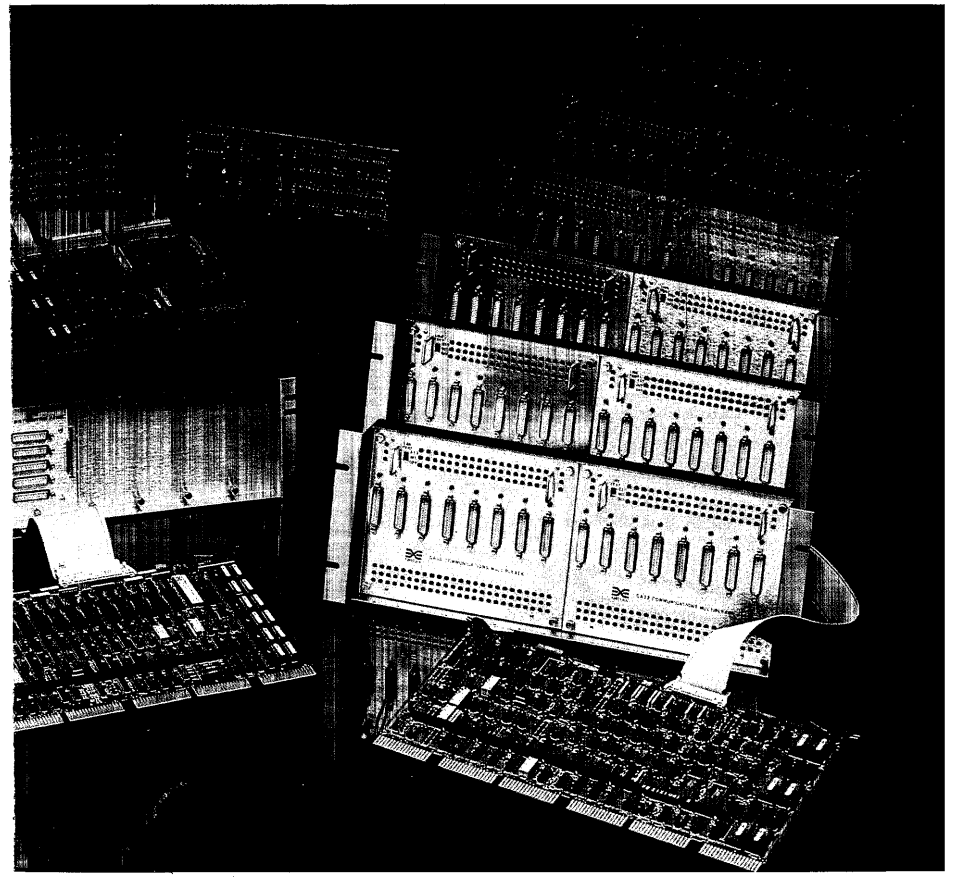
COMMUNICATIONS PRODUCTS HANDBOOK



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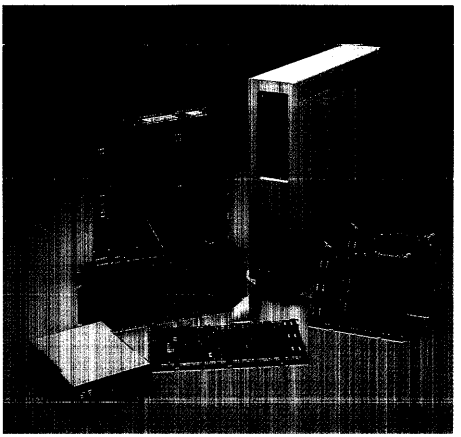

Our Track Record.

Emulex is the acknowledged champion in the field of disk, tape, communications controllers and subsystems for Digital Equipment Corporation (DEC) equipment. In little more than five years we have achieved a performance history for the industry to envy. Emulex controllers have routinely broken all the records for disk, tape and communications capability. And we have earned a reputation for quality and consistency that is second to none.

From the LSI, through the PDP minis, to the high-capability VAX super minis, the Emulex product line has matched and surpassed original equipment hardware across the full line of DEC systems.

Now with the emergence of DEC's new micros such as the MICRO/PDP-11 and MICRO/VAX, Emulex looks forward to proving itself again to DEC OEMs and system houses.

Emulex is looking beyond the DEC world, too. Through its Persyst product line, the company also markets a complete line of memory graphics communications, and functions enhancement products for the IBM PC and other compatible microcomputers. We feel the Emulex brand of quality and performance will be more than competitive in the PC world at large. A series of new host adapters will allow Emulex controllers and subsystems to compete across the board. Winning is a philosophy at Emulex. And competition always brings out our best.

EMULEX

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COMMUNICATIONS PRODUCTS HANDBOOK

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The Emulex *Controller Handbook* began as a set of simple typewritten notes prepared with the objectives of: (1) explaining the underlying concept of the Emulex product line; and (2) giving a prospective user enough information to make an informed judgement on its applicability to his particular needs.

The Emulex *Controller Handbook* still seeks to meet these objectives. But keeping up with output from our engineering group continues to be a challenge. During the past year, Emulex has introduced fifteen new products for a total of thirty-five distinct products. At least the eight new products now in development will be added by the time the next issue arrives. Compounding this problem is the enormous functional flexibility in the line which leads to a vast number of different models and versions provided for almost every basic hardware product offered. Additionally, Emulex mass storage controllers are designed to work with a very large percentage of the many 8 and 14 inch hard disk drives and 1/2 inch magnetic tape transports and streaming devices offered by different peripheral manufacturers.

As a result of the rapid expansion of the Emulex product line, the Controller Handbook has been expanded to three separate volumes, each of which concentrates on a specific group of products. This *Communications Products Handbook* provides an elementary study of communications concepts and describes the complete line of Emulex communications multiplexers and subsystems for DEC CPU's. The *Disk and Tape Products Handbook* describes the Emulex line of disk and tape controllers for DEC LSI-11, PDP-11, and VAX-11 CPU's. The third book is the *Micro-Products Handbook,* which describes the newest Emulex products, a series of controllers, host adapters, and packaged subsystems which interface to the versatile new Small Computer System Interface (SCSI).

The handbooks are organized to present an overview of each product line, including some background on the characteristics of the peripheral devices supported and the input/output environment in which the products operate. Detailed application information - such as media type, formatted capacities, emulation modes, and hardware specifications - are provided in a series of Appendices.

As in the previous Issue, the content of these handbooks has also been expanded to include some other useful information, not only about Emulex products but also about peripheral devices made by others. Useful data, such as infant mortality and calculated and actual MTBF figures for controller products, is included. Also, specific applications are outlined and the optimum solutions discussed.

The accompanying table gives an overview of the present Emulex product line and several new products scheduled for introduction in 1984. This matrix shows the breadth of coverage and the general scope of peripheral selection available to Emulex customers.

When Emulex began operations in late 1978, it was dedicated to providing to DEC computer users a broad series of products based on design excellence and built to exacting standards of quality and reliability. We continue that commitment today along with the policy and dedicated staff to completely support our products in the U.S. and abroad. As we grow and move into new markets, we believe that this philosophy and discipline is essential for long-term success in markets which exist by virtue of the technical excellence and quality inherent in the industry. Users of alternate sources of peripherals and CPU enhancements should expect and demand the same or better standards when considering alternate sources for their needs. We at Emulex intend to be recognized for our technical leadership and product quality . . . as the Genuine Alternative.

TABLE F-1 Emulex Product Family

PRODUCT CLASS	LSI-11 QBus	PDP-11 Unibus	PDP-11/70 Cache Bus	VAX-11 Unibus	VAX-11/750 CMI Bus	VAX-11/780 SBI Bus	Other
Large Disk Controller	SC03/BX SPE 44	SC21/B SC31/BX SPE 44	SC72/BX SPE 44	SC21/V SC31/BX SPE 44	SC7000/B1 SC750/B2 SC758/B1 SPE 44	SC7000/B1 SC780/B2 SC788/B1 SPE 44	
Small Disk CMD/SMD Disk Controller	SC02/A,C,L UC01/L UC02/M	SC12/A,C,L UC12/M		SC12/V UC12/M			
Half-Inch Tape, Unformatted: Start/Stop	TC01/N TC01/P	TC11/N TC11/P		TC11/N TC11/P			
Half-Inch Tape, Formatted: Streamer and/or Start/Stop GCR Formatted	TC02/FS	TC12/FS TC13		TC12/FS TC13	TC7000	TC7000	
One-Quarter Inch Tape, Formatted: Streamer	TC05/SX	TC15/SX		TC15/SX			
Communications Multiplexer	CS01/H CS02/H	CS11/H CS11/V CS21/H CS21/Z STATCON 11 STATCON 21		CS11/F CS11/U CS21/F CS21/U CS21/Z CS32/F STATCON 11 STATCON 21 STATCON 32			
Micro-Controllers							Medalist Champion Titleist IBM Host Adapter Multibus Host Adapter
Packaged Subsystems	SABRE Vault Medley Decathlon Javelin	Vault Medley Decathlon Javelin		Vault Medley Decathlon Javelin			SABRE Vault Medley Decathlon Javelin

THE COMPANY

Emulex Corporation designs, manufactures and markets communications and mass storage peripheral controller and subsystem products for use with minicomputers and microcomputers manufactured by Digital Equipment Corporation (DEC)*. Additionally, Emulex designs, manufactures, and markets disk and tape controllers, host adapters, and packaged subsystems for use with the IBM-PC and Intel's Multibus.

During its four year history, the Company has developed over forty distinct hardware product lines - described inside - which cover all models of the DEC LSI-11, PDP-11, and VAX-11 computers. As of January 1984, over 25,000 of these units have been delivered. This superb product line reflects the basic strength of Emulex, namely its excellent technical group, which currently has more new products typical of those in our present product lines under development. We believe that these products will make the same dynamic contribution to the industry as have the current Emulex products.

The company also markets a complete line of memory, graphics, communications, and functional enhancement products for personal computers made by IBM and other micro-computer manufacturers through its wholly-owned subsidiary, Persyst (Personal Systems Technology, Inc.), located in Irvine, California.

Emulex intends to continue an aggressive development program and to maintain our position as a recognized technology leader. The engineering staff has been expanded in all areas to make certain that we meet this objective and we will continue this expansion effort for the foreseeable future.

Corporate Organization

Emulex was founded in September 1978. The Corporation has experienced significant revenue growth since its inception. Net sales for fiscal year ending June 1983 were $31,012,089. Sales for the first six months of fiscal year 1984 exceed $28 million. The Company is publicly held with shares traded on the over-the-counter market under the NASDAQ symbol EMLX. For further information on these aspects of Emulex Corporation, please write the company at its Costa Mesa corporate headquarters and request the latest annual report.

Facilities

Corporate facilities located in Costa Mesa, California, presently include over 100,000 square feet of modern, industrial buildings, with approximately 48,000 devoted to production and an additional 30,000 square feet dedicated to product development and technical support.

September 1984 is the target completion date for a new two-story 60,000 square foot engineering and manufacturing building located adjacent to

the Costa Mesa headquarters facility. The Emulex manufacturing facility in Dorado, Puerto Rico, has been expanded to a total of 51,000 square feet. The Company also opened a new 6000 square-foot headquarters facility in Bracknell, England, for sales administration, repair and service support throughout the United Kingdom and Europe. In addition, a future plant site has been chosen near Dublin, Ireland, to inaugurate a new European manufacturing operation later during 1984. The company has 16 direct sales/field support offices located across the U.S., with international sales offices in the United Kingdom, The Netherlands, West Germany, Australia, and Canada.

Manufacturing

Manufacturing is dedicated to high-volume production of the Company's proprietary controller products. Production planning is oriented to a build-to and ship-from inventory. Quality control and testing procedures are stressed to assure a level of excellence to match that of the product designs.

Infant mortality failures are minimized by thorough pretesting and burn-in prior to shipment of a controller. All Emulex stand-alone controllers incorporate almost 100% active component parts. These parts are pretested and pre-aged for a period of 160 hours at 70°C prior to the time of assembly. Completed assemblies are further burned-in under dynamic microcode execution for a period of at least 96 hours in an environmental oven, which automatically cycles the temperature from 5-50 degrees C. This testing occurs after parts have been thermal-shocked during the flow solder process. Any dynamic failure which occurs results in a microcode self-test failure. The defective component is then isolated and replaced and the assembly completes the cycling process.

As a result, MTBF (Mean-Time-Between-Failure) figures for Emulex stand-alone controllers are extremely favorable, with a range of 28,000 to 76,000 hours, depending on the product. Complete details on specific MTBF and infant mortality rate figures for Emulex communications controller products are found in Appendix J of this Handbook.

Micro-Products From Emulex

In addition to the basic stand-alone controller products for mini and super-mini computers, Emulex now offers a Genuine Alternative for microcomputer and personal computer applications. As always this new line of disk, tape, and packaged subsystem products offers the same high quality and unexcelled performance that the computer world has come to expect from Emulex.

The new micro-controllers for disk and tape applications incorporate Emulex's latest design feature, VLSI chips designed in-house to meet the quality and performance specifications required to be an innovative leader in the microcomputer field.

These controllers support the latest industry bus structure technology. This includes the Small Computer System Interface (SCSI) and the Enhanced Small Disk Interface (ESDI). Used in combination with Emulex host

adapters, the micro-controllers can interface multiple types of 5-1/4" disk and tape drives to a variety of host processors via the SCSI bus. Different disk controllers tie ESDI and/or ST506 types of drives to the SCSI bus. Host adapters of several types then connect from the host processor to the SCSI bus. A new micro-tape controller interfaces in a similar manner to a 1/4" tape cartridge drive.

Emulex also offers complete 5-1/4" Winchester disk and 1/4" cartridge tape packaged subsystems for DEC LSI-11 through 11/23 PLUS, PDP-11, VAX-11 Series computers, MICRO/PDP-11, and MICRO-VAX. These products are marketed and sold as complete system units, including controller or coupler, storage media (disk or tape), and power supply, all housed in a standard chassis. The systems also include all cables and diagnostics, and emulating host adapter if applicable. As with all Emulex products, these packaged subsystems are pretested and burned in prior to delivery to the installation site.

For more information on Emulex Micro-Products, please contact your local Emulex Sales Representative.

Subsystem Products

Emulex offers a complete line of peripheral 14" stand-alone disk and 1/2" stand alone tape subsystems to U.S. customers only. Housed in an adjacent facility, the Subsystems Group integrates Emulex controllers with a wide range of disk and tape drives obtained by Emulex from several leading peripheral suppliers. These subsystems support the full range of DEC LSI-11, PDP-11, and VAX-11 computers. Installation of these subsystems is handled by the Emulex Field Service group. All peripherals and media are pretested and burned in at Emulex prior to delivery to the installation site. Detailed information regarding Emulex Subsystem Products is found in separate "Disk Subsystems" and "Tape Subsystems" brochures. These brochures, as well as information regarding the application/purchase of subsystems, are available from your local Emulex Sales Representative, or the Emulex Subsystems Group, phone 714/662-5600.

Sales Programs

Emulex products and subsystems are sold throughout the U.S. by a direct sales organization with offices in 16 U.S. cities and 6 foreign countries. Users may also purchase Emulex products through a well-established Authorized Dealer, Sales Representative, and reseller organization, both domestically and in most countries throughout the free world.

Emulex now conveniently offers GSA Contracts to agencies of the U.S. Government (Contract Number GS-00K-8401S5575).

Details of Emulex sales programs are available through your nearest Emulex Sales Representative.

Technical Support

Application support consultation is always available. Emulex provides a dedicated technical support staff of senior hardware and software engineers at its headquarters in Costa Mesa, California. In addition, each regional sales office has a pre-sales support engineer on hand to answer

any questions you may have. The staff is available to all users for any required telephone assistance. System support specialists are located in Emulex field service offices in New York, Boston, Philadelphia, Pittsburgh, Washington, D.C., Chicago, Houston/Dallas, Atlanta, San Francisco, and Los Angeles. These specialists are dedicated to the on site installation and support of Emulex products in these key geographical areas. Additional field service offices are planned in other major metropolitan areas in the near future. It is the policy of the Company to provide the full level of such assistance required to properly integrate and use all Emulex products.

The Company conducts regularly-scheduled, customer and service courses at its facilities on an approximately monthly basis. Specialized courses at customer locations are provided by arrangement.

Product Repair

Emulex maintains a dedicated, well staffed and equipped repair facility at its headquarters. It is policy to promptly honor all requests for source. Requests for both routine and expedited support should be directed to the Repair Center.

For U.S. customers, a unique end-user swap-out policy is available to Emulex subsystem customers, whereby a replacement product will be shipped to the customer's site within 24 hours after a request is made.

Field Service

Emulex has a formal service agreement with Control Data Corporation/ Engineering Services Division for maintenance of its complete controller and subsystem product line. This program now covers 50 key U.S. cities, with plans for expansion in other locations. In each location, Control Data offers complete DEC system maintenance of LSI-11, PDP-11, and VAX-11 based systems as well as maintenance for Emulex products, thus providing a single vendor service arrangement. In addition, maintenance of Emulex products is also offered in the countries of Canada, United Kingdom and Germany. For information, contact Emulex directly or Control Data at 800/328-3980.

A similar arrangement has been implemented with General Electric in key cities across the U.S. Information on this program is available from Emulex. Other excellent organizations, such as Tymeshare and Grumman furnish maintenance on a regional or national basis.

INTRODUCTION

Communication Products

The Emulex communications product line is made up of five front-end communications multiplexers, designated the CS01, CS02, CS11, CS21 and CS32 Series. The CS01 was introduced in May of 1982 as the first Emulex multiplexer for use on LSI-11 through LSI-11/23 PLUS CPU's. Capable of handling up to 64 lines, the CS01 is offered in a single CS01/H model which emulates DEC's DH11.

One new addition to the communications family is the CS02. Designed for software-transparent operation with LSI-11 Series and MICRO/PDP-11 CPU's, this 16-line multiplexer emulates either the DHV11 or the DH11.

The CS11 Series is Emulex's entry into the communications multiplexer product line. The heart of this product is the CC11 Communications Controller which incorporates the exact same bipolar microprocessor architecture as that implemented in the SCXX and TCXX disk and tape controller products. Mounted on a single hex pcb, this unique device is capable of supporting four different basic emulation models and a STATCON system via simple PROM changes. All of the emulations offer not only higher performance, but also a whole list of useful features and benefits not contained in their DEC counterparts.

Two DH11-compatible models of the CS11 are offered: the CS11/H for PDP-11 computers and the CS11/U for VAX-11 computers. Both of these emulation models are functionally equivalent to up to four DEC DH11 16-line asynchronous multiplexers. The single controller board in both of these models replaces nine boards in a double system unit for every 16-line DEC DH11 which it replaces—that's up to 36 boards for a 64-line system.

A DV11-compatible version of the CS11, the CS11/V, is available for users who need to combine both byte synchronous and asynchronous communications in a single multiplexer. This product is functionally equivalent to two 16-channel DEC DV11 synchronous/asynchronous multiplexers. The same hardware components used in the CS11/H and the CS11/U achieve similar benefits here.

The newest model in the CS11 Series, the CS11/F, is a DMF32 replacement designed for software and diagnostic transparent operation with VAX-11 CPU's. The CS11/F emulates the asynchronous multiplexer portion of the DMF32 only. It is capable of handling up to 48 lines.

The STATCON SERIES 11 combines the CS11 Communications Multiplexer and one or more local statistical port concentrators to handle up to 64 local and/or remote lines on VAX-11 or PDP-11 computers.

Emulex introduced the CS21 Series in November of 1981. This product is a single-board 16-line version of the CS11 and is designed for smaller systems which do not need the expansion capacity of the CS11. Like the CC11, the single CC21 controller board used in the CS21 is capable of supporting four different basic emulation models and a STATCON system via simple PROM changes. The CS21/H emulates the DH11 for PDP-11 computers. The CS21/U emulates the DH11 for VAX-11 computers. The CS21/Z emulates the DZ11-E for PDP-11 and VAX-11 computers, and the CS21/F emulates the asynchronous multiplexer portion of the DMF32 for VAX-11 computers.

The STATCON SERIES 21 combines the CS21 Communications Multiplexer and one or more local statistical port concentrators to allow use of up to 32 local and/or remote lines on VAX-11 or PDP-11 CPU's.

The newest multiplexer in the Emulex communications product line, introduced in February of 1984, is the CS32 Series for VAX-11 CPU's. Another DMF32 emulaton, the CS32 comes in a single model: the CS32/F. The CS32/F consists of a single-board communications controller attached to a maximum of eight 16-line distribution panels. The STATCON SERIES 32 combines the CS32 multiplexer and one or more local statistical port concentrators to allow up to 256 local/remote lines to be connected to a VAX-11 CPU.

Disk Products

When introduced in early 1979, the Emulex SCXX Series of disk controllers represented the first complete family of synergistic disk controller products for all makes and models of DEC LSI/PDP-11 host computers. This unique situation continues today, but on a greatly expanded base of product offerings. These controllers have a common 2901 bipolar bit-slice microprocessor-based architecture which is carried throughout all hardware configurations. From this design base, microcoded versions are derived to support almost every non-captive 8 and 14 inch form factor disk drive incorporating an SMD interface. This technology encompasses fixed and moving head drives, drives with fixed, fixed/removable, and/or removable media. It applies, as well, to drives of different sizes (e.g. 8", 14" diameter) and capacities.

Complete detailed information regarding Emulex disk products can be found in the Emulex *Disk and Tape Products Handbook.* Please write the corporate headquarters to request a copy.

Tape Products

The Emulex TCXX tape controller/coupler product line is a direct derivative of the disk controller technology. The TCXX tape controller/coupler series uses the same basic microprocessor architecture common to all Emulex controller products. This synergistic design approach results in providing the same basic user benefits in all Emulex products — regardless of peripheral type or host computer model.

Complete detailed information regarding Emulex tape products can be found in the Emulex *Disk and Tape Products Handbook.* Please write the corporate headquarters to request a copy.

Micro-Products

Emulex now offers a Genuine Alternative for microcomputer and personal computer applications. This new line of disk, tape, and packaged subsystems products offers the same high quality and performance that the computer world has come to expect from Emulex.

Three micro-controller products, designed to mount physically on the peripheral device, have been introduced: the Medalist and Champion disk controllers, and the Titleist tape controller. Additionally, there are currently five host adapters available for interfacing a wide variety of host processors to the Small Computer System Interface (SCSI): the UC01, UC02, UC12, IBM Host Adapter (Model HA01), and the Multibus Host Adapter (Model HA51). The Micro-Products line also includes five complete disk and tape packaged subsystems: SABRE, Vault, Medley, Decathlon, and Javelin.

Complete details on these Emulex products may be found in the Emulex *Micro-Products Handbook*. Please write the corporate headquarters and request a copy.

Summary

The Emulex product line philosophy and architecture has permitted rapid development and volume production of an almost unlimited range of controller versions and drive configurations for the DEC LSI/PDP/VAX-11 lines. The benefit to Emulex customers has been our ability to provide immediate solutions to almost all current application problems, plus the inherent flexibility to handle foreseeable future requirements using the same product hardware.

But advantages to Emulex users do not stop at the product design level. A full-time senior applications staff is available on call, both before *and* after the sale, to identify and solve problems. Product repair services are conducted by the customer service group under marketing direction, using a staff and equipment dedicated to this sale function. And excellent field service is available across the U.S. and in several foreign countries through well-recognized third-party organizations trained and equipped by Emulex.

SECTION I
INTRODUCTION TO DATA COMMUNICATIONS

CHAPTER 1
PROCESSES AND ALTERNATIVES

To enable DEC computer users to communicate information across long and short distances in the most expedient, reliable, cost-efficient, and universally-compatible way possible: this is the goal of Emulex's communications specialists. Their agents for accomplishing this goal are the five multiplexer families that constitute the Emulex communications product line.

All data communications operate on two levels: the human level and the machine level. Coordinating these two levels in the accomplishment of the single goal described above requires several essential translation processes, each involving a choice between alternative means of implementation.

The purpose of this chapter is to provide an elementary description of the translation processes, to outline the alternatives, and to explain the reasons behind the choices that Emulex makes. Advanced readers should proceed directly to the next chapter.

HUMAN LANGUAGE TO MACHINE LANGUAGE

The internal language of all digital computers is always some type of binary, or two-element, code. Generally, the two elements used to construct all of the characters in the code are represented by the numbers 0 and 1, the only two digits in the base-two binary number system. If human beings are to communicate information via computers, then, they must first convert their own language to machine language. That is, they must decide upon a different combination of the binary digits 0 and 1 to represent each character—each letter, numerical digit, and punctuation mark used in human syntax.

Each binary digit in a code assumes the abbreviated name "bit". Each code uses a predetermined number of bits to represent each character.

TRANSMISSION MODES

Parallel Transmission

Now that we know *what* the language of computers consists of, we need to to determine *how* that language is conveyed. Internally, the components of

a computer communicate using a technique called "parallel transmission". Here, all of the bits in a character are transmitted simultaneously, each bit across its own wire. Data transmissions are thus extremely fast.

Parallel Transmission may be used for external communication between two different computers or other high-speed electronic devices. The potential for problems with external data transmission increases, however, proportionally to the distance between the devices. Electronic signals fade as they travel down a wire, while the noise factor grows stronger. Correcting these problems for *a single wire* is a costly process. Therefore, in most applications, the cost disadvantage of Parallel Transmission outweighs the speed advantage in external communications. Consequently, all Emulex communications products implement another transmission technique for their external communications: Serial Transmission.

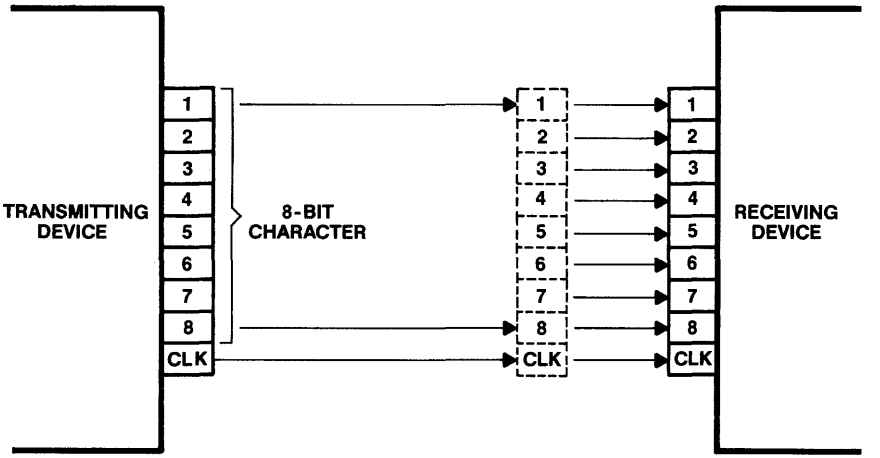


Figure 1-1 Parallel Transmission

Serial Transmission

In this mode, the individual bits in a character are sent across a single wire one at a time in succession, with no lapse of time or space between bits.

The benefits of this mode for long-distance transmissions are obvious. The user saves on the cost of implementing multiple signal wires and lessens the possibility of errors during transmission. He trades in the speed of parallel transmission for reliability, low cost, and reduced hardware.

Implementation of serial transmission does, however, require another translation. As stated above, the internal communication of computers and other high-speed electronic devices is generally parallel. Data traveling from one parallel device across a long distance to another parallel device must therefore undergo parallel-to-serial and serial-to-parallel conversions. Emulex products come equipped with the UART (Universal Asynchronous Receiver Transmitter) circuits that take care of these conversions.

There are two different ways of accomplishing serial transmission: synchronously or asynchronously.

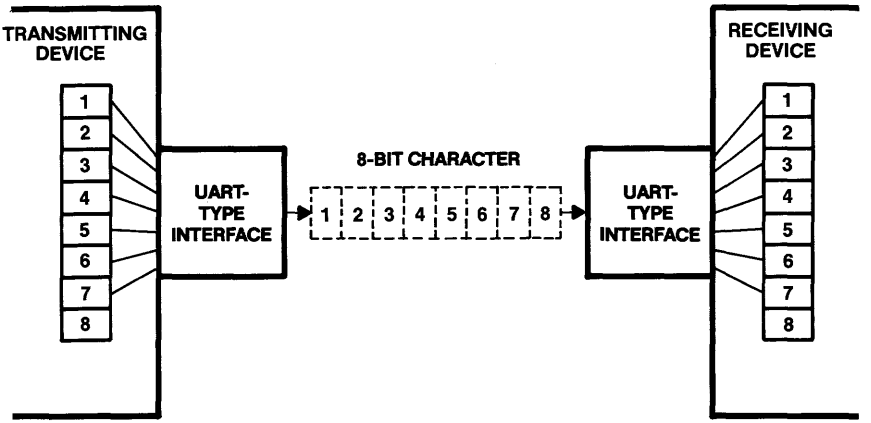


Figure 1-2 Serial Transmission

Synchronous Serial Transmission

Here, groups of characters are assembled, transmitted, and received together in ordered blocks counted off by a clock pulse. Each block contains special characters in addition to the data transmitted which are used for identifying the start of the block and for error detection. This type of serial transmission is often used for computer-to-computer transfers, where error-free communication is necessary. Implementing synchronous serial transmission does, however, present several complications.

As stated above, all characters in a particular binary code contain the same number of bits. The receiving device knows the number of bits in each character, but it must be told when to begin counting—when, in other words, it has received the first bit of the first character in the block. For when the receiving device recognizes the first bit, it can then count out and identify all of the characters in the block.

Synchronous communications devices, therefore, require a special communications protocol, or set of conventions, to coordinate or *synchronize* their data exchanges. There are many different protocols used in synchronous transmission. Some are byte-oriented protocols such as BISYNC and DDCMP. Others are bit-oriented protocols such as HDLC or SDLC. Byte-oriented protocols use SYNC characters to delineate blocks of characters or "frames". Bit-oriented protocols use a unique sequence of bits called a "flag" to delineate frames.

In the case of byte-oriented protocols, the SYNC character has a predetermined, constant bit organization that is distinctly different from all other characters in the particular machine code being used. The organization of the SYNC character is stored in the memory of the receiving device. When a

transmitted SYNC character matches the SYNC character in the receiving device's memory, then, the communicating devices are synchronized, and the receiving device can begin counting out characters.

If no SYNC character were used, the receiving device might begin to count in the wrong place, and all of the characters would overlap. The SYNC character is so important, in fact, that many protocols require that the SYNC character be sent twice at the start of each block in case the first one is transmitted incorrectly.

In addition to special protocols, synchronous transmissions require data buffering on both sides of the communication process. Blocks of characters waiting to be transferred and blocks of characters being received must be buffered until they can be processed. This is because, if an error is detected in a block, the receiving device will request a retransmission of the block from the transmitting device.

In many applications, such as the handling of terminals, the complications involved in implementing synchronous serial transmissions outweigh the capability for error detection and correction which most synchronous protocols have.

Emulex does offer one synchronous/asynchronous multiplexer: the CS11/V. This product supports byte-oriented, but not bit-oriented, protocols. All other Emulex communications products, however, implement asynchronous serial transmission.

Figure 1-3 Synchronous Serial Transmission

Asynchronous Serial Transmission

Here, characters are transferred one at a time, as soon as they are available for transfer. Each character consists of one start bit, five, six, seven, or eight data bits, one or more stop bits, and—sometimes—a parity or error-checking bit.

Because start and stop control bits are added to each character in asynchronous serial transmissions, asynchronous communications are less efficient than synchronous communications when transferring *large* numbers of characters. However, the transfer of data does not require a special protocol in the case of asynchronous transmission. Therefore, for small

data transfers or single-character transfers, asynchronous communications are more efficient.

In asynchronous serial transmission, the 1 element in any binary code is also called the "idle" state or the "mark" state. It is, in other words, the state in which the system rests between character transmissions. The beginning of a new character, then, is signified by the change from the 1 or idle state to the 0 state; i.e., the start bit is always a 0 preceded by a 1(s). When the receiving device recognizes a start bit, it counts off the predetermined number of bits that constitute the text of the character.

The text of a character is always followed by a stop bit(s). The stop bit(s) must always be a 1(s), so that, again, the start bit of the next character is a 0 preceded by 1(s).

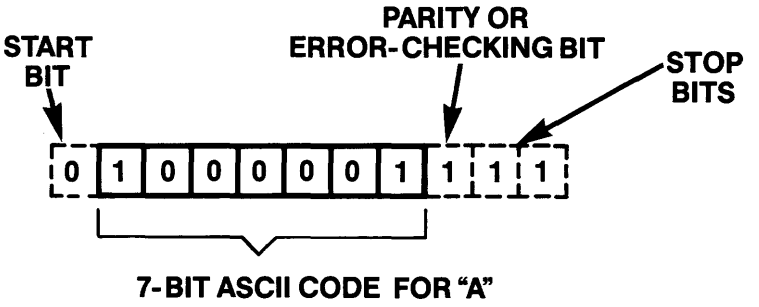


Figure 1-4 Asynchronous Serial Transmission

MACHINE LANGUAGE TO ELECTRIC SIGNALS

As stated earlier in this section, binary codes use two elements to construct all of the digital characters that represent the letters, numbers, and punctuation marks in human communication. These two elements are represented on paper and in our minds by the numbers 0 and 1. Yet how do computers and other high-speed electronic devices "see" them? How do they "read" or "write" them?

Many data communications electrical standards are in use today. The two most common ways of communicating the numbers 0 and 1 in serial data transmission, however, are: 20 mA (milliAmpere) Current Loop Transmission and EIA (Electronic Industry Association) RS-232-C Transmission.

20 mA Current Loop Transmission

Here, as the name suggests, a 20 mA current "loops" from the device sending data to the device receiving it. The flow of current signifies a 1 bit, the absence of current a 0 bit.

Emulex offers 20 mA Current Loop versions of most of its products. These products include: the CS01/H, the CS11/F, /H, and /U, and the CS21. Current Loop versions of the Statcon Series products are not available, however, as Current Loop transmission is not possible with modems.

EIA RS-232-C Transmission

Here, the transmitting device sends a negative voltage to the receiving device to signify a 1, and a positive voltage to signify a zero.

This method of transmission has become the industry standard. And it does support modem control signals. For these reasons, it is the standard interface used on all Emulex asynchronous serial communications products.

DIGITAL TO ANALOG

When data is transmitted from host computers to *remote* computers, terminals, or other high-speed electronic devices, one final translation is necessary.

Rather than start from scratch in the development of their own long-distance communications networks, computer engineers and system integrators opt to take advantage of the signal wire networks already established by the telephone communications industry.

The adopted signal wires, however, carry analog data, not digital. As stated above, digital communications are always based upon two elements, though those elements are represented or realized in several different ways: 0 and 1, space and mark, no current and current, positive and negative voltages.

Analog data, on the other hand, is the medium for voice transmission. As such, it must and does represent, in electronic waves, all of the modulations of human speech.

Digital data transmitted across a telephone network from one computer device to another must first be translated into analog data. It must be modulated as it leaves one digital device and demodulated as it enters another. It must, in short, pass through the digital-to-analog and analog-to digital translation devices appropriately called modems.

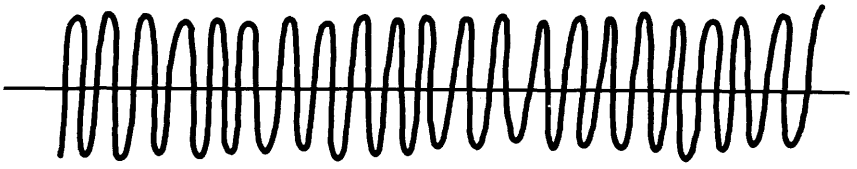
An analog electronic wave of constant amplitude, frequency, and phase travels continuously across each wire in a telephone network. This wave is called a "carrier", for it serves as the vehicle for all data transfers across the wires. Modems translate digital data to analog data by creating changes in a telephone network carrier wave that correspond to changes in a computer's digital signal wave.

All modems use digital data to modulate the carrier wave in one of three ways: Amplitude Modulation (AM), Frequency Modulation (FM), or Phase Modulation (PM). In amplitude modulation, a particular variation in the strength or intensity of the carrier wave's oscillation is used consistently to represent one state or element of a binary digital code. The normal condition of the wave represents the other element.

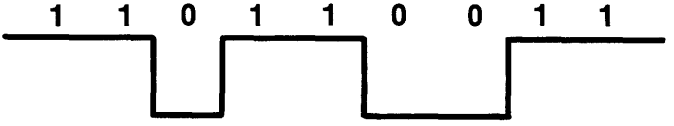
In frequency modulation, a particular variation in the periodic occurrence of the carrier wave's oscillation consistently signifies one element of the binary code, the normal condition of the wave the other element.

And lastly, in phase modulation, particular variations in the phase of the carrier wave's oscillation represent particular combinations of elements in a binary code.

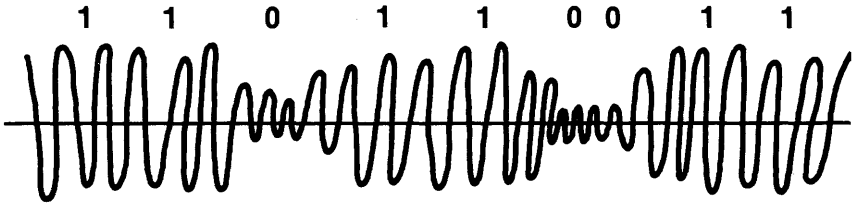
Figure 1-5 Digital to Analog Modulations



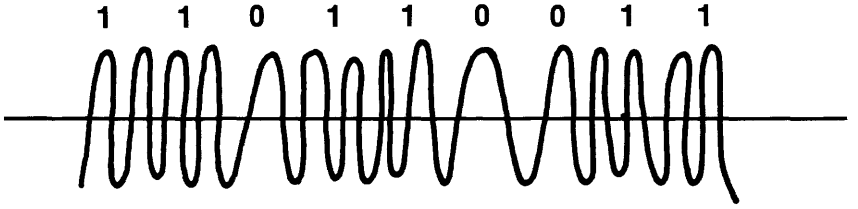
ANALOG CARRIER



BINARY DIGITAL SIGNAL



AMPLITUDE MODULATION



FREQUENCY MODULATION

It is important to note, in conclusion, that modem operations are not totally independent from the devices to which they are attached. On the contrary, these communications devices (computers, multiplexers, terminals) must supply the modem control circuits and signals that correspond to the modems being used.

SIMPLEX, HALF-DUPLEX, AND FULL-DUPLEX COMMUNICATIONS

External communications between computers and/or other high-speed electronic devices may operate on one of three different levels of sophistication or complexity. Such communications may be either Simplex, Half Duplex, or Full Duplex.

SIMPLEX communication is unidirectional. One device does all of the communicating. The other device is capable of receiving information only.

HALF-DUPLEX communications are bidirectional, but with only one side transmitting data at a time.

FULL-DUPLEX communications are full bidirectional transmissions. Both sides may transmit and/or receive data at the same time.

All Emulex communications multiplexers support full-duplex and simplex operations. Many of these multiplexers also support half-duplex operations, which require additional modem control signals.

SECTION II
COMMUNICATIONS PRODUCTS

CHAPTER 2
DEC COMMUNICATIONS MULTIPLEXERS

Emulex currently offers five different front-end communications multiplexer product lines, designated the CS01, the CS02, the CS11, the CS21, and the CS32 Series. Each product line consists of a set of hardware elements which are configured to provide various communications protocols and/or communications line disciplines. Each emulation is designed to function in the same manner as certain products offered by DEC and in the same fashion as the Emulex disk and tape controller products. Versions of the communication product line emulate the following five DEC communications multiplexers: the DZ11-E, the DH11, the DV11, the DMF32, and the DHV11. The general qualities, specific features, and model numbers of these DEC multiplexers are outlined below.

DZ11 Asynchronous Communications Multiplexer (PDP-11/VAX)
The DZ11 is designed for multiplexing a relatively small number of asynchronous lines into a Unibus system. It is characterized by programmed I/O operations for both input and output. Various versions are available, but no more than 8 channels may be serviced by a single CPU-imbedded board. Summaries of the DZ11's main features and models are given below. The DZ11 is supported across the entire DEC-11 line under RT11, RSX-11M, RSTS/E, VMS, and others.

Features:

- 8/16 Lines.
- Local operation at speeds to 9600 Baud (Bits Per Second).
- Programmable speeds and formats on a per line basis.
- Character interrupt output and input, Programmed I/O.
- Standard interfacing: EIA/RS-232-C and 20 mA Current Loop.
- Single hex board per 8 line increment.
- 16 line distribution panel (H317).
- Modem control: full duplex operation only with Bell 103 or 113 modems or equivalent.

Models: (PDP-11 & VAX-11)

- DZ11-DP: 8-line Async MUX, EIA/CCITT.
- DZ11-HP: 8 line Async MUX, Current Loop (20 mA).

NOTE:
DEC offers a DZ11-equivalent product for LSI-11 Series computers: DZV11, a four line asynchronous multiplexer supporting both EIA and CCITT transmission.

DH11 Asynchronous Communications Multiplexer (PDP-11)
The DH11 is designed for higher performance than the DZ11. The unit has Programmed Input/Output (I/O) for input operations, but uses DMA for output transmission to reduce CPU loading. And, it provides full modem control (full duplex, half duplex and echoplex transmission modes).

The DH11 is a relatively old design, consisting of multiple circuit boards contained in a specially wired, double system unit, 9-slot backplane. It comes in a variety of configurations which, along with the system's features, are summarized below.

The DH11 is supported on PDP-11 systems under RSX-11M, RSTS-E, and other DEC operating systems. It is not supported by either RT11 or VMS and, hence, is not offered by DEC in the LSI-11 and VAX-11 product lines except for users who develop their own software.

Features:

- 16 Lines.
- Programmable speeds, formats, and transmission modes on a per line basis.
- Full duplex, half duplex, echo plex.
- Split transmit/receive baud rates on per line basis.
- DMA transfers for output and character interrupt input (Programmed I/O).
- Full modem control.
- Dedicated 9 slot backplane (2SU) per 16 line increment.
- Standard interfacing: EIA/RS-232-C.
- 64-character receive buffer.

Models: (PDP-11)

- DH11-AP: Programmable 16 line Async MUX, EIA/CCITT, modem control (DM11-BB).
- DH11-DP: Programmable 16 line Async MUX, EIA/CCITT.

DV11 Synchronous/Asynchronous Communications Multiplexer (PDP-11)
The DV11 is designed to handle both synchronous and asynchronous communications lines through the same unit. Parameters may be configured in groups of four lines. The DV11 is characterized by the DMA operations for both input and output that handle its block-oriented synchronous lines. It also supports additional functional features required to optimize the synchronous communication protocol software executed by the CPU.

The DV11 is capable of handling IBM BISYNC, DEC DDCMP, and other byte-oriented protocols. It is supported on PDP-11's only under DECnet applications.

Features:
- 8/16 synchronous/asynchronous lines.
- DMA transmit and receive.
- Character formats and sizes switch-selectable in 4-line groups for synchronous mode.
- Speeds and character sizes programmable on a per line basis for asynchronous mode.
- Full modem control.
- Two program-selectable sync characters for each line.
- 128-character receive buffer.

Models: (PDP-11)
- DV11-AP: Double system unit contains all DV11 multiplexer logic except the line cards and the distribution panels. A total of two DV11-BA's, DV11-BB's, and DV11-BC's may be used with a DV11-AA. No lines are implemented.
- DV11-1P: Line cards and distribution panel for eight synchronous lines.
- DV11-2P: Line cards and distribution panel for eight asynchronous lines.
- DV11-3P: Line cards and distribution panel for four aynchronous and four synchronous lines.

DMF32 Multi-function Controller (VAX-11)
Designed for higher performance than DZ11's on VAX-11 computers, the DMF32 is currently being sold with VAX-11/730 systems using VMS Versions 3.0 and above. With the DMF32 unit, asynchronous transmit operations can be either Programmed I/O or DMA, depending on the amount of data being transmitted. The I/O driver makes the decision as to which method of transmission will be used, based on parameters identified during the SYSGEN process. The DMF32 is capable of both full-duplex and half-duplex operations.

The DMF32 is a multi-function controller that has eight asynchronous lines (only *two* of which have modem control), one synchronous line, and a parallel I/O port.

Features:
General to Multifunction Controller:
- 8-line asynchronous communications multiplexer.
- One synchronous line.
- Parallel I/O Port or DMA Line Printer Interface.
- Standard interfacing: EIA RS-232-C.
- Single hex board.

Asynchronous Multiplexer Portion:
- Speeds to 9600 Baud (bits per second).
- Programmable speeds and formats on a per line basis.
- Transmit operation can be either Programmed I/O or DMA.
- Modem control on ONLY two lines.
- Split transmit/receive speeds on two modem lines.
- 48-character receive buffer.

Models: (VAX-11)

- DMF32-LP: Standard with every VAX-11/730. No Distribution Panel frame supplied. Distribution Panel mounts in already existing frame.

DHV11 Asynchronous Communications Multiplexer (MICRO/PDP-11 and LSI-11)

The DHV11 is the latest communication offering from DEC. Designed for use with QBus processors, the DHV11 is a quad-size unit capable of handling eight asynchronous lines. All lines support DMA or silo output, silo input buffering, full modem control, and split speed capability.

Features:

- 8 lines.
- Programmable speeds, formats, and transmission modes on a per line basis.
- Full duplex and half duplex.
- DMA or Programmed output transmission.
- Split transmit/receive baud rates on a per line basis.
- Automatic XON, XOFF operation.
- 256-character receive buffer.

Models: (MICRO/PDP-11 and LSI-11)

- DHV11-AP: 8-line Async MUX.

CHAPTER 3
EMULEX VERSUS DEC

Emulex does not simply *copy* DEC products. Rather, Emulex takes the basic functional elements and the best features of DEC products and develops and/or improves them. Emulex also tries to fill holes left in the DEC product line. Emulex's goal in these endeavors is, again, to enable DEC users to communicate information in the most expedient, cost-efficient, reliable, and universally-compatible way possible.

Some aspects of the Emulex product architecture and some specific Emulex features or improvements over DEC reappear consistently throughout the Emulex product line. Noting these features now will enhance the discussions of individual Emulex products in the following section of this handbook.

Bit-Slice Microprocessor Architecture
All Emulex controllers feature bit-slice microprocessor architecture. Each slice contains all of the necessary elements of a CPU, including an arithmetic/logic unit and registers. A CPU of desired word length is constructed by paralleling a particular number of slices.

One of three high-speed bipolar technologies, bit-slice architecture is best suited to the Emulex product line for a number of reasons. For example, it supports development of common hardware blocks for use in a particular product family. In most cases, therefore, a simple PROM change enables a user to upgrade his emulation to any other emulation available in a given multiplexer family.

Bit-slice architecture also reduces the component count in a multiplexer system. Reduced component count means less space, less power, and less chance of component failure.

16-Bit Word DMA Transfer Processing
DMA (Direct Memory Access) capability enables different components in a system to transfer portions of data from the host system's memory without the intervention of the host processor. DMA transfers may be made in either 8-bit byte or 16-bit word increments.

DEC's DH11 is capable of 16-bit word DMA transfers. The DH11, however, is not capable of processing these transfers. It must process DMA transfers one byte at a time. The DH11 therefore slows throughput operations by transferring each DMA word twice from the main computer memory in order to process both bytes in the word.

All Emulex products that support DMA transfers can transfer *and* process 16-bit word DMA transfers. The word transfer for each line is stored in a

holding register on the controller and processed a byte at a time by the bit-slice microprocessor.

Increased FIFO Capacity

First In/First Out (FIFO or SILO) buffers serve as temporary storage for incoming data from the CPU. Data entering the buffer falls through to the bottom. Data leaving the buffer leaves from the bottom in the same order it entered. Data may enter or leave the buffer asynchronously in serial or parallel transmission.

FIFO buffers are vital components of high-speed communications systems for two reasons. First, they handle the influx of large amounts of data during peak input periods. Excess data is stored, not lost, until it can be processed. Second, FIFO buffers process data quickly and automatically without external addressing.

By implication, the larger the FIFO buffer, the greater the amount of data that can be handled at one time, i.e., the greater the system throughput. The majority of Emulex products have increased receive FIFO capacity as a standard or switch-selectable feature. Compare the FIFO capacities of all Emulex multiplexers to those of the DEC systems they emulate:

TABLE 3-1
DEC's DH11 vs. Emulex's DH11 Emulations

MULTIPLEXER	FIFO CAPACITY
DH11	64-character buffer per 16 lines.
EMULEX DH11 EMULATIONS	
CS01	**128-character buffer per 16 lines.**
CS11/H **CS11/U**	**Switch selection: 64 characters or 128 characters per 16 lines.**
CS02	**256-character buffer per 16 lines.**
CS21/H **CS21/U**	**Switch selection: 64 characters or 256 characters per 16 lines.**

TABLE 3-2
DEC's DMF32 (multiplexer portion) vs. Emulex's DMF32 Emulations

MULTIPLEXER	FIFO CAPACITY
DMF32	48-character buffer per 8 lines.
EMULEX DMF32 EMULATIONS	
CS11/F	**48-character buffer per 8 lines.**
CS21/F	**64-character buffer per 8 lines.**
CS32	**256-character buffer per 8 lines.**

TABLE 3-3
DEC's DZ11 vs. Emulex's DZ11 Emulation

MULTIPLEXER	FIFO CAPACITY
DZ11	64-character buffer per 8 lines.
EMULEX DZ11 EMULATION: CS21/Z	**Switch selection: 64 characters or 128 characters per 8 lines.**

TABLE 3-4
DEC's DV11 vs. Emulex's DV11 Emulation

MULTIPLEXER	FIFO CAPACITY
DV11	128-character buffer per 8/16 lines.
EMULEX DV11 EMULATION: CS11/V	**128-character buffer per 16 lines.**

TABLE 3-5
DEC's DHV11 vs. Emulex's DHV11 Emulation

MULTIPLEXER	FIFO CAPACITY
DHV11	256-character buffer per 8 lines.
EMULEX DHV11 EMULATION: CS02	**256-character buffer per 8 lines.**

Increased Line Capability

Line capability is often a primary consideration in multiplexer application configuration. Sometimes smaller applications, say 1-16 lines, not only suffice but match a user's particular needs. Other times, however, large numbers of lines are required. All of the DEC multiplexers emulated by Emulex support from 8-16 lines in their base state. Additional lines may be added to these systems—but only in conjunction with additional interface boards, power, bus loads, and backplane slots.

Several Emulex multiplexers, on the other hand, are designed specifically for large applications: the CS01/H, the CS11, and the CS32. All of these systems have only one controller/interface board, use only one bus load, fill only one backplane slot, and require only 4 amps from the internal CPU +5V power supply. Yet study TABLE 3-6:

TABLE 3-6
Line Capability of Emulex Multiplexers

EMULEX MULTIPLEXER	LINE CAPABILITY
CS01	8-64
CS11/F	16-48
CS11/H	8-64
CS11/U	8-64
CS11/V	8-32
CS32	16-128

Emulex's distribution panels and line adapters are the key to the major increase in the potential line capability of the above three multiplexer families. Similar to internal computer transmissions, data transfers between Emulex controllers and line adapters are on a parallel character basis. But communications between an Emulex multiplexer and local and/or remote terminals are on a serial basis. Special circuits are therefore required to serialize/de-serialize data: DUARTs for the CS32, and UARTS for all other Emulex multiplexers.

These circuits and all other active components are contained on the controller boards in smaller application multiplexers like the CS02 and the CS21. In larger application multiplexers like the CS01, the CS11, and the CS32, however, the UARTs/DUARTs, data and modem interface circuitry, and baud rate generators are positioned on the line adapters.

In this way, many more lines may be added *without* using additional power from the host CPU. The CS01, CS11, and the CS32 all require only 4 amps of +5V from their systems' internal CPU power supplies—regardless of the number of lines being used. This is possible because the panels used with these systems contain their *own* A/C power supply.

CHAPTER 4
EMULEX COMMUNICATIONS MULTIPLEXERS

Emulex currently offers five families of serial asynchronous and/or synchronous communications multiplexers, designated the CS01, the CS02, the CS11, the CS21, and the CS32 Series (See figures). Within the five families are products equivalent to DEC's DH11, DMF32, DV11, DZ11, and DHV11 for use on LSI-11, MICRO/PDP-11, PDP-11, and VAX-11 minicomputers.

For the CS01, the CS11, and the CS32, a configured subsystem consists of a set of building blocks, including a host-mounted controller and externally mounted panel(s) with active line adapters. For the CS21 and the CS02, a configured subsystem consists of a single host-mounted controller board, plus a single active or passive 16-line distribution panel. In each case, common hardware is used to implement all models in the product line. This means that in most cases, a simple PROM change enables the user to upgrade to any emulation for a given multiplexer family. Together, these product families offer users a variety of alternatives when multiplexing multiple serial terminals to DEC CPU's.

CS01/H COMMUNICATIONS MULTIPLEXER

General Description

DEC does not offer a QBus version of the DH11. Emulex offers two: the CS01/H and the CS02/H. Functionally equivalent to four DEC DH11's and four DEC DM11-BB's, the CS01/H handles from eight to 64 lines per controller at speeds of up to 19.2 Kbaud. Emulex-particular features of the CS01/H include: switch-selectable 64/128-character FIFO buffering per sixteen lines, DMA on transmit, 22-bit addressing, low power, and automatic internal self-test.

For detailed explanations of these features and other functional characteristics of the CS01/H, see Appendix A.

Subsystem Components

CC01 Communications Controller

An 8-bit microprocessor-based controller, the CC01 performs the majority of operations required to transfer data between the host CPU and the multiple terminals connected to the CP12 Distribution Panels. All communication protocol is handled by the CC01.

The firmware on the controller contains a standard microcode version designed to execute an exact emulation of DEC's DH11 Communications Controller. So, despite a wide variety of extra features, the CS01/H remains transparent to DEC operating systems and diagnostics.

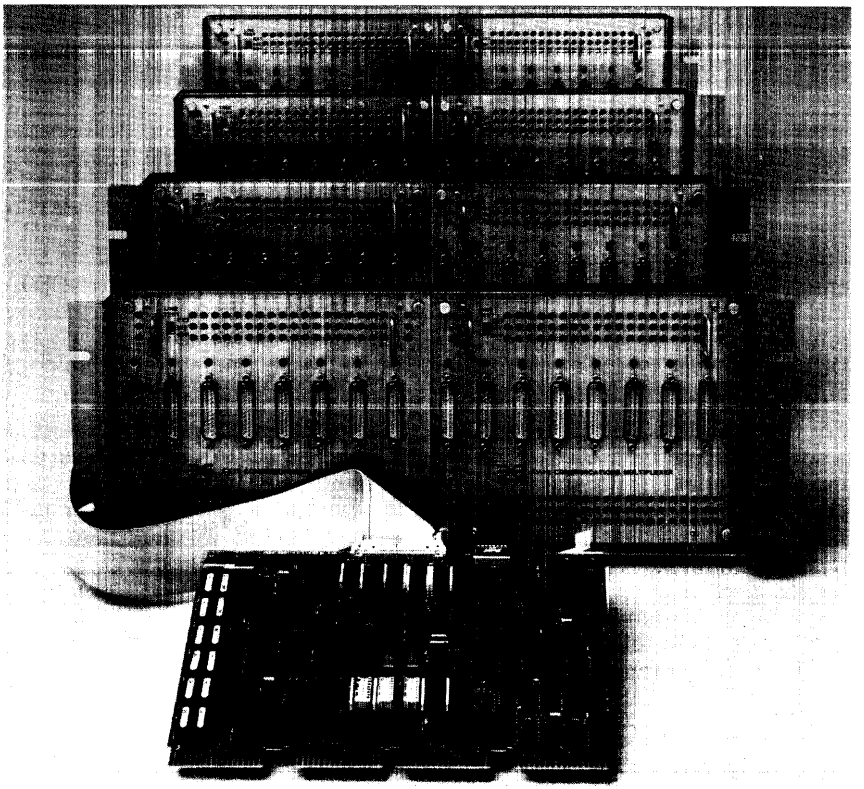


Figure 4-1 CS01/H Communications Multiplexer

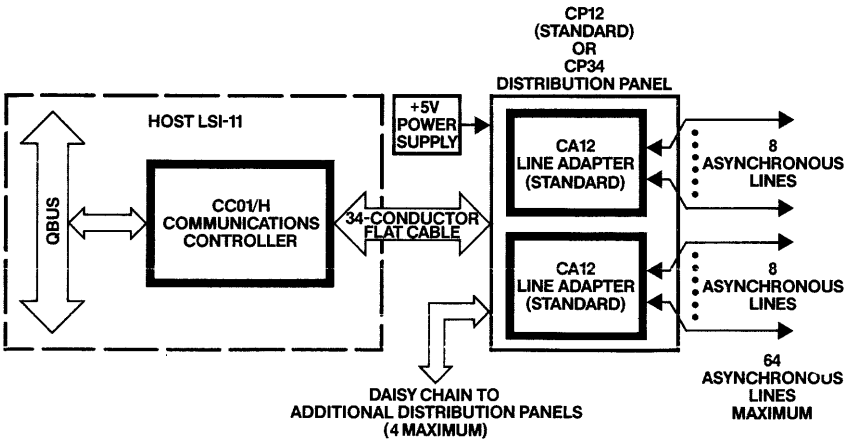


Figure 4-2 CS01/H Subsystem Organization

In addition to its regular transmission operations, the CC01 executes extensive automatic power-up self-tests and supports manual tests of individual line groups during normal multiplexer operation.

Packaged on a single quad-height, four-layer pcb, the CC01 occupies a single SPC slot, presents one bus load, and draws only four amps of +5V from the internal CPU power supply. No other backplane voltages are required.

CP12 Distribution Panel

In standard configurations, the CC01 controller serves as the interface between the host computer and one to four CP12 Distribution panels. The first panel is connected up to fifty feet from the controller by a 34-conductor flat cable. All additional panels are daisy-chained from the first panel. A terminator installs in the last panel in the chain. (The CC01 controller may also be connected to CP32 and CP34 distribution panels.)

One CP12 Distribution Panel consists of a mechanical chassis, a cable interface pcb, and a power supply of 50-60 Hz, 115/230 VAC, 35 watts. Alone, the mechanical chassis is basically a shell structure, designed to support the installation of either one or two 8-line adapter boards. These boards fit into the cutouts on the chassis and plug into the cable interface pcb.

Using the adapter boards, a single CP12 Distribution Panel may be configured for either eight or sixteen lines. And the type of adapter board — asynchronous, current loop, etc.—may be selected for each group of eight lines.

The integral power supply is a vital component of the CP12 Distribution Panel and of the CS01/H Multiplexer as a whole. When used with the CP12 panels, the CC01 Controller requires only a bare minimum of power from the internal host CPU power supply to support up to 64 lines: 4 amps of +5V. No additional power is required as lines are added.

CA12 Line Adapter Board

The CA12 8-line Adapter is a pcb which plugs into one of two cutouts in a CP12 Distribution Panel. Currently, two basic versions of the CA12 may be used with the CS01/H: RS-232-C and Current Loop. Both versions contain the UARTs and the line cable connectors that constitute the multiplexer's terminal interfaces.

Both versions also contain a loop-back plug for manual testing of individual 8-line groups. These tests may be initiated by positioning a "Line Test" switch in either "internal" or "external" mode. LED indicators above each line light up to indicate any failure on a line. Testing may be conducted in eight-line groups without interrupting the normal operations of the other lines.

CS02/H COMMUNICATIONS MULTIPLEXER

General Description

There are two versions of the CS02/H, one for DEC's MICRO/PDP-11 and one for the entire LSI-11 series, including the 11/23 PLUS. Both versions handle

sixteen asynchronous lines, and both provide functional emulation of either one 16-line DH11 multiplexer or two 8-line DHV11 multiplexers.

To provide two emulations for two computer systems, the CS02/H must be an extremely versatile system with an extra-wide variety of features. It must possess all that's good in the DHV11 as well as all that's good in the DH11. And it must make all these things work in two completely different environments.

The CS02/H accomplishes all of this and more. DEC does not offer DH11 performance for any of its QBus products. Emulex offers enhanced DH11 capability for all QBus products with the CS02/H, as well as the CS01/H.

As a DH11 emulation, the CS02/H quadruples the FIFO capacity of the DH11. As a DHV11 emulation, the CS02/H doubles the number of lines supported by the DHV11 while providing automatic internal DMA/PIO output selection and automatic XON, XOFF operation. Both emulations provide 22-bit addressing and internal power-up self-test, and both operate transparently to standard DEC operating software.

The overall organization of this multiplexer is best understood by studying each of the components separately.

Subsystem Components

CC02 Communications Controller

A single CC02 controller is used in all applications (both MICRO/PDP-11 and LSI-11) of the CS02/H. Packaged on one quad-size pcb, this 8-bit microprocessor-based controller holds all of the active circuitry for the multiplexer and thus performs all of the operations required to transfer data between the host CPU and the sixteen terminals connected to the multiplexer's distribution panel(s).

A set of firmware on the CC02 contains two standard emulations, one designed to emulate a single 16-line DH11 and one designed to emulate two 8-line DHV11's. An on-board switch enables the user to select and implement the microcode version/ emulation of his choice.

In addition to its regular operations, the CC02 automatically executes extensive self-tests each time the multiplexer comes on line.

The CC02 interfaces with two different distribution panels. When used with an LSI-11, the CC02 interfaces with one CP22 distribution panel. When used with a MICRO/PDP-11, the CC02 interfaces with either one or two distribution panels: the CP24 and the optional CP24/B.

CP22 Distribution Panel

This 16-line panel contains no active circuitry or power supply, only the mechanical connectors necessary to link the controller and the terminal lines. The mechanical interface consists of sixteen 25-pin male subminiature D-type connectors. The electrical interface is RS-423. Both are compatible with the RS-232-C EIA standard.

The CP22 supports twelve lines with partial modem control (full duplex applications) and four lines with full modem control (full and half duplex applications).

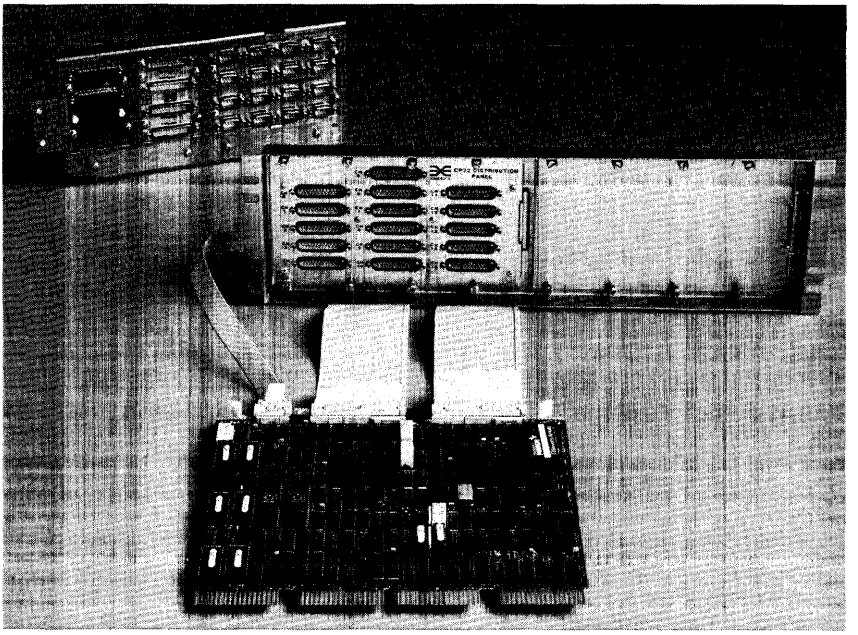


Figure 4-3 CS02/H Communications Multiplexer

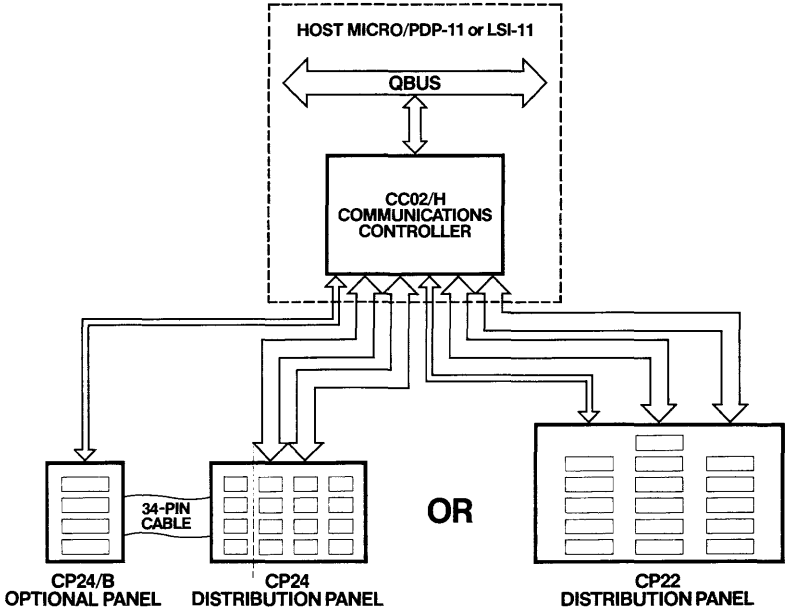


Figure 4-4 CS02/H Subsystem Organization

One CP22 distribution panel interfaces to a CC02 controller via two 50-pin cables and one 16-pin cable. FCC compliant, the CP22 panel installs in the place of standard DEC I/O connection panels (4 panel units).

CP24 Distribution Panel

Like the CP22, the CP24 distribution panel contains no active circuitry or power supply, only the mechanical connectors necessary to link the controller and the terminal lines. Unlike that of the CP22 panel, however, the mechanical interface of this panel consists of sixteen 9-pin male subminiature D-type connectors.

It should be noted that these connectors are not mechanically compatible with the 25-pin connectors of the RS-232-C EIA standard. The CP24 panel does perform comparably to the industry standard, nevertheless, for its RS-423 electrical interface *is* compatible with the RS-232-C interface.

Emulex opted to use the 9-pin connectors for a particular reason. The CP24 panel is designed to fit into an I/O cutout of the MICRO/PDP-11 patch panel. This cutout is quite small—too small to hold a panel with more than eight 25-pin connectors. Using the smaller 9-pin connectors in conjunction with an RS-423 electrical interface, then, enables Emulex to fit sixteen lines on a single panel without sacrificing or impairing the panel's performance.

The CP24 panel supports sixteen lines with partial modem control (full duplex applications). One CP24 panel interfaces with a CC02 controller via two 50-pin cables.

CP24/B Optional Distribution Panel

This optional panel is designed for those MICRO/PDP-11 users who require the extra lines and emulation flexibility of the CS02/H, but who also require full modem control on some lines (full and half duplex applications). The CP24/B provides four lines with full modem control.

Like the above two panels, the CP24/B contains no active circuitry. Its mechanical interface consists of four 25-pin male subminiature D-type connectors, compatible with the RS-232-C EIA standard.

The CP24/B installs into the second I/O cutout in the MICRO/PDP-11 patch panel and is linked to the CP24 panel by a short 34-pin ribbon cable. Note, however, that the CC02 controller is capable of handling a maximum of sixteen lines. Therefore, when the optional 4-line CP24/B panel is connected, the first four lines of the CP24 panel may not be used.

The CP24/B interfaces with a CC02 controller via one 16-pin cable.

CS11 SERIES COMMUNICATIONS MULTIPLEXERS

General Description

The development of bit-slice microprocessor architecture has enabled Emulex to produce a single standard design adaptable to all of their controller products. The CS11 multiplexer for VAX-11 and PDP-11 series computers extends this common architecture principle even further, featuring a single controller adaptable to four different emulation models:

CS11/F: Emulates the asynchronous portion of the DMF32 for use on VAX-11 Series CPU's; software and diagnostic transparent; 16, 32, or 48 lines per controller.

CS11/H: Full DH11/DM11-BB emulation for PDP-11 Series CPU's; software and diagnostic transparent; 8-64 lines per controller. Will run on VAX-11 Series CPU's equipped with the UNIX operating system.

CS11/U: Full DH11/DM11-BB emulation for VAX-11 Series CPU's; uses Emulex VMS/UH software support package; 8-64 lines per controller.

CS11/V: Full DV11 emulation for PDP-11 Series CPU's; software and diagnostic transparent; 8-32 lines per controller.

PROM sets containing standard microcode versions for each of the above emulations arranged with various types of line adapter boards provide the user with unprecedented flexibility in system application. And all four emulations feature speeds up to 19.2 Kbaud, word transfers in DMA operations, optimum packaging, low power, and automatic and manual internal self-test.

Subsystem Components

CC11 Communications Controller

The basic CC11 is an 8-bit microprocessor-based controller which performs the majority of operations required to transfer data between the host CPU and the multiple terminals connected to the Distribution Panels. All communication protocol is handled by this unit. Standard microcode versions execute exact emulations of three different DEC controllers: the DH11, the DV11, and the DMF32. The CC11 is transparent to the standard DEC operating and diagnostic software used with these units. The CC11 is configured for the different emulations via PROM and line adapter changes.

In addition to its standard communications operations, the CC11 also executes extensive power-up self-tests. 8-line channel groups may be tested during normal operation through manual intervention.

The CC11 is packaged on a single hex-height board. The unit occupies a single SPC slot, presents one bus load, and draws approximately 4 amps of +5V. No other backplane voltages are required.

CP12 Distribution Panel

The same distribution panel as that used in the CS01/H series, the CP12 is standard panel used in CS11 configurations. The CP12 is particularly suited to the diverse large-scale applications of the CS11 multiplexer for several reasons. First, each CP12 houses its own power supply of 50-60 Hz, 115/230 VAC, 35 watts. So as lines are added, power is added, *without* draining the host CPU power supply.

Second, the mechanical chassis and cable interface board of the CP12 are designed to support the installation of one or two 8-line adapter boards. The type of adapter board—RS-232-C, current loop, etc.—may be selected for each group of eight lines to match the requirements of a particular emulation configured on the controller.

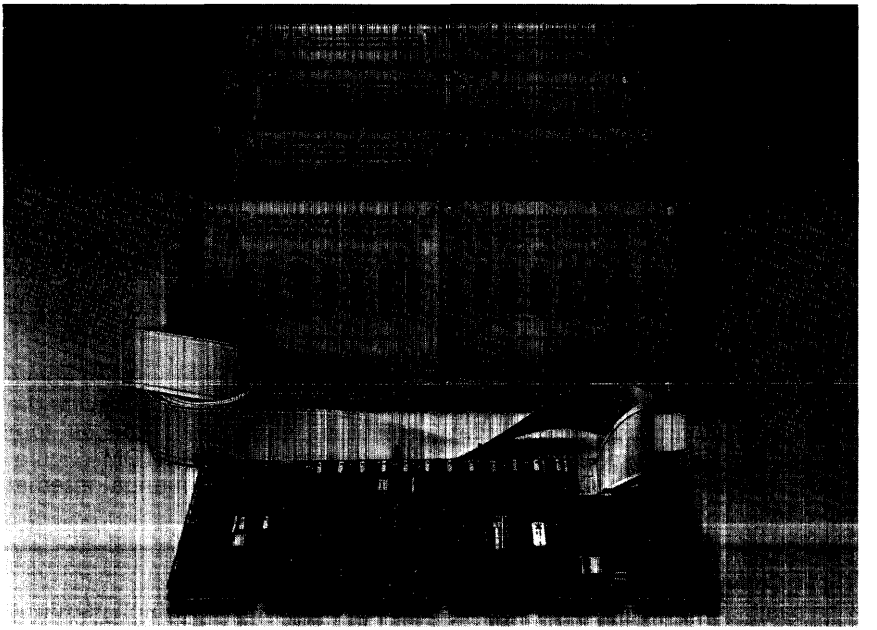


Figure 4-5 CS11 Series Communications Multiplexer

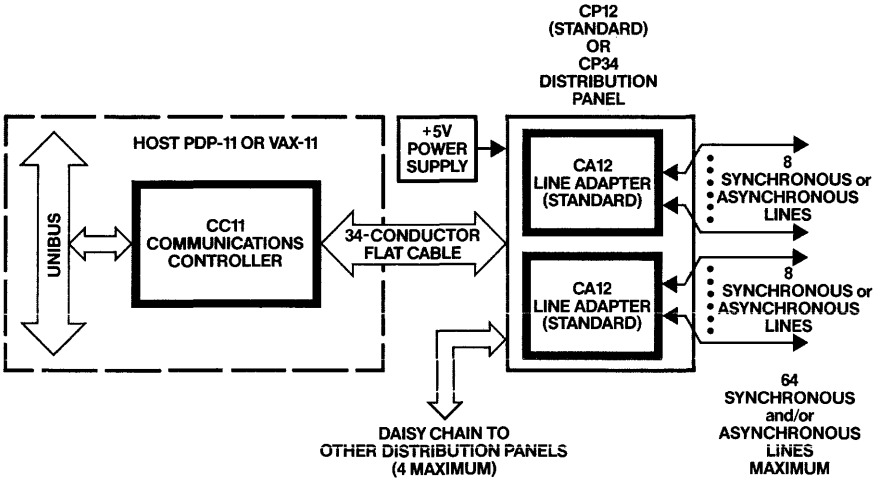


Figure 4-6 CS11 Subsystem Organization

The first CP12 Distribution Panel may be connected up to fifty feet from the CC11 Controller by a 34-conductor flat cable. One to three additional panels may be daisy-chained from the first panel for a multiplexer maximum of 64 lines.

Note: The CC11 controller may also be connected to CP32 and CP34 distribution panels.

CA12 Line Adapter

Currently, three versions of the CA12 Adapter may be used with the CS11: the CA12/H for asynchronous only RS-232-C applications, the CA12/C for current loop applications, and the CA12/V for synchronous/asynchronous RS-232-C applications. All three versions contain the UARTs and the line cable connectors that constitute the multiplexer's terminal interfaces.

All three versions also contain a loop-back plug for manual testing of individual eight-line groups. These tests may be initiated by positioning a "Line Test" switch in either "internal" or "external" mode. Fault LED's are positioned above each line. Testing may be conducted in eight-line groups without interrupting the normal operations of other lines.

Models

CS11/F

A single hex board, multi-function controller, the DEC DMF32 breaks down into three major components: an 8-line asynchronous terminal interface, a synchronous port, and a parallel port. The asynchronous terminal interface portion of the controller supports a feature unavailable on most other DEC multiplexers: automatic internal selection of buffered Programmed I/O or DMA output of characters.

Emulex recognized the value of this feature, believing that many users would like to see it extended to larger applications. So Emulex introduced the CS11/F, a multiplexer model which emulates only the asynchronous terminal interface portion of the DMF32. By eliminating the synchronous and parallel ports on the CS11/F, Emulex created a controller capable of supporting 16, 32, or 48 lines, all with automatic DMA/Programmed I/O selection.

All of the lines on the CS11 support full duplex modem control. This is not possible on the DMF32. The component density required to support three different types of interfaces on a single board forces DEC to limit the modem control of the asynchronous terminal interface portion of the DMF32 to full duplex on two lines only.

Designed for VAX-11 series computers, the CS11/F operates transparently to the VAX/VMS DMF32 I/O Driver, DEC's EVDLC Diagnostics, and DEC's VAX/VMS Operating Systems Versions 3.0 and above. The CS11/F supports both RS-232-C and Current Loop transmissions and data rates up to 19.2 Kbaud per line.

CS11/H

The primary selling features of this high-performance DH11/DM11-BB emulation are a massive increase in line capability coupled with a massive reduction in hardware. DEC's DH11 with DM11-BB modem control handles 16

asynchronous lines, requires nine backplane slots, presents three loads to the Unibus, and draws 11.2 amps of +5V from the CPU internal power supply.

Now consider the Emulex alternative. The CS11/H DH11/DM11-BB emulation handles 8-64 asynchronous lines, requires one backplane slot, presents one load to the Unibus, and draws only 4 amps of +5V from the CPU internal power supply. Moreover, the CS11/H doubles the DMA transfer rate and maximum potential data rate of the DH11 and provides optional double FIFO capacity.

The CS11/H is designed for use with PDP-11 series computers. It may, however, also be used with VAX-11 Series CPU's equipped with the UNIX operating system. Normally, the CS11/H operates transparently to all common DEC PDP-11 operating systems and to DEC's Diagnostics Kit ZJ179. When used with VAX-11's, the CS11/H operates transparently to the UNIX operating system. In either case, the CS11/H supports both RS-232-C and Current Loop transmissions.

CS11/U

DEC does not offer a high performance DH11 product for their VAX-11 series. Emulex does: the DH11-compatible CS11/U. The CS11/U features the same massive increase in line capability and massive reduction in hardware as the CS11/H. Functionally equivalent to four DH11's and four DM11-BB's, then, the 8-64 line CS11/U also supports both RS-232-C and 20 mA Current Loop transmissions and features DMA word transfers, data rates up to 19.2 Kbaud, and optional 64/128-character FIFO buffering.

The CS11/U implements DEC VAX/VMS Operating System software, versions 2.0 and above, using the specially developed Emulex VMS/UH software/diagnostics package.

CS11/V

Designed for PDP-11 series computers, the CS11/V emulates the DEC DV11 multiplexer with DM11 modem control. The primary difference between the CS11/V and the other members of the CS11 family is that the CS11/V offers synchronous as well as asynchronous transmission. 8-line groups may be arranged asynchronously or synchronously on two CP12 distribution panels for a maximum of 32 lines.

The CS11/V is software transparent on the PDP-11 Unibus and is supported by the following software packages: DECnet-11M PLUS, DECnet-IAS, DECnet-11s, and DECnet-11M.

The single controller board of the CS11/V is functionally equivalent to two DEC DV11's, each of which employs a dedicated 9-slot backplane. And, the CS11/V offers the following features: word DMA transfers, internal self-test, asynchronous speeds up to 19.2 Kbaud, and synchronous speeds up to 9.6 Kbytes per second.

CS21 SERIES COMMUNICATIONS MULTIPLEXERS

General Description

The 16-line CS21 Communications Multiplexer is designed for those VAX/PDP-11 users who need the high performance, upgrade capability, low

power, internal self-test, and compact packaging of the CS11, but not the large numbers of lines. Too many extra lines and the added hardware necessary to implement them only overcomplicate the requirements and escalate the cost of these users' small applications. Like that of the CS11, the single controller in the CS21 Series is capable, through PROM changes, of four different emulations:

CS21/F: Emulates the asynchronous portion of the DMF32 for use on VAX-11 CPU's; software and diagnostic transparent with VMS Versions 3.0 and above; 16 lines per controller.

CS21/H: DH11/DM11-BB emulation for PDP-11 Series computers; software and diagnostic transparent; 16 lines per controller. Will run on VAX-11 CPU's with UNIX operating system.

CS21/U: DH11/DM11-BB emulation for VAX-11 CPU's; uses Emulex VMS/UH software support package; 16 lines per controller.

CS21/Z: Full DZ11-E emulation for PDP-11 and VAX-11 CPU's; software and diagnostic transparent with VMS Versions 3.0 and above; 16 lines per controller.

Subsystem Components

CC21 Communications Controller

Like the CS11, the CS21 features one hex-size 8-bit microprocessor-based controller board capable, through PROM substitution, of four different high-performance emulations. Unlike the CC11, however, the CC21 Controller Board contains *all* of the active circuitry for its multiplexer system, including the UART, data, and modem interface circuitry.

The CC21 Controller handles sixteen lines, occupies a single hex-size SPC slot, presents one load to the Unibus, and draws approximately 8 amps of +5V and 0.25 amps of ±15V from the internal CPU power supply.

CP22, CP23, and CP25 Distribution Panels

Two 50-conductor flat cables attach the CC21 controller to one of three 16-line distribution panels: the standard CP22 RS-232-C Distribution Panel, the CP23 Current Loop Distribution Panel, or the new CP25 RS-422/RS-232-C Long-Drive Distribution panel.

Unlike the CP12 panel, these three panels do not contain their own power supply and do not support the installation of separate line adapter boards. All components required to interface the system's controller to its terminal lines are integral parts of the panels themselves.

The CP25 panel is one of two very new additions to the Emulex Communications product line. It features RS-422 and/or RS-232-C interface capability, strap-selectable on a per line basis. The differential RS-422 capability allows a terminal or other external asynchronous device to be located up to 4000 feet from the distribution panel of the host system. This distance is far greater than that possible with any RS-232-C or Current Loop interfaces.

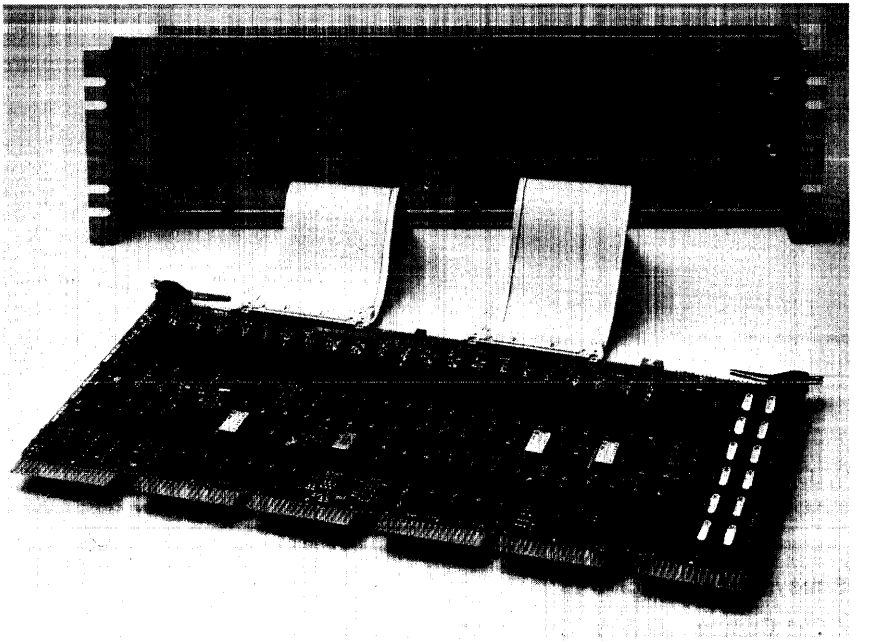


Figure 4-7 CS21 Series Communications Multiplexer

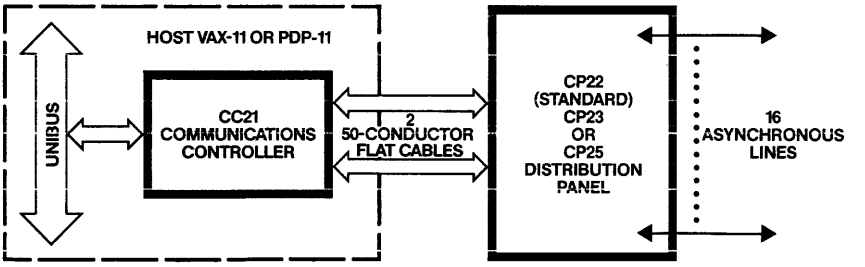


Figure 4-8 CS21 Subsystem Organization

Models

CS21/F

Like the CS11/F, the CS21/F emulates the asynchronous terminal interface portion of DEC's DMF32 while providing full duplex modem control on every line. With sixteen possible lines, then, the CS21/F is the ideal low-cost, small-application multiplexer for VAX-11 users who do not require the synchronous and parallel ports of the DMF32, but who do require automatic internal selection of Programmed I/O or DMA output and modem control on every line.

Designed for VAX-11 series computers, the CS21/F operates transparently to the VAX/VMS DMF32 I/O Driver, to DEC's EVDLC and EVDAC Diagnostics, and to DEC's VAX/VMS Operating Systems Versions 3.0 and above.

The CS21/F supports data rates up to 19.2 Kbaud and 16-bit word DMA transfers.

CS21/H

Like the CS11/H, the 16-line CS21/H emulates DEC's DH11 for PDP-11 series computers. The CS21/H does not, however, provide DM11-BB modem control (half duplex, full duplex, and echoplex). Instead, the CS21/H provides the more limited full-duplex modem control of the DZ11.

In most applications, the numerous advantages of the CS21/H over the DH11 far outweigh this minor disadvantage. Consider the following comparisons. Both the CS21/H and the DH11 handle sixteen asynchronous lines. Yet the CS21/H requires only one backplane slot for every DH11 nine, presents one bus load for every DH11 three, draws 8 amps of +5V for every DH11 11.2. And the CS21/H is capable of quadrupling the DH11's FIFO capacity, of operating at twice the DH11 maximum data rate, and of performing word rather than byte DMA transfers.

The CS21/H operates transparently to all common DEC PDP-11 operating systems and to DEC's ZJ179 Diagnostics Kit.

CS21/U

The VAX-11 counterpart of the CS21/H, the 16-line CS21/U emulates the DH11 with DZ11-type modem control (full duplex) and features switch-selectable 64/256-character FIFO buffering, DMA word transfers, and data rates up to 19.2 Kbaud.

The CS21/U runs with DEC VAX/VMS Operating System software, versions 2.0 and above, using the specially developed Emulex VMS/UH software/diagnostics package.

Packaging characteristics and performance advantages of the CS21/U are the same as those for the CS21/H.

CS21/Z

Designed for use with both the PDP-11 and the VAX-11 Series, the CS21/Z emulates the 16-channel DEC DZ11-E. The CS21/Z occupies a single hex SPC slot and controls a maximum of 16 terminals or like devices. A com-

parable DZ11-E 16-line configuration requires two controllers occupying two SPC slots.

The CS21/Z has two other major advantages over the DZ11-E. First, the CS21/Z has the option to increase the receiver buffer size from 64 characters per 16 lines to 128 characters. The DZ11-E receive buffer is only 64 characters per 8-line increment.

Second, the CS21/Z has the option to increase the transmitter buffer size from 1 character to 16 characters. The DZ11 has only a 1-character buffer.

CS32/F COMMUNICATIONS MULTIPLEXER

General Description

The differences between this communications multiplexer and its DEC counterpart are perhaps greater than any others in the DEC/Emulex relationship. Like the CS11/F and the CS21/F, the CS32 emulates the 8-line asynchronous terminal interface portion of the DEC DMF32.

Through automatic internal selection of buffered Programmed I/O or DMA output transmissions, the DMF32 was designed to slash the data transfer overhead of the VAX-11/730's. Two of the eight lines in the DMF32 interface support full modem control and split speed capability. The eight lines together have one 48-character FIFO buffer.

Now consider the CS32. Capable of supporting up to 128 physical lines, this multiplexer is *sixteen times* the functional equivalent of its DMF32 counterpart. And *all* of the CS32's lines have full modem control, automatic DMA/PIO output selection, and split speed capability. For PIO transmissions, the CS32 has a 32-character output buffer on each line. And, for DMA operations, the CS32 supports word, rather than byte, transfers.

The CS32 operates transparently to DEC EVDLC Diagnostics and VAX/VMS Operating Systems Software Versions 3.0 and above. The CS32 occupies a single Unibus SPC slot, presents one bus load, and requires only 4 amps of the internal CPU +5V power supply.

Subsystem Components

CC32 Communications Controller

The basic CC32 is an 8-bit microprocessor-based controller which performs the majority of operations required to transfer data between the host CPU and the multiple terminals connected to the Distribution Panels. All communication protocol is handled by this unit. A standard microcode version executes an exact emulation of the asynchronous portion of sixteen DMF32 controllers.

In addition to its standard communications operations, the CC32 also executes extensive power-up self-tests. 8-line channel groups may be tested during normal operation through manual intervention.

The CC32 is packaged on a single hex-height, 2-sided pcb. The unit occupies a single SPC slot, presents one bus load, and draws approximately 4 amps of +5V. No other backplane voltages are required.

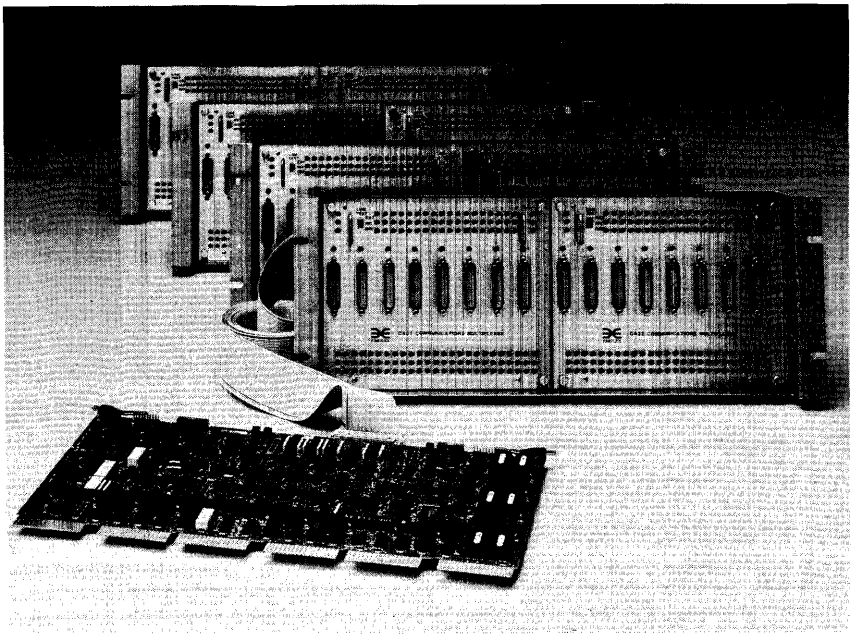


Figure 4-9 CS32/F Communications Multiplexer

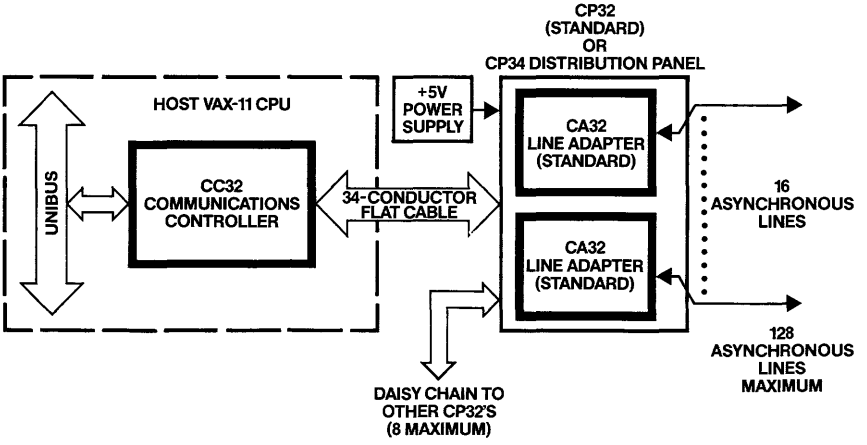


Figure 4-10 CS32/F Subsystem Organization

CP32 Distribution Panel

The CC32 controller serves as the interface between the host computer and one to eight CP32 Distribution panels. The first panel is connected up to fifty feet from the controller by a 34-conductor flat cable. All additional panels are daisy-chained from the first panel. A terminator installs in the last panel in the chain.

Similar to the CP12, the CP32 Distribution Panel consists of a mechanical chassis, a cable interface board, and a power supply of 50-60 Hz, 115/230 VAC, 35 watts. Alone, the mechanical chassis is basically a shell structure, designed to support the installation of either one or two 8-line adapter boards. These boards fit into the cutouts on the chassis and plug into the cable interface pcb.

Using the adapter boards, a single CP32 Distribution Panel may be configured for either eight or sixteen lines.

The integral power supply is a vital component of the CP32 Distribution Panel and of the CS32 Multiplexer as a whole. When used with the CP32 panels, the CC32 Controller requires only a bare minimum of power from the internal host CPU power supply to support up to 128 lines: 4 amps of +5V. No additional power is required as lines are added.

CA32 Line Adapter Board

The CA32 8-line Adapter is an option which plugs into one of two cutouts in a CP32 Distribution Panel. One CA32 contains eight RS-232-C line cable connector interfaces and UART-type circuits necessary for parallel-to-serial and serial-to-parallel conversions. One CA32 also contains a loop-back plug for manual testing of individual 8-line groups. These tests may be initiated by positioning a "Line Test" switch in either "internal" or "external" mode. LED indicators above each line light up to indicate any failure on a line. Testing may be conducted in eight-line groups without interrupting the normal operations of the other lines.

CP34 DISTRIBUTION PANEL

This new FCC-compliant, 16-line panel is scheduled for release around the middle of 1984. The CP34 features RS-423/RS-232-C *and* RS-422 long-drive interface capability, strap-selectable on a per-line basis. In addition, all lines on this panel support single-ended full DMF32/DH11 RS-232-C modem control for dial-up support.

The differential RS-422 capability of the CP34, new to the Emulex product line, allows terminals and/or other asynchronous devices to communicate with the host system at speeds up to 38.4 Kbaud, while situated up to 4000 feet away.

The CP34 is designed to be compatible with most DEC FCC cabinets, occupying the same physical mounting space (5.25" x 19") as the DEC I/O connection panels. Similar to Emulex's CP12 and CP32 Distribution Panels, the CP34 comes equipped with its own power supply. Unlike the other two panels, however, the CP34 does not support independent line adapter boards. All interface circuitry is integrated into the panel itself. Conse-

quently the interface channels must always be arranged in 16-line, rather than 8-line increments.

The interface flexibility, full modem control, and optimum packaging of the CP34 make it a panel of unsurpassed performance. In light of this fact, Emulex has designed the CP34 to operate with all of their large-application multiplexer systems (excluding the Statcon Series 11 and the CS11/V). The CS34 may substitute for, and will eventually replace, the CP12 and CP32 Distribution Panels.

CHAPTER 5
SOFTWARE CONSIDERATIONS

Table 5-1 catalogs the various DEC operating systems supported by Emulex Communications Products.

TABLE 5-1
Emulex Communications Products
Operating System Support

	MICRO-RSX	RSX-11M	RSX-11M PLUS	RSTS/E	RT-11	DSM-11	PDP-11 UNIX (V7M)	TSX-PLUS	VAX/VMS	VAX UNIX	TOPS-10***	TOPS-20***
CS01/H		X	X	X		X	X	F				
CS02/H	X	X	X	X		X	*	F				
CS11/F									X	F		
CS11/H		X	X	X		X	X	F		X	X	X
CS11/U		S	S	S		S	S		X	S	S	S
CS11/V**												
CS21/F									X	F		
CS21/H		X	X	X		X	X	F		X	X	X
CS21/U		S	S	S		S	S		X	S	S	S
CS21/Z		X	X	X	X	X	X	X	X	X	X	
CS32/F									X	F		
CSM11/MH		X	X	X		X	X	F		X	X	X
CSM11/MU		S	S	S		S	S		X	S	S	S
CSM21/MH		X	X	X		X	X	F		X	X	X
CSM21/MU		S	S	S		S	S		X	S	S	S
CSM21/MZ		X	X	X	X	X	X	X	X	X		
CSM32/MF									X	F		

* = DH11-mode only.

S = Supported but not generally recommended.

F = Future.

** = CS11/V is supported by diagnostics on PDP-11's only. There is no driver support available under any operating system. However, support is available under DECNET-11M, DECNET-11M PLUS, a nd DECNET-11S, as well as under third-party software.

*** = Requires DNXX front-end processor.

CHAPTER 6
EMULEX DISTRIBUTION PANELS

The continual upgrading and development of Emulex's communications distribution panels has produced a number of extremely flexible and often interchangeable panels. For user convenience, the following charts illustrate the standard panel configurations for each Emulex communications multiplexer, as well as all distribution panel, line adapter, and emulation options.

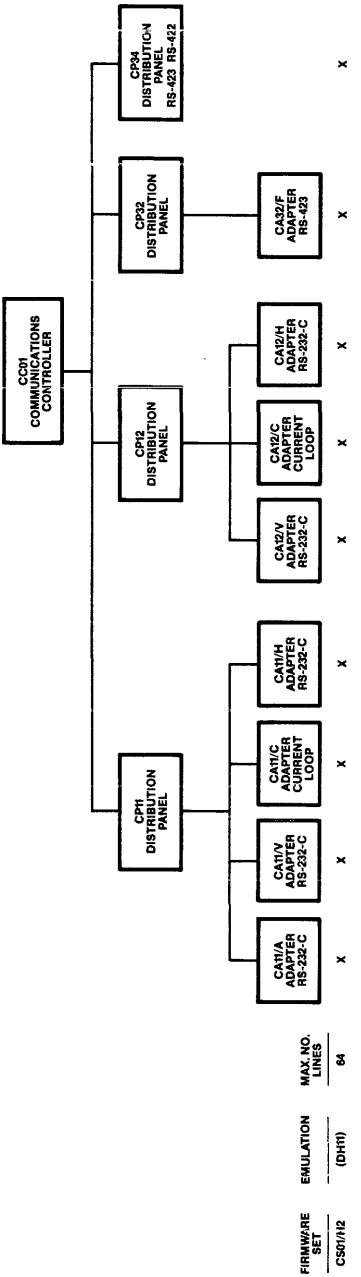


Figure 6-1 CS01 Series

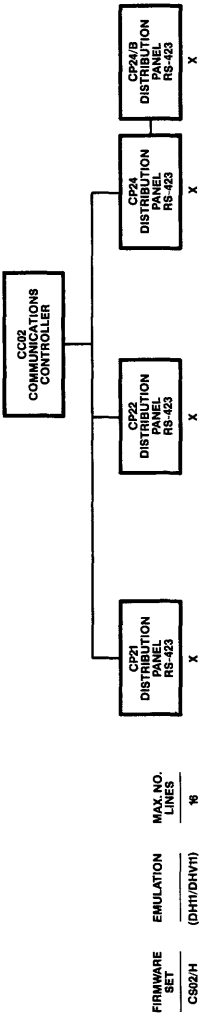


Figure 6-2 CS02 Series

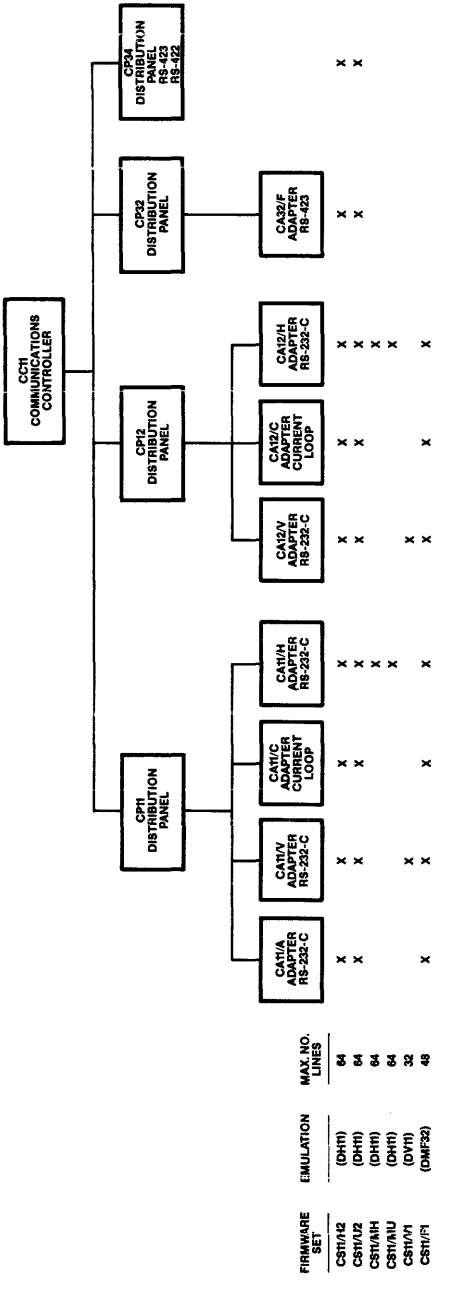


Figure 6-3 CS11 Series

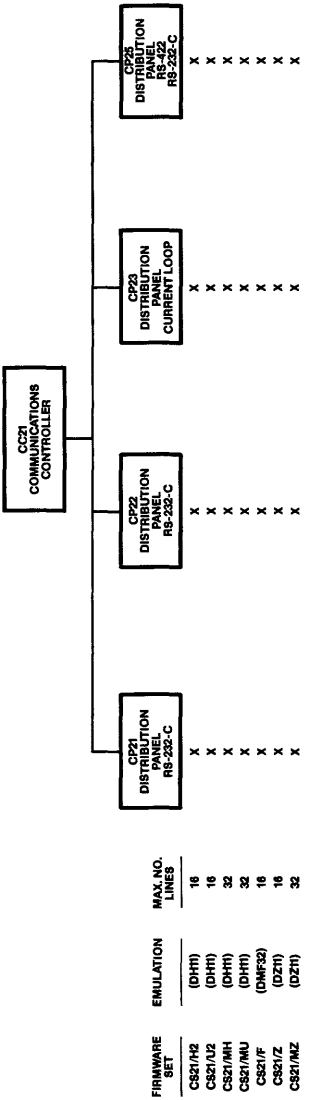


Figure 6-4 CS21 Series

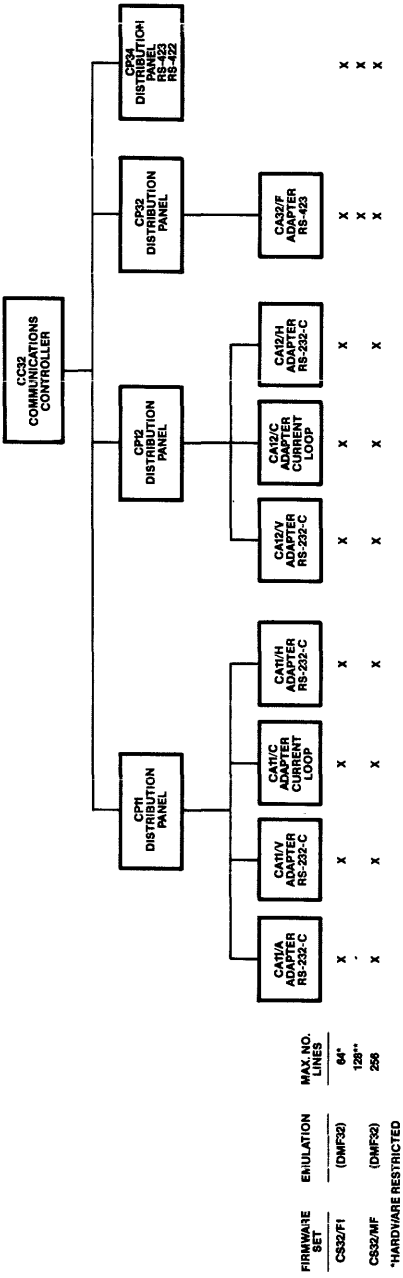


Figure 6-5 CS32 Series

SECTION III
STATCON SERIES COMMUNICATIONS SUBSYSTEMS

CHAPTER 7
INTRODUCTION

Traditionally, user options were limited when it came to satisfying both remote and local communication requirements for a single host minicomputer system. Support for remote users had to be provided on a line-by-line basis. That is, each communications channel dedicated for support of remote users required an attendant pair of modems and its own telephone line. And, of course, the physical ports dedicated to remote communications were not available for local use.

Solutions to this problem have been developed in recent years. All have sought to meet the following objectives:

1. To multiplex data for transmission to and from the host computer and local/remote terminal sites.
2. To demultiplex data at the proper destinations.
3. To provide error-free data transfers.
4. To reduce hardware requirements and costs without sacrificing performance.
5. To eliminate the need for changes or additions to resident software.
6. To reduce the numbers of communication ports and telephone lines.
7. To increase the number and transfer speed of available local and remote lines.

Only Emulex succeeds in making all of the above objectives reality. Compare Emulex's solution to those others currently in use:

EXAMPLE A: Host Communications to Port Concentrator to Remote Concentrator.

In this method, data from various channels is multiplexed *within the host processor itself,* then sent in a composite stream through one port to a port concentrator and on to a remote concentrator. In other words, the host processor provides communication protocol and handles all multiplexing tasks, while the port concentrator provides port-sharing capability, data buffering, error control, and link maintenance.

The main benefit of this method is obvious: the user requires fewer computer ports for remote applications. More ports and lines are subsequently available for local communications, and redundant telephone line and modem costs are eliminated.

Unfortunately, the main disadvantage of this method is also obvious: massive, complicated, and costly additions to the resident host software are required. Alone, the resident minicomputer software does not have the communication protocol necessary for implementing the multiplexing process.

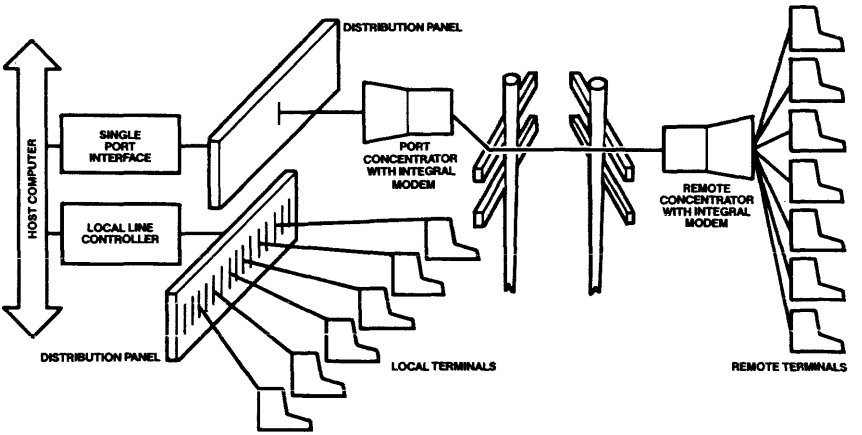


Figure 7-1

EXAMPLE B: Master/Slave Data Concentrators.

Here, remote communications are accomplished as follows. One data-concentrating unit operates at each end of a transmission line. Working with a multi-line controller, the "Master" concentrator multiplexes data from up to sixteen physical ports at the host computer site, sending it across a single line to the "Slave" concentrator at the remote site. The Slave, configured and instructed by the Master, demultiplexes the transmitted data, dividing and distributing it to a number of terminals. In this method, the relationship between ports (communication interfaces) and terminals is one-to-one.

This method has several benefits. It eliminates redundant telephone line and modem costs. In addition, all communication protocol and any error correction procedures used between the concentrators are embedded in the controller and/or concentrator firmware, so no changes to the resident software are necessary.

Although this system does significantly reduce hardware requirements/costs, each logical channel still requires one port/communication interface, and each remote site requires one controller and two concentrators. Moreover, an additional, separate controller is required for local line applications. Line capability is limited by all of these factors.

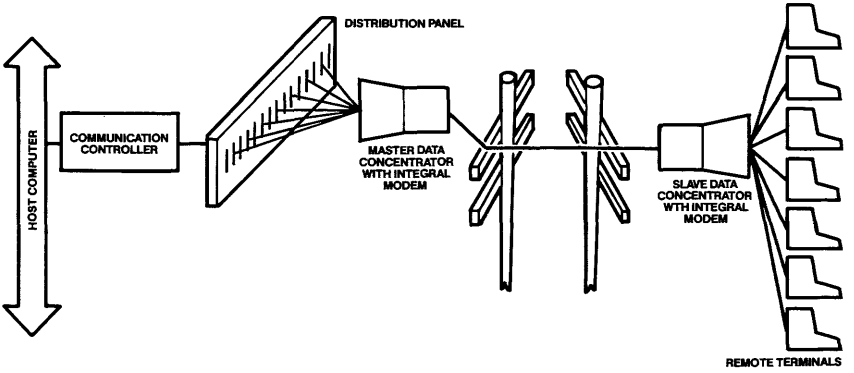


Figure 7-2

The Emulex Method

Emulex's Statcon Series subsystems combine the best elements of the above two methods—port concentration and data concentration—*without* requiring changes to any part of the host processing system.

In a Statcon system, the multiplexing/demultiplexing of up to 256 remote *and/or* local lines is handled by a single controller board. No changes to the resident software are required, for all Statcon systems operate transparently to the host processor. In addition to multiplexing/demultiplexing, the Statcon controller manages system configuration and assumes partial responsibility for error control.

Multiplexed data from up to sixteen channels passes through a single asynchronous RS-232-C port to a port concentrator. Emulex has endowed its port concentrators with firmware "intelligence", enabling them to interface with Emulex controllers and making them "masters" over remote concentrator "slaves." A port concentrator aids the controller in its multiplexing tasks, establishes and maintains the link with the remote concentrator, configures the remote concentrator, and buffers data during peak loading periods.

Statcon Series systems, then, eliminate redundant telephone line, modem, cabling, and controller hardware costs. And, with port concentration and statistical multiplexing, they allow for error-free transmission over more lines at faster rates than any other product.

For more details and information on specific Statcon products, read through the following sections.

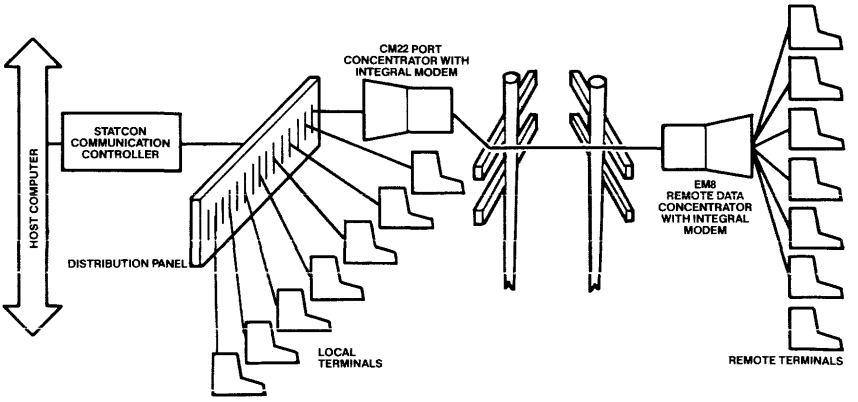


Figure 7-3

CHAPTER 8
STATCON COMPONENTS

On the simplest level, a Statcon system consists of an Emulex statistical multiplexer plus one new firmware set, one port concentrator with/without an integral modem, and one remote concentrator with/without an integral modem.

Controller

The controllers in the Statcon 11, 21, and 32 subsystems are merely firmware-upgraded versions of the controllers in Emulex's corresponding CS11, CS21, and CS32 communications multiplexers. All are single hex-size printed circuit boards. All plug directly into a single Unibus SPC backplane slot. And all share the same bit-slice microprocessor architecture inherent in all Emulex products.

Like all versions of Emulex communications controllers, the Statcon controllers provide local terminal channel support and perform the emulations supported by their particular subsystems. The Statcon 11 emulates the DH11 for VAX/PDP-11 computers. The Statcon 21 emulates either the DH11 or the DZ11-E for VAX/PDP-11 computers. And the Statcon 32 emulates the asynchronous multiplexer portion of the DMF32 for VAX-11 computers.

The new firmware in the Statcon systems, however, expands the controllers' intelligence and, subsequently, their duties. Now the Statcon controllers are responsible for statistically multiplexing/demultiplexing channel data for remote channel operation, for self-configuration, for serving as the interface between the host CPU and port concentrators, for monitoring data rate and flow changes, for modem control, and for diagnostic remote/local loopback.

It should be noted that all Statcon multiplexers are Statistical Multiplexers. In keeping with the general definition of the word "multiplexer", the multiplexer portion of the Statcon gathers data from a number of different channels and sends it in a composite data stream across a single link to terminals in a local and/or remote sites. Or, in the other direction, the multiplexer gathers data from a number of terminals and sends it in a composite data stream to the host computer.

Statistical Multiplexers rely on the assumption that computer channels and terminals rarely, if ever, transmit constantly at their maximum speed. Under this assumption, data from many channels may be multiplexed on a link which is running at a slower speed than would be necessary to handle all channels running at their maximum speeds simultaneously.

The Statistical Multiplexing process is faster and more efficient than Time-Division Multiplexing. In Time-Division Multiplexing, every block in the data

stream is uniform in size and reserves space for data from every channel—even those that are inactive. Statistical Multiplexing reserves space only on an as-needed basis.

Distribution Panel(s)
Statcon controllers interface with both local and remote channels via one or more 16-line/port distribution panels. The Statcon 11 interfaces with CP12 panels, the Statcon 21 with a single CP22 panel, and the Statcon 32 with CP32 or CP34 panels. The first panel in a Statcon 11 or a Statcon 32 subsystem may be located up to fifty feet from the host processor. Any/all additional panels are daisy-chained to the first panel.

Each of the sixteen RS-232 interface ports on a distribution panel is dedicated to either local or remote service through user-selectable configuration switches located on the Statcon's port concentrator. Remote ports are always assigned first. (Refer to the Statcon Configuration section of this handbook for more information on this subject.)

In a Statcon system, each local terminal always has a one-to-one relationship with a particular port on a distribution panel. Up to sixteen terminals positioned in the same *remote* area, however, may share a single port with the help of a port concentrator.

Port Concentrator(s)
The CM22 Port Concentrator is a standalone component positioned between a single RS-232-C distribution panel port and a telephone line. The cable that connects the CM22 to the RS-232-C port is referred to as the local composite link. If the CM22 has an integral modem, that modem is connected directly to a four-wire telephone line via a Telco adapter; otherwise, a modem must be supplied by the user.

Like the system controller, the CM22 Port Concentrator contains special firmware which enables it to relieve the host processor of some complicated, yet essential, communications tasks. Specifically, the port concentrator is responsible for establishing and maintaining a constant synchronized link with the remote data concentrator, for downline loading configuration information from the controller to the remote data concentrator, for buffering data during retransmission or temporary line outages on the link, and for instigating retransmission-on-error.

The port concentrator's firmware "intelligence" makes it "master" over the remote data concentrator. One port concentrator accepts a composite stream of data from up to sixteen logical controller channels for transmission down a telephone line, through the remote concentrator, to sixteen physical terminals in a remote site.

Remote Data Concentrator(s)
One EM8 Data Concentrator is positioned at each remote site in any Statcon configuration to serve as the interface between a telephone communications line and up to sixteen terminals or devices. All of the terminals and devices connect directly to the EM8 itself. The EM8 must interface with the telepone line via a modem. (The EM8 may be purchased with or without an integral modem.)

Like the other components in a Statcon system, the EM8 operates in two directions. On one hand, it demultiplexes the composite data stream arriving on the telephone line from the port concentrator, distributing the separated data to the appropriate terminals. On the other hand, the EM8 multiplexes data from its attached terminals for transmission via the port concentrator to the host processor.

CHAPTER 9
THE STATCON PROCESS

Configuration

Power up. Immediately, the controller executes extensive internal tests of itself and all connected distribution panels. Upon satisfactory completion of these tests, the controller proceeds to configure the entire Statcon system in the following manner.

First, the controller examines the user's on-board switch setting to determine the total number of lines to be emulated. Then the controller examines the switch setting on the first port concentrator to determine the number of port concentrators it will be interfacing with and thus the number of distribution panel ports it must reserve for remote communications.

No. of port concentrators = No. of remote sites = No. of distribution panel ports reserved for remote communications.

The controller next interrogates each of the port concentrators individually to determine how many of the total number of emulating lines are to be reserved for remote terminals. Up to sixteen lines destined for the same remote site may be processed by a single port concentrator.

The controller assigns one "logical" terminal line to each remote physical terminal. The controller *always* assigns the remote lines first.

When all of the remote lines are assigned, the controller allocates any remaining logical terminal lines to available ports. Because each local terminal line must have its own port, the number of available ports is equal to the number of local physical terminals that may be assigned. (Remember: the total number of physical terminals is always less than or equal to the number of logical terminals).

Note: With Statcon 21, only one 16-channel distribution panel is used in all applications. Depending on his application configuration, then, a user may run out of ports before he runs out of logical terminal lines.

Multiplexing

For local communications, the controller and the distribution panel(s) together are simply the multiplexing interface between a number of terminal lines and a central computer. The controller gathers information and CPU instructions from all of the local terminal registers in its memory and sends all of this data across a single link to the distribution panel(s). There, the data is immediately divided and distributed to the various local terminals through communication channels, or ports—one port for each terminal.

Remote communications carry this process several steps further. Similiarly to the process described above, the controller gathers data from all of the remote registers in its memory and sends this information across a single link to the distribution panel. But now, the controller sends all data destined for any number of terminals at the same remote site to *one* distribution panel port. Data for up to sixteen terminals destined for the same site may be processed by one port—with the help of a port concentrator.

Port Concentration

At this point, the controller begins to act as interpreter between the host CPU and one or more CM22/EX Port concentrators. One port concentrator must interface with each distribution panel port reserved for remote communications. By implication then, one port concentrator manages the communications for up to sixteen terminals in one remote site.

While the controller is multiplexing data, the port concentrator is working to maintain a constant synchronized link with a remote concentrator positioned at the remote site. (The port concentrator automatically initializes the link during the power-up sequence of the multiplexer and maintains this link at all times to ensure rapid communication response at all times).

If modem control is enabled, the modem signal status for each remote channel passes transparently through the controller to the port concentrator and on to the remote concentrator.

When all of the above preparatory measures are complete, the port concentrator sends the data down the line to the remote concentrator at the remote site. There, the data in the composite stream is "demultiplexed". That is, the data is divided and distributed to the appropriate remote terminals.

Data from the remote terminals traveling back to the host processor is multiplexed by the remote concentrator.

CHAPTER 10
STATCON PRODUCTS

STATCON SERIES 11

General Description

The Statcon Series 11 is a combination of the proven CS11 multi-line communications multiplexer with special microprogramming, and one or more CM22/EX local statistical port concentrators. EM820 remote concentrators, with or without integral modems may be purchased separately. (Together the system is called the CSM11/MX/EX.)

Designed for software-transparent operation with DEC's PDP-11 and VAX-11 Series computers, the Statcon Series 11 handles all aspects of multiplexing, demultiplexing, error correction, link initialization and synchronization, and remote concentrator configuration for up to 64 local and/or remote lines.

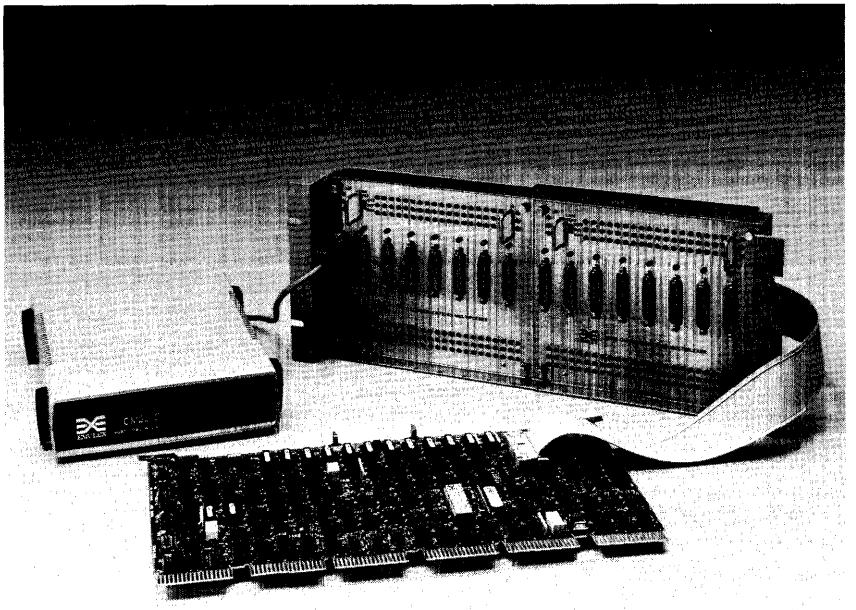


Figure 10-1 Statcon Series 11 Communications Subsystem

Models

There are two basic models of the Statcon Series 11:

CSM11/MH: Provides full DH11 performance on the PDP-11; transparent to PDP-11 diagnostic and operating system software.

CSM11/MU: Provides full DH11 performance on the VAX-11; uses EMULEX VMS/UH software package.

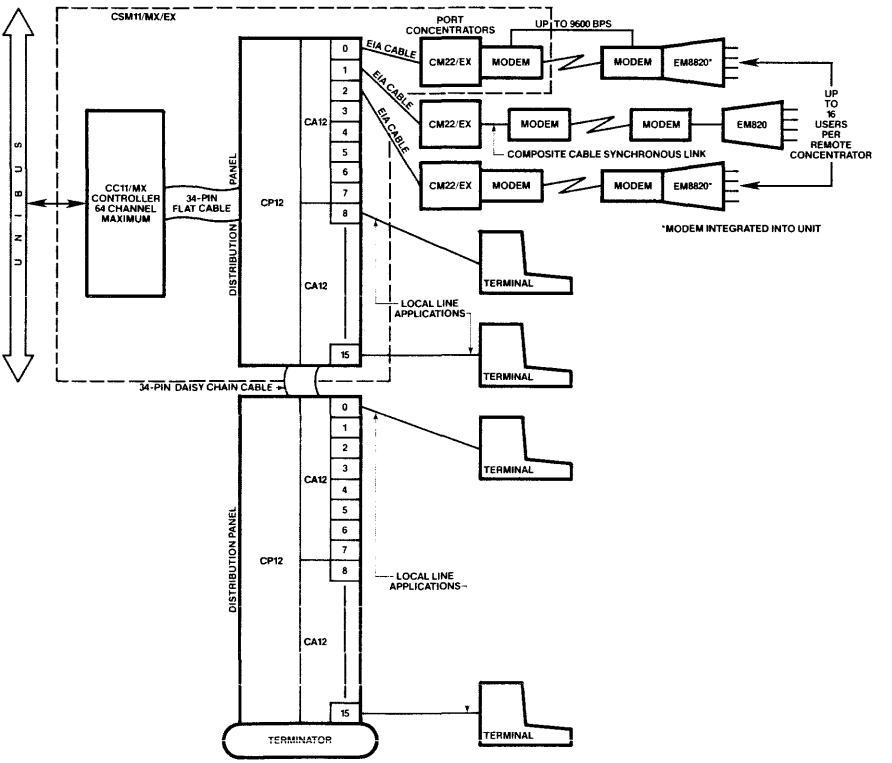


Figure 10-2 Statcon Series 11 Subsystem Organization

Features

Both models in the Statcon Series 11 feature the following important benefits:

Compact Packaging. The basic CC11 Controller plugs into a single Unibus SPC slot with only one unit load on the Unibus. The 7.00" high CP12 Distribution Panel(s) contain RS-232-C subminiature D-type connectors and are daisy-chained to the controller board via one 34-conductor flat cable.

Extra High Performance. The controller processes up to 19.2 Kbaud per line for a total composite data rate of 50,000 characters per second. Full 16-bit word transfers are made on all DMA operations.

Modem Control. With both the DH11 emulation and remote line application, the full complement of DH11/DM11-BB modem control signals are used. Remotes may function in either full or half duplex mode.

Internal Self-Test. The CC11 Controller automatically executes an extensive self-test as part of the power-up sequence and provides a set of simple off-line tests for localizing faults.

Low Power. Only 4 amps are required from the internal CPU +5V power supply.

PDP-11 users requiring the performance of a DH11-type product should opt for the CSM11/MH model which gives these extra features and benefits:

DMA Transmit Operation. DMA of characters transmitted from the CPU greatly reduces CPU and Unibus loading compared to that of interrupt-driven multiplexers using only Programmed I/O operations.

Programmable Receive FIFO. The receive FIFO buffer comes with programmable capability to interrupt at 1 to 63 characters FIFO fill level. Priority is given to input data handling during peak transmission loads.

Local Line Format Flexibility. Program selection is available for the following line parameters: speed (to 19.2 Kbaud); character size (5-8 bits); stop bits (1, 1.5, 2 bits); transmission mode (half duplex, full duplex, echoplex); parity (odd, even, none).

Remote Line Format. Supports odd and even parity for the following rates: 9600, 4800, 2400, 1800, 1200, 600, 300, 200, 150, 134.5, 110, 75, 50 baud.

Line Speed Flexibility. All DH11 baud rates on local lines. Most commonly used DH11 baud rates on remote lines.

Software Transparency. The CSM11/MH emulates up to four DH11/DM11-BB type controllers, while executing standard DEC operating system software. DEC diagnostics are transparent if the statistical multiplexer option is not enabled.

For VAX-11 users needing the performance of a DH11-type product, the CSM11/MU provides the answer. Tests show that the CSM11/MU consumes less CPU time than the DZ11 in block-oriented output applications. The CC11/MU controller version is optimized for VAX Unibus operation.

Because there is no standard DH11 software support in VMS, Emulex has developed the VMS/UH software package. This package consists of a terminal driver and diagnostics (stand-alone, plus on-line exerciser), both of which are supported internally by Emulex for VMS Versions 2.0 and above. This software package is provided on either RX01 diskette for the VAX-11/780 or TU58 tape cartridge for the VAX11/750 and VAX-11/780.

STATCON SERIES 21

General Description

With the Statcon Series 21, PDP-11 and VAX-11 users can realize a maximum of 32 lines of remote and/or local communication through a single hex-size Unibus controller. The Statcon Series 21 combines the field-proven CS21 multi-line communications multiplexer with special microprogramming and a CM22/EX local statistical port concentrator. Collectively labeled the CSM21/MX/EX, the Statcon Series 21 handles all aspects of multiplexing, demultiplexing, error handling, link initialization, and remote concentration needed to transfer error-free data through a single RS-232-C port.

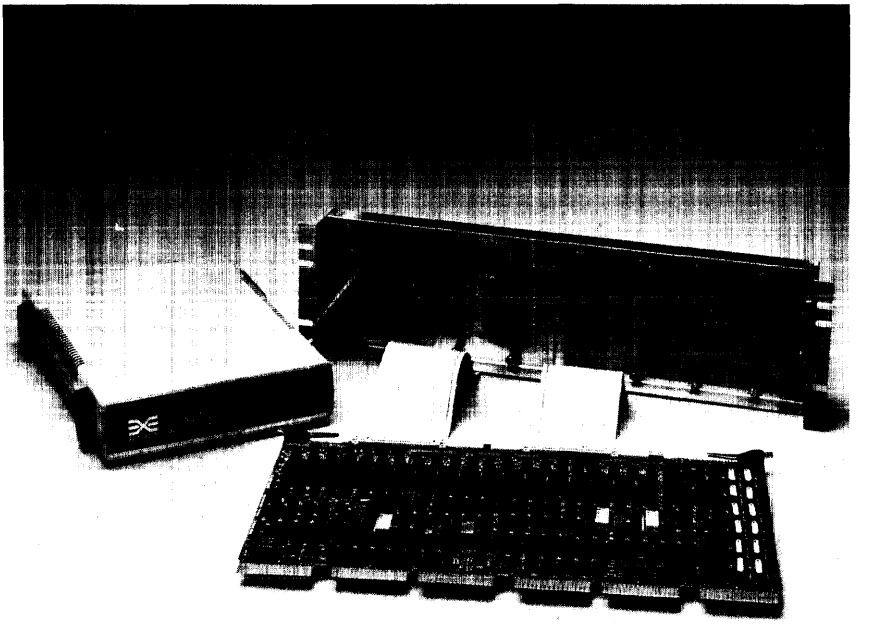


Figure 10-3 Statcon Series 21 Communications Subsystem

Models

There are three basic models in the Statcon Series 21:

CSM21/MH: Provides full DH11 performance on PDP-11 CPU's; transparent to PDP-11 diagnostic and operating system software.

CSM21/MU: Provides full DH11 performance on the VAX-11; uses Emulex VMS/UH software package.

CSM21/MZ: Supports full DZ11-E emulation; transparent to DEC diagnostic and operating system software on both PDP-11 and VAX-11 CPU's.

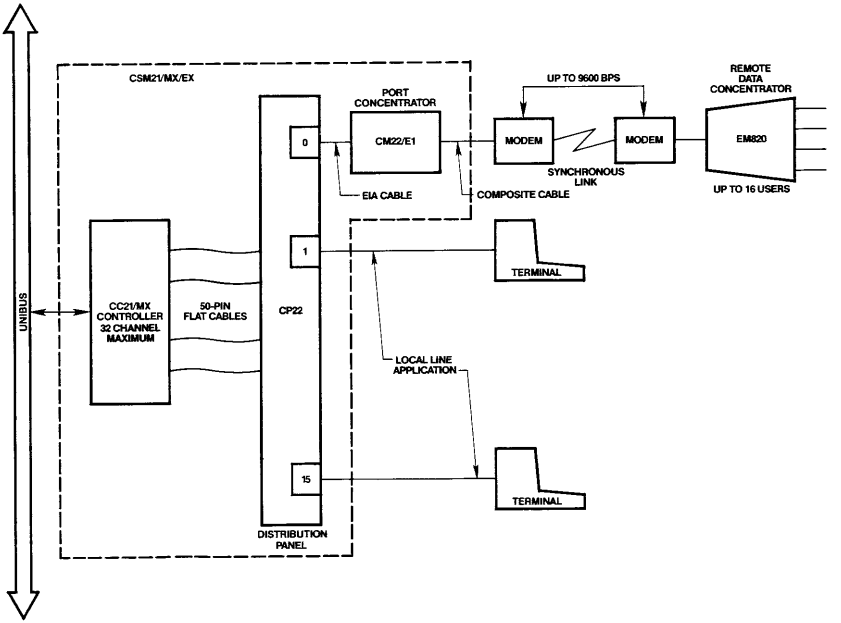


Figure 10-4 Statcon Series 21 Subsystem Organization

Features

All three models in the Statcon Series 21 feature the following important benefits:

Compact Packaging. The basic CC21 Controller plugs into a single Unibus SPC slot with only one unit load on the Unibus. The 5.25" high CP22 Distribution Panel contains RS-232-C subminiature D-type connectors and is attached to the controller board via two 50-pin conductor flat cables.

Extra High Performance. The controller processes up to 19.2 Kbaud per line for a total composite data rate of 50,000 characters per second. Full 16-bit word transfers are made on all DMA operations.

Modem Control. With both the DH11 emulation and remote line application, the full complement of DH11/DM11-BB modem control signals are used. Remotes may function in either full or half duplex mode.

Internal Self-Test. The CC21 Controller automatically executes an extensive self-test as part of the power-up sequence and provides a set of simple off-line tests for localizing faults.

Low Power. Only 8 amps are required from the internal CPU +5V power supply.

PDP-11 users requiring the performance of a DH11-type product should opt for the CSM21/MH model which provides these extra features and benefits:

DMA Transmit Operation. DMA of characters transmitted from the CPU greatly reduces CPU and Unibus loading compared to that of interrupt driven multiplexers using only Programmed I/O operations.

Programmable Receive FIFO. The receive FIFO buffer comes with programmable capability to interrupt at 1 to 63 characters FIFO fill level. Priority is given to input data handling during peak transmission loads.

Local Line Format Flexibility. Program selection is available for the following line parameters: speed (to 19.2 Kbaud); character size (5-8 bits); stop bits (1, 1.5, 2 bits); transmission mode (half duplex, full duplex, echoplex); parity (odd, even, none).

Remote Line Format. Supports odd and even parity for the following rates: 9600, 4800, 2400, 1800, 1200, 600, 300, 200, 150, 134.5, 110, 75, 50 baud.

Software Transparency. The CSM21/MH emulates up to two DH11/DM11-BB type controllers, while executing standard DEC operating system software. DEC diagnostics are transparent if the statistical multiplexer option is not enabled.

For VAX-11 users requiring the performance of a DH11-type product, the CSM21/MU provides the answer. Tests show that the CSM21/MU consumes less CPU time than a DEC DZ11 in block-oriented output applications. The CC21/MU controller version is optimized for VAX Unibus operation.

Because there is no standard DH11 software support in VMS, Emulex has developed the VMS/UH software package. This package consists of a terminal driver and diagnostics (stand-alone, plus on-line exerciser), both of

which are supported internally by Emulex for VMS versions 2.0 and above. This software package is provided on either RX01 diskette for the VAX-11/780 or on TU58 tape cartridge for the VAX-11/750 and the VAX/11-780.

For users that simply want a better DZ11-type product, the CSM21/MZ model emulates two DEC DZ11-E controllers and is fully software transparent across the PDP-11 and VAX-11 processor families.

STATCON SERIES 32

General Description

The Statcon Series 32 is a combination of the proven CS32 multi-line communications multiplexer with special microprogramming and one or more CM22/EX local statistical port concentrators. EM820 remote data concentrators may be purchased separately.

The functional equivalent of the asynchronous multiplexer portions of 32 DEC DMF-32 controllers, the Statcon Series 32 is capable of handling all aspects of multiplexing, demultiplexing, error correction, link maintenance, and remote concentrator configuration for up to 256 remote and local lines. The single model in the Statcon Series 32, the CSM32/MF/EX, is supported through the complete VAX-11 processor family when running under the VMS Operating System, Versions 3.0 and above.

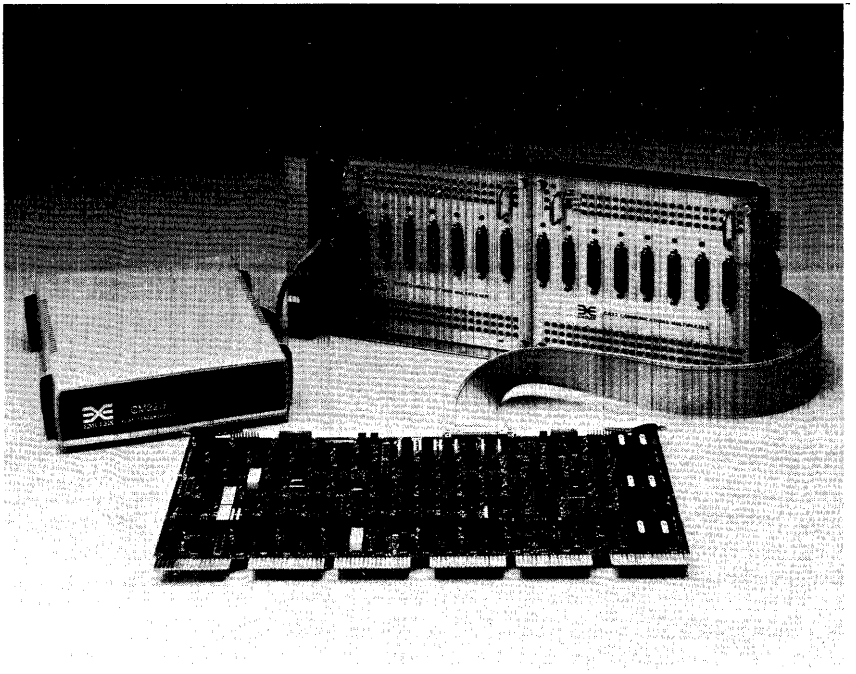


Figure 10-5 Statcon Series 32 Communications Subsystem

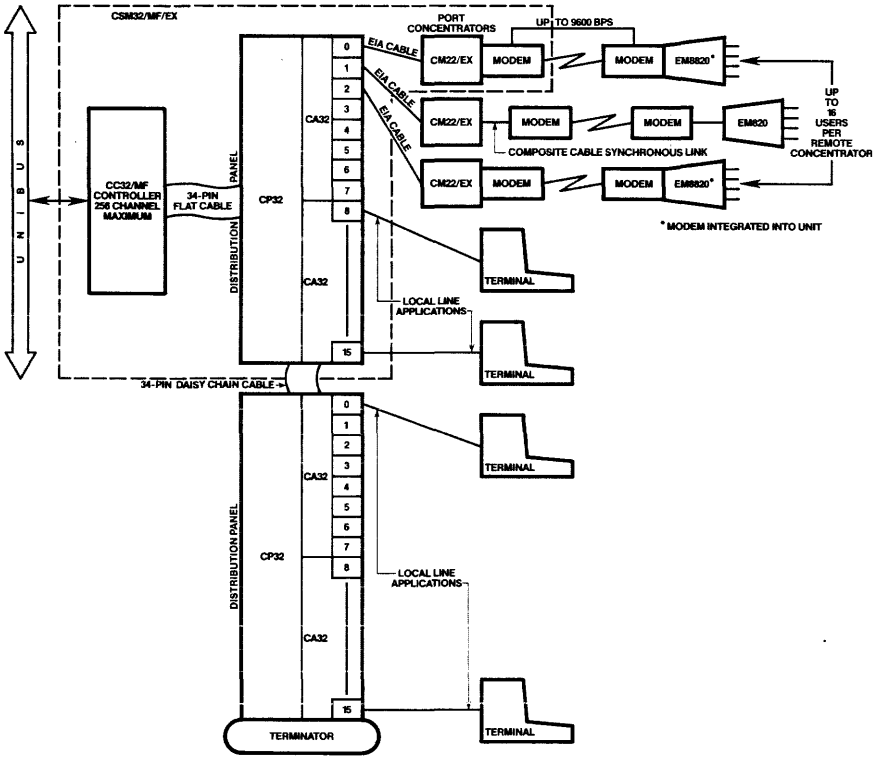


Figure 10-6 Statcon Series 32 Subsystem Organization

Features

DMA or Programmed I/O for Transmit Operations. Transmit functions are governed by the VMS/DMF32 software driver. Depending upon the character count to be transmitted, the DMF32 I/O driver will set the controller to do DMA or Programmed I/O transfers.

Packaging Flexibility. The CC32 communications controller, capable of handling up to 256 local/remote lines, plugs into a single Unibus SPC slot. A maximum of eight distribution panels, each containing sixteen terminal ports, are daisy-chained via a single 34-conductor flat cable. A CM22/EX port concentrator and a remote data concentrator are added for each remote link.

Modem Control. All 256 local/remote lines have full modem control as a standard feature. This allows for either full or half duplex operation.

Upgrade Flexibility. Emulations are configured by firmware selection. Current Series 32 versions may be upgraded/altered to other model functions through simple PROM changes.

Software Transparency. The Statcon Series 32 emulates the DEC DMF32 and is transparent to DEC operating systems software and diagnostics on VAX-11 computers.

Line Speed Flexibility. All commonly used baud rates are available, plus split speeds for different rates in transmit and receive operations.

Low Power. Only 4 amps are required from the +5V internal CPU power supply. Each distribution panel contains its own power supply, so no additional CPU power is required as lines are added.

TABLE 10-1 Statcon Models/Emulations

STATCON	MODEL	CPU	EMULATION	TOTAL NO. OF TERMINALS (LOCAL AND REMOTE)	TOTAL NUMBER OF DISTRIBUTION PANEL PORTS
11	CSM11/MH CSM11/MU	PDP-11 VAX-11	DH11 DH11	64 64	64 64
21	CSM21/MH CSM21/MU CSM21/MZ	PDP-11 VAX-11 PDP-11 AND VAX-11	DH11 DH11 DZ11-E	32 32 32	16 16 16
32	CSM32/MF	VAX-11	DMF32	256	128

CHAPTER 11
CONFIGURING THE STATCON

All Statcon Series products offer unprecedented flexibility in local and remote system configuration. Together, the three Statcon products are capable of meeting virtually any line requirement a user may have. Statcon products offer so many configuration options, in fact, that many users feel overwhelmed. The following five configuration guidelines are provided to help all users to channel Statcon's burgeoning potential into workable communications systems that match or surpass their needs.

STEP 1: Determine the maximum number of terminals that may be used by the system. Each Statcon controller "knows" that it can handle a specific number of terminals. It "sees" each of these terminals as a channel register in its memory.

Statcon 11: Up to 64 terminals.
Statcon 21: Up to 32 terminals.
Statcon 32: Up to 256 terminals.

The sum total of local and remote terminals can never exceed this logical, or controller acknowledged, maximum number. This is the first limiting or boundary factor to remember while configuring a Statcon system.

STEP 2: Determine the maximum number of ports available to each system. Each Statcon controller is capable of interfacing with a specific number of distribution panels. And each distribution panel provides 16 ports.

Statcon 11: Up to 4 distribution panels/64 ports.
Statcon 21: 1 distribution panel/16 ports.
Statcon 32: Up to 8 distribution panels/128 ports.

Up to sixteen terminals located in the same remote site may share a single distribution panel port. Each local terminal, however, must have its own distribution panel port. The number of available ports on the distribution panel, then, is the second boundary factor to remember while configuring a Statcon system.

STEP 3: Determine the number of remote sites. For the configuration purposes here, define "remote site" as a location separate from the building that houses the host computer which requires from 1 to 16 terminals. Each remote site requires one distribution panel port, one port concentrator, and one remote concentrator.

In other words, the number of remote sites = the number of distribution panel ports reserved for remote communications = the number or port concentrators required = the number of remote concentrators required.

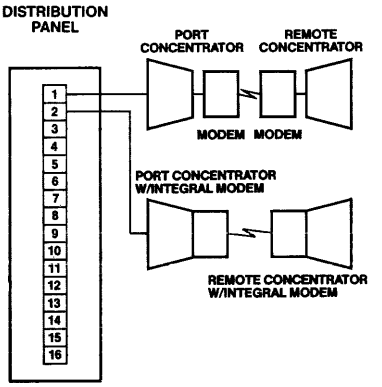


Figure 11-1 Configuration Example: Statcon Distribution Panel, Port Concentrators, Modems, and Remote Concentrators.

STEP 4: Determine the number of terminals at each remote site. The total number of remote terminals must never exceed the maximum number of logical terminal registers recognized by the system's controller. Keeping within this boundary, then, each remote site may have from 1 to 16 terminals.

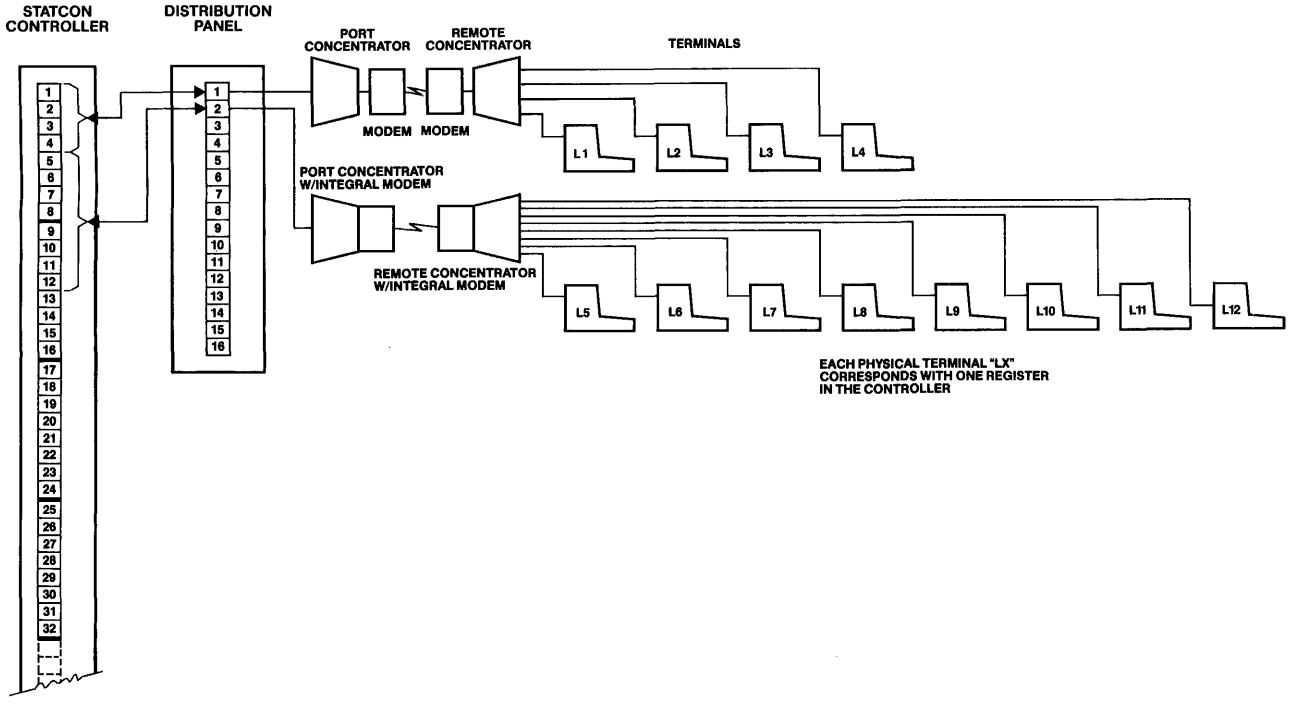


Figure 11-2 Configuration Example: Statcon Controller, Distribution Panel, Port Concentrators, Modems, Remote Concentrators, and Remote Terminals.

STEP 5: Determine the number of local terminals that may operate at the host site. The number of local terminals is dependent upon two factors: the number of unused logical terminal registers and the number of available ports.

The number of unused logical terminal registers = the maximum number of terminals recognized by the controller – the number of assigned remote terminals.

The number of ports available for local terminals = the total number of ports – the number of remote sites.

Remember, each *local* terminal must have its own port.

The number of local terminals, then, may be limited either by the number of remote terminals *or* by the number of available ports.

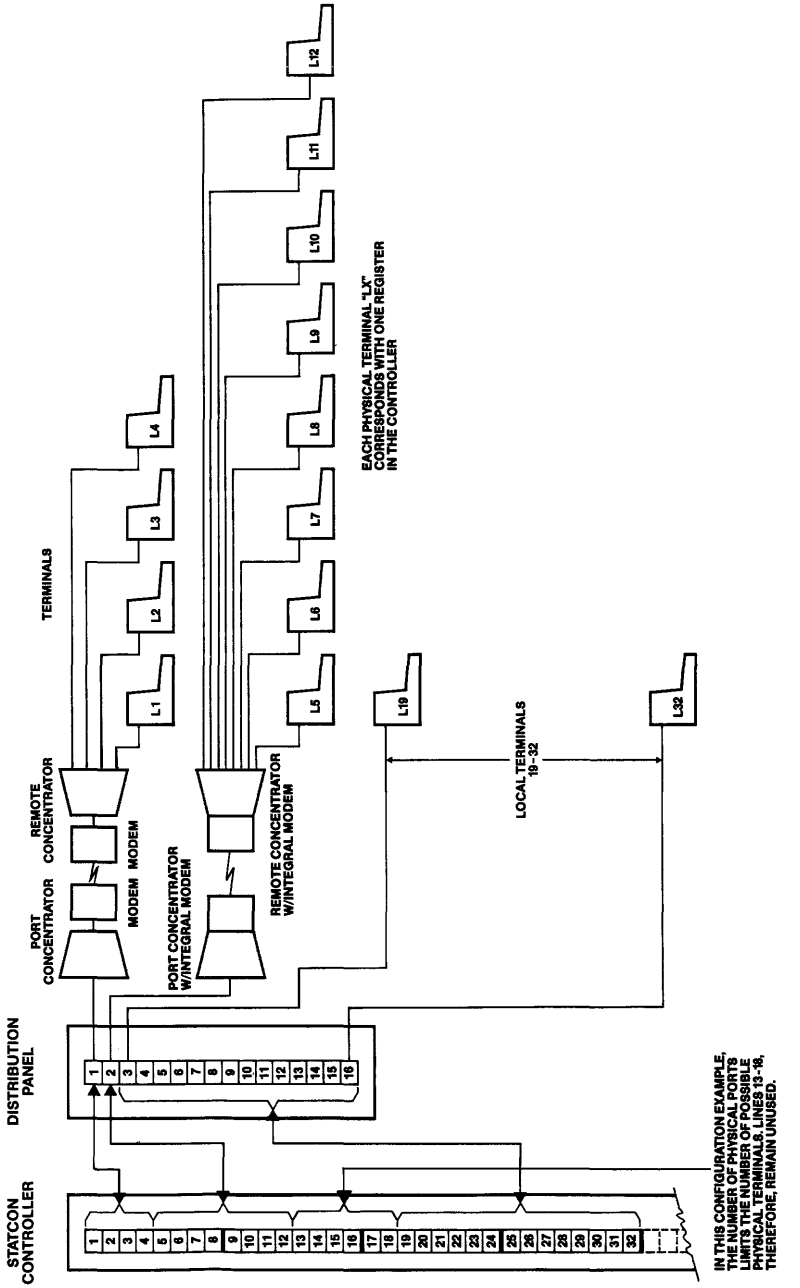


Figure 11-3 Configuration Example: Complete Statcon System.

APPENDIX A
CS01/H COMMUNICATIONS MULTIPLEXER

THE CS01/H IS THE ONLY HIGH-PERFORMANCE MULTIPLEXER...

...available for the LSI-11 Q Bus. Lets you get away from those cycle-stealing, interrupt-driven DLV11's and DZV11's that eat up precious bus bandwidth. And in the process, lets you concentrate a lot of lines—up to 64 in fact—with no more CPU cabinet space and power than even 4 lines usually require. If you need high performance and flexibility, these unique features of the CS01 give you what you're looking for:

DMA ON TRANSMIT OPERATION. DMA of characters transmitted from the CPU memory, controlled by individual byte count and address registers for each line, greatly reduces CPU and Q Bus loading over that of interrupt-driven multiplexers with programmed output operations.

DOUBLE FIFO INPUT. 128 character FIFO (double capacity over DEC DH11) for each group of 16 received data lines, with capability to interrupt at any level of FIFO full up to 63 character level. Priority is given to input data handling to accommodate peak data loads.

LINE INTERFACE ADAPTABILITY. Asynchronous line interfaces of all types—including RS-232 with full DM11-BB compatible modem control as a standard feature—are included in the CS01/H. Current loop interface is also available.

LINE FORMAT FLEXIBILITY. Program selection of the following line parameters: speed (to 19,200 baud); character size (5–8 bits); stop bits (1, 1½, 2 bits); transmission mode (full duplex, half duplex or echoplex); parity (odd, even, none).

SOFTWARE SUPPORT. The CS01/H emulates the DEC DH11 multiplexer allowing transparent execution of standard, currently available DEC PDP-11 diagnostics and LSI-11 operating systems software.

LINE SPEED FLEXIBILITY. All commonly used DH11 baud rates, plus split line speeds for different rates on transmit and receive.

YOU ALSO GET A WHOLE SPECTRUM OF NEW BENEFITS OVER ANY OTHER Q BUS MULTIPLEXER...

...because the CS01/H provides a combination of features not available in any other product.

OPTIMUM PACKAGING. The basic communications controller, capable of handling 64 lines, plugs into a single quad slot with only one unit load on the bus. A single 34-conductor flat cable daisy chains to a maximum of four external distribution panels which contain the line adapter circuitry.

HIGH PERFORMANCE. Up to 19.2 Kbaud per line with a total composite data rate of 50,000 characters per second on a single controller. Multiple controllers may be used for increased capacity. Full 16-bit word transfers are made on DMA operations, rather than the byte transfers used in DH11's.

INTERNAL SELF-TEST. The communication controller automatically executes an extensive test both on itself and on each of the connected line adapters as part of the power-up sequence. Line loop test can also be manually initiated.

LOW POWER. Only 4 amps are required from the internal CPU +5 volt power supply. Each distribution panel contains its own supply, so no additional CPU power is required as lines are added.

CONFIGURATION FLEXIBILITY. Each communications controller emulates up to four 16-line DH11's and four DM11's for a maximum of 64 lines. Various types of line adapters may be mixed in 8-line groups.

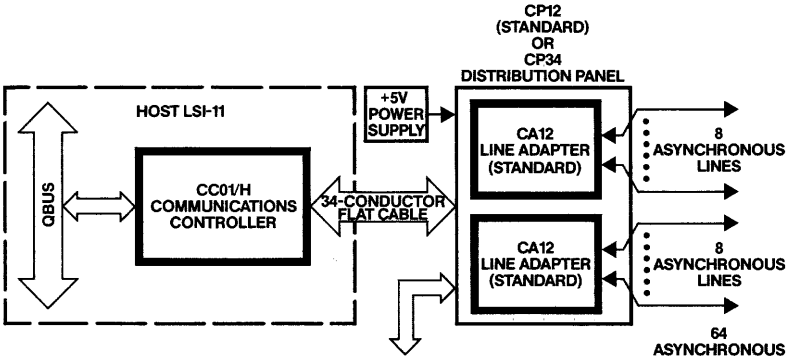
CONVENIENCE FEATURES. Operating mode options and/or special firmware enhancements are selected by slide switches for each 8-line group. A line fault LED is provided for each line.

REMOTE LINE INTERFACING. The distribution panels may be located up to 50 feet from the CC01 controller for conveniently locating line terminals and minimizing terminal cable lengths.

COMMON HARDWARE. The CS01 system uses the identical distribution panels and line adapters used in the CS11 series for VAX/PDP-11 CPU's, which minimizes parts types and spares stocking for multiple CPU types.

22 BIT ADDRESS OPTION. The CC01 controller is implemented with a full 22-bit hardware address for optional expansion by microcode to handle the 4 MByte memory addressing capacity of the LSI-11/23 PLUS.

APPENDIX A
CS01/H COMMUNICATIONS MULTIPLEXER



- 1 or 2 CA11's per CP11.
- 1-4 CP11's per CC01/H.
- CA11/H includes Full DM11-BB Modem Control.
- Terminator installed on last CP11.
- 8-64 lines per subsystem.

SYSTEM ORGANIZATION IS THE KEY TO PROVIDING THESE UNIQUE BENEFITS.

The basic element of the CS01/H multiplexer is the CC01/H Communications Controller. This unit is contained on a single quad size board and incorporates the same basic microprocessor design inherent in all EMULEX products.

The controller interfaces 1-4 CP11 Distribution Panels via a 34-conductor flat cable. Each panel contains up to two 8-channel CA11 Line Adapters and an integral power supply. The line adapters provide the data and modem interface circuitry plus the 'USART' type circuits which provide the serial-to-parallel and parallel-to-serial conversions normally found in these types of devices.

The USART's also contain a baud rate generator. Data transfer between the line adapters and the communications controller are on a parallel character basis. Line adapters may be configured to different interface standards (e.g., current loop).

The unique system organization gives users flexibility where it is needed. Channels can be added in 8 rather than 16 line increments; the type of interface can be changed, mixed and matched as needed. All these variations go outside the CPU so you probably never have to restructure the chassis or add expansion boxes to accommodate additional lines as is necessary with other multi-board multiplexers. An OEM configuration without CP11 power supplies is also available to permit system integrators to minimize cost by making use of available system power supplies.

If more than 64 lines are needed, only one additional stand-alone board is placed on the Q Bus to handle a second group of 64 lines. And a simple CC01 firmware change can give you an entirely different communication product to handle future needs that may not be anticipated today.

APPENDIX A
CS01/H COMMUNICATIONS MULTIPLEXER

CS01/H SUBSYSTEM SPECIFICATIONS

Characteristic	Specification
CC01/H CONTROLLER	
Design	High-speed bipolar microprocessor based controller for implementation of all CS01 functional operations.
Function	Provides complete functional emulation of four DH11 multiplexers and DM11-BB modem controls.
Software Compatibility	Diagnostics: ZJ179 (DH) and ZJ118 (DM) kits. Operating Systems: RSX11M, RSX11M PLUS, RSTS/E.
No. of Distribution Panels	1 to 4.
No. of Lines	8 to 64.
Throughput	50,000 characters per second total.
Distribution Panel Interface	Eight-bit bidirectional data bus with necessary addressing and control in a single 34-conductor flat cable.
Receive FIFO	Switch selectable 64-character or 128-character input FIFO for each functional 16-channel DH11; interrupt programmable for any level of FIFO full up to 63 character level.
CPU Interface	Standard Q Bus A-B connector interface. Parity checked on all memory reads. One unit bus load.
DMA Address Range	0-128K words standard; 0-4 MBytes optional.
DMA Transfers	16-bit word.
Device Address	Selectable with switches and PROMs to cover all DEC-defined DH11 assignments.
Vector Address	Switch selectable.
Priority Level	BR5 for DH11; BR4 for DM11.
Indicator	Controller fault.
Option Switches	DIP switches for selection of configuration and options.
Packaging	Single quad size four layer printed circuit board.
Power	5V ±5%, 4 amps.
CP11 DISTRIBUTION PANEL	
Configuration	Seven inch high panel for two 8-channel line adapters, including power supply and cable interface.
Dimensions	7" high x 19" wide x 7" deep.
Weight	20 lbs.
Power	Self-contained supply, 50-60 Hz 115/230 vac., 35 watts (may be deleted for OEM configurations).
CA11/H LINE ADAPTER (RS232)	
Configuration	Two sided PCB measuring 6½" x 8" which plugs into CP11 Distribution Panel.
Interface	RS232, with full DM11-compatible modem control.
Connectors	Standard EIA RS232, 25-pin male connector.
Transmission Modes	Half duplex, full duplex, echoplex.
Line Formats	Character lengths: 5-8 bits. Stop bits: 1, 1½, 2. Parity: odd, even, none.
Data Rates	50, 75, 110, 134.5, 150, 200, 300, 600, 1200, 1800, 2400, 4800, 9600, 19200 baud.
Distortion	Transmitter: less than 2% intersymbol. Receiver: up to 43% intersymbol distortion and speed variation.
Modem Control	RTS, DTR, CTS, CD, RI (or DSR), Secondary RX and TX.
Self-Test	Panel switch manually initiates self-test of the 8-line adapter.
Fault Indicator	LED self-test fault indicator per line.
CA11/C ADAPTER (CURRENT LOOP)	
Configuration	Two sided PCB measuring 6½" x 8" which plugs into CP11 Distribution Panel.
Interface	Current Loop—active or passive transmitter, active or passive receiver.
Connectors	Screw-type terminals.
Transmission Modes	Half duplex, full duplex, echoplex.
Data Rates	50, 75, 110, 134.5, 150, 200, 300, 600, 1200, 1800, 2400, 4800, 9600, 19200 baud.
Line Formats	Character lengths: 5-8 bits. Stop bits: 1, 1½, 2. Parity: odd, even, none.
Distortion	Transmitter: less than 2% intersymbol. Receiver: up to 43% intersymbol distortion and speed variation.

APPENDIX B
CS02/H COMMUNICATIONS MULTIPLEXER

FOR THE MICRO/PDP-11...

...EMULEX presents the CC02 communications controller and CP24 distribution panel combination. This multiplexer system yields RS-423 (RS-232-C compatible) capability on sixteen full-duplex lines. An optional CP24/B panel extends four of these lines to full modem control.

FOR THE LSI-11/2 THROUGH THE LSI-11/23 PLUS...

...EMULEX introduces the CC02 communications controller and CP22 distribution panel combination. Here, twelve lines with partial modem control (full duplex applications) and four lines with full modem control (full or half duplex applications) function together in one small distribution panel. All sixteen channels contain RS-423 (RS-232-C compatible) electrical interfaces.

BOTH VERSIONS HANDLE SIXTEEN LINES. BOTH CONFORM TO EXISTING SPACE WITHIN THE DEC SYSTEMS. AND BOTH PROVIDE THE FOLLOWING SPECIAL FEATURES:

TWO EMULATIONS. Through switch selection, a single CC02 controller provides functional emulation of either one DH11 *or* two DHV11's.

HIGH PERFORMANCE. All sixteen lines of the CS02/H can transmit at 38.4 Kbaud for a total throughput of 60K characters per second (8-bit characters with 1 start, 1 stop, and 1 parity bit).

LINE FORMAT FLEXIBILITY. The following line parameters are available for program selection: speed (to 38.4 Kbaud per line); character size (5-8 bits); stop bits (1, 1.5, 2 bits); parity (odd, even, none).

SOFTWARE SUPPORT. An emulation of either the DEC DHV11 or the DEC DH11, the CS02/H allows transparent execution of standard DEC operating software.

INTERNAL SELF-TEST. Power-up self-tests of the controller circuitry reinforce system reliability each time the multiplexer comes on line.

LINE SPEED FLEXIBILITY. All commonly used line speeds are available, plus split speeds for different rates in transmit and receive operations.

22-BIT ADDRESS. The CC02 controller is implemented with full 22-bit hardware addressing to handle the 4 MByte memory capacity of the LSI-11/23 PLUS.

EXTRA FIFO CAPACITY. As a DH11 emulation, the CS02/H provides one 256-character FIFO buffer per sixteen lines. That's four times the FIFO capacity of the corresponding DEC product. As a DHV11 emulation, the CS02/H provides one 256-character FIFO buffer for each group of eight lines in the sixteen-line system.

WHEN USED AS A DHV11 EMULATION, THE CS02/H FURTHER ENHANCES ITS PERFORMANCE WITH...

DMA/PIO OUTPUT SELECTION. Software driver selection of either DMA or PIO output operation ensures maximum efficiency with minimum CPU overhead in all applications. All DMA transfers are performed in word rather than byte increments.

AUTOMATIC XON, XOFF OPERATION. This software driver-selectable option allows the controller to use XON/XOFF protocol to manage data flow in either direction on a per line basis without program intervention. CPU overhead and the possibility of lost characters are thereby reduced.

BACKED BY QUALITY COMPONENTS AND EXCELLENT SERVICE, OUR HIGH-PERFORMANCE QBUS PRODUCTS ARE SET FOR A LONG RUN.

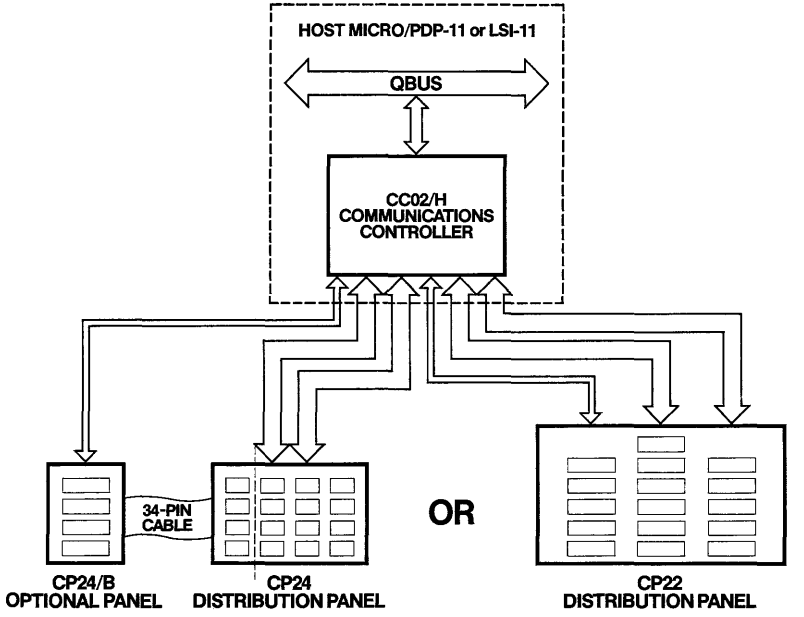
All active components are pre-aged for over 160 hours. All final product assemblies are environmentally cycled at full power for over 96 hours. And all EMULEX products are backed by a full one year warranty and supported worldwide by the company's technical applications group.

INCREASED LINE CAPABILITY AND OPTIMUM PACKAGING MAKE THE CS02/H SERIES A SURE HIT...

The central element of both multiplexer configurations in the CS02/H Series is the CC02 Communications Controller. A single quad-size board requiring only one bus load, the CC02 contains all of the active circuitry in the system, including USART line interfaces for all sixteen multiplexer channels.

Several different distribution panels interface with the CC02 in the manner described and illustrated on the following page.

APPENDIX B
CS02/H COMMUNICATIONS MULTIPLEXER



CS02/H SUBSYSTEM ORGANIZATION

When used with the MICRO/PDP-11, the CC02 controller interfaces with either one or two distribution panels: the CP24 and the optional CP24/B. Alone, the CP24 provides sixteen lines with partial modem control. The optional CP24/B panel provides four lines with increased modem control.

Note, however, that when the optional CP24/B panel is connected, the first four lines of the main CP24 panel may not be used. The total number of lines which may be connected to the CP24 panel(s) at one time, then, is always sixteen.

Note also that the sixteen 9-pin connectors on the CP24 panel are not mechanically compatible with the RS-232-C EIA standard, which calls for a 25-pin connector. However, the electrical interface is RS-423 which *is* RS-232-C compatible.

Both the CP24 and the CP24/B distribution panels install into the I/O cutouts of the MICRO/PDP-11 patch panel.

When used with LSI-11/2 through LSI-11/23 PLUS, the CC02 controller interfaces with a single sixteen-line CP22 distribution panel. This panel supports twelve lines with partial modem control (full duplex applications) and four lines with full modem control (full or half duplex applications). All of the lines contain RS-423 (RS-232-C compatible) electrical interfaces. FCC compliant, the CP22 panel installs in place of standard DEC I/O panels.

APPENDIX B
CS02/H COMMUNICATIONS MULTIPLEXER

CS02/H SUBSYSTEM SPECIFICATIONS

Characteristic	Specification
CC02/H CONTROLLER	
Design	High-speed bipolar microprocessor-based controller for implementation of all CS02/H functional operations.
Function	Through switch selection, provides functional emulation of either the DEC DH11 or two DEC DHV11's on 16 asynchronous channels.
Software Transparency/ Compatibility	All common DH11/DM11 and DHV11 operating systems.
No. of Distribution Panels	All LSI-11 Systems: 1 CP22 panel. MICRO/PDP-11: 1 CP24 panel and 1 optional CP24/B panel.
No. of Lines	16.
Line Formats	Character Lengths: 5-8 bits. Stop Bits: 1, 1.5, 2. Parity: Odd, even, none.
Data Rates	50, 75, 100, 110, 134.5, 150, 200, 300, 600, 1200, 1800, 2400, 4800, 9600, 19200, 38400 baud.
Throughput	60,000 characters per second total.
Distribution Panel Interface	CP22: Sixteen 25-pin male subminiature D-type connectors. CP24: Sixteen 9-pin male subminiature D-type connectors. CP24/B: Four 25-pin male subminiature D-type connectors.
Receive FIFO	DH11 Emulation: 256 characters deep per 16 lines. DHV11 Emulation: 256 characters deep per 8 lines.
CPU Interface	Standard QBus A-B connector interface. Parity checked on all memory reads. One unit bus load.
DMA Address Range	22 bits.
DMA Transfers	16-bit word with parity check.
Device Address	Selectable with switches and PROMs to cover all DEC-defined DH11 and DHV11 assignments.
Vector Address	Switch selectable.
Priority Level	BR5.
Indicators	Green "On Line" LED: Controller on line. Red "Fault" LED: Power-up self-test failure. Red "Activity" LED: Host CPU/ Controller interaction in progress.

Characteristic	Specification
Distortion	Transmitter: Less than 2% intersymbol. Receiver: Up to 43% intersymbol distortion and speed variation.
Option Switches	Dip switches for selection of controller options.
Packaging	Single quad-size four-layer pcb.
Power	5V, 6 amps. 12V, 1 amp.
CP22 DISTRIBUTION PANEL	
Configuration	4.6" high panel for 16 RS-423 (RS-232-C compatible) lines.
Dimensions	4.6" high x 8.4" wide x 2" deep (w/FCC).
Weight	2 lbs.
Electrical Interface	RS-423. Compatible with the RS-232-C EIA standard.
Mechanical Interface	Sixteen 25-pin male subminiature D-type connectors.
Transmission Modes	4 lines: full duplex or half duplex. 12 lines: full duplex.
Modem Control	DTR, RING, and CAR on 12 lines. DTR, RING, CAR, CTS, RTS, and DSR on 4 lines.
CP24 DISTRIBUTION PANEL	
Configuration	3.3" high panel for 16 RS-423 (RS-232-C compatible) lines.
Dimensions	3.3" high x 5.3" wide x 1.7" deep.
Weight	8.5 ounces.
Electrical Interface	RS-423. Compatible with the RS-232-C EIA standard.
Mechanical Interface	Sixteen 9-pin male subminiature D-type connectors.
Transmission Mode	Full Duplex.
Modem Control	DTR, RING, and CAR.
CP24/B OPTIONAL DISTRIBUTION PANEL (for MICRO/PDP-11)	
Configuration	3.3" high panel for 4 RS-423 (RS-232-C compatible) lines.
Dimensions	3.3" high x 2.6" wide x 1.7" deep.
Weight	4.5 ounces.
Electrical Interface	RS-423. Compatible with the RS-232-C EIA standard.
Mechanical Interface	Four 25-pin male subminiature D-type connectors.
Transmission Modes	Full Duplex or Half Duplex.
Modem Control	DTR, RING, CAR, CTS, RTS, and DSR.

APPENDIX C
CS11 SERIES COMMUNICATIONS MULTIPLEXERS

THE CS11 SERIES:

A CHOICE FOR TODAY...

The following four emulations are available for your selection. Choose the one that matches your present application requirements.

CS11/F: Use DEC software and get up to 48 lines of DMF32 performance on VAX-11's.

CS11/H: Use DEC software and get up to 64 lines of DH11 performance on PDP-11's.

CS11/U: Use EMULEX software and get up to 64 lines of DH11 performance on VAX-11's.

CS11/V: Use DEC software and get up to 32 lines of DV11 performance on PDP-11's.

A CHOICE FOR TOMORROW...

All versions of the CS11 let you add channels as they are required. The CS11/V lets you mix asynchronous and synchronous line adapters in eight-line groups. And, a simple PROM change lets you change emulations at any time. So go ahead — grow, change, diversify. EMULEX stays with you.

ALL FOUR VERSIONS MAKE THESE SPECIAL FEATURES STANDARD...

HIGH PERFORMANCE. Each controller has a potential transmit rate of 19.2 Kbaud per line and total composite data rate of 50,000 characters per second. Multiple controllers may be used in a single system. All DMA transfers occur in 16-bit words. (The CS11/F is further enhanced by the highly efficient DMF32 terminal handler.)

INTERNAL SELF-TEST. Power-up self-tests of the controllers and all connected line adapters ensure top system performance at all times. Additional line loop tests may be manually initiated.

LOW POWER. Because each distribution panel contains its own power supply, the multiplexer systems require only 4 amps from the internal CPU +5V power supply. No additional CPU power is required as lines are added.

CONVENIENCE FEATURES. Operating mode options and/or special firmware enhancements are selected by slide switches for each 8-line group. A line-fault LED is provided for each line.

OPTIMUM PACKAGING. Each CS11 controller is contained on a single hex-size circuit board. Each plugs into a single Unibus SPC slot with only one unit load on the Unibus. A single 34-conductor flat cable daisy chains from the controllers to their various distribution panels.

REMOTE LINE INTERFACING. The distribution panels may be located up to 50 feet from the CS11 controllers.

FOR SOFTWARE TRANSPARENCY AND DMA/PROGRAMMED I/O TRANSMISSION ON VAX-11'S...

...select the CS11/F. With a single controller board plugged into a single SPC Unibus slot, this multiplexer accomplishes the work of six DMF32's for DEC's VAX-11 supermini computer.

The CS11/F provides up to 48 asynchronous lines. The DMF32 handles only eight. And, unlike the DMF32, *all* of the CS11/F's lines maintain full modem control.

Though equipped with a large number of extra features, the CS11/F remains software-transparent to DEC's DMF32. Thus, you can get better performance with the DMF32 terminal handler, take advantage of all standard, currently available VAX/VMS operating systems software and diagnostics, *and* increase efficiency with automatic DMA/Programmed I/O transmission selection.

FOR DH11 PERFORMANCE WITH MAXIMUM LINE CAPABILITY...

...choose the CS11/H for PDP-11's or the CS11/U for VAX-11's. The CS11/H utilizes DEC software to achieve full DH11 performance on up to 64 lines for the PDP-11. That's performance equivalent to four 16-line DH11's and four DM11's!

Similarly, the CS11/U utilizes EMULEX VMS/UH software to achieve full DH11 performance on 64 lines for the VAX-11. Again, as with the CS11/H, that's performance equivalent to four DH11's and four DM11's. The EMULEX VMS/UH software package supports the CS11/U on the VAX-11 Unibus under VMS and provides terminal-handling routines plus stand-alone and line diagnostics in execution code for easy load-and-go integration with VMS.

If more than 64 lines are needed on PDP-11 or VAX-11 systems, have no fear. The optimum packaging of the CS11/H and the CS11/U leaves plenty of space and power for additional EMULEX controller boards and distribution panels.

Extra features of both the CS11/H and the CS11/U include:

DMA ON TRANSMIT OPERATION. DMA of characters transmitted from the CPU memory greatly reduces CPU and Unibus loading over that of interrupt-driven multiplexers with programmed output operations. Controlled by individual byte count and address registers for each line, the DMA output transfers are performed in word rather than byte increments.

APPENDIX C
CS11 SERIES COMMUNICATIONS MULTIPLEXERS

VARIABLE FIFO CAPACITY. To prevent data overruns during high peak input rates, the input FIFO capacities of the CS11/H and the CS11/U are switch-selectable: 128 characters per 16 input lines or the standard 64 characters per 16 input lines.

LINE INTERFACE ADAPTABILITY. Asynchronous line interfaces of all types — including RS232 with full DM11-compatible modem control as a standard feature — are included in the CS11/H and the CS11/U. Current Loop interface is also available as an option.

FOR SPECIAL PDP-11 APPLICATIONS REQUIRING SYNCHRONOUS AND/OR ASYNCHRONOUS COMMUNICATIONS MULTIPLEXING...

...the CS11/V is a must. The CS11/V emulates one or two functional 16-line DV11's (with DM11 modem control) for a maximum of 32 lines. The system's line adapters may be mixed in 8-line, synchronous or asynchronous groups.

Software transparent to the DV11, the CS11/V permits execution of all standard, currently available DEC diagnostics and operating software.

As an individual application in the CS11 Series, the CS11/V supports the following special features:

SYNC CHARACTERS. Four different synchronous character pairs per line may be set up under program control.

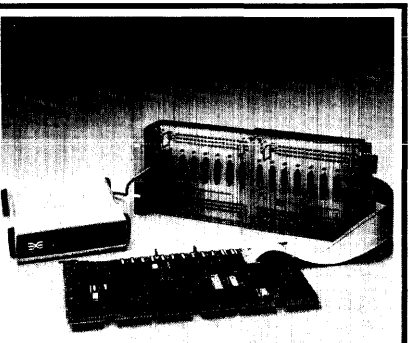
SYNCHRONOUS/ASYNCHRONOUS LINE INTERFACE ADAPTABILITY. Synchronous and/or asynchronous line interfaces of all types — including RS232 with full DM11-compatible modem control as a standard feature — are provided in the CS11/V. The 32 possible lines of the CS11/V may be arranged synchronously or asynchronously in groups of eight.

DMA ON TRANSMIT AND RECEIVE OPERATIONS. Controlled by individual byte count and address registers for each line, DMA of characters to and from the CPU memory greatly reduces Unibus loading over that of multiplexers with programmed input and/or output.

FLEXIBLE DESIGN. CS11/V control table implementation permits programmable, hardware independent, flexible handling of special characters and protocols.

PROGRAMMABLE BLOCK CHECKS. Three different hardware-calculated block checks are available for selection:

LRC-8, CRC-16, and CRC/CCITT.



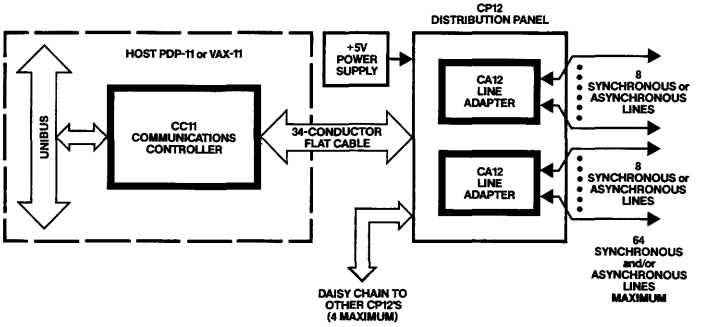
The STATCON 11 Communications Multiplexer/ Port Concentrator from Emulex Corporation.

SPECIAL NOTE:
For users who need both local and remote terminal handling, the STATCON SERIES 11 handles all aspects of multiplexing, demultiplexing, error handling, link initialization, link synchronization and remote concentrator configuration to transfer error-free concentrated data through one to sixteen RS-232 ports. All this in a manner that is completely transparent to the system's operating software. Up to 64 local and remote lines may be installed in any DEC PDP-11 or VAX-11 computer using a single UNIBUS backplane slot.

SO TAKE YOUR CHOICE...

...and remember — at EMULEX, all active components are pre-aged for over 160 hours. All final product assemblies are environmentally cycled at full power for over 96 hours. And all products are backed by a full one-year warranty and supported worldwide by the company's technical applications group.

APPENDIX C
CS11 SERIES COMMUNICATIONS MULTIPLEXERS



CS11 BLOCK DIAGRAM

The central element of all four multiplexer emulations in the CS11 Series is the CC11 Communications Controller, a single pcb which mounts in any available hex-height SPC slot of a DEC Unibus backplane or system unit.

The CC11 controller contains a microprocessor programmed to implement all four of the emulation models. Adaptation from one model to another is made through a simple PROM change.

One CC11 controller interfaces one to four CP12 Distribution panels via a 34-conductor flat cable. Each FCC-compliant CP12 panel contains one or two 8-channel CA12 line adapters and an integral power supply. The line adapters provide data and modem interface circuitry, plus the "USART"-type circuits which provide the serial-to-parallel and parallel-to-serial conversions conducted by the multiplexer system. The USART's also contain a baud rate generator and modem circuitry. Data transfers between the line adapters and the controller are on a parallel-character basis.

Channels may be added and different interface standards may be configured in eight-line increments. If more than 64 lines are needed, additional controller boards and line adapters may be installed in the space saved by the CS11's compact packaging.

CS11 SERIES SPECIFICATIONS

Characteristic	Specification
CP12 DISTRIBUTION PANEL	
(FCC Compliant. For use with all emulations.)	
Configuration	Seven-inch high panel for two 8-channel line adapters, including power supply and cable interface.
Dimensions	7" high x 19" wide x 7" deep.
Weight	19 pounds.
Power	Self-contained supply. 50-60 Hz, 115/230 VAC, 35 watts.
CA12/H RS-232 LINE ADAPTER	
(For use with CS11/F, H, and U.)	
Configuration	Two-sided PCB measuring 6.5" x 8" which plugs into one half of the CP12 Distribution Panel.
Interface	RS-232-C, with DM11-compatible modem control.
Connectors	Standard EIA RS-232-C 25-pin male connectors.
Indicators	Fault LED per line.
Transmission Modes	Half duplex, full duplex, echoplex.
Modem Control Signals	RTS, DTR, CTS, CD, RING (or DSR), Secondary Rx, and Tx.
CA12/C CURRENT LOOP LINE ADAPTER	
Configuration	Two-sided PCB measuring 6.5" x 8" which plugs into one half of the CP12 Distribution Panel.
Interface	20 mA Current Loop.
Connectors	Terminal strip interface.
Indicators	Fault LED per line.
Transmission Modes	Full duplex.

APPENDIX C
CS11 SERIES COMMUNICATIONS MULTIPLEXERS

CS11 SERIES SPECIFICATIONS

Characteristic	Specification		
CC11 CONTROLLER	**CS11/F**	**CS11/H**	**CS11/U**
Design	High-speed bipolar microprocessor-based controller for implementation of all functional operations.		
Function	Provides functional emulation of the asynchronous multiplexer portion of the DEC DMF32 with full modem control. For use with the VAX-11.	Provides functional emulation of the DEC DH11 asynchronous multiplexer with full DM11 modem control. For use with the PDP-11.	Provides functional emulation of the DEC DH11 asynchronous multiplexer with full DM11 modem control. For use with the VAX-11.
Software Transparency/ Compatibility			
Diagnostics:	DEC EVDLC	DEC ZJ179 Kit (PDP-11)	DEC ZJ179 Kit (PDP-11)
Operating Systems:	DEC VAX/VMS versions 3.0 and above.	All common DEC PDP-11 operating systems.	DEC VAX/VMS versions 2.0 and above using EMULEX VMS/UH software.
Line Formats	Character length: 5-8 bits. Stop bits: 1, 2. Parity: Odd, even, none.	Character length: 5-8 bits. Stop bits: 1, 1.5, 2. Parity: Odd, even, none.	
Data Rates (Baud)	50, 75, 110, 134.5, 150, 300, 600, 1200, 1800, 2000, 2400, 4800, 9600, 19200. Split speeds on transmit and receive.	50, 75, 110, 134.5, 150, 200, 300, 600, 1200, 1800, 2400, 4800, 9600, 19200. Split speeds on transmit and receive.	
Distortion	Transmitter: Less than 2% intersymbol. Receiver: Up to 43% intersymbol distortion and speed variation.		
Number of Distribution Panels	1 to 3.	1 to 4.	
Number of Lines	16, 32, 48.	8 to 64.	
Throughput	50,000 characters per second composite data rate for all input/output operations (maximum theoretical).		
Receive FIFO	48 characters per 8-line DMF32 emulation.	Switch selection — 64 characters (standard) or 128 characters per 16 lines; interrupt programmable for 1 to 63 characters FIFO fill level.	
CPU Interface	Standard Unibus SPC interface with one bus load on all signal lines.		
DMA Address Range	0-128K words.		
DMA Transfers	16-bit word parallel with parity check.		
Device Address	Selectable with switches and PROMs to cover all DEC-defined DMF32, DH11, and DV11 assignments.		
Vector Address	Loaded by system software.	Switch-selectable for DH11 and DM11.	
Priority Level	BR5 for DMF32.	BR5 for DH11 and BR4 for DM11.	
Indicator	Controller self-test fault.		
Option Switches	Dip Switches for selection of configuration and controller options.		
Packaging	Single hex-size two-layer pcb.		
Power	5V ± 5%, 4 amps.		

APPENDIX C
CS11 SERIES COMMUNICATIONS MULTIPLEXERS

CS11/V SERIES SPECIFICATIONS

Characteristic	Specification
CC11/V CONTROLLER	
Design	High-speed bipolar microprocessor-based controller for implementation of all CS11/V functional operations.
Function	Provides complete functional emulation of one or two DV11 multiplexers with DM11 modem control. For use with the PDP-11.
Software Transparancy/ Compatibility	Diagnostics: DEC ZJ192 Kit. Operating Systems: DECNET-11M and DECNET-IAS.
No. of Distribution Panels	1 or 2.
No. of Lines	8, 16, 24, or 32.
Throughput	50,000 characters per second total.
Distribution Panel Interface	Eight-bit bidirectional data bus with necessary addressing and control in a single 34-conductor flat cable.
Receive FIFO	128-character FIFO for each functional 16-channel CS11/V (DV11).
Transmit FIFO	64-entry NPR status SILO Program.
Block Checks	Program selectable: LRC-8, CRC-16, CRC/CCITT.
Protocols	DDCMP, BISYNC, and other byte synchronous block protocols.
CPU Interface	Standard Unibus SPC interface. One bus load.
NPR Transfers	16-bit word parallel, transmit and receive, with parity check on memory read operations.
NPR Address Range	0–128K words.
Device Address	Selectable with switches and PROMs to cover DEC-defined DV11 assignments: 775000, 775040, 775100, 775140.
Vector Address	Switch-selectable for DV11 and DM11.
Priority Level	BR5 for DV11 and BR4 for DM11.
Indicator	Controller self-test fault.
Option Switches	Dip switches for selection of configuration and options.
Packaging	Single hex-size two-layer pcb.
Power	5V ± 5%, 4 amps.

Characteristic	Specification
CA12/V LINE ADAPTER	
Configuration	Two-sided PCB measuring 6.5" x 8" which plugs into one half of the CP12 Distribution Panel.
Interface	RS-232-C, with DM11-compatible modem control.
Connectors	Standard EIA RS-232-C 25-pin male connector.
Indicators	Fault LED per line.
Transmission Modes	Programmable: half duplex or full duplex.
Synchronous Line Formats	8-bit characters, no parity.
Asynchronous Line Formats	Character length: 5–8 bits. Stop bits: 1, 1.5, 2. Parity: Odd, even, none.
Synchronous Data Rates (Baud)	1200, 2400, 4800, 9600. (Internal, switch selectable).
Asynchronous Data Rates (Baud)	50, 75, 110, 134.5, 150, 200, 300, 600, 1050, 1200, 1800, 2000, 2400, 4800, 9600, 19200, or external clocking. (Software selectable).
Synchronous Clocks	External and internal; internal common to all lines.
Distortion	Transmitter: less than 2% intersymbol. Receiver: up to 43% intersymbol distortion and speed variation.
Sync Characters	Four switch-selectable sets of 2 sync characters each. Software selects A or B sync character in each set.
Modem Control Signals	RTS, DTR, New Sync/Secondary Tx.
Modem Status Signals	CTS, Carrier Detect, Ring, Data Set Ready/Secondary Rx.
Modems Accommodated	Synchronous: 201, 208, 209. Asynchronous: 103, 202, 212.

APPENDIX D
CS21 SERIES COMMUNICATIONS MULTIPLEXERS

IF YOU NEED ASYNCHRONOUS COMMUNICATIONS FOR YOUR VAX OR PDP-11...

...the EMULEX CS21 Series lets you choose the alternative that best suits your application:

CS21/F—gives DMF-32 performance on the VAX-11; transparent to VAX-11 diagnostic and operating software.

CS21/H—gives full DH11 performance on the PDP-11; transparent to PDP-11 diagnostic and operating software.

CS21/U—gives full DH11 performance on the VAX-11; uses EMULEX VMS/UH software package.

CS21/Z—gives full DZ11E emulation; transparent to DEC diagnostic and operating software on both the PDP-11 and VAX-11.

Regardless of which model you choose, modem control is included as a standard feature.

The communications controller is packaged on a neat single hex-height pcb that goes straight into a standard SPC slot in a DEC backplane or system unit. Two standard 50-conductor flat cables interface to the EMULEX CP21 16-line EIA distribution panel. Or if you prefer, you can use the DEC H317 panel provided for DZ11's (and vice versa). In any case, you wind up with one extra SPC slot for every DZ11E replaced, and eight extra slots for every DH11/DM11 combination replaced.

The CS21 Series is ideal for systems with smaller terminal groups, typically from 16 to 32 lines, where backplane board space and/or power are not critical; and where the line adapter flexibility and full DM11 modem control of EMULEX's companion CS11 Series of products is not desired.

REGARDLESS OF THE CS21 MODEL USED YOU GET THESE IMPORTANT BENEFITS

COMPACT PACKAGING. The basic CC21 Communications Controller, capable of handling 16 lines, plugs into a single Unibus SPC slot with only one unit load on the Unibus. The 5¼ inch high CP21 distribution panel contains the RS232-C subminiature-D type connectors and connects to the controller board via two 50-pin conductor cables.

EXTRA HIGH PERFORMANCE. The controller processes up to 19.2 Kbps per line with a total composite controller data rate of over 50,000 characters per second. Full 16-bit word transfers are made on all DMA operations.

MODEM CONTROL. All DZ11 Modem Control Signals are included as a standard feature. This allows for full-duplex operation.

INTERNAL SELF TEST. The Communications Controller automatically executes an extensive test as part of the power-up sequence.

LOW POWER. Only 8 amps are required from the internal +5 volt CPU power supply.

FLEXIBILITY. Emulations are configured by PROM selection only. Models are switch selected.

UPGRADE CAPABILITY. Current versions of the CS21 may be upgraded/altered to any other model through a simple PROM change. All other hardware is identical.

LOCAL/REMOTE CAPABILITY. Through a simple PROM set change and the addition of an EMULEX CM22/EI Port Concentrator, any model of the CS21 can be converted to the STATCON SERIES 21. The STATCON SERIES 21 combines both standard host computer multiplexing and remote statistical port concentration capabilities into one neat package.

SPECIAL NOTE. For users who need both local and remote terminal handling, the STATCON SERIES 21 handles all aspects of multiplexing, demultiplexing, error handling, link initialization, link synchronization and remote concentrator configuration to transfer error-free concentrated data through a single RS-232 port. All this in a manner that is completely transparent to the system's operating software. Up to 32 local and remote lines may be installed in any DEC PDP-11 or VAX-11 computer using a single UNIBUS backplane slot.

REMOTE LINE INTERFACING. The distribution panel may be located up to 50 feet from the CC21 controller for conveniently locating line terminals and minimizing terminal cable lengths.

FOR PDP-11 USERS WHO WANT DH11 LEVEL PERFORMANCE AT LESS THAN A DZ11 PRICE...

...the CS21/H model gives you these extra features and benefits:

DMA ON TRANSMIT OPERATION. DMA of characters transmitted from the CPU memory, controlled by individual byte count and address registers for each line, greatly reduces CPU and Unibus loading over that of interrupt-driven multiplexers with programmed output operation (e.g., DZ11).

PROGRAMMABLE RECEIVE FIFO. The receive FIFO provides buffering for received characters with programmable capability to interrupt at 1 to 63 characters FIFO fill level. Priority is given to input data handling to accommodate peak transmission loads.

QUADRUPLE FIFO CAPACITY. The input FIFO capacity can be set for 256 characters per 16 input lines versus the standard DH11 64 characters per 16 input lines; option switch permits selection of single or quadruple FIFO capacity for diagnostic compatibility.

LINE FORMAT FLEXIBILITY. Program selection of the following line parameters: speed (to 19,200 bps); character size (5–8 bits); stop bits (1, 1½, 2 bits); transmission mode (full duplex, half duplex or echoplex); parity (odd, even, none).

LINE SPEED FLEXIBILITY. All commonly used line speeds, plus split line speeds for different rates in transmit and receive.

SOFTWARE TRANSPARENCY. The CS21/H emulates the DEC DH11, and on the PDP-11 Series, executes standard diagnostics and operating system software.

APPENDIX D
CS21 SERIES COMMUNICATIONS MULTIPLEXERS

FOR VAX-11 USERS WHO PREFER DH11 OPERATION...

...the CS21/U provides the answer. Tests show that the CS21/U consumes less CPU time than the DZ11 in block-oriented output applications. And this capability is yours along with the other DH11 advantages already identified.

Because there is no standard DH11 software in VMS, EMULEX has made the investment for you and fully supports this product with its own in-house staff.

The CC21/U controller version is optimized for VAX Unibus operation and operates the EMULEX-developed VMS/UH software package, consisting of a terminal driver and diagnostics (stand-alone plus on-line exerciser), supported internally by EMULEX for VMS Versions 2.0 and above. Software is provided on either RX01 diskette or TU58 tape cartridge.

FOR VAX-11 USERS WANTING DMF-32 PERFORMANCE AND SOFTWARE TRANSPARENCY...

...the CS21/F is the answer. Our CS21/F provides software and diagnostic transparent communication to your VAX CPU (VMS Version 3.0 and above). It also provides modem control on *ALL lines* instead of only two as with DEC's DMF-32. With our CS21/F you also save an SPC slot, have the remotes you need and take advantage of the dramatically improved performance of the DMF-32 VMS terminal handler.

Because the transmit functions of the CS21/F are governed by the VMS/DMF-32 software driver, the CS21/F will do either DMA or Programmed I/O, depending on the character count. Full 16-bit word transfers are made on all DMA operations.

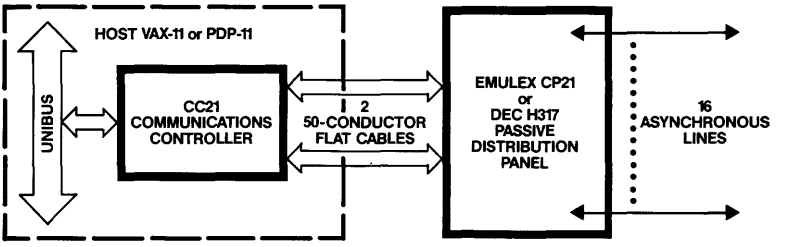
AND FOR USERS THAT SIMPLY WANT A BETTER DZ11 TYPE UNIT AT A LOWER PRICE...

...the CS21/Z model fills the bill. In standard mode, it's transparent to DEC software across the PDP-11 and VAX-11 lines. Switch selectable single or double FIFO operation is included. And you save a full board slot for every DZ11E replaced. But that's not all because the CS21/Z has a built-in timer for the receive FIFO which augments the fixed 16-character alarm level of the DEC DZ11. This insures that received characters won't be trapped in the FIFO for long periods if the input rate is low. And as an extra feature, we provide a switch selectable enhancement option which gives an increase in performance by providing a 16 character per line transmit buffer, with optional full XON/XOFF support, at the expense of installing a set of patches into the standard DEC DZ11 drivers.

SO TAKE YOUR CHOICE...

...of CS21 models for today's needs. You can always move up or down with the same hardware. And look to EMULEX for future additions to all its communications product lines that will expand and enhance your investment.

CS21 SUBSYSTEM ORGANIZATION



CS21 BLOCK DIAGRAM

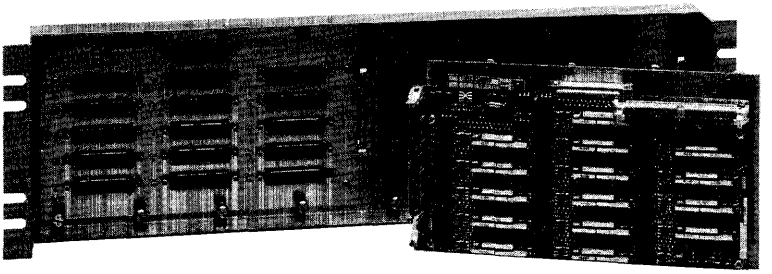
Functional organization and physical implementation are key features of the CS21 Series. The single CC21 Controller board contains all active circuitry in the system, including the USART line interfaces for all 16 channels. The board installs in any standard SPC slot of the host CPU and connects to the passive CP21 RS232 Distribution Panel by two 50-conductor flat cables. The panel interface is compatible with the standard DEC H317 for DZ11's, permitting use of either panel.

APPENDIX D
CS21 SERIES COMMUNICATIONS MULTIPLEXERS

CS21 SERIES SPECIFICATIONS

Characteristic	Specification
CC21 CONTROLLER	
Design	High-speed bipolar microprocessor-based controller for implementation of all functional operations.
Function	
DH11 and DZ11:	Provides complete functional emulation of the DEC DH11 or DZ11 asynchronous communication line multiplexer and DZ11 modem control.
DMF-32:	Provides functional emulation of the DEC DMF-32 asynchronous communication line multiplexer and modem control.
Software Transparency/ Compatibility	Diagnostics: DH11—ZJ179 Kit (PDP-11) DMF-32—EVDLC, EVDAC (VAX-11) DZ11—ZJ223 Kit (PDP-11) DZ11—EVDAA (VAX-11) Operating Systems: DH11—All common PDP-11 operating systems. DMF-32—VAX/VMS Version 3.0 and above. DZ11—All common PDP-11 and VAX operating systems (VMS, UNIX).
Transmission Modes:	Full duplex.
Line Formats	Character lengths: 5-8 bits. Stop bits: 1, 1½, 2. Parity: Odd, even, none.
Data Rates (Baud)	DH11: 50, 75, 110, 134.5, 150, 200, 300, 600, 1200, 1800, 2400, 4800, 9600, 19200. DMF-32 and DZ11: 50, 75, 110, 134.5, 150, 300, 600, 1200, 1800, 2000, 2400, 4800, 9600, 19.2 Kbps. Split transmit receive rates.
Distortion	Transmitter: Less than 2% intersymbol. (3% for DZ11 at 19.2 Kbaud.) Receiver: Up to 43% intersymbol distortion and speed variation.
Numbers of Lines	16 Asynchronous (DH11). 8 or 16 Asynchronous (DMF-32 and DZ11).
Throughput	Over 50,000 characters per second composite rate for all input/output operations.
Receive FIFO	
DH11:	Switch selection—64 characters (standard) or 256 characters for the 16 lines; interrupt programmable for 1 to 63 characters FIFO fill level.
DMF-32:	Standard—64 characters per 8 lines.
Receive FIFO (continued)	DZ11: Switch selection—64 characters (standard) or 128 characters per 8 lines. Standard FIFO alarm set at 16 characters; double FIFO alarm set at 64 characters. Includes 0.1-second FIFO timer to avoid trapped characters because of slow receive data rates.
Transmit Buffer (DZ11)	Switch enabled, 20 characters per line for enhanced DZ11 operation (requires software patches to diagnostics and operating system). Includes XON/XOFF control.
CPU Interface	Standard Unibus SPC interface, one bus load on all signal lines.
DMA Address Range (DH11)	0-128K words.
DMA Transfers (DH11)	16-bit word parallel with parity check.
Device Address	Selectable with switches and PROM's to cover most DEC-defined DMF-32, DH11 and DZ11 assignments.
Interrupt Arbitration	Enhanced.
Vector Address	Switch-selectable for DM11 and DH11, or DZ11. Standard DMF-32 register.
Priority Level	BR5 for DH11, DMF-32 or DZ11 BR4 for DM11
Indicator	Controller self-test fault LED.
Option Switches	DIP switches for selection of controller options.
Packaging	Single hex-size four layer printed circuit board.
Power	5v + 5%, 8 amps -15v ± 5%, 200 mA +15v ± 5%, 200 mA
CP21 DISTRIBUTION PANEL	
Configuration	5¼ inch high panel for 16 EIA RS-232 lines with DZ11-compatible modem control. Standard RS-232-C, 25-pin male connectors.
Modem Control Signals	To: DTR, (or RTS). From: CD, ring (or DSR).
Dimensions	5.25" high x 19" wide x 3" deep.
Weight	2 lbs.
Controller Interface	Two 50 conductor flat cables, compatible with DEC H317 Distribution Panel.

APPENDIX E
CP22/CP23 SERIES DISTRIBUTION PANELS



MORE LINES...LESS SPACE

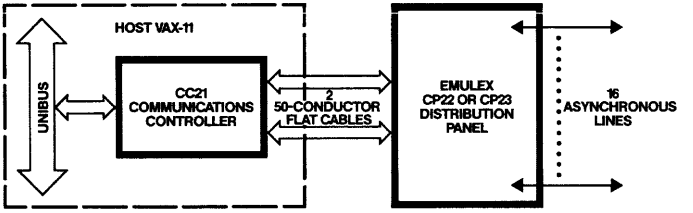
The CP22 and CP23 Distribution Panels are the answer to handling more lines in less cabinet space in your DEC* VAX-11 CPU. The CP22 will handle sixteen lines with RS-232 capability. The CP23 handles sixteen lines with either RS-232 or Current Loop capability, on a per-line basis, governed simply by the user's cable makeup. Either panel is available in a standard or optional FCC-compliant version.

The CP22 and CP23 panels are functional components of the CS21 Communications Subsystem, handling terminal interfacing for the CC21 Controller Board. The CC21 board installs in any standard SPC slot in the host CPU and connects to the appropriate distribution panel via two 50-conductor flat cables.

* DEC and VAX are trademarks of Digital Equipment Corporation.

APPENDIX E
CP22/CP23 SERIES DISTRIBUTION PANELS

APPLICATION DIAGRAM:

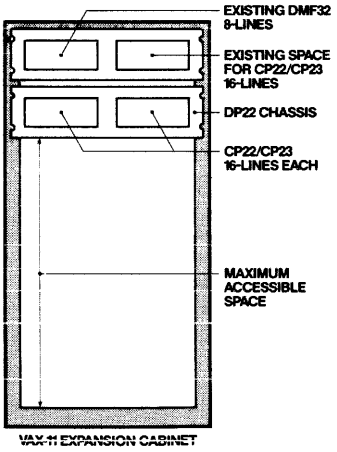


CS21/FX SUBSYSTEM WITH CP22 OR CP23 DISTRIBUTION PANELS

MOUNTING/APPLICATION:

The 16-line CP22 or CP23 distribution panels can each install in an existing DEC DMF32 8-line panel space. Each panel may also be installed as a single or double unit in the EMULEX DP22 chassis which can be mounted in optional rack space within an expansion cabinet. In any mounting configuration, the CP22 or CP23 provides twice the number of lines in the same space as compared to DEC DMF32 panels or EMULEX CP21 panels.

TYPICAL MOUNTING:



SPECIFICATIONS:

Characteristic	Specification
Configuration:	CP22: 4.6" high panel for 16 EIA RS232 lines.
	CP23: 4.6" high panel for 16 EIA RS232 or Current Loop lines.
Interface:	CP22: Standard RS 232-C.
	CP23: Standard RS 232-C or 20mA Current Loop; Interchangeable per line, per user cables.
Connectors:	RS 232-type, 25-pin male connectors.
Modem Control Signals:	CP22: DTR, CD, ring.
	CP23: DTR, CD, ring. Options: DTR/RTS, DSR/ring.
Dimensions:	4.6" high x 8.4" wide x 2" deep (w/FCC).
Weight:	2 pounds.
Controller Interface:	Two 50-conductor flat cables, compatible with DEC H317 distribution panel.
Transmission Mode:	Full duplex.

APPENDIX F
CS32/F COMMUNICATIONS MULTIPLEXER

THE SOLUTION TO ADDING A LARGE NUMBER OF TERMINALS TO YOUR VAX-11 CPU WITHOUT SACRIFICING COMPUTER PERFORMANCE.

DEC's DMF32 Communications Controller slashed data transfer overhead to improve efficiency 200–400% over the DZ11-E, and the CS32 takes full advantage of this built-in efficiency. Bus transfer methods are dynamically selected by software, based on the amount of data to be transmitted. Programmed I/O (PIO) transfers, which are buffered, are more efficient for short-burst transmissions. When transmitting larger amounts of data, the VMS/DMF driver selects the DMA transfer method in which the controller, after receiving the DMA address and byte count parameters, accesses main memory directly. The result: the CPU has more time to perform its main task — processing user applications.

EMULEX introduces expanded communications capability for your VAX with the new EMULEX CS32 Communications Multiplexer. The CS32 starts out by giving you sixteen asynchronous lines — the equivalent of two DMF32's. Then, just by adding distribution panels, the same single board will take care of up to 128 lines. For the same number of lines, you would need sixteen DEC DMF32 boards plus expansion chassis to hold them.

Unlike the DMF32, which only has full modem control on two of its eight lines, the CS32 has full DMF32 modem control on *every* line, letting you choose between full-duplex or half-duplex operation. Plus ALL lines have split-speed capability.

AND THERE ARE EVEN MORE REASONS WHY...

...the EMULEX CS32 Series is the ideal solution for applications involving large numbers of local terminals. With the CS32 you realize these important extra benefits.

EXPANDED RECEIVE SILO. Holds up to 255 receive characters per eight line emulation. The eight lines of the DEC DMF32 share only a 48 character receive SILO.

32 CHARACTER OUTPUT SILO. The CS32 has a 32 character output buffer on each line to increase the efficiency of Programmed I/O output transfers.

LOW POWER. Only 4 amps are required from the CPU +5 volt power supply. Each distribution panel contains its own power supply, so no additional CPU power is required as lines are added.

UPGRADE FLEXIBILITY. Emulations are configured by PROM selection. Current CS32 versions may be upgraded/altered to other model functions through simple PROM change.

PACKAGING FLEXIBILITY. The basic communications controller, capable of handling up to 128 local lines plugs into a single Unibus slot in the CPU. A single 34-conductor flat cable daisy chains to a maximum of eight distribution panels containing sixteen terminal connectors each.

LINE FORMAT FLEXIBILITY. Program selection of the following line parameters: speed (to 38.4K baud); character size (5–8 bits); stop bits (1, 1½, 2 bits); transmission mode (full duplex, half duplex); parity (odd, even, none).

INTERNAL SELF TEST. The communications controller automatically executes an extensive test both on itself and on each of the connected line adapters as part of the power-up sequence. Line loop text can also be manually initiated.

LOCAL/REMOTE CAPABILITY. Through a simple PROM change and the addition of an EMULEX CM22 Port Concentrator, the CS32 Series can be converted to the STATCON Series 32. The STATCON Series 32 incorporates standard host computer multiplexing and remote statistical port concentration capabilities into a single product able to handle up to 256 local/remote lines on a single-board controller.

SPECIAL NOTE. For users who need both local and remote terminal handling, the STATCON Series 32 handles all aspects of multiplexing, demultiplexing, error handling, link initialization, link synchronization and remote concentrator configuration to transfer error-free concentrated data through a single RS-232 port. All this in a manner that is completely transparent to the system's operating software. Up to 256 local and remote lines may be installed in any VAX-11 computer using a single Unibus backplane slot.

FULL MODEM CONTROL. Emulation offers DMF compatible half and full duplex modem control on all 128 lines. Each DEC DMF32 offers eight asynchronous lines maximum, only two of which have modem control.

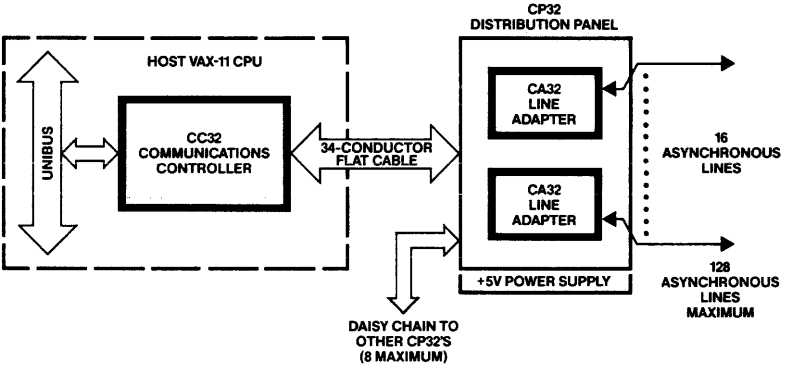
REMOTE LINE INTERFACING. The CP32 distribution panels may be located up to 50 feet from the controller for minimizing terminal cable lengths and/or conveniently locating the panels.

SOFTWARE TRANSPARENCY. The CS32 Series is transparent to the DEC DMF32 operating systems software and diagnostics on VAX-11 computers.

SPLIT SPEED CAPABILITY. Full split speed capability on all 128 lines. DEC DMF32 offers split speed capability on only two of its eight asynchronous lines.

CS32 BLOCK DIAGRAM

Functional efficiency and physical economy are key features of the CS32. The single CC32 controller board is the transparent interface between the VAX-11 system and the user. The board installs in any standard hex SPC slot of the host CPU and connects to the CP32 distribution panels via a 34-conductor flat cable. Each distribution panel contains sixteen RS232-C subminiature D-type connectors. RS232 adapters include full modem control for half-duplex or full-duplex operation.



WE OFFER MORE THAN JUST A GREAT PRODUCT.

With the CS32 you get superb quality and excellent support from the EMULEX team. All pcb components are pre-aged for over 160 hours, and final product assemblies are environmentally cycled for over 96 hours (while operating) to insure ultimate reliability from the moment they are installed. Plant production capability exists to meet the highest of volume requirements. All EMULEX products are backed by a full one year warranty and supported worldwide by the company's technical applications group.

APPENDIX F
CS32/F COMMUNICATIONS MULTIPLEXER

CS32 SERIES SPECIFICATIONS

CC32 CONTROLLER

Characteristic	Specification
Design	High-speed bipolar microprocessor based controller for implementation of all functional operations.
Function	Provides functional emulation of up to 16 DEC DMF32 asynchronous multiplexers with full modem control on all lines.
Software Transparency/ Compatibility	Diagnostics: EVDLC EVDAC Operating Systems: VAX/VMS Version 3.0 and above.
No. of Distribution Panels	1 to 8.
Number of Lines	16 to 128.
Line Formats	Character lengths: 5-8 bits. Stop bits: 1, 1½, 2 Parity: Odd, even, none.
Data Rates (Baud)	50, 75, 110, 134.5, 150, 300, 600, 1200, 1800, 2000, 2400, 3600, 4800, 7200, 9600, 19.2K, 38.4K Baud, plus 1x and 16x ext, clock. Split transmit/ receive rates.
Throughput	50,000 characters per second composite rate for all input/output operations (maximum theoretical).
Bus Interface	Standard Unibus SPC interface, one bus load on all signal lines.
DMA Address Range	0-128K words.
DMA Transfers	16-bit word parallel with optional parity check.
Device Address	Selectable with switches to cover all DEC-defined DMF32 assignments.
Interrupt Arbitration	Enhanced.
Vector Address	Standard DMF32 register.
Priority Level	BR5 or BR6 (switch selectable).
Indicators	Controller fault, Unibus activity, and on-line LEDs.
Option Switches	DIP switches for selection of configuration and controller options.
Packaging	Single hex-size four layer printed circuit board.
Power	5v ± 5%, 4 amps.
FCC Compliance	Subsystem complies with FCC regulations when installed entirely within a single cabinet. Shielded cables are optional for external mounting of distribution panels.

CP32 DISTRIBUTION PANEL

Configuration	Seven inch high panel for two 8-channel line adapters, including power supply and cable interface.
Dimensions	7 inches (17.78cm) high 19 inches (48.26cm) wide 7 inches (17.78cm) deep
Weight	20 pounds (9 kilos).
Power	Self-contained supply, 50-60 Hz, 115/230 VAC, 35 watts.

CA32 RS-232 LINE ADAPTER

Configuration	Four-layer PCB measuring 6½" x 8" which plugs into CP32 Distribution Panel.
Interfaces	25 pin RS232-C male connector. Drivers and receivers are RS232/RS423 compatible.
Indicators	Fault LED per line.
Transmission Modes	Half-duplex, full-duplex.
Modem Control Signals	RTS, secondary RTS, data signal rate select, DTR, User Transmit.
Modem Status Signals	DSR, RING, CAR, CTS, Secondary CAR, User RX.
Distortion	Transmitter: Less than 2% intersymbol. Receiver: Up to 43% intersymbol distortion and speed variation.

APPENDIX G
STATCON SERIES 11 COMMUNICATIONS SUBSYSTEM

INTRODUCING THE STATCON SERIES 11—UP TO 64 LINES OF TRANSPARENT COMMUNICATION—ONLY ONE BOARD SLOT AND NO SOFTWARE CHANGES...

The unique EMULEX CS11 has already solved many of the communication problems inherent in DEC systems by affording users a much needed reduction in physical space, power, and cabling requirements.

The STATCON SERIES 11 is the latest product in this family. It is a combination of communication techniques; multiplexing for local applications and port concentration for efficient remote applications. And it solves a lot of additional problems.

The STATCON SERIES 11 is a combination of the proven CS11 multi-line communications controller (multiplexer) with special microprogramming and the CM22/EX local statistical port concentrator (together called the CSM11/MX/EX). The STATCON SERIES 11 handles all aspects of multiplexing, demultiplexing, error handling, link initialization, link synchronization, and remote concentrator configuration to transfer error-free concentrated data through a *single* computer RS-232 port. All this in a manner that is completely *transparent* to the system's operating software. Up to 64 local and remote lines may be installed in any DEC PDP-11 or VAX-11 computer using a single UNIBUS backplane slot.

The multiplexing functions are EXACTLY like those achieved with the CS11/H (PDP/DH11) and CS11/U (VAX/DH11). In addition, EMULEX adds the cost-effective application of port concentration for handling remote communication with a minimum of telephone lines.

ENGINEERING EXCELLENCE AND HARDWARE RELIABILITY ARE THE KEY...

The same microprocessor architecture that made EMULEX famous has been implemented in the STATCON SERIES 11. This proven approach represents a simple, economical, and state-of-the-art method for providing the kind of performance and reliability that has become the STANDARD for all EMULEX communication products.

IF YOU NEED ASYNCHRONOUS COMMUNICATIONS FOR YOUR VAX OR PDP-11...

...the EMULEX STATCON SERIES 11 lets you select the alternative that best suits your application:

- **CSM11/MH**—gives full DH11 performance on the PDP-11; transparent to PDP-11 diagnostic and operating system software.
- **CSM11/MU**—provides full DH11 performance on the VAX-11; uses EMULEX VMS/UH software package.

REGARDLESS OF THE MODEL USED, YOU GET THESE IMPORTANT BENEFITS...

COMPACT PACKAGING. The basic CC11 Controller plugs into a single UNIBUS SPC slot with only one unit load on the UNIBUS. The 7.00 inch high CP11 distribution panel contains the RS-232-C subminiature-D type connectors and attaches to the controller board via one 34-pin conductor flat cable.

EXTRA HIGH PERFORMANCE. The controller processes up to 19.2 Kbaud per line with a total composite controller data rate of 50,000 characters per second. Full 16-bit word transfers are made on all DMA operations.

MODEM CONTROL. With both the DH11 emulation and remote line application, the *full* complement of DH11/DM11-BB modem control signals are used. Remotes can function in a full- or half-duplex mode.

INTERNAL SELF TEST. The CC11 controller automatically executes an extensive test as part of the power-up sequence and provides a set of simple off-line tests for localizing faults.

LOW POWER. Only 4 amps are required from the internal +5 volt CPU power supply.

REMOTE LINE INTERFACING. The first CP11 distribution panel may be located up to 50 feet from the CC11 controller to assist in conveniently locating line terminals and minimizing terminal cable lengths.

FOR PDP-11 USERS WHO WANT DH11 LEVEL PERFORMANCE...

...the CSM11/MH model gives you these extra features and benefits:

DMA TRANSMIT OPERATION. DMA of characters transmitted from the CPU memory greatly reduces CPU and UNIBUS loading compared to that of interrupt-driven multiplexers using programmed I/O operations.

PROGRAMMABLE RECEIVE FIFO. The receive FIFO provides buffering for received characters with programmable capability to interrupt at 1 to 63 characters FIFO fill level. Priority is given to input data handling to accommodate peak transmission loads.

LOCAL LINE FORMAT FLEXIBILITY. Program selection of the following line parameters: speed (to 19,200 baud); character size (5-8 bits); stop bits (1, 1.5, 2 bits); transmission mode (half duplex, full duplex, echoplex); parity (odd, even, none).

REMOTE LINE FORMAT. Supports odd and even parity for the following rates: 9600, 4800, 2400, 1800, 1200, 600, 300, 200, 150, 134.5, 110, 75, 50 baud.

LINE SPEED FLEXIBILITY. All DH11 baud rates on local lines. Most commonly used DH11 baud rates on remote lines.

SOFTWARE TRANSPARENCY. The CSM11/MH emulates up to four DH11/DM11-BB type controllers and executes standard operating system software. The DEC diagnostics are transparent if the statistical multiplexer option is not enabled.

APPENDIX G
STATCON SERIES 11 COMMUNICATIONS SUBSYSTEM

FOR THE VAX-11 USERS WHO NEED DH11 LEVEL PERFORMANCE...

...The CSM11/MU provides the answer. Tests show that the CSM11/MU consumes less CPU time than the DZ11 in block-oriented output applications. The CC11/MU controller version is optimized for VAX UNIBUS operation. These capabilities are yours along with the other DH11 advantages already identified.

Because there is no standard DH11 software support in VMS, EMULEX has developed the VMS/UH software package; consisting of a terminal driver and diagnostics (stand-alone plus on-line exerciser), all supported internally by EMULEX for VMS Versions 2.0 and above. This software package is provided on either RX01 diskette for the VAX-11/780 or TU58 tape cartridge for the VAX-11/750 and VAX-11/730.

SO TAKE YOUR CHOICE...

...from the STATCON SERIES 11 models available for today's needs. You can always move up or down with the same hardware. And look to EMULEX for future additions to its communications product lines that will expand and enhance your investment.

WHAT ARE THE ADVANTAGES OF THE STATCON SERIES 11?

In the past, user options were limited when it came to satisfying both remote and local communication requirements. In remote applications, to achieve the economy of Port Concentration, users were required to either develop sophisticated demultiplexing software in the host or to install complete Master and Slave Data Concentrators. Now the programming effort is no longer necessary; nor do you have to purchase "duplicate" hardware as in the Master and Slave Data Concentrator applications.

The STATCON SERIES 11 supplies the economy, efficiency, and software transparency needed to satisfy both local and remote communication capabilities in PDP-11 and VAX-11 environments.

WHAT IS SOFTWARE DEMULTIPLEXING?

SOFTWARE DEMULTIPLEXING is a technique where a user-developed program combines the data from multiple small buffers in main memory into a single "composite" data stream for transmission to a remote communication site. The program is also used to separate the composite data stream when it is received from the remote site. Other responsibilities are: maintaining communication "link" synchronization, insuring that data is error-free, data buffering, and configuring the remote terminal characteristics.

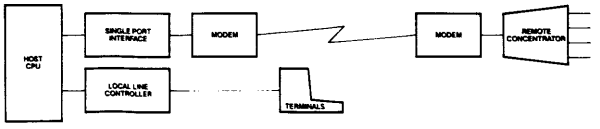
The traditional way to save computer ports has been to utilize a remote terminal concentrator and perform "software demultiplexing" in the host processor. By emulating the computer-site multiplexer, a "software demultiplexing" program allows a single computer port to communicate with a remote terminal concentrator over a communication link. Below are the various methods currently in use to accomplish remote communication:

EXAMPLE A:

THE ANTIQUE METHOD

HOST COMMUNICATIONS PORT TO REMOTE DATA CONCENTRATOR

This method requires the development of expensive custom software to achieve remote communication concentration. The software demultiplexing program MUST emulate the replaced host concentrator in EVERY DETAIL. The error control protocol in this application makes the software development non-trivial because it must retransmit data when an error is detected and respond when the remote requests a retransmission. Since software demultiplexing is not a trivial task, typically only the large and/or sophisticated user has an interest in this type of application.



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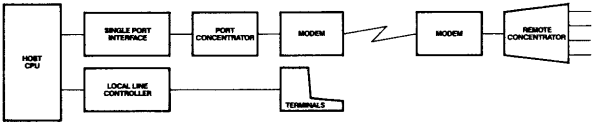
HOST COMMUNICATIONS INTERFACE TO PORT CONCENTRATOR TO REMOTE DATA CONCENTRATOR

In this method, a Port Concentrator is used to off-load program tasks that are considered Master/Slave communications. This means that the Port Concentrator has to have some built-in "intelligence" for handling Slave Concentrator requests and maintaining data link integrity.

Each remote concentrator requires a dedicated host-mounted interface. The multiplexing/demultiplexing tasks must still be handled by custom software as defined in Example A above.

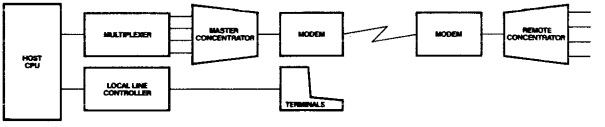


EXAMPLE C:

THE CURRENT METHOD

MASTER/SLAVE DATA CONCENTRATORS

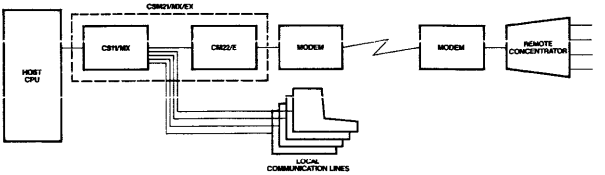
The Master/Slave Data Concentrator method is considered a simpler means of implementing remote communication because software transparency is assured. Unfortunately, this scheme involves the use of multiple data concentrators. The host-side concentrator is connected to a multi-line controller (multiplexer) by up to 16 cables, depending on the type of controller used. A duplication of controllers and data concentrators is necessary for each increment of 8 to 16 lines. While the user is freed from writing expensive custom software, the cost of the Master/Slave Data Concentrator concept becomes significant depending on the number of remote devices involved in the application.



THE EMULEX METHOD

The STATCON SERIES 11 combines the proven CS11 Communications Multiplexer with special microprogramming (together called the CSM11/MX) and the CM22/EX local statistical port concentrator. STATCON handles all aspects of "software demultiplexing" necessary to transfer concentrated data between the host computer and remote data concentrator. It does this through a single asynchronous RS-232 port.

With the CC11/MX computer interface and the CM22/EX Port Concentrator performing the software demultiplexing, the EMULEX approach is considerably easier and less expensive than the previously described methods. The STATCON SERIES 11 method is transparent to the host computer. Neither the "software demultiplexing" programming effort nor duplicate hardware is required as with previous methods. The CM22/EX has the built-in "intelligence" required to maintain the Master/Slave relationship and the CC11/MX performs the remainder of the "software demultiplexing" task.



APPENDIX G
STATCON SERIES 11 COMMUNICATIONS SUBSYSTEM

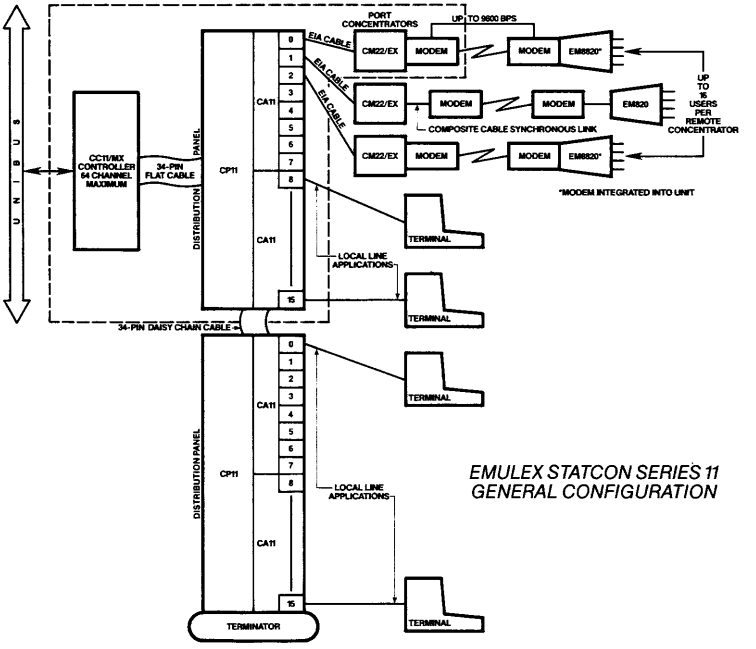
DATA FLOW CONTROL: XON/XOFF flow control is handled by the remote concentrator on an individual channel basis. Therefore, when a flow control character is received, the appropriate action takes place immediately.

Since the CC11/MX handles the above functions, the Operating System does not have to be patched or otherwise changed to accommodate the Port Concentrator application.

FOR LOCAL APPLICATIONS, the technique is EXACTLY like that employed in the CS11 64-line Asynchronous Communication Controller.

Local lines are those lines remaining after the remote lines are assigned. Each local terminal is attached to one of the 16 EIA connectors of the CP11 distribution panel that is not used as a Remote.

This portion of the emulation is the same as if a multi-line communication controller were installed. The same attributes of programmable line speed, character length, stop bits, and parity are implemented. The maximum terminal speed is 19,200 bps as versus 9600 bps for the equivalent DEC communication controller.



EMULEX STATCON SERIES 11 GENERAL CONFIGURATION

HOW TO CONFIGURE A STATCON SERIES 11...

The STATCON SERIES 11 has the flexibility to meet virtually any remote/local line requirement a user may have totalling up to 64 lines. By using a simple formula, users can calculate how many "virtual" lines are usable as local lines after remote lines are allocated:

No. of Physical Connectors - No. of Remotes = No. of Available Locals

APPENDIX G
STATCON SERIES 11 COMMUNICATIONS SUBSYSTEM

WHAT ARE THE ADVANTAGES OF A PORT CONCENTRATOR?

The CM22/EX Port Concentrator represents a unique alternative to software demultiplexing. The Port Concentrator is designed to provide the port sharing economy of software demultiplexing, while eliminating the programming complexity involved in the software demultiplexing task. All this through a simple asynchronous interface to the CC11/MX multi-line controller.

The CM22/EX is a low-cost unit which functions as a single-channel master concentrator, allowing one asynchronous computer port to communicate with up to 16 devices at a remote Data Concentrator.

In addition to simplifying host computer programming, the CM22/EX Port Concentrator greatly simplifies software checkout by providing loopback tests, which allow testing of the link between the CM22/EX and the remote data concentrator, independent of host intervention.

THE EMULEX CM22/EX PORT CONCENTRATOR

The CC11/MX Communication Controller and the CM22/EX Port Concentrator perform all the work required to communicate with a Remote Data Concentrator. Some of the separate functions of the CM22/EX Port Concentrator are described below:

RETRANSMISSION-ON-ERROR. All data flow between the CM22/EX and a remote concentrator is transmitted in numbered blocks. Each block is terminated by a 16-bit Cyclic Redundancy Check (CRC) character. If an error occurs, the sender is requested to retransmit data beginning with the first detected bad block. This feature presents error-free data to the host and the remote user.

DATA BUFFERING. Data buffering requirements, caused by backup of data due to retransmissions or temporary line outages on the link, are handled automatically by the Port Concentrator.

COMMUNICATION LINK SYNCHRONIZATION. The CM22/EX maintains constant synchronization with the remote unit. This is necessary to insure rapid response and minimum delay whenever there is data to transmit.

COMMUNICATION LINK INITIALIZATION. The Port Concentrator automatically initializes the link during the power up sequence and takes care of the initialization procedure whenever the remote concentrator restarts after a power outage. This process also occurs if the remote data concentrator is manually reset.

CONFIGURATION OF REMOTE CONCENTRATOR. The Port Concentrator requires configuration information from the host only once. The Port Concentrator assumes responsibility for down-line loading the configuration information to the remote.

LOOPBACK TEST MODES. A local or remote loopback test may be initiated manually or through the Command Port of the CM22/EX.

COMMAND PORT. The CM22/EX Command Port offers a wide variety of monitoring, test, and control facilities. It may be connected to a dial-up or dedicated terminal, or directly to a computer port, and may operate at up to 1200 bps.

The following are the capabilities of the Command Port...

MESSAGE BROADCAST permits a message to be transmitted from the Command Port to selected channels or to all channels.

DYNAMIC CHANNEL RECONFIGURATION allows the data rate to be changed for a selected channel, or allows generation of specific delays for carriage return, line feed, and form feed.

REMOTE BUSY permits busy-out of dial-up modems attached to individual channels on the remote.

ALARM MESSAGES with time and date of occurrence are generated automatically each time the CM22/EX locally or remotely experiences a buffer-full or buffer-overflow condition. Alarm messages are also generated if the CM22/EX encounters unusually high line error rates or loses synchronization on the high-speed composite link.

PERIODIC REPORTS provide statistics on data traffic, average and peak buffer memory utilization by channel, block retransmissions, and evaluation of telephone line quality.

THE EMULEX CC11/MX COMMUNICATION CONTROLLER

FOR REMOTE APPLICATIONS, the CC11/MX communications controller acts as an interpreter between the Host and the CM22/EX Port Concentrator.

Among the duties performed by the CC11/MX are the following:

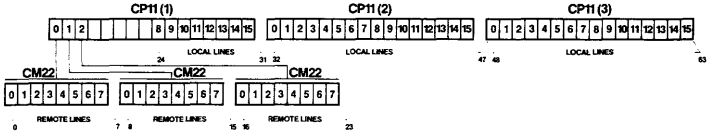
MULTIPLEX/DEMULTIPLEX: A high speed link supports up to 16 logical communication channels. The CC11/MX is responsible for multiplexing and demultiplexing the data received and sent by the Host.

MODEM CONTROL: If modem control is enabled, the modem signal status for each remote channel on the link is passed transparently through the CM22/EX. If modem control is not enabled, the CM22/EX will not pass modem information to or from the remote concentrator.

DATA RATE CHANGES: Individual channel rate changes are passed through the CM22/EX to the remote Data Concentrator.

REMOTE/LOCAL LOOPBACK: The CC11/MX can initiate remote or local loopback of the composite interface for diagnostic purposes.

APPENDIX G
STATCON SERIES 11 COMMUNICATIONS SUBSYSTEM



THIS CAN BE ILLUSTRATED IN THE FOLLOWING EXAMPLE:

	CP11	CC11
Link 0	16	64
	-1 CM22	-8 # Remotes
Link 1	15	56
	-1 CM22	-8 # Remotes
Link 2	14	48
	-1 CM22	-8 # Remotes
	13 Unused physical connectors	40 Unassigned "virtuals"

40 - 13 = 27 Unused "virtuals"

Adding another 16-line CP11 distribution panel will allow the user 16 more local line applications, leaving 11 unassigned "virtual" lines.

27 - 16 = 11

By adding still another 16-line CP11 distribution panel, the user can implement the remaining 11 lines—for a total of 64—leaving 5 connectors on the first CP11 distribution panel unused.

STATCON SERIES 11 CONFIGURATIONS

Below is a partial list of possible configurations. The final selection of STATCON SERIES 11 components should be based upon the most effective use of lines for a particular installation. Users are urged to call and discuss their particular application.

# CM22'S	REMOTE LINES PER LINK USED							# CP11'S 16 LINES EACH	LOCAL CONNECTORS		MAX LINES USED OF 64
	0	1	2	3	4	5	TOTAL		AVAILABLE	USED	
2	8	8					16	1	14	14	30
2	8	8					16	2	30	30	46
2	8	8					16	3	46	46	62
2	16	16					32	1	14	14	46
2	16	16					32	2	30	30	62
3	12	12	12				36	1	13	13	49
3	12	12	12				36	2	29	28	64
4	8	8	8	8			32	1	12	12	44
4	8	8	8	8			32	2	28	28	60
4	12	12	12	12			48	2	28	16	64
6	8	8	8	8	8	8	48	1	10	10	58
6	8	8	8	8	8	8	48	2	26	16	64

GENERAL SPECIFICATIONS

Characteristic	Specification
CC11 CONTROLLER	
Design	High-speed bipolar microprocessor-based controller for implementation of all functional operations.
Function	Provides complete functional emulation of the DEC DH11 asynchronous communication line multiplexer and DM11-BB modem control.

Characteristic	Specification
Software Transparency/ Compatibility	Diagnostics: DH11—ZJ179 Kit (PDP-11) ECS11—EMULEX (VAX-11). Operating Systems: DH11/PDP-11—Driver supplied with operating system. DH11/VAX-11/VMS—EMULEX supplied I/O driver. DH11/VAX-11/UNIX—Driver supplied with operating system.

APPENDIX G
STATCON SERIES 11 COMMUNICATIONS SUBSYSTEM

GENERAL SPECIFICATIONS

Characteristic	Specification
CC11 CONTROLLER	
Line Formats	Character Lengths: 5 to 8 bits. Stop Bits: 1, 1.5, 2 Parity: Odd, Even, None.
Data Rates	(Bits Per Second) Local: 50, 75, 110, 134.5, 150, 200, 300, 600, 1200, 1800, 2400, 4800, 9600, 19200. Remote: 9600, 4800, 2400, 1800, 1200, 600, 300, 200, 150, 134.5, 110, 75, 50.
Distortion	Transmitter: Less than 2% intersymbol. Receiver: Up to 43% intersymbol distortion and speed variation.
Number of Lines	8 to 64 Asynchronous. A detailed chart which outlines configuration possibilities appears on page 7.
Throughput	50,000 characters per second composite rate for all input/output operations (maximum theoretical).
Receive FIFO	64 characters per 16 lines; interrupt programmable for 1 to 63 characters FIFO fill level.
CPU Interface	Standard UNIBUS SPC interface, one bus load on all signal lines.
DMA Address Range	0 to 128K words.
DMA Transfers	16-bit word parallel with parity check.
Device Address	Selectable with switches and PROMs to cover all DEC-defined assignments.
Vector Address	Switch-selectable for DH11/DM11.
Priority Level	BR5 for DH11. BR4 for DM11.
Indicator	Controller self-test fault (on) and activity (flashing).
Option Switches	DIP switches for selection of controller options.
Packaging	Single hex-size four layer printed circuit board.
Power	(Backplane requirement) +5V, 5%, 4 amps.
CP11 DISTRIBUTION PANEL	
Configuration	Seven inch high panel for two 8 channel line adapters, including power supply and cable interface.
Dimensions	7" high x 19" wide x 7" deep.
Weight	20 pounds.
Power	Self contained supply, 50-60Hz, 115/230 VAC, 35 watts.
CA11/H RS-232 LINE ADAPTER	
Configuration	Two-sided PCB measuring ½" x 8" which plugs into CP11 Distribution Panel.
Interface	RS-232-C, with DM11-compatible modem control.
Connectors	Standard EIA RS-232-C, 25-pin male connector.
Indicators	Fault LED per line.
Transmission Modes	Half duplex, full duplex, echoplex, split speed.* *Note: Receiver speed must be the same for all split speed channels on a 16 line distribution panel.
Modem Control Signals	RTS, DTR, CTS, CD, RING (or DSR), Secondary Rx, and Tx.
CA11/C CURRENT LOOP LINE ADAPTER	
Configuration	Two-sided PCB measuring 6½" x 8" which plugs into CP11 Distribution Panel.
Interface	20mA Current Loop.
Connectors	Terminal strip interface.
Indicators	Fault LED per line.
Transmission Modes	Full duplex only.
CM22/E PORT CONCENTRATOR SPECIFICATIONS	
Host-Side Interface	Configured as Data Communication Equipment (DCE). Data Rates: Asynchronous 9600 or 19200 bps. EIA, RS-232-C (CCITT V.24/V.28) serial asynchronous; Full Duplex Female 25-pin D-Type connector.
Composite-Side Interface	Configured as Data Terminal Equipment (DTE). Data Rates: Synchronous up to 9600 bps. EIA, RS-232-C (CCITT V.24/V.28) serial synchronous with external timing; Full Duplex. Male 25-pin D-Type connector.
Physical Dimensions	Standalone: 8" wide x 2" high x 11" deep. Weight = 4 lbs. Rack-mount chassis: 19" wide x 3.5" high x 11" deep.
Operating Environment	32 to 114 degrees F; 0 to 95% relative humidity.
Power	115/230/VAC, 10%, 45 to 65 Hz, 15 watts.

APPENDIX H
STATCON SERIES 21 COMMUNICATIONS SUBSYSTEM

INTRODUCING THE STATCON SERIES 21—UP TO 32 LINES OF TRANSPARENT COMMUNICATION—ONLY ONE BOARD SLOT AND NO SOFTWARE CHANGES...

With the introduction of the CS21, EMULEX made a significant contribution to solving the communication problems inherent in DEC systems; while affording users a much needed reduction in physical space and electrical requirements.

The STATCON SERIES 21 is another product in this family. It is a combination of communication techniques; multiplexing for local applications and port concentration for efficient remote applications.

The STATCON SERIES 21 is a combination of the proven CS21 multi-line communications controller (multiplexer) with special microprogramming and the CM22/EX local statistical port concentrator (together called the CSM21/MX/EX). The STATCON SERIES 21 handles all aspects of multiplexing, demultiplexing, error handling, link initialization, link synchronization, and remote concentrator configuration to transfer error-free concentrated data through a single computer RS-232 port. All this in a manner that is completely transparent to the system's operating software. Up to 32 local and remote lines may be installed in any DEC PDP-11 or VAX-11 computer using a single UNIBUS backplane slot.

The multiplexing functions are EXACTLY like those achieved with the CS21/H (PDP/DH11), CS21/U (VAX/DH11), and CS21/Z (DZ11/E). In addition, EMULEX adds the cost-effective application of port concentration for handling remote communication with a minimum of telephone lines.

ENGINEERING EXCELLENCE AND HARDWARE RELIABILITY ARE THE KEY...

The same microprocessor architecture that made EMULEX famous has been implemented in the STATCON SERIES 21. This proven approach represents a simple, economical, and state-of-the-art method for providing the kind of performance and reliability that has become the STANDARD for all EMULEX communication products.

IF YOU NEED ASYNCHRONOUS COMMUNICATIONS FOR YOUR VAX OR PDP-11...

...the EMULEX STATCON SERIES 21 lets you select the alternative that best suits your application:

- **CSM21/MH**—gives full DH11 performance on the PDP-11; transparent to PDP-11 diagnostic and operating system software.
- **CSM21/MU**—provides full DH11 performance on the VAX-11; uses EMULEX VMS/UH software package.
- **CSM21/MZ**—supports full DZ11-E emulation; transparent to DEC diagnostic and operating system software on both the PDP-11 and VAX.

No matter which model you choose, modem control is included as a standard feature.

REGARDLESS OF THE MODEL USED, YOU GET THESE IMPORTANT BENEFITS...

COMPACT PACKAGING. The basic CC21 Controller plugs into a single UNIBUS SPC slot with only one unit load on the UNIBUS. The 5.25 inch high CP21 distribution panel contains the RS-232-C subminiature-D type connectors and attaches to the controller board via two 50-pin conductor flat cables.

EXTRA HIGH PERFORMANCE. The controller processes up to 19.2 Kbaud per line with a total composite controller data rate of 50,000 characters per second. Full 16-bit word transfers are made on all DMA operations.

MODEM CONTROL. For local line applications all DZ11 modem control signals are included as a standard feature. This allows full-duplex operation. For the DH11 emulation remote line application, the full complement of DH11/DM11-BB modem control signals are used. Remotes can function in full- or half-duplex mode.

INTERNAL SELF TEST. The CC21 controller automatically executes an extensive test as part of the power-up sequence and provides a set of simple off-line tests for localizing faults.

LOW POWER. Only 8 amps are required from the internal +5 volt CPU power supply.

REMOTE LINE INTERFACING. The CP21 distribution panel may be located up to 50 feet from the CC21 controller to assist in conveniently locating line terminals and minimizing terminal cable lengths.

FOR PDP-11 USERS WHO WANT DH11 LEVEL PERFORMANCE...

...the CSM21/MH model gives you these extra features and benefits:

DMA TRANSMIT OPERATION. DMA of characters transmitted from the CPU memory greatly reduces CPU and UNIBUS loading compared to that of interrupt-driven multiplexers using programmed I/O operations.

PROGRAMMABLE RECEIVE FIFO. The receive FIFO provides buffering for received characters with programmable capability to interrupt at 1 to 63 characters FIFO fill level. Priority is given to input data handling to accommodate peak transmission loads.

LINE FORMAT FLEXIBILITY. Program selection of the following line parameters: speed (to 19,200 baud); character size (5-8 bits); stop bits (1, 1.5, 2 bits); transmission mode (full-duplex or half-duplex); parity (odd, even, none).

APPENDIX H
STATCON SERIES 21 COMMUNICATIONS SUBSYSTEM

LINE SPEED FLEXIBILITY. All commonly used baud rates.

SOFTWARE TRANSPARENCY. The CSM21/MH emulates two DH11/DM11-BB type controllers and executes standard operating system software. The DEC diagnostics are transparent.

FOR THE VAX-11 USERS WHO NEED DH11 LEVEL PERFORMANCE...

...THE CSM21/MU provides the answer. Tests show that the CSM21/MU consumes less CPU time than the DZ11 in block-oriented output applications. The CC21/MU controller version is optimized for VAX UNIBUS operation. These capabilities are yours along with the other DH11 advantages already identified.

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AND FOR USERS THAT SIMPLY WANT A BETTER DZ11 TYPE UNIT...

...The CSM21/MZ model emulates *two* DEC DZ11-E controllers and is fully software transparent across the PDP-11 and VAX-11 processor families.

SO TAKE YOUR CHOICE...

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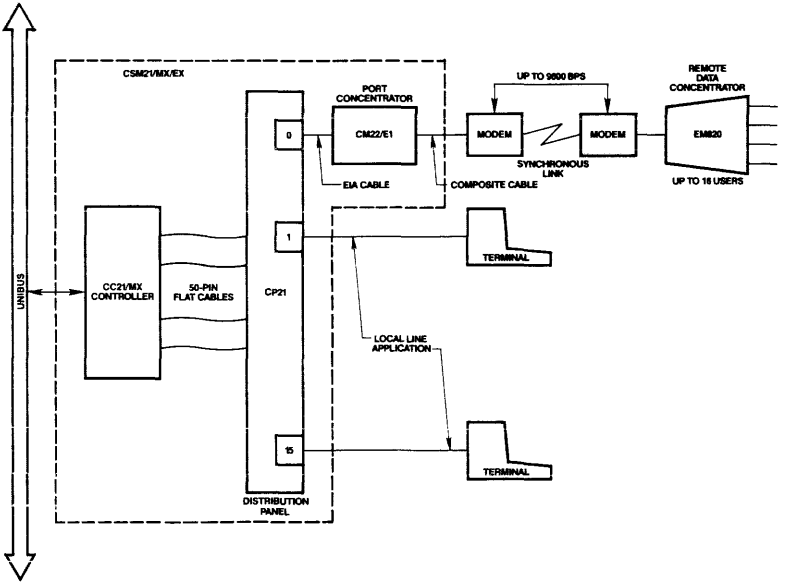

EMULEX STATCON SERIES 21 BASIC CONFIGURATION

APPENDIX H
STATCON SERIES 21 COMMUNICATIONS SUBSYSTEM

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The traditional way to save computer ports has been to utilize a remote terminal concentrator and perform 'software demultiplexing' in the host processor. By emulating the computer-site multiplexer, a 'software demultiplexing' program allows a single computer port to communicate with a remote terminal concentrator over a communication link. Below are the various methods currently in use to accomplish remote communication:

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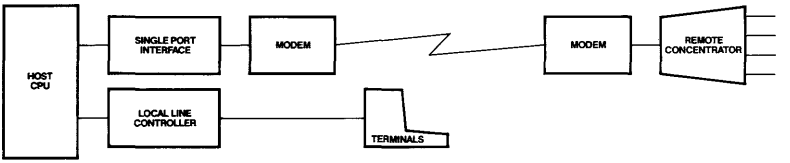

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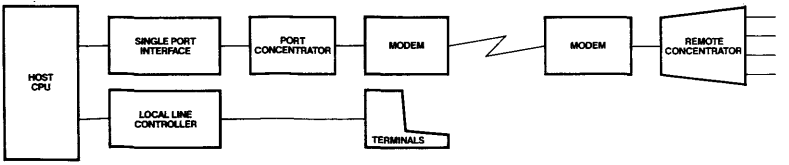

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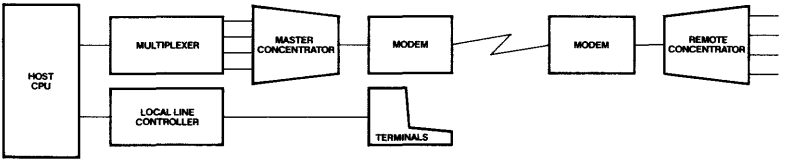
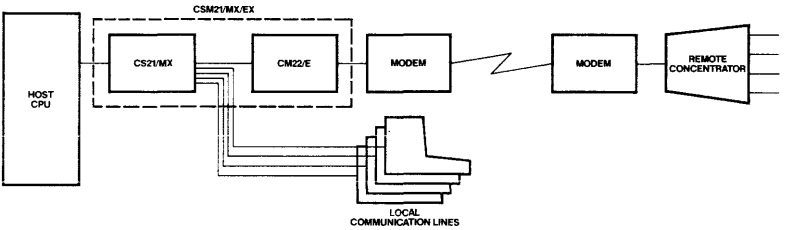


THE EMULEX METHOD

The STATCON SERIES 21 combines the proven CS21 Communications Multiplexer with special microprogramming (together called the CSM21/MX) and the CM22/EX local statistical port concentrator. STATCON handles all aspects of 'software demultiplexing' (multiplexing, demultiplexing, error handling, link initialization and synchronization, and remote concentrator configuration) necessary to transfer concentrated data between the host computer and remote data concentrator through a single asynchronous RS-232 port.

With the CC21/MX computer interface and the CM22/EX Port Concentrator performing the software demultiplexing, the EMULEX approach is considerably easier and less expensive than the previously described methods. The STATCON SERIES 21 method is transparent to the host computer. No longer is the 'software demultiplexing' programming effort necessary and duplicate hardware is no longer required. The CM22/EX has the built-in 'intelligence' required to maintain the Master/Slave relationship and the CC21/MX emulates the remainder of the 'software demultiplexing' task.



APPENDIX H
STATCON SERIES 21 COMMUNICATIONS SUBSYSTEM

WHAT ARE THE ADVANTAGES OF A PORT CONCENTRATOR?

The CM22/EX Port Concentrator represents a unique alternative to software demultiplexing. The Port Concentrator is designed to provide the port sharing economy of software demultiplexing, while eliminating approximately 60% of the programming complexity involved. All this through a simple asynchronous interface to the CC21/MX multi-line controller.

The CM22/EX is a low-cost unit which functions as a single-channel master concentrator, allowing one asynchronous computer port to communicate with up to 16 devices at a remote Data Concentrator.

In addition to simplifying host computer programming, the CM22/EX Port Concentrator greatly simplifies software checkout by providing a loopback test facility, which allows testing of the link between the CM22/EX and the remote data concentrator, independent of host intervention.

THE EMULEX CM22/EX PORT CONCENTRATOR

The CM22/EX Port Concentrator performs more than half the work required to communicate with a Remote Data Concentrator. Some of those functions are described below:

RETRANSMISSION-ON-ERROR. All data flow between the CM22/EX and a remote concentrator is transmitted in numbered blocks. Each block is terminated by a 16-bit Cyclic Redundancy Check (CRC) character. If an error occurs, the sender is requested to retransmit data beginning with the first detected bad block. This feature presents error-free data to the host and the remote user.

DATA BUFFERING. Data buffering requirements, caused by backup of data due to retransmissions or temporary line outages on the link, are handled automatically by the Port Concentrator.

COMMUNICATION LINK SYNCHRONIZATION. The CM22/EX maintains constant synchronization with the remote unit. This is necessary to insure rapid response and minimum delay whenever there is data to transmit.

COMMUNICATION LINK INITIALIZATION. The Port Concentrator automatically initializes the link during the power up sequence and takes care of the initialization procedure whenever the remote concentrator restarts after a power outage. This process also occurs if the remote data concentrator is manually reset.

CONFIGURATION OF REMOTE CONCENTRATOR. The Port Concentrator requires configuration information from the host only once. The Port Concentrator assumes responsibility for 'down-line loading' the configuration information to the remote.

LOOPBACK TEST MODES. A local or remote loopback test may be initiated manually or through the Command Port of the CM22/EX.

COMMAND PORT. The CM22/EX Port Concentrator is equipped with a Command Port which offers a wide variety of monitoring, test, and control facilities. The Command Port may be connected to a dial-up or dedicated terminal, or directly to a computer port, and may operate at up to 1200 bps.

The following are the capabilities of the Command Port...

MESSAGE BROADCAST permits a message to be transmitted from the Command Port to selected channels or to all channels.

DYNAMIC CHANNEL RECONFIGURATION allows the data rate to be changed for a selected channel, or allows generation of specific delays for carriage return, line feed, and form feed.

REMOTE BUSY permits busy-out of dial-up modems attached to individual channels on the remote.

ALARM MESSAGES with time and date of occurrence are generated automatically each time the CM22/EX locally or remotely experiences a buffer-full or buffer-overflow condition. Alarm messages are also generated if the CM22/EX encounters unusually high line error rates, or loses synchronization on the high-speed composite link.

PERIODIC REPORTS provide statistics on data traffic, average and peak buffer memory utilization by channel, block retransmissions, and evaluation of telephone line quality.

THE EMULEX CC21/MX COMMUNICATION CONTROLLER

FOR REMOTE APPLICATIONS, the CC21/MX communications controller acts as an interpreter between the Host and the CM22/EX Port Concentrator.

Among the duties performed by the CC21/MX are the following:

MULTIPLEX/DEMULTIPLEX: A high link supports up to 16 logical communication channels. The CC21/MX is responsible for multiplexing and demultiplexing the data received and sent by the host.

MODEM CONTROL: If modem control enabled, the modem signal status for each remote channel on the link is passed transparently through the CM22/EX. If modem control is not enabled, the CM22/EX will not pass modem information to or from the remote concentrator.

DATA RATE CHANGES: Individual channel rate changes are passed through the CM22/EX to the remote Data Concentrator.

APPENDIX H
STATCON SERIES 21 COMMUNICATIONS SUBSYSTEM

LINK ERROR STATUS: Link status is sent by the CM22/EX and interpreted by the CC21/MX for error reporting to the I/O driver. Depending on the type of error status received, the CC21/MX may take the appropriate action independently.

REMOTE/LOCAL LOOPBACK: The CC21/MX can initiate remote or local loopback of the composite interface for diagnostic purposes.

DATA FLOW CONTROL: Flow control is generally initiated by the CM22/EX or each channel can control data flow through the normal XON/XOFF function. On occasion, the CC21/MX will control the data flow.

Since the CC21/MX handles the above functions, the Operating System does not have to be patched or otherwise changed to accommodate the Port Concentrator application.

FOR LOCAL APPLICATIONS, the technique is EXACTLY like that employed in the CS21 16-line Asynchronous Communication Controller.

Local lines are those lines remaining after the remote lines are assigned. Each local terminal is attached to one of the 16 EIA connectors of the CP21 distribution panel that is not used as a Remote.

This portion of the emulation is the same as if a multi-line communication controller were installed. The same attributes of programmable line speed, character length, stop bits, and parity are implemented. The modem control portion is the same as the DEC DZ11; only full-duplex operations are supported. Word transfers on the UNIBUS are still implemented as compared to the DEC method of byte transfers. The maximum terminal speed is 19,200 bps as versus 9600 bps for the equivalent DEC communication controller. In other words, the same features utilized in the CS21 16-line controller are implemented.

GENERAL SPECIFICATIONS

Characteristic	Specification
CC21 CONTROLLER	
Design	High-speed bipolar microprocessor-based controller for implementation of all functional operations.
Function	Provides complete functional emulation of the DEC DH11 or DZ11 asynchronous communication line multiplexer and DZ11 modem control or DM11-BB modem control for the DH11 emulation.
Software Transparency/ Compatibility	Diagnostics: DH11—ZJ179 Kit (PDP-11). ECS11—EMULEX (VAX-11). DZ11—ZJ223 Kit (PDP-11). EVDAA (VAX-11). Operating Systems: DH11/PDP-11—Driver supplied with operating system. DH11/VAX-11/VMS—EMULEX supplied I/O driver. DH11/VAX-11/UNIX—Driver supplied with operating system. DZ11/PDP-11—Driver supplied with operating system. DZ11/VAX-11/VMS—Driver supplied with operating system. DZ11/VAX-11/UNIX—Driver supplied with operating system.

Characteristic	Specification
Transmission Modes	(Local = multiplexer; Remote = concentrator) DH11—Local = Full Duplex only. Remote = Full Duplex, Half Duplex. DZ11—Local = Full Duplex only. Remote = Full Duplex, Half Duplex.
Line Formats	Character Lengths: 5 to 8 bits. Stop Bits: 1, 1.5, 2. Parity: Odd, Even, None.
Data Rates	(Bits Per Second) *Local Only DH11: 50, 75, 110, 134.5, 150, 200, 300, 600, 1200, 1800, 2400, 4800, 9600, 19200.* DZ11: 50, 75, 110, 134.5, 150, 300, 600, 1200, 1800, 2400, 4800, 9600, 19200.*
Distortion	Transmitter: Less than 2% intersymbol. (3% for DZ11 at 19.2 Kbaud.) Receiver: up to 43% intersymbol distortion and speed variation.
Number of Lines	32 Asynchronous.
Throughput	50,000 characters per second composite UNIBUS rate for all input/output operations.

APPENDIX H
STATCON SERIES 21 COMMUNICATIONS SUBSYSTEM

GENERAL SPECIFICATIONS (continued)

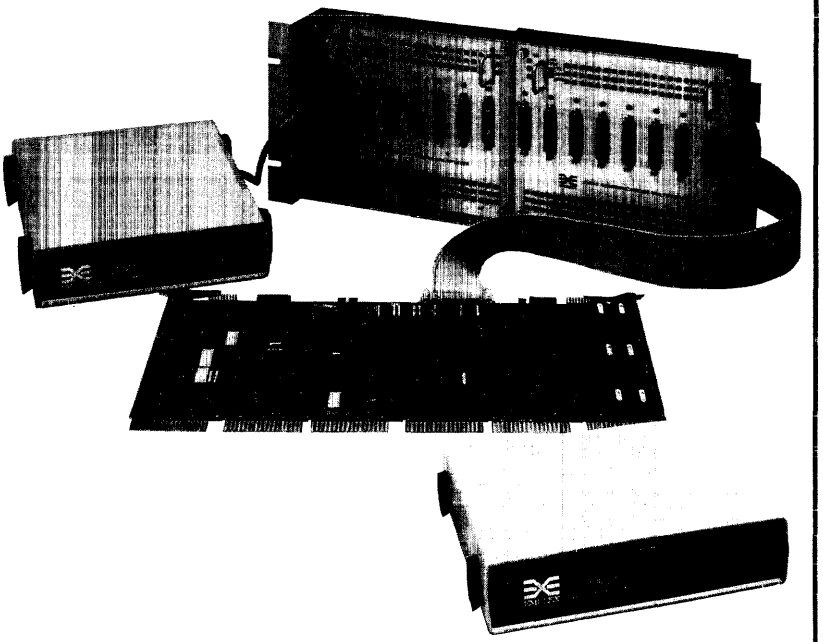
Characteristic	Specification
Receive FIFO	DH11—64 characters per 16 lines; interrupt programmable for 1 to 63 characters FIFO fill level. DZ11—64 characters per 8 lines. Standard FIFO alarm set at 16 characters.
CPU Interface	Standard UNIBUS SPC interface, one bus load on all signal lines.
DMA Address Range (DH11)	0 to 128K words.
DMA Transfers (DH11)	16-bit word parallel with parity check.
Device Address	Selectable with switches and PROMs to cover all DEC-defined DH11/DM11 and DZ11 assignments.
Vector Address	Switch-selectable for DH11/DM11 and DZ11.
Priority Level	BR5 for DH11 or DZ11—BR4 for DM11.
Indicator	Controller self-test fault (on) and activity (flashing).
Option Switches	DIP switches for selection of controller options.
Packaging	Single hex-size four layer printed circuit board.
Power	(Backplane requirement) +5v, 5%, 8 amps -15v, 5%, 200 mA +15v, 5%, 200 mA

CP21 DISTRIBUTION PANEL

Configuration	5.25 inch high panel for 16 EIA RS-232 lines with DZ11 compatible modem control. Standard RS-232-C, 25 pin male connectors.
Modem Control Signals	To: DTR (and/or RTS). From: CD, Ring (or DSR).
Dimensions	5.25" high x 19" wide x 3" deep.
Weight	2 pounds.
Controller Interface	Two 50-connector flat cables, compatible with DEC H317 Distribution Panel.

CM22/E PORT CONCENTRATOR SPECIFICATIONS

Characteristic	Specification
Host-Side Interface	Configured as Data Communication Equipment (DCE). Data Rates: Asynchronous—9600 or 19200 bps. EIA, RS-232-C (CCITT V. 24/V. 28) serial asynchronous; Full Duplex. Female 25-pin D-Type connector. Connector pin assignments are as follows: 1 Protective Ground 2 Transmit Data 3 Receive Data 4 Request to Send (RTS) 5 Clear to Send (CTS) 6 Data Set Ready (DSR) 7 Signal Ground 8 Carrier Detect—(DCD) 20 Data Terminal Ready (DTR) 22 Ring Indicator (RI) 25 Busy Out
Composite-Side Interface	Configured as Data Terminal Equipment (DTE). Data Rates: Synchronous up to 9600 bps. EIA, RS-232-B (CCITT V. 24/V. 28) serial synchronous with external timing; Full Duplex. Male 25-pin D-Type connector. Connector pin assignments are as follows: 1 Protective Ground 2 Transmit Data 3 Receive Data 4 Request to Send (RTS) 5 Clear to Send (CTS) 6 Data Set Ready (DSR) 7 Signal Ground 8 Carrier Detect—(DCD) 15 Transmitter Signal Element Timing 17 Receiver Signal Element Timing 20 Data Terminal Ready (DTR) 24 Transmitter Signal Element Timing (DTE Source)
Physical Dimensions	Standalone: 8" wide x 2" high x 11" deep. Weight = 4 pounds. Rack-mount chassis: 19" wide x 3.5" high x 11" deep.
Operating Environment	32 to 114 degrees F; 0 to 95% relative humidity.
Power	115/230 VAC, 10%, 45 to 65 Hz, 15 watts.



SINGLE COMMUNICATIONS CONTROLLER HANDLES REMOTE SITES AND LOCAL TERMINALS, TOO?

The EMULEX STATCON SERIES handles your terminal communication needs at multiple remote locations, without cumbersome, expensive hardware or excessive data line costs. Using EMULEX's Statistical Port Concentrators and Remote Concentrators, each remote site needs only one communication link (one computer port). Local terminals take advantage of large controller capacity through the remaining communication ports not used for remotes.

* DEC, VAX, PDP, LSI, Massbus, Unibus, and VMS are trademarks of Digital Equipment Corporation.

APPENDIX I
STATCON SERIES 11/21/32 COMMUNICATIONS SUBSYSTEMS

SELECTING AND CONFIGURING A STATCON SYSTEM

The STATCON Series has the flexibility to meet virtually any remote/local line requirement a user may have, totalling up to 256 terminals (depending on STATCON model). By adding the number of *remote LOCATIONS* to the number of *local terminals*, users can calculate how many physical line connectors are required at the host computer. Adding the remote and local *terminal* requirements together gives the total system terminal count.

For example, a total of 24 terminals at three remote locations are connected to a system with 27 local terminals, then:

The total number of terminals = 24 remote + 27 local = 51 system terminals

STATCON 21 handles only 32 terminals, so the choice is between STATCON 11 or STATCON 32. But that decision may depend on emulation, since STATCON 32 operates with standard system software on the VAX.

3	remote locations (concentrator links)
+27	local terminals
30	total physical connectors required (Since connectors are supplied in panels of 16 connectors each, then two panels would be needed.)

HERE'S AN EXAMPLE TO HELP YOU DETERMINE YOUR CONFIGURATION:

Write-in your figures next to our examples. (Be sure to consider future growth when adding up your totals.) Then compare your totals with the table below to make your system selection.

Link 1	1 CM22 Concentrator	8 remote terminals — Chicago
Link 2	1 CM22 Concentrator	8 remote terminals — Atlanta
Link 3	1 CM22 Concentrator	8 remote terminals — New York
Other Links:	_____	_____ — _____
	_____	_____ — _____
	+27 local connectors	+27 local terminals
	30 total connectors	51 total terminals

✓	# PANELS REQ'D	# CONNECTORS AVAILABLE	AVAILABLE WITH STATCON MODEL #		
			11	21	32 (VAX)
	1	16	X	X	X
	2	32	X		X
	3	48	X		X
	4	64	X		X
	5	80			X
	6	96			X
	7	112			X
	8	128			X
		TOTAL TERMINALS AVAILABLE:	64	32	256
		EMULATIONS AVAILABLE:	DH11	DH11, DZ11	DMF32

SYSTEM EXPANSION: Each STATCON controller can handle up to 16 concentrator links. Each additional 16-line distribution panel will allow the user 16 more local line applications. More remote/local terminals and distribution panels can be added until reaching the maximum number of connector panels or terminals.

APPENDIX J
Emulex Controller Reliability Data

MTBF calculations for various Emulex Communications Multiplexers are as follows:

CS01	Communications Multiplexer	= 66,080 Hours MTBF
CS11	Communications Multiplexer	= 72,000 Hours MTBF
CS21	Communications Multiplexer	= 56,914 Hours MTBF

The MTBF calculations do not include stress factor derating nor do they include an "infant mortality" factor. The above MTBF figures do not take into consideration the interconnecting cable assemblies required to operate the respective peripherals.

Field failure data given in the following table indicates that actual failure rates are substantially lower (i.e. greater measured MTBF) than predicted by the above calculations for all products. Emulex defines an "infant mortality failure" as one which occurs during the first 90 days from date of shipment, hence, the MTBF figures exclude these failures. Mechanical failures are included except for those determined to be obvious physical abuse.

Infant mortality failures are controlled by thorough pretesting and burn-in prior to shipment of a controller. All Emulex controllers incorporate approximately 90% active component parts which are pretested and pre-aged for a period of 160 hours at 70 degrees C prior to assembly. Completed assemblies are further burned-in under dynamic microcode execution for a period of at least 96 hours in an environmental oven which automatically cycles the temperature between 0 - 55°C. This testing occurs after parts have been thermal-shocked during the flow solder process. Any dynamic failure which occurs, results in a microcode self-test failure; the defective component is isolated and replaced and further cycling occurs. This type of handling has resulted in infant mortality rates given in the following table.

TYPE	CALCULATED MTBF (HRS)	INFANT MORTALITY RATE*		
		ACTUAL MTBF (HRS)	UNIT POPULATION	ACCUM. THRU 11/83
CS01	66,080	114,766	287	.35%
CS11	72,000	165,970	1849	1.57%
CS21	56,914	108,936	1123	1.78%

*Defects within first 90 days.

APPENDIX K
EMULEX SOFTWARE PRODUCTS

EMULEX software engineering has created a number of software products. Several of these products relate to certain Emulex communications controller products and are normally shipped with those controllers. All of the software products, however, may also be ordered separately.

The following table shows the relationship between Emulex communications hardware and software products. Also included in the table are the software product part numbers.

TABLE K
Emulex Software Products

RELATED HARDWARE PRODUCT	SOFTWARE PRODUCT (PART NUMBER)	MEDIA	DESCRIPTION
CS11/U CS21/U	VAX/UMS DRIVER[2] (VD9951001) (VD9960401) (VD9960501)	MANUAL TU58[3] FLOPPY[3]	VAX/VMS device driver to support CS11/U or CS21/U under DEC VMS operating system.
	DIAGNOSTIC[4] (VX9960401)	TU58[3] FLOPPY[3]	Test the basic functionality of the CS11/U or CS21/U.

Notes

1. Diagnostic listings are not shipped with all devices. Instructions for the use of Emulex diagnostics are contained in the appropriate device manuals.
2. All VAX/VMS device drivers are distributed as a single distribution.
3. VAX-11/750 systems use TU58 Distribution media. VAX-11/780 systems use floppy distribution media.
4. All VAX/VMS device diagnostics are distributed as a single distribution.
5. Also, all CS11 and CS21 VAX configurations which are available.

FIELD SERVICE OFFICES

System support specialists are located in Emulex field service offices in key cities across the U.S. These specialists are dedicated to the on-site installation and field support of Emulex products in these key geographical areas. It is the policy of the company to provide the highest quality of support to the customer for proper integration and use of all Emulex products.

CALIFORNIA
Orange County
3545 Harbor Boulevard, P.O. Box 6725
Costa Mesa, CA 92626
714/662-5600

Los Angeles Area
3250 Wilshire Blvd., Suites 943-944
Los Angeles, CA 90010
213/384-6936

San Francisco Area
510 Lawrence Expressway, Suite 210
Sunnyvale, CA 94086
408/773-1661

PENNSYLVANIA
Philadelphia Area
ADP Building, Route 1, Suite 100
Chadds Ford, PA 19317
215/358-1300

GEORGIA
345 Market Place, Suite 107
Roswell, GA 30075
404/587-3610

ILLINOIS
957-C Plum Grove Road
Schaumburg, IL 60195
312/490-0050

NEW HAMPSHIRE
New England Area
402 Amherst Road, Nashua, NH 03063
603/882-6269

NEW JERSEY
New York Area
Glenpointe Centre East
300 Frank W. Burr Boulevard
Teaneck, NJ 07666-6783
201/836-3717

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EMULEX CORPORATION
Unit 6, The Western Centre
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Tele: 344-484234 • Telex: 849781 **EMULEX G**

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Ermekeilstr. 1, 5300 Bonn 1
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3545 Harbor Boulevard, P.O. Box 6725
Costa Mesa, California 92626
Tele: 714/662-5600
TWX: 910-595-2521 EMULEX CSMA
Telex: 183627 EMULEX CSMA

ADDITIONAL SALES INFORMATION

DOMESTIC SALES

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714/662-5600

Los Angeles Area
3250 Wilshire Blvd., Suites 943-44
Los Angeles, CA 90010
213/384-6936

San Diego Area
8388 Vickers Street, Suite 214
San Diego, CA 92111
619/277-0719

San Francisco Bay Area
510 Lawrence Expy., Suite 210
Sunnyvale, CA 94086
408/773-1661

FLORIDA
2055 Wood Street, Suite 102
Sarasota, FL 33577
813/955-8015

GEORGIA
345 Market Place, Suite 107
Roswell, GA 30075
404/587-3610 • TWX: 810-766-0804

ILLINOIS
957-C Plum Grove Road
Schaumburg, IL 60195
312/490-0050 • TWX: 910-291-0391

MICHIGAN
4000 Prudential Town Center
Suite 1301
Southfield, MI 48075
313/352-6750

NEW HAMPSHIRE
New England Area
402 Amherst Street
Nashua, NH 03063
603/882-6269 • TWX: 710-228-8968

NEW JERSEY
New York Area
Glenpointe Centre East
300 Frank W. Burr Boulevard
Teaneck, NJ 07666-6783
201/836-3717

OHIO
Anderson Hills Office Park
8078 E. Beechmont Avenue
Cincinnati, OH 45230
513/474-4226

PENNSYLVANIA
Philadelphia Area
ADP Building, Route 1, Suite 100
Chadds Ford, PA 19317
215/358-1300

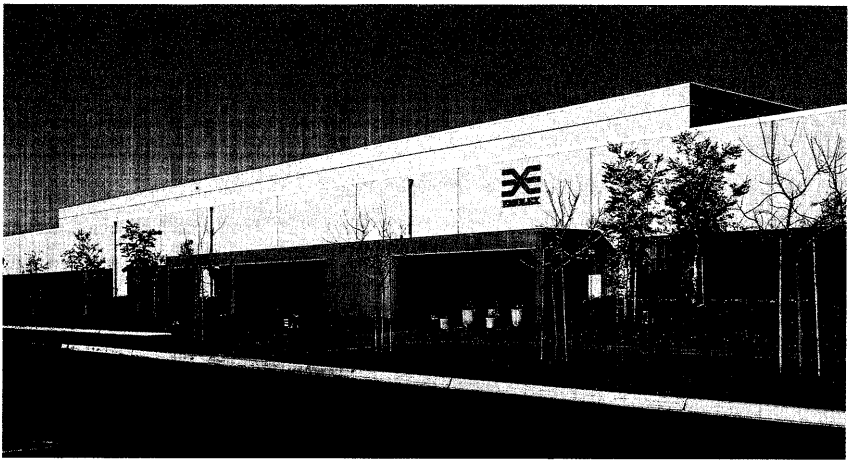
Bethlehem Area
528 North New Street
Bethlehem, PA 18018
215/867-4104

TEXAS
Dallas
4100 Spring Valley, Suite 400
Dallas, TX 75234
214/392-1822

Houston
7322 Southwest Freeway
Suite 1000
Houston, TX 77074
713/271-0805 • 713/271-0806

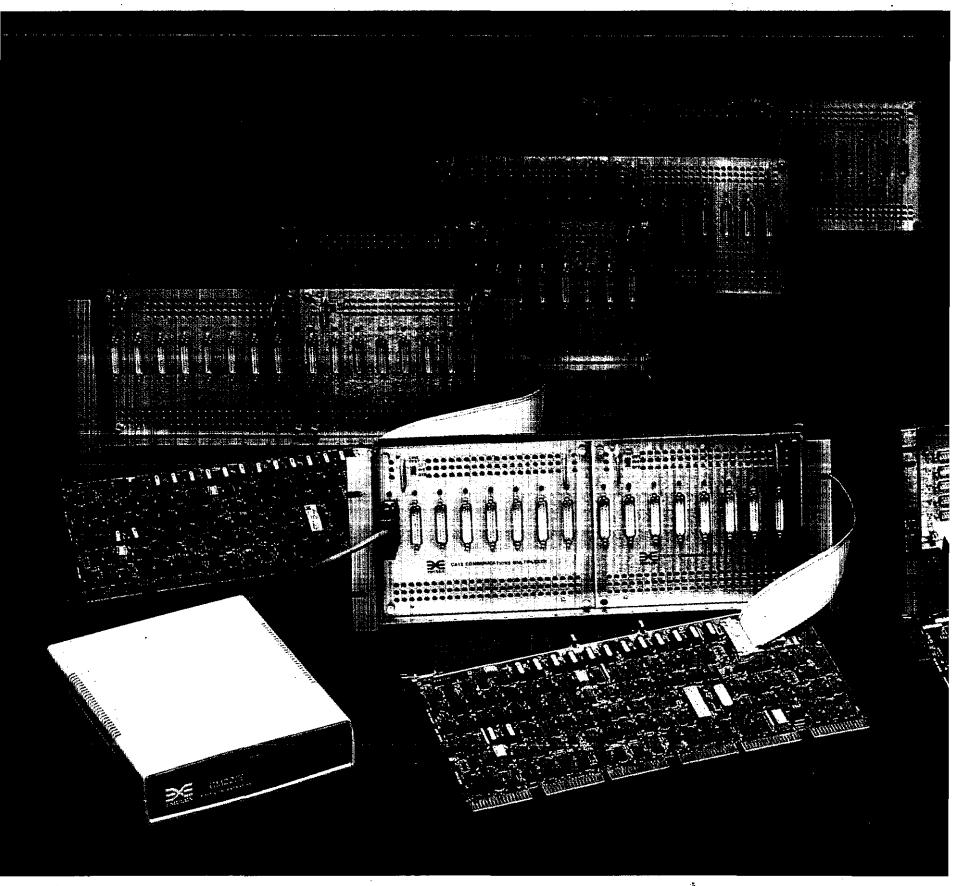
WASHINGTON, D.C.
Government Contracts
11260 Roger Bacon Drive, 3rd Floor
Reston, VA 22090
703/471-1001

OTHER U.S. SALES AREAS CALL:
CORPORATE HEADQUARTERS
3545 Harbor Boulevard, P.O. Box 6725,
Costa Mesa, California 92626
714/662-5600 • 800/854-7112



Corporate facilities located in Costa Mesa, California, presently include over 100,000 square feet of modern, industrial buildings, with approximately 48,000 devoted to production and an additional 30,000 square feet dedicated to product development and technical support.

Recently, ground was broken for a new two-story 60,000 square foot engineering and manufacturing building located adjacent to the Costa Mesa headquarters facility. The EMULEX manufacturing facility in Dorado, Puerto Rico, has been expanded to a total of 51,000 square feet. The company also opened a new 6000 square-foot headquarters facility in Bracknell, England, for sales administration, repair and service support throughout the United Kingdom and Europe. In addition, a future plant site has been chosen near Dublin, Ireland, to inaugurate a new European manufacturing operation later during the fiscal year. These join numerous direct sales offices located across the U.S., with international sales offices in the United Kingdom, The Netherlands, West Germany, Australia, and Canada.



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