33-centimeter Kenwood TK-941 Conversion

The following documentation is largely based on a set of separate documents that are already available on the internet. While performing a conversion of two Kenwood TK-941 radios, I found the available documentation to be both incomplete and somewhat incoherent. I performed the radio programming sequence a total of five times, discovering nuances at each programming instance, before the radios were operational.

This document attempts to gather all other information regarding the Kenwood TK-941 the conversion process in a single stand-alone document. It is hoped that having a single stand-alone document will make the conversion process easier others who wish to perform the conversion process. This disclaimer is not an attempt to discredit those who have provided most of the conversion process online, but is meant to gather those sources into a single document and fill in information that had not been disclosed.

Ray Montagne - W7CIA

Programming Requirements

Programming of the Kenwood TK-941 radio requires the Kenwood KPG4 programming cable and the following software:

- Kenwood KPG-25D Programming Software
- KwID or equivalent table data for channel / frequency conversion
- KW900EZP
- HxD or any Hex Editing program

The radios will be programmed to the following specification:

Kenwood TK-941 33cm Radio Programming Information			
Receive		Transmit	
Frequency	Decode	Frequency	Encode
902.2125	None	927.2125	None
902.2125	DCS023	927.2125	DCS023
902.2250	None	927.2250	None
902.2250	DCS023	927.2250	DCS023

Two frequencies were chosen in order to provide a back-up pair for frequency allocation in the event that the primary frequency is not available. The primary frequency pair is 927.2250 / 902.2250 with the back-up pair of 927.2125 / 902.2125. Each frequency was programmed into two memory channels with one channel operating in carrier only and the second channel operating in digital coded squelch. This was done, in part, to provide easy access to a receiver configuration where a -12 dB SINAD measurement could be performed (by selecting the carrier only channel).

The frequency must be converted to a Kenwood Channel Number prior to programming. The following table, obtained from the KW900EZP program documentation by K2MCI, is used to obtain the channel number for the target frequencies:

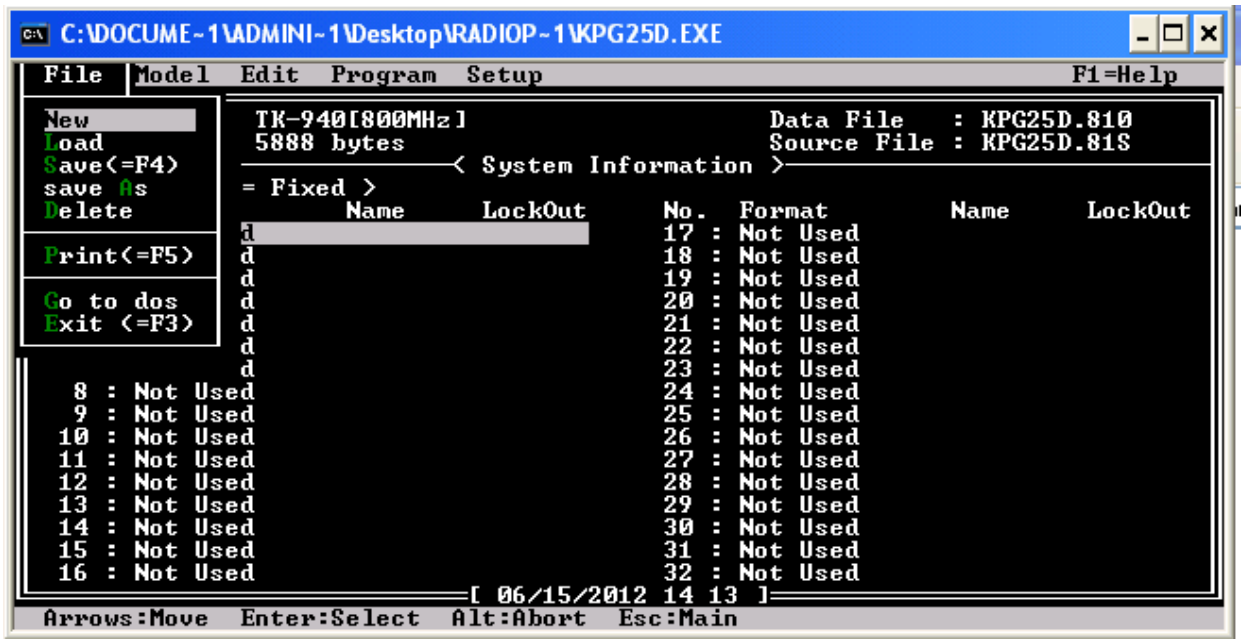
Kenwood TK-941 33cm Radio Frequency to Channel Conversion					
927 902	919 907	920 908	921 909	926 903	Frequency MHz
	80	160	240	320	0.0000
1	81	161	241	321	0.0125
2	82	162	242	322	0.0250
3	83	163	243	323	0.0375
4	84	164	244	324	0.0500
5	85	165	245	325	0.0625
6	86	166	246	326	0.0750
7	87	167	247	327	0.0875
8	88	168	248	328	0.1000
9	89	169	249	329	0.1125
10	90	170	250	330	0.1250
11	91	171	251	331	0.1375
12	92	172	252	332	0.1500
13	93	173	253	333	0.1625
14	94	174	254	334	0.1750
15	95	175	255	335	0.1875
16	96	176	256	336	0.2000
17	97	177	257	337	**0.2125**
18	98	178	258	338	**0.2250**
19	99	179	259	339	0.2375
20	100	180	260	340	0.2500
21	101	181	261	341	0.2625
22	102	182	262	342	0.2750
23	103	183	263	343	0.2875
24	104	184	264	344	0.3000
25	105	185	265	345	0.3125
26	106	186	256	346	0.3250
27	107	187	257	347	0.3375
28	108	188	258	348	0.3500
29	109	189	259	349	0.3625
30	110	190	260	350	0.3750
31	111	191	261	351	0.3875
32	112	192	262	352	0.4000
33	113	193	263	353	0.4125
34	114	194	264	354	0.4250
35	115	195	265	355	0.4375
36	116	196	266	356	0.4500
37	117	197	267	357	0.4625
38	118	198	268	358	0.4750
39	119	199	269	359	0.4875
40	120	200	270	360	0.5000
41	121	201	271	361	0.5125
42	122	202	272	362	0.5250
43	123	203	273	363	0.5375
44	124	204	274	364	0.5500
45	125	205	275	365	0.5625
46	126	206	276	366	0.5750
47	127	207	277	367	0.5875
48	128	208	278	368	0.6000
49	129	209	279	369	0.6125

Kenwood TK-941 33cm Radio Frequency to Channel Conversion (continued)					
927 902	919 907	920 908	921 909	926 903	Frequency MHz
50	130	210	280	370	0.6250
51	131	211	281	371	0.6375
52	132	212	282	372	0.6500
53	133	213	283	373	0.6625
54	134	214	284	374	0.6750
55	135	215	285	375	0.6875
56	136	216	286	376	0.7000
57	137	217	287	377	0.7125
58	138	218	288	378	0.7250
59	139	219	289	379	0.7375
60	140	220	290	380	0.7500
61	141	221	291	381	0.7625
62	142	222	292	382	0.7750
63	143	223	293	383	0.7875
64	144	224	294	384	0.8000
65	145	225	295	385	0.8125
66	146	226	296	386	0.8250
67	147	227	297	387	0.8375
68	148	228	298	388	0.8500
69	149	229	299	389	0.8675
70	150	230	300	390	0.8750
71	151	231	301	391	0.8875
72	152	232	302	392	0.9000
73	153	233	303	393	0.9125
74	154	234	304	394	0.9250
75	155	235	305	305	0.9375
76	156	236	306	396	0.9500
77	157	237	307	397	0.9625
78	158	238	308	398	0.9750
79	159	239	309	399	0.9875

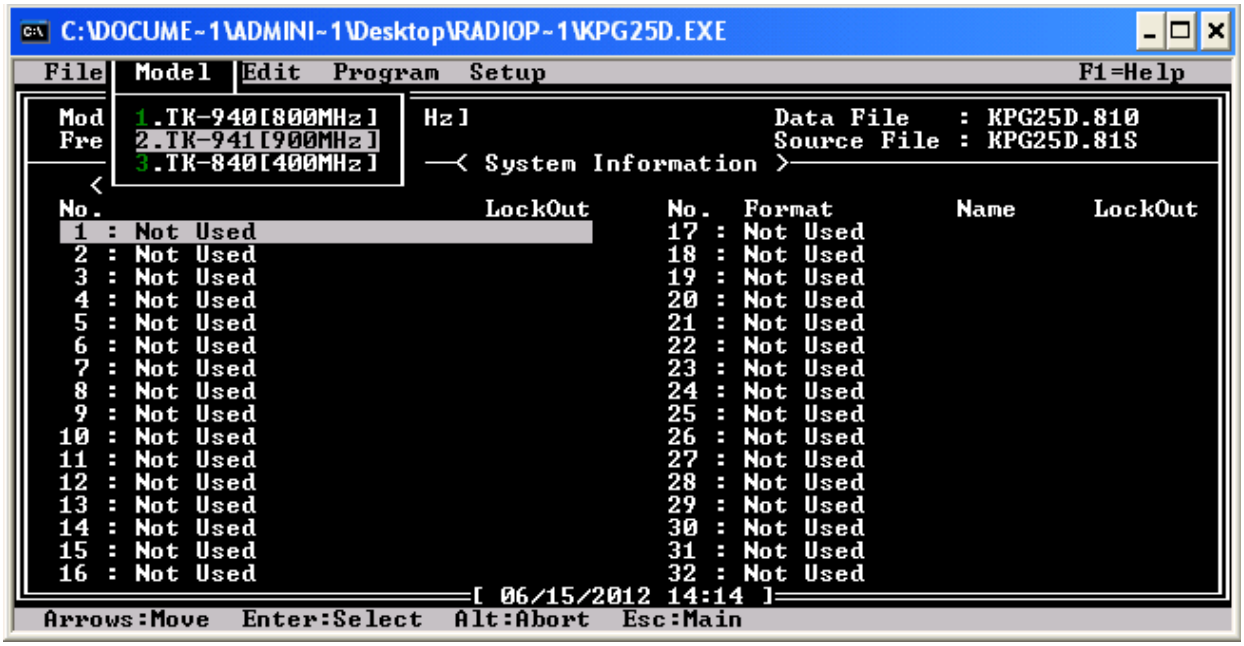
The target frequency pairs of 927.2125 / 902.2125 and 927.2250 / 902.2250 use FCC channels 17 and 18 respectively.

Programming Procedure

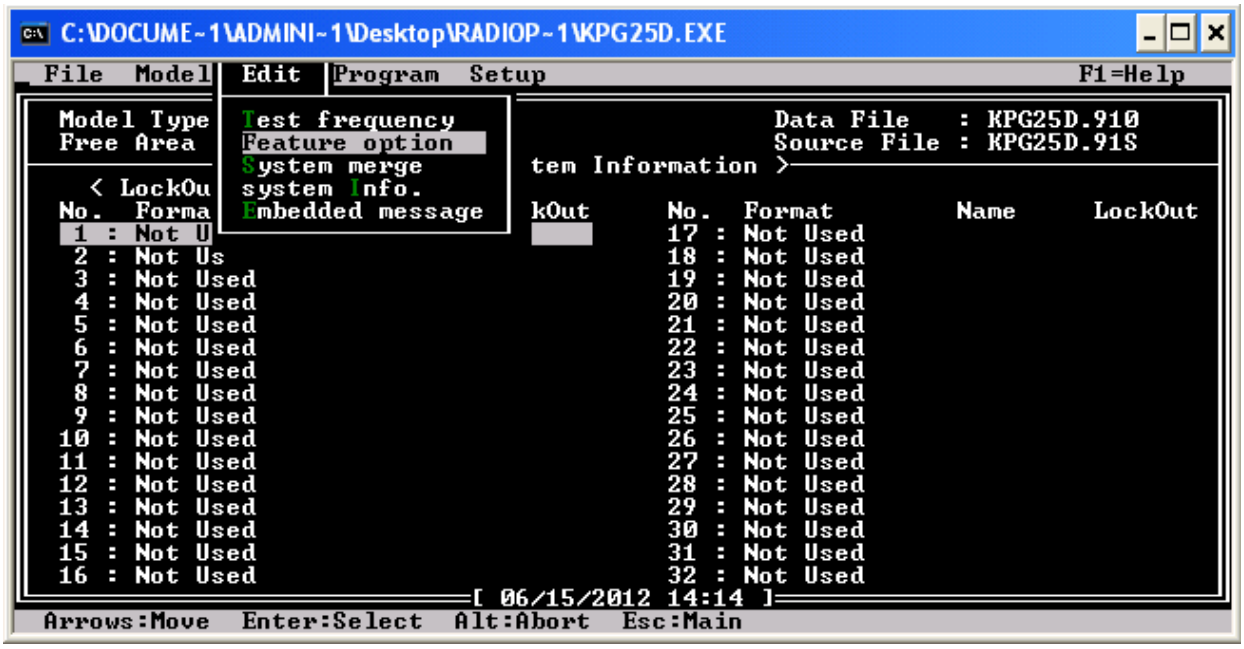
I. Launch **KPG-25D.exe** and start with an empty template by selecting **New** from the **File** menu.



II. Set the **Model** to **TK-941**.



III. Select **Feature Option** from the **Edit** menu.



IV. Set the **T.O.T. (Dispatch)** parameter to **600**. This is the transmission time limit, in dispatch mode, expressed in 15 seconds per step with a range of from 15 seconds to 600 seconds. The default is 60 seconds. These are set to 10 minutes (600 seconds) so that the timers in the repeater controller can be used.

V. Set the **T.O.T. (Tel)** parameter to **600**. This is the transmission time limit, in telephone mode, expressed in 15 seconds per step with a range of from 15 seconds to 600 seconds. The default is 180 seconds. These are set to 10 minutes (600 seconds) so that the timers in the repeater controller can be used.

VI. Set the **Drop out delay time** parameter to **1**. This sets the time between carrier detect drop out and the resumption of scanning. This parameter can be set from 0 to 254 seconds at 1 second per count. The default is 3 seconds.

VII. Set the **dwell time** parameter to **1**. This sets the time between the end of transmission and the resumption of scanning. This parameter can be set from 0 to 254 seconds at 1 second per count. The default is 15 seconds.

VIII. Set the **Transpond delay time** parameter to **3**. This sets the delay from the decode of a transpond enabled ID to the beginning of a transpond transmission. This parameter can be set from 0 to 254 seconds at 1 second per count. The default is 3 seconds. If this parameter is set to a value greater than the **Drop out delay time** then the **Drop out delay time** will be used as the **Transpond delay time**.

IX. Set the **TX inhibit time** parameter to **5.0**. This parameter sets the period of time that the transmitter is inhibited after an inhibited ID is detected. The value can be set from 0.5 seconds to 8.0 seconds in 0.5 second steps.

X. Set the **Aux switch** parameter to **N/A**. This parameter toggles the following functions off:

A. **N/A:** No function

B. **Option Sig:** Option signaling board reset switch.

C. **Manual Relay:** Auxiliary output signal ON/OFF.

D. **Horn Alert:** Horn Alert ON/OFF

E. **Telephone Search:** Automatically searches for a vacant telephone channel (trunked system).

F. **ALP/Sys.Grp.:** Toggle display between alphanumeric or the system & group number.

G. **Fixed Call:** Reset radio to a pre-programmed system & group.

H. **Del/Add:** Provides the user system Delete / Add button.

XI. Set the **Scan switch** parameter to **List scan**. This parameter sets the scan type selection as follows:

A. **N/A:** Disables the scan switch function and sounds an alert tone (if programmed) when the scan key is pressed.

B. **List Scan:** Automatic roaming scan.

C. **Fix System Scan:** Operator selectable system scan.

XII. Set the **Revert sys type** parameter to **Last Use**. This parameter sets the programmable transmit destination system & group during scanning. Options include:

A. **Last Used:** Last transmitted system & group.

B. **Last Called:** Last received system & group.

XIII. Set the **Free System ring back** parameter to **No**. This feature is only active during telephone use (trunked system). The radio will beep when the telephone interconnect line is not busy.

XIV. Set the **Clear to talk beep** parameter to **Yes**. Upon successful access of a trunked system, this beep tone sounds to alert the user they can begin speaking.

XV. Set the **System search** parameter to **None**. While a selected system is busy (the radio sounds an intercept tone) then release the PTT key, the radio will start to search for an available system automatically or manually. Options include:

A. **None:** Disable system search.

B. **Auto:** During the intercept tone, keep the PTT key held down and press the SCAN key. Upon release of the SCAN key, system search begins.

C. **Manual:** During the intercept tone, releasing the PTT will initiate auto system search.

XVI. Set the **Display Character** parameter to **Grp Name**. This parameter selects the display character Group name (Alphanumeric) or System & Group number. If you select the AUX switch as the display character, this selection will be just as default. Options include:

A. **Sys Grp:** Set the display character as System & Group number.

B. **Grp Name:** Set the display character as alphanumeric (pre-programing necessary).

XVII. Set the **Minimum volume** parameter to **0**. The minimum volume is the level which will be set automatically every time you turn on the radio. If the volume is adjusted below this level prior to turning the radio off, the volume will be set to this level the next time the radio is turned on. In order to ensure that the speaker is quiet at the repeater site, this value is set to zero. The default value is 8.

XVIII. Set the **Off hook scan** parameter to **Disable**. The radio is able to scan, even with the mic off hook. Options include:

A. **Enable:** Scan start & stop is independent of the mic hook switch.

B. **Disable:** Mic must be on hook for scanning to start.

XIX. Set the **Off hook horn alt** parameter to **Disable**. Horn alert is auto disabled when the microphone goes off hook Options include:

A. **Enable:** Off hook auto disable.

B. **Disable:** Manual disable only.

XX. Set the **Off hook decode** parameter to **Enable**. The radio is still tone squelched, even though the mic is in the off hook condition (valid for QT, DQT and Option Signaling board decode). Options include:

A. **Enable:** Decode signaling active even in the off hook condition.

B. **Disable:** Decode signaling is disabled during off hook.

Setting this parameter to **Enable** allows the radio to operate in decode without having to wire the off-hook signal to the on-hook position.

XXI. Set the **Access logic sig** parameter to **Sngl. Pulse**. This logic signal is useful for external radio control unit (i.e. Mobile Data Terminal, Computer Aided Dispatch or Over The Air Re-Programming etc) that require a signal at the time of successful trunked repeater access. Options include:

A. **Continuous:** Logic Level high during length of access.

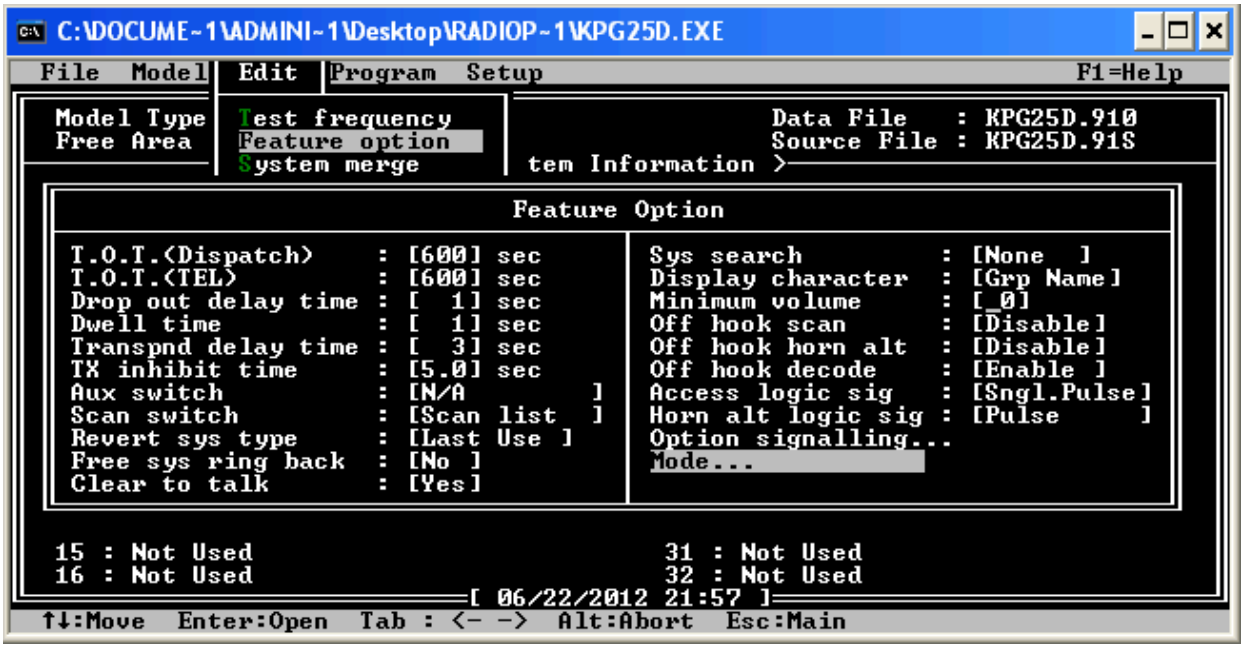
B. **Sng. Pulse:** Logic level high pulse at the time of a successful handshake.

XXII. Set the **Horn alt logic sig** parameter to **Pulse**. The Horn Alert logic can be used to drive a vehicle horn relay, light or other device. The logic level signal can be set for a continuous (EX: light) or momentary pulse output (EX: vehicle horn relay). Options include:

A. **Continuous:** Continuous logic level low output until reset.

B. **Pulse:** Momentary logic level low output.

XXIII. The options should now appear as:

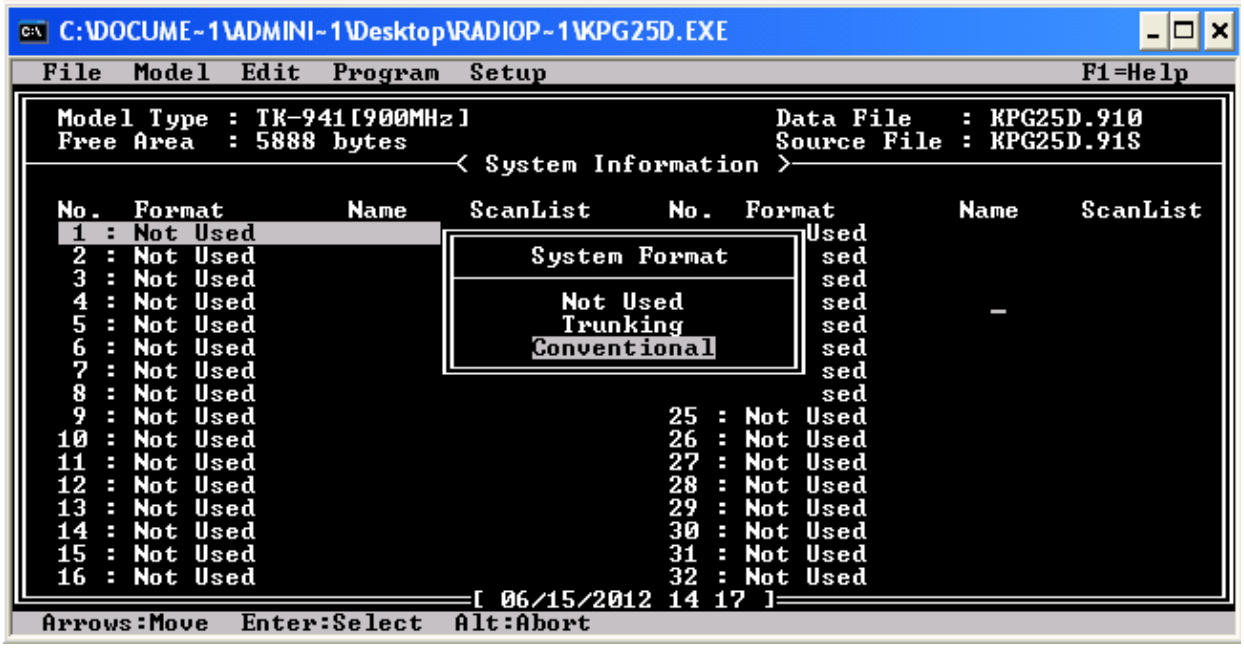


XXIV. Layout all of the repeater input frequencies in the first group. Setup each repeater output frequency in a separate system. Using the **Kenwood3.exe** program, the hexadecimal representation of each frequency can be determined (as seen in the table below).

Group & System Configuration								
System	**Group 1**	**Group 2**	**Group 3**	**Group 4**	**Group 5**	**Group 6**	**Group 7**	**Group 8**
1	KC7MCC TX A 927.2125 Carrier CH. 17 **0xD197**	KC7MCC TX A 927.2125 Encode CH. 17 **0xD197**	KC7MCC RX A 902.2125 Carrier CH. 17 **0x0190**	KC7MCC RX A 902.2125 Encode CH. 17 **0x0190**	KC7MCC TX B 927.2250 Carrier CH. 18 **0xD297**	KC7MCC TX B 927.2250 Encode CH. 18 **0xD297**	KC7MCC RX B 902.2250 Carrier CH. 18 **0x0290**	KC7MCC RX B 902.2250 Encode CH. 18 **0x0290**

The carrier access groups are not intended for active use but support test configurations, such as performing a -12 dB SINAD measurement on a receiver.

XXV. Set the system configuration to **Conventional**.



XXVI. Hit **Enter** to edit the system configuration.

XXVII. Program each group as follows:

A. Set the **FCC** field to **200**.

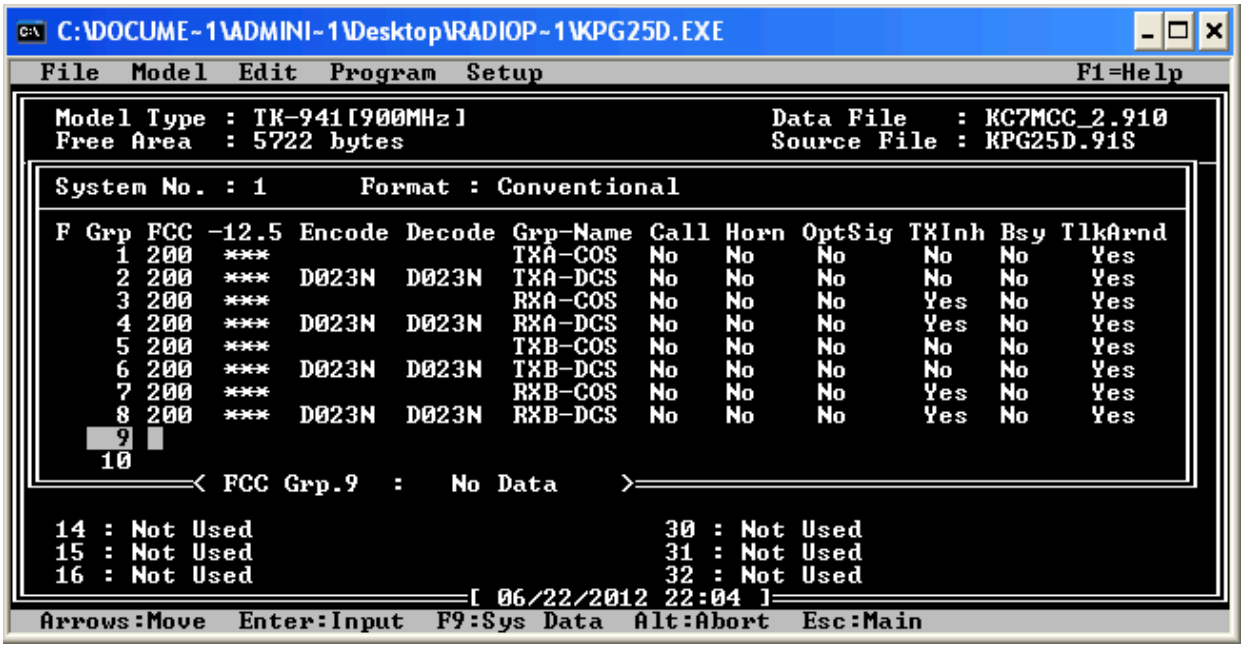
B. Set the transmit **Encode** field as appropriate.

C. Set the receive **Decode** field as appropriate.

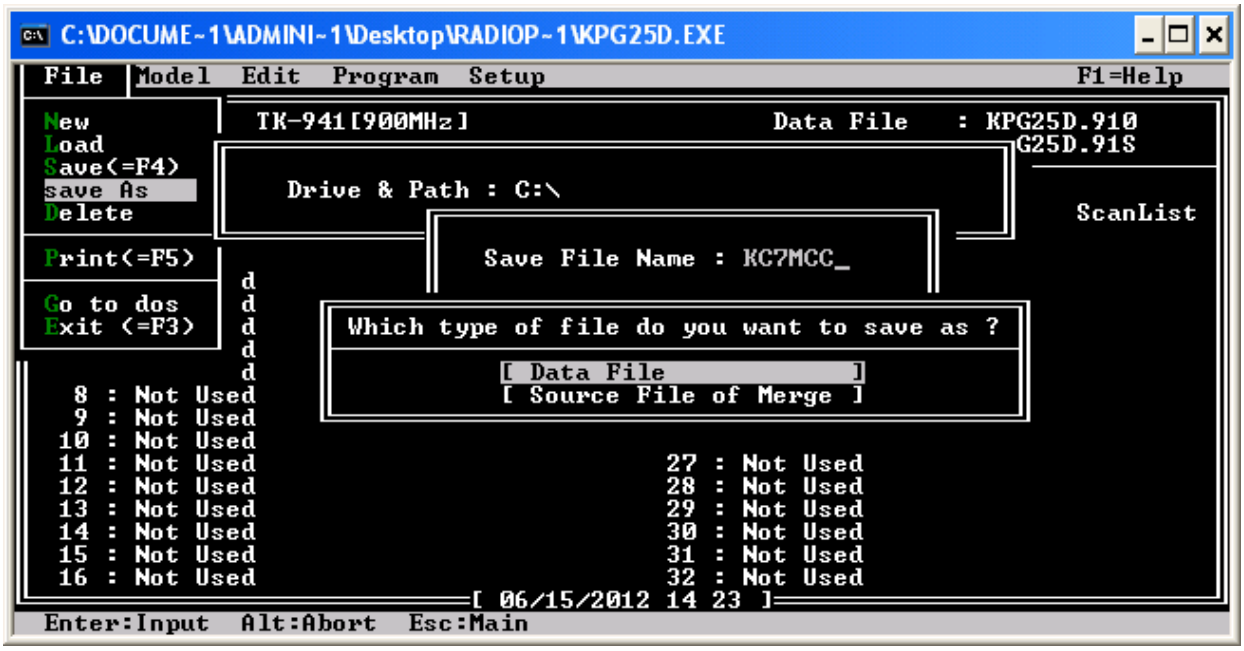
D. Set the **Grp-Name** field as appropriate. Use unique text that will help you identify the group name when using the **HxD** program at a later step.

E. Set the **TlkArnd** field to **Yes**.

F. Leave all other fields at their default values.



XXVIII. Save the **KPG25D** configuration file.

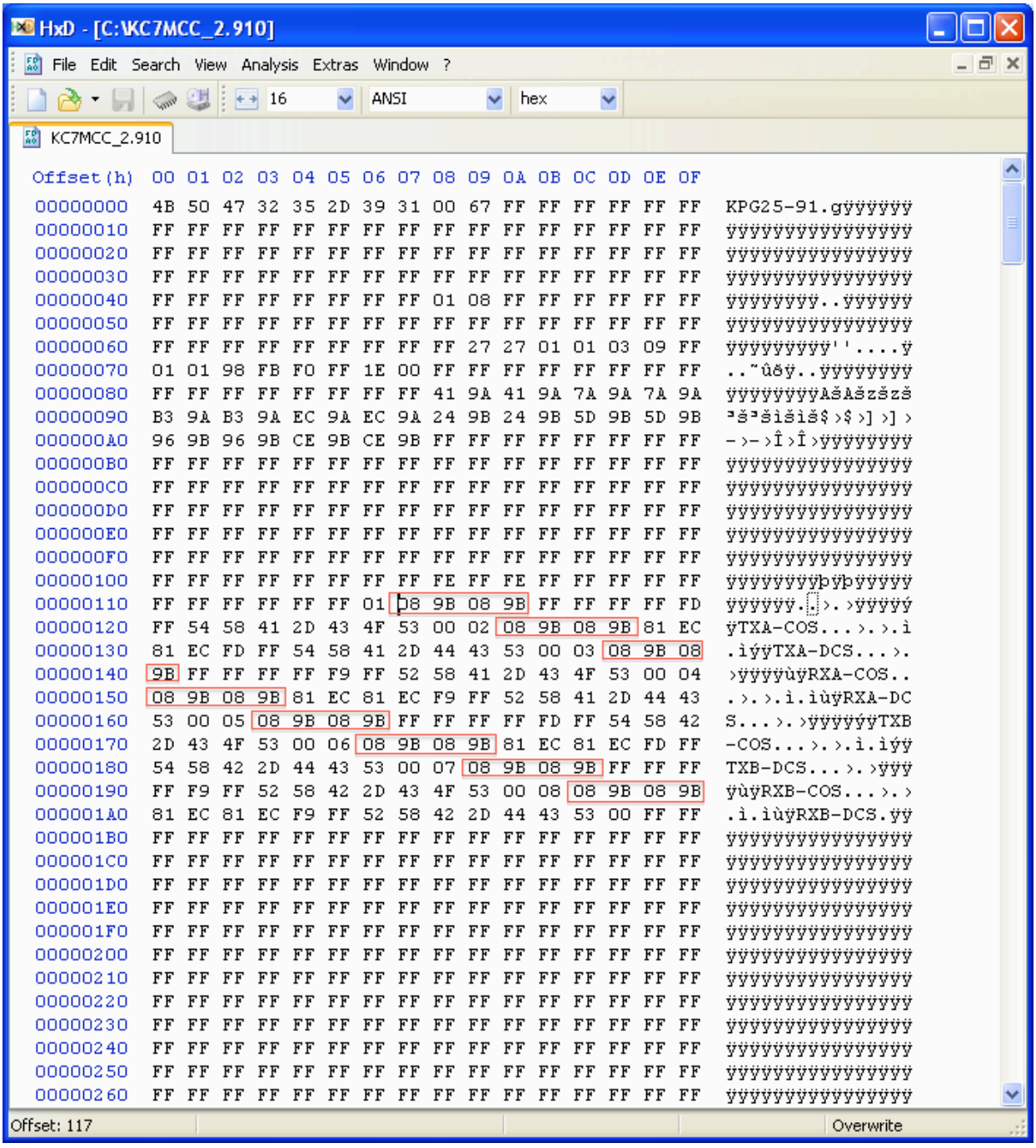


XXIX. Exit the **KPG25D.exe** program.

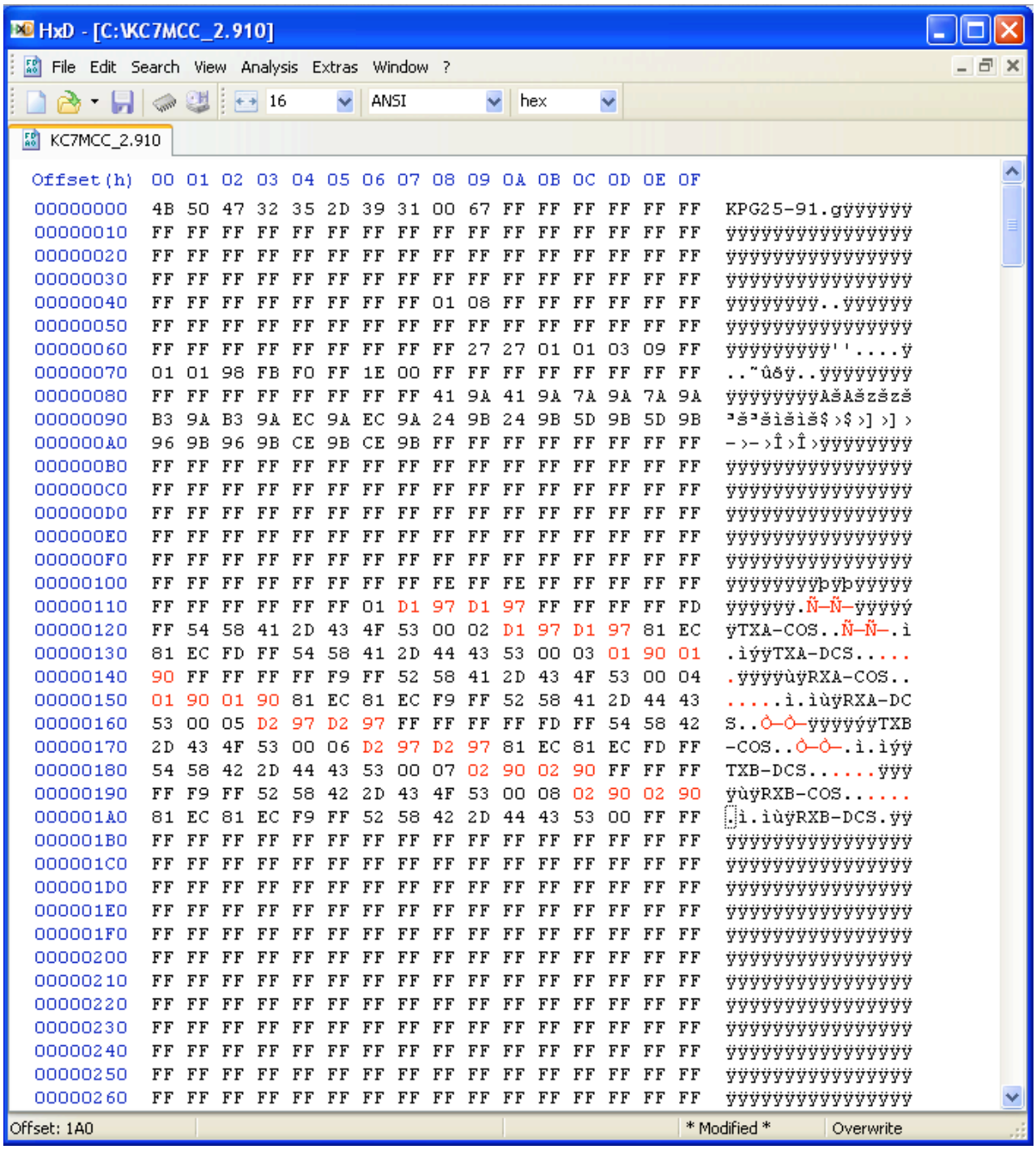
XXX. The **KPG25D.exe** program will have inserted a value of **0x089B**, corresponding to channel 200 or 937.5000 MHz, into each of the frequency slots. The channel numbers are stored as a 16-bit word in little endian format. Endian swapping the default channel value results in a value of **0x9B08**, which converts to a decimal value of 39688. The decimal channel value can be determined by subtracting the target frequency from 937.5000 MHz and then dividing by the channel frequency step size of 0.0125 MHz. The resulting value is then subtracted from a value of 38923, converted back to hexadecimal and then endian swapped into little endian format before storing the frequency. *This is apparently what the **Kenwood3.exe** program does (except that the conversion to decimal and endian swapping is not required in programming since little endian is the native format for x86 processors).*

XXXI. Launch the **HxD.exe** program.

XXXII. Open the KPG25D data file with the **HxD** program.



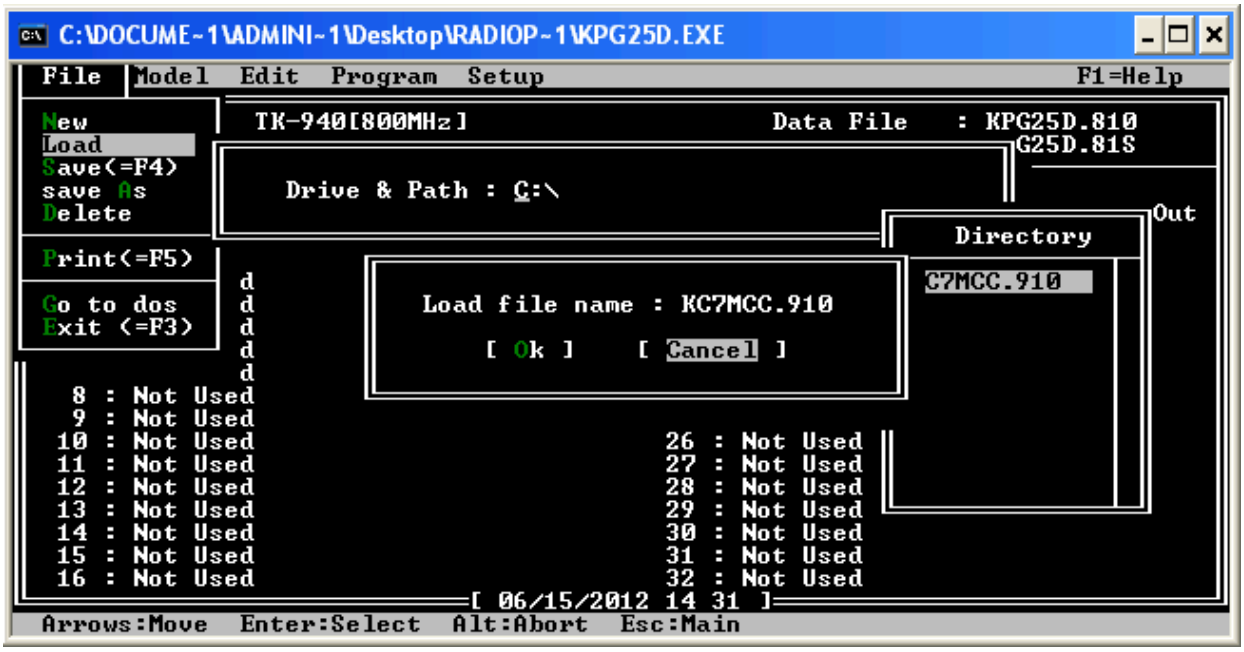
XXXIII. Locate each frequency entry with a value of **0x089B** and edit the value to the appropriate value obtained from the **Kenwood3.exe** program. The **Grp-Name** field data will be visible in the window and will help to locate the **0x089B** value associated with a specific group name..



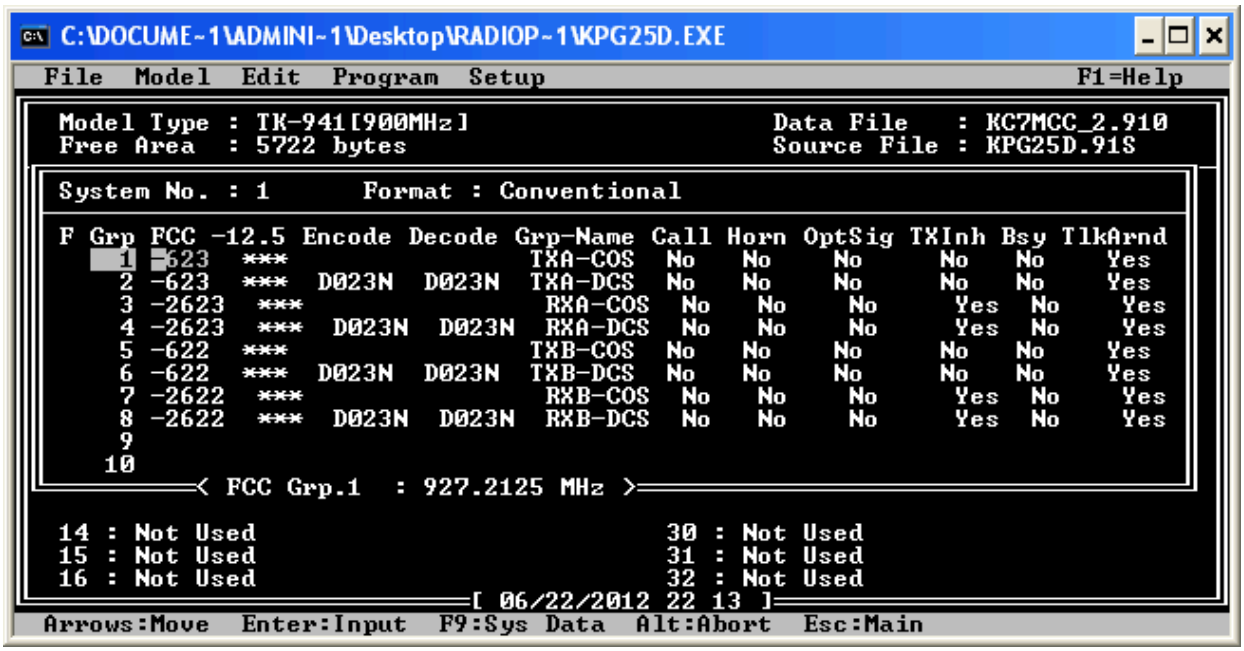
XXXIV. Save the file and exit the **Kenwood3.exe** program.

XXXV. Launch the **KPG25D.exe** program.

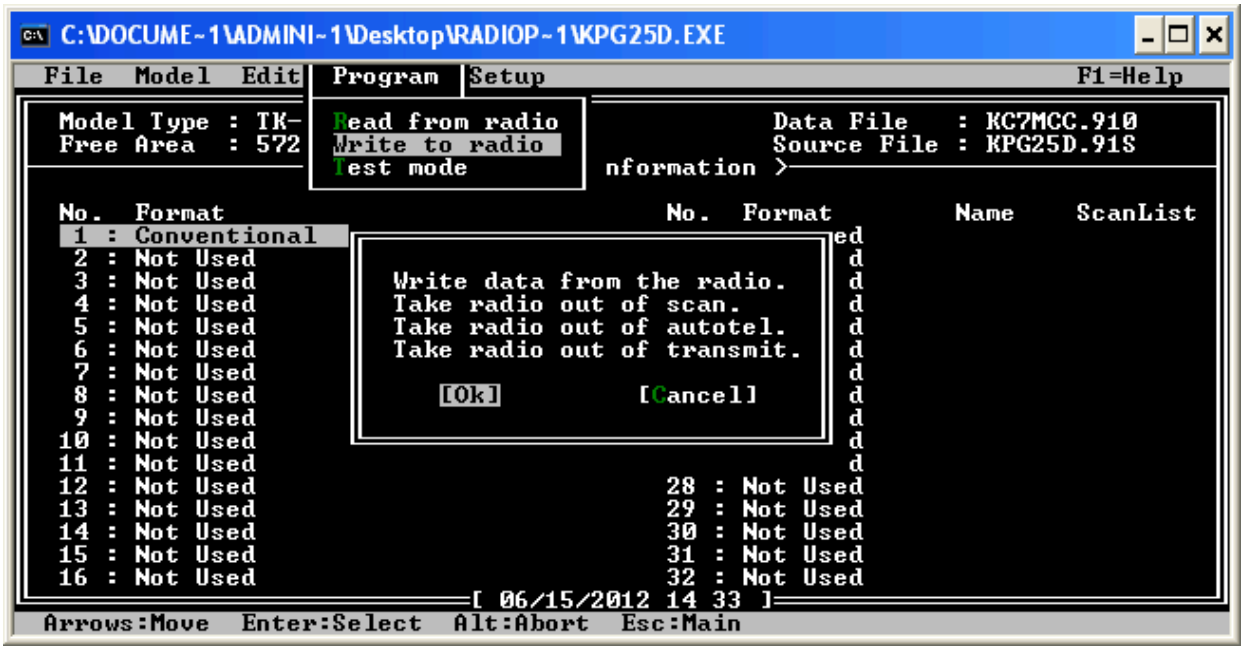
XXXVI. Load the KPG25D data file.



XXXVII. A view of the **Feature option** window will show the new channel data.



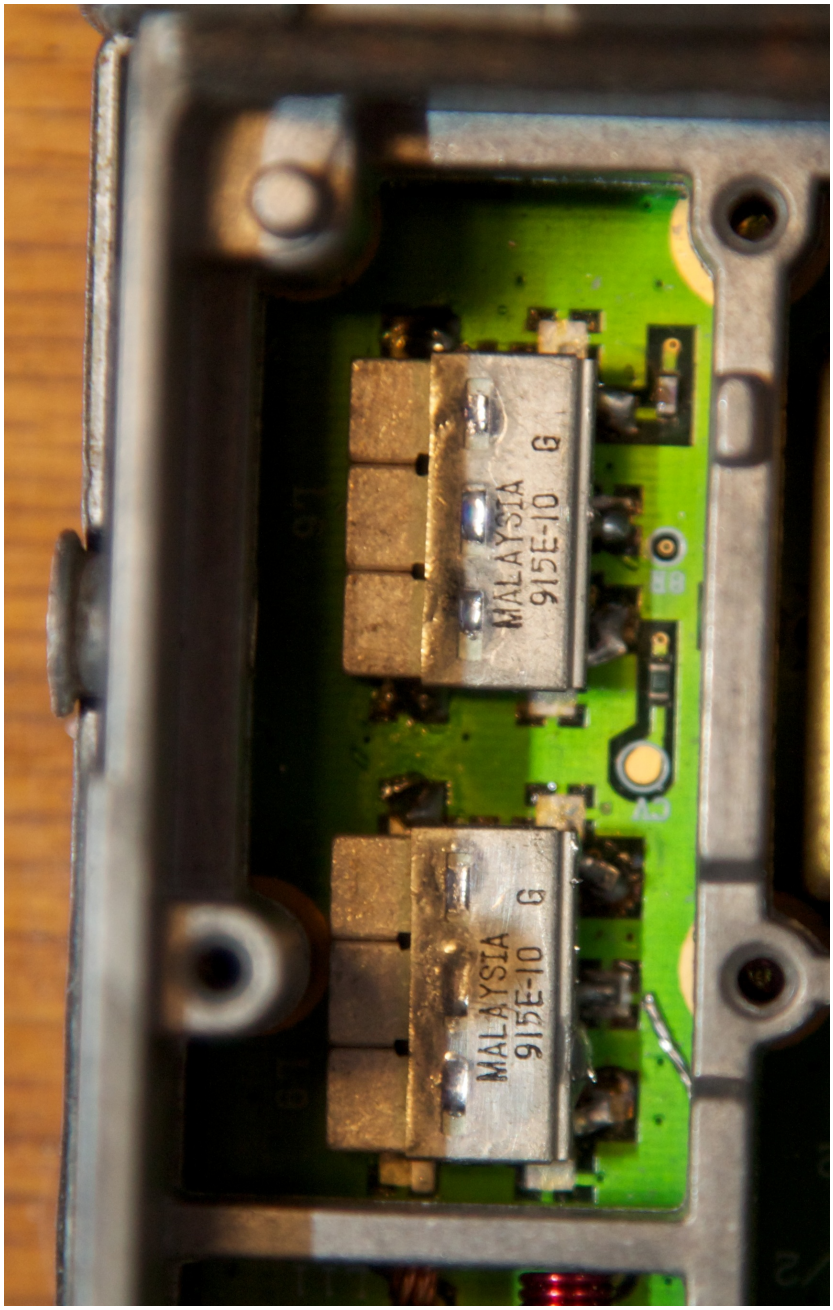
XXXVIII. Program the radio.



Filter Installation

Two TK-941 radios are used to implement the full-duplex link back-bone, with one radio acting as the transmitter and the other radio acting as the receiver. The front-end filter on the receive radio must be swapped out with a filter that has the bandpass frequency having the receive frequency fall within the bandpass.

A hot air SMD station was used to remove the pair of filters from the TK-941 receive radio front-end. 915 MHz filters were then installed using a standard soldering station. Note that the filter terminals did not align with the solder pads on the printed circuit board. The terminals had to be bent in to contact the pads prior to soldering. A check was made, using an Ohm meter, to verify that the terminals did not short to the ground traces surrounding the filter terminal pads.

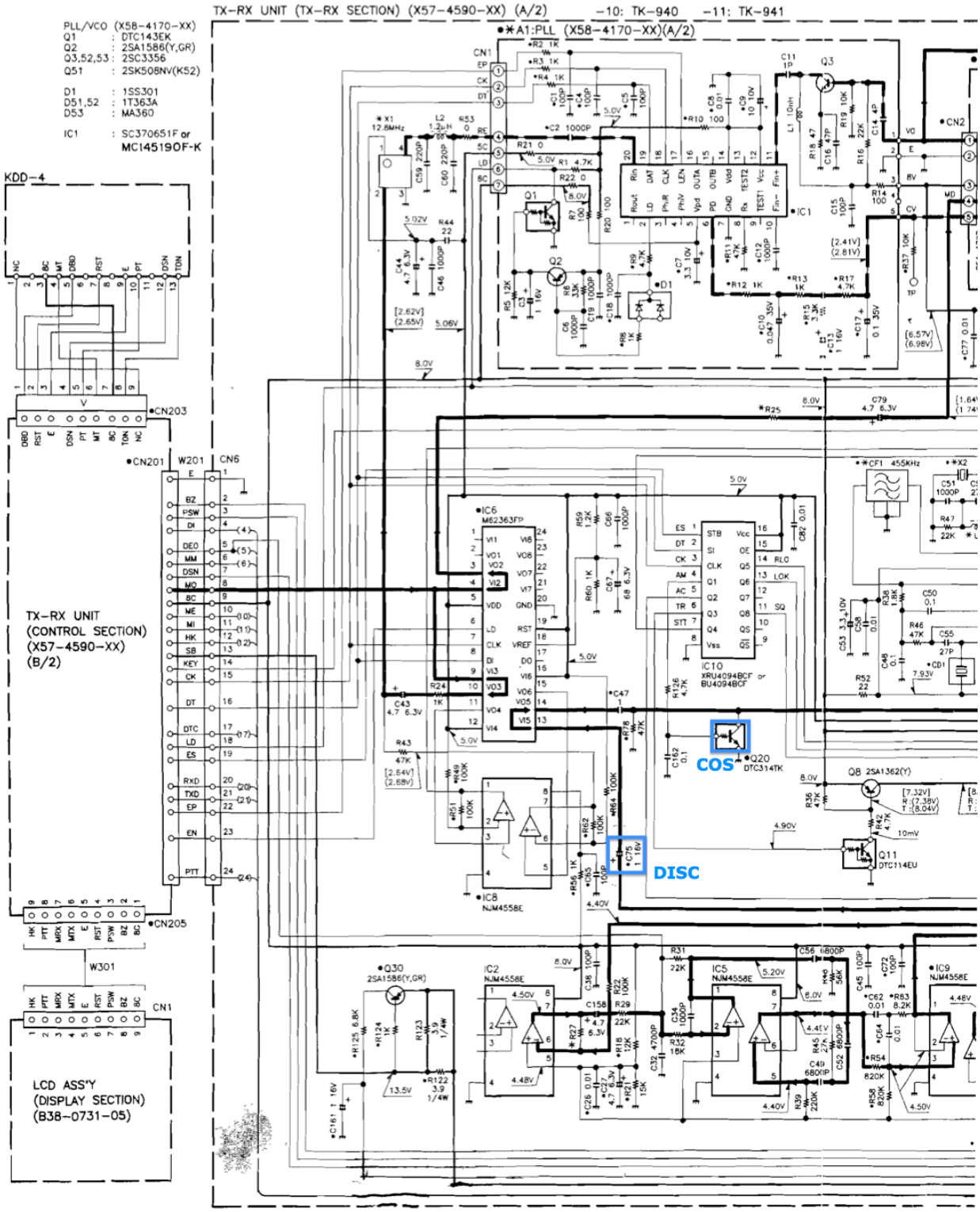


Upon completion of the filter installation, the VCO was adjusted to obtain VCO lock.

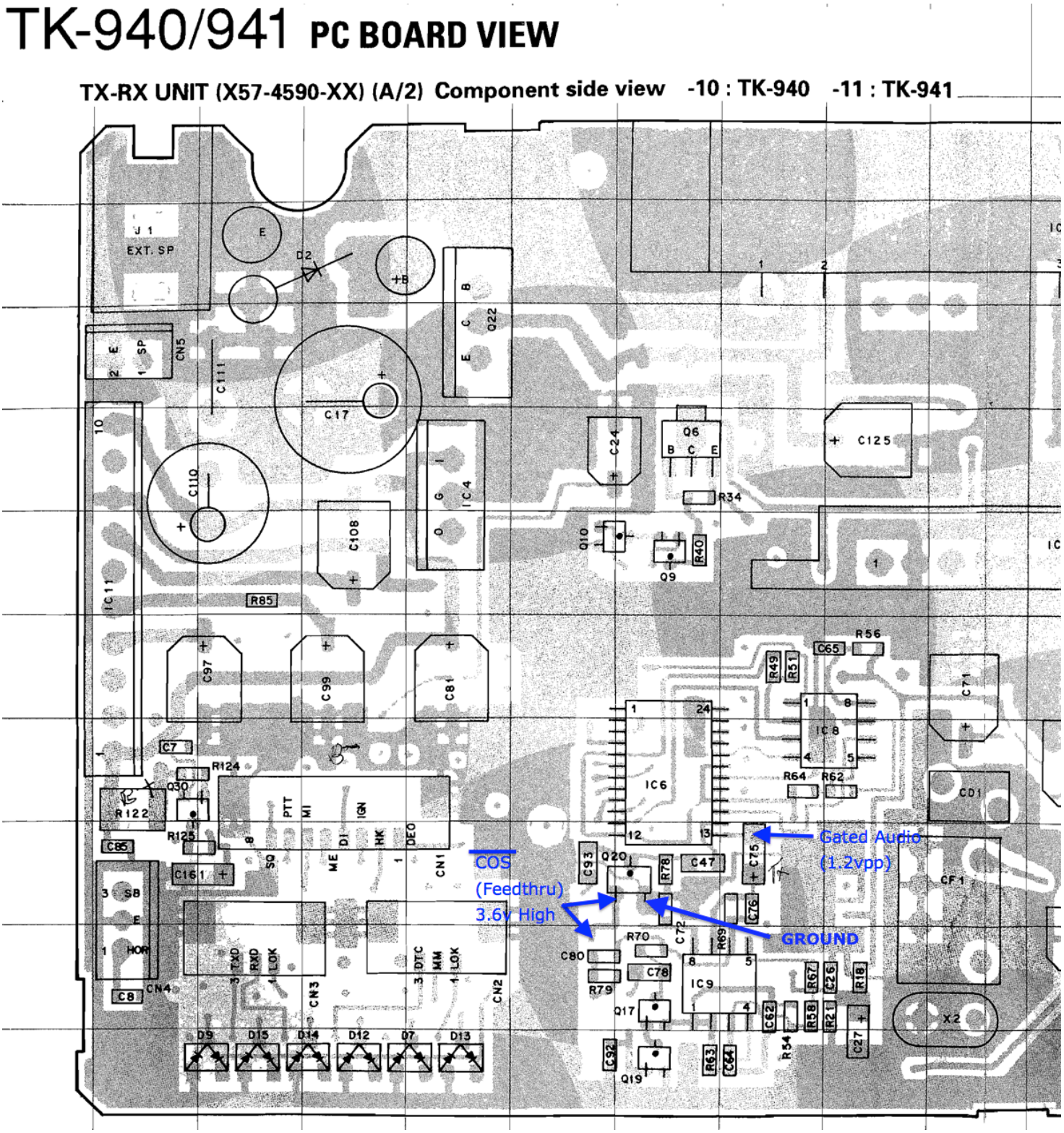
Repeater Controller Interface - Receive Radio

The repeater controller interface requires access to the COS signal and de-emphasized audio. The signal driving the BASE of Q20 presents an Active LOW COS. Further, the COS signal carries only the COS when programmed for COS access or the logical NAND of COS and Tone Decode when programmed for tone or DCS access. The observed logic level on the COS signal shows 3.6 volts when HIGH.

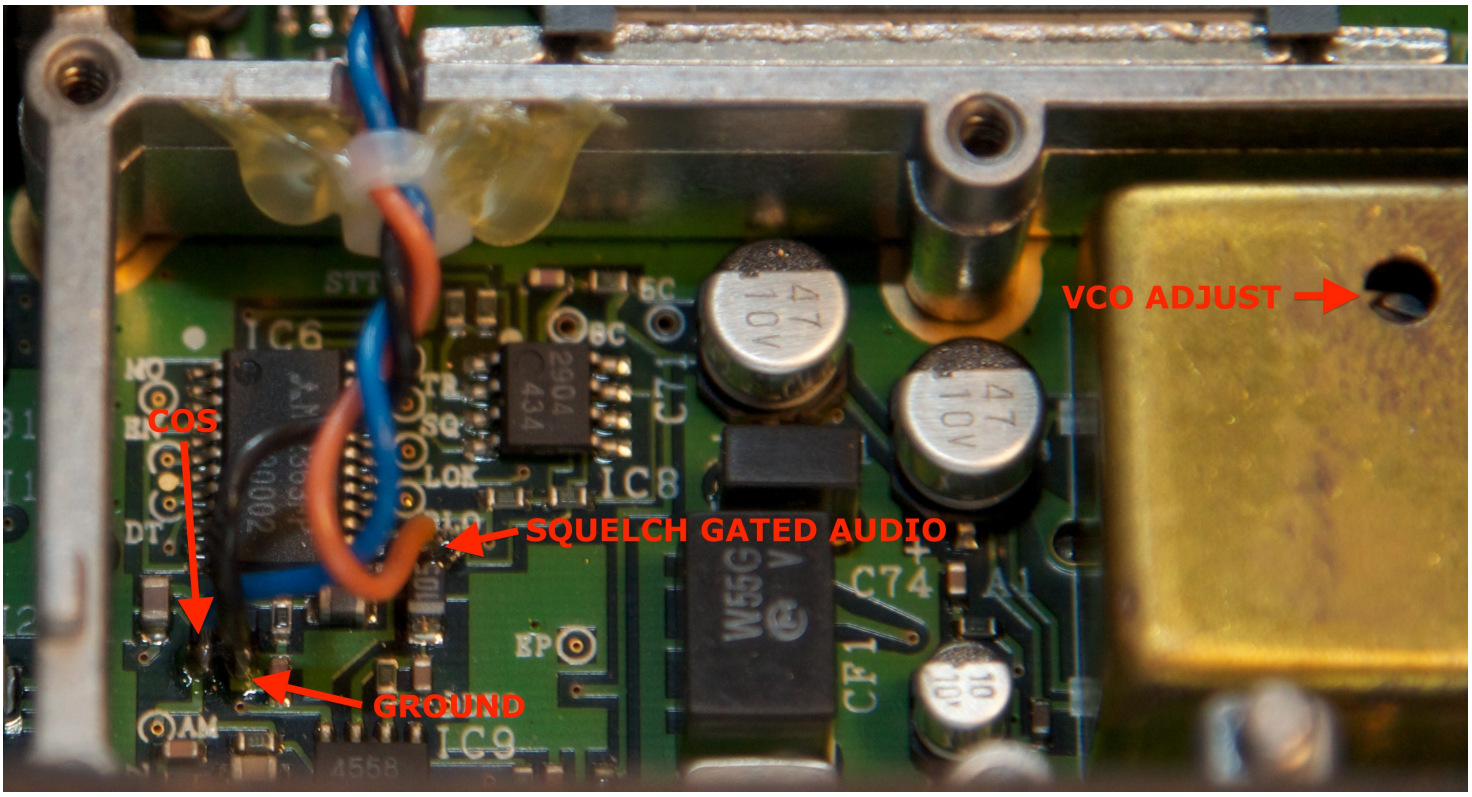
Squelch gated de-emphasized audio is available at the junction of C75 and IC6-13. The signal level of the audio, using a 1KHz tone with 3KHz deviation (as used for a -12 dB SINAD measurement), was observed to be 1.2 Vpp.



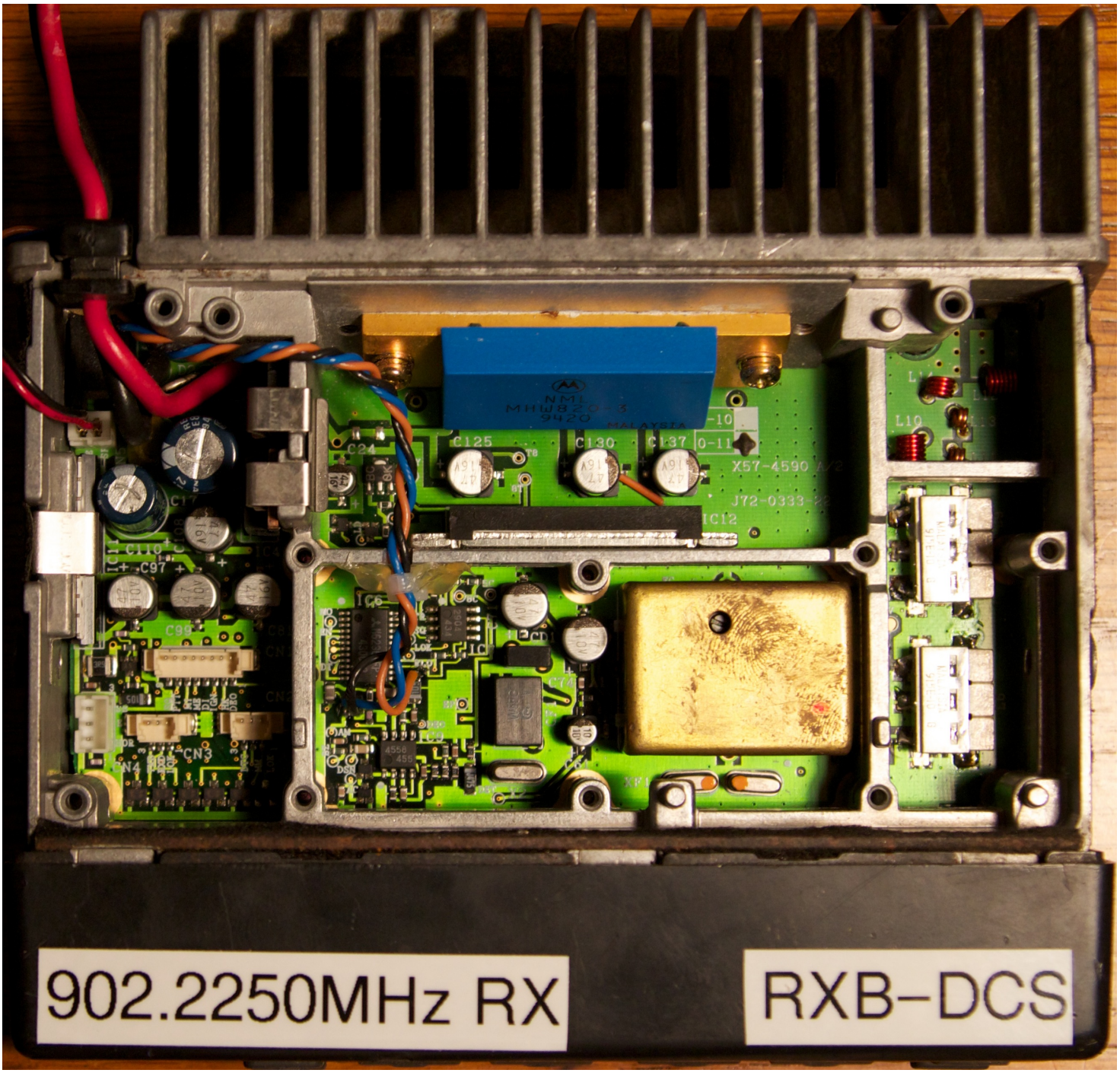
The following annotated PCB view shows where to connect the COS and Gated Audio signals to interface to the repeater controller.



The following image shows the repeater controller interface wires attached to the receive radio. The COS wire is blue. The squelch gated de-emphasized audio is orange. A black ground connection is made at emitter of Q20. A Dremel tool was used to grind a small slot to route the cable out of the RF shielded area where the interface signals are available. A Hot Glue gun was used to fasten down the wires, providing strain relief for the PCB pad connections.

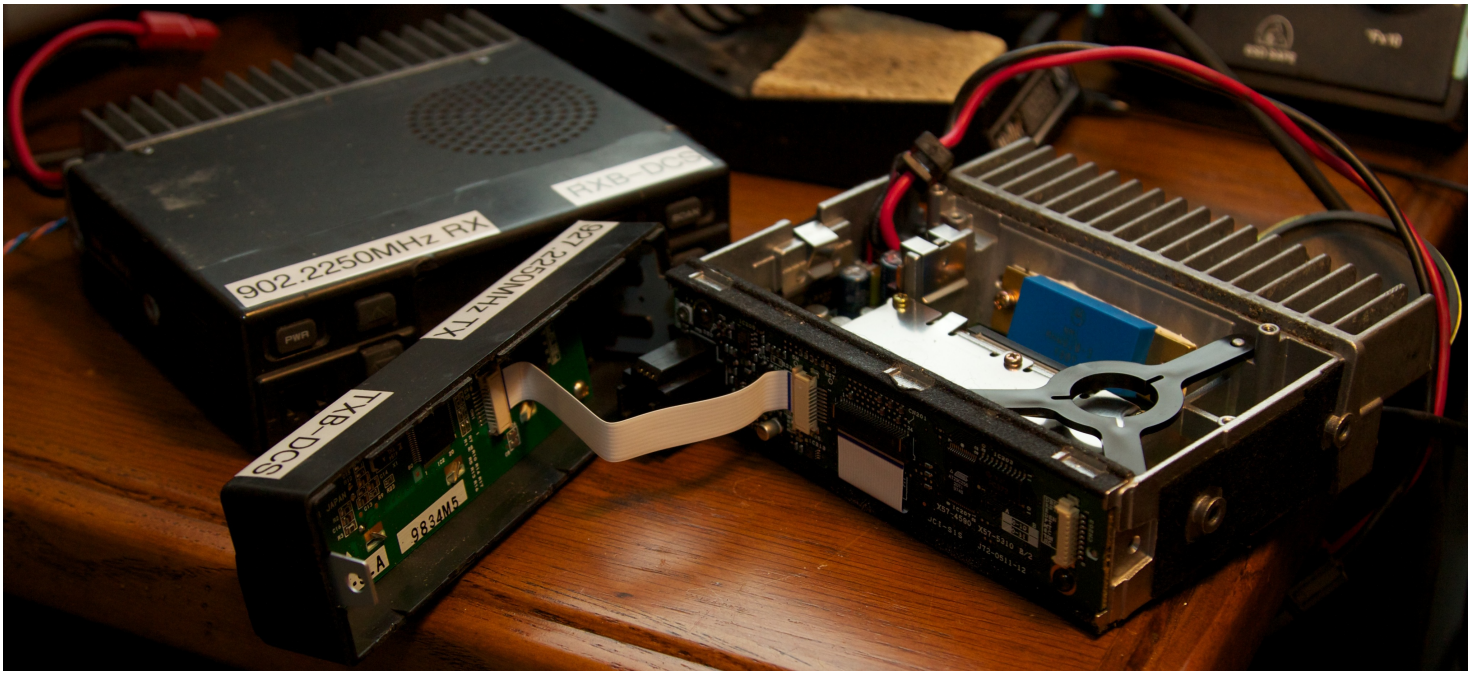


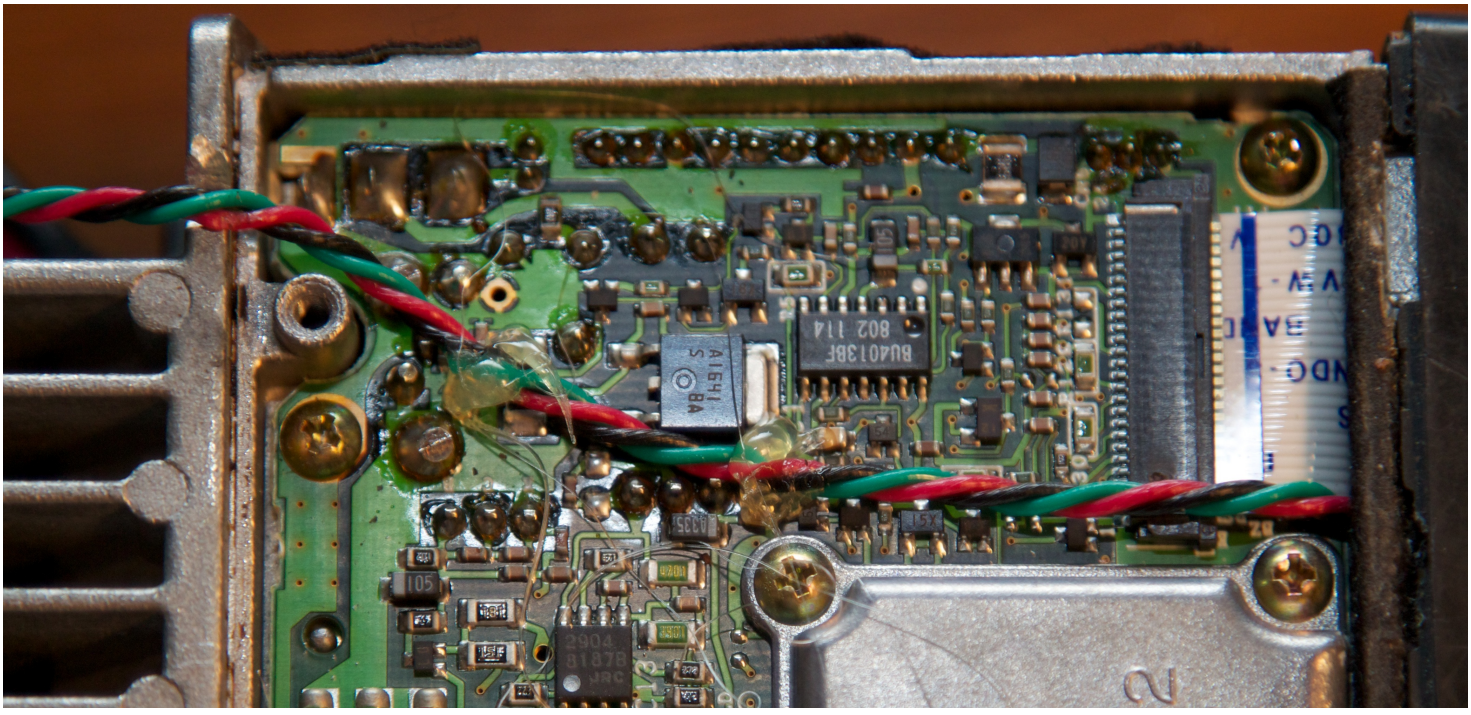
The power cable chassis strain relief can be lifted, exposing a small but removable plug. Removing this plug allows for routing of the repeater controller interface wires out of the radio chassis.



Repeater Controller Interface - Transmit Radio

The transmit radio requires access to the PTT and Microphone input signals. The front panel was removed in preparation to route wires from under the power cable and on to through the chassis to the front panel PCB.





The attachment points on the back of the front panel PCB are well marked as follows:

1. PTT: Push-to-talk (Green Wire)
2. ME: Microphone Return (audio-signal-ground - Black Wire)
3. MI: Microphone Input (Red Wire)