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DECdataway
user's guide

digital
INDUSTRIAL PRODUCTS

EK-ISB11-UG-001

**DECdataway
user's guide**

digital equipment corporation • maynard, massachusetts

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CHAPTER 1

INTRODUCTION

1.1 SCOPE

This manual contains a general description of the DECdataway subsystem, including detailed information necessary to install and service the DECdataway cable. It also presents an overall view of the subsystem, its physical description, and specifications.

1.2 GENERAL DESCRIPTION

DECdataway consists of an ISB11-A controller interfaced with a PDP-11 computer and to a desired number of terminals and peripherals (slaves), each containing a port. The port connector has address jumpers installed so that the controller can select any one device with which to communicate. A port can have more than one address as discussed further in Note 2, Paragraph 3.2.4.3.2. The number of addresses per controller may not exceed 63. The DECdataway cable is linear and free of any branches, stubs, splitters, or repeaters as described in detail in Chapter 3. Positioning of the controller is optional. Figure 1-1 is a block diagram of two typical DECdataway configurations (see Figure 3-2 for total cable length).

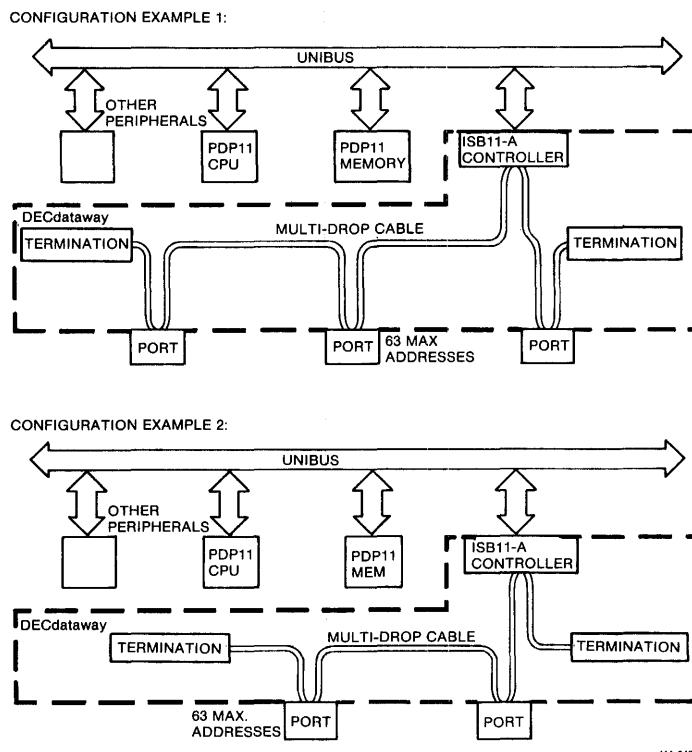


Figure 1-1 Typical DECdataway Configurations

DECdataway provides the capability to transfer data between a PDP-11 and a maximum of 63 slaves in a block or message-oriented fashion via controller and multidrop cable. Data transfer between the PDP-11 and the controller is accomplished by the Unibus; data transfer between the controller and slaves is via the multidrop cable.

Unibus: The Unibus program controlled interface appears as eight bytes of read/write registers in the PDP-11 external page. These registers are used primarily as a one-way port by the CPU to pass information to the controller.

Communication of data from the controller to the CPU is done via an area in main memory set aside by the operating system.

DECdataway (Multidrop) Cable: A shielded, twisted pair cable provides a path for information transfer between the controller and the ports; transfers are executed sequentially.

1.2.1 DECdataway Functions

The controller is always master of the DECdataway and all transactions on the bus consist of two messages: (1) a command from the controller to the port and (2) a response from the port to the controller. There is one exception in that the controller has the capability of broadcasting a message to all ports simultaneously with no response allowed from any port.

Each message is formatted in DSBC (DEC Serial Bus Control) protocol to ensure error-free communication between the controller and ports by assuring accurate recovery from communication errors.

1.2.1.1 Controller Functions

- Controls access to the bus and thereby establishes bus priorities via the “round robin” polling scheme.
- Recovers from bus error conditions and reports errors to host.
- Monitors bus connections and notifies the host of devices that connect or disconnect to/from the bus
- Maintains a logically separate nonprocessor request (NPR) in and NPR out channel for each device on the bus (64 into host CPU including one unsolicited data channel and 64 out of host CPU including one broadcast channel).
- Formats information transfers into messages with DSBC Protocol, and adds sequencing and Cyclic Redundancy Checking (CRC) information to each data transfer.
- Receives messages in DSBC protocol and passes data to the host via an NPR.
- Notifies the host of successful completion of message transfers.

1.2.1.2 Port Functions:

- Receives messages in DSBC protocol and checks for port address and error-free message reception. If these conditions are met, acts in response to the received command.
- Transfers responses back through the bus to the host in DSBC protocol.
- Performs DSBC protocol functions for bus initialization (and reinitialization) and error recovery.

1.2.2 DECdataway Performance

If a communication error is detected during a transaction between the controller and a port, the controller generates a recovery procedure so that the transaction is successfully completed. A transaction may involve information transfer in one or two directions on the bus (only one transaction in a broadcast). The controller supports messages with up to 255 bytes (maximum) of information. A single bus transaction between the controller and a port can result in up to 255 bytes of information being moved in each direction on the bus in the correct order and without error. It is this ability to move error-free blocks of information of variable length in a single bus transaction that gives the DECdataway the throughput potential to be an effective multidevice bus for both terminals and process control peripherals.

The performance of the DECdataway is a function of:

- The communication rate
- The number and type of devices on the bus.
- The protocol used on the bus.

DECdataway data efficiency is the percent of data bytes versus total message transactions for (1) data transferred in one direction only and (2) in both directions for a complete transaction. Single byte transfers make poor utilization of the bus; transfers of 8 to 16 bytes can achieve 50% utilization.

1.3 PHYSICAL DESCRIPTION

The DECdataway consists of an ISB11-A controller that includes a KMC11-A microprocessor (M8204) module, a line unit (M820YE) module, and associated interface cables. Both modules must be mounted in a DD11-C, DD11-D, or equivalent Small Peripheral Controller (SPC) system unit.

CAUTION
A DD11-B system unit must not be used.

1.3.1 KMC11-A Microprocessor Specifications

The KMC11-A consists of a single hex height multilayer module (M8204).

- Cycle time – 300 ns
- Power requirements – 5.0 A @ +5 V
- Environment must be in accordance with applicable portions of DEC Std. 102 for Class C environment. However, in most cases, the computer system is restricted to Class A.

1.3.2 M8202YE DECdataway Line Unit Module Specifications

This module must be used with the KMC11-A microprocessor; it is not a stand-alone device.

| | |
|--------------------|---|
| Power Requirements | +4.75 V to +5.25 V @ 3.0 A (max.) +14 V to +16 V @ 0.1 A (max.) -14 V to -16 V @ 0.1 A (max.) |
|--------------------|---|

| | |
|----------------|-------------|
| Operating mode | Half Duplex |
|----------------|-------------|

| | |
|-------------|-------------------------------------|
| Data format | Synchronous serial by bit LSB first |
|-------------|-------------------------------------|

| | |
|----------------|----------------------------------|
| Character size | 8 bits plus 0 to 2 stuffing bits |
|----------------|----------------------------------|

| | |
|----------------------------------|--|
| Data rate | 55,500 bits/second |
| Modulation | Biphase (space) |
| Transmitter timing | Adjustable RC clock |
| Receiver timing | From received signal. |
| Line interface | Transformer coupled |
| Transmitter signal | 6 V peak (min.) into terminated 200 Ω cable |
| Receiver signal threshold | 150 mV peak (min.) |
| Error-free signal level | 250 mV peak (min.) |
| Common mode isolation | 350 Vac peak (min.) 500 Vdc |
| Receiver bandpass | 6 kHz – 130 kHz 3 db points |

1.3.3 Cable Specifications

The integral modem is designed to operate with shielded, balanced, or unbalanced 75 to 200 Ω cables. Digital Equipment Corporation recommends Belden 9182 cable. The cable consists of a shielded, twisted pair of 22 AWG conductors. The maximum length for this cable is 45.72 m (15,000 ft). This distance must include the length contributions required at the host and terminals for servicing.

Belden 9182 Specifications:

Physical Design

| | |
|-------------------------------------|---|
| Conductors | 22 AWG stranded tinned copper (19X34) |
| Dielectric material | Cellular polypropylene |
| Nominal insulation thickness | 1.65 mm (0.065 in) |
| Number of pairs | One |
| Shield | Duofoil (polyester film laminated on both sides with aluminum foil) |
| Drain wire | 22 AWG (19X34) tinned copper |
| Jacket | PVC |
| Jacket thickness | 0.89 mm (0.035 in) |
| Cable Nominal Diameter | 10.26 mm (0.404 in) |

Electrical Characteristics

| | |
|--|---------------------------|
| Nominal dc resistance of conductor at 20° C (68° F) | 52.5 Ω/km (16 Ω/1000 ft) |
| Nominal capacitance between conductors of a pair | 29.5 pF/m (9 pF/ft). |
| Nominal velocity (V) of propagation (% of velocity of light) | 67 @ 56 kHz |
| Nominal impedance (Z_0) of a pair (ohms) | 150 @ 1 MHz; 200 @ 56 kHz |

1.3.4 Optional Cables

Other cables than Belden 9182 may be used, provided the following criteria are met. However, if cable impedance is less than 200 Ω, then the maximum distance is reduced.

- Characteristic impedance $75 \leq Z_0 \leq 200 \Omega$ measured at 56 kHz.
- Cable loss <15 db measured at 56 kHz with termination at both end points.
- Cable run is homogeneous with shield continuity maintained.
- Step response $\leq 5 \mu s$ 10% – 90% risetime measured differentially at end point and driven from a differential source into terminated line.
- Conductor size – 22 AWG.

1.3.5 Line Termination

The ends of the cable must be terminated in the characteristic impedance of 200 Ω measured at 56 kHz. The ports and controller *do not* provide termination.

1.3.6 Applicable Documents

Digital Site Preparation Guide (EK-CORP-SP)
DECdataway Technical Manual (EK-ISB11-TM)*
KMC11 General Purpose Microprocessor User's Manual (EK-KMC11-OP)
KMC11 General Purpose Microprocessor Technical Manual (EK-KMC11-TM)*
DMC11 IPL Synchronous Line Unit Maintenance Manual (EK-KMCLU-MM)*
Remote Terminals RT801, 803, 805 User's Guide (EK-RT80X-UG)
DPM Terminals Application Programmer's Manual (AA-C878A-TC)
DECdataway Noise Specification (A-SP-ISB11-0-X)
Diagnostic listings (Refer to Paragraph 4.2.2)

*This document is available as part of DIGITAL's microfiche libraries. Printed copies can be obtained from Digital Equipment Corporation, Communications Services, Northboro, MA 01532.

1.4 PROGRAMMING INFORMATION

NOTE

There is no programming information provided in this User's Guide. For programming information on the DECdataway, refer to DPM Terminals Application Programmer's Manual (AA-C878A-TC).

CHAPTER 2

SITE PREPARATION AND PLANNING

2.1 INTRODUCTION

Since installation of the ISB11-A DECdataway subsystem is to be done in conjunction with a host PDP-11 system, the assumption is made that site preparation and planning guidelines for the host system have been fulfilled. This chapter contains additional guidelines pertaining to accessibility, space requirements, and environmental and electrical considerations that will facilitate the DECdataway cable installation and produce efficient total system operation and performance.

2.2 ACCESSIBILITY AND SPACE REQUIREMENTS (Figure 2-1)

Successful installation of DECdataway requires thorough investigation of the existing site and those areas in which peripherals/terminals are to be located to ensure that proper access points are provided between the system and the devices for servicing the connecting cable. Therefore, spacing of junction boxes along the cable route must be planned accordingly.

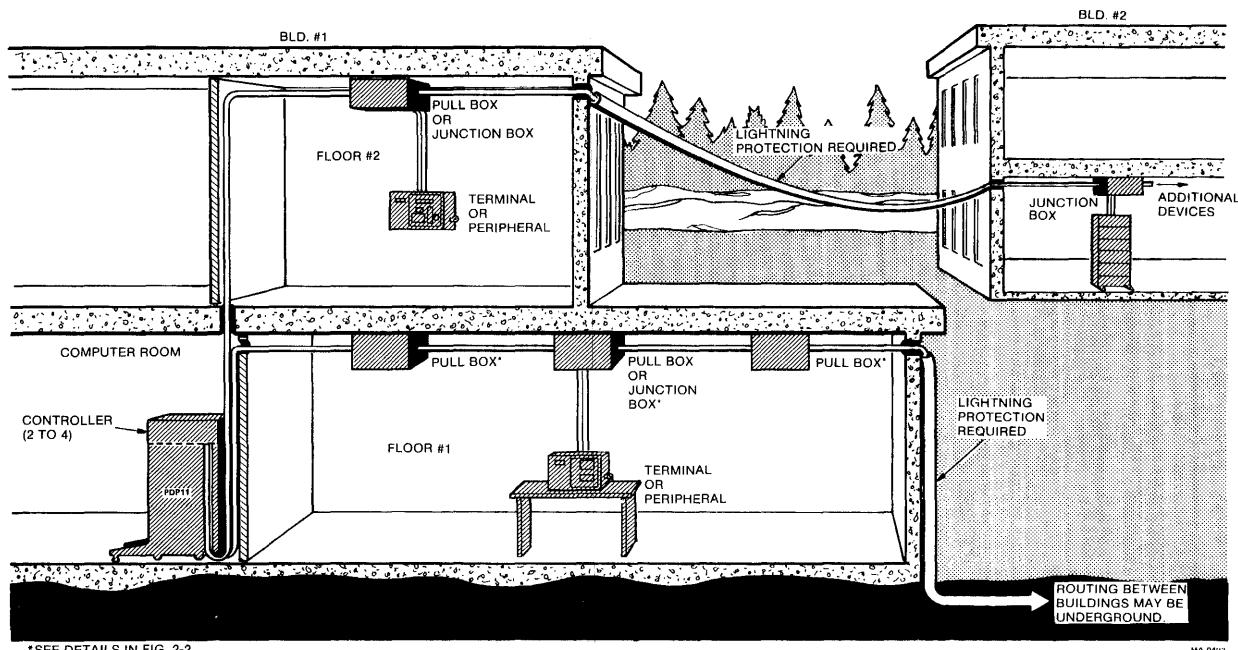


Figure 2-1 Accessibility and Space Requirements

2.2.1 Access

Access to the M8204 Microprocessor module and the M8202YE Line Unit module is assured in the site preparation and planning guidelines applicable to the host.

Junction and pull box locations must be in areas that are easily accessible to ensure ease of cable maintenance.

2.2.2 Space Requirements

Spacing related to DECdataway with emphasis on cable lengths and junction and pull box locations is determined by the number of peripherals or terminals associated with a specific installation with possible expansion considerations.

2.3 ENVIRONMENTAL CONSIDERATIONS

Area environment can have a substantial effect upon the overall reliability of the system. Several factors must be considered with respect to the areas in which the cable is to be routed.

Temperature: Cable attenuation increases with temperature. Also, routing cables in areas where temperatures exceed vendor specifications of nominal room temperatures and allowable deviations cause cables to age faster than at the normal rates.

Moisture: Moisture-related impurities may enter the cable through cuts or scratches on the outer jacket or through improperly installed connectors. Minute amounts of water vapor will condense into water and can migrate along the shield. Water condensed from a polluted atmosphere can contaminate the entire length of the cable, shorten its life, and seriously degrade its performance.

2.3.1 Hostile Environment

DIGITAL has designed a special enclosure which solves many of the mechanical, electrical, and environmental problems of housing and protecting standard rack-mounted computer equipment in a hostile environment. It is the customer's responsibility to protect the DECdataway cable within such an environment.

2.3.2 Static Electricity

Static electricity, a result of physical action, can affect the operational characteristics of a computer, related peripheral equipment, and cabling. Vibration and friction are the most common causes of static that could affect cabling associated with DECdataway. In planning the cable route, ensure that the cable is installed in areas where vibration of cable carriers and mountings is at a minimum.

2.4 ELECTRICAL CONSIDERATIONS

The following ground considerations pertain to cable routing and maximum lengths, junction box tie points, safety precautions, and future expansion provisions.

2.4.1 Ground Requirements

Ground requirements as they relate to the PDP-11 system are presented in detail in respective system manuals provided with each shipment. This discussion relates to proper grounding practices that apply to the DECdataway cable and junction/pull boxes.

The outer shield of the cable must be grounded near, but not to, the computer system chassis. The ground conductor should be connected to one of the following.

- Cold water pipe electrode
- Power service conduit
- Service equipment enclosure
- Grounding electrode of the power service of a multigrounded neutral power system.

If it is not possible to ground the cable shield by any of these methods, one of the following methods may be used.

- An electrode of not less than 6.096 m (20 ft) of bare copper conductor, no smaller than 4 AWG, encased in at least .0508 m (2 in) of concrete and located near the bottom of a concrete foundation footing that is in direct contact with the earth.
- An effectively grounded metal structure.
- An extensive underground gas piping system where acceptable to both the servicing gas supplier and to the authority having jurisdiction.
- A ground rod or pipe driven into permanently damp earth.

WARNING

Under no circumstances shall the grounding conductor be connected to a steam or hot water pipe, a lightning rod conductor, or pipe or rod electrodes grounding, other than multiground neutral power circuits.

Lightning protection should be installed in cases where the cable is routed from one building to another. Methods should conform to the requirements of the Lightning Protection Code (NFPA 78) issued by the National Fire Protection Association.

2.5 CABLE ROUTING CONSIDERATIONS (Figure 2-2)

It is imperative that cabling be installed in such a way as to protect it from damage from excessive heat, moisture, or mechanical stress. Preferably cables should be enclosed in a metal conduit, but metal troughs are acceptable. Rigid steel conduits afford better noise protection than the thin wall type. Conduit runs must be laid to avoid low points where moisture could accumulate. All cabling should be carefully located to avoid coupling from sources of high-intensity electrical transients such as large motors. Additional information is provided in Chapter 3, Installation.

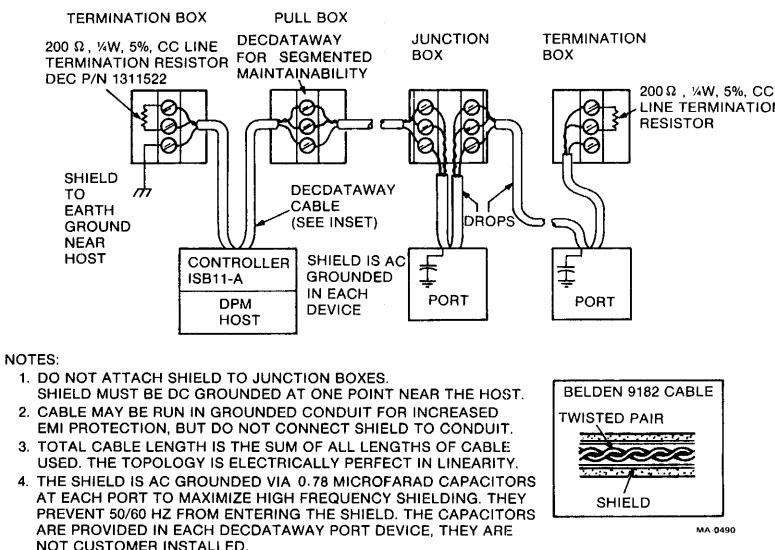


Figure 2-2 Cable Routing

To obtain the ultimate benefits of accuracy, cabling between the system and the peripherals or terminals should be given the same care as with any highly accurate process instrument. Good cable-routing practices are an extremely important part of reducing noise problems. Maintaining the maximum practical separation between electric power conductors and the DECdataway cable protects the actual signals being transmitted by the cable from noise coupling.

As indicated in Chapter 1, DIGITAL recommends the use of Belden 9182 cable. A shielded, twisted pair of 22 AWG conductors can be used. The maximum length from the ISB11-A to all DECdataway ports is 4572 m (15,000 ft), *including* the length contributions of drops from the trunk as indicated in Figure 2-2. This length applies to Belden 9182 only.

2.6 SAFETY PRECAUTIONS

The site preparation and planning guidelines in this chapter, the installation procedures in Chapter 3, and the user maintenance information in Chapter 4 have been prepared to ensure optimum operation and reliability of DECdataway and also provide protection to operating personnel. Please read these chapters thoroughly prior to installing and maintaining the system.

CHAPTER 3 INSTALLATION

3.1 INTRODUCTION

CAUTION

**Read Chapters 2 and 3 thoroughly prior to installing
the DECdataway subsystem.**

Installation of the DECdataway subsystem is divided into two parts. The first, section 3.2, discusses the DECdataway cable and its connections to the DECdataway controller and to the DECdataway ports of terminals and peripherals.

The second, section 3.3, discusses the DECdataway controller (ISB11-A). This includes setting of address and vector switches on the KMC11-A Microprocessor module (M8204) and the Line Unit module (M8202-YE).

Diagnostic checkout procedures for stand-alone and system acceptance are also included.

3.2 DECDATAWAY CABLE

3.2.1 Introduction

Installation procedures, guidelines, and recommendations are provided in this section to ensure proper installation and operation of the DECdataway.

Prerequisites for proper installation are:

- Planning the physical location of the PDP-11 and all terminals.
- Providing a maintenance area as close to the host system as possible.
- Generating a map of cable routing.
- Selecting a cable that conforms to the cable specifications given in Chapter 1.
- Ensuring that cable routing is within an environment that meets standards specified by the vendor.
- Procuring the proper hardware and tools necessary to perform the installation and checkout procedures.

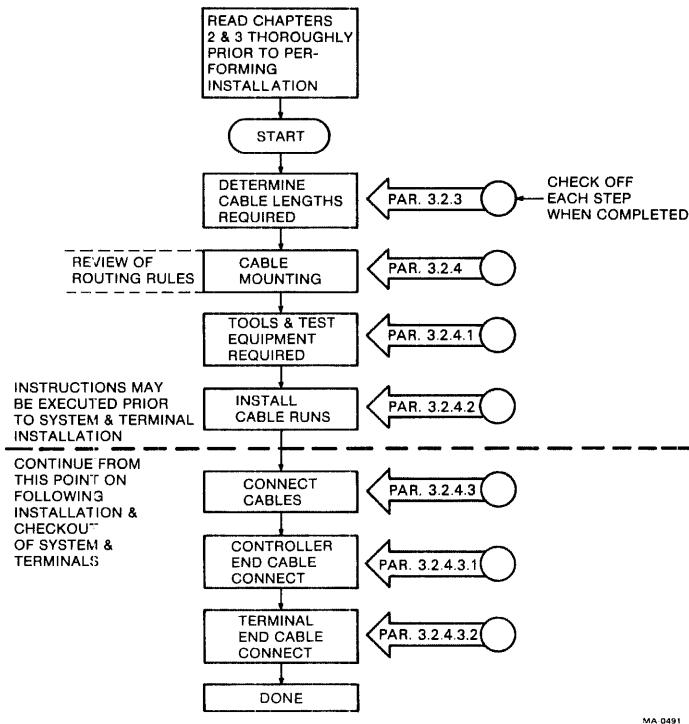


Figure 3-1 Installation Flowchart

3.2.2 Installation Sequence

Installation is performed in the step-by-step procedure reflected in the flowchart of Figure 3-1. Read each step carefully, perform indicated operation, then check off the corresponding block in the flowchart upon its completion.

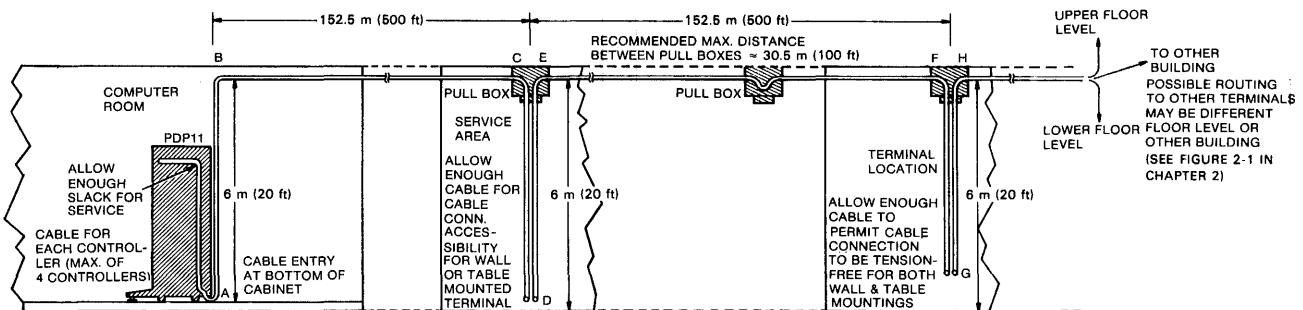
3.2.3 Cable Lengths Required (Figure 3-2)

With reference to Chapter 2 and the map layout (prerequisite), make a detailed floor plan that must include:

- The physical location of the PDP-11.
- The physical location of each terminal.
- The length of cable required from the controller in the PDP-11 cabinet to the first terminal. Allow enough slack at both ends of the cable for servicing (service loop).
- The length of cable required between each terminal, again allowing for service loops.
- The length of cable required from the controller to the maintenance area if closer than the first terminal. The maintenance area is to be treated as another terminal connection.
- All cable lengths are to be clearly identified on the floor plan.

NOTE

Generate a floor plan for each controller and associated terminals.



NOTES:

- TOTAL CABLE LENGTH SHOWN IS 335 m (1100 ft) THE SUM OF A THROUGH H (I.E., AB + BC + CD + DE + EF + FG + GH = 20' + 500' + 20' + 20' + 500' + 20' + 20' = 1100'). TOTAL LENGTH FROM TERMINATION TO TERMINATION IS NOT TO EXCEED 4.5 KM (15,000 ft).
- REFER TO INSTALLATION PROCEDURES SUPPLIED WITH PDP11 SYSTEM AND TERMINALS PURCHASED TO DETERMINE CABLE LENGTHS REQUIRED AT RESPECTIVE LOCATIONS.
- DETERMINE TOTAL CABLE LENGTH REQUIRED USING MAP LAYOUT INCLUDING SLACK REQUIRED TO ALLOW FOR CABLE CONNECTOR ACCESSIBILITY AND TENSION-FREE CONNECTIONS.
- DETERMINE TOTAL CABLE LENGTHS FOR EACH APPLICATION OF ADDITIONAL CONTROLLERS WITH A MAXIMUM OF FOUR.
- TWO POSSIBLE CONFIGURATIONS ARE SHOWN IN FIGURE 1-1 OF CHAPTER 1

MA 0494

Figure 3-2 Total Cable Length

3.2.4 Cable Mounting

It is the customer's responsibility to ensure that the cable is routed in accordance with the cable-routing practices described in Chapter 2. The cable recommended by DIGITAL is the Belden 9182 shielded, twisted pair. To ensure satisfactory cable performance, cable must be routed away from electrical power equipment and lighting fixtures to avoid electrical and electromagnetic interference.

For more interference information pertaining to various noise sources and noise measurements, refer to the DECdataway Noise Specification listed in Applicable Documents, Paragraph 1.3.6 of Chapter 1.

It is also recommended to keep all cabling away from the following at the minimum distance indicated:

- Fluorescent, incandescent, and neon lighting fixtures: 1 m (3.3 ft).
- Power wiring, transformers, generators, and alternators: 3.05 m (10 ft).
- Air conditioners, elevators, escalators, large blowers, and machine tools: 3.05 m (10 ft).
- Radios and televisions: 91.44 cm (3 ft).
- Intercommunication systems and security signal systems 91.44 cm (3 ft).
- RF stabilized arc welders: 4.3 m (14 ft).
- 3 KW plastic welders: 14 m (45 ft).
- 3 KW wood gluers: 14 m (45 ft).
- 12 KW plastic preheaters: 4.3 m (14 ft).
- RF induction heaters: 7.3 m (24 ft).
- Automotive induction noise: 3.7 m (12 ft).

- Transmitting systems (e.g., commercial broadcast, citizen radio, navigation, radar, and relay communications) with the following output power.

50 KW: 2000 m (6600 ft)
 100 W: 100 m (330 ft)
 5 W: 20 m (66 ft)

Cabling between buildings must be:

- In earth protected conduit if run underground.
- Protected against strain and lightning as required by the national electrical and local codes if run overhead.

3.2.4.1 DECdataway Assembly Items Required – Table 3-1 lists the tools and supplies required to assemble a DECdataway system.

Table 3-1 DECdataway Assembly Items

| Item | Description | Part No. | Quantity |
|-------------|--|-----------------------------|-----------------|
| 1 | Pin extraction tool | AMP 305183 | 1 |
| 2 | Pin insertion tool | AMP 91002-1 | 1 |
| 3 | Crimping tool | AMP 90277-1 | 1 |
| 4 | Termination resistors (200 Ω, 1/4 W, 5%, cc) | DEC 13-11522 | 2 per cable |
| 5 | Cable | Belden 9182 is recommended. | A/R |
| 6 | Conduit, junction boxes, pull boxes, and mounting hardware | | A/R |
| 7 | Electrical assembly hand tools (i.e., wire strippers, small Phillips screwdriver, and knife or cable stripper) | | 1 each |
| 8 | Electrical supplies (i.e., electrical tubing, vinyl tape, cable tie wraps, etc.) | | A/R |
| 9 | VOM or DVM (see Table 4-1) | | |

3.2.4.2 Installing Cable Runs and Associated Hardware

- Refer to the detailed floor plan and install conduits or troughs with required hardware including pull boxes. Recommended distance between pull boxes is approximately 30.48 m (100 ft). A 90° conduit bend is equal to 9.14 m (30 ft) of a straight conduit run. All pull boxes must be grounded in compliance with local and municipal electrical codes.
- Measure and cut required cable length for first run (from controller to service area or first terminal, whichever is the closest).
- Using a VOM or DVM, measure dc resistance of the cable wires with the far ends shorted together (refer to vendor cable specifications). Make a table to record same and keep for future reference as shown in Table 3-2 example format.

Table 3-2 Cable Measurements Example

| Run | | Length (ft) | Propagation Delay* | | | DC Resistance | | |
|----------------|-----------------|----------------|--------------------|------|-----------|---------------|------|-----------|
| From | To | | Spec | Free | Installed | Spec | Free | Installed |
| Controller | Service Area | 100 | Xns/ft | † | ‡ | XΩ/ft | † | ‡ |
| Controller | Terminal No. 1 | X ft | Xns/ft | † | ‡ | XΩ/ft | † | ‡ |
| Terminal No. 8 | Terminal No. 20 | X ft | Xns/ft | † | ‡ | XΩ/ft | † | ‡ |

NOTE
100 ft = 30.48 m

*This block applies only if TDR is used

†Record prior to installation

‡Record following installation

- Time Delay Reflectometry (TDR) techniques provide a useful tool and may be used in checking a possible defect in a long cable run. If TDR is to be used, it will be useful in future maintenance to have data taken when the cable is installed. For further information on TDR, refer to the maintenance chapter in the DECdataway Technical Manual (EK-ISB11-TM).
- Extra DECdataway cable should be kept on hand or easily available for replacement due to maintenance. It should be stored in an environment that is recommended by the manufacturer.
- Install first cable run. An antifriction agent should be used to avoid excessive tension on the cable when pulling cable through a conduit, provided that the agent is not damaging to the cable jacket. Great care should be exercised in pulling cable through sharp bends in the conduit where tension may be increased and cause conductor to short circuit to shield.
- Following installation of the first run, repeat dc resistance and record measurement under “Installed” column in Table 3-2. If cable was installed properly, measurements should not differ from those recorded prior to installation.

- Refer to Figure 4-1 in Chapter 4, User's Maintenance, and check for shorts between:
 - Cable wires (2)
 - Each cable wire and shield
 - Shield to conduit (except section connected to ISB11-A).
- Repeat foregoing procedure for each cable run.

3.2.4.3 Cable Connections – Each DECdataway consists of a continuous, homogenous length of shielded, twisted pair cable (DIGITAL recommends Belden 9182) with a 200Ω termination resistor fixed across the signal pair at each end. Each DECdataway has one “DECdataway Controller Connector” and from one to 63 “DECdataway Port Connectors” as required by the application. If the customer has chosen to cover his RT8XX terminals under the FDM Addendum, one port connector must be dedicated to the maintenance area. The controller connector may be placed anywhere along the length of the cable. The port connectors may also be placed anywhere along the length of the cable. The only restriction on how close together port connectors may be placed is the need for sufficient slack to enable servicing the terminals conveniently. DIGITAL recommends a minimum of 3.05 m (10 ft) of cable between port connectors. The maximum total length of cable permitted is 4572 m (15,000 ft), if Belden 9182 is used. The maximum length of cable is not specified for any other cable type.

There is only one controller for each DECdataway, therefore no address selection is necessary. The addresses of the DECdataway port connectors are set by jumpers inserted in each port connector at the time of installation. This arrangement, along with the fact that the DECdataway is a true multidrop communications line, will allow terminals to be removed from and replaced on the line for servicing without disturbing the DECdataway operation.

An installation kit may be purchased from DIGITAL, containing all parts, special tools, and instructions necessary to install an average-sized DPM DECdataway system. Table 3-3 specifies parts for the two kits available. The DPMXX-A kit contains all the parts and special tools (except wire) necessary to build two controller connectors and twenty port connectors. The DPMXX-B kit contains the same types and quantities of parts as DPMXX-A, except there is no crimping tool included. The number of kits required for each type of DPM system is detailed in Table 3-4 with the kits to be purchased.

Table 3-3 Parts List for DPMXX-A

| Item | Description | Part No. | Quantity |
|------|------------------------|--------------|----------|
| 1 | Port Plug | AMP 206037-1 | 20 |
| 2 | Port Cable Clamp | AMP 206322-1 | 20 |
| 3 | Cable Contact | AMP 66592-2 | 100 |
| 4 | Port Address Contact | AMP 66594-2 | 240 |
| 5 | Extraction Tool | AMP 305183 | 1 |
| 6 | Insertion tool | AMP 91002-1 | 1 |
| 7 | Crimping Tool* | AMP 90277-1 | 1 |
| 8 | Controller Plug | AMP 206153-1 | 2 |
| 9 | Controller Cable Clamp | AMP 206358-1 | 2 |
| 10 | Controller Contact | AMP 66589-2 | 10 |
| 11 | Termination Resistor | DEC 13-11522 | 4 |

*For DPMXX-B, Delete Item 7.

Table 3-4 DPMXX Installation Kits

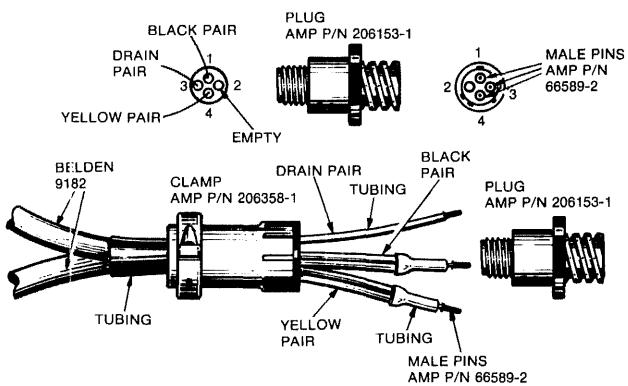
| For System Type | With Number of Ports | Purchase |
|-----------------|----------------------|------------------------|
| DPM 61 or 64 | 1 - 20 | 1 DPMXX-A |
| | 21 - 40 | 1 DPMXX-A + 1 DPMXX-B |
| | 41 - 60 | 1 DPMXX-A + 2 DPMXX-B |
| | 61 - 80 | 1 DPMXX-A + 3 DPMXX-B |
| | 81 - 100 | 1 DPMXX-A + 4 DPMXX-B |
| | 101 - 120 | 1 DPMXX-A + 5 DPMXX-B |
| | 121 - 126 | 1 DPMXX-A + 6 DPMXX-B |
| DPM 84 or 87 | 1 - 20 | 1 DPMXX-A |
| | 21 - 40 | 1 DPMXX-A + 1 DPMXX-B |
| | 41 - 60 | 1 DPMXX-A + 2 DPMXX-B |
| | 61 - 80 | 1 DPMXX-A + 3 DPMXX-B |
| | 81 - 100 | 1 DPMXX-A + 4 DPMXX-B |
| | 101 - 120 | 1 DPMXX-A + 5 DPMXX-B |
| | 121 - 140 | 1 DPMXX-A + 6 DPMXX-B |
| | 141 - 160 | 1 DPMXX-A + 7 DPMXX-B |
| | 161 - 180 | 1 DPMXX-A + 8 DPMXX-B |
| | 181 - 200 | 1 DPMXX-A + 9 DPMXX-B |
| | 201 - 220 | 1 DPMXX-A + 10 DPMXX-B |
| | 221 - 240 | 1 DPMXX-A + 11 DPMXX-B |
| | 241 - 256 | 1 DPMXX-A + 12 DPMXX-B |

A DPMXX-A may be substituted for any DPMXX-B kit if more than one set of tools is desired.

Instructions for connecting the DECdataway cable to its respective connectors are presented in two parts: connection to the controller connector and connection to the port connector.

3.2.4.3.1 Connection to the Controller (refer to Figure 3-3 and Table 3-5) – Perform the following steps when connecting the DECdataway cable to a controller.

1. Locate the two DECdataway cable ends in the DPM Systems area and cut them off evenly. Ensure that the finished connector will reach the controller pigtail inside the system cabinet with enough slack, approximately 1.52 m (5 ft) for the BA11 mounting rack to be pulled out for service.
2. Strip back the sheath of both cable ends 7.5 cm (3 in), and remove the foil sheath and filler.
3. Slide one 50 mm (2 in) length of insulating tubing over both cable ends, holding them together.
4. Join both drain wires together. Insulate them with a piece of tubing 7 cm (2.75 in) long, and crimp them together in one male pin (AMP P/N 66589-2), using AMP tool P/N 90277-1.
5. Strip 2.54 cm (1 in) of insulation from each of the four signal wires.
6. Twist each pair of like color wires together (black to black and yellow to yellow) and cover each pair of bare wires with a piece of tubing (heat shrinkable preferred), 20 mm (0.75 in) long.



MA-0489

Figure 3-3 DECdataway Controller Connector

Table 3-5 Controller Connection Parts List

| Item | Description | Part No. | Quantity |
|------|-------------|--------------|----------|
| 1 | Plug | AMP 206153-1 | 1 |
| 2 | Clamp | AMP 206358-1 | 1 |
| 3 | Male Pins | AMP 66589-2 | 3 |

7. Crimp the two black wires together into one male pin using the AMP tool (AMP P/N 90277-1).
8. Repeat step 7 for the yellow pair of wires.
9. Slide the cable clamp (AMP P/N 206358-1) over the assembled cable end. Make sure all three pairs (yellow, black, and drain) are inside the clamp body.
10. Insert the three male pins into the controller plug (AMP P/N 206153-1), using the insertion tool (AMP P/N 91002-1). Observe color coding as follows: black pair to 1, yellow pair to 4, and drain pair to 3. Pin 2 is not used (see Figure 3-3).
11. Slide the cable clamp body up to the plug and screw both parts together.
12. Slide the 50 cm (2 in) length of tubing (from step 3) up to the cable clamp body and insert it into the body far enough so that it will be secured by the cable clamp.
13. Select the right size clamp and secure it to the cable clamp body using both screws provided. Tighten the clamp sufficiently to provide strain relief for the pin connections. Secure the tubing with a tie wrap.

14. Inspect the controller connector assembly and label as necessary (1, 2, 3, or 4). Should any pins need to be removed from the plug, use the AMP extraction tool (AMP P/N 305138).

NOTE

It does not matter electrically which signal pair (black or yellow) goes to which pin (1 or 4). However, following a standardized connection scheme (as recommended here) will facilitate cable maintenance.

3.2.4.3.2 Connection to One DECdataway Port (refer to Figure 3-4 and Table 3-6) – Perform the following steps when connecting the DECdataway cable to one port.

NOTES

1. For best throughput, port address selection should start at address 1 and run continuously through the highest address to be used on each DECdataway. If the RT8XX terminals are covered under the FDM Addendum service agreement, address 1 is recommended for the maintenance area. Otherwise, the physical location of addresses is not restricted and any address location scheme that is convenient for a given application may be used.
2. It should also be noted that the DPM01 contains four addresses and that the DPM50 contains two addresses. If these devices are used, then the total number of devices on the line would be less than 63. The port connector should be wired for the lowest of the allocated addresses (e.g., if a DPM01 is used and is allocated for addresses 1 through 4, then address 1 would be wired in the connector and addresses 2 through 4 should not be used by any other device).

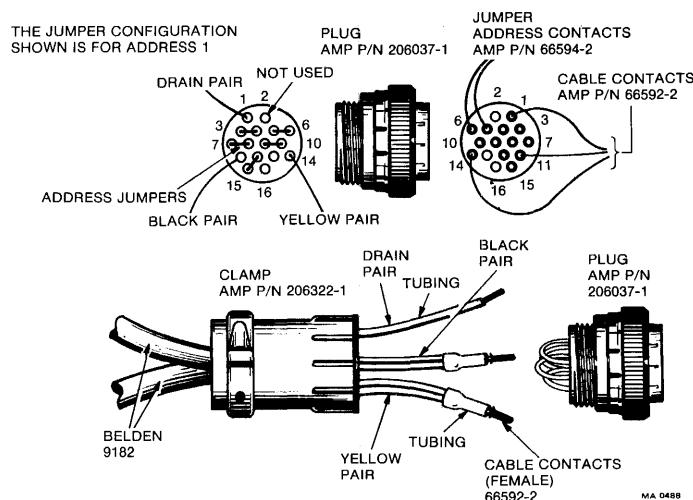


Figure 3-4 DECdataway Port Connector

Table 3-6 Port Connection Parts List

| Item | Description | Part No. | Quantity |
|-------------|---------------------------------------|-----------------|-----------------|
| 1 | Plug | AMP 206037-1 | 1 |
| 2 | Clamp | AMP 206322-1 | 1 |
| 3 | Cable Contact | AMP 66592-2 | 3 |
| 4 | Address Jumper Contact | AMP 66594-2 | 0 - 12 A/R |
| 5 | Address Jumper Wire (22 AWG Stranded) | Any | A/R |

1. Refer to Table 3-6 and Figure 3-4 and assemble the required parts.
2. Make from 1 to 6 address jumpers as required; refer to Table 3-7 for addressing information. Cut the required number of jumpers from 22 AWG stranded wire. Crimp a female pin (AMP P/N 66594-2) on each end of each jumper, using AMP tool (AMP P/N 90277-1).
3. Insert the jumpers into the plug (AMP P/N 206037-1). Refer to Table 3-7 and Figure 3-4 for jumper locations.
4. Label the clamp body (AMP P/N 206322-1) clearly with the selected address in decimal numbers.
5. Locate the two cut ends of the DECdataway cable at the physical port location. Cut the ends off evenly, ensuring sufficient slack, about 1.22 to 1.52 m (4 to 5 ft) for a service loop. This will allow convenient servicing of the DECdataway device.
6. Strip 3 cm (1.25 in) of sheath from each cable end. Remove the exposed foil shield and filler.
7. Strip 1.6 cm (5/8 in) of insulation from each black and yellow signal wire.
8. Join the two drain wires together and insulate them with a 2.5 cm (1.0 in) long piece of tubing.
9. Join the pair of black signal wires together and insulate them with 2 cm (0.75 in) long piece of tubing (heat shrinkable preferred).
10. Repeat step 9 for the yellow pair.
11. Crimp each pair (drain, black, and yellow) into one of the three cable contact female pins (AMP P/N 66592-2).
12. Slide the cable clamp (AMP P/N 206322-1) over the assembled cable end, ensuring that all three pairs (drain, black, and yellow) are inside the cable clamp body.

Table 3-7 DECdataway Port Address Selection

(See legend at end of Table.)

| Address Octal/Decimal | | Pin Locations | | | | | | No. JMP |
|--------------------------|----|---------------|-----|-----|------|-------|-------|------------|
| | | 3 4 | 5 6 | 7 8 | 9 10 | 12 15 | 13 16 | |
| 1 | 1 | - | - | - | - | - | - | 5 |
| 2 | 2 | - | - | - | - | - | - | 5 |
| 3 | 3 | - | - | - | - | - | - | 4 |
| 4 | 4 | - | - | - | - | - | - | 5 |
| 5 | 5 | - | - | - | - | - | - | 4 |
| 6 | 6 | - | - | - | - | - | - | 4 |
| 7 | 7 | - | - | - | - | - | - | 3 |
| 10 | 8 | - | - | - | - | - | - | 5 |
| 11 | 9 | - | - | - | - | - | - | 4 |
| 12 | 10 | - | - | - | - | - | - | 4 |
| 13 | 11 | - | - | - | - | - | - | 3 |
| 14 | 12 | - | - | - | - | - | - | 4 |
| 15 | 13 | - | - | - | - | - | - | 3 |
| 16 | 14 | - | - | - | - | - | - | 3 |
| 17 | 15 | - | - | - | - | - | - | 2 |
| 20 | 16 | - | - | - | - | - | - | 5 |
| 21 | 17 | - | - | - | - | - | - | 4 |
| 22 | 18 | - | - | - | - | - | - | 4 |
| 23 | 19 | - | - | - | - | - | - | 3 |
| 24 | 20 | - | - | - | - | - | - | 4 |
| 25 | 21 | - | - | - | - | - | - | 3 |
| 26 | 22 | - | - | - | - | - | - | 3 |
| 27 | 23 | - | - | - | - | - | - | 2 |
| 30 | 24 | - | - | - | - | - | - | 4 |
| 31 | 25 | - | - | - | - | - | - | 3 |
| 32 | 26 | - | - | - | - | - | - | 3 |
| 33 | 27 | - | - | - | - | - | - | 2 |
| 24 | 28 | - | - | - | - | - | - | 3 |
| 35 | 29 | - | - | - | - | - | - | 2 |
| 36 | 30 | - | - | - | - | - | - | 2 |
| 37 | 31 | - | - | - | - | - | - | 1 |
| 40 | 32 | - | - | - | - | - | - | 5 |
| 41 | 33 | - | - | - | - | - | - | 4 |
| 42 | 34 | - | - | - | - | - | - | 4 |
| 43 | 35 | - | - | - | - | - | - | 3 |
| 44 | 36 | - | - | - | - | - | - | 4 |
| 45 | 37 | - | - | - | - | - | - | 3 |
| 46 | 38 | - | - | - | - | - | - | 3 |
| 47 | 39 | - | - | - | - | - | - | 2 |
| 50 | 40 | - | - | - | - | - | - | 4 |
| 51 | 41 | - | - | - | - | - | - | 3 |
| 52 | 42 | - | - | - | - | - | - | 3 |
| 53 | 43 | - | - | - | - | - | - | 2 |
| 54 | 44 | - | - | - | - | - | - | 3 |
| 55 | 45 | - | - | - | - | - | - | 2 |

Table 3-7 DECdataway Port Address Selection (Cont)

(See legend at end of Table.)

| Address Octal/Decimal | Pin Locations | | | | | | No. JMP |
|--------------------------|---------------|-----|-----|------|-------|-------|------------|
| | 3 4 | 5 6 | 7 8 | 9 10 | 12 15 | 13 16 | |
| 56 | 46 | | - | | | - | 2 |
| 57 | 47 | | - | | | - | 1 |
| 60 | 48 | | - | - | - | - | 4 |
| 61 | 49 | | - | - | - | - | 3 |
| 62 | 50 | | - | - | | - | 3 |
| 63 | 51 | | - | - | | - | 2 |
| 64 | 52 | | - | | - | - | 3 |
| 65 | 53 | | - | | - | - | 2 |
| 66 | 54 | | - | | | - | 2 |
| 67 | 55 | | - | | | - | 1 |
| 70 | 56 | | | - | - | - | 3 |
| 71 | 57 | | | - | - | - | 2 |
| 72 | 58 | | | - | | - | 2 |
| 73 | 59 | | | - | | - | 1 |
| 74 | 60 | | | | - | - | 2 |
| 75 | 61 | | | | - | - | 1 |
| 76 | 62 | | | | | - | 1 |
| 77 | 63 | | | | | - | 0 |

LEGEND

1. Address 0 is reserved for the system broadcast.
2. - = Jumper In (Logic 0)
3. (Blank space) = Jumper out (Logic 1)
4. This pattern of physical addresses is duplicated for each DECdataway on a DPM system.

13. Using the insertion tool (AMP P/N 91002-1), insert wires into the plug as follows: The black pair in 11, the yellow pair in 14, and the drain pair in 1.

NOTE

Pin 2 is not used. The other pins (3,4,5,6,7,8,9,10,12,13,15,16) will be used according to the port address selected. The orientation of the signal pair, black to 11 and yellow to 14, is not electrically significant. However, maintaining a standardized wiring scheme, as recommended, will facilitate cable maintenance. Refer to Figure 3-4.

14. Slide the cable clamp up to the plug and thread the two parts together tightly.

15. Select the right size clamp and secure it to the clamp body with both screws. Tighten the clamp sufficiently to provide strain relief for the cable pins.

NOTE

A possible variation of this procedure would be to assemble the required port connectors before the cable installation, using short lengths of cable, 1.52 to 6 m (5 to 20 ft). Then connect the preassembled and preaddressed port connectors into the DECdata-way cable using butt splices or screw terminal strips. Important considerations in this case would be to ensure a continuous run of a homogeneous cable type and to observe color coding when making cable splices. It is recommended that crimp-type wirenuts (P/N AMP 330718 or 35115) be used for splices on the DECdataway cable.

3.3 ISB11-A DECDATAWAY CONTROLLER

3.3.1 Introduction

This section describes the hardware and software necessary to install and check out the ISB11-A controller. Acceptance test procedures are performed on the controller as a stand-alone entity and also when the controller is connected to a DECdataway port, using a test cable.

3.3.1.1 ISB11-A Hardware – The hardware that makes up an ISB11-A controller is listed in Table 3-8. Items 1 through 4 are shipped as part of the controller and items 5 through 7 are part of the host system.

Table 3-8 ISB11-A Hardware

| Item | Hardware | Description |
|------|----------------------------------|------------------------|
| 1 | M8204 | KMC11-A Microprocessor |
| 2 | M8202-YE | ISB11-A Line Unit |
| 3 | BC08S-01 | Interconnection Cable |
| 4 | 70-14152 | ISB11-A Test Cable |
| 5 | DD11-C or DD11-D | Backplane |
| 6 | DPM61, 64, 84, or 87 | System |
| 7 | RT801, 803, 805, DPM01, or DPM50 | DEC Dataway Peripheral |

3.3.1.2 ISB11-A Software – The software package shipped with the ISB11-A controller for stand-alone checkout is the LIBKIT ZJ234-RB, and it contains the following diagnostics:

MAINDEC-11-DZKCA
 MAINDEC-11-DZKCC
 MAINDEC-11-DZKCD
 MAINDEC-11-DZKCE
 MAINDEC-11-DZKCF

The software diagnostics used in checking out the ISB11-A at the system level are:

DEC/X11 with the KMC11 module (MAINDEC-11-DXKMC)

NOTE
Any one of the following may be used.

MAINDEC-11-DZQRA-A-HC
MAINDEC-11-DZQRA-A-DC
MAINDEC-11-DZQRA-A-MC9

3.3.1.3 Acceptance Procedures – The acceptance procedures are discussed in three separate paragraphs: a physical check, a stand-alone diagnostic, and a system diagnostic.

3.3.1.3.1 Physical Check

NOTE
This procedure is written in case modules M8204 and M8202-YE are not installed prior to shipment. In most cases they are installed, and this procedure can be checked for accuracy.

1. Determine the backplane slots where the M8204 and M8202-YE modules will be located.

NOTE
These modules are to be firmly seated adjacent to each other in hex SPC slots (discussed later in this procedure) in a DD11-C or DD11-D backplane.

2. On the backplane, check that the supply voltages are within the following tolerances.

| Min | Voltage Nominal | Max | Backplane Pin |
|------------|------------------------|------------|----------------------|
| +4.75 | +5 | +5.25 | C1A2 |
| -14.25 | -15 | -15.75 | C1B2 |
| +14.25 | +15 | +15.75 | C1U1 |

3. The NPG grant continuity wire from CA1 to CB1 must be removed from the backplane slot where the M8204 module is to be located.
4. Set the ISB11-A to the following addresses by setting M8204 switches as shown for the appropriate system.

| System | Address | Vector |
|-----------------|----------------|---------------|
| DPM61 and DPM64 | 760140 | 400 |
| | 760150 | 410 |
| DPM84 and DPM87 | 760140 | 400 |
| | 760150 | 410 |
| | 760160 | 420 |
| | 760170 | 430 |

5. Set M8202-YE switches on all three switch packs to OFF.
6. Insert both modules (M8204 and M8202-YE) firmly into the backplane per information given in Step 1.
7. Connect J1 of the M8204 to J1 of the M8202-YE using BC08S-01 interconnection cable.
8. Repeat step 2. If adjustments are required, refer to DECdataway Instruction Manual (EK-ISB11-TM).

3.3.1.3.2 Standalone Diagnostics

1. Create a chain under XXDP of the following diagnostics in the order shown:

MAINDEC-11-DZKCC
MAINDEC-11-DZKCD
MAINDEC-11-DZKCA
MAINDEC-11-DZKCE
MAINDEC-11-DZKCF

2. If an RK05 is used for the diagnostic medium, a normal XXDP chain will fail to continue properly after DZKCC and DZKCA. This is because they test the KMC11-A ability to force AC LO. Insert several lines of console printing in the chain file immediately following diagnostics DZKCC and DZKCA. This allows the RK05 enough time to recover. Otherwise, an RK05 device error will be indicated on the XXDP monitor.
3. Run each diagnostic for at least three passes, whether they are run from an XXDP chain file or run separately.
4. Set the switch register to 00000. Each diagnostic will auto-size the system, report the ISB11-As at nonstandard floating addresses, and proceed to run all the ISB11-A on the system.

3.3.1.3.3 System Diagnostics – The system diagnostics are divided into two categories: a DEC/X11 and a user mode.

DEC/X11

1. Load DEC/X11 and run for one half hour.

NOTE

For DPM6X systems, one KMC11 module is needed.

For DPM8X systems, two KMC11 modules are needed.

2. Set the NPR rate for 14 μ s/NPR.
3. Set the NPR/BR rate to 30 NPR/BR.
4. Set SR1 bits 13 and 12 to 0 for both transmit and receive NPRs

User Mode

Because the ISB11-A protocol is half duplex, a full system test requires that the controller be connected to one or two DECdataway peripherals and the Serial Bus Exerciser (MAINDEC-11-DZKCH) be run. The procedure will vary according to the type of DPM system being used.

The procedures are as follows:

1. For each ISB11-A to be tested, obtain one or two DECdataway peripherals.
2. Make sure that they have been checked using their ROM resident diagnostic. Refer to the Remote Terminals RT801, 803, 805 User's Guide or DPM01 User's Guide for details.
3. Connect the peripherals to the controller using the ISB11-A test cable (70-14152) provided with the host system.

NOTE

The two port connectors of the test cable are wired for addresses 1 and 2.

4. The variations in procedure are due to the different media used on the different DPM systems. Each RSX11-M test pack contains an RSX11-M operating system image for a minimum configuration DPM system.

Each test pack will contain two diagnostic tasks (MAINDEC-11-DZKCH and MAINDEC-11-DZKCI) and will be shipped on a medium appropriate for the target system:

MAINDEC-11-DZQRA-A-HC on RK05 for DPM61-A
MAINDEC-11-DZQRB-A-HC on RK05 for DPM61-B

MAINDEC-11-DZQRA-A-DC on RK06 for DPM64-A and 84-A
MAINDEC-11-DZQRB-A-DC on RK06 for DPM64-B and 84-B

MAINDEC-11-DZQRA-A-MC9 on 9-track magtape for DPM87-A
MAINDEC-11-DZQRB-A-MC9 on 9-track magtape for DPM87-B

5. For DPM61, 64, and 84 systems: Boot the disk pack containing the user mode diagnostic package and run the serial bus exerciser (MAINDEC-11-DZKCH) for one hour, without errors.
6. For DPM87 systems: Boot the user diagnostic package magtape and transfer the operating system onto the RP06 using the instructions provided with the tape.

Boot the RP06 and run the serial bus exerciser (MAINDEC-11-DZKCH) for one hour, without errors. This requires a scratch RP06 disk pack. This disk pack is shipped with the system.

CHAPTER 4

USER'S MAINTENANCE

4.1 INTRODUCTION

User's maintenance consists mainly of preventive maintenance. This chapter provides a description of the DECdataway preventive maintenance that can be performed by the customer and includes a list of tools and test equipment required. A maintenance node should be provided by the user in the event maintenance is required by a DIGITAL Field Service engineer.

4.2 PREVENTIVE MAINTENANCE

Preventive maintenance consists of periodic inspection of the DECdataway cable and connections as well as running diagnostic tests at periodic intervals to ensure proper equipment operation and minimum unscheduled down time.

4.2.1 Cable Inspection

For maintenance purposes, the user should keep a record of the initial cable characteristics that were taken during installation, as shown in the example in Chapter 3 (Table 3-2).

After the system becomes operational, record the received signal amplitude at the furthest terminal from the ISB11-A controller. This measurement should be repeated and recorded periodically at specified times. If there should be a 20 percent deviation in the signal amplitude, then the following steps should be taken.

1. Disconnect the cable section furthest from the ISB11-A.
2. Disconnect all terminals in that section from the cable.
3. Disconnect termination resistor, if applicable.
4. Measure both open and short circuit resistance of that cable section. Refer to Figure 4-1 and check for shorts between:

Cable wires (2)
Each cable wire and shield
Shield to conduit (except section connected to ISB11-A).

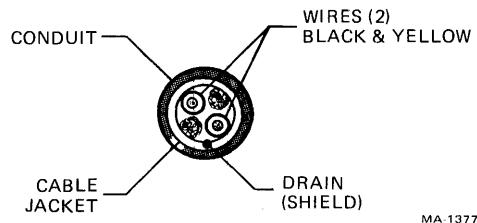


Figure 4-1 Cable Check Points for Shorts

5. If the resistance indicates less than $20\text{ M}\Omega$, inspect cable for contamination of the dielectric or wear from sharp bends, stress points, aging, or excess heat exposure.
6. If the circuit resistance indicates a higher reading than the one recorded at the time of installation, then inspect the cable for loose or contaminated connectors and excessive tension.
7. Repeat steps 1 through 6 for each cable section back to the ISB11-A.

4.2.2 Diagnostics

The DECdataway subsystem consists of eight diagnostic tests. The diagnostic process begins with a statement of the problem. An attempt should then be made to categorize the problem as ISB11-A related, DECdataway related, or terminal related. If this cannot be determined, running the diagnostics in the order shown next will isolate and classify the problem.

Detailed discussions of the content, use, and interpretation of each diagnostic is documented separately. The documents and programs are shipped with the system. The order in which diagnostics must be performed is as follows:

The first five tests listed here are stand-alone diagnostics and must be performed first and in the order given.

MAINDEC-11-DZKCC: Basic R/W and Microprocessor Tests
MAINDEC-11-DZKCD: KMC11 Low Speed Jump and Memory Tests
MAINDEC-11-DZKCA: KMC11 CPU Micro-Diagnostics
MAINDEC-11-DZKCE: DDCMP Mode Line Unit Tests
MAINDEC-11-DZKCF: Bit stuff Mode Line Unit Tests

The following three tests listed are performed on a system level and must also be performed in the order given, following the stand-alone tests.

MAINDEC-11-DXKMC: KMC11 DEC/X11 Exerciser Module

NOTE

The following diagnostics are run on-line under the RSX-11M software operating system.

MAINDEC-11-DZKCH: Serial Bus Exerciser
MAINDEC-11-DZKCI: Remote Terminal Exerciser.

4.3 TOOLS AND TEST EQUIPMENT

Tools and test equipment used for preventive maintenance, diagnostic testing, and installation are listed in Table 4-1. This is in addition to standard hand tools (e.g., screw drivers, pliers, etc.).

Table 4-1 Tools and Test Equipment

| Equipment | Manufacturer | Part No./Reference |
|---|-----------------------------|------------------------------------|
| Multimeter (VOM) or Digital Voltmeter (DVM) | Triplet or Simpson Fluke | Model 630-NA or 260 Model 8040A |
| Oscilloscope | Tektronix | Type 453 or equiv. |
| X10 probes (2) | Tektronix | P6008 |
| Extraction tool | AMP | 305183 |
| Insertion tool | AMP | 91002-1 |
| Crimping tool | AMP | 90277-1 |
| Software Diagnostic tools | DIGITAL | See Par. 3.3.1.2 |

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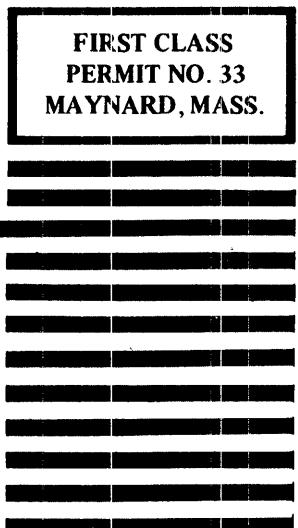
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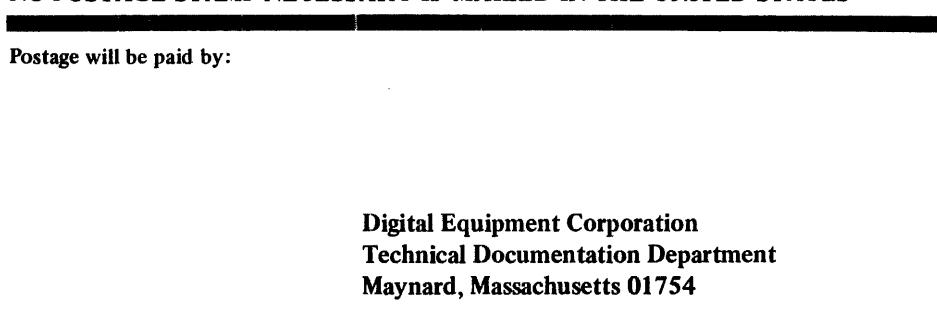
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