SPECIFICATION OF A VOR SYSTEM

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The submitted paper presents the importance of navigation aids for civil aviation, with an emphasis on safety and economic efficiency of air transport and its impact on the environment. The main attention is paid to beacons CVOR 431 and DVOR 432. uvádzamne specification of these systems under a simplified functional block diagrams. Also roadworthiness system and operating conditions CVOR421 and DVOR432.

K e y w o r d s: Air navigation, VOR, CVOR, DVOR, Radio beacon, Navigation systems, Navigation

1 INTRODUCTION

Air traffic has become an important mode of transport in the current modern times. In addition to technical development of aircraft and navigation equipment, based on the use of knowledge of several scientific disciplines, takes on the attention of aviation safety factor. Significant increase in passenger traffic is set to minimize the number of accidents by maximizing level of security.

Given the fact that aviation despite terrorist attacks and economic problems continue to rise, it is necessary to resolve questions airspace capacity. This is connected resolve technical issues precise positioning of aircraft to ensure the safety of individual flights in the airspace. The higher level of security also contributes to navigational aids which help to correct aircraft to navigate in the air. Between terrestrial navigation aids include the VOR radio beacon.

2 VOR SYSTEM

Very High Frequency Omnidirectional Radio Range VOR navigation system, which was created in 1946 in the USA. ICAO adopted it in 1949. It is one of the basic instruments used in navigation instrument for determining direction of flight. It is a device that is used to navigate for short distances (up to 300-400 km from the facility). [12]

2.1 Principle of operation

Suppose there are two lights located at the same site, of which one is a rotating beam of green light that is visible only when the beam is focused on the observer, and the other beam is white light that is visible from all sides. The green light is rotated at 10 degrees per second, which means that a complete rotation in 36 seconds, and when it is oriented to magnetic north, the switch causes the white light blinking after a while. Observer with a stopwatch can record the time interval between the white flash and other green flash; angular velocity of the rotating green light may determine the direction of the lights. For example, if the observer sees the green light to 10 seconds after the white light is on, then the observer in the direction of 100 ° from the magnetic beam, that is, the 100 ° radial. Location observer is, of course, flipped 100 ° or 280 °. [12]

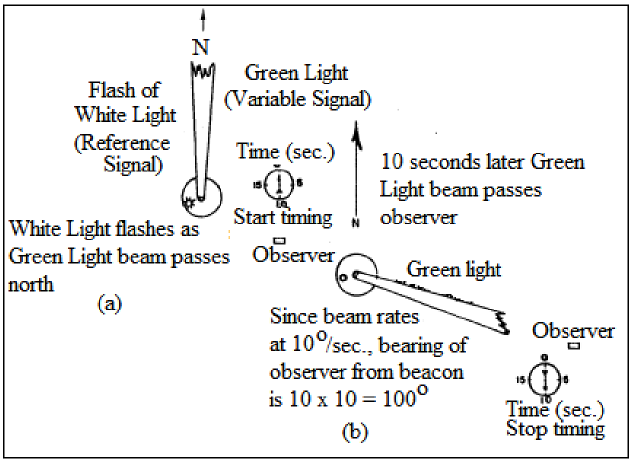

Fig. 1 Basic principle of operation of VOR [10]

Instead of light signals, VOR beacon sends two VHF radio signals from the same device. One of these signals is analogous to white light, the so-called. reference phase is omnidirectional and radiate from the station in a circular pattern. Phase of this signal is constant in azimuth over 360 °. Second signal, similar to the green light is transmitted as the rotating field. This signal is rotated uniformly at 1800 rounds per minute, varies in phase with azimuth and is called the variable phase. For this reason, a different phase of the signal at any point around the own station. Magnetic North is used as a basis for measuring the phase relationship between the reference and the different signals. These two signals are arranged to magnetic north, which is currently in phase. [12]

2.2 Technical description of CVOR 431

Device CVOR 431 (Convectional VHF Omnidirectional Radio Range) is VOR beacon manufactured by Thales Group. The CVOR installation comprises the following main components andaccessories - transmitter rack housing the transmitter, antenna system, emergency power supply, cable set, grounding and monitor dipole. [1]

Transmitter rack housing the transmitter, monitor andpower supply/battery charging (BCPS), single or dual version. These components are housedin a building or shelter. Since there is possibility of generatedoxyhy-drogen, the battery is separately housed. The CVOR antenna is locatedon a counterpoise. Both are mountedon the roof of the shelter. [1]

Fig. 2 CVOR 431 [3]

The antenna system is connectedvia 3 coaxial cables, which are fed to the transmitter rack via an opening in the center of the shelter roof. External signals obtainedvia the monitor dipole (or 2 monitor dipoles) are supplied to the monitoring system. In a configuration where one dipole is used together with dual monitoring the coaxial connecting cable between the monitor dipole and the monitor is led in the shelter to a divider, which distributes equivalent signals to the dual monitors. Monitor dipole is mounted on a separate mast in a distance of 8 m from the center of the antenna andat a height of 2 m above the counterpoise. A grounding network must be laidaroundthe shelter; but there are no special requirements with re- spect to its symmetry. The CVOR transmitter can be controlled, monitoredandmaintainedfrom the tower via a respective remote control andmonitoring system. [1]

2.3 Funkcional description of CVOR 431

The VOR radiates a radio frequency carriers with which are associated two separate 30 Hz modulations. One of these modulations is such that its phase is independent of the azimuth of the point of observation (reference phase). The other modulation (variable phase) is such that its phase at the point of observation differs from that of the reference phase by an angle equal to the bearing of the point of observation with respect to the VOR. Classical VOR operates by transmitting a rotating cardioid shaped antenna horizontal pattern at 30 revolutions per second for the variable phase. The reference signal is provided by amplitude modulating the carrier with a subcarrier of 9960 Hz which is in turn frequency modulated by a 30 Hz sine wave with a deviation of ±480 Hz. The AM and FM are independent of one another and can be demodulated separately. The carrier, with the subcarrier and the reference signal, is radiated via an antenna with an omnidirectional characteristic, whereas the rotating signal is radiated via the sideband signals UA and UB of crossed dipole antennas (Dipole A and Dipole B). The sideband signals are modulated with cos ϕ resp. sin ϕ. The sideband signal is either added to the carrier or subtracted from it, depending on the phase relationship. [1]

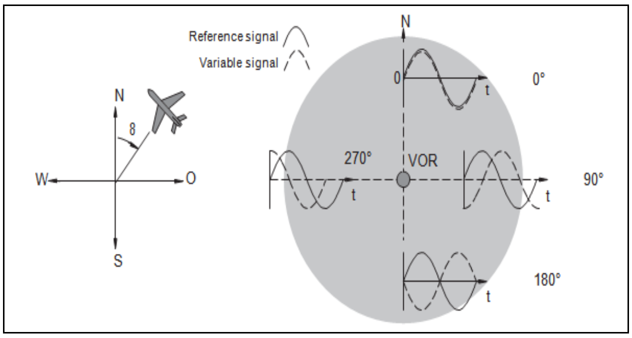

Fig. 3 Azimuth angle between aircraft andgroundstation [1]

The audio modulation signals are generated digitally in the block Modulation Signal Control and Measurement. The signal generation control is done by microprocessor techniques. Control loops including measurement circuits are used to generate the RF-signals Carrier (CSB), Sideband A (SBA) and Sideband B (SBB) feeding the VOR antenna system. The carrier frequency is generated by a synthesizer, which delivers its output signals to three modulator modules. One modulator, and in addition for the 100 W version the carrier amplifier CA-100, is used to generate the Carrier Signal with Side-bands (CSB) and the remaining two modulators generate Sideband A (SBA) and Sideband B (SBB). The modulators amplify the RF-frequency signal from the synthesizer and the RF-envelopes are controlled by the modulation signal generator and control circuits. Bidirectional couplers are used to get probes of the actual signal amplitude and RF-phases. By comparing the actual signal values with programmed values within the memory of the microprocessor the control voltages are derived by the microprocessor and fed back to the modulator modules. The Modulation Signal Control and Measurement is realized within the VOR 431 equipment with the modules Modulation Signal Genera- tor Generator (MSG) and Control Coupler (CCP). [1]

2.4 Advantages and disadvantages of CVOR 431

CVOR advantage is that it allows more accurate and more precise compared to navigation systems used previously. This leads to increased safety of flying and streamlines air navigation. Another advantage is that system can be used of day and night and in all weather conditions. It is possible to navigate multiple planes simultaneously. The system creates an invisible virtual highway along which aircraft are guided to the desired location nearby. [1]

The disadvantage of the system is part of its obsolescence, because today is developing new systems for aircraft navigation. In the U.S., according to FAA facilities for most of its life, even if some of them are working lifetime expired. Materials are worn to environmental influences, there is also mechanical damage and repair is too demanding, both physically and financially. Major disadvantage is also that it can not receive the signal at low level and also that it is susceptible to signal interference effect of the terrain. [1]

3 DVOR SYSTEM

DVOR is a radio navigation device developed from classical VOR system. It uses the Doppler Effect and complex antenna system, which achieves significantly higher accuracy signal. DVOR is installed mainly in places where they are difficult geographical conditions. Principle of operation DVOR is based on the measurement of phase two 30Hz signals emitted by the device. One signal (reference) is transmitted in all directions in the same phase. Phase of the second signal (variable) is a function of azimuth. Phase angle, measured onboard receiver responds azimuth. [9]

Fig. 4 DVOR system [8]

3.1 Principle of operation

Today's airway network is marked by a number of CVOR and DVOR ground beacons operating in the 108...118 MHz frequency range and having a transmission range of up to 300 km (optical propagation characteristics of VHF). CVOR/DVOR produces azimuth information which enables the pilot of an aircraft to fly from one (D) VOR station to another on a preselected course. Deviations from this course are indicated by an instrument giving the information "fly to the right" or "fly to the left" and also a "to/from" indication showing whether the aircraft is flying toward the beacon or away from it.[12]

In the DVOR the functions of the two 30 Hz modulations have been interchanged as compared with the conventional VOR. This means that the 30 Hz modulation which amplitude - modulates the VHF carrier now acts as the reference signal, whilst the directional, frequency - modulated 30 Hz modulation (variable signal) is contained in the 9960 Hz subcarrier. The modulated carrier signal is transmitted omnidirectionally by a stationary center antenna. It is amplitude-modulated with the voice (300...3000 Hz) and the identity code in addition to the 30 Hz reference signal. The 9960 Hz subcarrier signal is transmitted by a sideband radiator, which can be considered to be rotating along a circular path. The radiated sideband frequency is offset by +9960 Hz or -9960 Hz with respect to the carrier frequency. If the sideband radiator rotates with a frequency of 30 Hz, the Doppler Effect will cause the subcarrier to be frequency-modulated as a function of the azimuth. [12]

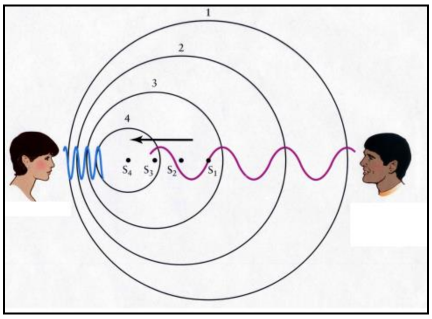

Fig. 5 The Doppler effect [5]

The Doppler effect), named after the Austrian physicist Christian Doppler, who proposed it in 1842 in Prague, is the change in frequency of a wave (or other periodic event) for an observer moving relative to its source. It is commonly heard when a vehicle sounding a siren or horn approaches, passes, and recedes from an observer. Compared to the emitted frequency, the received frequency is higher during the approach, identical at the instant of passing by, and lower during the recession. When the source of the waves is moving toward the observer, each successive wave crest is emitted from a position closer to the observer than the previous wave. Therefore each wave takes slightly less time to reach the observer than the previous wave. Therefore the time between the arrivals of successive wave crests at the observer is reduced, causing an increase in the frequency. While they are travelling, the distance between successive wave fronts is reduced; so the waves "bunch together". Conversely, if the source of waves is moving away from the observer, each wave is emitted from a position farther from the observer than the previous wave, so the arrival time between successive waves is increased, reducing the frequency. The distance between successive wave fronts is increased, so the waves "spread out". For waves that propagate in a medium, such as sound waves, the velocity of the observer and of the source is relative to the medium in which the waves are transmitted. The total Doppler Effect may therefore result from motion of the source, motion of the observer, or motion of the medium. Each of these effects is analysed separately. For waves which do not require a medium, such as light or gravity in general relativity, only the relative difference in velocity between the observer and the source needs to be considered. [9]

3.2 Technical description of DVOR 432

Device DVOR 432 (Doppler VHF Omnidirectional Radio Range) is VOR beacon manufactured by Thales Group. The DVOR installation comprises the following main components and accessories, like transmitter rack, emergency power supply (48 v lead battery), antenna system, pin-diode switching unit (PDSU), monitor dipole, cable set and grounding. [6]

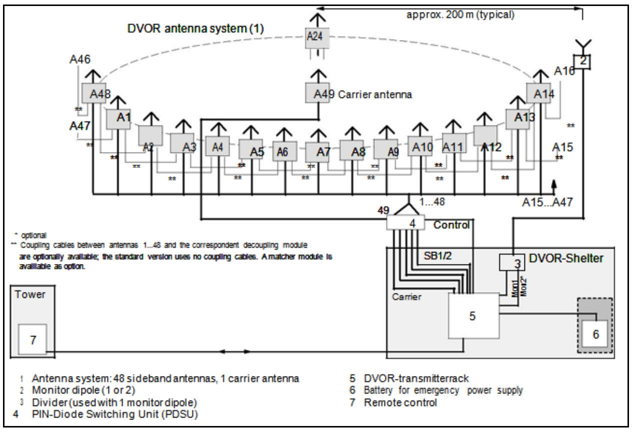

Fig. 6 DVOR 432 system overview [6]

Transmitter rack housing the transmitter and monitor, single or dual, the antenna switching control and RF feeding (ASU subassemblies) and a power supply/battery charging (BCPS). Emergency power supply (48 V lead battery) is housed in a building or shelter. Since there is possibility of generated oxyhydrogen, the battery is separately housed. The DVOR antenna system comprises 49 individual antennas mounted on a counterpoise with a diameter of approx. 26 m (optional: 30 m) and supported at a height of 3, 5, 7 or 10 m above the ground by an appropriate number of struts. [1,2,12] The PDSU is seen as part of the ASU subassemblies. As standard, it is located outside the shelter and mounted with an appropriate support below the DVOR counterpoise. Optionally it can also be mounted within the shelter. The nearfield monitor dipole is mounted on a mast in a distance of approx. 200 m from the center of the counterpoise at a height of approx. 1.3 m above the counterpoise. The cabinet and the PIN-diode switching unit below the counterpoise are connected via 5 coaxial RF-cables and a control cable. The switching unit feeds the antenna system via 48+1 coaxial cables. External signals obtained via the 1 (or optional 2) nearfield monitor dipole(s) are supplied to the monitoring system (consisting of 1 or 2 monitors). If only 1 nearfield monitor dipole is used (standard installation) the coaxial connecting cable between the monitor dipole and the monitor is led in the building or shelter to a divider, which distributes equivalent signals to the dual monitors. A grounding network must be laid around the shelter; but there are no special requirements made with respect to its symmetry. The DVOR transmitter can be controlled, monitored and maintained from the tower via a respective remote control and monitoring system (e.g. RMMC). [6]

3.3 Funkcional description of DVOR 432

The NAVAIDs system consists of hardware based on RF and AF subassemblies and of software which controls the hardware to a large extent. The system is subdivided into the following units - Transmitter in dual or single version (TX1, TX2), Monitor in dual or single version (MSP1, MSP2), Local/Remote Communication Interface (LRCI), Power supply, Antenna switching control and RF distribution and Antenna system. [6]

Transmitter and monitor are dualized, whereby each monitor monitors the aerial transmitter. The remaining subassemblies in the signal path of the transmitter are not dualized. These are mostly components which cannot be practically dualized, such as RF duplexer, antenna switching control and RF distribution, the antennas and cables and the main passive components which are inherently reliable. Each transmitter comprises an RF section, in which the carrier frequency is generated, modulated and amplified to the output power level, and the Modulation Signal Generator, which generates the modulation signals controlled by its microprocessor, carries out the evaluation for control of the signal shape (amplitude/phase) and supplies control signals to the RF section. Each transmitter has a separate power supply. If one transmitter fails, the other remains operational. [6]

The RF Duplexer supplies the signal of one transmitter to the antennas via the PIN-Diode Switching Unit (PDSU), while the output power of the standby transmitter is switched to a dummy load. Amplitude and phase are controlled such that the specified signal-in-space pattern is obtained. The two monitors monitor the generated and radiated DVOR signal directly by one (or two) nearfield dipole(s). As an option up to three nextfield dipoles located at the counterpoise edge can be used instead of the nearfield dipole. The monitor consists of the Monitor Signal Processor, which ensures of correct radiation of the signal. It evaluates the signals of the internal sensors and the field dipole(s). The selected RF signals are amplified, normalized to a certain level, demodulated, filtered and converted to individual, digital values. The Monitor Signal Processor evaluates the measured values by means of a Fourier analysis and compares them with the reference values. The monitor changes over or shuts down the transmitter, if a limit is exceeded. The results can be read out and interpreted locally or remotely via a connected PC equipped with the suitable software (e.g. ADRACS). A system status indication is also displayed on the local indication panel. The monitors exchange status signals. If one monitor fails, the intact monitor decides immediately without waiting for a response from the other. This ensures that the monitors react fast and correctly in all situations, even if one of them fails. The transmitters and the monitors are independent of one another. Depending on the stipulated safety class, either one or two monitors are provided. [6]

3.4 Advantages and disadvantages of DVOR 432

If the CVOR radio beacons installed near the barriers or mountainous terrain, there is no distortion respectively, damage signal. JUSTICE system solves this problem by using the above-mentioned Doppler Effect, in this case, is the basis of system of antennas that suppresses the effects of multilateral propagation and provides accurate radials. Against CVOR still has the advantage that it is more accurate and reliable. Advantage is even simpler assembly, respectively, locations and in transit.[6]

Disadvantages beacons CVOR and DVOR are inefficient and uneconomical repair, operation and maintenance, and moral obsolescence with Exceedances life. Many of these beacons have exceeded their lifetime, or do not have much to do. Although the devices are functional and still in operation, but their repairs are becoming more demanding and due to its financial costs and their inefficiency.[6]

4 CONCLUSION

The submitted paper that we carry out an analysis beacons CVOR 431 and DVOR 432 and presents their characteristics, principles of operation of individual segments, such as the monitor, transmitter, receiver and technical data on the basis of a functional block diagrams. We describe the operation and maintenance of these systems, which are manufactured by Thales Group.

Based on ICAO recommendations, summarized in DOC 9750 (Global Air Navigation Plan for CNS / ATM Systems), radio beacons will be phased out of service and being replaced by satellite navigation systems. ICAO forecast says the growth in air traffic, which also increases the requirements for navigation systems. Currently used by navigation systems may no longer be sufficient to cover that demand. Transition and implementation of new systems poses a question and resolve the many questions and concerns. Therefore goes much more time to achieve this goal. The purpose of the development of these systems is to improve aviation safety, reduce costs and increase efficiency of economy and air traffic.

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