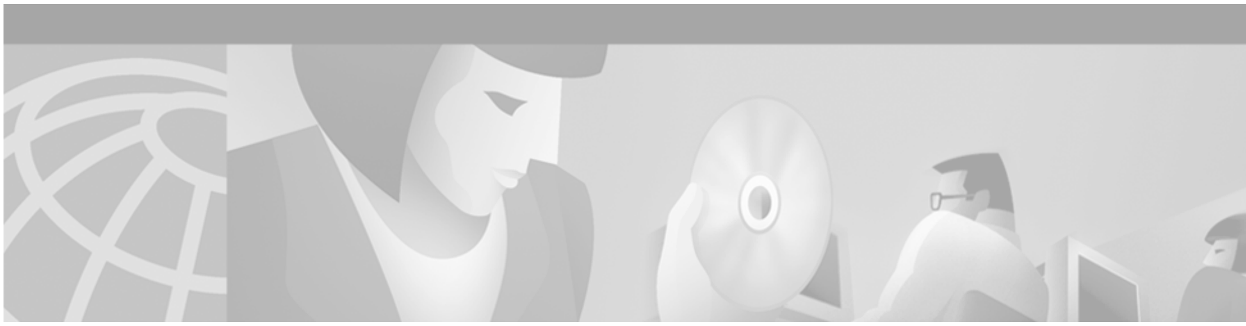

Preface

Objectives

The *Cisco VCO/4K Hardware and Software Planning Guide* contains hardware and software configuration guidelines for VCO/4K systems. System engineers can use this document to determine the VCO/4K hardware requirements for their application.

Note This document represents the most current information about VCO/4K mechanical assemblies. If you need information pertaining to VCO/4K assemblies, circuit cards, or other components that are not included in this document, see the following URL on Cisco's web site for legacy VCO/4K information:

http://www.cisco.com/univercd/cc/td/doc/product/tel_pswt/index.htm

Audience

This manual is intended for VCO/4K system users and third-party support personnel. If you are unfamiliar with the VCO/4K system, refer to the "Related Documentation" section on page viii.

This manual assumes that the host application (if it is a hosted system) is written to conform to the *VCO API Programming Reference Manual*. However, that does not preclude problems occurring between the application and the VCO/4K system.

Each release of the VCO/4K system software is described in the *Cisco VCO/4K System Software Release Notes*, the *Cisco VCO/4K SS7 ISUP Release Notes*, and the *Cisco VCO/4K TCAP Release Notes* that contain detailed information on changes from one release to the next. If your VCO/4K system includes the SS7 subsystem, refer to the *SS7 Release Notes*.

Document Organization

This document is organized as follows:

- Chapter 1, "VCO/4K Hardware Configuration Guidelines," presents the guidelines that govern proper configuration of a VCO/4K system.
- Chapter 2, "Network Interface and Service Circuit Cards," describes the VCO/4K port interface and service circuit cards.

- Chapter 3, "Peripheral Equipment," describes the VCO/4K peripherals.
- Chapter 4, "Spare Parts Lists," lists the spare parts.
- Chapter 5, "Software and System Capacity," describes VCO/4K system software capacity guidelines.
- Chapter 6, "System Configuration Guidelines," describes VCO/4K configuration guidelines and Cisco recommendations.
- Appendix A, "Service Circuit Channel Requirements," contains guidelines for determining the service circuit card requirements for your application.

Document Conventions

This document uses the following conventions:

Note Means *reader take note.* Notes contain helpful suggestions or references to material not covered in the manual.

Caution Means *reader be careful.* In this situation, you might do something that could result in equipment damage or loss of data.

Warning **Means *danger.* You are in a situation that could cause bodily injury. Before you work on any equipment, you must be aware of the hazards involved with electrical circuitry and be familiar with standard practices for preventing accidents. To see translated versions of the warning, refer to the *Regulatory Compliance and Safety* document that accompanied the device.**

Related Documentation

The following documents are referenced from this guide or contain information that is directly related to system performance and configuration.

Knowledge of PSTN communication protocols is also important.

VCO/4K System

- *Cisco VCO/4K System Software Release Notes*
- *Cisco VCO/4K SS7 ISUP Release Notes*
- *Cisco VCO/4K TCAP Release Notes*
- *Cisco VCO/4K Product Overview*
- *Cisco VCO/4K Mechanical Assemblies*
- *Cisco VCO/4K System Maintenance Manual*
- *Cisco VCO/4K Standard Programming Reference*

- *Cisco VCO/4K Extended Programming Reference*
- *Cisco VCO/4K System Administrator's Guide*
- *Cisco VCO/4K Ethernet Guide*
- *Cisco VCO/4K Site Preparation Guide*
- *Cisco VCO/4K Hardware Installation Guide*
- *Cisco VCO/4K Card Technical Descriptions*
- *Cisco VCO/4K Troubleshooting Guide*
- *Cisco VCO/4K TeleRouter Reference Guide*
- *Ring Generator Instruction Sheet* (included with the ring generator kit)

The VCO/4K documents are available at:

`http://www.cisco.com/univercd/cc/td/doc/product/tel_pswt/`

Third-Party Documents

The following third-party documents are recommended by Cisco:

- Theodore Frankel's *ABC Of the Telephone: Traffic Series – Tables For Traffic Management And Design*
- International Telecommunications Union ITU-T Q.931 ISDN documentation
- ANSI T1.113-1992, SS7 ISUP documentation
- OEM manuals supplied with peripheral equipment installed as part of the system configuration
- The documentation set produced for the host computer system
- Documentation for the application software package developed to run on the host

Obtaining Documentation

The following sections explain how to obtain documentation from Cisco Systems.

World Wide Web

You can access the most current Cisco documentation on the World Wide Web at the following URL:

http://www.cisco.com

Translated documentation is available at the following URL:

http://www.cisco.com/public/countries_languages.shtml

Documentation CD-ROM

Cisco documentation and additional literature are available in a Cisco Documentation CD-ROM package, which is shipped with your product. The Documentation CD-ROM is updated monthly and may be more current than printed documentation. The CD-ROM package is available as a single unit or through an annual subscription.

Ordering Documentation

Cisco documentation is available in the following ways:

- Registered Cisco Direct Customers can order Cisco product documentation from the Networking Products MarketPlace:

  http://www.cisco.com/cgi-bin/order/order_root.pl

- Registered Cisco.com users can order the Documentation CD-ROM through the online Subscription Store:

  http://www.cisco.com/go/subscription

- Nonregistered Cisco.com users can order documentation through a local account representative by calling Cisco corporate headquarters (California, USA) at 408 526-7208 or, elsewhere in North America, by calling 800 553-NETS (6387).

Documentation Feedback

If you are reading Cisco product documentation on Cisco.com, you can submit technical comments electronically. Click **Leave Feedback** at the bottom of the Cisco Documentation home page. After you complete the form, print it out and fax it to Cisco at 408 527-0730.

You can e-mail your comments to bug-doc@cisco.com.

To submit your comments by mail, use the response card behind the front cover of your document, or write to the following address:

Cisco Systems
Attn: Document Resource Connection
170 West Tasman Drive
San Jose, CA 95134-9883

We appreciate your comments.

Obtaining Technical Assistance

Cisco provides Cisco.com as a starting point for all technical assistance. Customers and partners can obtain documentation, troubleshooting tips, and sample configurations from online tools by using the Cisco Technical Assistance Center (TAC) Web Site. Cisco.com registered users have complete access to the technical support resources on the Cisco TAC Web Site.

Cisco.com

Cisco.com is the foundation of a suite of interactive, networked services that provides immediate, open access to Cisco information, networking solutions, services, programs, and resources at any time, from anywhere in the world.

Cisco.com is a highly integrated Internet application and a powerful, easy-to-use tool that provides a broad range of features and services to help you to

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http://www.cisco.com

Technical Assistance Center

The Cisco TAC is available to all customers who need technical assistance with a Cisco product, technology, or solution. Two types of support are available through the Cisco TAC: the Cisco TAC Web Site and the Cisco TAC Escalation Center.

Inquiries to Cisco TAC are categorized according to the urgency of the issue:

- Priority level 4 (P4)—You need information or assistance concerning Cisco product capabilities, product installation, or basic product configuration.
- Priority level 3 (P3)—Your network performance is degraded. Network functionality is noticeably impaired, but most business operations continue.
- Priority level 2 (P2)—Your production network is severely degraded, affecting significant aspects of business operations. No workaround is available.
- Priority level 1 (P1)—Your production network is down, and a critical impact to business operations will occur if service is not restored quickly. No workaround is available.

Which Cisco TAC resource you choose is based on the priority of the problem and the conditions of service contracts, when applicable.

Cisco TAC Web Site

The Cisco TAC Web Site allows you to resolve P3 and P4 issues yourself, saving both cost and time. The site provides around-the-clock access to online tools, knowledge bases, and software. To access the Cisco TAC Web Site, go to the following URL:

http://www.cisco.com/tac

All customers, partners, and resellers who have a valid Cisco services contract have complete access to the technical support resources on the Cisco TAC Web Site. The Cisco TAC Web Site requires a Cisco.com login ID and password. If you have a valid service contract but do not have a login ID or password, go to the following URL to register:

http://www.cisco.com/register/

If you cannot resolve your technical issues by using the Cisco TAC Web Site, and you are a Cisco.com registered user, you can open a case online by using the TAC Case Open tool at the following URL:

http://www.cisco.com/tac/caseopen

If you have Internet access, it is recommended that you open P3 and P4 cases through the Cisco TAC Web Site.

Cisco TAC Escalation Center

The Cisco TAC Escalation Center addresses issues that are classified as priority level 1 or priority level 2; these classifications are assigned when severe network degradation significantly impacts business operations. When you contact the TAC Escalation Center with a P1 or P2 problem, a Cisco TAC engineer will automatically open a case.

To obtain a directory of toll-free Cisco TAC telephone numbers for your country, go to the following URL:

http://www.cisco.com/warp/public/687/Directory/DirTAC.shtml

Before calling, please check with your network operations center to determine the level of Cisco support services to which your company is entitled; for example, SMARTnet, SMARTnet Onsite, or Network Supported Accounts (NSA). In addition, please have available your service agreement number and your product serial number.

CHAPTER 1

VCO/4K Hardware Configuration Guidelines

Nonredundant System

The basic nonredundant VCO/4K system is configured with the following hardware components:

- The system enclosure
- One power supply module
- Control circuit cards
  - One Combined Controller Assembly with CPU (located in slots 3 and 4)
  - One Network Bus Controller 3 (NBC3) with Digital Tone Generator 2 (DTG-2) mezzanine card (located in slot 1)

> **Note** Systems running VCO/4K V5.2(0) or higher may use SPC-TONE in place of DTG-2. See the *Cisco VCO/4K System Software Release Notes* for additional details.

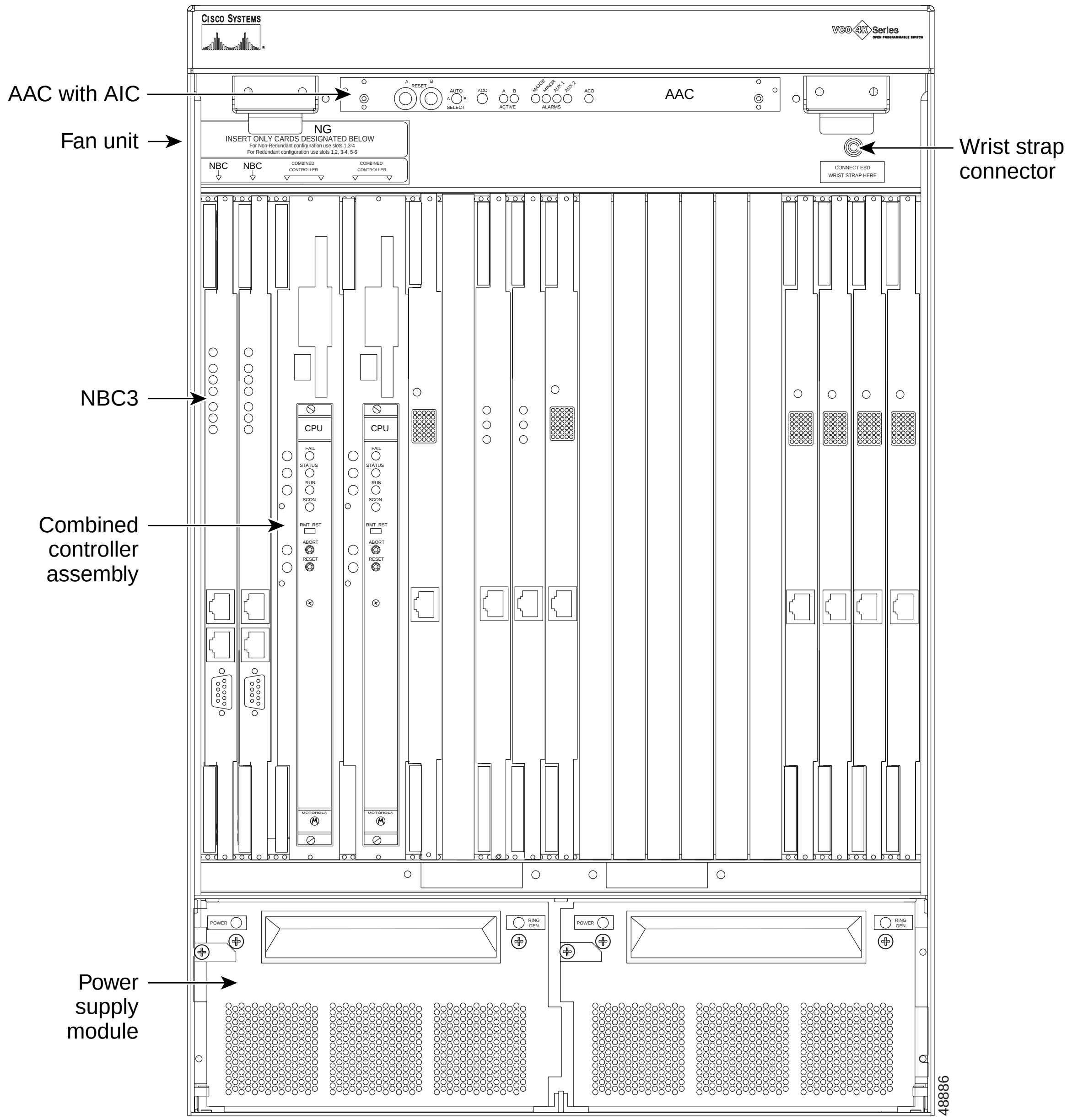
  - One Alarm Arbiter Card (AAC)
  - One Storage/Control I/O Module (located to the rear of slots 3 and 4)
- One ring generator (optional) (located above the power supply)

> **Note** A ring generator is needed only if you are using an LTC-8 or SLIC-2 card for local direct phone connection.

- One fan unit

Figure 1-1 shows a basic VCO/4K system with the front door removed.

Figure 1-1 Nonredundant VCO/4K System (Front View)



Redundant System

To configure a basic VCO/4K system for redundancy, add the following hardware components:

- A second Combined Controller Assembly with CPU in card slots 5 and 6
- A second NBC3 with DTG-2 in card slot 2

Note Systems running VCO/4K V5.2(0) or higher may use SPC-TONE in place of DTG-2. See the *Cisco VCO/4K System Software Release Notes* for additional details.

- A second Storage/Control I/O Module in slots 5 and 6 of the I/O module rack at the back of the system
- A second power supply module to the right side of the power subsystem (load sharing) with one (optional) ring generator

Note A ring generator is needed only if you are using an LTC-8 or SLIC-2 card for local direct phone connection.

Redundant systems do not require a second AAC or fan unit.

Expansion

The system enclosure has 15 slots for adding network interface cards and service circuit cards.

Basic System Configuration Table

Table 1-1 is the configuration table for basic VCO/4K systems.

Table 1-1 Basic VCO/4K System Configuration

Basic System Configurations	Quantity	Assembly Number	Price Each	Extended
Basic DC or Dual DC system (nonredundant)				
Control, Storage, and Power Redundancy Package (DC)[1]				
Basic AC System (nonredundant)				
Control, Storage, and Power Redundancy Package (AC)[1]				
19-inch rack-mounting kit				
24-inch rack-mounting kit				
Documentation set (included with each basic system)			no charge	
Additional copies of documentation (by set or volume)				
		A. Subtotal Equipment Price		

1. This package contains a Combined Controller with CPU, Storage/Control I/O Module, Power Supply Module, and NBC3.

C H A P T E R 2

Network Interface and Service Circuit Cards

VCO/4K systems have 15 slots available for network interface (ICC with ICC I/O and D+I with D+I I/O, SLIC, and LTC8) and service circuit cards (SPC with SRM, IPRC8, IPRC64, IPRC128, DTG, and SSC). Network interface cards (also known as port interface cards) require I/O Modules to connect to network interface cables.

The population rules for network and service circuit cards are as follows:

- Maximum number of cards is 15.
- Network interface and service circuit cards must be installed in slots 7 through 21. Slots 1 through 6 are reserved for the control circuit cards.
- I/O Modules for the port interface cards must be installed in slots 7 through 21 of the I/O Module rack at the back of the system. Slots 3 through 6 are reserved for the Storage/Control I/O Modules. Slots 1 and 2 are used for receiving BITS clock timing. (The BITS Clock Adapter Kit is required for BITS clock timing.)

Note The instructions in this chapter require that you have determined the number of DS0 network channels and DS0 service circuit channels that you need. Traffic engineering processes and procedures determine these numbers for your installation. Appendix A, "Service Circuit Channel Requirements," provides an overview of this process.

Interface Cards and I/O Modules

This section briefly describes each ICC interface card and I/O Module available for the VCO/4K system. For more information on the cards described in this section, refer to the *Cisco VCO/4K Card Technical Descriptions.*

Port Interface Cards

The digital port interface cards are the following:

- *Interface Controller Card (ICC) with T1 I/O Module*—Supports 4, 8, or 16 DS1 level network interface spans (depending on I/O Module).
- *Interface Controller Card (ICC) with E1 I/O Module*—Supports 4, 8, or 16 DS1 level network interface spans (depending on I/O Module).

Table 2-1 is the configuration table for the interface cards.

Table 2-1 Digital Trunk Interface Card Configuration Table

Digital Trunk Types	Type of Card	Max DS1 Spans per Card	I/O Cards Needed	Total DS1 Spans[1] (or DS1 resources)
Interface Controller Card with T1 I/O Module	ICC-16 Span T1 I/O Module	16		
Interface Controller Card with T1 I/O Module	ICC-8 Span T1 I/O Module	8		
Interface Controller Card with T1 I/O Module	ICC-4 Span T1 I/O Module	4		
Interface Controller Card with E1 I/O Module	ICC-16 Span E1 I/O Module	16		
Interface Controller Card with E1 I/O Module	ICC-8 Span E1 I/O Module	8		
Interface Controller Card with E1 I/O Module	ICC-4 Span E1 I/O Module	4		
Total I/O Cards Needed				

1. Total Number of DS1 Resources added to the VCO/4K database (worst case) = ((Number of 16xT1 I/O cards) x 16) + ((Number of 8xT1 I/O cards) x 8) + ... ((Number of nxT1 I/O cards) x n).

To calculate the number of network interface cards required for your application, complete the steps in the following sections.

ICC with T1 I/O Module

Step 1 Divide the number of required DS0 network channels by 24 to calculate the number of DS1 spans required. Round up any fraction to the next whole number. Use the following formula:

DS0 Network Channels ÷ 24 = No. of Spans

Step 2 Divide the number of spans by 16 to establish the number of 16 Span I/O cards. (You can substitute a Four Span or Eight Span I/O Module.) Round up any fraction to the next whole number. Use the following formula:

No. of spans 16 = No. of 16 Span I/O Cards

ICC with E1 I/O Module

Step 1 Divide the number of required DS0 network channels by 30 to calculate the number of spans required. Round up any fraction to the next whole number.

DS0 Network Channels ÷ 30 = No. of Spans

Step 2 Divide the number of spans by 16 to establish the number of 16 Span I/O cards. (You can substitute a Four Span or Eight Span I/O Module.) Round up any fraction to the next whole number.

No. of spans 16 = No. of 16 Span I/O Cards

Drop and Insert (D+I) Card and I/O Module

One D+I card with one I/O module can support eight 56-kbps or 64-kbps SS7 data circuits. Use two D+I cards with two I/O modules to provide redundancy.

Note No more than two D+I cards are needed in a system because the VCO/4K SS7 Subsystem can support only 16 SS7 data connections (or 8 redundant connections) to the STP.

Service Circuit Cards

The following service circuit cards are available:

- *Integrated Prompt/Record Card (IPRC)*—Plays and records digitized voice prompt information. The following versions of the IPRC card are available:

Card Name	Number of service circuit channels to play pre-recorded voice information to the network
IPRC84	8
IPRC64	64
IPRC128	128

All channels can operate at the same time.

- *Subrate Switch Card (SSC)*—Allows the system to switch voice and data calls at N x 8 kbps rates (where N equals the number of service circuit channels), improving trunk efficiency up to eight times by packing eight subrate channels within a traditional 64-kbps channel. The SSC enables the VCO/4K to be used as Base Station Controllers (BSCs) in wireless telephone networks or other networks that carry compressed audio.

- *Service Platform Card (SPC) with Service Resource Module (SRM) daughter cards with 8 DSPs per SRM*—Provides a flexible platform for software-controlled services including: DTMF generation and reception; call progress analysis (tone reception); conferencing; MF and MFCR2 reception, (DT.
- *DTG-2*—DTMF, and static tone generation.
- *SPC-TONE*—DTMF, and static tone generation.

Appendix A, "Service Circuit Channel Requirements," contains some guidelines for determining the type and number of service circuit channels required for your application.

Table 2-2 Service Circuit Card Configuration Table

Card Maintenance Screen Name (Resource Name)	Function	Max Number of Service Circuits per Resource	Total Number of Service Circuits Needed (From Appendix A) Divided by the Max Number of Service Circuits per Resource	Total Resources Needed (Round to Next Whole Number)
Tone Generator (DTG-2 or SPC-TONE)	Static tone generation and outpulses DTMF, MF, or MFCR2 digits[1]	63		2[2]
SPC-OUTPL	Outpulses DTMF, MF, or MFCR2 digits	63		
SPC-DTMF	Collects DTMF digits	32		
SPC-MFR1[3]	Collects MF digits	32		
SPC-MFR2	Collects MFCR2 digits	24		
8 Port Prompt/Record	Plays pre-recorded voice messages to the network	8		
64 Port Prompt/Record		64		
128 Port Prompt/Record		128		
Subrate Switch Card		varies[4]		

1. You can use SPC-OUTPL for outpulsing digits and the tone generator solely for generating static tones.
2. Two tone generator resources are needed for redundant systems but you then have only 63 maximum circuit ports, not 128.
3. Displays as SPC-MFRC.
4. Allocated by the system in increments of 8, depending how you first configure the Subrate Configuration screen. All increments allocated fall within the "licensed time slot pool," not the "free time slot pool." See the *Cisco VCO/4K System Administrator's Guide* to help you determine the working number you need to use.

Calculating Required Resources

DTG-2 or SPC-TONE

Every system requires one DTG-2 card. You must have two DTG-2 cards or one SPC-TONE for redundant systems.

SRMs and SPC

Calculate the number of SRMs required using the following formula:

Minimum Number of SRMs = (Total number of SPC=OUTPL, SPC-DTMF, SPC-MFR1, and SPC-MFCR2 resources) ÷ 8

Round up to the next whole number.

Calculate the number of SPCs required using the following formula:

Minimum Number of SPCs = (Minimum number of SRMs) ÷ 4

Round up to the next whole number.

To provide for card redundancy, multiply the minimum number of SRMs by 2 and multiply the minimum number of SPCs by 2.

Note Distribute the SRMs evenly over the SPCs.

IPRC Cards

Obtain the total number of Port Prompt/Record resources needed from Table 2-2.

Calculate the minimum number of IPRC cards required based on card capacity (128, 64, or 8) and the total number of resources needed.

To provide for card redundancy, multiply the minimum number of IPRCs by 2.

Note The total number of IPRC cards (of any type) cannot exceed 8 for redundant systems (4 for nonredundant systems).

SSC Cards

You will need one SSC card; two for redundancy.

Licensed Time Slot Capacity Assessment

The total number of licensed time slots (channels) cannot exceed 3960 (4088 total channels –128 channels reserved for the DTG-2).

With the exception of the SPCs providing DTMF, CPA, and MF services, each channel on the VCO/4K must have a licensed time slot allocated to it in order to operate. Time slots are allocated to channels when resources (network interface spans and service circuit resources) are added to the system database and are not deallocated until these resources are removed. Time slot allocation associated with the spans and resources are shown in Table 2-3.

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Table 2-3 Time Slot Allocation

Hardware Name (for reference)	Resource Name Displayed on the Card Maintenance Screen	Licensed Time Slots per Resource Name Used
DTG-2	Tone Generator	128[1 2]
IPRC8	8 Port Prompt/Record	008
IPRC64	64 Port Prompt/Record	064
IPRC128	128 Port Prompt/Record	128
SSC	Subrate Switch Card	varies/ programmable[3]
D+I	Drop and Insert Card	008
ICC	ICC-T1	024
ICC	ICC-E1	032
LTC-8	8-Line Test Card	008
ICC	ICC-T1 PRI/NI2	024
ICC	ICC-T1 PRI/5ESS	024
ICC	ICC-T1 PRI/4ESS	024
ICC	ICC-T1 PRI/NTI	024
ICC	ICC-T1 PRI/NTT	024
ICC	ICC-E1 PRI/NET5	032
ICC	ICC-E1 PRI/QSIG	032
ICC	ICC-E1 PRI/TS014	032
SPC	SPC-DTMF	none[4]
SPC	SPC-CPA	none[4]
SPC	SPC-MFR1	none[4 5]
SPC	SPC-MFCR2	024
SPC	SPC-OUTP	064
SPC	SPC-CONF	032
—	virtual ports	none[4 6]
SPC-TONE	SPC-TONE	64

1. Whether one or two DTG-2 cards are active, only 128 ports will be allocated by the system.
2. All resources listed below the DTG-2 card in this table, and which fall within the “licensed time slot pool”, can be added to the system provided that the total number of time slots added does not exceed 3960.
3. Allocated by the system in increments of 8, depending how you first configure the Subrate Configuration screen. All increments allocated fall within the “licensed time slot pool”, not the “free time slot pool”.
4. The resource indicated uses time slots from the “free time slot pool”, not the “licensed time-slot pool”.
5. SPC-MFR1 is displayed to the user as SPC-MFRC.
6. Virtual ports are an integral part of the system but are not displayed from the Card Maintenance screen nor can the user allocate them. Virtual ports can be viewed from the Diagnostic menu / Port Display screen.

Calculating Needed Licensed Time Slots

Calculate the number of licensed time slots you need using this formula:

Licensed Time Slots Needed (≤ 3960) =

((No. of Resources of type 1) x (licensed time slots used per that resource))

+((No. of Resources of type 2) x (licensed time slots used per that resource))

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.

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+((No. of Resources of type n) x (licensed time slots used per that resource))

Assessing Resource Capacity

The system permits no more than 240 resource IDs (0 to 239) in total.

A resource ID is assigned to every resource added to the database from the Card Maintenance screen. A single-span card is assigned a single ID, a multispan card is assigned an ID for each span. For example: a 4xT1 would be assigned four IDs, an ICC card with 16 spans would be assigned 16 IDs. An SPC card is assigned an ID for each DSP configured. Therefore, an SPC card with a full complement of SRMs and DSPs would be assigned 32 IDs (4 SRMs x 8 DSPs/SRM). All resources require a resource ID, but not all resources added to a VCO/4K take up licensed resource time slots. SPC-DTMF, SPC-MF, and SPC-CPA resources do not draw from the licensed resource time slot pool, but rather draw from the nonlicensed time slot pool.

The number of IDs assigned can become an issue if, for example, a system needs to be configured with 160 T1s (that is, 160 IDs) and it also needs 12 SRMs (configured for DTMF, MF, and CPA and that is 96 IDs). This results in a total of 256 IDs for these resources, and the system is then exhausted of IDs before all the resources can be added, because the total number of IDs cannot exceed 240.

In most system configurations, as resources are added which take up licensed time slots, the system will run out of licensed time slots (i.e., reach the licensed time slot limit of 3960) before the ID limit of 240 is reached.

DTMF, MF, and CPA do not take up licensed time slots but are nevertheless assigned resource IDs. Adding a large number of DTMF, MF, or CPA resources could result in a configuration where a system could run out of IDs before reaching the licensed time slot limit of 3960.

Once you have determined the number of network resources needed and service circuit resources needed, ensure that the total does not exceed 240.

Resources are listed by displayed name in Table 2-3.

Peripheral Equipment

This chapter describes the process of identifying the peripheral equipment required to meet general system implementation requirements. For complete information about peripheral equipment, cabling, and setup parameters, refer to the *Cisco VCO/4K Site Preparation Guide*.

Peripheral Equipment and Accessories

VCO/4K systems require the following peripheral equipment to perform system functions and support remote maintenance:

- One master console VDT
- One system printer
- One remote maintenance modem

Peripheral equipment must meet the specifications detailed in this chapter in order to guarantee full VCO system operation.

Video Display Terminals

The master console should be a VDT capable of emulating a VT220. A VT220/320 type digit keypad on the keyboard allows the administrator to use preprogrammed administration keys for viewing and altering database information.

One three-conductor, shielded, male/female (DB-25P-to-DB-25S) EIA/TIA-232 cable is required to directly connect a VDT to a dedicated serial port (Serial Port 1/Console) on the Storage/Control I/O Module. See the *Cisco VCO/4K Hardware Installation Guide* for the pinout details for the master console cable.

Printers

A dot-matrix printer with a Centronics-type parallel interface is required for printing out periodic system reports. One 36-conductor, shielded, male/male Centronics-type cable is required to directly connect a printer to the parallel port on the Storage/Control I/O Module.

Note Cisco strongly recommends the use of a printer for obtaining hard copy of message traces during the development of VCO/4K application programs. The printout facilitates debugging and provides the information required to obtain Cisco technical support.

Remote Maintenance Modem

Cisco TAC may require remote access to the VCO/4K system, which is accomplished by a modem.

Note Cisco recommends a separate, dedicated line for the modem connection.

Automatic External A/B Transfer Switch

For systems with redundant control, an automatic EIA/TIA-232 A/B transfer switch may be used to interface a single VDT, printer, or remote maintenance modem to the system. One A/B switch drive cable is also required between the Alarm Arbiter Card and each A/B switch. The cable is prewired for daisy-chain connection to colocated switch units. One A/B transfer switch unit is required for each peripheral device to be switched.

The A/B transfer switch unit automatically connects a peripheral device to the Active side of the redundant control system.

Summary of Peripheral Equipment

Enter your total VDT, printer, and modem requirements in Table 3-1.

Table 3-1 VDT, Printer, and Modem Configuration

VDTs, Printers, Modems	Quantity
VT320 Video Display Terminal	
Parallel Printer	
External EIA/TIA-232 A/B Switch	
Modem	
Drive Cable for External A/B Switch	

Table 3-2 shows the peripheral cable components. (Contact your Cisco sales representative for current assembly numbers and prices.) Enter the quantity and price for each component to calculate the total cost of cables.

Table 3-2 Peripheral Cable Configuration

Peripheral Cables	Assembly Number	Quantity
Printer Cable—Centronics M/M, 20 ft		
Adapter Cable—Centronics/DB25, M/M, 15 ft		
4-Conductor, M/M, EIA/TIA-232, 10 ft		
4-Conductor, M/M, EIA/TIA-232, 25 ft		
4-Conductor, M/M, EIA/TIA-232, 50 ft		
4-Conductor, M/F, EIA/TIA-232, 10 f.		
4-Conductor, M/F, EIA/TIA-232, 25 ft		
4-Conductor, M/F, EIA/TIA-232, 50 ft		
9-Conductor, M/M, EIA/TIA-232, 10 ft		
9-Conductor, M/M, EIA/TIA-232, 25 ft		
9-Conductor, M/M, EIA/TIA-232, 50 ft		

Spare Parts Lists

This chapter contains tables that list the spare parts for the VCO/4K system (contact your Cisco Systems sales representative for current assembly numbers and prices):

- Table 4-1 lists the System Spares Kit and kit replacement parts.
- Table 4-2 lists the Power Subsystem spare parts.
- Table 4-3 lists the port interface and service circuit card spares.
- Table 4-4 list the miscellaneous spare parts.

Table 4-1 System Spares Kit and Replacement Parts

System Controller Spares	Assembly Number	Quantity[1]
System Spares Kit		1
System Spares Kit Contents (quantity)		
CPU[1]		
SWI/Floppy/Carrier Assembly[1]		
Storage/Control I/O Module[1]		
Alarm Arbiter Card (AAC)[1]		
Network Bus Controller 3 (NBC3)[1]		
Digital Tone Generator 2 (DTG-2)[1]		

1. Typically order one per system.

Table 4-2 Power Subsystem Spare Parts

Power Subsystem Spare Parts	Assembly Number	Quantity
–48 VDC Power Supply Module		
120 VAC Power Supply Module		

Table 4-3 Network Interface and Service Circuit Card Spares

Variable Item Spares	Quantity	Assembly Number
Interface Controller Card (ICC) with 16 Span T1 I/O Module		
Interface Controller Card (ICC) with 8 Span T1 I/O Module		
Interface Controller Card (ICC) with 4 Span T1 I/O Module		
Interface Controller Card (ICC) with 16 Span E1 I/O Module		
Interface Controller Card (ICC) with 8 Span E1 I/O Module		
Interface Controller Card (ICC) with 4 Span E1 I/O Module		
IPRC (8 port)		
IPRC (64 port)		
IPRC (128 port)		
Subrate Switch Card (SSC)		
Service Platform Card (SPC)		
Service Resource Module (SRM)		
D+I Card		

Table 4-4 Miscellaneous Spare Parts

Power Subsystem Spare Parts	Assembly Number	Quantity
Fan Unit		
Spare Fuse Kit (AC or DC)		
Ring Generator (optional)		

Software and System Capacity

System Configurations

Performance is most critical in heavily loaded and fully configured systems; this chapter deals primarily with systems that have these types of configurations.

This information is derived from testing that closely simulates real-world system configurations. Your system may, because of the many variables involved, need some further tuning to achieve desired results. The guidelines presented in Chapter 6 apply to all systems and will ensure the most effective results.

Software Functionality

When the information in this chapter is influenced by the VCO/4K system software, functional downloads to hardware, or chosen protocols, specific information is provided. The effect of host application software is beyond the scope of this information. Cisco recommends that you closely coordinate your system hardware configuration with your host application developer.

Scalability

Performance, configuration, and system scaling are all closely interrelated. Refer to this guide if you are adding hardware or functionality to an existing system. System expansion is easier and more efficient if the system was configured from the beginning with consideration for future performance as well as for initial needs.

Current Performance Capacities

Many factors contribute to total system performance. This chapter identifies those factors that are influenced by the VCO system design. Several call models based on real-world customer installations are also presented to illustrate how systems have been configured to meet specific needs.

Overview of Performance Limits

All VCO systems have an A bus and a B bus, which together allow access to approximately 2,000 ports (2K systems). Only VCO systems that are equipped with a C-bus hardware kit are capable of accessing approximately 4,000 ports (4K systems).

Note All VCO/4K chassis have the C-bus kit installed at the factory. The C-bus kit must be installed, if needed, in the VCO/20 chassis.

The extended mode API for 4K systems supports increased addressing capability as a result of the C-bus. Both 2K and 4K systems can use the extended mode API, but only 4K systems have access to 4,000 ports.

Often it is best to develop an application in extended mode API even for 2K systems. Frequently 4K systems are later added to an installed base; thus applications written for 4K mode will run in either system.

Table 5-1 describes the interoperability between the two modes and the two APIs.

Table 5-1 Relationship Between 2K Mode and 4K Mode Systems and the Standard and Extended API

	API	
Operating Mode	**Standard**	**Extended**
2K mode (no C-bus)	Yes	Yes
4K mode (C-bus)	No	Yes

System performance, as measured by call rate, depends on the following:

- The call models that are being used
- The protocols employed
- Individual card hardware design limits
- Interactions between cards (especially the SPC/ICC relationship in 4K systems, at present)
- The host hardware (and the application software on the host)
- The complexity of the call handling, and other functionality choices particular to the installation
- Network traffic on a host-controlled system

A 2K system is limited to two internal time division multiplexing (TDM) buses, identified as the A and B buses. The addressing capacity for each bus is 1024 time slots, or 2048 time slots in total. Of this total, some time slots are used by the system. If a 2K switch is properly configured and takes into account the limits of other resource capacities, it can support up to 1936 nonblocking ports (see Table 5-2).

Table 5-2 Time Slots Available—No C-Bus

Time Slots	T1 Spans	E1 Spans
Total	2048	
Reserved	112	
DTG	128	
Available for use	1808	
Used by network interfaces	1800	1760
Available for services	8	48

A 4K system has an additional TDM bus called the C-bus. Systems with this bus enabled are considered 4K systems. When the C-bus is enabled, it adds 2048 time slots to the switch capacity. A properly configured 4K system, operating within the limits of other system resources, can support a total of up to 4088 nonblocking ports (see Table 5-3).

Table 5-3 Spans Supported—With C-Bus

Bus / Total Spans	T1 Spans	E1 Spans
C-bus	85	64
B-bus	37	28
A-bus	42	31
Total spans supported	164	123

Design Limits

The VCO system places fixed limits on many resources as a part of its design. These limits are listed in Table 5-4.

Note The resource limits shown in Table 5-4 are the maximum design limits supported by the system. Under certain load conditions these limits may not be achieved. In addition, capacities are not cumulative—not all maximums may be supported at the same time.

Table 5-4 Fixed Resources

Resource	Unit of Measure	Limit/Value (with ICC/SPC cards only)	
		2K mode	4K mode
Total inpulse rules	per system	30	255
Total outpulse rules	per system	30	255
Max tokens per rule	per system	16	16
Resource groups	per system	63	224
Members of a group	per system	999	1920

Table 5-4 Fixed Resources (continued)

Resource	Unit of Measure	Limit/Value (with ICC/SPC cards only)	
		2K mode	4K mode
Virtual ports	per system	255	999
TeleRouter			
Tables	per system	10	10
Patterns	per system	1000	1000
Host Ethernet sockets	per side[1]	8	8
Start and end records	per system	3200	3200
Call capacity	per system	Call model dependent.	Call model dependent.
Conferences			
Total active conferences	per system	255	255
Maximum talk/listen legs	per conference	7 2-way-legs[2] + n 1-way-legs[3], or 8 2-way-legs[2]	7 2-way legs[2] + n 1-way legs[3], or 8 2-way legs[2]
Outpulse Channels	per DTG	63	63
NFAS (network and call model dependent)			
One NFAS Group (up to 20 spans)	number of ports	478B+2D, 479B+1D	478B+2D, 479B+1D
IPRCs (nonredundant/redundant)	per system	4/8	4/8
Minutes per IPRC	per card	35 minutes	35 minutes[4]
IPRC libraries	per system	16	16
IPRC prompts	per library	256	256
Time slots	per system	up to 1936	up to 4088
Total ISDN message templates	per system	96	96
Message template capacity (ISDN)	per system	15 tokens	15 tokens
Total supervision templates (Answer)	per system	24	24
Total host links (5-8 - host, 1 - telnet, 2 - SNMP)	per side	8	8
Ports (with SPC cards)			
CPA	per DSP	32	32
Conference	per DSP	32[5]	32[5]
DTMF	per DSP	32	32
MFR1 (displays as MFRC)	per DSP	32	32
MFCR2	per DSP	24	24

Table 5-4 Fixed Resources (continued)

Resource	Unit of Measure	Limit/Value (with ICC/SPC cards only)	
		2K mode	4K mode
OUTPL[6]	per DSP	63	63
SPC Cards			
SRM/SPC	per SPC card	4	4
DSP/SRM	per SRM	8	8
DTG/DTG-2 outpulse channels	per card	63	63
Card IDs (see Card ID Design Considerations, page 5-6)	per system	0 to 239 (240 total)	0 to 239 (240 total)
SPC-TONE	per system	64	64

1 The number of Ethernet sockets that are enabled (and used) affects system call processing throughput.
2 A 2-way-leg is a port (leg) that has talk and listen capability.
3 A 1-way-leg is a port (leg) that has listen-only capability.
4 IPRC is play-only in 4K mode.
5 For 3-way conferences the limit is 30 (of 32) usable ports.
6 SPC outpulse channels were not supported prior to V5.1(2).

System Capacities

This section summarizes performance guidelines that can be used to optimize your system. These guidelines are based on Cisco Systems test results and field deployments.

Existing Capabilities

This section contains recommendations and examples to illustrate changes that were implemented at field sites to improve performance.

Configuration Guidelines for VCO/4K Systems with Service Circuits

Service circuits include: SPC-DTMF, SPC-CPA, SPC-MFR1, SPC-MFCR2, SPC-CONF, SPC-TONE, and SPC-OUTP (V5.1(2) and later).

Note In VCO/4K systems having both SPC and DTG OUTP resources, do not change the status of a DTG card to out of service unless you first verify that the SPC-OUTP card is in service and is added to a resource group.

Table 5-5 lists current issues and possible solutions for systems with the SPC card.

Note The primary purpose of the SPC card configuration suggestions in Table 5-5 is to maximize throughput in high-traffic situations. This does not mean that an SPC card will not support more than two SRMs. The core idea is to evenly distribute the load across SPCs, SRMs, and DSPs.

Table 5-5 SPC Card Capabilities

Issue	Recommendations for Improving Performance
To maximize simultaneous seizures (SPC-DTMF)	Physically interleave the DSPs as you assign them to resource groups. For example: 1-1-9-1-1 1-1-10-1-1 1-1-9-1-2 1-1-10-1-2
SRM module distribution on SPC cards	Whenever possible, distribute the SRM load over the SPC cards evenly. Instead of using one SPC with four SRMs, use two SPCs with two SRMs each.
DSP algorithms	Configure the DSPs on an SRM with different resource types. Rather than configuring all DSPs on an SRM for DTMF type, for example, interleave them with CPA type (depending on the call model) from the Card Maintenance screen.

Configuration Guidelines for VCO/4K Systems with ICC Cards

Table 5-6 lists the current issue and possible solutions for systems with the ICC card.

Table 5-6 ICC Card Capabilities

Issue	Recommendations for Improving Performance
ICC Card Resource Groups	Interleave resource groups such that the same SRM/DSP within a group or same set of ICC spans do not assume most of the load. ICC resource groups should be set to cyclic hunting. For maximum performance, the load per ICC card should be limited. Ensure that the NBC3 card LP-140 is at the latest revision.[1] Physically check boards to ensure that all other cards are at the latest revision[1].

1. Refer to the Cisco VCO/4K System Software Version 5.x(x) Release notes for each release.

Card ID Design Considerations

The system is designed to permit no more than 240 card IDs (0 to 239) in total.

A card ID is assigned to every resource based on the card type. A single-span card is assigned a single ID, a multispan card is assigned an ID for each span. For example, a 4xT1 would be assigned four IDs, and an ICC card with 16 spans would be assigned 16 IDs. An SPC card is assigned an ID for each DSP configured. Therefore, an SPC card with a full complement of SRMs and DSPs would be assigned 32 IDs. All resources require a card ID, but not all resources added to a VCO/4K take up time slots. DTMF, MF, and CPA resources do not take up time slots.

The number of IDs assigned can become an issue in cases where, for example, a system needs to be configured with 160 T1s, (160 card IDs) and it also needs 12 SRMs (configured for DTMF, MF, and CPA—96 card IDs). This results in a total of 256 IDs for these cards, and the system is then exhausted of card IDs before all the card resources can be added.

In most system configurations, as resources are added which take up time slots, the system runs out of time slots before the card ID limit of 240 is reached. However, since DTMF, MF, and CPA do not take up time slots but they are assigned a card ID, a potential exists where adding a large number of DTMF, MF, or CPA resources could result in a configuration where a system could run out of card IDs.

If your system requires a large number of DTMF, MF, and CPA resources, then carefully plan the ID resources in accordance with the number of T1 spans in your system.

ICC-T1 Mixed Protocols

The ICC-T1 can be configured with many combinations of ISDN and non-ISDN protocols. Support is limited to a maximum of two protocols per ICC. Due to the vast number of combinations, Cisco Systems has not tested all possible span/protocol combinations. Do not configure the ICC-T1 with any combination of ISDN and non-ISDN protocols unless it has been tested by Cisco Systems.

Table 5-7 lists the mixed protocols tested by Cisco Systems.

Table 5-7 ICC-T1 Mixed Protocols Tested by Cisco Systems

	Test Combination		
Test	Group/Span	Group/Span	Result
1	ICC-T1, SF/AMI, E&M	ICC-T1, ESF/B8ZS, E&M	Pass
2	ICC-T1, ESF/B8ZS, Clear	ICC-T1, ESF/B8ZS, E&M	Pass
3	ICC-T1, ESF/B8ZS, Clear	ICC-T1, SF/AMI, E&M	Pass
4	ICC-ISDN, ESF/B8ZS, NTI	ICC-T1, ESF/B8ZS, E&M	Pass
5	ICC-ISDN, ESF/B8ZS, NTI	ICC-T1, SF/AMI, E&M	Pass
6	ICC-ISDN, ESF/B8ZS, NTI	ICC-T1, ESF/B8ZS, Clear	Pass
7	ICC-ISDN, ESF/B8ZS, 4ESS	ICC-T1, SF/AMI, E&M	Pass
8	ICC-ISDN, ESF/B8ZS, 4ESS	ICC-T1, ESF/B8ZS, Clear	Pass
9	ICC-ISDN, ESF/B8ZS, 4ESS	ICC-T1, SF/AMI, Clear	Pass
10	ICC-ISDN, ESF/B8ZS, NI2	ICC-T1, SF/AMI, E&M	Pass
11	ICC-ISDN, NFAS	ICC-T1, ESF/B8ZS, E&M	Pass
12	ICC-T1, SF/AMI, FXOLS	ICC-T1, SF/AMI, FXOGS	Pass
13	ICC-T1, ESF/B8ZS, FXOLS	ICC-T1, SF/AMI, FXOGS	Pass
14	ICC-T1, ESF/B8ZS, FXOLS	ICC-T1, ESF/B8ZS, FXOLS	Pass
15	ICC-T1, SF/AMI, FXOLS	ICC-T1, ESF/B8ZS, FXOLS	Pass
16	ICC-T1, SF/AMI, FXOLS	ICC-T1, SF/AMI, FXSLS	Pass
17	ICC-T1, SF/AMI, FXSLS	ICC-T1, SF/AMI, FXSGS	Pass

Table 5-7 ICC-T1 Mixed Protocols Tested by Cisco Systems (continued)

Test	Test Combination		Result
	Group/Span	Group/Span	
18	ICC-T1, ESF/B8ZS, FXSLS	ICC-T1, SF/AMI, FXSGS	Pass
19	ICC-T1, ESF/B8ZS, FXSLS	ICC-T1, ESF/B8ZS, FXSLS	Pass
20	ICC-T1, SF/AMI, FXSLS	ICC-T1, ESF/B8ZS, FXSLS	Pass

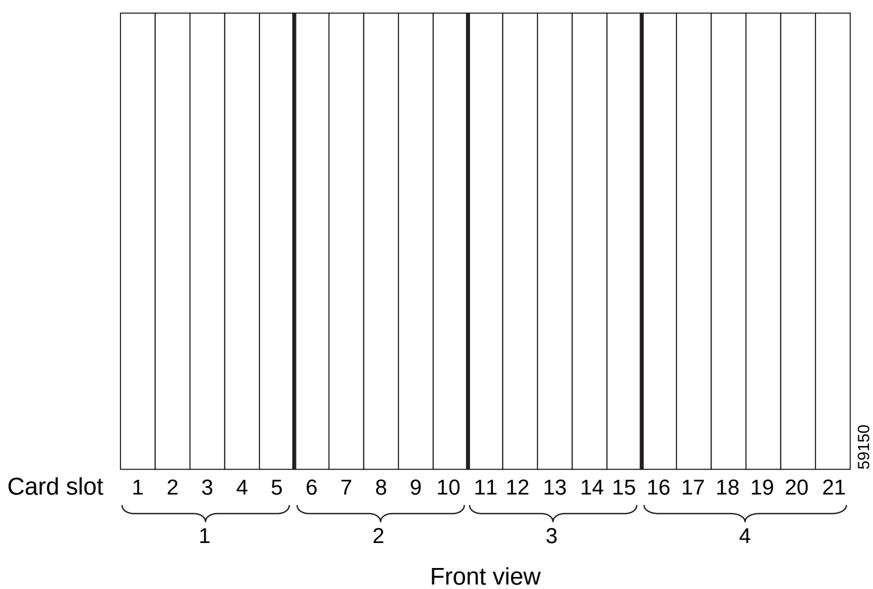
Guidelines for Matching Database and Physical Cards

System performance can be improved if you ensure that the database assignments correspond to the physical cards in the system. In particular, you should not have ICC spans defined that are not connected but which are in a maintenance state or an alarm state. The system will poll these spans as though they were active. This is unnecessary overhead.

Power Distribution Guidelines

The DC power is distributed to the midplane in four quadrants in a VCO/20 or VCO/4K system. These translate to slots 1 to 5, 6 to 10, 11 to 15, and 16 to 21. (See Figure 5-1.) If fully loaded SPC cards are installed in a single quadrant, they may draw enough current during download to compromise the midplane power distribution. Distribute SPC cards in separate quadrants to alleviate this problem. Because there are two NBC cards and two Combined Controller cards in a redundant system, only three quadrants (2, 3, and 4) are available in those systems.

Figure 5-1 Four VCO Midplane DC Power Distribution Quadrants



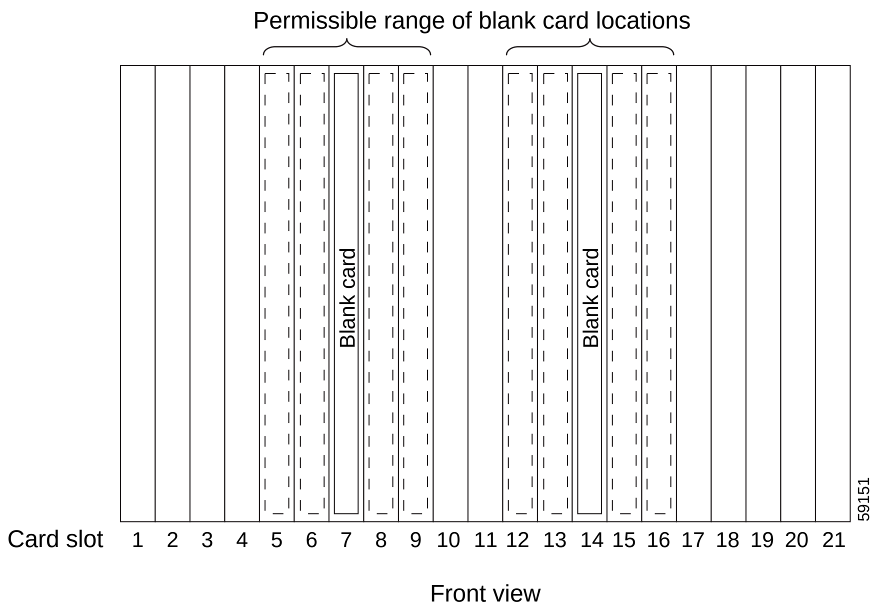
Blank Cards Required to Maintain NEBS Compliance

Depending on the system you ordered, your VCO/4K may have been shipped with two blank cards that are integral to maintaining NEBS GR-63-CORE compliance for the system. These cards have a metal blade in place of the usual PCB. The metal blade compartmentalizes the system to retard the propagation of fire within the card cage. (See Figure 5-2.)

These blank cards must remain within two slots of their original locations (normally, systems are shipped with the blank cards in slots 7 and 14). If the system is fully loaded, these cards may be replaced by functional cards.

Note The blank cards are an additional requirement to a full complement of blank faceplates on unused slots. Both are required.

Figure 5-2 Location of Blank Cards for NEBS Compliance



Scalability from Single Span and 4xE1/T1 Cards

The migration from single span and 4xE1/T1 port interface cards to ICC 8- and 16-span cards does not support a direct scaling of capacity.

The system and card limits are a result of design limitations at several points in the overall capacity. As an example, a 16-span ICC card will not carry 16 times the number of calls that a single-span card would.

The ICC card has the following advantages:

- Greater physical port density
- Reduced cost per port

System Configuration Guidelines

This chapter describes the issues to consider when putting together a new system or upgrading an existing system.

Ethernet Connections

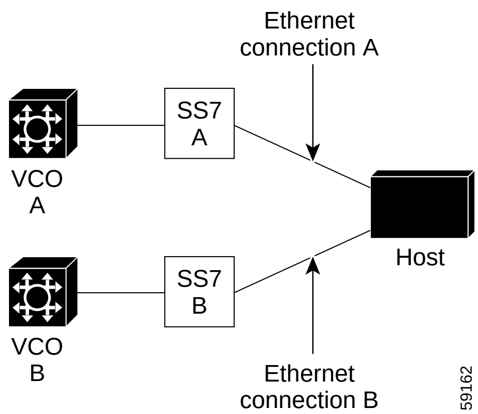
A dedicated Ethernet connection for your host-to-switch connection and for SS7-to-switch installations eliminates contention delays imposed by other traffic. Sites where the connection is shared with other business traffic may function adequately until either the host-to-switch traffic or the other traffic increases to the point where delays are incurred. The number of open sockets affects the available call processing time on the VCO's CPU.

Note Multiple VCO hosts may not necessarily mean multiple physical hosts. For example, in an SS7 configuration the circuit interworking box acts as a gateway to the VCO system and supports up to eight physical host connections with the VCO.

Ethernet Connections and Redundancy in SS7 Systems

Cisco cannot guarantee that systems configured with a single Ethernet connection between the host and the SS7/VCO pairs (see Figure 6-1) will successfully do a switchover from the active to the standby sides if only Ethernet connection A (or B) is installed. If the feature flag to allow switchover upon host link failure is set, switchover does not occur unless both Ethernet connections A and B are installed.

Figure 6-1 Ethernet Connections and SS7/VCO Redundancy Switchover



SS7 Stacks for Country Variants

The following country SS7 stacks variants are available:

- ANSI—Used in North America.
- ITU—Used outside North America.
- China TUP—Used in China.

Note Contact your Cisco sales representative for the list of available country variants.

ARP Cache Entries

Note The following information applies only to system software prior to V5.1(2).

The VCO does not correctly respond to an Address Resolution Protocol (ARP) message requesting a Media Access Control (MAC) address. Instead of sending a reply to the requesting device, it responds with a broadcast message.

For example, host A sends a broadcast ARP message to a VCO switch with IP address x.x.x.x requesting the MAC address of the switch. The switch responds with a broadcast ARP reply. Because host A did not receive the needed MAC address, it must always send a broadcast ARP request whenever it wants to communicate with the switch. Repeated broadcast messages cause congestion on the Ethernet network.

The workaround (prior to V5.1(2)) is to statically define the VCO's MAC address (both sides, if redundant) in the devices that are likely to send an ARP message for the VCO's MAC address. This includes hosts, routers, SS7 stations, VRUs, and so forth.

Note Refer to the product manual of each device for instructions on how to statically define (force) a MAC address into its ARP cache.

TeleRouter as Host Backup

The TeleRouter functionality is built into the VCO/4K as a virtual host. It can be configured to do automatic call handling and routing without host intervention. It can also be configured to do backup call handling. This means that the TeleRouter virtual host can take over in the event of loss of communication between the VCO and the host. The following are given as some of the configuration changes needed to use the TeleRouter as a host backup:

- The host application must be designed to work with TeleRouter
- Use inpulse rules to accept the incoming call
- Use REP EACH to capture all digit fields
- Use WAIT TIME to pause the call
- Set up the host to abort the inpulse rule and send a message to route the call under normal circumstances
- If the host does not abort the rule, the TeleRouter ROUTE token takes over after the WAIT TIME expires

Another example could use the Host setup timer and a NOHOST token in the inpulse rule.

Note This backup mechanism must be carefully tested before being placed in service. This mechanism does not work with SS7 systems.

For more details on using the TeleRouter, refer to the *Cisco VCO/4K TeleRouter Reference Guide*.

Calculating Resource Needs

When you are designing a new system to meet specific needs, determine the hardware requirements of the switch. Alternately, you may want to determine if a defined system will satisfy the needs of a specific site. You can work from a base of the available time slots that are a function of physical system constraints. From that base, and a given card population, you can determine what can be allocated.

For either approach, you must also consider what effect the host application might have.

Note This section provides guidelines for resource calculation. Final system design requires input and guidance from a Cisco Systems Engineer (SE).

Calculating Loading

Use the following steps to determine the resources required to support a given call loading:

Step 1 Determine the call loading on the switch, based on the following:

- Incoming traffic load
- Time required to complete the transaction; for DTMF ports, the digit collection time
- Grade of service—usually P.01 (1% blocking)

Traffic load can be based on the following:

- Busy hour call (BHC), if known.
- Million minutes per month. Calculate the calls per day and then use the percentage of calls in the busy hour. With this information you can calculate backward to obtain BHC rate.

In addition to BHC or the calculated rate (above), you need the average call hold-time.

Assume the calls arrive uniformly for the hour. (This has been proven reliable in actual practice.) Simultaneous seizures are usually not an issue in this calculation.

Step 2 Determine the call flow.

a. Calculate the following, based on the call rate and expressed in erlangs. Erlangs are based on a statistical distribution of call arrivals and average call times. Erlang-B is best for voice traffic:

- How many network ports are needed?
- How many connections are needed for VRU and other application-specific peripherals?
- How many ports are needed for resources (DTMF, for example)?

The above calculations result in a total port count.

b. From the port count, calculate the number of E1/T1 spans needed.

The difficulty in assigning a number to the resource port needs is because it is heavily call model dependent. You should work with the application developer to define the needed resources—where, when, and for how long. This may be mostly DTMFs used to tie to external IVR resources.

c. From the port count, calculate the number of SPC/SRMs needed.

Step 3 Determine signaling requirements.

a. Note the following:

- With SS7 or PRI there is no in-band signaling.
- If in-band signaling is used, it is usually MF or MFCR2.
- With MF you need a port for a short time—6 seconds or so.

b. Perform the same erlang analysis as for the voice traffic (Step 2 a.), but for a time of 4 to 8 seconds (typical) rather than the average call time.

Note the following:

- MFCR2 is an international requirement and is the same as MF. The only exception is that it is two-way. Use 10 to 12 seconds in your calculations.
- CPA usage is typically 20 seconds or so. Generally, the CPA determines a busy condition or an answer before it gives back the port.
- A special (and relatively unusual) situation occurs when the interface is not to a switch or is to a connection that does not have answer supervision. This requires that the CPA listen for voice (actual answer by a person) or a hang up. This could result in the CPA being connected for the entire call. This occurs occasionally on international calls. The erlang analysis for this component is therefore based on the entire call time.

Step 4 Determine conferencing requirements.

This involves passing ports to external IVRs for messages or other interactive functions. The IVR passes the port back, but the IVR requires the port for a while. This means that there is a three-way call during this time (in/out/IVR). Typically this is for 20 seconds or so. By the very nature of conferencing, you must assume that three ports are in use for a portion of the call.

Step 5 Determine IPRC usage requirements.

IPRC prompts need a port for about 6 seconds. On rare occasions, such as when a user supplies music, the time requirement can extend over a much longer time.

Step 6 Calculate resource requirements.

As an example:

a. Calculate MF ports when no call loading is given, by doing the following:

Convert ports to erlangs. This is the total number of incoming network ports. With a 1% grade of service, and a trial and error approach, consult erlang tables to identify the erlang value that represents the number of ports you have. (Start with a number 3% to 6% less than the number of ports.)

Unless you have been given the Average Call Hold Time (ACHT) for the application, assume 3 minutes.

b. Use the following equation to convert erlangs to BHCs:

BHC = erlangs x 3600/ACHT (in seconds)

With this incoming BHC you can calculate the MF ports required. For MF ports you can assume that the average hold time is 6 to 10 seconds to deal with the ANI and DNS. The port is normally released back to the pool after this time.

c. Use the following equation to calculate the number of MF erlangs:

MF erlangs = BHC/3600/MF AHT (in seconds)

d. Use the erlang tables to convert erlangs to a number of MF ports.

Note Erlang B values can be calculated using formulas found in various telecommunications sources. Tables of calculated values also exist that can help you determine loading for a specific customer.

Other Considerations

The longer the average call, the less that is required of the CPU. Conversely, shorter calls tend to place more load on the CPU. Longer calls are very likely to require more system physical resources.

When the system is heavily loaded, the system CPU is taxed to the point where the system console may respond slowly.

Port/Time Slot Allocation

Port/time slot allocation does not affect system performance. However, an understanding of the allocation algorithm is useful when you perform system configuration. You can achieve more efficient port assignments if you know how the system is designed to allocate physical resources. Allocation varies by system type and by span type.

Time Slot Availability

The fundamental difference between 2K and 4K systems is time slot availability as a result of the C-Bus. There are also a small number of additional time slots used by the 2K system that are freed up to become a resource in 4K systems.

To achieve maximum efficiency when a system is heavily loaded, it is useful to know how allocation actually happens. Within a span, time slots are contiguous, but the spans/service do not necessarily have to be adjacent to other spans on the same card.

The 0 to 7 bit section at the beginning of the A-bus is unavailable for either 2K or 4K systems. It is a VCO/4K system software limitation and results, in a 4K system, in the total time slot availability actually being 4087 rather than the binary 4K of 4096.

Time Slot Availability in a Fully Licensed VCO/4K

Use the following guidelines when you configure time slots and logical interfaces in your fully licensed VCO/4K system:

- Listen and transmit time slots—4088.
- Listen-only time slots—4000 (these are separate from the listen and transmit time slots).
- Logical number of time slots—240. A logical number is defined as one interface or card number. For example, a fully loaded ICC constitutes 16 logical time slots. An SPC can have 32 logical time slots. It is not possible to have more than 240 logical time slots.

Note If you exceed these maximum numbers as you configure your system, error messages are generated in the system log file. Refer to *Cisco VCO/4K System Messages* for more information.

Span and Slot Availability–C-Bus Disabled

Figure 6-2 shows the available time slots for a 2K system (C-bus disabled).

Figure 6-2 Time Slot Availability by Bus—C-Bus Disabled

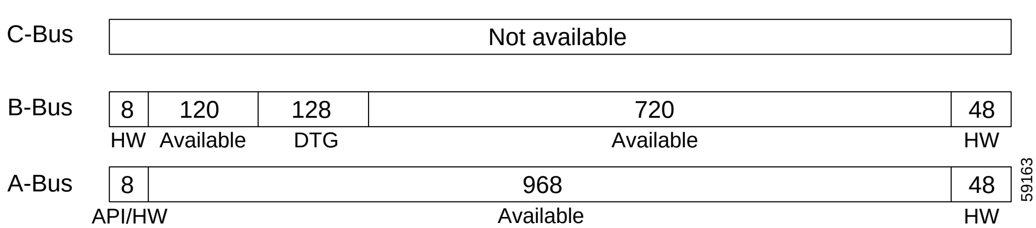


Table 6-1 lists the number of spans supported.

Table 6-1 Spans Supported—No C-Bus

Bus / Total Spans	T1 Spans	E1 Spans
C-bus	0	0
B-bus	35	25

Table 6-1 Spans Supported—No C-Bus (continued)

Bus / Total Spans	T1 Spans	E1 Spans
A-bus	40	30
Total spans supported	75	55

See Table 5-2 on page 5-2 for a list of the number of time slots available.

Span and Slot Availability–C-Bus Enabled

In a 4K system with a C-bus, all the space above 2K can be used. Figure 6-3 shows the available time slots for a 4K system.

Figure 6-3 Time Slot Availability by Bus—C-Bus Enabled

Table 6-2 shows the number of time slots available.

Table 6-2 Time Slots Available—With C-Bus

Time Slots	T1 Spans	E1 Spans
Total	4096	
Reserved	8	
DTG	128	
Available for use	3960	
Used by network interfaces	3936	
Available for services	24	

See Table 5-3 on page 5-3 for a list of the number of spans supported.

Time Slot Considerations for Older Cards in a VCO/4K System

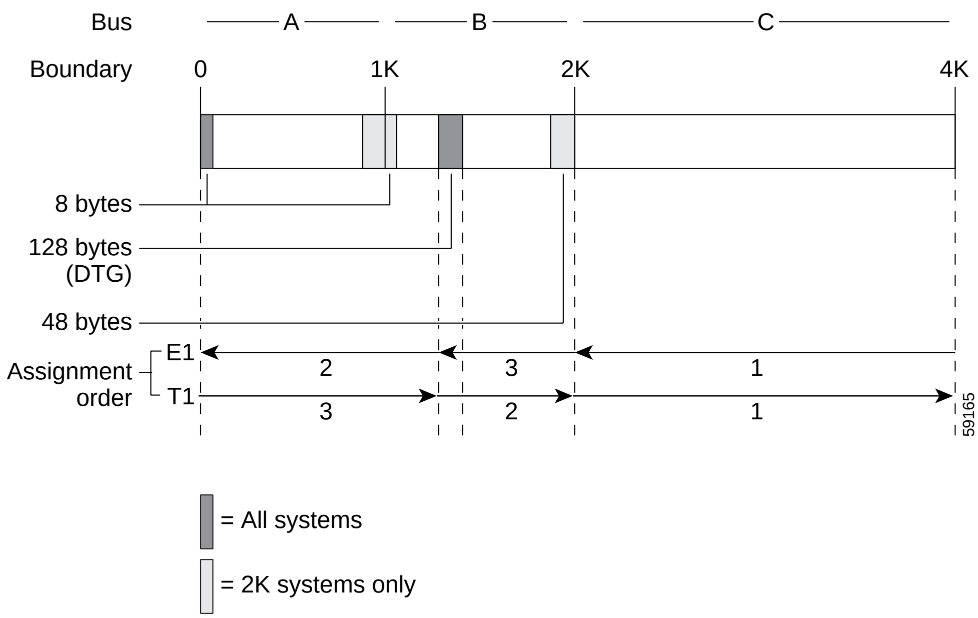
Older cards (such as IPRC, D&I, LTC-8) installed in VCO/4K systems must obey the following rules:

- An IPRC-64 (for example) requires 64 consecutive time slots on the A- or B-bus (The C-bus cannot be used, the port addresses must be less than 08 00).
- The time slots must not straddle bus boundaries (the A- to B-bus boundary is 03 FF to 04 00).
- The unavailable ports on a VCO/4K system are: 00 00 to 00 07 and 04 80 to 04 FF.

Time Slot Mapping by Bus Type

The manner in which time slots are assigned depends on the nature of the span (E1 or T1). E1 spans are assigned in multiples of 32 and T1 spans in multiples of 24. The order in which the three possible segments (from 0 up: 1st K, 2nd K, or 3rd 2K) is also a function of span type (see Figure 6-4).

Figure 6-4 Time Slot Mapping



When allocating E1 spans to a 4K system, the allocation order proceeds from the top down (in general): 4095 to 2048, 1151 to 8, and then 2047 to 1152 (no DTG). If you are adding E1 spans, the first span would go in 4064 to 4095, then 4032 to 4063, and so on; then 1120 to 1151, 1088 to 1119, and so on; and then 2016 to 2047, and so on.

When allocating E1 spans to a 2K system, the allocation order also proceeds from the top down but has to skip the holes created by hardware limits (see Figure 6-2, Figure 6-4, and Table 5-2 on page 5-2).

When allocating T1 spans to a 4K system, the allocation order proceeds from the bottom up: 2048 to 4097, 1280 to 2047, 8 to 1279 (no DTG). The first span would be 2048 to 2071, and so on.

When allocating T1 spans to a 2K system, the allocation order also proceeds from the bottom up but has to skip the holes created by hardware limits (see Figure 6-3, Figure 6-4, and Table 5-2 on page 5-2 and Spans Supported—With C-Bus, page 5-3).

Time Slot Assignment

Table 6-3 describes how several time slot assignment parameters are handled by 2K and 4K systems.

Table 6-3 Time Slot Assignment Parameters by Bus Type

Parameter	2K (Non-C-bus)	4K (C-bus)
When assigned to a card	When added to the database	When added to the database

Table 6-3 Time Slot Assignment Parameters by Bus Type (continued)

Parameter	2K (Non-C-bus)	4K (C-bus)
Assignment by card port capacity	Full capacity (contiguous)	Partial capacity (noncontiguous)
Assignment of unused slots	Time slots must be contiguous All time slots assigned to a card must be on the same bus	Unused slots flexibly assignable (span-by-span) to any Type 2 card[1]

1. The network type 2 card is the ICC card.

VCO/4K Companding Algorithms

A VCO/4K is configured to use only one companding law internally. The following terms are synonymous and refer to the companding law:

- Backplane law
- DTG/DTG2 law
- Internal law
- System law

Backplane law was previously the most popular choice, system law has become the terminology of choice with VCO/4K. All tones are generated (for example, DTG) and interpreted (for example, SPC and CPA) under whichever law (A or mu) is set for the system law. In other words, all service cards in a given switch operate under the law that is set as the system law.

Note The DTG law for each DTG/DTG2 card is specified in the *Cisco VCO/4K Tone Plan Release Notes*.

For older cards (for example, PRI/N, CPA, and 4xT1), the system law is set individually on each card by a hardware jumper. New cards (for example, SPC and ICC), get the system law via software from the system-law feature flag from within the System Features screen. This feature flag is Set system to A-law, where Y sets the system law to A and N sets it to mu. All of these settings (jumpers on the cards and the feature flag) must match, either all mu or all A.

For connections to the network, the companding law is set via software to match the particular network connection. For older cards, it is set for each span, in the upper section of the span configuration screen. For the ICC, the law is set for each port/channel in the lower portion of the configuration screen, so it can be set differently for different ports in the same span. (An exception is an ICC span configured for ISDN. Then, as with the older cards, the law setting is done for all channels on the span at once.)

Note Companding law is specified from the Database Administration menu. See the *Cisco VCO/4K Tone Plan Release Notes* for more information.

If the law setting for a network connection matches the system law, no conversion is done. If the law setting doesn't match, then the PCM stream is converted before further processing is done by the switch. The conversion is done on the network card.

In the worst case, if for example the system law is set to A, and a call comes in via an ICC configured as mu and goes out on a PRI/N configured as mu (but jumpered to A), then the PCM stream will be converted twice, mu-to-A by the ICC then A-to-mu by the PRI/N, even if there is no law-dependent internal processing (such as tone generation) done on the call.

The VCO can process A law and mu law calls simultaneously because they are all converted to whatever the system law is.

The ICC has a third choice, SYS, for port law settings. You should not do any conversion—assume the network connection uses the same law as is configured for the system. The SYS choice is typically used for data channels such as an SS7 stream.

Note The older cards do not have the SYS choice in the configuration screen. For any spans carrying data, you must ensure that you set the span law the same as the backplane law.

You cannot set the law for ISDN D-channels and E1 framing channels; the network card knows not to convert those.

Association Between Tones and the Companding Law

The DTG/DTG2, which does only tone generation, has the encoded waveforms stored directly as tables of bits in the firmware. For each tone plan, you have to install a separate set of DTG firmware, with its own set of proms. The bit pattern in each table is the A- or mu-law encoded form of the particular waveforms, as determined by the tone plan's requirements.

The SPC has the A- or mu-law conversion embedded in the DSP software. The basic DSP algorithms do their work internally with linear 16-bit representations; the outgoing stream is then compressed into 8 bits (in the case of tone generation), or the incoming stream is first expanded from 8 bits (in the case of tone interpretation), by a layer of DSP software that performs the compression/expansion for either A or mu law, whichever is set as the system law.

APPENDIX A

Service Circuit Channel Requirements

This appendix provides guidelines to help you determine the number of DTMF Receiver channels (SPC-DTMF), MF Receiver channels (SPC-MF, displays as SPC-MFRC) and/or Integrated Prompt/Record Card (IPRC) channels required to maintain a desired grade of service in a variety of VCO/4K system configurations.

Note Because of the complexity and variability in conference calls, this appendix does not address the number of Conference channels (SPC-CONF) required in a VCO/4K application.

This appendix also does not address the number of Call Progress Tone Analyzer ports needed (SPC-CPA).

To account for SPC/SRM and IPRC redundancy, you may need to multiply the number of service circuit channels determined here by a factor of 2.

Estimating Average SPC-DTMF and SPC-MF Channel Total Hold Time

Use the following guidelines to determine your SPC-DTMF and SPC-MF channel requirements:

1. Determine the number of channels needed depending on the SPC-DTMF and SPC-MF requirements of the application. SPC-DTMFs and SPC-MFs are required when the network interface span, configured for in-band signaling, passes digits inbound.
2. To determine the number of receiver channels required in a particular application, use traffic tables which assume constant holding times with lost calls delayed (refer to the “Service Circuits and Traffic Tables” section on page A-3).
3. Setup and holding times (or total hold time) for VCO/4K receiver channels must consider the following variables:
   - In host-controlled applications, the polling time over the communications links, as well as the number of command/report exchanges per call must be factored into the setup time.
   - Setup time varies with grade of service; as the amount of traffic through the system increases, setup time will increase. A timeout occurs if a receiver port cannot be obtained within 3 seconds after receipt of the appropriate command by the VCO/4K.
   - Receivers are generally attached for the duration of an inpulse rule, except where both DTMF and MF receivers are used in the same rule.
   - Receivers can be attached and held indefinitely via host command.

- In many host applications, receiver channels are used in tandem with voice prompts. The receivers tend to remain attached during the setup and holding times for the voice prompt(s). Thus the total holding time for a receiver channel must include the setup time and holding times for IPRC circuits and prompts (refer to the "Estimating Average IPRC Channel Total Hold Time" section on page A-2).

4. Use the most conservative estimate for holding time when using traffic tables to estimate the number of circuits required.

Note The best way to determine setup and holding times is to run simulated traffic through a VCO/4K host application system using the desired call scenario. Accuracy in determining the average holding time will vary directly with the number of simulations and traffic loads.

Estimating Average IPRC Channel Total Hold Time

Each VCO/4K system optionally equipped with voice prompting may include at least two IPRCs (64 or 128 channels each). The second IPRC may be added to the system for load-sharing redundancy. If an IPRC should fail, the system will continue to provide voice announcements as long as the other IPRCs remain functional. If more than 128 IPRC channels are needed, you must add a second set of cards.

Note The VCO/4K system design limits the number of IPRC cards to 8 (four sets of cards).

The key factors in determining the number of IPRC channels in a VCO/4K system are to estimate the number of anticipated calls per hour and to estimate the message time per call scenario.

1. To determine the number of IPRC channels required in a particular application, use traffic tables which assume constant holding times with lost calls delayed (refer to the "Service Circuits and Traffic Tables" section on page A-3).
2. Use the most conservative estimate for holding time when using traffic tables to estimate the number of circuits required.

Note The best way to determine setup and holding times is to run simulated traffic through a VCO/4K host application system using the desired call scenario. Accuracy in determining the average holding time will vary directly with the number of simulations and traffic loads.

The number of voice prompts required per call is reasonably constant, if you assume:

- A 15 to 25 percent margin of error for retries due to a caller's improper entry of information.
- The typical call scenario is consistently applied to all calls made through the system.

Setup and holding times for IPRC channels must take into account a number of variables:

- In host-controlled applications, the polling time over the communications links, as well as the number of command/report exchanges per call scenario must be factored into the setup time.
- Setup time varies with grade of service; as the amount of traffic through the system increases, setup time will increase. A timeout occurs if an IPRC port cannot be obtained within 3 seconds after receipt of the appropriate command by the VCO/4K.
- IPRC circuits are generally attached for the duration of an inpulse rule.

Note For assistance in determining anticipated traffic and VCO/4K service circuit requirements, contact your Cisco Systems Sales Engineer.

VCO/4K Subrate Switch Requirements

The VCO/4K system requires only one Subrate Switch Card (SSC).You can add a second SSC for redundancy. The system does not support more than two SSC cards.

Service Circuits and Traffic Tables

Traffic tables are not provided in this appendix. The information in this appendix, combined with your estimates of anticipated traffic on a group of channels, enables you to use traffic tables. Although you may obtain the recommended traffic tables from a variety of sources, the tables referred to in this appendix are in Theodore Frankel's *ABC Of the Telephone: Traffic Series – Tables For Traffic Management And Design.* See the "Related Documentation" section on page viii.

The tables in Frankel's publication are computer derived and preceded by a detailed explanation of their contents and range of parameters. The book also includes general descriptions of traffic characteristics, examples of the application of traffic tables to practical applications, and a selected bibliography on traffic engineering.

Traffic Management and Design Overview

When determining the number of service circuit channels for your system, ensure that all traffic estimates reflect the volume of traffic anticipated during the system's *busy hour.* Traffic volume is measured in a numeric value. This value indicates the average number of simultaneously existing calls.

The Erlang is the basic unit of measurement for traffic used in traffic tables. One Erlang (60 minutes) is the equivalent of 36 CCS (hundred call seconds) per busy hour.

The following characteristics govern calls into a telecommunications system:

- Relative number of users
- Holding time (elapsed time each call will occupy the DS0 port)
- Servers (number of talking paths available in one group to handle calls offered to them)
- Efficiency of the group of paths that handles the calls

These factors interact to produce the system's grade of service. The industry-standard acceptable grade of service is one to three calls per one hundred finding DS0 ports unavailable.

Traffic tables offer a means for determining the number of service circuits or channel DS0s needed to carry a given volume of traffic in relation to a stated probability of loss. This probability of loss reflects the likelihood that the caller will encounter the all-circuits-busy or unavailable tone.

The assumptions on which busy hour traffic formulas appropriate for VCO/4K systems are based include:

- All calls originate at random (with reference to time).
- Users generate their calls independently of each other.
- Expected traffic density is the same for every user.

- Number of sources is significantly large–approaches infinity.
- A call failing to immediately find a server enters a FIFO (first-in, first-out) queue until one becomes available. When one becomes available, the server is seized and held for a full holding time (lost calls delayed).
- Holding times are constant and equal.

Theodore Frankel's book includes a Master Flow Chart for selecting the proper traffic tables. The path to be followed for VCO systems is as follows:

- Traffic Theory
- Lost Calls Delayed
- Delay Theory
- Constant holding time distribution
- Serve queue first in first out
- Crommelin-Pollaczek
- Tables 8 through 10

The following notations are used in the traffic tables:

A = (calls per hour X holding time (in seconds))/3600 sec/hr = Erlangs

N = Number of servers in a full availability group

L = Number of originating traffic sources

h = Holding time in seconds for which a server is occupied by a call

P = Probability of loss (blocking delay)

P(>0) = Probability of delay greater than *0*

P(>t) = Probability of delay greater than *t*

t = Multiple of holding time *h*

D1 = Average delay on all calls

D2 = Average delay on calls delayed, expressed as multiple of holding time *h*

a = Traffic per source, Erlang

The number of users is assumed to be large (infinite sources), and the probability of any user originating a call is assumed to be the same as that of any other user (equal traffic density per source).

VCO/4K Traffic Engineering Example

The number of network interface channels (DS0s) and/or service circuit resource channels (such as DTMF) needed for the VCO in question to successfully service a given market area is a function of the following:

- The incoming call rate, expressed as a Busy Hour Call (BHC) Rate, that the VCO/4K will be handling.
- The duration of time the service circuit channel is required to complete a call setup transaction. For example, in the case of a DTMF channel, the duration of time for which a DTMF channel is required to complete a call setup transaction is a function of the number of digits to be collected at the beginning of the call.

- The Grade of Service (blocking factor). Usually this is 1% blocking, or P01 Grade of Service, but may be more or less stringent depending upon the requirements of environment.

Two options are shown. The first option assumes a specified BHC rate. The second option assumes a specific number of DS0 channels.

Option 1: Calculating the Required Number of MF or DTMF Channels

Note These calculations assume a specified BHC rate.

MF Channels

Step 1 Use the following equation to calculate the number of MF Erlangs:

MF Erlangs = BHC/3600/MFAHT, where MFAHT is the Average Hold Time for an MF channel expressed in seconds. A common MFAHT is in the range of 6 to 10 seconds.

Step 2 Go into the Erlang tables to convert erlangs to quantity of MF channels.

Step 3 Go to Chapter 1.

DTMF Channels

Step 1 Use the following equation to calculate the number of DTMF Erlangs:

DTMF Erlangs = BHC/3600/DTMFAHT, where DTMFAHT is the Average Hold Time for a DTMF channel expressed in seconds. A common DTMFAHT is in the range of 20 seconds.

Step 2 Go into the Erlang tables to convert erlangs to quantity of DTMF channels.

Step 3 Go to Chapter 1.

Option 2: Calculating the Required Number of MF or DTMF Channels

Note These calculations assume a specified number of network interface channels (DS0s).

Step 1 You need to first make an assumption as to the average hold time for an MF or DTMF channel.

Step 2 Convert network interface channels to Erlangs, and then, using 1% Grade of Service (blocking), by trial and error, use the Erlang tables to identify which Erlang value is representative of the number of ports. Pick an Erlang number that corresponds to 3% to 6% less than the number of network interface channels you need.

Step 3 Make an assumption as to the Average Call Hold Time (ACHT) for the application and express that in seconds; that is, 3 minutes (180 sec), unless you have been specifically given this information.

Step 4 Use the following equation to convert Erlangs to Busy Hour Calls (BHC):

BHC = Erlangs X 3600/ACHT

Step 5 Now that you have the incoming call rate expressed in BHC Rate, you can use this to begin calculating the number of MF or DTMF channels required.

MF Channels

Step 1 Use the following equation to calculate the number of MF Erlangs:

MF Erlangs = BHC/3600/MFAHT, where MFAHT is the Average Hold Time for an MF channel expressed in seconds. A common MFAHT is in the range of 6 to 10 seconds.

Step 2 Go into the Erlang tables to convert erlangs to quantity of MF channels.

Step 3 Go to Chapter 1.

DTMF Channels

Step 1 Use the following equation to calculate the number of DTMF Erlangs:

DTMF Erlangs = BHC/3600/DTMFAHT, where DTMFAHT is the Average Hold Time for an MF channel expressed in seconds. A common DTMFAHT is in the range of 20 seconds.

Step 2 Go into the Erlang tables to convert erlangs to quantity of DTMF channels.

Step 3 Go to Chapter 1.