

EECS 373: N64 Controller

How it Works



Introduction

- The Controller
- Components:
 - Buttons
 - Joystick
 - Memory/Rumble Pack
- Communication with External Devices
 - Hardware
 - Protocol
 - Arbitration
 - Commands

The Controller

- 14 Buttons
 - Four buttons arranged as a directional pad on the top left (up, down, left, right)
 - Start button in the top middle (start)
 - Six action buttons on the top right (A,B, 4 c's)
 - One action button on the front left (L)
 - One action button on the front right (R)
 - One action button in the bottom middle (Z)
- Analog joystick on the top middle
- Optional Rumble or Memory Pack



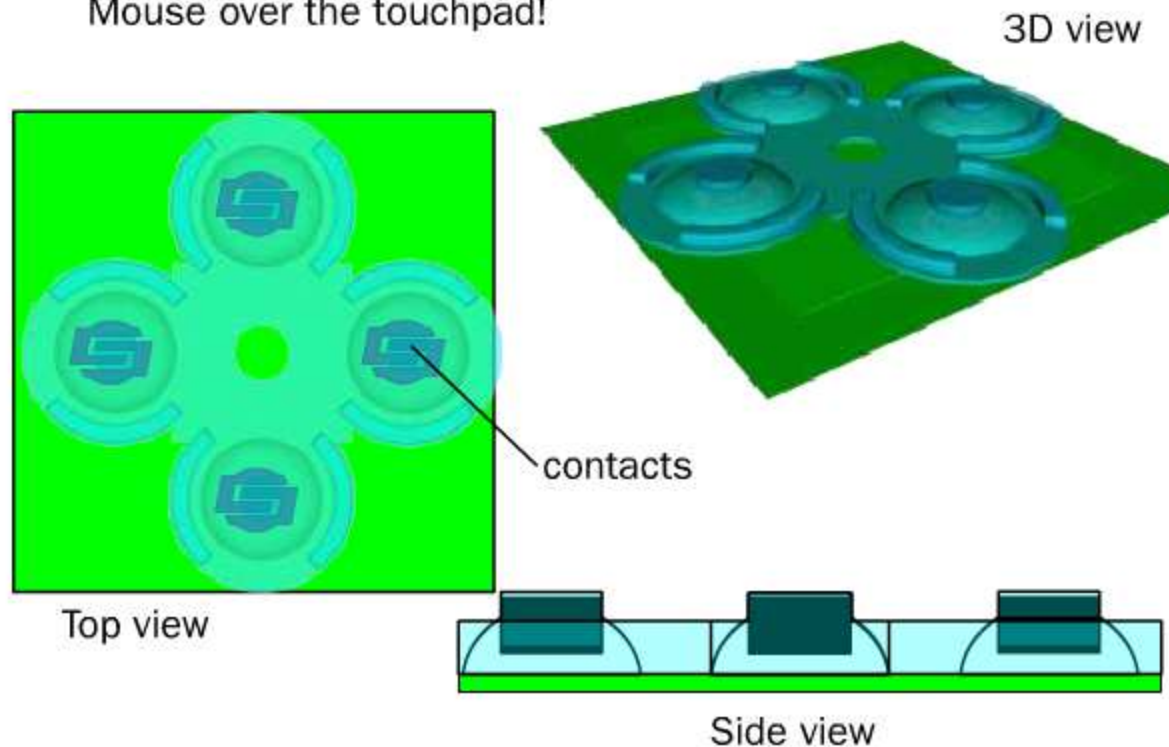


Components: Buttons

- A small metal disk beneath the button is pushed into contact with two strips of conductive material on the circuit board inside the controller.
- While the metal disk is in contact, it conducts electricity between the two strips.
- The controller senses that the circuit is closed and remembers that data to send to the N64.

Buttons

Mouse over the touchpad!



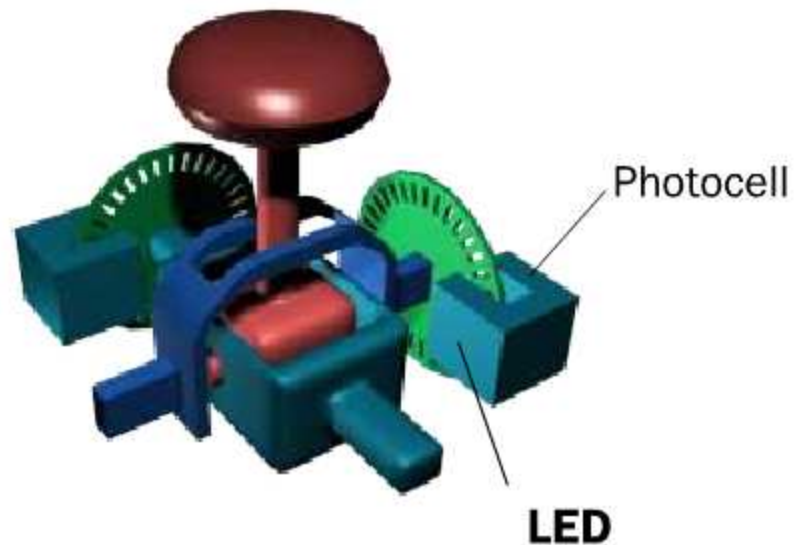
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Components: Joystick

- Detachable from rest of unit
 - 6 pin interface: 2 for power, 4 for data
- Uses wheels in between LED and photocell
 - “Counts” position using light passed through
 - Monitors output of photocells to determine position

Components: Joystick

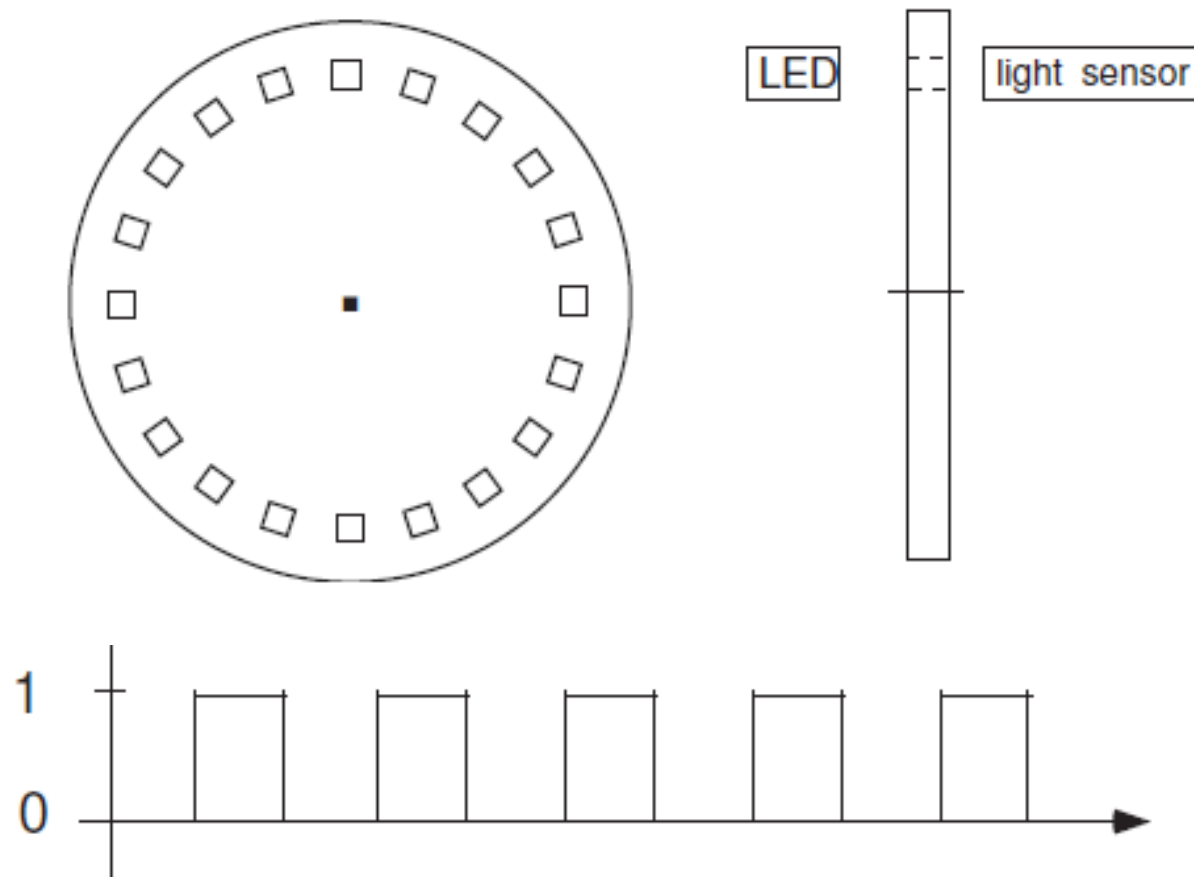


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Components: Joystick





<http://electronics.howstuffworks.com/n643.htm>

Components: Packs

- Rumble Pack
 - Force feedback
 - Uses a motor attached to an unbalanced weight
 - Motion of the unbalanced weight causes the controller to vibrate
- Memory Pack
 - Flash Memory

Communication: Hardware

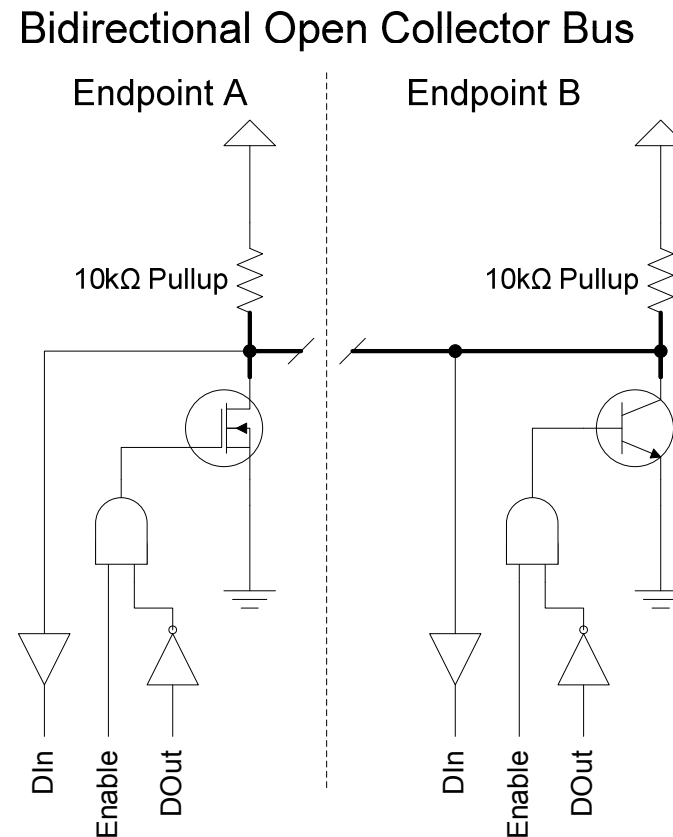
N64 Controller 3 pin connector



- Three wires
 - Ground
 - Data
 - Bidirectional
 - Asynchronous
 - Serial Interface
 - Power
 - +3.6 Volts
 - Will operate between 3.0 and 3.8 V

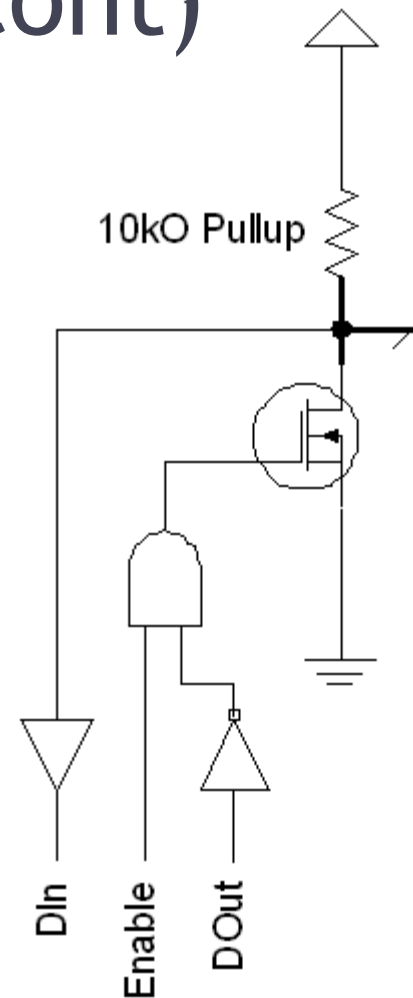
Communication: Bus

- Open collector bus
 - Uses pull up resistor to keep data line high at all times
- Pull low to send 0
- Leave alone to send 1
 - **NEVER DRIVE THE LINE HIGH**



Communication: Bus (cont)

- How it works
 - Pull up resistor weakly pulls the bus high
 - Send a 0, transistor closes path to ground



Communication: Bus (cont)

- Can't short circuit open collector bus



Source 1



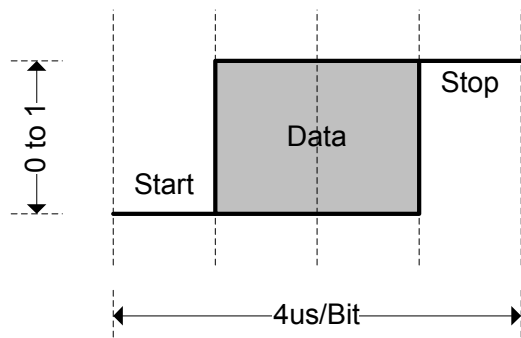
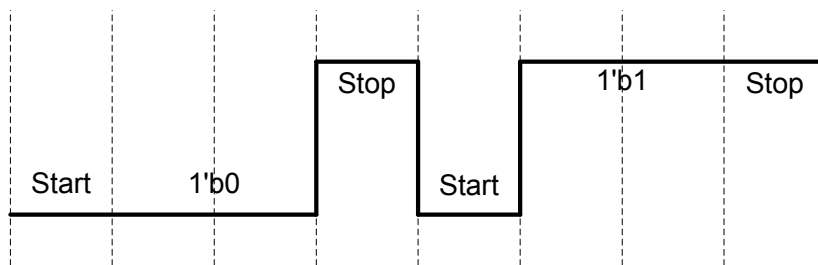
Source 2



Result

NO CONFLICT

Communication: Protocol

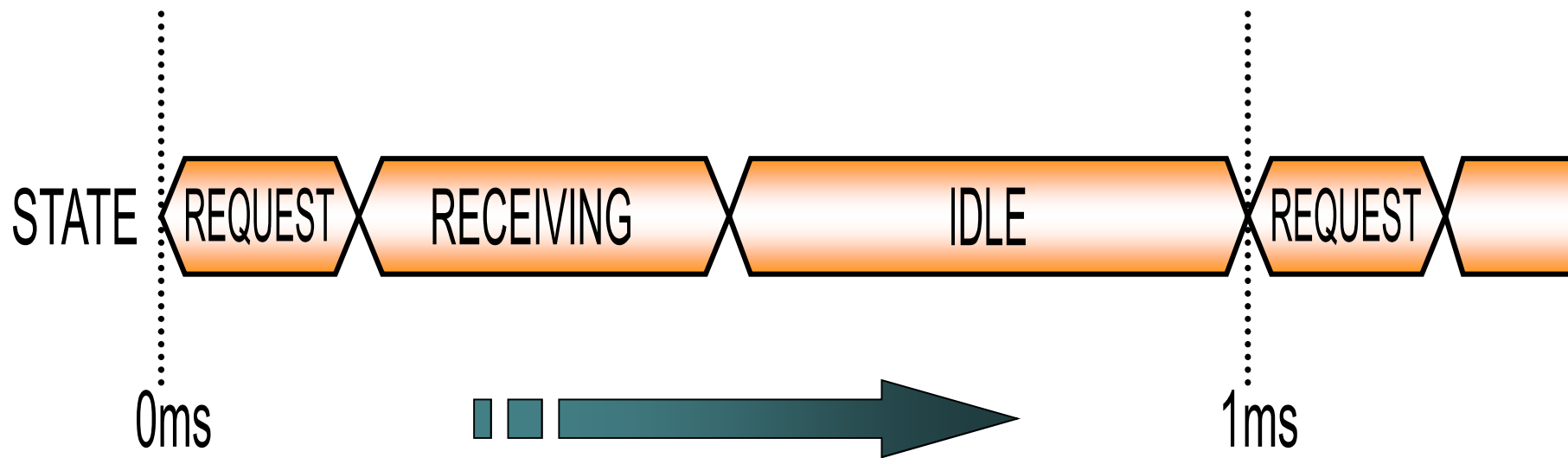


- Data determined by duty cycle
- Each bit (Manchester Encoding):
 - Start sub-bit (low)
 - Two data sub-bits
 - Stop sub-bit (high)
- Series of bits followed by stop bit

Commutation: Arbitration

- Uses a challenge-response scheme (polling)
 - Send request to controller
 - After request is complete, controller responds
 - Quiet state: 200 us controller will not respond to polling requests
 - Repeat process
- One controller and challenge-response = no contention for bus

Communication: Process

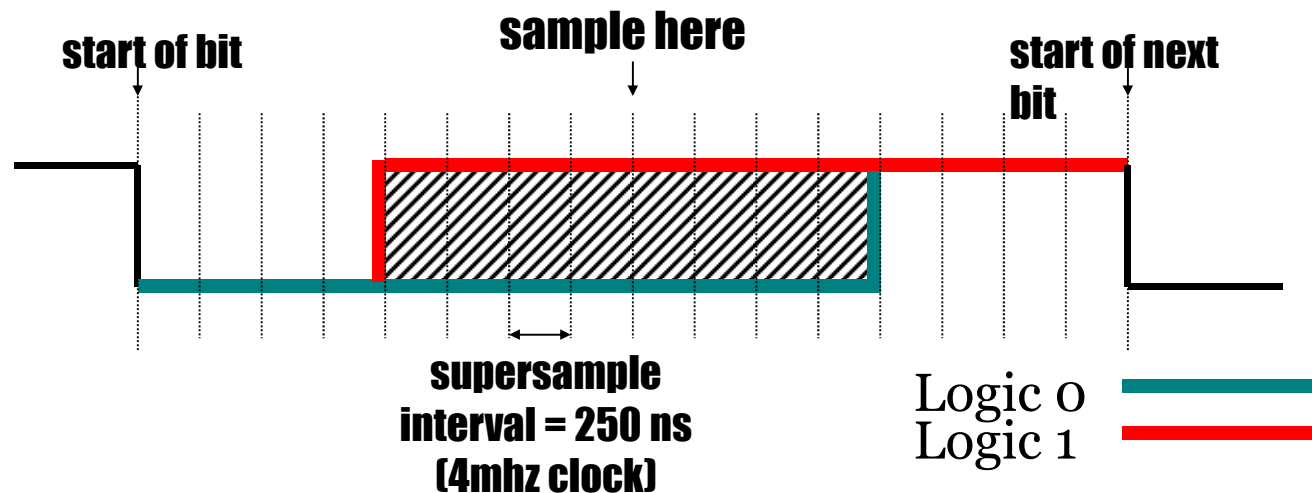


Communciation: Commands

- 8'hFF: Reset Controller
- 8'h00: Get Status
 - Checks state of controller
- 8'h01: Get Buttons
- 8'h02: Read Mempack
- 8'h03: Write Mempack
- 8'h04: Read EEPROM
- 8'h05: Write EEPROM

Communication: Timing

- Requesting: 4 MHz clock (internal clock)
- Responding: 250 kHz
 - 16 samples of each transmission bit
 - Wait 8 cycles, sample, wait for next falling edge



Communication: Response (Buttons)

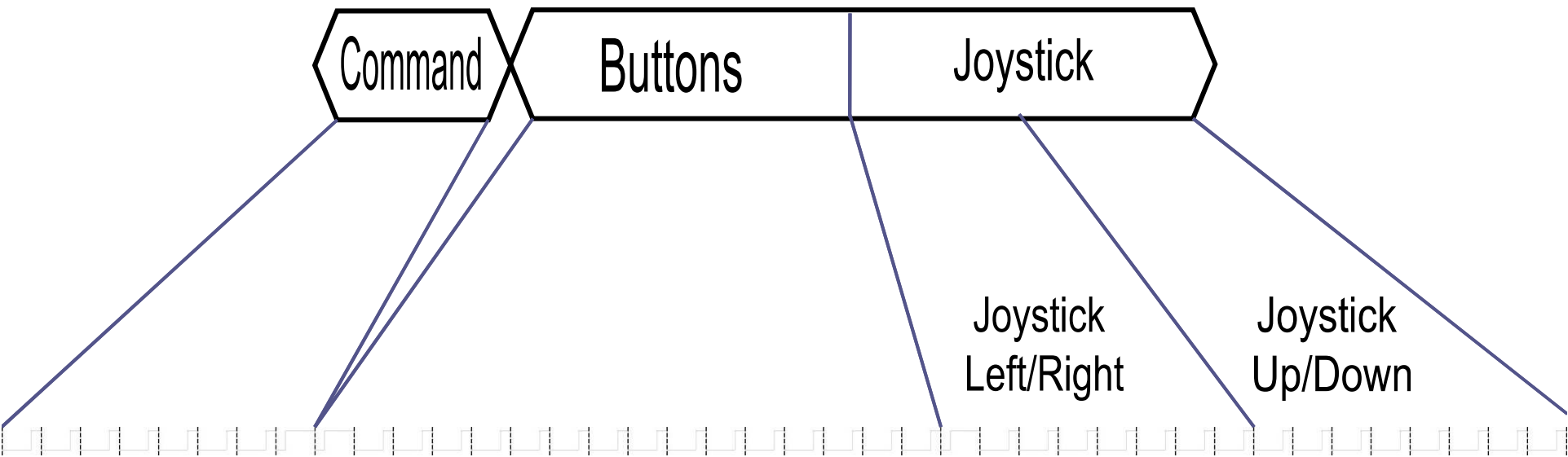
Bit	Button
0	A
1	B
2	Z
3	Start
4	Directional Up
5	Directional Down
6	Directional Left
7	Directional Right
8	N/A
9	N/A
10	L
11	R
12	C Up
13	C Down
14	C Left
15	C Right

Communication: Response (Joystick)

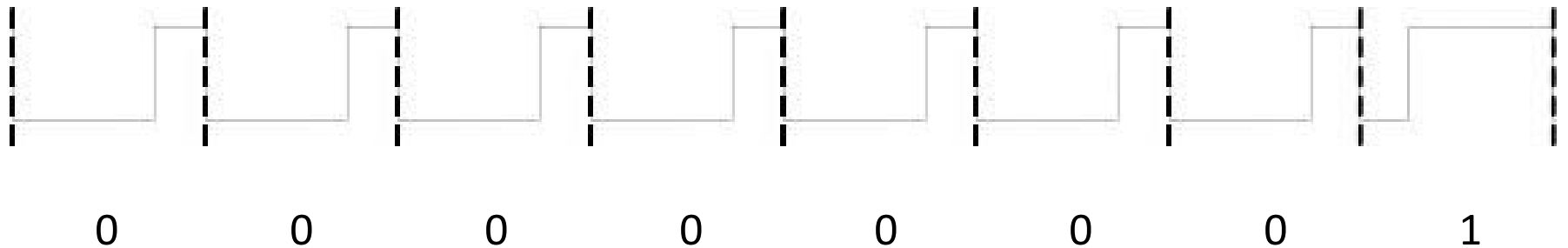
- 16 bits
 - First 8 bits = signed X position
 - Second 8 bits = signed Y position
- From center:
 - Up and left = positive
 - Down and right = negative

Position	Bits
Left Extreme Edge	01111111
Left Off Center	00000001
Center	00000000
Right Off Center	11111111
Right Extreme Edge	10000000

Age Group	Percentage
18-24	10%
25-34	20%
35-44	30%
45-54	40%
55-64	50%
65-74	60%
75-84	70%
85+	80%



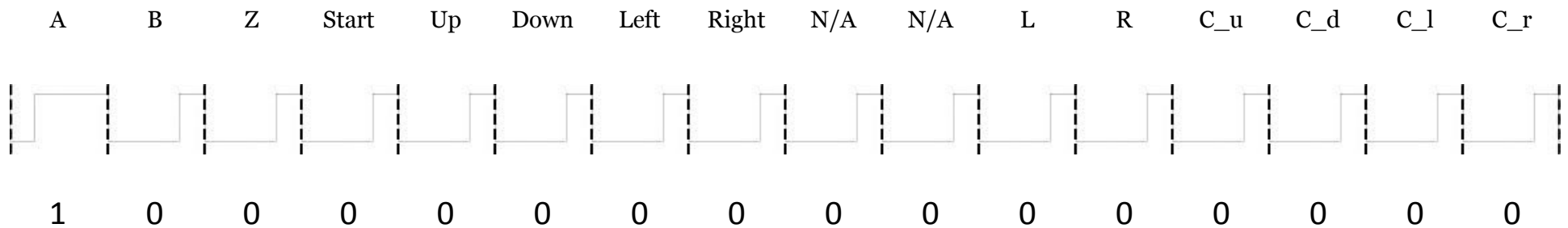
Communication: Example Command



- 8'h01 : Get Buttons

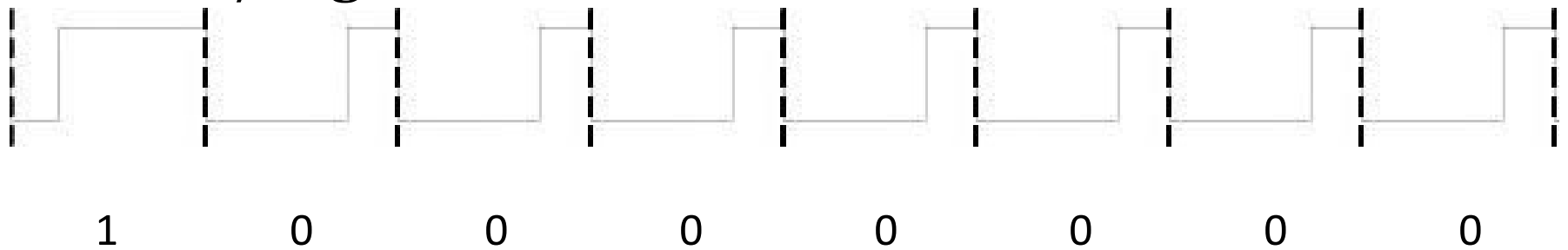
Communication: Example Buttons

- Only A pressed

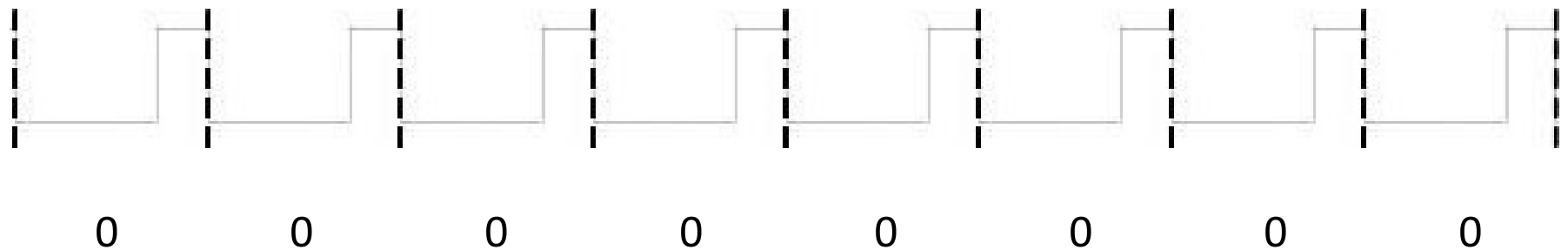


Communication: Example Joystick

- Left/Right



- Up/Down





Conclusion

- The Controller
- Components:
 - Buttons
 - Joystick
 - Memory/Rumble Pack
- Communication with External Devices
 - Hardware
 - Protocol
 - Arbitration
 - Commands
- Questions?

References

- <http://electronics.howstuffworks.com/n643.htm>
- <http://courses.cit.cornell.edu/ee476/FinalProjects/s2002/jew17/lld.html>
- <http://www.mixdown.ca/n64dev/>
- <http://inst.eecs.berkeley.edu/~cs150/fa04/Lab/Checkpoint1.PDF>
- http://inst.eecs.berkeley.edu/~cs150/sp01/Labs/lablecc_kpt1.ppt
- <http://www.eecs.umich.edu/courses/eecs461/lecture/Lecture3.pdf>