HIGH-FREQUENCY CIRCUITS OF AN AIRPORT SURVEILLANCE SYSTEM

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The paper discusses the practical implementation of third generation radio compass for the needs of an airport surveillance system. The paper consists of four parts. Configurations of the third generation radio compasses are discussed in the first part. Evaluation of the exchange principle angle beacons is discussed in the second section. The third part of the paper contains measured data and the fourth section presents the tracking system. The main contribution of this work is the production of radio compass for the needs of the local positioning system made out of affordable components.

K e y w o r d s: direction finding, balance modulator, octane, circuit

1 INTRODUCTION

ADF - Automatic direction finder is autonomous on-board equipment, usually used on helicopters and airplanes. ADF automatically finds the angle of receiving signal and this way provides continuously bearing information to stations (BIS).

ADF provides also these services:

1. flight to beacon, or flight from beacon with visualization (BIS),
2. realization landing manoeuvre OSP,
3. listening identification signals in 190 - 1799 kHz band.

The principle of ADF is based on comparing amplitudes and phases from loop and sense antennas. Each ADF has four basics component:

1. antennas system,
2. circuits for adjusting the received signals,
3. evaluation circuit,
4. control and display block.

The information displayed on an indicator for a pilot represents angle between X body axis and axis to transmitter. The band of ADF is from 190 to 1799 kHz, accuracy displayed BIS is from ± 1° to ± 3°. Range depends on antennas position on the airplane and on the effective height of sense antenna and effective area of loop antenna. Operating ADF also depend on sensitivity of receiver high frequency circuits, transmitted power from transmitter, flight level, type and construction of airplane, etc. In height of 10000m approximately is range ADF cca 300km.

We can historically classify ADF to three generations:

1. generation uses moving loop antenna and sense antenna, signals are evaluated on analogue principle with cardioids,

2. generation uses solid state loop antenna and sense antenna, signals are evaluated on analogue principle with use cardioids, for find BIS is used searching coil inside goniometer with is used principle of cardioids

3. generation has same antenna system as the second generation, but for the finder transmitter a sine-cosine modulated HF signal and consequence numerical analyses are used.

Although the principle of navigation using radio compasses are relatively old and little used, it is still installed on-board of today aircrafts and avionics companies producing them even in the latest glass cockpits. This is evidenced by ADF-900 Direction Finding from Rockwell-Collins installed on-board the most advanced transport aircraft of today consortium Boeing 787 Dreamliner.

2 THIRD GENERATION ADF

Antenna system radio compasses III. Generation is made up of identical antenna system as the II generation. Focus on beacons is no longer used, nor goniometer principle cardioid. The principle focus is the sine-cosine modulation signals from the loop antenna and the sum of the signal from the directional antenna and the actual evaluation provides a microprocessor using a mathematical model by comparing the amplitude of the resulting signal quadrants. The principle of signal evaluation allowed a completely different approach to the construction of electronic circuitry and mechanical design itself compass. This dramatically reduced weight and dimensions. People that are not used in the construction of the desired moving parts to increase reliability, while the theoretical to reduce production costs. Graphical display is provided using the associated information on the navigation screen. The signals from the antennas are reinforced frame and switched fourfold rectangular signals are shifted to each other by 90 °. Switched signals are summed and subsequently summed and amplified signal from the directional antenna. One resulting signal is processed by the receiver; the transmitter is further converted to a digital signal and finally evaluated by a microprocessor and displayed indicator. Evaluation focus is built on mutual comparison signal amplitudes of each quarter.

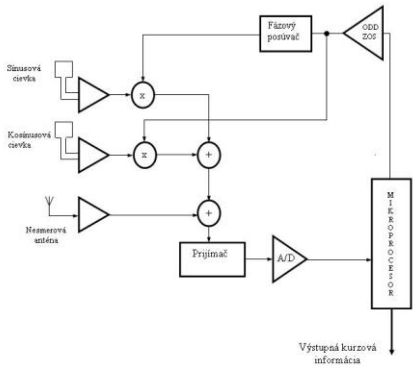


Fig. 1 The block diagram of III. generation ADF

Principle of operation counting partial signals better approximate the following courses in targeting α = 130 °:

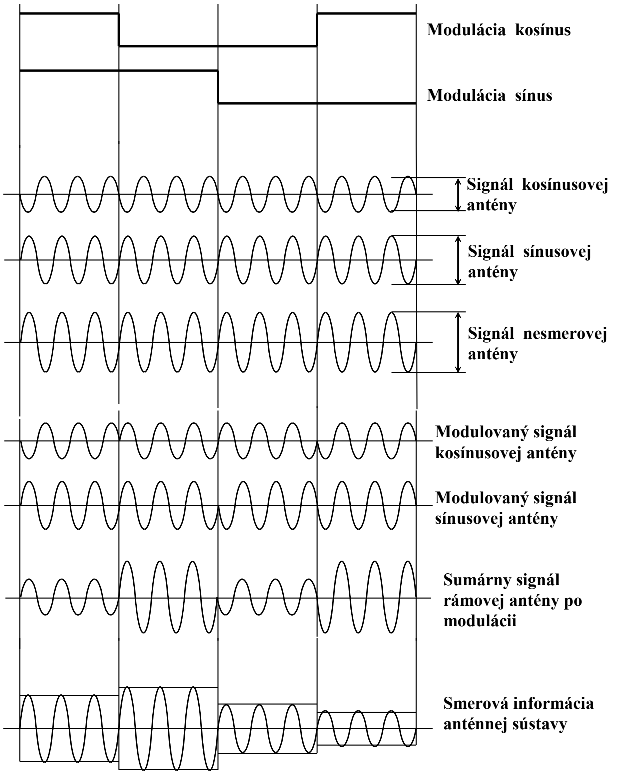


Fig. 2 Waveforms in the ADF III. generation

3 THE PRINCIPLE OF EVALUATING THE EXCHANGE ANGLE BEACONS

Basis for evaluation of the algorithm consists of comparing the four amplitudes of 45 ° which divides the circle into eight parts. The principle I have reached based on graphical analysis of waveforms. The precise specification of the individual octants is transferred using only the two amplitudes and calculating an angle through Approximation dish, which the constants A, B and C were determined using qti-plot. Constants are different for each octant.

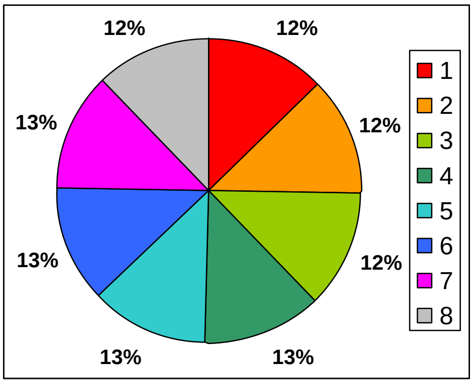
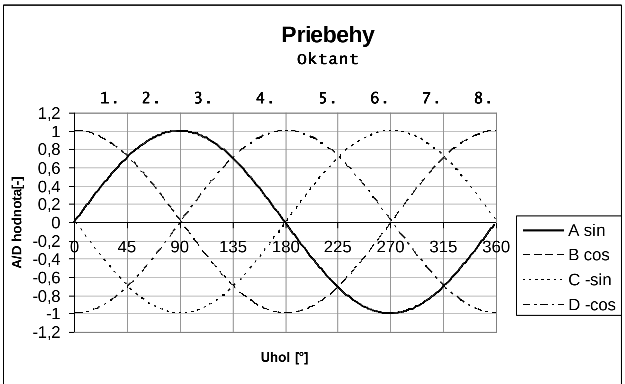


Fig. 3 Ideal distribution of octants in the ring

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1.oktant: (B>A).(B>C).(B>D) . (A>=C) = 1  [ 0°-45°   ]
2.oktant: (A>B).(A>D).(A>C) . (B>=D) = 1  [ 45°-90°  ]
3.oktant: (A>B).(A>D).(A>C) . (D>B)  = 1  [ 90°-135° ]
4.oktant: (D>A).(D>C).(D>B) . (A>=C) = 1  [ 135°-180°]
5.oktant: (D>A).(D>C).(D>B) . (C>A)  = 1  [ 180°-225°]
6.oktant: (C>D).(C>B).(C>A) . (D>=B) = 1  [ 225°-270°]
7.oktant: (C>D).(C>B).(C>A) . (B>D)  = 1  [ 270°-315°]
8.oktant: (B>A).(B>C).(B>D) . (C>A)  = 1  [ 315°-360°]
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Fig. 4 Waveforms and the algorithm

The table below shows recorded the values of constants dish to share single octant amplitudes in it.

Tab. 1 Table of constants

	A (x^2)	B (x)	C	Ratio
1.Octant	35,46093	-126,82	91,41888	B/A
2.Octant	16,25368	-61,8957	90,25186	B/A
3.Octant	-16,5091	61,89565	89,694	D/A
4.Octant	16,25368	-61,6341	180,2519	A/D
5.Octant	-16,5091	61,89565	179,694	C/D
6.Octant	16,25368	-61,6341	270,2519	D/C
7.Octant	-16,5091	61,89565	269,694	B/C
8.Octant	16,25368	-61,6341	360,2519	C/B

To verify the accuracy of the evaluation of the angle were drawn up table of ideal waveforms of four quadrants (A, B, C, D), where the values are in increments of one degree. From zero degrees after three hundred and sixty degrees, this forms a complete circle.

Use the table to demonstrate the functionality of the evaluation aimed angle duplication without focus octant, and the substantial accuracy of angle, where the average error in the whole circle was 0.026 degree. This is absolutely sufficient accuracy due to the fact that the system has a precision of 806 KDF +/- 3 °.

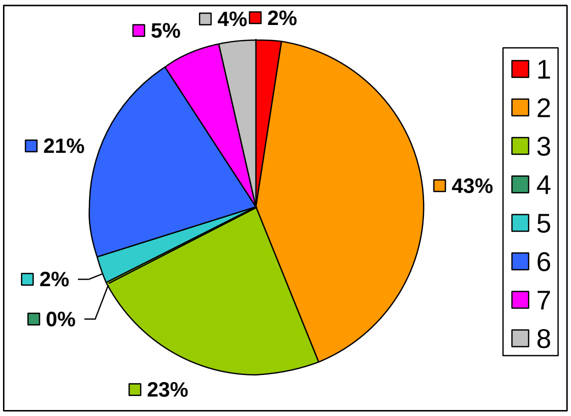

Fig. 6 Types of octants in the ring 702kHz Čižatice

4 MEASURED DATA

The measurements were performed at a frequency of 702kHz where the received signal from the transmitter Čižatice. Receiving antenna was placed at the Department of avionics TUKE and razed to the geographic north. According to the map in Fig. 38 is the angle between geographic north receiving antenna and transmitter rounded 52 °.

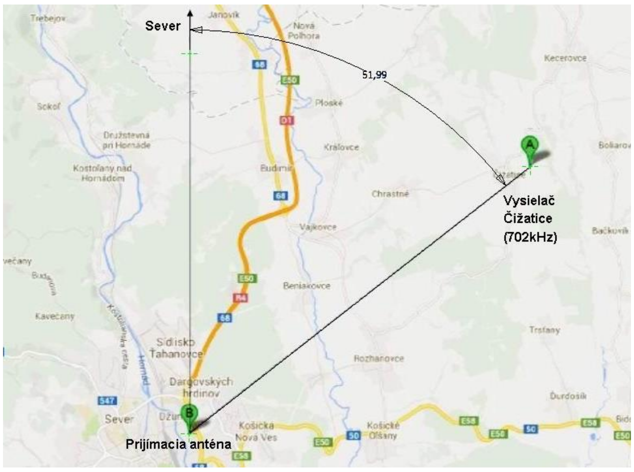

Fig. 5 Map location of transmitter and receiver

In this measurement, samples were taken in count per step 300, wherein a step is a rotation of 1.5 °. The volume of the radio was set to level 21 Volume. Looking back angle conversion was calculated median problem in one full revolution, which has a value -10.565923805 °. Based on the angle of displacement octants focus radio to zero on the platform set at 36 °. This makes it possible to determine the value of a static error setting the platform to true north, which has a value of 15.99 °.

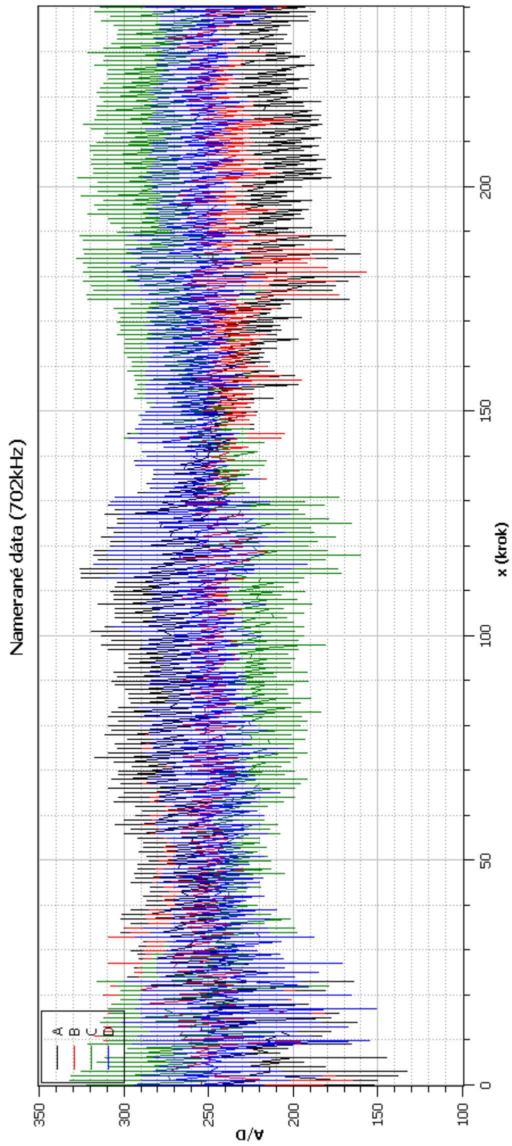

Fig. 7 Measured data 702kHz Čižatice

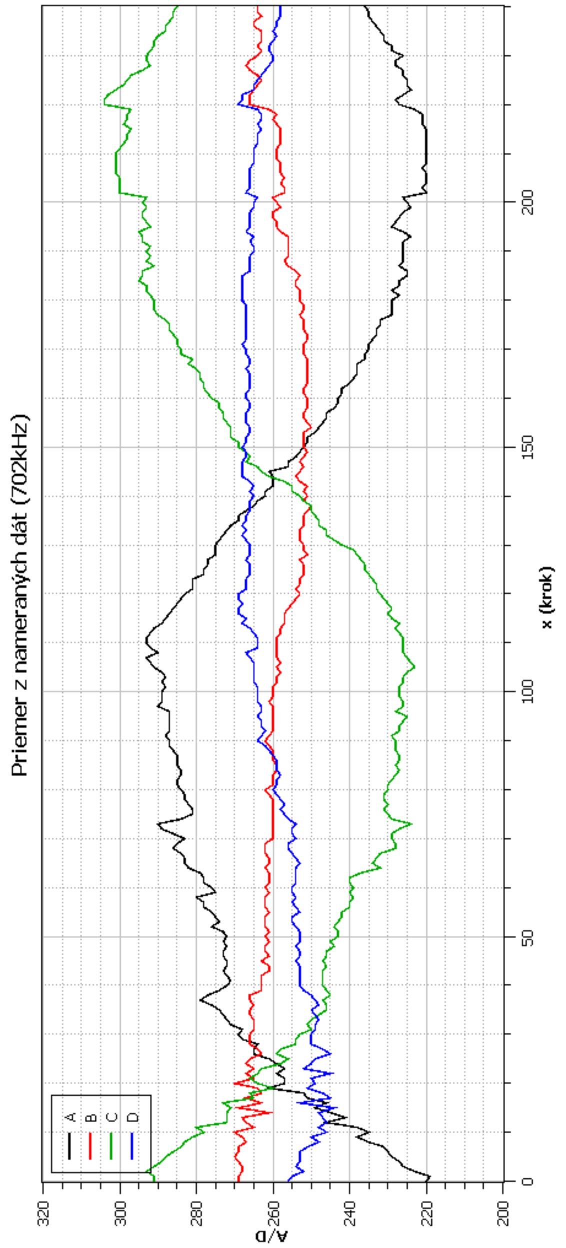

Fig. 8 Averaged data 702kHz Čižatice

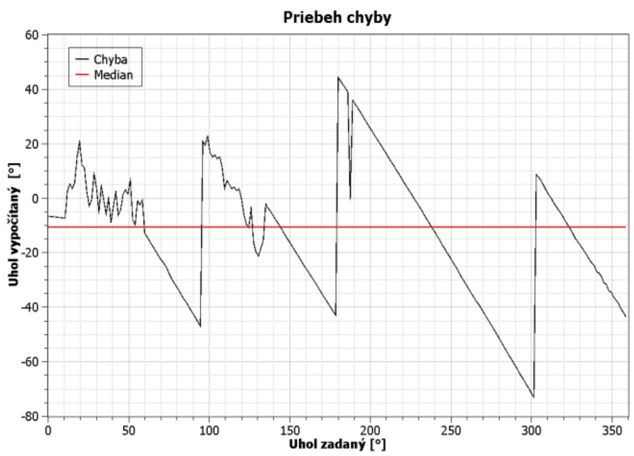

Fig. 9 Course error 702kHz Čižatice

4 AIRPORT SURVEILLANCE SYSTEM

Currency positional angle from each station - the site of the radio compasses is determined to true north, and its position is aligned with the digital map of the area. Transmitter - search object, sends a signal that is captured by each radio compass which determines the exchange rate transmitter angle to this way is shown in Fig. 42 Exchange angles to the transmitter of each radio compass are centrally processed based on the mathematical model and subsequently evaluated by the calculated location of the property. Thus, in one central positional station, the position of the search object, this is plotted in the digital map. For determining exchange angles aim in real-time as best seems Direction Finding III. generation, due to its higher speed evaluation exchange angle compared to previous generations. The greater number of positional stations we have, the more accurate it is possible to determine the location of the search object - the transmitter. Such a local positioning system is a cheap, effective and accurate positioning system for air, but also vehicular traffic with a wide array of possible applications.

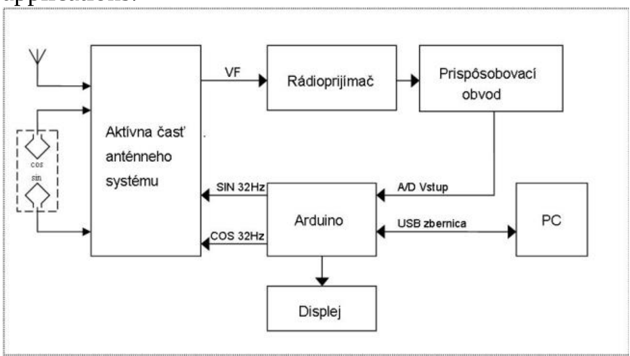

Fig. 81 Block diagram of an ADF III. generation, needed for the navigation system

The following figure shows a local positioning system at an airport Košice.

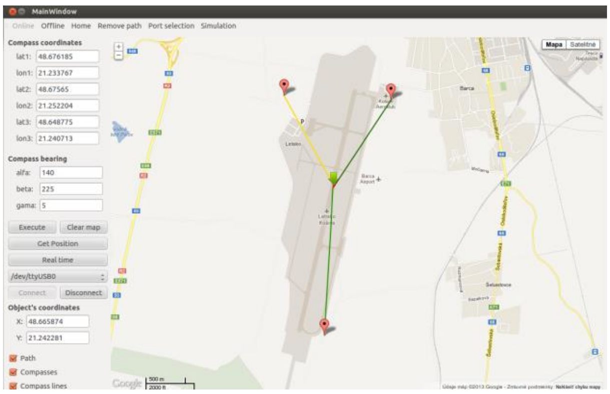

Fig. 92 Local tracking system at the Košice airport. **Chyba! Nenašiel sa žiaden zdroj odkazov.**

The disadvantage of this system is that it is a system in place, that is, has a limited range, which is characterized by a range of individual radio compasses.

Also, with the increasing of the distance from the transmitter increases the error of the calculated position from the actual position of the object, which, however, the dimensions of the Košice airport, for example, had very serious. [2]

The advantage of this system is that it is a separate system that does not require additional devices or sensors. Just once to determine the GPS location positioning stations for their location and then is able to work independently. Said system can be placed in different places without restriction and theoretically should work since the mid-range waves, interference or transmission of radio waves is not as great as at shorter wavelengths. This is a centralized system, that is, all the information is transferred to one of the central station, where they are processed, so it is possible to monitor and control the movement of the position of one point and without high costs of implementing such a system. The system is able to work with a large number of positional stations, whereby it is possible to increase the accuracy of tracking objects.

6 CONCLUSION

The goal was to create a high-frequency circuits, radio compasses third generation to meet the needs of the local airport tracking system. The paper managed to create the active involvement of the antenna using SMD technology, and encapsulated with the principle Faraday cage. Within this thesis also managed to create a passive part of the antenna system, which has managed to create a complete antenna system usable in different types of radios. The work was used by commercial radio receiver with digital tuning, because of the complexity of the radio itself, and also a particular problem itself is a combination of the resulting signal demodulation. Therefore, the signal was used to digitize the output of the low-frequency radio receiver. Furthermore circuits were created for the adaptation of the demodulated signal circuits and power adjustments modulation signal. At work, I also managed to make a mathematical description of the modulation signals active antenna. Based on the available literature, such a mathematical description has not yet been realized and published. Based on the analysis of graphs ideal signals I was able to determine the algorithm targeting signal and the calculation aiming angle. The sum required radio compasses as a whole, I created a calibration rig with stepper motor winding and circuit switching, and thus I automate the entire measurement circle. The measured characteristics are noisy, because the signal was not modulated combination of specific intermediate frequency demodulator, but was taken from the low-frequency output of the reasons above. The captured signal was applied to the filter window size of 3, and the median and diametric. The above results show that the statistical noise suppression and a tighter focus are better to apply the average recorded samples. Measured characteristics correspond to the theoretical assumptions which confirm the correctness of the whole concept. Further work could be addressed by implementing a suitable demodulator and reducing noise, further implementation thus created radio compasses for the needs of the local positioning system.

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