DR-142 and DR-442

PROGRAMABLE FM RECEIVER MODULE
OPERATING AND SERVICE MANUAL

RITRON INC.

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DR-142/442 Specifications

	DR-142	DR-442
FCC ID:	AIERIT17-142R	AIERIT17-442R
Frequency Range:	136-156 MHz or 154-174 MHz	400-420 MHz or 450-470 MHz
Bandwidth:	20 MHz	20 MHz
Synthesizer Step Size:	2.5 kHz	6.25 kHz
FCC Rule Parts:	15	
RF Channels:	8 Independent RX frequencies	
Frequency Stability:	+/-2.5 PPM (-30°C to +60°C)	
Tone/Code Signaling:	CTCSS (Quiet Call) and DCS	
Maximum Data rate:	9600 bps with 4-level FSK	
Power Supply:	8 to 16.7 VDC	
RX Standby Current:	20 mA at 13.8 VDC	
Dimensions:	5”H x 3”W x 1.25”D	
Weight:	3.8 oz.	
Sensitivity (12 dB SINAD):	0.25 µV	0.25 µV
Adjacent channel:		
wide	-70 dB	-70 dB
narrow	-60 dB	-60 dB
Spurious rejection:	-65 dB	-60 dB
Image rejection:	-80 dB	-60 dB
Intermodulation:	-65 dB	-60 dB
FM hum and noise:		
wide	-45 dB	-45 dB
narrow	-40 dB	-40 dB
Conducted spurious:	-57 dBm	-57 dBm
Noise squelch attack time: (20 dB SINAD)	< 15 ms	< 15 ms
RSSI squelch attack time:	< 5 ms	< 5 ms
RSSI squelch sensitivity:	Manually adjustable; factory set for –106 dBm	
Noise squelch sensitivity:	Manually adjustable; factory set for 13 dB SINAD (about –121 dBm)	
AUX OUT frequency response:	6 - 3000 Hz @ +1 / -3 dB	
Audio Output	>700 mW into 8 Ω, with less than 5 % THD	

Sub D 15 Pin Connector

The DR-142/442 is equiped with a 15 pin female sub D connector with the following functions:

Pin#	Function
1	least significant channel select bit (CS0)
2	channel select 1 (CS1)
3	Most significant channel select (CS2)
4	N/A
5	N/A
6	+ 8 to 16.7 VDC input
7	N/A
8	auxilary ouput
9	PC programing port
10	Volume adjust with external 10k pot
11	Auxilary monitor input (pull to ground to open squelch) or valid tone indicator (low)
12	Speaker output
13	Carrier detect output (pulls to 5 VDC through 390 ohms)
14	N/A
15	ground

INTRODUCTION

GENERAL

RITRON's DR-142 receiver module is designed to operate over 136-156 MHz or 154-174 MHz. The DR-442 operates over 400-420 MHz or 450-470 MHz. The units receives voice through a nominal 1 watt speaker output. It supports up to 9600 bps 4-level FSK through its auxiliary output port.

Each radio can be “dealer or factory” programmed to contain a unique set of eight operating frequencies and options. When all three channel select inputs are tied to ground the radio operates on channel 1. The channel selection is done in a binary manner on the CS2, CS1 and CS0 inputs. Quiet Call (CTCSS) or Digital Quiet call (DCS) tones can be programmed per channel.

Model Identification

The DR-142/442 model, serial number and FCC Identification are displayed on a label located on the bottom of the PCB.

FCC Label

An FCC label must be visible on the unit as installed in its final configuration. If the unit is to be used as shipped from RITRON, this would be no problem since an FCC label is affixed to the bottom of the PC board. If the DR-142/442 is to be installed in an enclosure, the installer must ensure that either the FCC label on the unit is visible through a door, window or other opening, or add a label to the outside of the enclosure. If a label is to be added to the outside of the enclosure, the label must be of a type which is not easily removed or damaged and contains wording: Contains FCC ID: AIERIT17-142R for the DR-142 and FCC ID: AIERIT17-442R for the DR-442.

Unauthorized Modifications

Note: The manufacturer is not responsible for any radio or TV interference caused by unauthorized modifications to this equipment. Such modifications could void the user’s authority to operate the equipment.

MAINTENANCE INFORMATION

Surface Mount Repair

RITRON surface mount products require special equipment and servicing techniques. Improper servicing techniques can cause permanent damage to the printed circuit boards and/or components, which is not covered by RITRON's warranty. If you are not completely familiar with surface mounted component repair techniques, RITRON recommends that you defer maintenance to qualified service personnel.

Precautions for Handling CMOS Devices

This radio contains complementary metal-oxide semiconductor (CMOS) devices, which require special handling techniques. CMOS circuits are susceptible to damage by electrostatic or high voltage charges. Damage can be latent, with no failure appearing until weeks or months later. For this reason, take special precautions any time you disassemble the radio. Follow the precautions below, which are even more critical in low humidity environments.

1) Storage/transport - CMOS devices that will be stored or transported must be placed in conductive material so that all exposed leads are shorted together. CMOS devices must not be inserted into conventional plastic "snow" or plastic trays of the type that are used for other semiconductors.
2) Grounding - All CMOS devices must be placed on a grounded bench surface. The technician that will work on the radio/CMOS circuit must be grounded before handling the radio. Normally, the technician wears a conductive wrist strap in series with a 100K Ohm resistor to ground.
3) Clothing - Do not wear nylon clothing while handling CMOS circuits.
4) Power off - Remove power before connecting, removing or soldering a PC board that contains CMOS devices.
5) Power/voltage transients - Do not insert or remove CMOS devices with power applied. Check all power supplies to be used for testing CMOS devices, making sure that no voltage transients are present.
6) Soldering - Use a grounded soldering iron for soldering CMOS circuitry.
7) Lead-straightening tools - When straightening CMOS leads, provide ground straps for the tool used.

Synthesizer Shield

The synthesizer shield should not be removed, unless a component must be replaced. This shield is soldered to the main PC board.

DESCRIPTION OF INPUT/OUTPUT

Channel Select (pins 3,2,1)
Three lines control the channel selection; CS2, CS1, CS0. The inputs have binary weighting of 4, 2 and 1 respectively. Tying an input to ground gives it a zero weighting. Thus, if no inputs are tied low channel eight is selected. In this case the 111 in binary or 7 in decimal is the eighth channel. 000 would be channel 1.

Power Input (pin 6)
A power source of 8 to 16.7 VDC with 0.5 Amp capability should be connected here. Once power is applied to pin 6 of the radio the microcontroller will start and load the receive frequency of the channel designated by CS2, CS1 and CS0 (pins 3, 2 and 1).

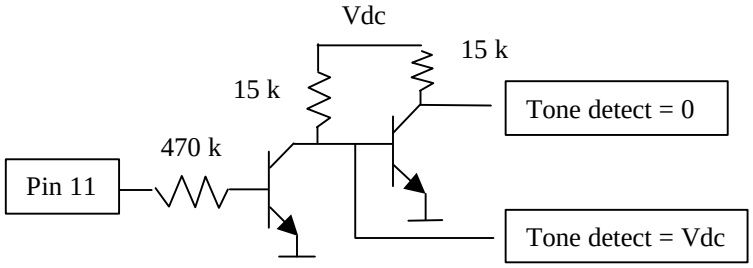
Auxiliary Output (pin 8)
An output loading of 600 ohms or greater should be applied to this output. With a 600 ohm load the output exhibits a frequency response of 6 Hz to 3000 Hz. Higher load impedances will lower the low end frequency response. The output is adjustable with an internal potentiometer. It is preset at the factory to give 1 volt peak to peak output when receiving a +/- 1.5 kHz (+/- 3 kHz for WB) deviated signal. If the correct CTCSS or DCS tone is present the radio will unsquelch the SPEAKER and AUX_OUT lines.

Programming Port (pin 9)
This line is a bi-directional programming port to be connected to a RITRON programming cable. The other end of the programming cable connects to the PC's serial port 25 pin D-sub connector. The appropriate DR-142/442 programming software must be run for configuring the transceiver.

External Volume Potentiometer (pin 10)
Connecting a 10K pot to ground at this point will allow the speaker volume to be adjusted. For maximum range the internal volume pot R350 should be set to the maximum.

Monitor Input (pin 11)
Bringing this input to ground will switch the auxiliary and speaker outputs on. Normally the AUX_OUT and SPEAKER_ OUT are switched on only when a carrier with required tone is detected. Alternately, since pin 11 gets pulled low when a carrier with correct tone is detected, the following external circuitry can be used as a tone detect output. Pin 11 can still be pulled low to monitor channel.

External circuit to use AUX_MON input as Tone Detect output



Speaker (pin 12)
A speaker with 8 ohms or higher should be connected to pin12. A nominal 1 watt of audio power at 10% THD is expected. If the correct CTCSS or DCS tone is present the radio will unsquelch the SPEAKER and AUX_OUT lines. The speaker volume is preset by an internal potentiometer (R350) to yield 2 volts RMS into 8 ohms. If your application requires a different audio level two options exist. One is to open the transceiver unit by removing the 4 corner screws on the connector end of the radio case, pull out the PCB and reset the volume potentiometer (R350). The second is to place 10k potentiometer from pin 10 to ground to adjust speaker volume.

Carrier Detect Output (pin 13)
This line will be pulled to 5 volts through a 390 ohm resistor when a carrier is present.

PROGRAMMING THE RADIO USING A PC COMPUTER

RITRON's programming kit, DTXL-PCPK-2.0, allows programming of the DR-142/442 model radios using a PC compatible computer.

The PC Programming Kit Includes:

1) Ritron Transceiver programming software, DTXL-PCPS-2.0, which is contained on 3.5" diskettes.
2) Ritron PC to radio adapter cable, 9/RTC-PAS, which is terminated at one end with a DB-25F connector, at the other end with a 6 pin modular plug.
3) Another cable, DTXP-PAC, with a modular jack (which mates to the previous cable) on one end with a DB-15M on the other end to mate to the radio. Power leads are also provided. Red is positive.

The PC Programming Kit Requires: A PC compatible computer with Windows 95 or later. The computer must have an RS-232 serial port available. A hard disk drive is recommended.

Programming the DTX-142/442: To program the DR-142/442 do the following:

1) Connect the PC's RS-232 port to 9/RTC-PAS and DTXP-PAC programming cable. Connect DTXP-PAC to DTX-142
2) Apply 8 to 16.7 VDC power to pin 6 of the DB15 (Red wire)
3) Insert disk 1 in floppy disk drive. View the disk contents and double click on **setup.exe**. Follow the instructions on screen. When finished the software will be resident on the PC's hard disk.

Using the Programming Software

Upon starting the software a form appears identifying the radio frequency band and channel information. The channel information will not be correct, however, until the radio is read. If no radio is connected when the software is started the model displayed will be that of the last radio read by the software and the default parameters for that radio. To read the radio contents click *radio* on the menu bar and then *read radio*. Allow several seconds for the reading to take place. To change a parameter click a white field or double click the channel field to access it. Once changes are made to program the unit click *radio* then *program radio*. Again allow several seconds for programming. Files can be saved and read using the *File* menu option.

Channel features can be programmed differently on each channel. Receive frequencies and QC or DQC tones on a channel can be different. A channel can also be moved or deleted. An ID string of up to 72 characters can be entered to allow PC programmers to identify radios.

Computer Software Copyrights

DR-142/442 THEORY OF OPERATION

INTRODUCTION

The DR-142/442 is an eight-channel synthesized receiver unit capable of data reception at rates up to 9600 bps when using 4-level FSK. The unit maintains under 20 mA current consumption at 13.8 VDC when in the receive standby mode. The current drain goes up as the voltage goes down.

POWER SUPPLY AND VOLTAGE DISTRIBUTION

The DR-142/442 is powered by an 8 to 16.7 VDC external power supply. F601 is a 3A fuse in series with J301 for short circuit protection. Zener diode D601 prevents over voltage damage by blowing the F601 fuse when over 18 volts is applied. If reverse battery voltage is applied F601 will blow by conducting current through D601.

The DR-142/442 is designed to consume low current by using a switching DC/DC converter called a buck converter. Receiver standby current is less than 20 mA at 13.8 volts. The buck converter outputs about 40 mA at 6.2 volts. The conversion efficiency of the buck converter is about 85%. Lowering the supply voltage will cause more current to be drawn from the supply. The buck converter output of 6.2 volts feeds a 5 volt low drop out regulator U602 used for powering audio and micro controller circuits. Also on the buck converter output is a 6 volt regulator used to power the synthesizer. IC U405A voltage clamp consisting of Q601, 2 and 3 limits audio PA voltages to about +14 volts. This circuitry is enabled by Q604 only when receiving a carrier or when AUX_MON is enabled.

REFERENCE OSCILLATOR

Reference oscillator Y301 is a temperature compensated, voltage controlled crystal oscillator (TCVCXO) operating at 14.4 MHz. The Pin 4 output of the TCVCXO provides a reference for the frequency synthesizer U401 at Pin 8. The reference oscillator also feed pin 7 of the U301 microcontroller through a buffer amplifier Q310 and a Schmit inverter U303 to obtain a 14.4 MHz clock. The Y301 pin 4 output is also multiplied (tripled) up to 43.2 MHz by Q104 and its associated circuitry to provide a receiver second local oscillator signal.

SYNTHESIZER

The DR-142/442 radio is built around a PLL synthesizer that consists of a receiver voltage-controlled oscillator (VCO). U401 contains both a prescaler and synthesizer controller. The prescaler squares and divides the VCO output present at pin 5 by either 8 or 9, determined by a synthesizer controller logic signal. The prescaler changes once every reference cycle at the appropriate time to yield the right frequency. U401 contains a digital phase detector that works as follows. Micro controller U301 clocks new data into U401 internal buffer in synchronization with clock pulses. The channel information is stored in EE memory of U301 and is loaded into RAM when the channel is selected.

The receive synthesizer works 43.65 MHz higher (VHF) or 43.65 MHz lower (UHF) than the actual RF receiver band The loop filter C403, C404,C405, R407 and R408 transform the pin 2 output signal to a DC voltage for application to the VCO tuning varactors CR405 and CR406. The synthesizer system is “locked” when the phase and frequency of both the reference and the divided VCO signal are the same. When the synthesizer is locked pin 14 goes high. If the loop becomes unlocked pin 14 goes low.

RECEIVER

Receiver Front End

The signal from the antenna passes through the transmitter low pass filter and then goes to the tunable bandpass filter L101 and L102 for VHF or L101, L102, L107 and L108 for UHF. Q101 amplifies the signal about 13 dB before going through another band pass filter and mixer matching stage. The receiver is turned on by Q107 and Q108 supplying RX_5v when RXEN of U301 goes high.

The amplified received input signal is applied to the base of mixer Q102. The 1st local oscillator signal from the synthesizer module is buffered and filtered by band pass amplifier Q106 and then applied to the source of Q102. L109, C114 and C115 tune the drain output of Q102 to 43.65 MHz and apply it to Y101 and Y103, a 43.65 MHz four-pole crystal filter. Q103 and associated components amplify the 43.65 MHz IF signal and apply it to the input of the 2nd mixer at Pin 16 of U101.

FM Receiver Subsystem

A multi-function integrated circuit, U101 and associated components form the FM-receiver subsystem. The subsystem performs the following functions as a 2nd mixer, IF amplifier and FM detector. The second local oscillator at 43.2 MHz is applied to the 2nd local oscillator input at Pin 1 of U101. The 43.65 MHz signal at Pin 16 and the 2nd local oscillator are mixed, with the resulting 450 KHz output signal appearing at Pin 3. This signal is filtered by a 450 kHz 6-pole ceramic filter YF101 and applied to the input of the limiting IF amplifier at Pin 5. IC101 pin 6 de-couples the IF amplifier. An internal quadrature detector, whose center frequency is determined by the 450 kHz quadrature resonator Y102, detects the FM IF signal. One input of the quadrature detector is connected internally to the IF signal from pin11 while the other input is the phase-shifted signal from Y102 at Pin 10. Demodulated audio appears at Pin 9, where a low-pass filter R323 and C309 removes spurious second IF output prior to application to the voice, tone or squelch conditioning audio circuitry.

Two types of squelch circuits exist on the DR-142/442, an RSSI squelch and a noise squelch. Both types can be used simultaneously or one or the other can be used. The RSSI (receive signal strength indicator) squelch, which is typically set around –110 dBm, must be set to open at a higher level than the noise squelch. This is necessary since the RSSI measures total power in the receiver IF band pass. All background noise, which at VHF can be high, is seen as signal. The advantage of the RSSI squelch is that it opens and closes the audio paths very quickly. The noise squelch has the advantage that it can be set at a much lower level, typically –122 dBm for a 12 dB SINAD. It takes longer to open and close the squelch. If both are used simultaneously, since they are wired ORed together at U301 pin 32, the squelch will open quickly and close slowly for strong signals. If only RSSI is desired R145 can be removed.

Voice and Tone Conditioning in Receiver

Three post demodulation paths are provided in the DR-442. U304c provides DC level translation to bias succeeding op amp stages at about 2.5 volts.

The audio path goes through a fourth order 300 Hz high pass filter U305c and d. C326, R353 and R351 de-emphasis the audio. The 1 watt audio amp is turned on by Q311 and Q312. Error tones from come through C325 from pin 13 of U301.

The data path goes through U304a and b. U305b is a second order 3000 Hz low pass filter. U304a produces phase shift around 3000 Hz to equalize time delay. R337 and C316 provide another low pass filter pole. U307a is an adjustable gain buffer stage. This stage is squelched by Q314.

Sub-audible signals go through a third order 250 Hz low pass filter U304d, R342, and C316. Pin 27 of U301 decodes the CTCSS or DCS signal. In the case of CTCSS an internal discrete Fourier transform looks for the wanted tone. Decode bandwidth is about +/-2 Hz.

MICROCONTROLLER

The DR-142/442 receiver is electronically controlled by U301, an 8-bit flash programmable microcontroller. U301 has A/D inputs and PWM outputs for processing analog signals. Radio characteristics are stored in internal EE memory. Its RS232 port is used in programming the radio's personal characteristics such as frequencies and tones.

PIN	DESCRIPTION
1	N/A
2	N/A
3	GROUND
4	+5 VDC V_{CC} supply voltage.
5	GROUND
6	+5 VDC V_{CC} supply voltage
7	XTAL1 is 14.4 MHz reference input from Y301.
8	Input is normally high when PLL is locked and low when unlocked.
9	Output goes high to produce high power RF output.
10	Output drops low momentarily to produce synthesizer latch enable (LE) pulses.
11	Output goes high to enable receiver (RXEN).
12	Output goes high to enable transmitter (TXEN).
13	N/A
14	SQUELCH output goes high to apply power to audio amp U306 for receiver speaker audio or radio alert tones.
15	DATA output sends serial data to frequency synthesizer U401 to program frequency information. Also used for flash programming (MOSI)
16	CLK output sends serial data clock pulses to frequency synthesizer. Also used in flash programming (MISO).
17	output is set permanently low to allow CS0 to be a channel select input bit.
18	AVCC supplies +5VDC.
19	Input is used to measure receiver RSSI.
20	AREF supplies the reference level for the A/D and is connected to the regulated +5 VDC.
21	AGND supplies A/D ground.
22	Not used
23	Input is pulled low when the CS2 frequency bit input is tied to ground.
24	Input is pulled high when CS0 channel select bit is pulled low.
25	Output is set permanently low to allow CS1 to be a channel select input bit.
26	Input is pulled high when CS1 channel select bit is pulled low.
27	CTCSS IN is an A/D input sampling the CTCSS or DCS waveform.
28	Not used
29	RESET is held low to start the radio in a known state on power up.
30, 31	SERIAL DATA PORT links the microcontroller to communications from an external data terminal via programming port pin 9 of J301. This allows programming of the DR-442 EE memory used to store channel frequency and configuration information.
32	CARDET gets pulled low when a RF carrier is detected by the U101.

DR-142/442 ALIGNMENT PROCEDURE

An authorized RF service technician must perform test and alignment of the DR-142/442. Do not attempt service of the DR-142/442 if not completely familiar with frequency synthesized radio operation.

RECOMMENDED TEST EQUIPMENT

1) 0 to +15 VDC, 0.5 A current-limited power supply
2) RF Communications Test with:
   - Frequency Counter
   - SINAD Measuring Device
3) Oscilloscope
4) VTVM or DMM
5) RITRON PC Programming Kit

RADIO PREPARATION

1) Solder a coaxial cable to the antenna port.
2) Connect the FM communications test set to the antenna connector.
3) Connect RITRON programming cable to radio and PC.
4) Apply 8 to 16.7 VDC to the red wire with the black to ground.
5) Run RITRON software and read the radio.
6) Program any two channels of your choice for band edge tune up; one to the low side of the operating band and one to the high side (Hint: use a bit of an offset from even frequencies to avoid receiver interference. A good choice is 136.1 and 156.1 MHz for the low split DR-142 or 450.1 and 470.1 MHz for the high split DR-442.)
7) Type in these RX frequencies in both channels.
8) Program the radio with these parameters.

REFERENCE FREQUENCY

The DR-142/442 is preset at the factory to be set on frequency. If you need to readjust do the following:

1) Make sure that the unit is at room temperature (approximately +25° C)
2) Set the RF communications test set to the transmit frequency counter mode.
3) Select low edge channel on channel select inputs CS2, CS1 and CS0.
4) Insert a small insulated antenna loop probe into the access hole of the VCO shield. Make sure not to short supply.
5) Read the frequency. Frequency read should be 43.65 MHz higher (lower for DR-442) than desired receive frequency. Error should be less than +/- 150 Hz.
6) Adjust the trimmer cap on the rectangular reference frequency oscillator Y301 if not within specs.

RECEIVER FRONT END TUNNING

The DR-142 receiver is factory tuned for a frequency range of 136 to 156 MHz (low split) or 154 to 174 MHz (high split). The DR-442 receiver is factory tuned for a frequency range of 400 to 420 MHz (low split) or 450 to 470 MHz (high split). If receiver appears to be less sensitive on one of the band edges the front end tuning coils may need readjustment. Connect a SINAD meter to the SPEAKER output (pin 12). Unsquelch the audio amp by grounding pin 11. Set the generator to the upper band edge frequency programmed at –121 dBm with +/- 1.5 kHz deviation for a narrow band or +/- 3.0 kHz for a wide band receiver. Adjust coil cores L101 and L102 in until SINAD starts to drop. L107 and L108 must also be adjusted for the DR-442. Back off slightly to maintain best SINAD. Now, set generator to the lowest frequency programmed at –121 dBm. Similar SINAD readings as the high band edge frequency should be obtained. If not, adjust coils slightly. Recheck high end and balance performance.

RECEIVER SQUELCH

The DR-142/442 is capable of two squelch operating modes. Also, both can operate simultaneously. See the theory above. The units can be configured as the user requires. When a low level signal appears the noise squelch opens when the carrier level with 1.5 kHz (3.0 kHz for wideband) deviation is –122 dBm or greater. When the signal appearing is –108dBm or greater the RSSI squelch opens the audio with an even faster attack time. The above levels are factory set levels. Ambient noise will affect the level at which the RSSI should be set. The squelch level ideally should be set on the desired frequency, in the actual location the radio will be used and connected to the desired antenna. The level should be set high enough to reject most false signals.

If a very fast receiver decay time (or squelching after signal disappears) is needed the noise squelch should be defeated by turning the R144 pot fully counterclockwise or removing R145 or Q110.

To adjust squelch levels for simultaneous use do the following:

Set RSSI squelch level first:

1) Temporarily defeat noise squelch pot by turning R 144 to counterclockwise minimum setting.
2) Adjust RSSI pot R123 fully counterclockwise to squelch audio. Be sure AUX_MON line is high to allow squelching.
3) Set generator to –108dBm on channel desired with 1.5 kHz deviation (3.0 kHz for wideband) and 1 kHz tone. Add any CTCSS or DCS as needed.
4) Turn R123 clockwise until audio opens. Go no further if you want only RSSI squelch functionality.

Now set noise squelch:

1) Select a channel.
2) Adjust squelch pot R144 fully counter clockwise.
3) Ground monitor input (pin 11) to open receiver.
4) Adjust the communications test set generator on frequency with an output level yielding 13 dB SINAD. The deviation should be +/- 1.5 kHz (3.0 kHz for wideband) with a 1 kHz audio signal.
5) Release monitor input.
6) Slowly adjust squelch pot R144 clockwise until squelch opens.
7) Reduce generator level until radio squelches.
8) Increase generator level until audio opens. Confirm squelch hysteresis is between 0.5 and 5 dB.