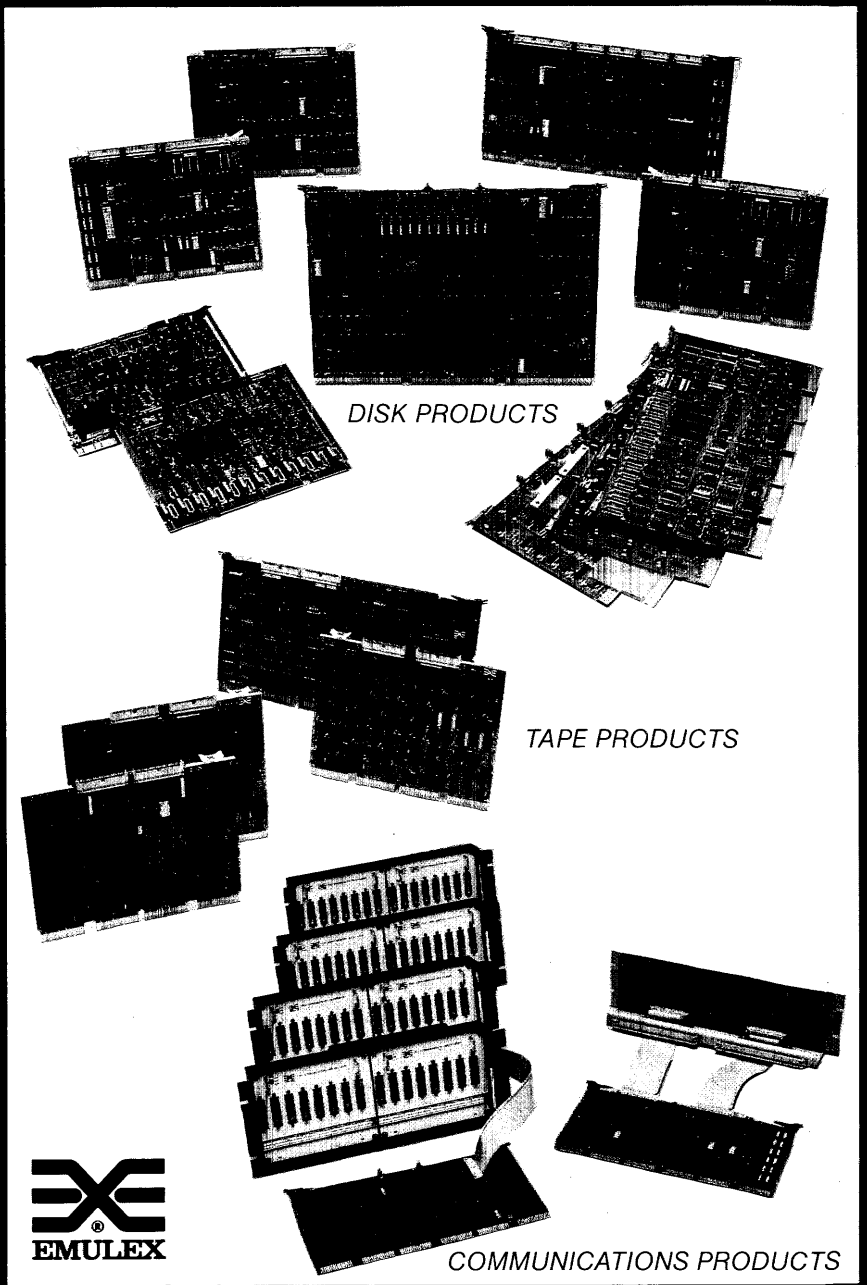
CONTROLLER HANDBOOK
PERIPHERALS AND COMMUNICATIONS



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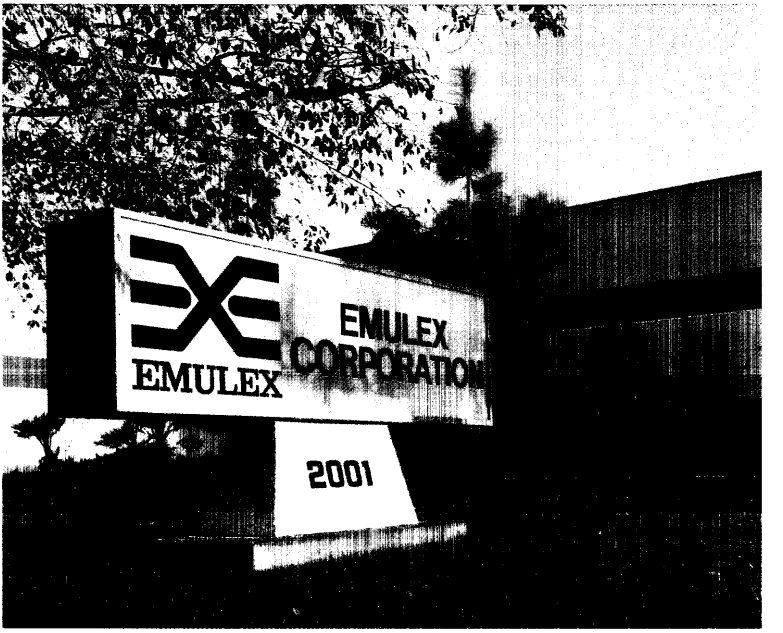

Emulex Corporation headquarters in Santa Ana, California.

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AND
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ISSUE NUMBER 3, MARCH 1982

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FORWARD

This Publication marks the third formal issue of what originally was 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. Issue No. 1 covered only our three original hardware products; Issue No. 2 covered the then current line of eight hardware products; this issue adds five more for a total of thirteen distinct hardware products plus three software products which support controllers under the VAX/VMS operating system. And at least the three new products now in development will be added by the time Issue No. 4 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 offered by different peripheral manufacturers.

This handbook is organized to present an overview of each product line, including some background on the characteristics of the peripheral devices supported and the DEC 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.

The content of this handbook has also been expanded to include some other useful information, not only about Emulex products but also about peripheral devices made by others. A technical summary of all non-captive 8" and 14" drives potentially applicable to Emulex controllers has been added as a guide to potential users. Other useful data, such as infant mortality plus calculated and actual MTBF figures for controller products, is included.

The accompanying table gives an overview of the present Emulex product line and several new products scheduled for introduction early in 1982. This matrix shows the breadth of DEC CPU 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. We believe that this philosophy and

TABLE 1-1

PRODUCT CLASS	EMULEX PRODUCT FAMILY					
	LSI-11 QBus	PDP-11 Unibus	PDP-11/70 Cache Bus	VAX Unibus	VAX-11/750 CMI Bus	VAX-11/780 SBI Bus
Large Disk Controller	SC01/A,B,C (8) SC23	SC21/B,C	SC71/B	SC21/V	(2) SC750/B	(3) SC780/B
Small Disk CMD/SMD Disk Controller	(1) SC02/A,C,L (1) SC04/C,L (9) SC02/B	(1) SC12/A,C,L		SC12/C		
Half-Inch Tape, Unformatted; Start/Stop	TC01/N TC01/P	TC11/N TC11/P		TC11/NV TC11/NP		
Half-Inch Tape, Formatted; Streamer and/or Start/Stop GCR Formatted	(4) TC02	(5) TC12		(5) TC12	(10) TC750	(10) TC780
Communications Multiplexer	(7) CS01/H	CS11/H CS11/V CS21/H (6) CS21/Z	CS11/H CS11/V CS21/H (6) CS21/Z	CS11/U CS21/U (6) CS21/Z		

NOTES:

(1) New L Versions scheduled: SC02/L-May, SC12/L-June, SC04/L-April

(2) New Product scheduled for February.

(3) New Product scheduled for May.

(4) New Product scheduled for July.

(5) New Product scheduled for June.

(6) New Z Version scheduled for March.

(7) New Product scheduled for June.

(8) New Product scheduled for August.

(9) New B Version scheduled for May.

(10) New Product, expected in Q3, 1982.

COMMENTS:

(1) L Version is RL01/02 emulation for SC02,/04,12.

(2) SC04 has ANSI interface.

(3) TC02 and TC12 are TS11 emulations; Supported on PDP-11 and VAX-11 Unibus by DEC.

(4) SC21/V, TC11/V, CS11/U, and CS21/U require Emulex-supplied software package.

(5) SC12/C has RK07 support under VMS. TC12 has TS11 support under VMS. SC750 and SC780 are transparent to VMS software.

discipline is essential for long-term success in a market which exists by virture of the technical excellence and quality inherent in DEC CPU's. 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.

COMPANY PROFILE

Emulex Corporation designs, manufactures and markets mass storage peripheral controller and communications multiplexer products for use with minicomputers and microcomputers manufactured by Digital Equipment Corporation (DEC).

During its three year history, the Company has developed thirteen distrinct hardware product lines - described inside - which cover all models of the DEC LSI-11, PDP-11, and VAX-11 product lines. To date, over 6000 of these units have been delivered. This superb product line reflects the basic strength of EMULEX, namely its excellent technical group, which currently has a long list of 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.

We intend 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, and has experienced continuing revenue growth since its inception. Net sales for fiscal year 1981 were $10, 052,002 as compared to $4,732,866 for fiscal 1980. The Company is publicly held.

FACILITIES

Corporate facilities presently include over 42,500 square feet of modern, industrial buildings, with approximately 15,000 devoted to production and an additional 20,500 square feet dedicated to product development, technical support, and the newly formed Emulex Subsystems Group. These facilities are located in Santa Ana, California. Additionally, EMULEX has direct sales offices located in Nashua, New Hampshire; Fort Lee, New Jersey; Southfield, Michigan; Philadelphia, Pennsylvania; San Francisco, California; and London, England.

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. As a result, infant mortality rates are very low and MTBF (Mean-Time-Between-Failure) figures for EMULEX products are extremely favorable, with a range of 28,000 to 76,000 hours, depending on the product. Complete details on specific IMR and MTBF figures for each EMULEX product are given in Appendix M of this CONTROLLER HANDBOOK.

EMULEX SUBSYSTEMS GROUP

EMULEX offers complete peripheral disk and tape subsystems in addition to its basic stand-alone controller products. Housed in an adjacent facility, the Subsystems Group handles both the subsystem integration and installation of configurations for the VAX-11, PDP-11 and LSI-11 series. All peripherals and media are extensively pretested and burned in at EMULEX prior to delivery to the installation site. For information regarding the application/purchase of subsystems, contact the Emulex Subsystems Group, phone 714/966-3091 or 714/557-7580.

TECHNICAL SUPPORT

Competent, ready application support consultation is always available. EMULEX provides a dedicated technical support staff of senior hardware and software engineers at its headquarters in Santa Ana, California and at its Eastern office in Nashua, New Hampshire. The staff is available to all users for telephone assistance, field support, and on-site installation. 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 a monthly basis. Specialized courses at customeer locations are provided by arrangement.

FIELD SERVICE

EMULEX has a formal service agreement with Control Data/Engineering Services for maintenance of its complete controller and subsystem product line. This program now covers key U. S. cities with immediate plans for expansion in 5 more locations. In each location, Control Data offers complete DEC system maintenance as well as maintenance for EMULEX products, thus providing a single vendor service arrangement. Subsystem maintenance of EMULEX products is also offered in other U. S. cities and in the countries of Canada, United Kingdom and Germany. For information, contact EMULEX directly or Control Data at 800-328-3980. A similar arrangement is in early phases with General Electric. Other excellent organizations, such as Tymshare, furnish maintenance on a regional or national basis.

A. 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 PDP/LSI-11 host computers. This unique situation continues today but on a greatly expanded base of product offerings. These controllers have a common microprocessor-based architecture which is carried throughout all hardware configurations. From this design base, microcoded versions are derived to support almost every non-captive OEM disk drive incorporating modern SMD and/or Winchester technology. 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.

Because of the single-thread architecture, a given microcode version is carried almost without change between the different hardware models offered for LSI-11, 11/2, 11/23; PDP-11/04-60, PDP-11/70, and VAX-11 series mainframes. This means that a user can generally expect to be able to put the same makes and models of disk drives on every level of DEC CPU and to be able to use the same basic operating and diagnostic software in every similar configuration. Conversely, any given Emulex controller model can be configured (or reconfigured) to any standard (or custom) version by simply installing the proper microcode PROM chips and/or setting on-board configuration option switches. The advantages to the user of this approach in such factors as application flexibility, spares stocking, quantity purchasing, and long-term end product growth, is obvious.

Equally important to the Emulex product concept is packaging. Each hardware model is designed specifically - and exclusively - for an intended DEC host computer. The mechanical and electrical design is optimized for that application, and is not simply "adapted" as are some other competing designs.

The LSI-11 (SC01) and PDP-11 (SC11) controllers are a two-board configuration designed with a common piggy-back board which contains the microprocessor. The SC21 is a single-board controller for PDP-11 and VAX-11 Unibus applications and has supplanted the SC11 in many applications. The PDP-11/70 controller (the original SC70 and the later SC71 models) are contained on three active boards plus one small signal interconnect board (because of signal distribution considerations in the host backplane) but carries the same design architecture as the other controllers.

In this issue, the company's new series of low-cost quad board controllers for small-to-medium capacity 8" and 14" drives has been added. These are the SC02 and SC04, having SMD and ANSI interfaces, respectively, for the LSI-11 Series CPU's; and the SC12 which is a Unibus companion to the SC02.

Also introduced in this issue is the EMULEX SC750 controller designed specifically for the VAX-11/750 CPU. This controller is packaged on a single board and offers software transparency to VMS and UNIX users who wish to incorporate large disks compatible with the DEC Massbus class controllers.

In all cases, the Emulex controllers mount directly in a standard backplane or system unit; no specially wired unit, no wiring modifications, no separate "boat anchor" boxes and cables, and no extra power supplies are required. These controllers are inexpensive and easy to ship, install, remove, relocate, and return for repair, if necessary. The result is minimum cost to purchase and use after initial acquisition. And the use of fewer components and ancillary parts, plus elimination of wired interconnects, means greater inherent reliability of the product.

On the drive side, all controller products except the SC04 incorporate the standard SMD interface as originally defined by CDC, later adopted as the industry standard, and now offered on almost all 14" and many 8" class drives. The standard physical connection is the so-called "flat cable" interface; Emulex also has an adapter for the less-common "round cable" interface connectors.

In introducing the SC04 for the LSI-11 CPU's, Emulex has explicitly endorsed the ANSI interface specification for 8" diameter disk drives. One reason for the delay in marketing acceptance for the 8" class products is that there were almost as many interface designs as there were companies in the business (about 30), and this has made it impossible for controller suppliers to respond to the needs of many users. Unique interfaces require special-purpose controllers, and the result is generally sole sourcing of both the drive and controller. This places the user in an uncomfortable, if not dangerous, situation. EMULEX believes that a common interface, permitting application of controllers to a broad spectrum of peripheral devices, is a healthy situation for both manufacturers and users alike. It is hoped that peripheral manufacturers will respond by offering the ANSI interface as an option, if not a standard, in their 8" product lines.

Emulex presently supports a very broad range of disk drives of varying capacity, configuration, and media. The list of standard versions offered is constantly growing to meet the needs of all potential users. As new drive technology emerges, new controller versions will be introduced to ensure that customers can continue to upgrade their own products.

Generally, disk drive selection is coupled to the controller microcode version since the objective is to derive a complete subsystem which emulates, and is software transparent to, an existing DEC subsystem. The customary approach is to map a defined "logical drive" unit onto a designated physical drive. The configuration of the drive (e.g., number of tracks and cylinders, bit density, etc.) determines the feasibility of using a given disk drive with a given microcode emulation.

In the original SC01 and SC11 controllers, a different version of each

basic emulation was required to support each unique drive configuration, resulting in a long list of PROM sets which had to be supported. All subsequent controllers have been designed to incorporate a "universal" type emulation (e.g. RM02, RK06, etc.) and a unique configuration PROM which defines the drive parameters with later controllers. It is also possible to mix drive types/capacities on the same controller. Selection of drive configurations and mixes is made by means of option switches on the board, without requiring a PROM set change.

Emulex also supports several custom microcode versions which meet the software/disk drive requirements of specific OEM customers. Because these custom adaptations still use hardware common to the standard product line, development cost and lead times can be held to an absolute minimum, and production purchasing and planning problems for building and delivering such products are essentially nil. Users with unique application requirements are encouraged to discuss the feasibility of a custom microcode package.

B. TAPE PRODUCTS

The Emulex TCXX tape controller product line is a direct derivative of the disk controller technology. The TCXX tape controller 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.

The TCXX Series is designed to interface to any standard half inch, reel-to-reel, magnetic tape drive incorporating an industry standard (Pertec) interface. Because of the degree of commonality among drives in this category, all tape peripherals are supported by a single microcode version of the controllers.

The TCXX controllers follow the same dedicated design concept of the disk controller series. The LSI-11 controller (TC01) is contained on two quad height boards, one containing the Phase Encoded (PE) demodulation circuitry. The PDP-11 controller (TC11) is contained on a hex height controller/formatter board, plus the same PE board used for the TC11. These controllers mount directly in a standard backplane or system unit. Since the quad PE board does not interface to the bus, it need not be adjacent to the controller board and often can be located in one of the "free" quad slots at the front or rear of a system unit. The result is an optimum product for the application.

C. COMMUNICATION PRODUCTS

The first of an extensive planned family of Communication Controllers and related products is the CS11 Series. Initially, the version offered was the CS11/H, which is functionally equivalent to up to four DEC DH11 16-line asynchronous multiplexers.

The heart of the product is the CC11 Communication Controller which incorporates the exact same bipolar microprocessor architecture that is implemented in the SCXX and TCXX disk and tape controllers. Mounted on

a single hex pcb, this unique device completely emulates up to four equivalent DH11 units. It also offers not only higher performance, but also a whole list of useful features and benefits not contained in the original DEC product. The single board replaces nine boards in a double system unit for every 16-line DEC DH11 which it replaces, or up to 36 boards for a 64-line system.

Two DH11 compatible models are offered: the CS11/H (for PDP-11) and the CS11/U (for VAX-11) computers. A DV11 compatible version, the CS11/V, is also available for users who need to combine both 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 are used to achieve similar benefits for the user as the CS11/H model.

Considerable product flexibility is provided in the distribution panels where various types of line adapters may be selected to provide mixtures of line interfaces (e.g. RS-232, current loop) in 8 rather than 16 line increments.

The latest offering in the Emulex communication product family is the CS21 Series introduced in November 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. The CS21 Series includes a DH11 emulation and a DZ11 emulation. For the PDP-11 series, both products are available to give users selection of either product at the same price. The DH11 version is also supported by EMULEX on the VAX-11 to give users the availability of a high-performance multiplexer.

The CS21 is offered in three versions: the CS21/H which is functionally identical to a 16-line version of the DH11-compatible CS11/H and is for use on PDP-11 series computers; the CS21/U which is a 16 line version of the DH11 for VAX-11 systems; and the CS21/Z which is functionally idential to a DEC DZ11E 16-line asynchronous multiplexer. A statistical multiplexer front end is also planned for this product line.

D. 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
DISK CONTROLLERS

A. DISK DRIVE CONSIDERATIONS

Because of the recent proliferation of excellent disk products, a user can consider an almost unlimited selection of drives to meet mass storage requirements. Emulex controllers have the inherent capability to effectively use all applicable disk drives now available and known to be forthcoming in the near future. Because CDC has so far served the largest segment of the independent disk drive market, their product line has set a certain level of de-facto standard at the hardware interface level. Fortunately for the industry, there are many excellent alternative selections to be made, some of which are a second-source type design and others of which are uniquely configured for specific price/performance/application objectives. The Emulex objective is to support as many different drive makes/models as possible, either through standard or custom microcode versions. Users are encouraged to discuss drive selection with us prior to making a final decision.

For convenience, disk drives are considered below relative to the kind of media used. The CDC nomenclature is used as a basis for this discussion.

1. Removable Media Drives

The basic removable media drive supported is the Storage Module Drive (SMD) type, using a removable, multi-platter pack with moving heads. Capacity now ranges from 40 - 600+ MBytes. Capacity of a model is basically determined by the number of platters, track density, and bit packing density. The basic SMD drive incorporates a top loading removable disk pack. There is one front loading cartridge type drive available, with either 50 or 80 MByte capacity. All current drives of this type use a 14" diameter platter.

Emulex controllers are designed to handle an upper bit rate limit of 9.67 MHz derived from an approximate 6000 bpi density at 3600 RPM used in most SMD class drives.

Currently, standard controller versions are available to support SMD class drives having 40, 50, 80, 200, 300, 500 and 600 MByte unformatted capacities. Typical makes/models presently supported include those given in Table 1-2.

2. Fixed Media Moving Head Drives

These drives generally incorporate so-called Winchester technology and mount the fixed media in a sealed enclosure for high reliability and low cost. There are a large number of such drives presently available, and many new designs are scheduled to appear soon. Generally, these drives use the same high packing density and rotational

speed as the SMD's, and the Emulex controllers are capable of handling these designs on a functional and performance level. This type drive is produced with platter sizes of 5 1/4", 8", and 14" diameters. Most 14" drives and a few 8" drives offer an SMD interface option, and most 8" drives do not, and probably no 5 1/4" drives will have this facility. Current Emulex controllers can support all drives with an SMD interface. Future models will support 8" and 5 1/4" drives with lower cost interfaces.

Some fixed media drives offer optional fixed head-per-track storage to augument the moving head storage. For example, the CDC 9730 series has optional fixed head storage of 0.96 or 1.92 (unformatted) MBytes. Later versions of SC21, SC71 series microcode supports this capability; generally, some revisions of the DEC operating software will be required to make effective use of this feature.

Typical 14" disk drives supported are given in Table 1-3. This list will be continually expanding because of the present high level of design activity by the drive manufacturers.

3. Fixed/Removable Media Drives

Typical 14" drives in this category presently supported by Emulex are given in Table 1-4.

The basic minimum drive of this type consists of one removable pack plus one fixed platter. One or two addtional fixed platters can be added for expanded capacity. This type drive is similar to the older 2315/5440 type cartridge disk drives but is considerably more effective on both a performance and cost-per-megabyte basis. The removable pack provides an excellent backup to the fixed media and can also serve as a data/software exchange medium within a user's system.

Originally, drives in this category all had 14" platters with SMD interfaces. Smaller capacity drives of this type using 8" platters are now announced or in production. These all have SMD interface options and they will be supported by current Emulex controllers.

Table 1-2

Typical Removable Media Drives
Supported By SCXX Series Controllers

MAKE	MODEL					
	40/50 MB	80 MB	160 MB	200 MB	300 MB	500/ 600 MB
CDC	9760(1)	9762			9766	
Century (4)		T-82RM		T-202	T-302RM	T-602(3)
Ampex		980	9160	9200	9300	
Memorex				677	677-30 (5)	
Ball		BD-80				

Notes

1. The CDC 9760 (40) MB is supported as a one-half RM02 emulation, switch selectable, in standard microcode versions SC11/B1, SC70/B1 only.

2. The T-602 was originally announced as 600 MBytes, but will be slightly in excess of 500 MBytes.

3. The standard T-82 and T-302 drives have 815 cylinders; the RM versions have 823 cylinders, which is required for operation in the B1 controller versions without software patches. Emulex does not supply patches for 815 cylinder drives, and the RM versions are recommended.

4. The Memorex 677-30 is a 300 MByte upgrade of the 200 MByte 677and may be retrofitted in the field to the higher capacity. Configuration is the same as CDC 9766, but the media is not interchangable with CDC or with the DEC RM05.

5. The above list may not be complete. Check with the factory for models not shown.

TABLE 1-3

Typical 14" Fixed Media Moving Head Drives
Supported by SCXX Series Controllers

MAKE/MODEL	CAPACITY					
	12-20 MB	20-40 MB	40-70 MB	70-80 MB	130-170 MB	600+ MB
CDC 9730 (1,2)	12	24		80	160	
CDC 9775						675
Memorex 612		28	56	84		
Ohio Scientific 33XX	13.5	27	40,54	67,80		
Kennedy 53XX	14		42	70,80		
Priam 50		34	68		159	
Fujitsu 228X			66		132,166	
Memorex 659						675

Notes

1. CDC designates the 9730 as a Mini-Module Drive (MMD) which is available in the indicated capacities. The 9730-80 is functionally indentical to the 9762.

2. The CDC 9730 Series also has optional fixed head-per-track storage which is supported by the SC21 controller.

3. The above list is not complete, and no 8" drives are given.

TABLE 1-4

Typical Fixed/Removable Media Drives
Supported by SCXX Series Controllers

MAKE	CAPACITY		
	32 MB	64 MB	96 MB
CDC 9448 (CMD)	32	64	96
Ampex DFR 900	32	64	96

Notes

1. The CDC, and Ampex packs are not interchangeable with any DEC media. CDC/Ampex packs are interchangeable.

B. DEC DISK SUBSYSTEM CHARACTERISTICS

Emulex disk controller products are designed to provide the same functional capability as any one of three large-capacity disk subsystems which incorporate a controller plus one or more disk drives sold and supported by DEC. A summary of these subsystem formatted drive configurations is given in Table 1-5.

It should be noted that all referenced DEC large capacity disk subsystems apply only to the PDP-11 minicomputer series (Unibus, Massbus). DEC does not offer a large disk on its LSI-11 microcomputer series; the only hard disks offered are the 5 and 10 MByte RL01/02 drives. Emulex also currently offers RL01/02 equivalent products a discription of these can be found following the discussion of large capacity devices.

Emulex offers large and small capacity disk controllers across the entire mini and microcomputer line by using the functional characteristics of the DEC subsystems and adapting them to the appropriate bus structure.

1. RP11E/RP02/RP03

The RP11E controller interfaces to the PDP-11 Unibus and supports either RP02 or RP03 disk drives (refer to Figure 1-1). These devices are older disk pack designs which are no longer in production. Although this subsystem is no longer sold by DEC, it is supported by most current software although later versions of some operating systems will probably drop this support.

The RP02 has a capacity of 20.8 MBytes; the RP03 is a double track density version with a formatted capacity of 41.6 MBytes.

Although the hardware is obsolete by today's standards, this subsystem configuration is still supported under most current DEC PDP-11/04-70 (but not VAX) operating system versions, including RT-11, the functional emulation provided by Emulex controllers is convenient for handling certain disk drives, particularly those having capacities below 80 MBytes.

The RP02/03 disk drives rotate at 2400 RPM and pack data at about 2000 bpi. This is in contrast to today's large drives which typically rotate at 3600 RPM with bit densities of up to 6000 bpi. From a functional standpoint, this is of no consequence, and because Emulex controllers handle the more modern drives, the performance of the emulating subsystem will be considerably improved, with an average data rate of 4-5 times the RP02 or RP03.

The DEC RP11E controller does not provide any error correcting capability since this was not common for the low density RP02/03 packs. However, ECC is generally

TABLE 1-5

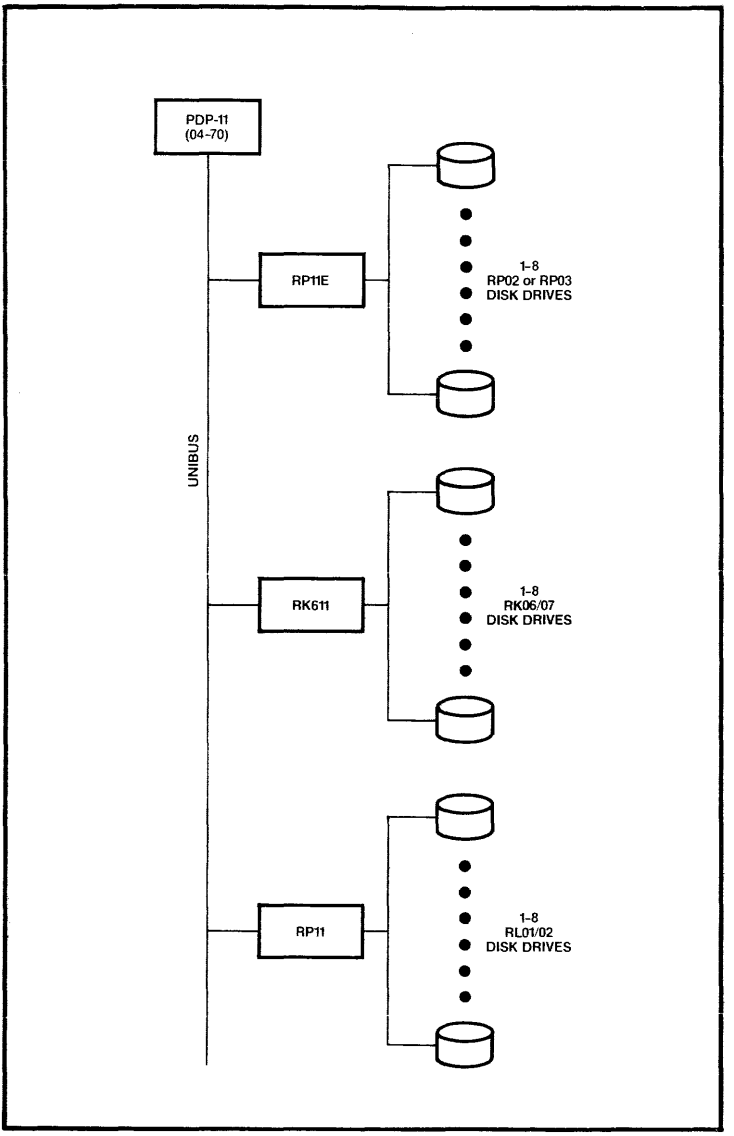
Characteristics of DEC Disk Subsystems

CONTROLLER	RL11		RK611		RP11E		RH11, RH70					
Drive	RL01	RL02	RK06	RK07	RP02	RP03	RM02	RM03	RM05*	RM80	RP06	RP07
Platters/Drive	2	2	2	2	11	11	3	3	11	4	11	17
Tracks/Cylinder	2	2	3	3	20	20	5	5	19	14	19	32
Cylinders/Drive	256	512	411	822	203	406	823	823	823	561	815	630
Sectors/Track	40	40	22	22	10	10	32	32	32	32	22	50
Bytes/Sector	256	256	512	512	512	512	512	512	512	512	512	512
MBytes/Drive	5.2	10.4	13.9	27.8	20.8	41.6	67.2	67.4	256.2	124.0	174.4	516
Speed	2400	2400	2400	2400	2400	2400	2400	3600	3600	3600	3600	3633
Bit Density (BPI)	3725	3725	2400	2400	2020	2020	6060	6060	6060	6339	4040	11,139
Data Rate (K Words/Sec) - Average	512.5	512.5	270	270	102.4	102.4	403	492	493	492	400	1080.0

* DEC has not announced an RM05 drive for the Unibus RH11 Massbus interface.

FIGURE 1-1

DEC UNIBUS DISK SUBSYSTEMS



considered mandatory for the modern high density media, and Emulex controllers provide this necessary capability (switch option) as an extended controller feature. The controller will automatically perform error correction and will also provide status information for logging detected errors under the operating system. Some controller designs emulating the RPllE have been provided by other manufacturers which overlooked inclusion of ECC capability; this is a significant omission when the controller is used with a high-density drive.

2. Massbus Disks (RM03/05, RM80, RP04/06, RP07)

The DEC Massbus concept entails providing a separate peripheral I/O bus on which all high-speed devices, such as disk and tape drives, are attached. A diagram of the Massbus disk peripheral organization for the three different applicable CPU's is shown in Figure 1-2.

As shown, the Massbus itself is common to all systems which handle Massbus peripherals. The bus is created by a Massbus Adapter: RH11 for Unibus-only machines, 11/04/-11/60; RH70 for the 11/70, RH750 and RH780 for the VAX-11/750 and VAX-11/780, respectively.

In the smaller machines, the RH11 interfaces only to the Unibus, and all data, control, and status transfers take place over this path. In the PDP-11/70, the RH70 adapter interfaces to the internal memory bus (sometimes referred to the Cache bus, although this is somewhat of a misnomer) for DMA data transfers and to the Unibus for control and status transfers. The DMA transfers are in 32-bit double-word form, whereas the Unibus transactions are in 16-bit word form. Also, data transferred over the 11/70 Unibus requires a memory address mapping since the Unibus address is limited to 128K words. The standard software drivers for 11/70 Massbus peripherals do not contain any mapping provision. Therefore, if a controller emulating a Massbus drive is run on the 11/70 Unibus, the software must be modified accordingly.

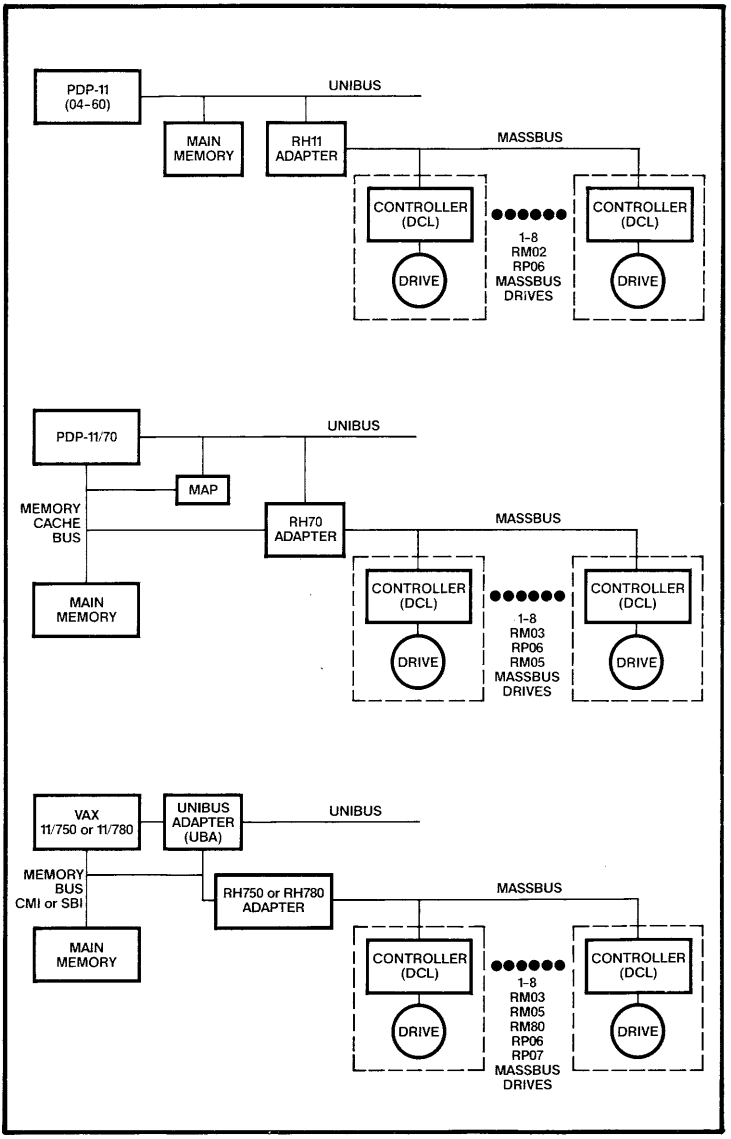
The VAX-11/780 is organized somewhat similar to the 11/70 in that the RH780 Massbus adapter interfaces to the internal memory bus (SBI) and to the Unibus Adapter (UBA). A controller emulating a Massbus peripheral, when run on a VAX Unibus, will require a custom driver because of the memory address limitation. However, UBA data transfers are 32 bits which reduces the effective internal transfer rate between the UBA and memory.

The more recently announced VAX-11/750 also incorporates a high speed memory bus in addition to a standard Unibus. The RH750 Massbus adapter interfaces RM03/05, RM80, and RP06 drives in a similar manner to the RH780. It should be noted that the 750 and 780 memory buses are entirely different so that the RH750 and 780 Massbus Adapters are functionally the same but require entirely different implementations.

In all cases, the Massbus disk drives are functionally identical. Each drive contains its own controller (DCL) which is considered integral to the drive itself. This concept is convenient in that the same drive can presumably be connected to any Massbus. It does, however result in considerable hardware redundancy.

FIGURE 1-2

MASSBUS ORGANIZATION



The currently available Massbus disk drives are:

RM02	- 67 MByte,	2400 RPM,	6000 bpi
RM03	- 67 MByte,	3600 RPM,	6000 bpi
RM05	- 256 MByte,	3600 RPM,	6000 bpi
RP04/05	- 87 MByte,	3600 RPM,	4000 bpi
RP06	- 174 MByte,	3600 RPM,	4000 bpi
RP07	- 538 MByte,	3600 RPM,	6000 bpi (Winchester)
RM80	- 121 MByte,	3600 RPM,	6000 bpi (Winchester)

The RM02 and RM03 are an OEM version of the 80 MByte CDC 9762. The RM02 is slowed down to 2400 RPM for Unibus operation (this speed reduction is required more by DEC because of inadequate buffering in the controller than because of a limitation on Unibus bandwidth). Emulex controllers have more than adequate buffering to support the 3600 RPM operation of standard drives. The RM03 is run at 3600 RPM and is used on the PDP-11/70 and VAX-11/780. The RM05 is presently offered by DEC only on these models.

The recently announced DEC RM05 is an OEM version of the 300 MByte CDC 9766 drive, operating at 3600 RPM. The only configuration difference is 19 data tracks in the 300 MByte vs. 5 data tracks in the 80 MByte (CDC 9762) drive. DEC may announce an equivalent to the RM05 for Unibus operation, presumably slowed to 2400 RPM (denoted as RM04 in Table 1-4), but no data is available on such product plans.

The RP04/05 drives are half density versions of the RP06 and are no longer in production. Emulex does not presently use the RP04/05 formats but does emulate the RP06 configuration. The RP06 is available on all 11-Series machines and is an OEM version of the Memorex 677 disk drive. The RM80 is a recently introduced 124 MByte Winchester and is offered only on the VAX-11/750 and 780 CPU's. The larger RP07 538 MByte Winchester is supported by DEC only on the VAX-11/780.

DEC uses the designator "J" for RH11 adapter and "W" for a RH70 or RH780 adapter. Thus, the adapter and first drive of a system are denoted as given in the following examples:

RJM02 - Unibus RM02 (2400 RPM) 67 MB drive

RWM03 - 11/70 RM03 (3600 RPM) 67 MB drive

REM03 - 11/780 RM03 (3600 RPM) 67 MB drive

RWM05 - 11/70 RM05 (3600 RPM) 256 MB drive

REM05 - 11/780 RM05 (3600 RPM) 256 MB drive

RJP06 - Unibus RP06 (3600 RPM) 174 MB drive

RWP06 - 11/70 RP06 (3600 RPM) 174 MB drive

REP06 - 11/780 RP06 (3600 RPM) 174 MB drive

3. RK611/RK06/RK07

The DEC RK06 and RK07 are removable cartridge disk drives having 13.9 and 27.8 MByte formatted capacities, respectively. The RK611 controller is a Unibus interface device (refer to Figure 1-1), and these subsystems are supported on the Unibus under all current operating systems for the PDP-11 and VAX series. The RK06 is no longer in production, having been replaced by the double track density RK07.

The RK06/07 drives are proprietary to and made only by DEC, including the media. Therefore, there is no industry equivalent drive available. The RK06 format is used by Emulex to support the current fixed/removable combination drives and will also be used for other drives in the future.

The RK06/07 is available for all PDP-11 and VAX-11 series machines via the RK611 Unibus interface.

4. RL11/RL01/RL02

The DEC RL01 and RL02 are top-loading, rack-mounted cartridge disk drives having 5.2 and 10.4 MByte formatted capacities, respectively. The RL11 controller is a Unibus interface device while the RLV11 controller is used on the LSI-11 Q-Bus.

C. EMULEX DISK CONTROLLER SUMMARY

The following summarizes the basic Emulex disk controller products and the range of applications presently supported by each. More detail on the features and specifications for each controller model and the versions available is given in the Appendices. In addition, for quick reference, SECTION VI (BLUE) and SECTION VII, found on pages 125 - 148 give complete information on all Emulex products, emulations and the drives and software supported by each. The list of standard versions is continually being expanded to include support for drives which are not listed here, and users are urged to inquire on the availability of support for any drive of particular interest.

1. Hardware Designs

The following briefly summarizes the many hardware designs - SC01, SC02, SC04, SC11, SC12, SC21, SC70, SC71 and SC750 - now in the SCXX series family. The purpose is to define the differences which exist among these products. The many features - common to all - are covered in product literature, manuals, and the specifications, given in the Appendices of this handbook.

a. SC01 for the LSI-11, 11/2 and 11/23. Packaged on two quad-sized PC boards (one bus load) which plugs into a standard Q-Bus quad backplane.

The SC01 is available in three standard models of DEC fixed and moving head storage subsystems.

Model SC01/A supports standard SMD (removable media), MMD (fixed media), and CMD (removable/fixed media) type drives of various capacities. It emulates the DEC RP11 controller combined with multiple RP02 (20.8 MByte) or RP03 (41.6 MByte) disk drives. The newer SC02/A is now recommended for most RP02/03 emulations.

Model SC01/B supports standard SMD (removable media) or MMD (fixed media) type drives of 80, 160, 200, 300 or 600 MByte capacity. It emulates DEC's RH11 Massbus controller combined with multiple RM02 (67.4 MByte), RM05 (256 MByte), or RP06 (174.4 MByte) disk drives.

The Model SC01/C emulates DEC's RK611 controller combined with multiple RK06 (13.9 MByte) disk drives. Logical RK06 disks are mapped onto a single surface of 32-96 MByte CMD type drives, providing 27.8 - 83.4 MByte capacity per drive, and system capacities of up to 8 logical units (111.2 MBytes) on any applicable mix of 32, 64 and 96 MByte spindles. Model C controller features are more extensive than those of the RP11, but less than those of the RH11. The SC01/C is well suited for the CMD type drives having

removable cartridges. The newer SC12/C is now recommended for most RK06/07 emulations.

Generally speaking, operating system is a factor in drive/controller selection. DEC currently supports RT11 and RSX11M on LSI-11, 11/2, and 11/23, but RSTS may also be available soon. Both RSTS-E and RSX11M are offered for these CPU's by various third parties. RSX11M is fully supported by DEC on the 11/23. The DEC RP02/03 and RK06/07 are supported by RT11, RSX11M, RSTS-E, and almost, if not all, other existing operating systems. The RM02/03/05 and RP06 are relatively new products and are supported only by later versions of the larger operating systems (RSX11M, RSTS-E, etc.). Therefore, RT11 users should not plan to use and RM (B) emulation unless they intend to write custom software drivers. RSTS-E and RSX11M users may employ any version.

The SC01 has all features of the large SC11 and SC70 series controllers, including 3 sector buffer and full ECC capability, except: (1) it supports two physical drives; (2) bus register start and vector addresses are not slide/switch selectable. The buffer scheme guarantees that the controller will not overrun ("data late"), and it can be run at low priority to avoid locking out other DMA devices, even running at the 9.67 MHz serial disk data rates.

Appendix A (p. 81) gives more detail, on the features and specifications of the Model SC01. Also, see Tables SC01/A, /B and /C, pp. 134 - 135, for information on the drives and software supported by these specific emulations.

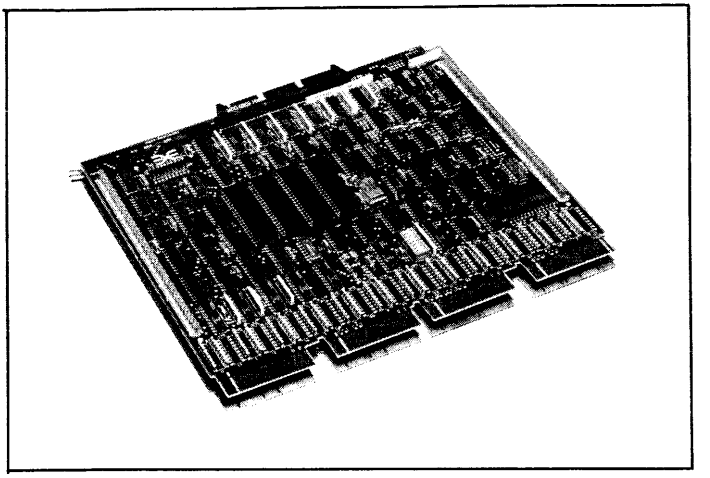


FIGURE 1-3 Emulex SC01 Series

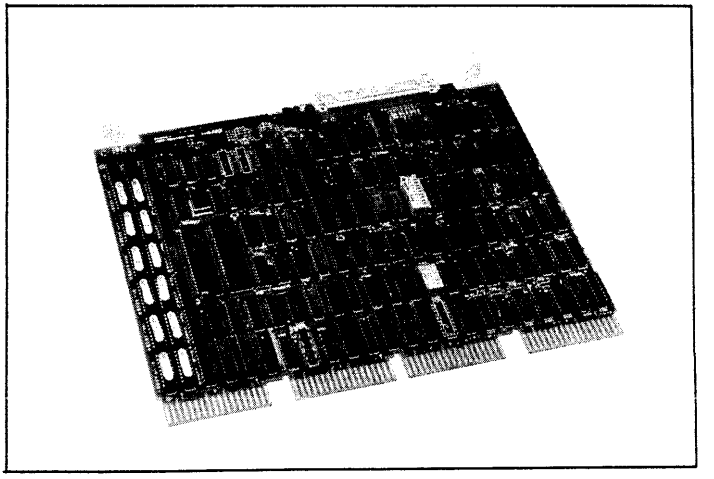


FIGURE 1-4 Emulex SC02 Series

b. SC02 for the LSI-11, 11/2 and 11/23. Packaged on a single quad-sized PC board which plugs into a standard Q-Bus quad backplane. Incorporating a standard SMD interface, the SC02 is optimum for 14" drives up to 160 MBytes (including CMD type drives) and for all current 8" drives which offer an SMD interface option.

The SC02 is available in three standard models which emulate standard DEC disk storage subsystems. The SC02 includes a configuration PROM which permits definition of up to 64 different switch selectable combinations of disk drive configurations on two controller ports.

Model SC02/A emulates the DEC RP11E controller with standard-sized RP02 (20.8 MByte), RP03 (41.6 MByte) or expanded capacity, logical units. The SC02/A includes all RP11E functional features and capability plus extended features, such as automatic pack formatting and switch selection of transparent ECC, with errors reporting to system software. This model supports essentially all standard SMD (removable media), Winchester (fixed media), and CMD (removable/fixed media) type drives of various capacities from 12-160 MBytes.

Model SC02/C emulates DEC's RK611 controller combined with multiple RK06 (13.9 MByte) or RK07 (27.8 MByte) logical units. The SC02/C includes all RK611 capability plus the same extended features provided in the Model A series. It is particularly well-suited for support of 32-96 MByte CMD-type drives having a removable and multiple fixed platters, with a logical RK06 mapped onto each data surface. The SC02/C also supports other 8" and 14" drives by mapping 1 or more standard RK06/RK07 drives onto 1 or 2 physical drives.

Model SC02/L emulates DEC's RL11 combined with multiple RL01 (5.2 MByte) or RL02 (10.4 MByte) logical units. It includes all RL11 capability plus the same extended features provided in the Model A series. The Model SC02/L supports essentially all standard SMD, Winchester, and CMD-type drives of various capacities from 8 - 60 MBytes.

The SC02 has many features in common with other SCXX series controllers, including ECC and CRC capability and bus register start and vector addresses that are slide/switch selectable. The buffer scheme, which uses 3-to-1 sector interlace media formatting, eliminates the possibility of data late conditions and permits the controller to be operated at low bus priorities.

Appendix B (p. 84) gives more detail on the features

and specifications of the Model SC02. Also see Tables SC02/AX and SC02/CX, pp. 136 - 139, for information on the drives and software supported by these specific emulations.

c. SC04 for the LSI-11, 11/2 and 11/23. Packaged on a single quad-sized PC board which plugs into a standard Q-Bus quad backplane. Incorporating a standard ANSI X3T9.3 interface, the SC04 controller can handle up to eight drives of two different capacities per controller. The SC04 is designed specifically to integrate small-to-medium capacity 8" Winchester disk drives in the range of 12 - 80 MBytes.

The SC04 is offered in two versions. The SC04/C emulates the DEC RK611 controller combined with multiple RK06 (13.9 MByte) and RK07 (27.4 MByte) logical units mapped on to the drive surfaces. The RK06/07 emulation provides performance advantages over the RL01/02 emulation commonly used for small capacity drives, including: greater total system capacity; special read/write across cylinder boundaries, hardware read switching; and overlapped seeks on multiple drives.

Model SC04/L emulates the DEC RL11 controller combined with multiple RL01 (5.2 MByte) or RL02 (10.4 MByte) logical units. It includes all RL11 capability plus other enhancements.

The Model SC04/L supports standard Winchester and CMD-type drives of various capacities from 8 - 60 MBytes.

Appendix C (p. 87) gives more detail on the features and specifications of the Model SC04. Also see Tables SC04/CX, p. 139 for information on the drives and software supported by this specific emulation.

d. SC11 for the PDP-11/04 through 11/60. Packaged on two PC boards - the quad microprocessor board which is common to the SC01, plus a hex-size board with SPC interface - which plugs into any SPC slot pair. Supports up to four physical drives, and bus register start and vector addresses are slide/switch selectable. The SC11 uses the same buffer strategy as the SC01.

The SC11 is available in three basic standard models of current PDP-11 fixed and moving head storage subsystems.

Model SC11/A supports standard SMD (removable media), MMD (fixed media), and CMD (removable/fixed media) type drives of various capacities. It emulates the

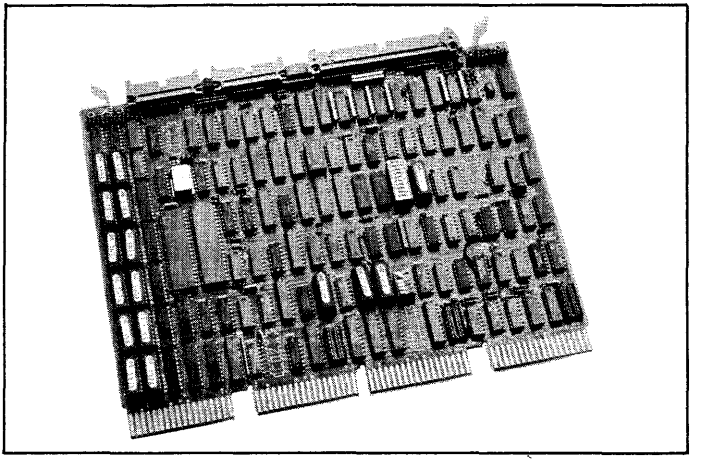


FIGURE 1-5 Emulex SC04 Series

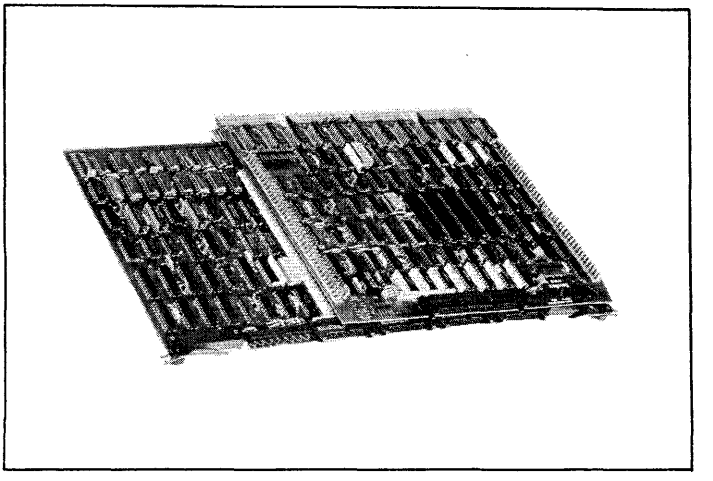


FIGURE 1-6 Emulex SC11 Series

DEC RP11 controller combined with multiple RP02 (20.8 MByte) or RP03 (41.6 MByte) disk drives.

Model SC11/B supports standard SMD (removable media) or MMD (fixed media) type drives of 80, 160, 200, 300, or 600 MByte capacity. This model emulates DEC's RH11 Massbus controller combined with multiple RM02 (67.4 MByte) or RP06 (174.4 MByte) disk drives. The newer SC21/B is now recommended for most RM emulations.

Model SC11/C emulates DEC's RK611 controller combined with multiple RK06 (13.9 MByte) disk drives. With the SC11/C, logical RK06 disks are mapped on to a single surface of 32-96 MByte CMD type drives, providing 27.8 - 83.4 MByte capacity per drive, and system capacities of up to 8 logical units (111.2 MBytes) on any applicable mix of 32, 64 and 96 MByte spindles. The newer SC12/C is now recommended for most RK06/07 emulations.

Appendix D (p.90) gives more detail on the features and specifications of the Model SC11. Also see Tables SC11/A and /B, pp. 140 - 142, for information on the drives and software supported by these specific emulations.

e. SC12 for the PDP-11/04 through 11/60, and VAX-11/750 and 780. Packaged on a single quad-sized PC board which plugs into a standard Unibus backplane. The SC12 supports up to two 8-inch or 14-inch physical drives having capacities in the range of 8-160 MBytes. The SC12 controller is format compatible with Emulex SC02 and SC04 controllers, which are used with the LSI-11 Q-Bus. SC12 features include a choice of two selectable bus register start locations, selectable bus addressing, and two selectable vector addresses.

The SC12 is available in three standard models for emulation of specific DEC subsystems.

The SC12/C emulates the RK611/711 controller combined with multiple RK06 and RK07 drives to support SMD type drives which have both fixed and removable media and capacities in the range of 16 - 300 MBytes.

The SC12/L emulates DEC's RL11 controller combined with multiple RL01 and RL02 disk drives in the range of 8 - 60 MBytes.

The SC12/V emulates DEC's RK711 controller combined with multiple RK07 drives on the VAX-11 Unibus.

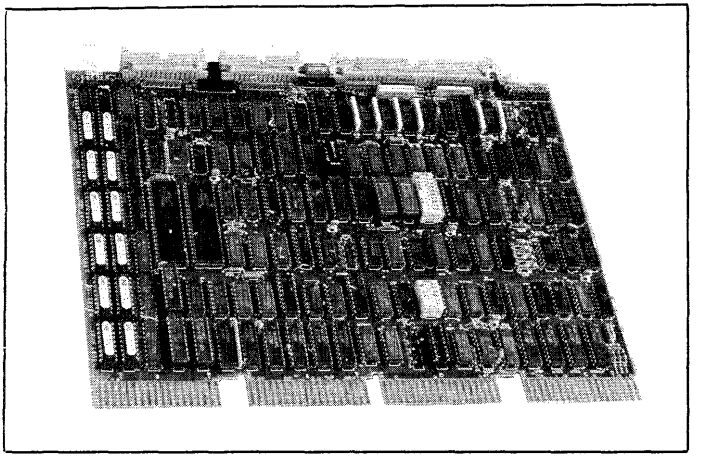


FIGURE 1-7 Emulex SC12 Series

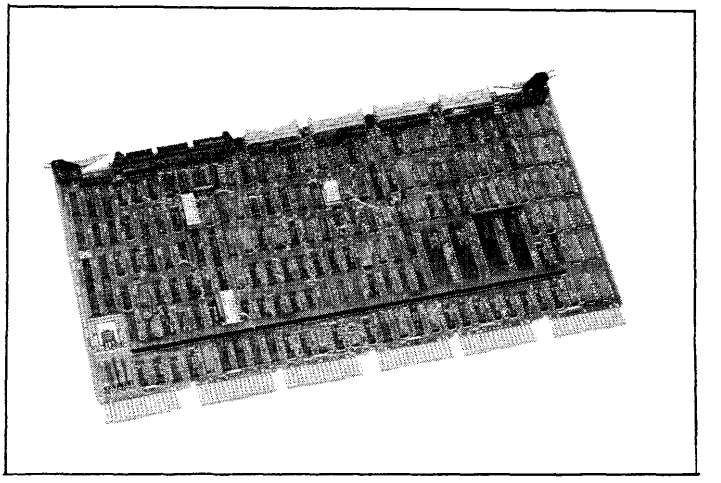


FIGURE 1-8 Emulex SC21 Series

Users considering Winchester and/or CMD drives or smaller minicomputer configurations can use the SC12 as a low cost alternative to the EMULEX high-performance SC21 controller.

The SC12 can also be used with smaller capacity drives on the VAX-11/750 and soon-to-be-announced VAX-11/730. In particular, the CMD 14-inch drive can be run in a software transparent mode as multiple RK06/07 drives on the VAX Unibus using the SC12/V.

Appendix E (p. 92) gives more detail on the features and specifications of the Model SC12. Also see Tables SC12/CX, pp. 142 - 144, for information on the drives and software supported by these specific emulations.

f. SC21 for the PDP-11/04 through 11/60, and VAX-11/750 and 780. This controller is a second-generation version of the SC11, packaged on a single hex-size PC board. In addition to improved performance, this controller provides several new useful features, including the ability to operate many combinations of disk drives having different configurations on the same controller.

The SC21 is available in two standard models which emulate standard DEC disk storage subsystems.

Model SC21/B emulates DEC's RH11 interface with RM02 (67.4 MByte), RM05 (256.1 MByte), or RP06 (174.4 MByte) logical units. The SC21/B includes all standard functional features plus extended features such as command pack formatting and auto bootstrap. This Model supports standard SMD and Winchester-type drives of 40-600 MByte capacity.

Model SC21/C emulates the DEC RK611 controller combined with multiple RK06 (13.9 MByte) or RK07 (27.8 MByte) logical units. It includes all RK611 capability plus the same extended features provided in the Model B series. The SC21/C is particularly well-suited for support of 32-96 MByte CMD-type drives having a removable and multiple fixed platters, with a logical RK06 mapped onto each data surface.

Model SC21/V emulates DEC RM03 (80 MByte) and RM05 (300 MByte) storage subsystems. The standard SC21 controller has been provided with specialized microcode to optimize the data transfer strategy to the VAX Unibus adapter. The SC21/V includes the Emulex-developed VAX/UM software package, which completely supports installation, operation, and maintenance of the SC21/V on the VAX-11/750 and VAX-11/780 computers under VMS, (Version 2.0 and above). On the 11/750, drives may be operated as the

system disk or as a data disk; on the 11/780, the drive is used as a data storage device.

Appendix F (p. 95) gives more detail on the features and specifications of the Model SC21. Also, see Tables SC21/B, /C, and /V, pp. 144 - 145, for information on the drives and software supported by these specific emulations.

g. SC70 for the PDP-11/70. Interfaces directly to the PDP-11/70 internal memory (Cache) bus with full 22-bit (2 Megaword) memory addressing capability to ensure software transparency and full system performance. Packaged on three active PC boards plus one small signal interconnect PC board which plugs directly into the RH70 controller backplane. Supports up to four physical drives, and bus register start and vector addresses are slide/ switch selectable. The SC70 uses the same buffer strategy as the other controllers.

SC71 for the PDP-11/70. The model SC71 has been introduced as an improved version of the SC70 and incorporates the same capability as the SC21 in that it operates different drive configurations on the same controller. The SC71 has the same basic board set and can incorporate the same microcode as the SC70. Hence it is completely interchangable with the older model. An SC70 can be converted to an SC71 by change of one pcb and microcode PROM's.

Appendix G (p. 98) gives the features and specifications of the SC70 and SC71, respectively. Also, see Tables SC70/B and SC71/B, pp. 145 - 147 for information on the drives and software supported by these specific emulations.

h. SC750 for the VAX-11/750. Packaged on a single "extended" hex-sized PC board which plugs into a standard RH750 backplane interface. The SC750 provides everything provided by DEC Massbus controllers - VMS software execution, high-speed CMI bus data transfer, mixed drive capability, and large disk storage capacity. In addition, there is single board packaging, built-in disk formatting and a wide selection of drives.

The SC750 is available in two models which emulate standard DEC Massbus disk subsystems supported under VMS and UNIX on the VAX-11/750 computer. Model SC750/B1 provides concurrent emulation of an RM03 (67.1 MByte), RM05 (256.1 MByte), and/or RM80 (121.3 MByte) Massbus disk subsystem. The Model SC750/B2 emulates DEC's RP06 (174.4 MByte) removable Massbus disk subsystem.

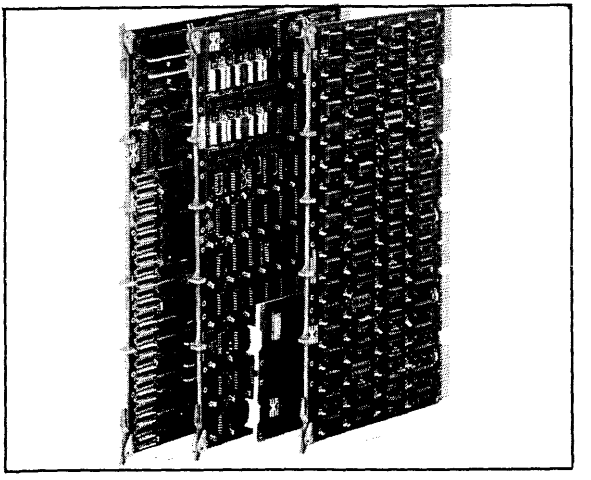


FIGURE 1-9 Emulex SC70/71 Series

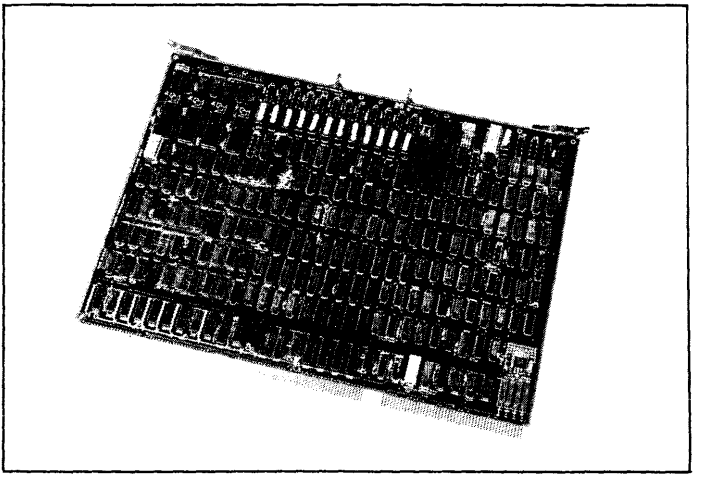


FIGURE 1-10 Emulex SC750 Series

Appendix H (p. 101) gives the features and specifications of the Model SC750. See Tables SC750/B1 and /B2, p. 148, for information on the drives and software supported by these specific emulations. Also, Section IV, B gives further details on the SC750.

2. Microcode Models

There are four basic microcode models - designated Models A, B, C, and L - which correspond to an existing DEC controller design. In the original SCXX controller designs - SC01, SC11 and SC70 - the basic models have multiple microcode versions which handle the different disk drive configurations supported by the controller. In principal, each of these models/versions could be provided on any of the controller hardware designs. All possibilities have not been implemented for practical reasons. Any disk controller may be reconfigured to any model/version by changing only the microcode PROM chips.

In the later Emulex controller designs - SC02, SC04, SC12, SC21, SC71 and SC750 - the same basic models (A, B, C, L) are provided, but drive configuration is accomplished by means of a configuration PROM and option switches on the board. Therefore, different operating modes required to adapt the controller to a drive is inherent to the microcode for each model, and different PROM sets are not required to support different drive types.

a. Model A.

Emulates the DEC RP11E controller. The RP11E controller is an early design, no longer in production since the drives it supported (RP02, RP03) are obsolete by today's standards. Functionally, however, this model has a number of distinct advantages which make it particularly attractive:

(1) It is supported by RT11 and is therefore directly useful in most existing LSI-11 installations;

(2) It is a simpler architecture than other models, and users with custom operating systems can easily write supporting software drivers;

(3) It is well suited to many smaller disk drives which fit nicely within the RP02 (21 MB) or RP03 (42 MB) logical capacities;

(4) The RP11 controller architecture permits physical sectors on the disk to be arranged in any order by software and thus permits a sector interlace scheme to

be set up by the application program. This could be useful in a heavy loaded and/or slow bus system (such as an LSI-11);

(5) Header CRC and 32-bit ECC code capability is included in the SCXX/A, and the controller is set up to make error corrections transparent to the software. Error flagging is still accomplished so that the software can perform its usual error logging function.

(6) The Model A is applicable to almost all LSI-11, 11/2 and 11/23 installation regardless of the disk drive. There is no practical application of this model for drives greater than 80 MBytes (or 96 MBytes for a CMD type drive); therefore Emulex does not support this model on the SC21, SC70/71, or SC750 controllers.

b. Model B

Emulates the more modern DEC RH11 (PDP-11/04 through 11/60), RH70 (PDP-11/70), or RH750 Massbus Adapter with disk drives and DCL. Note that the Massbus Adapters interface to the Unibus and to an internal memory bus to create an external Massbus which goes to the so-called Massbus peripherals - RM02/03, RM05, RM80, and RP06. (Refer to Figure 1-2.)

The imbedded RH11 and RH70 interfaces contain only a small part of the total controller hardware. The majority of the controller hardware is distributed physically in each Massbus-type drive. Therefore, each time a DEC Massbus drive is added, a large portion of the control logic is duplicated. (Add-on DEC drives cost almost as much as the first drive and controller).

The SCXX/B does not create a Massbus per se. It functionally emulates, and therefore replaces, the entire Massbus subsystem. The SCXX/B controls multiple drives without adding duplicate hardware, and the cost differential compared to a DEC subsystem further improves in multidrive installations. Figure 1-11 shows the organization of SCXX controllers which emulate Massbus operation.

The B model is particularly attractive to the CDC 9762 or an equivalent (80 MB), CDC 9730 (160 MB), CDC 9766 or equivalent (300 MB), and Memorex 677 (200 MB) users. The DEC RM02/03, RM05, and RP06 subsystems are, in fact, versions of the CDC 9762, CDC 9766, and Memorex 677 drives, respectively. The Model B emulation is, therefore, an exact replica of those disk subsystems.

The SCXX/B emulation furthermore offers media compatibility with DEC RM02/03, RM05, and RP06 packs when used with CDC-compatible 80 and 300 MByte SMD drives, or Memorex 677 drives, respectively. The SCXX/B also provides a number of enhancements which may also prove to be important.

FIGURE 1-11

SCXX CONTROLLER SUBSYSTEMS

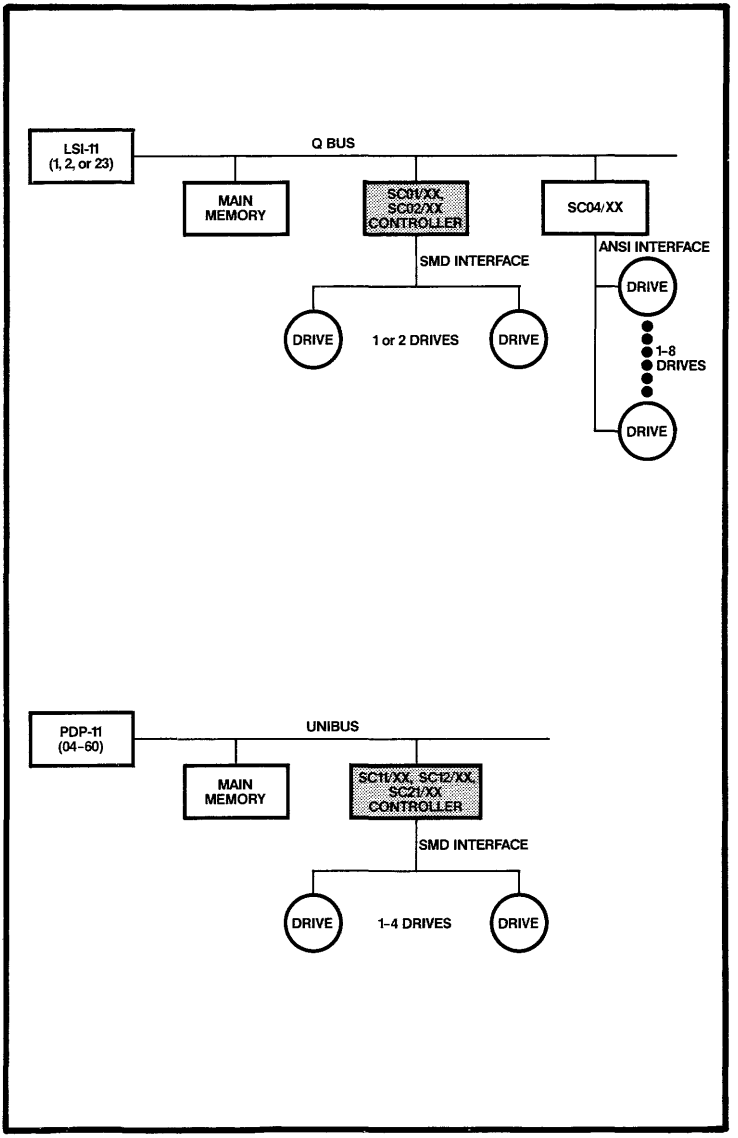
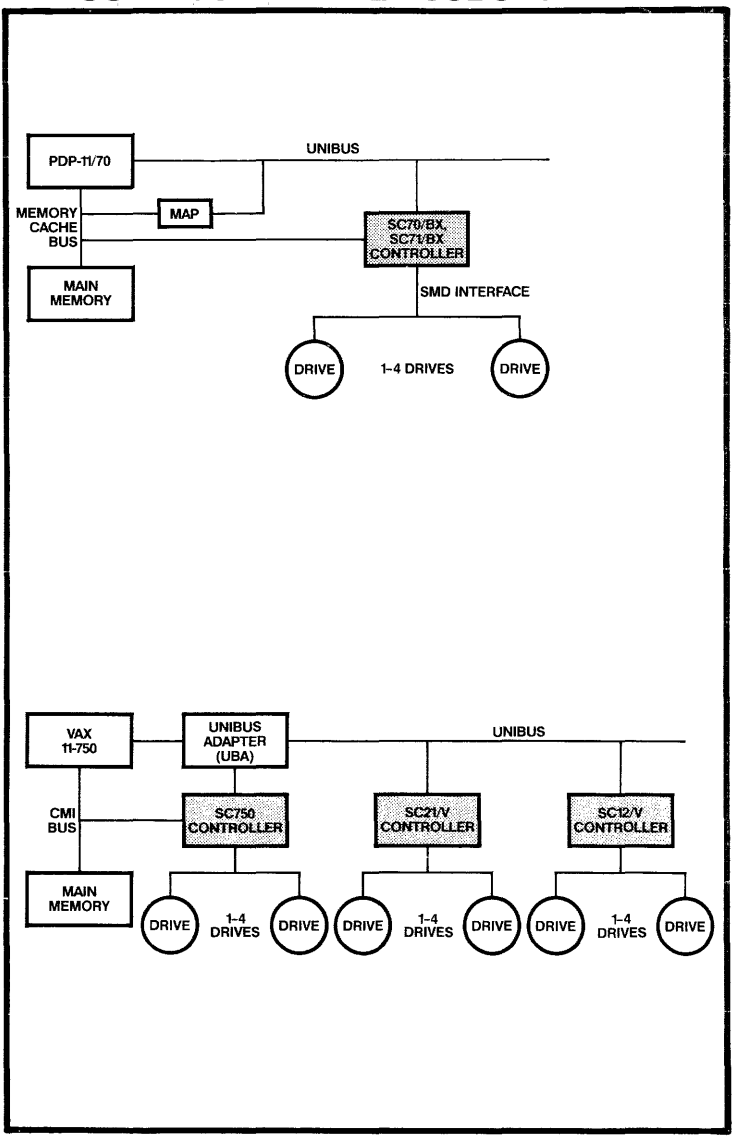


FIGURE 1-11

SCXX CONTROLLER SUBSYSTEMS



In addition, the Model B controller supports dual-port drive operations by separate controllers and the Model A does not. Thus, the Model B is required for applications that call for dual-port capability (note: current DEC software does not support dual port operations, and custom drivers are required).

The Model B is the only controller model which can reasonably support drives above 80 MBytes since DEC has offered these capacities only on the RH11/RH70/RH750/RH780 Massbus Adapters. Therefore, users who someday plan to use very large capacity drives should consider the B Model. However, an A Model controller can always be reconfigured with a PROM set change. In the LSI-11 area, users should use the 11/23 and RSX11M to incorporate the larger drives (above 80 MB) or plan to support their own drivers and/or operating system.

A 300 MByte drive today is generally more cost-effective than a 200 MByte drive, since the only difference is the bit packing density (4000 vs. 6000) and there is very little cost difference for the extra 100 MBytes. However, the standard DEC RP06 is 175 MB formatted on a 200 MB drive, and a software "patch" is needed to expand the drive size parameters in the software drivers to fully utilize a 300 MB capacity. The SCXX/B offers switch option configurations which permit a 300 MB drive to be operated either as an expanded RM02/03 (19 tracks vs. 5) or RP06 (32 sectors vs. 22). DEC has announced a 300 MB system, designated the RM05, which corresponds to the SCXX/B1 expanded versions, (i.e., the 19 track RM02/03). As soon as drivers appear in all DEC operating systems, no patch will be necessary to the 300 MB operating software. (Note: RM05 drivers have been initially offered in VMS and RSX11M-plus. Hopefully these will also be made available in other operating systems. Presently, the DEC RM05 is available only for PDP-11/70 and VAX-11/780 applications).

The Model B is the most, if not the only, practically applicable model of the SC70, since most users will be considering drives of 80 MByte and above.

For the newer SC21, SC71 and SC750 controllers, there are two basic versions provided: a B1 which emulates the RM02/03/05 (and RM80 on the SC750) format, and a B2 which emulates the RP06 format. These controllers are capable of handling a mix of drive capacities on a single controller by means of a configuration PROM. Therefore, essentially any drive configuration may be defined and handled by these controllers without changing the basic microcode as is required in the original controller designs. Option switches select the desired drive combination.

c. Model C

Emulates the DEC RK611 controller and RK06 disk drive which has a formatted capacity of 14 MBytes. This model is provided specifically to support the fixed/removable drive configuration (e.g., CDC 9448, Ampex DFR 900).

Formatting of this type drive requires that a logical unit be mapped onto each data surface of the drive to permit complete logical blocks to be transferred between the fixed surfaces and the removable cartridge. Since the 14 MByte RK06 formatted capacity fits exactly on a single surface, users may run standard drivers without size parameter modification. In addition, the RK06 is supported under current versions of RT11, RSX11M, RSTS-E, and VMS, meaning standard software is available across all VAX/PDP/LSI-11 models.

It should be pointed out that the media of these drives is not interchangeable with the DEC RK06. The CDC and Ampex packs are also not physically interchangeable. Users are cautioned that these drives do not serve as an RK06 replacement in situations where DEC software interchangeabilty, via this media, is a requirement.

Later versions of this model are planned to support other drive types as logical RK06 or RK07 units.

This model is not applicable to the SC70 since the RK06/07 is a Unibus device. However, the SC11/C, SC12/C, or SC21/C may be run on the 11/70 Unibus with full software support (unmodified) in all DEC operating systems. To acheive RK06/07 emulation with software transparency to DEC's VMS on VAX-11 computers, the SC12/C should be used.

d. Model L

Emulates the DEC RL11 controller and RL01/02 disk drive which as a formatted capacity of 5.2 and 10.4 MBytes, respectively. This model is provided specifically to support small capacity drives, primarily 8". The RL emulation is very convenient because it is supported universally across the LSI-11 and PDP-11 product lines. The RL emulation suffers some performance limitative compared to other models because of burdens placed on supporting drives. Also, the maximum RL subsystem capacity is 40 MBytes which is too restrictive for many applications. A major advantage of the RL emulation is in its advantage to utilize standard DEC software written to support the full 22-bit memory address range (4 MBytes) of the recently-announced PDP-11/23 PLUS. This is presently the only hard disk supported by DEC on this expanded addressing range machine.

D. SOFTWARE CONSIDERATIONS

For Unibus-oriented (PDP-11/04 through 11/60), Q-Bus-oriented (LSI-11, 11/2, 11/23), and 11/70 machines, the standard SCXX products are made to look functionally like the DEC controller they emulate (plus, of course, the enhancement features which may or may not be used). Every microcode version is also designed to execute the associated DEC diagnostics as a further test and proof of its software transparency. This design philosophy is of major benefit to users for a number of reasons. The most significant is that special drivers do not have to be written to use an Emulex controller with operating software written for a standard DEC controller. The user, therefore, is relieved of writing his own software.

A fundamental design philosophy in all Emulex controllers designed for software transparency, is to extend the design compatibility to include execution of the standard DEC diagnostics as well as the system operating software. This principle requires extra effort in the design phase and extra hardware in the controller; but, this discipline gives a much higher level of confidence in achieving true software transparency and protection against future software revisions which might find new "holes" in the emulation.

In addition, new emulation versions can be created without requiring implementation of a whole new diagnostic package, a fact which can be of immense benefit to a user who later needs adaptation of his controllers to a new or revised application requirement.

A factor which may influence controller model and/or disk drive selection is the fact that there is not an exact replica of a DEC disk subsystem for every possible version of controller and type of disk drive which can be handled by the versions of the SCXX series. Therefore, many such combinations do not exactly conform to the same logical size definition of the baseline DEC unit. For example, when a certain drive provides greater potential capacity, it is desirable to use it; conversely, for a drive having smaller capacity, software access must be limited to the physical drive size to avoid undesired software "crashes".

For example, the SCXX/B2 may be run as a standard 22-sector RP06 (174.4 MB), or as an expanded 32-sector RP06 (253.7 MB) unit. The latter selection is desirable when using a 300 MB (vs. a 200 MB) drive. However, the software driver has certain numerical values which must be redefined in the operating system to permit access to this increased capacity. The basic requirement is to "patch" in new maximum data block limits which are converted by the operating system software drivers into the track and sector addresses which match those of the drive being used. This principle applies to "patching up" for expanded logical sizes and "patching down" for contracted logical sizes. These patches do not modify code sequences in the driver and are generally entered as part of the system generation procedure or into absolute locations later. It

should be noted that "patching up" is not always necessary if the additional capacity is not to be used. "Patching down" where the physical drive capacity could be exceeded is, however, always required to avoid overrunning the drive capacity. It should be noted that "patching up" to expand logical capacity is a routine procedure. The system first brought up with the disk at standard capacity, and then patches are installed as part of a sysgen procedure.

"Patching down" to contract logical drive capacity can be a problem, however, if the disk itself is used as the only system device since the boot operation will usually overrun the smaller drive and cause a system error before the patches can be installed. Therefore, another system device must be available to make use of a patched-down capacity drive.

The specific parameters depend upon such factors as operating system, emulation, and drive type. Emulex supplies these parameters and entry procedures for the most commonly used DEC operating systems. In addition, these same kinds of patches are also necessary in the corresponding diagnostics. The required diagnostic patches for a specific controller version are generated by Emulex as part of the initial development effort, and such modifications are provided to users who have standard diagnostics at their site. Such procedures entail modifications of a limited number of locations. While it may be desirable to stay with a version which requires no patching (e.g., RM02/03), adaptability to a specific application often makes this small effort more than worthwhile.

Emulex currently supports the models SC12/V and SC21/V disk controllers on the VAX-11/750 and 11/780 Unibus. The SC12/V is an RK07 equivalent and runs under the standard RK07 driver in VMS. However, the larger 80-600 MByte drives, such as RM03's, RM05's, etc., are supported under VMS only as Massbus devices, and the standard drives rely on the hardware memory mapping facilities of the RH750 and RH780 interfaces which are not available to Unibus devices. Hence, the SC21/V, which is supported on the Unibus, requires a driver - supplied by Emulex - to be incorporated. The Emulex driver emulates an RM03 or RM05 and produces a compatible disk pack to the equivalent DEC media. VMS is structured for easy incorporation of user-supplied drivers, and the original Emulex driver has been used without modification under all published versions of VMS. System generation with the Emulex drivers and SC21/V has proven to be a straightforward procedure.

Considerations for the specific DEC operating systems supported can be found in the following paragraphs. These notes assume some familiarity with the operating systems and discuss only the special points that must be kept in mind when configuring Emulex disks with those systems.

RT11 V 4.0

RT11 is a single-user real-time system designed for use with the small-to-medium sized PDP-11 processors. Being a small system, RT11 is not designed for use with large mass storage devices, and will not support any Emulex "B" emulations, because it does not include driver software for the RP06 or RM02/03/05 disks.

RT11 V4.0 will not support any disks with a logical size greater than 65536 decimal blocks. It includes RP03 support only by mapping two logical drives onto one physical drive. Though this is similar to the way same of Emulex' controllers remap drives, this is done internally by the operating system, and not the controller. The controller will still look at the drive as one RP03. Between controller remapping and RT11 software remapping, RT11 V4.0 can be patched to handle any of the standard SCXX/AX emulations, using drives of up to 80 megabytes.

RSTS/E V7.0

RSTS/E is a multi-user timesharing system for the medium-to large-sized PDP-11 processors that include memory management. RSTS/E V7.0 has two releases, V7.0-07 (Sysgen level 'G'), and V7.0-08 (Sysgen level 'H'). The only difference between the two is that V7.0-08 includes support for the RM05 300MB disk. V7.0-07 will support only RM02 and RM03 emulations for DR-type disks.

RSTS/E will support all of the standard SCXX/AX, /BX, and /CX emulations available from Emulex, though some of the /AX and /BX emulations will require patching. Supported patches are available from Emulex (either in the technical documentation or from the software support center) for some of the more common expanded or reduced emulations at no charge. Patches for other emulations can be specially created at a nominal charge.

All patches to RSTS/E must be done when running from the disk; those systems that include a RSTS-supported disk other than the Emulex disk being installed will have no problem, as RSTS can be patched while it is on the standard disk. Customers that run their Emulex subsystem in a DEC-compatible mode will likewise have no patching problems.

Customers that have only a magnetic tape and the Emulex disk controller on their system, and who wish to run in non-standard capacity, will have to go through some extra steps in order to do their sysgen

and create a system disk at the expanded capacity. These extra steps are detailed in the patch procedure appendices in the individual controller technical manuals.

RSX11M V3.2:

RSX11M is a multiuser, real-time software system designed to run on any PDP-11 processor from the 11/04 through the 11/70. RSX11M V3.2 can use any if the standard SCXX/AX, /BX, and /CX emulations except for the /B1 RM05 emulations (it does support RM02 and RM03). The RM05 is not a supported device under this version of the operating system.

As in RSTS, some of the /AX and /BX will require patches to be applied to the operating system, and patches are available for the most popular emulations. As in RSTS, any system that includes the Emulex disk subsystem and at least one other standard disk subsystem will have no problem having patches installed because the patches are installed on the standard disk, and the patched system is used to initialize the Emulex disk. There is only one limitation that arises in the patching scheme: if the expanded or reduced mode would require a geometry change (modifying the number of tracks per cylinder or sectors per track) on any system that has only a tape drive and the Emulex modified disk capacity subsystem, the patch cannot be installed and the disk will have to be run in DEC-compatible mode.

RSX11M-PLUS (+) V1.0:

RSX11M-PLUS is an enhanced version of RSX11M, designed to take advantage of the new large-capacity disk drives, especially the advanced features of the PDP 11/44 and 11/70 processors. These are the only processors presently supported. RSX11M+ does not support the RP02/03 or the RK06, so no Emulex 'A' emulations are supported, and only the 'C' emulation controllers that support RK07 (not RK06) drives are supported. All 'B' emulations are supported, as RSX11M+ does allow the use of RP06 and RM02/3/5 disks. As in the other operating systems, any non-standard emulations of these disks will need patching, and patching will require the existence of some standard disk device on the system. If the only devices on the system are a tape drive and the Emulex disk subsystem, and if the patch that would applied would necessitate a geometry change (modifying the number of tracks per cylinder or sectors per track), the patches cannot be installed and disk will have to be run in DEC-compatible mode.

SECTION II
TAPE CONTROLLERS

Emulex currently offers two tape controllers, the Models TC01 and TC11 for the LSI-11 (Q Bus) and PDP-11 (Unibus) series of computers, respectively. Appendix I (p. 104) contains a summary of features and specifications for each model. The TC11 may also be operated on the VAX Unibus using a software driver supplied by Emulex (refer to Section IV for details on Emulex products for the VAX series).

A. DEC TAPE SUBSYSTEMS

Functionally, the Emulex TC01 and TC11 tape controllers emulate the DEC TM11 controller which is combined with one or more TU10 transports having the following characteriestics (the subsystem is designated TE10):

9 Track
800 bpi
45 ips
10 1/2" (2400 ft.) reel

The TM11 interfaces directly to the Unibus and is applicable to and supported on all PDP-11/04 through 11/70 cpu's; it is not supported by VMS on VAX-11/750/780 systems.

DEC also offers three other Unibus-oriented tape subsystems:

TJE16 - 9 Track, 800 bpi (NRZ) or 800/1600 bpi (Dual Density), 45 ips, Tension Arm, 10-1/2" reel.

TS03 - 9 Track, 800 bpi (NRZ), 12 1/2 ips, Tension Arm, 7" reel.

TS11 - 9 Track, 1600 bpi (PE), 45 ips, Tension Arm, 10 1/2" reel.

For high performance (i.e., greater than 45 ips), DEC offers a series of tape subsystems adapted to the Massbus by an appropriate Massbus adapter (RH11 for the Unibus, RH70 for the 11/70, RH750/780 for the VAX-11/750/780). The Massbus tape controller/formatter (TM02) is contained within each tape transport just as is done in the disk peripherals. (Refer to Figure 1-2.) The subsystems available in this series are:

TJU45 (RH11)
TWU45 (RH70, RH780) - 9 Track, 800/1600 or 1600 bpi, 75 ips, Vacuum Column, 10 1/2" reel.

TWU77 (11/70, 11/780) - 9 Track, 800/1600 or 1600 bpi, 125 ips, Vacuum Column, 10 1/2" reel

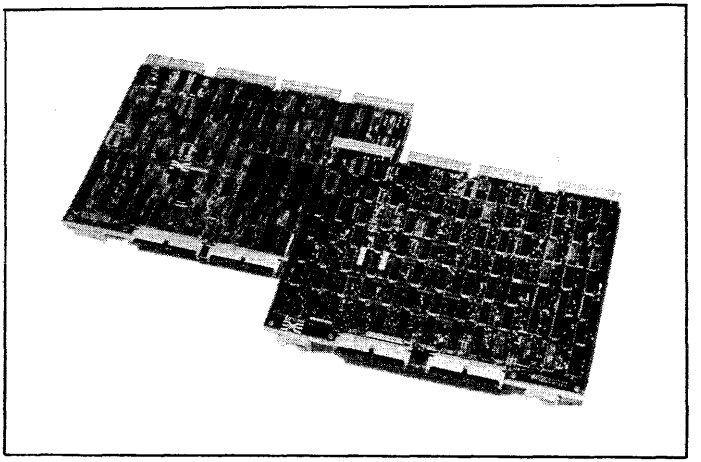


FIGURE 2-1 Emulex TC01 Series

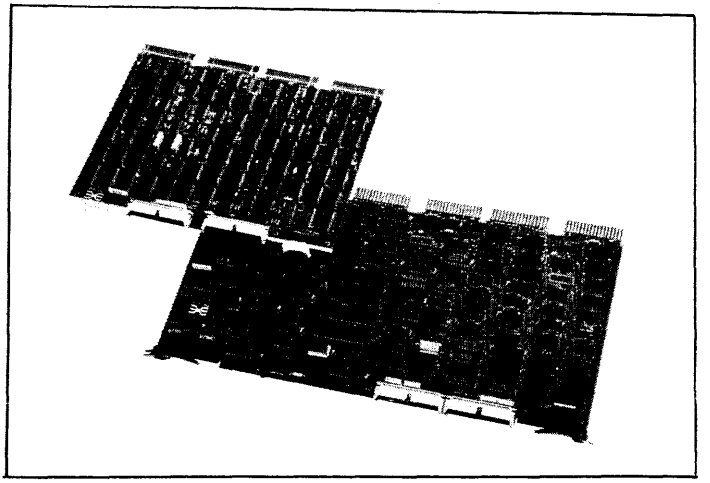


FIGURE 2-2 Emulex TC11 Series

Except for the Massbus peripherals, each tape controller is different. For the Massbus devices, each peripheral has a separate controller/formatter which creates considerable hardware redundancy at no increase in performance.

It should be noted that for the 11/70, DEC usually recommends the TWU45 or TWU77 since data transfers in these subsystems are made directly to/from memory rather than via the Unibus. However, the TE10 is supported on the 11/70 Unibus by all current software operating systems, and performance is usually acceptable for this configuration.

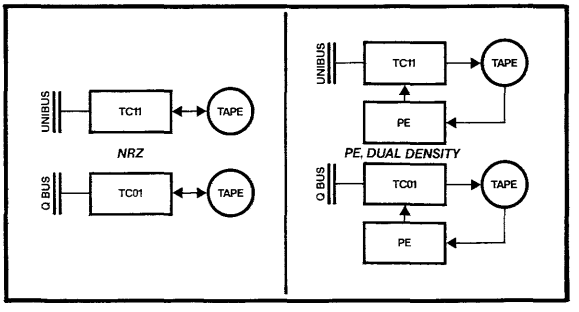
B. EMULEX TAPE CONTROLLERS

The basic TCXX tape controller is contained on a single PC board. The TC01 is a quad height board and interfaces to the LSI-11 Q Bus via the A,B connector rows. The TC11 is a hex height board and interfaces to the Unibus via a standard 4-connector SPC slot. These controller boards perform all tape control and formatting operations for densities of up to 800 bpi (NRZ). The design incorporates a high-performance microprocessor common to both controllers, an approach which provides many inherent benefits to the user.

For handling 1600 bpi (PE) formats, a second quad height board is added. This board is common to both the TC01 and TC11 and contains the PE decode/deskew circuitry for the 9 parallel data channels on the tape. The PE board does not present any load to the bus circuitry except for power and ground connections. A diagram of the tape interconnects is shown below in Figure 2-3.

The PE board may be mounted remotely from the controller board since the two are connected by a soft over-the-top flat cable. This is convenient since there are often "free" quad slots available in backplane locations which contain bus jumpers or other dual height boards in the A and B connectors.

FIGURE 2-3
TAPE INTERCONNECTS



Thus for the PDP-11 Unibus series of DEC computers, Emulex offers a single controller that will handle tape transports having the following ranges:

12.5 - 125 ips

800, 1600, 800/1600 bpi

Tension Arm or Vacuum Column

Any reel size

DEC does not offer an open reel magnetic tape for the LSI-11 series of computers nor has it announced plans to do so. However, with the TC01 the user may handle any of the same 800,1600, or 800/1600 bpi tapes available on the PDP-11 series. The only difference in performance is that the TC01 can handle speeds of 75 ips maximum versus the 125 ips capability of the TC11.

The only criteria for interfacing a tape transport to either controller is that it has an industry standard interface (generally called a Pertec interface).

For application on the PDP-11/70, experience has shown that the Massbus interface is usually not needed from a performance standpoint. Many Emulex controllers are successfully installed and operating on the 11/70 with 125 ips tapes. Since the TE10 is supported in this manner by standard software, this approach offers a much more economical system comparable performance to the DEC Massbus tape subsystems.

C. FEATURES AND ADVANTAGES

Emulex tape controllers represent the most advanced, modern design architecture available today. These controllers, now fully proven in hundreds of installations and available in production quantities, offer more features and advantages than any other products on the market. The following is an informal review of these advantages.

1. Packaging

Packaging is an important benefit of the TC01/TC11 because:

- An external "boat anchor" or multi-board wired system unit is eliminated. Standard backplane slots are used.

- Fewer parts and no special backplane wiring provide greater inherent reliability.

- The problem of switching around system units in a DEC box to change bus priority is elimnated. With the TC01/TC11, only boards are moved, not modules.

- The controller and PE boards need not be in adjacent slots, and the PE needs only power and ground. This can be handy in making full use of available slots. There are often "free" quad slots available in PDP-11 backplanes. And in the 11/70, the PE board can go into an empty RH70 interface slot instead of a Unibus SPC. Since there are only four SPC slots provided, a complete expansion box may be eliminated in some cases.

2. Self-Test

Only a microprocessor-based controller can reasonably offer this important and very useful feature. Both the TC01 and TC11 incorporate extensive self-test microcode, with the following tests all performed upon unit power-up:

- Microprocessor - instructions, sequencer, control memory, etc.

- Write Clock time base.

- 10 KHz maintenance timer.

- DMA transfers over Unibus (data and control circuits).

- PE Read logic - simulated records transferred with variable data patterns and bad tracks; received data is monitored, (pre and postambles are detected and all status bits are checked).

- Errors found during self-test are flagged to board level by LED error lamps. Also, an activity LED indicates normal operation.

The advantages of this kind of controller verification should be obvious. Usually a suspected controller problem can be confirmed or eliminated over the telephone.

3. Software and Diagnostic Transparency

The TM11/TU10 emulation is supported by DEC operating and diagnostic software on the PDP-11 series. The following extra provisions are made to insure this critical feature:

- The controllers handle odd byte count and odd byte starting location whereas certain other controllers do not perform these functions.

- The PE mode is handled in a completely transparent manner to DEC software. This is essential because the DEC TU10 is an NRZ (800 bpi) unit only. The TC01/TC11 have a provision for software density select, but the drive select switch will override software control in the PE mode. This avoids any need to modify standard software.

- The controllers have the same blank tape timeout feature (about 15 ft.) as the DEC TM11. This prevents tape runaway, and also satisfies a DEC diagnostic test for this feature.

- There is a special non-standard way the TM11 handles the tape mark. Controllers which do not handle this non-standard function properly will cause system failure under certain operating systems.

- The TC01/TC11 generate both CRC and LRC in the PE mode to satisfy diagnostic checks (LRC is not used in PE, but the standard diagnostics assume the system is NRZ and look for the LRC).

4. Performance

Emulex tape controllers support full range performance of conventional tape drives from 12.5-125 ips (75 ips for the TC01) at densities of 200, 556, 800 and 1600 bpi. The units also transfer full 16-bit words, not bytes, via DMA. Several other controllers transfer bytes, and that means lower system performance. For example, at 1600 bpi/125 ips, the data rate is 100 Kw/s or 200 Kb/s. With a 1-us memory, the full-word DMA transfers use 10 percent of total bus bandwidth. On a byte basis, the tape controller consumes 20 percent. This level of activity may have serious impact on heavily-loaded systems.

5. Convenience and Utility

No other controllers offer the same overall degree of convenience, utility, and flexibility as the TCXX Series. For example:

- Speed of operation is selectable by option switches in the range from 12.5-125 ips. For all 9 track drives, two different speed drives can be operated at the same time.

- An IBM compatibility mode is provided which allows characters to be reversed in the word.

- An edit feature is provided which will allow an individual record within a block to be rewritten without doing the whole block over.

- If the wrong kind of tape is mounted on the transport for the controller setup (i.e., NRZ tape in PE mode), the controller

will automatically take the drive off line when operation is started. Standard software would never detect such a condition flagged only by a status bit.

SECTION III
COMMUNICATIONS PRODUCTS

Emulex currently offers two different front-end communications multiplexer product lines, designated the CS11 and CS21 series, respectively. These product lines consist of a set of hardware elements which are configured to provide various communications protocols and/or communications line disciplines and are designed to correspond to certain products offered by DEC in the same manner as the disk and tape controller products. Versions of these product lines cover the following equivalent DEC multiplexers:

DZ11E — 16-line asynchronous multiplexer, programmed input and output.

DH11 — 16-line asynchronous multiplexer, programmed input, DMA output.

DV11 — 8-32 line synchronous/asynchronous multiplexer, DMA input and output.

Characteristics of the DEC units followed by a description of the Emulex CS11 and CS21 products are defined below.

A. DEC COMMUNICATIONS MULTIPLEXERS

DEC presently offers three basic types of multiplexers for its PDP-11 series computers: DZ11, DH11, and DV11. Table 3-1 summarizes the basic characteristics of these three products.

A basic multiplexer characteristic to consider is the method of CPU communication, i.e. either programmed or DMA data transfer. Programmed operations are usually initiated by interrupts when a character must be processed.

For input handling, interrupt-driven operations are often adequate since many sources, such as keyboards, present data at slow, random rates. However, input processing is usually more critical than output because limited buffering can result in data loss if CPU response is too slow.

For outputs, systems are often characterized by the transmission of complete data blocks rather than isolated characters. For example, VDT input characters are often echoed back to the transmitter by the multiplexer rather than the CPU. The CPU then sends only complete screen blocks out to the terminals. Line printers are another example of block-oriented outputs. The output response time is often not as critical since most block-oriented devices are buffered to accumulate a block (or more) before operation is begun.

TABLE 3-1 DEC COMMUNICATIONS MULTIPLEXERS

1. DZ11 Asynchronous Communications Multiplexer (PDP-11/VAX)

   * 8/16 Line Multiplexer
   * Local operation at speeds to 9600 Baud (Bits Per Second)
   * Programmable speeds and formats on a per line basis
   * Character interrupt output transfers and input transfers
   * Standard interfacing-EIA/RS232C and 20 milliamp 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

   DLV11 Asynchronous Communications Multiplexer (LSI-11)

   * 4 Line Multiplexer
   * Local operation at speeds up to 9600 Baud (Bits per second)
   * Programmable speeds and formats on a per line basis
   * Character interrupt output transfers and input transfers
   * Modem control - full duplex operation with Bell 103 or 113 modems or equivalent
   * Single quad board per 4 line increment
   * Standard interfacing - EIA/RS232C

2. DH11 Asynchronous Communications Multiplexer (PDP-11)

   * 16 Line Multiplexer
   * Programmable speeds, formats, and transmission modes on a per line basis
   * Local operation at speeds formats, and transmission modes on 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 transfers
   * Full modem control
   * Dedicated 9 slot backplane (2SU) per 16 line increment
   * Standard interfacing - EIA/RS232C and 20 MA current loop
   * 64 Character receive buffer

3. DV11 Synchronous/Asynchronous Communications Multiplexer (PDP-11)

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

Another basic characteristic is whether the communications are synchronous or asynchronous in nature. Asynchronous transmission relys on resynchronization and data recovery on a character-by-character basis, with each containing its own sync bit(s). There is likewise little provision for error detection (parity only) and no provision for error correction. For this reason, each character is usually echoed back for checking.

Synchronous transmission is generally designed for communication of large error-free data blocks at high speeds over relatively poor quality lines. It therefore involves methods - termed line protocol - for synchronizing on a block basis and for highly reliable detection (and often correction) of large numbers of errors within a block. For this reason, programmed interrupt-driven operations are generally not desirable.

1. DZ11

   The DZ11 is designed for multiplexing of 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, and either 8 or 16 channels may be obtained on a CPU-imbedded board. A summary of the main versions is given in Table 3-2. The DZ11 is supported across the entire DEC-11 line.

TABLE 3-2

DZ11 Versions Offered (PDP-11 & VAX-11/780)

*	DZ11-A	8 line Async MUX, EIA/CCITT
*	DZ11-B	8 line Add-on, EIA/CCITT
*	DZ11-C	8 line Async MUX, Current Loop (20MA)
*	DZ11-D	8 line Add-on, Current Loop (20MA)
*	DZ11-E	16 line Async MUX, EIA/CCITT
*	DZ11-F	16 line Async MUX, Current Loop (20MA)

The DZ11 is supported across the PDP-11 and VAX-11 products under RT11, RSX11M, RSTS-E, VMS and others.

For the LSI-11, there is a single equivalent product available. A summary of it is given in Table 3-3.

TABLE 3-3

DZV11 Version Offered (LSI-11)

*	DZV11-B	4 line Async MUX, EIA/CCITT

2. DH11

The DH11 is designed for higher performance than the DZ11. The unit has programmed input operations but uses DMA for output transmission to reduce CPU loading. The DH11 also permits somewhat more flexibility in data formatting than the DZ11. It also provides echoplex and half-duplex with full modem control, features not available with the DZ11.

The DH11 is a relatively old design and consists of multiple circuit boards contained in a specially wired double system unit 9 slot backplane. It comes in a variety of configurations, summarized in Table 3-4.

TABLE 3-4

DH11 Versions Offered (PDP-11)	
* DH11-AD	Programmable 16 line Async MUX, EIA/CCITT, modem control (DM11-BB)
* DH11 AE	Programmable 16 line Async MUX, EIA/CCITT

The DH11 is supported on PDP-11 systems under RSX11M, RSTS-E, IAS, and Decnet. It is not supported by 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.

3. DV11

The DV11 is designed to handle both synchronous and asynchronous communications lines in the same unit. Lines may be configured in groups of four. There are various configurations , summarized in Table 3-5. The DV11 is characterized by DMA operations for both inputs and outputs to handle the block-oriented synchronous lines, and it also includes additional functional features required to optimize the synchronous communication protocol software executed by the CPU.

The DV11 is oriented for handling both the IBM BISYNC and DEC DDCMP protocols. It is supported on PDP-11's only under IAS and Decnet.

TABLE 3-5

DV11 Versions offered (PDP-11)

* DV11-AA	Double system unit contains all DV11 logic except the line cards and distribution panel. 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-BA	Line cards and distribution panel for eight synchronous lines.
* DV11-BB	Line cards and distribution panel for eight asynchronous lines.
* DV11-BC	Line cards and distribution panel for four aynchronous and four synchronous lines.

B. EMULEX COMMUNICATIONS MULTIPLEXERS

Emulex currently offers two families of serial asynchronous/synchronous communications multiplexers designated the CS11 and CS21 Series', respectively (see Figures 3-1 and 3-3). Within these two families are products equivalent to DEC's DH11, DV11 and DZ11 for use on PDP-11, VAX-11/750 and VAX-11/780 minicomputers. Appendices J and K (pp. 107 - 112) give more detail on the features and specifications of these products.

Both the CS11 and CS21 represent a new and unique concept in communications multiplexers. For the CS11, a configured subsystem consists of a set of building blocks, including a host-mounted controller and an external mounted panel with active line adapters. For the CS21, a configured subsystem consists of a single host-mounted controller board plus a single passive 16-line distribution panel. In both cases, common hardware is used to implement all models in the product line. Together, these product families offer users a variety of alternatives to multiplexing multiple serial terminals to DEC CPU's.

1. CS11 General Description

a. CS11 Series Organization

The EMULEX CS11 series is a set of hardware and firmware elements which may be assembled into a complete communications multiplexer subsystem. Organization of the EMULEX CS11 Communications Multiplexer subsystem is shown in Figure 3-2.

The basic element of the subsystem is the CC11 Communications Controller, a single pcb which mounts in any available hex height SPC slot of a DEC-11 backplane or system unit. The CC11 incorporates the same basic microprocessor design inherent in all EMULEX products. The controller microprocessor is programmed to implement the different emulation models available, and adaptation is made by installation of the proper PROM set in sockets on the CC11 board.

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 "UART" parallel-to-serial data conversion. The UART's also contain a baud rate generator and modem control

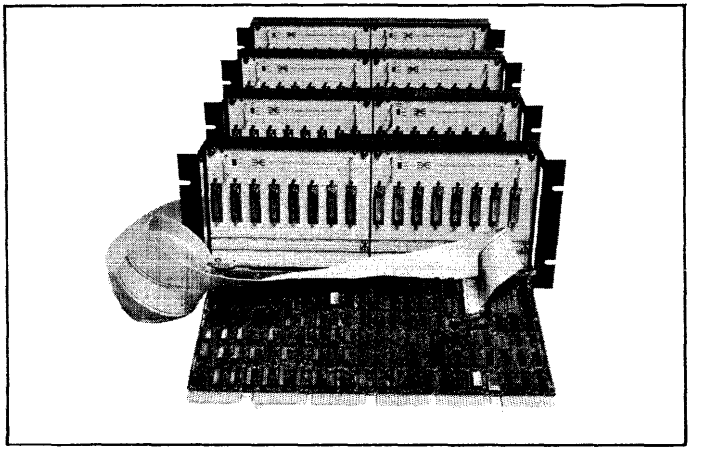
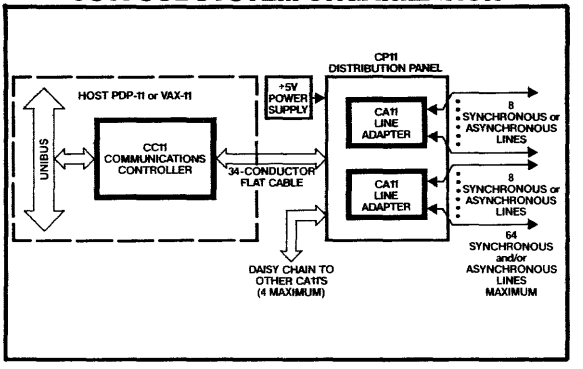


FIGURE 3-1 Emulex CS11 Series

FIGURE 3-2

CS11 SUBSYSTEM ORGANIZATION



- 1 or 2 CA11's per CP11; Autocalling unit can replace a CA11.
- EIA or Current Loop per 8 lines.
- 1 to 4 CP11's per CC11.
- 8-64 lines per subsystem.
- CA11/A RS232 panel includes DM11 Modem Control.
- CA11/V panel for CS11/V.
- CA11/C panel for Current Loop.
- Terminator installed on last CP11.

circuitry. 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. Channels can be added in 8 and/or 16 line increments. The type of interface can be changed, mixed, and matched as needed. If more than 64 lines are needed, additional CC11 controller boards may be placed on the Unibus to handle additional line adapters for up to 64 lines per CC11 added.

The CS11 is ideal for applications involving large numbers of terminals - typically 32 or more - and/or where backplane space and power is at a premium. The CS11 also offers exceptional flexibility at the adapter panel level with 8-line modularity and a broad selection of present and future adapter types. Users of large numbers of terminals and/or those with changing requirements should, therefore, find the CS11 Series an ideal choice for the present, with open-end flexibility for the future.

b. CS11 Subsystem Components

1. CC11-Communications Controller

The basic CC11 is an 8-bit microprocessor-based controller which performs all operations required to transfer data between the CPU host and the multiple terminals connected to the Distribution Panels. All communication protocol is handled by this unit. Standard microcode versions execute an exact emulation of specific DEC Communications Controllers (e.g. DH11) and the CC11 is transparent to the standard DEC operating and diagnostic software. The CC11 also executes extensive self test and subsystem diagnostics upon initial power-up, also in 8-line groups during normal operation through manual intervention (setting a switch on the Line Adaptor board).

The CC11 is configured for different emulations by PROM and Line Adapter changes.

The CC11 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 +5 volts. No other backplane voltages are required.

2. CP11-Distribution Panel

The CP11 Distribution Panel includes a mechanical chassis, a pcb interface board, and a power supply. To this assembly is added either one or two Line Adapter boards which

plug into the mother board.

A Distribution Panel may, therefore, be configured for either 8 or 16 lines and the type of line interfaces can be selected in groups of 8. A total of 4 CP11's and therefore a total of 64 lines may be handled by a single CC11 controller.

The first CP11 may be mounted up to 50 feet from the CC11 controller.

3. CA11-Line Adapter

The CA11 Line Adapter is a pcb which plugs into one of 2 positions in the CP11. Currently, there are basic versions of CA11 assemblies, one for RS232, and one for current loop. These two units contain the UARTS and line cable connectors for the various terminal interfaces. A loop-back plug is included to permit testing of individual lines. The test is initiated by positioning the "Line Test" switch in either the "internal" mode or the "external" mode. LED indicators above each line will go on if that line fails a test. Testing can be done on an eight-line group without interrupting normal operation on other lines.

c. CS11 Models

The following models are available in the CS11 Series:

CS11/H — Full DH11 emulation for the PDP-11 series CPU's; software and diagnostic transparent; 8 - 64 asynchronous lines per controller. Will run on VAX-11/750 and VAX-11/780 systems equipped with a UNIX operating system.

CS11/U — Full DH11 emulation for the VAX-11 series of CPU's; uses Emulex VMS/UH software support package; 8 - 64 asynchronous lines per controller.

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

1. CS11/H Communications Multiplexer

The CS11/H is for use with PDP-11 series computers and emulates four of DEC's DH11's and four of DEC's DM11's using a single hex SPC

slot for 64 terminal lines. A comparable configuration with DEC's DH11 and DM11 would take 36 board slots because each DH11 with DM11 modem control employs 9 boards slots per 16-lines.

There are three main performance advantages of the CS11/H compared to DEC's DH11/DM11:

a. On DMA output, the CS11/H performs word rather than byte transfers. This doubles data transfer rate capability.

b. The CS11/H can transmit and receive data at up to 19.2K bytes, as compared to a maximum of 9.6K bytes for the DEC DH11.

c. The CS11/H has switch-enabled extra buffering for input characters. The DEC DH11 can buffer only 64 characters per 16 lines as compared to 128 characters per 16 lines in the CS11/H.

2. CS11/U Communications Multiplexer

The CS11/U emulates DEC's DH11 and is for use with VAX-11/750 and 11/780 computers. It consists of the CS11 hardware (with enhanced microcode) and the EMULEX VAX/UH software package, including a driver and diagnostics, developed and supported in-house by EMULEX. The VMS/UH software package is compatible with VAX/VMS. Like the CS11/H, just one hex-sized board handles from 8 to 64 asynchronous lines. The same performanace advantages which apply to the CS11/H also apply to the CS11/U.

NOTE: DEC does not offer a DH11 for their VAX-11 series, providing instead the lower-performance DZ11 for VAX applications. Thus, to achieve the performance advantages of the DH11 on VAX-11 systems and optimize use of the VAX itself, one may employ the Emulex CS11/U. Refer to Appendix P for performance comparison data on DH11 vs. DZ11 on VAX CPU's.

3. CS11/V Communications Multiplexer

The CS11/V, DV11-compatible for PDP-11 systems, handles a mix of synchronous/asynchronous lines in 8-line groups to a maximum of 32 channels. This is functionally equivalent to two DEC DV11's which employ a dedicated 9 slot backplane each, for a total of 18 to do the

same function. Other advantages of the Emulex CS11/V over DEC's DV11 are:

a) A rigorous self test to verify basic subsystem operation before the CS11/V is put online.

b) The CS11/V, as other CS11 emulations, performs a word transfer during DMA operations. The DEC DV11 performs byte transfers during DMA. This in effect allows a maximum of 19.2K bytes per second to be transferred during asynchronous operations. The DV11 has a maximum capability of 9.6K bytes per second during asynchronous operations.

c) Since the CS11/V is firmware driven, future expansion to handle other synchronous protocols is easily achieved. Being a fixed hardware design, the DEC DV11 will only be able to handle BISYNC and DDCMP protocols for synchronous operations.

Synchronous transfers are equivalent on both the Emulex CS11/V and the DEC DV11 because data rate is a function of the transmit clock.

2. CS21 General Description

a. CS21 Series Organization

The main element of the subsystem is the CC21 Communications Controller, a single pcb which mounts in any hex height SPC slot of a DEC-11 backplane. The controller microprocessor is programmed to implement the different emulation models available, and adaptation is made by installation of the proper PROM and USART set in sockets on the CC21 controller board. Organization of the EMULEX CS21 Communications Multiplexer is shown in Figure 3-4.

All line adapter circuitry is contained on the CC21 controller, and a simple passive CP21 Distribution Panel with 16 RS-232 connectors is used. This panel is functionally identical to the DEC H317 panel used with the DEC DZ11. Since CC21's and DZ11's are output pin compatible, a CC21 and DZ11 may coexist on either a DEC H317 or Emulex CP21 Distribution Panel.

The CS21 Series is ideal for applications involving a small number of terminals, typically 32 or less, where backplane space and power are not critical, and where the line adapter flexibility of the CS11 Series is not required.

b. CS21 Subsystem Components

1. CC21 - Communications Controller

The basic CC21 is an 8-bit microprocessor-based controller which performs all operations required to transfer data between the CPU host and the multiple terminals connected to the Distribution Panels. All communication protocol is handled by this unit. Standard microcode versions execute on exact emulation of specific DEC Communication Controllers (e.g. DH11) and the CC21 is transparent to the standard DEC operating and diagnostic software. The CS21 also executes self-test and subsystem diagnostics upon initial power-up.

The CC21 is configured for different emulations by PROM's and by USART chips since the DEC emulation DH11 and DZ11 multiplexers have different sets of line speeds.

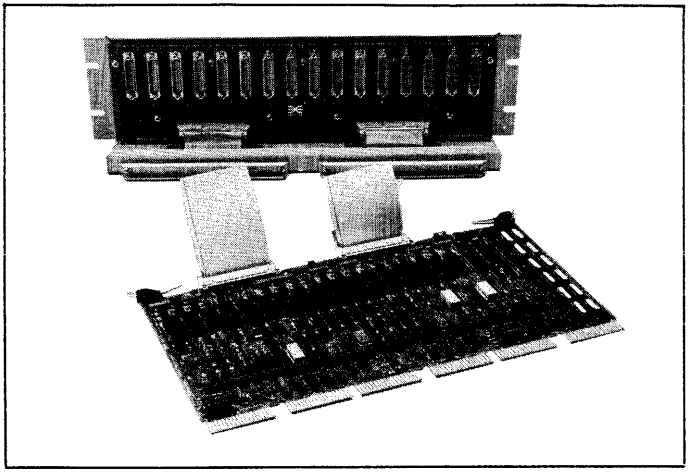
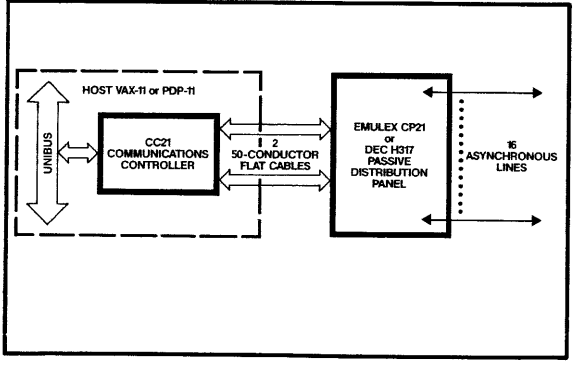


FIGURE 3-3 Emulex CS21 Series

FIGURE 3-4

CS21 SUBSYSTEM ORGANIZATION



The CC21 is packaged on a single hex height 2-sided pcb. The unit occupies a single SPC slot, presents one bus load, and draws approximately 8 amps of power from +5 volts, and 0.25 amps of power from ± 15 volts.

2. CP21 - Distribution Panel

The CP21 Distribution Panel includes a mechanical chassis and a pcb interface board. There are optional mounting brackets if the unit is to be installed inside a cabinet. The CP21 is compatible with a DEC H317 Distribution Panel.

c. CS21 Models

The following models are available on the CS21:

CS21/H — Full DH11 emulation, for the PDP-11 series of cpu's; software and diagnostic transparent; 16 lines per controller. Will run on VAX-11 series CPU's if equipped with UNIX operating system.

CS21/U — Full DH11 emulation, for the VAX-11 series of CPU's; uses Emulex VMS/UH software support package; 16 lines per controller.

CS21/Z — Full DZ11E emulation, for the PDP-11 and VAX-11 series of CPU's; software and diagnostic teransparent; 16 lines per controller.

1. CS21/H Communications Multiplexer

The CS21/H is for use with PDP-11 series computers and emulates one DEC DH11 with DZ11 type modem control (full duplex only). The CS21/H occupies a single hex SPC slot. The CS21/H controls a maximum of 16 terminals or like devices. A comparable DEC DH11 configuration occupies 9 slots per 16 lines.

The CS21/H has three main performance advantages over the DEC DH11/DM11.

a) On DMA output, the CS21/H performs a word rather than a byte transfer. This doubles data transfer rate capability.

b) The CS21/H can transmit and receive data at up to 19.2K bytes/second as compared to DEC's DH11/DM11 maximum of 9.6 Kbytes/second.

c) Input data buffering can be expanded to 256 characters per 16 lines as compared to the DEC DH11/DM11 maximum of 64 characters per 16 lines.

Modem control capability is limited and allows only the full-duplex mode of data transfer to be used. This characteristic is similar to the DEC DZ11.

2. CS21/U Communications Multiplexer

The CS21/U emulates DEC's DH11/DM11 and is for use with the DEC VAX family of computers. It consists of the CS21 hardware and the Emulex VAX/UH software package, which includes a terminal driver and diagnostics developed and supported by Emulex. The UH software package is compatible with VAX/VMS Version 2.0 and above.

Packaging characteristics and performance advantages are the same as the CS21/H.

NOTE: DEC does not offer a DH11 for their VAX-11 series, providing instead the lower performance DZ11 for VAX applications. Refer to Appendix P for performance comparison data on DH11 vs. DZ11 on VAX CPU's.

3. CS21/Z Communications Multiplexer

The CS21/Z is for use with PDP-11 and VAX-11 series computers and emulates the 16-channel DZ11E. The CS21/Z occupies a single hex SPC slot and controls a maximum of 16 terminals or like devices. A comparable DEC DZ11E 16-line configuration requires two controllers occupying two SPC slots.

The CS21/Z is functionally compatible with the DEC DZ11, but has two distinct advantages over the DZ other than less backplane space.

a) The CS21/Z has the option to increase the receiver buffer size from 64 characters per 16 lines to 128 characters. The DEC DZ11 is only 64 characters per 16 lines.

b) The CS21/Z has the option to increase the transmitter buffer size from 1 character to 16 characters. The DEC DZ11 has only a 1 character buffer.

3. PERFORMANCE CONSIDERATIONS - EMULEX COMMUNICATIONS MULTIPLEXERS

a. CS11 Performance Considerations - CS11/H, CS11/U and CS11/V

The CS11/H, CS11/U and CS11/V Communications Controllers - use the same basic microprocessor architecture as the Emulex disk and tape controllers and generally offer the same features and advantages inherent in all Emulex controller designs. Microcode implements all basic control, status, and data transfer operations.

Since the CC11 microprocessor time-shares operations on each line, there is a design limit on the composite average input/output data rate. This design limit is 50,000 characters/second. It should be noted that this composite average rate is much greater (by a factor of three or four) than a typical driver can handle.

Most CS11/H and CS11/U installations may be expandable to the full 64-line capacity regardless of the line signaling rates of the individual channels. This is because asynchronous communications in minicomputer based systems usually consist of keyboard terminals which transmit characters to the CS11 at the rate of only a few characters per second. CS11/V installations may always be expanded to full 32-line capacity.

b. CS21 Performance Considerations - CS21/H and CS21/U

The CS21/H and CS21/U likewise use the microprocessor architecture inherent in EMULEX tape and disk controllers offering the features and advantages common to disk and tape controller designs.

As in the CS11 Series, the CC21 microprocessor time-shares operations on each line. Hence, there is a design limit on the composite average input/output data rate of 50,000 characters/second. As noted above, this composite average rate is greater than a typical driver can handle(by a factor of three or four).

c. CS21 Performance Considerations - CS21/Z

The CS21/Z uses the same basic Communications Controller (CC21) that is used for the CS21/H and U.

Throughput considerations are more of a factor for the CS21/Z (DZ11 emulation) than with the CS21/H and CS21/U (DH11 emulation) because for each character transmitted or received, the CPU must be interrupted.

Enhancements to the receive operation are handled in the same manner as the CS21/H and CS21/U - the receive FIFO is expandable to 128 characters per 8 lines. In order to

achieve better transmit operation, the transmit buffer size is expandable to 16 characters versus a buffer size of only one character for the DEC DZ11.

NOTE: Appendix P gives comparison data taken from benchmark tests performed by EMULEX on the VAX-11/750 and VAX-11/780. The comparison study shows that the DH11 takes about 50 percent less CPU time than the DZ11 per terminal.

SECTION IV
VAX SERIES PRODUCTS

A. INTRODUCTION

The VAX series presently consists of the VAX-11/780 and the newer VAX-11/750. The 750 has an entirely different hardware design but preserves the overall architecture of the 780, with upward/downward compatibility. A single operating system, VMS, is provided by DEC for both machines; UNIX is available from third-party organizations. The VAX series has a 32-bit word length, and PDP-11 software is not directly usable.

Unofficial reports indicate DEC plans to offer at least 5 models in the VAX series, including models above and below the 750 and 780. It is anticipated that each will have an entirely different memory bus structure and that each will require a different Massbus Adapter (i.e. interface equivalent to the RH780 and RH750) if one is, in fact, provided for that model. It is anticipated that all VAX-11 series machines will incorporate a Unibus structure for basic input/output.

VMS supports Massbus peripherals (refer to Section I, B.2 above) only through a Massbus Adapter. Since the RH750 has just recently been completed, only the RM80 (120 MB Winchester) is presently available for that system as a Massbus device. The RK07 is provided as a Unibus peripheral for the 11/750. On the more mature 11/780 model, the RK07 plus larger Massbus peripherals are available, including: RM03, RM05, RM80, RP06 and RP07.

Emulex offers a Massbus-equivalent emulating controller (SC750) which interfaces to the internal high-speed memory bus (CMI) of the VAX-11/750. It also supports an equivalent Massbus type disk controller on the VAX Unibus - the SC21/V - which emulates DEC RM03 (80 MByte) and RM05 (300 MByte) storage subsystems. Emulex also supplies one Unibus disk controller and a Unibus tape controller:

SC12/V Disk Controller (RK07 Compatible)

TC11/V Tape controller (TU10 Compatible)

In addition to the above disk and tape controllers, the following communications multiplexers are available from Emulex on the VAX Unibus:

CS11/U (DH11 Compatible)

CS21/U (DH11 Compatible)

CS21/Z (DZ11 Compatible)

See Figure 4-1 for a composite picture of these products.

B. SC750 DISK CONTROLLER

The SC750 Disk Controller is a single-board unit much like the SC21, but it interfaces to the internal CMI bus for high-speed 32-bit parallel DMA data transfers. Since it functionally emulates the RH750 and Drive Control Logic of the Massbus, it is software transparent under any operating system designed for Massbus disk devices.

A block diagram of the VAX-11/750 is shown in the accompanying figure, and photographs show the physical layout of the RH750 interface area and the Emulex SC750 controller.

The 11/750 contains three prewired slots for installation of single-board RH750 interface boards. Separate controllers are implemented by the external Drive Control Logic (DCL) which can handle two disk drives. Up to 8 drives may be installed on an RH780.

The SC750 contains the entire CMI interface and drive controller logic for up to four physical drives and 8 logical drives on a single board of identical dimensions to the RH750. The controller has an SMD interface and can utilize essentially all drives having this standard. Since the SC750 emulates the entire Massbus complex, it is functionally transparent to any software written to support the RH750.

The CMI interface provides optimium performance at the system level since data transfers (32-bit parallel) are made directly to/from memory, with low-speed control and status transfers made via the Unibus Adapter. The use of multiple controllers should also improve throughput in very heavily loaded systems.

DEC presently offers only a 121 MByte Winchester, the RM80, on the RH750. VMS software, however, also supports the RM03 (80 MByte SMD), RM05 (300 MByte SMD), RP06 (200 MByte SMD) and RP07 (600 MByte Winchester).

The Emulex SC750 has two microcode sets which provide the following emulations by switch selection on the board.

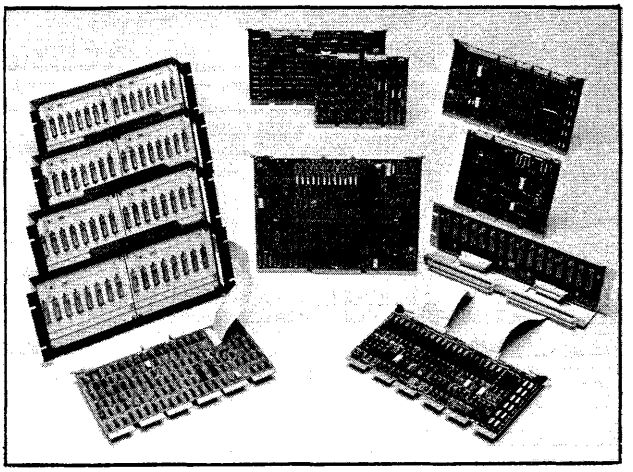


FIGURE 4-1 Emulex VAX-11 Series Products

FIGURE 4-2

VAX-11/750 CMI BUS ORGANIZATION

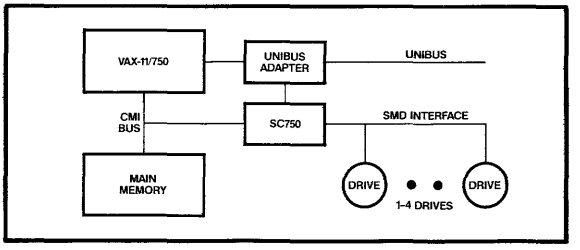


TABLE 4-1
SC750 BASIC EMULATIONS

EMULATION		FORMATTED CAPACITY	DRIVES (TYPICAL)	COMMENTS
Model	Type			
SC750/B1	RM03	67 MB	9762 SMD	Media Compatible
		67 MB	9730-80 MMD	Std. RM03
		67 MB	DM 980 SMD	Std. RM03
		134 MB	9730-160 MMD	2 X RM03
		134 MB	Fuj-2284 SMD	2 X RM03
	RM05	256 MB	9766 SMD	Media Compatible
		256 MB	CDS T302RM SMD	Std. RM05
		256 MB	DF 9330 SMD	Std. RM05
		512 MB	9775 FMD	2 X RM05
	RM80	121 MB	9730-160 MMD	Std. RM80
		121 MB	Fuj-2284 SMD	Std. RM80
		243 MB	DF 9330 SMD	2 X RM80
SC750/B2	RP06	174 MB	Memorex 677 SMD	Std. RP06
		349 MB	Fujitsu "Eagle"	2 X RP06

The above configurations are all software transparent, require no patches to standard VMS drivers, and are media compatible with the DEC drive for SMD units.

These are by no means the limit of drive manufacturers and/or types. As with all Emulex controllers, essentially any drive with the SMD interface can be supported; some may require patches to the VMS driver if the drive configuration does not match that of a DEC unit.

The SC750 configuration PROM permits different drive configurations in each model to be selected without changing emulation PROMS. In addition, drive capacities can be mixed as desired. For example, a 300 MByte SMD might be used as backup for a 675 MByte FMD. By placing multiple logical drives on one spindle, the system will run with standard software.

The SC750 has also been designed for handling the very high speed data rates - up to 15 MHZ - anticipated for several new high-density drives such as the 475 MByte Fujitsu Eagle.

A summary of the primary features of the SC750 controller is given in Table 4-2. A more complete description of the product and technical specifications are given in Appendix H.

The SC750 represents the optimium approach to adapting large-capacity, high-performance disk drives to the VAX-11/750. It contains all the key

features and benefits as the corresponding EMULEX PDP-11 and 11/70 controllers, plus more. And it has the flexibility and performance to adapt new peripheral devices to the system as they are developed by independent peripheral manufacturers.

TABLE 4-2

SC750 FEATURE/BENEFIT SUMMARY

FEATURE	BENEFIT
Single extended hex board package	Uses standard RH750 slot; no backplane modificiations, easy physical installation
Software transparent	No software changes
Configuration PROM	No microcode changes for drive selection; mixed-drive configurations
Common design to all Emulex controllers	Proven design, parts commonality, established production methods and equipment
Self-test	High confidence at subsystem level, easy trouble shooting
High performance	Equal to RH750 with equivalent drives; can handle high data rate drives (15 MHz) for future performance/capacity improvements
Low power	Reduced power loading, higher reliability

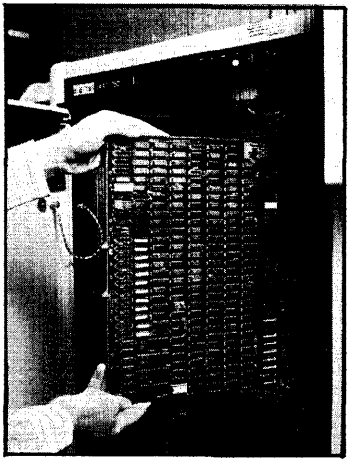


FIGURE 4-3

Integration of SC750 into VAX-11/750 computer.

C. SC21/V DISK CONTROLLER

Since the SC21 interfaces only to the Unibus, there is no CMI (11/750) or SBI (11/780) interface and all data transfers take place over the Unibus Adapter (UBA). The DEC software for RM devices takes advantage of extended SBI or CMI controller memory address capability, hence it does not support the memory mapping which must take place using the limited 18-bit address facility of the Unibus. For these reasons, system performance may be reduced, and a custom software package is required.

Emulex supports the SC21/V model on the VAX Unibus. Because of the very efficient implementation of the SC750 controller for the 11/750, there is only a small cost advantage with the SC21/V, and most users will generally elect the SC750 unless the need is to add storage capacity at minimum cost.

On the VAX-11/780 the same memory address limitation of the SC21/V requires separate software. However, there is a very large cost differential between an SBI controller and the SC21/V. In addition, installation of an SBI controller involves physical modification to the VAX SBI area which can be a consideration. Also, multiple Unibus Adapters (UBA's) can be installed on the 11/780 to gain performance advantages.

The SC21/V uses the VAX/UM software package written and supported by Emulex. This software offers more flexibility than standard DEC software, and it permits drives to be handled as either a system disk or a data disk on the Unibus of either VAX model. Elements of the VMS/UM software package are:

The VAX/UM software package completely supports installation, operation, and maintenance of the SC21/V based subsystem on the VAX-11/750 and 11/780 computers under VMS, Version 2.0 and above. Drives may be operated as the system disk or as a data disk on both the 11/780 and 11/750.

VMS/UMD DRIVER. Provides handling of mixed-drive capacities running as basic RM03/05 type devices. Non-standard drive configurations defined by the SC21 configuration PROM are automatically handled by the driver to eliminate any need for driver patching or modification.

VMS/UMF FORMATTER. Invokes SC21 built-in hardware formatter, thus eliminating need for separate software routine. Reads and prints out configuration of each installed drive.

VMS/UMB BOOT. Permits disk drives to be operated as the system disk by providing capability to the boot from either an RX01 floppy or TU58 cartridge using standard boot PROM's in the system, or from the disk drive (at higher speeds) using a special bootstrap PROM supplied with each controller.

VAX/UMX DIAGNOSTICS. Stand-alone package tests controller functions, basic disk functions and transfers, and Unibus operations. On-line package provides performance exerciser for media and drive testing in

the operating system environment.

The following points should be noted in considering the use of Unibus controller rather than a Massbus equivalent on the VAX series.

1. The standard DEC VMS disk software for RM03/05 and RP07 cannot be used. While this is not as convenient, a Unibus controller will prove to be a very capable alternative to a Massbus emulator. The Emulex VMS/UM software support package has been proven in many existing customer installations, because:

   a. VMS is itself designed for convenient addition of user-supplied, enternal drivers. Standard DEC documentation and classes are, in fact, available for instructing users in the techniques and procedures. This organization does not hold true for PDP-11 series operating systems, such as RSX11M and RSTS, where the DEC drivers must be overlaid with new software. The proper integration of such modifications into those operating systems, as opposed to VMS, represents major effort and an in-depth knowledge of the design of the entire operating system.

   b. The VMS interface does not change with each version of VMS. Any such change would require every user to rewrite his drivers and present a significant problem to much of the VAX user base. As a result, the Emulex driver has been used in unaltered form through Versions 1.6, 2.0, and 2.2. Emulex users, therefore, do not experience the difficulty associated with other operating systems and are not dependent on Emulex for frequent updates.

   c. Installation of a Unibus subsystem with the software package has proven as simple as any other approach. Physical installation is, of course, easier than inserting multiple boards into the RH780 area and does not require physical disassembly and rewiring of the sensitive SBI backplane.

   d. The Emulex software is designed with more features than the standard DEC driver. For example, the drive-type code is read upon command by the SC21/V and passed directly to the driver. During initialization, the driver configures itself to the specific combinations of drives on the controller, hence, users may add drives of different configuration/capacity and run them on the same controller. This feature is not provided in standard DEC software. (The same features are contained in the Berkeley UNIX drivers).

   e. All Emulex VAX software is written and supported in house by a permanent programming staff. Emulex owns and uses three VAX systems (2 11/750's and 1 11/780) for both development and production and is a VMS subscriber. Users are therefore insured that revisions, updates, and improvements are supplied on a timely and continuing basis. All software carries an initial 12 month warranty, and continuing support

is available thereafter for a nominal fee.

2. Concern is often stated over possible overloading of the VAX Unibus. This could be a potential difficulty; however,

   a. Quite acceptable performance has been achieved on many SC21/V existing installations.

   b. When the Unibus disk is used for data storage in conjunction with a Massbus system disk, an overlap of operations is acheived. This may enhance rather than degrade system performance.

   c. If a UBA is added for disk operations on the VAX-11/780, better system performance is, often obtained. The added cost of the extra UBA is a negative factor, but the combined cost of the SC21/V and the UBA may not exceed that of an SBI controller, and it will certainly be less than another RH780 plus drive. The heavy buffering on the SC21/V, plus its adaptive DMA throttle feature, permits it to be run at low bus priorities and permits other device interrupts to be processed in a controlled, timely manner.

3. The SC21/V will fit across the entire VAX product line without either hardware or software driver changes. This will not be true for any Massbus-equivalent controller because the memory bus structure and packaging are entirely different (e.g. 750 vs. 780). The SC21/V will be immediately applicable, to each new VAX model introduced.

4. The SC21/V can be used as either a system disk or a data disk on the 11/750 and 11/780. Since many VAX's are delivered with a Massbus system disk, the SC21/V is often used to add large data storage to the system. The split between system disk and data disk operations on separate busses can be advantageous in many applications.

5. Any SC21 can be converted to/from any version, including the V, with a PROM change only. Users who need multiple versions or wish to change CPU's later, can use SC21's interchangeably.

The final selection of a controller is based upon the best combination of factors for each installation. The advantages of the SC21/V have made it an excellent choice for many users who have found the above meaningful.

D. SC12/V DISK CONTROLLER

The SC12/V is the RK06/07 compatible version of the standard SC12 controller described fully in Section I (p. 30 - 32).

DEC supports the 28 MByte RK07 across the VAX product line under VMS as a Unibus disk device. It may be used as a system disk. The RK07 is a

removable cartridge disk manufactured by DEC and is not available as an independent peripheral.

The SC12/V is important to VAX users who wish to adapt smaller capacity drives to the VAX Unibus since the RK06 (14 MByte) RK07 (28 MByte) software can be used transparently with other disks. The CMD (fixed and removable media) with logical RK06's mapped on each surface is attractive in many cases because the backup issue is solved with one device.

E. TC11/V TAPE CONTROLLER

The TC11 emulates the basic DEC TM11 controller which supports the TU10 tape transport as described in Section II.

The TU10 is not supported under VMS, hence it is necessary to have a software driver added. Emulex has written and supports a complete tape package, VMS/UT, which can adapt any industry standard tape transport to the VAX Unibus. The VAX/UT software package completely supports installation, operation, and maintenance of the TC11/V based subsystem on the VAX-11/750 and 11/780 computers under VMS, Versions 2.0 and above. The VMS/UT elements are:

VMS/UTD DRIVER. Provides handling of all tape transport speeds, densities, and mixes permitted by the standard TC11 controller. Operator density select is included.

VMS/UTX DIAGNOSTICS. Stand-alone package test controller functions, and transfers, and Unibus operations. On-line package provides performance exerciser for media and drive testing in the operating system environment.

The decision to add tape to the VAX Unibus is generally not so great a consideration as for disk since it is never a system device, and the performance requirements are not as demanding. The TC11/V represents a very effective and ecomonical approach and should be seriously considered in lieu of a Massbus type system.

F. CS11 AND CS21 MULTIPLEXERS

The only communications multiplexer supported by DEC on the VAX series is the DZ11. This is a Unibus device which incorporates interrupt driver program control for the input and output of characters.

Many users have encountered serious performance problems in supporting large numbers of asynchronous terminals on a VAX system. Since many terminal devices are block-oriented on output, a DH11-type device can potentially provide performance advantages over the DZ11.

Emulex supports three multiplexer products on the VAX series:

CS11/U

CS21/U

CS21/Z

The U models are essentially the same as the H models for DH11 emulation on the PDP-11 but are optimized for VAX Unibus operations. The Emulex VMS/UH software package, consisting of diagnostics and a handler, is supplied with each U model controller. This package has been written in-house by Emulex and is fully supported. The VAX/UH software package consists of a DH11/compatible driver plus diagnostics which completely supports installation, operation, and maintenance of the CS11/HV subsystem on the VAX-11 series of computers under VMS, Version 2.0 and above. Elements of the VMS/UH software are:

VAX/UHD DRIVER. Provides DH11-compatible handling of asynchronous communications lines to provide improved performance by elimination of character-by-character interrupts for output transmission.

VAX/UHX DIAGNOSTICS. Stand-alone package tests controller and line functionality, including either internal or external loop-back. A real-time exerciser is also included.

The CS21/Z is a standard DZ11E emulation (16 channels) and therefore runs transparently under VMS. It is useful for users who do not need DH11 performance, find the slightly lower price of the CS21/Z attractive, and/or do not wish to use external VMS software.

It should be noted that the CS21/Z has a so-called "enhanced" mode which provides an output FIFO for loading multiple characters ready in memory when are output interrupt occurs. This mode of operation requires a patch to the standard VMS software driver. Emulex generally recommends the use of the CS21/U in lieu of this mode because:

(1) Installation of the full Emulex VMS/UH software package is no more difficult than installing the "enhanced" DZ driver patches;

(2) The DZ patches will always be modified with each VMS revision; the Emulex VMS/UH package will almost never require revision on a VMS revision since it is an external driver, and therefore the patched DZ approach requires more support than the VMS/UH package;

(3) The performance of the buffered DZ can seldom if ever exceed that of the full DH, and generally, it will be lower.

NOTE: Using the DH11 emulation over the standard DZ11 can produce significant performance improvement. In Appendix P, a set of test data is presented comparing the performance of the Emulex CS11/U with the VMS/UH software against that of the DEC DZ11 on both the VAX-11/750 and 11/780 CPU's.

G. VAX SOFTWARE SUPPORT

All VMS/UX software packages have been developed and are supported in-house by the Emulex software support group. All elements of every package, hardware and software, cary a one year design warranty plus update service for additions and revisions made, including any required by new releases of VMS software. Update service is available beyond one year at nominal cost.

Distribution media supplied with each controller is either TU58 compatible cartridge (VAX-11/750) or RX01 compatible diskette (for VAX-11/780), each media containing the applicable driver/diagnostic package. Except for stand-alone diagnostics, all software is in VMS execution code, permitting easy, immediate integration into the system (load-and-go operation.).

EMULEX

APPENDIX A
EMULEX MODEL SC01
LARGE DISK CONTROLLER

THIS FIRST—AND BEST—LSI-11 DISK CONTROLLER GIVES YOU ALL THE ADVANTAGES OF...

USING **standard** DEC operating systems and diagnostic software.

INCORPORATING currently available large capacity **storage module, Winchester,** or **fixed-head** type disk drives.

IMBEDDING the controller in only **two existing quad slots** of your standard LSI-11 backplane.

PERFORMING a comprehensive set of **self-test and subsystem diagnostics.**

WORKING properly when you plug it in and **continuing to work reliably** for thousands of hours.

YOU GET ALL THESE ADVANTAGES BECAUSE...

The SC01 was designed specifically and exclusively to integrate large capacity moving head disk drives with the LSI-11. Incorporating a standard SMD interface, it is optimum for SMD class drives having capacities of 80 MBytes and above. Using advanced, modern microprocessor architecture, the SC01 has been configured through various firmware versions, to emulate DEC's RP11/RP02/RP03 (Model A), RH11/RM02/RM05/RP06 (Model B), and RK611/RK06 (Model C—on CMD drives).

The unit is an excellent companion to the EMULEX SC02 disk controller which is optimized for small-to-medium 8" and 14" class drives having capacities of 12-160 MBytes. Together with other EMULEX SC0X models, which offer alternate interface configurations (e.g. ANSI), users have complete flexibility in selecting drives and controllers for every LSI-11 hard disk application.

THE SC01 DESIGN CONTINUES TO SET THE STANDARD FOR USE OF LARGE DISK CONTROLLER TECHNOLOGY ON THE LSI-11

The following combination of features illustrate why one of the SC01 standard versions meet all requirements for the LSI-11 application of large-capacity disk subsystems.

ADVANCED MICROPROCESSOR ARCHITECTURE. A unique (Patent Pending) design incorporates high-speed bipolar technology to meet the performance demands of present and anticipated storage module and Winchester disk control/data transfer rates and to provide complete application flexibility, including programmed emulations of existing controller designs.

COMPACT PACKAGING. Only two quad height pcb's plug into any pair of standard Q Bus slots to minimize mounting space requirements, eliminate "boat anchor" boxes and cables, simplify spares stocking requirements, avoid specially wired system units/backplanes, reduce component count, and maximize inherent reliability.

INTERNAL SELF-TEST. Automatic self-test and operator-initiated subsystem diagnostics, supported by error display lamps, are contained in on-board firmware.

STANDARD SMD INTERFACE. Any two industry compatible drives, all operating at serial data rates up to 10 Mhz, may be integrated into a single subsystem. The SC01 is adaptable to all known present and future disk products of this type. Fully buffered disk I/O circuitry permits operation at radial distances up to fifty feet and daisy chain distances up to one hundred feet.

STANDARD Q BUS INTERFACE. The controller interfaces via one of the two pcb's to any standard Q Bus slot, uses approved bus drivers and receivers, and presents only one unit load to all signal lines. Bus addressing is to 128K Words with interrupt capability.

LARGE DISK I/O BUFFER. A 2048 byte RAM memory provides a full three sector data buffer in all applications. This level of buffering is essential on the relatively slow Q Bus because it completely eliminates "data late" worries, permits multiple contiguous sector reads, eliminates the need for a sector interlace scheme, and permits the controller to be operated at a low bus priority level while handling the full data transfer rate performance of modern SMD type disk drives.

ECC/CRC HARDWARE. Thirty-two bit ECC for data error detection/correction (single 11-bit error burst), and sixteen-bit CRC for header error detection, all under microprogram contol, is provided in all controller versions.

CONVENIENCE FEATURES. A host of items—such as convenient priority level jumpers and selectable bus address range and configuration/operational options—eliminates multiple hardware versions and makes the unit simple and easy to configure. On-board LED's provide error condition and operating mode display.

COMMON HARDWARE. Identical physical circuit boards, adapted through firmware only, are used for all SC01 versions, including special applications, which eliminates the need for using different hardware for different disk capacities, controller versions, and software modes.

GENERAL SPECIFICATIONS

The following specifications apply to all SC01 series large disk controllers.

Characteristic	Specification
FUNCTIONAL	
Design	High-speed bipolar microprocessor-based controller for integration of industry-standard SMD, fixed-head, and Winchester type mass storage devices to host LSI-11 computer; incorporates unique (Patent Pending) design to achieve extreme high-speed operations with minimum hardware.
Computer Interface	Standard Q Bus via quad interface on B board (power and ground only to A board).
Disk Interface	Storage Module Drive (SMD) interface standard; serial data rate up to 10 Mhz.
Bus Address Range	0-128K Words.
Bus Register	Four selectable start locations.
Base Address	Selectable.
Vector Address	Fixed by firmware.
Priority Level	Jumper selectable, BR4 or 5.
Error Control	On-board 32-bit ECC and 16-bit CRC hardware for error detection/correction under microprogram control.
Status Display	Edge-mounted LED for mode/error/status display under microprogram control.
Option Switches	Eight on-board slide switches for selection of program-controlled operating/configuration options.

Characteristic	Specification
FUNCTIONAL	
Buffer Memory	2048 byte high-speed RAM buffer, accessible to the microprogram, for data buffering and internal storage operations. Typically 1536 bytes used for data buffering.
PHYSICAL	
Packaging	Two printed circuit boards interconnected by Amp Mod 1 pins; standard Q Bus 4-connector interface. Extractor handles provided for easy insertion/removal.
Mounting	Any two adjacent Quad slots in standard backplane or system unit.
Cable Connectors	One common 60-pin control (A) flat cable connector on A board; two 26-pin radial data (B) flat cable connectors on B board.
Physical Drives	1 or 2 per controller.
ELECTRICAL	
Q Bus Interface	Approved line drivers/receivers used exclusively; one unit load per bus signal line.
Disk Interface	Differential line drivers and receivers used on all signal lines. Daisy chain (A) and radial (B) cable lengths up to 100 and 50 feet, respectively.
Power	+5±5%, 9 Amps max; standard backplane/system unit pins used.
ENVIRONMENTAL	Exceeds all environmental ranges and conditions specified for commercial LSI-11 computers and applicable disk drives.

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STANDARD MODELS

The SC01 is available in the three basic standard models of DEC fixed and moving head storage subsystems. All models execute applicable DEC standard diagnostics, operating systems, and applications software.

• Model SC01/A

Supports standard SMD (removable media), MMD (fixed media), and CMD (removable/fixed media) type drives of various capacities. Emulates the DEC RP11 controller combined with multiple RP02 (20.8 MByte) or RP03 (41.6 MByte) disk drives. Either standard, expanded, or contracted size logical drive units are mapped onto 1 or 2 physical drives, depending on version/mode. Controller includes all standard features plus switch selection of transparent ECC with software error reporting. Characteristics of four of nine available standard versions are summarized here. Supported by RT11 and RSX11M.

CHARACTERISTIC	VERSION			
	SC01/A1	SC01/A2	SC01/A3	SC01/A4
Drive Type — Capacity	SMD-80	SMD-80	MMD-12/24	CMD-32/64/96
Emulation	RP02	RP03	RP02	RP02
Mode	Standard	Expanded	Contracted/Std.	Contracted
Platters/Drive	3	3	2/4	2/4/6
MBytes/Logical Unit	20.8	62.4	10.4/20.8	13.4
Logical Units/Drive	3	1	1	2/4/6
MBytes/Drive	62.4	62.4	10.4/20.8	26.8/53.6/80.4
Drives/Controller, Max	2	2	2	2/2/2
MBytes/Controller, Max	124.8	124.8	20.8/41.6	53.6/107.2/107.2

• Model SC01/B

Supports standard SMD (removable media), or MMD (fixed media) type drives of 80, 160, 200, 300, or 600 MByte capacity. Emulates DEC RH11 Massbus controller combined with multiple RM02 (67.4 MByte), RM05 (256 MByte), or RP06 (174.4 MByte) disk drives. Either standard, expanded, or contracted size logical units are mapped onto 1 or 2 physical drives, depending on version/mode. Controller includes all standard features plus: pack format command; auto bootstrap command; transparent data checksum; and programmable bus DMA bandwidth control. Two standard versions are shown; B3 and B4 versions support 160 and 600 MByte drives. Supported by RSX11M on LSI-11/23.

CHARACTERISTIC	VERSION			
	SC01/B1		SC01/B2	
Drive Type — Capacity	SMD-80	SMD-300	SMD-200	SMD-300
Emulation	RM02	RM02	RP06	RP06
Mode	Std.	Exp.	Std.	Exp.
Platters/Drive	3	10	10	10
MBytes/Logical Unit	67.4	256.1	174.4	253.7
Logical Units/Drive	1	1	1	1
MBytes/Drive	67.4	256.1	174.4	253.7
Drives/Controller, Max	2	2	2	2
MBytes/Controller, Max	134.8	512.2	348.8	507.4

• Model SC01/C

Emulates DEC RK611 controller combined with multiple RK06 (13.9 MByte) disk drives. Logical RK06 disks are mapped onto a single surface of 32-96 MByte CMD type drives, providing 27.8-83.4 MByte capacity per drive, and system capacities of up to 8 logical units (111 MBytes) on any applicable mix of 32, 64, and 96 MByte spindles. Controller features are more extensive than those of RP11, but less than those of RH11 and unit is well suited for the CMD type drives having removable cartridges. Supported by RT11 and RSX11M.

CHARACTERISTIC	VERSION		
	SC01/C1		
Drive Type — Capacity	CMD-32	CMD-64	CMD-96
Platters/Drive	2	3	4
MBytes/Logical Unit	13.9	13.9	13.9
Logical Units/Drive	2	4	6
MBytes/Drive	27.8	55.6	83.4
Drives/System, Max	2	2	1
MBytes/System, Max	55.6	111.2	83.4

EMULEX

APPENDIX B
EMULEX MODEL SC02
SMALL/MEDIUM DISK CONTROLLER

DESIGNED FOR HANDLING SMALL TO MEDIUM CAPACITY DISK DRIVES, THE SC02 GIVES YOU THE ADVANTAGES OF...

USING standard DEC operating systems and diagnostic software.

IMBEDDING the controller in any single quad slot of a standard LSI-11 backplane.

PERFORMING the full error detection/correction algorithms required for reliable application of modern, high-density disk drives.

EXECUTING a comprehensive set of self-test diagnostics as part of every startup operation.

REPLACING separate system bootstrap, bus terminator, and real time clock hardware with built-in options on the board.

INCORPORATING most currently available small to medium size 8" and 14" disk drives.

MIXING different types and capacities on one controller for optimizing combinations of fixed (Winchester) and/or removable media drives.

YOU GET OPTIMUM COST/ PERFORMANCE IN THIS RANGE BECAUSE...

The SC02 was designed specifically and exclusively to integrate small-to-medium capacity moving head disk drives with the LSI-11. Incorporating a standard SMD interface, it is optimum for 14 inch drives up to 160 MBytes (including CMD type drives) and for all current 8" drives which offer an SMD interface option. The unit is an excellent companion product to the Emulex SC01 controller which is designed for SMD class drives having capacities of 80 MByte and above. Together with other Emulex SCOX models which offer alternate interface configurations (e.g. ANSI), users have complete flexibility in selecting drives and controllers for every LSI-11 hard disk application.

UNIQUE, UNCOMPROMISING DESIGN GIVES YOU BIG SYSTEM CAPABILITY IN A SMALL, ECONOMICAL PACKAGE

The SC02 design is based on Emulex microprocessor technology, already proven in thousands of controller installations. The following combination of features makes it an unbeatable choice for effectively using today's 14" and smaller 8" disk drives in LSI-11 based systems.

MICROPROCESSOR ARCHITECTURE. The same basic Emulex bipolar microprocessor architecture which consistently sets the industry standards is used to give the SC02 broad flexibility and high performance.

COMPACT PACKAGING. Only one quad height pcb plugs into any standard Q Bus slot to minimize mounting cost and complexity.

SOFTWARE TRANSPARENCY. Microcode versions provide software transparent emulation of DEC RP02/03 and RK06/07 subsystems, including execution of standard system level diagnostics, which permits use of standard operating system drivers.

ECC/CRC HARDWARE. The standard 32-bit ECC used for SMD-class disk error detection/correction (single 11-bit error burst), combined with a 32-bit header CRC, is provided to insure reliable operation with all types of high-density drives, particularly those with removable media.

BUILT-IN CLOCK. Hardware included on the board provides software-controllable line time clock (BDV11-compatible).

BOOTSTRAP/TERMINATOR OPTION. Sockets are provided for insertion of 512 word bootstrap PROMs and Q Bus terminator resistors. Combined with the clock, these facilities can often eliminate separate system hardware (typically the BDV11) used for these functions.

MIXED DRIVE CAPACITY. Disk drives having different combinations of heads, surfaces, and densities can be handled by the controller; the drive type code can be read directly from the controller by software to permit adaptive configuring by custom software drivers.

LOW POWER. Only 5.7 amps is required from the CPU internal +5V power supply (no +12V power required) via standard backplane power pins.

INTERNAL SELF TEST. Extensive self-test routines, contained in microcode, automatically verify controller operation when power is applied.

DISK SECTOR BUFFER. A full 512 byte data buffer permits multiple sector reads with a 3-to-1 sector interlace format. Buffer operation eliminates possibility of "data late" conditions and permits controller to be operated at low bus priorities.

SMD INTERFACE. Any two industry compatible drives, each operating at serial data rates to 10 MHz, may be integrated.

AND YOU GET MORE THAN JUST A GREAT PRODUCT

With the SC02 you get superb quality and excellent support. Production capability exists to meet the highest of volume requirements. All components are pre-aged for over 160 hours, and final product assemblies are environmentally cycled over a temperature range for over 48 hours (while operating) to insure high reliability from the moment they are first installed. All products are backed by a full one year warranty and supported internationally by the Emulex technical applications group.

GENERAL SPECIFICATIONS

The following specifications apply to all SC02 Series disk controllers.

Characteristic	Specification
FUNCTIONAL	
Design	High-speed bipolar microprocessor-based controller for integration of industry-standard SMD, fixed-head, and Winchester type mass storage devices to host LSI-11 computer; incorporates unique design to achieve extreme high-speed operations with minimum hardware.
Computer Interface	Standard Q Bus.
Disk Interface	Storage Module Drive (SMD) interface standard; serial data rate up to 10 MHz.
Bus Address Range	0-128K Words.
Bus Register	Two selectable start locations.
Vector Address	Four selectable vectors.
Priority Level	Level 5 & 4.
Error Control	On-board 32-bit data ECC and header CRC hardware for error detection/correction under microprogram control.
Status Display	Edge-mounted LED for activity/error/status display under microprogram control.
Option Switches	On-board slide switches for selection of program-controlled operating/configuration options.
Bootstrap/ Terminator Option	Sockets provided for 512 word bootstrap PROMS and Q Bus termination resistor packs.
Software Controllable Line-Time Clock	BDV11 compatible clock control.

Characteristic	Specification
FUNCTIONAL	
Buffer Memory	1024 byte high-speed RAM buffer, accessible to the microprogram, for data buffering and internal storage operations. Typically 512 bytes used for data buffering.
Media Format	3 to 1 sector interlace.
PHYSICAL	
Packaging	One printed circuit board, standard Q Bus 4-connector interface.
Mounting	Any quad slot in standard backplane or system unit.
Cable Connectors	One common 60-pin control (A) flat cable connector and two 26-pin radial data (B) flat cable connectors.
Physical Drives	1 or 2 per controller.
Logical Drives	1 to 8 per controller.
ELECTRICAL	
Q Bus Interface	Approved line drivers/receivers used exclusively; one unit load per bus signal line.
Disk Interface	Differential line drivers and receivers used on all signal lines. Daisy chain (A) and radial (B) cable lengths up to 35 and 25 feet respectively.
Power	+5V ± 5%, 5.7 amps max; standard backplane/system unit pins used.
ENVIRONMENTAL	Exceeds all environmental ranges and conditions specified for commercial LSI-11 computers and applicable disk drives.

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STANDARD MODELS

The SC02 is available in two standard models which emulate standard DEC disk storage subsystems. All models execute applicable DEC diagnostics, operating systems, and applications software.

The SC02 includes a configuration PROM which permits definition of up to 64 different switch selectable combinations of disk drive configurations on the two controller ports. This permits essentially unlimited selection of drive type/capacity combinations.

• Model SC02/A

Emulates the DEC RP11E controller with standard sized RP02 (20.8 MByte), RP03 (41.6 MByte) or expanded capacity, logical units. Controller includes all RP11E functional features/capability plus extended features, such as automatic pack formatting and switch selection of transparent ECC with error reporting to system software. Supports essentially all standard SMD (removable media), Winchester (fixed media), and CMD (removable/fixed media) type drives of various capacities from 12-160 MBytes. A single microcode package with switch selection of desired configuration supports all drives applicable to this model.

4 of 64 Switch-Selectable Drive Configurations

CHARACTERISTIC	CONFIGURATION NUMBER			
	0	1	2	3
Drive Type — Capacity	SMD-80	SMD-80	MMD-12/24	CMD-32/64/96
Emulation	RP02	RP03	RP02	RP02
Mode	Standard	Expanded	Contracted/Std.	Contracted
Platters/Drive	3	3	2/4	2/4/6
MBytes/Logical Unit	20.8	62.4	10.4/20.8	13.4
Logical Units/Drive	3	1	1	2/4/6
MBytes/Drive	62.4	62.4	10.4/20.8	26.8/53.6/80.4
Drives/Controller, Max.	2	2	2	2/2/2
MBytes/Controller, Max.	124.8	124.8	20.8/41.6	53.6/107.2/107.2

• Model SC02/C

Emulates the DEC RK611 controller combined with multiple RK06 (13.9 MByte) or RK07 (27.8 MByte) logical units. Controller includes all RK611 capability plus the same extended features provided in the Model A series. Particularly well-suited for support of 32-96 MByte CMD-type drives having a removable and multiple fixed platters, with a logical RK06 mapped onto each data surface. Also supports other 8" and 14" drives by mapping 1 or more standard logical RK06/07 drives onto 1 or 2 physical drives. A single microcode package with switch selection of desired configuration supports all drives applicable to this model.

3 of 64 Switch-Selectable Drive Configurations

CHARACTERISTIC	CONFIGURATION NUMBER		
	0	1	2
Drive Type — Capacity	CMD-32	CMD-64	CMD-96
Platters/Drive	2	3	4
MBytes/Logical Unit	13.9	13.9	13.9
Logical Units/Drive	2	4	6
MBytes/Drive	27.8	55.6	83.4
Drives/System, Max.	2	2	1
MBytes/System, Max.	55.6	111.2	166.8

EMULEX

APPENDIX C
EMULEX MODEL SC04
SMALL/MEDIUM DISK CONTROLLER

DESIGNED FOR HANDLING SMALL TO MEDIUM CAPACITY WINCHESTER DISK DRIVES, THE SC04 GIVES YOU THE ADVANTAGES OF...

USING standard DEC operating systems and diagnostic software.

IMBEDDING the controller in any single quad slot of a standard LSI-11 backplane.

ENJOYING the protection of full error detection/correction algorithms required for reliable application of modern, high-density disk drives.

EXECUTING a comprehensive set of self-test diagnostics as part of every startup operation.

REPLACING separate system bootstrap, bus terminator, and real time clock hardware with built-in options on the board.

INCORPORATING a currently available small to medium size 8" Winchester disk drives with ANSI interface.

MIXING different types and capacities on one controller for optimizing system configuration.

YOU GET OPTIMUM COST/PERFORMANCE IN THIS RANGE BECAUSE...

The SC04 was designed specifically and exclusively to integrate small-to-medium capacity 8" Winchester disk drives with the LSI-11, incorporating a standard ANSI interface. The unit is an excellent companion product to the EMULEX SC01 controller which is designed for SMD class drives having capacities of 80 MByte and above. Together with other EMULEX SCOX models which offer alternate interface configurations (e.g. SMD), users have complete flexibility in selecting drives and controllers for every LSI-11 hard disk application.

UNIQUE, UNCOMPROMISING DESIGN GIVES YOU BIG SYSTEM CAPABILITY IN A SMALL, ECONOMICAL PACKAGE

The SC04 design is based on EMULEX microprocessor technology, already proven in thousands of controller installations. The following combination of features makes it an unbeatable choice for effectively using today's 8" disk drives in LSI-11 based systems.

MICROPROCESSOR ARCHITECTURE. The same basic EMULEX bipolar microprocessor architecture which consistently sets the industry standards is used to give the SC04 broad flexibility and high performance.

COMPACT PACKAGING. Only one quad height pcb plugs into any standard Q Bus slot to minimize mounting cost and complexity.

SOFTWARE TRANSPARENCY. Microcode provides software transparent emulation of DEC RK06/07 subsystems, including execution of standard system level diagnostics, which permits use of standard operating system drivers.

ECC/CRC HARDWARE. The standard 32-bit ECC used for SMD-class disk error detection/correction (single 11-bit error burst), combined with a 32-bit header CRC, is provided to insure reliable operation with all types of high-density drives, particularly those with removable media.

22-BIT ADDRESSING. Full 22-bit hardware addressing provided to support full 4096 MByte memory capacity, planned for future LSI-11 models.

BUILT-IN CLOCK. Hardware included on the board provides software-controllable line time clock (BDV11-compatible).

BOOTSTRAP/TERMINATOR OPTION. Sockets are provided for insertion of 512 word bootstrap PROMs and Q Bus terminator resistors. Combined with the clock, these facilities can often eliminate separate system hardware (typically the BDV11) used for these functions.

MIXED DRIVE CAPACITY. Disk drives having different combinations of heads, surfaces, and densities can be handled by the controller; the drive type code can be read directly from the controller by software to permit adaptive configuring by custom software drivers.

LOW POWER. Only 5.7 amps is required from the CPU internal +5V power supply (no +12V power required) via standard backplane power pins.

INTERNAL SELF TEST. Extensive self-test routines, contained in microcode, automatically verify controller operation when power is applied.

DISK SECTOR BUFFER. A full 512 byte data buffer permits multiple sector reads with a 3-to-1 sector interlace format. Buffer operation eliminates possibility of "data late" conditions and permits controller to be operated at low bus priorities.

ANSI INTERFACE. Up to eight drives having the ANSI X3T9.3 interface may be daisy chained on one controller.

AND YOU GET MORE THAN JUST A GREAT PRODUCT

With the SC04 you get superb quality and excellent support. Production capability exists to meet the highest of volume requirements. All components are pre-aged for over 160 hours, and final product assemblies are environmentally cycled over a temperature range for over 48 hours (while operating) to insure high reliability from the moment they are first installed. All products are backed by a full one year warranty and supported internationally by the EMULEX technical applications group.

GENERAL SPECIFICATIONS

The following specifications apply to all SC04 series disk controllers.

Characteristic	Specification
FUNCTIONAL	
Design	High-speed bipolar micro-processor-based controller for integration of industry-standard 8" Winchester type mass storage devices to host LSI-11 computer; incorporates unique design to achieve extreme high-speed operations with minimum hardware.
Computer Interface	Standard Q Bus.
Disk Interface	ANSI X3T9.3 specification. Up to 8 drives, 2 different capacities per controller.
Bus Address Range	0-4096 MBytes (22 bits).
Bus Register	Two selectable start locations.
Vector Address	Four selectable vectors.
Priority Level	Level 5.
Error Control	On-board 32-bit data ECC and header CRC hardware for error detection/correction under microprogram control.
Status Display	Edge-mounted LED for activity/error/status display under micro-program control.
Option Switches	On-board slide switches for selection of program-controlled operating/configuration options.
Bootstrap/ Terminator Option	Sockets provided for 512 word bootstrap PROM and Q Bus termination resistor packs.
Software Controllable Line-Time Clock	BDV11 compatible clock control.

Characteristic	Specification
FUNCTIONAL	
Buffer Memory	1024 byte high-speed RAM buffer, accessible to the micro-program, for data buffering and internal storage operations. Typically 512 bytes used for data buffering.
Media Format	3-to-1 sector interlace.
PHYSICAL	
Packaging	One printed circuit board, standard Q Bus 4-connector interface.
Mounting	Any quad slot in standard backplane or system unit.
Cable/Connector	One 50-pin daisy chain flat cable connector.
Physical Drives	1 to 8 per controller.
ELECTRICAL	
Q Bus Interface	Approved line drivers/receivers used exclusively; one unit load per bus signal line.
Disk Interface	ANSI X3T9.3 spec.; 3 meters max. cable length.
Power	+5V ± 5%, 5.7 amps max; standard backplane/system unit pins used.
ENVIRONMENTAL	Exceeds all environmental ranges and conditions specified for commercial LSI-11 computers and applicable disk drives.

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DISK DRIVE CONFIGURATIONS

The SC04/C emulates the DEC RK611 Controller combined with multiple RK06 (13.9 MByte) and RK07 (27.4 MByte) logical units mapped on to the drive surfaces. The RK06/07 emulation provides performance advantages over the RL01/02 emulation commonly used for small capacity drives, including: greater total system capacity; special read/write across cylinder boundaries; hardware head switching; and overlapped seeks on multiple drives.

A unique Configuration PROM permits switch selection of any one of 64 combinations of two drive configurations. Logical units are mapped in contracted, standard, or expanded capacities to best utilize the formatted capacity of each drive model. The controller executes DEC software drivers and diagnostics transparently for standard logical drive sizes; patches are required for non-standard logical mappings. EMULEX-furnished diagnostics are self-sizing and automatically adapt their functions to non-standard drive sizes.

The following manufacturers have announced ANSI interfaces for their products:

Manufacturer	Model	Capacities
Ampex	DF840, 880	41.7, 82.9
BASF	617X	8.0, 24.0, 40.0
Kennedy	7300	41.4
Pertec	D8000	20.3
Priam	1070, 2050, 3450	10.8; 21.2, 35.3
SLI	Cheyenne	7.3, 22.0, 36.7, 51.4
Toshiba	843X	10.0, 20.0
3M	8431, 8432, 8533	10.0, 20.0, 60.0

Users should contact EMULEX for details of configuration and support for a particular drive type/manufacturer.

APPENDIX D
EMULEX MODEL SC11
LARGE DISK CONTROLLER

THE FIRST AND ONLY DISK CONTROLLER THAT GIVES YOU THE ADVANTAGES OF...

USING standard DEC PDP-11 operating systems and diagnostic software.

INCORPORATING currently available **storage module, Winchester,** or fixed-head type disk drives.

IMBEDDING the controller in only **two existing SPC slots** of your standard backplane or system unit.

PERFORMING a comprehensive set of **self-test and subsystem diagnostics.**

WORKING properly when you plug it in and **continuing to work reliably** for thousands of hours.

YOU GET THESE ADVANTAGES BECAUSE...

The SC11 was designed specifically–and exclusively–for application in the PDP-11 computer. Since it is not simply a general purpose controller which has been adapted to operate on the Unibus, its packaging and performance are far more efficient than that of any other similar product. Using advanced, modern microprocessor architecture, the SC11 has been configured through various firmware versions to emulate existing DEC disk storage systems, right down to execution of their diagnostics. In addition, many extra features have been added, and custom modes of operation can be provided for special applications.

THE SC11 DESIGN OBSOLETES PREVIOUS APPROACHES–SETS A NEW STANDARD FOR LARGE DISK CONTROLLER TECHNOLOGY

The following combination of key features exist only in the SC11, and illustrate why one or more of the product's standard or custom versions is by far the best choice for your PDP-11 mass storage application.

ADVANCED MICROPROCESSOR ARCHITECTURE. A unique (Patent Pending) design incorporates high-speed bipolar technology to meet the performance demands of present and anticipated storage module and Winchester disk control/data transfer rates and to provide complete application flexibility, including programmed emulations of existing controller designs.

COMPACT PACKAGING. Only two pcb's plug into any pair of standard SPC slots to minimize mounting space requirements, eliminate "boat anchor" boxes and cables, simplify spares stocking requirements, avoid specially wired system units/backplanes, reduce component count, and maximize inherent reliability.

INTERNAL SELF-TEST. Automatic self-test and operator-initiated subsystem diagnostics, supported by error display lamps, are contained in on-board firmware.

LOW POWER. Only 9 amps are required from your internal +5 volt source which eliminates the need for separate power supplies and special cooling provisions.

STANDARD SMD INTERFACE. Any four industry compatible drives, all operating at serial data rates up to 10 Mhz, may be integrated into a single subsystem. The SC11 is adaptable to all known present and future disk products of this type. Fully buffered disk I/O circuitry permits operation at radial distances up to fifty feet and daisy chain distances up to one hundred feet.

STANDARD UNIBUS INTERFACE. The controller interfaces via one of the two pcb's to any standard SPC slot, uses approved bus drivers and receivers, and presents only one unit load to all signal lines. The SC11 also performs parity checks on all Unibus data transfers.

LARGE DISK I/O BUFFER. A 2048 byte RAM memory provides a full three sector data buffer in all applications, eliminates "data late" worries, permits multiple contiguous sector reads, allows complete flexibility in selection of data packing/interlace strategy, and permits the controller to be operated at a low bus priority level.

ECC/CRC HARDWARE. Thirty-two bit ECC for data error detection/correction (single 11-bit error burst), and sixteen-bit CRC for header error detection, all under microprogram control, is provided in all controller versions.

CONVENIENCE FEATURES. A host of items–such as convenient priority level jumpers and slide switch selection of bus address range, interrupt vector, and configuration/operational options–eliminates multiple hardware versions and makes the unit simple and easy to configure. On-board LED's provide error condition and operating mode display.

COMMON HARDWARE. Identical physical circuit boards, adapted through firmware only, are used for all SC11 versions, including special applications, which eliminates the need for using different hardware for different disk capacities, controller versions, and software modes.

GENERAL SPECIFICATIONS

The following specifications apply to all SC11 series large disk controllers.

Characteristic	Specification
FUNCTIONAL	
Design	High-speed bipolar microprocessor-based controller for integration of industry-standard SMD, fixed head, and Winchester type mass storage devices to host PDP-11 computer; incorporates unique (Patent Pending) design to achieve extreme high-speed operations with minimum hardware.
Computer Interface	Standard Unibus via SPC interface on B board (power and ground only to A board). Unibus data parity check performed on all transfers.
Disk Interface	Storage Module Drive (SMD) interface standard; serial data rate up to 10 Mhz.
Bus Address Range	0-128K Words.
Bus Register Base Address	Slide switch selectable, range 760000_8-777770_8.
Vector Address	Slide switch selectable, range 0-774_8.
Priority Level	Jumper selectable, BR4-7.
Error Control	On-board 32-bit ECC and 16-bit CRC hardware for error detection/correction under microprogram control.
Status Display	Eight edge-mounted LED's for mode/error/status display under microprogram control.
Option Switches	Eight on-board slide switches for selection of program-controlled operating/configuration options.

Characteristic	Specification
FUNCTIONAL	
Buffer Memory	2048 byte high-speed RAM buffer, accessible to the microprogram, for data buffering and internal storage operations. Typically 1536 bytes used for data buffering.
PHYSICAL	
Packaging	Two printed circuit boards interconnected by Amp Mod 1 pins; standard SPC 4-connector interface. Extractor handles provided for easy insertion/removal.
Mounting	Any two adjacent SPC slots in standard backplane or system unit.
Cable Connectors	One common 60-pin control (A) flat cable connector on A board; four 26-pin radial data (B) flat cable connectors on B board.
Physical Drives	1-4 per controller.
ELECTRICAL	
Unibus Interface	Approved line drivers/receivers used exclusively; one unit load per bus signal line.
Disk Interface	Differential line drivers and receivers used on all signal lines. Daisy chain (A) and radial (B) cable lengths up to 100 and 50 feet respectively.
Power	+5V ±5%, 9 amps max; −15V ±5%, 0.7 amps max; standard backplane/system unit pins used.
ENVIRONMENTAL	Exceeds all environmental ranges and conditions specified for commercial PDP-11 computers and applicable disk drives.

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APPENDIX E
EMULEX MODEL SC12
SMALL/MEDIUM DISK CONTROLLER

DESIGNED FOR HANDLING SMALL TO MEDIUM CAPACITY DISK DRIVES, THE SC12 GIVES YOU THE ADVANTAGES OF...

USING standard DEC operating systems and diagnostic software.

IMBEDDING the controller in any single quad slot of a standard VAX or PDP-11 backplane.

PERFORMING the full error detection/correction algorithms required for reliable application of modern, high-density disk drives.

EXECUTING a comprehensive set of self-test diagnostics as part of every startup operation.

INCORPORATING most currently available small to medium size 8" and 14" disk drives.

MIXING different types and capacities on one controller for optimizing combinations of fixed (Winchester) and/or removable media drives.

YOU GET OPTIMUM COST/ PERFORMANCE IN THIS RANGE BECAUSE...

The SC12 was designed specifically and exclusively to integrate small-to-medium capacity moving head disk drives with the VAX or PDP-11. Incorporating a standard SMD interface, it is optimum for 14 inch drives up to 80 MBytes (including CMD type drives) and for all current 8" drives which offer an SMD interface option. The unit is an excellent complementary product to the EMULEX SC21 controller, designed for SMD class drives having capacities of 80 MByte and above. The SC12, a Unibus companion for, and format compatible with, EMULEX SC02 and SC04 controllers, introduced previously for use with the LSI-11 Q-Bus.

UNIQUE, UNCOMPROMISING DESIGN GIVES YOU BIG SYSTEM CAPABILITY IN A SMALL, ECONOMICAL PACKAGE...

The SC12 design is based on EMULEX microprocessor technology, already proven in thousands of controller installations. The following combination of features makes it an unbeatable choice for effectively using today's 14" and small 8" disk drives in VAX and PDP-11 based systems.

MICROPROCESSOR ARCHITECTURE. The same basic EMULEX bipolar microprocessor architecture which consistently sets the industry standards is used to give the SC12 broad flexibility and high performance.

COMPACT PACKAGING. Only one quad height pcb plugs into any standard Unibus slot to minimize mounting cost and complexity.

SOFTWARE TRANSPARENCY. Microcode versions provide software transparent emulation of DEC RP02/03 and RK06/07 subsystems, including execution of standard system level diagnostics, which permits use of standard operating system drivers.

ECC/CRC HARDWARE. The standard 32-bit ECC used for SMD-class disk error detection/correction (single 11-bit error burst), combined with a 32-bit header CRC, is provided to insure reliable operation with all types of high-density drives, particularly those with removable media.

MIXED DRIVE CAPACITY. Disk drives having different combinations of heads, surfaces, and densities can be handled by the controller; the drive type code can be read directly from the controller by software to permit adaptive configuring by custom software drivers.

LOW POWER. Only 5.7 amps is required from the CPU internal +5V power supply (no -15V power required) via standard backplane power pins.

INTERNAL SELF TEST. Extensive self-test routines, contained in microcode, automatically verify controller operation when power is applied.

DISK SECTOR BUFFER. A full 512 byte data buffer permits multiple sector reads with a 3-to-1 sector interlace format. Buffer operation eliminates possibility of "data late" conditions and permits controller to be operated at low bus priorities.

SMD INTERFACE. Any two industry compatible drives, each operating at serial data rates to 10 MHz, may be integrated.

AND YOU GET MORE THAN JUST A GREAT PRODUCT...

With the SC12 you get superb quality and excellent support. Production capability exists to meet the highest of volume requirements. All components are pre-aged for over 160 hours, and final product assemblies are environmentally cycled over a temperature range for over 48 hours (while operating) to insure high reliability from the moment they are first installed. All products are backed by a full one year warranty and supported internationally by the EMULEX technical applications group.

GENERAL SPECIFICATIONS

The following specifications apply to all SC12 Series disk controllers.

Characteristic	Specification
FUNCTIONAL	
Design	High-speed bipolar microprocessor-based controller for integration of industry-standard SMD, fixed-head, and Winchester type mass storage devices to host VAX or PDP-11 computer; incorporates unique design to achieve high-speed operations with minimum hardware.
Computer Interface	Standard Unibus.
Disk Interface	Storage Module Drive (SMD) interface standard; serial data rate up to 10 MHz.
Bus Address Range	0-128K Words.
Bus Register	Four selectable start locations.
Vector Address	Four selectable vectors.
Priority Level	Level 5.
Error Control	On-board 32-bit data ECC and header CRC hardware for error detection/correction under microprogram control.
Status Display	Edge-mounted LED for activity/error/status display under microprogram control.
Option Switches	On-board slide switches for selection of program-controlled operating/configuration options.
Buffer Memory	1024 byte high-speed RAM buffer, accessible to the microprogram, for data buffering and internal storage operations. Typically 512 bytes used for data buffering.
Media Format	3 to 1 sector interlace.

Characteristic	Specification
PHYSICAL	
Packaging	One printed circuit board, Unibus 4-connector interface.
Mounting	Any quad slot in standard backplane or system unit.
Cable Connectors	One common 60-pin control (A) flat cable connector and two 26-pin radial data (B) flat cable connectors.
Physical Drives	1 or 2 per controller.
Logical Drives	1 to 8 per controller.
ELECTRICAL	
Unibus Interface	Approved line drivers/receivers used exclusively; one unit load per bus signal line.
Disk Interface	Differential line drivers and receivers used on all signal lines. Daisy chain (A) and radial (B) cable lengths up to 35 and 25 feet, respectively.
Power	+5V ± 5%, 5.7 amps max; standard backplane/system unit pins used.
ENVIRONMENTAL	Exceeds all environmental ranges and conditions specified for commercial VAX or PDP-11 computers and applicable disk drives.

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STANDARD MODELS

The SC12 is available in two standard models which emulate standard DEC disk storage subsystems. All models execute applicable DEC diagnostics, operating systems, and applications software.

The SC12 includes a configuration PROM which permits definition of up to 64 different switch selectable combinations of disk drive configurations on the two controller ports. This permits essentially unlimited selection of drive type/capacity combinations.

• Model SC12/A

Emulates the DEC RP11E controller with standard-sized RP02 (20.8 MByte), RP03 (41.6 MByte) or expanded capacity logical units. Controller includes all RP11E functional features/capability plus extended features, such as automatic pack formatting and switch selection of transparent ECC with error reporting to system software. Supports essentially all standard SMD (removable media), Winchester (fixed media), and CMD (removable/fixed media) type drives of various capacities from 8-80 MBytes. A single microcode package with switch selection of desired configuration supports all drives applicable to this model.

4 of 64 Switch-Selectable Drive Configurations

CHARACTERISTIC	CONFIGURATION NUMBER			
	0	1	2	3
Drive Type — Capacity	SMD-80	SMD-80	MMD-12/24	CMD-32/64/96
Emulation	RP02	RP03	RP02	RP02
Mode	Standard	Expanded	Contracted/Std.	Contracted
Platters/Drive	3	3	2/4	2/4/6
MBytes/Logical Unit	20.8	62.4	10.4/20.8	13.4
Logical Units/Drive	3	1	2	2/4/6
MBytes/Drive	62.4	62.4	10.4/20.8	26.8/53.6/80.4
Drives/Controller, Max.	2	2	2	2/2/2
MBytes/Controller, Max.	124.8	124.8	20.8/41.6	53.6/107.2/107.2

• Model SC12/C

Emulates the DEC RK611 controller combined with multiple RK06 (13.9 MByte) or RK07 (27.8 MByte) logical units. Controller includes all RK611 capability plus the same extended features provided in the Model A series. Particularly well-suited for support of 32-96 MByte CMD-type drives having a removable and multiple fixed platters, with a logical RK06 mapped onto each data surface. Also supports other 8" and 14" drives by mapping 1 or more standard logical RK06/07 drives onto 1 or 2 physical drives. A single microcode package with switch selection of desired configuration supports all drives applicable to this model.

3 of 64 Switch-Selectable Drive Configurations

CHARACTERISTIC	CONFIGURATION NUMBER		
	0	1	2
Drive Type — Capacity	CMD-32	CMD-64	CMD-96
Platters/Drive	2	3	4
MBytes/Logical Unit	13.9	13.9	13.9
Logical Units/Drive	2	4	6
MBytes/Drive	27.8	55.6	83.4
Drives/System, Max.	2	2	1
MBytes/System, Max.	55.6	111.2	166.8

IT'S A PROVEN, HIGH VOLUME PRODUCT...

The EMULEX SC21 Series large disk controller for DEC PDP-11 and VAX-11 computers is a direct follow-on to the EMULEX SC11 controller, introduced in early 1979 and now recognized as *the* product that changed the entire nature of disk controller design.

The SC21 is neatly packaged on a single pcb versus the two-board packaging of the SC11. But more importantly, the SC21 provides more features and better performance than any other Unibus controller available today. The design reflects the experience gained from delivery and installation of over 1500 SC11's and the result is a new, improved product whose hardware/firmware design has already been proven under every available DEC operating system, and with every applicable industry disk drive. Users can therefore count on receiving a controller backed by proven performance, on-time delivery in volume quantities, and solid technical support.

LIKE ALL EMULEX CONTROLLERS...

...the SC21 was designed specifically—and exclusively—for application on the DEC Unibus.

Using the same proven architecture inherent in the entire EMULEX disk and tape controller family, proven microcode versions are available for emulating all applicable DEC disk subsystems using essentially any industry drive with a standard SMD interface. Naturally, all standard models for the PDP-11/04-11/60 Series are DEC diagnostic and operating software compatible. And the SC21 generates DEC-compatible media where the pack is identical to that of the equivalent DEC drive.

AND FINALLY YOU CAN GET ALL THESE ADVANTAGES ON YOUR VAX-11...

The Model SC21/V (VAX/VMS) disk controller version consists of a hardware/software package designed to add economical big disk storage to a VAX-11 system. Hardware is the standard, proven SC21 controller coupled with a special microcode package to optimize the controller for VAX Unibus operation. Software consists of four modules: Formatter, Driver, Boot (for the VAX-11/750), and Diagnostics. This package provides complete capability to install and operate large capacity disk drives on the Unibus of VAX-11 Series computers. It gives you the same storage capability as typical DEC Massbus installations at a fraction of the cost.

ONLY THE SC21 PROVIDES THIS COMPLETE LIST OF FEATURES AND BENEFITS...

...which are implemented in all models/versions of the product.

SINGLE BOARD PACKAGE. For some users, this may be convenient since it saves a bus slot versus the SC11. But what really counts is that there has been no compromise made in either features or performance; both areas have, in fact, been improved and expanded.

MIXED DISK DRIVE CAPACITIES. Disk drives having different configurations (i.e. number of heads and cylinders) may be operated together on the controller. Switch settings permit selection of any one of 32 different combinations of predefined drive configurations.

ADAPTIVE DMA THROTTLE. This exclusive SC21 feature was developed based on experience in a broad range of installations. During each DMA data transfer burst, the controller measures the waiting time for other pending NPR requests and interrupts its own DMA activity to permit other DMA transfers to occur. In addition, a programmable "deadband" time is provided between bursts to insure that CPU functions, including interrupt servicing, are not locked out for excessive periods of time by the high-speed disk transfers.

BUS EFFICIENCY. The SC21 has the most efficient implementation available in a microprocessor-based design and reduces bus delays on programmed I/O and DMA transfers to insignificant levels.

LOW POWER. Only 8 amps at +5V and 0.7 at -15V are required from the internal computer power supply.

RELIABILITY. Calculated MTBF is 30,000 hours; measured results show a much higher actual MTBF figure.

SOFTWARE TRANSPARENCY. All standard models for the PDP-11 Models 04 through 60 are compatible with and transparent to DEC diagnostics and operating systems, such as RSTS-E, RSX11M, etc.

MEDIA COMPATIBILITY. Data packs are compatible and interchangeable between DEC RM02/03 (80 MByte), RM05 (300 MByte) and RP06 (200 MByte) drives and an SC21-based subsystem incorporating media-compatible disk drives.

INTERNAL SELF TEST. Automatic self test executed by internal microcode with LED error status provided.

LARGE DISK I/O BUFFER. A full three sector buffer is provided to eliminate "data late" worries even when operated at low bus priorities. This facility, combined with the Adaptive DMA Throttle feature, permits a system to always operate at optimum rates regardless of Unibus configuration.

FOUR DRIVE SMD INTERFACE. Four disk ports are provided on the controller to eliminate auxiliary paddle boards or wiring panels for handling multidrive installations. The standard SMD interface permits operation at radial B-cable distances of 50 feet and cumulative daisy chain A-cable lengths of 100 feet.

UNIVERSAL DRIVE PORTS. Drive ports on the board are entirely transparent to drive number. Therefore, any drive number can be set up on any port and changed at any time without reconfiguring the controller.

ECC/CRC HARDWARE. Thirty-two bit ECC for data error detection/correction (single 11-bit error burst) and 16-bit CRC for header error detection is provided.

COMMON HARDWARE. Controller models/versions are implemented strictly through microcode and on-board operation switches using common hardware.

COMPLETE RANGE OF MODELS. Users may select from many proven emulation models/versions to optimize the controller and disk drives for a particular application. These models include: RH11 controller (RM02/05); and RK611 controller (RK06/07).

WIDE CHOICE OF DRIVES. Available models collectively support essentially all disk drives having an industry standard SMD interface, regardless of manufacturer and/or drive configuration, including the fixed head-per-track feature found in many fixed media, moving-head drives.

DUAL PORT DRIVE SUPPORT. Dual port drive operations are supported in applicable emulation models.

STANDARD MODELS

The SC21 is available in three standard models which emulate standard DEC disc storage subsystems. All models for the PDP-11 execute applicable DEC standard diagnostics, operating systems, and applications software. Refer to the EMULEX "Controller Handbook" for detailed functional characteristics of each model.

• Model SC21/B

Emulates the DEC RH11 interface with RM02 (67.4 MByte), RM05 (256.1 MByte), or RP06 (174.4 MByte) logical units. Controller includes all standard functional features plus extended features such as command pack formatting and auto bootstrap. Supports standard SMD and Winchester-type drives of 40-600 MByte capacity; packs are compatible with DEC media and drives equivalent to DEC RM02, RM05, and RP06. Provided in four versions:

SC21/B1
Emulates DEC RJM02 and RJM05 subsystems using drives of 40-600 MByte capacity.

SC21/B2
Emulates DEC RJP06 subsystem using drives of 200-600 MByte capacity.

SC21/BE
Same as SC21/B1 except provides transparent, on-board error correction plus optional selection of sector count in place of word count capability.

SC21/BF
Emulates DEC RJM02 with provision to support the fixed head-per-track features of various fixed media moving-head drives of 80-160 MByte capacity.

• Model SC21/C

Emulates the DEC RK611 controller combined with multiple RK06 (13.9 MByte) or RK07 (27.8 MByte) logical units. Controller includes all RK611 capability plus the same extended features provided in the Model B series. Particularly well-suited for support of 32-96 MByte CMD-type drives having a removable and multiple fixed platters, with a logical RK06 mapped onto each data surface.

• Model SC21/V

Emulates DEC RM03 (80 MByte) and RM05 (300 MByte) storage subsystems. The standard SC21 controller has been provided with specialized microcode to optimize the data transfer strategy to the VAX Unibus Adapter. The SC21/V includes the Emulex-developed VAX/UM software package, which completely supports installation, operation, and maintenance of the SC21/V on the VAX-11/750 and VAX-11/780 computers under VMS, (Version 2.0 and above). On the 11/750, drives may be operated as the system disk or as a data disk; on the 11/780, the drive is used as a data storage device. Software is provided on either RX01 diskette or TU58 cartridge and carries a one-year warranty/update service.

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GENERAL SPECIFICATIONS

The following specifications apply to all SC21 Series large disk controllers.

Characteristic	Specification
FUNCTIONAL	
Design	High-speed bipolar microprocessor-based controller for integration of essentially any disk drive having an industry-standard SMD interface to host PDP-11 or VAX-11 computer.
Computer Interface	Standard Unibus via SPC interface. Memory data parity check performed on all transfers.
Disk Interface	Storage Module Drive (SMD) interface standard; serial data rate up to 10 Mhz.
Number of Drives	1-4
Drive Configurations	A different drive configuration (type, size, etc.) may be operated on each port, with switch selection of up to 32 combinations of drives on the 4 available ports.
DMA Address Range	0-128K Words.
Base Address	Four preprogrammed addresses, switch-selectable.
Vector Address	Four preprogrammed vector addresses, switch-selectable.
Priority Level	BR5
Error Control	On-board 32-bit ECC and 16-bit CRC hardware for error detection/correction under microprogram control.
Status Display	Two edge-mounted LED's for error and activity display.
Option Switches	On-board slide switches provided for convenient selection of program-controlled operating/configuration options.
Buffer Memory	2048 byte high-speed RAM buffer, accessible to the microprogram, for data buffering and internal storage operations. Typically 1536 bytes (3 sectors) used for data buffering.

Characteristic	Specification
FUNCTIONAL (continued)	
DMA Transfers	16 word burst per controller DMA request. Burst is interruptable by other DMA requests. "Deadband" period between bursts is programmable/selectable.
PHYSICAL	
Packaging	Single hex height circuit board. Standard SPC 4-connector interface. Extractor handles provided for easy insertion/removal. Unique board stiffener eliminates typical hex board warping problems and insures integrity of backplane connector alignment.
Mounting	Any standard SPC slot in backplane or system unit.
Cable Connectors	One common 60-pin control (A) flat cable connector plus four 26-pin radial data (B) flat cable connectors.
ELECTRICAL	
Unibus Interface	Approved line drivers/receivers used exclusively; one unit load per bus signal line.
Disk Interface	Differential line drivers and receivers used on all signal lines. Daisy chain (A) and radial (B) cable lengths up to 100 and 50 feet, respectively.
Power	+5V ± 5%, 8 amps max; -15V ± 5%, 0.7 amps max; standard SPC backplane/system unit pins used.
ENVIRONMENTAL	
	Exceeds all environmental ranges and conditions specified for commercial PDP-11 and VAX-11 computers and applicable disk drives.

THE SC71 GIVES YOU ALL THE BASIC ADVANTAGES OF....

USING Standard DEC PDP-11 operating systems and diagnostic software.

INTERFACING directly to the internal 11/70 cache bus for optimum performance.

INCORPORATING up to four storage module, and/or Winchester, type disk drives in mixed configurations.

IMBEDDING the controller in the existing slots of the RH70 standard backplane.

PERFORMING a comprehensive set of self-test and subsystem diagnostics.

WORKING properly when you plug it in and continuing to work reliably for thousands of hours.

AND IT ALSO LETS YOU...

MIX disk drives of different type and capacity on the same controller for added system flexibility. Switch settings permit selection of up to 32 combinations of predefined disk drive configurations.

YOU GET THESE ADVANTAGES BECAUSE...

The SC71 was designed specifically—and exclusively—for application in the PDP-11/70 computer. It is **not** simply a general purpose controller which has been adapted to operate on the cache bus. Its packaging and performance are therefore far more efficient than that of any other similar product. Using advanced, modern microprocessor architecture, the SC71 has been configured through various firmware versions to emulate existing DEC disk storage systems, right down to execution of their diagnostics. In addition, many extra features have been added, and custom modes of operation can be provided for special applications.

WHILE YOU STILL GET THESE OTHER KEY FEATURES...

The following combination of key features exist only in the SC71, and illustrate why one or more of the product's standard or custom versions is by far the best choice for your PDP-11/70 mass storage application.

ADVANCED MICROPROCESSOR ARCHITECTURE. The same unique design, already proven in all EMULEX disk controller products, incorporates highspeed bipolar technology to meet the performance demands of present and anticipated storage module, and/or Winchester, disk control/data transfer rates and to provide almost unlimited application flexibility.

MEDIA COMPATIBILITY. Data packs are compatible and interchangeable between DEC RM02/03 (80 MByte), RM05 (300 MByte) and RP06 (200 MByte) drives and the corresponding SC71-based subsystem incorporating media compatible disk drives.

COMPACT PACKAGING. Only one small interconnect plus three active pcb's plug directly into the RH70 backplane area to minimize mounting space requirements, eliminate "boat anchor" boxes and cables, simplify spares stocking requirements, avoid specially wired system units/backplanes, reduce component count and maximize inherent reliability.

INTERNAL SELF-TEST. Automatic controller self-test, supported by error display lamps, is contained in on-board firmware.

LOW POWER. Only 11 amps are required from the internal +5 volt source which eliminates the need for separate power supplies and special cooling provisions.

STANDARD SMD INTERFACE. Any four industry compatible drives, all operating at serial data rates up to 10 MHz, may be integrated in mixed configurations into a single subsystem. The SC71 is adaptable to all known present and future disk products of this type. Fully buffered disk I/O circuitry permits operations at radial distances up to fifty feet and daisy chain distances up to one hundred feet.

CACHE BUS INTERFACE. The SC71 interfaces directly to the internal cache bus for high speed DMA transfers. This eliminates the expensive Massbus, optimizes system performance, and preserves software transparency. A full 2 Megaword memory address range is provided.

LARGE DISK I/O BUFFER. A 2048 byte RAM memory provides a full two sector data buffer in all applications.

ECC/CRC HARDWARE. Thirty-two bit ECC for data error detection/correction (single 11-bit error burst), and sixteen-bit CRC for header error detection, all under microprogram control, is provided in all controller versions.

CONVENIENCE FEATURES. A host of items—such as convenient priority level jumpers and switch selection of bus address range, interrupt vector, and configuration/operational options—eliminates multiple hardware versions and makes the unit simple and easy to configure.

COMMON HARDWARE. Identical physical circuit boards, adapted through firmware only, are used for all SC71 versions, including those for fixed and moving head disks, to eliminate the use of different hardware for each disk type and capacity, controller version, and/or software mode.

GENERAL SPECIFICATIONS

The following specifications apply to all SC71 series large disk controllers.

Characteristic	Specification
FUNCTIONAL	
General	All general EMULEX SC71 and DEC RH70/RM03/RM05/RP06 functional specifications apply.
Design	High-speed bipolar microprocessor-based controller for integration of industry-standard SMD and Winchester type mass storage devices to host PDP-11/70 computer; incorporates unique design to achieve extreme high-speed operations with minimum hardware.
Computer Interface	Direct to internal cache bus via RH70 backplane. Data parity check performed on all transfers.
Self Test	Controller executes internal self-test at power-up; LED display of error conditions.
Bus Address Range	0-2048 K Words.
Bus Register Base Address	Switch selectable, range 760000-777770.
Vector Address	Switch selectable, range 0-774.
Priority Level	Jumper selectable, BR4-7.
Error Control	On-Board 32-bit ECC and 16-bit CRC hardware for error detection/correction under microprogram control.
Status Display	Edge-mounted LED's for mode/error/status display under microprogram control.
Option Switches	Five on-board switch positions for selection of program-controlled operating/configuration options.
Data Transfer, Cache Bus	Double 32-bit word transfer per access.
Data Transfer, Disk	9.67 MHz serial rate; 512 word (2 Sector) buffer. Multiple successive adjacent sector transfers across track boundaries within a cylinder without sector interlace or loss of disk rotation.
Buffer Memory	2048 byte high-speed RAM buffer, accessible to the microprogram, for data buffering and internal storage operations. Typically 1024 bytes used for data buffering.

Characteristic	Specification
PHYSICAL	
Packaging	One small interconnect plus three stand-alone active printed circuit boards; edge connector interface to cache bus and Unibus. Extractor handles provided for easy insertion/removal.
Mounting	Standard available slots in RH70 interface area.
Cable Connectors	One common 60-pin control (A) flat cable connector on A board; four 26-pin radial data (B) flat cable connectors on B board.
Physical Drive	1-4 per controller.
ELECTRICAL	
Unibus Interface	Approved line drivers/receivers used exclusively; one unit load per bus signal line.
Disk Interface	Storage Module Drive (SMD) interface standard; serial data rate up to 10 MHz. Differential line drivers and receivers used on all signal lines. Daisy chain (A) and radial (B) cable lengths up to 100 and 50 feet, respectively.
Dual Port Drives	All standard versions support standard operations on dual port drives.
Power	+5V±5%, 1 amp maximum; -15V±5%, 1 amp maximum.
SOFTWARE COMPATIBILITY	
	Standard Diagnostics: ZJ241-RB kit and ZJ180-RB
	Operating Systems: RSTS-E; RSX11M; RSX11M+
Extended Operations	Disk Pack Format Command Bootstrap Read Command Checksum Operations.
ENVIRONMENTAL	
	Exceeds all environmental ranges and conditions specified for commercial PDP-11/70 computers and applicable disk drives.

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STANDARD VERSIONS

The EMULEX Model B (RWM03/RWM05/RWP06 emulation) is provided in two standard versions which handle drive capacities in the range of 80-600 MBytes. Either standard or "expanded" logical RM03 (67.4 MByte), RM05 (256.2 MByte), or RP06 (174.4 MByte) units are mapped onto the disk drive in use. All versions execute DEC diagnostics, operating systems, and applications software.

• SC71/B1

Emulates the DEC RH70 with one or more of the following subsystem configurations selected by on-board option switches. All configurations support 1-4 physical drives per controller.

- Standard RM03 logical drive mapped onto an 80 MByte SMD type drive;
- "Expanded" RM03 logical drive of 134.8 MBytes mapped onto a 160 MByte MMD type drive;
- Standard RM05 logical drive of 256.1 MBytes mapped onto a 300 MByte SMD type drive; or "expanded" RM03;
- "Expanded" RM03 or "expanded" RM05 of 539.4 MBytes mapped onto a 600 MByte FMD type drive.

The standard logical mapping executes original diagnostic and operating software. Expanded logical mappings require size parameter patches to the standard software. Different drive sizes may be mixed/matched using this emulation.

• SC71/B2

Emulates the DEC RH70 with one or more of the following configurations selected on-board option switches. All configurations support 1-4 physical drives per controller.

- Standard RP06 logical drive mapped onto a 200 MByte SMD type drive;
- "Expanded" RP06 logical drive of 253.7 MBytes mapped onto a 300 MByte SMD type drive;
- "Expanded" RP06 logical drive of 534.1 MBytes mapped onto a 600 MByte FMD type drive.

The standard logical mapping executes original diagnostics and operating software. Expanded logical mappings require size parameter patches to the standard software. Different drive sizes may be mixed/matched using this emulation.

DISK SUBSYSTEM CHARACTERISTICS

CHARACTERISTIC	DEC SPECIFICATION		EMULEX SPECIFICATION							
	RWM03	RWP06	SC71/B1					SC71/B2		
Drive Type—Capacity	RM02-80	RP06-200	SMD-80	MMD-160	SMD-300	SMD-300	FMD-600	SMD-200	SMD-300	FMD-600
Emulation	N/A	N/A	RM03	RM03	RM03	RM05	RM03/05	RP06	RP06	RP06
Mode	N/A	N/A	Std.	Exp.	Exp.	Std.	Exp./Exp.	Std.	Exp.	Exp.
Platters/Drive	3	10	3	3	10	10	10	10	10	10
Tracks/Cylinder	5	19	5	10	19	19	40	19	19	40
Cylinders/Drive	823	815	823	823	823	823	823	815	823	823
Sectors/Track	32	22	32	32	32	32	32	22	32	32
Data Bytes/Sector	512	512	512	512	512	512	512	512	512	512
MBytes/Logical Unit	67.4	174.4	67.4	134.8	256.2	256.2	536.7	174.4	256.2	536.5
Logical Units/Drive	1	1	1	1	1	1	1	1	1	1
MBytes/Drive	67.4	174.4	67.4	134.8	256.2	256.2	539.4	174.4	253.7	534.1
Drives/Controller, Max	8	8	4	4	4	4	4	4	4	4
MBytes/Controller, Max	539.4	1395.5	269.7	539.2	1024.8	1024.8	2157.4	697.7	1014.8	2136.5
Speed, RPM	3600	3600	3600	3600	3600	3600	3600	3600	3600	3600
Bit Density, BPI	6060	4040	6060	6060	6060	6060	6060	4040	6060	6060
Data Rate (K Words/Sec)	491.5	337.9	491.5	491.5	491.5	491.5	491.5	337.5	491.5	491.5

EMULEX®

THE EMULEX SC750 DISK CONTROLLER...

...represents the first optimized, full-performance alternative controller for adding large disk storage to the VAX-11/750. Users will realize maximum system performance with the SC750. They may select from the many excellent, cost-effective disk products—from 80-675 MBytes and serial data rates up to 15 MHz—offered by independent peripheral manufacturers. And at the same time make use of existing software with this transparent controller. The SC750 technology is proven, reliability is exceptional, and the product is manufactured and fully tested to exacting, well established standards before delivery. And it's backed up and supported worldwide by an experienced dedicated technical staff.

LIKE ALL EMULEX CONTROLLERS...

...the SC750 has been designed specifically—and exclusively—for its host CPU environment, namely the VAX-11/750 CPU Memory Interchange (CMI) bus. The result: packaging is optimum, performance is maximized, and cost is minimized. Using the same bipolar microprocessor design architecture proven in the thousands of EMULEX controllers already delivered, the SC750 has the performance, flexibility, and extra useful features and benefits that will serve its purpose for years to come.

CONSIDER THE ADVANTAGES...

...of the SC750 to see why this product is the best choice you can make to handle a VAX-11/750 disk storage requirement.

MICROPROCESSOR ARCHITECTURE. Bipolar bit slice design, used in all EMULEX controllers, gives the product high performance and flexibility while reducing component count for low cost and high reliability.

SINGLE BOARD PACKAGE. A single extended hex height pcb, containing the entire CMI interface and disk controller, installs directly in any one of three available RH750 slots without modification to the VAX-11/750 backplane.

TRANSPARENT OPERATION. Standard versions of the SC750 emulate the DEC RH750 with attached RM03, RM05, RM80 or RP06 drives and operate transparently to VAX/VMS and UNIX operating systems, and DEC diagnostics.

MEDIA COMPATIBILITY. Disk packs formatted by the SC750 are compatible and interchangeable with DEC RM02/03 (80 MByte), RP06 (200 MByte), and RM05 (300 MByte) packs when an equivalent SMD type drive is used.

HIGH SPEED DATA TRANSFER. Data is transmitted as 32-bit parallel words between the SC750 and internal memory via the CMI bus for maximum system performance.

HIGH PERFORMANCE DISK CAPABILITY. The SC750 is designed to handle serial data rates up to 15 MHz as required by the new high-density disk drives available and under development.

ECC/CRC HARDWARE. Thirty-two bit ECC for data error detection/correction (single 11-bit error burst) and 16-bit CRC for header error detection is provided.

INTERNAL SELF TEST. Automatic self test is executed at power up by internal microcode; LED fault status is provided.

LOW POWER. Only 10 amps at +5V and 0.7 amps at -15V are required from the internal computer power supply.

MIXED DRIVE CAPACITIES. Disk drives having different configurations (i.e. number of heads and cylinders) may be operated together on the controller. Switch settings permit selection of any one of 32 different combinations of predefined drive configurations on the four disk ports.

UNIVERSAL DRIVE PORTS. Four physical drive ports on the board are entirely transparent to drive number. Therefore, any drive unit number can be set up on any port and changed at any time without reconfiguring the controller.

DRIVE CONFIGURATION READOUT. Drive configuration (cylinders, tracks, sectors) can be read by the CPU to permit writing custom self-configuring drives for non-standard drive capacities.

WIDE CHOICE OF DRIVES. SC750 models collectively support essentially all disk drives having an industry standard SMD interface, regardless of manufacturer and/or drive configuration.

VAX-11/750 COMPATIBLE CABLING. A cable adapter board provided by EMULEX with the SC750 installs directly on the CMI backplane connector pins to implement the same cable ingress/engress scheme used for standard DEC VAX-11/750 peripherals.

GENERAL SPECIFICATIONS

The following specifications apply to all SC750 Series large disk controller models.

Characteristic	Specification
FUNCTIONAL	
Design	High-speed bipolar microprocessor-based controller for integration of disk drives with an SMD interface to host VAX-11/750 computer.
Computer Interface	VAX-11/750 CMI bus via RH750 backplane interface.
Disk Interface	Storage Module Drive (SMD).
Disk Data Rate	Serial Data rate up to 15 Mhz.
Number of Drives	1-4 physical; 1-8 logical.
Drive Configurations	A different drive configuration (type, size, etc.) may be operated on each port, with switch selection of up to 32 combinations of four drives.
DMA Address Range	16 Megabytes
CMI Address (Hex)	F28000, F2A000, F2C000, F2E000
Vector Address (Hex)	150, 154, 158, 15C
Priority Level	BR5
Error Control	32-bit ECC for data and 16-bit CRC for headers. Correction of single error burst up to 11 bits.
Status Display	Two edge-mounted LED's for self test fault and data transfer activity.
Option Swtiches	On-board slide switches provided for convenient selection of: base address, arbitration levels, and drive combinations.
Data Buffer	512 Bytes
Self Test	Controller executes extensive self test routines at power up; LED fault display.
Extended Operations	Disk format command.
DMA Transfers	32-bit parallel via CMI bus.

Characteristic	Specification
PHYSICAL	
Packaging	Single extended hex height circuit board. Standard RH750 backplane interface. Extractor handles provided for easy insertion/removal. Unique board stiffener eliminates typical hex board warping problems and insures integrity of backplane connector alignment.
Mounting	Any standard RH750 slot in VAX-11/750 backplane (3 available).
Cables	One common 60-conductor control (A) flat cable plus four 26-conductor radial data (B) flat cables, from EMULEX cable adapter plugged onto VAX-11/750 backplane connector pins.
ELECTRICAL	
Disk Interface	Differential line drivers and receivers used on all signal lines. Daisy chain (A) and radial (B) cable lengths up to 100 and 50 feet, respectively.
Power (from CPU)	+5V + 5%, 10 amps max; -15V ± 5%, 0.7 amps max.
ENVIRONMENTAL	Exceeds all environmental ranges and conditions specified for commercial VAX-11/750 applicable disk drives.
COMPATIBILITY	
Media	Format same as DEC packs.
Software Transparency	Operating Systems: VMS; UNIX.
	Diagnostics: EVRAA, EVRAC, EVRDA, EVRDB, EVRGA, EVRGB.

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STANDARD MODELS

The SC750 is available in two models which emulate standard DEC Massbus disk subsystems supported under VMS and UNIX on the VAX-11 series of computers. Each model executes basic diagnostic and all operating system software. Refer to the EMULEX "Controller Handbook" for detailed functional characteristics of the DEC peripherals.

Each emulation includes all basic functional features of the equivalent DEC subsystem, plus extended capability which includes built-in disk formatting and the ability to operate with a mix of standard and non-standard drive types and capacities. The drive configuration on each controller port is defined by a unique Configuration PROM which may direct standard, expanded, or contracted logical units to be mapped on each physical drive. One or two logical units may be mapped onto each physical drive to handle large drive capacities with unpatched DEC diagnostics and operating software.

• Model SC750/B1

Provides concurrent emulation of an RM03, RM05, and/or RM80 Massbus disk subsystem.
The emulation mode for each drive attached is defined to the controller by the drive type code contained in the Configuration PROM. Any drive type may be handled on any port and any or all of the above mixed drive type emulations may be run concurrently on one controller, using unmodified software.

Logical drive formatted capacities are: RM03—67.1 MBytes; RM05—256.1 MBytes; RM80—121.3 MBytes. Either one or two logical units may be mapped onto each physical drive. For drives equivalent to the CDC 9762 and 9766, disk packs written by the SC750 are compatible and interchangeable with the DEC RM03 and RM05 packs respectively.

A small sample of possible disk drive types and formatted capacities for use with the SC750/B1 are summarized below. Refer to the EMULEX "Controller Handbook" for more detail.

UNFORMATTED DRIVE		EXAMPLE DRIVE MODELS	EMULATION MAPPINGS	FORMATTED CAPACITY (MB)
TYPE	CAPACITY (MB)			
SMD	80	CDC 9762 Ampex DM 980	RM03	67.1
Winchester	160	CDC 9730-160 Fujitsu 2284	RM80 or 2 X RM03	121.3 or 134.2
SMD	300	CDC 9766 CDS T302RM	RM05	256.1
Winchester	330	Ampex DF 9330	RM05 or 2 X RM80	256.1 or 242.6
Winchester	675	CDC 9775	2 X RM05	512.2

• Model SC750/B2

Emulates the DEC RP06 removable media Massbus disk subsystem. The logical RP06 unit is 174.4 MBytes. One or two logical units are mapped onto each physical drive on the controller. A small sample of possible disk drive types and formatted capacities for use with the SC750/B2 are summarized below. The Memorex 677 is media compatible with the DEC RP06.

UNFORMATTED DRIVE		EXAMPLE DRIVE MODEL	EMULATION MAPPING	FORMATTED DRIVE CAPACITY
TYPE	CAPACITY (MB)			
SMD	200	Memorex 677	RP06	174.4 MB
Winchester	474	Fujitsu "Eagle"	2 X RP06	348.8 MB

EMULEX MODEL TC11 AND TC11/V FOR PDP-11 AND VAX-11 COMPUTERS.

THIS MODERN, PROVEN CONTROLLER GIVES YOU ALL THE ADVANTAGES...

INCORPORATING any industry standard reel-to-reel magnetic tape drives—NRZ, PE, and Dual Density—at speeds up to 125 ips.

IMBEDDING the controller in only one (NRZ) or two (PE/Dual Density) existing SPC slot(s) of your standard backplane or system unit.

EXECUTING standard DEC PDP-11 system and diagnostic software.

OPERATING on the VAX-11 using the VMS/UT software package, designed and fully supported by EMULEX.

PERFORMING a comprehensive set of controller-generated self-test and extended subsystem diagnostics.

WORKING when you plug it in and continuing to work reliably for thousands of hours.

YOU GET THESE ADVANTAGES—AND MORE—BECAUSE...

The TC11 was designed specifically—and exclusively—for the VAX/PDP-11 Unibus. Because it is not just a "universal" type controller adapted to operate on a Unibus, its packaging and performance are optimum in every respect. And the unique, powerful bipolar microprocessor-based architecture provides a lot more: full performance required for high-speed/high-density operations; PDP-11 diagnostic and operating software transparency; VAX/VMS software compatibility with the EMULEX supplied package; and extensive controller self-test and extended subsystem diagnostic operations executed entirely by controller firmware.

COMPARE THIS COMBINATION OF KEY FEATURES AGAINST THOSE OF ANY OTHER PRODUCT...

...and we think you will agree that the TC11 is the best choice for meeting all your VAX/PDP-11 tape subsystem requirements.

COMPACT PACKAGING. Only one stand-alone pc board, plugged into any standard SPC slot, handles all NRZ formatting and control operations; a second quad height pcb, plugged into any other convenient SPC slot, adds full phase encode (PE) capability.

TRANSPARENT PDP-11 OPERATION. The TC11, combined with any standard tape drive, emulates the functions of a TU10/TM11 subsystem, including execution of standard PDP-11 diagnostic programs.

COMPATIBLE VAX-11 OPERATION. The TC11/V, combined with any standard tape drive and the EMULEX VMS/UT software driver/diagnostic package, provides reliable, economical tape storage on all VAX-11s.

INTERNAL SELF-TEST. The TC11 automatically performs extensive tests, not only of itself (including all elements of the PE electronics) but also of the computer interface. On-board LED displays pinpoint a probable controller or PE board failure.

FLEXIBLE, HIGH-PERFORMANCE DRIVEN INTERFACE. Any four industry standard tape drives—operating with 9 tracks, at densities up to 1600 bpi, speeds up to 125 ips, and at a cumulative cable distance of 25 feet—may be incorporated. Overlapped tape rewinds are permitted.

STANDARD UNIBUS INTERFACE. The controller interfaces, via the controller pc board only, to any standard SPC slot and presents only one unit load on all lines. Full 16-bit word NPR data transfers are made, and the controller checks for parity errors if a parity controller is installed in the system.

FLEXIBLE FORMATTING. Data may be packed in either DEC or IBM format, 9 channel. Tape drives may be daisy-chained together. User may edit previously recorded records.

DATA INTEGRITY. LRC and CRC (9 track) is generated and checked. Read-after-write parity check is made on all recorded characters.

VAX PRODUCT SUPPORT

The VMS/UT software package—developed and fully supported by EMULEX—consists of a driver (VMS/UTD) and diagnostics (VMS/UTX) which completely supports installation, operation, and maintenance on VAX-11/750, 780 computers under VMS version 2.0 and above. Software is supplied with each controller on either TU58 compatible cartridge (11/750) or RX01 compatible diskette (11/780) and carries a one-year warranty and update service.

EMULEX MODEL TC01 FOR LSI-11 COMPUTERS.

THIS FIRST—AND BEST—IMBEDDED DUAL DENSITY CONTROLLER THAT GIVES YOU THE ADVANTAGES OF...

EXECUTING standard DEC and PDP/LSI-11 system and diagnostic software.

INCORPORATING any industry-standard reel-to-reel magnetic tape drives—PE and Dual Density—at speeds up to 75 ips.

IMBEDDING the controller in only one or two existing quad slots of your standard LSI-11 backplane or system unit.

PERFORMING a comprehensive set of controller-generated self-test and subsystem diagnostics.

WORKING when you plug it in and continuing to work reliably for thousands of hours.

YOU GET THESE ADVANTAGES—AND MORE—BECAUSE...

The TC01 was designed specifically—and exclusively—for the LSI-11 computer. Because it is not just a "universal" or Unibus type controller adapted to operate on the Q Bus, its packaging and performance are optimum in every respect. And the unique, powerful bipolar microprocessor-based architecture provides a lot more: full performance required for high-speed/high-density operations; complete diagnostic and operating software transparency; and extensive controller self-test and subsystem diagnostic operations executed entirely by controller firmware.

COMPARE THIS COMBINATION OF KEY FEATURES AGAINST THOSE OF ANY OTHER PRODUCT...

...and we think you will agree that the TC01 is the best choice for meeting all your LSI-11 tape storage requirements.

COMPACT PACKAGING. Only two stand-alone pc boards, plugged into any two standard quad slots, handle all NRZ/PE formatting and control operations.

TRANSPARENT OPERATION. The TC01, combined with any standard tape drive, emulates the functions of DEC TU10/TM11 subsystem, including execution of standard diagnostic programs.

INTERNAL SELF-TEST. The TC01 automatically performs extensive tests, not only of itself (including all elements of the PE electronics) but also of the computer interface. On-board LED displays define a probable controller or PE board failure.

FLEXIBLE, HIGH-PERFORMANCE DRIVE INTERFACE. Any four industry standard 9-track tape drives—operating at densities of 800/1600 bpi, speeds up to 75 ips, and at a cumulative cable distance of 25 feet—may be incorporated. Overlapped tape rewinds are permitted.

STANDARD Q BUS INTERFACE. The unit interfaces via the controller pc board only to any standard Q Bus quad slot and presents only one unit load on all lines. Full 16-bit word NPR data transfers are made, and the controller checks for parity errors on all memory read operations.

FLEXIBLE FORMATTING. Data may be packed in either DEC or IBM format. User may edit previously recorded records.

DATA INTEGRITY. LRC and CRC (9-track) is generated and checked. Read-after-write parity check is made on all recorded characters.

RELIABLE OPERATION. Unit meets all specs over wide voltage margin and clock margin ranges. Timing is generated by crystal clock. Conservative derating is made on all components. Environmental range exceeds that of all commercial LSI-11 host computers and applicable industry tape drives.

SPECIFICATIONS (TC01, TC11, TC11/V)

Characteristic	Specification
FUNCTIONAL	
Design	High-speed 16-bit bipolar microprocessor controller.
CPU's	TC01: LSI-11, 11/2, 11/23 TC11: PDP-11/04 thru 11/70 TC11/V: VAX-11/750, 11/780
Computer Interface	
TC01/N (NRZ)	Standard Q Bus via quad interface on controller board (A-B connectors).
TC11/N (NRZ)	Standard Unibus via SPC interface on controller board (C-F connectors).
PE Board	Power and ground pins only (common to TC01 and TC11 except for NPG grant line strapping).

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SPECIFICATIONS (TC01, TC11, TC11/V)

Characteristic	Specification
Tape Speed	
TC01	One selectable: 12.5, 15, 18, 75, 25, 37.5, 45 and 75 ips.
TC11, TC11/V	Two selectable: Same as TC01 plus 125 ips.
Bus Address Range	0-128 K Words.
Register Base Address	772520_8
Interrupt Vector	224_8
Priority Level	5
Tape Transports	Type: ½ inch, reel-to-reel, IBM standard format. Interface: Pertec-standard. Heads: Dual gap, read-after-write. Track/Densities: 9 Track, 800/1600 bpi.
Number of Transports	Daisy-Chain, 1-4 drives. Simultaneous rewind operations permitted.
Data Checking	Read-after-write parity check on all characters; LRC and CRC (9 track).
Self-Test	Controller automatically executes extensive power-up self-test which includes: microprocessor, write clock generator, DMA, and PE Read Board. Runs simulated PE records into PE Read Board with various data Bad Tracks configuration. Complete read out of test progress and errors via tape controller registers. Various operating modes allow for fault detection and scope display.
Fault/Activity Display	LED indicates detected board fault and controller read/write activity.
Option Switches	
Controller Board	Six on-board slide switches for selection of program-controlled operation/configuration options.
PE Board	Tape speeds set up by slide switches.
PHYSICAL	
Packaging	
TC01/N (NRZ)	Quad-size board, standard quad slot.
TC11/N (NRZ)	Hex-size board, standard SPC slot.
PE Board	Quad-size board, standard quad or SPC slot.
Cabling	One 40-conductor flat cable between boards and two 40-conductor flat cables to first tape transport.
Adapters	Daisy-Chain cable adapters available for most industry tape drives.
ELECTRICAL	
Computer Interface	
TC01	To standard Q Bus using DEC approved drivers and receivers; one unit load per bus line.
TC11	To standard Unibus using DEC approved drivers and receivers; one unit load per bus line.
Transport Interface	24ma drivers used on all output lines, receivers or all inputs, max 25 feet cumulative daisy-chain cable length.
Power	
TC01/N (NRZ)	+5v±5%, 5 amps.
TC11/N (NRZ)	+5v±5%, 5 amps.
PE Board	+5v±5%, 2 amps.
ENVIRONMENTAL	Exceeds all environmental ranges and conditions specified for commercial LSI-11, PDP-11, VAX-11 computers and applicable tape drives.
SOFTWARE	
LSI-11 and PDP-11 Diagnostics	DEC ZJF12-RB Kit
Operating Systems	All applicable to TU10/TM11 subsystem on PDP/LSI-11.
VAX-11 (TC11/V)	EMULEX VMS/UT package includes driver and on-line diagnostic in execution code for load- and-go integration into VMS, plus stand-alone diagnostic. Furnished on TU58 or RX01-compatible media. Fully supported for VMS V2.0 and above.

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THE IDEAL SOLUTION FOR APPLICATIONS INVOLVING LARGE NUMBERS OF TERMINALS—TYPICALLY 32 OR MORE...

...the EMULEX CS11 Series lets you choose the alternative that best suits your application.

CS11/H—gives full DH11 performance on the PDP-11; transparent to PDP-11 diagnostic and operating software.

CS11/U—gives full DH11 performance on the VAX-11; uses EMULEX VMS/UH software package.

CS11/V—gives full DV11 emulation; allows synchronous/asynchronous communication with transparency to DEC diagnostic and operating software.

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. With the CS11/H and CS11/U, the controller interfaces 1-4 CP11 Distribution Panels via a 34-conductor flat cable. Thus, in a 64-line configuration you save 32 SPC slots over DEC's DH11. With the CS11/V, the controller interfaces 1 or 2 CP11 Distribution Panels, mixed if you wish in synchronous/asynchronous groups of eight. This model saves you 16 SPC slots over DEC's DV11!

The CS11 Series is ideal for systems with large numbers of terminals and/or where backplane space and power is at a premium. The CS11 also offers exceptional flexibility at the adapter panel level with 8-line modularity and a broad selection of present and future adapter types. Users of large numbers of terminals and/or those with changing requirements should, therefore, find the CS11 Series an ideal choice for the present, with open-end flexibility for the future.

REGARDLESS OF THE CS11 MODEL USED, YOU GET THESE IMPORTANT BENEFITS...

OPTIMUM PACKAGING. The basic communications controller, capable of handling 64 lines (DH11), or 32 lines (DV11), plugs into a single Unibus SPC slot with only one unit load on the Unibus.

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 made on DMA operations, rather than the byte transfers used in some 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 on each 8-line group.

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

CONFIGURATION FLEXIBILITY. 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 CC11 controller for conveniently locating line terminals and minimizing terminal cable lengths.

FUTURE BENEFITS. The basic CS11 hardware components are directly adaptable to other multiplexer products (e.g., DH11 to DV11) merely by changing firmware PROM's.

FOR PDP-11 USERS WHO WANT INCREASED DH11 PERFORMANCE AT AN ECONOMICAL PRICE...

...the **CS11/H** gives you these extra features and benefits:

EXTRA FIFO CAPACITY. The input FIFO capacity may be switch selected for either 128 characters per 16 input lines or for the standard 64 characters per 16 input lines to insure handling of high peak input rates without data overrun.

WORD TRANSFERS ON DMA OUTPUT. The CS11/H performs word rather than byte transfers on DMA output. This doubles data transfer rate capability to 19.2 Kbytes over DEC's DH11 9.6 Kbyte maximum.

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

...the **CS11/U** provides the answer. Improve system performance over what you get using the customary cycle-stealing interrupt-driven DZ11's. And save a lot of valuable internal board slots in the process (one board vs. eight for 64 DZ11 channels).

The CS11/U model is supported by the EMULEX-developed VMS/UH software package, which provides the terminal handling routines plus stand-alone and line diagnostics. Distributed on TU58 tape or RX01 diskette, in execution code for easy load-and-go integration with VMS Versions 2.0 and above. Hardware and software are backed by one year warranties and the EMULEX reputation for quality, reliability, and support.

AND FOR USERS WHO NEED THE UTILITY AND PERFORMANCE OF A DV11-TYPE PRODUCT...

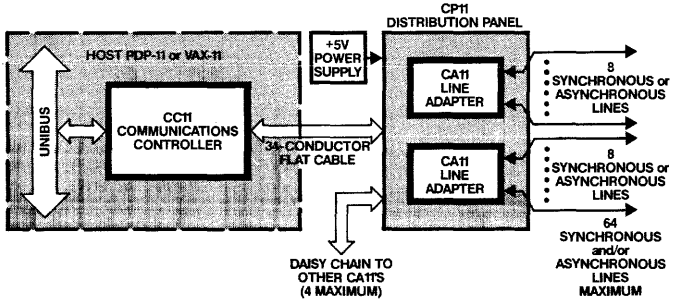
...the **CS11/V** is your choice. The CS11/V, DV11 compatible for PDP-11 systems, handles a mix of synchronous/asynchronous lines in 8-lines groups to a maximum of 32 channels. Among the many advantages of the EMULEX CS11/V over DEC's DV11 are:

RIGOROUS SELF TEST. The communication controller executes an extensive self test to verify basic subsystem operation before the CS11/V is put on line.
WORD TRANSFER DURING DMA OPERATION. The CS11/V, as other CS11 emulations, performs a word transfer during DMA operations. The DEC DV11 performs byte transfers during DMA. This, in effect, allows a maximum of 19.2 Kbytes per second to be transferred during asynchronous operations, while DEC's DV11 only has a maximum capability of 9.6 Kbytes.

EASE OF FUTURE EXPANSION. Since the CS11/V is firmware driven, future expansion to handle other synchronous protocols is easily achieved.

SO TAKE YOUR CHOICE...

...of CS11 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.



CS11 BLOCK DIAGRAM.

Functional organization and physical implementation are key features of the CS11 Series. The single CC11 Controller board contains all active circuitry in the system, including the USART line interfaces for all 8-64 channels. The board installs in any standard SPC slot of the host CPU and connects to the CP11 Distribution Panels by a single 34-conductor flat cable. RS-232 and/or Current Loop adapter panels (CA11) may be installed.

CS11 SERIES SUBSYSTEM SPECIFICATIONS

Characteristic	Specification
CC11 CONTROLLER	
Design	High-speed bipolar microprocessor based controller.
Function	Emulation of four DH11 or two DV11 multiplexers and DM11 modem controls.
Software Compatibility	Diagnostics: ZJ179 (DH), ZJ192 (DV) and ZJ118 (DM) kits.
	Operating Systems:
CS11/H	PDP-11: RSX11M, RSX11M+, RSTS/E.
CS11/U	VAX-11: VMS with EMULEX VMS/UHX software package or CS11/U model.
CS11/V	PDP-11: DECNET-11M, DECNET-1AS.
No. of Distribution Panels	CS11/H, CS11/U: 1 to 4. CS11/V: 1 to 2.

Characteristic	Specification
No. of Lines	CS11/H, CS11/U: 8 to 64. CS11/V: 8 to 32.
Throughput	50,000 characters per second total.
Distribution Panel	Eight-bit bidirectional data bus with necessary addressing and control in a single 34-conductor flat cable.
Receive FIFO	
CS11/H, CS11/U	64-character or 128-character (switch selectable) FIFO for each functional 16-channel DH11; Interrupt programmable for any level of FIFO full.
CS11/V	128-character FIFO for each functional 16-channel DV11.
CPU Interface	Standard Unibus SPC interface. Parity checked on all memory reads. One bus load.

CS11 SERIES SUBSYSTEM SPECIFICATIONS CONTINUED

Characteristic	Specification
DMA/NPR Address Range	0–128 words.
DMA/NPR Transfers	16-bit word.
Device Address	Selectable with switches and PROMs to cover all DEC-defined DH11 and DV11 assignments.
Vector Address	Switch selectable.
Priority Level	BR5 for DH11, DV11 BR4 for DM11
Indicator	Controller fault.
Option Switches	DIP switches for selection of configuration and options.
DH11 Characteristics (CS11/H, CS11/U):	
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 and ext. 1X clock.
Modem Control Signals	RTS, DTR, CRS, CD, RI (or DSR), Secondary Rx and Tx.
DV11 Characteristics (CS11/V):	
Synchronous Line Formats	Programmable Character Length: 8 bits. Programmable Parity: none.
Asynchronous Line Formats	Programmable Character Lengths: 5–8 bits. Stop bits: 1, 1½, 2 Parity: odd, even, none.
Data Rates	Synchronous: 1200, 2400, 4800, 9600 baud (internal, switch selectable). Asynchronous: 50, 75, 110, 134.5, 150, 300, 600, 1200, 1800, 2000, 2400, 3600, 4800, 7200, 9600, 19,200 baud (software selectable).
Synchronous Clocks	External and internal; internal common to all 16 lines.
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.

Characteristic	Specification
DV11 Characteristics (continued)	
Modem Status Signals	CTS, Carrier Detect, Ring, Data Set Ready/Secondary RX.
Modems Accommodated	Synchronous: 201, 208, 209 Asynchronous: 103, 202, 212.
Packaging	Single hex-size two 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.
CA11/A RS-232 LINE ADAPTER	
Configuration	Two sided PCB measuring 6½" 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.
Distortion	Transmitter: less than 2% intersymbol. Receiver: up to 43% inter-symbol distortion and speed variation.
CA11/C CURRENT LOOP LINE ADAPTER	
Configuration	Two sided PCB measuring 6½" x 8" which plugs into CP11 Distribution Panel.
Interface	20 mA Current Loop.
Connectors	Terminal strip interface.
Indicators	Fault LED per line.
Transmission Modes	Full duplex.
Distortion	Transmitter: less than 2% intersymbol. Receiver: up to 43% inter-symbol distortion and speed variation.

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/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 up to 32 lines, where backplane board space and/or power are not critical; and where the line adapter flexibility 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 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. 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.

CONVENIENCE FEATURES. All operation mode operations and/or special firmware enhancements are selected by on-board slide switches.

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 baud); 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 baud rates, 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.

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

...the CS21/U provides the answer. Tests show that the CS21/U consumes less CPU time, typically 50% less 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.

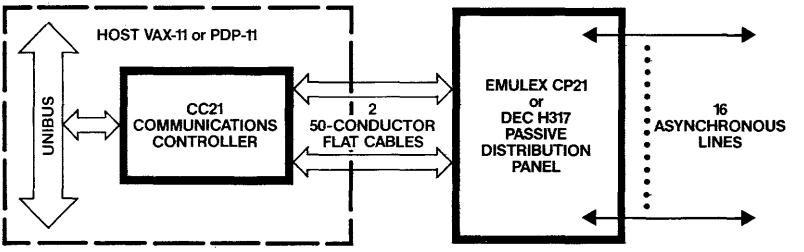
AND FOR USERS THAT SIMPLY WANT A BETTER DZ11 TYPE UNIT AT A LOWER PRICE...

...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 a slight increase in performance by providing a 16 character per line transmit buffer, with optional full XON/XOF 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.

EMULEX

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CS21 SERIES 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.
Software Transparency/ Compatibility	Diagnostics: DH11—ZJ179 Kit (PDP-11) DZ11—ZJ223 Kit (PDP-11) DZ11—EVDAA (VAX-11) Operating Systems: DH11—All common PDP-11 operating systems DZ11—All common PDP-11 and VAX operating systems (VMS, UNIX).
Transmission Modes:	DZ11—Full duplex DH11—Half duplex, full duplex, echoplex.
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. DZ11: 50, 75, 110, 134.5, 150, 300, 600, 1200, 1800, 2000, 2400, 3600, 4800, 7200, 9600, 19.2 KB.
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.
Throughput	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. 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 0.75-second FIFO timer to avoid trapped characters because of slow receive data rates.
Transmit FIFO (DZ11)	Switch enabled, 16 characters per line for enhanced DZ11 operation (requires software patches to diagnostics and operating system). Includes XON/XOF 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 all DEC-defined DH11 and DZ11 assignments.
Vector Address	Switch-selectable for DM11 and DH11, or DZ11.
Priority Level	BR5 for DH11 or DZ11 BR4 for DM11
Indicator	Controller self-test fault.
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 L
EMULEX CABLES AND ADAPTERS
FOR
DISK AND TAPE PRODUCTS

A. DISK CABLES

All disk cables and cable sets are applicable to all controller models, except Models SC04 and SC750, and are defined in Table L-1.

A Drive Cable Set consists of one 60-conductor and one 26-conductor cable of equal length. Each cable is terminated on the controller end by a flat cable header which interfaces to a standard flat cable connector on the controller. The drive connector interface must conform to either the CDC 'Flat Cable' or 'Round Cable 75-Pin' specification. This cable set connects to the first drive in the system.

NOTE:

a. Standard cables furnished by the drive manufacturer may be used.

b. The A Cable terminator is not available from EMULEX and must be purchased for installation on the last drive in the system.

B Cables for second, third, and fourth disk drives are ordered according to desired length. The A Cable (60-conductor) is daisy-chained from drive-to-drive and is usually shorter than the B Cable (26-conductor) which must be connected radially from the controller.

TABLE L-1
DISK DRIVE CABLES

	DESCRIPTION	AVAILABLE LENGTHS
DISK FLAT CABLE SET (for first drive)	Cable pair of equal length consisting of one 60-conductor daisy-chain A Cable and one 26-conductor radial B Cable; each terminated at both ends with standard flat cable connectors.	8 ft. set 15 ft. set 25 ft. set 35 ft. set 50 ft. set
DISK ROUND CABLE SET (for first drive)	Same as Disk Flat Cable Set, except A and B Cables are fitted with 75 pin round cable adapters on drive end.	8 ft. set 15 ft. set 25 ft. set 35 ft. set 50 ft. set

TABLE L-1
DISK DRIVE CABLES cont...

The following individual cables may be used for adding after the first in the system, where the A and B Cables may be of different length.

DISK A CABLE Flat/Flat	Single 60-conductor A Cable with flat connectors on both ends. For daisy-chain of two drives, each having a flat cable interface. Daisy-chain lengths over 15 ft. are not recommended.	8 ft. cable 15 ft. cable
DISK A CABLE Flat/Round	Same as flat/flat A Cable, except one end has 75-pin round cable connector. Used for daisy-chain between a drive with a flat cable interface and a drive with a round cable interface.	8 ft. cable 15 ft. cable
DISK A CABLE Round/Round	Same as flat/flat A Cable, except has 75-pin round cable connector on both ends of cable. Used for daisy-chain between two drives with a round cable interface.	8 ft. cable 15 ft. cable
DISK B CABLE Flat	Single 26-conductor B Cable with flat connectors on both ends. For radial connection of other than first drive; drive has flat cable interface.	8 ft. cable 15 ft. cable 25 ft. cable 35 ft. cable 50 ft. cable
DISK B CABLE Round	Same as flat B Cable, except with 75-pin round cable adapter on drive end.	8 ft. cable 15 ft. cable 25 ft. cable 35 ft. cable 50 ft. cable

B. SC04 DISK CABLE - (ANSI Interface)

The ANSI Interface Cable is a 50-conductor flat cable with a 3M-type connector on each end. This cable is terminated on the controller end by a flat cable header which interfaces to a standard flat cable connector on the controller. The drive connector interface must conform to the ANSI standard specification. This cable connects to the first drive in the system and additional drives to the system are connected with an identical cable.

TABLE L-2
ANSI DISK DRIVE CABLE

	DESCRIPTION	AVAILABLE LENGTHS
ANSI DISK Flat Cable	Single 50-conductor flat cable with 3M type connector on each end.	2 ft. cable 4 ft. cable 6 ft. cable 8 ft. cable 10 ft. cable

C. SC750 DISK CABLE

The Model SC750 disk controller utilizes a special cable set to attach the first drive in a VAX-11/750 subsystem. A description of this cable set and available lengths is given in TABLE L-3.

An SC750 Drive Cable Set consists of one SU75, or A Cable, (60-conductor) and one B Cable (26-conductor) of equal length.

The A Cable attaches to the SU75 Cable Adapter Board through one 34 and one 26 (3M-type) connector. The other end of this cable is a standard 60-conductor flat cable interface and attaches to the first drive in the system.

TABLE L-3
SC750 DISK DRIVE CABLES

	DESCRIPTION	AVAILABLE LENGTHS
DISK FLAT CABLE SET (for first drive)	Cable pair of equal length consisting on one 60-conductor daisy-chain SU75 A Cable and one 26-conductor radial B Cable.	15 ft. set 25 ft. set 35 ft. set 50 ft. set

After the initial installation of the above SC750 Drive Cable set, A and B cables found in TABLE L-1 may be used for the addition of second, third and fourth drives into the subsystem.

B. TAPE CABLES

Tape Cables are special to EMULEX controllers and cannot be ordered from a drive manufacturer. They are priced separately from the controller to permit length selection or to be built by users who wish to do so.

A Controller-To-Drive Cable Set consists of:

* Two 40-conductor flat cables, terminated on the controller end by a flat cable connectors; on the transport end, one cable is split into two 20-conductor parts, and the three ends are terminated in flat cable connectors.

* A terminator/adapter pcb for each transport end connector which converts the flat cable connectors to the pcb edge connector used by the standard Pertec interface.

* An 11-inch controller/PE interconnect cable for use with TC01/P and TC11/P.

The following cable set lengths are available:

NOTE:

Most transport interfaces limit total cable length for all drives in a daisy-chain to 25 ft. max.

CONTROLLER-TO-DRIVE
CABLE SET

8 ft. set
15 ft. set
25 ft. set

A Daisy-Chain Cable Set consists of :

* Two 40-conductor flat cables, with one cable split into two 20-conductor parts at both ends; the three parts at both ends of the cable set are terminated with flat cable connectors.

* A daisy-chain/adapter pcb for the three connectors at the daisy-chain end which convert the flat cable connectors to the pcb edge connectors used by the standard Pertec interface.

THE DAISY-CHAIN CABLE SET is available in the following lengths:

8 ft. set
15 ft. set

APPENDIX M
EMULEX CONTROLLERS
Reliability Data

MTBF calculations for various Emulex Controllers are as follows:

SC01 Disk Controller = 34,257 Hours MTBF

SC02 Disk Controller = 76,000 Hours MTBF

SC11 Disk Controller = 29,132 Hours MTBF

SC21 Disk Controller = 30,000 Hours MTBF

SC70/71 Disk Controller = 29,276 Hours MTBF

TC01 Disk Controller = 41,000 Hours MTBF

TC11/P Tape Controller = 31,555 Hours MTBF

CS11 Communications Multiplexer = 27,800 Hours MTBF

CS21 Communications Multiplexer = 56,914 Hours MTBF

The MTBF calculations were made utilizing CDC Standard 1.12.000 and do not include stress factor derating nor do they include an "infant mortality" factor. None of the above MTBF figures take into consideration the interconnecting cable assemblies required to operate the respective peripherals.

Field failure results based 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 of operation, 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 almost 100% active component parts which are pretested and pre-aged for a period of 160 hours at 70°C prior to incorporation at 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 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 the assembly repeats the entire cycling process. This type of handling has resulted in infant mortality rates given in the following table.

TYPE*	CALCULATED MTBF	MTBF			INFANT MORTALITY RATE			
		UNIT POP. 10/80-9/81	CUMUL. HOURS 10/80-9/81	ACTUAL MTBF 10/80-9/81	10/80-3/81		4/81-9/81	
					UNIT POP.		UNIT POP.	
SC01	34,257	537	1,649,400	35,856	342	5%	195	4.1%
SC02	76,000	**						
SC11	29,132	533	2,272,800	30,713	368	4.6%	80	1.3%
SC21	30,000	799	2,052,300	52,623	314	6.1%	624	2.9%
SC70/71	29,276	427	1,994,700	64,345	263	6.1%	164	1.2%
TC01	41,000	214	568,300	113,660	120	1.7%	86	1.2%
TC11/P	31,555	607	1,522,900	44,791	265	6.4%	342	1.5%
CS11 16 lines	27,800	**						
CS21 16 lines	56,914	**						

NOTES:

*Assumes 100 hours/week running time.

**Not yet available.

APPENDIX N
SCXX SERIES
ERROR DETECTION AND CORRECTION METHODS

All Emulex SCXX series disk controllers incorporate techniques for detection and/or correction of errors which may occur in data recorded on the magnetic media of the drive. This entails use of a redundancy encoding of the information transferred by the controller to the drive and a decoding of this same redundancy encoding of information read back from the drive by the controller.

The characteristics of a redundancy scheme depend on the choice of polynomial which depends on the type of errors to be expected. For example, data transmission usually suffers from long burst errors, whereas high-speed solid-state memories typically suffer from isolated single-bit errors. Error characteristics associated with rotating magnetic memories generally fall between these two extremes in the form of short, concentrated bursts of errors arising from bad spots or dust particles on the medium.

The polynomial used is a so-called Fire Code having the following form:

$$P(X) = P1(X) \quad (X^C/2 + 1)$$

Where P (X) is the generator polynomial for a Fire Code which must have two properties: (1) P1 (X) is a primitive (irreducible) polynomial of degree M and order E. (Note, the degree of a polynomial is defined to be the greatest power of X in which the coefficient is non-zero and E is defined to be (2M-1); and (2) the parameter C must not be divisable by E.

The above Fire Code polynomial will have the following properties: (1) the length of the code, N, is equal to the least common multiple of E and C, which works out to be (2M-1)-C; (2) the number of redundancy bits is equal to (M+C); and (3) the number of information bits, M, is equal to (2M-1)-C- (M+C).

The specific polynomial implemented in the SCXX Series disk controllers is as follows:

$$P(X) = (X^{11} + X^2 + 1) \quad (X^{21} + 1)$$

$$= X^{32} + X^{23} + X^{21} + X^{11} + X^2 + 1$$

The degree of the P1 (X) portion is 11 and E is therefore equal to $(2^{11} - 1)$ or 2047. The length of the code is equal to (E-C) where C equals 21. Hence, code length equals (2047 - 21) bits. The number of redundancy bits is equal to (M + C) or (11 + 21) = 32.

The above polynomial will support a record length up to 2680 words and each record will be followed by a 32-bit checkword. It will

detect two error bursts of combined length 22, one error burst of length 32, and any odd number of errors; it will correct any single error burst up to 11 bits long.

The SCXX Series controllers have an ECC (error correction code) capability which will detect and correct an error by reconstructing a portion of the data within the specified code word length, which is fixed. The burst ECC code will correct an error which must fall within the specified length of the burst. The actual location of the burst within the code word (data field of a sector) is irrelevant. The SCXX controller contains the hardware/firmware to find the burst within which the read error is included and determine the exact location of the burst within the data field. Any errors outside the specified burst length will be detected but not corrected. The ECC hardware of the controller, in this case, will indicate detection of a hard or uncorrectable error.

Depending upon the specific controller microcode version, correctable errors will be handled by the controller itself whereas in other cases the error pattern and position information are presented to the CPU for software handling.

For example, the SCXX/A series emulates the very early DEC RP11-E controller which did not incorporate any error correction scheme, hence, neither the controller nor the software handlers made provision for anything other than logging the fact that an error had been detected (simple parity). In the SCXX/A, the controller performs the ECC encoding/decoding and will notify the CPU of a detected error and also make the correction automatically if desired.

In the usual SCXX/B (RM02, 05, RP06 emulation) and /C (RK06, 07 emulation) series, on the other hand, the DEC procedure is to present the error pattern/location to the CPU for software operations, and this is the procedure followed in the standard Emulex models (NOTE: Special /B versions have also been developed which do implement the error correction in the controller).

It should be noted that when an error is detected by the controller, further block transfers from the disk are immediately inhibited until the software issues a restart command, the CPU therefore has a complete disk revolution (typically 16.7 ms) to execute the correction by software which is ample time to finish correction and issue the restart before the next sector comes up again. If the controller makes the correction, the same full revolution is also lost, and the overall time required to do the error correction is the same in either case.

There is also little or no system performance difference regardless of how the error correction is handled since correctable errors are not frequently found, typically once or twice per day for large (80-300 MByte) removable media disk drives. Therefore, there is usually no excessive burden placed on the software to perform the error correction rather than doing it in the controller hardware. In some applications, however, it has proven convenient to

incorporate error correction in the controller hardware (e.g. where data is being "scattered" into many different memory areas) and for this reason the special B versions have been provided.

APPENDIX O
EMULEX SOFTWARE PRODUCTS

EMULEX Software Engineering has created a number of software products. These products relate to certain EMULEX controller products and are normally shipped with these controllers. These software products may also be ordered separately.

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

TABLE O-1
EMULEX SOFTWARE PRODUCTS

RELATED HARDWARE PRODUCT	SOFTWARE PRODUCT (PART NUMBER)	MEDIA	DESCRIPTION
SC02/AX	DIAGNOSTIC (PX9960002) (PX9960302)	LISTING[1] MAG TAPE	Tests basic functionality of SC02/A (RP02/RP03) and provides a formatting utility to initialize and test the media.
SC02/CX	DIAGNOSTIC (PX9960001) (PX9960301	LISTING[1] MAG TAPE	Tests basic functionality of SC02/C (RK06/RK07) and provides a formatting utility to initialize and test the media.
SC21/V1	VAX/VMS DRIVER[1] (VD9951001) (VD9960401) (VD9960501)	MANUAL TU58[3] FLOPPY[3]	VAX/VMS device driver to support SC21/V1 under DEC VMS operating system.
	DIAGNOSTIC[4] (VX9960401) (VX9960501)	TU58[3] FLOPPY[3]	Tests basic functionality of SC21/V1 (RM03/RM05) and provides a formatting utility to initialize and test the media.

TABLE O-1 cont...

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 (DH11) under DEC VMS operating system.
	DIAGNOSTIC[4] (VX9960401) (VX9960501)	 TU58[3] FLOPPY[3]	Test the functionality of the CS11/U or CS21/U.
TC11/V	VAX/VMS DRIVER[2] (VD9951001) (VD9960401) (VD9960501)	 MANUAL TU58[3] FLOPPY[3]	VAX/VMS device driver to support TC11/V under DEC VMS operating system.
	DIAGNOSTIC[4] (VX9960401) (VX9960501)	 TU58[3] FLOPPY[3]	Performs functional testing of the TC11/V.

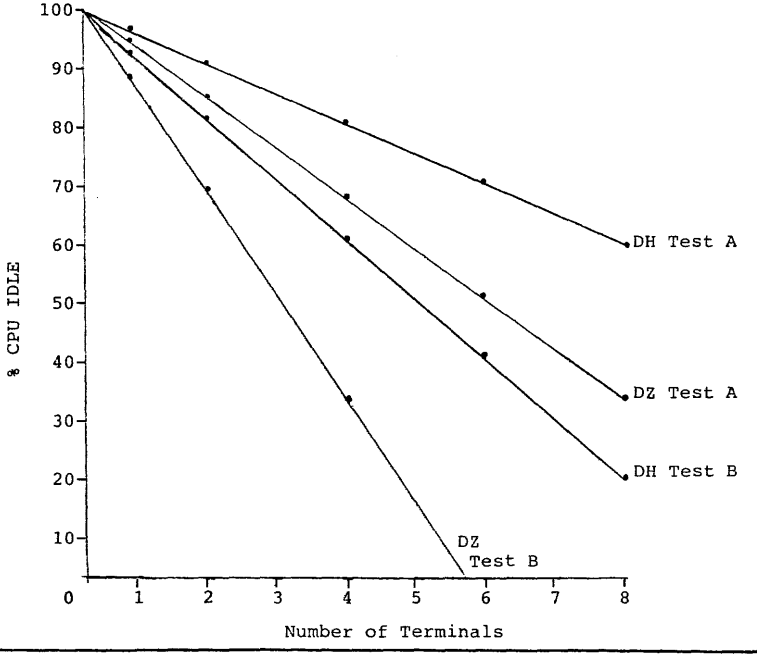
NOTES:
1. DIAGNOSTIC LISTINGS ARE NOT SHIPPED WITH ALL DEVICES. INSTRUCTIONS ON THE USE OF EMULEX DIAGNOSTICS ;IS CONTAINED THE APPROPRIATE DEVICE MANUAL.
2. ALL VAX/VMS DEVICE DRIVERS ARE DISTRIBUTED AS A SINGLE DISTRIBUTION.
3. VAX-11/750 SYSTEMS USE TU58 DISTRIBUTION MEDIA. VAX-11/780 SYSTEMS USE 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.

DH11 vs DZ11
Output Performance on the VAX-11/750

Test A: 80 character QIO write function every 200 milliseconds on each 9600 baud terminal (400 characters/sec)

Test B: 80 character QIO write function every 100 milliseconds on each 9600 baud terminal (800 characters/sec)

Number of Terminals	Test A % CPU IDLE		Test B % CPU IDLE	
	DH	DZ	DH	DZ
1	95	91	90	83
2	90	83	80	66
4	80	67	61	31
6	70	49	41	0
8	60	34	21	0



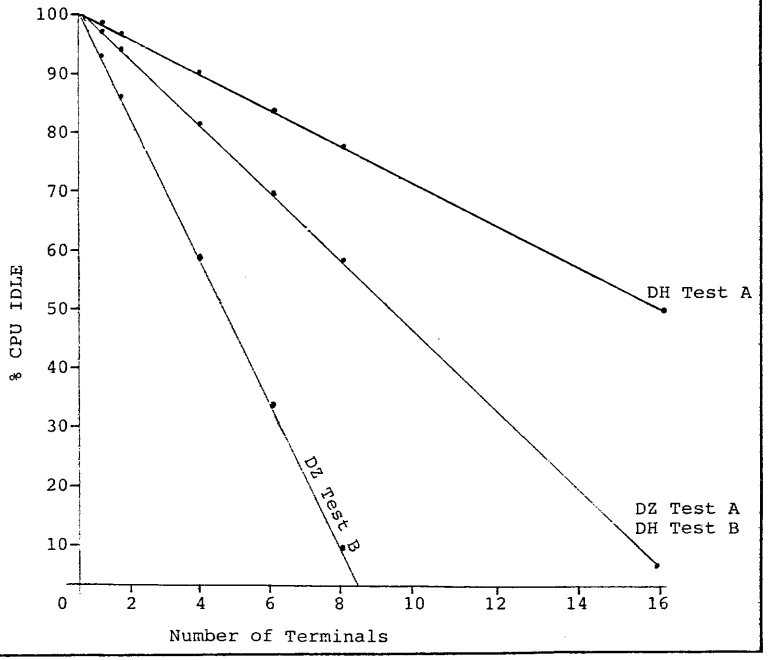
DH11/DZ11 Performance Comparison - VAX-11/780

DH11 vs DZ11
Output Performance on the VAX-11/780

Test A: 80 character QIO write function every 200 milliseconds on each 9600 baud terminal (400 characters/sec)

Test B: 80 character QIO write function every 100 milliseconds on each 9600 baud terminal (800 characters/sec)

Number of Terminals	Test A % CPU IDLE		Test B % CPU IDLE	
	DH	DZ	DH	DZ
1	97	94	94	88
2	94	88	88	76
4	88	76	76	52
6	82	64	64	28
8	76	52	52	05
16	52	2	6	0



NOTES:

SECTION VI
DISK DRIVES VS EMULEX
DISK CONTROLLERS

The following BLUE section of this handbook is a technical summary of non-captive 8" and 14" drives potentially applicable to Emulex disk controllers. See SECTION I for a detailed discussion of disk drive considerations and subsystem characteristics.

The GOLD SECTION VII which follows is an EMULEX DISK CONTROLLER VS DISK DRIVE summary. It gives further detail on specific Emulex disk controller emulations and the drives and software supported by each.

Users are urged to inquire on the availability of support for any drive of particular interest.

MANUFACTURER	SIZE	CAPACITY	CYL	TRK	SECT	INTRFC	CONTROLLER/EMULATION
AMPEX							
DF-980	14"	82.9 MB (F)	823	5	32	SMD	SC01/A1,A2,B3; SC02/AX,CX; SC11/A1,A2,B3; SC12/CX; SC21/B1; SC70/B3; SC71/B1; SC750/B1
DF-9165	14"	165.9 MB (F)	823	10	32	SMD	SC01/B3; SC02/AX,CX; SC11/B3; SC12/CX; SC21/B1; SC70/B3; SC71/B1; SC750/B1
DF-9330	14"	330.3 MB (F)	1024	16	32	SMD	SC21/B1; SC71/B1; SC750/B1
DFR-932	14"	16.3 MB (F) 16.3 MB (R)	823 823	1 1	32 32	SMD	SC01/A4,C1; SC02/AX,CX;; SC11/A4,C1, SC12/CX; SC21/C1
DFR-964	14"	48.9 MB (F) 16.3 MB (R)	823 823	3 1	32 32	SMD	SC01/A4,C1; SC02/AX,CX; SC11/A4,C1, SC12/CX; SC21/C1
DFR-996	14"	81.5 MB (F) 16.3 MB (R)	823 823	5 1	32 32	SMD	SC01/A4,C1; SC02/AX,CX; SC11/A4,C1; SC12/CX; SC21/C1
DM-940	14"	41.4 MB (R)	411	5	32	SMD	SC01/B1; SC11/B1; SC70/B1; SC71/B1
DM-980	14"	82.9 MB (R)	823	5	32	SMD	SC01/A1,A2,B3; SC02/AX,CX; SC11/A1,A2,B3; SC12/CX; SC21/B1; SC70/B3; SC71/B1; SC750/B1
DM-9160	14"	165.8 MB (R)	1645	5	32	SMD	SC01/B3; SC02/AX,CX; SC11/B3; SC12/CX; SC21/B1; SC70/B3; SC71/B1; SC750/B1
DM-9200	14"	206.3 MB (R)	815	19	22	SMD	SC01/B4; SC11/B4; SC21/B2; SC70/B4; SC71/B2; SC750/B1

MANUFACTURER	SIZE	CAPACITY	CYL	TRK	SECT	INTRFC	CONTROLLER/EMULATION
AMPEX							
DM-9300A	14"	309.5 MB (R)	815	19	32	SMD	SC01/B2,B3;, SC11/B3,B4; SC21/B1,B2; SC70/B3,B4; SC71/B1,B2; SC750/B1
BALL[1]							
BD-80	14"	82.1 MB (R)	823	5	32	SMD	SC01/A1,A2,B3; SC02/AX,CX; SC11/A1,A2,B3; SC12/CX; SC21/B1; SC70/B3; SC71/B1; SC750/B1
BD-160	14"	158.6 MB (R)	1645	5	32	SMD	SC01/B3; SC02/AX,CX; SC11/B3; SC12/CX; SC21/B1; SC70/B3; SC71/B1; SC750/B1
BASF							
6172	8"	24.0 MB (F)	614	3	23	SMD	SC01/A9; SC02/AX,CX; SC11/A9; SC12/CX
6172	8"	24.0 MB (F)	614	3	23	ANSI	SC04/CX
6173	8"	40.0 MB (F)	614	5	23	SMD	SC02/AX,CX; SC12/CX
6173	8"	40.0 MB (F)	614	5	23	ANSI	SC04/CX
CENTURY DATA/XEROX[2]							
TRIDENT T82	14"	82.9 MB (R)	823	5	32	SMD	SC01/A1,A2,B3; SC02/AX,CX; SC11/A1,A2,B3; SC12/CX; SC21/B1; SC70/B3; SC71/B1; SC750/B1
TRIDENT T202	14"	208.1 MB (R)	815	19	22	SMD	SC01/B2; SC11/B4; SC21/B2; SC70/B4; SC71/B2; SC750/B1
TRIDENT T302	14"	315.2 MB (R)	823	19	32	SMD	SC01/B2,B3; SC11/B3,B4; SC21/B1,B2; SC70/B3,B4; SC71/B1,B2; SC750/B1

MANUFACTURER	SIZE	CAPACITY	CYL	TRK	SECT	INTRFC	CONTROLLER/EMULATION
CONTROL DATA/MPI							
9448-32 (PHOENIX)	14"	16.3 MB (F) 16.3 MB (R)	823 823	1 1	32 32	SMD	SC01/A4,C1; SC02/AX,CX; SC11/A4,C1; SC12/CX; SC21/C1
9448-64 (PHOENIX)	14"	48.9 MB (F) 16.3 MB (R)	823 823	3 1	32 32	SMD	SC01/A4,C1; SC02/AX,CX; SC11/A4,C1; SC12/CX; SC21/C1
9448-96 (PHOENIX)	14"	81.5 MB (F) 16.3 MB (R)	823 823	5 1	32 32	SMD	SC01/A4,C1; SC02/AX,CX; SC11/A4,C1; SC12/CX; SC21/C1
9455 (LARK)	8"	8.3 MB (F) 8.3 MB (R)	203 203	2 2	32 32	SMD	SC02/AX
9730-12	14"	12.9 MB (F)	320	2	35	SMD	SC01/A3; SC02/AX; SC11/A3
9730-24	14"	25.8 MB (F)	320	4	35	SMD	SC01/A3; SC02/AX; SC11/A3
9730-80	14"	82.9 MB (F)	823	5	35	SMD	SC01/A1,A2,B3; SC02/AX,CX; SC11/A1,A2,B3; SC12/CX; SC21/B1; SC70/B3; SC71/B1; SC750/B1
9730-160	14"	165.9 MB (F)	823	10	32	SMD	SC01/B3; SC02/AX,CX; SC11/B3; SC12/CX; SC21/B1; SC70/B3; SC71/B1; SC750/B1
9733-5	14"	5.1 MB (F)	64	4	32	SMD	SC21/B1,B2; SC71/B1,B2

MANUFACTURER	SIZE	CAPACITY	CYL	TRK	SECT	INTRFC	CONTROLLER/EMULATION
CONTROL DATA/MPI							
9760	14"	41.4 MB (R)	411	5	32	SMD	SC01/B1; SC11/B1; SC21/B1; SC70/B1; SC71/B1
9762	14"	83.0 MB (R)	823	5	32	SMD	SC01/A1,A2,B3; SC02/AX,CX; SC11/A1,A2,B3; SC12/CX; SC21/B1; SC70/B3; SC71/B1; SC750/B1
9764	14"	157.4 MB (R)	411	19	32	SMD	SC01/B3; SC11/B1; SC21/B1; SC70/B1; SC71/B1
9766	14"	315.2 MB (R)	823	19	32	SMD	SC01/B2,B3; SC11/B3,B4; SC21/B1,B2; SC70/B3,B4; SC71/B1,B2; SC750/B1
9775	14"	675.0 MB (F)	842	40	32	SMD	SC01/B3,B2; SC11/B3,B4; SC21/B1,B2; SC70/B3,B4; SC71/B1,B2; SC750/B1
FUJITSU							
M2280K/N	14"	84.3 MB (F)	823	5	32	SMD	SC01/A1,A2,B3; SC02/AX,CX; SC11/A1,A2,B3; SC12/CX; SC21/B1; SC70/B3; SC71/B1; SC750/B1
M2284K/N	14"	168.5 MB (F)	823	10	32	SMD	SC01/B3; SC02/AX,CX; SC11/B3; SC12/CX; SC21/B1; SC70/B3; SC71/B1; SC750/B1
M2311K	8"	48.2 MB (F)	589	4	32	SMD	SC01/B3; SC02/AX,CX; SC12/CX; SC21/B1; SC71/B1
M2312K	8"	84.4 MB (F)	589	7	32	SMD	SC01/B3; SC02/AX,CX; SC12/CX; SC21/B1; SC71/B1

MANUFACTURER	SIZE	CAPACITY	CYL	TRK	SECT	INTRFC	CONTROLLER/EMULATION
KENNEDY COMPANY							
5301-14	14"	14.1 MB (F)	700	2	35	SMD	SC01/A7; SC11/A7
5302-42	14"	42.3 MB (F)	700	4	35	SMD	SC01/A8; SC11/A8
5303-70	14"	70.6 MB (F)	700	5	35	SMD	SC01/A8; SC02/AX,CX; SC11/A8; SC12/CX
5380	14"	83.0 MB (F)	823	5	32	SMD	SC01/A1,A2,B3; SC02/AX,CX; SC11/A1,A2,B3; SC12/CX; SC21/B1; SC70/B3; SC71/B1; SC750/B1
7300	8"	41.4 MB (F)	411	5	32	SMD	SC01/B1; SC02/AX,CX; SC11/B1; SC12/CX; SC21/B1; SC70/B1; SC71/B1
7300	8"	41.4 MB (F)	411	5	32	ANSI	SC04/CX
MEMOREX							
612-25	14"	25.1 MB (F)	350	4	35	SMD	SC01/A7; SC02/AX,CX; SC11/A7; SC12/CX
612-56	14"	56.0 MB (F)	350	8	35	SMD	SC01/A7; SC02/AX,CX; SC11/A7; SC12/CX;
612-84	14"	84.0 MB (F)	350	12	35	SMD	SC01/A6,A7; SC02/AX,CX; SC11/A6,A7; SC12/CX
677-0X	14"	208.2 MB (R)	815	19	22	SMD	SC01/B2; SC11/B4; SC21/B2; SC70/B4; SC71/B2; SC750/B1
677-30	14"	309.5 MB (R)	823	19	32	SMD	SC01/B3,B2; SC11/B3,B4; SC21/B1,B2; SC70/B3,B4; SC71/B1,B2; SC750/B1

MANUFACTURER	SIZE	CAPACITY	CYL	TRK	SECT	INTRFC	CONTROLLER/EMULATION
3M (TOSHIBA CORPORATION)							
8432	8"	20.0 MB (F)	280	4	28	ANSI	SC04/CX
8533	8"	60.0 MB (F)	838	4	28	ANSI	SC04/CX
MITSUBISHI							
2860-1	8"	7.4 MB (F)				SMD	*
2860-2	8"	50.7 MB (F)				SMD	*
M2884-1	14"	86.1 MB (F)				SMD	*
M2884-2	14"	129.2 MB (F)				SMD	*
8431	8"	10.0 MB (F)				ANSI	SC04
8432	8"	20.0 MB (F)				ANSI	SC04
NEC INFORMATION SYSTEMS							
D-1210	14"	20.8 MB (F)				SMD	*
D-1220	14"	41.5 MB (F)				SMD	*
D-1230	14"	83.1 MB (F)				SMD	*
2220	8"	25.5 MB (F)	415	3	32	SMD	*
2230	8"	42.5 MB (F)	415	5	32	SMD	*
NIPPON PERIPHERALS, LTD.							
NP30-40	*	.* MB (*)	370	5	35	SMD	SC02/AX.
NP30-80	*	.* MB (*)	370	11	35	SMD	SC02/AX.
NP30-120	*	.* MB (*)	568	11	35	SMD	SC02/AX.
OHIO SCIENTIFIC (OKIDATA)							
3301	14"	14.0 MB (F)				SMD	SC01/A3; SC11/A3
3302	14"	28.0 MB (F)				SMD	SC01/A3,A6; SC11/A3,A6
3303	14"	42.0 MB (F)				SMD	SC01/A8, SC11/A8,B1; SC70/B1
3304	14"	56.0 MB (F)				SMD	SC01/A6; SC11/A6
3305	14"	67.0 MB (F)				SMD	SC01/A8; SC11/A8
3306	14"	80.0 MB (F)				SMD	SC01/A6,A7; SC11/A6,A7

MANUFACTURER	SIZE	CAPACITY	CYL	TRK	SECT	INTRFC	CONTROLLER/EMULATION
ONTRAX CORPORATION							
SERIES 8	8"	34.0 MB (F)				ANSI	SC04
SERIES 8	8"	68.0 MB (F)				ANSI	SC04
SERIES 8	8"	136.0 MB (F)				ANSI	SC04
PERKIN ELMER							
VANGUARD 8	8"	35.1 MB (F)				SMD	*
VANGUARD 8	8"	35.1 MB (F)				ANSI	SC04
PERTEC							
D8000	8"	20.3 MB (F)				ANSI	SC04
PRIAM							
DISKOS 2050	8"	21.2 MB (F)	525	3	23	SMD	SC02/AX,CX; SC12/CX
DISKOS 3450	8"	35.3 MB (F)	525	5	23	SMD	SC02/AX,CX; SC12/CX
DISKOS 3350	14"	33.9 MB (F)	561	3	32	SMD	SC02/AX,CX; SC12/CX
DISKOS 6650	14"	67.7 MB (F)	1122	3	35	SMD	SC02/AX
DISKOS 15450	14"	157.9 MB (F)	1122	7	35	SMD	SC02/AX
SLI							
3100-3	8"	36.7 MB (F)	656	5	19	SMD	SC02/AX,CX; SC12/CX
3100-3	8"	36.7 MB (F)	656	5	19	ANSI	SC04
3100-4	8"	51.4 MB (F)	656	7	19	SMD	SC02/AX,CX; SC12/CX
3100-4	8"	51.4 MB (F)	656	7	19	ANSI	SC04
TOSHIBA CORPORATION (3M)							
MK-80F-10	8"	14.5 MB (F)				SMD	*
MK-80F-30	8"	38.3 MB (F)				SMD	*

1 BALL DISKS COME IN 3 MODELS: MOD 1=TRIDENT INTERFACE AND MEDIA; MOD 2=TRIDENT MEDIA AND SMD INTERFACE; MOD 3=SMD INTERFACE AND MEDIA.

2 TRIDENT DRIVES SHOULD BE ORDERED WITH AN 'RM' EXTENSION (FOR 823 CYL).

* INFORMATION UNAVAILABLE AT TIME OF PRINTING. CALL EMULEX FOR DETAILS.

SECTION VII
EMULEX DISK CONTROLLERS
VS DISK DRIVES

The following GOLD section is a technical summary of specific Emulex disk controllers applicable to non-captive 8" and 14" disk drives. These charts also specify DEC software supported by each. See SECTION I for a detailed discussion of disk drive considerations and subsystem characteristics.

The previous BLUE SECTION VI is a DISK DRIVE VS EMULEX DISK CONTROLLER technical summary of non-captive 8" and 14" drives potentially applicable to Emulex disk controllers.

Users are urged to inquire on the availability of support for any drive of particular interest. Also, since DEC operating systems are subject to constant upgrade, and there may be some incompatibility between these charts and new releases of DEC software, questions regarding currently supported DEC software should be directed to Emulex for verification.

EMULEX CONTROLLER	MBYTES/ LOGICAL UNITS	LOGICAL UNITS/ DRIVE	MAX # DRIVES/ CONTROLLER	MAX # MBYTES/ CONTROLLER	COMMENTS	DRIVES SUPPORTED	SOFTWARE SUPPORTED				
							RT11	RSX 11M	RSX 11M+	RSTS/E	VMS
SC01/A1	20.8 MB	3 RP02	2	124.8 MB	6 LOGICAL UNITS MAX. STD. RP02	CDC 9448-96 (5) CDC 9762 (1)	S S	S S	N N	S S	N N
SC01/A2	62.4 MB	1 RP03	2	124.8 MB	2 LOGICAL UNITS MAX. EXP. RP03	CDC 9448-96 (5) CDC 9762 (1)	E E	E E	N N	E E	N N
SC01/A3	10.4 MB	1 RP02	2	20.8 MB	2 LOGICAL UNITS MAX. CONTRACTED RP02	CDC 9448-96 (5) CDC 9730-12 KENNEDY 5301-14 OHIO SCIENTIFIC (Okidata) 3301	C C C C	C C C C	N N N N	C C C C	N N N N
	20.8 MB	1 RP02	2	41.6 MB	2 LOGICAL UNITS MAX. STD. RP02	CDC 9448-96 (5) CDC 9730-24 MEMOREX 612-25 OHIO SCIENTIFC (Okidata) 3002	S S S S	S S S S	N N N N	S S S S	N N N N
SC01/A4	13.4 MB 13.4 MB 13.4 MB	2 RP02 4 RP02 6 RP02	2 2 2	53.6 MB 107.2 MB 167.2 MB	8 LOGICAL UNITS MAX. CONTRACTED RP02	CDC PHOENIX 9448-32 (5) CDC PHOENIX 9448-64 (5) CDC PHOENIX 9448-96 (5)	C C C	C C C	N N N	C C C	N N N
SC01/A6	20.8 MB	3 RP02	2	124.8 MB	6 LOGICAL UNITS MAX. STD. RP02	MEMOREX 612-84	S	S	N	S	N
SC01/A7	20.8 MB	1 RP02	2	41.6 MB	2 LOGICAL UNITS MAX. STD. RP02	MEMOREX 612-52 OHIO SCIENTIFIC (Okidata) 3302	S S	S S	N N	S S	N N
	41.6 MB	1 RP03	2	83.2 MB	2 LOGICAL UNITS MAX. STD. RP03	MEMOREX 612-56 OHIO SCIENTIFIC (Okidata) 3304(53.8)	S S	S S	N N	S S	N N
	62.4 MB	1 RP03	2	124.8 MB	2 LOGICAL UNITS MAX. EXP. RP03	MEMOREX 612-84	E	E	N	E	N
SC01/A8	32.2 MB	1 RP02	2	64.4 MB	2 LOGICAL UNITS MAX. EXP. RP02	KENNEDY 5303 (42) OHIO SCIENTIFIC (Okidata) 3303 (40.4)	E E	E E	N N	E E	N N
	53.8 MB	1 RP03	2	107.6 MB	2 LOGICAL UNITS MAX. EXP. RP03	KENNEDY 5305 (70) OHIO SCIENTIFIC (Okidata) 3305 (67.3)	E E	E E	N N	E E	N N
SC01/A9	20.8 MB	1 RP02	2	41.6 MB	2 LOGICAL UNITS MAX. STD. RP02	BASF 6172 (23.5)	S	S	N	S	N

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EMULEX CONTROLLER	MBYTES/ LOGICAL UNITS	LOGICAL UNITS/ DRIVE	MAX # DRIVES/ CONTROLLER	MAX # MBYTES/ CONTROLLER	COMMENTS	DRIVES SUPPORTED	SOFTWARE SUPPORTED				
							RT11	RSX 11M	RSX 11M+	RSTS/E	VMS
SC01/B1	33.6 MB	1 RM02	2	67.3 MB	2 LOGICAL UNITS MAX. CONTRACTED RM02	AMPEX DM-940 CDC 9760	N N	C C	C C	C C	N N
	67.4 MB	1 RM02	2	134.8 MB	2 LOGICAL UNITS MAX. STD. RM02 (COMPATIBLE TO A DEC RM02)	CDC PHOENIX 9448-96 (5) CDC 9762 (1)	N N	S S	S S	S S	N N
	134.8 MB	1 RM02	2	269.7 MB	2 LOGICAL UNITS MAX. EXP. RM02	CDC 9730-160 (2)	N	E	E	E	N
	256.2 MB	1 RM02	2	512.4 MB	2 LOGICAL UNITS MAX. EXP. RM02 (EQUALS A DEC RM05)	CDC 9766 (4)	N	E	E	E	N
SC01/B2	67.4 MB	1 RP06	2	134.8 MB	2 LOGICAL UNITS MAX. CONTRACTED RP06	CDC 9762 (1)	N	C	C	C	N
	174.4 MB	1 RP06	2	348.8 MB	2 LOGICAL UNITS MAX. STD. RP06 (COMPATIBLE TO A DEC RP06)	MEMOREX 677-0X (3)	N	S	S	S	N
	256.2 MB	1 RP06	2	512.4 MB	2 LOGICAL UNITS MAX. EXP. RP06	CDC 9766 (4)	N	E	E	E	N
SC01/B3	67.4 MB	1 RM02	2	134.8 MB	2 LOGICAL UNITS MAX. STD. RM02 (COMPATIBLE TO A DEC RM02)	CDC 9762 (1)	N	S	S	S	N
	134.8 MB	1 RM02	2	269.7 MB	2 LOGICAL UNITS MAX. EXP. RM02	CDC 9730-160 (2)	N	E	E	E	N
	256.2 MB	1 RM02	2	512.4 MB	2 LOGICAL UNITS MAX. EXP. RM02 (EQUAL TO A DEC RM05)	CDC 9766 (4)	N	E	E	E	N
	512.4 MB	1 RM02	2	1024.8 MB	2 LOGICAL UNITS MAX. EXP. RM02	CDC 9775 MEMOREX 659	N N	E E	E E	E E	N N
	256.2 MB	1 RM05	2	512.4 MB	2 LOGICAL UNITS MAX. STD. RM05 (COMPATIBLE TO A DEC RM05)	CDC 9766 (4)	N	S	S	S	N
	512.4 MB	1 RM05	2	1024.8 MB	2 LOGIC L UNITS MAX. EXP. RM05	CDC 9775 MEMOREX 659	N N	E E	E E	E E	N N
SC01/C1	13.9 MB 13.9 MB 13.9 MB	2 RK06 4 RK06 6 RK06	2 2 2	55.6 MB 111.2 MB 111.2 MB	8 LOGICAL UNITS MAX. STD. RK06	CDC PHOENIX 9448-32 (5) CDC PHOENIX 9448-64 (5) CDC PHOENIX 9448-96 (5)	S S S	S S S	N N N	S S S	N N N

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							RT11	RSX 11M	RSX 11M+	RSTS/E	VMS
SC02/AX	11.4 MB 18.5 MB	1 RP02 RP02	2 2	22.8 MB 37.0 MB	2 LOGICAL UNITS MAX. CONTRACTED RP02	CDC 9730-12 PRIAM DISKOS-2050	C C	C C	N N	C C	N N
	20.8 MB	RP02	2	41.6 MB	2 LOGICAL UNITS MAX. STD. RP02	PRIAM DISKOS-3350	S	S	N	S	N
	21.6 MB 22.9 MB 30.1 MB 30.8 MB 31.8 MB 33.0 MB 36.1 MB 40.9 MB	1 RP02 1 RP02 1 RP02 1 RP02 1 RP02 1 RP02 1 RP02 1 RP02	2 2 2 2 2 2 2 2	43.2 MB 45.8 MB 60.2 MB 61.6 MB 63.6 MB 66.0 MB 72.2 MB 81.8 MB	2 LOGICAL UNITS MAX. EXP. RP02	BASF 6172 CDC 9730-24 PRIAM DISKOS-3350 PRIAM DISKOS-3450 SLI CHEYENNE 3 NISSEI NP30-40 BASF 6173 FUJITSU 2311	E E E E E E E E	E E E E E E E E	N N N N N N N N	E E E E E E E E	N N N N N N N N
	6.6 MB 13.4 MB 14.7 MB	2 RP02 2 RP02 2 RP02	2 2 2	26.4 MB 53.6 MB 58.8 MB	4 LOGICAL UNITS MAX. CONTRACTED RP02	CDC 9455 CDC PHOENIX 9448-32 (5) CDC PHOENIX 9448-32 (5)	C C C	C C C	N N N	C C C	N N N
	20.8 MB 20.8 MB	3 RP02 3 RP02	2 2	124.8 MB 124.8 MB	6 LOGICAL UNITS MAX. STD. RP02	KENNEDY 5303-70 NISSEI NP30-80	S S	S S	N N	S S	N N
	24.2 MB 25.0 MB	3 RP02 3 RP02	2 2	145.2 MB 150.0 MB	6 LOGICAL UNITS MAX. EXP. RP02	CDC 9762 (1) MEMOREX 612-84	E E	E E	N N	E E	N N
	14.7 MB	4 RP02	2	117.6 MB	8 LOGICAL UNITS MAX. CONTRACTED RP02	CDC PHOENIX 9448-64 (5)	C	C	N	C	N
	13.4 MB 14.7 MB	6 RP02 6 RP02	2 2	107.2 MB 117.6 MB	8 LOGICAL UNITS MAX. CONTRACTED RP02	CDC PHOENIX 9448-96 (5) CDC PHOENIX 9448-96 (5)	C C	C C	N N	C C	N N
	20.8 MB 20.8 MB	7 RP02 7 RP02	2 2	166.4 MB 166.4 MB	8 LOGICAL UNITS MAX. STD. RP02	CDC 9730-160 (2) AMPEX 93160	S S	S S	N N	S S	N N

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							RT11	RSX 11M	RSX 11M+	RSTS/E	VMS
SC02/AX	41.6 MB	3 RP03	2	124.8 MB	6 LOGICAL UNITS MAX. STD. RP03	CDC 9730-160 (2)	S	S	N	S	N
	44.6 MB	1 RP03	2	89.2 MB	2 LOGICAL UNITS MAX. EXP. RP03	SLI SHEYENNE 4	E	E	N	E	N
	57.3 MB	1 RP03	2	114.6 MB	2 LOGICAL UNITS MAX. EXP. RP03	KENNEDY 5300-70	E	E	N	E	N
	60.3 MB	1 RP03	2	120.6 MB	2 LOGICAL UNITS MAX. EXP. RP03	PRIAM DISKOS-6650	E	E	N	E	N
	71.6 MB	1 RP03	2	143.2 MB	2 LOGICAL UNITS MAX. EXP. RP03	FUJITSU 2312	E	E	N	E	N
	73.7 MB	1 RP03	2	147.4 MB	2 LOGICAL UNITS MAX. EXP. RP03	CDC 9762 (1)	E	E	N	E	N
	134.0 MB	1 RP03	2	268.0 MB	2 LOGICAL UNITS MAX. EXP. P03	PRIAM 15450	E	E	N	E	N
	50.8 MB	2 RP03	2	203.2 MB	4 LOGICAL UNITS MAX. EXP. RP03	NISSEI NP30-120	E	E	N	E	N
	73.7 MB	2 RP03	2	294.8 MB	4 LOGICAL UNITS MAX. EXP. RP03	CDC 9730-160 (2)	E	E	N	E	N
SC02/CX	13.9 MB	1 RK06	2	37.8 MB	2 LOGICAL UNITS MAX. STD. RK06	PRIAM DISKOS-2050	S	S	S	S	N
	13.9 MB	2 RK06	2	55.6 MB	4 LOGICAL UNITS MAX. STD. RK06	CDC PHOENIX 9448-32 (5)	S	S	S	S	N
	13.9 MB	2 RK06	2	55.6 MB	4 LOGICAL UNITS MAX. STD. RK06	PRIAM DISKOS-3350	S	S	S	S	N
	13.9 MB	2 RK06	2	55.6 MB	4 LOGICAL UNITS MAX. STD. RK06	PRIAM DISKOS-3450	S	S	S	S	N
	13.9 MB	2 RK06	2	55.6 MB	4 LOGICAL UNITS MAX. STD. RK06	SLI SHEYENNE 3	S	S	S	S	N
	13.9 MB	3 RK06	2	83.4 MB	6 LOGICAL UNITS MAX. STD. RK06	FUJITSU 2311	S	S	S	S	N
	13.9 MB	3 RK06	2	93.4 MB	6 LOGICAL UNITS MAX. STD. RK06	SLI SHEYENNE 4	S	S	S	S	N
	13.9 MB	4 RK06	2	111.2 MB	8 LOGICAL UNITS MAX. STD. RK06	CDC PHOENIX 9448-64 (5)	S	S	S	S	N
	13.9 MB	6 RK06	2	111.2 MB	8 LOGICAL UNITS MAX. STD. RK06	CDC PHOENIX 9448-96 (5)	S	S	S	S	N

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							RT11	RSX 11M	RSX 11M+	RSTS/E	VMS
SC02/CX	28.0 MB	1 RK07	2	56.0 MB	2 LOGICAL UNITS MAX. STD. RK07	PRIAM DISKOS-3350	S	S	S	S	N
	28.0 MB	1 RK07	2	56.0 MB	2 LOGICAL UNITS MAX. STD. RK07	PRIAM DISKOS-3450	S	S	S	S	N
	28.0 MB	1 RK07	2	56.0 MB	2 LOGICAL UNITS MAX. STD. RK07	SLI SHEYENNE 3	S	S	S	S	N
	28.0 MB	2 RK07	2	112.0 MB	4 LOGICAL UNITS MAX. STD. RK07	AMPEX 165-210	S	S	S	S	N
	28.0 MB	2 RK07	2	112.0 MB	4 LOGICAL UNITS MAX. STD. RK07	KENNEDY 5300-70	S	S	S	S	N
	28.0 MB	3 RK07	2	168.0 MB	6 LOGICAL UNITS MAX. STD. RK07	CDC PHOENIX 9448-96 (5)	S	S	S	S	N
	28.0 MB	3 RK07	2	168.0 MB	6 LOGICAL UNITS MAX. STD. RK07	AMPEX 9160	S	S	S	S	N
	28.0 MB	5 RK07	2	224.0 MB	8 LOGICAL UNITS MAX. STD. RK07	AMPEX 9160	S	S	S	S	N
	28.0 MB	5 RK07	2	224.0 MB	8 LOGICAL UNITS MAX. STD. RK07	CDC 9730-160 (2)	S	S	S	S	N
	28.0 MB	6 RK07	2	224.0 MB	8 LOGICAL UNITS MAX STD. RK07	AMPEX 165-210	S	S	S	S	N

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							RT11	RSX 11M	RSX 11M+	RSTS/E	VMS
SC02/CX	13.9 MB 28.0 MB	1 RK06 1 RK07	2 2	27.8 MB 56.0 MB	4 LOGICAL UNITS MAX. 1 RK06 & 1 RK07 /DR.	FUJITSU 2311	S	S	S	S	N
	13.9 MB 28.0 MB	1 RK06 1 RK07	2 2	27.8 MB 56.0 MB	4 LOGICAL UNITS MAX. 1 RK06 & 1 RK07 /DR.	MEMOREX 612-56	S	S	S	S	N
	13.9 MB 28.0 MB	1 RK06 1 RK07	2 2	27.8 MB 56.0 MB	4 LOGICAL UNITS MAX. 1 RK06 & 1 RK07 /DR.	SLI SHEYENNE 4	S	S	S	S	N
	13.9 MB 28.0 MB	1 RK06 2 RK07	2 2	27.8 MB 112.0 MB	6 LOGICAL UNITS MAX. 1 RK06 & 2 RK07 /DR.	CDC PHOENIX 9448-96 (5)	S	S	S	S	N
	13.9 MB 28.0 MB	1 RK06 2 RK07	2 2	27.8 MB 112.0 MB	6 LOGICAL UNITS MAX. 1.RK06 & 2 RK07 /DR.	CDC 9762 (1)	S	S	S	S	N
	13.9 MB 28.0 MB	1 RK06 2 RK07	2 2	27.8 MB 112.0 MB	6 LOGICAL UNITS MAX. 1 RK06 & 2 RK07 /DR.	FUJITSU 2312	S	S	S	S	N
	13.9 MB 28.0 MB	1 RK06 2 RK07	2 2	27.8 MB 112.0 MB	6 LOGICAL UNITS MAX. 1 RK06 & 2 RK07 /DR.	MEMOREX 612-84	S	S	S	S	N
	13.9 MB 28.0 MB	2 RK06 2 RK07	2 2	55.6 MB 112.0 MB	8 LOGICAL UNITS MAX. 2 RK06 & 2 RK07 /DR.	CDC PHOENIX 9448-96 (5)	S	S	S	S	N
SC02/LX	THE EXACT MAPPING OF THE NUMBER OF LOGICAL UNITS PER THE NUMBER OF PHYSICAL UNITS IS NOT DETERMINED AT THE TIME OF PRINTING. PLEASE CONTACT EMULEX FOR INFORMATION ON THIS PRODUCT.					SC02/LX	THE DRIVES FOR THIS EMULATION WERE NOT DETERMINED AT THE TIME OF PRINTING. PLEASE CONTACT EMULEX FOR INFORMATION REGARDING THIS PRODUCT.				
SC04/CX	THE EXACT MAPPING OF THE NUMBER OF LOGICAL UNITS PER THE NUMBER OF PHYSICAL UNITS IS NOT DETERMINED AT THE TIME OF PRINTING. PLEASE CONTACT EMULEX FOR INFORMATION ON THIS PRODUCT.					AMPEX DF-840 AMPEX DF-880 BASF 6172 BASF 6173 KENNEDY 7300 PERTEC D8000 PRIAM 2050 PRIAM 3450 SLI 2 (22.0 MB) SLI 3 (36.7 MB) SLI 4 (51.4 MB) TOSHIBA 8432 3-M 8432 3-M 8533	S S S S S S S S S S S S S S	S S S S S S S S S S S S S S	S S S S S S S S S S S S S S	S S S S S S S S S S S S S S	N N N N N N N N N N N N N N
SC04/LX	THE EXACT MAPPING OF THE NUMBER OF LOGICAL UNITS PER THE NUMBER OF PHYSICAL UNITS IS NOT DETERMINED AT THE TIME OF PRINTING. PLEASE CONTACT EMULEX FOR INFORMATION ON THIS PRODUCT.					SC04/LX	THE DRIVES FOR THIS EMULATION WERE NOT DETERMINED AT THE TIME OF PRINTING. PLEASE CONTACT EMULEX FOR INFORMATION REGARDING THIS PRODUCT.				

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							RT11	RSX 11M	RSX 11M+	RSTS/E	VMS
SC11/A1	20.8 MB	3 RP02	3	166.4 MB	8 LOGICAL UNITS MAX. STD. RP02	CDC PHOENIX 9448-96 (5) CDC 9762 (1)	S S	S S	N N	S S	N N
SC11/A2	62.4 MB	1 RP03	4	249.6 MB	4 LOGICAL UNITS MAX. EXP. RP03	CDC PHOENIX 9448-96 (5) CDC 9762 (1)	E E	E E	N N	E E	N N
SC11/A3	10.4 MB	1 RP02	4	41.6 MB	4 LOGICAL UNITS MAX. CONTRACTED RP02	CDC PHOENIX 9448-96 (5) CDC 9730-12 KENNEDY 5301-14 OHIO SCIENTIFIC (Okidata) 3301	C C C C	C C C C	N N N N	C C C C	N N N N
	20.8 MB	1 RP02	4	83.2 MB	4 LOGICAL UNITS MAX. STD. RP02	CDC PHOENIX 9448-96 (5) CDC 9730-24 MEMOREX 612-25 OHIO SCIENTIFIC (Okidata) 3302	S S S S	S S S S	N N N N	S S S S	N N N N
SC11/A4	13.4 MB 13.4 MB 13.4 MB	2 RP02 4 RP02 6 RP02	4 2 2	107.2 MB 107.2 MB 107.2 MB	8 LOGICAL UNITS MAX. CONTRACTED RP02	CDC PHOENIX 9448-32 (5) CDC PHOENIX 9448-64 (5) CDC PHOENIX 9448-96 (5)	C C C	C C C	N N N	C C C	N N N
SC11/A6	20.8 MB	3 RP02	3	166.4 MB	8 LOGICAL UNITS MAX. STD. RP02	MEMOREX 612-84	S	S	N	S	N
SC11/A7	20.8 MB	1 RP02	4	83.2 MB	4 LOGICAL UNITS MAX. STD. RP02	MEMOREX 612-25 OHIO SCIENTIFIC (Okidata) 3302 (27)	S S	S S	N N	S S	N N
	41.6 MB	1 RP03	4	166.4 MB	4 LOGICAL UNITS MAX. STD. RP03	MEMOREX 612-56 OHIO SCIENTIFIC (Okidata) 3304 (53.8)	S S	S S	N N	S S	N N
	62.4 MB	1 RP03	4	249.6 MB	4 LOGICAL UNITS MAX. EXP. RP03	MEMOREX 612-84	E	E	N	E	N
SC11/A8	32.2 MB	1 RP02	4	128.8 MB	4 LOGICAL UNITS MAX. EXP. RP02	KENNEDY 5303 (42) OHIO SCIENTIFIC (Okidata) 3303 (40.4)	E E	E E	N N	E E	N N
	53.8 MB	1 RP03	4	215.2 MB	4 LOGICAL UNITS MAX. EXP. RP02	KENNEDY 5305 (70) OHIO SCIENTIFIC (Okidata) 3305 (67.3)	E E	E E	N N	E E	N N
SC11/A9	20.8 MB	1 RP02	4	83.2 MB	4 LOGICAL UNITS MAX. STD. RP02	BASF 6172 (23.5)	S	S	N	S	N

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							RT11	RSX 11M	RSX 11M+	RSTS/E	VMS
SC11/B1	33.6 MB	1 RM02	4	134.6 MB	4 LOGICAL UNITS MAX. CONTRACTED RM02	AMPEX DM-940 CDC 9760	N N	C C	C C	C C	N N
	67.4 MB	1 RM02	4	269.7 MB	4 LOGICAL UNITS MAX. STD. RM02 (COMPATIBLE TO A DEC RM02)	CDC PHOENIX 9448-96 (5) CDC 9762 (1)	N N	S S	S S	S S	N N
	256.2 MB	1 RM02	4	1024.8 MB	4 LOGICAL UNITS MAX. EXP. RM02 (EQUAL TO A DEC RM05 IN SIZE)	CDC 9766 (4)	N	E	E	E	N
SC11/B2	67.4 MB	1 RP06	4	269.7 MB	4 LOGICAL UNITS MAX. CONTRACTED RP06	CDC 9762 (1)	N	C	C	C	N
	174.4 MB	1 RP06	4	697.7 MB	4 LOGICAL UNITS MAX. STD. RP06 (COMPATIBLE TO A DEC RP06)	MEMOREX 677-0X (3)	N	S	S	S	N
	256.2 MB	1 RP06	4	1024.8 MB	4 LOGICAL UNITS MAX. EXP. RP06	CDC 9766 (4)	N	E	E	E	N
SC11/B3	67.4 MB	1 RM02	4	269.7 MB	4 LOGICAL UNITS MAX. STD. RM02 (COMPATIBLE TO A DEC RM02)	CDC PHOENIX 9448-96 (5) CDC 9762 (1)	N N	S S	S S	S S	N N
	134.8 MB	1 RM02	4	539.4 MB	4 LOGICAL UNITS MAX. EXP. RM02	CDC 9730-160 (2)	N	E	E	E	N
	256.2 MB	1 RM02	4	1024.8 MB	4 LOGICAL UNITS MAX. EXP. RM02 (EQUAL TO A DEC RM05)	CDC 9766 (4)	N	E	E	E	N
	551.8 MB	1 RM02	4	2207.2 MB	4 LOGICAL UNITS MAX. EXP. RM02	CDC 9775 MEMOREX 659	N N	E E	E E	E E	N N
	256.2 MB	1 RM05	4	1024.8 MB	4 LOGICAL UNITS MAX. STD. RM05 (COMPATABLE TO A DEC RM05)	CDC 9766 (4)	N	S	S	S	N
	551.8 MB	1 RM05	4	2207.2 MB	4 LOGICAL UNITS MAX. EXP. RM05	CDC 9775 MEMOREX 659	N N	E E	E E	E E	N N

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							RT11	RSX 11M	RSX 11M+	RSTS/E	VMS
SC11/B4	4.2 MB	1 RP06	4	16.8 MB	4 LOGICAL UNITS MAX. CONTRACTED RP06 HEAD/TRACK TYPE DRIVE	CDC 9733-5	N	C	C	C	N
	174.4 MB	1 RP06	4	697.7 MB	4 LOGICAL UNITS MAX. STD. RP06 (COMPATIBLE TO A DEC RP06)	MEMOREX 677-0X (3)	N	S	S	S	N
	256.2 MB	1 RP06	4	1024.8 MB	4 LOGICAL UNITS MAX. EXP. RP06	CDC 9766 (4)	N	E	E	E	N
	551.8 MB	1 RP06	5	2207.2 MB	4 LOGICAL UNITS MAX. EXP. RP06	CDC 9775 MEMOREX 659	N N	E E	E E	E E	N N
SC12/CX	13.9 MB	1 RK06	2	27.8 MB	2 LOGICAL UNITS MAX. STD. RK06	PRIAM DISKOS-2050	S	S	S	S	N
	13.9 MB	2 RK06	2	55.6 MB	4 LOGICAL UNITS MAX. STD. RK06	CDC PHOENIX 9448-32 (5)	S	S	S	S	N
	13.9 MB	2 RK06	2	55.6 MB	4 LOGICAL UNITS MAX. STD. RK06	PRIAM DISKOS-3350	S	S	S	S	N
	13.9 MB	2 RK06	2	55.6 MB	4 LOGICAL UNITS MAX. STD. RK06	PRIAM DISKOS-3450	S	S	S	S	N
	13.9 MB	2 RK06	2	55.6 MB	4 LOGICAL UNITS MAX. STD. RK06	SLI SHEYENNE 3	S	S	S	S	N
	13.9 MB	3 RK06	2	83.4 MB	6 LOGICAL UNITS MAX. STD. RK06	FUJITSU 2311	S	S	S	S	N
	13.9 MB	3 RK06	2	83.4 MB	6 LOGICAL UNITS MAX. STD. RK06	SLI SHEYENNE 4	S	S	S	S	N
	13.9 MB	4 RK06	2	111.2 MB	8 LOGICAL UNITS MAX. STD. RK06	CDC PHOENIX 9448-64 (5)	S	S	S	S	N
	13.9 MB	6 RK06	2	111.2 MB	8 LOGICAL UNITS MAX. STD. RK06	CDC PHOENIX 9448-96 (5)	S	S	S	S	N

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EMULEX CONTROLLER	MBYTES/ LOGICAL UNITS	LOGICAL UNITS/ DRIVE	MAX # DRIVES/ CONTROLLER	MAX # MBYTES/ CONTROLLER	COMMENTS	DRIVES SUPPORTED	SOFTWARE SUPPORTED				
							RT11	RSX 11M	RSX 11M+	RSTS/E	VMS
SC12/CX	28.0 MB	1 RK07	2	56.0 MB	2 LOGICAL UNITS MAX. STD. RK07	PRIAM DISKOS-3350	S	S	S	S	N
	28.0 MB	1 RK07	2	56.0 MB	2 LOGICAL UNITS MAX. STD. RK07	PRIAM DISKOS-3450	S	S	S	S	N
	28.0 MB	1 RK07	2	56.0 MB	2 LOGICAL UNITS MAX. STD. RK07	SLI SHEYENNE 3	S	S	S	S	N
	28.0 MB	2 RK07	2	112.0 MB	4 LOGICAL UNITS MAX. STD. RK07	AMPEX 165-210	S	S	S	S	N
	28.0 MB	2 RK07	2	112.0 MB	4 LOGICAL UNITS MAX. STD. RK07	KENNEDY 5300-70	S	S	S	S	N
	28.0 MB	3 RK07	2	168.0 MB	6 LOGICAL UNITS MAX. STD. RK07	CDC PHOENIX 9448-96 (5)	S	S	S	S	N
	28.0 MB	3 RK07	2	168.0 MB	6 LOGICAL UNITS MAX. STD. RK07	AMPEX 9160	S	S	S	S	N
	28.0 MB	5 RK07	2	224.0 MB	8 LOGICAL UNITS MAX. STD. RK07	AMPEX 9160	S	S	S	S	N
	28.0 MB	5 RK07	2	224.0 MB	8 LOGICAL UNITS MAX. STD. RK07	CDC 9730-160 (2)	S	S	S	S	N
	28.0 MB	6 RK07	2	224.0 MB	8 LOGICAL UNITS MAX. STD. RK07	AMPEX 165-210	S	S	S	S	N
	13.9 MB 28.0 MB	1 RK06 1 RK07	2 2	27.8 MB 56.0 MB	4 LOGICAL UNITS MAX. 1 RK06 & 1 RK07 /DR.	FUJITSU 2311	S	S	S	S	N
	13.9 MB 28.0 MB	1 RK06 1 RK07	2 2	27.8 MB 56.0 MB	4 LOGICAL UNITS MAX. 1 RK06 & 1 RK07 /DR.	MEMOREX 612-56	S	S	S	S	N
	13.9 MB 28.0 MB	1 RK06 1 RK07	2 2	27.8 MB 56.0 MB	4 LOGICAL UNITS MAX. 1 RK06 & 1 RK07 /DR.	SLI SHEYENNE 4	S	S	S	S	N
	13.9 MB 28.0 MB	1 RK06 2 RK07	2 2	27.8 MB 112.0 MB	6 LOGICAL UNITS MAX. 1 RK06 & 2 RK07 /DR.	CDC PHOENIX 9448-96 (5)	S	S	S	S	N
	13.9 MB 28.0 MB	1 RK06 2 RK07	2 2	27.8 MB 112.0 MB	6 LOGICAL UNITS MAX. 1 RK06 & 2 RK07 /DR.	CDC 9762 (1)	S	S	S	S	N
	13.9 MB 28.0 MB	1 RK06 2 RK07	2 2	27.8 MB 112.0 MB	6 LOGICAL UNITS MAX. 1 RK06 & 2 RK07 /DR.	FUJITSU 2312	S	S	S	S	N
	13.9 MB 28.0 MB	1 RK06 2 RK07	2 2	27.8 MB 112.0 MB	6 LOGICAL UNITS MAX. 1 RK06 & 2 RK07 /DR.	MEMOREX 612-84	S	S	S	S	N
	13.9 MB 28.0 MB	2 RK06 2 RK07	2 2	55.6 MB 112.0 MB	8 LOGICAL UNITS MAX. 2 RK06 & 2 RK07 /DR.	CDC PHOENIX 9448-96 (5)	S	S	S	S	N

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							RT11	RSX 11M	RSX 11M+	RSTS/E	VMS
SC12/LX	THE EXACT MAPPING OF THE NUMBER OF LOGICAL UNITS PER THE NUMBER OF PHYSICAL UNITS IS NOT DETERMINED AT THE TIME OF PRINTING. PLEASE CONTACT EMULEX FOR INFORMATION ON THIS PRODUCT.					SC12/LX	THE DRIVES FOR THIS EMULATION WERE NOT DETERMINED AT THE TIME OF PRINTING. PLEASE CONTACT EMULEX FOR INFORMATION REGARDING THIS PRODUCT.				
SC12/V	THE EXACT MAPPING OF THE NUMBER OF LOGICAL UNITS PER THE NUMBER OF PHYSICAL UNITS IS NOT DETERMINED AT THE TIME OF PRINTING. PLEASE CONTACT EMULEX FOR INFORMATION ON THIS PRODUCT.					SC12/V	THE DRIVES FOR THIS EMULATION WERE NOT DETERMINED AT THE TIME OF PRINTING. PLEASE CONTACT EMULEX FOR INFORMATION REGARDING THIS PRODUCT.				
SC21/B1	4.2 MB	1 RM02	4	16.8 MB	4 LOGICAL UNITS MAX. CONTRACTED RM02	CDC 9733-5	N	C	C	C	N
	67.4 MB	1 RM02	4	269.6 MB	4 LOGICAL UNITS MAX. STD. RM02 (COMPATIBLE TO A DEC RM02)	CDC PHOENIX 9448-96 (5) CDC 9762 (1)	N N	S S	S S	S S	N N
	134.4 MB	1 RM02	4	539.2 MB	4 LOGICAL UNITS MAX. EXP. RM02	CDC 9730-160 (2)	N	E	E	E	N
	256.2 MB	1 RM02	4	1024.8 MB	4 LOGICAL UNITS MAX. EXP. RM02 (EQUAL TO A DEC RM05)	CDC 9766 (4)	N	E	E	E	N
	512.4 MB	1 RM02	4	2049.6 MB	4 LOGICAL UNITS MAX. EXP. RM02	CDC 9775 MEMOREX 659	N N	E E	E E	E E	N N
	256.2 MB	1 RM05	4	1024.8 MB	4 LOGICAL UNITS MAX. STD. RM05 (COMPATIBLE TO A DEC RM05)	CDC 9766 (4)	N	S	S	S	N
	512.4 MB	1 RM05	4	2049.6 MB	4 LOGICAL UNITS MAX. EXP. RM05	CDC 9775 MEMOREX 659	N N	E E	E E	E E	N N
SC21/V1	67.4 MB	1 RM02	4	269.6 MB	4 LOGICAL UNITS MAX. STD. RM02 (COMPATIBLE TO A DEC RM03)	CDC 9762 (1)	N	N	N	N	S
	134.8 MB	1 RM02	4	539.2 MB	4 LOGICAL UNITS MAX. EXP. RM02	CDC 9730-160 (2)	N	N	N	N	E
	256.2 MB	1 RM02	4	1024.8 MB	4 LOGICAL UNITS MAX. EXP. RM02	CDC 9766 (4)	N	N	N	N	E
	256.2 MB	1 RM05	4	1024.8 MB	4 LOGICAL UNITS MAX. STD. RM05 (COMPATIBLE TO A DEC RM05)	CDC 9766 (4)	N	N	N	N	S
	512.4 MB	1 RM05	4	2049.6 MB	4 LOGICAL UNITS MAX. EXP. RM05	CDC 9775 MEMOREX 659	N N	N N	N N	N N	E E

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							RT11	RSX 11M	RSX 11M+	RSTS/E	VMS
SC21/B2	4.2 MB	1 RP06	4	16.8 MB	4 LOGICAL UNITS MAX. CONTRACTED RP06 HEAD/TRACK DR.	CDC 9733-5	N	C	C	C	N
	67.4 MB	1 RP06	4	269.6 MB	4 LOGICAL UNITS MAX. CONTRACTED RP06	CDC 9762 (1)	N	C	C	C	N
	134.4 MB	1 RP06	4	537.6 MB	4 LOGICAL UNITS MAX. CONTRACTED RP06	CDC 9730-160 (2)	N	C	C	C	N
	174.4 MB	1 RP06	4	697.6 MB	4 LOGICAL UNITS MAX. STD. RP06 (COMPATIBLE TO A DEC RP06)	MEMOREX 677-0X (3)	N	S	S	S	N
	256.2 MB	1 RP06	4	1024.8 MB	4 LOGICAL UNITS MAX. EXP. RP06	CDC 9766 (4)	N	E	E	E	N
	512.4 MB	1 RP06	4	2049.6 MB	4 LOGICAL UNITS MAX. EXP. RP06	CDC 9775 MEMOREX 659	N N	E E	E E	E E	N N
SC21/C1	13.9 MB 13.9 MB 13.9 MB	2 RK06 4 RK06 6 RK06	4 2 2	111.2 MB 111.2 MB 111.2 MB	8 LOGICAL UNITS MAX. STD. RK06	CDC PHOENIX 9448-32 (5) CDC PHOENIX 9448-64 (5) CDC PHOENIX 9448-96 (5)	S S S	S S S	N N N	S S S	N N N
SC70/B1	33.6 MB	1 RM03	4	134.6 MB	4 LOGICAL UNITS MAX. CONTRACTED RM02	AMPEX DM-940 CDC 9760	N N	C C	C C	C C	N N
	67.4 MB	1 RM03	4	269.7 MB	4 LOGICAL UNITS MAX. STD. RM02 (COMPATIBLE TO A DEC RM03)	CDC PHOENIX 9448-96 (5) CDC 9762 (1)	N N	S S	S S	S S	N N
	256.2 MB	1 RM03	4	1024.8 MB	4 LOGICAL UNITS MAX. EXP. RM02 (EQUAL TO A DEC RM05 IN SIZE)	CDC 9766 (4)	N	E	E	E	N
SC70/B2	67.4 MB	1 RP06	4	269.7 MB	4 LOGICAL UNITS MAX. CONTRACTED RP06	CDC 9762 (1)	N	C	C	C	N
	174.4 MB	1 RP06	4	697.7 MB	4 LOGICAL UNITS MAX. STD. RP06 (COMPATIBLE TO A DEC RP06)	MEMOREX 677-0X (3)	N	S	S	S	N
	256.2 MB	1 RP06	4	1024.8 MB	4 LOGICAL UNITS MAX. EXP. RP06	CDC 9766 (4)	N	E	E	E	N

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							RT11	RSX 11M	RSX 11M+	RSTS/E	VMS
SC70/B3	67.4 MB	1 RM03	4	269.7 MB	4 LOGICAL UNITS MAX. STD. RM03 (COMPATIBLE TO A DEC RM03)	CDC PHOENIX 9448-96 (5) CDC 9762 (1)	N N	S S	S S	S S	N N
	134.8 MB	1 RM03	4	539.4 MB	4 LOGICAL UNITS MAX. EXP. RM03	CDC 9730-160 (2)	N	E	E	E	N
	256.2 MB	1 RM03	4	1024.8 MB	4 LOGICAL UNITS MAX. EXP. RM03 (EQUAL TO A DEC RM05)	CDC 9766 (4)	N	E	E	E	N
	551.8 MB	1 RM03	4	2207.2 MB	4 LOGICAL UNITS MAX. EXP. RM03	CDC 9775 MEMOREX 659	N N	E E	E E	E E	N N
	256.2 MB	1 RM05	4	1024.8 MB	4 LOGICAL UNITS MAX. STD. RM05 (COMPATABLE TO A DEC RM05)	CDC 9766 (4)	N	S	S	S	N
	551.8 MB	1 RM05	4	2207.2 MB	4 LOGICAL UNITS MAX. EXP. RM05	CDC 9775 MEMOREX 659	N N	E E	E E	E E	N N
SC70/B4	4.2 MB	1 RP06	4	16.8 MB	4 LOGICAL UNITS MAX. CONTRACTED RP06 HEAD/TRACK TYPE DRIVE	CDC 9733-5	N	C	C	C	N
	174.4 MB	1 RP06	4	697.7 MB	4 LOGICAL UNITS MAX. STD. RP06 (COMPATABLE TO A DEC RP06)	MEMOREX 677-0X (3)	N	S	S	S	N
	256.2 MB	1 RP06	4	1024.8 MB	4 LOGICAL UNITS MAX. EXP. RP06	CDC 9766 (4)	N	E	E	E	N
	551.8 MB	1 RP06	5	2207.2 MB	4 LOGICAL UNITS MAX. EXP. RP06	CDC 9775 MEMOREX 659	N N	E E	E E	E E	N N

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							RT11	RSX 11M	RSX 11M+	RSTS/E	VMS
SC71/B1	4.2 MB	1 RM03	4	16.8 MB	4 LOGICAL UNITS MAX. CONTRACTED RM03	CDC 9733-5	N	C	C	C	N
	67.4 MB	1 RM03	4	269.6 MB	4 LOGICAL UNITS MAX. STD. RM03 (COMPATIBLE TO A DEC RM03)	CDC PHOENIX 9448-96 (5) CDC 9762 (1)	N N	S S	S S	S S	N N
	134.4 MB	1 RM03	4	539.2 MB	4 LOGICAL UNITS MAX. EXP. RM03	CDC 9730-160 (2)	N	E	E	E	N
	256.2 MB	1 RM03	4	1024.8 MB	4 LOGICAL UNITS MAX. EXP. RM03 (EQUAL TO A DEC RM05)	CDC 9766 (4)	N	E	E	E	N
	512.4 MB	1 RM03	4	2049.6 MB	4 LOGICAL UNITS MAX. EXP. RM03	CDC 9775 MEMOREX 659	N N	E E	E E	E E	N N
	256.2 MB	1 RM05	4	1024.8 MB	4 LOGICAL UNITS MAX. STD. RM05 (COMPATIBLE TO A DEC RM05)	CDC 9766 (4)	N	E	E	E	N
	512.4 MB	1 RM05	4	2049.6 MB	4 LOGICAL UNITS MAX. EXP. RM05	CDC 9775 MEMOREX 659	N N	E E	E E	E E	N N
SC71/B2	4.2 MB	1 RP06	4	16.8 MB	4 LOGICAL UNITS MAX. CONTRACTED RP06 HEAD/TRACK DR.	CDC 9733-5	N	C	C	C	N
	67.4 MB	1 RP06	4	269.6 MB	4 LOGICAL UNITS MAX. CONTRACTED RP06	CDC 9762 (1)	N	C	C	C	N
	134.4 MB	1 RP06	4	537.6 MB	4 LOGICAL UNITS MAX. CONTRACTED RP06	CDC 9730-160 (2)	N	C	C	C	N
	174.4 MB	1 RP06	4	697.6 MB	4 LOGICAL UNITS MAX. STD. RP06 (COMPATIBLE TO A DEC RP06)	MEMOREX 677-0X (3)	N	S	S	S	N
	256.2 MB	1 RP06	4	1024.8 MB	4 LOGICAL UNITS MAX. EXP. RP06	CDC 9766 (4)	N	E	E	E	N
	512.4 MB	1 RP06	4	2049.6 MB	4 LOGICAL UNITS MAX. EXP. RP06	CDC 9775 MEMOREX 659	N N	E E	E E	E E	N N

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							RT11	RSX 11M	RSX 11M+	RSTS/E	VMS
SC750/B1	67.4 MB	1 RP06	4	269.6 MB	4 LOGICAL UNITS MAX.A STD. RM03 (COMPATIBLE TO A DEC RM03)	CDC 9762 (1)	N	N	N	N	S
	134.4 MB	1 RM03	4	539.2 MB	4 LOGICAL UNITS MAX. EXP. RM03 (EQUAL TO A DEC RM80)	CDC 9730-160 (2)	N	N	N	N	S
	256.2 MB	1 RM03	4	1024.8 MB	4 LOGICAL UNITS MAX. EXP. RM03	CDC 9766 (4)	N	N	N	N	E
	512.4 MB	1 RM03	4	2049.6 MB	4 LOGICAL UNITS MAX. EXP. RM03	CDC 9775 MEMOREX 659 STC 8775	N N N	N N N	N N N	N N N	E E E
	256.2 MB	1 RM05	4	1024.8 MB	4 LOGICAL UNITS MAX. STD. RM05 (COMPATIBLE TO A DEC RM05)	CDC 9766 (4)	N	N	N	N	S
	512.4 MB	1 RM05	4	2049.6 MB	4 LOGICAL UNITS MAX. EXP. RM05	CDC 9775 MEMOREX 659 STC 8775	N N N	N N N	N N N	N N N	E E E
SC750/B2	174.4 MB	1 RP06	4	697.6 MB	4 LOGICAL UNITS MAX. STD. RP06 (COMPATIBLE TO A DEC RP06)	MEMOREX 677-0X (3)	N	N	N	N	S
	348.8 MB	2 RP06	4	2790.4 MB	8 LOGICAL UNITS MAX. STD. RP06	FUJITSU EAGLE	N	N	N	N	S

FOOT NOTES:

1) AMPEX DM-980, DF-980; BALL BD-80; CENTURY DATA T-82; CDC 9762, 9730-80;FUJITSU 2280; KENNEDY 5380

2) AMPEX DF-9165; BALL BD-160; CDC 9730-160; FUJITSU 2284

3) AMPEX DM-9200; CENTURY DATA T-202; MEMOREX 677-0X

4) AMPEX DM-9300; CENTURY DATA T-302; CDC 9766; MEMOREX 677-30

5) AMPEX DRF-932, DFR-964, DFR-996; CDC 9448-32, 9448-64, 9448-96

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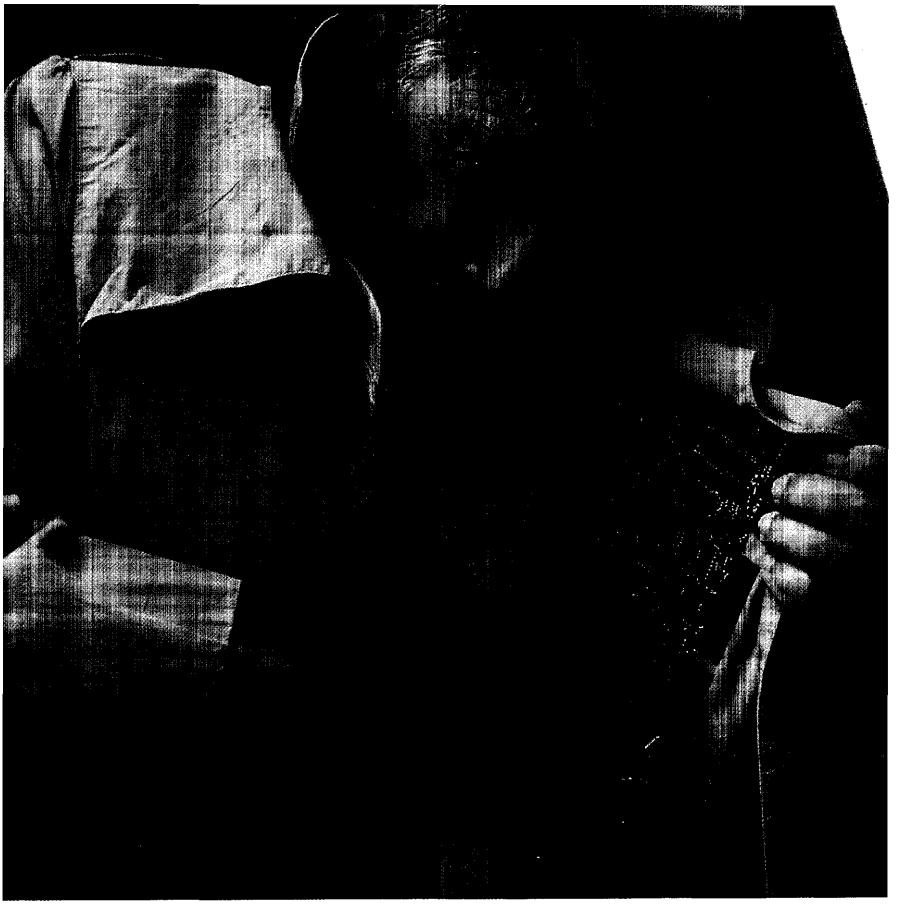


A few years ago, you bought DEC controllers or you took chances.

Time was you couldn't trust anyone. Price was often lower. Delivery was sometimes faster. But let's just say quality, reliability and service left lots to be desired (if the product even worked at all).

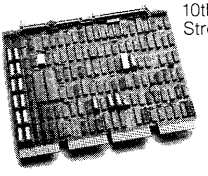
Times change. Enter Emulex.

First we decided that price shouldn't be the only reason to buy our controllers even though they cost less. The design goal of every tape, disk and communications controller we make is to go DEC one better. Emulex controllers actually optimize the DEC systems in which they're installed.

Emulex controllers would also be easier to install – plug 'em right into a backplane – hardware and software transparent.

We decided, also, to concentrate our expertise on DEC. We know DEC computers and designed products to improve them. Others didn't. You wouldn't remember their names.

In the last two years one Emulex success has led to another. Today, Emulex provides OEMs and end users with the industry's broadest line of controllers that improve DEC performance across the board. we did anything wrong, it was i setting a new standard. Comp itors stopped imitating DEC anc started trying to imitate us.



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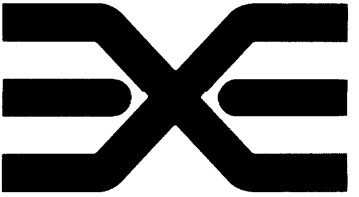

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