

MODULE 7: Analog Transmission

BU SUMMER CHALLENGE Electrical Engineering: Smart Lighting Project

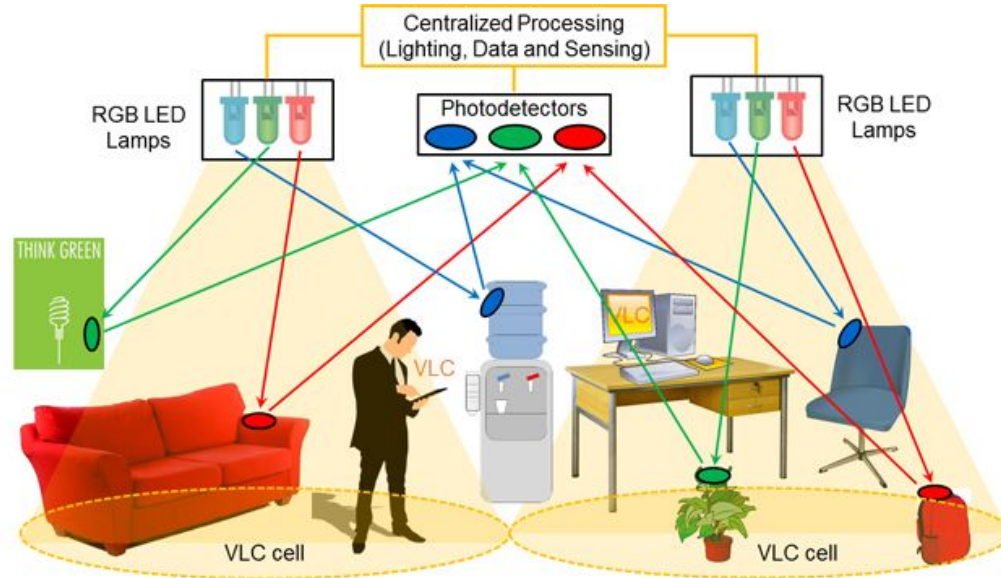
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Overview

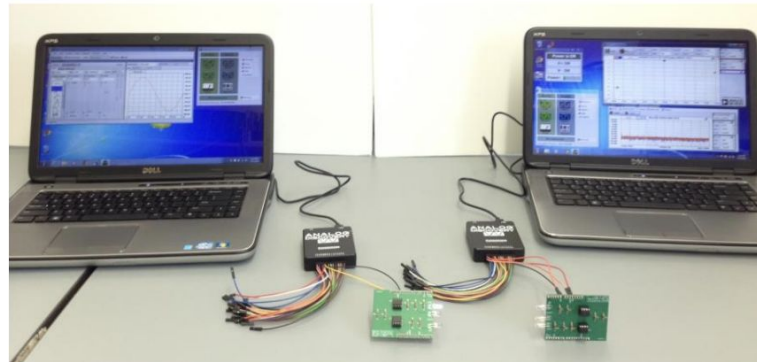
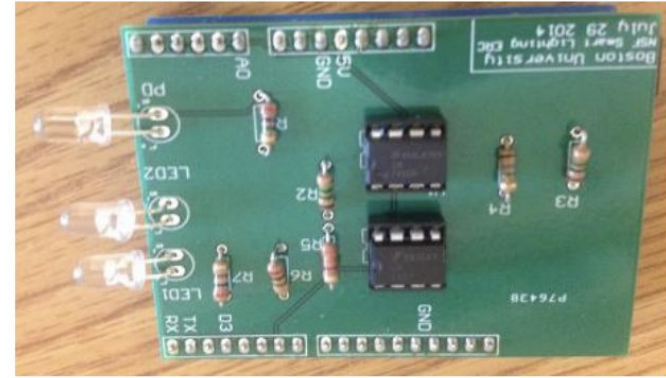
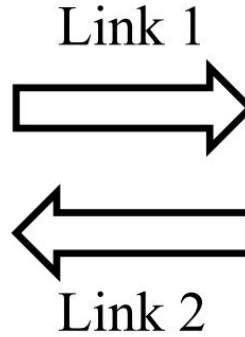
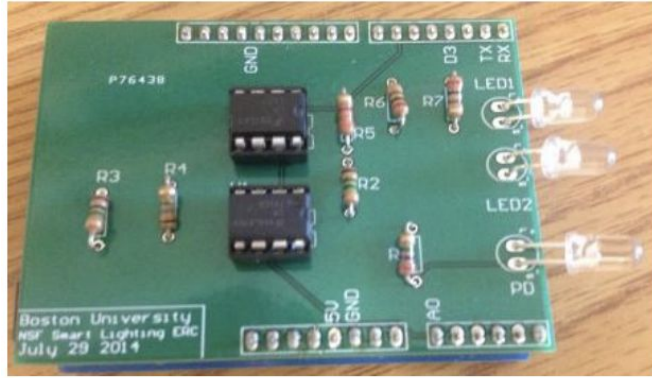
- Visible Light Communication
- Audio Signals
- Amplitude Modulation
- Digital Sampling and Binary Representation
- Experiment
 - Analog Modulation with VLC Transceivers

Visible Light Communication (VLC)

Radio spectrum is congested, visible spectrum has potential!



Visible Light Communication Transceiver

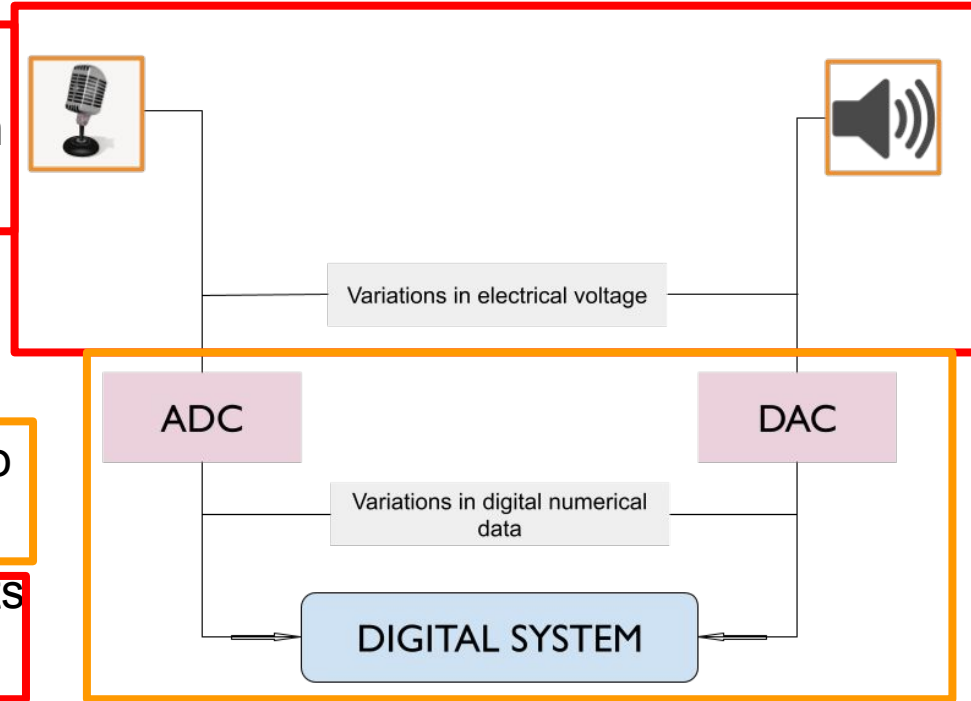


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Audio Signals

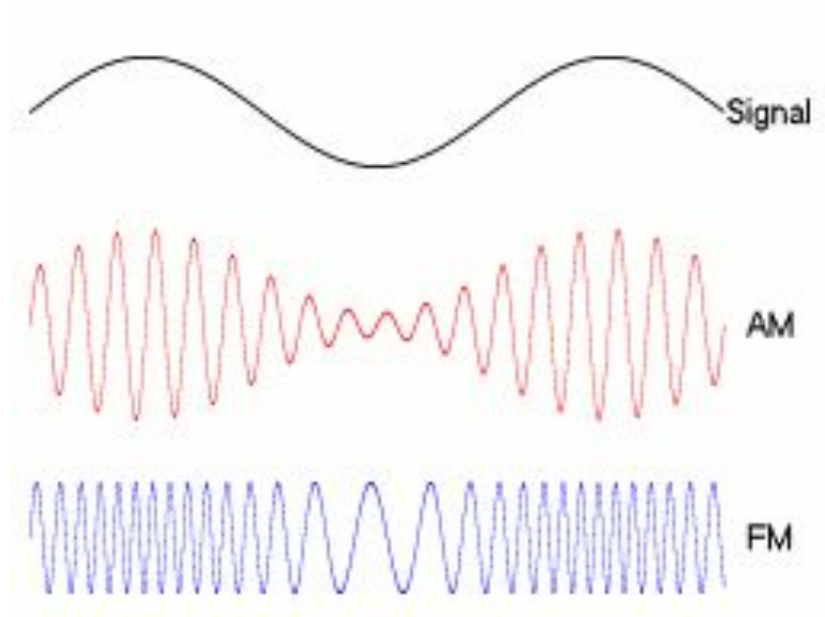
- Acoustic Input (e.g., microphone) converts air pressure variations into an electrical signal.
- ADC converts to digital data representing the sampled electrical signal.
- DAC converts digital samples back into a continuous time electrical signal
- Acoustic output (e.g., speaker) converts voltage back to air pressure variations.



Audio Signals

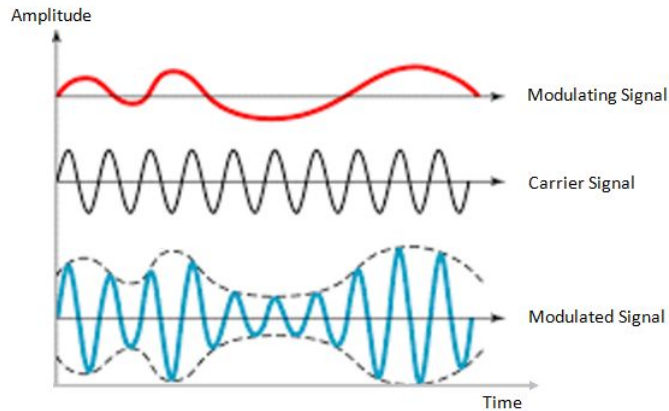
- AM Radio? FM Radio?
 - AM: Amplitude Modulation
 - FM: Frequency Modulation
 - Sirius Satellite Digital Radio

Electrical signal is transmitted via electromagnetic signals at a specified carrier frequency.



Amplitude Modulation

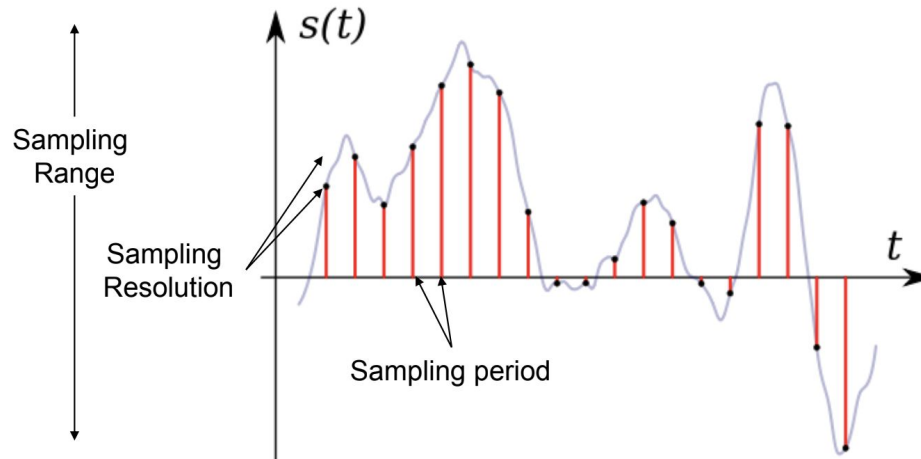
- ★ Carrier Modulation: “Placement” of input signal onto a high frequency carrier for transmission
- ★ Carrier Demodulation: Retrieving the baseband or low frequency signal from the carrier-modulated signal



In VLC signals, optical intensity is modulated. Carrier frequency is NOT required. Technically, the signal is modulated in THz

Digital Sampling

- To convert an analog signal into a digital representation:
 - Discrete time samples
 - Discrete value amplitude



Binary Representation

- We typically consider numbers in decimal, base-10
$$39512 = 3(10000) + 9(1000) + 5(100) + 1(10) + 2(1)$$
- Binary is a numeric system with base-2
 - Value of any digit (or bit) can either be '0' or '1'
 - Each digit is a power of 2 rather than a power of 10

16	8	4	2	1
↓	↓	↓	↓	↓
1	1	0	1	0

$$1(16) + 1(8) + 0(4) + 1(2) + 0(1) = 26$$

- A byte is a set of 8 bits

Digital Sampling

Digital sample values are stored in binary

Binary Form					Decimal Form
16	8	4	2	1	
0	0	0	0	0	0
0	0	0	0	1	1
0	0	0	1	0	2
0	0	0	1	1	3
0	0	1	0	0	4
0	0	1	0	1	5
0	0	1	1	0	6
0	0	1	1	1	7
0	1	0	0	0	???
1	0	0	0	0	???
1	1	1	1	1	???

Nyquist Sampling Theorem

Reconstruction of a signal is possible when sampling frequency is greater than twice the maximum frequency of the signal being sampled

- Human hearing can recognize frequencies up to 20kHz
- The typical sampling rate for audio is 44.1kHz. Why?
- Digital Storage Example:
 - How much space is needed for 70 minutes of music with 16 bit resolution?

$$(2 \text{ channels}) \left(16 \frac{\text{bits}}{\text{sample}} \right) \left(44.1 \text{k} \frac{\text{samples}}{\text{second}} \right) \left(60 \frac{\text{seconds}}{\text{minute}} \right) (70 \text{ minutes})$$
$$= 5,927,040,000 \text{ bits}$$



Student Presentations

Presentation Order

- Team 1 Soldering
- Team 2 Visual Light Communication
- Team 3 LEDs
- Team 4 Analog signals
- Team 5 Resistors
- Team 6 Parallel and series circuits
- Team 7 Photodiodes
- Team 8 Resistors and Capacitors

Experiment

- Generate analog signals between VLC transceivers
 - Observe on oscilloscope and spectrum analyzer
 - Transmit audio file (bu.edu/peaclab/busc24)

Think – Pair – Share

