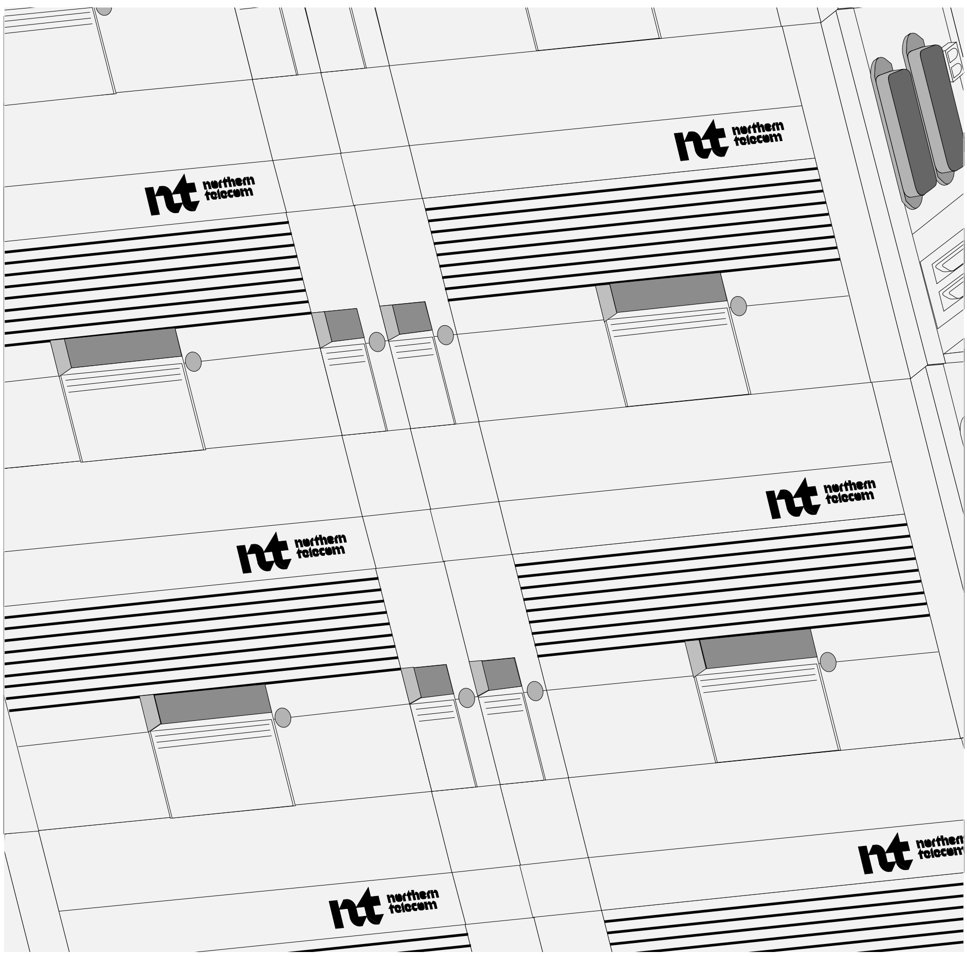
NT4K00LA 323-3001-155

SONET Products

AccessNode

Line Card Application and Special Service Engineering

Issue 3.0 October 1999



NORTEL NETWORKS™

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Publication number: 323-3001-155
Document release: Issue 3.0
Date: October 1999

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Printed in Canada

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Publication history

October 1999

AN17.20 Standard release of the document, Issue 3.0. Added information on IDSL to chapter 1. Also in chapter 1, moved information on 3DS0 ISDN from the “Locally Switch Services—2-wire applications” to “Nonlocally switched services—2-wire applications.”

June 1999

AN17 Standard release of the document, Issue 2.0. Changes include support for 3DS0 ISDN.

February 1999

AN16 Standard release of the document, Issue 1.0.

- Added references to DMS-X interface to APC-100 in Chapter 1.

June 1998

AN15 Standard 01.01 release of the document.

September 1997

AN14 Standard 01.01 release of the document.

July 1996

AN12 Standard 01.01 release of the document.

November 1995

AN11Standard 02.01 release of the document.

April 1995

AN10 Standard release of the document.

March 1995

Addendum release to the standard AN08 version of this document. Changes include information about error correction on digital data services (DDS) in Chapter 1.

December 1994

AN08 Standard release of the document. Changes include: TR-08 line card services in Chapter 1, additional balance networks for the NT4K67 station line card in Chapter 2, and other minor changes.

November 1994

AN07 Standard release reissued with improvements.

April 1994

AN07 Standard release of the document.

May 1993

FWP06 Standard release of the document.

Contents

About this document

This document describes some of the applications for AccessNode line cards. It includes engineering information for determining the values of transmission path parameter for special services circuits. This document applies to the current release for systems in North America and Hong Kong.

Audience

This document is for system engineers and administrators from Nortel Networks or a telephone operating company.

How to use this document

This document describes AccessNode's line card applications and explains how to determine line card prescription settings.

Line card applications

Line card applications for universal, integrated and DS1 tandem applications are listed and described in Chapter 1 of this document.

Determining prescription settings

Most provisioning information is defined in the customer service order for the circuit being provisioned. This document shows you how to determine initial provisioning values for transmission path parameters. Chapter 2 covers hybrid balance, equalization, and gain for 2-wire circuits, and Chapter 3 covers equalization and gain for 4-wire circuits. Instructions refer to the cable makeup and to tables in "Appendix A: Tables of prescription settings." Chapter 4 covers gain transfer and carrier serving area (CSA) guidelines.

If you do not know the cable makeup, see Chapter 5 of this document for procedures to determine the equalization, gain, and impedance of the 4-wire line card.

After you determine prescription settings, see *Line Card Provisioning Procedures*, 323-3001-315, in *Operations, Administration, and Provisioning*, Volume 4B, to provision a new customer line. After you complete initial provisioning, execute the loop lineup tests to verify or fine-tune the settings.

References in this document

This document refers to the following documents:

Description, Volume 2B

- *Line and Loop Testing Overview*, 323-3001-115
- *Line Card Specifications*, 323-3001-181

Operations, Administration, and Provisioning, Volume 4B

- *Line Card Provisioning Procedures*, 323-3001-315
- *Line Card Testing Procedures*, 323-3001-316

Line card applications

This chapter describes how to use AccessNode line cards for various customer services in North America and Hong Kong. It includes the following information:

- engineering information
- provisionable service codes and parameters for each line card type
- market applications for each line card
- details for equipping line cards
- provisioning service codes for each market

> ***Note 1:*** For specification details about line cards, see *Line Card Specifications*, 323-3001-181, in *Description*, Volume 2B.
>
> ***Note 2:*** In general, the line cards are designed to carrier serving area (CSA) design limits. For more information about CSA limits, see Chapter 4, "Circuit engineering guidelines."

Chapter contents

This chapter contains the following topics:

Introduction to system applications and circuits

Before you use this document, you need to know about the different applications and circuit types.

Application types

AccessNode supports the following applications:

Universal applications contain universal digital loop carrier (UDLC) circuits. They may contain DS1 tandem, DS1 transport, and DS3 transport circuits. Universal applications require an access bandwidth manager (ABM) shelf at both the fiber central office terminal (FCOT) and the remote fiber terminal (RFT).

Integrated applications contain GR-303 DMS, GR-303 MVI, or TR-08 circuits. They may contain DS1 tandem, DS1 transport, and DS3 transport circuits. Integrated applications can reside on either an ABM or a transport bandwidth manager (TBM) shelf at the FCOT. An integrated application requires an ABM shelf at the RFT.

Combined applications contain UDLC circuits plus GR-303 DMS, GR-303 MVI, or TR-08 circuits. They may contain DS1 tandem, DS1 transport, and DS3 transport circuits. Combined applications require an ABM shelf at both the FCOT and the RFT.

High capacity transport circuit types

AccessNode supports the high capacity transport circuits listed in Table 1-1.

Table 1-1
High capacity transport circuits

Circuit type	Application	Mapper	Mapper locations
Transport DS1	Any application with available slots	DS1/VT	Both the FCOT and RFT
Transport DS3	Any application except a combined application with an operations controller (OPC) at the FCOT	DS3/STS	Both the FCOT and RFT

DS0 circuit types

AccessNode supports the following types of DS0 circuits:

DS1 tandem circuits carry DS0 traffic to the FCOT from RFT line card terminations. The traffic enters and exits the FCOT on DS1s. Tandem circuits are nonlocally switched or nonswitched. They require a DS1/VT mapper at the FCOT.

Integrated circuits carry DS0 traffic to the FCOT from RFT line card terminations. The traffic enters and exits the FCOT on DS1s. Integrated circuits terminate on a digital switch. They require a DS1/VT mapper at the FCOT and the RFT. (GR-303 and DS1 tandem circuits can use the same mapper.)

Universal circuits exit the FCOT at the voice frequency level. They require line cards at both the FCOT and the RFT.

Line card service capabilities

The following AccessNode line cards offer a full range of services:

- NT4K65 Epsilon station line card
- NT4K65CA Epsilon station line card (for Hong Kong only)
- NT4K67 Omega 2-wire station line card
- NT4K68 Omega 2-wire office line card
- NT4K69 Omega 4-wire line card
- NT4K77 Omega 6/8-wire line card
- NT4K78 Omega 2-wire manual ringdown line card
- NT4K79 Omega 2-wire universal voice grade line card

These line cards allow the remote provisioning of both service type and transmission parameters. Table 1-3 on page 1-10 shows the service types associated with each line card.

Omega line cards

Omega line cards support locally switched services and special services. The special services can be locally switched, nonlocally switched, or nonswitched. Omega line cards are service-adaptive. Rather than replacing the line card to add a new subscriber service, you download service-specific software to the line card. The software load is data-filled with parameter values defined by the line card's circuit design. Because of this service adaptability, an Omega line card supports a variety of services.

Omega 2-wire line cards support the following applications for locally switched services:

- single-party residential (POTS)
  - CLASS/CMS service
- coin
  - dial tone first
  - coin first
  - semi-postpay
- Meridian Digital Centrex
  - single-party
  - attendant console, integrated application only
  - electronic business set (EBS), GR-303 DMS applications only
- integrated services digital network (ISDN), GR-303 DMS and GR-303 MVI applications only
- loop reverse battery, GR-303 MVI applications only

- business services
  - single-party business
  - switched voiceband data
  - WATS line
  - 800-service line
  - secretarial line
  - off-premise extension (OPX), bridged at the central office end
- PBX trunks
  - direct-outward-dial (DOD)
  - direct-inward-dial (DID)
  - local central office (CO)
  - WATS trunks
  - 800-service trunks

Omega 2-wire line cards support the following applications for nonlocally switched services:

- foreign exchange (FX) lines
  - single-party
  - WATS line (interoffice)
  - 800-service line (interoffice)
  - secretarial line (interoffice)
  - off-premise extension (OPX), bridged at the station end (interoffice)

Omega 2-wire line cards support the following applications for nonswitched services:

- off-premise station (OPS)
- private line automatic ringdown, types 1 and 2 (PLAR1, PLAR2)
- private line analog data
  - transmission only (TO)
  - equalized transmission only (ETO)

NT4K65 Epsilon 2-wire station line card

The NT4K65 Epsilon 2-wire station line card is a low-cost alternative to the NT4K67 Omega station line card for basic POTS locally switched services in universal and integrated applications.

The NT4K65 line card supplies a current source (battery feed) interface for both analog and digital 2-wire subscriber loops. It limits current to reduce power dissipation when driving short loops. It can provide loop supervision up to a service range of 1900 ohms.

> ***Note:*** The Epsilon line card does not meet TR57 off-hook requirements for loop resistance greater than 1000 ohms.

In a universal application, the NT4K65 Epsilon line card installs in the RFT and the NT4K68 Omega office line card installs in the FCOT. The line card is provisioned with a POTSRT service code.

In an integrated application, the NT4K65 Epsilon line card installs in the RFT. GR-303 MVI applications require the NT4K65AB version of the Epsilon line card. The line card is provisioned as LSR (loop-start residential) in a GR-303 DMS application, as POTSRT in a TR-08 application, or as MVIPOTS in a GR-303 MVI application.

See Table 1-3 on page 1-10 for a list of this line card’s service codes.

NT4K67 Omega 2-wire station line card

The NT4K67 Omega 2-wire station line card supplies a current source (battery feed) interface for both analog and digital 2-wire subscriber loops and for 2-wire analog special services. It has current limiting to reduce power dissipation when driving short loops.

When the customer loop exceeds 1000 ohms, the 2 dB attenuation in the line card is removed so that the serving range can be extended. Under the correct conditions (such as loaded cable), this line card can power a POTS loop up to a service range of 1900 ohms, including the set.

For COIN, the NT4K67 line card supplies loop powering and signal transmission up to 1370 ohms, including the set. The service range for other services is within CSA guidelines. Table 1-11 on page 1-30 lists the loop ranges of other services using this line card.

See Table 1-3 on page 1-10 for a list of this line card’s service codes.

NT4K68 Omega 2-wire office line card

The NT4K68 Omega 2-wire office line card supplies a current sink loop interface for 2-wire central-office switched and nonswitched special service line circuits. It operates on a loop length within CSA loop guidelines. Current limiting reduces power dissipation when connected to conventional loop feeds. See Table 1-3 on page 1-10 for a list of this line card’s service codes.

NT4K69 Omega 4-wire line card

The NT4K69 Omega 4-wire line card supplies 4-wire special services (nonlocally switched and nonswitched). The Omega 4-wire line card provides an interface for both analog and digital 4-wire special services.

The NT4K69 Omega line card supports the following applications for nonlocally switched services:

- foreign exchange (FX) interoffice trunks
  - long distance
  - automatic call distributor (ACD)
  - WATS
  - 800-service

The NT4K69 Omega line card supports the following applications for nonswitched services:

- PBX tie trunks with duplex (DX) signaling
- private line analog data
  - transmission only (TO)
  - equalized transmission only (ETO)
- digital data service (DDS)
  - dataport, office channel unit (OCUDP)
  - dataport, digital signal zero (DS0DP)

See Table 1-3 on page 1-10 for a list of this line card’s service codes.

NT4K77 Omega 6/8-wire line card

The NT4K77 Omega 6/8-wire line card supplies an interface for analog 6/8-wire nonswitched and nonlocally switched special services. It supports the following applications for nonlocally switched services:

- FX trunks for long distance, ACD, WATS, or 800-service
  - tandem carrier interface (three-state) for services requiring loop or ground start supervision

The NT4K77 Omega line card supports the following applications for nonswitched services:

- PBX tie trunks
  - E&M two-state signaling (type 1, 2, or 3)
  - pulse link repeater, two-state (type 1 or 2)
  - tandem two-state signaling (type 1 or 2)

- outside plant station (OPS)
  - — tandem carrier interface (three-state)

See Table 1-3 on page 1-10 for a list of this line card's service codes.

NT4K78 Omega 2-wire manual ringdown line card

The NT4K78 Omega 2-wire manual ringdown (MRD) line card supplies an interface for a manual ringdown line, which is one type of point-to-point private line (nonswitched) service.

An MRD service requires the NT4K78 Omega 2-wire MRD line card at the RFT. In a point-to-point fiber-fed system, the equipment required at the FCOT depends on the circuit destination. The equipment could be another NT4K78 Omega MRD line card, a DS0 channel on a DS1/VT mapper, or an NT4K77 Omega 6/8-wire line card. In a DS1-fed or single-ended system, no FCOT equipment is required.

See Table 1-3 on page 1-10 for a list of this line card's service codes.

NT4K79 Omega 2-wire universal voice grade line card

The NT4K79 Omega universal voice grade (UVG) line card is a lower cost alternative to the NT4K67 Omega station line card for basic locally switched services.

In a universal application, the NT4K79 UVG line card is installed at the RFT, and the NT4K68 Omega office line card is installed at the FCOT. The UVG line card supports UVGRT and POTSRT service codes.

In an integrated application, the NT4K79 UVG line card is installed at the RFT. In a GR-303 DMS application, the UVG line card supports LSR and loop ground business (LGB) service codes. In GR-303 MVI applications, the UVG line card is provisioned with the MVIPOTS or MVIUVG service code.

The NT4K79 UVG line card supports the following operating features:

- loop-start and ground-start signaling
- on-hook transmission
- CLASS
- toll diversion

See Table 1-3 on page 1-10 for a list of this line card's service codes.

Service codes associated with each line card

Several service code tables follow. Table 1-2 lists the DMS SuperNode card codes equivalent to the AccessNode GR-303 DMS service codes.

Table 1-2
GR-303 DMS service code equivalent names

AccessNode service code	DMS SuperNode cardcode
LSR	RDTLSG
LGB	RDTLSG
COIN	RDTCON
EBS	RDTEBS
ISDN	RDTISD
ILCLSR	RDTILC

Table 1-3 on page 1-10 lists the service codes that are assignable to each line card. The function column lists the full name of the service. Unless otherwise noted, the service codes apply to universal and DS1 tandem applications. Service codes for an integrated application are noted as GR-303 DMS or GR-303 MVI applications.

Table 1-3
Service codes associated with each line card

PEC Line card type	Service code	Function
NT4K65 Epsilon 2-wire station ***Note 1:*** MVIPOTS requires NT4K65AB. ***Note 2:*** Hong Kong requires NT4K65CA.	POTSRT	plain old telephone service
	LSR	plain old telephone service on GR-303 DMS, DMS Access, and DMS-X interface to APC-100
	MVIPOTS	plain old telephone service on GR-303 MVI
NT4K67 Omega 2-wire station	FXS	foreign exchange, station end
	DPO	dial pulse originating
	TOS	transmission only
	ETOS	equalized transmission only
	UVGRT	universal voice grade
	POTSRT	plain old telephone service
	COINRT	coin service
	MVIUVG	universal voice grade on GR-303 MVI
	MVIPOTS	POTS on GR-303 MVI, loop start only
	MVICOIN	coin service on GR-303 MVI
	PLAR1	private line automatic ringdown, original signaling standard
	PLAR2	private line automatic ringdown, newer signaling standard
	LSR	(loop start) residence POTS on GR-303 DMS, DMS Access, and DMS-X interface to APC-100
	LGB	(ground start) business UVG on GR-303 DMS, DMS Access, and DMS-X interface to APC-100

—continued—

Table 1-3 (continued)
Service codes associated with each line card

PEC **Line card type**	**Service code**	**Function**
NT4K67 Omega 2-wire station	COIN	coin service on GR-303 DMS and DMS Access
	EBS	electronic business set on GR-303 DMS and DMS Access
	ISDN_U	business ISDN on GR-303 DMS
	ISDN_U (GR-303_ISDN)	business ISDN on GR-303 MVI
	3DS0 ISDN or IDSL	in non GR-303 networks both of these services require a NT4K67AC Rel. 20 or higher
NT4K68 Omega 2-wire office	FXO	foreign exchange, office end
	DPT	dial pulse terminating
	TOO	transmission only
	ETOO	equalized transmission only
	UVGCT	universal voice grade
	POTSCT	plain old telephone service
	COINCT	coin service
	MVILRB	loop reverse battery, GR-303 applications on #5ESS switches only
NT4K69 Omega 4-wire analog or digital	FXO	foreign exchange, office end
	FXS	foreign exchange, station end
	DX	duplex signaling
	TO	transmission only
	ETO	equalized transmission only
	DDS	digital data service

—continued—

Table 1-3 (continued)
Service codes associated with each line card

PEC Line card type	Service code	Function
NT4K77 Omega 6-wire or 8-wire	E&M1	E&M signaling, type 1
	E&M2	E&M signaling, type 2
	E&M3	E&M signaling, type 3
	PLR1	pulse link repeater, type 1
	PLR2	pulse link repeater, type 2
	TDM1	tandem signaling, type 1, two-state
	TDM2	tandem signaling, type 2, two-state
	TDM1O	tandem signaling, type 1 office end, three-state
	TDM1S	tandem signaling, type 1, station end, three-state
	TDM2O	tandem signaling, type 2, office end, three-state
	TDM2S	tandem signaling, type 2, station end, three-state
NT4K78 Omega 2-wire ringdown	MRD	manual ringdown
NT4K79 Omega UVG 2-wire station	UVGRT	universal voice grade on UDLC
	MVIUVG	universal voice grade on GR-303 MVI
	POTSRT	plain old telephone service on UDLC
	MVIPOTS	plain old telephone service on GR-303 MVI
	LSR	loop-start residential POTS on GR-303 DMS
	LGB	loop-start/ground-start business UVG on GR-303 DMS

—end—

Line card compatibility in universal application

Table 1-4 shows the combinations of compatible service codes in a universal application where line cards are installed at both the FCOT and the RFT.

Table 1-4
Service code and line card compatibility (universal application)

PC-10800

RFT \ FCOT	2W FXO	2W FXS	2W DPT	2W DPO	2W TOS	2W TOO	2W ETOS	2W ETOO	2W UVGCT	2W POTSCT	2W COINCT	4W DX	4W TO	4W ETO	4-W FXO	4W FXS	4W DDS	6W E&M1	8W E&M2	8W E&M3	6W PLR1	8W PLR2	6W TDM1	8W TDM2	6W TDM1O	6W TDM1S	8W TDM2O	8W TDM2S	2W MRD	2W PLAR1	2W PLAR2
2W FXO		■														■									■		■				
2W FXS	■														■											■		■			
2W DPT				■																			■	■							
2W DPO			■																				■	■							
2W TOS					■	■	■	■					■	■																	
2W TOO					■	■	■	■					■	■																	
2W ETOS					■	■	■	■					■	■																	
2W ETOO					■	■	■	■					■	■																	
2W UVGRT									■																						
2W POTSRT										■																					
2W COINRT											■																				
4W DX												■						■	■	■	■	■	■	■							
4W TO					■	■	■	■					■	■																	
4W ETO					■	■	■	■					■	■																	
4W FXO		■														■									■		■				
4W FXS	■														■											■		■			
4W DDS																	■														
6W E&M1												■						■	■	■	■	■	■	■					■		
8W E&M2												■						■	■	■	■	■	■	■					■		
8W E&M3												■						■	■	■	■	■	■	■							
6W PLR1												■						■	■	■	■	■	■	■					■		
8W PLR2												■						■	■	■	■	■	■	■					■		
6W TDM1			■	■								■						■	■	■	■	■	■	■					■		
8W TDM2			■	■								■						■	■	■	■	■	■	■					■		
6W TDM1O	■														■											■		■			
6W TDM1S		■														■									■		■				
8W TDM2O	■														■											■		■			
8W TDM2S		■														■									■		■				
2W MRD																		■	■		■	■	■	■					■		
2W PLAR1																															
2W PLAR2																															■
2W ILCPOTS										■																					

■ Compatibility between FCOT and RFT line card services

□ Incompatibility between FCOT and RFT line card services

A line card compatibility table is not needed for DS1 tandem or integrated applications, because the only line card for each circuit is at the RFT.

Summary of service code parameters by line card

Tables 1-5 to 1-9 list and describe the provisionable parameters for each universal service code as it applies to each type of line card.

- Table 1-5: Epsilon and Omega 2-wire station line cards (NT4K65, NT4K67, and NT4K79 UVG)
- Table 1-6: Omega 2-wire office line card (NT4K68)
- Table 1-7: Omega 4-wire line card (NT4K69)
- Table 1-8: Omega 6/8-wire line card (NT4K77)
- Table 1-9: Omega 2-wire manual ringdown line card (NT4K78)

Table 1-5
Provisionable parameters for the NT4K65/67/79 2-wire station line cards

	Service codes							
Provisionable parameters	2W COIN RT	2W DPO	2W ETOS	2W FXS	2W POTS RT	2W TO S	2W UVG RT	2W PLAR
2-wire equalization slope		●	●	●				●
Balance resistance (simplex)								
Battery and ground pulsing (on/off)		●						
Busy tone								●
Cable (loaded/nonloaded)								
Customer remote test								
Data rate 2.4, 4.8, 9.6, 19.2, 56, or 64kb/s								
DDS line type								
Error correction								
Hybrid balance		●	●	●		●		●
Impedance 2-wire		●	●	●		●		●
Impedance 4-wire (transmit and receive)								
Trunk conditioning (on/off)		●		●				
Fulltime OHT (on/off)	●			●	●		●	
Receive equalization bandwidth								
Receive blocking			●			●		
Receive gain		●	●	●		●		●
Receive equalization height								
Receive on-hook transmission gain				●			●	
Receive equalization slope								
Red-lined connection	●	●	●	●	●	●	●	●
Sealing current								
Secondary channel								
Signaling leads (norm/reverse)								
Transmit equalization bandwidth								
Transmit blocking			●			●		
Transmit gain		●	●	●		●		●
Transmit equalization height								
Transmit on-hook transmission gain				●			●	
Transmit equalization slope								
Zero-code suppression								

Note: This table lists the provisionable parameters for POTS service on the NT4K65 Epsilon 2-wire line card, for POTS and UVG services on the NT4K79 Omega UVG 2-wire station line card, and for all of the listed services on the NT4K67 Omega 2-wire station line card.

Table 1-6
Provisionable parameters for the NT4K68 2-wire office line card

Provisionable parameters	Service codes: 2W COIN CT	2W DPT	2W ETOO	2W FXO	2W POTS CT	2W TOO	2W UVG CT
2-wire equalization slope		●	●	●			
Balance resistance (simplex)							
Cable (loaded/nonloaded)							
Customer remote test							
Data rate 2.4, 4.8, 9.6, 19.2, 56, or 64kb/s							
DDS line type							
Error correction							
Hybrid balance		●	●	●		●	
Impedance 2-wire		●	●	●		●	
Impedance 4-wire (transmit and receive)							
Trunk conditioning (on/off)		●		●			
Fulltime OHT (on/off)	●			●	●		●
Receive equalization bandwidth							
Receive blocking			●			●	
Receive gain		●	●	●		●	
Receive equalization height							
Receive on-hook transmission gain							
Receive equalization slope							
Red-lined connection	●	●	●	●	●	●	●
Sealing current							
Secondary channel							
Signaling leads (norm/reverse)							
Transmit equalization bandwidth							
Transmit blocking			●			●	
Transmit gain		●	●	●		●	
Transmit equalization height							
Transmit on-hook transmission gain							
Transmit equalization slope							
Zero-code suppression							

Table 1-7
Provisionable parameters for the NT4K69 4-wire line card

Provisionable parameters	Service codes					
	4W DDS	4W DX	4W ETO	4W FXO	4W FXS	4W TO
2-wire equalization slope						
Balance resistance (simplex)		●				
Cable (loaded/nonloaded)		●	●	●	●	
Customer remote test (notes 1, 2)	●					
Data rate 2.4, 4.8, 9.6, 19.2, 56, or 64kb/s	●					
DDS line type	●					
Error correction	●					
Hybrid balance						
Impedance 2-wire						
Impedance 4-wire (transmit and receive)		●	●	●	●	●
Trunk conditioning (on/off)		●		●	●	
Fulltime OHT (on/off)						
Latching loopback	●					
Receive equalization bandwidth		●	●	●	●	
Receive gain		●	●	●	●	●
Receive equalization height		●	●	●	●	
Receive on-hook transmission gain						
Receive equalization slope		●	●	●	●	
Red-lined connection	●	●	●	●	●	●
Sealing current			●			●
Secondary channel (notes 1, 2)	●					
Signaling leads (norm/reverse)		●		●	●	
Transmit equalization bandwidth		●	●	●	●	
Transmit blocking						
Transmit gain		●	●	●	●	●
Transmit equalization height		●	●	●	●	
Transmit on-hook transmission gain						
Transmit equalization slope		●	●	●	●	
Zero-code suppression (note 2)	●					

Note 1: for OCUDP DDS function only
Note 2: not valid for 64k rate

Table 1-8
Provisionable parameters for the NT4K77 6/8-wire line card

Provisionable parameters	Service codes										
	6/8W E&M1	6/8W E&M2	6/8W E&M3	6/8W PLR1	6/8W PLR2	6/8W TDM1	6/8W TDM1O	6/8W TDM1S	6/8W TDM2	6/8W TDM2O	6/8W TDM2S
2-wire equalization slope Balance resistance (simplex) Cable (loaded/nonloaded) Customer remote test											
Data rate 2.4, 4.8, 9.6, 19.2, 56, or 64kb/s DDS line type Error correction Hybrid balance											
Impedance 2-wire Impedance 4-wire (transmit and receive) Trunk conditioning (on/off) Fulltime OHT (on/off)	●	●	●	●	●	●	●	●	●	●	●
Receive equalization bandwidth Receive blocking Receive gain Receive equalization height	●	●	●	●	●	●	●	●	●	●	●
Receive on-hook transmission gain Receive equalization slope Red-lined connection Sealing current	●	●	●	●	●	●	●	●	●	●	●
Secondary channel Signaling leads (norm/reverse) Transmit equalization bandwidth Transmit blocking											
Transmit gain Transmit equalization height Transmit on-hook transmission gain Transmit equalization slope	●	●	●	●	●	●	●	●	●	●	●
Zero-code suppression											

Table 1-9
Provisionable parameters for the NT4K78 2-wire manual ringdown line card

	Service codes	
Provisionable parameters	2W MRD	
2-wire equalization slope		
Balance resistance (simplex)		
Cable (loaded/nonloaded)		
Customer remote test		
Data rate 2.4, 4.8, 9.6, 19.2, 56, or 64kb/s		
DDS line type		
Error correction		
Hybrid balance		
Impedance 2-wire		
Impedance 4-wire (transmit and receive)		
Trunk conditioning (on/off)		
Fulltime OHT (on/off)		
Receive equalization bandwidth		
Receive blocking		
Receive gain	●	
Receive equalization height		
Receive on-hook transmission gain		
Receive equalization slope		
Red-lined connection	●	
Sealing current		
Secondary channel		
Signaling leads (norm/reverse)		
Transmit equalization bandwidth		
Transmit blocking		
Transmit gain	●	
Transmit equalization height		
Transmit on-hook transmission gain		
Transmit equalization slope		
Zero-code suppression		

Service codes and their provisionable parameters

Table 1-10 lists the provisioning range and default values of the provisionable parameters (attributes) for each service code for the 2-wire source, 2-wire sink, 4-wire, and 6/8-wire line cards. These parameters are explained in *Line Card Provisioning Procedures*, 323-3001-315, in *Operations, Administration, and Provisioning*, Volume 4B.

Table 1-10
Service codes and their attribute values

Service code	Wire type	Attribute	Range	Default
FXO	2-wire	Transmit Gain	–5.0 to 6.5 dB	0.0 dB
		Receive Gain	–10.0 to 3.5 dB	0.0 dB
		Equalization	0 to 6	0
		Hybrid Balance	0 to 121	66
		Impedance	600 ohm, 900 ohm	900 ohm
		Off-hook trunk conditioning	On or Off	On
		Full-time on hook transmission	On or Off	Off
		Red-lined connection	On or Off	Off
FXS	2-wire	Transmit Gain	–5.0 to 6.5	–2
		Receive Gain	–10.0 to 3.5	–2
		Transmit OHT Gain	–10 to 0	–2
		Receive OHT Gain	–10 to 0	–2
		Equalization	0 to 6	0
		Hybrid Balance	0 to 136	136
		Impedance	600 ohm, 900 ohm	900 ohm
		Off-hook trunk conditioning	On or Off	On
		Full-time on hook transmission	On or Off	Off
		Red-lined connection	On or Off	Off

—continued—

Table 1-10 (continued)
Service codes and their attribute values

Service code	Wire type	Attribute	Range	Default
DPT	2-wire	Transmit Gain	–5.0 to 6.5	0.0
		Receive Gain	–10.0 to 3.5	0.0
		Equalization	0 to 6	0
		Hybrid Balance	0 to 121	68
		Impedance	600 ohm, 900 ohm	600 ohm
		Off-hook trunk conditioning	On or Off	On
		Red-lined connection	On or Off	Off
DPO	2-wire	Transmit Gain	–5.0 to 6.5	–2.0
		Receive Gain	–10.0 to 3.5	–2.0
		Dial pulse node	Loop or Battery ground	Loop
		Equalization	0 to 6	0
		Hybrid Balance	0 to 135	2
		Impedance	600 ohm, 900 ohm	900 ohm
		Off-hook trunk conditioning	On or Off	On
		Red-lined connection	On or Off	Off
TOS	2-wire	Transmit Gain	–5.0 to 6.5	–2.0
		Receive Gain	–10.0 to 3.5	–2.0
		Hybrid Balance	0 to 135	38
		Impedance	600 ohm, 900 ohm	600 ohm
		Transmit Blocking	Enabled, Disabled	Disabled
		Receive Blocking	Enabled, Disabled	Disabled
		Red-lined connection	On or Off	Off

—continued—

Table 1-10 (continued)
Service codes and their attribute values

Service code	Wire type	Attribute	Range	Default
TOO	2-wire	Transmit Gain	–5.0 to 6.5	0.0
		Receive Gain	–10.0 to 3.5	0.0
		Hybrid Balance	0 to 121	66
		Impedance	600 ohm, 900 ohm	900 ohm
		Transmit Blocking	Enabled, Disabled	Disabled
		Receive Blocking	Enabled, Disabled	Disabled
		Red-lined connection	On or Off	Off
ETOS	2-wire	Transmit Gain	–5.0 to 6.5	–2.0
		Receive Gain	–10.0 to 3.5	–2.0
		Equalization	0 to 6	0
		Hybrid Balance	0 to 135	38
		Impedance	600 ohm, 900 ohm	600 ohm
		Transmit Blocking	Enabled, Disabled	Disabled
		Receive Blocking	Enabled, Disabled	Disabled
		Red-lined connection	On or Off	Off
ETOO	2-wire	Transmit Gain	–5.0 to 6.5	0.0
		Receive Gain	–10.0 to 3.5	0.0
		Equalization	0 to 6	0
		Hybrid Balance	0 to 121	66
		Impedance	600 ohm, 900 ohm	900 ohm
		Transmit Blocking	Enabled, Disabled	Disabled
		Receive Blocking	Enabled, Disabled	Disabled
		Red-lined connection	On or Off	Off
MRD	2-wire	Transmit Gain	–5.0 to 0.0	–1.0
		Receive Gain	–10.0 to 0.0	–1.0
		Red-lined connection	On or Off	Off

—continued—

Table 1-10 (continued)
Service codes and their attribute values

Service code	Wire type	Attribute	Range	Default
PLAR1	2-wire	Transmit Gain	–5.0 to 6.5	–1.0
		Receive Gain	–10.0 to 3.5	–1.0
		Hybrid Balance	0 to 135	38
		Equalization	0 to 6	0
		Busy tone	On or Off	Off
		Impedance	600 ohm, 900 ohm	600 ohm
		Red-lined connection	On or Off	Off
PLAR2	2-wire	Transmit Gain	–5.0 to 6.5	–1.0
		Receive Gain	–10.0 to 3.5	–1.0
		Hybrid Balance	0 to 135	38
		Equalization	0 to 6	0
		Busy tone	On or Off	Off
		Impedance	600 ohm, 900 ohm	600 ohm
		Red-lined connection	On or Off	Off
UVGCT	2-wire	Full–time on hook transmission	On or Off	Off
		Red-lined connection	On or Off	Off
UVGRT	2-wire	Transmit OHT Gain	–10 to 0	–10
		Receive OHT Gain	–10 to 0	–10
		Full-time on hook transmission	On or Off	Off
		Red-lined connection	On or Off	Off
POTSCT	2-wire	Full-time on hook transmission	On or Off	Off
		Red-lined connection	On or Off	Off
POTSRT	2-wire	Full-time on hook transmission	On or Off	Off
		Red-lined connection	On or Off	Off
COINCT	2-wire	Full-time on hook transmission	On or Off	Off
		Red-lined connection	On or Off	Off

—continued—

Table 1-10 (continued)
Service codes and their attribute values

Service code	Wire type	Attribute	Range	Default
COINRT	2-wire	Full-time on hook transmission	On or Off	Off
		Red-lined connection	On or Off	Off
ILCPOTS	2-wire	Test head	1 or 2	1
		Type	control (dialup or dedicated), or monitor	monitor
DX	4-wire	Transmit Gain	–7.0 to 17.5	0.0
		Receive Gain	–16.0 to 8.5	0.0
		Transmit Equalizer Slope	0 to 15	0
		Transmit Equalizer Height	0 to 16	0
		Transmit Equalizer Bandwidth	0 to 16	0
		Receive Equalizer Slope	0 to 15	0
		Receive Equalizer Height	0 to 16	0
		Receive Equalizer Bandwidth	0 to 16	0
		Balance Resistance	1300, 1500, 1700, 1900, 2100, 2300, 2500, 2700, 2900, 3100, 3300, 3500, 3700 ohm	1300 ohm
		Cable	Nonloaded, Loaded	Nonloaded
		Transmit Impedance	150 ohm, 600 ohm, 1200 ohm	600 ohm
		Receive Impedance	150 ohm, 600 ohm, 1200 ohm	600 ohm
		signaling Leads	Normal, Reversed	Normal
		Off-hook Trunk Conditioning	On or Off	On
		Red-lined connection	On or Off	Off

—continued—

Table 1-10 (continued)
Service codes and their attribute values

Service code	Wire type	Attribute	Range	Default
TO	4-wire	Transmit Gain	–7.0 to 17.5	0.0
		Receive Gain	–16.0 to 8.5	0.0
		Transmit Impedance	150 ohm, 600 ohm, 1200 ohm	600 ohm
		Receive Impedance	150 ohm, 600 ohm, 1200 ohm	600 ohm
		Sealing Current	Off, Continuous, Reverse, Sink	Off
		Red-lined connection	On or Off	Off
ETO	4-wire	Transmit Gain	–7.0 to 17.5	0.0
		Receive Gain	–16.0 to 8.5	0.0
		Transmit Equalizer Slope	0 to 15	0
		Transmit Equalizer Height	0 to 16	0
		Transmit Equalizer Bandwidth	0 to 16	0
		Receive Equalizer Slope	0 to 15	0
		Receive Equalizer Height	0 to 16	0
		Receive Equalizer Bandwidth	0 to 16	0
		Cable	Nonloaded, Loaded	Nonloaded
		Transmit Impedance	150 ohm, 600 ohm, 1200 ohm	600 ohm
		Receive Impedance	150 ohm, 600 ohm, 1200 ohm	600 ohm
		Sealing Current	Off, Continuous, Reverse, Sink	Off
		Red-lined connection	On or Off	Off

—continued—

Table 1-10 (continued)
Service codes and their attribute values

Service code	Wire type	Attribute	Range	Default
FXO	4-wire	Transmit Gain	–7.0 to 17.5	0.0
		Receive Gain	–16.0 to 8.5	0.0
		Transmit Equalizer Slope	0 to 15	0
		Transmit Equalizer Height	0 to 16	0
		Transmit Equalizer Bandwidth	0 to 16	0
		Receive Equalizer Slope	0 to 15	0
		Receive Equalizer Height	0 to 16	0
		Receive Equalizer Bandwidth	0 to 16	0
		Cable	Nonloaded, Loaded	Nonloaded
		Transmit Impedance	150 ohm, 600 ohm, 1200 ohm	600 ohm
		Receive Impedance	150 ohm, 600 ohm, 1200 ohm	600 ohm
		signaling Leads	Normal, Reversed	Normal
		Off-hook Trunk Conditioning	On or Off	On
		Red-lined connection	On or Off	Off

—continued—

Table 1-10 (continued)
Service codes and their attribute values

Service code	Wire type	Attribute	Range	Default
FXS	4-wire	Transmit Gain	–7.0 to 17.5	0.0
		Receive Gain	–16.0 to 8.5	0.0
		Transmit Equalizer Slope	0 to 15	0
		Transmit Equalizer Height	0 to 16	0
		Transmit Equalizer Bandwidth	0 to 16	0
		Receive Equalizer Slope	0 to 15	0
		Receive Equalizer Height	0 to 16	0
		Receive Equalizer Bandwidth	0 to 16	0
		Cable	Nonloaded, Loaded	Nonloaded
		Transmit Impedance	150 ohm, 600 ohm, 1200 ohm	600 ohm
		Receive Impedance	150 ohm, 600 ohm, 1200 ohm	600 ohm
		signaling Leads	Normal, Reversed	Normal
		Off-hook Trunk Conditioning	On or Off	On
		Red-lined connection	On or Off	Off
DDS	4-wire	Data Rate	2400 bps, 4800 bps, 9600 bps, 19.2K bps, 56K bps, 64K bps	64K bps
		DDS Line Type	OCUDP,DS0DP	FCOT: DS0DP, OCUDP RFT: OCUDP
		Error Correction	On or Off	Off
		Secondary Channel (notes 1, 2)	On or Off	Off
		Zero Code Suppression (note 2)	On or Off	On
		Cust. Remote Test (notes 1, 2)	On or Off	Off
		Latching loopback	On or Off	On
		Red-lined connection	On or Off	On

Note 1: for OCUDP DDS function only ***Note 2:*** not valid for 64k rate

—continued—

Table 1-10 (continued)
Service codes and their attribute values

Service code	Wire type	Attribute	Range	Default
EM1	6/8-wire	Transmit Gain	∠7.0 to 17.5	0.0
		Receive Gain	∠16.0 to 8.5	0.0
		Off-hook Trunk Conditioning	On or Off	On
		Red-lined connection	On or Off	Off
EM2	6/8-wire	Transmit Gain	–7.0 to 17.5	0.0
		Receive Gain	–16.0 to 8.5	0.0
		Off-hook Trunk Conditioning	On or Off	On
		Red-lined connection	On or Off	Off
EM3	6/8-wire	Transmit Gain	–7.0 to 17.5	0.0
		Receive Gain	–16.0 to 8.5	0.0
		Off-hook Trunk Conditioning	On or Off	On
		Red-lined connection	On or Off	Off
PLR1	6/8-wire	Transmit Gain	–7.0 to 17.5	0.0
		Receive Gain	–16.0 to 8.5	0.0
		Off-hook Trunk Conditioning	On or Off	On
		Red-lined connection	On or Off	Off
PLR2	6/8-wire	Transmit Gain	–7.0 to 17.5	0.0
		Receive Gain	–16.0 to 8.5	0.0
		Off-hook Trunk Conditioning	On or Off	On
		Red-lined connection	On or Off	Off
TDM1	6/8-wire	Transmit Gain	–7.0 to 17.5	0.0
		Receive Gain	–16.0 to 8.5	0.0
		Off-hook Trunk Conditioning	On or Off	On
		Red-lined connection	On or Off	Off

—continued—

Table 1-10 (continued)
Service codes and their attribute values

Service code	Wire type	Attribute	Range	Default
TDM2	6/8-wire	Transmit Gain	–7.0 to 17.5	0.0
		Receive Gain	–16.0 to 8.5	0.0
		Off-hook Trunk Conditioning	On or Off	On
		Red-lined connection	On or Off	Off
TDM1O	6/8-wire	Transmit Gain	–7.0 to 17.5	0.0
		Receive Gain	–16.0 to 8.5	0.0
		Off-hook Trunk Conditioning	On or Off	On
		Red-lined connection	On or Off	Off
TDM1S	6/8-wire	Transmit Gain	–7.0 to 17.5	0.0
		Receive Gain	–16.0 to 8.5	0.0
		Off-hook Trunk Conditioning	On or Off	On
		Red-lined connection	On or Off	Off
TDM2O	6/8-wire	Transmit Gain	–7.0 to 17.5	0.0
		Receive Gain	–16.0 to 8.5	0.0
		Off-hook Trunk Conditioning	On or Off	On
		Red-lined connection	On or Off	Off
TDM2S	6/8-wire	Transmit Gain	–7.0 to 17.5	0.0
		Receive Gain	–16.0 to 8.5	0.0
		Off-hook Trunk Conditioning	On or Off	On
		Red-lined connection	On or Off	Off
		—end—		

Loop ranges of 2-wire station line cards

Table 1-11 summarizes the loop range, ringer capability (at the limit of the loop range), and other features of services using 2-wire station line cards.

Table 1-11
Loop ranges of 2-wire station line cards

2-wire service	Line card	Loop range	Ringer capability	Features
POTS or LSR	NT4K65	1900 Ω (1470 Ω + 430 Ω set) loaded/nonloaded	4 REN	Loop start, CLASS, forward disconnect, hook flash
POTS	NTN502AA		5 REN (bridged) 6 REN (to ground)	
POTS or LSR	NT4K79 NT4K67	1900 Ω (1470 Ω + 430 Ω set) loaded/nonloaded	4 REN (5 REN if <900 Ω)	Loop start, CLASS, forward disconnect, hook flash, 150 V dc for message waiting lamp on LSR
COIN	NT4K67	1370 Ω (820 Ω +550 Ω set)		Dial tone first, coin first, semi-post pay
UVG	NT4K79 NT4K67	1250 Ω (820 Ω + 430 Ω set)	5 REN	Auto LS/GS signaling, auto loss adjustment, 600 Ω impedance
LGB	NT4K79 NT4K67	1250 Ω (820 Ω + 430 Ω set) loaded/nonloaded	5 REN	150 V dc for message waiting lamp on loop start option
EBS	NT4K67	1230 Ω excl. set nonloaded		Centrex EBS (P-phone) support
ISDN	NT4K67	1300 Ω or 18 kft nonloaded; max. 42 dB loss at 40 kHz		T38601, TR-393, 2B1Q, 2B+D
FXS	NT4K67	1250 Ω (820 Ω + 430 Ω set)	5 REN	Auto LS/GS signaling, adjustable equalization, precision hybrid balance, impedance, and levels
PLAR	NT4K67	1250 Ω (820 Ω + 430 Ω set) loaded/nonloaded	5 REN	

—continued—

Table 1-11 (continued)
Loop ranges of 2-wire station line cards

2-wire service	Line card	Loop range	Ringer capability	Features
TO/ETO	NT4K67	1820 Ω (820 Ω + 1000 Ω terminal)		Adjustable equalization, precision hybrid balance, impedance, and levels
DPO	NT4K67	1200 Ω incl. local switch resistance		Reverse battery signaling, adjustable equalization, precision hybrid balance, impedance, and levels
MRD	NT4K78	1500 Ω	3 REN	
		—end—		

Omega line card transmission levels

Table 1-12 lists the minimum and maximum transmission level and the attenuator range for each Omega line card.

Table 1-12
AccessNode Omega line card transmission levels

	Tx input level at T, R (A/D) dB			Rx output level at T, R (D/A) dB		
Line card	**Min TLP**	**Max TLP**	**Attenuator range**	**Min TLP**	**Max TLP**	**Attenuator range**
NT4K67 2-wire station	–6.5	5.0	0 to 11.5	–10.0	3.5	0 to 13.5
NT4K68 2-wire office	–6.5	5.0	0 to 11.5	–10.0	3.5	0 to 13.5
NT4K69 4-wire	–17.5	7.0	0 to 24.5	–16.0	8.5	0 to 24.5
NT4K77 6/8-wire	–17.5	7.0	0 to 24.5	–16.0	8.5	0 to 24.5
NT4K78 2-wire manual ringdown	0.0	5.0	0 to 5.0	–10.0	0.0	0 to 10.0

Locally switched services—2-wire applications

This topic describes locally switched services on 2-wire line cards (LSS 2W). It includes the following information for each application, if it is applicable:

- supported services or sub-applications
- engineering information
- required line cards and service codes to implement an application
- supported signaling types
- an illustrated layout of a typical application

Table 1-13 lists and describes GR-303 MVI switched services supported on AccessNode line cards installed at the RFT.

Table 1-13
GR-303 MVI switched services

Service	Service code	Supported line cards	PEC
single-party residential plain old telephone service (POTS)	MVIPOTS	Omega 2-wire station Omega UVG station Epsilon 2-wire station	NT4K67AB/AC NT4K79AA/AB NT4K65AB
coin services	MVICOIN	Omega 2-wire station	NT4K67AB/AC
business lines and PBX trunks, universal voice grade, CLASS	MVIUVG	Omega 2-wire station Omega UVG station	NT4K67AB/AC NT4K79AA/AB
PBX DID trunks, other services using loop reverse battery	MVILRB (5ESS only)	Omega 2-wire office	NT4K68AA
ISDN-basic rate access	ISDN_U (GR303_ISDN)	Omega 2-wire station	NT4K67AB/AC

GR-303 MVI-specific software loads for the above service codes provide default values for GR-303 MVI services.

(LSS 2W) Single-party residential (POTS)

Universal application

Installing the following cards implements POTS service in a universal application:

- NT4K68 Omega 2-wire office line card at the fiber central office terminal (FCOT)
- One of the following line cards at the remote fiber terminal (RFT):
  - — NT4K65 Epsilon 2-wire station line card
  - — NT4K67 Omega 2-wire station line card
  - — NT4K79 Omega UVG station line card

The line card at the FCOT is provisioned with a service code of POTSCT. The line card at the RFT is provisioned with a service code of POTSRT. Table 1-5 on page 1-15 and Table 1-6 on page 1-16 list the provisionable parameters for these service codes.

GR-303 DMS application

The following line cards at the RFT implement POTS service in a GR-303 DMS application:

- NT4K65 Epsilon 2-wire station line card
- NT4K67 Omega 2-wire station line card
- NT4K79 Omega UVG station line card

The line card is provisioned in MAPCI at the DMS SuperNode with a service code of loop start residential (LSR).

GR-303 MVI

The following line cards at the RFT implement POTS service in a GR-303 MVI application:

- NT4K65AB Epsilon 2-wire station line card
- NT4K67 Omega 2-wire station line card
- NT4K79 Omega UVG station line card

At the RFT, use the MVIPROV CI tool to change the line card service type to MVIPOTS and the call reference value for the RFT slot, if either change is necessary. For more information, see *Line Card Provisioning Procedures*, 323-3001-315, in *Operations, Administration, and Provisioning*, Volume 4B. POTS service provisioning is performed at the local digital switch.

Impedance

In North American systems, impedance is automatically set to 900 ohms + 2.16 mF at the FCOT and 900 ohms + 2.16 mF at the RFT. In Hong Kong systems, impedance is automatically set to 600 ohms + 2.16 mF at the FCOT and 600 ohms + 2.16 mF at the RFT.

Ringing types

LSS2W supports the following ringing types:

- 20 Hz bridged
- bridged coded ringing (teen service)
- duplex ringing cadences (up to 4 per line)
- individual line revertive (single-party intercom)

Address signaling types and supervision types

Dial pulse (DP) and dual-tone multifrequency (DTMF) are the supported address signaling types. The following supervision types are supported:

- loop start
- forward disconnect
- line side answer supervision

CLASS/CMS features are also supported.

Line side answer supervision

Line side answer supervision (LSAS) supplies a reverse polarity supervision signal on universal (UDLC) switched access lines provisioned with the following service codes:

- POTSCT/POTSRT
- UVGCT/UVGRT
- 2WFXO/2WFXS

LSAS provides a reverse polarity supervision signal toward the calling party when the called party answers. If the calling party goes on-hook first, the LSAS signal returns to normal polarity immediately. If the called party goes on-hook first and the calling party remains off-hook, the LSAS signal returns to normal polarity either immediately (#5ESS method) or after a fixed interval (DMS-100 method).

LSAS can be a billing on/off signal for equipment such as PBXs, interexchange carriers, owner-operated coin telephones, and junk dialers.

Note 1: The POTSCT, UVGCT, and FXO service codes provide normal polarity to the RFT while on-hook. The polarity follows what is presented by the central office switch while off-hook.

Note 2: The Epsilon NT4K65 station line card does not support LSAS.

Note 3: See *Line Card Specifications*, 323-3001-181, in *Description*, Volume 2B, for the reverse polarity loop range.

Figure 1-1 and Figure 1-2 show typical universal and integrated applications of single-party service in point-to-point fiber-fed systems. Figure 1-3 and Figure 1-4 on page 1-36 show integrated applications of single-party service in DS1-fed and single-ended systems. Integrated applications in point-to-point systems require an FCOT equipped with DS1 facilities on a DS1/VT mapper. Integrated applications in single-ended or DS1-fed systems do not require FCOT equipment.

Figure 1-1
Single-party residential service (universal application)

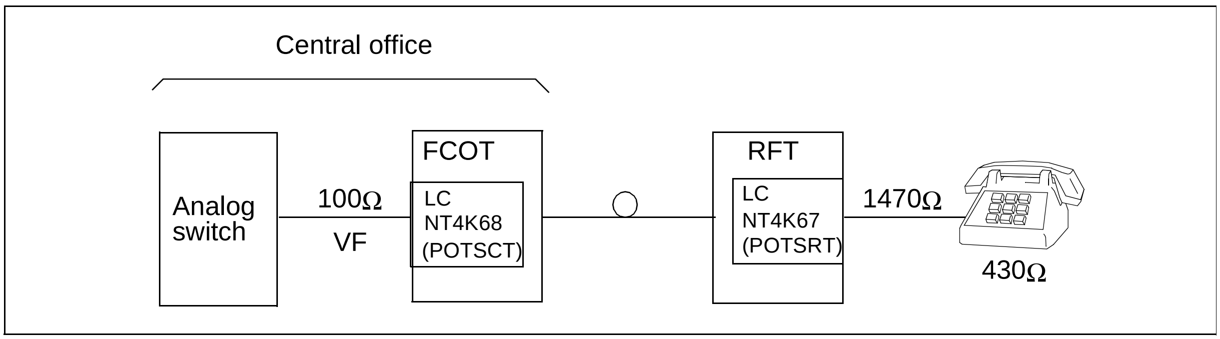


Figure 1-2
Single-party residential service (integrated application on a point-to-point system)

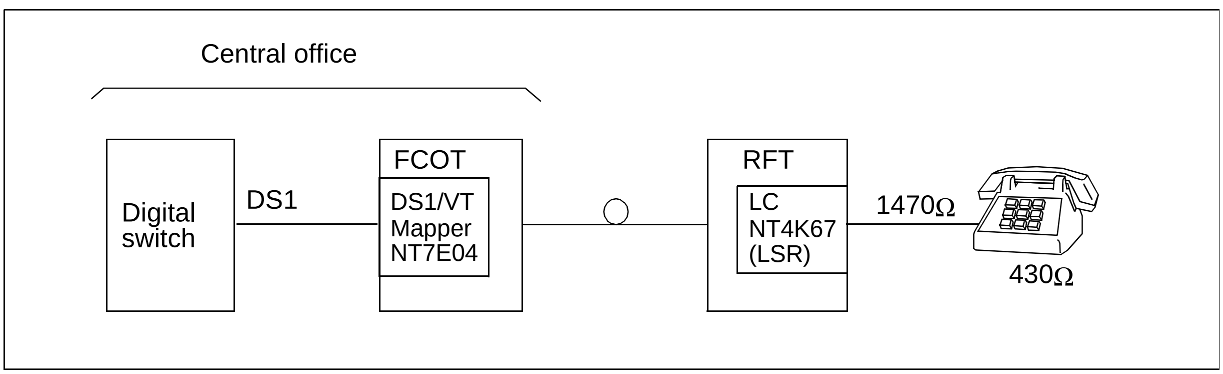


Figure 1-3
Single-party residential service (integrated application on a DS1-fed system)

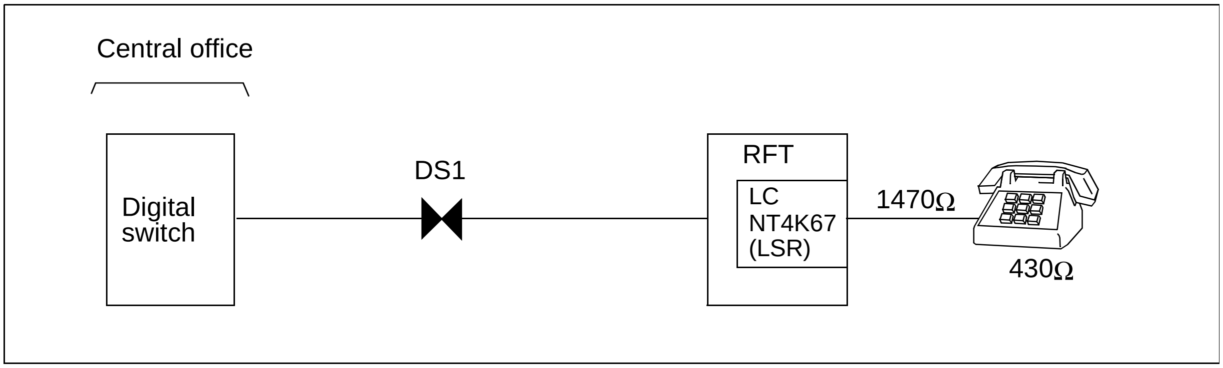
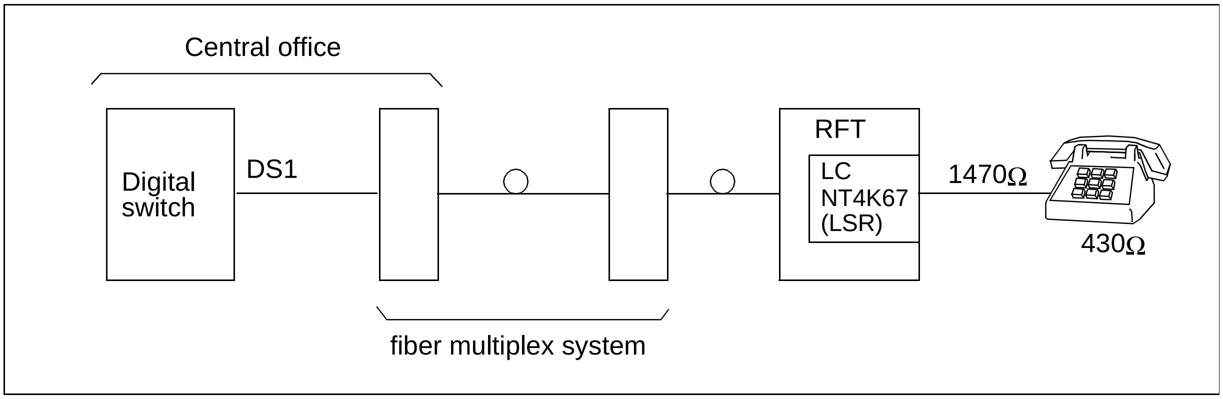


Figure 1-4
Single-party residential service (integrated application on a single-ended system)



(LSS 2W) Coin services

Universal application

The following cards implement coin services in a universal application:

- NT4K68 Omega 2-wire office line card at the FCOT
- NT4K67 Omega 2-wire station line card at the RFT

The FCOT line card is provisioned with a service code of COINCT. The RFT line card is provisioned with a service code of COINRT. Table 1-5 on page 1-15 and Table 1-6 on page 1-16 list the provisionable parameters for this service code.

Integrated application

In a GR-303 DMS application, an NT4K67 Omega 2-wire station line card is installed at the RFT and provisioned at the DMS SuperNode MAPCI with a service code of COIN.

In a GR-303 MVI application, an NT4K67 Omega 2-wire station line card is installed at the RFT. At the RFT, the MVIPROV CI tool is used to change the line card service type to MVICOIN and the call reference value for the RFT slot, if either change is necessary. For more information, see *Line Card Provisioning Procedures*, 323-3001-315, in *Operations, Administration, and Provisioning*, Volume 4B. Coin service is provisioned at the local digital switch.

> ***Note:*** For a COIN service terminating on a 5ESS switch with floating positive battery and loop supervision at the FCOT, make sure that the ground reference bit is set on the 5ESS switch.

Ringing types

Coin lines are 20 Hz bridged ringing with dial pulse (DP) or dual-tone multifrequency (DTMF) address signaling.

Coin applications

The following coin applications are supported without special provisioning:

- dial tone first
- coin first
- semi-postpay
- charge-a-call (coinless coin) service
- private coin service

Dial tone first

This application provides a dial tone as soon as the telephone set goes off-hook, but coins must be deposited before the end of dialing. Calls such as 0, 0+, 411, and 911 can be completed without a coin. Other calls attempted without a coin are sent to reorder tone or a recorded announcement. Loop start supervision provides this coin service. Coin collect and coin return signals (± 130 V) are supported.

Coin first

A dial tone is not provided until the telephone set goes off-hook and the specified coins are deposited. Calls such as 0, 0+, 411, and 911 return the initial coin deposit at the end of the call. The deposit of the coin causes the coin phone to connect the ring side of the line to ground. This initiates the call request to the local switch. Coin first uses a line with ground start supervision and coin telephone set. Coin collect and coin return signals (± 130 V) are supported.

Semi-postpay

Semi-postpay is the simplest variant of coin telephone service. A dial tone is received when the phone goes off hook. Calls must be established before any coins are deposited. When the called party answers, the coin phones outgoing speech path is not connected until a coin (equal in value to the initial charge) is deposited. Loop reverse battery supervision from the local switch (also called line-side answer supervision [LSAS]) inhibits the outgoing speech until a coin is deposited.

Semi-postpay phones cannot return coins or test for coin presence. All deposited money is collected.

Charge-a-call (coinless coin) service

Charge-a-call allows calls without coin deposits. Charges are collect or are made to a credit card, calling card, or third number. A special coinless telephone set capable of reading a credit card is required. signaling is similar to a standard non-coin telephone set. Credit card information is transmitted by DTMF tones. The service is transparent to an AccessNode system.

Private coin service

Private coin service is similar to public coin telephone service except that a customer (for example, a convenience store), rather than a telephone company, owns and maintains the telephone set. Signaling is similar to a standard coin telephone set. The difference between private and public coin is the way the call is treated for billing and operator assistance. The service is transparent to an AccessNode system.

Illustrations

Figure 1-5 and Figure 1-6 show typical universal and integrated applications of COIN service in point-to-point fiber-fed systems. Integrated applications in single-ended or DS1-fed systems do not require FCOT equipment.

Figure 1-5
Typical universal application of COIN service

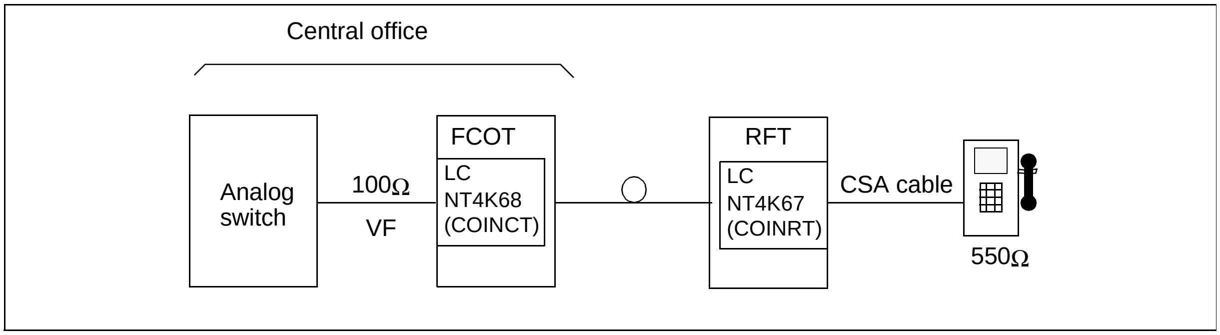
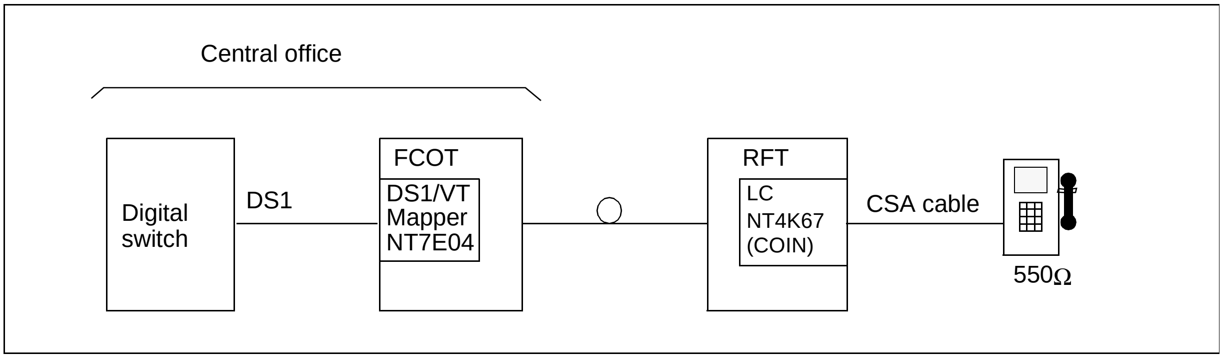


Figure 1-6
Typical integrated application of COIN service



(LSS 2W) Meridian Digital Centrex

AccessNode provides access to all basic Meridian Digital Centrex (MDC) features now available on the DMS SuperNode. Business subscribers can access these features using one of the following MDC applications on the local DMS SuperNode switch:

- single-party (basic 500/2500 set)
- attendant console
- electronic business set (EBS), integrated application only

Single-party service

Single-party service supplies basic telephone service to a single subscriber (POTS). An individual line serves one main station. You may connect additional stations as extensions of the main station. Additional stations do not have any impact on call processing.

In addition to POTS-type service, single-line MDC offers the following business-related features:

- abbreviated dialing for internal numbers
- call forward
- call park
- call pickup
- call waiting
- conference calling
- last number redial
- ring again
- transfer
- message waiting

Message waiting

The loop-start option of the Loop Gnd Bus service supports message waiting. On a single line analog telephone set equipped with a message-waiting lamp, the lamp illuminates when a message is waiting at a message desk, at an attendant console, or on the user's voice mail system. The lamp is activated by applying pulsed dc voltage to the ring side of the line at –150 V, cycled at 500 ms on and 500 ms off, while the set is on-hook. A one-second pause occurs after every fifth lamp flash. A telephone set not equipped with a message-waiting lamp receives interrupted dial tone when a message is waiting.

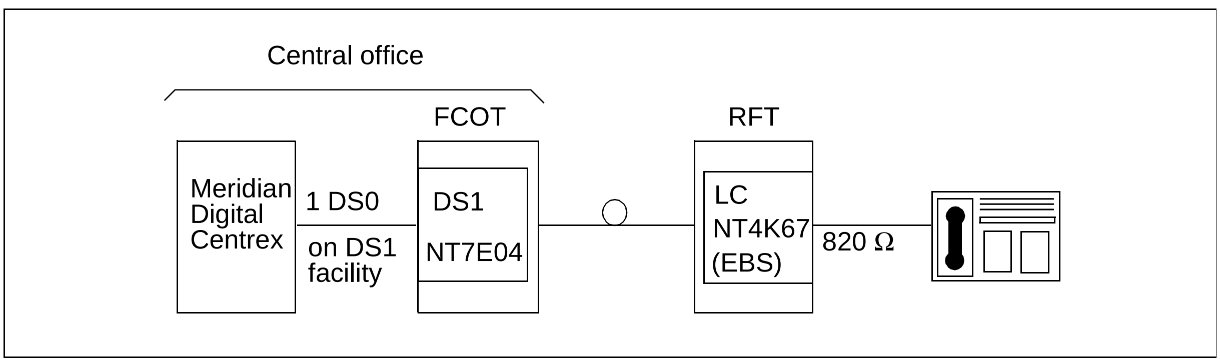
Attendant console

The attendant console, a centralized operator position, is a feature of DMS SuperNode Meridian Digital Centrex. It is the answering point for dial 0 calls from CENTREX stations, incoming calls that are not directed to a specific CENTREX station, overflow, and intercept. Attendant console uses push-button keys for all control and connecting functions. It requires three loops, which appear as nailed-up connections between the attendant console and the DMS SuperNode. Two loops are for voice-band data, and one loop is for voice.

Electronic business set

AccessNode provides transparency between a DMS SuperNode switch and the customer's electronic business set (EBS). Figure 1-7 shows a typical application of EBS service (integrated application) in a point-to-point fiber-fed system. Integrated applications in single-ended or DS1-fed systems do not require FCOT equipment.

Figure 1-7
Typical integrated application of MDC electronic business set service



Note 1: The transmission of voice frequency (VF) and signaling data between the line card and telephone set is done only with non-loaded cable.

Note 2: The maximum loop loss between the remote terminal at 8 kHz is 24 dB—equivalent to a 1230 ohm loop of 16 kft using 26 gauge wire.

Note 3: A talk battery current of at least 48 V dc is required to maintain a 16 milliampere current to the set in loops greater than 820 ohms.

Ringing types

AccessNode supports the following MDC ringing types:

- 20 Hz bridged
- bridged-coded ringing (teen service)
- individual line revertive (single-party intercom)
- special centrex cadences

Address signaling types and supervision types

AccessNode supports the following MDC supervision types:

- loop start
- forward disconnect
- LSAS

The following address signaling types are supported:

- DP
- DTMF

CLASS/CMS features are also supported.

MDC in a universal application

The following table describes the implementation of MDC services in a universal application. Table 1-5 on page 1-15 lists the provisionable parameters for each service code.

Universal application	
Service	**Line card (service code)**
MDC single line	FCOT: NT4K68 Omega 2-wire office line card (UVGCT or POTSCT)
	RFT: NT4K65 Epsilon 2-wire station line card (POTSRT) or NT4K67 Omega 2-wire station line card (UVGRT or POTSRT) or NT4K79 Omega 2-wire UVG line card (UVGRT or POTSRT)
—continued—	

Universal application	
Service	**Line card (service code)**
Attendant console	FCOT: three NT4K68 Omega 2-wire office line cards (UVGCT or POTSCT)
	RFT: three NT4K65 Epsilon 2-wire station line cards (POTSRT) or NT4K67 Omega 2-wire station line cards (UVGRT or POTSRT) or NT4K79 Omega 2-wire UVG line cards (UVGRT or POTSRT) or any combination of these three
Note: For the two data lines terminating at the attendant console, the line cards must have the Full-time on-hook transmission parameter provisioned to ON. (Another approach for the data lines is to use FCOT/RFT line cards, NT4K68/NT4K67, provisioned as TOO/TOS, respectively, or as ETOO/ETOS.)	
—end—	

MDC in an integrated application

The following table describes the implementation of MDC services in an integrated application. Table 1-5 on page 1-15 lists the provisionable parameters for each service code.

Integrated application	
Service	**RFT line card (service code)**
Electronic business set	NT4K67 Omega 2-wire station line card (EBS)
MDC single line	NT4K65 Epsilon 2-wire station line card (LSR) or NT4K67 Omega 2-wire station line card (LGB or LSR) or NT4K79 Omega 2-wire UVG line card (LGB or LSR)
Attendant console	three NT4K65 Epsilon 2-wire station line cards (LSR) or NT4K67 Omega 2-wire station line cards (LGB or LSR) or NT4K79 Omega 2-wire UVG line cards (LGB or LSR) or any combination of these three

(LSS 2W) Business services (locally switched portion of some services)

This topic describes AccessNode locally switched business services.

Single-party service (basic 500/2500 set)

The single-party service supplies basic telephone service to a single subscriber (POTS). An individual line serves one main station. Additional stations can be connected as extensions of the main station. Additional stations do not impact call processing.

In GR-303 MVI applications, single-party business service requires one of the following line cards at the RFT:

- NT4K65AB Epsilon 2-wire station line card
- NT4K67 Omega 2-wire station line card
- NT4K79 Omega 2-wire UVG line card

At the RFT, the MVIPROV CI tool is used to change the line card service type to MVIPOTS and the call reference value for the RFT slot, if either change is necessary. For more information, see *Line Card Provisioning Procedures*, 323-3001-315, in *Operations, Administration, and Provisioning*, Volume 4B. POTS is provisioned at the local digital switch.

Business POTS service supports loop start and forward disconnect supervision types. It supports DP and DTMF address signaling. CLASS/CMS features are also supported.

Business POTs supports the following ringing types:

- 20 Hz bridged
- bridged-coded ringing (teen service)
- individual line revertive (single-party intercom)
- special centrex cadences

Switched voiceband data

Switched voiceband data transmits data over voice frequency lines using external voiceband modems. All capabilities and characteristics of the line are the same as those described for the single-party service (basic 500/2500) set.

WATS lines

This service supplies outward wide area telecommunication service (WATS) to a station set. WATS allows the completion of a measured number of dialed long distance calls to specific calling bands (selected geographical regions) for which a customer has contracted for a fixed monthly charge.

A WATS line terminates on a telephone set or a key system and uses loop-start and forward-disconnect supervision. Ringing is 20 Hz bridged. WATS supports DP and DTMF address signaling.

WATS trunks

This service provides outward WATS to a local PBX trunk. A WATS trunk terminates on a PBX and uses ground-start supervision. Ringing is 20 Hz bridged. It supports DP and DTMF address signaling.

WATS is a toll-billing option on any line or trunk.

800-service line

This service provides 800-service from a local central office to a customer telephone set. The called party subscribes to the service and pays for toll calls. This service, formerly known as INWATS, allows only incoming calls. Completed calls are not charged to the calling party.

An 800-service line terminates on a telephone set or a key system and uses loop-start or forward disconnect supervision. Ringing is 20 Hz bridged. It supports DP and DTMF address signaling types.

800-service trunk

This service provides 800-service from a local central office to a customer PBX or automatic call distributor (ACD). An 800-service trunk terminates on a PBX and uses ground-start supervision. Ringing is 20 Hz bridged. It supports DP and DTMF address signaling types.

The 800-service is a toll-billing option on any line or trunk.

Secretarial line

A secretarial line provides answering service when a customer is not available to answer calls. Secretarial lines, similar to off-premise extension (OPX) lines, bridge the customer’s line to the secretarial service. The secretarial line may be bridged at the main station, but normally, both lines are bridged at the central office serving the main station.

In an integrated application, digital bridging implements this service. A universal application bridges an outside plant loop to the FCOT line card. In both applications, bridge lifters isolate alternating current between the FCOT line card and the plant loop.

Off-premise extension

Off-premise extension (OPX) supplies service to an extension telephone located off the premises of the main station. Service is bridged either at the MDF or within software on a local central office switch. A universal application bridges an outside plant loop to the FCOT line card. An integrated application uses digital bridging. In both applications, bridge lifters isolate alternating current between the FCOT line card and the plant loop.

Table 1-14 lists the implementation of business services in a universal application. See Table 1-5 on page 1-15 for the provisionable parameters for each service code.

Table 1-14
Business services in a universal application

Universal application	
Service	**Line card (service code)**
switched voiceband data, WATS, 800-service, secretarial line, or off-premise extension	FCOT: NT4K68 Omega 2-wire office line card (UVGCT or POTSCT)
	RFT: NT4K65 Epsilon 2-wire station line card (POTSRT), or NT4K67 or NT4K79 Omega 2-wire station line card (UVGRT or POTSRT)
Note: Nortel Networks recommends UVG or FX if you require ground start capability.	

Table 1-15 lists the implementation of business services in an integrated application.

Table 1-15
Business services in an integrated application

Integrated application	
Service	**RFT line card (service code)**
switched voiceband data, WATS, 800-service, secretarial line, or off-premise extension (see Note)	In a GR-303 DMS application, use NT4K65 Epsilon 2-wire station line card (LSR), NT4K67, or NT4K79 Omega 2-wire station line card (LSR or LGB), provisioned at the DMS SuperNode MAP. In a GR-303 MVI application, use NT4K65AB Epsilon 2-wire station line card, NT4K67, or NT4K79 Omega 2-wire station line card at the RFT. At the RFT, use the MVIPROV CI tool to change the line card service type to MVIPOTS (for loop start) or MVIUVG (for ground start) and to change the call reference value for the RFT slot, if a change is necessary. Service is provisioned at the local digital switch.
Note: The secretarial line and off-premise extension services are offered from a digital bridge connection.	

Table 1-16 lists ringing, signaling, and supervision types supported for business services.

Table 1-16
Ringing, signaling, and supervision types

Types of ringing, signaling, and supervision supported			
Service	**Ringing**	**Address signaling**	**Supervision**
switched voiceband data	20 Hz bridged	DP, DTMF	Loop start, ground start, forward disconnect
WATS, 800-service	20 Hz bridged	DP, DTMF	Loop start and forward disconnect, ground start (WATS trunk and 800 trunk)
secretarial line	20 Hz bridged	DP, DTMF	Loop start, forward disconnect

(LSS 2W) ISDN service

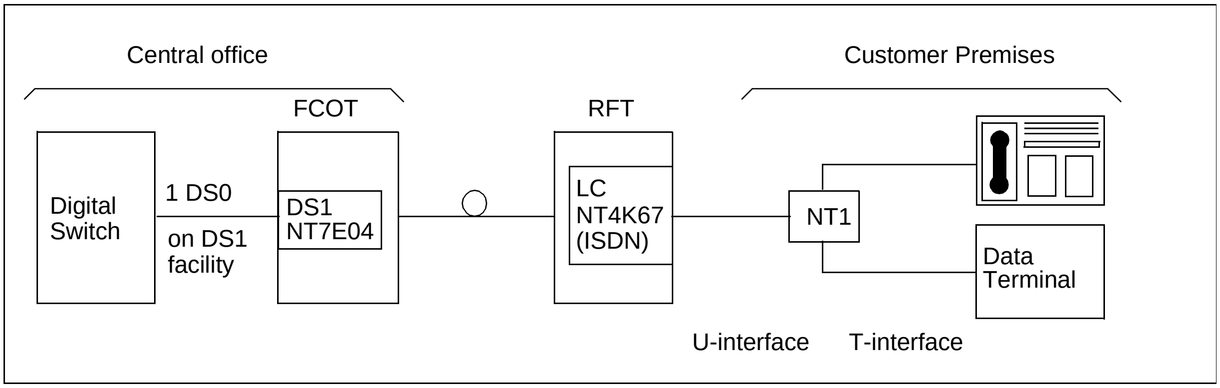
ISDN service gives a 2B+D clear-channel bandwidth between the local digital switch and the network termination (NT1) at the customer premises. Two 64-kb/s B channels are for voice or data. One 16-kb/s D channel carries customer packet data and carries signals between the local digital switch and the ISDN terminal equipment. For bandwidth efficiency, four D channels are multiplexed on a single DS0 channel. B channels are dynamically allocated per call.

In GR-303 DMS applications, ISDN-BRA service requires one NT4K67 Omega 2-wire station line card at the RFT, provisioned for ISDN service at the DMS SuperNode maintenance and administration position (MAP). The service appears as ISDN_U in the RFT Line Card Equipment screen.

In GR-303 MVI applications, ISDN-BRA service requires one NT4K67 Omega 2-wire station line card at the RFT. At the RFT, the MVIPROV CI tool is used to change the call reference value (CRV) for the RFT slot, if necessary. The service appears as GR303_ISDN.

On a ring or point-to-point fiber-fed system, a DS0 channel is assigned on a GR-303 DS1 facility (on a DS1/VT mapper) at the FCOT. In single-ended and DS1-fed systems, no FCOT equipment is required. Figure 1-8 shows a typical integrated ISDN application.

Figure 1-8
Typical integrated application of ISDN service



ISDN service is provisioned at the DMS SuperNode maintenance and administration position (MAP) using the ISDN service code. You can provision up to 672 ISDN lines on a single RFT equipped with the multihosting option (324 lines per switch). GR-303 MVI switch interfaces might have a different ISDN line capacity. For example, to assign 672 RFT lines for ISDN services on DMS-100, you would equip the RFT with the multihosting option and terminate lines on two DMS-100 switches.

Line testing

Both the line test position (LTP) of the DMS SuperNode MAP and TL1 commands from an operations support system (OSS) connected through the OPC monitor performance and run tests. The OPC performs protocol conversion and transmits control signals to the line card and NT1. All GR-303 applications use TL1 commands from OSS. GR-303 DMS applications can perform line tests from the LTP of the DMS SuperNode MAP.

Based on cyclic redundancy check (CRC) comparisons, the following three performance parameters are derived from monitoring maintenance bits for each of near-end (line card) and far-end (NT1) points of the U-interface:

- near-end block error (NEBE) and far-end block error (FEBE)
- errored seconds (ES)
- severely errored seconds (SES)

Test loopback capabilities at the line card toward the test control source include the following GR-303 loopbacks:

- 2B+D tip and ring loopback, non-transparent
- digital loopback of channel B1, transparent
- digital loopback of channel B2, transparent

Test loopback capabilities at the line card toward the test control source include the following 3DS0 ISDN loopbacks:

- bidirectional digital loopback of channel 2B+D
- bidirectional digital loopback of channel B1
- bidirectional digital loopback of channel B2

Test loopback capabilities at the NT1 toward the test control source include the following:

- 2B+D loopback, transparent
- B1 loopback, transparent
- B2 loopback, transparent

All loopbacks except the 2B+D loopback at the NT1 are service-affecting.

(LSS 2W) PBX trunks

The following 2-wire PBX trunk applications are supported:

- direct-inward-dial (DID)
- direct-outward-dial (DOD)
- local central office (CO) trunks

DID trunks

In a universal application, DID trunks use an NT4K67 Omega 2-wire station line card provisioned for DPO service at the FCOT and an NT4K68 Omega 2-wire office line card provisioned for DPT service at the RFT. In an integrated application, DID trunks use an NT4K68 Omega 2-wire office line card provisioned for DPT service at the RFT.

> ***Note:*** Except for DID service, most PBX trunks in a universal application use an NT4K68 Omega 2-wire office line card at the FCOT, provisioned as UVGCT, and an NT4K67 Omega 2-wire station line card at the RFT, provisioned as UVGRT. In an integrated application, PBX trunks use an NT4K67 Omega 2-wire station line card at the RFT, provisioned as UVGRT.

In a GR-303 MVI application using 5ESS, DID trunks use an NT4K68 Omega 2-wire office line card. At the RFT, Use the MVIPROV CI tool to change the call reference value (CRV) for the RFT slot, if necessary. For more information, see *Line Card Provisioning Procedures*, 323-3001-315, in *Operations, Administration, and Provisioning*, Volume 4B. DID trunk service is provisioned at the local digital switch.

DID trunks connect a PBX to the local central office. They allow one-way operation only (CO to PBX). Incoming calls terminate directly to a specific PBX station. The CO sends the station number (usually the last three or four digits of the dialed number) to the PBX so that the PBX can route the call. These trunks appear as loop reverse battery trunks at the central office equipment.

DID trunks support DP and DTMF address signaling and battery and ground or loop reverse battery supervision. The trunks use either wink delay dial or immediate start signaling protocols.

DMS-100 GR-303 applications do not support DID trunks. However, DID trunks are supported using a DS1 tandem connection, which terminates a DS0 channel on the line trunk controller (LTC) or digital trunk controller (DTC) of the DMS-100 switch. This arrangement uses an NT4K68 Omega 2-wire office line card at the RFT and a DS1 tandem channel on a DS1 mapper at the RFT or FCOT, provisioned for DPT service. The physical arrangement is similar to that shown for loop-start/ground-start trunks in Figure 1-10 on page 1-50.

DOD and local CO trunks

DOD service gives a station direct access to the message network for completing calls from a PBX to a central office. DOD trunks connect a PBX to the local central office. They allow one-way operation only (PBX to CO). The PBX station user can originate a central office call without the assistance of an attendant. The user dials an access code (usually 9), receives a second dial tone from the local switch through the DOD trunk, then dials the destination number. These trunks appear as ground-start station lines at the central office equipment. The service code is UVG (universal) or LGB (integrated).

DOD trunks support DP and DTMF address signaling. The ringing type is 20 Hz bridged. Supervision types are loop or ground start.

Level 9 trunks are identical to local CO trunks. The PBX typically records the number of calls made on individual guest room message registers so that a guest can be billed for the number of calls made. The most common method of activating these registers is based on the CO returning reverse battery answer supervision when an outgoing call is answered. The PBX recognizes the answer supervision and pegs one call against the guest room from which the call was made.

Local CO trunks (often called CO trunks) connect a PBX to the local central office. These trunks appear as ground-start station lines at the central office equipment. Local CO trunks allow two-way operation, but are ringdown in one direction (CO to PBX) and dial pulse in the other direction (PBX to CO).

Local CO trunks support DP and DTMF address signaling. The ringing type is 20 Hz bridged. Supervision types are ground start, toll diversion, and reverse battery answer.

In GR-303 DMS applications, DOD and local CO trunks use an NT4K67 Omega 2-wire station line card at the RFT. The line card is provisioned at the DMS SuperNode MAP as loop-start/ground-start business (LGB) service.

In GR-303 MVI applications, DOD and local CO trunks use an NT4K67 Omega 2-wire station line card at the RFT. At the RFT, the MVIPROV CI tool is used to change the line card service type to MVIUVG and the call reference value for the RFT slot, if either change is necessary. For more information, see *Line Card Provisioning Procedures*, 323-3001-315, in *Operations, Administration, and Provisioning*, Volume 4B. Service is provisioned at the local digital switch.

Figure 1-9 and Figure 1-10 show typical universal and integrated applications of PBX trunks in point-to-point fiber-fed systems. No FCOT equipment is required for integrated applications in single-ended or DS1-fed systems.

Figure 1-9
Typical universal application of PBX trunks

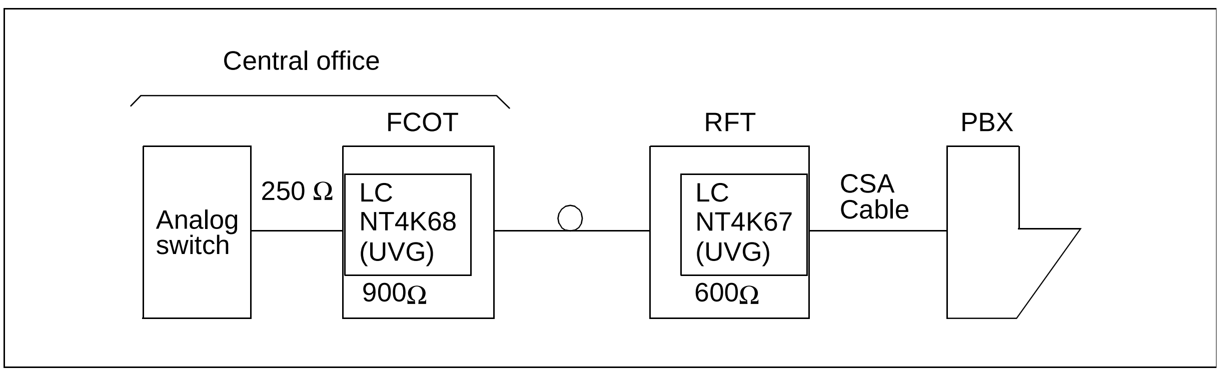
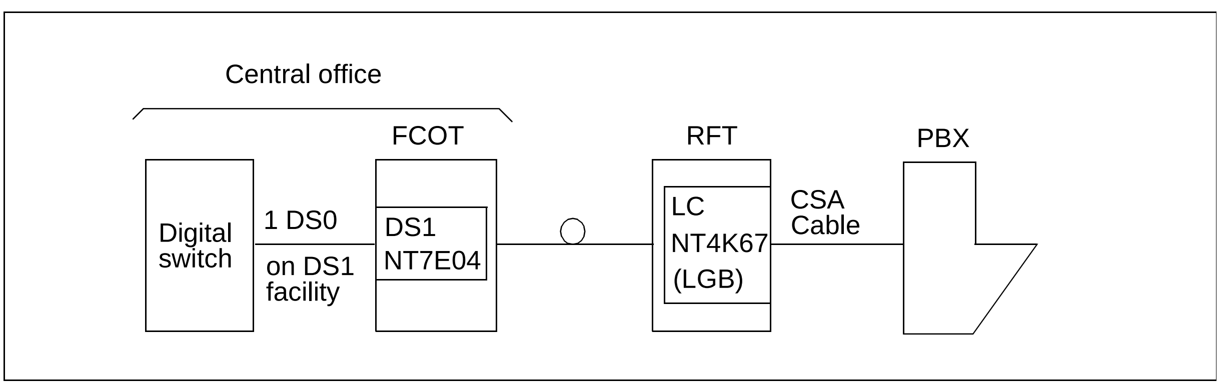


Figure 1-10
Typical integrated loop-start/ground-start business (LGB) application of PBX trunks



(LSS 2W) TR-08 services

AccessNode line cards installed at the RFT support the following TR-08 services:

Service	Service code	Line card
single-party residential or plain old telephone service (POTS)	POTSRT	NT4K65 Epsilon line card NT4K67 Omega station line card NT4K79 UVG line card
coin	COINRT	NT4K67 Omega station line card
business lines and PBX trunks, universal voice grade, CLASS	UVGRT	NT4K67 Omega station line card NT4K79 UVG line card
direct-in-dial PBX trunks, dial pulse terminating	DPT	NT4K68 Omega office line card
integrated remote test unit (IRTU) line card	ILC	none (requires a line card slot though)

TR-08-specific software loads for the above service codes supply the default values for TR-08 services. For more details about a service application, see the description of the service under its own heading in this chapter. The IRTU line card service is described in *Line and Loop Testing Overview*, 323-3001-115, in *Description*, Volume 2B.

DS1 tandem interfaces, not the TR-08 interface, support the following SLC-96 special services:

- 4-wire E&M
- 2-wire FXS loop start or ground start
- 2-wire FXO loop start or ground start
- 4-wire FXS or FXO
- 4-wire DX
- 2-wire TO
- 4-wire TO or ETO
- DDS (OCUDP)

AccessNode does not support the following SLC-96 services: superimposed ringing, multiparty, frequency selective ringing, and two-party service.

Nonlocally switched services—2-wire applications

Services in this group are nonlocally switched services on 2-wire line cards (NLSS 2W).

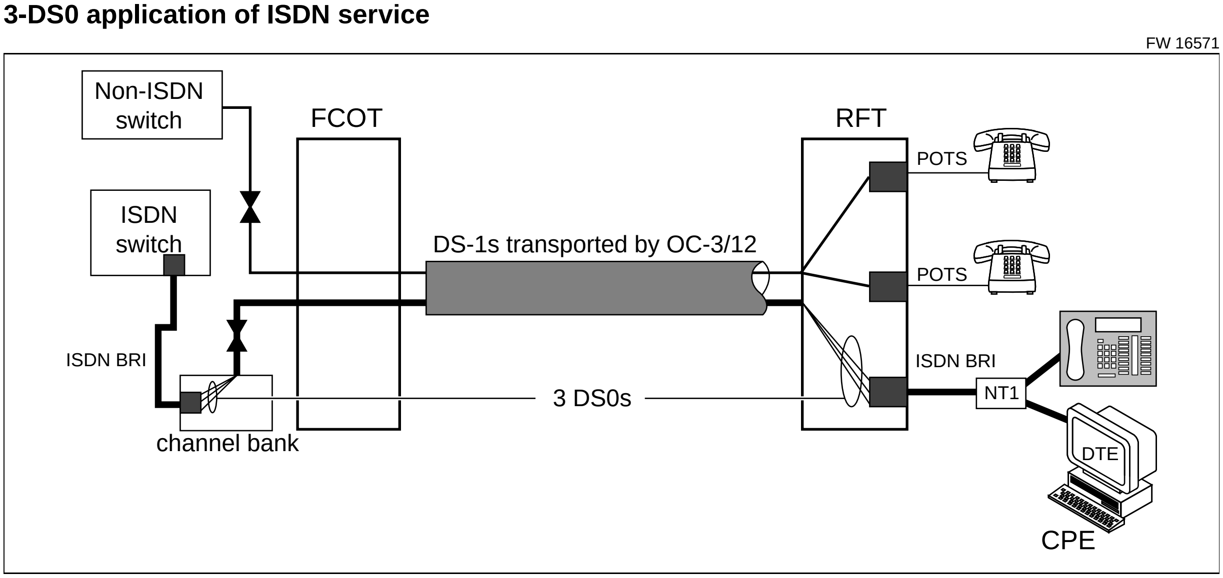
(NLSS 2W) 3DS0 ISDN

AccessNode supports ISDN BRA service in the IDLC configuration through the GR-303 MVI and Nortel Networks's proprietary GR-303 DMS interface. AccessNode supports ISDN BRA in a non-integrated configuration using the 3DS0 ISDN application for the following situations:

- AccessNode is deployed using TR-08 interface for POTS
- AccessNode is connected to DMS-10 using the DMS Access interface
- the local switch will not handle ISDN service which requires ISDN circuits to be routed to an ISDN switch that is not accessible through a GR-303 interface group (multi-hosting)

To implement 3-DS0 ISDN, you need one NT4K67AC (Rel. 20 or greater) line card at the RFT. For non-integrated ISDN service, the ISDN BRI signal uses three DS0 channels of a Tandem DS1 for DS1-fed applications. For single ended or point-to-point applications, the 3-DS0s are transported to the CO via fiber and connect to a Tandem DS1. See Figure 1-11.

Figure 1-11
3-DS0 application of ISDN service



The connection between the line card and the NT1 at the customer premises forms the ISDN U-interface. The customer can connect up to eight pieces of terminal equipment to the NT1. Sealing current from the line card can maintain the loop integrity of the U-interface.

(NLSS 2W) Foreign exchange lines and trunks

Foreign exchange (FX) service provides a trunk between a local customer line and a nonlocal central office switch. This service is typically used by businesses to allow customers in another city to call them without making a toll call.

An access line called an FX line provides FX service. The line card termination nearest to the telephone set is called a foreign exchange station (FXS). The line card termination nearest to the switching office is called a foreign exchange office (FXO).

FX applications include:

- FX single-party
- interoffice WATS line
- interoffice 800-service line
- interoffice secretarial line
- interoffice off-premise extension

In a universal application, FX service is implemented by installing an NT4K68 Omega 2-wire office line card provisioned with a service code of FXO at the FCOT and an NT4K67 Omega 2-wire station line card provisioned with a service code of FXS at the RFT. In a DS1 tandem application, an NT4K67 Omega 2-wire station line card provisioned with a service code of FXS is installed at the RFT. See Table 1-5 on page 1-15 for the provisionable parameters associated with these service codes.

Table 1-17 lists ringing, signaling, and supervision types supported for FX lines and trunks.

Table 1-17
FX ringing, signaling, and supervision

Service	Ringing	Address signaling	Supervision
FX single-party line, WATS line, 800-service line	20 Hz bridged	DP, DTMF	Loop start, forward disconnect
FX trunk, WATS trunk 800-service trunk	20 Hz bridged	DP, DTMF	Ground start

Figure 1-12 and Figure 1-13 show typical universal and DS1 tandem applications of FX line service in point-to-point fiber-fed systems. For DS1 tandem applications in single-ended or DS1-fed systems, no FCOT equipment is required.

Figure 1-12
Typical universal application of a 2-wire FX line over interoffice cable

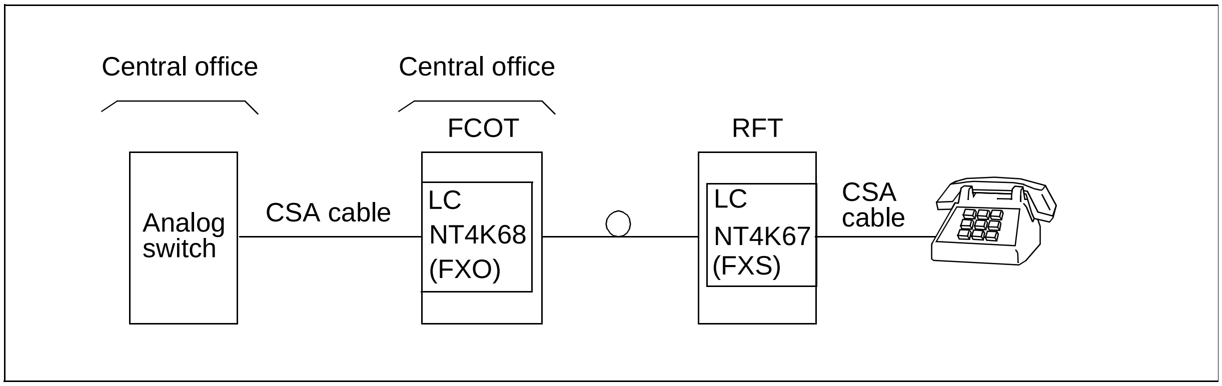
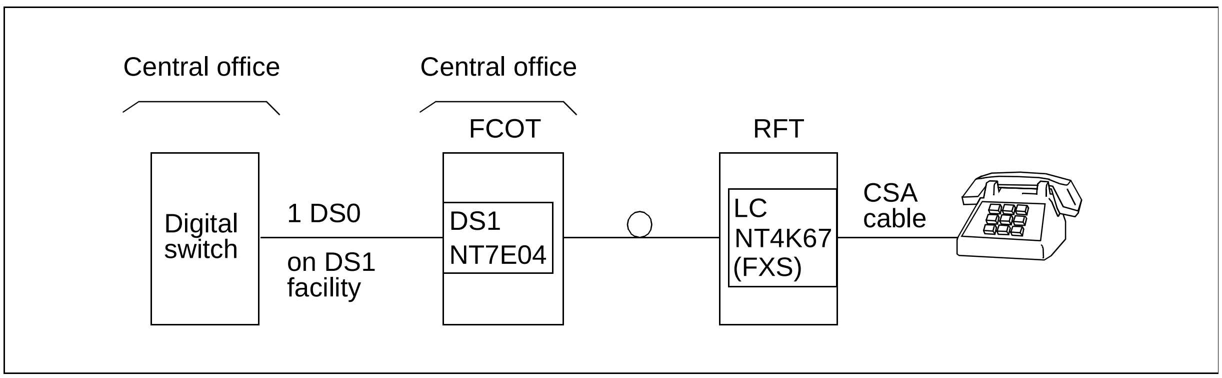


Figure 1-13
Typical DS1 tandem application of a 2-wire FX line



Typical applications of FX trunk service to a PBX are shown in the following figures:

- Figure 1-14 on page 1-55 shows FX trunk service over interoffice cable in a universal application.
- Figure 1-15 on page 1-55 shows FX trunk service over a pulse-code modulation (PCM) carrier in a universal application.
- Figure 1-16 on page 1-55 shows FX trunk service on DS1 tandem in a point-to-point fiber-fed system. No FCOT equipment is required for DS1 tandem applications in single-ended or DS1-fed systems.

Figure 1-14
Typical universal application of a 2-wire FX trunk over interoffice cable

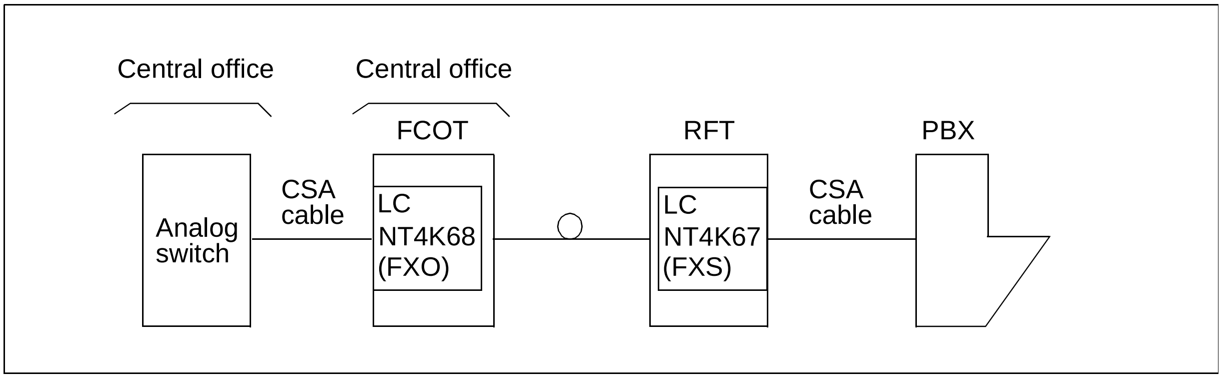


Figure 1-15
Typical universal application of a 2-wire FX trunk over PCM carrier

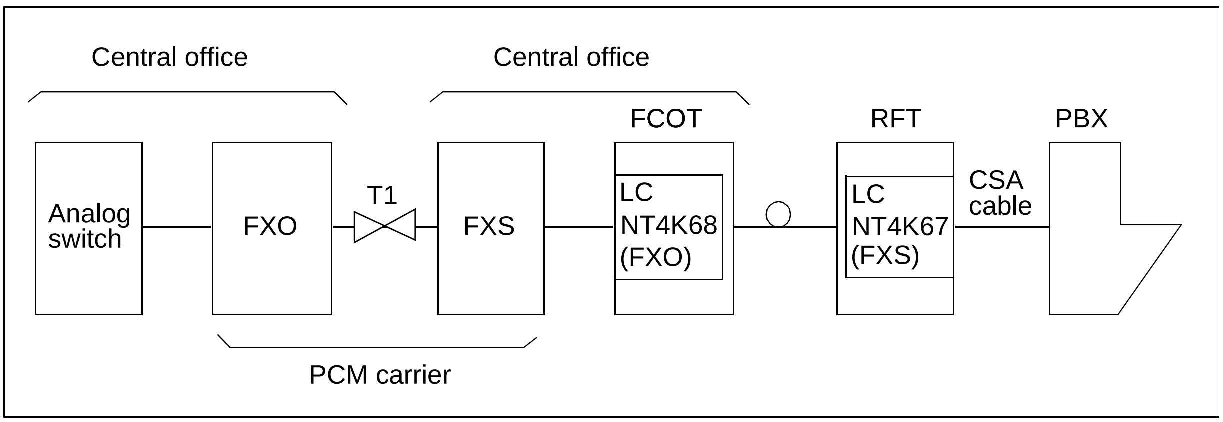
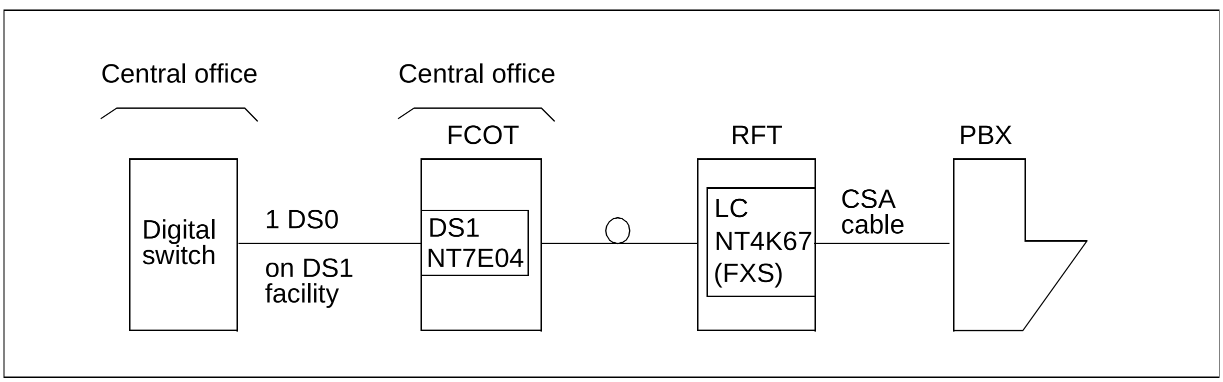


Figure 1-16
Typical DS1 tandem application of a 2-wire FX trunk



Nonswitched services—2-wire applications

Nonswitched services on 2-wire line cards (NSS 2W) serve the following applications:

- off-premise station (OPS)
- the following point-to-point private lines:
  - — transmission only (TO)
  - — equalized transmission only (ETO)
  - — manual ringdown (MRD)
  - — private line automatic ringdown (PLAR)

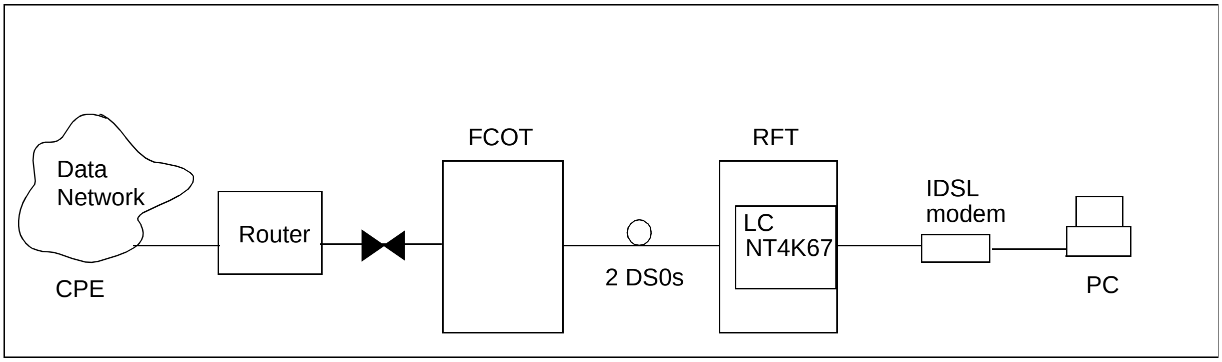
(NSS 2W) IDSL

IDSL provides high speed data service on a copper pair using standard ISDN loop technology. Rates of 64 or 128 kb/s are available. IDSL is a universal service. A local digital switch is not required.

AccessNode provides one to two nailed up pipes. One pipe (B1 or B2) provides 64 kb/s. Two pipes (B1 + B2) provides 128 kb/s data service. The channels are mapped onto DS1 Tandem links. Because AccessNode provides these clear channel DS0s, the transfers are transparent within the system and will not have to deal with data network protocols. This service is sometimes referred to as “Always On.”

The CPE consists of an Ethernet connection from a PC to an IDSL modem. The CPE is responsible for handling the data network protocols, such as RFC 1490. The IDSL modems DSL loop connection is sent to a NT4K67AC rel 20 line card. The line card is provisioned with the IDSL service, which provides two DS0 channels, similar to the 3DS0 ISDN service. See “(NLSS 2W) 3DS0 ISDN” on page 1-52. The channels are then mapped onto a DS1 Tandem link. Provisioning is accomplished by TL1 commands. The Tandem is connected to a router, which is the interface to the data network. See Figure 1-17.

Figure 1-17
IDSL application



(NSS 2W) Off-premise station (OPS)

Off-premise station (OPS) gives a subscriber a PBX station (telephone set) located remotely from the PBX. It supplies a line from a PBX to a telephone set at different premises (FXS: station end, FXO: PBX end). An NT4K67 Omega 2-wire station line card is installed at the station end, and an NT4K68 Omega 2-wire office line card is installed at the PBX end.

OPS supports DP and DTMF address signaling. The ringing type is 20 Hz bridged. The supervision type is loop start.

Figure 1-18 and Figure 1-19 show typical universal applications of off-premise station service with a PBX off the FCOT and with a PBX off the RFT. Figure 1-20 on page 1-58 and Figure 1-21 on page 1-58 show typical universal and DS1 tandem applications of off-premise station service in point-to-point fiber-fed systems. For DS1 tandem applications in single-ended or DS1-fed systems, no FCOT equipment is required.

Figure 1-18
Intra-office OPS line with PBX off the FCOT (universal application)

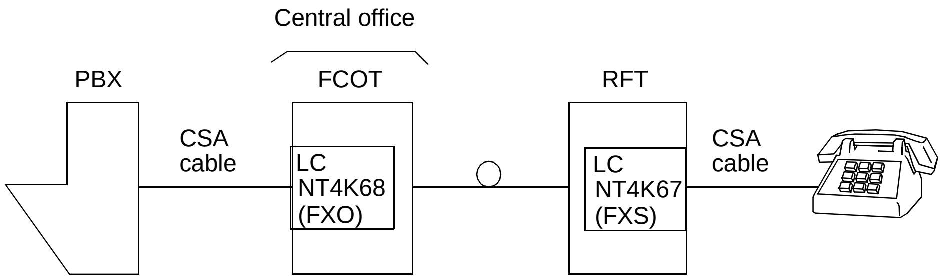


Figure 1-19
Intra-office OPS line service with PBX off the RFT (universal application)

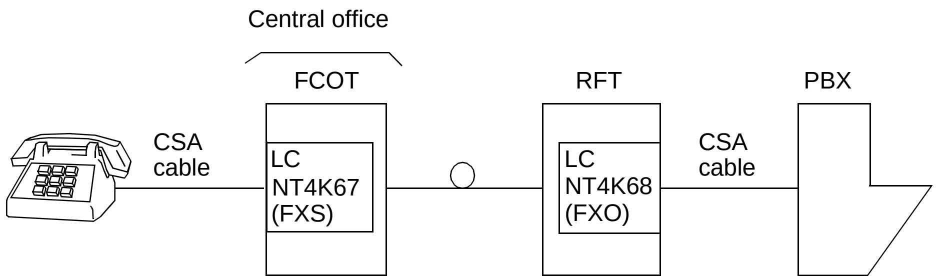


Figure 1-20
Interoffice OPS line service (universal application)

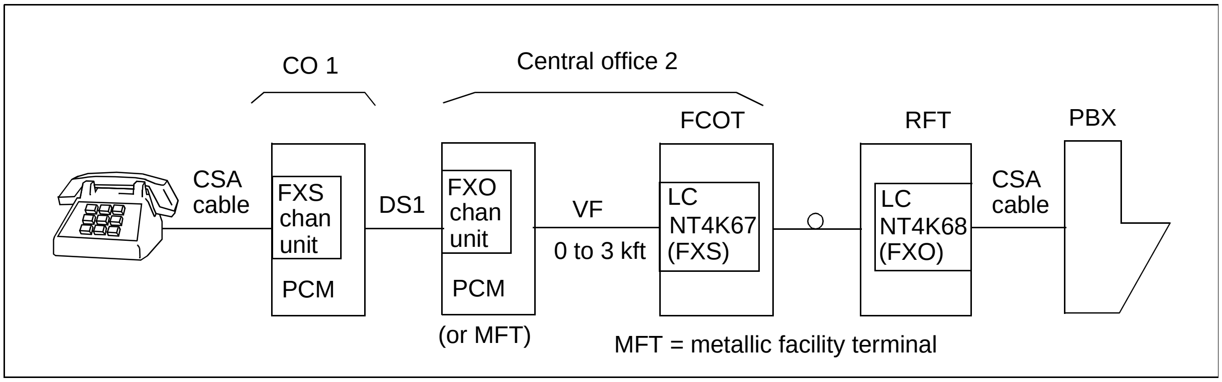
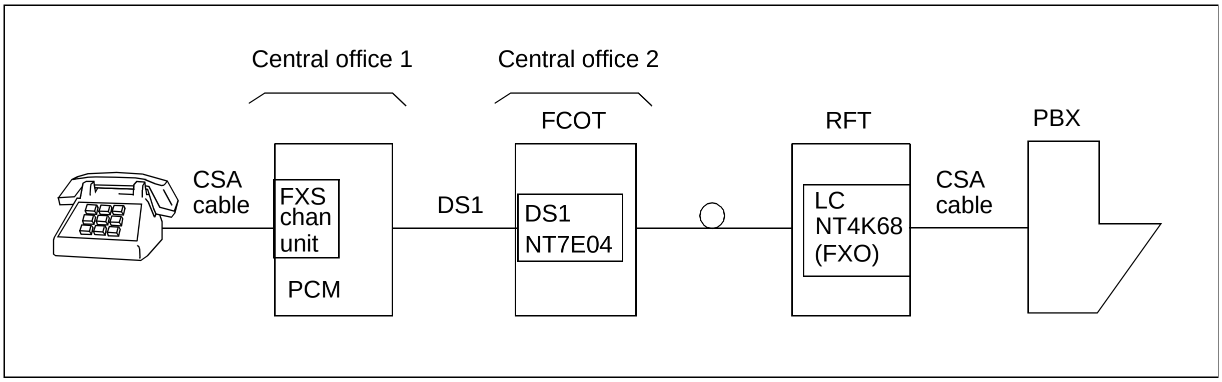


Figure 1-21
Interoffice OPS line service (DS1 tandem application)



(NSS 2W) Private line analog data (TO, ETO)

A private line analog data line connects customer equipment without passing through central office switches. The line provides a point-to-point dedicated analog line for transmitting data using modems (also called Full Period Private Line for voiceband data). This is a nailed-up connection with no supervision or signaling, making it transmission only (TO service). As an option, equalization can be added to improve data transmission quality (ETO service).

The NT4K68 Omega 2-wire office line card sinks the sealing current, and the NT4K67 Omega 2-wire station line card sources the sealing current. In a universal application, you can implement private line analog data services by installing any combination of line cards and service codes at the FCOT and the RFT. For example, you can provision the NT4K68 with a service code of TOO or ETOO or provision the NT4K67 with a service code of TOS or ETOS. The choice of line cards and provisioning depends on whether you want to sink or source the sealing current. Similarly, the RFT supports either of these line cards in a DS1 tandem application. Table 1-5 on page 1-15 and Table 1-6 on page 1-16 list the provisionable parameters for these service codes.

Figure 1-22 and Figure 1-23 (on page 1-60) show typical universal and DS1 tandem applications of TO service in point-to-point fiber-fed systems. For DS1 tandem applications in single-ended or DS1-fed systems, no FCOT equipment is required.

Figure 1-22
Typical universal application of a 2-wire TO service

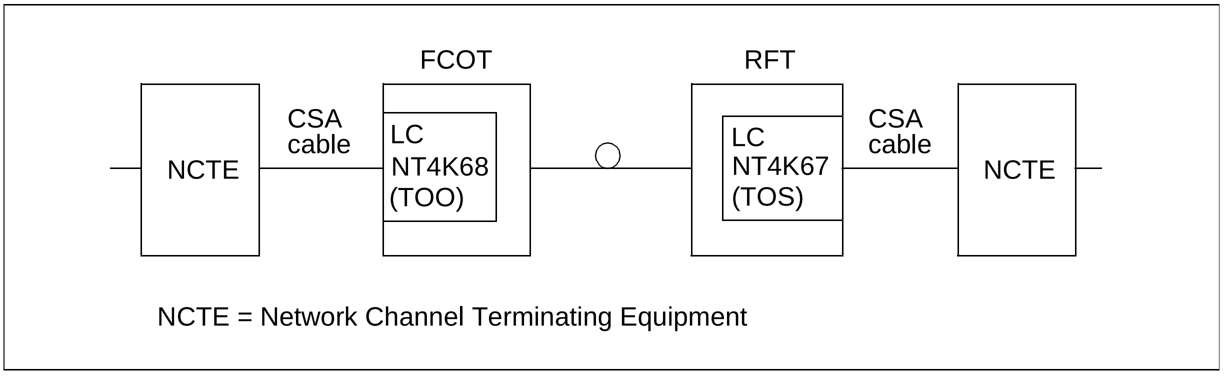
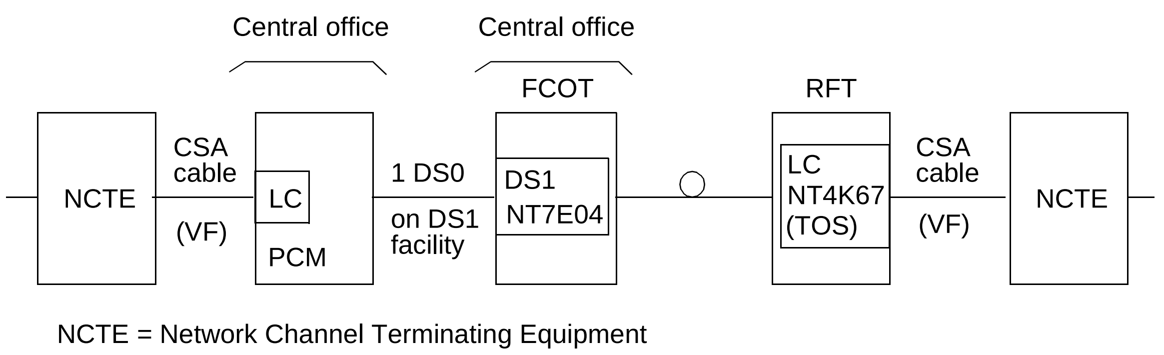


Figure 1-23
Typical DS1 tandem application of a 2-wire TO service



(NSS 2W) Manual ringdown

Manual ringdown (MRD) service is a 2-wire point-to-point private line with manual signaling between two customer premises. The calling party manually presses a button to apply an ac ringing voltage to the called party's telephone set. Each customer's station equipment includes a ringing source and a loop feed interface with a ringing control means from the set to the customer premises common equipment. The manual signaling method works identically in either direction.

The NT4K78 Omega manual ringdown line card at the called end generates the ac ringing voltage in response to the ringdown signal from the calling party. It discontinues ringing of the called end, then provides a voice path, at the first instance of one of the following conditions:

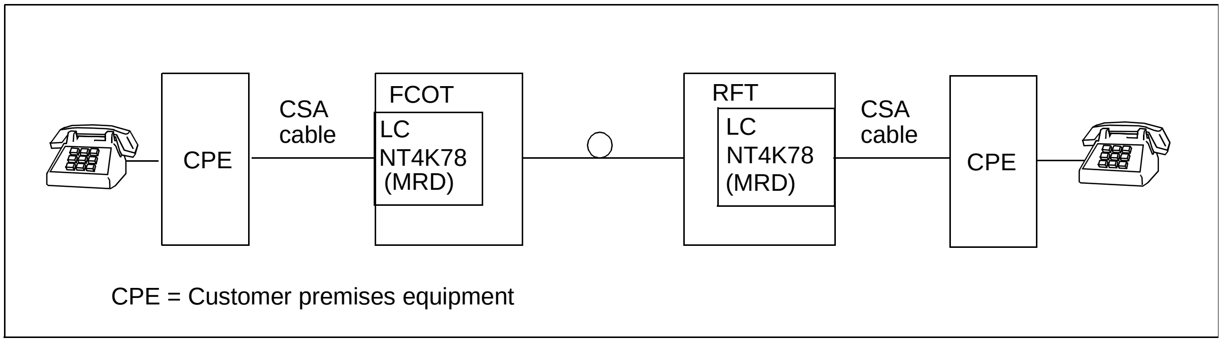
- the discontinuation of the ringing command from the calling end
- the detection of a loop closure (off-hook causing ring trip) at the called end
- a time-out of five seconds

The manual ringdown service is provisioned as MRD on the NT4K78 Omega 2-wire manual ringdown line card. Line card provisioning is performed from the operations controller (OPC). Line cards can be preprovisioned before actual installation in the copper-distribution shelf. See Table 1-9 on page 1-19 for the provisionable parameters associated with this service code.

The MRD line card supports a number of applications with several types of customer premise equipment (CPE), including key telephone systems (utilizing key telephone sets, or turrets), and PBXs.

A local manual ringdown service with one leg of the circuit on AccessNode (and the other leg on VF cable) uses the NT4K78 line card and MRD service code at both FCOT and RFT. Figure 1-24 shows a typical universal application of MRD service.

Figure 1-24
Local MRD service, universal application



Another MRD application has both legs of the circuit on AccessNode. This service uses two MRD line cards at the RFT (or on two RFTs). The VF tandem connection is made at the FCOT (or at two FCOTS) using one of the following arrangements:

- an E&M-to-PLR type 1 or 2 connection on two NT4K77 line cards
- a two-state tandem type 1 or 2 connection on two NT4K77 line cards
- two MRD line cards (NT4K78) back-to-back with 0 dB loss (not recommended because of effects on timing specifications)

Figure 1-25 on page 1-62 shows a voice-frequency tandem application with a path from a subscriber on one AccessNode system to a subscriber on another AccessNode system. The line-card bridge at the FCOTs can be NT4K77 6/8-wire line cards or NT4K78 2-wire MRD line cards set for 0 dB loss.

Figure 1-25
MRD service using voice frequency tandem, universal application

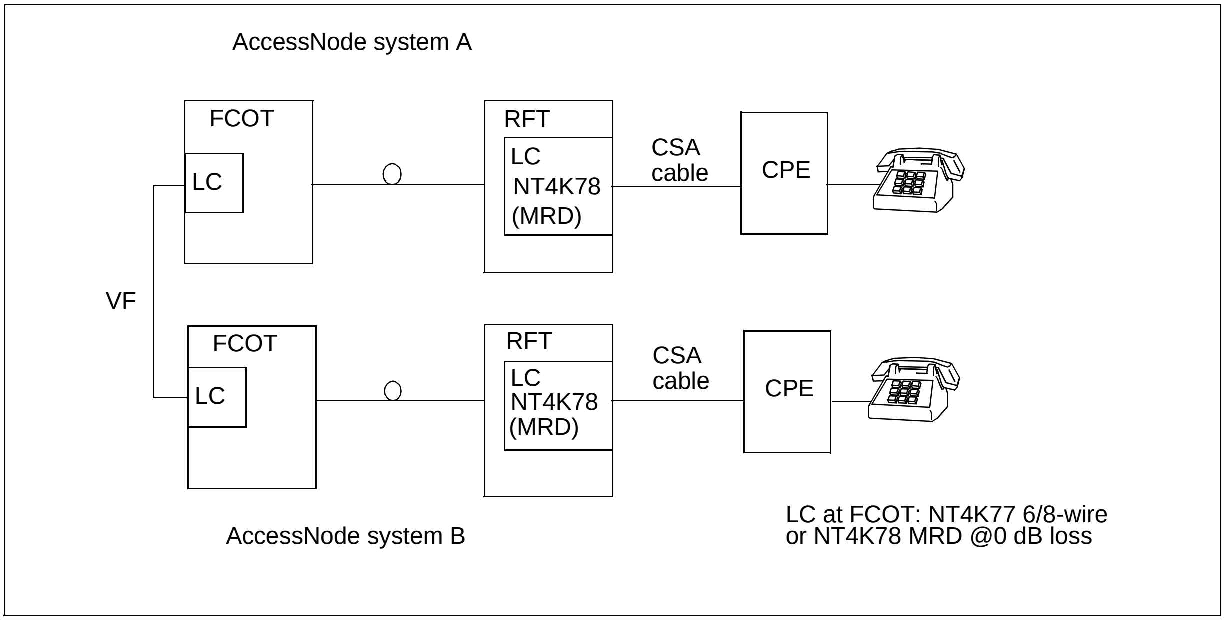
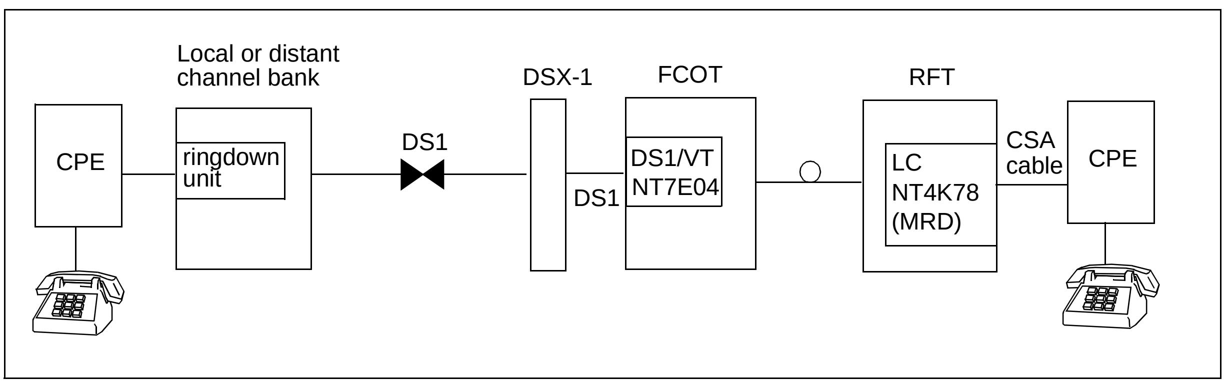


Figure 1-26 shows a typical DS1 tandem application of MRD service in point-to-point fiber-fed systems. For DS1 tandem applications in single-ended or DS1-fed systems, no FCOT equipment is required.

Figure 1-26
Typical MRD service, DS1 tandem application



(NSS 2W) Private line automatic ringdown (PLAR)

Private line automatic ringdown (PLAR) service, a private line between two customer premises, rings the called party's phone when the calling party's telephone goes off-hook. The action of the calling party picking up the handset initiates the ringing. The calling party does not need a call-initiate button.

When the busy tone option is on, the following sequence occurs:

1 If the called end is still on-hook after two minutes, then the alerting signal ceases.
2 The audible ringback in the transmit (Tx) direction is replaced by a fast busy tone for two minutes.
3 The fast busy is replaced by a howler for two minutes.
4 The howler is replaced by quiet PCM.

PLAR service is provisioned as PLAR1 or PLAR2 on the NT4K67 2-wire Omega station line card. PLAR1 meets the original (1982) signaling standard for PLAR, and PLAR2 meets the newer (proposed in 1985) standard signaling scheme. PLAR1 applies only to DS1 tandem applications.

A number of PLAR circuit arrangements are possible:

- Figure 1-27 shows a local private line automatic ringdown service using the NT4K67 line card and PLAR2 service code at both FCOT and RFT.
- Figure 1-28 on page 1-64 shows a typical DS1 tandem application of PLAR2 service in a point-to-point fiber-fed system. For DS1 tandem applications in single-ended or DS1-fed systems, no FCOT equipment is required.

Figure 1-27
Typical universal application of local PLAR service

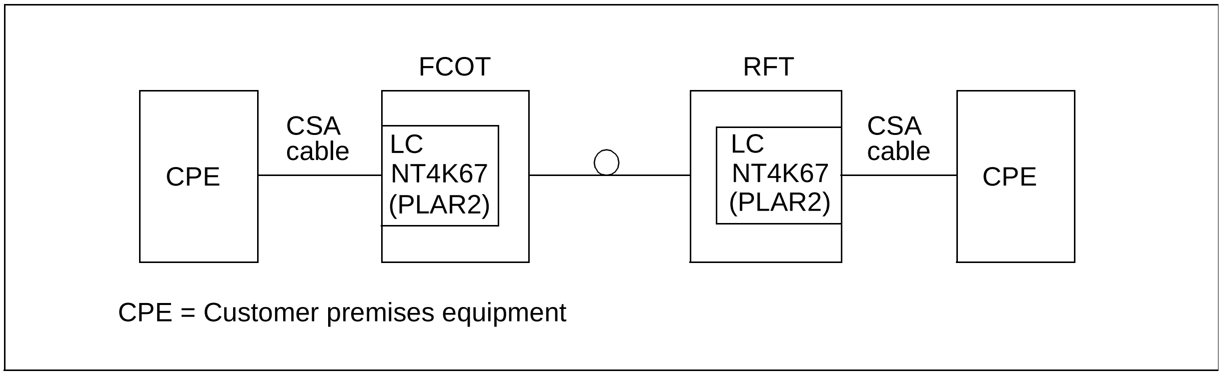
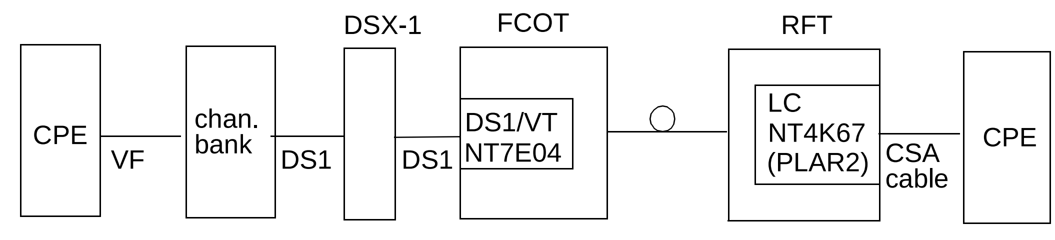


Figure 1-28
Typical DS1 tandem application of PLAR service



Nonlocally switched services—4-wire applications

This topic describes nonlocally switched services on 4-wire line cards (NLSS 4W).

(NLSS 4W) Foreign exchange lines and trunks

The following services can be provided on a foreign exchange (FX) circuit:

- long distance trunk
- automatic call distributor (ACD) trunk
- WATS line or trunk
- 800-service line or trunk

In a universal application, you implement FX service by installing an Omega 4-wire line card provisioned for foreign exchange office (FXO) at the FCOT and an NT4K67 Omega 2-wire station line card or 4-wire line card provisioned for foreign exchange station (FXS) at the RFT.

In a DS1 tandem application, you install an Omega 4-wire line card provisioned for FXS at the RFT. Table 1-7 on page 1-17 lists the provisionable parameters for this service code.

FX supports the following address signaling types:

- dial pulse (DP) and multifrequency (MF) for long distance trunks and ACD trunks
- dial pulse (DP) and dual-tone multifrequency (DTMF) for WATS and 800-service lines or trunks

Supervision types are loop start and ground start.

Figure 1-29 on page 1-65 and Figure 1-30 on page 1-65 show typical universal applications of FX service.

Figure 1-31 on page 1-65 shows a typical DS1 tandem application of FX service in a point-to-point fiber-fed system. For DS1 tandem applications in single-ended or DS1-fed systems, no FCOT equipment is required.

Figure 1-29
Typical universal application of FX 4-wire line circuit

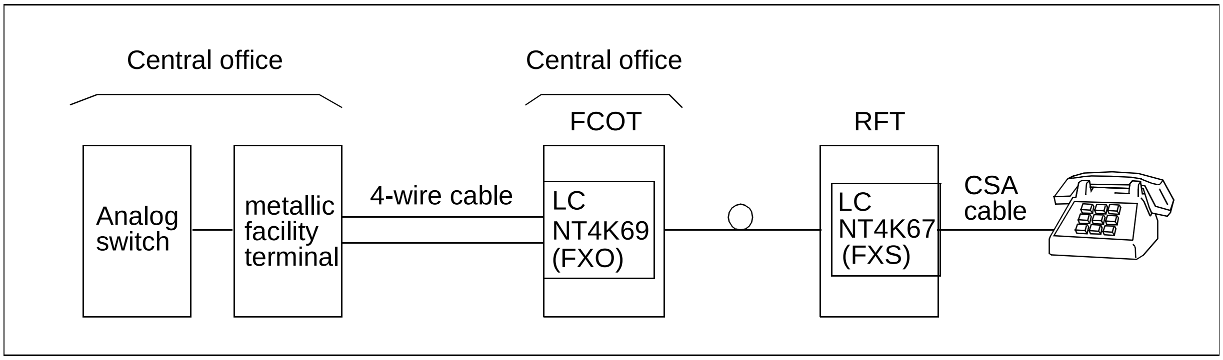


Figure 1-30
Typical universal application of FX trunk over interoffice cable

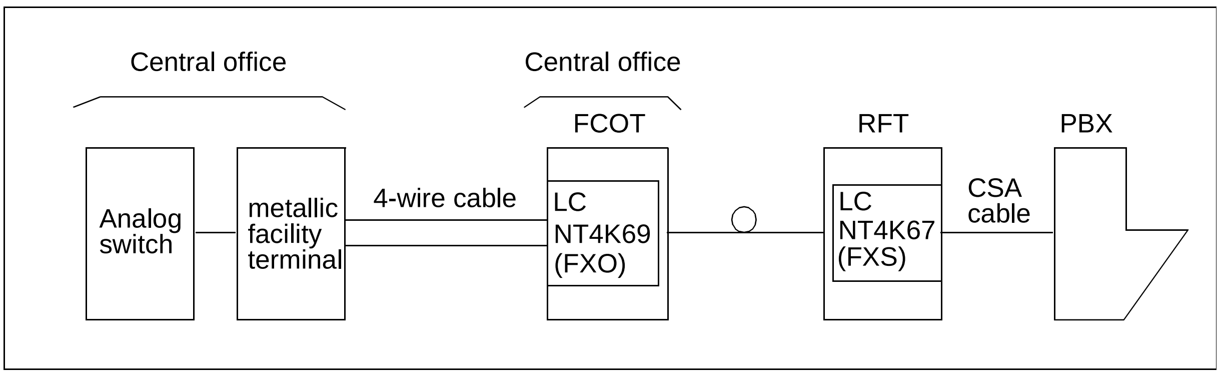
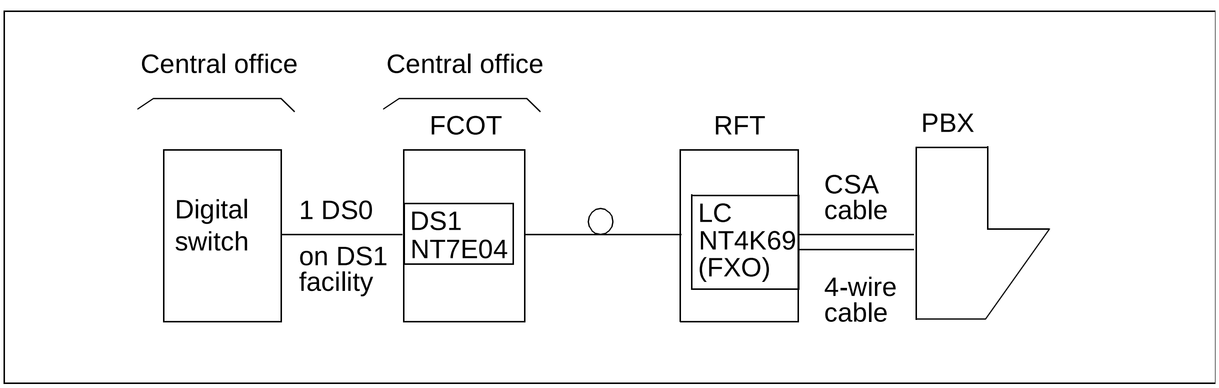


Figure 1-31
Typical DS1 tandem application of FX trunk



Nonswitched services—4-wire applications

This topic describes nonswitched services on 4-wire line cards (NSS 4W).

(NSS 4W) PBX tie trunks — duplex (DX) signaling

PBX tie trunks interconnect PBXs without passing through central office switches. Some full period private line voiceband data services, such as PBX trunks, provide DX signaling.

> ***Note:*** If a DX circuit in the FCOT is connected to a DX circuit in the RFT, at least one side of the DX circuit must be terminated prior to placing the circuit in service.

In a universal application, you implement DX service by installing an Omega 4-wire line card at the FCOT and an Omega 4-wire line card or 6/8-wire line card at the RFT. You provision one of the line cards with a service code of DX. You provision the other line card with a DX service code or with a service code, such as E&M or PLR, on an Omega 6/8-wire line card.

In a DS1 tandem application, you install an Omega 4-wire line card at the RFT and provision the line card with a service code of DX. Table 1-7 on page 1-17 lists the provisionable parameters for this service code.

DX service supports dial pulse (DP) and dual-tone multifrequency (DTMF) address signaling.

Figure 1-32 and Figure 1-33 on page 1-67 show typical universal and DS1 tandem applications of DX service.

Figure 1-32
Typical universal application of PBX tie trunks using DX signaling

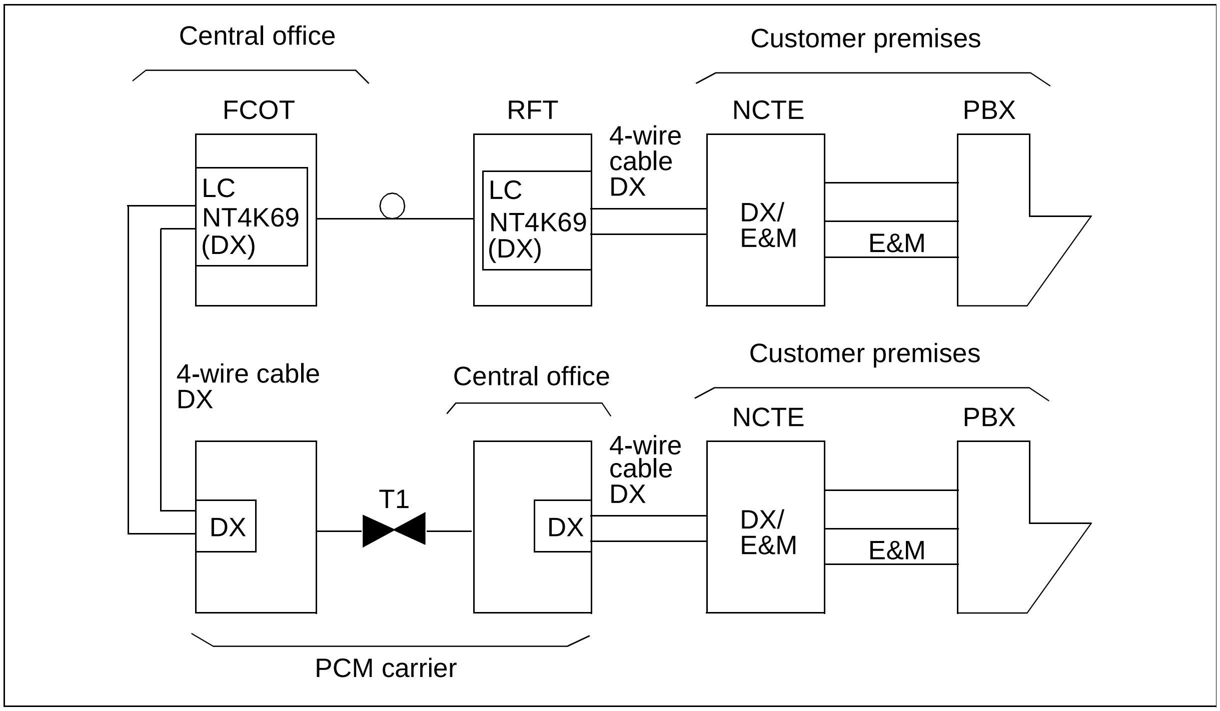
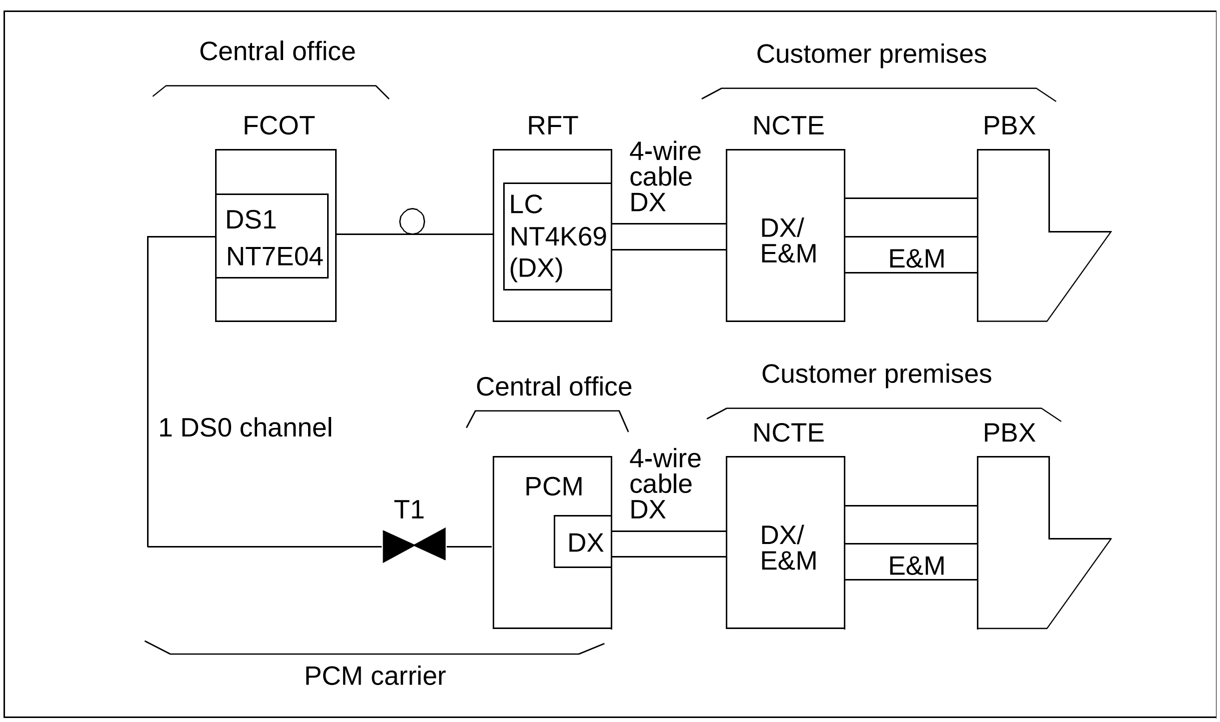


Figure 1-33
Typical DS1 tandem application of PBX tie trunks using DX signaling



(NSS 4W) Private line analog data

Private line analog data lines interconnect customer equipment without passing through central office switches.

Circuit types include:

- Equalized transmission only (ETO)
- Transmission only (TO)

In a universal application, you implement these services by installing an Omega 4-wire line card provisioned with service code TO or ETO at the FCOT and an Omega 4-wire line card provisioned with service code TO or ETO at the RFT.

In a DS1 tandem application, you install an Omega 4-wire line card provisioned with service code TO or ETO at the RFT. Table 1-7 on page 1-17 shows the provisionable parameters for this service code.

Figure 1-34 and Figure 1-35 (on page 1-69) show typical universal and DS1 tandem applications of TO service in point-to-point fiber-fed systems. For DS1 tandem applications in single-ended or DS1-fed systems, no FCOT equipment is required.

Figure 1-34
Typical universal application of TO service

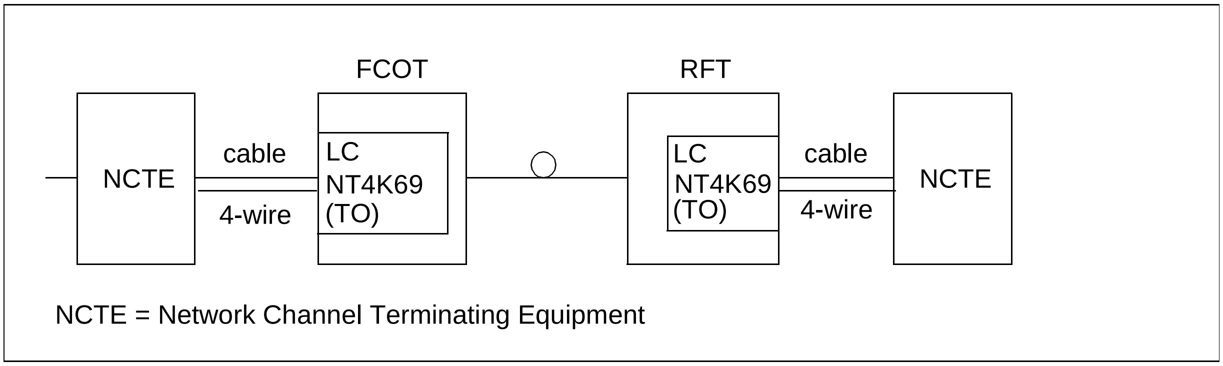
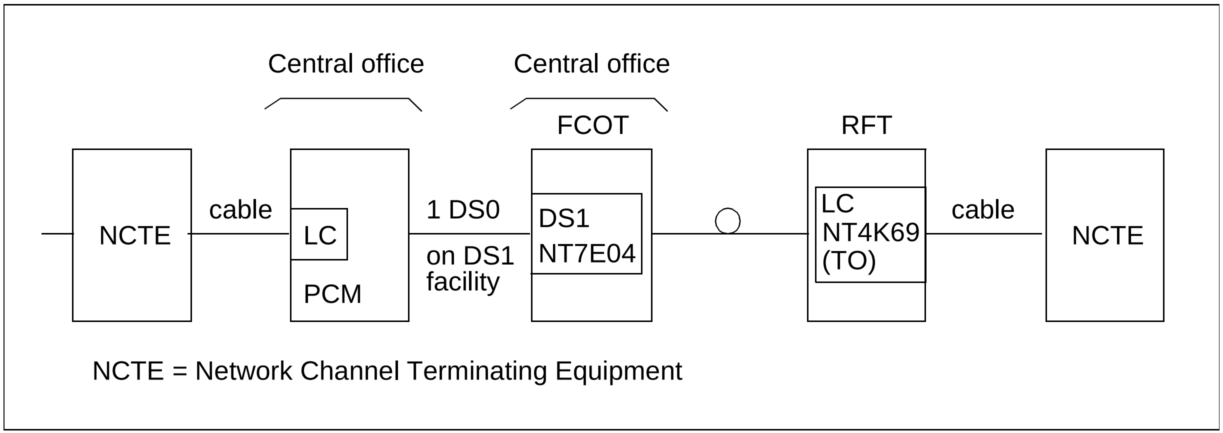


Figure 1-35
Typical DS1 tandem application of TO service



(NSS 4W) Digital Data Service (DDS)

This service accesses digital data service (DDS) and digital channel service (DCS). DDS and DCS comprise point-to-point and multipoint 4-wire private line full-duplex data transmission operating at synchronous rates of 2.4, 4.8, 9.6, 19.2, 56, and 64 kb/s. The 64 kb/s rate operates on a clear-channel DS0.

You implement DDS by provisioning the NT4K69 Omega 4-wire line card with a service code of DDS and a function code of digital signal zero-dataport (DS0DP) or office channel unit-dataport (OCUDP). The DS0DP and OCUDP functions are in different software loads. Table 1-7 on page 1-17 lists the provisionable parameters for DDS service.

DDS is a synchronized network. Before DDS circuits access the DDS network, the DDS DS0 cross-connect in the central office collects and synchronizes the circuits. DS0DP interfaces to the DDS DS0 cross-connect. It is used at the FCOT in a universal application. When a data service is to be tied into the DDS network, the external synchronization interface (ESI) card must be installed at the FCOT and connected to a 64/8 kHz composite clock.

OCUDP interfaces to the customer loop portion of a DDS line. In a universal application, it is used at the RFT or at both the FCOT and the RFT. In an integrated application, it is used at the RFT.

Provisioning commands for services in universal and DS1 tandem applications are entered through the operations controller (OPC) user interface. Service in an integrated application is provisioned at the DMS SuperNode MAPCI user interface.

Data applications

AccessNode supports the following data applications:

- local data service in a universal application (FCOT OCUDP to RFT OCUDP)
- DDS in a DS1 tandem application (FCOT DS0 to RFT OCUDP)
- DDS in a universal application (FCOT DS0DP to RFT OCUDP)

Figure 1-36 shows local data service in a universal application, which requires one 4-wire line card at the FCOT provisioned for DDS (OCUDP) and one 4-wire line card at the RFT provisioned for DDS (OCUDP). For a local, independent data service, the ESI source is not important. The loop-timed RFT is sufficient to synchronize the data service.

Figure 1-36
Typical universal application of local data service

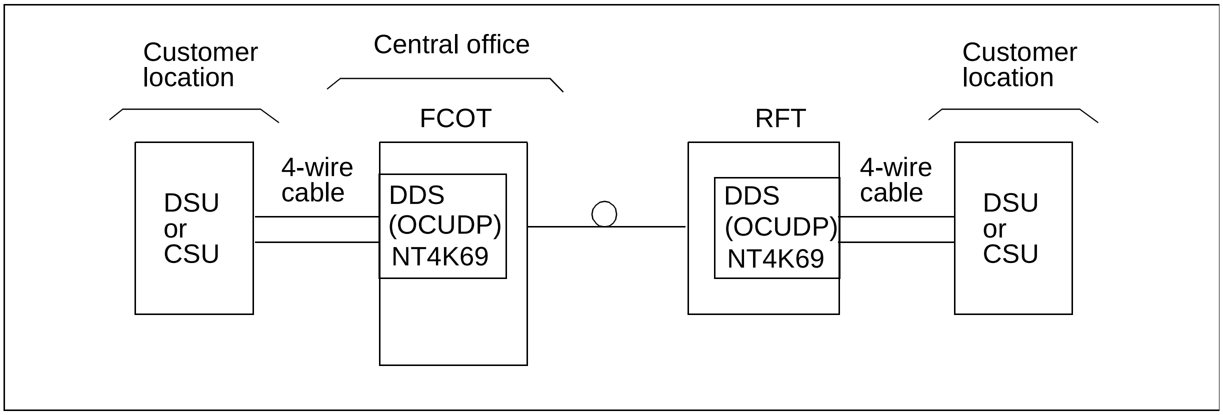


Figure 1-37 shows DDS in a DS1 tandem application, which requires one 4-wire line card at the RFT provisioned for DDS (OCUDP). In a point-to-point fiber-fed system, DDS service on DS1 tandem requires a DS0 channel on a DS1/VT Mapper at the FCOT. The ESI card must also be installed at the FCOT, connected to a DS1 clock source, and provisioned for BITSDS1. In DS1-fed and single-ended systems, RFT synchronization is derived from incoming DS1 or optical facilities, and no FCOT equipment is required.

Figure 1-37
Typical DS1 tandem of DDS service

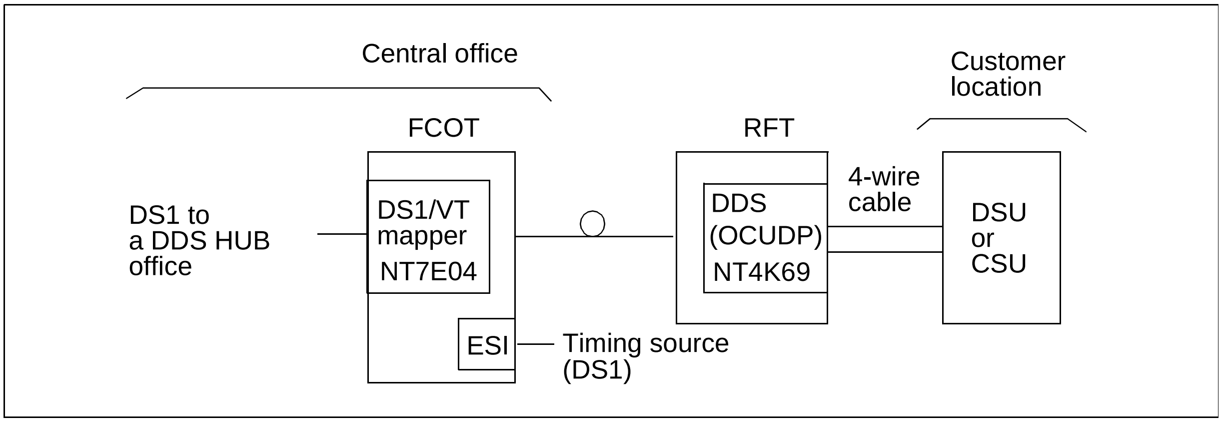
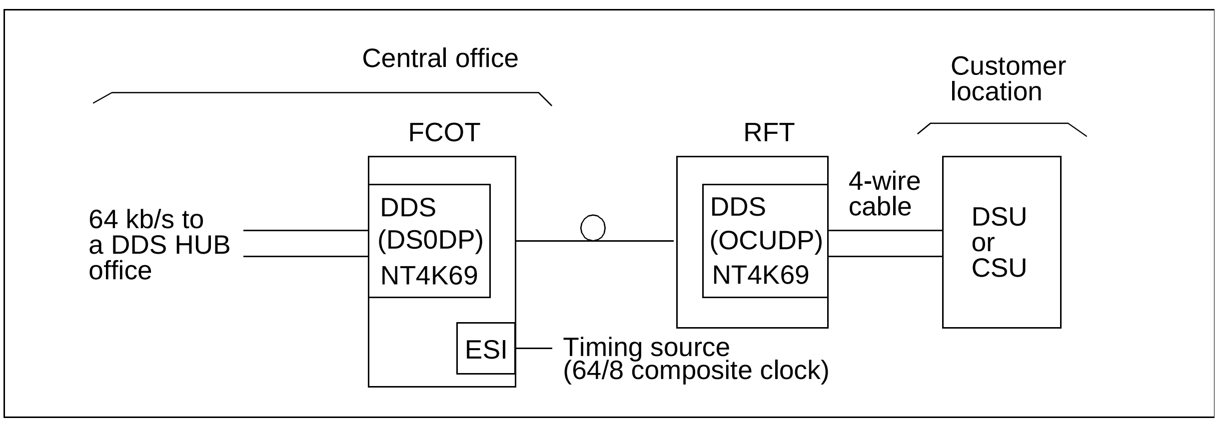


Figure 1-38 shows DDS in a universal application, which requires one 4-wire line card at the FCOT provisioned for DDS (DS0DP) and one 4-wire line card at the RFT provisioned for DDS (OCUDP). At the FCOT, the ESI card must be installed, connected to a 64/8 kHz composite clock source, and provisioned for BITSCC.

Figure 1-38
Typical universal application of DDS service



Some features of DDS applications

At the customer location, the user connects to the DDS line at a channel service unit (CSU) or at a combined data service unit/channel service unit (DSU/CSU). The DSU/CSU recovers timing, encodes and decodes signals, loops back signals, and interfaces for various subrates. The CSU provides only the subscriber interface and the signal loopback.

The DSU/CSU converts the baseband data signal from a standard interface (RS232, RS449, or V.35) to a bipolar signal for transmission over a 4-wire facility to the OCUDP in the AccessNode. The bit rate on this path varies with the data rate delivered to the end user. The OCUDP converts the signal from the access loop format to the DDS 64 kb/s DS0 format. You can provision the OCUDP for a data rate of 2.4, 4.8, 9.6, 19.2, 56, or 64 kb/s.

The OCUDP can operate with up to 45 dB of loss (measured at one half the bit rate) between the OCUDP and the DSU/CSU. In customer premise applications, this long-loop capability allows the use of inexpensive twisted-pair cabling.

AccessNode also supports a DDS secondary channel within each connected channel.

Error correction

Error correction can be provisioned to ON or OFF for each DDS circuit. Subrate DDS circuits (2.4, 4.8, 9.6, or 19.2 kb/s) support error correction *within* the DS0 datastream.

DDS circuits operating at 56 and 64 kb/s require a second DS0 on the network side of the line card when the error-correction option is ON. The second DS0 channel for error correction has the following impact:

- the additional DS0 assignment must be coordinated with other equipment connected to the circuit
- service to an existing DDS service is temporarily interrupted when the error correction function is turned ON or OFF (affects services in both universal and DS1 tandem applications)
- service to an existing DDS service on DS1 tandem is permanently interrupted if the error correction function is turned ON when a different service is provisioned in the next higher-numbered DS0 channel *(service is restored by turning error correction OFF again).* Service is interrupted because the OPC provisioning manager tries (but is unable) to assign the adjacent DS0 channel for error correction.

Loopback functions

When you enable the latching loopback function, the line card recognizes the following loopback functions:

DS0DP:

- L1 lineside latching loopback
- L2 dropside latching loopback

OCUDP:

- channel service unit (CSU) latching loopback
- office channel unit (OCU) latching loopback

DDS synchronization

The DDS network is synchronous. One hub office contains a timing supply that acts as a master timing reference for an entire subnetwork. The timing is derived from upstream DS1s and successively passed on to equal or lower-order networks. This approach synchronizes the entire DDS network by creating a tree-structured timing scheme.

To maintain digital synchronization in a point-to-point system, the external synchronization interface (ESI) circuit pack, NT7E27, must be installed at the FCOT and connected to a building integrated timing supply (BITS).

For DDS DS0DP service, the ESI timing reference source must be a 64/8 kHz composite clock. The composite clock provides 64 kHz synchronization and 8 kHz phase alignment to all DS0s on the AccessNode. The composite clock source must be within 1500 feet (450 m) of a DDS DS0 cross-connect. An acceptable alternative source is an incoming DS1 signal directly connected to a 64/8 kHz composite clock.

For DDS OCUDP service, the ESI timing reference source can be an incoming DS1 signal. In integrated applications, the reference DS1 is from the local digital switch. For universal applications, if DS0DP service will be added at the FCOT at a later date, a 64/8 kHz composite clock is recommended.

In the FCOT user interface, the ESI timing reference is provisioned as BITSCC if the BITS source is a 64/8 kHz composite clock, or BITSDS1, if the source is a DS1 signal. In the RFT user interface, the RFT is provisioned as looptimed from the Shelf Equipment screen.

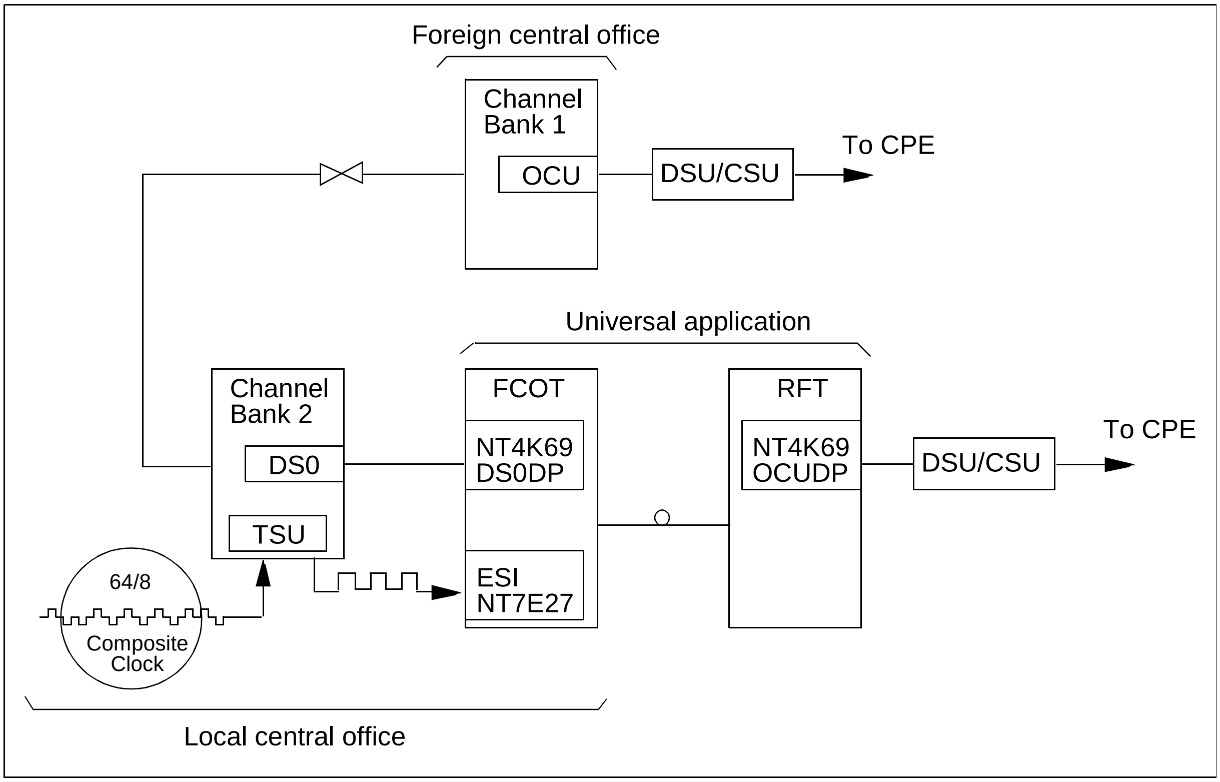
In DS1-fed systems, the RFT is looptimed timed in one of the following ways:

- from an incoming DS1 facility connected directly to a stratum 1 BITS or equivalent timing source
- from an incoming DS1 facility connected indirectly through a pulse-code modulation (PCM) channel bank or switch that is connected to the BITS

In single-ended systems, the RFT is looptimed to the network element to which its OC-3 optical carrier is connected. The system is synchronized from a stratum 1 BITS.

Figure 1-39 on page 1-74, Figure 1-40 on page 1-75, and Figure 1-41 on page 1-76 show typical DDS synchronization arrangements in point-to-point fiber-fed systems. In DS1-fed or single-ended systems, no FCOT equipment is required.

Figure 1-39
Typical private data line, universal application

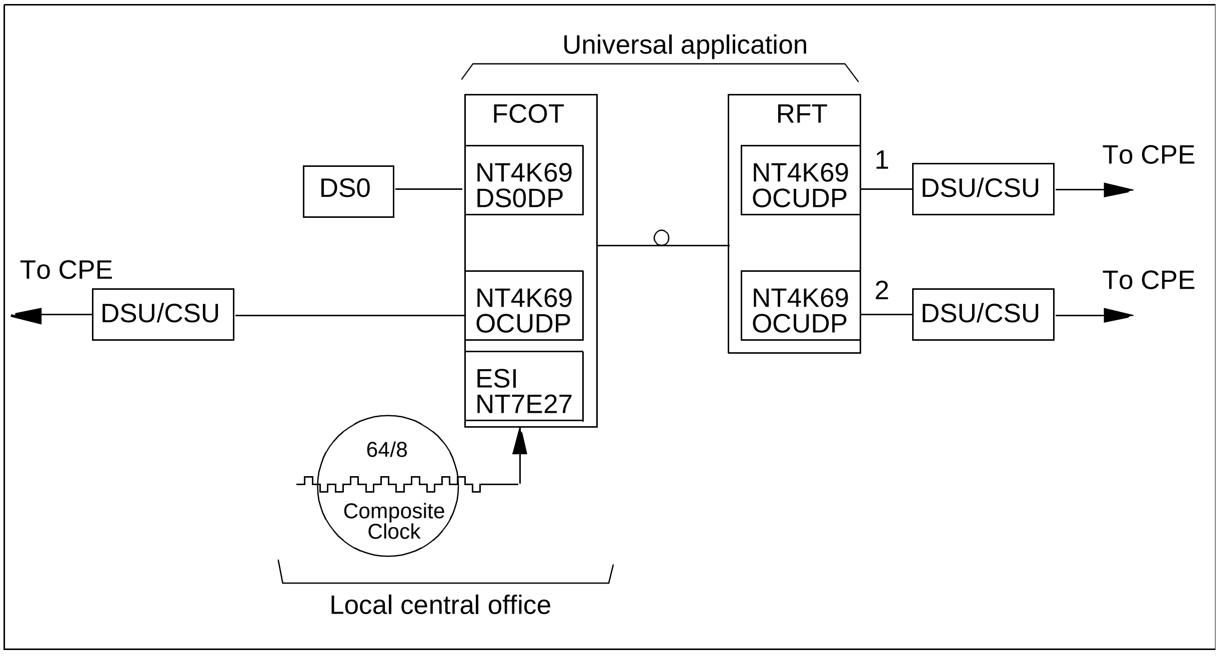


The following table explains the timing arrangements for Figure 1-39.

Network element	**DDS function**	**PEC**	**Timing**
Channel bank 1	OCU		Looptimed from channel bank 2
Channel bank 2	DS0		Timed from composite clock
FCOT	DS0DP	NT4K69	Timed from the composite clock by way of the Timing service unit (TSU) of channel bank 2 (BITSCC)
RFT	OCUDP	NT4K69	Looptimed from FCOT

Figure 1-40 shows a universal application in which one location is near the RFT and another is near the FCOT. The private data line is carried entirely by the AccessNode. For another application, a DS0DP line card is used at the same FCOT to feed other DS0DP line cards or a DDS multiplexer for transport to a foreign DDS office. In this scenario, the FCOT must be externally timed to the composite clock for the DS0DP line card.

Figure 1-40
DDS network service layout, universal application

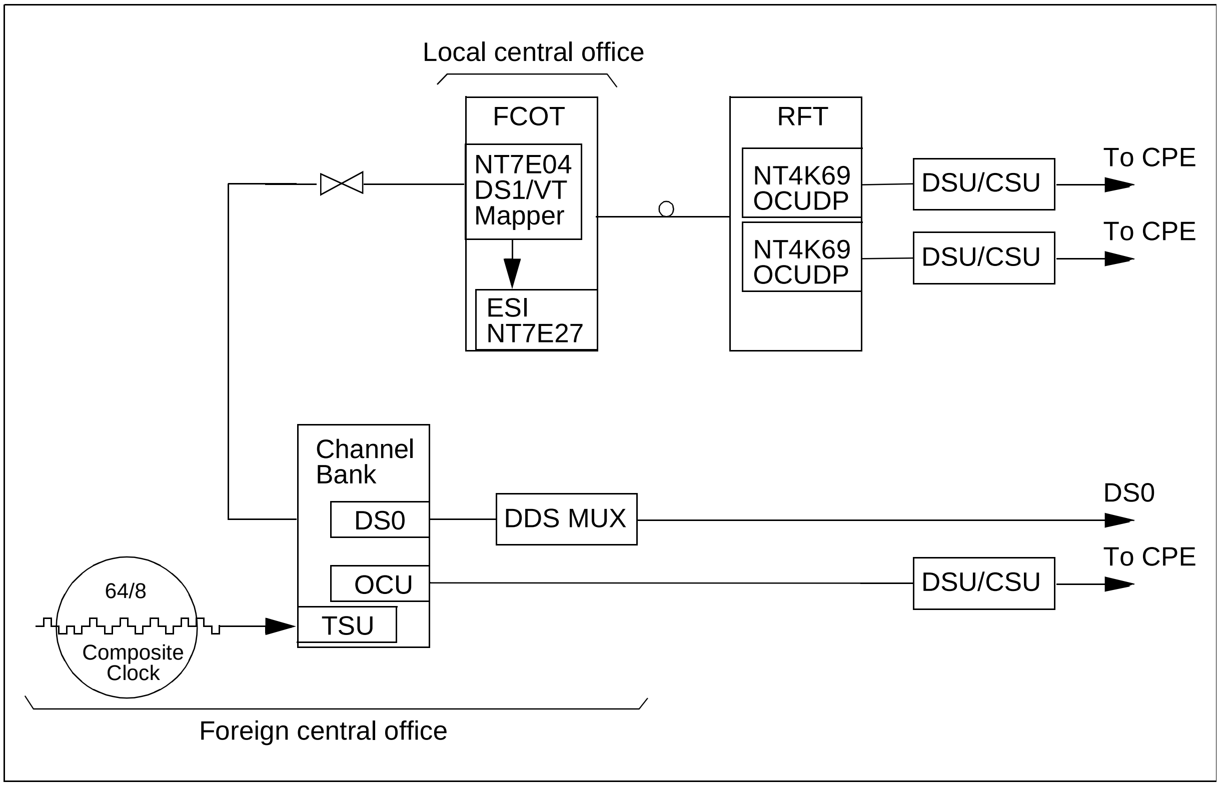


The following table explains the timing arrangements for Figure 1-40.

Network element	**DDS function**	**PEC**	**Timing**
RFT	OCUDP (1)	NT4K69	Looptimed from FCOT
RFT	OCUDP (2)	NT4K69	Looptimed from FCOT
FCOT	OCUDP	NT4K69	Composite clock (BITSCC)
FCOT	DS0DP	NT4K69	Composite clock (BITSCC)

Figure 1-41 shows a DS1 tandem application of DDS in a point-to-point fiber-fed system. The channel bank provides timing to the FCOT-RFT pair. The DS1/VT mapper card has at least one DS1 facility provisioned for DS1 tandem circuits. This provides interoffice transport for special service DS0s, such as the DDS DS0 circuit in this figure.

Figure 1-41
DDS layout, DS1 tandem application



The following table explains the timing arrangements for Figure 1-41.

Network element	**DDS function**	**PEC**	**Timing**
RFT	OCUDP	NT4K69	Looptimed from FCOT
FCOT	DS1/VT mapper	NT7E04	DS1 signal from channel bank (BITSDS1)
Channel bank	OCU		Composite clock
Channel bank	DS0		Composite clock

Nonlocally switched services—6/8-wire applications

This topic describes nonlocally switched services on 6/8-wire line cards (NLSS 6/8W).

(NLSS 6/8W) FX trunks

The 6/8-wire line card supports foreign exchange (FX) lines and trunks for long distance, automatic call distributor (ACD), WATS, or 800-service using tandem carrier interface (three-state) signaling.

Tandem signaling is used when two carrier systems are connected back-to-back, usually at a central office, to support services that require loop or ground-start signaling. You can provision the NT4K77 Omega 6/8-wire line card for the following tandem signaling interfaces:

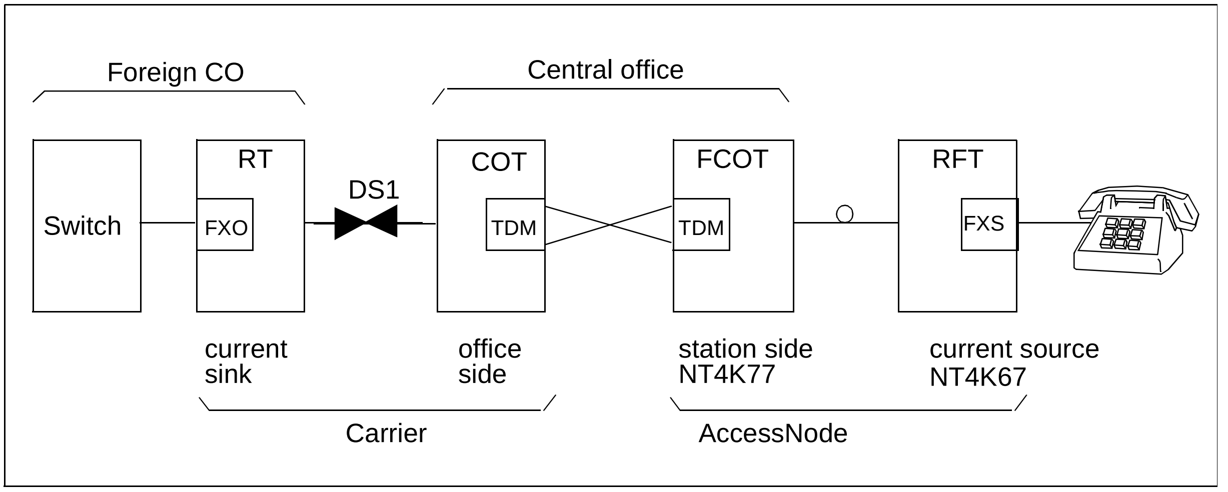
- three-state, station side:
  - 6-wire, type 1
  - 8-wire, type 2
- three-state, office side:
  - 6-wire, type 1
  - 8-wire, type 2
- two-state:
  - 6-wire, type 1
  - 8-wire, type 2

When you provision the NT4K77 line card for station-side tandem, it allows three states of signaling in each direction. The station-side line card interface sends loop-open, loop-closed, and ring-ground toward the connecting equipment. It detects loop-current-feed-open, loop-current-feed, and ringing from the connecting equipment. The station-side tandem is at the FCOT with a loop or ground-start current feed line card at the RFT.

When you provision the NT4K77 Omega 6/8-wire line card for office-side tandem, it sends loop-current-feed-open, loop-current-feed, or ringing toward the connecting equipment. It detects loop-open, loop-closed, and ring-ground from the connecting equipment. The office-side tandem is at the FCOT with a loop or ground-start current sink line card at the RFT.

Figure 1-42 on page 1-78 shows a typical universal application of tandem signaling in nonlocally switched services in FX line and trunk services.

Figure 1-42
Typical universal application of FX line or trunk using tandem carrier interface



Nonswitched services—6/8-wire applications

This topic describes nonswitched services on 6/8-wire line cards (NSS 6/8W).

(NSS 6/8W) PBX tie trunks

PBX tie trunks connect PBXs without passing through central office switches. It requires an Omega 6/8-wire line card at both the RFT and the FCOT. PBX tie trunks support ear and mouth (E&M) and pulse link repeater (PLR) signaling types.

Figure 1-43 on page 1-79 shows PBX tie trunks in a universal application of DX service. Installing an Omega 4-wire line card at the FCOT and an Omega 6/8-wire line card at the RFT provisioned for E&M implements the service. In a DS1 tandem application, an Omega 6/8-wire line card is installed at the RFT.

Omega 6/8-wire line cards have five E&M and PLR service codes. Table 1-8 on page 1-18 lists the provisionable parameters for each service code.

PBX tie trunks support dial pulse (DP) and dual-tone multifrequency (DTMF) address signaling. Supervision types are E&M and PLR.

Figure 1-43 and Figure 1-44 (on page 1-79) show typical universal and DS1 tandem applications of PBX tie trunks in a point-to-point fiber-fed system. For DS1 tandem applications in single-ended or DS1-fed systems, no FCOT equipment is required.

Figure 1-43
Typical universal application of PBX tie trunks

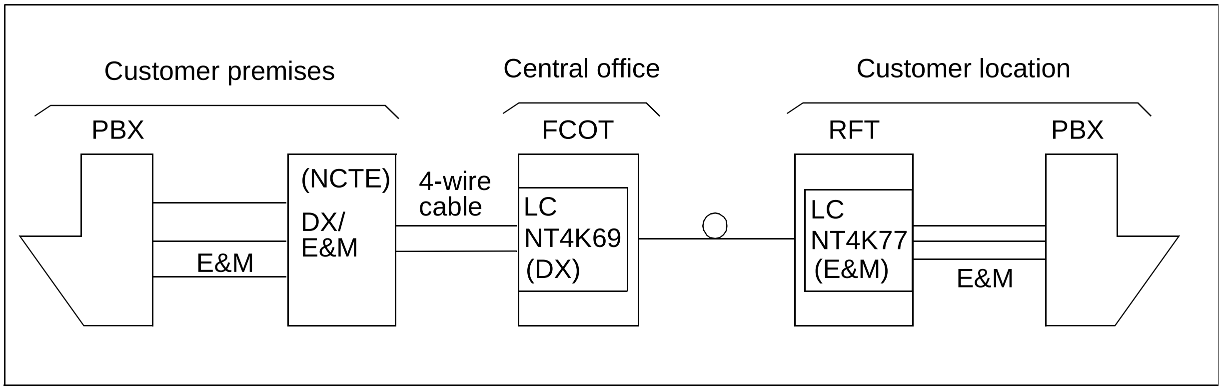
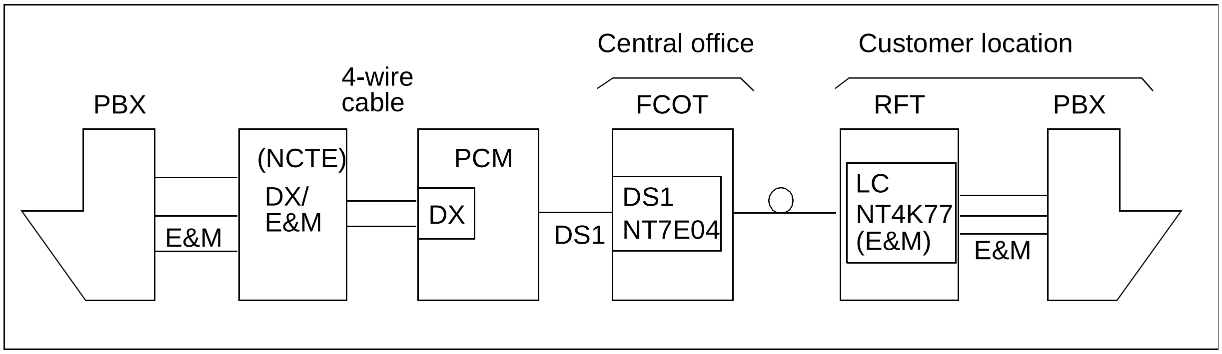


Figure 1-44
Typical DS1 tandem application of PBX tie trunks

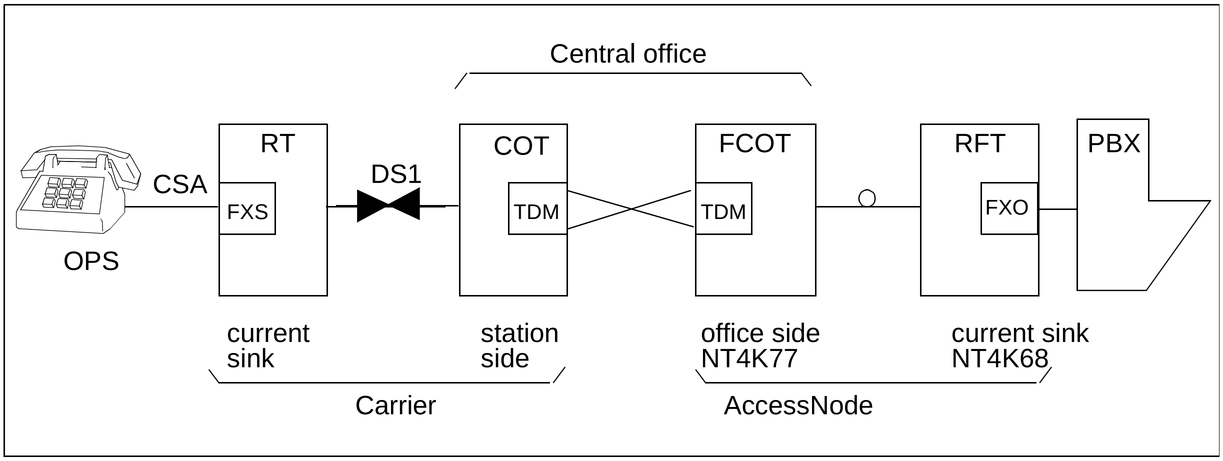


(NSS 6/8W) Off-premise stations

The 6/8-wire line card supports off-premise stations (OPS) using tandem carrier interface (three-state) signaling. Operation is similar to the description for FX services using a tandem carrier interface on page 1-77.

Figure 1-45 on page 1-80 shows a typical universal application of tandem signaling of a nonswitched service, such as an off premise station (OPS) service.

Figure 1-45
Typical universal application of OPS using tandem carrier interface



Determining equalization, gain, and balance for 2-wire line cards

This chapter describes how to determine parameter settings for 2-wire line cards. The following tables show each line card's service code requirements for balance, equalization, off-hook gain, and on-hook transmission (OHT) gain provisioning. The topics following these tables describe the steps to determine the parameters for balance, equalization, off-hook gain, and OHT gain.

Note: The 2-wire line cards perform within the design limits for carrier serving areas (CSA). For more information about CSA limits, see Chapter 4.

NT4K67 station service codes	Hybrid balance	Equalization	Gain (off-hook)	OHT Gain
POTSRT	no	no	no	no
COINRT	no	no	no	no
UVGRT	no	no	no	yes
FXS	yes	yes	yes	yes
DPO	no	no	yes	no
TOS	yes	no	yes	no
ETOS	yes	yes	yes	no
PLAR	yes	yes	yes	no

NT4K79 station service codes	Hybrid balance	Equalization	Gain (off-hook)	OHT Gain
POTSRT	no	no	no	no
UVGRT	no	no	no	yes

NT4K68 office service codes	Hybrid balance	Equalization	Gain (off-hook)	OHT Gain
POTSCT	no	no	no	no
COINCT	no	no	no	no
UVGCT	no	no	no	no
FXO	yes	yes	yes	no
DPT	no	no	yes	no
TOO	yes	no	yes	no
ETOO	yes	yes	yes	no

NT4K78 ringdown service code	Hybrid balance	Equalization	Gain (off-hook)	OHT Gain
MRD	no	no	yes	no

Chapter contents

This chapter includes the following topics:

Circuit engineering for integrated applications

Table 2-1 summarizes loop range, ringer capability (at the limit of the loop range), and other features of integrated services using 2-wire station line cards.

Table 2-1
Loop ranges of 2-wire station line cards

2-wire service	Line card	Loop range	Ringer capability	Features
POTS, LSR, or MVIPOTS	NT4K65 (NT4K65AB for MVIPOTS)	1900 Ω (1470 Ω + 430 Ω set) loaded/nonloaded	4 REN	Loop start, CLASS, forward disconnect, hook flash
POTS, LSR, UVG, or MVIPOTS	NT4K79 NT4K67	1900 Ω (1470 Ω + 430 Ω set) loaded/nonloaded	4 REN (5 REN if <900 Ω)	Loop start, CLASS, forward disconnect, hook flash, 150 V dc for message waiting lamp on LSR
COIN or MVICOIN	NT4K67	1370 Ω (820 Ω +550 Ω set)		Dial tone first, coin first
UVG or MVIUVG	NT4K79 NT4K67	1250 Ω (820 Ω + 430 Ω set)	5 REN	Auto loop start/ground start signaling, auto loss adjustment, 600 Ω impedance
MVILRB	NT4K68	820 Ω + terminal resistance		
ISDN_U or GR303_ISDN	NT4K67	1300 Ω or 18 kft nonloaded; max. 42 dB loss at 40 kHz		ANSI T1.601, TR-393, 2B1Q, 2B+D

Default values of line card parameters

For each Omega 2-wire line card, GR-303 MVI services use default values for hybrid balance, equalization, off-hook gain, on-hook transmission (OHT) gain, and other parameters. Table 2-2 lists line card parameters and their default values.

Table 2-2
Line card parameter values for GR-303 MVI services

Service code	Parameter	Default
MVIPOTS	Full-time on hook transmission	Off
	Red-lined connection	Off
	Transmit Gain	–2 dB
	Receive Gain	–2 dB
	Impedance	900 ohm
	Hybrid balance filter	2
	Transmit, Receive OHT Gain	–3 dB
MVICOIN	Full-time on hook transmission	Off
	Red-lined connection	Off
MVIUVG	Transmit OHT Gain	–10
	Receive OHT Gain	–10
	Hybrid balance filter	3
	Impedance	600 ohm
	Automatic gain	On
	Full-time on hook transmission	Off
	Red-lined connection	Off
MVILRB	Transmit Gain	0.0
	Receive Gain	0.0
	Equalization	0
	Hybrid Balance filter	68
	Impedance	900 ohm
	Off-hook trunk conditioning	On
	Red-lined connection	Off

Loop engineering rules

The following rules define the limits to which loops can be engineered for proper operation of plain old telephone service (POTS) services on AccessNode:

- The maximum permitted loop is 1470 ohms.
- The maximum permitted loop loss is 8 dB.
- The maximum nonloaded loop, including bridge taps, is 12 kft.
- Loops longer than 12 kft require full H88 loading. As per the definition of H88 loading, the preferred length of the first and last sections is 3 kft. However, to permit flexibility in the placement of the remote terminal and the customer location, you can deviate from H88 loading as follows:
  - — The remote terminal end-section may be in the range 1.5 to 7.5 kft.
  - — The customer terminal end-section may be in the range 3 to 12 kft, including bridged taps.
- The sum of the lengths of all bridged taps is restricted to 6 kft.

Requirements

Before you determine the parameter settings for a circuit, you need the following items:

- a service order (including a circuit design) for the new circuit
- a copy of the 2-wire Parameter Settings Worksheet

Note: A master copy of the 2-wire Parameter Settings Worksheet, suitable for reproduction, is at the end of this chapter.

Determining hybrid balance and equalization settings

Follow these instructions to determine the hybrid balance and equalization settings of a 2-wire circuit. Perform the following steps in sequence. Write the results of each step on your copy of the 2-wire Parameter Settings Worksheet.

1 Complete the instructions in the following table to determine the line card impedance:

If the line card is	**Then** the line card impedance is
connected to a trunk cable	600Ω+2.16 μF
connected to a loop	600Ω+2.16 μF
connected to a terminal interface in the remote fiber terminal (RFT)	600Ω+2.16 μF
connected to a switch	900Ω+2.16 μF
connected to a 2-wire/2-wire voice frequency (VF) repeater	900Ω+2.16 μF
connected to a carrier interface	900Ω+2.16 μF
located in the fiber central office terminal (FCOT)	900Ω+2.16 μF
located in an RFT and providing direct-in-dial (DID) or off-premises station service to a PBX	900Ω+2.16 μF

2 Get the cable terminating impedance from the service order.

3 Determine the equivalent length of the cable facility.

Note: If the facility contains 25-gauge MAT cable, convert it to an equivalent length of 26-gauge cable by multiplying its length by a factor of 0.77. For a multi-gauge facility, add up all lengths in each gauge (excluding bridged taps) to obtain a single value for each gauge.

a. Record the length of the major gauge. The major gauge is the gauge of the longest length.

b. For a multi-gauge facility, record the length of the minor gauge. The gauge with the second longest length is the minor gauge. (Short sections of other gauges might be used for stubs or fusing in carrier serving area (CSA) cable. You can disregard them.)

c. If the facility contains a bridged tap adjacent to the major gauge, at the junction of two gauges, or at an unknown location, see Table 2-3 on page 2-7 for the equivalent length in the major gauge.

d. If the facility contains a bridged tap adjacent to the minor gauge, and if the bridged tap is at the end of the cable, see Table 2-3 on page 2-7 for the equivalent length in the minor gauge.

Table 2-3
Equivalent length of bridged taps

Bridged tap Length (kft)	Equivalent length (kft) by cable gauge			
	19	**22**	**24**	**26**
0.5	0.5	0.5	0.4	0.3
1.0	1.0	0.9	0.8	0.7
1.5	1.5	1.4	1.3	1.1
2.0	2.0	1.9	1.7	1.6
2.5	2.5	2.4	2.2	2.1

e. If you converted the bridged tap to an equivalent length of minor gauge, add the length of the bridged tap to the minor gauge length.

f. Convert the total minor gauge length to an equivalent length in the major gauge by multiplying the total minor gauge length by the applicable conversion constant from Table 2-4 or Table 2-5 on page 2-8. (Table 2-4 is for 900/600 ohms and Table 2-5 is for 600/600 ohms.)

g. To determine the total equivalent cable length, add the lengths of the major gauge and the converted minor gauge.

Table 2-4
Minor to major gauge conversion constants (K_M) (900/600 ohms)

This table applies to 2-wire circuits with Line card impedance = 900 Ω, cable termination impedance = 600 Ω				
Major gauge	**Minor gauge**			
	19	**22**	**24**	**26**
19	1.00	1.01	1.10	1.11
22	0.99	1.00	1.09	1.10
24	0.91	0.92	1.00	1.05
26	0.90	0.91	0.95	1.00

Table 2-5
Minor to major gauge conversion constants (K_M) (600/600 ohms)

This table applies to 2-wire circuits with Line card impedance = 600 Ω, cable termination impedance = 600 Ω				
Major gauge	**Minor gauge**			
	19	**22**	**24**	**26**
19	1.00	1.07	1.13	1.22
22	0.97	1.00	1.09	1.17
24	0.89	0.91	1.00	1.08
26	0.81	0.84	0.92	1.00

4 Look up the equalization setting in one of the following tables:

— For the NT4K68 office line card, see Table 6-1 on page 6-3.

— For the NT4K67 station line card, see Table 6-2 on page 6-4 or Table 6-3 on page 6-5. Table 6-2 lists equalization settings for a line card impedance of 900Ω+2μF. Table 6-3 lists equalization settings for a line card impedance of 600Ω+2μF.

5 Look up the hybrid balance setting in one of the following tables:

— For the NT4K68 office line card, see Tables 6-4 through 6-9 on pages 6-6 through 6-11. Use the line card impedance and the cable termination impedance to determine the correct table.

— For the NT4K67 station line card, see Tables 6-10 through 6-15 on pages 6-11 through 6-15. Use the total equivalent cable length to determine the correct table.

— For the NT4K67 station line card, see Table 2-6 for other balance networks (settings).

Table 2-6
Additional NT4K67 station line card compromise balance networks

NT4K67 station line card additional compromise balance networks	**Setting**
Nonloaded balance network	0
Loaded balance network	1
900 Ω + 2.16 μF balance network	2
Universal voice grade balance network	3
to provide the best average balance performance for universal applications, while still meeting a 900 Ω + 2.16 μF performance specification: 18 dB ERL, 10 dB SRL_{HI} and SRL_{LO}	136

Determining the 1-kHz loss

Follow these instructions to determine the 1-kHz loss of the non-loaded cable facility. Follow the steps in sequence and enter the results of each step in your working copy of the 2-Wire Parameter Settings Worksheet.

1 Determine the total cable resistance, not including bridged tap resistance.

a. Determine the resistance of the major gauge by multiplying its length by the appropriate resistance constant K, from Table 2-4 on page 2-7.

b. Determine the resistance of the minor gauge in the same way.

c. Add the cable resistances from steps 1a. and 1b.

Cable gauge	Constant K (ohms per kilofoot)	
	Loaded	**Nonloaded**
19	17.6	16.3
22	33.9	32.8
24	53.4	51.9
25 (MAT)	67.0	65.5
26	84.8	83.3

2 Determine the total actual cable length, including the bridged tap length.

a. Add the actual cable lengths of the major and minor gauge.

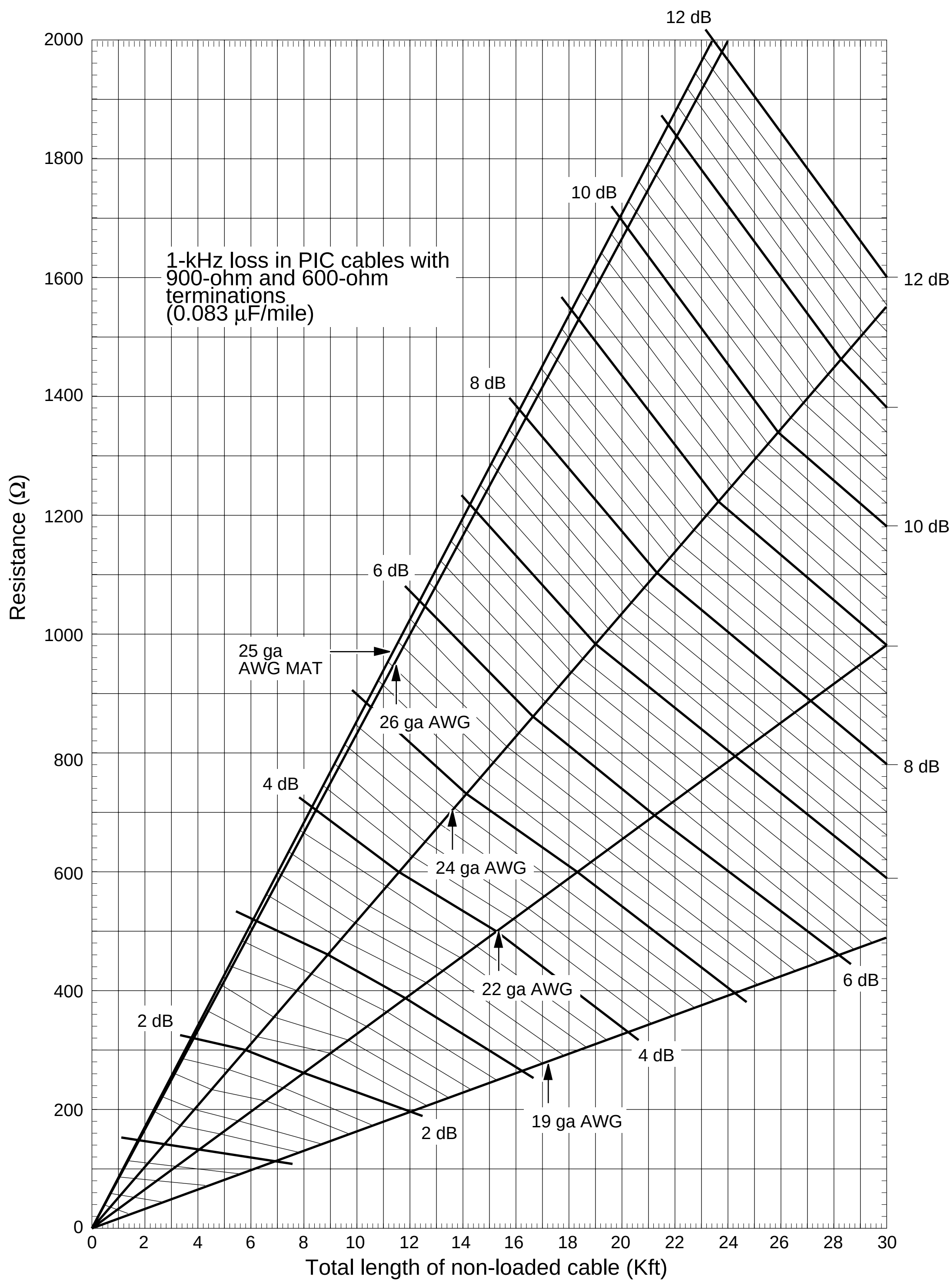
b. Determine the actual bridged tap length.

c. Add the lengths from steps 2a. and 2b.

3 Using resistance (from step 1c.) and length (from step 2c.), determine the 1-kHz cable loss. Using the applicable graph from page 2-10 or page 2-11, locate the total resistance and total cable length, then read the cable loss at the intersection point.

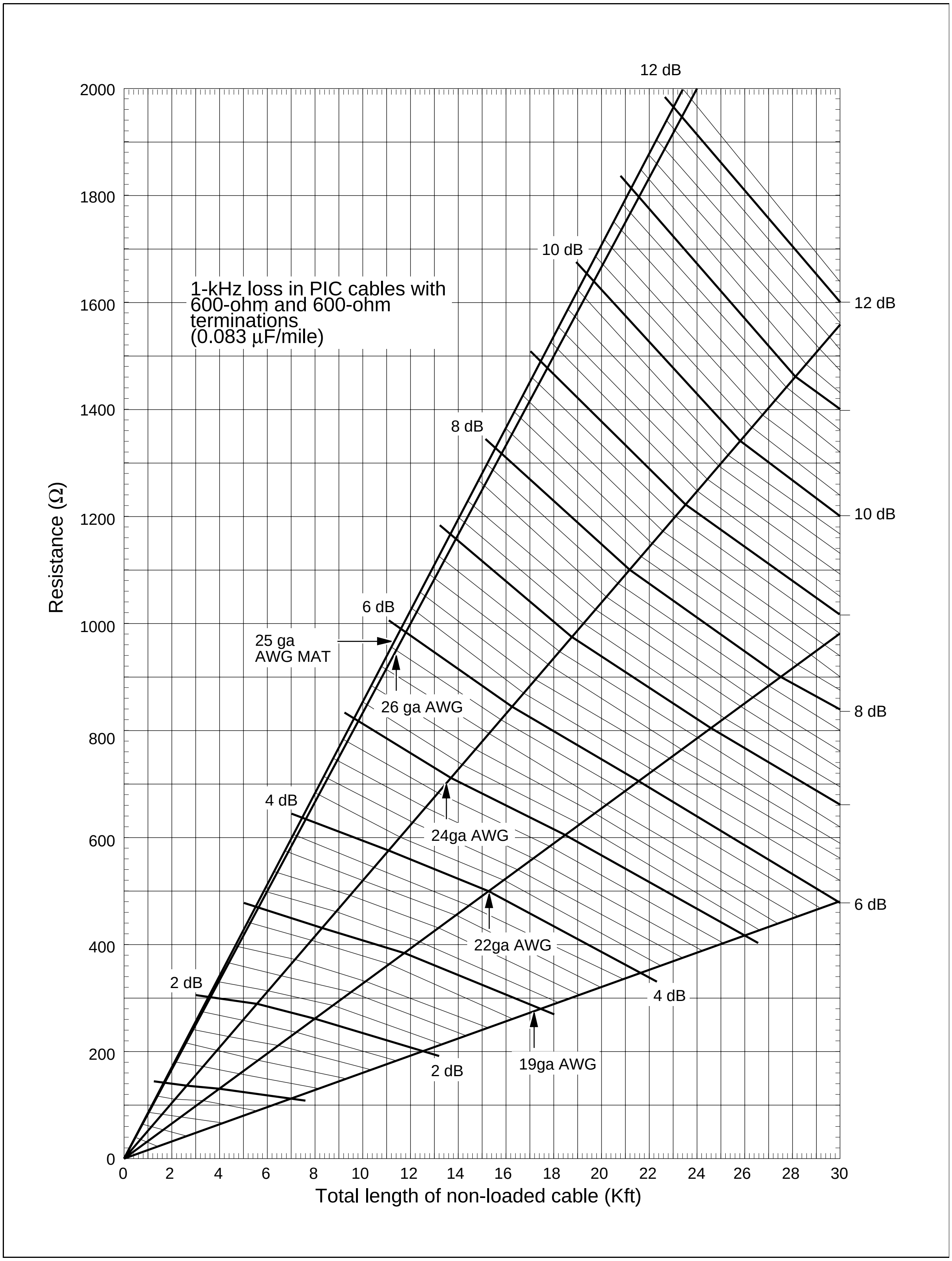
Note: Use the graph on page 2-10 for 900-ohm line card impedance and 600-ohm network interface termination impedance. Use the graph on page 2-11 for 600-ohm line card impedance and 600-ohm network interface termination impedance.

PC-10917



1-kHz loss in PIC cables with 900-ohm and 600-ohm terminations (0.083 µF/mile)
Resistance (Ω)
Total length of non-loaded cable (Kft)
0
200
400
600
800
1000
1200
1400
1600
1800
2000
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
2 dB
4 dB
6 dB
8 dB
10 dB
12 dB
25 ga AWG MAT
26 ga AWG
24 ga AWG
22 ga AWG
19 ga AWG

PC-10967


12 dB
10 dB
8 dB
6 dB
4 dB
2 dB
12 dB
10 dB
8 dB
6 dB
4 dB
2 dB
1-kHz loss in PIC cables with
600-ohm and 600-ohm
terminations
(0.083 µF/mile)
25 ga
AWG MAT
26 ga AWG
24ga AWG
22ga AWG
19ga AWG
Resistance (Ω)
2000
1800
1600
1400
1200
1000
800
600
400
200
0
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30
Total length of non-loaded cable (Kft)

Determining the TLP and gain settings

Follow these instructions to determine transmission level point (TLP) settings and gain settings. Enter the results on page 2 in your copy of the 2-Wire Parameter Settings Worksheet. Figure 2-1 on page 2-13 shows gain and transmission level points.

1 Determine the Tx TLP and Tx gain.

   a. Get the Tx $TLP_{(NI\ or\ TERM)}$ from the service order.

   b. Get the 1-kHz loss (see “Determining the 1-kHz loss” on page 2-9 for instructions) and record the loss as an unsigned number.

   c. Tx TLP = Tx $TLP_{(NI\ or\ TERM)}$ – 1-kHz loss

   d. Tx gain = –Tx TLP

2 Determine the Rx TLP and Rx gain.

   a. Get the Rx $TLP_{(NI\ or\ TERM)}$ from the service order.

   b. Enter the 1-kHz loss on the worksheet.

   c. Rx TLP = 1-kHz loss + Rx $TLP_{(NI\ or\ TERM)}$

   d. Rx gain = Rx TLP

Note 1: Tx TLP is the transmit TLP of the line card.

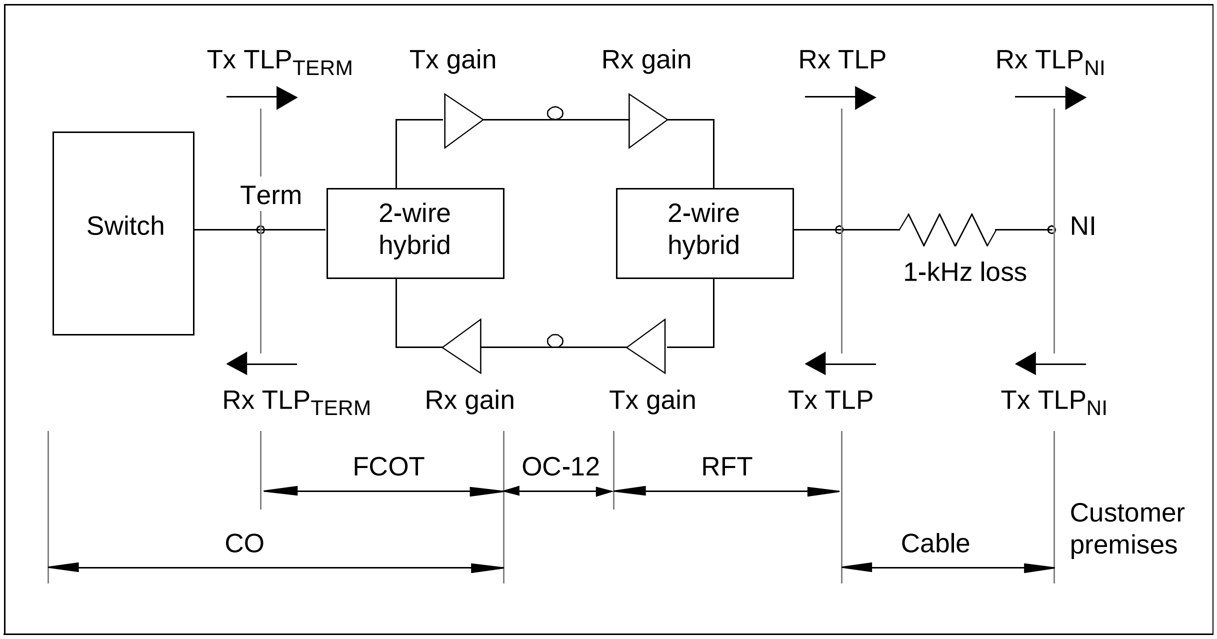
Note 2: Rx TLP is the receive TLP of the line card.

Note 3: The 1-kHz cable loss is the 1-kHz insertion loss or transducer loss of the cable, and is entered as a positive number.

Note 4: Tx $TLP_{(NI\ or\ TERM)}$ is the transmit TLP at the network interface (NI) or at a terminal interface (Term).

Note 5: Rx $TLP_{(NI\ or\ TERM)}$ is the receive TLP at the network interface (NI) or at a terminal interface (Term).

Figure 2-1
Illustration of gain and transmission level point in a universal application



Provisioning 2-wire on-hook transmission (universal application)

The on-hook transmission (OHT) feature in AccessNode provides a voice frequency (VF) transmission path from the fiber central office terminal (FCOT) to a remote fiber terminal (RFT) when the line is on-hook. OHT also allows simultaneous transmission in both directions.

Several applications use on-hook transmission. Calling party identification requires only one direction of transmission, FCOT to RFT. Other applications, such as alarm or meter reading, require transmission in both directions.

You can provision fulltime OHT through the operations controller (OPC) user interface by selecting fulltime OHT = YES. This method provisions OHT continuously in both directions when the line card is idle (on-hook).

> ***Note:*** OHT is automatically turned off during ringing bursts or open switching intervals (OSI).

If you provision fulltime OHT = NO, OHT activation occurs in the following situations:

- The FCOT applies a 20-Hz ringing into the 2-wire office line card (NT4K68) for more than 400 mS. This provides a VF path (OHT) within 400 mS after the end of each ringing burst. The VF path is present during each silent interval between ring bursts.
- An open systems interconnection (OSI) of 100 to 500 mS is transmitted into the FCOT office line card (NT4K68). OHT occurs within 200 mS of the end of the OSI and lasts for at least 15 seconds.

For an end-to-end (FCOT-to-RFT or RFT-to-FCOT) application, the 1-kHz insertion loss during OHT should be 5 dB greater than the off-hook loss.

At the user interface, you can provision the OHT transmit and receive loss for foreign exchange (FX) and universal voice grade (UVG) applications over a range of 0 to –10 dB, in 1-dB steps, in both directions. OHT defaults to –3 dB in both directions for POTS applications.

In a universal circuit using office line card NT4K68 and station line card NT4K67, the end-to-end OHT loss is the sum of the following:

- the loss contributed by the office line card (–1.0 dB for 900-ohm impedance, –1.5 dB for 600-ohm impedance)
- the OHT loss provisioned at the user interface for the station line card

OHT provisioning guidelines for FX and UVG

Follow these guidelines to provision loss in foreign exchange (FX) and universal voice grade (UVG) circuits:

- The OHT loss in the direction that OHT is required should be –5 dB relative to the off-hook loss.
- For VF OHT stability, provision the maximum loss in the direction that OHT is not required.
- If full-time OHT is required, provision OHT Tx gain and Rx gain to equal –5 dB, FCOT to RFT, relative to the off-hook level.

POTS service: off-hook and OHT fixed gain (NT4K65 and NT4K68)

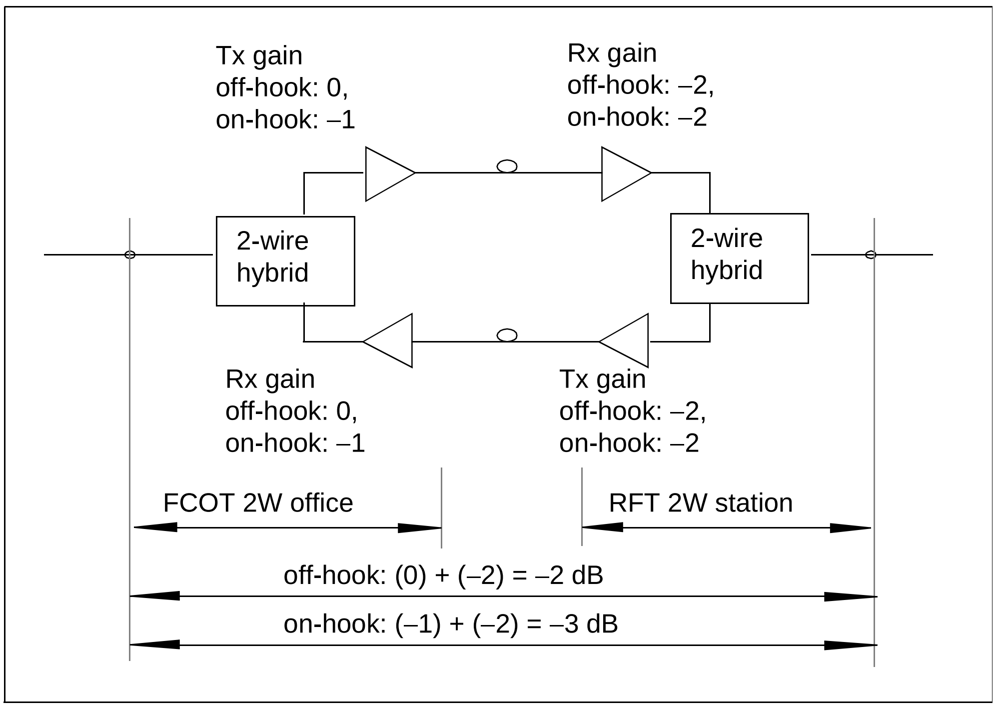
You cannot provision off-hook and on-hook transmission (OHT) gain parameters for POTS on NT4K65 and NT4K68 line cards. Table 2-7 shows the fixed gain parameters for POTS on these line cards.

Table 2-7
Fixed POTS gain settings for NT4K65 and NT4K68

Line card	Fixed off-hook gain	Fixed on-hook gain
NT4K65 Epsilon station line card	–2 dB	–2 dB
NT4K68 Omega 2-wire office line card	0 dB (in both directions)	–1 dB (in both directions)

Figure 2-2 shows the transmit (Tx) and receive (Rx) gain for NT4K65 and NT4K68 POTS circuits.

Figure 2-2
Tx and Rx gain



Calculating OHT losses for POTS, MVIPOTS, and LSR

Use the following formulas to calculate universal digital loop carrier (UDLC) OHT losses between the fiber central office terminal (FCOT) and remote fiber terminal (RFT).

UDLC: FCOT to RFT

OHT loss = (–1) + (–2) = –3 ± 0.5 dB

UDLC: RFT to FCOT

OHT loss = (–1) + (–2) = –3 ± 0.5 dB

The following formulas are for calculating GR-303 MVI or GR-303 DMS OHT losses between the switch interface and the RFT.

GR-303 DMS or GR-303 MVI: switch interface to RFT

OHT loss = –2.0 dB

GR-303 DMS or GR-303 MVI: RFT to switch interface

OHT loss = –2.0 dB

POTS service: off-hook and OHT fixed gain (NT4K67 and NT4K68)

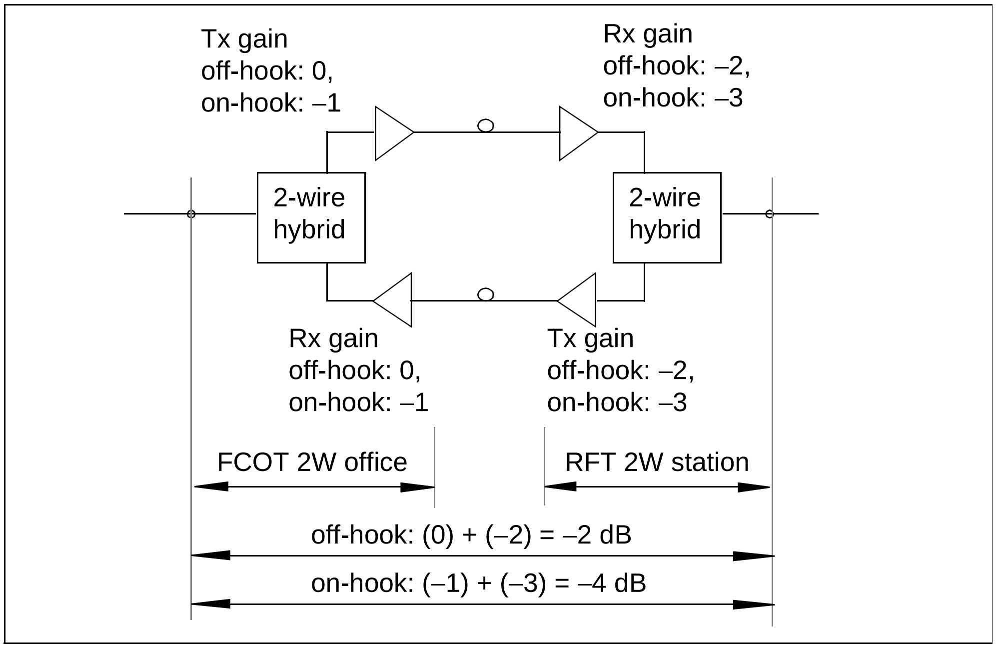
You cannot provision off-hook and on-hook transmission (OHT) gain parameters for POTS on NT4K67 and NT4K68 line cards. Table 2-8 shows the fixed gain parameters for POTS on these line cards.

Table 2-8
Fixed POTS gain settings for NT4K67 and NT4K68

Line card	Fixed off-hook gain	Fixed on-hook gain
NT4K67 Omega 2-wire station line card	–2 dB (see Note)	–3 dB (in both directions)
NT4K68 Omega 2-wire office line card	0 dB (in both directions)	–1 dB (in both directions)
Note: The fixed off-hook gain is –2 dB in both directions on short loops (up to approximately 1065 ohms). If the loop exceeds approximately 1065 ohms, the off-hook gain of –2 dB in both directions is removed to extend the serving range.		

Figure 2-3 on page 2-17 shows the typical layout for POTS gain on a short loop.

Figure 2-3
POTS gain on a short loop



Calculating OHT losses for POTS, MVIPOTS, and LSR

Use the following formulas to calculate universal digital loop carrier (UDLC) OHT losses between the fiber central office terminal (FCOT) and remote fiber terminal (RFT).

UDLC: FCOT to RFT

OHT loss = (–1) + (–3) = –4 ± 0.5 dB

UDLC: RFT to FCOT

OHT loss = (–1) + (–3) = –4 ± 0.5 dB

Use the following formulas to calculate GR-303 DMS or GR-303 MVI OHT losses between the switch interface and the RFT

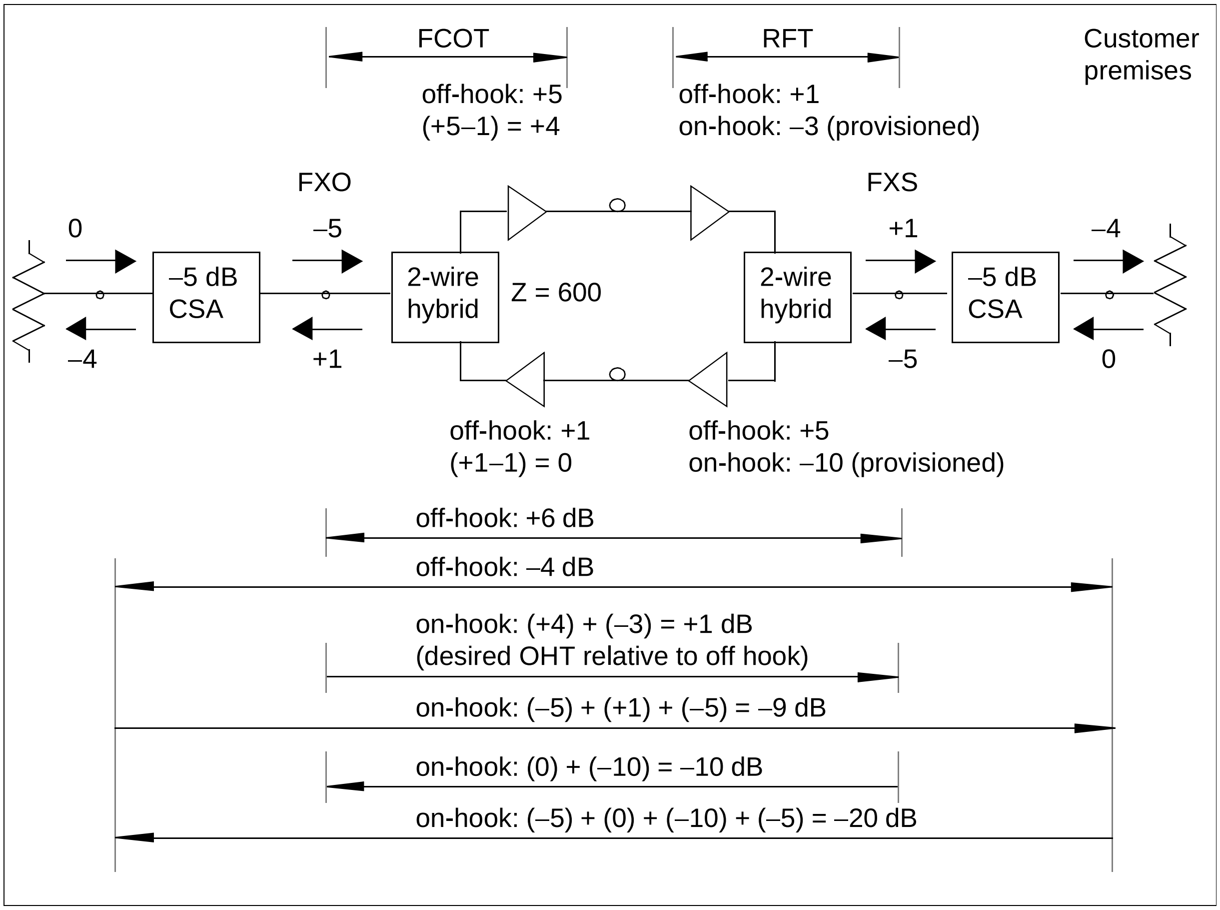
GR-303 DMS or GR-303 MVI: switch interface to RFT

OHT loss = –5.0 dB (not coincidental with a terminating call)
OHT loss = –0.0 dB (coincidental with a terminating call)

GR-303 DMS or GR-303 MVI: RFT to switch interface

OHT loss = –5.0 dB (not coincidental with a terminating call)
OHT loss = infinite (coincidental with a terminating call)

FX service: off-hook and OHT gain provisioning



Calculating OHT Tx/Rx gains for FX (to adjust FXS station line card)

The requirements are:

- –5 dB OHT loss, FCOT to RFT, relative to the off-hook loss
- maximum OHT loss, RFT to FCOT, relative to the off-hook loss

Procedure, FCOT to RFT:

1 Determine the off-hook Rx gain in the FXS line card at the RFT.

2 Prescribe the OHT Rx gain as follows:
OHT Rx gain = the desired OHT loss + the off-hook Rx gain + 1 dB

Procedure, RFT to FCOT:

1 Determine the off-hook Tx gain in the FXS line card at the RFT.

2 Prescribe the OHT Tx gain as follows:
OHT Tx gain = the desired OHT loss + the off-hook Tx gain + 1 dB

Calculating the illustrated example, FCOT to RFT:

1 Off-hook Rx gain (FXS) = +1.0 dB

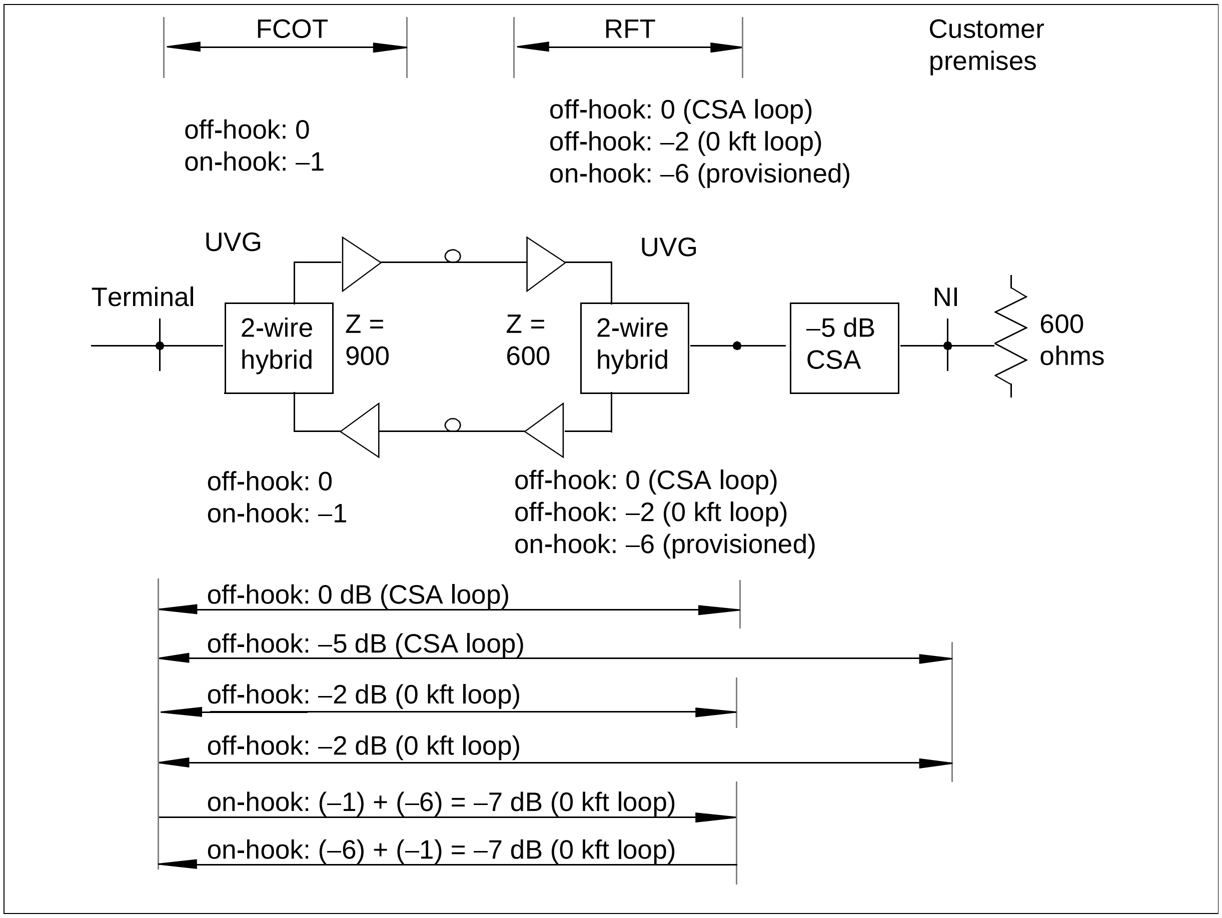
2 Prescribe the OHT Rx gain = –5 + 1 + 1 = –3 dB

Calculating the illustrated example, RFT to FCOT:

1 Off-hook Tx gain (FXS) = +5.0 dB

2 Prescribe the OHT Tx gain = maximum = –10.0 dB

UVG service: off-hook switching loss and provisioned OHT loss



Calculating OHT Tx/Rx gains for UVG (2-wire station line card)

The UVG service has automatic switching loss which guarantees –2 to –5 dB of off-hook loss, terminal to network interface (NI), over loop lengths of 0 kft to the CSA maximum. Use the following off-hook transmit and receive gains in equations: Tx gain = Rx gain = 0 dB.

The requirement is 5 dB OHT loss, both directions, relative to the off-hook loss with CSA loop, or not more than a total of 13 dB loss terminal to NI.

FCOT to RFT:

1 The off-hook Rx gain = 0 dB in the 2-wire station line card.

2 Prescribe the OHT Rx gain as follows:
OHT Rx gain = the desired OHT loss + the off-hook Rx gain + 1 dB

RFT to FCOT:

1 The off-hook Tx gain = 0 dB in the 2-wire station line card.

2 Prescribe the OHT Tx gain as follows:
OHT Tx gain = the desired OHT loss + the off-hook Tx gain + 1 dB

Calculating OHT Tx and Rx gains:

1 Prescribe the OHT Rx gain = –8 + 0 + 1 = –7 dB

2 Prescribe the OHT Tx gain = –8 + 0 + 1 = –7 dB

2-wire parameter settings worksheet

The following pages contain the master copy of the 2-wire parameter settings worksheet, suitable for photocopying. Prepare one copy for each circuit that requires determination of balance, gain, or equalization.

2-wire parameter settings worksheet

Pg 1 of 2

AccessNode system:	______________	Circuit number:	______________
Location name:	______________	Circuit type (service):	______________
CDS shelf number / slot number:	______________	Date:	______________

Two-wire balance and equalization

Step

1) Line card impedance: __________

2) Cable termination impedance: __________

3) Cable equivalent length calculations:

A) MAJ gauge (___) GA: Length = __________ kft

B) MIN gauge (___) GA: Length = __________ kft

C) Equiv. length of bridged tap (MAJ gauge) = __________ kft
(Table 2-3 on page 2-7)

D) Equiv. length of bridged tap (MIN gauge) = __________ kft
(Table 2-3 on page 2-7)

E) Find total length of MIN gauge and convert to MAJ gauge:
(steps B + D = ________ kft) x K_M ______ = __________ kft
(Table 2-4 on page 2-7 and Table 2-5 on page 2-8)

F) Equiv. length of MAJ gauge (______): A + C + E = [ ] kft

4) Equalization setting (Tables 6-1 to 6-3): [ ]

5) Hybrid balance setting (Tables 6-4 to 6-15): [ ]

Two-wire nonloaded 1-kHz loss

Step

1) Total cable resistance (not including bridged tap) (Table 2-4 on page 2-7)

A) MAJ gauge (___) GA: Length _____ kft x K ______ = __________ ohms

B) MIN gauge (___) GA: Length _____ kft x K ______ = __________ ohms

C) Total resistance (steps 1A + 1B) = [ ] ohms

2) Total cable length (including bridged tap):

A) Main cable length (MAJ + MIN gauge lengths) = __________ kft

B) Actual bridged tap length: __________ kft

C) Total length (steps 2A + 2B) = [ ] kft

3) 1-kHz loss (Use the graph on page 2-10 or page 2-11): [ ] dB

2-wire parameter settings worksheet

Pg 2 of 2

AccessNode system: ____________	Circuit number: ____________
Location name: ____________	Circuit type (service): ____________
CDS shelf number / slot number: ____________	Date: ____________

TLP calculation and gain settings (Figure 2-1 on page 2-13)

Step				
1)	A)	Tx $TLP_{(NI)(Term)}$	____________	dB
	B)	1-kHz loss (enter a positive, unsigned number)	____________	dB
	C)	Tx TLP = Tx $TLP_{(NI\ or\ Term)}$ – 1-kHz loss =	[ ]	dB
	D)	Tx gain = – (Tx TLP) =	[ ]	dB
2)	A)	Rx $TLP_{(NI)(Term)}$	____________	dB
	B)	1-kHz loss (enter a positive, unsigned number)	____________	dB
	C)	Rx TLP = Rx $TLP_{(NI\ orTerm)}$ + 1-kHz loss =	[ ]	dB
	D)	Rx gain = Rx TLP =	[ ]	dB

Legend

MAJ: major gauge

MIN: minor gauge

K: value from Table 2-4 (ohms per kft)

NI: network interface

Term: terminal interface

K_M: minor to major GA conversion constant from Table 2-4 or Table 2-5

Determining equalization and gain for 4-wire line cards

This chapter describes how to use cable makeup information to set the slope (SL), the height (HT), and the bandwidth (BW) equalization settings for Omega 4-wire line cards. This chapter also contains formulas to determine the transmit (Tx) and receive (Rx) gain for the line cards. You must calculate the gain before you set the equalization.

> ***Note:*** The line cards perform within carrier serving area (CSA) design limits. For more information about CSA limits, see Chapter 4.

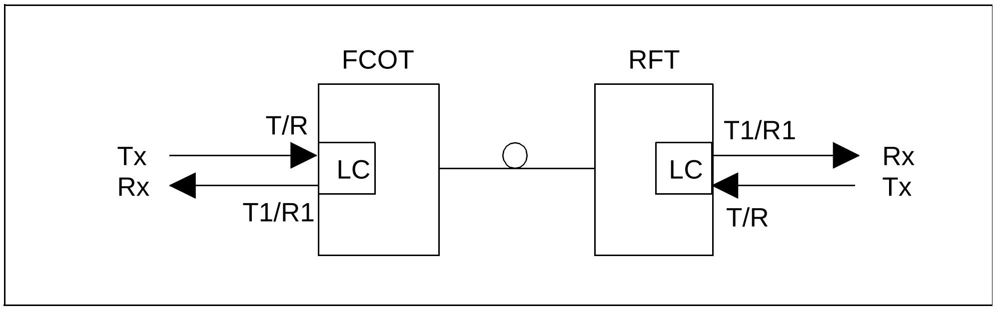
Chapter contents

This chapter includes the following topics:

Calculating gain

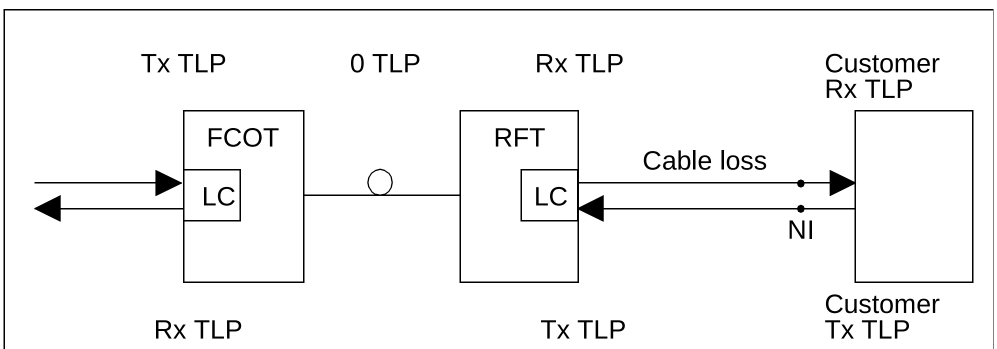
Provisioning gain in the transmit (Tx) and the receive (Rx) paths of a line card adjusts the levels at the inputs and outputs of the voice frequency (VF) to the transmission level point (TLP) required by the external circuit. The direction of transmission is determined from the direction of the overall circuit, as shown in Figure 3-1.

Figure 3-1
VF transmit and receive directions



Before you calculate gain, you must know the cable loss (if any) and the desired TLP at the VF interface to the line card. Figure 3-2 shows the location of the VF interface to the line card.

Figure 3-2
Transmit and receive TLPs



Note: –16 dB < Rx TLP < +8.5 dB
–17.5 dB < Tx TLP < +7 dB

As shown, the line card provides a maximum Rx TLP value of +8.5 dB (into the receive pair of the 4-wire circuit) and supports a minimum Tx TLP value of –17.5 dB (from the transmit pair of the 4-wire circuit). This range accommodates the industry-standard carrier-interface Tx and Rx TLP values of –16 dB and +7 dB respectively, with up to 1.5 dB of loss between the card and the TLP.

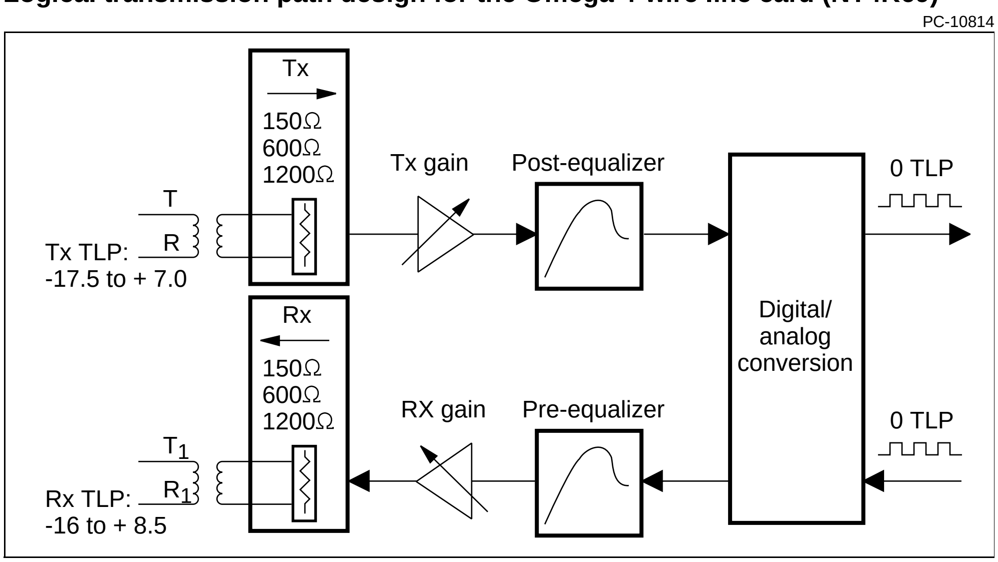
Gain is set at the line card to compensate for the loss in the VF cable to which the line card is connected. When properly adjusted, the gain provisioned in the line card translates a signal level applied at the Tx TLP to 0 TLP (0 dBm) in the OC-12 transmit signal. The same is true in the receive direction.

The default setting of the Tx gain and the Rx gain is 0.0 dB. This topic describes how to determine the Tx and Rx gain settings for a 4-wire line card.

> ***Note:*** To make gain adjustments, use the OPC Provisioning Manager, described in *Line Card Provisioning Procedures*, 323-3001-315, in *Operations, Administration, and Provisioning*, Volume 4B.

Figure 3-3 shows a logical transmission path for 4-wire VF line cards.

Figure 3-3
Logical transmission path design for the Omega 4-wire line card (NT4K69)



Use the following formulas to calculate Tx and Rx gain, given the Tx TLP level at the line card input and the Rx TLP level at the line card output.

Transmit path gain (Tx gain) = –TxTLP

Receive path gain (Rx Gain) = +RxTLP

Determining line card equalization settings

In a universal configuration, the fiber central office terminal (FCOT) line card does not need to be adjusted to equalize the central office voice frequency (VF) cable. Only the remote fiber terminal (RFT) line card needs adjustment to equalize the customer loop.

This topic has directions for selecting the slope (SL), height (HT), and bandwidth (BW) post-equalization settings for line cards that use active equalization with 19, 22, 24, 25 MAT and 26-gauge nonloaded and loaded cable. “Mismatch equalization”on page 3-12 discusses passive impedance mismatch equalization. The topics that follow this one yield cable loss values for overall end-to-end circuit design. Use the tables in Appendix A to determine the settings for cables of known makeup. For cables of unknown makeup or for cables not listed in Appendix A, see Chapter 5 “Determining equalization and gain (cable makeup unknown)”.

Requirements

Before you determine parameter settings for a circuit, make sure you have the following items:

- a service order (including a circuit design) for the new circuit
- a copy of the 4-Wire Parameter Settings Worksheet

Note: A master copy of the 4-Wire Parameter Settings Worksheet, suitable for reproduction, starts on page 3-15.

Determining the 1-kHz loss on a 4-wire circuit

Follow these instructions to determine the 1-kHz loss on a 4-wire circuit on a single-gauge or multi-gauge cable. Perform the following steps in sequence and write the results of each step on a copy of the 4-Wire Parameter Settings worksheet.

For nonloaded single-gauge cable

1. Record the equivalent length in the worksheet.
2. Use the equivalent length in Table 6-17 to determine the 1-kHz loss.

For nonloaded multi-gauge cable

1. Record the length of each gauge, with its resistance constant K, from Table 2-4 on page 2-7. Add the cable resistances, excluding bridged taps.
2. Add the actual length (in kft) of all gauges, including bridged taps.
3. Use the total resistance (excluding the bridged tap) and the total length (in kft) (including the bridged tap) to determine the 1-kHz loss from the graph on page 2-11.

For loaded single-gauge or multi-gauge cable

1 Attempt to remove all bridged taps from the loaded cable facility.

2 Record the length of each gauge (in kft) along with its loss constant K_L, from Table 3-1.

3 Add the losses for each cable gauge.

Table 3-1
H88 loaded cable loss at 1 kHz

This table applies to 4-wire circuits with: Line card impedance = Cable termination impedance = 1200 Ω, and half-end sections.	
Cable gauge	**K_L (dB loss per kilofoot)**
19	0.08
22	0.15
24	0.23
25 (MAT)	0.25
26	0.35

Determining the TLP and gain settings for a 4-wire line card

Follow these instructions to determine the transmission level point (TLP) and gain settings for loaded or nonloaded cable. Complete the following steps in sequence and write the results of each step on a copy of the 4-Wire Parameter Settings worksheet. (For an application diagram, see Figure 3-2 on page 3-2.)

1 Get the value for 1-kHz loss (see “Determining the 1-kHz loss on a 4-wire circuit” on page 3-4) and record the loss on the 4-Wire Parameter Settings worksheet.

2 Get the values for Rx TLP_{NI} and Tx TLP_{NI} from the service order.

3 Calculate the values for receive (Rx) transmission level point (TLP) and transmit (Tx) TLP. as follows:

Rx TLP = 1-kHz loss + Rx TLP_{NI}

Tx TLP = Tx TLP_{NI} – 1-kHz loss

4 Calculate the values for Rx gain and Tx gain.

Rx gain = Rx TLP

Tx gain = – (Tx TLP)

General near-end TLP guidelines

Nortel Networks recommends the following minimum and maximum TLP levels at the tip and ring leads of the 4-wire Omega line cards:

- Minimum input level of –9 TLP for 600 or 1200 ohm termination. (This is the Tx TLP from the perspective of the external circuit.)
- Maximum output level of +6 TLP for 600 or 1200 ohm source impedance. (This is the Rx TLP from the perspective of the external circuit.) The +6 TLP maximum is recommended to avoid crosstalk.

  Note: This TLP range translates to a maximum allowable cable loss of 15 dB.

Determining 4-wire equalization settings with loaded cable

Complete the following steps in sequence to determine the post-equalization settings for loaded cable. Write the results of each step on a copy of the 4-Wire Parameter Settings worksheet.

For single-gauge loaded cable

1 Determine the cable length and gauge and record the values as MAJGA1 in A in the calculations for equalization for loaded cable.

2 See Table 6-22 to determine the settings for bandwidth, height, and slope. Record the values in G.

For two-gauge loaded cable

1 Determine the length and gauge of both cables and record the values as MAJGA1 in A and MAJGA2 in B in the calculation for equalization for loaded cable.

2 Determine the entry point to Tables 6-18, 6-19, or 6-20 (see “Guidelines for determining entry point to Tables 6-18, 6-19, or 6-20” on page 3-7 for directions). From the entry point, determine the settings for bandwidth, height, and slope. Record the values in G.

For loaded cable, with more than two gauges

1 Determine the two gauges with the most 1-kHz loss. These two gauges are MAJGA1 and MAJGA2. (The loss is determined in the procedure “Determining the 1-kHz loss on a 4-wire circuit” on page 3-4). Record the length of MAJGA1 in A and MAJGA2 in B.

2 The remaining cables are the minor gauge cables. Record the lengths of MINGA1 in C and MINGA2 in D.

3 Determine the equivalent lengths of MAJGA1 and MAJGA2 as follows: add the length of each minor gauge to the length of the major gauge that is nearest in gauge size.

  The equivalent length of MAJGA1 = A + (C or D). The equivalent length of MAJGA2 = B + (C or D).

4 Using the equivalent lengths of MAJGA1 and MAJGA2, determine the entry point to Tables 6-18, 6-19, or 6-20 from the guidelines that follow. From the entry point, determine the settings for BW, HT, and SL. Record the values in G.

Guidelines for determining entry point to Tables 6-18, 6-19, or 6-20

Complete the following steps to determine the entry point to one of the tables.

1 Add the equivalent lengths of MAJGA1 and MAJGA2 to get the total cable length (TCL).

2 Go to the area of the table with the TCL that is closest to the total cable length. If the total cable length is midway between two TCL values, choose the TCL that contains the closest match to both cable gauges according to the following guidelines.

- If the lengths of both gauges of cable are midway between two values in the table, round the fine gauge to the next longer value.
  - Example: An H88 loaded cable facility composed of 21 kft of 26-gauge and 15 kft of 24-gauge has a total cable length of 36 kft. The Table 6-20 entry point is TCL = 36. Round the length of the 26-gauge cable to the next larger value and choose the 24/12 line. This gives bandwidth (BW), height (HT), and slope (SL) values of 1, 3, and 13.
- If the length of only one gauge of cable is midway between two values in the table, round the other gauge of cable to the nearest value.
  - Example 1: An H88 loaded cable facility composed of 35 kft of 26-gauge and 9 kft of 24-gauge has a total cable length of 44 kft. The Table 6-20 entry point is TCL = 42. Since the 9-kft cable is midway between values, round the other cable to the closest value, which is 36 kft. Choose the 36/6 line and BW, HT, and SL values of 15, 2, and 14.
  - Example 2: An H88 loaded cable facility composed of 31 kft of 26-gauge and 9 kft of 24-gauge has a total cable length of 40 kft. The Table 6-20 entry point is TCL = 42. Since the 9-kft cable is midway between values, round the other cable to the closest value, which is 30 kft. Choose the 30/12 line and BW, HT, and SL values of 1, 3, and 13.
- If the length of neither cable gauge is midway between two values in the table, choose the entry line closest to the actual lengths.
  - Example: An H88 loaded cable facility composed of 7 kft of 26-gauge and 55 kft of 24-gauge has a total cable length of 62 kft. The Table 6-18 entry point is TCL = 60. The line closest to the actual lengths is 6/54, giving BW, HT, and SL values of 4, 2, and 2.

Determining 4-wire equalization settings with nonloaded cable

Complete the following instructions to determine the post-equalization settings for nonloaded cable. Follow the steps in sequence and record the results on your copy of the 4-Wire Parameter Settings Worksheet.

For single-gauge nonloaded cable

1 Determine the cable length (in kft) and gauge and record the values as MAJGA1 in A in the equalization calculation for nonloaded cable.

2 If the cable has a bridged tap, get its equivalent length (in kft) from Table 3-2 on page 3-10 and record the length in B.

3 Determine the equivalent length by adding MAJGA1 length (A) and the equivalent bridged tap length (B) and record it in L.

4 Look up the settings for bandwidth (BW), height (HT), and slope (SL) in Table 6-17. Use the equivalent length from L, rounded to the nearest whole number (in kft), to find the correct settings. Record the settings in N.

For two-gauge nonloaded cable

1 Determine the length (in kft) and gauge of the two cable gauges, and record the values as MAJGA1 in A and MAJGA2 in B.

2 If the cable has bridged taps, convert their lengths to an equivalent length of MAJGA1 or MAJGA2 using Table 3-2 on page 3-10. Use the bridged tap conversion rules on page 3-9. Record the equivalent length of the bridged tap (in kft) in B or D under the major gauge to which it was converted.

3 Determine the MAJGA1 equivalent length (A + B) and record it in L.

4 Determine the MAJGA2 equivalent length (C + D) and record it in M.

5 Round the equivalent lengths of MAJGA1 and MAJGA2 to the nearest whole number (in kft). Use the equivalent lengths to look up the settings for BW, HT, and SL in Tables 6-21, 6-22, or 6-23. Record the settings in N.

For nonloaded cable with more than two gauges

1 Determine the two longest gauges and record the length (in kft) and gauge as MAJGA1 in A and MAJGA2 in C.

2 Complete the following substeps to determine the minor gauges (designated MINGA1 and MINGA2).

   a. Follow the minor-to-major gauge conversion rules on page 3-11 to determine which minor gauge to convert to MAJGA1. Record the value (designated MINGA1) in E.

   b. Follow the conversion rules to determine which minor gauge to convert to MAJGA2. Record the value (designated MINGA2) in H.

3 If the cable has a bridged tap, convert its length to an equivalent length of MAJGA1, MAJGA2, MINGA1, or MINGA2 using Table 3-2 on page 3-10. Follow the bridged tap conversion rules on page 3-9.

4 If a bridged tap is converted to a minor gauge, add its length to the length of the minor gauge before you convert the minor gauge to a major gauge (E + F or H + J).

5 Convert the lengths of the minor gauges to an equivalent length of a major gauge. Use Table 3-3 on page 3-10 and follow the minor-to-major gauge conversion rules on page 3-11. Record the length in G or K.

6 Determine the equivalent length of MAJGA1 (A + B + G) and record it in L.

7 Determine the equivalent length of MAJGA2 (C + D + K) and record it in M.

8 Look up the settings for BW, HT, and SL in Tables 6-21, 6-22, or 6-23. Round the equivalent lengths of MAJGA1 and MAJGA2 to the nearest whole number (in kft) and use the equivalent lengths to find the correct table settings. Record the settings in N.

Bridged tap conversion rules (use Table 3-2)

- If the bridged tap is at the end of the cable, convert it to the adjacent gauge.
- If the bridged tap is connected at the junction of two gauges, convert it to the gauge of the longest length.

Table 3-2
Equivalent length of bridged taps

Bridged tap	**Equivalent length (kft) of bridged tap**			
Length (kft)	**19 GA**	**22 GA**	**24 GA**	**26 GA**
0.5	0.4	0.4	0.4	0.3
1.0	0.9	0.8	0.7	0.6
1.5	1.4	1.3	1.1	0.9
2.0	1.9	1.7	1.5	1.3
2.5	2.3	2.1	1.9	1.6
3.0	2.8	2.6	2.3	2.0
3.5	3.4	3.1	2.7	2.3
4.0	3.9	3.6	3.2	2.7
4.5	4.4	4.1	3.6	3.1
5.0	5.0	4.6	4.1	3.5
5.5	5.5	5.1	4.5	3.9
6.0	6.1	5.6	5.0	4.4

Table 3-3
Minor-to-major gauge conversion constants (K_M) (600/600 ohms)

This table applies to 4-wire circuits with Line card impedance = 600 Ω, cable termination impedance = 600 Ω				
Major gauge	**Minor gauge**			
	19	**22**	**24**	**26**
19	1.00	1.19	1.41	1.70
22	0.87	1.00	1.17	1.38
24	0.76	0.86	1.00	1.17
25 MAT	0.77	0.77	0.77	0.77
26	0.67	0.74	0.86	1.00

Minor-to-major gauge conversion rules (use Table 3-3)

- If the minor gauge is between two major gauges, convert it to the major gauge that is closest in gauge size.
  - Example 1: If the minor gauge is 22, and the major gauges are 19 and 26, convert the 22-gauge cable to 19-gauge.
  - Example 2: If the minor gauge is 22, and the major gauges are 19 and 24, convert the 22-gauge cable to either major gauge.
- If the minor gauge is not between two major gauges, convert it to the major gauge to which it is physically closest.

Determining settings for a facility containing 19-gauge cable

Because only small amounts of 19-gauge cable are in the outside plant environment, 19-gauge cable is not included in the charts of mixed-gauge cable prescription settings. When you encounter facilities with 19-gauge cable, reduce the total cable to an equivalent single-gauge facility as follows:

1. Add all cable lengths of a gauge together. The longest length of a single gauge is the major gauge, all others are minor gauges.
2. Use Table 3-3 on page 3-10 to convert all minor-gauge cable lengths to the equivalent length of the major gauge.
3. Add the converted lengths together and round the sum to the nearest whole number. This is the table entry point.
4. From the appropriate table in Appendix A for single gauge cables, record the bandwidth, height, and slope.
5. Complete the instructions in the following table:

If the cable is	Then
22, 24, or 25 gauge loaded cable, or 19 gauge loaded or nonloaded cable	determine the cable loss by multiplying the lengths of cable by the appropriate cable loss constant from Table 3-1 on page 3-5
22, 24, or 26 nonloaded cable	determine the cable loss using Table 6-17

6. Add all losses together to determine the total cable loss.

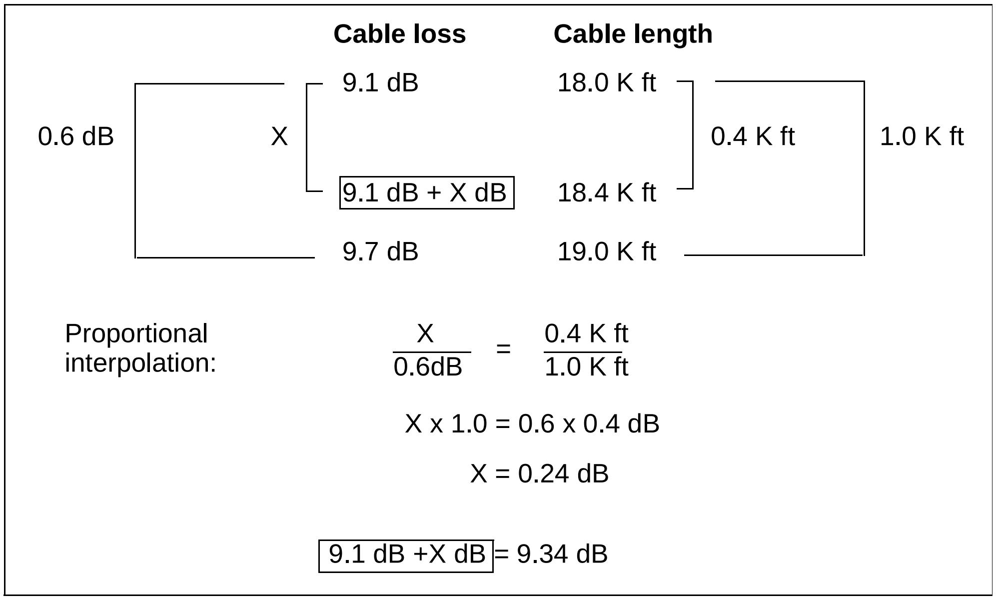
Using interpolation on results from tables

When you work with Table 6-17 to determine loss in a cable, you can interpolate to find a more accurate value. The following example shows how to use interpolation.

Given 18.4 kft of 26-gauge cable, find the approximate loss in the cable. Then use interpolation to refine the loss value.

From Table 6-17, 18 kft of cable has a loss of 9.1 dB and 19 kft has a loss of 9.7 dB. Using interpolation, 18.4 kft has an approximate loss of 9.3 dB. Figure 3-4 shows the calculations.

Figure 3-4
Calculations to interpolate cable loss



Pre-equalization

The Omega 4-wire line card offers the option of active pre-equalization in addition to post-equalization. First, perform post-equalization at each end of the loop. If one end cannot be equalized, perform pre-equalization to meet the requirements. The method for pre-equalization is identical to the method for post-equalization. To avoid crosstalk to other cable pairs and possible clipping of the signal, do not exceed +6 Rx total cable length (TLP) at high frequencies.

Mismatch equalization

In general, Nortel Networks recommends prescription settings for pre- and post-equalization for the most accurate results. In practice, it is sometimes satisfactory (and faster to administer) to use the 150-ohm mismatch technique for equalization. Setting the transmit and receive ports to 150 ohms impedance results in a passive pre- and post-equalization that meets the roll-off requirements for a wide range of nonloaded cable facilities. For these facilities, any network channel terminating equipment (NCTE) at the distant end does not have to provide equalization. However, the range of cable facilities that can be equalized in this manner is substantially increased if the far end provides 150-ohm mismatch equalization.

Using mismatch equalization produces mismatch loss. Table 3-4 on page 3-13 lists and describes the loss.

Table 3-4
Effective cable transducer loss using 150-ohm terminations (L_{mis})

Kft	Gauge							
	19		**22**		**24**		**26**	
	600/150 Ω mismatch	**150 Ω both ends**	**600/150 Ω mismatch**	**150 Ω both ends**	**600/150 Ω mismatch**	**150 Ω both ends**	**600/150 Ω mismatch**	**150 Ω both ends**
6					5.0		6.0	
8	4.0		4.8		5.7		7.0	
10	4.3		5.3		6.4		7.9	11.5
12	4.7		5.9		7.2		8.9	12.5
14	5.0	7.2	6.5	9.1	7.9	11.0		13.5
16	5.5	7.6		9.7		11.8		14.5
18		7.9		10.3		12.5		
20		8.3		10.9		13.3		

Use the listed values in Table 3-4 to calculate gain settings of the remote fiber terminal (RFT) line card, as follows:

Tx gain = L_{mis} – NCTE TxTLP

where

NCTE Tx TLP = TLP entering the cable at the customer equipment end

L_{mis} = value from Table 3-4

Rx gain = L_{mis} + NCTE Rx TLP

where

NCTE Tx TLP = TLP leaving the cable at the customer equipment end

L_{mis} = value from Table 3-4

The calculated settings shown above give the proper end-to-end loss in the NCTE-to-RFT path in both directions. However, if the circuit has to be sectionized to locate a loss problem, the measured level at the cable interface will be offset several dB from the calculated TLP. Although the mismatch loss is assigned to the cable, it actually takes place inside the 4-wire Omega line card.

Determining DX balance resistance

You must provision duplex (DX) balance resistance when you provision the NT4K69 line card for DX service.

The DX balance range is from 0 to 2400 ohms in 200-ohm increments. The provisioned resistance represents the total 4-wire simplex resistance of the transmit (Tx) and receive (Rx) cable. The required resistance does not include the 1250-ohm far-end DX termination. Assuming that the Tx and Rx cable makeup are the same, the value of the DX balance resistance, R_{DX}, is calculated as follows:

$$R_{DX} = R_{loop}/2$$

where

R_{loop} is equal to the 2-wire loop resistance of one direction.

To determine the value of R_{loop}, multiply the length of each gauge by its associated resistance constant to obtain the individual resistance for each gauge of cable. R_{loop} is the sum of these individual resistances.

4-wire parameter settings worksheet

The following pages contain the master copy of the 4-wire parameter settings worksheet, suitable for photocopying. Prepare one copy for each circuit that requires determination of gain or equalization.

Figure 3-5
4-wire parameter settings worksheet

4-wire parameter settings worksheet

Page 1 of 3

AccessNode system: ______	Circuit number: ______
Location name: ______	Circuit type (service): ______
CDS shelf number / slot number: ______	Date: ______

1-kHz loss on nonloaded cable (single or multi-gauge, with or without bridged taps)

A) GA1 (______GA) Length ________(kft) x K (from Table 2-4) = __________ ohms

B) GA2 (______GA) Length ________(kft) x K (from Table 2-4) = __________ ohms

C) GA3 (______GA) Length ________(kft) x K (from Table 2-4) = __________ ohms

D) GA4 (______GA) Length ________(kft) x K (from Table 2-4) = __________ ohms

E) Total resistance, excluding bridged taps: A + B + C + D = [ ] ohms

F) Total bridged tap length: __________ kft

G) Equivalent length, including bridged taps: A + B + C + D + F = [ ] kft

H) Total 1-kHz loss (see Note 1): [ ] dB
For single-gauge cable, use Table 6-17 or the graph on page 2-11.
For multi-gauge cable, use page 2-11.

1-kHz loss on loaded cable (single or multi-gauge)

A) GA1 ______GA) Length _____(kft) x K_L (from Table 3-1) = __________ dB

B) GA2 (______GA) Length _____(kft) x K_L (from Table 3-1) = __________ dB

C) GA3 (______GA) Length _____(kft) x K_L (from Table 3-1) = __________ dB

D) GA4 (______GA) Length _____(kft) x K_L (from Table 3-1) = __________ dB

E) Total 1-kHz loss (see Note 1): A + B + C + D = [ ] dB

TLP and gain for loaded and nonloaded cable

A) (See Note 1) Tx TLP = Tx TLP_{NI} – 1-kHz loss = _____ – _______= [ ] dB

B) Tx gain = – (Tx TLP) = [ ] dB

C) (See Note 1) Rx TLP = Rx TLP_{NI} + 1-kHz loss = _____ + ______ = [ ] dB

D) Rx gain = Rx TLP = [ ] dB

Note 1: Record an unsigned number for a 1-kHz loss.

4-wire parameter settings worksheet

AccessNode system:	________	Circuit number:	________
Location name:	________	Circuit type (service):	________
CDS shelf number / slot number:	________	Date:	________

Equalization for loaded cable, single or multi-gauge

A) MAJGA1 (______GA) Length = ________ kft

B) MAJGA2 (______GA) Length = ________ kft

C) MINGA1 (______GA) Length = ________ kft

D) MINGA2 (______GA) Length = ________ kft

E) (See Note 2) Equivalent length MAJGA1: A + (C or D) = [ ] kft

F) (See Note 3) Equivalent length MAJGA2: B + (C or D) = [ ] kft

G) Equalization settings (See Note 4):
For single-gauge cable, use Table 6-16
For multi-gauge cable, use Table 6-18, 6-19, or 6-20
[ ] BW [ ] HT [ ] SL

Note 2: Add C or D to A, whichever gauge is closest to MAJGA1.

Note 3: Add C or D to B, whichever gauge is closest to MAJGA2.

Note 4: See “Guidelines for determining entry point to Tables 6-18, 6-19, or 6-20” on page 3-7.

4-wire parameter settings worksheet

Page 3 of 3

AccessNode system:	____________	Circuit number:	____________
Location name:	____________	Circuit type (service):	____________
CDS shelf number / slot number:	____________	Date:	____________

Equalization for nonloaded cable, single or multi-gauge, with or without bridged taps

A) MAJGA1 (______GA) Length = __________ kft

B) Equivalent length of bridged tap (Table 3-2) = __________ kft

C) MAJGA2 (______GA) Length = __________ kft

D) Equivalent length of bridged tap (Table 3-2) = __________ kft

E) MINGA1 (______GA) Length = __________ kft

F) Equivalent length of bridged tap (Table 3-2) = __________ kft

G) Convert MINGA1 to MAJGA1
(E ________ + F _________) x K_M __________ (Table 3-3) = __________ kft

H) MINGA2 (______GA) Length = __________ kft

J) Converted length of bridged tap (Table 3-2) = __________ kft

K) Convert MINGA2 to MAJGA2
(H ________ + J _________) x K_M __________ (Table 3-3) = __________ kft

L) Equivalent length MAJGA1: A + B + G = [ ] kft

M) Equivalent length MAJGA2: C + D + K = [ ] kft

N) Equalization settings (See Note 5):
For single-gauge cable, use Table 6-17
For multi-gauge cable, use Table 6-21, 6-22, or 6-23
[ ] BW [ ] HT [ ] SL

Note 5: See “Determining 4-wire equalization settings with nonloaded cable” on page 3-8.

Circuit engineering guidelines

This chapter contains circuit engineering guidelines for determining gain transfer on 2-wire circuits. It also contains advice about loop length in the design of a carrier serving area (CSA). Determination of gain transfer includes the consideration of gain, loss, frequency roll-off, precision balance capability, and margin of stability.

Chapter contents

This chapter includes the following topics:

Two-wire gain transfer

Two-wire line cards used at the fiber central office terminal (FCOT) and remote fiber terminal (RFT) for special services applications can provide end-to-end analog gain to remove some cable loss. The sum of the following factors determines the amount of gain the line cards can provide and still maintain stability:

- the total gain in both directions of transmission
- the total hybrid loss contributed by each line card

The total hybrid loss must be greater than the total gain to maintain stability. A stability margin of at least 3 dB is desired.

The stability (or singing) margin is the combination of the following conditions:

- the difference in the amount of gain prescribed in both directions to meet the end-to-end loss objectives for a particular service
- the amount of additional gain necessary to create instability (singing)

Stability must be maintained in the talking mode as well as in the idle mode. Some new services, such as remote meter reading or alarm service, may require two-way on-hook transmission (in the idle mode) for sending analog data. You must maintain sufficient hybrid loss to prevent a near singing (near instability) condition. A near singing condition can distort data transmitted to the terminal so that the data receiver cannot synchronize to the signal.

You can remotely provision the 2-wire NT4K67 and NT4K68 line cards for gain, equalization, and hybrid balance. Therefore, they can provide 2-wire to 2-wire gain transfer in special services applications.

Several methods can determine the stability margin. The following topics describe line card characteristics and present guidelines for determining the limits of gain transfer.

Gain transfer design rules

This section describes the gain transfer design rules for the AccessNode.

Maximum gain

With the maximum carrier serving area (CSA) cable interface on one line card, a terminal interface on the other line card, and the line card gains set to meet a terminal-to-NI loss of 3 dB (where NI = network interface) for both directions of transmission:

maximum gain (total one way) = +2 dB

With the maximum CSA cable interface on both the fiber central office terminal (FCOT) and the remote fiber terminal (RFT), and with line card gains set to meet an NI-to-NI loss of 3 dB for both directions of transmission:

maximum gain (total one-way) = +7 dB

Maximum and minimum TLP levels

maximum receive output level = +3.5 dB

minimum transmit input level = –6.5 dB

Maximum 1-kHz cable loss

With the maximum-length CSA cable on one end of the AccessNode:

maximum 1-kHz loss = 5 dB

With the maximum-length CSA cable on both ends of the AccessNode:

maximum 1-kHz loss = 10 dB

Note: The precision hybrid balance settings, equalization range, and transmission level point (TLP) range are sufficient to accommodate cable up to CSA limits. Using cables longer than the CSA limit causes poor return loss or instability, inadequate frequency response, and insertion loss.

Frequency response roll-off

Instability usually occurs in frequency bands at the extreme ends of the voice frequency (VF) bandwidth. Since stability is related to gain, Nortel Networks recommends that the frequency response be rolled off as much as possible at 404 Hz and 2804 Hz, relative to 1004 Hz, while still keeping it within the trunk or line frequency response requirements.

Precision balance capability

A precision hybrid balance filter can provide hybrid loss so that echo return loss (ERL) = 26 dB and singing return loss (SRL) = 20 dB for the line card impedances, cable lengths, and cable terminations listed in Table 4-1. The hybrid balance filter must match the cable and termination closely to achieve maximum hybrid loss.

Table 4-1
NT4K67 impedances and cable terminations

NT4K67 Line card impedance	Cable length and gauge	Termination impedance
600 ohms + 2.16 μF	0 to 3 kft for 19, 22, 24, 26 ga	600 ohms + 2.16 μF
600 ohms + 2.16 μF	0 to 12 kft for 19, 22, 24 ga 0 to 9 kft for 26 gauge	600 ohms 600 ohms
600 ohms + 2.16 μF	0 to 12 kft for 19, 22, 24 ga 0 to 9 kft for 26 gauge	900 ohms 900 ohms
600 ohms + 2.16 μF	0 to 12 kft for 19, 22, 24 ga 0 to 9 kft for 26 gauge	500 telephone set
900 ohms + 2.16 μF	0 to 3 kft for 19, 22, 24, 26 ga	900 ohms + 2.16 μF
900 ohms + 2.16 μF	0 to 12 kft for 19, 22, 24 ga 0 to 9 kft for 26 gauge	600 ohms 600 ohms
900 ohms + 2.16 μF	0 to 3 kft for 19, 22, 24, 26 ga	900 ohms + 2.16 μF
600 ohms + 2.16 μF	0 to 12 kft for 19, 22, 24 ga 0 to 9 kft for 26 gauge	600 ohms 600 ohms
600 ohms + 2.16 μF	0 to 12 kft for 19, 22, 24 ga 0 to 9 kft for 26 gauge	600 ohms + 2.16 μF 600 ohms + 2.16 μF
600 ohms + 2.16 μF	0 to 12 kft for 19, 22, 24 ga 0 to 9 kft for 26 gauge	900 ohms + 2.16 μF 900 ohms + 2.16 μF

To determine the stability (singing) margin for a 2-wire to 2-wire gain transfer design, take the difference between the sum of the one-way gains in both directions of transmission and the sum of the singing return losses at each line card hybrid. Transmission test equipment can determine the singing return loss at each end, or you can retrieve the information from cable lineup records. Choose the singing return loss low (SRL_{LO}) or the singing return loss high (SRL_{HI}) reading, whichever is worse, where worse is a value closer to zero.

Cable lineup records include the cable section's structural return loss and terminal return loss. If the records contain the singing return loss measurements at both ends, you can use them in the stability margin calculations. If you use the structural return loss and terminal return loss from records, they must first be referred back to the line card and added (in watts) to obtain the singing return loss.

Determining stability margin by calculation

(See Figure 4-1 on page 4-5 for concepts.)

The following calculations assume that the critical frequency of oscillations is the same at both ends of the circuit and that the phase of the reflected signal is in phase with the incident signal. Terminal SRL taken from records and referred back to the line card through the cable at a frequency other than the critical frequency can have some error. Therefore, the calculations give a reasonable approximation for stability margin.

- gain (FCOT) = Tx gain + Rx gain
- gain (RFT) = Tx gain + Rx gain
- total RL (FCOT) = gain (FCOT) + SRL (FCOT)
- total RL (RFT) = gain (RFT) + SRL (RFT)
- stability margin = RL (FCOT) + RL (RFT)

where

RL	return loss
SRL	singing return loss

Note: A minus (–) result indicates the stability margin. A positive (+) result indicates an unstable or singing condition.

Determining stability margin by using test equipment

(See Figure 4-1 on page 4-5 for the test layout.)

1 Design the gain transfer circuit with the gain, equalization, and hybrid balance that meets the end-to-end transmission objective. Prescribe these parameters at the FCOT and the RFT.

2 Choose one of the following methods to determine the total return loss, SRL, at one end of the circuit:

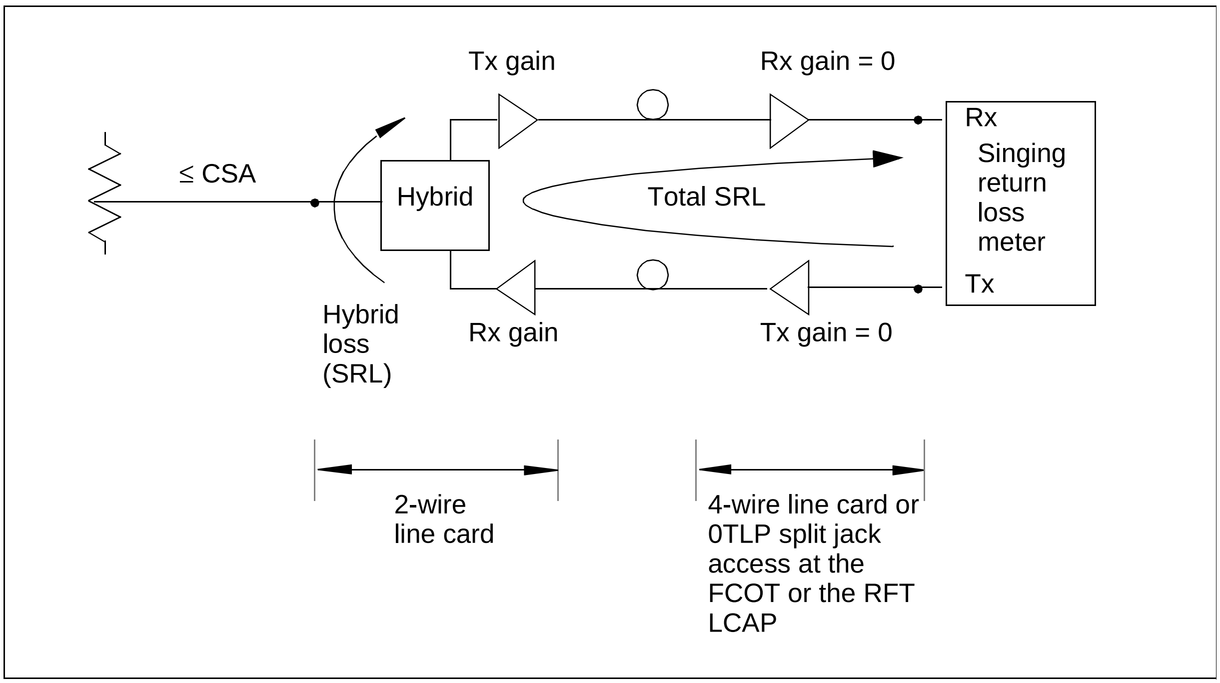
- Use a 4-wire circuit at the measuring end with the transmit and receive gain set to 0.
- Use the 0TLP split function at the jack access on the local craft access panel (LCAP).

The measured SRL represents the “total return loss” in the calculation method. Record this as a positive (+) or negative (–) value.

3 Repeat step 2 at the other end. Record this value.

4 Add the two measured values from steps 2 and 3. The result is the stability margin. A –3 dB singing return loss (SRL_{HI} or SRL_{LO}) is the minimum acceptable stability margin. Nortel Networks recommends an SRL (stability margin) of –6 dB or better.

Figure 4-1
Test layout for determining stability margin



Carrier serving area guidelines

A carrier serving area (CSA) is a geographical area served by a digital loop carrier (DLC) from a single remote terminal (RT) site and within which all local loops — without any conditioning or design — can provide the following:

- conventional voice-grade message service
- 64 kb/s and lower-rate digital data service
- some 2-wire locally switched voice-grade special services

The maximum loop length in a CSA is 12 kft for 19-, 22-, and 24-gauge cables and 9 kft for 26-gauge cables. This length includes bridge taps. The maximum allowable bridge tap length is 2.5 kft. No single bridge tap should exceed 2.0 kft (except for short sections used for stubbing and fusing).

All CSA loops must be nonloaded and should not have more than two gauges of cable.

If 26-gauge cable is included in multi-gauge cable, the total cable length including bridged taps, may not exceed:

$$12 - \frac{3(L_{26})}{9 - L_{BTAP}} \text{ kft}$$

Where:
L_{26} = total length in kilofeet of 26-gauge cable (excluding any 26-gauge bridge taps)

L_{BTAP} = total length in kilofeet of all bridge taps in the cable

The area around the serving-end office (within 9 kft for 26-gauge cable, and 12 kft for 19-, 22-, and 24-gauge cables) is not a CSA, but it is compatible with the CSA concept in transmission performance and supported services.

Determining equalization and gain (cable makeup unknown)

This chapter describes how to determine gain, equalizer height, slope, and bandwidth settings for 4-wire line cards when you do not know the cable makeup or when the cable makeup is not listed in the tables in Appendix A.

> ***Note:*** The line cards perform within carrier serving area (CSA) design limits. For more information about CSA limits, see Chapter 4.

Chapter contents

This chapter includes the following topics:

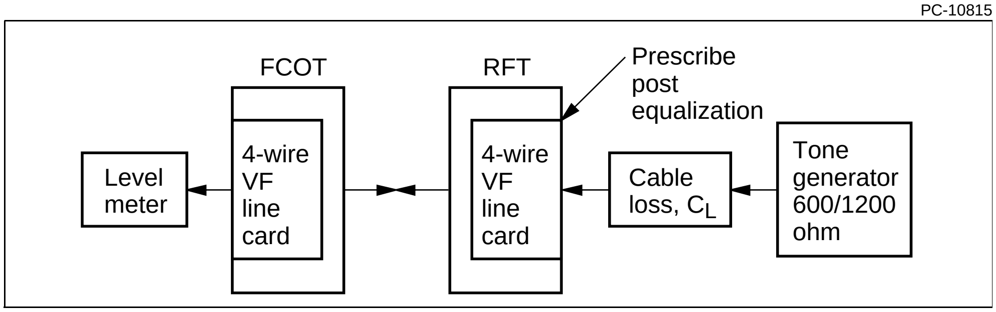
Read the entire set of instructions and work through the examples at the end of the chapter before you determine the equalization for any cable.

Equalization procedure

The equalization procedure requires some initial provisioning of the 4-wire voice frequency (VF) line card so that alignment tones can be sent through AccessNode.

Tones at 404, 1004, and 2804 Hz sent to the far end determine the loss characteristics of the cable facility. Figure 5-1 on page 5-2 shows the typical test layout.

Figure 5-1
Typical cable loss measurement



Comparing loss data to the slope and height charts (Tables 5-1 on page 5-8 and 5-2 on page 5-9) gives the optimum equalizer settings for the desired roll-off response of the circuit. A craftsperson can then provision the line card that interfaces the cable and verify the equalized response. If the card is not within desired limits, the craftsperson can fine-tune it to correct the response.

Initial setup

Except when cable makeup is known and can be simulated by computer or artificial line, some initial provisioning is needed to send tones through the AccessNode. Provision the fiber central office terminal (FCOT) and the remote fiber terminal (RFT) line card equalization to the following settings:

- SL = 0
- HT = 0
- BW = 0
- Tx gain = –TxTLP = 0
- Rx gain = +RxTLP = 0 (Transmission level points (TLP) are at the metallic side of the line card.)

This initial provisioning guarantees AccessNode a flat frequency response, in each direction, between the FCOT and the RFT.

Nonloaded/loaded, impedance setting

Steps 1 and 2 on the Equalization worksheet

Make a copy of the Equalization worksheet in Figure 5-2 on page 5-4 to record data from the following steps.

1 Set the impedance of the line card that faces the cable to IMP = 600.

2 Set the cable loading factor, loaded/nonloaded to nonloaded (L/N = N) for the following conditions:

— The cable loading is unknown.

— The cable is nonloaded.

— The cable is loaded with greater than a half end section (that is, with an end section length greater than one half the nominal load coil spacing). Provision IMP = 1200 and L/N = L only if the cable is loaded with a half end section or less.

3 Enter this data into your copy of the Equalization worksheet.

Figure 5-2
Equalization worksheet

Equalization Worksheet						
Step 1	L/N =					
Step 2	IMP =					
Step 3	Cable Loss					
	404 Hz =	________	dB			
	1004 Hz =	________	dB			
	2804 Hz =	________	dB			
Step 4						
A	1004 Hz Loss =	________	dB	2804 Hz Loss =	________	dB
B	404 Hz Loss =	________	dB	1004 Hz Loss =	________	dB
C	404 Hz Difference =	________	dB	2804 Hz Difference =	________	dB
Step 5						
A	404 Hz Roll-Off =	________	dB	2804 Hz Roll-Off =	________	dB
B	Add (Step 4C + Step 5A) =	________	dB	Difference (Step 4C Step 5A) =	________	dB
Step 6						
A	HT____ 404 Hz Loss =	________	dB	2804 Hz Gain =	________	dB
B	Difference (Step 5B Step 6A) =	________	dB	Difference (Step 5B Step 6A) =	________	dB
Step 7						
A	SL = ____ 404 Hz Loss =	________	dB	2804 Hz Gain =	________	dB
B	BW = ___ (Always use a value of 16 for the initial setting)					
Step 8	Estimated Roll-Off Error (Difference Step 6B-7A)					
	404 Hz: _____ _____dB			2804 Hz: _____ _____dB		
Step 9	Provision line card facing the cable					
Step 10	Verify equalized response					

Cable loss

Step 3 on the Equalization worksheet

Determine the cable loss at 404, 1004, 2804 Hz and enter the data in the Equalization worksheet. If you know the cable makeup, you may derive this data from artificial cable or computer simulation. If you do not know the cable makeup, you can send tones end to end as shown in Figure 5-1 on page 5-2.

Because previous provisioning leaves AccessNode tone-transparent, loss data can be taken by sending tone from either end. You can do this if the facility makeup is the same in both directions of the 4-wire circuit.

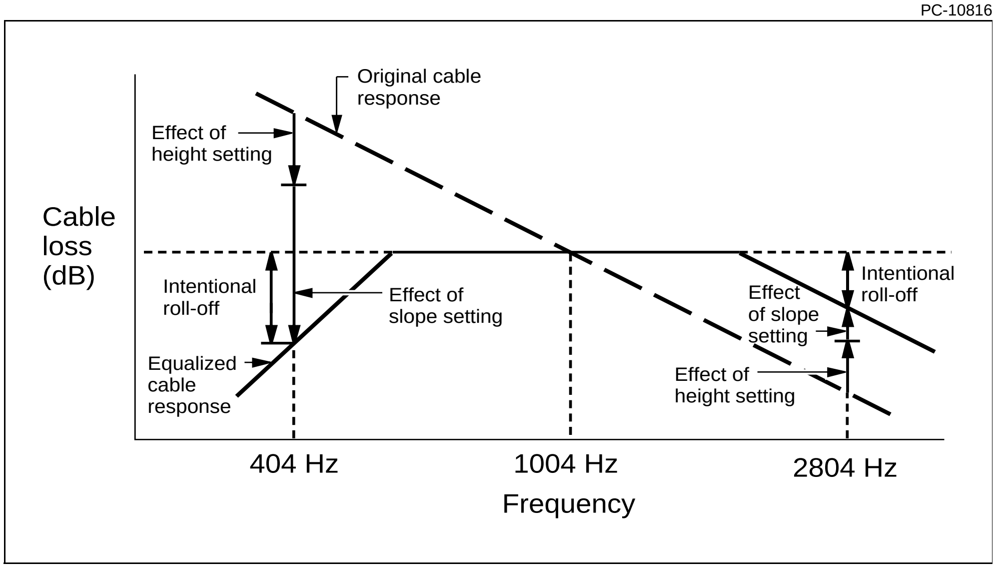
Loss difference

Step 4 on the Equalization worksheet

Calculate the loss difference between 404 Hz and 2804 Hz relative to 1004 Hz on the worksheet. The difference represents the combined total response that must be compensated for by the slope and height equalizer settings to meet 0 dB roll-off requirements. Figure 5-3 shows the effects of slope and height settings on the frequency response.

Figure 5-3
Accumulated effects of height and slope setting on equalized cable response

PC-10816



Intentional roll-off

Steps 5A and 5B on the Equalization worksheet

Intentional roll-off is usually added at 404 Hz and 2804 Hz for additional stability when 4-wire lines are terminated with 2-wire converters (hybrids). Complete the following steps to determine intentional roll-off:

1 Write the desired roll-off value (in dB) on the worksheet.

2 Add the results of Step 4C on the worksheet and the intentional roll-off from Step 5A for the 404 Hz value.

3 Take the *difference* between Step 4C and 5A for the 2804 Hz value.

These values give the 404 Hz loss and 2804 Hz gain that must be achieved by slope and height settings in to equalize the circuit to the desired roll-off characteristics.

Height setting

Step 6A on the Equalization worksheet

Complete the following steps to determine the height setting for *loaded* cable:

1 Take the 2804 Hz difference value in Step 5B and match it with the closest 2804 Hz gain value in the loaded cable height/slope chart (Table 5-1 on page 5-8).

2 Enter the closest 2804 Hz gain value, its associated 404 Hz loss value, and the height setting on the worksheet.

Note: Select the smaller 2804 Hz gain value if the difference of step 5B falls between two values.

Complete the following steps to determine the height setting for *nonloaded* cable:

1 Take the 2804 Hz difference value in Step 5B, divide it by two, and match it with the closest 2804 Hz value in Table 5-2 on page 5-9.

2 Enter this gain value, the associated 404 Hz attenuation, and the height settings on the worksheet.

Note: Select the next smaller value if the difference of step 5B falls between two table entries.

This height setting provides only a portion of the total 404 Hz loss and 2804 Hz gain necessary to equalize the circuit to the roll-off requirements.

Slope setting

Steps 6B and 7A on the Equalization worksheet

Take the difference between Step 5B and 6A at 404 Hz and 2804 Hz. This value represents the additional 404 Hz loss and 2804 Hz gain that the slope setting must provide to equalize the circuit to the desired roll-off requirements. Write the result in 6B of the worksheet.

Complete the following steps to determine the slope setting:

1. Compare the 404 Hz loss value in Step 6B to the appropriate table (that is, loaded/nonloaded cable slope and height settings chart) and match it with the closest 404 Hz loss value. Since the 2804 Hz gain is affected, a compromise setting may be necessary to more closely meet the roll-off requirements at 404 Hz and 2804 Hz.
2. Enter the chosen 404 Hz loss value, the associated 2804 Hz gain, and the slope setting in step 7A of the worksheet.

Table 5-1
Loaded cable slope and height chart (IMP = 1200, BW = 16)

Height chart			**Slope chart**		
HT setting	**404 Hz loss (dB)**	**2804 Hz gain (dB)**	**SL setting**	**404 Hz loss (dB)**	**2804 Hz gain (dB)**
0	0.0	0.0	0	0.0	0.0
1	0.0	0.4	1	0.3	0.1
2	0.2	0.8	2	0.5	0.2
3	0.3	1.2	3	0.7	0.2
4	0.4	1.7	4	0.9	0.3
5	0.5	2.2	5	1.2	0.3
6	0.7	2.6	6	1.3	0.3
7	0.9	3.2	7	1.7	0.4
8	1.2	3.9	8	1.8	0.4
9	1.3	4.3	9	1.9	0.5
10	1.5	4.7	10	2.0	0.5
11	1.7	5.0	11	2.0	0.5
12	2.0	5.4	12	2.0	0.5
13	2.4	5.7	13	2.1	0.5
14	2.7	6.1	14	2.3	0.5
15	3.2	6.5	15	2.7	0.6
Note to Height chart: Take 2804 Hz difference in Step 5B, and select the closest 2804 Hz gain value in this chart. Enter data in Step 6A of worksheet. If value of Step 5B falls between two 2804 Hz gain values above, select smaller value.			***Note to Slope chart:*** Take 404 Hz difference in Step 6B and select the closest 404 Hz loss value in this chart. Some compromise may be necessary to satisfy the 2804 Hz and 404 Hz roll-off objective. Enter slope data in Step 7A of worksheet. If Step 6B value is between two loss values, above, select larger value.		

Table 5-2
Nonloaded cable slope and height chart (IMP = 600, BW = 16)

Height chart			**Slope chart**		
HT setting	**404 Hz loss (dB)**	**2804 Hz gain (dB)**	**SL setting**	**404 Hz loss (dB)**	**2804 Hz gain (dB)**
0	0.0	0.0	0	0.0	0.0
1	0.1	0.3	1	0.4	0.7
2	0.1	0.8	2	0.8	1.3
3	0.2	1.4	3	1.2	1.7
4	0.3	1.7	4	1.5	1.9
5	0.5	2.2	5	1.9	2.4
6	0.6	2.6	6	2.2	2.6
7	0.9	3.3	7	2.5	2.8
8	1.3	3.9	8	2.8	2.9
9	1.4	4.3	9	3.0	3.1
10	1.5	4.8	10	3.3	3.2
11	1.8	5.1	11	3.6	3.3
12	2.1	5.4	12	3.7	3.4
13	2.4	5.7	13	3.9	3.5
14	2.8	6.1	14	4.1	3.5
15	3.1	6.5	15	4.3	3.6
Note to Height chart: Take 2804 Hz difference in Step 5B. Divide by 2 and select. Select the closest 2804 Hz gain value in this chart. Enter height data in Step 6A on worksheet. Select smaller value if value of Step 5B falls between two gain values above.			***Note to Slope chart:*** Take 404 Hz difference in Step 6B. Select the closest 404 Hz loss value in this chart. Some compromise may be necessary between slope and height settings to satisfy the roll-off objective at 404 Hz and 2804 Hz. Select larger value when Step 6B value is between two loss values above. Enter slope data into Step 7A of worksheet.		

Bandwidth setting

Step 7B on the Equalization worksheet

Always set to the bandwidth to BW = 16 for the first attempt to equalize the circuit. If you find a midband gain when you test the frequency sweep of the equalized circuit, provision a reduction in bandwidth setting until the response is within limits.

Estimated roll-off error

Step 8 on the Equalization worksheet

The roll-off error occurs because the exact value for 404 Hz loss and 2804 Hz gain may not be available in the chart, and a compromise value was chosen to match roll-off requirements as closely as possible

To calculate the roll-off error take the difference between step 6B and 7A.

- If the 404 Hz loss value in Step 7A is larger than the value in Step 6B, then the 404 Hz error will add loss to the 404 Hz roll-off objective.
- If the 2804 Hz gain value in Step 7A is smaller than the value in Step 6B, then the 2804 Hz error will add loss to the 2804 Hz roll-off objective.

Provision line card

Step 9 on the Equalization worksheet

Provision the line card that faces the cable with the data from the worksheet. Include L/N, IMP, HT, SL and BW parameters. You do not need 1004 Hz compensation for the equalization settings. The 1004 Hz level will remain the same as it was when the original loss measurement was made. Tx and Rx gain adjustment, based on the required TLP, will be made in a later procedure.

Equalization verification

Step 10 on the Equalization worksheet

Transmit tones end-to-end to verify that the response is within acceptable limits. If the response is acceptable, go to “Tx and Rx gain calculations from cable loss data”on page 5-11. If the response is not satisfactory, go to “Equalization fine-tuning” on page 5-10.

Equalization fine-tuning

If the first attempt to equalize the line does not bring the response within the desired limits, you must fine-tune the slope, height, and bandwidth settings.

> ***Note:*** You must understand the effects of changing each setting to successfully fine-tune the response. See Figure 5-3 on page 5-5 before you begin.

Table 5-2 on page 5-9 shows that an increase in the height setting causes 2804 Hz gain and 404 Hz loss. Increasing the slope setting produces similar results, although the 2804 Hz gain changes less as the slope setting increases.

Table 5-1 on page 5-8 shows that a change in the height setting produces exactly the same effect as the nonloaded mode for a bandwidth setting of 16. Increasing the slope setting provides loss at 404 Hz, but has a minimal effect on the 2804 Hz gain. No equalization setting affects the 1004 Hz level, therefore no compensation is needed when you calculate attenuation settings.

Fine-tuning guidelines

Use the following guidelines if fine-tuning is needed after an initial equalization attempt.

If 404 Hz response is out of limits

- Decrease slope setting for more gain.
- Increase slope setting for more loss.

You may need to increase or decrease height settings to compensate for changes in high frequency (2804 Hz) response.

If 2804 Hz response is out of limits

- Increase slope setting for more gain.
- Decrease slope setting for more loss.

You may need to increase or decrease slope settings to compensate for changes in low frequency (404 Hz) response.

If midband (2000 Hz) response is out of limits

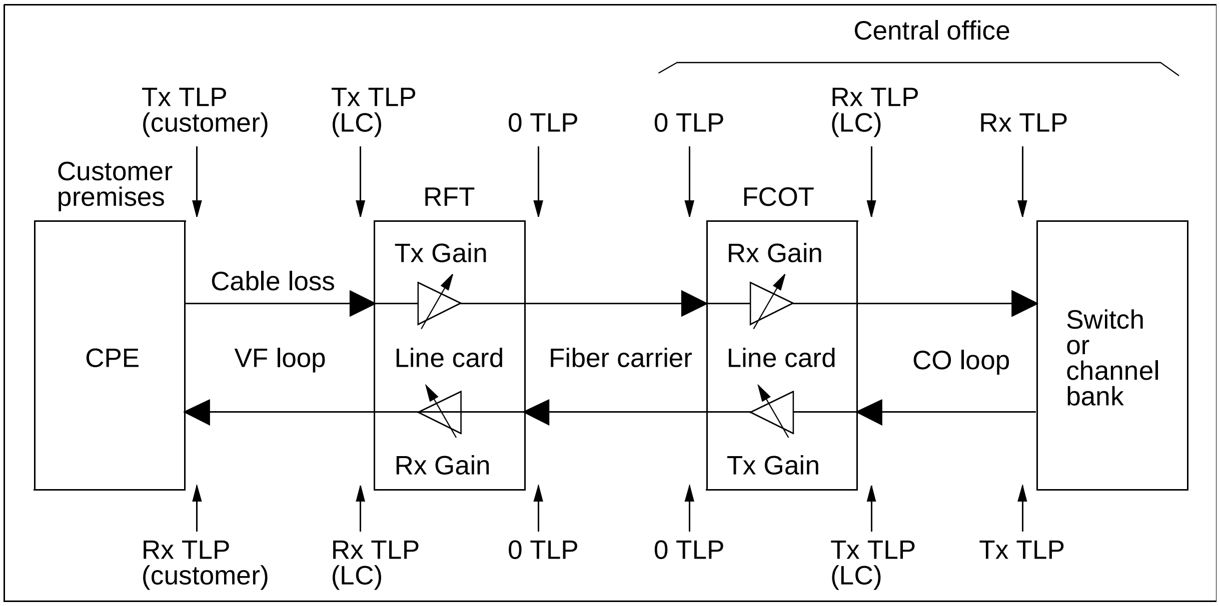
- Decrease bandwidth for more loss in the 2000 Hz range.
- Keep the slope and height unchanged.

If the response has ripples across the passband, the cable facility is probably loaded with impedance mismatch at the half-end section at either the line card or far-end termination equipment. To compensate for this effect, change the line card or far-end termination impedance (or both) to 1200 ohms, then retest.

Tx and Rx gain calculations from cable loss data

Figure 5-4 on page 5-12 shows the definition of transmit and receive directions in a customer loop with digital loop carrier.

Figure 5-4
AccessNode transmission level points



If you know the near-end transmission level points (TLP), you can calculate transmit/receive gain settings using the following formulas:

- Tx gain = –TxTLP
- Rx gain = +RxTLP

When you do not know the near-end TLPs, complete the following steps to determine the gain settings from far-end TLPs and the 1004 Hz cable loss (obtained earlier in this chapter).

1 Calculate near-end TLPs using the following formulas:

$TxTLP = \text{customer } Tx_{TLP} - C_L$
$RxTLP = \text{customer } Tx_{TLP} + C_L$

Where:
TxTLP = transmit TLP at line card (TLPs are referenced to 0 dBm0)
RxTLP = receive TLP at line card
customer RxTLP = receive TLP at customer premises equipment
customer TxTLP = transmit TLP at customer premises equipment
C_L = Cable loss at 1004 Hz (positive value)

2 Calculate the gain settings using the following formulas:

Tx gain = –TxTLP
Rx gain = +RxTLP

Where:

Tx gain = line card transmit gain setting (See Figure 3-3 on page 3-3 for definition of transmit direction)
Rx gain = line card receive setting (See Figure 3-3 for definition of receive direction)

Near-end TLP guidelines

Nortel Networks recommends the following minimum and maximum TLP levels at the tip and ring leads of the 4-wire Omega line cards:

- Minimum input level of –9 TLP for 600 or 1200 ohm termination. (This is the transmit TLP from the perspective of the external circuit.)
- Maximum output level of +6 TLP for 600 or 1200 ohm source impedance. (This is the receive TLP from the perspective of the external circuit.) The +6 TLP maximum is recommended to avoid crosstalk.

The preceding TLP range translates to a maximum allowable cable loss of 15 dB.

Equalization examples

Following are three sample equalization exercises that illustrate the use of the worksheet and how equalization is performed for some typical cable makeups.

Example 1

The loss for an unknown cable facility was measured and recorded as shown on the worksheet for Example 1, Figure 5-6 on page 5-17. The worksheet shows the following information:

- Slope, height, and bandwidth settings were determined.
- The roll-off error was calculated. The roll-off objective is 0.5 dB at 404 Hz and 2804 Hz.
- The line card was provisioned and the equalized response was measured as shown by the following loss data:
  - 404 Hz Loss = 7.1 dB
  - 1004 Hz Loss = 6.6 dB
  - 2804 Hz Loss = 6.9 dB

- Notice that the 0.5 dB roll-off at 404 Hz was achieved and that it corresponds to the 0.0 dB roll-off error calculated in the worksheet. The 2804 Hz roll-off is measured to be 0.3 dB, which does not meet the 0.5 dB objective, but is exactly as estimated for the roll-off error. The error happened because an exact value for the calculated 2804-Hz gain or 404-Hz loss was not in the slope/height table, and the closest value was chosen.
- A frequency sweep test of the passband revealed that the midband gain relative to 1004 Hz was within limits, eliminating any requirement to reduce the bandwidth setting.
- The 0.2 dB roll-off error was acceptable, so no further equalization steps were needed.

Example 2

A cable of known makeup (see Figure 5-5) needs to be equalized. The cable composition is not in Appendix A, so equalization must be performed from cable loss data.

Figure 5-5
Cable makeup for Example 2

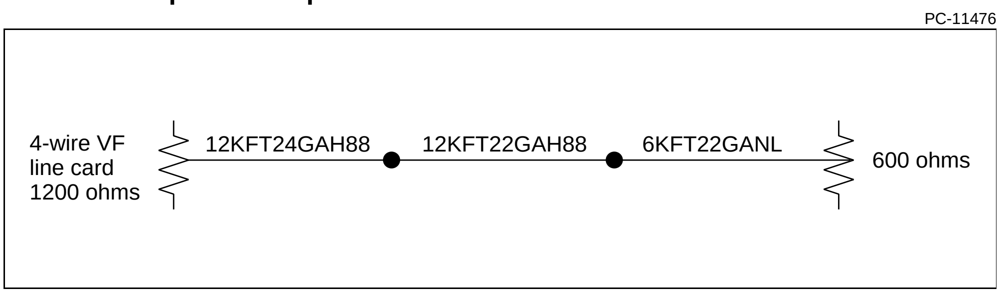


Figure 5-7 on page 5-18 shows the worksheet for Example 2.

- In steps 1 and 2, settings of L/N = L and IMP = 1200 were selected because the first load coil was within 3,000 ft of the VF line card.
- The loss data was measured as shown on the worksheet.
- Slope, height, and bandwidth settings were determined.
- The roll-off error was calculated, the roll-off objective being 1.5 dB at 404 Hz and 2.0 dB at 2804 Hz.
- The line card was provisioned.
- The equalized response was measured as shown by the following loss data:
  - — 404 Hz Loss = 7.6 dB
  - — 1004 Hz Loss = 6.1 dB
  - — 2804 Hz Loss = 8.1 dB

- The roll-off response of 1.5 dB and 2.0 dB at 404 Hz met objectives (although the 404 Hz roll-off error of 0.1 dB was estimated on the worksheet).
- A frequency sweep test of the passband revealed that there was no midband gain in the 2000 Hz range, and there was no reason to reduce the bandwidth setting.

Example 3

Figure 5-8 on page 5-19 shows that the loss for an unknown cable facility was measured and recorded.

- Slope, height, and bandwidth settings were determined.
- The roll-off error was calculated, the roll-off objective being 1.5 dB at 404 Hz and 2.0 dB at 2804 Hz.
- The line card was provisioned.
- The equalized response was measured as shown by the following loss data:
  - — 404 Hz Loss = 10.0 dB
  - — 1004 Hz Loss = 8.4 dB
  - — 2804 Hz Loss = 9.3 dB
- The roll-off response was very close to the estimated roll-off error in the worksheet.
- A frequency sweep test of the passband revealed that there were significant ripples in the passband as shown in the following data:
  - — 1800 Hz Loss = 6.7 dB
  - — 2100 Hz Loss = 7.4 dB
  - — 2400 Hz Loss = 6.8 dB
- The fine-tuning procedure indicated a likely impedance mismatch to the loaded cable with the half-end section at either the line card or the terminal equipment end of the cable.
- The line card facing the cable was reprovisioned for SL = 0, HT = 0, BW = 15, N/L = L, and IMP = 1200 to match the impedance of the possible half-end section of the loaded cable.
- The loss data was taken again and entered in the worksheet for a second attempt to determine the equalization settings (Figure 5-9 on page 5-20).
- Slope, height, and bandwidth settings were determined.
- The roll-off error was calculated.
- The line card was reprovisioned with the new equalization settings.

- The equalized response was measured as shown by the following data:
  - — 404 Hz Loss = 10.1 dB
  - — 1004 Hz Loss = 8.5 dB
  - — 2804 Hz Loss = 10.3 dB
- The roll-off relative to 1004 Hz was measured at 1.6 dB at 404 Hz and 1.8 dB at 2804 Hz. This corresponds with the predicted roll-off error calculated in the worksheet in Figure 5-9 on page 5-20. From these results, the cable terminating at the line card was assumed to be loaded. No further equalization steps were necessary.

Figure 5-6
Example 1 equalization exercise

Equalization Worksheet				
Step 1	L/N =	N		
Step 2	IMP =	600		
Step 3	Cable Loss			
	404 Hz =	5.3 dB		
	1004 Hz =	6.6 dB		
	2804 Hz =	11.9 dB		
Step 4				
A	1004 Hz Loss =	6.6 dB	2804 Hz Loss =	11.9 dB
B	404 Hz Loss =	5.3 dB	1004 Hz Loss =	6.6 dB
C	404 Hz Difference =	1.3 dB	2804 Hz Difference =	5.3 dB
Step 5				
A	404 Hz Roll-Off =	0.5 dB	2804 Hz Roll-Off =	0.5 dB
B	Add (Step 4C + Step 5A) =	1.8 dB	Difference (Step 4C Step 5A) =	4.8 dB
Step 6				
A	HT 5 404 Hz Loss =	0.5 dB	2804 Hz Gain =	2.2 dB
B	Difference (Step 5B Step 6A) =	1.3 dB	Difference (Step 5B Step 6A) =	2.6 dB
Step 7				
A	SL = 4 404 Hz Loss =	1.3 dB	2804 Hz Gain =	2.8 dB
B	BW = 15 (Always use a value of 16 for the initial setting)			
Step 8	Estimated roll-off error (difference Step 6B-7A)			
	404 Hz: ____ 0.0 dB		2804 Hz: GAIN 0.2 dB	
Step 9	Provision line card facing the cable			
Step 10	Verify equalized response			

Figure 5-7
Example 2 equalization exercise

Equalization Worksheet				
Step 1	L/N =	L		
Step 2	IMP =	1200		
Step 3	Cable Loss			
	404 Hz =	5.4 dB		
	1004 Hz =	6.0 dB		
	2804 Hz =	9.1 dB		
Step 4				
A	1004 Hz Loss =	6.0 dB	2804 Hz Loss =	9.1 dB
B	404 Hz Loss =	5.4 dB	1004 Hz Loss =	6.0 dB
C	404 Hz Difference =	0.6 dB	2804 Hz Difference =	3.1 dB
Step 5				
A	404 Hz Roll-Off =	1.5 dB	2804 Hz Roll-Off =	2.0 dB
B	Add (Step 4C + Step 5A) =	2.1 dB	Difference (Step 4C Step 5A) =	1.1 dB
Step 6				
A	HT 2 404 Hz Loss =	0.2 dB	2804 Hz Gain =	0.8 dB
B	Difference (Step 5B Step 6A) =	1.9 dB	Difference (Step 5B Step 6A) =	0.3 dB
Step 7				
A	SL = 4 404 Hz Loss =	2.0 dB	2804 Hz Gain =	0.3 dB
B	BW = 15 (Always use a value of 16 for the initial setting)			
Step 8	Estimated roll-off error (difference Step 6B-7A)			
	404 Hz: LOSS 0.1 dB		2804 Hz: ______ 0.0 dB	
Step 9	Provision line card facing the cable			
Step 10	Verify equalized response			

Figure 5-8
Example 3 equalization exercise, first attempt

Equalization Worksheet				
Step 1	L/N =	N		
Step 2	IMP =	600		
Step 3	Cable Loss			
	404 Hz =	7.5 dB		
	1004 Hz =	8.3 dB		
	2804 Hz =	15.1 dB		
Step 4				
A	1004 Hz Loss =	8.3 dB	2804 Hz Loss =	15.1 dB
B	404 Hz Loss =	7.5 dB	1004 Hz Loss =	8.3 dB
C	404 Hz Difference =	0.8 dB	2804 Hz Difference =	6.8 dB
Step 5				
A	404 Hz Roll-Off =	1.5 dB	2804 Hz Roll-Off =	2.0 dB
B	Add (Step 4C + Step 5A) =	2.3 dB	Difference (Step 4C Step 5A) =	4.8 dB
Step 6				
A	HT 5 404 Hz Loss =	0.5 dB	2804 Hz Gain =	2.2 dB
B	Difference (Step 5B Step 6A) =	1.8 dB	Difference (Step 5B Step 6A) =	2.6 dB
Step 7				
A	SL = 6 404 Hz Loss =	1.9 dB	2804 Hz Gain =	3.6 dB
B	BW = 15 (Always use a value of 16 for the initial setting)			
Step 8	Estimated roll-off error (difference Step 6B-7A)			
	404 Hz: LOSS 0.1 dB		2804 Hz: GAIN 1.0 dB	
Step 9	Provision line card facing the cable			
Step 10	Verify equalized response			

Figure 5-9
Example 3 equalization exercise, second attempt

Equalization Worksheet				
Step 1	L/N =	L		
Step 2	IMP =	1200		
Step 3	Cable Loss			
	404 Hz =	7.0 dB		
	1004 Hz =	8.3 dB		
	2804 Hz =	13.6 dB		
Step 4				
A	1004 Hz Loss =	8.3 dB	2804 Hz Loss =	13.6 dB
B	404 Hz Loss =	7.0 dB	1004 Hz Loss =	8.3 dB
C	404 Hz Difference =	1.3 dB	2804 Hz Difference =	5.3 dB
Step 5				
A	404 Hz Roll-Off =	1.5 dB	2804 Hz Roll-Off =	2.0 dB
B	Add (Step 4C + Step 5A) =	2.8 dB	Difference (Step 4C Step 5A) =	3.3 dB
Step 6				
A	HT 7 404 Hz Loss =	0.9 dB	2804 Hz Gain =	3.2 dB
B	Difference (Step 5B Step 6A) =	1.9 dB	Difference (Step 5B Step 6A) =	0.1 dB
Step 7				
A	SL = 4 404 Hz Loss =	2.0 dB	2804 Hz Gain =	0.3 dB
B	BW = 15 (Always use a value of 16 for the initial setting)			
Step 8	Estimated roll-off error (difference Step 6B-7A)			
	404 Hz: LOSS 0.1 dB		2804 Hz: GAIN 0.2 dB	
Step 9	Provision line card facing the cable			
Step 10	Verify equalized response			

Appendix A: Tables of prescription settings

This appendix contains tables of prescription settings for line cards. Chapters 2 and 3 refer to these tables for determining settings for 2-wire and 4-wire line cards, respectively.

Chapter contents

The table on the next page lists the prescription setting tables in this chapter.

Table 6-1
NT4K68 equalization settings (600+2)

This table applies to the 2-wire sink line card (NT4K68) used on single-gauge CSA cables without bridge taps.
Line card impedance = 600Ω+2µF.
Cable termination = 600 or 900 Ω.

Cable length	**26 AWG**		**24 AWG**		**22 AWG**		**19 AWG**		**25 AWG**	
(kft)	**600**	**900**	**600**	**900**	**600**	**900**	**600**	**900**	**600**	**900**
1.0	0	0	0	0	0	0	0	0	0	0
1.5	0	0	0	0	0	0	0	0	0	0
3.0	0	0	0	0	0	0	0	0	0	0
3.5	0	0	0	0	0	0	0	0	0	0
3.75	0	1	0	0	0	0	0	0	0	0
4.0	0	1	0	0	0	0	0	0	0	0
4.25	0	1	0	1	0	1	0	1	0	0
4.5	0	1	0	1	0	1	0	1	0	0
4.75	1	1	1	1	0	1	0	1	0	0
5.0	1	1	1	1	0	1	0	1	0	0
5.25	1	1	1	1	1	1	1	1	0	1
5.5	1	1	1	1	1	1	1	1	0	1
6.0	1	1	1	1	1	1	1	1	0	1
6.25	1	2	1	1	1	1	1	1	1	1
6.5	1	2	1	1	1	1	1	1	1	1
6.75	1	2	1	2	1	2	1	1	1	1
7.0	1	2	1	2	1	2	1	1	1	1
7.25	2	2	1	2	1	2	1	2	1	1
7.5	2	2	1	2	1	2	1	2	1	1
7.75	2	3	2	3	1	2	1	2	1	1
8.0	2	3	2	3	1	2	1	2	1	1
8.25	2	3	2	3	2	3	2	2	1	2
8.5	2	3	2	3	2	3	2	2	1	2
8.75	3	4	2	3	2	3	2	3	1	2
9.0	3	4	2	3	2	3	2	3	1	2
9.25	3	4	3	4	2	3	2	3	1	2
9.5	3	4	3	4	2	3	2	3	1	2
9.75	4	5	3	4	3	4	2	3	1	3
10.0	4	5	3	4	3	4	2	3	2	3
10.25	4	5	3	5	3	4	3	4	2	3
10.5	4	5	3	5	3	4	3	4	2	3
10.75	4	5	4	5	3	4	3	4	2	4
11.0	4	5	4	5	3	4	3	4	3	4
11.25	-	-	4	5	4	5	3	4	3	4
11.5	-	-	4	5	4	5	3	4	3	4
11.75	-	-	5	6	4	5	4	5	3	4
12.0	-	-	5	6	4	5	4	5	3	4

Table 6-2
NT4K67 equalization settings (900+2)

This table applies to the 2-wire source line card (NT4K67) used on single-gauge CSA cables.
Line card impedance = 900Ω+2μF.
Cable termination = 600 Ω, 900 Ω, or a model 500 telephone set.

Cable length (kft)		Cable gauge (AWG)			
from	**to**	**19**	**22**	**24**	**26**
0	0.5	0	0	0	0
0.5	1	0	0	0	0
1	1.5	0	0	0	0
1.5	2	0	0	0	0
2	2.5	0	0	0	0
2.5	3	0	0	0	0
3	3.5	0	0	0	0
3.5	4	0	0	0	0
4	4.5	0	0	0	0
4.5	5	0	0	0	0
5	5.5	0	0	0	0
5.5	6	0	1	0	0
6	6.5	0	1	1	0
6.5	7	0	1	1	1
7	7.5	1	1	1	1
7.5	8	1	1	1	1
8	8.5	1	1	1	1
8.5	9	1	1	1	1
9	9.5	1	2	1	-
9.5	10	1	2	1	-
10	10.5	1	2	2	-
10.5	11	2	2	2	-
11	11.5	2	3	3	-
11.5	12	2	3	3	-

Table 6-3
NT4K67 equalization settings (600+2)

This table applies to the 2-wire source line card (NT4K67) used on single-gauge CSA cables.
Line card impedance = 600Ω+2µF.
Cable termination = 600 Ω, 900 Ω, or a model 500 telephone set.

Cable length (kft)		Cable gauge (AWG)			
from	**to**	**19**	**22**	**24**	**26**
0	0.5	0	0	0	0
0.5	1	0	0	0	0
1	1.5	0	0	0	0
1.5	2	0	0	0	0
2	2.5	0	0	0	0
2.5	3	0	0	0	0
3	3.5	0	0	0	0
3.5	4	0	1	0	1
4	4.5	0	1	0	1
4.5	5	1	1	0	1
5	5.5	1	1	0	1
5.5	6	1	1	1	1
6	6.5	1	1	1	1
6.5	7	1	1	1	2
7	7.5	1	1	1	2
7.5	8	1	2	1	2
8	8.5	1	2	1	2
8.5	9	1	2	2	2
9	9.5	1	2	2	-
9.5	10	2	3	2	-
10	10.5	2	3	2	-
10.5	11	2	3	3	-
11	11.5	2	3	3	-
11.5	12	3	3	3	-

Table 6-4
NT4K68 balance settings (600+2/600)

This table applies to the 2-wire sink line card (NT4K68).
Line card impedance = 600Ω+2µF
Termination impedance = 600 Ω

(kft)	19 AWG	22 AWG	24 AWG	26 AWG
0.0	10	10	10	10
0.5	10	10	10	10
1.0	10	10	10	16
1.5	5	5	5	16
2.0	5	5	5	16
2.5	5	5	11	17
3.0	0	6	11	17
3.5	0	6	11	17
4.0	0	6	12	18
4.5	0	6	12	18
5.0	1	7	12	18
5.5	1	7	12	18
6.0	1	7	13	19
6.5	1	7	13	19
7.0	2	8	13	19
7.5	2	8	13	20
8.0	2	8	14	20
8.5	2	8	14	20
9.0	3	8	14	20
9.5	3	9	14	-
10.0	3	9	15	-
10.5	3	9	15	-
11.0	4	9	15	-
11.5	4	9	15	-
12.0	4	9	15	-

Table 6-5
NT4K68 balance settings (600+2/600+2)

This table applies to the 2-wire sink line card (NT4K68).
Line card impedance = 600Ω+2μF
Termination impedance = 600Ω+2μF

(kft)	19 AWG	22 AWG	24 AWG	26 AWG
0.0	21	21	21	21
0.5	21	26	31	36
1.0	21	26	31	36
1.5	21	26	31	36
2.0	22	27	32	37
2.5	22	27	32	37
3.0	22	27	32	37
3.5	22	27	32	38
4.0	23	28	33	38
4.5	23	28	33	38
5.0	23	28	33	39
5.5	23	28	33	39
6.0	23	28	34	39
6.5	24	29	34	39
7.0	24	29	34	40
7.5	24	29	34	40
8.0	24	29	34	40
8.5	24	29	35	40
9.0	24	30	35	40
9.5	25	30	35	-
10.0	25	30	35	-
10.5	25	30	35	-
11.0	25	30	35	-
11.5	25	30	35	-
12.0	25	30	35	-

Table 6-6
NT4K68 balance settings (600+2/900+2)

This table applies to the 2-wire sink line card (NT4K68). Line card impedance = 600Ω+2.2μF Termination impedance = 900Ω+2.2μF				
(kft)	**19 AWG**	**22 AWG**	**24 AWG**	**26 AWG**
0.0	47	47	47	47
0.5	47	47	47	47
1.0	47	47	58	58
1.5	48	48	58	58
2.0	48	48	48	58
2.5	48	48	48	59
3.0	49	49	59	59
3.5	49	49	54	60
4.0	41	49	54	60
4.5	41	50	54	60
5.0	42	50	55	61
5.5	42	50	55	61
6.0	42	51	55	61
6.5	43	51	55	61
7.0	43	51	56	62
7.5	43	51	56	62
8.0	44	52	56	62
8.5	44	52	56	62
9.0	44	52	57	62
9.5	45	52	57	-
10.0	45	53	57	-
10.5	45	53	57	-
11.0	46	53	57	-
11.5	46	53	57	-
12.0	46	53	57	-

Table 6-7
NT4K68 balance settings (900+2/600)

This table applies to the 2-wire sink line card (NT4K68).
Line card impedance = 900Ω+2µF
Termination impedance = 600Ω

(kft)	19 AWG	22 AWG	24 AWG	26 AWG
0.0	69	69	69	69
0.5	69	69	69	69
1.0	69	69	69	70
1.5	72	72	71	70
2.0	72	72	71	73
2.5	72	72	71	73
3.0	72	76	75	74
3.5	77	76	75	74
4.0	77	76	75	78
4.5	77	76	79	78
5.0	77	81	79	80
5.5	82	81	79	80
6.0	82	81	83	84
6.5	82	81	83	84
7.0	82	85	83	84
7.5	86	85	87	88
8.0	86	85	87	88
8.5	86	85	87	89
9.0	86	91	92	90
9.5	93	91	92	-
10.0	93	91	94	-
10.5	93	95	94	-
11.0	96	95	94	-
11.5	96	95	97	-
12.0	96	95	97	-

Table 6-8
NT4K68 balance settings (900+2/600+2)

This table applies to the 2-wire sink line card (NT4K68).
Line card impedance = 900Ω+2.2μF
Termination impedance = 600Ω+2.2μF

(kft)	19 AWG	22 AWG	24 AWG	26 AWG
0.0	98	98	98	98
0.5	98	98	98	98
1.0	98	98	98	99
1.5	101	101	99	99
2.0	101	101	99	100
2.5	101	101	102	100
3.0	101	101	102	103
3.5	104	105	102	103
4.0	104	105	106	107
4.5	104	105	106	107
5.0	104	105	106	107
5.5	110	111	108	109
6.0	110	111	108	109
6.5	110	111	108	109
7.0	110	114	113	112
7.5	115	114	113	112
8.0	115	114	113	116
8.5	115	118	117	116
9.0	115	118	117	116
9.5	115	118	117	-
10.0	119	118	117	-
10.5	119	120	121	-
11.0	119	120	121	-
11.5	119	120	121	-
12.0	119	120	121	-

Table 6-9
NT4K68 balance settings (900+2/900+2)

This table applies to the 2-wire sink line card (NT4K68). Line card impedance = 900Ω+2µF Termination impedance = 900Ω+2µF				
(kft)	**19 AWG**	**22 AWG**	**24 AWG**	**26 AWG**
0.0	66	66	66	66
0.5	66	66	66	66
1.0	66	66	66	66
1.5	65	64	64	64
2.0	65	64	64	64
2.5	63	63	65	65
3.0	63	63	65	65

Table 6-10
NT4K67 balance settings (600+2/900)

This table applies to the 2-wire source line card (NT4K67). Line card impedance = 600Ω+2µF Termination impedance = 900Ω					
Cable length (kft)		**Cable gauge (AWG)**			
from	**to**	**19**	**22**	**24**	**26**
0	0.5	84	77	70	63
0.5	1	84	77	70	63
1	1.5	84	77	70	64
1.5	2	84	77	71	64
2	2.5	85	78	71	64
2.5	3	85	78	71	65
3	3.5	85	78	72	65
3.5	4	85	78	72	65
4	4.5	86	79	72	66
4.5	5	86	79	72	66
5	5.5	86	79	73	67
5.5	6	86	80	73	67
6	6.5	87	80	73	67
6.5	7	87	80	73	68
7	7.5	87	80	74	68
7.5	8	87	81	74	69
8	8.5	88	81	74	69
8.5	9	88	81	74	69
9	9.5	88	82	75	-
9.5	10	88	82	75	-
10	10.5	89	82	75	-
10.5	11	89	83	76	-
11	11.5	89	83	76	-
11.5	12	89	83	76	-

Table 6-11
NT4K67 balance settings (600+2/500 set)

This table applies to the 2-wire source line card (NT4K67). Line card impedance = 600Ω+2µF Termination impedance = 500 set					
Cable length (kft)		**Cable gauge (AWG)**			
from	**to**	**19**	**22**	**24**	**26**
0	0.5	120	112	99	90
0.5	1	120	112	99	90
1	1.5	121	112	100	91
1.5	2	121	113	100	91
2	2.5	121	113	101	92
2.5	3	122	113	102	92
3	3.5	122	114	102	93
3.5	4	122	114	103	93
4	4.5	122	114	103	94
4.5	5	123	115	103	94
5	5.5	123	115	104	95
5.5	6	123	115	105	95
6	6.5	123	116	105	96
6.5	7	124	116	106	96
7	7.5	124	116	106	97
7.5	8	124	117	107	97
8	8.5	125	117	107	98
8.5	9	125	117	108	98
9	9.5	125	118	108	-
9.5	10	125	118	109	-
10	10.5	126	118	109	-
10.5	11	126	119	110	-
11	11.5	126	119	110	-
11.5	12	126	119	111	-

Table 6-12
NT4K67 balance settings (600+2/600+2)

This table applies to the 2-wire source line card (NT4K67). Line card impedance = 600Ω+2.2µF Termination impedance = 600Ω+2.2µF					
Cable length (kft)		**Cable gauge (AWG)**			
from	**to**	**19**	**22**	**24**	**26**
0	0.5	11	9	7	4
0.5	1	11	9	7	4
1	1.5	11	9	7	5
1.5	2	12	10	8	5
2	2.5	12	10	8	6
2.5	3	12	10	8	6

Table 6-13
NT4K67 balance settings (900+2/900+2)

This table applies to the 2-wire source line card (NT4K67). Line card impedance = 900Ω+2.2 µF Termination impedance = 900Ω+2.2µF					
Cable length (kft)		**Cable gauge (AWG)**			
from	**to**	**19**	**22**	**24**	**26**
0	0.5	134	132	130	127
0.5	1	134	132	130	127
1	1.5	134	132	130	128
1.5	2	135	133	131	128
2	2.5	135	133	131	129
2.5	3	135	133	131	129

Table 6-14
NT4K67 balance settings (900+2/600)

This table applies to the 2-wire source line card (NT4K67). Line card impedance = 900Ω+2µF Termination impedance = 600Ω					
Cable length (kft)		**Cable gauge (AWG)**			
from	**to**	**19**	**22**	**24**	**26**
0	0.5	32	26	20	13
0.5	1	32	26	20	13
1	1.5	32	26	20	13
1.5	2	32	26	20	14
2	2.5	32	27	21	14
2.5	3	33	27	21	15
3	3.5	33	27	21	15
3.5	4	33	27	21	15
4	4.5	33	28	22	16
4.5	5	34	28	22	16
5	5.5	34	28	22	16
5.5	6	34	28	22	17
6	6.5	34	29	23	17
6.5	7	35	29	23	18
7	7.5	35	29	23	18
7.5	8	35	29	23	19
8	8.5	35	30	24	19
8.5	9	36	30	24	19
9	9.5	36	30	24	-
9.5	10	36	30	24	-
10	10.5	36	31	25	-
10.5	11	37	31	25	-
11	11.5	37	31	25	-
11.5	12	37	31	25	-

Table 6-15
NT4K67 balance settings (600+2/600)

This table applies to the 2-wire source line card (NT4K67).
Line card impedance = 600Ω+2µF
Termination impedance = 600Ω

Cable length (kft)		Cable gauge (AWG)			
from	**to**	**19**	**22**	**24**	**26**
0	0.5	57	51	45	38
0.5	1	57	51	45	38
1	1.5	57	51	45	38
1.5	2	57	51	45	39
2	2.5	57	52	46	39
2.5	3	58	52	46	40
3	3.5	58	52	46	40
3.5	4	58	52	46	40
4	4.5	58	53	47	41
4.5	5	59	53	47	41
5	5.5	59	53	47	42
5.5	6	59	53	47	42
6	6.5	59	54	48	42
6.5	7	60	54	48	43
7	7.5	60	54	48	43
7.5	8	60	54	48	44
8	8.5	60	55	49	44
8.5	9	61	55	49	44
9	9.5	61	55	49	-
9.5	10	61	55	49	-
10	10.5	61	56	50	-
10.5	11	62	56	50	-
11	11.5	62	56	50	-
11.5	12	62	56	50	-

Table 6-16
4-wire equalization settings (loaded cable)

Input impedance = 1200 Ω
Cable termination impedance = 1200 Ω

Cable makeup	Settings		
	BW	**HT**	**SL**
19H88/18KF	1	1	0
19H88/24KF	1	1	0
19H88/30KF	1	1	0
19H88/36KF	1	1	0
19H88/42KF	1	1	0
19H88/48KF	1	1	0
19H88/54KF	1	1	0
19H88/60KF	1	1	0
19H88/66KF	1	1	0
19H88/72KF	1	1	0
19H88/78KF	1	1	0
19H88/84KF	1	1	0
19H88/90KF	1	1	0
19H88/96KF	1	1	0
19H88/102KF	6	3	0
19H88/108KF	6	4	0
19H88/114KF	6	4	0
19H88/120KF	6	4	0
19H88/126KF	6	4	0
19H88/132KF	6	5	0
19H88/138KF	6	5	0
19H88/144KF	6	5	0
19H88/150KF	6	5	0
22H88/18KF	6	3	0
22H88/24KF	6	3	0
22H88/30KF	6	3	0
22H88/36KF	6	3	0
22H88/42KF	6	3	2
22H88/48KF	6	3	2
22H88/54KF	8	4	0
22H88/60KF	4	3	2
22H88/66KF	4	3	2
22H88/72KF	4	3	2
22H88/78KF	4	3	1
22H88/84KF	1	1	1
22H88/90KF	7	4	1
22H88/96KF	7	4	1
22H88/102KF	7	4	1

—continued—

Table 6-16 (continued)
4-wire equalization settings (loaded cable)

Input impedance = 1200 Ω Cable termination impedance = 1200 Ω			
	Settings		
Cable makeup	**BW**	**HT**	**SL**
24H88/18KF	1	1	2
24H88/24KF	1	1	2
24H88/30KF	1	1	4
24H88/36KF	1	1	4
24H88/42KF	1	1	5
24H88/48KF	1	1	5
24H88/54KF	1	1	5
24H88/60KF	1	1	5
24H88/66KF	1	1	6
24H88/72KF	1	1	6
26H88/12KF	4	3	4
26H88/18KF	13	3	6
26H88/24KF	4	3	8
26H88/30KF	1	1	9
26H88/36KF	11	2	12
26H88/42KF	15	2	14
—end—			

Table 6-17
4-wire equalization settings (non-loaded cable)

Input impedance = cable termination impedance = 600 Ω				
Cable makeup	**Setting**			**1 kHz Cable loss (dB)**
	BW	**HT**	**SL**	
19NL/1KF	1	1	0	0.1
19NL/2KF	1	1	0	0.3
19NL/3KF	1	1	0	0.4
19NL/4KF	1	1	0	0.5
19NL/5KF	1	1	0	0.7
19NL/6KF	10	4	0	0.8
19NL/7KF	6	4	1	1.0
19NL/8KF	6	4	1	1.2
19NL/9KF	10	4	1	1.3
19NL/10KF	9	5	1	1.5
19NL/11KF	15	5	1	1.7
19NL/12KF	15	5	2	1.9
19NL/13KF	15	5	2	2.1
19NL/14KF	15	6	2	2.3
19NL/15KF	15	6	2	2.5
19NL/16KF	15	6	2	2.7
19NL/17KF	15	6	2	2.9
19NL/18KF	15	7	2	3.1
19NL/19KF	15	7	2	3.4
19NL/20KF	15	7	2	3.6
19NL/21KF	15	7	3	3.8
19NL/22KF	15	7	3	4.1
19NL/23KF	15	7	3	4.3
19NL/24KF	15	8	3	4.5
19NL/25KF	15	8	4	4.8
19NL/26KF	15	8	4	5.0
19NL/27KF	15	8	4	5.3
19NL/28KF	15	8	5	5.5
19NL/29KF	15	8	5	5.8
19NL/30KF	15	8	6	6.0
19NL/31KF	15	8	6	6.3
19NL/32KF	15	8	6	6.5
19NL/33KF	15	8	7	6.8
19NL/34KF	15	8	7	7.0
19NL/35KF	15	9	7	7.3
19NL/36KF	15	9	7	7.6
19NL/37KF	15	9	7	7.8
19NL/38KF	15	9	8	8.1
19NL/39KF	15	9	8	8.3
19NL/40KF	15	10	8	8.6

—continued—

Table 6-17 (continued)
4-wire equalization settings (non-loaded cable)

Input impedance = cable termination impedance = 600 Ω				
Cable makeup	**Setting**			**1 kHz Cable loss (dB)**
	BW	**HT**	**SL**	
19NL/41KF	15	10	8	8.8
19NL/42KF	15	10	9	9.1
19NL/43KF	15	10	9	9.3
19NL/44KF	15	10	10	9.6
19NL/45KF	15	10	10	9.8
19NL/46KF	15	11	10	10.1
19NL/47KF	15	11	11	10.3
19NL/48KF	15	12	11	10.6
19NL/49KF	15	12	11	10.8
19NL/50KF	15	12	11	11.1
19NL/51KF	15	12	11	11.3
19NL/52KF	15	12	12	11.6
19NL/53KF	15	12	12	11.8
19NL/54KF	15	12	13	12.1
19NL/55KF	15	12	13	12.3
19NL/56KF	15	13	13	12.6
19NL/57KF	15	13	13	12.8
19NL/58KF	15	13	13	13.1
19NL/59KF	15	13	14	13.3
19NL/60KF	15	13	14	13.6
19NL/61KF	15	14	14	13.8
19NL/62KF	15	14	14	14.0
19NL/63KF	15	14	14	14.3
19NL/64KF	15	14	15	14.5
19NL/65KF	15	14	15	14.8
19NL/66KF	15	15	15	15.0
22NL/1KF	1	1	0	0.2
22NL/2KF	1	1	0	0.5
22NL/3KF	1	1	0	0.7
22NL/4KF	1	1	0	1.0
22NL/5KF	1	1	0	1.2
22NL/6KF	8	4	0	1.5
22NL/7KF	10	4	0	1.7
22NL/8KF	10	4	1	2.0
22NL/9KF	10	4	1	2.2
22NL/10KF	10	4	1	2.5
22NL/11KF	11	5	1	2.8
22NL/12KF	11	6	1	3.1
22NL/13KF	11	6	2	3.4
22NL/14KF	11	6	2	3.6
—continued—				

Table 6-17 (continued)
4-wire equalization settings (non-loaded cable)

Input impedance = cable termination impedance = 600 Ω				
Cable makeup	**Setting**			**1 kHz Cable loss (dB)**
	BW	**HT**	**SL**	
22NL/15KF	11	7	2	3.9
22NL/16KF	11	7	3	4.2
22NL/17KF	11	7	3	4.6
22NL/18KF	12	7	4	4.9
22NL/19KF	12	7	4	5.2
22NL/20KF	14	7	4	5.5
22NL/21KF	15	7	4	5.8
22NL/22KF	15	8	4	6.1
22NL/23KF	15	8	4	6.5
22NL/24KF	15	9	4	6.8
22NL/25KF	15	9	4	7.1
22NL/26KF	15	10	4	7.5
22NL/27KF	15	10	5	7.8
22NL/28KF	15	10	5	8.2
22NL/29KF	15	10	6	8.5
22NL/30KF	15	10	7	8.8
22NL/31KF	15	11	7	9.2
22NL/32KF	15	11	7	9.5
22NL/33KF	15	11	8	9.9
22NL/34KF	15	11	8	10.2
22NL/35KF	15	11	8	10.6
22NL/36KF	15	11	9	11.0
22NL/37KF	15	12	9	11.3
22NL/38KF	15	12	9	11.6
22NL/39KF	15	12	9	12.0
22NL/40KF	15	12	10	12.3
22NL/41KF	15	13	10	12.7
22NL/42KF	15	13	11	13.0
22NL/43KF	15	14	11	13.4
22NL/44KF	15	14	11	13.7
22NL/45KF	15	14	12	14.1
22NL/46KF	15	14	14	14.4
22NL/47KF	15	15	12	14.8
22NL/48KF	15	15	10	15.1
24NL/1KF	1	1	0	0.4
24NL/2KF	1	1	0	0.7
24NL/3KF	1	1	0	1.1
24NL/4KF	1	1	0	1.5
24NL/5KF	1	1	0	1.8
24NL/6KF	10	4	0	2.2
—continued—				

Table 6-17 (continued)
4-wire equalization settings (non-loaded cable)

Input impedance = cable termination impedance = 600 Ω				
Cable makeup	**Setting**			**1 kHz Cable loss (dB)**
	BW	**HT**	**SL**	
24NL/7KF	6	3	1	2.5
24NL/8KF	6	3	1	2.9
24NL/9KF	8	4	1	3.2
24NL/10KF	11	5	1	3.6
24NL/11KF	13	5	1	4.0
24NL/12KF	13	6	1	4.3
24NL/13KF	15	6	1	4.7
24NL/14KF	15	6	2	5.1
24NL/15KF	15	6	2	5.5
24NL/16KF	15	7	2	5.9
24NL/17KF	15	8	2	6.3
24NL/18KF	15	8	3	6.7
24NL/19KF	15	8	3	7.1
24NL/20KF	15	8	3	7.5
24NL/21KF	15	8	4	7.9
24NL/22KF	15	9	4	8.4
24NL/23KF	15	9	4	8.8
24NL/24KF	15	10	5	9.2
24NL/25KF	15	10	5	9.6
24NL/26KF	15	10	5	10.1
24NL/27KF	15	11	6	10.5
24NL/28KF	15	11	6	11.0
24NL/29KF	15	11	7	11.4
24NL/30KF	15	12	7	11.8
24NL/31KF	15	12	7	12.3
24NL/32KF	15	12	8	12.7
24NL/33KF	15	13	8	13.2
24NL/34KF	15	14	8	13.6
24NL/35KF	15	14	8	14.0
24NL/36KF	15	15	11	14.5
24NL/37KF	15	15	11	14.9
24NL/38KF	15	15	11	15.4
26NL/1KF	1	1	0	0.6
26NL/2KF	1	1	0	1.2
26NL/3KF	1	1	0	1.7
26NL/4KF	1	1	0	2.2
26NL/5KF	1	1	0	2.7
26NL/6KF	8	4	0	3.2
26NL/7KF	8	4	1	3.7
26NL/8KF	8	4	1	4.2
—continued—				

Table 6-17 (continued)
4-wire equalization settings (non-loaded cable)

Input impedance = cable termination impedance = 600 Ω				
Cable makeup	**Setting**			**1 kHz Cable loss (dB)**
	BW	**HT**	**SL**	
26NL/9KF	10	5	1	4.7
26NL/10KF	12	5	1	5.1
26NL/11KF	13	6	1	5.6
26NL/12KF	13	6	2	6.1
26NL/13KF	13	6	2	6.6
26NL/14KF	15	7	2	7.1
26NL/15KF	15	8	2	7.6
26NL/16KF	15	8	2	8.1
26NL/17KF	15	8	3	8.6
26NL/18KF	15	9	3	9.1
26NL/19KF	15	9	3	9.7
26NL/20KF	15	10	4	10.2
26NL/21KF	15	10	4	10.7
26NL/22KF	15	10	5	11.3
26NL/23KF	15	11	6	11.8
26NL/24KF	15	11	6	12.4
26NL/25KF	15	11	6	12.9
26NL/26KF	15	13	7	13.5
26NL/27KF	15	13	7	14.0
26NL/28KF	15	14	7	14.6
26NL/29KF	14	15	8	15.0
26NL/30KF	14	15	9	15.7
—end—				

Table 6-18
4-wire equalization settings (loaded 24-22 multi-gauge cable)

Input impedance = 1200 Ω Cable termination = 1200 Ω				
Cable length (kft)		**Equalizer settings**		
24 AWG	**22 AWG**	**BW**	**HT**	**SL**
TCL = 18				
6	12	4	2	0
12	6	3	3	2
TCL = 24				
6	18	4	2	0
12	12	3	3	1
18	6	3	3	2
TCL = 30				
6	24	4	2	0
12	18	3	3	2
18	12	3	3	2
24	6	3	3	2
TCL = 36				
6	30	4	2	1
12	24	3	3	1
18	18	3	3	2
24	12	3	3	2
30	6	1	1	3
TCL = 42				
6	36	4	2	1
12	30	3	3	1
18	24	3	3	2
24	18	3	3	2
30	12	1	1	3
36	6	3	3	3
TCL = 48				
6	42	4	2	1
12	36	3	3	1
18	30	3	3	3
24	24	3	3	2
30	18	1	1	3
36	12	3	3	3
42	6	1	1	4
—continued—				

Table 6-18 (continued)
4-wire equalization settings (loaded 24-22 multi-gauge cable)

Input impedance = 1200 Ω Cable termination = 1200 Ω				
Cable length (kft)		**Equalizer settings**		
24 AWG	**22 AWG**	**BW**	**HT**	**SL**
TCL = 54				
6	48	4	2	0
12	42	3	3	2
18	36	3	3	3
24	30	3	3	2
30	24	1	1	3
36	18	3	3	3
42	12	1	1	4
48	6	2	6	4
TCL = 60				
6	54	4	2	2
12	48	3	3	1
18	42	3	3	3
24	36	3	3	2
30	30	1	1	3
36	24	3	3	3
42	18	1	1	4
48	12	2	6	4
54	6	1	1	5
TCL = 66				
6	60	4	2	2
12	54	3	3	1
18	48	3	3	3
24	42	3	3	2
30	36	1	1	3
36	30	3	3	3
42	24	1	1	4
48	18	2	6	4
54	12	1	1	5
60	6	1	1	5

—continued—

Table 6-18 (continued)
4-wire equalization settings (loaded 24-22 multi-gauge cable)

Input impedance = 1200 Ω Cable termination = 1200 Ω				
Cable length (kft)		**Equalizer settings**		
24 AWG	**22 AWG**	**BW**	**HT**	**SL**
TCL = 72				
6	66	4	2	1
12	60	3	3	1
18	54	3	3	3
24	48	3	3	2
30	42	1	1	3
36	36	3	3	3
42	30	1	1	4
48	24	2	6	4
54	18	1	6	4
60	12	1	1	5
66	6	1	1	6
TCL = 78				
6	72	4	2	2
12	66	3	3	1
18	60	3	3	3
24	54	3	3	2
30	48	1	1	3
36	42	3	5	3
42	36	1	1	4
48	30	1	1	5
TCL = 84				
6	78	4	2	2
12	72	3	3	2
18	66	3	3	3
24	60	3	3	2
30	54	1	1	3
36	48	1	1	4
42	42	1	1	4

—continued—

Table 6-18 (continued)
4-wire equalization settings (loaded 24-22 multi-gauge cable)

Input impedance = 1200 Ω Cable termination = 1200 Ω				
Cable length (kft)		**Equalizer settings**		
24 AWG	**22 AWG**	**BW**	**HT**	**SL**
TCL = 90				
6	84	4	2	2
12	78	3	3	2
18	72	3	3	3
24	66	3	3	3
30	60	1	1	3
TCL = 96				
6	90	2	4	1
12	84	3	3	2
18	78	3	3	3
TCL = 102				
6	96	2	4	2
—end—				

Table 6-19
4-wire equalization settings (loaded 26-22 multi-gauge cable)

Input impedance = 1200 Ω Cable termination = 1200 Ω				
Cable length (kft)		**Equalizer settings**		
26 AWG	**22 AWG**	**BW**	**HT**	**SL**
TCL = 18				
6	12	1	1	1
12	6	3	6	4
TCL = 24				
6	18	3	6	1
12	12	1	1	2
18	6	3	6	5
TCL = 30				
6	24	1	1	1
12	18	3	6	2
18	12	3	6	4
24	6	3	6	8
TCL = 36				
6	30	1	1	1
12	24	3	6	2
18	18	3	6	4
24	12	3	6	8
30	6	3	6	8
TCL = 42				
6	36	1	1	1
12	30	3	6	2
18	24	3	6	4
24	18	3	6	8
30	12	3	6	8
36	6	8	4	13
TCL = 48				
6	42	1	1	1
12	36	3	6	2
18	30	3	6	5
24	24	3	6	8
30	18	3	6	8
36	12	1	1	12
42	6	9	4	14

—continued—

Table 6-19 (continued)
4-wire equalization settings (loaded 26-22 multi-gauge cable)

Input impedance = 1200 Ω Cable termination = 1200 Ω				
Cable length (kft)		**Equalizer settings**		
26 AWG	**22 AWG**	**BW**	**HT**	**SL**
TCL = 54				
6	48	1	1	1
12	42	3	6	2
18	36	3	6	6
24	30	3	6	8
30	24	3	6	8
36	18	15	2	12
42	12	9	4	13
TCL = 60				
6	54	1	1	1
12	48	3	6	2
18	42	3	6	6
24	36	3	6	8
30	30	3	6	8
36	24	15	2	13
42	18	4	4	13
TCL = 66				
6	60	1	1	1
12	54	3	6	4
18	48	3	6	6
24	42	3	6	7
30	36	3	6	10
36	30	2	3	14
42	24	4	4	13
TCL = 72				
6	66	1	1	1
12	60	3	6	4
18	54	3	6	6
24	48	3	6	7
30	42	3	6	11
36	36	4	8	13
42	30	2	4	15

—continued—

Table 6-19 (continued)
4-wire equalization settings (loaded 26-22 multi-gauge cable)

Input impedance = 1200 Ω Cable termination = 1200 Ω				
Cable length (kft)		**Equalizer settings**		
26 AWG	**22 AWG**	**BW**	**HT**	**SL**
TCL = 78				
6	72	1	1	2
12	66	3	6	4
18	60	3	6	6
24	54	3	6	7
30	48	3	6	11
36	42	5	4	13
42	36	2	4	15
TCL = 84				
6	78	8	4	1
12	72	3	6	4
18	66	3	6	6
24	60	3	6	7
30	54	3	6	11
36	48	1	1	13
42	42	2	4	15
TCL = 90				
6	84	1	1	2
12	78	3	6	4
18	72	4	8	6
24	66	3	6	7
30	60	3	6	11
36	96	2	4	15
—end—				

Table 6-20
4-wire equalization settings (loaded 26-24 multi-gauge cable)

Input impedance = 1200 Ω Cable termination = 1200 Ω				
Cable length (kft)		**Equalizer settings**		
26 AWG	**24 AWG**	**BW**	**HT**	**SL**
TCL = 12		8	4	0
TCL = 18				
6	12	8	4	1
12	6	1	1	6
TCL = 24				
6	18	1	1	2
12	12	1	1	4
18	6	1	1	9
TCL = 30				
6	24	1	1	4
12	18	8	4	6
18	12	1	1	5
24	6	1	3	13
TCL = 36				
6	30	1	1	5
12	24	8	4	6
18	18	1	1	6
24	12	1	3	13
30	6	1	3	13
TCL = 42				
6	36	1	1	5
12	30	8	4	6
18	24	1	1	6
24	18	1	3	13
30	12	1	3	13
36	6	15	2	14
TCL = 48				
6	42	1	1	5
12	36	8	4	6
18	30	8	4	6
24	24	1	3	13
30	18	1	3	13
36	12	8	3	14
36	6	2	4	15
—continued—				

Table 6-20 (continued)
4-wire equalization settings (loaded 26-24 multi-gauge cable)

Input impedance = 1200 Ω Cable termination = 1200 Ω				
Cable length (kft)		**Equalizer settings**		
26 AWG	**24 AWG**	**BW**	**HT**	**SL**
TCL = 54				
6	48	1	1	5
12	42	6	3	6
18	36	8	4	7
24	30	1	3	13
30	24	1	3	13
36	18	2	4	15
42	12	2	4	15
48	6	2	4	15
TCL = 60				
6	54	1	1	6
12	48	6	3	6
18	42	8	4	7
24	36	1	3	13
30	30	7	4	13
36	24	2	4	15
TCL = 66				
6	60	1	1	6
12	54	6	3	6
18	48	8	4	8
24	42	2	4	15
30	36	2	4	15
36	30	2	4	15
—end—				

Table 6-21
4-wire equalization settings (non-loaded 26/22 AWG multi-gauge cable)

Input impedance = 600 Ω Cable termination = 600 Ω				
Cable length (kft)		**Equalizer settings**		
26 AWG	**22 AWG**	**BW**	**HT**	**SL**
TCL = 7				
5	2	7	3	1
6	1	7	3	1
TCL = 8				
4	4	7	3	1
5	3	7	3	1
6	2	7	3	1
7	1	7	3	1
TCL = 9				
3	6	9	3	1
4	5	9	3	1
5	4	7	3	1
6	3	9	4	1
7	2	9	4	1
8	1	9	4	1
TCL = 10				
2	8	9	3	1
3	7	10	4	1
4	6	10	4	1
5	5	9	4	1
6	4	9	4	1
7	3	11	4	1
8	2	11	4	1
9	1	11	4	1
TCL = 11				
1	10	10	4	1
2	9	10	4	1
3	8	10	5	1
4	7	10	5	1
5	6	10	5	1
6	5	11	4	1
7	4	11	4	1
8	3	12	5	1
9	2	12	5	1
10	1	12	5	1
—continued—				

Table 6-21 (continued)
4-wire equalization settings (non-loaded 26/22 AWG multi-gauge cable)

Input impedance = 600 Ω Cable termination = 600 Ω				
Cable length (kft)		**Equalizer settings**		
26 AWG	**22 AWG**	**BW**	**HT**	**SL**
TCL = 12				
1	11	10	5	1
2	10	10	5	1
3	9	10	5	2
4	8	10	5	2
5	7	10	5	2
6	6	12	5	1
7	5	12	5	1
8	4	12	5	1
9	3	12	5	2
10	2	12	5	2
11	1	12	5	2
TCL = 13				
1	12	10	5	2
2	11	10	5	2
3	10	10	5	2
4	9	10	5	2
5	8	10	5	2
6	7	10	5	2
7	6	12	5	2
8	5	12	5	2
9	4	12	5	2
10	3	12	5	2
11	2	12	5	2
12	1	12	5	2
TCL = 14				
1	13	10	5	2
2	12	10	5	2
3	11	10	6	2
4	10	10	6	2
5	9	10	6	2
6	8	12	6	2
7	7	12	5	2
8	6	12	5	2
9	5	12	5	2
10	4	12	5	2
11	3	14	6	2
12	2	14	6	2
13	1	14	6	2

—continued—

Table 6-21 (continued)
4-wire equalization settings (non-loaded 26/22 AWG multi-gauge cable)

Input impedance = 600 Ω Cable termination = 600 Ω				
Cable length (kft)		**Equalizer settings**		
26 AWG	**22 AWG**	**BW**	**HT**	**SL**
TCL = 15				
1	14	10	6	2
2	13	10	6	2
3	12	10	6	3
4	11	10	6	3
5	10	10	6	3
6	9	10	6	3
7	8	10	6	3
8	7	14	6	2
9	6	14	6	2
10	5	14	6	2
11	4	14	6	2
12	3	14	7	2
13	2	14	7	2
14	1	14	7	2
TCL = 16				
1	15	10	6	3
2	14	10	6	3
3	13	10	6	3
4	12	10	6	3
5	11	10	6	3
6	10	10	6	3
7	9	10	6	3
8	8	14	7	2
9	7	14	7	2
10	6	14	7	2
11	5	14	7	2
12	4	14	7	2
13	3	14	7	2
14	2	14	7	2
15	1	14	7	2
—continued—				

Table 6-21 (continued)
4-wire equalization settings (non-loaded 26/22 AWG multi-gauge cable)

Input impedance = 600 Ω Cable termination = 600 Ω				
Cable length (kft)		**Equalizer settings**		
26 AWG	**22 AWG**	**BW**	**HT**	**SL**
TCL = 17				
1	16	10	6	3
2	15	10	6	3
3	14	11	6	4
4	13	11	6	4
5	12	11	6	4
6	11	11	6	4
7	10	11	6	4
8	9	11	6	4
9	8	14	7	2
10	7	14	7	2
11	6	14	7	2
12	5	14	7	2
13	4	14	7	2
14	3	14	7	3
15	2	14	7	3
16	1	14	7	3
TCL = 18				
1	17	11	6	4
2	16	11	6	4
3	15	11	6	4
4	14	11	6	4
5	13	11	6	4
6	12	11	6	4
7	11	11	6	4
8	10	11	6	4
9	9	14	7	3
10	8	14	7	3
11	7	14	7	3
12	6	14	7	3
13	5	14	7	3
14	4	14	7	3
15	3	14	8	3
16	2	14	8	3
17	1	14	8	3

—continued—

Table 6-21 (continued)
4-wire equalization settings (non-loaded 26/22 AWG multi-gauge cable)

Input impedance = 600 Ω Cable termination = 600 Ω				
Cable length (kft)		**Equalizer settings**		
26 AWG	**22 AWG**	**BW**	**HT**	**SL**
TCL = 19				
1	18	11	6	4
2	17	11	6	4
3	16	13	6	4
4	15	13	6	4
5	14	13	6	4
6	13	13	6	4
7	12	13	6	4
8	11	13	6	4
9	10	14	6	4
10	9	14	8	3
11	8	14	8	3
12	7	14	8	3
13	6	14	8	3
14	5	14	8	3
15	4	14	8	3
16	3	14	8	3
17	2	14	8	3
18	1	14	8	3
TCL = 20				
1	19	13	6	4
2	18	13	6	4
3	17	14	6	4
4	16	14	6	4
5	15	14	6	4
6	14	14	6	4
7	13	14	6	4
8	12	14	6	4
9	11	14	7	4
10	10	14	8	3
11	9	14	8	3
12	8	14	8	3
13	7	14	8	3
14	6	14	8	3
15	5	14	8	3
16	4	14	8	3
17	3	14	9	3
18	2	14	9	3
19	1	14	9	3

—continued—

Table 6-21 (continued)
4-wire equalization settings (non-loaded 26/22 AWG multi-gauge cable)

Input impedance = 600 Ω Cable termination = 600 Ω				
Cable length (kft)		**Equalizer settings**		
26 AWG	**22 AWG**	**BW**	**HT**	**SL**
TCL = 21				
1	20	14	6	4
2	19	14	6	4
3	18	14	7	4
4	17	14	7	4
5	16	14	7	4
6	15	14	7	4
7	14	14	7	4
8	13	14	7	4
9	12	14	7	4
10	11	14	7	4
11	10	14	8	3
12	9	14	9	3
13	8	14	9	3
14	7	14	9	3
15	6	14	9	3
16	5	14	9	3
17	4	14	9	3
18	3	14	9	3
19	2	14	9	3
20	1	14	9	3

—continued—

Table 6-21 (continued)
4-wire equalization settings (non-loaded 26/22 AWG multi-gauge cable)

Input impedance = 600 Ω Cable termination = 600 Ω				
Cable length (kft)		**Equalizer settings**		
26 AWG	**22 AWG**	**BW**	**HT**	**SL**
TCL = 22				
1	21	14	7	4
2	20	14	7	4
3	19	14	7	4
4	18	14	7	4
5	17	14	7	4
6	16	14	7	4
7	15	14	7	4
8	14	14	7	4
9	13	14	8	4
10	12	14	8	4
11	11	14	9	4
12	10	14	9	4
13	9	14	9	4
14	8	14	9	4
15	7	14	9	4
16	6	14	9	4
17	5	14	9	4
18	4	14	9	4
19	3	14	9	5
20	2	14	9	5
21	1	14	9	5

—continued—

Table 6-21 (continued)
4-wire equalization settings (non-loaded 26/22 AWG multi-gauge cable)

Input impedance = 600 Ω Cable termination = 600 Ω				
Cable length (kft)		**Equalizer settings**		
26 AWG	**22 AWG**	**BW**	**HT**	**SL**
TCL = 23				
1	22	14	7	4
2	21	14	7	4
3	20	14	8	4
4	19	14	8	4
5	18	14	8	4
6	17	14	8	4
7	16	14	8	4
8	15	14	8	4
9	14	14	8	4
10	13	14	8	4
11	12	14	8	4
12	11	14	9	4
13	10	14	9	4
14	9	14	9	5
15	8	14	9	5
16	7	14	9	5
17	6	14	9	5
18	5	14	9	5
19	4	14	9	5
20	3	14	10	6
21	2	14	10	6
22	1	14	10	6

—continued—

Table 6-21 (continued)
4-wire equalization settings (non-loaded 26/22 AWG multi-gauge cable)

Input impedance = 600 Ω Cable termination = 600 Ω				
Cable length (kft)		**Equalizer settings**		
26 AWG	**22 AWG**	**BW**	**HT**	**SL**
TCL = 24				
1	23	14	8	4
2	22	14	8	4
3	21	14	8	4
4	20	14	8	4
5	19	14	8	4
6	18	14	8	4
7	17	14	8	4
8	16	14	8	4
9	15	14	9	4
10	14	14	9	4
11	13	14	9	4
12	12	14	9	4
13	11	14	9	4
14	10	14	9	5
15	9	14	10	6
16	8	14	10	6
17	7	14	10	6
18	6	14	10	6
19	5	14	10	6
20	4	14	10	6
21	3	14	10	6
22	2	14	10	6
23	1	14	10	6
—continued—				

Table 6-21 (continued)
4-wire equalization settings (non-loaded 26/22 AWG multi-gauge cable)

Input impedance = 600 Ω Cable termination = 600 Ω				
Cable length (kft)		**Equalizer settings**		
26 AWG	**22 AWG**	**BW**	**HT**	**SL**
TCL = 25				
1	24	14	8	4
2	23	14	8	4
3	22	14	9	4
4	21	14	9	4
5	20	14	9	4
6	19	14	9	4
7	18	14	9	4
8	17	14	9	4
9	16	14	9	5
10	15	14	9	5
11	14	14	9	5
12	13	14	9	5
13	12	14	10	6
14	11	14	10	6
15	10	14	10	6
16	9	14	10	6
17	8	14	10	6
18	7	14	10	6
19	6	14	10	6
20	5	14	10	6
21	4	14	10	6
22	3	14	10	6
23	2	14	10	6
24	1	14	10	6
—continued—				

Table 6-21 (continued)
4-wire equalization settings (non-loaded 26/22 AWG multi-gauge cable)

Input impedance = 600 Ω Cable termination = 600 Ω				
Cable length (kft)		**Equalizer settings**		
26 AWG	**22 AWG**	**BW**	**HT**	**SL**
TCL = 26				
1	25	14	9	4
2	24	14	9	4
3	23	14	9	5
4	22	14	9	5
5	21	14	9	5
6	20	14	9	5
7	19	14	9	5
8	18	14	9	5
9	17	14	9	5
10	16	14	9	5
11	15	14	9	5
12	14	14	9	5
13	13	14	10	6
14	12	14	10	6
15	11	14	10	6
16	10	14	10	6
17	9	14	10	6
18	8	14	10	6
19	7	14	10	6
20	6	14	10	6
21	5	14	10	6
22	4	14	10	6
23	3	14	10	7
24	2	14	10	7
25	1	14	10	7

—continued—

Table 6-21 (continued)
4-wire equalization settings (non-loaded 26/22 AWG multi-gauge cable)

Input impedance = 600 Ω Cable termination = 600 Ω				
Cable length (kft)		**Equalizer settings**		
26 AWG	**22 AWG**	**BW**	**HT**	**SL**
TCL = 27				
1	26	14	9	5
2	25	14	9	5
3	24	14	9	5
4	23	14	9	5
5	22	14	9	5
6	21	14	9	5
7	20	14	9	5
8	19	14	9	5
9	18	14	9	6
10	17	14	9	6
11	16	14	9	6
12	15	14	9	6
13	14	14	9	6
14	13	14	10	6
15	12	14	10	6
16	11	14	10	6
17	10	14	12	6
18	9	14	12	7
19	8	14	12	7
20	7	14	12	7
21	6	14	12	7
22	5	14	12	7
23	4	14	12	7
24	3	14	12	7
25	2	14	12	7
26	1	14	12	7

—continued—

Table 6-21 (continued)
4-wire equalization settings (non-loaded 26/22 AWG multi-gauge cable)

Input impedance = 600 Ω Cable termination = 600 Ω				
Cable length (kft)		**Equalizer settings**		
26 AWG	**22 AWG**	**BW**	**HT**	**SL**
TCL = 28				
1	27	14	9	5
2	26	14	9	5
3	25	14	9	6
4	24	14	9	6
5	23	14	9	6
6	22	14	9	6
7	21	14	9	6
8	20	14	9	6
9	19	14	9	7
10	18	14	9	7
11	17	14	9	7
12	16	14	9	7
13	15	14	9	7
14	14	14	12	7
15	13	14	12	7
16	12	14	12	7
17	11	14	12	7
18	10	14	12	7
19	9	14	12	7
20	8	14	12	7
21	7	14	12	7
22	6	14	12	7
23	5	14	12	7
24	4	14	12	7
25	3	14	13	7
26	2	14	13	7
27	1	14	13	7

—continued—

Table 6-21 (continued)
4-wire equalization settings (non-loaded 26/22 AWG multi-gauge cable)

Input impedance = 600 Ω Cable termination = 600 Ω				
Cable length (kft)		**Equalizer settings**		
26 AWG	**22 AWG**	**BW**	**HT**	**SL**
TCL = 29				
1	28	14	9	6
2	27	14	9	6
3	26	14	9	7
4	25	14	9	7
5	24	14	9	7
6	23	14	9	7
7	22	14	9	7
8	21	14	9	7
9	20	14	9	7
10	19	14	10	7
11	18	14	10	7
12	17	14	10	7
13	16	14	10	7
14	15	14	10	7
15	14	14	12	7
16	13	14	12	7
17	12	14	12	7
18	11	14	12	7
19	10	14	12	7
20	9	14	13	7
21	8	14	13	7
22	7	14	13	7
23	6	14	13	7
24	5	14	13	7
25	4	14	13	7
26	3	13	14	8
27	2	13	14	8
28	1	13	14	8

—continued—

Table 6-21 (continued)
4-wire equalization settings (non-loaded 26/22 AWG multi-gauge cable)

Input impedance = 600 Ω Cable termination = 600 Ω				
Cable length (kft)		**Equalizer settings**		
26 AWG	**22 AWG**	**BW**	**HT**	**SL**
TCL = 30				
1	29	14	9	7
2	28	14	9	7
3	27	14	10	7
4	26	14	10	7
5	25	14	10	7
6	24	14	10	7
7	23	14	10	7
8	22	14	10	7
9	21	14	10	7
10	20	14	10	7
11	19	14	10	7
12	18	14	10	7
13	17	14	10	7
14	16	14	10	7
15	15	14	13	7
16	14	14	13	7
17	13	14	13	7
18	12	14	13	7
19	11	14	13	7
20	10	14	13	7
21	9	13	14	8
22	8	13	14	8
23	7	13	14	8
24	6	13	14	8
25	5	13	14	8
26	4	13	14	8
27	3	13	14	9
28	2	13	14	9
29	1	13	14	9
—end—				

Table 6-22
4-wire equalization settings (non-loaded 24-22 multi-gauge cable)

Input impedance = 600 Ω Cable termination = 600 Ω				
Cable length (kft)		**Equalizer settings**		
24 Ga	**22 Ga**	**BW**	**HT**	**SL**
TCL = 9				
7	2	7	3	1
8	1	7	3	1
TCL = 10				
5	5	10	4	1
6	4	10	4	1
7	3	10	4	1
8	2	10	4	1
9	1	10	4	1
TCL = 11				
2	9	10	4	1
3	8	10	4	1
4	7	10	4	1
5	6	10	4	1
6	5	10	4	1
7	4	10	4	1
8	3	10	4	1
9	2	10	4	1
10	1	10	4	1
TCL = 12				
1	11	10	5	1
2	10	10	5	1
3	9	10	5	1
4	8	10	5	1
5	7	10	5	1
6	6	14	5	1
7	5	14	5	1
8	4	14	5	1
9	3	14	5	1
10	2	14	5	1
11	1	14	5	1

—continued—

Table 6-22 (continued)
4-wire equalization settings (non-loaded 24-22 multi-gauge cable)

Input impedance = 600 Ω Cable termination = 600 Ω				
Cable length (kft)		**Equalizer settings**		
24 Ga	**22 Ga**	**BW**	**HT**	**SL**
TCL = 13				
2	12	10	5	2
3	11	10	5	2
4	10	10	5	2
2	9	10	5	2
3	8	10	5	2
4	7	10	5	2
5	6	14	5	1
6	5	14	5	1
7	4	14	5	1
8	3	14	5	1
9	2	14	5	1
10	1	14	5	1
TCL = 14				
1	13	10	5	2
2	12	10	5	2
3	11	10	5	2
4	10	10	5	2
5	9	10	5	2
6	8	10	6	2
7	7	14	5	1
8	6	14	5	1
9	5	14	5	2
10	4	14	5	2
11	3	14	5	2
12	2	14	5	2
13	1	14	5	2

—continued—

Table 6-22 (continued)
4-wire equalization settings (non-loaded 24-22 multi-gauge cable)

Input impedance = 600 Ω Cable termination = 600 Ω				
Cable length (kft)		**Equalizer settings**		
24 Ga	**22 Ga**	**BW**	**HT**	**SL**
TCL = 15				
1	14	10	6	2
2	13	10	6	2
3	12	10	6	2
4	11	10	6	2
5	10	10	6	2
6	9	10	6	3
7	8	10	6	3
8	7	14	5	2
9	6	14	5	2
10	5	14	5	2
11	4	14	5	2
12	3	14	5	2
13	2	14	5	2
14	1	14	5	2
TCL = 16				
1	15	10	6	3
2	14	10	6	3
3	13	10	6	3
4	12	10	6	3
5	11	10	6	3
6	10	10	6	3
7	9	10	6	3
8	8	14	5	2
9	7	14	5	2
10	6	14	5	2
11	5	14	6	2
12	4	14	6	2
13	3	14	6	2
14	2	14	6	2
15	1	14	6	2
—continued—				

Table 6-22 (continued)
4-wire equalization settings (non-loaded 24-22 multi-gauge cable)

Input impedance = 600 Ω Cable termination = 600 Ω				
Cable length (kft)		**Equalizer settings**		
24 Ga	**22 Ga**	**BW**	**HT**	**SL**
TCL = 17				
1	16	10	6	3
2	15	10	6	3
3	14	10	6	4
4	13	10	6	3
5	12	10	6	3
6	11	11	6	4
7	10	11	6	4
8	9	11	6	4
9	8	14	6	2
10	7	14	6	2
11	6	14	6	2
12	5	14	7	2
13	4	14	7	2
14	3	14	7	2
15	2	14	7	2
16	1	14	7	2
TCL = 18				
1	17	11	6	4
2	16	11	6	4
3	15	11	6	4
4	14	11	6	4
5	13	11	6	4
6	12	11	6	4
7	11	11	6	4
8	10	11	6	4
9	9	14	7	2
10	8	14	7	2
11	7	14	7	2
12	6	14	7	2
13	5	14	7	3
14	4	14	7	3
15	3	14	7	3
16	2	14	7	3
17	1	14	7	3

—continued—

Table 6-22 (continued)
4-wire equalization settings (non-loaded 24-22 multi-gauge cable)

Input impedance = 600 Ω Cable termination = 600 Ω				
Cable length (kft)		**Equalizer settings**		
24 Ga	**22 Ga**	**BW**	**HT**	**SL**
TCL = 19				
1	18	11	6	4
2	17	11	6	4
3	16	11	6	4
4	15	11	6	4
5	14	11	6	4
6	13	13	6	4
7	12	13	6	4
8	11	13	6	4
9	10	13	6	3
10	9	14	7	3
11	8	14	7	3
12	7	14	7	3
13	6	14	7	3
14	5	14	7	3
15	4	14	7	3
16	3	14	7	3
17	2	14	7	3
18	1	14	7	3

—continued—

Table 6-22 (continued)
4-wire equalization settings (non-loaded 24-22 multi-gauge cable)

Input impedance = 600 Ω Cable termination = 600 Ω				
Cable length (kft)		**Equalizer settings**		
24 Ga	**22 Ga**	**BW**	**HT**	**SL**
TCL = 20				
1	19	13	6	4
2	18	13	6	4
3	17	13	6	4
4	16	13	6	4
5	15	13	6	4
6	14	14	6	4
7	13	14	6	4
8	12	14	6	4
9	11	14	6	4
10	10	14	7	3
11	9	14	7	3
12	8	14	7	3
13	7	14	7	3
14	6	14	7	3
15	5	14	7	3
16	4	14	7	3
17	3	14	7	4
18	2	14	7	4
19	1	14	7	4

—continued—

Table 6-22 (continued)
4-wire equalization settings (non-loaded 24-22 multi-gauge cable)

Input impedance = 600 Ω Cable termination = 600 Ω				
Cable length (kft)		**Equalizer settings**		
24 Ga	**22 Ga**	**BW**	**HT**	**SL**
TCL = 21				
1	20	14	6	4
2	19	14	6	4
3	18	14	6	4
4	17	14	6	4
5	16	14	6	4
6	15	14	7	4
7	14	14	7	4
8	13	14	7	4
9	12	14	7	4
10	11	14	7	4
11	10	14	7	3
12	9	14	7	3
13	8	14	7	3
14	7	14	7	3
15	6	14	7	3
16	5	14	7	4
17	4	14	7	4
18	3	14	7	4
19	2	14	7	4
20	1	14	7	4
—continued—				

Table 6-22 (continued)
4-wire equalization settings (non-loaded 24-22 multi-gauge cable)

Input impedance = 600 Ω Cable termination = 600 Ω				
Cable length (kft)		**Equalizer settings**		
24 Ga	**22 Ga**	**BW**	**HT**	**SL**
TCL = 22				
1	21	14	7	4
2	20	14	7	4
3	19	14	7	4
4	18	14	7	4
5	17	14	7	4
6	16	14	7	4
7	15	14	7	4
8	14	14	7	4
9	13	14	7	4
10	12	14	7	4
11	11	14	7	4
12	10	14	7	4
13	9	14	7	4
14	8	14	7	4
15	7	14	7	4
16	6	14	7	4
17	5	14	8	4
18	4	14	8	4
19	3	14	8	4
20	2	14	8	4
21	1	14	8	4

—continued—

Table 6-22 (continued)
4-wire equalization settings (non-loaded 24-22 multi-gauge cable)

Input impedance = 600 Ω Cable termination = 600 Ω				
Cable length (kft)		**Equalizer settings**		
24 Ga	**22 Ga**	**BW**	**HT**	**SL**
TCL = 23				
1	22	14	7	4
2	21	14	7	4
3	20	14	7	4
4	19	14	7	4
5	18	14	7	4
6	17	14	8	4
7	16	14	8	4
8	15	14	8	4
9	14	14	8	4
10	13	14	8	4
11	12	14	8	4
12	11	14	8	4
13	10	14	8	4
14	9	14	8	4
15	8	14	8	4
16	7	14	8	4
17	6	14	8	4
18	5	14	8	4
19	4	14	8	4
20	3	14	8	4
21	2	14	8	4
22	1	14	8	4

—continued—

Table 6-22 (continued)
4-wire equalization settings (non-loaded 24-22 multi-gauge cable)

Input impedance = 600 Ω Cable termination = 600 Ω				
Cable length (kft)		**Equalizer settings**		
24 Ga	**22 Ga**	**BW**	**HT**	**SL**
TCL = 24				
1	23	14	8	4
2	22	14	8	4
3	21	14	8	4
4	20	14	8	4
5	19	14	8	4
6	18	14	8	4
7	17	14	8	4
8	16	14	8	4
9	15	14	8	4
10	14	14	8	4
11	13	14	8	4
12	12	14	9	4
13	11	14	8	4
14	10	14	8	4
15	9	14	8	4
16	8	14	8	4
17	7	14	8	4
18	6	14	8	4
19	5	14	9	5
20	4	14	9	5
21	3	14	9	5
22	2	14	9	5
23	1	14	9	5

—continued—

Table 6-22 (continued)
4-wire equalization settings (non-loaded 24-22 multi-gauge cable)

Input impedance = 600 Ω Cable termination = 600 Ω				
Cable length (kft)		**Equalizer settings**		
24 Ga	**22 Ga**	**BW**	**HT**	**SL**
TCL = 25				
1	24	14	8	4
2	23	14	8	4
3	22	14	8	4
4	21	14	8	4
5	20	14	8	4
6	19	14	9	4
7	18	14	9	4
8	17	14	9	4
9	16	14	9	4
10	15	14	9	4
11	14	14	9	4
12	13	14	9	4
13	12	14	9	5
14	11	14	9	5
15	10	14	9	5
16	9	14	9	5
17	8	14	9	5
18	7	14	9	5
19	6	14	9	5
20	5	14	9	5
21	4	14	9	5
22	3	14	9	5
23	2	14	9	5
24	1	14	9	5
—continued—				

Table 6-22 (continued)
4-wire equalization settings (non-loaded 24-22 multi-gauge cable)

Input impedance = 600 Ω Cable termination = 600 Ω				
Cable length (kft)		**Equalizer settings**		
24 Ga	**22 Ga**	**BW**	**HT**	**SL**
TCL = 26				
1	25	14	9	4
2	24	14	9	4
3	23	14	9	4
4	22	14	9	4
5	21	14	9	4
6	20	14	9	5
7	19	14	9	5
8	18	14	9	5
9	17	14	9	5
10	16	14	9	5
11	15	14	9	5
12	14	14	9	5
13	13	14	9	5
14	12	14	9	5
15	11	14	9	5
16	10	14	9	5
17	9	14	9	5
18	8	14	9	5
19	7	14	9	5
20	6	14	9	5
21	5	14	9	5
22	4	14	9	5
23	3	14	9	5
24	2	14	9	5
25	1	14	9	5

—continued—

Table 6-22 (continued)
4-wire equalization settings (non-loaded 24-22 multi-gauge cable)

Input impedance = 600 Ω Cable termination = 600 Ω				
Cable length (kft)		**Equalizer settings**		
24 Ga	**22 Ga**	**BW**	**HT**	**SL**
TCL = 27				
1	26	14	9	4
2	25	14	9	4
3	24	14	9	4
4	23	14	9	4
5	22	14	9	4
6	21	14	9	5
7	20	14	9	5
8	19	14	9	5
9	18	14	9	5
10	17	14	9	5
11	16	14	9	5
12	15	14	9	5
13	14	14	9	5
14	13	14	9	5
15	12	14	9	5
16	11	14	9	5
17	10	14	9	5
18	9	14	9	5
19	8	14	9	5
20	7	14	9	5
21	6	14	9	5
22	5	14	10	6
23	4	14	10	6
24	3	14	10	6
25	2	14	10	6
26	1	14	10	6
—continued—				

Table 6-22 (continued)
4-wire equalization settings (non-loaded 24-22 multi-gauge cable)

Input impedance = 600 Ω Cable termination = 600 Ω				
Cable length (kft)		**Equalizer settings**		
24 Ga	**22 Ga**	**BW**	**HT**	**SL**
TCL = 28				
1	27	14	9	5
2	26	14	9	5
3	25	14	9	5
4	24	14	9	5
5	23	14	9	5
6	22	14	9	6
7	21	14	9	6
8	20	14	9	6
9	19	14	9	6
10	18	14	9	6
11	17	14	9	6
12	16	14	9	6
13	15	14	9	6
14	14	14	10	6
15	13	14	10	6
16	12	14	10	6
17	11	14	10	6
18	10	14	10	6
19	9	14	10	6
20	8	14	10	6
21	7	14	10	6
22	6	14	10	6
23	5	14	10	6
24	4	14	10	6
25	3	14	10	6
26	2	14	10	6
27	1	14	10	6

—continued—

Table 6-22 (continued)
4-wire equalization settings (non-loaded 24-22 multi-gauge cable)

Input impedance = 600 Ω Cable termination = 600 Ω				
Cable length (kft)		**Equalizer settings**		
24 Ga	**22 Ga**	**BW**	**HT**	**SL**
TCL = 29				
1	28	14	9	6
2	27	14	9	6
3	26	14	9	6
4	25	14	9	6
5	24	14	9	6
6	23	14	9	7
7	22	14	9	7
8	21	14	9	7
9	20	14	9	7
10	19	14	9	7
11	18	14	9	7
12	17	14	9	7
13	16	14	9	7
14	15	14	9	7
15	14	14	10	6
16	13	14	10	6
17	12	14	10	6
18	11	14	10	6
19	10	14	10	6
20	9	14	10	6
21	8	14	10	6
22	7	14	10	6
23	6	14	10	6
24	5	14	10	7
25	4	14	10	7
26	3	14	10	7
27	2	14	10	7
28	1	14	10	7

—continued—

Table 6-22 (continued)
4-wire equalization settings (non-loaded 24-22 multi-gauge cable)

Input impedance = 600 Ω Cable termination = 600 Ω				
Cable length (kft)		**Equalizer settings**		
24 Ga	**22 Ga**	**BW**	**HT**	**SL**
TCL = 30				
1	29	14	9	7
2	28	14	9	7
3	27	14	9	7
4	26	14	9	7
5	25	14	9	7
6	24	14	10	7
7	23	14	10	7
8	22	14	10	7
9	21	14	10	7
10	20	14	10	7
11	19	14	10	7
12	18	14	10	7
13	17	14	10	7
14	16	14	10	7
15	15	14	10	7
16	14	14	10	7
17	13	14	10	7
18	12	14	10	7
19	11	14	10	7
20	10	14	10	7
21	9	14	10	7
22	8	14	10	7
23	7	14	10	7
24	6	14	10	7
25	5	14	11	7
26	4	14	11	7
27	3	14	11	7
28	2	14	11	7
29	1	14	11	7
—end—				

Table 6-23
4-wire equalization settings (non-loaded 26-24 multi-gauge cable)

Input impedance = 600 Ω Cable termination = 600 Ω				
Cable length (kft)		**Equalizer settings**		
26 Ga	**24 Ga**	**BW**	**HT**	**SL**
TCL = 6				
5	1	7	3	0
TCL = 7				
3	4	5	2	1
4	3	7	3	1
5	2	7	3	1
6	1	7	3	1
TCL = 8				
1	7	5	2	1
2	6	5	2	1
3	5	5	2	1
4	4	7	3	1
5	3	7	3	1
6	2	7	3	1
7	1	7	3	1
TCL = 9				
1	8	7	5	1
2	7	7	5	1
3	6	7	5	1
4	5	7	5	1
5	4	9	5	1
6	3	9	5	1
7	2	9	5	1
8	1	9	5	1
TCL = 10				
1	9	10	4	1
2	8	10	4	1
3	7	10	4	1
4	6	10	4	1
5	5	11	4	1
6	4	11	4	1
7	3	11	4	1
8	2	11	4	1
9	1	11	4	1
—continued—				

Table 6-23 (continued)
4-wire equalization settings (non-loaded 26-24 multi-gauge cable)

Input impedance = 600 Ω Cable termination = 600 Ω				
Cable length (kft)		**Equalizer settings**		
26 Ga	**24 Ga**	**BW**	**HT**	**SL**
TCL = 11				
2	9	12	4	1
3	8	12	4	1
4	7	12	4	1
5	6	12	4	1
6	5	12	5	1
7	4	12	5	1
8	3	12	5	1
9	2	12	5	1
10	1	12	5	1
TCL = 12				
1	11	14	5	1
2	10	14	5	1
3	9	14	5	1
4	8	14	5	1
5	7	14	5	1
6	6	12	5	2
7	5	12	5	2
8	4	12	5	2
9	3	12	5	2
10	2	12	5	2
11	1	12	5	2
TCL = 13				
1	12	14	5	1
2	11	14	5	1
3	10	14	5	1
4	9	14	5	1
5	8	14	5	1
6	7	14	5	1
7	6	12	5	2
8	5	12	5	2
9	4	12	5	2
10	3	12	5	2
11	2	12	5	2
12	1	12	5	2

—continued—

Table 6-23 (continued)
4-wire equalization settings (non-loaded 26-24 multi-gauge cable)

Input impedance = 600 Ω Cable termination = 600 Ω				
Cable length (kft)		**Equalizer settings**		
26 Ga	**24 Ga**	**BW**	**HT**	**SL**
TCL = 14				
1	13	14	5	2
2	12	14	5	2
3	11	14	5	2
4	10	14	5	2
5	9	14	5	2
6	8	14	5	1
7	7	14	6	2
8	6	14	6	2
9	5	14	6	2
10	4	14	6	2
11	3	14	6	2
12	2	14	6	2
13	1	14	6	2
TCL = 15				
1	14	14	5	2
2	13	14	5	2
3	12	14	5	2
4	11	14	5	2
5	10	14	5	2
6	9	14	5	2
7	8	14	6	2
8	7	14	6	2
9	6	14	7	2
10	5	14	7	2
11	4	14	7	2
12	3	14	7	2
13	2	14	7	2
14	1	14	7	2
—continued—				

Table 6-23 (continued)
4-wire equalization settings (non-loaded 26-24 multi-gauge cable)

Input impedance = 600 Ω Cable termination = 600 Ω				
Cable length (kft)		**Equalizer settings**		
26 Ga	**24 Ga**	**BW**	**HT**	**SL**
TCL = 16				
1	15	14	6	2
2	14	14	6	2
3	13	14	6	2
4	12	14	6	2
5	11	14	6	2
6	10	14	6	2
7	9	14	7	2
8	8	14	7	2
9	7	14	7	2
10	6	14	7	2
11	5	14	7	2
12	4	14	7	2
13	3	14	7	2
14	2	14	7	2
15	1	14	7	2
TCL = 17				
1	16	14	7	2
2	15	14	7	2
3	14	14	7	2
4	13	14	7	2
5	12	14	7	2
6	11	14	7	2
7	10	14	7	3
8	9	14	7	3
9	8	14	7	2
10	7	14	7	2
11	6	14	7	3
12	5	14	7	3
13	4	14	7	3
14	3	14	7	3
15	2	14	7	3
16	1	14	7	3
—continued—				

Table 6-23 (continued)
4-wire equalization settings (non-loaded 26-24 multi-gauge cable)

Input impedance = 600 Ω Cable termination = 600 Ω				
Cable length (kft)		**Equalizer settings**		
26 Ga	**24 Ga**	**BW**	**HT**	**SL**
TCL = 18				
1	17	14	7	3
2	16	14	7	3
3	15	14	7	3
4	14	14	7	3
5	13	14	7	3
6	12	14	7	3
7	11	14	7	3
8	10	14	7	3
9	9	14	7	3
10	8	14	7	3
11	7	14	7	3
12	6	14	8	3
13	5	14	8	3
14	4	14	8	3
15	3	14	8	3
16	2	14	8	3
17	1	14	8	3
TCL = 19				
1	18	14	7	3
2	17	14	7	3
3	16	14	7	3
4	15	14	7	3
5	14	14	7	3
6	13	14	7	3
7	12	14	7	3
8	11	14	7	3
9	10	14	7	3
10	9	14	8	3
11	8	14	8	3
12	7	14	8	3
13	6	14	8	3
14	5	14	8	3
15	4	14	8	3
16	3	14	8	3
17	2	14	8	3
18	1	14	8	3

—continued—

Table 6-23 (continued)
4-wire equalization settings (non-loaded 26-24 multi-gauge cable)

Input impedance = 600 Ω Cable termination = 600 Ω				
Cable length (kft)		**Equalizer settings**		
26 Ga	**24 Ga**	**BW**	**HT**	**SL**
TCL = 20				
1	19	14	7	3
2	18	14	7	3
3	17	14	7	3
4	16	14	7	3
5	15	14	7	3
6	14	14	7	3
7	13	14	7	4
8	12	14	7	4
9	11	14	7	4
10	10	14	8	3
11	9	14	8	3
12	8	14	8	3
13	7	14	8	3
14	6	14	9	4
15	5	14	9	4
16	4	14	9	4
17	3	14	9	4
18	2	14	9	4
19	1	14	9	4

—continued—

Table 6-23 (continued)
4-wire equalization settings (non-loaded 26-24 multi-gauge cable)

Input impedance = 600 Ω Cable termination = 600 Ω				
Cable length (kft)		**Equalizer settings**		
26 Ga	**24 Ga**	**BW**	**HT**	**SL**
TCL = 21				
1	20	14	7	4
2	19	14	7	4
3	18	14	7	4
4	17	14	7	4
5	16	14	7	4
6	15	14	7	4
7	14	14	8	4
8	13	14	8	4
9	12	14	8	4
10	11	14	8	4
11	10	14	9	4
12	9	14	9	4
13	8	14	9	4
14	7	14	9	4
15	6	14	9	4
16	5	14	9	4
17	4	14	9	4
18	3	14	9	4
19	2	14	9	4
20	1	14	9	4

—continued—

Table 6-23 (continued)
4-wire equalization settings (non-loaded 26-24 multi-gauge cable)

Input impedance = 600 Ω Cable termination = 600 Ω				
Cable length (kft)		**Equalizer settings**		
26 Ga	**24 Ga**	**BW**	**HT**	**SL**
TCL = 22				
1	21	14	8	4
2	20	14	8	4
3	19	14	8	4
4	18	14	8	4
5	17	14	8	4
6	16	14	8	4
7	15	14	8	4
8	14	14	8	4
9	13	14	8	4
10	12	14	8	4
11	11	14	9	4
12	10	14	9	4
13	9	14	9	4
14	8	14	9	4
15	7	14	9	4
16	6	14	9	5
17	5	14	9	5
18	4	14	9	5
19	3	14	9	5
20	2	14	9	5
21	1	14	9	5

—continued—

Table 6-23 (continued)
4-wire equalization settings (non-loaded 26-24 multi-gauge cable)

Input impedance = 600 Ω Cable termination = 600 Ω				
Cable length (kft)		**Equalizer settings**		
26 Ga	**24 Ga**	**BW**	**HT**	**SL**
TCL = 23				
1	22	14	8	4
2	21	14	8	4
3	20	14	8	4
4	19	14	8	4
5	18	14	8	4
6	17	14	8	4
7	16	14	9	5
8	15	14	9	5
9	14	14	9	5
10	13	14	9	5
11	12	14	9	5
12	11	14	9	5
13	10	14	9	5
14	9	14	9	5
15	8	14	9	5
16	7	14	9	5
17	6	14	10	6
18	5	14	10	6
19	4	14	10	6
20	3	14	10	6
21	2	14	10	6
22	1	14	10	6

—continued—

Table 6-23 (continued)
4-wire equalization settings (non-loaded 26-24 multi-gauge cable)

Input impedance = 600 Ω Cable termination = 600 Ω				
Cable length (kft)		**Equalizer settings**		
26 Ga	**24 Ga**	**BW**	**HT**	**SL**
TCL = 24				
1	23	14	9	5
2	22	14	9	5
3	21	14	9	5
4	20	14	9	5
5	19	14	9	5
6	18	14	9	5
7	17	14	9	5
8	16	14	9	5
9	15	14	9	5
10	14	14	9	5
11	13	14	9	5
12	12	14	10	6
13	11	14	10	6
14	10	14	10	6
15	9	14	10	6
16	8	14	10	6
17	7	14	10	6
18	6	14	10	6
19	5	14	10	6
20	4	14	10	6
21	3	14	10	6
22	2	14	10	6
23	1	14	10	6

—continued—

Table 6-23 (continued)
4-wire equalization settings (non-loaded 26-24 multi-gauge cable)

Input impedance = 600 Ω Cable termination = 600 Ω				
Cable length (kft)		**Equalizer settings**		
26 Ga	**24 Ga**	**BW**	**HT**	**SL**
TCL = 25				
1	24	14	9	5
2	23	14	9	5
3	22	14	9	5
4	21	14	9	5
5	20	14	9	5
6	19	14	9	5
7	18	14	9	5
8	17	14	9	5
9	16	14	9	5
10	15	14	9	5
11	14	14	9	5
12	13	14	9	5
13	12	14	10	6
14	11	14	10	6
15	10	14	10	6
16	9	14	10	6
17	8	14	10	6
18	7	14	10	6
19	6	14	10	6
20	5	14	10	6
21	4	14	10	6
22	3	14	10	6
23	2	14	10	6
24	1	14	10	6
—continued—				

Table 6-23 (continued)
4-wire equalization settings (non-loaded 26-24 multi-gauge cable)

Input impedance = 600 Ω Cable termination = 600 Ω				
Cable length (kft)		**Equalizer settings**		
26 Ga	**24 Ga**	**BW**	**HT**	**SL**
TCL = 26				
1	25	14	9	5
2	24	14	9	5
3	23	14	9	5
4	22	14	9	5
5	21	14	9	5
6	20	14	9	5
7	19	14	10	6
8	18	14	10	6
9	17	14	10	6
10	16	14	10	6
11	15	14	10	6
12	14	14	10	6
13	13	14	10	6
14	12	14	10	6
15	11	14	10	6
16	10	14	10	6
17	9	14	10	6
18	8	14	10	6
19	7	14	10	6
20	6	14	12	7
21	5	14	12	7
22	4	14	12	7
23	3	14	12	7
24	2	14	12	7
25	1	14	12	7

—continued—

Table 6-23 (continued)
4-wire equalization settings (non-loaded 26-24 multi-gauge cable)

Input impedance = 600 Ω Cable termination = 600 Ω				
Cable length (kft)		**Equalizer settings**		
26 Ga	**24 Ga**	**BW**	**HT**	**SL**
TCL = 27				
1	26	14	10	6
2	25	14	10	6
3	24	14	10	6
4	23	14	10	6
5	22	14	10	6
6	21	14	10	6
7	20	14	10	6
8	19	14	10	6
9	18	14	10	6
10	17	14	10	6
11	16	14	10	6
12	15	14	10	6
13	14	14	10	6
14	13	14	12	7
15	12	14	12	7
16	11	14	12	7
17	10	14	12	7
18	9	14	12	7
19	8	14	12	7
20	7	14	12	7
21	6	14	12	7
22	5	14	12	7
23	4	14	12	7
24	3	14	12	7
25	2	14	12	7
26	1	14	12	7

—continued—

Table 6-23 (continued)
4-wire equalization settings (non-loaded 26-24 multi-gauge cable)

Input impedance = 600 Ω Cable termination = 600 Ω				
Cable length (kft)		**Equalizer settings**		
26 Ga	**24 Ga**	**BW**	**HT**	**SL**
TCL = 28				
1	27	14	10	6
2	26	14	10	6
3	25	14	10	6
4	24	14	10	6
5	23	14	10	6
6	22	14	10	6
7	21	14	10	7
8	20	14	10	7
9	19	14	10	7
10	18	14	10	7
11	17	14	10	7
12	16	14	10	7
13	15	14	10	7
14	14	14	12	7
15	13	14	12	7
16	12	14	12	7
17	11	14	12	7
18	10	14	12	7
19	9	14	12	7
20	8	14	12	7
21	7	14	12	7
22	6	14	12	7
23	5	14	12	7
24	4	14	12	7
25	3	14	12	7
26	2	14	12	7
27	1	14	12	7

—continued—

Table 6-23 (continued)
4-wire equalization settings (non-loaded 26-24 multi-gauge cable)

Input impedance = 600 Ω Cable termination = 600 Ω				
Cable length (kft)		**Equalizer settings**		
26 Ga	**24 Ga**	**BW**	**HT**	**SL**
TCL = 29				
1	28	14	10	7
2	27	14	10	7
3	26	14	10	7
4	25	14	10	7
5	24	14	10	7
6	23	14	10	7
7	22	14	11	7
8	21	14	11	7
9	20	14	11	7
10	19	14	11	7
11	18	14	11	7
12	17	14	11	7
13	16	14	11	7
14	15	14	11	7
15	14	14	13	7
16	13	14	13	7
17	12	14	13	7
18	11	14	13	7
19	10	14	13	7
20	9	14	13	7
21	8	14	13	7
22	7	14	13	7
23	6	13	14	8
24	5	13	14	8
25	4	13	14	8
26	3	13	14	8
27	2	13	14	8
28	1	13	14	8

—continued—

Table 6-23 (continued)
4-wire equalization settings (non-loaded 26-24 multi-gauge cable)

Input impedance = 600 Ω Cable termination = 600 Ω				
Cable length (kft)		**Equalizer settings**		
26 Ga	**24 Ga**	**BW**	**HT**	**SL**
TCL = 30				
1	29	14	11	7
2	28	14	11	7
3	27	14	11	7
4	26	14	11	7
5	25	14	11	7
6	24	14	11	7
7	23	14	11	7
8	22	14	11	7
9	21	14	11	7
10	20	14	11	7
11	19	14	11	7
12	18	14	11	7
13	17	14	11	7
14	16	14	11	7
15	15	13	14	8
16	14	13	14	8
17	13	13	14	8
18	12	13	14	8
19	11	13	14	8
20	10	13	14	8
21	9	13	14	8
22	8	13	14	8
23	7	13	14	8
24	6	13	14	8
25	5	13	14	8
26	4	13	14	8
27	3	13	14	8
28	2	13	14	8
29	1	13	14	8
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Publication number: 323-3001-155
Document release: Issue 3.0
Date: October 1999
Printed in Canada

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