FieldComm Association WA4FC/R | 1262.000 MHz input - 1282.000 MHz output FM repeater: CTCSS 88.5 Hz

Technical Description of the WA4FC 1262/1282 MHz FM Repeater

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Overview. This document describes the technical design and features of the WA4FC 1.2 GHz FM repeater system. The design is based on external up/down frequency conversion utilizing two commercial VHF FM transceivers. A simple controller uses Dual Tone Multi Frequency (DTMF) signals for control and setting of parameters for the system. A 900 MHz control link is also provided, which doubles as a link to the WA4FC 900 repeater and beyond. A duplexer combines receive and transmit using a common antenna.

VHF Transmitter. A Kenwood TK-780H transceiver is modified to provide a transmit intermediate frequency of 188.5 MHz using wide FM modulation (16K0F3E). Hardware modification consists of removal of the PA module and bypassing from its input to output connections with a leaded capacitor. The automatic power control circuit in the transceiver is "fooled" into outputting a constant level by insertion of a +5 volt signal to the connection which normally controls the PA module. A fixed +5 volt regulator for this purpose is mounted in the space where the PA module was removed. This results in an output of about +20 dBm (100 milliwatts).

The 188.5 MHz intermediate frequency is quite a bit above the specified normal range of coverage, requiring the VCO to be tweaked upward, which proved easily accomplished.

Kenwood program KPG-49D is used for all radio programming. For use as a repeater transmitter, the transceiver is programmed to transmit on only the one desired frequency with a CTCSS encode setting of 88.5 Hz. The display is programmed to indicate "1282.0 TX". The option setting for COM2 is set to "AUX HOOK/PTT" to enable external PTT input on pin 8 of the KCT-19 Accessory connection cable. The PTT input logic sense options setting is set to active low.

A zero Ohm chip resistor must be moved from R94 to R24 to enable external microphone audio input on pin 5 of the KCT-19 accessory connection cable. The internal speaker is no longer required and is removed. The antenna pigtail is removed and replaced with a fixed mounted SMA female jack.

Key programming is not required and all keys are set to "None".

The microphone jack does not provide a local talk function because it does not activate the controller as in repeater transmit mode, so the PA is not activated. It is still used for programming.

VHF Receiver. A second Kenwood TK-780H is used to provide the receiver intermediate frequency of 168.5 MHz using wide FM like the transmitter. The PA module is removed simply because it is no longer needed. The 168.5 MHz intermediate frequency is within the normal specified range of the transceiver so it may be programmed directly with no hardware change.

For use as a repeater receiver, the transceiver is programmed to receive only and to toggle between carrier squelch and CTCSS operation. The CTCSS decode tone is set to 88.5 Hz on the "1262.0 TOR" channel. A carrier squelch channel ("1262.0 COR") with CTCSS set to "None" is used for testing only. For this testing, the A, B, C, D or SCN keys are programmed to activate the receiver and send a PTT output to the controller. White noise will be output by the transmitter. The channel is returned to TOR for normal repeater use.

The Squelch detect output logic sense options setting is active low. The selected tone or carrier squelch output is brought out on pin 11 of the interface accessory cable. Receiver detector audio output, independent of speaker volume setting, is on pin 4.

The antenna pigtail is removed and replaced with a fixed mounted SMA female jack.

The microphone jack does not function because the radio is programmed for receive only, although it is still used for programming.

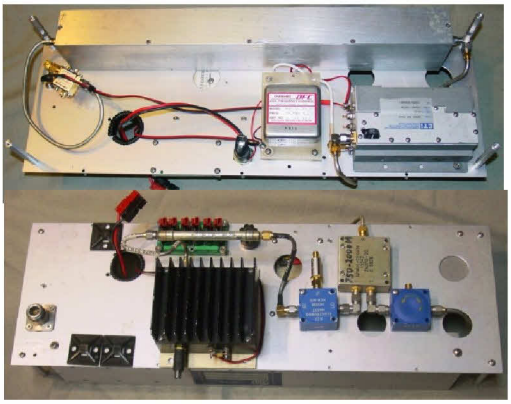
Link Transceiver. A Kenwood TK-981 link transceiver functions as a standard transceiver on any of the programmed channels typical of the Richmond 900 user group. The Key programming is slightly different, with A and B used to change channel within a System (Group up/down). The reason for this difference is that the radio D key is bad, therefore could not be programmed in the standard manner used for Richmond area radios.

Modifications for external PTT, external microphone audio input and squelch detect logic sense options are set up as for the above TK-780H Transmitter and receiver.

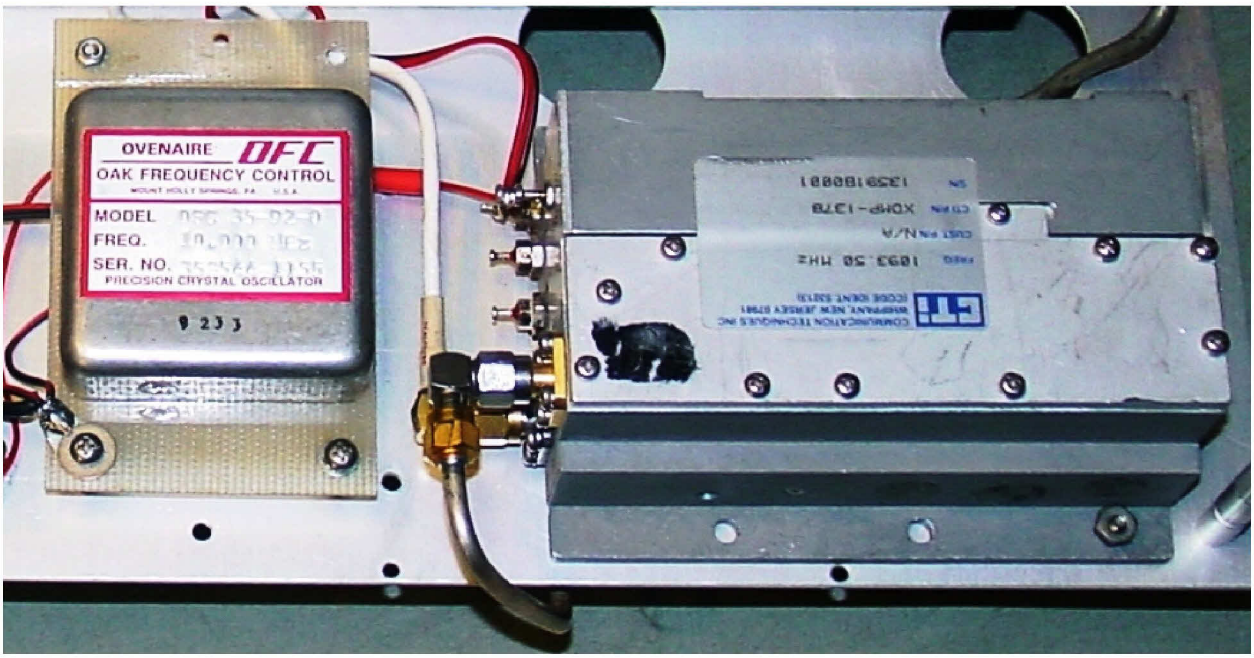
The microphone jack functions normally for local talk and programming.

Link transmitter output is set to approximately five watts. Since the system is collocated with the linked 900 MHz system, a dummy load is connected, which provides sufficient signal to complete the link. A 900 MHz antenna can be added if direct control is later determined to be necessary.

Transverter section. The VHF intermediate frequency transmit and receive frequencies are up and down converted respectively in the transverter section. The transverter consists of a local oscillator, mixers, filters and amplifiers. SMA connectors are used for all transverter section signal connections. The pictures to the right show the bottom and top views of the transverter section. The long rectangular box is the 1262 receive filter. The coaxial transmit image filter is the cylindrical device shown just above the black finned transmit amplifier. The blue square devices are the mixers.



The local oscillator operates at a fixed frequency of 1093.5 MHz. Adding the VHF transmit frequency to the local oscillator frequency produces the desired 1282.0 output as well as an undesired lower sideband frequency of 905 MHz, which must be filtered out. Similarly, the receive intermediate frequency of 168.5 MHz results from the mixing of the 1262.0 MHz desired receive frequency with the 1093.5 MHz local oscillator frequency. The undesired image frequency of 925 MHz must also be filtered out. The duplexer provides additional filtering of any residual image responses.

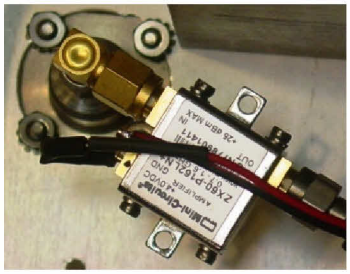


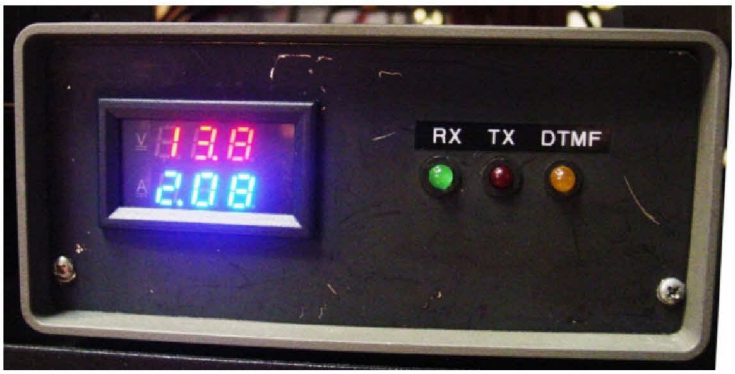
The 10 MHz TCXO pictured on the above left provides an accurate reference to the local oscillator, a CTI XDMP phase locked oscillator module. The +13 dBm output of the XDMP pictured on the right of is

coupled into an MCL two port power divider, which provides a local oscillator output of about +10 dBm to two separate packaged mixers, for receive and transmit.

The +20 dBm transmit intermediate frequency signal is attenuated using a fixed 10 dB attenuator and fed to the transmit mixer. The mixer output then goes through a filter to remove the unwanted lower frequency mixing product. An MCL packaged amplifier completes the transverter to provide an output of approximately 500 milliwatts needed to drive the PA stage.

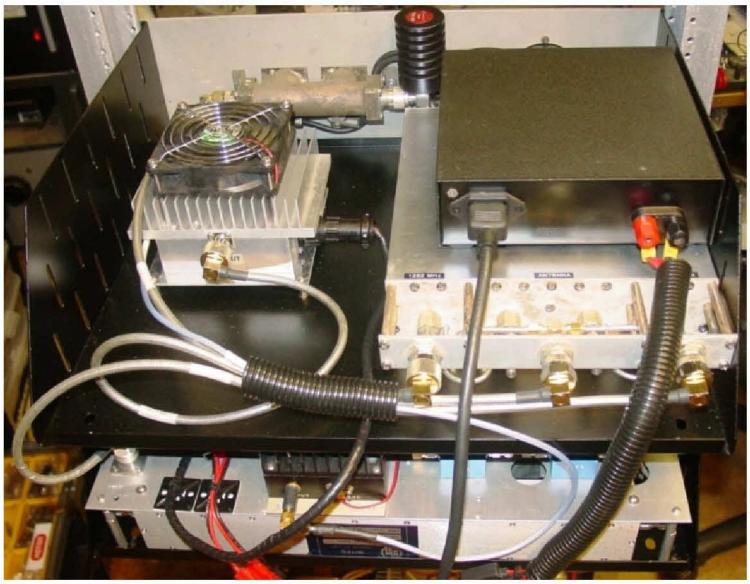
The receive signal path is similar to the transmit, other than the low noise amplifier signal direction. An MCL LNA is used to provide gain on receive and to set the system noise figure. The picture to the right shows the LNA. A type N to SMA adapter is used to provide a rigidly mounted receiver input connection. The voltage required for the LNA is 4 volts nominal, which is obtained from the 5 volt regulator which is mounted on the TCXO board. Two 1N4001 diodes in the power input line to the LNA drop the voltage to just under 4 volts.





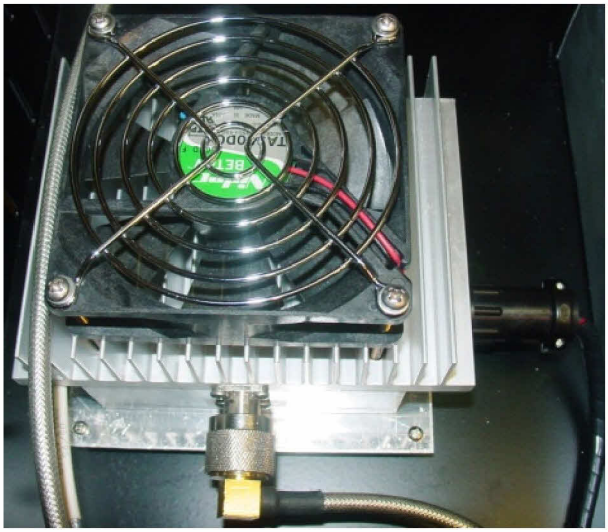
Controller. A Hamtronix Elektra 2000 DTMF controller is used to interface the VHF receiver and transmitter and the UHF link transceiver. Controller functions are described in the manual. The controller is mounted inside a metal enclosure and the LED indicators are remoted to the front panel. Controller level settings are accessible through a slot in the top of the enclosure. The controller enclosure is retained with Velcro and can be lifted up and pulled forward slightly to provide access to the level controls.

Physical configuration considerations. The is contained in 3U rack shelves. The VHF and UHF radios and controller are mounted in the front of the main shelf. The transverter section is mounted at the rear of the main shelf. The second rack shelf contains the duplexer and PA assemblies. The Bird wattmeter panel is mounted across the front of the second shelf. The rear view of the two rack assemblies shows the interconnecting cables. The dummy load shown is where antenna connects for repeater use.



Power distribution. A single switching 20 amp 13.8 volt power supply provides all necessary power to the repeater components. Two fused pigtails connect to the repeater unit and power amplifier, with one spare. PowerPole connectors are used throughout. A junction box is provided to distribute DC power. A digital volt ammeter is provided on the front panel of the controller enclosure to monitor the system components other than the PA. A separate 2 amp 3AG fuse is located on the transverter to protect the active transverter modules.

Power Amplifier. A Downeast Microwave 2330PA uses a Mitsubishi RA18H1213G RF power module to provide approximately 30 watts output. Drive is routed from the transverter MCL amplifier stage. A 3 dB attenuator on the MCL amplifier reduces the drive level to meet the PA requirements. The attenuator should be left in place on the MCL amplifier because it can be damaged by transmitting into an open circuit. The logic level output from the controller is matched to the power amplifier PTT input using two 2N7000 inverting switches in series. This circuit is built into the PA enclosure. The PA has a built-in thermostatic control to keep the amplifier cooled. To ensure that the fan runs only when the repeater is active, a fan timer delay circuit is built into the PA enclosure.



Duplexer. A Paladin D1270-4 duplexer connects the single antenna to both receive LNA and transmit PA. The low insertion loss of this duplexer allows the PA to provide almost 30 watts into the feedline.

RF Power metering. A Bird Thruline directional coupler is connected between the duplexer common port and the feedline to the antenna. A 50E element samples the forward power of approximately 30 watts. A 5E element samples reflected power from the antenna. Returned power should be less than 1 watt (1.45:1 SWR). The reflected power element should not be rotated because the full 30 watts might damage it or the meter.

Normal operation. Power to the entire repeater may be shut of quickly by toggling the front panel power switch on the power supply. When power is restored, both VHF radios should boot up with the frequencies displayed. The UHF link will also boot up to display frequency if turned on using the IO button. The controller will boot up within a few seconds, with the LED indicators functioning as described in the Hamtronix Elektra 2000 manual.

Nominal 13.8 volts is displayed on the LED dual meter built into the controller enclosure. Current readings depend on the state of the repeater system. About 1 amp is normal when idle. About 5 amps is normal when the repeater is transmitting and the link transmitter is active. When the entire repeater

is active and the PA is on the overall current is about 15 amps. The LED meter does not indicate the PA current of about 10 amps.

Antenna. A Diamond F1230A base station vertical having a quoted gain of 13.8 dB is connected through LDF4 jumpers and LDF5 feedline to provide an ERP of 600+ watts. The antenna provides a DC ground to dissipate static charge buildup. A surge protector is located at the shelter entrance to further protect the system from surges.

Acknowledgements. As always, thanks to the XYL, Cissy N4ZRW, for unwavering logistical support and encouragements. Cissy has a historical connection with this project. In 1990, her first contact as a newly licensed Technician Plus was through the Memphis 1282 MHz repeater being tested at our house. She somehow sensed that her license had arrived in the mail. She took a hand held rig with her down the driveway to the mailbox where she found out her callsign. Cissy called me through the repeater on her way back to the house.

Thanks to Jim Bates K8OI for encouragement and for providing logistical support to this project. Jim has a base, a mobile and a handheld rig ready to go, a sure indication of his enthusiasm.

Thanks to Fred Towers WB4KXS for obtaining the controller and for his unplanned assimilation on the 23 CM band.

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