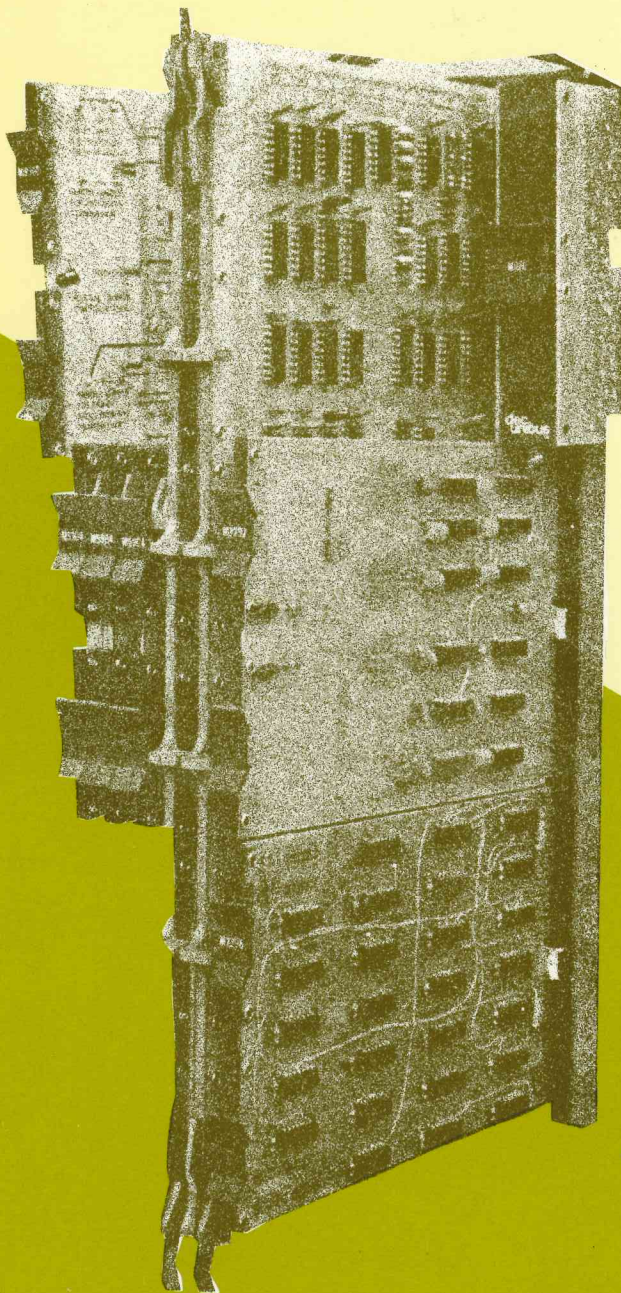


RH11/RH70 MASSBUS Controllers

A Self-Paced Course

Workbook 1




digital

RH11/RH70 MASSBUS CONTROLLERS SELF-PACED COURSE

WORKBOOK I

Document EY-D3021-WB-001
A Portion of Course EY-D3038-SP-001

Student Guide 

Introduction to RH11/RH70
Massbus Controllers 

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OUTLINE

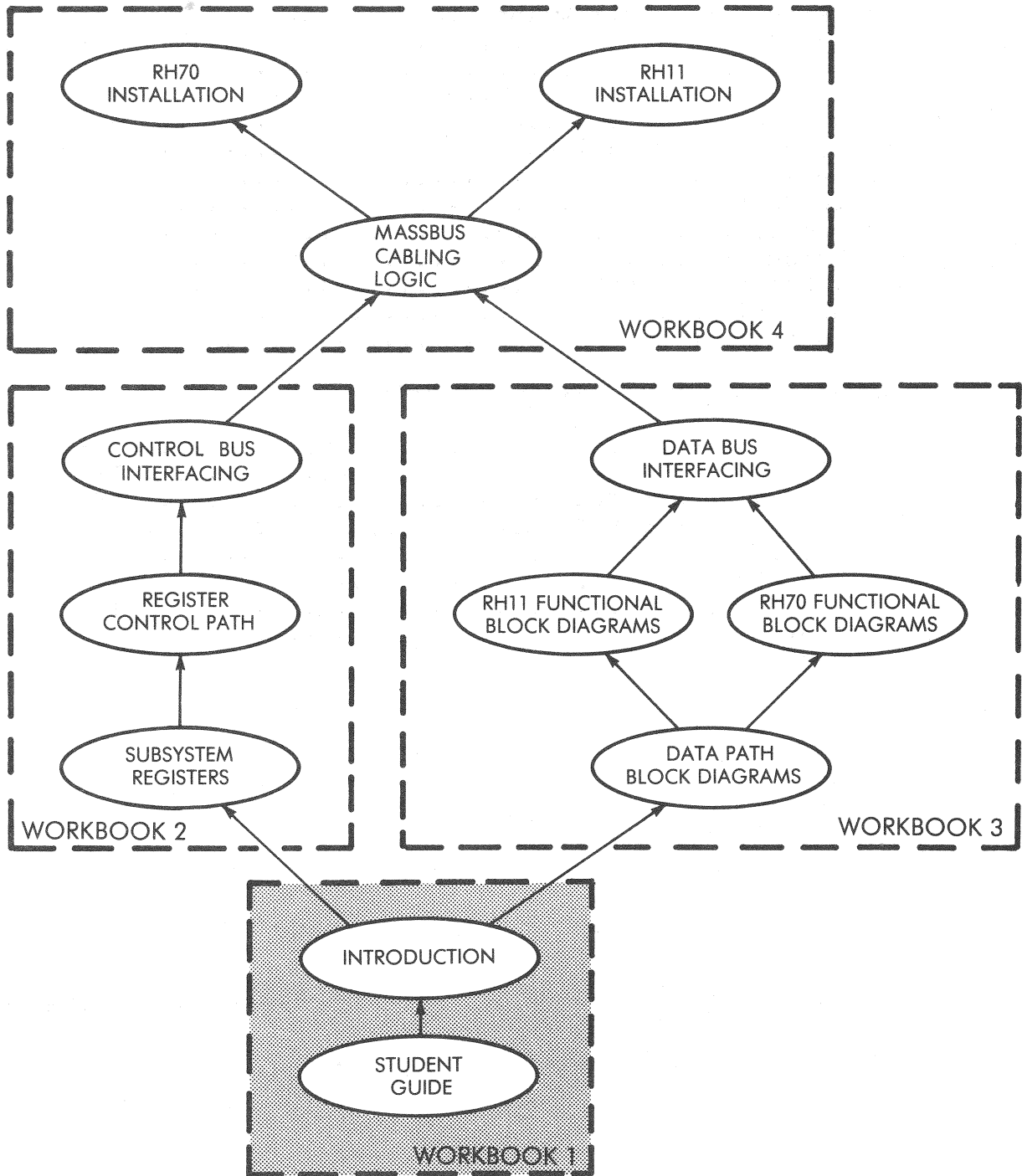
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COURSE MAP



Student Guide



STUDENT GUIDE

COURSE DESCRIPTION

This self-paced instruction (SPI) course describes the RH11 and RH70 Controllers. The course consists of 11 separate modules. Each of these modules includes a test which you must successfully complete before you can begin studying the next module.

The modules cover such topics as:

- Register reading and writing
- Error bit definitions
- Data flow for each command type
- Interfacing the controllers to various peripherals
- Interfacing the controllers to the Massbus
- Installation of the controllers into an existing subsystem.

The course has no laboratory exercises included. This is due partly because there are no adjustments to make on either controller, and partly because there is no removal/replacement of component parts. Any diagnostics that are written for the Massbus Controllers are written specifically for a peripheral device, and, as such, cannot be covered adequately in this course of instruction.

PREREQUISITES

Before starting this course, you must have taken the following courses or have the equivalent experience and knowledge from on the job training:

- "Introduction to the PDP-11" A/V course
- System training on a PDP-11 processor.

The knowledge you must have from this training should include the following:

- Basic peripheral addressing on the Unibus
- Unibus signal transmission
- Programming a peripheral on the Unibus.
- RH70 Cache Interface

In addition, it would be helpful (but it is not mandatory) to have had experience in working with disk and/or tape subsystems. This will aid you in grasping the controller concepts.

PREREQUISITE TEST DESCRIPTION

Take the Prerequisite Test (at the end of this Student Guide) to demonstrate your knowledge in the prerequisite areas.

COURSE GOALS

This course will provide you with the knowledge necessary to distinguish between the two types of Massbus Subsystem problems: controller or device. In addition, this course will explain the different module/jumper configurations to assist you in installations.

COURSE NON-GOALS

This course does not use the Field Maintenance Print Set to explain individual circuit operation. The print set may be followed, however, as the block diagrams are studied. The diagrams are labeled so that you can find the associated circuitry easily. The detailed description chapter of the device maintenance manuals have good circuit descriptions of each module.

This course does not describe diagnostic operation or decoding, as they are device-specific tools. Individual peripheral devices are also not described, but may be referenced.

MAINTENANCE PHILOSOPHY

The primary maintenance philosophy is to isolate controller malfunctions to the module level, and then replace the module.

COURSE OUTLINE

Introduction to RH11/RH70 Massbus Controllers

- RH11 Configurations
- RH70 Configurations

Subsystem Registers

Uses and descriptions of the following:

- CS1
- CS2
- WC
- BA
- DB

Register Control Path

- Reading Local Registers
- Writing Local Registers
- Reading Remote Registers
- Writing Remote Registers
- RH70 Differences

Control Bus Interfacing

Interfacing signal definitions for the accessing of registers

Data Path Block Diagrams

- Basic RL11 Block Diagram Description
- RH70 Differences

RH11 Functional Block Diagrams

- Read Data
- Write Data
- Write Check

RH70 Functional Block Diagrams

- Maintenance
- Read Data
- Write Data
- Write Check

Data Bus Interfacing

Interfacing Signal Definitions for the Transferral of Data

Massbus Cabling Logic

- Definitions
- Uses
- Signal Transmission

RH11 Installation

- Modules
- Jumpers
- Cables

RH70 Installation

- Modules
- Jumpers
- Cables

HOW THE COURSE IS ORGANIZED

Course Map - This course is contained in four workbooks as shown in the course map (Figure 1). Each workbook contains two to four modules. The course starts at the bottom of the map. Complete each module in the sequence illustrated. No new modules should be started until all modules whose arrows lead into it have been completed. For example, do not study the "Massbus Cabling Logic" module until you complete both prerequisite modules "Control Bus Interfacing" and "Data Bus Interfacing".

Module Contents - Each module contains at least one objective which states what you will be able to do to when you complete the module. In addition, each of the modules lists additional resources, should you desire extra work. You should at least skim over the related topic areas that are listed. This is so that you will become familiar with the location of the various subject areas in the technical manuals.

Testing - The modules contain exercises which allow you to see if you are ready for the module test. After successfully completing the exercises, take the module test. It will cover the material defined in the objectives. To complete each module satisfactorily, you must meet the criteria stated in each objective.

As you complete each module test, the course administrator will check your answers and review the material with you. As you satisfactorily complete each module, the course administrator will update the Master Progress Plotter and your Personal Progress Plotter (page SG-7) to keep a record of your progress.

If you do not satisfactorily complete a module, review the material. Assistance from the course administrator and/or a peer may be in order so that you will understand the material and be able to re-take the test. All answers to the module tests are contained in a separate package.

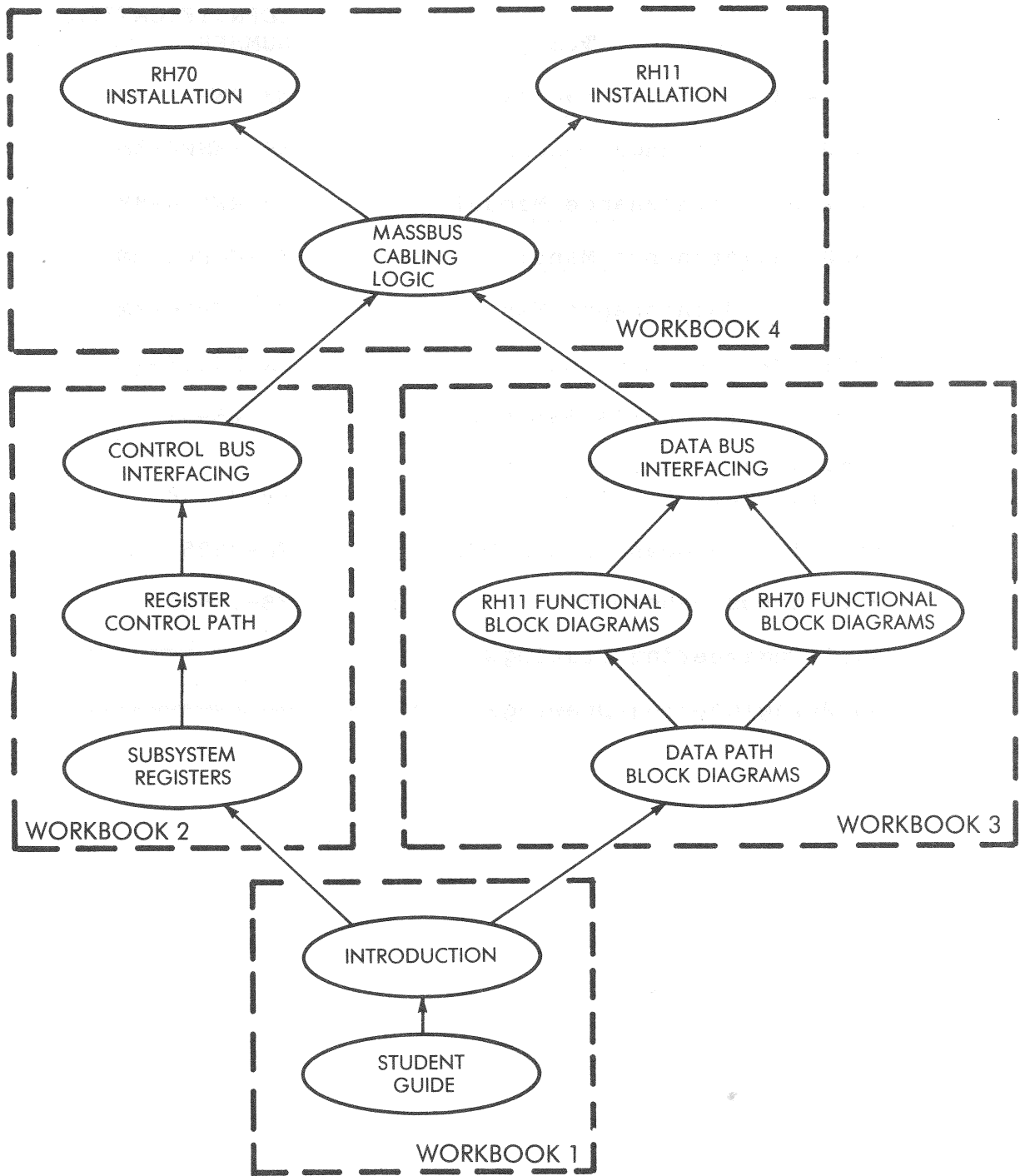


Figure 1 Course Map

COURSE RESOURCES

RESOURCE TITLE	DOCUMENT IDENTIFICATION NUMBER
RWP04 Maintenance Manual	EK-RWP04-MM
RWS04 Maintenance Manual	EK-RWS04-MM
RWP05/06 Maintenance Manual	EK-RWP56-MM
RJP04 Maintenance Manual	EK-RJP04-MM
RJP05/06 Maintenance Manual	EK-RJP56-MM
TJU16 Maintenance Manual	EK-TJU16-MM
PDP-11 Peripherals Handbook	EB-05961
PDP-11/04/05/10/30/40/45 Processor Handbook	EB-05138
PDP-11/70 Processor Handbook	EB-05952
PDP-11 Bus Handbook	EB-17525
RH11 Engineering Drawings	
RH70 Engineering Drawings	

PERSONAL PROGRESS PLOTTER

MODULE HEADINGS	DATE ACHIEVED	INITIALS
INTRODUCTION		
SUBSYSTEM REGISTERS		
REGISTER CONTROL		
CONTROL BUS INTERFACING		
DATA PATH BLOCK DIAGRAMS		
RH11 FUNCTIONAL BLOCK DIAGRAMS		
RH70 FUNCTIONAL BLOCK DIAGRAMS		
DATA BUS INTERFACING		
MASSBUS CABLING LOGIC		
RH11 INSTALLATION		
RH70 INSTALLATION		

COURSE OBJECTIVES

Upon successful completion of this course, you will be able to:

1. Define the characteristics and configurations of the RH11 and RH70 controllers.
2. Define the uses of the various controller registers.
3. Trace through a block diagram of the register control path. This demonstrates a knowledge of the process of the reading and writing of a "local" and "remote" registers.
4. Define the interfacing signals on the Massbus.
5. Define the functions of the various circuits represented on the "Data Path Block Diagram".
6. Trace through the "Data Path Functional Block Diagram" defining the flow of data for each of the following commands:
 - a. Read
 - b. Write
 - c. Write Check
7. Trace the transitions of interfacing signals on the Massbus cables utilizing the transceiver logic diagrams. This demonstrates a knowledge of how information is transferred thereby allowing you to identify problem areas more readily.
8. Demonstrate proper knowledge of jumper usage and layout in the installation of an RH Controller.
9. Differentiate between controller errors and device errors when given a list of subsystem errors.

Introduction to RH11/RH70 Massbus Controllers

INTRODUCTION TO RH11/RH70 MASSBUS CONTROLLERS

INTRODUCTION

The Massbus is the Digital Equipment Corporation I/O bus that handles peripherals designed for mass storage.

Some of these devices are:

- RS03/04 Fixed Head Disks
- RP04/05/06, RM02/03 Movable-Head Disk Drives
- TU16/45, TE16 Magtape Transports

This bus system offers standard communications between these devices and the RH controllers. The PDP-10, 11, 20 and VAX Product Lines all have an RH Controller for their respective peripheral devices. Each RH Controller, in turn, has been designed so that it can handle any of several peripheral devices without any modification to the controller logic beyond jumpering different addresses.

The different controllers are:

- RH11 (used on all PDP-11 processors but 11/70)
- RH70 (used only on the 11/70)
- RH780 (used only on the VAX 11/780 CPU)
- RH20 (used only on the DEC 2040 and 2050 CPUs)
- RH11-C (a modified RH11, used with the 2020 CPU)

This course will teach you the general theory of operation and characteristics of just the RH11 and RH70 Controllers and the Massbus. This knowledge will help you service these controllers effectively.

OBJECTIVES

Be able to answer multiple-choice questions on the characteristics and configurations of RH11 and RH70 Controllers and the Massbus.

ADDITIONAL RESOURCES

RJP04 Maintenance Manual, Pages 1-1 to 1-8 up to Paragraph 1.3.2.4

TJU16 Maintenance Manual, Pages 1-1 to 1-6 up to Paragraph 1.4

RJS04 Maintenance Manual, Pages 1-1 to 1-6 up to Paragraph 1.4

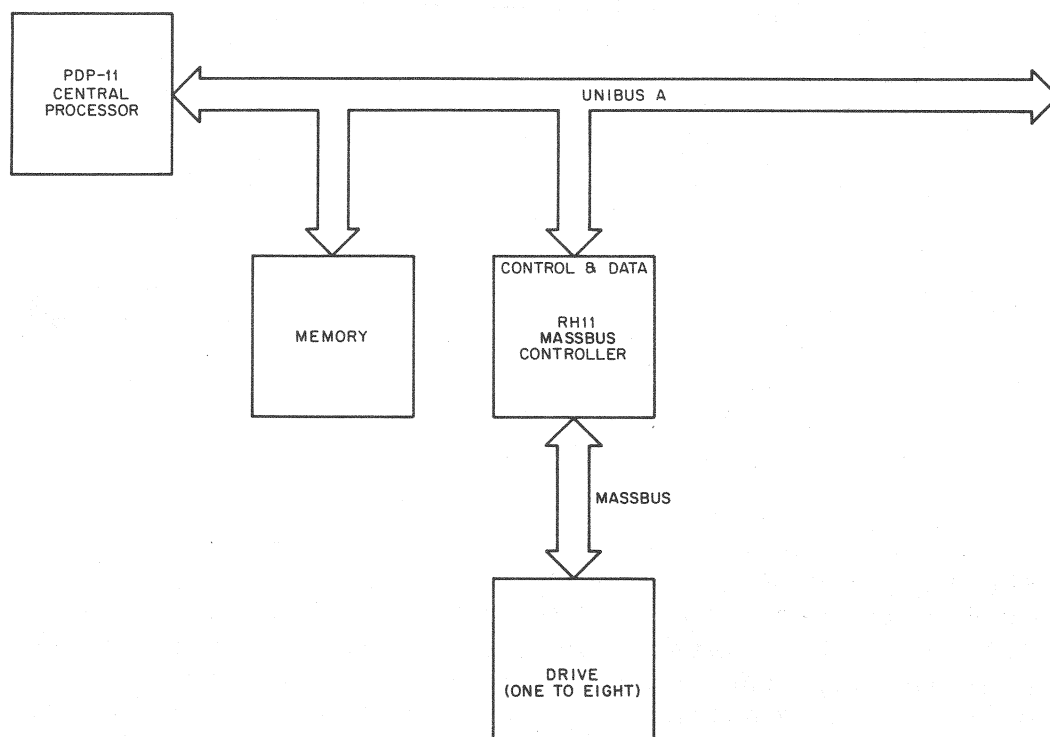
RJP05/06 Maintenance Manual, Pages 1-1 to 1-5

RWP04 Maintenance Manual, Pages 1-1 to 1-5

INTRODUCTION TO RH11/RH70 MASSBUS CONTROLLERS

RH11 CONFIGURATIONS

Figure 1 shows that the RH11 Controller acts as a Unibus device much like an RK11-D or RK611 Controller. All information transfer (control and data) takes place on the Unibus. The RH11 is capable of controlling up to eight disk drives and their associated interfaces (i.e., RP04 DCL or RM02 Adapter). It can also control up to eight TM02/03 Magtape Formatter units, each of which supervises up to eight tape transports.



C2-3000

Figure 1 RH11 Simplified System Diagram

Figure 2 illustrates the configuration of a standard PDP-11/45/50/55 subsystem. In this configuration Unibus A and Unibus B are jumpered together. This configuration is similar to Figure 1.

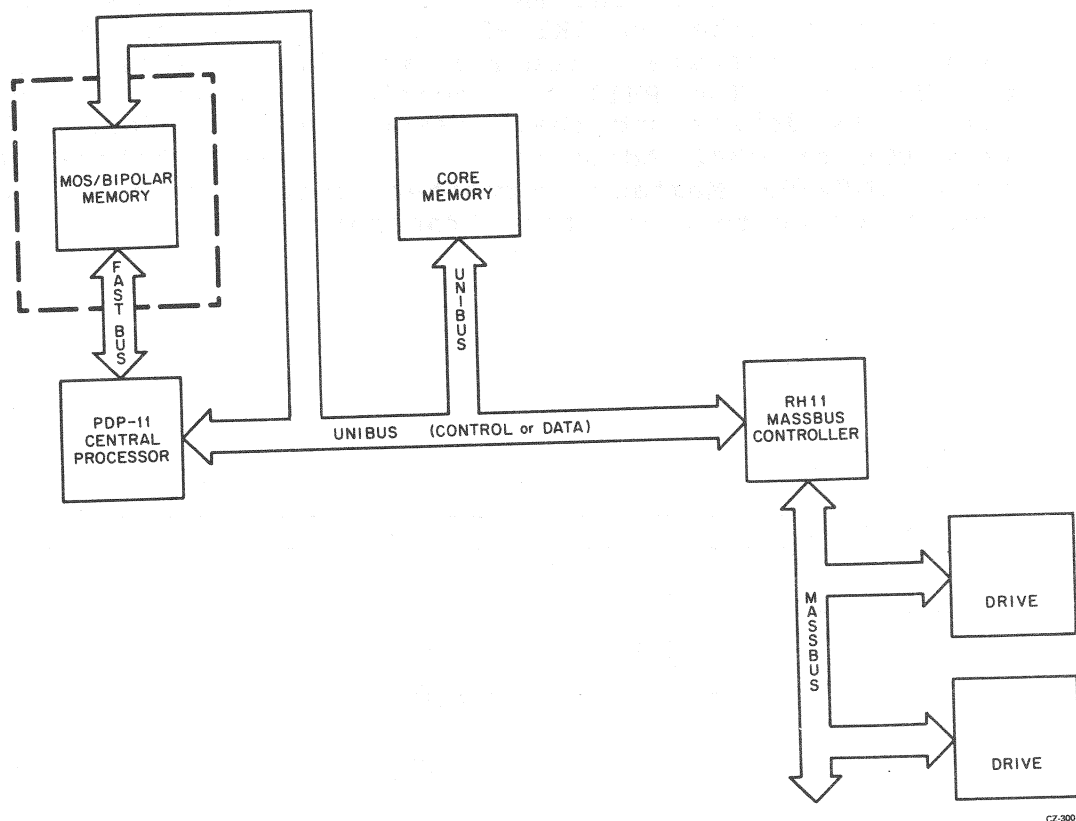


Figure 2 PDP-11/45 - RH11 Subsystem

Figure 3 represents a typical configuration for the PDP-11/45/50/55 and the RH11. This configuration uses the dual port capacity of the RH11. Unibus A and Unibus B are used for data transfers. The proper Unibus is selected by the host software. Register access for control information is only by Unibus A. This type of configuration is only set up for Computer Special Systems designs.

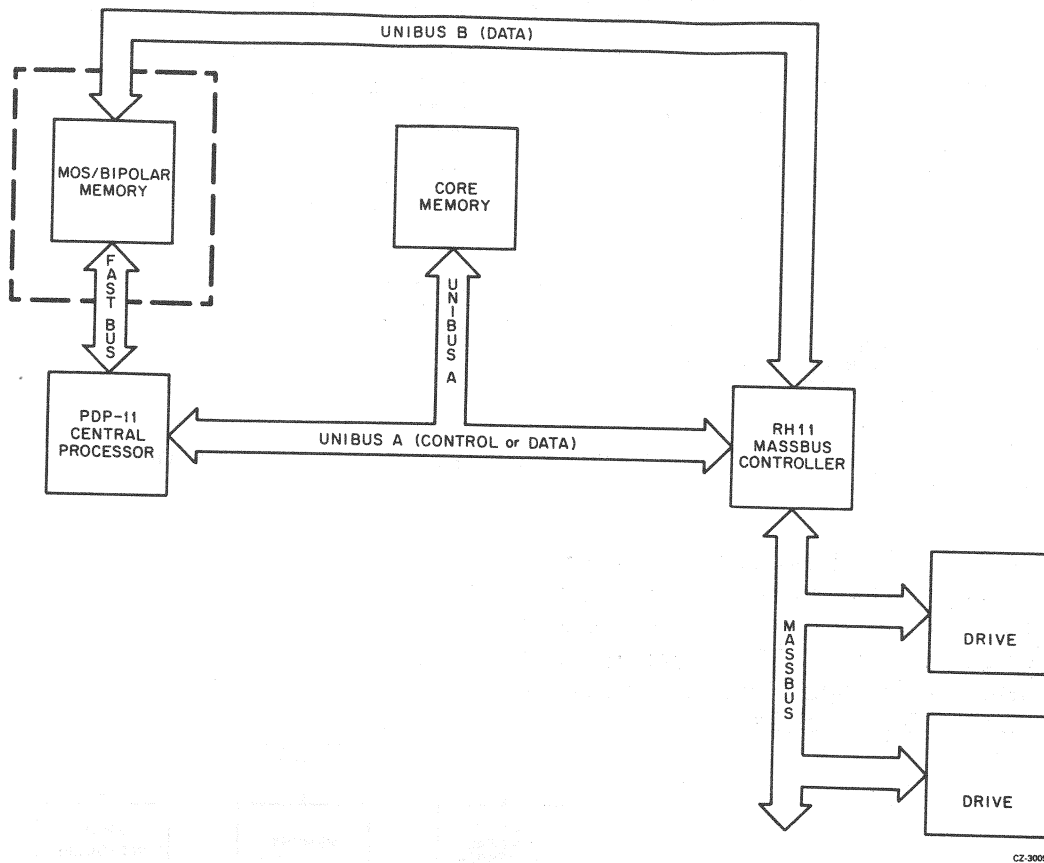
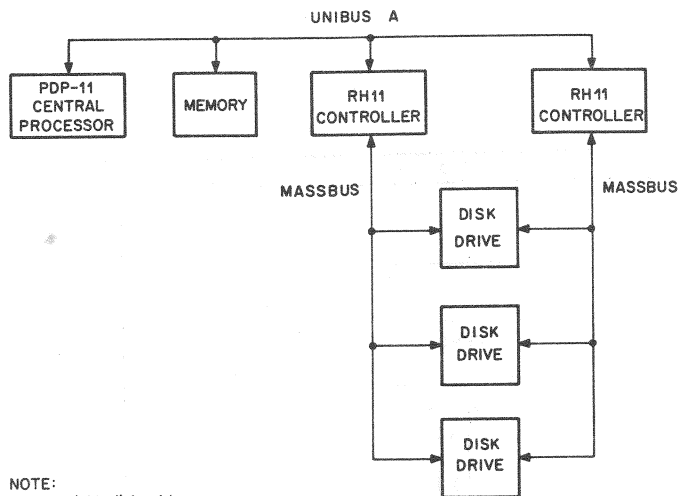


Figure 3 RH11 Multiport System

Figure 4 illustrates a dual controller option with one processor. For Batch operation this would give greater access to files, resulting in faster throughput. This configuration can only exist with dual-port drives such as the RP04/05/06 and RM02.



NOTE:
Up to eight disk drives can
be connected to the Massbus.

11-2505

Figure 4 Dual Controller Option (With One Processor)

Figure 5 illustrates another configuration with a dual-port drive. A customer desiring two CPUs with the same data base could have a system like this.

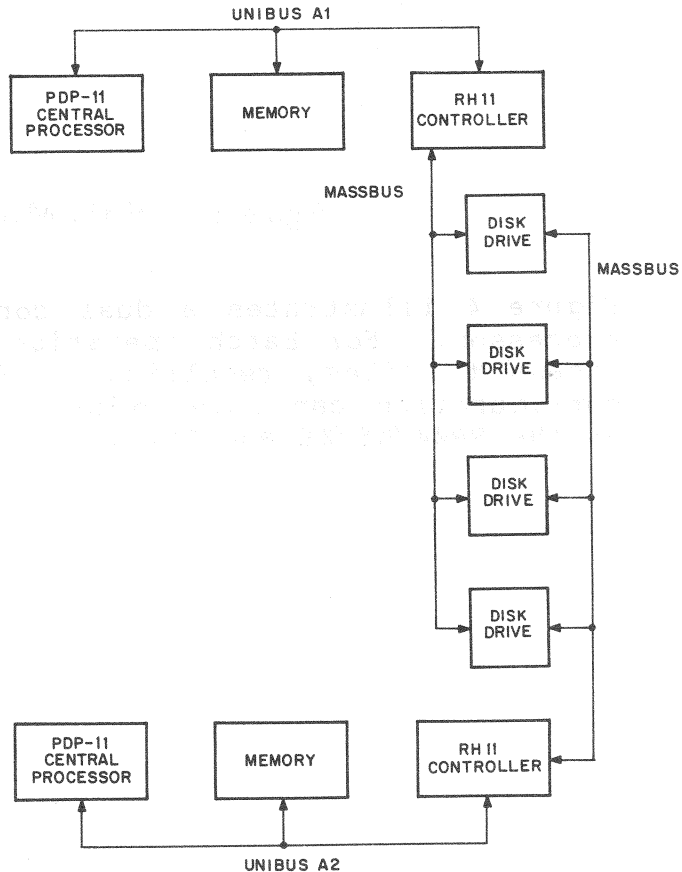


Figure 5
Dual Port Option
(With Dual Processors)

NOTE:
Up to eight disk drives can be
connected to the Massbus.

11-2504

NOTE

Not all PDP-11 operating system software supports dual-porting.

Although not shown in these illustrations, the Massbus is actually cabled to:

- Drive Control Logic (DCL) for the RP's
- RM Adapter for the RM's
- Tape Formatter (TM02/03) for the tape drives

The DCL and RM Adapter are sets of logic, one per drive, designed by DEC and attached to the drives to adapt the Massbus to the vendor drive. One RH11 can control up to eight drives cabled to these adapters.

Figure 6 illustrates a magnetic tape subsystem. The first magtape unit contains a TM02/03 tape formatter and controls up to seven more slaves. This means that one RH is capable of controlling up to 64 tape drives.

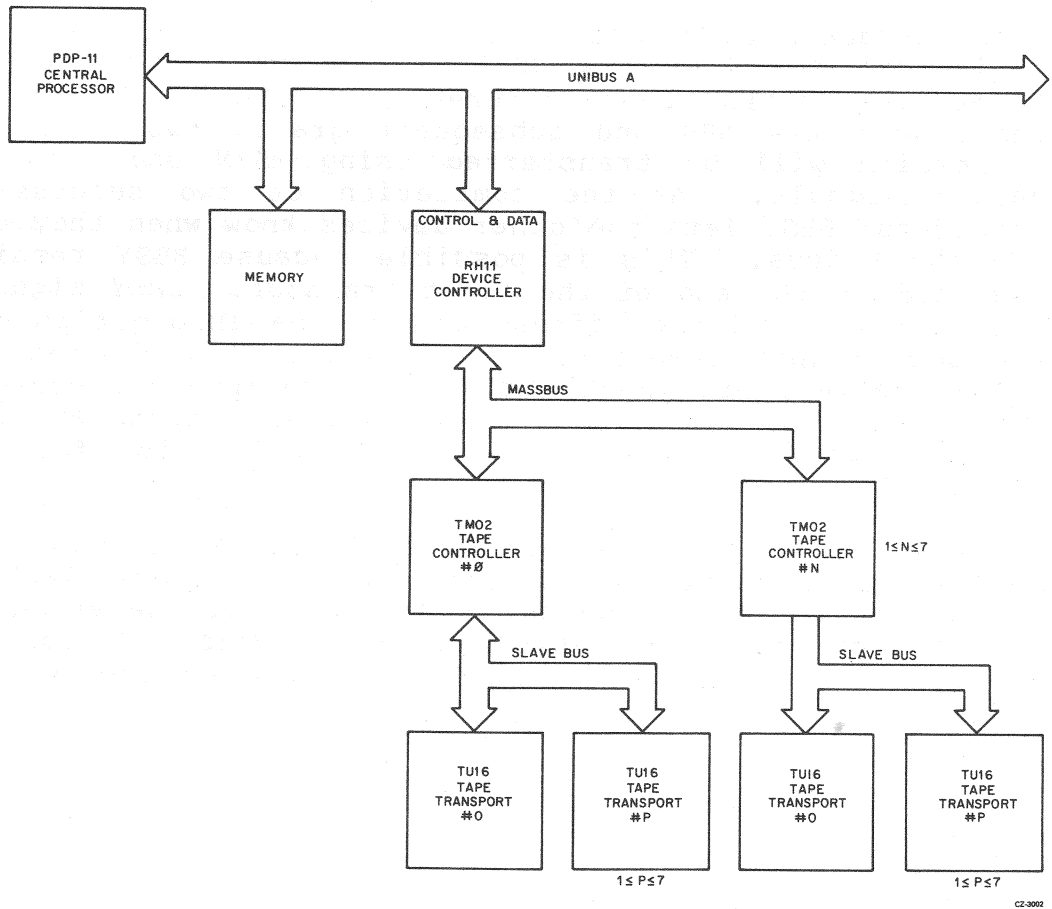


Figure 6 TJU16 Subsystem Simplified Block Diagram

The fixed head disk, RS03/04, is cabled directly to the Massbus and the RH can control up to eight daisy-chained drives.

Note that an RH cannot run different peripheral types on the same Massbus controller. Such a configuration is physically possible, but present system software cannot handle this type of arrangement.

These configurations show a few possible Massbus configurations. Because the peripheral devices themselves are independent of the processors, they can be installed on any product line processor with no change to the controller logic. The processor must contain a Massbus controller and the proper software to operate the peripheral.

DATA CONTROL

This section introduces the Data Control Path. The "Data Path Block Diagrams" and "Functional Block Diagrams" modules describe the data path in more detail.

Back-To-Back Data Transfers - To speed up throughput from peripheral to core, the RH11 can do what is known as "back-to-back NPR memory-referenced cycles." This means that, with one NPR and subsequent grant, two words in succession will be transferred using MSYN and SSYN as gating signals. At the completion of two successive transfers, BBSY lets the other devices know when they can use the Unibus. This is possible because BBSY remains asserted at the end of the first transfer. BBSY signals the RH11 to send the address and D line information for the second word transfer. This method of data transfer allows faster throughput for Massbus peripherals because there is no wait time for the second word transfer, and the device does not have to request arbitration for the Unibus.

Two is the maximum number of cycles. More than two cycles would create a backlog for non-Massbus devices attempting to use the Unibus. This mode of operation is normal for Unibus A only. However, Unibus A can be de-selected to single NPR's via a jumper on one of the modules.

Unibus B (Bus Hog Mode) - Unibus B handles the data transfers differently. It can operate in "bus hog" mode. In other words, after the NPR request and subsequent grant has been made, BBSY remains asserted. Therefore, words can be transferred as fast as memory can accept them.

Fast memory and fast bus transfers do not make much difference if the peripheral is slow. Bus hog mode is for the high-speed disks, where the word transfer rates range from two to four microseconds per word. (Older disks have transfer rates in the range of 7-16 microseconds per word.) Unibus A can handle high-speed data transfers, but if it has an assortment of other peripherals on it, the system could become overloaded or I/O-bound.

Not all systems can utilize Unibus B, however. Thus, the RH11 contains a Silo Memory so that the controller can operate on a standard Unibus with a fast peripheral.

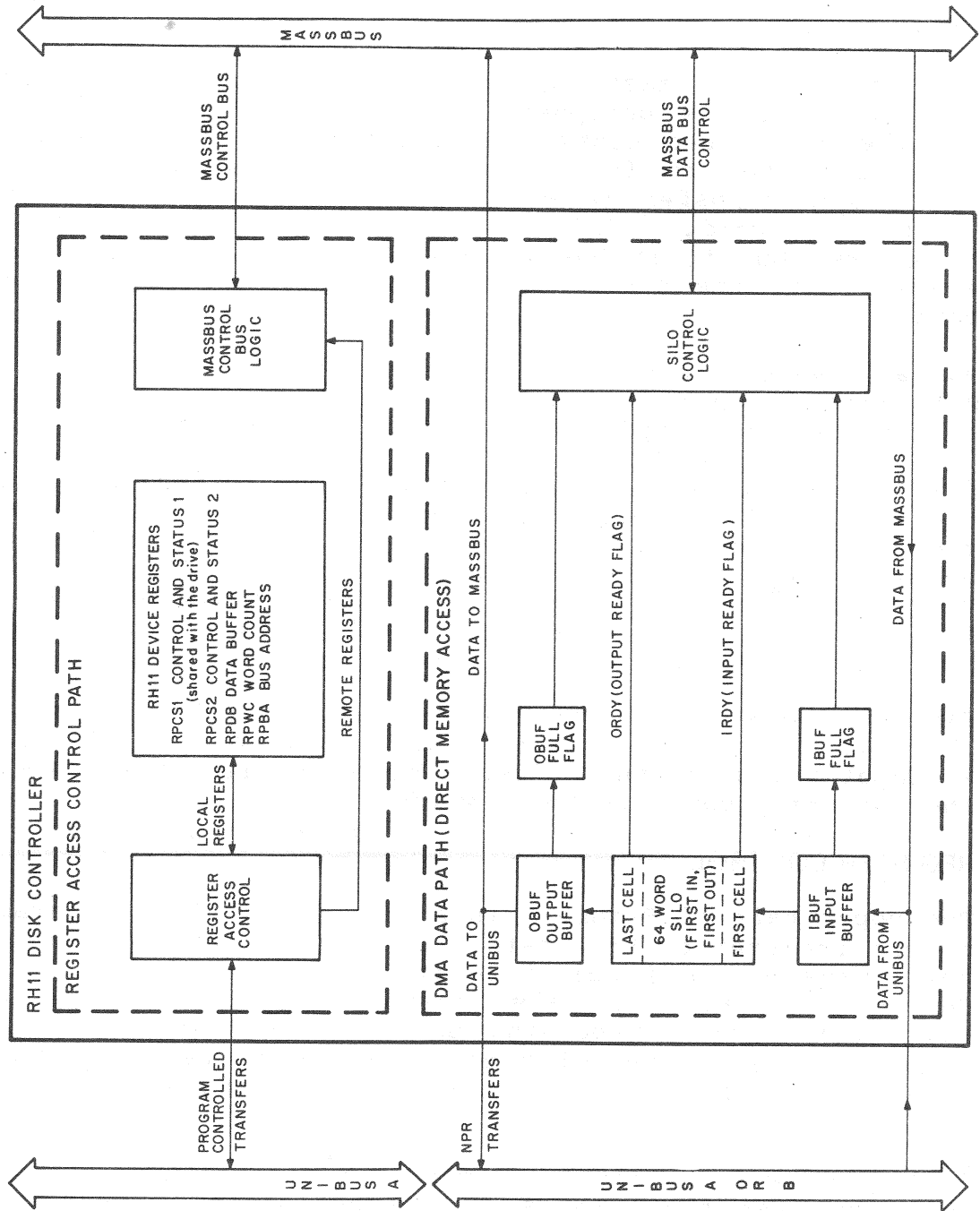
Silo - The Silo is a 64 word MOS-type memory that buffers the data. This reduces the timing differences between the Unibus and Massbus speeds. Data is transferred between the peripheral device and the RH11 at a synchronous rate of two to four microseconds per word. The Silo buffers the data while NPR's (occurring asynchronously) transfer the data to/from memory.

Figure 7 (lower half) shows a simplified block diagram of the data path, including the Silo. Notice the Silo has an input and an output buffer. These two registers raise the buffering capacity to 66 words.

REGISTER CONTROL ---

The upper half of Figure 7 is a simplified block diagram of the register control path. Notice that only Unibus A can transfer register information to/from the RH11 Controller. Figure 7 also lists the registers in the RH11 Controller. Depending upon the peripheral, there could be eight to sixteen other registers in the subsystem. These registers would be contained in the device logic.

System software accesses peripheral registers through the RH11 and over the Massbus to the peripheral. Detailed information on registers and register selection is in other course modules.



02-3003

Figure 7 RH11 Simplified Block Diagram

MASSBUS

The Massbus carries a standard set of interfacing signals covering every facet of communication for several different devices (such as RS03/04, RP04/05/06, TU16/45 and RM02/03). Massbus signals are divided into two groups called the Control Bus and the Data Bus. The Control Bus (see Figure 7) is responsible for transferring information to or from registers in the peripheral itself. The Data Bus contains the interfacing signals that carry the data between the RH Controller and the peripheral.

RH70 DIFFERENCES

The RH70 was designed to accommodate the bus structure in the PDP-11/70. Figure 8 illustrates the RH70 subsystem. The RH70 uses three buses:

- Unibus (register or control information only)
- RH70/Cache Interface Bus (data only)
- Massbus (control and data to/from device).

The PDP-11/70 mainframe has room in its backplane for four RH70's.

The register access control path is similar to that of the RH11, the difference being two additional registers. A comparison between Figure 7 and Figure 9 reveals these two registers. The Unibus is the only bus that is used for register access.

The data path is different for the RH70. Notice that the data buffer in the RH70 is only eight words in depth (see Figure 9). Less buffering is needed because of the bus arrangement and because the Cache Interface Bus can transfer two words at a time. The RH70 buffer is made up of registers, but the overall operation is still a first-in first-out sequence.

NOTE

The data does not go into the actual Cache memory as indicated by Figures 8 and 9. The data goes through the memory bus drivers included in the blocks labeled "Cache Memory". The Cache contains the necessary priority arbitration logic to select the appropriate controller when multiple requests are initiated.

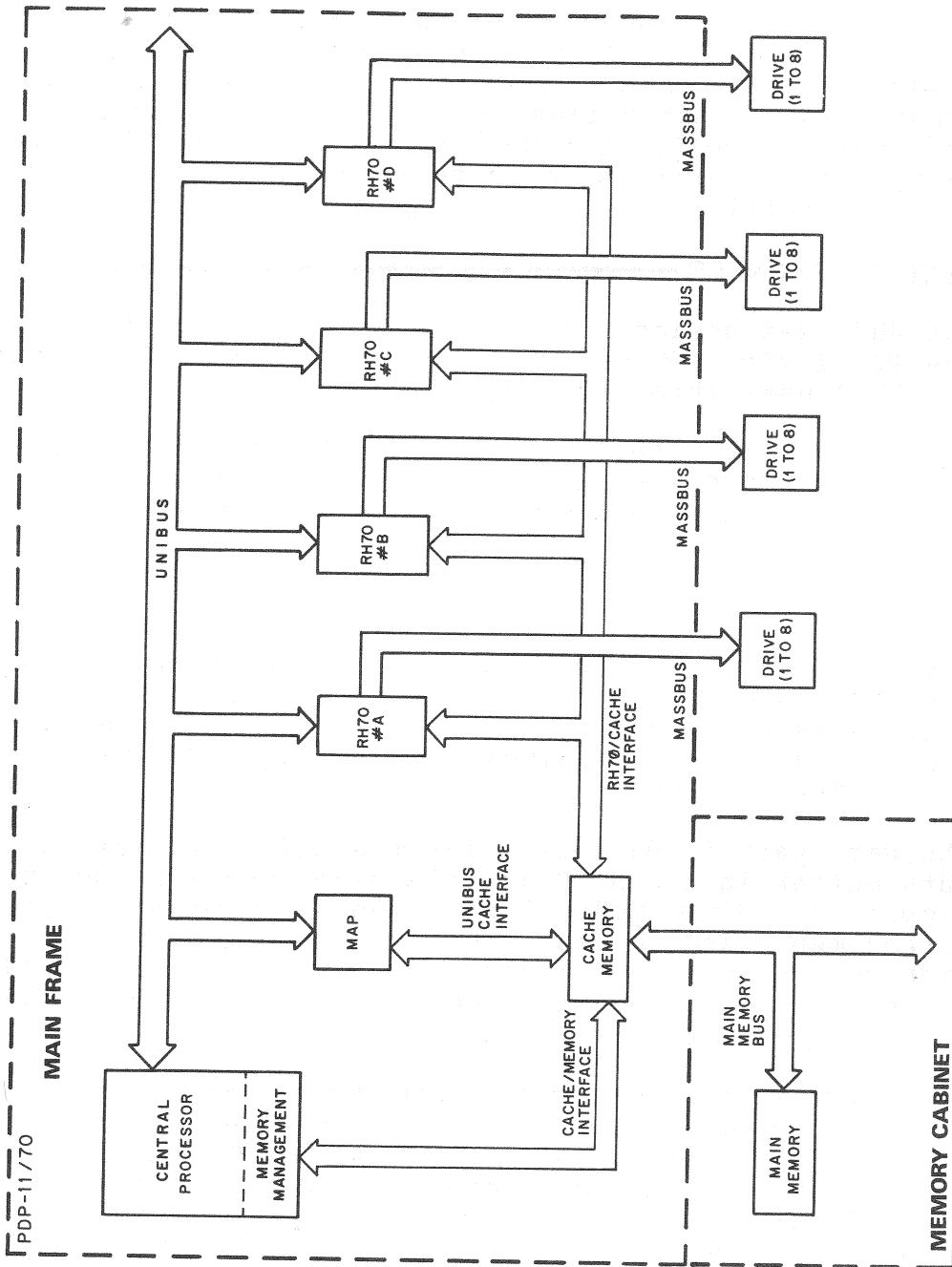
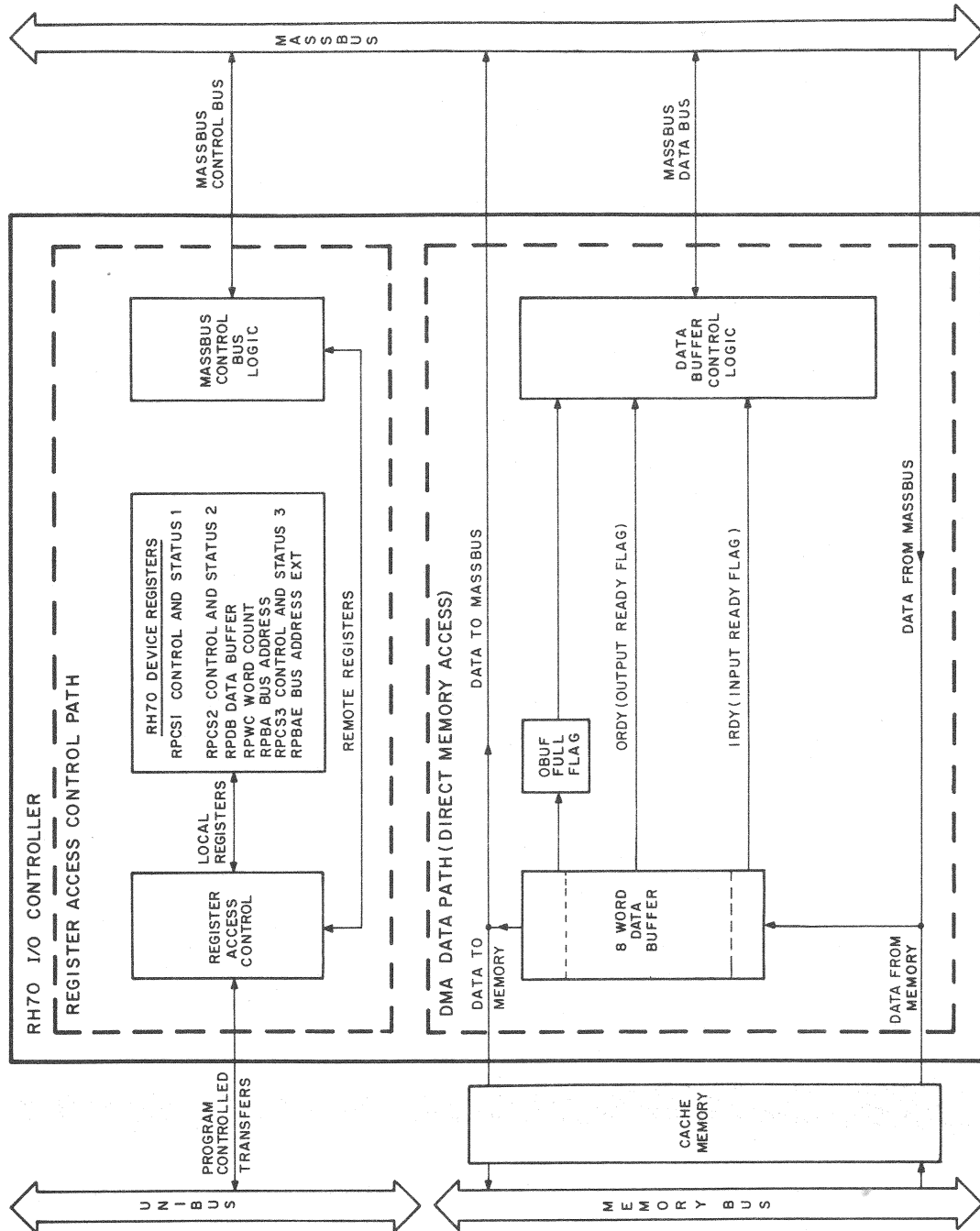
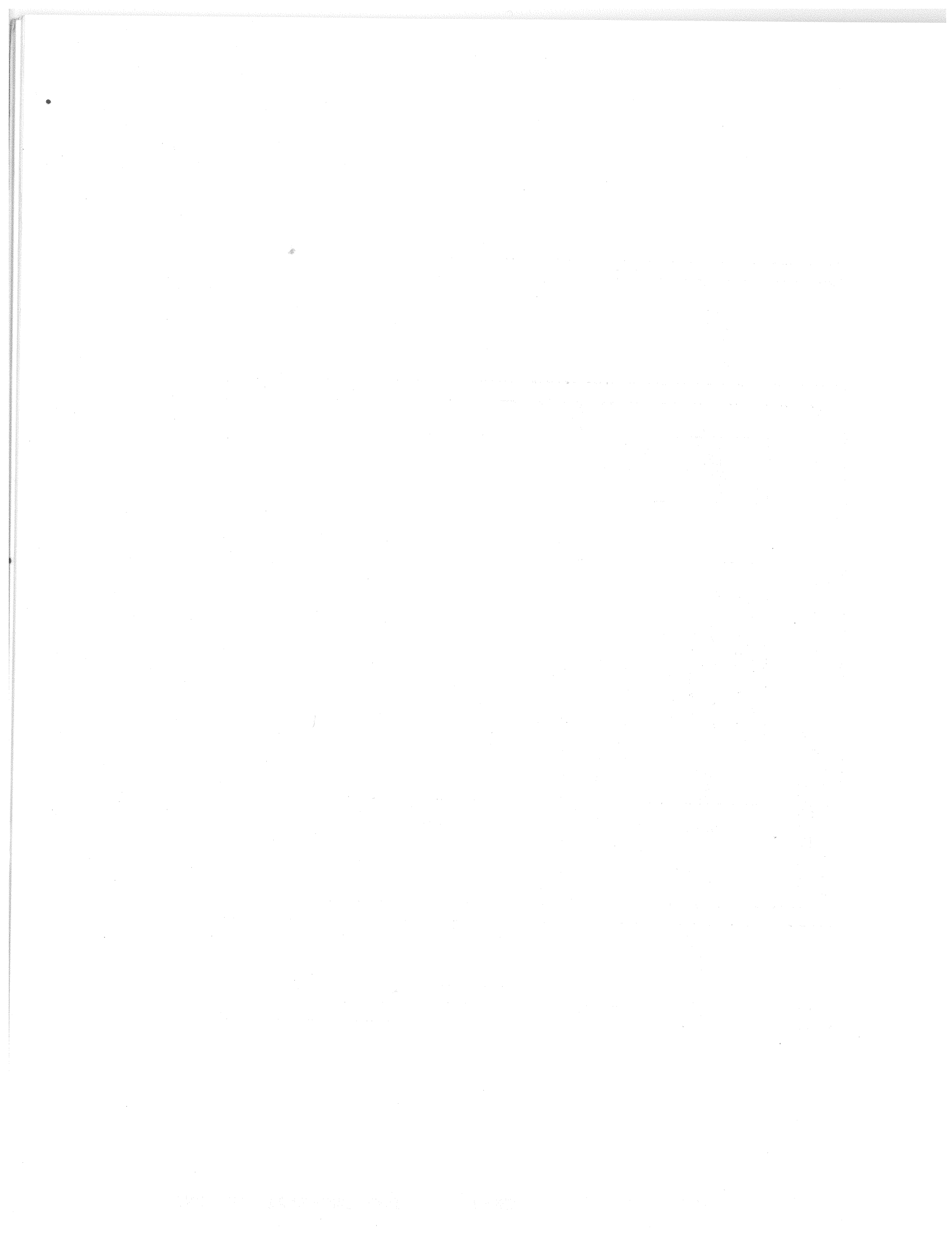


Figure 8 RH70 Simplified System Block Diagram



02-3004

Figure 9 RH70 Simplified Data Path Diagram



SUMMARY

Listed below are several capabilities of the RH11 Controller:

- Standard set of communication signals between it and any Massbus device
- Capable of a dual bus to the CPU
- Unibus A for control of the RH11 and the device
- Unibus A and B, selectable by software, used for data transfer (only on 11/45, 50 and 55)
- Unibus B can be set up in "bus hog" mode (only on 11/45, 50 and 55).
- 64 word first-in, first-out Silo

The Massbus is divided into a Data Bus and Control Bus. The Data Bus is used for data transfer between the RH controller and the device. The Control Bus provides the means of communications between the RH and the device.

The RH70 interfaces with three buses. The Unibus carries control and register information between the CPU and the RH70. Data is transferred two words at a time over the Cache Interface Bus. As in the RH11, the Massbus is used for control and data transfer between the RH70 and the device. Data is buffered via an 8-word first-in, first-out register Silo.

EXERCISES

Answer the following questions using any of your reference materials. Discuss any problems you have with another student or your course administrator. The solutions are on the next page.

1. Which Unibus is used to transfer control (programming) information to the RH11?
2. Data can be transferred on more than one Unibus from/to the RH11.
 - A. True
 - B. False
3. What three types of devices can an RH control?
 - A.
 - B.
 - C.
4. What is meant by "back-to-back NPR memory reference cycles"?
5. Write a brief description of the function of the Silo.

EXERCISES (CONT)

6. Which three buses interface to the RH70?
- A.
 - B.
 - C.
7. The RH70 can transfer two words in parallel on the Cache interface bus.
- A. True
 - B. False

SOLUTIONS

1. Unibus A
2. A. True
3. A. Removable-pack disk drives (RP04/05/06 and RM02/03)
B. Tape drives (TU16/45)
C. Fixed-head disk drives (RS03/04)
4. This means that with one NPR request and subsequent grant, two words will be transferred in succession using MSYN and SSYN as gating signals.
5. The Silo is a 64 x 18-bit word MOS-type memory that buffers the data and eases the timing differences between the Unibus and Massbus speeds. The Silo has an input and an output register for a total buffering capacity of 66 words.
6. A. Unibus
B. Massbus
C. Cache interface bus
7. A. True



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