MOTOROLA INC.

Universal Simulcast Controller Interface (USCI)

Model TRN7349A

Installation Guide

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MOTOROLA INC.

Universal Simulcast Controller Interface (USCI)

Introduction

A quality installation and maintenance program is the key to trouble free equipment operation. This manual is for experienced technicians familiar with Motorola trunked SMARTNET equipment. Motorola recommends reading the entire manual before beginning the installation. The information in this section describes the basic functions, installation, and maintenance of the Universal Simulcast Controller Interface (USCI).

Technical Support

During installation, optimization, and maintenance of trunked systems, technical personnel should contact, as necessary, the following support services provided by Motorola.

Motorola Systems Support

If this product requires servicing, there is an 800-number to call for assistance with trouble reporting and product diagnosis. Before calling for assistance, collect the following information to speed up the process of analyzing and correcting the problem.

- Central controller system ID number (Example: 2CB5)
- Type of system (Simulcast, AMSS, etc.)
- Software versions of the central controller (CSC Board)
- Symptoms of the problem you have observed
- If the problem can be reproduced, the steps that cause it to occur
- When you first noticed the problem
- Location of the system
- The date the product was put in service
- Any unusual circumstances that may have contributed to the problem; i.e., loss of power to the system

MOTOROLA SYSTEMS SUPPORT
(800) 228-4500

Motorola Hi-Tech Service Center

IMPORTANT
Due to the advanced technology and manufacturing process of the Motorola trunked equipment, you should not attempt to repair modules in the field. Motorola suggests you call the Hi-Tech Service Center for a replacement, and then send the failed module to the service center for repair. In addition, Hi-Tech repairs central controller boards, power supplies and modems. Retain the original shipping cartons in case you need to relocate or transport the equipment in the future.

Contact the Motorola Hi-Tech Service Center at:

1335A Basswood Drive
Schaumburg, Illinois 60173
(708) 576-7300

MOTOROLA HI-TECH SERVICE CENTER
(708) 576-7300
or
(800) 448-3245

Motorola Midwest Depot

The Motorola Midwest Depot repairs modules associated with the Micor and MSF 5000 base station repeaters. In addition, Midwest Depot repairs mobile and portable radios and other RF-related equipment.

Contact Motorola Midwest Depot at:

1318 N. Plum Grove Road
Schaumburg, Illinois 60173
(708) 576-5760

MOTOROLA MIDWEST DEPOT
(708) 576-5760
or
(800) 421-4564

Safe Handling of CMOS Integrated Circuit Devices

Refer to publication 68P81106E84, Safe Handling of CMOS Integrated Circuit Devices (located at the beginning of this manual), for more information on this subject. Always use the wrist strap when handling any board or module.

FCC Requirements

FCC regulations state:

- Only personnel holding a general class commercial radio telephone operator's license or non-licensed persons working under the immediate supervision of licensed operators should make adjustments to radio transmitters.
- The power input to the final RF stage shall not exceed the maximum power specified on the current station authorization. Measure the power input and record the results:
  - During initial installation of the transmitter.
  - When making adjustments affecting the carrier frequency or modulation characteristics of the transmitter.
  - At one year intervals.
- Frequency and deviation of a transmitter must be checked:
  - During initial installation of the transmitter.
  - When making adjustments affecting the carrier frequency or modulation characteristics of the transmitter.
  - At one year intervals.

Description

In a simulcast trunked radio system, the Universal Simulcast Controller Interface (USCI) is an important element to the audio network. It links the audio/data from the central controller and the DIGITAC (or Spectra-TAC) with the microwave transmit audio/data. With the USCI, Simulcast systems can use analog (Dual Path) or digital (Digital Path) microwave for audio and data distribution to the remote sites.

In two-level and four-level systems, each base station repeater channel requires a TRN7349A, USCI module. A T5180A, Simulcast Controller Interface (SCI) card cage houses up to eight USCI modules and a single system can have a maximum of four SCI card cages. An individual card cage must have a TPN1153A, 13.8V DC power supply as shown in Figure 1. Each USCI module connects to the central controller via TKN8560A, central controller interface cable. A TELCO 25-pair cable (p/o kit TRN7092A) connects four USCI modules to one punchblock (for distribution to the microwave).

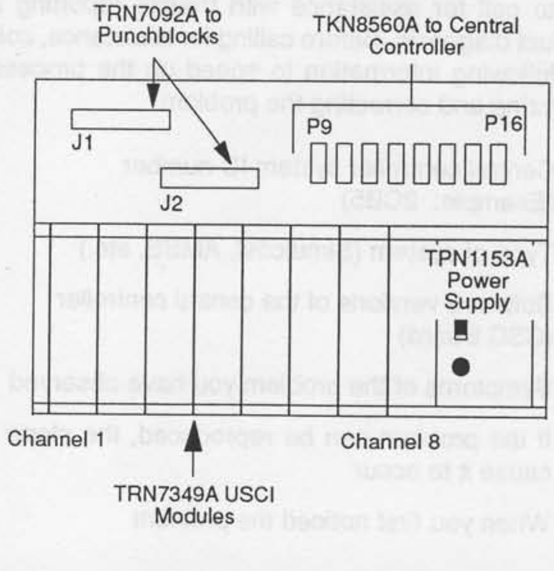

Figure 1. Universal Simulcast Controller Interface Chassis With Eight Modules

Four-Level Systems

Four-level secure simulcast systems use Prime Site Four-level Recovery Encode Decode (PS-FRED) modules to intercept the coded audio before it reaches the USCI. The PS-FRED reformats the data and sends it to the microwave multiplexer, so you must have one PS-FRED module for each secure RF channel. You must daisy-chain the SCI card cage to the PS-FRED card cage. The PS-FRED channels must connect to the same USCI channel (e.g., PS-FRED channel one must connect to USCI channel 1).

USCI Module Functional Description

Figure 2 illustrates the five functional blocks of the USCI. These include: Transmit Audio, Central Controller Interface, Failsoft Control Circuitry, TData Distribution Circuitry, and FSK Encoder.

Transmit Audio Circuitry

The transmit audio input to the USCI module is compressed (if necessary), pre-emphasized, clipped, and low-pass filtered for transmission. The transmit audio circuitry has the following characteristics:

- Input Level (1 kHz test tone):
  - -10 dBm with no compression
  - -8.1 dBm with compression
- Input Termination: 600 Ohms balanced
- Pre-emphasis: 6 dB per octave from 300 Hz to 3 kHz
- Clipping: limits output to 80% deviation at transmitter for clear audio
- Low pass filter: corner frequency = 8 kHz
- Maximum output level: 700 mV P-P typical; 740 mV P-P maximum
- Output termination: 600 Ohms balanced
- Signal-to-noise: 50 dB minimum for clear audio
- Frequency Response: +1 to -3 dB from 300 Hz to 3 kHz for 6 dB per octave pre-emphasis with input level of -20 dBm
- Distortion: less than 1% for 1 kHz test tone input of -15 dBm

Central Controller Interface

The USCI acts as an interface between the trunked central controller and all remote site transmitters. The USCI distributes lowspeed and highspeed data, acts on the PTT and Highspeed Indicate control signals from the central controller, and sends the TStat indications back to the central controller.

The central controller interface circuitry accepts TData, PTT, and Highspeed Indicate from the trunked central controller. It distributes the signals to the Failsoft Control Circuitry and the TData Distribution Circuitry sections. The central controller Interface also generates a PTT and TStat output signal.

NOTE

The USCI expects all TData from the Transmitter Interface Board (TIB) to be unfiltered and 9V P-P. The USCI also expects the Highspeed Indicate In line from the TIB to act as a High/Low line.

Failsoft Control Circuitry

Automatic Wide Area Failsoft

The failsoft control circuitry monitors the TData input for data. It places the module in the failsoft mode when no data transitions are detected for 300 mS. The failsoft and PTT LEDs turn on; TStat switches high and sends a PTT and failsoft indication. It also generates an alert tone and passes it to the audio output terminals.

The failsoft signal has the following characteristics:

- Failsoft time-out period: 300 mS nominal
- Alert tone format: 900 Hz tone with a duration of 284 mS, repeated at 9.7 second intervals
- Alert tone level: 13.6% of system deviation
- Failsoft word format: Hex word $A510C sent at 150 baud to the TData Distribution Circuitry (see the *TData Distribution Circuitry* section.)
- Clock: Crystal controlled with a 3.6864 MHz output frequency

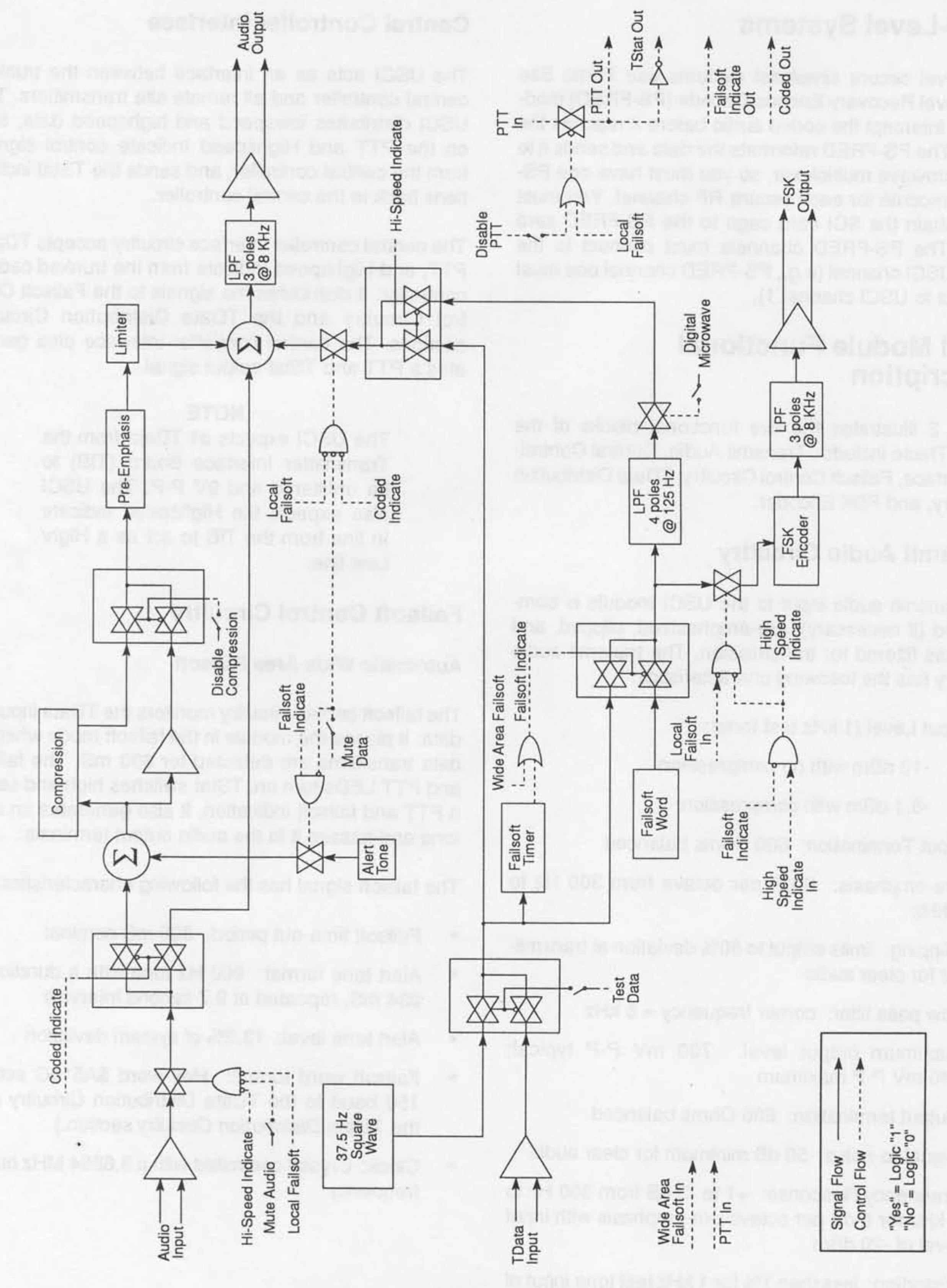

Figure 2. USCI Functional block Diagram

Forced Wide Area and Local Failsoft

If you want the system to enter the wide area failsoft mode because of an alarm condition (such as losing part of the microwave network), the alarm can force the USCI into wide area failsoft. This forced mode operates exactly as the automatic wide area failsoft mode except the central controller continues sending TData when the USCI is forced into wide area failsoft.

The user can decide if each site in a simulcast system should be in local failsoft during a system alarm condition. In this case, the USCI can be forced into local failsoft mode. The USCI effectively shuts down during local failsoft. It mutes the audio and data paths, disables the PTT, TSTAT, and alert tone signals, and sends a constant 1200 Hz from the FSK encoder during local failsoft. The remote site receivers do not detect any audio or data from the prime site and enter the failsoft mode.

TData Distribution Circuitry

The TData Distribution Circuitry routes the TData through the USCI according to its mode of operation set by switch SW2-4. If this is a Dual Path Simulcast system (switch SW2-4 closed), using analog microwave equipment, the USCI routes the lowspeed and disconnect data, and the failsoft word to the FSK Encoder section.

If this is a Digital Path Simulcast system (switch SW2-4 open), using digital microwave equipment, the USCI allows the lowspeed and disconnect data, and failsoft word to pass through a low pass filter (a 4-pole Bessel filter with a cutoff frequency of 120 Hz) and sums it with the audio path. Both systems sum the Highspeed data directly with the audio path without any filtering.

FSK Encoder

The FSK encoder accepts the squared lowspeed TData or failsoft word, synchronizes the data with a 614.4 kHz clock, and encodes the data as 1200 Hz and 2400 Hz tones. These tones are buffered and sent through a lowpass filter to remove all high order harmonics. The output consists of an amplifier with a fixed or adjustable gain (jumper selectable) driving a balanced, dual-opamp line driver stage.

User Interface

To aid in optimizing and troubleshooting, the following sections explain the service functions of the USCI.

SW1 Test Modes

Closing any one of the four DIP switches of SW1 causes the green power LED to flash on and off. The flashing power LED indicates the USCI is in the test mode. The module cannot process calls when in the test mode.

The following are brief explanations of the tests you can perform using switch SW1.

- Mute Data Path: Closing switch SW1-1 prevents the lowspeed and highspeed data from being summed into the audio path. This also disables the alert tone generator. This mode is useful for audio path optimization and level setting with no data present. Switch SW1-1 does not affect the FSK path.
- Mute Audio Path: Closing switch SW1-2 mutes the audio path and allows only data out of the audio outputs. This mode is useful for data path optimization and level setting without removing the audio input signal. Unlike past versions of the Simulcast Digital Microwave Interface (SDMI), the alert tone does not mute when the audio path is muted. When adjusting the data deviation, use the test data signal described in *Generate Test Data*.
- Generate Test Data: Closing switch SW1-3 substitutes a 37.5 Hz square wave for TData and disables the highspeed indicate. This mode is useful for optimizing the FSK path as well as the data/audio path. The test data signal also provides a 50% duty lowspeed signal for setting the lowspeed deviation levels.
- Disable PTT: Closing switch SW1-4 prevents a PTT from being sent to all the remote sites. By disabling the PTT, you can send individual PTT signals to specific sites with a Prime Optimization Node (PON) or Simulcast Distribution Amplifier (SDA) DIP switches.

Potentiometers R110 and R143 (front panel)

Potentiometer R110, on the front of the USCI, sets the audio output level. This adjustment does NOT affect the clipping level. You can adjust this pot for ±3 dB of gain/attenuation for the non-compressed audio path.

The lower potentiometer (R143) adjusts the gain in the data path (not the FSK path). The Lowspeed TData levels in a trunked system are usually one third the deviation level of the test tone (e.g., test tone = 60% system deviation, lowspeed TData = 20% system deviation).

Phone Jacks J2, J3, and J4 (front panel)

- J2 is a high impedance, transmit path optimization input. It allows you to inject tones into the transmit path, prior to the summing circuitry of the USCI, to help optimize the simulcast system.
- J3 is a bridged monitor for the audio input signal. To use this jack as an input, remove any connection to the audio inputs on the punchblock. This prevents double termination of the input. When the jack is used to monitor the incoming signals, the audio level is unaffected.
- J4 is a sampling jack for TData from the FSK data path. You can sample TData from this jack without disturbing the data paths.

LED Indicators

- The green LED indicates the presence of 13.8V DC on the USCI. If the 500 mA fuse on the module blows, the green LED turns off. If one of the SW1 DIP switches closes, the green LED flashes to alert the user the USCI cannot properly handle the trunking calls. Disable the channel at the trunked central controller any time the green LED is flashing.
- The red LED indicates the keying of the transmitters at all sites. The red LED is on if the central controller is sending a PTT indication, or if the USCI is in the wide area failsoft mode. Closing switch SW1-4 turns the red PTT LED off, if lit, and starts the green power LED flashing.
- The yellow LED indicates failsoft mode. If the module is in the trunked mode, the yellow failsoft LED is off. If the module is in wide area failsoft, the yellow LED is on. If the module is in local failsoft, the yellow LED flashes.

DIP Switches

SW1 Functions

This four position switch is located at the front of the USCI. You can use this switch to test the USCI. If you have a flashing power (green) LED, one of the four switches is closed and indicates a non-functional channel.

The SW1 DIP switch operates as follows:

- Switch SW1-1 mutes the data path and disables the alert tone generator. Close switch SW1-1 when making audio path measurements without data or alert tone signals present. This switch does not affect the FSK data path.
- Switch SW1-2 mutes the audio path. Close switch SW1-2 when making data path measurements without audio present. Use this switch instead of removing the test tone inputs.
- Switch SW1-3 routes test data, 37.5 Hz square wave, to the TData Distribution Circuitry instead of TData. Closing SW1-3 places the module in the trunked mode (if pins 16 and 18 aren't grounded). The test data is the same amplitude as the lowspeed TData and can be used to set the system data deviation levels. The simulcast system optimization can use this test data.
- Switch SW1-4 disables PTT. Closing SW1-4 allows individual site keying with a Simulcast Distribution Amplifier (SDA) or a Prime Optimization Node (PON) while the USCI is in failsoft. Closing switch SW1-4 is an effective way to remove a channel from service since it also disables TStat.

SW2 Functions

This four position DIP switch is near the back of the USCI. You only need to set the switches on SW2 once, during equipment setup.

- Switch SW2-1 disables the Highspeed Indicate when closed. Every trunked simulcast system needs the Highspeed Indicate enabled. Conventional simulcast systems, using a USCI for audio processing, close SW2-1 to keep the audio path from muting. The Highspeed Indicate is held low by the trunked central controller. Closing switch SW2-1 holds the Highspeed Indicate line low for conventional systems.
- Switch SW2-2 disables the compression circuit in the audio path. Close switch SW2-2 for the simulcast systems in bands where companding is not used (806 MHz).
- Switch SW2-3 selects which failsoft mode has priority when failsoft occurs. If SW2-3 is open, the USCI is in the wide area failsoft mode if indications for both wide area and local failsoft are present. If SW2-3 is closed, the USCI is in the local failsoft mode if indications for both wide area and local failsoft are present. See the *Failsoft Control Circuitry* section for more information on wide area and local failsoft.

- Switch SW2-4 selects the path the lowspeed data takes within the USCI. If the simulcast system uses a digital microwave distribution system (Digital Path), SW2-4 must be open. The USCI filters and sums the lowspeed data into the audio path. Close switch SW2-4 if the simulcast system uses an analog microwave distribution system (Dual Path). The USCI squares the lowspeed data and FSK encodes it. Dual and Digital Path sum the highspeed data into the audio path unfiltered.

Theory of Operation

Refer to the schematic diagrams for the following explanations.

Transmit Audio Circuitry

Balanced Input Stage

The transmit audio enters the USCI on pins 2 and 3 of edge connector J1. This is a balanced 600 Ω input consisting of an opamp buffer for each line input whose output feeds the input of an opamp differential stage. This input configuration presents the input line with a balanced impedance while minimizing the common mode line noise. It also transforms the balanced signal into a single ended signal (U1-1) for driving the next stage. A matched resistor package, RD1, provides a precise balance to the single-ended converter.

Audio Path Mute Gate

The audio path on the USCI, U5-12, can be muted for three different reasons. First, the Highspeed Indicate from the central controller mutes the audio path while the highspeed, 3600 baud, data is being sent. Second, the audio path mutes when the USCI is forced into local failsoft. Third, you can mute the audio path with switch SW1-2 during the system setup and optimization procedures.

Coded Indicate

The DIGITAC tells the USCI when a coded call is in progress by pulling J1-15 low. U28-11 pulls U2-11 low to select the coded audio path when Coded Indicate In is low. When U2-11 is low, the compression circuitry is bypassed in the clear audio path. This minimizes the noise generated in the clear audio path. During a coded call, U13-1 is high, U19-12 is low, and opto-isolator U9 is on. Coded Indicate Out is a floating output, so it can connect to the microwave equipment running on -24V DC or -48V DC. Coded Indicate Out (+), J1-7, connects to the more positive potential on the M-lead, and Coded Indicate Out (-), J1-7, connects to the more negative potential on the M-lead. Since microwave equipment operates on negative DC voltages, Coded Indicate Out (-) typically connects to a fixed negative voltage, and Coded Indicate Out (+) connects to the switchable M-lead input.

Clear/Coded Audio Path Switching

The output of the audio path mute gate, U5-11, connects to the clear/coded analog mux gate, U2-14. This mux gate passes the audio to the clear audio path when Coded Indicate In, J1-15, is *not* held low. Following the mux gate, the signal splits with the clear audio, U2-13, going through either the compression stage or a simple gain stage, and the coded audio, U2-12, going through a very high gain stage to square the DVP data. The two paths meet at the summing amplifier, U8-9.

Alert Tone Summer

The Clear audio first passes through a summing amplifier serving two purposes. The alert tone, generated in the failsoft circuitry, is summed with the audio path at U7-13. Also, the gain for the entire clear audio path can be set with potentiometer R110. It allows a ±3 dB variation in the gain of the audio path.

Compression

The audio branches into two paths at U7-14. For systems requiring no compression, the audio passes through a simple gain amplifier (A = 1.545). For systems requiring compression, such as 896 MHz trunking, the audio is compressed with a 2:1 compressor, U4. The peak-to-peak voltage at U2-1 (V_o) can be expressed as the square root of the product of the peak-to-peak voltage at U7-14 (V_i) and 2.19V (peak-to-peak voltage of a 0 dBm signal): $V_o = \sqrt{2.19\, V_i}$ The compressor time constants have been chosen to match those used in the subscriber units in the 896 MHz systems.

Compressed and non-compressed audio meet at the mux gate U2. Compressed audio is present at U2-15 only if switch SW2-2 is open *and* Coded Indicate is high (clear audio). Non-compressed audio is present at U2-15 if switch SW2-2 is closed or Coded Indicate is low (for encrypted voice, the compressor is turned off to prevent high levels of noise at the output of the compressor when no signal is present at its input).

Pre-emphasis

Once compressed or non-compressed audio is chosen at U2-15, the clear audio is passed through the pre-emphasis filter. The pre-emphasis filter frequency response increases 6 dB per octave from 300 Hz to 3 kHz. The response levels off at 12 kHz and starts to fall off at 6 dB per octave at 15 kHz. The gain of the pre-emphasis stage at 1 kHz is 1.82.

Slew Rate Limiter

Severely filtered square waves can overshoot as much as 20%. To minimize overshoot, the USCI employs a slew rate limiter to prevent the formation of square waves when audio is in hard clip. The pre-emphasized audio from U1-14 is low pass filtered and connects to U3-13. As long as the amplitude of the waveform at U3-13 is less than the limiter's threshold, diodes CR119 and CR120 are off and U3-12, U3-13, and U3-7 constitute a unity gain voltage follower. When the input signal becomes large enough, the current through R175 turns on either CR119 or CR120. The slew rate limiter becomes a comparator driving an integrator. The input voltage at U3-13 is compared to the output voltage of the integrator, U3-7, and forces the voltage at U3-7 to be equal to the voltage at U3-13. When the signal becomes large enough to be limited, the voltage at U3-14 is rail to rail, and the diodes clamp that voltage across R176. R176 and C112 form an integrator with U3-7 slewing at the rate of Vdiode/(R176 x C112) V/S. The slew rate for this circuit is 55.6V/mS; at the audio output, the slew rate is 3.6V/mS.

Limiter

Once the signal is slew rate limited, it is amplitude limited. The supply voltage at U3-4 determines the maximum voltage output at U3-7. If the output voltage of the module is too high, the power supply voltage can be reduced. CR301 is placed between the 13.8V and U3-4 to provide a symmetrical output at U3-1. All of the circuitry after the limiter is based on the assumption that the limiter output at U3-1 is 11.15V P-P; the maximum output level, at the audio outputs, is 705 mV P-P. If over-deviation is a problem, adjust the limiter output by reducing the voltage of the power supply. *R110 cannot change the maximum peak-to-peak output of the USCI.* The gain for the limiter stage in the linear region is 3.39.

Summing Amplifier

U8-9 sums many of the USCI signals for routing to the audio path for transmission. For a Dual Path system, either audio (U3-1), encrypted audio (U3-8), or highspeed data (U2-4) is allowed to pass through to the audio outputs. For a Digital Path system, either audio plus lowspeed data (U3-1 + U2-4), encrypted audio (U3-8), or highspeed data (U2-4) is allowed to pass through to the audio outputs. The output also sums the optimization input (U7-8) into the audio path. The summing amplifier provides a gain of 0.063 for clear audio, a gain of 0.048 for encrypted audio, a gain of 0.074 (+4, -3 dB) for highspeed and lowspeed data, and unity gain for the optimization input.

NOTE

The optimization input may be used to input PL or DPL signals for conventional simulcast. Switch SW2-1 should be closed to prevent the audio path from muting, and switch SW1-1 closed to stop the alert tone from entering the audio path.

Splatter Filter

Following the summing amplifier, the signal passes through a splatter filter. The filter is not the final filter before transmission, only a means to attenuate the higher harmonics present in the highspeed data and coded audio. The filter has a 3 pole Bessel response with a cutoff frequency of approximately 8 kHz. The Bessel filter is used because of its linear phase response.

Balanced Line Driver

The output of the splatter filter (U8-1) feeds the audio output balanced line driver. Because there is an odd number of inverting stages in the audio path (alert tone summer, compressor, pre-emphasis, limiter, and summing amplifier), the noninverted driver (U8-14) provides the Audio Out (-) and the inverted driver (U8-7) provides the Audio Out (+). When the audio outputs are properly terminated (600 Ω across J1-4 and J1-5), and the audio output level adjusted for -10 dBm, the signal at J1-5 adds to the inverted signal at J1-4 to yield a 693 mV P-P signal.

Clocks

Many of the digital circuits on the USCI rely on the clocking signals generated on the board. All clocks are derived from Y1, a 3.6864 MHz crystal.

The clock signals are:

- 3.6864 MHz: present at U22-1, U26-10, and U29-14 (master)
- 614.4 MHz: present at U29-5, U30-3, U30-11, and U31-10 (FSK data synchronization)
- 1800 Hz: present at U26-15 and U18-3 (failsoft timer)
- 900 Hz: present at U26-1, U20-10, and U27-1 [U27-2 and U21-8] (alert tone generator)
- 2400 Hz: present at U31-13 and U32-6 (FSK logic "0")
- 1200 Hz: present at U31-12 and U32-13 (FSK logic "1")
- 150 Hz: present at U31-1, U24-10, U22-10, and U22-15 (failsoft word generator)
- 37.5 Hz: present at U31-3 and R230 (Test data)
- 1.8 Hz: present at U20-12, U21-2, U23-13, and R235 (flashes power LED and failsoft LED)

Central Controller Interface

The USCI acts as an interface between the trunked central controller and all remote site transmitters. The USCI distributes the lowspeed and highspeed data, acts on the PTT and Highspeed Indicate control signals from the central controller, and sends the TStat indication back to the central controller.

NOTE

The USCI expects the TData from the Transmitter Interface Board (TIB) to be unfiltered and 9V P-P. If the central controller is equipped with the TRN8663A version TIBs, you must set the Dual Path bit in the CSC software (option D568AA) for Digital or Dual Path systems. If the central controller is equipped with the TRN8663B turbo TIBs, set the correct jumpers to bypass the data filters. For example, set jumper JU1 on the TIB to the "A" position to bypass the data filters. Refer to the TIB manual, 68P81084E51, for the TIB jumper configurations.

Differential Data Input

The central controller sends trunking data (TData) to the USCI via J1-21 (TData) and J1-22 (TGnd). The input is AC coupled so the ground-referenced TData from the central controller can be transformed to 6.9V-referenced TData at U15-14. As long as the Test Data switch, SW1-3, is not closed, TData passes through the analog multiplexer (U14-3 and U14-4). TData is sent to the data detector (C208), the lowspeed data filters (U14-2), and the lowspeed/highspeed data selector (U2-3).

TData Routing

- Lowspeed Data: The TData sent to U14-2 passes to U14-15 if the module is not in failsoft. If the module is in failsoft, the failsoft word from U17-1 is present at U14-15. Once data is at U14-15, it is sent to R211 for FSK encoding and to R262 for low pass filtering. The lowpass filter is a two stage, four pole filter with a 3 dB point of approximately 125 Hz. The phase in the passband of the lowpass filter is linear, and the amplitude response falls off at the rate of 24 dB per octave above 180 Hz. R262 and R263 divide the TData signal by three to provide the 3:1 highspeed to lowspeed ratio necessary for trunked system specifications. The lowspeed TData signal is approximately 2.9V P-P at U14-12.

- Analog/Digital Microwave Switch: The difference between a USCI configured for a Dual Path system and one configured for a Digital Path system is the way it processes the lowspeed data. In Dual Path systems, the audio and the lowspeed data are kept separated. The audio is routed to the remote sites via a DSB wideband modem, and the lowspeed data is FSK encoded and routed to remote sites via a SSB modem. Highspeed data is sent down the audio path in Dual Path systems.

  In Digital Path systems, the lowspeed data is summed with the audio before being distributed to remote sites. During system set up, you must set switch SW2-4 properly for a Dual Path or a Digital Path system. If S2-4 is closed, U14-11 is held high, the filtered lowspeed data at U14-12 is cut off and VC (6.9V at U14-13) is summed into the audio path. Thus SW2-4 is closed for Dual Path systems. If SW2-4 is open, U14-11 is pulled down by R233 and the filtered lowspeed at U14-12 is allowed to pass to U14-14. SW2-4 is open for Digital Path systems.

- Highspeed/Lowspeed Data Multiplexer: The highspeed indicate control line, U21-10, dictates whether highspeed data or lowspeed data (or 6.9V) is summed into the audio path. If U21-10 is high, highspeed passes from U2-3 to U2-4 and into the audio path. If U21-10 is low, filtered lowspeed (or 6.9V) is summed into the audio path.
- TData Gain Setting: The TData signal at U2-4 passes to R143, a 50 kΩ potentiometer (pot). This pot allows a 4 dB boost or 3 dB attenuation of the TData signal. The standard level setting procedures requires a 3:1 test tone to lowspeed data ratio. If the audio output is -10 dBm (693 mV P-P), set the lowspeed data for 231 mV P-P. Highspeed data should have the same amplitude as audio.
- Data Path Mute: To prevent the summing of TData into the audio path, force U5-6 low. This can happen in three different situations. First, you can close switch SW1-1 to disable the data path during optimization of the audio path. Second, if you make a coded call, this prevents TData from entering the audio path (since it is not used during a coded call). Third, if the module is in local failsoft, this prevents TData from entering the audio path.

Highspeed Indicate

NOTE

The USCI expects the Highspeed Indicate In line from the TIB to act as a H/L line. If the central controller is equipped with TRN8663A version TIBs, you must set the Dual Path bit in the CSC software (option D568AA) for Digital or Dual Path systems. If the central controller is equipped with TRN8663B turbo TIBs, the correct jumpers must be set. For example, the channel 1 Mute line on the TIB is configured as H/L indicate when jumper JU3 is in the "B" position. Refer to the central controller manual for the TIB jumper configurations.

When the central controller sends the lowspeed data or disconnect data, it holds the Highspeed Indicate In line, J1-19, low. When the central controller sends the highspeed handshake or control channel data, it allows J1-19 to be pulled high by R206. Also, if the central controller fails, J1-19 is pulled high by R206, so the USCI needs to decide whether Highspeed Indicate In is high because highspeed data is being sent, or because the central controller has failed. Therefore, Highspeed Indicate In is ANDed with failsoft Indicate, U13-3, so the module knows highspeed data is actually being sent when the module is not in failsoft mode.

Highspeed Indicate In is actually ANDed with three other signals. Inverted failsoft indicate is present at U21-11; U21-11 is high when the module is *not* in failsoft Mode. U21-12 is pulled high by R215 when switch SW2-1, highspeed indicate disable, is open. Highspeed Indicate In is diode-ANDed with the Test Data switch, SW1-3; As long as SW1-3 is open and Highspeed Indicate In is pulled high, U21-10 is pulled high. Thus, highspeed indicate on the module is allowed to be high at U21-10 only if Highspeed Indicate In, J1-19, is high, the Test Data switch SW1-3 is open, the highspeed indicate disable switch SW2-1 is open, and the module is not in failsoft Mode. Inverted highspeed indicate is supplied at U13-11.

Push-To-Talk (PTT) and TStat

PTT indication originates at the central controller. It pulls J1-23 low when the station is keyed, and R139 pulls J1-23 high when the station is dekeyed. PTT In is then NANDed with failsoft Indicate; if the module is in failsoft mode, a PTT indication is generated to key the stations to transmit failsoft word and alert tone. The PTT Out signal is generated when U13-13 is high. U10-11 then switches low, and the diode in U11 is forward biased and 10 mAmps of current is supplied to PTT Out (+) and (-), J1-13 and J1-11. PTT Out (+), J1-13, must be connected to the more positive potential on the M-lead, and PTT Out (-), J1-11, must be connected to the more negative potential on the M-lead. Since microwave equipment operates on negative DC voltages, PTT Out (-) is typically connected to a fixed negative voltage, and PTT Out (+) is connected to the switchable M-lead input.

The USCI uses TSTAT to inform the central controller it is ready to transmit. The central controller asserts a PTT on J1-23 and listens for TStat on J1-20. U13-13 switches high, U19-15 switches low, U19-10 switches high, and opto-isolator U12 is turned off. R165 then pulls J1-20 above 3V so the central controller knows it can assign that channel. When PTT is not present, TStat should be less than 1V.

The red LED, DS2, tells you PTT is being sent to the modems and TStat is being returned to the central controller. You can disable PTT and TStat in two different ways. When the module is in local failsoft, the remote site transmitters key themselves according to their programming, so a global PTT from the USCI is not needed. PTT and TStat are disabled in the local failsoft mode.

During optimization, you should key individual sites rather than all sites. Also, maintenance may be needed on a USCI while the module is still in the card cage. Closing switch SW1-4 disables the PTT and TStat so the remote sites may be keyed individually from the PON or the Simulcast Distribution Amplifier, and the central controller does not assign the channel under test because it does not receive the TStat signal. When PTT and TStat are disabled, U5-5 is pulled low, and U19-3 and U19-14 are pulled low by R148. TStat, J1-20, is less than 1V and U11 does not supply any current to PTT Out (+) and (-).

FSK Encoder

You do not want to send lowspeed data and audio through the same modems in simulcast systems using analog microwave distribution. The lowspeed data is FSK encoded and transmitted to the remote sites via SSB modems (Dual Path).

Input Section

The lowspeed and disconnect data to be FSK encoded is present at U14-15. The data runs through a comparator with hysteresis and squared rail-to-rail at U16-8. At this point, the data may be shut off from the rest of the FSK encoder if the module is in local failsoft mode or if the data is highspeed data. U27-6 is pulled low to prevent the data from reaching U27-9. R219 pulls U28-5 high when no data is present so the module's output is a constant 1200 Hz. The data at U28-4 feeds the front panel jack, J4, enabling you to monitor the data being fed to the FSK encoder.

Data Synchronization

The data at U28-4 passes through two D flip-flops, triggered by the 614.4 kHz clock, to synchronize the off-board data with the on-board clocks. An XOR gate compares the data at U30-1 to the data at U30-13. When the data at U30-1 and U30-13 are not identical, counter U31 is reset by U26-3. U31 generates the 1200 Hz and 2400 Hz signals present in the FSK signal. When the counter is reset, it ensures the zero crossing of the FSK signal corresponds to an edge transition in the data. The synchronization procedure isolates the data transitions to within 1.6 uS to minimize edge jitter during FSK decoding. When lowspeed data signals are generated on board, the synchronization procedure is unnecessary because the data and the FSK tones are generated by the same master clock. Therefore, the reset signal from U28-3 is ANDed with the Test Data control line (U14-9) and inverted failsoft Indicate (U13-5). When failsoft word or test data are passing through the FSK encoder, U31 is never reset.

FSK Encoder

The lowspeed data is FSK encoded by the four NAND gates of U32. The squared lowspeed data is input at U32-9 and U32-12. If the data is a logic one, U32-10 and U32-5 are low; U32-4 and U32-1 are high; U32-11, U32-2, and U32-3 are all a 1200 Hz square wave. If the data is a logic zero, U32-10 and U32-5 are high; U32-11 and U32-2 are high; U32-4, U32-1, and U32-3 are a 2400 Hz square wave.

Tone Filtering and Gain Adjustment

After the data has been FSK encoded, the supply-to-supply signal is attenuated by R238 and R239, and buffered. The signal at U16-14 is 373 mV P-P and biased to VC (6.9V). The FSK signal passes through a linear phase three pole lowpass filter with a cutoff of approximately 3 kHz. Finally, the FSK signal is fed to a 600 Ω balanced line driver. A properly terminated FSK output (600 Ω load across J1-10 and J1-8) yields a level of about -15 dBm. The 1200 Hz has a higher level reading in dBm (about -13.5 dBm) since it is not a pure sine wave.

Failsoft Modes

The USCI can operate with two different failsoft modes. Wide area failsoft is used when the trunked central controller fails. All sites are keyed and failsoft word and alert tones are continuously broadcast until the central controller is trunking. Automatic local failsoft is used when some other part of the system fails, such as part of the microwave distribution system. All functions on the USCI are shut off; the audio and data paths are muted, PTT and TStat are disabled and the FSK encoder outputs a constant 1200 Hz tone. Each remote site responds as if the prime site failed and reverts to some pre-programmed state.

Failsoft Timer

The failsoft timer monitors all TData from the central controller. The TData is fed to C208 of the data detector. C208 allows the data signal to be biased to 6.9V quickly (C203 and C204 are so large it can take the TData a few seconds to reach 6.9V). R223 and R225 create a DC reference of 6.2V for the data detector. The signal at U17-13 is compared to the 6.2V DC level on U17-12. U17-14 switches high every time the TData signal passes below 6.2V. Counter U18 resets every time U17-14 switches high. If there is no TData present, U17-14 and U18-2 remains low. U18 counts to 300 mS and switches U18-13 high. The module is now in the wide area failsoft mode, and U18-13 remains high as long as U17-14 stays low.

Failsoft Indicate

The USCI is in wide area failsoft if Failsoft Indicate is high. Wide area failsoft occurs automatically if TData is absent from the central controller, or if J1-18 is pulled low to force the module into wide area failsoft. U13-3 is high to provide Failsoft Indicate and U13-5 is low to provide inverted Failsoft Indicate. Failsoft Indicate is used to switch failsoft word into the TData path (U14-10); turn on the alert tone generator, U6-9; generate Failsoft Indicate Out; and initiate PTT, U19-5. Inverted Failsoft Indicate is used to disable the FSK synchronization, U23-6; disable highspeed indicate, U21-11; and disable Local Failsoft In, U27-5. Failsoft Indicate Out, J1-14, is generated by U10. When U19-4 is low (failsoft mode), the diode in U10 is forward biased and J1-14 is held below 1V. When U19-4 is high (trunked mode), U10 is turned off, and R163 pulls J1-14 high.

Failsoft Word Generator

Failsoft word is generated continuously by the USCI. A 150 Hz clock from U31-1 drives shift register U24. The shift register's outputs are used by U22-6 and U22-7 to generate the next data bit. Each new data bit enters the serial data port U24-11. Starting data is reloaded into the shift register U24 after six positive transitions of the data stream are counted at U25-9. The 150 Hz signal is used at U22-10 and U22-15 to achieve proper edge synchronization for resetting the counter at U25-15 and parallel loading the starting data. Failsoft word is sent to U22-12 from U25-9. The data is inverted at U22-11 and inverted and gain adjusted at U17-1. Failsoft word in the pattern 1010 0101 0001 0000 1100 1 should be present at U14-1 with an amplitude of 8.8V P-P.

Alert Tone Generator

Alert tone is generated only when the module is in failsoft mode and the Data Mute switch, SW1-1, is open. U6-10 is high and allows the 900 Hz clock to pass from U27-1 to U27-2. A 900 Hz tone burst of 300 mS duration is present at U21-9 every 9.7 seconds. The tone burst amplitude is attenuated by R257 and R260, and C217 lowpass filters the tone burst. Alert tone is then AC coupled by C102, and summed into the audio path by R112. The amplitude of alert tone at the audio outputs should be around 200 mV P-P.

Local Failsoft

The USCI is forced in local failsoft by pulling J1-16 low. When the module is in local failsoft, most functions are turned off. U33-11 is pulled low, switching U33-10 low and muting the audio path. U33-8 is pulled low, switching U33-9 low and muting the data path. U6-13 is pulled low, switching U6-11 low and disabling PTT. U23-8 is pulled low, switching U23-10 low and shutting off data to the FSK encoder. U27-12 is pulled low, prohibiting Failsoft Indicate from turning on the yellow failsoft LED, DS3. A 1.8 Hz square wave triggers the yellow LED to flash, indicating local failsoft mode.

Wide Area/Local Failsoft Precedence

When the USCI receives indications it should be in wide area *and* local failsoft modes simultaneously, switch SW2-3 determines which mode takes precedence. When SW2-3 is open, U27-5 is controlled by inverted Failsoft Indicate. If the module is in wide area failsoft, Local Failsoft In does not pass through (to the rest of the module) and the module remains in wide area failsoft. If the module is trunking, U27-5 is high, Local Failsoft In is passed through to the rest of the module. When SW2-3 is closed, U27-5 is always high. Any time Local Failsoft In is pulled low, the module goes in local failsoft mode.

Installation

The USCI is a direct replacement for the TRN9962A Simulcast Controller Interface (SCI) used in Dual Path systems, and the TRN7228A Simulcast Digital Microwave Interface (SDMI) used in Digital Path systems. The USCI performs all the functions of the SCI, plus compression. It also performs all the functions of the SDMI, plus encrypted voice processing. Depending on your system, your installation may include upgrading an existing system, or installing new equipment.

Pre-Installation

Unpacking

While you should test a piece of equipment before installation, elaborate and lengthy "burn-in" schemes are not necessary. This was done at the plant. Verify the equipment arrived safely and in good physical condition. Complete RF and audio alignments are not necessary until the equipment is assembled at the site.

Inventory

Compare the physical pieces to the packing list to ensure all equipment has arrived. If possible, verify the sales order against the packing list and physical count to accurately account for all equipment ordered by the salesperson. If any pieces are missing, contact your Motorola Service Representative for further information.

Visual Inspection

Carefully unpack the equipment and check for any obvious damage. When unpacking the equipment, inspect all packing materials and cartons for any loose components. Inspect all sides of the cabinets for possible damage in shipment. When inspecting electrical components, observe recommendations for safe handling of CMOS devices to avoid the possibility of static damage. Inspect the rack wiring to ensure all connections are in place. Inspect modules for damage to controls or connectors. Report any damage to the transportation company immediately. If you see damage, also contact your Motorola Service Representative for further information.

Hardware Upgrade Requirements

This section provides the requirements for replacing an SCI or SDMI with a USCI. If you're installing the USCI in a new system, continue with *Equipment Installation*.

Prerequisites

You may use the same card cage, but you may need to change some wiring at the punchblocks because the USCI does not always use the same pin numbers for the various signals.

When replacing a SCI or SDMI module, do the following:

Step 1. Remove power from the system.

Step 2. Put on your static wrist strap.

Step 3. Identify the existing circuit board part number (normally etched on the solder side of the board).

Step 4. Compare it with the following:

- SCI - TRN9962A, board version numbers 84D82190T01 or T02.
- SDMI - TRN7228A, board version numbers 84D84147T01 or T02.

If your board version, T01 or T02, is not the same as those listed, contact your Motorola representative.

Step 5. Record this board number for later use.

Step 6. Determine the version of the Transmitter Interface Board (TIB) in the central controller. The USCI expects the TData and Mute line from the Transmitter Interface Board (TIB) to be configured a particular way. The USCI requires the TData from the TIB to be unfiltered and the MUTE line as a H/L line.

Step 7. Do one of the following:

- If the central controller is equipped with the TRN8663A version TIBs, set the Dual Path bit in the CSC software (option D568AA), even if the system is Digital Path. Only authorized Motorola service personnel can reprogram codeplugs.
- If the central controller is equipped with the TRN8663B turbo TIBs, you must set the correct jumpers. Refer to the TIB section of the central controller manual, 68P81085E10, for the TIB jumper configurations. For example, set jumper JU1 on the TIB to the "A" position to bypass data filters. The USCI also expects the MUTE Line from the TIB to act as a H/L line. Set jumper JU3 to the "B" position to accomplish this configuration. You must set the jumpers properly for all channels.

Step 8. Continue with *Replacing a SCI or SDMI with a USCI*.

Replacing a SCI or SDMI with a USCI

Step 1. Gather the following tools and equipment:

- Static wrist strap;
- The USCI module(s) and associated cables;

- The Simulcast Distribution Amplifier(s) (SDA) and associated hardware if you have a Digital Path system.

Step 2. Remove power from the system.

Step 3. Put on your static wrist strap.

Step 4. Identify the number you recorded in step 5 of *Prerequisites* .

Step 5. Do one of the following:

- Continue with *Replacing an SCI (T01 or T02)*.
- Continue with *Replacing an SDMI (T01)*.
- Continue with *Replacing an SDMI (T02)*.

Replacing an SCI (T01 or T02)

Use this procedure to replace a TRN9962A, SCI, T01 or T02 version with a USCI.

Step 1. Remove power from the SCI card cage.

Step 2. Remove the existing SCI modules.

Step 3. Set switch SW1, on the USCI, to the open position. Refer to Table 1.

Step 4. Determine your system configuration and set switch SW2, on the USCI. Refer to Table 2.

Step 5. Insert the USCI modules in the SCI card cage.

Step 6. Switch the FSK (+) and (-) output leads at the punchblock.

Step 7. Apply power to the SCI card cage.

Step 8. Continue with *Level Settings*.

Replacing an SDMI (T01)

Use this procedure to replace a TRN7228A, SDMI, T01 version with a USCI.

Step 1. Remove power from the SCI card cage.

Step 2. Remove the existing SDMI modules.

Table 1. SW1 Switch Settings

Switch #	Open	Closed
S1-1	Normal Operation	Mute Data Path
S1-2	Normal Operation	Mute Audio Path
S1-3	Normal Operation	Send 37.5 Hz Test Data
S1-4	Normal Operation	Disable PTT and TStat

Table 2. Switch SW2 Module Configuration Settings

Switch #	Open	Closed
S2-1	Highspeed Indicate Enabled	Highspeed Indicate Disabled
S2-2	2:1 Compression Enabled	2:1 Compression Disabled
S2-3	Wide Area Failsoft Mode Primary	Local Failsoft Mode Primary
S2-4	Digital Microwave Distribution	Analog Microwave Distribution

Step 3. Set switch SW1, on the USCI, to the open position. Refer to Table 1.

Step 4. Determine your system configuration and set switch SW2, on the USCI. Refer to Table 2.

Step 5. Insert the USCI modules in the SCI card cage.

Step 6. Add a Simulcast Distribution Amplifier (SDA - Model Q3195A) if you do not already have one installed.

Step 7. Disconnect the Audio Output 2 (+) and (–) terminals at the punchblock.

Step 8. If you do not have a secure Digital Path system, continue with step 10.

Step 9. Connect the Coded Indicate Out (+) and (–) to the SDA via the punchblock. Refer to Figures 3 through 6.

Step 10. Disconnect the Audio Output 3 (+) and (–) terminals at the punchblock.

Step 11. Connect the PTT Out (+) to the switchable M-lead input on the SDA (pin 43) via the punchblock. Refer to Figures 3 through 8.

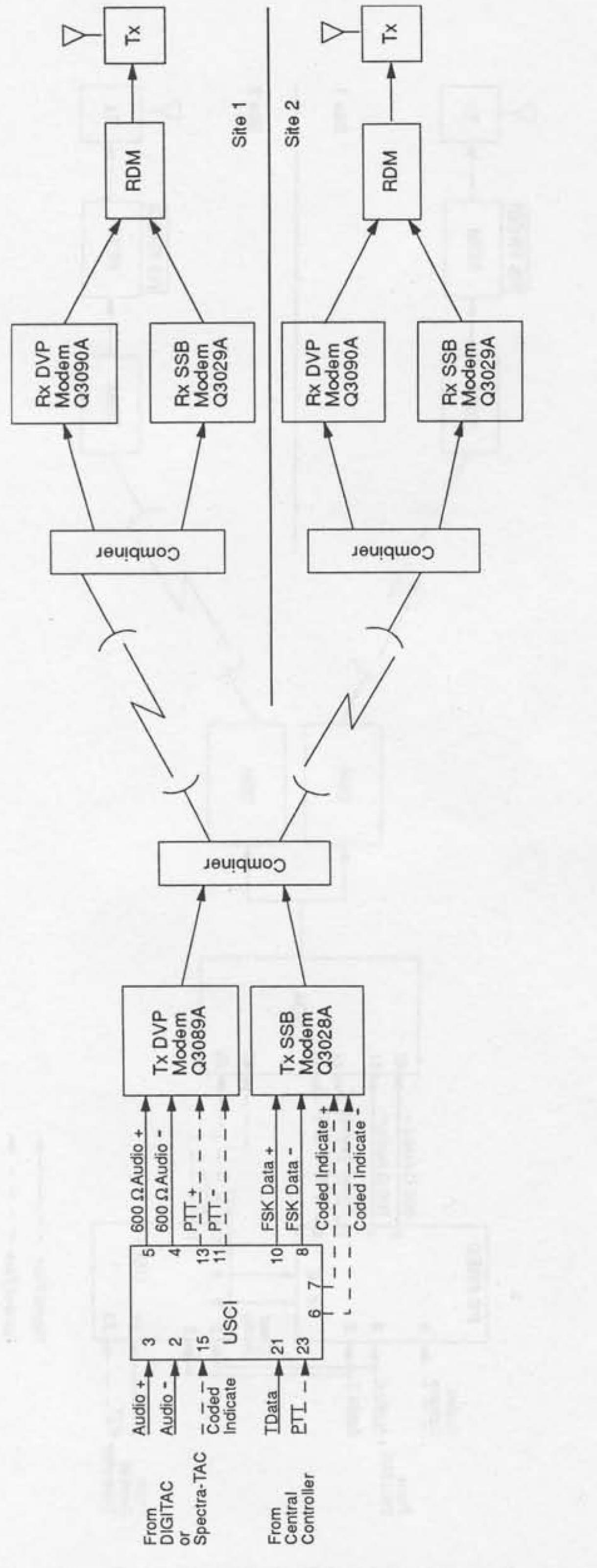

Figure 3. Dual Path Simulcast, Two-Level Encryption

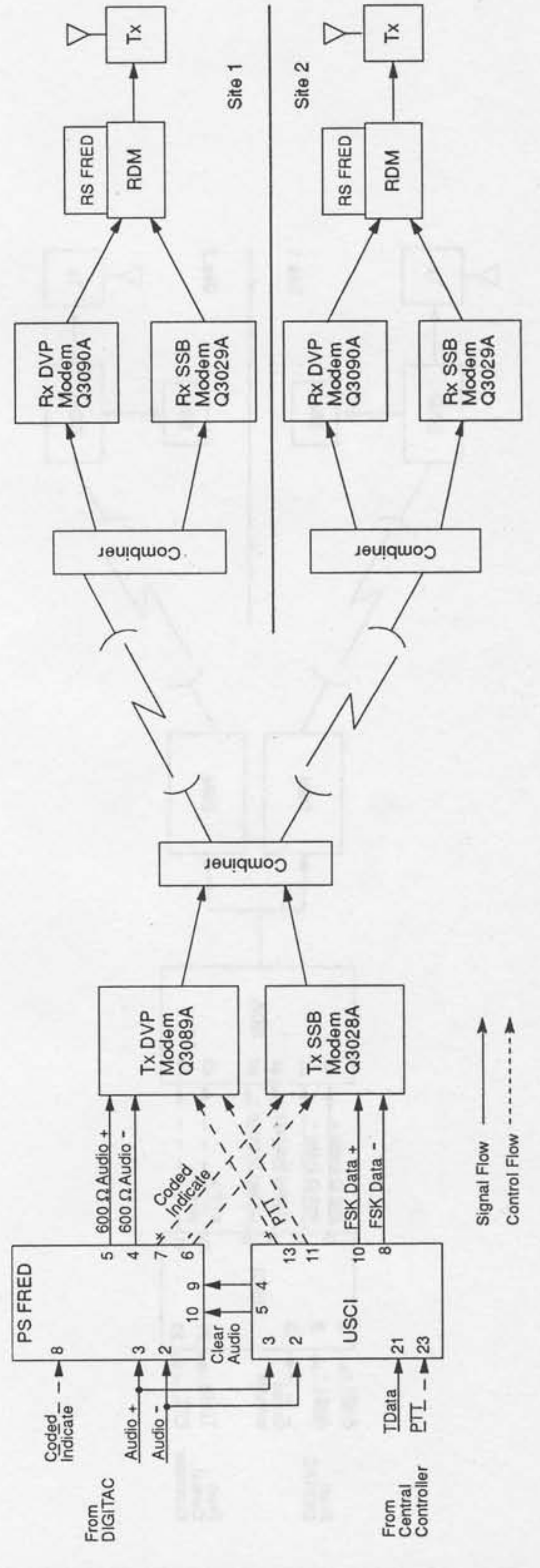

Figure 4. Dual Path Simulcast, Four-Level Encryption

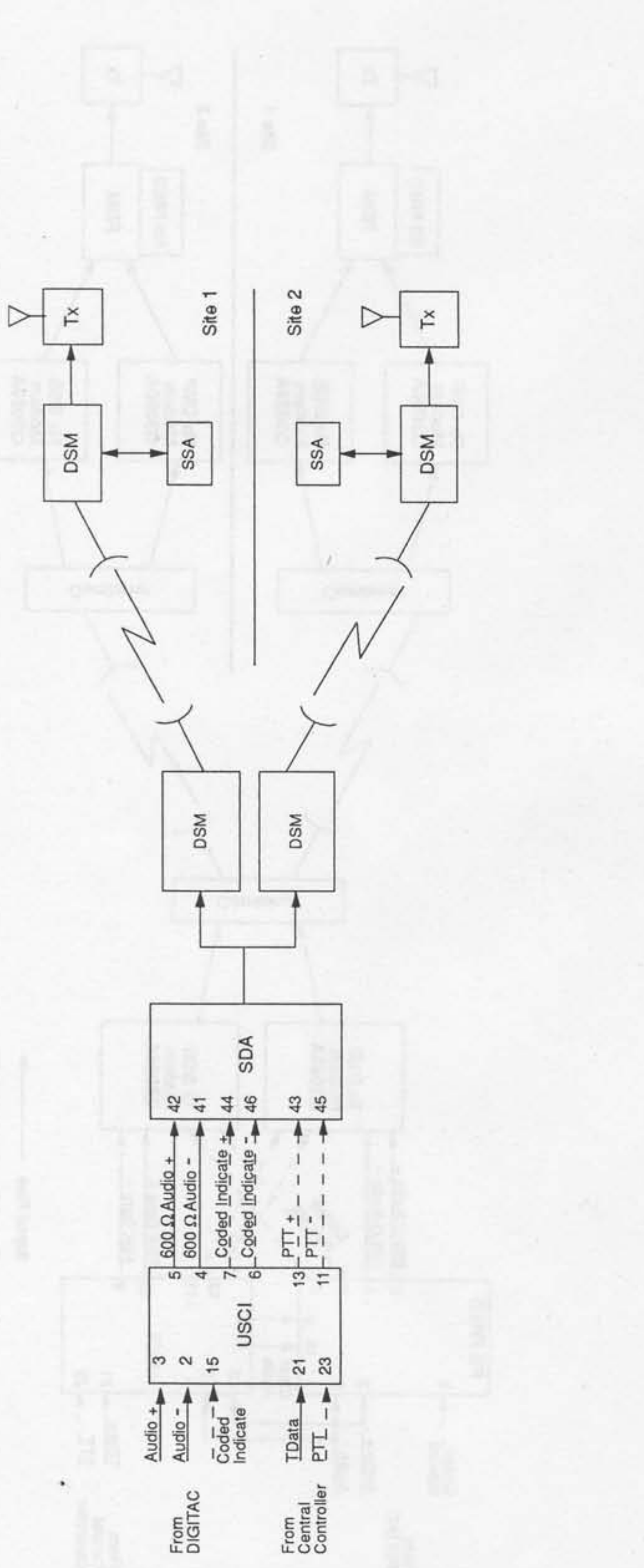

Figure 5. Digital Path Simulcast, Two-Level Encryption

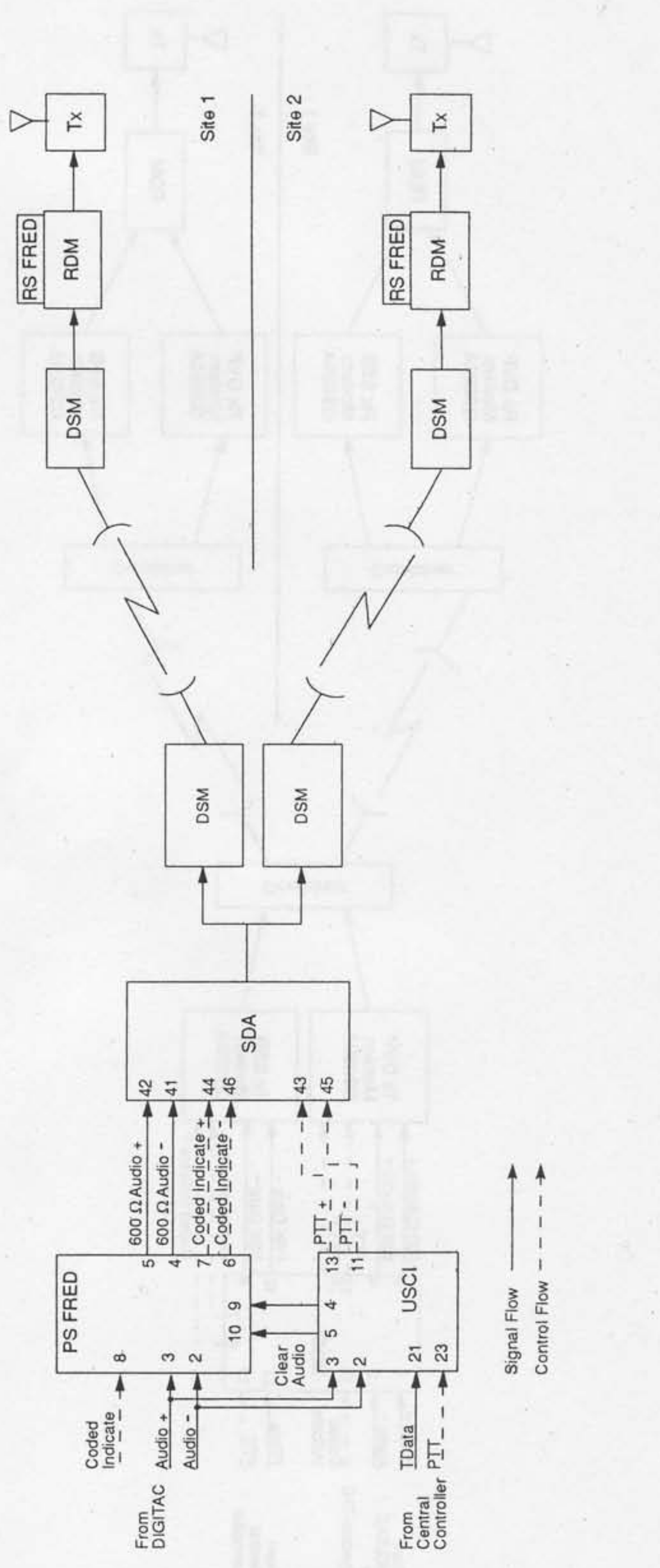

Figure 6. Digital Path Simulcast, Four-Level Encryption

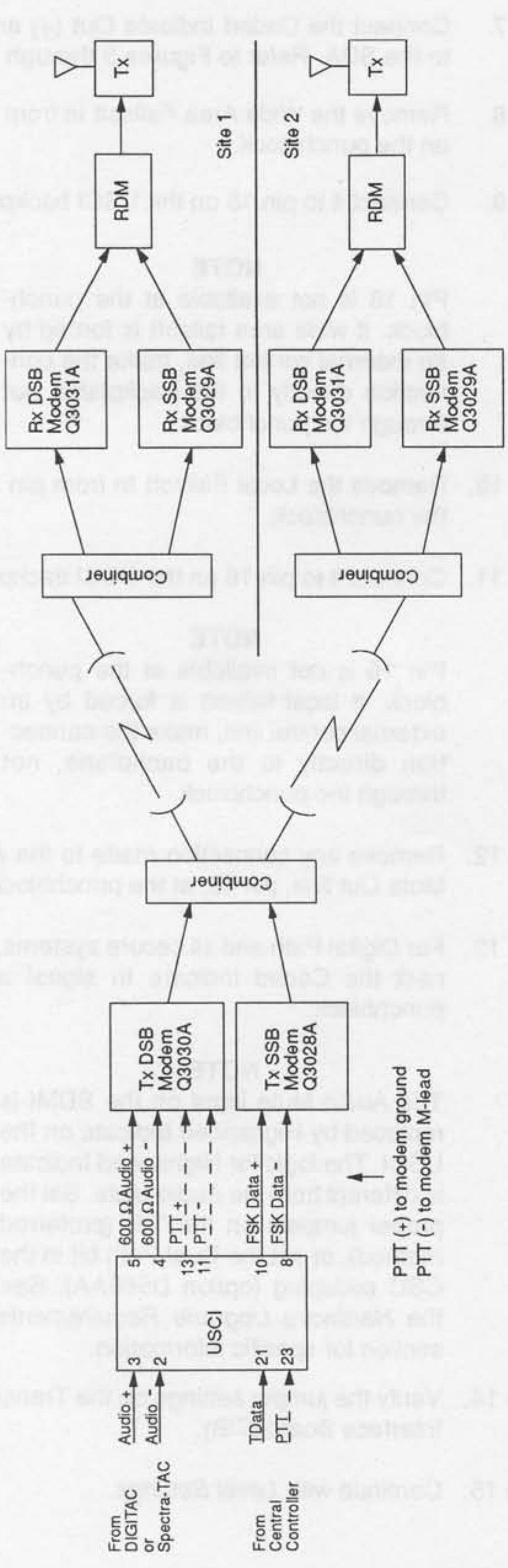

Figure 7. Dual Path Simulcast, Non-Secure Channels

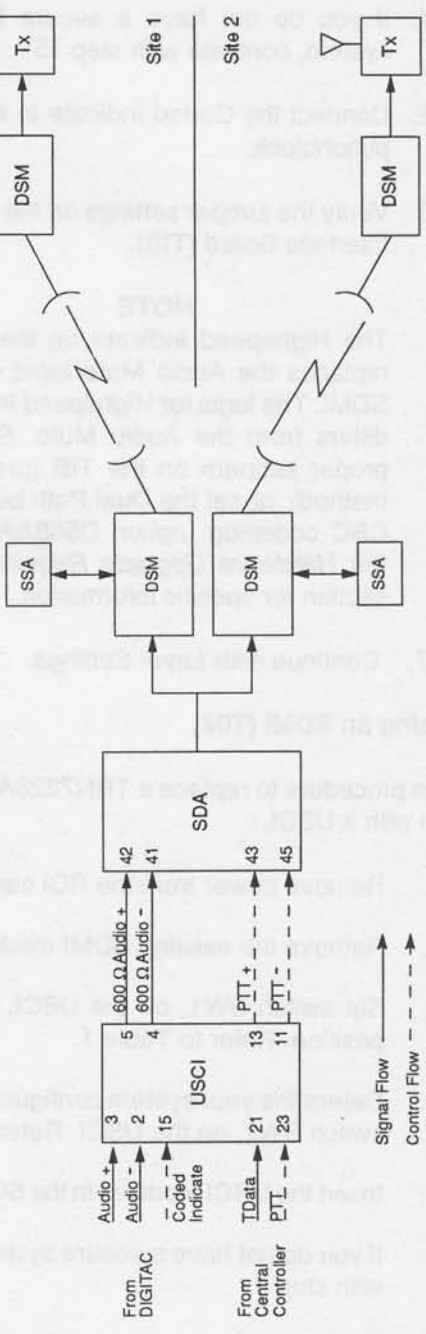

Figure 8. Digital Path Simulcast, Non-Secure Channels

Step 12. Connect the PTT Out (–) output to the fused –9V output on the SDA (pin 45) via the punchblock.

The PTT Out 2 and PTT Out 3 become the PTT Out (+) and PTT Out (–) respectively.

Step 13. Disconnect PTT Out 1 from the punchblock.

Step 14. If you do not have a secure Digital Path system, continue with step 15.

Step 15. Connect the Coded Indicate In signal at the punchblock.

Step 16. Verify the jumper settings on the Transmitter Interface Board (TIB).

NOTE
The Highspeed Indicate on the USCI replaces the Audio Mute input on the SDMI. The logic for Highspeed Indicate differs from the Audio Mute. Set the proper jumpers on the TIB (preferred method), or set the Dual Path bit in the CSC codeplug (option D568AA). See the *Hardware Upgrade Requirements* section for specific information.

Step 17. Continue with *Level Settings*.

Replacing an SDMI (T02)

Use this procedure to replace a TRN7228A, SDMI, T02 version with a USCI.

Step 1. Remove power from the SCI card cage.

Step 2. Remove the existing SDMI modules.

Step 3. Set switch SW1, on the USCI, to the open position. Refer to Table 1.

Step 4. Determine your system configuration and set switch SW2, on the USCI. Refer to Table 2.

Step 5. Insert the USCI modules in the SCI card cage.

Step 6. If you do not have a secure system, continue with step 8.

Step 7. Connect the Coded Indicate Out (+) and (-) to the SDA. Refer to Figures 3 through 6.

Step 8. Remove the Wide Area Failsoft In from pin 8 on the punchblock.

Step 9. Connect it to pin 18 on the USCI backplane.

NOTE
Pin 18 is not available at the punchblock. If wide area failsoft is forced by an external control line, make the connection directly to the backplane, not through the punchblock.

Step 10. Remove the Local Failsoft In from pin 10 at the punchblock.

Step 11. Connect it to pin 16 on the USCI backplane.

NOTE
Pin 16 is not available at the punchblock. If local failsoft is forced by an external control line, make the connection directly to the backplane, not through the punchblock.

Step 12. Remove any connection made to the Audio Mute Out line, pin 15, at the punchblock.

Step 13. For Digital Path and all secure systems, connect the Coded Indicate In signal at the punchblock.

NOTE
The Audio Mute input on the SDMI is replaced by Highspeed Indicate on the USCI. The logic for Highspeed Indicate is different from the Audio Mute. Set the proper jumpers on the TIB (preferred method), or set the Dual Path bit in the CSC codeplug (option D568AA). See the *Hardware Upgrade Requirements* section for specific information.

Step 14. Verify the jumper settings on the Transmitter Interface Board (TIB).

Step 15. Continue with *Level Settings*.

Equipment Installation

This procedure provides the steps to install the USCI and the associated hardware into a Simulcast system.

Card Cage Installation

Step 1. Gather the following tools and equipment:

- Static wrist strap
- Various sizes of Phillips head screwdrivers
- Various sizes of flat bladed screwdrivers
- Various wrenches (i.e., crescent, combination)
- The USCI card cage and mounting hardware (TRN7091A)
- The USCI module(s) and associated cables

Step 2. Make sure all power is turned off.

Step 3. Put on your static wrist strap.

Step 4. Refer to Figure 9. From the front of the rack, place the USCI card cage in the rack.

NOTE

If you are upgrading the system to Four-level Recovery Encode Decode (FRED) at a later date, leave rack space for the Prime Site FRED card cages. The FRED card cages has the same dimensions as the USCI card cage. One Prime Site FRED accommodates eight secure channels. Refer to Figure 9 for the recommended rack configuration for implementing FRED.

Step 5. Secure the USCI card cage to the rack with four screws (two on each side).

Step 6. Repeat 4 and 5 for each additional USCI card cage.

Step 7. Continue with *USCI Power Supply Connections.*

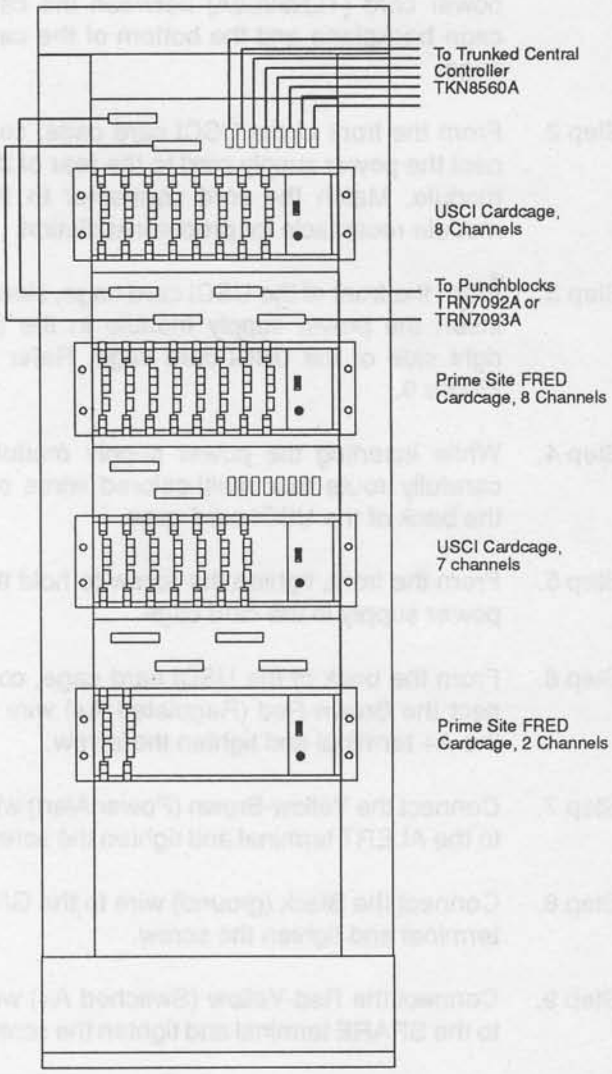

Figure 9. Front View of USCI in a Rack Mount

USCI Power Supply Connections

The USCI requires a modular power supply that slides into the SCI card cage. Each card cage has a dedicated supply that powers up to eight USCI modules.

Step 1. From the back of the rack, carefully route the power cord (TLN5960A) between the card cage backplane and the bottom of the card cage.

Step 2. From the front of the USCI card cage, connect the power supply cord to the rear of the module. Match the cord connector to the module receptacle for proper installation.

Step 3. From the front of the USCI card cage, slowly insert the power supply module in the far right side of the USCI card cage. Refer to Figure 9.

Step 4. While inserting the power supply module, carefully route four multi-colored wires out the back of the USCI card cage.

Step 5. From the front, tighten the screw to hold the power supply in the card cage.

Step 6. From the back of the USCI card cage, connect the Brown-Red (Regulated A+) wire to the A+ terminal and tighten the screw.

Step 7. Connect the Yellow-Brown (Power Alert) wire to the ALERT terminal and tighten the screw.

Step 8. Connect the Black (ground) wire to the GND terminal and tighten the screw.

Step 9. Connect the Red-Yellow (Switched A+) wire to the SPARE terminal and tighten the screw.

Step 10. Route the power cable along the side of the rack.

Step 11. Secure the power cable to the chassis with cable ties.

A second set of terminals and diodes, CR1 and CR2, on the USCI main board are used to connect a second power supply for redundancy.

Step 12. Apply power to the card cage.

Step 13. With a voltmeter, measure the 13.8V power supply.

Step 14. Do one of the following:

- If the reading is 13.8V, continue with step 15.
- If the reading is not 13.8V, adjust the power supply until it reads 13.8V then continue with step 15.

Step 15. Remove power from the card cage.

Step 16. Continue with the *USCI Module Installation.*

USCI Module Installation

NOTE

The PS-FRED channels must connect to the same USCI channel (e.g., PS-FRED channel one must connect to USCI channel one).

Step 1. Set switch, SW1, on the USCI, to the open position. Refer to Table 1.

Step 2. Determine your system configuration and set switch, SW2, on the USCI. Refer to Table 2.

Step 3. Starting with the left-most slot, insert the Channel 1 USCI module in the card cage.

NOTE

Each slot corresponds to a given channel from the central controller. If a channel is not used, skip the slot. This is very important when you use four-level secure modules.

Step 4. Repeat steps 1 through 3 for each module of each card cage.

Step 5. Continue with *Cabling Installation.*

Cabling Installation

The following procedures explain the cabling of the USCI card cage to the central controller and punch-block.

USCI to Central Controller

This procedure provides the steps to connect the USCI card cage to the central controller.

Step 1. Label each end of the TKN8560A cable with the appropriate channel information (with tags as described in the Quality Standards manual).

NOTE
Each TKN8560A cable has a tag denoting which end of the cable to plug into the USCI card cage.

Step 2. Refer to Figures 1 and 9. From the front of the USCI card cage, connect the 15-pin connector to the appropriate channel connector (P9-P16) on the USCI card cage.

Step 3. Slide the lock into place, securing the 15-pin connector to the port.

Step 4. Route the TKN8560A cable between the USCI and the central controller interface chassis.

Step 5. Connect the 15-pin connector to the appropriate channel connector (J101-J128) on the central controller interface chassis.

Step 6. Slide the lock into place, securing the 15-pin connector to the interface chassis.

Step 7. Repeat steps 2 through 6 for each channel in the system.

Step 8. Continue with *USCI to Punchblock*.

USCI to Punchblock

Step 1. From the front of the USCI, connect the TRN7092A or TRN7093A cables to J1 and J2 on the USCI interface board.

Step 2. Secure the cables to J1 and J2 with the velcro strap.

Step 3. Route the cable to the punchblocks.

Step 4. Connect the cable to the punchblock. Refer to the *Backplane Interconnection Definitions* of section 68P81081E62 of this manual.

Step 5. Connect the punchblock terminal clips to the appropriate connectors.

Step 6. Continue with *Level Settings*.

Level Settings

The USCI is part of a simulcast system; therefore, all levels are set during the system optimization. If the USCI doesn't appear to be working, use *Functional Tests* to troubleshoot the problem. Refer to the following sections for optimizing the USCI.

- *Dual Path Simulcast Trunked System Optimization*, Motorola Part No. 68P81081E71.
- *Digital Path Trunked Simulcast System Optimization*, Motorola Part No. 68P81126E83.

Troubleshooting

Due to the advanced technology and manufacturing process of Motorola trunked system equipment, a technician should not attempt to repair any boards in the field. Motorola recommends only authorized Motorola service depots make module repairs. Before sending a module for service, check to see if one or more of the following potential problems is affecting the proper operation of the USCI. If any of the tests are negative, include this information when you send the module to a Motorola service depot.

To verify module functionality, use the *Functional Tests* section. The following procedures establish the location of the malfunction and determine if the USCI is at fault.

Common Problems

One or more of the switches on SW1 is closed

If the green power LED is flashing on the USCI, the module is in a test mode and can not process calls. For a trunked simulcast system to function properly, make sure all SW1 switches are open.

Switch SW2 improperly configured

Read the *SW2 Functions* section for a description of the SW2 switch settings.

TIB not jumpered properly

Refer to the *Theory of Operation, Central Controller Interface* section about configuring the TIBs for the central controller. The USCI expects the data to be unfiltered and 9V P-P from the central controller. The USCI also expects the Mute line from the TIB to act like a H/L line: high for highspeed data, low for lowspeed and disconnect data.

Audio Output (+) and (–) lines reversed

Make sure the Audio Output (+) and (–) lines are properly connected (not inverted) to the USCI and associated hardware.

In Dual Path systems, only highspeed data passes through the audio outputs. Therefore, a USCI connected backwards does not transmit valid control channel data, or complete the highspeed handshake for a dispatch call.

In Digital Path systems, all data passes through the audio outputs. Control channel data is unusable and lowspeed, disconnect, and failsoft data is not recognized by the subscriber units.

Clocks

You can trace many problems on the USCI to the clock. A simple way to tell if the on-board clock is running, is to close one of the SW1 switches on the front of the module. If it is running, the green power LED flashes on and off at a rate of 1.8 Hz. If the green LED is not flashing, the module requires service.

If you suspect a problem in a USCI module, replace the problem module with a spare module. If no spare module is available, borrow a module from a functioning channel. If the problem persists after the module is replaced, examine the USCI backplane and punchblock for proper wiring. When the same problem seems to exist in different modules, the problem is often (but not always) outside the module.

Audio Path

No Audio (test tone in, but no test tone out)

Step 1. Check all audio input and output connections to the punchblock.

Step 2. Make sure you plug the 50-pin TELCO cable securely on the USCI backplane, as well as at the punchblock.

Step 3. Make sure switch SW1-2 is open.

Step 4. Make sure J1-19 (Highspeed Indicate In) is held low by the central controller when you plug in the central controller interface cable.

Step 5. Wire the audio mute line from the TIB as an H/L line. Refer to the *Hardware Upgrade Requirements* section.

Step 6. Make sure J1-16 (Local Failsoft In) is high.

Step 7. Perform the tests described in the *Audio Output Level* and *Maximum Output Level* sections of this manual.

Audio Over-deviation at the Transmitter

Step 1. To verify the transmitter's in-cabinet repeat option is not active, do the following:

a. Inject a +10 dBm, 1 kHz sinewave into the USCI. The audio path should remain intact.

b. Key the channel with a radio and talk over the test tone.

c. Monitor the transmit frequency with a service monitor. The transmitter deviation should remain constant, near ±5 kHz.

d. If the deviation varies with the speech, the transmitter's in-cabinet repeat option is active. Disable the in-cabinet repeat option in the base station codeplug.

Step 2. With the +10 dBm, 1 kHz sinewave still being sent to the USCI, monitor the transmitter, without voice, with an oscilloscope.

Step 3. If the sinewave causes over-deviation, adjust the USCI power supply for 13.8V.

WARNING

Reduce the output level of the USCI by decreasing the power supply voltage, but only as a last resort. Ensure the power supply voltage never drops below 12V.

Step 4. If the power supply is at 13.8V and the sinewave is still causing over-deviation, reduce the deviation level at the transmitter.

Data Paths

No Data Out Of Audio Outputs (Digital Path)

Step 1. Make sure switch SW1-1 is open.

Step 2. Make sure switch SW2-4 is open.

Step 3. Close switch SW1-3 to send test data through the USCI.

Step 4. Monitor the Data Monitor jack, J4, for a 37.5 Hz square wave.

Step 5. Monitor the audio outputs for a filtered 37.5 Hz square wave.

Step 6. Perform the tests described in the *Data Output Level* and *Frequency Response of Lowspeed Data Path* section.

Step 7. Open switch SW1-3.

Step 8. Remove all test equipment.

FSK Encoder Not Working (Steady 1200 Hz Tone Output)

Step 1. Make sure the module is NOT in local failsoft mode (J1-16 is NOT low).

Step 2. If you plugged in the central controller interface cable, make sure J1-19 (Highspeed Indicate In) is held low by the central controller.

Step 3. Make sure the audio mute line from the TIB is wired as a H/L line. Refer to the *Theory of Operation, Central Controller Interface* section.

FSK Encoder Output Level Too Low

Step 1. Make sure the FSK output is not double or triple terminated (only one 600 Ω load).

Step 2. Check the power supply voltage. A low power supply voltage lowers the FSK output.

Step 3. Adjust the power supply only if the maximum output level can be increased (refer to the *Audio Path* and *Audio Over Deviation at the Transmitter* sections).

Failsoft Modes

Module Does Not Enter Wide Area Failsoft Mode

Step 1. Check the operation of the 1800 Hz failsoft timer clock at U18-3 with an oscilloscope.

Step 2. Make sure switch SW1-3 is open.

Step 3. Make sure no signal is present at J1-21.

Step 4. Make sure J1-16 is not grounded.

Step 5. Ground J1-18 (to force wide area failsoft). If module does not go into wide area failsoft mode, send module for repair.

Step 6. Remove all grounds.

Step 7. Remove all test equipment.

Module Does Not Enter Local Failsoft Mode

Step 1. Make sure J1-16 is grounded (to force local failsoft).

Step 2. Check the setting of SW2-3. The module reverts to wide area failsoft if no TData is sent by the central controller.

Step 3. If switch SW2-3 is closed, the module should be in local failsoft mode. Refer to the *SW2 Functions* section for an explanation of local/wide area failsoft mode precedence. A flashing yellow LED indicates local failsoft mode.

Step 4. Make sure the audio and data paths mute, the FSK encoder sends a steady 1200 Hz tone, and PTT is disabled. Refer to the *Force Local Failsoft* section for this test.

Module Won't Exit Wide Area Failsoft Mode

Step 1. Check the operation of the 1800 Hz failsoft timer clock at U18-3 with an oscilloscope.

Step 2. Make sure a 9V P-P TData signal is present at J1-21.

Step 3. Close switch SW1-3 to send test data.

Step 4. If the yellow LED is still on, repeat the tests in the *Force Local Failsoft, Force Wide Area Failsoft*, and *Wide Area/Local Failsoft* Precedence sections. While sending test data, record the failsoft functions working and the ones not working.

Step 5. If the yellow LED is off, the TData input circuitry is damaged.

Step 6. Open switch SW1-3.

Module Does Not Exit Local Failsoft Mode

Step 1. Make sure the voltage at J1-16 is greater than 12V.

Step 2. If the module is still in local failsoft mode, send it for repair.

FSK Encoder

The FSK decoded data at the RDM does not correspond to the data at the TData input.

Step 1. Close SW2-4. This sets the USCI's configuration for a Dual Path system.

Step 2. Simultaneously monitor the TData input (J1-21) and the Data Monitor jack (J4) to assure the FSK encoder is receiving the correct data. If the module is in failsoft mode, J4 shows failsoft word, and J1-21 is flat.

Step 3. Close switch SW1-3 to send test data.

Step 4. Check the Data Monitor jack (J4) for a 37.5 Hz square wave.

Step 5. Monitor the Data Monitor jack (J4) and the FSK Out (+) line (J1-10) with a dual trace oscilloscope. Trigger with the signal at J4.

Step 6. Check the relationship between the data transitions and the frequency changes.

Step 7. If a 37.5 Hz square wave is not detected at the RDM, check the continuity of the FSK data path between the USCI and RDM.

NOTE

Since the RDM is translating the tones into 1s and 0s, the polarity of the FSK Out (+) and Out (–) is not important.

Step 8. Remove all test equipment.

Step 9. Open switch SW1-3 and SW2-4.

Functional Tests

The following procedures can aid you in troubleshooting a malfunctioning USCI module. While running the following tests, make sure the module is out of service and not connected to any other part of the system. If you must test the module in the card cage of an active system, disconnect the central controller interface cable (TKN8560A) from the backplane. Also disconnect the audio inputs and outputs and the FSK output at the punchblock. You must set switches SW1 and SW2 to the settings stated in each test procedure. The four SW1 DIP switches are used to put the USCI into four different test modes. When one or more of the switches are closed, the power LED should flash. If the LED doesn't flash, the on board clock is probably not running.

Each procedure performs a check of the input and output for each major circuit of the card. If you encounter an error, do the following:

1. Make sure the injected signals, connections, and terminations are correct.
2. Take the measurement again.
3. If the measurement is incorrect, do one of the following:
   - If your system is under warranty or other service agreement, send the module to Hi-Tech for repair. Include information about the problem and tests you have conducted with the respective results.

- If your system is not under warranty or other service agreement, you can repair the module with the information provided in this manual.

IMPORTANT

Motorola recommends sending the module to Hi-Tech for repair.

Test Equipment Required

- Transmission Test Set — HP3551A (or equivalent)
- Two channel oscilloscope with invert and add capability — Tektronix 464 Storage Scope or 465B Oscilloscope (or equivalent)
- Volt/Ohmmeter (VOM) — Fluke 8010A Digital Multimeter (or equivalent)
- Audio oscillator — HP204D (or equivalent)

Audio Output Level

Step 1. With the audio oscillator, inject a -10 dBm, 1 kHz signal to the audio inputs, pins 2 (-) and 3 (+) on the backplane of the USCI card cage.

Step 2. Close switch SW1-1 to mute the data path.

Step 3. With the transmission test set attached to the audio outputs (J1-5 and J1-4) and in the terminate mode, adjust R110 for a -10 dBm signal.

Step 4. Connect channel 1 of the oscilloscope to J1-5, Audio Out (+), and channel 2 of the oscilloscope to J1-4, Audio Out (-).

Step 5. Invert channel 2, and add channel 1 to channel 2. You should see an undistorted sinewave with a peak-to-peak amplitude of approximately 700 mV.

Step 6. Disconnect all test equipment.

Step 7. Return switch SW1-1 to the open position.

Step 8. Continue with *Maximum Output Level*.

Maximum Output Level

Step 1. With the VOM, monitor J1-12 on the leftmost module.

Step 2. Adjust the power supply for a 13.8V DC level.

Step 3. With the audio oscillator, inject a +10 dBm signal to the audio inputs (J1-3 and J1-2).

Step 4. Close switch SW1-1 to mute the data path.

Step 5. Terminate the output with the Transmission Test Set.

Step 6. Connect channel 1 of the oscilloscope to Audio Out (+) (J1-5) and channel 2 of the oscilloscope to Audio Out (-) (J1-4).

Step 7. Invert channel 2, and add channel 1 to channel 2.

Step 8. Measure the peak-to-peak voltage at the audio outputs (J1-5 and J1-4).

NOTE

The output waveform should be trapezoidal, and its amplitude should not exceed 740 mV P-P. Nominal voltage level is 705 mV P-P. If the amplitude exceeds 740 mV P-P, then reduce the voltage on the power supply until the amplitude is 740 mV P-P or less.

Step 9. Disconnect all test equipment.

Step 10. Return switch SW1-1 to the open position.

Step 11. Continue with *Pre-Emphasis*.

Pre-Emphasis

Step 1. With the audio oscillator, inject a -20 dBm, 1 kHz signal to the audio inputs (J1-3 and J1-2).

Step 2. Close switch SW1-1 to mute the data path.

Step 3. With the transmission test set in the terminate mode, monitor the audio outputs (J1-5 and J1-4).

Step 4. Adjust R110 for a -20 dBm output level at the audio outputs (J1-5 and J1-4).

Step 5. Check the following frequencies and levels:

Frequency	Levels
300 Hz	-30.46 dB (+1 dB, -3 dB)
600 Hz	-24.46 dB
1.2 KHz	-18.46 dB
3 KHz	-12.8 dB
6 KHz	-16.5 dB
12 KHz	-22.5 dB
24 KHz	< -35 dB

Step 6. Disconnect all test equipment.

Step 7. Return switch SW1-1 to the open position.

Step 8. Continue with *2:1 Compression.*

2:1 Compression

Step 1. With the audio oscillator, inject a -8.1 dBm, 1 kHz signal to the audio inputs at J1-3 and J1-2.

Step 2. Open switch SW2-2 to enable compression.

Step 3. Close switch SW1-1 to mute the data path.

Step 4. Monitor the audio output with the transmission test set in the terminate mode.

Step 5. Adjust R110 for an output level of -10 dBm.

Step 6. Decrease the oscillator level by 2.0 dBm. The output level should decrease by 1.0 dBm (± 0.1 dBm).

Step 7. Decrease the oscillator level by another 2.0 dBm. The output level should be 2.0 dBm (± 0.2 dBm) below the original output level.

Step 8. Change the oscillator level to -11.94 dBm. The output level should be -11.94 dB (± 0.1 dBm).

Step 9. Close SW2-2 to disable compression.

Step 10. With the audio oscillator, inject a -10 dBm, 1 kHz signal to the audio inputs at J1-3 and J1-2.

Step 11. Monitor the audio output with the transmission test set in the terminate mode.

Step 12. Adjust R110 for an audio output level of -10 dBm.

Step 13. Remove all test equipment.

Step 14. Return switch SW1-1 to the open position.

Step 15. Continue with *Coded Indicate.*

Coded Indicate

Step 1. Remove power from the USCI card cage.

Step 2. Ground J1-6.

Step 3. Temporarily attach (don't solder) a 10 kΩ pull-up resistor between J1-7 and J1-12.

Step 4. Apply power to the USCI card cage.

Step 5. Using the voltmeter, measure the voltage at J1-7. The voltage should be greater than 12V.

Step 6. Ground J1-15 (Coded Indicate In).

Step 7. Measure the voltage at J1-7 with the voltmeter. The voltage should be less than 1V.

Step 8. Remove power from the USCI card cage.

Step 9. Remove the grounds from J1-6 and J1-15.

Step 10. Remove the pull-up resistor from J1-7.

Step 11. Remove all test equipment.

Step 12. Apply power to the USCI card cage.

Step 13. Continue with *PTT In and Out, TStat.*

PTT In and Out, TStat

Step 1. Connect the audio oscillator to the TData input (J1-21) and TGnd (J1-22).

Step 2. Set the audio oscillator frequency for 20 Hz and an amplitude of 3.1V RMS.

Step 3. Verify the PTT LED is off.

Step 4. Remove power from the USCI card cage.

Step 5. Ground J1-11.

Step 6. Temporarily attach (don't solder) a 10 kΩ pull up resistor between J1-13 and J1-12.

Step 7. Apply power to the USCI card cage.

Step 8. Measure the voltage at J1-13 with the voltmeter. The voltage should be greater than 12V.

Step 9. Measure the voltage at J1-20 with the voltmeter. The voltage should be less than 1V.

Step 10. Ground J1-23 and verify the red LED turns on.

Step 11. Measure the voltage at J1-13 with the voltmeter. The voltage should be less than 1V.

Step 12. Measure the voltage at J1-20 with the voltmeter. The voltage should be greater than 3V.

Step 13. Close switch SW1-4 to disable the PTT and TStat signals.

Step 14. Measure the voltage at J1-13 with the voltmeter. The voltage should be greater than 12V.

Step 15. Measure the voltage at J1-20 with the voltmeter. The voltage should be less than 1V.

Step 16. Remove power form the USCI card cage.

Step 17. Remove the grounds from J1-11 and J1-23.

Step 18. Remove the pull-up resistor from J1-13.

Step 19. Apply power to the USCI card cage.

Step 20. Return switch SW1-4 to the open position.

Step 21. Remove all test equipment.

Step 22. Continue with *Highspeed Indicate/Audio Mute.*

Highspeed Indicate/Audio Mute

Step 1. With the Transmission Test Set, inject a -10 dBm, 1 kHz signal to the Audio inputs at J1-3 and J1-2.

Step 2. With the audio oscillator, inject a 3.1V RMS, 20 Hz signal to the TData input (J1-21) and TGnd (J1-22).

Step 3. Open switch SW2-1 to enable the Highspeed Indicate.

Step 4. Close switch SW2-4 for analog microwave mode.

Step 5. Monitor the audio outputs at J1-5 and J1-4 with the oscilloscope. You should only see the 20 Hz signal at the output.

Step 6. Ground J1-19 (Highspeed Indicate In). You should only see the 1 kHz audio signal at the audio outputs.

Step 7. Remove the ground from J1-19.

Step 8. Close switch SW1-3 to send the 37.5 Hz Test TData. You should see the 1 kHz audio signal at the audio outputs.

Step 9. Open switch SW1-3 to remove the 37.5 Hz Test signal.

Step 10. Remove the 3.1V RMS, 20 Hz signal from the TData input (J1-21) and TGnd (J1-2). You should see the 1 kHz audio signal and the alert tone appearing every 9.7 seconds at the audio outputs.

Step 11. Return the 3.1V RMS, 20 Hz signal to the TData input (J1-21) and TGnd (J1-22).

Step 12. Close switch SW2-1 to disable the Highspeed Indicate. You should see the 1 kHz audio signal at the audio outputs.

Step 13. Return switch SW2-4 to the open position.

Step 14. Remove all test equipment.

Step 15. Continue with *Data Output Level.*

Data Output Level

Step 1. Make sure switch SW1-1 is open. This unmutes the data path.

Step 2. Close switch SW1-2 to mute the audio path.

Step 3. Close switch SW1-3 to enable the 37.5 Hz square wave test data.

Step 4. With an oscilloscope, measure the audio outputs at J1-5 and J1-4.

Step 5. Adjust R143 for a 231 mV P-P, or about -18.6 dBm, at the audio outputs at J1-4 and J1-5.

Step 6. Return all SW1 switches to the open position.

Step 7. Remove all test equipment.

Step 8. Continue with *Frequency Response of Lowspeed Data Path.*

Frequency Response of Lowspeed Data Path

Step 1. With the audio oscillator, inject a 3.1V RMS, 20 Hz signal to the TData input jacks, J1-21 and J1-22.

Step 2. With the voltmeter, measure the output levels at the audio outputs, J1-5 and J1-4.

Step 3. Adjust the input amplitude, slightly, to obtain an easy reference level.

Step 4. Record the output level of the audio outputs, J1-5 and J1-4.

Step 5. Refer to Table 3 for the frequency response levels. Adjust the audio oscillator for each of the frequencies in the table.

Step 6. Verify the reading is within tolerance for each frequency.

Step 7. Remove all test equipment.

Step 8. Continue with *FSK Encoding of Lowspeed Data.*

Table 3. Frequency Response of Lowspeed Data

Frequency (in Hz)	Reading (in dB)	Tolerance (in dB) Below the level at 20 Hz
20	0	Reference point
40	-0.3	±0.5
80	-1.3	±0.5
120	-2.7	±0.5
126	-3.0	±0.5
160	-4.9	±1.0
200	-9.0	±1.0
300	>-20	

FSK Encoding of Lowspeed Data

Step 1. Remove all signals from the TData input by removing cable TKN8560A.

Step 2. Monitor the Data Monitor jack, J4, with channel 1 of the oscilloscope.

Step 3. Monitor J1-10 with channel 2 of the oscilloscope. Trigger on channel 1.

The failsoft word should be present on channel 1. The FSK version of the data should be present on channel 2.

Step 4. Make sure logic “0” corresponds to 2400 Hz and logic “1” corresponds to 1200 Hz.

Step 5. Remove all test equipment.

Step 6. Continue with *Data Detection and Failsoft Indicate.*

Data Detection and Failsoft Indicate

Step 1. With the audio oscillator, inject a 0 mV, 20 Hz signal to the TData input jacks, J1-21 and J1-22.

Step 2. Make sure the yellow failsoft LED and the red PTT LED come on.

Step 3. Change the audio oscillator's amplitude to 3.1V RMS.

Step 4. Make sure the module leaves failsoft instantly and the yellow and red LEDs turn off.

Step 5. Measure the voltage at J1-14 (Failsoft Indicate Out) with a voltmeter. The voltage should be greater than 12V.

Step 6. Change the audio oscillator's amplitude to 0 mV.

Step 7. Make sure the yellow and red LEDs turn on approximately 300 mS after changing the amplitude.

Step 8. Measure the voltage at J1-14 with a voltmeter. The voltage should be less than 1V.

Step 9. Remove all test equipment.

Step 10. Continue with *Failsoft Word and Alert Tone.*

Failsoft Word and Alert Tone

Step 1. Remove all signals from the TData input by removing cable TKN8560A.

Step 2. Close switch SW1-2 to mute the audio path.

Step 3. Make sure switch SW2-4 is open. This places the module in the digital microwave configuration.

Step 4. Monitor the filtered Failsoft Word at the audio outputs with an oscilloscope.

Failsoft word is 150 baud with the following binary pattern: 1010 0101 0001 0000 1100 1.

Step 5. Open switch SW1-2 and close switch SW2-4.

Step 6. With an oscilloscope, make sure the Failsoft Word is not present at the audio outputs. You should see the alert tone at the audio outputs. The alert tone consists of a 900 Hz pulse train with a 300 mS duration every 9.7 seconds.

Step 7. Return switch SW2-4 to the open position.

Step 8. Remove all test equipment.

Step 9. Continue with *Force Local Failsoft.*

Force Local Failsoft

Step 1. Close switch SW1-3 to enable the 37.5 Hz test data.

Step 2. Make sure the module is in the trunked mode. The yellow LED is OFF.

Step 3. Ground J1-16 (Force Local Failsoft). You should see the yellow LED flashing and the red LED off.

Step 4. With the oscilloscope, make sure there are no signals present at the audio outputs, J1-5 and J1-4.

Step 5. With the oscilloscope, make sure there is a constant 1200 Hz tone present at the FSK outputs.

Step 6. Ground J1-23 (PTT In).

Step 7. Make sure the red LED stays off.

Step 8. With the voltmeter, measure the TStat voltage remains low (less than 1V).

Step 9. Remove the grounds from J1-16 and J1-23.

Step 10. Return switch SW1-3 to the open position.

Step 11. Remove all test equipment.

Step 12. Continue with *Force Wide Area Failsoft.*

Force Wide Area Failsoft

Step 1. Close switch SW1-3.

Step 2. Ground J1-18. The module should enter the failsoft mode.

Step 3. Make sure the red and yellow LEDs come on.

Step 4. Measure the voltage at J10-14 with a voltmeter. The voltage should be less than 1V.

Step 5. Close switch SW1-2 to mute the audio path.

Step 6. Make sure switch SW2-4 is open. This places the module in the digital microwave configuration.

Step 7. Monitor the filtered Failsoft Word with an oscilloscope at the audio outputs. Failsoft word is 150 baud with the following binary pattern: 1010 0101 0001 0000 1100 1.

Step 8. Open switch SW1-2 and close switch SW2-4.

Step 9. With the oscilloscope, make sure the Failsoft Word is not present at the audio outputs. You should see the alert tone at the audio outputs. The alert tone consists of a 900 Hz pulse train with a 300 mS duration every 9.7 seconds.

Step 10. Return switches SW1-3 and SW2-4 to the open position.

Step 11. Remove the ground from J1-18.

Step 12. Remove all test equipment.

Step 13. Continue with *Wide Area/Local Failsoft Precedence.*

Wide Area/Local Failsoft Precedence

Step 1. Ground J1-16 and J1-18.

Step 2. Open switch SW1-3.

With SW2-3 open, the module is in wide area failsoft mode (steady yellow LED).

Step 3. Close switch SW1-3.

With SW2-3 closed, the module is in local failsoft mode and you should see a flashing yellow LED.

Step 4. Remove the grounds from J1-16 and J1-18.

Step 5. Return switch SW1-3 to the open position.

MODEL QLN3174A

DISTRIBUTION AMPLIFIER

1. MANUAL NUMBERS OF RELATED EQUIPMENT

Ultraport PCM Channel Bank	68P06908E24–O (5S–SP5940046)
Installation/Maintenance Instruction Manual for *Ultraport* PCM Channel Banks	68P06908E26–O (10S–SP5940046)
Q3208A DSM with Prime Site Adjustment Q3209A DSM with Remote Site Adjustment Digital Simulcast Multiplex Channel Unit and Associated Equipment	68P80500A08–O (120S–SP5940046)

2. STRUCTURE

The structure of the distribution amplifier shelf, punch block, cables, and distribution amplifier tanapa is as shown below. The Q3195A Distribution Amplifier Shelf, QRN4876A Punch Block, QKN4348A 50 Foot Cable, QKN4347A 25 Foot Cable, and QLN3174A Distribution Amplifier are all structured as stand alone units (i.e., they are not structured to higher levels). Note that some of the kit level items such as the QRN4877A Card Cage contain lower level assemblies and piece–parts not explicitly listed below.

1) Distribution Amplifier Shelf Q3195A includes:

Card Cage	QLN3238A
Power Cable	QKN4349A

The Card Cage QLN3238A includes:

Card Cage	QRN4877A
Interconnect Board	QRN4862A

2) Distribution Amplifier QLN3174A

3) Punch Block QRN4876A

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171 N. Covington Drive, Bloomingdale, IL 60108

68P06908F38–B
(115S–SP5940046)

3. ATTACHMENTS

— QRN4878A Distribution Amplifier Board Schematic Diagram and Circuit Board Detail	116–SP5940046
— Parts List	116PL–SP5940046
— QRN4862A Interconnect Board Schematic Diagram	117–SP5940046

4. DESCRIPTION

4.1 The distribution amplifier board (QRN4878A) splits 600 ohm transmit audio from a Simulcast Digital Microwave Interface (SDMI) into ten equal 600 ohm line outputs with no net loss. Each 600 ohm line output is intended to drive a 600 ohm line input of a Digital Simulcast (DSM) Channel Unit (Models Q3122B, Q3200A, Q3208A, Q3209A) destined for a different UHF or VHF simulcast transmitter. However, any 600 ohm balanced line may be driven, including the input of another distribution amplifier.

4.2 The distribution amplifier accepts a nominal line input test tone level of –10 dBm and delivers –10 dBm at each of the ten output lines. The amplifier is virtually noiseless and distortionless as required by the simulcast system application. In addition, the amplifier provides extended low frequency response for low frequency tone transmissions such as Private–Line™, or low speed digital transmissions such as Digital Private–Line™ or Trunked System Low Speed Data. Group Delay Distortion is negligible as required for such high speed digital transmissions as the Trunked System High Speed Data signals.

4.3 If more than ten simulcast transmitters are on the same channel, one of the ten 600 ohm line outputs should be used to drive the 600 ohm input line of another distribution amplifier. This results in a capacity of nineteen lines. If more than nineteen line outputs are required, the process may be repeated again, resulting in a total capacity of twenty–eight 600 ohm line outputs for delivery to as many as twenty–eight Digital Simulcast Multiplex Channel Unit 600 ohm line inputs (See Figure 1.)

4.4 In general, not all of the 600 ohm line outputs will be utilized in a given system configuration. In this case, each unused line should be terminated in a 600 ohm resistive load which is provided on the distribution amplifier module.

4.5 The distribution amplifier can also split two signaling lines, each ten ways, for distribution to the remote sites. Typically, these will be transmitter PTT lines.

4.6 Front accessible DIP switches on the distribution amplifier are provided for manually generating PTT (or other signal) and also for disabling any individual PTT (or other signal) line. This feature is of value during alignment and testing of the simulcast system.

4.7 If more than ten simulcast transmitters are on the same channel, the PTT (M–Lead) Splitters must be cascaded by wiring the common output of the first module to the input of the next, and so on. (See Figure 1.)

4.8 In a trunked system, the PTT line would be generated on the SDMI. In a non–trunked system, the PTT line would be generated by the voting equipment.

4.9 Equipment specifications are shown in Table 1.

5. THEORY OF OPERATION

(Refer to attached schematic diagram 116–SP5940046.)

5.1 REGULATOR

5.1.1 Regulated power is provided to op amplifier U303 and Push–to–Talk (PTT) and Encrypted Voice Code Detect (EVCD) switching circuits via two negative voltage regulators (U301 and U302). U301 utilizes feedback resistors R301 and R302 to regulate the –42 to –56 volt (–48 volt nominal) battery potential to –18 volts. The –18 volt supply is applied to three different circuits.

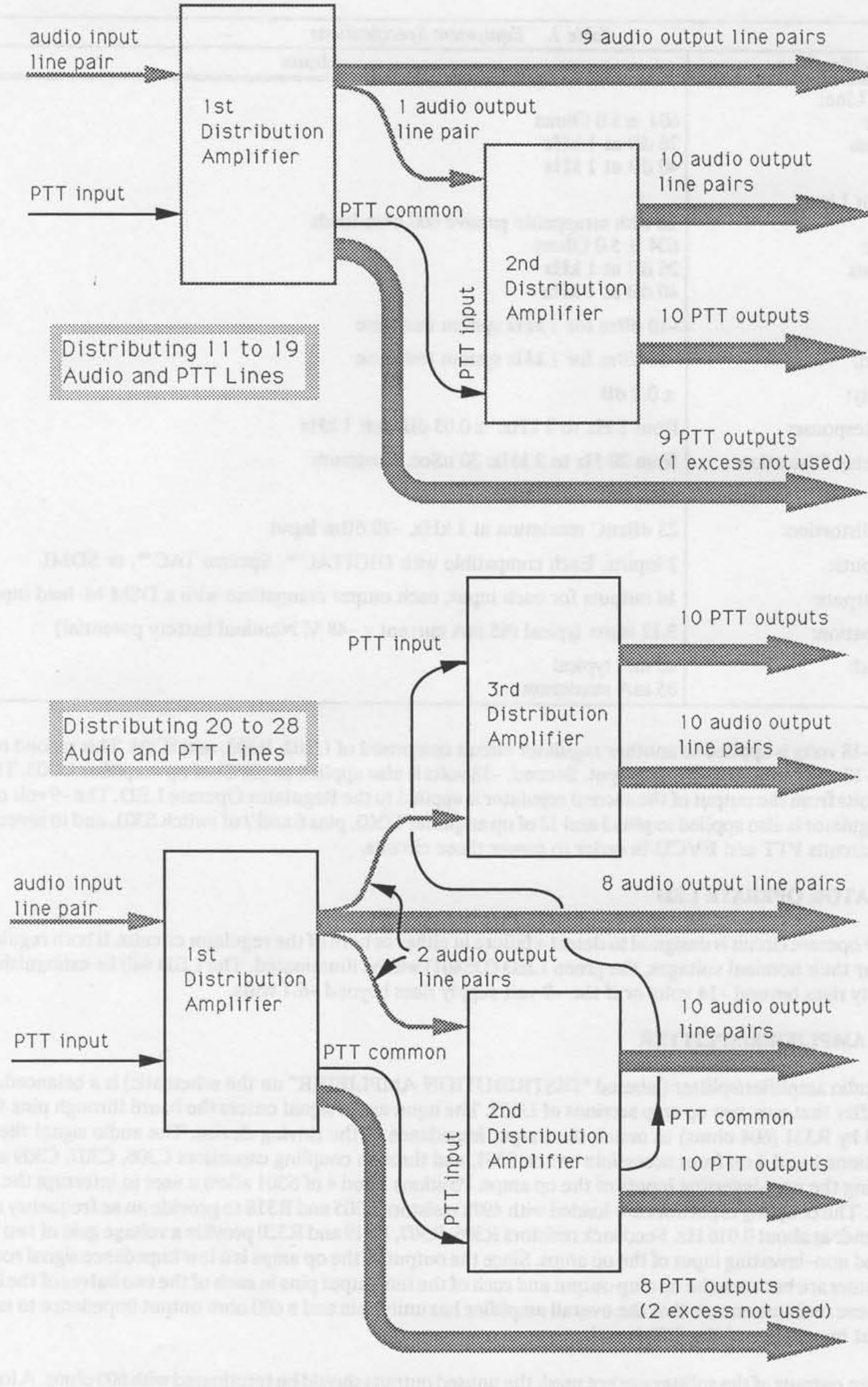

Figure 1. Distribution Amplifier Interconnections

Specifications	Limits
Table 1. Equipment Specifications	
Audio Input Line:	
Impedance	604 ±5.0 Ohms
Return Loss	26 dB at 1 kHz
Balance	40 dB at 1 kHz
Audio Output Lines:	
Number	10 with strappable passive 600 ohm loads
Impedance	604 ±5.0 Ohms
Return Loss	26 dB at 1 kHz
Balance	40 dB at 1 kHz
Input Level:	-10 dBm for 1 kHz system test tone
Output Level:	-10 dBm for 1 kHz system test tone
Level Stability:	±0.2 dB
Amplitude Response:	from 2 Hz to 3 kHz: ±0.05 dB. ref: 1 kHz
Envelope Delay Distortion:	from 20 Hz to 3 kHz: 30 uSec. maximum
Idle Noise:	15 dBrnC maximum
Noise Plus Distortion:	23 dBrnC maximum at 1 kHz, -10 dBm input
Signaling Inputs:	2 inputs. Each compatible with DIGITAC™, Spectra TAC™, or SDMI.
Signaling Outputs:	10 outputs for each input, each output compatible with a DSM M-lead input.
Power Dissipation:	3.12 watts typical (65 mA current x -48 V. Nominal battery potential)
Current Load:	65 mA typical 85 mA maximum

5.1.2 First, -18 volts is applied to another regulator circuit comprised of U302, R303, and R304. This second regulator converts the -18 volt input to a -9 volt output. Second, -18 volts is also applied to pin 11 of op amplifier U303. Third, -18 volts and -9 volts from the output of the second regulator is applied to the Regulator Operate LED. The -9 volt output of the second regulator is also applied to pins 3 and 12 of op amplifier U303, pins 6 and 7 of switch S301, and to several nodes on signaling circuits PTT and EVCD in order to power those circuits.

5.2 REGULATOR OPERATE LED

The regulator operate circuit is designed to detect a failure in either or both of the regulatoı circuits. If both regulators are operating near their nominal voltages, the green LED (DS401) will be illuminated. The LED will be extinguished if the -18 volt supply rises beyond -14 volts or if the -9 volt supply rises beyond -6.7 volts.

5.3 AUDIO AMPLIFIER/SPLITTER

5.3.1 The audio amplifier/splitter (labeled "DISTRIBUTION AMPLIFIER" on the schematic) is a balanced, non-inverting amplifier that uses two op amp sections of U303. The input audio signal enters the board through pins 41 and 42 and is loaded by R331 (604 ohms) to match the output impedance of the driving device. The audio signal then passes through positions 1 and 4 on front accessible switch S301, and through coupling capacitors C306, C307, C309 and C310 before reaching the non-inverting inputs of the op amps. Positions 1 and 4 of S301 allow a user to interrupt the audio to the amplifier. The coupling capacitors are loaded with 499k resistors R305 and R318 to provide an ac frequency response high-pass corner at about 0.016 Hz. Feedback resistors R306, R307, R319 and R320 provide a voltage gain of two between the output and non-inverting input of the op amps. Since the output of the op amps is a low impedance signal source, ten 301 ohm resistors are between the op amp output and each of the ten output pins in each of the two halves of the balanced amplifier. These resistors ensure that the overall amplifier has unity gain and a 600 ohm output impedance to match the 600 ohm input impedance of the DSM card.

5.3.2 If all ten outputs of the splitter are not used, the unused outputs should be terminated with 600 ohms. A load of 604 ohms is supplied for each output and can be switched in by closing the appropriate switch position on S302.

5.3.3 One distribution amplifier can drive up to ten DSM cards. There is one DSM card per simulcast site, per audio channel. If an audio channel has more than ten simulcast sites, one or more outputs of the driving distribution amplifier can be used to drive other amplifiers.

5.4 SIGNALING CIRCUITS

5.4.1 The distribution amplifier board has two signaling/relay circuits (M–leads) labeled PTT (Push–to–Talk) and EVCD (Encrypted Voice Code Detect). The two circuits are identical to each other in operation and composition and are designed to be keyed in either of two ways. These ways are:

1) Shorting the two input leads together either by a hard short–circuit closure as in *Spectra–TAC*, or by a saturated opto–isolator output as in the Simulcast Digital Microwave Interface, or

2) A high (+13.8 V) potential falling to a low (approximately equal to 0 volt) potential as in *DIGITAC.*

5.4.2 If the driving device uses a short circuit or saturated opto–isolator closure, positions 1 and 2 of S102 and S202 should be closed. If the driving device uses a high–potential to low–potential key, then positions 1 and 2 of S102 and S202 should be open. Positions 3 and 4 of S102 and S202 are not connected.

5.4.3 The output of the signaling circuit is intended to drive the input of the M–leads on the DSM board only. Note that the jumpers on the M–leads on the DSM board must be set in the following way:

M1	M2
P302: Position B	P304: Position B
P303: Position A	P305: Position A

5.4.4 The operation of the signaling circuits is as follows. R103 (R203) and R108 (R208) form a voltage divider that holds the potential of Q101 (Q201) emitter at about –1 volt. When the circuit is unkeyed, Q101 (Q201), Q102 (Q202), and Q103 (Q203) are all cutoff. When the circuit is keyed, all the transistors are saturated. The approximate potential at each of the transistor terminals is as follows for each state:

	Keyed	Unkeyed
Q101 (Q201)		
Base	–1.7 volts	–1.0 volt (*Spectra–TAC*, SDMI), +2.8 volt (*DIGITAC*)
Emitter	–1.1 volts	–1.0 volt
Collector	–1.1 volts	–9.2 volts
Q102 (Q202)		
Base	–8.4 volts	–9.2 volts
Emitter	–9.2 volts	–9.2 volts
Collector	–9.1 volts	–0.1 volts
Q103 (Q203)		
Base	–0.72 volts	–0.07 volts
Emitter	0.0 volts	0.0 volts
Collector	–0.04 volts	–4.5 volts

5.4.5 The three front accessible switches S101, S201, and S301 (positions 2 and 3) enable the user to have manual control of the signaling. Both S101 and S201 are ten position switches, each position of which can prevent or allow its corresponding site to be keyed depending on whether the switch position is open or closed, respectively. S101 controls Push–to–Talk (or M–lead 1), and S201 controls Encrypted Voice Code Detect (or M–lead 2). Note that even if a given switch position is closed, its site will be keyed only if the input to the signaling circuit is keyed. The user can manually force either signaling circuit to be keyed by closing positions 2 or 3 of S301. S301 position 2 keys the Push–to–Talk or M–lead 1 and S301 position 3 keys the Encrypted Voice Code Detect or M–lead 2.

5.4.6 Each of the two signaling circuits can key the appropriate M–lead input in as many as ten sites. If a system has more than ten sites per audio channel, pin 47 of the PTT circuit and pin 48 of the EVCD on the primary distribution amplifier can be connected to pins 43 and 44 respectively of the secondary distribution amplifier board. This cascading of boards is possible provided that S201 and S202 positions 1 and 2 are set to "closed" on the secondary board. S102 and S202 positions 1 and 2 on the secondary board must be closed regardless of the setting of those switches on the primary board. If there are more than nineteen simulcast sites in a system, the signaling inputs on the tertiary card must be driven by pins 47 and 48 of the secondary card, not the primary card. Note that this cascading scheme for the signaling circuits is different from that for the audio circuit.

6. PROPER SWITCH SETTINGS FOR NORMAL OPERATION

Refer to Figure 1 for more than ten simulcast sites.

S101, S201: Any position driving a DSM M–lead input: closed.

Any position **not** driving a DSM M–lead input: open.

S102, S202: If either one or both of the following two conditions apply:

1) *DIGITAC* is the triggering equipment, or

2) Key–up is triggered by a positive potential (+ 13.8 volts) changing to ground on pin 43 for PTT (M–lead 1) and/or pin 44 for EVCD (M–lead 2), then;

Positions 1 and 2: open
Positions 3 and 4: don't care.

If any of the following three conditions apply:

1) *Spectra–TAC* or SDMI is the triggering equipment, or

2) Key–up is triggered by a dead short–circuit or a saturated opto–isolator between pins 43 and 45 for PTT (M–lead 1) and/or pins 44 and 46 for EVCD (M–lead 2), or

3) Key–up is triggered by another distribution amplifier (i.e., pin 47 of the primary amplifier to pin 43 of the secondary amplifier for PTT or M–lead 1 and pin 48 of the primary amplifier to pin 44 of the secondary amplifier for EVCD or M–lead 2), then;

Positions 1 and 2: closed
Positions 3 and 4: don't care.

S301: Positions 1 and 4: closed
Positions 2 and 3: open

S302: Any position driving a DSM card or another distribution amplifier: open.

Any position not driving a DSM card or another distribution amplifier: closed.

7. TROUBLESHOOTING

In case of difficulty, use the following procedures.

Problem:	No audio or low level audio (e.g., –3.54 dBm0) at the input of the DSM board.
Procedure:	Make sure the audio signal is available from the SDMI or the voting equipment to the distribution amplifier audio input (pins 41 and 42). If audio is present at the input, make sure that both positions 1 and 4 of switch S301 are closed so that the input signal can reach the amplifier. If an audio signal is present at the input of the DSM board but is low in level (most likely by 3.54 dB), make sure that the position on switch S302 corresponding to the output in question is open. If the switch is closed, a 604 ohm load is connected in parallel with the 604 ohm load of the DSM audio input. The additional 604 ohm resistor causes excessive loading of the distribution amplifier output.
Problem:	Unable to key either of the signaling circuits of the DSM board with the PTT or EVCD circuits.
Procedure:	Verify that the keying signal is available from the *Spectra–TAC*, SDMI, *DIGITAC*, or the voting equipment to the input pins of the distribution amplifier signaling circuit(s). If the signal from the driver is present, verify that positions 1 and 2 of switches S102 and S202 are set properly. Set positions 1 and 2 to closed if the driving device is a *Spectra–TAC* or Simulcast Digital Microwave Interface (SDMI). If the driving device is a *DIGITAC*, set positions 1 and 2 to open. If the distribution amplifier board signaling circuitry still will not transmit the keying signal to the DSM board at a given site, verify that the appropriate position on switch S101 for M–lead 1 (or PTT) or S201 for M–lead 2 (or EVCD) is closed. If the switch position in question is open, no signal can be transmitted to the site.
Problem:	M–leads on the DSM boards remain keyed even when no keying signal is present from the voting equipment (*Spectra–TAC, DIGITAC*, or SDMI).
Procedure:	Make sure that positions 2 and 3 of switch S301 are in the open position. If either or both of positions 2 and 3 of switch S301 are closed, the corresponding signaling circuit (PTT or EVCD or both) will be keyed on regardless of the signal from the voting equipment. If the DSM M–leads are still on when no triggering signal is being delivered from the voting equipment, verify that positions 1 and 2 of switches S102 and S202 are in the proper position for the type of voting equipment being used. Positions 1 and 2 of switches S102 and S202 should be in the closed position if the driving device is a *Spectra–TAC* or SDMI and in the open position if the driving device is a *DIGITAC*.

8. RACKING AND SET–UP

The QRN4878A Distribution Amplifier Kit mounts in the QRN4877A Card Cage Kit. This card cage kit may be mounted to any standard rack, including a rack containing up to two DSM channel banks. If the distribution amplifier shelf is mounted on a rack that also holds channel banks, the distribution amplifier shelf should be mounted above the channel banks. (**Note:** A 7 RU space must be allowed above and below this shelf. Option P14 heat baffle can be substituted for a 7 RU space.)

Power is applied to the distribution amplifier shelf through the QKN4349A Power Cable Kit. This power cable kit consists of two ten–foot long wires (one red and one black) with a connector at one end. The connector fits into a mating power connector on the distribution amplifier backplane. The free end of the black wire is connected to ground and the free end of the red wire is connected to a battery potential of between –21 and –56 volts (–48 volts nominal).

Signals are carried to and from the distribution amplifier through either the QKN4348A 50–Foot Cable Kit or the QKN4347A 25–Foot Cable Kit. At one end of the cable is a connector mounted at 180° from the cable wires. The 180°

mounted cable connector is to be attached to a mating connector on the distribution amplifier backplane directly behind a distribution amplifier board. A small metal clip is provided at this cable connector to secure the cable connector to the backplane mating connector. At the other end of the cable is a connector mounted at 90° from the cable wires. This 90° mounted cable connector is to be attached to the QRN4876A Punch Block and secured with a Velcro strap provided on the punch block. Note that the position numbers on the punch block do not match the card edge connector numbers which are shown on the circuit schematics. A cross reference of edge connector pin numbers and Telco cable/punch block pin numbers is provided in Table 1 on QRN4862A Interconnect Board Schematic Diagram, Motorola Microwave No. 117-SP5940046-1 at this end of this manual.