Using Integrated Circuits*

Developing and Designing Interactive Devices

March 20, 2018

* originally by Megan Wachs

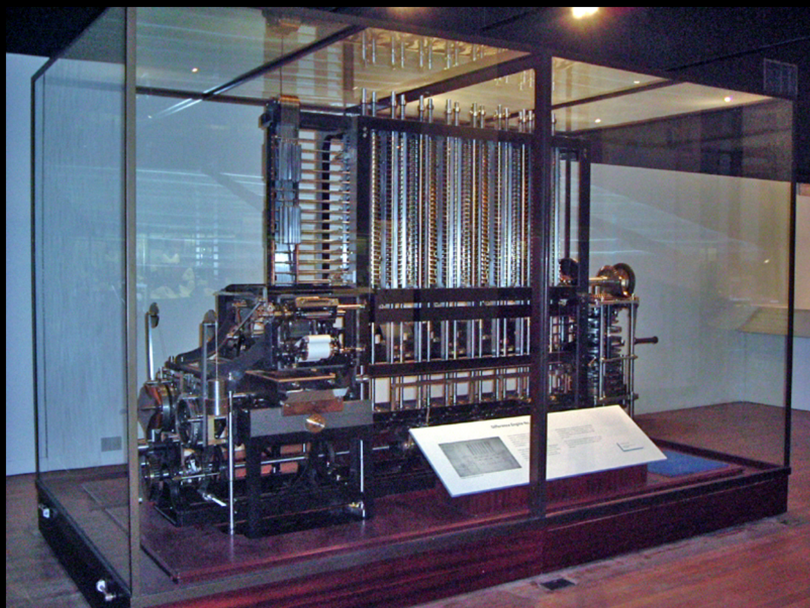
Lab debrief

Highlights? Questions?

Before Integrated Circuits

Mechanical Computing

1849

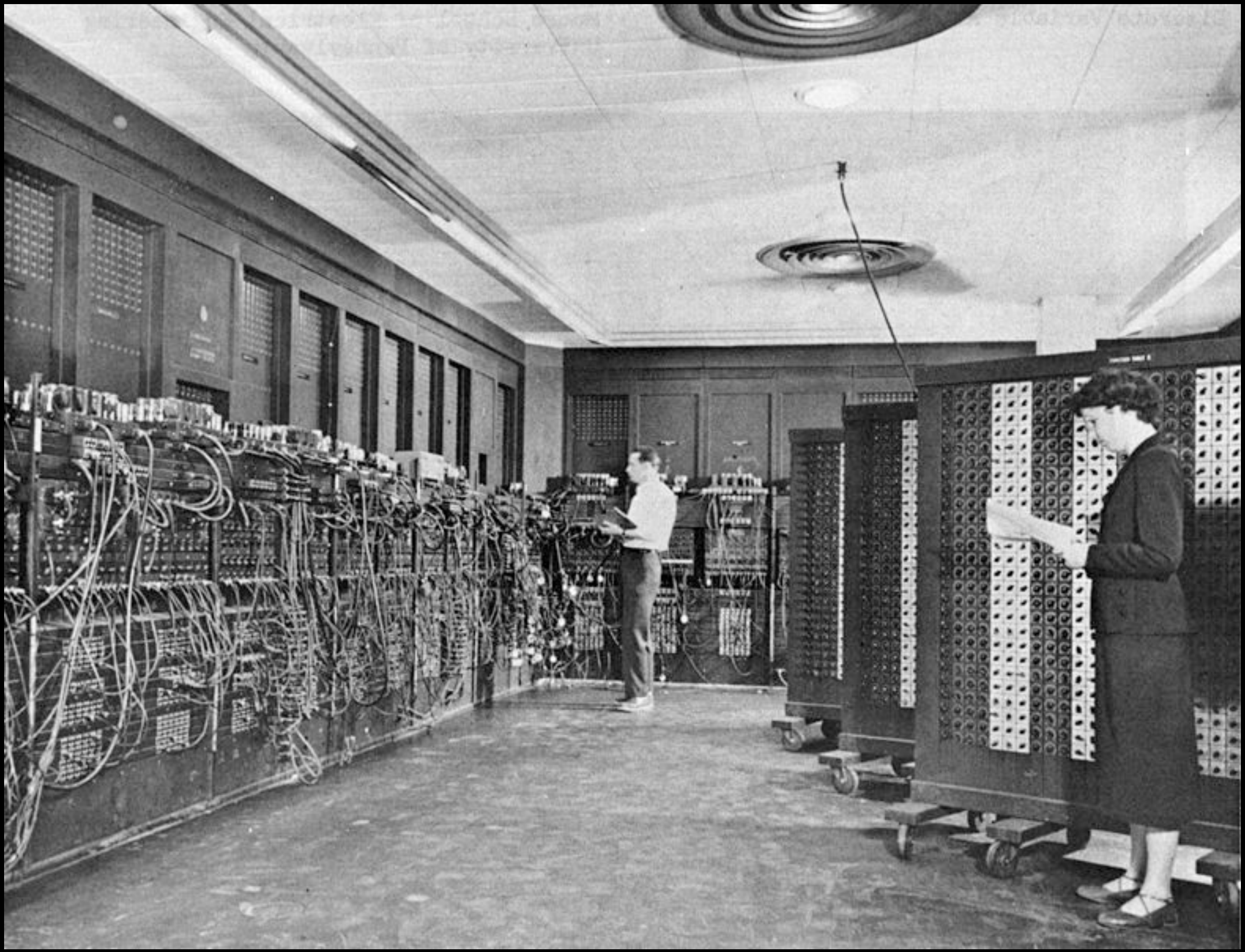


Wikimedia, by Joe D in January 2005.

Wikimedia, Carsten Ullrich, 2005

Before Integrated Circuits

Vacuum Tubes

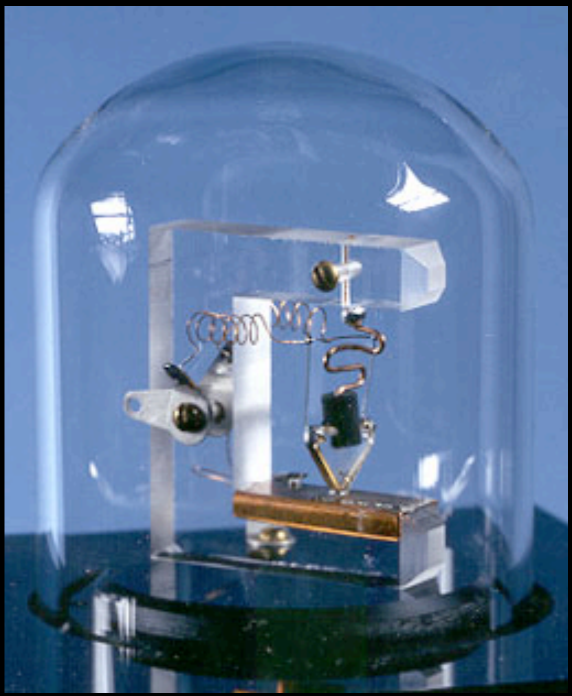


1945

Wikimedia, US Army Photo

Before Integrated Circuits

Transistors

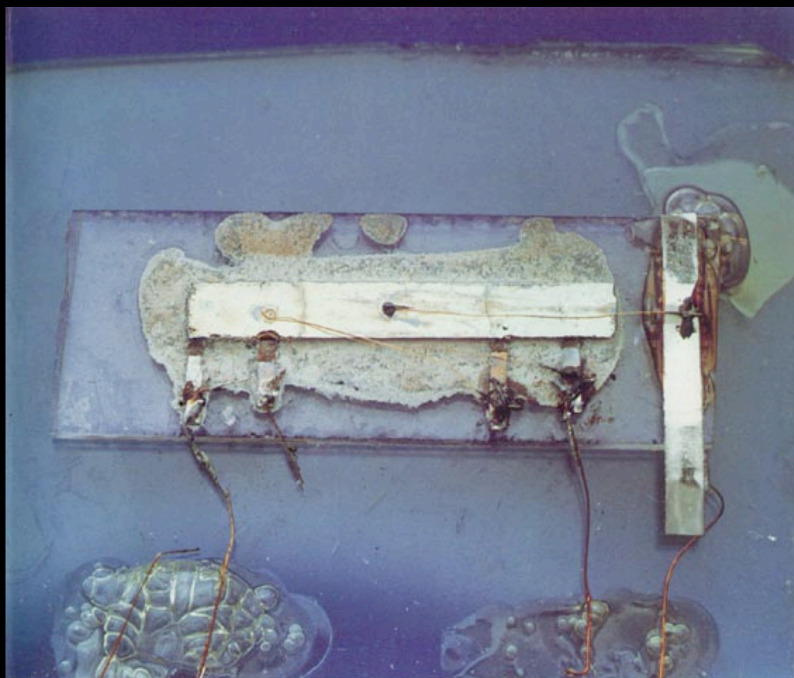


1947

1955

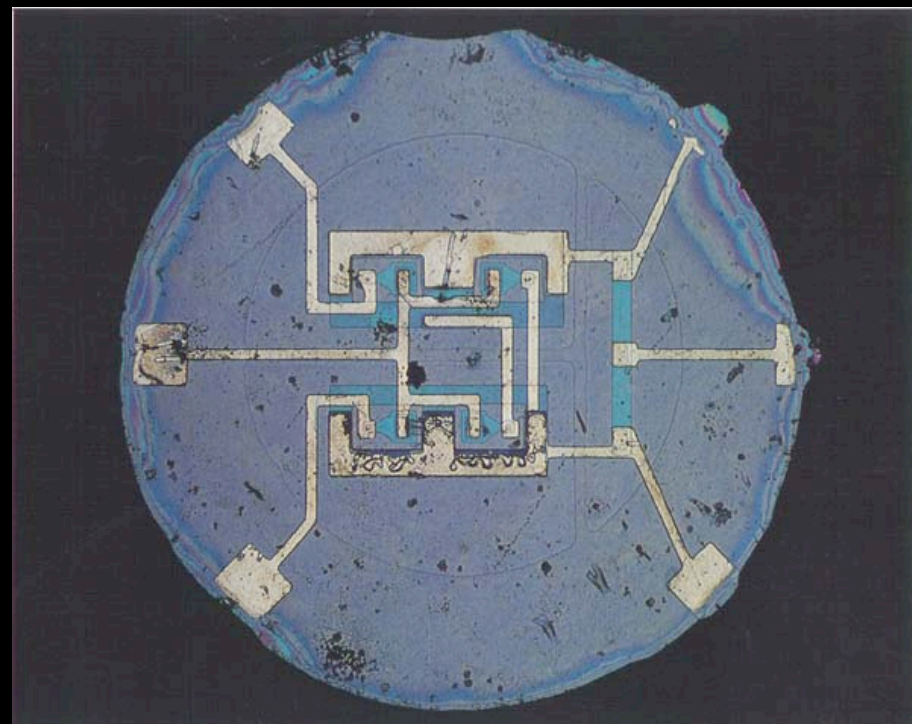
Integrated Circuits

Multiple Components on a Single Substrate



STATE OF THE ART ©Copyright Stan Augarten

1958



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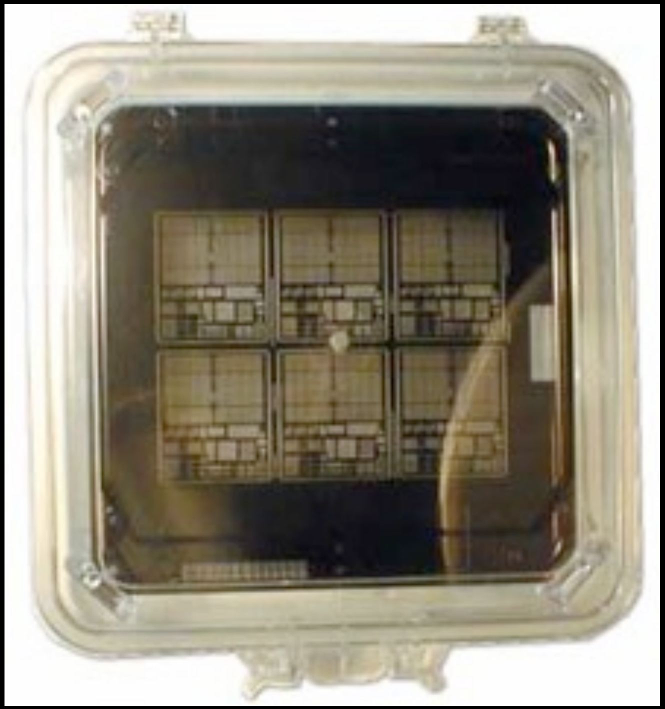
1961

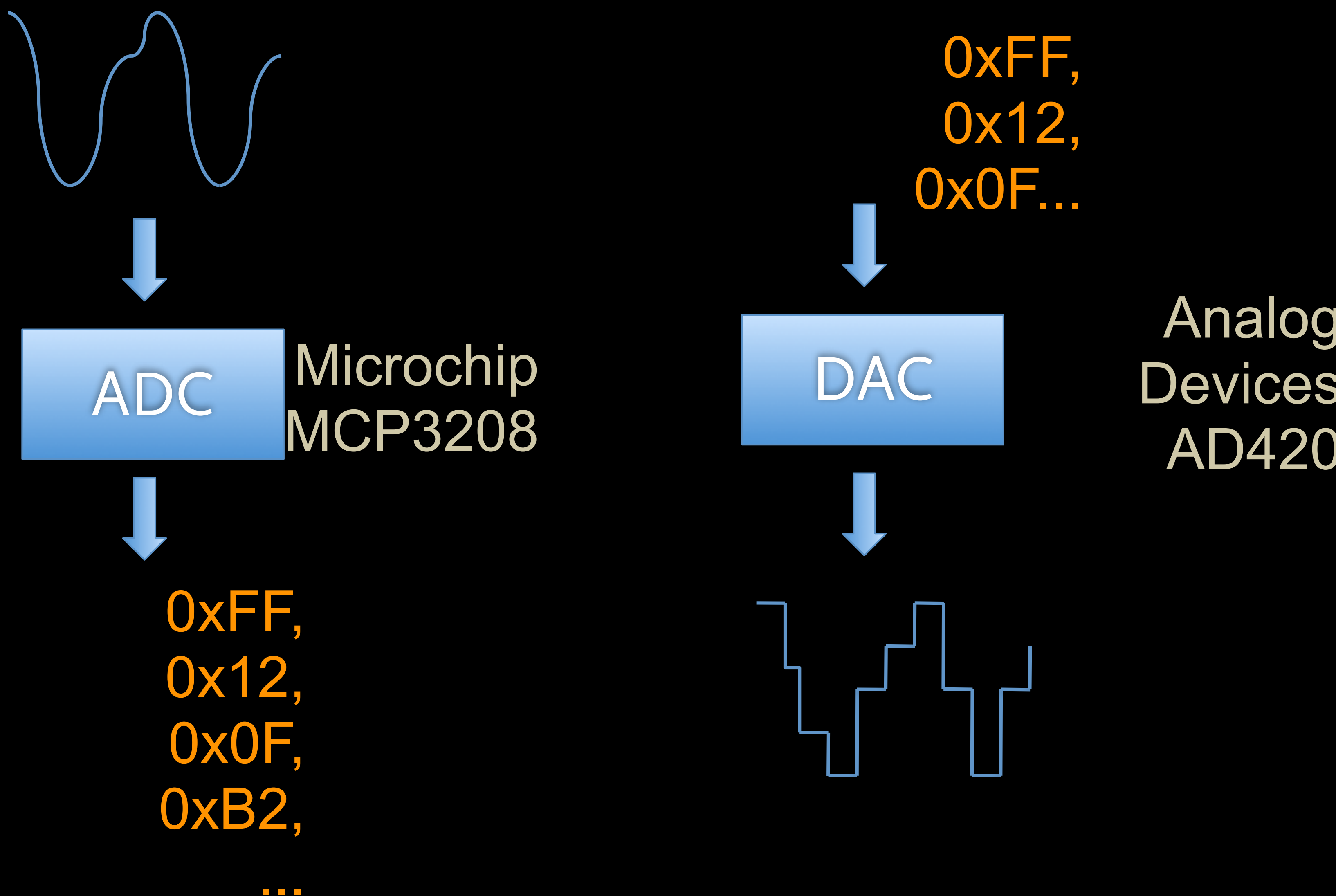
Integrated Circuits Manufacturing

Similar to Silkscreening



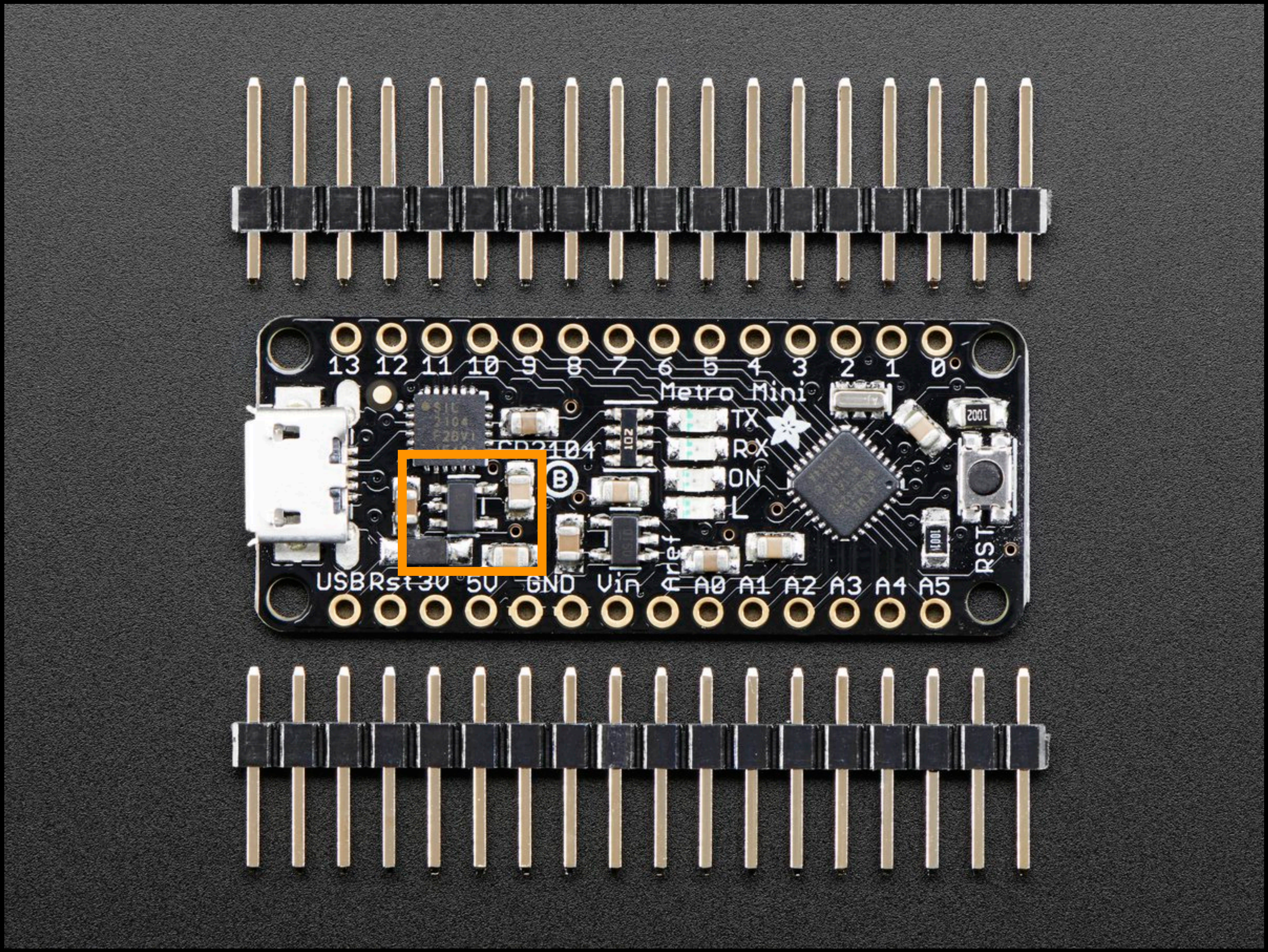
ADCs and DACs

Converting from Analog to Digital, and Back again

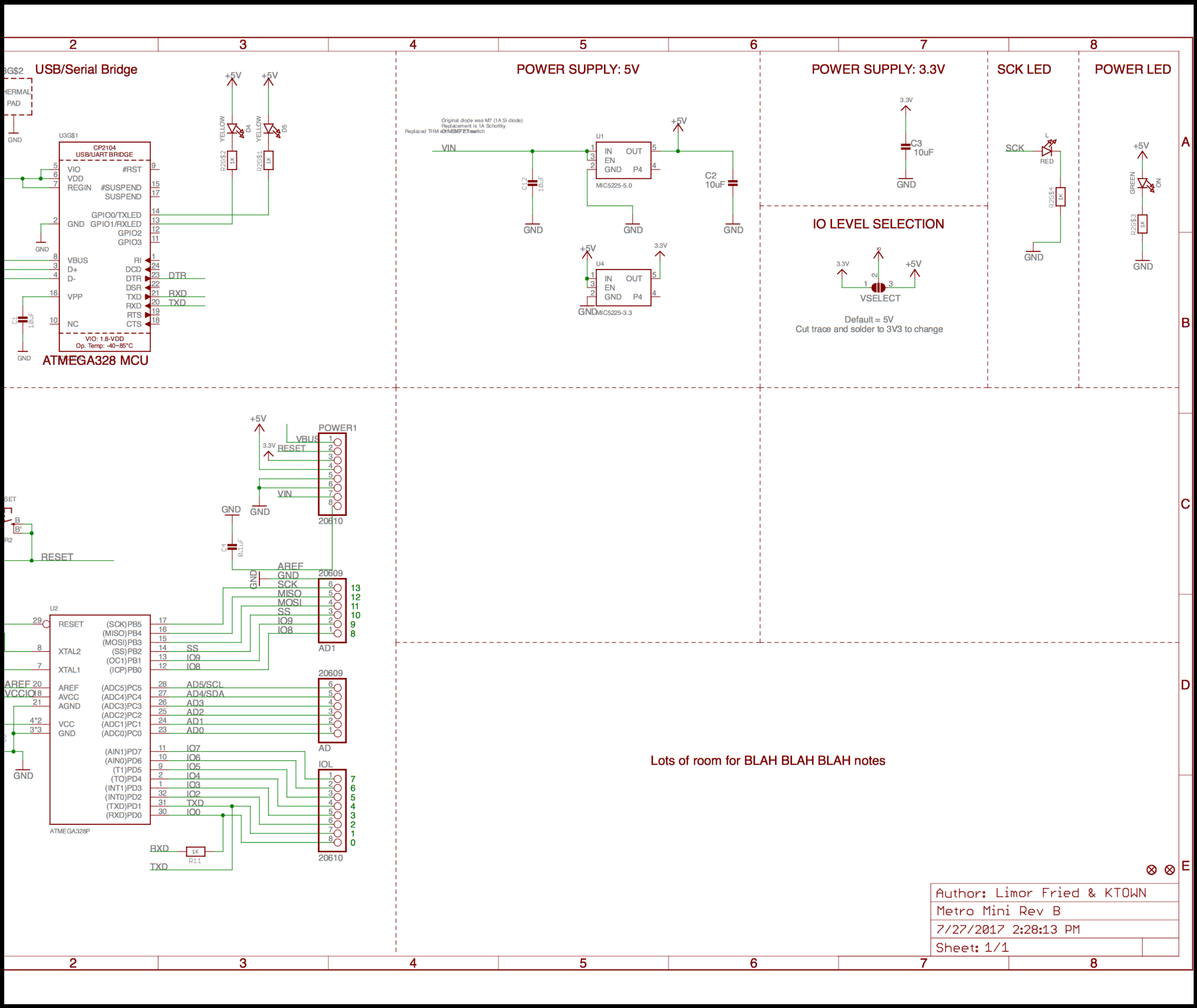


Analog ICs

You have already used a few!

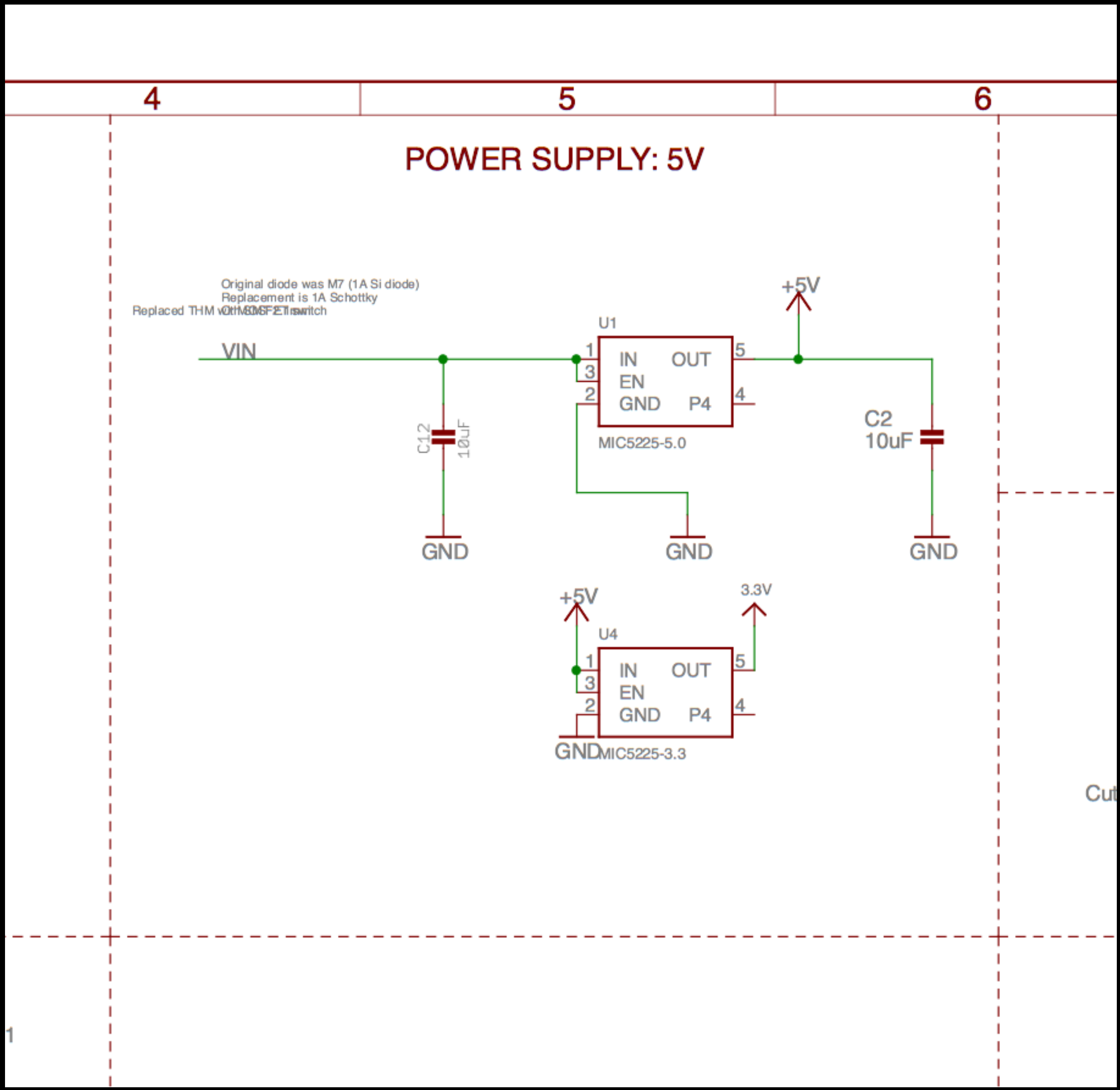


Analog ICs



USB/Serial Bridge
POWER SUPPLY: 5V
POWER SUPPLY: 3.3V
SCK LED
POWER LED
IO LEVEL SELECTION
VSELECT
Default = 5V
Cut trace and solder to 3V3 to change
ATMEGA328 MCU
Lots of room for BLAH BLAH BLAH notes
Author: Limor Fried & KTOWN
Metro Mini Rev B
7/27/2017 2:28:13 PM
Sheet: 1/1

Analog ICs



4
5
6
POWER SUPPLY: 5V
Original diode was M7 (1A Si diode)
Replacement is 1A Schottky
VIN
C12
10uF
GND
U1
IN
EN
GND
OUT
P4
MIC5225-5.0
+5V
C2
10uF
U4
3.3V
MIC5225-3.3
Cut

MIC5225

Ultra-Low Quiescent Current 150mA μCap Low Dropout Regulator

General Description

The MIC5225 is a 150mA highly accurate, low dropout regulator with high input voltage and ultra-low ground current. This combination of high voltage and low ground current makes the MIC5225 ideal for a wide variety of applications including USB and portable electronics applications, using 1-cell, 2-cell or 3-cell Li-Ion battery inputs.

A μCap LDO design, the MIC5225 is stable with either a ceramic or tantalum output capacitor. It only requires a 2.2μF capacitor for stability.

Features of the MIC5225 includes enable input, thermal shutdown, current limit, reverse battery protection, and reverse leakage protection.

Available in fixed and adjustable output voltage versions, the MIC5225 is offered in the IttyBitty® SOT23-5 package with a junction temperature range of –40°C to +125°C.

Data sheets and support documentation can be found on Micrel's web site at www.micrel.com.

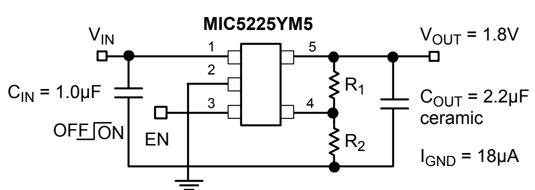
Features

- Wide input voltage range: 2.3V to 16V
- High output accuracy of ±2.0% over temperature
- Guaranteed 150mA output
- Very low ground current: 29μA
- Low dropout voltage of 310mV at 150mA
- μCap: Stable with ceramic or tantalum capacitors
- Excellent line and load regulation specifications
- Reverse battery protection
- Reverse leakage protection
- Zero shutdown current
- Thermal shutdown and current limit protection
- IttyBitty® SOT23-5 Package

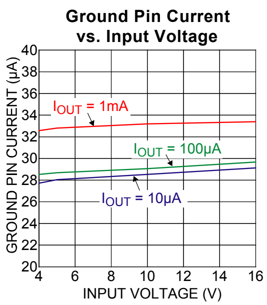
Applications

- Cellular phones
- Keep alive supply in notebook and portable computers
- Battery-powered equipment
- Consumer/personal electronics
- High-efficiency linear power supplies
- Automotive electronics

Typical Application



Ultra-Low Current Adjustable Regulator Application



IttyBitty is a registered trademark of Micrel, Inc.

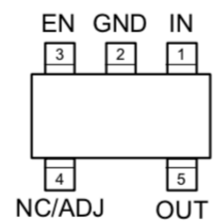
Ordering Information

Part Number	Marking*	Voltage**	Junction Temp. Range	Package	Lead Finish
MIC5225-1.5YM5	QT15	1.5V	–40° to +125°C	5-Pin SOT23	Pb-Free
MIC5225-1.8YM5	QT18	1.8V	–40° to +125°C	5-Pin SOT23	Pb-Free
MIC5225-2.5YM5	QT25	2.5V	–40° to +125°C	5-Pin SOT23	Pb-Free
MIC5225-2.7YM5	QT27	2.7V	–40° to +125°C	5-Pin SOT23	Pb-Free
MIC5225-3.0YM5	QT30	3.0V	–40° to +125°C	5-Pin SOT23	Pb-Free
MIC5225-3.3YM5	QT33	3.3V	–40° to +125°C	5-Pin SOT23	Pb-Free
MIC5225-5.0YM5	QT50	5.0V	–40° to +125°C	5-Pin SOT23	Pb-Free
MIC5225YM5	QTAA	Adj.	–40° to +125°C	5-Pin SOT23	Pb-Free

* Under bar symbol (_) may not be to scale.

** For other voltage options available. Contact Micrel Marketing for details.

Pin Configuration



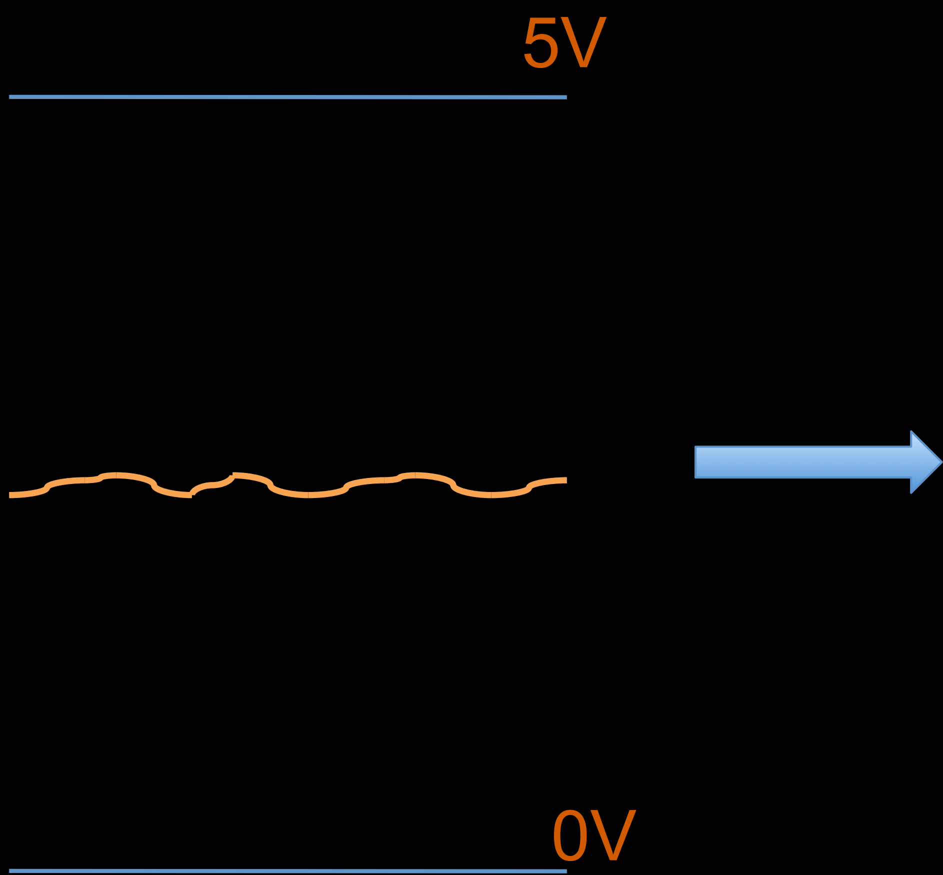
5-Pin SOT23 (M5)

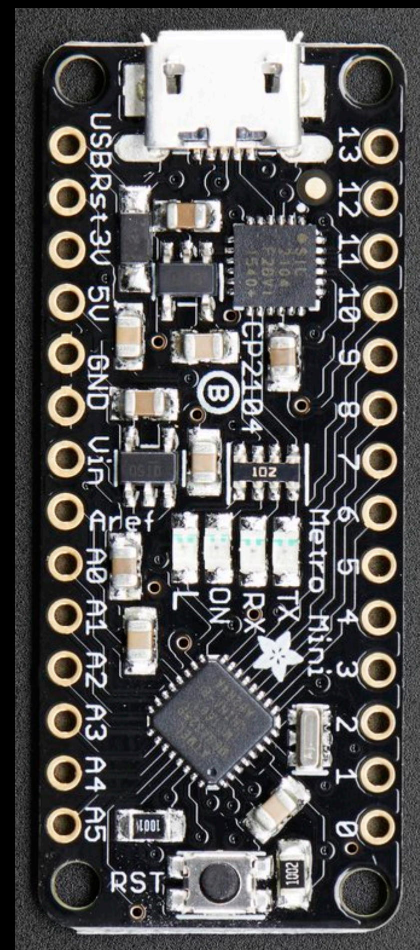
Pin Description

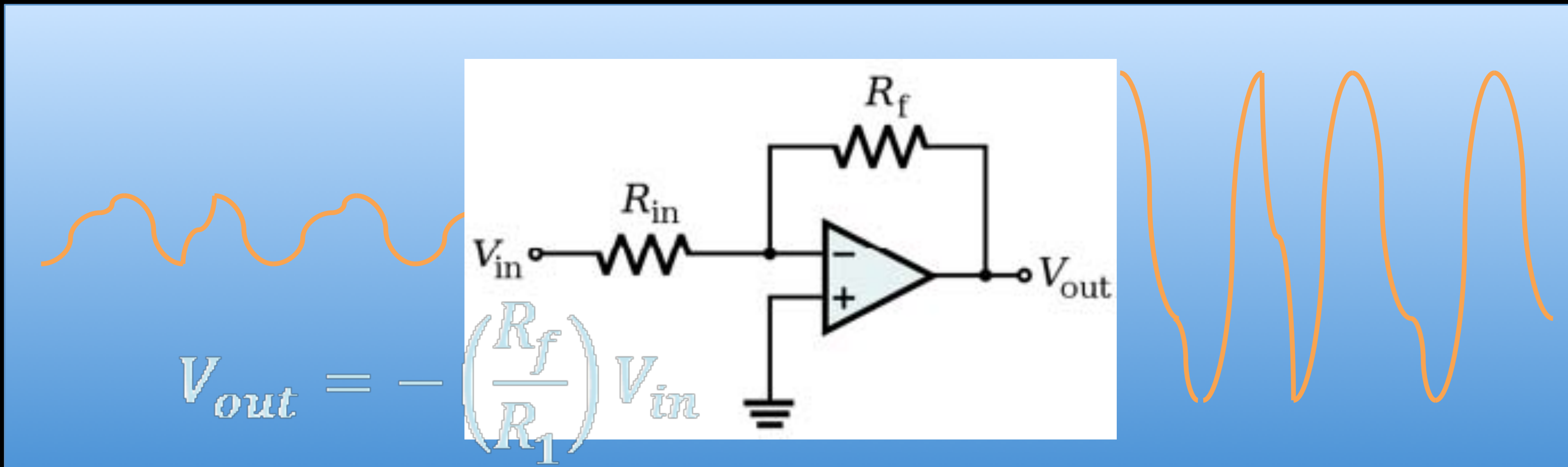
Pin Number	Pin Name	Pin Function
1	IN	Supply Input.
2	GND	Ground.
3	EN	Enable (Input): Logic Low or Open = Shutdown; Logic High = Enable.
4	NC (Fixed)	No Connect.
	ADJ (Adjust)	Adjust (Input): Feedback input. Connect to resistive voltage-divider network.
5	OUT	Regulator Output.

Analog ICs

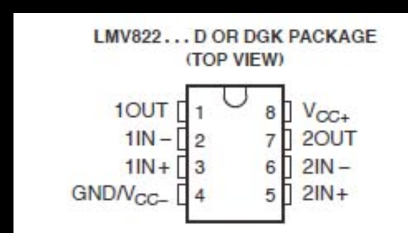
Operational Amplifier







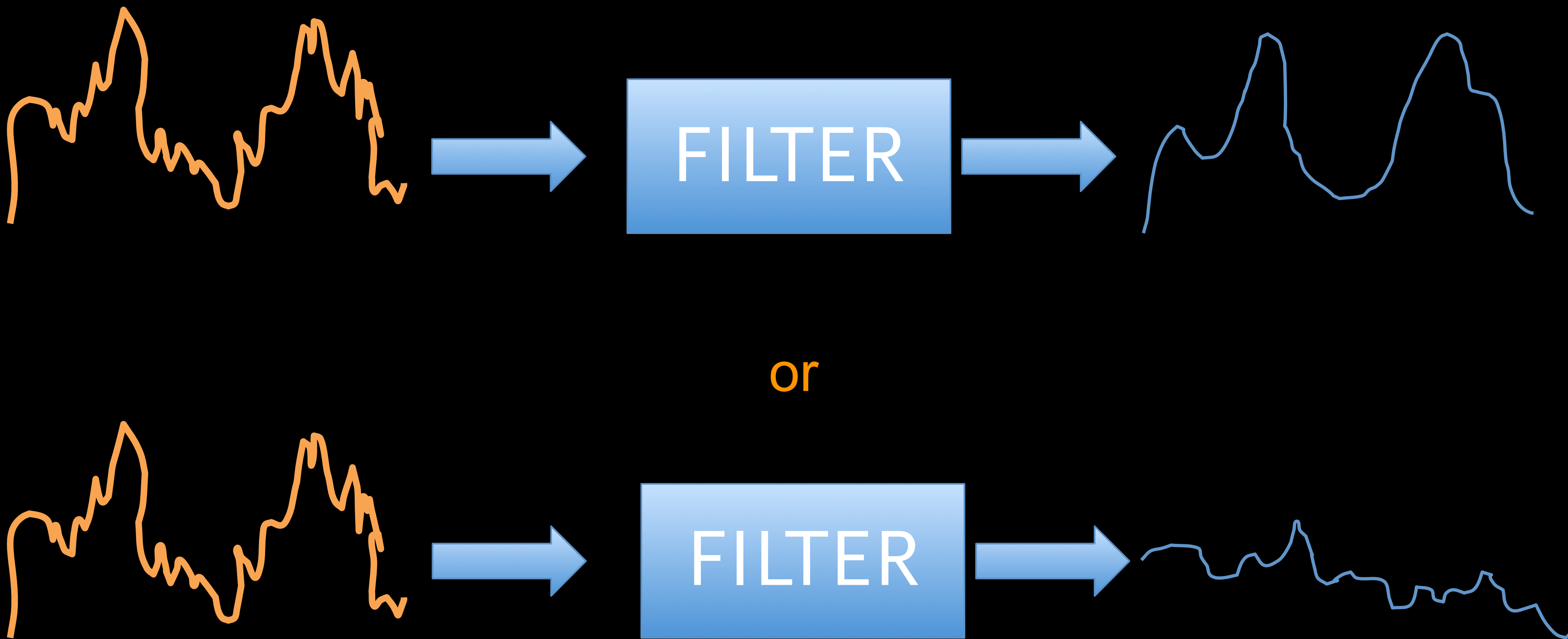
$$V_{out} = -\left(\frac{R_f}{R_1}\right)V_{in}$$



Texas Instruments
LMV822

Analog ICs

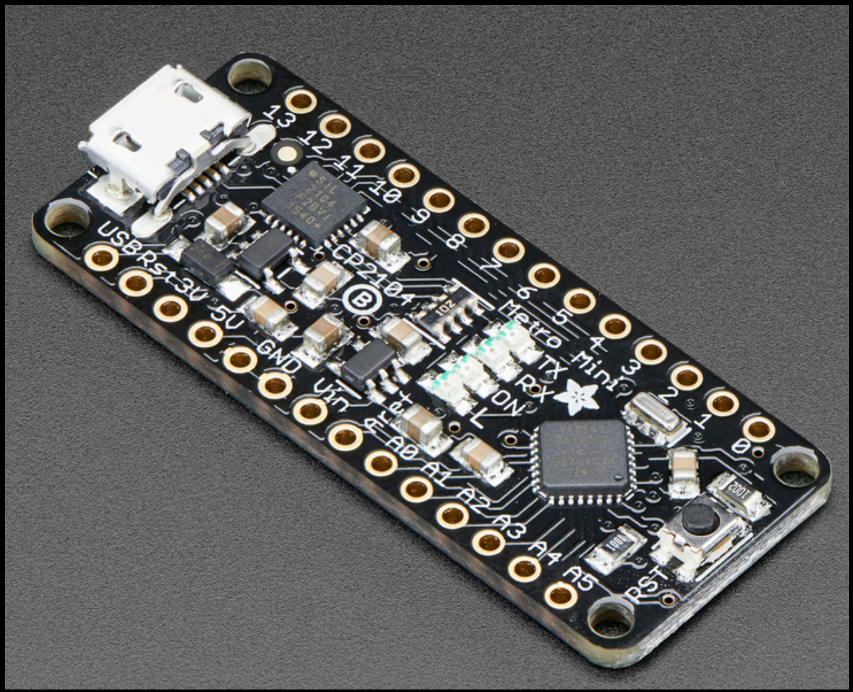
Filter Chips

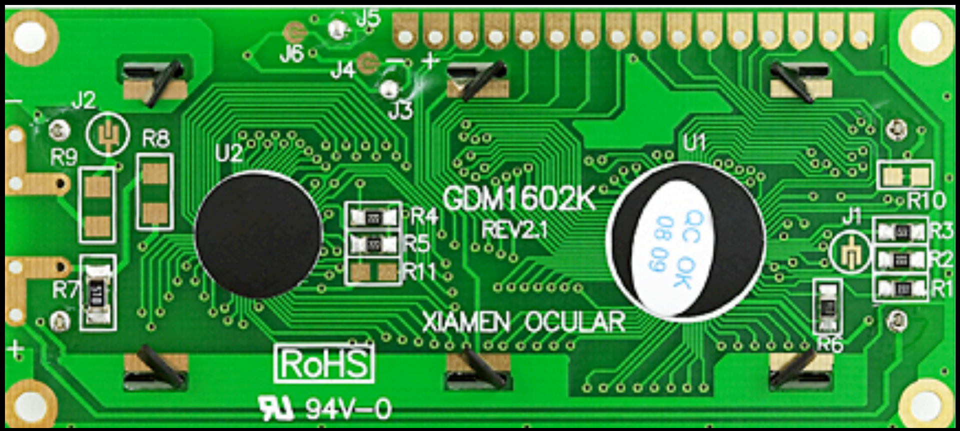


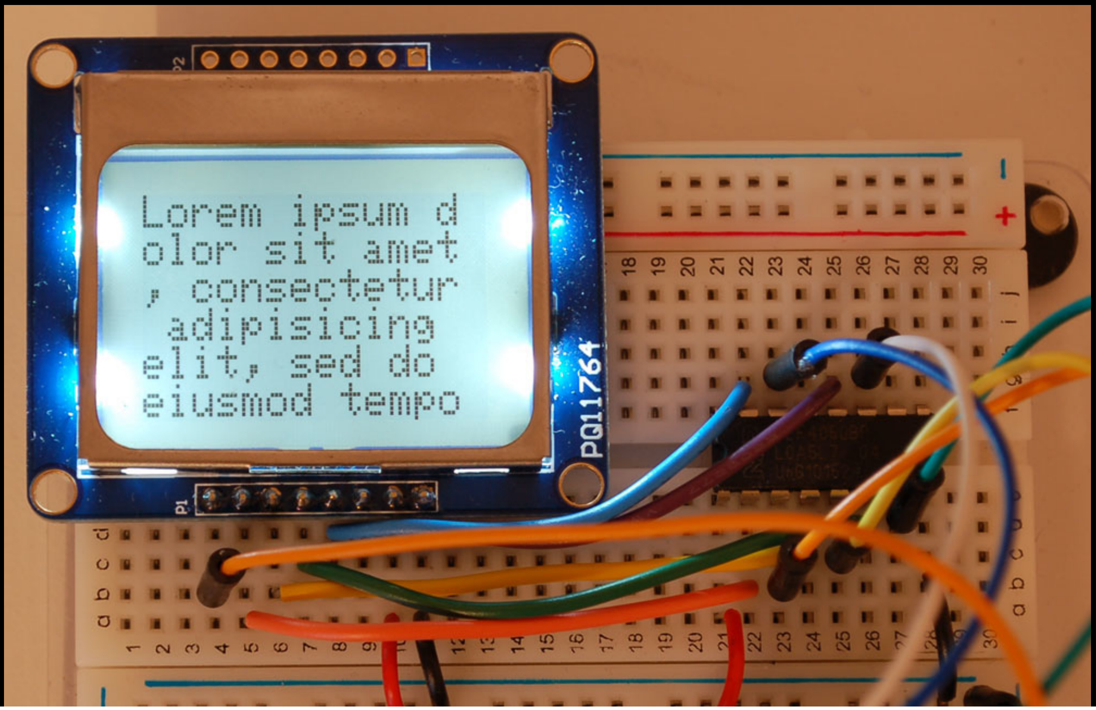
Can design your own with R’s and C’s

Digital ICs

You've already used a ton!



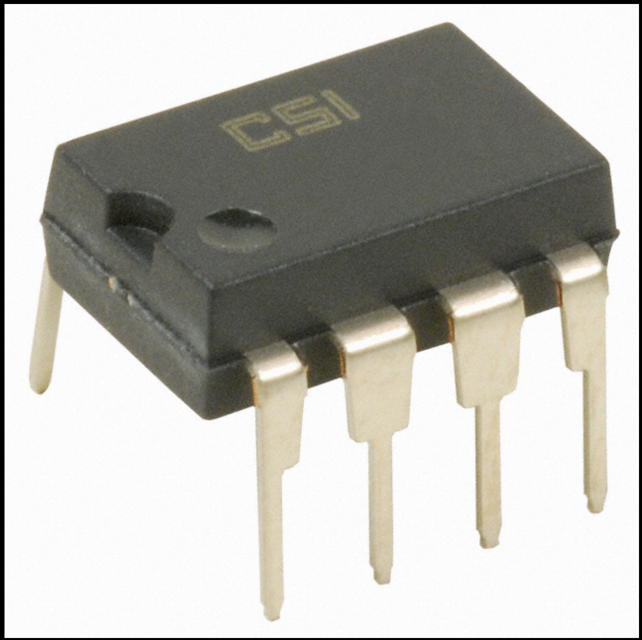




Digital ICs

Memory

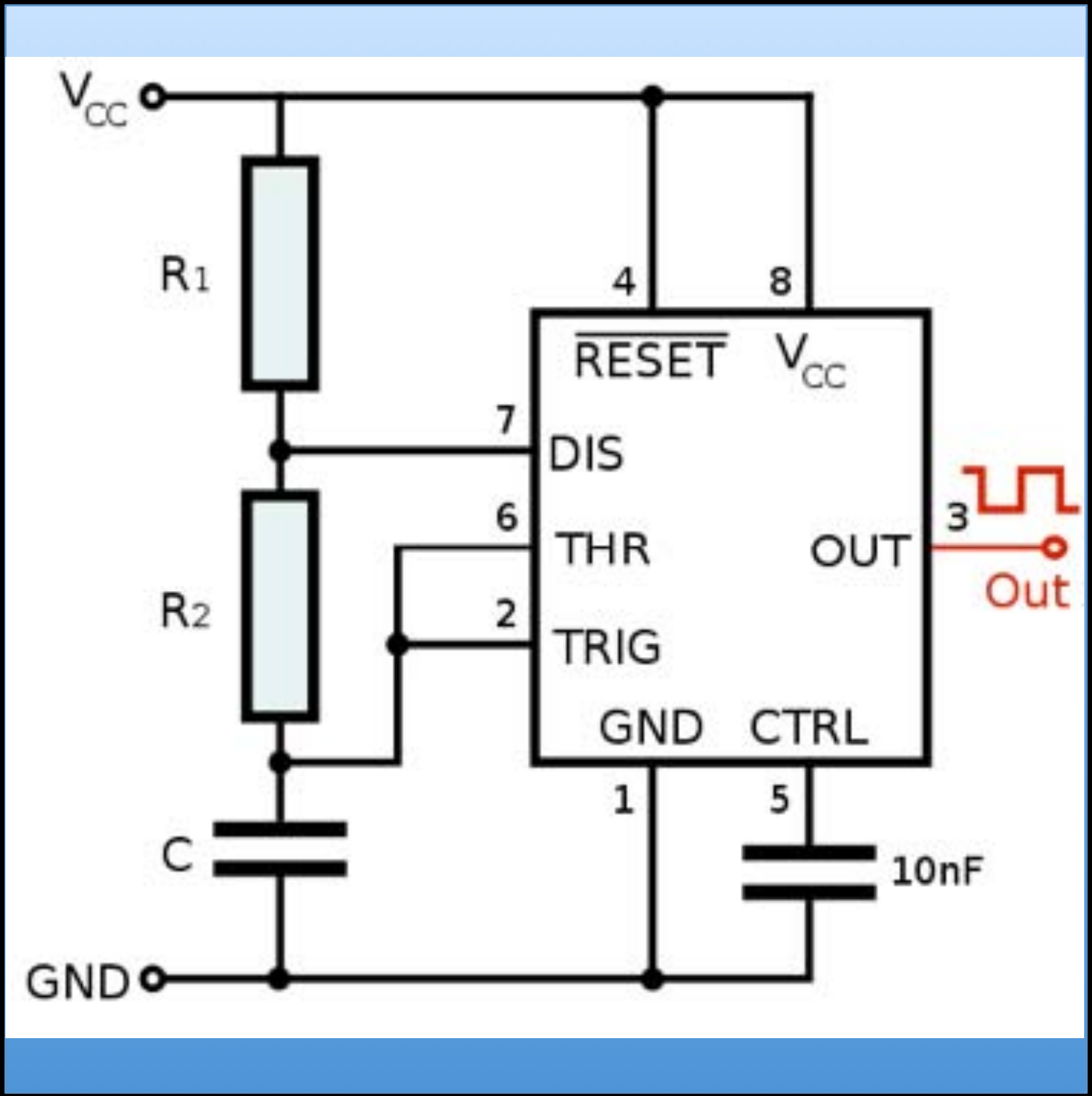
FLASH



EEPROM

Digital ICs

555 Timer



$$f = \frac{1}{\ln(2) \cdot C \cdot (R_1 + 2R_2)}$$

Digital ICs

555 Timer

ASTABLE OPERATION

When the circuit is connected as shown in figure 4 (pin 2 and 6 connected) it triggers itself and free runs as a multivibrator. The external capacitor charges through R_A and R_B and discharges through R_B only. Thus the duty cycle may be precisely set by the ratio of these two resistors.

In the astable mode of operation, C charges and discharges between 1/3 V_{CC} and 2/3 V_{CC}. As in the triggered mode, the charge and discharge times and therefore frequency, are independent of the supply voltage.

Figure 5 shows actual waveforms generated in this mode of operation.

The charge time (output HIGH) is given by :

$t1 = 0.693\ (R_A + R_B)\ C$

and the discharge time (output LOW) by :

$t2 = 0.693\ (R_B)\ C$

Thus the total period T is given by :

$T = t1 + t2 = 0.693\ (R_A + 2R_B)\ C$

The frequency of oscillation is then :

$$f = \frac{1}{T} = \frac{1.44}{(R_A + 2R_B)C}$$

The duty cycle is given by : $D = \dfrac{R_B}{R_A + 2R_B}$

Figure 4

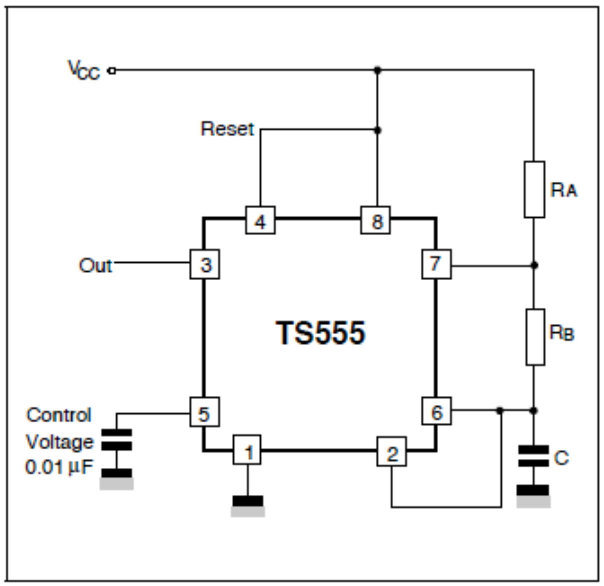
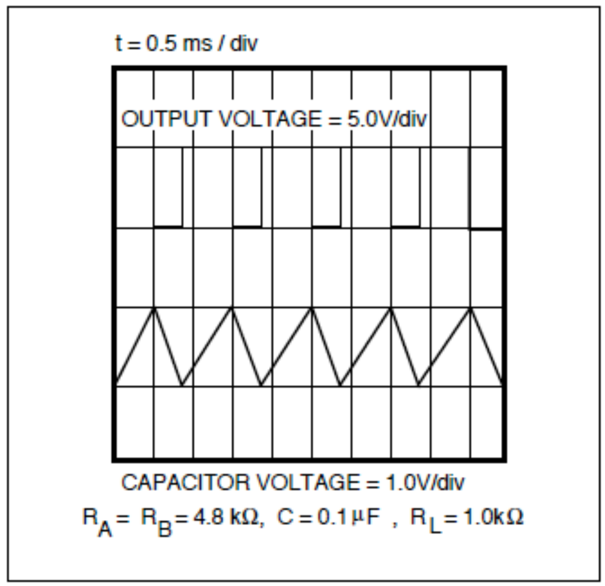
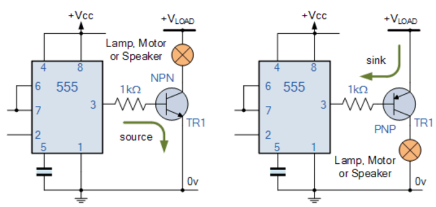


Figure 5





555 Timer Tutorial

The 555 Timer is a commonly used IC designed to produce a variety of output waveforms with the addition of an external RC network

We have seen that Multivibrators and CMOS Oscillators can be easily constructed from discrete components to produce relaxation oscillators for generating basic square wave output waveforms. But there are also dedicated IC's especially designed to accurately produce the required output waveform with the addition of just a few extra timing components.

One such device that has been around since the early days of IC's and has itself become something of an industry "standard" is the **555 Timer Oscillator** which is more commonly called the **"555 Timer"**.

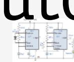
The **555 timer** which gets its name from the three 5kΩ resistors it uses to generate the two comparators reference voltage, is a very cheap, popular and useful precision timing device that can act as either a simple timer to generate single pulses or long time delays, or as a relaxation oscillator producing stabilized waveforms of varying duty cycles from 50 to 100%.

The 555 timer chip is extremely robust and stable 8-pin device that can be operated either as a very accurate Monostable, Bistable or Astable Multivibrator to produce a variety of applications such as one-shot or delay timers, pulse generation, LED and lamp flashers, alarms and tone generation, logic clocks, frequency division, power supplies and converters etc, in fact any circuit that requires some form of time control as the list is endless.

The single 555 Timer chip in its basic form is a Bipolar 8-pin mini Dual-in-line Package (DIP) device consisting of some 25 transistors, 2 diodes and about 16 resistors arranged to form two comparators, a flip-flop and a high current output stage as shown below. As well as the 555 Timer there is also available the NE556 Timer Oscillator which combines TWO individual 555's within a single 14-pin DIP package and low power CMOS versions of the single 555 timer such as the 7555 and LMC555 which use MOSFET transistors

Read more Tutorials in Waveform Generators

Related Tutorials



555 Oscillator Tutorial

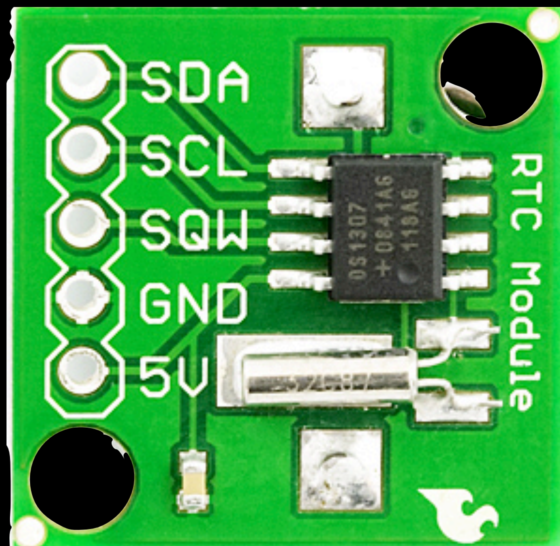
Jan 15th, 2016

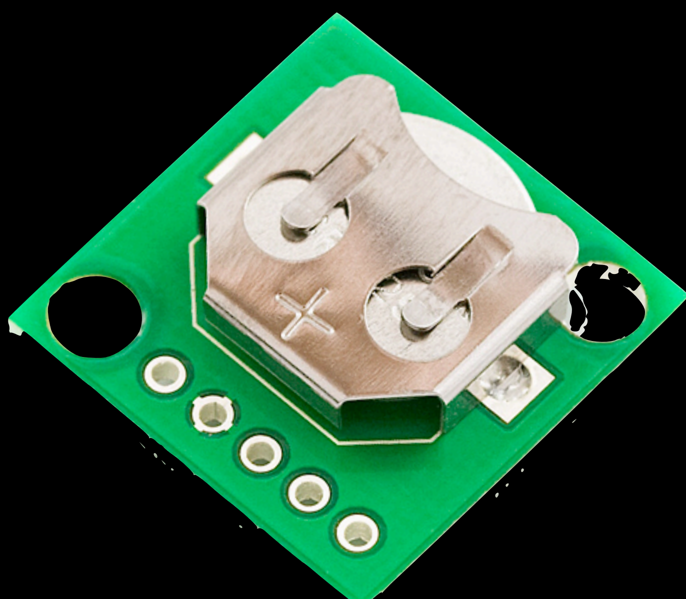
The 555 IC can be used to create a free running astable oscillator to continuously produce square [...]

https://www.electronics-tutorials.ws/waveforms/555_timer.html

Digital ICs

Real-Time Clocks





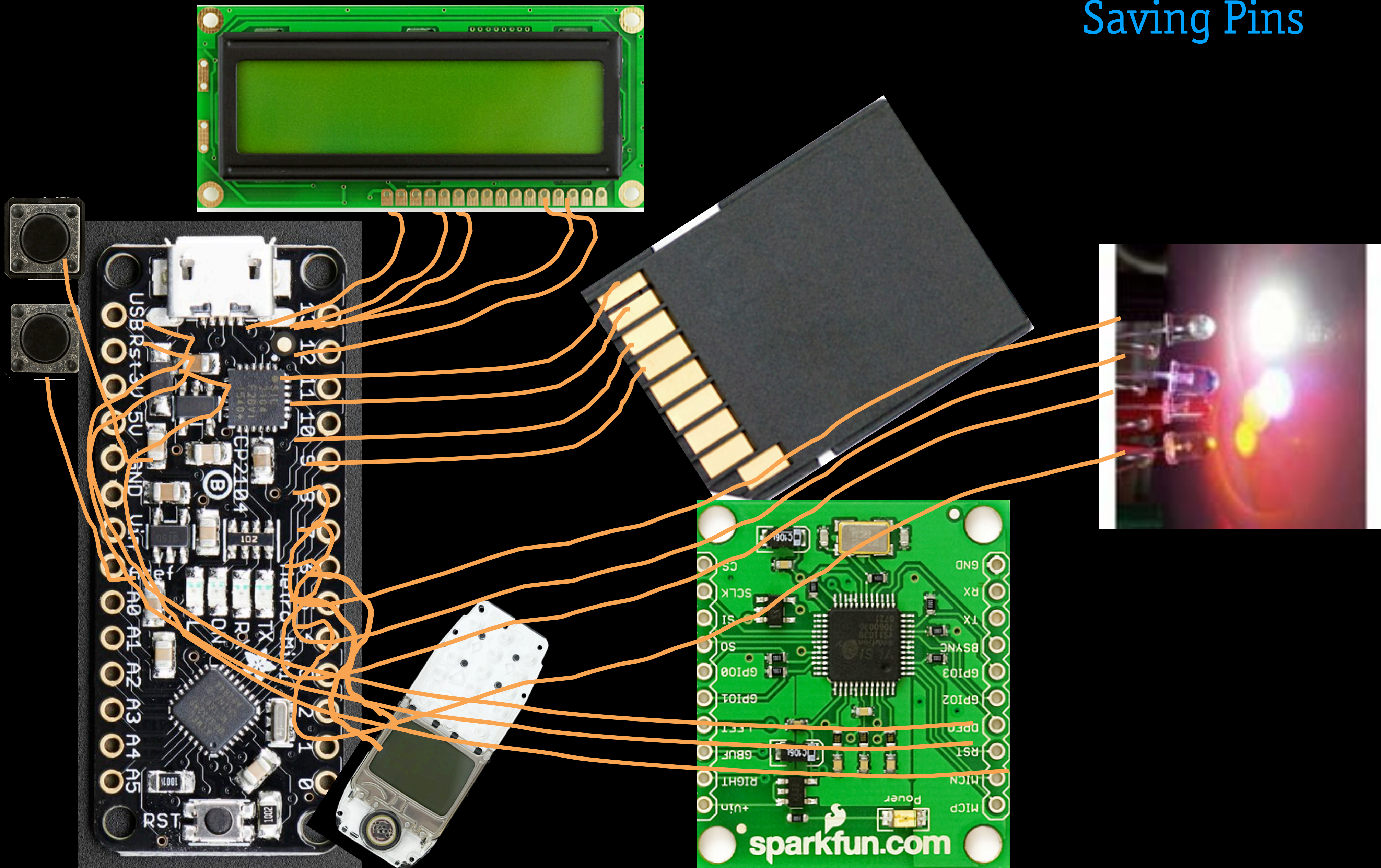
- Seconds, minutes, hours, date, month, and year
- Battery lasts for 7-9 years
- Keeps track of leap years!

DS1307

http://www.sparkfun.com/products/99

Digital ICs

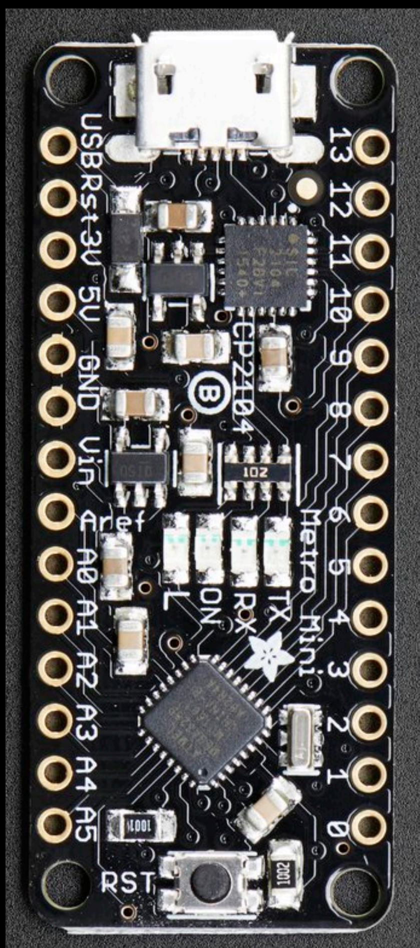
Saving Pins

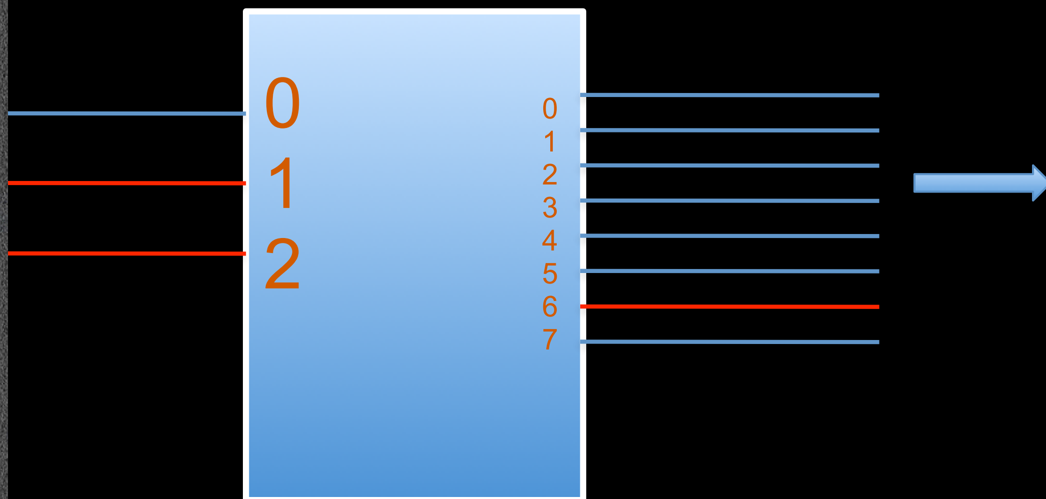


Digital IC’s

Decoder

chip select lines





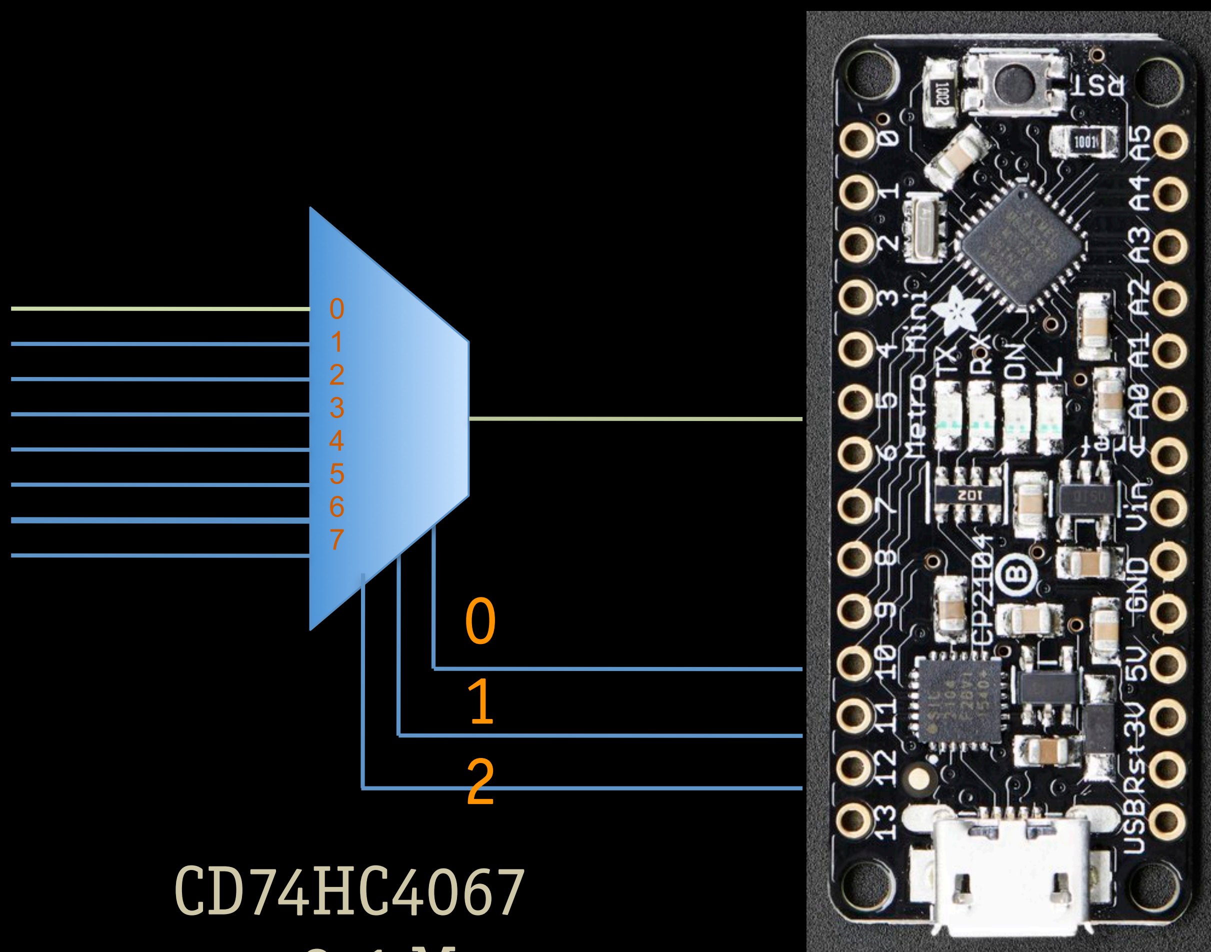
74HC238
3-8 Decoder

If red indicates HIGH

(0)*20+(1)*21+(1)*22=6

Digital IC's

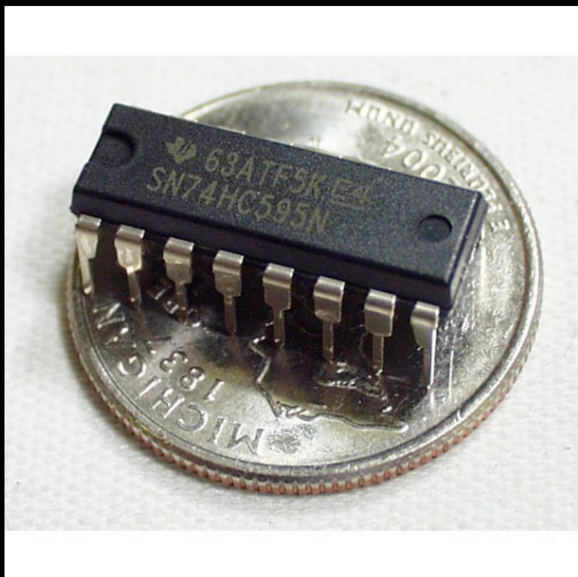
Multiplexer (aka MUX)

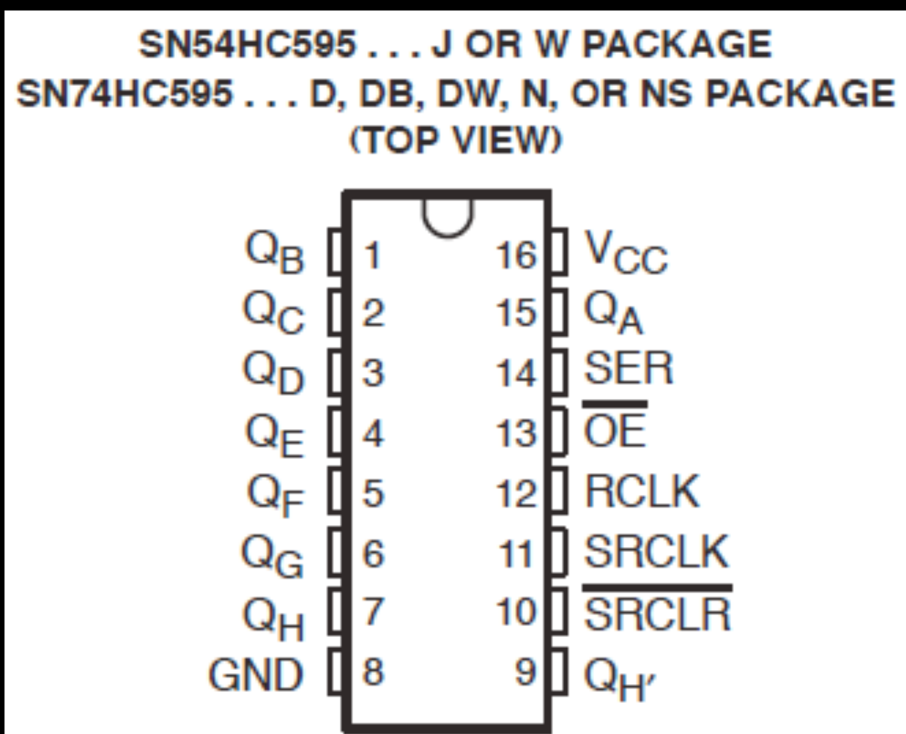


CD74HC4067
8-1 Mux
(works for Analog too)

Digital IC's

Shift Register



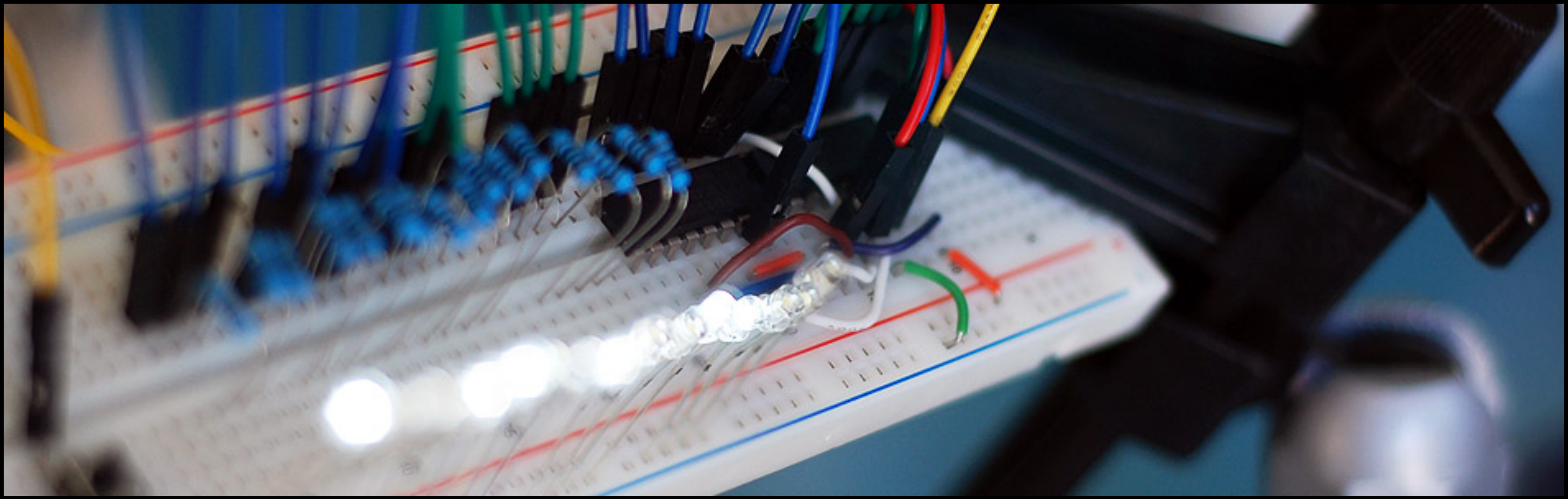


Data is read in on the serial (SER) input line

Data is shifted once with each clock cycle (SCLK).

The "register clock" (RCLK)acts as a clutch, and holds current values when set LOW.

Digital IC's
Shift Register



http://bildr.org/2011/02/74hc595/

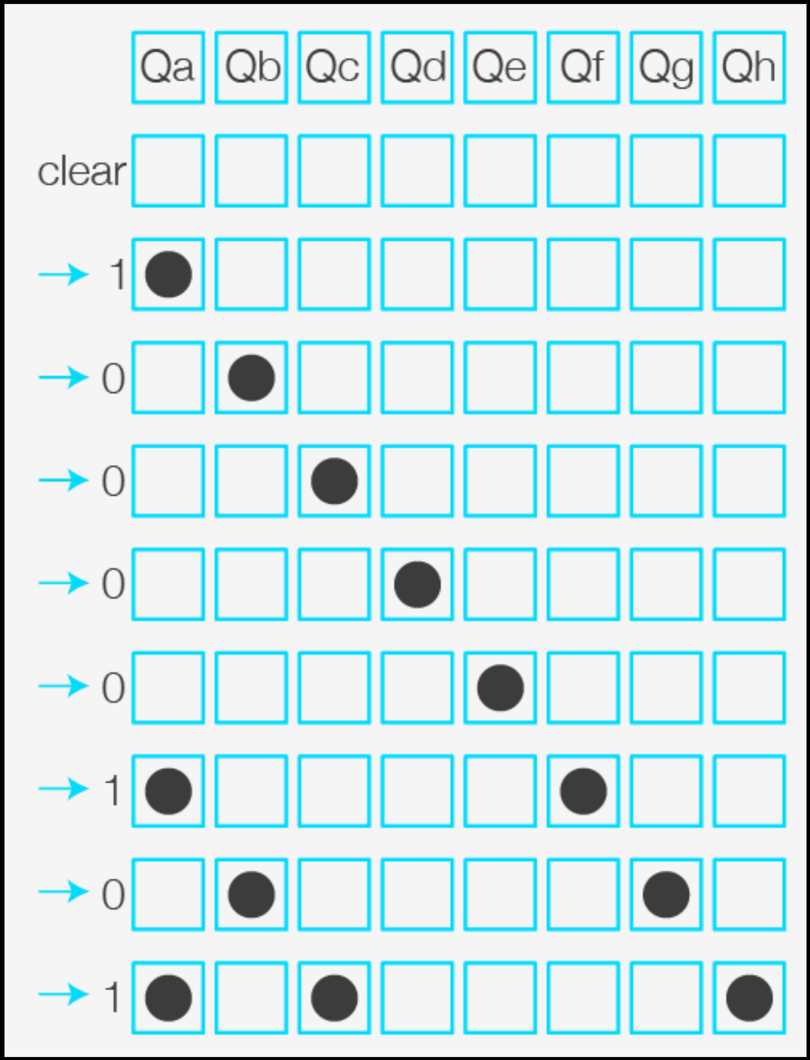
Say you want to control a huge number of LEDs with your Arduino

Digital IC's

Shift Register

To turn on the 1st, 3rd, and 8th LED:

- Pull SRCLR low to clear the register
- Pull RCLK low to clutch the output
- Pulse SER 1, 0, 0, 0, 0, 1, 0, 1 with each CLK pulse
- Pull RCLK high to turn on the LEDs

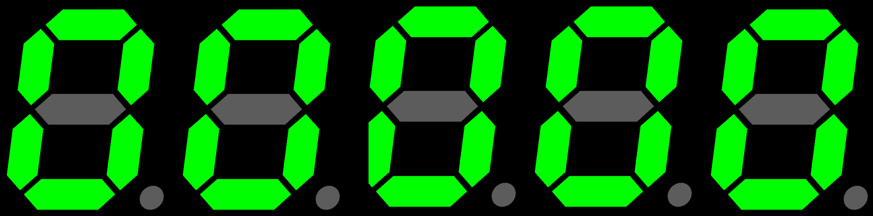


Integrated Circuits...

So many more!

- Specialized Processors (like Mp3 Decoder chips)
- Digital Signal Processors

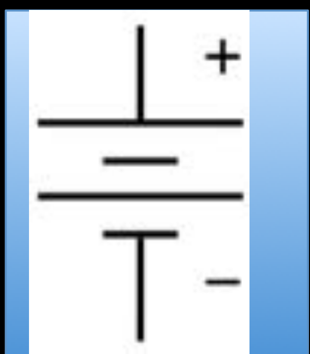
- 7-Segment Display Driver (MC14489B)



- Check out Adafruits's General IC's page for more!

Choosing ICs

Voltage & Current

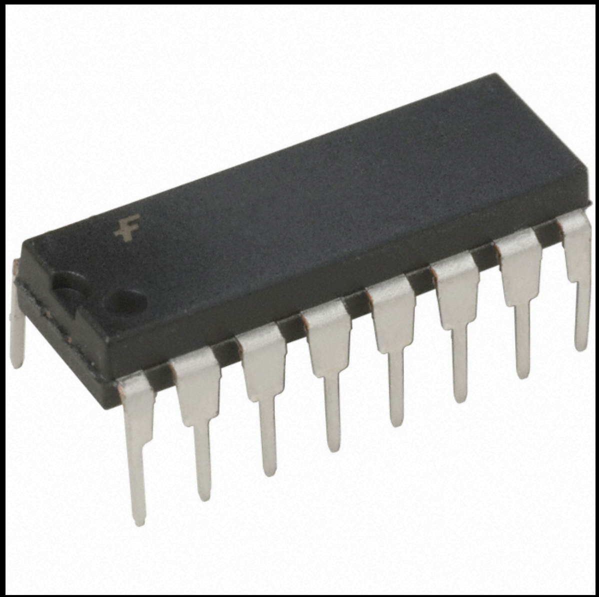


Choosing parts with the same operating voltage will save major headaches and components!

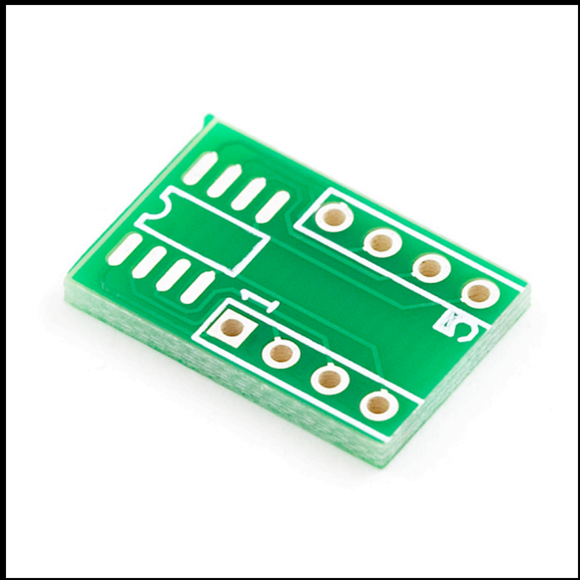
Keep your power source in mind.. USB, batteries, and voltage regulators can only provide so much current.

Choosing ICs

Packaging



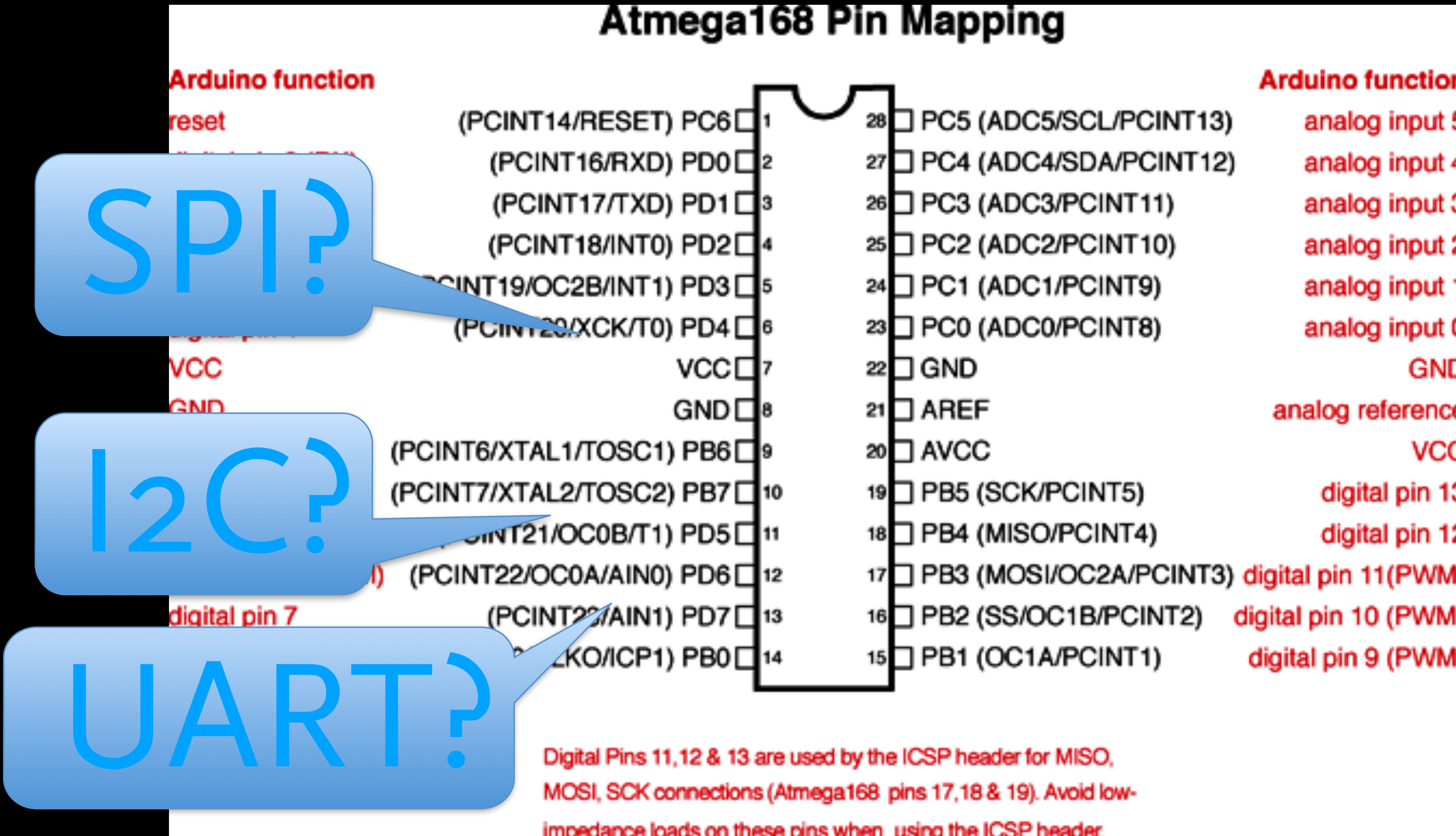
16-DIP



8-SOIC to DIP Adapter

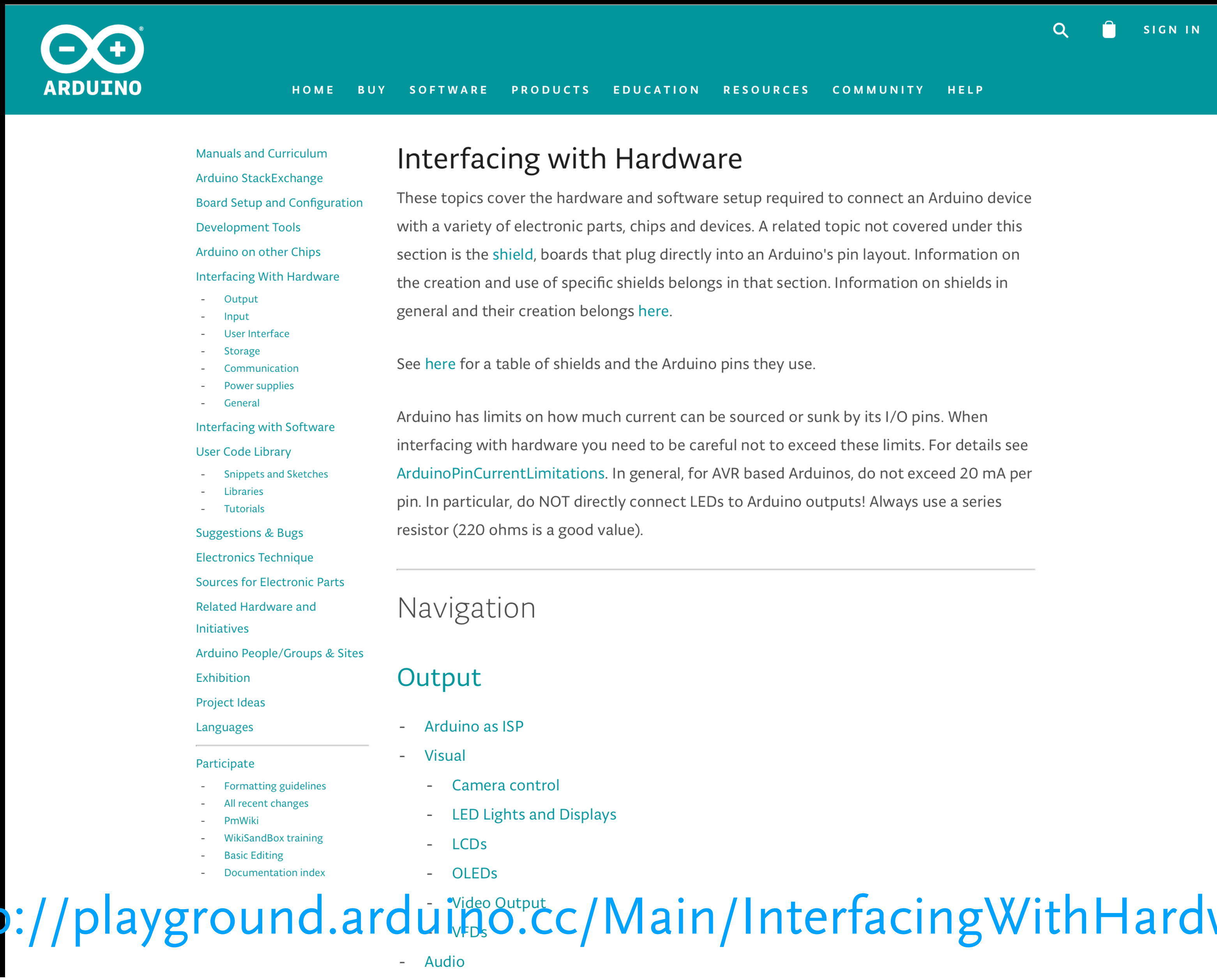
Choosing ICs

Communication Interface



Choosing ICs

Community Support



http://playground.arduino.cc/Main/InterfacingWithHardware

Lab Preview:
Paper Puppeting