

Out of the Box DR-1 Interface

Assistance in setting up a Yaesu Fusion DR-1(X) repeater

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Introduction

This paper describes a method of connecting the Yaesu DR-1(X)¹ Fusion repeaters to other analog radio equipment including links and repeaters. The interface has the following features:

- No modifications are made to the DR-1. This method will always work regardless of any future firmware changes Yaesu may make.
- There is no possibility to “hang” or “brick” the repeater. The repeater is being used as Yaesu designers intended it to be used.
- The interface can be connected to any type of controller that supports more than one port (since the goal is to bridge from the DR-1 to another repeater or radio.
- The design does not require software or any special components. All necessary information is provided in this document so *you* can build it yourself. And *you* will know how it works!
- The interface is simple. It only requires a single electrical connection to the DR-1 and that one connection is an output.
- With the exception of one item, the interface is inexpensive to build. And that one item has resale value and general Ham use beyond its use with the interface.

I expect this to be an “open source” type of project. I hope that people will experiment and come up with ideas for features and improvements. This is a fluid document. There will be changes, so be sure to check back for any updates.

If interest warrants it, a PCB might be made available once the design has settled down. Keeping with the open source policy, the PCB design files will be available.

Because I have a DR-1, FT-7800, FR-6000, and Scm 7330, examples in this document are centered around these products. But there is no inherent need to use these specific products. Substantial savings are possible by using a less expensive controller or a home-built controller. (See the Open Source Controller Project.)

¹ The solution works on both the DR-1 and DR-1X. It does not depend on firmware version.

Interface Description

The basic problem with supporting both analog and digital is that you don't know if the signal is analog or digital until you start receiving it. We can't say for sure if it's digital until the final CRC is verified on the first packet. If the signal was analog and we were assuming it was digital, 100 ms of transmission could be lost. The same is true if we're detecting digital, but rely on the CTCSS which may take 100 ms to decode. It turns out that the only place the digital or analog decision should be made is at a controller that has full access to the Rx IF. It needs to make an instant decision so that no part of the transmission is lost. Therefore a requirement of this project is to use the internal DR-1(X) controller for all analog vs digital decision making.

Another reason to use the internal controller is that Yaesu will be making firmware changes and there's no telling what a firmware update might do to its behavior. Thus another requirement is that the solution is insensitive to Yaesu firmware changes.

It turns out that the firmware for making an external controller work well with the DR-1(X) has been available for a long time - it's the firmware in a Fusion radio. It knows everything about detection and switching - and we don't have to write it and debug it!

The Out-of-the-Box solution therefore takes something "out of the box", namely an FT1DR HT, and uses it to create the interface.

The solution is very flexible and your implementation can be quite a bit different. I used an Scom 7330 controller because I had it, but it could be any multiport controller. The FT1DR is located at the repeater site, but it could be located much farther away at another repeater site.

The solution permits:

1. Using an FM-only repeater to simulcast digital and/or analog signals on the DR-1(X).
2. The FM user is also heard on the DR-1(X) in the last mode the DR-1(X) was used (digital or analog). The obvious benefit to this is that folks with Fusion radios can have Fusion fun (and it is fun) while still communicating with the digitally-challenged. After all, how are people suppose to learn about Fusion Fun if they can't talk to people using it? And, let's face it, we paid extra \$\$ for our Fusion radios and we'd like to take advantage of what they can do!
3. Connect a simplex radio to the DR-1(X) such that it will simulcast the DR-1(X) on FM. (Only works well if all FM users are within simplex range.)
4. Combine all of the above so that the DR-1(X) and FM repeaters can use the simplex radio to link to another repeater (using FM).
5. Connect the DR-1(X) to the simplex radio and still operate the FM repeater stand-alone.
6. Use the Scom 7330 to put recorded announcements out on the DR-1 (analog or digital).
7. Use DTMF on the DR-1(X) to control the linking and repeater connection².

The ultimate solution would, of course, also support a digital connection between two DR-1s. That would actually take work. We made the decision in mid 2014 that we would wait for Yaesu to solve this problem Still waiting, but I do believe it will come. When it does, and if we no longer need the Out-of-the-Box solution, then we at least have a spare FT1D. :-)

² The vocoder regenerates DTMF tones.

Issues

One liability with the solution is that the digital vocoder is sensitive to noise. Going from digital to FM works well, but if the quality of the input FM signal is poor, then the vocoder performance will be poor. It's extremely important to have audio levels adjusted properly and to filter low frequency components such as CTCSS and DCS. Unfortunately Yaesu radios don't appear to provide much filtering in this regard.

- Over-driving the vocoder causes compression and brings up the level of any noise on the analog signal.
- A noisy FM signal also degrades the encoding process significantly
- Digital to FM always seems to work well, however it is tricky to get good analog to digital performance

An analog audio processing module is really needed before driving into any digital Tx. It should reject unwanted frequency bands (mostly below 300 Hz and above 3.5 KHz) as well as provide automatic gain control. This may be a future project.

On-The-Air Results

This system has now been in use at W0MDT/K9EQ since the end of August. It is used to simulcast our Fusion net and has been well accepted by both FM and digital users. There have been no hang-ups or issues with either repeater. The only problem has been RF issues when the two meter link is running. Just too many transmitters in one place (4).

Design Description

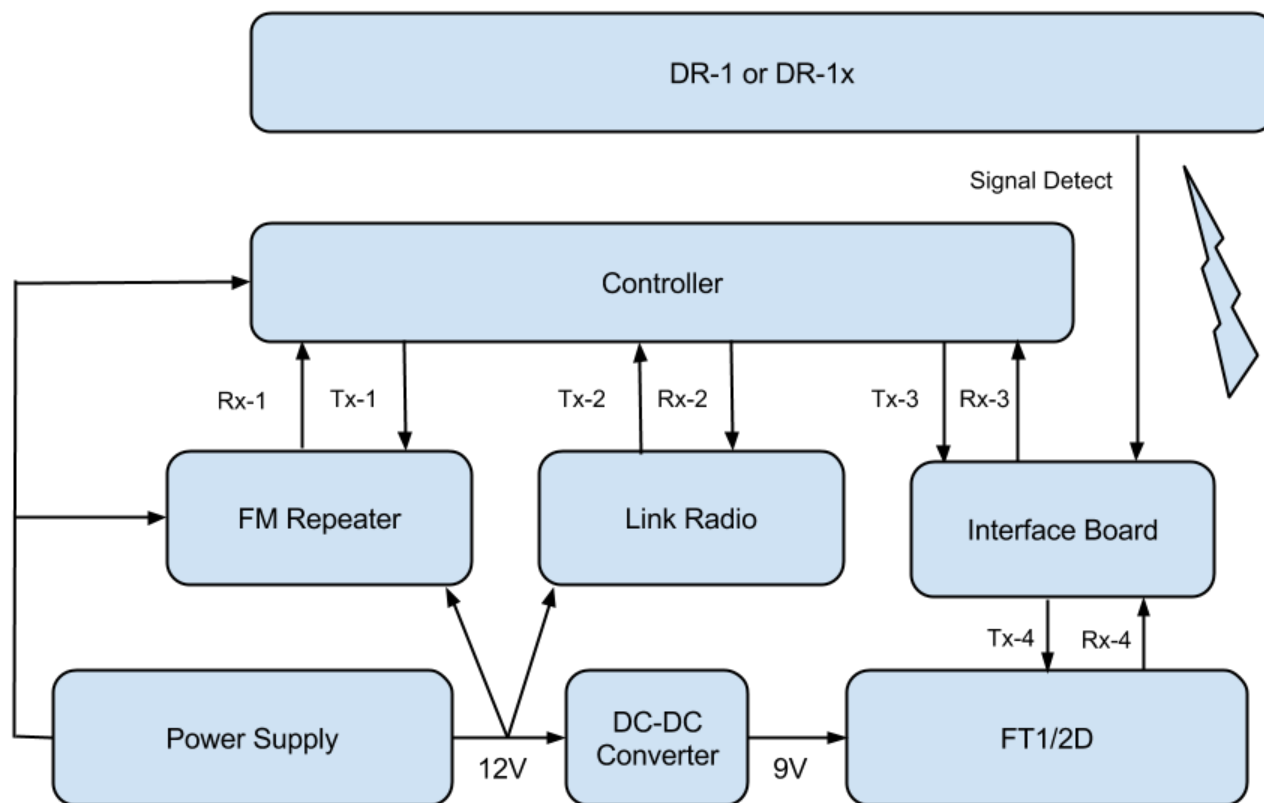
Refer to Figure 1, Block Diagram

1. A common power supply is used to provide power to the DR-1(X) side. Another common power supply is used to supply the non-DR-1(X) equipment which includes the FM repeater, FT1D, and controller.
2. The DR-1(X) is set up for Auto/Auto (will accept analog or digital and retransmit in that same mode).
3. The FT1D is connected to power via a DC-DC converter³ to lower the 13.8 V to 9 V (or even less). This reduces heating of the FT1DR on long transmissions. (The FT1DR is run at 100 mW and should probably drive into a dummy load to reduce RF in the area.)
4. The FT1DR is set up as follows:
 - a. TOT 3 minutes
 - b. APO Off (very important!!!)
 - c. AMS on, TX-M (manual) - allows the FT1DR to automatically switch with the repeater.
 - d. Battery removed (reduces heating)
 - e. Tx power 100 mW
 - f. Set to the DR-1's Tx and Rx frequency
 - g. Call sign programmed with that of the FM repeater. I.e., K9EQ/.075.
 - h. Volume and microphone gain adjusted to provide good digital->FM->digital performance (high enough but not too high).
 - i. Can program GPS to QTH of repeater or other location.
5. The FT1DR connects to the interface board via the headset connector.
6. The controller connects to the interface board.

³ See parts list

7. A single connection from the 10-pin connector on the DR-1(X) connects to the interface board. This provides an indication that a signal is being received. This comes straight from the receiver, not the controller.
 - a. Note: It is not necessary to provide this connection. It is also possible to enable the 2nd band of the FT1DR to receive the DR-1's Tx. A photo sensor is then placed over the green Rx indicator lamp. The one wire from the DR-1(X) was chosen since it was easier (but did add to the cost to buy the Yaesu 10-pin cable).
8. The FM repeater and two meter remote base connect to the controller through the two remaining ports.

Figure 1 Block Diagram



Operation

This section describes operation of the OTB Interface.

DR-1(X) Transmit

When the DR-1(X) transmits, it can either be in Digital (D) or Analog (A) mode. The mode is determined by the mode of the input signal. When the FT1DR receives the DR-1's signal, it automatically switches to the correct mode since AMS is enabled.

Audio from the FT1DR is always analog and will be that of either a D or A transmission since all switching is automatic.

The Channel Busy signal (sometimes called COR or COS) is only asserted when the DR-1(X) repeater is receiving a signal. This is important because you don't want the FM hang time to hold up the analog output. It also prevents a key-up when the repeater's FM ID is sent.

Channel Busy is a simple digital signal that is available at the 10-pin connector (that is internally wired directly to the Rx/Controller). This connector is essentially identical to that of all other radios that use a 6-pin or 10-pin packet connector⁴.

The output of the OTB Interface is no different from that of any other conventional analog radio meaning that it can connect to any conventional controller.

DR-1(X) Receive

The DR-1(X) will receive any input signal that comes from a user or from the FT1D connected to the OTB Interface.

When Tx is asserted to the FT1DR, it will transmit using the last mode that it heard - which is set by the last user to transmit to the repeater.

Analog/Fusion Repeater

If the OTB Interface connects to a conventional analog repeater, this allows digital users to use digital on the Fusion repeater while analog users can also participate on the analog repeater.

A simpler solution would be to provide a simplex output. For example, a Fusion repeater on two meters could be interfaced to an inexpensive simplex transceiver on 220 or 440 MHz.

If the OTB Interface is connected to a computer, then the Fusion repeater can get access to analog repeater networks such as EchoLink, IRLP, AllStar, or Skype⁵.

⁴ The 10-pin connector just adds serial data communications to the pins already available on the 6-pin connector.

⁵ Skype requires the use of a VOX circuit.

Bill of Materials

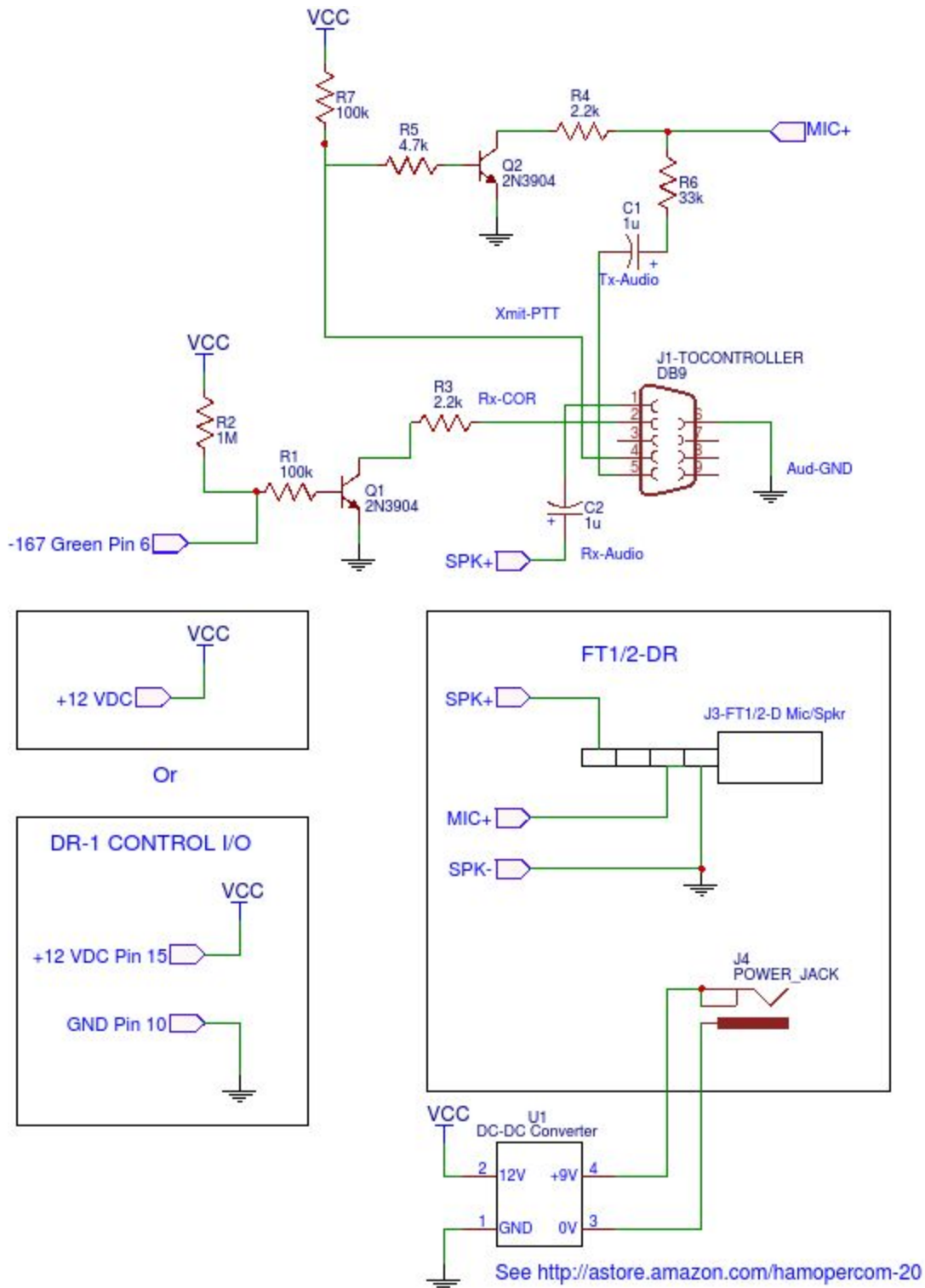
Table 1 Bill of Materials

Identifier	Quantity	Part ID
C1, C2	2	1 uf 25V Electrolytic capacitor
CBL1	1	CT-167 Cable, Yaesu
J1		DB-9
J2		
J3	1	FT1/2DR Speaker/mic connector
J4	1	FT1/2DR Power connector
Q1, Q2	2	2N3904 General purpose NPN transistor
R1, R7	2	100k Resistor
R2	1	1M Resistor
R3, R4	2	2.2k Resistor
R5	1	4.7k Resistor
R6	1	33k Resistor
U1	1	DC-DC Buck converter (optional)

Electrical Interface

The OTB Interface schematic is shown in Figure 2. Most of the circuitry is involved in isolating the audio and control signals on the FT1D interface - which does this all using three wires (including ground).

Figure 2 OTB Interface Schematic



WOMDT Block Diagram



Change History

Change History

Rev	Date	Change
1	4-Nov-2015	Initial release
2	25-Mar-2016	Corrected schematic to add Mic connection - Thanks to K5JG Other minor corrections
3	28-Apr-2016	Included the correct (I hope) schematic. Sorry to everyone for the mixup.

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Parking Lot

Things this document needs

- Complete the bill of materials

Issues

- The Vocoder needs to have real clean audio that doesn't include CTCSS, DCS, or high frequency noise introduced by an FM link. (The vocoder was designed to be connected to a microphone directly, not an FM receiver. Therefore we really need a good signal processing board. It should be a band-pass with sharp edges at 300 and 3,500 Hz. It must be ~40 dB down at 280 and 3,600 Hz. Also need a good AGC/limiter to equalize different audio levels. Analog devices makes a nice part that could do this well.

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While there is absolutely no blame on our part for any error we make, no matter how stupid or unkind, your suggestions or corrections to this document are appreciated and will be considered for inclusion in the next version.

I have no formal relationship with Yaesu, other than I signed an NDA and contract for the Beta program, and contracts to purchase repeaters.

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