CONSIDERATIONS REGARDING DATA TRANSMISSION USING THE INTERNET/WIRELESS SYSTEMS

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Abstract: *Data transmissions with frequency and amplitude modulation have a large use in command and control at long distances for unpiloted aerial vectors. The article presents an image of the theoretical and practical part of the data transmission through the sinusoidal components that are used and determine the frequency used and the speed of the data transferred.*

Keywords: *NIC (Network Interface Controller), frequency, data security, UAV (unmanned aerial vehicles), Simulink*

1. INTRODUCTION

Nowadays communications are realized through a variety of methods at low cost limiting the benefits of a network and its partners. Given the financial problems in the recent years (global crisis) we must take in consideration any opportunity that appears.

Communications means a network with a large range of widgets interconnected between them. These widgets are connected through the same medium or different mediums with different capabilities. Widgets connected between them can exchange documents, video files, and audio files and can also take over some capabilities from other widgets. For example, a normal house has at least one TV connected through cable or satellite, games, portable video games, desktop computer, laptop, mobile phone etc. In a "house" these widgets are connected between them and form a network of widgets. Some of these are connected through optical fiber (Ethernet) or wireless (Wifi). See figure 1 [1].

Data transmissions with frequency and amplitude modulation are used in a wide range in the aerodynamic domain through data acquisition from the sensors and control of the unpiloted aerial vectors from distance, figure 2 [2].
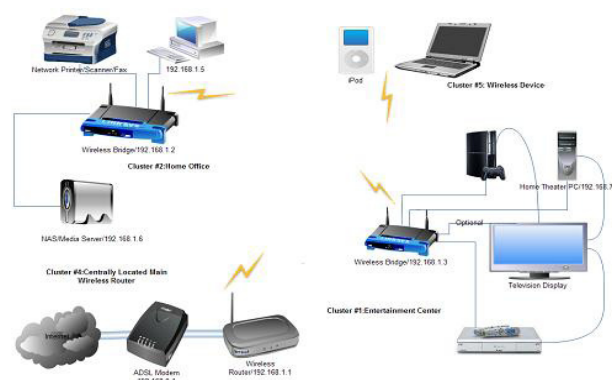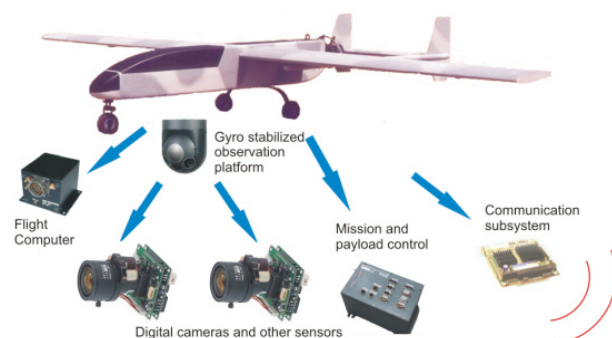

Fig. 1 Home network [1]

Fig. 2 UAV data transmission [3]

2. THEORETICAL REFERE

Starting from these conditions we will analyze the mathematical part of the wireless network interface to observe the range of frequency and the speed of the data submitted [4].

The frequency components of a square wave with A as the amplitude can be expressed as:

$$s(t) = A \times \frac{4}{\pi} \times \sum_{k,odd,k=1}^{\infty} \frac{\sin(2\pi f)}{k};$$

(1)

2.1. Mathematical model. Using the data mentioned earlier we will analyze the sinusoidal wave forms to establish the functionality of the network interface controller knowing the frequency and the sinusoidal components.

We will present a case of wave form

Wave form with three components (sinusoidal):

$$s(t) = \frac{4}{\pi} \left[\begin{array}{l} \sin(2\pi \mathbf{f}) + \dfrac{1}{3}\sin(2\pi(3f)t) \\ + \dfrac{1}{5}\sin(2\pi(5f)t) \end{array} \right]$$

(2)

If $f = 10^6$ cycles per second, meaning 1 MHz (the frequency band of the signal is 1MHz= 10^6 Hz)

$$s(t) = \frac{4}{\pi} \left[\begin{array}{l} \sin(2\pi \times f \times t) + \dfrac{1}{3}\cdot\sin(2\pi \times 3 \times f \times t) \\ + \dfrac{1}{5}\cdot\sin(2\pi \times 5 \times f \times t) \end{array} \right];$$

$$s(t) = \frac{4}{\pi} \left[\begin{array}{l} \sin(2\pi \times 10^6 \times t) + \dfrac{1}{3}\cdot\sin(2\pi \times 3 \times 10^6 \times t) \\ + \dfrac{1}{5}\cdot\sin(2\pi \times 5 \times 10^6 \times t) \end{array} \right];$$

The maximal value of the band will be:

$$(5 \times f \times 10^6) - (f \times 10^6) =$$
$$= (5 \times 1 \times 10^6) - (1 \times 10^6) = 4 \times 10^6 \, Hz = 4MHz.$$

The minimal value of the band will be:

$$(3 \times f \times 10^6) - (f \times 10^6) =$$
$$= (3 \times 1 \times 10^6) - (1 \times 10^6) = 2 \times 10^6 \, Hz = 2MHz.$$

The maximal and minimal value of the band creates the frequency range of the signal.

For $f=1MHz$, the period of the frequency is:

$$T = \frac{1}{f} = \frac{1}{10^6} = 10^{-6} = 1\mu s.$$

If the wave form contains a string of 1 and 0, a bit appears at $0,5\mu s$ for a data rate that is $2 \times 10^6 bps = 2Mbps = $ the speed of the internet, 2 representing the number of bits in 1 μs for $f = 1Mhz$.

2.2. Proposed cases. Using the theoretical information [4] we will analyze a larger area of sinusoids with different frequencies or speeds to determine the rest of the components.

2.2.1. First case. We will use four sinusoidal components and $f = 1MHz$

$$s(t) = \frac{4}{\pi} \left[\begin{array}{l} \sin(2\pi f) + \dfrac{1}{3}\cdot\sin(2\pi(3f)t) \\ + \dfrac{1}{5}\cdot\sin(2\pi(5f)t) + \dfrac{1}{7}\cdot\sin(2\pi(7f)t) \end{array} \right];$$

$$s(t) = \frac{4}{\pi} \left[\begin{array}{l} \sin(2\pi \times f \times t) + \dfrac{1}{3}\cdot\sin(2\pi \times 3 \times f \times t) \\ + \dfrac{1}{5}\cdot\sin(2\pi \times 5 \times f \times t) + \dfrac{1}{7}\cdot\sin(2\pi \times 7 \times f \times t) \end{array} \right];$$

$$s(t) = \frac{4}{\pi} \left[\begin{array}{l} \sin(2\pi \times 10^6 \times t) \\ + \dfrac{1}{3}\cdot\sin(2\pi \times 3 \times 10^6 \times t) \\ + \dfrac{1}{5}\cdot\sin(2\pi \times 5 \times 10^6 \times t) \\ + \dfrac{1}{7}\cdot\sin(2\pi \times 7 \times 10^6 \times t) \end{array} \right];$$

$f = 1MHz$ and, $T = \frac{1}{f} = \frac{1}{10^6} = 10^{-6} = 1\mu s$ 1 bit at $0,5\mu s$.

$$N \times 10^6 = 2 \times 10^6 bps = 2Mbps$$

Bandwidth:
The maximal band value will be:

$$(5 \times f \times 10^6) - (f \times 10^6) =$$
$$= (7 \times 1 \times 10^6) - (1 \times 10^6) = 6 \times 10^6 \, Hz = 6MHz.$$

The minimal band value will be:

$$\left(3 \times f \times 10^6\right) - \left(f \times 10^6\right) =$$
$$= \left(3 \times 1 \times 10^6\right) - \left(1 \times 10^6\right) = 2 \times 10^6 \, Hz = 2MHz.$$

Frequency range: *2MHz, 3MHz, 4MHz, 5 MHz, 6MHz.*

2.2.2. Second case. We will use four sinusoidal components and $f = 4MHz$

$$s(t) = \frac{4}{\pi} \begin{bmatrix} \sin(2\pi f) + \frac{1}{3} \cdot \sin(2\pi(3f)t) \\ + \frac{1}{5} \cdot \sin(2\pi(5f)t) + \frac{1}{7} \cdot \sin(2\pi(7f)t) \end{bmatrix};$$

$$s(t) = \frac{4}{\pi} \begin{bmatrix} \sin(2\pi \times f \times t) + \frac{1}{3} \cdot \sin(2\pi \times 3 \times f \times t) \\ + \frac{1}{5} \cdot \sin(2\pi \times 5 \times f \times t) + \frac{1}{7} \cdot \sin(2\pi \times 7 \times f \times t) \end{bmatrix};$$

$$s(t) = \frac{4}{\pi} \begin{bmatrix} \sin(2\pi \times 4 \times 10^6 \times t) \\ + \frac{1}{3} \cdot \sin(2\pi \times 3 \times 4 \times 10^6 \times t) \\ + \frac{1}{5} \cdot \sin(2\pi \times 5 \times 4 \times 10^6 \times t) \\ + \frac{1}{7} \cdot \sin(2\pi \times 7 \times 4 \times 10^6 \times t) \end{bmatrix};$$

$f = 4MHz$ and

$$T = \frac{1}{f} = \frac{1}{4 \cdot 10^6} = 0,25\mu s; 0,125\mu s \, 1bit:$$

Example bit 1 and bit 0, at $0,25\mu s$ being 2 bits:1 and 0. $1\mu s : 0,125\mu s = 8$ bits:4 bits of 1 and 4 bits of 0.
$N \times 10^6 = 8 \times 10^6 bps = 8Mbps$ is the speed of the internet or the specific network.

Bandwidth:
The maximal band value will be:
$$\left(7 \times f \times 10^6\right) - \left(f \times 10^6\right) =$$
$$\left(7 \times 4 \times 10^6\right) - \left(4 \times 10^6\right) = 24 \times 10^6 \, Hz = 24MHz.$$

The minimal band value will be:
$$\left(3 \times f \times 10^6\right) - \left(f \times 10^6\right) =$$
$$\left(3 \times 4 \times 10^6\right) - \left(4 \times 10^6\right) = 8 \times 10^6 \, Hz = 8MHz.$$

Frequency range: *8MHz, 12MHz, 16MHz, 20MHz, 24MHz.*

2.2.3. Third case. We know the speed of the internet or the specific network and use 5 sinusoidal components

$v_r = 100Mbps; v_r = $ Internet speed or network speed;

$$N \times 10^6 = 100 \times 10^6 bps = 100Mbps;$$

if $N = 100 \Rightarrow 1\mu s : 100 = 0,01\mu s$ for a bit

$$\Rightarrow T = \frac{1}{f} = \frac{1}{x \cdot 10^6} = 0,01\mu s;$$

$0,02\mu s$ represents the period when 1 and 0 bit work and form a square wave form

$$\Rightarrow x = \frac{1}{0,02\mu s \cdot 10^6 \, Hz} =$$

$$\frac{10^2 \cdot 10^6 s}{2s \cdot 10^6 \, Hz} = 50Hz \Rightarrow f = 50Mhz.$$

$$s(t) = \frac{4}{\pi} \begin{bmatrix} \sin(2\pi f t) + \frac{1}{3} \cdot \sin(2\pi(3f)t) \\ + \frac{1}{5} \cdot \sin(2\pi(5f)t) + \frac{1}{7} \cdot \sin(2\pi(7f)t) \\ + \frac{1}{9} \cdot \sin(2\pi(9f)t) \end{bmatrix}$$

$$s(t) = \frac{4}{\pi} \begin{bmatrix} \sin(2\pi \times f \times t) + \frac{1}{3} \cdot \sin(2\pi \times 3 \times f \times t) + \\ \frac{1}{5} \cdot \sin(2\pi \times 5 \times f \times t) + \frac{1}{7} \cdot \sin(2\pi \times 7 \times f \times t) \\ + \frac{1}{9} \cdot \sin(2\pi \times 9 \times f \times t) \end{bmatrix};$$

$$s(t) = \frac{4}{\pi} \begin{bmatrix} \sin(2\pi \times 50 \times 10^6 \times t) \\ + \frac{1}{3} \cdot \sin(2\pi \times 3 \times 50 \times 10^6 \times t) \\ + \frac{1}{5} \cdot \sin(2\pi \times 5 \times 50 \times 10^6 \times t) \\ + \frac{1}{7} \cdot \sin(2\pi \times 7 \times 50 \times 10^6 \times t) \\ + \frac{1}{9} \cdot \sin(2\pi \times 9 \times 50 \times 10^6 \times t) \end{bmatrix};$$

Bandwidth:
The maximal band value will be:
$$\left(9 \times f \times 10^6\right) - \left(f \times 10^6\right) =$$
$$= \left(9 \times 50 \times 10^6\right) - \left(50 \times 10^6\right) = 400 \times 10^6 \, Hz = 0,4GHz.$$

The minimal band value will be:

$$(3 \times f \times 10^6) - (f \times 10^6) =$$

$$= (3 \times 50 \times 10^6) - (50 \times 10^6) = 100 \times 10^6 Hz = 0,1 GHz.$$

Frequency range:

$0,1 GHz; 0,15 GHz; 0,2 GHz; 0,25 GHz;$

$0,3 GHz; 0,35 GHz; 0,4 GHz;$

    2.2.4. Fourth case. We know the internet speed or the speed of the network and use 3 sinusoidal components, the cheapest wireless network or the use of computer modems to have internet access:

$v_r = 7,2 Mbps; v_r =$ Internet speed or network speed;

$N \times 10^6 = 7,2 \times 10^6 bps = 7,2 Mbps;$ if $N = 7,2$

$\Rightarrow 1\mu s : 7,2 = 0,13888889 \mu s$ for 1 bit

$\Rightarrow T = \dfrac{1}{f} = \dfrac{1}{x \cdot 10^6} = 0,27777778 \mu s;$

$0,27777778 \mu s$ Represents the period when 1 bit of 1 and 1 bit of 0 forms a square wave form

$\Rightarrow x = \dfrac{1}{0,27777778 \mu s \cdot 10^6 Hz} =$

$\dfrac{10 \cdot 10^6 s}{2,7777778 s \cdot 10^6 Hz} = 3,6 Hz \Rightarrow f = 3,6 MHz.$

$$s(t) = \frac{4}{\pi} \left[\begin{array}{l} \sin(2\pi f t) + \dfrac{1}{3} \cdot \sin(2\pi(3f)t) \\ + \dfrac{1}{5} \cdot \sin(2\pi(5f)t) \end{array} \right];$$

$$s(t) = \frac{4}{\pi} \left[\begin{array}{l} \sin(2\pi \times f \times t) + \dfrac{1}{3} \cdot \sin(2\pi \times 3 \times f \times t) \\ + \dfrac{1}{5} \cdot \sin(2\pi \times 5 \times f \times t) \end{array} \right];$$

$$s(t) = \frac{4}{\pi} \left[\begin{array}{l} \sin(2\pi \times 3,6 \times 10^6 \times t) \\ + \dfrac{1}{3} \cdot \sin(2\pi \times 3 \times 3,6 \times 10^6 \times t) \\ + \dfrac{1}{5} \cdot \sin(2\pi \times 5 \times 3,6 \times 10^6 \times t) \end{array} \right];$$

Bandwidth:
The maximal band value will be:

$$(5 \times f \times 10^6) - (f \times 10^6) =$$

$$(5 \times 3,6 \times 10^6) - (3,6 \times 10^6) = 14,4 \times 10^6 Hz = 14,4 MHz.$$

The minimal band value will be:

$$(3 \times f \times 10^6) - (f \times 10^6) =$$

$$(3 \times 3,6 \times 10^6) - (3,6 \times 10^6) = 7,2 \times 10^6 Hz = 7,2 MHz.$$

Frequency range:

$7,2 MHz; 10,8 MHz; 14,4 MHz;$

    The problems that appear during a transmission are: attenuation, delay distortion, noise, and channel capacity.
A signal is attenuated if the emission or receiver antenna lies in an industrial area or the building where it lies contains a special alloy that shields the signal losing a big part of its emission/ reception power.
    Delay distortion is caused by the fact that the velocity of signal propagation through a guided medium varies with the frequency.
Noise is an undesired signal that is inserted into the real signal during transmission.
    Channel capacity is the maximum rate at which data can be transmitted over a communication path or channel.

3. DATA TRANSMISSION WITH FREQUENCY MODULATION

    The use of data transmission with frequency and amplitude modulation has a large range of use in command and control of the unpiloted aerial vectors. These offer the advantage of hardware miniaturization combined with new mission directives that were not possible in the past due to the limited technology. The software analysis medium Matlab/Simulink 2010 [5][6] offers a image of the transmission data (figure 3 and figure 4) in the UAV domain.
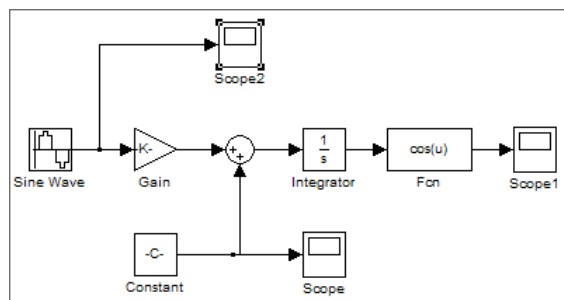
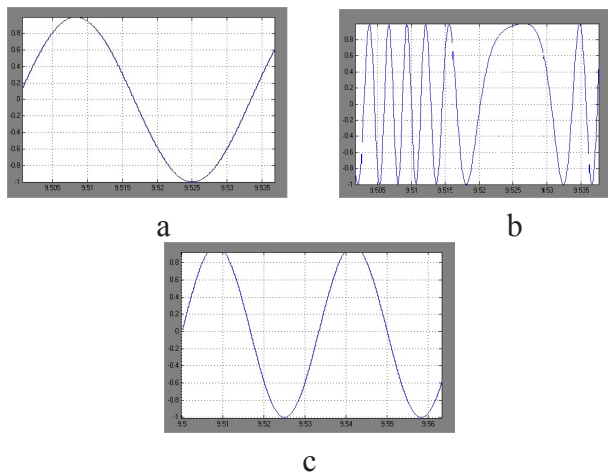Fig. 3. Simulink model in FM modulation

a

b

c

Fig. 4. Modulating signal (a), output (modulated) signal (b) and carrier signal (c)

The radio command and control system is subjected to a analysis and has the following characteristics represented in table 1 [7]:

Table 1. FUTABA 6XEAP-characteristics

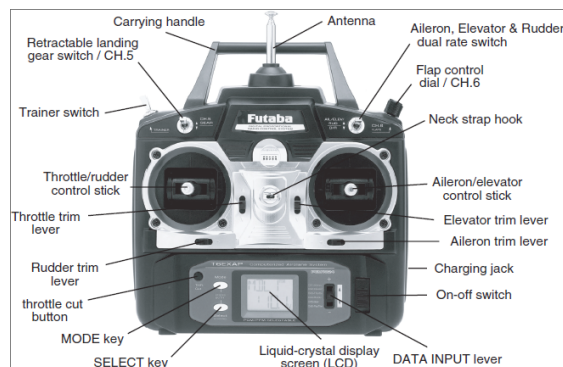| Emision T6EXAP	
Working Frequency	35MHZ /40 MHz
Number of channels	6
Tension	9,6÷12V
Modulation	FM / PPM
Discharge	250mA/h
Receiver R127DF/R136F	
Type	FM
Tension	4,8÷6V
Discharge	9,5mA la 4,8V
Weight	42,5g/27,8g
Servomotors S3003/S3004 Standard	
Force in action	3,2kg/cm
Operation speed	$0,23s/60^0$
Weight	37,2g/38g

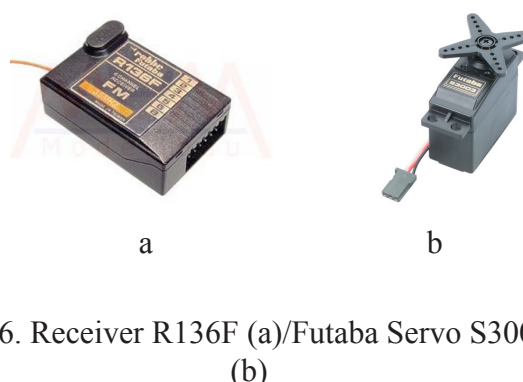Fig.5. Radio system FUTABA 6EXAP

a

b

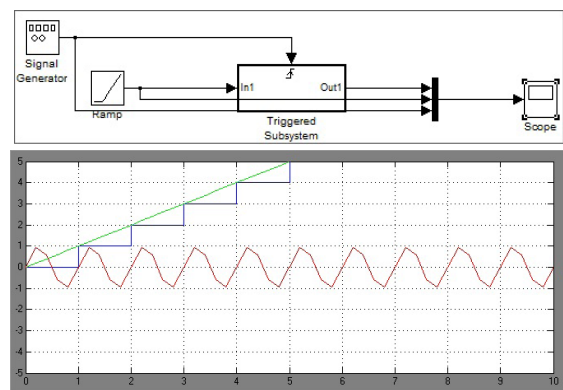Fig.6. Receiver R136F (a)/Futaba Servo S3003 (b)

Fig.7 Simulink model for Futaba system

4. CONCLUSIONS & PROPOSALS

Worldwide wireless transmission data have applications in civilian and military life, especially in robotics and unmanned aerial vehicles (UAV).

In this article we pointed out the theoretical principles of data transmission and the elements that can influence it.

Thus, we presented the influence of the number of sinusoidal components of the band and frequency fundamentals against the bandwidth and much more against the extreme values of it (minimal and maximal).

The values have a direct influence concerning the speed of the transmission.
It is clear that a large band assures a high speed for data transmission with implications in the distortions that may appear and concerns regarding the costs.

Last but not least the simulations realized in the Simulink medium explains the FM modulation/demodulation process that is essential for a correct functionality of the transmitter mentioned and presented concise in the paper.

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