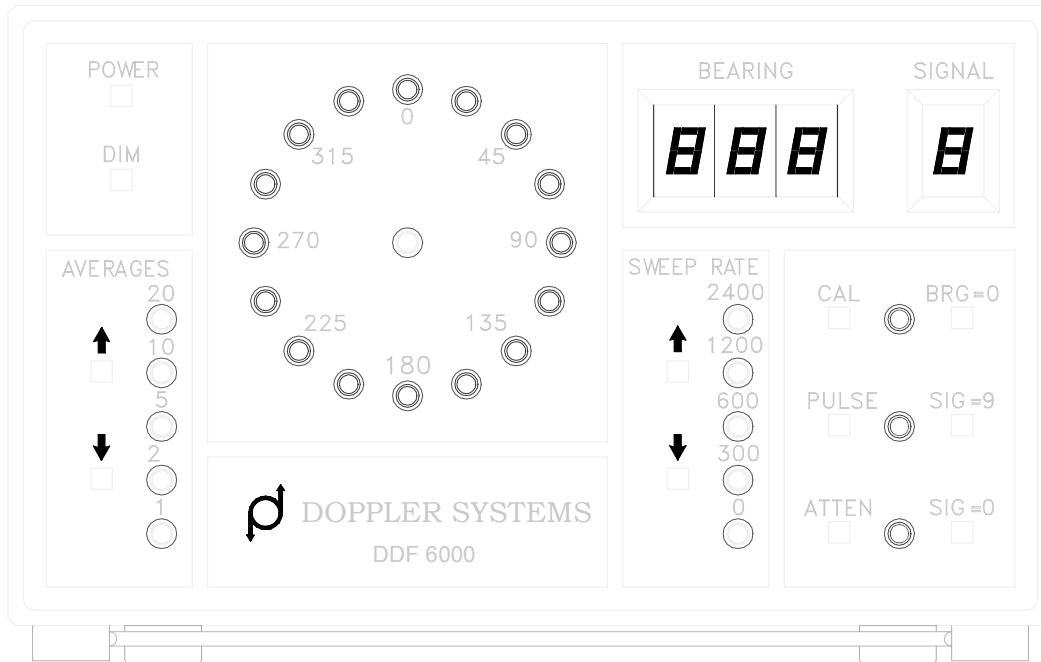


# DDF6000D RADIO DIRECTION FINDER USER MANUAL



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# Doppler Systems Inc.

## European Union Declaration of Conformity Industrial Equipment



**The EU Directives covered by this Declaration:**

89/336/EEC Electromagnetic Compatibility Directive, amended by 92/31/EEC & 93/68/EEC

**The Product Covered by this Declaration:**

Doppler DDF6000 Radio Direction Finder (including Antenna Subsystem Models 6052, 6053, 6054, 6055, 6056, and 6057) Ser # SSSS (S = 5001-6000)

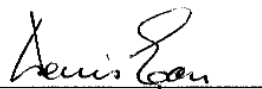
**The Basis on which Conformity is being Declared:**

The product identified above complies with the requirements of the above EU Directives by meeting the following standards:

- \* EN 50081-2(1994) "Electromagnetic Compatibility - Generic Emission Standard Part 2. Industrial Environment"
  - EN55022(1995) "Radiated Emissions Test", in accordance with the limits specified in EN55022(1995) for *Class B Devices*, and performed using the methods and procedures detailed in CISPR 22(1993) [including Correction #1 (Feb. 1995) and Amendment #1 (April 1995)], using instrumentation, equipment, and facilities in conformance with the requirements of CISPR 16-1(1993).
- \* EN 50082-2(1995) "Electromagnetic Compatibility - Generic Immunity Standard Part 2. Industrial Environment"
  - IEC 801.2(1991) "Electrostatic Discharge [ESD] Immunity Test", performed in accordance with the instrumentation, equipment, facilities, limits [i.e. Criteria B], methods, and procedures specified therein (i.e. +/- 8 kV Air Discharge [Level 3] and at all Lower Levels, and +/- 4 kV Contact Discharge [Level 3] and at all Lower Levels).
  - ENV 50140(1994) "Radio-frequency Electromagnetic Fields Immunity Test", performed in accordance with the instrumentation, equipment, facilities, methods, procedures, and limits specified therein, (i.e. 3 V/m, with 80% AM Modulation at a 400 Hz rate, at both H and V Polarization, over the frequency range 80 MHz to 1000 MHz, Criteria A).
  - IEC 801.4(1988) "Electrical Fast Transients [EFT] Test", in accordance with the instrumentation, equipment, facilities, methods, procedures and limits [Criteria B] specified therein (i.e. Direct Injection of +/- 1 kV EFT on DC Input Ports, and Capacitive Clamp Injection of +/- 1 kV EFT on long (i.e. > 3 meters) Non-process Control I/O Lines, and Capacitive Clamp Injection of +/- 1 kV EFT on Process Measurement and Control Lines).
  - ENV 50141(1994) "Radio-frequency Common Mode Immunity Test", performed in accordance with the instrumentation, equipment, facilities, methods, procedures, and limits specified therein, (i.e. 3 Vrms, with 80% AM Modulation at a 400 Hz rate, over the frequency range 150 kHz to 80 MHz, Criteria A).
- \* prETS 300 339(1993) "Radio Equipment and Systems (RES); Generic Electro-Magnetic Compatibility (EMC) for radio equipment"
  - EN55022(1995) "DC Conducted Emissions Test", in accordance with the limits specified in prETS 300 339(1993) and EN55022(1995) for *Class B Devices*, and performed using methods and procedures detailed in CISPR 22(1993) [including Correction #1 (Feb. 1995) and Amendment #1 (April 1995)], using instrumentation, equipment, and facilities in conformance with the requirements of CISPR 16-1(1993).
  - prETS 300 339(1993) "DC Voltage Variation Immunity Test" [Clause 9.5], in accordance with the instrumentation, equipment, facilities, methods, procedures and limits [Criteria B] specified therein (i.e. operate through under conditions of +/- 10% voltage variation in the DC input power).
  - prETS 300 339(1993) "DC Transients and Surges Immunity Test" [Clause 9.6], in accordance with the instrumentation, equipment, facilities, methods, procedures and limits [Criteria B] specified in ISO 7637-1(1990) (i.e. operate through ISO 7637-1(1990) Test Pulse #1, Test Pulse #2, Test Pulse #3a, Test Pulse #3b, Test Pulse #4, and Test Pulse #7, each as modified by prETS 300 339(1993) Clause 9.6).

The technical documentation required to demonstrate that this product meets the requirements of the EMC Directive has been compiled by the signatory below and is available for inspection by the relevant enforcement authorities. The CE mark was first applied in 1996.

Authority: Denis Egan  
European Representative for Doppler Systems Inc.  
PO Box 2 Seaton, Devon  
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Signature:   
Date: August 5<sup>th</sup>, 1996

Telephone/Fax: 1297-62-56-90

**Attention**

The attention of the specifier, purchaser, installer or user is drawn to special measures and limitation to use, which must be observed when product is taken into service to maintain compliance with the above directives. Details of these special measures and limitations are in the product manual.

## Warranty Information

Doppler Systems Inc. will repair or replace, at their option, any parts found to be defective in either materials or workmanship for a period of one year from the date of shipping. Defective parts must be returned for replacement. In the US, contact the factory, or overseas your local distributor, for advice about returning any defective parts or equipment.

If a defective part or design error causes your radio direction finder to operate improperly during the one-year warranty period, Doppler Systems Inc. will service it free of charge if returned at owner's expense. If improper operation is due to an error on the part of the purchaser, there will be a repair charge.

Doppler Systems Inc. are 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 Inc. and does not cover incidental or consequential damages.

Doppler Systems radio direction finding equipment is designed to for locating interfering radio signals. **It is not intended for use as a navigation aid, and in particular it is not to be used for aircraft or marine navigation.**

## Accessories Included

- (1) User manual
- (1) 12 VDC, 1.5 amps, 110 VAC wall mount power supply (North American models)
- (1) DC power cable DDF6110 (automobile cigarette lighter plug to 2.5mm plug)
- (2) 3.5 mm phone jack to 3.5 mm phone jack cable #40DK40
- (1) 3.5 mm phone jack to RCA phono jack cable #40DK25
- (2) 3.5 mm phone jack #750
- (1) Software manual
- (1) Set of software (CD or floppy disks)

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## 1.0 Introduction

The DDF6000D is a high performance radio direction finding system that operates using the synthetic Doppler principle in which a circular array of antennas are combined in a way that simulates a single element rotating in a circular path. As the simulated element approaches the wave front of an RF signal, the frequency increases due to the Doppler effect, and as it recedes from the transmitted source, the frequency decreases. The amount of frequency change (deviation) is related to the speed of rotation and the diameter of the antenna array, while the modulation frequency is equal to the frequency of rotation (the antenna sweep frequency). When connected to a narrow band communication receiver, the sweep frequency is present on the audio output. To obtain the bearing angle, the direction finder processes this audio output.

Many features are present in the DDF6000D:

- The system may be used with either an 8-element high accuracy fixed site antenna or a 4-element magnetic mount antenna for mobile operation.
- The sweep frequency may be set to 300, 600, 1200 or 2400 Hz to avoid tone frequencies that may be present in the signal modulation.
- Advanced signal processing is used to detect the signal with the receiver either squelched or unsquelched. Both continuous and 150 millisecond pulsed signals can be processed.
- The sweep direction automatically reverses from clockwise to counterclockwise to compensate for asymmetries in the receiver.
- An internal audio amplifier and loudspeaker are provided for monitoring the signal, and a sharp notch filter removes the sweep frequency for clarity.
- Two serial ports permit remote control of both the direction finder and an associated receiver from a single PC COM port. The secondary serial port may be configured for either RS232 (ASCII) operation or as a CIV bus.
- The display is housed in an attractive metal enclosure to enhance electromagnetic compatibility (EMC). The fixed site antennas are constructed of corrosion resistant materials and are designed for wind speeds up to 45 m/s (100 mph).

## 2.0 Specifications

Performance specifications apply to a DDF6000D when connected to a fixed site antenna (DDF6052 - DDF6057) and a narrow band fm receiver such as the Icom R7000, R7100 or R8500.

Frequency range (Depends on antenna; -xx indicates cable length in feet).	125-175 MHZ (DDF6052-xx) 175-250 MHZ (DDF6053-xx) 250-350 MHZ (DDF6054-xx) 350-500 MHZ (DDF6055-xx) 500-700 MHZ (DDF6056-xx) 700-1000 MHZ (DDF6057-xx)
Bearing display	16-LED circle and 3-digit LED display
Bearing display rate	2 Hz
Bearing accuracy (1 sigma)	2 degrees
DF sensitivity (typical)	-130 dBm, continuous signal -126 dBm, pulsed signal
Bearing averaging (selectable)	1, 2, 5, 10 or 20 samples
Antenna sweep rate	300, 600, 1200 or 2400 Hz
RF attenuator (selectable)	0 or 20 dB
Audio input range	0.01 to 0.6 VRMS
Audio output	0.5 watts maximum
S-meter input range	-10 to +10 VDC
Serial interfaces	(2) RS232 ports (1) CIV port
Power requirement	11 to 14 VDC
Current consumption	1.2 amp
Operating temperature (display)	0 to 50 degrees C
Dimensions (display - H x W x D)	108 x 171 x 235 mm (4.25 x 6.75 x 9.25 in)
Weight (display)	1.9 Kg (4.1 lbs)

## 3.0 Controls and Connectors

Figure 3-1 on shows the front panel controls and figure 3-2 shows the rear panel connectors. The items marked ▲ in the following paragraphs refer to the controls and connectors in these figures.

▲1 Press the red power switch to turn the unit on or off.

▲2 Press this switch to dim the front panel LEDES. Pressing it again returns the LEDES to full brightness.

▲3 Bearing data is computed twice per second. The front panel displays a moving average of the last N bearings calculated. The number of bearings averaged, N, may be increased or decreased by pressing the up or down arrow keys. Note that selecting N = 1 causes CW and CCW rotation bearings to be displayed, while higher settings average both CW and CCW rotations (recommended).

▲4 Bearing is displayed by illumination of one of the red LEDES on the circular display. The center yellow LED indicates that power is on.

▲5 Bearing angles in degrees are displayed in the 7-segment display. Both the circular LED display and the digital display are held for 10 seconds after the signal disappears. To help distinguish when the bearing is updating and when it is being held, the decimal point following the units' digit alternates on to off whenever the bearing updates.

▲6 Signal strength is indicated in this 7-segment display. It should be calibrated so that the signal strength is 0 when no signal is present and 9 when a very strong signal is present. See the description of controls ▲8, ▲10 and ▲11 for the method of calibrating the S-meter. The S-meter displays a dash if the S-meter input is not connected or if the display has not been calibrated.

▲7 Antenna rate of rotation can be increased or decreased by pressing the up or down arrows here. When a sweep rate of 0 is selected, all antennas are turned ON. This mode is useful in detecting a very weak signal, but bearings are not displayed.

▲8 Switch enables or disables the calibration mode. The calibration mode must be enabled for the bearing and S-meter calibration switches to be effective.

▲9 Pressing this switch when the calibration mode (see ▲8 above) is enabled causes the present bearing to be set to 0 degrees. Momentarily pressing this switch when the calibration mode is not enabled causes the present bearing to be incremented by 1 degree. If the switch is held down, the bearing changes in steps of 10 degrees.

▲10 Switch calibrates the S-meter to 9 on the present signal, provided the calibration mode is enabled (see ▲8 above).



▲11 Switch calibrates the S-meter to 0 on the present signal, provided the calibration mode is enabled (see ▲8 above).

▲12 Press this switch to change the direction finder alternately from the Continuous to the Pulse mode and back. The DF should be used in the Continuous mode on most signals (voice, unmodulated carriers, etc.) and in the Pulse mode when the signal is known to be on for 150 milliseconds every 0.5 seconds.

▲13 Switch causes a 20 dB attenuation of the RF input to the commutation electronics.

▲14 J1 is an RS232 serial interface configured as a DCE. May be connected directly to PC using a 9-pin male to 9-pin female straight through cable. See section 6.2.1, for details of this interface.

▲15 J2 is an RS232 serial interface configured as a DTE. May be connected to a PC via a null modem or to a receiver having an RS232 input. See section 6.2.2, for details of this interface.

▲16 J3 is the receiver audio input. Connect to the external speaker output of your receiver using the supplied 3.5 mm to 3.5 mm cable or make a custom cable using the supplied 3.5 mm plug.

▲17 J4, CIV interface. May be connected to the CIV remote control interface on your receiver using the supplied 3.5 mm to 3.5 mm cable. See section 6.2.3, for details of this interface.

▲18 J5 is the S-meter input. Connect to the receiver's S-meter output using the supplied 3.5 mm to RCA phono jack cable or make a custom cable using the supplied 3.5 mm plug.

▲19 J6 is the external speaker output. May be connected to an external speaker (not supplied) using a 3.5 mm plug.

▲20 J7 is the DC power input. Connect to +12 VDC using the supplied 2.5mm to cigar plug cable, or on North American models from the supplied 110 VAC power supply.

▲21 J8 is the antenna control cable output. Connect to the 15-pin cable supplied with the 6000 series fixed site antennas or the RF summer DDF6060 used for mobile operation.

▲22 J9 is the antenna switch output. Used with DDF6071 two-antenna switch unit to select VHF or UHF antennas, or with the DDF6076 three-antenna switch to select VHF, UHF1 or UHF2 antennas. Note that this is a 3.5 mm stereo jack. When used with the DDF6071, use the 3.5 mm mono cable provided with the switch, and when used with the DDF6076, use the 3.5 mm stereo cable provided with it.

▲23 J10 is the auxiliary input. (Reserved for future expansion).

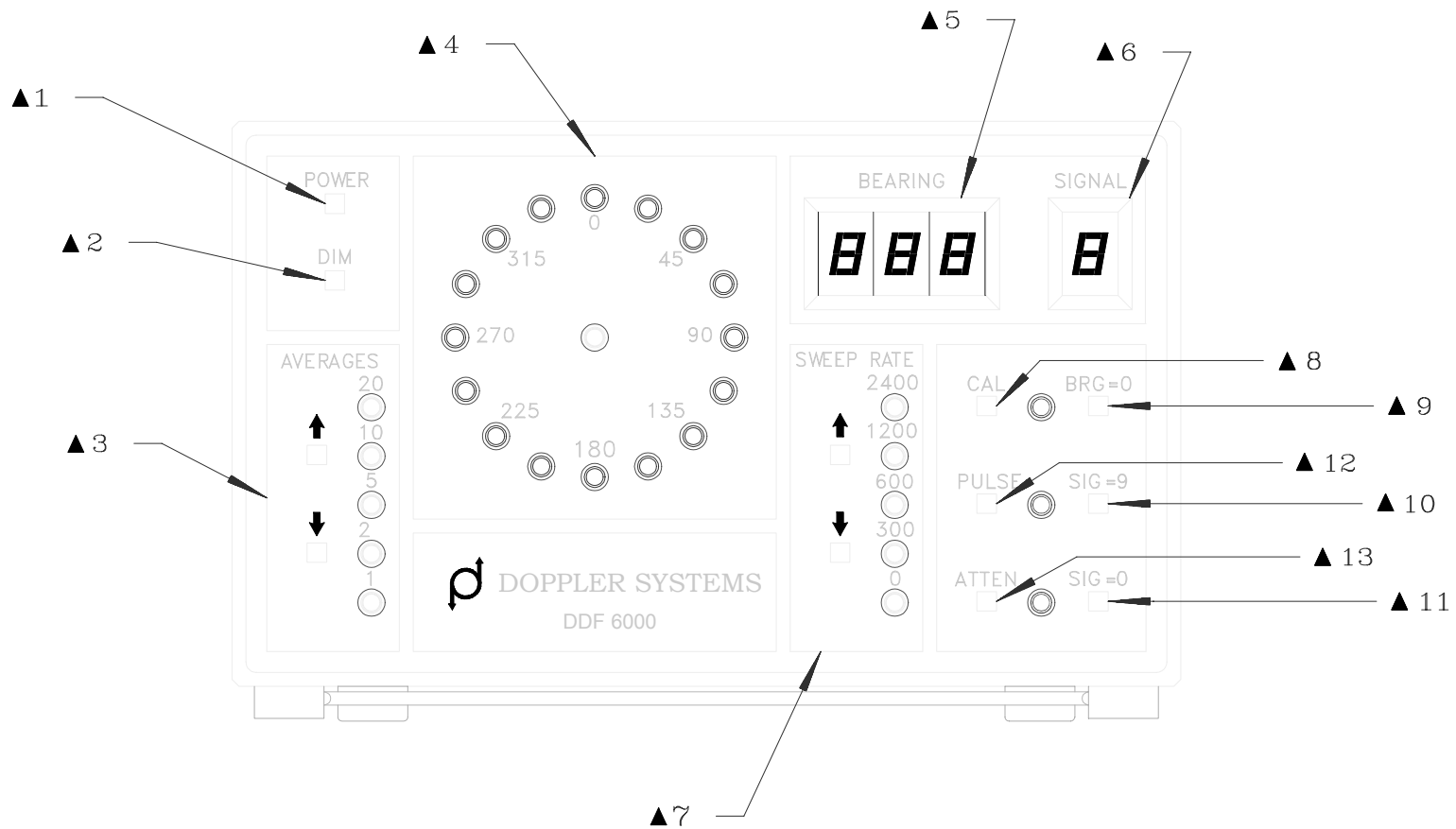


Figure 3-1  
Front Panel Controls

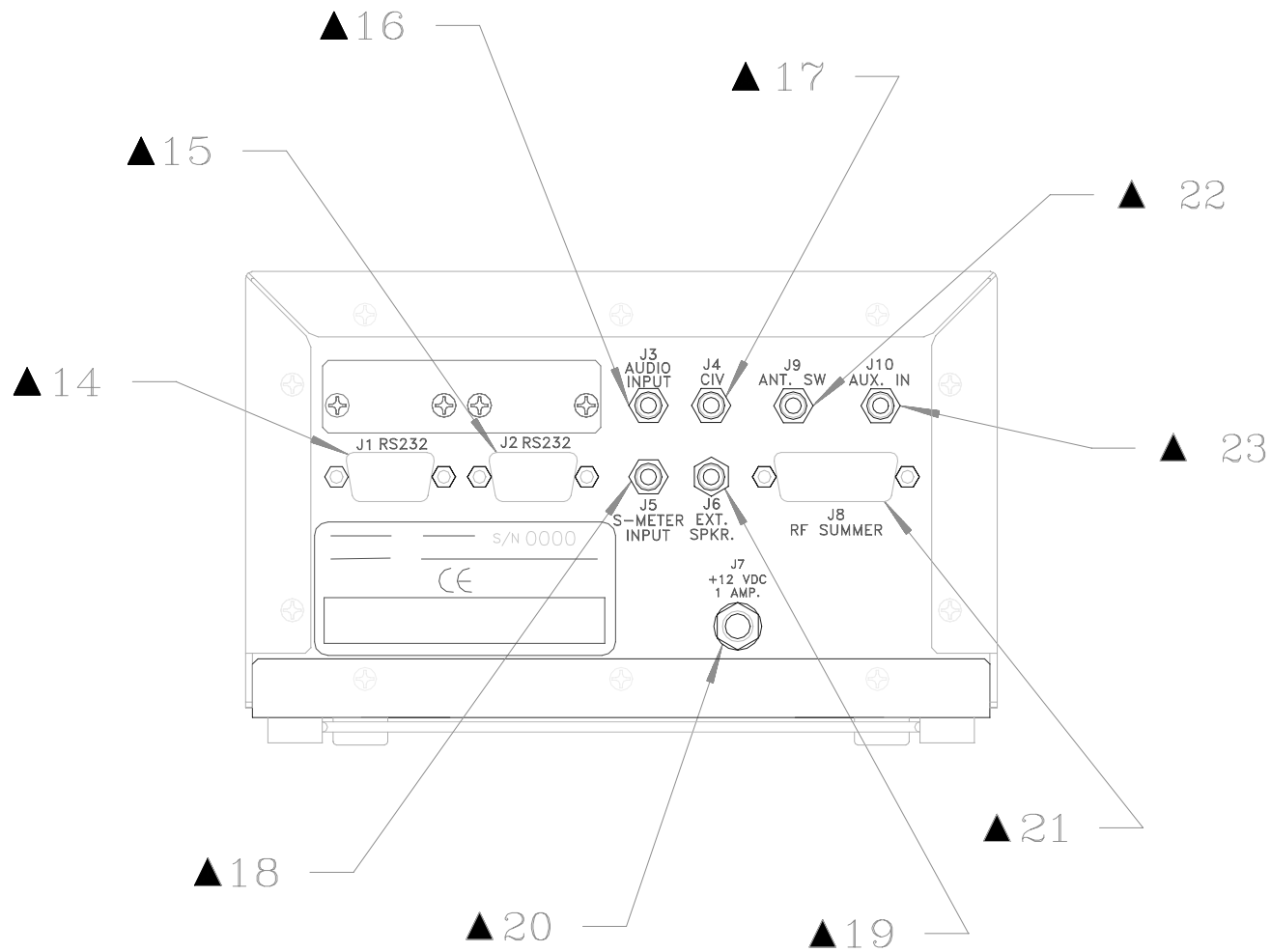


Figure 3-2  
Rear Panel Connectors

## 4.0 Installation

### 4.1 Fixed site selection

For maximum range, you will want to select a fixed site location that has a high elevation and a clear line of sight to the area you intend to direction find in. Unfortunately, broadcast and other transmitters already occupy many such sites, and these must be avoided, as the direction finder is very broad banded. Before expending any great effort installing the direction finder at any fixed site, try it out first.

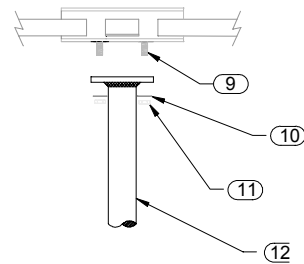
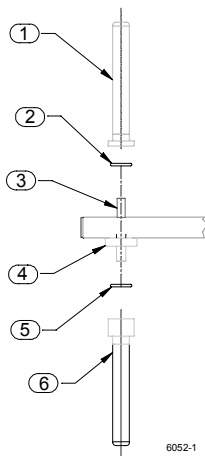
The input preamplifiers used in the summing electronics can be damaged if exposed to more than a few hundred mill watts of RF power. Normally, this is not a problem, but you should not locate the DF antenna very close to a transmitter (especially one in the same frequency band as the DF antenna).

If you plan to link the DF to another location using a data radio, you should select a data radio in a frequency band different from that of the direction finder. Position the data radio antenna for minimum coupling to the direction finder antenna.

### 4.2 Fixed site installation

The 6000 fixed site direction finder antennas are designed for mast mounting. Your DF antenna should be mounted on the top of the mast, and should be clear of other metal objects, antennas, etc. A side arm mount on a tower would be a very poor choice for mounting the antenna.

Assemble the antenna as shown in the following figures.



6052-3

When installing the antenna elements ('1' and '6'), note that the upper elements are white and have a 1/4-20 thread and the lower elements are black and are threaded 5/16-24. An anti-oxide lubricant has been applied to the internal threads of these elements, which **must not be removed**. Also note that an O-ring ('2' and '5') is provided with each antenna element. **Verify that these O-rings are still in place before installing the elements.** Tighten each of the elements (by hand) so that the O-rings are compressed (about 1/4 turn after they make contact).

Remove the lockwashers and nuts ('10' and '11') from the mounting studs '9', then attach the mast '12' to the hub using the same hardware. The assembled antenna is shown in Figure 4-1.

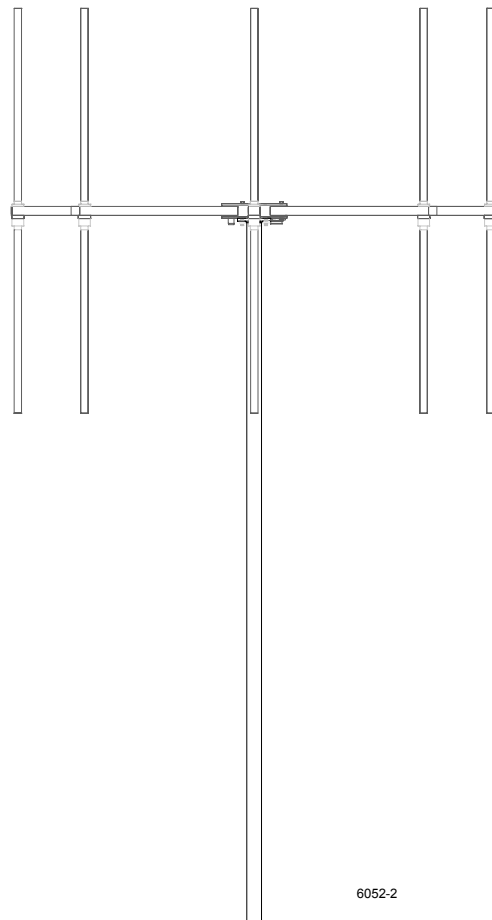
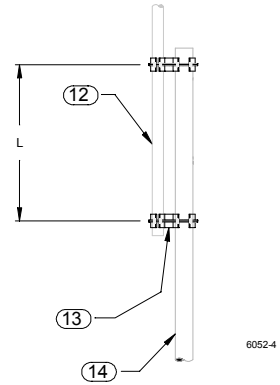
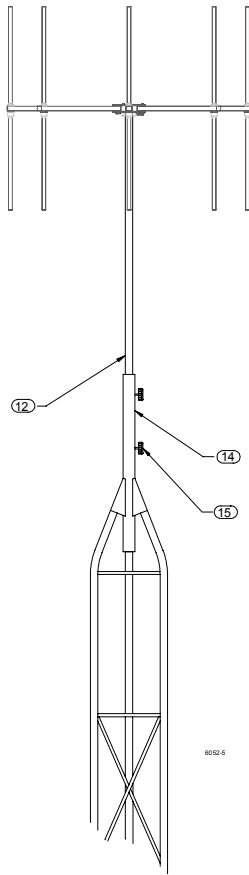


Figure 4-1  
Fixed Site Antenna



The antenna must be mounted to the top of a tower or mast. If your tower accepts a mast at its top, mount the antenna as shown on the figure on the left. If you are mounting the mast to another mast, use coupling clamps such as Decibel Products Model DB-365-OS. Space the two clamps about 18 inches apart as shown on the figure on the right.

**Use care when lifting the antenna assembly once the elements are attached. The threaded studs used to attach the antenna elements cannot support heavy or sudden loads produced by bumping or dropping the antenna.**

After installing the antenna, secure the control and RF cables to the mast using nylon ties so that they are kept away from the antenna elements.

The audio output from the receiver should be connected to the DF audio input (J3) using the 40DK40 cable provided. The receiver's S-meter output can be connected to J5 using cable 40DK25. DC power is connected through J7 from a 12 VDC/1.5A power supply. Figure 4-2 shows the fixed site system cabling.

### **4.3 Mobile installation**

Four antenna elements are used for mobile operation. At frequencies below 500 MHz, magnetically mounted quarter wave whips are used. These antennas must provide a good coupling to the ground plane, and must be of exactly the same type. It is especially important that the coaxes used have the same length. Doppler Systems antennas DDF6061, 6062, and 6068 all use the same magnetic mount base and cover the frequency ranges 88-136, 136-500, and 52-88 MHz respectively. Cut the whips to resonance using the chart provided with the antennas and space them between 1/8 and 1/4 wavelength apart on the car roof. **To avoid damage to the input circuitry used in the RF summer, touch the antenna ground plane before attaching the whips to the magnetic mounts.** It is important that the vehicle provides at least 1/4 wavelength of ground plane outboard of the antennas.

It is a good idea to remove any other antenna from the car when using the direction finder to avoid its affecting the response pattern of the antenna. If you need to use another antenna, try experimenting with its location to minimize the coupling with the DF antenna.

Do not transmit more than a few watts in the immediate vicinity of the DF antenna - especially if the transmit frequency is in the same frequency range as that of the DF antenna. It is possible to damage the RF summer if more than a few hundred milliwatts of RF power are induced into its input.

Place the RF summer (DDF6060) on the car with the cables oriented towards the rear of the car. Connect the magnetic mount antenna cables to the corresponding TNC connectors on the RF summer. (That is, the left front antenna to the left front connector, etc.) Locate the summer near the back of the car (the lid of the trunk or boot) so that the magnetic mount antenna cables do not have excessive slack. Secure the four antenna cables together with nylon ties so that they are not free to move around and touch the antenna elements. Route the control and RF cables through an open window to the direction finder and receiver.

For mobile operation in the 700-1000 MHz band, antenna DDF5067 should be mounted directly on top of the RF summer. This antenna provides an extended ground plane, a wind shroud, and four stub type antennas built into TNC connectors. Place the assembled RF summer/antenna in the center of the car roof.

Connect the receiver audio output to the DF audio input (J3) using the supplied 40DK40 cable and connect the S-meter output to J5 with cable 40DK25. The DF power is supplied to J7 from the cigar lighter using cable DDF6110. If you want to power the receiver from the same outlet, use a "Y" adapter. Wiring of the mobile DF is shown in figure 4-3.

## **4.4 Phone jacks**

The phone jacks used on the DDF6000D are Switchcraft “Tini-Jax” connectors. These are commonly referred to as 3.5 mm connectors, but they actually measure 3.58 mm (0.141 inch) diameter. Other 3.5 mm connectors such as are used on ICOM receivers measure closer to 3.50 mm (0.138 inch) diameter. For reliable operation, mating plugs must be Switchcraft Type 750, which are supplied with the DDF6000D. These plugs normally mate with the 3.5 mm jacks used on the ICOM receivers, but the ICOM 3.5 mm plugs do not reliably mate with the Switchcraft Tini-Jax connectors used in the DDF6000D.

Cables 40DK40 (3.5 mm to 3.5 mm) and 40DK25(3.5 mm to RCA plug) are built with the Switchcraft 750 style plug.

Occasionally, a 3.5 mm jack may be encountered that will not accept the Switchcraft 750 plug. If this occurs, you can either replace the Switchcraft plug with a 3.5 mm plug, or modify the Switchcraft plug by lightly sanding the tip to reduce its outside diameter.

## **4.5 ICOM R7000 Receiver**

The ICOM R7000 can easily be modified to provide an S-meter output for the DDF6000D. Remove the top cover and locate the Main Unit PWB on the left side of the receiver and the spare RCA phono jack (J7) on the rear panel. Solder a 5.1 K resistor to the center pin of J7 and solder an insulated wire to the other end of the resistor. Route the wire to the topside of the Main Unit and carefully solder the other end of the wire to pin 1 of IC4. IC4 is an 8-pin DIP op amplifier type NMJ4558D. (Solder the wire directly to the IC lead using a minimum amount of heat and a very small tip iron).

## **4.5 ICOM R7100 and R8500 Receivers**

On the ICOM R7100 or R8500 you can connect the S-meter input directly to the AGC output jack. Note that the AGC jack on the R8500 receiver is used for two functions. Normally, it provides an AGC output that is compatible with the DDF6000; however, it can also be used for a discriminator output by changing a jumper inside the receiver. Refer to the R8500 manual if it appears that the receiver jack is not providing an AGC output.

The default CIV address for the R8500 is 4A (hex). This is 74 (decimal). Some of the software programs require a decimal entry while others require a hex entry. The R8500 allows baud rates of 300, 1200, 4800, 9600 or 19200. Do not attempt to connect the R8500 to the direction finder at 2400 baud on port 1 (the CIV jack). The R8500 can be programmed for “transceive” operation in which any change of its frequency (for example, turning the front panel tuning knob) causes the new



frequency to be broadcast on the CIV port. **Be sure that transceiver is turned OFF.** Refer to the R8500 instruction manual for these settings.

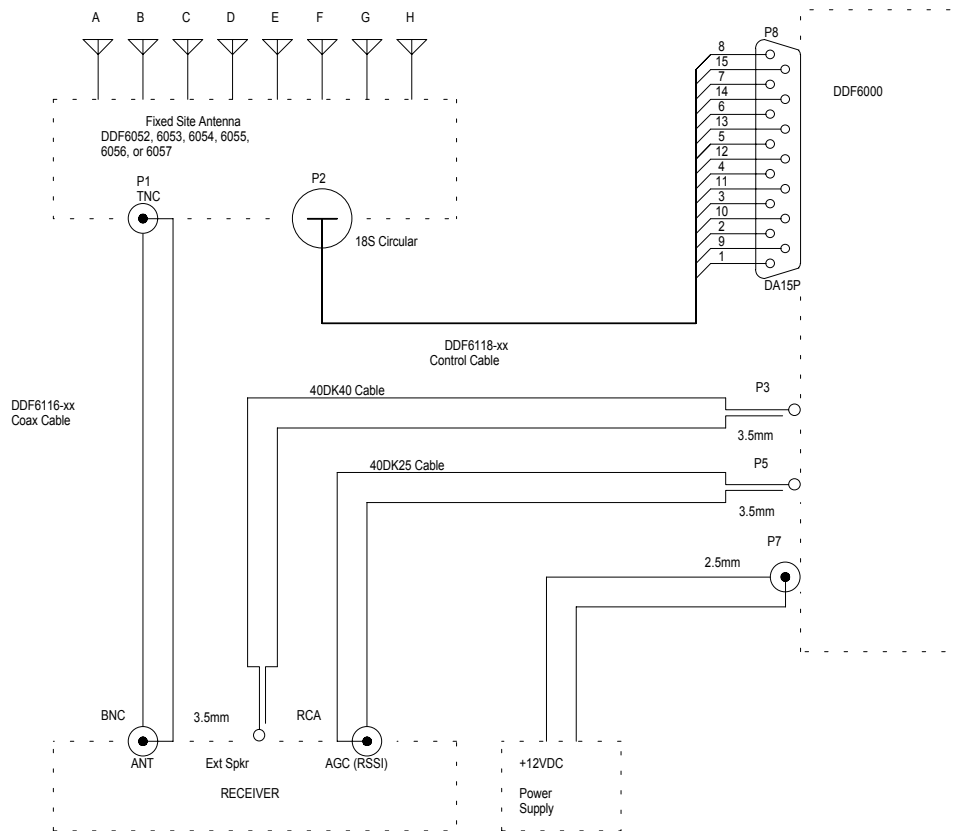


Figure 4-2  
Fixed Site Cabling

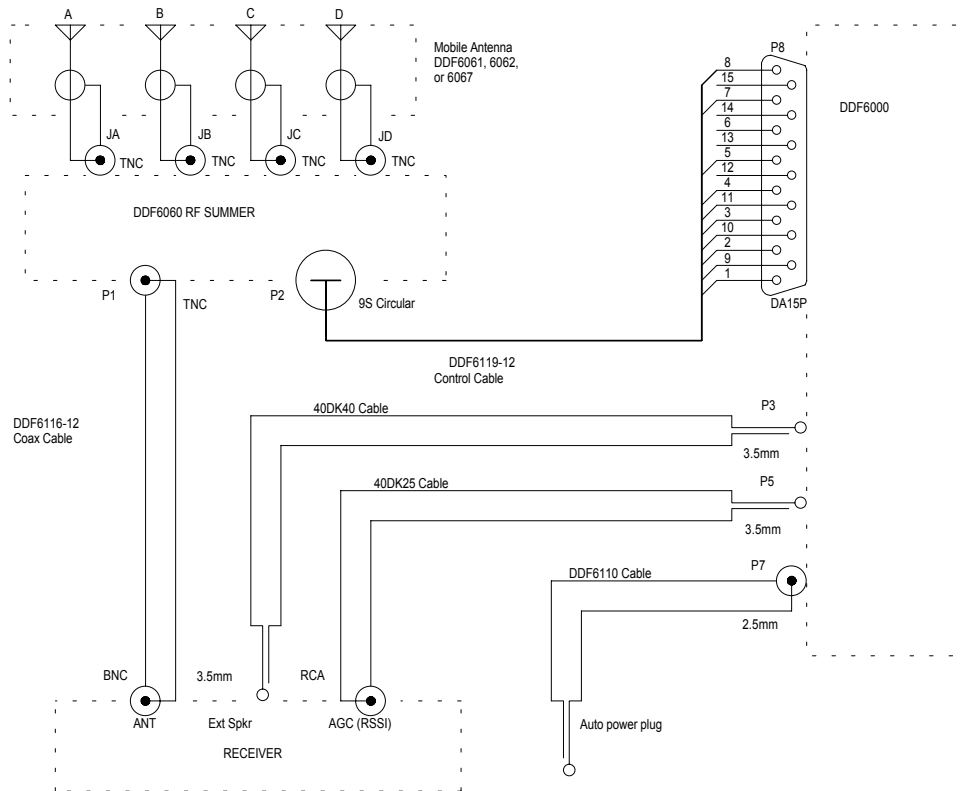


Figure 4-3  
Mobile Installation Cabling

## 5.0 Operation

### 5.1 Turn-on initialization

During the initial turn-on of the DDF6000D, the parameter values that were last set (sweep rate, port 2 communications parameters, etc.) are restored. There are two exceptions:

(1) The software determines whether a 4 or an 8-element antenna is installed and selects the corresponding waveforms.

(2) The software determines whether a plug has been inserted in the CIV jack (J4) and selects the appropriate protocol (either CIV or ASCII).

During the initial turn-on, the bearing and S-meter displays will momentarily indicate the software version used by the processor and the DF serial address. The later is especially important because it can be changed (under serial command) and if the address is forgotten, no CIV communication is possible. The software version is displayed as X.XX in the bearing window and 1 in the S-meter window. The DF address will be displayed as XXX (the decimal address value) in the bearing window and 2 in the S-meter window.

It is also possible to restore the factory default values of all parameters by entering from the front panel controls: Sweep rate = 0, CAL enabled, BRG = 0. The default parameters are listed in Table 6-1. Note, however, that the bearing calibration values will also be returned to the factory default values and a recalibration will probably be necessary.

### 5.2 Calibration

The bearing angle and the S-meter display are easily calibrated from the front panel.

If you are using the direction finder in a car or boat, calibrate the bearing display so it reads 0 degrees when receiving a signal from straight ahead. To perform this calibration, use a strong steady signal such as a repeater output, NOAA weather station, etc. Be sure the vehicle is in an area free of reflections with a clear line of sight to the known transmitter. Select the CAL mode by pressing the CAL switch. The CAL light will remain ON. Then press the BRG = 0 switch, and the bearing should read 0 degrees. Repeat this procedure for sweep rates of 300, 600, 1200 and 2400 Hz. Do not try to calibrate the bearing to 0 with the sweep rate set for 0; this is a special command that is used to restore the factory default parameter settings (see above).

If you are using the direction finder at a fixed location, use the following alternate procedure to calibrate the bearing. Tune in a known transmission and determine the bearing from the direction finder site using a map. Increment the bearing angle by pressing the BRG = 0 switch without first enabling the CAL switch. Each time the switch is pressed, the bearing will increment 1 degree, but

if the switch is held in, the bearing will increment in steps of 10 degrees. Hold the switch down until the bearing is close to the desired value, and then pulse it in the remaining steps.

The direction of rotation reverses every 0.5-second. This feature allows nonlinearities in the receiver to be compensated by averaging consecutive bearing readings. If the number of averages is selected to be 1 the individual bearing data will be displayed, and if the system needs calibration, the readings will alternate between two different values. Be sure to recalibrate the unit if you see this occurring. Normally, you should operate the direction finder with 2 or more averages selected in order to obtain the benefits of the clockwise/counterclockwise rotation.

If the S-meter is not connected to the receiver, or if it has not been calibrated, the S-meter will display a dash. To calibrate the S-meter, the CAL switch must first be enabled, then the SIG=9 switch pressed when a strong signal is present, and the SIG=0 switch when no signal is present.

### ***5.3 Direction finding in the continuous mode***

Switch to the continuous mode (Pulse mode OFF).

The simulated rotation of the antenna by the direction finder produces a tone in the receiver's audio output, which you will not normally hear because it is filtered out in the direction finder before it is passed to its speaker; you can hear it if you wish by removing the audio plug from the receiver's external speaker output.

The DF measures the magnitude and the phase of the tone every 10 milliseconds and calculates bearing angle from this data every second.

The DF software determines whether a signal is present by examining the statistics of the sweep frequency data. If the average amplitude of the tone exceeds the variation of the data about the average, then it is concluded that a signal is present and the bearing is displayed. This scheme makes the system independent of the receiver's volume control setting, so the volume may be set at any comfortable level. In addition, the receiver's squelch can be set normally or it can be opened so that the receiver is unsquelched. If no signal is present, the DF will detect this condition from the lack of a stable sweep tone, and will not update the display.

The sweep rate can be adjusted set to 300, 600, 1200 or 2400 Hz from the front panel. Maximum sensitivity and stability is obtained at the higher sweep rates, but there may be occasions when a lower sweep rate is desired. For example, if the signal itself contains a 1200 Hz tone, you would want to use a sweep rate other than 1200 Hz. A sweep rate of 2400 Hz results in a peak deviation that exceeds the bandwidth of most narrow band fm receivers. You will notice distortion of the transmitted audio with this sweep rate when receiving with a narrow band fm receiver. This sweep rate is useful however if you need to DF a wide band fm signal for which you must, of course, use a wide-band (150 KHz bandwidth) receiver.

The front panel display updates twice every second. Bearings are retained for 10 seconds, and then the display is blanked. To distinguish an updated bearing from a retained bearing of the same value, the decimal point on the display alternates ON and OFF whenever the display is updated.

If the number of averages is set to 1, then the bearing display is that calculated by the software during the preceding 0.5-second interval. The processor can also calculate a moving average of the preceding bearings. This will cause the bearing angle to be more stable, but it will also be less responsive to actual changes in the bearing. As discussed in Section 5.2, the antenna sweep direction is reversed every 0.5 seconds to permit reduction of errors due to nonlinearities in the receiver. While the direction finder can be used with the number of averages set to 1, it is usually best to set it to 2 or higher to obtain the benefits of averaging opposite direction sweeps.

The preamplifiers used in the direction finder antenna electronics have a gain of about 13 dB and a noise figure of about 3.6 dB. These are very broadband devices, which can generate intermod products if very strong input signals are present. Depending on the location of the antenna and the frequency band being used, you may notice an increase in the noise level of the receiver that is due to mixing of two strong input signals (for example, a broadcast fm station and a television video or audio signal). Enabling the attenuator switch on the direction finder that applies attenuation of 20 dB between each antenna element and its associated preamplifier can reduce the intermod.

#### ***5.4 Direction finding in the pulse mode***

The pulse mode logic has been optimized for pulse duration of 150 milliseconds and a period of 0.5 second. The type of transmitter or beacon used for target tracking frequently generates this type of pulse. It is possible to change the pulse duration and period to other commonly used values as described in Section 6.4. Enter the pulse mode by pressing the Pulse Mode switch.

As in the continuous mode, the processor again samples the sweep frequency data every 10 milliseconds and calculates the bearing angle each 0.5 second. To determine whether a signal (pulse) was present during the 0.5-second interval, a correlation calculation is made. The amplitude of the tone is calculated over every 150-millisecond subinterval and the subinterval with the highest value is noted. The amplitude is then calculated over the 350-millisecond interval that does not include the selected 150 milliseconds. The two averages are then compared, and if a criterion is exceeded, it is concluded that a pulse occurred during the display interval. The bearing angle is then calculated from the phase of the tone data in the selected 150-millisecond interval.

This method permits the receiver volume to be adjusted without affecting the bearing, and the receiver squelch can be set normally or left open. Maximum sensitivity is obtained with the receiver unsquelched.

Consecutive bearings may be averaged. The number of samples averaged may be selected to be 1, 2, 5, 10 or 20. Unlike the continuous mode, the antenna sweep direction is not reversed in the PULSE mode because consecutive pulses may not be coming from the same transmitter.

## **5.5 Homing**

When the direction finder is used to home on a signal source, the following guidelines should be followed.

Take an assistant with you. Don't try to read the display and drive at the same time.

Try to keep out of high multipath areas (buildings, etc.) as long as possible.

Avoid strong interfering signal locations (broadcast stations, etc.)

Keep moving when the signal is present. Multipath averages out spatially (not temporally).

## **6.0 Remote Control**

### **6.1 Introduction**

Serial communication ports are provided at two of the rear panel connectors chosen from the three available. Port #0 is connected at J1; port #1 is connected to J4 and port #2 to J2. On power turn-on, the DDF6000D determines whether a plug has been inserted into the 3.5 mm jack J4, and if it has, the system operates using CIV protocol at port #0 (J1) and port #1 (J4). The DE9P connector at J2 (port #2) is not used in this mode. If during power turn-on, a plug was not inserted into J4, then both port #0 (at J1) and port #2 (at J2) will operate using ASCII message protocol. Port #1 (J4) is not used in this case.

CIV is a packet format 2-wire bus system developed by ICOM and used in most of their radios. Multiple CIV devices can be placed on the CIV bus to communicate with each other. Each device has a unique address.

### **6.2 Hardware Interfaces**

Figure 6-1 shows the wiring of serial interface connectors J1, J2 and J4. Note that the signal names are defined for the Data Terminal Equipment (DTE) device, so that TXD is an input and RXD an output on J2 that is wired as Data Control Equipment (DCE).

#### **6.2.1 Connector J1 (port #0)**

Connector J1 is a DE9S wired as Data Control Equipment (DCE). All voltage levels and impedances are RS232. J1 may be connected to the serial port of a PC using a straight through DE9P to DE9S cable.

CTS, RTS, DSR, DTR, CD and RD are not connected.

The port #0 baud rate is 2400 with 8 data bits; no parity and 1 stop bits.

#### **6.2.2 Connector J2 (port #2)**

Connector J2 is a DE9P wired as Data Terminal Equipment (DTE). Transmit and receive voltage levels and impedances are RS232. J2 may be connected to a PC using a null modem DE9S to DE9S cable.

RTS, CTS, DSR, DTR, CD and RD are not connected.

The default baud rate of port #2 is 1200 with 8 data bits, no parity and 1 stop bit. The baud rate may be changed to 2400, 4800 baud or 9600, parity may be changed to even or odd, the number of data bits can be changed to 7 and the stop bit length can be changed to 2 by serial commands.



### **6.2.3 Connector J4 (port #1)**

Connector J4 is a 3.5 mm jack connected for CIV bus operation. Transmit and receive voltage levels are TTL. The output is pulled up to +5 VDC through a 5.1 K resistor.

The default baud rate is 1200 with 8 data bits, no parity and 1 stop bit. The baud rate may be changed to 2400, 4800 baud or 9600, parity may be changed to even or odd, the number of data bits can be changed to 7 and the stop bit length can be changed to 2 by serial commands.

## **6.3 Message Protocol**

### **6.3.1 ASCII Protocol**

ASCII messages may contain any string of standard (7 bit) ASCII characters (hex 00 through 7F). A <CR> (hex 0D) character terminates the string. 80 characters (including the <CR>) is the maximum length of the string.

Line-feed characters (hex 0A) are ignored.

### **6.3.2 CIV Protocol**

CIV message format is:

PR PR RA TA CN SC DT SF

where PR is the preamble (hex FE), RA is the receive address, TA is the transmitter address, CN is the command number, SC is the (optional) subcommand, DT is the data (and may be several characters in length), and SF is the message suffix (hex FD). 80 characters is the maximum length of a CIV message (including prefixes and suffix).

Received messages are buffered, and if a jamming character (hex FC) is detected anywhere within the message, the message is ignored. Also, the received message must begin with at least two prefix characters or it will be ignored.

## **6.4 DDF6000D Messages**

### **6.4.1 ASCII Protocol**

In ASCII mode, DDF6000D commands may be received through port #0 (J1) or port #2 (J2). The first character in the message must be a \$ (hex 24) which is followed by a 1 to 3 character command, followed by the <CR> character. Valid DDF6000D commands are listed in Table 6-1.

Recognized DDF6000D commands (except for commands 0, 982, 983 and 997) are executed and acknowledged by the message "\$OK<CR>".

Unrecognized DDF6000D commands (such as \$409<CR>) are acknowledged with the message "\$NG<CR>".

The response to command 0 (DF data request) is the message "XXXYZ<CR>". In this message, XXX is the bearing angle, Y is the signal strength, and Z is a parameter indicating the validity of the returned data. All characters are ASCII digit characters (hex 31 means 1).

In the DDF6000D, bearing and signal strength are computed on a 0.5 second interval. The sampling interval of the serial readout (command 0) may be shorter or longer than 0.5 second, and the validity flag Z provides a method to synchronize the two clock cycles. After the data is read out serially, the validity flag is set to zero, so if a second readout is made before the bearing is updated, the validity flag Z is returned equal to 0. After the data is updated within the DDF6000D, the validity flag is set to 1 if the data meets the signal to noise requirement, and it is set to 2 if it does not.

It is recommended that the PC which is requesting the bearing data do so at a rate of approximately twice per second, and that it ignore any returned data that does not have a validity Z equal to 1.

The response to command 982 (identify hardware) is H6000C<CR>. All characters are ASCII.

The response to command 983 (identify software) is S4.01<CR> assuming that the software contained in the EPROM is version 4.01. All characters are ASCII.

The response to command 997 (send panel message) is PXYZ<CR> that is decoded as described below. All characters are ASCII.

Number of averages	X
1	0
2	1
5	2
10	3
20	4

Sweep rate	Y
0	0

300	1
600	2
1200	3
2400	4

Cal	Pulse	Atten	Dim	Z
Off	Off	Off	Dim	0
Off	Off	Off	Bright	1
		Etc.		
On	On	On	Dim	E
On	On	On	Bright	F

#### 6.4.2 CIV Protocol

DDF6000D commands may be received through port #0 (J1) or port #1 (J4). The transmit address in the message must be that of the controller (hex E0) and the recipient address must be the DDF6000D (default hex 01). Valid DDF6000D commands are listed in the Table beginning on page 24.

Recognized DDF6000D commands (except for commands 0, 982, 983 and 997) are executed and acknowledged by the CIV OK message "FE FE E0 01 FB FD" (assuming the DF address has not been changed from the default value of hex 01).

Unrecognized commands are acknowledged by the No Good message "FE FE E0 01 FA FD (again assuming the default DF address).

The response to command 0 (DF data request) is the message "FE FE E0 01 U V FD". In the message, U and V contain the bearing, S-meter and validity data using a simple data compression scheme. To decompress the data, the PC must implement the following calculation:

```

validity = int (V/64)
temp1 = int (V - 64*validity)
temp2 = int (temp1/16)
temp3 = temp1 - 16*temp2
smeter = temp3 - 1;
angle = temp2*200 + U

```

In the DDF6000D, bearing and signal strength are computed on a 0.5 second interval. The sampling interval of the serial readout (command 0) may be shorter or longer than 0.5 second, and the validity flag Z provides a method to synchronize the two cycles. After the data is read out serially, the validity flag is set to zero, so if a second readout is made before the bearing is updated, the validity flag Z is returned equal to 0. After the data is updated within the DDF6000D, the validity flag is set to 1 if the data meets the signal to noise requirement, and it is set to 2 if it does not.

It is recommended that the PC which is requesting the bearing data do so at a rate of approximately twice per second, and that it ignore any returned data that does not have a validity Z equal to 1.

The response to command 982 (identify hardware) is FE FE E0 01 H 6 0 0 0 C FD assuming that the DF address is 01. The characters H, 6, 0 and C are ASCII (for example hex 36 = 6).

The response to command 983 (identify software) is FE FE E0 01 S 3 . 0 1 FD assuming that the DF address is 01 and that the EPROM is version 3.01. The characters S, 3, ., 0, and 1 are ASCII (for example, hex 33 = 3).

The response to command 997 (send panel message) is FE FE E0 01 P X Y Z FD assuming that the DF address is 01. The characters P, X, Y and Z are ASCII. X, Y and Z are integers that are decoded as indicated in the tables given in the preceding section 6.4.1 to determine the panel settings.

## **6.5 Non DDF6000D messages**

### **6.5.1 ASCII Protocol**

Non-DDF6000D messages may be received on port #0 (J1) or port #2 (J2). These are any ASCII messages in which the first character is not a "\$". Such messages are not acknowledged but are retransmitted on the opposite serial port from the one they are received on. That is, port #0 received messages are sent to port #2 and port #2 received messages are sent on port #0.

### **6.5.2 CIV Protocol**

Non-DDF6000D messages may be received on port #0 (J1) or port #1 (J4). These are any valid CIV messages not addressed to the DDF6000D. Such messages are not acknowledged but are retransmitted on the opposite serial port from the one they are received on. That is, port #0 received messages are sent to port #1 and port #1 received messages are sent on port #0.

## **6.6 Typical Operation**

### **6.6.1 PC connected directly to port #0 (J1); ASCII protocol**

Figure 6.2 shows the wiring. Note that this arrangement can be used when running the utility programs TERM or RDFCMD but not BrgTrack (see description of software in section 7.0)

## **6.6.2 PC connected to port #0 (J1), RS232 receiver connected to port #2 (J2)**

A PC can be connected to port #0 and a receiver having an RS232 interface (such as the AOR series) connected at port #2 (J2). The baud rate, number of data bits and number of stop bits at port #2 must match those of the receiver, but these parameters can be different from those used on port #0.

Figure 6-3 shows the wiring. ASCII protocol is used on both ports 0 and 2.

## **6.6.3 PC connected to port #0 (J1), CIV protocol**

Figure 6.4 shows the wiring. Note that the plug at J4 must be inserted before turning the DDF6000D on. This setup may be used with the BrgTrack program described in section 7.0.

## **6.6.4 PC connected to port #0 (J1), ICOM receiver connected to port #1 (J4)**

A PC can be connected to port #0 and a CIV device (such as an ICOM receiver) connected to port #1. The baud rate, number of data bits and number of stop bits at port #1 must match those of the receiver, but these parameters can be different from those used on port #0.

Figure 6-5 shows the wiring for this setup. The CIV cable connectors must be Switchcraft type 750 plugs such as those provided with the DDF6000D. (These connectors are slightly larger than the 3.5 mm connectors provided with ICOM equipment. They are compatible with ICOM jacks, but the ICOM plugs are not compatible with those used on the DDF6000D. For dimensional details, see section 4.4).

This configuration causes CIV protocol to be used at both ports #0 and #1.

Commands from the PC to the DDF6000D are sent on port #0 using the CIV message format (to default address 01 from address hex E0). Messages from the DDF6000D to the PC are similarly sent on port #0 using CIV format to hex E0 from default address hex 01. Valid DDF6000D commands are acknowledged with the ICOM OK message hex code FB. Invalid messages are acknowledged with the ICOM No Good message hex FA.

Commands from the PC to a CIV receiver are sent on port #0 in CIV format. Such messages should be addressed to the receiver and not the DDF6000D. These commands are then re-sent by the DDF6000D on port #1. Messages from the receiver to the PC (such as OK or NG) are sent to the DDF6000D in CIV format on port #1, and then re-sent over port #0 to the PC. Such messages should be addressed to the PC (hex E0) and not to the DDF6000D (default hex 01).

## **6.6.5 Two DDF6000Ds with Icom Receivers Connected to PC Using Serial Data Expander**

When a wired connection to the remote DF site is required (using for example telephone line modems), the Serial Data Expander, DDF6077 may be used. This device must be used in the CIV mode where only one device at a time is ever transmitting. Figure 6-6 shows the wiring. Fewer

direction finder sites may be used with the DDF6077, or multiple DDF6077's may be daisy-chained if more than three DFs are to be connected. Each DF and Icom receiver must have a unique CIV address.

### **6.6.6 Two DDF6000Ds with Icom Receivers Connected to PC Using Radio Modems**

The PC connects to a radio modem at the control site and port #0 of each DDF6000D is connected to a radio modem at the remote location. ICOM receivers are connected to each remote DDF6000D via Port #1 (J4). Each DDF6000D and ICOM receiver must have different CIV addresses. Note that CIV protocol must be used when a radio modem provides remote operation. If a particular site does not use a CIV receiver, a spare Switchcraft type 750 plug must be inserted into the DDF6000D J4 to cause the DF to operate with CIV protocol. (Of course, no remote control of the receiver is provided with this connection).

Figure 6-7 shows a typical arrangement including the wiring needed to connect with the Young Design Inc. (YDI) radio modems. We recommend their model 24R or 24CM radio modem. These units should be operated in the Data Activation Mode with the End of Transmission (EOT) character set for hex FD. Be sure to set the baud rate to 2400, the data bits to 8, no parity and 1 stop bit using the setup software provided with the radio modems. We have found that a Transmitter Buffer Delay of 50 milliseconds and receiving carrier detect to data delay of 10 milliseconds works well. The anti-streaming timer can be set to 1 second. Contact Young Design Inc., 103 Rowell Court, Falls Church, VA 22046, Tel 703-237-9090, Fax 703-237-9092, <http://www.ydi.com>.

### **6.6.7 Modem Setup**

Please see the application notes on our web site, [www.dopsys.com](http://www.dopsys.com), for the settings used with other modems (both radio and telephone line).

### **6.6.8 Command Interlock**

**Beginning with firmware version 4.04, all serial commands except for commands 0, 15 and 16 require that the CAL flag be first enabled.** This interlocking feature was added to reduce the probability of a parameter being changed due to a bit error on the serial input. As an example, to change the number of averages to 1, first send command 15 (cal flag = ON), and then send command 1 (set number of averages = 1). The direction finder will automatically turn the cal flag OFF after receiving the second command.

Table 6-1  
DDF6000D Serial Command List

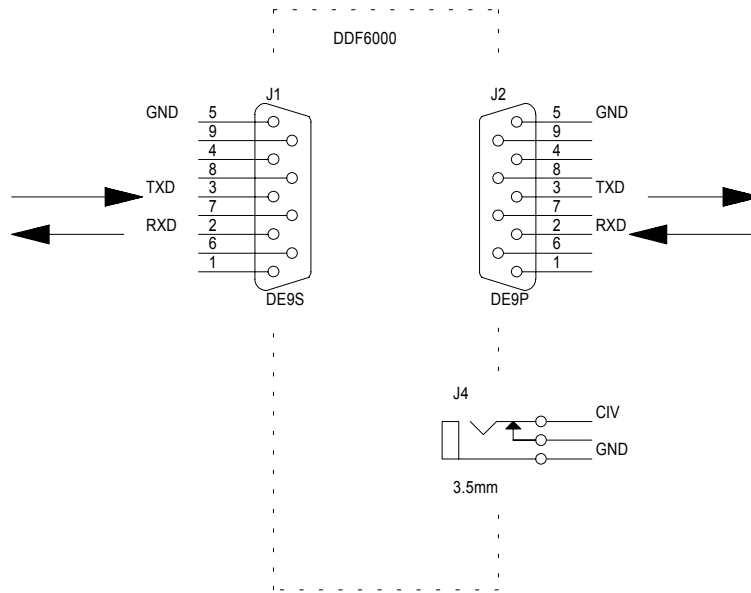
All serial commands except for commands 0, 15 and 16 require that the CAL flag be first enabled

Command Number	Description of Command. Default values shown in bold.
0	Request bearing data
1	Number of averages = 1
2	Number of averages = 2
3	Number of averages = 5
4	Number of averages = 10
5	Number of averages = 20
6	Sweep rate = 0
7	Sweep rate = 300
8	Sweep rate = 600
9	Sweep rate = 1200
10	Sweep rate = 2400
11	Attenuator = ON
12	Attenuator = OFF
13	DF mode = PULSE
14	DF mode = CONTINUOUS
15	Cal flag = ON
16	Cal flag = OFF
17	Cal bearing to zero
18	Cal S-meter to zero
19	Cal S-meter to nine
20	Intensity = BRIGHT
21	Intensity = DIM
22	Port1&2 baud rate = 1200
23	Port1&2 baud rate = 2400
24	Port1&2 baud rate = 4800
25	Port1&2 baud rate = 9600

26	Port1&2 data bits = 7
27	Port1&2 data bits = 8
28	Port1&2 stop bits = 1
29	Port1&2 stop bits = 2
30	Port1&2 parity = NONE
31	Port1&2 parity = EVEN
32	Port1&2 parity = ODD
33 through 239	Calibrate the bearing to the value given by the command number - 33. For example, command 33 calibrates the bearing to 0 degree.
240 through 255	These commands are not allowed because of conflicts with the CIV control characters.
256 through 408	Calibrate the bearing to the value given by the command number - 49. For example, command 256 calibrates the bearing to 207 degrees.
409 through 495	Not defined.
496 through 511	These commands are not allowed because of conflicts with the CIV control characters.
512 through 670	Set the address of the DDF6000 used for CIV communications to the value of the command - 511. For example, command 512 sets the address to 1.
671 through 751	Not defined.
752 through 767	These commands are not allowed because of conflicts with the CIV control characters.
768 through 899	Not defined.
900 through 920	Set the signal to noise ratio threshold used in the continuous mode to the value given by the (command number - 900)/10. For example, command 912 sets the threshold to 1.2
921 through 976	Not defined.
979	Select UHF1 antenna.
980	Output bearing data automatically.
981	Turn off automatic data output.
982	Identify hardware.
983	Identify software.
984	Enable self-test input (disconnects receiver input).
985	Disable self-test input (connects receiver input).
986	Enable front panel switches.

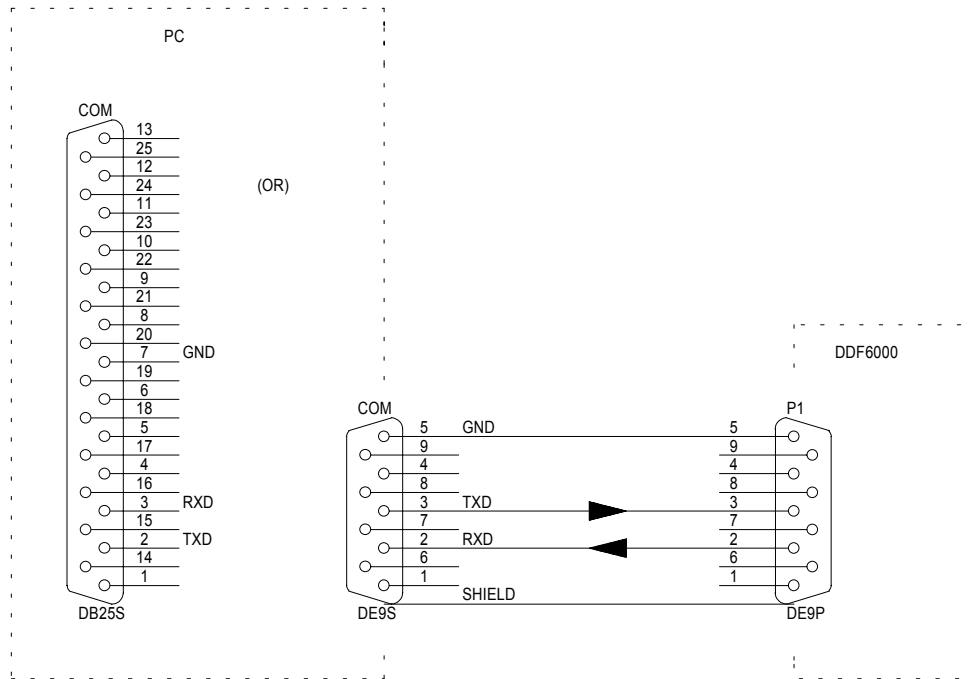


987	Disable front panel switches.
988	Select VHF antenna.
989	Select UHF2 antenna.
990	Set time period for display update and pulse rep rate to 0.5 seconds.
991	Set time period for display update and pulse rep rate to 1.0 second.
992	Set time period for display update and pulse rep rate to 1.5 seconds.
993	Set pulse on time to 150 milliseconds for correlator.
994	Set pulse on time to 180 milliseconds for correlator.
995	Set pulse on time to 200 milliseconds for correlator.
996	Test LEDS.
997	Send panel message.
998	Set factory defaults.
999	Reset processor.



NOTE: Panel mount connectors shown.  
RS232 Signal names are DTE.

Figure 6-1  
DDF6000 Serial Interfaces



Note: Cable end connectors shown.

Figure 6-2  
Local DF in ASCII Mode

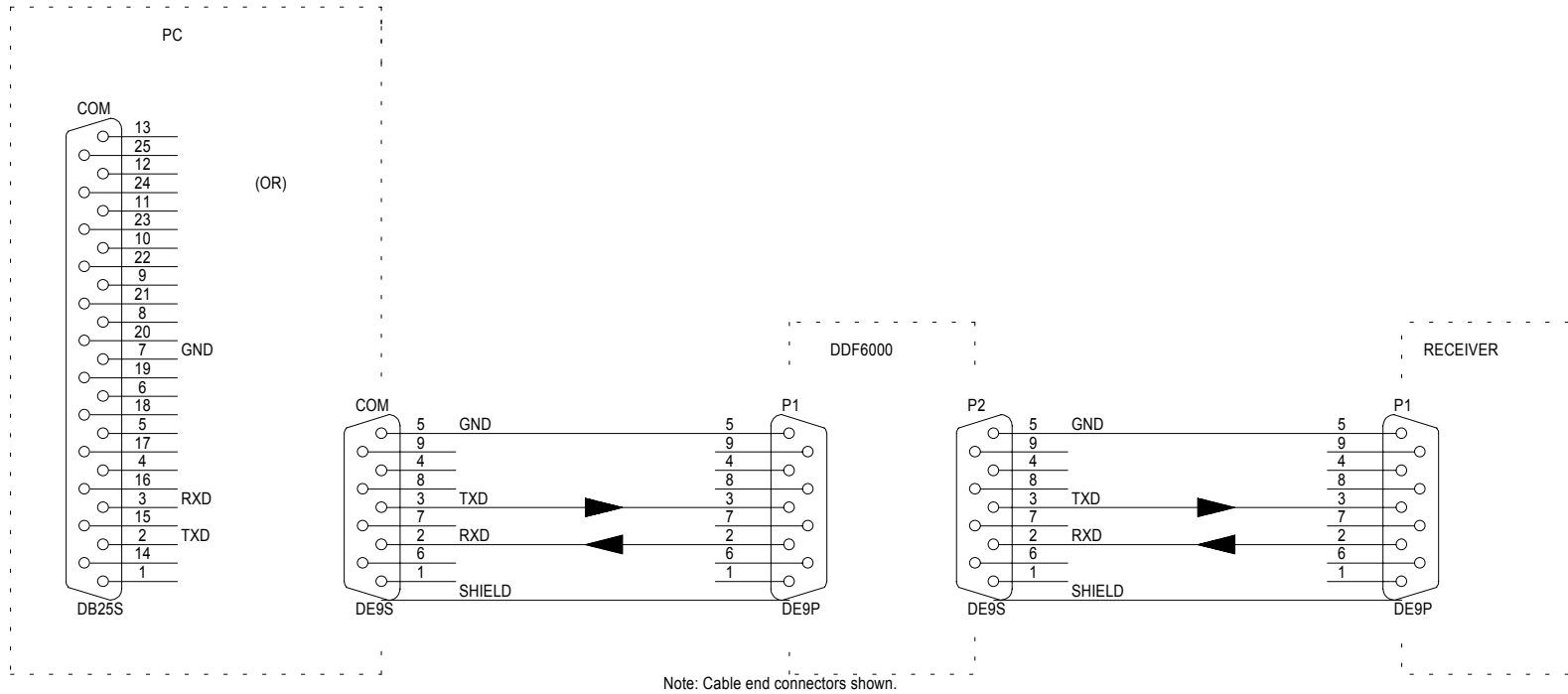
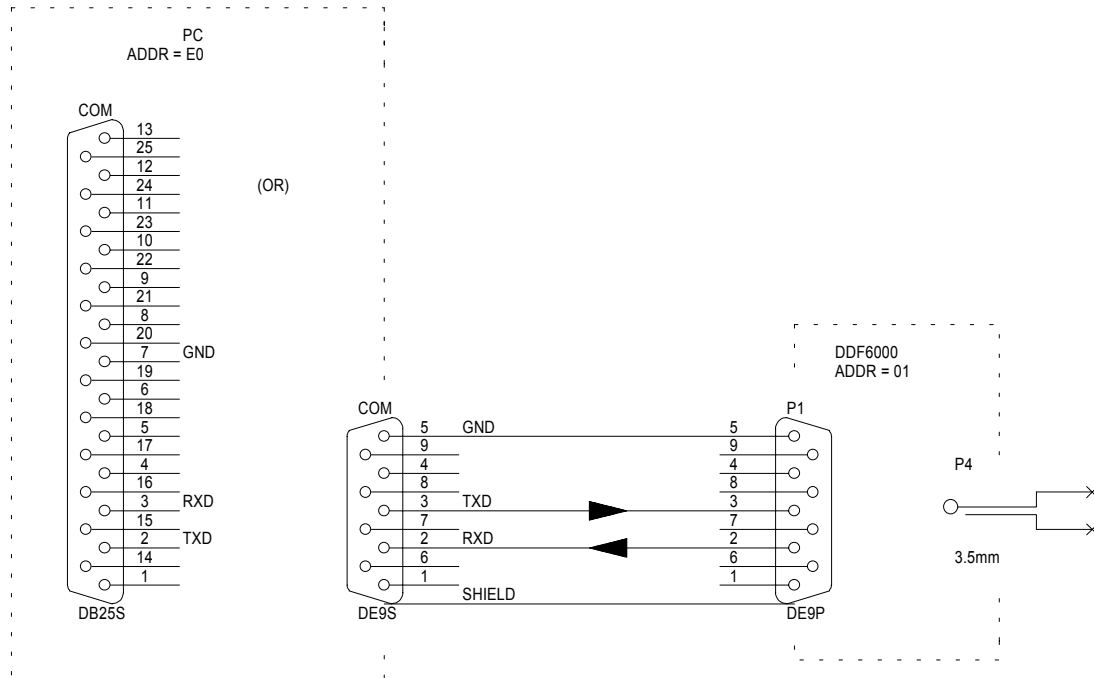


Figure 6-3  
Local DF with ASCII Receiver



Note: Cable end connectors shown.  
Default CIV addresses shown.

Figure 6-4  
Local DF in CIV Mode

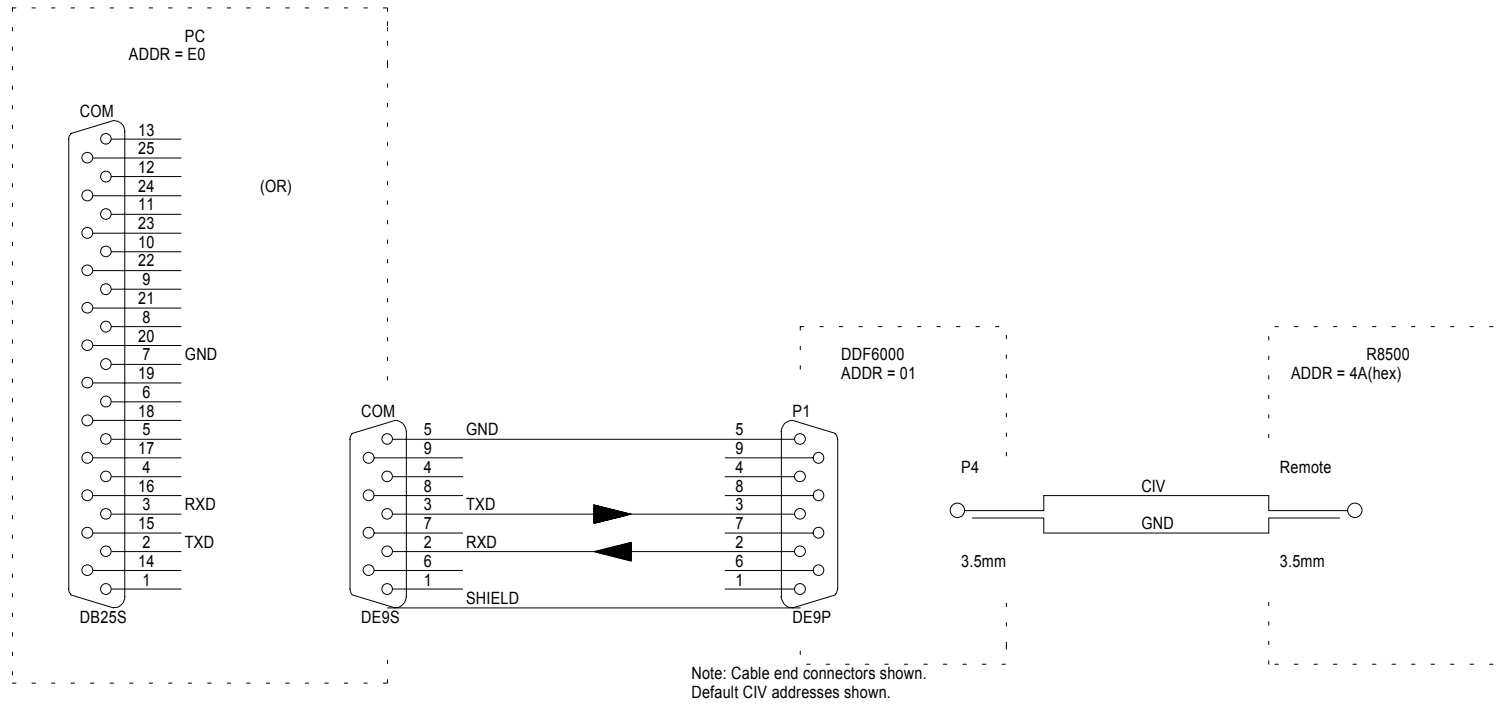


Figure 6-5  
Local Site with CIV Receiver

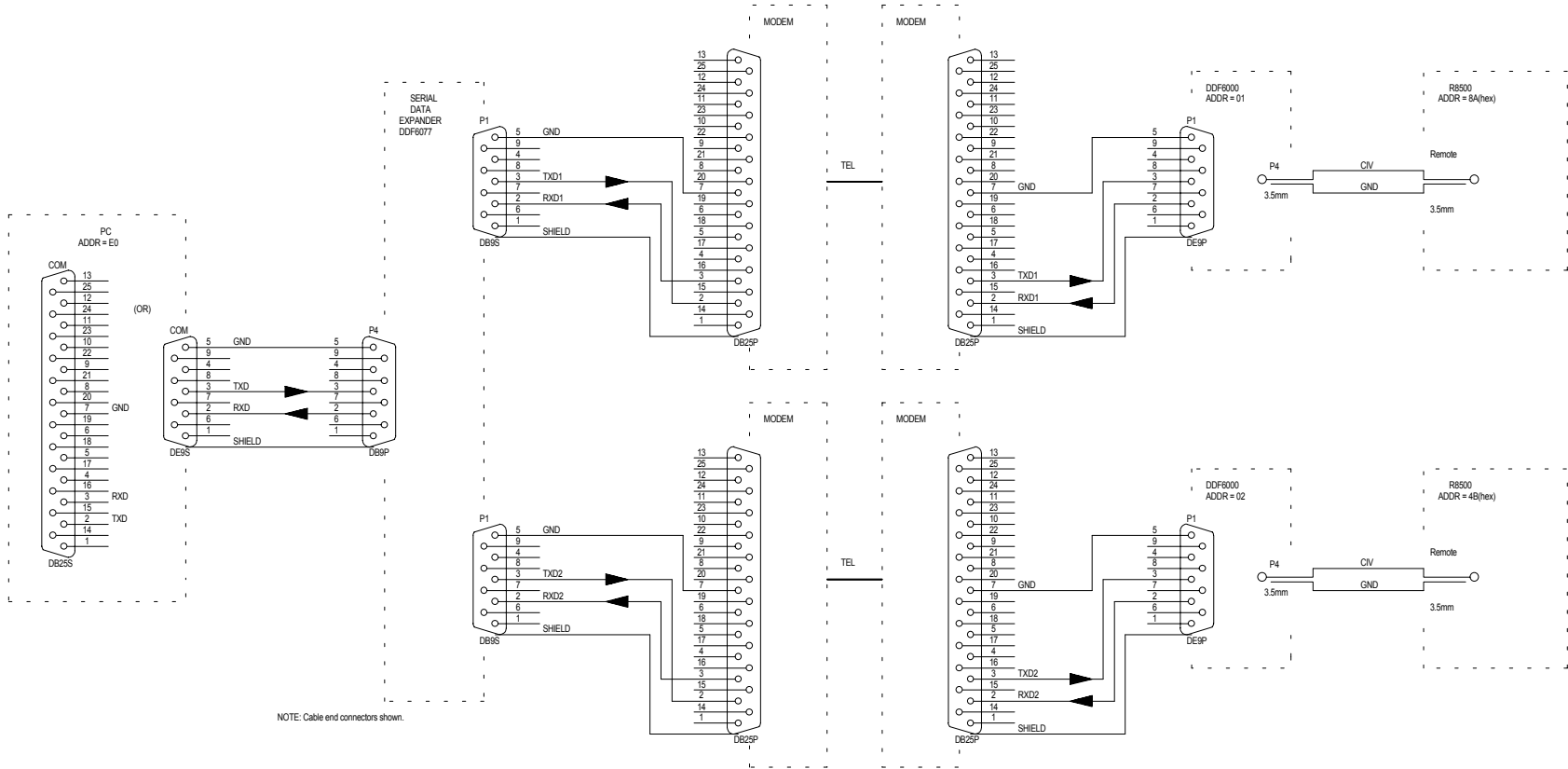


Figure 6-6  
Two Remote Sites Using  
Telephone Modems

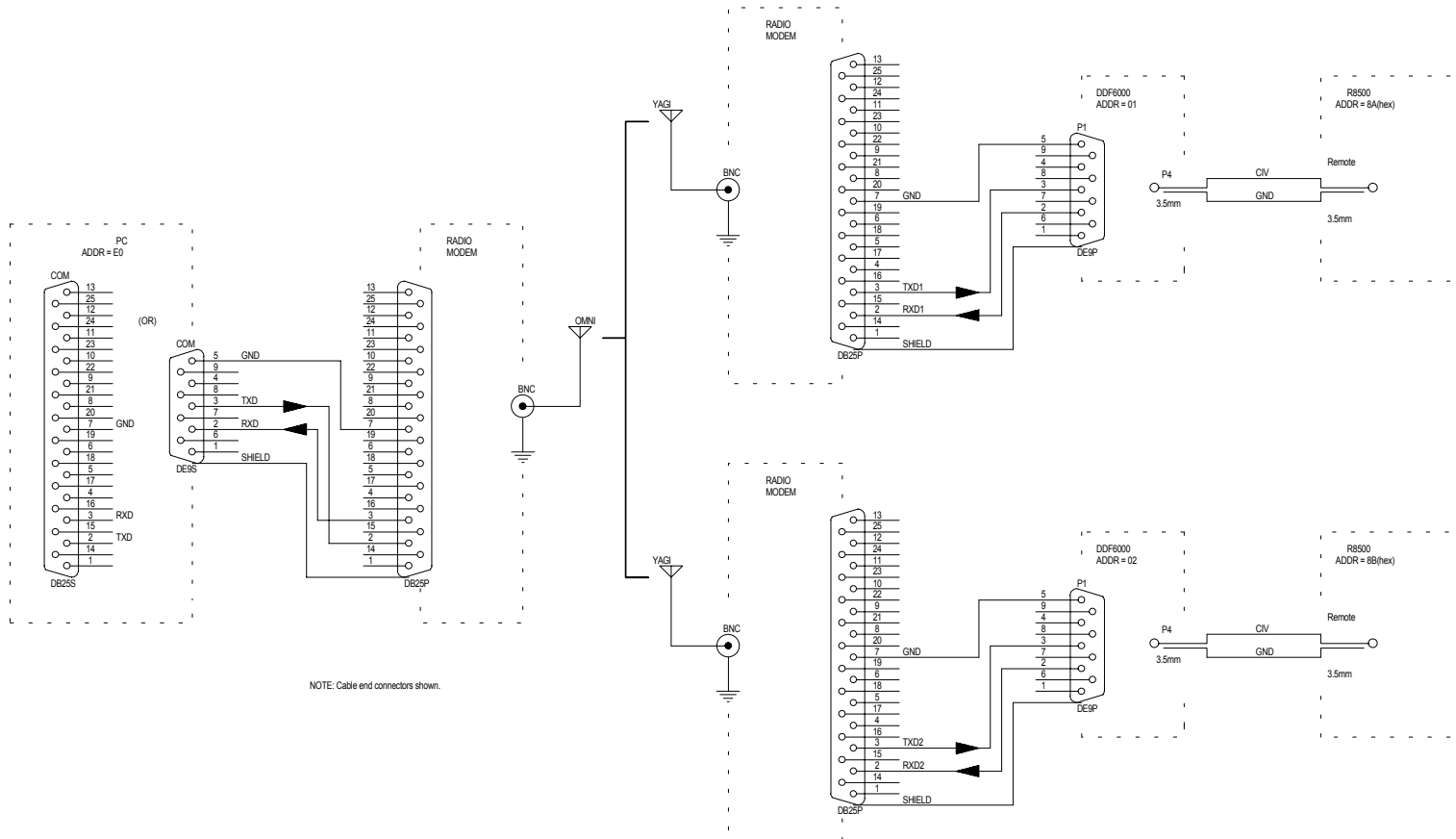


Figure 6-7  
Two Remote Sites Using Radio Modems

## 7.0 Test Software

### 7.1 Introduction

The DDF6000D includes a CD or disk set containing the Bearing Track software and two utility programs that can be used to operate the direction finder using a PC. These programs, called RDFCMD and TERM, run under DOS. The programs can be installed using the installation CD. Execute the programs by selecting them from the Bearing Track item under the Programs menu in the Start menu.

### 7.2 RDFCMD

This is a menu driven program that provides access to all DDF6000D serial commands. Connect DF port #0 (J1) to a free PC COM port using a straight through cable that contains at least RXD, TXD and GRD lines. (See figure 6-3 or 6-4).

Run RDFCMD and supply the communications parameters requested. The protocol can be either ASCII or CIV, but it must match the DF. **Remember that all commands except the bearing data request and the CAL ON command must be preceded by the CAL ON command.**

From the MAIN menu, enter 0 to request the bearing data. The program will display the command as sent, the response as received, and the decoded bearing data (bearing in degrees, S-meter, and validity character - see sections 6.4.1 or 6.4.2).

Enter command 1 to go to the front panel menu. Enter 15 to turn the CAL light ON. Then enter 1 to change the number of averages to 1. To return the number of averages to 2, enter command 15 followed by command 2. <ESC> returns to the Main menu. Other menus are available to change the DF port #2 communications parameters (to match a particular receiver), and to command frequency changes to the receiver. You issue a command from another menu to the direction finder, you will first have to go to the front panel menu and turn the CAL light ON, hit <ESC> to get to the Main menu, then go to the menu required for the other command.

This program can be used when the PC and direction finder port#0 are connected via a radio modem set. RDFCMD can also be used to test port #1 (J4) using an RS232 to CIV converter (ICOM CT17) or to test port #2 (J2) using a null modem cable.

### 7.3 TERM

This is a simple terminal program that can be used to check out the communications if you have a problem establishing a connection using RDFCMD. Because TERM obtains its commands directly



from the keyboard, only ASCII commands can be entered. Be sure that DF connector J4 is unplugged and recycle the power to the DF before using the program.

Type the command \$15<Enter> followed by \$1 <Enter> to change the number of averages to 1, \$15 <Enter> followed by \$2 <Enter> to change it back to 2, etc. The program will display the command as sent and the response as received. The response should be "OK".

This program can also be used on DF port #2 (J2) if a null modem is placed between the PC and the DF port. The baud rate, data bits and stop bits must match those of port #2.

Program TERM cannot be used if the DF is configured for CIV protocol.

## ***7.4 Triangulation Software***

The above software programs are intended to permit simple remote control operation of the direction finder and testing of the two serial ports. Full control of a network of one or more direction finders with automatic triangulation and map display is available with the program Bearing Track. See the separate manual, which comes with the Bearing Track program.

## **8.0 Servicing**

### **8.1 Schematics**

A complete set of schematics is provided at the end of this section as an aid to troubleshooting and to clarify interfaces. Because the DDF6000D is a microprocessor-based system that uses high-density surface mount technology in the RF summer/antenna, it is recommended that the unit be returned to the factory for repair. The only exception is for upgrading of the program EPROM that is described below.

The circuitry used in the DDF6000D is susceptible to electrostatic discharge. Observe proper ESD precautions when servicing the unit.

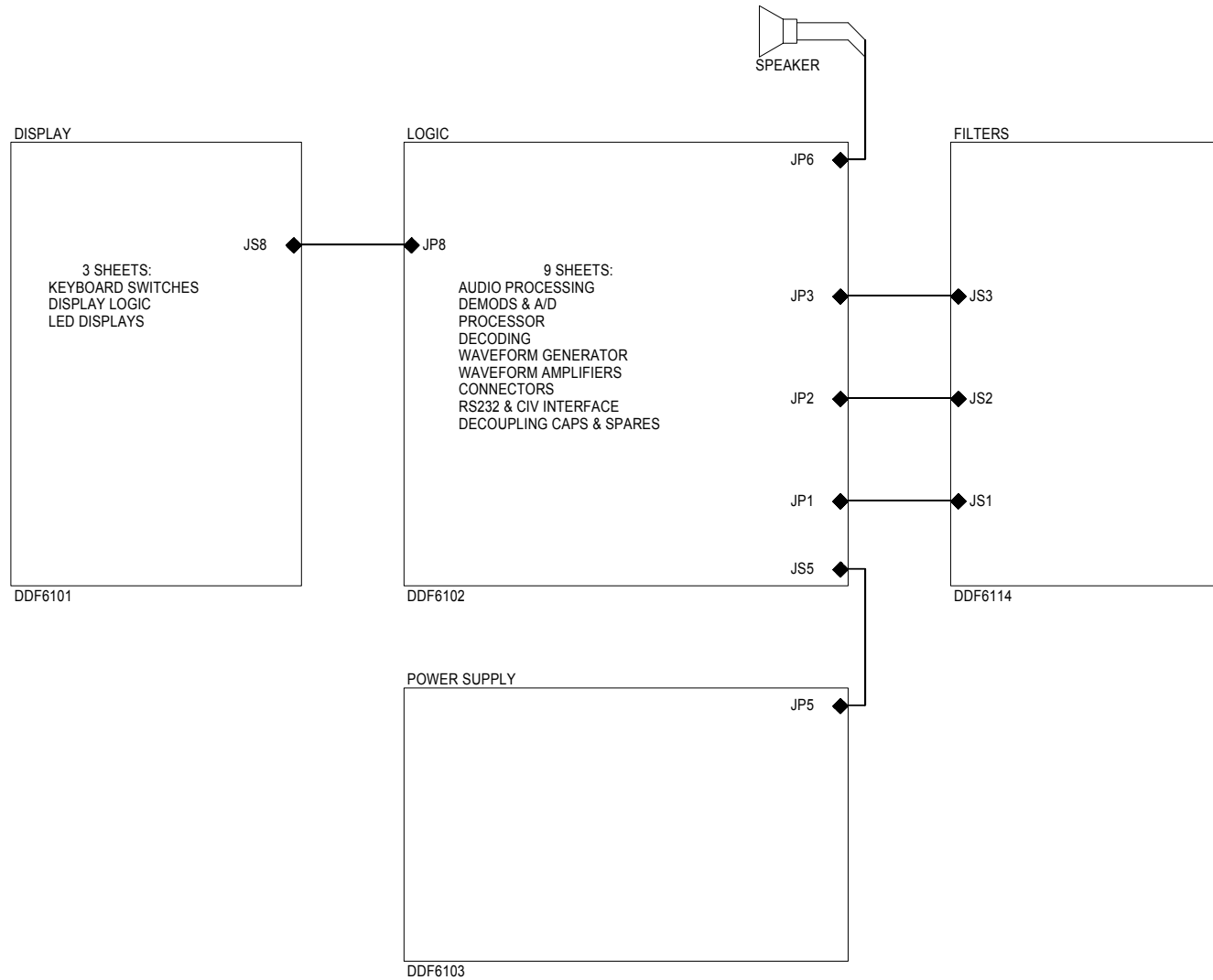
Overseas customers should refer to the relevant Doppler Distributor.

### **8.2 EPROM replacement**

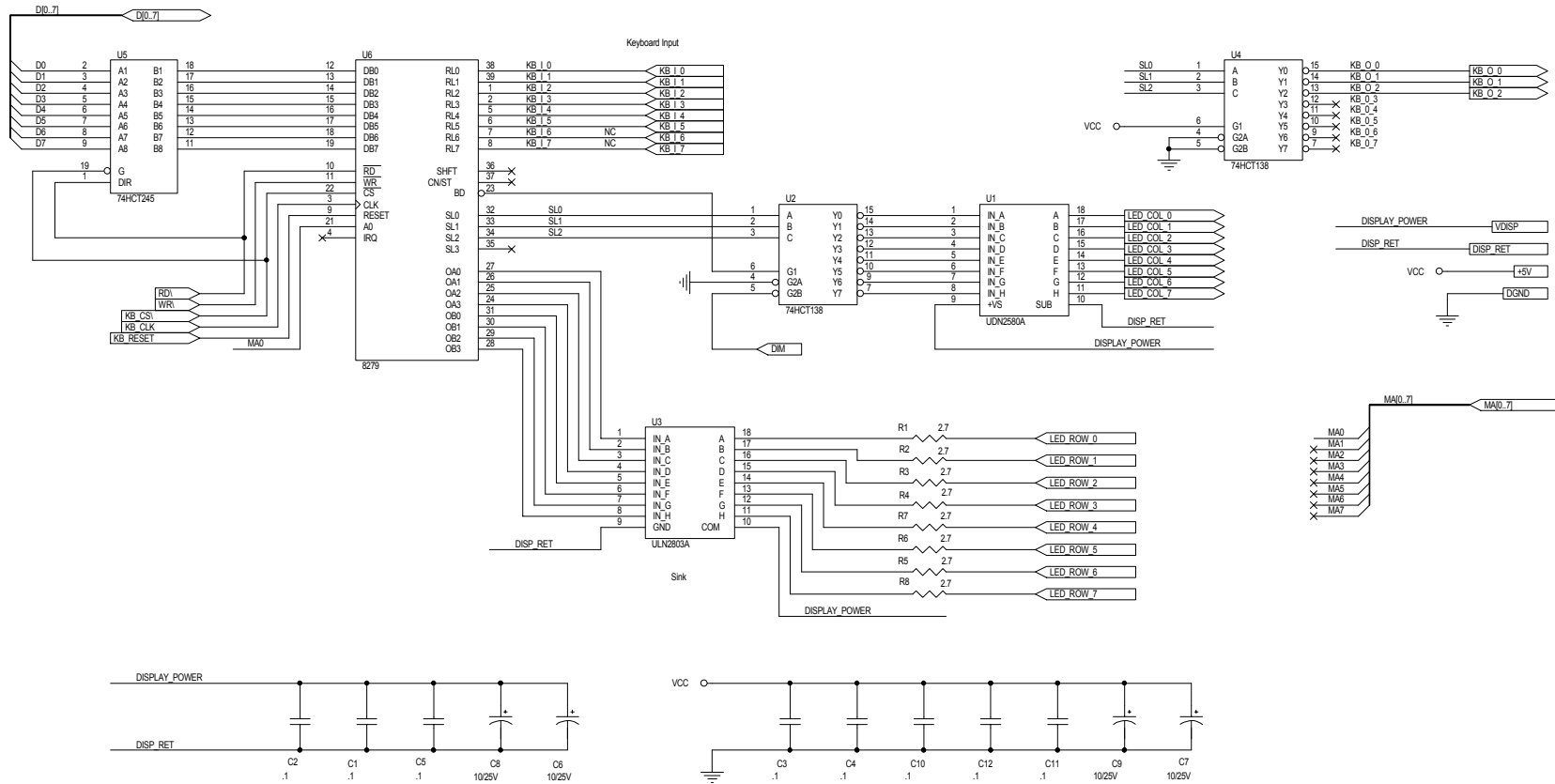
Remove the top cover by removing the (23) black 4-40 screws on the top, sides and back of the unit. Tip the top cover up and disconnect the speaker leads so the cover can be removed completely.

Replace the EPROM U123 using proper IC removal and insertion tools and observe electrostatic discharge precautions.

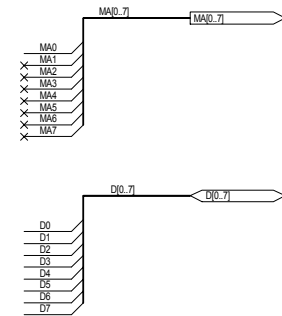
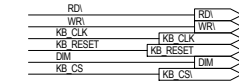
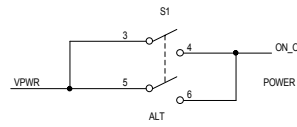
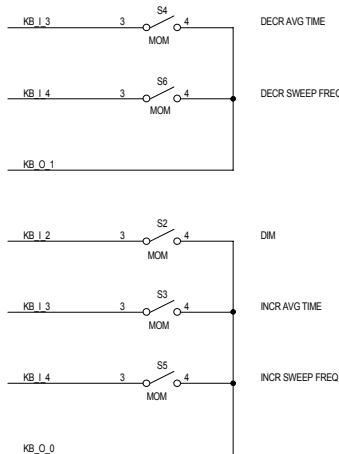
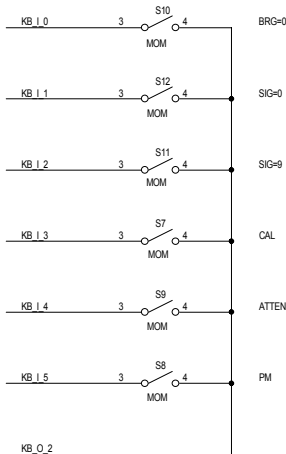
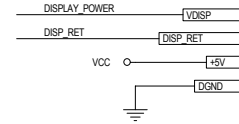
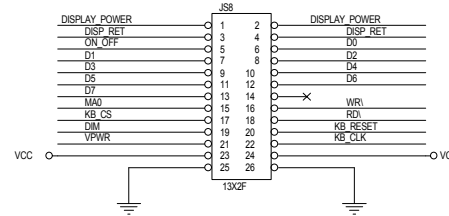
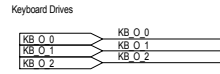
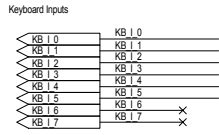
Reconnect the speaker leads and replace the top cover using the black 4-40 screws.



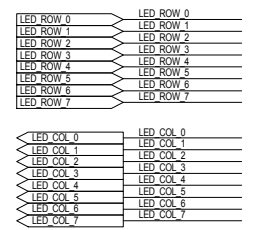
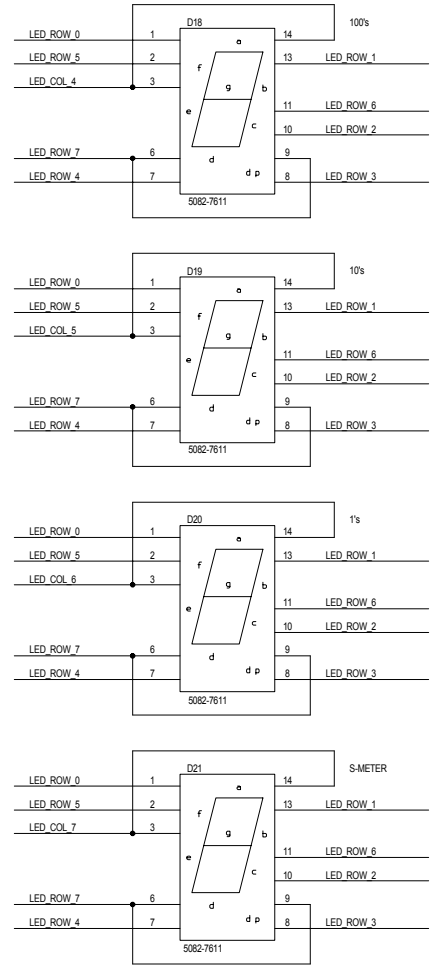
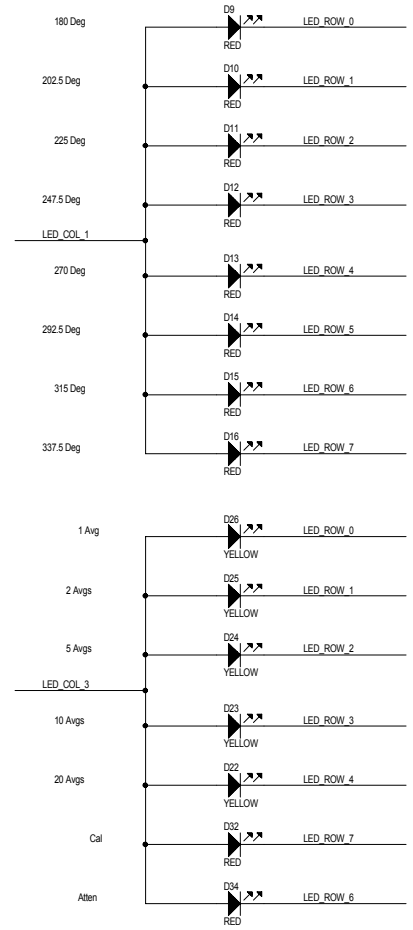
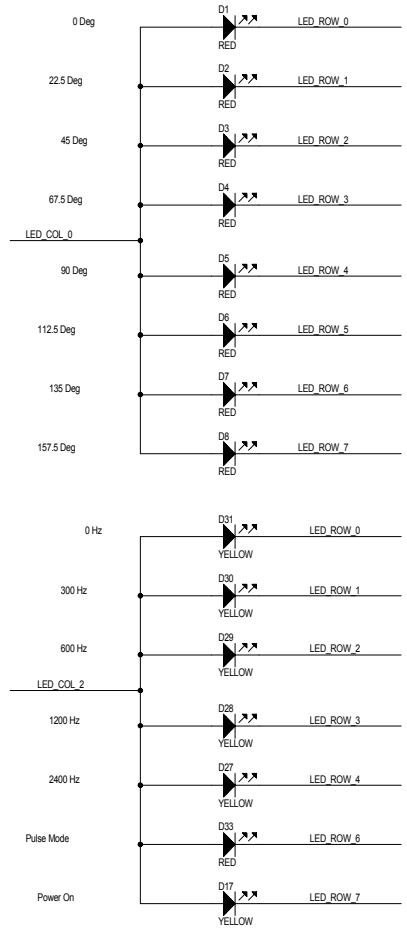
DDF6000 Display Processor



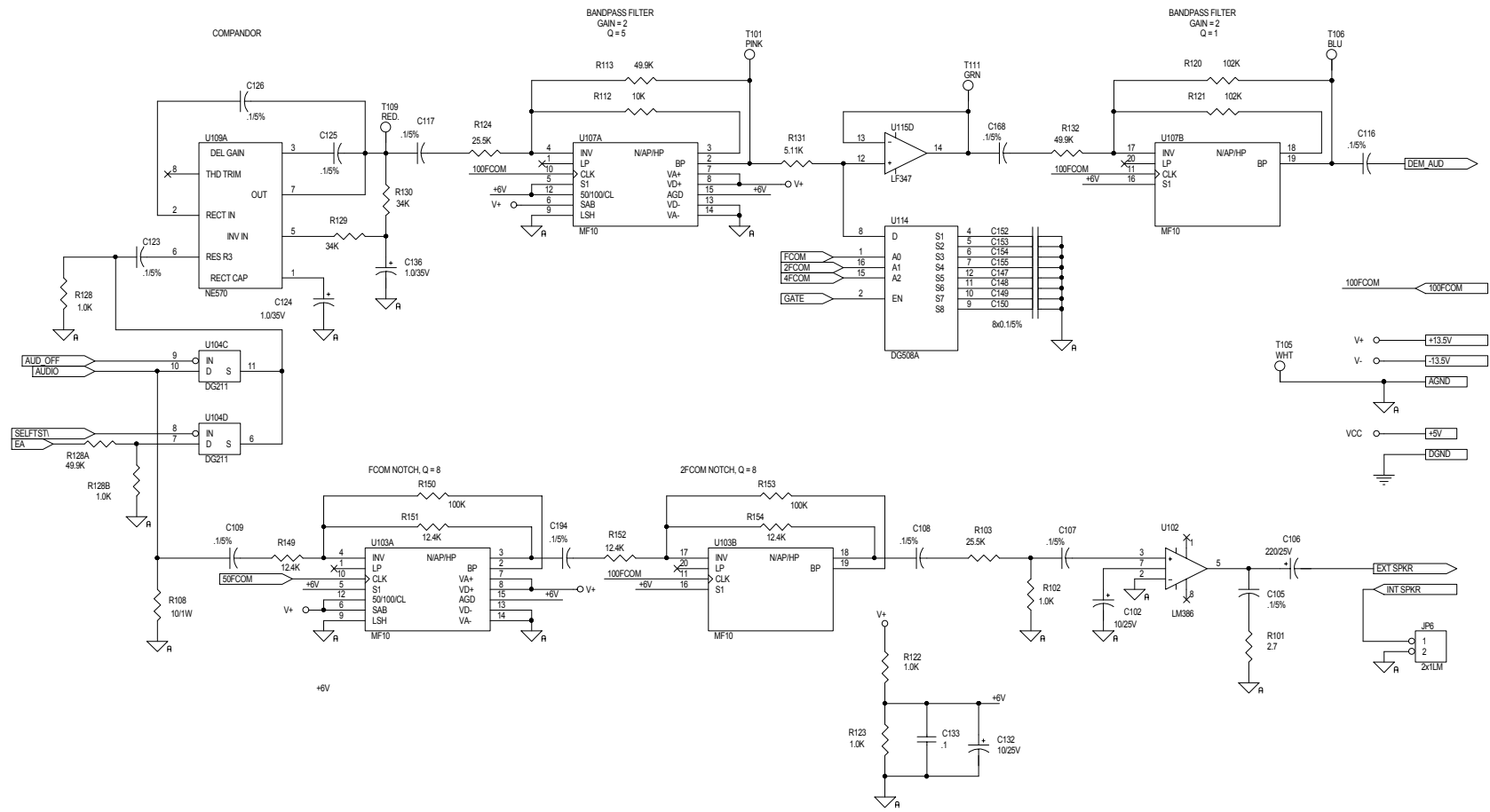
DDF6101 Display Logic



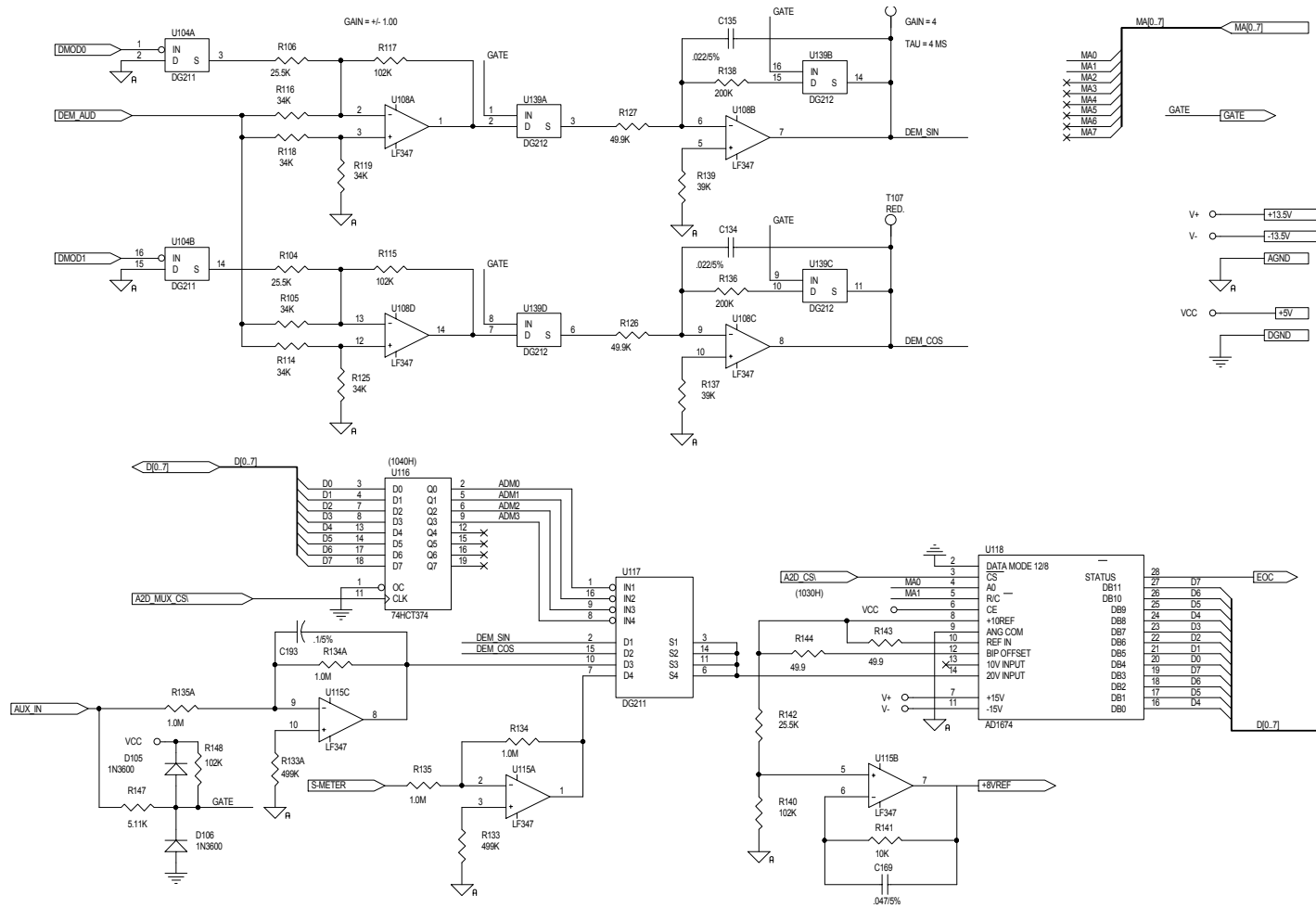
## DDF6101 Keyboard Switches



## DDF6101 LED Displays



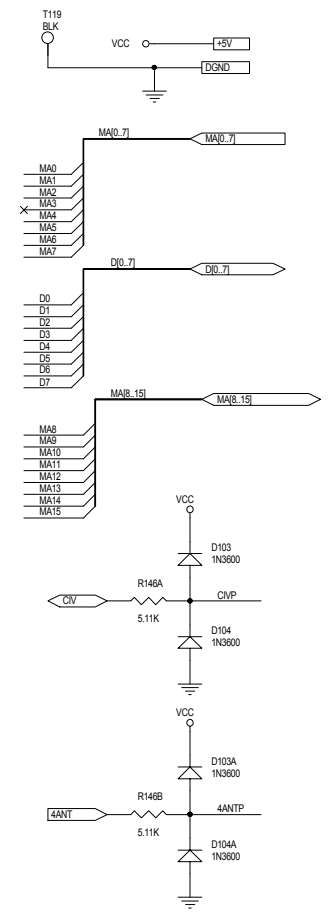
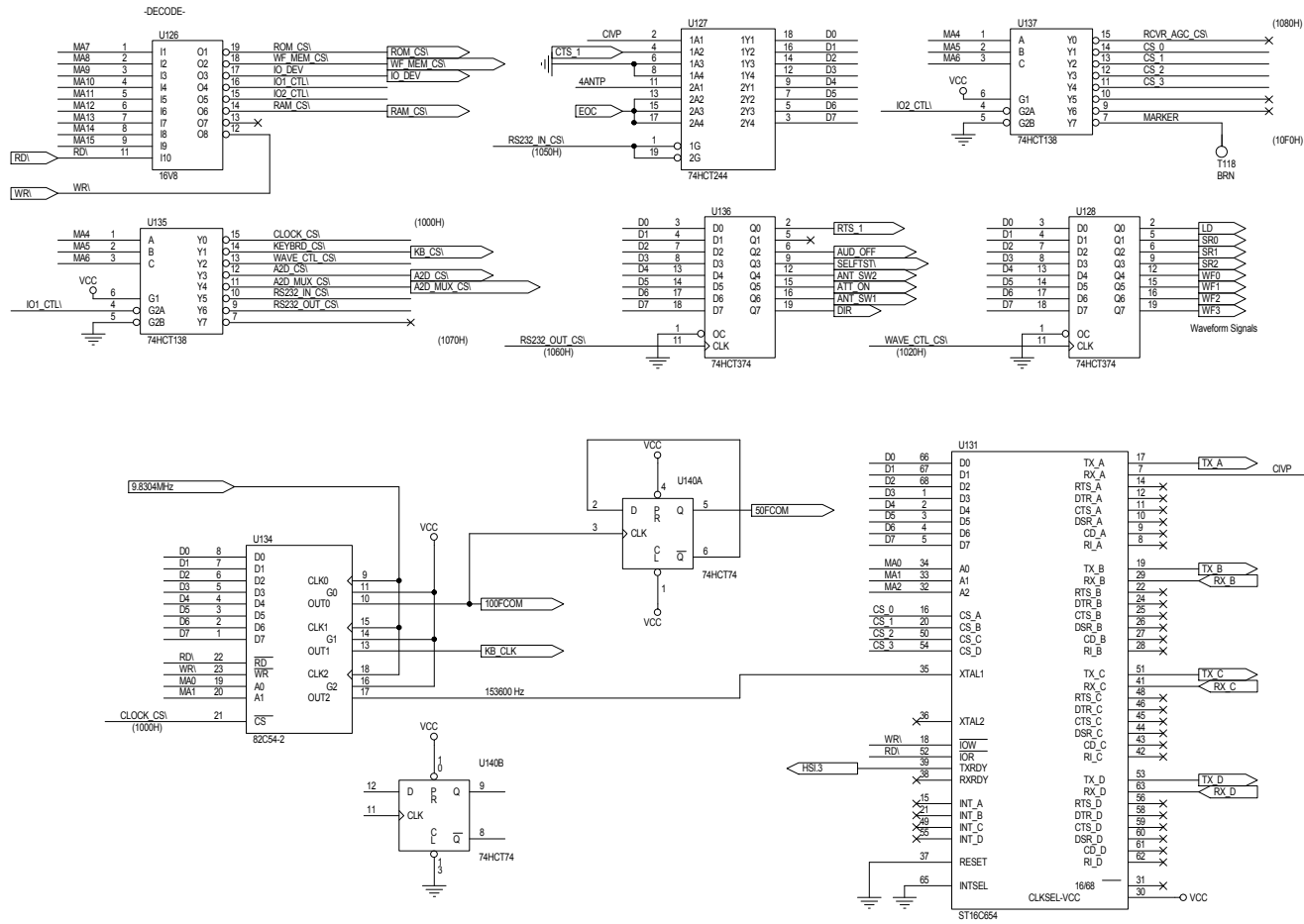
DDF6102 Audio Processing



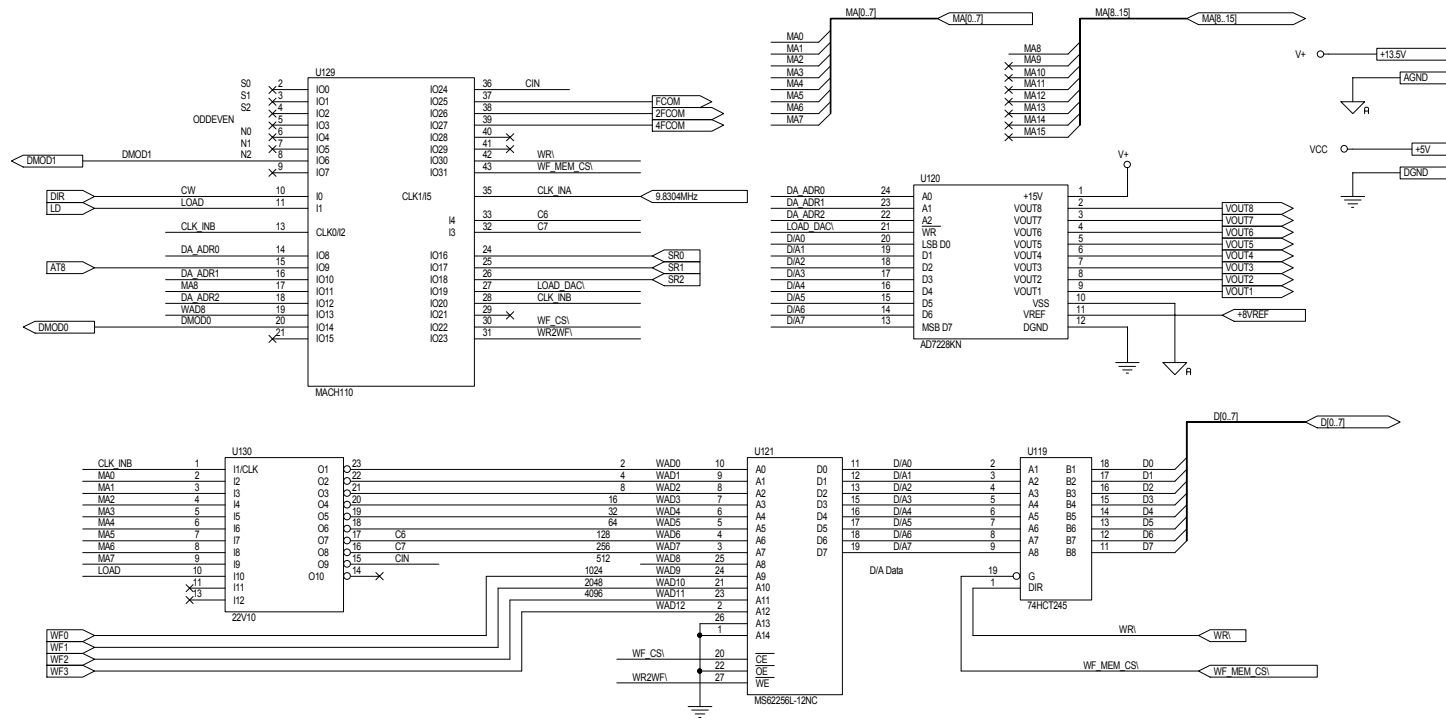
DDF6102 Demods & A/D



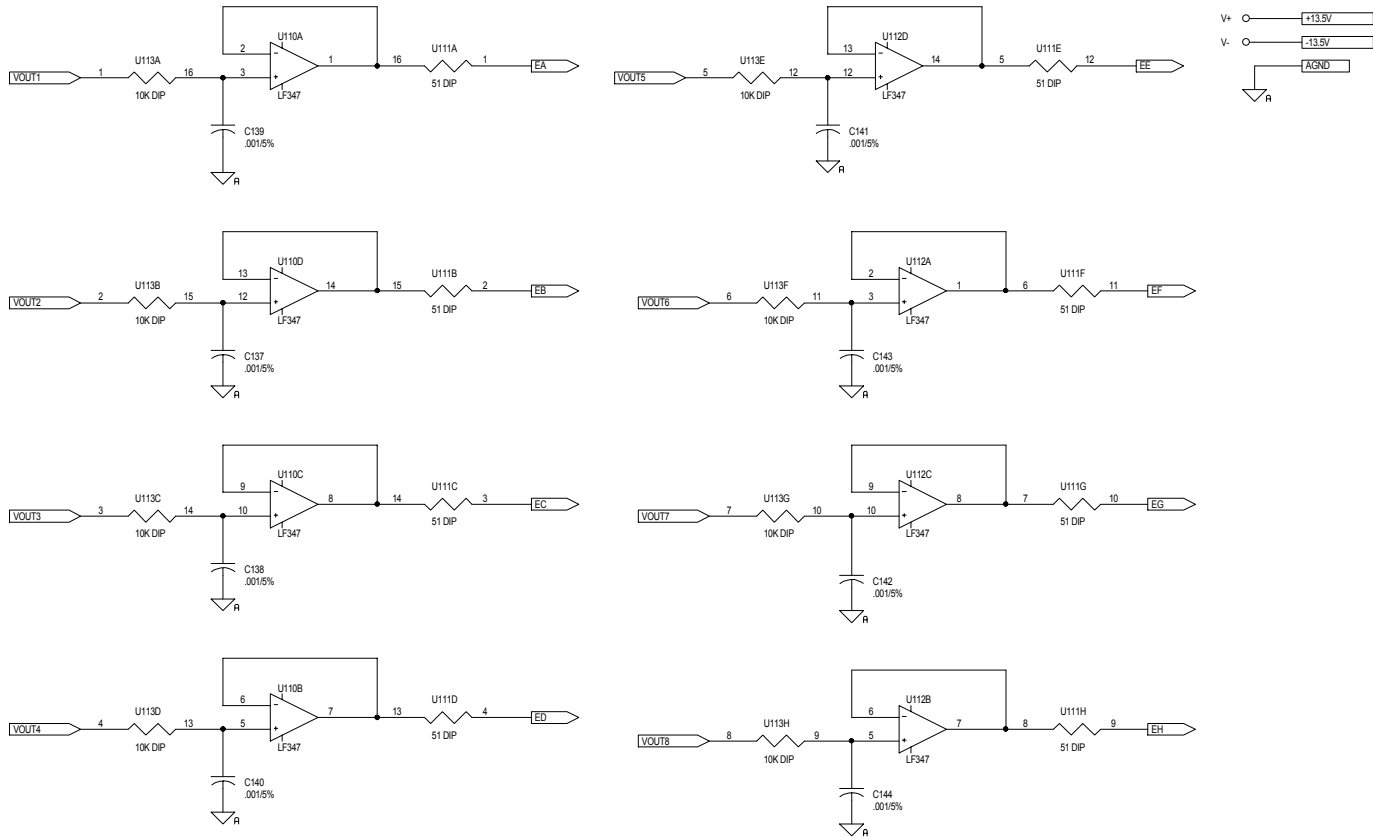




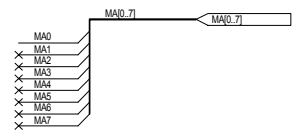
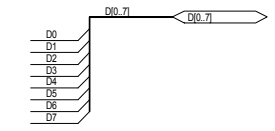
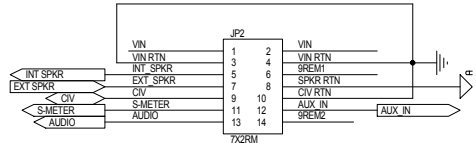
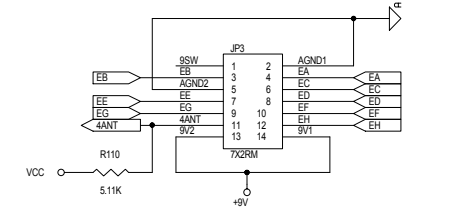
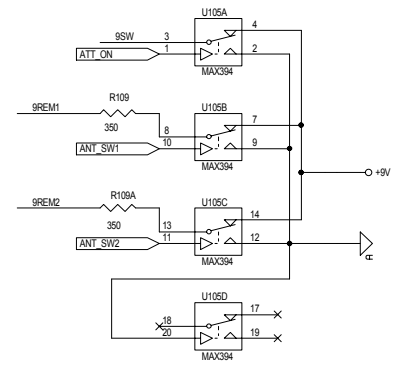
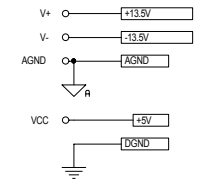
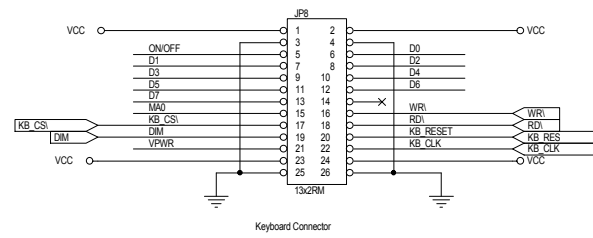
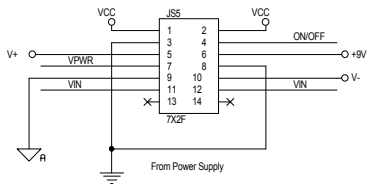
### DDF6102 Decoding



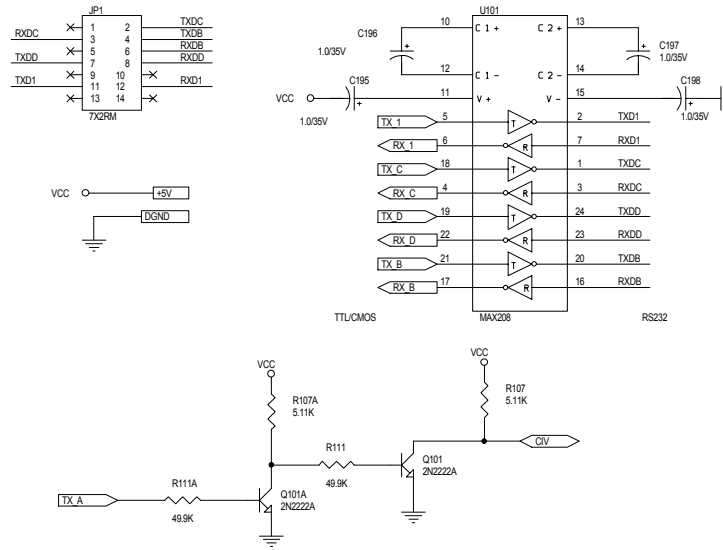
DDF6102 Waveform Generator



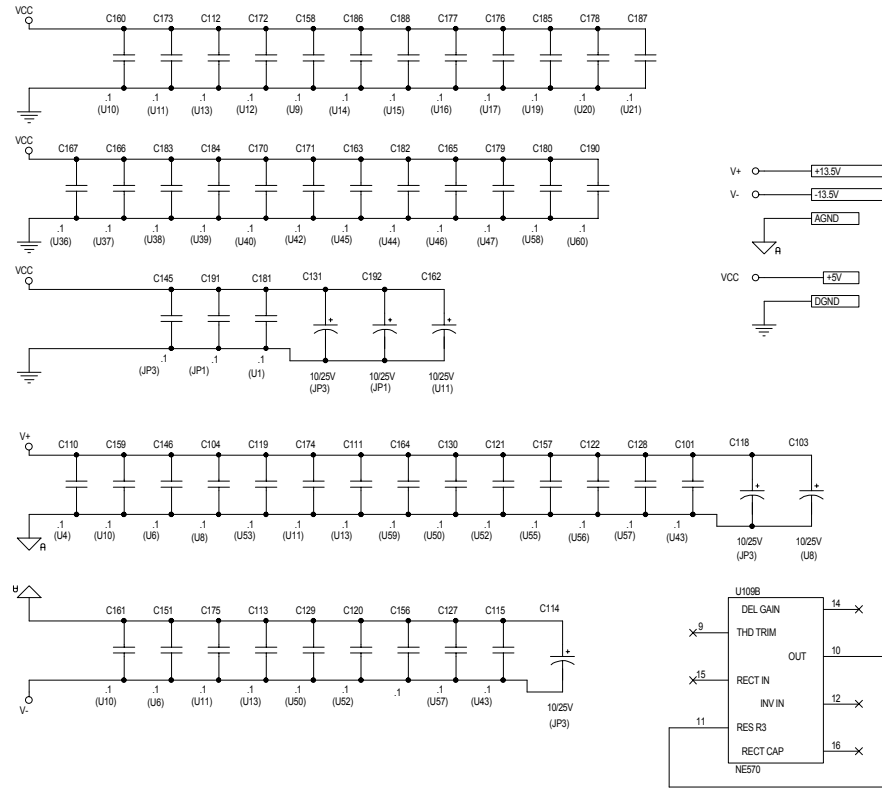
DDF6102 Waveform Amplifiers



DDF6102 Connectors



DDF6102 Serial Interfaces



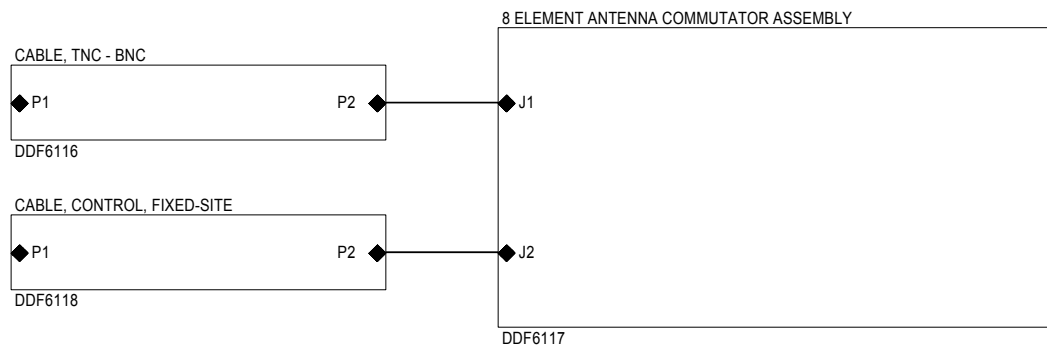
### DDF6102 Decoupling Capacitors



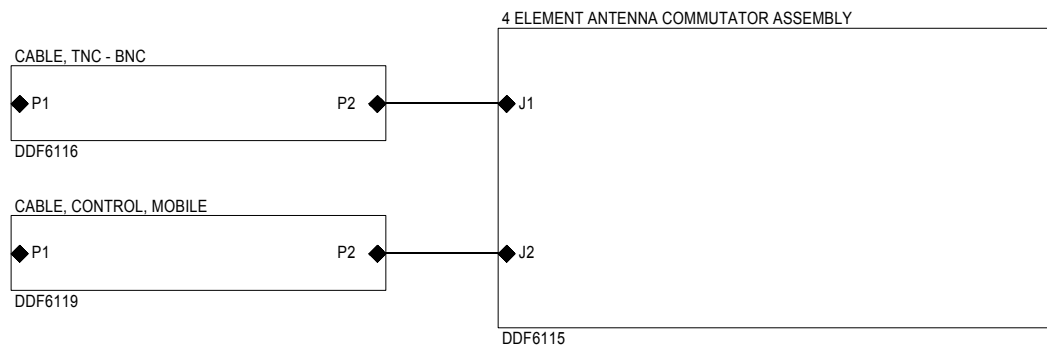




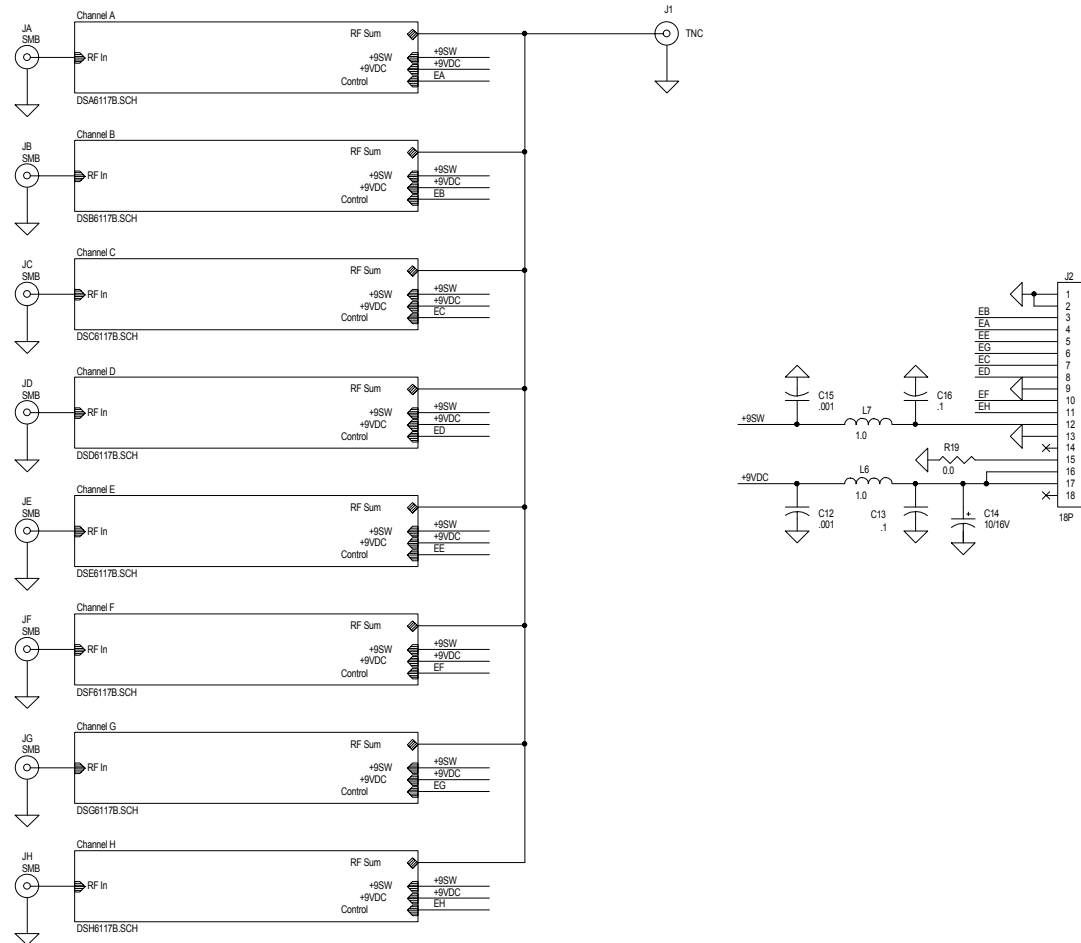
ANTENNAS DDF605X



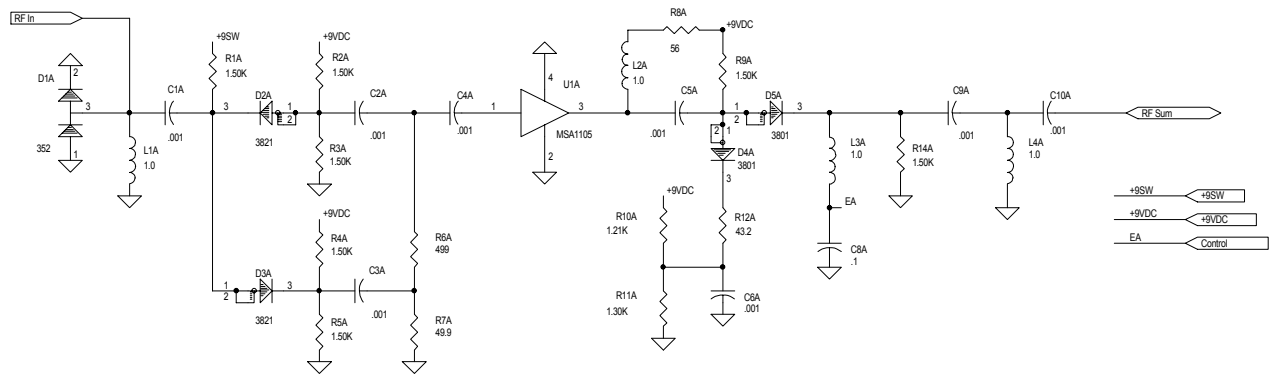
ANTENNAS DDF606X



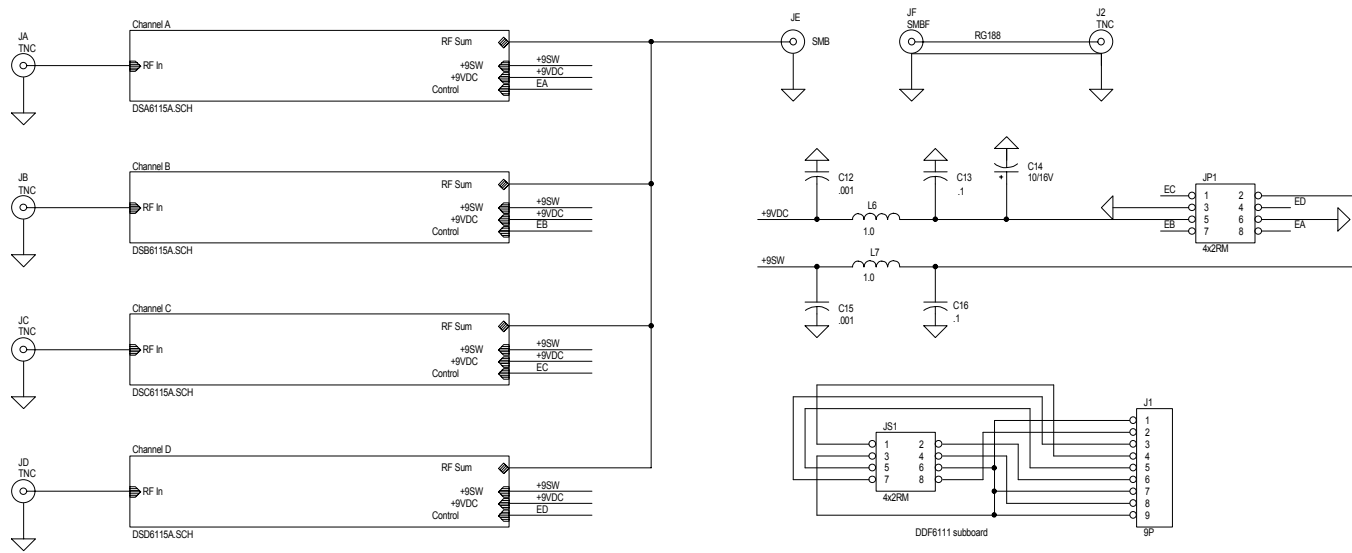
DDF605X and DDF606X  
Antenna Schematics



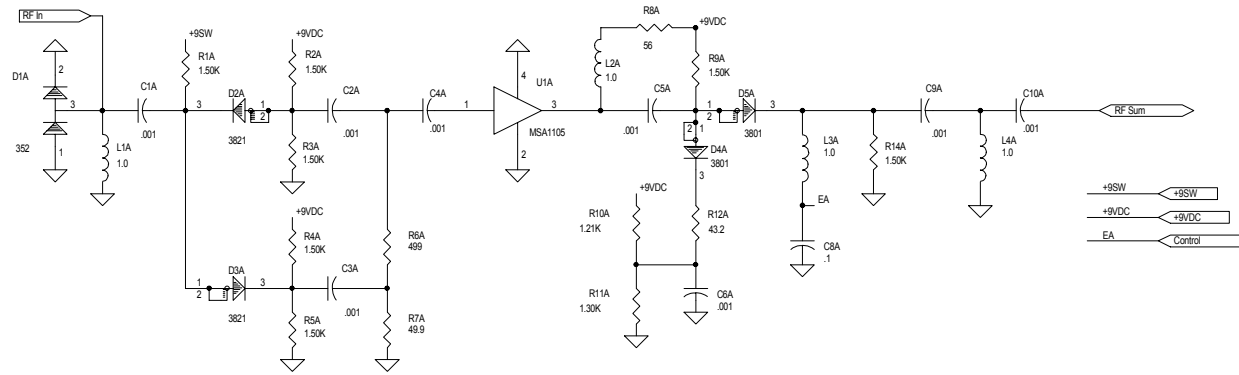
DDF6117  
8-Element Commutator Assembly



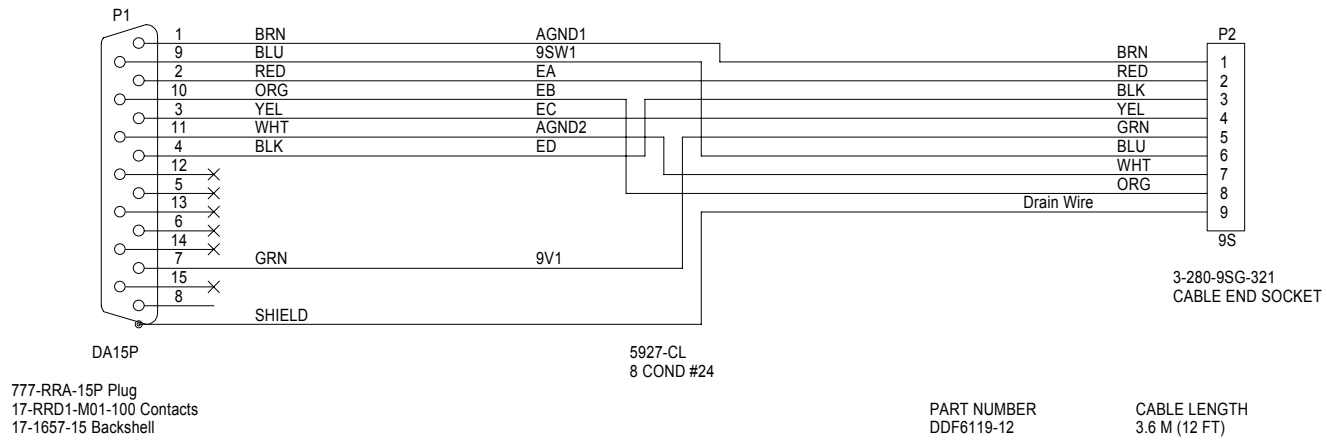
DDF6117 Channel A



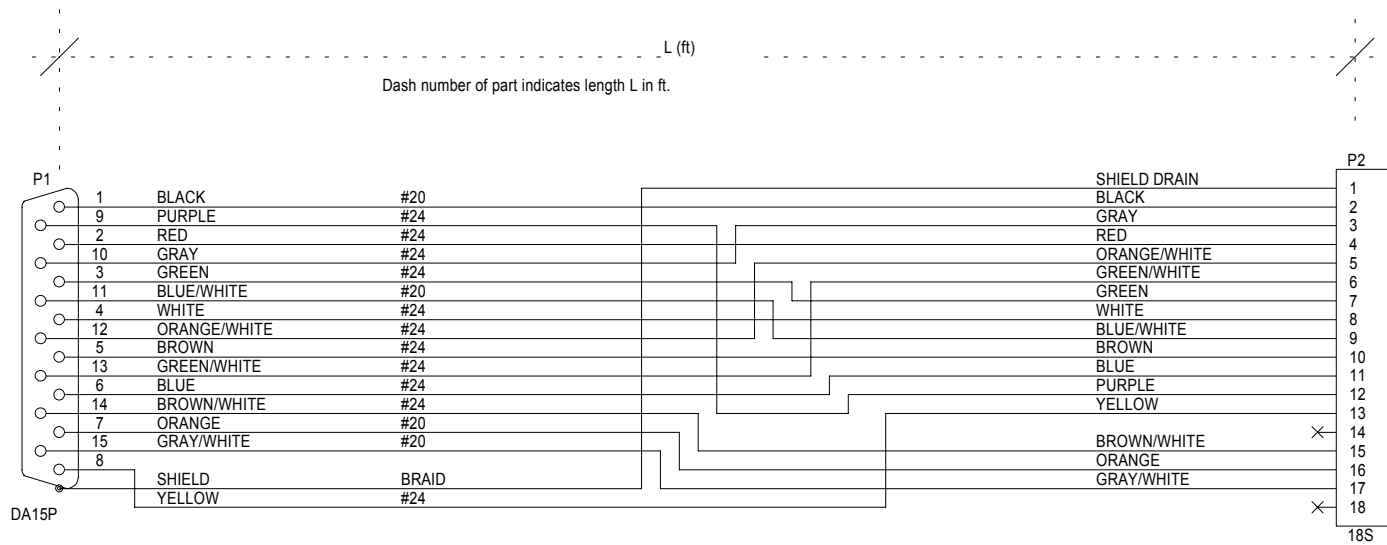
DDF6115  
4-Element Commutator Assembly



DDF6115  
Channel A

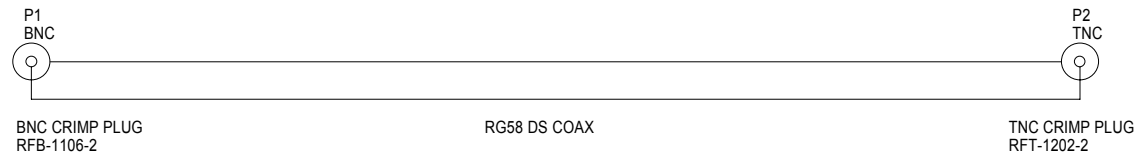


## DDF6119 Mobile Control Cable



## DDF6118 Fixed Site Control Cable





PART NUMBER	CABLE LENGTH
DDF6116-12	3.6 M (12 FT)
DDF6116-25	7.6 M (25 FT)
DDF6116-50	15.2 M (50 FT)
DDF6116-75	22.9 M (75 FT)
DDF6116-100	30.5 M (100 FT)

**DDF6116**  
Coax Cable