



TX/Communications Canada Inc.

# ***Infinity TX-2400L /XL***

## **Digital Switching System**

### **General Description**

Date: July 2002  
TX-2400L/XL-Sys-GD-001

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## Introduction

This section provides general information about the capabilities, design, and the operation of the

**Infinity TX-2400L/XL**. To know more about the supplementary services and interfaces of **TX-2400L/XL**, refer to:

- Appendix A for the list of features
- Appendix B for System Peripherals ( ISDN Attendant Consoles, ISDN Feature Set)
- Appendix C for System built in **IVM (Integrated Voice Mail)**
- Appendix D for ACD (Automatic Call Distribution) feature

**TX-2400L/XL** is a very modern and versatile SWITCH for Private, Rural and Public applications. The basic system is a digital switching exchange, providing connection of pulse code modulation (PCM) voice and data paths between ports of various types, under centralized stored program control.

**TX-2400L/XL** can provide up to 3,840 Digital/Analog ports with no blocking and concentration. The PCM switching network of TX-2400L/XL is a distributed configuration. Each shelf has its own resident PCM switch and passive inter-shelf highways under control of Central Control Unit (CCU) connect all line shelves.

TX-2400L/XL is a versatile system for additional different applications such as:

- Channel Banks
- Digital Cross Connect
- MUX Drop and Insert
- HDSL Link
- Access Switch to Wireless Radio
- Transit and Tandem Switch

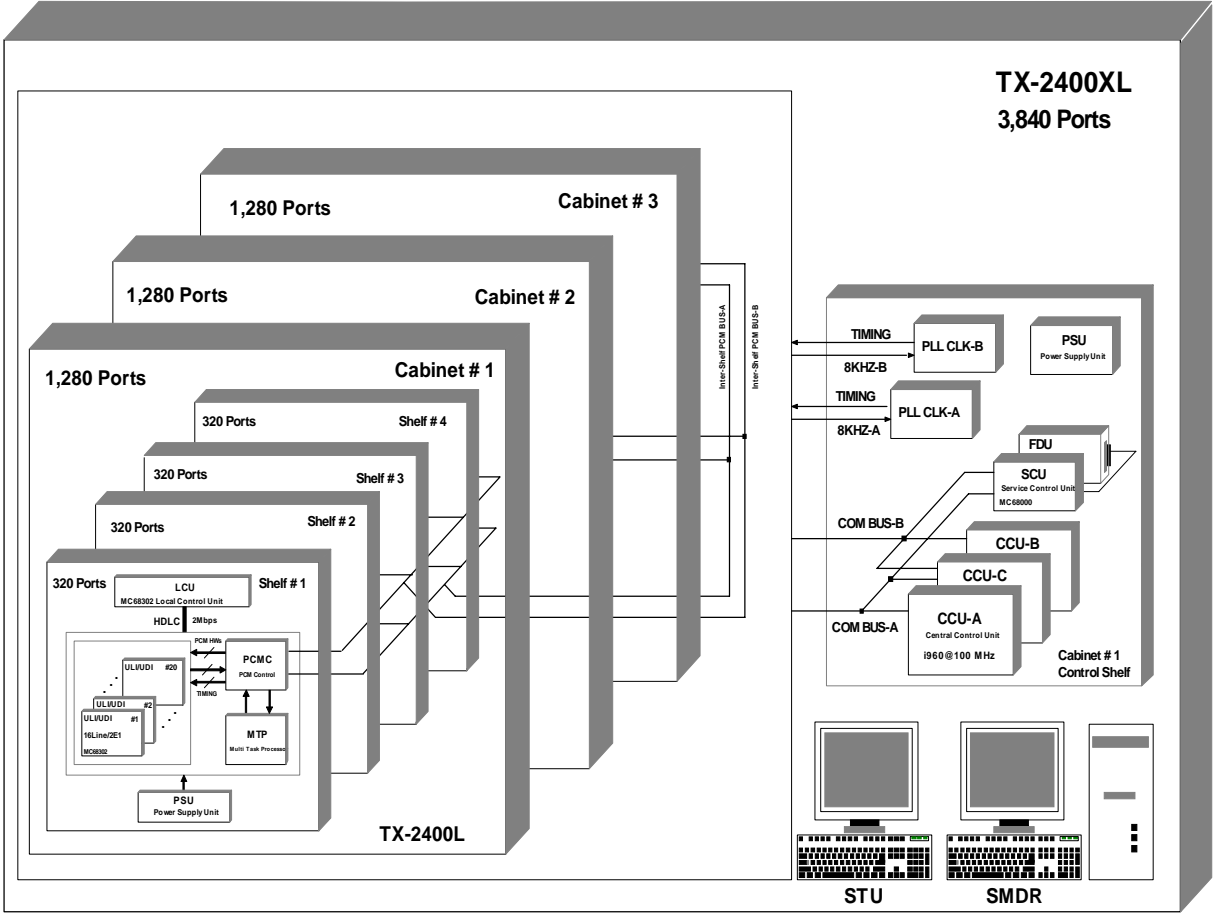
The equipment is designed in modular units using standard components and connections for ease of installation and maintenance. Plug-in printed circuit card modules are used for all interface types and common control equipment. All interconnections between racks and shelves are by plug and jack.

Up to 3,840 Erlang traffic can be handled by a fully loaded system resulting in 138,000 BHCA @ 100 Sec. Call Average Holding Time.

The **TX-2400L** includes one cabinet that accommodates one Control Shelf and up to 4 Line Shelves, results 1,280 Analog/Digital ports. The **TX-2400XL** adds two additional cabinets to the **TX-2400L** for system capacity expansion and it could interface to 3,840 Analog/Digital ports.

The simplified block diagram of both, TX-2400L and TX-2400XL system are illustrated below:

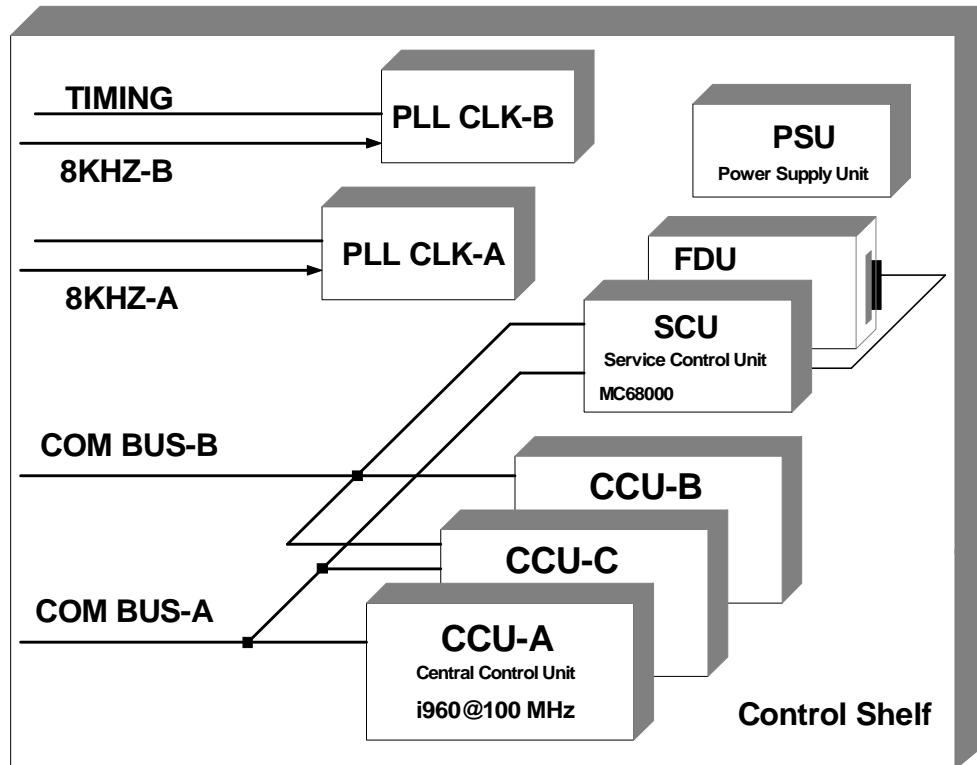




**TX-2400XL Simplified Block Diagram**

### 1. Control Shelf:

The Control shelf houses the Common Control equipment, which controls the Infinity TX-2400L/XL system and provides interconnection between the various modules.



### 1.1 Central Control Unit (CCU):

The **CCUs** (CCU-A, CCU-B and CCU-C) control all call processing for the system and interact with the Line shelves Control Units (LCUs) via duplicated control buses which are distributed throughout the system.

In addition, they monitor each other and communicate with the SCU.

#### - Hot Standby Triplication:

When the Hot Standby Common Control Assembly is installed, there is no interruption in call processing if the Common Control Processor fails. The system is run in triplicated mode, all processors (A, B and C) run in loose synchronism, all receiving identical information from the peripheral processors, and all computing this data in the same manner.

A three-way comparison of the responses to this data is made among the three CCUs. This comparison of each transaction is done primarily in hardware, and in the event of a mismatch, a *Majority Vote* is taken and the "Odd" CCU will remove itself from service. After suitable self-diagnosis (resetting, reloading, etc.), the faulty CCU (CCU-A in this example) will request to rejoin the triplicated synchronism and does so if possible. There follows a brief transfer of the current, call related, and status data from CCU-B to CCU-A. If the shelf diagnosis has revealed a hard fault, then CCU-A would register an "Out of Sync" alarm and would stay out of service until manually investigated. This alarm becomes visible and audible at the service terminal and attendant console.

#### - Duplicated Data Bus:

The Data bus structure is fully duplicated with an A and a B side. All main processors receive data from the peripheral processors over one of these buses always. By default, CCU-A (Operating on the A Bus) is termed the master CCU, and is the only one that outputs to the peripherals. On a Majority Vote acting against CCU-A, CCU-B forces a "Bus Switch" and takes over this communication while CCU-A retires itself.

### Specifications

- a. Intel 50 MHz i960JD Processor.
- b. 24 MHz external CPU Clock.
- c. 6.0 MHz +/- 50 ppm (filtered) back-plane reference PLL clock.
- d. 2 M bytes system RAM, expandable to 128 M bytes
- e. 2 M bytes system ROM, expandable to 128 M bytes
- f. Lithium battery for SRAMs back up, minimum data retention period of one year when power lost.
- g. Two HDLC channels for future use.
- h. Triplication circuitry for system fault tolerance.

The CCU system design contains an Intel 50 MHz i960JD RICS controller. The i960 provides a 32-bit linear address space and 32-bit wide internal and external data BUS. The CPU has 1 KB internal RAM at zero wait state access, 4 KB of instruction cache and 2 KB of data cache. The CPU is taking an external 24 MHz clock to provide 48MHz internal clock operating speed. The 24 MHz clock is needed for back plane system clock synchronous to compatible the existing TX2400 systems.

The system ROM and system RAM space are optional expanded to 128 MB each. The larger memory size is used for special applications, such as large data base for call logging, SS7 protocol, and etc.

The standard installation of memory size in the CCU circuitry is 2 MB ROM (Flash) and 2 MB Static RAM (SRAM). The system memory can be expanded to 128 MB Flash memory (total 8 SIMM) and 128 MB SRAM (total 8 SIMM),

## 1.2 Service Control Unit (SCU):

The Service Control Unit (SCU) provides many important functions necessary for system operation, maintenance, and control. It is an individual module that resides in the control shelf of the system and in the common control/line shelf of the INFINITY 'M' system. The critical functions of the SCU are as follows.

The SCU provides the system's man-machine interface through terminal and modem peripherals, allowing interaction via the service equipment with the processor system, to monitor or change the data base of the control program, and give information on system operation (traffic statistics, faults, etc.).

Fault conditions generated in various system circuit cards are applied directly to the SCU and alarm signals can be generated accordingly.

The SCU control program is either stored in on-card ROM or an EPROM/OTP memory card. In conjunction with the various peripheral devices the control program performs the following functions:

The SCU provides the system cold start loader (BOOT) via a Floppy Disk drive or memory card interface. The Floppy Disk drive is accessed through the SCU Peripheral Interface (SPI), which is a generic multiplexed bus interfacing the Floppy Disk Unit card slot with the SCU. The memory card interface can be used for system boot and configuration or as added program RAM.

- a) Provide the service personnel with a means to control and modify the operation of the system, and to display the status of system operation.
- b) Receive fault conditions from various circuits in the system and generate alarm signals accordingly.
- c) Communicate with the Central Control Units (CCUs) through the System Bus A & B.

The system triplication feature is supported by the SCU. The SCU interacts directly with CPUs A & B via BUS A & B, and indirectly with CPU C via BUS B.

The SCU interfaces to the Floppy Disk Unit via a generic multiplexed bus allowing any card in the Floppy Disk Unit slot to communicate with the SCU. Primarily the Floppy Disk Unit will be used as a peripheral card slot containing Floppy Disk Drives, Hard Disk Drives, Serial ports, and Parallel ports. Configuration information can be uploaded to the system through this interface. Call accounting information can be saved on permanent storage devices and retrieved when needed.

A symbolic representation of the SCU is illustrated in the block diagram of Figure 1 below.

|                       |   |
|-----------------------|---|
| Microprocessor        | Motorola MC68EC000  |
| Clock Frequency       | MCLK 12 MHz (MPU clock)<br>SCLK 6MHz (SPI clock)<br>FCLK 1.5MHz (IBI clock) |
| RAM Size              | 128KBytes expandable to 2MBytes   |
| ROM Size              | 256 KBytes  |
| Memory Addressing     | Direct, non-paging  |
| Data Retention        | Supercap backs up 4 RAM sockets<br>and Real Time Chip                       |
| Operating Temperature |   |

The Inter-processor Bus Interface is the physical interface between the SCU and the Central Control Units in the system. For the Infinity 'L' system this interface includes the triplication feature. This allows the SCU to communicate directly with CCU-A and CCU-B via BUS A and B, and indirectly with CCU-C via BUS B. In the Infinity 'M' system, this interface consists of communication directly between the SCU and the CCU (i.e. no triplication).

The Service Terminal (ST) is used to examine or alter the programming of the INFINITY Digital SYSTEM as well as to diagnose problems in the system's operation. The Station Message Detail Recording (SMDR) interface is used for hardcopy reporting of call account information. The ST and SMDR interface both locally and/or remotely with the system via the SCU card. Locally this connection is an RS-232C interface through standard EIA-25 pin connectors on the back plane. Two data/fax modems on-card the SCU provide the remote interface. Connection to these modems is via a 4-wire modular jack on the faceplate; and, for the ST, a wire wrapped connection from the back plane to an existing extension.

The Service Terminal and SMDR local interface to the SCU is via dual universal asynchronous receiver/transmitter (DUART) and RS-232C level translators. The DUART provides parallel to serial conversion, and the level translators isolate RS-232C and CMOS logic signal levels. Each interface consists of two data and two control lines: Receive (Rx), Transmit (Tx), Request to Send (RTS), and Clear to Send (CTS). Serial data is transmitted over data lines Rx and Tx. The control lines RTS and CTS are accessible in DUART control and status registers respectively.

The interface signals for both the Service Terminal and SMDR are connected to two standard DB25 pin connectors on the back plane.

Two, independent, full-duplex asynchronous receiver/transmitter channels

Independently programmable baud rate for each receiver and transmitter selectable from industry standard baud rates

The Service Terminal and SMDR remote interface to the SCU is via two on-card data/fax modems.

These modems are full-featured, self-contained data/fax solution. No external micro-controller for data or fax control is required. Dialing, call progress, and telephone line interface functions are fully supported and controlled through the AT command set. All that is required for connection to the Tip and Ring lines is a front end interface. The Service Terminal modem uses a discrete front end emphasizing a low cost solution.

The SMDR modem uses a Data Access Arrangement module emphasizing a small layout area, mid-cost optional feature.

Data modes perform complete handshake and data rate negotiations. All tone and pattern detection required by the applicable CCITT or Bell standard is supported.

Fax modes support Group 3 fax requirements. Fax data and fax control (V.21) performed by the modem is controlled and monitored through the fax EIA-578 class 1 command interface. Full HDLC formatting, flag insertion/deletion, and CRC generation/checking is provided.

### **Remote Interface Features**

#### Data modes

- CCITT V.22bis (2400bps), V.22 (1200bps)

- Bell 212A (1200bps) and 103 (300bps)

- Enhanced AT commands

- S-Register Settings

#### Group 3 fax modes

- V.29 (9600/7200 bps) transmit

- V.27 ter (4800/2400 bps) transmit and receive

- V.21 Channel 2 (300bps) transmit and receive

- EIA-578 Service Class 1 commands

Full error correction (V.42 LAPM, MNP2-4) and data compression (V.42bis, MNP 5) capabilities

supported through the Rockwell Protocol Interface (RPI) and host communication software

NVRAM interface allows storage of two user configurations and four 36-digit dial strings

Programmable sleep mode and wake-up

Automatic adaptive/fixed compromise equalization

**Data Modes**

The AT commands and S-register settings define data mode operation. Supported modem protocols and data rate selection are illustrated in Tables below:

| Protocol | Modulation | Transmitter Frequency (Hz) | Carrier +/- 0.01% | Data Rate (bps) |
|----------|------------|----------------------------|-------------------|-----------------|
| V.22 bis | QAM        | Answer<br>2400             | Originate<br>1200 | 2400            |
| V.22     | DPSK       | 2400                       | 1200              | 1200            |
| Bell     | DPSK       | 2400                       | 1200              | 1200            |
| 212A     | FSK        | 2225 M                     | 1270 M            | 300             |
| Bell 103 |            | 2025 S                     | 1070 S            |                 |

**Fax Modes**

Fax mode operation is defined by the AT+F commands. Supported modem protocols are illustrated in Table 10.5. Automatic origination of fax calls is supported. Answering of fax calls is identical to answering of data calls with minor exceptions. Fax data transmission and reception can be performed with or without HDLC framing.

| Protocol | Modulation | Transmitter Frequency (Hz) | Carrier +/- 0.01% | Data Rate (bps) |
|----------|------------|----------------------------|-------------------|-----------------|
| V.29     | QAM        | Receive<br>NA              | Transmit<br>1700  | 9600            |
|          | QAM        | NA                         | 1700              | 7200            |
| V.27 ter | DPSK       | 1800                       | 1800              | 4800            |
|          | DPSK       | 1800                       | 1800              | 2400            |
| V.21     | FSK        | 1650 M                     | 1650 M            | 300             |
|          |            | 1850 S                     | 1850 S            |                 |

## **PCMCIA INTERFACE**

The PC Memory Card International Association (PCMCIA) was formed with the goal of promoting interchangeability of Integrate Circuit Cards (IC Cards) among a variety of computer and other electronic products. Both data storage (memory) and peripheral expansion (I/O) card types are defined by this standard This implementation adheres to the PC Card Standard Release 2.0 and permits Type I and Type II 68 pin cards to operate in the same slot.

This interface is primarily intended for memory card usage. The motivation behind this interface is to provide a convenient means of software upgrades by using bootable memory cards and to provide extra RAM storage space. Some common I/O interface applications are Modems, LANs, and Mass Storage. For example, for the Infinity 'M' system where no Floppy Disk or Hard Disk is available, a PCMCIA Hard Disk I/O card can be used as a means of permanent storage.

### 1.3 Floppy Disk Unit (FDU):

The Floppy Disk Unit (FDU) which is mounted on the Control Shelf, is used to store system configuration

data (e.g. Class of Service, Directory Numbers) which must be loaded into the system on start up or a reset following discharge of the battery which supports the CCU RAM.

Two Disk Drive are provided on the FDU, one for configuration data and the other for stored data.

The Disk Drives are compatible with standard, double sided, high-density 3.5" diskettes (1.44 MB).

The Floppy Disk Unit (FDU) is a full size card that occupies three slots on the system control shelf. The FDU gives the system access to floppy disk drives for various system operations.

It is used as a cold start boot for standard or custom system configurations, and also to save system configurations after they have been customized.

The Floppy Disk Unit (FDU) consists of the SCU Peripheral Interface, the FDU Control Block, the Floppy Disk Controller, and the Floppy Disk Interface including floppy disk drives and a PC Interface.

The SCU Peripheral Interface is a multiplexed bus that controls microprocessor and DMA accesses to and from the FDU. The FDU Control Block performs the necessary address decoding for the Floppy Disk Controller and multiplexes the Floppy Disk Interface with the PC Interface. The Floppy Disk Controller provides all the functionality between the host processor and the cable connector to the floppy disk drive (Floppy Disk Interface). This controller integrates formatter/controller, data rate selection, clock generation and drive interface drivers and receivers. The Floppy Disk Interface is a dual in line row of header pins where all the signals originate or terminate at the Floppy Disk Controller. Up to four 3.5" disk drives on a single cable can interface to this row of header pins. The PC Interface is a dual in line row of header pins providing all the necessary control and data signals from the SCU Peripheral Interface and FDU Control Block to perform a transfer of address and data bytes to or from some external peripheral device not on the FDU.

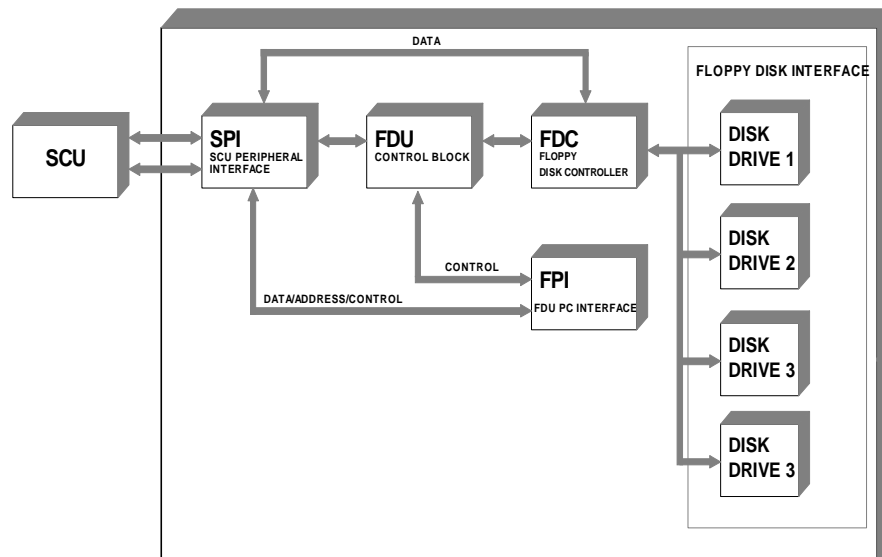
The FDU is configured for two 3.5" disk drives, which are mounted vertically on top of each other with access to each through the front faceplate. Either double density or high-density 3.5" diskettes can be used. This gives the Infinity system access to either 720Kbytes or

1.44Mbytes of disk storage respectively. Note that either drive can handle both types of diskettes.

As mentioned before, the FDU can access both double density and high-density 3.5" disk drives. At any one time the maximum storage capacity is 1.44Mbytes per disk drive for a total of

2.88Mbytes. The data transfer rate of the Floppy Disk Unit (FDU) is determined by the transfer capacity of a single command and the data transfer rate between the Floppy Disk Controller and the floppy disk drives. The transfer capacity of both double density and high density diskettes is 15,360 bytes. The data transfer rate varies depending upon the density of the diskette. For double density diskettes the transfer rate is 250Kbits/second, for high density it is 500Kbits/second.

Assuming that the disk drive read/write head must be loaded and unloaded for each command, add an additional 30ms for each command. Noting that the time taken to program the floppy disk controller for a read/write operation is much less than the time to transfer one byte of data between the controller and drive, the overall data rate is 55.7Kbytes/second for 1.44Mbyte diskettes and 29.45Kbytes/second for 720Kbyte diskettes.



#### 1.4 PLL CLOCK:

The Clock card on the Control Shelf provides timing signals for the whole system and may be duplicated for added security. The "A" Clock serves as the primary clock and the "B" Clock card as the secondary Clock, which is synchronized to it. Both Clocks are monitored continuously and a failure of one causes the system to switch to the other and generate an alarm at the attendant console.

Within the Clock card are provided six individual circuits, which are the System Clock, a System Reset, a Dummy Handshake, a Cabinet Address Decoder, a Line Shelf Address Buffer, and a Multiplexer.

In addition it provides power to the cabinet terminator board.

Whenever the system is equipped with digital trunk(s), clock synchronization at the system is necessary as to achieve proper timing for data transmission. Therefore, it is required the system PCM clocks (8KHz and 8.192MHz) to be in sync with an 8KHz trunk timing reference.

For a system, which has more than one timing reference, the PLL CLOCK card should be able to select and switch reference so that the PCM clocks are always synchronized to the best quality reference.

The clock design will provide synchronized clocks and will meet the standard and features as described in the EIA.

There are 2 clock cards located in the control shelf. Clock A is the primary clock source and clock B is the secondary clock source. Clocks generated from clock B are selected only when either clock A card is missing or outputs from A disappears. Except for triplication and the system being the master in a private or public network, clock B is identical to clock A. This allows clock B to take over when clock A is missed or not fully functioning. Clock cards performs the following main functions:

- A 6.0000 MHz single ended clock for the CCU cards on the Control Shelf.
- A 4KHz single ended Real Time clock for the SCU card. This is used for Real Time clock displays on the attendant consoles, SMDR time/date stamps, etc and the accuracy is 1 minute per month.
- Five 8KHz and five 8.19200MHz balanced clocks for all PCMPs in the system.
- 8KHz single ended clock for clock sync between A and B.

### PLL Performance

Acquisition time < 300mS  
Lock in range =  $\pm 130$ ppm.

### PCM Clock Specification

a) The 8M Clock Output

Frequency: 8.192MHz  
Number of output: 5  
Signal form: Differential, sine wave  
Clock Driver: 74F04  
Alignment: Leading edge  
Phase Difference:  $\pm \frac{1}{2}$  cycle of 2.048MHz clock  
Duty cycle:  $50 \pm 15\%$   
Output jitter: Meet the requirement specified in CCITT recommendation G.732 & Accunet, PUB62411.

b) The 8K Clock Output

Frequency: 8.000KHz  
Number of output: 5 (for Mercury Rel. 8)  
Signal form: Differential, square wave  
Clock Driver: 26LS31  
Alignment: Leading edge  
Phase Difference:  $\pm \frac{1}{2}$  cycle of 2.048MHz clock  
Duty cycle:  $50\% \pm 0.02\%$   
Output jitter: Meet the requirement specified in CCITT recommendation G.732 & Accunet, PUB62411.

### Timing Reference Input Specification

In slave mode, there are four 8KHz reference inputs to clock card. Each input is controlled by CPU software and it can be disabled manually by a DIP switch, S1.

In master mode, there is no reference input to clock card. Therefore, reference control does not apply to master clock and switch, S1, is not required.

### 8KI

This single ended signal has the highest priority among all the input references. On clock B, this sync input is coming from clock A. On clock A, this input is pulled high. Therefore, there is no 8KI clock on clock A.

### 8K-EXT

This single ended external reference signal has the second highest priority. This input must have a quality of stratum 3 or  $\pm 37$ ppm stability.

### 8K0A

This balanced clock is the primary reference, which comes from one T1/CEPT trunk. 8K0A has a quality of stratum 4 or  $\pm 50$ ppm. Second least priority is assigned to 8K0A.

### 8K0B

This balanced clock is the secondary reference, which comes from another T1/CEPT trunk. Clock quality of 8K0B is the same as 8K0A, and 8K0B has the least priority.

Reference is selected according to priority and the desired reference must be enabled before it can be chosen.

An automatic reference switchover occurs when the current reference has disappeared more than 400mS.

When all 4 references disappear or out of specification, then there will be no reference to select and the clock output should be free running.

#### 1.4 PSU (Power Supply Unit):

To provide continuous operation without call loss during brown outs and outages, the system operates from a single 48 VDC primary batteries supply. In the system each line shelf and each half of the common Control Shelf has its own DC/DC converter to supply the various Voltages required by the logic, processors, memories and peripheral circuitry, thus maintaining modularity. These modules plug into the shelf back plane as any other PCBs and in the case of Local line shelves, also contain the ringing generator for that shelf.

The PSU is a single PCB with the combination of DC/DC Converter, Ring generator and Alarm Monitoring circuitry.

The DC/DC Converter is a 200W isolated switching power supply that generates regulated +7.6V, +15V, -8V DC power from -48VDC input.

The Ring Generator supplies 20Hz/25Hz ringing voltage from -48VDC input. The shelf protection voltage circuit uses the ringing voltage to generate the shelf' most positive and most negative voltages for protection biasing.

Four signals are generated by the Alarm Monitoring Circuitry, LLA (Low voltage Limit Alarm), HLA (High voltage Limit Alarm), OVP (Over Voltage Protection) and OTS (Over Temperature Sense).

The out put voltage (+7.6VDC) is monitored for both upper and lower limit of 5%. Once the voltage drops or raises by 5%, the LLA or HLA is generated receptively. When the +7.6VDC output voltage increases more than 12% (i.e. about 8.5VDC), the OVP is generated and the PSU is shut down.

If the free air temperature around the PSU raises above 57°C, the OTS is generated.

The ringing voltage is monitored and alarm is raised if the voltage falls below 55Vrms for longer than 500mSec.

## 2. Line Shelf:

The Line Shelf is a basic building block of the TX2400L/XL system. It houses both a number of ULI/UDI (Universal Line Interface/Universal Digital Interface) cards as well as the control equipment which communicates between them and the Central Control Unit (CCU) and connects them to the central PCM network. Each Line Shelf accommodates one LCU, one PCM-C, one MTP, one PSU and up to 16 UDI/ULI cards. The following is a brief description of each:

### 2.1 LCU (Local Control Unit):

The Local Control Unit (LCU) is a microprocessor based card which is slave processor to the CCU, sending it only significant call activity information and responding to instructions receiving from it.

#### Specifications

- i. Motorola MC68302 Processor @ 25MHz.
- j. 512 Kbytes system RAM, expandable to 4 M bytes
- k. 512 Kbytes system ROM, expandable to 4 M bytes
- l. HDLC link operating at 2MHz.
- m. DMA functioning.
- n. 10 ms Real Time Clock
- o. Error/Alarm detection/reporting

Each Line Shelf is equipped with an LCU, which acts as an intelligent controller for all the cards on the shelf using direct communication to them via an HDLC link.

A ROM memory included in the LCU contains its operating program and also included is a RAM memory, which contains variable data such port status, PCM time slot assignments, timers and control information.

The LCU analyzes port status data, which it receives in a periodic scan, for significant call status data (e.g. Off-hook, DTMF received, etc.) to determine if the CCU should be signaled and/or if local shelf action should be initiated.

It also executes CCU instructions to set up and clear down PCM highway call paths and performs self-diagnostic tests when time permits.

Another function of the LCU is error handling and reporting error conditions to the CCU (e.g. isolating and removing defective hardware from service).

As a peripheral controller on the system, the LCU has access to the duplicated Inter-processor buses (A and B), but is capable of being addressed independently based on its unique identity which is set by strapping on the back plane of the Line Shelf.

There are five resets on the LCU: Power On, Local, System, External Command and Watchdog timer.

The LCU handles two types of interrupt requests: Maskable and Non-Maskable. These interrupts under certain conditions cause the LCU to stop its current routine, store the current information, and jump to a new routine indicated by the interrupt.

The LCU has a scheduling process that cycles continuously, deciding which of its associated routines should be run next based on the priority.

The message distributor controls the packaging and sending of messages to the CCU in response to its scan. It combines any information received from the ports(including the operator console) into one formatted message which goes to the CCU.

The LCU consists of the following functional blocks.

- Processor and memory
- PCMP interface
- Scanner emulation
- CCU communication interface
- Miscellaneous

The processor and memory block consists of a 68302 processor running at 25MHz. This processor consists of a 68000 core processor with three serial channels, three configurable timers, and other configurable I/O. In this application, one of the serial channels is reserved for HDLC communication with the line cards. This replaces the 80C152 micro-controller on the older LCU design. The memory has been modified to either accept the existing memory map or to allow for changes if expansion is required.

The PCMP interface is basically a copy of the old PCMP interface. The PCMP's memory is mapped into the LCU's address space. When the LCU writes to the PCMP, a copy is placed in a designated region of the LCU memory. This operates as shadow memory. When desired, the LCU can read either from the shadow memory or from the shadow memory copy. This can be used for debugging purposes. The PCMP interface has an addressable range of 2Kword, so the data bus is the full 16 bits.

Miscellaneous circuit includes power supply, real time logic to provide 10 ms interrupts, watchdog circuit.

**Following Alarm messages are sent to CCU by LCU:**

- Clock Alarm - This alarm used to come from the PCMP and indicates the status of the 'A' side clock. No indication was provided for the 'B' clock. The new clock alarm is created from whichever clock ('A' or 'B'), is provided from the PCMP and indicates that no clock is provided.
- Voltage Alarm - This alarm was previously provided by the power supply. alarm now monitors the +7.6V into the LCU. A resistor divider sets thresholds of 2.38V and 2.58V to compare with a 2.5 volt reference. This resistor divider will trigger the alarm if the voltage is 5% high or 3% low. The +7.6V voltage supply should be within 1% maximum over all operating conditions as specified in the power supply specification.
- Over-temperature Alarm - This monitors the cabinet ambient temperature. An NTC resistor is used with a resistor divider and a Schmidt inverter to create the alarm. This alarm should come on when the ambient temperature rises above 57 degrees, however this detection scheme is subject to wide variance.
- Battery Alarm - This alarm monitors the -48V supply to the line cards. This alarm will normally only occur when a fuse is not installed or blown. Functionally, this alarm has been copied from the scanner.
- Ring Generator Alarm - This alarm monitors the voltage of the ring generator. If the voltage falls below about 90V, the alarm will turn on. This alarm will normally turn on when the load on the ringer is too high, indicating that too many phones are ringing at one time and the phone ringer may not be heard by the user. Functionally, this alarm is copied from the scanner.

## 2.2 PCM-C (PCM Control):

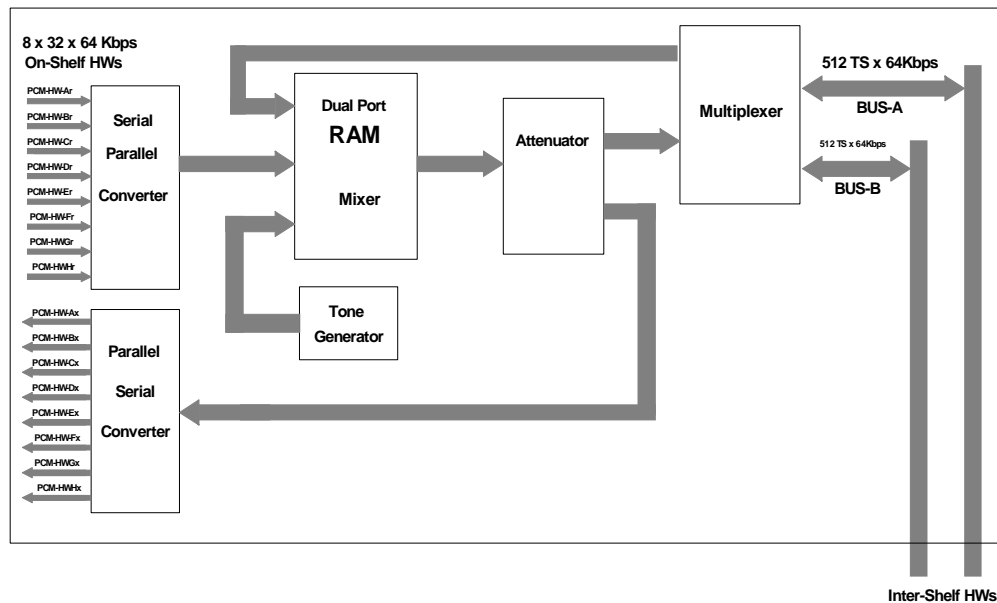
The PCM Control (PCM-C) is the interface between the inter-shelf PCM highways and the PCM network within a Line Shelf. Acting on commands from the LCU, it performs digital time and space switching of PCM data samples between the intra-shelf paths and between the twelve serial intra-shelf paths and the eight parallel inter-shelf highways.

Within the unit is a digital tone generator that generates up to thirty-two individual tones, which any two of them are mixed to provide the supervisory tones for the system. These tones can then be attenuated to the appropriate level and switched to any of the PCM-C outputs.

Each PCM can mix (linearly add) any two PCM input signals to produce a composite output PCM signal for conferencing purposes. The PCM signals may be two voices, two tones or one voice and one tone.

The LCU can read from the PCM-C RAM as well as write to it. This feature is provided to enhance system integrity.

An additional function of the PCM-C is the generation of clock signals for the shelf from the system master clocks and the monitoring of these master clocks. The simplified diagram of the proprietary switching network inside the PCM-C is illustrated below:



The PCM-C reads data from each of the 32 timeslots on each of the 8 internal highways which are connected to the port interfaces on the shelf and from each of the 32 timeslots on each of 8 access buses going to the inter-shelf highways then stores the data in a RAM.

The LCU configures an address map in the PCM-C and it is used to extract samples from the RAM of Tone generator, add them when required and output the resultant data to the appropriate path and timeslot.

The On-shelf highways are unidirectional serial paths (i.e. eight in each direction from PCM-C to port interfaces) but the inter-shelf highway timeslots may be used for transmission in either direction (i.e. to or from the shelf depending on the call set up).

The PCM-C receives and monitors both the primary and secondary clocks (both 8.192 MHz and 8KHz) from the system master clock(s), deriving from them the timing signals for the Line Shelf modules and PCM CODEC frame synchronization.

Both the digital tone generator and the attenuation block utilize PROM look-up tables to derive the required signals and levels.

#### **Specifications:**

- PCM Paths:
  - Inetr-shelf Highways: Eight Parallel Bi-directional buses operating at 4.096 MB/Sec.
  - Local Highways: Eight Serial Input and Output buses operating at 2.048 Mbites/Sec.
- Clocks:
  - 8.192 MHz to LCU
  - 2.048 MHz to ULI /UDI
  - 8 KHz Frame sync. to ULI/UDI
  - 32 KHz to PSU
- Attenuation Range: 0 to 23 dB
- Tones: Up to 32

### 2.3 MTP (Multi Task Processor):

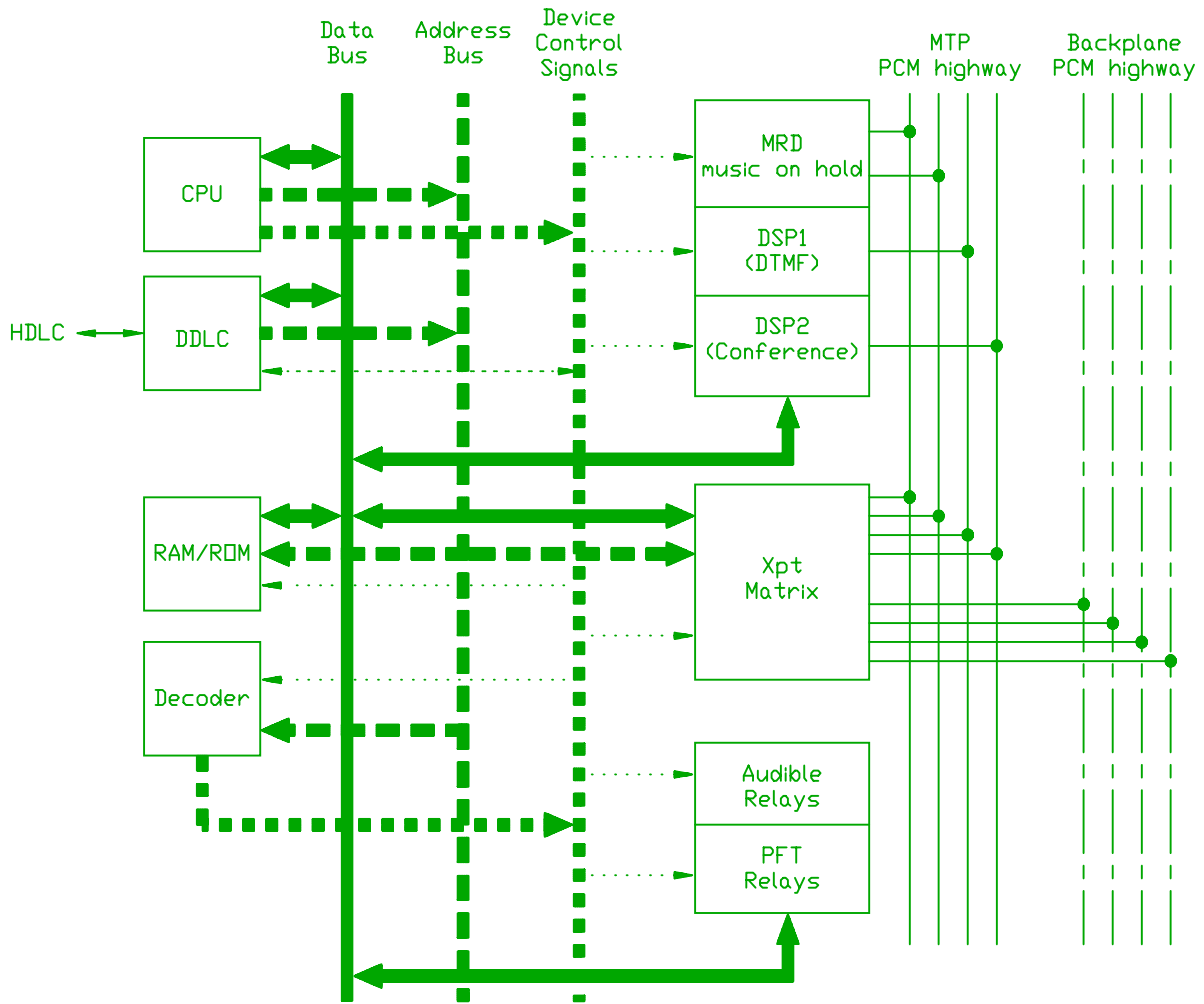
MTP is a microprocessor-equipped card, which includes PFT (Power failure Transfer), audible alarm, two DSPs for processing speech data. One of them is used for DTMF decoder only. The other DSP can be used for other purpose, such as multi-party conferencing. A 16-bit 68HC000 is used to control the entire MTP.

A DDLC (Dual Data Link Controller) is used to communicate with the LCU (Local Control Unit) through the HDLC link.

#### Specifications

MTP board is capable of the following functions:

- 32 DTMF detectors (28 accessible by users)
- 16 ways multi-party conference per card (Optional)
- Power Failure Transfer
- 1 Alarm relay
- 3 Department audible relays
- Expansion port for MRD (Message recording device) or music synthesiser board.
- Music source for music on hold.



**MTP simplified block diagram**

## 2.4 Line Interface Cards:

Two universal cards are employed by the system to accommodate all different Digital and Analog applications, **ULI** and **UDI**:

The Universal Line Interface card (ULI) is the basic building platform for all of the analog port interfaces to the system. It occupies a single card slot in a TX-2400 system and accommodates up to 16 ports depending on its resident plug in sub-modules.

When used with various interface modules, the ULI can provide interface circuits for:

- Standard Telephone lines (Dial Pulse or DTMF)
- **Pay telephones (Coin Box)**
- **Magneto Telephones**
- **Ground Start CO lines with/without meter pulsing**
- **Loop start CO lines with/without meter pulsing**
- **Direct Inward Dialing (DID)**
- **E&M Trunks (Four, six or eight wires)**

**Each type of interface module is assigned a unique hardwired code, which can be read by the ULI on power up.**

The ULI provides control of line signaling and on board Digital Signal Processor (DSP) that can support the processing of analog signals on the line.

The ULI accepts 16 plug in modules which, may be used on a port basis (e.g. standard telephone lines) or combined to provide multiple functions for less than 16 ports (e.g. depending on programming 1 module equals 2 for wire E&M trunks, 1 six E&M trunks or 1 eight wire E&M trunk).

Communication between the ULI and the LCU is via an HDLC link.

An integral part of the ULI operation is the use of software programmable DSP based CODECs, which allow for the synthesis of a variety of different termination impedances, insertion losses, gain and phase voice band frequency response and transhybrid losses.

The ULI card is designed to meet or exceed CCITT, Belcore LSSGR, EIA-464, FCC part 68, ETSI ETS300-001, DOC CS-03, ULI459, CSA C22.2 # 225-M90 specifications and recommendations for both in premise and off premise use.

The 16 port ULI is comprised of a synchronous serial controller for HDLC communication with the LCU, an array of sockets to receive various types of interface modules, an array of eight dual DSP based CODECs for u-Law and A-Law analog to digital and digital to analog conversion, a digital cross-point matrix switch for time slot assignment and switching and a microprocessor to coordinate and control communication among these blocks.

The Digital cross-point matrix switch coordinates the transfer of bidirectional PCM data between the back plane PCM highways and the IOM-2 interface that is shared by the CODEC array.

The **ULI (Universal Line Interface)** is equipped with a processor to control all types of Analog ports, such as Ordinary Subscriber Lines, Metering Subscriber Lines, Coin Box, E&M, DID, DOD and CO Trunks with all the standard signaling. Each ULI accommodates 16 analog ports of each type.

**Specifications:**

- a. MC68302 Microprocessor operating at 25 MHz clock.
- b. 4 MB system Flash program memory.
- c. 1 MB system RAM.
- d. Two HDLC channels at 2Mbps (1 active and 1 backup).
- e. On Card DSP for Tone detection and generation.
- f. On Card 256x256 Cross Point switch.
- g. Equipped with auxiliary Port for On-hook FSK transmission of Message Waiting, Calling Name and Number display, PCM data analysis for a thorough parametric transmission test of the voice path and for running diagnostics to permit trouble shooting in the field.
- h. 32 Analog Ports with full service capability.
- i. Visual Waiting.

**2.4.2 The Universal Digital Interface (UDI) card is the basic building platform for all the digital port interfaces to the system. It comes in both a one slot wide version and a two card slot wide version depending on its application. It provides a platform for various interface modules, which interface to digital lines and trunks. The UDI supports both ISDN Basic Rate (2B+D) and primary Rate (23B+D or 30B+D) interfaces.**

**The single card slot wide version when equipped with the appropriate modules provides for 8 ISDN BRI circuits which may be:**

- **Operator Consoles**
- **ISDN Telephones**
- **ISDN Trunks**

**The double width version when equipped with the appropriate modules provides for 1 to 2 links, which may be:**

- **E1 (CEPT) Digital Trunks**
- **T1 Digital Trunks**
- **E1 (CEPT)/ISDN Digital Trunks**
- **T1/ISDN Digital Trunks**

**Each type of interface module is assigned a unique hardwired code , which can be read by the UDI on power up.**

The **UDI** is a processor equipped card to control all types of Digital ports such as E1, T1, J1, ISDN-BRI, ISDN-PRI, with all types of signaling such as CCS#5, V5.2, CAS, R1, R2.

It could be directly connected to Fiber Optic cables by using an optional Back

card.

Each UDI card can accommodate two Link Modules, each of which can interface to:

- One ISDN-PRI,
- One 2Mbps Link,
- Four ISDN-BRI, U Interface (2B1Q)
- Fiber Optic
- X.25 Packet Switching for B channel, HDLC or other
- Voice Messaging node12xc
- Extra Memory Module
- UDI Tester Module

**Specifications:**

- a. MC68302 Microprocessor operating at 25 MHz.
- b. 2 MB system Flash/ROM program memory.
- c. 2 MB system RAM with Back-up battery.
- d. Two HDLC channels running @ 2Mbps for inter-system communication (1+1).
- e. On Card two DSP for Tone Processing/Conversion.
- f. On Card two 256x256 Cross Points for time slot based information switching.
- g. Equipped with powerful high density FPGAs and CPLDs.
- h. On Card 256 Kbytes SRAM for storing different tones PCM samples.
- i. 2 x E1/T1/J1 links with full service capability.
- j. 2 x 4 ISDN 2B1Q U interface service capability.

The **TX-2400L** system is available with a standard software package that is field configurable for various applications.

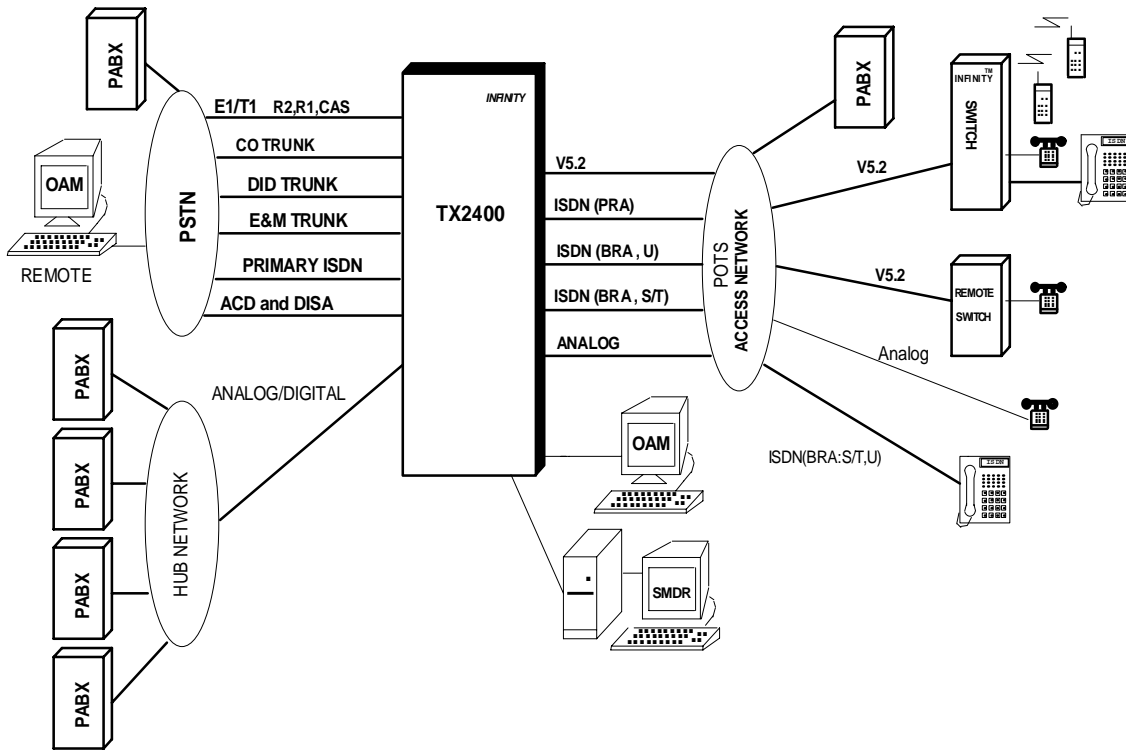
## System Specifications:

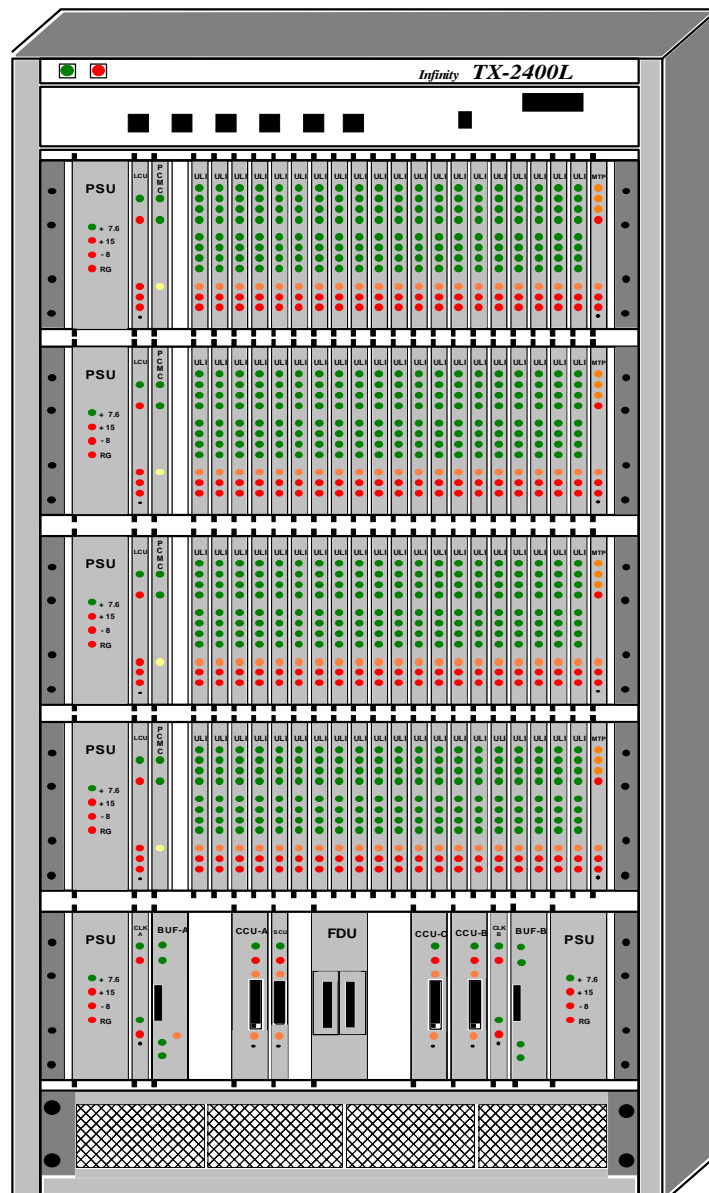
- PCM-TDM Technique
- **SPC** ( Stored Program Control)
- ITU-T, *Bellcore*, ETSI UL1459, FCC, UL and CSA Conformity
- HW/SW fully modular and scalable
- non-blocking, full available proprietary Switching Network
- Inter-System Communications on 2Mbps HDLC Link
- Intelligence : All control and line (Analog/Digital Interface) Cards
- Customized Application Capability due to the use of FPGA, CPLD, DSP on all Cards
- Alarm display of:
  - Temperature sensor
  - Thermal shutdown
- Capacity : 3,840 Ports
- Caller ID feature for all Lines complies with ETSI and Bellcore
- Message Waiting feature for all Lines complies with ETSI and Bellcore
- Microprocessors : 16, 32 bits wide powerful Processors
  - @ [25MHz (**MC68302**, IMP), 16MHz (**i960**, **RISC**)]
- 1 Erlang traffic/Port, Tone (DTMF, R1, R2) Processing Capability
- BHCA: 138,000 @100 Sec. Average Holding Time
- Interfaces :
  - Analog: All types of Analog Line and Trunk Modules
  - Digital: E1, T1, J1, ISDN-PRI, and ISDN-BRI

**Transmission Rate:** E1**Network:** 10BaseT Ethernet Connection Interface

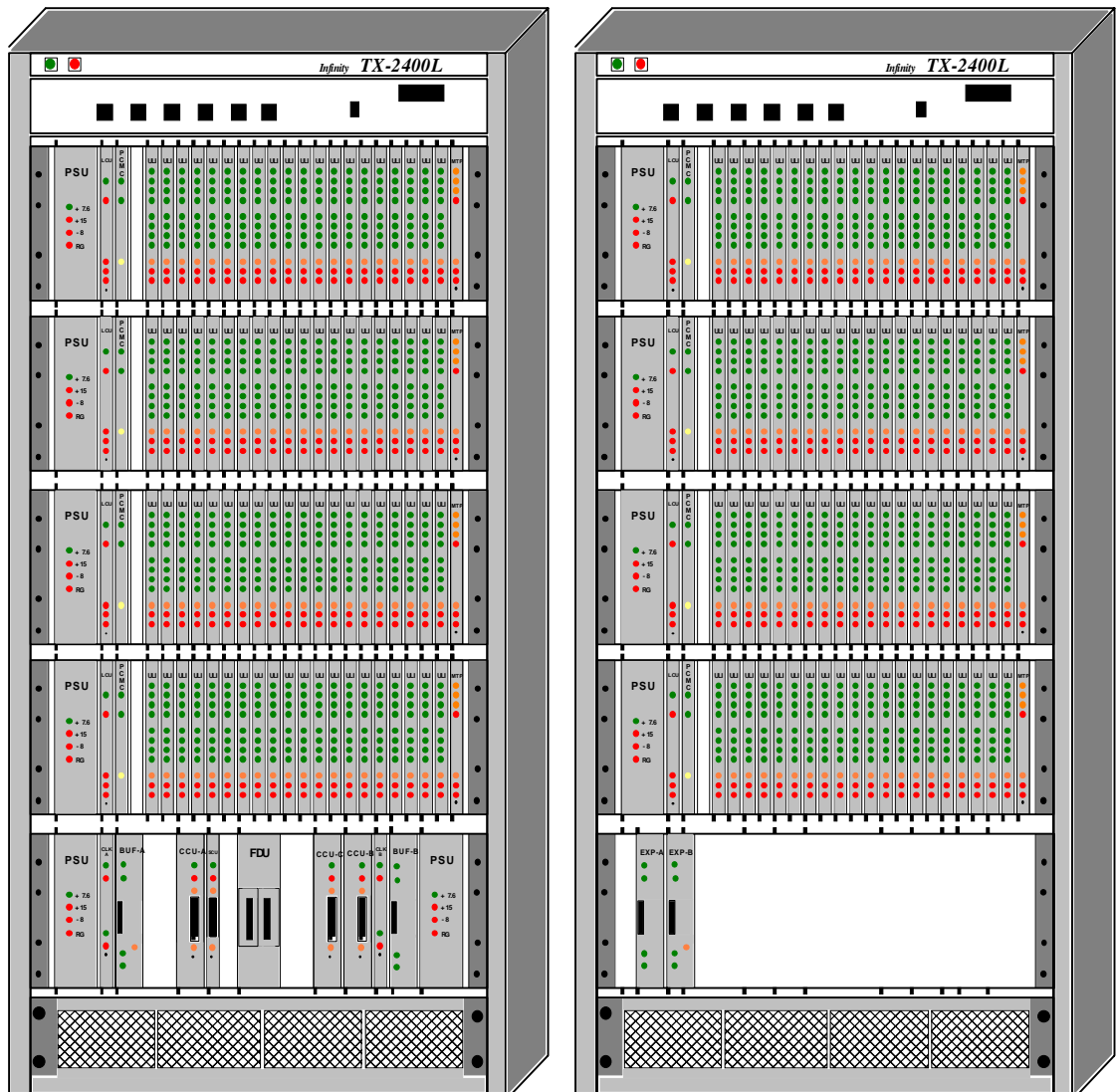
- Signaling : Loop Start ( 600/900 Ohm ), Ground Start ( 600/900 Ohm ),  
Battery Reversal, DTMF, R1, R2, CAS, CCS#5, ISDN-PRI, V5.2
- **X** Signaling to **Y** Signaling **Converter/Translator**
- Highly reliable common control equipment with extensive fault detection and recovery capabilities and component level troubleshooting
- Built in Remote maintenance facility
- Multiple ISDN Operators Console operation
- Blind ISDN Operator Console
- Voice recording capability on all consoles
- Built in directory
- Management monitoring and control features
- Flexible Numbering Plan
- 2 Hours of Digital Voice intercept Messaging per shelf
- Two external paging outputs
- Two external Music source inputs
- 8000 Seconds Voice Messaging/Announcement, up to 511 messages, 16 Sec. Each
- 100 Hours, 32 Channels Voice mail Capability
- Automatic Voice recording for malicious calls
- 16 way conference call
- Interactive Voice Response (I.V.R)

- Three Way Conference Call for all lines with injection of any separate message to each of the parties on the conference call without any interruption of live calls.
- 32 Channel ADPCM Voice Compression/Decompression on **IVM** (Integrated Voice Mail Card)
- Application : SWITCH, Small Transit Switch, Intermediate Gateway Switch, Signaling converter
- Power Consumption : Less than 1W/Port @ High traffic loads
- Built in 9600 Modem on MCU
- Built in RS232 serial port on all ULI and UDI cards for future applications
- Weight: 60 Kg (Fully loaded)
- Dimension:
  - Height: 42 cm
  - Width: 69 cm
  - Depth: 40 cm

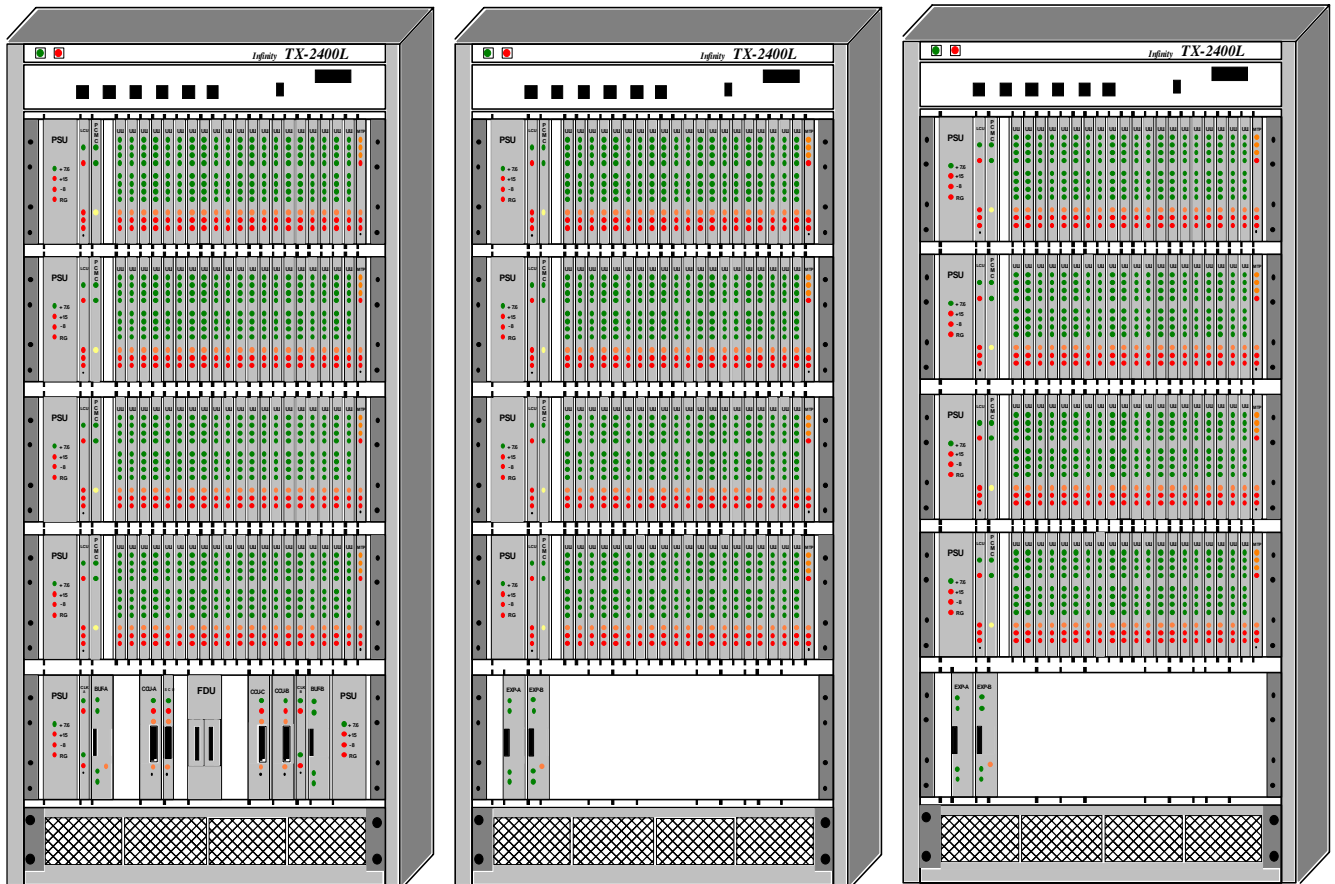




## TX-2400L/XL Basic cabinet



### TX-2400XL with two cabinets



### TX-2400XL with Three cabinets

## System Technical Data:

### 1. Tone Plan and Signaling

#### 1.1 Ringing Signal:

- Frequency: 20 Hz (25 Hz Optional)
- Amplitude: 50-90 Vrms
- Normal Cadence: 1 Second On, 3 Seconds Off
- Discriminating Cadence: 0.5 Second On, 0.5 Second Off  
0.5 Second On, 2.5 Second Off

#### 1.2 Dial Pulsing:

- Telephone:
 

|                  |             |
|------------------|-------------|
| Pulse rate       | 7 to 12 pps |
| Make/Break ratio | 55 to 72%   |
| Inter-digit Time | > 300 ms    |
- Incoming Trunk:
 

|                  |             |
|------------------|-------------|
| Pulse rate       | 7 to 12 pps |
| Make/Break ratio | 55 to 72%   |
| Inter-digit Time | > 300 ms    |
- Trunk Pulsing:
 

|                  |  |
|------------------|--|
| Pulse rate       | 10 pps @ better than 1%                              |
| Make/Break ratio | 40/60 or 34/66 with tolerance of<br>+/- 2ms on break |
| Inter-digit Time | 800 ms   |

1.3 Hook-Switch-Flash: Range 0.1 to 1.0 Second

1.4 Tone Signals:

|                           |                               |
|---------------------------|-------------------------------|
| Frequency Accuracy        | +/- 0.5%                      |
| Total Harmonic Distortion | > 40 dB below the Fundamental |
| Amplitude Variation       | < 3 dB of Nominal             |

| Tone Name                       | Frequency (Hz) | Level (dBm0) | Cadence  |
|---------------------------------|----------------|--------------|--|
| Dial Tone                       | 350/440        | -16          | Continuous   |
| Special Dial Tone               | 350/440        | -16          | Three 100 ms pulses separated by 100 ms, then continuous |
| Audible Ringing Tone            | 440/480        | -19          | 1 Sec. On, 3 Sec. Off                                    |
| Special Audible Ringing Tone    | 440/480<br>440 | -19<br>-19   | 0.8 Sec. On<br>0.2 Sec. On, 3 Sec. Off                   |
| Busy Tone                       | 480/620        | -22          | 0.5 Sec. On, 0.25 Sec. Off                               |
| Reorder Tone                    | 480/620        | -22          | 0.25 Sec. On, 0.25 Sec. Off                              |
| Call Waiting                    | 440            | -14          | 0.5 Sec. Burst   |
| Intrude Warning Tone (Barge In) | 440            | -14          | 1 Sec. Burst, then 200 ms pulses at 6 per minute         |
| Confirmation Tone               | 350/440        | -16          | Three 100 ms pulses separated by 100 ms                  |
| Intercept Tone                  | 400<br>620     | -14<br>-14   | 200 ms<br>200 ms Alternating                             |
| Urgent Camp On                  | 440            | -14          | 500 ms Burst repeated every 6 Sec.                       |
| Howler Tone                     | 1477/1500      |              | Gradually Increasing Level until PG state reached        |

Different Frequency and cadences are also available

## 1.5 Outgoing DTMF Trunk Signaling:

|                            |                  |
|----------------------------|------------------|
| Frequency Accuracy         | +/- 0.2%         |
| Total Level:               |                  |
| High Group                 | -9 dBm +/- 1dB   |
| Low Group                  | -11 dBm +/- 1 dB |
| Time On (Min)              | 100 ms           |
| Time between Signals (Min) | 100 ms           |

| Frequency | 1290 Hz | 1336 Hz | 1477 Hz |
|-----------|---------|---------|---------|
| 697 Hz    | 1       | 2       | 3       |
| 770 Hz    | 4       | 5       | 6       |
| 852 Hz    | 7       | 8       | 9       |
| 941 Hz    | *       | 0       | #       |

#### 1.6 Mechanical Data:

The TX-2400L/XL cabinet is a pre-wired structure, which can contain a complete Digital switch. It has the capacity for up to *four Line-Shelves* in addition to a *Control Shelf*.

An integral part of this cabinet, in addition to its cabling, is a fuse panel and a forced air cooling system.

The fuse panel provides independent fusing of each half of the Control Panel; for each Line Shelf, separate fuses for the power supply, the Voice Current Feed, and the power feed to the Attendant Console associated with the shelf, two fuses for the fans, and a fuse for the auxiliary power feed.

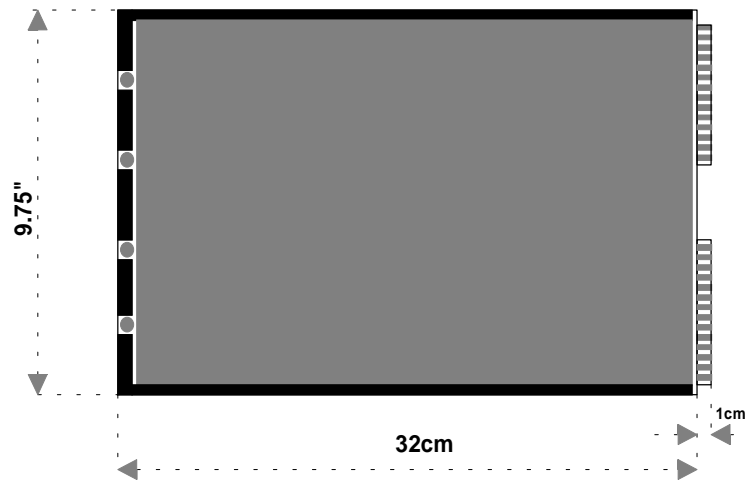
The cooling system consists of two pairs of fans mounted at the rear of the cabinet near the top. The air is drawn in from the front at the bottom and exhausted through the back at the top.

All connections to the cabinet are by plug and socket with the exception of the main power feed and ground coming in, and an auxiliary power feed which is on a terminal strip near the top of the cabinet on the inside wall.

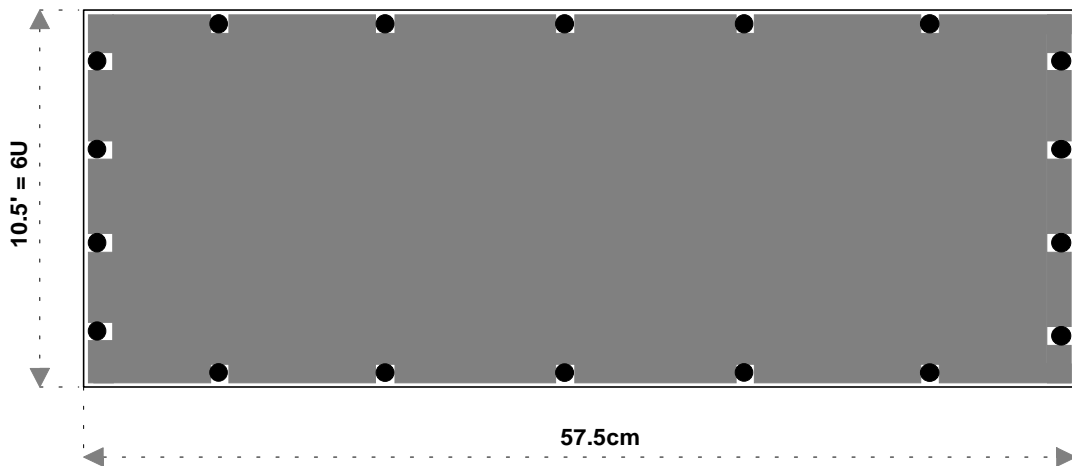
As mentioned before, the TX-2400XL consists of the same basic cabinet as the TX-2400L with the additional of two expansion cabinets.

Following pages are drawings showing the dimension of the Cards, the Card Cage and the Cabinet of the system:

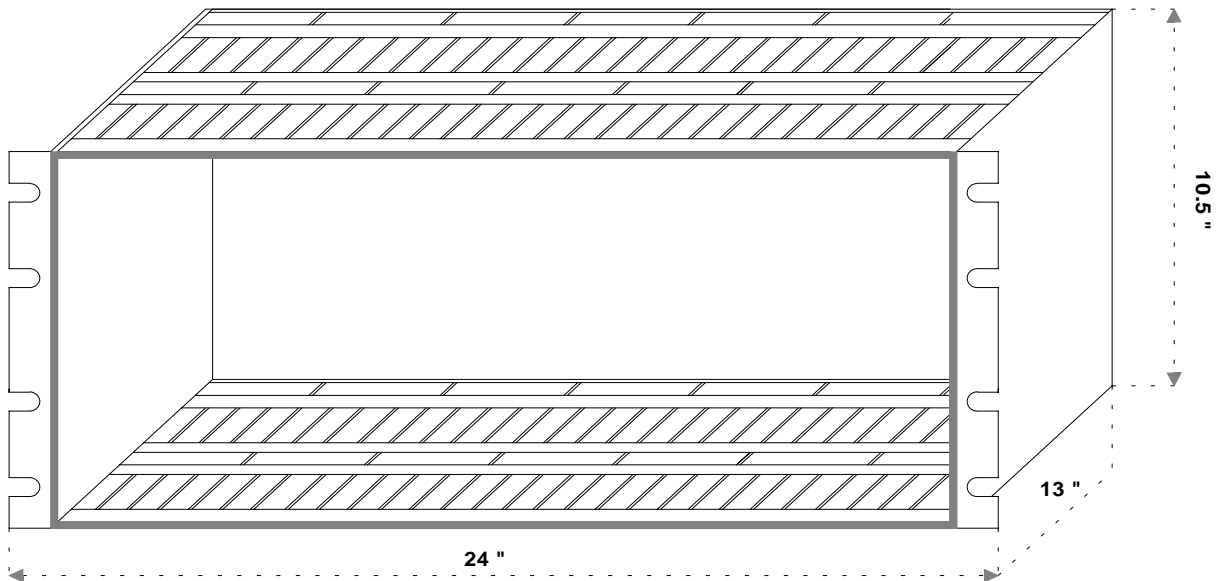
1. Control and Line interface cards:



2. System Back-Plane:

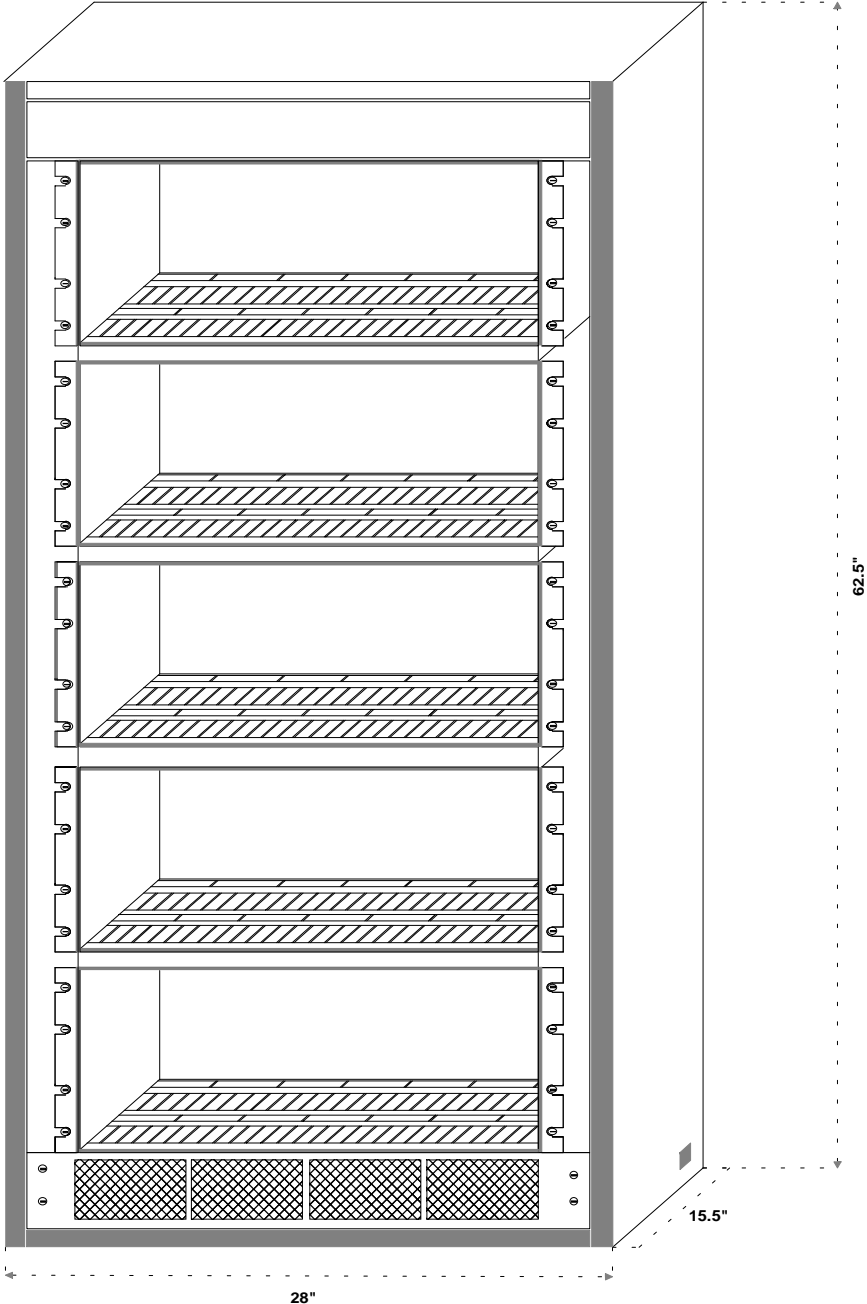


3. **System Card Cage:**

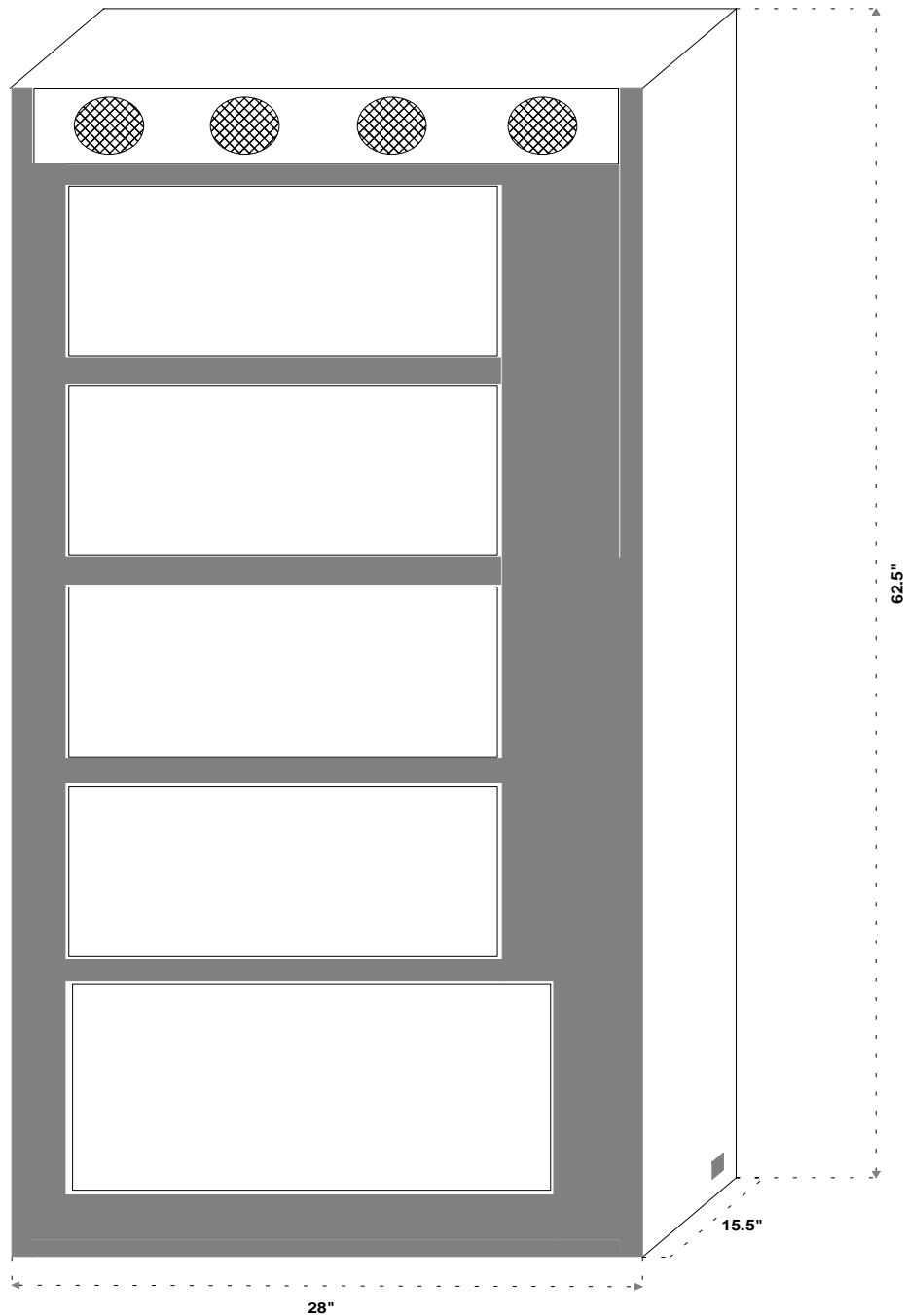


4. System Cabinet:

4.1 Front View



4.2 Rear View



## Administration and Maintenance

### Introduction:

The **TX-2400L/XL** switching system supports more than 200 commands for administering and maintaining the system. Commands are entered interactively on a service terminal, which can be local, or at remote location connected to the switch through a built in modem.

Various commands exist to change configuration data for the system, subscribers, attendants and trunks. The **TX-2400L/XL** switch also offers an extensive range of commands to trace faults on the system, display current status of calls and examine traffic statistics.

### THE SERVICE TERMINAL

The commands to the system are entered on the service terminal. Any responses resulting from the commands are displayed on the Service Terminal. Service terminals can be simple display units or Personal Computers running any serial communication program. One of these programs maybe **TX-2400L/XL**' own TXLINK. The advantage of using TXLINK is that configuration files can be saved and reloaded from the computer's memory.

### TERMINAL TYPES

Any data terminal device (including hard copy terminals) that meets the following requirements can be used as a Service Terminal:

- Display/print ASCII Character Set
- Generate all uppercase characters (CAPS LOCK capability)
- RS-232C Serial Interface

## CONNECTIONS

The Service Terminal can be located either on the same premises as the **TX-2400L/XL** switch, or at a remote location through the use of modems. Local connection of the Service Terminal to the **TX-2400L/XL** is via a serial port on the MCC port located on the back panel of the cabinet. Remote connection is via one of the 2 built in Modem ports on the back panel. To communicate with one another the communications setting of the **TX-2400L/XL**'s serial port and the Service Terminal must be identically configured. The default settings of the Service Processor are as follows:

- 9600 bits per second transmission speed
- 8 data bits and no parity
- 1 stop bits

For more information about connecting the Service Terminal to the **TX-2400L/XL** see the appropriate **TX-2400L/XL** Installation and Maintenance Manual and the terminal's documentation.

## TXLINK

TX Link is a proprietary software program that allows an IBM Personal Computer (PC) or compatible device to operate as a Service Terminal. Unlike a "dumb" terminal, using a PC permits the storage of the **TX-2400L/XL**'s configuration data on disk. In the event of a long-term power failure the configuration data can be reloaded from the PC to the **TX-2400L/XL**. The information and instructions provided in this document apply regardless of whether a dumb terminal or a PC is being used as a Service Terminal. See the TX Link User's Guide or System programming Guide for more information.

## USING TWO SERVICE TERMINALS

When two Service Terminals are connected to the **TX-2400L/XL** (one to the MCC serial port and the other to the Modem port) the first terminal to log on will have use of the Service Processor. Any attempt to access the Service Processor while it is in use will result in a "**COMMAND IN PROGRESS**" message.

Access to the Service Processor can be gained when the terminal that is currently using the Service Processor logs off, or when the command in progress has been processed. In either case, to get the attention of the Service Processor, see the STUG manual. When the Command Line prompt (<) appears enter a command must be entered before preset time out, otherwise the other terminal will regain control of the Service Processor.

## **SERVICE TERMINAL ERROR CODES**

A number of hexadecimal error codes may appear on the screen during the operation of the Service Terminal. These error codes are produced for a variety of reasons as explained in the Service Terminal Error Codes Table located in Appendix A of this guide.

## **COMMAND LISTING BY FUNCTION**

Some system components or features such as Least Cost Routing are programmed using two or more commands. For each significant component or feature, all of the commands required to make the component or feature operational are listed on the STUG manual.

## **DEFAULT CONFIGURATION**

When powered up for the first time the **TX-2400L/XL** automatically produces a configuration based on a five digit numbering plan and a scan of the hardware installed. The type of hardware in each slot will be reconfigured to the installed hardware. For each component or feature for which data can be altered, the default programming is stated. Among the more significant default conditions are:

- Equipment Shelves with ISDN Feature Sets (IFS) installed when the **TX-2400L/XL** is first powered up, are configured with CLS option 4 (i.e., Digiphone Broadcast enabled.)
- All lines that are associated with IFS are programmed as type S.
- All equipped ports are programmed as type T for analog ports (ULI) and S for digital ports (UDI).
- All subscribers are assigned to Station Class of Service 0 which allows unrestricted access for outgoing calls.
- The first audited trunk (loop or ground start) determines the trunk type of route 0. All subsequent trunks of the same type are assigned to this route.

# **Appendix A**

## **TX-2400L/XL**

### **List of Features**

## 1. SYSTEM FEATURES

- Account Code Capability
- Area/Office Code Exceptions
- Attendant Console
- Attendant Transfer - All Calls
- Authorization Codes
- Auto Attendant Operation
- Automatic Number Identification
- Automatic Station Release with Howler
- Camp-on Tone Suppression
- Class of Service (COS)
- Code Call Access
- Combination Trunks
- Common Control Switching Arrangement (CCSA)
- Configurable CO Numbering Plan
- Console-less Operation
- Department Call Control
- Diagnostic Circuitry
- Dictation Access and Control
- Digiphone/ISDN Feature Set
- Digital Trunk - CEPT
- Digital Trunk - R2 Signaling
- Direct Department Calling
- Direct-in Lines
- Direct Inward Dialing (DID)
- Direct Inward System Access (DISA)
- Direct Outward Dialing (DOD)
- DTMF System Out-pulsing
- Executive Override
- Facilities Administration and Control
- Flash - CO and Switch/Centrex
- Flexible Intercept
- Flexible Directory Numbers
- Flexible Station Programming - Circuits
- Flexible Station Programming - Features
- Fully Restricted Stations
- Hands free Stations
- Hotline Stations
- Hunt Groups
- ISDN Feature Set - Data Ports

Key System Operation  
Least Cost Routing (LCR)  
Linked Numbering with a Foreign Switch  
Maintenance Facility  
Message Announcement Module

Meter Pulses - Generation  
Miscellaneous Trunk Restriction  
Multi-Console Operation  
Multiple Listed Directory Numbers  
Multi-Party Conference  
Multi-tenant  
Multiple Trunk Groups  
Music on Hold  
Name Directory Dialing  
Night Service - Department  
Night Service - Station  
Night Service - System  
Off-Premises Extensions (OPX)  
Originating Restriction  
Outward Restriction  
Password Levels  
Power Fail Transfer  
Power Failure Restart - EPROM  
Processor Changes - Administration Panel  
Processor Changes - Remote Access  
Programmable Station Ringing Assignments  
Programmable Time Outs  
Radio Paging Access  
Remote Maintenance Facility  
Remote System Alarm Access  
Service Terminal Trace Commands  
Speed Dialing Restrictions  
Station DTMF to Dial Pulse Conversion  
Station Message Detail Recording (SMDR)  
Station Transfer Security  
Supervised Station Release  
Tandem Trunking  
Tariffs  
Tie Trunk Access  
Traffic Measurement  
Trunk Answer from any Station (TAFAS)  
Uniform Call Distribution (UCD)  
Voice Messaging  
Voice Paging - Phone Speakers

## 2. HOTEL/MOTEL/HOSPITAL FEATURES

- General Comments
- Attendant Hotel/Motel Console
- Automatic Controlled Station-to-Station Restriction
- Automatic Wakeup
- Do Not Disturb
- Electronic Message Registration
- Guest Phone
- In/Out Status
- Intercept Treatment - Attendant Night Barring
- Manual Originating Line Service (MOLS)
- Message Waiting
- Phone Status Display - Attendant
- Restrictive Station Control
- Room Number Correlation
- Room Status - Attendant
- Single Digit Dialing for Services
- Speed Calling for Services
- Supervised Station Release
- Termination Restriction - Attendant
- Maintenance Services
- Maintenance Display/Status

## 3. NETWORK FEATURE

- Automatic Overflow to Direct Distance Dialing (DDD)
- Call Queuing
- Centralized Attendant Service (CAS)
- Customer Administration Center - Network
- Electronic Tandem Switching Service
- In-Dialing Through the Main Switch
- Inter-Switch Call Transfer
- Inter-Switch Coordinated Numbering Plan
- Inter-Switch Features and Facilities
- Least Cost Routing - Network
- Main Switch
- Off-Network Optimum Exit Capacity
- Satellite Switch

Travelling Class Marks  
Tributary Switch

#### **4. ATTENDANT CONSOLE FEATURES**

Alphanumeric Display for Attendant Position  
Attendant Camp-on  
Attendant 15 Way Conference  
Attendant Control of Multi-Party Conference Access  
Attendant Control of Department Calls  
Attendant Control of Trunk Group Access  
Attendant Direct Paging Access  
Attendant Dial Tone Transfer  
Attendant Loop Transfer  
Attendant Overflow Facility  
Attendant Repertory Dialing  
Attendant DTMF Signaling  
Automatic Hold  
Automatic Recall  
Automatic Ring back on Held Call Busy Override  
Attendant Voice Recording Capability  
Attendant Busy Trunk Override  
Built In Directory No.  
Busy Verification of Stations  
Call Processing Indications  
Call Waiting Display  
Class of Service Display  
Class of Service Restrictions  
Digital Clock  
Emergency Priority Answer  
Incoming Call Identification  
Indication of Major Alarm Type  
Indication of Minor Alarm Type  
Interposition Calling  
Message Waiting  
Multiple Listed Directory Number - Attendant  
One-Way Automatic Splitting  
Serial Call  
Station Busy Lamp  
Station Number Display  
Switched Loop Operation  
Trunk Group Busy Lamp  
Trunk Number Display  
Trunk-to-Trunk Connections  
Trunk Verification by Attendant  
Voice Paging Access - "Meet-Me" With Trunk

Volume Control - Console Signal

## 5. STATION FEATURES

- Add-on Conference
- Answer Hold (Touch-tone and Rotary Phones Only)
- Automatic Call Back (On-hook camp-on)
- Call Forwarding
- Call Hold
- Call Hold Reminder
- Call Park
- Call Transfer
- Call Transfer with Camp-On
- Camp-On
- Consultation Hold - All Calls
- Conference Mode Display
- Data Privacy
- Dial Call Pickup
- Directed Call Pickup
- Direct Station Selection (DSS)
- Direct Trunk Access
- Direct Trunk Group Selection
- Discriminating Ringing
- Do Not Disturb (DND)
- Emergency Dialing
- Executive Busy Override
- Indication of Camp-on to Stations
- "Meet Me" Conference
- On-Hook Dialing
- Recall Dial Tone
- Saved Number Redial
- Speed Dialing - Individual
- Speed Dialing - System
- Station Busy Indicators
- Station Loop Circuit Terminations
- Station Override Security
- Station Tone Ringing
- Through Dialing
- Trunk-to-Trunk Connections - Stations
- Unauthorized Phone Use
- Voice Paging Access - "Meet Me"
- Voice Paging Access - "Meet Me" Page - Call Transfer

# **Appendix B**

## **TX-2400L/XL**

### **Peripherals**

- ISDN Attendant Consoles
- ISDN Feature Set (IFS)

**ISDN Attendant Consoles:**

The Attendant Console is a desktop unit that functions as the main answering position for the INFINITY system.

Attendants can process calls quickly and professionally, even during heavy call traffic, with all the information required right at their fingertips.

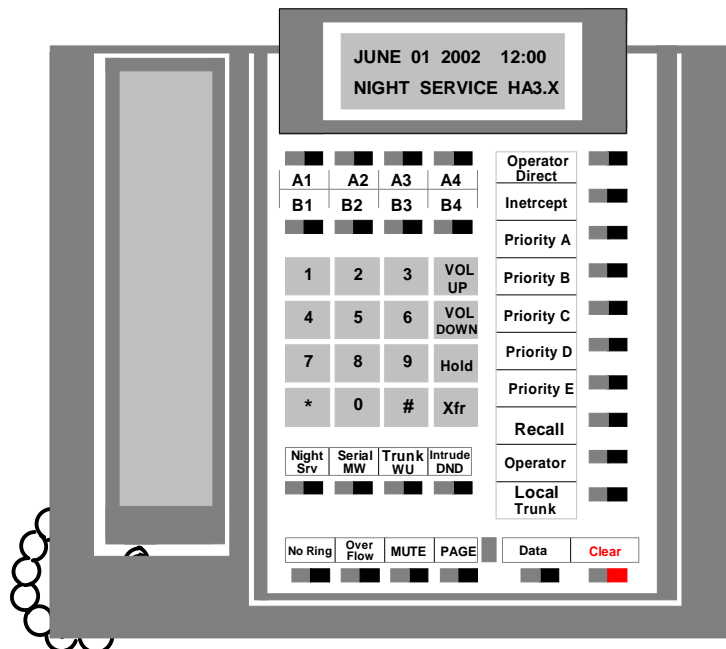
Clearly legible LCD's and easily operated keys increase efficiency. An external Busy Lamp Field (BLF) is available on request.

There are four Attendant Console models available. The choice of model will depend on your requirements.

### Basic Attendant Console:

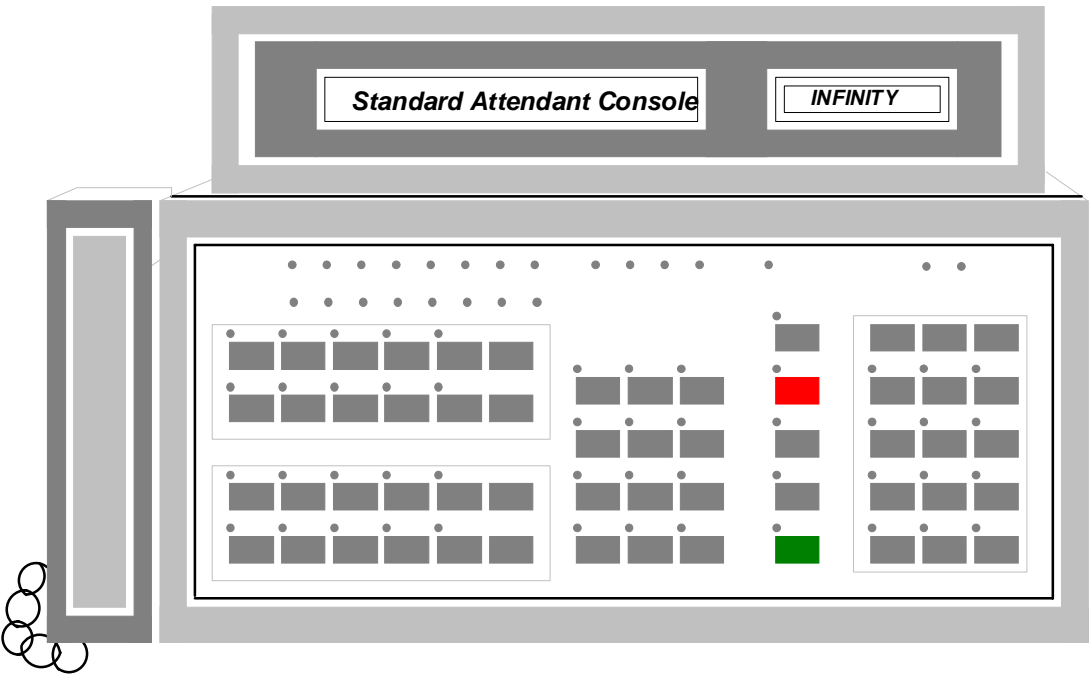
Although the Basic ISDN Attendant Console looks similar to the INFINITY Executive Feature Set (IFS), it provides additional capabilities essential to Attendant operation. Three different types of LCD screens provide Night Service, Call Processing and Attendant Self-Test.

A 20 character by two-line display provides call-processing information while the keycard layout encompasses most of the Standard ISDN Attendant Console keys, including 10 source keys. This basic model is equipped with a microphone and speaker for hands free operation and with an optional data port for PC connection.



**Standard Attendant Console:**

The standard ISDN Attendant Console provides features in addition to functions provided by the basic Console, such as answering trunk calls and providing local user assistance. The standard Console uses a 4-line by 40-character LCD display and 11 source keys for call processing information. Optional Audio Voice Recording is also available. It has a 1 x 8 character display for indicating the source Key queue lengths. An internal directory provides over 1500 subscriber lines with name identification. Five different screens provide Night Service, Call Processing, Directory assistance, Station Status Indicator and Test Mode.



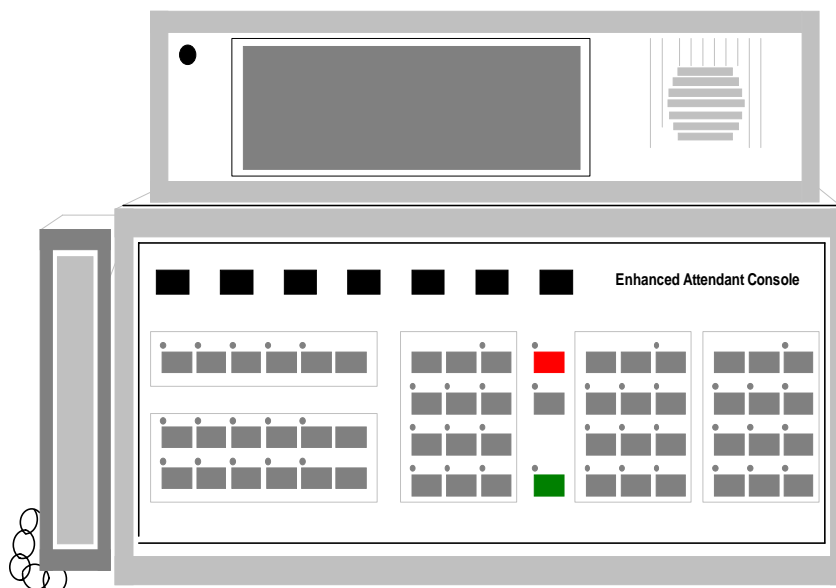
### Enhanced Attendant Console:

The Enhanced Attendant Console allows access to all the ISDN services offered with the INFINITY switch.

This console, in connection with your PC, will provide access to any data base inside or outside of the system. It is equipped with a data port for PC connection, full 2B+D capability and an internal directory of over 1500 subscriber lines with name, department and status. New features include a larger LCD with CRT option and a configurable display setup. Ease of operation is ensured by a Station Status Display of selected subscriber lines and a display of the number of calls queued up in the source keys.

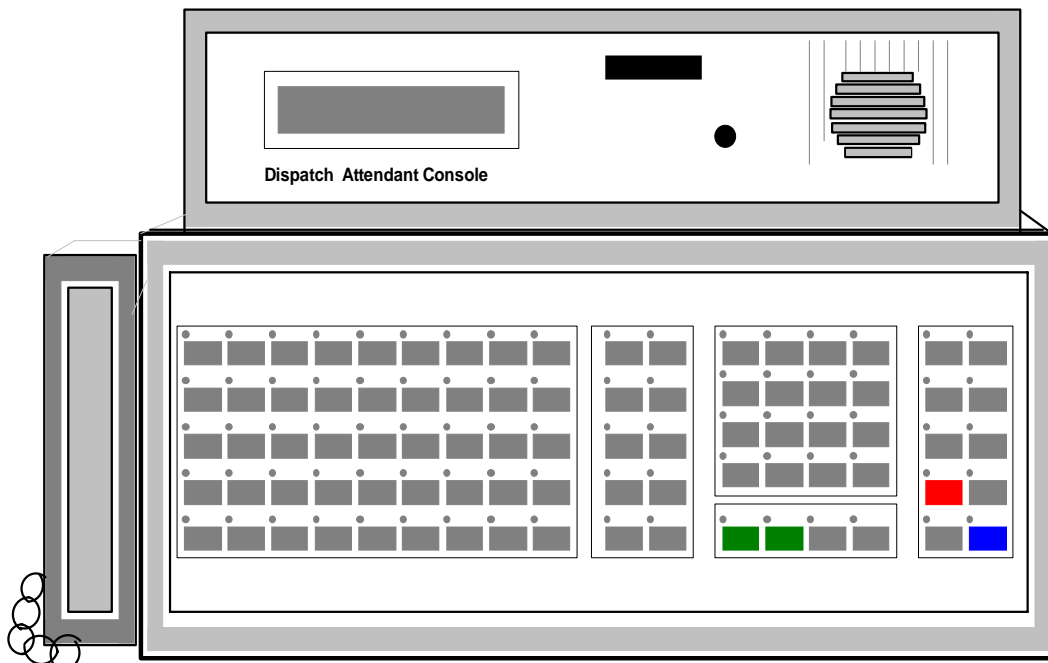
Function keys reduce keystrokes. Operation equipment includes a full size IBM compatible Keycard interface and a multi message voice-recording module.

In addition to all these advancements, the Enhanced ISDN Console supports visually impaired operators with Blind Console operation and Hands Free operation.



### Dispatch Console:

The Dispatch Console has similar capabilities to the Executive ISDN Feature Set with 55 programmable keys, for BLF or DSS. The Dispatch Console is equipped with a 4x40 LCD display and 1x8 LCD display. It is capable of audio recording output for recording devices and offers external ringer control.

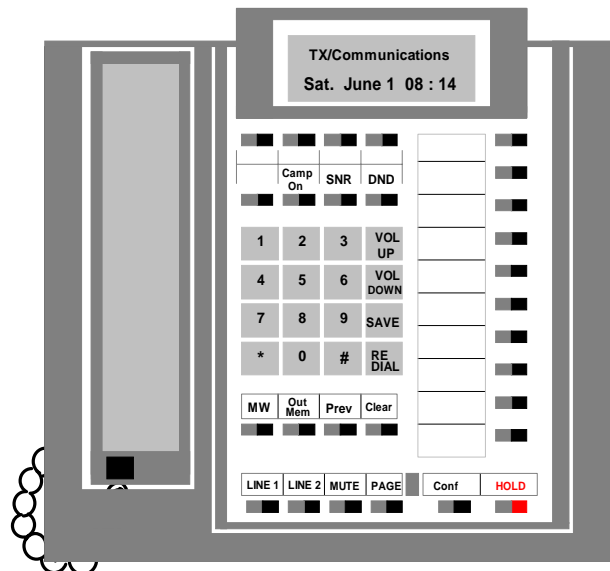


### ISDN Feature Set (IFS):

The Infinity family of switches provides over sixty features and facilities that, without an IFS, require a special access code. With an IFS, feature or facility selection is made by the push of a button. These sets can be customized by on-site programming to provide each user with the group of features judged most useful by the user.

Each feature button is multi-layered and can be assigned with a personal speed dial number in addition to any other feature. Flexibility and extreme ease of use make IFS ideal for executive, secretarial or special answering position stations.

For the secretary program, features include call signaling, call pick-up, busy lamps and single keystroke calling of pre-selected stations.



For special answerers there is a program hunting group features to provide message center, overflow answerer or call distribution and other features to streamline call answering and processing.

The **R** Interface DATA Port is compatible with the Hayes Smart Modem and provides RS-232C connection for up to 38.4Kbits and adaptation for V.110 bit rate.

Below, there is a partial list of the features offered:

### **Features:**

- Add-on conference
- Automatic Call Back
- Automatic DSS Intercom
- Automatic Ringback on Held Key
- Background Music
- Call Forwarding-Chain
- Call Forwarding-External
- Call Forwarding-Internal
- Call Forwarding-Busy Line-Internal
- Call Forwarding-Destination Display
- Call Forwarding-Don't Answer-External
- Call Forwarding-Don't Answer-Internal
- Call Forwarding-Preset
- Call Forwarding-Stored
- Call Hold
- Call Hold-Automatic Call Back
- Call Park
- Caller ID Line
- Camp-On
- Common Audible Ringing
- Consultation Hold-All Calls
- Conference Mode Display
- Data Privacy
- Delay Hotline
- Dial Access to Attendant

- Direct Call Pickup
- Do Not Disturb
- Emergency Dialing
- Executive Busy Override
- Flexible Station Controlled Conference
- Indication of Camp-on to Station
- Individual Transfer-All Calls
- Magneto Phone Monitoring

- Meet-Me Conference
- Multiple Discrimination Ringing
- On-Hook Dialing
- Party Line
- Prime Line Preference
- Recall Dial Tone
- Saved Number Redial
- Screened Call Transfer
- Speed Calling-Individual
- Speed Calling-System
- Station Busy Indicators
- Station Call Transfer and Camp-On
- Station Camp-On
- Station Loop Circuit Terminations
- Station Message Waiting
- Station Override Security
- Station Repertory Dialing
- Station Ringer Cutoff
- Station Tone Ringing
- Through Dialing
- Transfer Before Answer-recall
- Trunk-to-Trunk Connections-Stations
- Voice Calling with Hands-free Answer
- Voice Paging Access-Meet-Me
- Voice Paging Access-Meet-Me Page/Call Transfer
- Voice Paging Access Meet-Me with Trunk
- Volume Control-Station

# **Appendix C**

## **TX-2400L/XL**

### **Integrated Voice Mail**

#### **I.V.M**

##### **Product Specification**

## Introduction

The IVM (Integrated Voice Mail) is a menu driven system which can be customized to best suit the needs of your organization.

You can tailor options and menus to your site. Users can also customize personal greetings to communicate their availability daily, weekly or hourly if necessary.

The IVM provides 32 simultaneous connections to the voice mail facilities and because the voice mail for the **TX-2400L/XL** system is offered on an interface card, no additional subscribers are needed.

The Voice mail provides more than 2000 mailboxes each with 30 minutes of recording time.

IVM can manage communications without a live operator.

The IVM will greet caller with an introduction, ask them to provide the called party's extension or select from options, then transfer the calling party to their requested destination.

The IVM also offers advanced features that will request the calling party for their name for call screening, and can even announce the call over your in-house paging system.

The IVM can also direct the caller to prerecorded messages providing frequently requested information such as directions to your facility, department contacts, product information, etc.

The IVM programming can be done from the system's service terminal. Recording is done easily using a handset and following voice recorded instructions.

### **Administrative Features:**

- Automated Attendant for operator free reception and transfer
- System administration by telephone or Service Terminal
- Remote administration
- Multiple time of day configurations for each class of service, mailbox, menu, or

extension

- Call screening and paging options
- Set time and date
- Print or view system administration reports
- Add or delete mail boxes

### **Users Conveniences**

- First time user tutorial for easy set up of mail boxes
- Password protection
- Multiple messaging option including private, urgent, future delivery, and confirmation receipt
- Messages can be played faster, slower, louder, softer or skipped
- Each message can be replayed, saved, deleted, forwarded or replied to with annotation
- Date/time stamp and sending mailbox ID on every message
- Multiple greeting per mailbox, including standard, temporary, busy and time sensitive
- Call screening with calling party name played to mailbox owner who can then accept, reject, or forward the call to another station
- Address by name or mailbox number
- Re-record message reminder
- End of recording warning
- Return to personal operator

## **IVM (Integrated Voice Mail)**

### **Specifications**

The Integrated Voice Mail Card contains two micro-controllers, an i960 and a MC68302. The MC68302 is used for the **TX-2400L/XL** system interface, and the i960 is used for the user interface and storage. There is a 1KB DPR for inter-processor communications. The Voice Mail Card will use double line card slots.

### **i960 RISC Processor Section**

- a. Intel 100 MHz i960JT Processor
- b. 33 MHz external CPU clock.
- c. 2 M bytes system RAM, expandable to 64 M bytes (4 SIMMs).
- d. 2 M bytes system ROM, expandable to 64 M bytes (4 SIMMs).
- e. Real Time Clock.
- f. 10BaseT Ethernet connection.
- g. IDE Hard drive Interface.
- h. Built-in two IDE disk Drive, one of the drive is for Backup.
- i. Up to 64 MB PCMCIA Flash memory card.
- j. One RS232C serial port and modem.

### **MC68302 Processor Section**

- a. Motorola 16MHz MC68302 processor.
- b. 1 MB system RAM and 1 MB system ROM.
- c. One HDLC channel for system side communications.
- d. 8000 seconds voice messaging storing in the PCMCIA flash memory card.
- e. ADSP2184 32 channel DTMF decoder.
- f. 32 channel ADPCM voice compression / de-compression.

The Integrated **Voice Mail** card (IVM) is designed for the **TX-2400L/XL** systems. The Voice Mail card used in voice applications provides an IDE hard drive for the mass storage of incoming voice messages. The voice message data is directly captured from a PCM Highway and has 32 channels of simultaneously voice mail connections. The voice message is using 2:1 ADPCM compression and stored into the hard drive. The message will be retrieved from the hard drive and play back to the PCM highway.

The other application of the IVM is used for the Voice Recording Device. The voice messages are recorded in PCM format and stored into the PCMCIA Flash Memory card. The IVM supports up to 64 MB of PCMCIA Memory card and therefore provides about 8000 seconds of voice messaging. The voice messaging controller connects into two PCM Highways, it can broadcast any message into the PCM Highways from one to sixty-four time slots, or up to any sixty-four difference messages simultaneously, or in any combinations.

When the IVM is used for both applications at the same time, the limitation will be the voice mail and voice messaging combined together have the resources of maximum of 32 time slots for input and 64 time slots for output.

The IVM can be installed in a single slot card if only the voice messaging function and not the voice mail feature is used.

## Design Specification

The **IVM** is using an Intel 100 MHz i960JT RISC processor. The i960 provides a 32-bit linear address space and 32-bit wide internal and external data BUS.

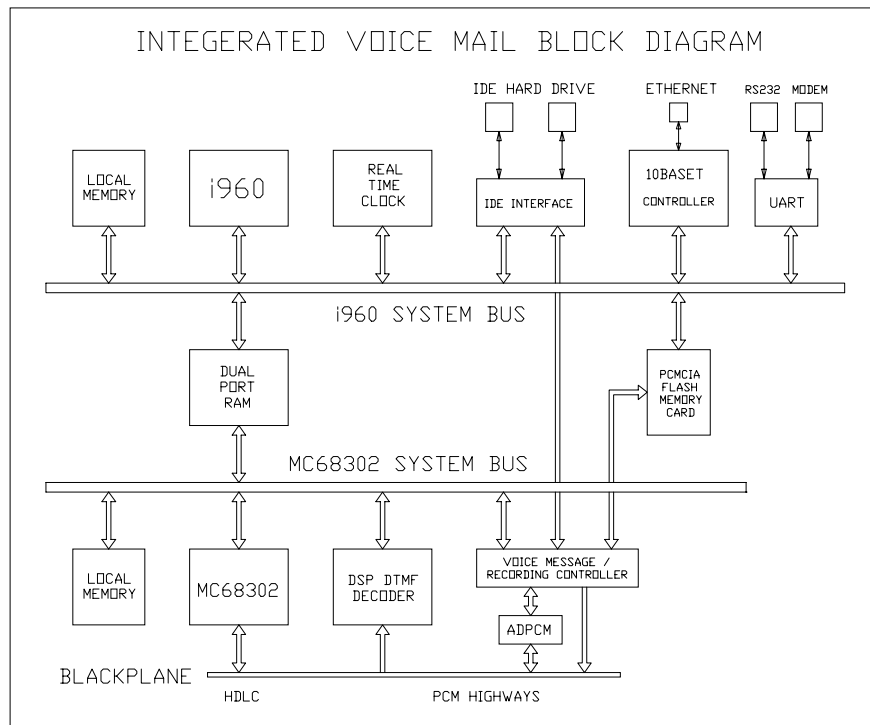
The i960 is mainly used for user interface and mass storage. The major task of the i960 is used to control the 10BaseT Ethernet connection, RS232 interface, modem interface, time keeping and IDE hard disk controlling.

The second processor is a Motorola 16 MHz MC68302 Integrated Multiprotocol Processor. It provides a 24 bit address space and 16 bit wide data BUS.

The MC68302 contains a communication processor to handle the SCC and a MC68000 CPU core.

The MC68302 is used for **TX-2400L/XL** system interface including HDLC communications, DTMF decoding and PCM Highway interface.

A DSP (Digital Signal Processor) is used on the MC68302 side. It is connected as a slave processor to the MC68302. The DSP is used for 32-channel DTMF decoding.



**VM Block Diagram**

## ASYNCHRONOUS SERIAL PORTS (Quad UART)

The IVM provides one serial interface for external connections. PORT 1 is configured to RS232C interface. Port 4 is used by the on card modem module (CH1794). The serial interfaces are supported by Philips Semiconductors SC28C94 Quad Universal Asynchronous Receiver/Transmitter (QUART). The QUART provides parallel to serial conversion, and the MODEM module interface. All four serial interfaces consists of two data and two control lines: Receive Data (RxD), Transmit Data (TxD), Request to Send (RTS), and Clear to Send (CTS). Serial data is sent over data input / output pins, RxD and TxD. The handshaking controls, RTS and CTS, are accessible in QUART control and status registers respectively.

Port 4 is used for the modem module, since the modem module provides RS232 serial interface only (TTL signal level). Two data and six control signals are used by modem. These signals are TxD, RxD, RTS, CTS, DTR (Data Terminal Ready), DCD (Data Carrier Detect), and RI (Ring Indicator).

The QUART can be programmed to generate an interrupt (QART\_IRQ) to the i960 when it requires service such as FIFO empty and the modem status request. It connects to the I960 memory mapped I/O bus (8-bit) in the range of 3FFF 0400H to 3FFF 04FFH. It will generate the Data Acknowledge (QART\_DT) signal to the i960 after each CPU R/W access.

## Modem Features

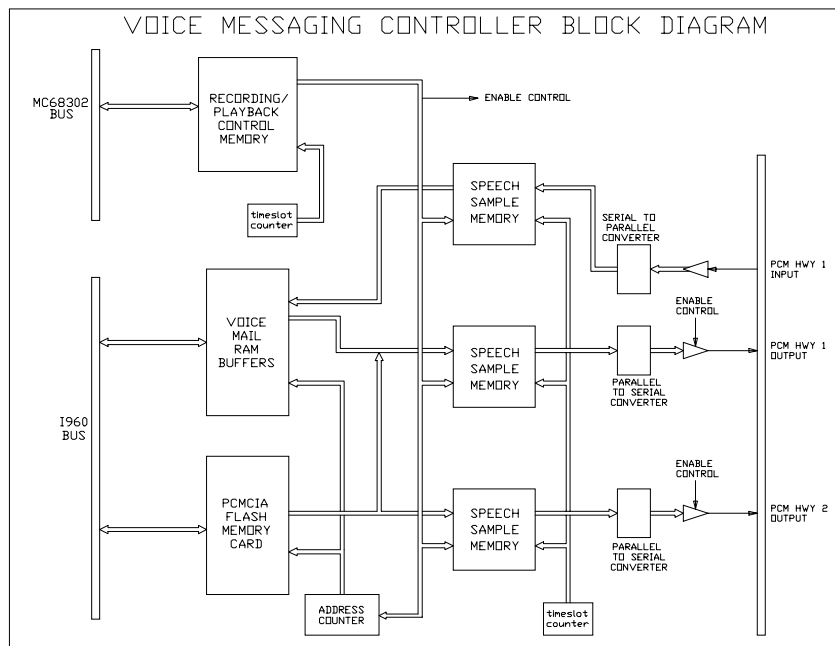
- CCITT V.34bis, V.34 V.FC, V.32bis, V.32, V.22bis, V.22A/B, V.23, V.21
- Bell 212A and 103
- Enhanced AT commands
- S-Register Settings
- Error correction – V.42 LAMPS, MNP 2-4 and NMP 10
- Data compression – V.42bis and NMP5
- DTE interface with speed up to 57.6 Kbps
- Automated baud rate adaptability utilising speed sensing, flow control, and data buffers

## IDE Interface

The IVM will support two standard ATA IDE (Integrated Drive Electronics) Hard Drives which are used on the PCs. The Hard drive is only used for Voice Mail message storage. When the Voice Mail feature is not used, the hard disk is not needed. The second drive is for data backup purpose.

The hard disk access should use LBA (Logical Block Address) instead of using CHS (Cylinder Head Sector) method. The LBA provides relatively simple and easy for software implementation. The LBA is accessing by dividing the total capacity of the hard drive into 512 byte block each. Each logical block is directly mapped into the 28-bit linear address space (137 GB max). The CPU side will see the hard drive as a large virtual memory array but each address access is fixed at 512 bytes.

Figure 5.0 Voice Messaging Controller Block Diagram



# **Appendix D**

## **TX-2400L/XL**

### **Automatic Call Distribution**

#### **A.C.D**

Application Note

## Introduction

**Automatic Call Distribution (ACD)** offers uniform call distribution of incoming calls to a group of station users. A group (referred to as a hunting group) is reached by dialing one master hunting directory number. The calls can be distributed using several different methods of hunting for a free member.

Incoming trunks can first be routed to a prerecorded announcement and then directed to a hunting group to ring one of free agents. If all the agents are busy the call can automatically be camped on to the hunting group to wait for a free agent. Please refer to Automatic Announcement for Incoming Trunks Application Note for more details.

Statistics on hunting group members (sometimes referred to as agents), the number of busy calls in a group, the number of calls waiting to be answered, the time to answer calls, etc. can be kept on a PC based terminal attached to a serial port on the Infinity system.

## Programming

Each hunting group must have a master directory number by which the group is called. The master directory number is defined using the CHM command (see the STUG manual for details). This command is also used to define the type of hunting for a particular group.

### Conditions:

- 64 Hunting Groups
- Calls made directly to hunting group members will not affect the established hunting sequences.
- Hunt Group Master Numbers must be associated with unequipped ports.
- Hunting bypass stations in Call Forward and DND.

## **Setup**

### **Setup of Call Accounting Software on PC**

The ACD software allows monitoring of incoming calls to the hunting groups. Current traffic status and the statistics reports for groups, agents, hunting group member phones can be generated.

The ACD software is a part of Call Accounting Software (CAS) which runs on PC Windows 95 or higher.

The Call Accounting Software should be install on a PC from the CD provided using the setup program.

Connect the PC COM2 serial port to an SMDR port of Infinity switch using speed 9600 baud. The PC can also be connected to a serial interface on an ISDN phone.

If the PC is connected to the SMDR port the SCU OPTION 1 or 2 and 5,6 should be enabled in CSC command. If the PC is connected to R interface on the ISDN phone the OPTION1 should be set to 8 by CPD command.

Follow the menu on the PC to use the ACD software package.

### **Setup of Music Source**

The incoming caller can be connected to a music source when all the agents are busy. External music source must be provided to the system as follows:

The music source on Infinity M or L connects to P1-25 and P1-50.

On Infinity S the music sources connect MUS 2 connectors at the back of the cabinet.

See *Music on Hold Application Notes* for more details.

### **Related Documents**

*Service Terminal Users Guide (STUG)*  
*Announcement for Incoming Trunks Application Note*  
*Message Recording Device Application Note*  
*Music on Hold Application Note*