CRC **CACTUS Radio Club, Inc.**

Technical Application Note #4

This Technical Application Note describes the modifications that need to be incorporated into a Link Communications RLC series controller to achieve near Cactus Standard Audio response. The following instructions are individually described:

General Information
Input (Receive) Buffer Modifications
RLC-MOT Squelch Interface Modifications
Output (Transmitter) Buffer Modifications
Telemetry Generator Modifications
Audio Alignment Procedure

These modification instructions also require the use of the Armadillo® 1016 Radio Card in each receiver and transmitter used, or its equivalent with the controller.

This Technical Application Note #4 is available in electronic form, in its entirety including the diagrams and pictures, that can be read with the Adobe Acrobat Reader application. To obtain an electronic copy of this document, send an e-mail message to Ken Robbins, WA6PYJ, at ken@cactus-intertie.org and request an electronic copy of **Technical Application Note #4 - Modification Instructions for the Link Communications RLC Series Controllers.**

General Information

All controllers used within the Cactus Intertie System are required to meet strict audio standards. See Technical Application Note #2 - Cactus Standard Audio Requirements. These standards ensure the high quality audio response is maintained throughout the entire linked system without degradation as the audio passes through the entire linked structure. Any deviation from the technical requirements requires written approval from the Cactus Radio Club, Inc. Generally, exceptions will only be given to those remote bases that are end points and will remain end points of a particular link path. The Link Communications RLC series controllers DO NOT meet the Cactus Intertie System audio standards as they are shipped from the manufacturer. These modification instructions, when incorporated into the Link Communications RLC series controllers, will provide near Cactus Intertie System standard audio. Approval for the use of a Link Communications Controller on the Cactus Intertie System must be obtained from the Cactus Board of Directors prior to an installation.

The Link Communications RLC series controllers are designed typically for single site systems. The controllers are designed for processing receiver de-emphasized speaker audio and providing transmitter pre-emphasized microphone audio. These instructions disable all audio processing within the controller, and changes the de-emphasized audio filter for the tone decoder. This basically turns the controller into a software controlled cross-point switch. An **Armadillo® 1016 Radio Card**, or its equivalent, is required to be installed in each transmitter and receiver to be used with the controller for the audio processing. The cards can be ordered from Armadillo Intertie, Inc., 900 Carnegie Ct., Allen, Texas, 75002. Bare circuit boards are approximately $10.00 and circuit boards with components (no ICs or pots) installed are approximately $50.00. Contact Steve Hicks by phone or e-mail (n5ac@swbell.net) for orders, current prices and any additional information.

Input (Receive) Buffer Modifications

The input (receive) buffer circuitry incorporates a de-emphasizing network and some models also incorporate an integrating amplifying circuit. Cactus technical audio standards require a flat voice audio response from the receiver, through the controller and out the transmitter.

In the original design, the input to the DTMF (dual tone multi-function) decoder (MT 8870) is driven from the output of the input (receive) buffer operational amplifier, which is also the buffered received audio output that drives the output (transmitter) buffer. The DTMF decoder requires de-emphasized audio to work properly. This causes a conflict with the flat repeat audio response required by Cactus.

The modification changes the design such that the de-emphasizing network as well as an integrating amplifying circuit are used to supply audio to the tone decoder only. Modifications to the circuitry are required because the low input impedance design allows the audio level on the audio buss to all the radio cards to change as each radio card is adjusted. This means that an adjustment of each radio card will affect the audio level supplied to all the other radio cards.

The Receive Audio Input Level Adjustment becomes the DTMF Input Level Adjustment only. A separate audio input path is used for the repeat audio. Because the input of the de-emphasis network is a low impedance (5.1K ohms), adjustment of the 10K level adjustment POT causes the overall amplitude level of the audio buss to change. Without these modification it would be necessary to make repeated adjustments to each radio card in the controller to ensure the proper level is supplied to each tone decoder.

Input (Receive) Buffer Modifications (cont.)

The modifications that need to be performed are to change the first 5.1K ohm resistor after the 10K ohm level adjust POT to 68K ohm to provide the proper isolation. To make up for the added attenuation, the 100K ohm feedback (gain) resistor of the input (receive) buffer operational amplifier needs to be changed to 1 Meg ohm and the 100pf capacitor across the feedback (gain) resistor needs to be changed to 470 pf. This performs the required de-emphasis for the tone decoder. Therefore the internal de-emphasis network is not needed so there should be NO grounding of the 0.1 µf capacitor, i.e. for the applicable controller model, set the DIP switch to OFF (S1-1) or do NOT install a grounding jumper. See the Link Comm manual, receiver de-emphasis network section.

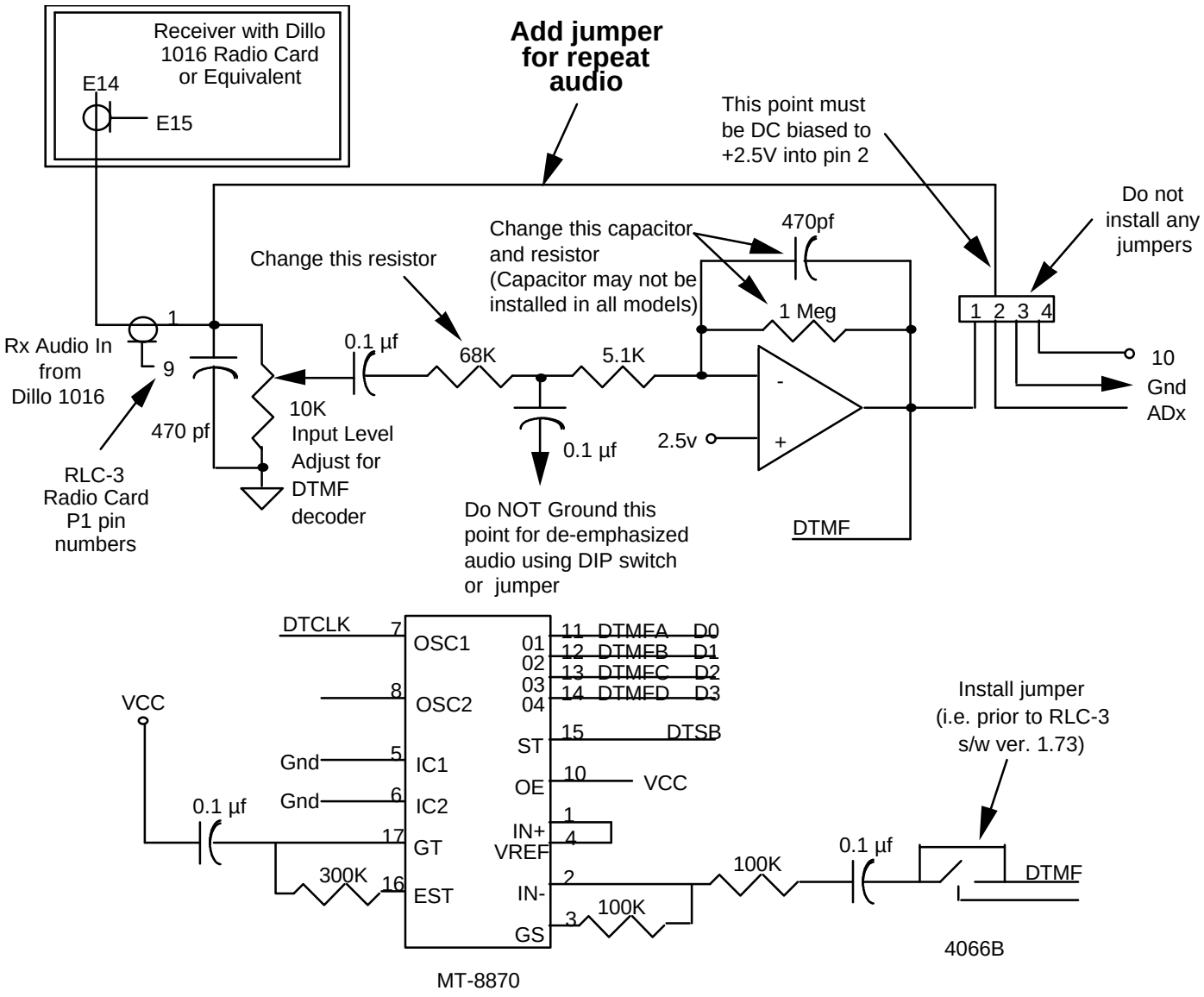
Some controller models have a 4066B CMOS switch in series with the DTMF audio to the tone decoder chip. This switch action needs to be disabled. This can be done in software, Version 1.73 or later for the RLC-3, or in hardware. Install a jumper across the switch connection for each tone decoder chip if the hardware modification is desired.

Use of the Armadillo 1016 Radio Card is the preferred method for the audio tailoring. One (1) 1016 Radio Card is required for each receiver and each transmitter that is used with the controller. The 1016 Radio Card should be installed in the receiver and the output (E14 hi , E15 low) should be connected directly to the Link Comm Radio Card DB 9 connector P1, at the RX Audio In pins (pin 1 hi, pin 9 low), with a shielded audio cable. On the Link Comm Radio Card, a jumper is required from the top of the 10K ohm level adjust POT to pin 2 (high) of the four (4) pin header connector. This jumper supplies the proper tailored audio from the 1016 Radio Card to the controller cross-point switch and the output (transmitter) buffers. Do not install any jumpers in the 4 pin header. The audio input, at pin 2 of the header, needs to be biased to +2.5 VDC. This can be accomplished by connecting 5 VDC through a 10K ohm resistor, or 10 VDC through a 27K ohm resistor to pin 2 of the header.

See the Input Buffer diagram below.

If the RLC-MOT Squelch Interface board is used instead of the Armadillo 1016 Radio Card, skip to the RLC-MOT Interface Board Modifications section for the continuation of the input (receive) buffer modifications.

Input (Receive) Buffer Modifications (cont.)



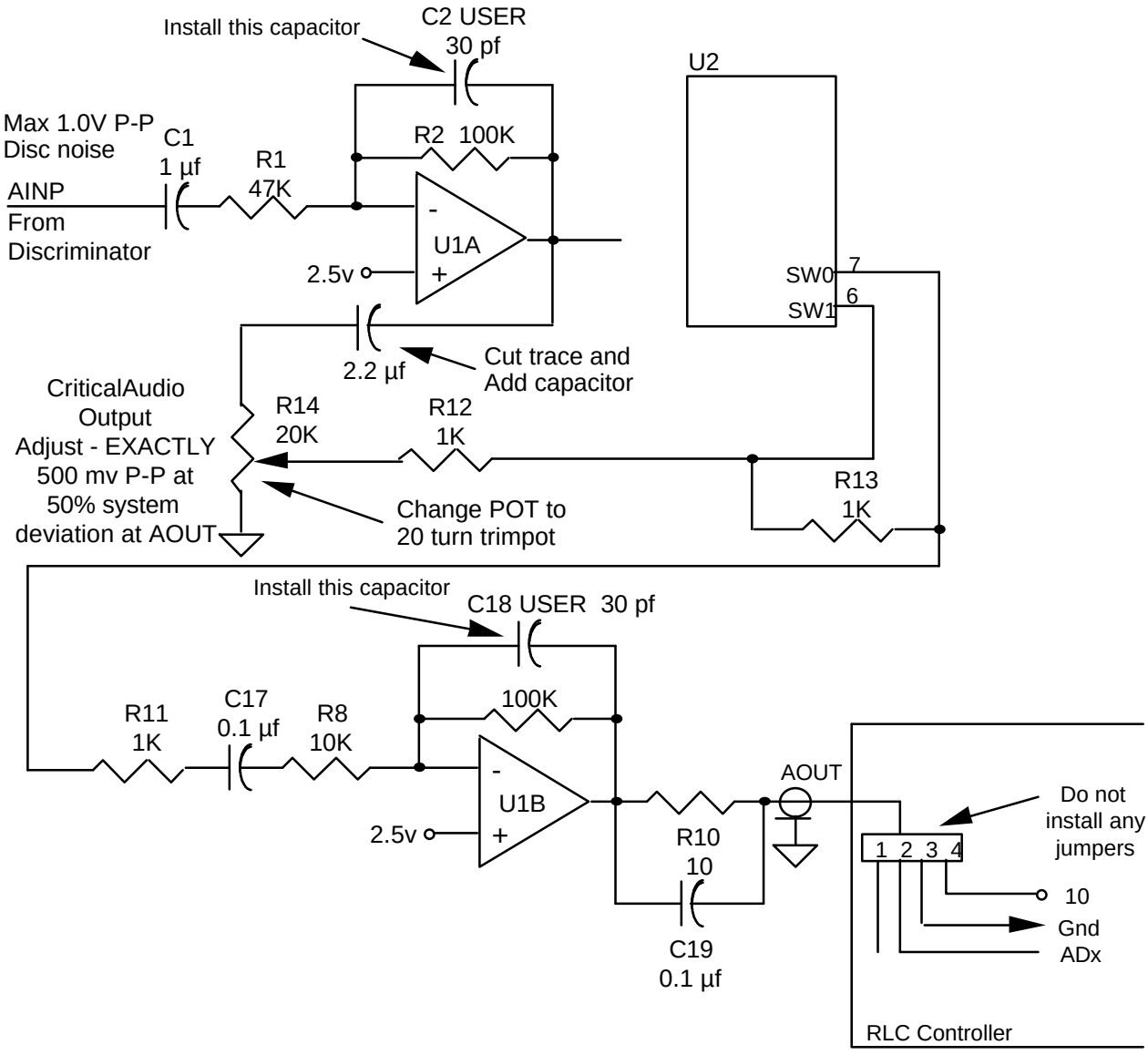
RLC-MOT Interface Board Modifications

If the preferred Armadillo 1016 Radio Card is not used, the RLC-MOT Interface board can be used to provide the squelched buffered discriminator audio into the main RLC controller. The two (2) USER capacitors, C2 and C18 may not be installed by the manufacturer. The USER capacitors, C2 and C18, should be installed and should have a value between 30 pf and 50 pf.

Cut the trace between the output of the U1A Op Amp and the input to the AUDIO OUTPUT ADJUST POT, R14, and install a 2.2 µf capacitor in series. Replace the single turn AUDIO OUTPUT ADJUST POT, R14, with a twenty (20) turn trimpot. Use no less than a ten (10) turn trimpot as this adjustment is very critical since this is the ONLY repeat audio adjustment available.

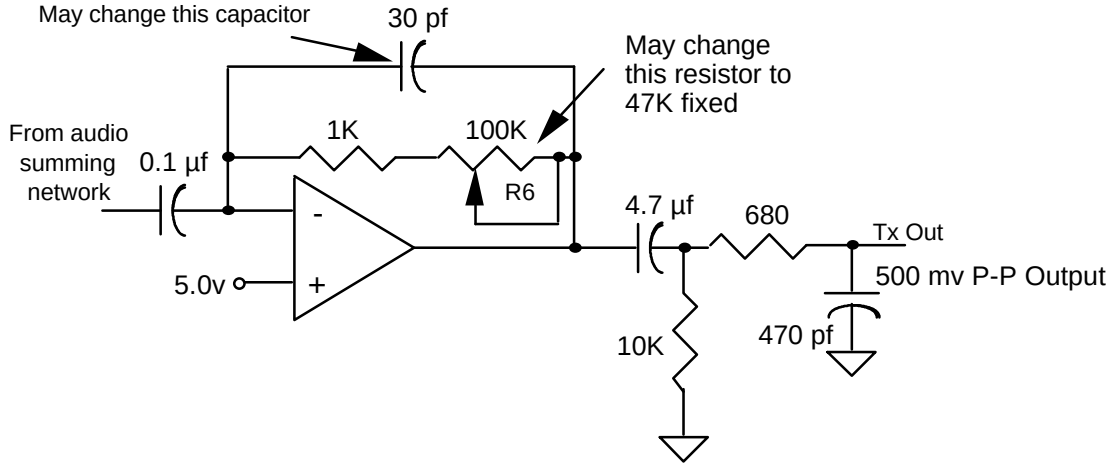
Ensure there is a maximum value of 1.0 V P-P of unsquelched discriminator noise supplied to the input (AINP) of the RLC-MOT Interface Board. Make whatever modifications necessary to ensure this value is not exceeded.

Use the AUDIO OUTPUT ADJUST trimpot, R14, to adjust the audio input level to the controller for the repeat audio. Use a shielded audio cable to supply the audio from the RLC-MOT Interface Board, AOUT at J1 pin 3, to the RX Audio In pins of the DB9 connector of the appropriate Link Comm Radio Card installed in the RLC controller board. This level should be set to exactly 500 mv P-P of receiver audio, using 50 % system deviation, at the RX Audio In pins of the DB9 connector of the appropriate Link Comm Radio Card installed in the RLC controller board. Remember that this point is biased to +2.5 VDC.

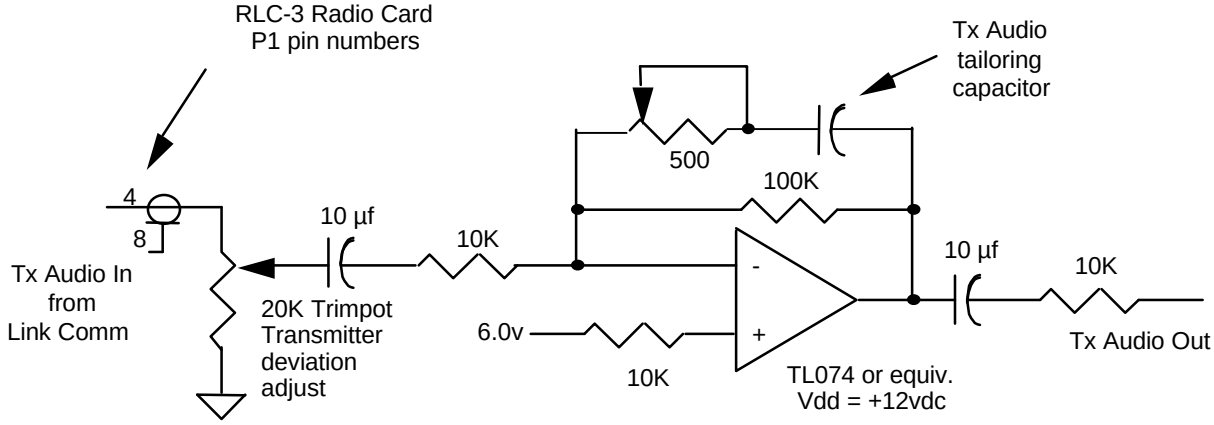


Output (Transmit) Buffer Modifications

The output (transmit) buffer circuitry incorporates an integrating amplifying circuit. Change the 100 pf capacitor that is in parallel with the feedback (gain) resistor(s) of the operational amplifier to 30 pf. See the Output Buffer diagram below. The 100K audio output trimpot value may be 200K in some models of the controller. The audio output trimpot may be replaced with a 47K ohm fixed resistor if desired. If the trimpot is used, the level should be adjusted for 500 mv P-P at the TX Out using 50% system deviation into the receiver.

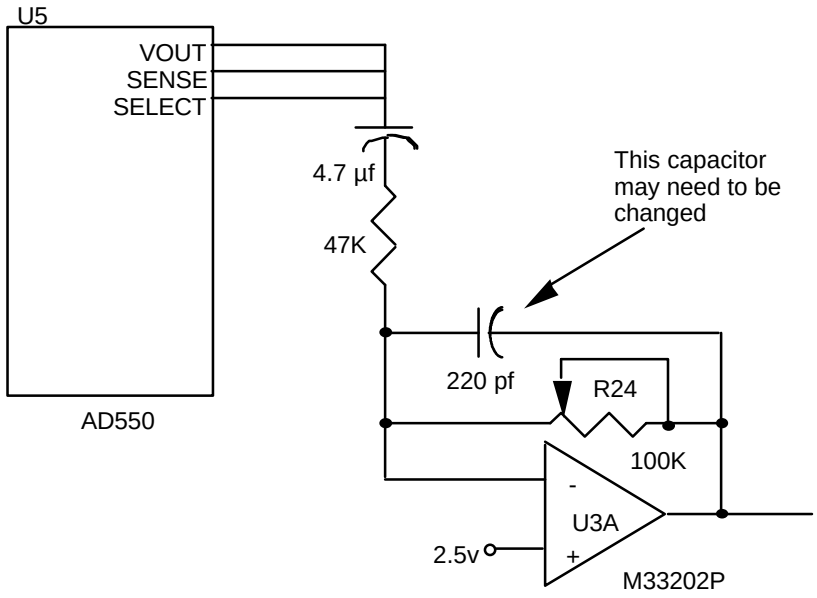


If the preferred Armadillo 1016 Radio Card is not used in each transmitter, an additional Transmitter audio buffer is required to be installed in each transmitter connected to the controller to perform the proper audio tailoring. The TX audio output of each Link Comm Radio Card DB 9 connector P1, at the TX Audio Out pins (pin 4 hi, pin 8 low), should be connected to the input of the corresponding Transmitter audio buffer with a shielded audio cable. An example of the Transmitter audio buffer is shown below.



Telemetry Generator Modifications

The de-emphasis of the telemetry tone generator may need to be modified to provide the proper audio quality to the transmitter. In some Link Comm controllers, the 220 pf capacitor may be 0.01µf. This capacitor needs to be changed to a value between 100 pf to 220 pf. The telemetry generator audio level should be set to 50 % system deviation after all other audio levels have been set.



Audio Alignment Procedure

After the controller has been interfaced with the radios, perform the following alignment procedure. The alignment should be performed in the order outlined in this procedure.

Receiver Audio Adjustments (refer to Technical Application Note 2 for additional information)

With the instrument(s) that will be used for the deviation level setting, connect the signal generator output to the deviation monitor input. Using a 900 Hz tone, set the deviation of the signal generator between 40% and 60% of full system deviation, 1.6 KHz to 2.4 KHz for a narrowband receiver (4.0 KHz) and, 4.0 KHz to 6.0 KHz for a wideband receiver (10.0 KHz). Pick a value that can be accurately measured with the deviation monitor. Make sure both agree on the deviation level.

1) Set up the controller so that all receive ports are in carrier squelch mode, no CTCSS required, and all transmitter ports are turned off.

2) Locate the TEST BUS connector. It is usually a 10 pin connector on the main controller board.

3) Attach an oscilloscope to pin 1. This point monitors the output of the Receive 1 Input Buffer amplifier at the point where it enters the cross-point switch.

4) Adjust the Receiver 1 squelch pot (R24 on the Dillo 1016 Radio Card) such that the receiver is squelched, i.e. no noise on the oscilloscope. If the RLC-MOT Interface Board is being used, adjust R3 for this measurement.

5) Inject a strong signal into Receiver 1. The signal should be modulated with a 900 Hz tone between 40% and 60% of full system deviation.

6) Adjust the Receiver 1 input level adjustment pot (R26 on the Dillo 1016 Radio Card) such that the signal on the oscilloscope is between 400 mv P-P and 600 mv P-P. The exact value will correspond to the percentage of input deviation injected into the receiver, i.e. 40% input deviation corresponds to 400 mv P-P and 60% input deviation corresponds to 600 mv P-P. If the RLC-MOT Interface Board is being used, adjust R14 for this measurement.

7) Repeat step 3 through step 6 for each of the remaining receivers. The pin number of the TEST BUS connector pins corresponds to each receiver, i.e. pin 1 - Receiver 1, pin 2 - Receiver 2, etc.

Tone Decoder Adjustment

1) Inject a strong signal into Receiver 1. The signal should be modulated with a 430 Hz tone at full system deviation. Use ±5 KHz deviation for a narrow band receiver and ±10 KHz deviation for a wide band receiver.

2) Attach an oscilloscope to pin 3 of the tone decoder chip that is connected to the receive 1 path that is to be adjusted.

3) If you have a variable audio generator, manually sweep the audio tone between 300 Hz and 600 Hz to find the audio tone frequency that has the highest amplitude level as shown on the oscilloscope. Typically the peak frequency will be approximately 430 Hz.

4) Adjust the input level to the tone decoder, using the Receiver 1 level control pot on the Link Comm Radio Card until the signal is clipped.

5) Slowly decrease the input level to the tone decoder, using the Receiver 1 level control pot, until the signal just comes out of clipping.

6) Repeat steps 1 through 5 for each of the remaining receiver port tone decoder chips.

Output (Transmitter) Buffer Adjustments

If the R6 pot on the Output (Transmitter) Buffer stage of the Link Comm Radio Card was NOT replaced with a fixed resistor, perform this adjustment.

1) Set up the controller so that all receive ports are in carrier squelch mode, no CTCSS required, and all transmitter ports are turned on.

2) With the signal generator still connected to the Receiver 1 input and generating a 900 Hz tone, attach the oscilloscope to the Transmitter 1 TX Audio output of the Link Comm Radio Card at P1 pin 4 (high) and pin 8 (low) or an equivalent point.

3) Adjust the R6 pot located on the Link Comm Radio Card such that the signal on the oscilloscope is between 400 mv P-P and 600 mv P-P. The exact value will correspond to the percentage of input deviation injected into the receiver, i.e. 40% input deviation corresponds to 400 mv P-P and 60% input deviation corresponds to 600 mv P-P.

4) Repeat step 2 and step 3 for each of the remaining Output (Transmitter) Buffers. The signal generator should remain connected to the Receiver 1 input and the oscilloscope should monitor each of the corresponding Output (Transmitter) Buffers.

Transmitter Audio Adjustments

1) Set up the controller so that all receive ports are in carrier squelch mode, no CTCSS required, and all transmitter ports are turned on.

2) Take any transmitter using CTCSS out of encode mode. If this is not possible, carefully measure the CTCSS peak deviation and add the deviation value to the target deviation levels specified in this procedure. Example: if the CTCSS peak deviation is 600 Hz and the audio target deviation specified is 2.5 KHz, the corrected deviation will be 3.1 KHz (0.6 + 2.5 = 3.1).

3) Measure transmitter noise by injecting a full quieting, on channel signal into a receiver. Adjust the monitor's frequency to measure the Transmitter 1 output. Turn Off the 900 Hz tone deviation at the generator and accurately measure the deviation of noise generated by the transmitter.

4) The proper deviation level that the transmitter is to be set to is the value chosen as a result of the 40% to 60% of full system deviation level chosen plus the transmitter noise level measured plus the CTCSS level.

5) Turn On the 900 Hz tone deviation signal into Receiver 1. The signal should be modulated with a 900 Hz tone between 40% and 60% of full system deviation.

6) With the signal still being injected to Receiver 1, monitor Transmitter 1 output with a deviation monitor. Adjust the Transmitter 1 output level adjust (R27 on the Dillo 1016 Radio Card) to achieve the 40% to 60% of full system deviation level chosen plus the transmitter noise level measured plus the CTCSS level. If a transmitter audio buffer card was built, adjust the 20K trimpot deviation adjust for this level.

7) Repeat step 2 through step 6 for each remaining transmitter output. The input signal should continue to be injected into Receiver 1 while adjusting each additional transmitter output to achieve the 40% to 60% of full system deviation level chosen plus the transmitter noise level measured plus the CTCSS level. Be careful to remember which transmitters are narrowband and which are wideband.

Transmitter Audio Adjustments (cont.)

8) Monitor Transmitter 1 output with a deviation monitor. The signal generator should still be connected to Receiver 1. Very carefully measure the output deviation. Calculate the output system deviation percentage.

9) With the monitor still connected to Transmitter 1, connect the signal generator to Receiver 2. Set the deviation of the 900 Hz tone on the signal generator to the EXACT same system deviation percentage that was calculated in step 8. Be careful to remember which receivers are narrowband and which are wideband. Make a slight adjustment to the Receiver 2 input level adjustment pot (R26 on the Dillo 1016 Radio Card or R14 on the RLC-MOT Interface Board) such that the signal measured on the Transmitter 1 monitor is the exact same level as measured in step 8. This trimming balances out the minor variations in level measurements between receivers.

10) Repeat step 9 for each remaining receiver input.

Tone Encoder Adjustment

1) Adjust the deviation monitor's frequency to measure the Transmitter 1 output. Command the controller to transmit the site ID (or any equivalent steady tone).

2) Adjust R24 on the Link Comm Port 1 Radio Card for 50% peak system deviation.

3) Adjust the monitor's frequency to measure the Transmitter 2 output. Prefix the controller from Receive 2 Link port so that the controller will generate dialtone to the Transmitter 2 output.

4) Adjust R24 on the Link Comm Port 2 Radio Card for 50% peak system deviation.

5) Repeat step 3 and step 4 for each remaining transmitter in the system. Be careful to remember which transmitters are narrowband and which are wideband.