Mobile Communications

EDACS® SIMULCAST SYSTEM OVERVIEW

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SIMULCAST SYSTEM DRAWINGS.....LBI-38878
EDACS INTERFACE PANEL LBI-38812
POWER SUPPLY.....LBI-38670

MAINTENANCE MANUAL

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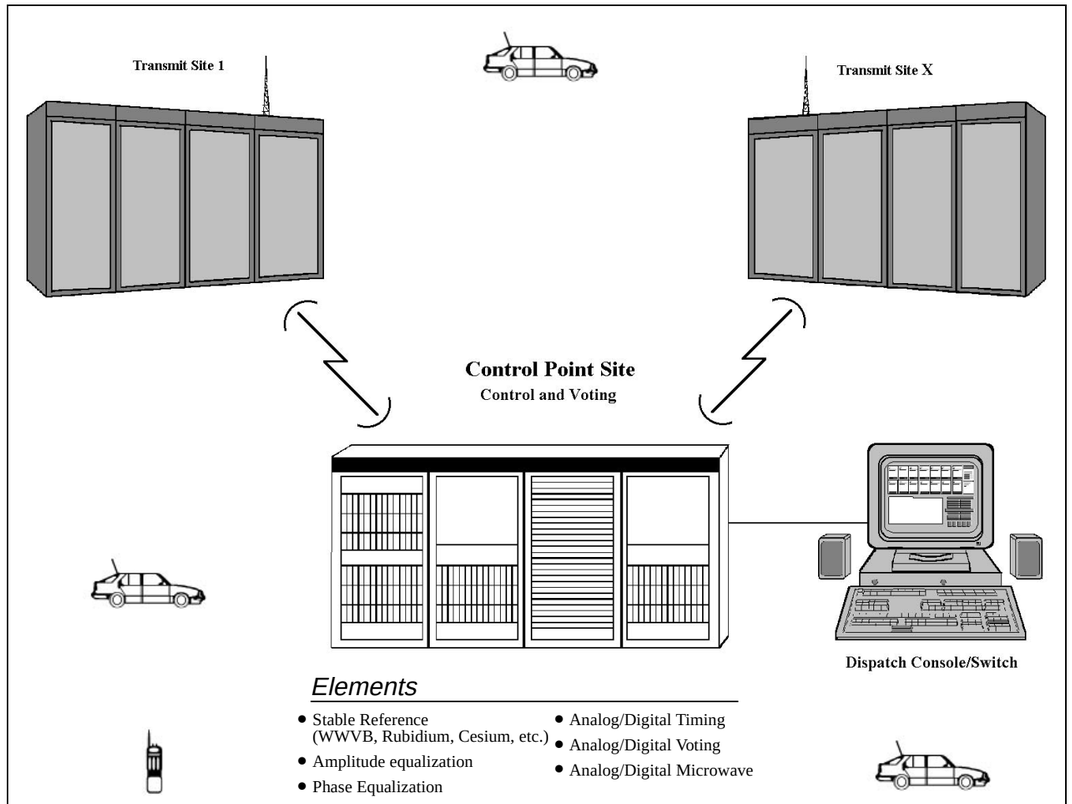


EDACS Simulcast System

EDACS SIMULCAST SYSTEM OVERVIEW

The EDACS Simulcast System enhances communications in areas where the size of the coverage area is too large and/or the communications paths are blocked or hindered by irregular terrain or other obstacles to be reliably serviced by a standard EDACS communications system. When these conditions exist and the talk out coverage is inadequate, the need for a simulcast system is indicated. It is also advantageous in areas where available frequencies are limited since it utilizes the same set of frequencies at each site. All transmissions are system wide i.e., messages are transmitted simultaneously from all sites on the same channel and on the same RF frequency. The EDACS simulcast system combines both digital and analog systems to accommodate transmission of data, digital voice and analog information.

A typical simulcast system includes a Control Point and two or more Transmit Sites. The Control Point exercises control over all Transmit Sites. All outbound call assignments are made and transmissions initiated from the Control Point and all inbound calls from mobiles or portables are received, voted, and processed before being sent to the Transmit Sites for retransmission.

CAPTURE/NON-CAPTURE ZONES

Since all transmitters operate on the same channel frequencies at all sites, one may question the quality of communications received in the coverage area due to the arrival, at different times, of two or more signals from the transmitter sites. When the receivers, mobile or portable, are near a transmitter, the receiver is captured by the strong local signal while signals from all other transmitters are blocked out. In other areas where two or more signals are received, neither one may be strong enough to capture the receiver. These identifiable areas are known as "non-capture" or "overlap" zones.

The "capture" zone is defined as the area in which the carrier level of one transmitter exceeds the second by approximately 8 dB. In this area, the mobile receiver will lock onto the stronger signal to the complete or nearly complete exclusion of the weaker signal. This area is known as the "capture" zone and provides the best audio quality in the system. See Figure 1.

In the "non-capture" or "overlap" zone, the mobile receiver accepts two or more signals. These signals mix randomly producing stronger or weaker signals. If the power level difference between the received carrier signals is less than 6 dB with voice modulation, audio intermodulation and distortion may occur. This distortion is evident by a crackling and popping sound heard over the speaker. Audio distortion increases to a maximum when the received carrier signals are equal. Good communication in these areas is maintained by precision system synchronization and equalization.

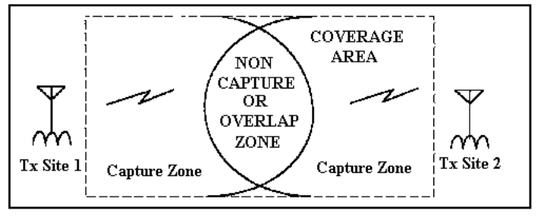


Figure 1. Radio Coverage Area

System synchronization and equalization assure that the received carrier signals do not detract from one another in the overlap zone but instead reinforce one another. In addition, the transmitter audio from each carrier signal must be delay equalized to minimize the crackle and pop heard in the received radio. To accomplish these objectives the EDACS simulcast system, through system trisynchronization, ensures that all digital signaling, digital voice, and analog voice are precisely synchronized to provide the most reliable and highest quality communications possible. Trisynchronization consists of time equalizing the high speed data (9600 baud), low speed data (150 baud), and the audio amplitude and phase of the transmitted analog messages.

LONG TERM SYSTEM STABILITY

In a typical simulcast system, transients such as lightning and weather disturbances will affect data synchronization. These transients may disrupt a microwave path or cause the microwave system to switch over to hot standby. Data synchronization **must be** maintained to achieve overall system communications integrity in the overlap zone.

Two methods are employed to assure long term system synchronization and stability:

- Frequency synchronization with WWVB or other stable frequency source
- A unique High Speed Data Auto Re-Synchronization system

The RF carrier frequency for each channel is maintained within 1 Hz of the frequency of all other transmitters in the simulcast system to minimize distortion due to heterodyning frequencies. To achieve this ultra high level of performance, the reference oscillator at each transmitter is locked onto a 60 kHz reference signal transmitted by WWVB. To ensure reliability, redundant WWVB receivers with individual ferrite loop antennas are connected to a distribution amplifier.

The accuracy of the 10 MHz oscillator, when locked to WWVB, is typically held within 0.01 Hz. During periods of short fades, the oscillator is held on the last frequency setting with a typical aging of plus or minus 3×10^{-10} per day.

NOTE

The frequency at each transmitter site drifts in the same direction and typically at the same rate and same time. Thus the important frequency drift differential remains very small, even with the loss of the 60 kHz reference signal.

SYSTEM SYNCHRONIZATION AND EQUALIZATION

The EDACS Simulcast System features precise synchronization of digital signaling, digital voice, and analog voice to achieve high quality communications. This is accomplished through trisynchronization, by synchronizing and time equalizing the high speed data, the low speed data, and the audio amplitude and phase of the transmitted message.

Proper synchronization of the high speed data is **extremely** important since the mobile units are totally dependent on control channel signaling to enable them to provide communications throughout the system. A control channel that is not synchronized or whose signaling is not received can result in total loss of communications for radios operating in the overlap zone. The radio then must re-establish the communications path.

High speed data is used for control channel messaging, the working channel handshake, trunked data, and digital voice,

whether Voice Guard or Aegis. The working channel handshake occurs before the prompt tone is received.

Low speed data (150 baud) is used on the working channels to provide the priority scan and Channel Guard functions during audio transmissions.

HIGH SPEED DATA. The "HSD Auto Re-Sync" (High Speed Data) circuitry continually re-synchronizes the control channel and the working channels. The control channel at each site is re-synchronized by breaking the continuous control channel data stream approximately once each minute for one time slot and then restarting all the control channels at exactly the same time. This assures automatic resynchronization of the control channels should they have broken sync. The EDACS mobile radio is not affected by resynchronization and continues to operate during this time. Once a radio is assigned a working channel, the working channel is re-synchronized with each operation of the PTT switch. (The HSD Auto Re-Synchronization circuit is built in and requires no special maintenance.)

NOTE

In an all digital systems where only EDACS Aegis radios are used, "HSD Auto RE-Sync" would be sufficient to provide long term stability, but EDACS supports systems with both digital and analog dispatch, requiring that audio amplitude and phase be supported.

Low Speed Data. Low speed data is time equalized to compensate for the varying distances of the transmitter sites from the Control Point.

Audio Amplitude And Phase. Finally, audio amplitude and phase responses are matched. By precisely matching the analog voice from each site, the receiving mobile unit in the overlap zone will consistently hear good quality clear audio.

SIMULCAST ALARM SYSTEM

The simulcast alarm system forwards current status information for the control channel and the working channels at all transmitter sites to the site controller. Each site is continuously exercised by regularly scheduled test calls, initiated by the site controller, to monitor operation of the control channel and the working channels including data signals. The results of a test of the clock signal and the per channel (pass/fail) test are forwarded by the test unit to the TUAI (test unit alarm interface). From the TUAI, the alarm status enters the EGE Alarm System where it is remoted to the Control Point. At the Control Point, the alarm status is forwarded to the control GETC for the designated channel failure. The control GETC, in turn, forwards this information to the site controller for disposition.

The equipment faults are logged by the site controller and the defective channel removed from service. If a control channel was removed from service, a good working channel is reassigned to operate as the new control channel. If the tested channel subsequently passes a test, it is returned to service. If not it remains in the failed mode until successfully retested. Sites are tested in parallel. If a channel fails at any one site, it is removed from service at all sites.

In addition to continuously monitoring the control and working channels, the simulcast alarm system provides:

- Low RF forward power alarms for each PA at each transmitter site.
- Low RF forward power and high reverse power alarms for up to 2 transmit antennas per transmitter site.
- Additional digital and analog inputs and digital outputs for additional system/customer requirements.

These additional inputs and outputs at the Control Point and at the Transmitter Site consist of:

48 Digital Inputs
32 Analog Inputs
32 Digital Outputs

Equipment for the alarm system includes:

- A test unit radio (1 at each simulcast transmitter site)
- A test unit alarm interface GETC (One GETC per 5 channels at each simulcast transmitter site)
- Remote Alarm Station (RAS) (1 at each simulcast transmitter site)
- Master Alarm Station (MAS)

A detailed description of the operation of the Alarm Subsystem is included in LBI-38495.

SYSTEM INTERFACE REQUIREMENTS

In addition to the simulcast and related peripheral equipment provided, audio/data lines must be installed to complete the voice and data paths to/from the multiplex equipment, the voter/simulcast equipment, and the downlink between the console or multisite switch and the site controller. The maximum number of 4-wire E & M voice channels required between the Transmit Site and the Control Point is equal to twice the total number of channels plus eight additional channels for alarm and control functions and the dual program channel. To assure a high quality simulcast system the audio/data lines must meet the Bell System Specification for 3002 grade levels and be routed over a phase/latency stable network.

A digital multiplex/microwave system is strongly recommended. If an analog multiplex system is employed, it must incorporate a "phase stable"/simulcast phase locked system.

Telephone lines are generally not acceptable for routing audio and data between the Transmitter Site and the Control Point.

Control Point Interface Requirements

Two 4-wire E & M multiplex channels are required between each Transmit Site and the Control Point for each channel. One multiplex channel sends delayed 9600 baud high speed (NRZ) data and A/D signals from the Control Point to the Transmit Site and the received data (converted by modem from 9600 baud NRZ data) from the Transmit Site to the digital voter at the Control Point. The second channel sends the delayed transmit audio signal and PTT to the transmitter and the received audio signal to the analog voter.

In addition to the above channels, one-half of a 4-wire E & M channel is used to transfer low speed trunking data to all Transmit Sites. Since this data is common to all channels only one channel is required per site. This data passes through the FSK modem which provides the audio component.

A dual program channel is required to transfer the 300 Hz time sync reference tone and the 2400 Hz bit timing reference tone to the Transmit Site. This channel requires six time slots.

The alarm and control information system requires a 4-wire E & M channel to transfer status and alarm information between the Control Point and the Transmit Site.

Transmit Site Interface Requirements

Since the Control Point and Transmit Site communicate directly with one another, the interface requirements at the Transmit Site are a mirror image of the Control Point.

Digital Channel Banks

The equipment required to transfer data and voice between the Control Point and the Transmit Sites consist of two 4-wire E & M channels (per RF channel), two 4-wire channels, and one program channel . The equipment is assigned as follows:

- One 4-wire E & M channel - Voice and PTT.
- One 4-wire E & M channel - Data and A/D.
- One 4-wire channel for alarms.
- One-half (inbound) 4-wire channel - 150 baud modem audio to site.
- One low noise channel - 300 Hz time sync reference tone.
- One low noise program channel - 2400 Hz bit timing reference signal.

NOTES

1 - Some digital channel banks have a "stereo" program card that meets the above requirement.

2 - Analog multiplex systems may not have a program card. Instead, a simulcast decoder card is used for each timing signal. Voice circuits (inbound) use simulcast decoder cards and received voice to voter circuits use a 1-way encoder card for each channel.

Simulcast Support Equipment

- Multiplex/microwave - Digital or Analog Multiplex System. Digital is preferred. Channel requirements as indicated above.
- Antenna System for WWVB receivers, if used. RG-58 feed may be used.
- CCM (Control Channel Monitor) - Monitors the outbound control channel messages from the Control Point and distributes this information to all receiver GETC's at the Transmit Site. The CCM consists of a radio receiver, buffer board, and related hardware. The radio does not need an external antenna system. The monitoring function is local to the site.

Multiplex Channels

The program channel transfers the 300 Hz time sync reference tone and the 2400 Hz bit timing reference tone to the Transmit Sites. The program channel must have a signal to noise ratio greater than -50 dB. This translates into a zero crossing jitter of less than 1 microsecond. The bandwidth of the program channel must be sufficient to pass the 300 Hz and 2400 Hz reference tones. Either a digital or analog multiplex system, equipped with Phase Lock Loop oscillators should be used to assure frequency stability.

STANDARD SYSTEM CONFIGURATIONS

The EDACS Simulcast System is available in several standard configurations that can be tailored to meet specific customer requirements. All systems are built to one of the following five configurations with sites and/or channels omitted when design requirements fall between configuration intervals. The current standard configurations are:

4 site - 10 channel
5 site - 5 channel
10 site - 10 channel
4 site - 20 channel
10 site - 20 channel

Figures 2 and 3 show a typical rack-up of the Control Point and Transmit Site equipment respectively for a 10 Site/10 Channel System.

Control Point

GETC Shelf. A separate control GETC is required for each channel.

Digital Delay Shelf. Each digital delay module accommodates two Transmit Sites (10 channel maximum). Therefore, the number of digital delay modules required in 10 channel systems equals the number of sites divided by 2. Up to 15 digital delay modules may be required for the various configurations. The digital delay module delays the transmission of data to the Transmit Sites so that the transmitted data arrives at each Transmit Site at the correct time.

Analog Delay Shelf. Each analog delay module accommodates one Transmit Site in the simulcast system. It provides audio delay for 12 voice signals and the 150 baud FSK signal (low speed) or 13 voice signals. If there are more than 10 channels, then the number of analog delay modules required is doubled. Up to 20 analog delay modules may be required for the various configurations - channels 1-10 (card 1) and channels 11 - 20 (card 2).

Analog Processing Shelf #1. Analog processing shelf #1 contains audio compressors, audio bridges, and audio equalizers. It provides linear audio compression with low distortion and provides amplitude and phase conditioning for the voice circuits. The audio bridge provides up to 10 single ended outputs and one transformer coupled output for expansion.

Analog Processing Shelf #2. Analog processing shelf #2 contains an audio bridge for low speed data distribution and a tone interface module. The tone interface module provides low pass filtering for the 300 Hz time sync reference tone and the 2400 Hz bit timing reference tone. Additionally, it provides RS-232 to TTL level conversion.

Test Equipment Rack. The test equipment rack provides the means to test, troubleshoot and align a simulcast system. It contains the master alarm system, alarm hybrid shelf, alarm monitor panel, control panels, digital storage scope, signal analyzer, equalizer test panel, alignment/test radio, balun panel, variable delay panels, transmission test set, and power supply.

Control Point And Transmit Site

Universal Sync Shelf. The universal sync shelf houses the alarm module, digital selectors, FSK modem, tone interface module, and up to seven universal sync modules. The alarm module monitors alarms for the digital selectors, tone interface, and the FSK modem.

Digital selector 1 (Control Point only) selects a valid low speed data stream while digital selector 2 (Control Point only) selects a valid high speed clock (9600 Hz). Both digital selectors automatically advance to the next source containing a valid signal. The tone interface module (Transmit Site only) provides detection and filtering of the 300 Hz time sync reference tone and 2400 Hz bit timing reference tone. The universal sync modules synchronize data transmitted from the Control Point to the Transmit Sites. Each module supports four channels.

SYSTEM OPERATION

CALL SEQUENCE

A call request is initiated from either a portable or mobile radio from somewhere in the coverage area. The request is transmitted over the control channel and received by the simulcast stations within range. This request is not processed at the simulcast stations, but instead is converted to modem audio and routed through the Transmit Site modem and multiplex/microwave equipment to the Control Point. Refer to Figure 4 for call sequence information.

The message transmitted from the mobile or portable radio is demodulated by a modem at the Control Point and reconverted to data. This data is routed to the control channel digital voter receiver GETC's associated with all Transmit Sites receiving the request. The message is checked for accuracy and forwarded to the digital voter selector GETC.

The selector GETC filters out duplicate messages and forwards each non redundant message to the simulcast control GETC for the control channel. The control channel GETC processes the message and passes it to the site controller which assigns it to a working channel.

The control GETC is the source of the outbound message. The message is time delayed specifically for each transmitter site, fed to the multiplex equipment and relayed to each Transmit Site.

At each Transmit Site, the signal is decoded by the receiving modem and forwarded to the universal synchronizer where it is resynchronized and clocked out at controlled time intervals to the Transmit Site station GETC. The data is

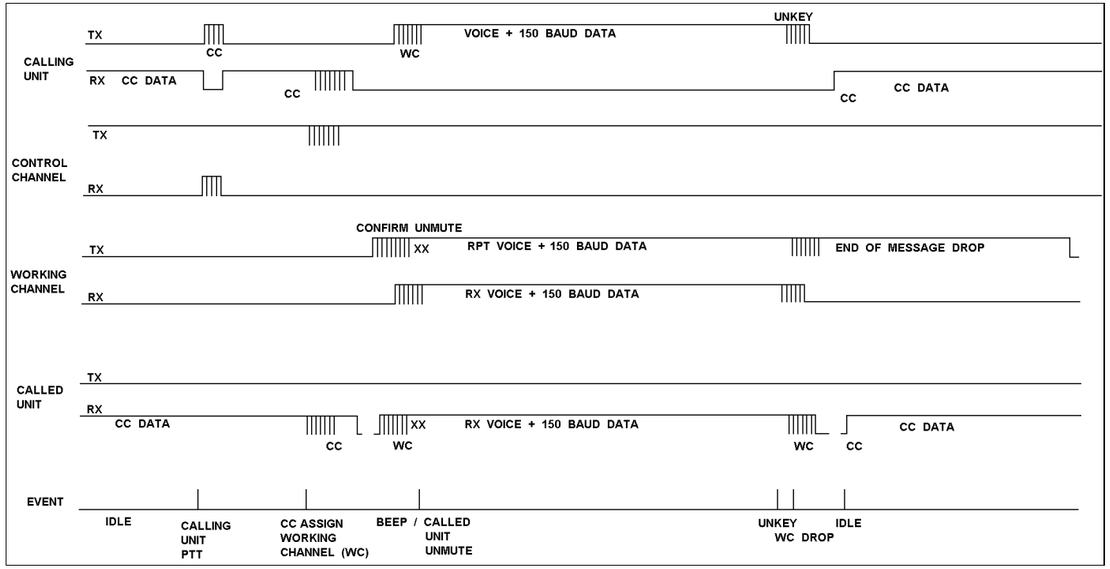


Figure 4. Call Processing Sequence Timing Diagram

passed through a filter and transmitted to the radios monitoring the control channel. The working channel control GETC keys the assigned transmitter at all Transmit Sites.

The calling unit sends a confirmation data signal on the working channel that is passed on to the assigned digital voters in the same manner as data for the control channel. The working channel control GETC receives the confirmation from the digital voter and switches all transmitters to the "voice" mode. This causes an A/D relay to key and send this data signal to all Transmit Sites via E & M signaling.

At the Control Point, all voter digital receiver GETC's receiving the confirmation message unmute the associated analog voter cards. This allows the analog voter to vote the best audio. The resulting voted audio is used as the audio source for simulcasting. The working channel digital voter receivers also look for messages from the sites to "update" the analog voter. The update allows new sites receiving the call to vote. The source audio received from the initiating caller (voter output) is split into as many signals as there are Transmit Sites. Each audio path is individually equalized, appropriately delayed, and routed to the Transmit Sites. With the A/D control signal active, the audio modulates, the RF carrier (equally and in phase) for the working channel at all Transmit Sites. The 150 baud data signal originated at the source site is also present as part of the voice signal.

When the call is completed (the radio initiating the call unkeys), a channel drop message is sent to the digital voter assigned to the working channel and its associated source GETC. The A/D relay reverts to the digital mode, inhibiting the voice and 150 baud low speed data and allowing the channel drop message to be sent to the called radios.

All radios are now in the idle mode monitoring the control call.

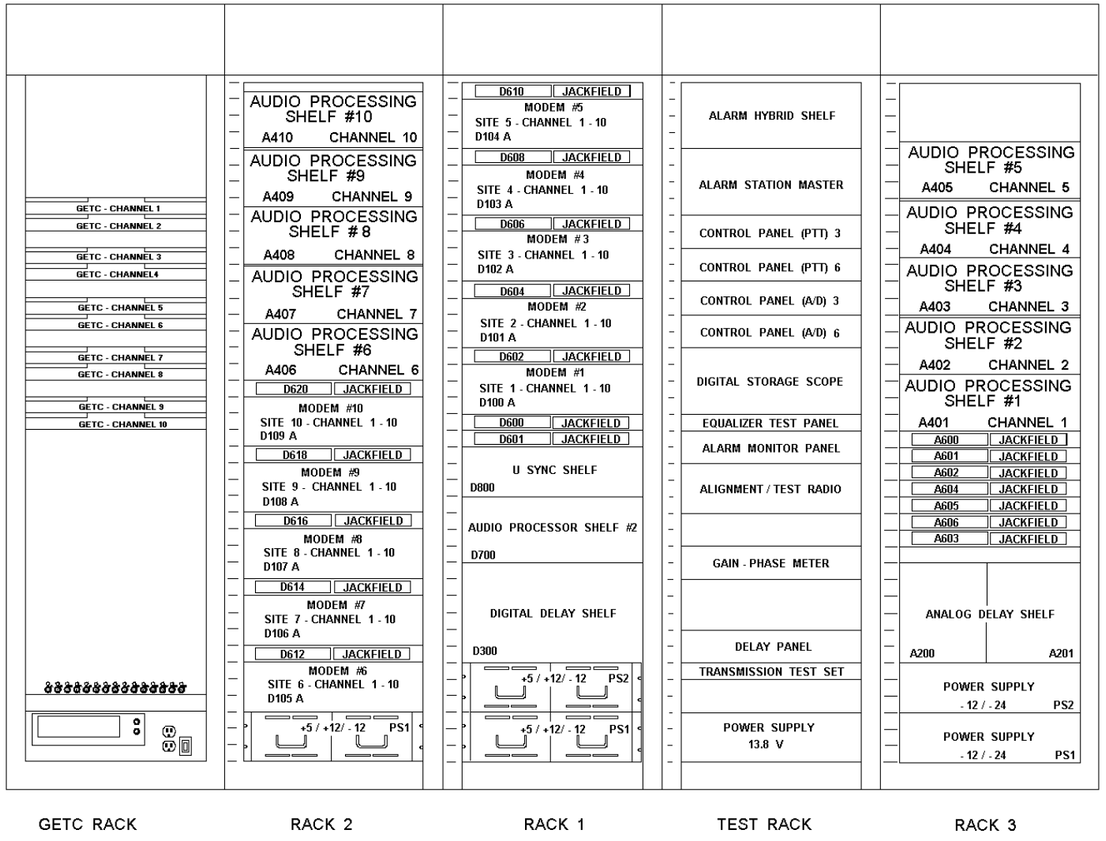
CONSOLE CALL OPERATION

Call requests originating from the dispatch console are communicated to the system via the 9600 baud high speed data line and the uplink/downlink GETC's. The GETC's provide the system interface. The request for a channel is handled in the same manner as a radio request. Operation is the same as described earlier with the message being sent to all Transmit Sites.

OPERATIONAL SUMMARY

Although similar in operation to standard trunked systems, there are several functions in simulcast systems that are different. They include:

Additional time required for processing. The control channel sends messages to the radios to allow them to remain active from channel request to channel assignment.



(19D904160 Sh. 10)

Figure 2. Typical 10 Site 10 Channel System Configuration (Control Point)

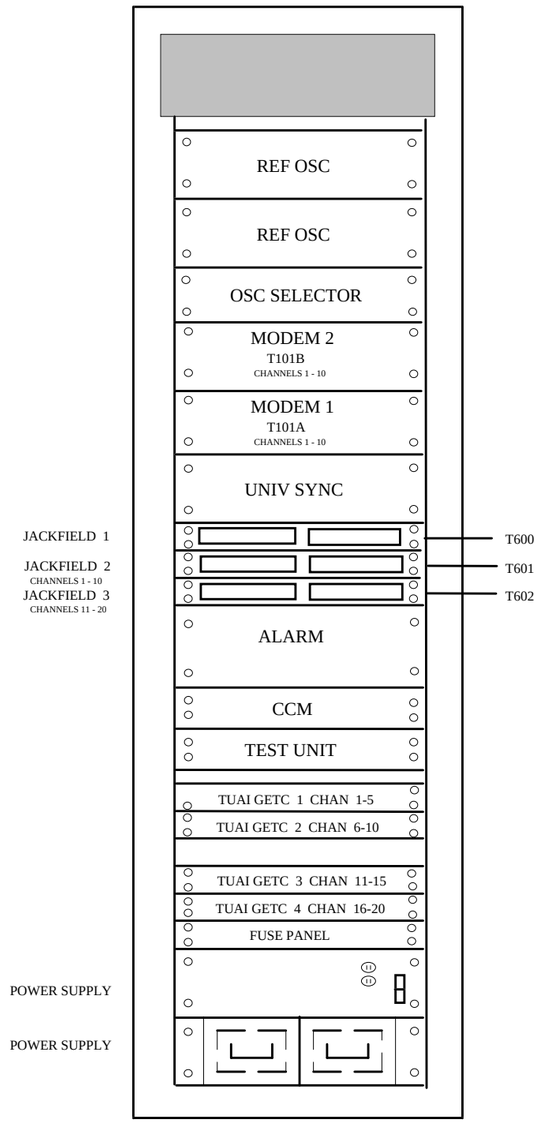


Figure 3. Typical Transmit Site Equipment Rackup (19D903776 Sh. 1)

MODULE LOCATION

Modem Shelf

Slot	Board	Channel
1	Modem Interface	1
2	Modem	1
3	Modem Interface	2
4	Modem	2
5	Modem Interface	3
6	Modem	3
7	Modem Interface	4
8	Modem	4
9	Modem Interface	5
11	Modem	5
12	Modem Interface	6
13	Modem	6
14	Modem Interface	7
15	Modem	7
16	Modem Interface	8
17	Modem	8
18	Modem Interface	9
19	Modem	9
9	Modem Interface	10
10	Modem	10

Universal Sync Shelf

1	Alarm Module	
2		
3	FSK Modem	
4	Tone Interface Module	
5	Universal Sync	1 - 4
6	Universal Sync	5 - 8
7	Universal Sync	9 - 12
8	Universal Sync	13- 16
9	Universal Sync	17 - 20

Alarm Shelf

1	Digital Input Module
2	CPU
3	A/D #1
4	
5	A/D #2
6	
7	A/D #3
8	
9	A/D #4
10	
11	2400 Baud Modem
12	Digital Output Module

Horiz Position Hybrid

All inbound data messages pass through the Control Point digital voter, whether its a control or working channel.

All voice (working channel) is processed by the analog voter associated with the channel that passes the simulcasted source audio.

All outbound data messages originate from the control GETC, whether its a control or working channel.

All outbound voice and 150 baud data originates from the Control Point and is under control of the A/D signal.

Data is synchronized by the 300 Hz and 2400 Hz tones originating from the Control Point.

The decision making site controller is always located at the Control Point.

Local telephone interconnect hardware (RIC, IC, and LIX) is located at the Control Point.

Consoles are interconnected at the EDACS voter. Their received audio originates from the working channel's analog voter. Their transmit audio becomes the working channel's source audio.

TRANSMIT SITE BYPASS OPERATION, OPTIONAL

One of the goals of any communications system is to maintain communications at all times. A need to bypass a Transmit Site, i.e., remove it from the operating simulcast system, may be required when either of the following conditions exist:

- failure of frequency standard sources at a Transmit Site.
- when the Transmit Site is isolated from simulcast control.

Should either of these events occur, your options are:

(1) Shut the site down, recognizing that coverage in this sites domain will only be provided by other transmitter sites.

(2) Assign the Transmit Sites a pre-designated "subset" of available channels on which to operate. The affected Transmit Site can then assume its own unique RF site identification.

NOTE

This subset of channels must be removed from service at other nearby sites.

It is recommended that dispatcher access to the bypassed site be made possible only over RF Control Stations with directional antennas.

Simulcast operation automatically resumes when the transmission path to the affected Transmit Site is restored or frequency standard resumes.

PROTOCOL FOR USING BYPASSED SITE

- Users must be trained to recognize a simulcast failure. CC Scan or NC indication.
- Users must be trained to switch to bypassed system for their area.
- Dispatchers must have RF control to the bypassed site to allow them to dispatch through it.
- Users and dispatchers must be trained to recognize when the simulcast system has returned to simulcast operation. CC Scan or NC.
- System Scan is not recommended since users operating in the same group may log onto different bypassed sites and not be able to communicate with each other. This can happen when operating in the same coverage area (overlap zone between sites) and users may not recognize this condition.

SYSTEM DESCRIPTION

A typical simulcast system includes simulcast equipment and certain non-simulcast radio equipment necessary for system operation. Non-simulcast equipment includes the system manager, site controller, Integrated Multisite and Console Controller, Control Console, Centralized Telephone Interconnect system, and microwave equipment. Refer to the appropriate equipment manuals for pertinent information.

For purposes of discussion, the EDACS Simulcast System is divided into two main functional areas: Control Point and Transmit Site.

NOTE

In some cases, one Transmit Site may be co-located at the Control Point.

The Control Point and the remote Transmit Sites are linked together by microwave or fiber optic cable through the multiplex equipment at the Control Point and the Transmit Sites. A typical block diagram of a three site simulcast system is shown in Figure 5.

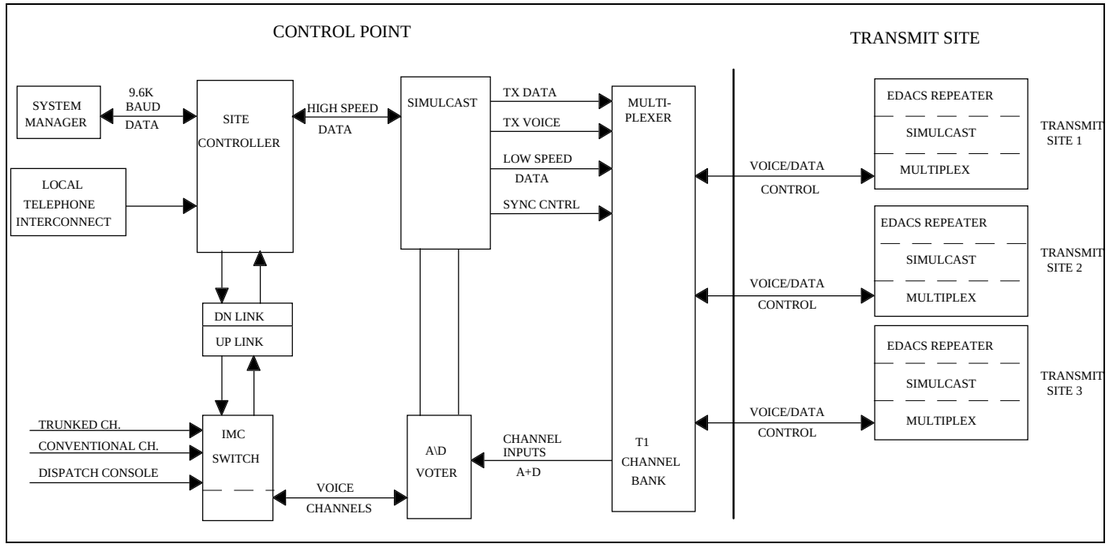


Figure 5 - Simulcast System Block Diagram

CONTROL POINT EQUIPMENT

System Manager

The system manager controls and monitors the EDACS Simulcast System through a computer with modem interface to the site controller. Through the system manager, an operator can customize the site parameters, user database, and execute all high level features.

Site Controller

The site controller interfaces with the system manager, IMC/CEC, and simulcast equipment to provide overall system management functions. It contains a DEC computer, the downlink GETC(s), a 9600 baud modem and the system database.

NOTE

All programming changes to the database are made through the system manager.

System management functions provided through the site controller include:

- Call Validation - Assures that only valid users have access to EDACS.
- Activity Logging - Logs each push-to-talk (PTT) and release.
- Full Dispatch Support - Supports Patch/Simulselect features.
- Eight Level Priority - Secures access for priority users when queued.
- Recent User Priority Increment - Assures completion of conversations.
- Dynamic Regrouping - Over-the-air dynamic regrouping programs temporary groups into radios for strategic purposes.
- Unit Disable - Takes a radio off the air.

The downlink GETC(s) provides the data interface to the IMC/CEC. The 9600 baud modem provides dedicated or dial up connection to the system manager.

Integrated Multisite And Console Controller (IMC)

The IMC provides intelligent interconnection of the EDACS Simulcast System, the dispatch console and possibly other systems, and the Centralized Telephone Interconnect System to form a fully integrated communications system supporting both voice communications and digital data.

Dispatch Console

A Dispatch Console System (optional) interfaces the dispatcher with the EDACS. The dispatch console enables the

dispatcher to communicate with personnel via all talk groups. He may also pre-empt communications on analog systems.

Voter

The voting system accommodates both analog voice and digital data. Analog voting is used for clear voice transmissions while digital voting is used for digitized voice and digital signaling.

Some minor modifications to the voter are required when a Rockwell modem is used for communications between the Transmit Site and the Control Point.

Local Telephone Interconnect System

The telephone interconnect system allows authorized radio units to communicate via the Public Switched Telephone Network. The interconnect system operates in the full duplex mode at the Control Point and in the half duplex mode at the radio user end. The telephone interconnect system operates under the direction of the site controller. It consists of the Repeater Interconnect Controller (RIC), Line Interconnect Controller (LIC), and Line Interconnect Crossbar (LIX). The functions provided include: audio compression, DTMF tone detection and generation, single tone generation, audio routing and control, DTMF dialing, and ring detection.

Repeater Interconnect Controller (RIC)

The repeater interconnect controller (optional) handles all the interconnect signaling and interfacing between the audio module in the EDACS voter and the simulcast equipment at the Control Point.

Simulcast Equipment

The functions provided by the simulcast equipment at the Control Point include: system interface, audio processing, system synchronization and equalization, and control circuits.

The simulcast equipment interfaces with the site controller, the multiplexer, and the A/D voter equipment. A channel can be assigned to operate as a working channel or control channel for the simulcast system.

Several equalization stages are required for each signal type. These include high speed data, low speed data, and analog voice information. The high speed data absolute delay is provided by a shift register data delay circuit. In addition, a unique data pattern is detected and used to generate a "timing bit" that is used to reset all sites to a known state. This "timing bit" ensures that the first data bit of the data message is transmitted in sync and precisely at the right time by all transmitter sites. This assures that the relative time delay of the high speed data signals transmitted from all transmitter sites (operating on the same channel) is maintained within one microsecond.

The simulcast equipment also generates low speed data (150 baud) to provide the priority function and to control the mobiles and portables assigned to this channel. The low speed data signal is converted to an analog signal by an FSK modem. The absolute time delay control of the converted signal is the same as a voice signal. The relative delay of the low speed data signal from different transmitters on the same channel is maintained within 0.01 bit time.

The analog voice signal is first processed by the compressor and amplitude/phase equalizer. The absolute delay is then provided by a digitally controlled analog delay unit. The relative phase between audio signals transmitted from different transmitter sites (on the same channel) is maintained within 25 degrees between 600 and 2600 Hz. The typical targeted adjustment values will be the same as the resolution of the phase measuring instruments, i.e. approximately 10 degrees in the same audio range. The relative audio amplitude response will be within 0.25 dB from 400 to 3000 Hz.

This information, along with the voted voice and digital data received from the A/D voter, is processed by the simulcast equipment and transmitted via the digital multiplexer to the Transmit Sites.

Analog/Digital Voters

The EDACS Simulcast System uses EDACS voters to select the best possible receive path for transmissions from the user equipment while operating in the full feature trunking and failsoft trunking modes. Each simulcast channel utilizes the analog/digital voters to process analog (voice) and digital information. The analog and digital voters operate in parallel and vote on channel inputs received from the remote Transmit Sites. The information from the selected path is forwarded to the GETC interface board in the simulcast equipment. Channel inputs from the Integrated Multisite and Console Controller switch (IMC) also pass through the console interface (part of the voter).

Digital data is synchronized with the simulcast system while the analog voice data is processed and forwarded to the multiplex and microwave link for direct transmission to the EDACS repeaters at the Transmit Sites.

Multiplexer

The multiplexer serves two functions: (1) it multiplexes data at the Control Point for transmission to the Transmit Site and (2) demultiplexes information received from the Transmit Sites and forwards it to the A/D voter and local simulcast equipment as required for processing.

The Control Point multiplexer receives voice, digital data, low speed data and system synchronization information from the simulcast equipment and multiplexes this information onto a single carrier for transmission to all Transmit Sites. Channel inputs from the Transmit Site are demultiplexed and forwarded to the A/D voter where the strongest path is voted and the message directed to the IMC and to the simulcast equipment for processing and retransmission to the Transmit Site.

The communications link between the Control Point and the Transmit Site may be completed by microwave or fiber optics.

TRANSMIT SITE EQUIPMENT

The Transmit Site completes the radio communications path between the Control Point and the radio operator. Equipment located at the Transmit Site includes the EDACS repeater station, multiplex equipment, and simulcast equipment.

Multiplex Equipment

The multiplexer serves two functions:

- it multiplexes data received from the Transmit Site simulcast equipment for transmission to the Control Point and
- it demultiplexes voice, digital data, low speed data and system synchronization information from the Control Point multiplexer. This information is demultiplexed to the audio level and forwarded to the Transmit Site simulcast equipment where it is resynchronized and sent to the EDACS station repeater for transmission to the mobiles and portables.

The communications link between the Control Point and the Transmit Site may be completed by microwave or fiber optics.

Simulcast Equipment

The simulcast circuitry receives the demultiplexed voice and data signals from the multiplexer, resynchronizes the information and passes it on to the station GETC for processing. From there it is passed to the EDACS repeater for retransmission to the mobiles and portables. Resynchronization is accomplished using the synchronization data received from the Control Point.

EDACS Repeater Station

The EDACS receiver receives voice and data information from the mobiles and portables, demodulates this information to the audio level and passes it to the GETC for I/O processing. The processed data is then sent via modem to the multiplexer for transmission to the Control Point.

Audio information received from the Control Point multiplexer is resynchronized and processed by the Transmit Site GETC before being retransmitted to the mobiles and portables.

FUNCTIONAL DESCRIPTION - CONTROL POINT

A functional description of the control channel, the analog voice path and the digital data path are included in this section. Figures 6, 7, and 8 comprise a functional block diagram of the simulcast system. Detailed signal flow and interconnection diagrams are located at the back of this manual.

CONTROL CHANNEL

Control GETC

The control GETC is essentially a processor board with specialized I/O capability. The GETC contains an EEPROM, 3 dip switches, and a series of jumpers that must be set for the particular application. Refer to the GETC manual for specific information. The GETC can function as a control channel GETC or a working channel GETC in the simulcast system. One GETC is required for each channel. Should the control channel GETC fail, it is immediately removed from service and a working channel GETC assigned to assume control of all the failed control channel GETC functions. The new control channel is assigned by the site controller.

The GETC communicates with and controls the EDACS repeater stations by transmitting the PTT and A/D information. This information is sent to the station via the control panel and E & M multiplex equipment.

Each control panel contains 75 3-position switches and controls only one function such as PTT or A/D for three sites, each with up to a maximum of 24 channels. These switches allow individual transmitters to be operated during alignment and test. Jackfield access is also provided to the transmit and receive audio circuits for alignment and test.

The GETC receives the 9600 Hz clock from the digital selector card in the universal synchronizer shelf. This clock is used to synchronize all GETC's in the simulcast system and is used to output processed data to the universal synchronizer. The GETC also provides the 9600 Hz clock to the universal synchronizer circuits. In addition, the GETC provides 150 baud data to digital selector 1 in the universal synchronizer

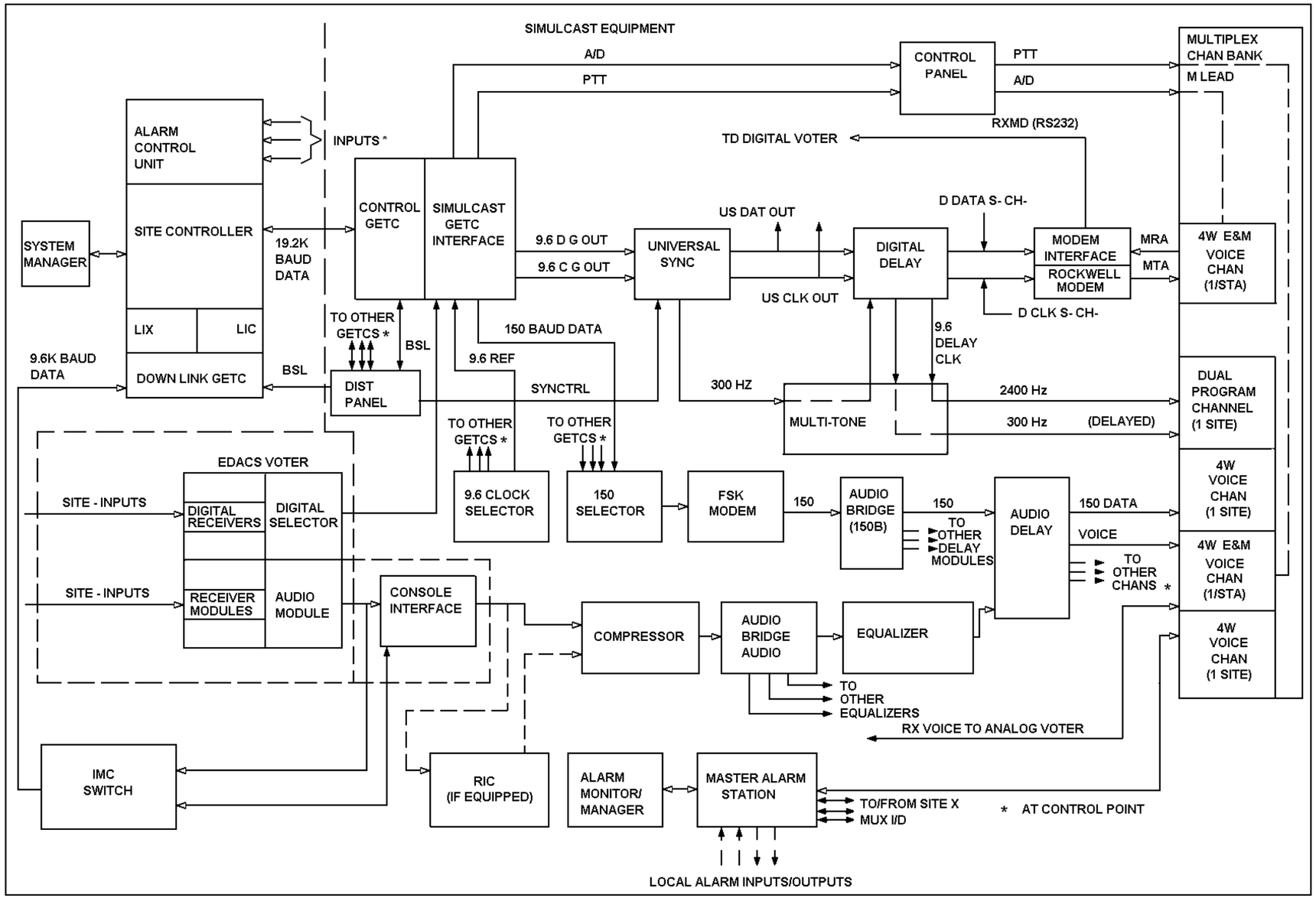


Figure 6- Simulcast System Functional Block Diagram (Sh. 1 of 3)

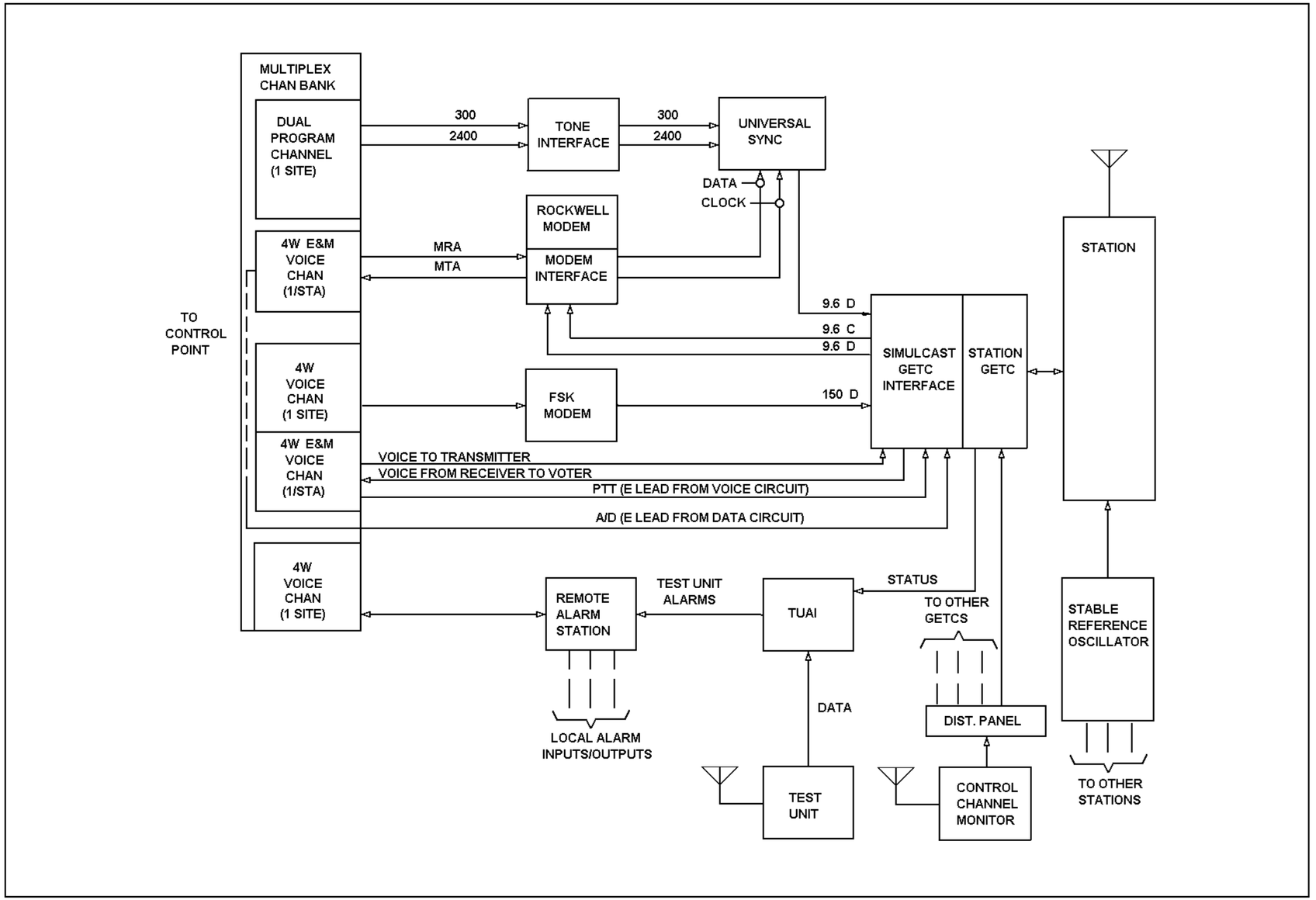


Figure 7- Simulcast System Functional Block Diagram (Sh. 2 of 3)

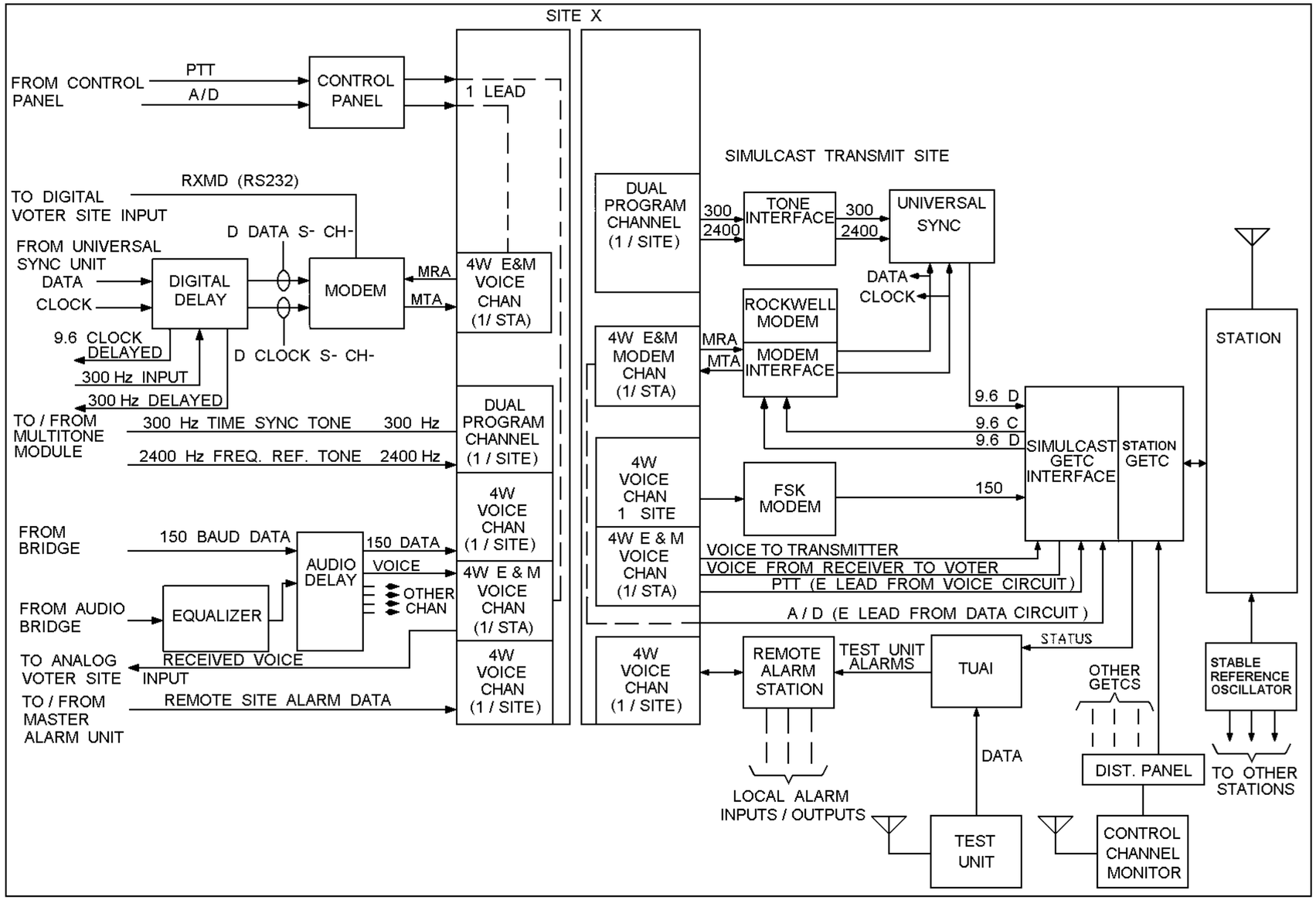


Figure 8- Simulcast System Functional Block Diagram (Sh. 3 of 3)

shelf. The 150 baud data handles the priority scan function for the mobiles and portables.

150 Baud Digital/9600 Baud Data Selector

The 150 baud data from each Control Point GETC is connected to one of 24 input lines. The 150 baud digital selector provides five digital output lines. It identifies the number of the active channel and displays that channel number on the LED display. A dip switch is set to restrict the input search to the number of active channel inputs.

The 150 baud data is output through RS-232 line drivers to five data output lines. Output line 1 is connected to the 150 baud FSK modem. The other 4 outputs are not used.

Digital selector 2 is a high speed digital data selector (9600 baud) used to automatically select a data stream (clock) or be manually advanced to select the next source containing a valid data stream. The source is displayed on the front of the module. The digital selectors are used only at the Control Point and set to select the built in 9600 Hz clock at ports 31 and 32.

150 Baud FSK Modem/Audio Bridge & Delay

The 150 baud data output from the digital selector is connected to the single-chip FSK modem. The FSK modem modulates the data which then resides in the audio passband. This data is applied to the audio bridge where it is split, as required, to provide data to each Transmit Site. The modulated data for each Transmit Site is individually time delayed by the audio delay board to compensate for the differences in time and distance from the Control Point to the specific Transmit Site. Each digital delay module provides 9600 baud data, 300 Hz time sync reference tone, and the 2400 Hz bit timing reference tone for two Transmit Sites. The delayed signals are fed to the multiplexer for transmission to all simulcast transmitters.

ANALOG VOICE PATH

Voice channel inputs are received from the Switch (IMC) or Transmit Sites via the analog voter and passed to the compressor located in the analog processing shelf.

Compressor

The compressor combines continuously adjustable linear gain with linear level limiting to provide a low distortion compressed voice frequency signal. The gain is adjustable within the range of 0 to 20 dB, with a maximum output level of +17 dBm.

A front panel adjustment allows the output signal to be set to any level between -30 and +17 dBm, with up to 30 dB gain. Compression is linear, resulting in less than 2% total distortion at 30 dB compression.

Audio Bridge

The audio bridge serves as a signal splitter to provide a separate buffered audio source for each site on a given channel. Its gain has been chosen so that the per site equalizer which follows operates well within the level adjustment range. A single audio bridge provides audio bridging of up to 10 single ended outputs. The output of the audio bridge is passed to the audio equalizer.

Audio Equalizer

The audio equalizer, also located in the analog processing shelf, provides precisely controlled amplitude and phase equalization for one voice circuit. The amplitude equalization circuitry is switch-optioned for flat response.

Phase equalization is provided by 13 individual delay sections, providing up to 1500 microseconds of continuously adjustable delay at equally spaced frequencies across the voice band. Delay may be adjusted at 200 Hz intervals from 600 to 3000 Hz. To eliminate frequency response fluctuations, up to 6 dB of inband amplitude ripple equalization is available at each of the 13 delay sections.

The equalizer also provides flat adjustable insertion gain from -15 to +15 dB to coordinate the module output level with a variety of input levels. The maximum output level of the module is +5 dBm. The terminating impedance at the module input and output ports is 600 ohms balanced. The equalized voice/analog output is then passed to the audio delay board.

Analog (Audio) Delay

The analog delay board delays all analog/voice signals received for transmission to the Transmit Site by an amount corresponding to its distance from the Control Point. Each analog delay board delays the audio signals for one specific transmitter. This ensures simultaneous arrival of the audio signals in the simulcast "overlap" region.

The amount of audio delay provided to the analog signals is determined by the setting of two pairs of dip switches on the audio board, one pair (S1 & S2) sets the delay for the primary audio path and the other pair (S3 & S4) sets the delay for the secondary path. The primary path is normally used while the secondary path is used in loop microwave system configurations. The delay is provided in increments of 1 microsecond with a maximum delay of 32 milliseconds. Delay is provided for up to 13 audio inputs.

Analog delay boards are used only at the Control Point.

DIGITAL DATA PATH

Inbound digital data on the control channel and digital voice from the digital voter are first processed by the Control Point GETC and then clocked through from the GETC to the universal sync board in the universal synchronizer shelf over the high speed (9600 baud) data lines.

Slaved 9600 Hz clock signals received from the GETC are applied to the universal sync board as well as the frame sync control (SYNCTRL) data from the distribution panel. The 9600 Hz reference for the master clock, generated on the digital data selector board, is also passed to other GETC's.

Universal Sync Board

The universal sync board synchronizes data at the Control Point and provides for synchronization of the data at the Transmit Sites. It receives the 9600 Hz reference clock and data from the GETC board and buffers it on a **F**irst **I**n **F**irst **O**ut (**FIFO**) basis. Each board is capable of buffering up to four channels. The 9600 Hz reference is used to generate the 9600 Hz master clock which, in turn, is used to synchronize the high speed 9600 baud data from the GETC. The data is then shifted out through the FIFO buffer to the digital delay board.

The universal sync board also utilizes the 9600 Hz clock to generate a 300 Hz square wave which is sent to the multi-tone board for buffering. After buffering, it is passed through the digital delay board to the multi-tone interface board where it is filtered and smoothed to provide a "cleaner" waveform to the multiplex equipment. The 300 Hz tone provides time synchronization for the data and is interrupted only when a control channel is changed. The zero crossings of the 300 Hz tone is also used to time the data release from the FIFO buffers.

By repositioning the appropriate jumpers, the universal sync board can be configured for Control Point or Transmit Site operation and for master or slave operation. At the Control Point it provides the resync data/clocks and tones required by the Transmit Site. In the master configuration, it also generates the clocks that are provided to all slaved universal sync boards. Up to seven boards may be installed in the universal sync shelf.

Digital Delay

The digital delay board provides time delay for all 9600 baud data, the 300 Hz time sync reference tone, and the 2400 Hz bit timing reference tone that is sent to each of the Transmit Sites at precisely the right time to ensure simultaneous arrival in the overlap region. The data transfer rate is 9600 baud. The 300 Hz reference tone is used for time synchronization and the 2400 Hz reference tone is used for frequency synchronization.

The digital delay board receives 9600 baud data and 9600 Hz clock from the universal sync board and 300 Hz time sync tone from the multi-tone interface board. The 300 Hz tone is delayed by the amount calculated for the specific Transmit Site and passed on to the dual program channel in the multiplexer. The 9600 Hz master clock is also delayed by the same amount, divided by 4 (2400 Hz), filtered and smoothed to provide a "cleaner" waveform. It is then passed to the same dual program channel in the multiplexer. The digital data is also delayed in time and passed to the modem interface board.

Each delay board provides specific time delays for two Transmit Sites. Delay is provided for two sets of twelve data/clock channels. One set of ten data channels and two clock signals (9600 Hz and 300 Hz) are delayed (as calculated) for each Transmit Site. The data clocks to be delayed are received from the universal sync boards and the multi-tone interface board. The twelve digital inputs for each site are delayed by the same amount.

Delay for each site is set by two banks of four dip switches. One bank of dip switches (S1 & S2 and S5 & S6) set the delay for the primary path and the other bank (S3 & S4 and S7 & S8) set the delay for the secondary path. (Complete dip switch definitions are given in LBI-38474). The delay is set in increments of one microsecond with a maximum delay of 32 milliseconds.

The digital delay board is used only at the Control Point and is located in the delay unit shelf assembly. Each shelf assembly can house up to 20 digital delay modules.

Modem Interface

A modem interface board is provided with each modem to convert the RS-232 signal input levels to TTL input levels and the TTL modem output levels to RS-232 output levels. The delayed clock and data signals received from the digital delay board are level converted by the modem interface board and forwarded to the Rockwell modem. The Rockwell modem transmits and receives 9600 baud serial data to and from 4-wire dedicated Bell Specification 3002 grade lines. The output of the Rockwell modem is interfaced with the 4-wire E & M voice channel in the multiplexer through the modem interface board. The 9600 baud modems are enabled for transmission by an active **R**equest-**T**o-**S**end (RTS) signal from the GETC's at the local site.

Each modem shelf houses up to 10 Rockwell modems with one modem dedicated to each channel. The total number of modems required at the Control Point is equal to the number of channels times the number of sites. Multiple

modem unit shelf assemblies are used in systems with more than 10 channels. The modem unit uses CCITT signaling to convert the data and clock information into a multi-amplitude-multi-phase analog signal. At power-up, the modem interface configures the 9600 baud modems for a default mode of operation which includes external data clock operation.

Subsystem Alarm Module

The subsystem alarm module monitors the status of the power supplies, control signals and fault signals. If a fault is detected, an LED on the module is turned on to provide a visual indication of the fault. The alarms are OR'ed together to provide a single system alarm output.

The alarm system is capable of monitoring:

48 digital inputs
32 digital outputs
25 channel inhibits and 5 system alarms per Transmit Site
32 analog inputs

Alarm Inputs Definitions

Digital and PTT - High impedance, +2.12 mA. @+50 V & -2.4 mA. @ -50 V.

Analog inputs - High impedance, -2.5, +2.5 Vdc.

Digital Outputs

Each output is an open collector circuit that can be used for power switching dc loads of up to +50 volts at 20 mA.

Each output is also provided with a diode clamp which may be used to limit the positive voltage swing of the output lines when used to control relay switching.

Alarm Monitor

The alarm monitor displays the status of the alarms at each site in the system and allows changing the characteristics of the alarms. The status information provided includes:

- Site number/name
- Digital Alarm Flag
- Analog Alarm Flag
- System outputs
- Alarm Disable Flag
- Channel Inhibit Data
- Reset all GETC's at a given site

Site Specific Alarm Monitor

This screen displays the Number/Name of each alarm at each site that has been enabled and indicates by reverse video which alarms are in the alarm condition. It also allows changing the manual type digital outputs.

Site Specific Status includes:

- Site number/name
- Digital Alarms
- Analog Alarms
- Matrixed Digital Outputs
- Matrixed System Outputs

Digital alarm characteristics that can be changed include:

- Name
- Enable/Disable
- Polarity
- Latched/Unlatched

Analog alarm characteristics that can be changed include:

- Name
- Threshold
- Polarity
- Latched/Unlatched
- Enable/Disable

Digital output characteristics that can be changed include:

- Name
- Auto/Manual On/Off

FUNCTIONAL DESCRIPTION - TRANSMITTER SITE

The Transmit Site completes the communication path and processes all control and interface functions between the mobiles and portables in the coverage area and the Control Point Site. It processes and resynchronization information received from the Control Point and transmits analog and digital voice information and data.

Information received from the mobiles and portables is processed immediately, multiplexed, and transmitted directly to the Control Point. In addition, equipment status at the Transmit Site is continuously monitored and the status information sent to the Control Point. Refer to Figures 6, 7, and 8 for a block diagram of the simulcast system. Signal Flow Block Diagrams and Interconnect Diagrams are located at the back of this manual.

PROGRAM CHANNEL

The 2400 Hz bit timing reference tone and the 300 Hz time sync reference tone are applied to the tone interface board. The tone interface board includes a zero crossing detector with a Schmitt trigger to provide hysteresis. The reference tones are limited and "squared up" to produce a square wave. These square waves are passed to the universal sync shelf, where the 2400 Hz bit timing reference tone is used to generate a master 9600 Hz clock using a phase lock loop (PLL) oscillator. The master clock along with the 300 Hz clock is provided to other slaved universal sync boards at the Transmit Site.

DIGITAL CHANNEL

Modem Operation

The modem receive audio (MRA) received from the multiplex digital channel (4-wire E & M) is passed through the Rockwell modem to the modem interface board where the levels change from TTL data to RS-232 levels. The modem also receives a 9600 Hz clock from the GETC board which is used to drive the internal clock. (At power-up, the modem shelf backplane configures the 9600 baud modems for a default mode of operation that includes external data clock operation.)

The modem unit assembly utilizes CCITT signaling to convert the multi-amplitude-multi-phase analog signal into the data and clock information passed to the universal sync board. Data is synchronized by the universal sync board with reference to the 9600 Hz master clock and shifted out to the GETC through a FIFO buffer. One modem is required for each operating channel at the Transmit Site.

The simulcast GETC interface card provides specialized I/O data processing. It responds to the A/D and PTT signals received from the multiplex equipment over the 4-wire E & M analog channel. It is through these data lines that the Control Point GETC controls the remote Transmit Site. When "D" is selected, the digital mode is active; conversely, when "A" is selected the analog (voice) mode is active. The data signals are then passed from the simulcast GETC interface to the station GETC and to the repeater transmitter for transmission.

The GETC contains an EEPROM, 3 dip switches and a series of jumpers that must be set for the particular application. Refer to the GETC applications manual for additional information.

CHANNEL TRACKING

The analog signals for the 150 baud data are received from the digital multiplexer and connected to the FSK modem. The modem demodulates the analog signal and extracts the 150 baud data. This data represents the channel tracking and update information received from the Control Point over the 4-wire E & M voice channel. The data is then processed by the simulcast station GETC before being transmitted.

INBOUND VOICE AND DATA

Inbound voice and data is received by the station receiver, demodulated to the voice level and sent to the station GETC for I/O processing. The voice signals are then sent directly to the multiplex equipment for transmission to the assigned voter at the Control Point. There is no synchronization required for the incoming voice and data at the Control Point.

RF FREQUENCY STABILITY

One critical parameter in the operation of the simulcast system is the frequency stability of the transmitted RF carrier frequency. The RF carrier frequency for each transmit channel must be within 1 Hz of the frequency of all other transmitters to minimize distortion due to heterodyning.

The stable reference oscillator used in the simulcast station determines the transmitter frequency stability. To achieve maximum frequency stability, the simulcast transmitter uses a Phase Locked Loop oscillator locked to WWVB. The WWVB receiver receives and locks onto the 60 kHz reference signal transmitted by the National Institute of Science and Technology, NIST, in Fort Collins, Co. To ensure reliable reception, each WWVB receiver is connected to a tower mounted ferrite loop antenna, oriented toward station WWVB.

Locking the reference oscillator to WWVB is accomplished by a closed loop servo system. This assures that given a four hour stabilization period and the absence of alarms, the EDACS simulcast transmitter average carrier frequency will be stable within 1 Hz.

Two WWVB receiver/oscillators are supplied to provide complete redundancy in the event of receiver or oscillator failure. A signal selector automatically switches to the backup WWVB receiver/oscillator when the selected signal is removed, when an alarm input occurs, or when the manual selection switch is pressed.

There is no periodic maintenance required to a closed loop system of this kind. The only maintenance required is failure maintenance in response to an alarm or user reported condition.

Other stable frequency sources such as Rubidium may be used in place of WWVB.

REMOTE ALARM SYSTEM

The Remote Alarm System (RAS) at the Transmit Sites is capable of monitoring 48 digital inputs, 25 PTT inputs, 32 analog inputs, and 32 digital outputs.

Alarm Inputs Definition

Digital and PTT - High impedance, +2.12 mA. @+50 V & -2.4 mA. @ -50 V.

Analog inputs - High impedance, -2.5, +2.5 Vdc.

Digital Output Definitions

Each output is an open collector circuit for power switching dc loads of up to 50 volts at 20 mA.

Each output is also provided with a diode clamp which may be used to limit the positive voltage swing of the output lines when used to control relay switching.

Alarm System Software

The software for the remote alarm is the same for all sites. It receives the information and sends it to the Master Alarm where it is sent to the RAS's and the alarm monitor. One or more alarm monitors (or PC compatible computer) can be connected to any or all stations as desired. The monitor can be used to show the alarm status from any site and allow the operator to change the digital output at any site, from anywhere in the system.

Site Specific Alarm Setup Screen

This screen displays the status of a specific site. The status displayed consists of:

- Site number/name
- Digital Alarms
- Analog Alarms
- Matrixed Digital Outputs
- Matrixed System Outputs

This screen also allows changing the following characteristics:

Analog Alarms
- Name
- Threshold
- Polarity
- Latched/Unlatched
- Enable/Disable

Digital Alarms
- Name
- Polarity
- Latched/Unlatched
- Enable/Disable

Digital Outputs
- Name
- Auto/Manual On/Off

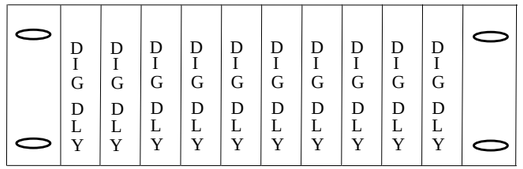
EQUIPMENT DESCRIPTION

The simulcast equipment is housed in 69, 83 or 86-inch open relay racks (19-inch) or cabinets. Each rack is custom configured to meet customer system requirements. They house delay shelves, universal synchronization shelves, modem shelves, GETC shelves, etc. All racks are electrically interconnected by overhead cabling. Simulcast equipment located at the Control Point includes the digital delay shelf, analog delay shelf, analog processing shelf #1 (Equalizer), and analog processing shelf 2. Equipment common to both sites include, the universal synchronization shelf, modem shelf, cross connects, and redundant power supplies. A breakdown of the equipment located in each shelf at the Control Point and the Transmit Site is given below.

CONTROL POINT ONLY

Digital Delay Shelf

The digital delay shelf assembly occupies 6 rack units containing one or two backplanes, each housing up to 10 digital delay boards. Each delay board provides clock and data 300 Hz time sync tone delay for two Transmit Sites. The backplane contains connectors to interface digital delay modules with the simulcast system. The location of the modules in the shelf is shown below and the slot assignments and functions are listed.



Digital Delay Shelf (Left Side)

Slot 1 - Data Delay, Site 1 & 2, Ch 1-10, 300 Hz Ref Tone and CLK

Slot 2 - Data Delay, Site 3 & 4, Ch 1-10, 300 Hz Ref Tone and CLK

Slot 3 - Data Delay, Site 5 & 6, Ch 1-10, 300 Hz Ref Tone and CLK

Slot 4 - Data Delay, Site 7 & 8, Ch 1-10, 300 Hz Ref Tone and CLK

Slot 5 - Data Delay, Site 9 & 10, Ch 1-10, 300 Hz Ref Tone and CLK

Slot 6 - Data Delay, Site 1 & 2, Ch 11-20, and CLK

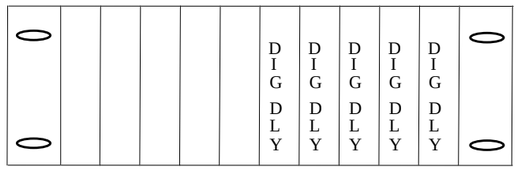
Slot 7 - Data Delay, Site 3 & 4, Ch 11-20, and CLK

Slot 8 - Data Delay, Site 5 & 6, Ch 11-20, and CLK

Slot 9 - Data Delay, Site 7 & 8, Ch 11-20, and CLK

Slot 10 - Data Delay, Site 9 & 10, Ch 11-20, and CLK

Digital Delay Shelf (right side)



Slot 1 - Data Delay, Site 1 & 2, Ch 21-25, and CLK

Slot 2 - Data Delay, Site 3 & 4, Ch 21-25, and CLK

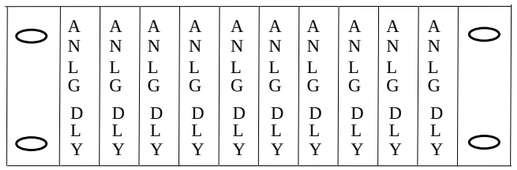
Slot 3 - Data Delay, Site 5 & 6, Ch 21-25, and CLK

Slot 4 - Data Delay, Site 7 & 8, Ch 21-25, and CLK

Slot 5 - Data Delay, Site 9 & 10, Ch 21-25, and CLK

Analog Delay Shelf

The analog delay shelf assembly occupies 6 rack units, containing one or two backplanes, each housing up to 10 analog delay boards. Each analog delay board provides voice and 150 baud data delay for 1 Transmit Site. The backplane contains connectors to interface the delay modules with the simulcast system. Slot assignments are listed below.



Analog Delay Shelf (Left Side)

Slot 1 - Analog Delay, Site 1, Ch 1-12 and 150 Baud Data and Ch 21, 22

Slot 2 - Analog Delay, Site 1, Ch 11-20 and Ch 23-25

Slot 3 - Analog Delay, Site 2, Ch 1-10 and 150 Baud Data and Ch 21, 22

Slot 4 - Analog Delay, Site 2, Ch 11-20 and Ch 23-25

Slot 5 - Analog Delay, Site 3, Ch 1-10 and 150 Baud Data and Ch 21, 22

Slot 6 - Analog Delay, Site 3, Ch 11-20 and Ch 23-25

Slot 7 - Analog Delay, Site 4, Ch 1-10 and 150 Baud Data and Ch 21, 22

Slot 8 - Analog Delay, Site 4, Ch 11-20 and Ch 23-25

Slot 9 - Analog Delay, Site 5, Ch 1-10 and 150 Baud Data and Ch 21, 22

Slot 10 - Analog Delay, Site 5, Ch 11-20 and Ch 23-25

Analog Delay Shelf (Right Side)

Slot 1 - Analog Delay, Site 6, Ch 1-10 and 150 Baud Data and Ch 21, 22

Slot 2 - Analog Delay, Site 6, Ch 11-20 and Ch 23-25

Slot 3 - Analog Delay, Site 7, Ch 1-10 and 150 Baud Data and Ch 21, 22

Slot 4 - Analog Delay, Site 7, Ch 11-20 and Ch 23-25

Slot 5 - Analog Delay, Site 8, Ch 1-10 and 150 Baud Data and Ch 21, 22

Slot 6 - Analog Delay, Site 8, Ch 11-20 and Ch 23-25

Slot 7 - Analog Delay, Site 9, Ch 1-10 and 150 Baud Data and Ch 21, 22

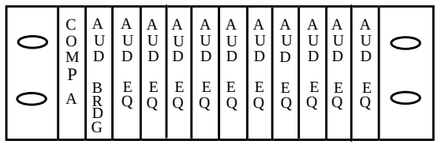
Slot 8 - Analog Delay, Site 9, Ch 11-20 and Ch 23-25

Slot 9 - Analog Delay, Site 10, Ch 1-10 and 150 Baud Data and Ch 21, 22

Slot 10 - Analog Delay, Site 10, Ch 11-20 and Ch 23-25

Analog Processing Shelf #1 (Equalizer)

Analog processing shelf 1 provides a backplane with connectors and printed wiring to interface compressors, audio equalizers, and audio bridge modules used in the simulcast system. Jumpers on the analog shelf backplane determine the configuration. The slot assignments are listed below.



Analog Processing Shelf 1 - Sites 1 10

Slot 1 - Compressor

Slot 2 - Audio Bridge

Slot 3 - Audio Equalizer Site 1

Slot 4 - Audio Equalizer Site 2

Slot 5 - Audio Equalizer Site 3

Slot 6 - Audio Equalizer Site 4

Slot 7 - Audio Equalizer Site 5

Slot 8 - Audio Equalizer Site 6

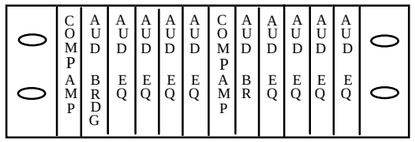
Slot 9 - Audio Equalizer Site 7

Slot 10 - Audio Equalizer Site 8

Slot 11 - Audio Equalizer Site 9

Slot 12 - Audio Equalizer Site 10

Analog Processing Shelf 1 - Sites 1-4



Slot 1 - Compressor

Slot 2 - Audio Bridge

Slot 3 - Audio Equalizer Site 1

Slot 4 - Audio Equalizer Site 2

Slot 5 - Audio Equalizer Site 3

Slot 6 - Audio Equalizer Site 4

Slot 7 - Compressor

Slot 8 - Audio Bridge

Slot 9 - Audio Equalizer Site 1

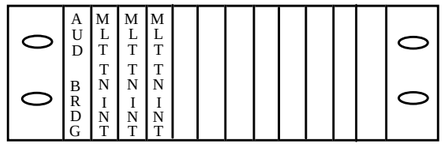
Slot 10 - Audio Equalizer Site 2

Slot 11 - Audio Equalizer Site 3

Slot 12 - Audio Equalizer Site 4

Analog Processing Shelf 2

Analog processing shelf 2 provides a backplane with connectors and printed wiring to interconnect the multi-tone interface and audio bridge modules used in the simulcast system. Slot assignments follow.



Analog Processing Shelf 2

Slot 1 - Audio Bridge (150 baud data from modem to sites 1-10)

Slot 2 - Multi-tone interface, sites 1-4

Slot 3 - Multi-tone interface, sites 5-8

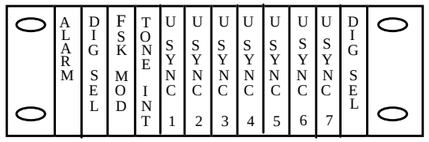
Slot 4 - Multi-tone interface, sites 9,10

Slots 5-12 - (Not Used)

EQUIPMENT COMMON TO CONTROL POINT AND TRANSMIT SITES

Universal Synchronization Shelf

The universal synchronizer shelf assembly provides a backplane with connectors and printed wire patterns to interface modules used in the simulcast system. Slots 1-13 are occupied; slots 13 to 21 are provided for future expansion. Positive 5 Vdc power for the shelf is provided through fuse F1. Slot assignments are listed below.



Universal Synchronizer Shelf

Slot 1 - Sub-System Alarm Board

Slot 2 - Digital Selector 1 - 150 Baud (Control Point Only)

Slot 3 - FSK Modem - 150 Baud

Slot 4 - Tone Interface Module - (Transmit Site Only)

Slot 5 - Universal Sync 1 - Channels 1-4

Slot 6 - Universal Sync 2 - Channels 5-8

Slot 7 - Universal Sync 3 - Channels 9-12

Slot 8 - Universal Sync 4 - Channels 13-16

Slot 9 - Universal Sync 5 - Channels 17-20

Slot 10 - Universal Sync 6 - Channels 21-24

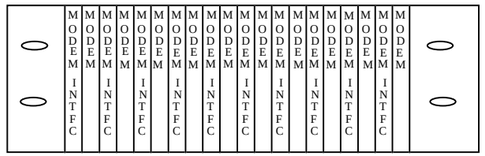
Slot 11 - Universal Sync 7 - Channel 25

Slot 12 - Digital Selector 2 - Master 9600 Hz Clock

Reference (Control Point Only)

Modem Shelf

The modem shelf assembly provides a backplane and printed wiring to accommodate up to 10 Rockwell modems and associated interface modules. Slot assignments are listed below.



Slot 1 - Modem interface 1 (PO1)

Slot 2 - Modem 1 (PO2)

Slot 3 - Modem interface 2 (PO3)

Slot 4 - Modem 2 (PO4)

Slot 5 - Modem interface 3 (PO5)

Slot 6 - Modem 3 (PO6)

Slot 7 - Modem interface 4 (PO7)

Slot 8 - Modem 4 (PO8)

Slot 9 - Modem interface 5 (PO9)

Slot 10 - Modem 5 (P10)

Slot 11 - Modem interface 6 (P11)

Slot 12 - Modem 6 (P12)

Slot 13 - Modem interface 7 (P13)

Slot 14 - Modem 7 (P14)

Slot 15 - Modem interface 8 (P15)

Slot 16 - Modem 8 (P16)

Slot 17 - Modem interface 9 (P17)

Slot 18 - Modem 9 (P18)

Slot 19 - Modem interface 10 (P19)

Slot 20 - Modem 10 (P20)

Cross Connects

Four cross connect panels are used in the simulcast system. Three of these are located at the Control Point and one at the Transmit Site. They are:

Digital Cross-Connect - Control Point
Analog Cross Connect - Control Point
Control Cross Connect - Control Point
Transmit Cross Connect - Transmit Site

Redundant Power Supplies

Redundant power supplies are used to increase the reliability of the simulcast system. Power supplies generally operate on 120 Vac and provide the system voltages and current required for operation. (The 19D902538G13 supply operates on either 120 or 240 Vac.) Voltages supplied include +5V, +12V, -12, and -24V.

Alarm/Status System

The Alarm/Status System consists of a Master Alarm Station (MAS) and up to 10 Remote Alarm Stations (RAS). The alarm system is mounted in two shelves: a standard bus system/alarm cross connect (4 rack units) and a hybrid mounting shelf (4 rack units). The alarm system is powered from the redundant power supplies in the simulcast system. The following modules are installed in the four rack unit shelf.

- 1 standard card cage
- 1 Standard BUS backplane
- 1 Hybrid card cage
- 1 CPU card
- 1 digital input card
- 1-4 analog input cards
- 1-3 digital output cards
- 1-10 modem/hybrid (1 pair per site)
- 1 alarm cross connect backplane

TEST EQUIPMENT RACK

A Test Equipment Rack is provided at the Control Point to enable the service technician to optimize system operation and to troubleshoot the system in the event of a malfunction. The operation of individual channels may be verified and delays and system equalization set as need be. The test equipment included in the rack is identified and a brief description of the function it serves is identified below.

- Test Delay Panel - Provides adjustable audio delay for phase sweeps.
- Transmission Test Set - Used to measure levels.
- Dynamic Signal Analyzer - Provides audio sweep alignment.
- Balun Panel - Provides multiple taps, and unbalanced/balanced matching, patching.
- Alignment/Test Radio - FMD (800 MHz) Used for over the air test and setup of the simulcast system. Shelf in-

cludes audio bridge card with special filter specific to alignment shelf.

- Digital Storage Scope - Used to display results of data and audio tests.
- Control Panels PTT & A/D - Provide normal system on and off override of transmit keying and audio/data path control for each site, on a per channel basis.
- Alarm Monitor - Pull out shelf contains a lap-top computer that provides a visual display of simulcast alarms and alarm configurations.
- Alarm Master Shelf - Contains CPU, modems, software, and digital I/O capability.
- Alarm Hybrid Shelf - Contains 2-wire/4-wire conversion for modems in Alarm Master Shelf.

SIMULCAST MAINTENANCE MANUALS

An "Index of Simulcast Maintenance Manuals", listed in the Table of Contents, provides the information relevant to understanding and troubleshooting the simulcast system. These manuals contain circuit analysis, assembly diagrams, outline diagrams, schematic diagrams, parts lists, IC data, etc., where applicable.

CROSS CONNECT SHELVES AND MODULE IDENTIFICATION

Simulcast system interconnection can be best understood by following the signal flow through the system. The basic building blocks are the cross connect panels and the shelves that house the modules.

Each item in the simulcast system is identified by a four digit number which defines the cross connect panel, module/board type, and the channel number. Cross connect panels are identified by an alpha/numeric sequence as follows:

B400 - Digital Cross Connect	Code "D"
B401 - Analog Cross Connect	Code "A"
B402 - Control Panel Cross Connect	Code "C"
B403 - Transmit Site Cross Connect	Code "T"

For example, refer to drawing 19C337469. The rack is identified as "B400", a digital cross connect panel and assigned code "D".

Next, notice the marking on a GETC I/F module, D501. "D" identifies it as a digital cross connect. Decoding information is provided below:

D 5 0 1

"D"	Digital Cross Connect
"5"	GETC I/F
"0"	Channel Number
"1"	Channel Number

Digit 1

A - Analog Cross Connect
C - Control Panel
D - Digital Shelf
T - Transmit Site Cross Connect

Digit 2

1 - Modem Shelf
2 - Analog Delay Shelf
3 - Digital Delay Shelf
4 - Analog Processing Shelf 1 (Equalizer)
5 - GETC Interface
6 - Jackfield
7 - Analog Processing Shelf #2
8 - Universal Sync Shelf
9 - Control Panel

Digits 3 & 4

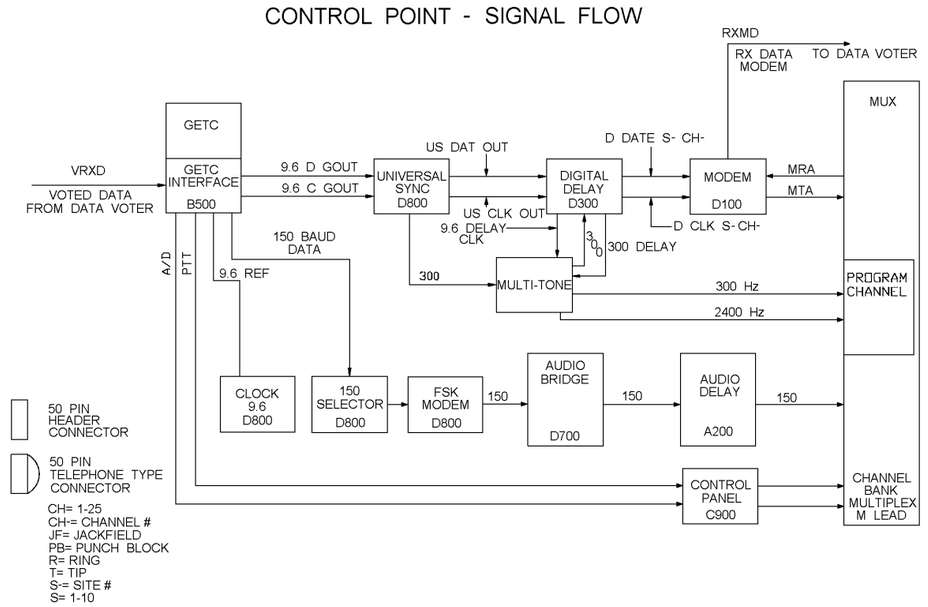
01 - Channel 1
02 - Channel 2
xx - Channel xx

SIGNAL FLOW DIAGRAMS

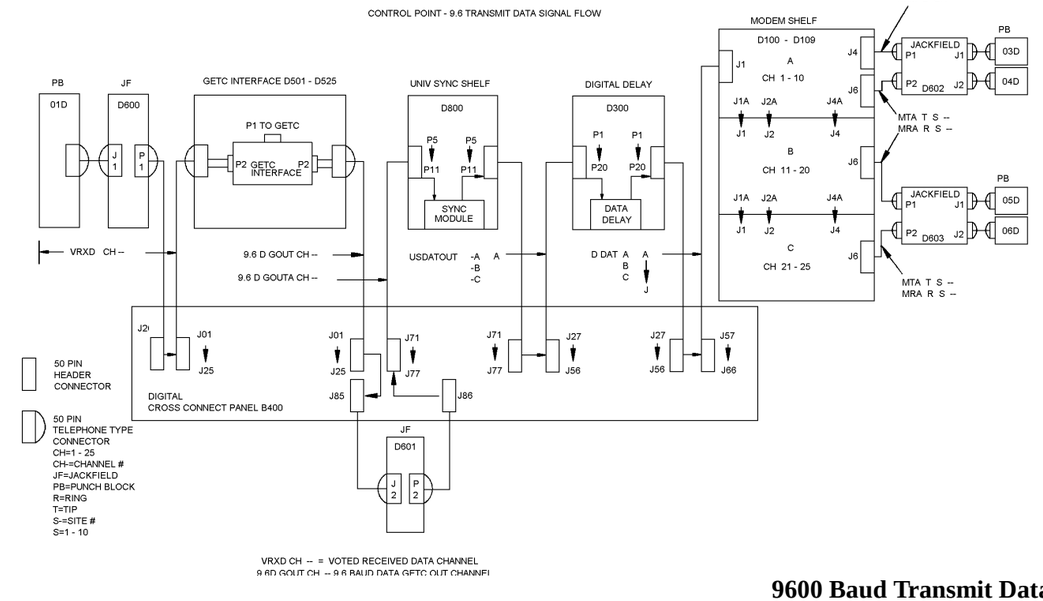
Signal Flow Diagrams are provided for both the Control Point Site and the Transmit Site. These diagrams show the origin of and interface to the multiplex equipment for data and control signals used in the EDACS Simulcast System. Such things as Clock, Tx Data, 300 Hz Time Synchronization Reference Tone and 2400 Hz bit timing reference tones, etc. are shown.

CROSS CONNECT WIRING

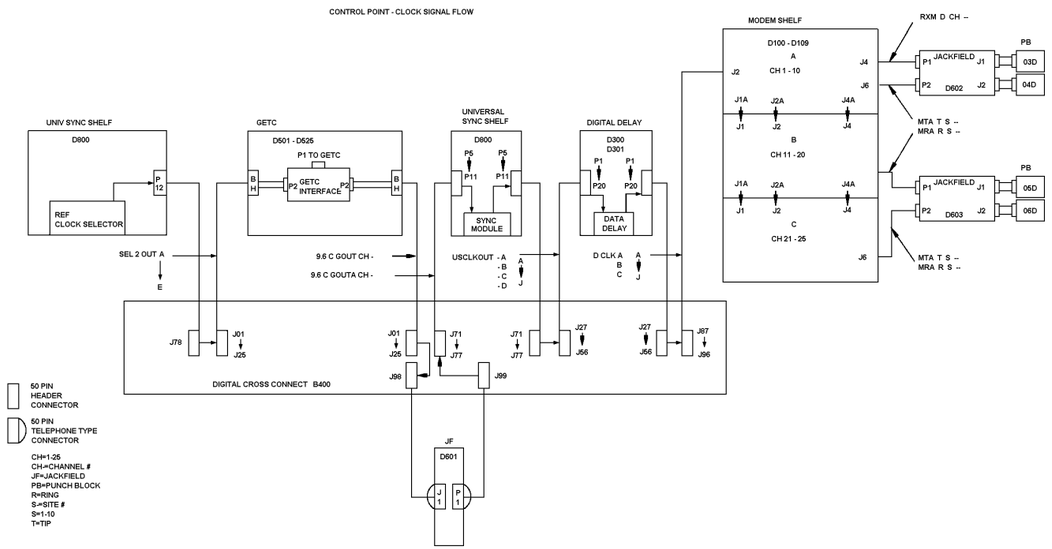
All cross connect and backplane wiring is shown in two ways in the Cross Connect Maintenance Manual. First, it is shown by connector number. This identifies the signal on each pin of the connector and the connector or point to which it connects. Second, a wiring list provides the same information, but in a different format. This list is called the "Function List" and takes a signal name and shows all the points where it connects.



Data/Clock Signal Flow
(19B235335 Rev. 1)

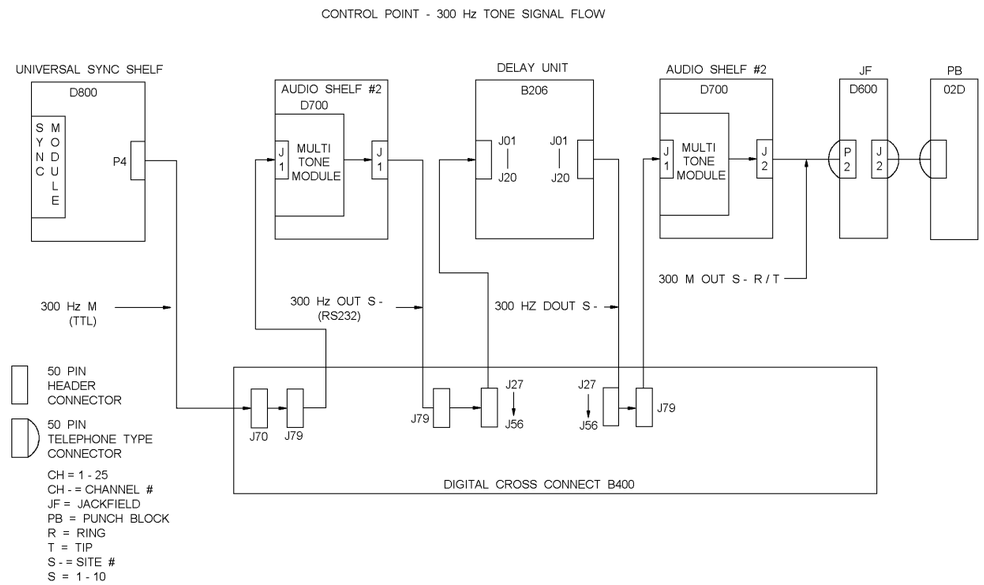


9600 Baud Transmit Data
(19B235336 Rev. 1)



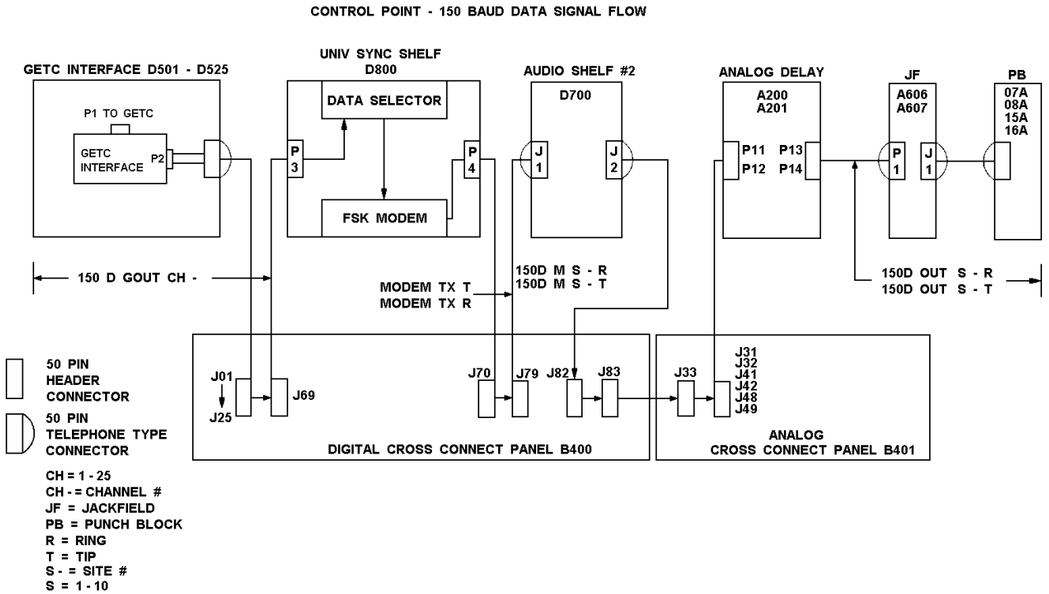
Clock Signal Flow

(19B235333 Rev. 1)



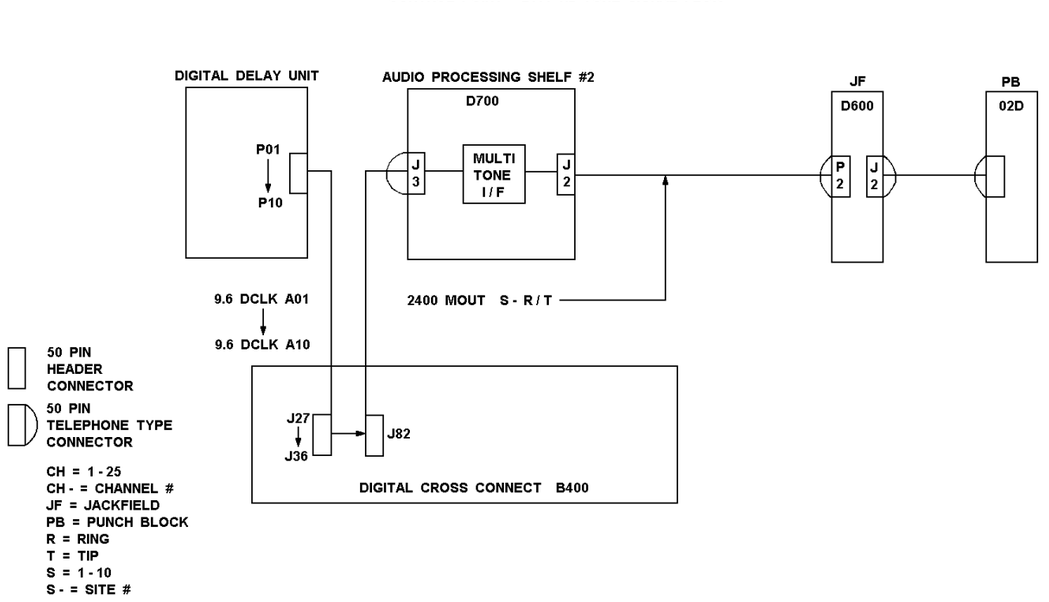
300 Hz Tone

(19B235331 Rev. 1)



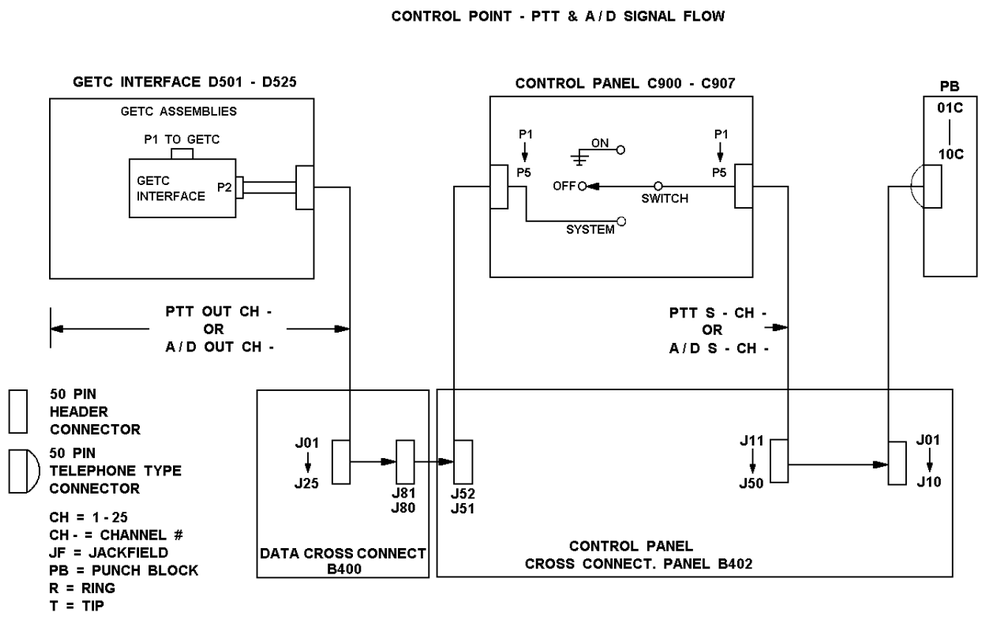
150 Baud Data

(19B235337 Rev. 0)



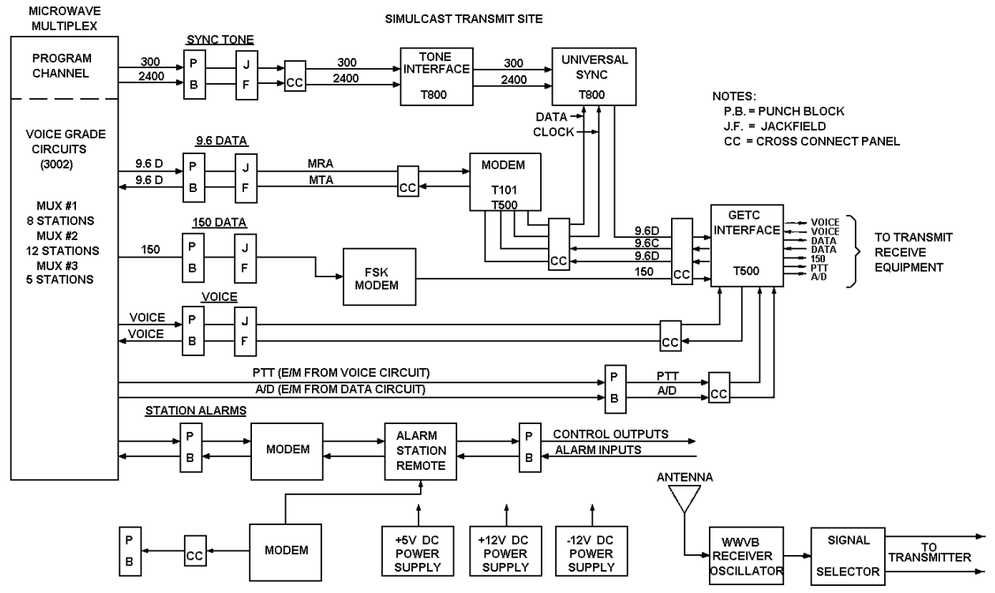
2400 Hz Tone

(19B235334 Rev. 0)



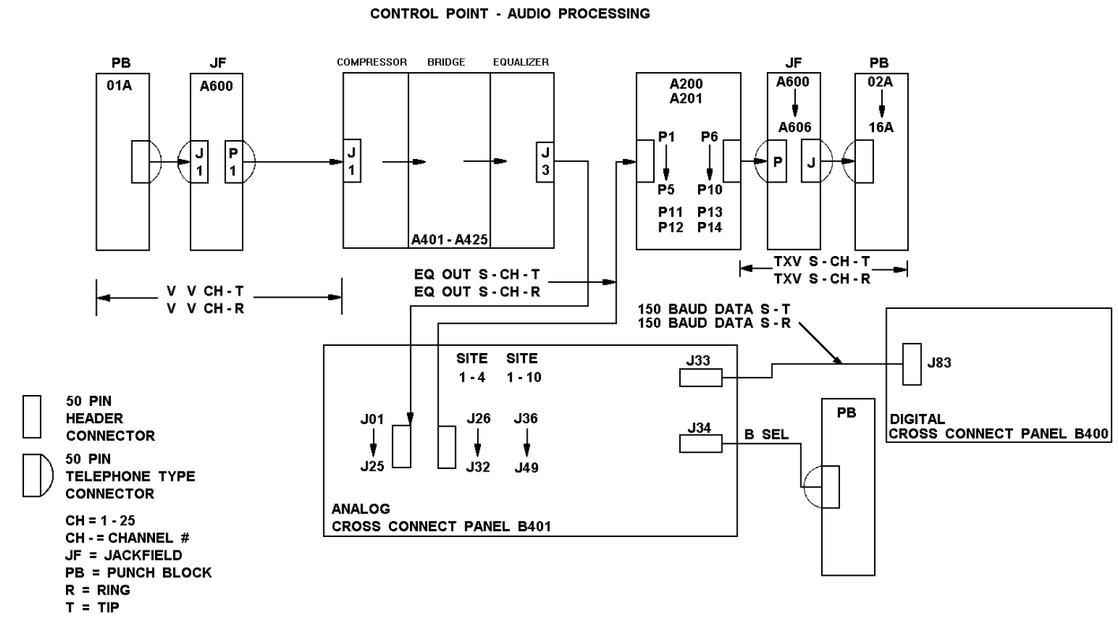
PTT & Analog/Digital

(19B235330 Rev. 0)



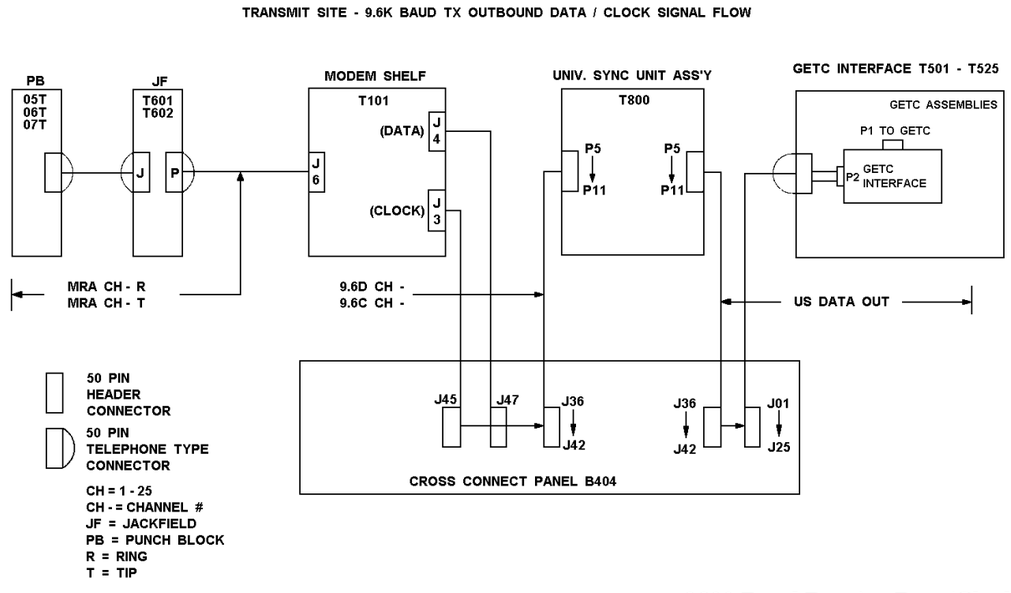
Simulcast Transmit Site

(19B235332 Rev. 2)



Audio Processing

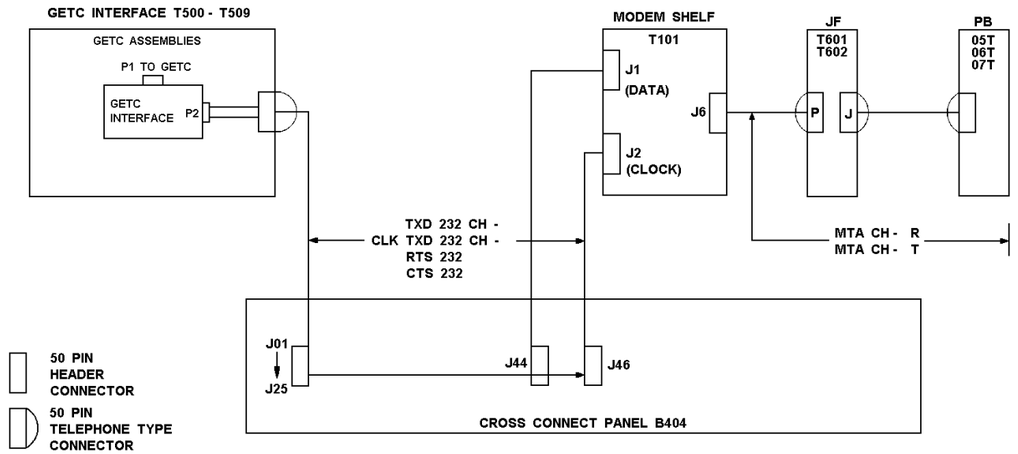
(19B235328 Rev. 0)



9600 Baud Receive Data/Clock

(19B235324 Rev. 0)

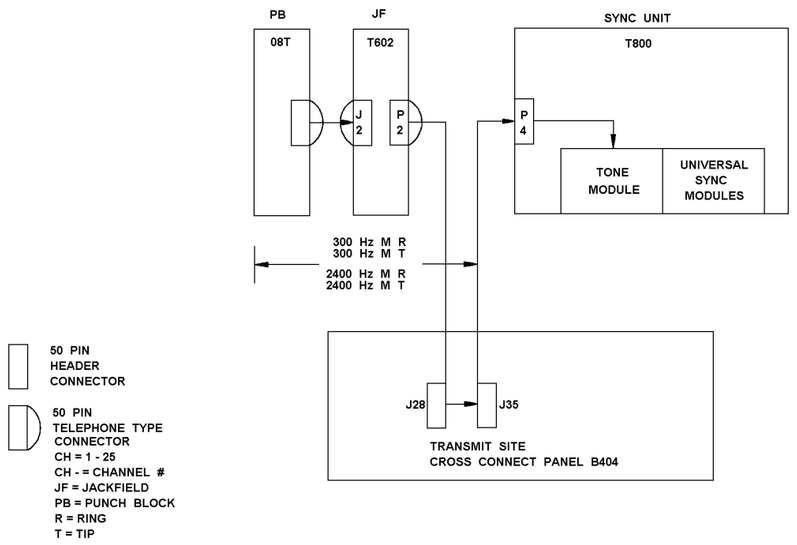
INBOUND SITE - 9.6K BAUD INBOUND DATA SIGNAL FLOW



9600Baud Transmit Data/Clock

(19B235323 Rev. 0)

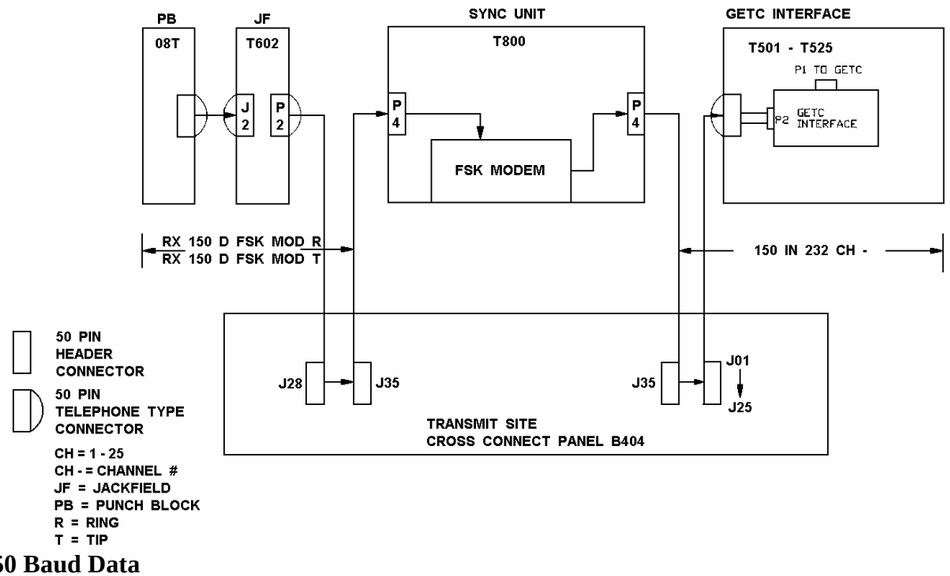
TRANSMIT SITE - SYNC TONE SIGNAL FLOW



Synchronizing Tone

(19B235326 Rev. 1)

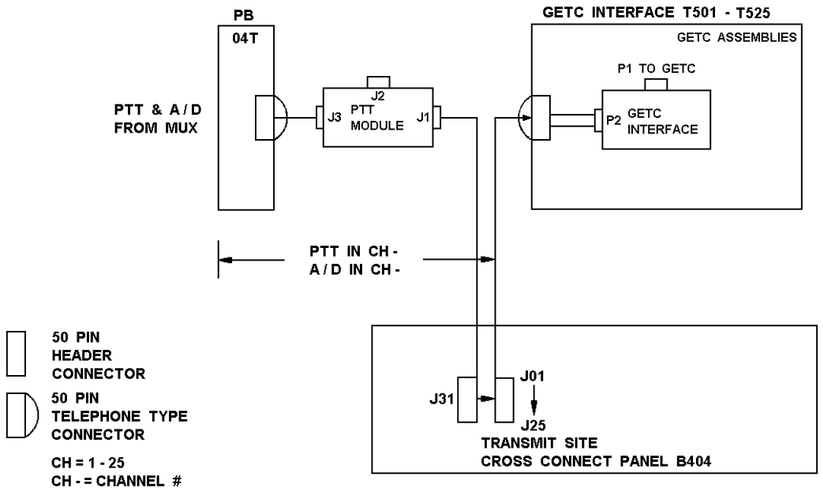
TRANSMIT SITE - 150 BAUD SIGNAL FLOW



150 Baud Data

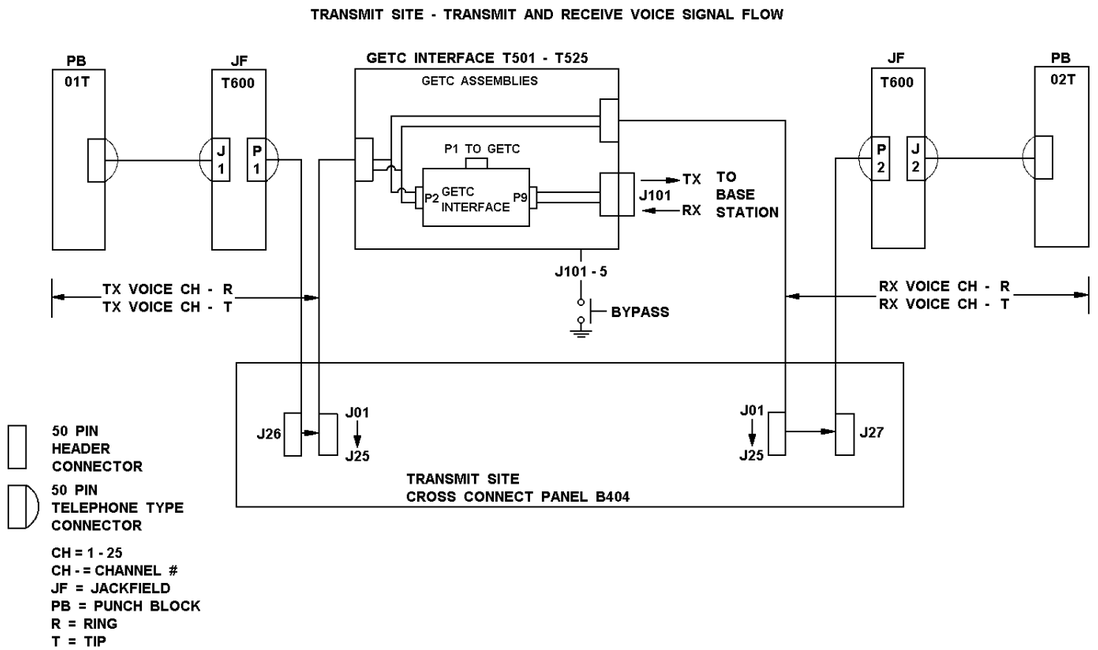
(19B235327 Rev. 0)

TRANSMIT SITE - PTT AND A/D SIGNAL FLOW



PTT & Analog/Digital

(19B235325 Rev. 1)



Transmit and Receive Voice
(19B235329 Rev. 0)

GLOSSARY

Aegis technology	Aegis is high speed, 9600 bit-per-second, digital communication technology.
Callee	The party to whom the call is placed, i.e. an individual or group of radios.
Caller	The originating party of the call request, i.e.an individual radio.
CEC	Console Electronic Controller (CEC) is the console switch that supports the C3 series consoles. Version of the technology generally known as MSC.
Control Channel	The repeater channel on which system control information is continually transmitted and channel request/status information is received from the field radio units. Any one repeater channel EDACS may serve as the control channel. The field radios monitor the control channel when not active on a working channel.
Control Point	Group of master hardware in a simulcast system. Typically includes GETCs, site controller, equalizing equipment, master alarm unit, and test equipment.
Data	Normally refers to digital information as from a data terminal. May also be used to refer to any digital information.
Data Rate	The speed that data is sent over a channel. EDACS wideband uses a 9600 baud data rate. Narrowband uses 4800 baud.
Data Terminal	A device containing a display and keyboard which supports the transmission of data. Interfaces to an EDACS radio through a Radio Data Interface (RDI).
Digital Call	Voice Guard or Aegis.
Digitization	The technique of converting a continuous analog waveform to binary digital data. See Vocoding.
Downlink	The data control link between EDACS and the CEC and/or IMC. The link operates at 9600 baud and can be supported on any 4-wire circuit.
EDACS	EDACS - Enhanced Digital Access Communication System.
Encapsulation	Formatting the digital data stream with information to enable synchronization and signaling functions.
Failsoft Trunking	A unique system feature that allows EDACS to continue to operate in the trunked mode even if the site controller(s) fails or is not part of the site in the case of basic EDACS.
Fault Tolerant	A design and implementation philosophy that permits a system to continue operating in the event of failure of major components. EDACS is a fault tolerant system.
GETC	Ericsson GE Trunking Card. The GETC performs the RF signal processing for the repeater station. It re-synchronizes the data information received by the repeater station, processes it and sends it back to the repeater station for transmission. The GETC is programmed with enough logic to handle effectively the "trunking" functionality without the need of a site controller.
Group (Talk Group)	A collection of people with a need to communicate with each other. When a caller places a call within a group, the system assigns the group to the same working channel. A group call can be placed on the agency, fleet or subfleet level.
Group Call	A call by any member of a group that puts all members of the group on the same working channel. All radios in the group can hear the call.
Group Scan	The radio monitors the control channel and responds to all group channel assignments associated with the "scan" list. The "priority" group is dictated by the group currently selected. If a call occurs on the "priority" group while monitoring one of the scan roups, the radio will quickly late enter into the "priority" group call.
Late Entry	If a radio is powered up while its talkgroup has a call in progress on a working channel, the radio will "Late Enter" into the call even though it missed the original channel assignment. This is achieved through the assignment updates the working channel continually transmits. A radio may "Late Enter" if the radio is turned on, passes through a coverage null or changes talk groups.
Login	A transmission from a field radio that informs the IMC or MSC that the specific unit is active on a certain group and

cell. Login, a programmable option, occurs when a radio scans from one cell to another cell, when a group is changed or when the radio is turned on.

Message — An alphanumeric communication preprogrammed into a field radio during normal PC programming. Messages are transmitted immediately via the control channel to the Request Status Monitor.

Message Trunking — Once assigned a working channel, the working channel remains assigned for the duration of the conversation. Keeping the working channel assigned is accomplished by putting a hang time on the repeater for several seconds. The hang time is variable on a per talkgroup basis. Usually only used for emergency calls.

Multisite — A network of multiple EDACS cells. Each cell networked may have a different number of working channels.

Priority Level — When all the working channels are busy, the next call request received is queued. Pre-assigned priority levels for each Group and Individual are used to determine which call request is assigned first. Eight priority levels are offered, seven may be assigned and the eighth, "Emergency", is reserved as the highest priority. Within a priority level, the call requests are assigned on a First-In-First-Out basis. 1 = highest priority; 8 = Lowest priority.

Priority Group Scan — The feature that allows an EDACS radio unit that has scanned into another call, to revert back to the priority group selected automatically.

Priority System Scan — A priority or "home" system is preprogrammed into the radio. The radio continually searches (scans) for its priority system and if found locks onto it. Priority System Scan improves network efficiency by keeping as many radios on the primary (priority) system as possible thus preventing unnecessary multisited calls. This feature is preprogrammed in the field radio by the PC Programmer.

Radio Data — A protocol and level converter which interfaces (RDI) between a data terminal and the mobile radio.

Range — Used interchangeably with coverage to define the limits of a two-way radio system. Range is the greatest distance between a two-way radio and a base station over which communications is possible. Coverage is the area surrounding a base station where communications with the mobiles or portables is possible.

Scan — The process of monitoring a selected list of groups in a field radio. If a call occurs on any of the scan list groups, the radio will switch to that group. The group manually selected is the priority group (also the transmitting group) and the radio will return to the priority group if a call occurs for that group even if the radio has been monitoring one of the other scan groups.

Simulcast — SIMULtaneous broadCAST by two or more transmitters located at different sites operating on the same RF frequency. Simulcasting requires precise RF frequencies, audio responses and synchronized data. A simulcast trunked cell consists of two or more transmitting sites. Each site has the same number of channels and uses a common set of RF frequencies. EDACS Simulcast "operates" as a single site trunked system irrespective of the number of sites simulcasted.

Simulselect — The process of a console operator communicating with two or more groups simultaneously using only one single radio channel. Different from patch; user radios still communicate a single talk group.

Site — Normally refers to the collection of EDACS equipment at a specific location such as the "North Site".

Site Controller — A DEC computer running Ericsson GE developed application software that controls the moment to moment trunking process plus such features as call validation, unit enable/disable, dynamic regrouping and queuing management. The site controller communicates to the system manager over an appropriate link.

Status — A short digital message transmitted/received on the control channel. Typically it is initiated by the radio operator to identify the current condition of the field unit, i.e. En Route, At Scene.

Synchronization — Digital technique of allowing a digital receiver to achieve time alignment with the incoming digital data stream from a transmitting radio.

System — Any EDACS configuration which stands alone. It may be BASIC Level 1, 2, 3, or 4, Voted or Simulcast. The basic feature set is identical on all systems.

System Manager — The System Manager is the human interface to the trunked system. The System Manager is a DEC multitasking computer which performs features such as establishing group/individual database, defining system parameters, generating management reports, unit enable/disable, and dynamic regrouping.

System Scan — The process that occurs in a field unit when the unit moves out of the coverage area of one cell. System Scan searches for another control channel from a preprogrammed list of cell frequencies.

System Update — Information sent periodically to EDACS radios concerning ongoing system activity.

Telephone Interconnect — Collocated with the site controller it interfaces the Public Switched Telephone Network to the t runked system. Allows radio operators to place or receive telephone calls. Telephone callers have the option of calling an individual or a group.

Test & Alarm Unit — Consists of two units: the Test Unit (TU) and the Alarm (TAU) and Control Unit (ACU). The TU continually tests channel operation for faults and provides an alarm notification to the site controller. The ACU consists of 32 alarm inputs and 8 relay outputs. The ACU allows for external device alarming to the system manager.

Tracking — In a Wide Area Network, all radio Login's are recorded into a database. Through the database, the IMC determines which cells are to be conferenced for the wide area calls. It is also the tracking mechanism which allows the IMC to limit the wide area call to only those cells in which a member of the group has logged into.

Transmission Trunking — Once assigned a working channel, the working channel remains assigned for the duration of the callers transmission. Upon the caller's inky, the system immediately de-allocates the channel and makes it available for reassignment. This is equivalent to a zero-second hang time. Because of the fast access and drop times of EDACS, transmission trunking is significantly more efficient than message trunking providing increased call throughput and/or fewer calls queued. Normally used in EDACS.

Trunking — The process of dynamically allocating channels from a pool to groups of people in need of communication.

Trunking Card (GETC) — A distributed processor in the base station that performs the trunking function in a system without a site controller and rechecks digital data on encrypted voice calls.

Unconfirmed Call — A call on a Multisite network that does not require all cells to have an available channel before the call is allowed to proceed. A cell late enters (if a channel was not initially available) as the call proceeds.

Vocoding — Digital technique to convert an analog voice signal to a digital data stream via the use of advanced signal processing algorithms.

Voice Guard — The Ericsson GE brand name for digital voice encryption. Voice Guard operates at the same data rate as the wide band EDACS signaling, 9600 baud, thus providing inherent radio-to-radio voice encryption capability on the system.

Working Channel — All repeater channels except the single control channel operate as a working channel. Radios intercommunicate (either Clear Voice, Voice Guard or Data) through a working channel.

INDEX OF SIMULCAST MAINTENANCE MANUALS

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Analog Delay Shelf	LBI-38990
Analog Delay Module	LBI-38473
Analog Processing Shelf #1	LBI-38479
Analog Processing Shelf 2	LBI-38480
Audio Bridge Module	LBI-38566
Balun Panel	LBI-38493
Compressor Module	Vendor- Tell Labs
Computer Shelf	LBI-38497
Control Channel Monitor	LBI-38224
Control Panel	LBI-38482
Cross-Connects	
Control	LBI-38491
Simulcast	LBI-38580
Transmit	LBI-38490
Delay Module	LBI-48474
Digital Control Point	LBI-38483
Digital Delay Shelf	LBI-38941
Digital Selector Module	LBI-38472
Equalizer	Vendor- CONVEX
FSK Modem Module	LBI-38487
GETC Application Manual	LBI-39074
GETC Interface Module	LBI-38486
GETC Maintenance Manual	LBI-38894
Modem Interface Module	LBI-38564
Modem Module	Vendor- Rockwell
Modem Shelf	LBI-38478
Multi-Tone Interface Module	LBI-38565
Power Supply	LBI-38481
Sub Alarm Module	LBI-38485
Tone Interface Module	LBI-38475
Universal Sync Module	LBI-38488
Universal Sync Shelf	LBI-38476
Simulcast Installation and Checkout	LBI-39069
Simulcast Station, MASTR IIe	LBI-38585
Simulcast Station, MASTR III	LBI-39068
Simulcast System Drawings	LBI-38878
TUAI Test Unit	LBI-38498

Configuration Drawings

Transmit Site Equipment	
Transmit Site	LBI-38921
Control Point Equipment	
4 Site 10 Channel System	LBI-38922
4 Site 20 Channel System	LBI-38925
5 Site 5 Channel System	LBI-38923
10 Site 10 Channel System	LBI-38924
10 Site 20 Channel System	LBI-38926
GETC/RIC	LBI-38927