ANTENNA MODEL FOR AIRCRAFT BROADBAND COMUNICATION

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Air traffic in recent years has seen a substantial increase in the amount of transported persons and material. This immediately also increased demand for quality of radio connection, transfer of spoken information as well as navigational data and data in general. As is well known, antennas are transmission elements between the power transmitter and a free media, where electromagnetic waves propagate as information carrier. Due to the position of antennas in the transmission chain, it is necessary to know the frequency band at which they are tuned. This frequency band determines range in which antennas work (transmit or receive). We can have transmitter or receiver of highest quality, but if the antenna is not properly adjusted, we will never get maximum performance of the transmitter or receiver.

K e y w o r d s: antenna, model, broadband, vswr

1 INTRODUCTION

This paper deals with the issue of aircraft's broadband communication antennas. Based on theoretical knowledge, there have been designed antennas of various shapes with capacitive loads and without the capacitive load for the 2.4 Ghz frequency band as well. This frequency band was chosen effectively for using in measurements of antenna's radiation characteristics on aircraft model in scale 1:20. Designed antennas were consequently analysed from the viewpoint of the impact of their selected sizes for their resonance properties. Based on the measurements taken, there were confirmed theoretical preconditions familiar in antenna's technology.

2 DESIGN AND IMPLEMENTATION OF ANTENNAS

To carry out the measurements, it was necessary to propose realized change of antennas dimensions, the material of which they made and prepare workplace.

We identify the most appropriate size of antennas depending on the frequency band, which is in the range 1-5 GHz. These antennas were divided into seven sets, where the basic variable was change of the width of the antenna, which gradually increased by 5 mm at an interval from 5 mm to 36 mm. Antenna height varied in each set from 10 mm to 70 mm.

After measurements of these antennas, we have created a new set. Changing dimension was bevel of antenna. This means that the antenna of the previous sets of rectangular shape is changed to hex with a taper at the bottom of the antenna, symmetrically on both sides in two variants 9 ˚ and 18 ˚ taper.

After these measurements, for each set of these antennas (rectangular and hexagonal shape) was added capacitive load with dimensions 7 x 64 mm, on top of the antenna.

Material called tined bronze, which was used to produce these antennas, is mainly used in electrical engineering for its good electrical properties. The most commonly used are CuSn3, CuSn6 and CuSn8 bronzes, bronze CuSn6 containing 5 to 7% tin, up to 0.25% phosphorus and the rest is copper.

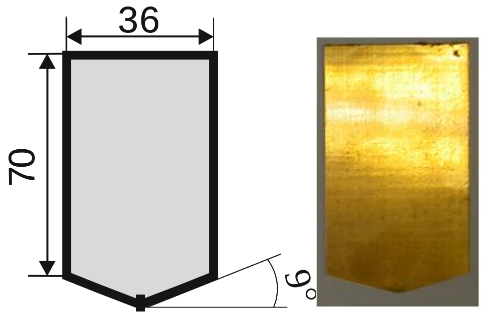

Figure 1: Antenna 36x70mm with 9 degree bevel

Measurements chain was simple. It consisted of Bird SA-6000EX analyser, HF connector type n-female RG213, computer and measured antenna, see Figure 2.

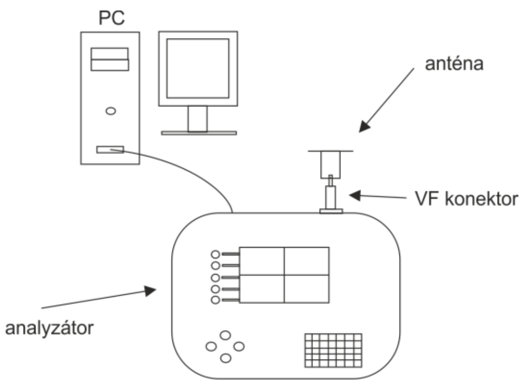

Figure 2: Measurements chain

3 MEASURING THE DATA

The resulting values of these measurements are graphs, which are expressed as frequency, bandwidth and VSWR value. For expressing bandwidth, the “absolute frequency method" (AFM) was used.

Bandwidth is usually defined as the width of the frequency band in which the linear gain of the antenna is at least half of that at its resonant frequency. Bandwidth is expressed in decibels [dB], as the offset of -0.3 dB/˚ compared to resonant frequency. Method of determining absolute frequency bandwidth is specified under the upper and lower cut-off frequency (shift of - 0.3 dB / ˚), or an indication of the center frequency (±) half-width of the frequency band. If the antenna has a bandwidth of 2113 to 2367 MHz, the arithmetic average of these frequencies gives us the so-called centre frequency and the difference between the average rate and the marginal rate is half the bandwidth that is 2250 ± 127 MHz.

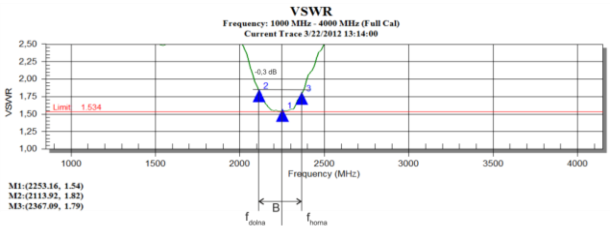

Figure 3: Bandwith of 36x70mm antenna

4 RESULTS OF MEASUREMENTS

From processed graphical waveforms was assessed the frequency dependence of antenna, where the width of the antenna was variable parameter. We produced several antennas, which length was varied in the range from 10 mm to 70 mm with step of 10 mm. Parametric quantity of measured antennas was the width of the antenna, which varied in the range from 5 mm to 36 mm in increments of 5 mm. In evaluating the electrical properties of antennas was considered the value of the resonant frequency, which was characterized in the measured frequency range with the lowest VSWR.

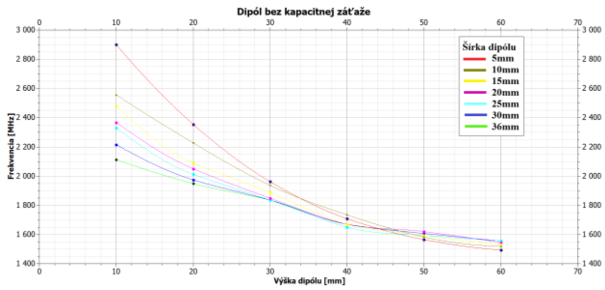

Figure 3: Antennas without capacitive load

In terms of changes of the antenna changes its resonant frequency almost linearly so that in reducing the rate of rise. At greater length of the antenna (eg 60 mm) when changing the length of 10mm (50 mm) causes a change in the resonance frequency of about 50MHz . With further shortening the antenna 10mm (40 mm), the resonant frequency of the antenna changes by about 100MHz . Further reduction of the antenna of the same section , means a further increase in the range of variation of the resonance frequency . The dependence of this change is not entirely linear . In addition to changing the length of the antenna parameters of the graph change the width of the antenna . For antennas with a large width of the antenna resonance frequency change is more gradual than in the narrower antennas . In this way we at least the length of the antenna (10 mm) and greatest width of the antenna (36 mm) reached the resonant frequency of 2100MHz . Similarly, at least the length of the antenna (10 mm) and the smallest width of the antenna (5 mm) was achieved resonant frequency to 2900MHz .

The same length as the antenna can . with its small dimensions change its resonant frequency by simply changing the width of the antenna . Due to this fact, we consider that a change of antennas ranging from 10 mm to 60 mm , we were able to change in its widest antenna resonant frequency of about 600MHz . But when you change the width of the antenna in the range from 5 mm to 36 mm , we were able to change the shortest antenna at its resonant frequency of about 800MHz . This change can be made only when the antenna is very short and has a small value of the coefficient of slenderness . For large antennas in our case (60 mm) to change the bandwidth is only very slight change in frequency ie about 60MHz .
On the chart it is possible to observe an interesting phenomenon , which confirms the theoretical knowledge of Amateur Radio . It is a fact that the closer to the length of the antenna to resonance frequency λ / 4 a situation where the thickness (width of the dipole) does not affect the resonant frequency of the antenna . The chart can be read , the resonant frequency of the λ / 4 dipole in this case is 1600MHz . At this frequency the wavelength of 187.5 mm and dimension λ / 4 represents 46.9 mm . Fixed resonant dipole length measured from the graph in this case would be 46 mm . The irregularity of these values represents the factor cuts antenna , which in this case has the λ / 4 value 0.98.

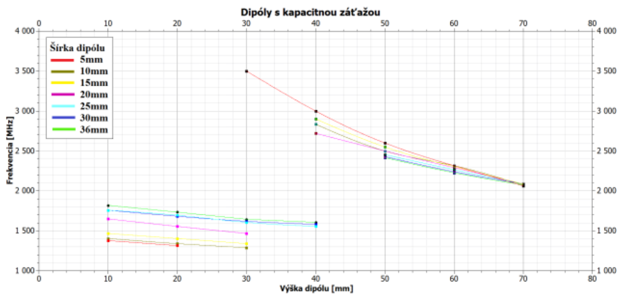

Figure 4: Antennas with capacitive load

After evaluation of antennas without capacitive loads were at the end of the same antennas soldered capacitive load of the same material, see Figure 5. Subsequently, these antennas gradually remeasured anytime, evaluated and results are presented in Figure 4.

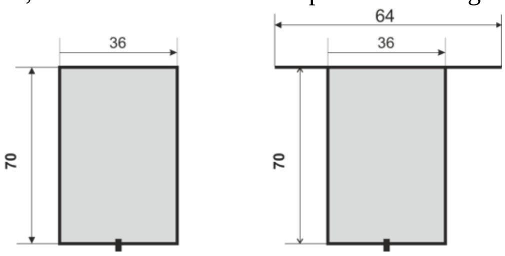

Figure 5: Antenna without and with capacitive load

From the above graphical representation is clear that the use of capacitive loads to evaluate antennas have been two major changes :

1.Shift of the resonance frequency of λ / 4 to lower values
2.Creation of resonance frequency λ / 2 at higher values

4.1 Shift of the resonance frequency of λ / 4 to lower values

Capacitive load evidently changed the resonant frequency of all the evaluated antennas . E.g. without capacitive loads should all antenna length of 10 mm at the resonant frequency of 2 GHz (2.1 ÷ 2.8) GHz and capacitive loads are frequency- shifted frequency antennas all below 2 GHz (1.6 to 1.8) GHz . Capacitive load caused a frequency shift of about 1GHz below . An interesting phenomenon in this case is that the frequency dependence of the antenna factor in increasing the slenderness antenna (for its renewal) remains as it was in chart . 1 All courses are changing almost parallel and can not be seen indication that all courses directed to a single point (as in Figure 1) . In addition, the capacitive load reduces the slope changes the resonant frequency . Antenna capacitive loads without a change in slope antenna 25 mm wide by 30 mm in the range of 2200MHz to 1650MHz , which represents changes 550MHz frequency range . Antenna 25mm wide capacitive load has slope changes within 30 mm from 1750MHz to 1550MHz , which is the frequency range changes only 200MHz .

4.2 Creation of resonance frequency λ / 2 at higher values

Capacitive load on the antennas used primarily to reduce the resonant frequency of the antenna without enlarging its dimensions . This important feature capacitive loads in practice very often , at different frequency bands used . According evaluated graph shows that the capacitive load makes sense to use only up to a certain value of the coefficient of slenderness antenna . This fact is reflected by the fact that beyond a certain value of the slenderness coefficient antenna starts to generate antenna λ / 2 resonant frequency . Resonant frequency " jumps " to higher levels and antenna seems like half woolen dipole . In view of the above, there is a change of resonant dipole character of λ / 4 to λ / 2 as follows :

- The dipole is 5 mm wide variation in length from 20 mm to 30 mm ,
- The dipole is 10 mm wide variation in length from 30 mm to 40 mm ,
- The dipole is 15 mm wide variation in length from 30 mm to 40 mm ,
- The 20mm wide dipole is changed in length from 30 mm to 40 mm ,
- The dipole is 25 mm wide variation in length from 40 mm to 50 mm ,
- The dipole is 30 mm wide variation in length from 40 mm to 50 mm ,
- The dipole is 36 mm wide variation in length from 40 mm to 50 mm .

When assessing the graphic resonant properties woolen half dipole with capacitive loads can give you a few facts . It is much more pronounced frequency variation λ / 2 dipole versus λ / 4 dipole depending on the length of the dipole . Neighborhood woolen dipole with capacitive loads and has a width of 25 mm slope changes within 30 mm from 1750MHz to 1550MHz (200MHz) . But the same dipole with capacitive loads in half woolen resonance width and the slope changes within 30 mm from 2840MHz to 2100MHz (740MHz) , which is significantly greater frequency difference .

It is also possible the graphical waveform graph no . 2 observed that the frequency within half woolen dipole with capacitive load in this case are similar to the character of the frequency changes as waveforms quarter woolen dipole without capacitive loads in chart . 1 It is a fact that the closer to the length of the antenna to resonance frequency λ / 2 a situation where the thickness (width of the dipole) does not affect the resonant frequency of the antenna . The chart can be read , the resonant frequency of the λ / 2 dipole in this case is 2100MHz . At this frequency the wavelength of 142.8 mm and dimension λ / 2 is the value of 71.4 mm . Fixed resonant dipole length measured from the graph in this case would be 70 mm . The irregularity of these values represents the factor cuts antenna , which in this case has to λ / 2 value of 0.98 also .

CONCLUSION

From the graphical display of measured values of dipole resonance frequency, depending on their length, can be concluded that the theoretical assumptions known from antenna theory are confirmed. Unexplained fact remains, which antenna parameter affects the position of the point at which the width of the dipole does not alter the resonance frequency.

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