GDC 036R304-000
Issue 1, June 1996

Technical Overview

TMS-3000

Transport Management System

General DataComm

General DataComm

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Antistatic Precautions

Electrostatic discharge (ESD) results from the buildup of static electricity and can cause computer components to fail. Electrostatic discharge occurs when a person whose body contains a static buildup touches a computer component.

The equipment may contain static-sensitive devices that are easily damaged and proper handling and grounding is essential. Use ESD precautionary measures when installing parts or cards and keep the parts and cards in antistatic packaging when not in use. If possible, use antistatic floorpads and workbench pads.

When handling components, or when setting switch options, always use an antistatic wrist strap connected to a grounded equipment frame or chassis. *If a wrist strap is not available, periodically touch an unpainted metal surface on the equipment.* Never use a conductive tool, like a screwdriver or a paper clip, to set switches.

Safety Guidelines

The following symbols are used when unsafe conditions exist or when potentially hazardous voltages are present:

⚠ *Caution statements identify conditions or practices that can cause damage to the equipment or loss of data.*

⚡ *Warning statements identify conditions or practices that can result in personal injury or loss of life.*

Always use caution and common sense. *To reduce the risk of electrical shock, do not operate equipment with the cover removed.* Repairs must be performed by qualified service personnel only.

- Never install telephone jacks in a wet location unless the jack is designed for that location.
- Never touch uninsulated telephone wires or terminals unless the telephone line is disconnected at the network interface.
- Use caution when installing telephone lines and never install telephone wiring during an electrical storm.

FCC Part 68 Compliance

Connection of data communications equipment to the public telephone network is regulated by FCC Rules and Regulations. This equipment complies with Part 68 of these regulations which require all of the following.

All connections to the telephone network must be made using standard plugs and telephone company provided jacks or equivalent. Connection of this equipment to party lines and coin telephones is prohibited. A label on the back of the front panel of data communications equipment and on the underside or rear panel of other equipment provides the FCC Registration number and the Ringer Equivalence Number (REN) for the unit. If requested, give this information to the telephone company.

If the unit causes harm to the telephone network, the telephone company may discontinue your service temporarily and if possible, you will be notified in advance. If advance notice is not practical, you will be notified as soon as possible and will be advised of your right to file a complaint with the FCC. The telephone company may change its communication facilities, equipment, operations and procedures where reasonably required for operation. If so, the telephone company will notify you in writing. You must notify the telephone company before disconnecting equipment from 1.544 Mbps digital service. All repairs or modifications to the equipment must be performed by General DataComm. Any other repair or modification by a user voids the FCC registration and the warranty.

Canada DOC Notification

The Canadian Department of Communications label identifies certified equipment. This certification means that the equipment meets certain telecommunications network protective, operational, and safety requirements. The Department does not guarantee the equipment will operate to the user's satisfaction.

Before installing this equipment, users should ensure that it is permissible to be connected to the facilities of the local telecommunications company. The equipment must also be installed using an acceptable method of connection. In some cases, the company's inside wiring associated with a single line individual service may be extended by means of a certified connector assembly (telephone extension cord). The customer should be aware that compliance with the above conditions may not prevent degradation of service in some situations.

Repairs to certified equipment should be made by an authorized Canadian maintenance facility designated by the supplier. Any repairs or alterations made by the user to this equipment, or equipment malfunctions, may give the telecommunications company cause to request the user to disconnect the equipment.

Users should ensure for their own protection that the electrical ground connections of the power utility, telephone lines, and internal metallic water pipe system, if present, are connected together. This precaution may be particularly important in rural areas. *Users should not attempt to make such connections themselves, but should contact the appropriate electric inspection authority, or electrician, as appropriate.*

Deutschland

Installations Anweisungen: Installieren Sie die Telefonleitungen nicht während eines Gewitters. Installieren Sie die Telefonleitungen nicht in einem feuchten Raum, auβer die Dose entspricht den Vorschriften für Feuchträume. Berühren Sie unisolierte Telefonleitungen oder Einrichtungen nicht, auβer diese sind vom Telefonnetz getrennt. Vorsicht bei der Installierung oder Änderung von Telefonleitungen. *Achtung:* Es gibt keine durch den Benutzer zu wartende Teile im Gerät. Wartung darf nur durch qualifiziertes Personal erfolgen.

Registration Status	Port ID	SOC	FIC	USOC

Preface

Scope

This manual is an overview of the Transport Management System (TMS-3000). This documentation is written for operators and installers, and assumes a working knowledge of data communications equipment.

Organization

This manual has only one chapter and an index, which contains the TMS-3000 subject and page number (*See Operation and Installation of the TMS-3000, GDC 036R303 for installing and configuring theTMS-3000, and for an explanation on how to monitor and manage network devices.*)

Document Conventions

Level 1 paragraph headers introduce major topics.

Level 2 paragraph headers introduce subsections of major topics.

Level 3 paragraph headers introduce subsections of secondary topics.

NOTE *Notes present special instructions, helpful hints or general rules.*

Related Publications

GDC publication numbers (e.g., GDC 032R163-000) are used to track and order technical manuals. Publication numbers use the following format:

GDC NNNRnnn-000 or GDC NNNRnnn-Vnnn

NNN	identifies the product family (e.g. UAS)
R	denotes a technical publication
nnn	a number assigned by Technical Publications
000	identifies a hardware product and does not change
Vnnn	designates software version associated with a product, which may be updated periodically

The issue number on the title page changes only when a hardware manual is revised or when a manual is reprinted for some other reason; it does not automatically change when the software is updated. A new Software Version is always Issue 1. Other specialized publications such as Release Notes or Addenda may be available depending on the product.

The following documents have additional information that may be helpful when using this product:

GDC Number	Product	Type of Manual
	Transport Management System	Product Portfolio
035R009-000	GPS-8B Power Supply	Operating and Installation
036R302-A7	TMS Packet Processor (TPP)	Addendum
036R303-000	TMS-3000	Installation and Operation
036R603-Vnnn	TMS-3000 Controller	Operation
036R305-000	Quad Stat Mux Channel	Operating and Installation
036R340-000	OCM-2000	Operating and Installation
036R342-000	OCM Packet Processor (OPP)	Operating and Installation
036R452-000	Sync Status Module	Instruction
S-036R042-001	Sync Status Module with Enhancements	Addendum
036R475-000	VLBRV	Operating and Installation
036R477-000	T1-DS0	Operating and Installation
036R478-000	Digital Bridging Card	Operating and Installation
036R479-000	Turbo Data Channel	Operating and Installation
036R480-000	CELP Channel	Operating and Installation
036R483-000	Turbo Data Channel-2, -5	Operation and Installation
036R485-000	T1-FT1	Operating and Installation
036R610-000	TMS-3000 Maintenance Console	User Guide
036R611-000	OCM-2000 Maintenance Console	User Guide

NOTE

Although supported by the TMS Controller, your version of the TPP or OPP cards may not support:

TPP Redundancy
Microcell
SNA/SDLC
PIR

Please refer to the appropriate version of the TPP and OPP release notes.

Glossary of Terms

ACM

The ACM (ADPCM Compression Module) provides the means for a single DS1 (CEPT) line, containing 24 (30) PCM voice circuits, to be brought into the TMS-3000 node and compressed via GDC proprietary ADPCM compression techniques. The compressed signal is then transported across a trunk.

ADPCM

Adaptive Differential Pulse Code Modulation (See ACM)

Aggregate

A connection between two TMS nodes where the entire trunk carries a single bundle carrying the data originating from the TMS channels. This term has conventionally been used to define the TMS's Aggregate Control Card trunk. Also, see Subaggregate.

Aggregate Control Card (ACC)

This module interfaces the 16.896 MHz Fast Bus with a full duplex aggregate trunk connected to a remote node. It buffers data from the Fast Bus and reforms it according to the transmit frame by adding overhead and frame sync bits. Piggyback Cards on board the Aggregate Control Card then prepare the data to comply with transmission standards (EIA or ITU-T). The receive section locates the frame sync bits in the receive aggregate data stream, and, using these bits as a reference, disassembles the remainder of the data stream into channel data, channel controls, and overhead bits.

Aggregate Trunk

A full duplex communication line which transports data between two nodes.

Alarms

These are raised when a malfunction is detected in the system. Major alarms need immediate attention. Minor alarms are not immediately detrimental to the working of the system. Major alarms indicate that hardware on a Common Module is malfunctioning. Minor alarms indicate that the malfunction is in one of the Data or Voice Channel Cards.

Anisochronous

The essential characteristic of a time-scale or a signal such that the time intervals between significant instants do not necessarily have the same duration or durations that are integral multiples of the shortest duration.

Asynchronous

Refers to operations that do not have a common clock.

Backplane

This is the back panel of TMS-3000's Main and Expansion Shelves. It holds the external connectors used by all the modules and covers the Main Harness Card.

Base Card

A board that can have one or more cards called "piggybacks" plugged into it. It can be tested, removed, and replaced as a unit independent from the piggyback card(s). B8ZS (Binary Eight Zero Suppression)

Timing is critical in a digital T1 network. If too many consecutive zeros are in the aggregate data stream, the system may lose synchronization. B8ZS is a method used to meet the "ones density" constraints by taking strings of zeros, converting them to ones and zeros, and placing them back into the aggregate bit stream.

bps

Bits per second transmitted or received. Also referred to as Hz

Bridge

A device for connecting similar LANs using the data link layer MAC source and destination addresses contained in the data frames of all LAN traffic.

Buffer

A storage device used to streamline data transfer when there is a slight difference in data rates caused by, for example, doppler shift or separate clock sources.

Bundle

A sequentially ordered group of DS0s that have a common termination point.

Card

An assembly of components that can be tested, removed, and replaced as a unit. A card usually refers to a single unit without piggybacks connected to it, although in this manual "card" is usually used interchangeably with "module."

CCM

OCM-2000 Common Control Module.

CDA Module

The CDA-T1 (Combined Digital Aggregate) Module allows the TMS-3000 using DS1 framing to operate on a DACS Network (byte-oriented). Also available in a ITU-T 2.048 Mbps version (CDA-E1)

CELP

The CELP Channel Module provides Codebook Excited Linear Prediction (CELP) voice encoding algorithms that maximize voice channel bandwidth utilization. The voice is compressed at rates of 4.8 Kbps, 6.4 Kbps, or 9.6 Kbps.

Channel

Endpoint of a circuit path. The channel is the card at each end of the path.

Channel Module

This Voice or Data Channel Module plugs into an Expansion Shelf, TMS Compact, MEGAMUX Plus or OCM. It interfaces external equipment (via cables) to a Channel Interface Card.

Channel Interface Card

This card interfaces with Channel Modules and the 16.896 MHz Fast Bus. It contains all the circuitry necessary to control, frame, multiplex, and demultiplex up to 64 channels onto the Fast Bus. Channel Card connections to the Channel Interface Card are made via a pair of ribbon cables that run from the backplane of the Expansion shelf, holding the channel cards, to the Main Shelf Backplane where the Channel Interface Card is located.

Circuit

An end-to-end data or voice path which can pass through several entities in a communication system. A circuit is described or referred to by the node/channel names which identify the endpoints of the circuit.

Channel Associated Signaling

Channel Associated Signaling (CAS) is used in conjunction with the ACM/E1 and CDA-E1 Modules. It is a bit-oriented signaling process specified in ITU-T specification G.704 and transferred on timeslot 16 of the frame.

Common Channel Signaling

Common Channel Signaling is supported as a transparent circuit for processing by remote customer equipment. One or more channels (64 kbps DS0) can be handled in this way and is configurable on a per channel basis. All background signaling bits for a CCS transparent circuit are forced to mark, in order to conserve priority control bandwidth throughout the TMS network and enable faster byte synchronization.

Common Module or Common Card

A generic term for any module that, when removed, will cause a major alarm. This includes all modules housed in the main TMS shelf plus the Expansion Modules located on each TMS Expansion Shelf.

Control Data

Control characters that are sent serially along with data. These characters cause functions such as framing, addressing, synchronization, and error checking to be performed. Control data are also used to indicate handshaking protocol.

CRC

Cyclic Redundancy Check

CSU

Channel Service Unit.

DACS Network

DACS (Digital Access Cross-connect System) is a byte oriented (DS0) digital T1 network service.

DCE

Data Communications Equipment.

Dial Backup

A feature that provides a direct node to controller link if normal supervisory communication between the TMS node and the Controller is disrupted. Dial Backup establishes the link using the internal GDC 212A modem on the Redundancy Control Card, or an external modem.

Digital Bridging

A function that provides for a single channel to broadcast to multiple channels and for those channels to respond to the single channel. In TMS-3000, the Digital Bridging Card (DBC) is used for this function

Diversity

The term for two aggregate trunk lines between the same nodes if one trunk is operational and the other is in stand-by in case the first goes down. Both lines are monitored for serviceability by firmware on the Aggregate Control Card. Switching of the line is controlled independently at both ends by the Aggregate Control Card.

DS0 (Digital Signal Level 0)

A single 64 kbps channel. The data stream is divided into 8-bit bytes. DS0 is a byte-oriented environment.

DS1 (Digital Signal Level 1)

A combination of 24 DS0 channels and 8000 framing bits into a 1.544 Mbps data stream.

DTE

Data Terminal Equipment.

ESCC

Enterprise System Control Card. A card that is installed in the TMS shelf to monitor and control the activities other cards in the shelf. The ESCC is responsible for several functions: Permanent storage of software programs for all of the common cards in the TMS-3000 network, communications with other ESCCs and SCCs in neighboring nodes, communications within the node, communications with the Controller if locally connected, and control of all customer traffic within the node. Supports non-disruptive software downloads, expanded non-volatile memory, better Fastbus select resolution, MicroCell Transport, and additional features.

ESF (Extended Superframe)

A modified D4 framing format. The basic D4 framing structure contains 1 frame bit followed by 24 eight-bit time slots or a 193 bit frame. An ESF contains 24 193-bit frames. ESF allows a greater amount of access to digital network services (See "Superframe").

Ethernet

A LAN for connecting devices within the same building, operating over twisted-pair wire or coaxial cable at speeds up to 10 Mbps. It operates at the Physical and Data Link layers of the OSI model, specifying CSMA/CD.

Expansion Shelf

Shelf that holds up to 16 Channel Modules and 2 Expansion Modules (one primary, one redundant). Since one Channel Interface Card can interface up to 64 channels, at maximum a Channel Interface Card is connected to 4 Expansion Shelves.

Fast Bus

The Fast Bus carries controls and data between the Channel Interface and the other common modules in the node. One bit of data is conveyed by every clock bit on this bus. Physically, it spans across the Main Harness Card.

Filtering

The process of prohibiting the transfer of data from one LAN to another based on some characteristic of the frame, such as MAC addresses of the frame or protocol type.

Forwarding

The process of transferring a data frame from one LAN to another based on some characteristic of the frame, such as MAC addresses of the frame or protocol type.

Frame Relay

A technique for fast transmission of LAPD frames where only three elements are utilized: the frame delimiters (flags), a two-octet address, and the frame check sequence (FCS). An integral number of user data bytes are contained between the address field and the FCS. This user data is passed transparently by the network. Frames with incorrect FCSs or frames which cannot be queued are discarded. It is left to the end-to-end higher level protocols to determine if a frame is missing and take appropriate action. Such techniques are optimized for reliable digital networks.

Frame Switching Network (FSN)

A set of core services provided to packet switching applications within the TMS-3000. Its fundamental purpose is to transfer a network frame from a source node to a destination node. The source node is the node where the frame is introduced into the network, and the destination node is specified by information contained in the frame.

HDLC

High-level Data Link Control.

Hertz

Cycles per second transmitted or received. Abbreviated Hz.

Hz

See Hertz.

IAC Module

ISDN Aggregate Control Card

IAR

Intelligent Automatic Routing (or Rerouting)

IMS

Internetworking Management System. An advanced network management system that allows you to monitor and manage network devices from a single workstation. IMS runs on a PC and is a Windows-based application that uses the standard window, menu and button design to provide an easy-to-use network management interface.

Intelligent Automatic Rerouting (IAR)

A Controller function that automatically determines proper routing of circuits around any failed node or facility.

ISDN

Integrated Services Digital Network

Isochronous

A method for transmitting asynchronous data by synchronous means. A transmission format where the asynchronous characters (i.e., those delineated with Start and Stop bits) are sent with a clocking connection between the transmitter and receiver.

ITU-T

International Telecommunications Union - Telecommunications Standardization Sector. A committee that sets international communications standards.

LAN

Local Area Network.

LAPD

Link Access Procedure-D.

LIM

TMS-2000 *Line* Interface Module. In the APEX ATM family of products, LIM is the *Link* Interface Module

Link

A transmission path between two stations, channels or parts of a communication s system.

LIS

Local In-channel Signaling.

LMI

Local Management Interface.

MAC

Media Access Control. This is a unique six byte address assigned to the LAN network interface. All LAN packets contain a source address field and a destination address field in the frame header.

Main Harness Card or Main Harness Backplane

This assembly is covered by the back panel of the Main Shelf. It contains the external connectors used by all the modules in the Main Shelf. Three buses on the Main Harness Card enable the modules to communicate with each other. These three buses are the Fast Bus, the MP Bus (or Communication Bus), and the Clock Bus.

MAU

Multiple Access Unit.

MicroCell Transport

A mechanism for communicating between multiple TPP modules in a single TMS-3000 node shelf via the Fastbus, allowing for the efficient transfer of packets or blocks of information. This feature requires an optional plug-in card for the TPP module.

MINIMUX

A self-contained TDM capable of multiplexing and de-multiplexing as many as six channels of synchronous, asynchronous, isochronous, or anisochronous data, or voice grade telephone signals.

Module

An assembly which has definable performance characteristics so that it can be tested, removed, and replaced as a unit. In a TMS-3000 system, each card on the Main Shelf and Expansion Shelves is a module. A module can have other cards called "piggybacks" or "plug-ins" installed on it. In most cases, in this manual, the terms "module" and "card" are used interchangeably. For example, Channel Interface Card and Channel Interface Module refer to the same component.

Multidrop

A circuit with 1 polling master and multiple end points (drops).

Multipoint

A circuit with multiple terminations with the same level of priority (no master).

Network

Term used to refer to a group of three or more nodes connected together with aggregate trunks. Not all the nodes in a network will necessarily be TMS-3000 nodes.

Network Frame

A contiguous group of octets (8-bit bytes) at the lowest sub-layer of the OSI data link layer (layer 2), bounded by HDLC flags. Unlike a TDM frame, it has no frame synchronization bit and no time slot interchange. A network frame may well be carried inside one or more TDM frames across a TMS circuit.

Node

Any addressable location within a network capable of carrying a TMS-3000 circuit. In a network, a TMS Compact in Philadelphia or an OCM-2000 in Boston are nodes (also see Tail Node).

OCM-1000

A point-to-point version of the OCM. The OCM-1000 does not operate with the TMS-Controller.

OCM-2000

Office Communications Manager. A feeder multiplexer that is used as a node in a TMS-3000 network. It is system of modules installed in a OCM-2000 Enclosure or OCM-2000 Shelf, separate from the TMS shelf, that multiplexes data from a variety of analog and digital devices, then transfers that data to the TMS for further routing. May also be referred to as TMS-2000 or OCM*TMS.

OCM*TMS

See OCM-2000.

OPP

OCM Packet Processor. A module installed in an OCM-2000 Enclosure or Shelf that interfaces externally with public frame relay networks or frame relay devices such as LAN bridges, routers and frame relay PADs. OPP is the OCM counterpart to the TPP.

Packet

A sequence of data, with associated control elements, that is switched and transmitted as a whole; refers mainly to the field structure and format defined within the CCITT X.25 recommendation; multiple packets may be required to carry one complete document or a lengthy block of information.

Packet Switching

A data transmission technique wherein user information is segmented and routed in discrete data envelopes called packets, each with its own appended control information for routing, sequencing, and error checking; a transmission technique that allows a communications channel to be shared by many users, each using the circuit only for the time required to transmit a single packet; a network that operates in this manner.

Piggyback Card

A card that plugs into a base card. The piggyback is a separate assembly that can be tested, removed, and replaced as a unit.

Plesiochronous

The essential characteristic of time-scales or signals such that their corresponding significant instants occur at nominally the same rate, any variation in rate being constrained within specified times. Note that two signals having the same nominal digit rate, but not stemming from the same clock or homochronous clocks, are usually plesiochronous; there is no time limit to the time relationship between corresponding significant instants.

Port

Any switchable entity. A port may be a logical entity that is not necessarily realized through a physical connector. For example, a single Frame Relay interface can support many Frame Relay ports. Traditionally, this has referred to a physical and electrical interface point on a TMS network interface card.

Printed Circuit Board (pcb)

See "card".

RCC

Redundancy Control Card

Redundant Controllers

In the TMS-3000, a network can contain more than one Controller. Software allows the use of multiple PC controllers. One master controller serves as the point of control for the entire network. All other controllers (subordinate) function as backups and as additional access points into the network. The master controllers responsibility is to synchronize its data base (only for the current network configuration data portion) with all subordinate controllers. Software allows up to five subordinate and one master controller.

Route

A logical path through a network from the transmitting equipment to the receiving equipment. The path can go through several nodes.

Router

A device for connecting LANs and other communications media using higher level protocols than the data link layers. Various higher level protocols require their own specific routing protocols, such as IP (Internetworking protocol suite) routing, IPX (Novell protocol suite) routing, Appletalk routing, and various international standard routing mechanisms.

SDLC

Synchronous Data Link Control. A bit-oriented synchronous communications protocol developed by IBM where the message may contain any collection or sequence of bits without being mistaken for a control character. SDLC is used in IBM's System Network Architecture (SNA).

SNA

Systems Network Architecture

Station Clock

An external group of modules that connects into the External Timing socket on the Main Harness Card. It monitors two incoming master clock sources (such as DDS). One of the clock sources is kept on standby in case the other fails. The incoming signal is used as the master clock for the network.

Subaggregate

A collection of data channels and supervisory communications and frame synchronization information routed to a single destination. One or more subaggregates may be carried on a single physical aggregate and routed to different destinations via a DACS network. Subaggregates can be of different types:

> TMS - This type carries TMS proprietary data which includes overhead of synchronization and supervisory communication as well as channel data.
>
> Network - This type carries network (DS0) compatible data. This data originates from a non-TMS device and terminates on a non-TMS device.
>
> X.50 - This type is considered as a network type subaggregate by CDAs and IACs, but as a TMS subaggregate to the OCM.

Supervisory Data

Information which travels from the Enterprise System Control Card via the MP Bus. It does not have any immediate bearing on the data being multiplexed. Instead, it keeps supervisory software in various parts of the system up to date.

Synchronous (Sync)

Two or more things or events are made to happen at the same time by means of a common clock signal.

Time Division Multiplexer (TDM)

A Time Division Multiplexer processes two or more channels of data for transmission over a shared trunk by allocating time slots to each channel.

TMS-3000 Controller

A computer that is connected to the Enterprise System Control Card in a TMS-3000 node via an external connection on the Main Harness Card. The recommended controller is a Pentium 90. It performs configuration and framing calculations for the entire network, as well as other status, diagnostics, and alarm functions. A Maintenance Console is not classified as a Controller because it has limited control over only one node.

Token Ring

A type of LAN that uses the token passing access method and arranges the computers in a ring sequence.

TPP

TMS Packet Processor. A module installed in a TMS-3000 main shelf that interfaces externally with public frame relay networks or frame relay devices such as LAN bridges, routers and frame relay PADs. It also has internal access to the Fastbus, allowing it to transfer frame relay, HDLC and SDLC data to other TPP modules in the shelf or to modules such as CIC, CDA, ACC and IAC.

TPP Pathway

A TMS circuit between any of the following: a synchronous data channel and a TPP module; two TPP modules; a TPP module and an OPP module; two OPP modules. This circuit is unique as it is destined to a TPP/OPP module within the TMS-3000/2000, rather than to an external interface.

Trunk

Defines a connection between a TMS port and a Network port (or another TMS port). Also see *Aggregate Trunk.*

Universal Voice Card

Provides full duplex voice communication capabilities in a TMS-3000. Pulse Code Modulation (PCM), Adaptive Differential Pulse Code Modulation (ADPCM) and Advanced Speech Processing (ASP) card configurations are available.

VLBRV

Very Low Bit Rate Voice Module. An analog voice channel card for TMS-3000, TMS Compact, Universal MM+ V4, MINIMUX, and OCM-2000 TDMs. Maximizes voice channel bandwidth utilization while offering low bit rate values of 9.6, 4.8, and 2.4 kbps.

WAN

Wide Area Network; a synchronous serial interface (i.e., a non-LAN interface).

XL Router

A series of multiprotocol routers that support routing and bridging of LAN, SNA, and HDLC protocols.

XNET

XNET, also referred to as Cross-Net, allows connection between two independently operating TMS-3000 networks. Supervisory communication does not pass between networks, maintaining independent control of each network. A network operator will be allowed to configure an XNET node and aggregate. The operator can then configure circuits to traverse the XNET aggregate. The operator running the other network must also configure a matching XNET node, aggregate and circuits. XNET allows limited diagnostic tests (loopbacks) to be performed.

TMS-3000 Technical Overview

Overview

The **TMS-3000 (Transport Management System 3000)** is an intelligent communications platform designed for provisioning digital circuits and frame-based services, and for internetworking corporate enterprise computing and communications resources (*See Figure 1*).

TMS Family

The TMS-Family includes the **OCM** (Office Communications Manager)**-1000**, the **OCM-2000**, TMS-3000, Network Termination Devices, and the **XL** series of multiprotocol routers.

The **TMSC** (TMS Compact) is a scaled-down version of a TMS-3000. Aggregate and channel capacities and shelf size are reduced to provide a fully functional TMS node that is cost-efficient and saves equipment space.

A TMSC node and a TMS-3000 node use the same set of printed circuit cards except the TMSC does not support the **TPP** (TMS Packet Processor). The TMSC node supports most TMS-3000 functions, and is end-to-end compatible with a TMS-3000 node, as well as with the OCM-2000.

Aggregate trunks are extended from a TMS-3000 node to TMSCs and OCM-2000 nodes at other locations. The TMS-3000 and TMSC use the same type of data channels, voice channels, **expansion shelves** (hold the channel cards), and power supplies. An aggregate trunk is a full duplex communication line which transports data between two nodes.

The OCM-2000 (also referred to as OCM*TMS or OCM) is used as a node in the TMS-3000 network. It is available in a shelf or standalone version. In addition to channel modules, the OCM has a **LIM** (Line Interface Module) and **CCM** (Common Control Module). Detailed information about the OCM-2000 is found in *GDC 036R340-000*.

Up to 16 non-redundant **ACC** (Aggregate Control Card) aggregate trunks are supported by a TMS-3000 node, with maximum bandwidth limited to 16.896 Mbps. Each aggregate trunk requires one ACC in the TMS-3000 node shelf. In a redundant system, two ACCs are required per aggregate trunk. Since there are 16 slots available in a redundant system, there are 8 pairs. Also, between 0 and 8 redundant channel interfaces are available. Each **CIC** (Channel Interface Card) can interface up to 64 local channels.

A TMSC supports one or two aggregate trunks. Each trunk requires an ACC, **CDA** (Combined Digital Aggregate), or **ACM** (ADPCM Compression Module) in the TMSC shelf. A third ACC, ACM, or CDA Module provides 1 of 2 redundant backup in a redundant system. A single CIC provides the interface for as many as 58 channels. In a redundant system, a second CIC is included in the shelf for redundant backup.

ACC, ACM, CIC, or CDA Modules fit into any of the 16 slots in the TMS-3000 Main shelf. A CIC must be paired with another CIC or an empty slot. TPP installation is covered in *GDC 036R302-A7*. In the TMSC, as many as 10 channel cards are installed in the main shelf in addition to the common cards.

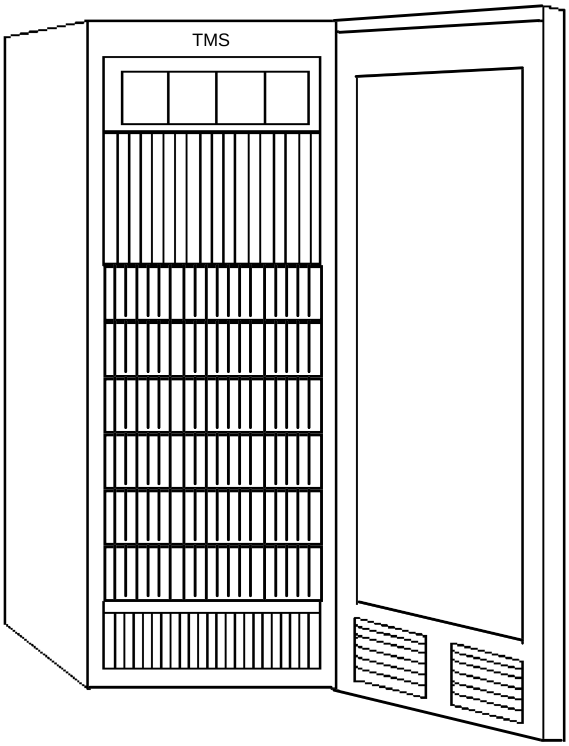


Figure 1 TMS-3000 Node

For more information on CICs and ACCs refer to GDC 036R303-000.

The CDA provides the TMS-3000 compatibility with a **DACS** (Digital Access Cross-Connect System) network, while providing the capability to place TMS-3000 channels onto a DS1 aggregate under a DS0 (byte-oriented) frame format. The channels are bit-interleaved within designated DS0 bundles (groups of DS0s).

In a TMS-3000, a maximum of 16 CDA Modules can be mounted on the main shelf. Each pair of slots must be configured as either redundant or non-redundant. Modules do not have to be configured the same way. In a redundant system, a maximum of eight pairs of CDA Modules are mounted in the main shelf.

Utilizing the CDA Module, the TMS-3000 node retains its efficient, proprietary, frame structure, inherent to a TDM with a bit-interleaved architecture. The CDA Module exchanges data with other CDA, ACC, or CICs in the TMS-3000 main shelf through the TMS-3000 **Fast Bus** (carries controls and data between the Channel Interface and the other common modules in the node). CDA and I/O ports interface to the network via 25-pin D connectors on the rear of the main shelf.

The balance of ACCs and CICs in the main shelf determines nodal functions. A redundant system, containing 16 CICs and no ACCs, functions as a channel switch. In this system, information is passed between local channels via the 16.896-MHz Fast Bus.

A system with 16 non-redundant or 8 redundant pairs of ACCs and no CIC is an aggregate switch. In this system, channel data is switched from one aggregate trunk to another.

The TMS-3000 also has redundant capability for its aggregate trunks using ACC-II modules (No CDA). This is called **Diversity**. In a diverse arrangement, both aggregate trunks are sending data, but only one trunk, the primary, is being received. Primary and secondary transmission allow minimal data loss during a diverse switch.

The **TMS Controller** communicates with each node in the system through the aggregate trunks. The Controller is a personal computer (PC) that is connected to the **ESCC** (Enterprise System Control Card) in a TMS-3000 node via an external connection on the **Main Harness Card** (contains the external connectors used by all the modules in the Main Shelf). The TMS-3000 System is fully software driven. For greater system reliability, redundancy is provided on all common cards **RCC** (Redundancy Control Card).

TMS-3000 Controller

With the TMS-3000 Controller, you are controlling the system, such as configuring and framing calculations for the entire network, as well as other status, diagnostics, and alarm functions.

Software in the TMS-3000 permits redundant (multiple) controllers. One node in the network is designated as the Master Controller site. The Master Controller communicates to other (slave) controllers through software. Multiple controllers can control a network from a remote location if a master site becomes isolated from the rest of the network.

At the other sites, alarms are reported locally by front panel indicators and through the slave controllers.

The TMS Controller uses an SCO XENIX operating system. The Controller requires a minimum of five-megabytes of RAM (eight-megabytes recommended) , an internal hard disk, a 1.44-megabyte floppy disk drive, two serial and parallel Input/Output ports, and a high resolution color monitor. More serial ports are acquired by adding an optional multiport card. The internal hard disk requires a minimum of 80 megabytes of storage for small networks (less than 15 nodes); larger networks need at least 200 megabytes.

NOTE

GDC reserves the right to make hardware and software updates. GDC strongly recommends that you buy your controller as part of the TMS-3000 system. Otherwise, forward compatibility cannot be guaranteed by GDC.

Introduction to Networks

A TMS-3000 network, as managed by the TMS-3000 Controller, is a network that is structured as a logical hierarchy. The network is the top of the hierarchy and is broken down into physical and logical components, with several structural levels. It is important that you understand the TMS-3000 hierarchy when operating the Controller.

The TMS-3000 configuration process is top down: You first create the network, then the nodes of the network, followed by the aggregate trunks between nodes, and finally the circuits. Each element of the network hierarchy must be in place before you can completely configure a lower level element. For example, routes cannot be configured until the network nodes and the trunks that connect them are configured. Circuits cannot be configured until the start and end nodes for the circuits are configured.

Two types of routing exist: **IAR** (Intelligent Automatic Routing) and manual. The IAR function automatically routes a circuit once it is created. (Note that local circuits whose beginning and end points are at the same node do not allow or require routes.) In manual routing, you define the path of the circuit through each node.

An existing network is controlled and maintained in accordance with the network hierarchy. The Status, Alarms, and Diagnostics routines are all organized according to the network structure. Obtain an overview of network operation by selecting one of these routines at the network level. Then focus on smaller segments of the network by selecting a node, circuit, or route for an operation. *Refer to Network Logical Components*, below for a definition of each element in the hierarchy.

The network hierarchy is also important when you are deleting a network element or adding elements to the network. When a network element is deleted, every element below it in the hierarchy is affected. For example, if an aggregate trunk is deleted, any routes that traverse that trunk are deleted by the system. Whenever you delete any network element, be sure that you understand the consequences of the deletion before you initiate it.

When a network element is added, that element must become connected to the existing network. Each level in the hierarchy must be addressed to ensure that the network modifications are made properly. For example, if a node is added to the network, aggregate trunks must be configured between it and previously configured nodes. Timing must be extended from the existing network to that node. Circuits and pathways cannot be created to carry data through the new node until these other requirements have been fulfilled.

Supervisory data routes (those routes carrying TMS-3000 network communications) are automatically created upon system installation.

Network Logical Components

The following paragraphs define each logical component in the network.

Network

The network is a complete TMS-3000 system. All nodes, routes, and circuits within a network are complete. A circuit or route in a network cannot extend to a TMS-3000 element outside the network.

A TMS-3000 network may include several different types of equipment. In addition to standard TMS-3000 nodes, other GDC multiplexers may be integrated into the network. The network configuration integrates these different equipment types into a single communications system.

One TMS-3000 Controller is required for a network. Up to three versions of a network may be configured and stored in a TMS-3000 Controller; however, only one configuration is operational (on-line) at any one time. More than one controller may be connected.

Node

A node is a junction in a network. At a node, data is transferred between: aggregates and other aggregates, channels and aggregates, or channels and other channels.

A node is classified into one of the following categories:

- TMS-3000 — This is a standard TMS-3000 node.
- TMS Compact (TMSC) — This is a small scale version of a TMS-3000 node with a limit of two aggregate trunks and 58 channels.

- Universal MM+ V4 — GDC single-aggregate multiplexer with a limit of 54 channels.
- OCM-2000 — OCM-2000 is a time division multiplexer that is used as a node in a TMS network. The OCM-2000 is available in both shelf and standalone versions. It is capable of supporting two Line Interface Modules, allowing for up to two subaggregate trunks. OCM-1000 acts as a point-to-point multiplexer, independent of a TMS network. OCM-2000 (also referred to as OCM*TMS) acts as a feeder multiplexer to the TMS-3000 network, using the CDA-T1 or CDA-E1.
- XNET — This feature allows the network operator to pass virtual voice and data circuits between two or more autonomous networks. Supervisory communications does not pass between networks, preserving independent control of each network. Each network operator is allowed to configure an XNET node and trunk. The operator can then configure circuits to traverse the XNET trunk. The operator running the other network must also configure the XNET node, trunk and circuits. Limited diagnostics (loopbacks) are allowed on XNET trunks. An XNET node is configured as a "tail-node" into a TMS-3000 or TMS Compact.
- Node Software and Firmware — Most cards at a TMS-3000 node are microprocessor controlled. Operating code is stored mostly as downloaded software, so that upgraded code may be downloaded from the TMS-3000 Controller to an ESCC whenever an upgrade is made.

A node is configured according to the cards installed in the shelf. The type of card in each shelf slot is specified during configuration, and the appropriate operating parameters are selected for the card in the slot.

Each ESCC, ACC, ACM, CIC, **DBC** (Digital Bridging Card provides for a single channel to broadcast to multiple channels and for those channels to respond to the single channel.), CDA, or **IAC** (ISDN Aggregate Control) Module contains firmware which holds the minimum amount of code required for node initialization. All other code is downloaded from the TMS-3000 Controller. Operating routines are provided for software downloads and verification of software and firmware revision levels.

Aggregate Trunk

An aggregate trunk connects two nodes. The trunk is terminated by an Aggregate Control, CDA, or IAC Module at each node.

The ACC has a capacity of 126 channels. A Universal MM+V4 aggregate trunk can support 54 channels. A CDA or IAC Module can support 254 channels.

TMS-3000 networks can also contain **subaggregates**, a collection of data channels and supervisory communications and frame synchronization information routed to a single destination. One or more subaggregates may be carried on a single physical aggregate and routed to different destinations via a DACS network.

Discussions of TMS-3000 networks also refer to bundles. A bundle is a group of DS0s that have a common termination point. A DS0 is a single 64 kHz channel.

Route

A route is a path between any two TMS-3000 or TMS Compact nodes in a network. The route comprises one or more aggregates or subaggregates with zero or more intervening nodes.

Routes are created by the Intelligent Automatic Routing (IAR) routine or by an operator defining a route manually. The intelligent automatic routing algorithm finds appropriate routes between any two nodes in the network (provided that each node has at least one aggregate trunk connecting it to another node, so that all nodes in the network are connected).

The intelligent automatic routing function provides all required routes, but routes may be configured manually by linking aggregate trunks until a desired path is created.

Circuits and Pathways

The traditional TMS is a time division multiplexer (TDM) that provides high capacity, protocol independent transfer of data, voice and video over T1, E1, ISDN, and switched 56K circuits in a managed private network. Traditional TMS circuits are configured for continuous full bandwidth utilization, with all network routing and end-to-end connections pre-determined by the network administrator. This circuit switching network guarantees exclusive and full use of a circuit for each configured connection, an optimum solution for a network with consistent, predictable usage that seldom requires changes. Each traditional TMS circuit is allocated and uses a portion of the node bandwidth, regardless of whether there is any data being transported. And each traditional TMS circuit has one and only one device connected at each of its two ends. A circuit is terminated by channel cards, CDA DTEC bundles, CDA clear bundles, X.50 switching bundles, or ACM common cards, depending on the circuit type. There are several types of circuits.

Many circuits may travel across a single route. The node endpoints of a circuit and a route are not necessarily the same; that is, a route may include several nodes, while a circuit may only travel between two of the nodes on that route. Several circuit types can be configured for the TMS-3000 and are also discussed in *TMS-3000 Operation and Installation.*

On the other hand, a device on a LAN (Local Area Network) can address any other device on the same LAN, or a device on another LAN or WAN (Wide Area Network) through a **bridge** or router. A bridge is a device for connecting similar LANs using the data link layer MAC source and destination addresses contained in the data frames of all LAN traffic. The TPP/OPP (TMS Packet Processor/OCM Packet Processor) brings this LAN/WAN internetworking capability, as well as **Frame Relay** (a technique for fast transmission of LAPD frames), to the TMS-3000.

TPP/OPP traffic uses a TPP pathway and may come from a variety of sources, including:

- **Ethernet** or token ring LANs (Ethernet is a LAN for connecting devices within the same building, operating over twisted-pair wire or coaxial cable at speeds up to 10 Mbps.)
- Frame relay network or frame relay device
- IBM **SNA/SDLC** (Systems network Architecture/Synchronous Data Link Control) device
- **HDLC** (High-level Data Link Control) device

and it may be routed a number of different ways:

- over aggregates as TMS circuits,
- between TPPs on the same TMS-3000 node,
- between OPPs on the same TMS-2000 node,
- direct connection between a TPP in a TMS-3000 node and an OPP in a TMS-2000 node, or
- direct connection between a TPP or OPP and a LAN*TMS.

The TPP/OPP supports direct-connect LAN interfaces: four Ethernet or four token ring interfaces per TPP (or two of each), and one Ethernet or token ring interface per OPP. LAN support is standard for the OPP and optional for the TPP.

The TPP/OPP supports two means for connecting non-LAN equipment: external DB-25 interfaces and TPP pathways. Each TPP supports two external DB-25 interfaces and each OPP supports one. These interfaces are typically used for the direct connection of high-speed routers, internodal links or for public frame relay service, for example. Each TPP supports up to 64 TPP pathways and each OPP supports one, with physical connectivity provided via standard **synchronous** data channel cards (i.e., the equipment cable is connected to a data channel card **backplane** connector). The OCM may be connected to a channel card using a clear channel to the CDA.

The TPP pathway uses synchronous TMS data channels carrying only packetized data, supporting standard TMS synchronous rates. The TPP pathway is characterized by the fact that at least one end of it must terminate on a TPP/OPP module. That is, TPP pathways do not provide end-to-end connections between two channel cards across the TMS-3000 network. Instead, a TPP pathway provides packet access to the **FSN** (Frame Switching Network) or serves as an internodal link within the FSN. An FSN is a set of core services provided to packet switching applications within the TMS-3000. Its fundamental purpose is to transfer a network frame from a source node to a destination node. The source node is the node where the frame is introduced into the network, and the destination node is specified by information contained in the frame. Logical connections between end users are made at the FSN logical level using combinations of TPP pathways. The TPP/OPP inspects each arriving packet, looking for the destination address. Based on its knowledge of the location of devices on the FSN, it then sends the packet toward its destination, which may be anywhere in the network. In contrast, a traditional TMS circuit is always routed the same way (except for Disaster Recovery and Reconfiguration or Time Oriented Reconfiguration).

Channel

A channel is one segment of a circuit providing a data path between two components in a TMS-3000 network. For example, a channel exists between a channel card and the Channel Interface Card that communicates with or between two Aggregate Control or Combined Digital Aggregate (CDA) Modules on opposite ends of an aggregate trunk.

The junction of two channel segments in a circuit in general is the node Fast Bus. Data is transferred from a CIC to an ACC across the Fast Bus or from one ACC to another across the Fast Bus. Data is not placed on the Fast Bus for network circuits that enter and exit a node on the same CDA card.

Each time a Fast Bus transfer occurs, data is placed on a different channel between two components. The TMS-3000 Controller determines which channels constitute a circuit and downloads the necessary transfer information to each node to control channel data transfers on each segment of a circuit.

The channel segments of a circuit are not generally accessible to you through TMS-3000 operating routines. You must configure the channel cards that terminate each end of a circuit; you may select status, or alarm displays for the channel cards. Diagnostics may also be initiated on channel cards. These tests involve a single channel end or the entire circuit between channel cards. The channel segments that make up a circuit between channel ends are not selectable through the TMS-3000 Controller. You may, however, list all the circuits passing over a given component of the TMS system.

Network Timing

TMS-3000 is a synchronous transport management system. All timing signals used to transfer data through any part of the system must be phase locked to a single source. The clock generator circuits in a TMS-3000 node may be phase locked to a timing signal from one of several sources.

Timing may be:

- generated internally (node is master timing source)
- phase locked to ports receive (or transmit) timing
- phase locked to an external source

The single timing source is called the "master" timing source. The master may be a node generating an internal timing signal. If a node internal timing signal is used, all other nodes in the network must be slaves. *Refer to the description of timing sources later in this chapter.*

An external device connected to a node may also generate the master timing signal. In either of these instances, that node is designated as the master timing node. Timing is extended from a master timing node to others via the aggregate trunks between nodes. Multiple master nodes may exist when timing is being derived from either external services or from facilities connected to those nodes.

Each node that is connected to the master node receives timing via the aggregate from the master node. These nodes are phase locked to the timing from the master node.

A typical network timing arrangement is illustrated in *Figure 1*. Nodes B, C, and D are each phase locked to receive timing from the ports that link them with the master timing node. Node E is phase locked to receive timing from the port that connects it with Node B. Node F is phase locked to receive timing from the port that connects it to Node D.

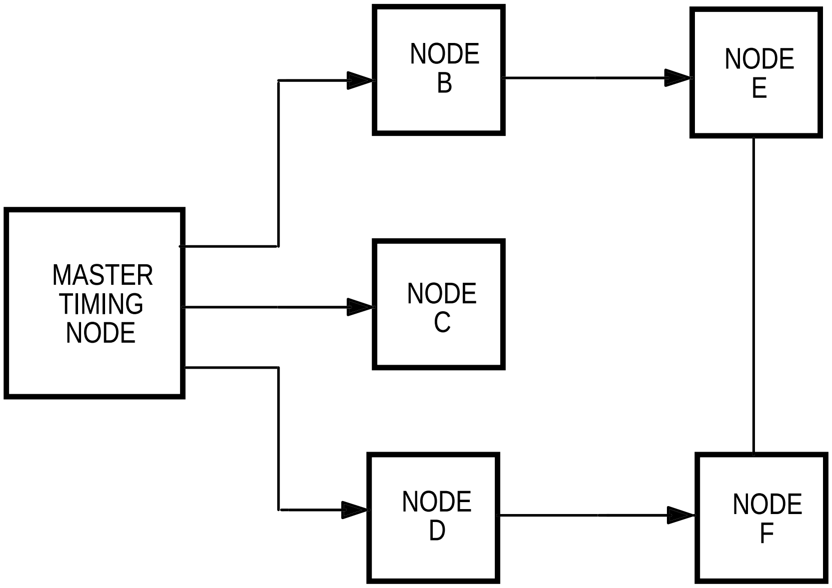


Figure 2 Typical Network Timing Arrangement

Note that the aggregate trunk between Node E and Node F is not critical to the network timing arrangement, because both nodes are phase locked to the master timing source through other ports.

In the event one of the ports serving Node E or Node F should fail, timing could be supplied through the port connecting Nodes E and F. This is an example of an alternative timing arrangement.

Timing can become more complex when the trunk service between two nodes is the transmit timing source for the aggregate trunk. AT&T DACS service or DDS service, for example, requires that the aggregate trunk use the service timing as the source of transmit timing at either end of the aggregate. In this situation, the DACS service or the DDS service must be the master timing source for the network. An aggregate trunk supplying a master timing source is termed a "FACILITY." The nodes at either end of the port are phase locked to the timing signal from the FACILITY port.

Other network nodes may be phase locked to ports extended from those nodes or may be phase locked to other FACILITY ports.

Where the facility provides the master timing source, all FACILITY ports in the network must be synchronized.

For example, you may have both DACS and DDS aggregates serving network nodes. These facilities must be phase locked to the same master timing source (in this example, AT&T supplies both services synchronized from the same master timing source).

The configuration information for an aggregate trunk identifies whether or not the port is FACILITY.

Whenever a node configuration includes at least one self-clocking aggregate, the node automatically phase locks to a FACILITY port. All clocks that are generated by the node, phase lock to the facility timing.

Network timing is configured through the Modify Network Clocking routine (one of the Configuration routines).

Up to 31 different timing levels may be created. Clock level 1 specifies timing for the network under normal operating conditions. Each subsequent level of timing specifies a different clock configuration. The network steps through each level of timing in the event of a timing failure, until synchronization is restored to the network. This timing system is described in Autoclocking.

Port Timing Interface

You must also select a source for transmit timing for each port. Internal timing (from the node) or external timing (from the aggregate) may be selected. It is important that ports transmit timing be selected properly, since the transmit timing at one end of an aggregate provides the receive timing at the other end, which may be the timing source for the node. Transmit timing is selected as part of the aggregate interface configuration for each Aggregate Interface Card at a node.

Autoclocking

The TMS-3000 Autoclocking system protects the network from timing-related failures. Timing for the network is defined by one or more clock levels, selected through the Modify Network Clocking routine (one of the Configuration routines). A complete network timing configuration is specified by each clock level.

In each level, a different master timing node may be designated for the network. Clock level 1 is the timing configuration for a normally operating network.

A level defines each node as having one of the following timing sources:

- Master/Internal — This node generates timing internally, and supplies timing for the network. All other nodes must receive timing from the internal master via aggregate trunks.

- Master/External — This node timing is phase locked to an external timing signal. The signal is received via the external timing connector J18 located on the TMS-3000 backplane.

  Other nodes then phase lock to timing from the external master node received through aggregate trunks. A clock level may include more than one external master. However, the external timing source for each node must be phase locked, so that each external master node is phase locked.

- Master/Facility — Some aggregate trunk services (DDS, for example) provide timing to the TMS-3000 nodes connected to them. Here, the aggregate trunk is considered the master timing source. Other TMS-3000 nodes in the network obtain timing from the TMS-3000 nodes connected to the aggregate masters.

  This type of aggregate trunk is called "Facility." You can select an aggregate master in any level if the aggregate interface configuration for the aggregate specifies it as "Facility." There can be more than one aggregate master in a clock level, as long as timing from all aggregate masters is synchronized.

  Internal, external, and aggregate masters can be mixed in a clock level. Once again, the timing signals from all masters in a clock level should be phase locked.

- Slave — This type of node receives timing through one of its aggregates from another TMS node in the network. The node selects which aggregate to accept timing from.

A port must be configured as "available" in the port configuration to allow the node to select it as a timing source.

Distance from Master Timing Source

A node should be as close to a master timing source as possible. There should be a minimum number of intermediate slave nodes between it and the master timing source.

Each time a timing signal passes through a slave node it is regenerated. The goal is to minimize the number of times that any node timing source is regenerated. These distances are expressed as "hops," where each aggregate trunk that passes a timing signal is counted as one hop.

In the event of a loss of network timing, the "Clock Switch per Hop Count" feature allows you the option of specifying if the TMS-3000 is to continue to search for a closer timing source.

Timing Status Information

Clock level configuration information is downloaded to each node as part of each backbone configuration data download. Each node has a timing source specified for each clock level. Every second, a node exchanges current timing level information with all of its immediate neighbor nodes (that is, all nodes connected to it by aggregate trunk). Each node therefore knows the clock level at which it and its immediate neighbors are operating. The number of hops (number of intermediate aggregate trunks) between each node and its master timing source is also part of the information exchanged.

A node that detects a failure of internal timing circuits reports an Internal Clock Fail alarm. An external master node reports an External Clock Fail alarm if the node cannot phase lock to its external timing source. A slave node or an aggregate master node interprets a timing failure as an aggregate problem and sets Controller Clock Fail in the aggregate status display.

Autoclocking Fallback

Each node in a TMS-3000 network is capable of detecting timing failures. Once a failure is detected, the node can select other timing sources or fall back to a lower clock level, depending on its current timing configuration and timing status information from neighbor nodes. No TMS-3000 Controller commands are required to initiate autoclocking fallback. This enables the node to operate in degraded communications conditions and restore normal operations to at least part of the network.

When a slave node recognizes a loss of phase lock or other timing problem in its present timing source, it switches to internal timing (it becomes an internal master). In this state, normal data communications may be disrupted, but the node is still capable of transmitting/receiving supervisory data from other nodes. The appropriate alarm messages are then generated. The node then waits 5 seconds, watching for a return to phase-locked timing. If the condition persists, the node declares itself to be unlocked, and transmits this information to all neighbor nodes. The node then waits 15 seconds. If the timing failure still exists, the node searches for another aggregate from which to accept timing.

A node uses several criteria for selecting an aggregate timing source:

- If a neighboring node is phase locked to a higher level clock source than the current level of the node, the node phase locks to receive timing from the aggregate connected to that neighbor node.
- If all neighboring nodes are at the same clock level, the node selects the aggregate that presents the least number of hops between itself and a master timing node. This feature may be disabled on the "Clock Switch Per Hop Count" feature.
- If all neighboring nodes are at the same clock level and have the same (equal) number of hops, the node selects the aggregate to receive timing based on specifying a preference number. The preference number has a range from 1 through 4.

The node clocking preference number is found on ACC, ACM, CDA, or IAC Controller Configuration displays. This value must be determined when you have several ACC, ACM, CDA, or IAC Modules in the node. If the node can select another timing source at the same or higher clock source, it does so, and declares itself locked to that source. The node then monitors timing to determine whether the new source is properly phase locked. If it is not, the cycle described above is repeated.

A node searches for another clock source at the same or higher level for 15 seconds. If none is found, the node falls back to the next lower clock level and assumes the timing configuration specified for that level. The node then stabilizes with a phase-locked timing source or enters a new unlocked timing cycle as described above.

In a situation of catastrophic timing loss, the network can "fall through" all configured levels of network timing. (This could also occur due to lack of network timing configuration.) If this occurs, each node becomes an "automaster" after falling through the lowest clock level. The node reverts to internal timing and remains so until it detects an automaster neighbor node with a lower node address. An automaster node with a higher node address always phase locks to an automaster node with a lower node address. Network timing is then resolved to phase lock to the lowest node address in the network or to some node that is configured as a master timing node.

A node that is configured as an aggregate master (that is, phase locked to a FACILITY aggregate such as DDS or DACS) is defaulted to a master node at clock level 1. However, you can change it to other levels. An example of autoclocking fallback is given in 1-3. In the network depicted, node A is the clock level 1 internal master; node B is the clock level 2 internal master.

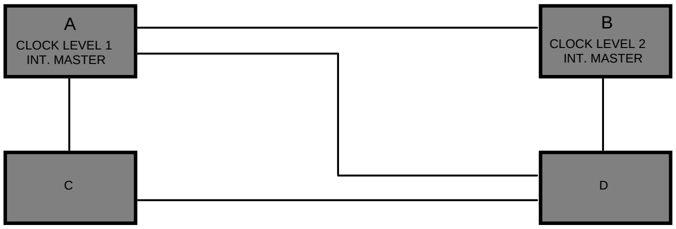


Figure 3 Autoclocking Example

1. In clock level 1, node A is an internal master. All other nodes are slave nodes.
2. Node A experiences a power failure. Nodes B, C, and D recognize a loss of synchronization in the aggregates from node A. After 5 seconds, they declare themselves unlocked and become internal masters.
3. Nodes B, C, and D wait 15 seconds. They all then begin searching for a locked aggregate source.
4. Since all three nodes were slaves at clock level 1, there is no phase-locked timing source at clock level 1. After searching for 15 seconds, all three nodes fall back to level 2.
5. At clock level 2, node B declares itself an internal master and sends this timing status information to node D, which is the only operational neighbor node. Node D receives this information and phase locks to the aggregate trunk from node B.
6. Node D changes its status to "locked" and sends this information to node C.

   Node C phase locks to the aggregate trunk from node D. Nodes B, C, and D are now synchronized.
7. Node A regains power and declares itself a level 1 internal master. Nodes B, C, and D receive this timing status and phase lock to the aggregates from node A. The network has now restored itself to normal operation without operator intervention.

Failure Simulation

You may test timing configurations in the on-line network by using the Failure Simulation (a diagnostic function selectable from the Equipment Diagnostics screen for an Aggregate Control Card).

The ACC Failure Simulation forces a selected aggregate trunk into a loss of synchronization. The simulation may be set to last for a selected period between 1 and 30 minutes.

NOTE

This routine disables the actual network node or aggregate and disrupts all data traffic through the device. Use this routine with caution. However, the routine does not fail CDA or IAC modules.

Station Clock

The GDC Station Clock assembly can be used as a clock source for network timing. It is a shelf-based unit, integrating multiple cards to provide a reliable network timing source for the TMS-3000. The Station Clock features redundant clock source input capability allowing the use of two separate master clock inputs (typically DDS) through a selectable interface, which can be programmed for V.35, RS-422, or RS-423 standards. Typical application of the station clock assembly is to provide master clock sources for multiplexers located at the same location.

NOTE

If you need to use a Station Clock with your system, contact your GDC sales representative for technical assistance.

The Station Clock Facility is usually located at the Master Node. Its master reference source may be any two of the 56 Kbps DDS circuits (or any other reference) entering the site. A timing reference signal is fed from the station clock assembly into the External Timing Connector (J18) of the TMS-3000. Dividing circuits on the ESCC use the reference to create the needed clocks. Multiplexers at all remote sites usually use the receive aggregate clock as their timing source. It may also be timed from station clock assemblies, as required.

Autopath

Autopath places intelligently controlled circuit routing at your fingertips. The TMS-3000 system routes circuits through the entire network with just the end points entered in by you. Autopath includes network load balancing, adaptive connectivity priority, and priority bumping on a network wide basis. Real time routing information is displayed, archived, or printed. Application circuits are identified on a per circuit or user group basis.

In the TMS-3000, circuit routing is accomplished through the use of specified aggregate parameters.

The TMS-3000 optimizes this routing based on aggregate link delay, error rate, and availability parameters. The shortest path between the two circuit end points that meets required circuit profiles is used, taking load balancing into consideration.
Three types of circuit routing are available:

1. Manual Preferred — You define the initial route and IAR reroutes the circuit if the chosen route is unavailable.
2. Manual Required — Circuit routes are defined by the network operator and the circuit is not rerouted during trunk failures.
3. Automatic — Autopath selects the optimum path based on circuit parameters.

The following are major Autopath features on the TMS-3000:

Link Parameters

Some aggregate trunk attributes are defined by you and include typical designations such as Encrypted or Satellite. An aggregate trunk attribute defines a route (labels the route) that a circuit follows.

Link parameters are found on the IAR Defaults screen. Link parameters are time delay, line error rate, and reliability of the facility. Different applications such as voice, X.25, SNA, and CAD/CAM have different requirements for these parameters. Network operators enter data pertaining to aggregate trunk characteristics during network configuration. Data entered is used in conjunction with circuit profiles for optimum routing.

Link Delay

This number, expressed in milliseconds, defines the inherent internodal delay. A value is entered for each aggregate trunk. With this feature, delay sensitive applications are routed via the best network path.

Link Error Rate

Defines the error rate performance of the aggregate. It is expressed in terms as " <1 error in 10 nth," where n is a value from 2 to 9. Circuits are routed on the best line for the application. With full ESF status reports from CDA displayed on command, this value can represent real time performance data.

Link Availability

This value represents the expected availability of the line facility and is expressed as a percentage with 100% being the best. This feature ensures that you can route critical applications via the most stable line.

Load Balancing

The autopath routine allows you to have built-in bandwidth access during line failure scenarios. Load balancing ensures that only a percentage of total circuit data is affected if a line fails by dividing the percentage of data carried across each aggregate trunk.

Link Attributes

An aggregate trunk attribute influences the route that a circuit follows. Attributes can typically be "Satellite" or "Encrypted." Autopath optimizes routing based on the specific needs of each application. Within the circuit profile screen, you must define the relationship between the group or circuits with that profile and the link attribute. The following options are available:

- Mandatory — Only links possessing this attribute (Yes) are allowed to comprise a segment of this circuit path.
- Desirable — If possible the IAR algorithm attempts to route circuits with this profile only on links possessing this attribute.
- Undesirable — If possible, the IAR algorithm attempts to route circuits with this profile only on links not possessing this attribute.
- Not Allowed — Only links not possessing this attribute (No) are allowed to comprise a segment of this circuit path.
- Don't Care — Possession of this attribute on a particular link does not affect routing decisions for circuits using this profile.

Circuit Attributes/Link Qualifiers

This function allows you to define four ASCII fields with labels for the system. These fields allow additional controls to be incorporated with initial routing and automatic routing calculations. Specifically, this function matches a subset of circuits to require or disallow the use of specific aggregate trunks in the system. This capability is paired with "Link Qualifiers."

For example, you define a label as "Region:" and the field as "UK." Now you define a circuit profile with the attribute "UK." Circuits with this profile are permitted to travel only over links with region defined as "UK" or "Don't Care."

If you specified a different aggregate trunk as "Don't Care," then any circuit could use this aggregate trunk. The following is an example of circuit attributes:

```
Region: UK

---------------------------------------------

Circuit Profile

Region: UK
```

In general, the following rules hold for circuit attributes and link qualifiers. The rules are listed in order of priority.

- If the circuit attribute for a given circuit is "None," then that circuit may traverse only links possessing the link qualifier "Don't Care."
- If the circuit attribute for a given circuit is "all" then that circuit may traverse any link.
- If the link qualifier for a particular link is "Don't Care," then any circuit may traverse that link.
- If the link qualifier for a particular link is an option different from the circuit attribute of a given circuit, that circuit may not traverse that link.
- If the link qualifier for a particular link is an option identical to the circuit attribute of a given circuit, that circuit may traverse that link.

Table 1 is an example of the use of these matching rules.

Table 1 Circuit Attributes/Link Qualifiers

Circuit Attribute	Link Qualifier			
	Europe	**America**	**Far East**	**Don't Care**
Europe	Allowed	Not Allowed	Not Allowed	Allowed
America	Not Allowed	Allowed	Not Allowed	Allowed
Far East	Not Allowed	Not Allowed	Allowed	Allowed
None	Not Allowed	Not Allowed	Not Allowed	Allowed
All	Allowed	Allowed	Allowed	Allowed

TMS-3000 Data Paths

A TMS-3000 system transfers TMS class data by creating a path from a channel card through a CIC and across an aggregate path. The data arrives at the CIC of the other node and finally to a destination channel card. The TMS-3000 Controller downloads the necessary configuration and routing information to each node. The multiplexing sequence is then calculated by each node to determine the exact order of data transfers at the node. The TMS-3000 is a bit-interleaved and byte-oriented multiplexing and switching system. As a bit-interleaved system, data or digitized voice signals are transmitted through the system one bit at a time.

The CDA Module introduces the capability of using the TMS-3000 with a DACS or D4 device communicating at the DS0 level. In this capacity, the TMS-3000 functions as a byte-oriented multiplexer.

This configuration shows the CDA Modules communicating at the DS1 (bit-oriented) level.

An IAC Module allows communication on the ISDN network. The IAC Module gives the TMS-3000 access to higher level digital services that are available on ISDN i.e., PRI. *Figure 4* illustrates two TMS-3000 nodes with all possible Aggregate Card types; including the ACM, CDA and IAC Modules.

A CIC selects transmit data from up to 64 channel cards. The sequence by which it selects data is controlled by the "transmit frame" of that CIC. The transmit frame is a sequence of select codes. Each select code instructs the card to select one bit of data from one channel. Some select codes also select control signals from channel interfaces for transmission through the system.

A frame is a complete cycle of proportionally distributed channel selects. Each channel is selected as often as required to insure that data does not overflow in any channel card buffer. When the CIC reaches the end of a frame, it begins the frame over again.

The CIC also contains a routing table, which indicates where data bits and controls are to be transferred. In most cases, the bit is transferred to an aggregate (ACC, CDA, IAC) for transmission to another node.

In the case of a local circuit, the bit is transferred to the same or another CIC at the node.

Data transfers between cards in a node are controlled by the ESCC. A 1 to 4-bit wide Fast Bus connects each of the sixteen cards in slots 1 – 16 of the TMS-3000 main shelf. Data and control bits are transferred between these cards, via the Fast Bus, at a rate of 16.896 MHz. The Fast Bus function in a TMS-3000 node is illustrated in *Figure 5*.

The ESCC sequentially selects each ACC, ACM, CIC, CDA, IAC, or TPP Module to place data or control bits onto the Fast Bus. The select process is determined by a Select RAM on the ESCC. The cards that require higher node bandwidths (2.112 MHz) must be selected twice as often as cards with 1.056 MHz of node bandwidth.

In addition to the data or control bit placed on the Fast Bus, there are four synchronization/overhead bits and an eleven-bit destination address. The address is a common card address and a channel address.

It specifies a common card that is to receive the bit from the Fast Bus, and a channel number associating the bit with a particular channel data path. If an ACC is specified by the common card address, that card accepts the bit from the Fast Bus. If the bit is a control bit, it is placed in a control buffer.

If the bit is a data bit, the card checks the channel number address, and places the bit in one of a set of buffers numbered from 1 to 128. The channel number specifies which buffer the bit is in. The CDA and IAC Modules all contain 128 channel buffers, while the ACC contains 128 channel buffers.

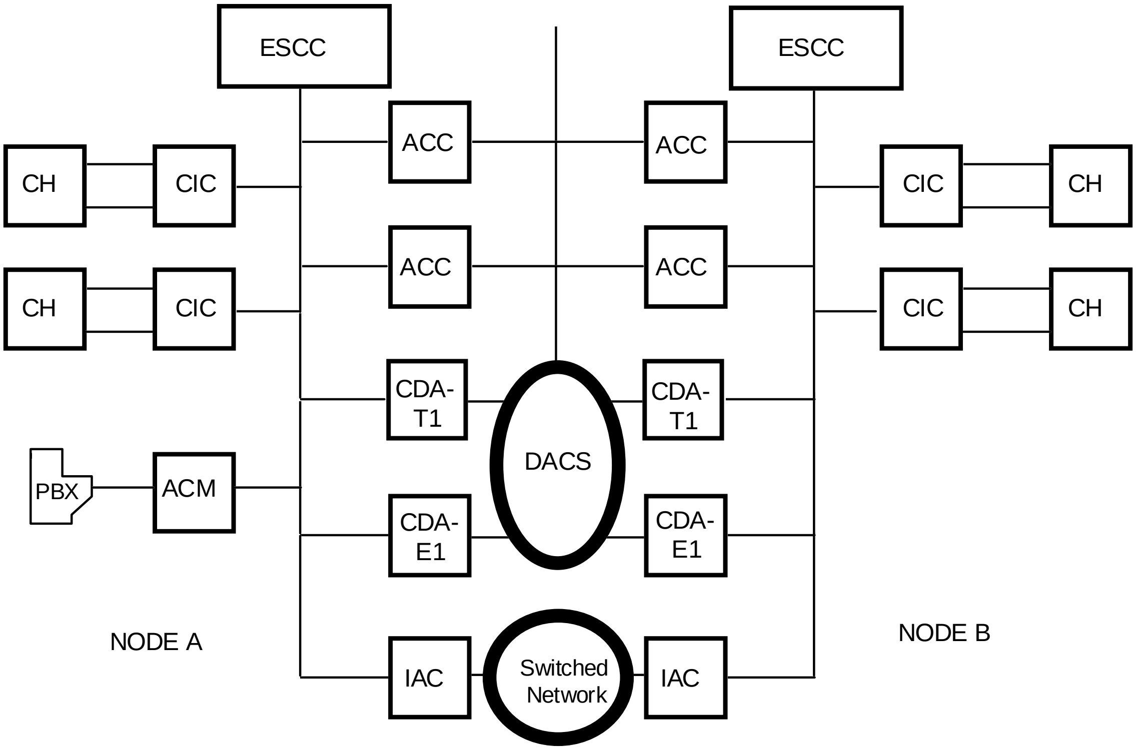
These buffers provide temporary storage until the ACC can multiplex the bit into the transmit aggregate data stream.

The ACC uses a transmit frame to multiplex data into an aggregate data stream. This frame is very similar to the CIC transmit frame. It contains a sequence of select codes which instruct the card to select a bit from one of the following:

- One of channel data buffers 1-128
- Control bit buffer
- Overhead/supervisory data bit

This last item refers to supervisory data that is normally sent from the TMS-3000 Controller or overhead data that is exchanged between an aggregate and its remote counterpart at a node.

Channel data, channel controls, and overhead data are multiplexed by the ACC into an aggregate data stream, which is transmitted across an aggregate trunk to an ACC at another node. The ACC that receives the aggregate data stream has a "receive frame" that is identical to the transmit frame used by the sending ACC.



Legend

ACC - Aggregate Control Card
ACM - ADPCM Compression Module
CH - Channel Shelves
CI - Channel Interface Cards
CDA-T1 - CDA-T1 Modules
CDA-E1 - CDA-E1 Modules
IAC - ISDN Aggregate Control Modules
ESCC - Enterprise System Control Modules

Figure 4 Typical Two Node System

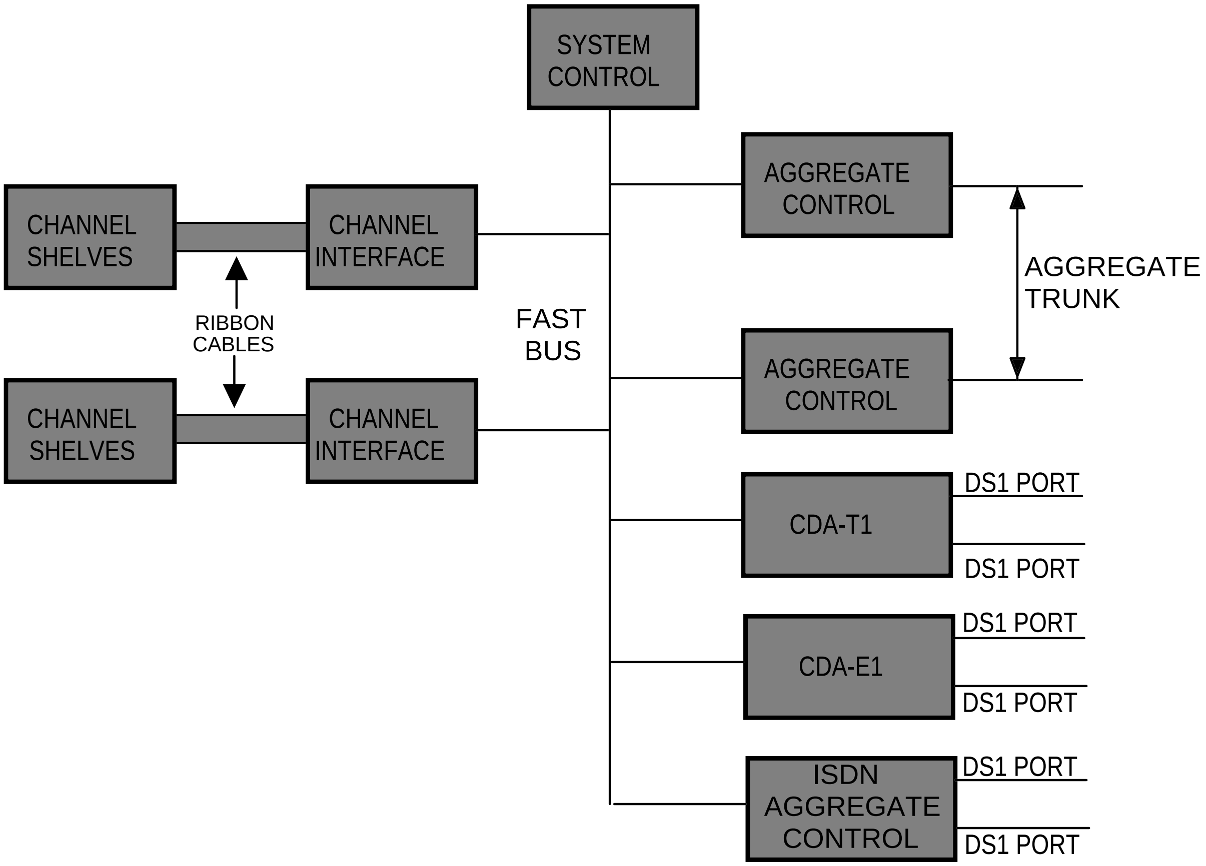


Figure 5 Typical Node

The ACC uses the receive frame to demultiplex the receive aggregate data. Channel data and controls are separated from supervisory data and overhead. A routing table supplies the destination address for each bit of channel data or channel controls. Data and control bits are then placed on the node Fast Bus, along with the destination address.

If the bit must pass through another aggregate trunk to reach another node, the process described above is repeated through another ACC. Each time data is transferred through an aggregate trunk, a routing table in the receiving ACC revises the destination address of the data or control bit. This enables the data path of a particular circuit data to traverse several aggregate trunks before reaching a destination node.

At the destination node, the bit is placed on the node Fast Bus with a destination address that specifies a CIC. The addressed CIC accepts the bit from the Fast Bus, determines whether it is a data or control bit, and distributes the bit to the channel card specified by the destination address.

If the bit is a control bit, it is used to update an output control signal from the channel card to the connected equipment. If the bit is a data bit, it is passed in the receive data stream to the equipment at the data rate configured for the channel card in the circuit configuration.

Refer to Frame and Routing Table Calculations later in this manual for information on the calculations necessary to create data paths like the one described above.

The ACM, CDA, IAC, or TPP Module communicates with the ESCC similar to an ACC, and the TMS-3000 Controller provides configuration, diagnostic, and alarm reporting for all Aggregate Card types.

Up to twelve ACM Modules can be installed in the TMS-3000 main shelf in a nonredundant system or 6 pairs in a redundant system. This limitation is due to power and cooling requirements of the main shelf. GDC advises you to install these cards away from the end slots of a shelf where airflow is more restrictive. The ESCC monitors the hardware and software operation of all common cards in the main shelf. If a hardware or software fault is detected by the ESCC, a fault sequence is initiated.

An alarm is generated, and the common card is placed into the standby mode, while the ESCC signals the RCC to place the standby common card into service. The actual switchover of a redundant card is under the control of the RCC. In the event of a link failure, the controller software determines alternate routing of channels around the failed link.

CDA Bit-Oriented Data

A CDA or IAC Module in a TMS-3000 node can send data in the proprietary bit format over a DS1 (U.S. or Europe) port provided that the TMS-3000 node it terminates at is also equipped with an identical card type. This operation is similar to using an ACC at two separate TMS-3000 nodes.

The following describes how bit-oriented data is processed within the CDA Module:

Bit-oriented data originates from a channel module and is placed onto the Fast Bus by either the CIC, DBC, ACM, ACC, or another CDA or IAC Module. Bit-oriented data consists of either channel data bits or channel controls. Six different channel controls are handled by the Fast Bus. One Fast Bus clock cycle transfers one channel data bit or three channel controls.

The Channel FIFO block consists of 256 individual FIFOs, one for each channel. The Channel FIFO buffers data arriving from the common cards in the shelf. It assembles data and controls into 12-bit words which are passed to the Data Engine.

The Data Engine frames data from various channels, along with synchronization and overhead information, into a subaggregate. This subaggregate is converted from serial to parallel and passed to the Data Exchange. The Data Engine generates various subaggregates with different channels in each. Each subaggregate occupies one or more 64 kHz DS0 time slots.

The following describes the data flow:

- The Data Engine handles one subaggregate at a time. It uses the frame for this subaggregate contained in the Frame RAM to determine the source of the next bit in the subaggregate. If this bit contains channel data or controls, data is taken from the channel FIFO for that particular channel and added to an 8-bit word which is stored in RAM. When eight bits have accumulated, the 8-bit byte is sent to the Data Exchange. Synchronization information is added directly by the Data Engine as well as overhead communication from the microprocessor.
- The Data Exchange allows the DS0 time slots containing the subaggregate of bit-oriented data to be routed to any DS0 time slot of either DS1 port.

Data is passed from the Data Exchange to the Input/Output Module which interfaces to the **CSU** (Channel Service Unit). The I/O Module accepts data in a parallel format from the Data Exchange and converts it to serial format. Frame and Overhead bits are added and the data is then electrically interfaced to the CSU. In the receive direction, the I/O Module synchronizes to the T1 line, recovers timing, and converts the data from a serial to parallel format. The Data Exchange provides the Time Slot Interchange and passes data to the Data Engine.

In the Data Engine, the subaggregate sync is recovered. Data and Controls are framed to the correct channel via the Fast Bus.

CDA Byte-Oriented Data

Byte-oriented (DS0) channels are 64 kHz channels that are from a digital PBX or a channel bank and contain either voice or channel data. A TMS-3000 node equipped with a CDA Module can send data to a channel bank, digital PBX or to another TMS-3000 node equipped with a CDA Module.

DS0 channels received from a DS1 port can be routed to the other DS1 port on the same CDA using the Time Slot Interchange function. DS0 channels can also be routed via the Fast Bus to DS1 ports on other CDA Modules.

The Input/Output Card on the CDA takes the eight bits from a DS0 byte and adds another four bits that represent signaling information used for voice channels. These 12 bits are sent to the Data Exchange. The 12-bits are routed to either the other DS1 port or passed to the Fast Bus and onto another CDA Module.

To place DS0 byte data onto the Fast Bus, the Data Engine breaks down the 12-bit word into three 4-bit "nibbles." Each nibble is transferred in one Fast Bus operation to the destination CDA Module. Three operations are involved to transfer one DS0 byte, whereas it takes eight operations to transfer eight bit-oriented channel data bits. The Channel FIFO on the destination CDA Module reassembles the three nibbles into a 12-bit word. The Data Engine on that Module passes the 12-bit word directly to the Data Exchange. There it is mapped to a particular time slot and passed to one of the Input/Output Cards for transmission over a DS1 port. The Input/Output Card provides the interface between the CDA Base Module and the T1 line. It is a removable card so that different interfaces can be installed easily. Currently, the T1 Input/Output Card operates on T1 networks at a rate of 1.544 MHz, and the E1 Input/Output Card operates on E1 networks at a rate of 2.048 MHz.

Frame and Routing Table Calculations

In the TMS-3000 Controller, data paths through the system are represented by data routes across aggregates and circuits which traverse these routes.

At a TMS-3000 node, the data paths are implemented as frames and routing tables. Frames are sequences of select codes that determine the multiplexing sequence for data selected from channels, and the sequence for data multiplexed into an aggregate data stream. At the aggregate level, a frame is also used to demultiplex aggregate data received from another node.

Data routing tables control the transfer of data between common cards at a node. Each time a bit is transferred from a card onto the node Fast Bus, a routing table in the source card supplies a destination address for the bit. The destination address specifies another card, which accepts the bit from the Fast Bus.

The address also includes a channel address, which defines the data path that the bit follows through the next channel segment. For a more detailed description of frame and routing table functions in the TMS-3000 system, *refer to TMS-3000 Data Paths*. The following paragraphs describe the series of calculations that transform route and circuit configurations in the TMS-3000 Controller into frames and routing tables at each TMS-3000 node:

When routes are configured in the TMS-3000 Controller, the controller maintains a list of each aggregate trunk involved in each route.

Every ACC, CIC, CDA, IAC, and TPP Module is considered to have a number of "slots" that represent the individual channels passing through that card. The number of slots for a card is equal to the number of circuits that the card, in its specific configuration, can support.

A redundant ACC, for example, has 126 slots. Any CIC has 64 slots. A redundant CDA or IAC Module pair supports up to 254 slots. A TPP module supports up to 64 slots.

Each time a circuit is routed via IAR, the TMS-3000 Controller uses the end node equipment and route information entered and determines the sequence of common cards that the circuit must pass through in the system. It then fills in one slot on each card in the data path.

The slot includes the node destination address for each channel. When a card transfers a bit to another card via the node Fast Bus, the destination address indicates which card it is going to and supplies a channel number indicating its channel segment in the receiving card.

A CIC requires a destination address for each bit of transmit data from a channel card. An ACC requires a destination address for each bit of data it receives and demultiplexes from an aggregate trunk. In each case, the bit is placed on the Fast Bus with the destination address. The card specified by the address takes the bit off the Fast Bus and transfers it in accordance with its channel number.

Destination addresses for a circuit link the various channel segments along that circuit. The slot also includes the data rate of the circuit, as well as the channel type and other circuit parameters.

The TMS-3000 Controller separates this configuration into data for each node. When you download a configuration, the information is received and processed by the ESCC at the node. The complete set of configuration information is stored by the ESCC. When a configuration is activated, the ESCC first transfers the required configuration information to each ACC, CIC, CDA, IAC, or TPP Module at the node. Each card then processes the configuration data in preparation for the activation of the configuration.

Channel interface parameters are transferred to CICs, which in turn transfer them to each channel card. Each CIC or ACC then uses the circuit data rate information to construct frames for the configuration.

The framing process is based on the data rates associated with each channel segment that passes through a card. The sequence of select codes that make up the frame must be distributed throughout the frame in proportion to the data rates of each channel segment. A 9600-Hz channel must have twice the number of selects as a 4800-Hz channel; a 4800-Hz channel must have twice the number of selects as a 2400-Hz channel. The sequence that is calculated by each card ensures that the order of data selection prevents data from overflowing the buffers in any channel.

The destination addresses for each channel segment are placed in routing tables for each card.

Once framing and transfers of configuration are complete, the node switches to the new configuration. When the switchover is complete, data is routed through the system in accordance with the routing tables and frames calculated by each network component.

Supervisory Data Paths

In a TMS-3000 system, the Controller must communicate with each node in the system; this is called supervisory data. Configuration data, diagnostic commands, and new programming must be downloaded to each node; status and alarm information must be sent from each node back to the Controller.

System information is exchanged across supervisory data paths that link the system together.

Supervisory data is transferred through the TMS-3000 system in packets. A packet sent from the TMS-3000 Controller includes the address of the node that is to receive and interpret the packet. A packet traveling from a node to the controller includes the address of the node connected to the controller. Various other pieces of overhead information are also included in the packet. For example, a packet is identified as traveling to or from the node connected to the controller. This indicates whether the packet is carrying information from or to the controller.

Supervisory Data Routes

The IAR routine creates two supervisory routes, one primary and one secondary, between every two nodes in the system. These routes determine the path that a packet follows through the network to get to a destination node. If an aggregate trunk failure blocks the primary route, the secondary route is used as the data path. If the "backbone" configuration or any configuration that specifically affects supervisory routes is changed in a TMS-3000, new primary and secondary supervisory routes are recalculated through IAR.

The IAR calculation uses overhead rates to select aggregate trunks as segments in a route between two nodes. If overhead for all trunks is equal, a route with the least number of aggregate trunks is selected as the primary route. The secondary route is then constructed with the same number of trunks, or as close to the same number as possible while attempting to avoid links (CDA or IAC subaggregates, or the ACC) already used by the primary supervisory route for controller-to-node communications. Sometimes the secondary route may be the same as the primary route between two nodes because of the network topology and routes assigned for other nodes.

If overhead rates are different for aggregate trunks (especially multiple trunks connecting two nodes) the calculation uses the aggregate trunk with the highest overhead rate for the primary route and the next lower overhead rate for the secondary routes.

The calculation minimizes the number of routes in the network. For that reason, if one route already connects several nodes, that route is used to connect any two of the nodes. The calculation does not create other separate routes to connect the nodes.

The characteristics of routes created by IAR are dependent on the exact characteristics of the network that IAR is applied to.

If any event disrupts the existing supervisory routing, the TMS-3000 Controller recalculates primary supervisory routes based on the current network topology.

The events that cause a supervisory route recalculation are:

- Change in status of node or aggregate trunk
- ACC, CDA, or IAC link down
- ACC, CDA, or IAC link recovery

When supervisory route restoral is initiated, new primary routes are generated. Any aggregate trunk which is disabled in all configurations is avoided when the recalculation occurs. Additionally, any aggregate trunk which is disabled for supervisory routing is not part of the supervisory path. The calculation thus finds and uses the available paths through the network. The supervisory path currently being used is visible via the Supervisory Routing Diagnostic Selection.

Node-to-Node Data Transfers

Once supervisory data routes have been generated for the network, the routing information is divided up and sent to each node. Each node stores a supervisory data routing table, which includes primary and secondary aggregate trunk numbers and bundle numbers for each node in the network (except itself). If a supervisory data packet is received by the node, the destination address is checked. If the packet is addressed to the node, the information is accepted. Otherwise, the node attempts to send out the packet through the primary aggregate trunk associated with the node specified in the packet address.

For example, note the simple delta network in *Figure 6*.

The IAR routine generates the following supervisory data routes:

Primary: A to B, B to C

Secondary: A to C, B to C

Each node receives the following supervisory data routing table:

Node A	**PRI**	**SEC**
B	1	3
C	1	3

Node B	**PRI**	**SEC**
A	1	5
C	5	5

Node C	**PRI**	**SEC**
A	5	3
B	5	5

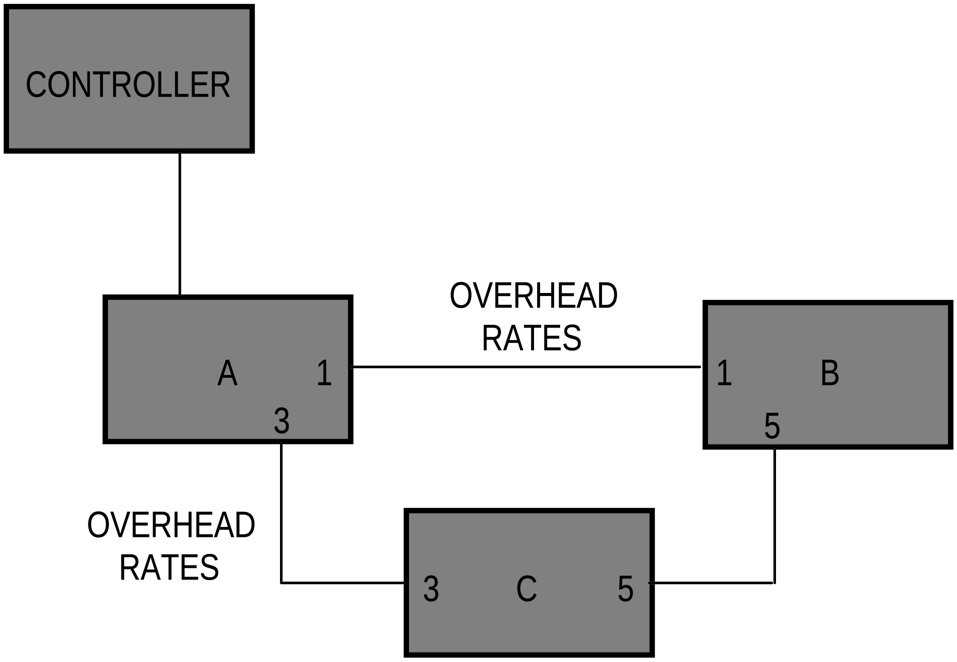


Figure 6 Simple Delta Network

If the TMS-3000 Controller sends a packet of information addressed to node B, the following sequence could occur:

1. The packet is passed from the controller to Node A. Node A checks its supervisory data routing table, finds the trunk associated with the primary route to Node B, and sends the packet through the ACC in slot 1 of the Node A main shelf.

   If the aggregate trunk between Node A and Node B is not functioning, Node A checks its routing table for the secondary trunk listed for Node B.

2. The packet is sent through the ACC in slot 3 of the main shelf. The packet overhead information is modified to indicate that the packet is being sent through a secondary route.

3. Node C reads the packet address, as well as the information that it is traveling on a secondary route, and check its routing table for the trunk associated with the secondary route to Node B.

   The packet is sent through the ACC in slot 5 and therefore reaches Node B along a secondary route.

In larger networks where a route may span several links or intervening nodes, a message from the controller may arrive at one of the intervening nodes where the next link on the primary path is down. In this case, the node switches the message over the secondary path from that node to the destination. If this secondary link is down, the message is routed back to the previous node from where it was received.

The previous node then attempts to send the message on its secondary link and so on, until the message arrives back at the local node connected to the controller. The local node may then try its secondary link. If all these attempts fail, the message is passed back to the controller and a "route is not available" is declared.

Intelligent Automatic Rerouting (IAR)

Ensuring connectivity of critical applications is done precisely with IAR (Intelligent Automatic Rerouting). In addition, simple prioritized rerouting and bumping schemes are used. IAR automatically lowers the circuit data rate to ensure that all nodes continue to communicate rather than just a select few. If bandwidth becomes limited, an alarm is generated for any unrouted circuits. The grade of service for each application is maintained and no human intervention is required.

With IAR, off-line test reports with printouts can be generated for disaster planning and recovery scenarios. Following recovery, you can return to the original configuration either manually or automatically.

Major IAR Features

Some major features of IAR in the TMS-3000 are described below:

Speed of Recovery

The ability to reroute a full T1 without timing out front end sessions is critical. IAR reroutes data before front end sessions time out. This ensures that you do not have to restart front end sessions manually.

Quality Rerouting

Your applications require different grades of service for uninterrupted and efficient operation during line failures. Circuits are rerouted to the best path for an application. This ensures the network continues support of all applications with the best response times.

Preemption Priority

Preemption priority determines whether unaffected circuits are bumped to accommodate higher priorities. This feature is accomplished in IAR on a network wide basis. With the IAR method of preemption, the entire network is managed on a priority basis rather than a node to node basis. This ensures the applications of highest priority are always rerouted on the best path and collisions of circuits or "glare" is avoided during reroutes.

Security of Sensitive Data

This ensures that data assigned to encrypted lines during IAR is not disclosed in the case of a line failure.

Management

Networks that become separated continue to run as subnetworks by means of redundant controllers. These subnetworks have management capabilities even during catastrophic line failure. Circuit routes are managed to ensure that transport resource allocations are meeting the customer requirements.

Circuit Fallback

You can enable or disable the ability of a circuit to switch to a lower data rate automatically. With SNA or SAA networks and voice, you are assured full connectivity by enabling this option.

Circuit Disconnected Alarms

When a circuit cannot be rerouted because a user is preventing reroutes of select circuits or no available paths, **alarms** are generated. The alarms are time/date stamped and logged to the controller.

Circuit Route Status

You can view the current route of any circuit at any time. Routes are displayed by aggregate trunk names for the entire route.

Off-line Testing

Network models are software generated without interrupting the operating network.

Reroute Timers Software Selected

To ensure that your needs are met for each aggregate trunk facility type, aggregate IAR initiation delay timers are set between 0 and 2400 seconds. This also ensures network stability. IAR may also be disabled on a per link basis.

Network Modeling (IAR Data)

You can simulate and plan for disasters on an aggregate trunk or node level anywhere in the network. This off-line simulation allows you to test and monitor conditions and to determine the impact on network communications from any change. You create a test script for the simulated network disaster. A test script is simply a line-by-line sequence of events that disables a portion of the network. After the test script has executed, you can see the routing of circuits through a failed network on the controller screen.

The Network Control Center can create network models typifying network failures. It determines the viability of recovery strategies without impacting network operation. After hours network testing is no longer required. Network models are stored or printed out for hard copy reference. With TMS-3000 software, a disaster contingency plan is a tested, rather than "best guess," approach to effective network planning.

Major IAR Test Script features on the TMS-3000 are described below.

Network Modeling

You can implement the following line-by-line functions in a test script:

- Network Optimization
- Link Up and Link Down
- CDA or IAC Module Up and Down
- CDA or IAC Ports Up and Down
- CDA or IAC Bundles Up and Down (Transport Only)
- Set Time-of-Day Reconfiguration

The network operator through menu driven selection can create any of the failures shown above. These failures invoke the IAR routine which determines the optimum channel routing from the quality based parameters. It does not download the changes into the network. In addition, simulation does not affect the active configuration database.

Circuit Status (Output)

The network operator is able to display or print out the circuit routing as a result of the test. Reroute scenarios are analyzed for disaster contingency planning.

Network Model Storage

Simulation results are stored within the TMS-3000 Controller. Test results are archived for later analysis to support "what if" disaster planning.

Time-Oriented and Disaster Recovery Reconfiguration

TOR (Time Oriented Reconfiguration) allows you to alter circuit routing to accommodate applications that may change from day to night. Voice traffic diminishes after business hours. Data traffic may change from single transaction based to wide band applications such as inventory updates and complete data base printouts. You may wish to alter the network to track the business day around the world. Circuit end points, like order entry applications, have to adjust as new order entry terminals on the West come on-line and terminals in the East shut down. Using TOR, the TMS-3000 enables you to perform this automatically without your intervention. The circuit changes can be scheduled based on a day/night, weekday/weekend, and holiday schedule. This provides maximum flexibility to accommodate ever-changing network application needs.

DRR (Disaster Recovery Reconfiguration) is a feature that allows you to alter circuit routing to accomodate redirection of applications in the event of trunk or, more commonly, nodal failures. For example, if the primary computer center fails, you may require automatic redirection of traffic to a secondary computer center. DRR works on a predefined set of strategies, a strategy being defined as a set of TOR/DRR configurations to be implemented based on a scenario. A scenario is a set of combinations of one or more failures.

Up to 16 strategies are available. A strategy is invoked by meeting any of up to a maximum of ten scenarios. When the criteria of meeting a strategy is met, the appropriate configuration, based on the current failure and time of day, is implemented by IAR. As long as this failure condition exists and no higher priority strategy failure conditions are met, all TOR configurations are those defined by the DRR strategy. But, if the conditions for more than one strategy is met, the strategy with the highest priority is in control.

TMS-3000 Modules

A TMS-3000 is made up of several types of cards that function together. These cards are divided into three broad categories:

- Common Cards
- Channel Cards
- Power Supplies

Common Cards

TMS-3000 common cards perform the multiplexing and demultiplexing of data. They also handle the control and support tasks of an individual TMS-3000 node. The common cards are:

In the Main Shelf

- ADPCM Compression Module (ACM)
- Aggregate Control Card (ACC)
- Channel Interface Card/Digital Bridging Card (CIC/DBC)
- Combined Digital Aggregate Module (CDA)
- Enterprise System Control Card (ESCC)
- ISDN Aggregate Control Card (IAC)
- Redundancy Control Card (RCC)
- TMS Packet Processor (TPP)

In the Expansion Shelf

- Expansion Module

NOTE

GDC recommends periodic testing of the "out of service" modules in a TMS-3000 that utilizes redundant common modules. In a TMS-3000, not all failures of the out-of-service module are detectable. Certain conditions may prevail causing disruption of the network when that module is placed into service.

There are 16 slots on the main shelf that can be filled with either CIC, ACC, CDA, ACM, or TPP modules. More CICs increase communication among the channel cards at the site. More ACCs increase the number of aggregate trunks with remote sites. Adding CDA modules increases the number of DS1 lines available and provides DS0 channel routing capabilities. TPP-FR (Frame Relay) cards are installed in Slots 7, 8, 9 and 10. TPP-LAN cards each require two slots and may be installed in Slots 5/6, 7/8, 9/10 and 11/12 (*Refer to GDC 036R302-A7 for operating and installation information for the TPP*).

The ESCC and RCC occupy reserved slots on the main shelf. These cards must not be installed in any of the 16 slots reserved for the ACC, CIC, CDA, or ACM Modules.

The ESCC controls data flow between any of the 8 CICs or one of the 16 ACC, CDA or ACM Modules. Data flows between the common cards via a 16.896 MHz bus. This bus contains the following:

- The address of the common card that receives the data or control information
- The address of the channel card selected for communication
- Data, control, and synchronization information

Channel Interface Card/Digital Bridging Card

A CIC is the node **Fast Bus** interface for up to 64 local channel cards (58 for TMSC). It multiplexes and demultiplexes data from Channel Cards onto a high-speed 16.896 MHz Common Equipment Bus. This bus allows communication to all common cards installed in the node. The

CIC is also responsible for frame calculation, channel control, and communication with the ESCCs and RCCs. If a CIC is not installed in the main shelf, channel data cannot be routed.

The DBC is supported by the TMS-3000 software. It is a printed circuit board assembly that may be installed in any of the sixteen common card slots of a TMS-3000 Main Shelf or in the CIC slots of a TMS Compact Shelf to allow multiple remote workstations to share a common communications path across the backbone network. The DBC is compatible with the buses of the Main Shelf and the Expansion Shelf. Its primary function is to support polling applications by allowing multidrop circuits to be created within the TMS-3000 network. The DBC also supports voice and video broadcasting applications.

The DBC performs the function of an MJU/MAU. In addition, it extends the network management capabilities of the Controller to multipoint circuits. This gives you the added functions associated with TMS-3000, including configuration, status, diagnostics, alarms, autopath, intelligent automatic reconfiguration, and TOR for all bridged data branches. *The DBC is described in detail in GDC 036R478-000.*

Aggregate Control Card

The ACC controls the transfer of data across an aggregate trunk to another TMS-3000, TMSC or OCM-2000. Data is derived from CIC, ACC, or CDA Modules via the Common Equipment Bus, assembled into an aggregate bit stream, and transmitted across the aggregate trunk. Data received from the aggregate trunk is de-multiplexed and distributed to either ACC, ACM, CIC, or CDA Modules.

NOTE

ACC links cannot be tied directly to OCMs. They must go through CDA-type modules.

The ACC also performs the frame calculation from configuration data received from the ESCC via the Communication Bus. It buffers the data coming in on the 16.896 MHz Common Equipment Bus. This data conforms with the transmit framing ordered by the ESCC.

Overhead and frame sync bits are added, and then the data passes through the aggregate interface for transmission across the aggregate trunk.

The Receive section synchronizes to the frame sync bits so that channel data, channel control, and overhead bits are sent to the correct channel destination via the Fast Bus and CICs.

The Aggregate Interface Plug-In Cards on the ACCs convert aggregate data to the signal standards required by a particular aggregate trunk. The Aggregate Interface Plug-In cards are:

EIA/TIA-232-E (ITU-T V.28)	ITU-T G.703 256 Kbps (75Ω or 120Ω)
ITU-T V.35	ITU-T G.703 2.048 Mbps (75Ω or 120Ω)
EIA RS-422/423 (MIL-STD-188-114) (ITU-T V.10, V.11)	T1/D4 (1.544 Mbps)
T1 (For Non-ATT T1 Lines Only)	T1/D4/E (1.544 Mbps)
ITU-T G.703 64 Kbps Codirectional	ITU-T G.704 2.048 Mbps (75Ω or 120Ω)
ITU-T G.703 64 Kbps Contradirectional	

G.704 Aggregate Interface Piggyback Card

The G.704 Aggregate Interface is a piggyback card that mounts onto the ACC, allowing connection to a ITU-T G.704/G.703 aggregate link. Its main purpose is to add ITU-T framing to the GDC proprietary framing format used on aggregate links. This causes a reduction in the aggregate bandwidth from 2.048 Mbps to N x 64 Kbps (where N is a value from 1 to 31) or 64 Kbps to 1.984 Mbps.

The G.704 Aggregate Interface Piggyback Card also features G.703 electrical/timing compatibility at 2.048 Mbps, G.823 input jitter/tolerance attenuation, HDB3 encoding, optional 75/120 ohm line impedance, and the ability to generate CRC4 multiframes including the CRC4 bits.

Elastic buffers provide the slip rate objectives of G.822 for terrestrial (**plesiochronous** data) and satellite links (plesiochronous or synchronous data). These buffers are introduced into the transmit and receive data streams to smooth out the effects of jitter and wander. The G.704 Aggregate Interface Piggyback Card reports alarms for these conditions: Carrier Detect, Local Out-of-Sync, and Remote Out-of-Sync.

T1-DS0/T1-FT1 Aggregate Interface Piggyback Cards

The T1-DS0 and T1-FT1 Aggregate Interface Piggyback Cards may be used for TELCO supplied services that are known in the industry as fractional T1 (FT1). In a fractional T1 application, the TDM equipment is connected to a Digital Access Cross Connect Switch (DACS) to route individual (56 or 64 Kbps) DS0 channels to various remote locations.

The T1-DS0 card (*GDC 036P335-000*) is used in Canada. The T1-FT1 card (*GDC 036R335-002*) is used in the USA.

The T1-DS0 and T1-FT1 Aggregate Interface Piggyback Cards are cards that plug into the ACC (*GDC 036P313-001*) of the TMS-3000.

NOTE

Due to option selection restrictions, the T1-DS0 Aggregate Interface Piggyback Card is not intended for use on ASDS (Alt. DS0) facilities.

The T1-DS0 and T1-FT1 Aggregate Interface Piggyback Cards allow point-to-point fractional T1 access within TMS-3000.

In point-to-point applications, the piggyback cards are a cost-effective alternative to the CDA Module.

The principal application for the cards is to offer a T1 interface that takes advantage of fractional T1 services. Instead of paying for a full T1 line, you pay only for the bandwidth needed by selecting the number (N) of DS0 channels (where 1≤N≤24). As bandwidth requirements change, you can change the number of DS0s. This is particularly useful at feeder nodes which typically have smaller bandwidth requirements.

Refer to GDC 036R477-000 (T1-DS0) and 036R485-000 (T1-FT1) for complete installation, operation, and specifications for the T1-DS0 and T1-FT1 Aggregate Interface Piggyback Cards.

Diversity

The ACC has the ability to support two aggregate ports between it and the ACC at a remote node. If communications are disrupted on one port, the card switches to the other port to resume data transfer. This feature is called Diversity. Diversity is a software selectable feature.

NOTE

The CDA/IAC, Module, ACM, TMSC, and the OCM-2000 LIM do not support diversity.

Diversity requires two aggregate paths between the two nodes. One path is designated the "A," and the other, the "B" trunk. Data is transmitted simultaneously across both paths, but received from only one port at a time.

If a failure condition (described below) is detected in the received data, the ACC switches from the port currently in use and begins receiving data from the unused port. The switchover is controlled by the ACC.

Diversity is enabled when an aggregate is configured for diversity in the node configuration. A jumper on the ACC must also be set to select diversity.

NOTE

Diversity should not be enabled if you use the AT&T Automatic Protection Capability for your aggregate trunk. Simultaneous use of both trunk backup systems could result in an indeterminate switching condition.

A diverse trunk arrangement between two nodes is illustrated by *Figure 7*. When a node is initialized, the "A" port is placed into service in all aggregates configured for diversity. The ACC then monitors the received data from the "A" port.

A switchover to the "B" port occurs when the ACC declares an Out of Sync alarm. The delay between synchronization loss and an Out of Sync alarm is determined by the setting of the Out of Sync delay, which is set during aggregate interface configuration for the card. The timer may be set for between 0 and 25 seconds, in 0.2-second intervals. A diversity switchover takes place 0.5 seconds after the Out of Sync alarm is generated.

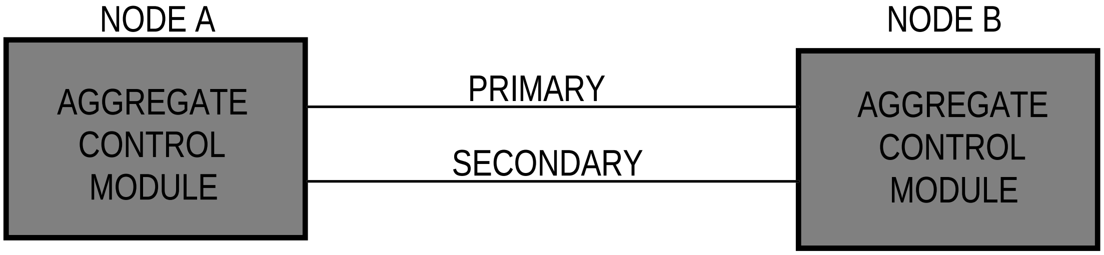


Figure 7 Aggregate with Diversity

A diversity switchover cannot occur if the out-of-service port is in a Fail condition. A Fail condition is reported by front panel LEDs on the ACC and by status displays for the aggregate in the Diagnostics or Status routines.

Exact switching sequence depends on the configuration of the aggregate.

If the aggregate is configured for diversity and redundancy, the diversity switch occurs first. A redundant switch from primary ACC to secondary ACC must then occur before another diversity switch can take place. In an aggregate with diversity and redundancy, switchovers happen in the following order:

1. Diversity Switch — "A" to "B" trunk
2. Redundant Switch — primary to secondary ACC (when secondary card goes into service, it receives data from B port).
3. Diversity Switch — "B" to "A" trunk
4. Redundant Switch — secondary to primary ACC

Note that the switching order can change if a Fail condition exists on the out-of-service port. The redundant switchover occurs when the Fail condition is cleared. In this case, a diversity switch takes place.

In a nonredundant diverse aggregate, switching only occurs between primary and secondary aggregate ports. The ACC continues to switch between the primary port and secondary port until normal communication resumes.

Diversity Status – To determine diversity status of an aggregate, refer to the status display for the appropriate ACC, available through both the Status and Diagnostics main menu selections.

You may also observe the front panel indicators on the ACC. The AGGR DIVERSITY indicators report which trunk is currently in service, and whether either trunk has failed (a failure is reported when data is not being received on the port).

Diversity Aggregate Connectors – When diversity is enabled in a TMS-3000 node, a pair of aggregate connectors on the main shelf backplane are associated with each redundant pair of ACCs in the shelf. The pair are positioned vertically; the upper connector, marked PRI, is used for connections to the primary trunk. The lower pair, marked SEC, are used for connections to the secondary trunk.

Any diversity application uses both aggregate connectors associated with a redundant pair of shelf slots. For this reason, if you configure a nonredundant diverse aggregate, then leave the remaining shelf slot (of the pair of slots) empty, since there are no aggregate connectors available to support another aggregate in the slot.

CDA Module

In a TMS-3000, a maximum of 16 CDA Modules can be mounted on the main shelf. Each pair of slots must be configured as either redundant or non-redundant. There is no requirement to configure all cards identically. In a redundant system, a maximum of eight pairs of CDA Modules are mounted in the main shelf. CDA and I/O ports interface to the network via the 25-pin D connectors on the rear of the main shelf.

Utilizing the CDA Module, the TMS-3000 node retains its efficient, proprietary, frame structure, inherent to a TDM using bit-interleaved architecture.

The CDA Module exchanges data with other CDA, ACC, or CICs in the TMS-3000 main shelf through the TMS-3000 Fast Bus. The CDA communicates with the ESCC as though it were a normal ACC. The Controller provides configuration, diagnostic, and alarm reporting for the CDA.

The CDA Module monitors alarm conditions and performs CRC error checking in accordance. Time Slot 16 (in the frame) is disassembled into signaling information and appended to the remaining time slots, which are sent to the CDA basecard.

The CDA Module operates on either a 120-ohm balanced or 75-ohm unbalanced line termination impedance. The card features local and remote loopback diagnostic capability, clock selection for data transmission and alarm detection circuitry. In addition, the card generates **CRC** (Cyclic Redundancy Check) and **CAS** (Channel Associated Signaling) multiframes.

The CDA Module is link independent and flexible for new link formats. Adding a G.732 plug-in piggyback card onto the CDA base card allows the CDA Module to be used on ITU-T networks at rates up to 2.048 Mbps (referred to as the CDA-E1 Module).

A CDA Module can be backed up by a redundant CDA Module. A redundant CDA pair occupies one primary/secondary pair of card slots in the TMS-3000 common shelf. A fully equipped TMS-3000 contains up to 16 CDA Modules. Switchover of a redundant CDA Module is under the control of the RCC. The redundant CDA Module is placed in service upon detection of a failure. In case of an aggregate link failure, software determines alternate routing of channels around the failed link. This eliminates a situation where restoral is prolonged by attempting to switch secondary CDA modules in and out of service.

Link Timing

Transmit timing for the CDA Module is configured through the Controller software. Each CDA Module has two aggregate ports (Ports A and B) from which node timing can be derived. Several timing selections are possible for each CDA port. To select CDA-provided node timing, you must first select the link destination type. The possible link destination types are Remote CDA, DACS Network, DTE device, and No Link. Next, clocking options for the interface and node are determined.

The interface clocking parameter selected provides the source of timing for aggregate data to be transmitted to the destination node. For a DACS network, the interface clocking source is generally the DACS network with the ESCC phase locking to a DACS link. The CDA Transmit clock is configured as "Node". In selecting DTE device as link and destination, you can choose the previous interface clocking options.

You must select one of three CDA options that affect the Node Clocking. These options are:

- Facility — Link provides timing for the entire node.
- Remote Node — CDA Module is allowed for use as a node timing source.
- Not Available — CDA Module cannot be used for a node timing source.

The preference option lets you assign a specified priority number to each clocking option. Preference values range from 1 to 4.

Fast Clock Switch

TMS-3000 software incorporates Fast Clock Switching of a CDA/ACM Module. When the CDA/ACM Module is supplying node clocking to the main backplane, another CDA/ACM Module (in the main shelf) can be automatically designated as a "Hot Standby" source for node clocking.

The primary or secondary port of the CDA/ACM Module has a T1 line coming into it. Timing derived from the line is monitored via a PAL (Programmable Array Logic) circuit on the CDA/ACM. The CDA/ACM Module supplies node clocking to the main backplane via the Lock Freq. line.

If the CDA/ACM Module supplying node clocking detects loss of carrier, it removes its clock from the backplane. Another CDA/ACM Module designated as the "Hot Standby" switches its clock on to the backplane. Because of the fast switching transition of the CDA/ACM clocks (within two clock cycles), it is labeled as a Fast Clock Switch. The switching transition of the clock meets the requirements of AT&T specification 62411.

CDA-E1

The CDA-E1 Module allows full duplex access to ITU-T structured public networks at 2.048 Mbps. This module performs the following in the TMS-3000:

- Microprocessor and Data Exchange Interface
- 2.048 Mbps Line Interface (CEPT duplex)
- Clock and data recovery (from CEPT line)
- Frame, CRC and CAS Multiframe Alignment
- Insertion and extraction of signaling bits and framing pattern
- CRC detection and generation
- Alarm detection and generation
- Local and Remote Loopback capability
- Channel Associated Signaling (CAS)
- System clock (SCC) or receive clock (RCLK) selection for transmission of data
- 75-ohm unbalanced or 120-ohm balanced line selection

CCS (Common Channel Signaling) is not selectable as an option on the CDA-E1 Module. CCS is supported transparently by assuming Time Slot 16 is a data channel (network).

The microprocessor performs four basic functions on the CDA-E1 Module. It initializes the E1 Input/Output plug-in card upon power up, scans for alarm conditions, initiates alarms to be transmitted, and performs serial to parallel bus conversion. The board interfaces with the Data Exchange on the CDA basecard via the I/O Bus. This bus is a parallel data bus with each transaction transferring 8 bits of data and 4 coded flag bits for signaling.

I/O Card – The CDA-E1 Input/Output Plug-In card has two major sections, the transmitter and the receiver section.

Transmitter:

The transmitter section contains a Time Slot Zero (TS0) data assembly that assembles framing, alarm, and national/international bits, according to timing information from the Transmit Frame Counter. The framing data is assembled in accordance with G.704 specifications.

A CRC Generator inputs the serial data from the Transmit framer and performs CRC encoding in accordance with G.704 specifications.

The resulting CRC remainder bits (4 per submultiframe), are fed back to the TS0 data assembly for insertion at the appropriate points during the next CRC submultiframe.

An HDB3 Encoder takes serial data from the Transmit framer and encodes it into HDB3 code in accordance with G.703 specifications. The resultant data is two TTL level signals representing positive and negative bi-polar pulses. These are fed to the CEPT line interface.

Under software command, the transmit serial data from the Transmit Framer, the Transmit Clock, the decoded HDB3 data and the Receive clock are substituted as inputs to the HDB3 encoder. This allows a remote loopback switch of received data to the remote end.

Receiver:

The HDB3 decoder inputs the TTL signals that represent received positive and negative bi-polar pulses respectively, from the CEPT line interface. It decodes these according to G.703 specifications into a serial 2.048 Mbps data stream. An input loss detector detects the absence of either received positive and negative bipolar pulses (representing data ones) for nine data periods and generates an alarm if this occurs.

Under software control, a local loopback switch substitutes the un-filtered receive data stream and the phase locked clock for the transmit data stream and the transmit clock, respectively, for use by the rest of the receive functions, thus causing a local data loopback.

A Receive Frame Sync Detector detects framing information in the received serial data stream. Frame sync is achieved when the correct framing sequence information is found. An alarm is generated if the framing sequence is not found.

The CRC Multiframe Sync Detector detects the one multiframe sync signal in the received data stream. The CDA-E1 Module acknowledges multiframe sync when the signal is detected. Loss of multiframe sync raises an alarm.

A CRC Analyzer decodes the receive serial data. Any remainder bits are compared with the CRC bits received during the next CRC sub-multiframe and any inequality is registered as a CRC error.

A Signaling Sync Detector detects the signal multiframe sync. The CDA-E1 is in multiframe sync when this signal is detected, otherwise an alarm is raised.

The CDA-E1 Module terminates into a line impedance of 75-ohms (co-axial) or 120-ohms (balanced).

The CDA-E1 Module interfaces and accepts data from the CDA basecard in the form of 64 Kbps time slots. It monitors the signaling information appended to each time slot and forms an additional time slot (TS 16). Data is then framed into the structured format specified by ITU-T G.704, and transmitted onto an E1 line at 2.048 Mbps. Conversely, the I/O card receives data from the E1 line, effects synchronization with this data and frames it into 64 Kbps time slots.

CDA-T1

The CDA-T1 Module is used to interface between the public T1 network and a TMS-3000 network. The module provides two ports that enable interfacing with a DACS, a D4 device (such as a channel bank or digital PBX), an internodal trunk with a CDA Module at another TMS-3000 node, or a T1 LIM at an OCM. The CDA contains a DS1 interface for domestic applications.

The CDA Module adds several important features to the TMS-3000:

- Converts TMS-3000 bit-oriented aggregate stream into a byte format. The converted bytes are transferred as DS0 channels through the CDA Module DS1 ports.
- Transfers byte-oriented DS0 channels between two DS1 ports on a CDA Module.
- Receives DS0 channels containing TMS-3000 channel data and converts the DS0-formatted bytes to a bit format. The TMS-3000 channels are then transferred to ACC or CICs at a TMS-3000 node.
- Synchronizes to DS1 data streams at each DS1 port.
- Transfers byte-oriented DS0 channels via the Fast Bus to the other CDA modules.

CDA/IAC Mapping Selects Management

The mapping selects resource consists of 256 selects if 2.112 MHz of backplane bandwidth is used and 124 selects if 1.056 MHz is used. A mapping select may also be considered to be 8 kHz of backplane bandwidth, hence the resource is indicated to you as 2.048 MHz or 992 kHz of backplane bandwidth. Each TMS DS0 regardless of occupation by circuits uses eight selects and each Network DS0 which must be sent to the backplane uses three selects each. IAC D-channel also uses eight mapping selects.

The following describes the proposal for mapping select implementation and discusses the limitations imposed.

At configuration time:

TMS link bundles are assumed to occupy: 8 * # DS0s selects

TMS/Network link bundles are assumed to occupy: 8 * # DS0s selects

X.50 switching bundles are assumed to use 8 * # DS0 selects

Network bundles are assumed to occupy: No selects

DTEC bundles are assumed to occupy: No selects

CLR bundles are assumed to occupy: No selects

The number of selects is visible. The number used is displayed as currently used bandwidth which equals 8 kHz * # selects.

Management of selects for Network DS0s, CLR DS0s, and DTEC connections are done by IAR. Under autopath, IAR maintains counts of used selects. When the circuit is routed over a Network Bundle, IAR allocates three selects in the case of data transfer to another card or no selects in the case of data transfer within the card. If a clear channel circuit is routed by IAR, the circuit occupies 8 * #DS0s mapping selects on the terminating CDA.

Bumping is allowed to gain backplane selects if required. Note however, that all TMS-type and X.50 switching bundles retain their selects regardless of bumping or IAR routing.

If the circuit is routed over a TMS/Network bundle or is defined to terminate on an X.50 switching bundle, selects are allocated for each DS0, hence no additional allocation is required. The ISDN card preprocessor also contributes to management of mapping selects.

If the IAC preprocessor is requested to initiate a call of a TMS or TMS/Network bundle it assumes that the call occupies 8 * # DS0s mapping selects and does not permit the call if the limit is exceeded. It is displayed as card bandwidth in the IAR bandwidth screens.

Conventional backplane bandwidth resource is not meaningful for CDA Modules. In all cases, the selects resource is fully utilized before the backplane bandwidth is utilized.

In order to be able to guarantee CDA Module bumpless swap, the use of TMS only bundles is recommended. TMS/Network bundles always cause bumping if the size of the TMS subaggregate is changed.

Backup Link Alarm Suppression (CDA/OCM)

Backup Link Alarm Suppression allows CDA/OCM `TMS` or `TMS/Network` bundles to be designated and used as backup links. When so designated, the bundle is treated as either idle or active, depending on the state (up/down) of the link or links it backs up. When idle, no circuits are routed across the backup bundle, and the idle backup bundle shows green in status and diagnostics regardless of the actual bundle status. When active, circuits may use the bundle and the reported status information is not filtered. The feature is invisible unless invoked. *For specific configuration procedures, refer to GDC 036R603-V220.*

When CDA backup links are present in the configuration, four new IAR status line messages may appear on the TMS Controller (Examples are shown below). All of these messages are informational only.

```
Initializing backup link: node 5, slot 12, subagg A-1
Deconfiguring backup link: node 5, slot 12, subagg A-1
Activating backup link: node 5, slot 12, subagg A-1
Deactivating backup link: node 5, slot 12, subagg A-1
```

`Initializing` indicates that the given bundle has just been named as a CDA backup link, and IAR is now going to treat it as such. Although this message primarily appears when IAR first learns about the backup link, it can also occur at other times, such as following an unrelated backbone change. For example, if a backup is active in the network and a slave controller is connected to the network, the message is seen on the slave when the primary link comes up and the backup is deactivated.

`Deconfiguring` is similar, and indicates that the named bundle is no longer receiving special treatment as a backup.

`Activating` means that IAR has learned of a link down condition on one of the primary links, and is now treating the backup as active. Like Initializing, this message can also occur at times other than initial activation.

`Deactivating` indicates a transition to idle.

ISDN Aggregate Control Module

The IAC-T1 module has the same functionality as the CDA-T1 with the addition of ISDN signaling support. The previous description of the CDA-T1 applies to the IAC with the following changes.

The IAC-T1 can only be connected to an ISDN network which supports the AT&T 41449 and 41459 protocol specifications. Byte oriented data is passed through a Network or TMS-3000/Network bundle. Byte oriented data cannot terminate on an IAC-T1 module.

The IAC-E1 can only be connected to an ISDN network which supports the Australian Telecom TS14.01 protocol specification. ISDN, by its nature, is always a CCS (Common Channel Signaling) format, the CCS being ISDN. The ISDN signaling channel is located in Time Slot 16. CAS (Channel Associated Signaling) is not supported. CRC-4 is always enabled on the IAC-E1 Module.

The IAC Module allows you to define backup links. These links are different because they are not always active in a given configuration. They are activated by the error condition of the primary link failing or by activating a new configuration where they are enabled. These links are not assigned to a fixed DS0 position at configuration. When they are activated, the IAR task determines which DS0 is available for the backup link. CDA cards can only have permanent links configured. IAC cards can have both permanent and backup links configured.

IAC-E1 Module

The IAC-E1 Module is a high speed aggregate I/O that allows the TMS-3000 to interface with CClTT Integrated Services Digital Network (ISDN) via the Primary Rate Access (PRA).

The IAC-E1 provides connection to the various service offerings of ISDN at the Primary Rate level. The ITU-T Primary Rate is generally known as PRA (Primary Rate Access). It features a 30B+D, 2.048 Mbps structure. The 30B segment refers to the 30 "bearer" channels used to pass information over the ISDN network. Each B-channel has 64 Kbps of bandwidth available for use. The 64 Kbps D-channel of ISDN is reserved for supervision and control (call set-up and signaling) of each PRA link.

The IAC-E1 is an evolutionary development that extends existing CDA-E1 technology utilizing the Time Slot Interchange and N X 64 subaggregate (bundling) capabilities. It provides two G.732-compliant, 2.048 Mbps ports for connection to ISDN PRA per ITU-T I.431. The IAC-E1 features a microprocessor card that extends local intelligence to support ISDN applications. It features LAPD (Link Access Protocol D-Channel) in full compliance with the ITU-T Q.921 link level protocol standard. This standard sets the ground rules for Layer 2 connectivity in ISDN PRA. The IAC-E1 is also fully compliant with ITU-T Q.931, which defines the network layer (Layer 3) of the ISDN protocol.

The IAC-E1 accommodates the ISDN channels as individual 64 Kbps B channels. The subaggregate structure of the IAC-E1 is similar to that of the CDA-E1, with the 16th time slot of the ISDN link reserved for the D-channel.

The IAC-E1 supports the features offered in Telecom Australia Macrolink services per the Austel T514.1 specification for the PRA interface. The IAC-E1 is compliant with Layers 1, 2, and 3 user-side protocols for connection from your location to the public network ISDN facilities. The IAC-E1 incorporates functions of Q.931 for Layer 3 as required for tariffed services in individual countries. Macrolink services in Australia are provided via Ericsson AXE10 central office switches. The IAC-E1 may also apply to other ITU-T countries as a function of switch type and service processing.

The IAC-E1 complies with the ITU-T 2.048 Mbps frame structure which calls for thirty-two 64 Kbps time slots numbered 0 to 31. Time Slot 0 is used for frame alignment for the entire 2.048 Mbps bit stream, while Time Slot 16 carries the D-channel. Time Slots 1-15 and 17-31 are available for allocation to B channels.

Each TMS-3000 node accommodates up to 16 IAC-E1s in a non-redundant configuration, or up to 8 in a redundant configuration. A maximum of 16 PRA links per node is available. In addition to the IAC-E1, the TMS-3000 node may also be equipped with ACCs, ACMs, CDA-E1s, CICs and, where applicable, CDA-T1s (1.544 Mbps).

IAC-T1 Module

The IAC-T1 Module is a high speed aggregate I/O that allows the TMS-3000 to interface with Integrated Services Digital Network (ISDN) via the Primary Rate Interface (PRI).

Physically, the only difference between the IAC-T1 and IAC-E1 is that the E1 version contains two I/O ports configured for G.732 (ITU-T). Each I/O card complies with I.431 for ITU-T applications. Operation of the IAC-T1 is similar to the IAC-E1.

The IAC-T1 provides connection to the various service offerings of ISDN at the Primary Rate level. The Primary Rate is generally known as PRI (Primary Rate Interface). It features a 23B+D, 1.544 Mbps structure. The 23B segment refers to the 23 "bearer" channels used to pass information over the ISDN network. Each B-channel has 64 Kbps of bandwidth available for use. The 64 Kbps D-channel of ISDN is reserved for supervision and control (call set-up and signaling) of each PRI link.

The IAC-T1 accommodates the ISDN channels as individual 64 Kbps B channels, or as 384 Kbps H0 channels (6 contiguous B channels). H0 channels are ideally suited to high speed data or video applications. TMS-3000 can use an H0 channel to carry a subaggregate or multiplexed individual circuits. The subaggregate structure of the IAC-T1 is similar to that of the CDA-T1, with the 24th time slot of the ISDN link reserved for the D-channel.

The IAC-T1 supports features offered in AT&T Accunet service per AT&T 41449 and 41459 specification for the PRI interface. The IAC-T1 is compliant with layers 1, 2, and 3 user-side protocols.

The IAC-T1 complies with the AT&T 1.544 Mbps frame structure which calls for 64 Kbps time slots numbered 1 to 24. Time Slot 24 carries the D-channel. Time Slots 1-23 are available for allocation to B channels or H0 channels.

Each TMS-3000 node accommodates up to 16 IAC-T1s in a non-redundant configuration, or up to 8 card pairs in a redundant configuration. A maximum of 32 PRI links per node is available. In addition to the IAC-T1, the TMS-3000 node may also be equipped with ACC, ACM, CDA and CIC cards.

Enterprise System Control Card

The TMS-3000 Enterprise System Control Card (ESCC) is a printed circuit board assembly that is installed in a TMS-3000 shelf to monitor and control the activities of all the other cards and modules in that shelf.

The ESCC is responsible for the following functions:

- Permanent storage of software programs for all of the common cards (ACC, CDA, CIC, DBC, ACM, IAC, and TPP) in the entire TMS-3000 network and the Office Communications Manager System (OCM-2000). The ESCC also stores configuration information for the local TMS-3000 node.
- Communication with the Controller, if locally connected.
- Communication with other ESCCs in neighboring TMS-3000 nodes in the TMS 3000 network.
- Communication within the node with all common and channel cards and with the redundant ESCC.
- Information transfer including common card program download (during software upgrade procedure), alarms, status, and configuration.
- Control of all customer data traffic between common cards within the TMS-3000 node and all block mode transfers within the TMS-3000 node between TPP modules. All customer data is transferred via the TMS Microcell Backplane. *Refer to the operating and installation instructions for the TPP card, covered in GDC 036R302-A7.*
- Generation of timing information for the local node and transfer of network timing between nodes.

  The ESCC complies with the Stratum 4 Enhanced Level Clocking specification as defined by *AT&T Tech. Ref. 62411.* A reference clock is accepted from any common card in the node or the external timing port. The ESCC phase locks to the reference and provides a stable timing output for use by all aggregates and channels. Additionally, a stable 512K output reference clock is supplied to let timing transfer to adjacent nodes or other equipment.
- Control of redundancy of the common cards in the local node. Based on the alarm information received from the local common cards, the ESCC can activate the standby card of any of the eight redundant pairs. This is done via a command sent from the ESCC to the RCC to do the redundant switch.
- Control of an external modem. You can use this modem to connect a remote Controller to the node.

ADPCM Compression Module (ACM)

The ACM provides the means for a single DS1 (E1) line, containing 24 (30) PCM voice circuits, to be brought into the TMS-3000 and compressed via GDC **ADPCM** (Adaptive Differential Pulse Code Modulation) compression techniques. After compression, these circuits are transported across a T1 aggregate via an ACC or framed into a TMS-3000 subaggregate, in bit format, of a CDA Module.

The termination of the voice circuit can occur on a GDC UVC (Universal Voice Card), via a CIC or **MINIMUX** (a self-contained TDM capable of multiplexing and de-multiplexing as many as six channels of synchronous, **asynchronous**, isochronous, or **anisochronous** data, or voice grade telephone signals). Also, it can be terminated via another ACM on a Digital PBX. Optionally, 30 PCM voice channels can be accommodated by making use of the ITU-T version of the card (ACM/E1).

The ACM is designed to be installed in the main shelf (similar to other common cards). You can mount as many as 12 ACMs in the main shelf.

ACM allows the compression of multiple voice channels affording a substantial bandwidth savings over 64K PCM. This bandwidth savings can be utilized for transporting data traffic on the same T1 pipe that previously carried only voice. Furthermore, during disaster recovery and fallback, and through the use of Intelligent Automatic Re-routing, the ADPCM voice channels can be compressed further to occupy even less bandwidth; this gives you more active circuits. A digital PBX can be transported via the TMS-3000 and terminated at an analog PBX.

The ACM also allows the GDC UVC cards to be converted to public network compatibility (byte oriented, 64 Kbps PCM).

The ACM also has pass-through channel capability which permits any or all channels to be passed unmodified (800 Hz overhead still required) through the module. This feature allows data (clear) or uncompressed voice to be passed by the ACM. This allows for signaling information (CCS) to be transported via any time slot.

The ACM can:

- invert the A bit signaling on a per channel basis
- bundle multiple time slots (14-18)
- bypass time slots 0 and 16
- monitor background statistics

TMS-3000 Compatibility

The ACM can exchange bit formatted channel data with CIC, CIC, or CDA Modules but is not end-to-end compatible across an aggregate trunk with any other common card except ACM. The ACM does not exchange byte (or nibble) formatted data with CDA modules. There are several reasons for this:

- The CDA uses byte-oriented channels for transporting network DS0s (64 Kbps) across the backplane. In the case of the ACM, this translates to 64 Kbps PCM channels. The ACM utilizes a proprietary bit format for exchange with the ACC, CIC or TMS-3000 circuits on the CDA.
- Byte-oriented channels reduce backplane bandwidth. The ACM uses only one backplane select when 30-32 Kbps ADPCM channels are configured. This format also allows network compatible 64 Kbps voice circuits with the ACM by using an external cable.
- The ACM does not perform any echo cancellation functions internally, either bulk or per channel. If you want this feature, an external bulk echo cancellation module can be supplied by GDC through a third party vendor. This module is connected between the ACM port and the DPBX, channel bank or public network.

ACM Network Compatibility

The ACM supports either a DS1 or G.732 interface. Connections to any DS1 can be either D4, T1/D4E(ESF), ACM/T1 or ACM/E1, assuming the ACM is the slave for any ESF communications. ACMs are always connected either to the public network, a PBX or a CDA Module through its I/O port.

ACM Voice Compression And Conversions

ACM/T1 supports as many as 24 voice circuits. With an ACM/E1, 30 voice circuits are supported. The ACM allows 64 Kbps, 32 Kbps, 24 Kbps or 16Kbps ADPCM rates. You can program all rates on a per channel basis, via the Controller. You can downspeed channels with IAR.

The programmable, per channel rate selection makes it flexible to tailor each configuration to the specific needs. This is illustrated in the following example:

Consider a network with an ACM feeding two ACC links (via the TMS-3000 backplane). One link is lightly loaded, and the other link is heavily loaded. The voice channels on the lightly loaded link may be configured to give the best speech quality (64 Kbps or 32 Kbps) while the channels on the heavily loaded link may be configured as 24 Kbps or even 16 Kbps in order to conserve bandwidth. A fallback configuration may, for example, change all voice circuits to 16 Kbps or drop the lowest priority circuits.

Because of compression algorithms, 800 Hz overhead is added to each channel for synchronization and transmission of signaling.

Code conversion of PCM data is supported on a per channel basis. The Controller configures the necessary conversions based on how you define code formats of circuit end points.

Allowable conversions are:

- Mu-Law to A-Law
- A-Law to Mu-Law
- Mu-Law to Mu-Law
- A-Law to A-Law/Pass-through

Individually selectable conversions allow international voice circuits to be converted to their required code without the need for multiple conversions.

Any or all circuits can be configured as pass-through (clear channel), to let data channels pass, unchanged, to their destination, and future common signaling channels to pass through for network or PBX processing.

The ACM supports DS1 robbed bit signaling as per the CDA DS1 I/O card. Signaling per ITU-T G.732 specifications is supported via the ACM/E1. ACM-to-UVC applications support "A" signaling only (2-state). This is 4-wire and E&M. In a PBX-to-PBX application, A, AB, or ABCD signaling can supported by using the background control path. More signaling information is found below.

ACM Clocking

ACM related clocking is described in two major sections. Node Clocking relates to the exchange between the ACM and ESCC. Module Clocking deals with clock issues peculiar to the ACM only.

- Node Clocking — The ESCC of the TMS-3000 can choose any aggregate card (including the ACM) to give a reference for all other cards in the system. An external clock is supplied as a reference. The ESCC uses that reference for its phase locked loops, whose outputs are used to generate the node clock bus. The node clock bus is used to derive all aggregate and channel rates in that node. The ESCC informs a card if it is to enable its clock as the reference. Likewise, the ACM informs the ESCC of its reference clock status so that an intelligent decision is made.
- Module Clocking — The ACM can obtain its transmit data clock from two sources: The clock bus or the derived clock from the I/O board. Module clocking is a configurable item. The complexity of clock selection on the ACM is simplified since there are only two link rates available. The rates are chosen by the operating environment and are 1.544 MHz for DS1 and 2.048 MHz for ITU-T. The ACM derived clock can also be used to supply the node with a clock via the Lock Freq. Bus.

There are two node timing modes that may be selected for the ACM. The selection made is based on the equipment type of the clock source on the other end of the ACM link.

- Not Available — Timing derived from the link is prohibited for use as a reference to the phase locked loop on the ESCC.
- Facility — Timing derived from the link is used as one of the selections for the reference to the phase locked loop on the ESCC.

  The Facility mode is selected when the link supplying the clock cannot exchange parameters with the node. Examples of such equipment are digital PBXs, network channel banks or DACS.

The autoclocking routines can configure the preference values. The *Operation Manual for TMS-3000 Controller, GDC 036R603-Vnnn*, provides more information on autoclocking and preference values for the ACM.

The transmit clock source used to time transmit data toward the link is selected as either of the following:

- Node — The internal clock bus generated on the ESCC provides the transmit clock. A selector on the ACM chooses the proper rate (1.544 MHz or 2.048 MHz), depending on the I/O interface.
- Receive — This selection causes the derived incoming receive clock to be looped back and used as the transmit clock.

Port Transmit Clock

The derived receive clock always functions to clock in the received data. The transmit clock, however, is supplied by two means:

- The transmit section is timed if the derived receive clock, used to time received data, is also used as the transmit clock to time transmit data. The derived clock is actually phase locked locally on the I/O plug-in before being used as the transmit clock to attenuate line jitter. This option is selected to allow an independently timed equipment type to free run.

NOTE

If a card configured in this mode is not selected as the node reference source, clock slips may occur because of the asynchronous interface within the node.

- The transmit section is node timed if the clock used to time transmit data is selected from the clock bus input to the ACM. The ESCC supplies the clocks on this bus, and clocks are locked according to the mechanism of the node clocking level.

The ACM may operate in plesiochronous mode, in which case clock slips are controlled and occur on frame boundaries.

ACM Primary Clock

In addition to supplying a transmit clock, the ACM must be able to supply a clock to the ESCC for phase locking the node. The clock used to receive data on the I/O card is always recovered from the received data itself. This clock (labeled a Primary Clock) is also available to the Lock Freq. Bus so the ESCC has access to it. Upon command from the ESCC, the ACM applies its recovered clock to the Lock Freq Bus. In this mode, the ACM is designated as the primary clock source. When configured as a primary clock source, the ACM operates in one of the following modes :

- Primary With Standby — As primary clock source, the ACM removes its clock from the Lock Freq Bus under certain failure conditions. This allows a secondary source or "hot standby" to drive the bus.
- Primary With No Standby — If no hot standby is configured in the node, the primary clock source continues to drive the Lock Freq bus, regardless of failure conditions encountered, until the ESCC commands it to remove its clock.

A primary clock failure is defined as a Loss of Carrier by the I/O Interface. This error is reported to the ESCC by a primary clock source (with or without standby), and by a hot standby card. The error also initiates a clock removal for primary clock source — with standby. Clocking parameters that are configurable include node timing and transmit clock source. Some parameters are observable only, which include clock failure reporting and standby switching.

If an ACM is configured as the primary clock source, it reports clock failure for the status display. If an ACM is configured as the hot standby, it reports when the primary clock failure is detected, and it has enabled its clock as the reference. The display reflects the hot standby service condition.

In the TMS-3000, the ESCC is the controller for all primary clock sources and the hot standby function. Based on a node configuration, the ESCC can select an ACM as a primary clock source with backup, primary clock source without backup, hot standby, or passive (no clock source action taken).

As a primary clock source, the ACM notifies the ESCC as soon as there is clock failure. Of three alarms monitored by the ESCC, only Loss of Carrier is reported. As a hot standby module, the ACM enables its clock and notifies the ESCC when it detects a primary clock fail. The ACM responds to a clocking change from the ESCC within three milliseconds of issuance.

The ESCC can override the primary clock, hot standby, and passive configurations on each ACM depending on the input status to its auto-clocking.

ACM Programmed as Hot Standby

The ACM can be programmed as a hot standby module, but only one ACM per node may be so designated at any time. The purpose of the hot standby module is to avoid unnecessary delays while waiting for the ESCC to detect that its phase lock loop has drifted into a fault condition and the auto-clocking algorithm is entered.

The hot standby is intended as a fast recovery mechanism if there is a primary clock failure. The ESCC switches to the ACM designated as the hot standby when its primary clock has degraded (loss of signal). The ACM disables its clock from the backplane and thereby forces a failure.

The hot standby ACM monitors the Lock Freq. Bus driven by the primary clock source. If a loss of clock is detected, the ACM immediately (within three microseconds of occurrence) supplies its clock to the Lock Freq. Bus.

Loss of clock is defined as two consecutive clock cycles missing on the Lock Freq. Bus. The ACM notifies the ESCC of loss of clock. The ESCC then notifies the Controller for configuration update and subsequent status display. At this point, it must be noted that the hot standby is not designated as the new primary clock source. The module simply enables its clock on the Lock Freq Bus upon failure detection and provides the same functions as a primary clock source without backup. The ESCC then designates this module or another module as the primary clock source with a backup.

ACM Signaling and Conditioning

ACM signaling and conditioning are covered in the *Operation Manual for TMS-3000 Controller, GDC 036R603-Vnnn.*

TPP/OPP

TPP modules are installed in the Main Shelf of the TMS-3000. OPP modules are installed in the OCM-2000. *Detailed installation instructions for TPP and OPP modules are found in GDC 036R302-A7 and GDC 036R342-000.*

Comprehensive management of the TMS-3000 system with TPP/OPP requires the TMS-3000 Controller and **IMS** (Internetworking Management Software). The TMS-3000 Controller, running under the XENIX operating system, is responsible for all physical layer management of the TMS-3000 and TMS-2000 network devices (TPP and OPP modules) and TPP pathway definitions.

The IMS is responsible for management of the LAN*TMS and other network devices within the FSN created with the TPP/OPP, plus logical layer management of the FSN. *For installation and use of the IMS, refer to the IMS User Guide. To manage the TPP and OPP from the IMS, refer to Managing TPP/OPP via the IMS, GDC S-078R001-A1.*

Physical Layer Network Management

The TMS-3000 Controller is responsible for physical layer management of the TPP/OPP through the existing TMS-3000 supervisory communications channels: TMS-3000 Controller to ESCC to TPP, or TMS-3000 Controller to CCM to OPP. Physical layer network management for TPP/OPP modules consists of:

- configuring TPP pathways between TPP/OPP modules in remote nodes.
- configuring TPP pathways between channel cards and TPP/OPP modules.
- allocating TMS-3000 Fastbus bandwidth to the TPP and support for MicroCell Transport between multiple TPPs within the same node.
- allocating sub-aggregate bandwidth between a TMS-2000 and a TMS-3000 node for TPP pathways.

- configuring the external DB-25 interfaces of the TPP/OPP module.

Logical Layer Network Management

The IMS is responsible for logical layer management. The IMS access point to the FSN is through an Ethernet or token ring connection to the extended LAN as part of the FSN, so the FSN must contain at least one LAN interface to allow connection of the IMS. A LAN segment and thus IMS can be located anywhere in the FSN. The FSN management path is separate from the TMS-3000 management path. FSN management packets traverse the FSN without involving other TMS-3000 management entities.

Once the physical layer TPP/OPP configurations are defined and downloaded to the TPP/OPP, the dynamic routing function within the TPP/OPP begins the exchange of link state information to determine the "best" route between TPP/OPP modules. These routes are independent of IAR. The FSN dynamic routing functions automatically reconfigure to adjust to the latest IAR link states.

The "best" route for the FSN dynamic routing function is based partially on the attributes of the TPP pathways and partially on the physical layer configuration parameters.

Logical layer network management for TPP/OPP modules consists of:

- managing the load sharing aspects of the FSN,
- optimizing the parameters which influence congestion control over the FSN.
- configuring the logical parameters of the **AOI** (Application Oriented Interface).

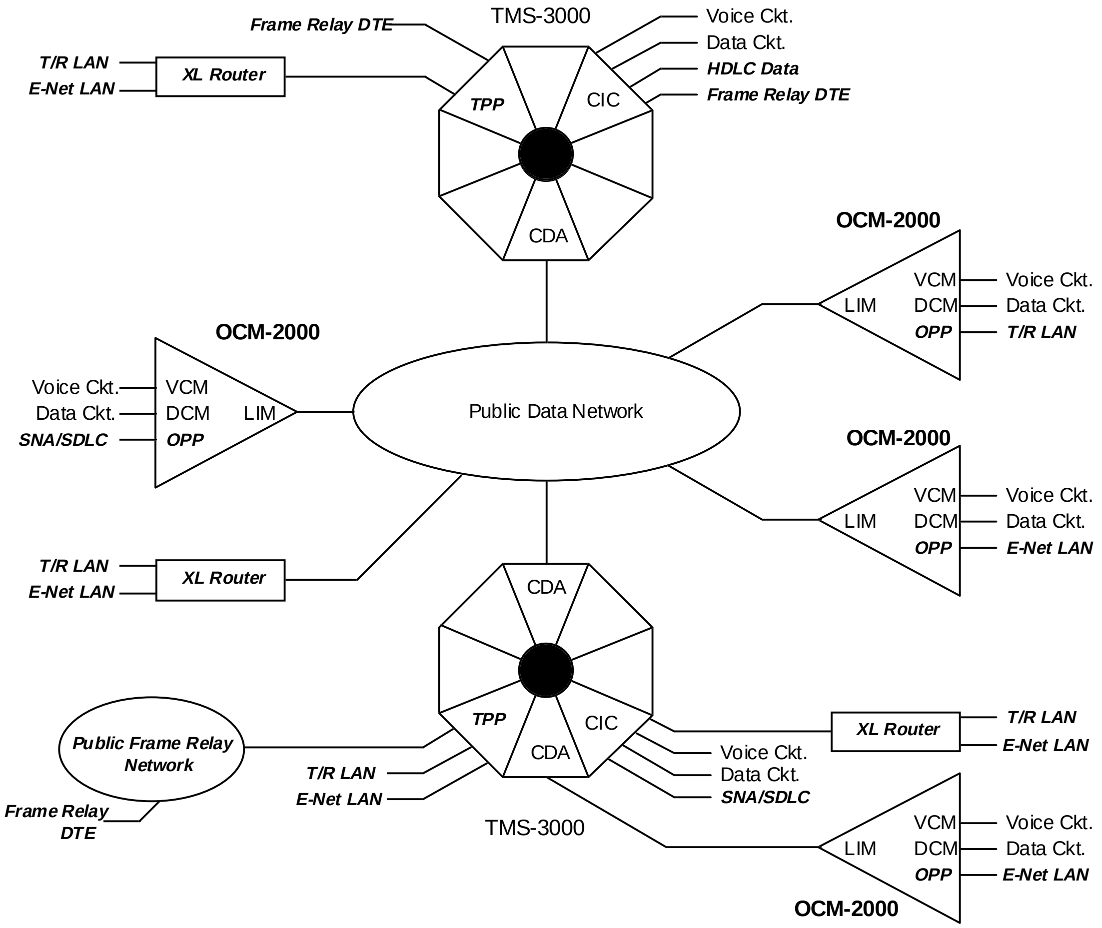
The AOI serves as an access point to the FSN. It prepares frames to enter the FSN in a uniform manner so the TPP may perform almost identical steps regardless of packet type or source of the packet. The AOI logical parameters include such functions as Port State and Frame Relay Access Line Management Options. If a LAN interface is used, the AOI logical configuration includes customizing the LAN bridging filtering function through the use of MAC addresses to include or exclude certain frames from the forwarding functionality.

The purpose of FSN bandwidth management is to allocate the available internodal bandwidth dynamically as frames arrive from the various sources, ensure that network congestion does not occur, and to notify the network management system in cases of continuous congestion. The routing protocols determine the paths each frame takes through the network, with certain routing protocols dynamically updating the path determination based on congestion.

Bandwidth management and congestion control is performed as frames are received from an FSN source and are presented for transmission via the internodal links. The particular management scheme is dependent on the type of traffic source (LAN, frame relay, etc.).

Figure 8 illustrates some of the types of internetworking the TMS-3000 provides with the addition of the TPP/OPP. The traditional types of data and devices are in a regular typeface, and the TPP/OPP-supported ones are in a bold italic typeface.

Table 2 lists parameters for the TPP/OPP and tells you whether to use the TMS-3000 Controller or the IMS to configure them.



Legend

TMS-3000: Transport Management System-3000

TPP: TMS Packet Processor

CIC: Channel Interface Module

CDA: Combined Digital Aggregate Module

OCM-2000: Office Communications Manager-2000

OPP: OCM Packet Processor

VCM: Voice Channel Module

DCM: Data Channel Module [Dual Data Module (DDM) or High-Speed Data Module (HSDM)]

XL Router: XL Router

Figure 8 LAN/WAN Internetworking

Table 2 Configuration Cross-Reference

Device/Parameter	TMS Controller	IMS
Ethernet LAN		
LAN Bridging/Routing Options		X
LAN Filters		
Host-to-Host		X
Host-to-Port		X
Multicast		X
Port-to-Host		X
Protocol Type Filters		X
Remote Disconnect Timer		X
Spanning Tree Parameters		X
Frame Relay DCE/DTE		
Permanent Virtual Circuit parameters		X
Type of Link Integrity Verification supported (Local In-channel Signaling (LIS), Local Management Interface (LMI), or None)		X
HDLC		
Clock speed (if Clocking is Generated)	X	
Clocking (Generated or Recovered)	X	
Control Signal processing	X	
HDLC station address: 0 (one HDLC station) or 1		X
Interface Type (RS-232, RS-422, V.35, Universal I/O)	X	
Protocol Independent Routing		
Congestion parameters		X
Re-routing period		X
SNA/SDLC		
Clock speed (if Clocking is Generated)	X	
Clocking (Generated or Recovered)	X	
Control Signal processing	X	
Interface Type (RS-232, RS-422, V.35, Universal I/O)	X	
SNA/SDLC station address: 0 (SNA Host address) or any valid SNA/SDLC station (cluster controller) address		X
Token Ring		
LAN Bridging/Routing Options		X
LAN Filters		
Host-to-Host		X
Host-to-Port		X
Multicast		X
Port-to-Host		X
Protocol Type Filters		X
Source Routing Parameters		X
Spanning Tree Parameters		X
WAN		
Clock speed (if Clocking is Generated)	X	
Clocking (Generated or Recovered)	X	
Control Signal processing	X	
Interface Type (RS-232, RS-422, V.35, Universal I/O)	X	

Redundancy Control Card (RCC)

Redundancy is the use of two identical TMS-3000 components to perform the same task, with one component in service and the other component in a standby mode. If a failure symptom is detected in the in-service card, the standby card is switched into service, so that a failing component may be bypassed instantly. This greatly increases system reliability.

The RCC causes switching from one card of a redundant pair to the other. In a redundant system, this is the only card without a twin in the main shelf. All other common cards are connected in series with an identical card that is on stand-by in case the primary card goes out of service.

Redundancy is optional in a TMS-3000 system. But redundancy is a fundamental design characteristic of TMS-3000. The TMS-3000 main shelf has been designed to support pairs of cards, and the connectors on the backplane have been arranged for optimal performance in a redundant system.

The following TMS-3000 components have redundant capability:

- ADPCM Compression Module (ACM)
- Aggregate Control Module (ACC)
- Channel Interface Module (CIC)
- Digital Bridging Card (DBC)
- Combined Digital Aggregate (CDA) Module
- ISDN Aggregate Control (IAC) Module
- Enterprise System Control Module (ESCC)
- Expansion Module
- GPS-8A, GPS-8B, and DPS-8A Power Supplies

The following OCM-2000 components have redundant capability:

- Line Interface Module (LIM)
- Common Control Module (CCM)
- GPS-11 Power Supply

Redundancy Switching Control

The ESCC determines the redundant status of each redundant pair of ACC, ACM, CIC, DBC, CDA, or IAC Modules. This status is transferred to the RCC on a regular basis, or whenever conditions warrant a redundant switch for some pair.

Redundancy is under the direct control of the RCC which maintains a set of primary/secondary signals directed to each redundant pair of cards. When the signal is in primary state (logic 1) the card in the primary slot is in service. When the signal is in secondary state (logic 0) the secondary card is in service.

The RCC determines if a card is present in each slot; if only one card of a redundant pair is present, that card remains in service. Similarly, if a CIC, DBC, CDA, IAC, or ACC is configured for nonredundant operation, it is not treated as a redundant card.

Switching between a redundant pair of ESCCs is controlled by the RCC. Each ESCC sends signals indicating hardware integrity to the RCC.

If one of these signals from the in-service ESCC turns off, the RCC switches the standby ESCC into service.

Additionally, there is a software-controlled signal that allows the in-service ESCC to switch itself out of service under the proper conditions.

Common Module Redundancy

In a redundant TMS-3000 system, primary and secondary ACM, CIC, ACC, ESCC, and CDA Modules are supplied in the system. Both primary and secondary cards are fully operational.

The ESCC monitors the TMS-3000. If a major alarm condition occurs - for example, if aggregate data synchronization is lost (an out-of-sync condition), the ESCC signals the RCC to switch between primary and secondary cards until the system is working again. During a redundant switchover, there is minimal data loss.

NOTE

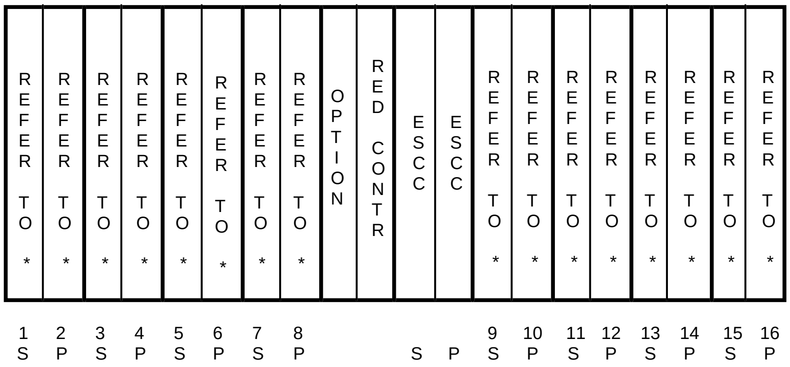
Test the "out of service" cards periodically in a TMS-3000 that which has redundant common cards. In a TMS-3000, not all failures of the out-of-service card are detectable. Certain conditions may prevail causing disruption of the network when that card is placed into service.

In *Figure 9*, The P indicates a primary card in a pair; the S indicates a secondary card in a pair. When power is applied to the node, or the ESCC is reset, the primary card in each pair of cards is placed in service. The standby card is kept as "hot" as possible; that is, it performs as many as possible of the tasks being performed by the in-service card. The CIC processes channel data, but does not transfer it to the node Fast Bus or the channels. The ACC receives and processes data but does not transmit data. The ESCC maintains data in card memory but does not receive commands from the TMS-3000 Controller. The in-service ESCC transfers all new information to the standby ESCC.

The numbered slots for common cards are paired as follows:

1-2 3-4 5-6 7-8 9-10 11-12 13-14 15-16

The redundant pairing of TMS-3000 main shelf cards is illustrated in *Figure 9.*



* Slots 1 through 16 utilize one of the following: ACC, ACM, CDA, CIC, CDA, IAC, and TPP.

Figure 9 Redundant Arrangement of TMS-3000 Main Shelf

NOTE

GDC recommends periodically testing the "out-of-service" cards in a TMS-3000 system that utilizes redundant common cards. In a TMS-3000, not all failures of the "out-of-service" card are detectable. Certain conditions may prevail causing disruption of the network when that card is placed into service.

The following describes the conditions under which the ESCC causes redundant switches for common cards.

Aggregate Control Card

The following conditions cause a redundant ACC switch:

- Module does not communicate with ESCC at node
- Module does not have operating software
- Slot is configured for CIC or ACC
- In service card has been removed from slot
- No aggregate data transition is present on trunk
- Module cannot achieve synchronization on data frame
- Synchronization with remote aggregate has been lost for a period of time determined by the aggregate Out of Sync delay
- Transmit or receive framing has failed in the card
- Channel controls are not being transmitted through the aggregate trunk
- Channel controls have overflowed in the ACC for a period of time
- Transmit or Receive timing has been absent for a period of time

If an ACC is configured for diversity as well as redundancy, some failure conditions can cause both diversity and redundancy switches. In these cases, the node performs a diversity switch before a redundancy switch. *Refer to Diversity (earlier in this chapter) for more information on diversity/redundant switching*.

ACM, CDA, or IAC Module

The following conditions cause a redundant ACM, CDA, or IAC switch:

- Module is unable to communicate with ESCC at node
- Module does not have operating software version properly loaded
- Slot is configured for a card type other than what is in the slot
- In service card has been removed from slot
- No aggregate data is present on link.
- Module cannot establish synchronization on data frame
- Synchronization with remote link has been lost for a period of time determined by the aggregate Out-of-Sync delay
- Transmit/Receive framing has failed in the card
- Transmit/Receive Timing has been absent for a period of time

Channel Interface Card/Digital Bridging Card

The following conditions cause a redundant CIC or DBC switch:

- The frame for channel data transmission has failed
- Module is not communicating with the ESCC
- Module is not passing channel controls
- Module does not have operating software
- Channel controls have overflowed in the card for a period of time
- Alarms
- Module has been removed from slot

Expansion Module

Redundant switching of an Expansion Module in an Expansion Shelf is controlled by the CIC that is linked to the Expansion Module. Currently, the Expansion Module only switches when the CIC switches or when its mate is removed.

Power Supply

Redundant power supplies are not under the control of the TMS-3000 node. The pair of power supplies share the load for the portion of the system that they supply power to. If one supply fails, the other supply is capable of supplying power until the defective power supply is replaced. Power supply failures are reported through front panel indicators on the card and through alarm messages and Controller status displays.

Redundancy Status/Indicators

Status displays report which card of a redundant pair of cards is in service. This information is available through the node status or individual card status displays.

Front panel indicators reflect redundancy status in a pair of cards. Cards have either an In Svce or a Standby indicator, or both; the green indicator is lit when the card is in the appropriate contaildition.

Power Supply Redundancy

Redundant power supplies may be used in a configuration, so that one power supply takes over if another fails. One power supply may be removed from the TMS-3000 shelf without disrupting the system. Power supply failures are reported as alarm conditions.

Optional Module

There is an optional slot in the Main Shelf that is reserved for future options and enhancements.

Channel Modules

Several types of channel cards are used on the TMS-3000.

NOTE

There are several versions of the Data Channel Module that are available for the TMS-3000. One version is identified as the Data II Channel Module, the second version is the Data III Channel Module, the third version is the Data IV Channel Module, and the fourth version is the Universal Data Channel (UDC) Module. The UDC Module is scheduled to replace the existing Data II, III, and IV Channel Modules. A fifth type, based on the UDC, is the G.703 Data Channel.

In most respects, all versions operate identically. The difference is that the Data III Channel Module supports multi-drop polling applications, while the Data II Channel module, without a polling piggyback card, does not. The Data IV and UDC modules contain a special Sync LSI chip that prevents lockup situations that can occur when using either card in multi-drop polling applications. In addition, the Data IV and UDC modules contain several options that are configured through software. The G.703 Data Channel supports 64 KHz, 128 KHz, or 256 KHz co-directional interfaces, the rate depending on the version of the card (s) installed in your system.

As mentioned earlier, there are two basic data channel modules available for OCM-2000, the single circuit and dual circuit versions. Additionally, for the OCM, an X.50 Data Channel card is available which supports up to four circuits per card and has the capability of terminating X.50 type circuits. The X.50 format is an ITU-T multiplex standard for a gross bit rate of 64 KHz.

Throughout this manual, all versions are implied when the Data Channel module is discussed. A detailed explanation of the differences between modules is given where applicable.

Data Channel Module

This card provides the channel interface for data multiplexed by the TMS-3000. The card is controlled by the CIC and can be programmed to accept any of the following types of data:

- Synchronous
- Asynchronous
- Isochronous
- **Anisochronous** (data transition-encoded according to ITU-T R.111 standards).

Note that the G.703 Data Channel only supports synchronous data.

Data rates for the channel are programmable; *See Appendix A in GDC 036R603-Vnnn for the various rates*. The Data Channel Module may be set to operate according to any of the following interfaces: EIA/TIA-232-E, MIL-STD-188-114, EIA RS-422/423, and ITU-T V.25. But the G.703 Data Channel is ITU-T G.703 only.

Normally all interface control signals are at EIA/TIA-232-E levels unless modified by an adapter. Available channel adapters extend interface characteristics of the Data Channel module. An RS-422/423 adapter supplies control signals at EIA RS-422 or 423 levels (the Data Channel module supplies only data and timing signals at those levels).

A digital line driver adapter is available. These adapters mount in a CP-12 shelf, which attaches to the back of the TMS-3000 Shelf.

The Data Channel Module accepts up to four input control signals from a channel device and transmits the states of these signals to the remote channel card where they are applied to the channel device as output control signals. The off-to-on transition of one of these signals may be transmitted as an in-band control, permitting rapid channel turnaround for polling and other channel applications.

The Data Channel Module may be set to exhibit the interface characteristics of DTE (Data Terminal Equipment) for interface connections to DCE (Data Communication Equipment), or may be set to exhibit the interface characteristics of DCE for interface connections to DTE.

Hyper Plug-In Card

In the TMS-3000, the Hyper Plug-In Card option allows data channels to operate error free in the presence of up to 32 bits of frame jitter. This feature extends the receive buffer up to 64 bits. Frame jitter can occur on high speed (384 Kbps or greater) data channels when more than one common card frame is “intermixed” by a CIC receive FIFO.

The Hyper Plug-In Card is a plug-in option on the TMS-3000 and mounts onto a Data III Channel, Data IV Channel or Universal Data Channel (UDC) Module.

The Hyper Plug-In Card is recommended for the following application:

- When a CIC is configured for a Data Channel of 384 Kbps (or greater) and more than one common card (ACC, CIC, ACM, or CDA Module) has channels terminating on the CIC. Additionally, the CIC must be terminating low speed channels (≤19.2 Kbps).

If an application exists for a Hyper Plug-In Card on a circuit which is configured between two TMS-3000s, a Hyper Plug-In Card should be installed on the Data III Channel, Data IV Channel, or UDC Module at both ends.

TID-III Data Channel Module

The TID-III (Time-Independent Data) Channel Module allows true isochronous/- plesiochronous data communication in a TMS-3000. The TID-III Data Channel Module accepts RS-422 data and clock inputs at any one of 18 standard rates from 1.0 Kbps to 1.024 Mbps. The TID-III is programmed to accommodate special rates or to automatically track variable rate input clocks up to a specified maximum.

The TID-III Data Channel Module utilizes both RS-422 clock and data inputs. These inputs are time dependent from the multiplexer timing. The isochronous/plesiochronous data is converted to the next higher TDM synchronous data rate. Time-independent data is then recovered at the remote end of the link and the appropriate clock is generated by a numerically controlled oscillator (NCO) for output of data.

The TID-III Data Channel Module consists of three pc boards. The transmitter board consists of an RS-422 interface, a logic interface circuit, control and status circuits, buffers, and front panel status indicators. The receiver board contains a data correlator, FIFO buffers, and data accumulator circuits. The numerically controlled oscillator (NCO) is a piggyback mounted on the receiver board. The function of the NCO is to generate the appropriate clock for data output. The TID-III Data Channel Module fits into the expansion shelf cabinet.

When installed in two TMS-3000s, the TID-III Data Channel Module pair establishes a full-duplex data link between corresponding TMS-3000 sites. TID-III Data Channel Modules may be installed at both ends of the link or, alternately, a TID-III Data Channel Module may be at one end of a link with either a TID I (ECH-11) or TID-II (ECH-12) Data Channel Module installed at the remote end.

The TID-III Data Channel Module is equipped with an automatic alarm detector which provides a front panel indication of alarm conditions if there is a malfunction.

The TID-III Data Channel Module provides five modes of operation. Modes 1 through 3 provide data bit delay, external receive clock timing, and allow tracking of varying input frequencies. Mode 4 emulates the operation of an ECH-11 channel. An automatic mode of operation (Mode 5) allows a TDM rate to be selected, and a channel tracks this rate within the range of 200 bps to 1.024 Mbps.

The TID-III Data Channel Module is configured through the Controller. A control interface is consistent with other TMS-3000 channels for control and status display screens. A TID control/status screen, comparable to other existing channel screens, is provided. Miscellaneous tests for the TID-III Data Channel Module are available. In addition, the TID-III Data Channel Module screen includes protected fields, conditional and otherwise, that may be necessary to prevent misconfiguration.

Voice II Channel Modules

The Voice II Channel cards convert voice grade telephone signals to synchronous data which are multiplexed to the remote site and reconstructed as voice signals.

Two types of Voice II Channel cards may be used with the TMS-3000 system. These are defined as follows.

Voice II/CVSD Channel Module

This card converts voice grade telephone signals to synchronous data, which is multiplexed to the remote site and converted back to a voice signal. The continuously-variable-slope delta (CVSD) modulation technique is used for the voice-to-data conversion process. Input and output amplitudes for the card are selectable.

Data rates are selectable from 14.4 Kbps to 64.0 Kbps. Voice quality improves as the data rate increases. *Appendix A in GDC 036R603-Vnnn lists the available rates.*

The card also supports all types of 4-wire E and M signaling. You can choose E-Lead states (idle or busy) for loss of synchronization or power.

Voice II/ASP Channel Module

The ASP (Advanced Speech Processing) module can give quality voice reproduction while using only 16.8 Kbps of aggregate bandwidth.

The data rate for the Voice II/ASP Channel Module is selectable at either 16 Kbps in the ASP mode or 64 Kbps in the PCM mode. Aggregate bandwidth of 16.8 Kbps for signaling and 64.8 Kbps for overhead are needed. A multirate ASP card is also available for the TMS-3000.

Universal Voice Card

The Analog Universal Voice Card configures the TMS to provide full-duplex voice communication capabilities. By using certain configurations of the Universal Voice card, Pulse Code Modulation (PCM) and Adaptive Differential Pulse Code Modulation (ADPCM) is provided. The card connects to the backplane of the TMS-3000 Channel Expansion shelf through dual 28-pin card edge fingers.

- Universal Voice Card (*GDC 036P265-002*) — This card provides PCM voice encoding at a data rate of 64 Kbps.
- Universal Voice Card (*GDC 036P265-003*) — This card provides ADPCM voice encoding at software controlled variable data rates of 16 Kbps, 24 Kbps, or 32 Kbps with a PCM fallback mode (PCM-T) at a 64 Kbps rate.

Echo Canceller Piggyback Card

The Echo Canceller Piggyback Card (*GDC 036P270-001*) mounts on the Universal Voice Card/PCM or the Universal Voice Card/ADPCM.

If a significant round-trip time delay (40 ms or more) occurs between the two ends of a line (caused by a long terrestrial line or a satellite link), an echo results which interferes with normal voice conversation. This echo may be eliminated by installing an Echo Canceller Piggyback Card on the Universal Voice Card located at each end of the system.

The design of the Echo Canceller is based upon an adaptive digital filter that attempts to model the impulse response of the analog path through the external hybrid circuitry. By passing speech from the far end of the line through this filter, the Echo Canceller is able to generate a synthetic echo, which is subtracted from the actual echo. In this manner, the actual echo is canceled.

VLBRV Module

The VLBRV (Very Low Bit Rate Voice)/FAX Module is an analog voice channel card for the TMS-3000, TMSC, and the MINIMUX TDM. It furnishes voice encoding algorithms that maximize voice channel bandwidth utilization while offering low bit rate values of 9600 and 4800 Kbps.

The VLBRV Module is found in transmission applications to maximize available bandwidth. Applications include digital services such as ASDS (FT-1), ADN, satellite and feeder for a customer to integrate both voice and data. Voice communication is two-way, simultaneous (full duplex).

The Operating and Installation Instructions for the VLBRV module are covered in detail in *GDC 036R475-000.*

CELP Channel Module

The CELP Channel Module furnishes **CELP** (Codebook Excited Linear Prediction) voice encoding algorithms to make the most of voice channel bandwidth. The voice is compressed at rates of 4.8 Kbps, 6.4 Kbps, or 9.6 Kbps.

The CELP consists of base and piggyback cards. The base card converts four-wire analog voice to 64 Kbps synchronous data. The piggyback card uses CELP technology to compress the 64 Kbps data to 4.8 Kbps, 6.4 Kbps, or 9.6 Kbps. An adaptive digital echo canceller removes 8-millisecond near-end echoes.

The Operating and Installation Instructions for the CELP module are covered in detail in *GDC 036R480-000.*

Sync Status Module

The Sync Status Module (SSM) functions with high security TDM systems that employ cryptographic equipment to scramble aggregate data. The SSM accepts an input to report the synchronization status of scrambled aggregate data and transmits a TDM synchronization status output signal to the cryptographic equipment.

The SSM also supports dial backup applications of diverse ACC links and distinct ACC links. It senses an out of sync condition of the primary ACC link and uses its output signal to connect the backup link.

The SSM can be used on TMS-3000 and TMS Compact. *Detailed information on the SSM hardware is found in GDC 036R452-000 and GDC S-036R042-001.*

Power Supplies

The power supplies for the TMS-3000 are modular and may be removed from their mounting shelves without disconnecting power cables.

Up to four power supplies may be mounted in the power supply shelf. Two modules supply sufficient power for one fully redundant TMS-3000 Main Shelf.

A third power supply can, in most cases, power six expansion shelves. A fourth power supply is used for redundancy. See your configuration package for exact configuration specifications. If your configuration uses many ACC or CDA Modules, you may need more power supplies. *Refer to Appendix B in the TMS-3000 Installation and Operation manual (GDC 036R303-000) to determine the power requirement needed for your system.*

The GPS-8A and GPS-8B power supplies work with ac supply power; the DPS-8A works with 48-volt dc supply power. Each is described below.

NOTE

TMS-3000 units provided by General DataComm Ltd. in the United Kingdom may use other power supplies. If your TMS-3000 is supplied through General DataComm Ltd., contact your area manager for details on your power supply.

GPS-8A

Different GPS-8A models are available for three different ac line voltages.

- GPS-8A — 100/117 V ac
- GPS-8AE — 220 V ac
- GPS-8AU — 240 V ac

For more technical characteristics *refer to Appendix B of the Installation and Operation manual (GDC 036R303-000) and the Instruction Manual for GDC GPS-8A, GDC 035R007-000.*

GPS-8B

The GPS-8B is a universal input unit. The ac power cord uses an international color-coded ac line cord terminated in a UL/CSA approved molded three-prong USA type plug.

For more technical characteristics refer to Appendix B of the Installation and Operation manual (GDC 036R303-000) and the Operating and Installation Instructions for GDC GPS-8B, GDC 035R009-000.

DPS-8A

The DPS-8A uses 48-volt dc supply power for TMS-3000 sites with dc battery power available.

Bandwidth and Channel Configuration

When configuring a TMS-3000 system, you must know the number of circuits that your system supports, and you must have the hardware to support your circuits. Once the equipment of the TMS-3000 network is installed (or at least selected) you must know how many circuits can be configured through a node, a particular aggregate trunk, or a CIC.

The primary limitations to the number of circuits in the system are the bandwidths supported by various network components and the number of channels (that is, discrete segments of a circuit) supported by network components.

When you configure a system, the TMS-3000 Controller checks certain of these limitations and prevents you from exceeding limits in a configuration. Use of IAR simulation routines allows off-line checks to prevent exceeding limits in a configuration.

These limitations are discussed in the following paragraphs.

Bandwidth

In a TMS-3000 system, the term bandwidth reflects the total number of bits that can be transferred through a network component. An aggregate trunk such as a T1 carrier, for example, is said to have 1.544 MHz of bandwidth, meaning that 1.544 million bits may be transferred across a T1 link in one second.

The bits passing through a component can be broken down into two basic data categories: user and overhead. User data includes your data and the data transferred by each circuit; transmission of user data is the basic purpose of TMS-3000 and most other networking systems. Overhead data is all the data that controls the transfer of user data. Overhead can include:

- Supervisory data exchanged between the TMS-3000 Controller and each node.
- Synchronization data exchanged by ACCs at either end of an aggregate trunk.
- Control signals transferred through the system along with user data.
- Various types of filler or adjustment bits that correct specific problems in the network.

The total bandwidth of a component includes all overhead and user data transferred through the component.

Node Bandwidth

A TMS-3000 node is said to have a maximum node bandwidth of 16.896 MHz. This means that the node Fast Bus transfers data between the ACC, CIC, CDA, or IAC Modules at the node at a rate of 16.896 million bits per second.

Each of the ACCs and CICs are allocated some fraction of that bandwidth, in increments of 1.056 MHz.

To allocate the node bandwidth, do the following. If the sum of channel data rates for a CIC is less than 1.056 MHz, then the node bandwidth allocation for that card is 1.056 MHz. If the sum is greater than 1.056 MHz the allocation is 2.112 MHz. The total sum of channel bandwidths for any CIC must be less than 2.112 MHz. (CIC bandwidth is discussed in more detail later in this chapter.)

ACC node bandwidth is allocated according to the aggregate rate for the card and/or the sum of data rates of all circuits passing through the ACC. If the aggregate rate is less than 1.056 MHz, then 1.056 MHz of node bandwidth is allocated to that card.

When the aggregate rate is greater than 1.056 MHz (e.g., the T1 carrier of 1.544 MHz), either 1.056 MHz or 2.112 MHz of node bandwidth may be allocated to the card. The selection is based on the sum of the data rates of all circuits passing through the ACC. If the sum is less than 1.056 MHz, you may allocate only 1.056 MHz of node bandwidth to the card, since that is all that is required to transfer circuit data to and from the card across the node Fast Bus. If the sum of all circuit bandwidths plus overhead is greater than 1.056 MHz, you must allocate 2.112 MHz to the ACC or all of the circuits cannot be routed via that trunk.

The number of high-speed aggregate trunks or channels at a node may be increased by allocating 1.056 MHz of node bandwidth for aggregates. For example, if eight T1 aggregates are assigned 2.112 MHz of node bandwidth each, the total node bandwidth is consumed by those eight T1 aggregates. However, if each T1 aggregate is assigned 1.056 MHz of node bandwidth, then an additional 8.448 MHz of node bandwidth is left available. More ACCs or CICs may be installed at that node.

To assist in the configuration of an ACC at a node, invoke an IAR simulation test which automatically keeps track of circuit routing and required card bandwidth. IAR does not generate a configuration where the sum of circuit bandwidths exceeds the node bandwidth allocated to the ACC. By examining the results of simulation tests, you may more easily determine if 1.056M or 2.112M of node bandwidth is required. Allow the maximum allocated node bandwidth to aggregates. This permits increased flexibility during IAR routing. On the CIC, bandwidth is dynamically maintained.

The sum of bandwidth allocated for each ACM, ACC, CIC, DBC, CDA, IAC, or TPP Module cannot exceed 16.896 MHz. If trying to create a node configuration that exceeds that number, you are not allowed to save the node configuration. (Do not be confused by the bandwidth of a redundant pair of cards. Since only one of the cards operates at one time, the bandwidth allocation is for the redundant pair of cards.)

All common card configuration displays report the total node bandwidth and the node bandwidth allocated to that particular card.

Priority Control Bandwidth

For CDA/IAC modules, Priority Control bandwidth for each channel is calculated as follows:

```
MDCB = (2 * channel rate) / (MCPP * Char length) CTL/SEC
Where MDCB = Minimum dedicated priority bandwidth
Where MCPP = Minimum number of characters per poll
Char length= Character length
```

Assume 8 bits for Sync channels and use the actual number plus stop bits for ASYNC.

Minimum MDCB is 100 baud.

If one control is selected:

```
RPB = Minimum allowed framing rate higher than:
(MDCB + Minimum standard rate (100 baud))
Where RPB = Required Priority Bandwidth
```

If two controls are selected:

```
RPB = Minimum allowed framing rate higher than (MDCB *2)
```

ACCs and CICs use the following formulas to calculate priority bandwidth per channel. Note that PR stands for Polls/Sec.

For the TMS-3000 ACC, the required priority bandwidth per channel on the link is calculated as follows:

```
RPB = PR * 44
```

For the Universal MM+V4 ACC, the required priority bandwidth per channel on the link is calculated as follows:

```
RPB = PR * 40
```

For the TMS-3000 ACC, the required priority bandwidth per channel on the backplane is calculated as follows:

```
RPB = PR * 2
```

For the TMS-3000 CIC, the required priority bandwidth per channel is calculated as follows:

```
RPB = 2 * PR * BCW
Where BCW = Bits per control word = 24
Therefore RPB = PR * 48
```

Aggregate Control Card Bandwidth

The bandwidth of an ACC is determined by its aggregate data rate (the data rate of the associated aggregate trunk) and the node bandwidth allocated to that node. The smaller of those two numbers is the total aggregate bandwidth.

As the IAR routes the circuits, the TMS-3000 Controller keeps track of the amount of aggregate bandwidth that each circuit requires from each ACC through which it passes. In addition, the controller must allow aggregate bandwidth for overhead data. For T1 trunks, you may choose a ones density channel of 48 to 192 kHz to be multiplexed into the aggregate data stream to maintain synchronization on the T1 line.

When a route is created that includes a particular ACC, the TMS-3000 Controller checks the aggregate rate of that card. Each time a circuit is added to that route, the TMS-3000 Controller subtracts the data rate of that circuit from the card allocated node bandwidth.

It also subtracts the amount of overhead bandwidth configured for that card. The overhead amount subtracted may be up to 800 Hz higher than the overhead amount displayed; this is because the exact amount of overhead required is calculated by the ACC itself and may be higher than the standard overhead amount displayed.

If the trunk is a T1 line in the configuration, the TMS-3000 Controller also subtracts the data rate assigned for Ones Density.

The number left after these subtractions is the remaining bandwidth of the ACC. The calculations may be represented more precisely as:

```
Remaining bandwidth = Total aggregate bandwidth – [Circuit
data  bandwidth + Overhead bandwidth + Ones density (if on)
+ Sum of required priority control bandwidth]
```

The Remaining Bandwidth figure is reported in the IAR Data display for an ACC. This number indicates how many more circuits may be configured through the aggregate before the aggregate bandwidth is reached.

CDA and IAC Module Bandwidth

The bandwidth of a CDA or IAC module is determined by its link data rate and the node bandwidth allocated to that node. Either of these two numbers may be a limiting factor based on configuration and routing. The following is a discussion of subaggregate and backplane bandwidth

Subaggregate:

When you configure circuits, the TMS-3000 Controller keeps track of the link bandwidth that each CDA or IAC circuit requires from each CDA or IAC module that it passes through. The controller must also allow link bandwidth for the following:

- Overhead data
- Synchronized Data and Bit 7 stuffing
- The number of DS0 channels in use.

A logical link for an IAC/CDA module is designated as a bundle. A bundle is a group of DS0s that have a common termination point (e.g., a channel bank).

This link bandwidth depends on the number of DS0s configured for the link.

The full bundle bandwidth is the number of DS0s `*` 64K. The following formula is used to calculate the remaining bundle bandwidth:

```
CDA or IAC Bundle Bandwidth = Bundle rate - (Supervisory
overhead + Sync. rate + Sum of channel rates + Sum of priority
control bandwidth)
```

Only TMS-3000 bundles have Overhead, Synchronization, and Required Priority Bandwidth.

Backplane:

You configure the CDA or IAC Module from the CDA or IAC port configuration display. Select either 2.048 MHz or 992 kHz for the Allocated Node Bandwidth. The Total Bandwidth of the CDA or IAC Module on the Fast Bus is calculated via mux mapping selects:

```
If 992 MHz, backplane selects = 124. If 2.048 MHz, backplane
selects = 256.

# selects used = (8 * # TMS DS0s) + (8 * # TMS/Network DS0s)
+ (8 * # X.50 switching DS0s) + (8 * # DS0s used for clear
channel circuits) + (3 * Network DS0s) placed on the
backplane.
```

Each select is considered to occupy 8 kHz of bandwidth. Total allowed bandwidth is 992 kHz or 2.048 MHz.

Network channels passing from Port A to Port B do not contribute to CDA- E1 or IAC Module Fast Bus bandwidth. If the required bandwidth exceeds 992 kHz, then select 2.048 MHz for the allocated bandwidth.

Once configured, the remaining node bandwidth and CDA or IAC Module bandwidth available are shown at the top of the CDA or IAC port configuration display.

Channel Interface Card Bandwidth

When configuring bandwidth in a CIC, you can choose only one selectable parameter (controller rate) from the Node Configuration display.

This parameter is the rate at which the CIC exchanges data with ACCs or other CICs at the node.

Select either 2.112 MHz or 1.056MHz. The selection depends on the data rates of the channels communicating through the channel interface. If the sum of the rates of the channels is less than 1.024 MHz, select 1.056 MHz (the 32 kHz remaining provides bandwidth for multiplexing of controls).

If any configuration requires more than 1.024 MHz of bandwidth, select 2.112 MHz or circuits are deleted. If no configuration requires more than 1.024 MHz of bandwidth, select 1.056 MHz .

Overhead Data reports an estimate of overhead bandwidth required by the CIC. Overhead includes bandwidth for multiplexing control and synchronization information from each channel. When 1.056 MHz is selected as the controller rate, 32 kHz of bandwidth is allocated toward overhead data. When 2.112 MHz is selected, 64 kHz of bandwidth is allocated toward overhead data.

The Allocated Bandwidth figure determines the amount of node bandwidth allocated to the CIC.

The Bandwidth Remaining figure specifies those circuits configured with an end channel card communicating through the displayed CIC.

The sum of the bandwidths of those circuits is subtracted from the controller rate, along with a standard amount for overhead.

The Bandwidth Remaining figure indicates how much bandwidth is available for configuration of additional circuits through the CIC.

Bear in mind, however, that overhead for the channel interface is calculated dynamically at the TMS-3000 node, in response to the specific requirements of the circuit configurations. When the Remaining Bandwidth figure becomes less than 9600 Hz, take care in adding any additional circuits through the interface.

The Total Node Bandwidth for a CIC is calculated as follows:

```
Total node bandwidth = Total node bandwidth allocation -
(Circuit data bandwidth + Overhead bandwidth + Required
priority control bandwidth)
```

A Remaining Node Bandwidth figure is displayed at the bottom of the screen. This reports the total node bandwidth not yet allocated to the common cards at the node.

This figure is the difference between the maximum node bandwidth (16.896 MHz) and the bandwidth presently allocated for each configured aggregate and channel interface. The maximum node bandwidth that may be supported is 16.896 MHz. If the total node bandwidth exceeds 16.896 MHz, this statement is reported in red.

ACM Bandwidth

The amount of bandwidth that may be used by ACM may be limited by the Line Format and Allocated Bandwidth selected in the Port Configuration screen as shown in *Table 3*. Whenever the Allocated Bandwidth field of the Port Configuration Screen is changed, the circuit bandwidth is checked. If the bandwidth required by the existing circuits exceeds the limit, i.e. the Total Available Bandwidth listed in *Table 3*, some circuit(s) are deleted until the bandwidth consumed by the remaining circuits is within the limit. The circuits having lowest priority are deleted first. If the Line Format is changed from T1 to E1 or vice versa, all of the exisitng circuits are deleted.

Table 3 **A**CM Bandwidth Limitations

Allocated Backplane Bandwidth	Line Format	Total Available Port Bandwidth	Backplane Overhead*	Backplane Control Bandwidth per Channel
2.112 MHz	E1	2.0392 MHz	64 kHz	800 Hz**
2.112 Mhz	T1	1.9888 MHz	64 kHz	800 Hz
1.056 MHz	E1	0.9832 MHz	64 kHz	800 Hz**
1.056 MHz	T1	0.9888 MHz	64 kHz	800 Hz
*Overhead is equal to the amount of bandwidth used by ACM for control signals.				
**8 K for bundle.				

TPP Bandwidth

The amount of bandwidth that may be used by TPP may be limited by the Allocated Bandwidth selected in the TPP Port Configuration Screen. Whenever the Allocated Bandwidth field of the Port Configuration Screen is changed, the circuit bandwidth is checked. If the bandwidth required by the existing circuits exceeds the limit, some circuit(s) are deleted until the bandwidth consumed by the remaining circuits is within the limit. The circuits having lowest priority are deleted first. You are also notified when this happens by EXCEEDED appearing under Node BW Remaining.

When you have installed multiple TPPs in a node, you must enable Microcell transport (TPP Port Configuration screen), and the TPP cards must have the Microcell Interface card. This parameter affects all TPP cards in the node, not just the slot you are configuring.

Channel Number Limitations

The ACC, CIC, CDA, IAC, ACM, and TPP Modules each have an upper limit to the number of channels (segments of a circuit) that they can support.

A CIC has a maximum of 64 channels. For an ACC, the calculation is more complex. Each redundant or nonredundant ACC contains the circuitry to support 128 channels. In each card, one channel is dedicated as the overhead channel that carries overhead data across that aggregate to the remote node. In addition a channel must be dedicated to ones density and/or bandwidth management. This leaves 126 channels available for use by circuits.

A redundant pair of CDA or IAC Modules supports up to 254 channels. A nonredundant CDA or IAC Module can support up to 127 channels. If a nonredundant CDA Module is paired with an empty slot in the main shelf, the channel capacity increases to 254 channels. An ACM has a maximum of 24 channels for T1 and 32 channels for E1.

A TPP module supports a maximum of 64 channels.

Data Rates

A TMS-3000 system may be configured to operate with special aggregate or channel rates that you can enter from the Modify Special Rates menu selection on the TMS Controller. Standard aggregate data rates are listed in *Table 4*. *Table 5* lists available non-standard aggregate rates. *Table 6* lists special channel interface rates.

Standard/Special Data Rates

The TMS-3000 Network TDM system provides many standard data rates for circuits and aggregate trunks. In some cases, however, an application may require a nonstandard data rate, either for an aggregate trunk or a circuit. Special data rates may be created to meet these needs.

Several steps are involved in the creation of standard data rates. The ESCC at a node generates a set of high-frequency clock signals and places them on clock buses which extend to all ACCs at a TMS-3000 node.

The following clock signals are placed on clock buses:

2.304 MHz

2.048 MHz

1.544 MHz

1.024 MHz (Channel Modules only)

921.6 KHz

896 KHz (ACCs only)

224 KHz

100 KHz

1.536 MHz/Programmed Rate 1

1.344 MHz/Programmed Rate 2

Each ACC and Channel Module contains circuitry to divide one of the clock bus frequencies and obtain the clock signal for the desired data rate. The divider circuits are capable of the following "divide" operations:

- Divide by 3
- Divide by 9
- Divide by a multiple of 2 (from 2 to the first power to 2 to the 12th power). Divide by 2 to the nth power where $1 \leq n \leq 12$.

The clock bus frequency may also be selected without any divide operation. For example, if 1.024 MHz is selected as a channel data rate, the frequency need not be divided.

Each ACC and channel card is programmed to select one of the clock bus frequencies and pass it through one of the divide circuits or a combination of divide circuits. The cards are reprogrammed whenever a new configuration is activated. For example, to obtain a 9600-Hz clock signal, 921.6 kHz may be divided by 3, and then by 32 (which is 2 to the 5th power).

A channel card is programmed to apply the clock bus 2 frequency to the divide by 3 circuit and the divide by 32 circuit. This produces a 9600-Hz clock signal for channel timing. *Figure 10* is a simplified block diagram of the standard data rate generator system for channel cards.

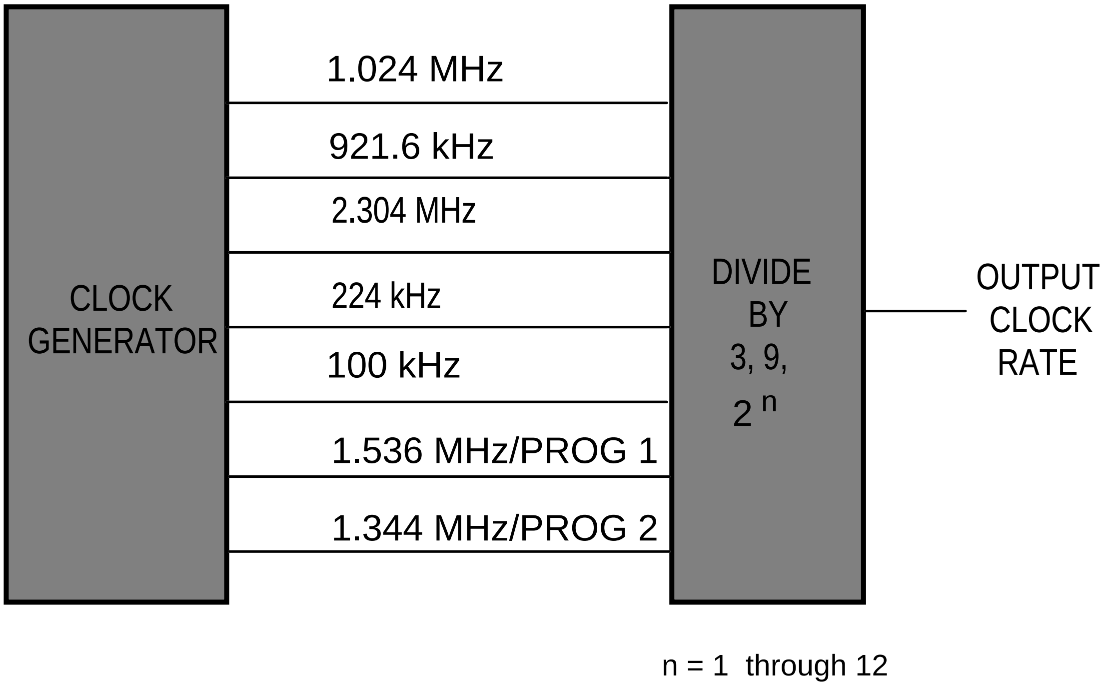


Figure 10 Standard Channel Clock Rate Generation

Special Data Rates

The TMS-3000 can generate special data rates; however, not all special data rates can be used. The following rules however, apply to special data rates:

- All special data rates must be evenly divisible by 25.
- Special data rates created for use on aggregate trunks may not be less than 4.8 kHz for a TMS-3000 node or less than 56 kHz for a Universal MM+V4 node.
- Some data rates may be generated, but may not be used as node timing sources.

Some special rates may be created by dividing one of the existing clock bus frequencies using the channel or aggregate clock dividers described above.

For some special data rates that cannot be produced using the standard clock dividers, the programmable clock generator on the ESCC is required. The programmable clock generator configuration selects one clock bus frequency and divides it to produce a nonstandard frequency. *Figure 11* is a simplified block diagram of the programmable clock generator.

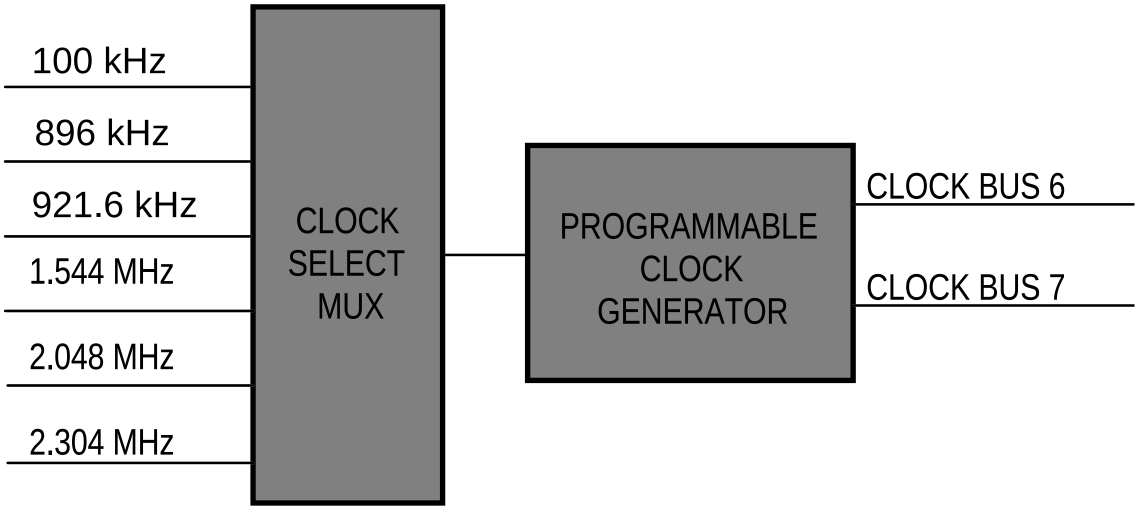


Figure 11 Programmable Clock Generator

As shown in *Figure 11*, the outputs of the programmable clock generator are placed on clock buses 6 and 7, respectively. When the programmable clock generator is not used, clock bus 6 carries a 1.536 MHz clock signal and clock bus 7 carries a 1.344 MHz clock signal.

Switches on the ESCC (Sw 3-4, Sw 3-5) determine which frequencies appear on clock buses 6 and 7. Sw 3-4 selects the clock signal for clock bus 6, either 1.536 MHz or programmable clock generator output 1 (PROG1). Sw 3-5 selects the clock bus signal for clock bus 7, either 1.344 MHz or programmable clock generator output 2 (PROG2).

When special rates are used, the 1.536 MHz and/or 1.344 MHz rates may not be available for use as aggregate data rates.

Also, if two special rates require different jumper settings at one node, then the two rates may not be used simultaneously at that node.

NOTE

If clock bus 6 is used for a special clock rate, 1.536 MHz is not available for use as an aggregate rate on RS-422 or V.35 aggregate trunks. However, 1.536 MHz is always available on T1/D4 aggregate trunks, regardless of the use of clock bus 6. T1/D4 aggregate data rates are derived from the 1.544 MHz clock signal.

The divider circuits on ACCs and channel cards are sometimes used to divide programmed frequencies and produce a special rate.

For example, to produce an 11.2 kHz clock signal, a 179.2 kHz clock signal could be generated by the programmable clock generator and placed on clock bus 6. A channel card could then divide that rate by 16 to create the 11.2 kHz clock signal.

Special rates are selected through the Modify Special Rates routine (one of the Configuration routines). Enter a desired rate; the Controller performs calculations and determines if the

- Rate can be generated
- Programmable clock generator (and clock buses 6 and 7) are required to produce the rate
- TMS-3000 node may be phase locked to the special rate
- Rate may be used for both channels and aggregates.

If the rate can be generated, it is displayed in the special rate list, along with other information on restrictions (if any) for rate usage. Whenever clock buses 6 or 7 are needed for the special rate, the display asks if the standard rates (1.536 MHz or 1.344 MHz) on those clock buses may be disabled. The special rate display then indicates the clock bus usage. Whenever a special rate requires these clock buses, you must make sure that:

- Jumpers X1 and X2 are placed properly to support clock bus usage.
- A configuration does not try to use two different clock bus frequencies on the same clock bus at the same node.

If you are unsure of the requirements for special rate usage, contact your GDC representative for information and assistance.

Table 4 Aggregate Data Rates

T1/D4 or T1/D4/E	**T1**	**ITU-T 2048M**	**64-kHz contra-dir**	**64-kHz co-dir**	**ITU-T V.35**	**MIL - STD 188-114**	**EIA/ TIA 232-E V.28**	**RS-422 (V.11)**	**RS-423 (V.10)**
1.536 M	1.544 M	2.048 M	64.00 K	64.00 K	4.8 K	4.8 K	4.8 K	4.8 K	4.8 K
					6.4 K	6.4 K	6.4 K	6.4 K	6.4 K
1.472 M*					7.2 K	7.2 K	7.2 K	7.2 K	7.2 K
					8.0 K	8.0 K	8.0 K	8.0 K	8.0 K
					9.6 K	9.6 K	9.6 K	9.6 K	9.6 K
					12.0 K	12.0 K	12.0 K	12.0 K	12.0 K
					14.0 K	14.0 K	14.0 K	14.0 K	14.0 K
					14.4 K	14.4 K	14.4 K	14.4 K	14.4 K
					16.0 K	16.0 K	16.0 K	16.0 K	16.0 K
					19.2 K	19.2 K	19.2 K	19.2 K	19.2 K
					24.0 K	24.0 K		24.0 K	24.0 K
					25.0 K	25.0 K		25.0 K	25.0 K
					28.0 K	28.0 K		28.0 K	28.0 K
					28.8 K	28.8 K		28.8 K	28.8 K
					32.0 K	32.0 K		32.0 K	32.0 K
					36.0 K	36.0 K		36.0 K	36.0 K
					38.4 K	38.4 K		38.4 K	38.4 K
					48.0 K	48.0 K		48.0 K	48.0 K
					50.0 K	50.0 K		50.0 K	50.0 K
					56.0 K	56.0 K		56.0 K	56.0 K
					57.6 K	57.6 K		57.6 K	57.6 K
					64.0 K	64.0 K		64.0 K	64.0 K
					72.0 K	72.0 K		72.0 K	72.0 K
					76.8 K	76.8 K		76.8 K	76.8 K
					96.0 K	96.0 K		96.0 K	96.0 K
					100.0 K	100.0 K		100.0 K	100.0 K
					112.0 K	112.0 K		112.0 K	
					115.2 K	115.2 K		115.2 K	
					128.0 K	128.0 K		128.0 K	
					144.0 K	144.0 K		144.0 K	
					153.6 K	153.6 K		153.6 K	
					192.0 K	192.0 K		192.0 K	

Table 4 Aggregate Data Rates (Cont.)

T1/D4 or T1/D4/E	T1	ITU-T 2048M	64-kHz contra-dir	64-kHz co-dir	ITU-T V.35	MIL - STD 188-114	EIA/ TIA 232-E V.28	RS-422 (V.11)	RS-423 (V.10)
					224.0 K	224.0 K		224.0 K	
					230.4 K	230.4 K		230.4 K	
					256.0 K	256.0 K		256.0 K	
					288.0 K	288.0 K		288.0 K	
					384.0 K	384.0 K		384.0 K	
					512.0 K	512.0 K		512.0 K	
					576.0 K	576.0 K		576.0 K	
					768.0 K	768.0 K		768.0 K	
					1.024 M	1.024 M		1.024 M	
					1.152 M	1.152 M		1.152 M	
					1.344 M	1.344 M		1.344 M	
					1.528 M*	1.528 M		1.528 M*	
					1.536 M	1.536 M		1.536 M	
					1.544 M	1.544 M		1.544 M	
					2.048 M	2.048 M		2.048 M	

*This rate must be externally provided. A special arrangement is required for use of these aggregate rates. Contact GDC for details.

Table 5 Special Non-Standard Aggregate Rates

ITU-T (V.35)	MIL-STD-188-114	EIA/TIA-232-E V.28	RS-422 (V.11)	RS-423 (V.10)
4825	4825	4825	4825	4825
5000	5000	5000	5000	5000
5250	5250	5250	5250	5250
5600	5600	5600	5600	5600
6000	6000	6000	6000	6000
6250	6250	6250	6250	6250
7000	7000	7000	7000	7000
8000	8000	8000	8000	8000
9000	9000	9000	9000	9000
9650	9650	9650	9650	9650
10000	10000	10000	10000	10000
11200	11200	11200	11200	11200
12500	12500	12500	12500	12500

Table 5 Special Non-Standard Aggregate Rates (Cont.)

ITU-T (V.35)	MIL-STD-188-114	EIA/TIA-232-E V.28	RS-422 (V.11)	RS-423 (V.10)
12800	12800	12800	12800	12800
14000	14000	14000	14000	14000
18000	18000	18000	18000	18000
19300	19300	19300	19300	19300
20000	20000		20000	20000
21000	21000		21000	21000
22400	22400		22400	22400
24125	24125		24125	24125
25000	25000		25000	25000
25600	25600		25600	25600
36000	36000		36000	36000
38600	38600		38600	38600
42000	42000		42000	42000
44800	44800		44800	44800
48250	48250		48250	48250
51200	51200		51200	51200
77200	77200		77200	77200
84000	84000		84000	84000
96000	96000		96000	96000
96500	96500		96500	
102400	102400		102400	
154400	154400		154400	
168000	168000		168000	
179200	179200		179200	
193000	193000		193000	
204800	204800		204800	
307200	307200		307200	
308800	308800		308800	
386000	386000		386000	
409600	409600		409600	
448000	448000		448000	
460800	460800		460800	
672000	672000		672000	
772000	772000		772000	
921600	921600		921600	
1344000	1344000		1344000	
	2034000			

Note**:** For the special nonstandard aggregate rate entry, any of the special rates listed in this table may be entered, in addition to the standard aggregate data rates listed in *Table 3*.

Table 6 Special Channel Interface Rates

ITU-T (V.35)	MIL-STD-188-114	EIA/TIA-232-E V.28	RS-422 (V.11)	RS-423 (V.10)
25	25	25	25	25
50	50	50	50	50
125	125	125	125	125
250	250	250	250	250
375	375	375	375	375
500	500	500	500	500
625	625	625	625	625
750	750	750	750	750
1125	1125	1125	1125	1125
1250	1250	1250	1250	1250
1400	1400	1400	1400	1400
1750	1750	1750	1750	1750
2250	2250	2250	2250	2250
2500	2500	2500	2500	2500
2625	2625	2625	2625	2625
2800	2800	2800	2800	2800
3000	3000	3000	3000	3000
3500	3500	3500	3500	3500
4500	4500	4500	4500	4500
4825	4825	4825	4825	4825
5000	5000	5000	5000	5000
5250	5250	5250	5250	5250
5600	5600	5600	5600	5600
6000	6000	6000	6000	6000
6250	6250	6250	6250	6250
7000	7000	7000	7000	7000
9000	9000	9000	9000	9000
9650	9650	9650	9650	9650
10000	10000	10000	10000	10000
11200	11200	11200	11200	11200
12500	12500	12500	12500	12500
12800	12800	12800	12800	12800
14000	14000	14000	14000	14000
18000	18000	18000	18000	18000
19300	19300	19300	19300	19300

Table 6 Special Channel Interface Rates (Cont.)

ITU-T (V.35)	**MIL-STD-188-114**	**RS-422 (V.11)**	**RS-423 (V.10)**
20000	20000	20000	20000
21000	21000	21000	21000
22400	22400	22400	22400
24125	24125	24125	24125
25600	25600	25600	25600
38600	38600	38600	38600
42000	42000	42000	42000
44800	44800	44800	44800
48250	48250	48250	48250
51200	51200	51200	51200
77200	77200	77200	77200
84000	84000	84000	84000
89600	89600	89600	89600
96500	96500	96500	96500
102400	102400	102400	102400
154400	154400	154400	154400
168000	168000	168000	168000
179200	179200	179200	179200
193000	193000	193000	193000
204800	204800	204800	204800
307200	307200	307200	307200
308800	308800	308800	308800
386000	386000	386000	386000
409600	409600	409600	409600
448000	448000	448000	448000
672000	672000	672000	672000
772000	772000	772000	772000
921600	921600	921600	921600

Note 1: For the special channel interface rate entry, any of the special rates listed in this table may be entered, in addition to the standard channel data rates listed in *Appendix A of GDC 036R603-Vnnn*.

Note 2: Special channel rates of 175, 350, and 700 may be selected if the special clock bus rate of 89.6K is the source.

Dial Backup

The Dial Backup function allows you to communicate from a Controller to a remote node that has become isolated from the network. Dial Backup utilizes Port 1 of the Controller as the alternate communications channel *(See Figure 12).* Port 1 of the Controller is defined as the DBU (Dial Backup) link. Port 0 is the primary port used for supervisory data connection to the TMS-3000.

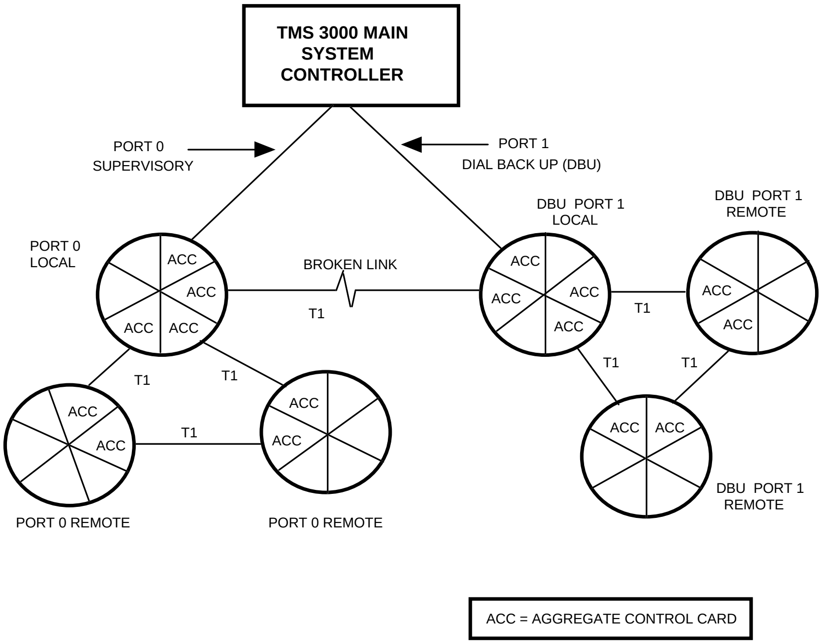


Figure 12 TMS-3000 Controller Configured for Dial Backup Operation

To access an isolated remote node, the local Controller has a phone number pre-stored in the node configuration screen. When the line is established, the Controller routes supervisory data along the DBU link. This permits the Controller to communicate not only with local nodes but the isolated network as well.

The Dial Backup port returns to normal once the Dial Backup function is terminated. This allows General DataComm Service to dial into the system from a remote terminal to troubleshoot the node.

You can initialize Dial Backup for test purposes. The Controller communicates on the DBU port. Messages addressed to the DBU port are sent to the remote node, but other nodes still communicate via the primary port.

Dial Backup uses an external modem at the remote node as well as the Controller, providing a high-security mode of Dial Backup. The Controller calls the remote node; the controller sends the password and the controller phone number to the remote node. The node validates the password, then the controller hangs up. The remote node calls back to reestablish the modem link so the problem can be diagnosed.

The passwords and method of Dial Backup are configured using the configuration routines of the Controller.

Physical Description

The main shelf of a TMS-3000 unit is contained in a dual mounting shelf with the following dimensions:

16.5 inches wide

14 inches high

16 inches deep

Channel expansion shelves have the following dimensions:

16.5 inches wide

7 inches high

10 inches deep

A separate power supply shelf for the GPS-8A, GPS-8B, or DPS-8A power supplies has the following dimensions:

17 inches wide

7 inches high

16 inches deep

TMS-3000 Main Shelf

A TMS-3000 Node includes a 16-slot main shelf that holds all ACC, ACM, CIC, CDA, IAC, TPP, and other common logic modules. Note that for TPP, there are two basic configurations, Frame Relay (FR) and Local Area Network (LAN). A TPP/FR card utilizes one main shelf slot, and the TPP/LAN card utilizes two main shelf slots. *Figure 13* illustrates the main shelf and the typical locations of each module.

Shelf slots are arranged in redundant pairs as follows:

1-2 3-4 5-6 7-8 9-10 11-12 13-14 15-16

Due to power limitations and cooling requirements, a maximum of 12 ACM Modules can be utilized in the TMS-3000 main shelf. The remaining 4 slots can contain either ACC or CIC, or CDA/IAC Modules. A maximum of 16 CDA/IAC Modules can be utilized in the TMS-3000 main shelf.

More CICs increase communication among the Channel Modules at the site. More ACCs increase the number of aggregate trunks with remote sites. Adding CDA modules increases the number of DS1 lines available and provides DS0 channel routing capabilities.

The ESCC and RCC occupy reserved slots on the main shelf. These cards must not be installed in any of the 16 slots reserved for the ACC, CIC, CDA or ACM Modules.

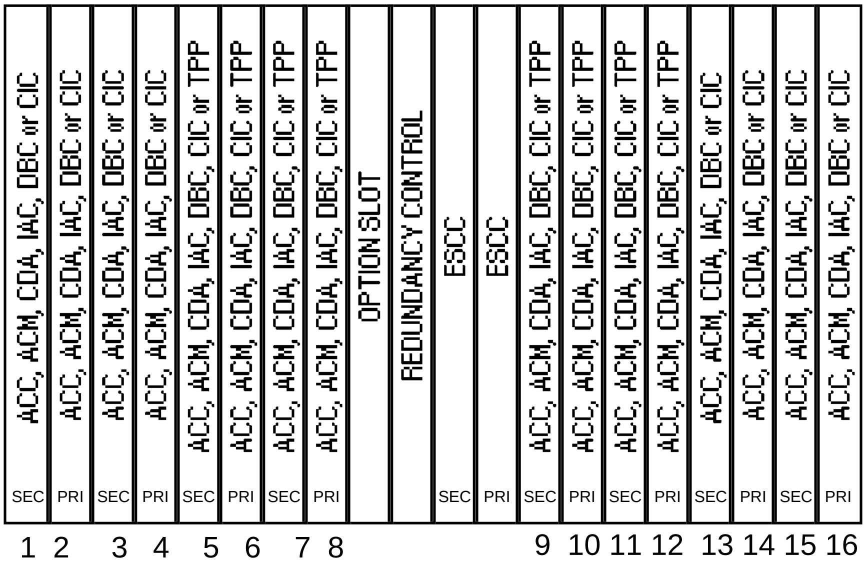


Figure 13 TMS-3000 Main Shelf

TMS-3000 Expansion Shelf

All channel modules at a TMS-3000 node reside in Expansion Shelves. A single Expansion Shelf holds up to 16 channel modules. An Expansion Module is required in each Expansion Shelf (two required for redundant operation). *See Figure 14*.

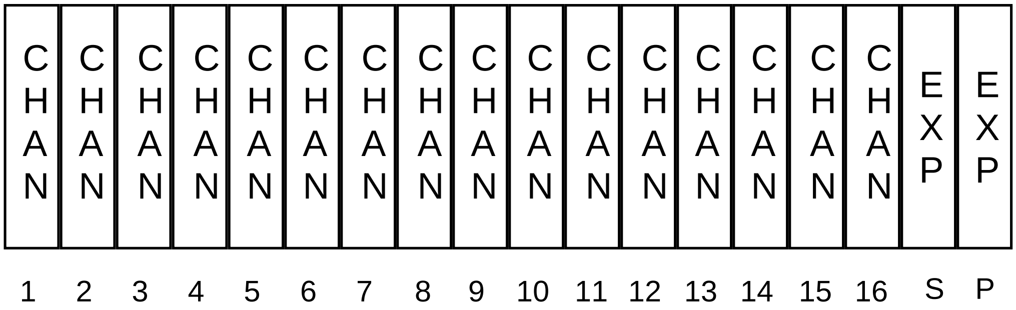


Figure 14 TMS-3000 Expansion Shelf

The Expansion Shelves house Data and Voice Channel Cards. These shelves are located underneath the TMS-3000 main shelf. Additional expansion shelves increase voice and data channel capacity at a TMS-3000 node. Each shelf holds up to 16 cards.

The TMS-3000 allows up to four expansion shelves to be mounted under the main shelf. Additional expansion shelves are incorporated by utilizing separate EP-4 or EP-2T cabinets. These shelves are attached to the main shelf with ribbon cables.

The Expansion Module includes a jumper option identifying a shelf as Expansion Shelf 1, 2, 3, or 4. The jumper setting assigns a shelf address to each Expansion Shelf linked to a particular CIC. Each channel slot in an Expansion Shelf is numbered from 1 to 16, from left to right. The channel slot number, in conjunction with the Expansion Shelf number, determines a unique channel number for each channel communicating through a CIC. The channel numbers range from 1 to a maximum of 64. Note that for a TMSC, channel numbers 11 – 16 are not used.

Flex Cards

Flex Cards represent an enhancement to the GDC TMS-3000. Flex Cards connect expansion shelves together, eliminating the need for ribbon cables. There are advantages with Flex Cards:

- Enhanced signal quality when using multiple shelves
- Easier installation and removal
- Improved reliability
- Improved access to the channel card EIA connector

The main shelf is still attached to the first expansion shelf by two ribbon cables. The lengths and number of connectors on each flex card differ to accommodate the number of expansion shelves configured for each channel group.

An optional Flex Card Upgrade Kit is used to add the Flex Cards to your present TMS-3000. This kit contains a redesigned rear cover which mounts behind the expansion shelf so that Flex Cards can be installed. The redesigned rear cover conceals the Flex Cards, offering a streamlined look behind the TMS-3000 system.

TMS Compact

There are two physical configurations of a TMSC node: standalone and rackmount.
A TMSC standalone consists of the TMSC main shelf only, with a standalone enclosure housing the main shelf. No more than 10 channels may be included in a standalone TMSC node. The standalone accepts ac power only. Dimensions of the standalone are:

19.25 inches wide
21.125 inches high
18.5 inches deep

A TMSC rackmount includes the TMSC main shelf and Channel Expansion shelves, as required, up to a maximum of three Channel Expansion shelves (a maximum of 58 channels).

In the rackmount configuration the expansion shelf (or shelves) must be next to the main shelf or directly under the main shelf. The TMSC rackmount is available in both ac- and dc-powered versions and may be housed in GDC EP-2T, EP-2M, or EP-4 cabinets.

The TMSC Main Shelf houses the TMSC Common Cards, 10 channel cards, and two DPS-8A, GPS-8A, or GPS-8B power supplies. Each section of the main shelf has a different depth. Dimensions of the TMSC Shelf follow:

16.5 inches wide
14 inches high
16 inches deep

Dimensions of a Channel Expansion Shelf are:

7 inches high
16.5 inches wide
10 inches deep

Equipment List

The components in redundant and non-redundant TMS-3000 units are presented in *Table 7*. The part numbers in the list generally represent assemblies made up of several discrete parts. *GDC 036R303-000* provides breakdowns of these assemblies into their respective parts. Technical characteristics of the TMS-3000 are presented in *Appendix B of the Installation and Operation manual (GDC 036R303-000).*

Table 7 Equipment List

Equipment Supplied	Designation	GDC Part No.
Common Equipment		
TMS-3000, Non-redundant	—	036M356-001
Enterprise System Control Card	ESCC	036M337-001
Aggregate Control Card	ACC-II	036M301-001
Aggregate Control Card*	ACC-IIE	036M313-003
CDA (Combined Digital Aggregate) Module*	CDA-T1	036M309-003
CDA-E1 (CDA ITU-T version) Module	CDA-E1	036M328-002
ACM /T1(ADPCM Compression Module)	ACM/T1	036M335-002
ACM/E1 (ADPCM Compression Module ITU-T version)	ACM/E1	036M335-001
Channel Interface Card	CIC-II	036P304-002
Redundancy Control Card	RCC-II	036P302-001
Expansion II*	EEC-II	036P307-002
TMS-3000 Expansion Shelf with Non-redundant Common Logic*	EXP 16/N	036M302-001
TMS-3000 Common Shelf Assembly	—	036B300-001
Backplane	—	036P300-001
TMS-3000 Expansion Shelf Assembly	—	036B301-001
Backplane	—	036P050-001
TMS-3000, Redundant	—	036M356-002
(2) Enterprise System Control Cards		036P336-001
(2) Aggregate Control Cards for each aggregate link leaving the node	ACC-II	036M313-001
(2) Channel Interface Cards for each group of channels being multiplexed	CIC-II	036P304-002
Redundancy Control Card	RCC-II	036P302-001
Expansion II*	EEC-II	036P307-002
TMS-3000 Expansion Shelf with Redundant Common Logic*	EXP 16/R	036M302-002
TMS-3000 Expansion Shelf Assembly*	—	036B301-001
Backplane	—	036P050-001
Software/Hardware		
TMS-3000 Software Set (4 node system)	—	036M318-001
TMS-3000 Software Set (128 node system)	—	036R316-001
TMS-3000 Controller Hardware Small System (4 Node)	—	036M314-001
TMS-3000 Controller Hardware Large System (128 Node)	—	036M317-001
* The number of these modules depends on the configuration of your system.		

Table 7 Equipment List (Cont.)

Equipment Supplied	Designation	GDC Part No.
Channel Equipment		
Data Channels:		
EIA/TIA-232-E Data II Channel	Data II/232	036M048-001
EIA RS-422 Data II Channel	Data II/422	036M048-002
EIA RS-423 Data II Channel	Data II/423	036M048-003
ITU-T V.35 Data II Channel	Data II/V.35	036M048-004
EIA/TIA-232-E DATA III Channel	Data III/232	036M058-001
EIA RS-422 DATA III Channel	Data III/422	036M058-002
EIA RS-423 DATA III Channel	Data III/423	036M058-003
ITU-T V.35 DATA III Channel	Data III/V.35	036M058-004
TID-III Data Channel Module	TID-III	18607-201
EIA/TIA-232-E Data IV Channel	Data IV/232	036M079-001
EIA RS-422 Data IV Channel	Data IV/422	036M079-002
EIA RS-423 Data IV Channel	Data IV/423	036M079-003
ITU-T V.35 Data IV Channel	Data IV/V.35	036M079-004
G.703 Data Channel		036P243-001
EIA/TIA-232-E UDC Module	UDC/232	036M078-001
EIA RS-422 UDC Module	UDC/422	036M078-002
EIA RS-423 UDC Module	UDC/423	036M078-003
ITU-T V.35 UDC Module	UDC/V.35	036M078-004
Hyper Plug-In Card	—	036P244-001
Voice Channels:		
Voice II/CVSD	Voice II/CVSD)	036P271-001
Voice II/ASP/16K	Voice II/ASP/16K	036M259-001
Voice II/ASP/Multi	Voice II/ASP/Multi	036M259-002
PCM Analog Universal Voice Card	UVC/PCM	036P265-002
ADPCM Analog Universal Voice Card	UVC/ADPCM	036P265-003
CELP	CELP	036M285-001 – 005
VLBRV	VLBRV	036M283-001, 002
Echo Canceller Card Plug-In	VEC1	036P270-001
Flex Board Assemblies		
Flex Board Assembly, L2	—	036P090-001
Flex Board Assembly, R2	—	036P091-001
Flex Board Assembly, L3	—	036P092-001
Flex Board Assembly, R3	—	036P093-001
Flex Board Assembly, L4	—	036P094-001
Flex Board Assembly, R4	—	036P095-001

Table 7 Equipment List (Cont.)

Equipment Supplied	Designation	GDC Part No.
Aggregate Interface Plug-In Cards		
EIA/TIA-232-E/ITU-T V.28 Aggregate Interface	EIF-E	036P041-001
ITU-T V.35 Aggregate Interface	EIF-V	036P042-001
EIA RS-422/423/MIL-STD-188/ITU-T V.10/V.11 Aggregate Interface	EIF-P	036P043-001
T1/D4 1.544 Mbps Aggregate Interface	T1/D4	036P315-002
	T1/D4	036P315-003
T1/D4/E Aggregate Interface	T1/D4/E (not for use in USA)	036P325-001
T1/FT1 Aggregate Interface	T1/FT1 (use in USA)	036P335-002
T1/DS0 Aggregate Interface	T1/DS0 (use in Canada)	036P335-001
ITU-T G.703 64 Kbps Codirectional Aggregate Interface	EIF-G	036P064-001
ITU-T G.703 2.048 Mbps 75-ohm Aggregate Interface	EIF-M1	036P065-001
ITU-T G.703 2.048 Mbps 120-ohm Aggregate Interface	EIF-M2	036P065-002
ITU-T G.703 64 Kbps Contradirectional Aggregate Interface	EIF-C	036P066-001
ITU-T G.703 256 Kbps 75-ohm Aggregate Interface	EIF-K1	336P065-001
ITU-T G.703 256 Kbps 120-ohm Aggregate Interface	EIF-K2	336P065-001
ITU-T G.704 2.048 MHz 75/120-ohm Aggregate Interface	—	036P281-001
T1-DS0 Aggregate Interface Piggyback	—	036P335-001
Power Supplies**		
GPS-8A Power Supplies, 100/117 V ac		
For 1 Non-redundant TMS-3000 Shelf	GPS-8A-1	035A001-001
For 1 Redundant TMS-3000 Shelf	GPS-8A-2	035A001-002
For 2 Non-redundant TMS-3000 Shelves	GPS-8A-3	035A001-003
For 2 Redundant TMS-3000 Shelves	GPS-8A-4	035A001-004
GPS-8A Power Supplies, 220 V ac		
For 1 Non-redundant TMS-3000 Shelf	GPS-8AE-1	035A002-001
For 1 Redundant TMS-3000 Shelf	GPS-8AE-2	035A002-002
For 2 Non-redundant TMS-3000 Shelves	GPS-8AE-3	035A002-003
For 2 Redundant TMS-3000 Shelves	GPS-8AE-4	035A002-004
GPS-8A Power Supplies, 240 V ac		
For 1 Non-redundant TMS-3000 Shelf	GPS-8AU-1	035A004-001
For 1 Redundant TMS-3000 Shelf	GPS-8AU-2	035A004-002
For 2 Non-redundant TMS-3000 Shelves	GPS-8AU-3	035A004-004
For 2 Redundant TMS-3000 Shelves	GPS-8AU-4	035A004-004

Table 7 Equipment List (Cont.)

Equipment Supplied	Designation	GDC Part No.
Power Supplies**		
GPS-8B Power Supplies, universal Vac		
For 1 Non-redundant TMS-3000 Shelf	GPS-8B-1-1	035A016-001
For 1 Redundant TMS-3000 Shelf	GPS-8B-1-2	035A016-002
For 2 Non-redundant TMS-3000 Shelves	GPS-8B-1-3	035A016-003
For 2 Redundant TMS-3000 Shelves	GPS-8B-1-4	035A016-004
DPS-8A Power Supplies, 48 V dc		
For 1 Non-redundant TMS-3000 Shelf	DPS-8A-1	041A003-001
For 1 Redundant TMS-3000 Shelf	DPS-8A-2	041A003-002
For 2 Non-redundant TMS-3000 Shelves	DPS-8A-3	041A003-003
For 2 Redundant TMS-3000 Shelves	DPS-8A-4	041A003-004
CDA I/O Plug-In Cards		
ITU-T G.732 (E1) I/O Plug-In Interface CEPT 2.048 MHz		036P282-001
T1 I/O Plug-In Interface 1.544 Mbps		036P310-001

*Required if updating an existing Transport Management System with Flex Board Assemblies. Not required on 036B301-001 if Revision F or later.

**If your configuration uses many ACCs, you may need more power supplies. *Refer to the power consumption section of Appendix A of the Installation and Operation of the TMS-3000 manual (GDC 036R304-000) to figure out the power requirement for your system.*

Configuration Examples

Because of the versatility of the TMS-3000, it is impossible to describe all of its configuration possibilities. Software does not allow a mixture of ACM, CDA, ACC or CICs in paired slots. Each common card must be paired with the same type of common card.

Aggregate Control Card and Channel Interface Card

Eight pairs of slots are reserved for the ACC and the CIC. The following rules apply:

1. Each CIC is capable of multiplexing a maximum 64 data and voice channels.
2. Each non-redundant CIC must be paired with an empty slot; only another CIC can go into the paired slot.
3. A non-redundant ACC configured for 128 channels must be paired with an empty slot. or another ACC/non-redundant 128.
4. Each ACC-II trunk reserves one channel (channel 0) to send system control supervisory information across the aggregate trunk.
5. If the aggregate has ones density "ON," then an additional channel is taken for ones density.
6. The allocated bandwidth must be considered when configuring a pair of CICs. If the sum of the data and voice channels interfaced by a CIC or another ACC equals less than 1/16 (1.056 Mbps) the bandwidth of the Fast Bus (16.896 Mbps), the bandwidth allocation is 1.056 Mbps. If the sum of data and voice channels equals more than 1/16 the bandwidth of the Fast Bus, the bandwidth allocation is 1/8 (2.112 Mbps) of the bandwidth of the Fast

Bus. For allocated bandwidth for ACCs, you have seven choices: 66.00KHz, 132.0KHz, 264.0KHz, 528.0KHz, 1.056MHz, 1.584MHz or 2.112MHz.

7. Because there is a control rate that takes up a small amount of bandwidth, the sum of the data and voice channels should not exceed 2.048 Mbps for a 1/8 allocation or 1.024 Mbps for a 1/16 allocation.

Table 8 shows two aggregate configuration examples. *Example 1* shows the configuration possibilities for a system with all non-redundant ACCs and all redundant CICs. Assume that each CIC is multiplexing the maximum 64 data and voice channels.

Think of the slots reserved for the ACC, CDA, CIC or ACM Module on the Main Shelf as eight pairs. Each pair of ACCs can interface a maximum of 256 TMS-3000 channels.

Example 2 in Table 8 shows a completely redundant system with a completely filled Main Shelf. It is assumed that each CIC is multiplexing the maximum 64 data and voice channels.

Both examples assume that the number of channels traveling over aggregates is the maximum number possible. Both also assume that no T1 trunks are being used.

CDA Module

Eight pairs of slots are reserved for the CDA Module. The following rules apply:

1. A non-redundant CDA Module supports up to 128 channels.
2. If a non-redundant CDA Module is paired with an empty slot, the channel capacity increases to 256 channels (selectable).
3. A redundant pair of CDA Modules can support up to 256 channels.
4. Two non-redundant CDA Modules can be paired if neither exceeds a 128-channel limit.
5. The allocated bandwidth must be considered when reserving backplane bandwidth for a CDA Module. If the sum of the data and TMS-3000 voice channels interfaced via the backplane by a CDA Module equals less than 1/16 (1.056 Mbps — one select) the bandwidth of the Fast Bus (16.896 MHz), the bandwidth allocation is 1.056 Mbps. If the sum of the data and TMS-3000 voice channels equals more than 1/16 the bandwidth of the Fast Bus, the bandwidth allocation should be 1/8 (2.112 Mbps) of the bandwidth of the Fast Bus (two selects).

ADPCM Compression Module

Six pairs of slots (12 ACMs) are reserved for the ACM. The following guidelines apply when configuring an ACM:

1. MSO Version 3.00 software (or later version) or GTS software is required to configure and install ACM. Earlier versions of TMS software do not support ACM.
2. An ACM can be configured as redundant or non-redundant.
3. Each installed ACM consumes one physical slot in the main shelf. Therefore, a redundant pair consumes two physical slots.
4. You may assign 1.056 or 2.112 Mbps of fast bus bandwidth to an ACM pair.
5. A redundant or non-redundant ACM in any slot has a standard aggregate pinout. ACM aggregate pinout is: Pins 2 and 14 (Transmit data) and Pins 3 and 16 (Receive data).

6. You can use any slot for a non-redundant ACM. The adjacent pair slot should be empty or used by another non-redundant ACM.
7. A redundant ACM switches to the standby ACM whenever the DS1 aggregate port detects an out-of-sync condition.
8. The DSBL switch on the front panel of the ACM places it in a low power drain mode for installing or removing the ACM.
9. ACM draws 5.8 amps from the + 5 V power supply.
10. Keep the ACM away from the end slots of the main shelf where there is minimal airflow.
11. The ACM cannot provide aggregate diversity.
12. A maximum of 12 ACMs (6 pairs) are to be installed in the main shelf regardless of the type of power supply installed.

Table 8 Aggregate Configuration Examples

Example 1. TMS-3000 Non-redundant Aggregate Configurations

Active Aggregate Ports	Non-RDN* Aggregate Control Cards	Channels Traveling over Aggregates	Channel Interface Cards	***Local Channels
0	0	0	16 (8 RDN Pairs)	512
1	1	63/127**	14 (7 RDN Pairs)	448
2	2	126	14 (7 RDN Pairs)	448
3	3	189/253	12 (6 RDN Pairs)	384
4	4	252	12 (6 RDN Pairs)	384
5	5	315/379	10 (5 RDN Pairs)	320
6	6	378	10 (5 RDN Pairs)	320
7	7	441/505	8 (4 RDN Pairs)	256
8	8	504	8 (4 RDN Pairs)	256
9	9	567/631	6 (3 RDN Pairs)	192
10	10	630	6 (3 RDN Pairs)	192
11	11	693/757	4 (2 RDN Pairs)	128
12	12	756	4 (2 RDN Pairs)	128
13	13	819/883	2 (1 RDN Pair)	64
14	14	882	2 (1 RDN Pair)	64
15	15	945/1009	0 (0 RDN Pairs)	0
16	16	1008	0 (0 RDN Pairs)	0

Example 2. TMS-3000 Redundant Aggregate Configurations

Active Aggregate Ports	Aggregate Control Card	Channels Traveling over Aggregates	Channel Interface Card	***Local Channels
0	0	0	16 (8 RDN Pairs)	512
1	2 (1 RDN Pair)	127	14 (7 RDN Pairs)	448
2	4 (2 RDN Pairs)	254	12 (6 RDN Pairs)	384
3	6 (3 RDN Pairs)	381	10 (5 RDN Pairs)	320
4	8 (4 RDN Pairs)	508	8 (4 RDN Pairs)	256
5	10 (5 RDN Pairs)	635	6 (3 RDN Pairs)	192
6	12 (6 RDN Pairs)	762	4 (2 RDN Pairs)	128
7	14 (7 RDN Pairs)	889	2 (1 RDN Pair)	64
8	16 *8 RDN Pairs)	1016	0 (0 RDN Pairs)	0

*Non-redundant in this example means two independent aggregates are next to each other — or an aggregate is paired with an empty slot.

**If all slots are filled/if paired slot is empty.

***Includes one channel for supervisory communications and may include one channel for ones density (if enabled).

Summary

In this manual we gave you an introduction to networks, the various parts of the TMS-3000 including the TMS-3000 Controller and several software features. We also discussed the hardware including the common cards, channel cards, power supplies, and shelves. Also discussed were special rates and dial backup. A parts list was provided. Examples of configuration parameters were discussed.

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