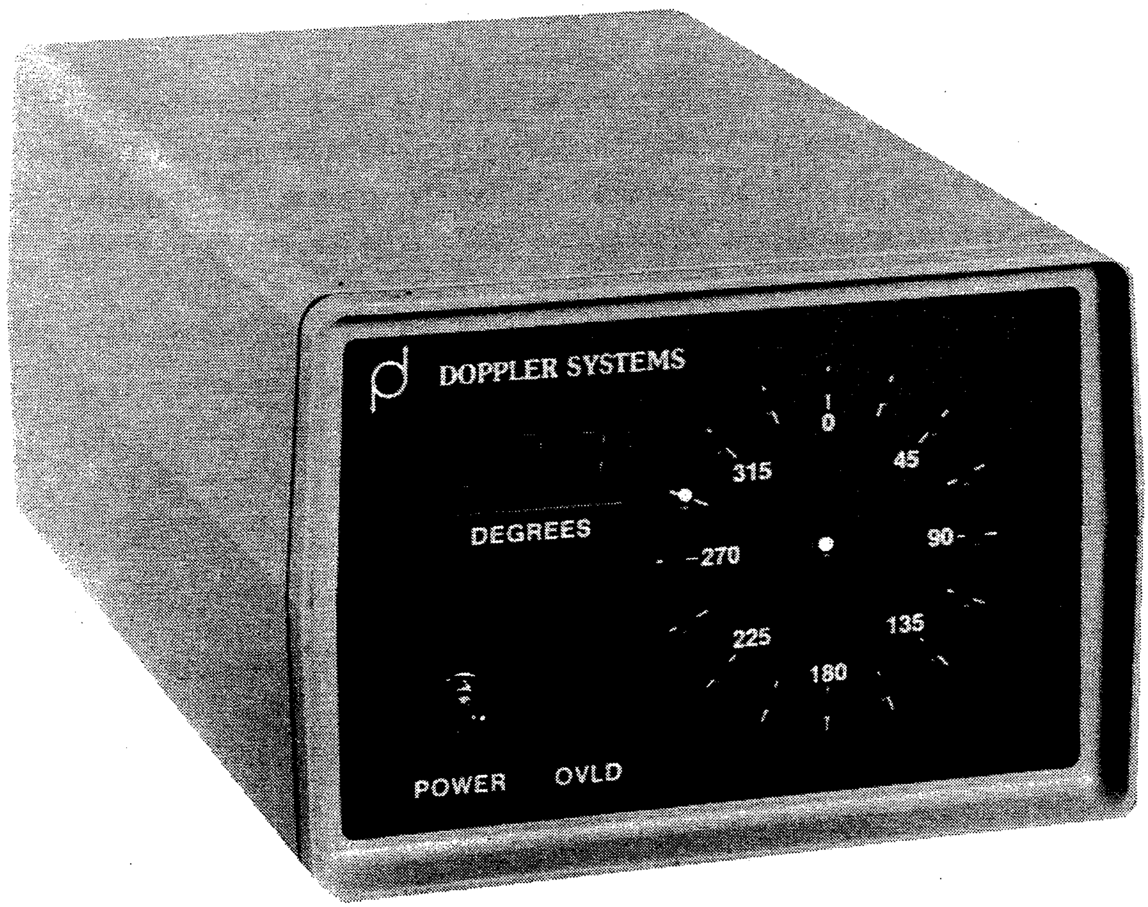
ASSEMBLY AND OPERATION
OF
RADIO DIRECTION FINDER MODELS
DDF-3001, 3002 AND 3003



DOPPLER SYSTEMS®
37002 Sidewinder Road
Carefree, Arizona 85377

Limited Warranty Information

Doppler Systems will repair or replace, at our option, any parts found to be defective in either materials or workmanship for a period of ninety (90) days from the date of shipping. Defective parts must be returned for replacement.

If a defective part or design error causes your Radio Direction Finder to operate improperly during the ninety day warranty period, Doppler Systems will service it free if returned at owner's expense. If improper operation is due to an error on the part of the purchaser, there may be a repair charge.

Doppler Systems is not responsible for damage caused by the use of improper tools or solder, failure to follow the printed instructions, misuse or abuse, unauthorized modifications, misapplication of the unit, theft, fire or accidents. This warranty applies only to the equipment sold by Doppler Systems and does not cover incidental or consequential damages.

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SECTION 1.0
INTRODUCTION

Radio direction finders based on the Doppler principle have been used in aeronautical applications for many years. While their performance is generally much better than other methods of direction finding, Doppler systems have been large, complex and expensive. In a typical system, an array of eight to sixteen antennas are switched electronically to approximate a single rotating antenna. The principle on which your Radio Direction Finder works* simulates a smoothly rotating antenna by continuously summing the outputs of four antennas mounted in a square array. As the simulated rotating antenna moves toward the rf source, an increase in the apparent signal frequency occurs, and as the antenna recedes from the source, this frequency decreases. This up-down (Doppler) shift is detected by your FM receiver and is present as a 300 Hz tone on the audio output. Since the phase of this tone is related to the bearing angle, your direction finder electronics can compute and display the bearing information without any modification to your receiver.

This manual contains the step by step assembly instructions for Radio Direction Finder Models DDF-3001, 3002 and 3003. It also gives detailed instructions for building an antenna suitable for either mobile or fixed location use with any of the models. Installation, calibration and a technical description which permits signal tracing to isolate any problems you might experience with the unit are also provided.

The three models differ in the display and the serial data interface provided. DDF-3001 is the basic unit which provides bearing display with an array of sixteen light emitting diodes spaced 22-1/2 degrees apart. Models DDF-3002 and 3003 also contain a digital readout giving 1 degree resolution. A serial audio frequency shift keyed interface suitable for remote readout, tape recording, telemetry, etc. is contained in Model DDF-3003.

Your kit consists of this manual, a plastic enclosure and several parts packages. Do not open any of these packages until instructed to do so to avoid losing or intermixing parts. Save the cardboard box and packing material just in case you have to return the unit to Doppler Systems for repair.

*patent pending

You have purchased an instrument which has been designed to give you trouble-free, accurate radio direction finding capability with your standard VHF-FM receiver. Be sure to read the general assembly instructions thoroughly and follow all of the directions carefully to avoid unnecessary problems later.

SECTION 2.0
ASSEMBLY PROCEDURE

2.1 GENERAL INSTRUCTIONS ON ASSEMBLY

This kit employs double-sided printed wiring boards (PWBs) having plated through holes for each of the major circuit assemblies. The circuit assemblies are interconnected by a system of plug in jumper cables, and all integrated circuits (ICs) are socket mounted to facilitate construction and maintenance. However, the relatively high density of the circuitry requires that proper tools and techniques be employed during kit assembly. This section should be read first to minimize the possibility of making a mistake.

Tools required to assemble the electronics include: small needle-nose pliers, small diagonal wire cutters, wire strippers, small screwdriver, 1/4 and 5/16-inch end wrenches, 1/2-inch deep well socket, soldering iron, vise, and IC insertion tool. It is highly recommended that a grounded temperature controlled soldering station such as the Weller® WTCPN be used. A conical tip of 1/32-inch diameter (700° F) is practically essential for the circuit board assembly while the 1/16-inch screwdriver tip (700° F) is more convenient for other use. A swivel type vise such as the Panavise® is strongly recommended as well. The OK Machine Tool® IC insertion tool MOS-1416 is also recommended.

A good quality resin flux cored solder (60% tin) should be used. A diameter of .031 inch is recommended.

Unless otherwise noted, all components are to be inserted from the front side of each PWB and soldered on the back side. In the assembly procedure, "insert" means to preform to leads to conform to the PWB hole spacing, insert the leads until the component body is flush with the board, then spread the leads slightly on the back side to hold the part in place when the board is turned over for soldering. Note that the hole spacing of most resistors and capacitors is uniform at 1/2 inch and 1/4 inch respectively. If a part does not appear to fit with this spacing, or a lead appears to fit too tightly into a hole, check that the correct hole is being used. Most of the feed through holes not used for component mounting are deliberately undersized.

You may need to spread the leads on the smaller mylar and mica capacitors slightly before insertion. Do not attempt to mount these parts flush with the board; 1/16 to 1/8-inch spacing is right.

Do not solder or trim leads except where noted. Trim leads parallel to the board just above the solder fillet. The pins on the dual inline package (DIP) sockets, DIP jumpers, and heavier gauge terminals such as used on the on-off switch and fuse holders are not trimmed. When soldering, place the PWB flat and hold the iron so that the tip end contacts the lead. Apply just enough solder to form a good bond and to enclose the hole around the lead. The solder should flow down into the hole slightly. When a step calls for tack soldering, place the PWB nearly vertical and allow the iron to heat the pad (not necessarily the lead). Feed solder to the pad with one hand while holding the iron with the other. When the solder begins to flow, keep the iron on the pad and use your other hand to seat the part flush with the top surface of the board. Then remove the iron and allow the solder to solidify. Tack soldered joints are always reflowed later, so electrical integrity and appearance are not too important; their purpose is to hold the part when the board is rotated horizontally for permanent soldering. Never try to cool a solder joint by blowing or wetting. If you should ever have to remove a soldered part, use a good quality desoldering tool.

Component values are given in the parts lists and the step by step procedure with their common or alternate markings in parentheses. The first three bands on carbon resistors are given. (The tolerance band, usually gold, is the fourth color.) Resistors should be installed so that the color bands read uniformly from left to right or from top to bottom. Ceramic, mylar and mica capacitor values are marked in several different ways. Small values may be printed directly in pF, for example, "22", "470", etc. Larger values may be printed on the part in uF directly, for example, ".022", ".1", etc. Alternatively, any size may be represented by three digits. In the latter case, the third digit indicates the number of zeros to be added to the first two digits to get the value in pF. For example, "104" = 100,000 pF = .10 uF; "472" = 4700 pF = .0047 uF; "270" = 27 pF. Mount these capacitors so that the value faces the nearest edge of the PWB.

Electrolytic capacitors are marked in uF. The insulated terminal is polarized positive and usually a "+" is printed on the side pointing to this terminal. Observe proper polarity when mounting electrolytics and bend the leads so that the value is readable after mounting.

Cathodes on axial diodes are marked by a stripe on the side nearest this terminal. On the light emitting diodes (LEDs), the plastic lens is formed into a "D" at the bottom. The flat portion of the "D" is nearest the cathode lead. Use particular care to avoid stressing the glass bodies of axial diodes or the plastic lenses of the LEDs.

Integrated circuits should be inserted using a grounded insertion tool. Before inserting, be sure the leads are straight. Pin 1 is identified variously by a molded dot on the top surface, a semicircular notch on the end, a rectangular notch on the end or a "1". Many of the integrated circuits used are CMOS devices capable of being damaged by static electrical charge accumulation. To minimize the possibility of damaging these devices, they should be left in their conductive foam until ready for installation.

The step by step assembly procedure which follows is written for the three models offered. Follow the steps indicated by parentheses in the column corresponding to your model direction finder and skip steps marked by a dash. Place a check mark between the parentheses to indicate a completed step. It is recommended that you double check part values and placement before each soldering operation. It is much more difficult to change a part once it is soldered in place.

2.2 POWER SUPPLY AND CLOCK ASSEMBLY

Unpack the package marked PK7-1, PK7-2 or PK7-3, depending on the model number ordered, and check off the parts supplied against the following parts list. Do not remove the integrated circuits from the protective foam at this time.

ITEM	DESCRIPTION	QUANTITY SUPPLIED, MODEL DDF—		
		3001	3002	3003
Parts Package		PK7-1	PK7-2	PK7-3
Printed Wiring Board	DDF 3017	1	1	1
Fuse Clips	---	2	2	2
Fuse	3AG-2A	1	1	1
DIP Sockets	14 pin gold 16 pin gold 8 pin tin 14 pin tin	1 1 1 1	1 1 1 2	1 1 1 3

ITEM	DESCRIPTION	QUANTITY SUPPLIED, MODEL DDF—		
		3001	3002	3003
Transistors	2N2222A	2	2	2
	2N2907A	1	1	1
	2N5320	1	1	1
	2N5322	1	1	1
Diodes	1N4001	2	2	2
Integrated Circuits	CD4001B (MC14001)	1	1	1
	CD4024	-	1	1
	LM320T-6 (7906)	1	1	1
	LM340T-8 (7808)	1	1	1
	LM380	-	-	1
	LM1458 (4558)	1	1	1
Crystals	1.2288 MHz	1	1	1
	1.7280 MHz	-	1	1
Resistors	2.7 ohm (RED-VIO-GLD)	-	-	1
	3.3K (ORG-ORG-RED)	1	1	1
	5.1K (GRN-BRN-RED)	-	-	1
	10K (BRN-BLK-ORG)	1	1	1
	13K (BRN-ORG-ORG)	1	1	1
	20K (RED-BLK-ORG)	-	-	1
	39K (ORG-WHT-ORG)	1	1	1
	51K (GRN-BRN-ORG)	2	2	2
	360K (ORG-BLU-YEL)	-	-	1
	9.1M (WHT-BRN-GRN)	1	2	2
Trim pot	500K (504)	1	1	1
Disc Ceramic Capacitors	.01 uF (103)	-	-	1
	.047 uF (473) or .05 uF (503)	1	2	2
	.1 uF (104)	6	6	9
Mylar Capacitors	.001 uF (102)	2	3	3
	.022 uF (223)	1	1	1
Electrolytic Capacitors	4.7 uF	1	1	1
	220 uF	3	3	3
	470 uF	-	-	1
Mica Capacitor	120 pF (121)	1	2	2

Assemble the printed wiring board following the steps given below for your model Direction Finder. Skip any step marked by a dash, and place a check mark between the parentheses after completing each step.

MODEL DDF-			STEP
3001	3002	3003	
( )	( )	( )	Position PWB DDF 3017 as shown in Figure 2.2-1.
			Note - When installing DIP sockets, stand the PWB in a nearly vertical orientation, and insert the socket. Tack solder the pins on the back side by flowing a small amount of solder on to the pad, then press the socket flush to the PWB before removing the iron from the back side.
( )	( )	( )	Insert U1 socket, 14 pin tin, pin 1 up. Tack solder pins 1 and 8.
--	( )	( )	Insert U2 socket, 14 pin tin, pin 1 up. Tack solder pins 1 and 8.
--	--	( )	Insert U8 socket, 14 pin tin, pin 1 up. Tack solder pins 1 and 8.
( )	( )	( )	Check that above sockets are flush on the PWB, turn the board over and solder all pins starting with the highest pin (14). Reflow the tack soldered pins also.
( )	( )	( )	Insert U7 socket, 8 pin tin, pin 1 up. Tack solder pins 1 and 5.
( )	( )	( )	Insert S8 socket, 16 pin <u>gold</u>, pin 1 left. Tack solder pins 1 and 9.
( )	( )	( )	Insert S7 socket, 14 pin <u>gold</u>, pin 1 left. Tack solder pins 1 and 8.
( )	( )	( )	Check that the above sockets are flush on the PWB, turn the board over and solder all pins starting with the highest numbered pin.

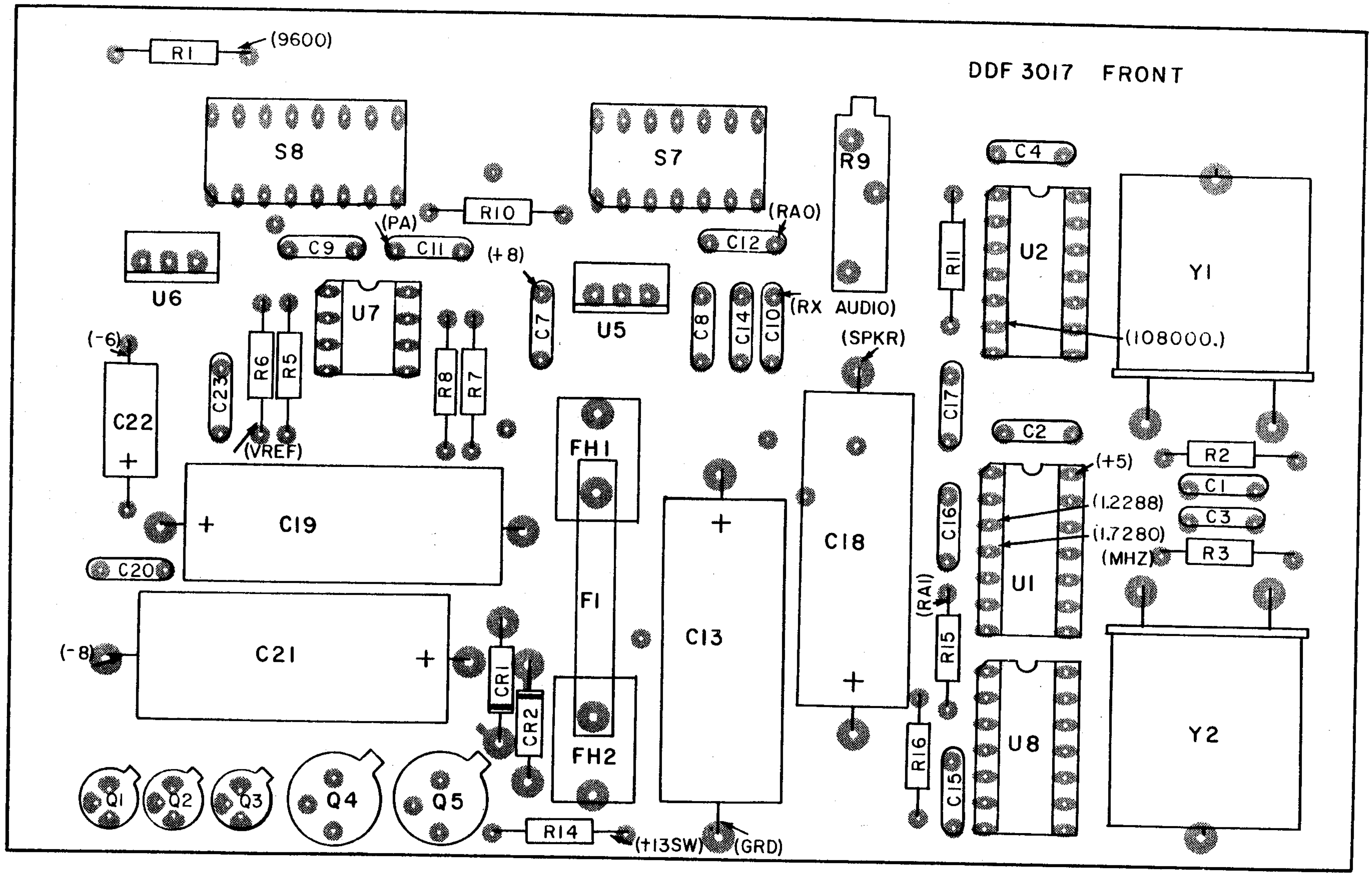


Figure 2.2-1

Power Supply and Clock PWB Assembly

MODEL DDF-			STEP
3001	3002	3003	
( )	( )	( )	Insert R1, 51K (GRN-BRN-ORG).
( )	( )	( )	Insert R6, 13K (BRN-ORG-ORG).
( )	( )	( )	Insert R5, 39K (ORG-WHT-ORG).
( )	( )	( )	Insert C23, .1 uF ceramic (104).
( )	( )	( )	Insert R8, 10K (BRN-BLK-ORG).
( )	( )	( )	Insert R7, 51K (GRN-BRN-ORG).
( )	( )	( )	Insert C7, .1 uF ceramic (104).
( )	( )	( )	Solder and trim leads.
( )	( )	( )	Insert C8, .1 uF ceramic (104).
( )	( )	( )	Insert C14, .1 uF ceramic (104).
( )	( )	( )	Insert C10, .022 uF mylar (223).
( )	( )	( )	Insert C20, .1 uF ceramic (104).
( )	( )	( )	Insert CR1, 1N4001, cathode down.
( )	( )	( )	Insert CR2, 1N4001, cathode up.
( )	( )	( )	Solder and trim leads.
--	--	( )	Insert R10, 20K (RED-BLK-ORG).
--	--	( )	Insert C12, .1 uF ceramic (104).
--	--	( )	Insert R11, 2.7 ohm (RED-VIO-GLD).
--	--	( )	Insert C17, .1 uF ceramic (104).
--	--	( )	Insert C16, .1 uF ceramic (104).
--	--	( )	Insert R15, 360K (ORG-BLU-YEL).
--	--	( )	Insert R16, 5.1K (GRN-BRN-RED).
--	--	( )	Insert C15, .01 uF ceramic (103).
--	--	( )	Solder and trim leads.

MODEL DDF-			STEP
3001	3002	3003	
( )	( )	( )	Insert R2, 9.1M (WHT-BRN-GRN).
( )	( )	( )	Insert C1, .001 uF mylar (102).
( )	( )	( )	Insert R14, 3.3K (ORG-ORG-RED).
( )	( )	( )	Insert C2, .047 uF ceramic (473).
( )	( )	( )	Insert C9, .1 uF ceramic (104).
( )	( )	( )	Insert C11, .001 uF mylar (102).
( )	( )	( )	Solder and trim leads.
--	( )	( )	Insert C4, .047 uF ceramic (473).
--	( )	( )	Insert C3, .001 uF mylar (102).
--	( )	( )	Insert R3, 9.1M (WHT-BRN-GRN).
--	( )	( )	Solder and trim leads.
( )	( )	( )	Insert Q4, 2N5320. Align tab as shown and space approximately 1/16" off PWB.
( )	( )	( )	Insert Q5, 2N5322. Align tab as shown and space approximately 1/16" off PWB.
( )	( )	( )	Solder and trim leads.
( )	( )	( )	Insert Q3, 2N2907A. Align tab as shown and space approximately 1/16" off PWB.
( )	( )	( )	Insert Q2, 2N2222A. Align tab as shown and space approximately 1/16" off PWB.
( )	( )	( )	Insert Q1, 2N2222A. Align tab as shown and space approximately 1/16" off PWB.

MODEL DDF-			STEP
3001	3002	3003	
( )	( )	( )	Solder and trim leads.
			Note - When installing the fuse holders, stand the board vertically, insert the holder, and hold it flush against the PWB using a pair of pliers. To tack solder, first apply solder directly to the iron tip, then apply the tip to the back side of the pad just above the fuse holder tab such that the solder flows down around the tab. When permanently soldering the two tabs on each holder, allow each tab to cool off sufficiently before applying heat to the other so that the holder does not come loose and fall from the board.
( )	( )	( )	Insert FH1, slotted end up. Tack solder bottom tab.
( )	( )	( )	Insert FH2, slotted end down. Tack solder bottom tab.
( )	( )	( )	Insert R9, 500K trim pot (504). Tack solder central terminal.
( )	( )	( )	Check that FH1, FH2, and R9 are flush on the PWB, then solder permanently.
			Note - U5 and U6 stand approximately 1/4" off PWB.
( )	( )	( )	Insert U5, LM340T-8 (7808), tab down. Tack solder.
( )	( )	( )	Insert U6, LM320T-6 (7906), tab down. Tack solder.
( )	( )	( )	Check that U5 and U6 are perpendicular to the PWB, then solder permanently and trim leads.
--	--	( )	Insert C18, 470 uF electrolytic, + down.
( )	( )	( )	Insert C13, 220 uF electrolytic, + up.
( )	( )	( )	Insert C19, 220 uF electrolytic, + left.
( )	( )	( )	Insert C21, 220 uF electrolytic, + right.
( )	( )	( )	Check polarities of these capacitors, then solder and trim leads.
			Insert C22, 4.7 uF electrolytic, + down.
			Note - Before inserting the crystals, hold each lead with pliers adjacent to the crystal holder and bend the lead by hand approximately 1/8 inch from the holder.

MODEL DDF-			STEP
3001	3002	3003	
( )	( )	( )	Insert Y1, 1.2288 MHz crystal.
--	( )	( )	Insert Y2, 1.7280 MHz crystal.
( )	( )	( )	Solder and trim leads.
( )	( )	( )	Carefully inspect the back side of the PWB for evidence of cold solder joints, solder bridges or missing solder connections, particularly on the DIP sockets. Reflow any questionable solder joints before proceeding with integrated circuit installation.
( )	( )	( )	Insert F1, 2 ampere 3AG fuse between FH1 and FH2.
( )	( )	( )	Insert U1, CD4001B (MC14001), pin 1 up.
--	( )	( )	Insert U2, CD4024 (MC14024), pin 1 up.
--	--	( )	Insert U8, LM380, pin 1 up.
( )	( )	( )	Insert U7, LM1458 (4558), pin 1 up.
( )	( )	( )	Install a 120 pF mica capacitor (121) between ground and the lead of crystal Y1 (and Y2 on Models 3002 and 3003) nearest the edge of the PWB. Cut both leads on the capacitor to 3/8 inch. Solder one lead to the ground foil between the crystal leads and wrap the other lead around the crystal lead nearest the right edge of the PWB. Solder.

2.3 SIGNAL PROCESSOR ASSEMBLY

Unpack the package marked PK-6 and check off the parts supplied against the following parts list. Do not remove the integrated circuits from the protective foam at this time.

ITEM	DESCRIPTION	QUANTITY SUPPLIED, MODEL DDF—		
		3001	3002	3003
Parts Package		PK-6	PK-6	PK-6
Printed Wiring Board	DDF 3016.	1	1	1
DIP Sockets	16 pin gold	1	1	1
	8 pin tin	5	5	5
	14 pin tin	1	1	1
	16 pin tin	7	7	7
	20 pin tin	1	1	1
DIP Jumper	16 pin, 3 inch long	1	1	1
Integrated Circuits	74LS273	1	1	1
	CA3240	1	1	1

ITEM	DESCRIPTION	QUANTITY SUPPLIED, MODEL DDF—		
		3001	3002	3003
	CD4008 (MC14008)	1	1	1
	CD4011 (MC14011)	1	1	1
	CD4040 (MC14040)	1	1	1
	CD4051 (MC14051)	2	2	2
	DDF 3109	1	1	1
	DDF 3110	1	1	1
	LM1458 (4558)	4	4	4
	MC1408	1	1	1
Diodes	1N4148	3	3	3
Resistors	1.0K (BRN-BLK-RED)	2	2	2
	1.2K (BRN-RED-RED)	1	1	1
	2.4K (RED-YEL-RED)	1	1	1
	3.0K (ORG-BLK-RED)	1	1	1
	3.3K (ORG-ORG-RED)	1	1	1
	4.3K (YEL-ORG-RED)	1	1	1
	5.1K (GRN-BRN-RED)	1	1	1
	10K (BRN-BLK-ORG)	5	5	5
	16K (BRN-BLU-ORG)	1	1	1
	20K (RED-BLK-ORG)	4	4	4
	27K (RED-VIO-ORG)	1	1	1
	30K (ORG-BLK-ORG)	1	1	1
	39K (ORG-WHT-ORG)	1	1	1
	100K (BRN-BLK-YEL)	1	1	1
	110K (BRN-BRN-YEL)	1	1	1
	200K (RED-BLK-YEL)	1	1	1
	240K (RED-YEL-YEL)	4	4	4
	390K (ORG-WHT-YEL)	1	1	1
	470K (YEL-VIO-YEL)	1	1	1
	510K (GRN-BRN-YEL)	1	1	1
	1.2M (BRN-RED-GRN)	1	1	1
Disc Ceramic Capacitors	.1 uF (104)	3	3	3
Dipped Mica Capacitors	3 pF (030)	1	1	1
	27 pF (270)	1	1	1
	120 pF (121)	1	1	1
	220 pF (221)	1	1	1
Mylar Capacitors	.001 uF (102)	3	3	3
	.0022 uF (222)	3	3	3
	.0047 uF (472)	1	1	1
	.047 uF (473)	11	11	11
	.1 uF (104)	1	1	1
Electrolytic Capacitors	1.0 uF	1	1	1

Assemble the printed wiring board following the steps given below for your model Direction Finder. Skip any step marked by a dash, and place a check mark between the parentheses after completing each step.

MODEL DDF-			STEP
3001	3002	3003	
( )	( )	( )	Position PWB DDF 3016 as shown in Figure 2.3-1.
( )	( )	( )	Insert U1 socket, 8 pin tin, pin 1 up. Tack solder pins 1 and 5.
( )	( )	( )	Insert U2 socket, 8 pin tin, pin 1 up. Tack solder pins 1 and 5.
( )	( )	( )	Insert U8 socket, 8 pin tin, pin 1 up. Tack solder pins 1 and 5.
( )	( )	( )	Insert U9 socket, 8 pin tin, pin 1 up. Tack solder pins 1 and 5.
( )	( )	( )	Insert U14 socket, 8 pin tin, pin 1 up. Tack solder pins 1 and 5.
( )	( )	( )	Check that above sockets are flush with PWB, turn the board over and solder all pins, beginning with the highest numbered pin (pin 8). Reflow the tack soldered pins.
( )	( )	( )	Insert U3 socket, 16 pin tin, pin 1 up. Tack solder pins 1 and 9.
( )	( )	( )	Insert U4 socket, 16 pin tin, pin 1 up. Tack solder pins 1 and 9.
( )	( )	( )	Insert U5 socket, 20 pin tin, pin 1 up. Tack solder pins 1 and 11.
( )	( )	( )	Insert U6 socket, 16 pin tin, pin 1 up. Tack solder pins 1 and 9.
( )	( )	( )	Insert U7 socket, 16 pin tin, pin 1 up. Tack solder pins 1 and 9.
( )	( )	( )	Check that the above sockets are flush with the PWB and solder all pins, starting with the highest numbered pins. Reflow the tack soldered pins.
( )	( )	( )	Insert U10 socket, 16 pin tin, pin 1 up. Tack solder pins 1 and 9.

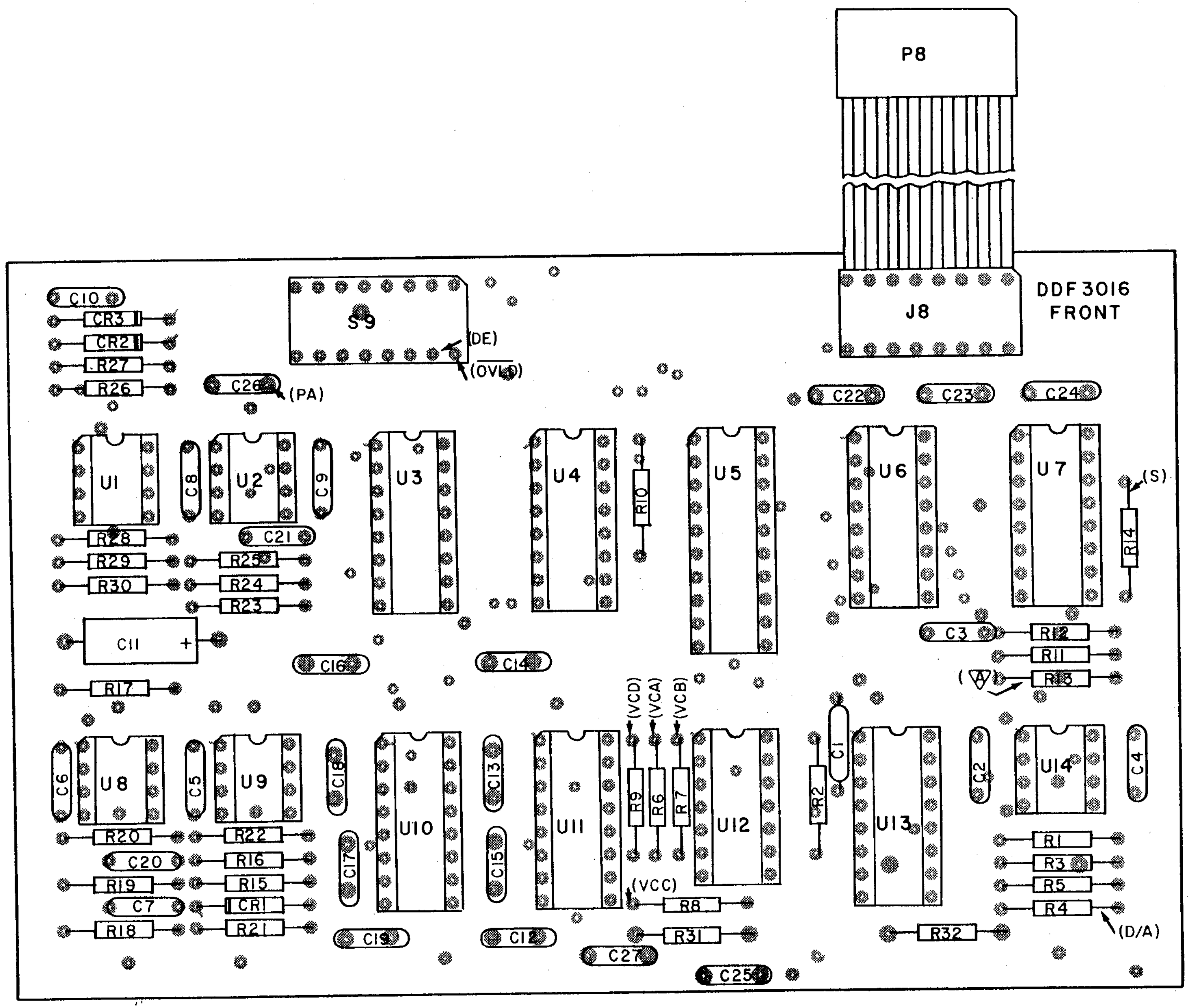


Figure 2.3-1

Signal Processor PWB Assembly

MODEL DDF-			STEP
3001	3002	3003	
( )	( )	( )	Insert U11 socket, 16 pin tin, pin 1 up. Tack solder pins 1 and 9.
( )	( )	( )	Insert U12 socket, 14 pin tin, pin 1 up. Tack solder pins 1 and 8.
( )	( )	( )	Insert U13 socket, 16 pin tin, pin 1 up. Tack solder pins 1 and 9.
( )	( )	( )	Check that the above sockets are flush with the PWB and solder all pins, starting with the highest numbered pins. Reflow the tack soldered pins.
( )	( )	( )	Insert S9 socket, 16 pin <u>gold</u>, pin 1 right. Tack solder pins 1 and 9.
( )	( )	( )	Insert the 16 pin, 3 inch DIP jumper at J8. Orient P8 above the PWB as shown in Figure 2.3-1. Pin 1 on both P8 and J8 are at top right. Tack solder pins 1 and 9 on J8.
( )	( )	( )	Check that S9 and J8 are flush with the PWB and solder all pins, starting with the highest numbered pin. Reflow the tack soldered pins.
( )	( )	( )	Insert C10, .047 uF mylar (473).
( )	( )	( )	Insert CR3, 1N4148, cathode right.
( )	( )	( )	Insert CR2, 1N4148, cathode right.
( )	( )	( )	Insert R27, 470K (YEL-VIO-YEL).
( )	( )	( )	Insert R26, 20K (RED-BLK-ORG).
( )	( )	( )	Insert R28, 510K (GRN-BRN-YEL).
( )	( )	( )	Insert R29, 390K (ORG-WHT-YEL).
( )	( )	( )	Insert R30, 110K (BRN-BRN-YEL).
( )	( )	( )	Solder and trim leads.
( )	( )	( )	Insert C21, .001 uF mylar (102).
( )	( )	( )	Insert R25, 240K (RED-YEL-YEL).
( )	( )	( )	Insert R24, 240K (RED-YEL-YEL).
( )	( )	( )	Insert R23, 200K (RED-BLK-YEL).

MODEL DDF-			STEP
3001	3002	3003	
( )	( )	( )	Insert C11, 1.0 uF electrolytic, + right.
( )	( )	( )	Insert R17, 10K (BRN-BLK-ORG).
( )	( )	( )	Insert R20, 240K (RED-YEL-YEL).
( )	( )	( )	Insert C20, .001 uF mylar (102).
( )	( )	( )	Insert R19, 240K (RED-YEL-YEL).
( )	( )	( )	Insert C7, .0022 uF mylar (222).
( )	( )	( )	Insert R18, 100K (BRN-BLK-YEL).
( )	( )	( )	Solder and trim leads.
( )	( )	( )	Insert R22, 20K (RED-BLK-ORG).
( )	( )	( )	Insert R16, 20K (RED-BLK-ORG).
( )	( )	( )	Insert R15, 30K (ORG-BLK-ORG).
( )	( )	( )	Insert CR1, 1N4148, cathode left.
( )	( )	( )	Insert R21, 1.2M (BRN-RED-GRN).
( )	( )	( )	Insert C19, .047 uF mylar (473).
( )	( )	( )	Insert C12, .047 uF mylar (473).
( )	( )	( )	Insert C16, .047 uF mylar (473).
( )	( )	( )	Insert C14, .047 uF mylar (473).
( )	( )	( )	Insert R8, 10K (BRN-BLK-ORG).
( )	( )	( )	Solder and trim leads.
( )	( )	( )	Insert C22, .1 uF ceramic (104).
( )	( )	( )	Insert C23, .1 uF ceramic (104).
( )	( )	( )	Insert C24, .1 uF ceramic (104).
( )	( )	( )	Insert C3, .0047 uF mylar (472).
( )	( )	( )	Insert R12, 20K (RED-BLK-ORG).
( )	( )	( )	Insert R11, 39K (ORG-WHT-ORG).

MODEL DDF-			STEP
3001	3002	3003	
( )	( )	( )	Insert R13, 27K (RED-VIO-ORG).
( )	( )	( )	Insert R1, 1.0K (BRN-BLK-RED).
( )	( )	( )	Insert R3, 3.0K (ORG-BLK-RED).
( )	( )	( )	Insert R5, 2.4K (RED-YEL-RED).
( )	( )	( )	Insert R4, 1.2K (BRN-RED-RED).
( )	( )	( )	Solder and trim leads.
( )	( )	( )	Insert C8, .001 uF mylar (102).
( )	( )	( )	Insert C9, .0022 uF mylar (222).
( )	( )	( )	Insert C6, .0022 uF mylar (222).
( )	( )	( )	Insert C5, .047 uF mylar (473).
( )	( )	( )	Insert C18, .047 uF mylar (473).
( )	( )	( )	Insert C17, .047 uF mylar (473).
( )	( )	( )	Insert C13, .047 uF mylar (473).
( )	( )	( )	Insert C15, .047 uF mylar (473).
( )	( )	( )	Solder and trim leads.
( )	( )	( )	Insert R10, 5.1K (GRN-BRN-RED).
( )	( )	( )	Insert R9, 10K (BRN-BLK-ORG).
( )	( )	( )	Insert R6, 10K (BRN-BLK-ORG).
( )	( )	( )	Insert R7, 10K (BRN-BLK-ORG).
( )	( )	( )	Insert R2, 1.0K (BRN-BLK-RED).
( )	( )	( )	Insert C1, 27 pF mica (270).
( )	( )	( )	Insert C2, 220 pF mica (221).
( )	( )	( )	Insert C4, .047 uF mylar (473).
( )	( )	( )	Insert R14, 4.3K (YEL-ORG-RED).
( )	( )	( )	Solder and trim leads.

MODEL DDF-			STEP
3001	3002	3003	
( )	( )	( )	Insert R31, 3.3K (ORG-ORG-RED).
( )	( )	( )	Insert C27, 120 pF mica (121).
( )	( )	( )	Insert C25, 3 pF mica (030).
( )	( )	( )	Insert R32, 16K (BRN-BLU-ORG).
( )	( )	( )	Insert C26, .1 uF mylar (104).
( )	( )	( )	Solder and trim leads.
( )	( )	( )	Carefully inspect the back side of the PWB for evidence of cold solder joints, solder bridges or missing solder connections - particularly on the DIP sockets. Reflow any questionable joints before proceeding with integrated circuit installation.
( )	( )	( )	Insert U1, LM1458 (4558), pin 1 up.
( )	( )	( )	Insert U2, LM1458 (4558), pin 1 up.
( )	( )	( )	Insert U8, LM1458 (4558), pin 1 up.
( )	( )	( )	Insert U9, LM1458 (4558), pin 1 up.
( )	( )	( )	Insert U3, CD4040 (MC14040), pin 1 up.
( )	( )	( )	Insert U4, CD4008 (MC14008), pin 1 up.
( )	( )	( )	Insert U5, 74LS273, pin 1 up.
( )	( )	( )	Insert U6, DDF 3109, pin 1 up.
( )	( )	( )	Insert U7, DDF 3110, pin 1 up.
( )	( )	( )	Insert U10, CD4051 (MC14051), pin 1 up.
( )	( )	( )	Insert U11, CD4051 (MC14051), pin 1 up.
( )	( )	( )	Insert U12, CD4011 (MC14011), pin 1 up.
( )	( )	( )	Insert U13, MC1408, pin 1 up.
( )	( )	( )	Insert U14, CA3240, pin 1 up.

2.4 BCD GENERATOR ASSEMBLY

Unpack the package marked 8-2 or 8-3, depending on the model number ordered, and check off the parts against the following parts list. (Skip to Section 2.5 if you have ordered Model 3001.) Do not remove the integrated circuits from the protective foam at this time.

ITEM	DESCRIPTION	QUANTITY SUPPLIED, MODEL DDF—		
		3001	3002	3003
Parts Package	---	-	PK8-2	PK8-3
Printed Wiring Board	DDF-3018	-	1	1
DIP Sockets	8 pin gold	-	-	1
	14 pin tin	-	4	7
	16 pin tin	-	8	9
	40 pin tin	-	-	1
DIP Jumpers	24 pin, 3-1/2" long	-	1	1
Wire for PWB Jumpers	2 inch long white	-	1	-
Integrated Circuits	74C903	-	1	2
	AY-3-1015D	-	-	1
	CD4001 (MC14001)	-	2	3
	CD4018 (MC14018)	-	-	1
	CD4040 (MC14040)	-	1	1
	CD4069 (MC14069)	-	1	1
	CD4076 (MC14076)	-	4	4
	CD4518 (MC14518)	-	2	2
	CD4556 (MC14556)	-	1	1
	XR2211	-	-	1
Resistors	5.1K (GRN-BRN-RED)	-	-	1
	9.1K (WHT-BRN-RED)	-	-	1
	10K (BRN-BLK-ORG)	-	-	1
	11K (BRN-BRN-ORG)	-	1	1
	13K (BRN-ORG-ORG)	-	-	1
	20K (RED-BLK-ORG)	-	-	1
	22K (RED-RED-ORG)	-	-	1
	33K (ORG-ORG-ORG)	-	-	3
	51K (GRN-BRN-ORG)	-	-	8
	100K (BRN-BLK-YEL)	-	-	1
	510K (GRN-BRN-YEL)	-	-	1
	1.0M (BRN-BLK-GRN)	-	1	1
Trimpot	5.0K (502)	-	-	1
Disc Ceramic Capacitors	.1 uF (104)	-	-	4

ITEM	DESCRIPTION	QUANTITY SUPPLIED, MODEL DDF—		
		3001	3002	3003
Mylar Capacitors	.001 uF (102)	-	1	2
	.0022 uF (222)	-	-	1
	.0047 uF (472)	-	-	2
	.01 uF (103)	-	-	1
	.022 uF (223)	-	-	1
	.047 uF (473)	-	1	1

Assemble the printed wiring board following the steps given below for your model Direction Finder. Skip any step marked by a dash, and place a check mark between the parentheses after completing each step.

MODEL DDF-			STEP
3001	3002	3003	
--	( )	( )	Position PWB DDF-3018 as shown in Figure 2.4-1.
--	( )	( )	Insert U17 socket, 16 pin tin, pin 1 up. Tack solder pins 1 and 9.
--	( )	( )	Insert U16 socket, 16 pin tin, pin 1 up. Tack solder pins 1 and 9.
--	--	( )	Insert U8 socket, 40 pin tin, pin 1 up. Tack solder pins 1 and 21.
--	--	( )	Insert U9 socket, 14 pin tin, pin 1 up. Tack solder pins 1 and 8.
--	( )	( )	Insert U10 socket, 14 pin tin, pin 1 up. Tack solder pins 1 and 8.
--	( )	( )	Insert U11 socket, 16 pin tin, pin 1 up. Tack solder pins 1 and 9.
--	( )	( )	Insert U12 socket, 16 pin tin, pin 1 up. Tack solder pins 1 and 9.
--	( )	( )	Insert U13 socket, 14 pin tin, pin 1 up. Tack solder pins 1 and 8.
--	( )	( )	Insert U14 socket, 16 pin tin, pin 1 up. Tack solder pins 1 and 9.

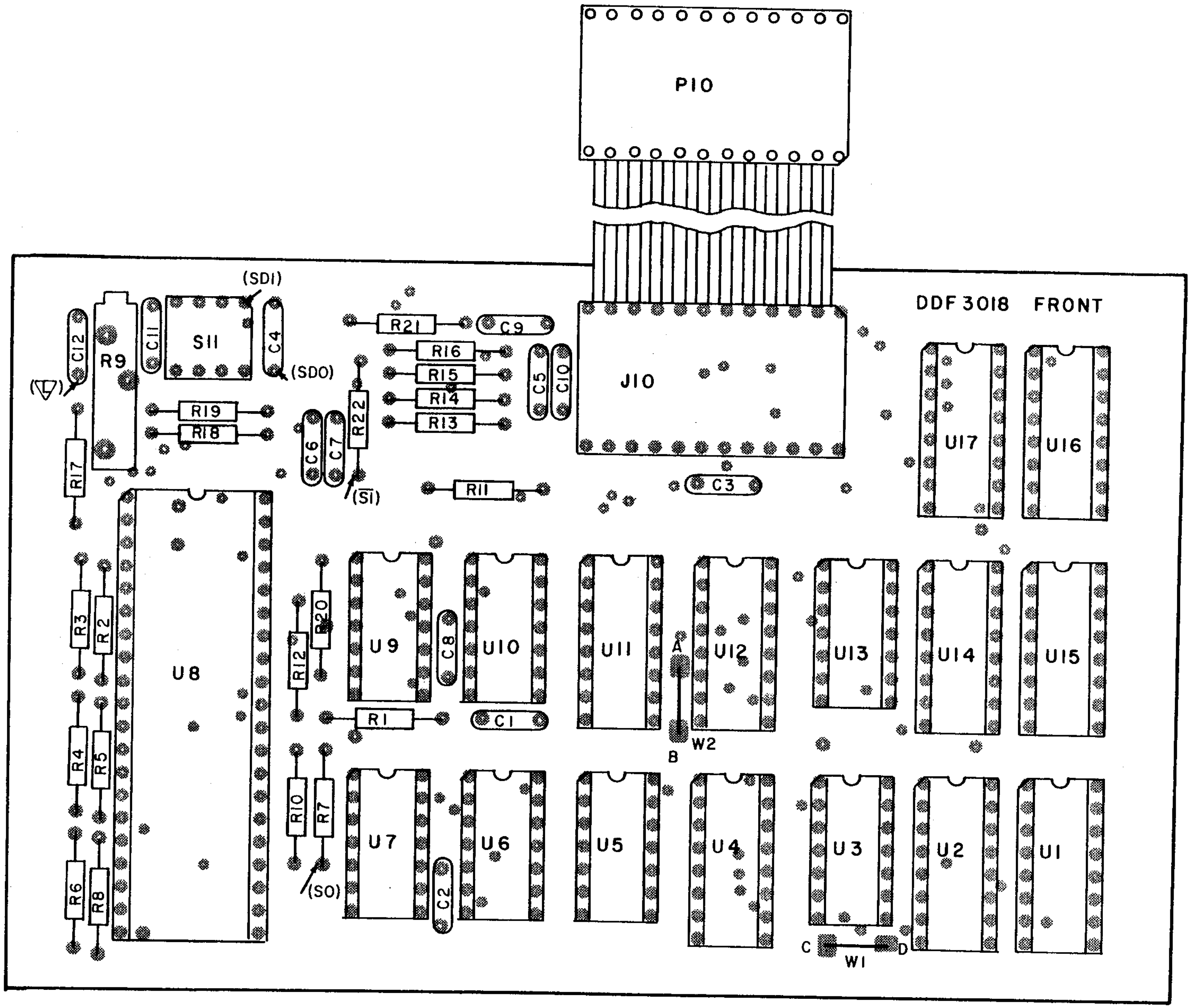


Figure 2.4-1

BCD Generator PWB Assembly

MODEL DDF-			STEP
3001	3002	3003	
--	( )	( )	Insert U15 socket, 16 pin tin, pin 1 up. Tack solder pins 1 and 9.
--	--	( )	Insert U7 socket, 14 pin tin, pin 1 up. Tack solder pins 1 and 8.
--	--	( )	Insert U6 socket, 14 pin tin, pin 1 up. Tack solder pins 1 and 8.
--	( )	( )	Insert U5 socket, 14 pin tin, pin 1 up. Tack solder pins 1 and 8.
--	--	( )	Insert U4 socket, 16 pin tin, pin 1 up. Tack solder pins 1 and 9.
--	( )	( )	Insert U3 socket, 14 pin tin, pin 1 up. Tack solder pins 1 and 8.
--	( )	( )	Insert U2 socket, 16 pin tin, pin 1 up. Tack solder pins 1 and 9.
--	( )	( )	Insert U1 socket, 16 pin tin, pin 1 up. Tack solder pins 1 and 9.
--	( )	( )	Check that sockets are flush on the PWB, then solder all pins, starting with the highest numbered pin. Reflow the tack soldered pins.
--	--	( )	Insert S11 socket, 8 pin <u>gold</u>, pin 1 to right. Tack solder pins 1 and 5.
--	( )	( )	Insert 24 pin, 3 1/2 inch DIP jumper at J10. Orient P10 above the PWB as shown in Figure 2.4-1. Pin 1 on both P10 and J10 are to the right. Tack solder pins 1 and 13 on J10.
--	( )	( )	Check that S11 and J10 are flush on the PWB, then solder all pins starting with the highest numbered pin. Reflow the tack soldered pins.
--	--	( )	Insert C12, .0047 uF mylar (472).
--	--	( )	Insert R17, 51K (GRN-BRN-ORG).
--	--	( )	Insert R3, 51K (GRN-BRN-ORG).
--	--	( )	Insert R2, 51K (GRN-BRN-ORG).
--	--	( )	Insert R4, 51K (GRN-BRN-ORG).
--	--	( )	Insert R5, 51K (GRN-BRN-ORG).

MODEL DDF-			STEP
3001	3002	3003	
--	--	( )	Insert R6, 51K (GRN-BRN-ORG).
--	--	( )	Insert R8, 51K (GRN-BRN-ORG).
--	--	( )	Solder and trim leads.
--	--	( )	Insert C11, .01 uF mylar (103).
--	--	( )	Insert C4, .1 uF ceramic (104).
--	--	( )	Insert C6, .1 uF ceramic (104).
--	--	( )	Insert C7, .1 uF ceramic (104).
--	--	( )	Insert R22, 510K (GRN-BRN-YEL).
--	--	( )	Insert R12, 33K (ORG-ORG-ORG).
--	--	( )	Insert R20, 5.1K (GRN-BRN-RED).
--	--	( )	Insert R10, 13K (BRN-ORG-ORG).
--	--	( )	Insert R7, 51K (GRN-BRN-ORG).
--	--	( )	Solder and trim leads.
--	--	( )	Insert R21, 100K (BRN-BLK-YEL).
--	--	( )	Insert C9, .022 uF mylar (223).
--	--	( )	Insert R16, 10K (BRN-BLK-ORG).
--	--	( )	Insert R15, 9.1K (WHT-BRN-RED).
--	--	( )	Insert R14, 22K (RED-RED-ORG).
--	--	( )	Insert R13, 33K (ORG-ORG-ORG).
--	( )	( )	Insert R11, 1M (BRN-BLK-GRN).
--	( )	( )	Insert C3, .047 uF mylar (473).
--	( )	( )	Insert R1, 11K (BRN-BRN-ORG).
--	( )	( )	Insert C1, .001 uF mylar (102).
--	( )	( )	Solder and trim leads.
--	--	( )	Insert C5, .0047 uF mylar (472).

MODEL DDF-			STEP
3001	3002	3003	
--	--	( )	Insert C10, .0022 uF mylar (222).
--	--	( )	Insert C8, .1 uF ceramic (104).
--	--	( )	Insert C2, .001 uF mylar (102).
--	--	( )	Insert R19, 20K (RED-BLK-ORG).
--	--	( )	Insert R18, 33K (ORG-ORG-ORG).
--	( )	--	Prepare two jumpers from the white insulated solid wire by stripping 1/4 inch from each end of two pieces 3/4 inch long.
--	( )	--	Insert jumper W2 between holes "A" and "B".
--	( )	--	Insert jumper W1 between holes "C" and "D".
--	( )	( )	Solder and trim leads.
--	--	( )	Insert R9, 5K trimpot (502). Tack solder center terminal.
--	--	( )	Solder the end terminals on R9, then reflow the tack soldered center lead.
--	( )	( )	Carefully inspect the back side of the PWB for evidence of cold solder joints, solder bridges or missing solder connections - particularly on the DIP sockets. Reflow any questionable joints before proceeding with integrated circuit installation.
--	--	( )	Insert U8, AY-3-1015D.
--	( )	( )	Insert U1, CD4076 (MC14076).
--	( )	( )	Insert U2, CD4076 (MC14076).
--	( )	( )	Insert U3, CD4069 (MC14069).
--	--	( )	Insert U4, CD4018 (MC14018).
--	( )	( )	Insert U5, 74C903.
--	--	( )	Insert U6, 74C903.
--	--	( )	Insert U7, CD4001 (MC14001).
--	--	( )	Insert U9, XR2211.

MODEL DDF-			STEP
3001	3002	3003	
--	( )	( )	Insert U10, CD4001 (MC14001).
--	( )	( )	Insert U11, CD4556 (MC14556).
--	( )	( )	Insert U12, CD4040 (MC14040).
--	( )	( )	Insert U13, CD4001 (MC14001).
--	( )	( )	Insert U14, CD4076 (MC14076).
--	( )	( )	Insert U15, CD4076 (MC14076).
--	( )	( )	Insert U16, CD4518 (MC14518).
--	( )	( )	Insert U17, CD4518 (MC14518).

2.5 DISPLAY DRIVER ASSEMBLY

Unpack the package marked PK5-1, PK5-2 or PK5-3, depending on the model number ordered, and check off the parts supplied against the following parts list. Do not remove the integrated circuits from the protective foam at this time.

ITEM	DESCRIPTION	QUANTITY SUPPLIED, MODEL DDF—		
		3001	3002	3003
Parts Package	---	PK5-1	PK5-2	PK5-3
Printed Wiring Board	DDF-3015	1	1	1
DIP Sockets	24 pin gold	-	1	1
	14 pin tin	2	2	2
	16 pin tin	1	5	5
	24 pin tin	1	1	1
DIP Jumper	16 pin, 5 inch long	1	1	1
Wire for PWB Jumpers	7 inch long white	1	-	-
Flexible Formed Jumpers	19 conductor, 1 inch long	1	1	1
	21 conductor, 3 inch long	-	1	1

ITEM	DESCRIPTION	QUANTITY SUPPLIED, MODEL DDF—		
		3001	3002	3003
Integrated Circuits	74154	1	1	1
	74C903	1	1	1
	74LS75	1	1	1
	CD4001 (MC14001)	1	1	1
	CD4076 (MC14076)	-	1	1
	CD4511 (MC14511)	-	3	3
Resistors	160 ohm (BRN-BLU-BRN)	-	21	21
	15K (BRN-GRN-ORG)	1	1	1
	20K (RED-BLK-ORG)	1	1	1
Trimpot	100K (104)	1	1	1
Disc Ceramic Capacitors	.047 uF (473) or .05 uF (503)	2	6	6
	.1 uF (104)	2	2	2
Dipped Mica Capacitor	220 pF (221)	1	1	1
Mylar Capacitor	.022 uF (223)	1	1	1

Assemble the printed wiring board following the steps given below for your model Direction Finder. Skip any step marked by a dash, and place a check mark between the parentheses after completing each step.

MODEL DDF—			STEP
3001	3002	3003	
( )	( )	( )	Position PWB DDF-3015 as shown in Figure 2.5-1.
( )	( )	( )	**Insert U2 socket, 16 pin tin, pin 1 right.** Tack solder pins 1 and 9.
( )	( )	( )	Insert U3 socket, 14 pin tin, pin 1 right. Tack solder pins 1 and 8.
--	( )	( )	Insert U4 socket, 16 pin tin, pin 1 right. Tack solder pins 1 and 9.
--	( )	( )	Insert U5 socket, 16 pin tin, pin 1 right. Tack solder pins 1 and 9.
--	( )	( )	Insert U6 socket, 16 pin tin, pin 1 right. Tack solder pins 1 and 9.

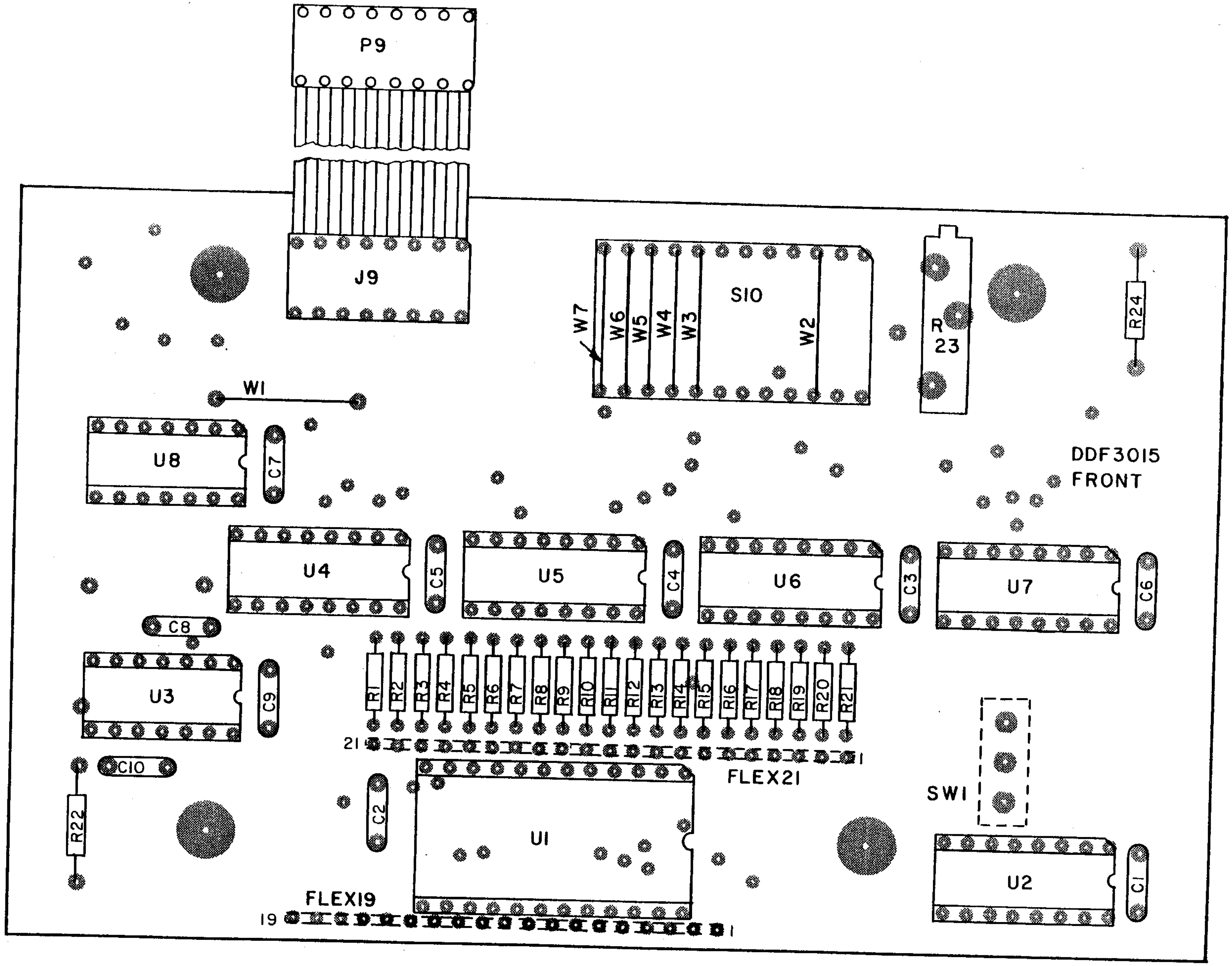


Figure 2.5-1

Display Driver PWB Assembly

MODEL DDF-			STEP
3001	3002	3003	
--	( )	( )	Insert U7 socket, 16 pin tin, pin 1 right. Tack solder pins 1 and 9.
( )	( )	( )	Insert U8 socket, 14 pin tin, pin 1 right. Tack solder pins 1 and 8.
--	( )	( )	Insert S10 socket, 24 pin <u>gold</u>, pin 1 right. Tack solder pins 1 and 13.
( )	( )	( )	Insert 16 pin, 5 inch DIP jumper at J9. Orient P9 above PWB and check that pin 1 on both P9 and J9 are to the right. Tack solder pins 1 and 9.
( )	( )	( )	Check that all sockets are flush on the PWB, then solder all pins, starting with the highest numbered pin on each socket. Reflow the tack soldered pins.
( )	--	--	Prepare 7 jumper wires by stripping 1/4 inch from each end of 1 1/8 inch pieces of the insulated white wire.
( )	--	--	Insert jumper W1.
( )	--	--	Insert jumper W2.
( )	--	--	Insert jumper W3.
( )	--	--	Insert jumper W4.
( )	--	--	Insert jumper W5.
( )	--	--	Insert jumper W6.
( )	--	--	Insert jumper W7.
( )	--	--	Solder and trim leads.
( )	( )	( )	Insert C7, .047 uF ceramic (473).
( )	( )	( )	Insert C8, .022 uF mylar (223).
( )	( )	( )	Insert C9, .047 uF ceramic (473).
( )	( )	( )	Insert C10, 220 pF mica (221).
( )	( )	( )	Insert R22, 15K (BRN-GRN-ORG).
( )	( )	( )	Insert C2, .1 uF ceramic (104).
( )	( )	( )	Insert C1, .1 uF ceramic (104).

MODEL DDF-			STEP
3001	3002	3003	
( )	( )	( )	Insert R24, 20K (RED-BLK-ORG).
( )	( )	( )	Solder and trim leads.
--	( )	( )	Insert R1 through R21, 160 ohm (BRN-BLU-BRN).
--	( )	( )	Solder and trim leads.
--	( )	( )	Insert C5, .047 uF ceramic (473).
--	( )	( )	Insert C4, .047 uF ceramic (473).
--	( )	( )	Insert C3, .047 uF ceramic (473).
--	( )	( )	Insert C6, .047 uF ceramic (473).
--	( )	( )	Solder and trim leads.
( )	( )	( )	Insert R23, 100K trimpot (104). Tack solder center terminal.
( )	( )	( )	Solder the end terminals on R23, then reflow the tack soldered center lead.
--	( )	( )	Insert the 21 pin, 3 inch flex lead jumper at FLEX21 from the <u>back</u> side of the PWB. Hold the jumper so that the pins are perpendicular to the board, and tack solder pins 1 and 21 on the <u>front</u> side.
( )	( )	( )	Insert the 19 pin, 1 inch flex lead jumper at FLEX19 from the <u>back</u> side of the PWB. Hold the jumper so that the pins are perpendicular to the board, and tack solder pins 1 and 19 on the <u>front</u> side.
( )	( )	( )	Solder all of the flex lead pins on the front side. Reflow the tack soldered pins last.
( )	( )	( )	Insert U1 socket, 24 pin tin, pin 1 right. Tack solder pins 1 and 13.
( )	( )	( )	Check that the socket is flush on the PWB, then solder all pins permanently, starting with pin 24. Reflow the tack soldered pins. Bend the flex leads away from the socket for access during soldering and avoid touching the flex leads with the iron.
( )	( )	( )	Carefully inspect the back side of the PWB for evidence of cold solder joints, solder bridges or missing solder connections - particularly on the DIP sockets. Reflow any questionable solder joints before proceeding with integrated circuit installation.

MODEL DDF -			STEP
3001	3002	3003	
( )	( )	( )	Insert U1, 74154, pin 1 right.
( )	( )	( )	Insert U2, 74LS75, pin 1 right.
( )	( )	( )	Insert U3, CD4001 (MC14001), pin 1 right.
--	( )	( )	Insert U4, CD4511 (MC14511), pin 1 right.
--	( )	( )	Insert U5, CD4511 (MC14511), pin 1 right.
--	( )	( )	Insert U6, CD4511 (MC14511), pin 1 right.
--	( )	( )	Insert U7, CD4076 (MC14076), pin 1 right.
( )	( )	( )	Insert U8, 74C903, pin 1 right.

2.6 DISPLAY ASSEMBLY

Unpack the package marked PK10-1, PK10-2 or PK10-3, depending on the model number ordered, and check off the parts supplied against the following parts list.

ITEM	DESCRIPTION	QUANTITY SUPPLIED, MODEL DDF—		
		3001	3002	3003
Parts Package	---	PK10-1	PK10-2	PK10-3
Printed Wiring Board	DDF-3011	1	1	1
Light Emitting Diodes	SBR3401 *Includes 2 spares. MAN74	20* -	20* 3	20* 3
Resistors	160 ohm (BRN-BLU-BRN) 300 ohm (ORG-BLK-BRN)	2 1	2 1	2 1
Miscellaneous Hardware	DDF-3108-1 label DDF-3108-2 label 4-40 x 1/4 inch round head machine screw No. 4 lockwashers 4-40 x 5/8 inch threaded spacers DDF-3106 plastic panel	1 - 8 8 4 1	- 1 8 8 4 1	- 1 8 8 4 1
Switch	SPST, wire wrap terminals (with mounting hardware)	1	1	1

Assemble the printed wiring board following the steps given below for your model Direction Finder. Skip any step marked by a dash, and place a check mark between the parentheses after completing each step.

MODEL DDF-			STEP
3001	3002	3003	
( )	( )	( )	Position PWB 3011 as shown in Figure 2.6-1.
( )	( )	( )	Insert R2, 160 ohm (BRN-BLU-BRN).
( )	( )	( )	Insert R1, 300 ohm (ORG-BLK-BRN).
( )	( )	( )	Insert R3, 160 ohm (BRN-BLU-BRN).
( )	( )	( )	Solder and trim leads.
( )	( )	( )	Pre-cut the leads on 18 LEDs (SBR3401)to just above the lead tabs as shown in Figure 2.6-2.
( )	( )	( )	Insert D1 through D16, SBR3401, cathodes facing out from the circular array. Do not apply pressure to the plastic lenses of the LEDs while inserting. The LEDs should be inserted so that approximately 1/16 inch spacing exists between the PWB and the bottom of the plastic lens assembly.
( )	( )	( )	Insert D17 and D18, SBR3401, cathode down.
( )	( )	( )	Place the foil front label over the top of the LEDs as a template to align the diodes on the board. (Do not remove the paper backing from the label.) Use care not to scratch the foil label. Set the assembly on a flat surface with the label side down and apply a small amount of downward pressure to the PWB so that all of the LEDs are positioned flat and in alignment with the label holes.
( )	( )	( )	Solder the cathode lead of each LED with the assembly board in this position.
( )	( )	( )	Carefully inspect the PWB to ensure that all of the LEDs are properly aligned. Remove the label, and solder the anode leads of each LED.
--	( )	( )	Insert D19, MAN74, decimal points down.
--	( )	( )	Insert D20, MAN74, decimal points down.
--	( )	( )	Insert D21, MAN74, decimal points down.
--	( )	( )	Tack solder pins 1 and 8 on D19, D20 and D21.

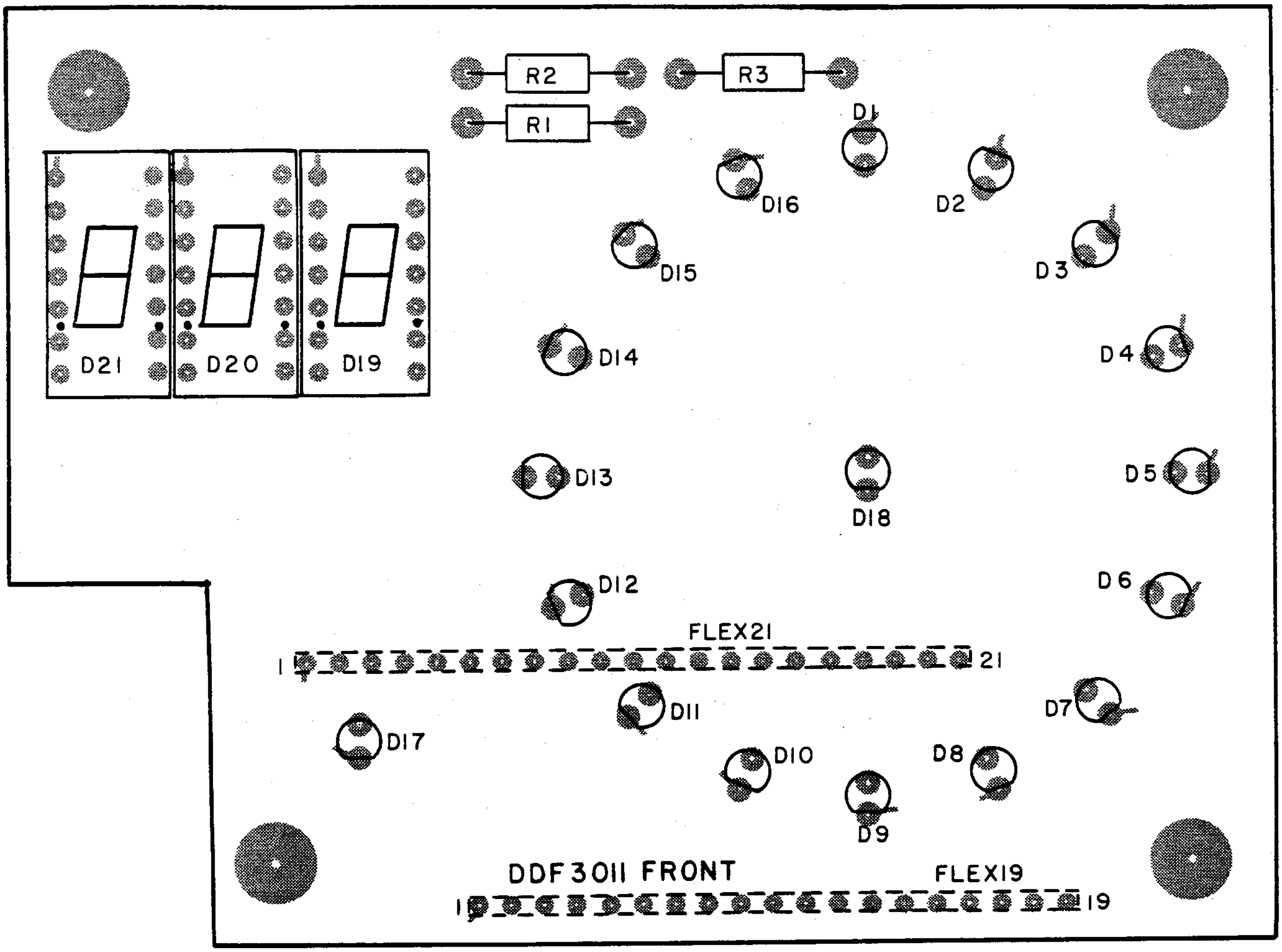


Figure 2.6-1
Display PWB Assembly

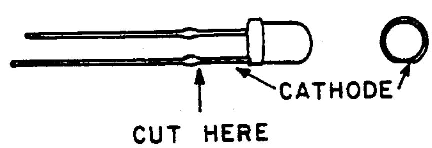


Figure 2.6-2
LED Lead Preparation

MODEL DDF-			STEP
3001	3002	3003	
--	( )	( )	Check that D19-21 are flush with the PWB, then solder all leads. Reflow the tack soldered leads last.
( )	( )	( )	Pre-form the flex lead(s) conected to the display driver assembly and position the two PWBs back to back as indicated in Figure 2.6-3.
--	( )	( )	Insert the pins from the longer flex tape through FLEX21 from the back side. Align the pins perpendicular to the board and tack solder pins 1 and 21.
--	( )	( )	Permanently solder all of the pins on FLEX21 from the front side. Use particular care to avoid touching any of the LEDs with the iron. Reflow pins 1 and 21 last.
( )	( )	( )	Insert the pins on the shorter flex tape through the back side holes in the PWB. Hold the tape so that the flex pins are perpendicular to the board and tack solder pins 1 and 19 on the front side. Use care that the soldering iron does not touch any of the LEDs.
( )	( )	( )	Permanently solder all of the pins on FLEX19 from the front side. Reflow pins 1 and 19 last.
( )	( )	( )	Start four #4-40 x 1/4 inch round head machine screws through #4 lock washers, PWB DDF-3011 and into 5/8 inch threaded spacers as shown in Figure 2.6-3. Do not tighten yet.
( )	( )	( )	Start four #4-40 x 1/4 inch round head machine screws through #4 lockwashers, PWB DDF-3015 and into the 5/8 inch threaded spacers.
( )	( )	( )	Tighten all eight screws carefully. Be sure that the lockwasher which is located between U1 and U2 on PWB DDF-3015 is positioned away from the large front side wire run. Check that the flex lead(s) are looped approximately as shown in Figure 2.6-3. Do not over tighten these screws, but be sure the lockwashers are tight.
( )	( )	( )	Install the front panel label to the red plastic front panel using the following procedure. (Note - read through the following two steps completely before beginning the assembly; the label cannot be satisfactorily removed once pressed into place.)

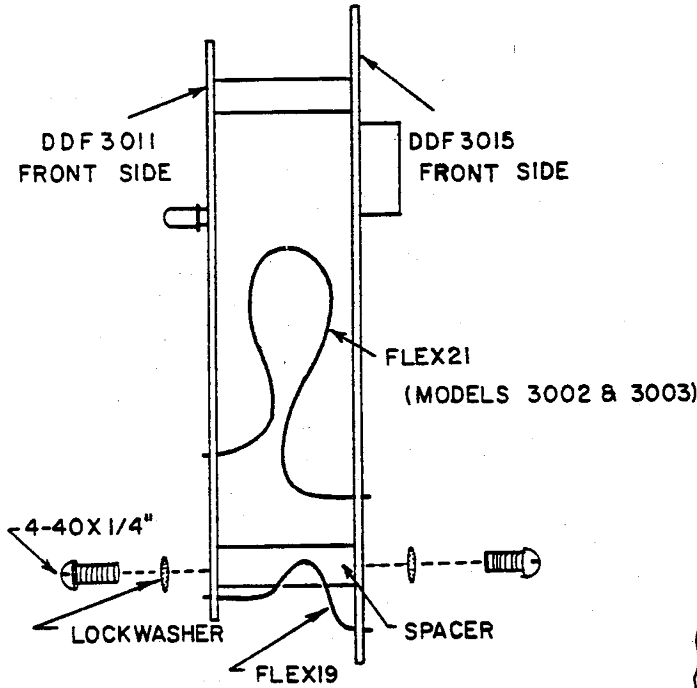


Figure 2.6-3
Display Module Assembly

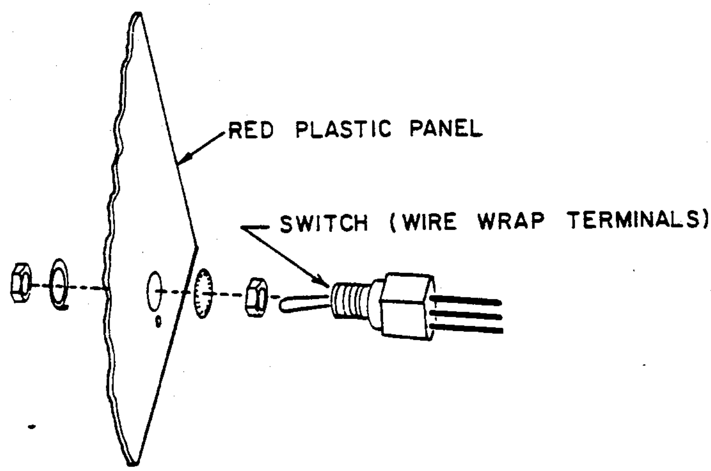


Figure 2.6-4
Front Panel Switch Mounting

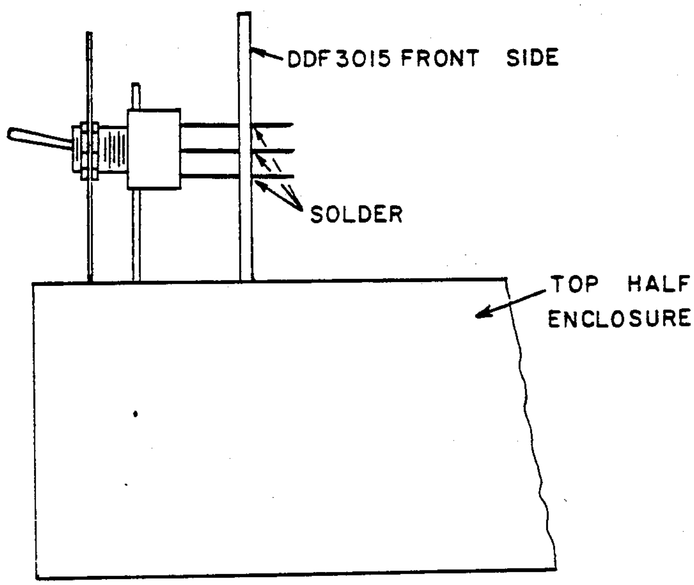


Figure 2.6-5
Front Panel Switch Soldering

MODEL DDF-			STEP
3001	3002	3003	
( )	( )	( )	Clean the red plastic panel with a soft cloth and set it on a flat surface with the switch holes closest to you and to your left.
( )	( )	( )	Peel back the bottom edge of the backing paper from the foil label approximately 1 inch and cut away the backing paper so that approximately 1/4 inch of the pressure sensitized adhesive is exposed when the backing is rolled back on the label. Do not touch the adhesive. Carefully align the bottom edges of the label and plastic panel and lightly set in place. Check that the other sides of the label align with the panel and make any small adjustments necessary at this time. When the label is correctly positioned, press the bottom edge in place, then carefully peel back the remaining backing paper from bottom to top. Press the label on to the panel with a soft cloth using a rolling (not rubbing) motion.
( )	( )	( )	Mount the switch to the front panel using the hardware supplied with the switch. See Figure 2.6-4 for the order in which to arrange this hardware. Tighten the two 5/16 inch hex nuts so that the top surface of the outer nut is flush with the switch bushing. Do not over tighten, but be sure the lockwasher is compressed into the panel.
( )	( )	( )	Insert the leads from the switch through the holes in PWB DDF-3015 from the back side. Do not solder at this time.
( )	( )	( )	With the top half of the chassis resting upside down on a flat surface insert the assembly consisting of the display PWBs and the front panel into the card guides in the chassis. Insert these upside down so that the switch is on top. This extablishes the relative spacing between the PWBs and the front panel. See Figure 2.6-5.
( )	( )	( )	Solder the three terminals from the front panel switch at SW1 on PWB DDF-3015 "front side" (which is now the surface furthest away from the front panel).

2.7 RF SUMMER ASSEMBLY

Unpack the package marked PK4 and check off the parts supplied against the following parts list.

ITEM	DESCRIPTION	QUANTITY SUPPLIED, MODEL DDF—		
		3001	3002	3003
Parts Package	---	PK4	PK4	PK4
Printed Wiring Board	DDF-3014	1	1	1
Transistors	3N211	4	4	4
Resistors	51 ohm (GRN-BRN-BLK) 220 ohm (RED-RED-BRN) 1.0K (BRN-BLK-RED) 2.4M (RED-YEL-GRN)	4 4 1 4	4 4 1 4	4 4 1 4
Disc Ceramic Capacitors	470 pF (471) .001 uF (102)	4 5	4 5	4 5
Coils	1 uH RF choke 3 1/2 inch bare wire AWG 22	1 1	1 1	1 1

Assemble the printed wiring board following the steps given below for your model Direction Finder. Skip any step marked by a dash, and place a check mark between the parentheses after completing each step.

MODEL DDF–			STEP
3001	3002	3003	
( )	( )	( )	Position PWB DDF-3014 as shown in Figure 2.7-1.
( )	( )	( )	Insert C1, 470 pF ceramic (471).
( )	( )	( )	Insert R1, 2.4M (RED-YEL-GRN).
( )	( )	( )	Insert R9, 220 ohm (RED-RED-BRN).
( )	( )	( )	Insert R13, 51 ohm (GRN-BRN-BLK).

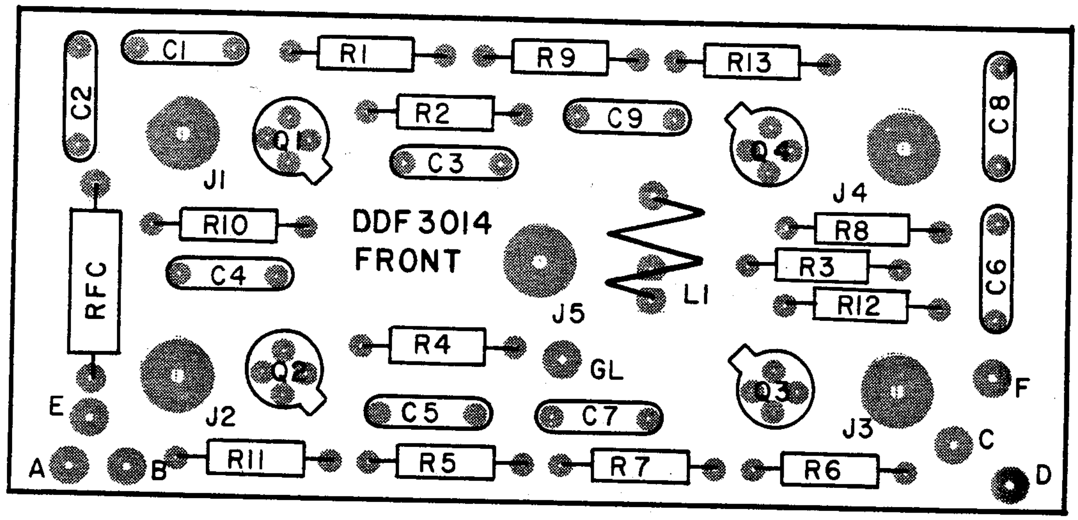


Figure 2.7-1
RF Summer PWB Assembly

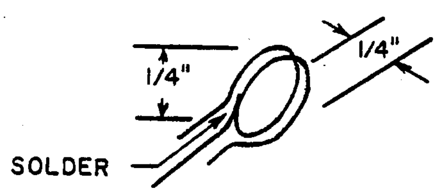


Figure 2.7-2
Coil Construction

MODEL DDF-			STEP
3001	3002	3003	
( )	( )	( )	Solder and trim leads.
( )	( )	( )	Insert R2, 220 ohm (RED-RED-BRN).
( )	( )	( )	Insert C9 and C3, .001 uF ceramic (102).
( )	( )	( )	Insert R10, 51 ohm (GRN-BRN-BLK).
( )	( )	( )	Insert C4, 470 pF ceramic (471).
( )	( )	( )	Solder and trim leads.
( )	( )	( )	Insert R4, 2.4M (RED-YEL-GRN).
( )	( )	( )	Insert C5, .001 uF ceramic (102).
( )	( )	( )	Insert C7, .001 uF ceramic (102).
( )	( )	( )	Insert R11, 51 ohm (GRN-BRN-BLK).
( )	( )	( )	Insert R5, 220 ohm (RED-RED-BRN).
( )	( )	( )	Solder and trim leads.
( )	( )	( )	Insert R7, 220 ohm (RED-RED-BRN).
( )	( )	( )	Insert R6, 2.4M (RED-YEL-GRN).
( )	( )	( )	Insert R8, 2.4M (RED-YEL-GRN).
( )	( )	( )	Insert R3, 1.0K (BRN-BLK-RED).
( )	( )	( )	Insert R12, 51 ohm (GRN-BRN-BLK).
( )	( )	( )	Solder and trim leads.
( )	( )	( )	Insert C8, 470 pF ceramic (471).
( )	( )	( )	Insert C6, 470 pF ceramic (471).
( )	( )	( )	Insert C2, .001 uF ceramic (102).
( )	( )	( )	Insert RFC, 1 uH.
( )	( )	( )	Solder and trim leads.
( )	( )	( )	Insert Q1, 3N211. Align tab as shown and space approximately 1/16 inch off PWB.
( )	( )	( )	Insert Q2, 3N211. Align tab as shown and space approximately 1/16 inch off PWB.

MODEL DDF-			STEP
3001	3002	3003	
( )	( )	( )	Insert Q3, 3N211. Align tab as shown and space approximately 1/16 inch off PWB.
( )	( )	( )	Insert Q4, 3N211. Align tab as shown and space approximately 1/16 inch off PWB.
( )	( )	( )	Form coil L1 by wrapping a 2-1/2 inch length of bare solid AWG22 wire around a 1/4 inch diameter rod 2 times. Solder a tap to the side of the coil using a 1 inch length of solid AWG22 wire. See Figure 2.7-2 for detailed coil dimensions.
( )	( )	( )	Insert coil at L1 and space it approximately 1/16 inch off PWB.
( )	( )	( )	Solder and trim leads.
( )	( )	( )	Carefully inspect the back side of the PWB for evidence of cold solder joints, solder bridges or missing solder connections. Reflow any questionable solder joints.

2.8 FINAL ASSEMBLY

Unpack the package marked PK1-1, PK1-2 or PK 1-3, depending on the model number ordered, and check off the parts supplied against the following parts list.

ITEM	DESCRIPTION	QUANTITY SUPPLIED, MODEL DDF-		
		3001	3002	3003
Parts Package	---	PK1-1	PK1-2	PK1-3
DIP Jumpers	8 pin, 12 inch long	-	-	1
	14 pin, 12 inch long	1	1	1
Integrated Circuit	LM340K-5 (7805K)	1	1	1
Switch	SPST, solder terminals (including hardware)	-	-	1
Connectors	Phono jacks (including hardware)	5	5	5
	15 pin receptacle	1	1	1
	15 pin plug	1	1	1
	15 pin backshell (with hardware)	1	1	1
	TO-3 socket	1	1	1

ITEM	DESCRIPTION	QUANTITY SUPPLIED, MODEL DDF-		
		3001	3002	3003
Miscellaneous Hardware	1/4 inch grommet	1	1	1
	DDF-3102 shield box	1	1	1
	DDF-3105 shield plate	1	1	1
	Angle brackets	2	2	2
	4-40 x 1/4 inch round head machine screws	2	2	2
	4-40 x 3/8 inch round head machine screws	2	2	2
	No. 4 lockwashers	4	4	4
	4-40 hex nuts	4	4	4
	6-32 x 3/8 inch round head machine screws	2	2	2
	No. 6 lockwashers	2	2	2
	6-32 hex nuts	2	2	2
	6-20 x 5/8 inch self tapping screws	2	2	2
	3/8 inch lockwashers	5	5	5
	1/4 inch hole plug	1	1	-
	No. 6 fibre washers	2	2	2
	TO-3 heat sink	1	1	1
	DDF-3104-1 label	1	-	-
	DDF-3104-2 label	-	1	-
	DDF-3104-3 label	-	-	1
Wire	2-1/2 inch white insulated AWG22	1	1	1
	2 inch bare AWG22	1	1	1
	1 inch bare AWG16	1	1	1

Assemble the chassis following the steps given below for your model Direction Finder. Skip any step marked by a dash, and place a check mark between the parentheses after completing each step.

MODEL DDF-			STEP
3001	3002	3003	
( )	( )	( )	Prepare the single ended 14 pin 12 inch DIP jumper P7 as shown in Figure 2.8-1. Strip each end 1/4 inch, twist the strands and tin lightly.
( )	( )	( )	Install a 1/4 inch grommet in the side of the aluminum shield box as shown in Figure 2.8-2.

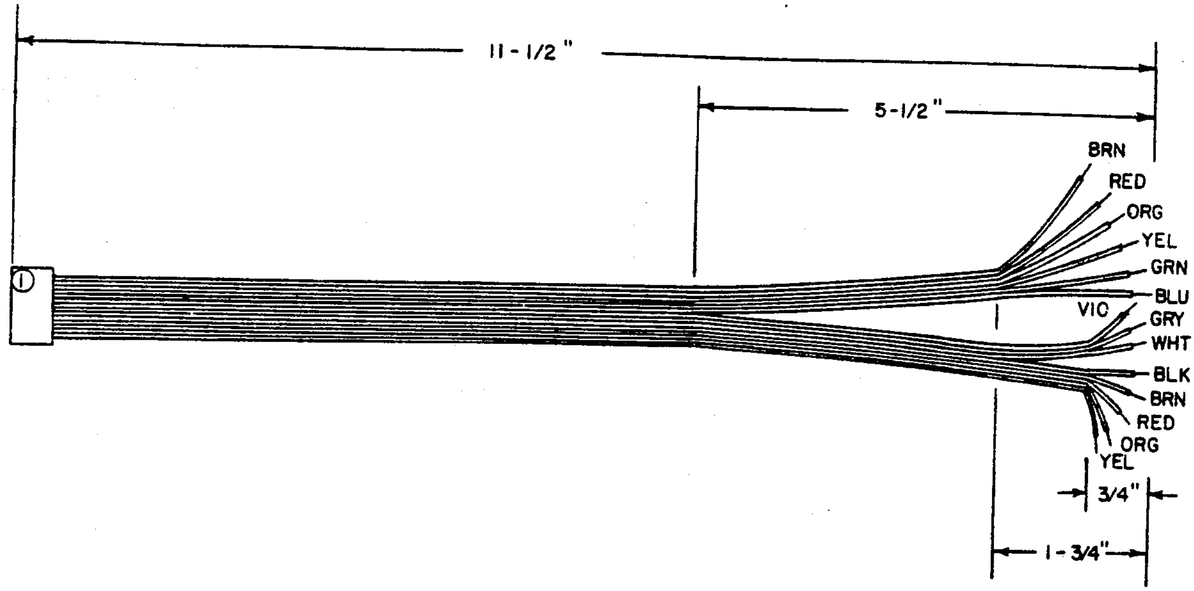


Figure 2.8-1

DIP Jumper P7 Preparation

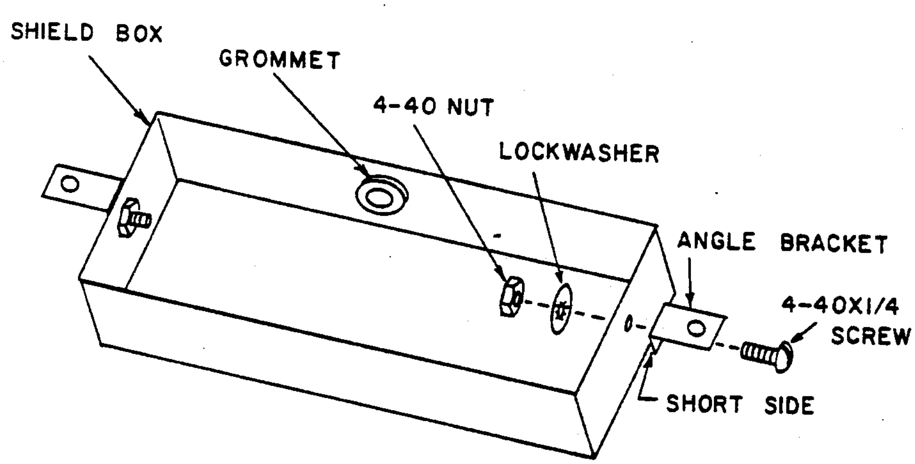


Figure 2.8-2

Shield Box Assembly

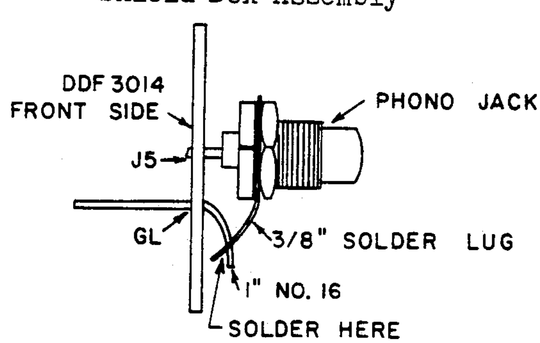


Figure 2.8-3

Ground Lug Installation

MODEL DDF-			STEP
3001	3002	3003	
( )	( )	( )	Mount an angle bracket to each side of the aluminum shield box as shown in Figure 2.8-2. Use two 4-40 x 1/4 inch round head machine screws, lockwashers and nuts. Mount the <u>shorter</u> side of the angle bracket to the shield box.
( )	( )	( )	Form the BRN-RED-ORG-YEL-GRN-BLU branch of P7 into a "U" shape and insert through the shield box grommet (plug P7 outside the box). Slide the box up the cable to the branch.
( )	( )	( )	Insert the stripped ends of these wires into PWB 3014 from the front side: Wire — Hole BRN — E RED — A ORG — F YEL — B GRN — D BLU — C
( )	( )	( )	Solder and trim these wires on back side.
( )	( )	( )	Change the soldering iron tip from the 1/32 inch conical tip to the 1/16 inch screwdriver tip for the remaining steps.
( )	( )	( )	Form the 1 inch piece of bare AWG16 wire and one of the phono jack ground lugs as shown in Figure 2.8-3. Temporarily mount the ground lug on the phono jack as shown and make any minor bends necessary in the AWG16 wire so that it lines up with hole GL when the tip of the phono jack is inserted through hole J5 from the <u>back</u> side of PWB DDF-3014.
( )	( )	( )	Solder the AWG16 wire to the ground lug.
( )	( )	( )	Insert four more phono jacks into holes J1, J2, J3, and J4 in PWB DDF-3014 from the back side. Temporarily mount phono jacks J1 - J5 on the outside of the top half of the enclosure using the 3/8 inch nuts supplied with the jacks. See Figure 2.8-4. The tips of all 5 phono jacks should protrude 1/32 inch above the front side of the board.
( )	( )	( )	With the board supported by the phono jacks, solder the 5 phono jack tips to the <u>front</u> side of the PWB at the point of contact. Do <u>not</u> attempt to fill the large holes with solder.

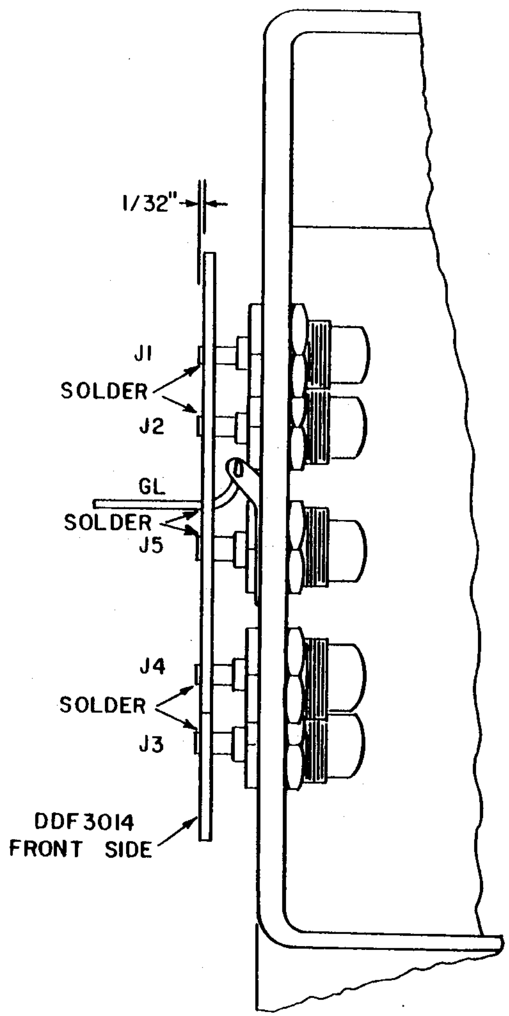


Figure 2.8-4
Phono Jack Connection to RF Summer PWB

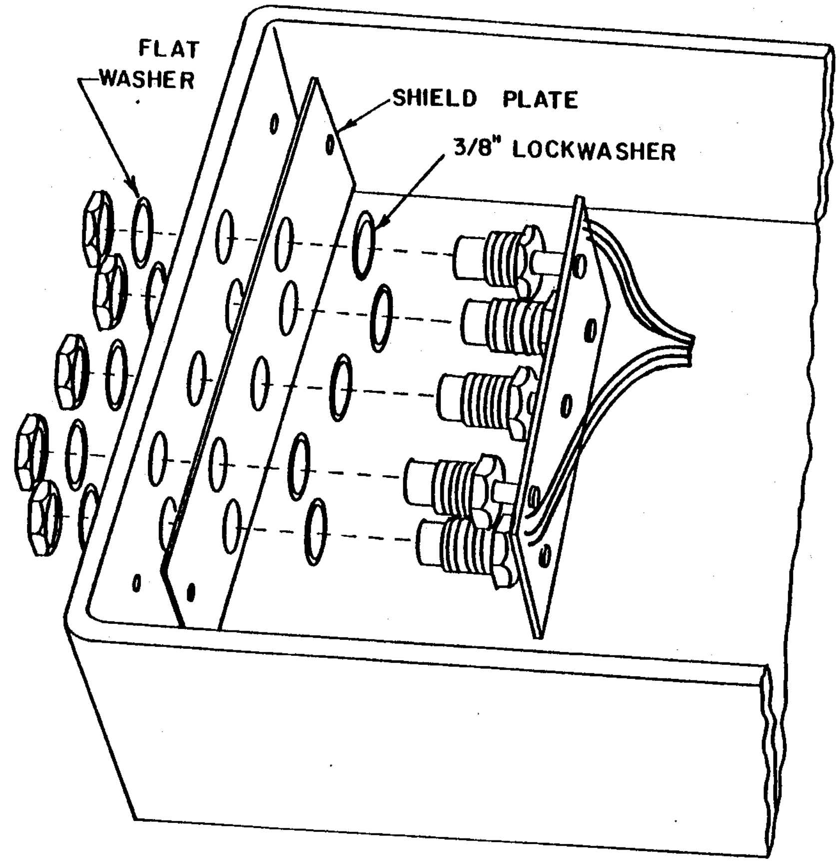


Figure 2.8-5
RF Summer PWB Installation

MODEL DDF-			STEP
3001	3002	3003	
( )	( )	( )	Solder and trim the AWG16 wire extending through hole GL on the front side.
( )	( )	( )	Remove the phono jack nuts used to temporarily support the PWB for soldering above. Insert the phono jacks through 3/8 inch lockwashers, the shield plate and through the top chassis holes. Orient the PWB so that the flat cable leads are closest to the grooved edge on the box. See Figure 2.8-5.
( )	( )	( )	Mount the phono jacks using the hex nuts shipped with the jacks. (Discard the unused soldering lugs.) Tighten the nuts just enough to compress the lock-washers slightly, but do not overtighten. Use a 1/2 inch deep well socket <u>without</u> a wrench to tighten these nuts.
( )	( )	( )	Inspect the phono jack tip solder joints on PWB DDF-3014. If over-tightening the phono jacks has caused a crack to form in the solder joint, carefully reflow it.
( )	( )	( )	Slide the shield box down the flat cable and mount it to the chassis top using 6-32 x 3/8 inch round head machine screws, #6 lockwashers and nuts. See Figure 2.8-6. Place a piece of masking tape across the flat surface of a small 1/4 inch end wrench and use the tape to hold each nut in place while starting the screws. See Figure 2.8-7.
( )	( )	( )	Gently pull any excess wire out of the shield box through the grommet.
( )	( )	( )	Cut and bend a 1 inch length of AWG22 bare wire into a "U" shape as shown in Figure 2.8-8. Insert the wire in pins 9 and 15 of the subminiature "D" plug (having male contacts). Align the long edge of this wire so that it touches the cup surface of connector terminal 10, 11, 12, 13 and 14.
( )	( )	( )	Solder pins 9 and 15. Caution: Avoid applying excess heat or pressure to the terminals on this <u>connector.</u>
( )	( )	( )	Prepare a 2 1/2 inch length of AWG22 white wire as shown in Figure 2.8-9.

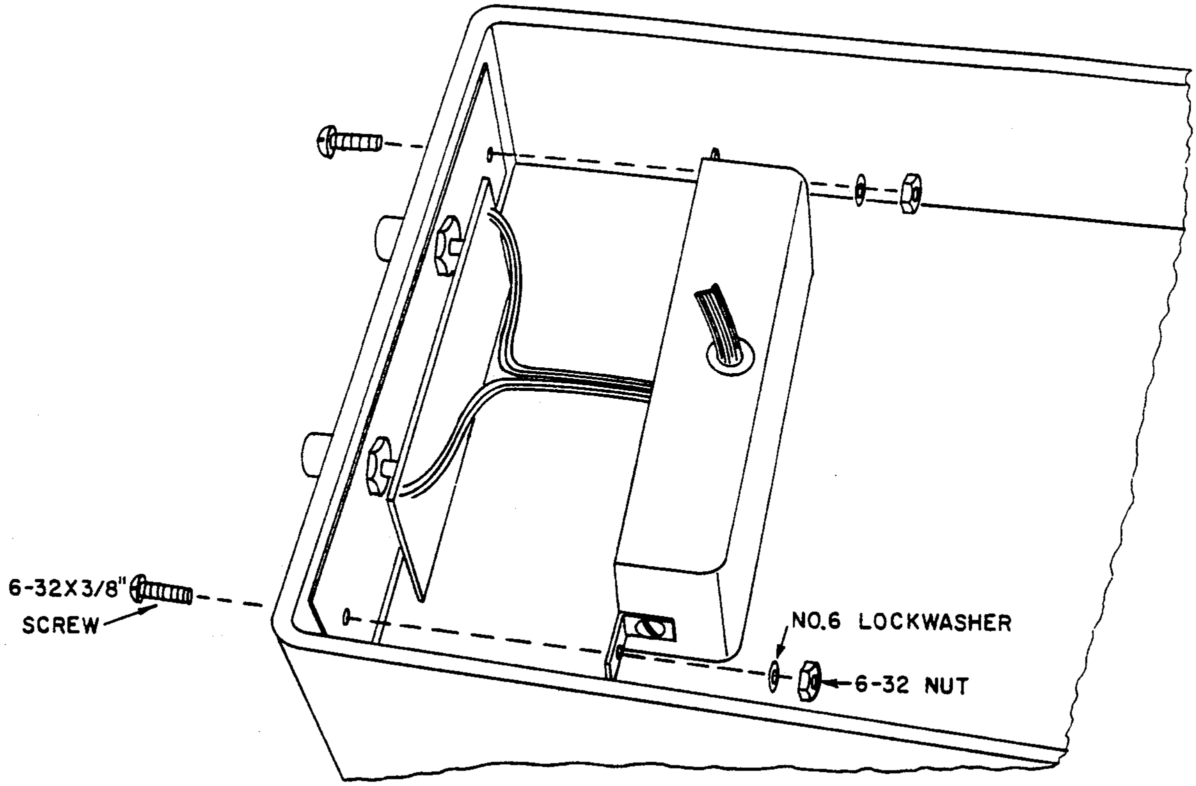


Figure 2.8-6
Shield Box Installation

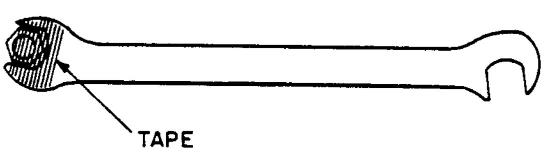


Figure 2.8-7
Use of Tape to Hold Nut

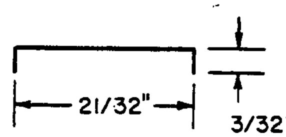


Figure 2.8-8
Connector Ground Jumper Preparation

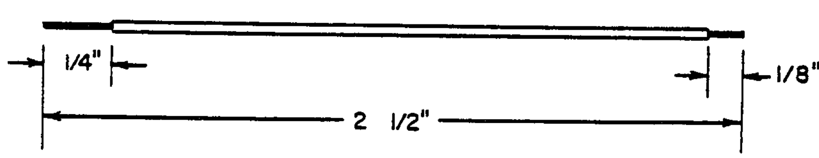


Figure 2.8-9
White Wire Preparation

MODEL DDF-			STEP
3001	3002	3003	
( )	( )	( )	Insert the 1/8-inch stripped end into pin 14 of the "D" connector between the terminal and the bare wire and solder. Check that the jumper wire is securely attached to terminal 14 after soldering.
( )	( )	( )	Insert short (1/4 inch) lengths of bare #22 wire into connector terminals 10, 11, 12 and 13 between the #22 jumper wire and the cup terminal.
( )	( )	( )	Solder pins 10, 11, 12 and 13 and trim off any excess length from the short wires used to fill the terminal pins. Be sure the jumper wire is soldered securely to each terminal.
( )	( )	( )	Mount the connector to the outside bottom half of the box using 4-40 x 3/8 inch round head machine screws, #4 lockwashers and hex huts. See Figure 2.8-10.
--	--	( )	Mount switch SW-2 from the inside of the box bottom using the hardware supplied with the switch. See Figure 2.8-10.
( )	( )	--	Mount the 1/4 inch hole plug in the box bottom from the outside.
( )	( )	( )	Mount the 7805 regulator on the outside of the box bottom using the heatsink, socket, (2) fibre washers and (2) 6-20 x 5/8 inch self-tapping screws. See Figure 2.8-11. Check that the pins and holes on these parts line up before tightening.
--	--	( )	Prepare the 8 pin DIP jumper cable P11 as shown in Figure 2.8-12. Twist and lightly tin the 6 stripped ends of each wire.
--	--	( )	Connect 3 of the leads from P11 to switch SW-2 as follows and solder. See Figure 2.8-13. BLU - bottom terminal VIO - center terminal GRY - top terminal
--	--	( )	Connect 3 wires from P11 to the "D" connector as follows and solder. See Figure 2.8-13. ORG - pin 1 RED - pin 2 BRN - pin 3

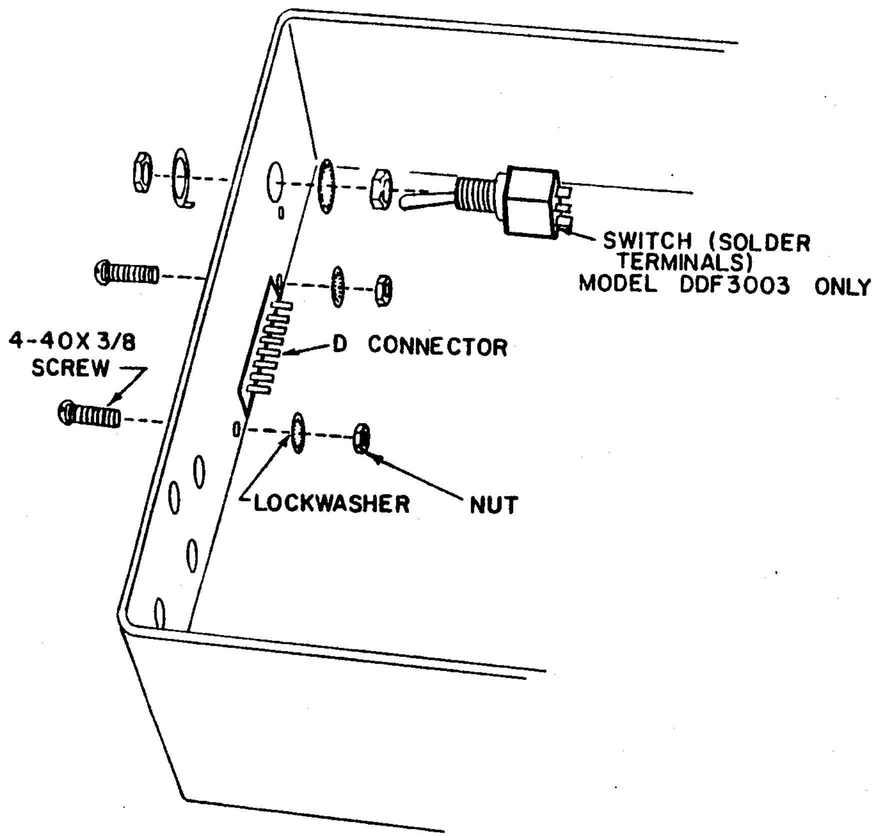


Figure 2.8-10

D Connector and Mode Switch Installation

(Note: Position of D connector may be higher in box than indicated in figure on some models.)

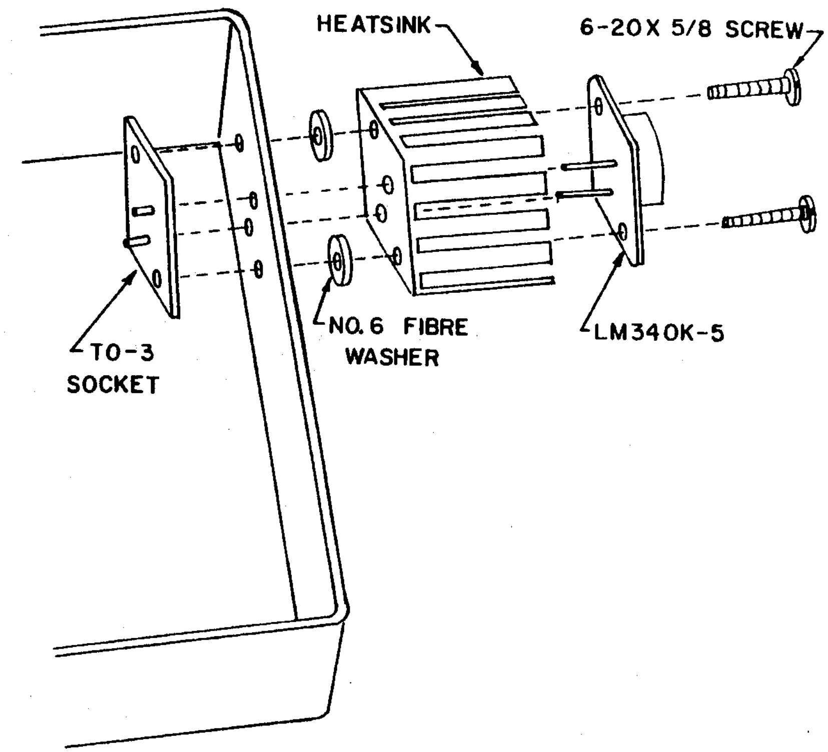


Figure 2.8-11

5 VDC Regulator Installation

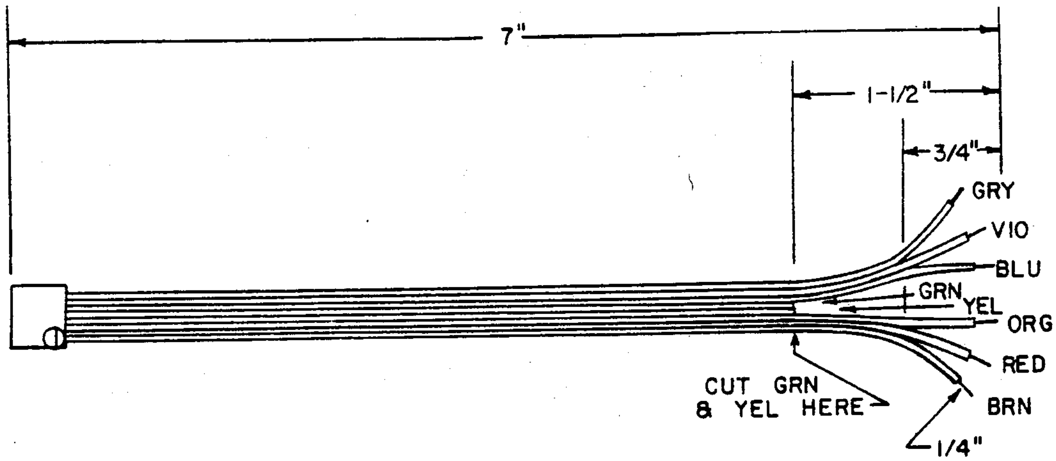


Figure 2.8-12

DIP Jumper P11 Preparation

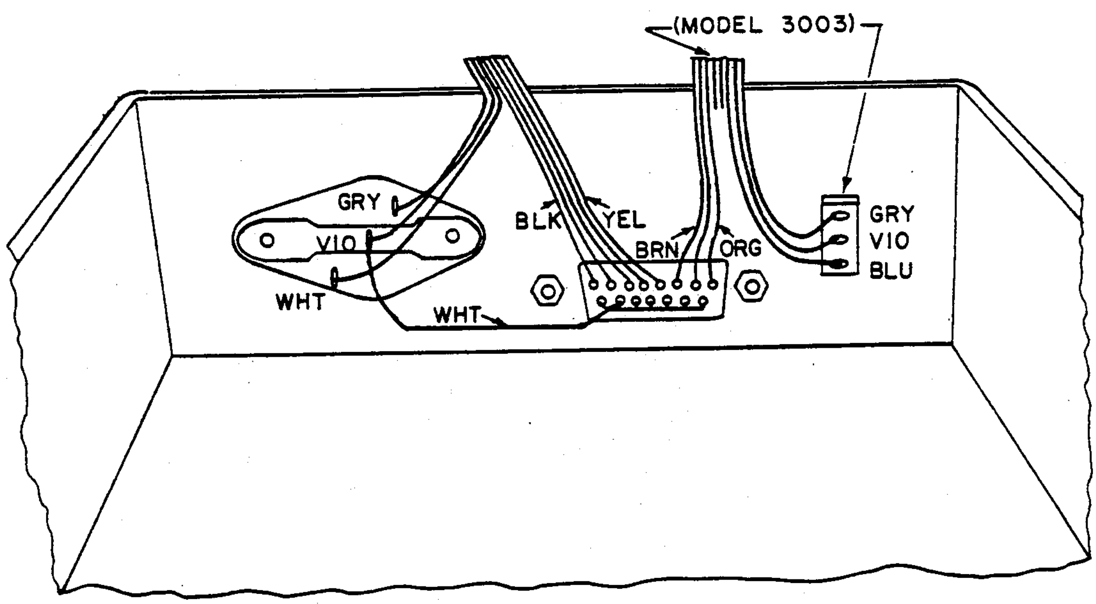


Figure 2.8-13

Rear Panel Wiring

(Note: On some models, position of D connector may be higher than that shown.)

MODEL DDF-			STEP
3001	3002	3003	
( )	( )	( )	Connect the white wire from connector pin 14 to the center terminal on the 7805 regulator socket. Do not solder yet. See Figure 2.8-13.
( )	( )	( )	Set the top box next to the bottom box and connect 3 wires from P7 as follows to the regulator socket. Solder each connection. See Figure 2.8-13. WHT - bottom terminal VIO - center terminal GRY - top terminal
( )	( )	( )	Connect the remaining 5 wires from P7 to the D connector and solder. See Figure 2.8-13. BLK - pin 8 BRN - pin 7 RED - pin 6 ORG - pin 5 YEL - pin 4
( )	( )	( )	Clean the surface of the bottom box just above the D connector with a soft cloth and mount the small foil label directly above or below the connector. See Figure 2.8-14.
( )	( )	( )	Insert the assembled printed wiring boards into the molded card guides in the bottom half of the enclosure as shown in Figure 2.8-15.
( )	( )	( )	Connect the DIP jumpers to the corresponding gold sockets as indicated in Figure 2.8-15. To assemble the upper and lower halves of the enclosure, turn the two halves so that they are facing each other, resting on the side closest to the on-off switch. Tilt the enclosures and position them so that the lower corner of each PWB engages the corresponding card guide on the lower side of the top half. Now straighten the two halves so that the upper corner of each board engages the upper card guide. Slide the two halves together about one inch and check that the cards are properly engaged in their tracks on both sides. Form the excess flat conductor wire on jumper P7 into a loop that will slide between the power supply PWB and the rear chassis wall in the lower enclosure as the two halves are brought together. Slide the two halves together slowly. If any resistance is noted, check for the source of the interference. It may be necessary to press lightly inward on the front panel top to obtain engagement with the molded track at the very top of the front panel. Do not use any tools during this

MODEL DDF-			STEP
3001	3002	3003	
			step; if all cards are properly aligned and the jumpers correctly formed, no prying or poking is required.
( )	( )	( )	Install the four long metric screws into the bushings in the bottom half of the enclosure and tighten.
			This completes assembly of the electronics portion of the direction finder. Antenna construction is discussed in Section 3 and installation and calibration is covered in Section 4.

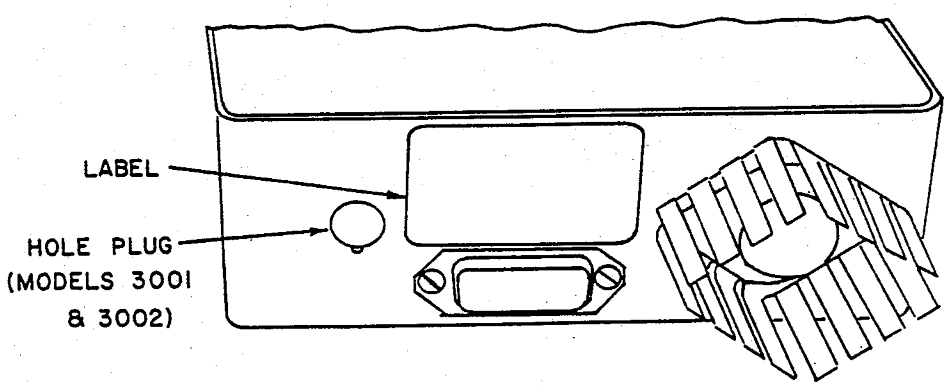


Figure 2.8-14

Rear Panel Label Installation

(Note: Position of D connector and label may be reversed on some models.)

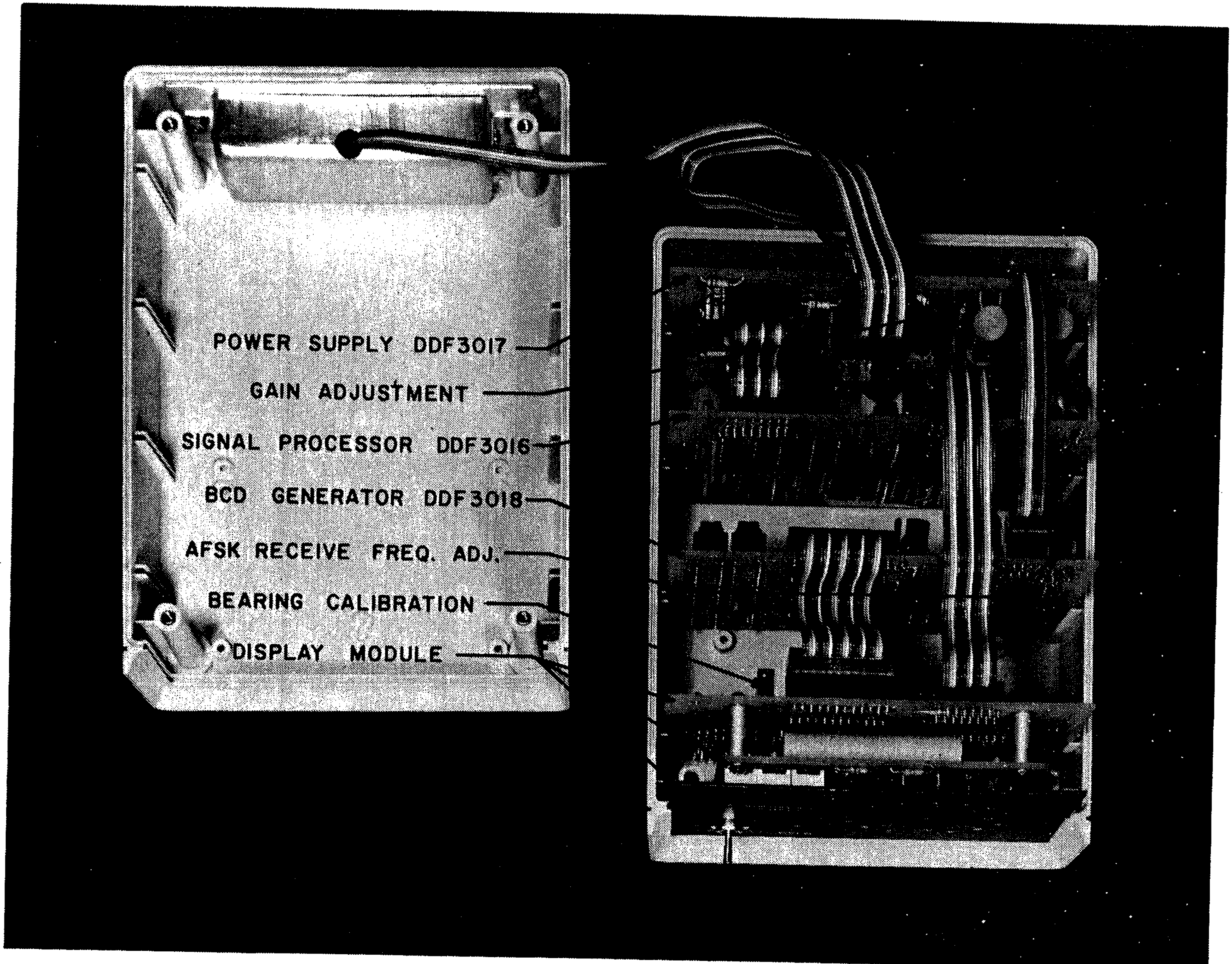


Figure 2.8-15

Printed Wiring Board Installation

SECTION 3.0
ANTENNA

Your direction finder electronics are designed for use with an antenna array having four identical elements located in the corners of a square array with sides less than one-half wavelength long. Analysis shows, however, that the best performance can be expected with an array size between 1/16 and 5/16 wavelength. Individual elements should be vertically polarized and non-directional in the horizontal plane. Antenna impedance and matching to the transmission lines are not especially important; however, each of the four lines must be of the same electrical length. For this reason, and to prevent excessive signal loss, the antenna should not be located too far from the electronics.

Element length may be increased to provide greater capture area and may be either balanced or unbalanced using a suitable ground plane. Mechanical stability is important, however, especially in a mobile application.

Good success has been obtained using magnetic mounted 1/4 wavelength whips on car tops. Be sure that the four antenna mounts are supplied with the same type of coax and cut to the same length within 1/2 inch.

A good basic design suitable for either fixed or mobile use is given here. Elements are approximately 1/4 wavelength long and are spaced 1/4 wavelength apart at 2 meters. Radials extend an additional 1/4 wavelength beyond the elements, giving the antenna compact and sturdy characteristics. All material should be available from local suppliers.

Antennas are also available from Doppler Systems. Write for information.

3.1 ANTENNA FABRICATION (DDF-3000)

The following aluminum and Teflon stock is required to fabricate a DDF-3000 antenna:

(1) - 6 ft x 1-1/2" x 1-1/2" x 1/8" aluminum angle
(2) - 12 ft x 3/8"OD x .035" wall aluminum tubing
(1) - 6 in x 1-1/2" x 1/8" Teflon rectangular bar

Cut two pieces 20-1/2" long and one piece 18-5/8" long from the aluminum angle. Save the remaining short length for use as a drill template with the teflon. Be sure to file all ends smooth after cutting.

From each of the 12 ft. pieces of tubing, cut one piece 57" long, two pieces 20-1/4" long and two pieces 19" long. If you are making the antenna for mobile mounting, cut four additional pieces 11/16" long from the remaining short lengths of tubing. File all ends smooth after cutting.

Mark and drill all of the holes shown in Figures 3-1 through 3-7. Use a countersink to debur all of the holes after drilling.

Cut the teflon into four pieces 1-1/2" long as shown in Figure 3-8. Clamp the four teflon pieces together between a piece of wood and the end of the drill guide. Drill the six 5/32" diameter holes through all four pieces.

3.2 ANTENNA ASSEMBLY (DDF-3000)

The following parts are required to assemble a DDF-3000 antenna:

(4) - Vertical Elements (Figure 3-1)
(4) - Short Radials (Figure 3-2)
(2) - Long Radials (Figure 3-3)
* (4) - Spacers (Figure 3-4)
(1) - Center Support (Figure 3-5)
(2) - Side Arms (Figure 3-6)
(4) - Teflon Insulators (Figure 3-8)
(16) - 6-32 x 1/2" round head machine screws
(16) - 6-32 x 3/4" round head machine screws
(4) - 6-32 x 1" round head machine screws
(24) - No. 6 flat washers
(32) - No. 6 split type lockwashers
(40) - 6-32 hex nuts
(8) - No. 6 locking type solder lugs
(4) - 8-32 x 1/2" round head machine screws
(4) - No. 8 split type lockwashers
(4) - 8-32 hex nuts
*(4) - 1/4-20 x 2" eye bolts
*(8) - 1/4-20 hex nuts
*(8) - 1/4" split type lockwashers
*(4) - 1/4-20 x 1-1/2" bolts

*(4) - 1/4" flat washers

*(4) - 1/4-20 insert suction cups

*(4) - adjustable straps with gutter clips

**(1) - 5/16 x 2" center-to-center x 3" long U-bolt

**(2) - 5/16 split type lockwashers

**(2) - 5/16 hex nuts

*Items required for mobile mounting.

**Items required for mast mounting.

(60ft) - RG 174/U or RG 58/U coax cable (Nominal length for 15 ft leadins. Adjust length as required for your installation).

(4) - Phono plugs (shielded type)

Cut the coax into four equal lengths. Try to match the line lengths within 1/2 inch. Be sure to use the same type coax for each leadin - preferably cut from the same original piece. Prepare them by soldering No. 6 solder lugs to both the inner conductor and the shield at one end, and a phono plug at the other.

Assemble the two arms to the support bracket using the 8-32 hardware as shown in Figure 3-9. Use a square to align the arms perpendicular to the support before tightening the screws.

At each end of the two arms, assemble a vertical element using the 6-32 hardware and a teflon insulator as shown in Figure 3-10. Check that the element is perpendicular to the arm and that the element mounting hardware does not touch the aluminum arm. Tighten the screws sufficiently to compress the lockwashers, but do not overtighten so as to crush the tubing or the teflon insulator. Connect the coax cable and tie it as shown as a strain relief.

Attach the short and long radials to the ends of each arm using the 6-32 hardware shown in Figure 3-11. If the antenna will be used on a car, also mount the suction cups and eye bolts as shown. Align the "eyes" so that they face outward from the suction cups. Figure 3-12 shows a typical installation.

Mark the phono jack ends of the coax cable "A", "B", "C" and "D" according to Figure 3-13. Mark antenna "A" also for ease in aligning the system later. Cables "A","B","C" and"D" must be connected in a counter-clockwise sequence when the antenna is viewed from above.

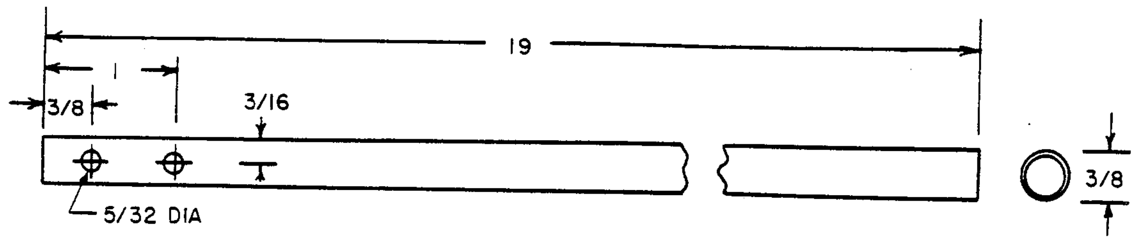


Figure 3-1
Vertical Element (4 Required)

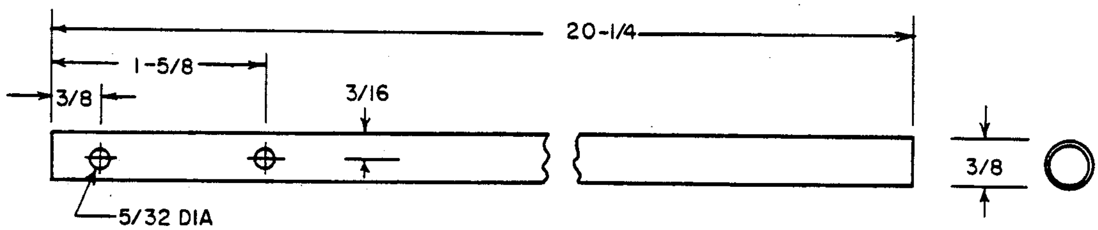


Figure 3-2
Short Radial (4 Required)

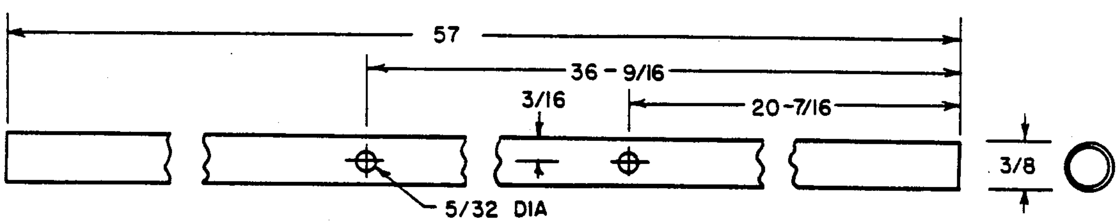


Figure 3-3
Long Radial (2 Required)

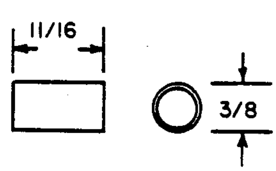
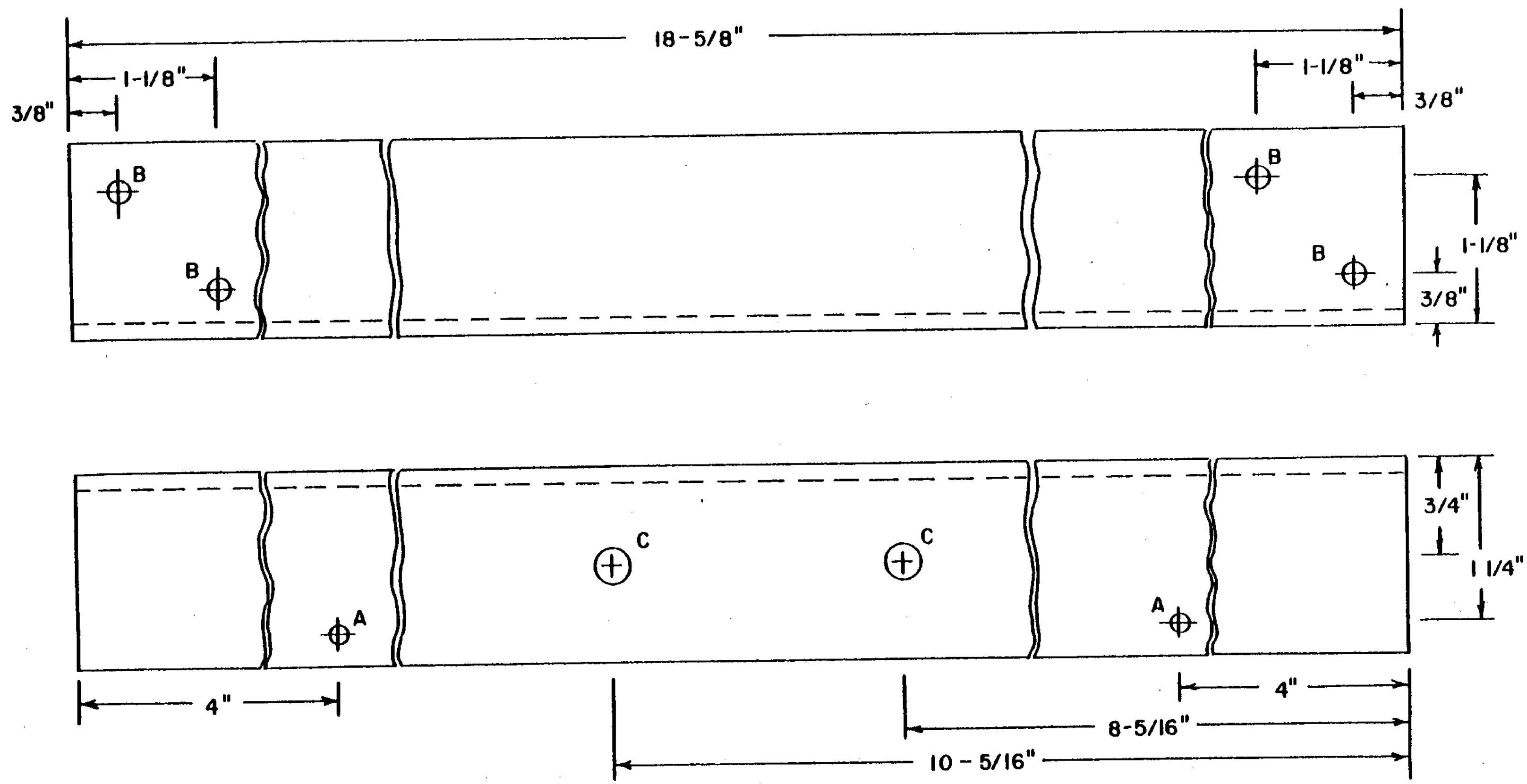


Figure 3-4
Spacer (4 Required)



DRILL	HOLES
5/32	A
11/64	B
5/16	C

Figure 3-5
Center Support (1 Required)

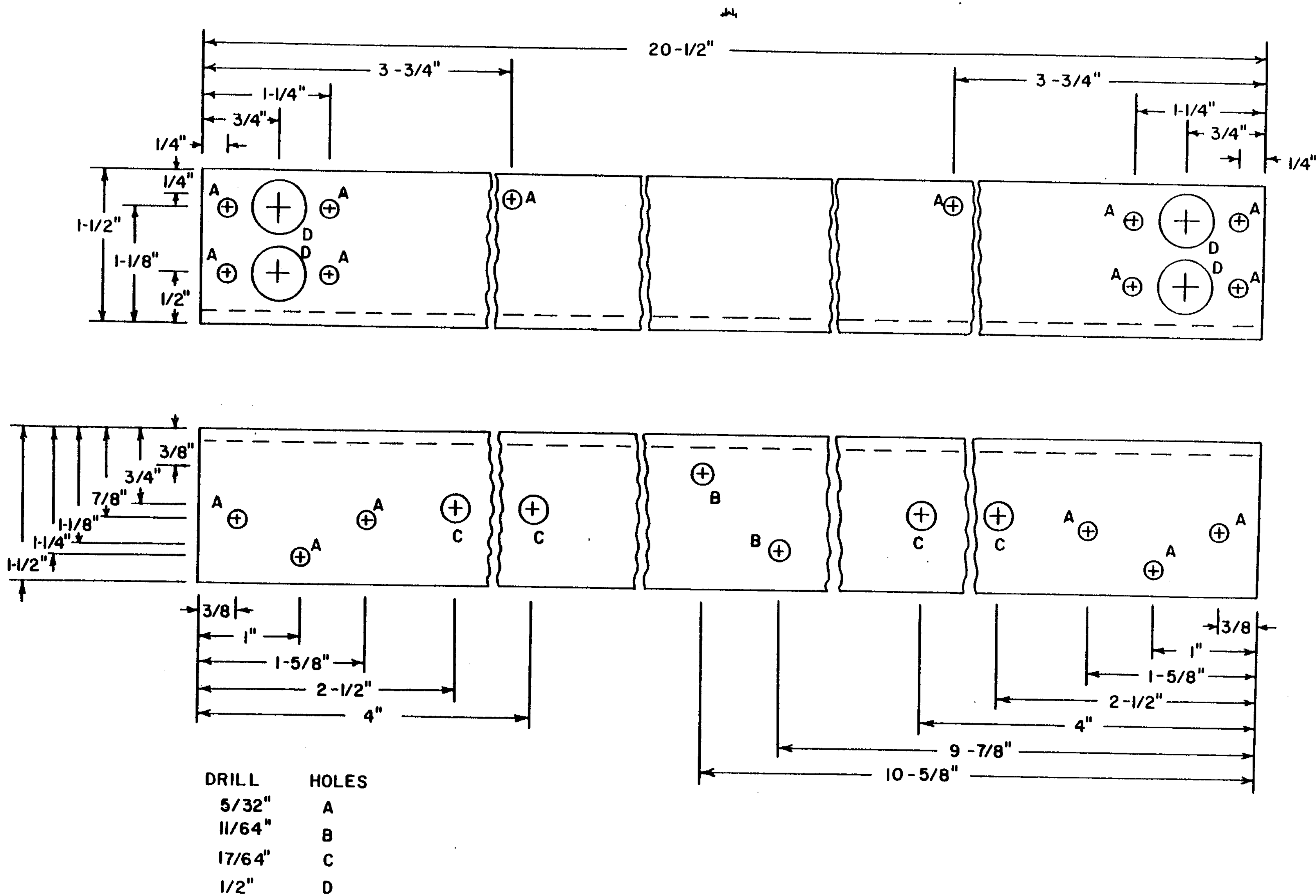


Figure 3-6
Side Arm (2 Required)

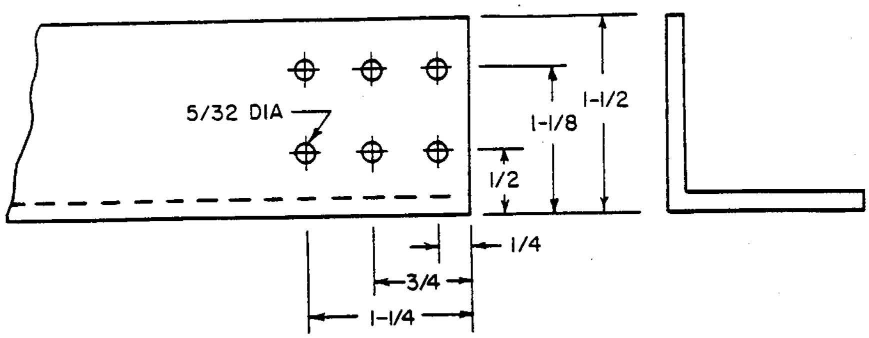


Figure 3-7
Drill Guide (1 Required)

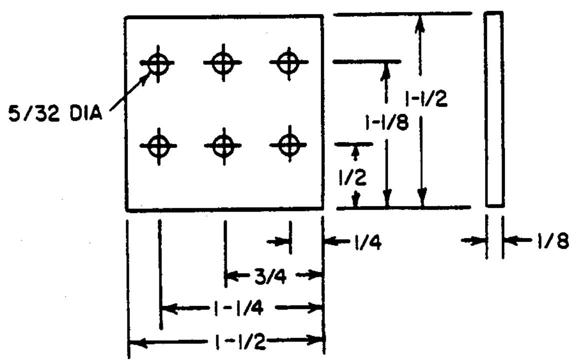


Figure 3-8
Teflon Insulator (4 Required)

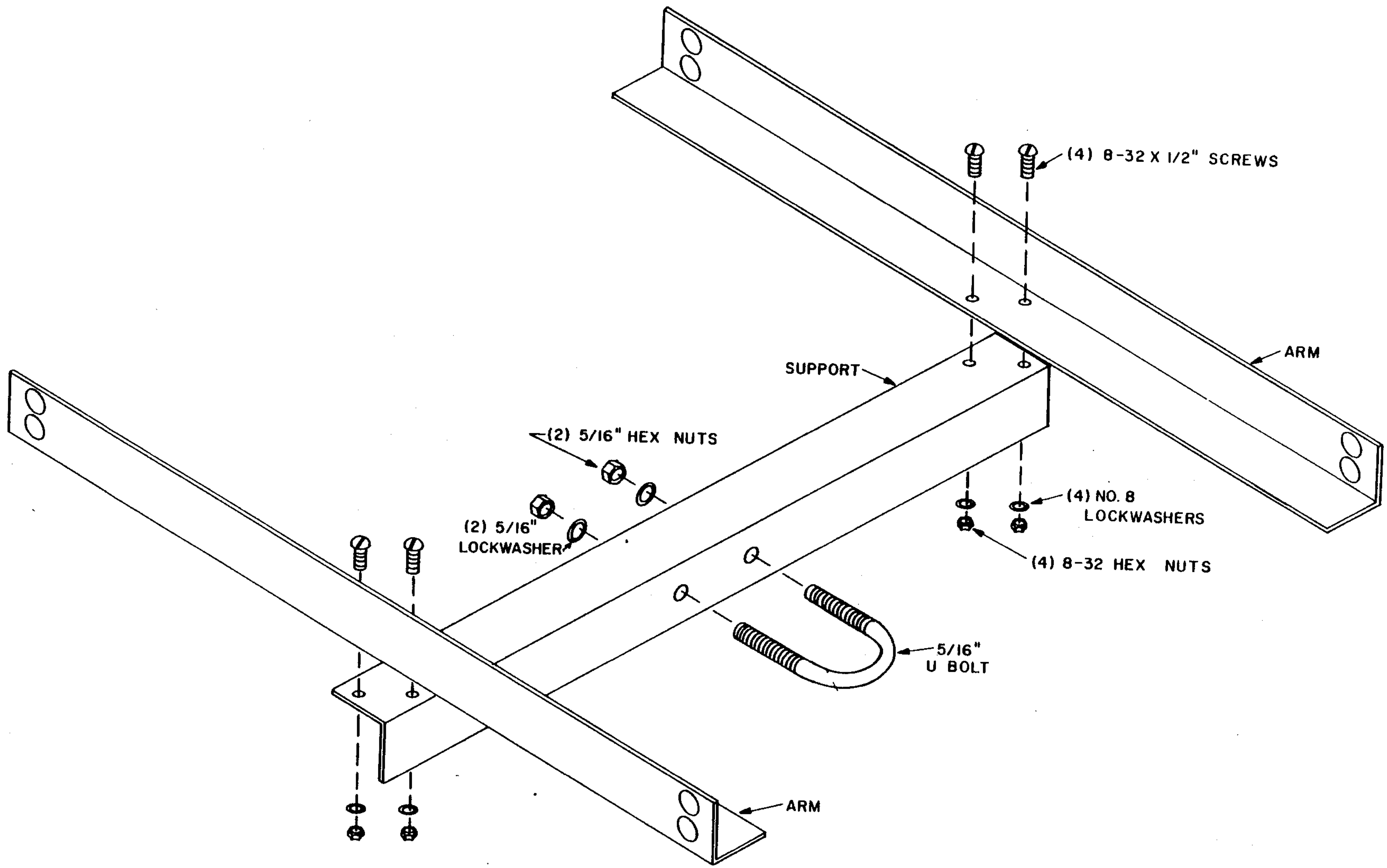


Figure 3-9
Arm and Support Assembly

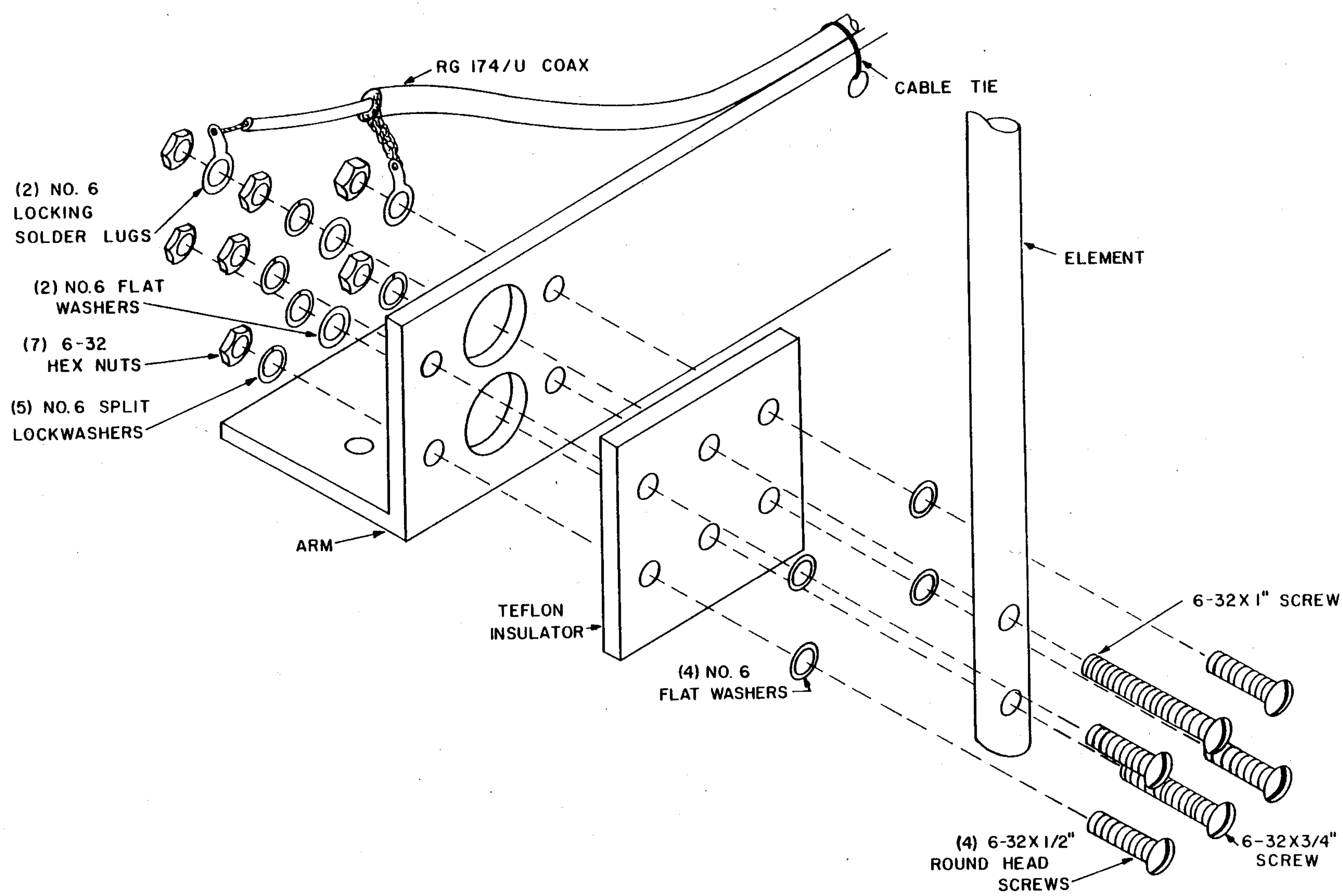


Figure 3-10
Vertical Element Assembly

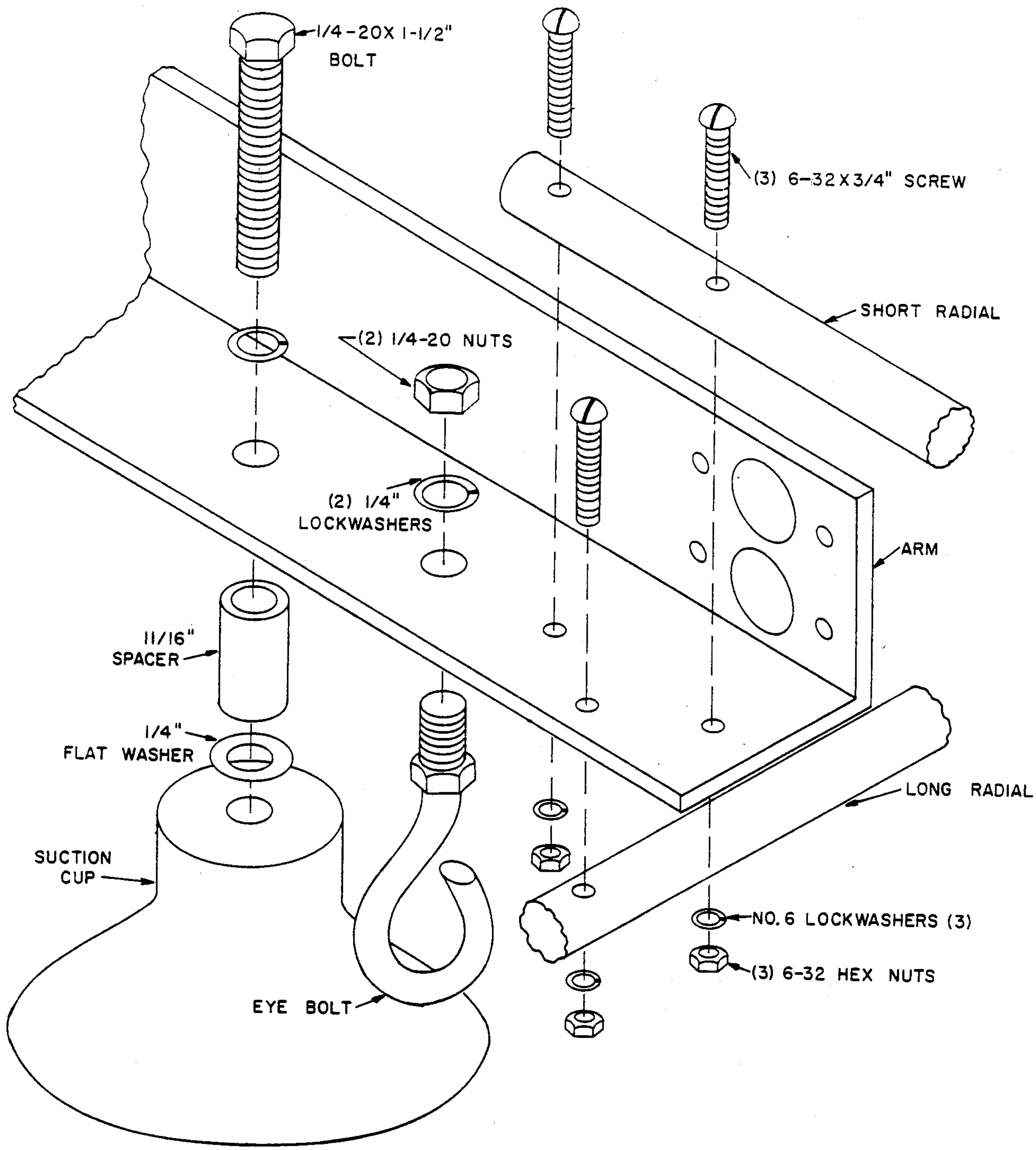


Figure 3-11
Radial Assembly

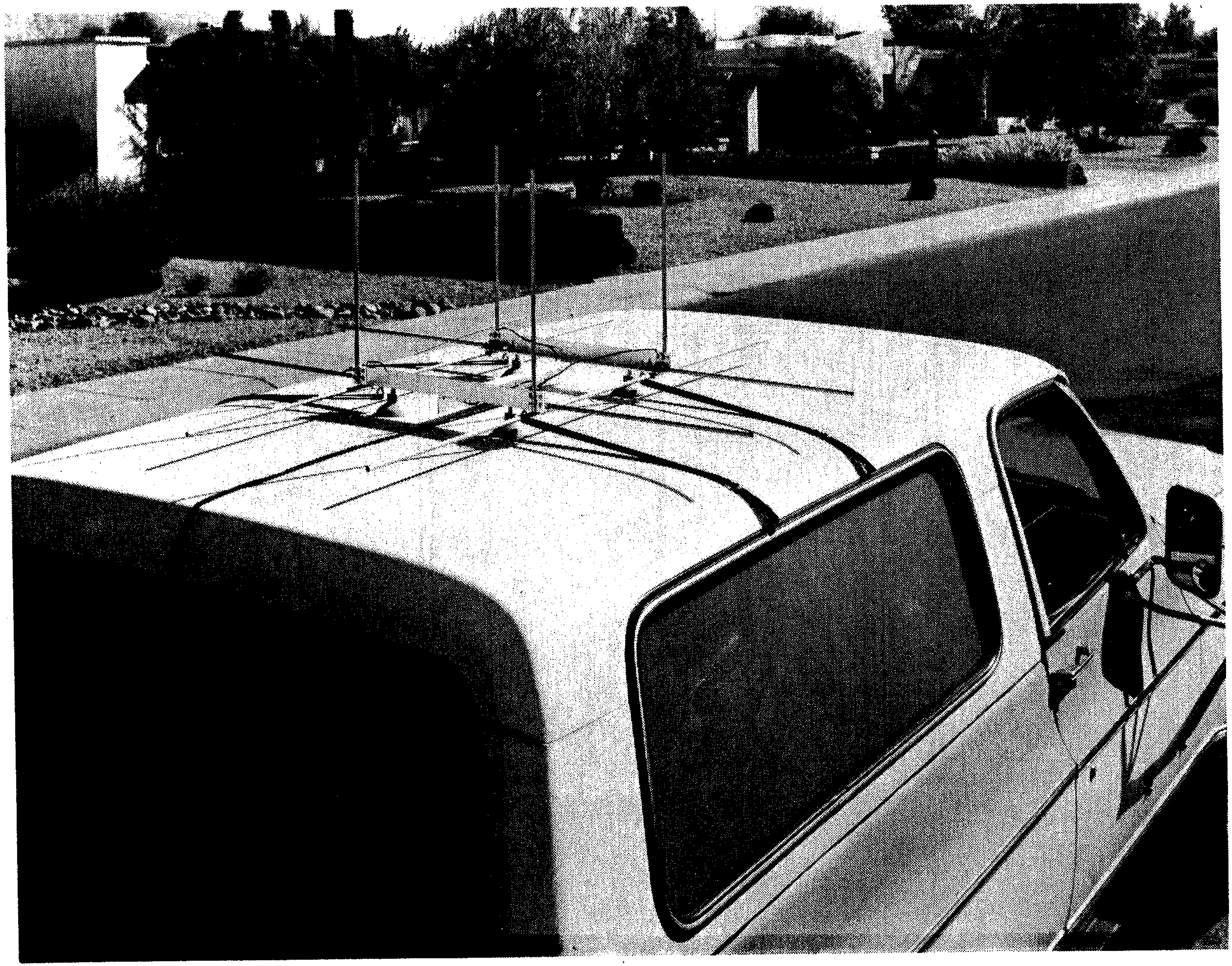


Figure 3-12
Typical Mobile Installation

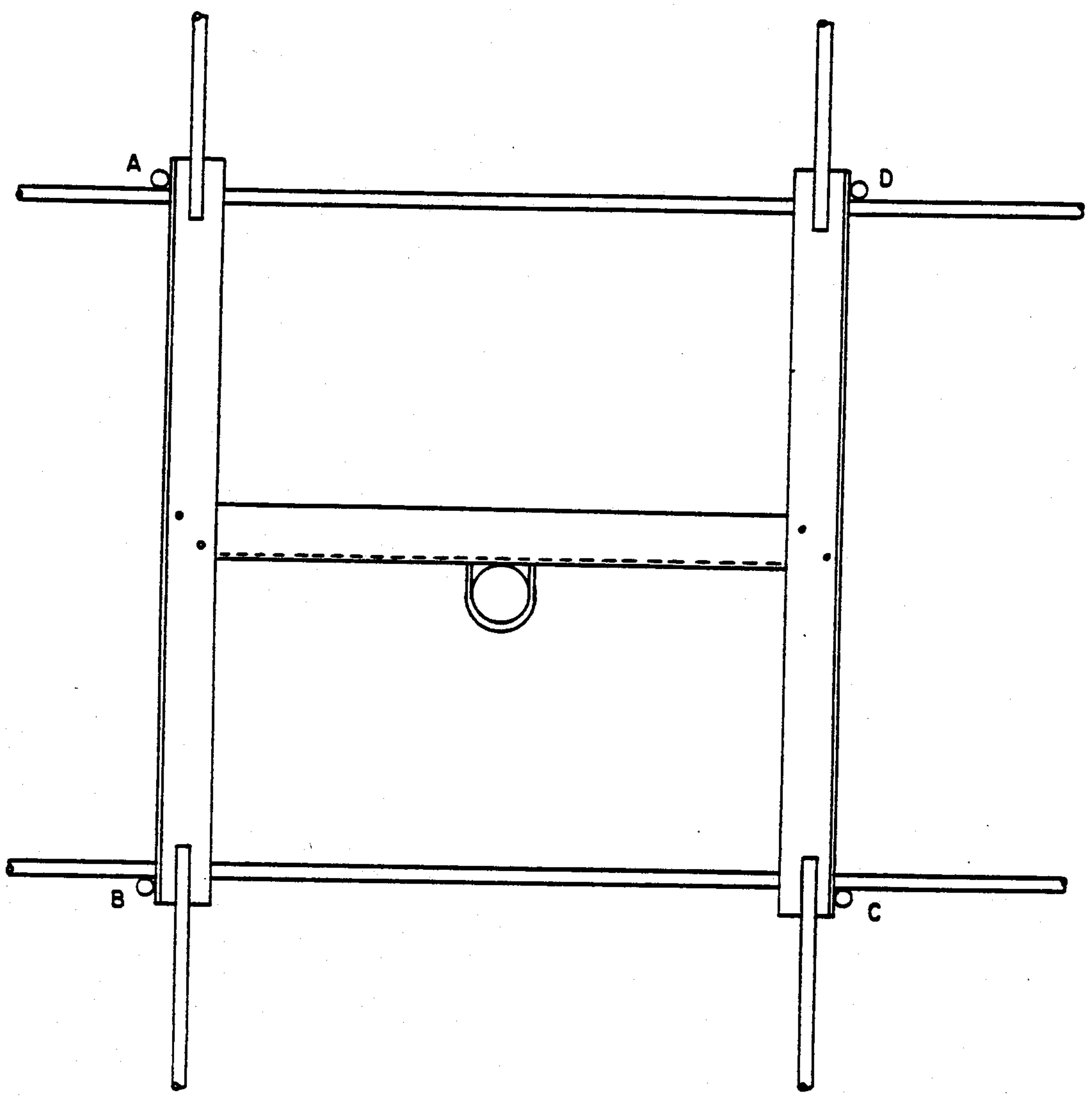


Figure 3-13
Antenna Element Identification

SECTION 4.0

INSTALLATION, ADJUSTMENT AND OPERATION

Primary power requirements for the electronics are 11.5 to 13.5 Vdc negative ground at 1 ampere maximum. Ordinary 12 Vdc automobile battery power may be used, or for fixed operation, an inexpensive 12.6 Vdc power supply may be used, such as Radio Shack® Model 22.127.

System interconnection without the serial interface (Models DDF-3001 and 3002) is particularly simple as indicated in Figure 4-1. While the external speaker connection can be used, you will probably find a more convenient connection to be the high and low ends of the receiver's volume control. This will enable the listening level of the receiver to be adjusted without affecting the audio input level to the direction finder.

The serial interface can be used in several ways as indicated in Figures 4-2 and 4-3. Bearing data and receiver audio may be recorded simultaneously as shown in Figure 4-2. Virtually any audio tape recorder in adequate for this application because of the low baud rate and wide FSK shift used for serial data transmission. A stereo system is recommended so that the normal receiver audio (voice) information may be recorded with the bearing data.

Two systems may be connected as shown in Figure 4-3 for remote data display. A switch could be installed at the central site to enable a single monitor point to display the bearing data received at two or more remote sites for triangulation. The possibilities for more complex system interconnects using digital processing for automatic triangulation and logging are exciting.

Calibration adjustments are very simple and should not be required after initial setup unless the antenna orientation is changed or a different receiver is used. Allow the receiver and direction finder to warm up before making final calibration adjustments, however. The location of the three calibration trimmer resistors is shown in Figure 2.8-15.

Wire the system interconnect cable as shown in Figure 4-4. Use AWG 22 wire for the power and speaker connections and a shielded microphone cable type of wire for the signal circuits.

After setting the receiver's volume control, the direction finder gain adjustment is made. Increase the gain until the overload LED flashes on voice peaks. (If this adjustment is very low, the display will remain blanked.) Setting is not critical, but the overload LED should blink occasionally during normal speech.

The direction finder bearing control should then be adjusted so that the correct bearing is displayed for a known transmitted signal. Do not use a nearby handie-talkie for this calibration as local reflections are sure to result in an error. A repeater station which is within the line of sight of the antenna makes the best calibration source. Changing channels will have very little effect on system calibration, so any convenient station within the band may be used. The display should be calibrated to display bearing relative to magnetic North in a fixed station setup and should correspond to straight ahead in a mobile application. The calibration range of the bearing control is approximately 90 degrees. If the system needs further correction, either rotate the antenna physically or switch the antenna inputs to the electronics. Be sure not to reverse the order of antenna rotation, however. The acceptable combinations of inputs are:

Input A	Input B	Input C	Input D
Ant. A	Ant. B	Ant. C	Ant. D
Ant. D	Ant. A	Ant. B	Ant. C
Ant. C	Ant. D	Ant. A	Ant. B
Ant. B	Ant. C	Ant. D	Ant. A

On Model DDF-3003, the serial interface receive frequency adjustment can by made by recording a few minutes of data, then playing it back in the Remote Display Mode while making this adjustment. Note the control settings where invalid data occurs, then set the control midway between these settings. If valid data is received up to one of the ends of the control adjustment, use the end point as the invalid data point. The setting of this control is not very critical.

In normal operation, you should hear a 300 Hz tone in the output of your receiver when the direction finder is on. This should not interfere with normal copy of the transmitted audio, however. Strong voice peaks will cause a variation in the indicated bearing. This is more noticable on deep male voices. These variations should average out, however. It is also possible to increase the electronic smoothing to minimize these variations as described in Section 6.4. This will slow down the response time of the system and is usually not desirable.

If you are using the direction finder to home in on a station with your car, you will also notice bearing variations due to reflections from passing trucks, buildings, etc. With experience, you will learn to identify a reflected signal from a direct bearing from its stability as you drive along and from the purity of the 300 Hz. audio tone. (Reflections tend to produce a more raspy sound).

A small rf gain loss occurs in the RF Summing circuit, but this can be minimized by adjusting coil L1 for the frequency band of interest. Slide back the shield case along the ribbon cable and compress or spread the turns on this coil while monitoring signal strength on your receiver. You should be able to peak the coil for a loss of 3 to 6 dB relative to the received strength from one of the antenna elements connected directly to the receiver. For operation below 135 MHz, it is necessary to add turns to L1 and/or shunt the coil with a small mica capacitor for resonance.

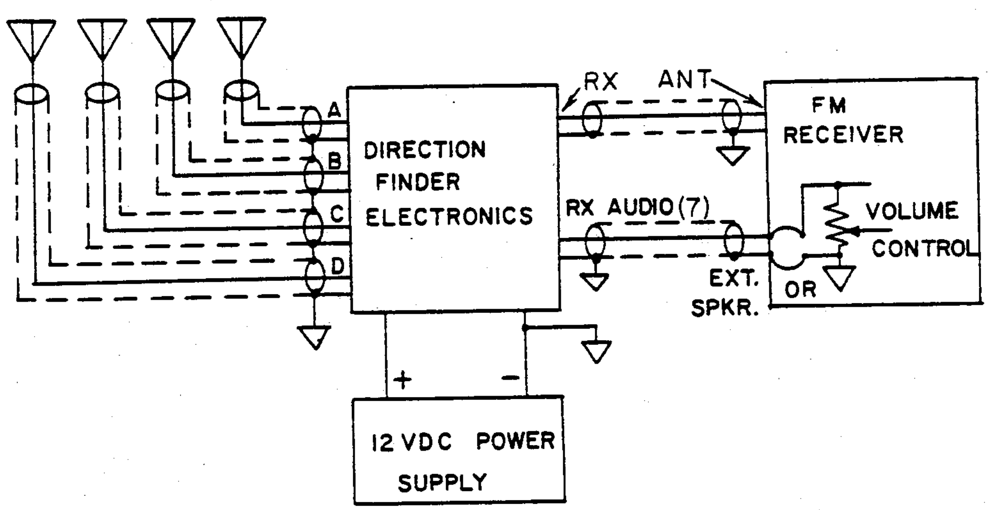


Figure 4-1

System Interconnect without Serial Interface

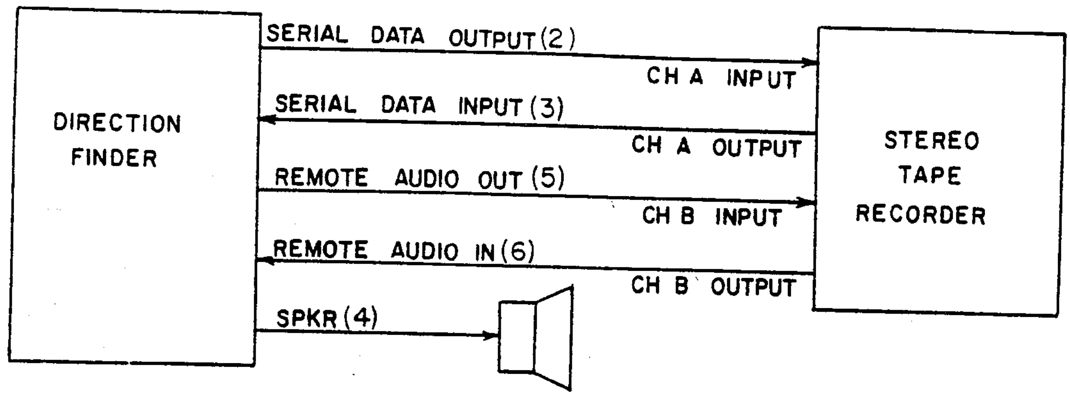


Figure 4-2

Use of Serial Interface for Data Recording

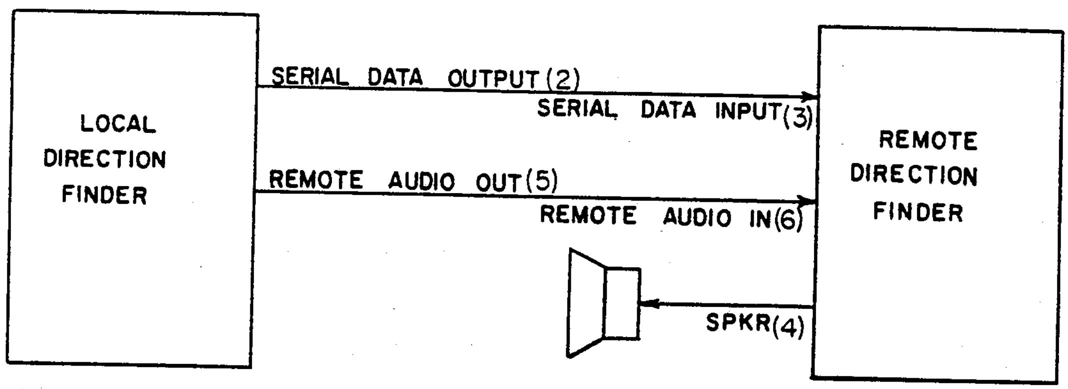


Figure 4-3

Use of Serial Interface for Remote Display

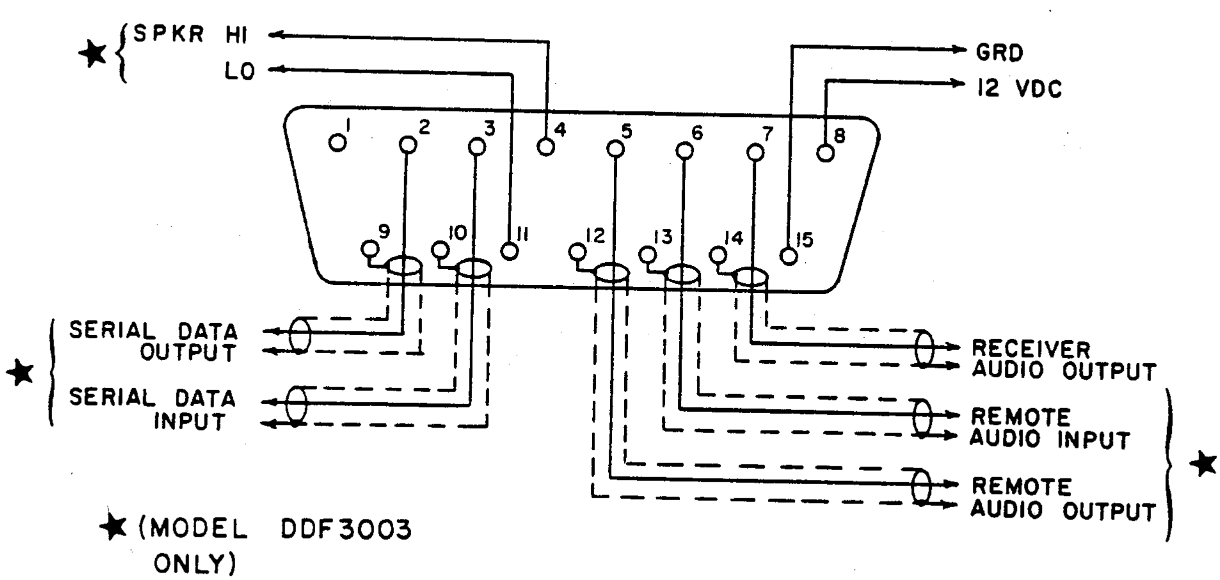


Figure 4-4

System Wiring to D Connector

SECTION 5.0

IN CASE OF TROUBLE

Together with Section 6.0, this section is intended to give you the information and procedures needed to locate and correct any problems that may occur in your direction finder electronics.

5.1 GENERAL PROCEDURES

Printed wiring cards may be removed from the enclosure to gain access to the various test points required for trouble shooting. To remove cards, first remove all power from the unit by disconnecting the D connector plug. Remove DIP jumpers as needed by inserting a small screwdriver between the mating surfaces at the side of each connector. Do not attempt to pull these small connectors apart by hand as the pins are easily bent in this manner.

Reconnect the cards outside the enclosure, resting them on their side edges. Place pieces of cardboard between the cards to prevent accidental shorting. Use extreme care when connecting scope probes to the circuitry to avoid shorts.

A good dc oscilloscope is required to check the various clock, audio and control voltage waveforms. Several short test leads having the small mini test clips on each end are needed to inject test signals as described below.

The scales used on the oscilloscope photos shown in this section are indicated on the photos themselves. The voltage shown in the upper left hand corner gives the vertical sensitivity in volts per major division. The sweep rate per major division is given in the top center. When a second trace is shown, its sensitivity in volts per major division is indicated in the lower left hand corner.

5.2 POWER SUPPLY VOLTAGES AND CLOCK WAVEFORMS

Use an oscilloscope to check the presence of the following voltages and digital clock frequencies on the Power Supply and Clock PWB DDF-3017.

Refer to Figure 2.2-1 for the location of these signals on the board. All signals are measured with respect to the "GRD" test point shown on this figure. If at any step the signals differ substantially from the nominal voltages, frequencies or waveforms shown, refer to the circuit description and schematic given in Section 6.7 to isolate the problem.

1. Check "+13SW"; it should be 11.5 to 13.5 Vdc.
2. Check "+5"; it should be 4.75 to 5.25 Vdc.
3. Check "1728000" on Models 3002 and 3003; it should look approximately as shown in Figure 5-1.
4. Check "1228800"; it should be approximately as shown in Figure 5-2.
5. Check "108000" on Models 3002 and 3003; it should be approximately as shown in Figure 5-3.
6. Check "9600"; it should be approximately as shown in Figure 5-4.
7. Check "-8"; it should be between -7 and -12 Vdc.
8. Check "-6"; it should be between -5.7 and -6.3 Vdc.
9. Check "VREF"; it should be between 1.8 and 2.2 Vdc.
10. Check "+8"; it should be between +7.6 and +8.4 Vdc.

5.3 CONTROL VOLTAGE WAVEFORMS

Use an oscilloscope to check the waveforms listed below on the Signal Processor PWB DDF-3016. Refer to Figure 2.3-1 for the location of these signals on the board. All signals are measured with respect to the analog ground shown on this figure. If at any stage the signals differ significantly from those shown below, refer to the circuit description and schematic given in Section 6.3 to isolate the problem.

1. Check "D/A"; it may be difficult to synchronize the scope on this waveform, but it should look approximately as shown in Figure 5-5.
2. Check "VCA", "VCB", "VCC" and "VCD"; these waveforms should all appear the same as that shown in Figure 5-6.

5.4 AUDIO SIGNAL WAVEFORMS

Disconnect the receiver audio output from the direction finder electronics and use two test leads to connect the signal "VCD" on Figure 2.3-1 through a resistance of approximately 1 megohm to the input "RX AUDIO" shown in Figure 2.2-1.

Use an oscilloscope to check the waveforms given below on the Signal Processor PWB and identified on Figure 2.3-1. Connect the external trigger on the scope to "VCD" for these measurements.

Refer to the circuit description and schematic given in Section 6.4 if the waveforms observed differ significantly from those shown in the accompanying figures.

1. Check "PA"; it should be approximately as shown in Figure 5-7.
2. Check the signal on pin 1 of U8; it should be approximately as shown in Figure 5-8.
3. Check the signal on pin 7 of U8; it should be approximately as shown in Figure 5-9.
4. Check the signal on pin 7 of U9; it should be approximately as shown in Figure 5-10.
5. Check the signal on pin 1 of U2; it should be approximately as shown in Figure 5-11.
6. Check the signal in pin 7 of U2; it should be approximately as shown in Figure 5-12.
7. Check the signal "S"; it should be approximately as shown in Figure 5-13.

5.5 SERIAL INTERFACE WAVEFORMS

On Model 3003 only, check the signals listed below using an oscilloscope. Disconnect the serial data input and output from any external equipment, and use a clip lead to connect these two points together ("SDO" to "SDI"). Refer to Figure 2.4-1 for the location of signals.

Trigger the oscilloscope off the signal on channel 1 (top trace). Refer to Section 6.6 if the waveforms differ significantly from those shown.

1. Check "SO" and "SDO"; the relationship between these signals should be approximately as shown in Figure 5-14.
2. Check "$\overline{\text{SI}}$" and "SDI"; the relationship between these waveforms should be approximately as shown in Figure 5-15.

5.6 FACTORY REPAIR SERVICE

In extreme cases when you are unable to troubleshoot and repair your direction finder electronics, you may return the unit to Doppler Systems for servicing. To return your electronics for repair, prepare a letter containing the following information: your name and address, purchase date of kit, a description of the problem and your authorization to ship the repaired unit back to you C.O.D. for service and shipping charges plus the cost of parts not covered by the warranty. Include a copy of this letter with your unit and mail a second copy directly to Doppler Systems, 5540 E. Charter Oak, Scottsdale, AZ. 85254.

Pack the assembled electronics in a sturdy box such as the one used for originally shipping the kit. Place at least three inches of resilient packing material on all sides between the equipment and the box. Seal the carton securely and send it by prepaid United Parcel Service or insured parcel post to: Doppler Systems, 5540 E. Charter Oak, Scottsdale, AZ 85254.

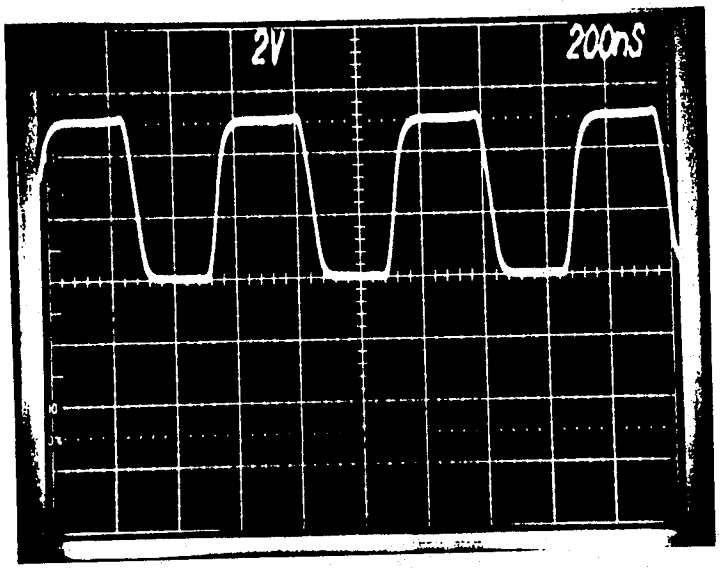


Figure 5-1
"1728000" Waveform

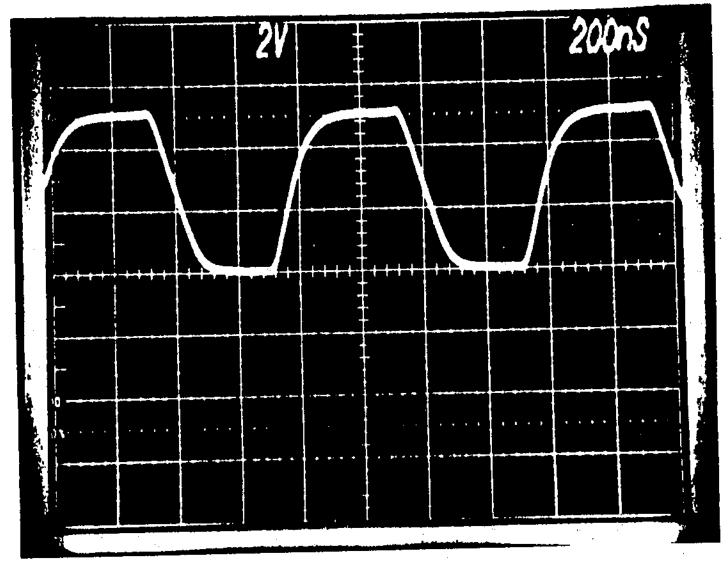


Figure 5-2
"1228800" Waveform

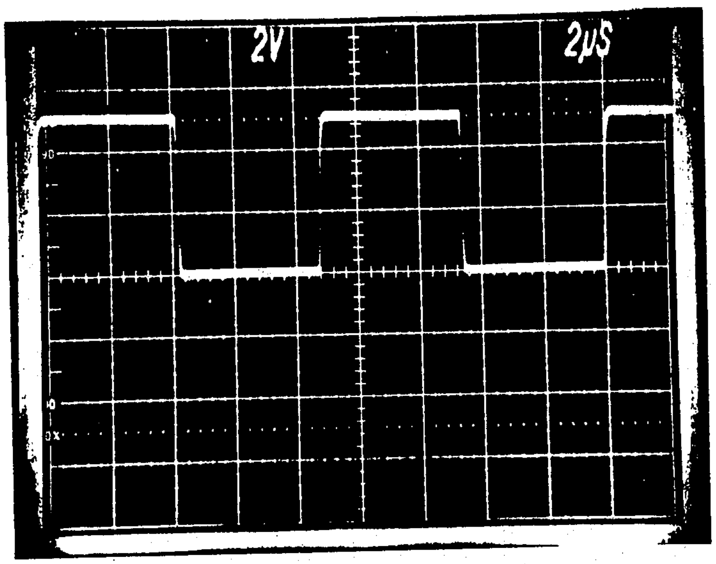


Figure 5-3
"108000" Waveform

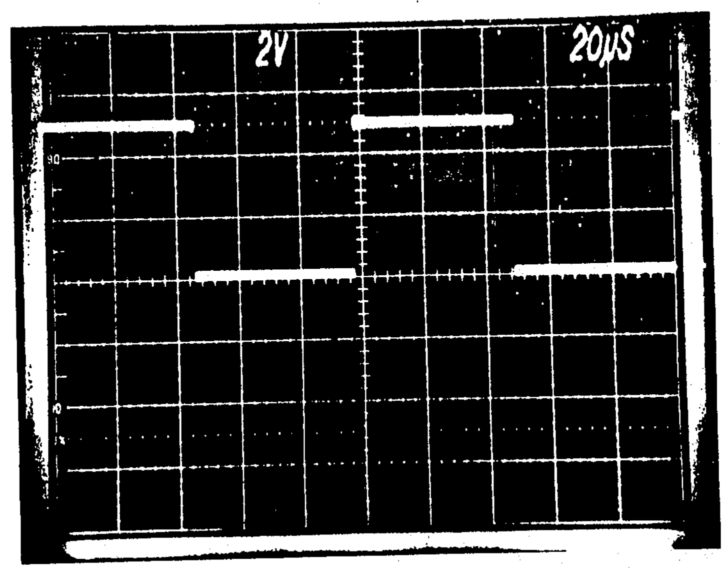


Figure 5-4
"9600" Waveform

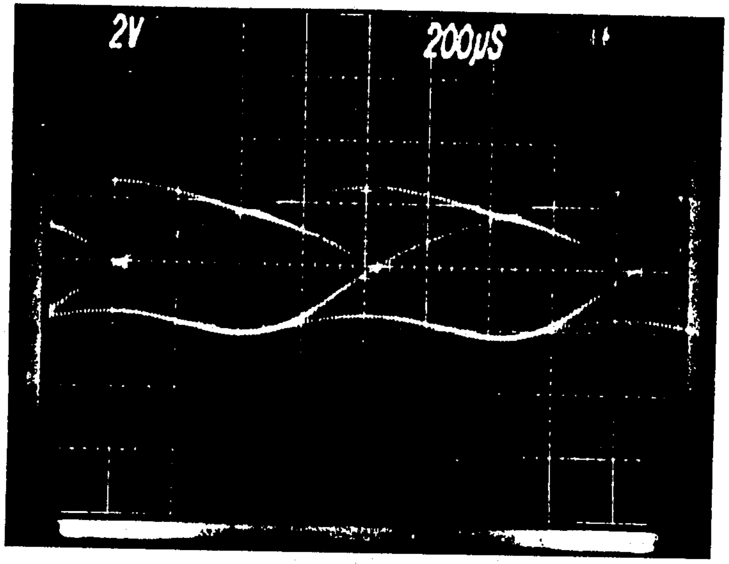


Figure 5-5
"D/A" Waveform

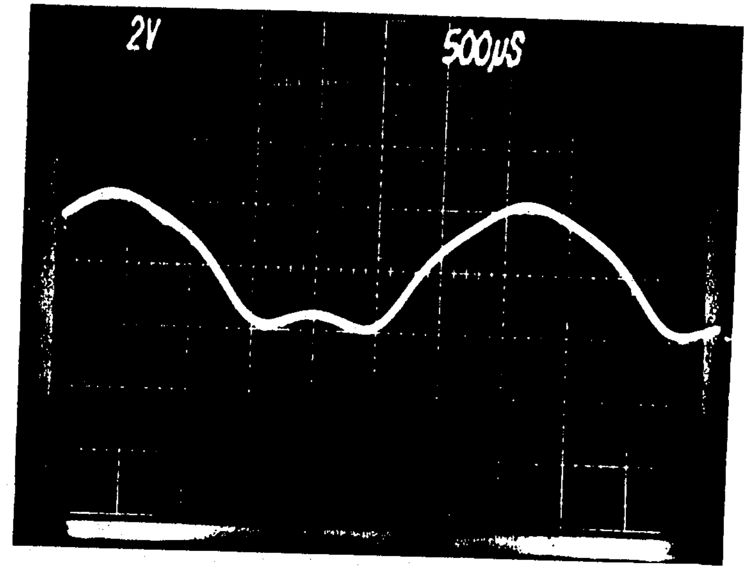


Figure 5-6
"VCA"; "VCB", "VCC" and "VCD" Waveforms

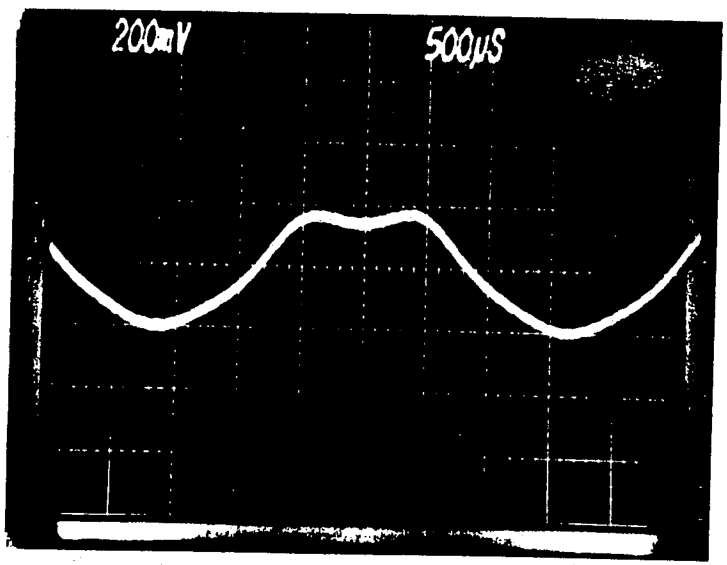


Figure 5-7
"PA" Waveform

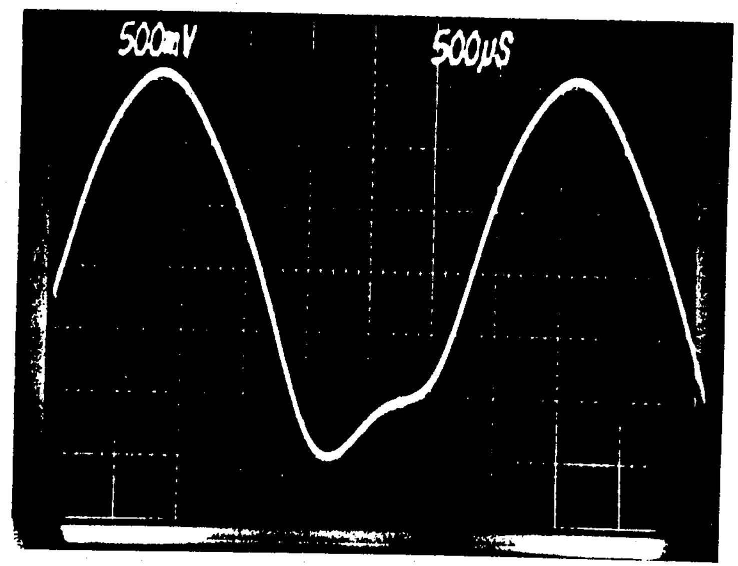


Figure 5-8
"U8-1" Waveform

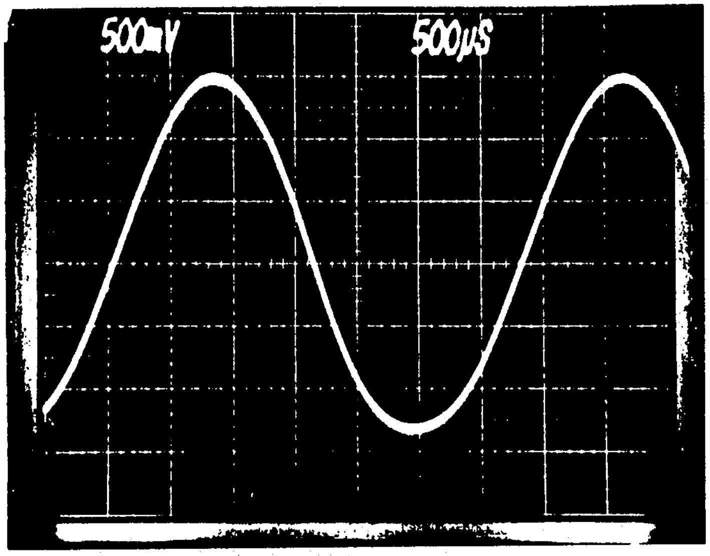


Figure 5-9
"U8-7" Waveform

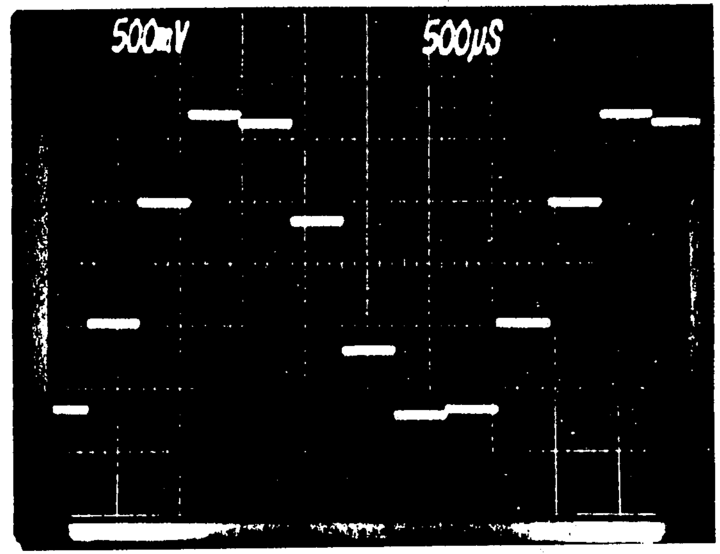


Figure 5-10
"U9-7" Waveform

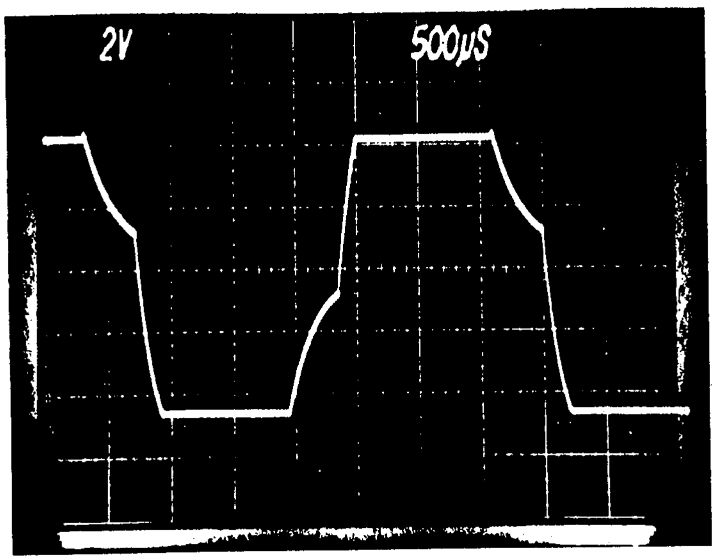


Figure 5-11
"U2-1" Waveform

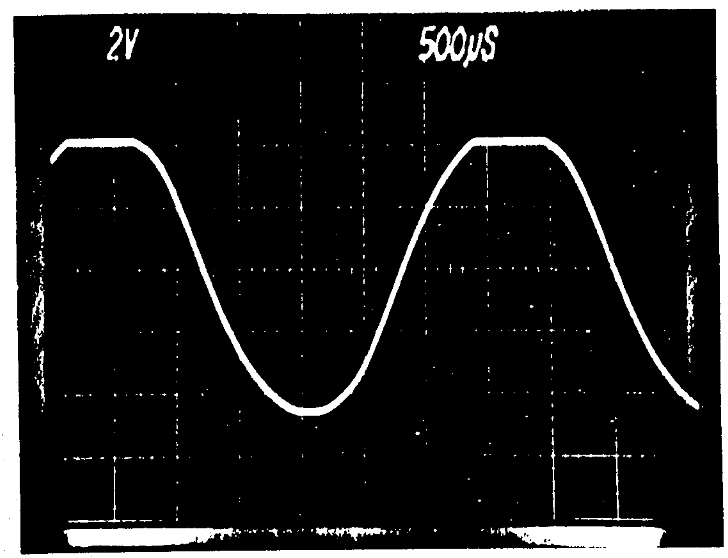


Figure 5-12
"U2-7" Waveform

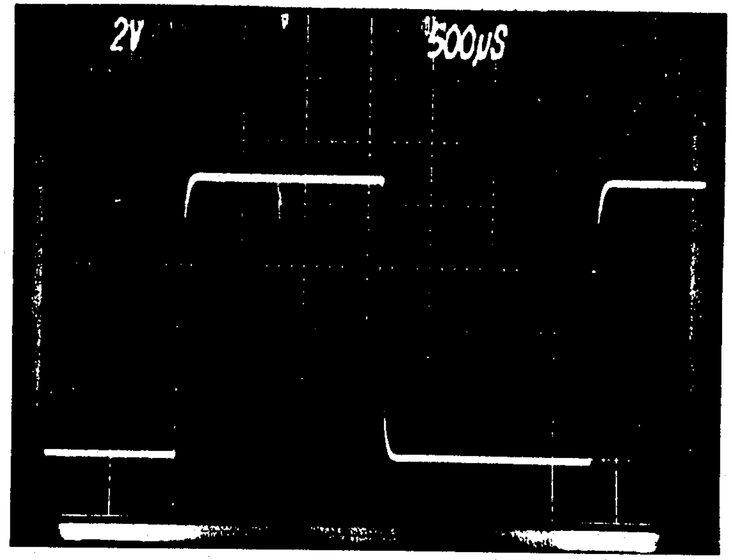


Figure 5-13
"S" Waveform

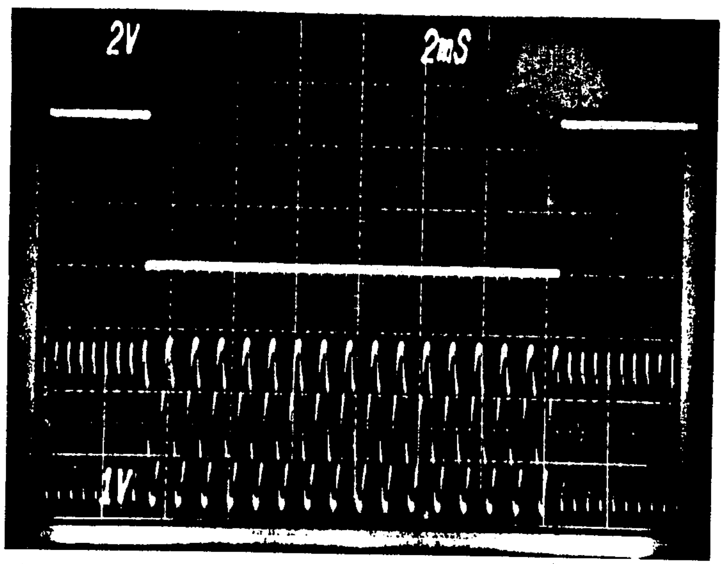


Figure 5-14
"SO" (Top) and "SDO" (Bottom) Waveforms

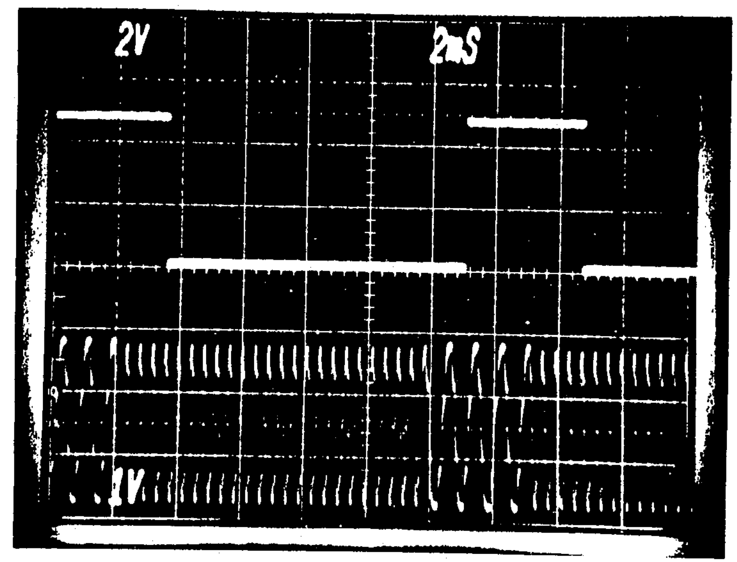


Figure 5-15
"$\overline{SI}$" (Top) and "SDI" (Bottom) Waveforms

SECTION 6.0
TECHNICAL DESCRIPTION

6.1 THEORY OF OPERATION

Radio direction finding (RDF) systems tend to fall into two general categories depending on whether or not they use the doppler shift principle. Most non-doppler RDFs employ directional antennas which produce peaks or nulls in the received signal amplitude as they are rotated. Doppler type systems, on the other hand, detect the phase modulation imparted to the received signal by translational motion of the receiving antenna. As a consequence of the "capture effect" of the FM receiver which detects the phase modulation, doppler type systems generally are less sensitive to site errors than amplitude measurement systems. The first know RDF based on detecting the doppler shift was patented by H. T. Budenbom in 1947 and used a motor driven antenna. Doppler RDFs today do not mechanically rotate an antenna, but instead rely on sequential switching between a series of antennas placed in a circular array to approximate a continuously rotating single element.

Sequentially switched arrays, although widely used, are not without problems of their own, however, They are generally large and unwieldy for mobile use at VHF frequencies, and the switching transients associated with the control signals used to switch between elements frequently result in receiver desensitization and susceptibility to off channel intermodulation. These problems are avoided in your RDF by linearly mixing the RF signals from four antenna elements in a continuous manner. The resultant signal closely approximates that which would be sensed by a single antenna smoothly rotating in a circular path.

The principle behind doppler direction finding can be explained by considering the geometry shown in Figure 6.1-1 which illustrates a simple antenna located at a distance R_1/λ and an angle θ from the reference position. Assume the incoming signal is located far (relative to the wavelength, λ) from the receiving antenna at the bearing ϕ shown. Then the voltage induced in the antenna can be written as

$$E_R = A \sin (\omega_c t + \psi)$$

where A is the received amplitude in volts, ω_c is the carrier frequency in radians per second, t is the time in seconds and is selected to start with a zero crossing of E_R at the origin and ψ is the phase shift in radians due to the antenna's being closer to or further from the transmitter. If the antenna is closer to the source, ψ would be positive, indicating a phase lead, etc. For the geometry shown,

$$\psi = \frac{2\pi R_1}{\lambda} \cos(\phi - \theta)$$

Now suppose the receiving antenna is permitted to rotate with velocity ω_d in a circular path of radius R_1/λ. Then $\theta = \omega_d t$ and the phase of the received signal is

$$\psi(t) = \frac{2\pi R_1}{\lambda} \cos(\phi - \omega_d t)$$

This equation indicates that the rotating antenna has caused the incoming carrier to become phase (and frequency) modulated. A standard FM receiver with de-emphasis will produce an audio output equal to the phase modulating the received signal (assuming the deviation is small compared to the discriminator full scale range).

$$E_{AUDIO} = K_A \frac{2\pi R_1}{\lambda} \cos(\phi - \omega_d t)$$

Thus the receiver's audio output is a sinusoid, having a frequency equal to the antenna commutation frequency ω_d, and a phase angle equal to the bearing angle ϕ. Electronic processing of the receiver's audio is used to separate the commutation frequency from other frequencies and to measure and display its phase.

Another way of looking at the problem is to consider the situation when the rotating antenna is at the angle where it is directly approaching the incoming signal. The maximum relative velocity causes an apparent increase in the carrier frequency at this point. Similarly, when the antenna has moved 180 degrees to the point where it is traveling away from the transmitter, the relative velocity is a minimum, and the carrier frequency appears to be lower. This is the familiar doppler shift phenomenon, but here the rotation of the antenna produces a periodic up/down shift, the phase of which is set by the bearing angle between receiver and transmitter.

The method used to simulate a physically rotating antenna in your RDF can be explained by referring to Figure 6.1-2. The real antennas are designated A, B, C and D and are located at the corners of a square. Antenna S is simulated by combining the ouputs of antennas A through D. Note that S is located on the inscribed circle of radius R_1/λ at the angle θ shown in Figure 6.1-2.

If an incoming signal were arriving from the left or right, the phase at A and B would be equal and the phase at C and D would also be equal. As long as the array is less the 1/2 wavelength on a side, the phase at point S may be computed by interpolating linearly between the phases to the left and right as indicated in the plot directly below the sketch on the antenna array:

$$\text{Phase at S} = \psi_S = \psi_{C \text{ or } D} + \left[\frac{(1 + \sin\theta)\, R_1/\lambda}{2\, R_1/\lambda}\right](\psi_{A \text{ or } B} - \psi_{C \text{ or } D})$$

$$= K_X\, \psi_{A \text{ or } B} + (1 - K_X)\, \psi_{C \text{ or } D}$$

$$\text{where } K_X = (1 + \sin\theta)/2$$

For example, is S is midway between A and D, $\theta = 0^\circ$, $K_X = 1/2$, $(1 - K_X) = 1/2$ and the phase is the simple average of the phases measured at A and D. If we now consider a signal originating from the top in Figure 6.1-2, the phase at S can be computed from that at A or D and that at B or C by interpolating along the Y direction. Referring to the graph to the left of the antenna:

$$\text{Phase at S} = \psi_S = \psi_{B \text{ or } C} + \left[\frac{(1 + \cos\theta)\, R_1/\lambda}{2\, R_1/\lambda}\right](\psi_{A \text{ or } D} - \psi_{B \text{ or } C})$$

$$= K_Y\, \psi_{A \text{ or } D} + (1 - K_Y)\, \psi_{B \text{ or } C}$$

$$\text{where } K_Y = (1 + \cos\theta)/2$$

These equations may be combined to give a two dimensional interpolation of phase.

$$E_S = K_X K_Y E_A + K_X(1 - K_Y)E_B + (1 - K_X)(1 - K_Y)E_C + (1 - K_X)K_Y E_D$$

The above mixing is not perfect since rf voltages rather than phase angles are being mixed; the errors, however, are small. The gain for antenna A is:

$$K_A = K_X K_Y = (1 + \sin\theta)(1 + \cos\theta)/4$$

This is shown plotted in Figure 6.1-3 over one cycle of rotation. Note that the gain peaks, as would be expected, at 45 degrees where the imaginary antenna is closest to antenna A. A second small gain increase also occurs

180 degrees from this location. The other antenna gains, K_B, K_C and K_D have identical shapes to K_A, but are displaced 90 degrees in phase (K_B lags K_A by 90 degrees, etc.).

A simplified functional block diagram of the complete radio direction finding system is shown in Figure 6.1-4. The rf summer combines the outputs of the four antennas through gains which vary according to the above equation. The phase modulated rf signal is applied to a conventional FM receiver which detects the phase modulation and provides the audio input to the doppler signal processor via connection to the external speaker output. Synchronous filtering removes the normal voice content leaving a sine wave having the same frequency as was used to modulate the antenna signals and a phase angle equal to the bearing angle. This sine wave acts as a trigger to latch the outputs of digital counters for display of the bearing in either a circular LED array and/or a three digit decimal display. An optional serial interface transmits the bearing data displayed by the unit or receives external bearing data as input for the display.

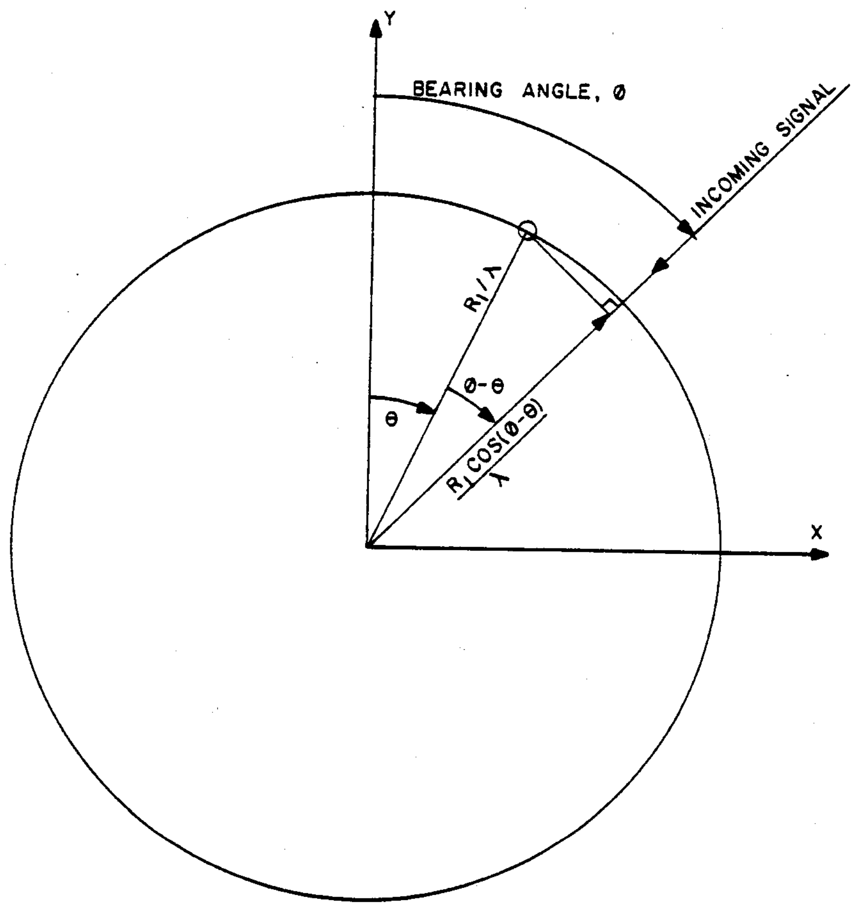


Figure 6.1-1
Doppler Direction Finding Antenna Geometry

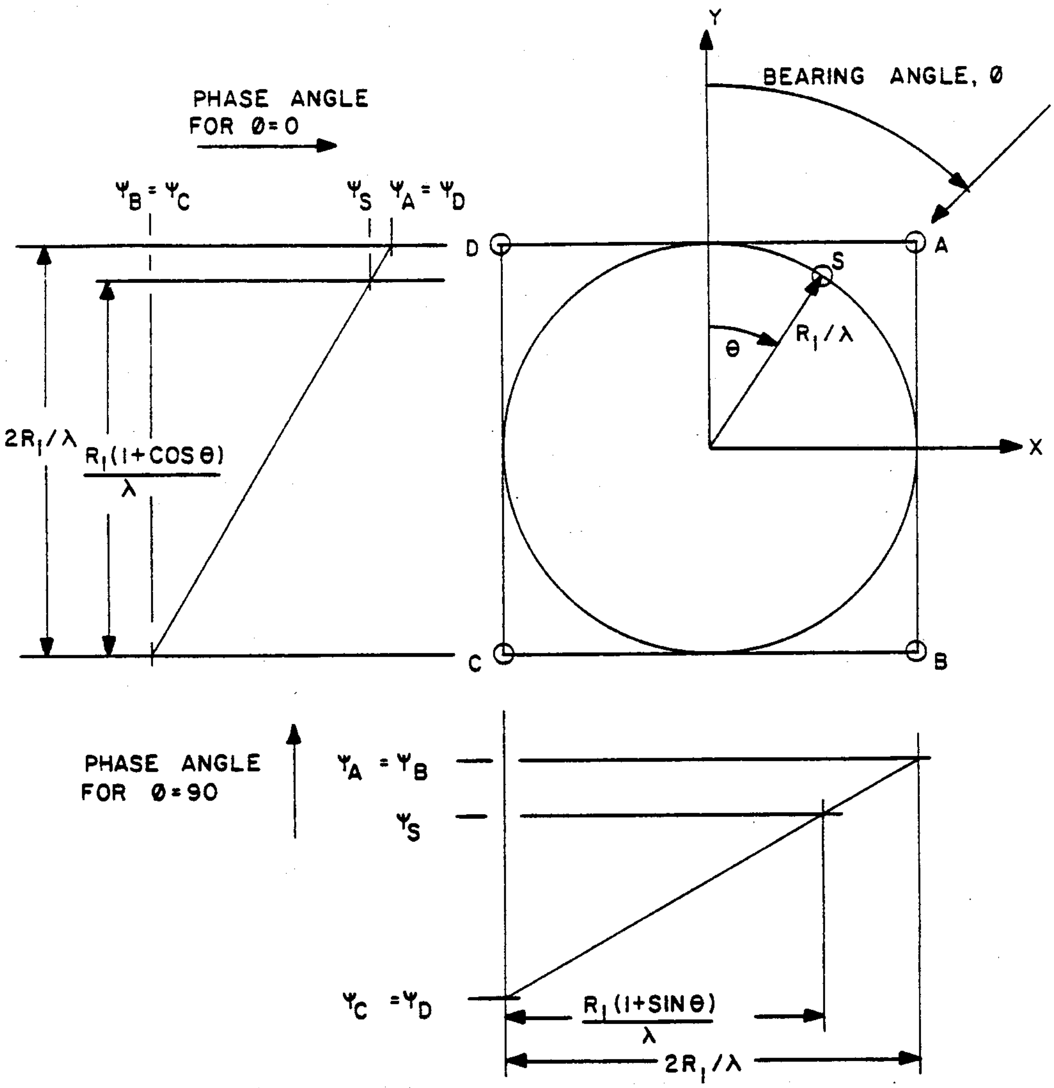


Figure 6.1-2

Phase Angle Interpolation Using Four Antennas

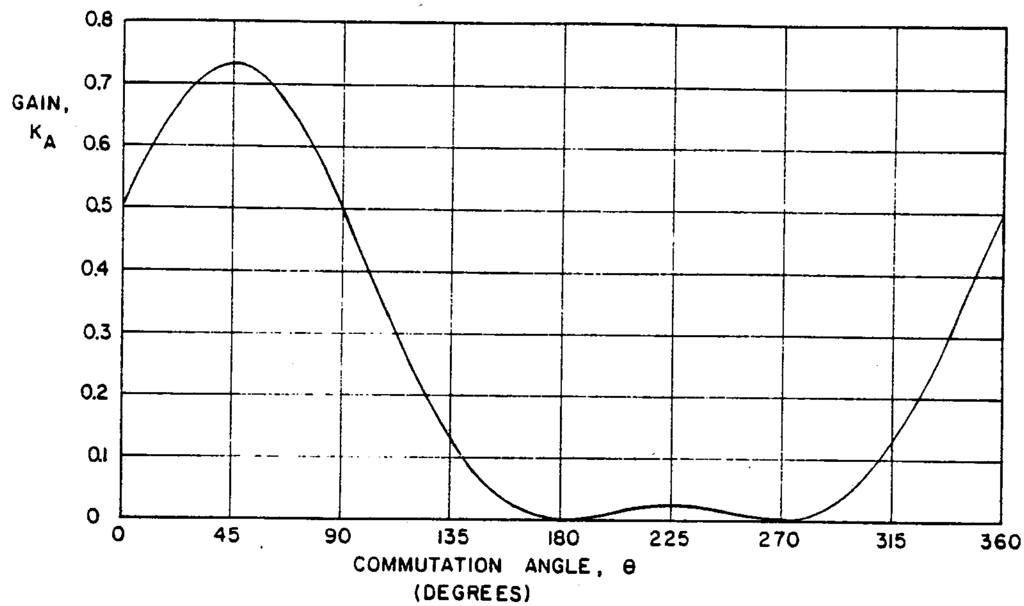


Figure 6.1-3

Antenna A Gain Required to Simulate Continuous Rotation

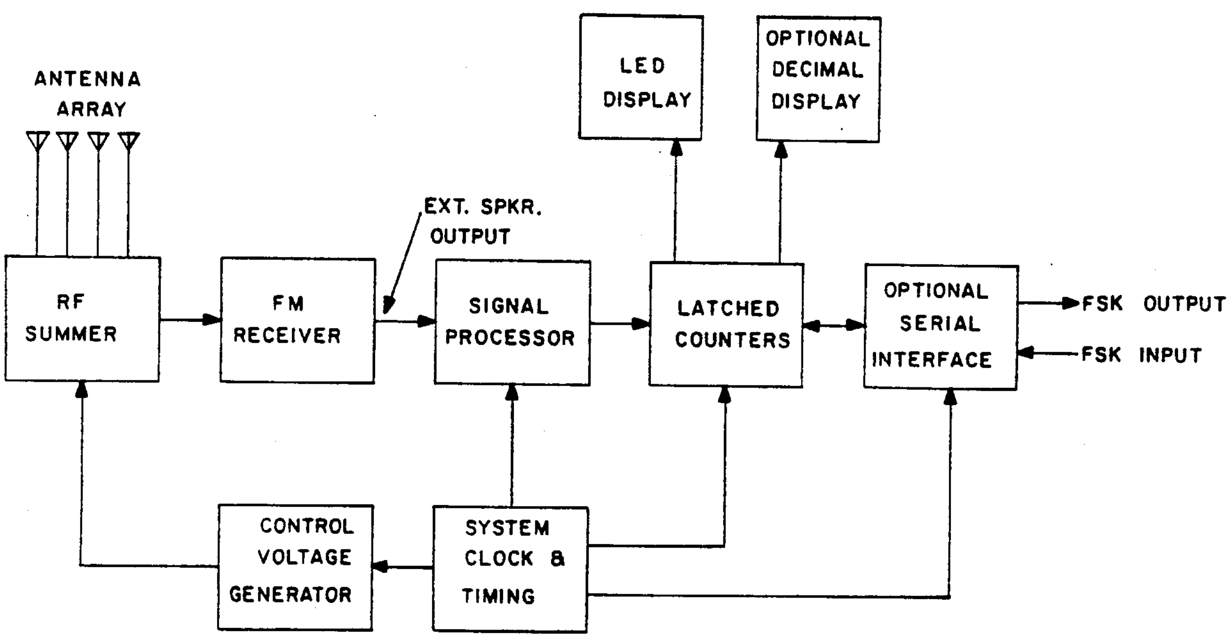


Figure 6.1-4

Block Diagram of Complete Direction Finding System

6.2 RF SUMMER

The circuit used for antenna summing should provide a low insertion loss, provide a stable and electronically controlled gain characteristic, have negligible phase shift variation with the control voltage, be compatible with a 50 ohm unbalanced input and lend itself to operating into a 50 ohm unbalanced output. The dual gate MOSFET operating in a common source configuration provides these characteristics.

Figure 6.8-1 is the schematic of the rf summer circuit. Each MOSFET acts as a current source into a common output impedance. The single tapped inductor is used to cancel the combined output susceptance of the four MOSFETs. Device input impedance is extremely high, and the circuit is broadbanded by the use of relatively low value resistors for line impedance termination at all inputs and the output. Some gain is lost, but it is quite acceptable (less than 6 dB) and could easily be made up with a preamplifier at the output if desired. The output voltage is the weighted sum of the four antenna voltages with the weighting determined by the transconductance of the FETs. Since the transconductance can be varied by the second gate control voltage, this provides the means for electronically combining the rf voltages.

6.3 CONTROL VOLTAGE WAVEFORM GENERATOR

Two 246 x 4-bit PROMs (Programmable Read Only Memories) are used to store the MOSFET waveform control gate. The PROM address is multiplexed in multiples of 90 degrees commutation angle, and the PROM output, after conversion to an analog voltage, is demultiplexed at the same time so that the entire PROM memory is utilized to generate each of the four control voltages. Figure 6.8-2A shows the schematic of the control voltage waveform generator.

Integrated circuit U3 is a 12-stage ripple carry binary counter that produces an 8-bit incrementing address to the PROMs. When driven at a frequency of 1228800 Hz, the PROM address will cycle at a rate of 300 Hz, which is the commutation frequency of the system. To multiplex the PROM, the two most significant bits are modified by adding a 0, 1, 2 and 3 sequentially to each of the PROM addresses using full adder U4. The resulting address is held temporarily in the 8-bit latch U5 which synchronizes the otherwise skewed output of the ripple counter.

Together the two PROMs U6 and U7 provide an 8-bit address by 8-bit output memory for the control waveform. Each address corresponds to 360/256 or 1.40625 degrees of commutation, while the output is scaled to cover the range -2.5 to +3.5 volts dc which provides a resolution of 6.0/256 = 0.0234 volts/step. The digital to analog converter U13 is used with a BIMOS operational amplifier U14A to minimize offset and noise. Integrated circuit U11 is an 8 channel analog demultiplexer which directs the converter output into one of the four dual gate MOSFETs. A small RC filter formed by resistors R6-R9 and capacitors C1, C4, C6 and C8 in the rf summer (Figure 6.8-1) is sufficient to hold the demultiplexed control voltage between updates. NAND gates U12A and U12C are used to inhibit the demultiplexer (U11) except during that portion of the cycle when the D/A ouput is stable. They also provide the synchronizing pulse to the octal latch (U5).

6.4 AUDIO SIGNAL PROCESSOR

Figure 6.8-2B shows the circuitry used to extract the 300 Hz doppler modulation frequency from the receiver's audio output and generate a logic signal synchronized to the phase of this signal for the display generator. Threshold detectors are also provided to give an overload indication to assist in setting up the audio gain of the circuit and to blank the display when no signal is present.

Preamplifier U7B, located on the power supply and clock PWB (Figure 6.8-6A), is ac coupled to the receiver and contains a gain adjustment variable over the range 0.2 to 10. Frequencies below 142 Hz are attenuated by the input filter and frequencies above 664 Hz are reduced by the feedback compensation. The preamplified audio "PA" is ac coupled above 159 Hz to amplifier U8A on the signal processor PWB (Figure 6.8-2B) which provides an additional gain 10 and further filtering above 724 Hz.

Amplifiers U8B and U2B are identical second order low pass filters tuned to a frequency of 469 Hz with critical damping.

The 8-section commutative filter composed of multiplexer U10 and follower amplifier U9B provides a 300 Hz bandpass synchronized to the antenna waveform frequency with a Q of 7540 RC where R is the series input resistor and C the value of each of the switched capacitors. As supplied, R = 1.2 Megohm and C = .047 uF providing a Q of 425. Since the Q of this circuit determines the speed of response of the system as well as the selectivity, a tradeoff can be made in the selection of resistor R. The value shown provides a good compromise, but individual users may prefer a somewhat faster or slower responding display. The one shot formed with NAND gate U12D is used to inhibit switching of the multiplexer during transition of its logic select inputs.

Amplifier U2A provides an additional gain 10 and helps to attenuate harmonics produced in the commutative filter above 796 Hz. Ac coupling is used to attenuate frequencies below 169 Hz because the commutative filter does pass dc. Amplifier U14B is used as a comparator to produce a square wave sync signal for the display generator. A BIMOS operational amplifier is used here for its very high slew rate. Ac coupling is employed to remove any dc offsets from the previous two stages, and a small RC filter at the output prevents extremely short sync pulses from being generated with zero input.

Amplifier U9A generates an overload signal which is helpful in setting the audio gain of the system. Blanking of the display in the absence of audio input (when the receiver is squelched) is accomplished by the half wave rectification of amplifier U1B and the comparator operation of amplifier U1A. A blanking delay of approximately 100 milliseconds is provided by the electrolytic capacitor.

6.5 DISPLAY

The circuitry required for a simple LED display is shown in Figure 6.8-3 and 6.8-4. Two one-shot circuits are used to convert the square wave sync signal S to a short positive clock pulse which is used to latch the binary clock count into quad latch U2. The first one-shot (U3B-U3A) has an adjustable delay time to permit calibration of the display over a 90 degree bearing angle. The second one-shot (U3C-U3D) generates a 10 microsecond latching pulse.

A 4 line to 16 line decoder (U1) drives the 16 LED circular display directly. (See Figure 6.8-4.) Two additional LEDs, D17 and D18, are used to indicate audio overload in the signal processing circuit and power on status.

When both LED and three digit decimal bearing readout is provided, the additional circuitry shown in Figure 6.8-3 as well as that given in Figure 6.8-5A is used. This circuit is designed for compatibility with the optional serial interface described below and uses a 4-bit data bus to transfer data between temporary holding registers and the display latches. If the serial interface is omitted, the two signals $\overline{SEND}$ and MS in Figure 6.8-5A must be tied to logic ground.

BCD counter latches U17B, U16A and U16B are driven by a 108000Hz clock signal and their contents latched into the tri-state latches U14, U1 and U15 by the delayed sync pulse. The binary clock count is simultaneously strobed into latch U2 by the same sync pulse. Since the maximum count is (decimal) 359, the maximum BCD count required for the hundreds digit is 3 (binary 0011). Since the two most significant bits of this digit are always zero, these bits are used to transfer the overload (MSB) and the display enable (MSB-1) information. A one-shot (U13A-U3A) is used to stabilize the overload flag for sampling.

Selection of the system clock frequencies was made in a manner so as to produce compatible binary and BCD counter frequencies. Over a complete commutation interval of 1/300 second, the 4-bit binary input to register U2 will increment through $\frac{2400}{300} \times 2 = 16$ counts. Each of these counts then corresponds to a 1/16th of a revolution on the LED circular display. Over the same time interval, the clock input to the BCD counters generates $\frac{108000}{300} = 360$ counts, or one count per degree. Small errors in the frequency of either clock will result in a display error which will accumulate rapidly unless the BCD counter is periodically synchronized back to the binary counter. The circuit consisting of flip flop U17A and the surrounding gates is used to reset the three BCD counters every complete cycle (as defined by the binary counters) so that the BCD and binary counts remain synchronized.

At a rate of 2.34375 times per second (each 426.666··· millisecond), data is transferred from tri-state registers U14, U1, U15 and U2 to latching registers U4, U5, U7 and U2 on the display driver PWB (Figure 6.8-3). Timing for the data transfer is obtained from the 12-bit counter U12, and the sequence is as follows for the case where a serial interface is not used. At the beginning of each transfer cycle (output of U12 all zeros), the input to registers U14, U1, U15 and U2 is disabled using their pin 9 control inputs. These inputs remain disabled during the first quarter of the transfer cycle (106.66··· milliseconds). During this same quarter cycle, the 1 or 4 decoder, U11B, places the tri-state output of the registers sequentially on to the bus using their pin 2 control inputs. The order of selection is U15 (overload-blanking-hundreds), U1 (tens), U14 (units) and U2 (binary). Each register is connected to the bus for 26.66··· milliseconds. While a tri-state register is connected to the bus, a corresponding display register (U4, U5, U7 and U2 on Figure 6.8-3) is strobed by a short pulse generated by one-shot U10C-U5E and steered to the correct display register via a second 1 of 4 selector (U11A). The data transferred to the display registers is held until the next update (426.66··· milliseconds later). Consequently, the display appears stable, but is still reasonably responsive to changes in the bearing data. Also, the data displayed is consistent (i.e., the binary and BCD data displayed are sampled simultaneously even though they are transferred sequentially).

Registers U4 and U5 on Figure 6.8-3 are BCD to 7 segment latching drivers which drive the units and tens displays directly. Latch U7 is a holding register which provides the 2 bits of hundreds data to the third BCD to 7 segment driver (U6). The blanking information and overload data are also available from outputs of latch U7. Quad latch U2 provides the binary LED data to the 1 of 16 selector U1.

6.6 SERIAL INTERFACE

The optional serial interface is shown in Figure 6.8-5B which permits remote transmission or reception of the displayed data using standard 300 Baud audio frequency shift tones. This data rate and the FSK tones used are compatible with data recording and playback using an inexpensive tape recorder.

The Universal Asynchronous Receiver Transmitter (UART) U8 is programmed for five data bits, no parity and 1-1/2 stop bits per character. The first four data bits of each character are simply the four data bus bits transferred to the display registers U4, U5, U7 and U2 on Figure 6.8-3. The fifth bit is used to signal the first character of the four character message; a zero represents the first character (overload-blanking-hundreds).

When locally received data is to be displayed, the UART operates in its transmit mode. The data transfer across the data bus operates exactly as explained above, and the data bus is strobed into the UART transmit buffer whenever any of the display registers is clocked. Thus, a four character word of data is sent every 426.666··· milliseconds. At 300 Baud, it requires (5 + 1-1/2)/300 seconds or 21.666··· milliseconds to send each character. Since data is taken from the bus each 26.666··· millisecond, this creates a gap of 5 milliseconds between consecutive characters.

When display of remote data is selected, the timing changes somewhat. All of the tri-state registers are removed from the data bus using their pin 1 control inputs, and the UART tri-state received data output is connected to the bus. When a first character has been received (bit 5 = 0 and $\overline{RDAV}$ = 0) a pulse is generated at MS which resets the 12-bit counter U12 on Figure 6.8-5A. Data transfer into the display registers then proceeds as usual except the UART supplies the data. The first data character is clocked into display register U7 on Figure 6.8-3 at 13.333··· milliseconds following data reception. Therefore, a large skew can be tolerated between local and remote clocks without affecting system operation.

In the local data display mode, digital data at 300 Baud from the UART serial output is used to select which of two clock frequencies, 9600 or 19200, is applied to the 4-bit Johnson counter U4 in Figure 6.8-5B. The counter outputs are applied through summing resistors to inverter U6E configured to work as an operational amplifier. The weighting of the three summing resistors R12, 13 and 14 is chosen such that the filtered output of U6E approximates a sine wave of frequency 1200 Hz when the UART output is "0" or 2400 Hz when the UART output is "1". Sinewave distortion is below 5% with this arrangement, and the FSK frequencies are as accurate as the system clock (which is crystal controlled).

When the system is in the remote data display mode, FSK input is demodulated in the decoder U9. The component values shown are optimized for 300 Baud, 1200/2400 Hz operation.

Additional audio circuitry is included with the serial interface option as a convenience when using the system with a two channel tape recorder. This is located on the power supply and clock PWB (Figure 3.8-6). FSK data is recorded on one channel, and the received audio out of preamplifier U7B is coupled through the RC circuit shown for simultaneous recording on the second channel ("RAO"). On playback, recorded audio "RAI" is amplified by U8 to drive a loudspeaker so that bearing data can be easily correlated with the received signal.

6.7 POWER SUPPLY AND CLOCK

The entire system is designed to operate from a single unregulated supply voltage between 11.5 and 14.5 V dc negative ground for mobile operation. Total input current is approximately one ampere with the display enabled. Figure 6.8-6 shows the power supply and clock circuits.

Gate U1D is biased for linear operation by the 9.1M feedback resistor and is used as a crystal oscillator running at a frequency of 1228800 Hz. Gate U1A acts as a buffer for the oscillator. Similarly, gates U1C and U1B form a crystal oscillator and buffer for 1728000 Hz on models having the digital display. U2 is utilized as a divide by 16 counter to generate 108000 Hz.

A TO-3 regulator mounted on the lower enclosure heat sink provides +5 Vdc for the digital logic, operational amplifiers and the displays. Regulator U5 provides +8 Vdc for the MOSFETs used in the rf summer.

Negative voltage is generated by a switching inverter/voltage doubler circuit that produces approximately -8 Vdc at the input to IC regulator U6. The -6 Vdc is used as the negative analog supply voltage.

Operational amplifier U7A generates the +2.0 Vdc reference used for D/A conversion and threshold comparison.

6.8 SCHEMATICS AND PARTS LISTS

The schematic diagrams given in this section are referenced by the circuit description given in sections 6.2 through 6.7. Each Figure corresponds to a printed wiring board and shows all of the parts required for Models DDF-3001, 3002 and 3003. A parts lists given for each PWB must be consulted to determine the parts and jumpers present on a specific model. Figure 6.8-7 is a schematic of the chassis mounted circuitry and the interconnections between the individual printed wiring boards.

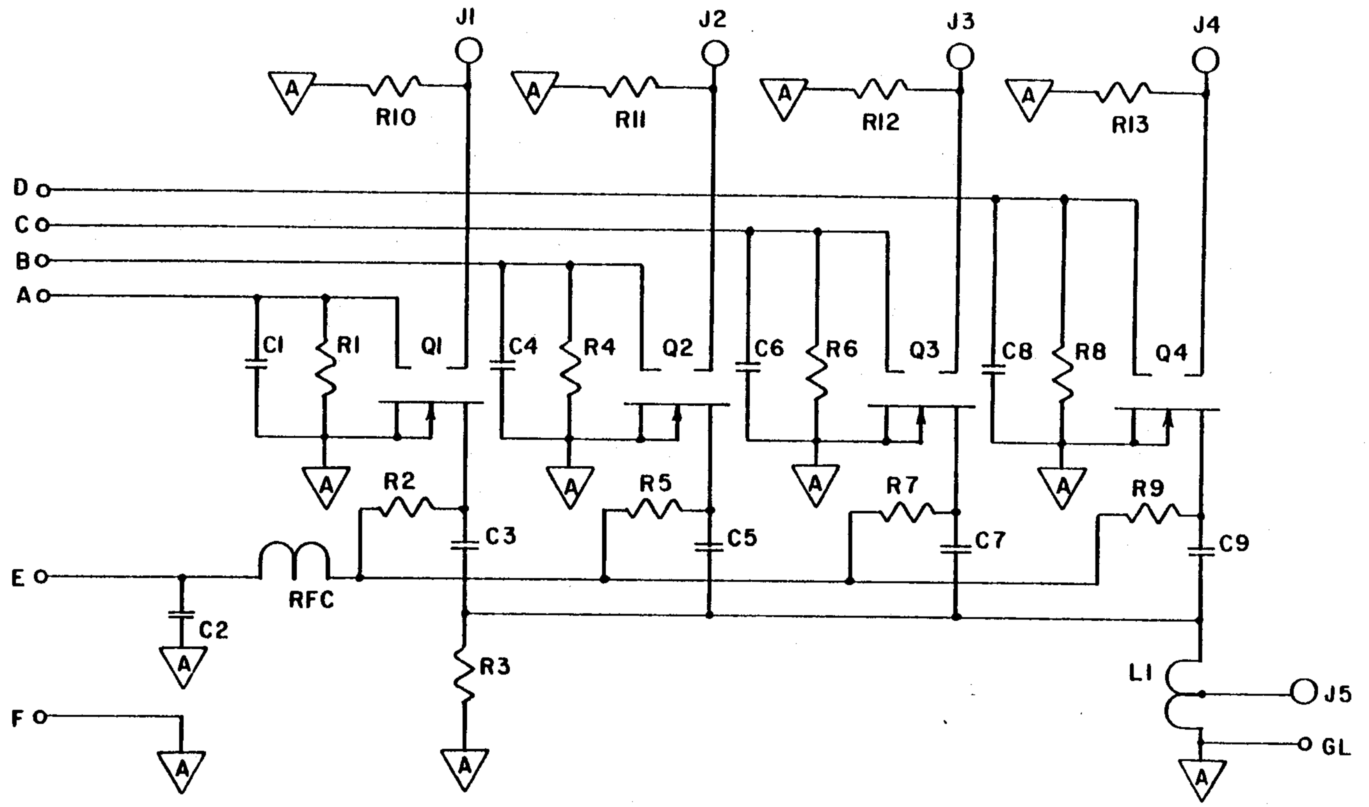


Figure 6.8-1A

RF Summer Schematic

(Printed Wiring Board DDF-3014)

REF. DESIG-NATION	DESCRIPTION	MODEL DDF-		
		3001	3002	3003
Q1-Q4	3N211	x	x	x
R1	2.4M	x	x	x
R2	220 ohm	x	x	x
R3	1.0K	x	x	x
R4	2.4M	x	x	x
R5	220 ohm	x	x	x
R6	2.4M	x	x	x
R7	220 ohm	x	x	x
R8	2.4M	x	x	x
R9	220 ohm	x	x	x
R10	51 ohm	x	x	x
R11	51 ohm	x	x	x
R12	51 ohm	x	x	x
R13	51 ohm	x	x	x
C1	470 pF	x	x	x
C2	.001 uF	x	x	x
C3	.001 uF	x	x	x
C4	470 pF	x	x	x
C5	.001 pF	x	x	x
C6	470 pF	x	x	x
C7	.001 uF	x	x	x
C8	470 pF	x	x	x
C9	.001 uF	x	x	x
RFC	1uH	x	x	x
L1	See Figure 2.7-2	x	x	x

Figure 6.8-1B

Parts List for PWB DDF-3014

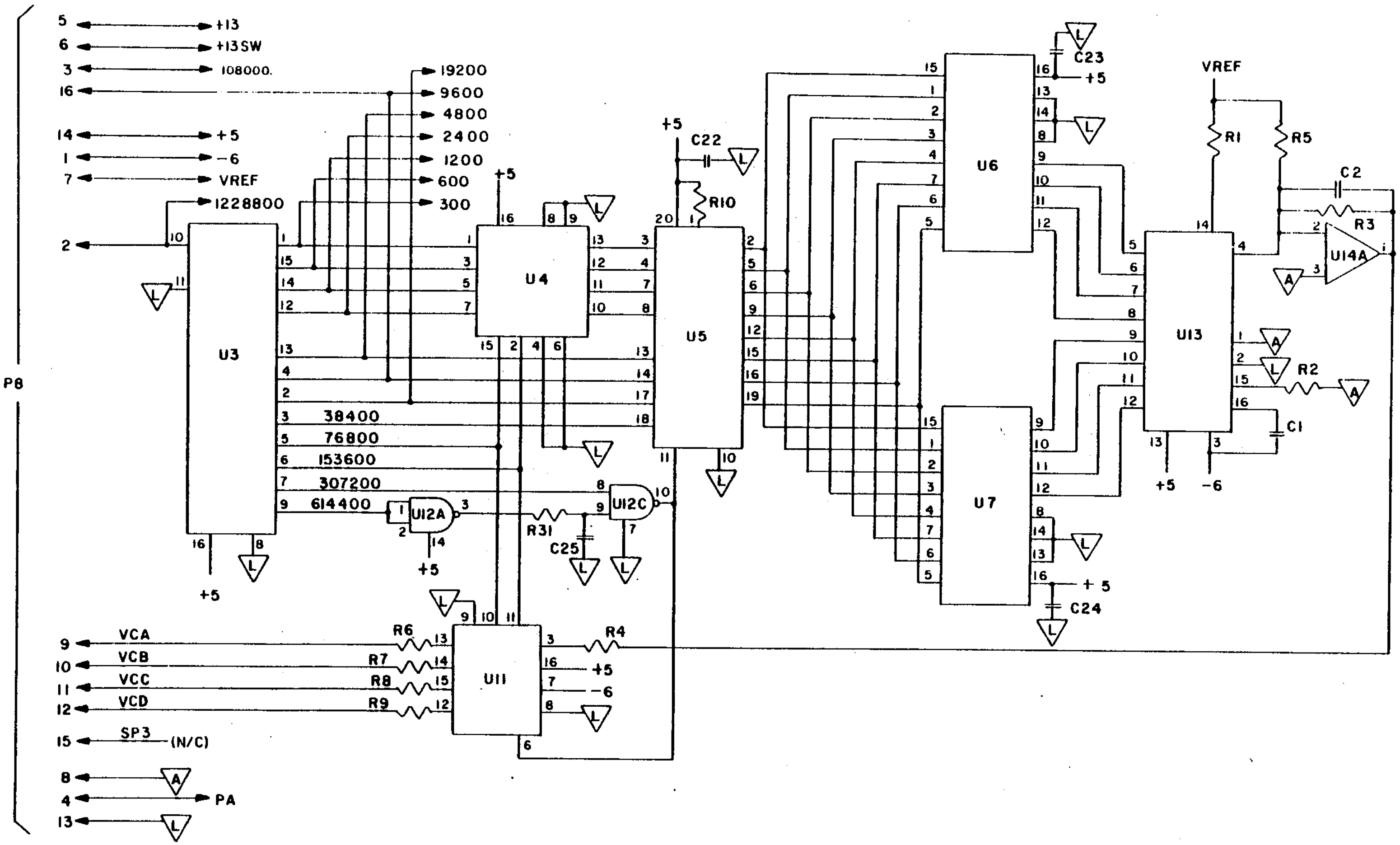


Figure 6.8-2A

Control Voltage Waveform Generator Schematic

(Printed Wiring Board DDF-3016)

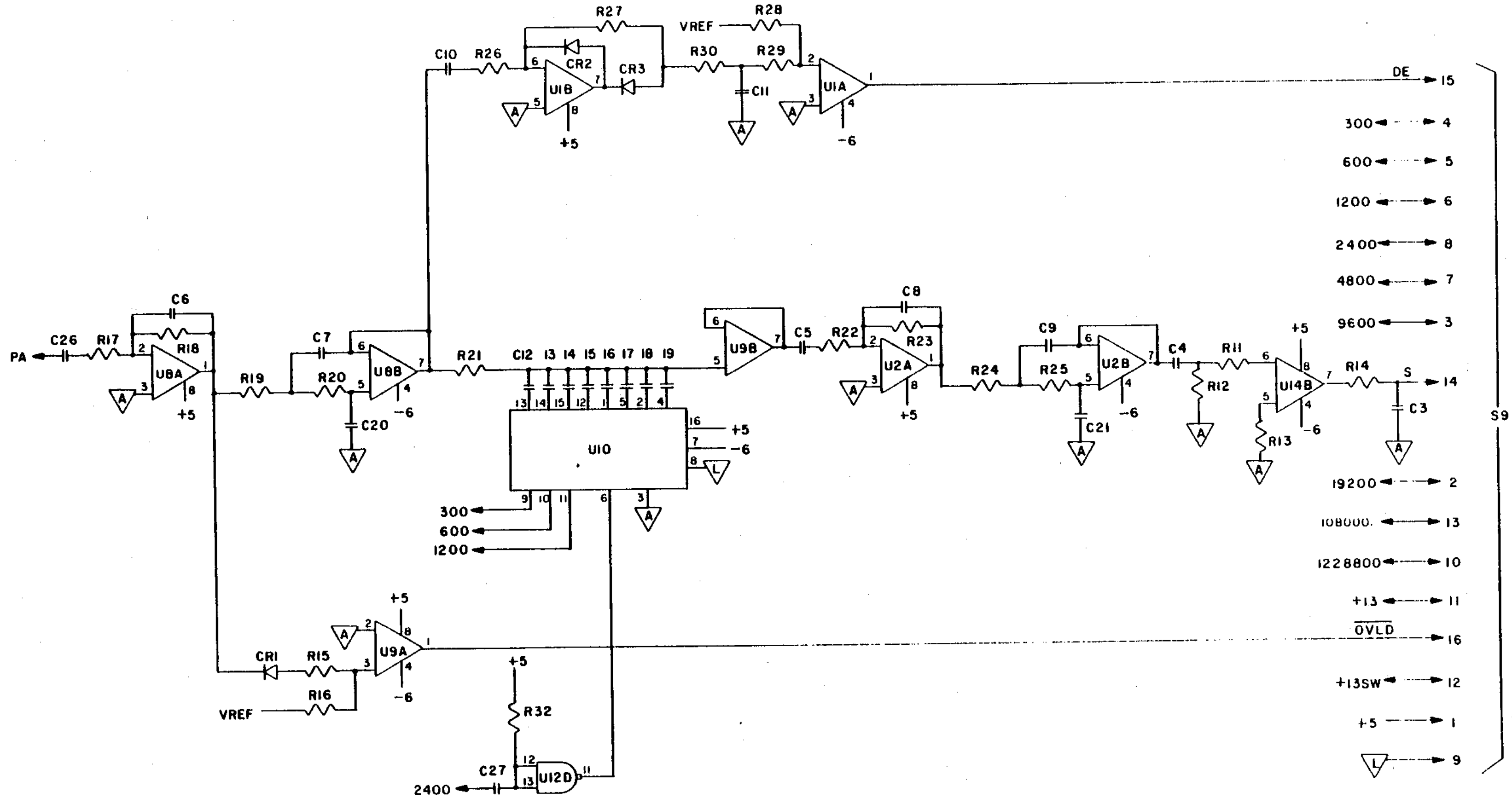


Figure 6.8-2B

Audio Signal Processor Schematic

(Printed Wiring Board DDF-3016)

REF. DESIG-NATION	DESCRIPTION	MODEL DDF- 3001	3002	3003
U1	LM1458	x	x	x
U2	LM1458	x	x	x
U3	CD4040	x	x	x
U4	CD4008	x	x	x
U5	74LS273	x	x	x
U6	DDF3109	x	x	x
U7	DDF3110	x	x	x
U8	LM1458	x	x	x
U9	LM1458	x	x	x
U10	CD4051	x	x	x
U11	CD4051	x	x	x
U12	CD4011	x	x	x
U13	MC1408	x	x	x
U14	CA3240	x	x	x
R1	1.0K	x	x	x
R2	1.0K	x	x	x
R3	3.0K	x	x	x
R4	1.2K	x	x	x
R5	2.4K	x	x	x
R6	10K	x	x	x
R7	10K	x	x	x
R8	10K	x	x	x
R9	10K	x	x	x
R10	5.1K	x	x	x
R11	39K	x	x	x
R12	20K	x	x	x
R13	27K	x	x	x
R14	4.3K	x	x	x
R15	30K	x	x	x
R16	20K	x	x	x
R17	10K	x	x	x
R18	100K	x	x	x
R19	240K	x	x	x
R20	240K	x	x	x
R21	1.2M	x	x	x

REF. DESIG-NATION	DESCRIPTION	MODEL DDF- 3001	3002	3003
R22	20K	x	x	x
R23	200K	x	x	x
R24	240K	x	x	x
R25	240K	x	x	x
R26	20K	x	x	x
R27	470K	x	x	x
R28	510K	x	x	x
R29	390K	x	x	x
R30	110K	x	x	x
R31	3.3K	x	x	x
R32	16K	x	x	x
CR1	1N4148	x	x	x
CR2	1N4148	x	x	x
CR3	1N4148	x	x	x
C1	27 pF mica	x	x	x
C2	220 pF mica	x	x	x
C3	.0047 uF mylar	x	x	x
C4	.047 uF mylar	x	x	x
C5	.047 uF mylar	x	x	x
C6	.0022 uF mylar	x	x	x
C7	.0022 uF mylar	x	x	x
C8	.001 uF mylar	x	x	x
C9	.0022 uF mylar	x	x	x
C10	.047 uF mylar	x	x	x
C11	1.0 uF electrolytic	x	x	x
C12	.047 uF mylar	x	x	x
C13	.047 uF mylar	x	x	x
C14	.047 uF mylar	x	x	x
C15	.047 uF mylar	x	x	x
C16	.047 uF mylar	x	x	x
C17	.047 uF mylar	x	x	x
C18	.047 uF mylar	x	x	x
C19	.047 uF mylar	x	x	x
C20	.001 uF mylar	x	x	x

Figure 6.8-2C

Parts List for PWB DDF-3016

REF. DESIG-NATION	DESCRIPTION	MODEL DDF-		
		3001	3002	3003
C21	.001 uF mylar	x	x	x
C22	0.1 uF	x	x	x
C23	0.1 uF	x	x	x
C24	0.1 uF	x	x	x
C25	3 pF mica	x	x	x
C26	0.1 uF mylar	x	x	x
C27	120 pF mica	x	x	x

Figure 6.8-2D

Parts List for PWB DDF-3016

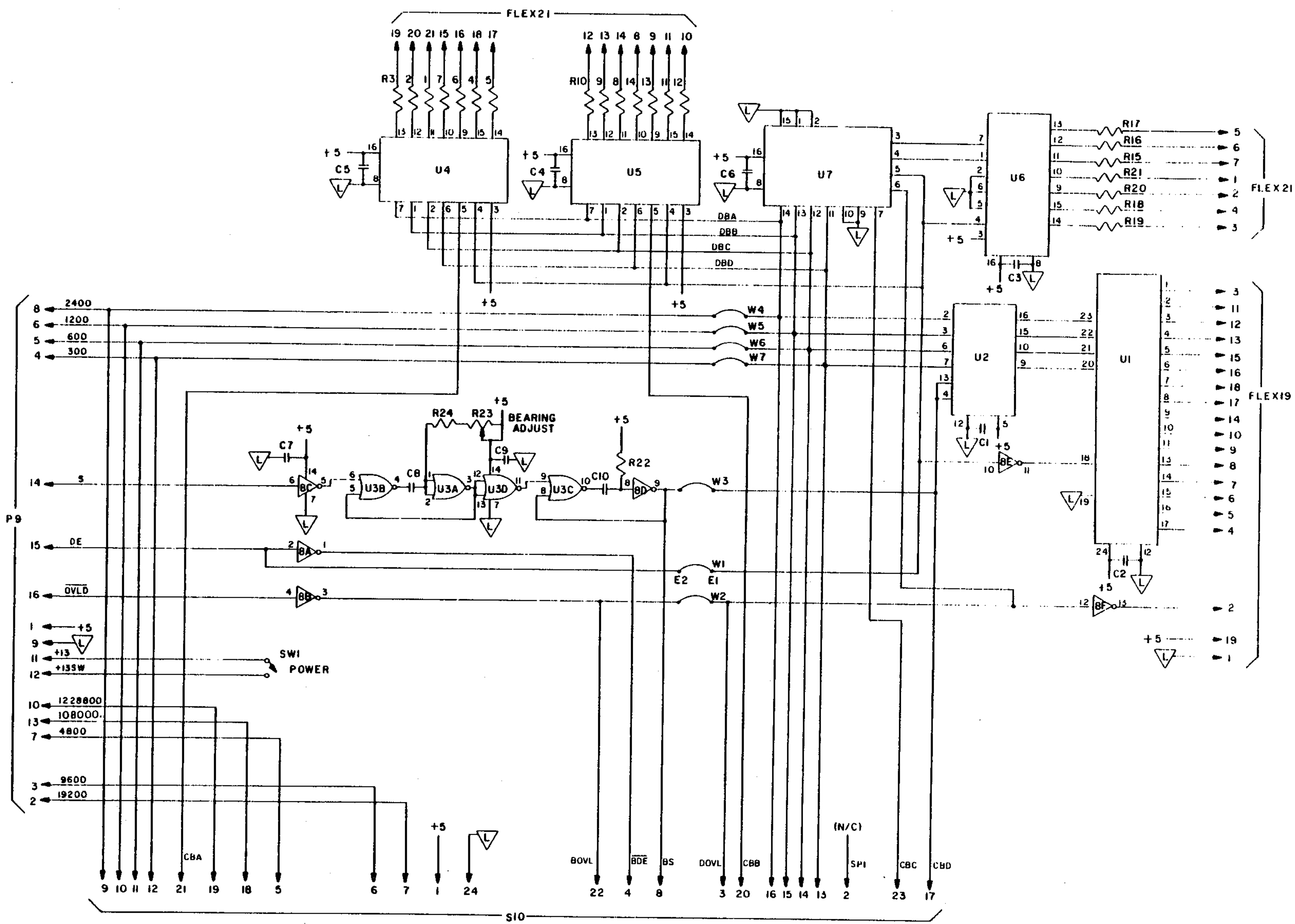


Figure 6.8-3A

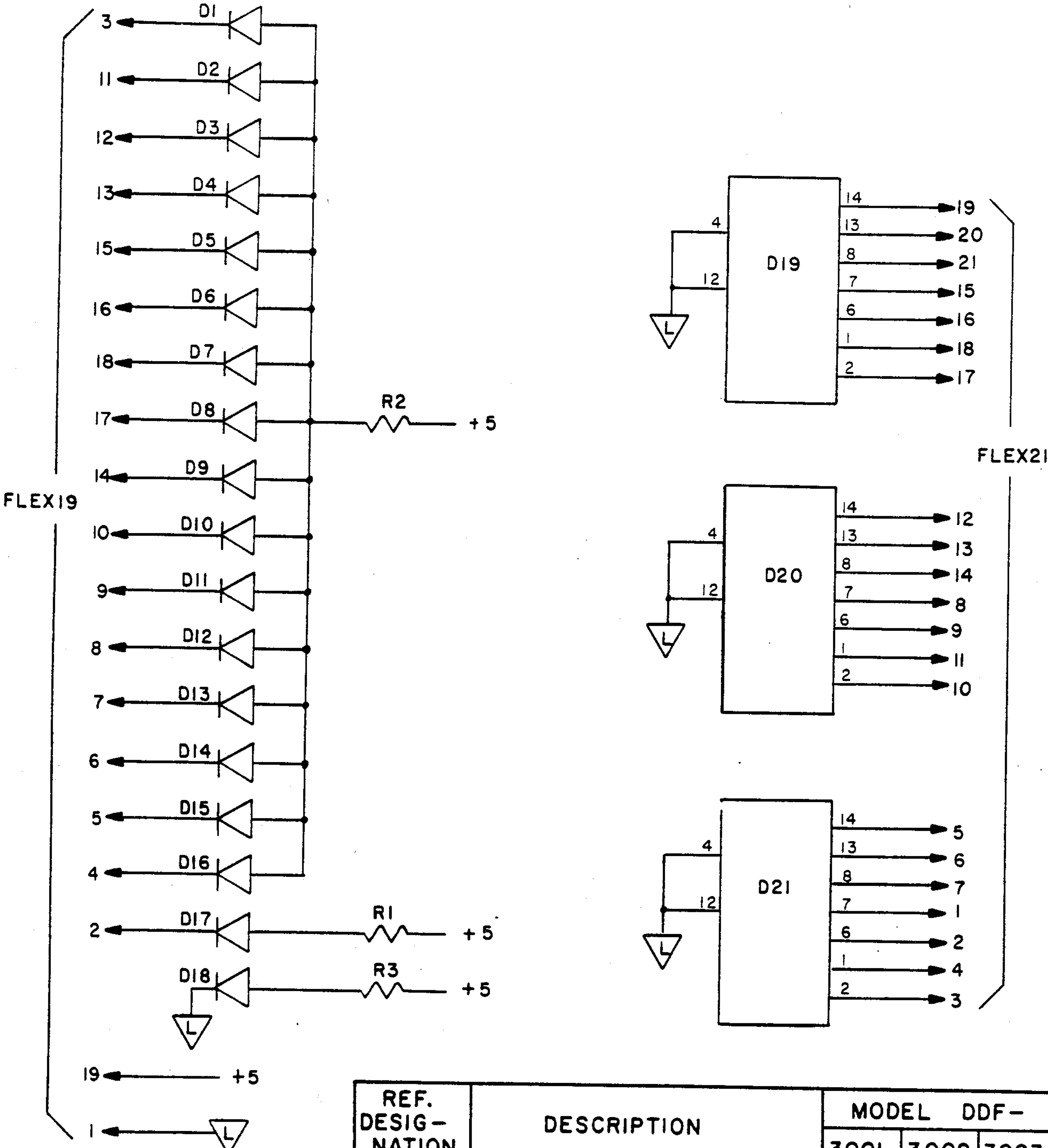
Display Driver Schematic

(Printed Wiring Board DDF-3015)

REF. DESIG-NATION	DESCRIPTION	MODEL DDF-		
		3001	3002	3003
W1	Jumper	x	-	-
W2	Jumper	x	-	-
W3	Jumper	x	-	-
W4	Jumper	x	-	-
W5	Jumper	x	-	-
W6	Jumper	x	-	-
W7	Jumper	x	-	-
U1	74154	x	x	x
U2	74LS75	x	x	x
U3	CD4001	x	x	x
U4	CD4511	-	x	x
U5	CD4511	-	x	x
U6	CD4511	-	x	x
U7	CD4076	-	x	x
U8	74C903	x	x	x
R1-R21	160 ohm	-	x	x
R22	15K	x	x	x
R23	100K, 15 turn	x	x	x
R24	20K	x	x	x
C1	0.1 uF	x	x	x
C2	0.1 uF	x	x	x
C3	.047 uF	-	x	x
C4	.047 uF	-	x	x
C5	.047 uF	-	x	x
C6	.047 uF	-	x	x
C7	.047 uF	x	x	x
C8	.022 uF mylar	x	x	x
C9	.047 uF	x	x	x
C10	220 pF mica	x	x	x

Figure 6.8-3B

Parts List for PWB DDF-3015



REF. DESIG- NATION	DESCRIPTION	MODEL DDF-		
		3001	3002	3003
D1-D18	SBR-3401	x	x	x
D19-D21	MAN74	-	x	x
R1	300 ohm	x	x	x
R2	160 ohm	x	x	x
R3	160 ohm	x	x	x

Figure 6.8-4
Display Schematic
(Printed Wiring Board DDF-3011)

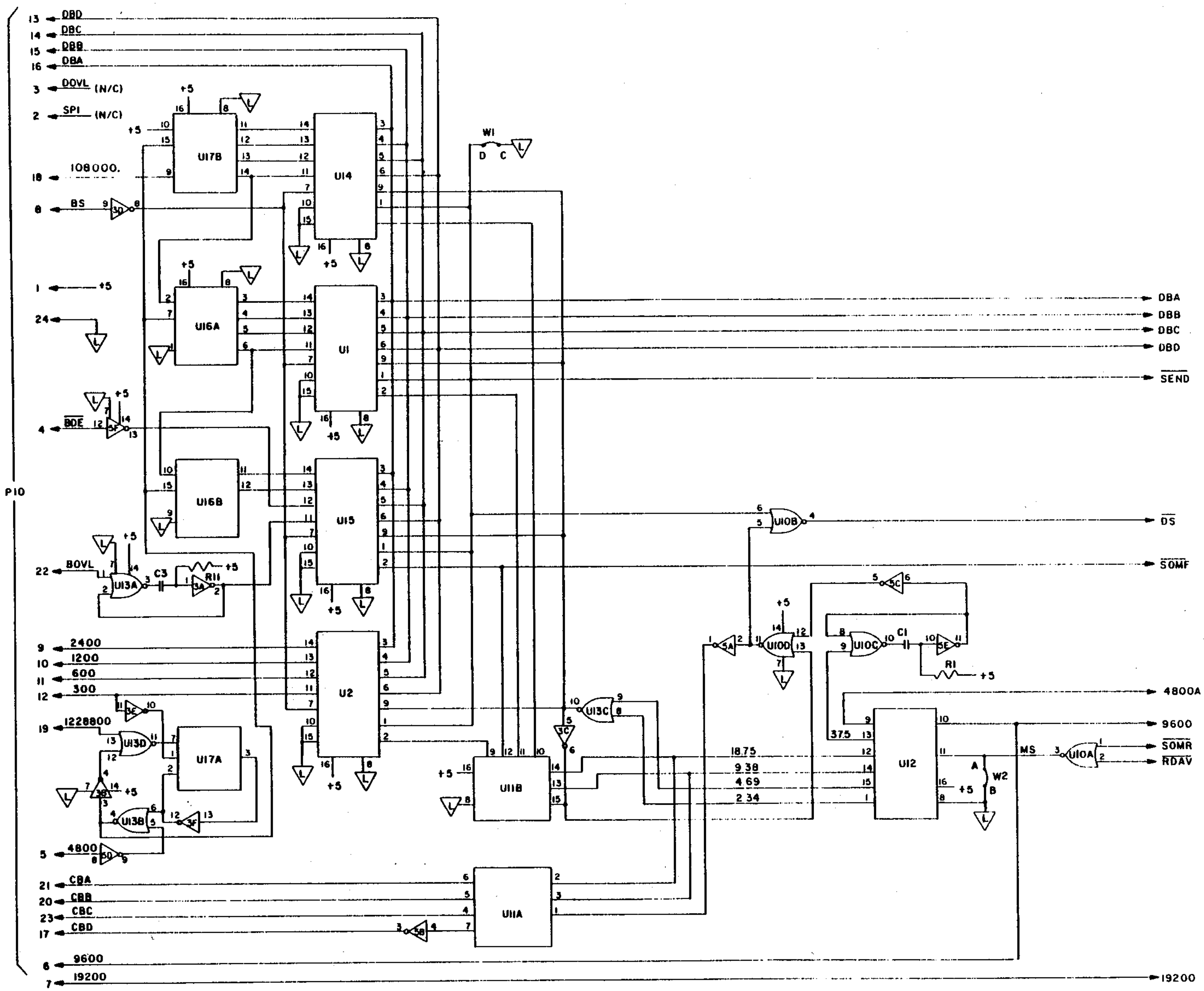


Figure 6.8-5A

BCD Generator Schematic

(Printed Wiring Board DDF-3018)

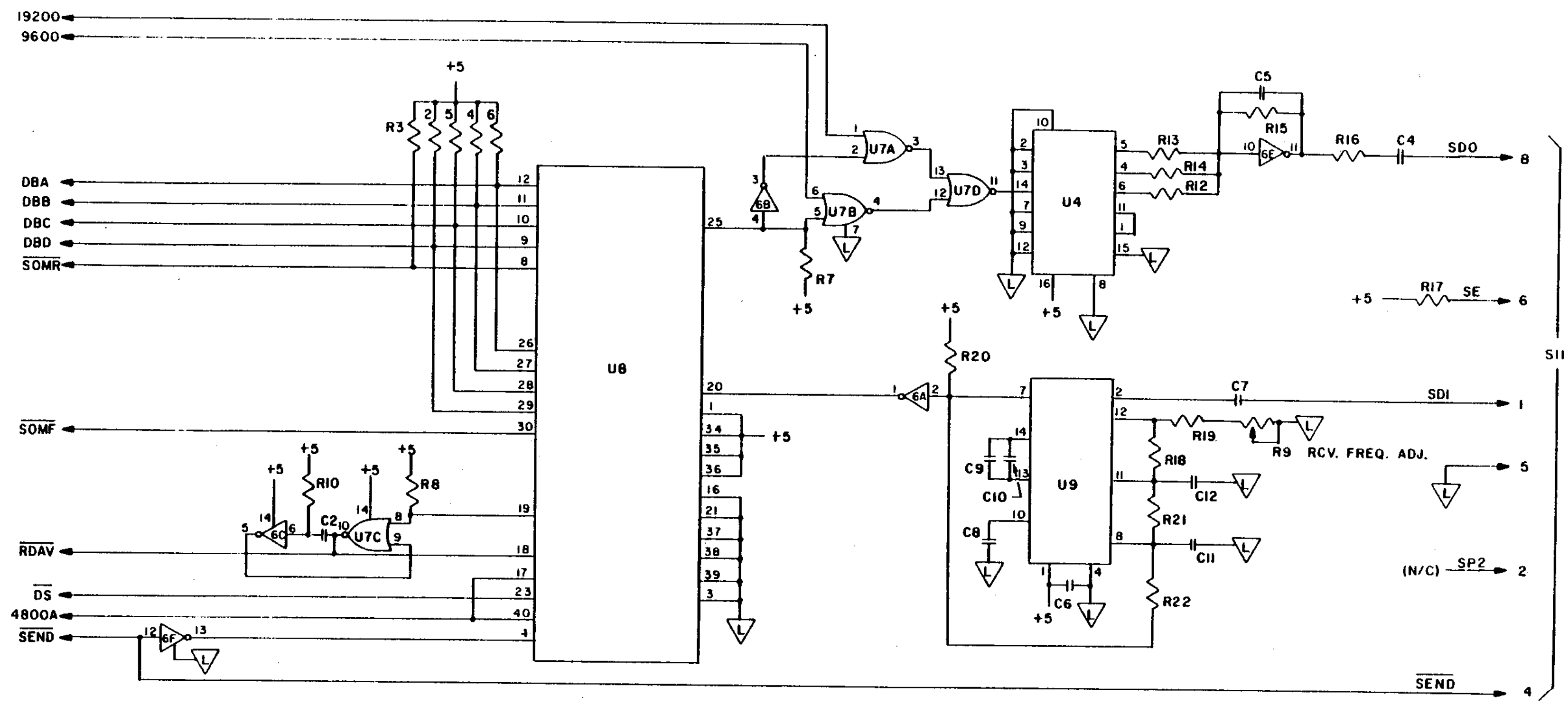


Figure 6.8-5B
Serial Interface Schematic
(Printed Wiring Board DDF-3018)

REF. DESIG-NATION	DESCRIPTION	MODEL DDF-		
		3001	3002	3003
W1	Jumper	-	x	-
W2	Jumper	-	x	-
U1	CD4076	-	x	x
U2	CD4076	-	x	x
U3	CD4069	-	x	x
U4	CD4018	-	-	x
U5	74C903	-	x	x
U6	74C903	-	-	x
U7	CD4001	-	-	x
U8	AY-3-1015D	-	-	x
U9	XR2211	-	-	x
U10	CD4001	-	x	x
U11	CD4556	-	x	x
U12	CD4040	-	x	x
U13	CD4001	-	x	x
U14	CD4076	-	x	x
U15	CD4076	-	x	x
U16	CD4518	-	x	x
U17	CD4518	-	x	x
R1	11K	-	x	x
R2	51K	-	-	x
R3	51K	-	-	x
R4	51K	-	-	x
R5	51K	-	-	x
R6	51K	-	-	x
R7	51K	-	-	x
R8	51K	-	-	x
R9	5.0K, 15 turn	-	-	x
R10	13K	-	-	x
R11	1M	-	x	x
R12	33K	-	-	x
R13	33K	-	-	x
R14	22K	-	-	x
R15	9.1K	-	-	x

REF. DESIG-NATION	DESCRIPTION	MODEL DDF-		
		3001	3002	3003
R16	10K	-	-	x
R17	51K	-	-	x
R18	33K	-	-	x
R19	20K	-	-	x
R20	5.1K	-	-	x
R21	100K	-	-	x
R22	510K	-	-	x
C1	.001 uF mylar	-	x	x
C2	.001 uF mylar	-	-	x
C3	.047 uF mylar	-	x	x
C4	0.1 uF	-	-	x
C5	.0047 uF mylar	-	-	x
C6	0.1 uF	-	-	x
C7	0.1 uF	-	-	x
C8	0.1 uF	-	-	x
C9	.022 uF mylar	-	-	x
C10	.0022 uF mylar	-	-	x
C11	.01 uF mylar	-	-	x
C12	.0047 uF mylar	-	-	x

Figure 6.8-5C

Parts List for PWB DDF-3018

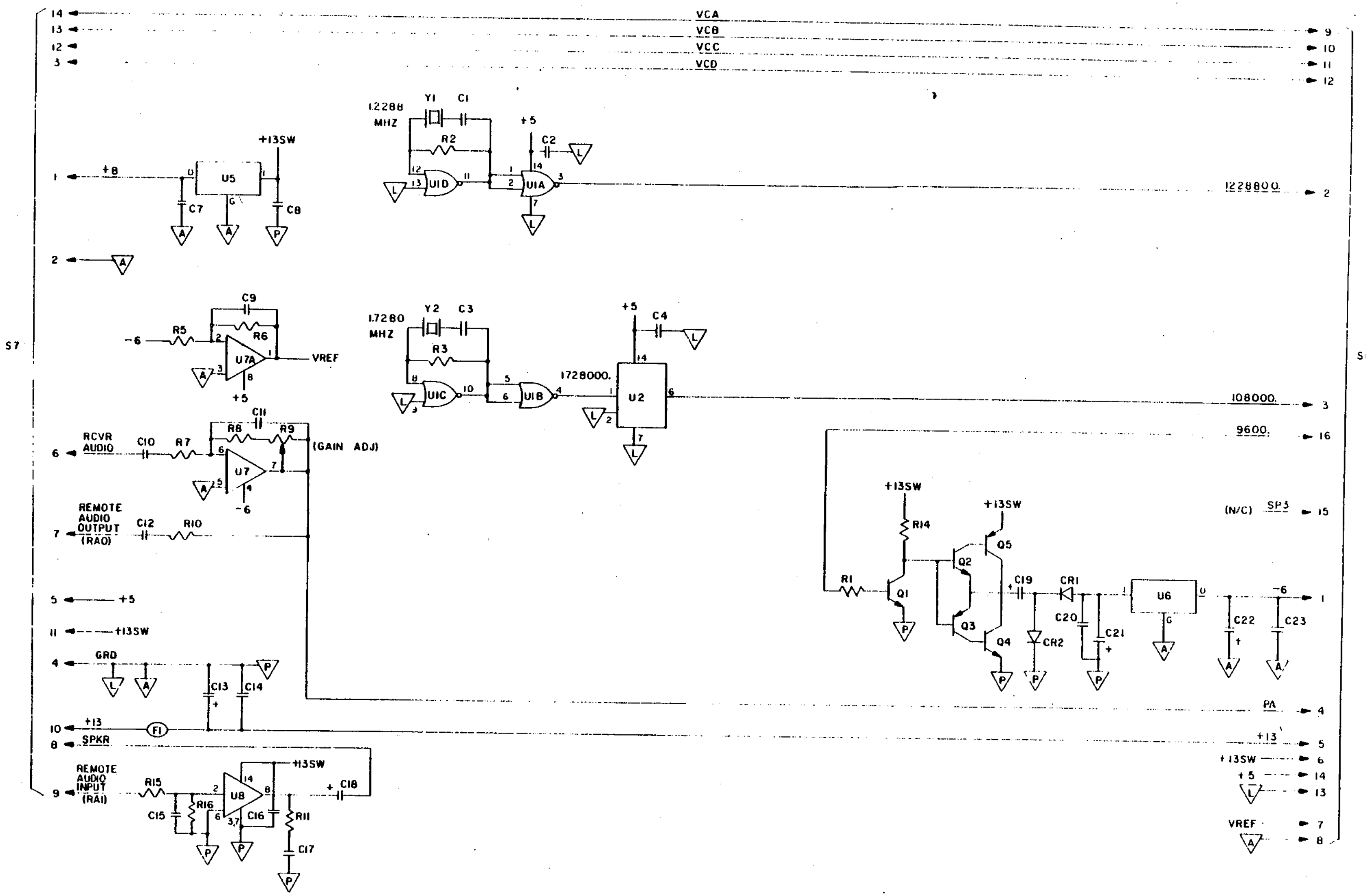


Figure 6.8-6A

Power Supply and Clock Schematic

(Printed Wiring Board DDF-3017)

REF. DESIG- NATION	DESCRIPTION	MODEL DDF-		
		3001	3002	3003
F1	2 Ampere, 3AG	x	x	x
Q1	2N2222A	x	x	x
Q2	2N2222A	x	x	x
Q3	2N2907A	x	x	x
Q4	2N5320	x	x	x
Q5	2N5322	x	x	x
CR1	1N4001	x	x	x
CR2	1N4001	x	x	x
U1	CD4001B	x	x	x
U2	CD4024	-	x	x
U5	LM340T-8	x	x	x
U6	LM320T-6	x	x	x
U7	LM1458	x	x	x
U8	LM380	-	-	x
Y1	1.2288 MHz	x	x	x
Y2	1.7280 MHz	-	x	x
R1	51K	x	x	x
R2	9.1M	x	x	x
R3	9.1M	-	x	x
R5	39K	x	x	x
R6	13K	x	x	x
R7	51K	x	x	x
R8	10K	x	x	x
R9	500K, 15 turn	x	x	x
R10	20K	-	-	x
R11	2.7 ohm	-	-	x
R14	3.3K	x	x	x
R15	360K	-	-	x
R16	5.1K	-	-	x

REF. DESIG- NATION	DESCRIPTION	MODEL DDF-		
		3001	3002	3003
C1	.001 uF mylar	x	x	x
C2	.047 uF	x	x	x
C3	.001 uF mylar	-	x	x
C4	.047 uF	-	x	x
C7	0.1 uF	x	x	x
C8	0.1 uF	x	x	x
C9	0.1 uF	x	x	x
C10	.022 uF mylar	x	x	x
C11	.001 uF mylar	x	x	x
C12	0.1 uF	-	-	x
C13	220 uF electrolytic	x	x	x
C14	0.1 uF	x	x	x
C15	.01 uF	-	-	x
C16	0.1 uF	-	-	x
C17	0.1 uF	-	-	x
C18	470 uF electrolytic	-	-	x
C19	220 uF electrolytic	x	x	x
C20	0.1 uF	x	x	x
C21	220 uF electrolytic	x	x	x
C22	4.7 uF electrolytic	x	x	x
C23	0.1 uF	x	x	x

Figure 6.8-6B

Parts List for PWB DDF-3017

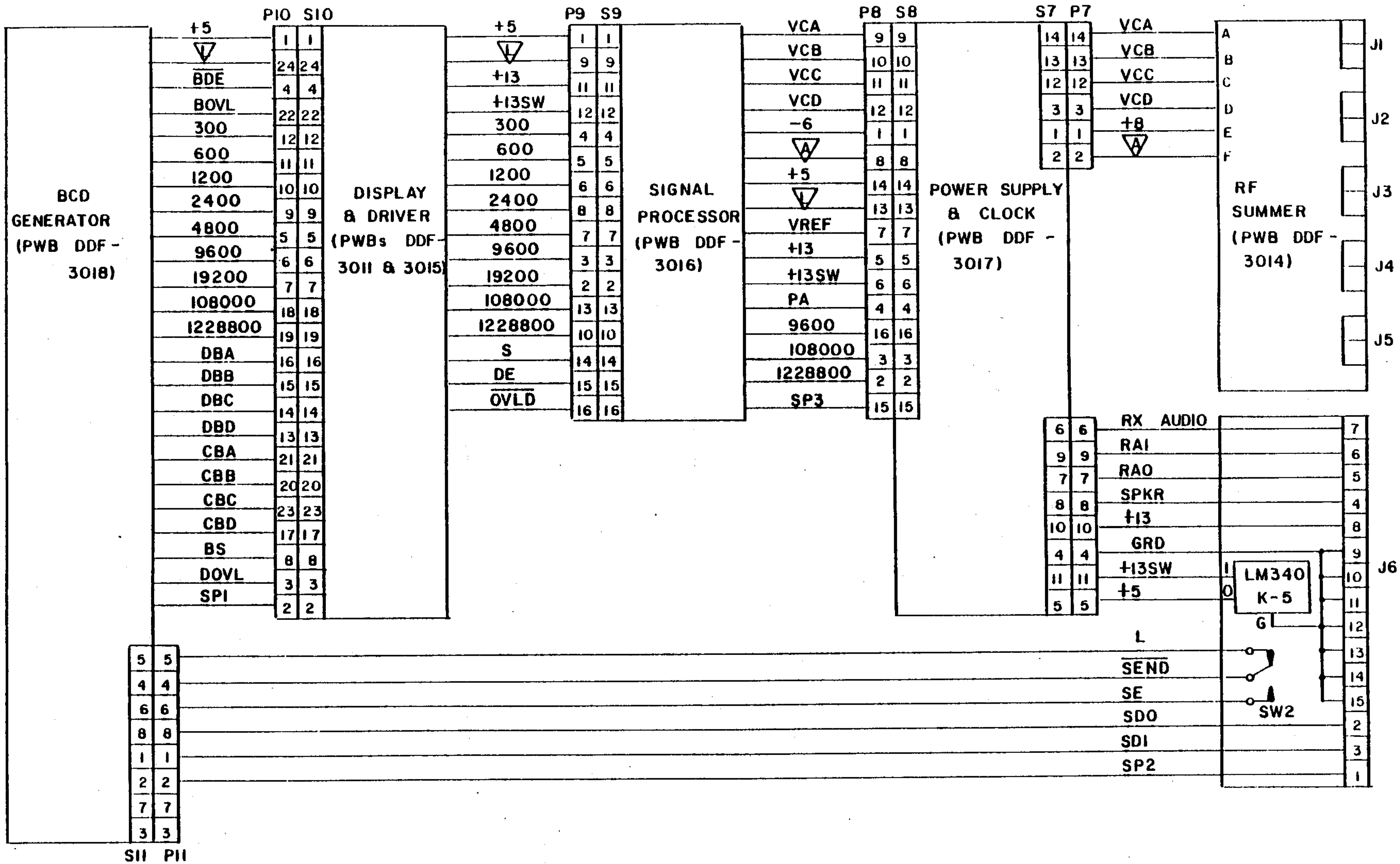


Figure 6.8-7

Chassis and PWB Interconnect Schematic