MODULE 8: Digital Transmission

BU SUMMER CHALLENGE
Electrical Engineering: Smart Lighting Project

Beste Oztop
PhD Student
Boston University
boztop@bu.edu

Important Announcements

Thursday, August 1:

- Seminar evaluations for EE: Smart Lighting – to be completed in class (10-15 minutes)
  - All evaluations are anonymous
  - Answer as thoroughly as possible
- Please bring a portable smart device (phone, tablet, or laptop)
- Please confirm your Kerberos username/password with your PA, if you don't know it already
- Group Photo!

Important Announcements

Friday, August 2:

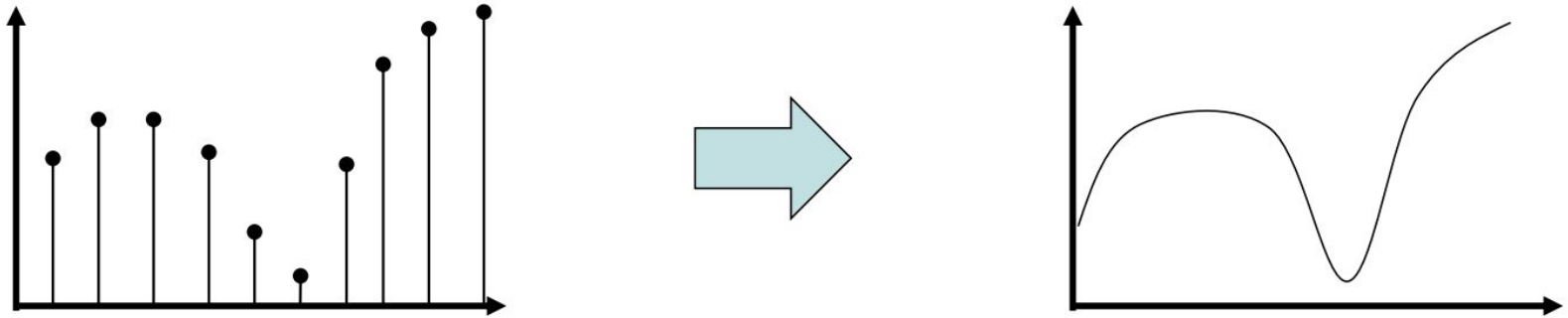
- Final Presentation in [..]:
- 5-6 minute presentation per group
- Prepare a PowerPoint presentation
- Remember to practice!

Overview

- Analog vs Digital Modulation
- Digital Modulation
- Digital Logic
- Arduinos
- Experiments
  - Digital data transmission
  - Programming Arduino

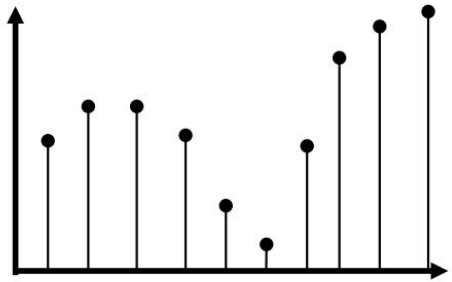
Analog vs. Digital Modulation

- Analog Modulation
  - Transmit and store signals in values representing magnitude



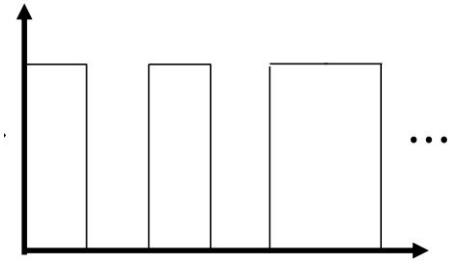
Analog vs. Digital Modulation

- Analog Modulation
  - Transmit and store signals in values representing magnitude
- Digital Modulation
  - Transmit and store signals as symbols that represent values that represent the data



…1010110…

In addition to signal values, digital modulation can transmit any digital data!



ASCII Characters

8 bits (1 byte) that represent an alpha-numeric character

Character

$$00110001 = \text{"1"}$$

$$00110010 = \text{"2"}$$

Value

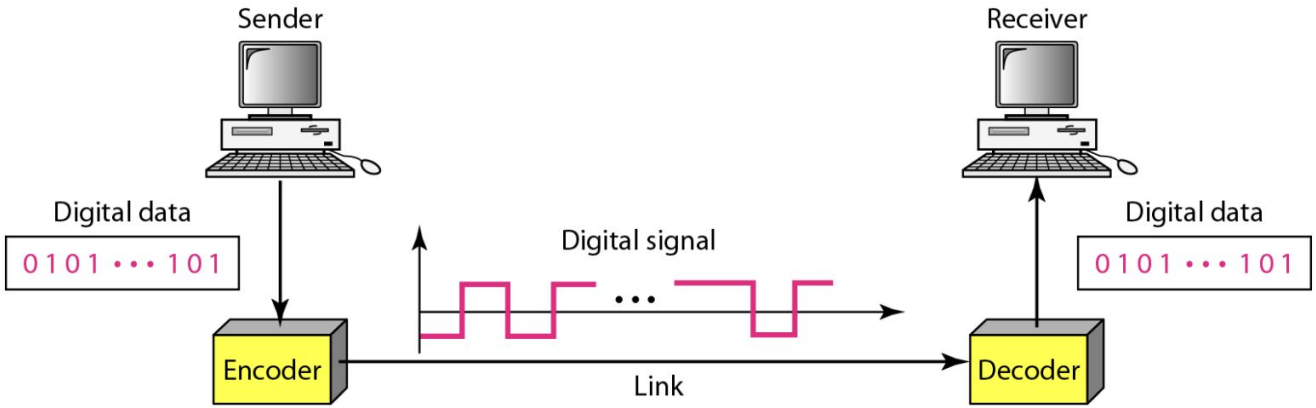
$$00000001 = 1$$

$$00000010 = 2$$

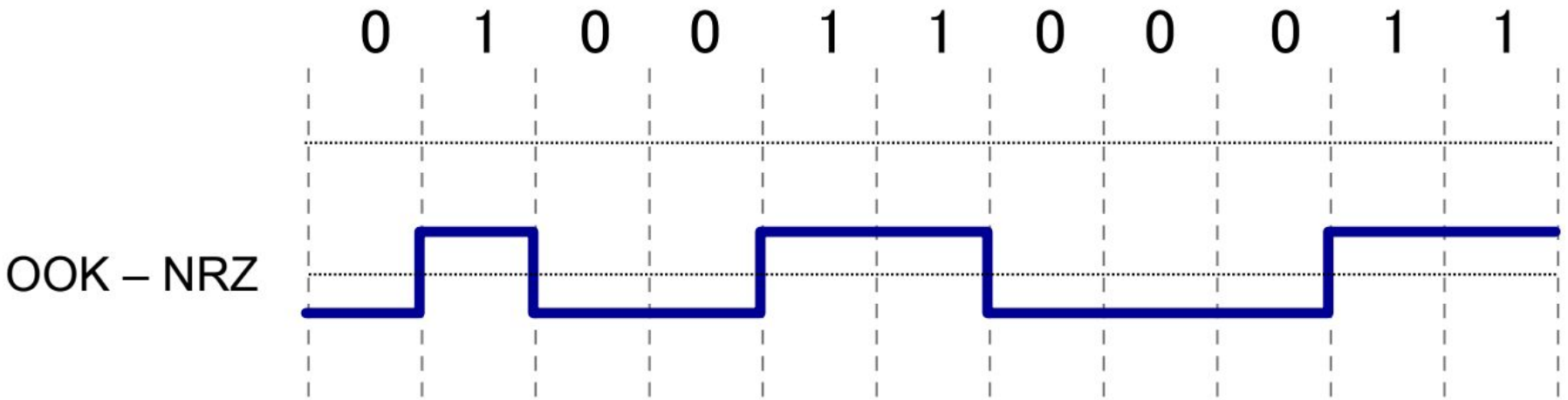
0	0011 0000	O	0100 1111	m	0110 1101
1	0011 0001	P	0101 0000	n	0110 1110
2	0011 0010	Q	0101 0001	o	0110 1111
3	0011 0011	R	0101 0010	p	0111 0000
4	0011 0100	S	0101 0011	q	0111 0001
5	0011 0101	T	0101 0100	r	0111 0010
6	0011 0110	U	0101 0101	s	0111 0011
7	0011 0111	V	0101 0110	t	0111 0100
8	0011 1000	W	0101 0111	u	0111 0101
9	0011 1001	X	0101 1000	v	0111 0110
A	0100 0001	Y	0101 1001	w	0111 0111
B	0100 0010	Z	0101 1010	x	0111 1000
C	0100 0011	a	0110 0001	y	0111 1001
D	0100 0100	b	0110 0010	z	0111 1010
E	0100 0101	c	0110 0011	.	0010 1110
F	0100 0110	d	0110 0100	,	0010 0111
G	0100 0111	e	0110 0101	:	0011 1010
H	0100 1000	f	0110 0110	;	0011 1011
I	0100 1001	g	0110 0111	?	0011 1111
J	0100 1010	h	0110 1000	!	0010 0001
K	0100 1011	I	0110 1001	'	0010 1100
L	0100 1100	j	0110 1010	"	0010 0010
M	0100 1101	k	0110 1011	(	0010 1000
N	0100 1110	l	0110 1100	)	0010 1001
				space	0010 0000

Digital Modulation

- Encoding binary data onto a set of possible symbols
- Example
  - On-Off Keying (OOK) represents 1 (bit) as a high voltage and 0 (bit) as a low or negative voltage.



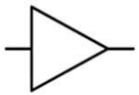
Digital Modulation



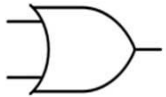
Digital Logic

Logic devices generate high and low output values that correspond to high and low input values

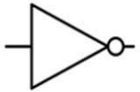
Buffer



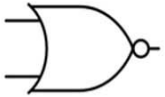
OR



Inverter



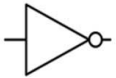
NOR



AND

A	B	Output
0	0	0
1	0	0
0	1	0
1	1	1

Inverter



Input	Output
0	1
1	0

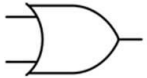
AND

XOR

NAND

XNOR

OR



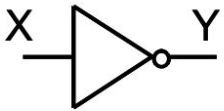
A	B	Output
0	0	0
1	0	1
0	1	1
1	1	1

XOR

A	B	Output
0	0	0
1	0	1
0	1	1
1	1	0

Digital Logic

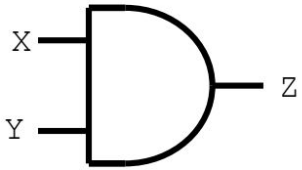
NOT



Y = ~X

X	Y
0	1
1	0

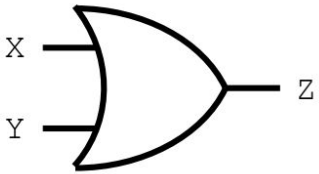
AND



Z = X & Y

X	Y	Z
0	0	0
0	1	0
1	0	0
1	1	1

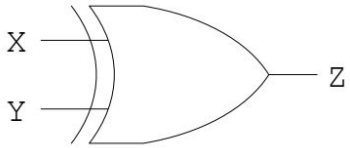
OR



Z = X | Y

X	Y	Z
0	0	0
0	1	1
1	0	1
1	1	1

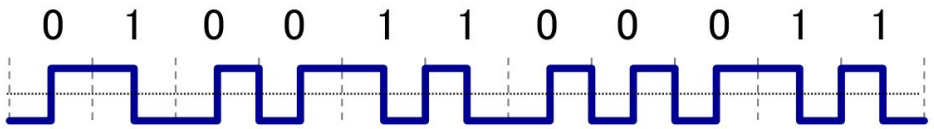
XOR

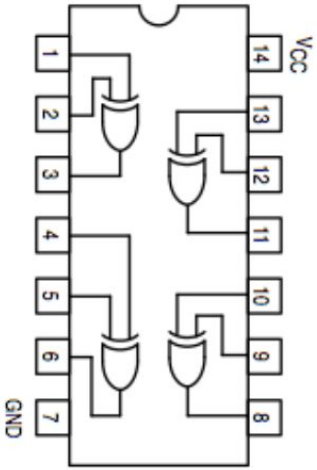


Z = X ^ Y

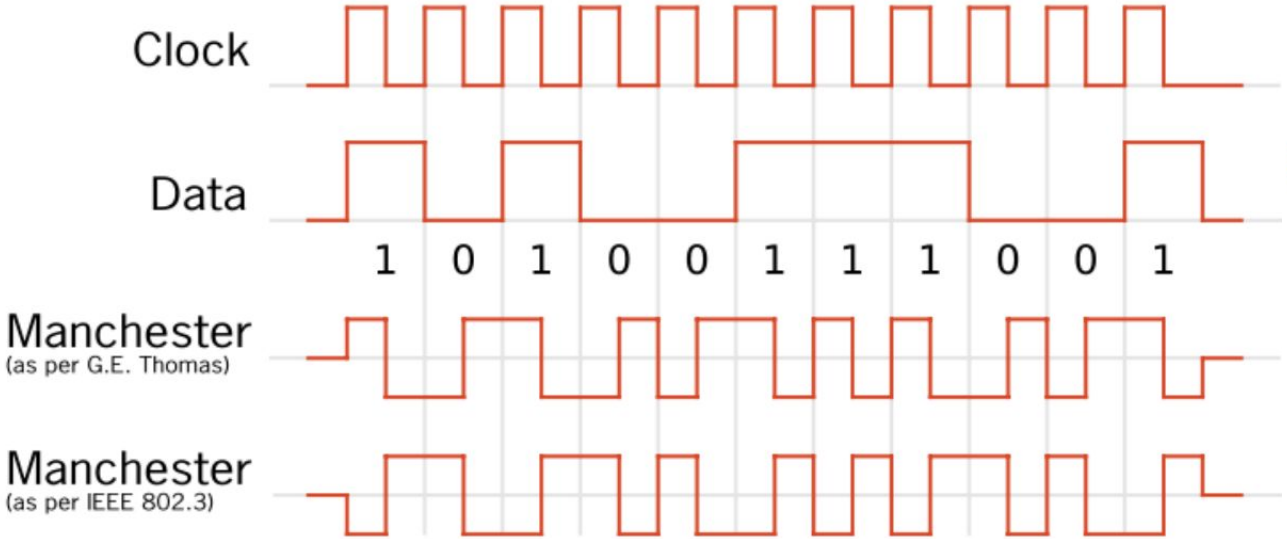
X	Y	Z
0	0	0
0	1	1
1	0	1
1	1	0

Experiment I





- Digital Modulation via VLC



Arduino

- Microprocessor vs. Microcontroller
  - Microprocessor: Takes data input, processes, and outputs new data
  - Microcontroller: Interacts with, or controls, hardware
- Embedded Software
  - Code - or instruction set - that runs on a microcontroller
  - Defines what the microcontroller does and how it reacts to input
- Arduino
  - Platform that makes embedded systems more accessible
  - Hardware is a development board containing a microcontroller and other peripherals
  - Software is simplified for ease of use and fast implementation

Serial Communication

- Process of sending data 1 bit at a time
- Serial Port
  - General purpose interface for communication between devices
  - E.g., RS-232 is a common standard for connecting audio-visual devices
- Arduino Serial Port
  - Arduino uses the USB as a serial connection
  - Before running: Port is used to upload code to the Arduino
  - After running: Port is used to send data between the Arduino and monitor
  - Additional serial port: Rx and Tx pins of the Arduino (Pins 0 and 1) can be used to communicate with other serial devices!

Think – Pair – Share