Benha University
Faculty of Engineering- Shoubra
Electrical Engineering Department
Fourth Year **(Communications & Electronics)**

Final-Term Exam
Date: Tuesday 10/5/2016
ECE 424: Lab (4)
Duration : 2 Hrs

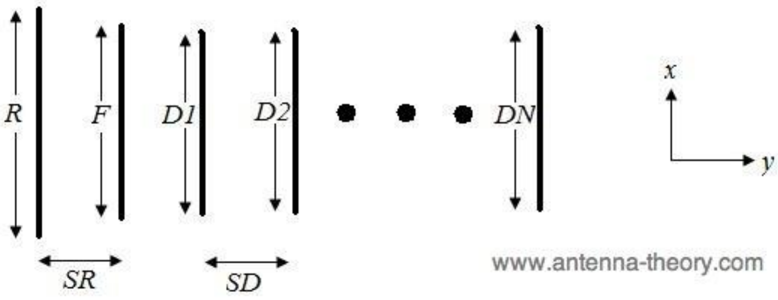
- Answer all the following question
- Illustrate your answers with sketches when necessary.
- The exam consists of One page

- No. of questions: 2
- Total Mark: 50 Marks
- Examiner: Dr. Ehsan Abbas – Dr. Michael Nasief

Question (1): Antenna Types:[25 Marks]

1. Explain the basic geometry and elements of Yagi-Uda antenna.

The basic geometry of a Yagi-Uda antenna is shown below in Figure below.



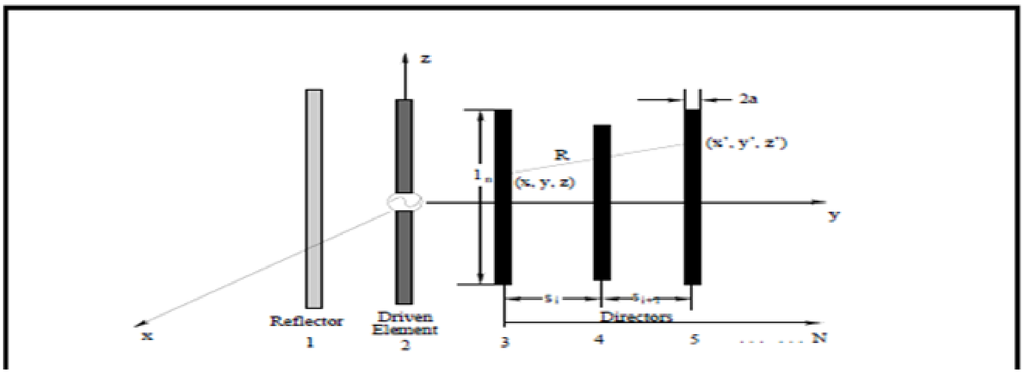
Geometry of Yagi-Uda antenna.

The yagi-uda antenna consists of 2 parts:

- **the antenna elements**
- **the antenna boom**

There are three types of elements:

- **the reflector (refl)**
- **the feed or driven element (de)**
- **the directors (dir)**



The Yagi antenna consists of a single 'feed' or 'driven' element, typically a dipole or a folded dipole antenna. This is the only member of the above structure that is actually excited (a source voltage or current applied). The rest of the elements are parasitic - they reflect or help to transmit the energy in a particular direction. The length of the feed element is given in Figure 1 as *F*. The feed antenna is almost always the second from the end, as shown in Figure 1. This feed antenna is often altered in size to make it resonant in the presence of the parasitic elements (typically, 0.45-0.48 wavelengths long for a dipole antenna).

The element to the left of the feed element in Figure 1 is the reflector. The length of this element is given as *R* and the distance between the feed and the reflector is *SR*. The reflector element is typically slightly longer than the feed element. There is typically only one reflector; adding more reflectors improves performance very slightly. This element is important in determining the front-to-back ratio of the antenna.

Having the reflector slightly longer than resonant serves two purposes. The first is that the larger the element is, the better of a physical reflector it becomes.

Secondly, if the reflector is longer than its resonant length, the impedance of the reflector will be inductive. Hence, the current on the reflector lags the voltage induced on the reflector. The director elements (those to the right of the feed in Figure 1) will be shorter than resonant, making them capacitive, so that the current leads the voltage. This will cause a phase distribution to occur across the elements, simulating the phase progression of a plane wave across the array of elements. This leads to the array being designated as a travelling wave antenna. By choosing the lengths in this manner, the Yagi-Uda antenna becomes an end-fire array - the radiation is along the +y-axis as shown.

The rest of the elements (those to the right of the feed antenna as shown) are known as director elements. There can be any number of directors *N*, which is typically anywhere from *N*=1 to *N*=20 directors. Each element is of length *Di*, and separated from the adjacent director by a length *SDi*. As alluded to in the previous paragraph, the lengths of the directors are typically less than the resonant length, which encourages wave propagation in the direction of the directors.

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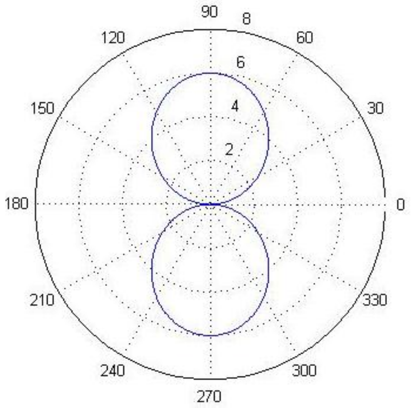
2. Draw the radiation pattern of half wave dipole antenna (show in your drawing the HPBW and the direction of maximum radiation), **and if we have a TV channel at 400 MHz frequency compute the antenna length.**

The directivity of a half-wave dipole antenna is 1.64 (2.15 dB). The HPBW is 78 degrees.The half power point is at $\theta_h=51^o$ and maximum at $\theta_{max}=90^o$. the radiation pattern is shown in figure below



$C = \lambda * F$

$3*10^8 = \lambda * 400 *10^6$

$\lambda = 3*10^8 / 400 *10^6 = 0.75$ m

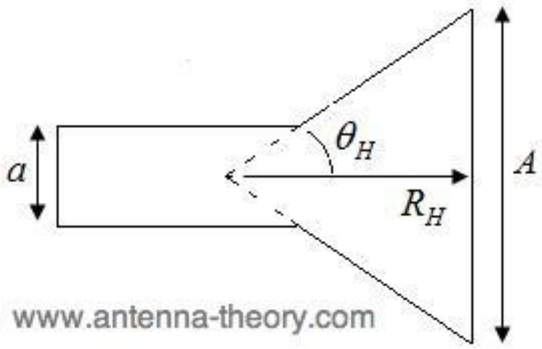
so antenna length = 37.5 cm

3. **What is the frequency range for the Pyramidal Horn antenna?**

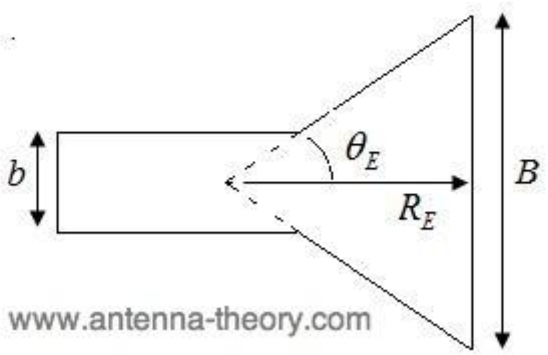
microwave frequency ranges (**from 1GHz up to 18 GHz**).

4. **What are the parameters that controls the gain of the Pyramidal Horn antenna?**

   The radiation pattern of a horn antenna will depend on *B* and *A* (the dimensions of the horn at the opening) and *R* (the length of the horn, which also affects the flare angles of the horn), along with *b* and *a* (the dimensions of the waveguide). These parameters are optimized in order to improve the performance of the horn antenna, and are illustrated in the following Figures.



Cross section of waveguide cut in the H-plane.



Cross section of waveguide cut in the E-plane.

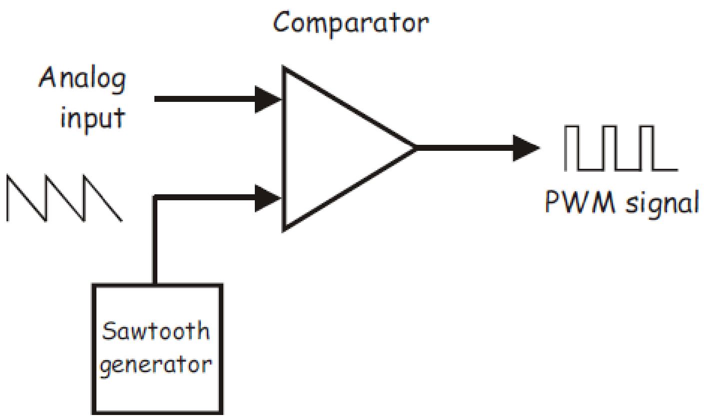
Observe that the flare angles (θ_E and θ_H) depend on the height, width and length of the horn antenna.

Given the coordinate system of Figure 6 (which is centered at the opening of the horn), the radiation will be maximum in the +z-direction (out of the screen).

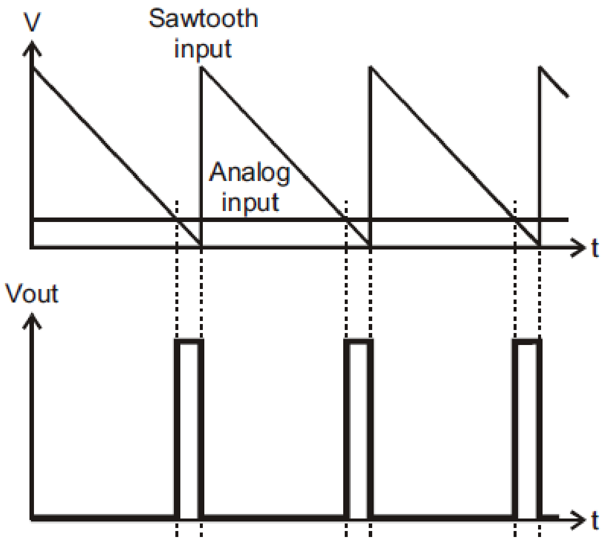
Question (2): Digital Communications: [25 Marks]

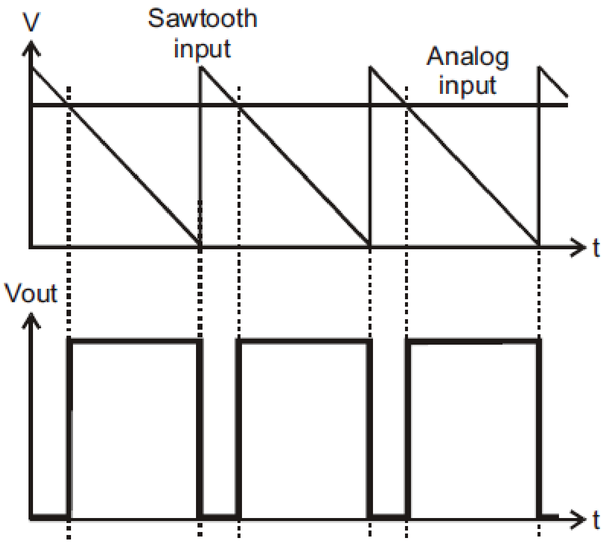
1. **Explain with the aid of block diagram the PWM generation.**

Another type of pulse modulation is called pulse-width modulation (PWM) or sometimes pulse-duration modulation (PDM). To understand PWM, let's consider a simple method for generating it that involves a comparator with a sawtooth waveform for one of its inputs. This is shown in Figure 1 below.

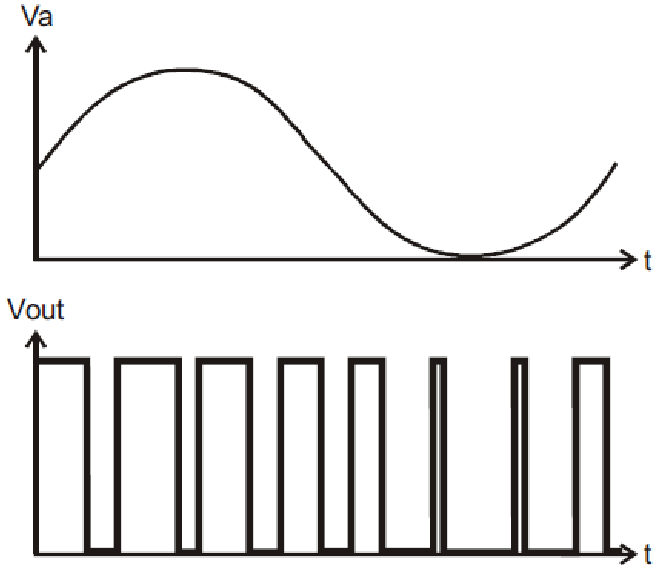


Recall that the comparator amplifies the difference between the voltages on its two inputs by an extremely large amount. So, when the instantaneous analog voltage is smaller than the instantaneous sawtooth voltage, the comparator's output is logic-0. And when the instantaneous analog voltage is larger than the instantaneous sawtooth voltage, the comparator's output is logic-1. That being the case, the comparator's output is a pulse train with a pulse-width that is a function of the size of the voltage on the analog input. Figure 2 on the next page demonstrates this by comparing the comparator's output for two DC voltages on the analog input.

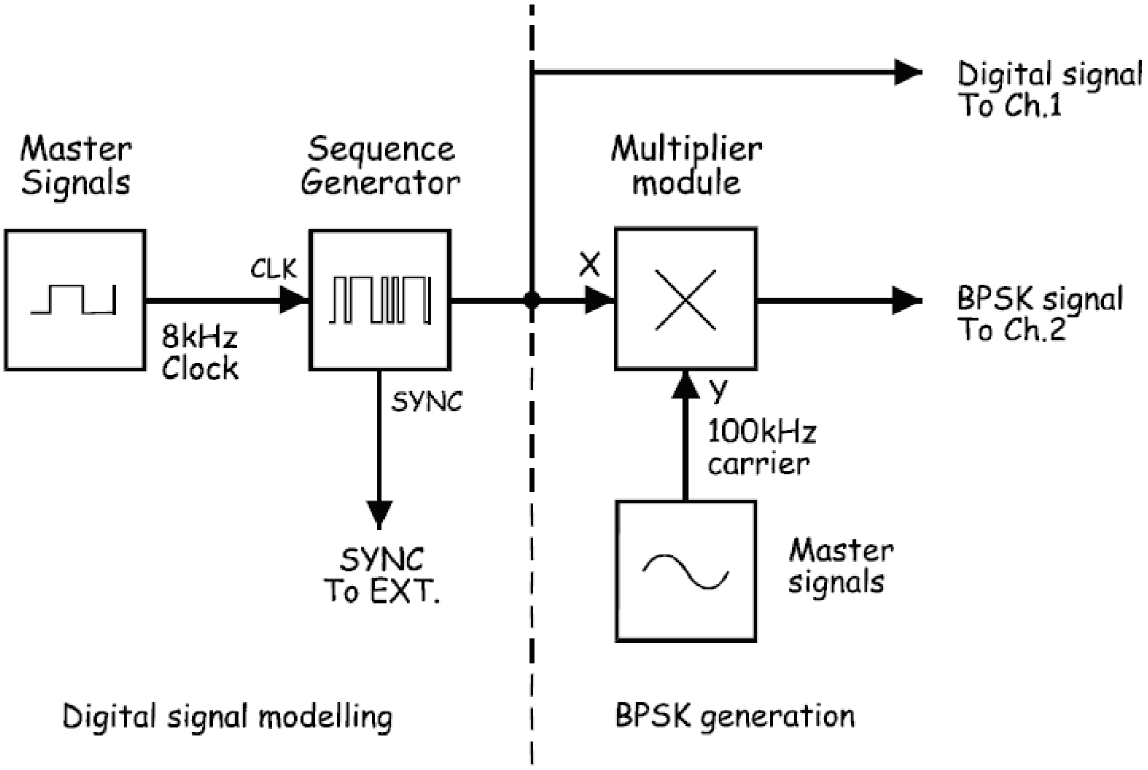




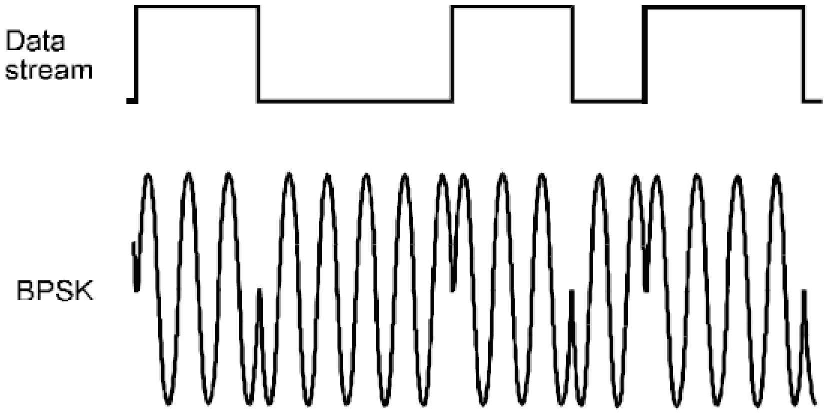
An example of the effect on the comparator's output for a sinewave analog input is shown in Figure 3 below.



2. **Explain with the aid of block diagram the BPSK generation and detection.**



Recall that ASK uses the digital data's 1s and 0s to switch a carrier between two amplitudes. FSK uses the 1s and 0s to switch a carrier between two frequencies. An alternative to these two methods is to use the data stream's 1s and 0s to switch the carrier between two phases. This is called *Binary Phase Shift Keying* (BPSK). Figure 1 below shows what a BPSK signal looks like time-coincident with the digital signal that has been used to generate it.



Notice that, when the change in logic level causes the BPSK signal's phase to change, it does so by 180°. For example, where the signal is travelling towards a positive peak the change in logic level causes it to reverse direction and head back toward the negative peak (and vice versa).

You may find it difficult to see at first but look closely and you'll notice that alternating halves of the BPSK signal's envelopes have the same shape as the message. This indicates that BPSK is actually *double-sideband suppressed carrier* (DSBSC) modulation. That being the case, BPSK generation and the recovery of the data can be handled by conventional DSBSC

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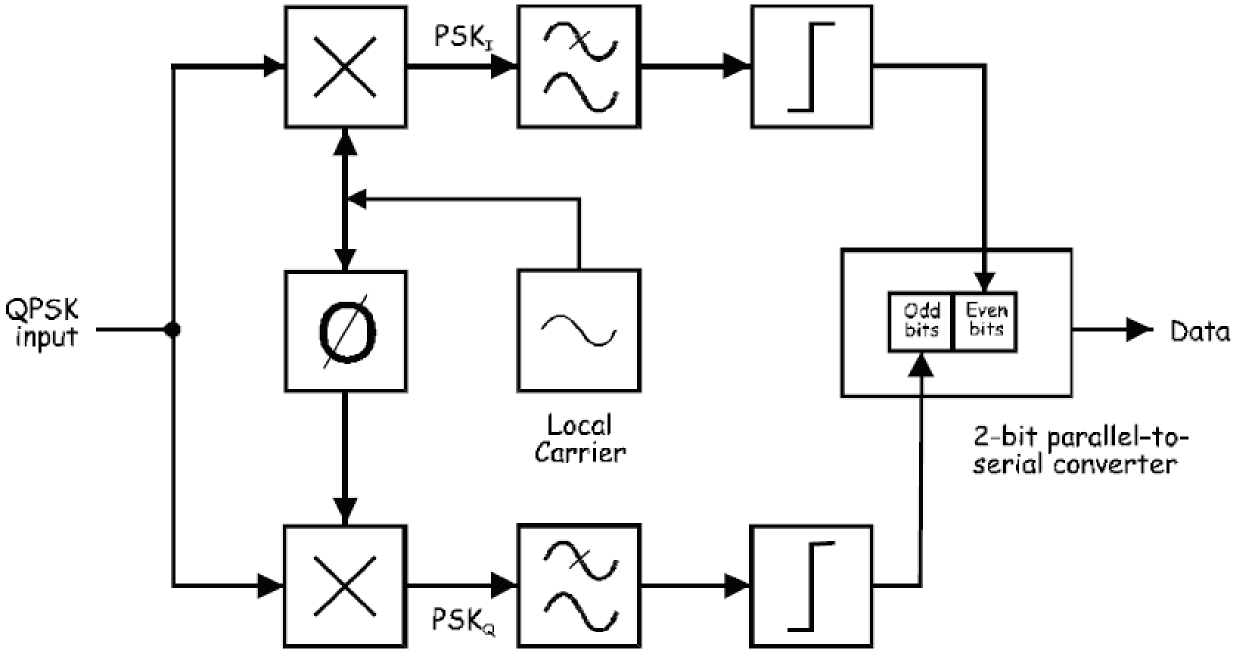
3. Describe the function and operation of the following block diagram:



Notice the arrangement uses two product detectors to simultaneously demodulate the two BPSK signals. This simultaneously recovers the pairs of bits in the original data. The two signals are cleaned-up using a comparator or some other signal conditioner then the bits are put back in order using a 2-bit parallel-to-serial converter.

To understand how each detector picks out only one of the BPSK signals and not both of them, recall that the product detection of DSBSC signals is "phase sensitive". That is, recovery of the message is optimal if the transmitted and local carriers are in phase with each another. But the recovered message is attenuated if the two carriers are not exactly in phase. Importantly, if the phase error is 90° the amplitude of the recovered message is zero. In other words, the message is completely rejected (this issue is discussed in Part E of Experiment 7).

The QPSK demodulator takes advantage of this fact. Notice that the product detectors in Figure 2 share the carrier but one of them is phase shifted 90°. That being the case, once the phase of the local carrier for one of the product detectors matches the phase of the transmission carrier for one of the BPSK signals, there is automatically a 90° phase error between that detector's local carrier and the transmission carrier of the other BPSK signal. So, the detector recovers the data on the BPSK signal that it's matched to and rejects the other BPSK signal.

Best Regards

Dr.Michael Nasief