Homework 1, Michael Kremer U45121665

Tuesday, February 2, 2021 3:38 PM

Due on Blackboard by Friday 02/12/2021, 6:00PM

Question 1

This question refers to the YouTube video shown during the first lecture (the video is accessible in the lecture material) about the USRP B200/B210 boards.

1. What does it mean that the USRP board is bus powered?
   Being bus powered means that the USRP draws its power from the voltage supply on its USB connection. This means there is no need for an extra external power supply.
2. What is USB 3.0 and how does it differ from USB 2.0?
   USB 3.0 is a revision of the USB standard, an upgrade from USB 2.0. despite having the same connector, USB 3.0 has 9 data wires while USB 2.0 only has 4 data wires. This means that USB 3.0 can transfer up to 5Gb/s compared to USB 2.0's 480Mb/s. USB 3.0 and USB 2.0 devices are compatible but when a USB 3.0 device connects to a USB 2.0, the data transfer rate will be scaled down to 2.0 standards.
3. What is the meaning of instantaneous bandwidth?
   Instantaneous bandwidth is the maximum continuous bandwidth which a device can generate or acquire at a given time.
4. The B210 has support for 2x2 MIMO. What does 2x2 MIMO mean?
   2x2 MIMO, multiple input multiple output, means that the B210 uses two antennas simultaneously. This means that the B210 has twice the throughput of a classic 1 antenna device.
5. What does it mean that the USRP supports full-duplex communication?
   Full-duplex communication means the USRP can both transmit and receive at the same time. A classic radio, like in the movies, can either transmit or receive at any given time. This is an example of half-duplex communication. In a full-duplex communication system, the radio would be able to transmit and receive at the same time.

Question 2

For each of the radio technologies listed below (several of which were mentioned in the same YouTube video), explain: (i) what the acronym stands for; (ii) the purpose of the technology; (iii) the total number of channels in the U.S.; (iv) the center frequency and bandwidth of each of the channels in the U.S.; (v) the modulation scheme that is used. Try to justify your answers using authoritative sources, such as government agencies web sites, technical standards, or the scientific literature (Wikipedia is generally not viewed as an authoritative source – however, external links provided by Wikipedia may be).

1) APRS: using http://www.aprs.org

I. Automatic Packet Reporting System.
II. APRS is a digital communication scheme for HAM radios. This can be used to distribute any relevant information to a local area.
III. In the US there is only one APRS channel, 144.39 MHz.
IV. The center frequency is 144.39 MHz and the bandwidth is 4 MHZ.
V. APRS uses a FSK, frequency shift keying, modulation scheme.

2) AIS: using https://www.navcen.uscg.gov/?pageName=aismain

I. Automatic Identification System
II. AIS is used for broadcasting navigational and registration information about any ships travelling on water. This can be used to identify ships and where they are heading.
III. AIS has two dedicated channels in the US
IV. AIS 1: 161.975 MHz, 25 kHz bandwidth
    AIS 2: 162.025 MHz, 25 kHz bandwidth
V. AIS uses a GMSK, gaussian minimum shift keying, modulation scheme.

3) ADS-B: using https://www.faa.gov/nextgen/programs/adsb/

I. Automatic Dependent Surveillance-Broadcast
II. ADS-B is used for real time aviation surveillance.
III. ADS-B has one dedicated channel in the US and one worldwide channel, so there are 2 total channels in the US
IV. Worldwide: 1090MHz, 50 kHz bandwidth
    US only: 978 MHz, 1.3 MHz bandwidth
V. ADS-B uses a PPM, Pulse Position Modulation, modulation scheme.

4) ACARS: using https://www.skybrary.aero/index.php/Aircraft_Communications,_Addressing_and_Reporting_System

I. Aircraft Communications, Addressing and Reporting System
II. ACARS is used to send messages between airplanes and ground stations.
III. There are 9 channels for ACARS in the US.
IV. 129.125 MHz, 10 kHz bandwidth
    130.025 MHz, 10 kHz bandwidth
    130.425 MHz, 10 kHz bandwidth
    130.450 MHz, 10 kHz bandwidth
    131.125 MHz, 10 kHz bandwidth
    131.550 MHz, 10 kHz bandwidth
    136.700 MHz, 10 kHz bandwidth
    136.750 MHz, 10 kHz bandwidth
    136.800 MHz, 10 kHz bandwidth
V. ACARS uses a MSK, Minimum-Shift keying, modulation scheme.

5) NFC: using https://nfc-forum.org

I. Near-field Communication
II. NFC is used as a low speed simple communication protocol for devices in close proximity. Common use cases are commerce, identity tags, and gaming.
III. There is 1 channel for NFC in the US.
IV. 13.56 MHz, 7 kHz bandwidth
V. NFC uses am ASK, amplitude shift keying, modulation scheme.

Question 3

This question is a review of basic concepts in signals and systems.

1. Consider a continuous signal $x(t)$ and the impulse (delta) function $\delta(t)$. Compute $x(t) * \delta(t)$, where $*$ is the convolution operator.

$$x(t) * \delta(t) = \int_{-\infty}^{\infty} x(\tau)\,\delta(t-\tau)\,d\tau$$

for all time t, $\delta(t-\tau) = 1$ when $t=\tau$, so as we integrate across τ, we get $x(\tau)$ for each $\tau = t$

so $\int_{-\infty}^{\infty} x(\tau)\,\delta(t-\tau)\,d\tau = \boxed{X(t)}$

1. Consider a single-input single-output linear time-invariant (LTI) system with impulse response h(t). Suppose the system is fed with an input signal $x(t)$. Find an expression for the output signal $y(t)$, as a function of $x(t)$ and h(t).

$$\boxed{y(t) = x(t) * h(t) \quad \text{or} \quad y(s) = X(s)h(s) \quad \text{or} \quad y(t) = \int_{-\infty}^{\infty} x(\tau)\,h(t-\tau)\,d\tau}$$

1. Consider two continuous signals $x(t)$ and $y(t)$, with respective Fourier transforms $X(f)$ and $Y(f)$. Find the Fourier transform of $x(t)y(t)$ as a function of $X(f)$ and $Y(f)$.

$$F[x(t)y(t)] = \int_{-\infty}^{\infty} \left[\frac{1}{2\pi} \int_{-\infty}^{\infty} x(a) e^{-jat}\,da \right] y(t)\, e^{-j\omega t}\,dt$$

$$= \frac{1}{2\pi} \int_{-\infty}^{\infty} x(a) \int_{-\infty}^{\infty} y(t)\, e^{-j(\omega - a)t}\,dt\,da$$

$$= \frac{1}{2\pi} \int_{-\infty}^{\infty} x(a)\, y(\omega - a)\,da$$

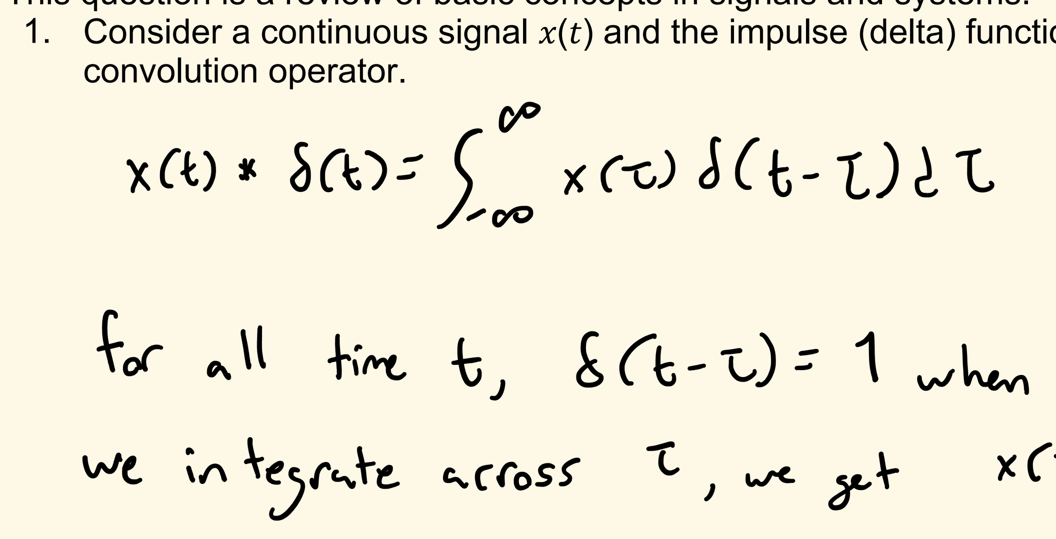
$$\boxed{F[x(t)y(t)] = \frac{1}{2\pi} X(f)\,Y(f)}$$

Question 4

Consider a carrier signal sin $(2\pi f\, t)$, where f = 10 Hz. The attached Matlab script carrier.m plots this signal over a time period of 3 seconds.

a) Suppose the signal is modulated using ASK with a clock frequency of 1 Hz. Assume the (absolute values) of the amplitude are H = 2 for the binary digit '1' and L = 1 for the binary digit '0'. Write a Matlab script that plots the modulated signal produced with the message M = '101' (call this script ASK.m). Please provide the code and a screenshot of the figure in your submission and attach the Matlab file.

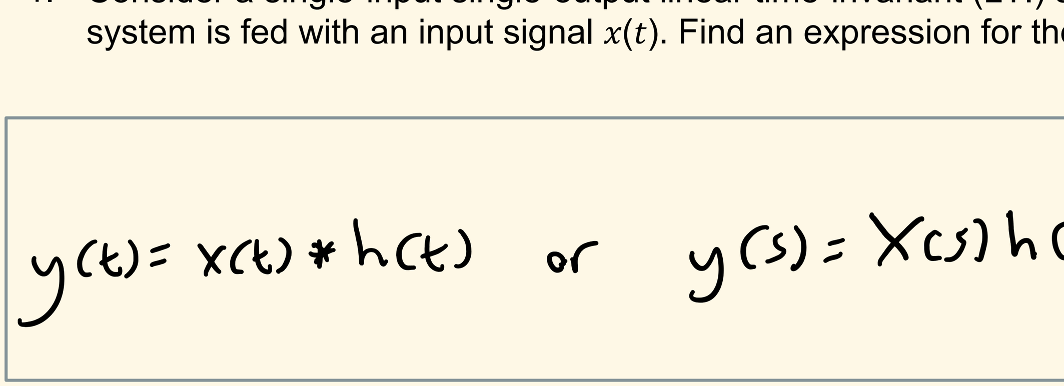
Here is the Figure and code



The code is also included in this submission

b) Suppose the signal is modulated using FSK with a clock frequency of 1 Hz. Assume Δf = 5 Hz, and $f + \Delta f$ represents the binary digit '1' and $f - \Delta f$ and represents the binary digit '0'. Write a Matlab script that plots the signal corresponding to the message M = '101' (call this script FSK.m). Please provide the code and a screenshot of the figure in your submission and attach the Matlab file.

Here is the Figure and code



The code is also included in this submission

Question 5

Provide answers as explicit as possible to the following questions, *without using a calculator*. Justify your solution.

a) Convert 8 mW into dBm.

1 mW = 0 dBM

× 2^3 + 3.3 dBM

$\boxed{8\text{ mW} = 9\text{ dBM}}$

b) Convert 7 dBm into mW.

10 dBM = 10 mW

-3 dBM /2

$\boxed{7\text{ dBM} = 5\text{ mW}}$

c) Suppose the RSSI of a signal at a receiver is -80 dBm and the SNR is 10 dB. What is the noise power at the receiver (in dBm)?

SNR = S - N

10 dBM = -80 dBM - N

$\boxed{N = -90\text{ dBM}}$