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Radio Transmission Detection using Doppler in UHF Frequency Band

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Abstract

The direction finder of a radio transmitter is a device that functions to find and determine the direction of a radio transmitter that works in the Ultra High Frequency (UHF) band. UHF frequency used is in the range of 420 - 440 MHz. The concept of Doppler radio is used as a method to determine the direction a radio transmitter is located. Radio Doppler use four receiving antennas which are installed at a certain distance so that it can produce a difference in frequency (Doppler) on each radio antenna because of the difference in the angle of the detected signal. The direction of the incoming signal will be displayed on a set of 16 LEDs and each LED will represent the direction of the incoming angle of 22.5 degrees. The detected frequencies are 422,580 MHz and 429,980 MHz originating from the UHF transmitter with 100mW of power and amplified with a radio frequency amplifier of 3 Watts power. The results show that the frequency of 429,980 MHz was detected with a maximum detectable distance of 1500 meters. The frequency of 422,580 can be detected with a maximum distance of 800 meters. This radio direction finder is can be used to find radio signal in UHF band frequency 420-440 MHz. The direction of the radio transmitter location is simply show in group of led's as a direction detector.

Keywords – Direction finder, doppler, UHF

1. Introduction

Handy Talky briefly referred to HT is a communication tool that looks similar to a cell phone that can communicate two or more people using radio waves and is often used for temporary communication because the channel can be changed at any time. Most handy talkies are used to perform both functions, speaking or listening. Handy talky is known as Two Way Radio, which can carry out two-way conversation, however the sender of the message and the recipient cannot talk at the same time. Handy talky has a greater frequency range and is free compared to walky talky. Handy Talky (HT) is different from Walky talky. A radio beacon's signal is received aboard a vehicle by device called radio direction finder (RDF) [1]. Although both of them refer to the same principle regarding two-way radio, both of them have differences. Handy talky requires permission to use it, while walky talky does not need it. The communication radio that works in the VHF or UHF band at first the distance that can be traveled by this tool is only as far as 2 miles, lately handy talky can cover up to a distance of 12 miles. a handheld direction finding and communication receiving system is researched and designed for recent [2]. Even with the addition of a repeater device, it can reach tens of kilometers, however it all depends on the geographical area. The difference between Handy Talky and Walky Talky is that handy talky and walky talky have the same principle, but handy talky requires permission to use it, while walky talky does not need permission. The use of HT

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is sometimes necessary to know the position of the user for certain purposes. In order to determine the position of this HT user, a tool to detect it is called the Radio direction finder (RDF). RDF is a direction-seeking radio set which is operated through reception of electromagnetic waves by transmitters emitted by transmitter stations. Antenna of Radio Direction Finder (RDF) will receive electromagnetic waves emitted by the station of the transmitter. Because the antenna is a good conductor, the electromagnetic waves from the transmitter received by the antenna will generate wave currents whose vibrations are the same as the vibrations of the electromagnetic waves from the transmitter. If the antenna frame field is in the direction of the signal coming from the transmitter, the voltage generated in the antenna will be maximum and if the antenna frame field is rotated 90^0 not in the direction of the signal coming, then no voltage will be generated in the antenna and the signal will not hear the signal received by the signal the antenna is forwarded to the receiver box and the transmitter's direction will be at the loudest sound. Because the directions are connected to the antenna, the direction the signal is coming can be read on the indicator.

Poirier D., Quinot and Silver H.W., investigates the design of a radio Direction Finder (DF) for rescue operation using victims' cellphone as localization beacons. It brings the hope of radio frequency to determine all signal include cellphone to determine [3,4]

Dermawan D. conducted a study to determine the direction and amplitude of a radio transmitter in the 146 MHz Very High Frequency (VHF) frequency band. The study was conducted in a limited area and a limited distance, the results of the direction shows using the display of a set of 16 pieces that represent one rotation so that one led shows a rotation of 22.5 degrees [5].

Radio Direction Finder uses doppler concept to process signal and works at High Frequency Band and a doppler antenna is use to determine direction of the any transmitter [5-8, 17]

Kossor M, is design a doppler radio direction finder include digital commutating filter and antenna switcher in Very High Frequency (VHF) band radio [9-11]

Suparman, Wafiuddin & Homam, Mariyam, development of transmitter and receiver for fox hunting activity. The transmitter uses Arduino Uno and Baofeng radios. The transmitter will be hidden in a designated area, and a Morse code that has been programmed in Arduino will be sent in a frequency range of 144 MHz and 145 MHz. The test is carried out at four locations with different distances, namely, 350, 550, 700 and 900 m. The antennas can work well up to 550 m from the transmitter [12].

Rustamaji, Kania Sawitri, Ghaniyman Fuad, The radio direction finder (RDF) as an element of a passive radar is used to determine the direction angle, based on a radio waves that emitted by an object. RDF works on HF bands as passive radar elements. The RDF can detect the angle of direction of horizontal plane of an object or AM transmitter from 0° to 360° in the frequency range between 4.02 to 10.76 MHz. The results of detecting the angle of direction of an object or a transmitting radio waves in the HF band, in the form of a signal level are then plotted on the polar diagram of the horizontal plane, and the sound can be heard through the loudspeaker [13].

Kristiyana S. Conducting research with the title RF Signal Direction Detector System Using Doppler Antennas. Two-way Communication Technology using electromagnetic waves is developing very rapidly. Various fields of public life, military, and emergency use radio frequency spectrum, which will certainly be very helpful. The weakness of this communication system, can not be used to emit a common frequency in the same time. If this happens the result will be closed communication (jammed) due to crowded frequency and sometimes even intentional to disrupt communication as is the case in the field of amateur radio frequencies. Radio Directional Finder has conventionally been in charge for many years which is used to search for direct frequency intruder transmitters which are now inefficient in terms of time and operations. The Doppler system application with the Adaptive system can be used as a basis for RadioStand Finder to detect the direction of the RF transmitter's position without direct mobility. Roanoke Doppler antenna is designed with a switching system and signal reception amplifier by a half-wavelength antenna square-4 arrangement that can determine the direction of the RF signal coming. Adaptive systems can help recipient systems lock direction information based on the greatest signal intensity [14-15].

M. C. E. Stieber outlines how the direction finder technology was exploited in the design of a device; capable of locating the where about of a UHF transmitter. The value of amplitude and frequency of the signal were employed in the determination of the signal source direction. The study emphasized on the utilization of low cost components. The assembled prototype offers 22.5˚ bearing coverage. The determination of the direction was achieved by differentiating the received frequency signal involving multiple antenna arrays. Direction of transmitter was determined by making the receiver antenna arrays emulating condition of motion with the use of antenna switcher. Received signals were converted into tones where larger signal amplitude translates to louder tone. Antenna arrays were arranged in specific manner where the tone volumes were compared and the direction within 360˚ position was determined. The result suggests that the system can provide the detection coverages up to 22.5 degree which is better than the existing solutions in terms of equipment selection, cost, and coverage [16].

T. Svantesson and M. Wennstrom exploiting the directional radiation patterns of a switched parasitic antenna (SPA) is considered. By employing passive elements (parasites), which can be shorted to ground using pin diodes, directional radiation patterns can be obtained. The direction finding performance of the SPA is examined by calculating a lower bound on the direction finding accuracy, the Cramer-Rao lower bound (CRB). It is found that the SPA offers a compact implementation with high-resolution direction finding performance using only a single radio receiver. Thus, exploiting SPAs for direction finding is an interesting alternative to traditional antenna arrays offering compact and low-cost antenna implementations [17].

2. Research Method

Figure 1 is a research flow chart diagram that is used as a basis for carrying out this research: In the initial stages of the design concept of the tool / Radio Doppler, that is, after that it enters the conceptual design stage of the tool after collecting data, the next stage is the design stage of making Radio Doplller , then go to the stage of testing the tool / Radio Doppler to find out the sensitivity of the tool in detecting the direction of the HT (Handy Talkie) / transmitter on the UHF channel.

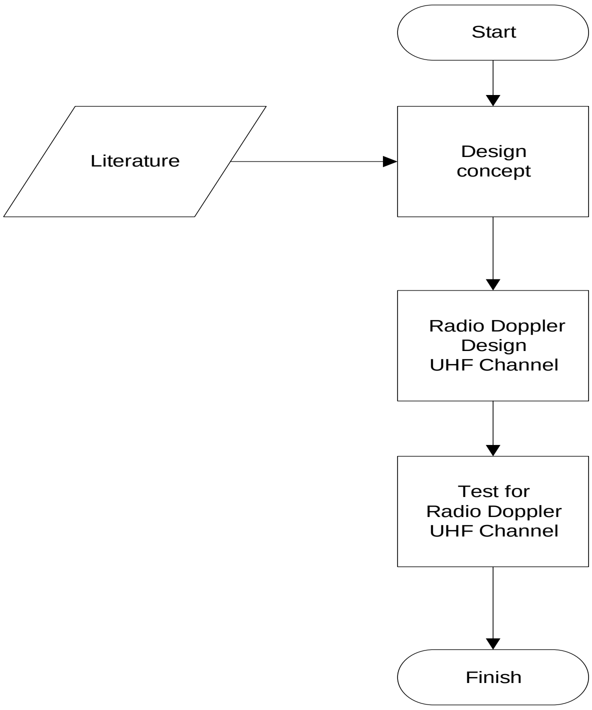


Figure 1. Research flow chart diagram

2.1 Doppler method

A classic example of the Doppler effect is when a car approaches the observer's source, the car horn sound is higher than (the frequency) the observer hears when the car moves away from the observer. Changes in frequency occur because the motion of the car shortens the wavelength of the sound heard lower than (frequency) the observer hears. This happens because the car away from the observer effectively increases the wavelength, then the frequency becomes low. A similar effect occurs because the antenna is not near or far from the transmitter source. The signal received from the antenna is sent to a transmitter whose frequency is higher than the actual transmission. The signal received by the antenna is sent to the actual transmission source which has a lower frequency as shown in figure 2 [9].

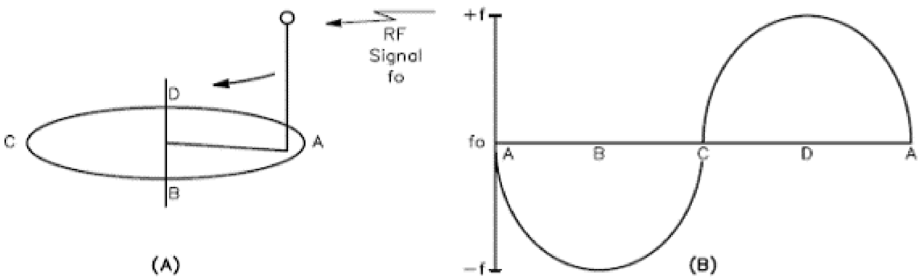


Figure 2. Frequency of Doppler antenna rotation

Considering the antenna positioned A, closest to the search source, the frequency of the signal received at point A is the same as the signal from the transmitter because it does not move towards or away from the search source. The frequency of the received signal decreases when the antenna moves from point A to point B and from point B to point C. Deviation The maximum frequency occurs when the antenna passes point B. The frequency of the signal received from point C is the same as the signal from the transmitter (no change) because the antenna is not near or far from the search source. When the antenna moves from point C to point D and from point D back to point A, the frequency of the received signal will increase. The maximum frequency deviation occurs again when the antenna passes point D. The Doppler frequency shift as a function of antenna rotation is illustrated in Figure 2 according to equation (1) [9].

$$dF = \frac{\omega r\, f_c}{c} \quad (1)$$

with:
dF = Change of peak frequency (Doppler shift in hertz)
ω = Rotational angle speed in radians per second (2 x π x rotation frequency)
r = Radius of antenna rotation (m)
f_c = Signal frequency (Hz)
c = speed of light (m / s)

To calculate how fast the antenna must rotate to produce the required Doppler frequency shift, given according to equation (2) [9].

$$fr = \frac{dF\ x\ 1879{,}8}{R\ x\ fc} \quad (2)$$

with:
f_r = frequency shift in hertz (Hz)
dF = Doppler shift in hertz (Hz)
R = Radius antenna rotation in inches (inch)
f_c = Frequency of the received signal in megahertz (MHz)

For example how fast the antenna must rotate to produce a Doppler shift of 500 Hz from the 446 MHz frequency, assuming the rotation radius is 5,75 inches, the frequency rotation is:

$$fr = \frac{500\ x\ 1879{,}8}{446\ x\ 5{,}75} = 366{,}5\ Hz$$

The rotation frequency of 366,5 Hz if described in rpm is 366,5 × 60 = 21.990 or nearly 22,000 revolutions per minute. The working principle of this Doppler RDF refers to the block diagram in figure 3. An 8 kHz clock oscillator controls a binary counter. The output of the binary counter connects three functions, the search antenna, controlling the LED display and running a digital filter. The output of the binary counter controls 1 of 4 sequential search antenna multiplexers or which are detected first so that they are selected (lit) at one time in commands A, B, C, D, A, and so on with a speed of 500 times per second. The counter output also controls 1 out of 16 multiplexers used to control LED displays with a search antenna. The RF signal received from the search antenna is connected to the input antenna of the VHF receiver as shown in Figure 3 [9].

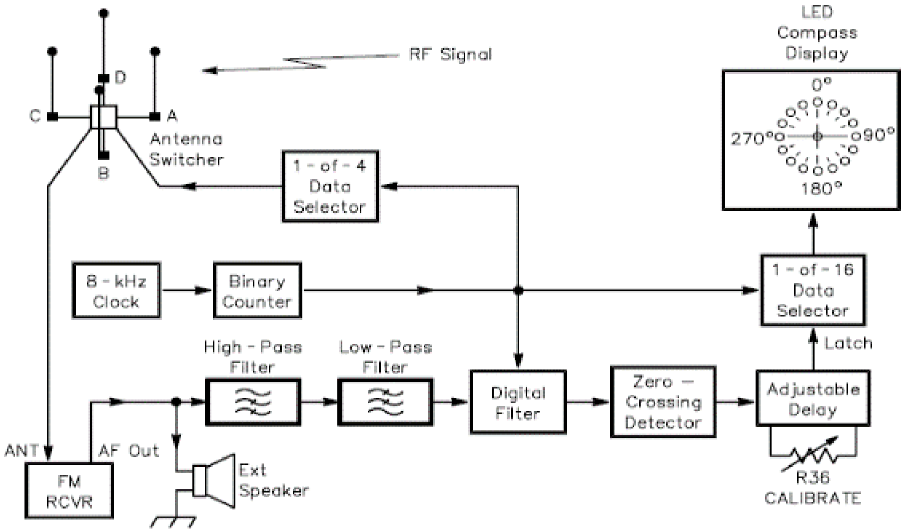


Figure 3. Block diagram of Radio Doppler

2.2 Antenna switcher design

The antenna switcher schematic is shown in figure 4 [10]. They consist of four channel of antenna and support systems. The inputs is J1-1, J1-2, J1-3 and J1-4 that originated from the data selector. The length of the whip antenna and distance between antenna for various frequencies is summarized as table 1.

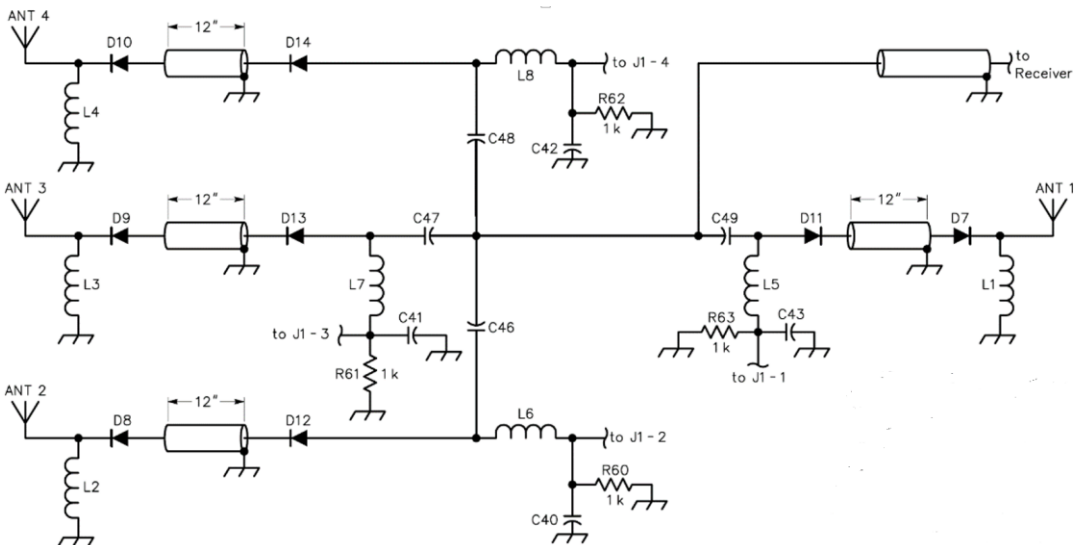


Figure 4. Antenna switcher schematic

Table 1. Whip length and distance between antenna for various frequencies

Frequency (MHz)	whip antenna (inch)	Distance between antenna (square) (inch)
146	20,06	18,25
223	13	11,5
446	6,68	5,75

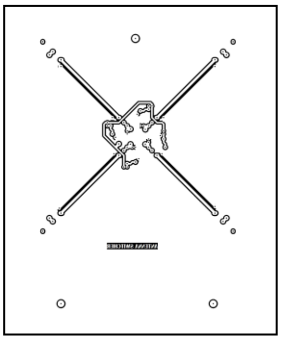
As we design for UHF frequency, we use length whip antenna 6,6875 inch and distance between antenna in square form 5,75 inch.

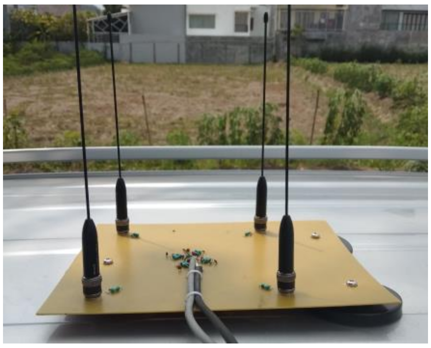
3. Result and discussion

The test is done by placing a volunteer with a transmitter (H-T) with a UHF frequency in a safe place (field for example) with a distance of about 1/4 to 1/2 mile away and straight to the RDF device. The volunteers were asked to send the transmission at low power (0.5 watts). The RDF operator must calibrate the RDF Display to show 0 ° straight ahead. The display should change to 180 ° which indicates the signal is coming directly from the rear of the car when the vehicle passes the transmitter. The test was carried out in a limited area around the ITDA campus environment with a maximum measurement radius of approximately 1,5 km. The transmitter is placed around the ITDA Advanced Electronic Lab, for UHF FM transmitters placed in the Advanced Electronics Lab and for ADF 4351 transmitters placed in the transmitter tower with a height of less than 8m height.

3.1 Antenna switcher

Antenna Switcher design and implementation is shown in figure 5. The left figure is show the lay out design and the right figure is show the installation of the antenna switcher on the roof of the car. Antenna whip length is 6,6875 inch and distance between antenna in square form is 5,75 inch. Placement of the antenna on the roof of the vehicle to facilitate signal reception without obstruction



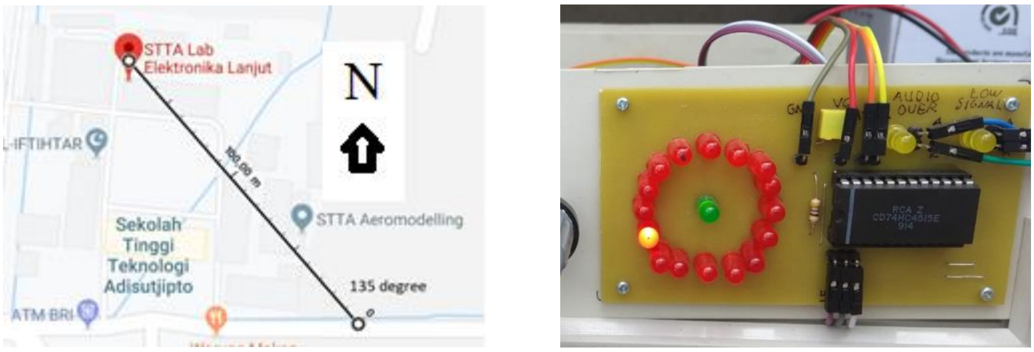


(a) (b)

Figure 5. Antenna Switcher (a)Layout design (b) Placement on the roof of the car

3.2 Testing the radio direction finder

Figure 6 shows the first measurement location, which is around the ITDA soccer field, which is 200 meters awayfrom the transmitter location. The Radio Direction Finder display for the first location is shown in Figure 6 (b). From figure 6 (a) it appears that the RDF is pointing to the North and the location of the transmitter is shown at 135 degree to the direction facing the RDF.



(a) (b)

Figure 6. Testing number 1 (a) Measurement location 1 (b) Display location 1 with a n angle of around 135^0

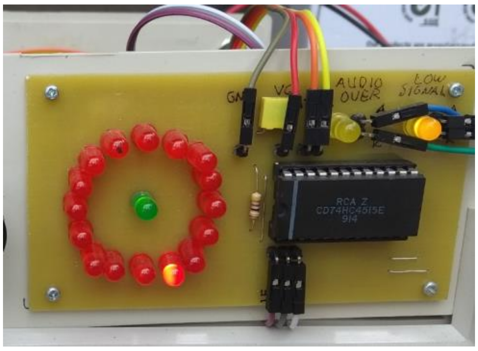
Figure 7 shows the location of the second measurement, which is around the Blok O Air Force resident which is about 400 meters away. The Radio Direction Finder display for the second location is shown in Figure 7(a). From figure 7 (a) it appears that the RDF is pointing to the North (Sekolah Tinggi Teknologi Adisutjipto) and the location of the transmitter is shown at 22,5 degree to the direction facing the RDF.

(a) (b)

Figure 7. Testing number 2
(a) Measurement location 2 (b) Display location 2 with an angle of about $22{,}5^0$

Figure 8 shows the location of the third measurement, which is also around the Air Force Academy which is about 1500 meters distance. The Radio Direction Finder display for the third location is shown in Figure 8 (b). The display in Figure 15 is the "invert" display by activating the "invert" switch. From figure 8 (a) it appears that the RDF is pointing to the West and the location of the transmitter is shown at 150 degrees to the direction facing the RDF.

From the three previous experiments it was found that the determining factor in this research was the magnitude of the signal emitted from the transmitter, the farther from the transmitter location the RDF could not detect the presence of the transmitter signal.



(a) (b)

Figure 8. Testing number 3

(a) Measurement location 3 (b) Display location 3 with an angle of around 150^0

4. Conclusion

The radio direction finder for the UHF frequency band has been successfully made, with a viewer in the form of 16 circular LEDs, which each LED represents an angle of 22.5 degrees. The detection range of this direction-seeking Radio Doppler can be used for a distance of approximately 1500 meters. Radio Doppler in the UHF frequency band can reach longer distsance than working at the VHF frequency band.

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