FYP THESIS REPORT

"DOPPLER RADIO DIRECTION FINDER"

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Certificate of Correctness and Approval

It is hereby certified that information in this thesis "**DOPPLER RADIO DIRECTION FINDER**" carried out by (1) Captain Jawad Ali Khan (2) Captain Muhammad Haseeb (3) Captain Mushahid Waqar (4) Captain Jawad Sheikh under the direction of Lt. Col. Hasnat Khurshid in partial fulfillment of our degree of Bachelor of Telecommunication Engineering is correct and approved. The material that has been used from other sources has been properly acknowledged/ referred.

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Dedication

This dissertation is dedicated in thanks to ALLAH ALMIGHTY our Creator who has blessed us with wisdom, knowledge and understanding then to our parents for their direction and their endless support.

Further to our Faculty for their guidance and supervision, without their help and supervision this project would not have been made possible.

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ABSTRACT

For detecting the source of signal for the instruments that are used for the direction finding is approximately as old as the approach of radio communication itself therefore, a considerable distribute of research has been taken out in various parts of the world on the various procedures accessible for radio direction finding today.

To designate the direction from which the signals are being received from a faraway station transmitting the signals the positioning of the special aerial receiving are being used in some of the procedures. While in the other systems, the implementation of the transmission principle subsumes with the characteristics of the direction or location finding.

The restriction in the precision of determining the location or direction by the method of wave propagation and other conditions is being demonstrated in many other papers.

The comparative merits of the calculation in the difference of phase of direction control and the arrival time of different elements of waves are discussed. Additional methods involve the experience and principles which are gathered with the new techniques demonstrating the impact of the spacing in aerial view, a subject which is famous to those who are anxious about the latest development in the topic of RDF.

For RDF installation, the major difficulty that arise is the selection a stationary site. Many RDFs that are now accessible now is having the accuracy of better than 1° and the precision of bearing is restricted only by the site station flaw. The considerable type of instruments is mostly those with having loop or Adcock aerial systems, and the range of frequency enfold is 100 kc/s – 300 Mc/s which are used in some systems frequently.

Special attention should be driven to the direction finder's calibration, especially those having the fixed systems of Adcock aerial.

CHAPTER 01: INTRODUCTION

This analysis revolves around the principles of Radio Direction Finding which is used for surveillance and navigation systems.

For locating the bearing of the transmitter Radio Direction Finding contains the device called Radio Beacon and its signal is catch up abroad a vehicle by the gadget known as ***Radio Direction Finder (RDF).***

In recent decades, a lot of interest has been gained by the Radio Finding Direction specifically on the UHF and VHF bands. For the determination of the root source of radio transmission there are many ways each of which is having their benefits and defects.

Directional Antennas are highly convincing in accessing the bearings from a fixed location due to their sizes with the best ratios that are front to back include Yagi or quad that are simple and easy to use as well. Despite when in driving a vehicle striving to slender the search location it's a bit stiff to use.

To car window fixing a two meter and four element quad or Yagi can be a big threat to safety. Whereas much more reliable, feasible and efficient way of slandering the search location includes Doppler principle and $4\left(\frac{1}{4}\right)\lambda$ mag-mount antennas.

Due to the opportunity of the satellite navigation systems Radio Navigation finding for navigation function (cooperative direction finding) is failing in keeping its importance.

Frequency increasing techniques are progressively used for wireless communication which is one more intellect for the importance of Radio Direction Finding (RDF) that implies a certain emitter can be only associated by the spectral components if the direction is known.

Therefore, In Radio Direction, Direction finding is an essential 1^{st} step.

By means of triangulation, Direction Finders advance across the country granting the permission to be located to a few kilometers (Normally 1% to 3% of the

Direction-Finding distances). With the help of Direction Finders which are installed or fixed in the ground the emitter location can be found more easily and squarely.

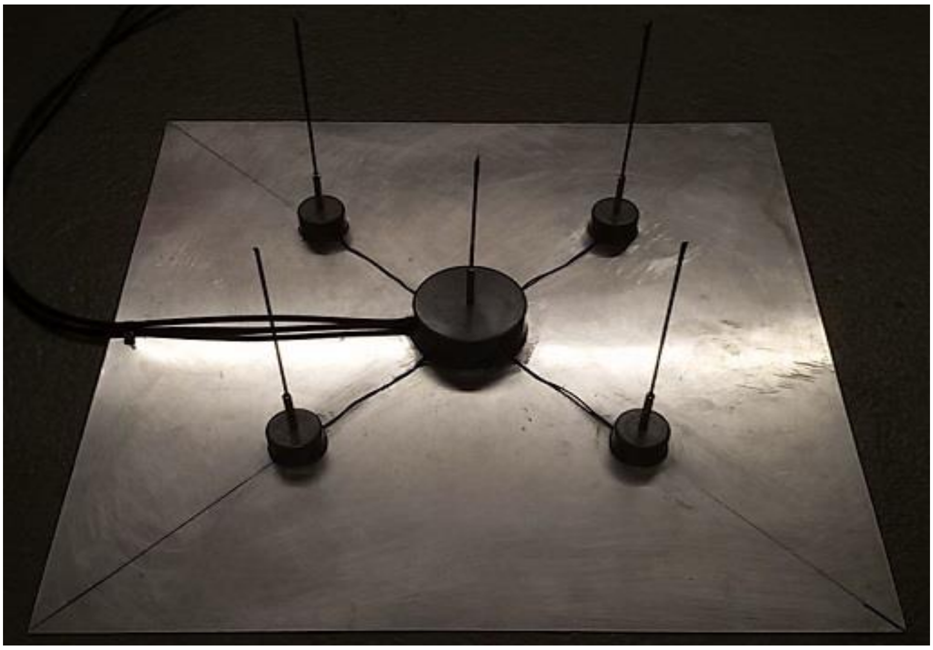


Figure 1 Amplitude Radio Direction Finder Array.

DOPPLER RADIO DIRECTION FINDER:

Due to the Doppler Effect, the received signal with the modulated frequency ω_0 with frequency rotation of the antenna duct ω_r if the elements of antenna go round in the circle of radius R:

- The frequency levels up if the direction of the antenna proceed towards the source of radiation.
- The frequency levels down if the direction of the antenna proceeds away from the source of radiation.

The instantaneous amplitude:

$$u(t) = a * cos\left(\omega_0 t + \frac{2\lambda R}{\lambda_0}\cos(\omega_r t - a) + \varphi\right) \quad \text{Eq (1)}$$

By differentiation, the instantaneous frequency is derived as:

$$\omega(t) = \frac{d\Phi(t)}{dt} = \omega_0 - \frac{2\lambda R}{\lambda_0}\omega_r \sin(\omega_r t - a) \quad \text{Eq (2)}$$

The demodulated Doppler signal is obtained after the filtering of the DC component ω_0:

$$S_D \equiv \frac{2\lambda R}{\lambda_0}\omega_r \sin(\omega_r t - a) \qquad \text{Eq (3)}$$

A reference signal of exactly same center of frequency acquire from the rotation of antenna when compared to the phase of the demodulated signal is:

$$S_r = -\sin \omega_r t \qquad \text{Eq (4)}$$

Submits the bearing α.

Therefore, the rotation of the elements of antenna which is mechanical in exercise neither desirable nor feasible. Many elements like crossed loops, dipoles and monopoles are set up in a circular shape and are scanned electronically with the help of the electronic switches as illustrated in figure below:

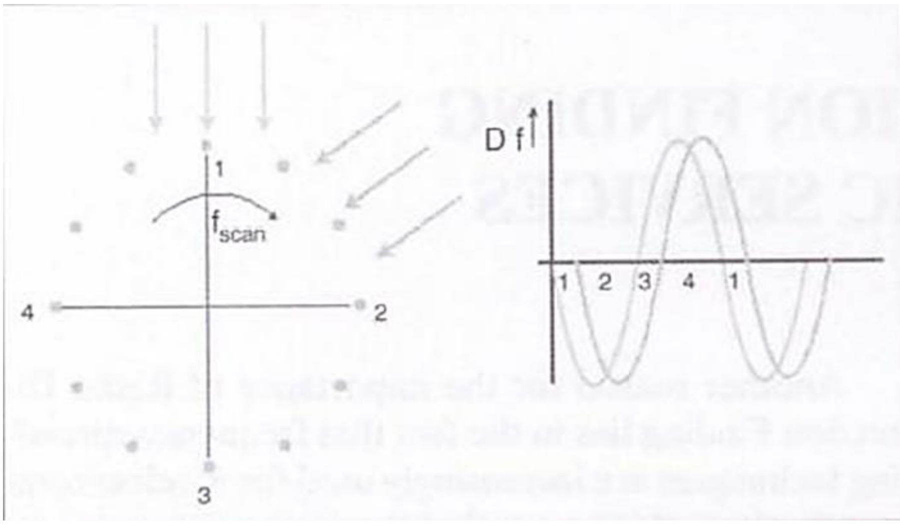


Figure 2 Principle of Doppler Direction Finder.

The spacing in the middle of the separate elements of antenna must be reduced than the half of the wavelength in operation to pick up the unambiguous DF results. The distance of about $^1/_3$ of minimum wavelength in operation is commonly adopted in practice. To get the bearing at least one antenna cycle of scanning is required which is a defect of the Doppler method due to the time consumption. In the VHF/UHF band one complete cycle get hold of about 6 m/s with the typical frequency rotation of 170 Hz.

CHAPTER 2: THEORY OF OPERATION

The Doppler effect which can be described as the effect produced by a moving source of waves in which there is an apparent upward shift in frequency for observers towards whom the source is approaching and an apparent downward shift in frequency for observers from whom the source is receding. The typical and classical example of the Doppler Effect is of a car that is approaching a motionless observer. To an observer the horn of the car resonances in a high pitch or frequency as the car approaches near. Since the motion of the car is causing the wavelength to get shorten the change in frequency comes about. As the car speeds away the horn of the car resonances in lower a pitch or frequency to the observer. The reason this happens is due to the car that is hurtling away from the observer which means the wavelength is increasing. The rate of cycles per second is stumpy that means the sound's frequency is also stumpy or low.

An identical effect occurs when an antenna is moved towards or away from a transmitting source. The signal which is received from an antenna moving towards the transmitting source appears to be at a higher frequency than that of the actual transmission. The signal which is received from an antenna moving away from the source of transmission appears to be lower in frequency than that of the actual transmission.

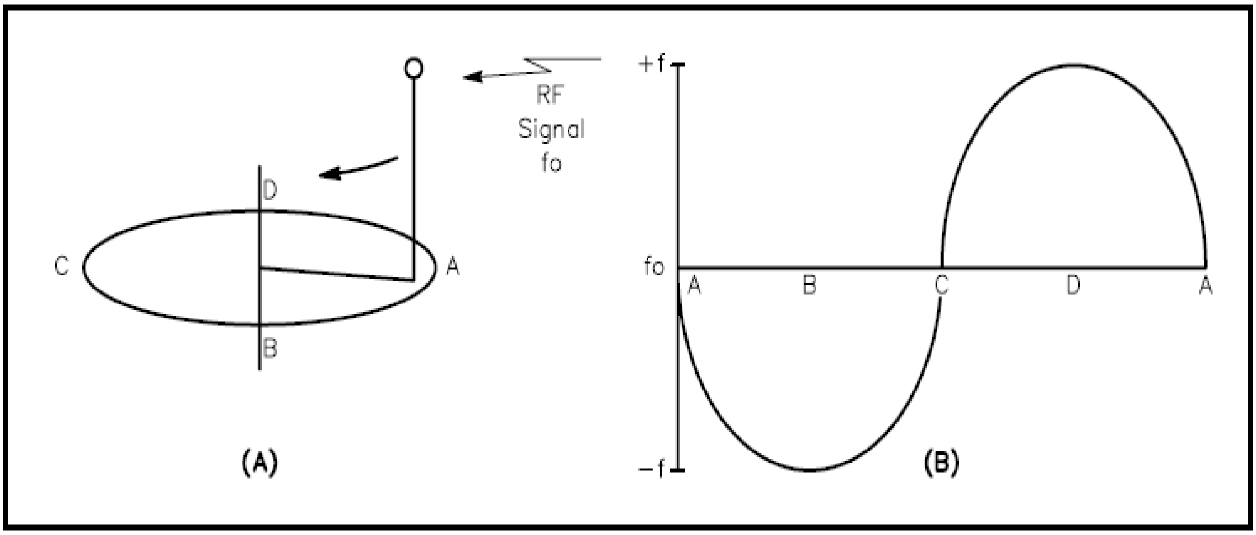


Figure 3 —At A, illustration of a rotating antenna. At B, Doppler frequency shift.

f_r

Suppose an antenna that is receiving the signal is turning in a pattern which is circular as it pictured in the Figure 3A above. Now believe that the antenna is at position A which is nearest to the transmission source. The frequency of the signal that is received at position A is equal to that of the signal that is transmitted because the antenna is not being moved away or near to the transmission source. As the antenna moves from position A to position B and from position B to position C the received signal's frequency keeps on decreasing. As the antenna passes through position B the frequency deviation that is occurred is maximum. The antenna is not moving towards or away from the source of transmission that is why the frequency of the received signal at point C is the same as that of the transmitted signal which means no shift. The frequency of the received signal is increased whilst the antenna is moved from position C to position D and from position D back to position A. As the antenna passes through point D maximum frequency deviation occurs again. As a function of rotation of antenna, the Doppler frequency shift can be shown in Figure 3B.

$$dF = \frac{\omega r f_c}{c} \qquad \text{Eq (5)}$$

Where

dF = Peak change in frequency (Doppler shift in Hertz)

ω = Angular velocity of rotation in radians per second (2 × π × frequency of rotation)

r = Radius of antenna rotation (meters)

f_c = Frequency of transmitted signal (Hertz)

c= Speed of light

We can also calculate how fast the antenna must be rotated in order to generate a given Doppler frequency shift with the following equation:

$$f_r = \frac{dF \times 1879.8}{R \times f_c} \qquad \text{Eq (6)}$$

Where

f_r = The frequency of rotation in Hertz

dF = The Doppler shift in Hertz

R = Radius of antenna rotation in inches

f_c = Carrier frequency of the received signal in megahertz

For instance, we will calculate how fast the antenna must be rotated to find the Doppler shift of five hundred hertz at 146 MHz, supposing that the antenna is whirling in a circle that has a radius of 13.39 inches. Then the rotation frequency can be given as follows:

$$f_r = \frac{500 \times 1879.8}{146 \times 13.39} \qquad \text{Eq (7)}$$

A 480 Hz of rotation frequency leads to 480 into 60 equals to 28,800 or approximately 30,000 r/min, which nearly excludes any aims of rotating the antenna mechanically. Luckily, Terrence Rogers, WA4BVY, proposed an ingenious method that works very well which is electrically spinning the antenna.

Rogers' proposed, the Dopplescant, is using eight 1/4-λ vertical whips that are arranged in a circular pattern. At a time only one antenna is electrically selected. By controlling the arrangement in which the antennas are chosen, the Dopplescant imitates a single 1/4-λ whip antenna moving in a circle. An intelligent feature in Rogers' design is the work of a digital audio filter to draw out the Doppler tone from voice, PL tones and noise. The article in QEX explains the process of such switched capacitor filters.

In more than 20 years, many modifications to Rogers' original design have evolved. A well-liked version presented by Chuck Tavaris, N4FQ, is labelled the Roanoke Doppler direction finder named for the Roanoke, Virginia, where it was built and used. Later when the Doppler tone was very weak or very strong modifications were suggested to avert false readings. By analysis and experimentation, it was brought to light that only four antennas are mandatory to deliver good operation. Methods of antenna switching were recommended for allowing the same antenna switching circuit to be used on very high frequency or ultrahigh frequency. It was embarked to construct a Doppler DF that has many of the upgraded attributes.

An attentive evaluation of the Roanoke design disclosed the use of 4000 series CMOS logic circuits which are somewhat obsolete, but for that there is a need of CMOS-to-LED display drivers to set off the LEDs. These integrated circuits drivers are still accessible, but are a bit costly (two thousand five hundred rupees for three of them). Another expensive aspect of the project is that four ¼ λ mag-mount antennas for the array are required. The most inexpensive mag-mount antenna that was affordable cost two thousand five hundred rupees each. Multiply that with four, and you have spent ten thousand rupees before any any electronics are added.

The proposal shows considerably upgraded filtering of audio, logic circuits of 74HC-series that are efficient enough of driving the Light Emitting Diode display precisely and a wideband of very high frequency/ultrahigh frequency antenna switcher that can be made for about six thousand seven hundred and thirty rupees as well as the four ¼ λ mag-mount antennas. The availability of high-quality PC boards and kits o parts made building this project uncomplicated, easy and low-budget. (Mouser, n.d.) Assembling the project is a lot more instructive and total cost of the project is about one third to the cost of a newly bought commercial RDF unit.

RADIO DIRECTION FINDERS SYSTEMS (UNOCCUPIED BY POLARIZATION ERRORS):

With two completely varying frameworks, the system is totally unoccupied by the polarization errors. Dominant stumbling block in the system of completely varying framework are as follows:

- With the elongation of waves there is a fierce reduction in the sensitivity of the system.
- Goniometric systems with varying framework, the engineering complexity is the set of the varying framework which is having the condition of planes to be parallel, For the unconnected arrival angles of waves having unassociated sensitivity.
- The plane of framework at the angle of 90 degrees, for the direction of propagation Sensitivity = 0.
- Two false minimums of the audibility of signals, an addition to the determination of faultless bearing leading to the presence of radiation pattern besides 0.

Hence, the false minimums in accordance with the RDF of waves are stronger, blunt and slightly unassociated from the truth therefore, it should be penned down that the lack is not essential virtually.

With the varying framework of systems, it is essential that the production must be large and thorough in construction. High accuracy of the parallelism of the planes of the framework is necessary to be fulfilled.

Antennas are designed in such a way that only the vertical component of the electric field would be accepted by the external system. The elimination of the polarization errors is led by the anomaly of the procedure of the horizontal component. The H-shaped system which is commonly known as easiest system in which the connection of the vertical wires antennas having the pattern as shown in below figure:

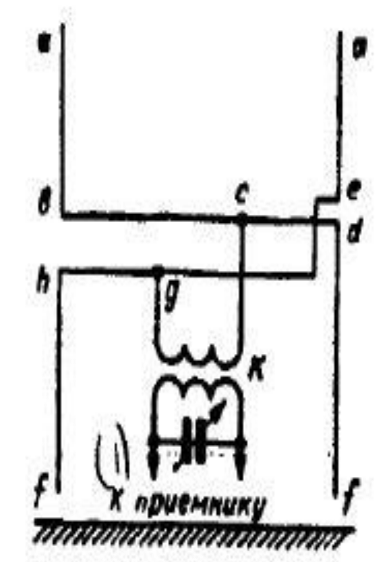


Figure 4 H- shaped system antennas.

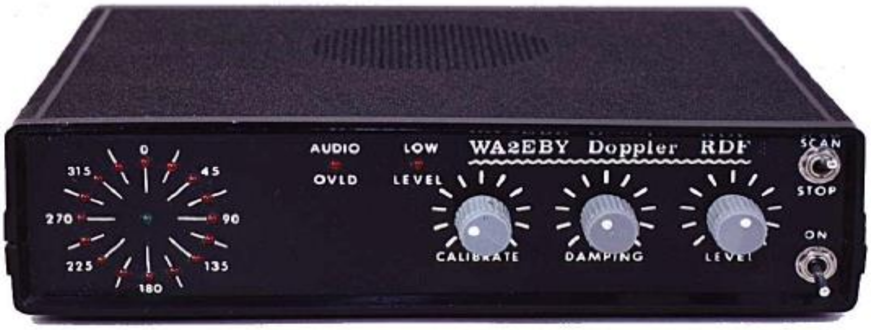


Figure 5 A Main unit front panel.

Figure 5: Main unit rear panel.

CHAPTER 03: CONSTRUCTION AND WORKING

CONSTRUCTION:

Main Board:

Due to the massive number of interconnections, PC board construction is being used for the main Doppler RDF board. If you want to have a detail insight and having patience (a plus point) then use point to point connections. To seclude analog and digital grounds part placement is used.

Into a $2 * 8 * 6.25$- inches (HWD) Plastic pack enclosure, the main PC board positioned pleasantly. On the front panel the ON/OFF and SCAN STOP Switches and controls include CALIBRATE, AUDIO LEVEL and DAMPING are being launched for comfortable access.

On the rear panel Dc power input, audio inputs and outputs and Doppler tone PHASE INVERT switch three is being placed. On the inside of the enclosure speakers are being placed and on the top are the holes for speaker for quality hearing.

Figure 6 A close up of Antenna Switcher.

LAYOUT OF BOARD:

For a Light Emitting Diode (LED) Array, a PC board untangled the fashioning and gives the steady disc-shaped design. If necessary, part placement is not crucial therefore, point to point wiring can be casted.

From the twenty-wire insulation Light Emitting Diode (LED) deadlock is constructed. The process of its construction goes by stripping off the wire and eliminating the 6” long plastic insulation single tube. Then equally divide the 6” long plastic insulation tube into sixteen pieces each of 0.20” long.

Afterwards, enthrone the deadlocks on every Light Emitting Diodes (LED) anode lead. The spacing of hole of the PC board differ to smooth the design. At all times, anode lead should be kept straight and if desirable, curve the cathode lead to get to the spacious mounting holes.

These deadlocks will guarantee the distance of all the display LED’s are identical. For LED’s D3, D4 and center green LED D16 replicate the alike procedure.

WORKING:

For better understanding of the function of the Doppler Radio Direction Finder (RDF) circuit, we see the diagram below.

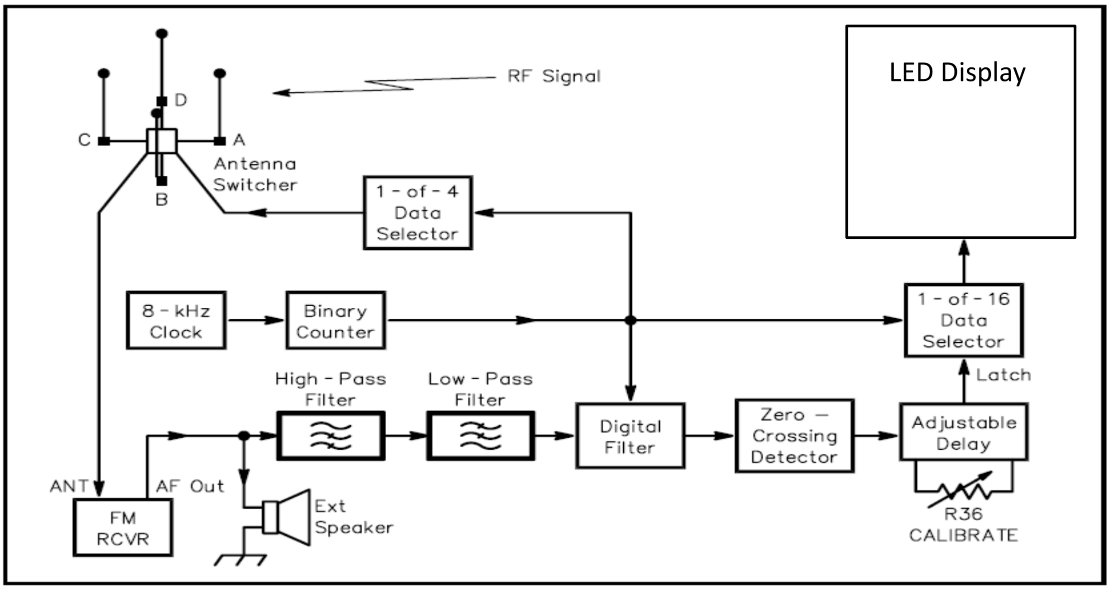


Figure 7 Diagram of the Doppler RDF system.

An 8 kHz clock oscillator powers a counter that is binary. Three synchronized functions are performed by the output counter: “spin” the antenna, operate the LED display and power the digital filter. The counter output drives a 1-of-4 multiplexer that rotates the antennas by consecutively selecting and turning it on one at a time in the order A, B, C, D, A, etc., at the rate of five hundred times per second. The result at the counter also power a one of sixteen multiplexer which is used up to produce the Light Emitting Diode display in sync with the antenna that is spinning. The radio frequency (RF) signal which is obtained from the spinning of the antenna is attached to the input of the antenna of a very high frequency (VHF) or ultrahigh frequency (UHF) frequency modulated receiver.

The spinning of the antenna obtrudes a variation of frequency of ±500 Hz on an obtained signal of 146 MHz. A frequency modulated receiver of 146 MHz is attached to the spinning antenna’s radio frequency (RF) output which demodulates the ±500 Hz frequency deviation and make it sounds like a 500 Hz tone with intensity set by the 500 Hz frequency deviation. The audio received, including 500 Hz Doppler tone, is then refined by a series of audio filters. A low-pass filter discards all acoustic frequencies that are more than five hundred hertz Doppler tone, and a very narrow bandwidth digital filter removes only the 500 Hz Doppler tone. A high pass filter discards PL tones and acoustic frequencies that are below the five hundred hertz Doppler tone.

The result of the filter that is digitalized shows the definite Doppler frequency shift that is described in Figure 3B. The Zero overpassing of the Doppler frequency shift arrangement tie into the position of antenna which is present straight towards (position A) which is the source of transmission or directly (position C) that is the opposite of transmission source. The zero overpassing signal is being passed from an adaptable interval before it bolts the direction that is indicating Light Emitting Diode. With the actual direction of the transmission the adaptable interval is used up to calibrate the Light Emitting Diode direction indicator.

Here I would like to mention the RDF Radio Direction Finding receiving and amplification system that was used in Geomagnetic Monitoring Study of the Himalaya Area in Search of Pre-Seismic Electromagnetic Signals which is located in Lariano, Rome, Italy; developed by the Radio Emissions Project, and used for this study. It consists of two Loop antennas, a radio amplifier (receiver), connected to the PC's microphone socket, via the Sound Blaster.

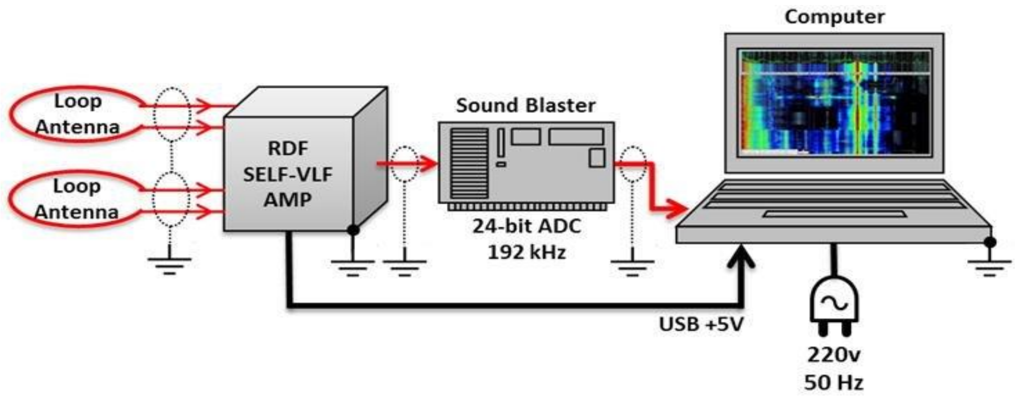


Figure 8 Schematization of the RDF Radio Direction Finding receiving and amplification system.

SWITCHING OF ANTENNA:

Given the figure below is the illustration of switching of antenna.

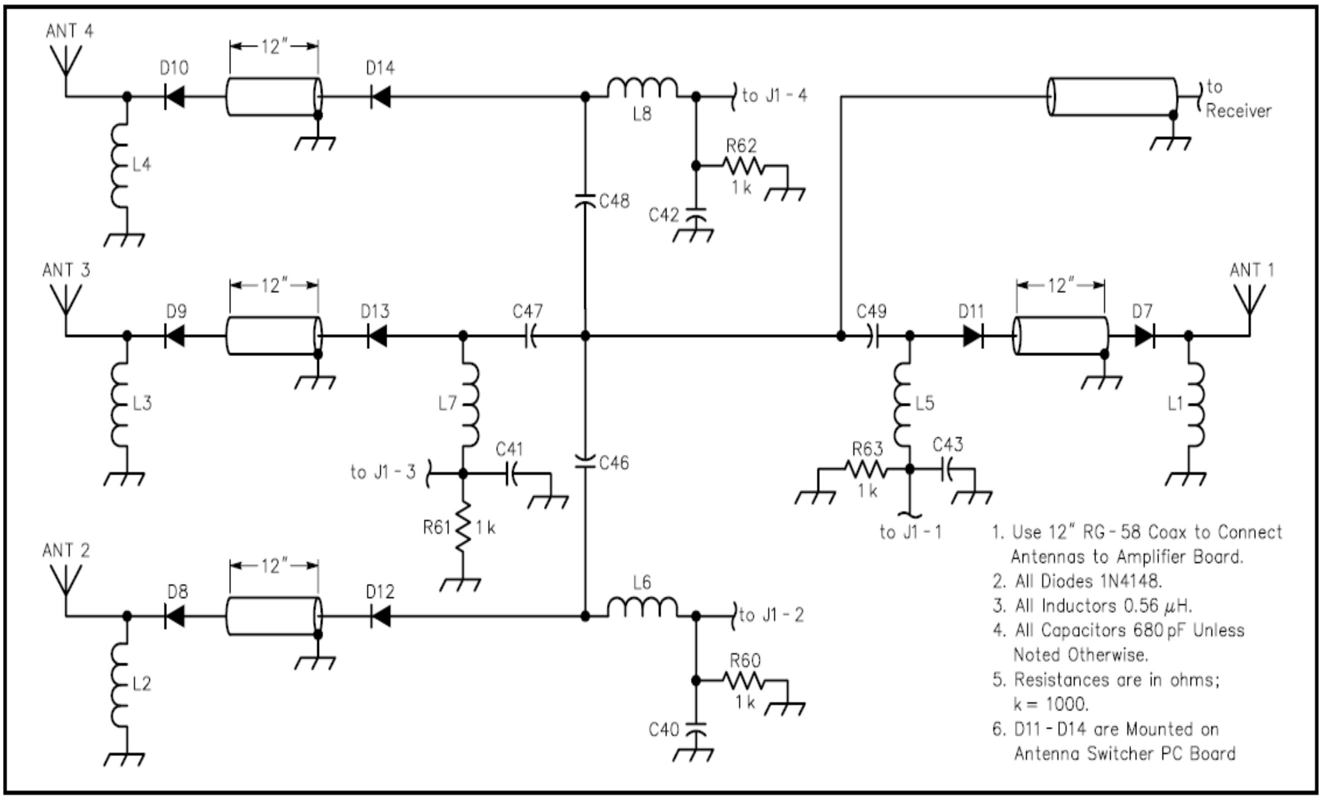


Figure 9: Schematic of Antenna Switcher

C40-43, C46-49—680 pF, 25 V are chip capacitors (140-CC502B681K)

D7-D14— are 1N4148 silicon diodes

(583-1N4148)

L1-L8— are Surface-mount inductor of 0.56 μH

(434-07-R56K)

R60-R63—are chip resistors of 1 kΩ

(71-CRCW1206-1.0K)

Miscellaneous

4—half inch hex spacers of brass

(534-1450C)

1—6- are pin DIN plug (171-0276)

4—#4-40 by 1 inch flat-head screws

12—#4-40 star locked washers

12—#4-40 nuts

4—1/16 diam × 36-inch-copper welded long rod (Lincoln R45)

5—Magnet strips 31/2 by 31/2 inches

4—bottle caps of soda (coca-cola) for antenna bases

10 feet of RG-58 coaxial, 95% shield

10 feet of 6-conductor #24 shielded wire (AWG)

When +5Volts is given to the pin 1 of J1, Antenna One is preferred. Electrons runs through a medium along Radio Finder RF choke Inductor L5 to Diode D5, Diode D7 and RF choke inductor L1 all the way to the ground.

Diodes D11 and D7 are forward biases by this current causing an increase in the junction capacitance. The junction capacitance which is relatively high implying to less reactance allowing the RF signal that are available on Antenna One to move comfortably along the diode D7.

In the coaxial cable which is twelve inches long joins the Diode D11 and capacitor C49 all the way up to the FM receiver. C49 is performing the role of blocking the direct current.

As Antenna One is chosen, the pins of J1 which are 2, 3 and 4 stand at zero volts dc. From the circuit beneficially secluded antennas 2, 3 and 4 and the diodes D8, D9 and D10 possess rock bottom capacitance without forward biasing.

Therefore, the diodes D7 and D14 act as the RF switcher. When forward biased they are considered close and open in the absence of forward biasing. Mimicking the spinning of antenna in the design of antenna 1,2,3,4. By putting in the current of 5 volts dc consecutively to the 1, 2, 3, 4, 1, and 1 is obtained easily.

It is very important to seclude all the unnecessary antennas from the circuit and circuit ground.

By isolating the unchosen antennas resulting in the unwanted addition of the antenna elements that are parasitic in nature which could lead to the distortion of the received signal direction indication.

For the diodes D7 and D14 which are performing the role as RF switcher it is generally proposed to use the PIN diodes ECG- 555 or MPN3404 for switching diodes. But they are costly as compared to the common 1N4148 switching diodes.

So, it’s been decided to contrast between the costly PIN diodes which costs approximately $10 corresponds to (1675.75 PKR) each as of today with the common 1N4148 switching diodes which costs nearly 4 cents which corresponds to (0.1817 PKR) each as of today.

By using a network analyzer both diodes type has been tested in the test circuit to estimate the insertion loss along with return loss (An estimation of how near the internal impudence as compared to the ideal 50 Ω) and both diodes.

The return loss of 0 decibels correlates with the infinite SWR (open or short circuit) whereas the return loss of a minus 20 decibels correlates with the satisfactory SWR with the ratio of 1.2:1.

By applying 15 mA of current in the forward direction the device is said to be on and by applying no current in the forward direction it is said to be off.

The results are shown in table one on which the test has been conducted.

Table 1 The Functions of Various Types of Diodes.

Diode Number and Type		**146 MHz**		**446 MHz**		**Cost (In $) Each**	**Cost (In PKR) Each**
		Return Loss in dB	**Insertion Loss in dB**	**Return Loss in dB**	**Insertion Loss in dB**		
HP3077-745	Off	0.160	66.000	0.030	49.500	$10.0	1675.75 PKR
PIN	On	23.000	0.440	15.100	0.790		
NSMP-3820	Off	0.100	47.300	0.100	27.000	$1.00	167.57 PKR
PIN	On	25.200	0.210	18.200	0.440		
ECG-553	Off	0.100	048.00	0.050	027.60	$2.00	335.15 PKR
PIN	On	21.400	0.760	19.100	01.00		
ECG-555	Off	0.100	29.100	2.800	04.50	$2.00	335.15 PKR
PIN	On	25.100	0.230	016.40	0.510		
MPN-3404	Off	0.100	042.70	0.300	20.300	$1.250	209.47 PKR
PIN	On	024.20	0.230	14.400	0.570		
1N914A	Off	0.100	056.30	0.200	037.10	$0.120	20.11 PKR
Switching	On	016.70	1.820	17.800	2.420		
1N4454	Off	0.060	49.000	0.280	029.50	$0.050	8.38 PKR
Switching	On	024.50	0.760	22.900	1.150		
1N4537	Off	0.050	048.00	0.270	30.800	$0.050	8.38 PKR
Switching	On	025.50	0.660	022.70	01.240		
333-1N4148	Off	0.100	50.500	0.370	033.40	$0.040	6.70 PKR
Switching	On	024.10	0.930	024.40	1.400		
583-1N4148	Off	00.04	047.10	0.270	029.00	$0.040	6.70 PKR

Switching	On	26.700	0.620	022.30	1.090		

It is no wonder that the costliest PIN gives the best results, the most common ECG-555 performed poor seclusion in the test of 4.5 decibels at UHF making itself not acceptable for its use on 446 MHz. However, it is the best selection for the application of VHF and UHF But, without giving the remarkable advancement in its performance it costs too much than the switching diodes.

Thus, for gaining the best results, Rectron 583-1N4148 is being used.

SWITCHING OF ANTENNA WITH DOUBLE SIDED PC BOARD:

For switching antenna circuit Double sided PC board assembling with holes that are plated is used. To reduce the effect of impudence discontinuities and route of signal to the summing point, micro-strip transmission lines are being recruit.

One and all of the 4 ¼ $-\lambda$ antennas can be made by the Double-sided PC board as illustrated in the figure below:

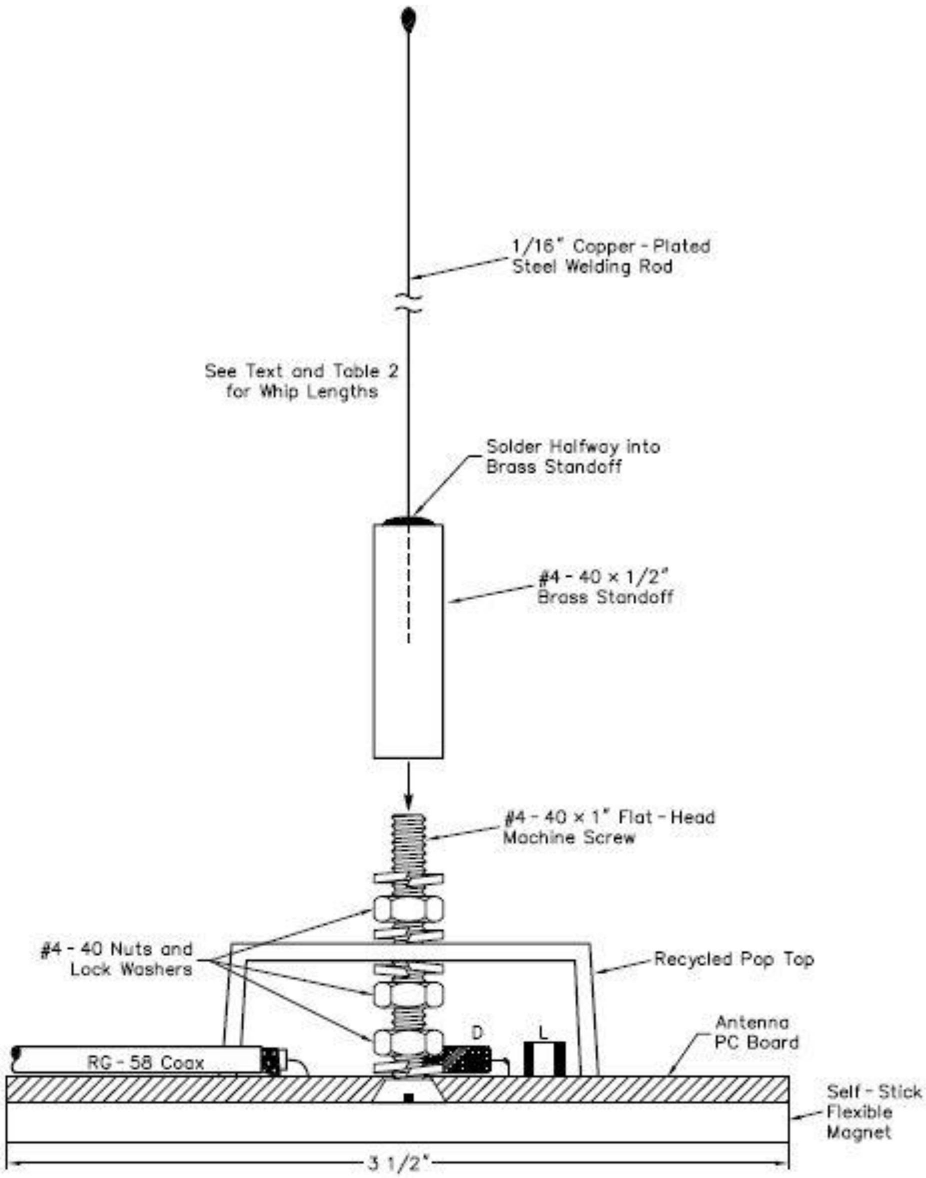


Figure 10 Four Pop Top Mag-Mount Antennas.

All of these PC board $2.5 * 2.5$ inch antennas hold a switching diode, mounting antenna stud and an RF choke which is affixed with the line of micro-strip. To the bottom of the surface affix a slim flexible magnet to each board making it a mag-mount antenna.

Form office supply stores, Business card size magnetic stuff is handy. This stuff is having the great cohesive backing. It also gives aid to the promotion of an excellent yet cheaper mag-mount antenna!

Pop tops (plastic soda bottles cap) can be used to put up a reinforcement to the mounting antenna stud. For the whip mounting screw drill the cap from the center engrave one side of that cap so that the coax can pass through it as illustrated in the figure above.

The switching of antenna on the PC board can be done by using a coax of twelve inch in length which is RG-58 that links all the antennas to the antenna switcher of the PC board. Keeping in mind that the lengths of the four coaxes should be fully accurate and identical.

By taking care of these measurements implies to the perfection of the RDF bearing indication. To affix the RG-58 to all the Pop tops Mag- mount PC board and PC board antenna switching hot melted glue or adhesive can be used.

For the best protection of the antenna switcher electronics sports drink or large fruit caps can be used.

From welding supply stores, Lincoln R45 (steel welding rods that are copper platted) and antenna whips that are classic are accessible. Within the zinc plated $4 - 40 * {}^{1}/_{2}$ inch hex deadlocks the rod is effortlessly fused midway.

Restricting the fuse to be flown into another half getting into the deadlock, a screw of $4 - 40 * {}^{1}/_{2}$ inch is being installed at the one end. At the other end antenna whip is being installed and fused so that it can remain in that location. When the fuse is being cooled eliminate the screw installed.

Caution:

Due to the variation in height of the plastic Pop tops they are not equal therefore install a screw antenna whip into the base of the pop top Mag mount.

Table below gives the information of the lengths of whip for frequencies operation on 146, 446 and 223 MHz:

Frequency (MHz)	**Whip Lengths (inches)**	**Antenna Spacing per Side (inches)**
146	$20^{1}/_{16}$	18.25
223	13	11.5
446	$6\ ^{11}/_{16}$	5.75

Table 2 Lengths of Antenna Whips and Spacing of Antenna to be used on three of the Bands.

From the upper surface of the mag mount to the rear surface of the whip tip length of whip can be calculated.

It can be observed that the lengths of the whips are somehow greater than the calculated ones by using the formula:

$$l = \ ^{234}/_{f}$$

For the sake of the coupling that is capacitive in nature between the car top and base of the mag mount the extra length is needed.

CHAPTER 4: CIRCUIT DESCRIPTION:

The below figure is the illustration of the WA2EBY Doppler Radio Direction Finder (RDF). The 8 kHz clock oscillator is the main component of the system which is constructed on every side of a 555 timer, an unstable multi-vibrator U4 IS composed.

For the determination of frequency of multi-vibrator's oscillator C26, R27, R28 and R29 is used. For the fine tuning of the frequency of oscillations to 8 kHz R28 and R29 is used in the series of connection.

Frequency of clock to be precisely corresponds to 8 kHz is not critical at all, but it is recommended that it should be modified to the frequency of ± 250 Hz for the reasons that is going to be considered shortly.

For U7 four bit- binary counter gives the clock 8 kHz of output for U4. And the output of U7 for the three bit- binary counter is used for the operation of the three synchronized functions.

SYNCHRONIZED FUNCTIONS:

Three synchronized functions will be discussed here;

1. Binary Counter U7 Spinning Antenna Array.
2. Sequencing the 16 LED display.
3. Operating the Digital Filter.

1. Binary Counter U7 Spinning Antenna Array:

The first function that is obtained from binary counter U7 spinning antenna array. Two most-significant bits of U7 to run 1-of-4 multiplexer U8 are used to get this done. The buffer U12 inverts the selected output of U8 (active low). To turn on the antenna to which it is connected sufficient current is supplied by buffered output of U12 (active high). (More specifics of by what means all this is accomplished will be discussed later.) Buffer outputs U12A, U12B, U12C and U12D are arranged in sequence. The antennas A, B, C, D, A, B, etc. are selected by corresponding buffer. The two most substantial bits of the counter U7 with the driving multiplexer U8 is dividing the 8 kHz clock by four, so each antenna is turned on for 0.5 milliseconds. For one complete spin of the antenna 0.5 milliseconds × 4 = 2.0 milliseconds are required, hence the 2 milliseconds or 500 Hz is frequency of rotation. A frequency modulated receiver that is attached to the RF output of the spinning antenna has a five hundred hertz tone inflicted on the obtained signal.

2. Sequencing the 16 LED Display:

Second synchronized function is sequencing the 16 LED display that is obtained from the U7 counter which is binary. This is accomplished by the utilizing the binary result of counter U7 for selecting the data outputs from one of sixteen of U11. The chosen output of U11 get decreased which allows the current to flow through current-limiting resistor R51 from the +5 V supply and to green center LED, D16, and direction that is specifying the red LEDs D17 through D32. As the Light Emitting Diode exhibit sequences by means of four direction indicating Light Emitting Diodes each antenna remains turned on, then it is being switched to the next antenna. A heading change of 22.5° is represented by each direction-indicating LED.

3. Operating the Digital Filter:

Operating the digital filter is the third synchronized capacity which is answerable for drawing out the Doppler tone. A speaker that is external and AUDIO LEVEL ADJUST potentiometer R50 is associated with 500 Hz Doppler tone present on the obtained acoustic result. A two-post Sallen-Key high-pass channel 6 that is worked around operation amp U1A sift through the sign. PL tones and sound frequencies that are over the 500 Hertz Doppler tone are sifted by it. Following, a four-shaft Sallen-Key low-pass channel is utilizing U1B and U1C band confines the sound frequencies that are over the 500 Hz Doppler tone. The band constrained sign is then placed in to the contribution of an advanced channel which is comprising of simple multiplexers U5, R18, R19 and C10 through C17.

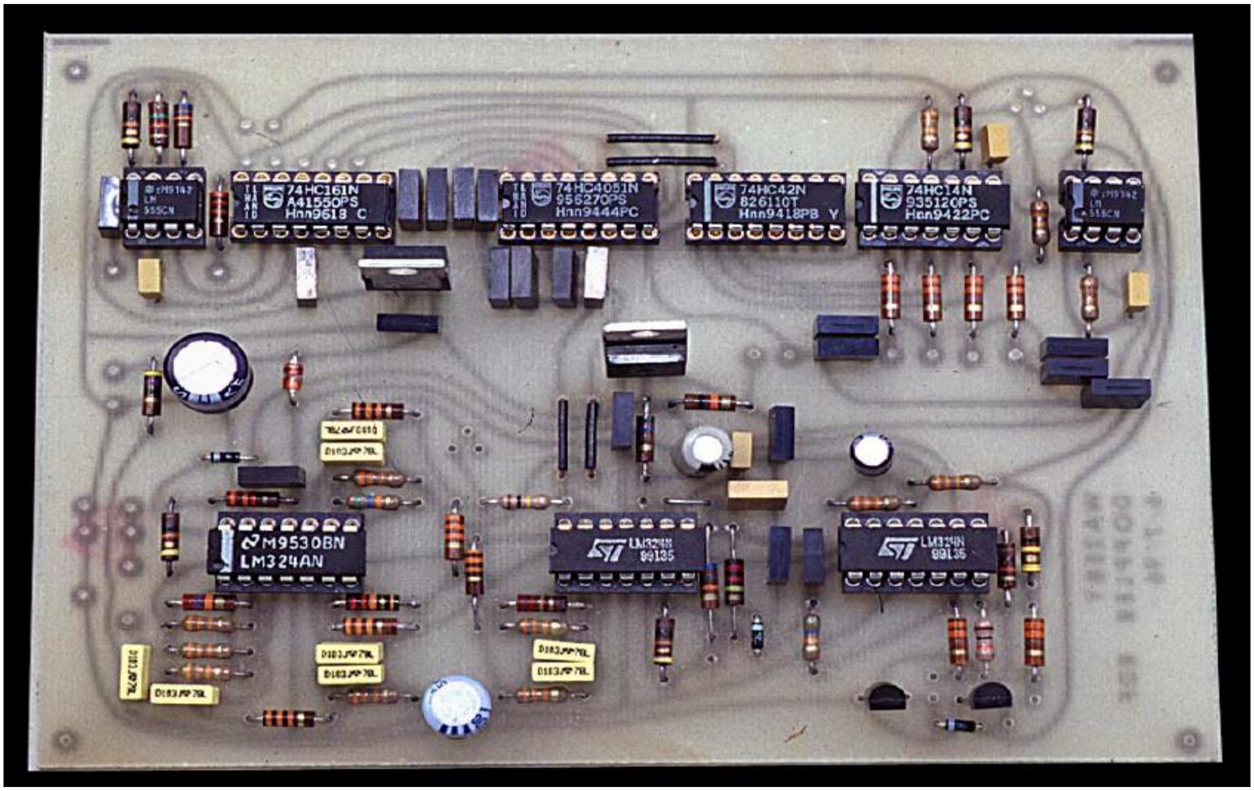
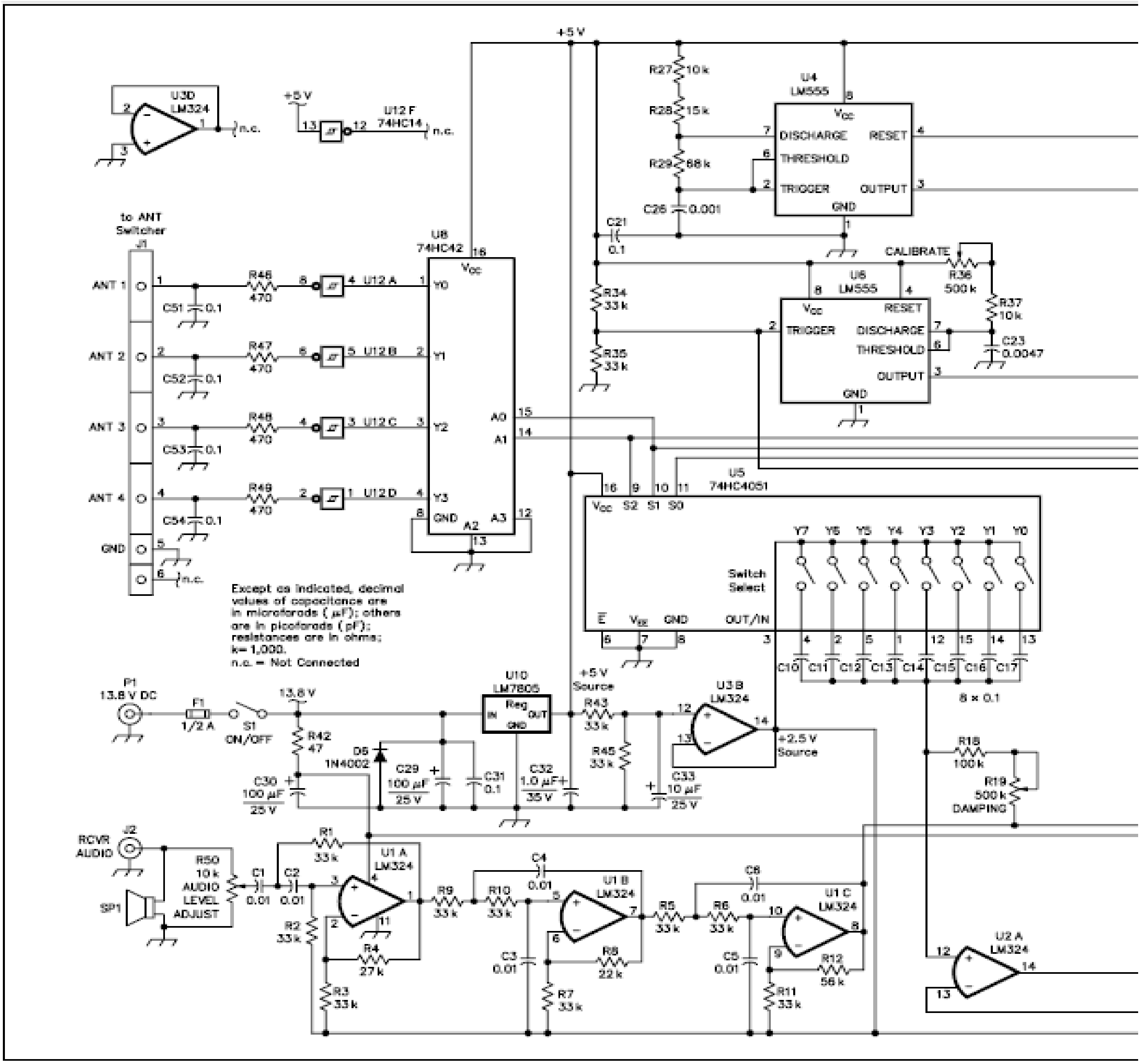


Figure 11 Main PC board



C1-C6, C18, C19, C38—
0.01 micro Farad of 25 V
(581-10NJ63)
C7, C9-C17, C21, C31,
C51-C54— are 0.1μF,
25 V (581-100NJ63)

C8, C25, C32—1 μF, 35 V
tantalum
(540-1.0M35)
C20—0.47 μF, 25 V (581-
470NK63)

C22, C24, C26—0.001 μF,
25 V, NP0
(581-UEC102J1)
C23—0.0047 μF NP0, 25
V
(581-UEC472J1)

C33—10 μF, 25 V electrolytic (140-XRL25V10)
C29, C30—100 μF, 25 V electrolytic (140-XRL25V100)
D1, D2, D5—1N4148 (583-1N4148)
D3, D4, D17-32—T1 red LED (351-3102)
D6—1N4002 (592-1N4002A)
D16—T1 green LED (351-3003)
Q1, Q2—2N3904 (592-2N3904)
R1-R3, R5-R7, R9-R11, R20, R26, R30,
R31, R34, R35, R38, R43, R45—33 kΩ (29SJ250-33K)

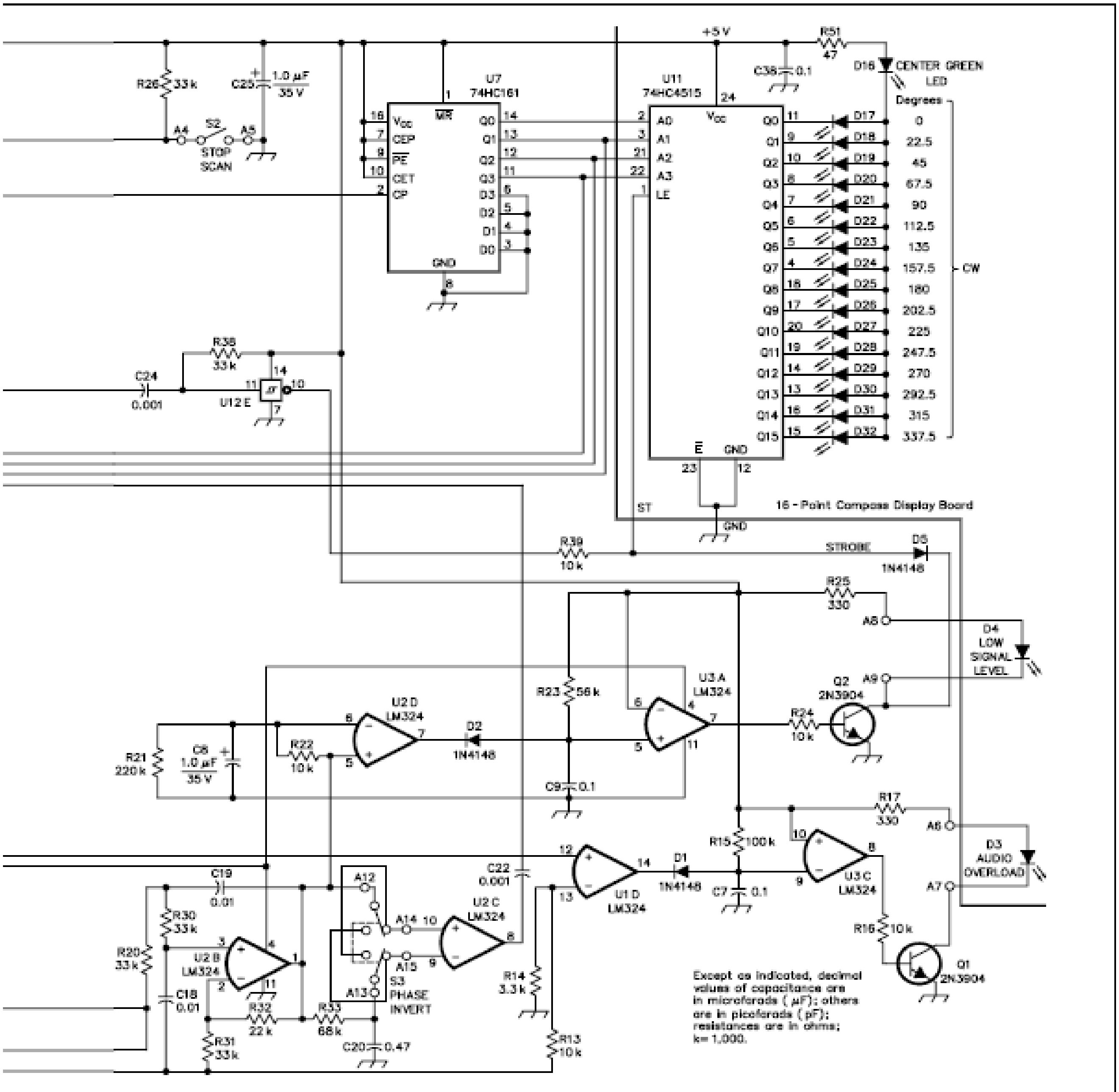


Figure 12 WA2EBY Doppler RDF system main circuit board.

R4—27 kΩ (29SJ250-27K)

R8, R32—22 kΩ (29SJ250-22K)

R12, R23—56 kΩ (29SJ250-56K)

R13, R16, R22, R24, R27, R37, R39—

10 kΩ (29SJ250-10K)

R14—3.3 kΩ (29SJ250-3.3K)

R15, R18—100 kΩ (29SJ250-100K)

R17, R25—330 Ω (29SJ250-330)

R19, R36—500 kΩ linear-taper pot

(31CN505)

R21—220 kΩ (29SJ250-220K)

R28—15 kΩ (29SJ250-15K)

R33, R29—68 kΩ (29SJ250-68K)

R42, R51—47 Ω (29SJ250-47)

R46, R47, R48, R49—470 Ω

(29SJ250-470)

R50—10 kΩ linear-taper pot (31CN401)

U1-U3—LM324 (511-LM324N)

U4, U6—LM555 (570-LM555CN)

U5—74HC4051 (570-CD74HC4051E)

U7—74HC161 (511-M74HC161)

U8—74HC42 (511-M74HC42)

U10—LM7805 (511-L7805CV)

U11—74HC4515 (570-CD74HC4515E)

U12—74HC14 (511-M74HC14)

Miscellaneous

F1—0.5 A fuse (5761-51500)

J1—6-pin DIN receptacle (16PJ224)

J2—3.5 mm audio jack (16PJ011)

P1—Coaxial dc receptacle (163-4305)

S1, S2—SPST (1055-TA1320)

S3—DPDT (1055-TA1360)

SP1—8 Ω speaker (253-2120)

CHAPTER 5: THE DIGITAL FILTER

To power the digital filter the 8 kHz clock is divided by two by using the three most-significant bits of U7, making the digital filter clock rate 4 kHz. The sole determination of the center frequency of the digital filter is done by dividing the clock frequency with the order of the filter. The filter's frequency of the center is 4 kHz divided by 8 which is equal to 500 Hz because it is an 8th-order filter.

This is exactly the same frequency at which the antenna is being spun, therefore, the Doppler tone frequency that is generated on the audio of the receiver which is associated to the antenna that is spinning is the same. This is actually a refined feature of the design of Doppler Radio Direction Finder (RDF). Utilizing the same oscillating clock for spinning the antenna and clocking the digital filter guarantees that the Doppler tone generated by operating of spinning is the digital filter's precise frequency center.

All the more if the vibrating frequency of the clock is being drifted, the Doppler tone is drifted correspondingly, since the same clocks runs it the center frequency of the digital filter go along with it specifically.

Within the eight kHz clock, immoderate drift must be prevented, nevertheless, since the low analog and the filters that are high pass lead up to the digital filter that have specified centers of passband of 500 Hz. A flow of ±62.5 Hertz (250 / 4) in the Doppler tone is generated due to flow of ±250 Hertz on the eight kHz clock. Due to the relatively low Q of the analog band-pass filter this value is allowable.

Calculation of Digital filter Q is done by dividing the center frequency of the filter by its bandwidth;

($Q = f_o / BW$) or 500 Hz / 4 Hz = 125.

It is very hard to understand this such a high digital filter Q with passive or active analog filters and maintaining an accurate center frequency is even more difficult because even a small change in the component tolerance or temperature would simply and easily detune or de-Q the filters as of the required five hundred Hertz Doppler tone frequency. There is no need of precision-tolerance components for digital filter to make the high Q possible. The comeback time of the digital filter is altered by changing the damping pot R19. Fast changes of the Doppler tone that are initiated by signals that are reflected on multipath, noise blast or high acoustic peaks connected with communication are averaged by this digital filter damping.

At the digital filter output a digitized portrayal of the Doppler tone has given. The digital steps in the waveform are filter out by a two-pole Sallen-Key low-pass channel that is worked around U2B which is giving a practically sinusoidal yield similar to the Doppler shift that is represented in picture representation 3B. The Doppler Effect is zero when there are zero crossings of this signal. U2C detects the zero crossings of the signal and accustomed to fire a multi-vibrator that is mono-stable (U6) that is built around a 555 timer. The output of U6 bolts the red-Light Emitting Diode in the presentation which is similar to the course of transmission in relation to the green middle Light Emitting Diode, D16. The calibration among the red direction-indicating LED and the actual source of transmission bolts in the presentation that is simply gained by altering the interval among the production of the bolted pulse to U11 and the Doppler-tone zero crossing firing of U6. This delay is determined by C23, R36 and R37. By expanding or diminishing the estimation of the potentiometer R36 the expanding or diminishing the interval is attained.

AUDIO-OVERLOAD INDICATORS AND LOW-SIGNAL-LEVEL:

Audio overload indicators and low signal level lockout are two most useful modifications that are included in this design. The amplitude of the Doppler tone at the input to the zero overpassing detector is uninterruptedly monitored by U2D. Whenever the Doppler tone amplitude drops below 0.11 Volts peak, the output of U2D goes low. This is accomplished by doing the referencing of the input of U2D that is negative to 2.39 Volts that is 0.11 Volts below the nominal value of 2.5 Volts reference level that is dc of U2B's output by the help of voltage dividers, R21 and R22. In the presence of the Doppler tone and at more than 0.11 Volts peak the output of U2D remains high. Whenever U2D goes low C9 discharges via D2, which cause the output of U3A (pin 7) to increase and go high, lighting up low signal level Light Emitting Diode, D4 by turning on Q2 via R2. While waiting for the Doppler tone to return with amplitude more than 0.11 Volts peak D4 remains on and C9 is being recharged by means of R23. By disabling the strobe input of

U11 the LED display remains locked at any time the Doppler tone is way too low for a precise and correct bearing. By pulling pin 1 of U11 low by means of D5 when Q2 is turned on this is accomplished.

When the audio clipping of the Doppler tone occurs, it is indicated by an audio overload indicator D3. If the level of signal from the digital filter is extremely high and can produce an incorrect bearing indication, results in clippings. Whenever the output of the digital filter drops below 0.6 Volts the output of U1D goes low as the amplitude of the Doppler tone proceeds to the 0 Volts supply rail. The output of U3C goes high which is caused by the discharge of C7 via D1, illuminating audio overload LED D3 by turning on Q1 via R16. It was chosen to not lock the display of LED on audio overload, for doing that it only needed to connect a diode in between pin 1 of U11 and the collector of Q1, just like in the low level lock out function.

PHASE CORRECTION:

S3, PHASE INVERT can fix it if the output of audio of the Doppler Radio Direction Finder (RDF) FM receiver is incorrectly phased. If the phasing is inaccurate, direction indications of the Light Emitting Diodes are one-eighty degree opposite to that of the definite source of the signal. By the movement of S3 to the reversed point the problem is corrected by allowing the trailing edge being sensed by U2C. When switching between different receivers this is specifically useful. To disable the antenna spinning, S2 deactivates the 8 kHz clock. This is helpful when it is tried listening to the signal received. It is hard to understand what is being disclosed particularly with the inadequate signals due to the existence of the Doppler tone in the obtained audio.

POWER SUPPLY:

Power is appropriated by means of ON/OFF switch S1 and a half (1/2) A wire (F1). By constraining the converse voltage to 0.7 V and permitting adequate current to stream to blow fuse F1 while D6 gives supply voltage reverse polarity shielding. U10 gives a controlled 5 Volt DC to all Integrated Circuits (ICs). From C29 through C33 are the detour filters. The 5 Volts dc yield of U10 drops by 2.5 Volts by the divider R43 and R45 that are resistive. For every simple filter that is analog and the advanced filter that is digital a noninverting voltage supporter U3B cushions the 2.5 Volts source, to yield a virtual reference of the ground. By the utilization of a 2.5 Volts of virtual ground that are above circuit ground control amps are permitted to process simple signals that are analog without the requirement of a negative voltage of power supply. Through the virtual ground level right in the center, 2.5 Volts voltage that is analog oscillate from almost 0 Volts to approach +5 Volts.

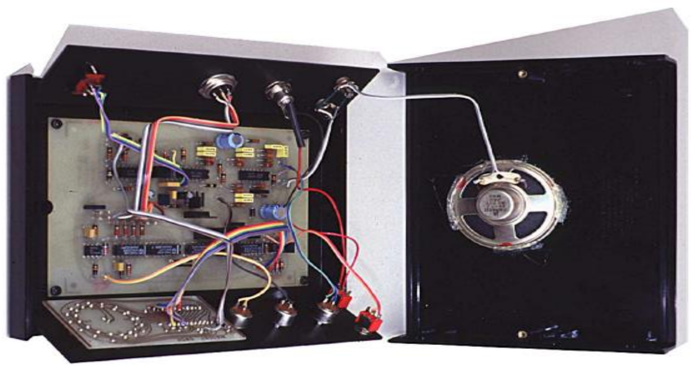


Figure 13 Inside view of main unit.

CHECK OUT:

Basic Testing:

Before turning on the power supply it is quite sage to check on the circuit for the one's workmanship. To calculate the resistance between the ground and power an ohmmeter is being used whose value must be longer than 2Ω.

To restrict the destruction in the event of problem, Limit the power supply current to 150 mA (whereas the drain limit of normal current is 100 mA) and 12 Volts dc to the RDF units should be applied.

The following supply voltages should be verified as:

On the output of U10, pin number 16 of U8, pin number 8 of U4, pin number8 of U6, pin number 16 of U7, pin number 24 of U11, and pin number 16 of U5, the voltage should be +5Volts.

Checking thoroughly the voltage should be 2.5Volts at pin number 14 of U3 and+12Volts at pin number 4 of U2 and U1.

Therefore, completing the fundamental requirements for the basic testing of the circuit Doppler RDF. These tests are suggested for the identification and troubleshooting of the problems if they arise.

But if you don't have any of these things then don't worry because normally up to the mark functioning can be attained with outmarch these assessments.

Functional testing:

Confirming the clock oscillator U4 performance prior to the connection as the switching of antenna by attaching to pin number 3 an oscilloscope. The result should be the occurrence of square wave at the output having the voltage of 5 Volts and period of 8 kHz (25$_{\mu s)}$.

For the best performance use a counter that can count frequency to prove that the frequency of clock is 8 kHz $\pm 250\ Hz$. To alter the frequency of clock the values of resistors R27 and R28 can be mutate, if desirable.

Recheck that the closing switch S2 holds the audacity disable the clock. By linking the oscilloscope to the pin number 14, 13, 12 and 11 consecutively and opening the SCAN STOP S2, the operation of the BCD counter U7 can be verified.

The frequency of the signal on the pins mentioned above should be 4, 2, 1, 0.5 kHz individually. Confirm the occurrence of the square wave on the buffer U12 output pins 2, 4, 6 and 8.

INDICATION OF SIGNAL-LEVELS:

To replicate the existence of the Doppler tone audio signal generator can be used for the test that are followed. To restrict the load on the signal generator, detach the AUDIO LEVEL potentiometer R50 from the speaker.

Link the input receiver terminal of the audio signal to the audio signal generator. Place the generator in such a way that the 500 Hz sine wave having an amplitude of one volts P-P can be applied.

Whirl the resistor R50 up till LED D3 of AUDIO OVERLOAD lights up then re-arrange the same resistor R50 up till the LED D4 of LOW SIGNAL LEVEL illuminates. Now set the resistor R50 in such a fashion that both the diodes D3 and D4 are darken.

For the reduction, the damping set the R19 DAMPING control resistor and R36 CALIBRATE control resistor to the midpoint of its range.

INDICATION OF DIRECTIONS:

While noticing the illumination of the LED gradually rearrange the audio generator to the frequency corresponds to 500 Hz. As doing so shows the direction indication of the LEDS around the green center of the LED which lights up.

When the frequency of the antenna rotation is arranged a bit lower than the generator frequency the illuminations of LED should revolve in clockwise direction. When the frequency of antenna rotation is equal to the generator frequency only by then one LED will be on.

As soon as the frequency of the antenna rotation is a bit higher than the generator frequency the LED illumination should revolve in the anti-clockwise direction. The transition level between the clockwise, anticlockwise, and halted directions are very hasty due to the sharpness of the digital filter.

In order to notice these transitions the capability of the audio generator in adjusting the frequency that is fine must be remarkable. If the frequency of the signal generator is exactly 10 Hz that is varying form the frequency of antenna rotation that is verified by U4 then all the LEDs in the exhibition may seemed to be on.

As the exhibition of the transition of the direction from clockwise to anticlockwise it is pleasant to watch on the pin number 1 of U1, the intensiveness of the digital filter. As the transition occurs, it can be observed that the Doppler tune of the generator, which is replicated broke out of the noise, climbs on the peak point and then go back to the noise.

CALIBRATION CONTROL:

By arranging the frequency of the antenna rotation exactly corresponding to the generator audio, the purpose of the CALIBRATE control can be verified and only one LED will light up at that point.

Notice the indication of the direction of the LED “move” on every side of the display by manually rearranging the CALIBRATE control to its full extent. The movement range should be greater than 360 degrees.

The frequency of generator be borne if there is a bit advancement in the LED which represents the indication of direction. Keeping the frequency of the generator simultaneously exact is a very tough task however it is not desirable in this experiment.

Detach the signal generator form the input terminal of audio and connect the speaker to the input terminal of audio.

ANTENNA SWITCHER:

Only a dc voltmeter is required for the verification of appropriate working of the sequencing circuit of antenna switcher. Plug to the Doppler Radio Direction Finder unit’s antenna switcher and maintain the position of the four mag-mount antennas on a table. Any of the whip antennas should not be installed for this test.

It is necessary that the antennas must be turned on in sequenced order to imitate an antenna spinning in a circular pattern for the Doppler Radio Direction Finder unit to operate accurately. Bogus RDF reading can be produced even if a single antenna turned on out of sequenced order. Spinning of antenna can be clockwise or counterclockwise as it does not matter. It will be assumed for this test that the antenna is spinning clockwise.

The antenna spinning is stopped by scan stop switch S2. In anticipation of the voltage on station J1 pin 1 of Figure 11 is read as +5 V, S2 is being opened and closed respectively. There should be 0 V on pins 2, 3 and 4. For antenna 1, pin 1 is the antenna-enabling signal. The corresponding mag-mount antenna on the table is labelled as antenna 1. While waiting for the voltage on terminal J1 pin 2 to read as +5 V, S2 should be close and open respectively. There should be 0 V on pins 1, 3 and 4.

For antenna 2, pin 2 is basically the antenna enabling signal and for a clockwise spin antenna 2 must be placed to the rightward of antenna 1 as it is beheld from the middle of the antennas. While waiting for the voltage on station J1 pin 3 is read as +5 V, S2 should be close and open accordingly. There should be 0 V on pins 1, 2 and 4.

For antenna 3, pin 3 is the antenna enabling signal and must be placed to the rightward of antenna 2 as it is beheld from the middle of the antennas. Until the voltage on terminal J1 pin 4 reads +5 V, close and open S2 accordingly. There should be 0 V on pins 1, 2 and 3. For antenna 4, pin 4 is the antenna enabling signal and it should be placed to the right of antenna 3 as it is viewed from the center of the antennas.

The RF procedure testing of the antennas is absolutely simple and easy. All of the four mag-mount antennas should be placed at the car roof around its center, positioning each antenna at an 18.25-inchsquare pattern at the corner for functioning on 146MHz. Any of the whip antennas should not be installed yet. The RF output of the switching antenna must be connected to a frequency modulated receiver or transceiver that is modified to a strong and durable National Oceanic and Atmospheric Administration (NOAA) weather signal that is being broadcast. We should make it certain that send out mode is disabled when a transceiver is being used.

S2 is opened and power is supplied to the Radio Direction Finder unit to discontinue the function of spinning. One switch antenna is taken and is touched to the mounting screw present on each and every one of the mag-mounted antennas. Signal strength reading must be provided by only one antenna and stating alike to it is connecting straight to the frequency modulated receiver. The switch is removed from the antenna that is selected and it should touch to every single one of the remaining three antennas. The communicating signal from NOAA must be nonexistent or weak. Until another antenna is selected opening and closing of S2 is done and the same test is repeated. Until it is verified that each antenna can be turned on while the other three remain off the process should be continued.

CHAPTER 6: OPERATION

For checking performance of the RDF unit, a lengthy, vacant locality that is isolated from High buildings and a parking lot will be best suitable. It is advised to take all necessary precautions, for every time during the operation of the RDF unit that is open-road. There should be as low as two people for all these operations and testing of the RDF unit: one person is required to handle the vehicle and the other is required to handle the RDF unit. With twenty pounds of fishing line every Pop Top Mag-Mount is secured with as a safety measure when the vehicle is being operated at speeds that corresponds to that of the highways.

All the 4 antennas whip are attached to the bases of mag-mount antenna that are stationed at the car top on almost at the center. The result of the Radio Direction of the antenna switcher is connected to a transceiver or an FM receiver that is tuned to a powerful signal of weather broadcast of NOAA.

Caution: Once more, transmit mode must be disabled if a transceiver is being used.

Audio of the receiver is adjusted to a level that is comfortable for him in the external speaker. By closing the switch S2 antenna is spun and 12 V is applied to the RDF unit. A 500 Hz tone should be heard as soon as S2 is closed that is imposed on the receiver audio. The LED D4 which is having the low signal strength and the same LED D4 having the surcharge of audio are put out by rotating the AUDIO LEVEL ADJUST control R50. If D3 and/or D4 are lighted up, these indications should not be trusted. With any light up LED, or one or two adjoining LEDs instead light up the direction indicating display should be relatively constant. To make the direction indicating LED consistent CALIBRATE control R36 is adjusted with the NOAA transmission's general direction in respect to the position of the car and the location.

Figure 14 Base of Single Antenna.

While the display is observed set the driver to slowly circle. As the car is moving in a circular direction it should be noted that the direction indicating LED moves in the opposite direction. With the changing direction of the car the position is changed relatively; however, the car that is driving around should remain fixed as indicated by the direction from the center of the circle. If the exhibition turns in the alike direction as the car, the switch S3 of the FLIP PHASE INVERT in the facing location to precise offset 180° phase. The rough calibration procedure is completed.

FINAL CALIBRATION:

While the car is moving a more accurate calibration can be attained. A volunteer is positioned with an H-T in a secured point on the side of a straight, lengthy and unoccupied road about one-fourth to half a mile away. While they are being traveled towards them the power transmission should be (0.5 W). The RDF display should be calibrated by the RDF operator for indicating 0° as straight ahead. For indicating that the signal is approaching directly from the back of the car, the display should alter to 180° as the vehicle passes by the transmitter. Reflected signals that are caused due to multipath propagation are moved out by calibration procedure functions that averages them.

The change in the Doppler tone as the car is moves is noticeable. In the nonattendance of reflected or multipath interference the Doppler tone will be heard like a clean, un-interfered sine wave of 500 Hz. Under these conditions, direction indications are the most consistent. The Doppler tone will sound croaky and distorted if the reflected or multipath signal are existing. False bearing indications may be there that cause these signal components to exist from different directions. Under these conditions the Light Emitting Diode display have a tendency to jump around arbitrarily. When the Doppler tone sounds croaky then taking bearing information should be avoided. By slowing down the response time of the digital filter display tension can be minimized. By increasing damping control R19 this can be achieved. One can get expert in the art of Doppler RDFing in a little to no time.

RDFing ON OTHER BANDS:

The wide bandwidth of antenna switching can be consumed on the additional bands for DFing, if the proper antenna spacing and antenna whip lengths are used this can be achieved. The antennas are arranged in a square pattern. Antenna spacing is typically 0.22 λ on each side. The lengths of whips are provided for the use of radio direction finder on 146,223 and 446 MHZ as described in the Table 2. The measurement of the lengths of whip are taken from the surface at top of the base of mag-mount PC-board till the antenna tip.

The inductors L1-L8 are the other band limiting constituents that are correlated with the antenna switcher. It is suggested that the inductor for the antenna switcher that is having a self-resonant frequency of 440 MHz with 0.56$_{\mu H}$ is desirable. By this inductor, from 146 MHz to 446 MHz an impedance of more than 500 Ω is presented. Substitution of the part is allowable if the inductive reactance of an inductor is as minimum as 500 Ω along with a self-resonant frequency that is significantly greater than the high-rise frequency at which the antenna switcher can be used.

CHAPTER 7: CONCLUSION

Camouflaged direction finders were handy to be used as portable direction finders and in vehicles for determining the existence of spies as from 1931. In 1941, direction finder for short wave working on the Doppler principle was built.

In 1943, the speedy advancement in the evaluation of radar in Great Britain oblige it desirable to enfold higher frequency ranges therefore, for RADAR OBSERVATION at around 3000 MHz the 1st Direction Finder was implemented.

Several functional features that are progressed over these years are amalgamated into one compressed layout in this project. By using components that are available commonly the wide bandwidth antenna switcher can be built, minimizing the overall price of the project significantly. In building this project, one can get an opportunity to acquire the knowledge of analog, digital and RF circuit. Also working and participating in this can be very amusing and exciting.

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