

Using Integrated Circuits*

Developing and Designing Interactive Devices

October 1, 2019

* originally by Megan Wachs

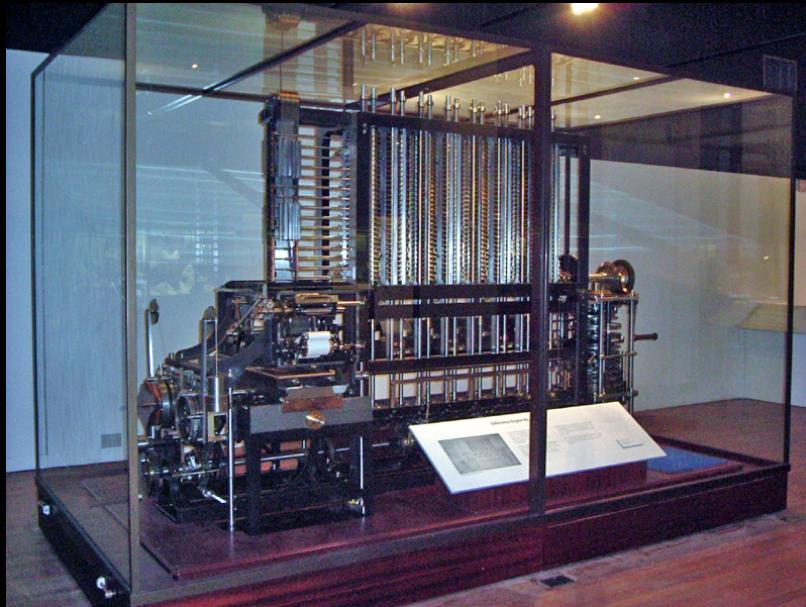
Lab debrief

Highlights? Questions?

Before Integrated Circuits

Mechanical Computing

1849



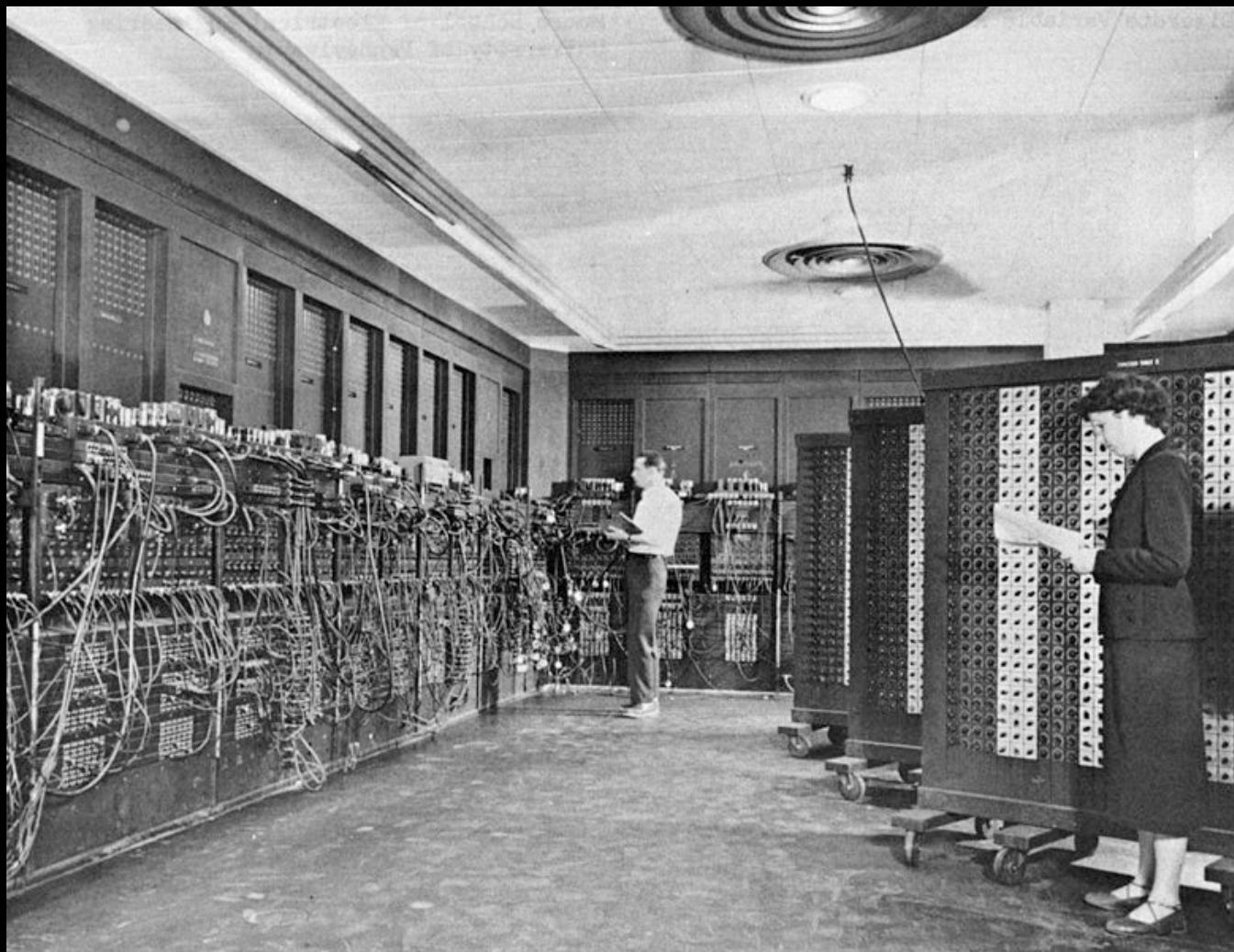
Wikimedia, by Joe D in January 2005.



Wikimedia, Carsten Ullrich, 2005

Before Integrated Circuits

Vacuum Tubes



1945

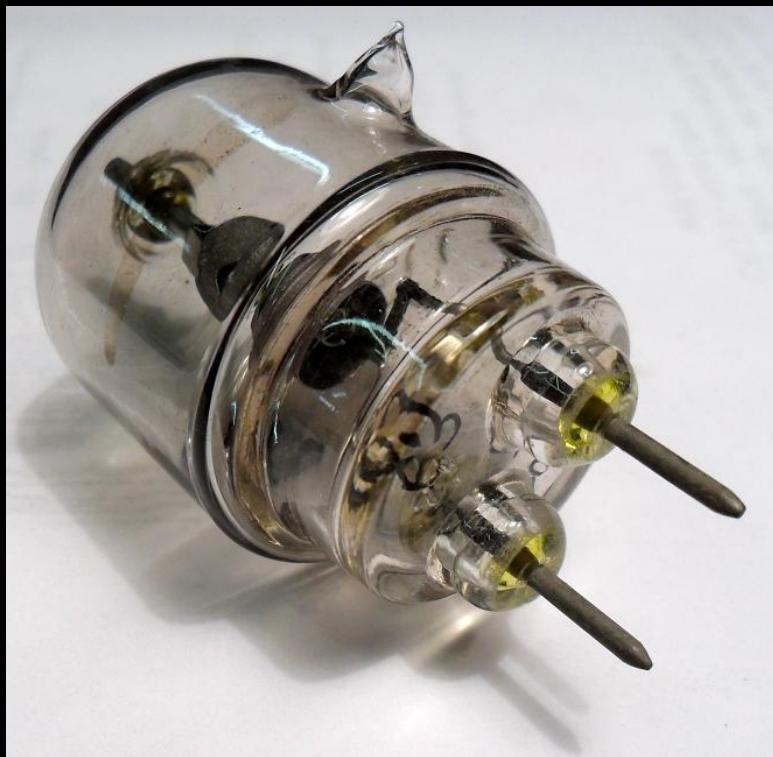


Wikimedia, US Army Photo

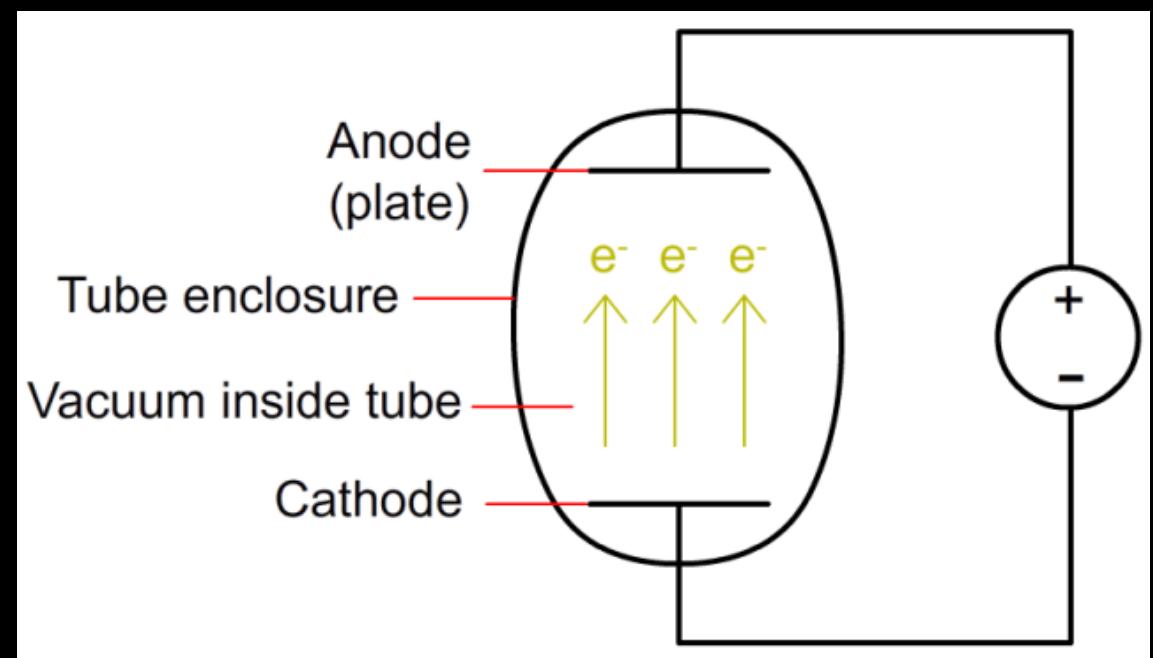
Before Integrated Circuits

Vacuum Tubes

1945



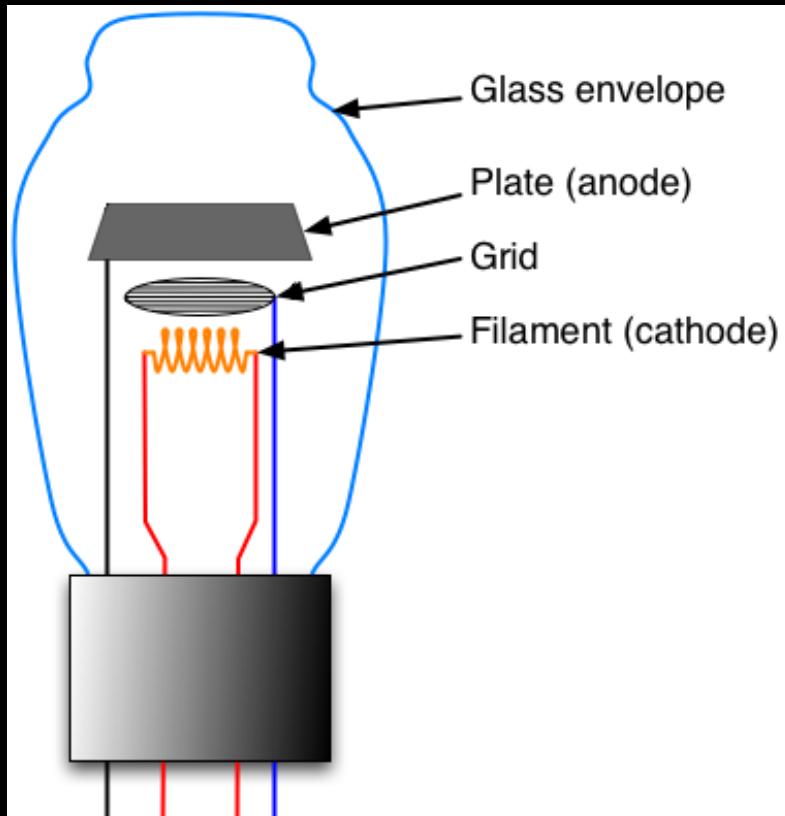
Old vacuum rectifier
<http://leedsradio.com/blog/?p=34>



<https://www.engineering.com/ElectronicsDesign/Articles/ArticleID/16337/Vacuum-Tubes-The-World->

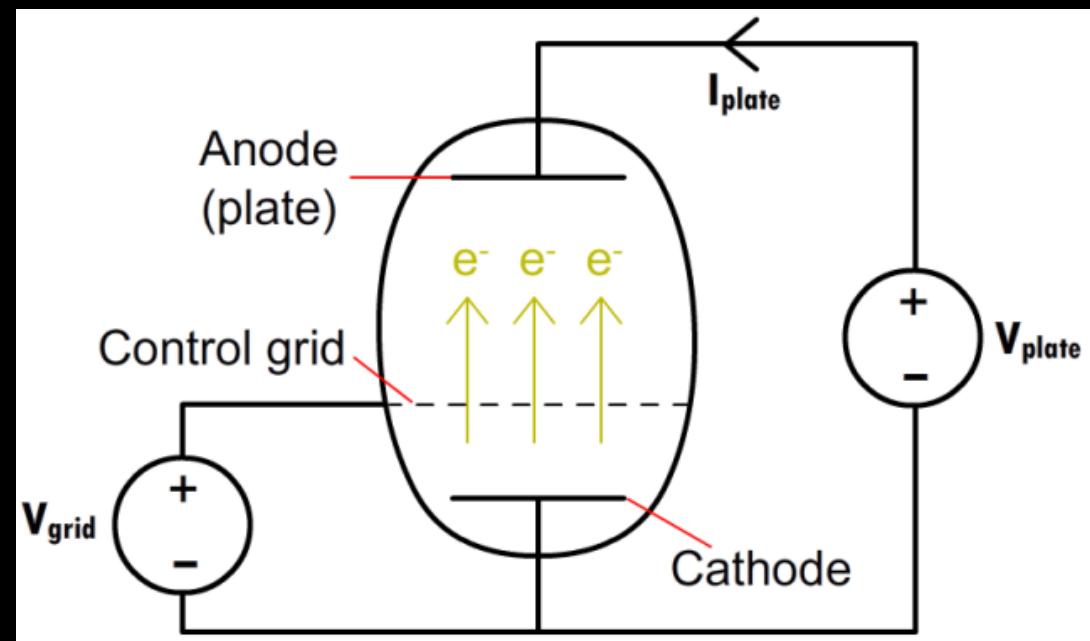
Before Integrated Circuits

Vacuum Tubes



Wikipedia, Triode Vacuum Tube

1945

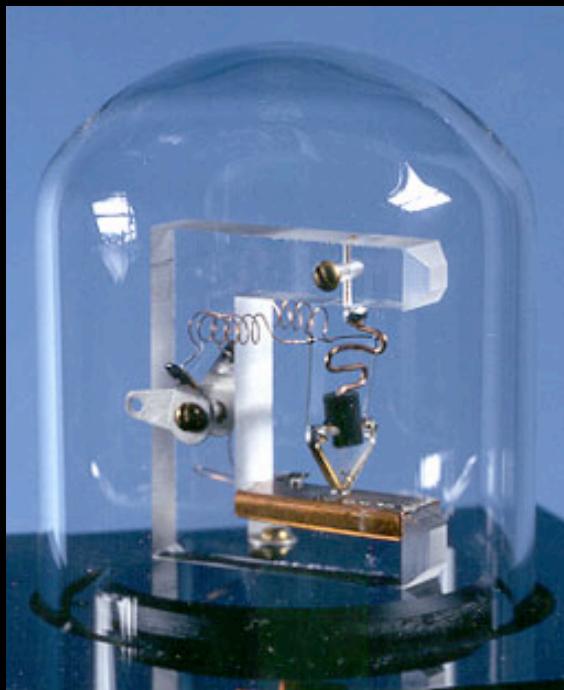


<https://www.engineering.com/ElectronicsDesign/ElectronicsDesignArticles/ArticleID/16337/Vacuum-Tubes-The-World->

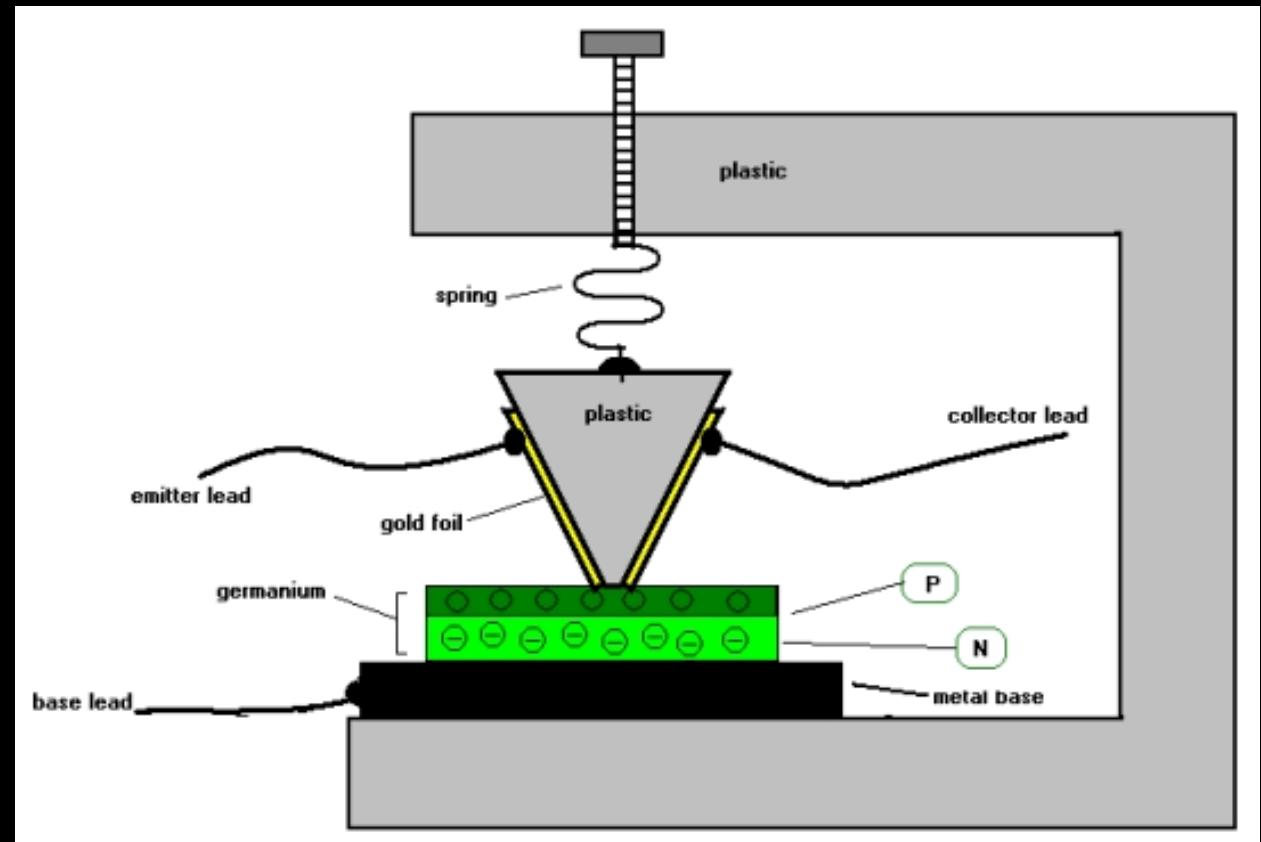
1947

Before Integrated Circuits

Transistors



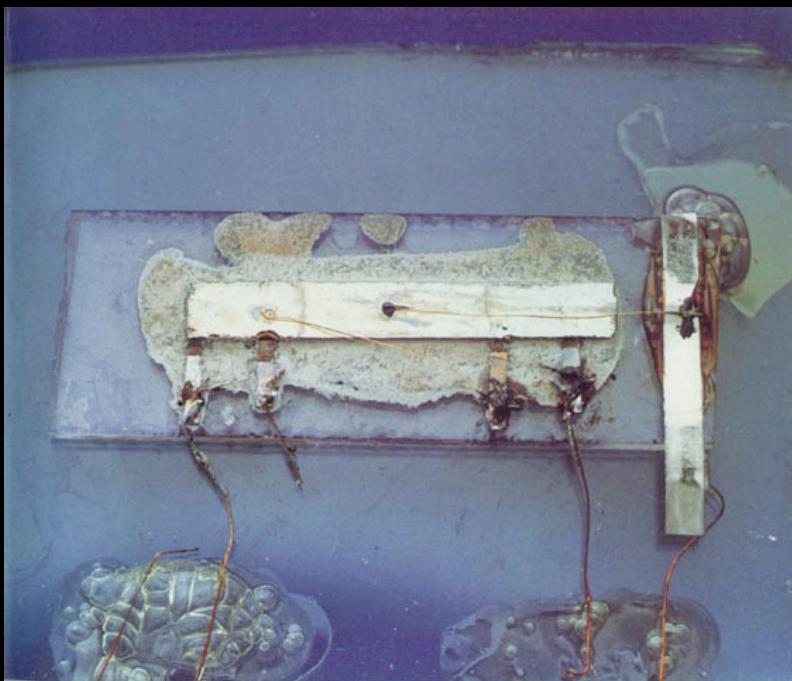
Wikipedia, First Transistor Replica



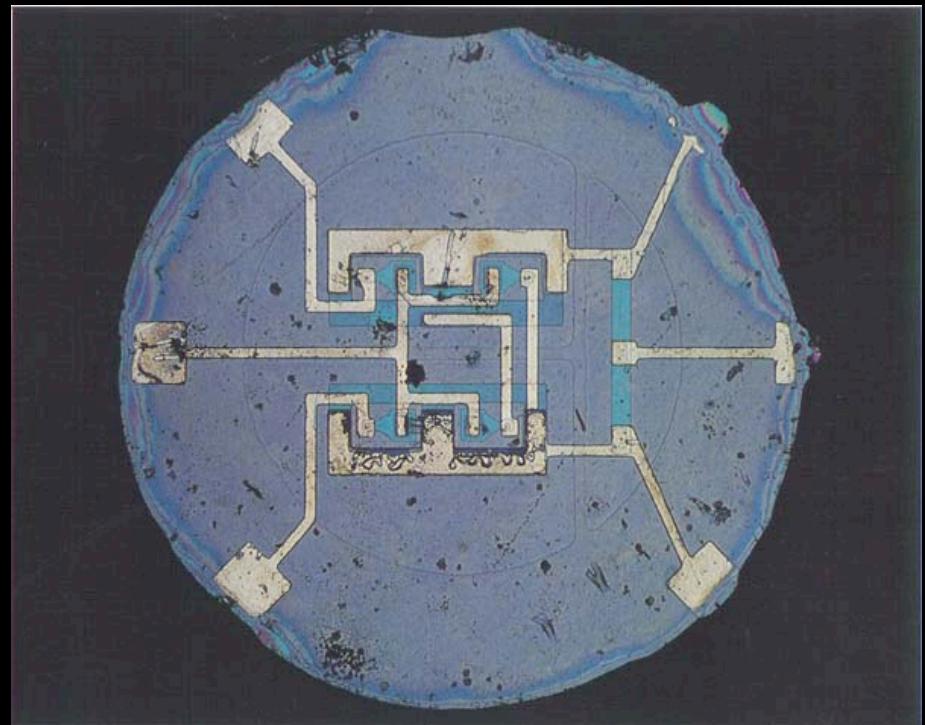
Wikipedia, Point Contact Transistor

Integrated Circuits

Multiple Components on a Single Substrate



Kilby's first Hybrid Integrated Circuit,
Wikipedia



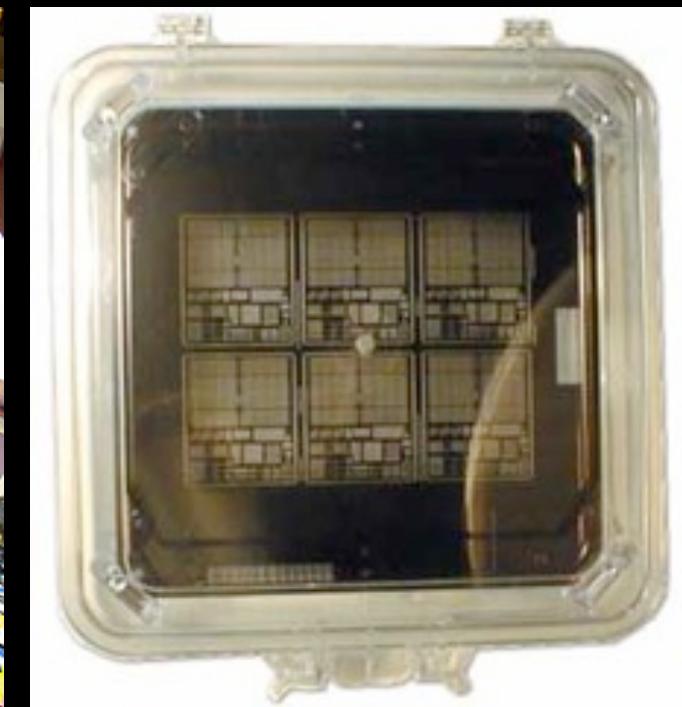
Noyce's first monolithic Silicon IC,
Fairchild Camera and Instrument Co.

1958

1961

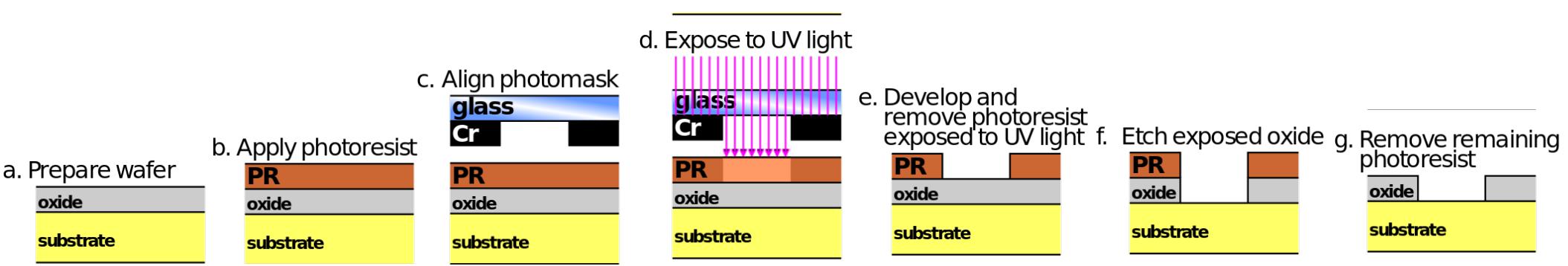
Integrated Circuits Manufacturing

Similar to Silkscreening



Integrated Circuits Manufacturing

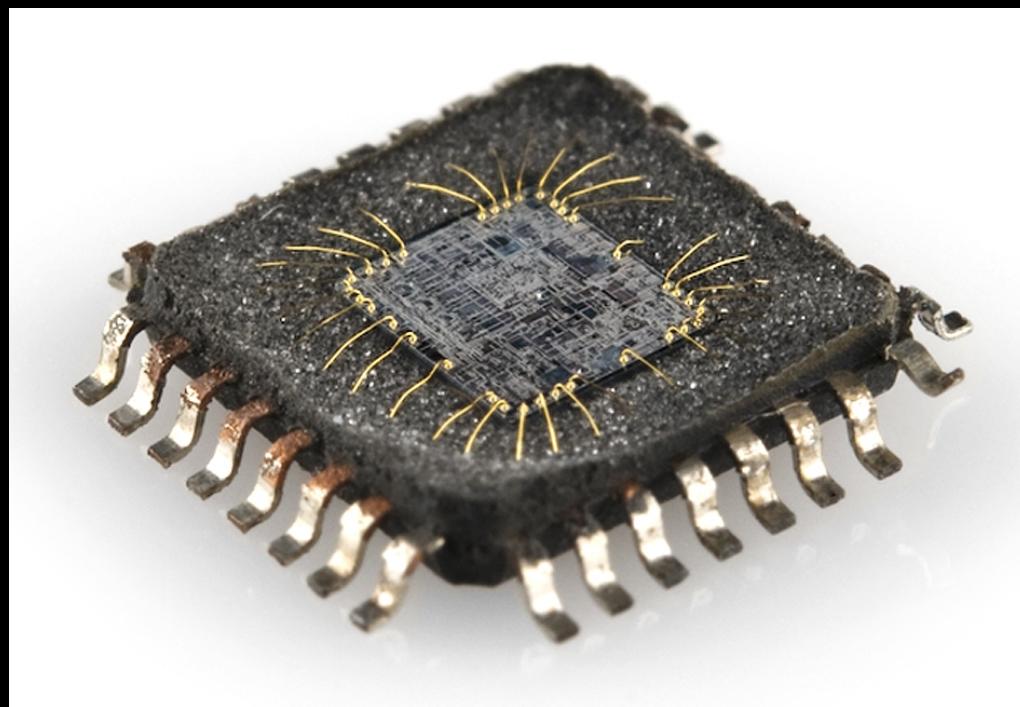
Photolithography



Photolithography
Wikipedia

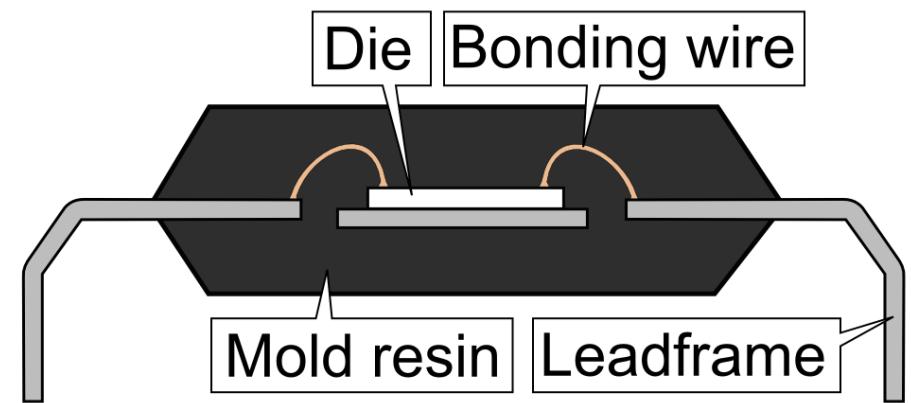
Integrated Circuit Packaging

Where does the silicon go?



The guts of an integrated circuit
<https://learn.sparkfun.com/tutorials/integrated-circuits/all>

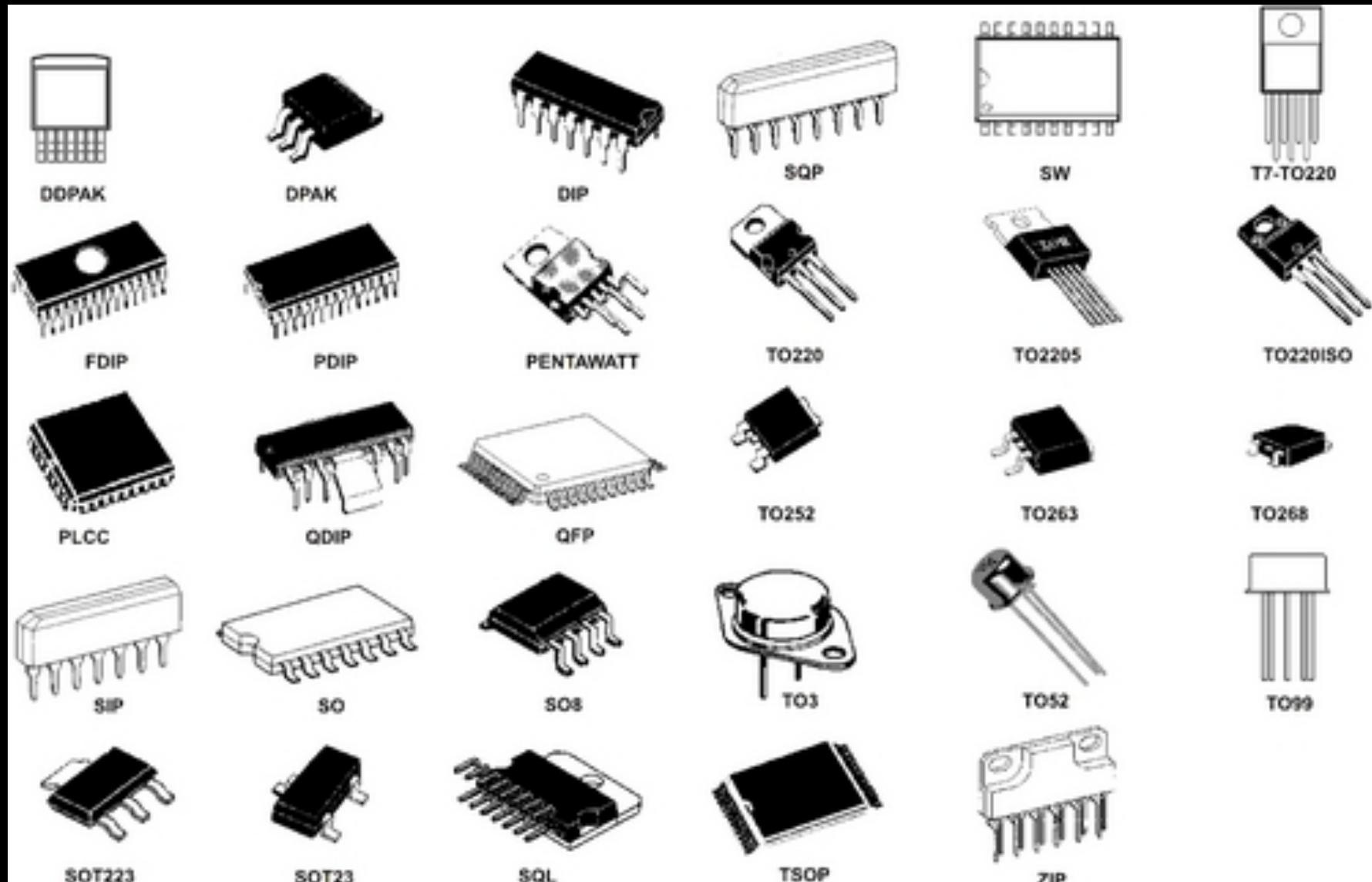
DIP



IC packaging, Wikipedia

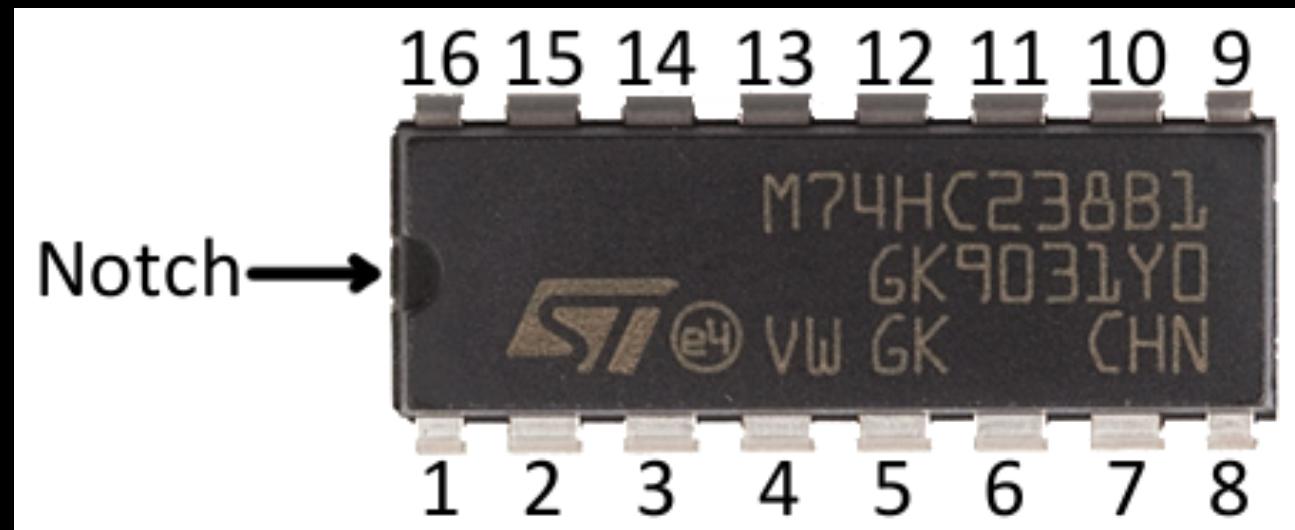
Integrated Circuit Packaging

Where does the silicon go?



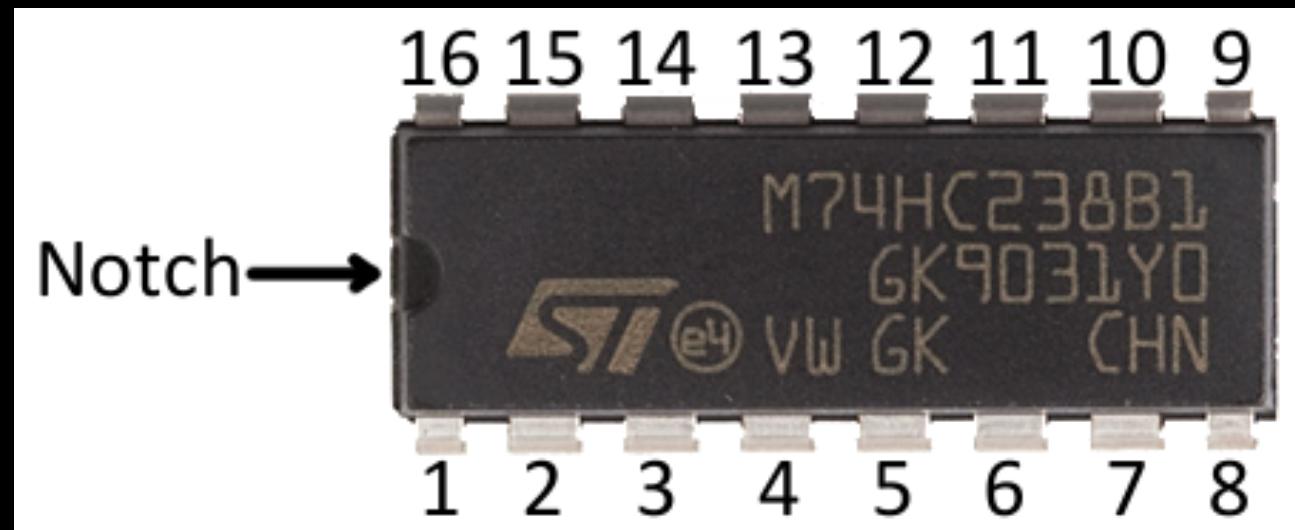
Integrated Circuit Packaging

Polarity, Pin numbering



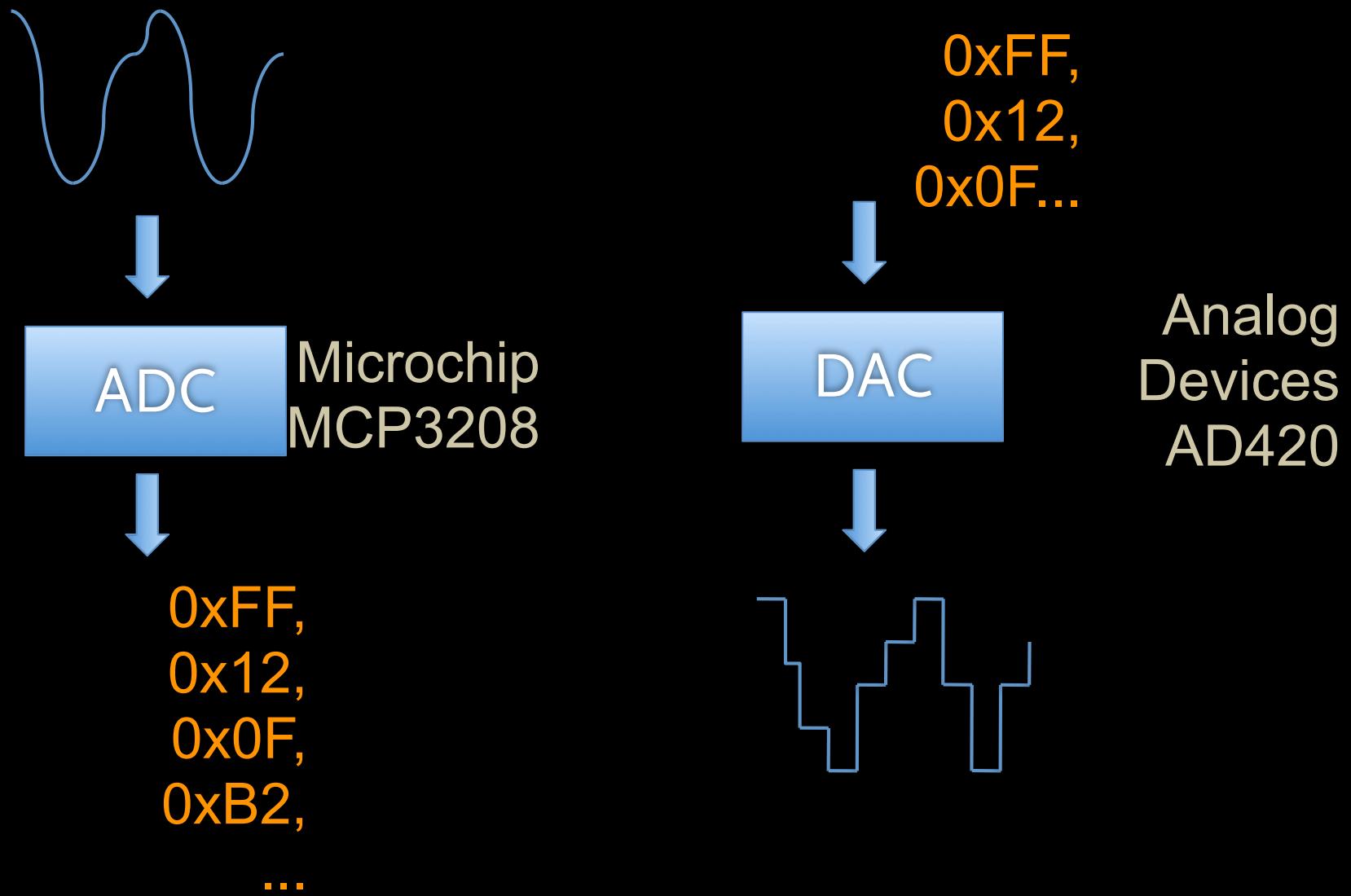
Integrated Circuit Packaging

Polarity, Pin numbering



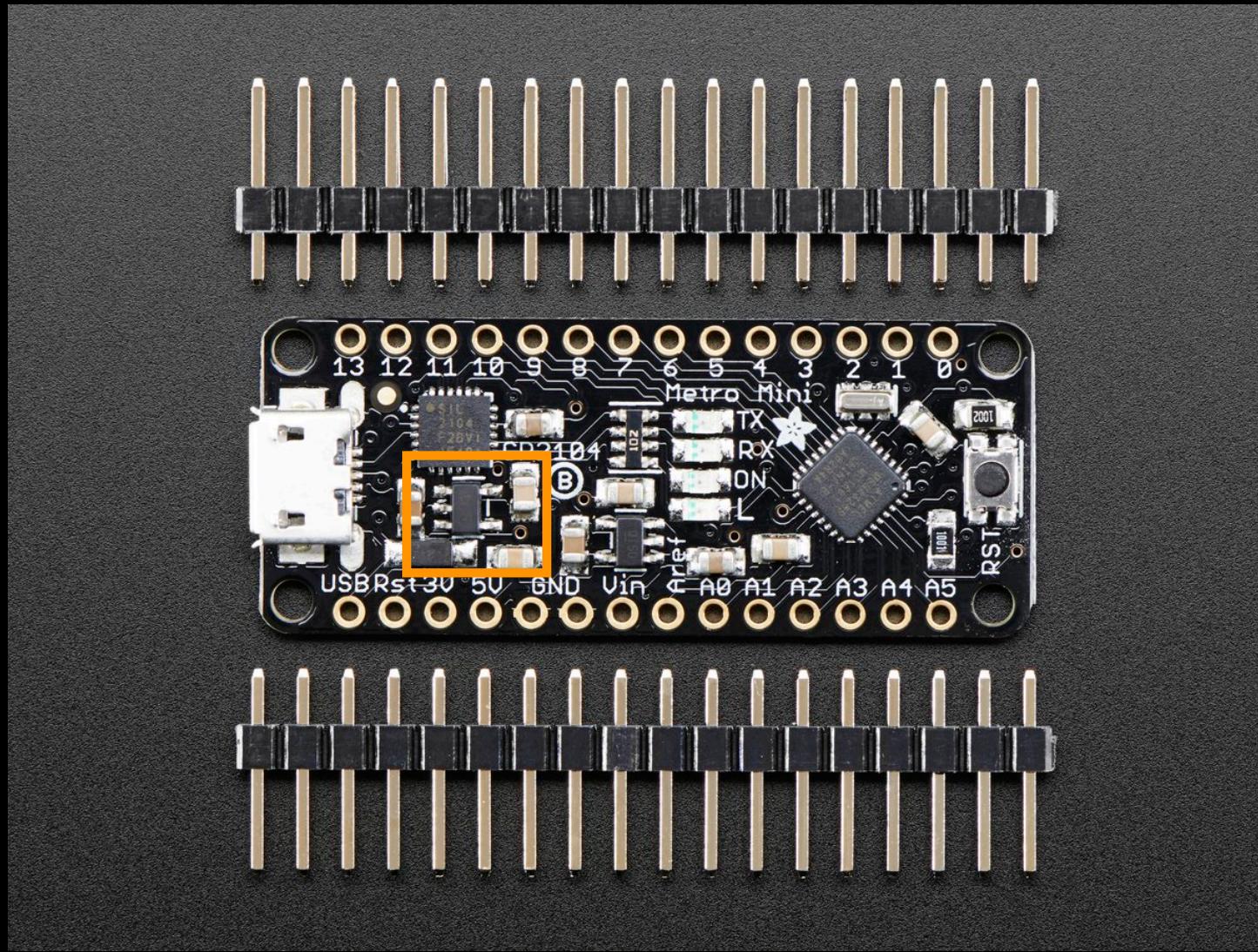
ADCs and DACs

Converting from Analog to Digital, and Back again



Analog ICs

You have already used a few!





MIC5225

Ultra-Low Quiescent Current
150mA μ Cap 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 μ Cap LDO design, the MIC5225 is stable with either a ceramic or tantalum output capacitor. It only requires a 2.2 μ F 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.

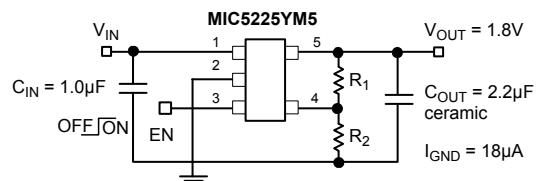
Features

- Wide input voltage range: 2.3V to 16V
- High output accuracy of $\pm 2.0\%$ over temperature
- Guaranteed 150mA output
- Very low ground current: 29 μ A
- Low dropout voltage of 310mV at 150mA
- μ Cap: 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

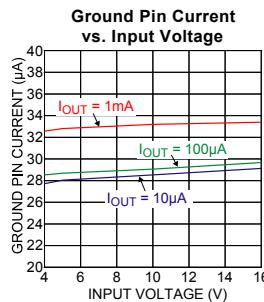
Applications

- 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.

Micrel Inc. • 2180 Fortune Drive • San Jose, CA 95131 • USA • tel +1 (408) 944-0800 • fax +1 (408) 474-1000 • <http://www.micrel.com>

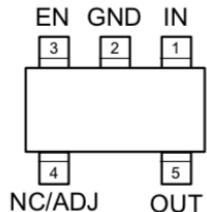
Ordering Information

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

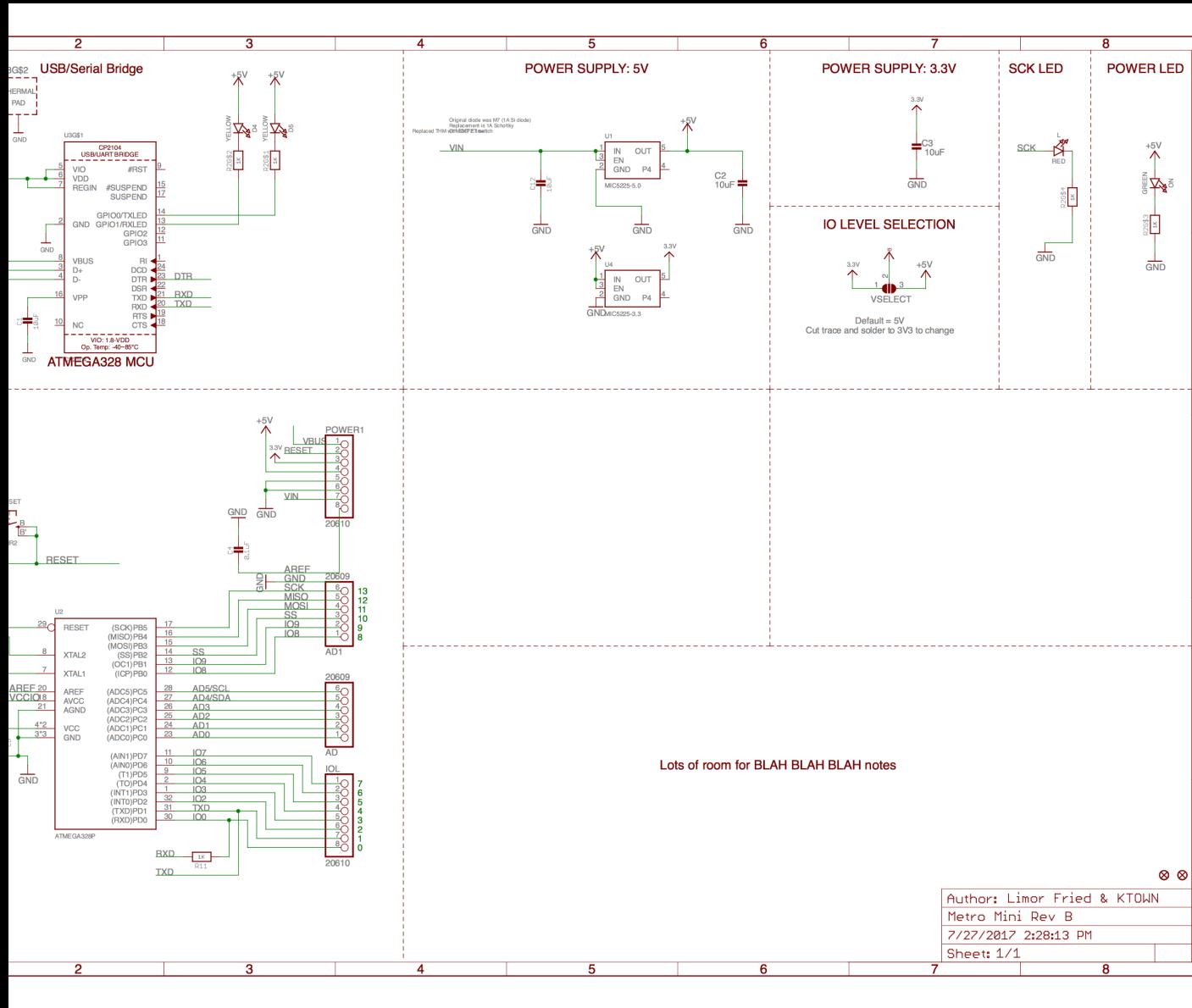


5-Pin SOT23 (M5)

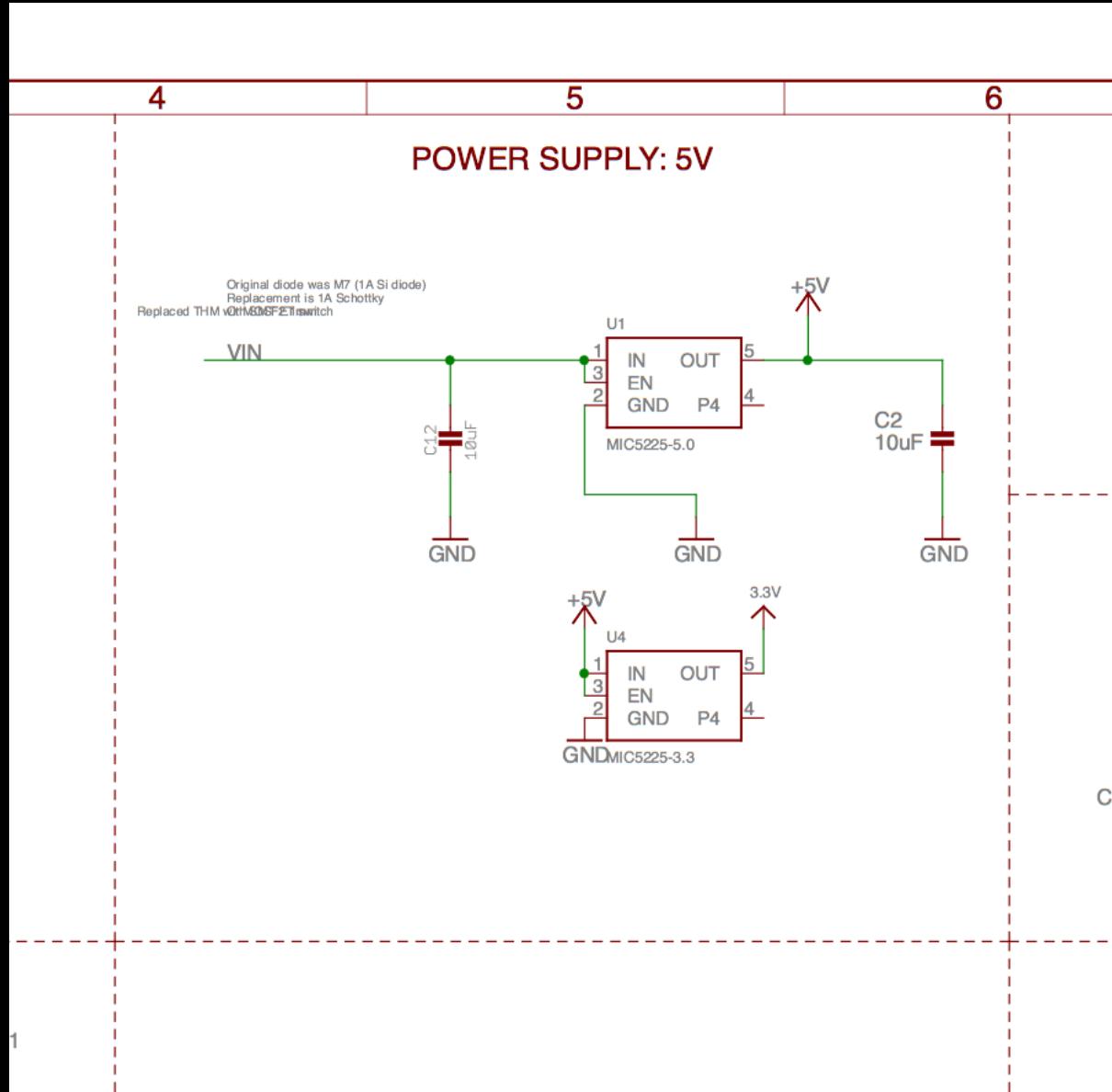
Pin Description

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



Analog ICs

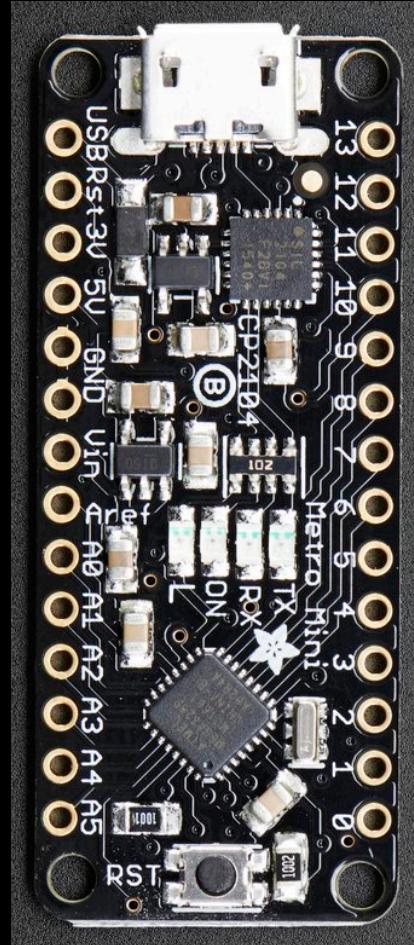


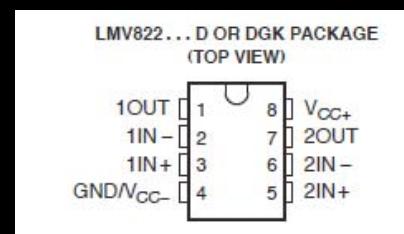
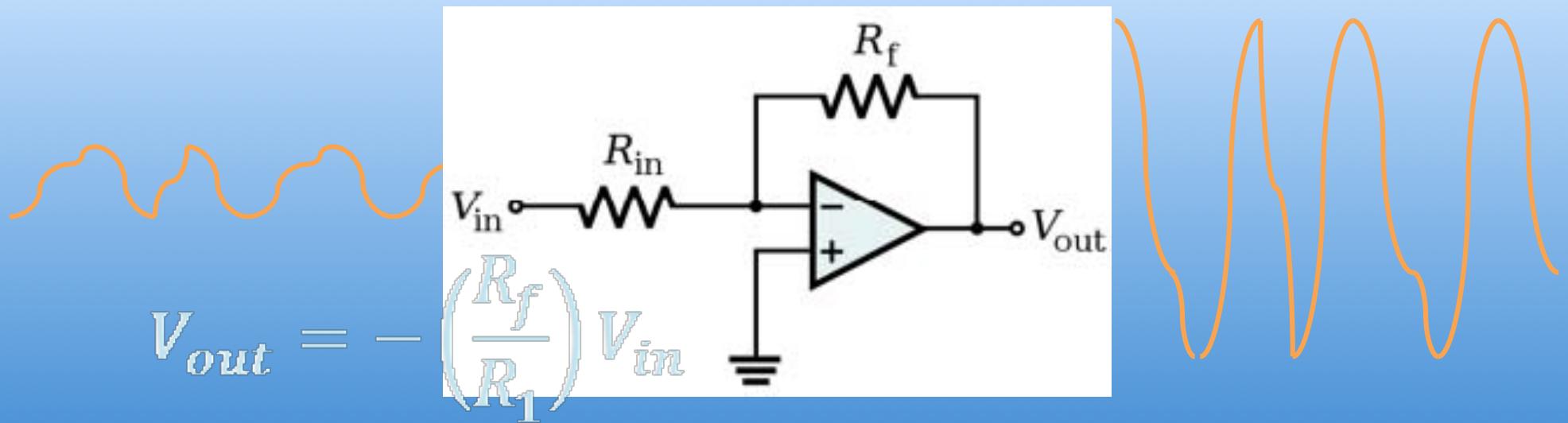
Analog ICs

Operational Amplifier

5V

0V





Texas Instruments
LMV822

Analog ICs

Filter Chips



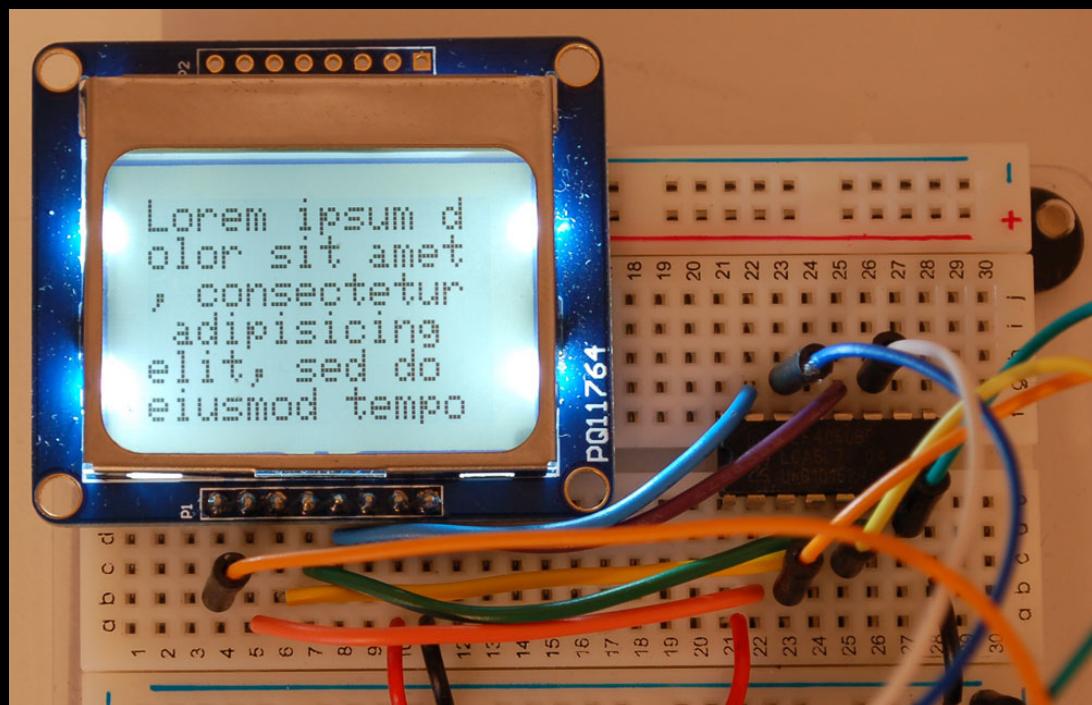
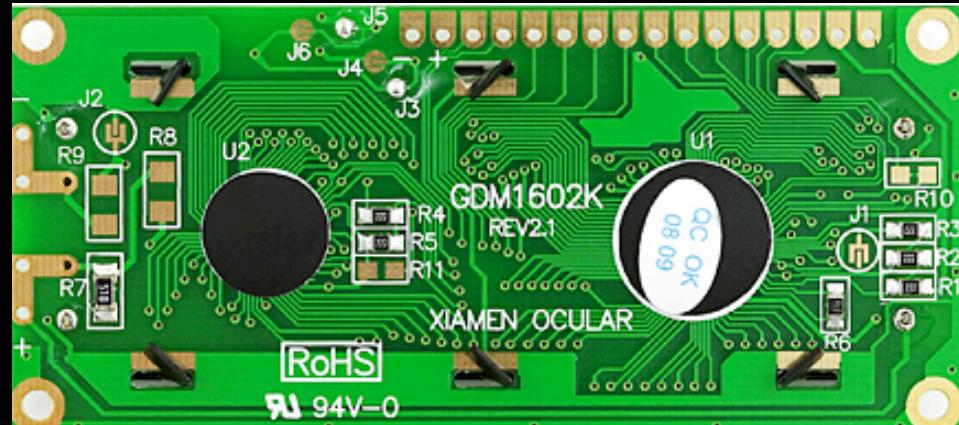
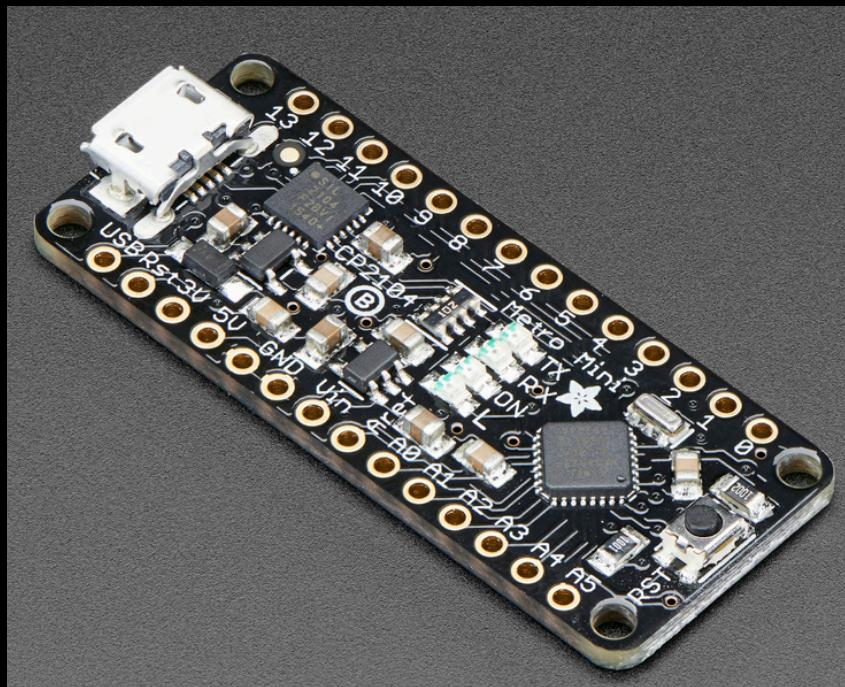
or



Can design your own with R's and C's

Digital ICs

You've already used a ton!

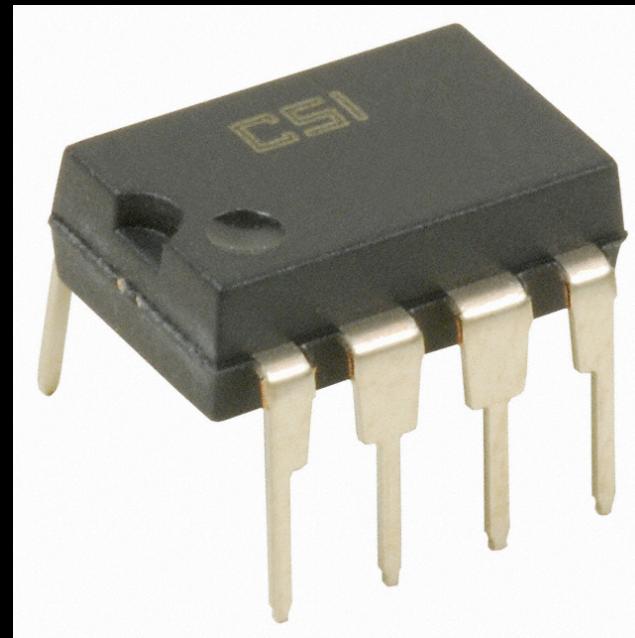


Digital ICs

Memory



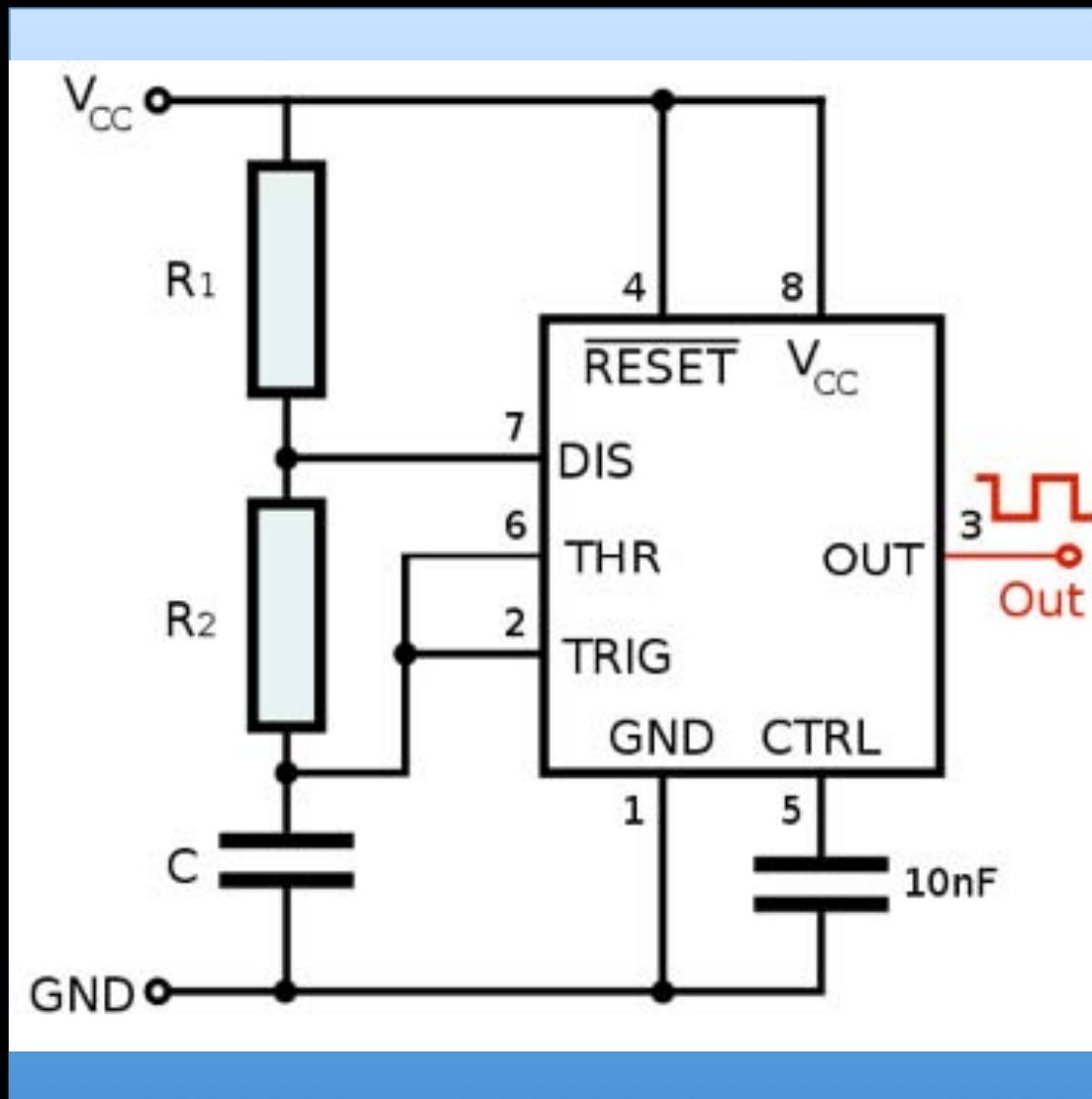
FLASH



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 :

$$t_1 = 0.693 (R_A + R_B) C$$

and the discharge time (output LOW) by :

$$t_2 = 0.693 (R_B) C$$

Thus the total period T is given by :

$$T = t_1 + t_2 = 0.693 (R_A + 2R_B) C$$

The frequency of oscillation is then :

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

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

Figure 4

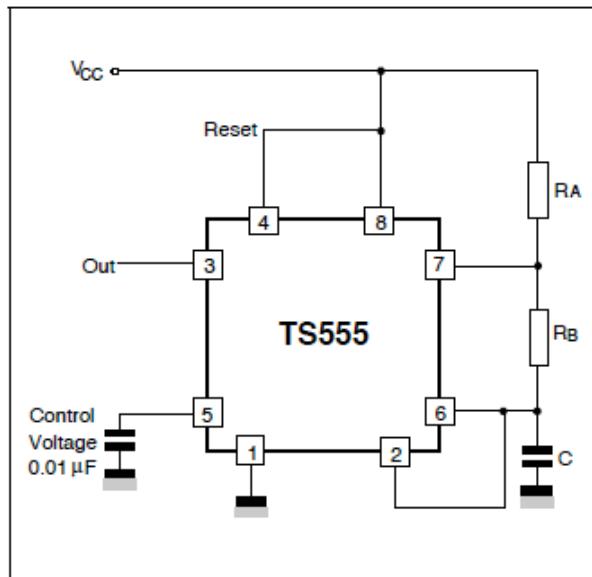
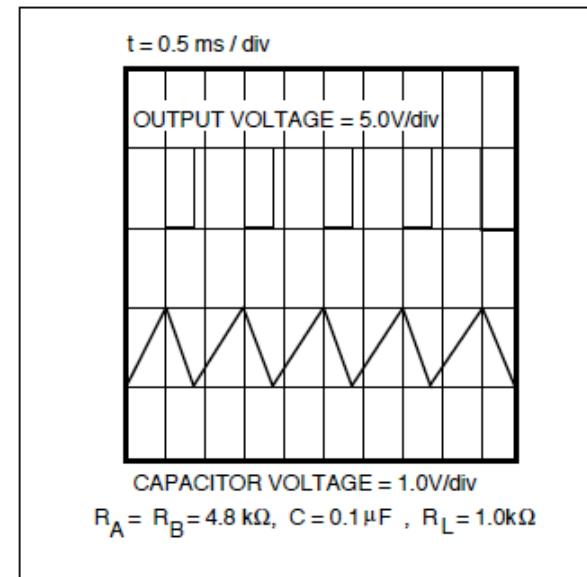
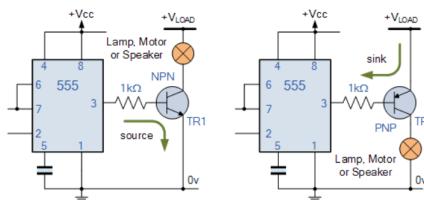


Figure 5





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 $5\text{k}\Omega$ 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.

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

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

1. Electrical Waveforms
 2. Monostable Multivibrator
 3. Bistable Multivibrator
 4. Astable Multivibrator
 5. Waveform Generators
- ▶ 6. 555 Timer Tutorial
7. 555 Oscillator Tutorial

Download Datasheets

POWERED BY DATASHEETS.COM

Part Number

e.g. LM317

Search

Related Tutorials

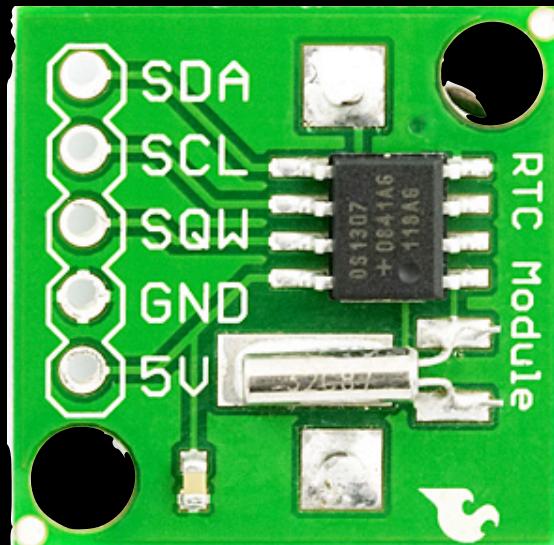
 555 Oscillator Tutorial

Jan 15th, 2016

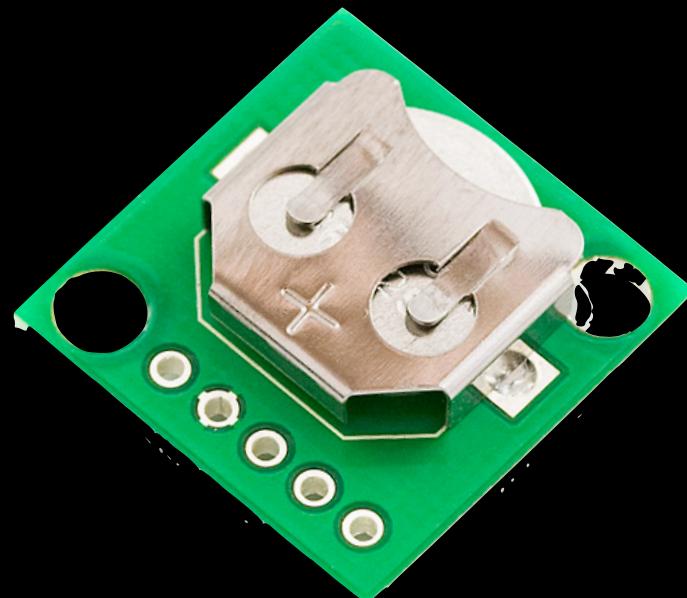
The 555 IC can be used to create a free running astable oscillator to continuously produce square [\[...\]](#)

Digital ICs

Real-Time Clocks



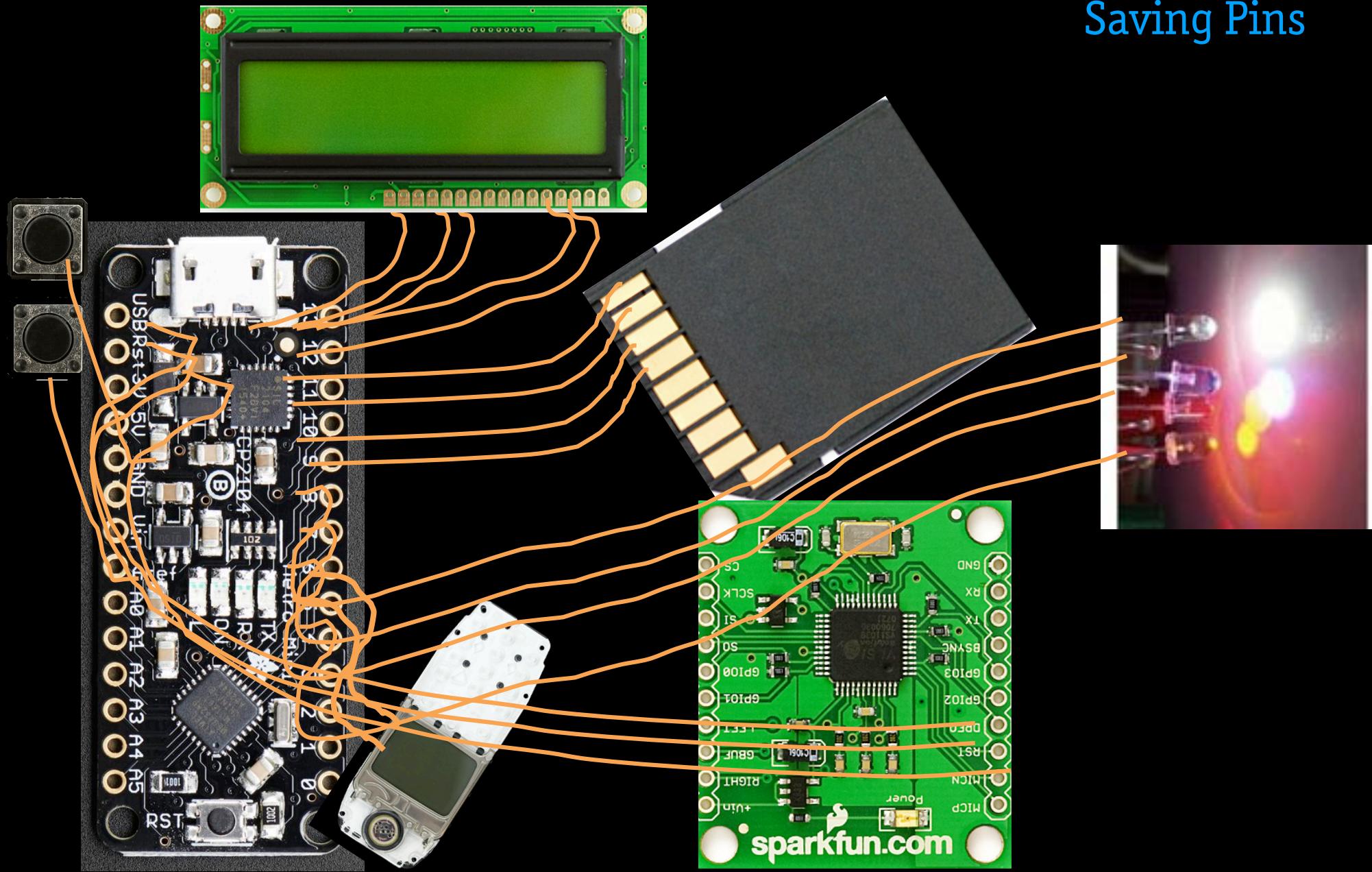
- Seconds, minutes, hours, date, month, and year
- Battery lasts for 7-9 years
- Keeps track of leap years!



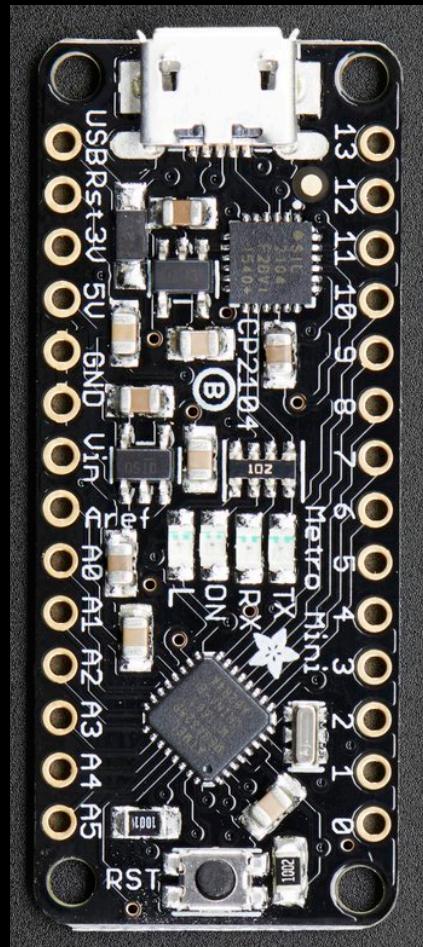
DS1307

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

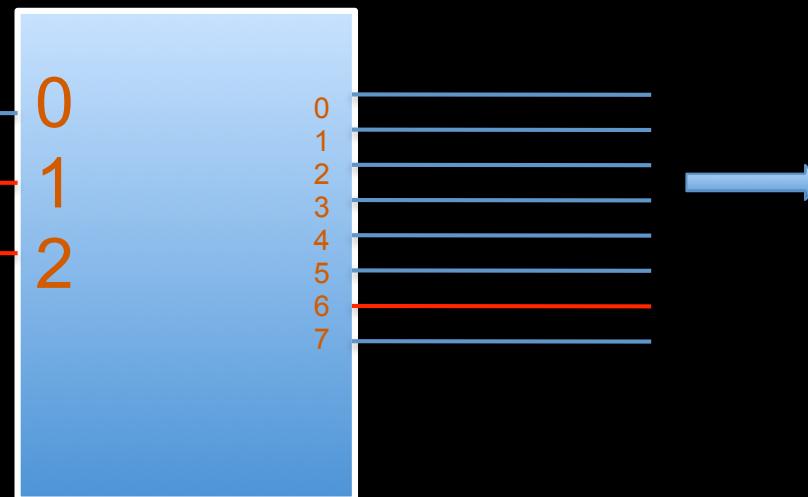
Digital ICs Saving Pins



Digital IC's Decoder



chip select lines



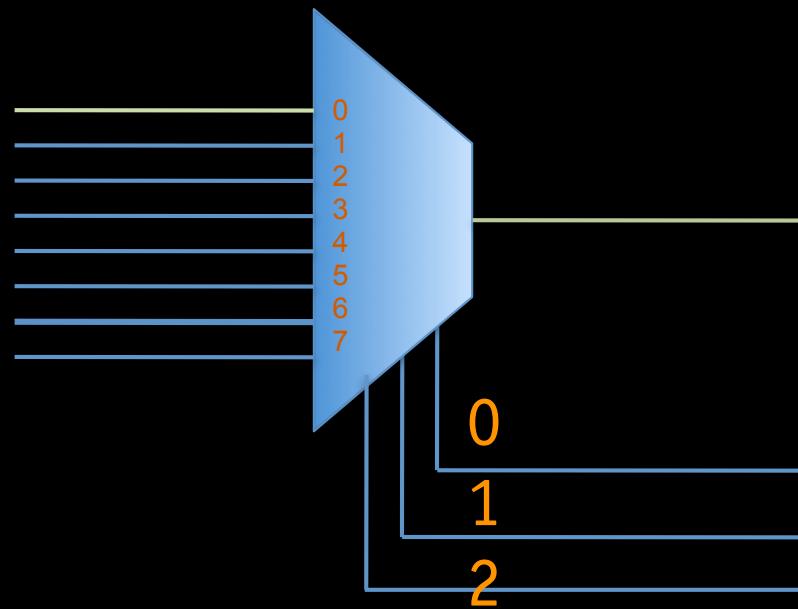
74HC238
3-8 Decoder

If red indicates HIGH

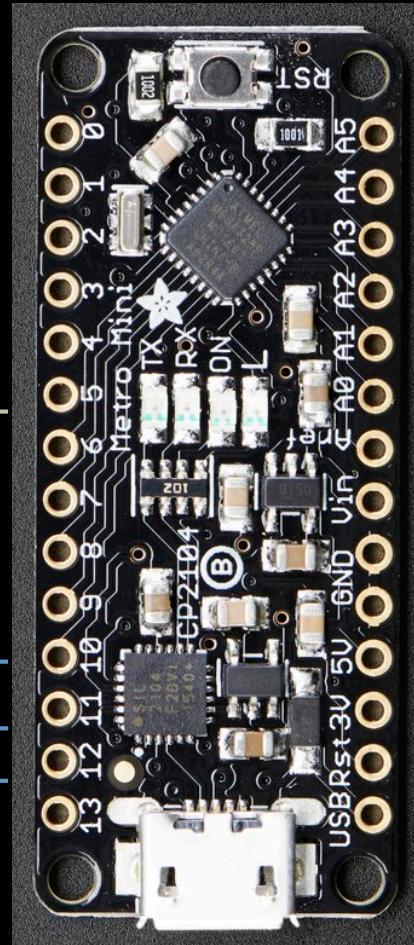
$$(0)*20+(1)*21+(1)*22=6$$

Digital IC's

Multiplexer (aka MUX)

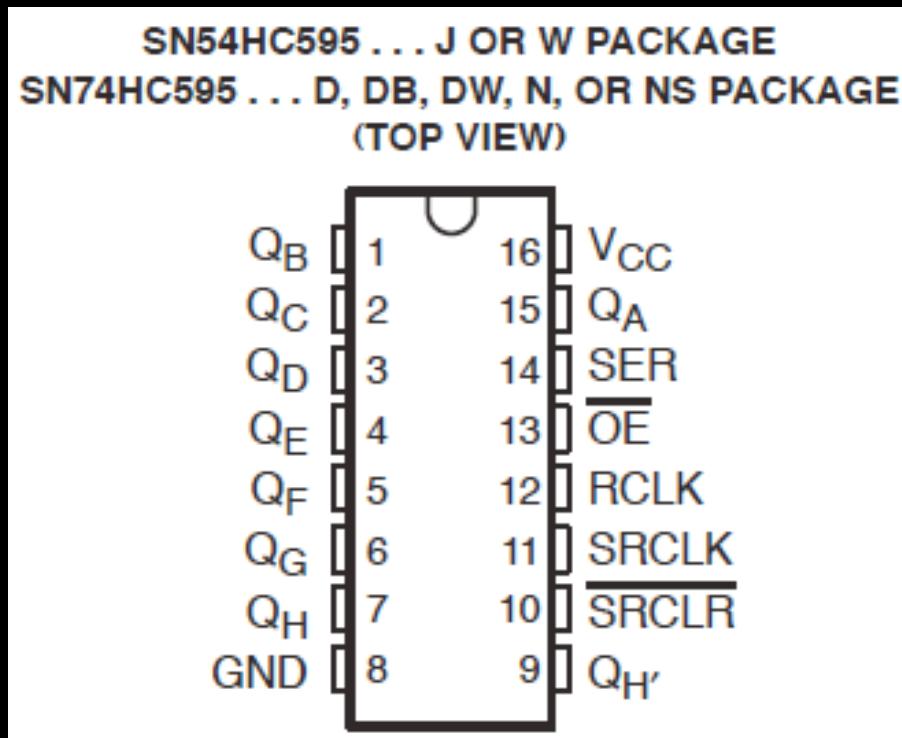
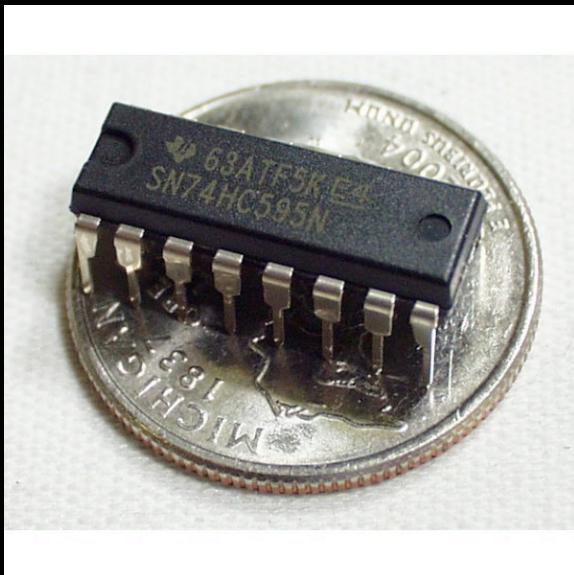


CD74HC4067
8-1 Mux
(works for Analog too)



Digital IC's

Shift Register

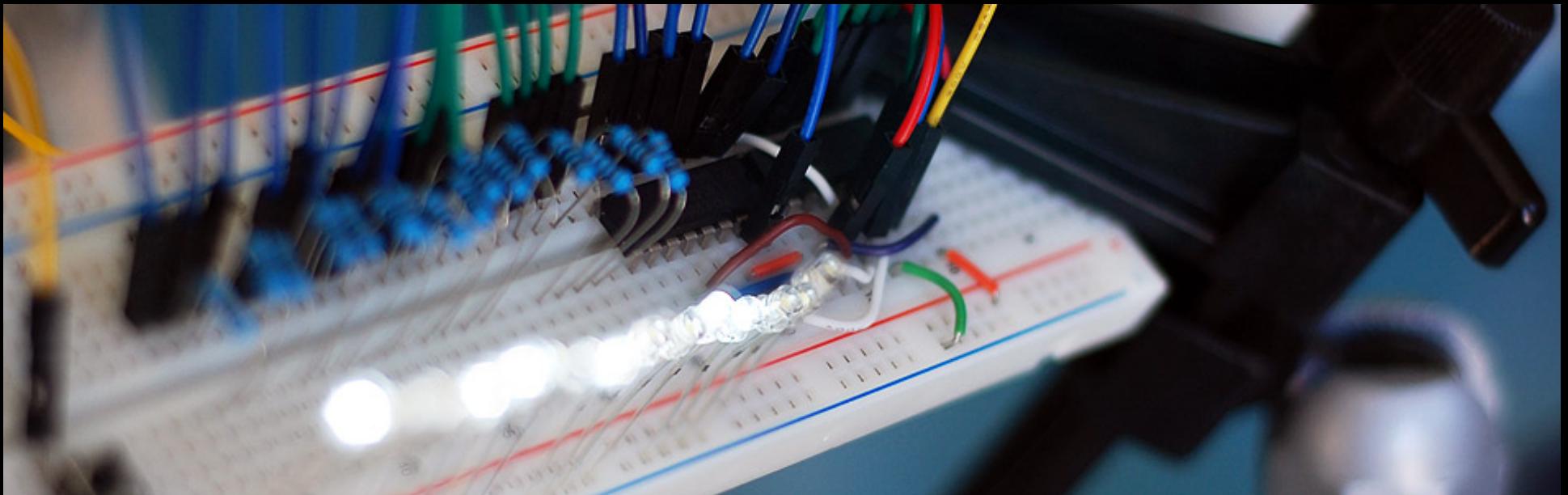


Data is read in on the serial (SER) input line

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

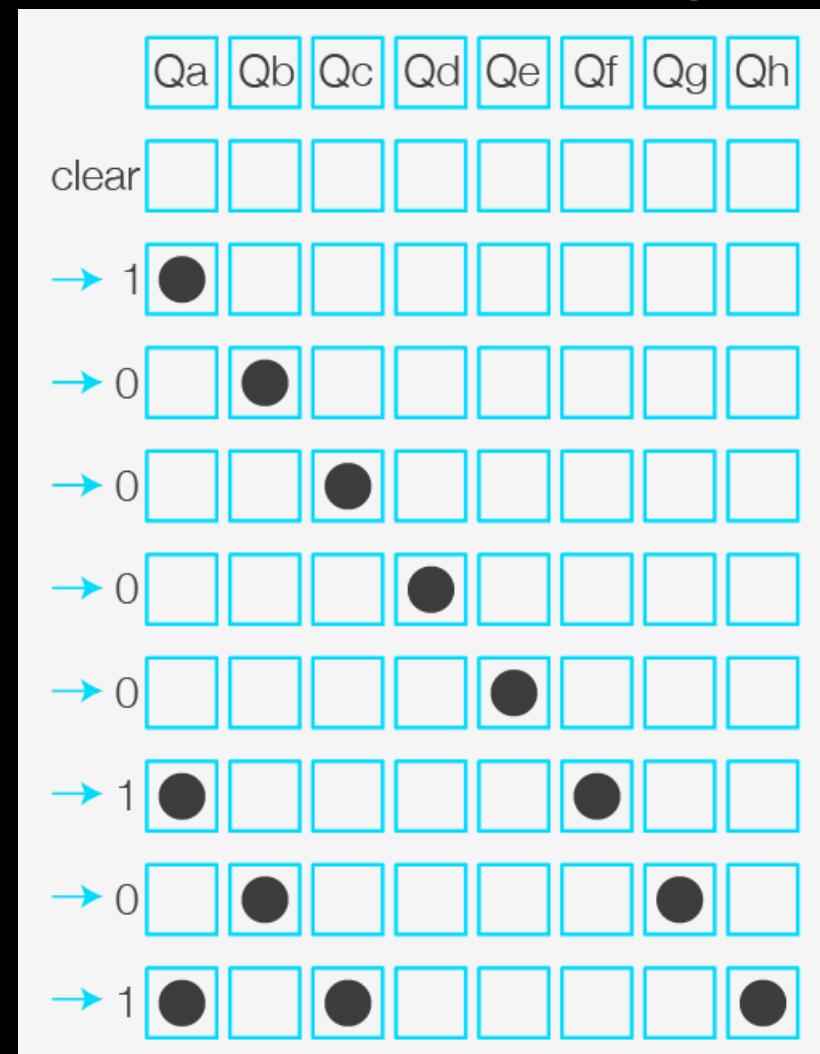
To turn on the 1st, 3rd, and 8th LED:

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



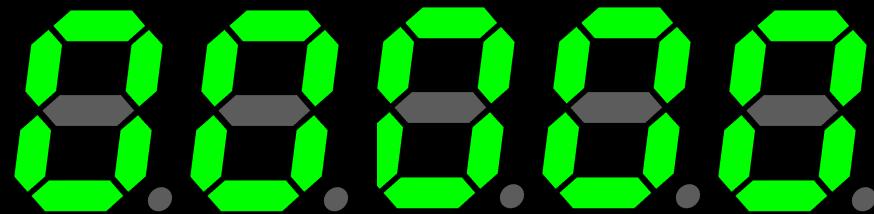
Integrated Circuits...

So many more!

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



- 7-Segment Display Driver (MC14489B)

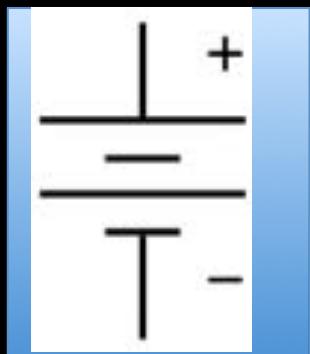


- Check out Adafruits's [General IC's](#) page for more!

Choosing ICs

Voltage & Current

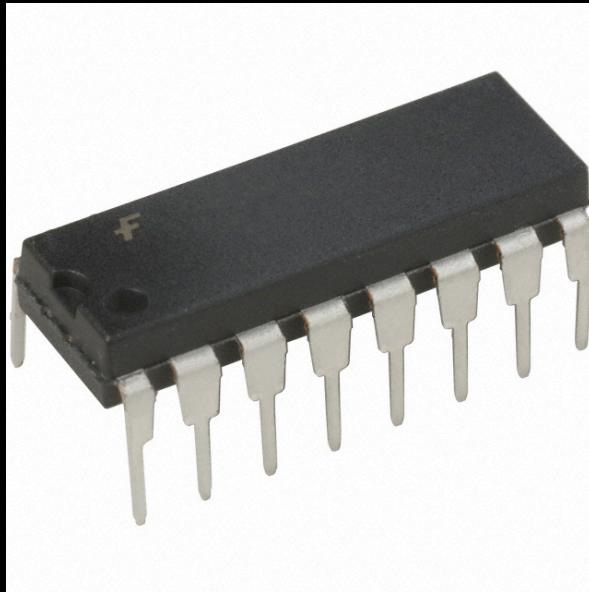
Choosing parts with the same operating voltage will save major headaches and components!



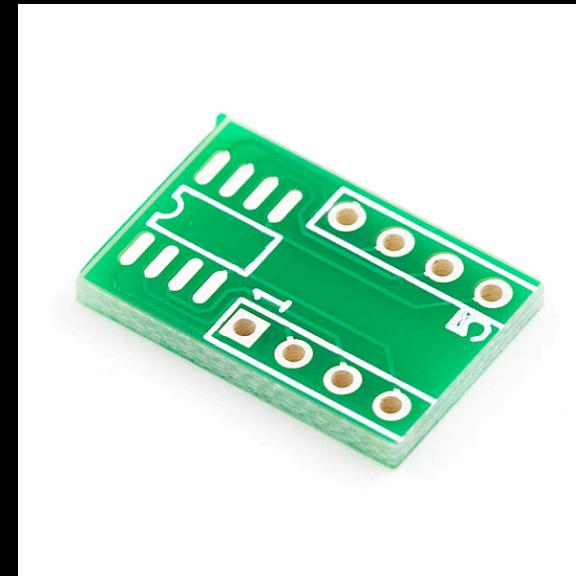
Keep your power source in mind.. USB, batteries, and voltage regulators can only provide so much current.

Choosing ICs

Packaging



16-DIP



8-SOIC to DIP Adapter

Choosing ICs

Communication Interface

Atmega168 Pin Mapping

Arduino function

reset

SPI?

VCC

I₂C?

digital pin 6 (PWM)

digital pin 7

UART?

Arduino function	Pin	Arduino function
(PCINT14/RESET) PC6	1	28 PC5 (ADC5/SCL/PCINT13)
(PCINT16/RXD) PD0	2	27 PC4 (ADC4/SDA/PCINT12)
(PCINT17/TXD) PD1	3	26 PC3 (ADC3/PCINT11)
(PCINT18/INT0) PD2	4	25 PC2 (ADC2/PCINT10)
(PCINT19/OC2B/INT1) PD3	5	24 PC1 (ADC1/PCINT9)
(PCINT20/XCK/T0) PD4	6	23 PC0 (ADC0/PCINT8)
VCC	7	22 GND
GND	8	21 AREF
(PCINT6/XTAL1/TOSC1) PB6	9	20 AVCC
(PCINT7/XTAL2/TOSC2) PB7	10	19 PB5 (SCK/PCINT5)
(PCINT21/OC0B/T1) PD5	11	18 PB4 (MISO/PCINT4)
(PCINT22/OC0A/AIN0) PD6	12	17 PB3 (MOSI/OC2A/PCINT3)
(PCINT23/AIN1) PD7	13	16 PB2 (SS/OC1B/PCINT2)
PKEO/ICP1) PB0	14	15 PB1 (OC1A/PCINT1)

Digital Pins 11,12 & 13 are used by the ICSP header for MISO, MOSI, SCK connections (Atmega168 pins 17,18 & 19). Avoid low-impedance loads on these pins when using the ICSP header.

Choosing ICs

Community Support

The screenshot shows the Arduino website's navigation bar at the top, featuring the Arduino logo, search, cart, and sign-in links. Below the navigation is a sidebar with various links related to hardware and software interfacing. The main content area is titled "Interfacing with Hardware" and discusses topics like connecting Arduino devices to various electronic parts, chips, and devices. It also mentions shields and provides a link to a table of shields and their pins. Another section covers current limits and pin limitations. The "Navigation" section lists categories like Output, Visual, Camera control, LED Lights and Displays, LCDs, OLEDs, Video Output, VFDs, and Audio.

ARDUINO

HOME BUY SOFTWARE PRODUCTS EDUCATION RESOURCES COMMUNITY HELP

Manuals and Curriculum
Arduino StackExchange
Board Setup and Configuration
Development Tools
Arduino on other Chips
Interfacing With Hardware

- Output
- Input
- User Interface
- Storage
- Communication
- Power supplies
- General

Interfacing with Software
User Code Library

- Snippets and Sketches
- Libraries
- Tutorials

Suggestions & Bugs
Electronics Technique
Sources for Electronic Parts
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Interfacing with Hardware

These topics cover the hardware and software setup required to connect an Arduino device with a variety of electronic parts, chips and devices. A related topic not covered under this section is the [shield](#), boards that plug directly into an Arduino's pin layout. Information on the creation and use of specific shields belongs in that section. Information on shields in general and their creation belongs [here](#).

See [here](#) for a table of shields and the Arduino pins they use.

Arduino has limits on how much current can be sourced or sunk by its I/O pins. When interfacing with hardware you need to be careful not to exceed these limits. For details see [ArduinoPinCurrentLimitations](#). In general, for AVR based Arduinos, do not exceed 20 mA per pin. In particular, do NOT directly connect LEDs to Arduino outputs! Always use a series resistor (220 ohms is a good value).

Navigation

Output

- Arduino as ISP
- Visual
 - Camera control
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 - LCDs
 - OLEDs
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<http://playground.arduino.cc/Main/InterfacingWithHardware>

Choosing ICs

Community Support



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WANT MORE?? Dont forget to see everything else in the [Part selector index!](#)

Introduction

General notes:

- The **C** or **I** after the name is Commercial or Industrial temp.
- The **P** or **N** after the name indicates DIP package

Where else to find chips

Hopefully we (and other nice people) will be able to keep the distributor links current. But if we cant you can always search at <http://www.findchips.com> or <http://www.octopart.com> for other distributors such as Arrow, Avnet, Future, Jameco, etc. If you have a non-US distributor you use please add the links below so people outside the US can buy from their local shops.

Power Supply

Please see [vreg](#) for regulators & other power converters

Op amps!

Op amps are like the flavor crystals of electronics!

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- ❖ RTC
- ❖ I/O Expanders and MUXes
- ❖ Mystical (Obsolete)