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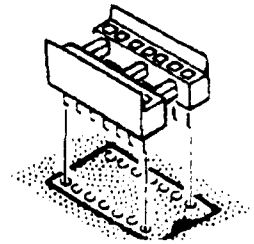
DOPPLER DF UNIT ASSEMBLY

Assembly instructions for this project will assume all components are to be mounted on the circuit board. Certain components (diodes, switches and trim pots) can be mounted on the enclosure and therefore will require some minor modification. Since the enclosure style can vary depending on the needs of the user, no description or templates are provided.

IC SOCKETS (Optional & Strongly Recommended)

- () 1. Locate and install the 14 pin IC sockets located at U1, U2, U9, U12, and U13. Make sure the notch on the socket is aligned with the notch marked on the circuit board.
- () 2. Locate and install the 16 pin IC sockets located at U3, U5, U6, and U10. Make sure the notch on the socket is aligned with the notch marked on the circuit board.
- () 3. Locate and install the 8 pin IC sockets located at U4, U14, and U8. Make sure the notch on the socket is aligned with the notch marked on the circuit board.
- () 4. Locate and install the 24 pin IC socket located at U7. Make sure the notch on the socket is aligned with the notch marked on the circuit board.

Note: To install a socket, be sure the socket pins are straight, then insert the socket pins and solder them to the foil.



RESISTORS

- () 5. Install the 33K ohm resistors in the following locations: R3, R4, R7, R8, R12, R13, R14, R19, R21, R32, R33.
- () 6. Install the 680 ohm resistors in the following locations: R24, R25, R26, R27.
- () 7. Install the 3.3K ohm resistors in the following locations: R28, R42, R43, R44.
- () 8. Install the 10K ohm resistors in the following locations: R18, R29, R45.
- () 9. Install the 47K ohm resistors in the following locations: R15, R17, R38.
- () 10. Install the 51K ohm resistors in the following locations: R2, R16.
- () 11. Install the 2.2K ohm resistors in the following locations: R5, R48.
- () 12. Install the 100K ohm resistors in the following locations: R11, R30.
- () 13. Install the 15K ohm resistors in the following locations: R6, R22.
- () 14. Install the 10 ohm resistor in the following location: R47.
- () 15. Install the 47 ohm resistor in the following location: R37.
- () 16. Install the 100 ohm resistor in the following location: R20.
- () 17. Install the 330 ohm resistor in the following location:

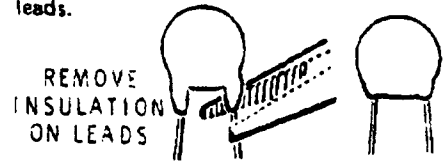
R31
RESISTORS (cont.)

- () 18. Install the 3K ohm resistor in the following location:
R46
- () 19. Install the 18K ohm resistor in the following location:
R10
- () 20. Install the 22K ohm resistor in the following location:
R9
- () 21. Install the 56K ohm resistor in the following location:
R41
- () 22. Install the 82K ohm resistor in the following location:
R23
- () 23. Install the 330K ohm resistor in the following location:
R40

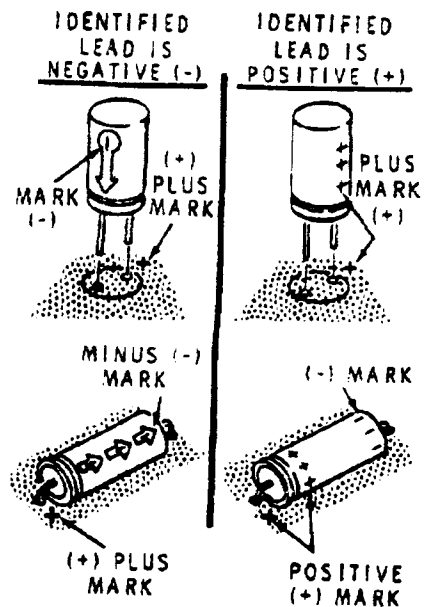
CAPACITORS

- () 24. Locate and install the .01 mfd capacitors in the following locations:
C1, C2, C3, C4, C5, C14, C15, C30, C31, C37, C39, C40, C41, C42, C43, C44, C45, C46, C47, C48, C49, C50, C51.
- () 25. Locate and install the .1 mfd capacitors in the following locations:
C6, C7, C8, C9, C10, C11, C12, C13, C21, C23, C25, C27, C29, C32, C38.
- () 26. Locate and install the .001 mfd capacitors in the following locations:
C17, C19, C20.
- () 27. Locate and install the .0022 mfd capacitor in the following location:
C18.
- () 28. Locate and install the .47 mfd capacitor in the following location:
Caution: Before you install an electrolytic capacitor, identify the leads. One lead will be marked (+) or (-). Be sure to install the positive lead in the positive hole.
C16.
- () 29. Locate and install the 1 mfd capacitor in the following location:
C28.
- () 30. Locate and install the 1 mfd capacitor in the following location:
C28.
- () 31. Locate and install the 4.7 mfd capacitors. (make sure the positive lead is inserted into the hole marked (+) on the circuit board) in the following locations:
C22, C24
- () 32. Locate and install the 10 mfd capacitors. make sure the positive lead is inserted into the hole marked (+) on the circuit board in the following locations:
C35, C36
- () 33. Locate and install the 100 mfd capacitor. make sure the positive lead is inserted into the hole marked (+) on the circuit board at the following location:
C26
- () 34. Locate and install the 220 mfd capacitors. make sure the positive lead is inserted into the hole marked (+) on the circuit board at the following locations:
C33, C34

NOTE: Before you install ceramic capacitors, use long-nose pliers to remove the excess insulation from the capacitor leads.



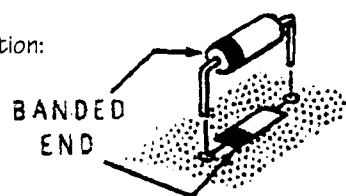
Caution: Before you install an electrolytic capacitor, identify the leads. One lead will be marked (+) or (-). Be sure to install the positive lead in the positive hole.



NOTE: When you install a diode, always match the band or bands on the diode with the band mark on the circuit board.

DIODES

- () 35. Locate and install Diode 1N4003. make sure the band on the diode is aligned with the band drawn on the circuit board at the following location:
D1
- () 36. Locate and install Diodes 1N4148. make sure the band on the diode is aligned with the band drawn on the circuit board at the following locations:
D3, D22, D23



TRIM POTS

- () 37. Install the 10K ohm Variable resistor (trim pot) at the following location:
R1
- () 38. Install the 500K ohm Variable resistors (trim pots) at the following locations:
R34, R35, R36

TRANSISTORS

NOTE: Heat sensitive components, use care when soldering.

- () 39. Install the 2N2222 transistors at the following locations:
Q1, Q2

SWITCHES

- () 40. Install the DPDT switch at the following location:
S1
- () 41. Install the SPST switches at the following locations:
S2, S3

LED's

- () 42. Install the LED's. make sure the minus lead is inserted into the hole marked (-) on the circuit board in the following locations:
D2, D4, D6, D7, D8, D9, D10, D11, D12, D13, D14, D15, D16, D17, D18, D19, D20, D21.

IC's

NOTE: Heat sensitive component, use care when soldering.

- () 43. Install LM7805 at the following location:
U11

NOTE: The following IC's Should not be installed until AFTER the checkout has been completed.

To install an integrated circuit, first refer to the figures and identify the #1 pin end. Position the pin #1 end toward the half moon mark on the circuit board and carefully insert the IC into the socket. Make sure all the pins are in their respective holes before seating the IC. If the IC needs to be removed, use an IC puller.

- () 44. Install the LM324 IC's at the following locations:
U1, U2, U12
- () 45. Install the CD4051 IC at the following location:
U3
- () 46. Install the 555 IC's at the following locations:
U4, U8
- () 47. Install the CD4049 IC at the following location:

U5

ICs (cont.)

- () 48. Install the 74LS75 IC at the following location:
U6
- () 49. Install the 74HC154 IC at the following location:
U7
- () 50. Install the CD4024 IC at the following location:
U9
- () 51. Install the CD4028 IC at the following location:
U10
- () 52. Install the 74LS00 IC at the following location:
U13
- () 53. Install the LM386 IC at the following location:
U14

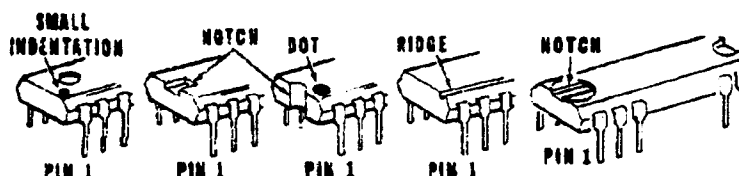
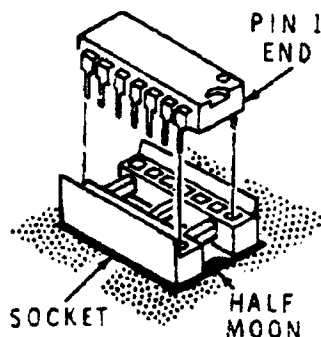
CONNECTORS

Note: If connectors are not used, solder wires in place of the connectors. Pin 1 is labeled P1.

- () 51. Install the 10 pin connector at the following location:
P1 Pin 1 is labeled P1.
(Pins 1 - 6 antenna Pin 6 not used. Pins 7 - 8 audio input. Pins 9 (+) 10 (-) power)
- () 52. Install the 2 pin connectors at the following locations:
J1, J2
(Pin J1= low detect circuit disable. Pin J2= speaker)

To install an integrated circuit, first refer to the figures and identify the #1 pin end. Position the pin #1 end toward the half moon mark on the circuit board and carefully insert the IC into the socket. Make sure all the pins are in their respective holes before seating the IC. If the IC needs to be removed, use an IC puller.

Before you install an IC, be sure the pins are straight. Then lay it down on one of its rows of pins, as shown at A, and roll it over until the pins are at right angles or are bent in slightly as shown at B. Repeat this process for the other row of pins.



ANTENNA ASSEMBLY

() 1. Refer to the Antenna Array image for construction information. Antenna length and spacing is $1/4$ wavelength of operating frequency. Coax lengths should be an electrical quarter wavelength long, which is .66 times the length of each vertical whip for ordinary coax (not foam dielectric).

Switching Circuit Enclosure

- () 1. Use a standard metal project box of sufficient size to mount and contain the switching circuit components.
- () 2. Mark the center on the bottom of the box and drill a $1/8$ " hole.
- () 3. At approx $1/2$ " spacing, drill 4 $1/8$ " holes around the center hole to form a square.
- () 4. At approx $1/2$ " spacing from the outer holes, drill 4 $1/8$ " holes.
- () 5. At each hole, mount an insulated standoff and a ground lug.
- () 6. On each end of the box, drill holes to pass the RG58 coax and the antenna signal wire.

Switching Circuit Assembly

- () 1. Using the circuit diagram, identify the 680 pf capacitors C101, C102, C103, C104. Connect one end of each of the capacitors to the center standoff and the other end to the 4 adjoining standoffs.
- () 2. Using the circuit diagram, identify the 6.8 uh chokes L101, L102, L103, L104 and connect one end to the outer standoffs and the other to the end of the 680 pf capacitors.
- () 3. Using the circuit diagram, identify the 680 pf capacitors C105, C106, C107, C108 and connect them between the outer choke standoffs and ground.
- () 4. Using the circuit diagram, attach the center conductor of the RG58 receiver coax to the center standoff, and the shield to the ground lug.
- () 5. Using the circuit diagram, attach the center conductor of the $1/4$ wavelength coax to the inner standoffs and the shields to the ground lugs.
- () 6. Using the circuit diagram, attach the antenna signal wires to the corresponding outer standoffs. Keep track of the wire color and the antenna it represents.
- () 7. Mount 4 standoffs and ground lugs on the antenna plate.
- () 8. Connect the free end of the $1/4$ wavelength coax center conductor to the standoffs, and the shields to the lugs.
- () 9. Connect the MPN-3401 diodes between the standoff and ground lugs. Make sure the banded end of the diode is towards ground.
- () 10. Connect another $1/4$ wavelength coax center conductor to the standoffs, and the shields to the lugs.
- () 11. Connect the free ends of this piece of coax to BNC connectors and mount them to the antenna plate.

ANTENNA ASSEMBLY (Optional)

The following design is an option for use with 4 magnetic mounted 1/4 wave antennas, mounted 1/4 wavelength apart.

The antennas require that the feedline be a measured odd multiple of a 1/4 wavelength. An example of this would be 140" coax for each antenna, using RG58 which has a velocity factor of .66.

This length of coax will work for 2mtrs, 220 MHz and 440MHz.

Switching Circuit Enclosure

- () 1. Use a standard metal project box of sufficient size to mount 4 SO239 connectors, and contain the switching circuit components.
- () 2. Mark the center on the bottom of the box and drill a 1/8" hole.
- () 3. At approx 1/2" spacing, drill 4 1/8" holes around the center hole to form a square.
- () 4. At approx 1/2" spacing from the outer holes, drill 4 1/8" holes.
- () 5. At each hole, mount an insulated standoff and a ground lug.
- () 6. On each end of the box, drill holes to pass the RG58 coax and the antenna signal wire.
- () 7. On the long side of the box, drill and mount the SO239 connectors.

Switching Circuit Assembly

- () 1. Using the circuit diagram, identify the 680 pf capacitors C101, C102, C103, C104. Connect one end of each of the capacitors to the center standoff and the other end to the 4 adjoining standoffs.
- () 2. Using the circuit diagram, identify the 6.8 uh chokes L101, L102, L103, L104 and connect one end to the outer standoffs and the other to the end of the 680 pf capacitors.
- () 3. Using the circuit diagram, identify the 680 pf capacitors C105, C106, C107, C108 and connect them between the outer choke standoffs and ground.
- () 4. Using the circuit diagram, attach the center conductor of the RG58 receiver coax to the center standoff, and the shield to the ground lug.
- () 5. Using the circuit diagram, attach the center conductor of the 1/4 wavelength coax to the inner standoffs and the shields to the ground lugs.
- () 6. Using the circuit diagram, attach the antenna signal wires to the corresponding outer standoffs. Keep track of the wire color and the antenna it represents.
- () 7. Connect the free end of the 1/4 wavelength coax to the SO239 connectors.
- () 8. Connect the MPN-3401 diodes between the center conductor of the SO239 connectors and ground. Make sure the banded end of the diode is towards ground.

CHECKOUT

A good dc oscilloscope with response to 15MHz or higher, and an audio frequency generator, will be very useful for checking out your Doppler unit. They'll also help you understand just how it works. You'll also need a good dc voltmeter.

- () 1. Carefully go over your wiring and look for errors.
- () 2. Before installing U1, put the ohmmeter probes across trim pot R34 and adjust it for 10 k ohms.
- () 3. Adjust R35 for minimum resistance. S2 should be open.

The first power application test should be done before the ICs are put into their sockets. Leave the antenna unit disconnected.

- () 4. Check power drain, which should be very low. Verify supply voltages and ground at the appropriate pins of the IC sockets. All digital ICs are powered from the 5 V source and the LM324s get power from S3 (+ 13 V).
- () 5. Remove power, install all the ICs, and reapply power. Measure the output voltage at regulator U11, it should be 5 Vdc. The bias source voltage at U2-1 should be 2.5 Vdc, and so should the audio stage outputs at U1-1, U1-7, U1-8, U2-14 and U1-14. The voltage at U2-6 should be 0.5 Vdc.
- () 6. Connect the oscilloscope to U8-3 and view the waveform. You should see the main clock signal as in Fig. It is a rectangular waveform of slightly more than 50 percent duty at about 8 kHz. Closing S2 inhibits this signal.
- () 7. Connect the oscilloscope to U9-12 U9-11 U9-9 and U9-6 (with S2 open). comparing them with the figure.
- () 8. Connect the oscilloscope to the antenna drive outputs at U5-15, U5-12, U5-10, and U5-6, comparing them with the figure.
- () 9. Temporarily disconnect the top lead of the 8 ohm speaker control (R1) to prevent it from loading the audio generator. Set the audio generator for a one volt peak to peak (P-P) sine wave at 350 hertz and connect it to the audio input at C1. Verify that the audio signal is present at U1-1, with amplitude of one volt P-P. Then check the signal at the filter outputs, U1-7 (0.7 V P-P) and U1-8 (2.6 V P-P).
- () 10. Reset the generator to 600 hertz, verify that the level into C1 is still one volt P-P, and look again at the filter outputs, this time for 0.45 V P-P at U1-7 and 0.8 V P-P at U1-8. This checks operation of the low pass filter.
- () 11. Set the generator for 500 hertz. When the input signal level is increased, the sine wave output of the last filter op-amp (U1-8) eventually starts clipping at the negative peak. The overload LED (D2) should light at just about the point where clipping at U1-8 begins. Reset the input level at C1 to one volt P-P after this test.

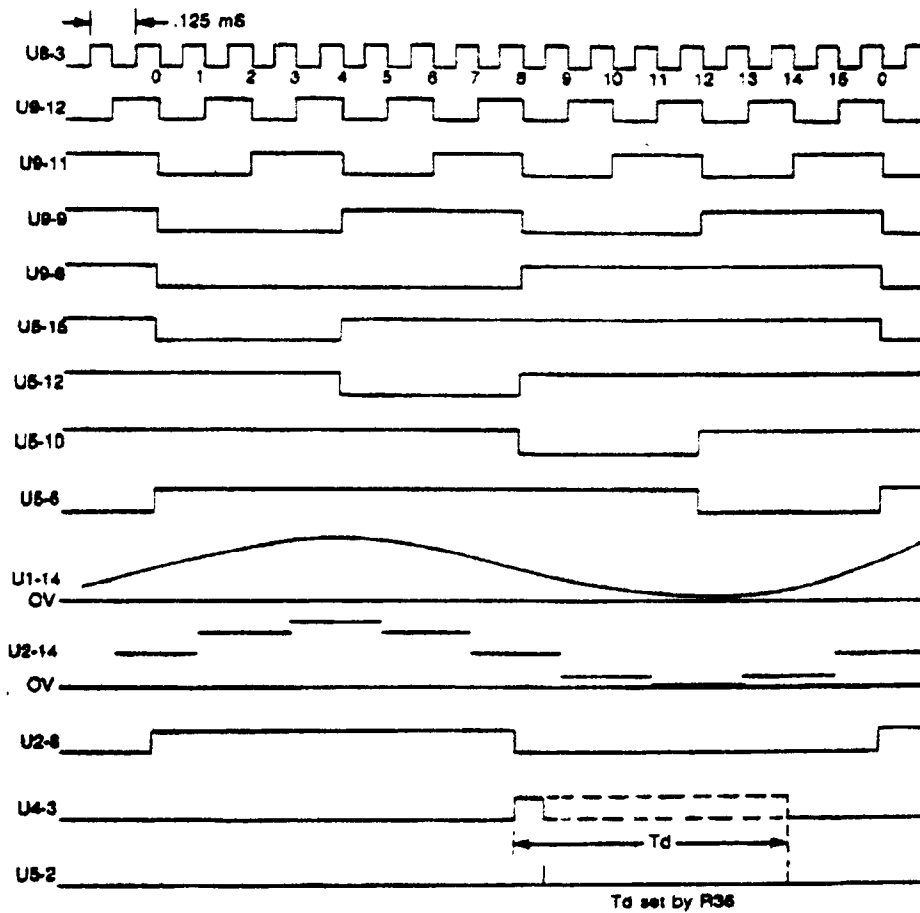
- () 12. Connect the oscilloscope to U1-14, the output-of the digital filter. Vary the audio oscillator frequency around the 500 Hz region and look for a peak in the waveform amplitude. You may have trouble finding the peak in the audio. This filter is extremely sharp, with a bandwidth of less than 2 hertz with R35 at minimum. When R35 is increased, the filter is even sharper. With the generator input centered in the filter, move the probe to U2-14 and notice the chopped sine wave effect. This is normal. The U1D filter stage cleans up the switched capacitor filter output, as illustrated. The phase relationship of U2-14 and U1-14 versus the other points varies.

When the audio oscillator frequency exactly equals the antenna rotation frequency, only one LED indicator in the circular display is on and the display is stationary. By varying the input frequency just a slight amount, the display can be made to rotate clockwise for lower frequency, and counterclockwise for higher frequency. The greater the frequency difference from filter center, the faster the rotation.

- () 13. Look At the waveform at U2-8. Use the second trace if you have a dual trace scope. The comparator output should be a nice square wave (rise and fall times about 40 microseconds) of near supply amplitude, switching at the midpoint of the sine wave of U1-14. Move the first trace probe to U4-3. At each negative transition of U2-8 the 555 should trigger. The pulse width should change when R36 is adjusted. Set R36 for minimum pulse width.
- () 14. Connect the antenna assembly to the DF unit. Connect the oscilloscope probe to each vertical antenna in succession. The signals should appear as U5-6, U5-10, U5-12, U5-15, In figure except that the amplitude will be only one diode drop (about 0.6 V). Disconnect the audio oscillator and reconnect R1 to the input circuit.

Make a quick bench check of the complete system before mounting it in the vehicle. Connect the antenna and audio leads to the radio. Tune it to a full-quieting station, such as an active local repeater. Set the speaker control (R1) full clockwise, and adjust the radio volume control for the loudest audio you'll ever want during a hunt. Back off on the radio volume control if you note distortion in the receiver audio amplifier. Note this receiver volume control position. Reduce R1 for a comfortable listening level. You should now be hearing the Doppler tone superimposed on the receiver audio. Adjust R34, the internal audio gain trimming pot, for occasional flashing of the overload indicator on voice peaks.

If the unit is working properly, the direction indication can be changed by rotating the antenna unit. Proximity effects will cause changes in the apparent direction when working indoors, so don't expect to get correct readings there. When everything seems to be working properly, mount the unit on the car and hook everything together.



CALIBRATION

The method of calibrating and checking a vhf Doppler seems obvious: Just walk around the vehicle with a transmitting handheld and adjust the calibration control on the DF for correct bearings. But take it from the many hams who have tried it that method won't give an accurate calibration. It is OK only for a rough check.

Nearby reflections and the near-field characteristics of the signal give you inconsistent indications. You'll be convinced the unit isn't working properly if you try a final calibration with this method.

A repeater or strong base station that is a mile or more away makes a much better first check. The signal should be strong. the path should be unobstructed, and the vehicle should be in a relatively clear area such as a large empty parking lot. Drive the car around in a circle and verify that the bearing is reasonably consistent. Again, don't expect super accuracy on this check, particularly if the repeater is many miles away. propagation can cause errors.

The best final calibration is done with the vehicle moving. N4FQ suggests calibrating the unit while moving slowly down a long stretch of straight (an vacant) road with a friend a quarter mile or so ahead. With the other vehicle keeping pace ahead of you (and preferably with someone else driving!), adjust the calibration pot, R36, until the top LED is on. Now pass the signal source, the bottom LED should now be on. Doing the calibration while in motion helps average out the local reflections which can throw off stationary bearings.

The receive frequency used for calibration can be anywhere in the band of interest, and it isn't necessary to recalibrate when you QSY. Be sure to run a check on signals to the right and left of the vehicle. This ensures that an error in wiring has not caused a mirror image display.

The level of the radio's volume changes the apparent direction of the signal. You can see this by tuning in a signal and varying the volume up and down. Make sure not to take bearings with too low an audio input level. Don't trust the display to remember a bearing after the signal disappears, take the reading while the signal is still there.

As you drive along note the amount of flutter on the display caused by multipath and reflections. The amount of flutter can be controlled by the setting of the damping control pot, R35. You'll probably want the damping to be at the maximum setting, unless the transmissions are extremely short.

Parts List For Doppler DF unit

Resistors (in ohms)

10	R47
47	R37
100	R20
330	R31
680	R24, R25, R26, R27
2.2K	R5, R48
3K	R46
3.3K	R28, R42, R43, R44
10K	R18, R29, R45
13K	R39
15K	R6, R22
18K	R10
22K	R9
33K	R3, R4, R7, R8, R12, R13, R14, R19, R21, R32, R33
47K	R15, R17, R38
51K	R2, R16
56K	R41
82K	R23
100K	R11, R30
330K	R40

Pots:

10K	R1
500K	R34, R35, R36

Capacitors (in mfd's) :

.001	C17, C19, C20
.0022	C18
.01	C1, C2, C3, C4, C5, C14, C15, C30, C31, C37, C39, C40, C41, C42, C43, C44, C45, C46, C47, C48, C49, C50, C51
.1	C6, C7, C8, C9, C10, C11, C12, C13, C21, C23, C25, C27, C29, C32, C38
.47	C16
1	C28 (Non-Polarized Electrolytic - Radial Leads)
4.7	C22, C24 (Electrolytic - Radial Leads)
10	C35, C36 (Electrolytic - Radial Leads)
100	C26 (Electrolytic - Radial Leads)
220	C33, C34 (Electrolytic - Radial Leads)

Diodes:

1N4003	D1
1N4148	D3, D22, D23

LED's:

(15ma max.)
D2, D4, D6, D7, D8, D9, D10, D11, D12, D13, D14, D15, D16, D17, D18,
D19, D20, D21

IC's:

LM324	U1, U2, U12
CD4051	U3
555	U4, U8
CD4049	U5
74LS75	U6
74HC154	U7 (Narrow Body Part - 300 mil spacing - National part)
CD4024	U9
CD4028	U10
LM7805	U11
74LS00	U13
LM386	U14

Transistors:

2N2222	Q1, Q2
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Switches:

DPDT	S1
SPST	S2, S3

Connectors:

6 Pin	P1 pins 1 - 6 (ANTENNA) pin 6 is not used
2 Pin	P1 pins 7 - 8 (AUDIO)
2 Pin	P1 pins 9 - 10 (POWER)
2 Pin	J1 (Shorting jumper to disable low detect circuit)
2 Pin	J2 (SPEAKER)

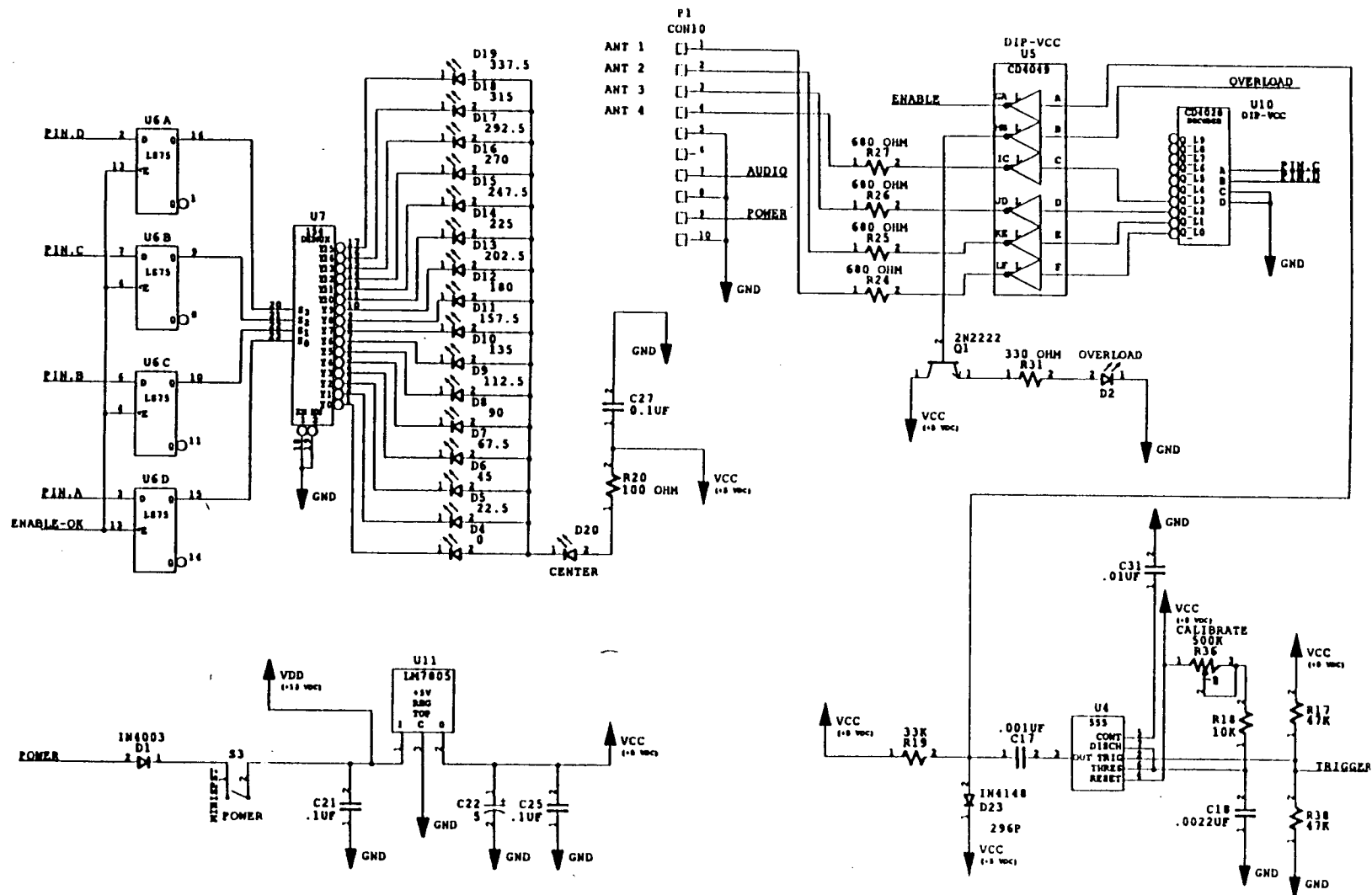
Note: Connector P1 can be a single 10 pin connector on .1" centers.

Antenna Parts:

MPN-3401	D101, D102, D103, D104 (PIN Diodes)
6.8uh	L101, L102, L103, L104
680pf	C101, C102, C103, C104, C105, C106, C107, C108
RG174	Coax - 8 Pieces 1/4 wavelength long times velocity factor of coax.(13.25" for 146MHz at velocity factor of .66)Notes: The square pad on the PCB is pin 1 for the device. This does not apply to Q1 and Q2. When installing P1, J1 and J2 connectors, you may want to put them on the solder side of the PCB, depending on your installation.

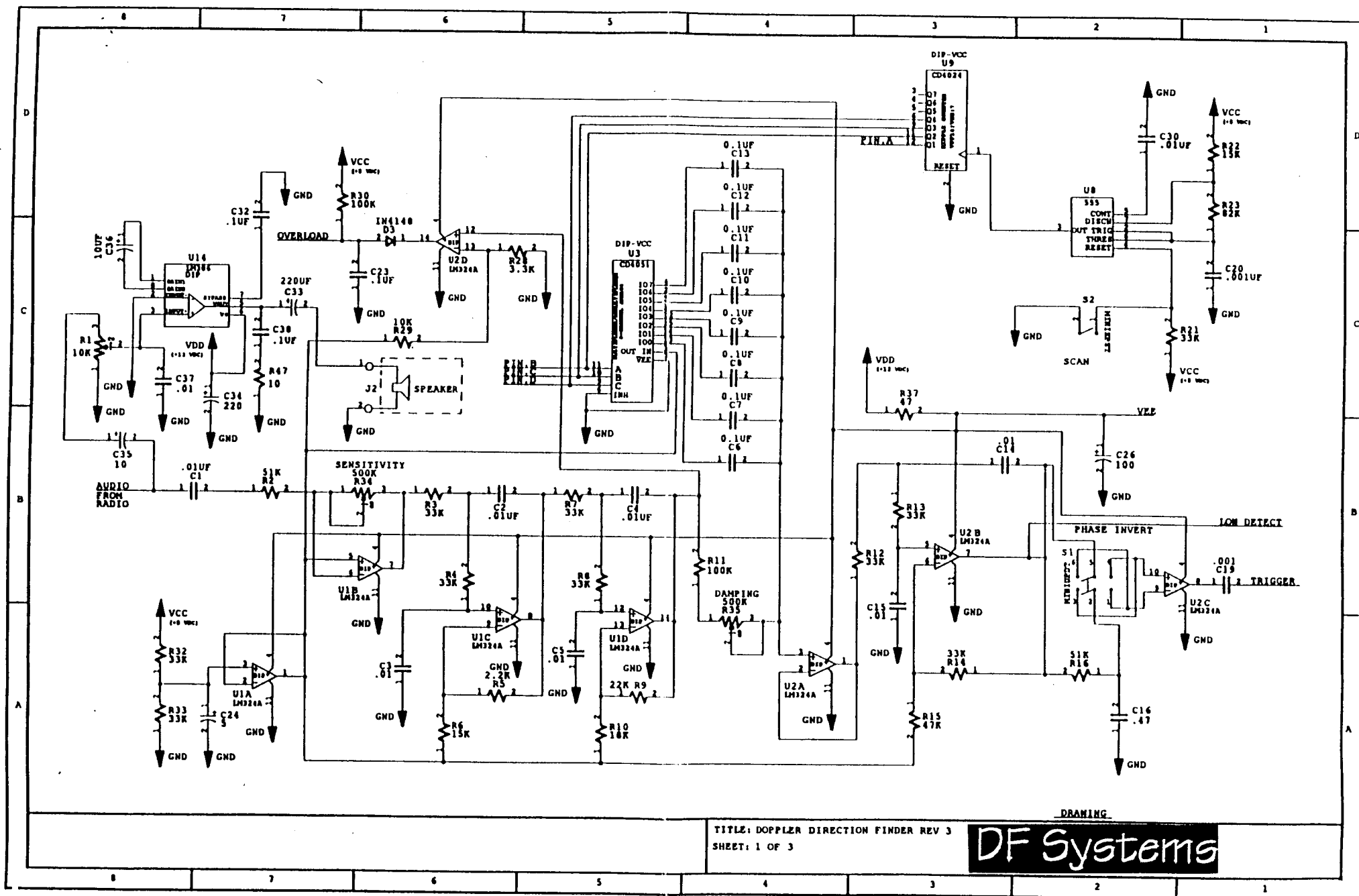
When the jumper is on J1, the low detect circuit is disabled and the LOW DETECT LED (D21) will always be off.

The SCAN switch (S2) STOPS the scan when turned ON. You should mount this switch upside down on the panel so it makes sense



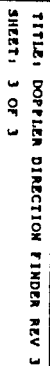
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DF Systems

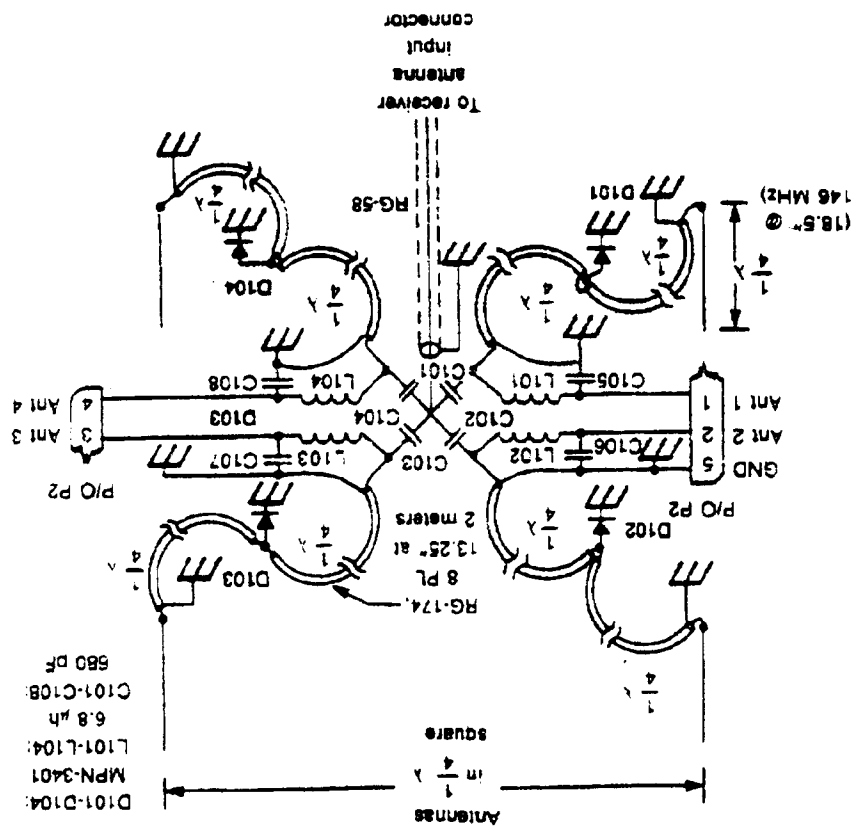


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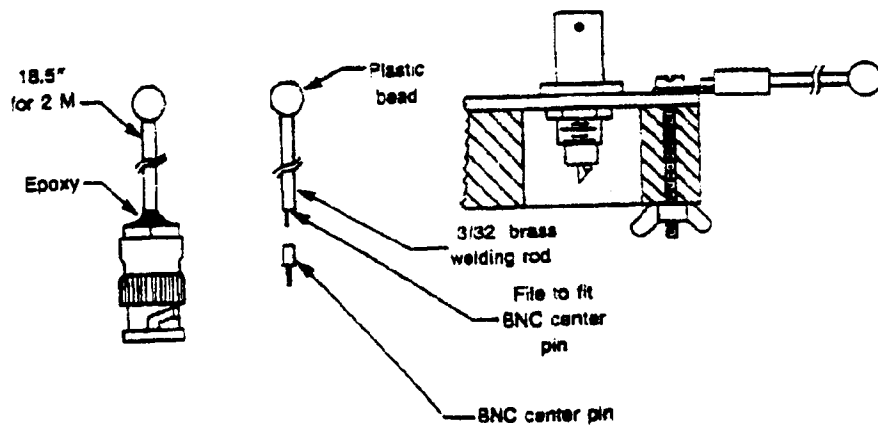
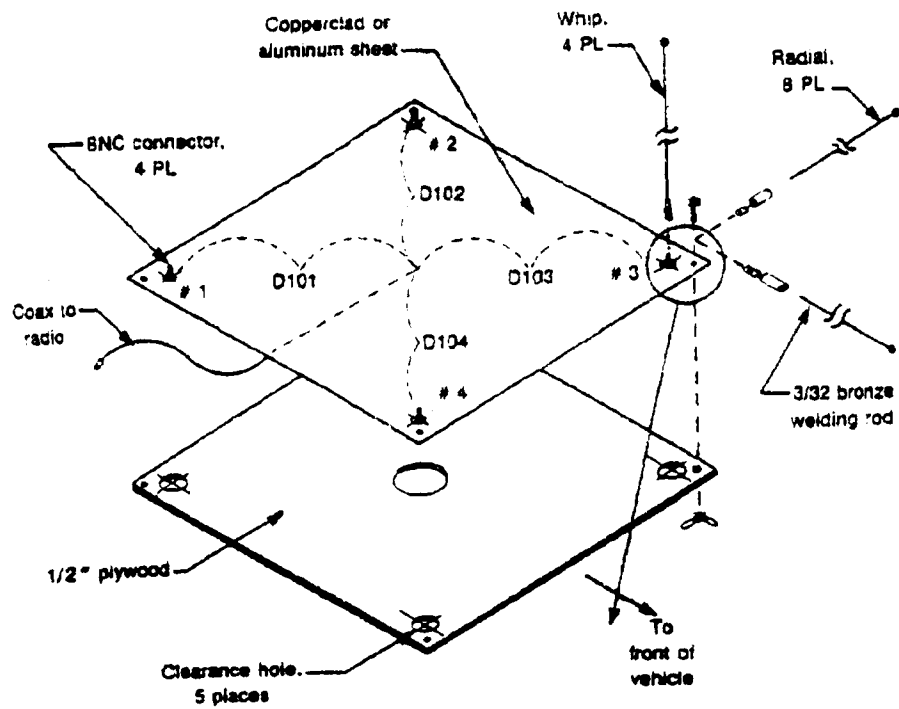
DF Systems

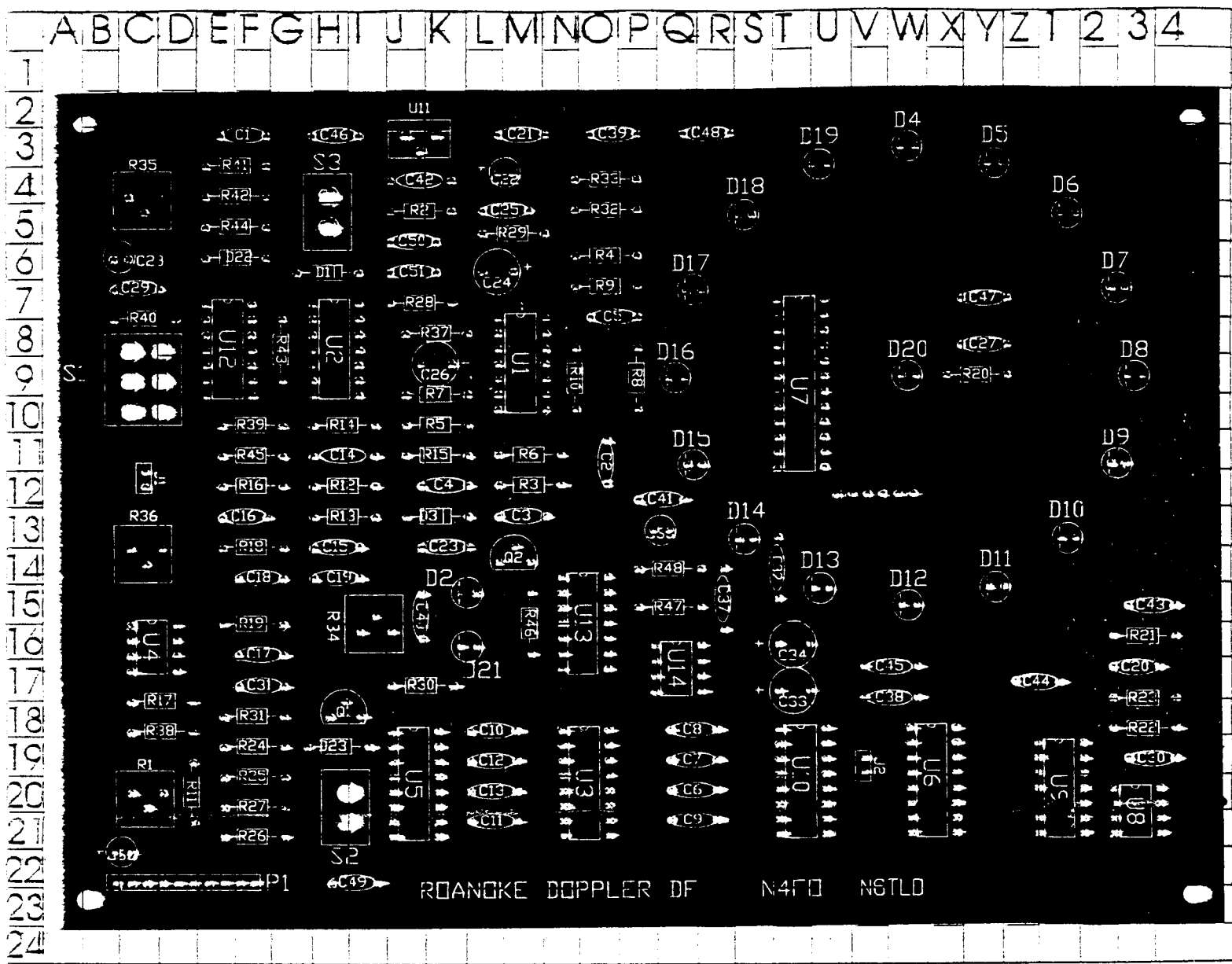


DF Systems



D101-D104:
MPN-3401
L101-L104:
6.8 μ h
C101-C108:
560 pF





GRID LOCATION

- B-21
- P-13
- K-12
- E-5
- U-12

NOTATION

- C35
- C36 (POS IS LEFT HOLE)
- D3 (PIN 1 IS RIGHT HOLE)
- D22 (PIN1 IS LEFT HOLE)
- PARALLEL DATA OUTPUT

PINOUT

- 1 - +5VDC
- 2 - GROUND
- 3 - BIT 1
- 4 - BIT 2
- 5 - BIT 3
- 6 - BIT 4