The power rail break in the proto board is not bridged.
- The strobe pin of the LM311 is pulled low.
- The ground pin of the LM311 is not grounded.
- Blowing up the TINAH. Please use LM311 to interface to the frequency generator.

Digital Inputs – Touch sensor

```
////////////////////////////////////
// Physics 253 - Lecture 1
// 2016
////////////////////////////////////

#include <phys253.h>
#include <LiquidCrystal.h>

void setup()
{
   #include <phys253setup.txt>
   Serial.begin(9600);
}

void loop()
{
  while(!startbutton())
  {
    LCD.clear();  LCD.home();
    LCD.print("Welcome to 253!");
    delay(1000) ;
    LCD.clear();  LCD.home();
    LCD.print("Pickup kits");
    LCD.setCursor(0,1) ;  LCD.print("at front of room");
    delay(1000) ;
  }

while (!stopbutton())
{
  LCD.clear();  LCD.home();
  if (digitalRead(0))
   {    LCD.print("switch NOT pressed");   }
  else
   {   LCD.print("Collision!!");   }
  delay(100) ;
}

while (!startbutton())
{
  LCD.clear();  LCD.home();
  if (analogRead(0)>knob(7))
  {    LCD.print("object NOT detected."); }
  else
  {    LCD.print("object nearby!!");   }
  delay(100) ;
}
}
```