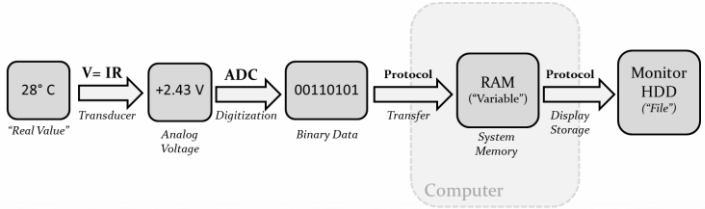


Part 1: Introduction to Data Acquisition (DAQ) - *Input*

How do you get data *into* (and *out of*) a computer?

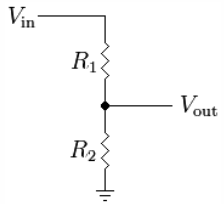
Data Acquisition (DAQ)

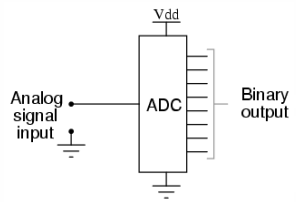
Definition

The process of measuring a real-word value via voltage conversion, digitization, and transfer to system memory. (for subsequent processing and storage).

What is the temperature outside?

*How do you get that **value** into a computer?*





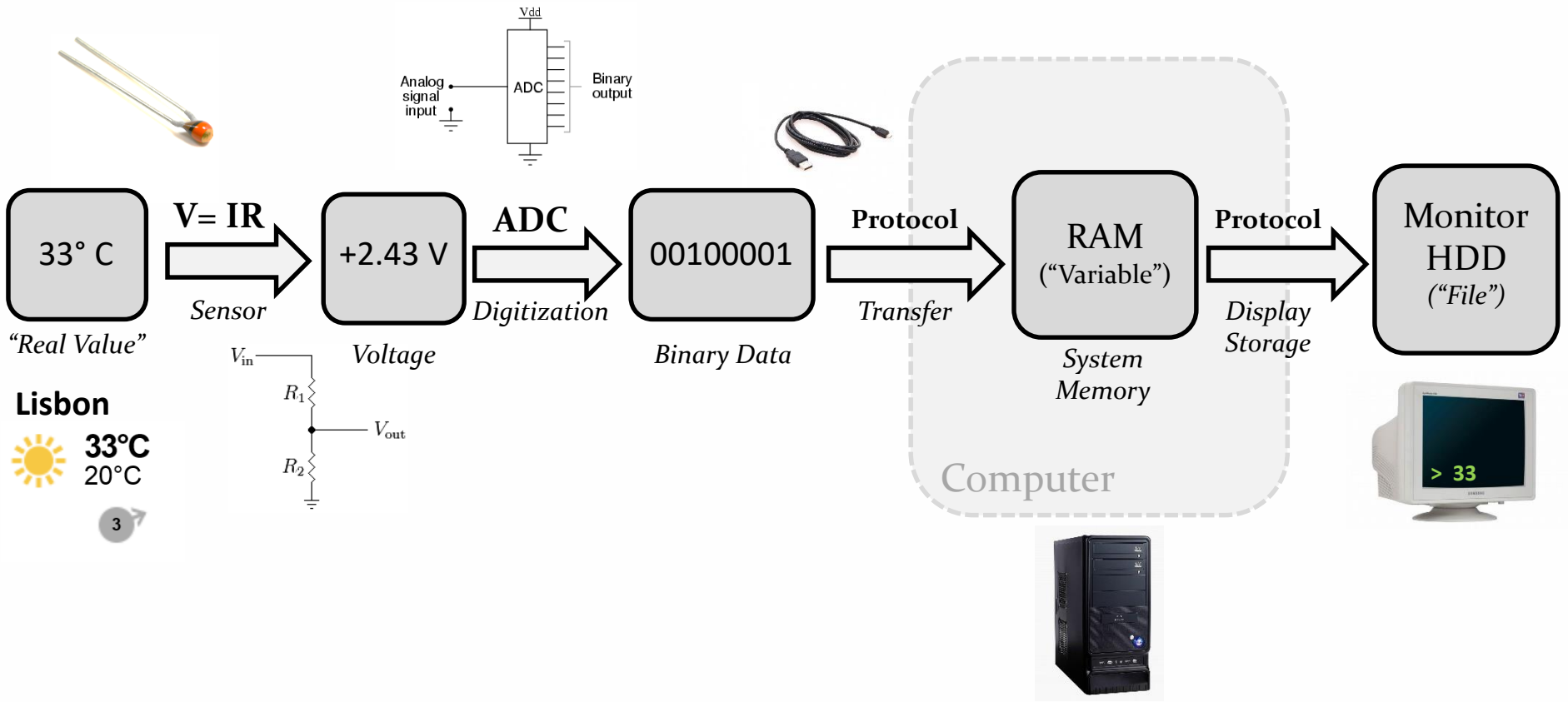
Utility

Without DAQ, then we would all be theoretical neuroscientists.

Data Acquisition (DAQ)

Definition

The process of measuring a real-word value via voltage conversion, digitization, and transfer to system memory. (for subsequent processing and storage).



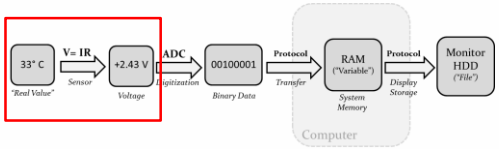
Utility

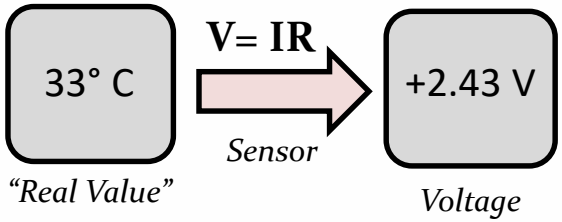
Anything is measurable…and everyone should no how to do this.

Sensor (voltage transducer)

Computers can only measure voltage. Therefore, any real-world quantity must be converted into a voltage before it can be measured and digitized.

Definition





LDR, **Thermistor**, Photodiode, etc.

Camera, E-phys System

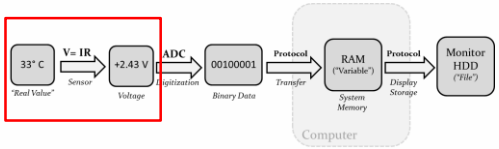
Microphone, Keyboard, Touchscreen

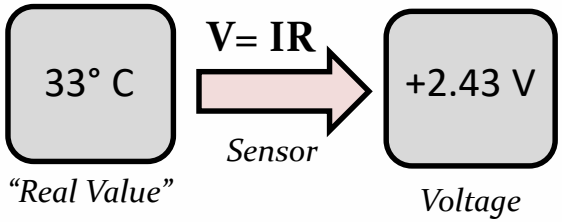
Utility

Ohm's Law

A linear relationship between Voltage, Current and Resistance exists for "Ohmic" circuit elements. This

Definition





V = IR

Ohm's Law

V - Voltage: Force pushing electrons (Volts)

I - Current: Number of electrons/second (Amps)

R - Resistance: Ease to electron flow (Ohms)

Ohm

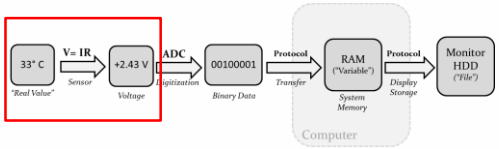
Utility

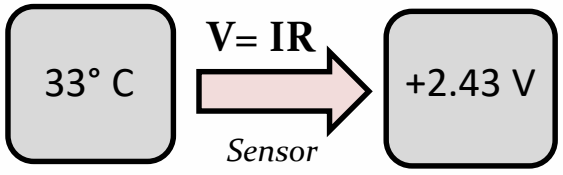
This linear relationship between passive circuit elements will solve the majority of electronics dilemmas.

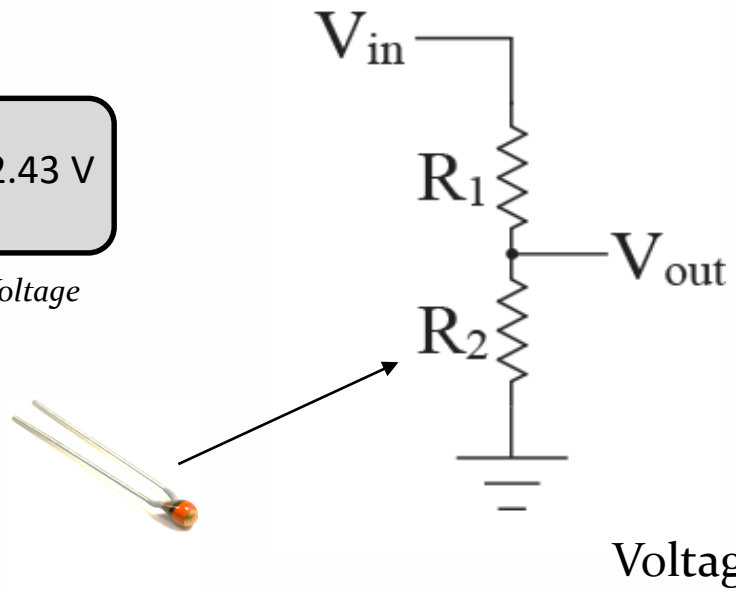
Voltage Divider

Two resistors will proportionally attenuate a voltage as current flows from a source to ground. This relationship can be used to create an intermediate voltage dependent on a variable resistor.

Definition







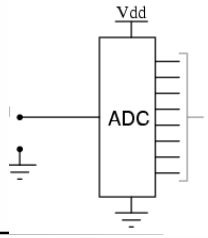
$$V_{out} = V_{in} * \frac{R2}{(R1 + R2)}$$

Voltage Divider

Utility

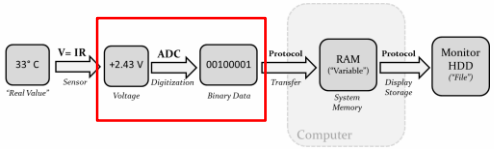
This circuit is everywhere in modern circuits. A sensor can be constructed by simply making one of the resistors dependent on a "real world" quantity. (pressure, temperature, light, rotation…sweat…anything!)

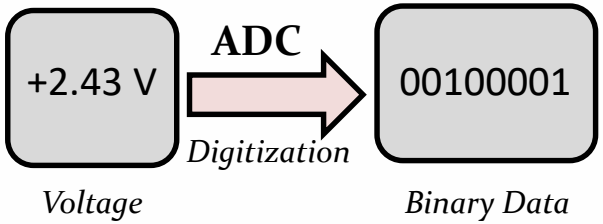
Analog to Digital Converter (ADC)

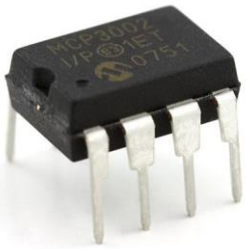


Definition

An integrated circuit that converts analog values to binary (digital) representation. They come in many flavours, speeds and bit depths.







An ADC converts analog voltage to a binary representation.

(Relevant Characteristics)

- **How fast?** (Sample Rate, Hz)
- **Resolution?** (#bits per sample)
- **Range** (of input voltage)

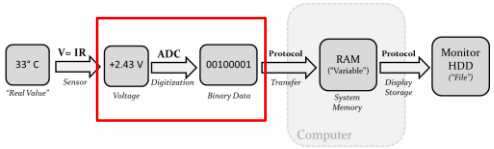
Utility

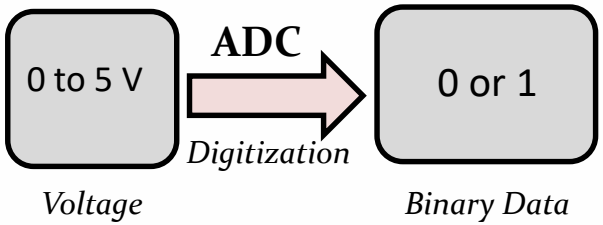
ADCs are everywhere. In your digital cameras, smartphone, and GPS. Everything a computer knows about the "real-world" goes through an ADC. There are many types, with many different features (speeds, resolution, noise, channels…).

Digital Input

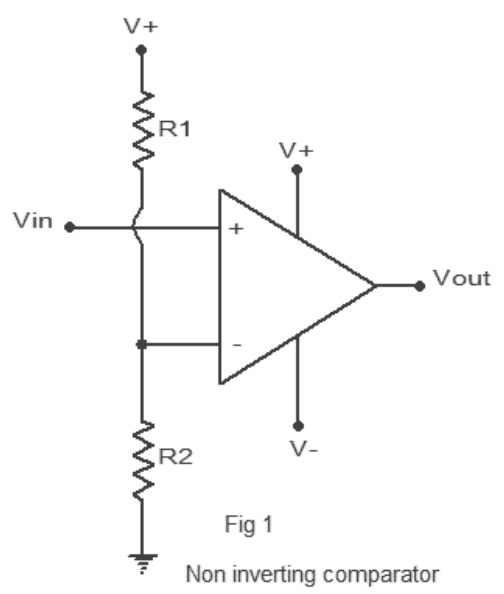
Definition

The process of measuring a real-word value via voltage conversion, digitization, and transfer to system memory. (for subsequent processing and storage).





Voltage Comparator



The simplest ADC: *1-bit*

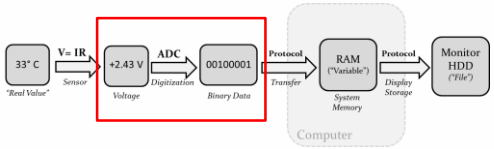
Utility

The "simplest" computer input. 0 or 1.

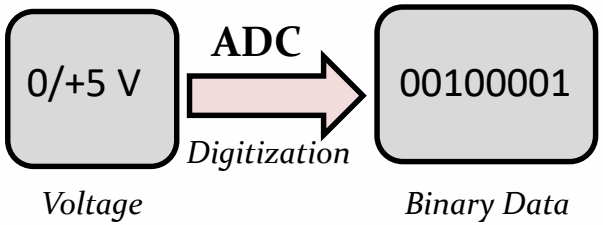
Analog Input: Flash ADC

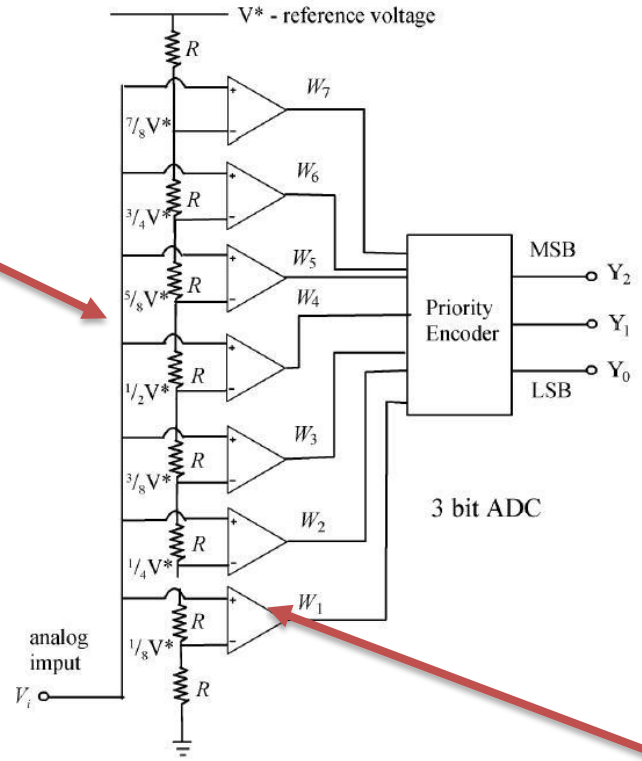
Definition

The process of measuring a real-word value via voltage conversion, digitization, and transfer to system memory. (for subsequent processing and storage).



Serial Voltage Divider





Flash ADC

Fast
Low Bit Depth
Large!

Comparator

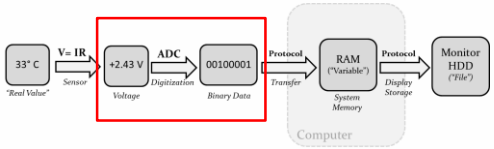
Utility

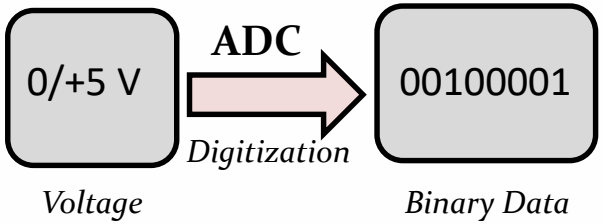
An easy to understand, but not often used version of an ADC. Very, very fast…but low bit depth.

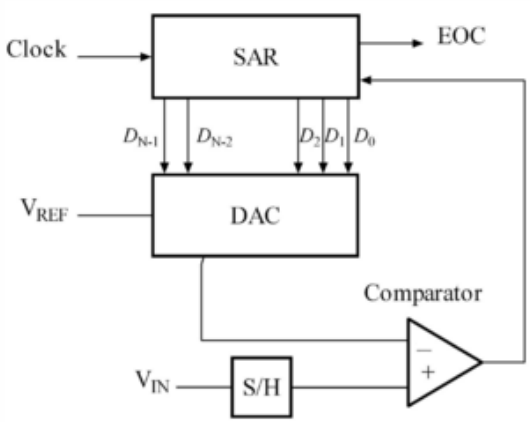
Analog Input: Successive Approximation ADC

Definition

The process of measuring a real-word value via voltage conversion, digitization, and transfer to system memory. (for subsequent processing and storage).







Successive Approximation ADC

Slow(er)
High Bit Depth
Small

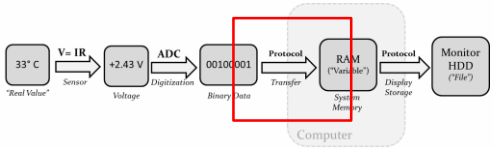
Utility

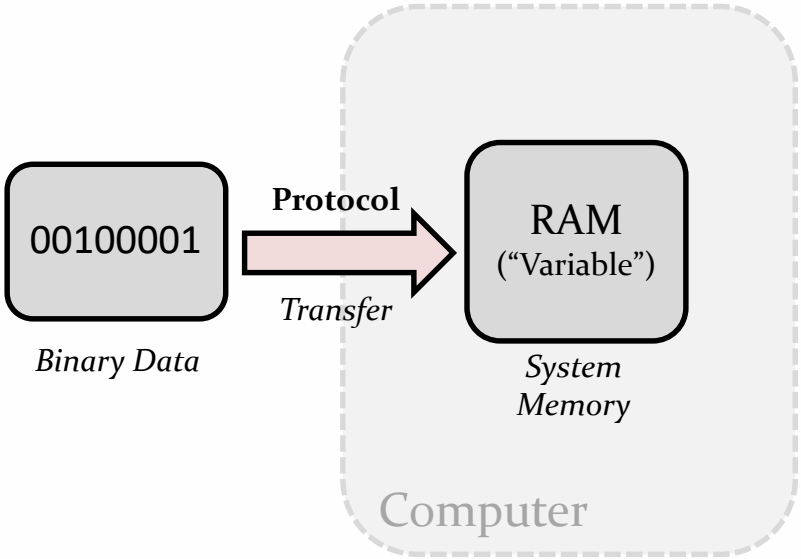
Much more common form of ADC.

Communication Protocol

A standard procedure for transferring binary information between digital devices,

Definition



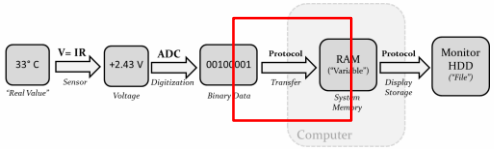


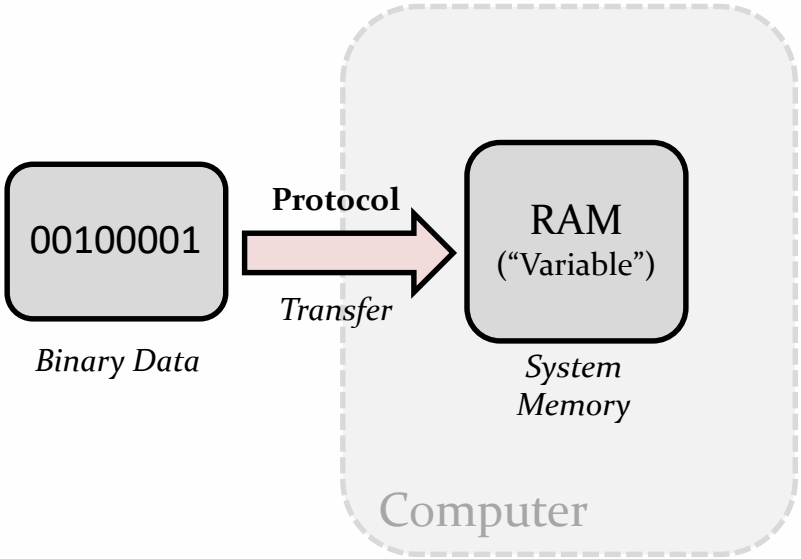
Utility

Serial Port (USART/USART – RS-232)

A standard procedure for transferring binary information between digital devices,

Definition



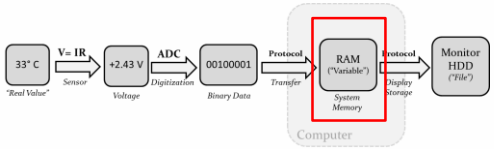


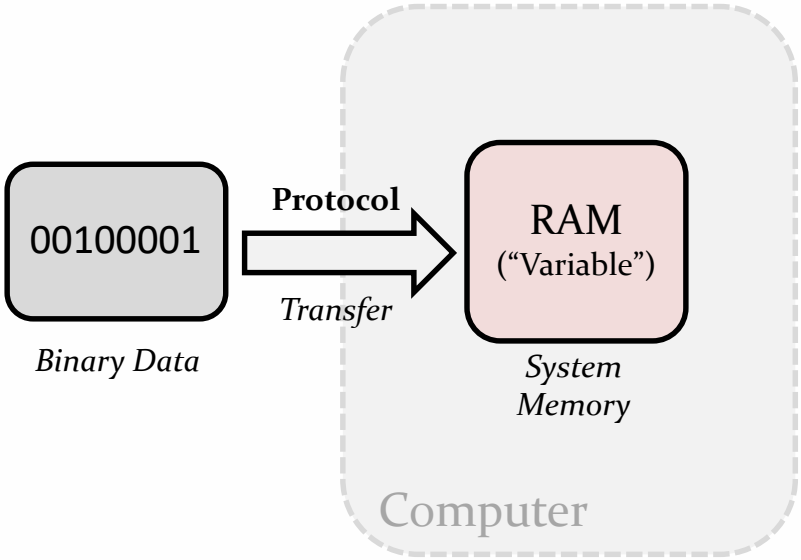
Utility

System Memory (RAM)

Definition

The process of measuring a real-word value via voltage conversion, digitization, and transfer to system memory. (for subsequent processing and storage).





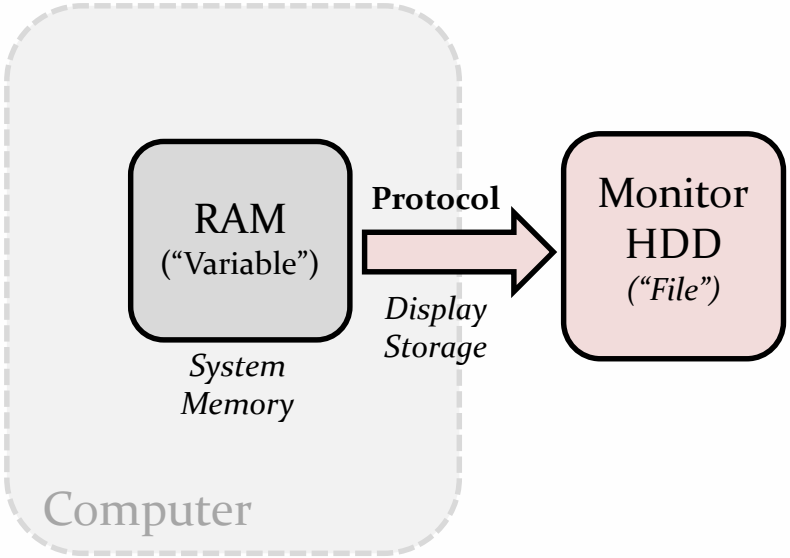
Utility

You can only "work" with data in System memory. This is where you can start doing analysis…roting data to other devices for control of storage. This is when your data is IN the computer.

Data Display/Storage

This is technically data "output"…but just for completeness.

Definition

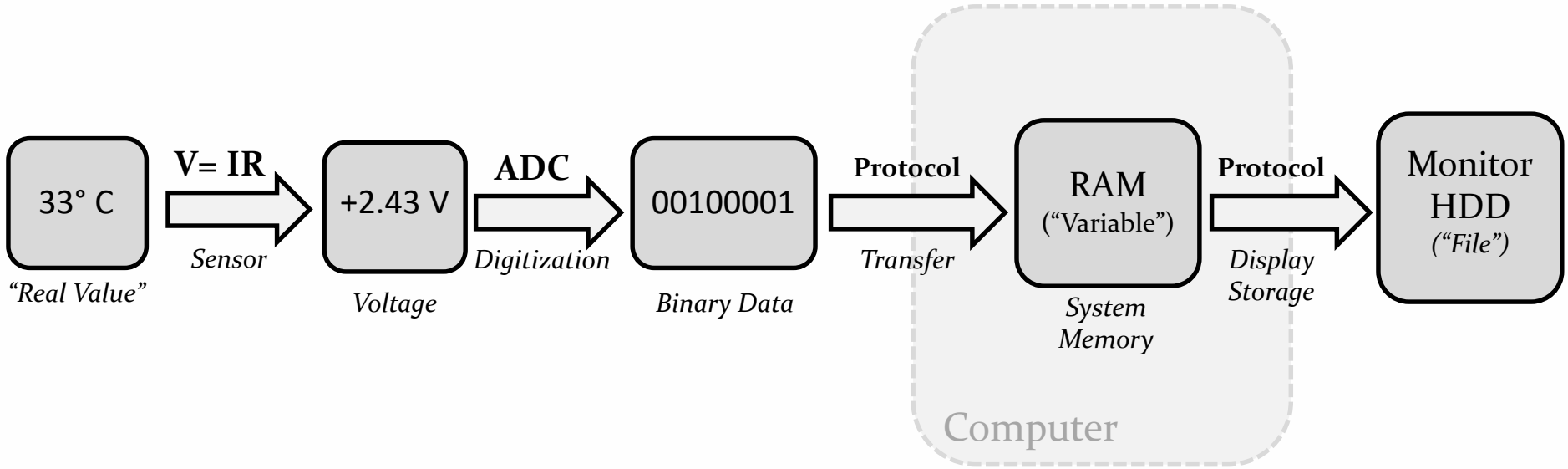


Utility

Data Acquisition (DAQ)

Definition

The process of measuring a real-word value via voltage conversion, digitization, and transfer to system memory. (for subsequent processing and storage).



Utility

This is how computers know about the world.

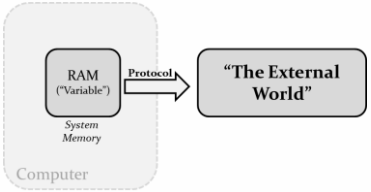
Microcontroller Worksheet

DAQ and Control with a simple microcontroller.

Definition

We 

Utility



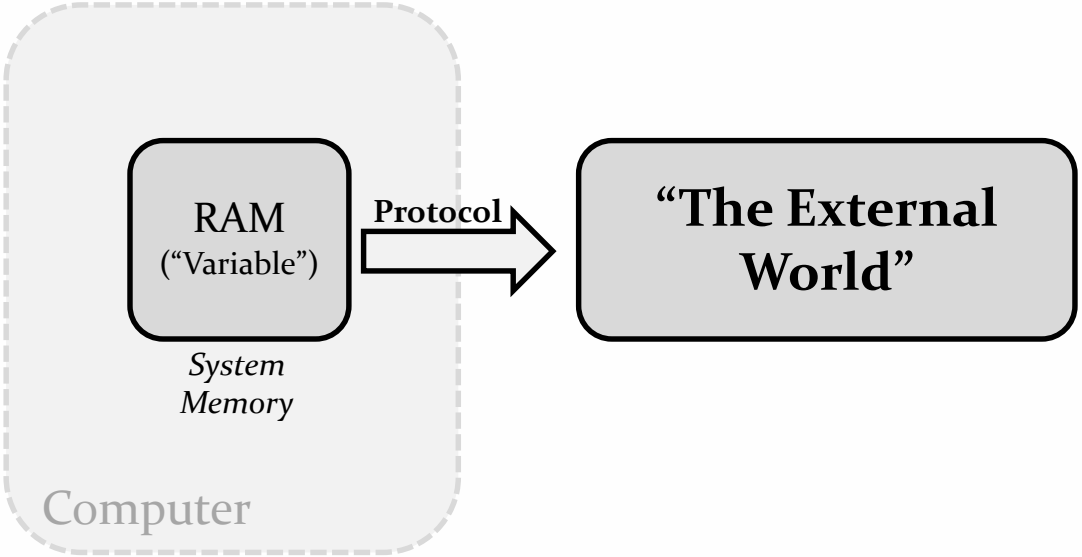
Part 2: Introduction to Actuation– *Output*

How do you get data *into* (and *out of*) a computer?

Control (with a binary computer)

Conversely to acquisition, computers can only output voltages.

Definition



If you want to...

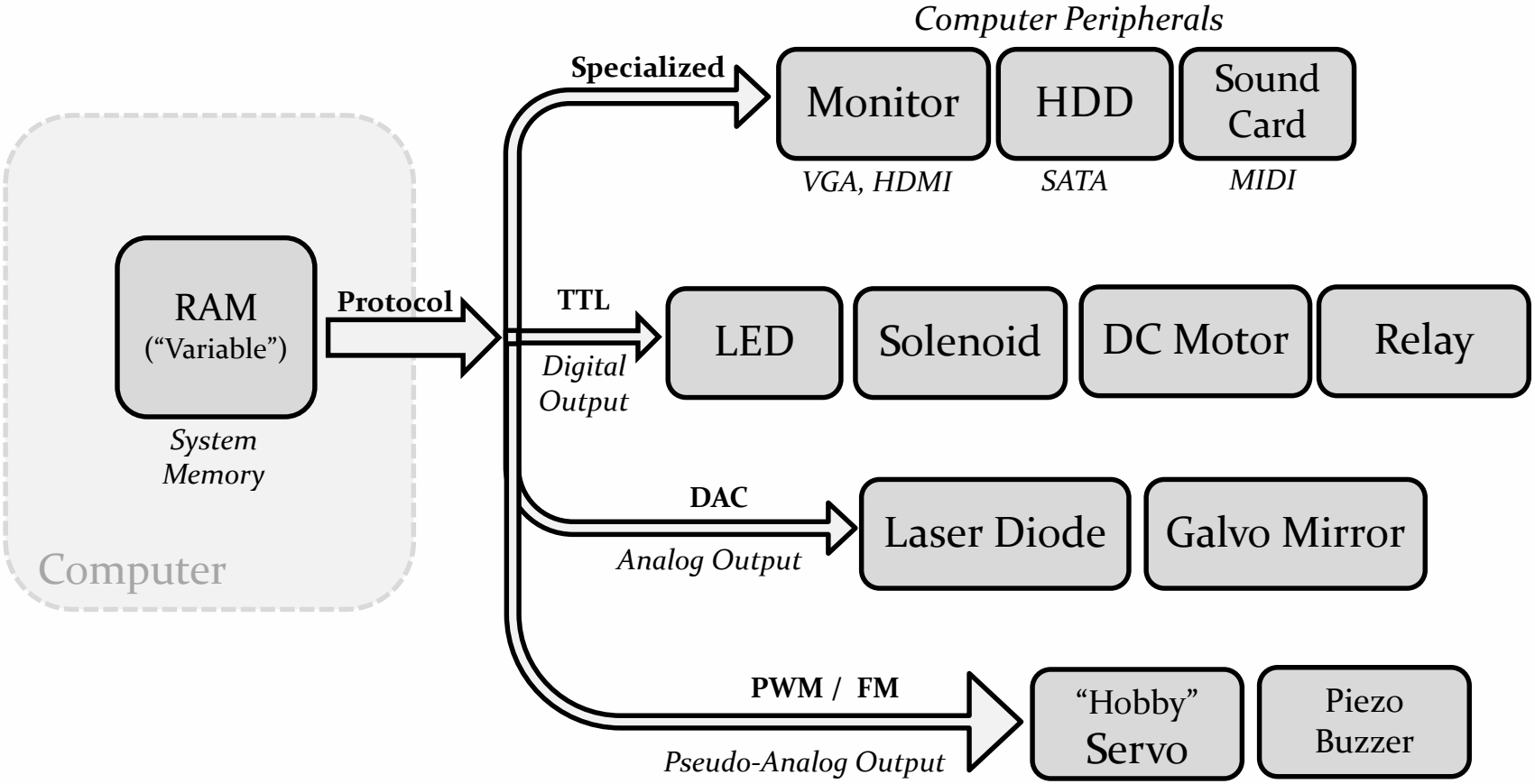
"Play a tone"
"Make something move"
"Turn on a light"
"Open a valve"
"Show a movie"
... etc.

Utility

Control (with a binary computer)

Conversely to acquisition, computers can only output voltages.

Definition

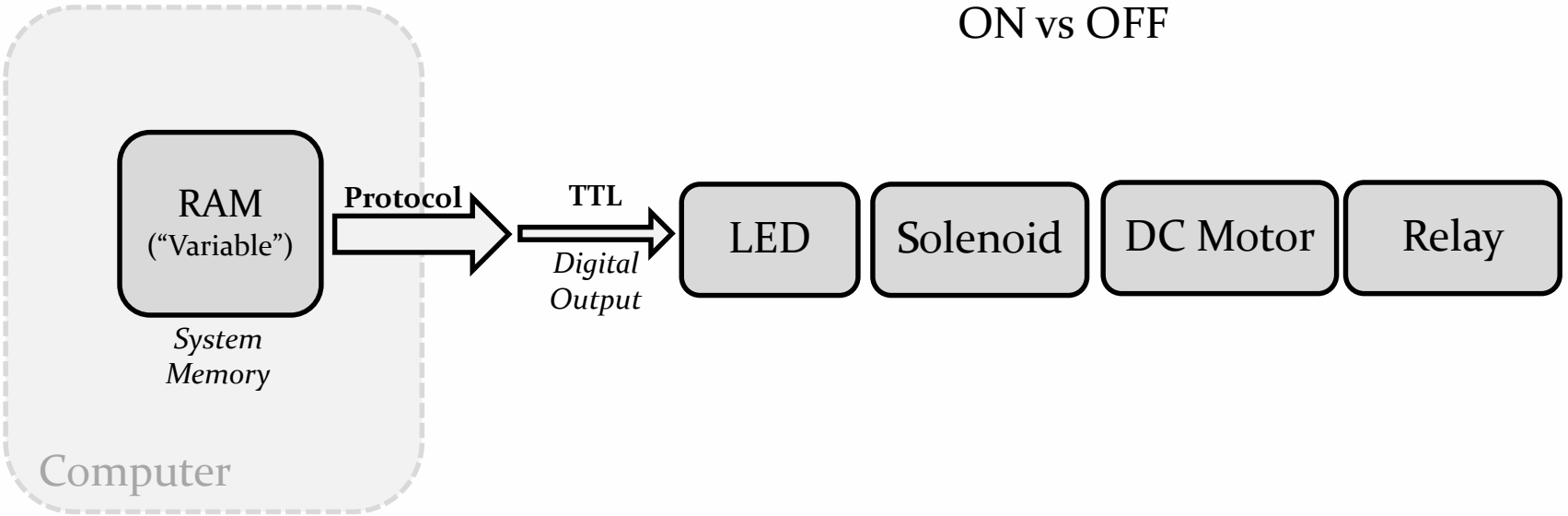


Utility

Digital Output

Conversely to acquisition, computers can only output voltages.

Definition



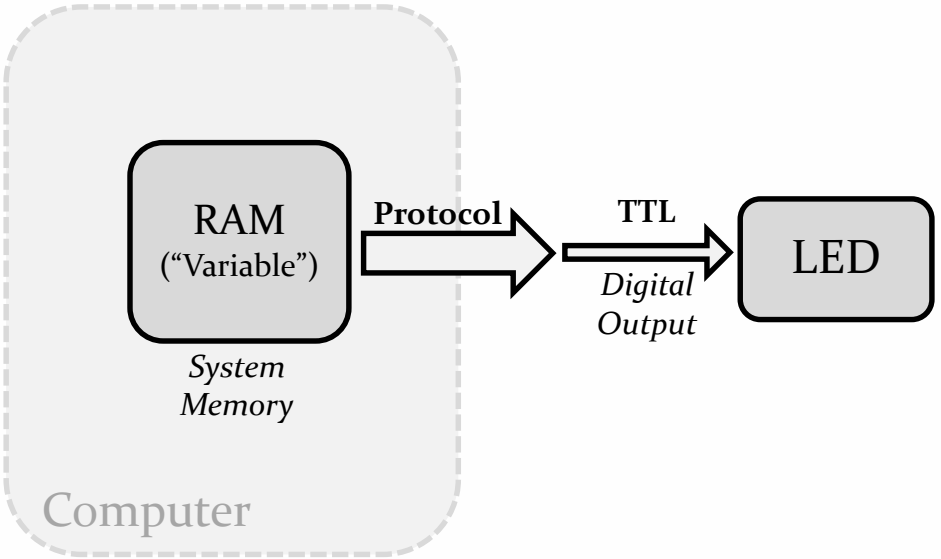
Utility

TTL: Transistor-Transistor Logic

Conversely to acquisition, computers can only output voltages.

Definition

0 to +5 *Volts*

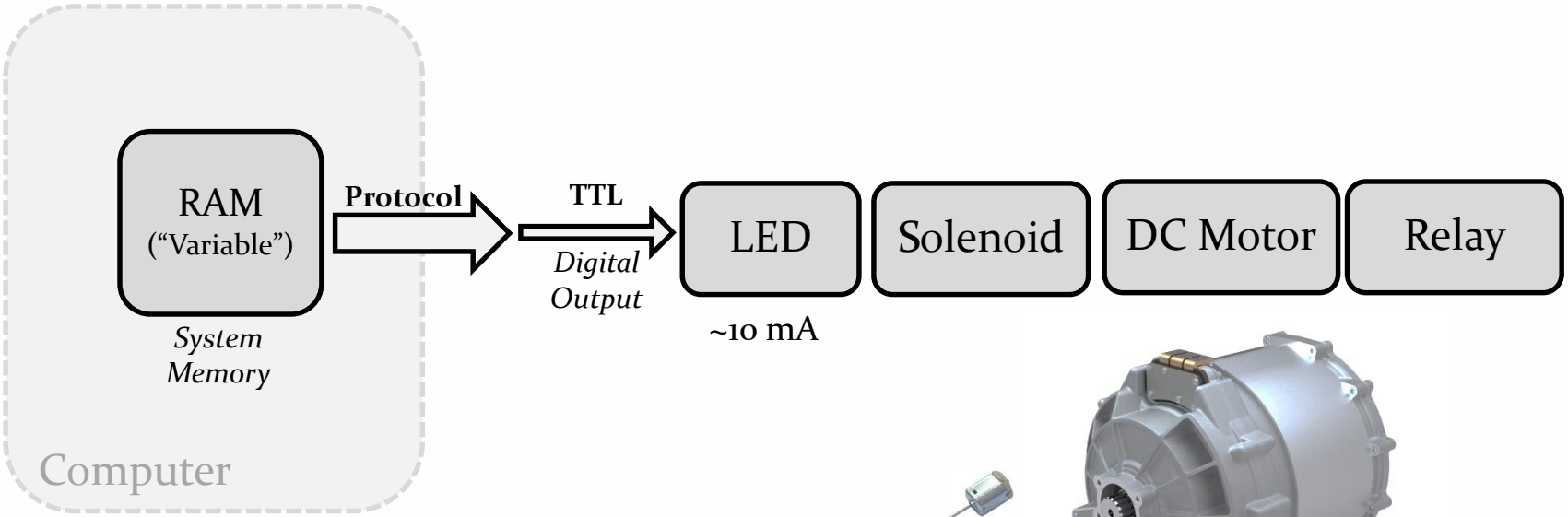


Utility

Digital Output

Conversely to acquisition, computers can only output voltages.

Definition



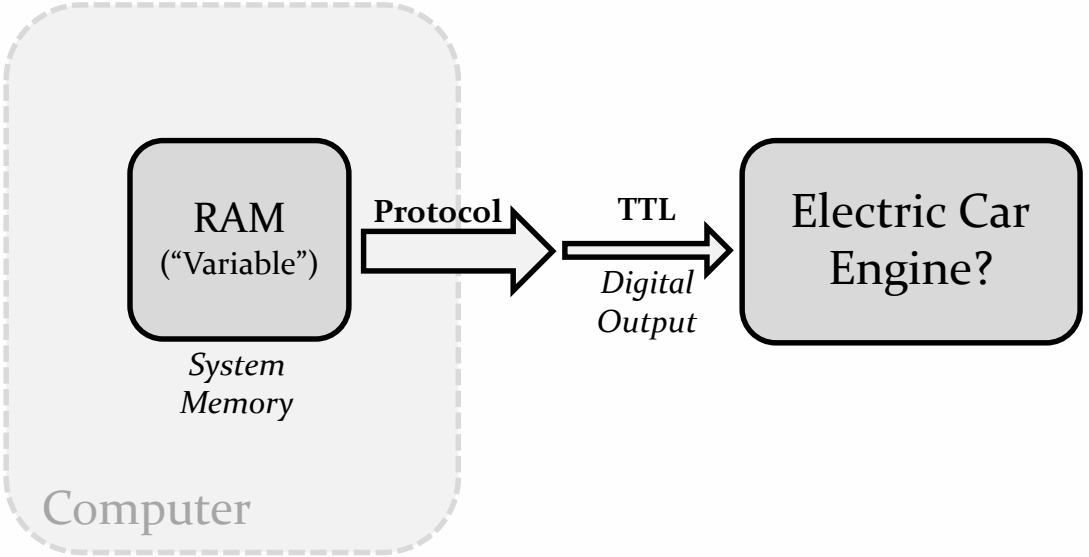
Can you start ("jump") your car with a USB port?

Utility

Electrical Load

An element in a circuit that consumes power. The more power consumed, the "heavier" the load.

Definition



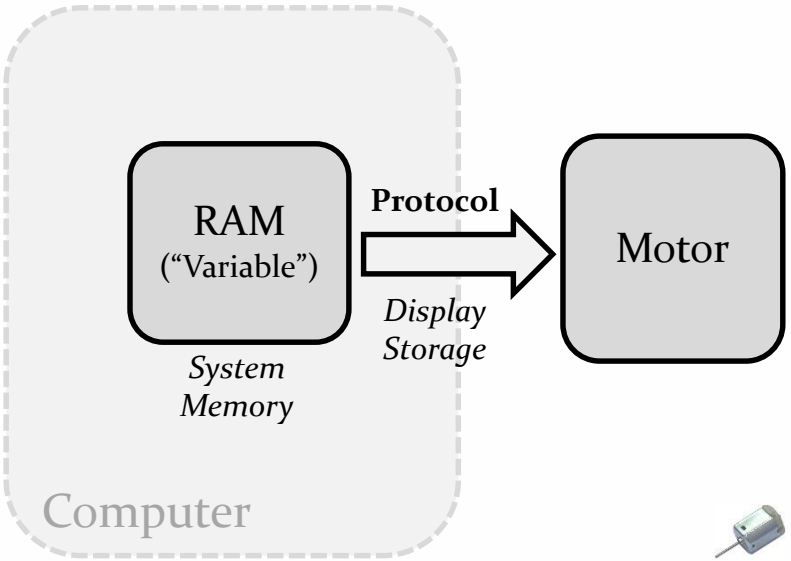
Power = V*I = $V*R^2$

Utility

Digital Output (Heavy Loads: > 100 mA)

Conversely to acquisition, computers can only output voltages.

Definition



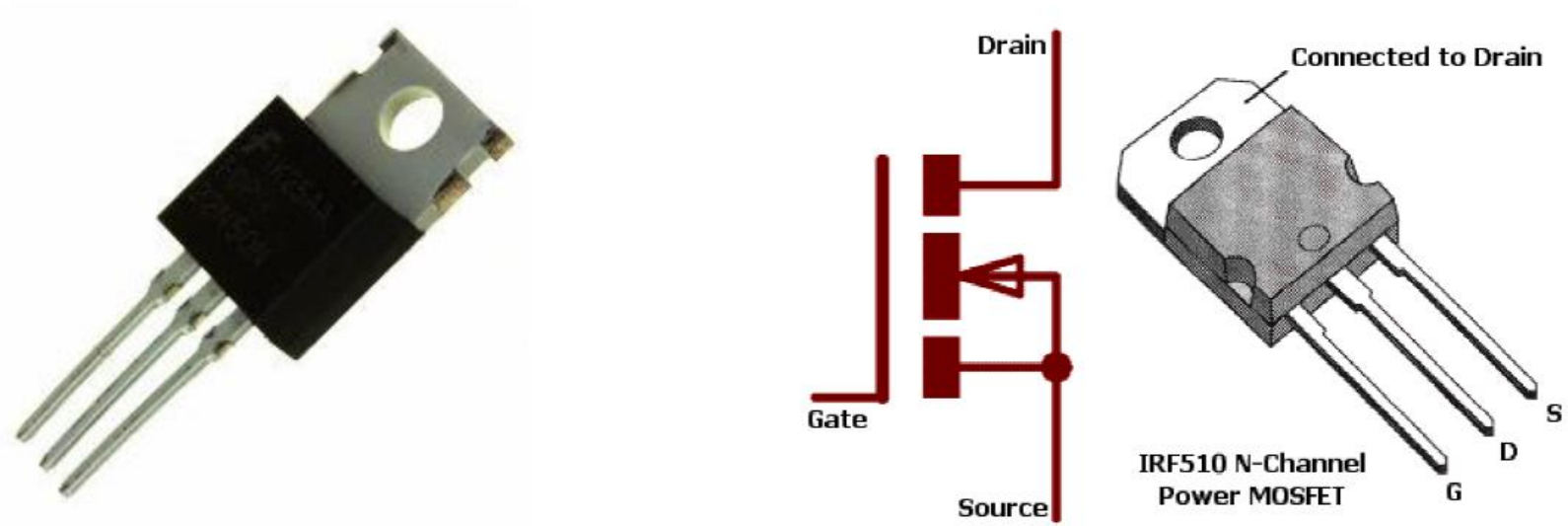
- "Make something move"
- "Turn on the room lights"
- "Drive a high power laser"
- ...

Utility

Transistor (MOSFET) Switch

PN-Junction, Gate, Holes, Doping, and more!

Definition



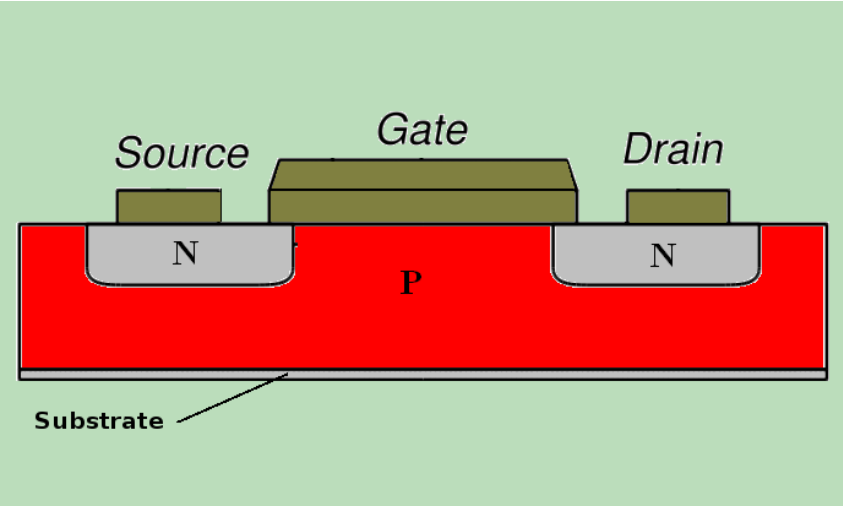
MOSEFT: Photo and Schematic of IRF510

Utility

The Silicon Transistor

PN-Junction, Gate, Holes, Doping, and more!

Definition



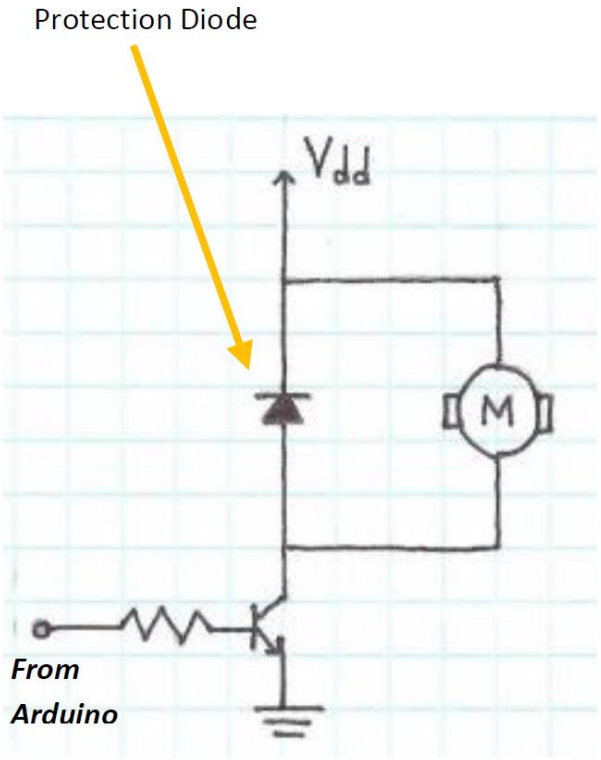
Utility

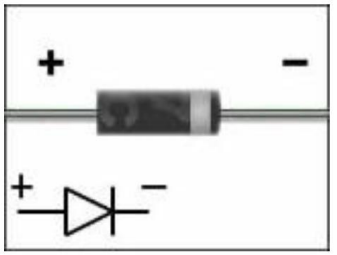
Transistor: Switching Inductive Loads

Current caused by induction can cause negative current flow (backwards), which can damage

Definition

Protection Diode





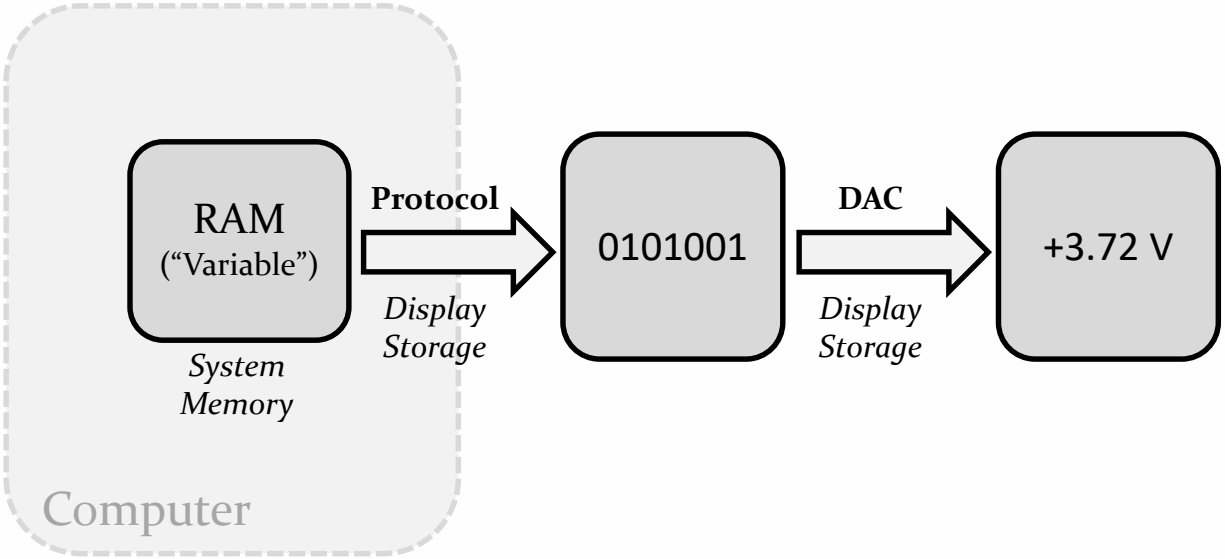
Diode: Picture and Schematic (with polarity)

Utility

Analog Output

Conversely to acquisition, computers can only output voltages.

Definition

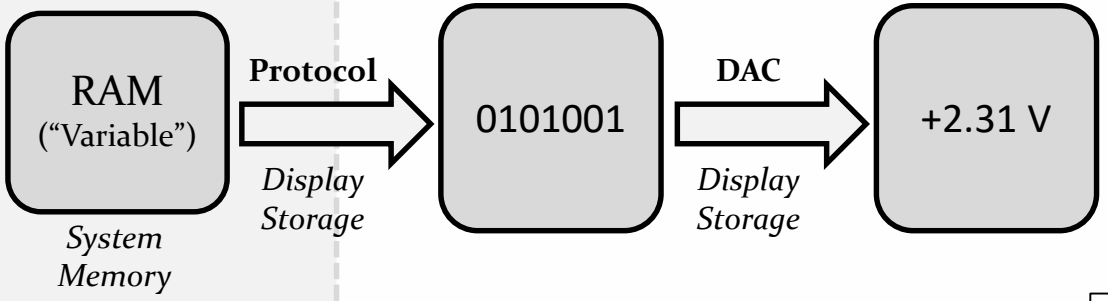


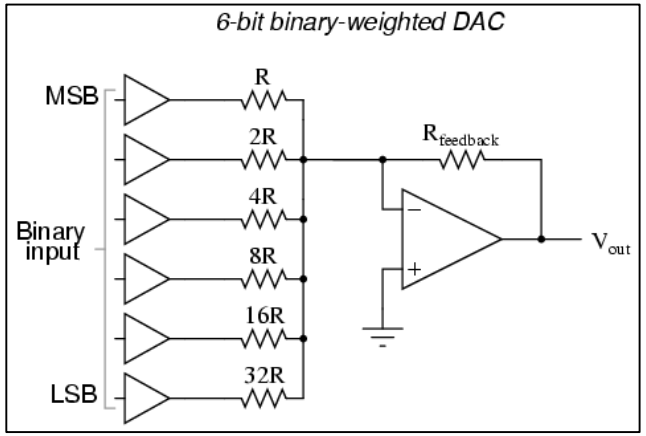
Utility

Digital-to-Analog Converter (DAC)

Conversely to acquisition, computers can only output voltages.

Definition





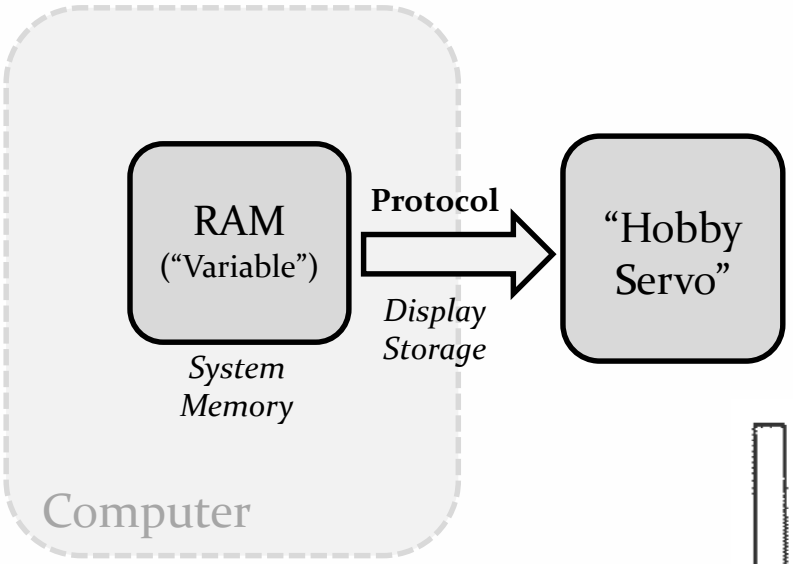
Note: The Arduino Uno has ***no*** DACs.

Utility

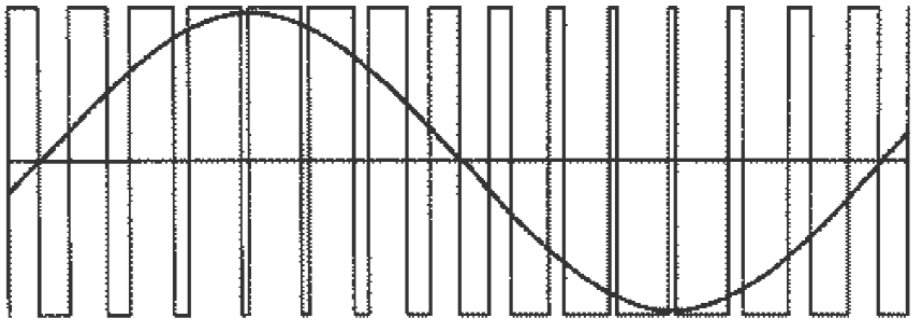
Pulse-Width Modulation (PWM)

Pesudo-Analog Output. Duty-cycle approximates an analog value.

Definition



PWM
(approx. sinewave)

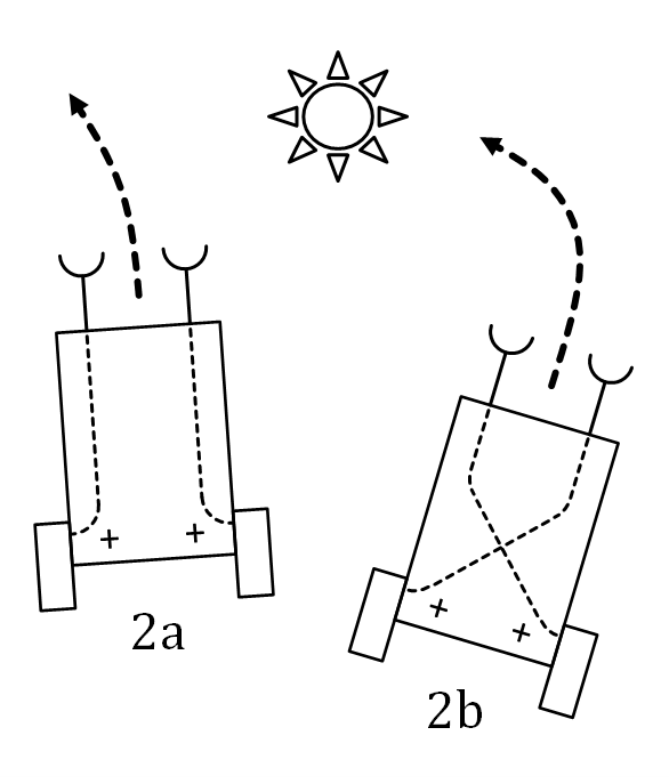


Utility

Vehicle Project

Autonomous Braitenberg vehicles that follow (or avoid) light.

Definition



Utility