Technical Manual

6026 TAPE TRANSPORT

015-000079-00

Warning:

This equipment generates, uses, and can radiate radio frequency energy and if not installed and used in accordance with the instruction manual, may cause interference to radio communications. It has been tested and found to comply with the limits for Class A computing devices pursuant to Subpart J of Part 15 of FCC Rules, which are designed to provide reasonable protection against such interference when operated in a commercial environment. Operation of this equipment in a residential area is likely to cause interference, in which case the user, at his own expense, will be required to take whatever measures may be required to correct the interference.

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6026 TAPE TRANSPORT

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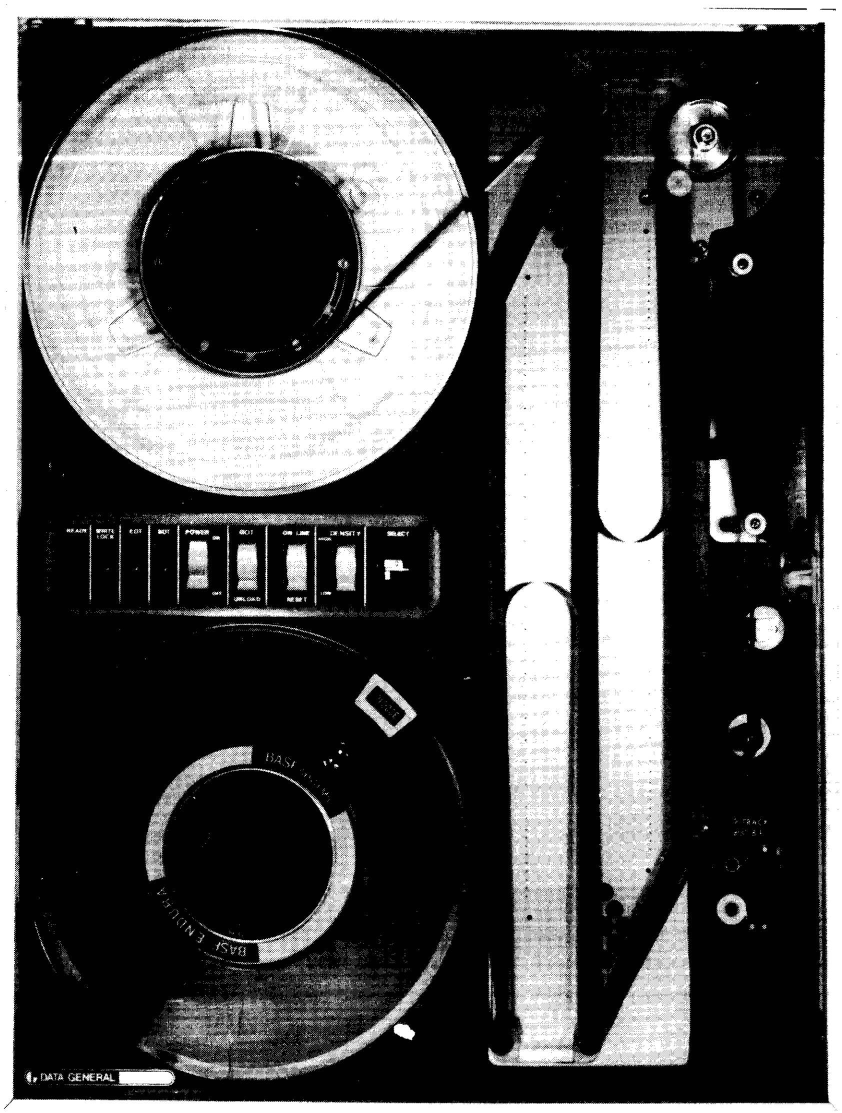
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6026 TAPE TRANSPORT

PREFACE

This manual introduces the model 6026 magnetic tape transport. We include enough information to give you a general idea of what the transport does and how it does it. This is not a repair manual, but it does introduce you to the schematics. You may wish to supplement your reading with the operators guide for peripherals (DGC No. 014-000095) or the field service manual for this transport (DGC No. 015-000080).

The manual is aimed at a wide variety of readers. Part One introduces the transport and briefly describes its properties. You may wish to read this part if you need general information about;

- Performance specifications
- Subsystem configurations
- Transport components
- Transport operation

Part Two includes a technical description of the transport assemblies and circuits. You will want to read this part if you intend to maintain or repair the unit.

Once you understand the organization of this manual, you will be able to quickly find the information you need and bypass material that is redundant or irrelevant.

PART I

Chapter 1, Transport Overview - Introduces the transport and lists its physical properties. Briefly describes the transport subassemblies.

Chapter 2, Transport Operation - Describes the transport controls and operations.

PART II

Chapter 3, Mechanical Assemblies - Describes the mechanical parts of the transport.

Chapter 4, Data Recording- Describes the circuits that read and write data on the tape. Also discusses the recording methods.

Chapter 5, Reel and Capstan Servos - Describes the circuits that power the reel and capstan motors.

Chapter 6, Power Supply - Describes the power supply and distribution circuits that power the blower, reel and capstan motors, transcription circuits and control logic.

APPENDICES

Appendix A, Documentation Summary - Lists documents you may need to study the transport in detail and troubleshoot faults.

Appendix B, Controller Interface Signals - Describes the bus that connects the transport to the controller.

Appendix C, Analog Building Blocks - Discusses some basic analog elements used in the transport.

Appendix D, Glossary of Terms - Defines some words and mnemonics used to describe tape transports.

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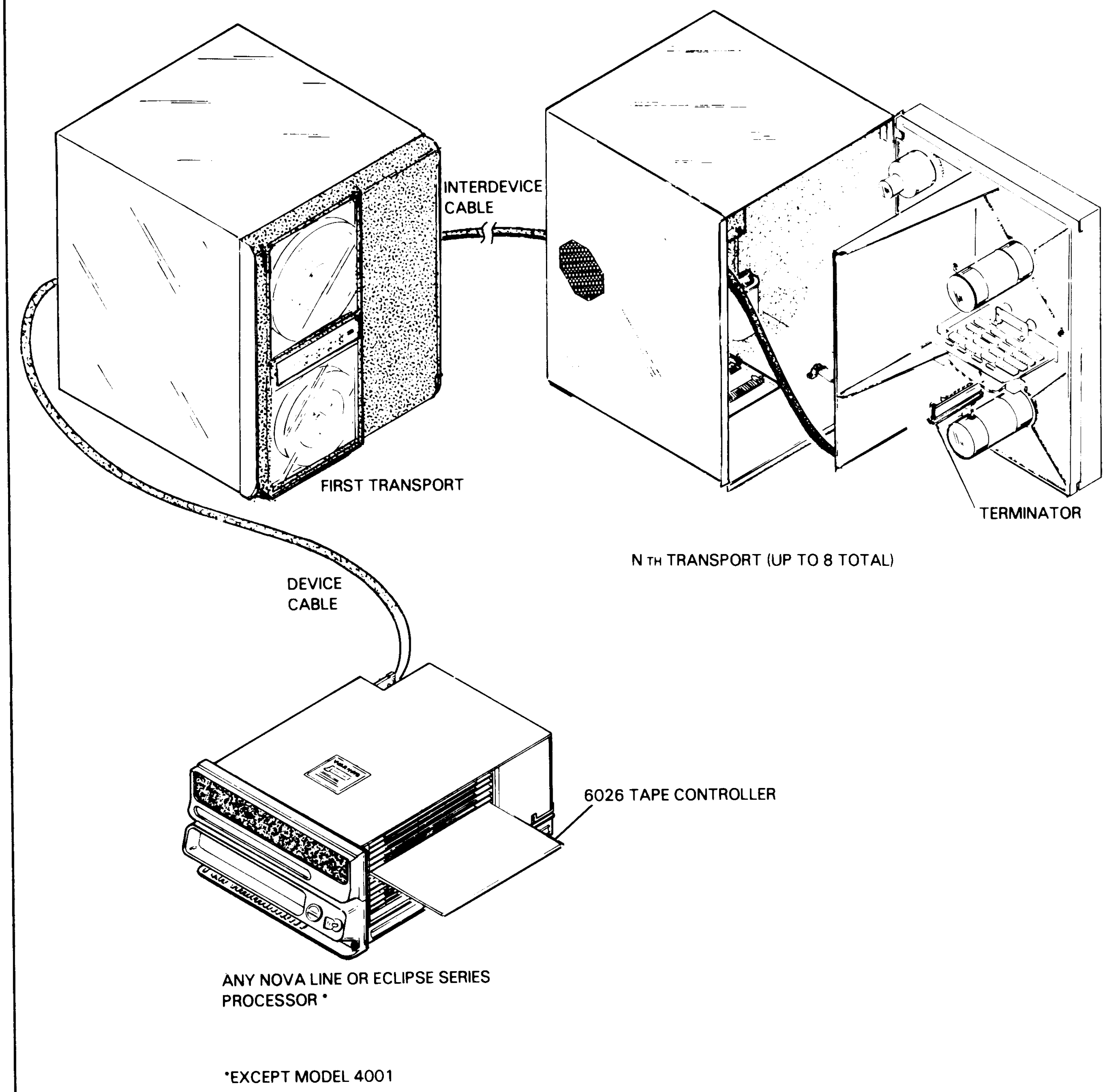
TAPE SUBSYSTEM CONFIGURATION



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CHAPTER I
TRANSPORT OVERVIEW

Data General's 6026 vacuum column tape transports record 9 track serial access data in NRZI or PE format on 1/2 inch magnetic tape. NRZI format supports up to 20 megabytes of storage with a density of 800bpi and a maximum transfer rate of 60 Kbytes/sec. PE format supports up to 36 megabytes of storage at 1600bpi and a maximum transfer rate of 120 Kbytes/sec. Tape speed is 75ips during data transfers and 200ips when rewinding.

INTRODUCTION

Data General's 6026 tape transport is a reliable, 75ips, 9-track vacuum column tape drive for half inch magnetic tape. Data is recorded in ANSI-compatible NRZI format at 800bpi or in ANSI-compatible Phase Encoded format at 1600bpi. The tapes produced are widely interchangeable with other industry standard tape units.

Magnetic tape transports move magnetic tape past a recording head where data is written and read in nine parallel tracks across the half inch tape width. The recording format requires the transport to bring the tape to a full stop and then to a full start within an interrecord gap (i.e. within 1/2" of tape). In addition, the tape speed must be accurate within 3% during data transfers.

Transports must be designed to handle tape gently without excessive tension and to stack tape evenly and uniformly on the reels. Data General's 6026 Transport has vacuum column tape buffers that provide uniform tape tension even during high speed rewinds.

A configuration diagram for the tape subsystem appears on the facing page. A subsystem may include up to eight transports which may be any mix of 6026 or 6020 series (9 track) units.

TRANSPORT CONFIGURATION

A block diagram of the transport is shown on the next page. The transport contains four principal systems which work independently to provide reliable, gentle tape handling. They are:

- The operators panel and control logic
- The recording circuits
- The capstan and its servo system
- The vacuum column servo systems.

Operators Panel and Control Logic

The operators panel and its associated control logic direct the local operation of the transport and link it to the computer's tape subsystem when the unit is on line. The operators panel contains switches for powering up the transport, loading the vacuum columns, and assigning the unit's identity in a tape subsystem. The control logic provides system status information to the computer when the unit is on line.

Recording Circuits

Data is recorded on tape along a 9-bit wide data path. Static deskew adjustments in each channel ensure that data characters are written in a straight line perpendicular to the length of the tape. A 9-bit wide path moves the data read from tape to the subsystem controller. A bank of amplifiers and peak detectors convert low amplitude analog pulses from the read head to TTL-level signals compatible with the controller. The data reading path also includes certain timing logic to properly synchronize NRZI data transfers. Since reading and writing are done independently of each other at the recording head, data can be verified almost immediately as it is written without reversing the tape to reread a section.

Capstan Servo

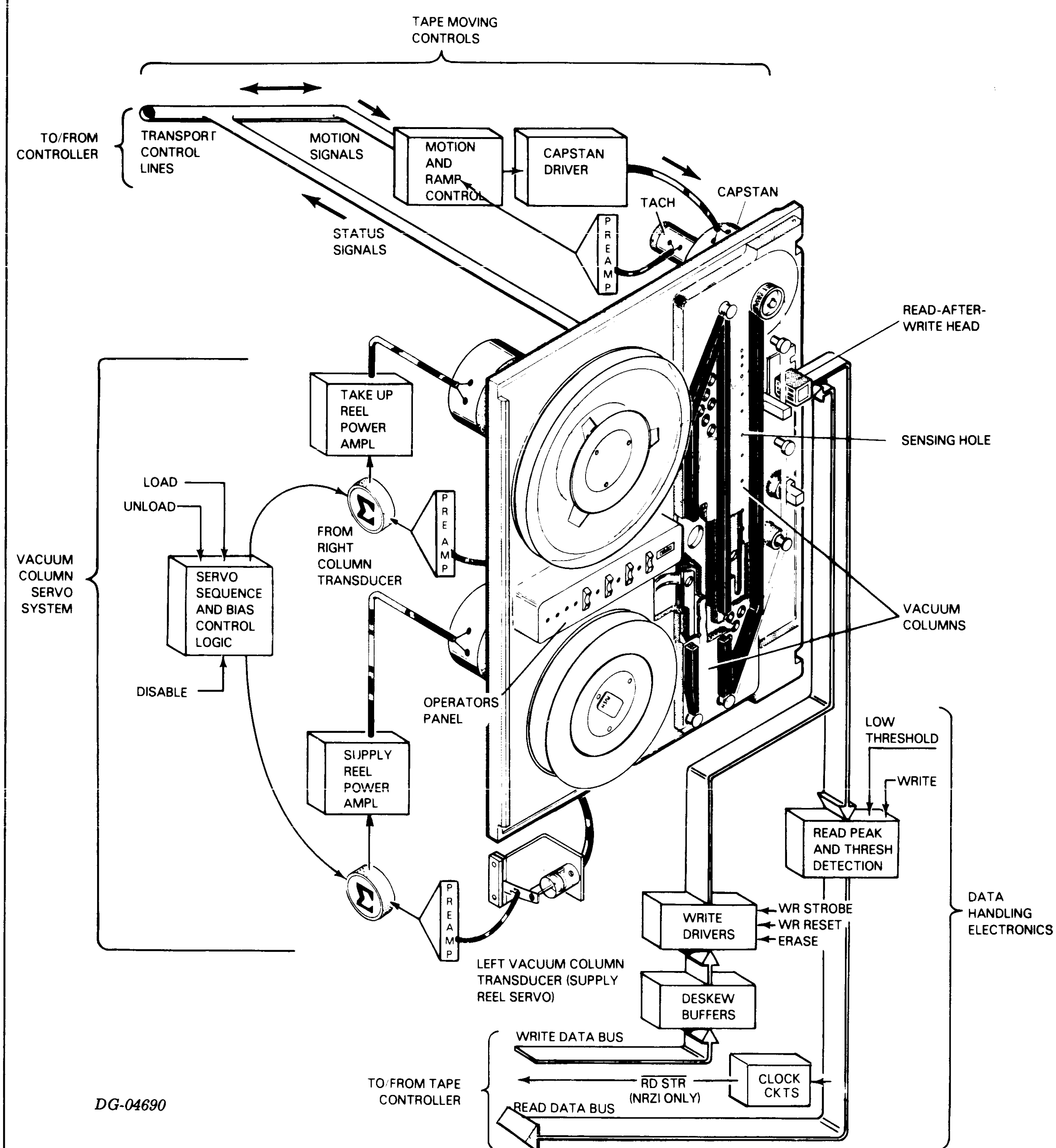
All tape motion is controlled by the capstan and its servo system shown at the top of the diagram. Motion commands from the tape subsystem controller (not shown) and from the transport's own control system cause the capstan to move the tape forward or backward at 75ips or to rewind at 200ips. All motion is accomplished with carefully controlled acceleration and deceleration curves to maintain accurate tape positioning. Precise control of the capstan's rotational velocity (and thus of the tape's speed) is achieved by using an error signal from the tachometer to supply servo correction information to the capstan driver.

Reel Servos and Vacuum Columns

The capstan rapidly accelerates the tape to full speed, and vacuum columns provide a reservoir of tape that is readily available for this fast start and stop activity. Tape is gently pulled into a loop within the column by vacuum while both the capstan and a reel motor can add tape to or remove tape from the column as needed. The columns provide buffering that allows the reel motors enough time to "catch up" to the speed of the capstan.

Each reel motor is associated with a vacuum column and a servo system that strives to keep the tape loop in each column positioned near the center of that column. The servo system does this by spinning the reel motor in the correct direction, adding or removing tape from the column, to achieve the right position. There are two reel servos as shown along the left side of the drawing. Each servo operates independently of the capstan servo and from the other reel servo; each includes a transducer and analog circuitry to determine the position of tape in a vacuum column along with the necessary drivers to spin the reel motor in the correct direction, at the correct speed.

6026 TRANSPORT



SUMMARY OF CHARACTERISTICS

GENERAL

Vacuum column tape buffers
Selectable NRZI or PE recording modes
Read after write (dual gap head)
Fully self contained (includes power supply and cooling fan)

MECHANICAL AND ENVIRONMENTAL

Dimensions	19" wide x 24 1/2" high x 19" deep from mounting surface
Weight	150 lbs
Mounting	standard 19" RETMA rack
Power cable	10' long

Power requirements

Volts +10/-15%	Amps max	Hertz ±1 hz
120	7.5	60
100	9	50
220	4	50
240	3.7	50

Heat dissipation	3000 btu/hr max
Temperature	
operating	40 to 100 F (transport)/60 to 90 F (media)
storage	-10 to 160 F (transport)/40 to 90 F (media)
Relative humidity	
operating	20 to 80% non-condensing
storage	15 to 95% non-condensing (transport) 20 to 80% non-condensing (media)
Altitude	5,000 ft max (10,000 ft max with high altitude option)

CAPACITY AND TIMING

Tape speed	75 ips record/playback ± 2% 200 ips rewind ±10%
Number of tracks	9
Data density	1600 bpi PE/800 bpi NRZI
Transfer rate	60 kbytes/sec NRZI/120 kbytes/sec PE
Transfer time	16.7 usec/byte NRZI/8.3 usec/byte PE
Storage capacity	20 mbytes NRZI/36 mbytes PE (2400 ft)
Tape	1/2" 2 mil computer grade
Reel size	up to 10 1/2" (2400 ft)
Inter-record gap	0.6" nom
Write track width	0.044" nom
Read track width	0.040" nom
Track spacing	0.055" nom
R/W gap separation	0.15" (2 msec)
Static skew	100 uinch max (READ). Electronic skew compensation during write.
Dynamic skew	75 uinch max
Start/stop time	
75 ips	5 msec ±10%
200 ips	500 msec ±10%
Start stop distance	
75 ips	0.19" ± 0.02"
200 ips	19" ± 2"
Load time	5 sec
Rewind time	2 min (10 1/2" reel)
Threading time	10 sec (experienced operator)

CONVENTIONS

Drawings

Data General logic prints are drawn in close accordance with MIL-STD-806C. With this convention, logical functions are drawn as physically implemented. That is, where discrete gates are used to implement a function, these gates are shown. On the other hand, where a more complex integrated circuit is used, for instance a multiplexor, the function it performs is shown as a rectangular box.

Signal Levels

Throughout this manual, a distinction is frequently made between electrical levels and logical values. To minimize confusion, electrical levels are always indicated by an "H" or "L", and logical values by a "1" or "0". As an electrical level, an "H" indicates that the signal is high (greater than +1.7 volts). An asserted, or true, signal is indicated by a logical "1" and a false signal by a "0".

Signal Names

In Data General equipment the assertion state of a signal can be either low or high, depending on how it is defined. To distinguish between the two types of signals a naming convention has been adopted which defines the relationship between the logical value and the electrical level of a signal. If the signal includes a horizontal bar over the name, as "$\overline{\text{WRITE}}$", then that signal is asserted when it is at a low electrical level. Conversely, a signal without the bar, "WRITE", is asserted when high.

Two signals having the same name but differing by the bar almost always refer to the same logical function and are electrical inverses of each other. Thus $\overline{\text{WRITE}}$ will be low when WRITE is high, and the two signals will be true at the same time.

Closely related, or bussed, signals are indicated by effectively subscripting a common label. For instance, suppose that BUS 0 through BUS 5 are all required to completely specify a function. All or part of such a group of signals is identified by placing brackets around the range of subscripts included, as BUS [0-5] . In this case, the suffix carries the information that there are six BUS lines under discussion, from BUS 0 through BUS 5, inclusive.

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CHAPTER II
TRANSPORT OPERATION

INTRODUCTION

The transport control logic does basic housekeeping for the magnetic tape transport whenever it is operating - whether under local, operator direction or under computer control. These housekeeping chores are implemented in sequences initiated by the computer or an operator, and they assure that all operations are carried out in a logically sound and orderly manner. Additionally, a failsafe system protects the tape from becoming damaged by failures in the transport. For example, when an operator mounts a reel of tape on the transport and presses BOT, a distinct series of circuit-level events take place to load the vacuum columns while several tests verify that the sequence is proceeding correctly.

Operator-initiated sequences include powering up, loading and unloading the tape buffers (vacuum columns), rewinding, resetting, and placing the transport "On Line" with the computer. Computer-directed operations include moving forward (for a read, write, erase or space forward command), and rewinding. When the transport is On Line, command and status information is exchanged through a signal network between the transport and the tape subsystem controller to prevent a large number of erroneous or meaningless operations. The failsafe or interlock system monitors certain key parameters in the transport such as the vacuum levels and power supply interruptions to protect the magnetic tape from physical damage in the event of a failure in the servo systems. All but the last of these control functions are discussed under separate headings in this section. The interlock system is intimately related to the operation of the analog servo systems; so it is described in Chapter V.

CONTROLS

Operators Console

You can control all of the transport functions from the console on the front of the transport. Switches on the console allow you to:

- power up the transport
- load, rewind and unload tape
- place the unit on line with the controller
- select a recording density
- assign the transport unit number

Indicator lights tell you that:

- the transport is ready to accept commands from the controller
- write operations are locked out
- the tape is positioned beyond the end of tape marker
- the tape is positioned at the beginning of tape marker
- the transport is powered up
- the transport is on line with the controller
- high density is selected

A brief description of the switches and indicators follows. For more detailed information, consult the operators manual for peripherals (DGC No. 014-000095).

Console Switches

Power A two position switch controls the ac power to the transport.
The power light illuminates when the drive is fully powered up.

BOT/Unload A two position momentary contact switch loads, rewinds and unloads the tape when the transport is off-line. BOT moves the tape to the BOT load point. If the tape was unloaded, BOT loads it and moves it forward to the BOT marker. If the tape was loaded, BOT rewinds it to the BOT marker. UNLOAD rewinds and then unloads the tape. (If the tape was already unloaded, UNLOAD unwinds the tape.)

On Line/ Reset A two position momentary contact switch places the transport online or offline. ONLINE connects the transport to the controller. (The transport goes online when the tape reaches BOT.) RESET stops all operations and connects the transport to the console. The online light illuminâtes when the transport is online.

Density A two position momentary contact switch selects the data density when the transport is offline. HIGH selects 1600 bpi PE and LOW selects 800 bpi NRZI. The denisty light illuminates when high density is selected.

Select An eight position thumbwheel switch selects the subsystem unit number of the transport.

Console Indicators

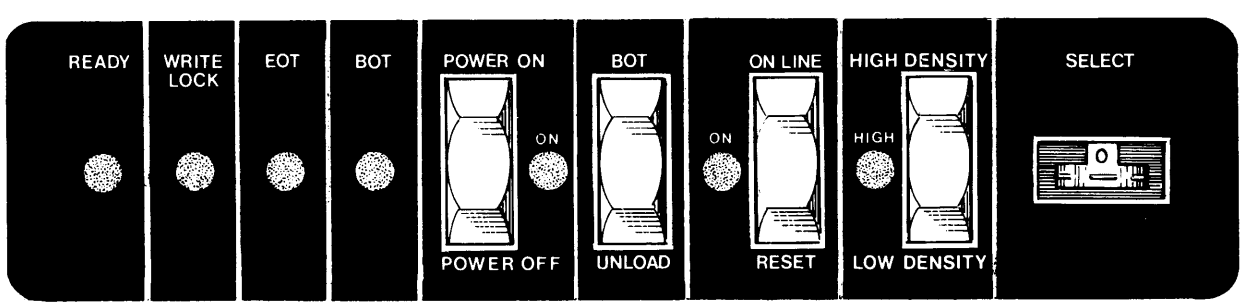
Ready A red light indicates that the transport is on-line, the tape is loaded and stopped, and the unit is ready to accept commands from the controller.

Write Lock A red light indicates that write operations are disabled.

EOT A red light indicates that the tape has moved beyond the EOT marker.

BOT A red light indicates that the tape is positioned at the BOT marker.

CONTROL PANEL



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Controller Commands

The subsystem controller directs the activities of a transport that is on-line. The interface signals command the transport to;

- RUN - move the tape at 75 ips in the direction specified by REV
- REV - the direction is reverse
- REWIND - rewind the tape
- READ - read data from the tape
- WRITE - write data onto the tape

These signals combine with additional control signals to specify all the transport functions (e.g., read low threshold or select recording density). You will find detailed descriptions of all the interface signals in Appendix B.

OPERATIONS

Flowchart Conventions

The logic flowcharts are, generally speaking, self-explanatory. However, certain conventions have been followed in constructing them so that the reader can conveniently use them as an introduction to the schematic circuit diagrams, (DGC NO.'s 001-000566, 001-000508, 001-001128 and 001-001160). The flowchart conventions are:

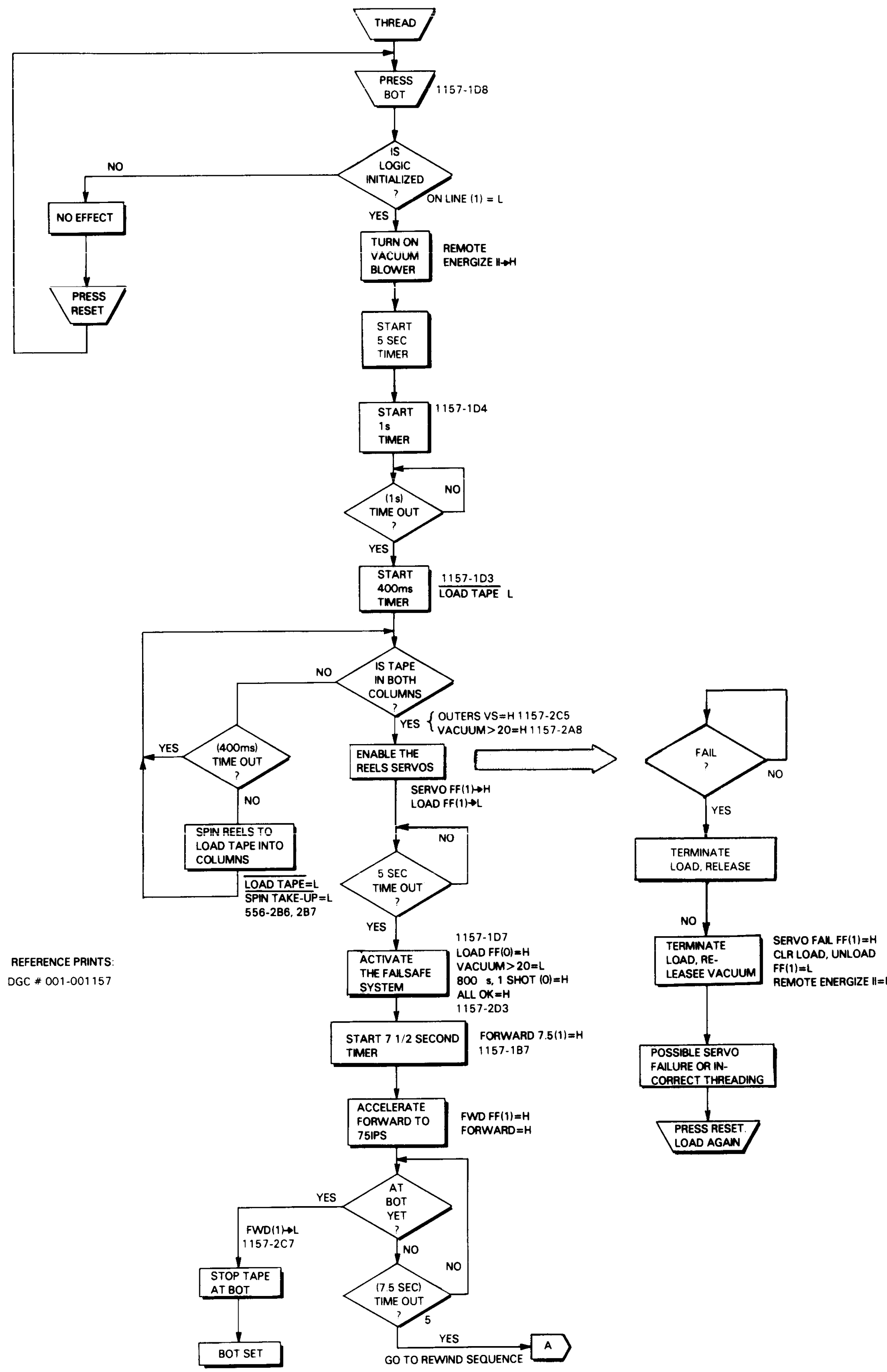
1. The number designated "Reference" at the bottom of the flowchart refers to the engineering schematic and revision level from which the flowchart was constructed.
2. The statement contained in any box of the flowchart describes a logic event or decision.
3. Where appropriate, actual logic values of certain signals are stated outside a box to show how the logic event is implemented.
4. In certain cases, parallel events are indicated in the logical flow. This occurs, for example, where a timer in one path can override and disable the action of a parallel path.

Load (BOT)

To load the tape drive the operator mounts a reel of tape, threads it around a simple tape path, around the take up reel, and presses BOT to initiate the load sequence. First, the vacuum system is turned on and its proper operation is verified. Both tape reels are then momentarily spun so that tape is fed into each vacuum column. (Injecting tape into the columns eliminates the irksome squeel characteristic of vacuum column transports.) If the tape stabilizes inside the columns within the proper time interval, the first half of the load sequence is considered successful and the servo failsafe system is placed in operation. A forward search is then made down the tape for a reflective tab marking the Beginning of Tape (BOT), or loadpoint. The tape stops at the loadpoint with the BOT indicator illuminated at the operators console.

Should the loadpoint marker not be found within 7 to 8 seconds (about 40 to 50 feet of tape will be searched), the transport will rewind the tape at high speed, searching backwards for the reflective tab. If the tab is not located during rewinding, the tape will simply spool off the take up reel and the failsafe system will terminate the load sequence. (This failure requires that the transport be reset. The Reset operation is discussed below.)

LOAD



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Unload (and Unwind)

Pressing the Unload switch can cause two distinctly different operations to take place depending on whether or not the vacuum columns are loaded. (The transport must be off line.) The two possible effects are called "unloading" and "unwinding". The Unload sequence is initiated by momentarily pressing Unload when the vacuum column buffers are operating. The unwind operation is performed by pressing and holding Unload when the vacuum columns are not operating. Releasing the switch causes the unwind operation to stop.

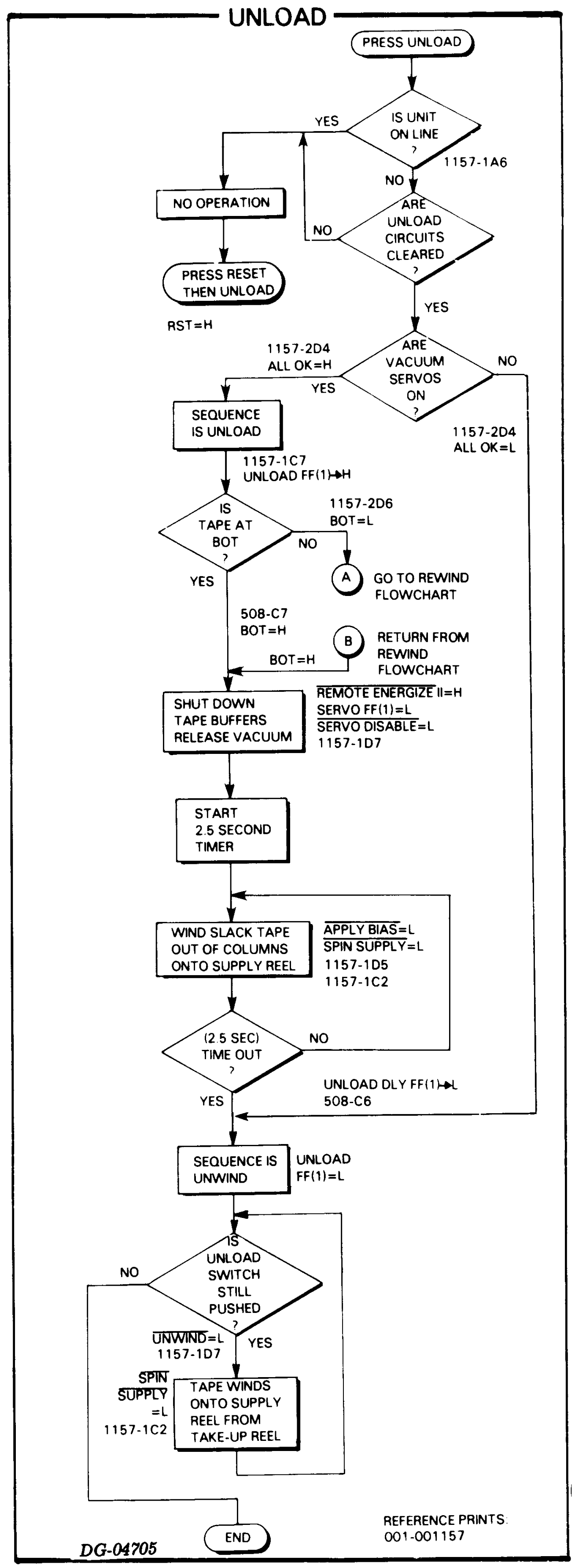
Unload

When the unload sequence is initiated, the transport rewinds tape to the loadpoint if it is not already there. The servos and servo failsafe system are disabled and then the vacuum in the tape buffers is released. Finally, the supply reel is spun momentarily to pull tape out of the columns.

Unwind

Pressing and holding Unload on a transport with the tape buffers shut down causes the supply and take up reels to slowly spin while the switch is held down. This slowly winds tape onto the supply reel. The spin rates of the two reels are adjusted so that a full, 10.5 inch supply reel spools tape at about the same rate as a nearly empty take up reel. If the unwind operation is used to slowly rewind an entire tape the spooling rates will not always match and some care must be taken to keep tape from spilling onto the floor. Light pressure should be applied to the HUB (not the flange) to slow the take up reel.

The slow reel-to-reel rewind can be used for recovering a tape stranded on a malfunctioning tape drive.



Rewind

There are three ways a rewind sequence can be initiated: via the operators console when the unit is off line and not under program or computer control, when the transport is On Line, and when a BOT reflector is not located during the forward search of the load sequence. In all cases the rewind sequence is identical. If the tape is at the loadpoint, there is no effect. If the tape is not already at the loadpoint, it accelerates to 200ips (nominal) in reverse until the loadpoint tab is detected (or until the tape unwinds from the take up reel). If a loadpoint marker is detected, the tape decelerates, reverses direction, and hunts forward to stop there.

On Line

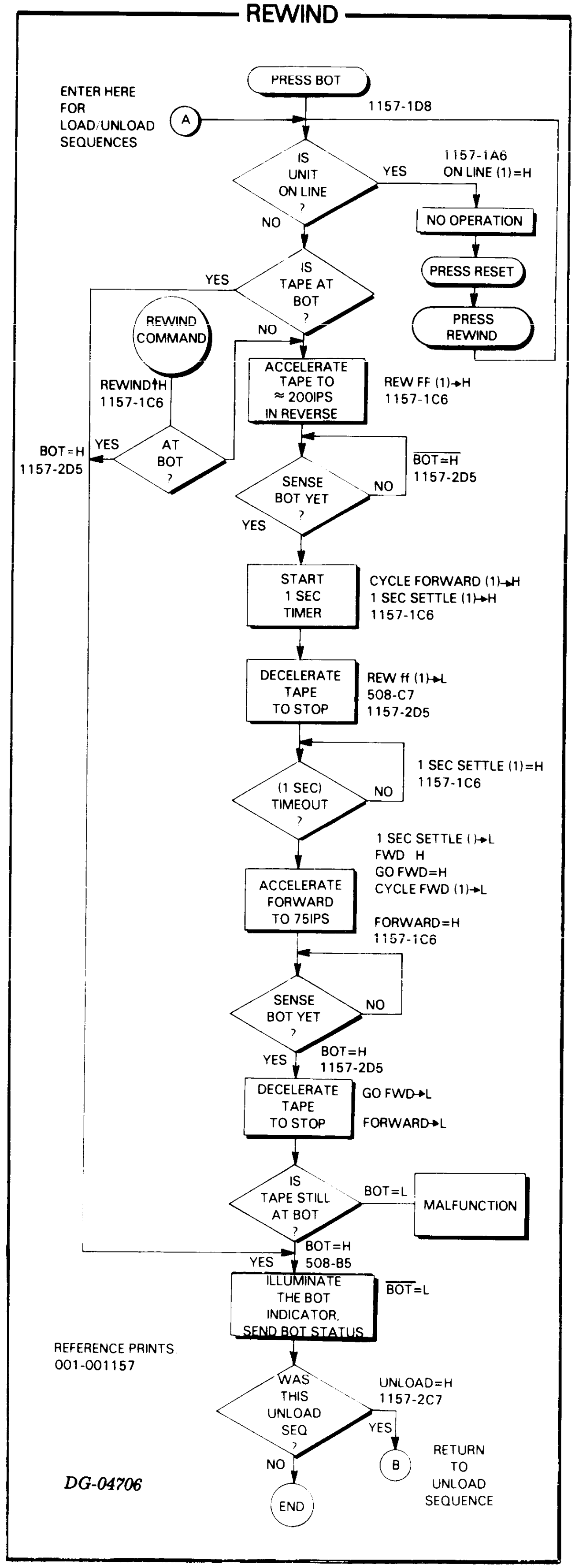
Pressing the On Line switch on the operators panel allows the transport to respond to commands issued by the tape subsystem controller once the tape is returned to BOT and the online light comes on. The identity of the transport within its subsystem is assigned by the position of the Unit Select switch on the operators panel.

NOTE *Indeterminate logical and status conditions can be encountered by the computer software if more than one transport in a tape subsystem is assigned the same unit number - even if only momentarily. Therefore the Unit Select switch should not be changed while the unit is On Line. Reset the transport before changing the Unit Select number.*

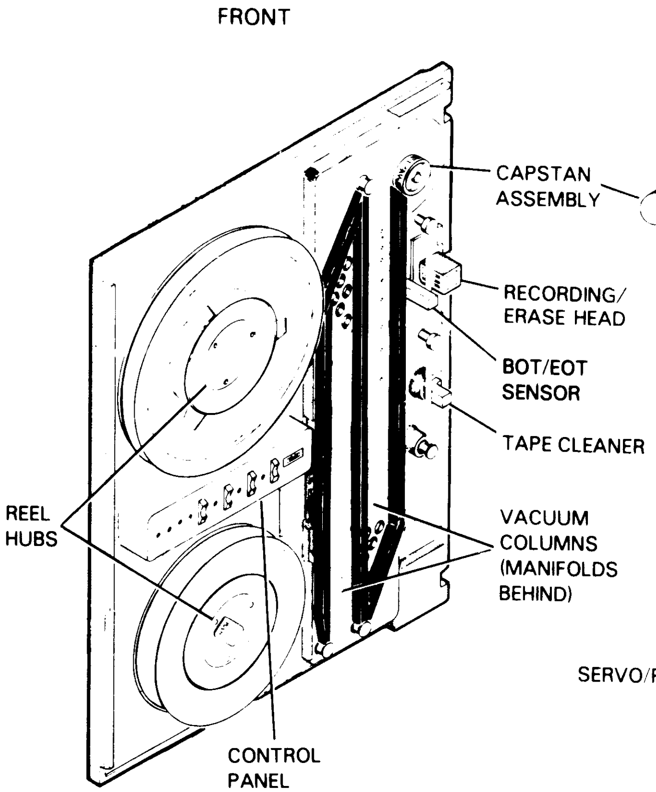
When the unit is placed On Line, the unit ready logic is also enabled, and the READY indicator on the operators panel should illuminate. The BOT/unload and density switches on the operators panel are disabled while the unit remains On Line.

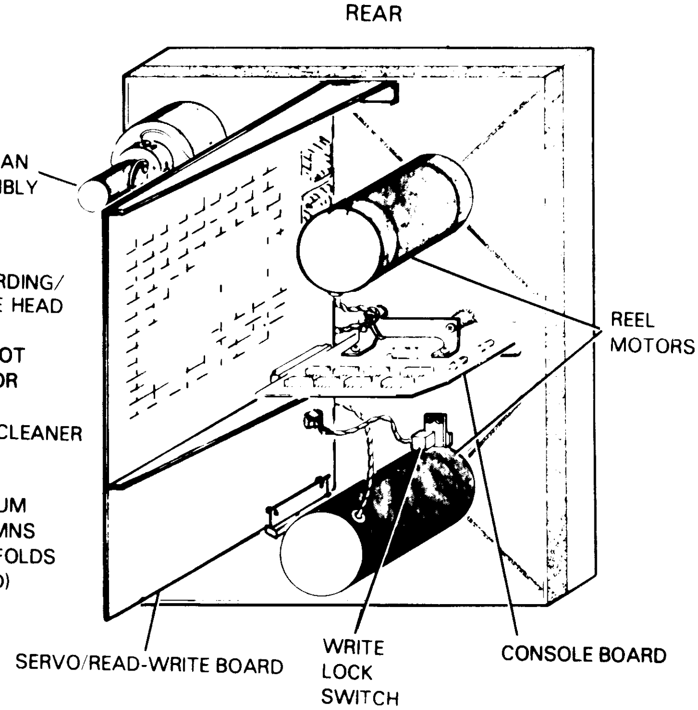
Reset

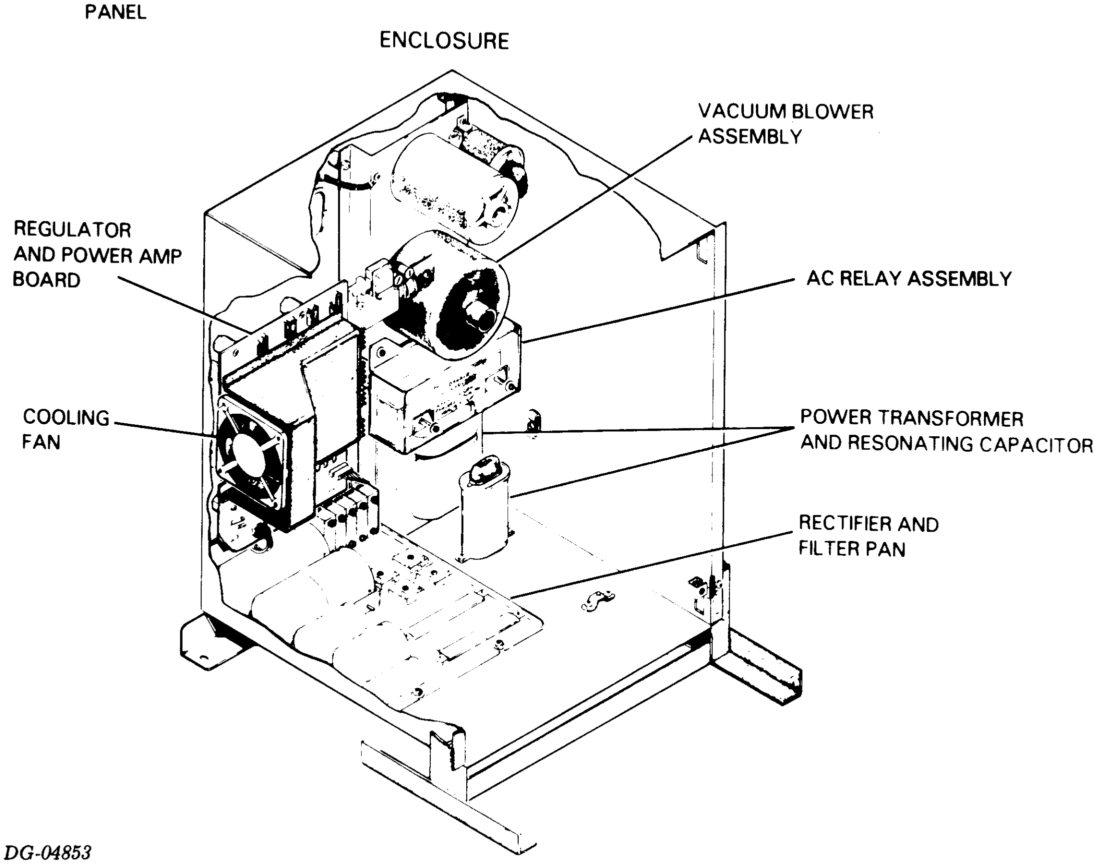
Pressing Reset can have two different effects: the first is to take a transport off line, placing it under local, operator control; the other is to reinitialize the control circuits after an unsuccessful load attempt or after a servo failure.



TRANSPORT ASSEMBLY







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CHAPTER III
MECHANICAL ASSEMBLIES

INTRODUCTION

The 6026 tape transports consist of eight principal assemblies:

- the vacuum blower assembly
- the enclosure assembly
- the vacuum columns and manifolds
- the capstan assembly
- the reel motors and hubs
- the BOT/EOT sensor
- the head assembly
- the write protect assembly.

There are additional components such as ventilating fans, tape guides, printed circuit boards, and the suction tape cleaner. All but the power supply and the vacuum blower are mounted on the main casting. Two printed circuit boards are mounted on the back of this casting which swings open frontwards to provide easy accessibility to all of the transport parts. The mechanical assemblies are described in this chapter.

An electromechanical wiring diagram, views, and part numbers of all parts in the 6026 transport are included in the illustrated parts breakdown (DGC No. 016-000477) shipped with each transport.

RECORDING DECK

Reel Motors And Hubs

The reel motors spin the tape reels in response to servo commands so that the tape remains balanced in each vacuum column. They attach to the casting with four socket head machine screws. The motors mount against precision machined surfaces on the back of the casting and normally do not require any shims.

Tape reels attach to a hub assembly on each motor's shaft. One reel (the take-up reel) is fixed in position on its hub. The other reel (the supply reel) contains the tape file and is held onto the hub with a push-tab locking mechanism. Both hub assemblies are secured on their respective motor shafts with taper-lock fittings. The lock ring in these fittings can be easily released to align the hub (and reel) position in the tape path. However, correct positioning of the hubs on the motor shafts requires careful alignment to ensure that tape is handled safely. *This should not be attempted without proper gauges and tightening torque specifications.*

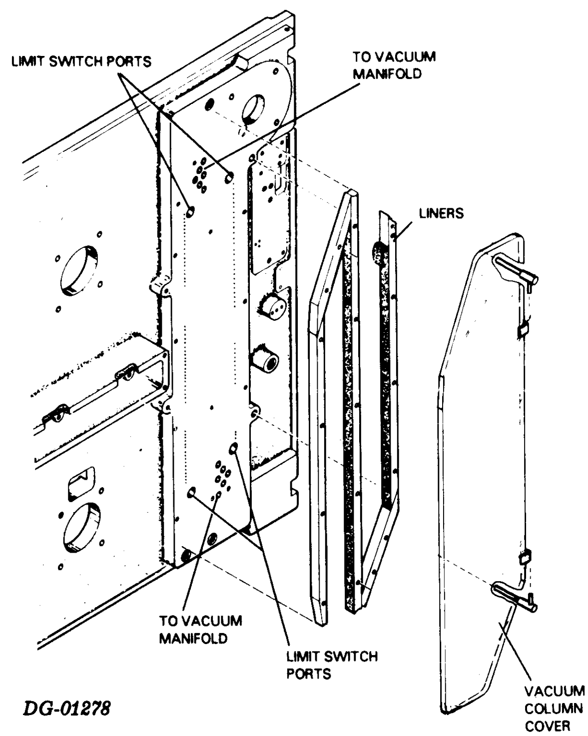
The hub mounted on the lower reel motor has a push-lock mechanism on which a supply reel of magnetic tape is mounted. The upper hub holds a 10.5 inch plastic take up reel.

Vacuum Columns And Manifolds

The vacuum columns are reservoirs which hold a loop of tape that can be quickly and gently accelerated or decelerated. These columns buffer the tape motion and allow for the slower response of the tape reels. They also maintain the tape at a constant tension. The organization of the vacuum columns, manifolds and the buffers' failsafe switch ports is shown in the illustration on this page.

The columns are cavities formed between machined liners that are bolted to the surface of the casting and covered with a clear plastic cover. There is sufficient clearance between the surface of the casting and the plastic cover to allow tape to slide freely inside the columns. The fit is sufficiently close, however, so that there will not be undue leakage of air from the open end of the column to the closed, evacuated end. Atmospheric pressure exerts an evenly distributed pressure on the tape, forming it into a loop when vacuum is present at the closed end of the column.

VACUUM COLUMNS

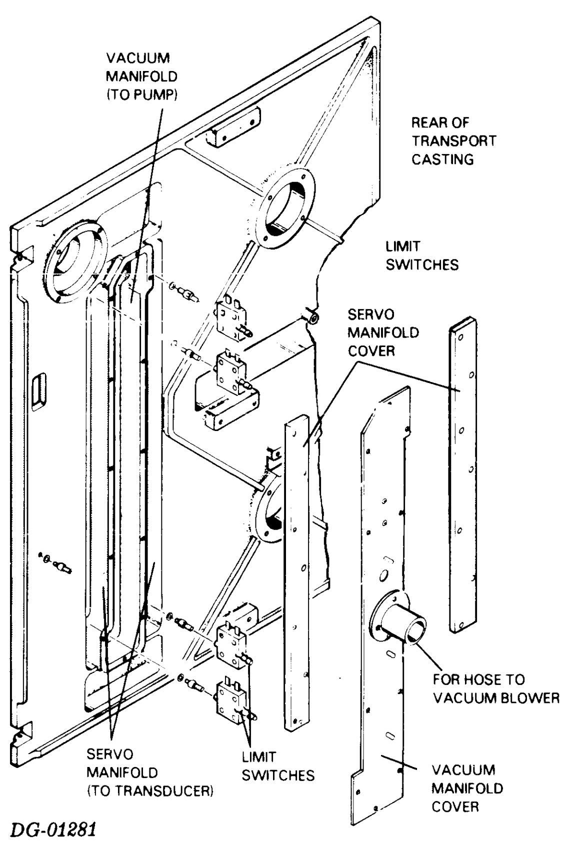


DG-01278

The manifolds are machined into the back of the casting and closed with metal covers. (The manifold covers are sealed with a sealing compound and should not be opened.) The main vacuum manifold connects the closed end of both columns together and to the vacuum blower. A small slide cover and vent allow adjustment of the final vacuum level in the manifold. The servo manifolds are located on each side of the main vacuum manifold; they connect a row of sensing holes in each column with a vacuum transducer and a servo system.

Start-up of the tape buffers proceeds in a necessary, orderly sequence under the control of the local control circuitry described in Chapter II. When the buffers are operating, the vacuum blower draws vacuum in both columns through the main vacuum manifold. This pulls a loop of tape into both columns. The tape loop in a column divides the row of sensing holes into two parts. The holes between the tape loop and the closed end of the column "see" nearly the full manifold vacuum. Those between the tape loop and the open end of the vacuum column "see" atmospheric pressure. The sensing holes connect to a servo manifold where a partial vacuum fluctuates in response to the position of tape in the column.

MANIFOLDS



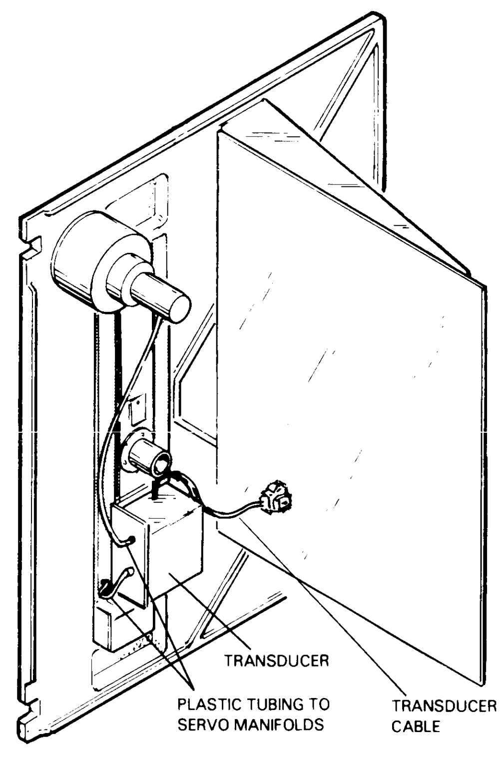
DG-01281

Hose nipples are threaded into the back of the casting at the extremities of each vacuum column. They connect through plastic tubes to pressure switches mounted on the main printed circuit board. These pressure switches are part of a failsafe system that monitors the tape buffers' operation. (These switches and the failsafe system are described in Chapter V.)

Transducer

The transducer converts pressure fluctuations in the servo manifolds to electrical signals proportional to the position of the tape loop in a vacuum column. Each manifold connects through a plastic tube to a transducer. Illustrations and an electrical description of the transducers is contained in Chapter V. The location of the transducer is shown below.

TRANSDUCER LOCATION



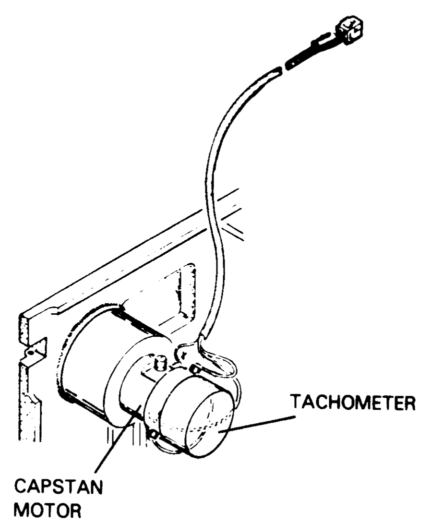
DG-04846

III

Capstan Assembly

The capstan moves the tape forward and backward in response to motion commands within the transport or from the subsystem controller. The tachometer provides the capstan's servo system with an electrical signal proportional to the capstan's rotation velocity. The capstan motor and tachometer are mounted together on a single shaft to form a single piggy-back unit. (Under NO condition should an attempt be made to separate the tachometer from the capstan motor.) The dual assembly mounts against a precision machined surface on the rear of the casting and normally does not require any shims. The position of the capstan motor is shown below. Four socket head screws attach the capstan assembly to the casting.

CAPSTAN/TACHOMETER LOCATIONS



DG-01311

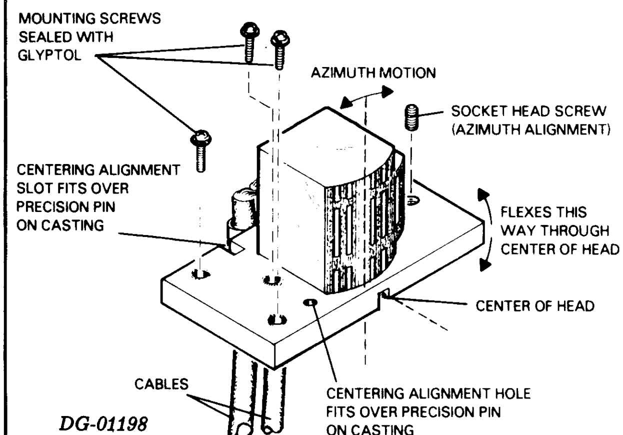
Recording Head

The recording head assembly includes 9 read heads, 9 write heads and a full width erase head. It is mounted so that it can be positioned correctly for accurate tape processing. The head assembly is shown below. The head is attached to an epoxy-composition block that attaches over guide pins in the casting and is secured with three screws. The dimensions of the head mounting plate and its mating surface on the casting are carefully controlled within tolerances that assure interchangeability of head modules from transport to transport without the need for shims.

Azimuth alignment is accomplished with a single screw which flexes the head mounting plate along a line through the center of the head. A spring washer places the azimuth adjustment under tension to eliminate creep.

> **NOTE** *To prevent scoring of the recording head use only soft cotton applicators against its surface. "Paper Towels", in general, have much too abrasive a surface and can damage both the head and eventually any tape that passes over it.*

RECORDING HEAD



DG-01198

BOT/EOT Sensor

The beginning and end of tape sensor contains two light emitting diodes (LED's) and two phototransistors in a sealed assembly. Each LED is paired with a phototransistor and scans half the width of tape for reflective markers that mark the Beginning of Tape (BOT) and End of Tape (EOT). Light from an LED reflects back to a phototransistor when the appropriate reflective tab passes the sensing assembly. The transport control logic sets and clears the BOT and EOT flags in the transport and tape subsystem status registers in response to the phototransistor signals. The correct positions for the BOT and EOT reflectors on the tape are shown below.

Tape Guides

There are two types of tape guides, nonroller head guides (2) and the roller guides (4). The head guides align the tape with the read and write surface of the transcription head; the roller guides stabilize the tape as it enters the vacuum columns.

The head guides are two ceramic washers mounted on chrome-plated posts over which the tape passes. The upper washer (away from the casting surface) is fixed in position, and is in contact with the certified reference edge of the tape. The lower washer is lightly spring loaded to maintain slight pressure against the tape. (Industry standard magnetic tape can vary in width up to 0.002 inches relative to the true, straight, reference edge.) The tape guides' spacings from the head and capstan are those which have been found to give optimum long and short term dynamic tracking over the head. The guides are precision machined parts and normally do not require alignment or shimming.

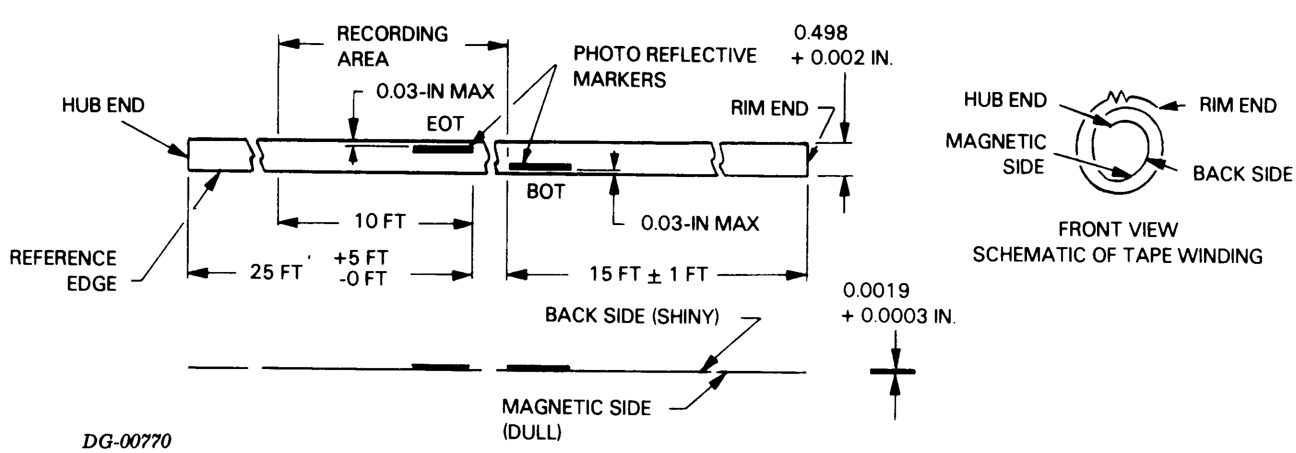
There are four molded plastic roller guides. They provide large radius, low friction guides for abrupt direction changes in the tape path - particularly at the vacuum column openings.

Tape Cleaner

Just before the tape passes over the head (in the forward direction), it passes over a suction tape cleaner that removes loose dust and tape debris. The cleaner is connected into the vacuum system, and the collected debris is vented out the back of the transport through one of the cooling fans. The surface of the cleaner is highly polished and the edges of the holes over which the tape passes are carefully chamfered to prevent abrasion of the tape's recording surface. Like the surface of the head, the suction tape cleaner should be cleaned only with soft cotton applicators.

III

LOCATING BOT/EOT REFLECTORS

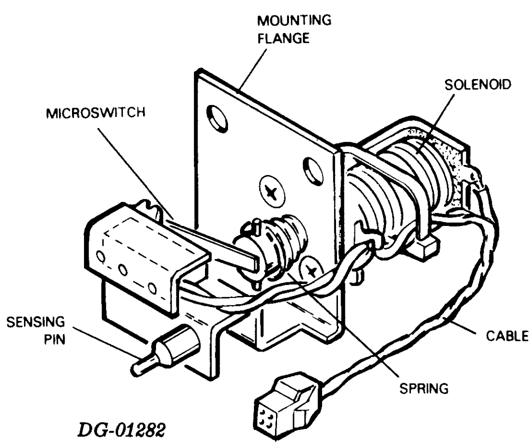


DG-00770

Write Lock Switch Assembly

The write lock switch is a sensing assembly that determines whether or not a tape file mounted on the transport is write protected. The assembly is shown below. It consists of a sensing pin, a micro-switch, a solenoid, and a spring. The sensing pin is aligned with the write lock groove on the back of tape reels. When an enabling ring is mounted in the groove, the solenoid pin is depressed, opening a switch with two effects: first the solenoid is energized to retract the sensing pin to prevent scraping; then the write and erase current driver circuits are connected to the dc voltage supply. (Write current does not actually flow through the heads unless the write current drivers are enabled, viz. during an erase or data writing operation.) To prevent undue scraping of the sensing pin against a write enabling ring, the pin is retracted at the beginning of a tape BOT operation, whenever the ring is detected.

WRITE LOCK SWITCH

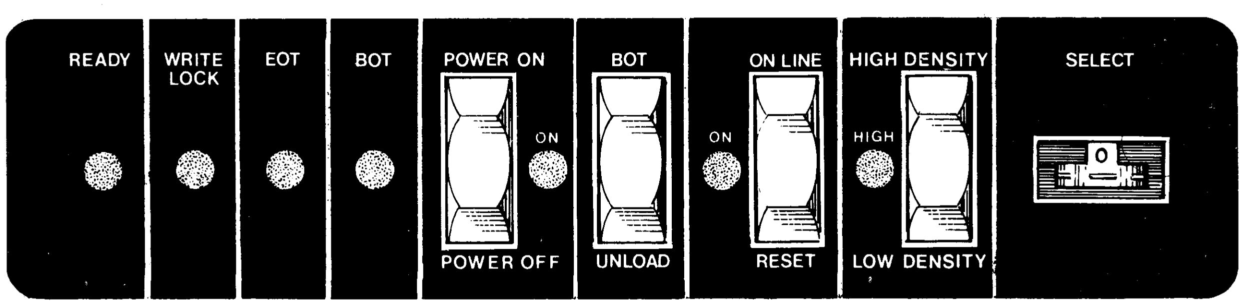


DG-01282

Control Panel

The control panel contains all the operator controls and indicators (the switches and lights mount on the control printed circuit board behind the recording deck.) Refer to Chapter II for a discussion of the control panel functions.

CONTROL PANEL

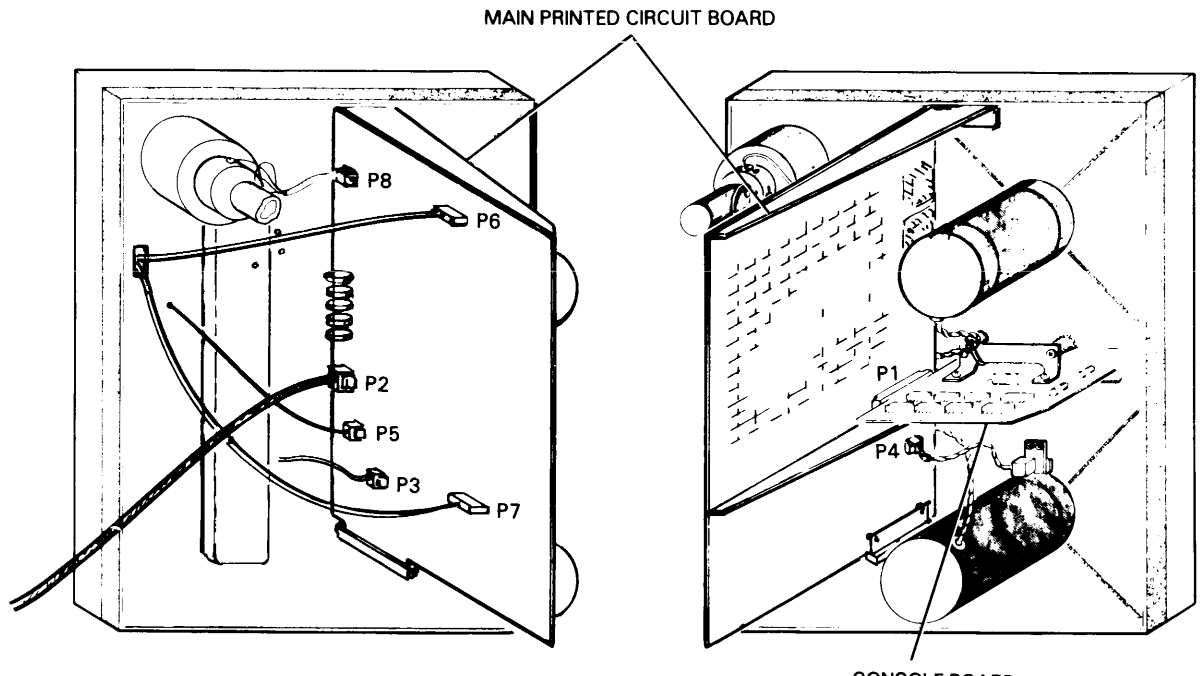


DG-04844

Printed Circuit Boards

There are two printed circuit boards mounted behind the recording deck. The largest circuit board mounts vertically on two brackets attached to the casting and measures approximately 15" x 23". It contains the data handling electronics, the capstan servo system, part of the control circuitry and part of the reel servos system (less power amplifiers). A smaller circuit board containing most of the control logic associated with the operator's panel mounts horizontally behind the casting. The control board plugs directly into the main board without a cable. Rocker switches, indicators and the thumbwheel switch for the operator's panel mount directly on the control board. All of the operator's panel switches and indicators can be removed at once by removing the control logic board. These two boards and their mounting positions are shown below.

CASTING-MOUNTED BOARDS



REAR VIEW OF CASTING

TRANSPORT ENCLOSURE

Vacuum Blower Assembly

The vacuum blower creates the vacuum needed to operate the vacuum tape buffers; it is shown in the illustration below. It consists of an ac induction motor, a starting capacitor, a centrifugal blower, a solenoid-actuated flap valve, a cable, a drive belt, pulleys, a mounting plate and assorted mounting hardware. The motor and centrifugal blower are fastened to the mounting plate in fixed positions; a semi-elastic flat belt drives the blower. The belt is self-tensioning, so that no adjustment is required. The flap valve mechanism is attached to the blower outlet with a short length of flexible tubing and secured with hose clamps.

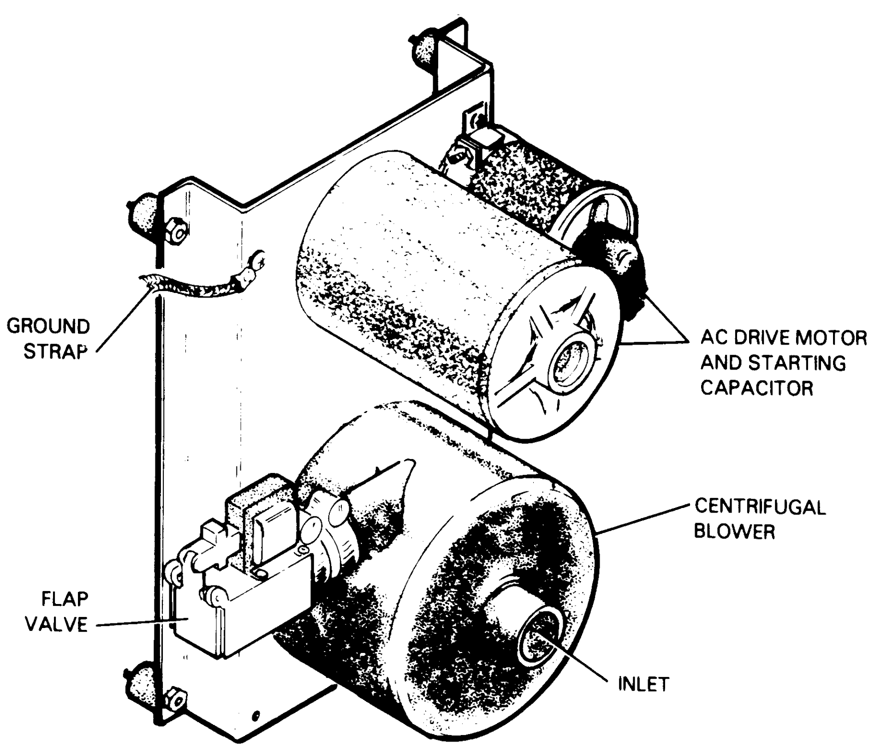
The blower motor is turned on and the flap valve opens when the TTL signal REMOTE ENERGIZE II asserts. Air is drawn into the inlet of the blower, placing the main vacuum manifold at a negative pressure approximately 30 inches of water. The flap valve provides quick release of the vacuum system when the blower is shut down by closing the blower's outlet. Shutdown is quicker with the flap valve than with normal coasting of the blower after power is removed. This is particularly important when the interlock system detects a failure and disables the servos, for residual vacuum in the tape columns could damage the tape when the servos are first turned off.

The entire assembly mounts on four rubber spacers, bolted to the rear of the transport enclosure. The four bolts holding the assembly to the enclosure are accessible from behind the enclosure. A grounding strap is installed between the mounting plate and the transport enclosure.

An alternate drive pulley (on the motor shaft) and solenoid are required for 50Hz or high altitude operation.

An access plate on the rear of the transport enclosure can be removed to expose the blower assembly and allow maintenance personnel to change the drive belt.

VACUUM BLOWER ASSEMBLY



DG-04762

Power Supply

The transport power supply provides low voltage dc power at several levels to energize the servo and logic circuits. The power supply components mount within the transport enclosure as shown in the following figure. There are five major subassemblies;

- AC relay module
- Power transformer and resonating capacitor
- Rectifier and filter pan
- Regulator and power amplifier board
- Cooling fan

The ac relay module is a removable subassembly that mounts on a subplate at the rear of the enclosure. It houses the ac power cord, line fuses, and solid state relays that distribute ac power to the power supply, blower and fan.

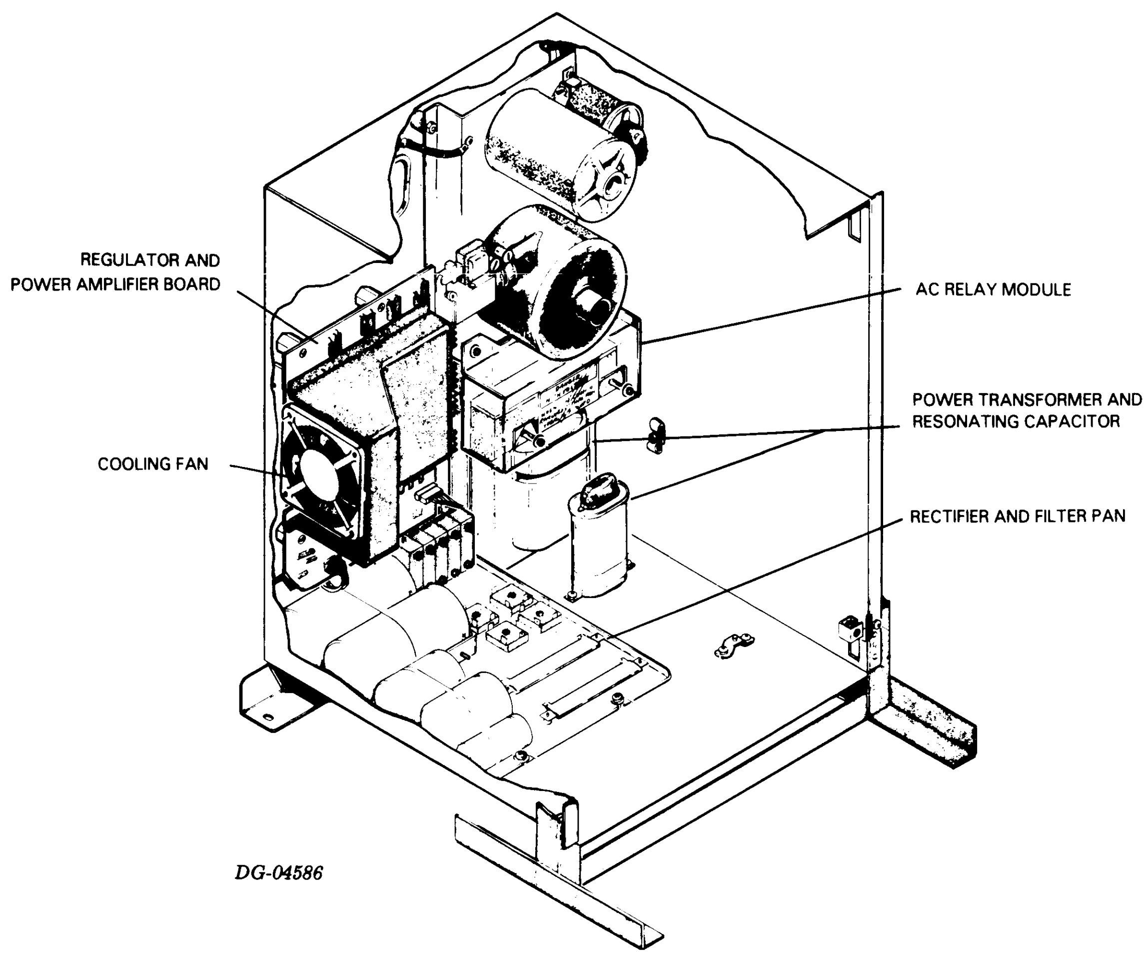
The ferro-resonant power transformer converts the ac line voltage to several coarsely regulated voltages for the power supply.

The rectifier and filter pan converts the ac outputs from the transformer to filtered dc voltages for the transport. The removable pan also supports a five pole dc circuit breaker that protrudes through the rear of the enclosure.

The regulator and power amplifier board contains circuits that regulate +5 volts and control some of the dc outputs from the rectifier and filter pan. It also contains the power amplifiers for the reel motors. The base of the card fits into a slot in a support bracket, and four screws secure the card. It is covered by a black plastic air plenum that channels air from the cooling fan across the heat sinks.

CAUTION *AC power is always present within the power supply assembly whenever the transport is plugged into a live ac line. To avoid a dangerous electrical shock, do not remove the plastic protective cover over the ac relay module.*

POWER SUPPLY

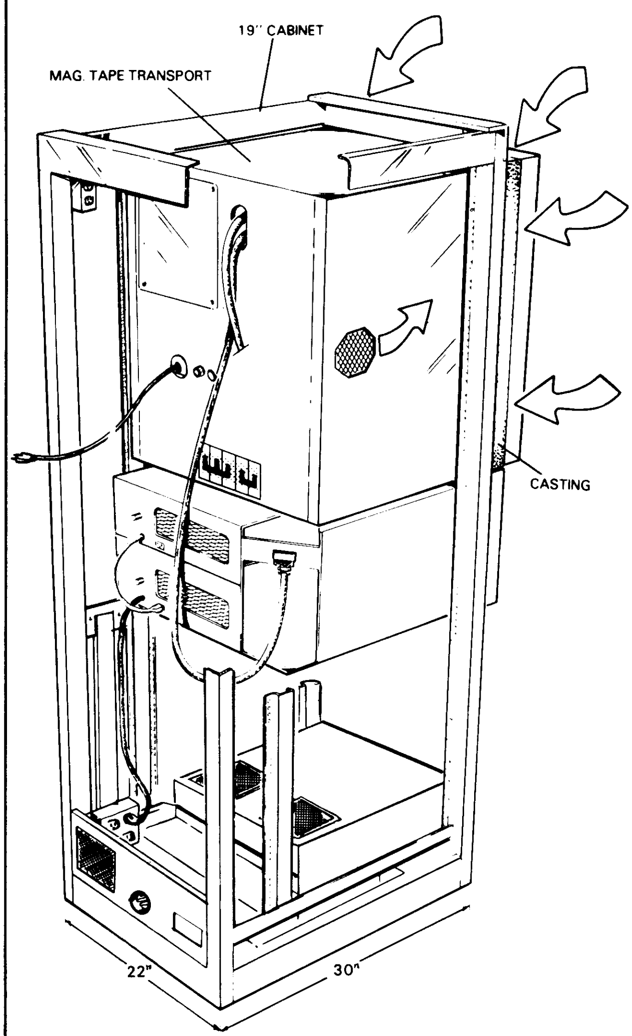


III

Air Flow and Ventilation

One compact fan provides ventilation for the transport as shown in the illustration below. It draws air into the enclosure around the edges of the recording deck casting, and exhausts it out the left side.

VENTILATION OF THE TRANSPORT



DG-04658

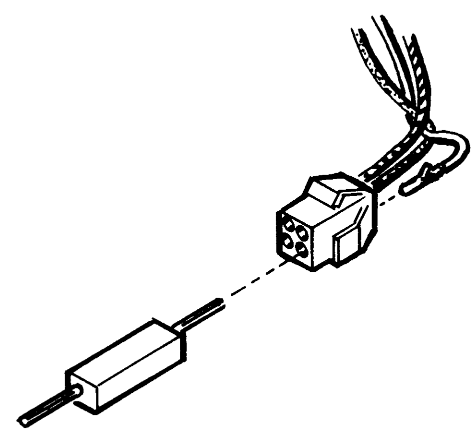
Internal Wiring and Cables

There are three major cables which distribute logic and servo power and certain logic signals between printed circuit boards. Subassembly cables connect subassemblies in the transport enclosure or on the front casting to appropriate connectors on printed circuit boards. There are subassembly cables associated with the ventilating fans, the vacuum blower, the servo transducer, the BOT/EOT sensor, the write lock switch, the capstan and the transcription heads.

Cable Connectors

The sketch below shows how some of the cable connectors are assembled. A small detent on each pin in the plugs must be depressed to remove the pins from the connector body.

ASSEMBLING CABLE CONNECTORS



DG-01283

CHAPTER IV
DATA RECORDING

INTRODUCTION

Digital data is transferred from the computer memory via the Data Channel in sixteen bit words and written on magnetic tape in nine parallel tracks. Data read from the tape is assembled into sixteen bit words and transferred to the computer memory. A more complete description of the data transfer characteristics is included in the technical manual for the 6026 tape subsystem controller (DGC No. 015-000081).

This chapter describes (a) the circuits that receive data from the tape subsystem controller and record it on tape; (b) the circuits that read data from tape, and send it to the controller. The beginning of this section presents a brief review of data recording principles.

ENCODING TECHNIQUES

The 6026 transport subsystem uses two very different techniques to encode binary data to a suitable recording format. Both techniques must allow reliable binary data and clock recovery from the encoded read data. They must also support some kind of error detection should the recording mechanism fail.

NRZI

The non-return to zero's inverted (NRZI) technique is used when moderate storage denisty is sufficient. It records a flux transition in the center of the frame for each bit (track) that contains a one. The absence of a flux transition therefore indicates a zero. Note, therefore, that if a one is present but not identified, it is interpreted as a zero. A longitudinal redundancy (parity) check (LRC) must therefore be used to detect this type of error.

The NRZI encoding scheme is not self-clocking. A given track could contain a long string of zeros, making it impossible to recover a clock. The NRZI technique therefore requires the clock circuits to examine all the bits in the frame in order to recover a clock (the odd parity bit guarantees that at least one bit will be a one). This makes the playback mechansim sensitive to skew. (It is physically impossible to record the bits in the frame along a straight vertical line. The deviation of the bits from this line is called skew.) When tapes are interchanged between transports, the skew could become large enough to move the bits into adjacent frames, which would result in data errors (this is the largest source of NRZI errors). Vertical redundancy (parity) check (VRC) and cyclic redundancy check (CRC) must be used to detect this type of error.

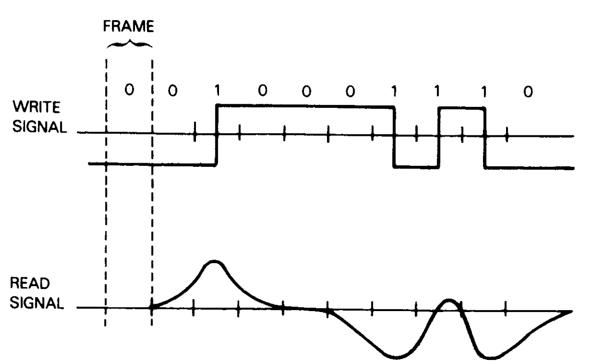
PE

The phase encoded (PE) technique is self-clocking and offers reduced error rates and higher storage density. The hardware is much more complex and expensive however, and higher quality recording tape is required. PE records flux transitions for both ones and zeros. It records a positive going transition at the center of a frame for each bit (track) that contains a one, and a negative going transition for a zero. In order to maintain the proper flux polarity, PE must record flux corrections between successive zeros or successive ones. This makes the maximum flux reversal density twice the bit density (3200 flux changes per inch (fci) for 1600 bits per inch (bpi)).

Note that, unlike NRZI, the PE technique distinguishes between the presence of a zero and the absence of any signal, such that dropout errors are detected immediately. The 6026 transport examines each track for a steady chain of flux reversals, and shuts down the read circuit for any track that goes dead. VRC can therefore be used to detect all PE errors.

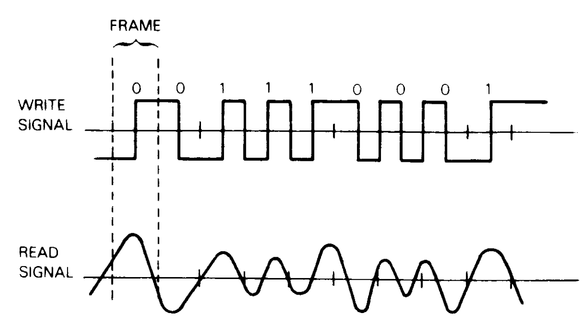
PE has another advantage. A clock signal can be readily recovered from each individual track. This allows the playback circuits to tolerate many frames of skew. Individual phase locked loops and deskew fifos in the controller recover the clocks and deskew the data. A coded burst at the beginning of the record synchronizes the phase locked loops. This has the added advantage of minimizing the effect of noise in the inter-record gap (irg).

NRZI WAVEFORMS



DG-04693

PE WAVEFORMS



DG-04694

RECORDING PRINCIPLES

The 6026 transport uses standard techniques for recording data. Data is recorded as a series of magnetic "events" or flux reversals. The following discussion is a simple introduction to a basic understanding of magnetic heads (both read and write) and the nature of digital magnetic reocrding.

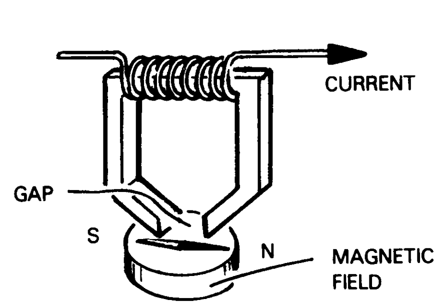
Conceptually, reading and writing digital data on magnetic tape are straightforward processes; although to efficiently implement them is a sophisticated art. It is important to realize that the reading process is a transition-detecting process. The construction of the read head dictates that the head can sense only the transitions between magnetic levels, not the levels that result from such transitions. This is directly analogous to the action of edge triggered logic commonly used throughout the digital industry (e.g., the clock input of a D-flip-flop). Consequently, the important considerations regarding the write head are those which directly relate to causing a magnetic transition-event at the read head.

First consider how magnetic transitions are written on tape.

Writing Data

The write head is an electromagnet shaped like the letter "C". Whenever current flows through the coil, a magnetic field is set up in the region named the gap. If the head or electromagnet were large enough, the direction of its field could be detected with a compass. The behavior of this imaginary compass illustrates how the field in a head behaves.

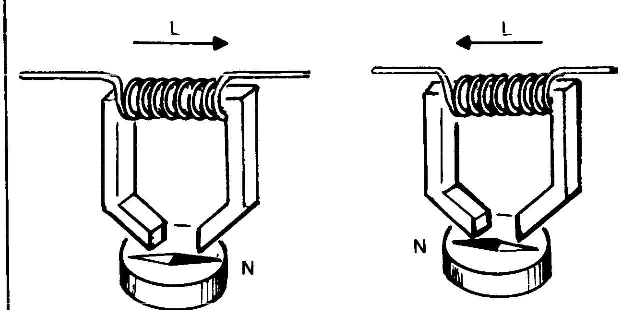
WRITE HEAD



DG-01263

If the compass were placed in the gap while current was flowing through the coil, the compass would orient itself across the gap with its North pointer directed toward one side of the gap. Now, if the current in the coil is reversed, the compass would suddenly swing around with "north" pointing to the opposite direction. This is because the direction of the magnetic field across the gap depends on the direction of current in the magnetizing coil.

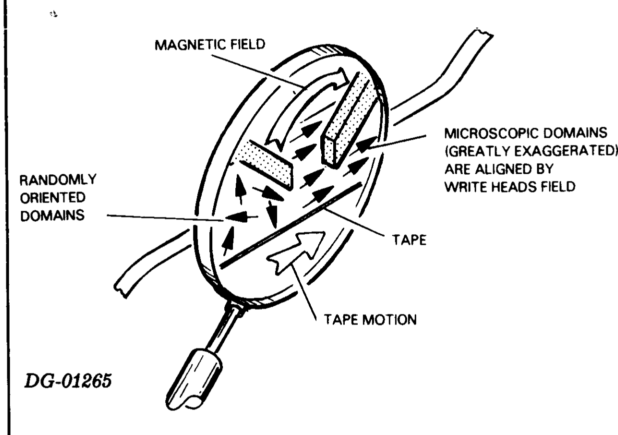
CURRENT REVERSED



DG-01264

The recording surface of magnetic tape is a thin layer of magnetic particles that behave like tiny compasses. Clusters of these particles, called domains, will tend to align with a strong magnetic field, and remain so aligned, indefinitely, after the field is removed. (Of course a subsequent field can realign the position of these magnetic domains.)

RANDOM DOMAINS



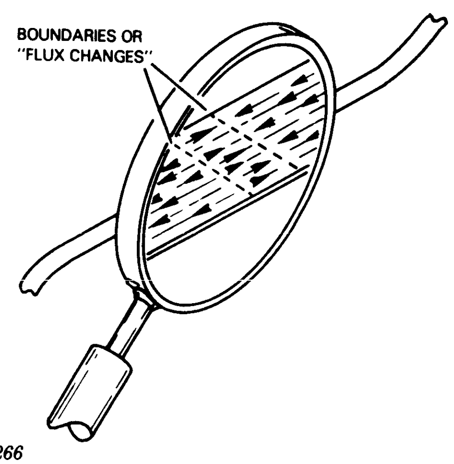
DG-01265

IV

As tape moves over the write head, the domains align themselves with the magnetic field as they pass across the gap. Each time the write current reverses, the resultant field will reverse and a boundary will be produced on tape with the domains on either side of the boundary pointing in opposite directions. The boundary is often called a flux reversal.

This flux reversal is the magnetic "event" which stores encoded information.

ALIGNED DOMAINS



DG-01266

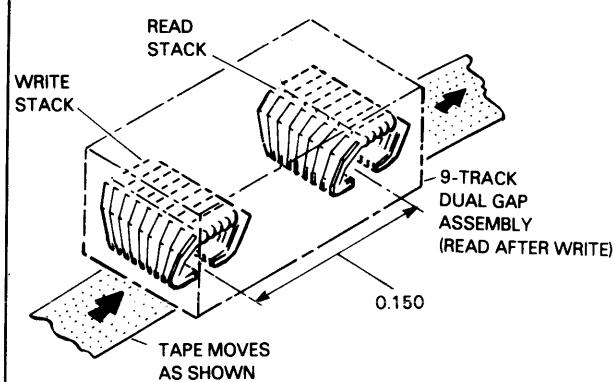
Reading Data

The read head is made just like the write head except the coil is connected to an amplifier instead of a current driver. A low amplitude pulse is produced by the read head whenever a flux reversal recorded on tape crosses the gap. The amplified pulses are interpreted by the read circuits to recover binary data.

It is possible to use the same "electromagnet" for both reading and writing by switching coil connections between a current driver and an amplifier to first write and then read the tape. If, however, separate heads are used, with the read head positioned "downstream" from the write head, data can be verified almost immediately, as it is written, without having to back up the tape to reread that section. This capability is called "read after write" or "dual gap" and is standard with Data General magnetic tape equipment.

In practice, the read and write heads are quite small, and positioned 0.15 inches apart. Nine read after write heads are stacked side by side to provide multi-track recording.

DUAL GAP



DG-01267

Recording Format

The terms "bit", "byte", "frame", "record" and "file" are described below to perhaps reduce industry-wide ambiguity in their use. These descriptions conform with the most generally accepted common usage.

Bits

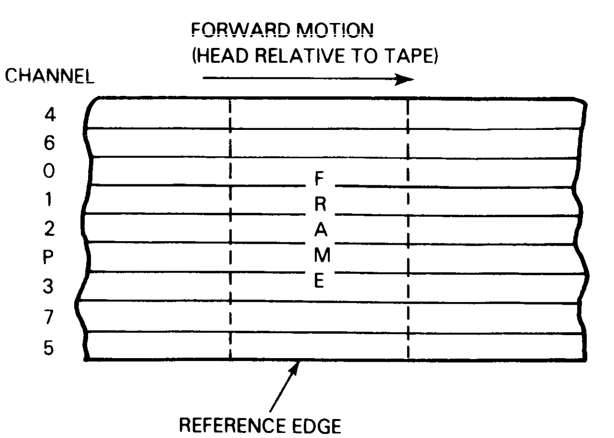
Data is stored as a "magnetic event" on the tape by the write head in the transport. As the tape moves past the write head, a sequence of data bits are written in each track along the length of the tape. The number of data bits per inch (bpi) determines the data density for that transport. 6026 transports can be selected to operate at two densities, 800bpi and 1600bpi.

Bytes and Frames

Industry compatible tape transports contain 9 write heads, allowing simultaneous recording of a number of parallel tracks along the length of the tape. The data bits written simultaneously by a number of heads, one bit in each track, define a frame on the tape. Each frame, therefore, appears across the width of the tape.

A frame is generally composed of a number of data bits and one odd parity bit. The odd parity bit is calculated to make the number of "ones" in the frame odd. This guarantees at least one "one" per frame to allow NRZI clock recovery. The data bits in a frame are collectively called a byte. The tape contains an 8-bit byte of data and a parity bit in each frame.

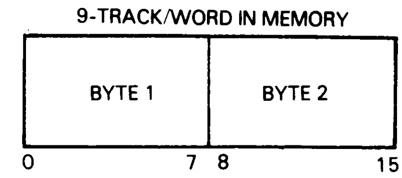
FRAME



DG-04695

Since DGC computers utilize a 16-bit word length, two bytes from the tape form one computer word as shown below.

DATA TRANSFER

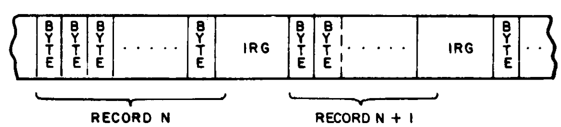


DG-00976

Records

Because the amount of data stored on magnetic tape usually contains several related computer words, the pairs of bytes on the tape for each word are grouped together to form records. Successive records are separated from each other by gaps on the tape. These gaps are d.c. erased and contain no flux transitions. The tape transport can only stop the tape in one of these interrecord gaps (IRG). The record is the smallest possible unit of addressable information on the tape.

RECORDS

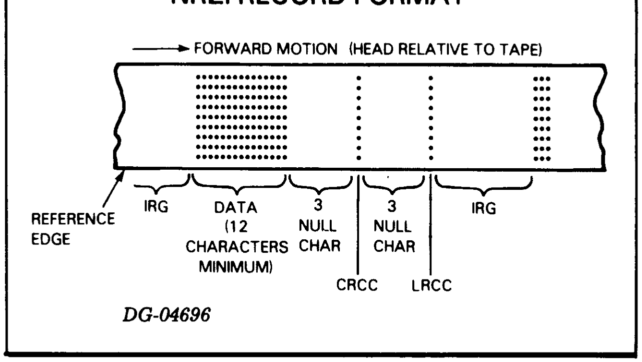


DG-00977

IV

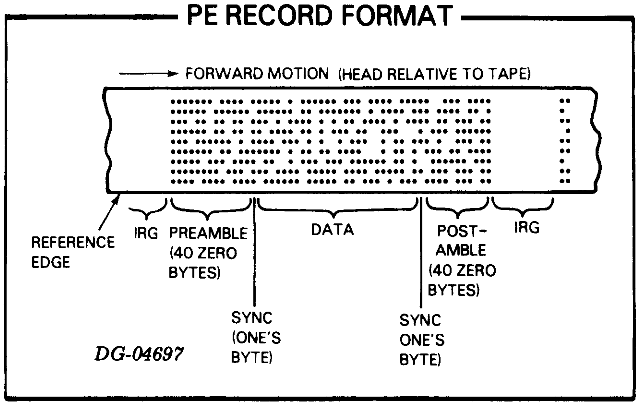
The format of a record differs for NRZI and PE. When data is recorded in NRZI format, a record contains a data field, a cyclic redundancy check character (CRCC) and a longitudinal redundancy check generator (LRCC). The CRC character is accumulated over the data field. The LRC character establishes even parity for each track in the record. (The LRCC causes the flux direction to be reset.)

NRZI RECORD FORMAT



When data is recorded in PE format, a record contains a preamble (to synchronize the clock), a sync byte (to define the start of the data field), a data field, a sync byte (to define the end of the data field) and a postamble.

PE RECORD FORMAT

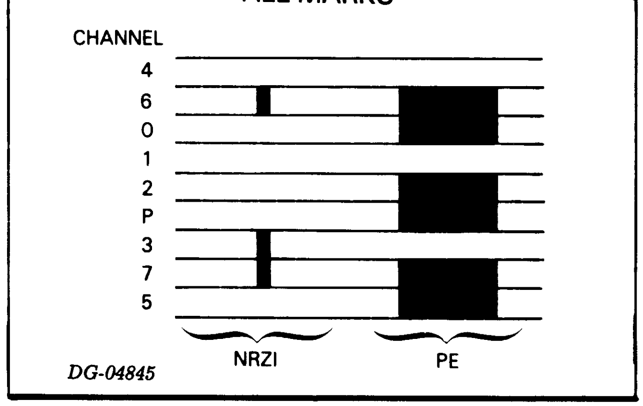


Note that the PE record format is symmetric. This allows both forward and reverse reads. The 6026 tape subsystem does not, however, implement reverse reads.

Files

The computer program groups several records together into a file. Files are separated by special file marks. For NRZI, a file mark consists of a single character record consisting of an ASCII DC_3 (023_8) followed by an LRCC. For PE, a file mark consists of 32 to 128 frames with "zeros" recorded in tracks 0, 2, 5, 6, 7 and P, and with tracks 1, 3 and 4 dc-erased.

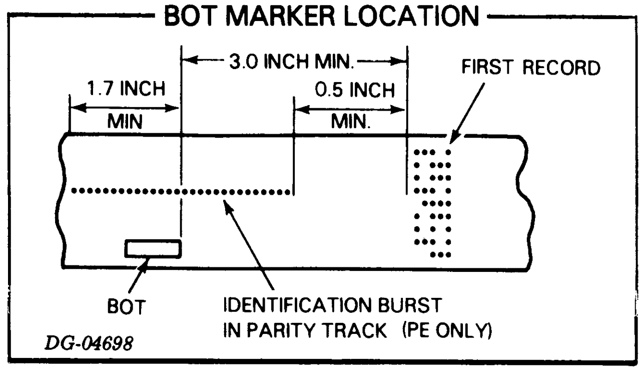
FILE MARKS



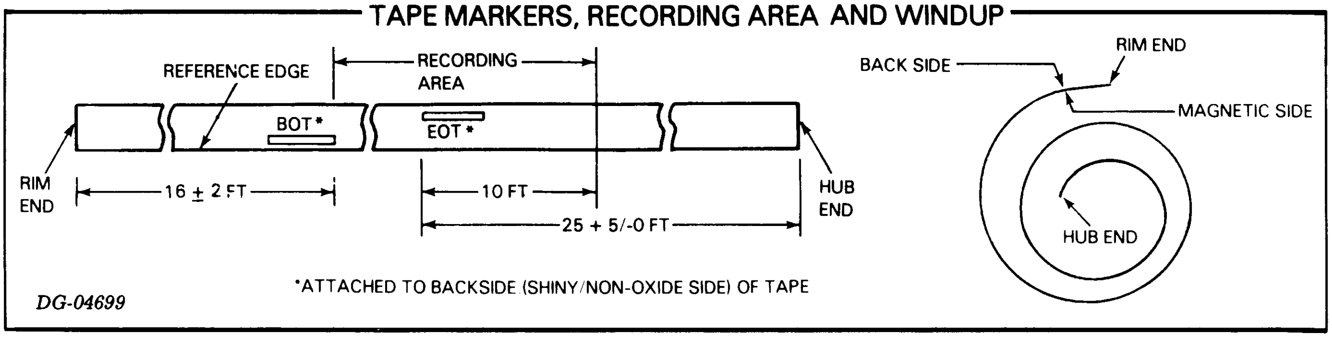
Tape Tabs

Reflective strips mark the physical beginning and end of the tape. The beginning of tape (BOT) marker locates the beginning of the recorded data. The PE format records an identification burst in the vicinity of the BOT marker. The end of tape (EOT) marker locates the approximate end of the recorded data (data may be recorded up to ten feet beyond the EOT marker).

BOT MARKER LOCATION



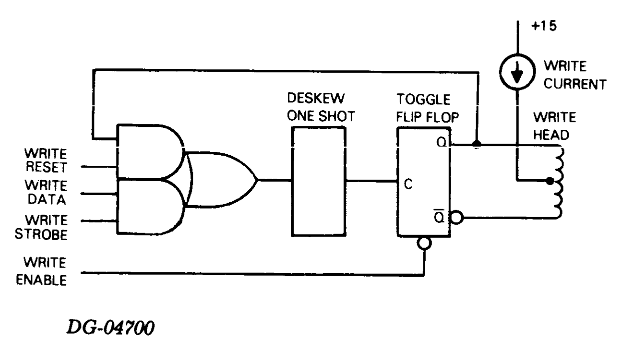
TAPE MARKERS, RECORDING AREA AND WINDUP



WRITE CIRCUITS

The data writing path consists of a nine bit wide data bus receiver (character plus parity), a deskew register and the write current drivers. Data flows from left to right in the simple diagram shown below. Only one channel is shown.

WRITE BLOCK DIAGRAM



Write Driver

The data lines are sampled on the leading edge of the data strobing signal from the controller. In channels where the data line is asserted, the current through the write head will reverse and a flux reversal will be recorded on tape. In order to ensure that the flux reversal on tape will be as sharp as possible (to reduce spurious noise), the write current drivers operate at 50mA for NRZI and 22mA for PE. In PE mode, the drivers boost the current to 38mA for the first 1.2 sec to improve the playback signal.

When power is first turned on at the transport, or when the write circuits are disabled, the current drivers are initialized to a specific current direction (even though the windings are not actually energized until a writing operation occurs). This initial condition can be arbitrarily called the plus (+) current direction with the resulting magnetic field on the tape being called $+\phi$. The reversed current and field are then called - and $+\phi$, respectively.

At the conclusion of a data transfer to tape, any number of the write windings may be in the negative or reversed condition, depending whether the number of flux reversals recorded in that track was odd or even. All of the windings are forced back to the initial, or positive, current direction when the write reset signal from the tape controller asserts. (This happens in NRZI mode only.)

The flux reversal resulting from any write winding going from negative to positive on the write reset strobe is recorded on tape. Since resetting the write channels means that the number of flux reversals in every track must be an even number, the character recorded is a parity character with each bit completing an even parity condition for its track. This character is often called the longitudinal redundancy check character or LRCC. (Note that only NRZI records an LRCC.)

In keeping with industry-wide formats for 9-track NRZI data recording, the tape controller sends the reset signal to write the LRCC on tape as the last character of a data record, separated by three character-periods from the previous character.

Static Deskew

Ideally, the nine individual segments in the write head are aligned in a straight line perpendicular to the tape, so that data characters are written without skew. In practice, manufacturing tolerances preclude such ideal heads, and a small but perceptible skew pattern is usually present. An adjustable monostable multivibrator (or "one shot") in each channel can be used to insert short delays, where appropriate, to compensate for the static skew of the head.

While the leading edge of the write strobe signal clocks the data character transferred between the tape controller and the transport, the trailing edge of the deskew one shot initiates the start of a current-reversal in a write head. The effects of static or geometric skew on the write head can be nearly eliminated, so that the data character is written on tape in a straight line across the tape.

The write deskew register is adjusted using a master skew tape, which is a precision standard, recorded using special equipment. A master skew tape contains successive frames of flux reversals written perpendicularly across the tape without skew, and with precise timing or spacing between frames. Master skew tapes of exceptional quality are available from several manufacturers.

The skew tape is used to measure the amount of skew in the read heads. The write circuits are then adjusted to produce the same amount of skew. This method assures that data is recorded without skew.

IV

Write Protection

The transport is equipped with write protection facilities that are controlled by the position of its write lock sensing pin, located behind the supply tape reel near its hub. A groove is molded on the back of the reels, and a plastic ring called an enabling ring can be inserted into that groove. When the ring is removed, the transport is write protected and data cannot be written. The write lock sensing pin checks whether or not an enabling ring is present on a tape reel. The write lock sensing pin and its companion assembly are described in Chapter II.

At the circuit level, write protection means that dc power is not supplied to the write drivers (an opened switch physically disconnects the write power supply line) and the signal W.L. asserts to notify the subsystem controller that the transport is write protected.

The heads are disconnected from their dc supply voltage whenever the sensing pin extends into the write lock groove of a tape supply reel. When a write protected reel is mounted on the transport, even a failure in the write circuits cannot destroy data. The solenoid is de-energized and releases the sensing pin whenever the vacuum columns are turned off so that the presence of an enabling ring is always checked at the beginning of a tape loading operation.

Power Fail Protection

The write circuits incorporate an additional feature to protect the transport from writing data during a power failure. A logic circuit immediately disables the write enable signal, effectively shutting off the write current drivers. The clamp circuit is activated by the power clear signal which goes false several milliseconds before the transport circuit performance can degrade during failing power. The "early" shut down of the write drivers prevents them from glitching data to tape during power failure.

Erase

A full width, noncontact erase head is positioned "upstream" from the write head. The erase head is energized during all writing and erasing operations. The erase head is disabled whenever the write lock sensing pin is activated. The erase current is 50mA, or 150% of the saturation current for the erase winding. This value of erase current gives -40dB erasure, minimum, as tape passes near the energized erase head. The tape does not touch the erase head, but passes within 0.003 to 0.005 inches of it.

READ CIRCUITS - NRZI

The NRZI read circuits recover data and a clock from flux reversals detected by the read head. They also monitor the quality of the analog read signal, and check for excessive skew.

Amplifier

A differential amplifier detects low level signals in the read head, and provides a high level output for the signal processing logic. Each flux reversal induces a momentary voltage in the read head. The gain of each amplifier is individually adjusted to give a nominal 12 volt peak to peak signal amplitude at the output for an all ones pattern. (Note that different gains are required for NRZI and PE. Thus, there are 18 individual adjustments. In this transport, the adjustments for NRZI are totally independent of those for PE. This means that service personnel can adjust the gain for one mode without affecting the adjustment for the other mode.)

Level Detectors

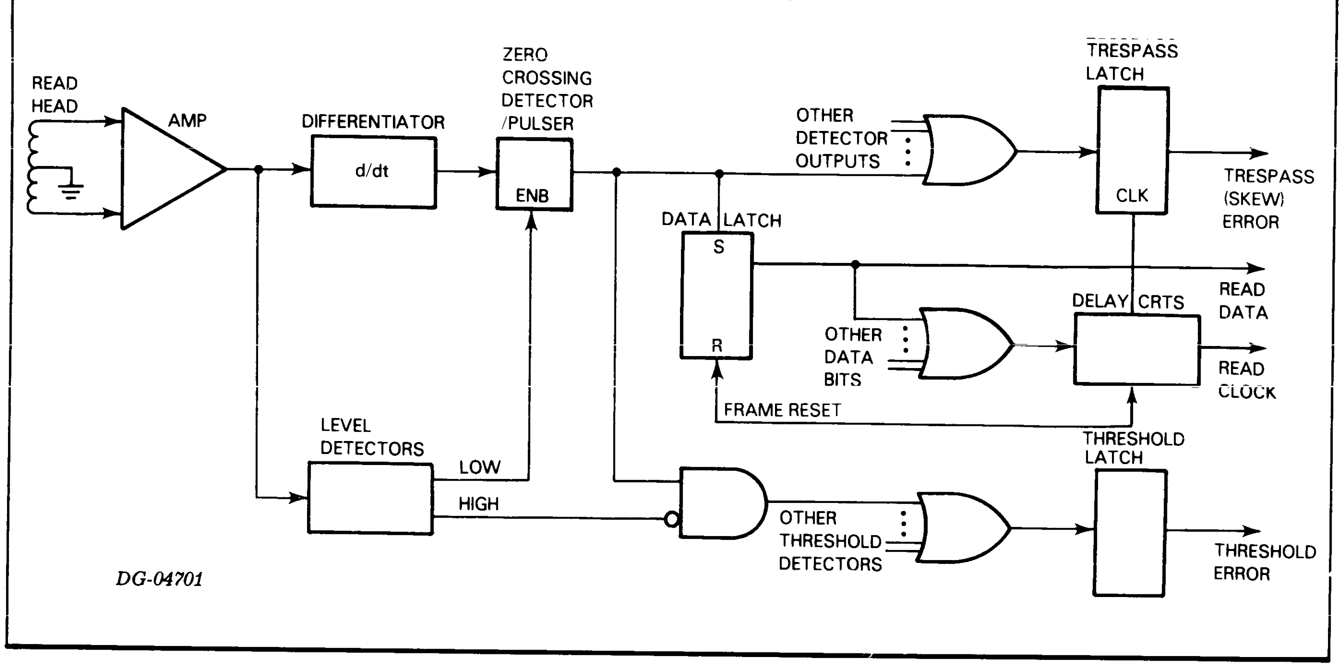
Two level detectors monitor the output of the read amplifier. The low threshold detector checks that the read signal meets a minimum playback threshold for reliable read data recovery. The data recovery circuits shut down if this threshold is not met. This threshold is switched to a higher level for a read while write operation.

The high threshold detector checks that the read signal meets an acceptable playback threshold. It signals a threshold error and disables the data latch if the signal level is too low. A special read low threshold command disables this detector to allow the transport to read marginal tapes. This threshold is also switched to a higher level for a read while write operation to provide assurance of recording integrity.

Differentiator

A differentiator produces an output that is proportional to the slope of the amplified read signal. The differentiated signal therefore has zero crossings at the peaks of the read signal. The bandwidth of the differentiator (sensitivity to high frequency signals) is set to filter out high frequency noise. (Note that the bandwidth is switched to a higher cutoff frequency in PE mode.)

NRZI READ BLOCK DIAGRAM



Zero Crossing Detector/Pulser

The zero crossing detector locates the zero crossings of the differentiated read signal. It is actually two comparators with their outputs exclusive-or'ed together. One comparator has low hysteresis (approximately 200 mv.). This means that its output goes high when the differentiated signal goes negative, and low when the signal goes positive. The other comparator has high hysteresis. Its output goes high only after the differentiated signal reaches a preset negative level, and low at a preset positive level. Because the differentiated signal has a slope in the zero crossing zone, the zero crossing detectors transition at different times. When the signal goes negative, the first zero crossing detector immediately goes high, followed shortly thereafter by the other detector. The exclusive-or gate asserts during this interim time period. The exclusive-or gate therefore produces a pulse for each zero crossing, regardless of polarity.

The hysteresis for the second comparator is switched to a lower level while writing to insure detection of erroneous (spurious) bits.

The exclusive-or gate drives a one-shot, which provides a uniform data pulse. The one-shot is disabled if the read signal does not meet low threshold requirements.

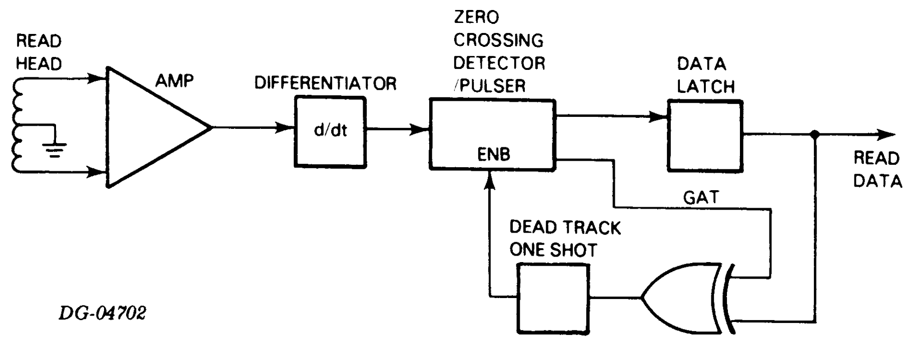
Data Register

The data register latches NRZI one's pulses detected by the zero crossing circuit. It holds the one until it is cleared by the read clock. Note that the absence of a pulse represents a zero. The latch therefore remains cleared while the read clock strobes zeros to the controller. As mentioned previously, the latch is disabled if the read signal does not meet high threshold requirements during a normal read or read after write operation.

Data Strobe

The clock circuits examine each frame for "ones". The first "one" to appear defines the beginning of the frame and fires a chain of one-shots. The skew one-shot defines a window in which all the remaining "ones" must appear, This window extends one third of the way into the frame. Any "one" that appears after this time, but before data is clocked to the controller, results in a no trespass (excessive skew) error. During a read operation, data is clocked to the controller at the midpoint of the frame. During a read while write operation, data is clocked two thirds of the way into the frame. The data clock fires an additional one-shot that resets the data register.

PE READ BLOCK DIAGRAM



READ CIRCUITS - PE

The PE read circuits recover a PE encoded data stream from the flux reversals detected by the read head. They send PE data to the controller, which recovers a clock and decodes the data. The PE circuits monitor the read signal and cause a dead track fault if flux transitions fail to appear at regular intervals in the record.

Amplifier

The amplifier is the same as that for NRZI. Its gain is adjusted to give a nominal 8 volt peak to peak signal amplitude at the output of the differentiator for an all ones or all zeros pattern (3200 fci).

Differentiator

The differentiator is the same as that for NRZI. It is set to the wide bandwidth mode.

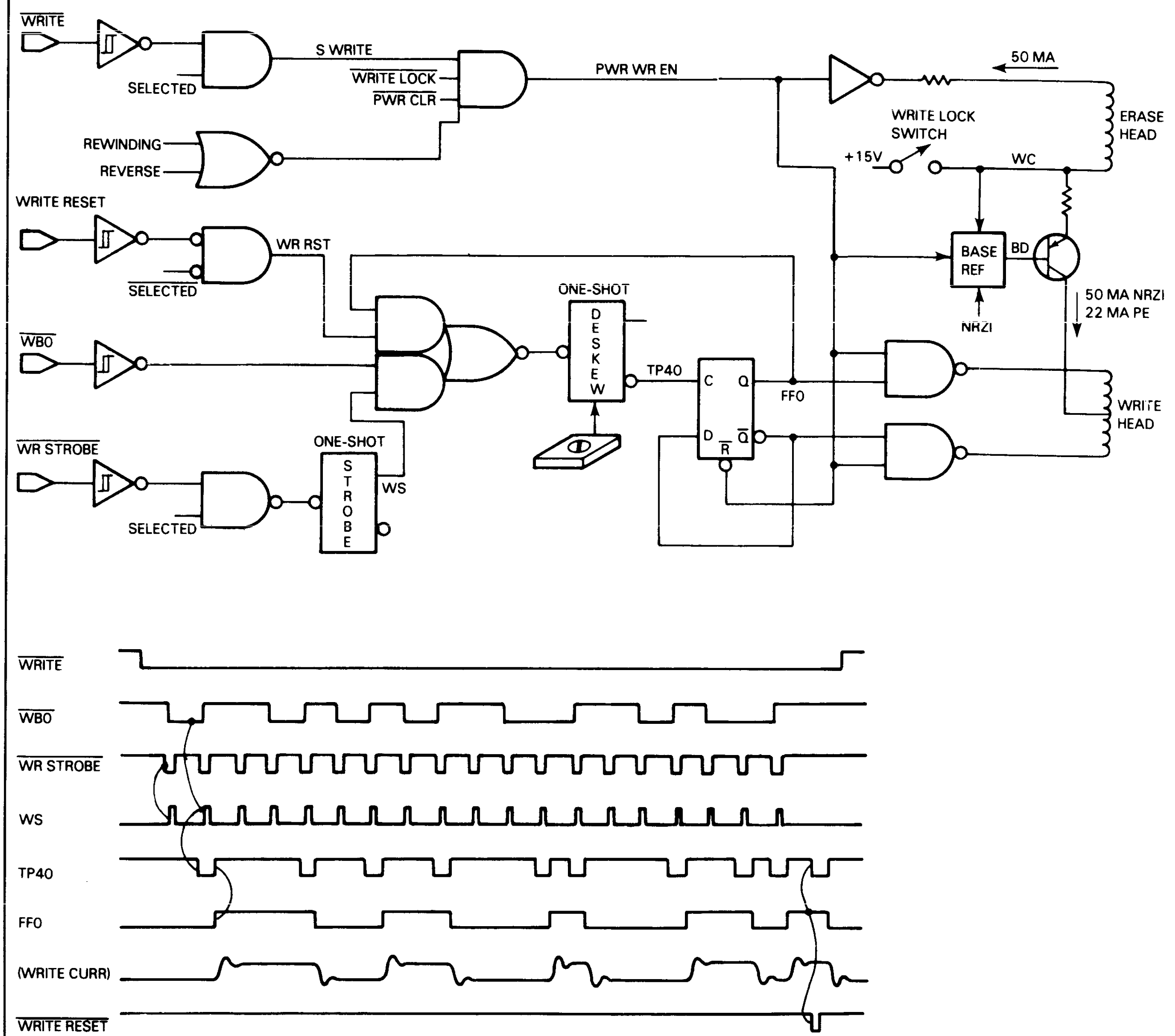
Zero Crossing Detector/Pulser

The zero crossing detector is the same as that for NRZI. The one-shot is disabled if the read circuits detect a dead track.

Data Register

The data register stores flux transitions (i.e., pulses from the zero crossing detector). A positive flux transition sets the latch and a negative transition clears the latch. The register therefore delivers PE encoded data to the controller. A one-shot monitors the output of the latch and the high hysteresis comparator. It retriggers if pulses appear at regular intervals. If the track goes dead, the one-shot times out and disables the zero crossing detector until the high hysteresis comparator again detects pulses.

WRITE CIRCUITS *



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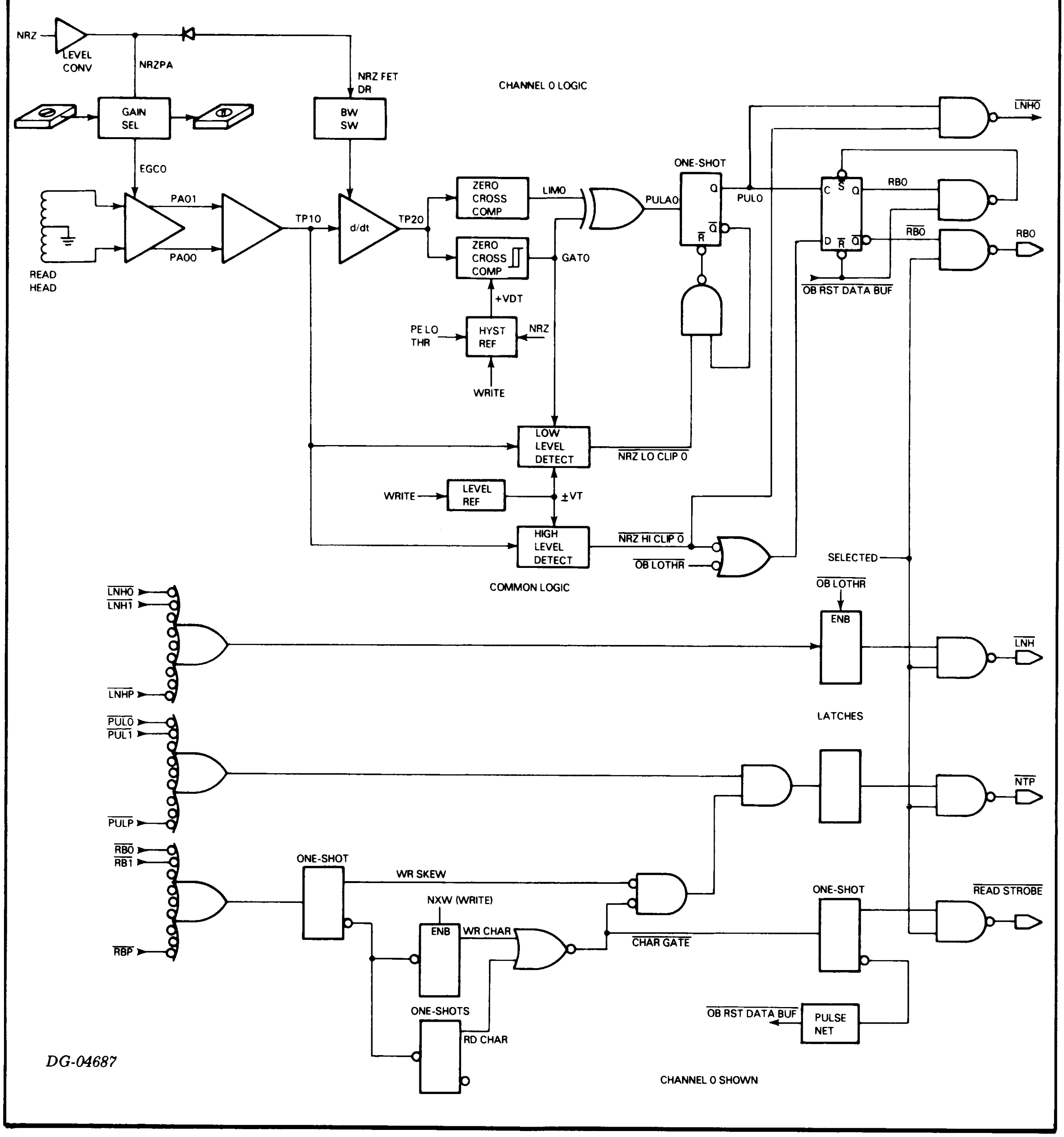
*CHANNEL 0 SHOWN

IV

READ CIRCUITS - NRZI



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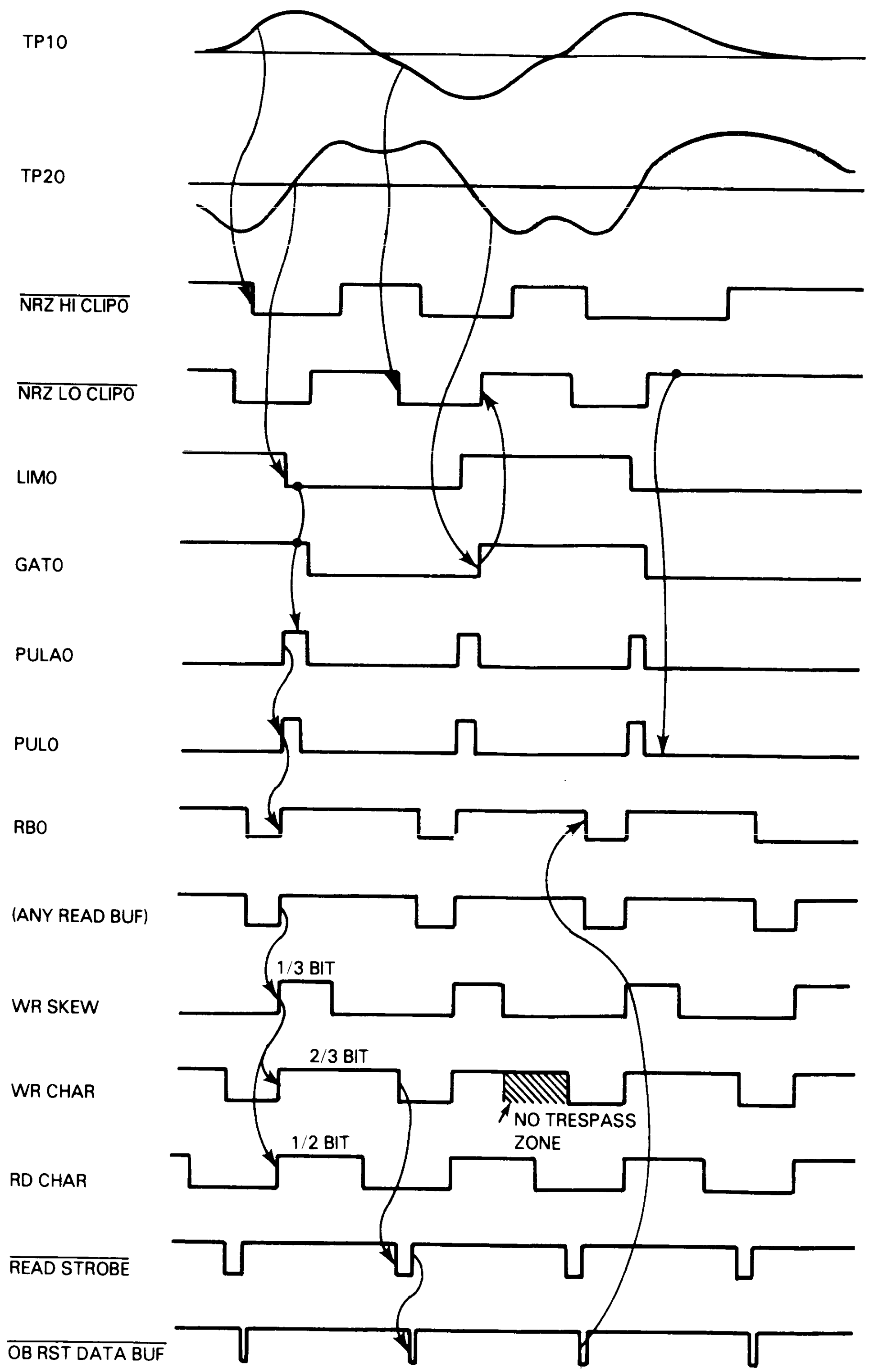
READ CIRCUITS - NRZI

READ WHILE WRITE TIMING



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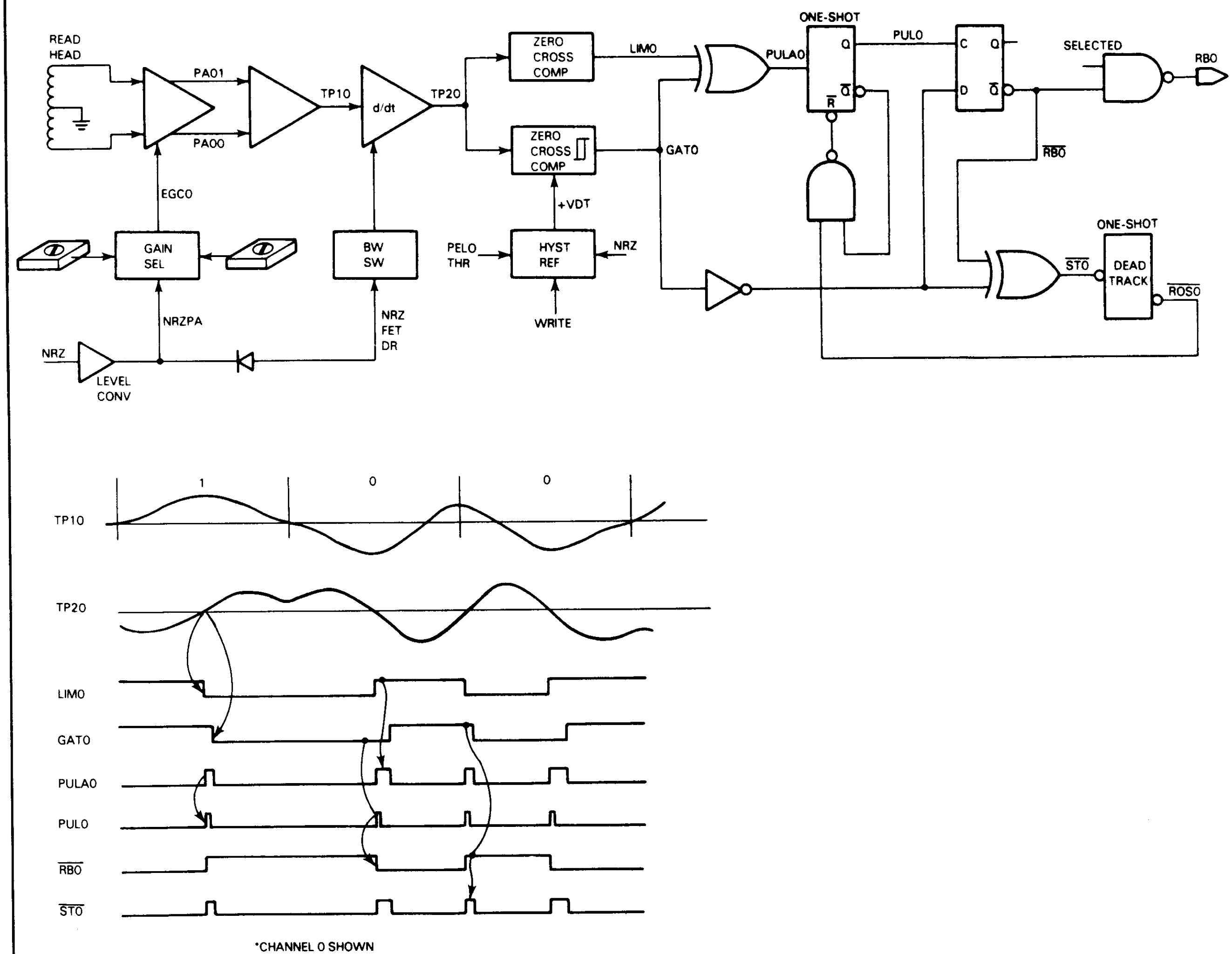
IV

READ CIRCUITS - PE *



*CHANNEL 0 SHOWN

DG-04688

CHAPTER V
REEL AND CAPSTAN SERVOS

INTRODUCTION

There are several self-contained electromechanical systems within the tape transport that use analog signals. As such, they present different operating principles than those that relate to most digital logic circuits. These analog systems include the capstan servo system and two vacuum column, tape reel servos. (There are two independent reel systems, one for each column and reel pair.) This chapter describes these analog systems. It also describes a small section of the transport's digital control logic that monitors the servos' operation. These logic circuits form an interlock, or failsafe, system that protects the tape from damage if there is a servo failure. The circuits that transcribe data to and from magnetic tape also use analog signals; they are discussed in Chapter IV.

The first part of this chapter will present some basic principles of servo systems. Detailed descriptions of the reel servos and the capstan servo are then presented followed by a description of the failsafe system.

SERVO PRINCIPLES

A servo is any closed-loop, electromechanical, feedback control system. The most important characteristic of a servo is its ability to measure some condition, determine the variation or "error" of that condition from what is desired, and then take the necessary action to reduce the error. The transport servos contain four basic elements in one form or another.

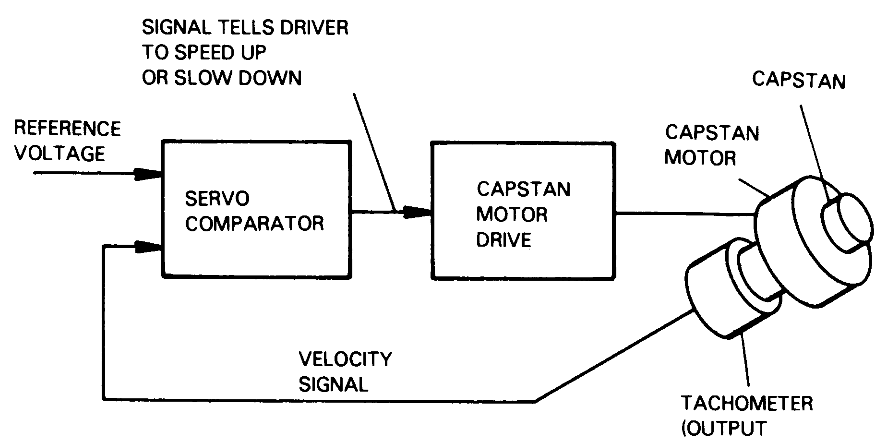
- A reference input that defines the desired output
- An output sensor
- A method for comparing the output with what is desired
- An actuator or driver which changes the output

For instance, the capstan is controlled by a servo. The simplified block drawing below shows how the four basic elements of a servo work together to control the capstan speed.

Power to rotate the capstan is provided by the driver circuit. A tachometer connected to that motor produces an analog signal that is proportional to how fast the capstan is spinning. This analog signal is compared to a reference input that represents the desired capstan speed. By comparing these two voltages, it can be determined if the capstan is spinning at the correct speed, or whether it's running faster or slower than desired.

If the measured speed is too high, the capstan driving circuit supplies less power and the capstan slows down. If the measured speed is too low, more power is provided to speed the capstan up. The servo continually measures the output speed and continually corrects the current supplied to the motor to maintain precise speed.

GENERALIZED SERVO



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REEL SERVO

There are two reel servo systems, one for each vacuum column and reel motor combination. Each system consists of;

- a vacuum-sensing transducer
- a preamplifier
- a summing amplifier
- a power amplifier
- a reel motor
- a vacuum column
- bias circuits.

The servos operate independently of each other, and independently of the capstan servo.

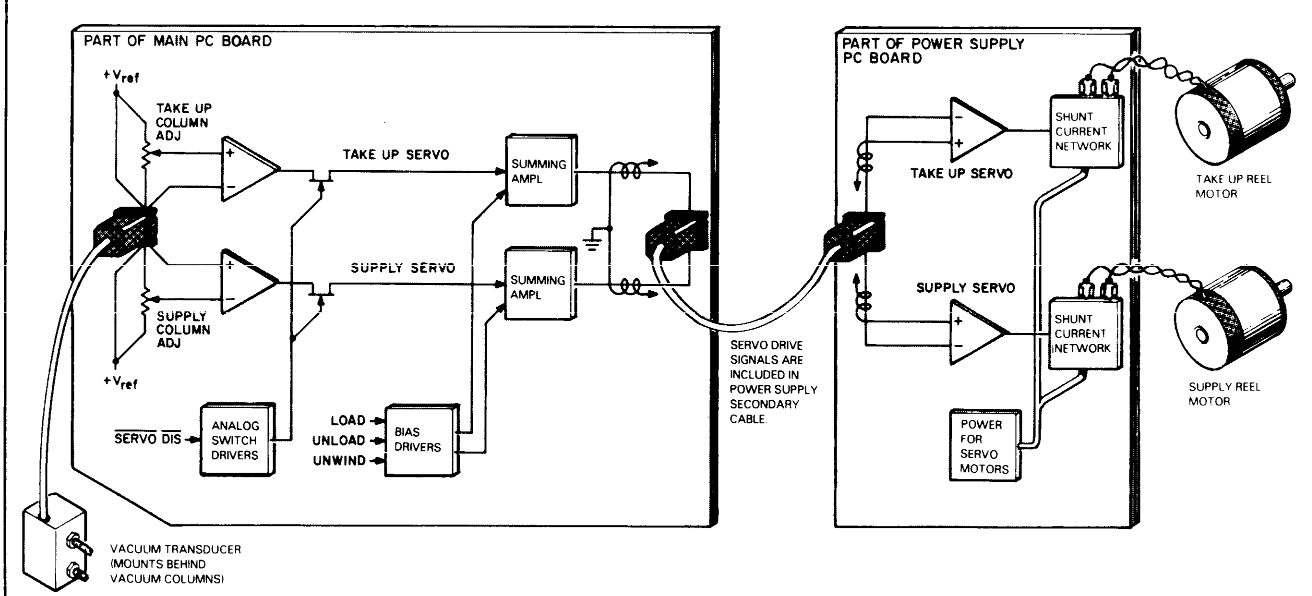
The two tape buffer servos operate in the same manner. Their organization is shown on this page. (The vacuum columns are omitted.) Since the servo components are located on several different subassemblies, the diagram also shows where the servo elements are located inside the transport.

The description that follows briefly summarizes the operation of the reel servos. Each major element in the servo is then described in detail. When the tape buffers are operating, a loop of tape is positioned in each vacuum column. One end of the tape loop goes around the capstan; for the purpose of this discussion it can be considered securely held and motionless.

The other end of the tape loop goes to a tape reel which can be rotated forward and backward by its reel motor.

An error signal, proportional to the tape's position above or below an equilibrium point near mid column is generated in the transducer. Pre-amplifier and an amplifier in each reel-column servo system conditions the signals from the pressure transducers and applies them to the input of the reel drivers. The reel driver controls servo power to the reel motor so it spins in the correct direction to reduce the error signal until the tape is at the equilibrium position. A single adjustment is provided to set the location of the equilibrium point within each column.

REEL SERVOS



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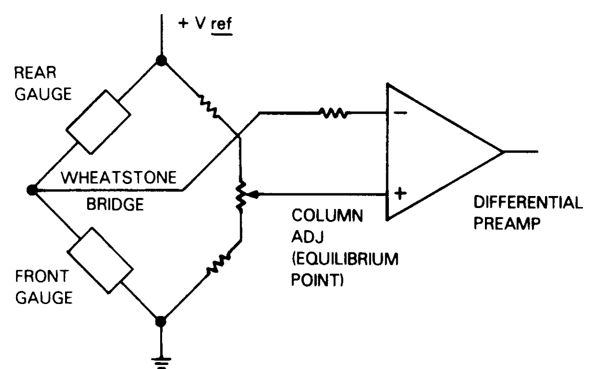
V

Vacuum Transducer

The pressure transducer generates an error signal that is proportional to how far the tape loop is above or below an equilibrium point in the vacuum column. Several small sensing holes, drilled in a row within the vacuum column, connect to a manifold machined into the casting behind the column. When the tape loop is in the column it divides the sensing holes into two groups - those that "see" atmospheric pressure and those that "see" vacuum. The average pressure in the servo manifold will change in steps as the tape moves up and down over the sensing holes inside the column. The illustration at right shows how this is done.

A small, spring-loaded pneumatic piston is connected through a short tube to the manifold. The piston moves within its cylinder in response to pressure fluctuations in the servo manifold, and flexes a spring arm on which two strain gauges are mounted. (A strain gauge is an electromechanical transducer whose resistance increases when it is stretched and decreases when it is compressed.) As the spring arm flexes, one strain gauge is compressed and the other is stretched. The two strain gauges are connected in a wheatstone bridge so the effects of temperature fluctuations are minimized. A highly regulated reference voltage is placed across the bridge, as shown below:

TRANSDUCER



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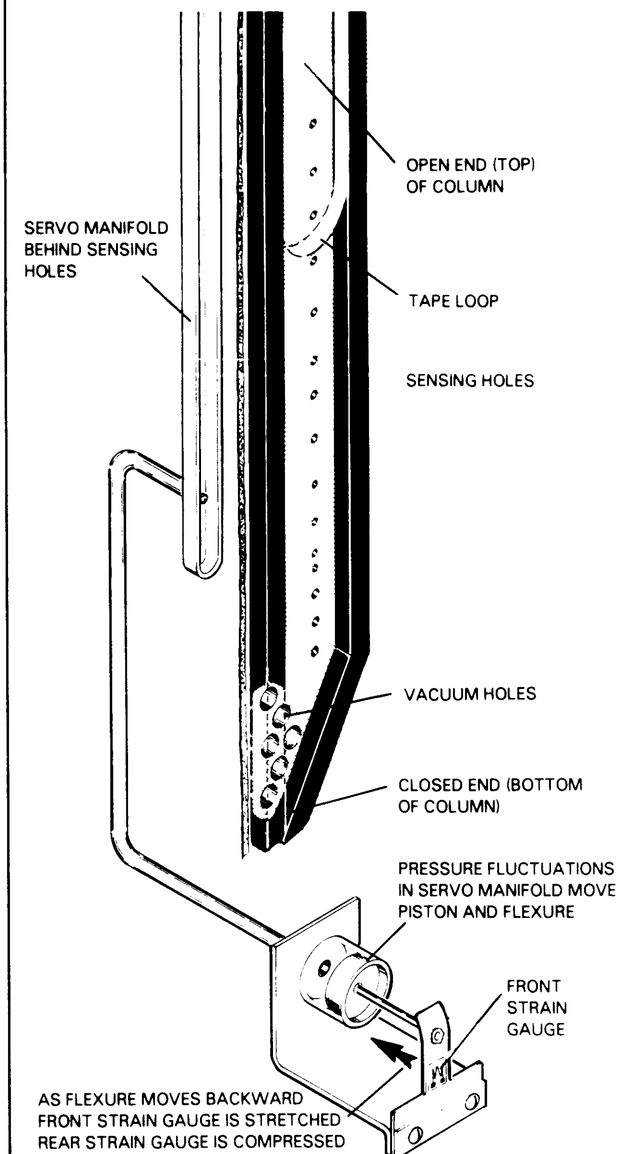
MANIFOLD AND TRANSDUCER



DG-01248

The two series-connected strain gauges along with a resistor network form a bridge circuit that includes an adjustment to set the equilibrium point for the tape loop within each vacuum column. The equilibrium point adjustment establishes what vacuum in the servo manifold will nearly balance the bridge circuit. If the tape loop rises above the equilibrium point, the vacuum in the transducer will decrease and the bridge will go out of balance, applying a low amplitude error signal to the servo preamplifier. If the tape loop falls below the equilibrium point, the vacuum in the transducer will decrease and an error signal of opposite polarity will be presented to the preamplifier.

NOTE *"Above"and "below" the equilibrium point are not reckoned relative to the ceiling and floor of the computer room, but to the open end (top) and closed end (bottom) of the vacuum columns.*

The output of the bridge, measured to ground with an oscilloscope, is nearly half of the reference voltage, or 5.3 volts, regardless of flexure position. The magnitude of the differential input signal to the transducer preamplifier is of the order of a few millivolts - even for large flexure movement. The preamplifier gain is extremely high, and it can saturate when the column adjustment is badly misaligned. When the column adjustment is correct, the error signal measured at the output test pad of a preamplifier will remain less than a volt (plus or minus) while the tape is at equilibrium and can swing from about -3 volts to +3 volts as the capstan accelerates and decelerates.

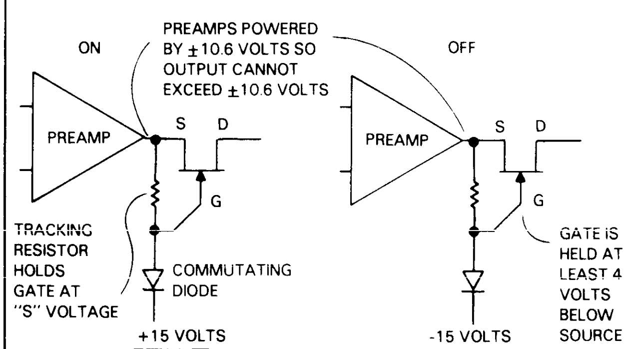
Servo Preamplifiers

The preamplifiers in both servo loops are identical. They are differential, scalar amplifiers which amplify the low level signal from the transducers. Power for the preamplifiers is taken from a special reference supply, which provides highly regulated dc voltages of +10.6 and -10.6 volts. The preamplifiers use precise voltage supplies to ensure exceptional noise immunity in the high-gain circuits.

An N-channel analog switch is used to enable and disable the output of each preamplifier. The switch is controlled by an additional switch that applies either +15 volts or -15 volts to the cathode of the commutating diode.

When the servos are enabled, the cathode of the commutating diode is connected to +15 volts. Because the preamplifier output at full saturation is limited by its supply voltage to 10.6Vdc the diode is always back biased and the gate is allowed to float. A tracking resistor is inserted between the source and the gate of the analog switch to ensure that they remain at the same potential. This is the fully ON condition for an N-channel switch, and it is shown on the left in the figure below:

TRANSDUCER PREAMPLIFIERS



DG-01250

When the servos are disabled, the cathode of the commutating diode is connected to -15 volts as shown on the right of the same figure. Since the downward saturation of the preamplifier is limited to -10.6 volts by its supply voltage, the diode is always forward biased and there will always be at least 4 volts from gate to source on the analog switch (pinch off is 3 volts), to hold it fully off.

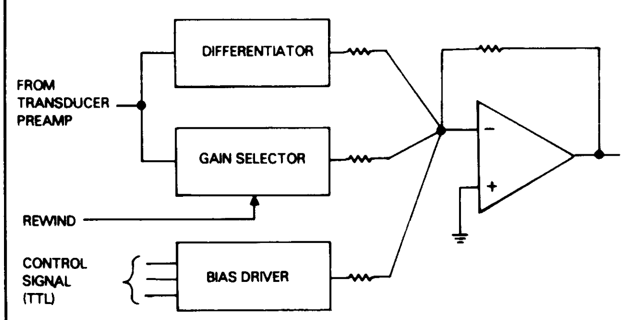
V

Summing Amplifier and Biasing Circuits

The second servo amplifier stage in the two reel servo systems are nearly identical. Each amplifier contains three gain selectors which change the degree of amplification performed on the signal from the first amplifier in response to certain operating conditions. Each contains a differentiator, so that not only the error signal from the transducer, but also its rate of change affect the response of the reel motors. Also, each amplifier contains certain bias-supplying circuits which are used during load, unload and unwind sequences.

The gain selectors, differentiators, and the bias circuits operate independently within each summing amplifier and are described on the following pages.

SUMMING NETWORK



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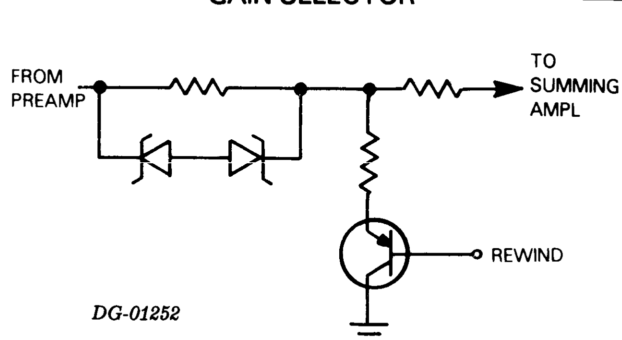
Gain Selectors

The three gain selectors change the amplification of the error signal from the first amplifier stage of both reel servos. There is a full gain condition and three reduced gain conditions. Full gain is realized whenever the tape loop within a servo's vacuum column is not in the immediate vicinity of that column's equilibrium point and the transport is not rewinding the tape. One of the reduced gain selectors is active whenever the transport is not rewinding and the other is active when the tape is in the immediate vicinity of a vacuum column's equilibrium point. Both reduced gain selectors may be active simultaneously, producing even more attenuation.

The equilibrium point gain reduction establishes a "dead zone" near the center of a column so that the servos will not continuously search for the exact center of the column. This means that power consumption by the servos will be reduced when the tape buffers are idle. (The buffers can be considered idle whenever the capstan is motionless.) This significantly reduces the amount of heat generated in the reel motors, the power amplifier and the power supply.

The near-equilibrium gain reduction is implemented by the switching action of two back to back, series-connected, zener diodes which shunt part of the input resistance of the summing amplifier as shown:

GAIN SELECTOR



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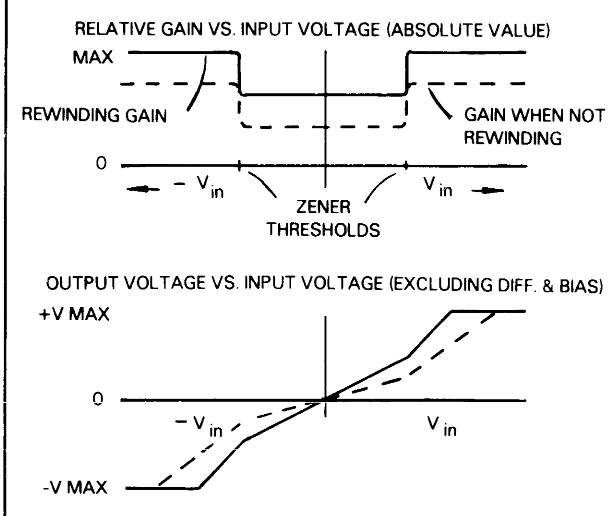
As long as the voltage across the shunted resistor, R1, does not exceed the zener breakdown voltage, the gain of the amplifier remains the ratio of the op amp's feedback resistance to the total input resistance. This is the reduced gain condition. When the voltage across the shunted resistor exceeds breakdown, the apparent input resistance to the op amp is reduced and the gain increases to its "full gain" condition.

An additional reduction of the summing amplifier gain is in effect whenever the transport is not rewinding. The transistor in the figure above shows how this is implemented. This gives the servo higher gain during rewinding. This higher gain is needed to accurately control the tape position in a column during high speed rewinding.

The combined effect of the gain selectors on the dc gain characteristics of the summing amplifier is summarized in the two graphs below. Only relative values of gain and voltage are shown.

RELATIVE GAIN VALUES



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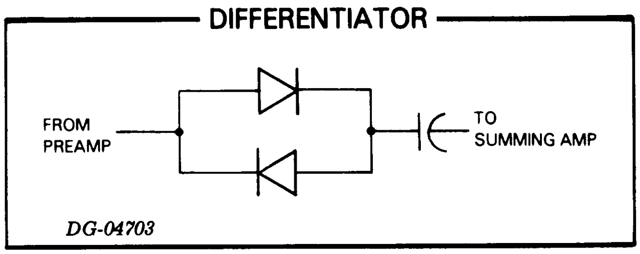
V

Differentiator

The output signal from the transducer is differentiated and the result is also applied to the summing node of the summing amplifier. This differentiated value represents how fast, and in which direction, the error signal is changing. As the error signal's rate of change increases from the equilibrium value, so does the corrective action taken by the servo to bring the tape loop back near mid column.

Because differentiators are sensitive to noise, a glitch filter is included in the circuit to prevent spurious spike transients from overloading the servo. The glitch filter is simply two diodes, connected in parallel (with opposite polarity) as shown below:



If the output of the summing amplifier is monitored with an oscilloscope, the interpretation of the waveforms must take into consideration the presence of the differentiated component. The behavior of a differentiator is not generally intuitive, and presence of the signal within the amplifier output can be confusing.

When the transport is rewinding, the relative weight or proportion of differentiated component in the amplifier output signal decreases because the gain of the undifferentiated component increases during rewind.

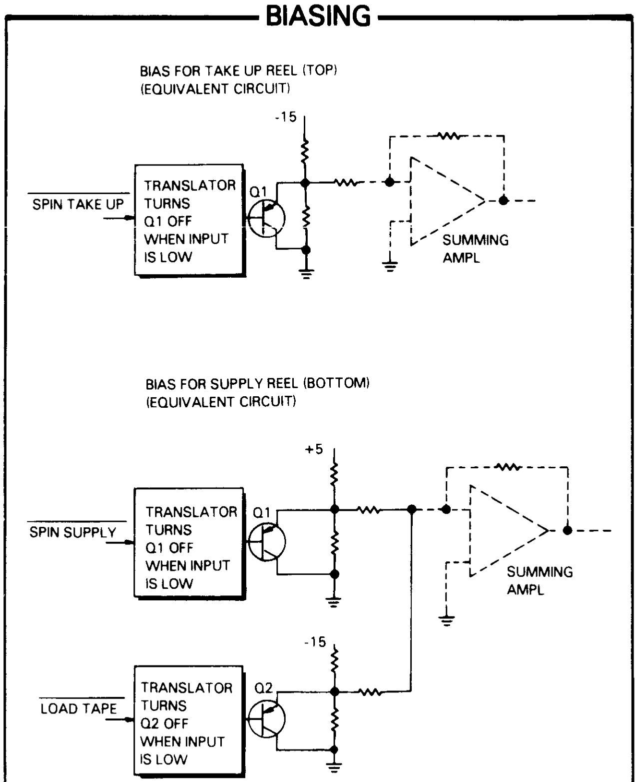
Bias Circuits

Certain dc bias signals can be applied to the summing node of each summing amplifier. These signals cause the reel motors to spin forward or backward at appropriate, fixed rates; they are used during the load, unload, and unwind operations. Three digital signals apply these signals to the summing amplifiers. The signals, their functions, and the magnitude of the applied bias levels are tabulated below.

SUPPLY SERVO ONLY		
LOAD TAPE	-3.6 Vdc	Load sequence only: spins supply reel CW.
SPIN SUPPLY	3.7Vdc	Supply load and unwind; spins take up CCW.
TAKE UP SERVO ONLY		
SPIN TAKE UP	-3.6Vdc	Load and unwind; spins take up CCW.

The following diagram shows the organization of the bias circuits and translators in the summing amplifiers. The translators convert TTL-level logic transitions to other, often higher, signal levels.

BIASING



DG-01323

During the load sequence, LOAD TAPE, and SPIN TAKE UP assert for 400 milliseconds shortly after the vacuum blower is energized. Both reel motors then spin in the direction that feeds tape into the vacuum columns. Injecting tape into the vacuum columns in this manner reduces the annoying squeal that is typical of vacuum columns as they first load tape. (The squeal is caused by the resonance of vibrating tape stretched across the mouth of the vacuum column.)

During an unload sequence, SPIN SUPPLY asserts for about 2.5 seconds shortly after the vacuum blower is turned off, and the vacuum columns have vented. This causes the supply reel motor (the bottom motor) to slowly spin counterclockwise (looking from the front) and gently wind onto the supply reel the tape that had been looped in the columns.

When the vacuum columns are already unloaded and an operator pushes and holds the unload switch (this is called the unwind function), two signals, SPIN SUPPLY and SPIN TAKE UP assert while the switch is held down. This causes the supply reel to slowly spin counterclockwise, unwinding the tape from the take up reel and winding it onto the supply reel. The bias voltages applied to the two summing amplifiers are adjusted so that a nearly full 10.5 inch supply reel spools the tape at the same rate the nearly empty take up reel unwinds it. This minimizes tension on the tape. For any other conditions such as when tape is on a small supply reel or when there is a sizable length of tape wrapped on the take up reel, the take up reel will unwind tape faster than the supply reel can spool it up. When this happens, as it might in an emergency rewind, care should be taken to prevent tape from cascading onto the floor.

Motor Drivers

The output of the summing amplifiers is carried through twisted-pair cables to the reel motor drivers located within the power supply module. The driver for each reel motor is similar to the scalar multiplier building block previously described. There are, however, two exceptions:

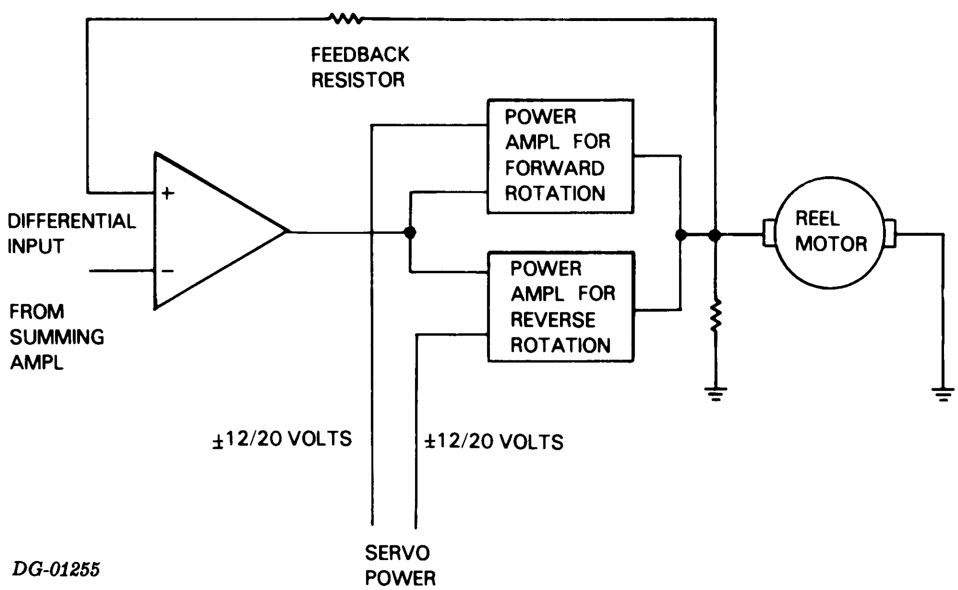
1. Input to the driver is differential rather than single-ended;
2. A power amplifier provides the output signal rather than the operational amplifier itself.

The differential input to the reel driver is used to cancel spurious noise pickup in the cable between a summing amplifier and a reel driver. The power amplifier is used because a reel motor can momentarily draw over 20 amps, far exceeding the direct sourcing capabilities of a single integrated operational amplifier. Current shunt circuits in each reel driver provide current to drive a reel motor from the +12/20 volt and -12/20 volt (dc) servo power supplies.

Each reel driver has two mirror-image current amplifiers. One amplifier provides current from the positive voltage when the motor rotates in one direction; the other provides current from the negative supply for the opposite motor rotation. The feedback resistor that determines the gain for the entire driver circuit connects "downstream" from the current source to ensure that the voltage signal applied to the reel motor accurately follows the input signal to the reel driver.

The servo power supplies (+12/20Vdc and -12/20Vdc) operate at the 12 volt level whenever the transport is not rewinding. When the transport rewinds, the servo supply voltages are increased.

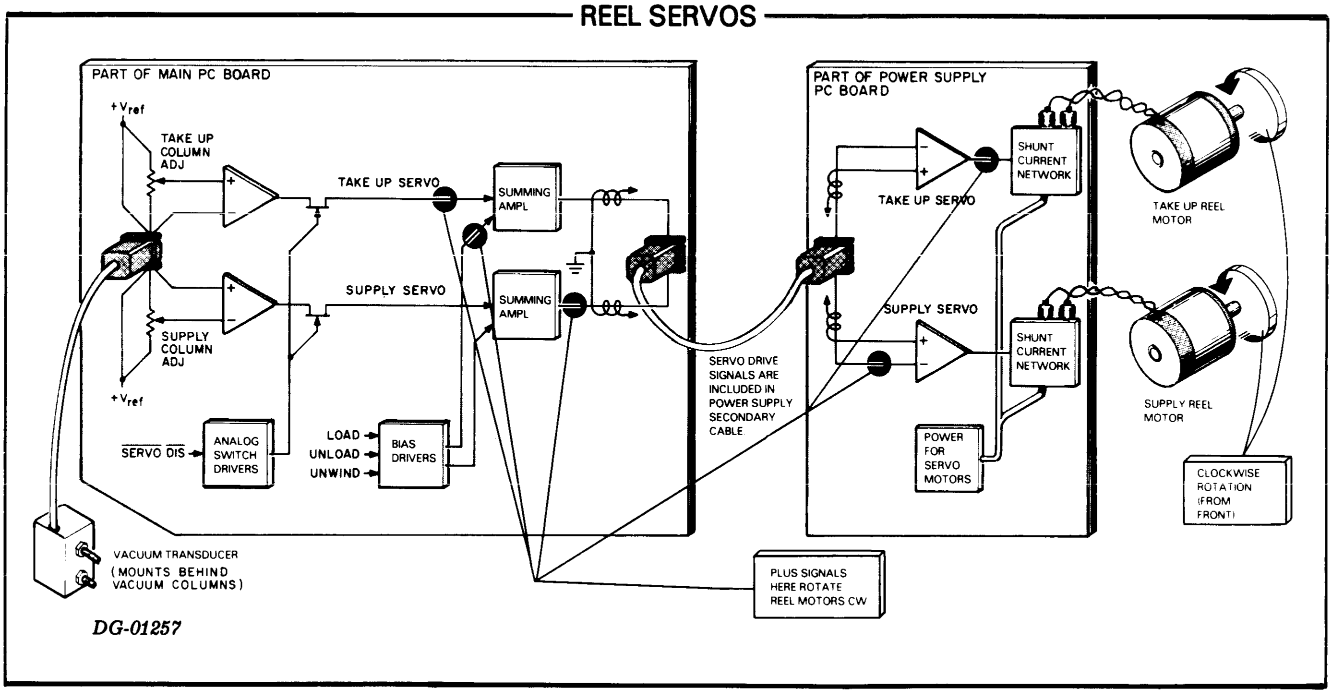
REEL MOTOR DRIVER



DG-01255

Signal Polarity and Motor Rotation

The diagram on this page shows the direction a reel motor rotates for the signal polarity at various locations in the reel servos.



DG-01257

V

CAPSTAN SERVO

The capstan servo system contains a capstan motor and its summing/driver amplifier, a tachometer, tachometer preamplifier, and motion and ramp generators. There are separate ramp generators for rewinding and for 75ips tape movement.

On this page, there is a functional diagram of the capstan servo system. The diagram also indicates the location of the servo elements within the transport. Servo operation is briefly described in the next few paragraphs; then each of the major servo elements is described in more detail within the chapters that follow.

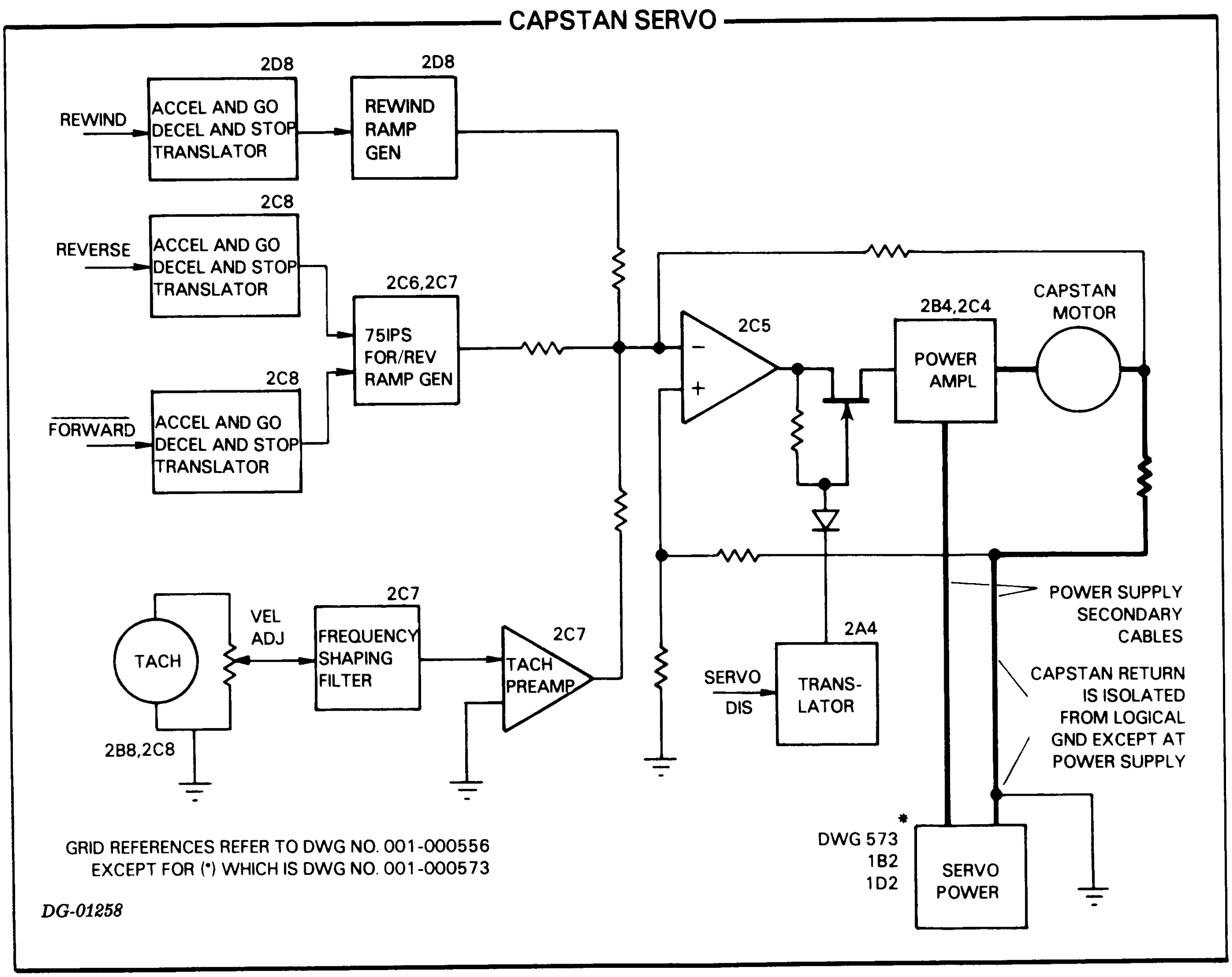
All motion of the tape past the transcription head is initiated and controlled by the capstan servo. Tape wraps 180 degrees around the no-slip surface of the capstan, and whenever the capstan motor turns, the tape moves accordingly.

TTL signals within the transport assert and initiate forward and reverse motion at 75ips or initiate rewinding at 200ips. The binary signals act through translators to apply certain voltage levels to the ramp generators. The ramp generators use these voltages to precisely control the acceleration and deceleration of the capstan.

There are two ramp generators. One ramp generator controls acceleration to and deceleration from 75ips, while another performs the same functions for rewinding.

An error signal from the tachometer, proportional in magnitude to the velocity of the capstan, is used to accurately control the speed of the capstan motor. The error signal is subtracted from the output signal of the ramp generator in the summing/driver amplifier. The resultant servo signal is amplified through a current amplifier to spin the capstan motor.

An analog switch in the summing/driver amplifier disables the capstan servo and stops the capstan motor if there is a failure in the transport servo-mechanisms.



Motion Selection and Ramping, 75ips

Acceleration and deceleration for all 75ips tape movements are initiated within the transport's local control logic through the action of two signals: FORWARD and REVERSE. When either signal asserts, a translator applies an appropriate reference voltage to the input of the 75ips ramp generator. When the reference voltage is positive, the capstan accelerates the tape forward and continues moving while the reference voltage is present. A negative signal causes reverse motion.

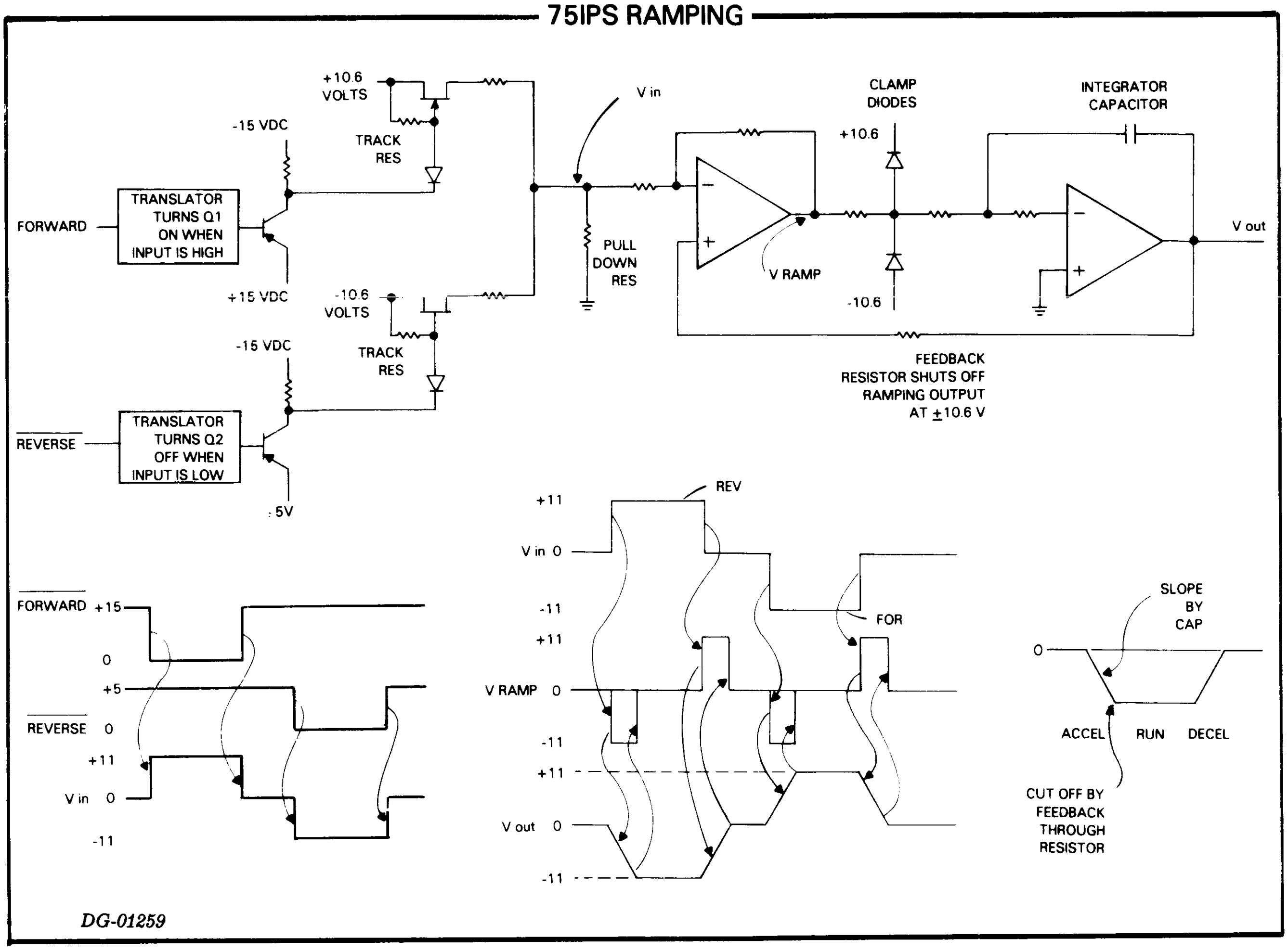
When a motion control signal asserts for any 75ips tape motion, its leading edge causes the ramp generator to begin a precisely controlled voltage ramp from zero volts to the value of the reference voltage. The transition of the asserted signal to its false condition removes the reference voltage from the ramp generator, initiating a deceleration ramp to zero volts. Logical interlocks prevent control signals for both forward and reverse motion from asserting simultaneously.

The illustration on this page shows the functional organization of the motion selectors and the ramp generator for 75ips movements. The accompanying waveforms show the signals throughout the network and how they change in response to motion commands.

The ramp generator is a two stage, gain-of-one, amplifier with a precisely limited slew rate that converts the step-transition signal from the translators to a straight-line ramping transition. For accelerating and decelerating the capstan, the ramp-time is 5.0ms.

The first stage of the two stage ramp generator has an approximate gain of 1000. Because of this, a voltage signal from the translator drives the first stage into saturation and the clamping diodes hold the signal V ramp at plus or minus 11.2 volts. Feedback is applied to the first stage from the output of the ramp generator through a resistor as shown. When the ramp reaches 11.2 volts, the feedback will "turn off" the first stage operational amplifier (the inverting and non-inverting inputs will be the same, V ref voltage).

75IPS RAMPING



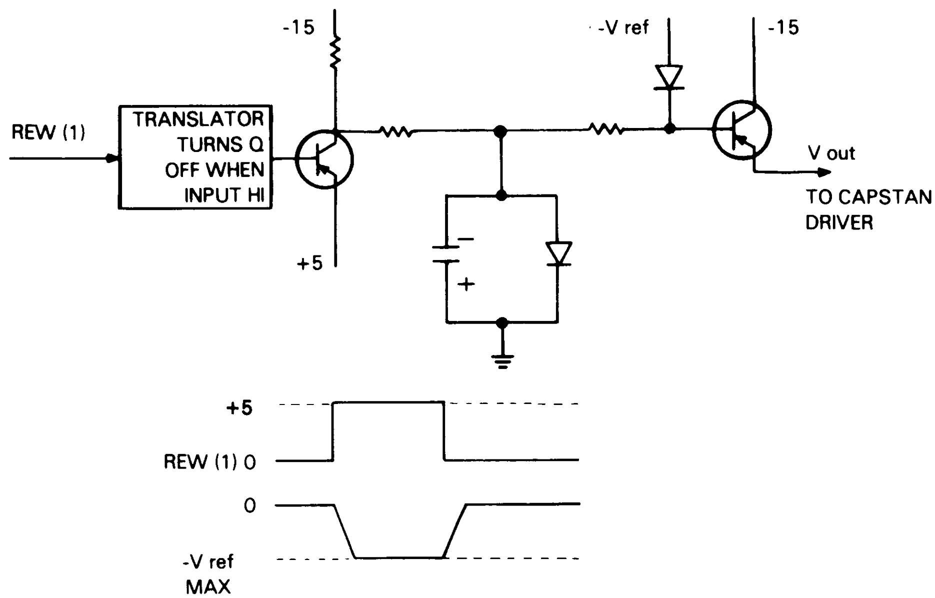
Motion Selection and Ramping, 200ips

Acceleration and deceleration for rewinding is initiated by the binary signal REW(1). When the signal asserts, a negative reference signal is applied to the ramp generator. The reference voltage is removed when the control signal goes false.

The ramp generator changes the step-transition output signal from the translator to an exponential ramp of about 500ms duration.

A functional diagram of the rewind selecting and ramping circuits is shown below with appropriate waveforms. The organization and operation is similar to that used for 75ips. However, the tolerances for rewinding are less stringent than for tape processing, and consequently, the feedback-controlled ramp circuits used for 75ips are not needed.

200IPS RAMPING



DG-01260

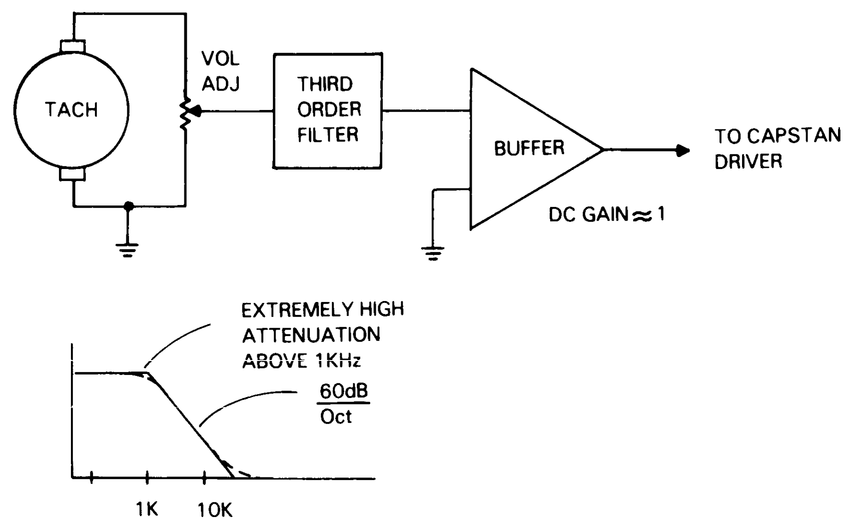
Velocity Control Tachometer

The tachometer, piggy back mounted with the capstan motor, generates an analog signal whose magnitude is proportional to the capstan's rotational velocity. This signal is used to calculate a servo error signal that controls the acceleration and deceleration of the capstan motor. The manner in which this is done is shown in the series of waveforms below.

In effect, the tachometer signal is subtracted from the reference signal of the ramp generator. When the capstan is initially at rest, the error signal that starts its motion is nearly the full output of the ramp generator. As the capstan begins to accelerate, the tachometer output increases and the error signal calculated in the servo diminishes. Eventually, the error signal will reach a minimum with the capstan rotating at the desired speed. (The error signal will never reach zero volts since some small amount of torque will be required by the motor to overcome friction.)

The organization of the tachometer and its preamplifier is shown below. The tachometer output is divided through a trimpot that provides an adjustment for setting the capstan velocity. The filter is needed to eliminate high frequency resonance between the capstan servo and the tachometer. The combination preamplifier and third order filter has a dc gain near -1 with flat response to 1kHz. Above 1kHz, the filter cuts off sharply (-60dB/decade), and effectively blocks all signals above 2kHz.

TACHOMETER FEEDBACK



DG-01261

Summing Amplifier and Motor Driver

The output signals from the ramp generator and from the tachometer are combined (summed) in the capstan summing/driver amplifier. The amplifier also controls the power supplied to the capstan motor. A functional diagram of the summing/driver amplifier is shown below.

Feedback to the inverting (-) input of the amplifier is taken from across a small resistor in series with the capstan motor. This signal represents the current through the capstan motor. That CURRENT feedback, rather than VOLTAGE feedback, used in this servo system is an important characteristic that distinguishes the operation of the capstan servo from the reel servos. Principally, it means that the error signal developed in the capstan servo represents how much the capstan motor must accelerate or decelerate; whereas the error signals in the reel servos represent the velocity and direction the motor must rotate.

(In a dc motor, the rotational velocity is directly proportional to the voltage applied across the armature, while the torque developed in the motor is directly proportional to the current through the armature. For a low inertia motor of the type used to rotate the capstan, acceleration of the armature will be nearly proportional to the developed torque.)

Since velocity is simply the integral of acceleration, the capstan motor is, in effect, an electromechanical integrator; its output (velocity) is the integral of its input (the armature current supplied by the summing and driving amplifier).

An important characteristic of an integrator is that its output is relatively insensitive to noise; likewise, the rotational velocity of the capstan is relatively insensitive to noise in the capstan servo, and this contributes favorably to the precision of the transport's tape velocity control.

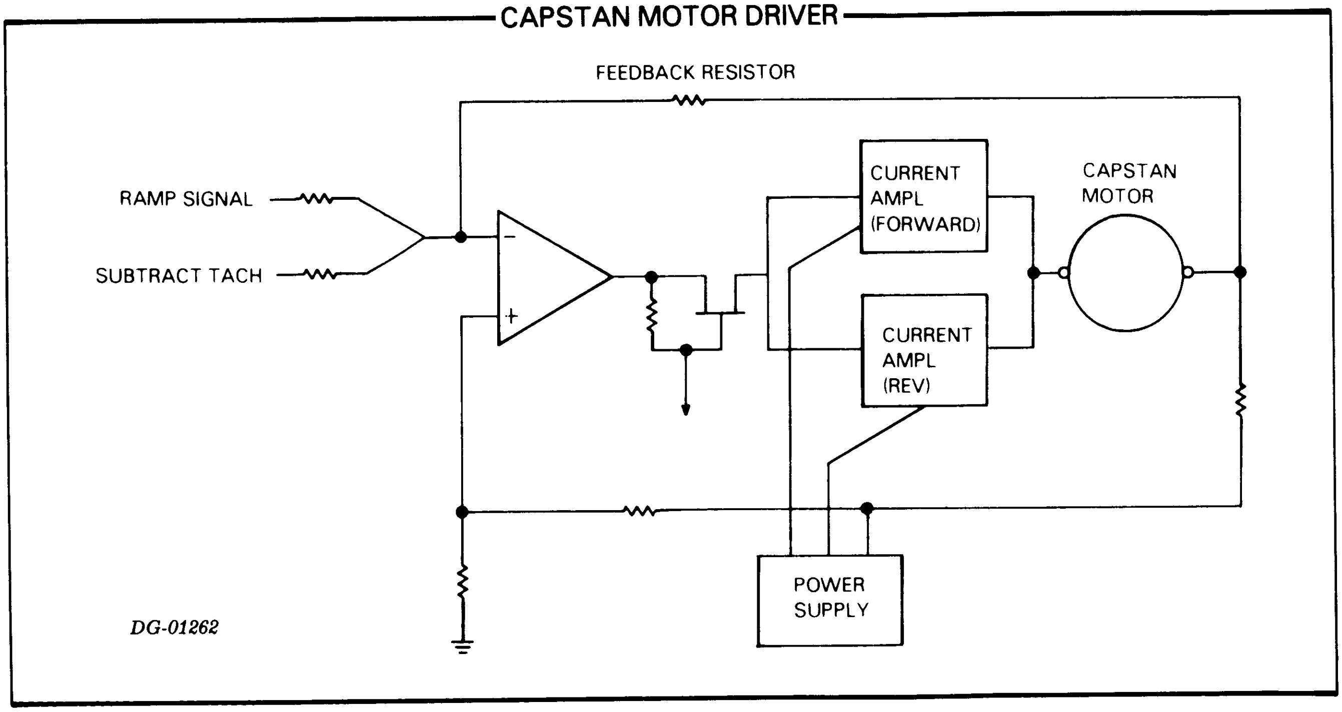
The feedback signal applied to the noninverting (+) input serves to cancel the effects of voltage drop and noise pickup in the cable between the power supply and the shunt current amplifiers.

The operation of an analog switch is described in detail within the section describing the reel servo preamplifiers. When the binary signal SERVO DIS asserts, the translator applies -15 volts to the gate of the analog switch, forcing it fully off. The circuit is then prevented from supplying current to the capstan motor. If the failsafe system disables the servos while the capstan is rotating, friction will quickly stop the motion.

There are two linear current amplifiers, identical in operation, that control current from the servo supply through the capstan. One amplifier controls positive current to the capstan; the other controls negative current.

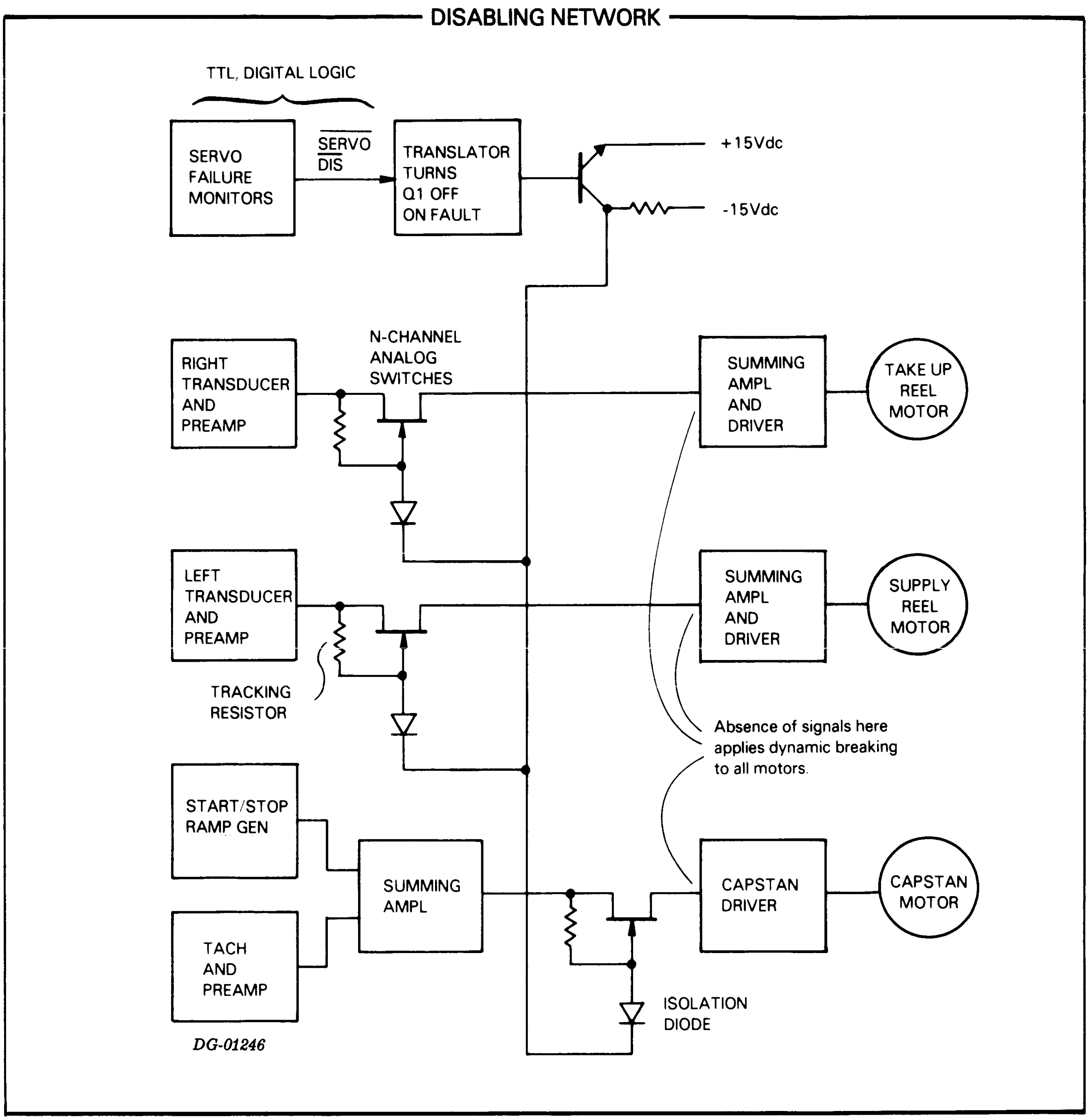
The power supply delivers power to the servos at either high (+20Vdc) or low (+12Vdc) voltage depending on the present transport operation. Low voltage is supplied whenever the transport is not rewinding. High voltage power is supplied during a rewind to provide additional power for the high speed motion.

CAPSTAN MOTOR DRIVER



SERVO DISABLING INTERLOCKS

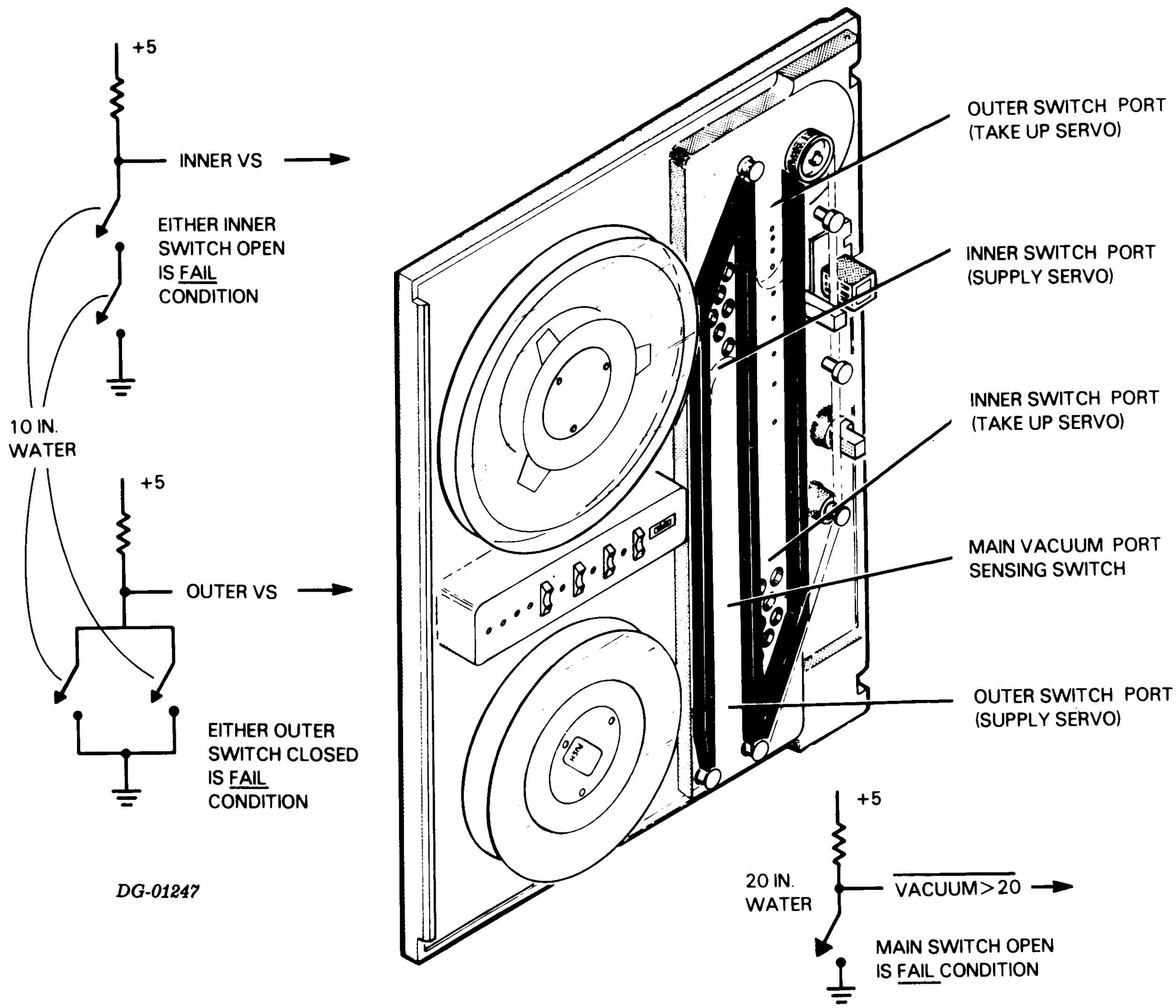
The transport servo interlocks monitor certain parameters in the servo systems and, in the event of a failure, they affect an orderly shut down of the systems in a manner that presents the least possible damage to the magnetic tape. If there is an incorrect voltage in any of the dc power supplies, an ac power interruption, a leak in the vacuum system or a failure in the servo amplifiers, the servo disabling system begins to shut down the servos. The vacuum is released, and the capstan and reel motors are dynamically braked (0 voltage is applied to each) to quickly stop all rotation. This leaves the tape slack and undamaged. A functional diagram of the interlock scheme is shown below:



V

There are five vacuum-sensing switches which are part of the servo disabling system. Four of the switches close at a vacuum of ten inches water; these switches detect excursion of the tape past the inner or outer extremities of the two vacuum columns. A fifth switch, closing at twenty inches of water, monitors the vacuum level in the primary vacuum manifold. The placement of the switches and their electrical configuration are shown below:

LIMIT SWITCHES



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CHAPTER VI
POWER SUPPLY AND DISTRIBUTION

INTRODUCTION

The 6026 transport power supply controls and converts ac supply power to low voltage dc for the transport circuits and servo motors. It employs a ferro-resonant transformer to provide the coarse regulation needed for the servo circuits and motors; series pass regulators provide accurately regulated voltages for the more critical circuits. An ac relay circuit enhances operator safety and convenience. It uses a low level control voltage to electronically switch ac power to the supply and blower. Finally, overvoltage and overcurrent detectors protect the supply and transport circuits.

SUPPLY SPECIFICATION

AC Power				
Voltage +10/-15%	Frequency ± 1 hz	Current Idle / Operating / Max		
100	60	3.5	5.5	6.5
120	60	3.5	5.5	6.5
100	50	3.5	5.5	6.5
220	50	3	4	4.5
240	50	3	4	4.5

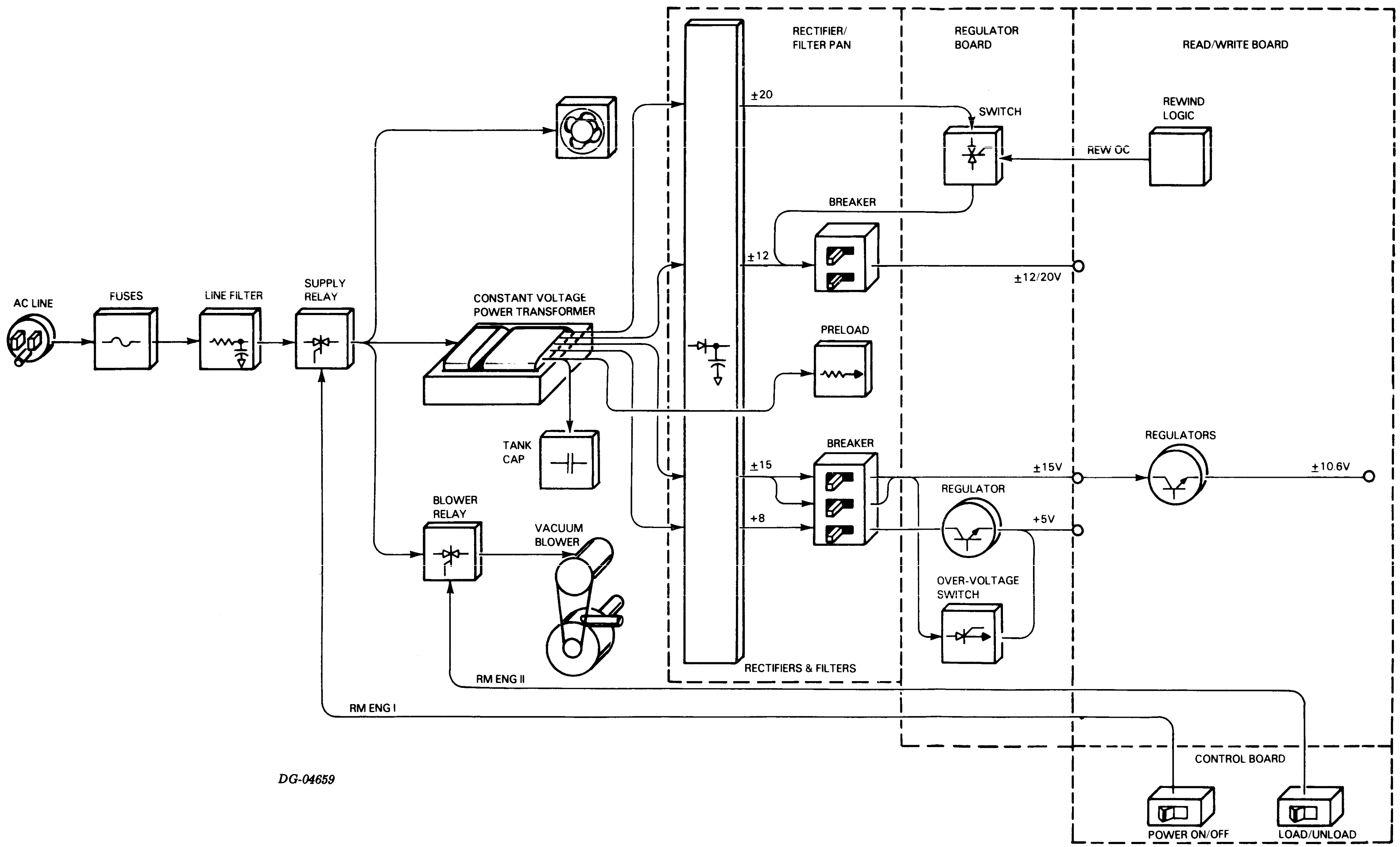
DC Power						
Voltage	Tolerance	Current Amps Max	Ripple Vpp	Regulator *	Source **	Destination
+12/20	10.5/18 to 13.5/22	17/4	1.5/0.5	xfmr	PS	servo motors
-12/20	-10.5/18 to -13.5/22	-17/4	1.5/0.5	xfmr	PS	servo motors
+15	13.5 to 16.5	2	0.8	xfmr	PS	servo amps
-15	-13.5 to -16.5	1	0.5	xfmr	PS	servo amps
+5	4.75 to 5.4	4	0.2	LS	PS (+8)	control logic
+10.6	± 5%	--	--	LS	R/W (+15)	servo pre-amps capstan servo
-10.6	± 5%	--	0.03	LS	R/W (-15)	servo pre-amps capstan servo
+V	3 to 24	--		none	PS	remote energ.

DG-04672

* refers to the regulation method
xfmr=ferroresonant transformer
LS= linear series pass regulator

** locates the source
PS=enclosure mounted power supply
R/W=read/write board
(the number in parenthesis indicates bulk supply voltage)

SUPPLY AND DISTRIBUTION BLOCK DIAGRAM



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CIRCUITS

The block diagram shows the major components of the power supply and distribution system. The ac input is shown at the left, and the regulated dc outputs appear at the right. AC power is fused and filtered, and connected to the ac relay module. The module produces a low level dc control voltage for the the panel mounted power switch. The switched control voltage energizes a solid state relay that connects ac power to the constant voltage transformer (CVT) and cooling fan. A second remote energize module routes power to the vacuum pump. (It derives its control voltage from the +5 VDC regulated output.)

The CVT outputs are rectified and filtered, and provide seven coarsely regulated dc voltages. The rewind logic controls a switch that allows the ±20 volt outputs to override the ±12 volt outputs; this provides increased voltage to the capstan and reel motors during a rewind operation. Preload resistors stabilize the CVT under light load conditions. A two pole dc circuit breaker prevents excessive current flow on the ±12/20 volt outputs, and a three pole breaker protects the ±15 and +8 volt outputs. Three linear series pass regulators provide additional operating voltages for the drive circuits, and an overvoltage crowbar opens the three pole breaker if the +5 volt output exceeds a preset limit.

VI

Fuses

The following table summarizes the fuse configurations:

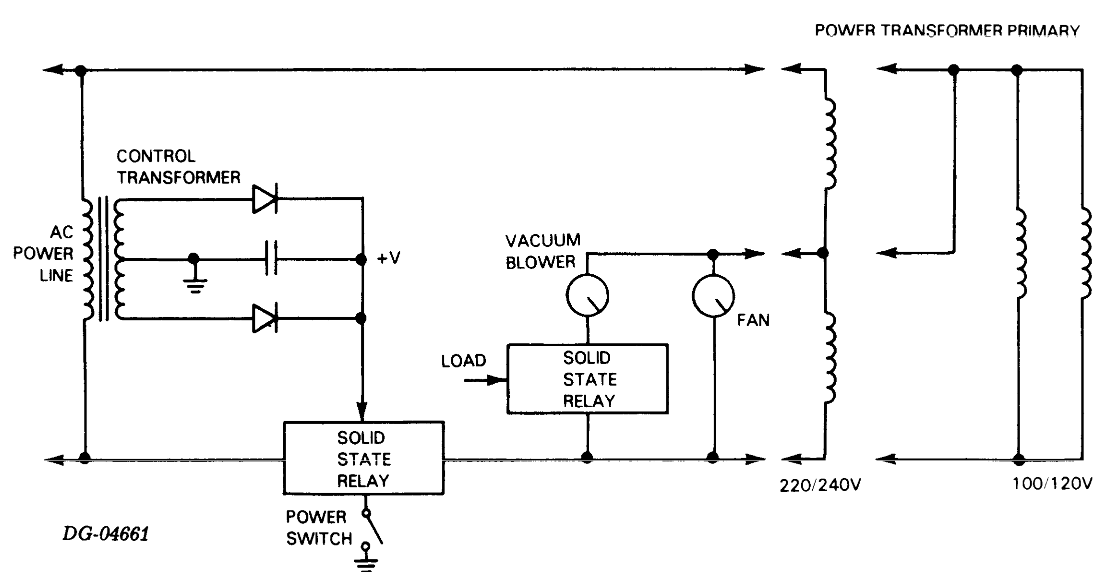
LINE VOLTAGE	FREQUENCY	NUMBER OF FUSES	RATING (AMPS)
120	60	1	8
100	50	2	8
220	50	2	5
240	50	2	5

The fuse(s) are accessible at the rear of the transport enclosure.

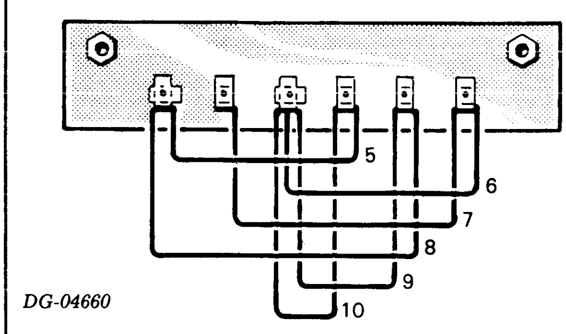
AC Relays

In the interest of operator convenience and safety, the ac circuits are energized from the operators panel using a low level dc control voltage. The ac relay circuits are shown in the following schematic diagram. The control transformer is energized whenever the transport is connected to the ac power line; it operates over the full range of line voltages. The transformer output is rectified and filtered to provide a low level dc control voltage. The power switch connects the control voltage to a solid state relay that energizes the CVT and cooling fan. The primary windings of the CVT are connected in series for 220/240 volt operation. In this configuration, the lower winding acts as an auto-transformer to provide 110/120 volts for the fan and vacuum pump. A second solid state relay energizes the vacuum blower when a tape is loaded.

AC RELAYS



POWER TRANSFORMER JUMPERS

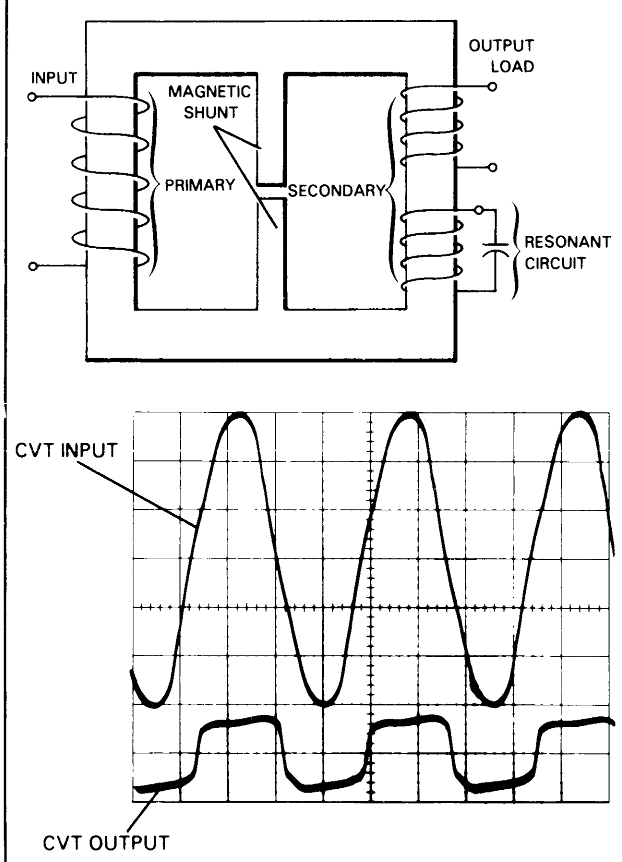


NOTE:
1. FOR 120 VAC 60Hz, ADD JUMPERS 5 AND 6
2. FOR 100 VAC 50Hz, ADD JUMPERS 7 AND 8
3. FOR 220 VAC 50Hz, ADD JUMPER 9
4. FOR 240 VAC 50Hz, ADD JUMPER 10

Constant Voltage Transformer

The structure of a constant voltage transformer differs from that of a conventional transformer. A magnetic shunt and resonant winding are added to control the flux linkage between the primary and secondary windings. When the primary voltage (and therefore the primary flux density) exceeds a minimum value, the resonant winding saturates the secondary half of the transformer core. This happens irrespective of the amount of current flow in the secondary windings. As the primary current rises, the additional flux is short circuited through the magnetic shunt, and does not link the secondary windings. This mechanism maintains a fixed secondary flux density, and regulates the secondary voltages. Because the secondary core saturates at the onset of each half cycle of the primary voltage, the transformer inherently limits current in the secondary windings and provides square wave outputs.

CONSTANT VOLTAGE TRANSFORMER



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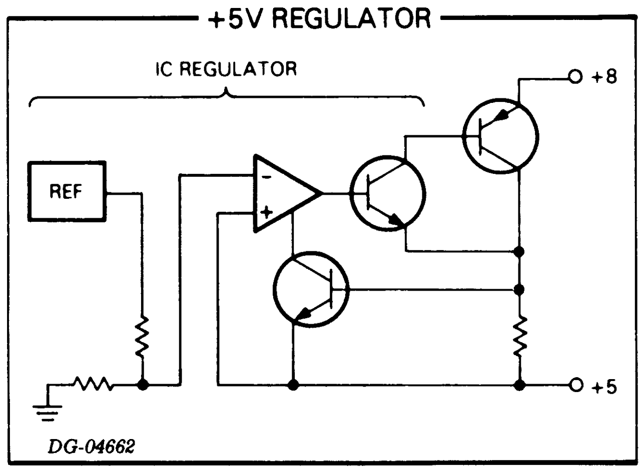
DC Grounds Isolation

Certain major branches of the dc grounding circuit are kept strictly isolated, save the one location where they are brought together. The write current return (WRITE GROUND), the capstan motor return (CAPSTAN GROUND), and the reel motor returns are isolated from all other dc grounds that are distributed and common throughout the transport. This eliminates the possibility of ground loop and common mode errors that could affect particularly the write circuits if strict isolation were not maintained. The ground returns join at the filter capacitor bus bar, which in turn is grounded to the transport enclosure.

VI

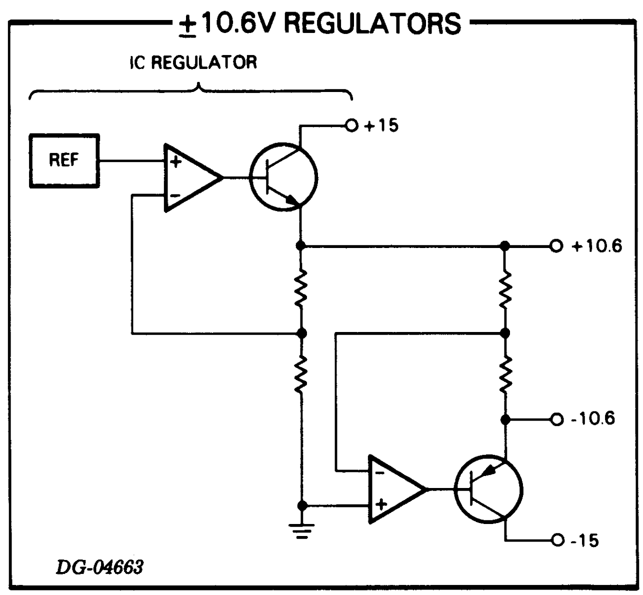
Voltage Regulators

The transport includes three voltage regulators. The +5 volt regulator is located in the power supply and the ±10.6 volt regulators mount on the read/write board. They are all variations of the linear series pass type, and are detailed below.



+5 Volt Regulator

The +5 volt regulator employs an integrated circuit that includes a precision reference and a comparator. The reference voltage is divided down to provide a nominal 5.2 volt reference for the comparator. The drive transistor controls the series pass transistor, and feedback to the comparator stabilizes the output voltage. A current sense resistor and associated transistor limit the output current to a preset maximum to protect the pass transistor from excessive power dissipation.



±10.6 Volt Regulators

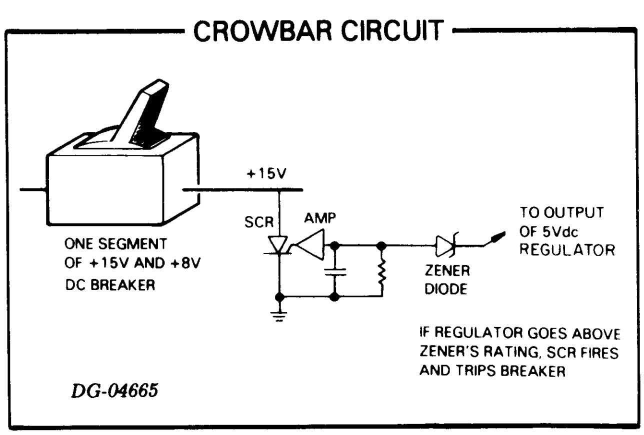
The +10.6 volt regulator is similar to the one described above. It dispenses with the external pass transistor and the current limiting circuit. The nominal 7.15 volt reference is applied directly to the comparator, and feedback from the output is divided to set the proper output voltage.

The -10.6 volt regulator employs an integrated circuit comparator and an external pass transistor. It derives its reference from the +10.6 volt supply. A resistive divider adds the reference and the output. The result is zero volts when the output is equal to but opposite from the reference. The comparator accepts a zero volt reference (ground) and stabilizes the output voltage. (The -10.6 volt regulator could be modeled as a unity gain inverting amplifier with a +10.6 volt input.)

Over Voltage Protection

Over voltage protection is applied to the +5 volt output to protect the logic circuits should the regulator fail. If the +5 volt output rises above approximately 6.8 volts, a zener diode forward biases an amplifier that fires a silicon controlled rectifier (SCR). The SCR short circuits the +15 volt output and trips the three pole circuit breaker, which disconnects ±15 volts and +8 volts, and thereby disables the +5 volt regulator.

As mentioned previously, the CVT transformer provides inherent over voltage protection on the ±12/20 and ±15 volt outputs.



APPENDIX A
DOCUMENTATION SUMMARY

DOCUMENTATION SUMMARY

MANUALS

015-000079	Technical Manual 6026 Tape Transport
015-000081	Technical Manual 6026 Tape Controller
015-000080	Technical Manual 6026 Tape Transport Field Service Maintenance Procedures
015-000021	Programmers Reference Manual for Peripherals
015-000028	Components Guide
010-000197	6026 Tape Subsystem Installation Data Sheets

PRINTS

005-008581	Documentation Package, 6026 Tape Transport
001-001128	Schematic, Power Supply
001-001157	Schematic, Console PCB
001-001158	Schematic, Read/Write PCB
001-001160	Schematic, Relay PCB
001-001175	Schematic, Tape Controller
001-001320	Schematic, Terminator
008-000433	Wire List, Vacuum Motor and Blower
008-000434	Wire List, Write Lock Switch
008-000435	Wire List, Power Supply Secondary
008-000436	Wire List, EOT/BOT Sensor
008-000440	Wire List, Capstan Motor and Tachometer
008-000441	Wire List, Transducer
008-002037	Wire List, Power Supply To Reel Motors
008-002038	Wire List, Supply PCB To Relay
008-002039	Wire List, Power Pan To Supply PCB
008-002040	Wire List, Power Pan To Transformer
008-002041	Wire List, Power Pan Internal Cable
008-002042	Wire List, AC
008-002063	Wire List, Fan Cable
016-000477	IPB
016-000439	IPL, Relay PCB
016-000451	IPL, Power Supply PCB
016-000547	IPL, Console PCB
016-000607	IPL, Read/Write PCB
016-000606	IPL, Controller PCB
019-000036	Mag Tape 10.5 Inch Reel

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APPENDIX B
CONTROLLER INTERFACE

The following table lists the signals that are exchanged between the tape transport and the tape subsystem controller when the unit is On Line.

Signal Name	Location at the Back Panel of a Data General Computer (The Tape Controller Slot)	Location at the I/O Connector of a DGC 6026 Series Transport
Motion Control Signals to the Transport		
RUN	A73	8
REV	B67	48
REWIND	B69	49
SEL 1	A75	7
SEL 2	A78	4
SEL 4	A79	19
Status Signals from the Transport		
TUR (unit READY)	B54	47
BOT	B53	46
EOT	B48	42
9 CH	A71	9
DENSITY 800	B49	43
REWINDING	B11	30
W.L. (Write Protected)	B36	39
DRIVE TYPE DM	A63	13
NTP (Trespass Error)	A81	20
LNH (Threshold Error)	A47	17
+5V		2
TERM PWR		44
Data Writing Signals		
WB. (P thru 7) (9 lines)	A59(P); A87(O); A85(1); A89(2); A84(3); A91(4); A86(5); B34(6); A83(7)	15(P); 26(O); 24(1); 27(2); 21(3); 3(4); 23(5); 38(6); 27(7);
WRITE STROBE	A77	5
WRITE RESET	A57	16
WRITE (Enable)	A61	14
Data Reading Signals		
RB (P thru 7) (9 lines)	B38(P); B31(O); B40(1); B25(2); B27(3); B13(4); B15(5); B19(6); B23(7);	40(P); 37(O); 41(1); 35(2); 36(3); 31(4); 32(5); 33(6); 34(7);
READ (Enable)	A76	6
READ STROBE	A49	18

DG-04713

WRITE (low true) - enables the recording circuits if there is a write ring on the supply reel.

READ (low true) - enables the read lines to send data and strobes.

RUN (low true) - causes tape motion in the direction specified by the REV signal.

REV (high true) - if high, the tape moves at 75 ips in reverse when RUN is issued. If low, the tape moves at 75 ips forward when RUN is issued. If high, the tape unloads when REWIND is issued. If high, selects 1600 bpi PE when WRITE RESET is issued; if low, selects 800 bpi NRZI when WRITE RESET is issued at BOT when not reading or writing.

REWIND (high true) - rewinds or unloads the tape (see REV).

SEL 1,2,4 - selects transports. Each transport decodes the address and only the transport with its thumbwheel switch set to the current address will enable its drivers and receivers to communicate with the controller.

TUR (low true) - indicates that the transport is on-line and that the tape is loaded and stopped.

REWINDING (low true) - indicates that the transport is initializing to the load point.

WL (high true) - indicates that the supply reel has no write enable ring.

9 CH (high true) - is always high.

DENSITY 800 (high true) - when high, indicates 800 bpi NRZI mode is selected. When low, indicates that 1600 bpi PE mode is selected.

EOT (low true) - indicates that the transport has encountered the EOT marker. Remains true until the tape moves in reverse past the entire EOT marker or rewind is issued.

BOT (low true) - indicates that the tape is positioned at the BOT point.

RDP, RD0, ... RD7 - are the read data lines. In NRZI mode, these lines are high for one and low for zero. In PE mode, a high going transition at data time represents a zero, and a low going transition at data time represents a one.

READ STROBE (low true) - strobes NRZI frames to the controller.

WBP, WB0, ... WB7 - are the write data lines. A low level causes a flux reversal to be recorded when the $\overline{\text{WRITE STROBE}}$ signal goes low.

$\overline{\text{WRITE STROBE}}$ (low true) - strobes write frames to the transport.

WRITE RESET (high true) - causes the write circuits to return to the inter-record gap polarity. Selects low threshold reads when READ is true and WRITE is false. Also selects the recording mode when READ and WRITE are false, the transport is ready and the tape is at BOT (see REV).

DRIVE TYPE DM (low true) - when low, indicates that a 6026 drive is connected to the bus.

$\overline{\text{NTP}}$ (low true) - indicates an overskew condition in NRZI mode.

$\overline{\text{LNH}}$ (low true) - indicates a marginal read signal in NRZI mode.

TERM PWR - powers the controller bus terminator.

APPENDIX C
ANALOG BUILDING BLOCKS

OPERATIONAL AMPLIFIERS AS ANALOG BUILDING BLOCKS

The operational amplifiers used in the 6026 transport servo systems control certain mechanical systems by performing electrical analogs of mathematical operations like addition, inversion, integration, differentiation, and scalar multiplication. Each of these functions can be implemented by connecting an "ideal" operational amplifier in a unique configuration. This provides a set of building blocks with each circuit representing a single mathematical function.

Ideal Operational Amplifier

The symbol for the ideal operational amplifier is a triangle, pointing to the right to conform with the commonly accepted direction of causality flow:

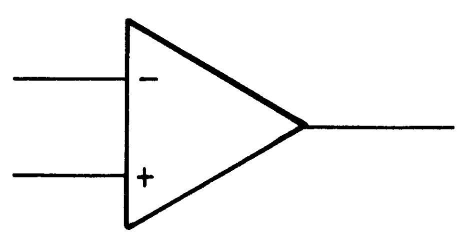
The gain of this amplifier is extremely high and its output signal will quickly reach a maximum (saturate) when there is merely a few millivolts or so difference between the input terminals (- and +).

Yet, the amplifier can be connected in certain configurations where:

a) the allowable input signal is not restricted to an amplitude of a few millivolts maximum, and

b) the amplifier circuit performs the mathematical functions scalar multiplication, differentiation, integration, and summation.

OPERATIONAL AMPLIFIER



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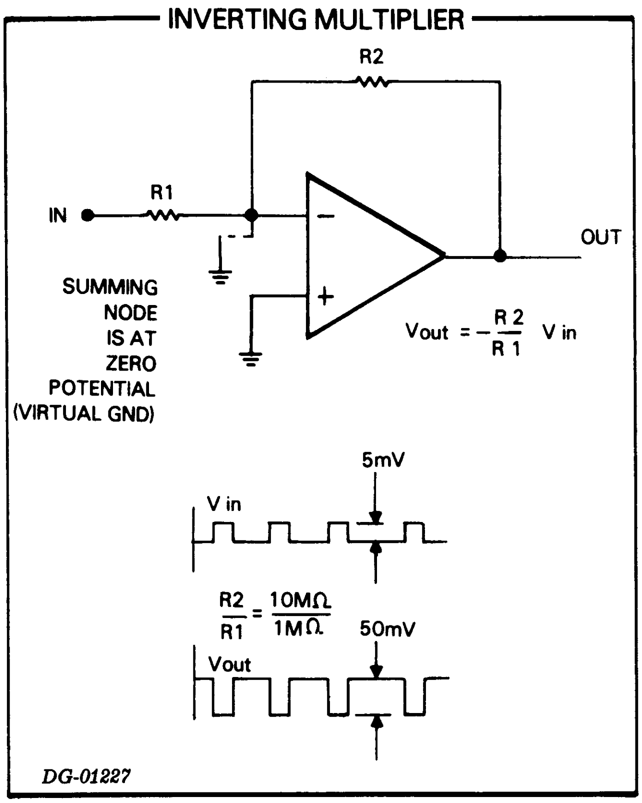
Scalar Multiplier

An operational amplifier can be connected to multiply a given input voltage by a constant scale factor. The output is usually inverted from the input signal. The inverting multiplier looks like this:

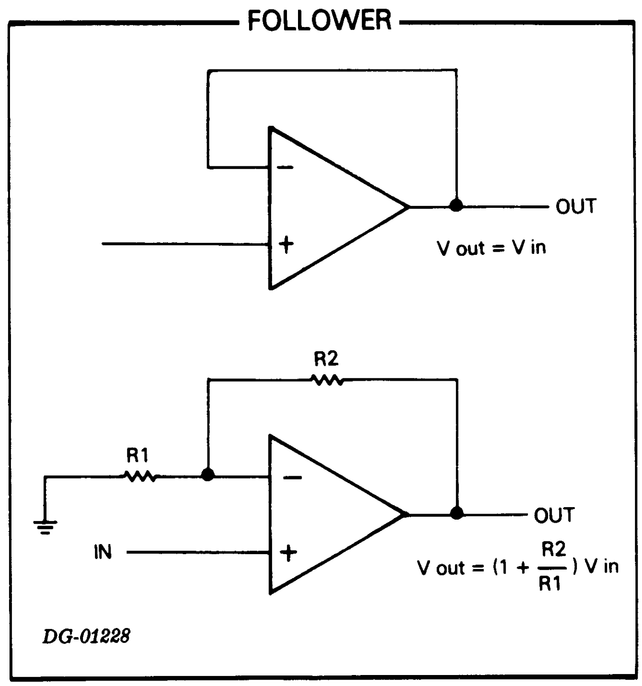


In this case, the gain is given by -R2/R1. If R2 is 10 megohm, and R1 is 1 megohm, and the input signal to the scalar is a series of positive pulses 5mV in amplitude, the output would be negative pulses of 50mV amplitude.

The summing node is shown at virtual ground only because the voltage between the two inputs of an operational amplifier must be very nearly zero to prevent the amplifier from saturating. In this case, the noninverting (+) input is grounded. (If the noninverting input (+) were held at 2 volts, the inverting node (-) would be 2 volts also.)

Followers

A noninverting version of the scalar multiplier, called a follower, can be used for isolating various amplifier stages and for drivers. There are two versions of the follower, the gain-of-one follower, and the follower-with-gain. This drawing shows how the followers are formed:

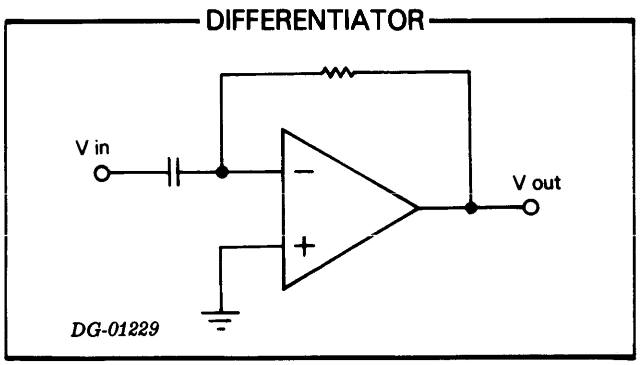


An important characteristic of the unity gain follower is that the output signal is independent of the values of input series resistors. (In the scalar amplifier, the input resistance and its component tolerance directly affect the output signal.) This characteristic makes the follower useful as an inexpensive, and precise, isolation or driver amplifier that doesn't require precision components.

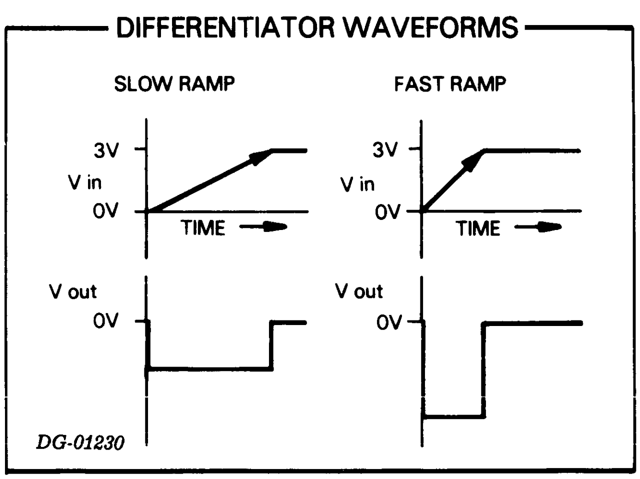
This independence from input series resistance is equally true for followers constructed around a single operational amplifier as well as for ensembles of operational amplifiers which, as a group, behave like a follower. (An example of such an ensemble is the 75ips ramp generator in the capstan servo.)

Differentiator

One of the analog building blocks performs the mathematical function differentiation. Differentiation of a signal yields a value that represents how fast that signal is changing. The differentiator is shown below.

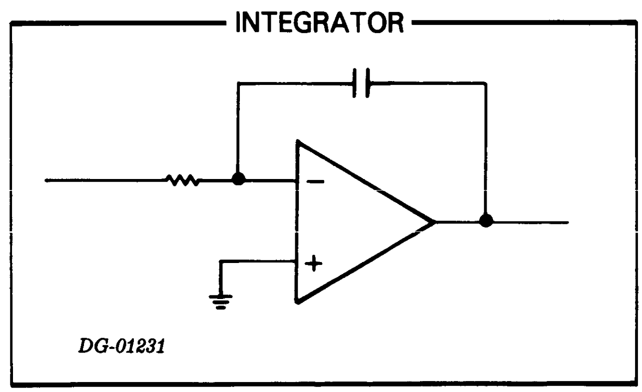


The waveforms below show how the differentiator's output might change for two similar (zero to three volt) voltage ramps that differ in rise time.

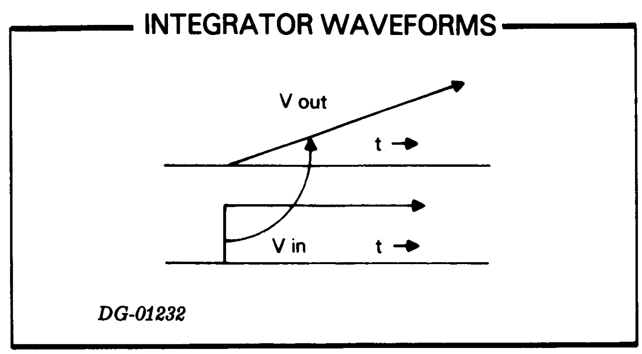


Integrator

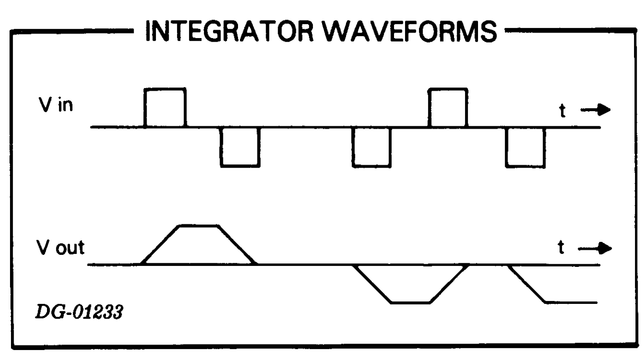
Another "building" block in the op-amp family used for analog functions is the integrator. In this configuration, too, the output is inverted with respect to input. The basic form of the integrator is this:



Assuming, for the moment, that the output voltage of this circuit is initially 0 volts, the output of the integrator for a constant voltage input looks like this:



And if the input signal is a square wave, the output of the integrator looks like this:

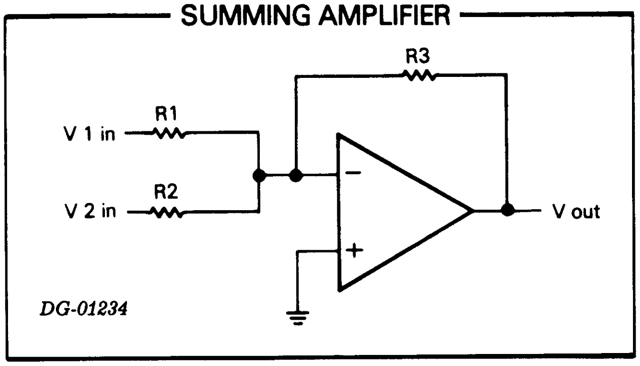


Summing Amplifier

The analog building blocks may have several inputs connected in parallel to the summing node. Each signal must be applied through its own input component (usually a resistor, but it may be a capacitor). The output signal of an amplifier with several input signals is the sum of the output signals that would occur for each input signal considered alone. Any analog building block with multiple, parallel inputs, is a summing amplifier.

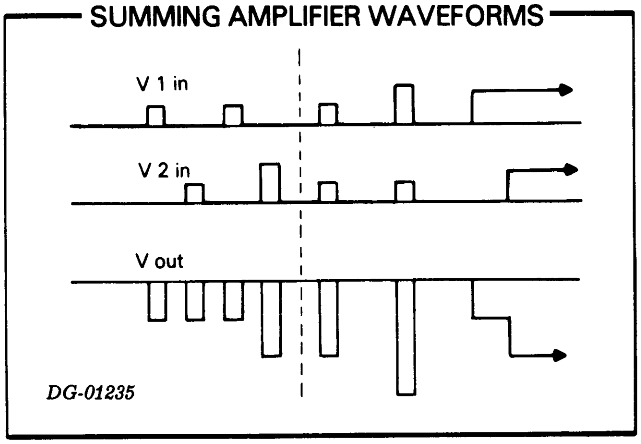
For example, this scalar multiplier has two inputs:

SUMMING AMPLIFIER



The waveforms below show what the output signal for this amplifier would be for the input signals shown. To the left of the vertical dashed line, one input signal is always zero so that the output for each input can be seen. To the right of the dashed line the input signals occur simultaneously and the combined output signal is shown accordingly.

SUMMING AMPLIFIER WAVEFORMS

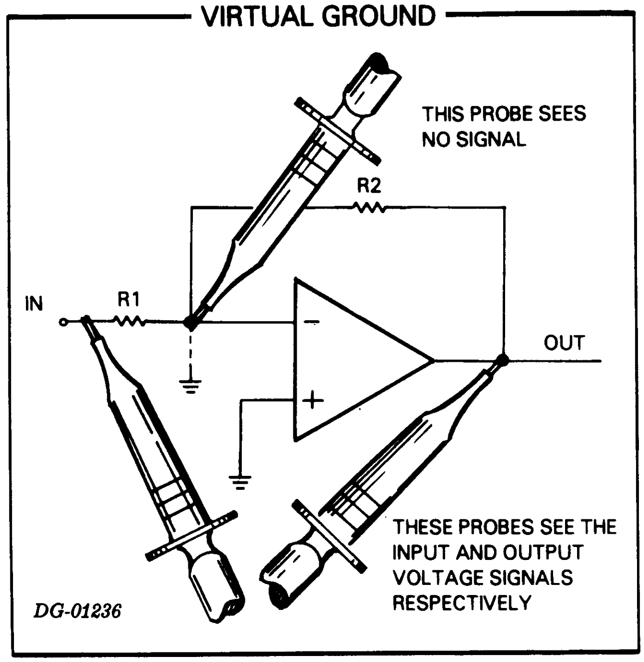


IMPORTANT CONSIDERATIONS

There are certain important considerations that apply to operational amplifier circuits:

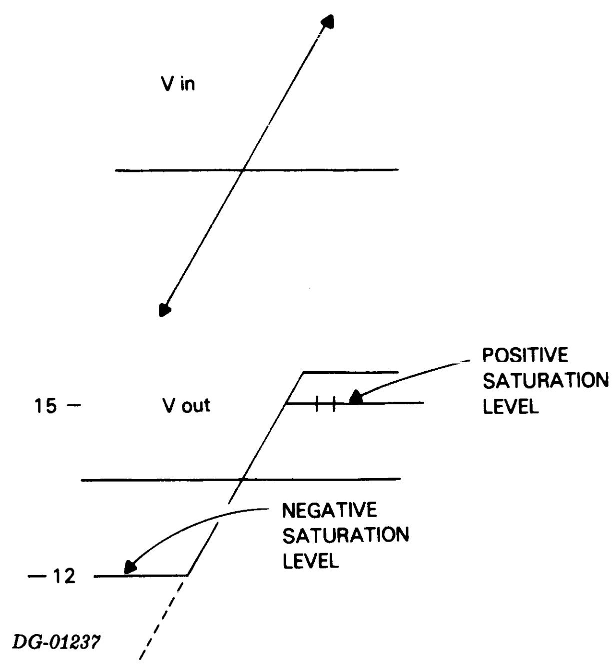
1. The input node (sometimes called the summing node) of any of the operational amplifiers described here is, by necessity, at very nearly the same potential as the noninverting (+) terminal. In many cases the amplifier is connected single-ended, that is, with the noninverting input (+) grounded. (For example, the oscilloscope probe connected to the summing node in the example below would show negligible voltage at that point.) However, the virtual ground, when shown in a drawing, implies an OPERATING constraint and NOT an actual electrical connection.

VIRTUAL GROUND



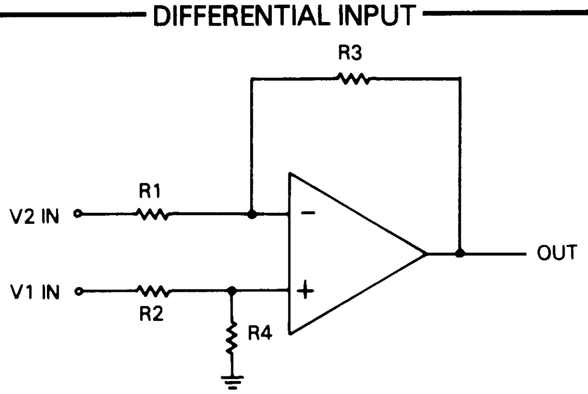
2. The output signal of an operational amplifier cannot exceed a saturation value. That value usually approximates the supply voltage from which the amplifier operates. (For example, an amplifier connected to +15Vdc and to -12Vdc will follow its predicted output response only in the range from -12 to +15 volts, as shown below.)

AMPLIFIER SATURATION



3. Input signals to all of the building blocks described to here have been shown single-ended, that is, the input and output signals have all been stated relative to ground, or zero volts. It is possible and often useful to combine the use of the noninverting and the inverting inputs of an amplifier to perform a mathematical function on a signal not referred to ground. (The differential input is particularly well suited for minimizing the effects of spurious pickup in cables.) A building block with differential input is shown below; it is basically an inverting multiplier and a noninverting amplifier combined in one circuit.

DIFFERENTIAL INPUT



WHEN R1 = R2 AND R3 = R4, THEN;
V OUT = R3/R1 (V2-V1).

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AMPLIFIER STABILITY

Analog circuits can become unstable under certain conditions. The analog blocks previously described use feedback signals to realize their mathematical functions, and control of that feedback is necessary to preserve the amplifier's stability. The irritating, ear-piercing, squeal that often occurs in public address systems is an example of what can happen when feedback becomes uncontrolled.

The descriptions of the various analog building blocks presented in the previous sections are elementary and do not reflect the difficulties encountered when such a circuit is built using real components. There are two areas where departures from the simplified descriptions can - and often do - cause instabilities. These areas are:

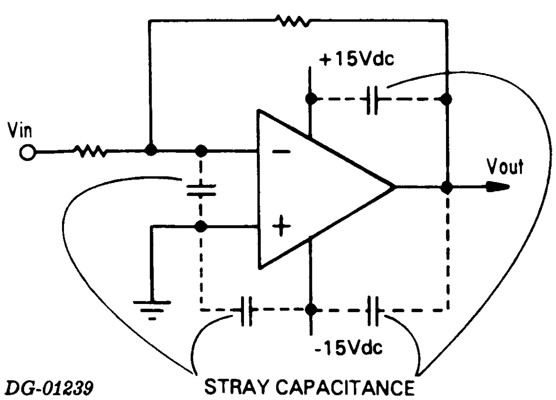
1. The environment: The circuits described do not show the small amount of capacitive pickup that always exists between the etched conductors (including power leads) on a printed circuit board.
2. Inside the integrated op amp chip: There is no "ideal" op amp. Manufacturers usually design such amplifiers for general purpose applications. These amplifiers are optimized to behave nearly "ideal"-ly only over a certain range of signal conditions.

Compensation techniques are available to prevent feedback instabilities from originating in either of these two areas. External compensation reduces the likelihood of instabilities arising in an amplifier because of stray pickup in the circuit environment. Internal compensation matches the integrated circuit's "ideal" range most closely with the signal conditions of the circuit.

External Compensation

Stray capacitance among the etched conductors on a printed circuit board can effect circuit performance by coupling part of the output signal of an amplifier back to the noninverting input (+) of the same amplifier. If at any frequency, the amount of stray coupling to the noninverting input exceeds the feedback to the inverting (-) input, the amplifier will oscillate or ring. This illustration shows some possible paths of capacitive pickup in a typical analog block. Clearly, the magnitude of the capacitively-coupled signal through any stray pickup path increases with frequency. For this reason, amplifier instability is usually recognized as spurious ringing.

STRAY CAPACITANCE



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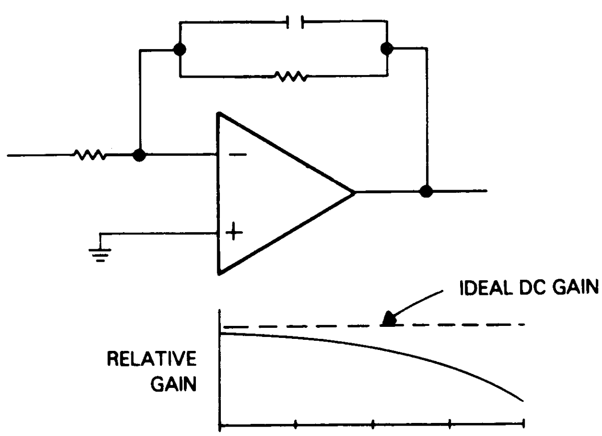
External compensation consists, therefore, of increasing the coupling for high frequency signals to the inverting input so that it will always dominate the positive feedback that may be spuriously coupled to the noninverting (+) input. This can easily be done by adding a high pass filter in the negative feedback loop of the multiplying, differentiating, and summing blocks. (In effect, the high pass filter already exists in an integrator.) A side effect of this compensation is somewhat reduced gain at high frequency, but this is usually ignored.

COMPENSATED AMPLIFIER



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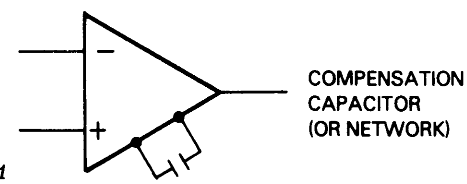
Internal Compensation

A pair of terminals are provided on most integrated op amps for compensating internally-caused instability. General purpose integrated operational amplifiers consist of several micro-circuit amplifiers, internally connected so that the overall amplifier performance best approaches the ideal operational amplifier described in the previous chapter.

These internal connections can cause instability under certain operating configurations. The special terminals allow a compensating network or component to be added that optimizes the operation of the amplifier for the configuration in which it is being used.



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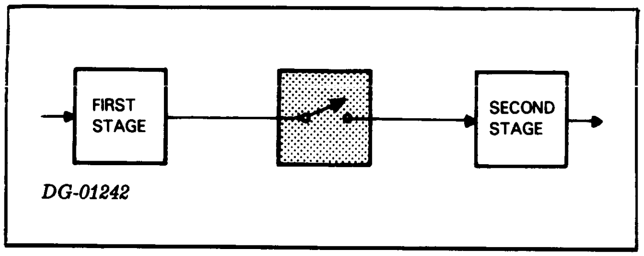
ANALOG SWITCHES

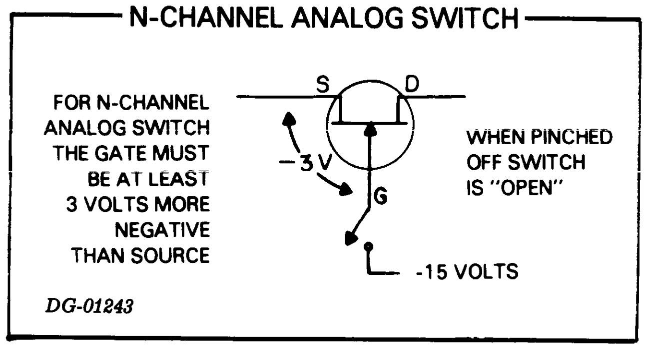
While the transistor can often be used as a switch, two special semiconductor devices provide superior switching for handling analog signals. These devices are the P-channel and the N-channel Field Effect Transistors (FET's) or analog switches. Analog switches are used in the transport's failsafe system to disable the servos when a failure is detected. They are also used to switch bandwidth in the read electronics.



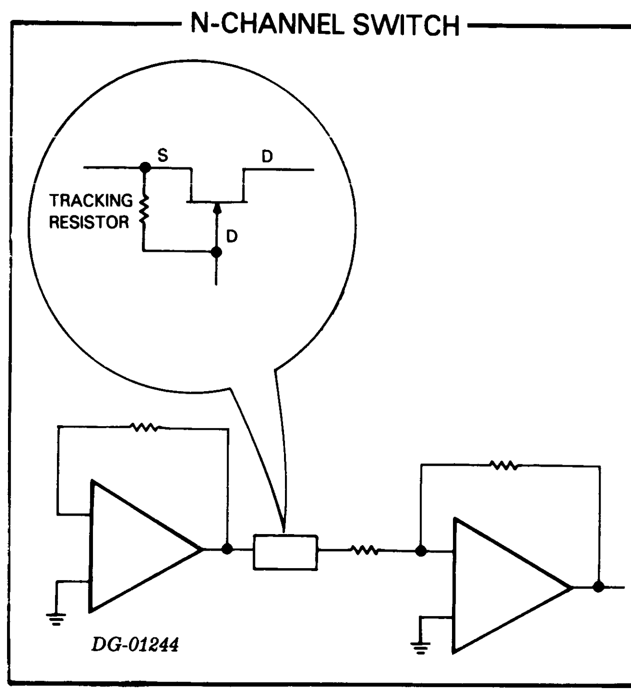
When the switch is open, the signal from the first stage is disconnected from the input to the second stage.

N-Channel Analog Switch

The important parameter in the N-channel analog switch is the "pinch-off" voltage. This is the minimum voltage that must be applied between the source and gate terminals of the FET to force the switch fully OFF, as shown below.



The analog switch is fully on whenever the voltage from source to gate is 0 volts (or some more negative voltage). When that voltage swings into an intermediate range (i.e., between 0 and 3V), the switch is in an indeterminate state which generally varies from device to device. A reference resistor is often used to force the switch's gate to track with its source. The tracking resistor forces the source-gate voltage to remain at precisely zero volts whenever the gate's driving circuit is not forcing the switch fully off.



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APPENDIX D
GLOSSARY OF TERMS

Azimuth - the angle of tilt from a vertical line. The recording head must be adjusted to align it perpendicular to the tape.

Bit - a binary unit of information. A bit can assume two values, zero or one.

Block - another name for record.

BOT - beginning of tape. A reflective marker denotes the start of the recording area on the tape.

BPI - bits per inch. The density of bits on the recorded tape.

Byte - a character of information containing eight bits.

Capstan - a wheel that rubs against the tape and pulls it backward or forward across the recording head.

Character - another name for byte. (9 track format).

CRC - cyclic redundancy check. A method for detecting transcription errors whereby the data record is divided by a selected polynomial and the remainder is retained as a checkword.

CVT - constant voltage transformer. A transformer that automatically regulates its secondary voltages over a range of line voltages and loads.

Deskew - an electronic method for eliminating skew.

EOT - end of tape. A reflective marker denotes the end of recording area on the tape.

FCI - flux changes per inch.

File - a group of records that make up a contiguous packet of information.

File Mark - a special record that signals the beginning of a new file.

Frame - one byte of information plus parity. (9 track format).

ID Burst - a code recorded at the beginning of the tape to identify that the information is recorded in PE mode.

IPS - inches per second. Refers to the speed of tape movement.

IRG - inter-record gap. An area of erased tape between records.

Load - pull the tape into the vacuum columns and advance the tape to BOT.

LRC - longitudinal redundancy check. Even parity accumulated along the length of a track.

NRZI - non return to zeros inverted. A method of encoding data that records ones as flux reversals.

Online - connected to and controlled by the controller.

Parity - a single bit error detection method that adds a parity check bit to the data to make the total number of ones either odd or even.

PCB - printed circuit board.

PE - phase encoded. A method of encoding data that records "ones" and "zeros" as flux reversals of opposing polarity.

Postamble - a recorded burst that follows a PE record.

Preamble - a recorded burst that precedes a PE record.

Record - a series of contiguous frames that make up a unit of information.

Rewind - return the tape to the BOT position.

Servo - a unit that positions a mechanical device in response to an electrical signal.

Skew - deviation of recorded information from a straight line perpendicular to the tape.

Snake - deviation of the tape from a true straight line.

Threshold - a voltage level a signal must exceed to be considered valid.

Transducer - a device that converts mechanical position to an electrical signal.

Unload - return the tape to BOT, shut down the vacuum system and pull the tape out of the vacuum columns.

Unwind - wind the tape onto the supply reel.

VRC - vertical redundancy check. Odd parity accumulated on a byte in a frame.

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ADDENDUM to 6026 Tape Transport Technical Manual

042-000033-00

This addendum updates manual 015-000079-00 to:

015-000079-01

See updating instructions on reverse.

Data General

This addendum updates this manual to include the following changes.

ITEM	DESCRIPTION
1	Change the manual number on the "Notice" page to 015-000079-01.
2	Insert the following note for reference: "The pictures in this manual are for reference only and may not show an exact visual replica of the product."
3	Add to picture on page opposite Page I-1 the following: "For specific interconnecting cable part numbers see 010-319."
4	References to 016-477 on Page III-1 should be ignored. This document has been discontinued.
5	Add the following note to the bottom of Page A-1: "Documentation numbers on this page are subject to change without notification."