Interfacing the Yaesu DR-1X

With

The S-Com 7330 Repeater Controller

For a Feature-Rich

Digital and Analog Experience!

An Install Guide by Justin Reed, NV8Q

As Implemented on the K-Link Network

http://ks0lnk.net

Version 3 - February 9, 2016

Introduction

The Yaesu DR-1X is a 50-watt (50% duty), dual-band (2 meter and 70 cm bands) FM and C4FM repeater, capable of operating in mixed-mode configuration. It includes an internal controller that provides basic repeat functions, remote kill/resurrect (using a Yaesu-proprietary sub-audible paging format), and an identifier. As with any other commercially-built repeater, it doesn't have any of the fancy "bells and whistles" that amateurs have become accustomed to over the past thirty years. The engineering team faced challenges during the design phase trying to get external controllers, RF linking, or linking via any of the RoIP services such as IRLP to work well, while retaining mixed-mode (AMS) functionality. The repeater cannot process external PTT, remote control, or AMS/FM mode changes simultaneously. It also cannot process an analog call from a controller while in AMS mode. Any of these events will cause a lock-up and require a trip to the repeater site to power cycle the unit, unless you use a remote controlled relay or power switch to do that. Thankfully, a few different solutions have been devised that allow the use of external controllers for FM operation while retaining the benefits of AMS/C4FM mode. One of the methods involves using the versatile S-Com 7330 controller. As a 7330 owner, you have a controller flexible enough to apply the necessary signaling as long as you wire everything up correctly and load the script kit referenced on page 11. This method gives you the ability to lock into analog mode based on a schedule, disable the repeater using DTMF, or any other application you can dream up. In fact, there are many features that can be modified, added, or removed. This document guides you through the process of putting it all together.

When you have completed the hardware installation and wiring and incorporated the necessary programming script, you will have a DR-1X repeater that works in C4FM and FM modes, can be linked within an analog system in FM mode, and can be used on the WiRES-X network using a remote-located node in analog or digital mode. And, if need be, you can disconnect the 7330 with internal modifications in place and the DR-1X can be programmed with correct channel settings to work as a normal out-of-the-box DR-1X; these modifications won't change how the repeater works when programmed normally.

It is strongly recommended before performing any modifications to the DR-1X to first bench-check all aspects of the repeater for proper operation. You are about to embark on a journey which will likely void warranty coverage, so you need to be sure you aren't working on a dud repeater to begin with (it does sometimes happen). Use a service monitor and make sure the unit receives and transmits on the programmed frequencies and CTCSS/DCS tones, and that the unit works in C4FM and FM modes. Also verify proper power output on both 2 meters and 70 centimeters at all three power levels. Only then should you proceed with the modifications with the following caveat: **NOTICE: This guide is provided without any warranty. I am not responsible if you screw up your equipment. You assume the risks associated with modifying the repeater beyond the manufacturer's established procedures. Take your time and proceed with care.**

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This install guide will describe how to utilize the Masters Communications SC-50 external squelch and CTCSS decoder board as part of this installation. The SC-50 uses the famous Motorola Micor bi-level squelch IC, which gives you an excellent noise-based squelch that closes very quickly upon loss of a full-quieting signal and closes with a 200 millisecond delay in cases where the uplink signal is below the 20 dB quieting threshold. This eliminates the squelch crash on strong signals and eliminates picket-fencing on weaker uplink signals. If a repeater user that is noisy into the repeater hears his own squelch crash, it's a sign that he is weak into the repeater. Careful setting of the 7330's audio delay will completely remove the fast squelch tail while leaving the slow squelch tail intact.

The DR-1X's internal squelch is based on uplink signal strength, not signal-to-noise. Further, the factory alignment of the squelch is usually too tight; even at the lowest user-accessible setting the squelch abruptly cuts off near the 20 dB quieting level, which means that you'll not be able to hear mobile stations in analog mode near the fringe of the repeater. It is possible to re-align the squelch to allow weaker signals to pass, but that is beyond the scope of this document. The SC-50 is noise-based and provides a much better squelch action, and that is why we are using it. Using a good external squelch will increase your receiver's effective range by about 15-20%. It should be noted that the internal squelch setting does not affect the processing of digital signals in any way as long as you set the squelch to the first notch above minimum (wide open). The add-on squelch will apply only to analog signals that are processed by the 7330.

The SC-50 also supplies the 7330 with CTCSS decoder logic that is independent of valid digital signals. This is required because the DR-1X PKSQL output goes active for valid C4FM signals and FM signals with valid CTCSS/DCS.

Note: If you wish to use DCS, you'll need to follow the same advice pertaining to the DR-1X's DCS setting (use a secret code to avoid internal decoding) and instead of using an SC-50, use a DCS-23 decoder and an MS-25 squelch board and follow the wiring diagram on page 14.

We are also using the SC-50's high-pass filtering in the receiver audio path. An additional advantage to using the SC-50 is that if the DR-1X locks up and you need to remotely reset it using a relay on the power input, you can do so because it continues to output discriminator audio during a locked up state, which means the audio, COR and CTCSS signals reach the 7330. If your 7330 has links or repeaters on the other ports, you can also issue the reset command via those ports as well.

Note: I do not recommend using other squelch boards paired with the Comm-Spec TS-32 or TS-64 CTCSS decoders due to inadequate high-pass filtering of higher CTCSS tones. In addition, the DR-1X does not high-pass filter the TX audio input. The combination of these issues has caused CTCSS beating which causes decoding issues on FTM-400 and FT-1D radios, and possibly others. The SC-50 has better high-pass filtering and does not exhibit this behavior.

Items you will need:

- DR-1X Repeater with firmware 1.00b or later.
- S-Com 7330 Controller with firmware release 1.5b or later.
- S-Com 7330 Radio Port Cable.
- Masters Communications SC-50 CTCSS decoder/Micor Squelch Board.
- Two DB25 male connectors and one DE15HD connector, with backshells.
- A service monitor and AC voltmeter or scope.
- The script kit at http://ks0lnk.net/documents/DR1X_script_kit.txt
- Radio Shack 276-195 20MM PC Board Standoffs.

Optional (but highly recommended) Items:

- Yaesu cable part number T9101626 (if you cut into yours)
- Bosch 12VDC 30 amp SPDT relay with a flyback diode across the coil

Features Included In the 7330 Script Kit:

- Sets AMS mode while Idle, unless Analog-only mode is active.
- Locks the 7330 PTT until an analog call or ID message is detected, if there is no digital call in progress.
- Upon originating an analog call, delays the external PTT 90 milliseconds until FM mode is selected.
- During an analog call, or immediately after an analog ID/message, the 7330 holds analog mode active for several seconds after the transmitter drops. This speeds the transmitter response time during a conversation (bypasses the above-mentioned PTT delay). The length of the analog hold timer is adjustable in the script.
- Analog call late entry. At the end of a digital call, if there is ongoing analog traffic coming in via another 7330 port you will join that conversation in progress.
- Digital call late entry. At the expiration of the analog mode timer, the remainder of an in-progress digital transmission will be repeated normally.
- Uses Logic Output 8 as a digital call indicator LED. (Can be removed).
- Provides a Transmitter PTT Master Disable/Enable function, which also prevents transmitting in digital mode.
- AMS disable (Forces analog full-time and removes the 90 ms. Key-up delay).
- Allows you to link analog traffic with any or all of the other two ports with no mode conflicts.
- Provisioned for an external relay on Logic Output 2 to remotely reset the DR-1X if needed. If your DR-1X is on a mountain top or far away, you need this.
- PTT Watchdog – in the (rare) event that the DR-1X gets stuck in TX while you are away, the 7330 will power cycle the DR-1X (requires relay on the power input).

These procedures will be detailed as part of the install:

- Removing (or moving) the DR-1X DC power supply.
- SC-50 squelch/CTCSS board installation.
- Adding a PTT sense wire to the TX Unit.
- The wiring between the DR-1X, SC-50, and 7330.
- The 7330 program script which handles mixed-mode call processing.
- Squelch and audio alignment through the 7330.
- Adding a DC relay for remote reboot capability.

Removing (Or Moving) The DR-1X DC Power Supply

In order to make room for the SC-50 it is helpful to either remove the DC Power supply or move it closer to the front panel. Our DR-1X is going into a rack that already has a 12 volt, 100 amp supply with a distribution panel and battery backup, so the internal power supply is surplus to our needs. The internal power supply is a TDK 12V 25 amp switching supply of high quality, so it would be great to power other repeaters or project or keep as a backup.

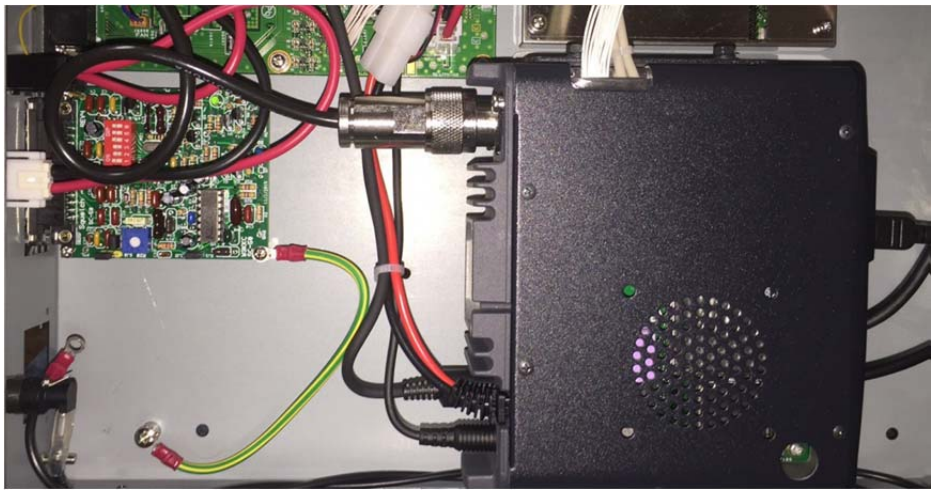
To remove the power supply:

- Remove the fifteen screws that fasten the top cover and remove the cover.
- Unplug the DC output cable from the DC power board near the center of the chassis.
- Remove the plastic safety cover from the AC terminal strip and remove the AC wiring from the power supply. You may also remove the AC socket from the rear panel and cover the open hole with HVAC tape.
- Remove the three T-8 Torx screws that secure the power supply to the bottom of the chassis.
- Unplug the three cables from the front of the RX Unit, remove the four screws that hold the RX Unit bracket assembly to the bottom of the chassis, and carefully tilt the RX unit out of the way so you can lift the power supply out.
- Re-fasten the RX unit to the chassis with the four screws you removed.
- Reconnect the three cables to the front of the RX Unit.

Installing the SC-50

- Using small side cutters, cut out the mesh grille as shown in the photo below, and then file the edges smooth.

- Use the SC-50 board as a template to mark the drill locations on the bottom of the chassis. Measure carefully so that the mounting face of the DB-25 connector is against the cutout.
- Drill the mounting holes in the DR-1X chassis.
- Mount the SC-50, component side up, to the chassis using the standoffs to check for proper fit. Then remove it so you can solder the PTT Sense wire in the next step.



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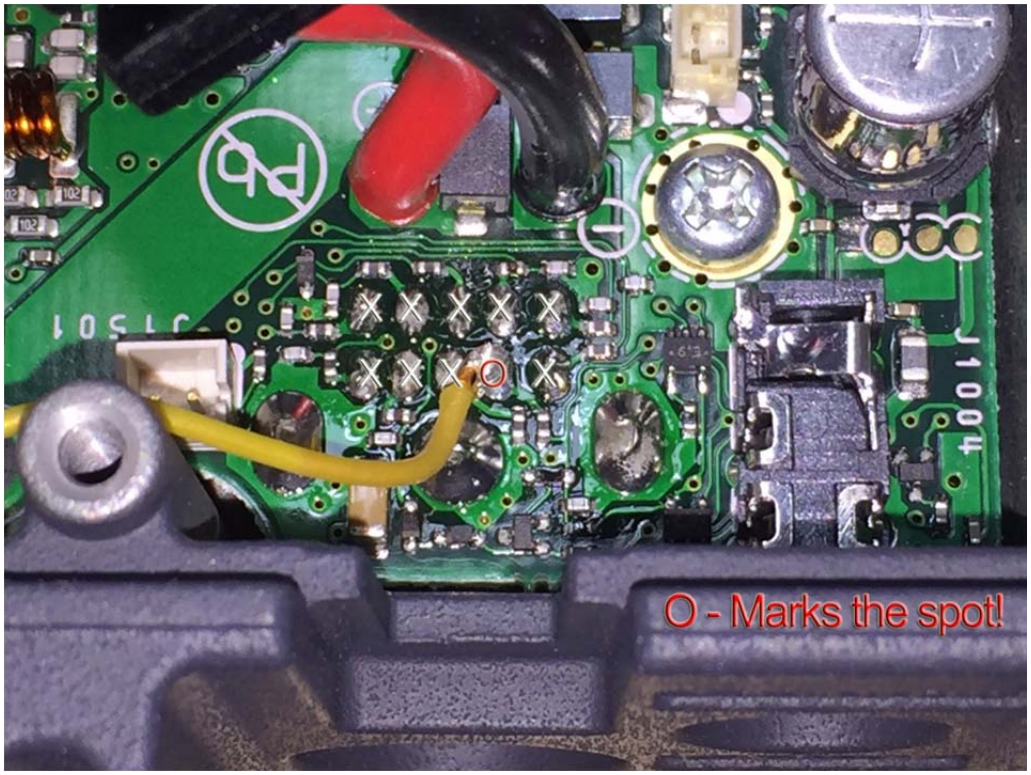
Adding a PTT Sense Wire to the TX Unit

You'll need to tap into the internal PTT line which will drive a logic input on the 7330. This input will trigger a routine in the 7330 programming script which will keep the 7330's PTT signal from colliding with a pre-existing internal PTT. There are two ways to get this PTT signal; you can carefully cut open the cable that runs from the 10-pin mini-DIN connector on the rear of the TX Unit over to the front of the RX Unit and splice into the yellow wire in that cable, or you can solder a wire directly to the PC Board inside the TX Unit. Since spare cables from Yaesu have been difficult to get, the preferred method is to solder directly to the PC Board. The internal PTT is active low.

- Remove the foam cooling baffle from the TX Unit.
- Disconnect all cables from the TX Unit, including the coax jumper, the data cable, the DC Power cable, and the front panel cable.
- Remove the four screws that attach the TX Unit and heat sink assembly to the chassis and remove the TX Unit.
- Remove four screws and open the top cover of the TX Unit.
- Lift the DC power pigtail out of its cutout and locate the place on the circuit board where the 10 pin connector is soldered.
- Carefully solder a piece of insulated 22 or 24 AWG solid conductor wire to the location shown on the photo below. It helps to bend the wire into a tight U-shape so it fits around the pin. This wire needs to be long enough to reach the SC-50. A little extra is nice.



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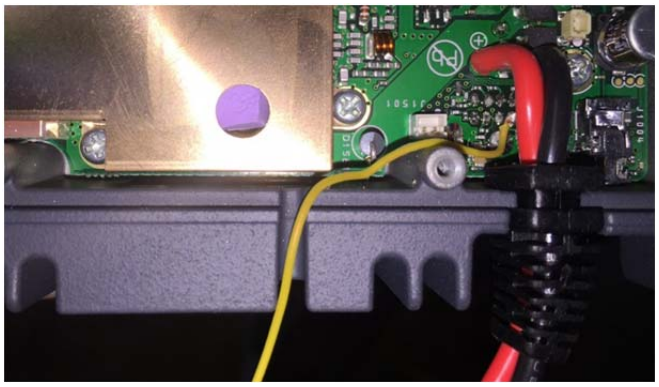
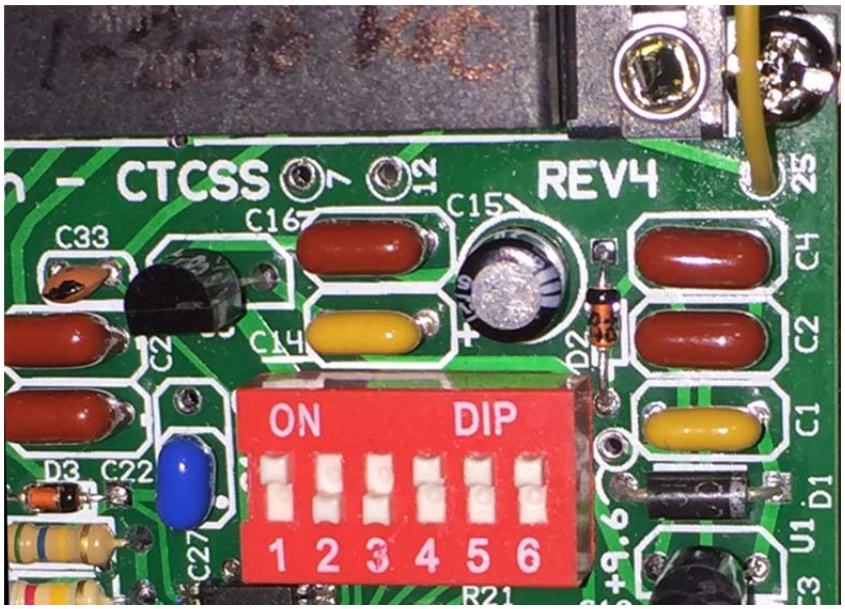
- Once the wire is soldered you can dress it along the rear of the unit and through the cutout used for the rear cooling fan wiring on the FTM-400.



- Put the DC Power pigtail and grommet back into the cutout.
- Re-install the top cover with four screws.
- Re-install the TX Unit back into the chassis with four screws.
- Re-connect the front panel, DC Power, rear data and coax connections.
- Re-install the foam cooling baffle.
- Run the wire through the grommet along with the fan wiring in the chassis center divider.
- Solder the end of this wire to the pin 25 connection point at the upper right corner of the SC-50 (yellow wire pictured below). This simply passes through to pin 25 on the DB25.



- Re-install the SC-50 into the chassis.
- Set the dip switches to select your desired CTCSS decode tone (dip switch chart is on page 15). The CTCSS encoder is programmable in the 7330 script.

There are three shunt jumpers on the SC-50. You should place the shunts on SJ1 and SJ4 positions. Rev. 4 of the board (shipped after 1/1/2016) has SJ5 which should be left on, which eliminates the need to jump pins 2 and 3 on the SC-50's DB-25 connector.

Wiring It All Together

The instructions that follow are written for the 7330 Radio Port Cable sold by S-Com.

The radio port cable uses two runs of Belden 9264 shielded cable for the transmitter and receiver audio paths, and five stranded 22 AWG wires of different colors. The cable assembly is 48 inches in length and is terminated with a DE9P male connector at one end, which plugs into the 7330 radio port.

Since 48 inches is a little longer than we typically need to reach between the DR-1X and the 7330, we're going to cut off about ten inches of wiring so that the piece with the DE9 is about 38 inches long or so. This will give us the cable and wire we need to connect between the DR-1X I/O port and the SC-50. You will need about ten inches of wire to make this connection.

The 7330 port wiring is already done for you. Now let's make the connections to the DR-1X and SC-50.

Using a male DE15HD connector and the port cable with the DE9, make these connections:

- Orange wire to DE15 pin 2. Then solder or wire bridge pins 1 and 2 (PTT).
- Black wire to DE15 pin 5 (Ground).
- Center conductor of TX AUDIO cable to DE15 pin 7 (TX Audio).
- Shield of TX AUDIO cable to DE15 pin 10 (Ground).
- White wire to DE15 pin 6 (CTCSS Encode).

Using a male DB25 connector and the port cable with the DE9, make these connections:

- Center conductor of RX AUDIO cable to DB25 pin 5 (Filtered Discriminator Audio).
- Shield of RX AUDIO cable to DB25 pin 18 (Ground).
- Yellow wire to DB25 pin 11 (COR).
- Violet wire to DB25 pin 10 (CTCSS).

Make these connections between the DE15 and the DB25 connectors using the 10 inch scraps:

- Orange wire between DB25 pin 13 and DE15 pin 15 (Switched VCC).
- Black wire between DB25 pin 19 and DE15 pin 11 (Ground/EXT Port 1).
- Center conductor of audio cable between DB25 pin 16 and DE15 pin 8 (Discriminator).
- Shield of audio cable between DB25 pin 20 and DE15 pin 10 (Ground).

Using two pieces of wire long enough to reach from the 7330's Logic I/O port to the DR-1X:

- Wire from DE15 pin 12 (EXT 2) to 7330 Logic port DB25 pin 1 (Output 1).
- Wire from SC-50 DB25 pin 25 (PTT Sense) to 7330 Logic port DB25 pin 10 (Input 10).

Note: If you have an older SC-50 board you will need to install a wire jumper between pins 2 and 3 on the SC-50 connector to send discriminator audio through the high-pass filter.

DR-1X Configuration and Setup

Reference the DR-1X Operating Manual to configure the following parameters.

- Input your callsign.
- Carefully input your uplink frequency (the frequency the repeater receives) and the downlink frequency (the frequency the repeater transmits on).
- Set Remote mode ON.
- Set the DCS Receive tone ON and the Transmit tone OFF.
- In the Signaling menu select a DCS code will be *kept secret and never used*.
- Set any DSQ Code you like, but to make it easier on travelers I recommend leaving it OFF unless you have interference from co-channel Fusion repeater users. (Note: The DSQ code is not a DCS/DPL code. It is used in digital mode only.)
- Enable 1200 baud packet mode. Most DR-1X's come from the factory set to 9600 baud. The external transmit audio path bypasses the pre-emphasis stage in 9600 baud mode, so unless you plan on adding your own pre-emphasis you will want to use 1200 baud or else your transmitter audio will sound muddy.

SC-50 Squelch

Setting this squelch is simple. With the DR-1X powered up and no signal present, adjust the ¾-turn pot on the SC-50 until the COS LED on the SC-50 extinguishes, then go just a smidge farther. This should be a good starting point until you're ready to fine-tune with a service monitor during audio level alignment.

7330 Configuration

Now you'll need to configure a few jumpers inside the 7330. The locations of these jumpers are highlighted on page 12. It should be noted that my DR-1X is installed to Port 2 of my 7330. These instructions are written for Port 2, so you'll need to make the appropriate changes if you are on a different port.

Logic Input Pullup

- Remove the J4 IN-1 jumper to avoid biasing the DR-1X internal PTT (if using Logic In 1)

Radio Interface J11 jumpers (if you are using Port 2)

- De-emphasis
- High Output
- Delay
- Set the delay pot to about 1/3 clockwise and fine-tune from there during audio setup.

CTCSS/Logic Out jumper

- Select CTCSS (The 7330 generates the CTCSS encoder signal)

COR/CTCSS Inversion jumpers

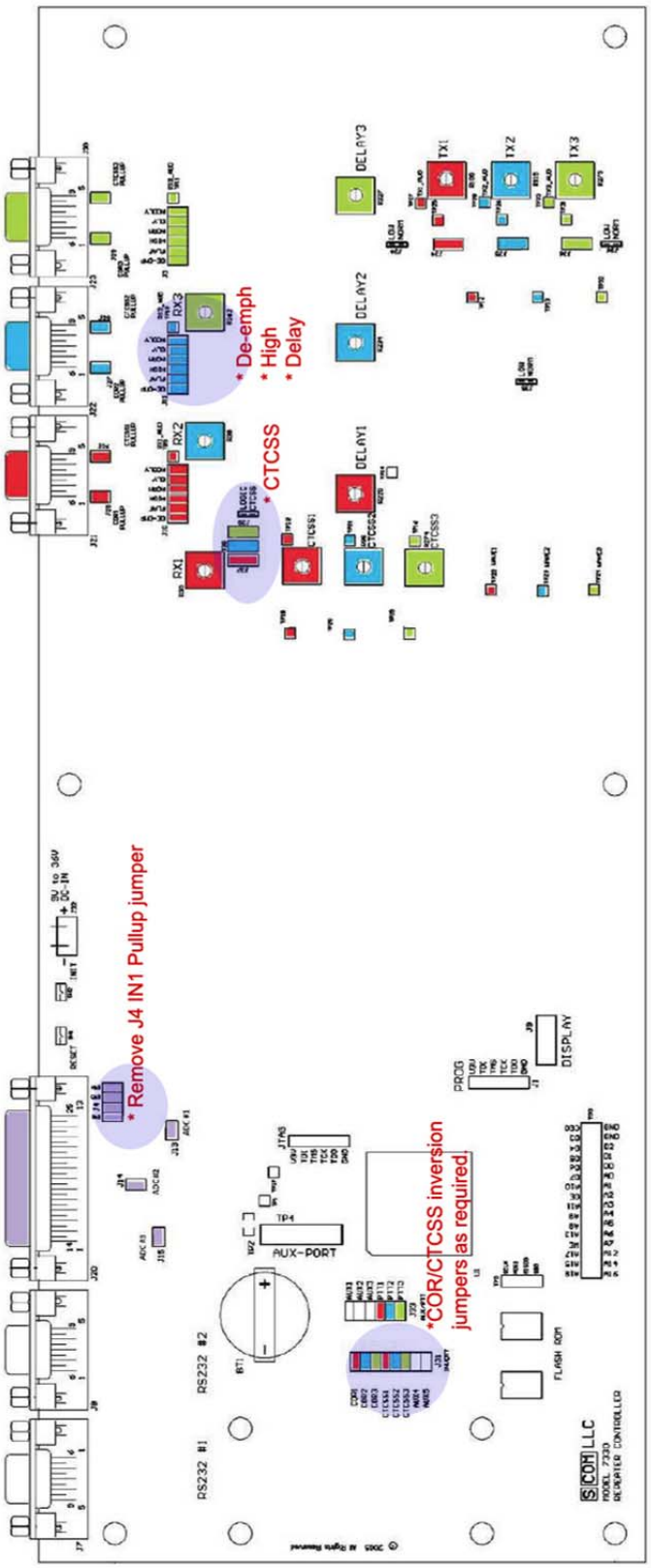
- COR and CTCSS inversion jumpers should both be installed for this port. My configuration has the pull-up jumper installed for CTCSS but not COR.

7330 DR-1X Script Kit

The always up-to-date script kit is at http://ks0lnk.net/documents/DR1X_script_kit.txt
The script kit requires S-Com version 3.4.1 or later. If you have an older version, you will have to upgrade to this version for this script kit to work. Cut and paste the script kit into Notepad and replace (MPW) with your actual Master Password, re-name the (MAC1) through (MAC5) macros, then cut and paste the script immediately below the line that sets your master password. This script also requires Macro-only password decoding to be enabled, and assumes you have no macro named D999 which is used to exit a true Boolean with no action taken.

The script kit uses the following resources:

- User softswitches 293 through 296
- User timers 08, 09, and 11
- Logic input 1 (DR-1X internal PTT sense)
- Logic Output 1 (AMS/FM Mode Select), Logic Output 2 (DC Power relay)
- Logic Output 8 (only an indicator LED for Digital Call Active)
- Macros D700 through D719, plus four more for Master PTT disable and Master AMS disable.
- Your custom ID's hang timers, courtesy tone, CTCSS configuration, etc.



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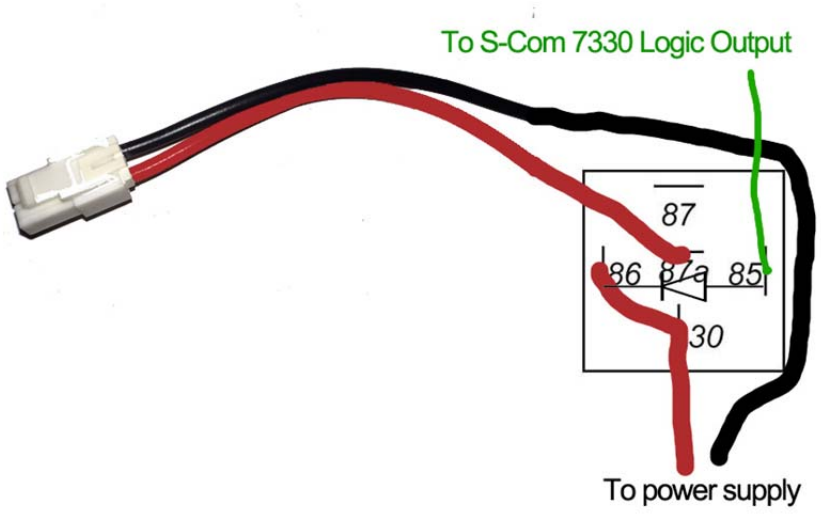
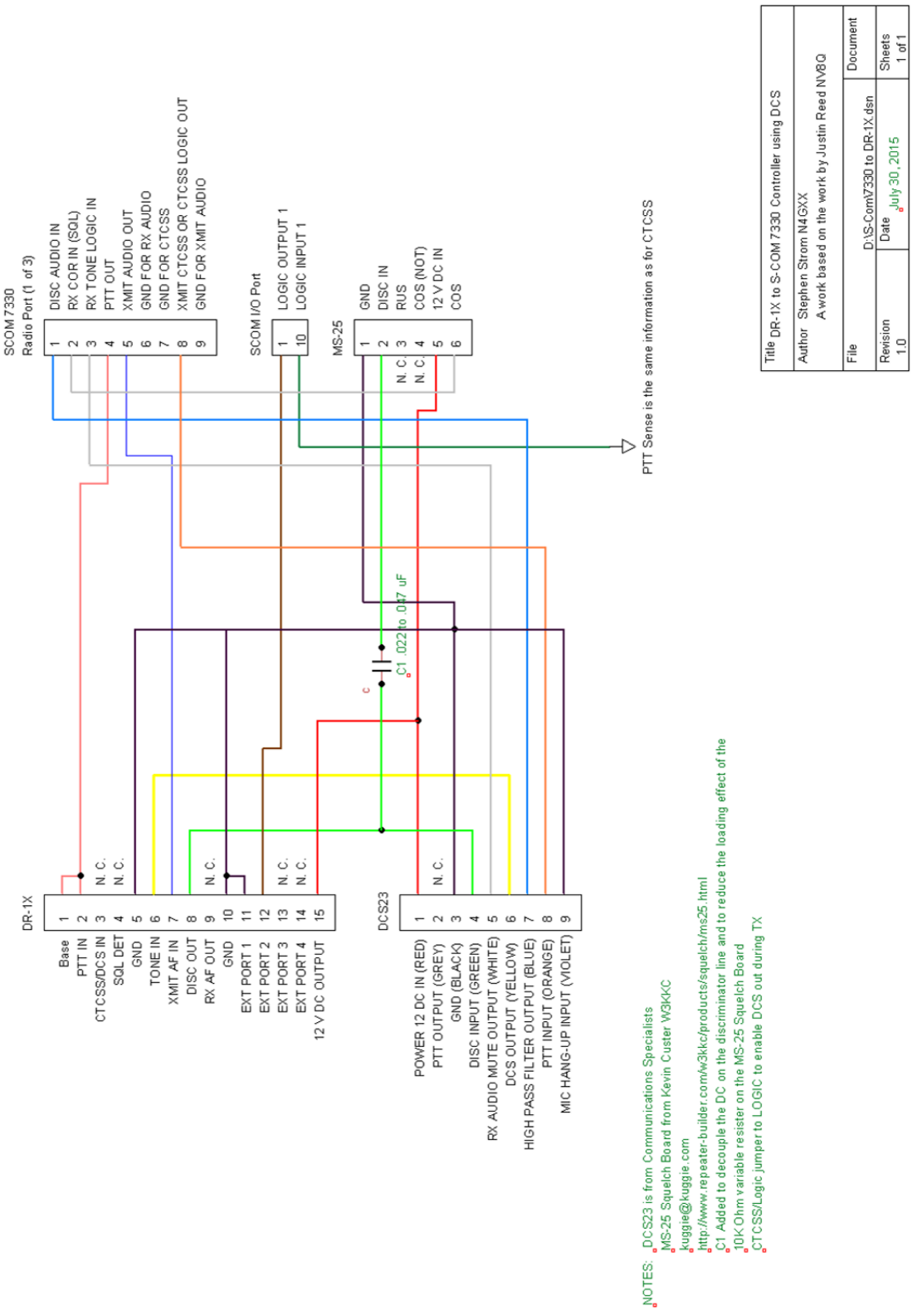
7330 Audio Level Alignment

- Setup the DR-1X and a service monitor on the frequency pair you intend to use, with the DR-1X transmitter terminated into a 50 ohm load or an input rated for the necessary power.
- Make sure the 7330 is programmed to generate a CTCSS tone.
- Turn the CTCSS 2 pot all the way down.
- Inject an on-frequency carrier at -60 dBm, modulated with a 1 kHz tone deviated at 3 kHz plus a valid CTCSS tone into the receiver with about 650 Hz deviation.
- Adjust the RX2 pot for 355mV AC (RMS) at the test point. This sets the input level at an optimum range for the DTMF decoder.
- Adjust the TX2 pot for 3 kHz deviation from the transmitter. Then vary the amount of deviation from the service monitor and verify the transmitter output matches it 1:1 up to at least 4 kHz.
- With an unmodulated (except for CTCSS) carrier into the receiver adjust the CTCSS pot for about 650 Hz deviation.
- Check the total maximum system deviation does not exceed +- 5 khz.
- Verify squelch operation and adjust the SC-50 squelch control as needed.
- Fasten the top cover to the chassis with 15 screws.

Other Modifications

- Consider drilling a hole in the top cover directly over the RX Unit's firmware update switch to allow quick access to the switch. This will save you a considerable amount of time and labor during the update process.
- Consider drilling a hole in the top cover directly over the SC-50's squelch pot for easier access.
- Below is a diagram for wiring a DC relay to allow remote power cycling of the DR-1X.





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SC-50 Dip Switch Settings

1 = ON

DIP#	1	2	3	4	5	6
067.0	0	0	0	0	0	0
069.3	0	1	1	0	0	0
071.9	0	0	0	0	0	1
074.4	1	0	0	0	0	0
077.0	0	0	0	0	1	1
079.7	0	1	0	0	0	0
082.5	1	0	0	0	0	1
085.4	1	1	0	0	0	0
088.5	1	0	0	0	1	1
091.5	0	0	1	0	0	0
094.8	0	1	0	0	0	1
097.4	1	0	1	0	0	0
100.0	0	1	0	0	1	1
103.5	1	1	0	0	0	1
107.2	1	1	0	0	1	1
110.9	0	0	1	0	0	1
114.8	0	0	1	0	1	1
118.8	1	0	1	0	0	1
123.0	1	0	1	0	1	1
127.3	0	1	1	0	0	1
131.8	0	1	1	0	1	1
136.5	1	1	1	0	0	1
141.3	1	1	1	0	1	1
146.2	0	0	0	1	0	1
151.4	0	0	0	1	1	1
156.7	1	0	0	1	0	1
159.8	0	1	1	1	0	0
162.2	1	0	0	1	1	1
167.9	0	1	0	1	0	1
173.8	0	1	0	1	1	1
179.9	1	1	0	1	0	1
183.5	1	0	1	1	0	0
186.2	1	1	0	1	1	1
189.9	0	0	1	1	0	0
192.8	0	0	1	1	0	1
196.6	1	1	0	1	0	0
199.5	0	1	0	1	0	0
203.5	0	0	1	1	1	1
206.5	1	0	0	1	0	0
210.7	1	0	1	1	0	1
218.1	1	0	1	1	1	1
225.7	0	1	1	1	0	1
229.1	0	0	0	1	0	0
241.8	1	1	1	1	0	1
250.3	1	1	1	1	1	1
254.1	1	1	1	0	0	0
NOTONE	1	1	1	1	0	0 (DO NOT USE)

Known Issues:

6/22/2015: An extended conversation on analog (without letting the transmitter drop) will cause the PTT Watchdog script to reset the DR-1X (if you have an AC or DC power interrupt relay installed). A longer watchdog timer and shorter dropout timer will help.

Notes:

6/22/2015: New version of the SC-50 board does not require a wire jumper across pins 2 and 3, as a shunt has been added on the board.

12/10/2015: The PTT watchdog timer may not be necessary with DR-1X firmware 1.00b or later, as we've not seen a "stuck on air" event since the upgrade.

1/1/2016: SC-50 Revision 4 includes improvements and adds SJ5 which connects discriminator audio to the input of the RX high pass filter. This eliminates the need for pins 2 & 3 to be jumped on the DB-25 connector of the SC-50.

1/21/2016: DR-1X firmware 1.00m and DSP 4.11 was installed on the test bed repeater. The new DSP is an amazing improvement in weak signal performance.

2/9/2016: You cannot use WiRES-X direct-connected to the DR-1X with an external controller attached. However, a WiRES-X node linked to the repeater via RF will work fine.