Welcome to Phys 319
Happy New Year

PHYS 319 Electrical Laboratory:

A project-oriented course introducing the design, construction and programming of microprocessor-controlled devices.

Course outline:

First 6 weeks:

Crash course in microprocessor programming in C and incorporating external hardware.

Working on example programs and explaining how hardware and software works

Next 6 weeks: projects of your choice

Old projects are on the web page.

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- Web Page:

https://phas.ubc.ca/~kotlicki/Physics_319/index.html

Labs: T, W, Th 2-6 pm Hebb 416

Lecture: T 11:30-12:30 Hebb 116

Past Projects

PID control for Segway
Weather station
3 axis robot arm by Nicholas di Lello
Gesture controlled calculator with light strip readout by Cassidy Donaldson
Digital inclinometer
Alarm Clock with music
Anchor lowering machine
Violin tuner
Robotic Arm by Aiden Smith
Car following black line
Pulse rate monitor
Internet connected personal fall detector
2 output metronome
Bike computer
Automatic string tuner by Paul Froese

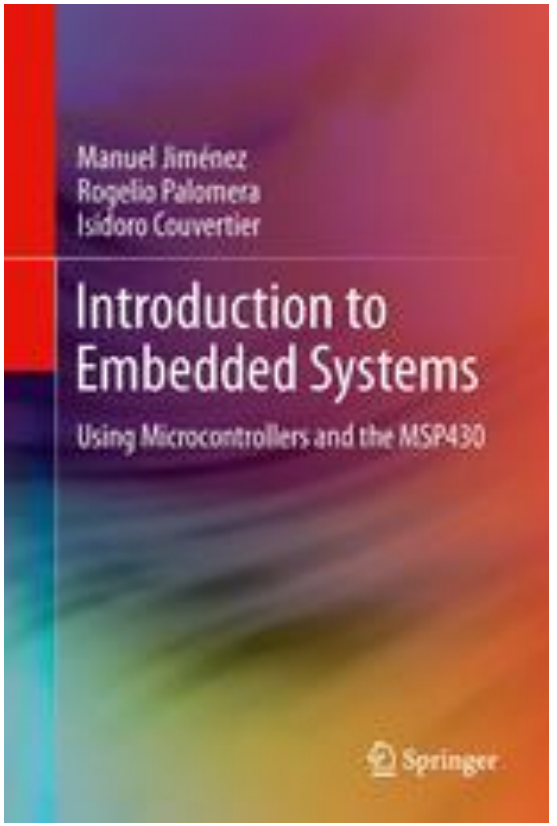
Why do we teach this course?

- Microprocessors are everywhere – maybe it is worth knowing something about them.
- Understanding microprocessor programming

  Including external hardware
- Learn how to quickly and cheaply build an instrument, a part of an industrial system or an appliance which will save a lot of yours or company time and money.
- Learn how to extract useful information from datasheets
- It is good experience for a summer job or grad school

Reference Text

Introduction to Embedded Systems Using Microcontrollers and the MSP430.



Available for download from the UBC library at

http://webcat2.library.ubc.ca/vwebv/holdingsInfo?bibId=7372090.

We won't follow this text, but its a great reference.

Library of the example codes

https://dev.ti.com/tirex/explore/node?node=A__ACtifcK4C02lASwKY7wrRA__msp430ware__IOGqZri__LATEST

Lab procedures:

- Individual project work
- Laptops – PC or Mac
- Notes (electronic only) in any format convertible to pdf
- Submitting lab reports and programs: on Canvas pdf format only
- Lab manual and Technical manuals (on line, frequent changes and updates!)
- Lab checks

Marking:

To pass the course you have to:

1. Submit all three reports and check all the required parts (show them working to the TAs or instructor)

2. Present the final project and submit the final report.

If any of these elements are missing, your grade will be lower of 45% or total of the points.

Marking:

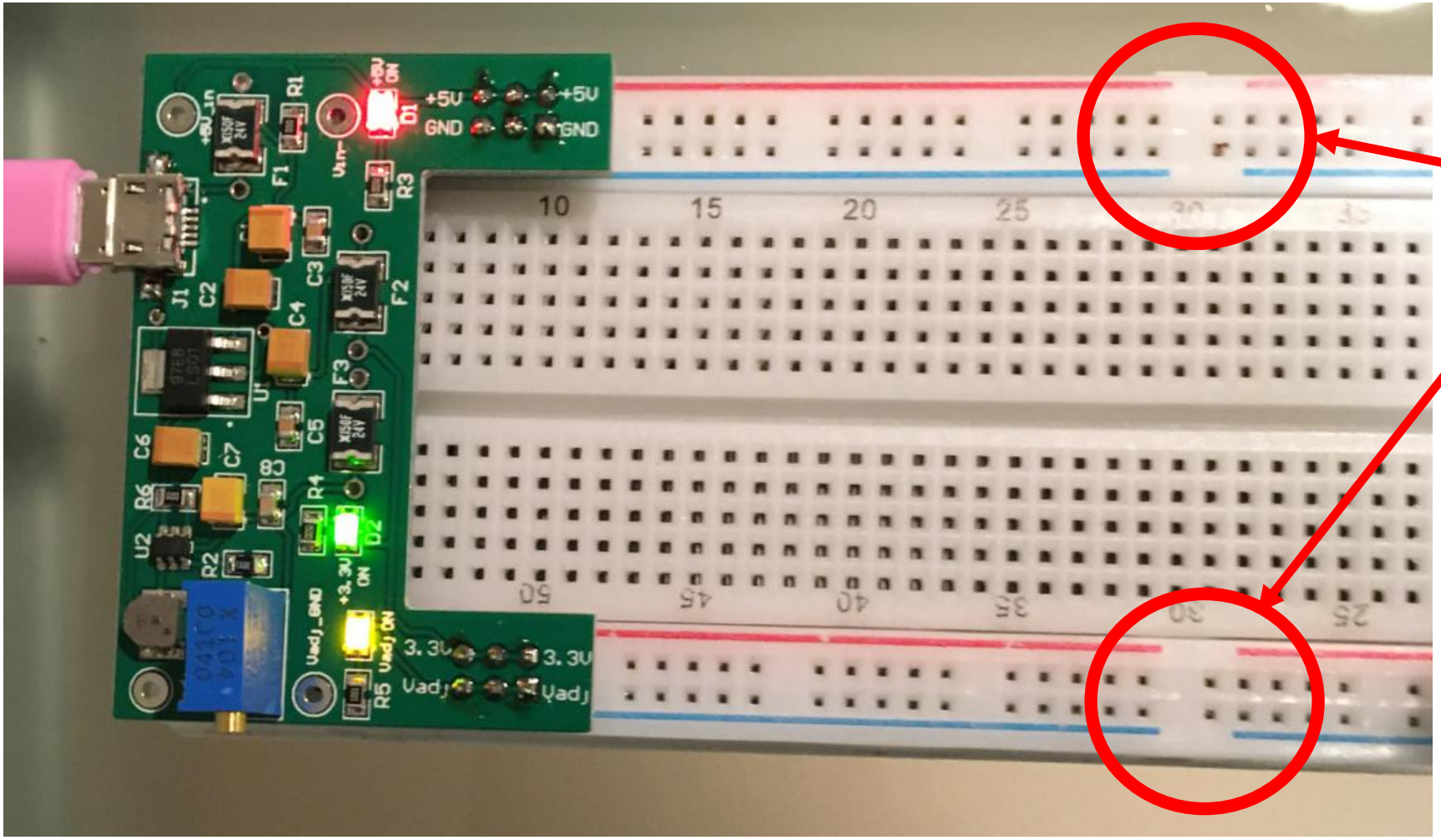
- A Lecture test 20%
- Activities 5%
- Programs and lab reports in first 6 weeks 20%
- Project proposal 3%
- Status report 2%
- Project quality and functionality 20%
- Presentation 10%
- Final report 20%

Late report submissions - 10% of the grade will be subtracted per day down to 50%. We often wave the subtractions for good reasons (not for…..)

Use of Generative Artificial Intelligence

- Students are permitted to use artificial intelligence tools, including generative AI, to gather information, review concepts or to help produce assignments or codes.
- However, students are ultimately accountable fotr he work they submit, and any content generated or supported by an artificial intelligence tool must be cited appropriately. You have to include in your notes the original text you used to be refined or enriched and all the prompts or commands you used to communicate with AI. Only the resulting text or program will be marked but all the original input has to be visible in the notes.
- Use of AI tools is not permitted during the lecture test.

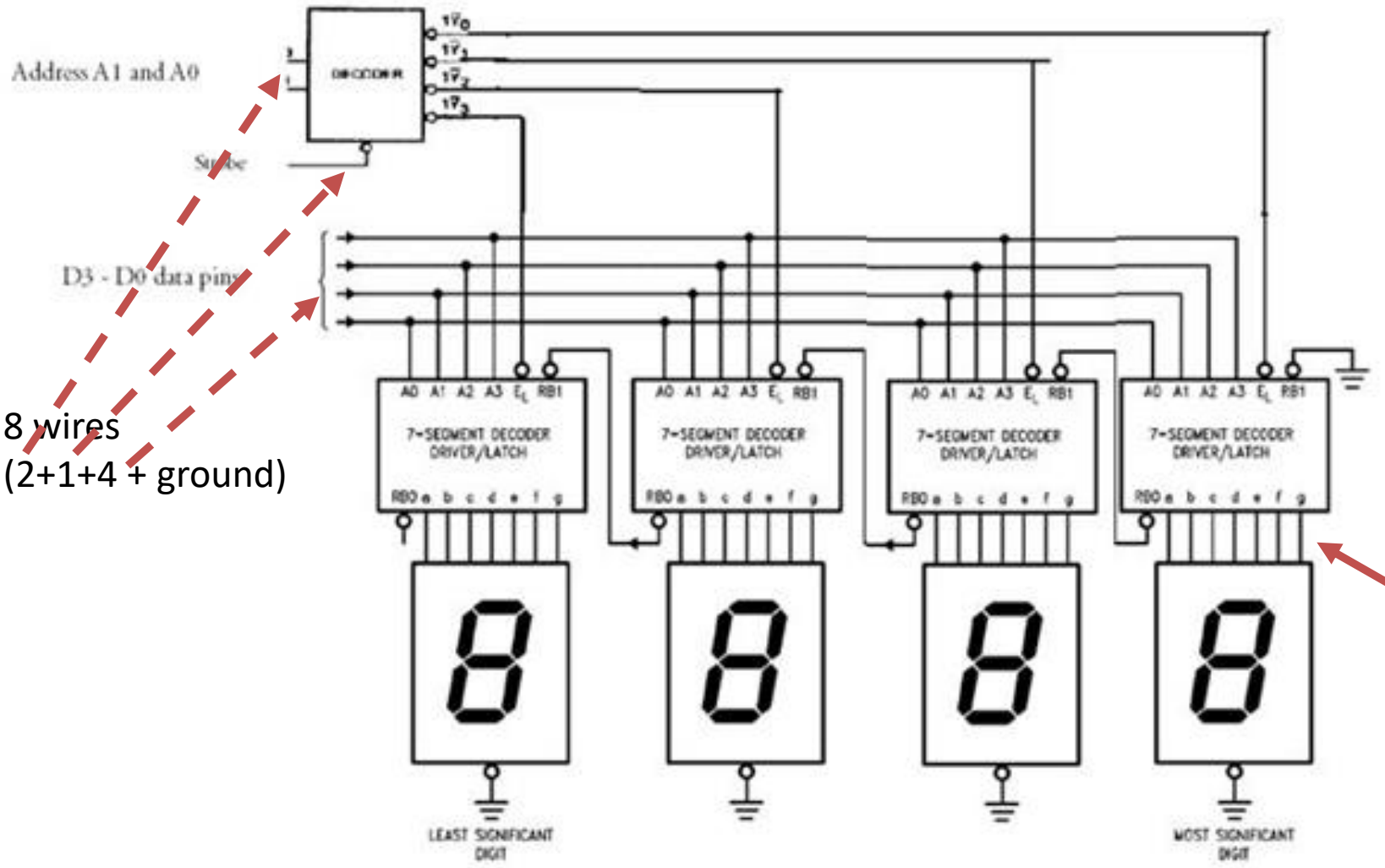
Board with power supply



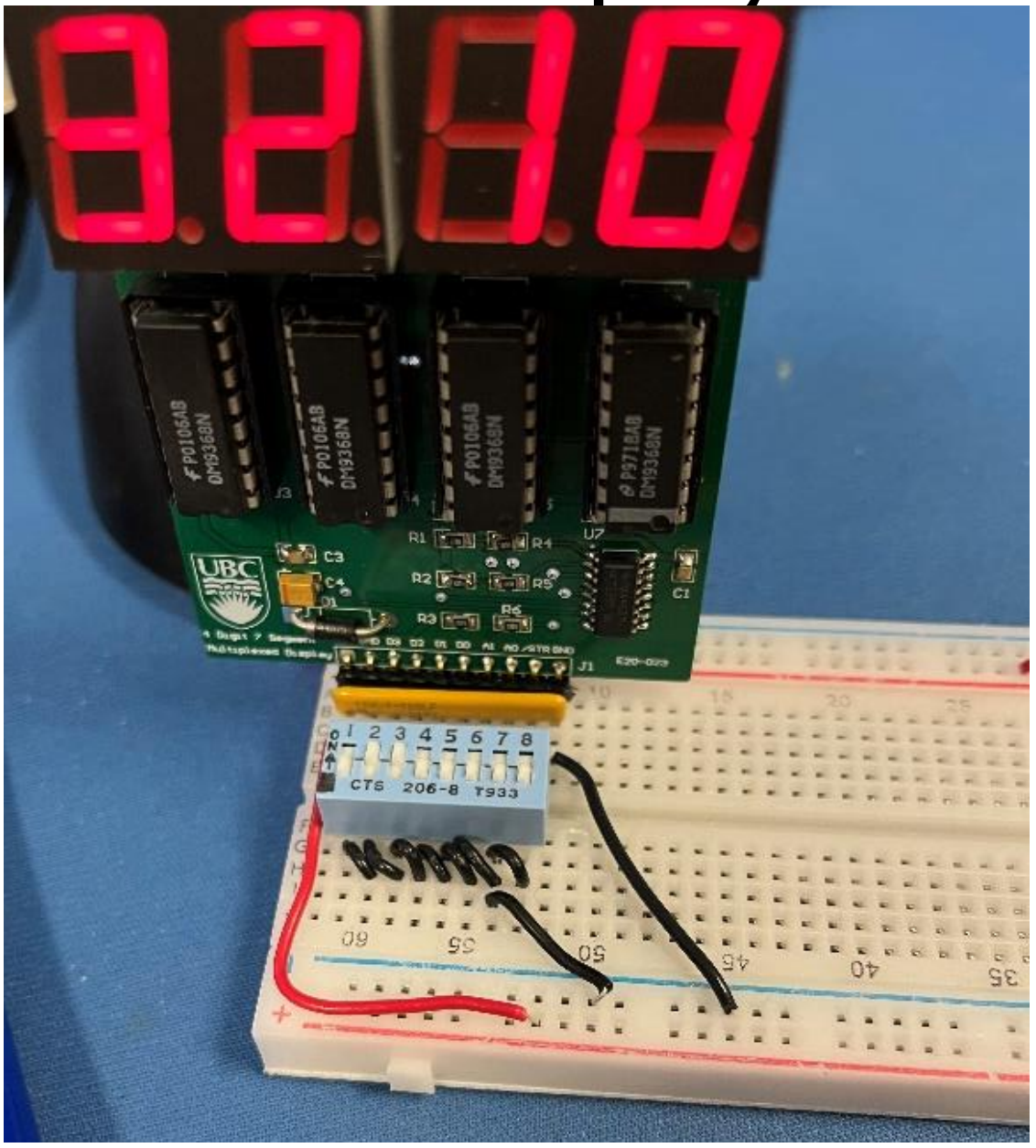
Notice 5V and 3.3V power supply, different than for 219

Adjustable voltage on the power supply (Vadj): Do not use it to power anything! It is only a low current reference voltage and it does not go to 0.

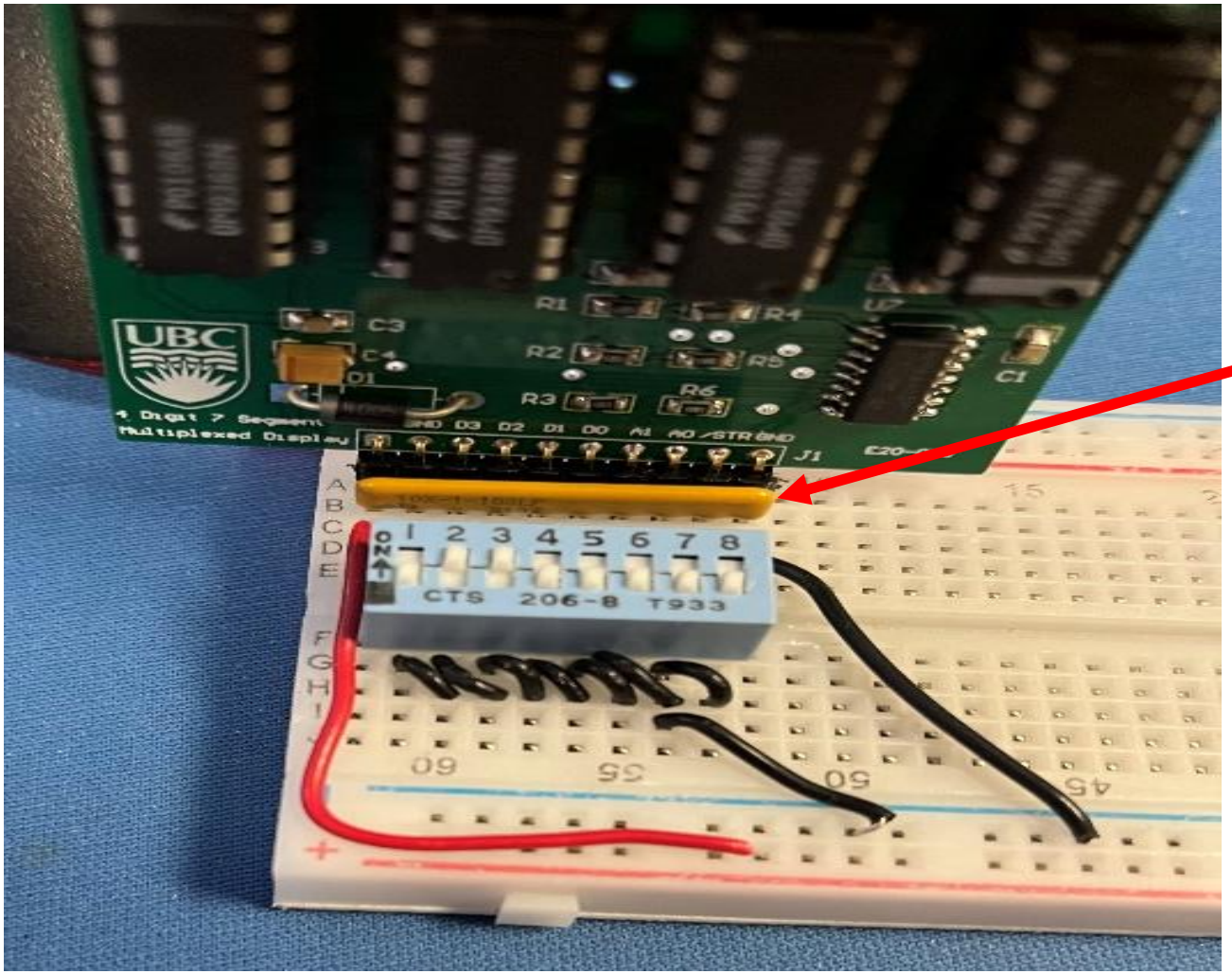
Multiplexed 7-segment Display



The actual display board

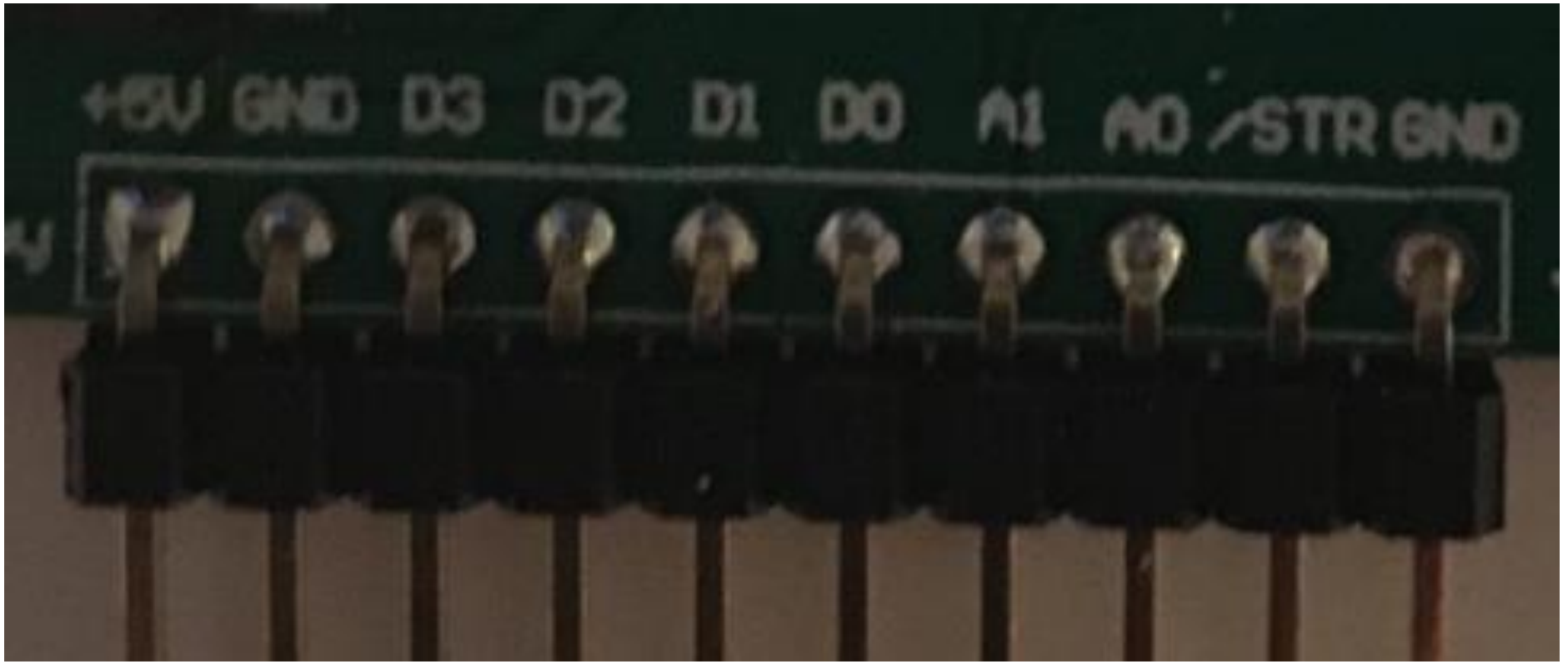


Connections to resistor block and switches

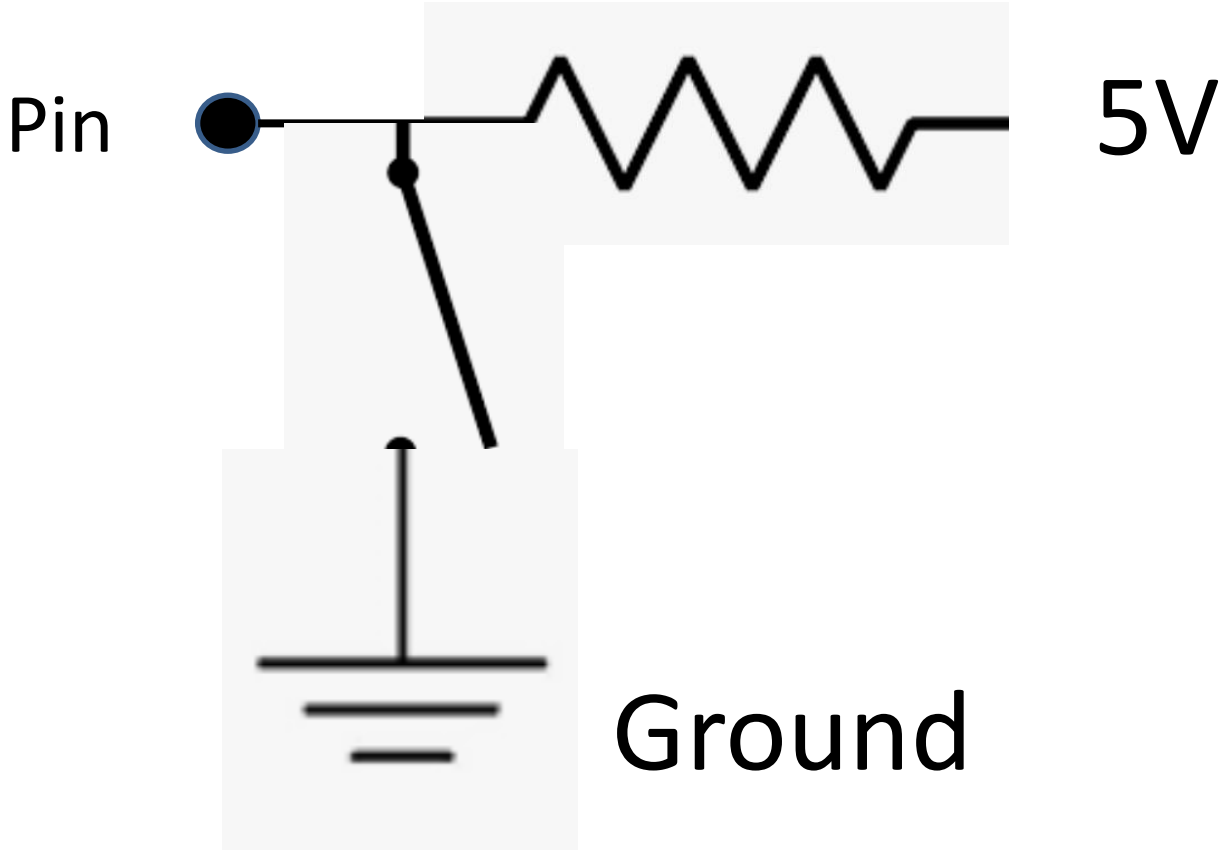


resistor block
With pin 1 on the left connected to red wire

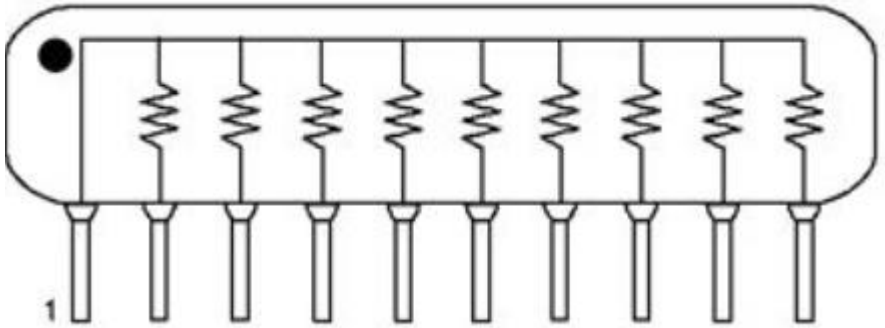
Pins of the display board



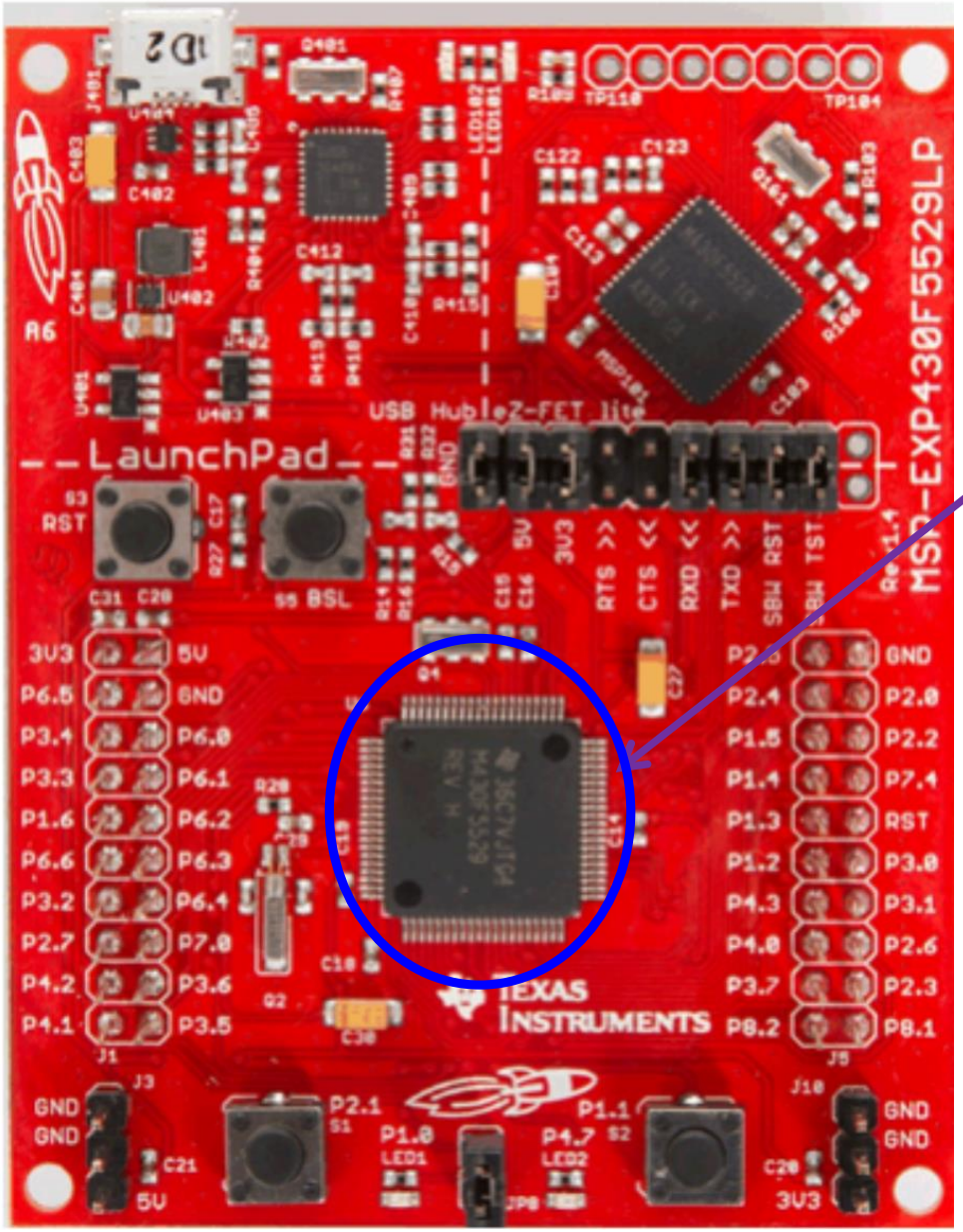
Each of the seven pins (/STR, A0, A1 and D0-D3) has to be connected like this for the first lab segment



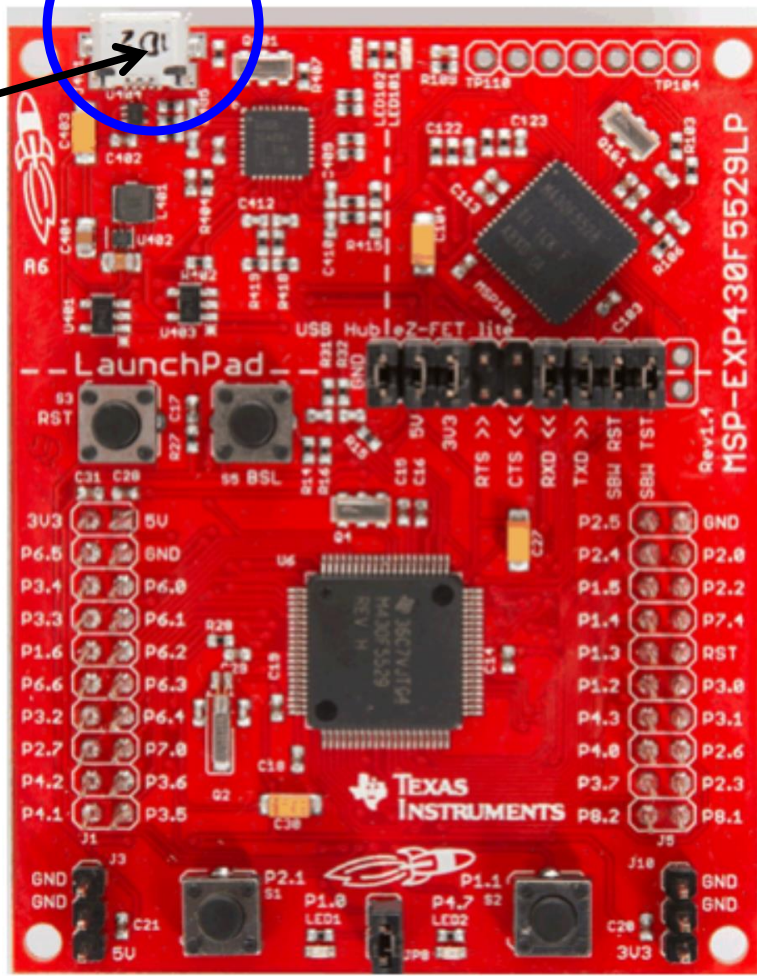
You should use this set of 8 resistors



Texas Instruments MSP430F5529 LaunchPad



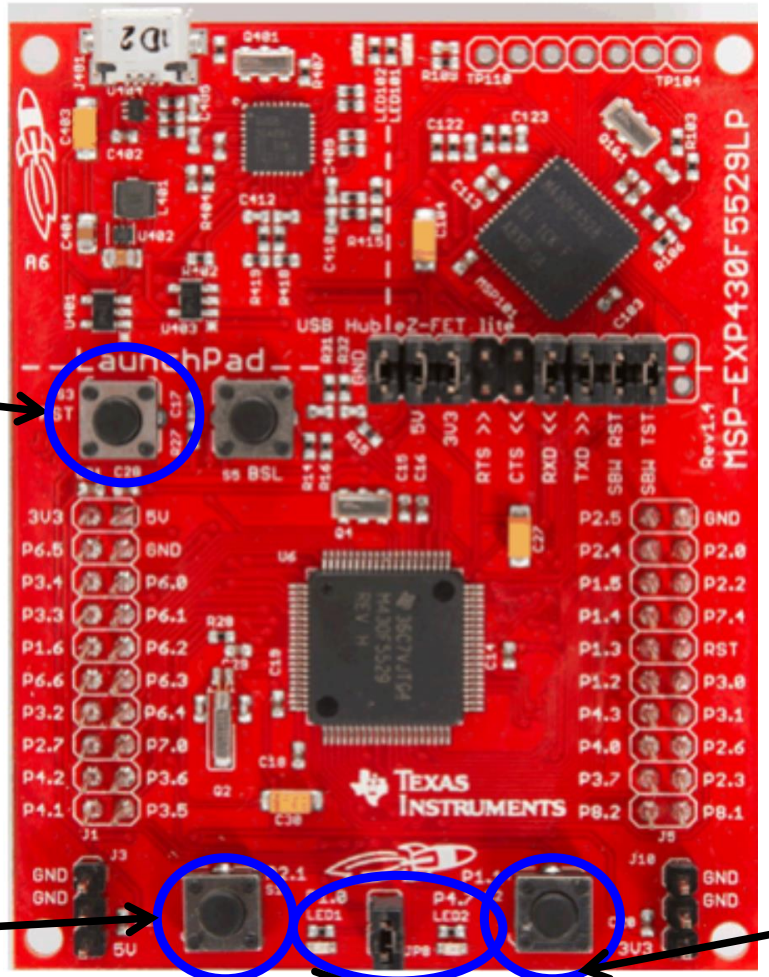
Texas Instruments MSP430 LaunchPad



USB connector:

1) loading programs into the MSP430
2) power
3) communications between program running on the MSP430 and a program on the host.

Texas Instruments MSP430 LaunchPad



Push button to reset
(debug has to be off
for this to work)

Push button for program use

Push button for program use

Two LED's for program use

Board Safety:

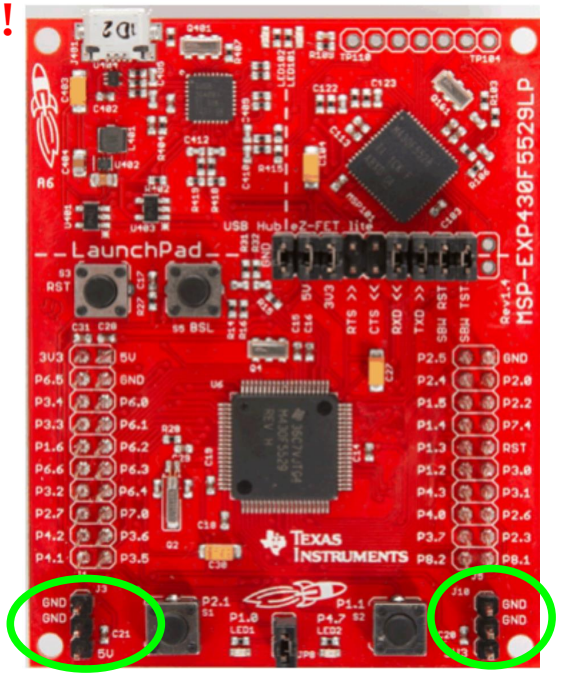
When Launchpad board is connected to USB:

- **don't** connect power sources to 5V or 3.3V pins (chip is USB powered). You can use these as sources to power low power sensors but not ultrasonic range sensor or motors
- **do** connect ground (GND) pin to your circuit (no floating ground)
- **do** always connect Px.x pins to your circuit through resistors

Any voltage higher than 3.6V or any negative voltage has the potential to damage the Launchpad board.

Any voltage higher than 5V or any negative voltage has the potential to damage the USB controller in your computer. Resistors in series with the 5V power supply make the likelihood of damage **much smaller!**

5V and ground



3.3 V and Gnd

How does the Microprocessor work?

- Performs simple operations:
  - add
  - subtract
  - compare
  - fetch/store bytes/words

(For the MSP430, a word is 16 bits = 2 bytes).

Binary numbers

- Decimal numbers
- There are 10 digits 0-9
- Each digit represents consecutive power of 10
- $256 = 2x10^2 + 5x10^1 + 6x10^0$
- Binary numbers
- There are only 2 digits 0 and 1
- Each digit represents consecutive power of 2
- Binary $101 = 1x2^2+0x2^1+1x2^0 = 5$ in decimal

Input – output port

- Connection of 8 pins which can receive or output voltages.
- When we use it as digital port the only possible inputs or outputs are about 0 V or about 3.3 Volts.
- The way each pin works depends on the state of number of 8 bits in various memory locations.
- To set the state of each of these locations we send to it an 8 digit binary number.
- The binary number is indicated with prefix 0b

General Purpose Input/Output (GPIO) Ports

Several registers control the configuration and operation of sets of pins.
In these registers, the different bits in the register control different pins.
For our microprocessor x can be any integer between 1 and 8 as we have 8 GPIOs. Not all the pins are accessible. x below can be an integer between 1 and 8.

PxDIR – sets the pin directions. Bit = 0 = input, Bit = 1 = output.
PxIN – input register. When configured for input, this register contains the digital input values
PxOUT – output register. When configured for output, writing to this register sets the outputs. When configured as input sets the pullup (1) or down (0)
PxREN – pullup/pulldown enable. Bit = 1, enable resistor (P1OUT sets whether pullup or down).
PxSEL – alternate function enable –0 means GPIO.
PxIE – Enable interrupt on some input port pins
PxIES – chooses if interrupt occurs on raising (0) or falling (1) edge

eg setting P1DIR = 0b00000011 configures pins P1.0 and P1.1 as outputs, P1.2-P1.7 as inputs

Before the first lab:

- read the lab manual parts 1, 2and 3
- Install Code Composer on your PC or Mac.
- We will test it during the first lab period.
- You are expected to do parts 1, 2 and 3 described in the manual in the first 2 weeks of the labs and submit your notes for marking at the beginning of third week's lab