Data Communications

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Serial vs Parallel

- Serial communications
  - Bits are sent one at a time
  - Which bit is sent first? MSB? LSB?
- Parallel communications
  - Multiple bits are sent at once
  - Requires multiple “wires”, potentially faster.
- Serial is more common because of easier hardware requirements (fewer wires matters a lot for long distances).

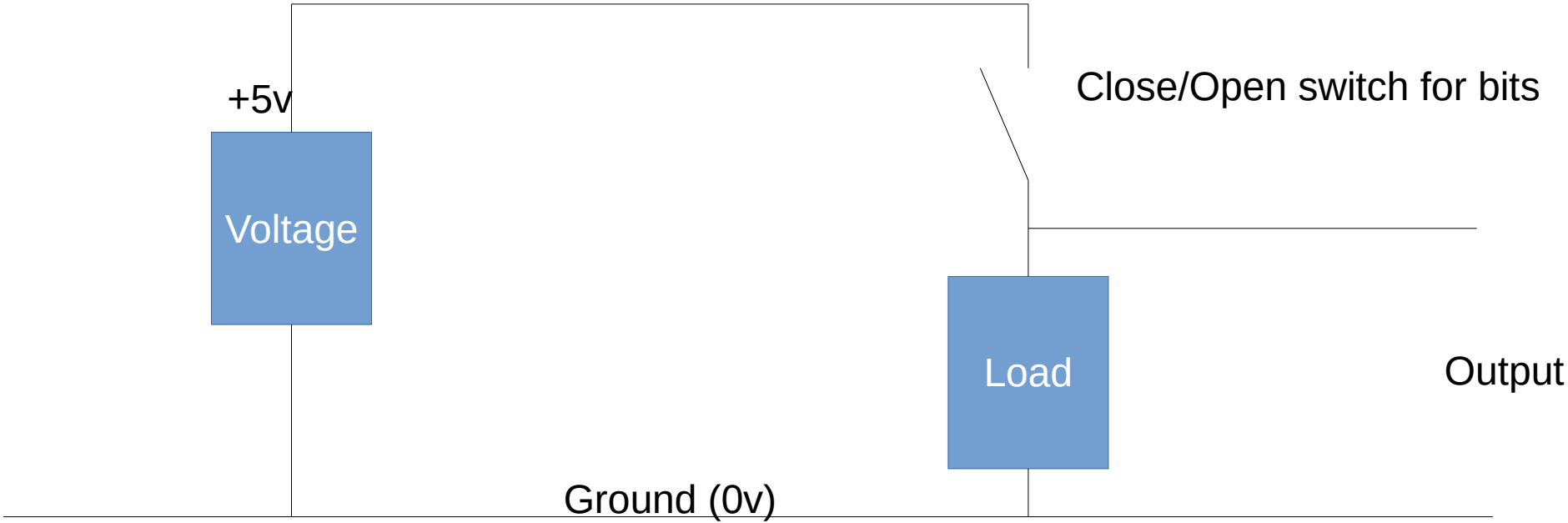
Synchronous vs Asynchronous

- Synchronous
  - Data transfer synchronized with a common clock signal
- Asynchronous
  - Sender sends at will, receiver must “sync up” with the signal
  - Generally more practical: senders and receivers can’t usually share a common clock (at the speeds of interest).

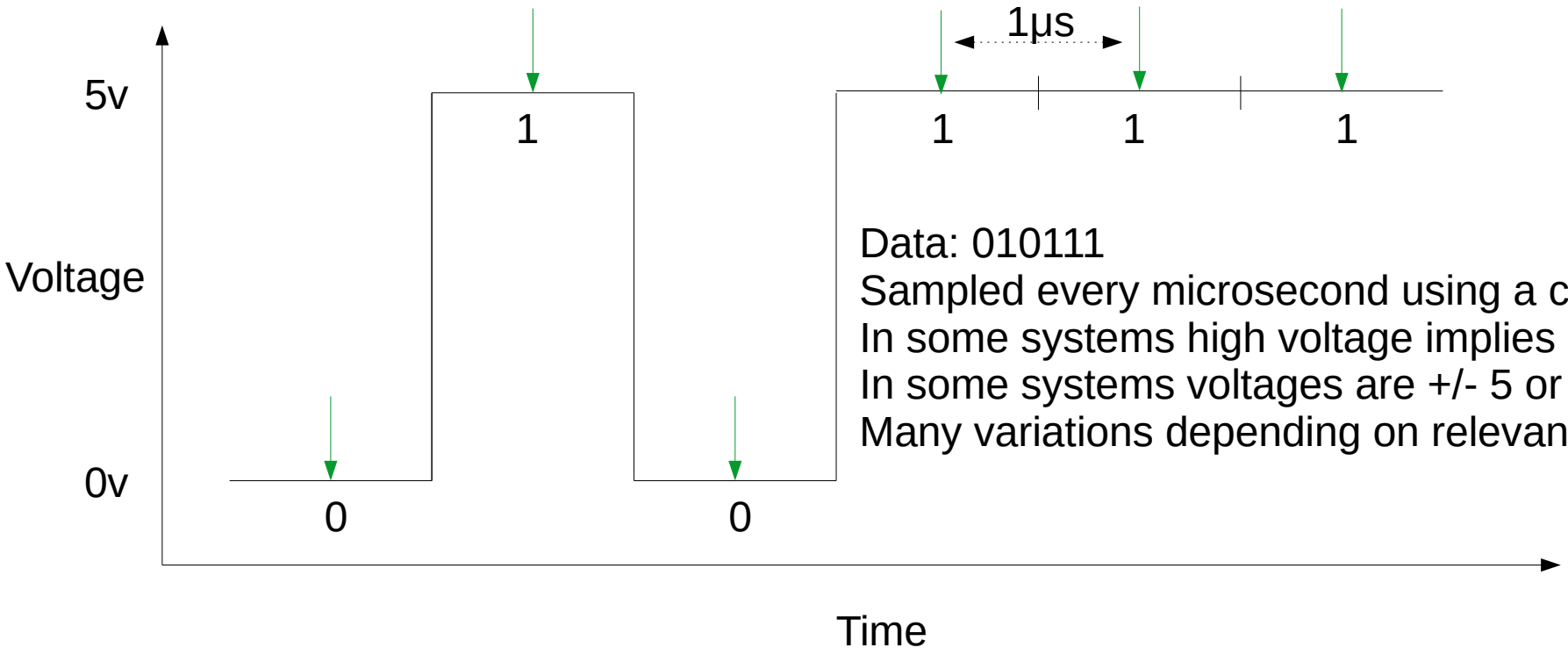
Digital Data

- Digital Data is just ones and zeros or “on” and “off.”
  - Very simple conceptually
- Multiple States?
  - What if we had four signal levels instead of two? Then we can send two bits at a time: level 1 => 00, level 2 => 01, level 3 => 10, level 4 => 11.
  - State transitions per second = “baud” rate. Bits per second = bit rate.
  - A four level system with a baud rate of 2400 might be able to send 4800 bits/s.

Simple Sending Circuit

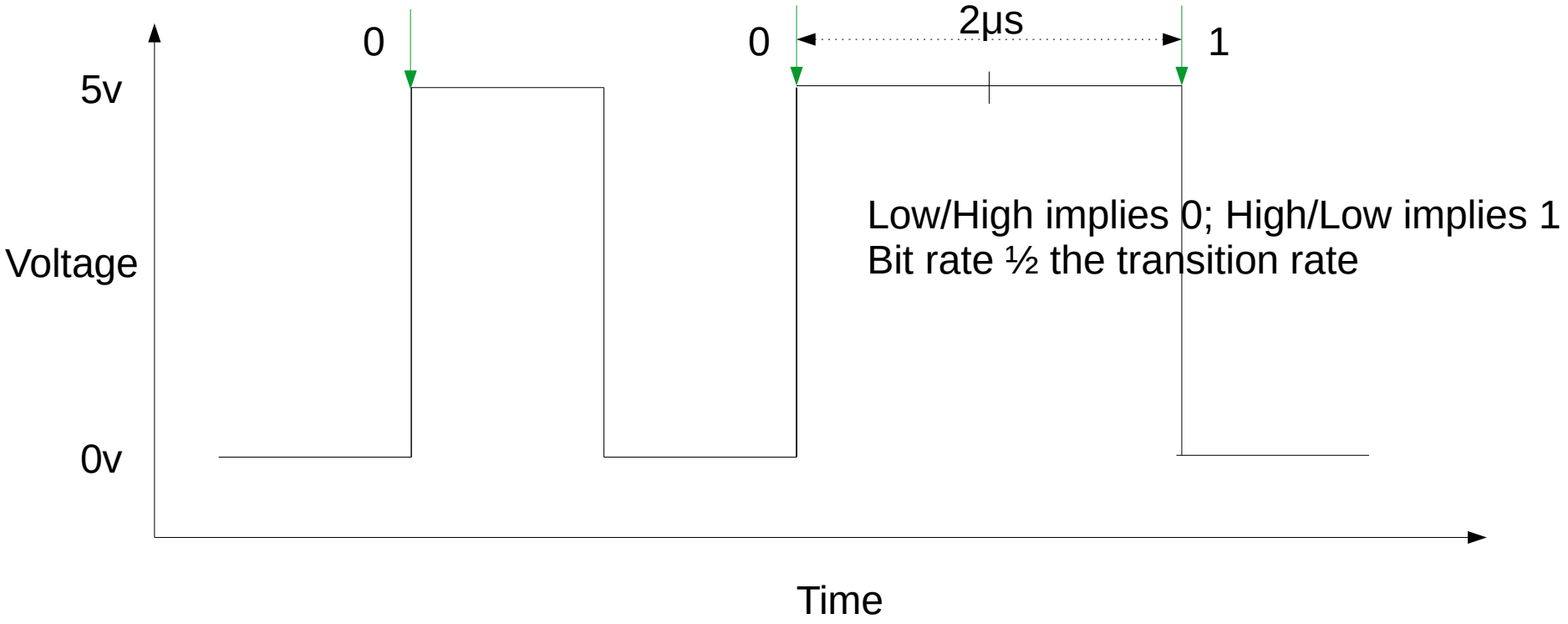


Sending Waveform #1

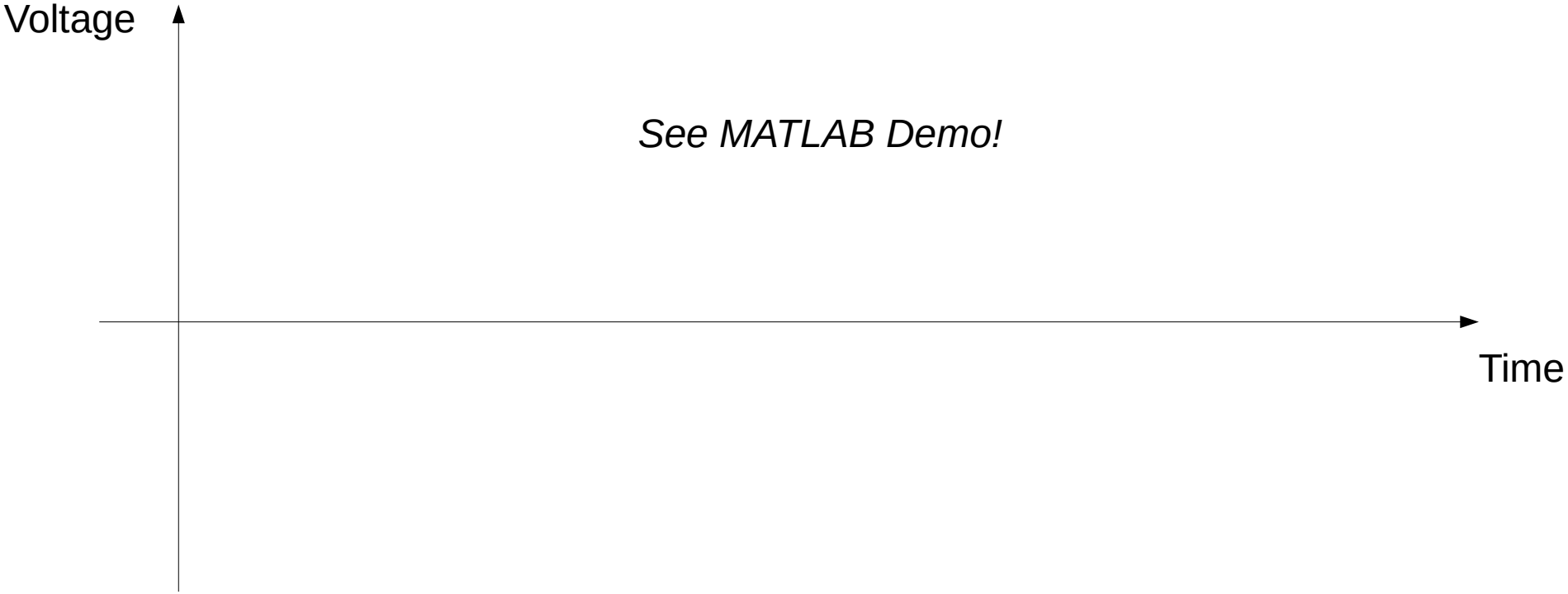


Data: 010111
Sampled every microsecond using a clock
In some systems high voltage implies “0”, etc.
In some systems voltages are +/- 5 or +/- 12
Many variations depending on relevant standard

Sending Waveform #2



Analog Communications



See MATLAB Demo!

Amplitude Modulation

- The amplitude of a “carrier frequency” is modulated (varies)
  - Simple to implement and decode
  - Susceptible to noise
- Bandwidth approximately twice the modulation frequency
- AM Radio (530 KHz to 1700 KHz)
  - Stations separated by 10 KHz
  - Maximum modulation frequency ~5 KHz (not high fidelity)

Frequency Modulation

- The carrier frequency is modulated according to the signal.
  - Less susceptible to noise
  - Tends to require greater bandwidth, but the relationship is complex.
- FM Radio (88.1 MHz to 107.9 MHz)
  - Stations separated by 200 KHz.
  - Stations send L+R and L-R and then decode two channels:

    (L+R) + (L-R) = 2*L

    (L+R) – (L-R) = 2*R

Phase Modulation

- Amplitude and Frequency remains constant, the signal’s phase is modulated instead.
  - Similar in some ways to frequency modulation, trickier to decode.

Digital Modulation

- ASK: Amplitude Shift Keying
  - 1/0 data encoded as amplitude changes
- FSK: Frequency Shift Keying
  - 1/0 data encoded as frequency changes
- PSK: Phase Shift Keying
  - 1/0 data encoded as phase changes.