Systems

Component Description-
IBM 3803/3420 Magnetic
Tape Subsystems

This manual describes the IBM 3802 Model 1 Tape Control and the IBM 3420 Models 3, 5, and 7 Magnetic Tape Units. The purpose of this manual is to provide a general introduction to the tape subsystem. Detailed operating information will be presented in future IBM publications.

Preface

This manual is written to provide a general introduction to the IBM 3803/3420 Tape Subsystem. Detailed operating information will be provided in future IBM publications.

This manual is written in four sections:

- **Section 1:** General information about the subsystem
- **Section 2:** The 3420 Tape Unit
- **Section 3:** The 3803 Tape Control
- **Section 4:** Special features

This manual requires no prerequisite reading; however, it is assumed the reader has a basic knowledge of stored program computers.

First Edition (November 1970)

Changes are periodically made to the information herein; any such changes will be reported in subsequent revisions or Technical Newsletters.

All specifications in this manual are nominal unless otherwise indicated.

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Abbreviations

BCD	binary coded decimal
BCDIC	binary coded decimal interchange code
BPI	bytes per inch
cm	centimeter
CPU	Central Processing Unit
EBCDIC	extended binary coded decimal interchange code
fci	flux changes per inch
FRU	field replaceable unit
I/O	input/output
ips	inches per second
Kb	kilobyte
Kd	kilodigit
mm	millimeter
ms	millisecond
NRZI	non-return to zero, IBM
OEMI	Original Equipment Manufacturers' Information
PE	phase encoded
ROS	read only storage
usec	microsecond

3803/3420 Magnetic Tape Subsystem

Section 1: Introduction

Basic Subsystem

The IBM 3803/3420 Magnetic Tape Subsystem consists of an IBM 3803 Model 1 Tape Control and the IBM 3420 Magnetic Tape Unit. The 3420 Tape Unit is available in three models. Tape speeds are 75, 125, and 200 inches per second (ips) for 3420 Models 3, 5, and 7, respectively (see Figure 1). With the single density feature, operation is nine-track, 1600 bytes per inch (BPI) phase encoded (PE) mode only. A 3803 Tape Control without any switching features can control up to eight 3420 Tape Units (1 x 8 configuration).

The 3803 Model 1 command set, status responses, and basic sense data are compatible with those for 2400-series tape programs. Any properly written, non-time-dependent program for 2400-series tape subsystems operates without change on a 3803/3420 subsystem with equivalent features.

Subsystem Highlights

The 3803/3420 Tape Subsystem offers the user six special features:

1. *Dual Density:* Allows processing of nine-track 800 BPI non-return to zero, IBM (NRZI) and 1600 BPI PE tapes on all nine-track tape unit models.

   Note: Either the single density, dual density, or seven-track feature must be specified when ordering the subsystem.

2. *Seven-Track:* Allows processing of seven-track 556/800 BPI NRZI tapes on all seven-track tape unit models. This subsystem can also process nine-track, 1600 BPI PE tapes on all nine-track tape unit models.

   Note: Either the single density, dual density, or seven-track feature must be specified when ordering the subsystem.

3. *Two Channel Switch:* Permits connection of the 3803 Tape Control to a second channel.

4. *2 Control Switch:* This is a switching feature for the tape control to provide access to a maximum of 16 tape units by any of two tape controls.

5. *3 Control Switch:* A switching feature for the tape control to provide access to a maximum of 16 tape units by any of three tape controls. All switchable tape units are attached to two of the tape controls.

6. *4 Control Switch:* A switching feature for the tape control to provide access to a maximum of 16 tape units by any of four tape controls. All switchable tape units are attached to two of the tape controls.

For additional information on these special features, see Section 4 of this manual.

Additional highlights of the 3803/3420 Tape Subsystem are:

- Resident microdiagnostics in the tape control to improve on-line testing.
- Radial attachment of tape units to permit off-line servicing without interfering with the subsystem.
- A new power latch on the reel hub that secures the file reel automatically.
- Automatic threading and cartridge loading (see Section 2).
- Improved rewind times (see Figure 1).
- The tape control has its own power cord and supplies power to the rest of the subsystem.

Recording medium	*Tape:* One-half inch (12,7 mm) magnetic tape; IBM Series/500, Dynexcel, or Heavy Duty. (See Section 2, "Magnetic Tape and Reels.")		
	Reels: Standard IBM 10.5-inch, 8.5-inch, or 6.5-inch reels. (Optional tape cartridge uses 10.5-inch reel, see Section 2, "Magnetic Tape and Reels.")		
Recording method and density	*Phase encoded (single density feature):* Nine-track (eight data tracks plus parity track), 1600 bytes per inch (63 bytes per mm).		
	Nine-track NRZI (special feature on 3803 Model 1 tape control and all 3420 tape units): Nine-track, 800 bytes per inch (31,5 bytes per mm).		
	Seven-track NRZI (special feature on 3803 Model 1 tape control and all 3420 tape units): Seven track (six data tracks plus parity track), 556/800 bytes per inch (21,9/31,5 bytes per mm).		
Read/write head	Two gap; 0.150 inch (3,81 mm) nominal between read and write gaps.		
Interblock gap	*Nine-track:* 0.6 inch (15,2 mm) nominal; 0.5 inch (12,7 mm) minimum.		
	Seven-track: 0.75 inch (19,05 mm) nominal.		
	3420 Model 3	*3420 Model 5*	*3420 Model 7*
Tape speed (read or write)	75 ips (190,5 cm/sec)	125 ips (317,5 cm/sec)	200 ips (508 cm/sec)
Read/write access times, nominal:*	4.0 ms	2.9 ms	2.0 ms
Data rates (Kb/sec; Kd/sec):			
1600 BPI PE	120/240	200/400	320/640
800 BPI NRZI	60/120 (seven- and nine-track)	100/200 (seven- and nine-track)	160/320 (seven- and nine-track)
556 BPI NRZI (seven-track)	41.7	69.5	111.2
Passing times per byte:			
1600 BPI PE	8.3 usec	5.0 usec	3.1 usec
800 BPI NRZI	16.7 usec	10.0 usec	6.2 usec
556 BPI NRZI (seven-track)	24.0 usec	14.4 usec	9.0 usec
Passing times, IBG:			
Nine-track (PE and NRZI)	8.0 ms	4.8 ms	3.0 ms
Seven-track (NRZI)	10.0 ms	6.0 ms	3.75 ms
Rewind time (2400 foot reel)	70 seconds	60 seconds	45 seconds
Rewind-unload time (2400 foot reel)	76 seconds	66 seconds	51 seconds
Load operation, approximate time to 'tape drive ready' (after reel/cartridge is mounted and LOAD REWIND is pressed)	10 seconds	10 seconds	7 seconds

*Access time is the interval from initiation of a write or forward read command, given when tape is not at load point, until the first data byte is read or written when tape is brought up to speed from stopped status. Figures do not include forward/backward status change (reversal) times.

Figure 1. Subsystem Performance Specifications

Section 2: 3420 Tape Unit

Unless otherwise noted, information presented in this section applies to all three models of the tape unit.

Automatic Threading

Tape is automatically threaded, loaded into the vacuum columns, and positioned at load point.

Optional Wraparound Tape Cartridge

When used with a solid-flange tape reel (standard IBM 10.5 inch), the IBM wraparound cartridge reduces tape handling and helps prevent contamination.

During a load operation, if the first threading sequence is unsuccessful, tape is rewound into the cartridge and a retry is attempted.

Tape Motion

The tape units use a tape transport design that minimizes tape wear and increases reliability. A single drive capstan moves tape forward or backward. Air bearings reduce friction and tape wear since the oxide (recording) tape surface contacts only the read/write head, the erase head, and the tape cleaner. The smooth (nonrecording) tape surface contacts the vacuum column sides, the drive capstan, and the air bearings. Short, tapered vacuum columns greatly reduce the amount of moving tape. These columns, plus the directly driven capstan, produce smooth and rapid start-stop motion.

Rewinding

Tape remains in the vacuum columns during high speed rewind operations. Rewind ends when a photocell senses a beginning-of-tape (load point) reflective marker on the tape surface.

If the tape unit was 'ready' before rewinding, it may now perform any new tape operation under program control.

During a rewind-unload operation, tape is rewound completely onto the file reel. The tape unit is in 'unloaded' status, with the tape reel latch unlocked and the window open. The operator can remove the file reel.

Read/Write Head

A two-gap read/write head allows read-back checking during a write operation. Moving forward during a write operation, tape passes first the write gap, then the read gap.

Erase Head

An erase head applies a strong magnetic field that erases the entire width of tape during write operations. Full-width erasure prevents interchangeability problems when tape is written on one tape unit and read on another, and reduces the changes of leaving extraneous bits in interblock gaps or skip areas.

During a write, write tape mark, or erase operation, the tape unit monitors the erase head operation. An erase head failure drops tape unit ready status and halts tape motion.

File Protection

Before writing, insert a write enable ring in the back of a file reel. To avoid destroying information on tape, remove the write enable ring. A reel without the ring is "file protected" (FILE PROTECT turns on and no writing can occur).

Nine-Track, 1600 BPI, PE Operation

In this mode of operation data is recorded parallel by bit, serial by byte, in nine tracks across the width of the tape. The data format uses eight of the nine bits for data, the ninth is a parity bit. Data is recorded in odd parity. The eight bits of one byte can represent an alphabetic character, zoned decimal digit, two decimal digits (packed), a special character, or eight binary bits.

Nine-Track, 800 BPI, NRZI Operation

Data representation is the same as for 1600 BPI PE operation. The dual density special feature is required for nine-track 800 BPI NRZI capability (see Section 4).

Seven-Track Operation

Data is recorded at either 556 or 800 BPI in seven-track operation. The seven-track special feature is required for this capability (see Section 4).

Magnetic Tape and Reels

Use IBM Series/500 Magnetic Tape, Dynexcel, Heavy Duty Tape, or competitive formulations which meet all current specifications in *Tape Specifications for IBM One-Half Inch Tape Drives at: 556 and 800 BPI and 3200 FCI*, Form GA32-0006. Do not use IBM Mylar* tape with the 3420 tape units.

Note: The tape specifiations state minimum requirements for use and may be revised from time to time as further needs are established. Attainment of specification does not ensure error free operation.

Use standard IBM 10.5-inch, 8.5-inch, or 6.5-inch reels, or competitive products which meet the specifications in Form GA32-0006.

*Trademark E.I. du Pont de Nemours and Company, Inc.

Section 3: 3803 Tape Control

General Characteristics

The tape control is designed to connect to the I/O Interface of either the IBM System/360 or System/370. The unit consists of a CE panel, two independent microprogram control sections, a read section, and a write section. With the single density feature, operating mode is 1600 BPI PE only. With the addition of the appropriate special feature, the tape control can process *either* nine-track, 800 BPI NRZI *or* seven-track, 556/800 BPI NRZI tape on those tape units having the companion NRZI feature. (See Figure 2.)

Note: "I/O Interface" refers to a set of lines over which the tape control and system channel exchange control and data signals. Interface lines and operations are described in *IBM System/360 Interface, Channel to Control Unit, Original Equipment Manufacturers' Information,* Form GA22-6843.

All data transfers are in burst mode. The tape control executes one command on one tape unit at a time. The tape control parity checks each byte. On write operations, bus out parity error is signaled and parity is corrected before the byte is sent to the tape unit. On read operations, tape control parity error is signaled and parity is corrected before the byte is placed on the interface. On sense operations, correct parity is supplied for each byte. Parity is also checked on command bytes.

I/O commands issued by the channel are executed with microprograms resident in two independent read-only storage (ROS) memories. One ROS unit controls communication lines to the channel, while the other ROS unit controls communication lines to the tape unit.

Addressing

Every tape unit has a unique device address. It consists of a channel address, a control unit address, and a tape unit address. Pluggable jumpers assign the tape control address when the system is installed. The tape control has separate device interface connectors for each tape unit address. A tape unit's address is determined by the tape control connectors to which it is attached. There is no address decoding at the tape unit or device interface level.

Metering

The tape control usage meter records elapsed time whenever the channel 'metering out' line is active and the tape control is in on-line status (enabled). The tape unit usage meter records elapsed time when the tape control 'metering out' line is active, tape unit is loaded, and the tape is not at load point. 'Metering in' is used by the central processing unit (CPU) metering circuits; this line is active from the time a command is accepted by the tape control until 'device end' is generated for that command. See *IBM System/360 I/O Interface: Channel to Control Unit OEMI,* Form GA22-6843.

On-Line and Off-Line Status

By placing the tape control in off-line status, a field engineer can use the CE panel switches and indicators to diagnose errors. The CE panel can also address selected diagnostic microprograms to verify specific tape control operations. A subroutine that detects a failure can be looped repeatedly to isolate a failing field replaceable unit (FRU).

Enable/Disable Switch

Set switch on ENABLE to place the tape control and attached tape units on-line. To take the tape control and tape units off-line, set switch on DISABLE. Switch operation is interlocked with the CPU program. The switch setting can be changed at any time, but the tape control changes status only when the CPU is in a halt or wait state.

A disabled tape control is nonexistent to the CPU program since the tape control does not return 'operational in' in response to a 'select out' from channel.

Power On/Off Sequence

Normal power on/power off sequencing for the 3803/3420 tape subsystem is controlled by system power interlock circuits. However, maintenance activities may necessitate dropping power in the tape control.

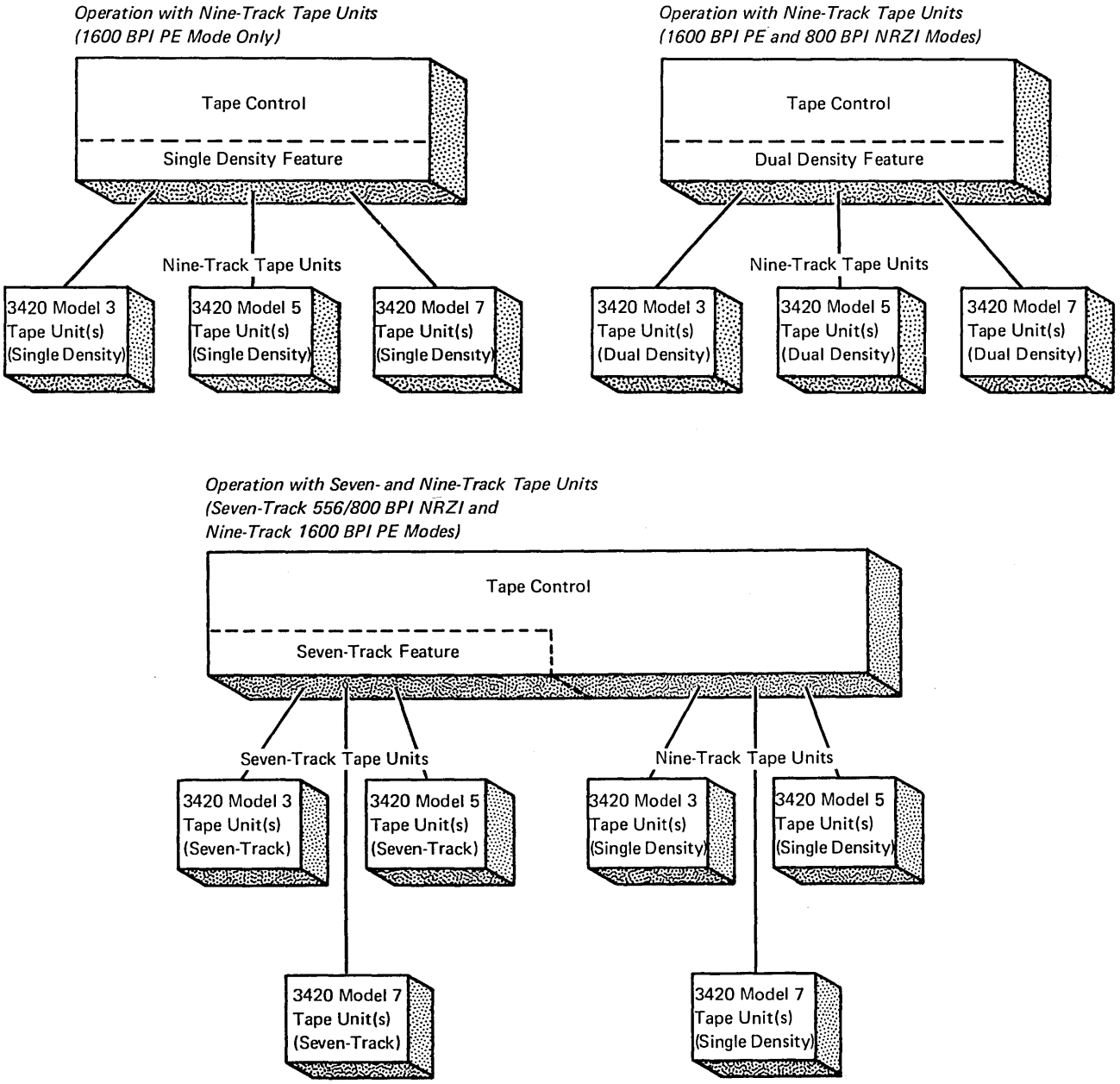


Figure 2. Dual Density and Seven-Track Operation

Section 4: Special Features

Six special features are available with the 3803/3420 Tape Subsystem. To assist in understanding the various subsystem configurations, the reader is referred to Figure 3 in several areas of the text.

DUAL DENSITY FEATURE

This feature allows the processing of nine-track, 800 BPI NRZI and 1600 BPI PE tapes. Before initiating a write operation, the channel issues a control command establishing the writing mode in the tape control and tape unit. A control command is not required for nine-track read operations.

Recognizing the presence or absence of a PE identification burst when reading from load point sets the tape unit and tape control to PE or NRZI mode. The tape unit retains its mode setting until the tape is again at load point.

Note: The dual density and seven-track features cannot be installed in the same tape control, nor can either be installed with the single density feature.

SEVEN-TRACK FEATURE

The seven-track feature allows the subsystems with seven-track tape units to read and write seven-track NRZI tape in binary format. If the tape control has the seven-track feature, it can operate with both seven-track NRZI and nine-track PE tape units. NRZI read and write operations are at 556 or 800 BPI, odd or even parity. Tape controls with seven-track compatibility have the translator and data conversion functions included.

Note: The dual density and seven-track features cannot be installed in the same tape control, nor can either be installed with the single density feature.

Translator Function

Use of the translator function causes eight-bit bytes from the I/O interface to be written on tape as six-bit BCD characters and six-bit BCD characters read from tape to be translated into their EBCDIC equivalents. When using the translator, data rates are not changed and there are no changes in the tape unit's operation.

Data Conversion Function

Writing a tape with data converter on causes four tape characters (24 bits) to be written for every three storage bytes (24 bits). Reading such a tape reverses the process by converting four tape characters into three storage bytes. Data conversion reduces the data transfer rate to 75% of the operating rate with data converter off.

TWO CHANNEL SWITCH FEATURE

This feature permits connection of the 3803 Tape Control to a second channel. Alternate path switching between two channels on the same system is under program control. Partitioning between channels, on two different systems, is done manually. (See Figure 3.)

DEVICE SWITCHING FEATURES

The three device switching features available with the tape subsystem are:

1. 2 Control Switch (2 x 16 configuration)
2. 3 Control Switch (3 x 16 configuration)
3. 4 Control Switch (4 x 16 configuration)

Each of these features is used with a Communicator. The communicator sends tape unit selection and device interface signals to one of two device switches, depending on whether tape units 0-7 or 8-F are being addressed. The location of the device switches depends on the configuration desired (See Figure 3).

The Communicator is installed by removing the selection logic circuits and the associated device interface cabling in the basic tape control. These are replaced by different logic circuits and cabling to the device switches shown in Figure 3.

2 Control Switch

A 2 x 16 configuration is obtained by installing a 2 Control Switch in each of two tape controls (designated Tape Controls 1 and 2 for reference). The 2 Control Switch is a 2 x 8 configuration of hardware switching logic, which allows access by two communicators (one in the same tape control and the other in a separate tape control) to any of eight tape units physically associated with the tape control. Tape Control 1 attaches tape units 0-7 and Tape Control 2 attaches tape units 8-F (See Figure 3).

3 Control Switch

A 3 x 16 configuration is obtained by installing a 3 Control Switch in Tape Controls 1 and 2. In addition, another tape control must be added to the configuration. Tape Control 3 does not contain any switch hardware or attach any tape units, but does contain the Communicator hardware (see Figure 3).

4 Control Switch

A 4 x 16 configuration is obtained by installing a 4 Control Switch in Tape Controls 1 and 2. In addition, two more tape controls must be added to the configuration. Tape Controls 3 and 4 do not contain any switch hardware or attach any tape units, but do contain the Communicator hardware (see Figure 3).

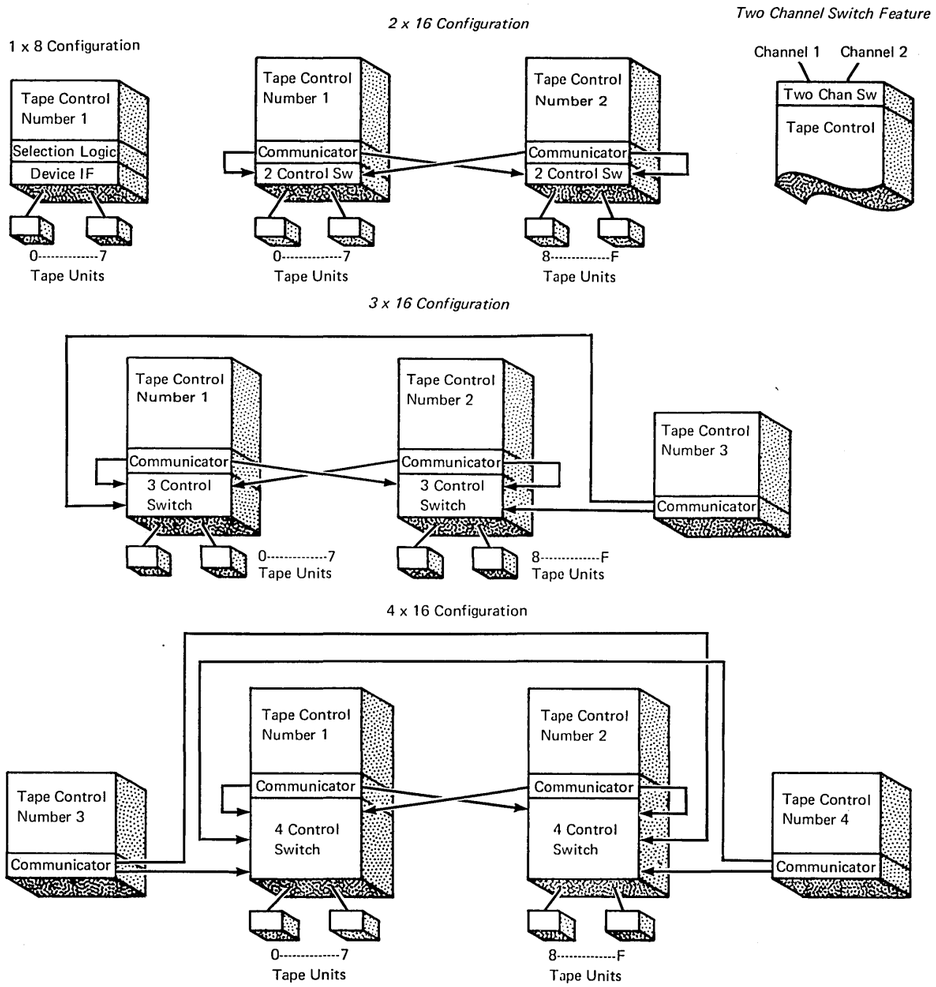
The 3 Control Switch and the 4 Control Switch are expansions of the 2 Control Switch. They allow access to the eight attached tape units by the additional communicators.

In all of the configurations, the device switch is logically invisible except for a 'busy' response to initial selection when the addressed tape unit is being used by another tape control and a 'device end' interrupt results. All device switch features contain priority logic to systematically allocate a tape unit in the event of conflicting tape control requests.

Toggle Switches

Included with the switching features is a set of toggle switches. These allow any tape unit to be made available or unavailable to any or all of the communicating tape controls. The toggle switches are mounted on the operator panels of Tape Controls 1 and 2. One row of eight switches is provided for each communicating tape control, including the tape control with the switches.

The eight switches in each row correspond to the eight tape units attached to the tape control on which the switches are mounted. Thus, Tape Unit 1 has a row of eight switches which control the availability of tape units 0-7 to Tape Control 1. Another row of eight switches controls the availability of tape units 0-7 to Tape Control 2, and up to a maximum of four rows of switches for the four tape controls in a 4 x 16 configuration. Similarly, Tape Control 2 can have two, three, or four rows of switches (the switches in each row corresponding to tape units 8-F) for a 2 x 16, 3 x 16, or 4 x 16 configuration), respectively. A particular switch being ON makes the corresponding tape unit available to the tape control represented by the row in which the switch is located. When the switch is OFF, the tape unit is not available. An attempted selection with the switch OFF results in a 'not operational' response.



Notes:
1. Maximum of 16 tape units and 4 tape controls.
2. Tape units attach only to tape controls with switch features.
3. Any or all control units may have two channel switch feature.

Figure 3. 3803/3420 Subsystem Configuration

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