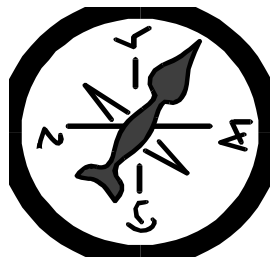


DOPPLER DIRECTION FINDER RADIO DIRECTION FINDER KIT

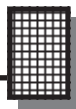


Ramsey Electronics Model No. DDF1

Get in on the fun of radio direction finding (RDF) with this super kit ! The latest in affordable Doppler direction finding equipment available in a complete kit form ..this one even includes the receiving antenna. A must for the "fox hunter" at an unheard of price!

- **Elegant and cost effective design thanks to WA2EBY ! Featured in May / June 1999 QST Articles.**
- **Solid state antenna switching for "rock solid" performance.**
- **Convenient LED 22.5 degree bearing indicator.**
- **Audio Level indicator for trouble free operation.**
- **Adjustable damping rate, phase inversion, scan enable / disable.**
- **Complete with home brew "mag mount" antennas and cable, designed for quick set up and operation.**
- **Utilizes latest high speed CMOS technology for signal conditioning and audio processing!**
- **Complete and informative instructions guide you to a kit that works the first time, every time - enhances resale value, too !**





PARTIAL LIST OF AVAILABLE KITS:

RAMSEY TRANSMITTER KITS

- FM10A, FM25B, FM30, FM Stereo Transmitters
- FM100B, FM35 Professional FM Stereo Transmitters
- AM1, AM25 AM Broadcast Band Transmitters

RAMSEY RECEIVER KITS

- FR1 FM Broadcast Receiver
- AR1 Aircraft Band Receiver
- SR2 Shortwave Receiver
- SC1 Shortwave Converter

RAMSEY HOBBY KITS

- LBC6K Laser Beam Communicator
- SG7 Personal Speed Radar
- SS70C Speech Scrambler/Descrambler
- TT1 Telephone Recorder
- LLS1 Laser Light Show
- MD3 Microwave Motion Detector
- LEDS1 LED Strobe Light
- BE66 Blinky Eyes Animated Display
- LTS1 Laser Trip Sensor
- ICI1C Infrared Switch Control Interface



RAMSEY AMATEUR RADIO KITS

- HR Series HF All Mode Receivers
- DDF1 Doppler Direction Finder Kit
- QRP Series HF CW Transmitters and QAMP Power Amplifiers
- CW7 CW Keyer

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DDF1 DOPPLER RADIO DIRECTION FINDER KIT INSTRUCTION MANUAL

Ramsey Electronics publication No. MDDF1 Revision 1.2c

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INSTRUCTION MANUAL FOR

DOPPLER RADIO DIRECTION FINDER

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RAMSEY ELECTRONICS, LLC
590 Fishers Station Drive
Victor, New York 14564
Phone (585) 924-4560
Fax (585) 924-4555
www.ramseykits.com

INTRODUCTION

Radio direction finding is a fascinating hobby that has been becoming more and more popular in today's portable world. More recently, Doppler "df-ing" has become the rage, with a display that gives you a direct bearing on the location of the transmitter. Pretty neat trick considering you don't need multiple separate receivers at different locations to triangulate on the mystery transmitter.

DDF1 THEORY OF OPERATION

The classic example of the Doppler effect is that of a car approaching a stationary observer. The car's horn sounds higher in pitch (frequency) to an observer as the car approaches. The change in frequency occurs because the motion of the car shortens the wavelength. The horn sounds lower in pitch (frequency) to the observer as the car speeds away. This occurs because the car is speeding away from the observer effectively increasing the wavelength. Fewer cycles per second, hence, lower-frequency sound. A similar effect occurs when an antenna is moved toward or away from a transmitting source. The signal received from an antenna moving toward the transmitting source appears to be at a higher frequency than that of the actual transmission. The signal received from an antenna moving away from the source of transmission appears to be lower in frequency than that of the actual transmission. Imagine a receiving antenna moving in a circular pattern as pictured in Figure 1A. Consider the antenna at position A, nearest the source of transmission. The frequency of the received signal at point A equals that of the transmitted signal because the antenna is not moving toward or away from the source of transmission. The frequency of the received signal decreases as the antenna moves from point A to point B and from point B to point C. Maximum frequency deviation occurs as the antenna passes through point B. The frequency of the received signal at point C is the same as that of the transmitted signal (no shift) because the antenna is not moving toward or away from the source of transmission. As the antenna moves from point C to point D and from point D back to point A, the frequency of the received signal increases. Maximum frequency deviation occurs again as the antenna passes through point D. The Doppler frequency shift as a function of antenna rotation is illustrated in Figure 1B.

$$dF = (\omega r f_c) / c$$

where:

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

ω = Angular velocity of rotation in radians per second ($2\pi \times$ frequency of rotation)

r = Radius of antenna rotation (meters)

f_c = Frequency of transmitted signal (Hertz)

c = Speed of light

We can calculate how fast the antenna must rotate in order to produce a given Doppler frequency shift with the following equation

$$f_r = dF \times 1879.8 / R \times f_c$$

where

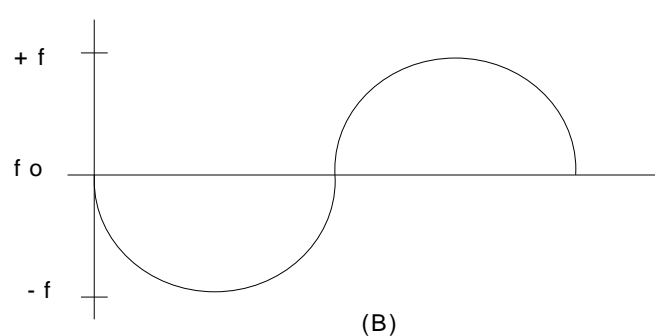
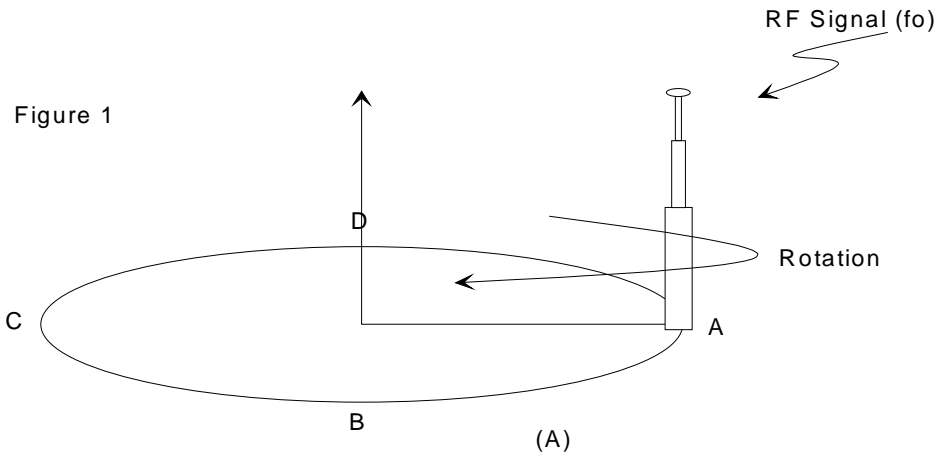
f_r = The frequency of the received signal in megahertz

dF = The Doppler shift in Hertz

R = Radius of antenna rotation in inches

f_c = Carrier frequency of the received signal in megahertz

As an example, let's calculate how fast the antenna must rotate in order to produce a Doppler shift of 500 Hz at 146 MHz, assuming the antenna is turning in a circle with radius 13.39 inches.



The frequency of rotation is:

$$fr = 500 \times 1879.8/146 \times 13.39$$

A rotation frequency of 480 Hz translates to $480 \times 60 = 28,800$ or almost 30,000 r/min, which pretty much rules out any ideas of mechanically rotating the antenna! Fortunately, Terrence Rogers, WA4BVY, proposed a clever method of electrically spinning the antenna that works very well. Roger's project, the DoppleScAnt, uses eight $1/4\text{-}\lambda$ vertical whips arranged in a circular pattern. Only one antenna at a time is electrically selected. By controlling the order in which the antennas are selected, the DoppleScAnt emulates a single $1/4\text{-}\lambda$ whip antenna moving in a circle. A clever feature in Roger's design is the use of a digital audio filter to extract the Doppler tone from voice, PL tones and noise.

The DDF1 design offers slightly improved audio filtering, 74HC-series logic circuits capable of driving the LED display directly, a wideband VHF/UHF antenna switcher and the four $1/4\text{-}\lambda$ mag-mount antennas. Total project cost is about one third the cost of purchasing a commercial RDF unit - and building the project is a lot more educational.

HOW IT WORKS

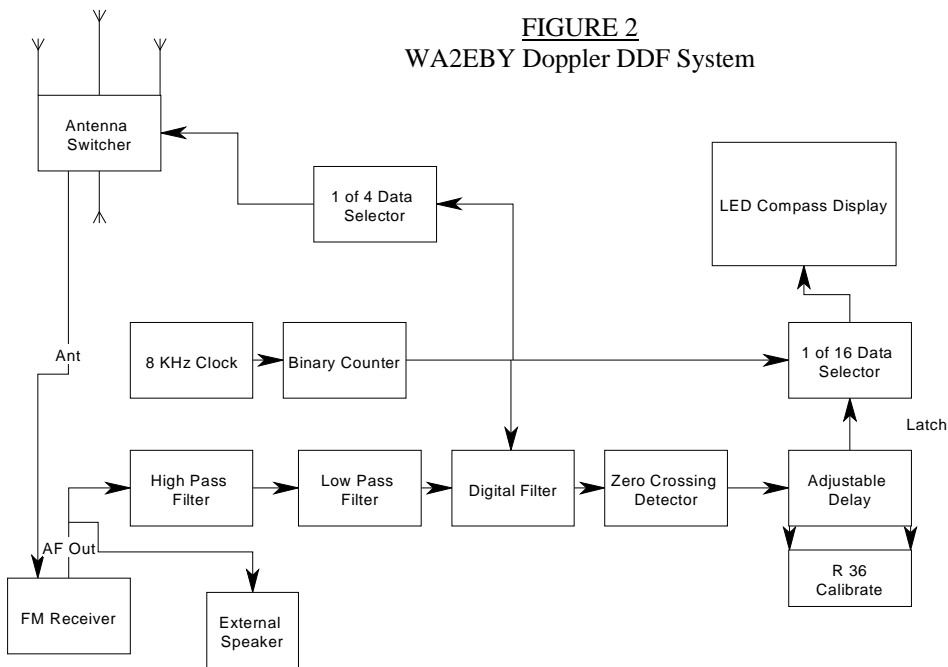
To understand the operation of the Doppler RDF circuit, see the block diagram of Figure 2. An 8 kHz clock oscillator drives a binary counter. The output of the counter performs three synchronized functions: "spin" the antenna, drive the LED display and run the digital filter. The counter output drives a 1 of 4 multiplexer that spins the antennas by sequentially selecting (turning on) one at a time in the order A,B,C,D,A, etc., at 500 times per second. The counter output also drives a 1 of 6 multiplexer used to drive the LED display in sync with the spinning antenna. The RF signal received from the spinning antenna is connected to the antenna input of a VHF or UHF FM receiver.

The spinning antenna imposes a 500 Hz frequency deviation on a 146 MHz received signal. A 146 MHz FM receiver connected to the spinning antenna's RF output demodulates the 500 Hz frequency deviation and sounds like a 500 Hz tone with loudness set by the 500 Hz frequency deviation. The receiver audio, including 500 Hz Doppler tone, is processed by a series of audio filters. A high pass filter rejects PL tones and audio frequencies below the 500 Hz Doppler tone. A low-pass filter rejects all audio frequencies above the 500 Hz Doppler tone, and a very narrow bandwidth digital filter extracts only 500 HZ Doppler tone.

The output of the digital filter represents the actual Doppler frequency shift shown in figure 1. - Zero crossings of the Doppler frequency shift pattern correspond to the antenna position located directly toward the source of transmission (position A) or directly opposite the source of transmission (position C). The zero-crossing signal passes through an adjustable delay before it

latches the direction indicating LED. The adjustable delay is used to calibrate the LED direction indicator with the actual direction of the transmission.

FIGURE 2
WA2EBY Doppler DDF System



CIRCUIT DESCRIPTION

Take a look at the schematic of the WA2EBY Doppler RDF on page 18. The heart of the system is an 8 kHz clock oscillator built around a 555 timer, U4, configured as an astable multivibrator. C26, R27, and R28, R29 determine the multivibrator's oscillation frequency. R27 and R28 are series connected to allow fine tuning the oscillation frequency to 8 kHz. It is important that the clock frequency be exactly 8 kHz; I recommend that it be adjusted to +/-250 Hz of that frequency for reasons that I'll discuss shortly. The 8 kHz output of U4 provides the clock for 4 bit binary counter U7. The 3 bit binary coded decimal (BCD) output of U7 is used to operate three synchronized functions.

Three Synchronized Functions

The first function derived from binary counter U7 is antenna array spinning. This is accomplished by using the two most significant bits of U7 to run 1 of 4 multiplexer U8. The selected output of U8 (active low) is inverted by buffer U12. The buffered output of U12 (active high) supplies current sufficient to turn on the antenna to which it is connected. (The details of how this is done will be covered later.) Buffer outputs U12A, U12B, U12C and U12D are sequenced in order. The corresponding buffer selects antennas A,B,C,D,A,B, etc. Driving multiplexer U8 with the two most significant bits of counter U7 divides the 8 kHz clock by four, so each antenna is turned on for 0.5 ms. One complete spin of the antenna requires $0.5 \text{ ms} \times 4 = 2.0 \text{ ms}$, thus the frequency of rotation is 2 ms or 500 Hz. An FM receiver connected to the spinning antenna's RF output has a 500 Hz tone imposed on the received signal.

Sequencing the 16 LED display is the second synchronized function from binary counter U7. This is done by using the binary output of counter U7 to select 1 of 16 data outputs of U11. The selected output of U11 goes low, allowing current to flow from the +5 V supply through current limiting resistor R51, green center LED D16, and direction indicating red LED's D17 through D32. Each antenna remains turned on as the LED display sequences through four direction indicating LED's, then switches to the next antenna. Each direction indicating LED represents a heading change of 22.5 degrees.

The third synchronized function is operating the digital filter responsible for extracting the Doppler tone. The 500 Hz Doppler tone present on the receiver audio output is connected to an external speaker and audio level adjust potentiometer R50. The signal is filtered by a two-pole Sallen Key high pass filter built around op amp U1A. It filters out PL tones and audio frequencies below the 500 Hz Doppler tone. Next, a four-pole Sallen-Key low band pass filter using U1B and U1C limits audio frequencies above the 500 Hz Doppler tone. This signal is then applied to the input of a digital filter consisting of analog multiplexer U5, R18, R19 and C10 through C17. (Readers interested in the detailed operation and analysis of this fascinating digital filter are encouraged to review QEX magazine for June 1999)

The Digital Filter

Using the three most significant bits of U7 to drive the digital filter divides the 8 kHz clock by the two, making the digital filter code rate 4 kHz. The center frequency of the digital filter is determined solely by the clock frequency divided by the order of the filter. This is an 8th order filter, which makes the center frequency of the filter $4 \text{ kHz} / 8 = 500 \text{ Hz}$. This is the exact frequency at which the antenna spins, hence, the same frequency of the Doppler tone produced on the receiver audio connected to the spinning antenna. This is truly an elegant feature of the Doppler RDF design. Using the same clock oscillator to spin the antenna and clock the digital filter ensures the Doppler tone produced by the spinning process is precisely the center frequency of

the digital filter. Even if the clock oscillator frequency drifts, the Doppler tone drifts accordingly, but the center frequency of the digital filter follows it precisely because the same clock runs it. Excessive drift in the 8 kHz clock should be avoided, however, because the analog high and low pass filters that precede the digital filter have fixed passband centers of 500 Hz. A drift of +250 Hz on the 8 kHz clock corresponds to +62.5 Hz (250/4) drift in the Doppler tone produced. This value is acceptable because of the relatively low Q of the analog bandpass filter.

Digital filter Q is calculated by dividing the filter's center frequency by its bandwidth ($Q=f/BW$) or $500\text{ Hz}/4\text{ Hz}=125$. It's very difficult to realize such a high Q filter with active or passive analog filters and even more difficult to maintain a precise center frequency. The slightest change in temperature or component tolerance would easily de-Q or detune such filters from the desired 500 Hz Doppler tone frequency. The digital filter makes the high Q possible and does so without the need for precision tolerance components. By varying damping pot R19, the response time of the digital filter is changed. This digital filter damping helps average rapid Doppler tone changes caused by multipath reflected signals, noise or high audio peaks associated with speech. A digitized representation of the Doppler tone is provided at the digital filter output. A two pole Sallen Key low pass filter built around U2B filters out the digital steps in the waveform providing a near sinusoidal output corresponding to the Doppler shift illustrated in Figure 1B

The zero crossings of this signal are detected by U2C and indicate exactly when the Doppler effect is zero. The output of U2C is used to trigger U6, a 555 timer configured as a monostable multivibrator. When U6 is triggered it's output, pin 3, goes high for the time determined by the setting of the "CALIBRATE" control, R36. When U6's output returns to a low U11's output is latched and the LED in the display corresponding to the direction of transmission is illuminated. Calibration of the actual direction of transmission and the direction indicating display is accomplished by changing the delay between the Doppler tone zero crossing and the time U11 is latched. C23, R36 and R37 determine this delay by adjusting the time u6's output is high after it is triggered by U2C.

Low Signal Level and Audio Overload Indicators

Two useful modifications included in this design are the low signal level lock-out and audio overload indicators. U2D continuously monitors the amplitude of the Doppler tone at the input to the zero crossing detector. U2D's output goes low whenever the Doppler tone amplitude drops below 0.11 V peak. This is done by referencing the negative input of U2D to 2.39 V, 0.11 V below the nominal 2.5 VDC reference level output of U2B by means of voltage divider, R21 and R22. U2D's output remains high when the Doppler tone is present and above 0.11 V peak. C9 discharges via D2 whenever U2D goes low, causing U3's output (pin 7) to go high, turning on Q2 via R24 and illuminating low signal level LED, D4. D4 remains on until the Doppler tone returns

with amplitude above 0.11 V peak and C9 recharges via R23. The LED display remains locked by disabling U11's strobe input whenever the Doppler tone is too low for an accurate bearing. This is done by pulling pin 1 of U11 low via D5 when Q2 is turned on.

Audio overload indicator D3 tells you that audio clipping of the Doppler tone is occurring. Clipping results if the signal level from the digital filter is too high and can produce an erroneous bearing indication. The output of U1D goes low whenever the output of the digital filter drops below 0.6 V as the amplitude of the Doppler tone approaches the 0V supply rail. C7 discharges via D1 and causes the output of U3C to go high, turning on Q1 via R16 and illuminating audio overload LED D3. We elected not to lock the LED display on audio overload; doing so, however, only requires connecting a diode between the collector of Q1 and pin 1 of U11, similar to the low level lock out function.

Phase Correction

If the audio output of the Doppler RDF FM receiver is incorrectly phased, S3, phase invert, can fix that. (If phasing is incorrect, LED direction indications are 180 degrees opposite that of the actual signal source.) Moving S3 to the opposite position corrects the problem by letting U2C sense the trailing edge. This is particularly useful when switching between different receivers. S2 disables the 8 kHz clock to disable the antenna spinning. This helps when you're trying to listen to the received signal. Presence of the Doppler tone in the received audio makes it difficult to understand what is being said, especially with weak signals.

Power Supply

Power is delivered via on/off switch S1. D6 provides supply voltage reverse polarity protection by limiting the reverse voltage to 0.7 V. U10 provides a regulated 5 VDC to all digital ICs. C29 through C33 are bypass filters. U10's 5 VDC output is dropped 2.5 V by resistive divider R43 and R45. Non-inverting voltage follower U3B buffers the 2.5 V source to provide a virtual ground reference for all analog filters and the digital filter. Using a virtual ground 2.5 V above circuit ground allows op amps to process analog signals without the need of a negative power supply voltage. Analog voltages swing from near 0 V to near +5 V with the virtual ground level right in the middle, 2.5 V.

DDF1 PARTS LIST

Sort and “check off” the components in the boxes provided. It’s also helpful to sort the parts into separate containers (egg cartons do nicely) to avoid confusion while assembling the kit. Leave the IC’s on their foam holder until ready for installation.

RESISTORS AND POTENTIOMETERS

- ☐ 2 47 ohm (yellow-violet-black) [R42,51]
- ☐ 2 330 ohm (orange-orange-brown) [R17,25]
- ☐ 4 470 ohm (yellow-violet-brown) [R46,47,48,49]
- ☐ 1 3.3K ohm (orange-orange-red) [R14]
- ☐ 7 10K ohm (brown-black-orange) [R13,16,22,24,27,37,39]
- ☐ 1 18K ohm (brown-gray-orange) [R28]
- ☐ 2 22K ohm (red-red-orange) [R8,32]
- ☐ 1 27K ohm (red-violet-orange) [R4]
- ☐ 19 33K ohm (orange-orange-orange)
[R1,2,3,5,6,7,9,10,11,12,20,26,30,31,34,35,38,43,45]
- ☐ 2 68K ohm (blue-gray-orange) [R29,33]
- ☐ 1 100K ohm (brown-black-yellow) [R18]
- ☐ 3 220K ohm (red-red-yellow) [R15,21,23]
- ☐ 1 PC mount 10K linear potentiometer (103) [R50]
- ☐ 2 PC mount 500K linear potentiometer (504) [R19,36]

CAPACITORS AND INDUCTORS

- ☐ 11 .001 uF disc capacitors (labeled .001 or 102) [DDF1 board
C22,24,26][ANTINT-1 board C1,2,3,4,5,6,7,8]
- ☐ 1 .0047 uF disc capacitor (labeled .0047 or 472) [C23]
- ☐ 10 .01uF disc capacitors (labeled .01 or 103 or 10nF)
[C1,2,3,4,5,6,9,18,19,38]
- ☐ 15 .1uF disc capacitors (labeled .1 or 104)
[C7,10,11,12,13,14,15,16,17,21,31,51,52,53,54]
- ☐ 1 .47 uF electrolytic capacitor (labeled .47) [C20]
- ☐ 3 1 uF electrolytic capacitor (labeled 1uF) [C8,25,32]
- ☐ 1 10 uF electrolytic capacitor (labeled 10uF) [C33]
- ☐ 2 100 uF electrolytic capacitors (labeled 100uF) [C29,30]
- ☐ 8 1.2 uH inductor (brown-red-gold) (ANTINT-1 board [L1,2,3,4],
ANTMTG-1 board, 1 ea.)

SEMICONDUCTORS AND INTEGRATED CIRCUITS

- ☐ 11 1N4148 small signal diode (small glass case with banded end)
[DDF1 board D1,2,5 ANTINT-1 board D1,2,3,4 ANTMGTG-1 board 1 ea.]
- ☐ 1 IN4000 type power diode (black epoxy package with cathode band)
[typically 4001 to 4007] [D6]
- ☐ 18 Mini red LED (light emitting diode)
[D3,4,17,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32]
- ☐ 1 Mini green LED (light emitting diode) [D16]
- ☐ 2 NPN Transistors (Three leads marked 2N3904) [Q1,2]
- ☐ 1 7805 Voltage Regulator IC (marked 7805) [VR1]
- ☐ 1 74HC14 IC (14 pin DIP IC) [U12]
- ☐ 1 74HC42 IC (16 pin DIP) [U8]
- ☐ 1 74HC161 IC (16 pin DIP IC) [U7]
- ☐ 1 74HC4051 IC (16 pin DIP IC) [U5]
- ☐ 1 74HC4515 IC (24 pin DIP IC) [U11]
- ☐ 3 324 Op Amp IC (14 pin DIP marked 324) [U1,2,3]
- ☐ 2 555 Timer IC (8 pin DIP IC marked 555) [U4,6]

MISCELLANEOUS COMPONENTS

- ☐ 3 PC mount slide switch [S1,2,3]
- ☐ 1 PC mount 2.1mm jack [J3] (speaker audio input)
- ☐ 1 2.1mm plug (for speaker audio input)
- ☐ 1 2.1 mm PC mount power jack [J1]
- ☐ 1 2 pin header (silver pins set in plastic) [J4]
- ☐ 1 DB 9 PC mount connector [J2]
- ☐ 1 DB 9 male connector
- ☐ 1 Miniature 8 ohm speaker
- ☐ 5' RG-174 mini coaxial cable
- ☐ 1 "Clamshell" abs plastic case with pre-punched panel set
- ☐ 1 Panel sticker set
- ☐ 8 #4-40 x 1/4" pc board mounting screws
- ☐ 6 #4 x 3/8" self tapping screws (case assembly)
- ☐ 4 #4 Internal tooth washers
- ☐ 2 6-32 x 3/8" PPH black screws
- ☐ 2 6-32 1/4" hex nuts
- ☐ 4 M3 x 10mm FHP screws
- ☐ 4 M3 kepnuts (nuts with lock washer attached)
- ☐ 4 Telescoping whip antennas
- ☐ 5 Round plastic caps
- ☐ 5 Flexible self adhesive magnetic strips

- ☐ 1 Main PC board (DDF-1)
- ☐ 1 Antenna switch board (ANTINT-1)
- ☐ 4 Antenna boards (ANTMTG-1)

REQUIRED ITEMS (But Not Supplied)

- ☐ 1 Length of RG58 cable for connecting between your radio and the DDF1. (Not supplied due to unknown length required!)
- ☐ 1 Length of 5(or more) conductor control cable such as CAT5 LAN cable (Not supplied due to unknown length required!)
- ☐ Hot glue or silicone RTV sealer/adhesive

RAMSEY Learn-As-You-Build KIT ASSEMBLY

There are numerous solder connections on the DDF1 printed circuit board. Therefore, PLEASE take us seriously when we say that good soldering is essential to the proper operation of your direction finder!

- Use a 25-watt soldering pencil with a clean, sharp tip.
- Use only rosin-core solder intended for electronics use.
- Use bright lighting, a magnifying lamp or bench-style magnifier may be helpful.
- Do your work in stages, taking breaks to check your work. Carefully brush away wire cuttings so they don't lodge between solder connections.

We have a two-fold "strategy" for the order of the following kit assembly steps. First, we install parts in physical relationship to each other, so there's minimal chance of inserting wires into wrong holes. Second, whenever possible, we install in an order that fits our "Learn-As-You Build" Kit building philosophy. This entails describing the circuit that you are building, instead of just blindly installing components. We hope that this will not only make assembly of our kits easier, but help you to understand the circuit you're constructing.

For each part, our word "install" always means these steps:

1. Pick the correct part value to start with.
2. Insert it into the correct PC board location.
3. Orient it correctly, follow the PC board drawing and the written directions for all parts - especially when there's a right way and a wrong way to solder it in. (Diode bands, electrolytic capacitor polarity, transistor shapes, dotted or notched ends of IC's, and so forth.)
4. Unless otherwise instructed, ALL components should be placed snugly against the board.
5. Solder all connections unless directed otherwise. Use enough heat and solder flow for clean, shiny, completed connections.
6. Trim or "nip" the excess component lead wire after soldering. Save some of the trimmed leads for later use.

DDF1 DOPPLER DIRECTION FINDER ASSEMBLY STEPS

IMPORTANT!!

Although we know that you are anxious to complete the assembly of your direction finder kit, it will become necessary to assemble in a specific order to accomplish the final components installation of your unit. Try to avoid the urge to “jump ahead” installing components. We’ll be installing components in blocks of the same type and/or value. Usually the component locations will start in the upper left of the board and proceed in a left to right, top to bottom order. Please also note that components will be mounted on BOTH SIDES OF THE PRINTED CIRCUIT BOARD so be sure to read ALL instructions and follow them in order.

FRONT PANEL STICKER INSTALLATION

We need to place the front panel sticker on the case first so it will be dry by the time you have finished the component assembly.

- ☐ 1. Locate the front sticker and top half of the case. This is the largest one with the most holes in it.
- ☐ 2. Lightly spray the cover surface with some window cleaner like Windex™. Now remove the protective paper backing from the sticker and apply it on the case. Since you used the window cleaner you can easily move the sticker around to align it with the holes in the case.
- ☐ 3. Gently smooth out the sticker with a soft cloth to remove any air bubbles and set it aside to dry.

COMPONENT ASSEMBLY.

The following components will be installed on top of the board which is the side with the most printing on it. Orient the board so “RAMSEY ELECTRONICS” and “DDF-1 REV1.2 KJW” is toward you.

Here we go!!!....First we’ll install the resistors. They may be installed in either direction and you should keep them tight to the board.

- ◆ Locate seven(7) 10K ohm [brown-black-orange]
 - ☐ 1. Install R24, 10K ohm.
 - ☐ 2. Install R16, 10K ohm (brown-black-orange). There is a plated through hole inside the silkscreen for R16 that is not the installation hole. Be sure to install the resistor lead in the proper hole.
 - ☐ 3. Install R13, 10K ohm.
 - ☐ 4. Install R22, 10K ohm.
 - ☐ 5. Install R39, 10K ohm.

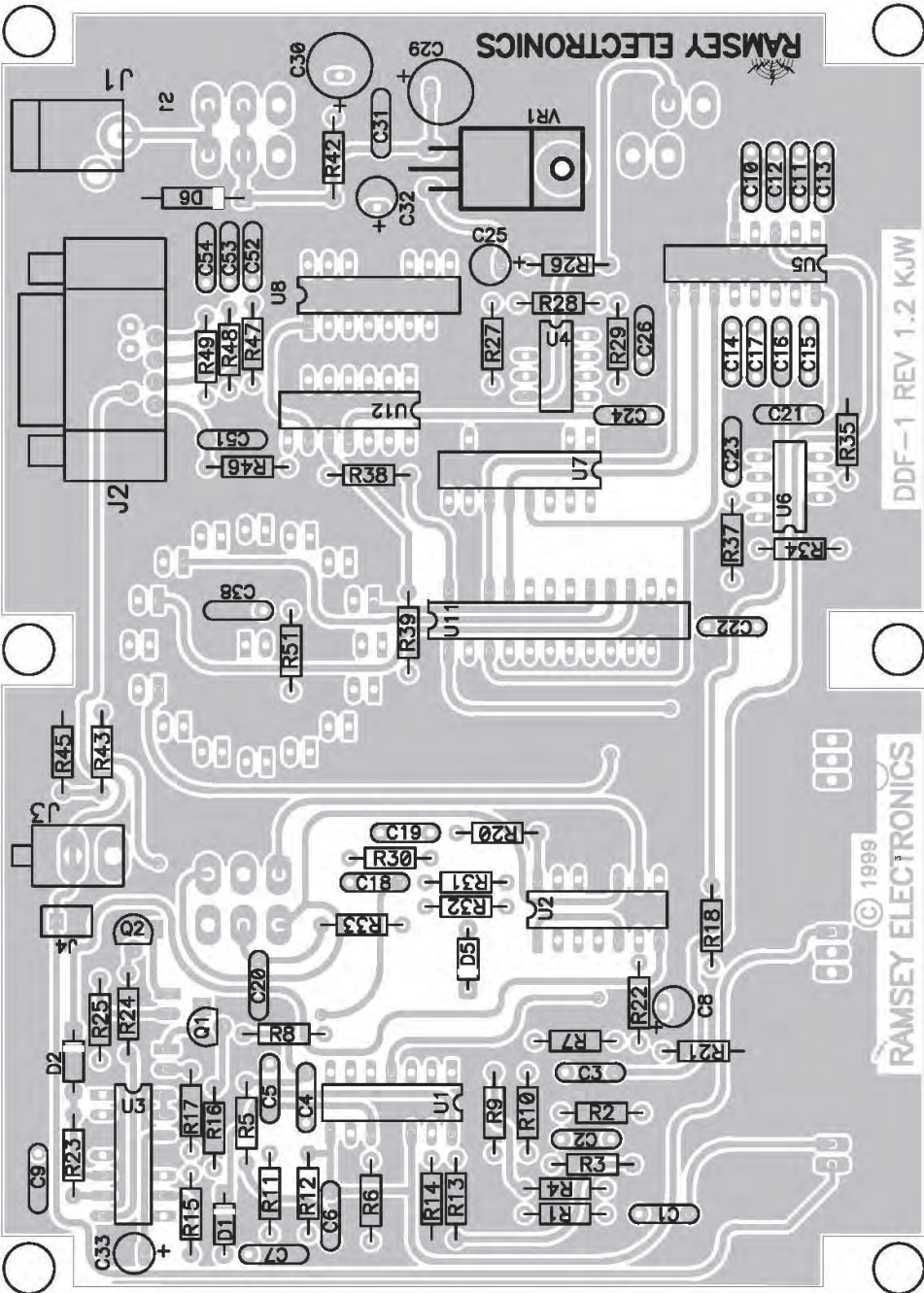
- ☐ 6. Install R37, 10K ohm.
- ☐ 7. Install R27, 10K ohm.
- ◆ Locate nineteen(19) 33K resistors [orange-orange-orange]
 - ☐ 8. Install R5, 33K ohm.
 - ☐ 9. Install R11, 33K ohm.
 - ☐ 10. Install R12, 33K ohm.
 - ☐ 11. Install R6, 33K ohm.
 - ☐ 12. Install R9, 33K ohm.
 - ☐ 13. Install R10, 33K ohm.
 - ☐ 14. Install R1, 33K ohm.
 - ☐ 15. Install R3, 33K ohm.
 - ☐ 16. Install R2, 33K ohm.
 - ☐ 17. Install R7, 33K ohm.
 - ☐ 18. Install R31 33K ohm.
 - ☐ 19. Install R30, 33K ohm.
 - ☐ 20. Install R20, 33K ohm.
 - ☐ 21. Install R45, 33K ohm.
 - ☐ 22. Install R43, 33K ohm.
 - ☐ 23. Install R38, 33K ohm.
 - ☐ 24 Install R34, 33K ohm.
 - ☐ 25. Install R35, 33K ohm.
 - ☐ 26. Install R26, 33K ohm.
- ◆ Locate four(4) 470 ohm resistors [yellow-violet-brown]
 - ☐ 27. Install R46, 470 ohm.
 - ☐ 28 Install R49, 470 ohm.
 - ☐ 29. Install R48, 470 ohm.
 - ☐ 30. Install R47, 470 ohm.
- ◆ Locate three(3) 220K ohm resistors [red-red-yellow]
 - ☐ 31. Install R23, 220K ohm.
 - ☐ 32. Install R15, 220K ohm.
 - ☐ 33. Install R21, 220K ohm.

- ◆ Locate two(2) 47 ohm resistors [yellow-violet-black]
 - ❑ 34. Install R51, 47 ohm.
 - ❑ 35. Install R42, 47 ohm.
- ◆ Locate two(2) 330 ohm resistors [orange-orange-brown]
 - ❑ 36. Install R25, 330 ohm.
 - ❑ 37. Install R17, 330 ohm.
- ◆ Locate two(2) 22K ohm resistors [red-red-orange]
 - ❑ 38. Install R8, 22K ohm.
 - ❑ 39. Install R32, 22K ohm.
- ◆ Locate two(2) 68K ohm resistors [blue-gray-orange]
 - ❑ 40. Install R33, 68K ohm.
 - ❑ 41. Install R29, 68K ohm.
- ◆ Locate One(1) 3.3K resistor [orange-orange-red]
 - ❑ 42. Install R14, 3.3K ohm.
- ◆ Locate one(1) 18K ohm resistor [brown-gray-orange]
 - ❑ 43. Install R28, 18K ohm.
- ◆ Locate one(1) 27K ohm resistor [red-violet-orange]
 - ❑ 44. Install R4, 27K ohm.
- ◆ Locate one(1) 100K ohm resistor [brown black-yellow]
 - ❑ 45. Install R18, 100K ohm.

Next we'll install the IC's and diodes. Be careful and install each IC in the correct orientation as indicated by the pattern on the board.

- ◆ Locate the three(3) LM324 Op-amp IC's, labeled LM324.
 - ❑ 46. Install U3, LM324 op amp.
 - ❑ 47. Install U1, LM324 op amp
 - ❑ 48. Install U2, LM324 op amp.
- ◆ Locate the 74HC4515 IC
 - ❑ 49. Install U11, 74HC4515 IC.
- ◆ Locate the 74HC161 IC
 - ❑ 50. Install U7, 74HC161 IC.
- ◆ Locate the 74HC14 IC
 - ❑ 51. Install U12, the 74HC14 inverter IC.

DDF-1 MAIN BOARD PARTS LAYOUT DIAGRAM



- ◆ Locate the two(2) 555 timer IC's
 - ❑ 52. Install U6, 555 timer IC.
 - ❑ 53. Install U4, 555 timer IC.
- ◆ Locate the 74HC4051 IC
 - ❑ 54. Install U5, 74HC4051 IC.
- ◆ Locate the 74HC42 IC
 - ❑ 55. Install U8, 74HC42 IC.
- ◆ Locate the 7805 three lead voltage regulator
 - ❑ 56. Install VR1, 7805 voltage regulator IC. Install as shown in the diagram by carefully pre-bending the component leads at right angles to the IC. The component should fit flush to the printed circuit board. Solder all three leads.

Note that the following diodes have a band on one end of the case. It is important that the band be positioned so it matches the band of the pattern on the board.

- ◆ Locate the 1N4002 diode, (black epoxy case with a white polarity "band")
 - ❑ 57. Install D6, 1N4002 diode.
- ◆ Locate the three(3) 1N4148 diodes, (small glass component marked with a polarity band)
 - ❑ 58. Install D2, 1N4148 diode .
 - ❑ 59. Install D1, 1N4148 diode.
 - ❑ 60. Install D5, 1N4148 diode.

Next come some capacitors This bunch will be ceramic disc type capacitors and they may be installed in any direction. Just remember to keep them close to the board so they look like a pro assembled your DDF1.

- ◆ Locate three(3) .001uF capacitors [marked 102]
 - ❑ 61. Install C22, .001uF disc capacitor.
 - ❑ 62. Install C24, .001uF disc capacitor.
 - ❑ 63. Install C26, .001uF disc capacitor.
- ◆ Locate ten(10) .01uF capacitors [marked 103]
 - ❑ 64. Install C9, .01uF capacitor.
 - ❑ 65. Install C5, .01uF capacitor.
 - ❑ 66. Install C4, .01uF capacitor.
 - ❑ 67. Install C6, .01uF capacitor.

- ☐ 68. Install C2, .01uF capacitor.
- ☐ 69. Install C3, .01uF capacitor.
- ☐ 70. Install C1, .01uF capacitor.
- ☐ 71. Install C18, .01uF capacitor.
- ☐ 72. Install C19, .01uF capacitor.
- ☐ 73. Install C38, .01uF capacitor.
- ◆ Locate fifteen(15) .1uF capacitors [marked 104]
 - ☐ 74. Install C7, .1uF capacitor.
 - ☐ 75. Install C51, .1uF capacitor.
 - ☐ 76. Install C54, .1uF capacitor.
 - ☐ 77. Install C53, .1uF capacitor.
 - ☐ 78. Install C52, .1uF capacitor.
 - ☐ 79. Install C21, .1uF capacitor.
 - ☐ 80. Install C14, .1uF capacitor.
 - ☐ 81. Install C17, .1uF capacitor.
 - ☐ 82. Install C16, .1uF capacitor.
 - ☐ 83. Install C15, .1uF capacitor.
 - ☐ 84. Install C10, .1uF capacitor.
 - ☐ 85. Install C12, .1uF capacitor.
 - ☐ 86. Install C11, .1uF capacitor.
 - ☐ 87. Install C13, .1uF capacitor.
 - ☐ 88. Install C31, .1uF capacitor.
- ◆ Locate one(1) .0047uF capacitors [marked .0047 or 472]
 - ☐ 89. Install C23, .0047uF capacitor.

This batch of capacitors are called electrolytic capacitors. They are polarized with a (+) and (-) lead and must be installed in the correct orientation. Ordinarily, only the negative side is marked on the capacitor body with a dark band and the (-) sign clearly shown, while the PC board has a "+" printed next to the pattern indicating the "+" lead. **Be careful and install the capacitors with the negative lead in the opposite hole from where the "+" is indicated on the board.** Failure to do so may result in the capacitor actually *EXPLODING* and causing possible damage to you and/or the board.

In addition to the capacitance and polarity markings you will also find a voltage indication. Any value greater than 16 volts is good for our application. The capacitors should fit snugly down on the PC board.

- ◆ Locate two(2) 100uF capacitors [100uF]
 - ❑ 90. Install C30, 100uF electrolytic capacitor.
 - ❑ 91. Install C29, 100uF. electrolytic capacitor.
- ◆ Locate three(3) 1uF capacitors [1uF]
 - ❑ 92. Install C8, 1uF electrolytic capacitor.
 - ❑ 93. Install C25, 1uF electrolytic capacitor.
 - ❑ 94. Install C32, 1uF electrolytic capacitor.
- ◆ Locate one(1) 10uF capacitor [1uF]
 - ❑ 95. Install C33, 10uF electrolytic capacitor.
- ◆ Locate one(1) .47uF capacitors [.47uF]

Notice the pattern on the board for this capacitor, C20, is incorrect. Be careful and install the “-” or banded lead so it is toward R8 and the edge of the board and the unmarked or “+” lead is toward the center of the board.

- ❑ 96. Install C20, .47 uF electrolytic capacitor.
- ◆ Locate two(2) 2N3904 transistors [2N3904 or 3904]
 - ❑ 97. Install Q2, 2N3904 transistor. The flat side must be placed as shown on the PC board, facing R24. Mount it as close to the board as possible without forcing it. Carefully solder all three leads.
 - ❑ 98. Install Q1, 2N3904 transistor. Be sure to orient the flat side as shown in the parts diagram and keep it close to the board as you did with Q2.
- ◆ Locate one(1) two pin speaker connector. This is a small connector which looks like two wire leads inserted through a piece of plastic. [Actually that’s exactly what it is :-)]
- ❑ 99. Install speaker connector J4.

That’s all the components that are installed on this side of the main circuit board. Take a few minutes to double check your work. Make sure all values are correct and take special notice of the placement of the diodes, IC’s and electrolytic capacitor orientation. It’s also a good idea to check your soldering and make sure you didn’t slobber any solder, (say that three times fast), across any connections. Remember that time spent here can save a lot of time (and expense and frustration!) when the unit is initially turned on.

CONTROL AND DIRECTION INDICATOR ASSEMBLY

In these assembly steps for the DDF1 main board, the components will be mounted to the **SOLDER SIDE** of the circuit board. That's the other side of the board from the previous steps and with the least amount of printing on it.

Make sure the cover with the sticker you applied is dry and the sticker is firmly attached before starting this part of the assembly.

- ❑ 100. Find the 3 DPDT slide switches. Looking at the bottom of the circuit board locate the positions of S1, S2, and S3 switches. Insert a switch into each location. It doesn't matter how the switches are oriented, just make sure each switch is flush to the circuit board. Check the placement of each switch by "test fitting" the circuit board into the upper half of the case assembly and ensure it operates smoothly. Make any adjustments required so they operate smoothly and then solder them on the other side of the board, (not to be confused with the other side of the tracks).
- ❑ 101. Locate the 10K potentiometer, labeled 10K or 103, on the side of the pot. Install this potentiometer in the R50 position. Once again make sure that this control is mounted flush to the circuit board and solder into place.
- ❑ 102. Locate the two(2) 500K, labeled 500K or 505, potentiometers and install them in the same way in the locations for R19 and R36 in the same manner as above.

Locate the 18 red and one green LED's. Look closely at one of these LED's and notice one lead is shorter than the other. This lead is the cathode or negative lead of the LED. Also notice that the plastic case has a flat area on the same side as this lead. The longer of the two leads is the anode, or (+) connection.

When installing these LED's the SHORT LEAD/FLAT AREA must be inserted in the rectangular pad and the flat area must match the printed symbol on the board.

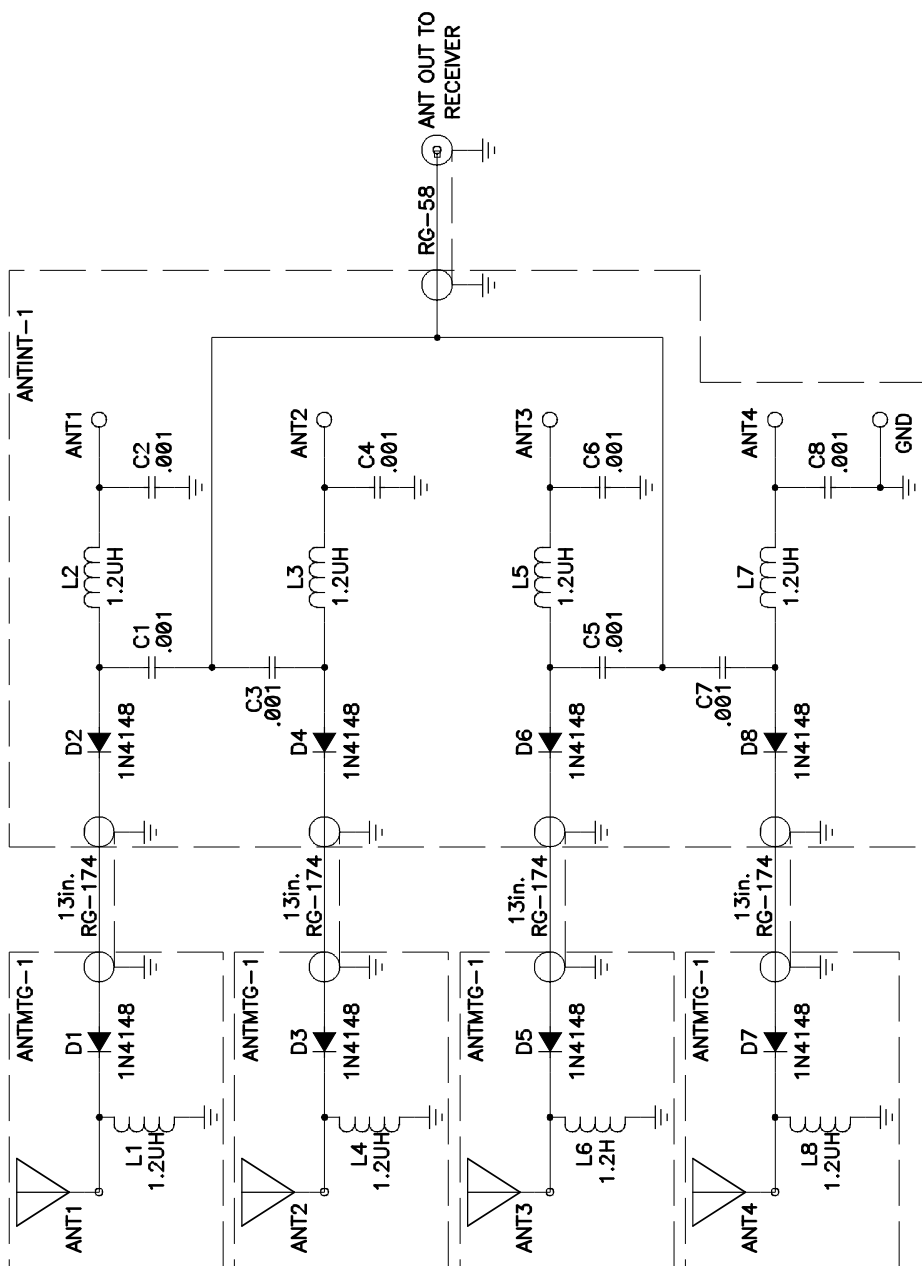
These are the direction heading and level indication LED's and they should be installed so they extend through top panel of the unit the same distance. These LED's are also inserted from the back side of the board matching the printed symbols. The following steps will assure the correct installation and height.

- ❑ 103. Insert, **BUT DO NOT SOLDER**, the 18 RED LED's into the locations D3, 4, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32.
- ❑ 104. Insert, **BUT DO NOT SOLDER**, the GREEN LED into location D16.

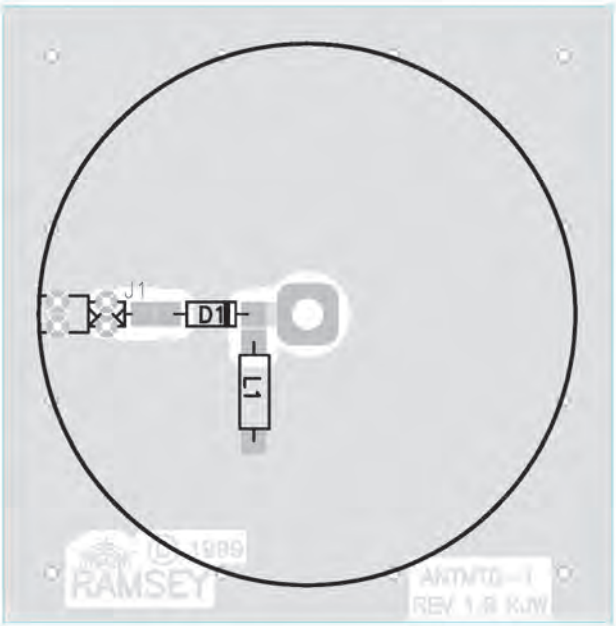
- ❑ 105. Temporarily fit the circuit board into the case top, and carefully tip the board and case over and allow the LED's to fall into their respective holes in the case.
- ❑ 106. With the 19 LED's correctly oriented and set to the correct height, solder into place while the circuit is in the case top. Be careful and don't touch the hot soldering iron to the case top. Doing so not only makes boo-boos in the case but is also smelly.
- ❑ 107. Install J1, the 2.1mm DC input connector. Notice that this mounts on the "component side of the circuit board and the solder leads push through the circuit board to protrude through the solder "pads" for connection. Be sure to push it firmly onto the circuit board as the alignment of this part is important in getting the case holes to line up with the part. Solder all three leads; don't be afraid to use enough heat to flow the entire connection and fill the holes.
- ❑ 108. Identify and install J3, the miniature audio input jack. Gently "rock" the component into place firmly onto the board before soldering.
- ❑ 109. In the same manner, identify and install J2, the DB 9 connector, which will output the switching control voltage to the antenna switch. This jack is a large plastic and metal connector with the board and cable connections at a right angle to each other. Be sure that the connector fits firmly to the printed circuit board. Solder all connections as well as the two large mounting tabs. The tabs will require a lot of heat to get the solder to flow evenly. Don't be afraid to get them really hot.

The main board assembly is complete! You are that much closer to a functioning Doppler DF system. Take a break...you have accomplished the biggest "chunk" of the kit. We also recommend you check over your work so far and make sure there are no missed or bridged(slobbered) solder connections and that all components are installed properly and the correct values. The next steps will assemble the antennas and switching system for the DDF1.

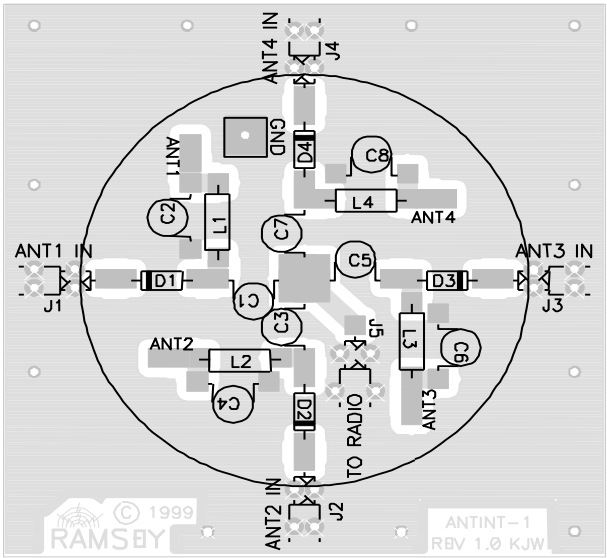
DDF-1 ANTENNA SCHEMATIC DIAGRAM



ANTMTG BOARD LAYOUT



ANTINT BOARD LAYOUT

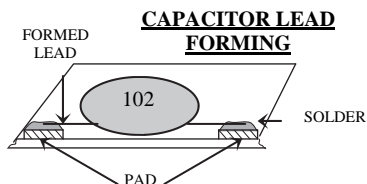
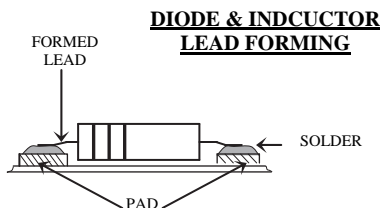


ANTENNA SYSTEM ASSEMBLY

Roll those sleeves back up; we'll get to the antenna switcher and individual antenna assemblies to complete the Doppler DF kit.

Have a look at the ANTINT-1 and ANTMTG-1 circuit boards. Note that these circuit boards will be operating at RF frequencies and proper assembly techniques (i.e. short component lead lengths, coaxial cable connections, etc.) will be critical on these boards. To minimize these impedance destroying lead lengths, we have opted for a "surface mount" procedure of the components. Instead of the typical "thru hole assembly" you have completed on the main board, the components on boards will be soldered on the same side of the circuit board. It is therefore necessary to pre-form the component leads and trim excess leads prior to the component being installed. Take a look at the drawing showing how to form the leads for the inductors and diodes. Remember to keep the body of all components tight to the board to minimize lead length.

- ☐ 1. Form and install the four(4) 1N4148 diodes D1, 2, 3, 4 into their respective positions on the circuit board. Use the shortest lead length possible. Note that these components are polarized. Install the banded end as shown in the parts diagram. Don't worry about too much heat from your soldering iron, you will not damage the diodes.
- ☐ 2. In the same manner form and install four(4) 1.2uH (brown-red-gold) inductors L1, 2, 3, and 4. Keep those lead lengths as short as possible.
- ☐ 3. Install eight(8) .001uF (marked 102), C1-C8, disc capacitors on the board. **Install these so they lay flat on the board keeping the leads as short as possible!**



WHIP ANTENNA AND ANTENNA MOUNTING BOARD INSTRUCTIONS

You will need to mount two components as well as an antenna whip to each ANTMTG board

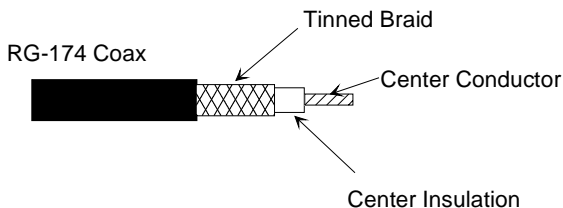
- ☐ 1. Install a 1N4148 diode on the ANTMTG circuit board in the same manner in which you did on the switcher, keeping those leads as short as possible.
- ☐ 2. Install the 1.2 uH inductor in the L1 position.
- ☐ 3. Repeat steps 1 & 2 for the remaining three(3) circuit board assemblies.

COAXIAL CABLE PREPARATION AND ASSEMBLY

We're getting very close to the end now! It is time to install the coaxial "jumpers" that connect the antenna switcher board to the individual antenna assemblies. To begin our preparation, locate the length of mini coax included with your kit.

- ❑ 1. Cut four 13 inch pieces of cable to connect the switcher to each antenna assembly.
- ❑ 2. "Prep" each of the coaxial cables as shown in the diagram. Be careful not to use too much heat when "tinning" the braid of the coax as this could damage the center insulating shield.

- ❑ 3. Position a prepared coax on the board so the center conductor is over the "J1" pad and the tinned braid does not touch the pad. Using some of your longer trimmed component leads, insert one end into one of the holes in the board on either side of the tinned braid of the coax and carefully bend it over the coax and into the hole on the other side of the coax.



- ❑ 4. Solder the coax center conductor to the circuit board. Make sure the braid does not touch the center conductor connection.
- ❑ 5. Apply a little solder to the wire you formed over the braid. **DO NOT USE TOO MUCH HEAT WHEN ATTACHING THE BRAID**, as this can cause the center insulation of the cable to melt.
- ❑ 6. Form another wire over the insulated area of the coax and through the holes on either side of the coax.
- ❑ 7. **Be careful and don't apply too much heat which can damage the coax and cause a short to center conductor.** Solder the two formed wires to the top side of the board like you did the other components and make sure there are no "bumps" on the back of the board since any solder or protruding lead will prevent the board from sitting flat on a surface.
- ❑ 8. Determine the length of cable you need to connect the ANTINT board to your receiver.
- ❑ 9. Using the length determined above, cut your own coax cable cut to length, such as type RG58, to the "TO RADIO" connection on the ANTINT board as described in steps 2, 3 and 4 above.

FINAL ANTENNA AND ANTINT ASSEMBLY

Locate the 4 antennas, 5 plastic caps, 4 lock washers, 4 M3 kepnuts, 4 M3 screws 4 antenna boards and 1 antenna switch board.. Refer to the following diagram and perform the following steps on each of the 4 antenna mounting boards.

Final Antenna Board Assembly

Use the picture on Page 30 as a guide to construct the antenna.

- ☐ 1. Insert an M3 screw through the center hole from the back of the antenna board.
- ☐ 2. Place a #4 internal tooth wash over the screw.
- ☐ 3. Screw one of the M3 kepnuts, (that's one of the nuts with a lock washer attached to it), onto the screw so the lock washer is facing away from the board and tighten it.
- ☐ 4. Remove the protective paper on a flexible magnet and attach the magnet to the bottom of the antenna board. We suggest you not trim the magnet since doing so will decrease the ability of the assembly to stay put on a magnetic surface. (BIGGER IS BETTER (-:)
- ☐ 5. Screw a whip antenna onto the M3 screw.
- ☐ 6. Make a small notch to fit over the coax on the bottom edge of the plastic cap. You can use a sharp hobby knife, side cutters or a hot tool such as your soldering iron. Melting with iron will be smelly... use your ingenuity here.
- ☐ 7. Slide a plastic cap down over the antenna and align the small cutout you made over the coax. This is a tight fit but I'm sure you can do it.
- ☐ 8. Repeat the above steps for each of the other 3 antenna assemblies..

Final ANTINT Board Assembly

In order to install the control cable between the antenna ANTINT board and the DDF1 controller you will need a cable with **at least 5 conductors**. A length of CAT5 LAN cable or any other cable with at least 5 conductors is acceptable. It is not necessary to have twisted pairs or shielding but a cable that is fairly small in diameter and flexible is probably best. It is **IMPORTANT** that the connections between the DB9 connector and ANTINT board be made in the correct sequence or your DDF1 will not function properly.

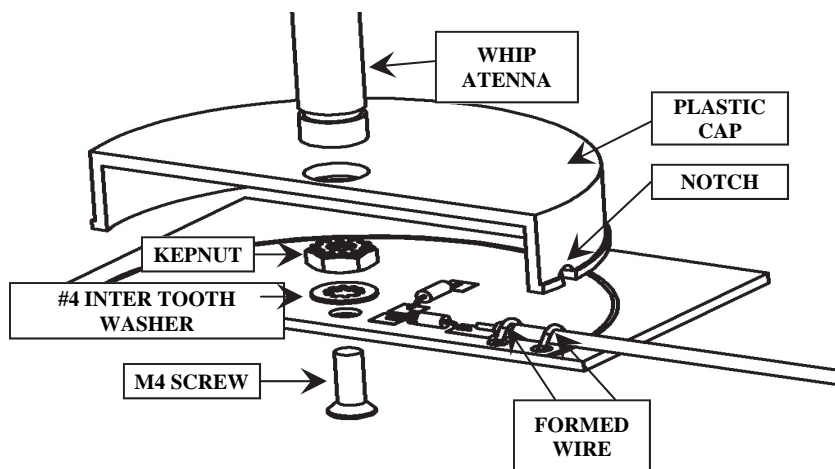
- ☐ 1. Determine the length of control cable you require and cut your cable to this length.
- ☐ 2. If your cable has only 5 conductors you may skip to the next step **NOW**. If you are using a cable with more than 5 conductors, identify and isolate 5 matching conductors on each end of the cable.
- ☐ 3. Refer to the DB9 diagram on page 30 and solder one each of the 5 wires in the cable to pins 1, 2, 3, 4 and 5. It is important you know which wire is connected to which pin so you can connected them to the ANTINT board in the next steps.
- ☐ 4. Connect the wire connected to pin 1 of the DB9 connector to the pad

labeled “ANT1” on the ANTINT board.

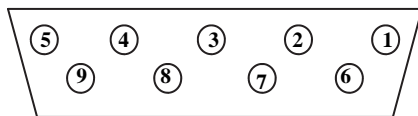
- ❑ 5. In the same way connect the wires connected to the DB9 connector pins 2, 3, and 4 to the “ANT2”, “ANT3” and “ANT4” respectively.
- ❑ 6. Connect the wire from pin 5 on the DB9 connector to the “GND” pad located near the “ANT4 IN” connection on the ANTINT board.
- ❑ 7. Verify that you have connected the control cable wires correctly. If they are not connected properly your DDF1 will not indicate the right direction of the elusive transmitter you are trying to find.
- ❑ 8. Connect the coax cables from the 4 antenna assemblies to the “ANT1 IN”, “ANT2 IN”, “ANT3 IN” and “ANT4 IN” connection points using the same procedure in steps 4 through 8 on page 28.

Congratulations, You have finished the major assembly of your DDF1. All that is left to do is some testing and then we'll have you put it in the case and weatherproof your antenna assembly. Don't get impatient and jump ahead. If there is a problem you may need to disassemble something if you go to the final assembly now.

ANTENNA ASSEMBLY DETAILS



DB9 CONNECTOR (REAR VIEW)



TESTING

Basic Testing

It is wise to review your workmanship, looking for circuit shorts or opens prior to applying power. Use an ohmmeter to measure the resistance between power and ground; the value should be greater than 2k ohms. Apply 12 VDC to the RDF unit with the power supply current limited to 150mA to prevent damage in the event of a problem (normal current drain is 100mA). Verify the presence of the following supply voltages: = 5V on the output of VR1, pin 16 of U8, pin 8 of U4, pin 8 of U6, pin 16 of U7, pin 24 of U11, pin 16 of U5. Verify +2.5 V on pin 14 of U3, verify +12 V on pin 4 of U1 and U2. This completes the basic testing of the Doppler RDF circuit.

The following tests are recommended to identify and troubleshoot problems, but don't worry if you don't have all the necessary test equipment. Satisfactory performance can usually be achieved without performing these tests.

Functional testing

Before connecting the antenna switcher, verify the operation of clock oscillator U4 by connecting an oscilloscope to pin 3. The output should be a square wave with an amplitude of 5 V and a period of 125 ms (8 kHz). Use a frequency counter to verify the clock frequency is 8 kHz +/- 250 Hz if you desire. Getting the clock frequency to exactly 8 kHz is not necessary for proper operation, however, the values of R27 and R28 can be changed to adjust the clock frequency. Verify that closing switch S2 disables the clock. Open S2 (scan stop) and verify the operation of BCD counter U7 by connecting the oscilloscope sequentially to pins 14,13,12, and 11. The signal frequency on these outputs should be approximately 4, 2, 1 and 0.5 kHz, respectively. Verify the presence of a square wave signal on pins 2,4,6 and 8 of buffer U12.

Signal Level Indicators

The following test uses an audio signal generator to simulate the presence of the Doppler tone. Disconnect the speaker from audio level control potentiometer R50 to prevent loading the signal generator. Connect an audio signal generator to the receiver audio input terminal. Set the generator to apply a 500 Hz sine wave with amplitude 1V P-P. Rotate R50 until the audio overload LED D3 illuminates. Then, adjust R50 until low signal level LED D4 lights. Adjust R50 so that LEDs D3 and D4 are off, set calibrate control R36 to the center of its range and adjust damping control R19 for minimum damping (fully CCW).

Direction Indicator

Adjust the frequency of the audio generator very slowly around 500 Hz while observing the LED display. You should see the direction indicating LEDs around the green center LED illuminating. The LED illumination should rotate clockwise when the frequency of the generator is set slightly lower than the antenna rotation frequency. (Only one LED will be on when the frequency of the generator equals the antenna rotation frequency.) The display should rotate counterclockwise. The audio generator must be capable of very fine frequency adjustment in order to observe the transition. All LED's in the display may appear to be on if the signal generator frequency is just 10Hz different from that of the antenna rotation frequency determined by U4. It is interesting to observe the sharpness of the digital filter on pin 1 of U2 on the oscilloscope as the display makes the transition from counterclockwise. You can see the simulated Doppler tone of the generator come out of the noise, peak and return into the noise as the transition takes place.

Calibration Control

Verify the function of the calibrate control by adjusting the audio generator equal to the antenna rotation frequency. At this point, only a single LED will illuminate. Rotate the calibrate control through out its range and observe the direction indicating LED "move" around the display. The range of movement should be more than 360 degrees. The direction indicating LED may move slightly if the generator frequency drifts. It is very difficult to keep the generator frequency synchronized exactly, but that's not necessary in this test. Disconnect the signal generator and reconnect the speaker to the receiver audio input terminal.

Antenna Switcher

Verifying proper operation of the antenna switcher sequencing circuit requires only a DC voltmeter. Connect the antenna switcher to the Doppler RDF unit and position the four mag-mount antennas on a table.

Remove the whip antennas from all the mounting boards for this test

It is essential that the antennas be turned on in sequence to emulate an antenna spinning in a circular pattern for the Doppler RDF unit to operate correctly. A single antenna turned on out of sequence is enough to produce a bogus RDF reading. It does not matter if the antenna spins clockwise or counterclockwise.

Scan/stop switch S2 stops the antenna from spinning. Close and open S2 until the voltage on terminal J2 pin 1 reads +1.4V. Pins 2, 3 and 4 should all read near 0V. Pin 1 is the antenna enable signal for antenna 1. Label the corresponding mag-mount antenna on the table as antenna 1. Close and open S2 until the voltage on terminal J2 pin 2 reads +1.4V. Pins 1,3, and 4 should all read near 0V. Pin 2 is the antenna enable signal for antenna 4

and should be positioned to the right of antenna 1 as viewed from the center of the antennas for a clockwise spin. Close and open S2 until the voltage on terminal J2 pin 3 reads +1.4V. Pins 1,2, and 4 should all read near 0V. Pin 3 is the antenna enable signal for antenna 3 and should be positioned to the right of antenna 2 as viewed from the center of the antennas. Close and open S2 until the voltage on terminal J2 pin 4 reads +1.4V. Pins 1, 2, and 3 should all read near 0V. Pin 4 is the antenna enable signal for antenna 2 and should be positioned to the right of antenna 3 as viewed from the center of the antennas.

RF Operation

Testing the RF operation of the antenna is quite simple. Place all four antenna mounting boards around the center of the car roof, placing each antenna at the corner of an 18.25 inch square pattern for operation on 146 MHz. Do not install any of the whip antennas yet. Connect the RF output of the antenna switcher to your FM receiver or transceiver tuned to the frequency desired.

CAUTION: MAKE SURE YOU DISABLE TRANSMIT MODE IF YOU ARE USING A TRANSCEIVER!

Apply power to the RDF unit and open S2 to stop the spinning process. Install a whip antenna on **ONE** of the antenna mounting boards. Using a low power transmitter such as a portable handheld transceiver on low power, walk a distance away from the antenna and transmit on the frequency your receiver is tuned to. Only one antenna should provide a signal strength reading similar to it being connected directly to the FM receiver. Remove the whip from the selected antenna and touch it to each of the other three antennas. The received signal should be weak or nonexistent. Close and open S2 until another antenna is selected and repeat the same test. Continue the process until you have verified each antenna can be turned on while the other three remain off.

Operation

Checking performance of the RDF unit is best done in a large, empty area away from tall buildings: a parking lot will do. Use caution at all times during open road operation of the RDF unit. Use a minimum of two people for all testing and operation of the RDF unit: one to operate the vehicle and the other to operate the RDF unit. The magnets securing your antennas to the roof of the car were designed for use at reduced speeds. If you intend to use the DDF1 at highway speeds, you may want to get some stronger magnets. The powerful magnets contained in computer hard drives are excellent for this application and can often be found at flea markets or surplus store for as little as \$1.00 or less. The typical magnet found in an audio speaker would also work well. As a safety measure, secure each mag-mount antenna with 20 pound fishing line when operating the vehicle at highway speeds.

Attach all four whip antennas to the mag-mount antenna bases placed about the center of the car top. Connect the RF output of the antenna switcher to a FM receiver transceiver tuned to the desired frequency.

CAUTION:

Make sure you disable transmit mode if you are using a transceiver!

It is best to use a smaller, handheld walkie talkie with your DDF1. The unit connects easily to the antenna on your handheld and because they have less output power, there is less chance of doing damage by accidentally transmitting into your DDF1.

Adjust the receiver's audio to a comfortable level in the external speaker. Apply 12 V to the RDF unit and "spin" the antenna by closing switch S2. As soon as S2 is closed, you should hear a 500 Hz tone imposed on the receiver audio. Rotate audio level adjust control R50 so that low signal level LED D4 and audio overload LED D3 are extinguished. Never trust directional indications if D3 and/or D4 are illuminated. The direction indicating display should be relatively constant with a single LED lit, or one or two adjacent LEDs alternately illuminating. Adjust calibrate control R36 so that the direction indicating LED is consistent with the general direction of the transmitter with respect to your location and the position of the car. Have the driver slowly circle while you observe the display. You should see the direction indicating LEDs illuminate in the opposite direction as the car is turning in a circle. The position changes relative to the changing direction of the car, however, the direction indicated from the center of the circle the car is driving should remain fixed. If the display turns in the same direction as the car, flip phase invert switch S3 to the opposite position to correct the 180 degrees phasing offset. This completes the rough calibration procedure.

Final Calibration

A more accurate calibration can be achieved while the car is in motion. Position a volunteer with a transmitter in a safe spot on the side of a long, straight and vacant roadway about 1/4 to 1/2 mile away. Have them transmit on low power (up to 5W) while traveling towards them. The RDF operator should calibrate the RDF display to indicate 0 degrees as straight ahead. The display should change to 180 degrees indicating the signal is coming from directly behind the car as the vehicle passes the transmitter. The moving calibration producer functions to average out false reflected signals caused by multipath propagation. You may notice that the Doppler tone changes as the car moves about. The Doppler tone will sound like a pure, undistorted 500 Hz sine wave in the absence of reflected or multipath interference. Direction indications are most reliable under these conditions. When reflected or multipath signals are present the Doppler tone will sound raspy and distorted. Those signal components may arrive from different directions causing false bearing indications. The LED display tends to jump around randomly under these conditions. Avoid taking bearing information when the Doppler tone sounds raspy. You can minimize display jitter by slowing the response time of the digital filter. This is accomplished by increasing damping control R19. With a little time, you can master the art of Doppler RDFing.

The wide bandwidth antenna switcher can be used for DFing on other bands, provided the proper antenna whip lengths and antenna spacing are used. Arrange the antennas in a square pattern. Typical antenna lengths for common frequencies is shown in the table below. Whip lengths are measured from the top surface of the mag-mount PC board base to the tip of the antennas.

You can determine the correct antenna length for other frequencies by interpolation of values from the table above. The Doppler DF'er will work on virtually any VHF/UHF frequency!

| Frequency | Antenna length in inches |
|-----------|--------------------------|
| 146 MHz | 18 |
| 223 MHz | 13 1/2 |
| 446 MHz | 7 7/8 |

FINAL CASE UP

OK... Now that you've completed testing and setting up your DDF1 it's time to make it look pretty. This is the final phase of your trip.

CASE ASSEMBLY

- ❑ 1. Place the main circuit board in the top half of the case and secure it in place using the 8 4-40x1/4 inch screws.
- ❑ 2. Notice that the bottom of the case has a bunch of holes drilled in it. Find the speaker and mount it over the holes using the 2 black 6-32 screws and 6-32 nuts. Tighten the screws in place.
- ❑ 3. Plug the wire from the speaker into J4, the 2 pin connector near the speaker input jack on the main board. It doesn't matter which way it is plugged in.
- ❑ 4. Place the top and bottom of the case together and use the six(6) 4-40 x 3/8 self tapping screws to secure them together.

FINAL ANTENNA SYSTEM ASSEMBLY

- ❑ 1. Make 6 small notches to fit over the cables on the bottom edge of the plastic cap for the antenna switch board. You can use a sharp hobby knife, side cutters or a hot tool such as your soldering iron. Melting with an iron will be smelly... use your ingenuity here.
- ❑ 2. Use hot glue or silicone calking and apply a bead around the base of the caps to attach the cap and seal the cable entry areas. You may also want to seal around the whip antennas.

TROUBLESHOOTING INSTRUCTIONS

While we had hoped that it wouldn't come to this, if you are having trouble with your direction finder, here are a few suggestions.

Use a methodical, logical troubleshooting technique. Most problems can be solved using common sense. A volt-ohm meter and a clear head are usually all that are needed to correct any problem. Over 95% of problems with kits returned for repair are due to misplaced parts and/or bad solder connections. Working backwards through the assembly steps will often lead you to the problem. We also suggest having someone else check over your work as it is very common to miss an error several times and you will get even more frustrated.

If you call our tech support for help please be sure to have the unit in front of you and also have a multimeter available. If you have an oscilloscope available that might also be helpful. Please understand that due to the complexity of the DDF1 it may be difficult to troubleshoot over the phone but at least it will be possible to get immediate real time information. If you decide to contact us by email it will be even more difficult and time consuming because we will need to ask questions and wait for answers numerous times.

CONCLUSION

We sincerely hope that you enjoy the use of this Ramsey product. As always, we have tried to compose our manual in the easiest, most “user friendly” format that is possible. As our customers, we value your opinions, comments, and additions that you would like to see in future publications. Please submit comments or ideas to:

Ramsey Electronics, LLC
Attn. Hobby Kit Department
590 Fishers Station Drive
Victor, NY 14564

And once again, thanks from the folks at Ramsey!

THE RAMSEY KIT WARRANTY

1. GENERAL:

Notice that this is not a "fine print" warranty. We want you to understand your rights and ours too! All Ramsey kits will work if assembled properly. The very fact that your kit includes this new manual is your assurance that prior to release of this kit, a varied group of knowledgeable people have assembled this kit from scratch using this manual. During this process, changes and additions are noted by each assembler and integrated into the final version of the manual...which you have! If you need help, please read through your manual carefully, all information required to properly build and test your kit is contained within the pages! However, customer satisfaction is our goal, so in the event that you do have a problem, please note the following:

2. DEFECTIVE PARTS:

It's always easy to blame a part for a problem in your kit. Before you conclude that a part may be bad, thoroughly check your work. Today's semiconductors and passive components have reached incredibly high reliability levels, and it's sad to say that our human construction skills have not! But on rare occasions a sour component can slip through. All of our kit parts carry the Ramsey Electronics Warranty that they are free from defects for a full ninety (90) days from the date of purchase. Defective parts will be replaced promptly at our expense. If you suspect any part to be defective, please mail it to our factory for testing and replacement. Please send only the defective part(s), not the entire kit. The part(s) MUST be returned to us in suitable condition for testing. Please be aware that testing can usually determine if the part was truly defective or damaged by assembly or usage. Don't be afraid of telling us that you "damaged it" or "burned it out", we're all human and in most cases, replacement parts are very reasonably priced. Remember, our goal for over three decades is to have a happy customer, and we're here to work WITH you, not AGAINST you!

3. MISSING PARTS:

Before assuming a part value is missing, check the parts listing carefully to see if it is a critical value such as a specific coil or IC, or whether a RANGE of values is suitable for the component (such as a "100 to 500 uF capacitor"). Often times, common sense will solve a mysterious missing part problem. If you're missing five 10K ohm resistors and received five extra 1K resistors, you can pretty much be assured that the "1K ohm" resistors are actually the "missing" 10 K parts ("Hum-m-m, I guess the orange band really does look red!") Ramsey Electronics project kits are packed with pride in the USA by our own staff personnel. While separate QC checks are made on all product kits, we too are human, and once in a great while there is a chance something can get through those checks! If you believe we packed an incorrect part or omitted a part clearly indicated in your assembly manual for your Ramsey kit, please contact us with information on the part you need. Contact our Repair Department via telephone, email or writing. Please have your invoice number and date of purchase handy.

4. REFUNDS:

All Ramsey products, kit or factory assembled units have an unconditional 10 day (from the date of purchase) return policy to examine our products. If you are not satisfied for any reason, you may return your unassembled kit with all the parts and instructions, or your factory assembled and tested product, together with your proof of purchase to the factory for a full refund less shipping. The return package should be packed securely. Insurance and tracking is highly recommended. A reminder, this applies to unassembled kits. They must be in the same new condition as received, not partially assembled! Assembled kits cannot be returned for credit. No RMA's are required; simply return to Ramsey Electronics LLC, Attn: Product Returns, 590 Fishers Station Drive, Victor, NY, 14564. If you have any questions, please contact us at 585-924-4560.

5. FACTORY REPAIR OF ASSEMBLED KITS:

Most of us at Ramsey are technically oriented and we do realize that things happen! Even following the best practices, with all of the best intentions, there is that chance that your kit doesn't work when you have completed it. Each manual goes into detailed troubleshooting based on the specific kit to help you troubleshoot the problem. We have found that 95% of returned kits involved wrongly installed components (wrong part or backwards polarity). This section of the warranty assumes you have gone through all those steps, and have now reached the point that you need to send it back.

To qualify for factory repair of customer assembled kits, the following conditions apply:

1. Kits must not be assembled with acid solder flux
2. Kit boards or circuits must not be modified in any manner from the version received
3. Kits must be fully assembled, not partially assembled. Our warranty does not include "finishing" your kit!
4. Must include a full description of the problem encountered including the troubleshooting steps you have already done.
5. Must not include non-standard, non-Ramsey accessories, cases, enclosures, knobs, etc. or any batteries.
6. Must include the minimum repair fee of \$25 USD in the form of check, money order or credit card authorization.
7. Ramsey Electronics, LLC reserves the right to refuse any repair due to excessive errors in construction methods.
8. If, due to customer construction methods, the repair is estimated to exceed the minimum flat rate, Ramsey Electronics, LLC will contact the customer to discuss the repairs needed and to receive authorization and payment for repair prior to repair.
9. In the unlikely case that a defective part is found to be the cause of the problem, the repairs will be made at no-charge to the customer, and any payments received for repair will be returned or credited back to the customer.
10. Properly pack your kit, insure the package, and use a carrier that can be tracked. Ramsey Electronics, LLC is not responsible for any loss or damage in shipment. Send the package together with your repair fee to the return address below. No RMA is required.

6. FACTORY REPAIR FEES:

Please understand that our Tech Support Group personnel are not volunteers! They are a dedicated group of highly trained technicians each configured with a very properly equipped test bench. Upon receipt of a repair, the setup, testing, diagnosis, repair, paperwork, and repacking of your kit requires nearly an hour of their time regardless of the size or complexity of the kit! The minimum repair fee represents ½ hour Tech Support time at \$50/hour USD. We try to keep all kit repairs within the realm of the \$25 flat rate whenever possible...and trust us; we exceed that time spent on most kits received more often than not!

7. CONTACT INFORMATION AND RETURN ADDRESS:

Technical Questions

RAMSEY ELECTRONICS, LLC

Attn: Tech Support
590 Fishers Station Drive
Victor, NY 14564
585-924-4560; 585-924-4886 Fax
techsupport@ramseyelectronics.com

Product Repair & Returns

RAMSEY ELECTRONICS, LLC

Attn: Repairs
590 Fishers Station Drive
Victor, NY 14564
585-924-4560; 585-924-4886 Fax
repairs@ramseyelectronics.com

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REQUIRED TOOLS

- Soldering Iron
- Thin Rosin Core Solder
- Needle Nose Pliers
- Small Diagonal Cutters

ADDITIONAL SUGGESTED ITEMS

- Helping Hands Holder for PC Board/Parts
- Desoldering Braid

Price: \$5.00

Ramsey Publication No. MDDF1

Instruction manual for:

RAMSEY MODEL NO. DDF1

DOPPLER RADIO DIRECTION FINDER



RAMSEY ELECTRONICS, LLC

590 Fishers Station Drive

Victor, New York 14564

Phone (585) 924-4560

Fax (585) 924-4555

www.ramseykits.com