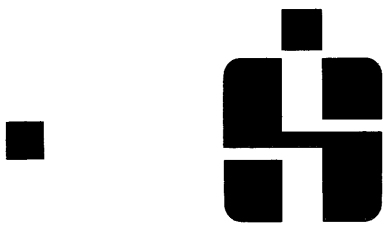
IS QIC2 Cartridge Tape Controller
Hardware Reference Manual



Integrated Solutions, Inc.

9110-101109-01

February 1985

IS QIC2 Cartridge Tape Controller
Hardware Reference Manual

INTEGRATED SOLUTIONS, INC.
2240 Lundy Ave.
San Jose, CA. 95131

9110-101109-01

February 1985

FCC WARNING

Class A Computing Devices

This equipment generates, uses, and may emit radio frequency energy. The equipment has been type tested and found to comply with the limits for a Class A computing device pursuant to Subpart J of Part 15 of FCC Rules, which are designed to provide reasonable protection against such radio frequency interference when operated in a commercial environment. Operation of this equipment in a residential area may cause interference in which case the user at his own expense may be required to take measures to correct the interference.

PREFACE

This manual describes the Integrated Solutions' QIC 2 Cartridge Tape Controller. The basic features of the QIC2 are described in Section 1; the specifications in Section 2. Section 3 contains very brief descriptions of the command set and notes any deviations from the DEC TS-11 implementation. Section 4 considers subsystem operations, including installation.

Since the QIC 2 emulates the TS-11, those users interested in a more detailed technical description of the QIC 2 will find the Digital Equipment TS -11 documentation useful, in particular:

TSV05 Tape Transport Subsystem, EK-TSV05-TM-001

☛ A note about terminology: the terms QIC2 and QICII are used throughout this manual. QIC2 is the name of the Integrated Solutions' Cartridge Tape Controller; QICII is a streaming cartridge tape unit interface specification and is used to designate those units that meet the specification. The IS QIC2 is designed to complement streaming tape units that conform to the QICII specification.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

SECTION 1: GENERAL DESCRIPTION

1.1 Introduction

The QIC2 is Integrated Solutions' TS-11 compatible 1/4" Cartridge Tape Controller. It is a single, dual-wide board that adhers to the DEC STD 160 specifications for the 22-bit LSI-11 bus and supports up to two TS-11 compatible cartridge tape transports.

1.2 Features

1.2.1 Cache Buffer

The QIC2 features a cache buffer, designed to complement high-speed streaming QICII cartridge tape units, which have a data transfer rate of 90 kilobytes per second. The cache buffer maximizes the throughput of the tape unit by minimizing data read overruns and data write underruns. Such overruns and underruns occur due to the mismatch between the data transfer rates of the cartridge tape unit (high) and the operating system (much lower); they reduce the effective data transfer rate of a cartridge tape unit to well below 90 kilobytes per second. With the QIC2, a tape unit effectively operates at 85 kilobytes per second when performing disk image backups and 45 kilobytes per second when performing file transfers.

Tape Write Operations

On tape write operations, write commands from the host processor are completed without starting tape motion until the cache buffer is full. While the QIC2 writes the tape and empties the buffer, additional tape write commands are accepted to refill empty buffer slots. If the host system is unable to keep up with the tape unit, the buffer empties and the tape stops in a buffer underrun condition. With the exception of a timeout timer overflow, tape writing is not resumed until the buffer is full again or a Write Tape Mark or a Rewind Command is received. In the latter case, the buffer is written onto the tape.

If the timer, which is active during tape write operations and keeps track of the last Write command received, overflows, all tape blocks in the cache buffer are written to the tape. In this manner, tape blocks will never be left in the buffer and lost when the tape cartridge is removed from the drive.

Tape Read Operations

On tape read operations, read commands from the host processor immediately cause tape motion to start. If the host processor is not ready to accept the data from the tape, the data is stored in the cache buffer until the host is ready to accept it. If the host is unable to accept data at the rate that it comes off the tape, the cache buffer eventually becomes full and tape motion stops. Tape motion is not resumed until the buffer is empty and a new tape read request from the host is pending. During the period after tape motion has stopped, tape read operations are processed by taking information from the buffer without causing tape motion to restart. If a Rewind or Skip File Marks command is issued with read-ahead information in the buffer, the buffer contents are discarded.

1.2.2 Variable Length Records

The QIC2 reads and writes 512-byte block records, but, like the TS-11, supports variable size records. To support variable length records, the QIC2 writes a 512-byte header block at the beginning of each record. This header block contains the length of the record in bytes and in 512-byte tape blocks. On read operations, the header block allows the QIC2 to track the length of the records on the tape. Supporting variable length records means the QIC2 operates more efficiently when writing long records since there is a fixed amount of overhead for each record.

1.3 Control Microprocessor

The QIC2 uses a 16-bit microprocessor to control all operations, including the cache firmware.

1.4 Cache Buffer

The cache buffer is implemented in either of two configurations:

six 2Kx8 RAMs (12K Bytes)
six 8Kx8 RAMs (48K Bytes)

At power-up time, the firmware automatically determines how much RAM is present on the IS QIC2. Therefore, no firmware or jumper changes are required when going from one RAM configuration to another.

1.5 PROMs

The IS QIC2 firmware is held in two 2716-type EPROMs. These EPROMs are on sockets and can easily be changed in the field if firmware upgrades are necessary.

1.6 Software Interface

1.6.1 Addressable Registers

The IS QIC2 supports two sets of two addressable registers which can be placed on any quad word boundary (i.e. bits 2,1, and 0 of the LSI-11 base address are all zero) in the LSI-11 bus I/O page. Each register set supports one of the two TS-11 emulating tape transports that are supported by the QIC2.

1.6.2 Commands

The entire TS-11 command set is supported except for commands that read the tape in the reverse direction and write retries. These TS-11 data recovery commands are not required, because the QIC2 has extensive error recovery firmware.

The commands and subcommands directly supported by the IS QIC2 are:

- Write Characteristics
- Get Status
- Read
- Write
- Format
  - Write Tape Mark
  - Erase
- Position
  - Skip Records Forward
  - Skip Records Reverse
  - Skip Tape Marks Forward
  - Skip Tape Marks Reverse
- Rewind
- Initialize

SECTION 2: SPECIFICATIONS

2.1 Form Factor

Dual Wide LSI-11 bus card; fully supports 22-bit addressing.

2.2 Addressing

The QICII uses four word address locations to support two TS-11 compatible tape transports. These address locations are settable on any eight byte boundary in the LSI-11 bus I/O page. The factory default setting is 772520_8 (TS-11 base address).

2.3 Interrupt level

BR4 - Vector 224_8

2.4 Diagnostics

Automatic self test at power-on with LED indication upon successful completion.

2.5 Electrical Requirments

+5 volts only, 2.5 amps

2.6 Interface

A single 50-pin ribbin cable interfaces the QIC2 controller to the tape drive. The controller supports up to two QICII drives.

2.7 Compatibility

Works with all standard QIC-II interface drives. Tape capacity is up to 100 megabytes per 600 ft. tape cartridge when using twelve track QIC-II interface drives.

2.8 Environmental

Temperature:

0 ° C to 50 ° C (operating)
-40 ° C to 65 ° C (non-operating)

Humidity:

10% to 90% (non-condensing)

SECTION 3: PROGRAMMING

3.1 Commands

This section gives a brief description of the commands supported by the QIC2. Deviations from the command set implemented by the TS-11 are noted. Since the QIC2 is designed to take advantage of existing TS drivers, and is compatible with the TS-11, users are referred to the DEC documentation cited in this manual's Preface for more information on the software interface.

3.1.1 Write Characteristics Command

The Write Characteristics command transfers the message buffer address, used at the completion of tape commands, to the TS-11. This message buffer address allows the TS-11 to transfer detailed status information back to the host. It is fully supported by the IS QIC2.

3.1.2 Get Status Command

The Get Status command simply passes detailed information about the tape transport back to the host through the message buffer; it does not move the tape. It is fully supported by the IS QIC2.

3.1.3 Read Command

The Read command has four subcommands associated with it:

Read Next (fully supported)
Read Previous
Reread Previous (fully supported)
Reread Next

Of these four subcommands, Read Next and Reread Previous are fully supported. The Read Previous and Reread Next commands, which cause the tape to be read in the reverse direction on the TS-11, are not supported on the IS QIC2 and will result in an illegal instruction termination if an attempt is made to execute them.

3.1.4 Write Command

The Write command has two subcommands:

Write
Write Data Retry

The Write command is fully supported but the Write Data Retry command is not supported and results in an illegal instruction termination if an attempt is made to execute it.

3.1.5 Format Command

The Format command has three subcommands:

Write Tape Mark
Write Tape Mark Retry
Erase

The Write Tape Mark command is implemented; the Write Tape Mark Retry is not and results in an error termination. The Erase command is implemented, but is treated as a NOP.

3.1.6 Position Command

The Position command has five subcommands - Skip Records Forward, Skip Records Reverse, Skip Tape Marks Forward, Skip Tape Marks Reverse and Rewind. The Rewind command, Skip Tape Marks Forward and Skip Tape Marks Reverse are fully implemented. The Skip Records Forward and Skip Records Reverse commands are fully implemented with the following important exception:

☛ NOTE - On the IS QIC2, the Skip Records Forward command is implemented by reading the number of records specified forward. The QICII specification does not allow a tape write operation to occur after a tape read operation has been started, other than at a file mark boundary. This means that once a Skip Records Forward command has been done, write operations are not permitted unless a file mark has been encountered. The Skip Records Reverse command is implemented on the IS QIC2 by rewinding the tape and skipping forward the appropriate number of records and has the same restriction that once a skip records reverse is done, no write operations are permitted unless the tape has been positioned at a file mark boundary. Because both the Skip Tape Marks Forward and Skip Tape Marks Reverse commands always leave the tape at a file mark boundary, the above restrictions do not apply to them.

SECTION 4: SUBSYSTEM OPERATIONS

4.1 Introduction

This section describes subsystem operations, including the configuration and installation of the QIC2.

4.2 Configuration Jumpers

The QIC2 has jumpers for controlling four major aspects of board operation:

RAM size
LSI-11 Bus Addressing
DMA Packet size
Interrupt Vector

Figure 4-1 shows the location of the jumpers on the board; Table 4-1 associates the operation with the jumpers and their factory configuration. For some needs they will have to be reconfigured, as described in the following paragraphs.

Table 4-1. Factory Jumper Settings

Default	Jumper	Setting
RAM Size	E16-E17	Connected
(12K)	E19-E20	Connected
Addressing	E11-E14	Connected
772520(8)	E2,E4,E6,E8	Each connected to E9
DMA Packet Size	E22-E23	Unconnected
(64 words per transfer)		
Interrupt Vector	E9-10	Unconnected

4.2.1 RAM Sise Jumpers

The RAM Size Jumpers - jumpers E16, E17, E18, E19, E20, E21 - support either six 2Kx8 (16K) or six 8Kx8 (64K) static RAMs in the RAM sockets, but not both simultaneously. The power-up firmware on the QIC2 board automatically determines which kind of RAMs are installed and whether the board has been populated with one, two or three sets of RAMs. Table 4-2 shows the available configurations.

Table 4-2. RAM Jumper Configurations

RAM Configuration	Jumper Setting
2Kx8	E16-E17 E19-E20
8Kx8	E17-E18 E20-E21

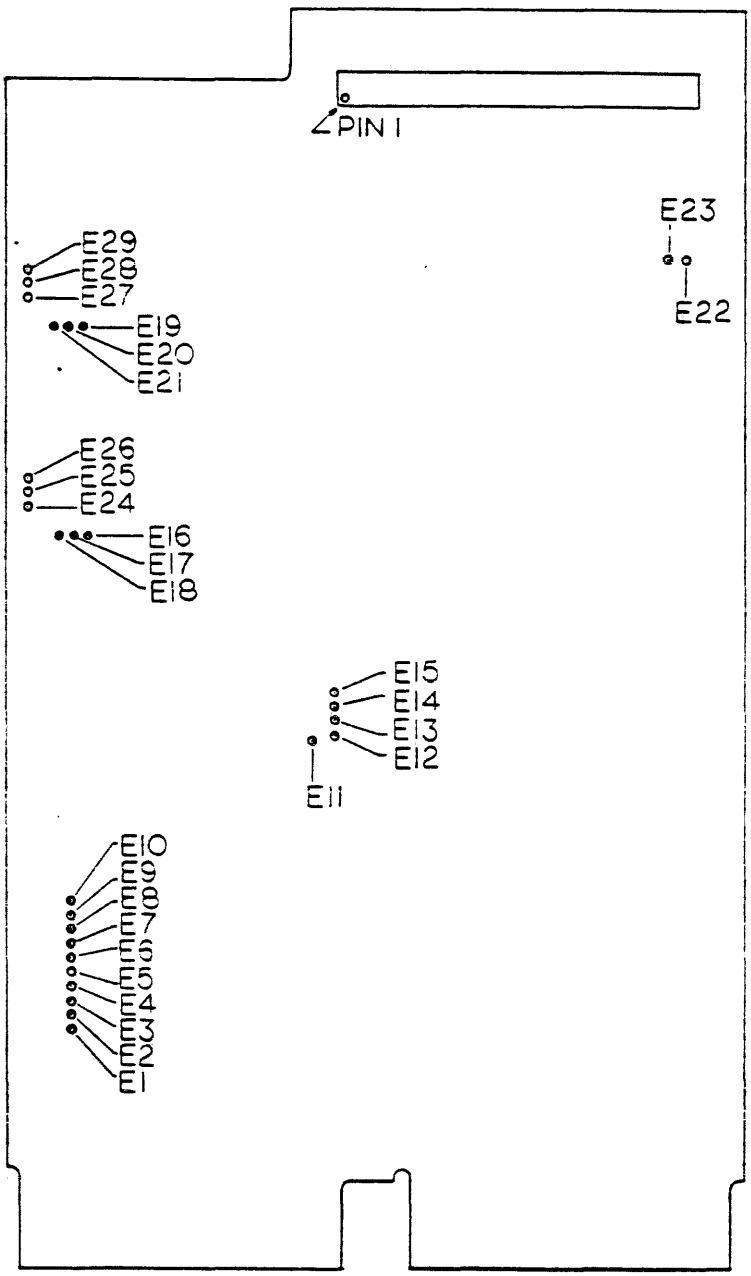


Figure 4–1. QIC2 Jumper Locations

4.2.2 Addressing Jumpers

The addressing jumper sets E1-E10 and E11-E15 (Table 4-3) control the base address for the QIC2 in the LSI-11 bus I/O page. The QIC2 controller can exist on any quad word boundary in the I/O page.

Table 4-3. Addressing Jumpers

LSI-11 BDAL Bits	Jumper Sets
12-11	E11-E15
10-3	E1-10
0-2	Not Applicable (These bits are zero)

Jumpers E11 through E15 (Table 4-4) control how the board is selected by BDAL bits 12 and 11. Jumper E11 is connected to only one of E12, E13, E14 (factory setting) or E15.

Jumpers E1 through E8 (Table 4-5) control the individual bits BDAL 10-3. Pin E9 is internally tied to ground; pins E1 through E8 should be selectively tied to E9 to cause the QIC2 registers to be selected when the corresponding address lines are zero. If a jumper is not tied to E9, the QIC2 registers are selected when the corresponding address bit is 1.

Table 4-4. Addressing Jumpers E11-E15

	QIC2 Register Selected	
Jumper Setting	BDAL 12	BDAL 11
E11-E15	1	1
E11-E14*	1	0
E11-E13	0	1
E11-E12	0	0

Table 4-5. Addressing Jumpers E1-E8

Jumper	BDAL	QIC2 Register Selected Address Bit Value
E1	BDAL 10	1
E2**	BDAL 9	0
E3	BDAL 8	1
E4**	BDAL 7	0
E5	BDAL 6	1
E6**	BDAL 5	0
E7	BDAL 4	1
E8**	BDAL 3	0

* This is the factory setting.

** These jumpers, all tied to E9, are the factory settings.

4.2.3 DMA Packet Size Jumper

Jumper E22-E23 selects between two possible packet sizes for the IS QIC2 controller. The default packet size (jumper removed) is 64 words per transfer. This mode is very effective for keeping the IS QIC2 streamer in streaming mode as much as is possible. However, the mode can be used only when there are no other DMA devices on the LSI-11 bus that will loose data if a DMA master occupies the bus for about 132 microseconds.

If jumper E22-E23 is inserted, the DMA packet size is reduced to 16 words per transfer. In this mode, the QIC2 is on the bus for just under 35 microseconds.

4.2.4 Interrupt Vector Jumpers

The interrupt vectors of the IS QIC2 are fixed in the firmware. Jumper E9-E10 allows the user to switch between the default vectors and an alternate set of interrupt vectors. Use of the alternate set is necessary if there is more than one TS-11 compatible controller in the system. The following table lists the default and alternate interrupt vectors for the IS QIC2:

Table 4–6. Interrupt Vector Jumper Settings

Controller	Default	Alternate
QIC2 #0	224(8)	374(8)
QIC2 #1	374(8)	376(8)

4.3 Installation

This section describes the integration of the Integrated Solutions' Cartridge Tape Subsystem, consisting of the QIC2 controller and Northern Telecom 1/4" Streaming Tape Drive, with Integrated Solutions' Optimum 5/00 and 5/10 systems. If you have purchased the QIC2 separately and do not plan on integrating it with an Optimum, this section will not be of much help other than to note that when installing the QIC2, ensure that the end of the 50-pin cable that connects the QIC2 with the tape drive has pin 1 of the cable oriented ***up***.

4.3.1 Material Requirements

To integrate the cartridge tape subsystem from Integrated Solutions' with the Optimum 5/00 and 5/10, ensure the following items are available:

- Integrated Solutions QIC2 Cartridge Tape Controller
- Northern Telecom 1/4 inch Streaming Tape Drive (Model 6109-90)
- 50-pin ribbon cable to connect the QIC2 to the Adapter Card (on the tape drive)
- Short 50-pin ribbon cable to connect the BSTI Controller Interface (also on the tape drive) to the Adapter Card
- Two 8-32 x 1/4 Machine Screws
- Two #8 Internal Lock Washers
- Straight Blade Screwdriver (not supplied by IS)

4.3.2 Installation Procedure

1. Reconfigure the QIC2 jumpers if necessary, as described in the first part of Section 4. In many cases, the factory configurations suffice and no reconfiguration is necessary.
2. Turn off the power on the Optimum.
3. Gracefully bring the system down as described in Unix 2.x (System III) Release Notes or the 4.2BSD System Administrator Guide.

4. Open the back door of the Optimum.
5. Remove the left (as you face the system from the rear) side panel. With your right hand holding the inside of the system, use your left hand to slide the left panel back about one inch. Lift the panel up and remove it. Set it aside.
6. Cut the tie wrap holding the two molex power connectors to the tape drive mounting bracket.
7. Using the screwdriver, loosen the four panel fastening screws holding the Tape Drive Mounting Bracket (upper corner) to the Optimum chassis. Remove the bracket from the system.
8. Remove the Tape Drive Shield from the mounting bracket by loosening the two 8-32 x 1/4 machine screws. It will not be needed; store it away.
9. Place the Northern Telecom Tape Drive unit onto the mounting bracket. Ensure that the two mounting holes near the front face of the tape drive match with the same two holes on which the tape drive shield was mounted.
10. Mount the tape drive onto the mounting bracket with the four 8-32 x 1/4 screws and lock washers.
11. Locate the two Optimum front panel Tape LED indicator wires (one is white, the other orange). One end of the wires connects to the LED Display board that sits behind the front panel LED indicators. The other end is fastened to the chassis behind the Control Logic board. Remove the end fastened to the chassis to expose the terminated contacts (male).
12. Replace the Tape Drive Mounting Bracket with the tape drive onto the chassis.
13. Insert the QIC2 Cartridge Tape Controller into the next available contiguous slot on the LSI-11 backplane. If you rearrange boards on the backplane to accommodate the QIC2, ensure that bus continuity is not broken.
14. Using the shorter of the two enclosed cable harnesses, connect J1 on the tape drive unit Adapter card (the outer, exposed card located on the tape drive) to J1 on the BSTI Controller Interface card (also located on the tape drive beneath the Adapter card). Ensure that pin 1 (signified by the blue line) on the ribbon cable is pointed *down*.
15. Connect the other 50-pin ribbon cable between the QIC2 and the tape drive Adapter card. At the QIC2 controller end of the cable, ensure that pin 1, marked by a small arrowhead etched in the plastic connector points *up*. (Also, pin 1 can be identified by a blue line that runs along the edge of the cable.) At the tape drive end of the connector, ensure that pin 1 points *down*.
16. Connect the two keyed power connectors of the AC/DC wiring harness to the tape drive unit.
17. On the tape drive, locate the two LED wires with female terminating contacts, (one white, the other orange). Connect them to the corresponding color-coded, male-terminating contact wires that hang exposed from the LED Display board.
18. Replace the Optimum side panel. Leave the back door open so you can view the QIC2 LED indicator when the system is powered on. The LED has several functions, described in the following section.
19. Turn the system power on.

4.3.3 QIC2 Power-On

After the system is turned on, the QIC2 performs an extensive memory diagnostic and sizing check, checks for the presence of the QICII Adapter (on the tape unit), and rewinds the cartridge tape if one is inserted in the drive and if it is not at the beginning of tape (BOT.) Upon successful completion of these operations, the QIC2 enters an idle state and the single LED on the QIC2 blinks at a 50% duty cycle at a 1/4 second on/off rate.

When the QIC2 LED indicates that all power-on tests have been completed successfully, close the rear door of the Optimum, and reboot the system.

☛ It may be necessary to rebuild your kernel if a TS tape driver has not already been installed. Refer to the Unix 2.x (System III) Release Notes or the 4.2BSD System Administrator Guide or contact Integrated Solutions Technical Support for help.

If the QIC2 fails any of its power-on routines, the LED flashes a pattern to indicate the probable cause of failure.

4.3.4 QIC2 Power-On Failures

The LED indicates three types of failures:

Power-On Memory Testing Failure
Absence of QICII Adapter
General Error Reporting

Power-On Memory Testing Failure

The extensive memory diagnostic and sizing check performed immediately after power-on can result in one of four failure types. These four failures are all considered fatal and result in the controller not coming ready: that is, the registers never appear in the LSI-11 bus I/O page. Each of the four failures has a unique pattern of long and short LED flashes:

Table 4-7. Power-On Memory Failure Indications

LED Failure Indication	Failure Location
short,short,short,short	memory bank zero (RAMs at 6L,8L)
short,short,short,long	memory bank one (RAMs at 6J,8J)
short,short,long,short	memory bank two (RAMs at 6F,8F)
short,short,long,long	no RAM in bank zero. The firmware self-sizes for any amount of memory that the QIC2 controller is populated with but there must always be RAM in bank 0.

No QICII Adapter attached or active

After checking the on-board memory, the controller checks for the presence of an active QICII Adapter (mounted on the tape drive). If the QICII Adapter is either not attached or not powered-up, the controller waits in a state where the LED flashes at 10 times per second until the QICII adapter becomes active. The QIC2 registers are not available during this time. Should this error occur, again remove the Optimum side panel and check the power and cable connections.

Other Fatal Errors

The QIC2 firmware has error traps for other fatal errors that should never occur during normal operation. All of these errors result in a coded blinking on the LED exactly like the blinking for power-up memory errors. The following list is included for reference purposes; the occurence of any one of these errors can only be cleared by resetting the controller.

Table 4-8. Fatal Error Indications

LED Failure Indication	Description
short,long,short,long	the QICII Adapter is active but there are no drives attached to it. The controller will never come ready in this case.
short,long,long,short	an error occurred in the tape unit on a Write File Mark Command
short,long,long,long	a sequencing error occured while reading records off the tape; a tape record was encountered that was not the same length as the 512 byte header block indicated it was.
long,short,short,short	a sequencing error on reads; the first tape block in a logical record was not a valid header block.
long,long,short,short	a full or empty queue problem; an attempt was made to read from an empty queue or write to a full queue.

4.4 Subsystem Capacity

The capacity of a cartridge tape used with a QIC2-controlled tape unit is a function of four variables, described in Table 4-9. To calculate the capacity of any given cartridge tape used in QIC2 tape subsystem, multiply the tape unit's track capacity by the number of tracks the tape unit supports. Table 4-10 shows the capacity of a single track for various length cartridge tapes.

Table 4–9. Tape Cartridge Capacity Variables

Variable	Description
tape length	available lengths: 300, 450, 555 and 600 feet
tape type	all tapes except the 600 foot tape, usually dsignated DC600A, record at 8000 bits per inch while the DC600A tape records at a flux density of 10000 bits per inch. Tape units which accept the DC600A tape should sense the presence of this tape and slow down their speed about 20% so that the data rate on and off the tape is still the same.
record length	the IS QIC2 has an extra 512 byte block of overhead per record
number of tracks written by the tape unit	QICII tape units are available with 4, 9 and 12 tracks.

Table 4–10. Tape Length/Single Track Capacity(MB)

Tape Length	Record Length		
	512 bytes	10K bytes	20K bytes
	Single Track Capacity (MB)		
300ft	1.8	3.42	3.51
450ft	2.7	5.13	5.26
555ft	3.33	6.33	6.49
DC600A	4.5	8.55	8.78

APPENDIX A: QIC2 LIMITATIONS

A.1 About This Appendix

This appendix summarizes the operating limitations imposed on the IS QIC2 due to the restrictions of the QICII specification itself.

A.2 Tape-to-Tape Transfers

When two tape units are attached to one IS QIC2, the QICII specification permits only one tape unit at a time to be away from BOT. Therefore, tape-to-tape transfers require that each transport have its own controller.

A.3 Space Records Forward and Reverse

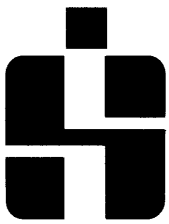
On the QIC2, the Space Records commands operate by reading blocks of tape and discarding the data. The QICII specification does not permit write operations to immediately follow read operations; the tape must be positioned at a file mark or rewound first. This same restriction applies to read followed by write operations; write operations are permitted only after a read operation has terminated at a file mark boundary.

A.4 Full TS-11 Implementation

The IS QIC2 is a full TS-11 implemtation, but it does not support any of the extended features of the TSV05 other than the extension of the packet transfer address to 22 bits to allow 22-bit addressing.

A.5 The Write Subsystem Memory

The Write Subsystem Memory on the TS-11 is strictly a diagnostic tool and is not supported on the IS QIC2.



Integrated Solutions Inc.
2240 Lundy Avenue
San Jose, CA 95131
408/943-1902
Telex No. 499 6929