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SADDAS; a self-contained analog to digital data acquisition system.

Walter Anton Petersen
Portland State University

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AN ABSTRACT OF THE THESIS OF Walter Anton Petersen for the Master of Science in Applied Science presented May 17, 1968.

Title: SADDAS, a Self-contained Analog to Digital Data Acquisition System.

APPROVED BY MEMBERS OF THE THESIS COMMITTEE:

Jack Riley, Chairman

J. Richard Kerr

Selmo Tauber

William Boore

SADDAS, a Self-contained Analog to Digital Data Acquisition System, converts analog voltage inputs to formatted BCD (binary coded decimal) digital magnetic tape. SADDAS consists of a 16 channel multiplexer, a 17 bit (4 digits + sign) 40 microsecond analog to digital converter, a 512 byte 8 bit core memory, a 30 IPS (inches per second) digital tape recorder recording at a density of 556 cpi (characters per inch), and a controller which integrates these instruments into a flexible and easy-to-use system. Sampling rates in excess of 360 samples per second may be used when converting seven channels of data, such as IRIG (Inter Range Instrumentation Group) analog magnetic tapes.

SADDAS

a

SELF-CONTAINED ANALOG TO DIGITAL DATA ACQUISITION SYSTEM

by

WALTER ANTON PETERSEN

A thesis submitted in partial fulfillment of the
requirements for the degree of

MASTER OF SCIENCE
in
APPLIED SCIENCE

Portland State University
1972

TO THE OFFICE OF GRADUATE STUDIES AND RESEARCH:

The members of the Committee approve the thesis of
Walter Anton Petersen presented May 19, 1972.

Jack Riley, Chairman

J. Richard Kerr

Selmo Tauber

William Boore

APPROVED:

Dr. Nan-Teh Hsu, Head, Department of Applied Science

David T. Clark, Dean of Graduate Studies and Research

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SADDAS

a

SELF-CONTAINED ANALOG TO DIGITAL DATA ACQUISITION SYSTEM

Walter A. Petersen

Department of Physiology

University of Oregon Medical School

INTRODUCTION

Background

A few years ago a medical research team had great need of a multichannel data acquisition and data processing system to investigate the neurophysiological basis of postural control. Postural control research up to that time was predominantly qualitative in nature, in that the raw data was mostly visual observation. Postural reactions elicited by a variety of positional situations, either natural or imposed, were qualitatively observed and recorded by skilled and dedicated investigators. However, they lacked the tools necessary to do quantitative postural control research.

Technological advances brought about by World War II lead to the development of sophisticated recording equipment, servo systems, and computers. With this armamentarium the researcher could now attack postural control mechanisms and its underlying neurophysiological basis in a quantitative fashion. Thus a new horizon in postural control research was opened up.

The essential tools for a quantitative approach to postural

control research are position, force, and angle transducers, multi-channel recording equipment, channel multiplexing and analog-to-digital converters, and a digital computer for data processing. Special transducers were conceived and built in the UOMS Department of Physiology. An FM tape recorder capable of recording channels to a band width of 20 kilohertz in the IRIG (Inter-Range Instrumentation Group) format was on hand. Lacking were analog-to-digital conversion equipment and a digital computer.

A supplementary research grant application was made to an appropriate federal agency to fund these necessary tools. Although the grant review committee recognized the novelty of the approach and the merit of the project, the request was not fully funded. The granting agency felt, and justifiably so, that they had already funded several computer installations in the vicinity that were not being utilized to their fullest capacity. Therefore, they provided \$20,000 to construct an interface to the then existing computers - an IBM 1410 and an SDS 920. The present thesis describes the evolution and implementation of this interface -- a self-contained analog-to-digital data acquisition system -- SADDAS.

Design Considerations

The computers initially available did not have electrical interfaces which were directly accessible to users. A direct tie-in to a computer's main frame was deemed impractical, since it was felt that substantial effort would be required to install an interface without causing multiple technical, practical, and legal problems with the

computer, its other users, and its manufacturer. Therefore, a very early decision was made to have a universal interface to all computers by transferring the data to the computer via binary coded decimal (BCD) digital magnetic tape. Since the actual interface to the computer would be via conventional media, the problems hopefully would be none.

Now that the basic needs of the researchers had been solved, in principle at least, by the conversion of seven track FM analog data tapes to seven track BCD formatter digital tapes, consideration was given to the other uses that such a system might have in a medical research environment.

It was recognized that FM tape as a recording medium for raw data was gaining in popularity, and therefore it was likely that a number of other investigators could make use of an analog-to-digital tape conversion system. Thus an additional design goal was to make the system easy to use, as well as easily available, to all those who needed such a capability. Secondly, it was recognized that the system required some rather expensive, but general purpose instruments, e.g.: an A/D (analog-to-digital) converter, a core memory, and a digital tape recorder. It is highly desirable that these expensive instruments not be totally dedicated to a single data conversion system, but that they be used for other purposes as well. Therefore, to the primary goal of digital conversion of postural control data were added two supplementary goals. First, easy accessibility and simplicity of use are necessary if other investigators with widely different problems are to use such a system effectively. Second,

efficient use of the dollars spent could be made if the instruments purchased had a utility beyond that of their principal function as system components. The fulfillment of these latter goals determined in large part the selection of specific system components constrained, of course, by consistency with the basic system philosophy.

THE "SADDAS" DATA ACQUISITION SYSTEM

System Philosophy

The principal purpose of SADDAS is the acquisition of data and its conversion to a form digestable by modern digital computers. In that computer time is expensive, it is very desirable that only meaningful data be presented to the computer. Thus, it is generally true that data must be edited (and/or condensed) if economical computer operation is to be achieved. Biological research, especially projects which are highly instrumental, can easily generate over-whelming amounts of raw data. Effective editing of the raw data during the conversion process is therefore essential. This editing phase is illustrated in Figure 1, Data Acquisition and Processing.

Figure 1 also illustrates the position and role of data processing in the cycle of research. Biological hypotheses are embodied in research paradigm - a model of what "might" be true. Experiments are designed to prove or disprove the hypotheses by collecting data which hopefully can support or reject the model. Disappointingly, often, the data only weakly supports or rejects the hypotheses. Given a clue, all-be-it small, the tenacious researcher, modifies his paradigm, asks a more incisive question, designs a new experiment, collects more data, and thus establishes a closed loop, or cycle, of research. Data acquisition and processing are essential elements of this loop and can be conveniently described, in Figure 1, as four phases: collecting, editing, converting and processing.

Figure 1.

Collecting Phase

In the collecting phase, raw data, hopefully manifest of the hypothesized underlying paradigm, is captured. In the past, this was usually a transient visual event and thus most often consisted in qualitative observation. Today sensitive instrumentation makes accurate quantitative observations routine, and methods of permanent recording makes the data accessible to many investigators and for years to come. Figure 1 schematically illustrates how the collecting phase consists of transduction of biological phenomena into electrical signals, and then the recording of those signals for subsequent analysis.

Editing Phase

As illustrated in Figure 1, the editing phase appears empty and inconsequential, but it is extremely important as it is the key to quality research. Significant results are made manifest, not by averaging all data - both good and bad - , but by skillfully correcting and/or validly excluding unreliable data.

Editing also consists of keeping track of the data and the conditions under which it was taken. For this reason SADDAS includes in it an ASR-33 Teletype for adding editorial comments to the data records at the time of A/D conversion. By placing the digital tape recorder in the incremental mode, comments typed in via the ASR-33 Teletype keyboard are written directly onto the digital magnetic tape as computer readable characters.

Converting Phase

The conversion phase consists of transforming the raw recorded data into a form suitable for analyses, or as labelled in Figure 1, processing. For hand-collected data, the conversion phase might consist of drawing a histogram or graph. For SADDAS conversion means converting multichannel continuous analog data to single channel discontinuous digital data. This requires simultaneous transformation of three facets of the data - 1: number of channels (7 to 1), 2: form (electrical analog to digital bits), and 3: time occurrence (continuous to periodic bursts).

Channel conversion of 7 parallel inputs to one serial output is achieved rather easily by using a multiplexer which periodically scans all channels sequentially and samples for a brief moment (5 microseconds) the data present on each channel. The multiplexer used in SADDAS can scan and sample 25,000 times per second.

Conversion of electrical analog signals to digital bits is accomplished by an analog-to-digital converter. With the SADDAS converter, accurate conversion to sign and four digits is accomplished in about 40 microseconds.

The most difficult conversion to accomplish was the timing - the analog data is continuous in time, the output of the A/D converter is continuous while converting (although it changes, every 10 microseconds), but the input to the digital tape recorder cannot be continuous. A convention in the computer industry is that computers read magnetic tape in blocks. A block (of records) is typically anywhere from 18 to 4096 characters in length. To delimit blocks, an

inter-record gap (IRG) consisting of no data for three-quarters of an inch must be written. The term "inter-record gap" was coined in the industry's infancy when a block typically consisted of a single record. During the time that an IRG passes the digital recording head, data cannot be read or written. Thus while an IRG is being formed a digital tape recorder cannot accept the serial output of an A/D converter. For an illustration of IRG's refer to the Magnetic Tape Format section of Figure 3. To solve this problem, a buffer memory is employed as a "catch-basin". Data from the A/D converter "passes-through" (i.e., is written into and read out of) the buffer memory on its way to the digital tape. During IRG's data is not read out of the memory. Therefore, data converted during the IRG accumulates in the buffer memory. When the tape recorder can accept data again, the accumulated contents of the memory are written to the tape.

The size of the buffer memory can limit the sampling rate of the system. Since the buffer memory accumulates data generated during IRG's, the digitized data rate (sampling rate $\times$ channel number $\times$ digits) must not fill up the buffer before an IRG is completed. The memory used in SADDAS is 512 8-bit bytes. Each channel sampled utilizes three bytes of memory. Thus, (if error (dropped data) is not to occur), only 170 data channel samples can be accumulated during an IRG. At 30 inches per second, an IRG ($3/4"$) lasts for $1/40$ th of a second. Thus the data rate limit through the buffer memory due to accumulation during IRG's is $40 \times 170 = 6800$ channel samples (4 digits + sign) per second. In terms of digital characters, this amounts to $4 \times 6800 = 27,200$ characters per second which far exceeds the writing

rate of the digital tape recorder used in SADDAS.

The digital tape recorder utilized in SADDAS operates in both an incremental mode (for adding editorial comments from a teletype) and in a continuous mode (for recording of the multiplexed and digitized data). At a tape speed of 30 inches per second and a recording density of 556 characters per inch, the peak recording rate is 16,680 characters per second. The effective rate is somewhat less due to the duty cycle factor imposed by the necessity for IRG's. This duty cycle is a function of the block length: $DS = BL / (BL + 417)$. With the conventional maximum block length of 4096, the duty cycle is 91% giving an effective recording rate of 15,150 characters per second. Of course, with shorter blocks, the effective rate is progressively lower.

The small block called CONTROL LOGIC is a controller and is the heart of SADDAS. It controls the multiplexer, the analog-to-digital converter, writing to and reading from the buffer memory, the formatting of the digitized data with the inclusion of data point identifiers, the generation of IRG's, and the operation of the tape recorder. Details of this logic will be discussed in the balance of this thesis.

Processing Phase

Referring again to Figure 1, the last phase in data acquisition and processing, is processing, or the actual analysis of data. The principle elements here are not instrumentation systems, such as SADDAS is, but cerebration and computational and data display assists,

such as computers and graphic devices. In Figure 1, the cerebration is embodied in "Questions". These questions are articulated in the form of computer programs which manipulate and display the data in a fashion that will hopefully manifest answers to the questions. Generally, the answers generate more questions, which then require more thought and additional experimental designs to elicit further answers. Thus, the cycle of research is closed.

As ultimately implemented, the digital tape recorder was also used to input BCD tapes to an IBM 1130 Computing System. The processing phase of Figure 1 illustrates this somewhat by having the BCD tape entering the SAC (Storage Access Channel) CHANNEL INTERFACE of the IBM 1130. The control electronics for the operation of the digital recorder as a computer tape transport and the electronic interface to the SAC CHANNEL is housed in the same electronics rack as the SADDAS, but is not actually an essential part of it. In the frontispiece, the tape control electronics and SAC interface is the rack (with handles) immediately below the tape recorder.

System Component Selection

The digital aspects of the data conversion problem are illustrated in Figure 2. Each channel of analog data is digitized into a 17 bit BCD format by an A/D (analog-to-digital) converter. This information must then be formatted and recorded into the six data tracks of a seven track digital magnetic tape recorder.

As discussed above, Figure 1 shows that the principle components of this conversion system are a multiplexer, an A/D converter, a

DATA RECORDS

7 TRACK DIGITAL MAGNETIC TAPE

BIT C IS ODD PARITY
GENERATED WITHIN
THE TAPE RECORDER

C B A 8 4 2 1

556 BPI CONTINUOUSLY RECORDED

at 30 IPS $\Rightarrow$ 16.7 KHz $\Rightarrow T_c = 60\mu S$

or 10 IPS $\Rightarrow$ 5.6 KHz $\Rightarrow T_c = 180\mu S$

RAYTHEON MULTIVERter

16 CHANNEL MULTIPLEXER

17 BIT BCD A/D CONVERTER

-1
2
3
4 } NEXT CHANNEL = -1.234

12
12
12
12 } FILLER DIGITS USED WHEN DATA IS
NOT AVAILABLE

0000 } = 0000,0010,0101 = 37
0010 } 12 BIT BINARY DATA
0101 } POINT IDENTIFICATION

-6.
5
4
3 } CHANNEL #1 = -6.543

+2.
4
2
4 } CHANNEL #2 = +2.424

Figure 2.

buffer memory, and a digital tape recorder, all of which were purchased items. The logic for their control and the electronics necessary for format conversions, data identification, and for the individual interfaces to the purchased units were locally constructed with RTL integrated circuits and a liberal sprinkling of discrete active and passive components.

Multiplexer and A/D Converter

The Raytheon Multiverter was attractive for this purpose because it performs both multiplexing and conversion functions in only 5 $\frac{1}{4}$ inches of rack height. Accuracy (.01%), high speed (39 usec for four decimal digits, 31 usec for three digits), 16 analog inputs (expandable to 96), and cost (around \$7,000) were all convincing reasons for its choice. Seven channels of three digit data can be converted in less than one-quarter millisecond, which is essentially simultaneity for most biological data. It is also useful for several other "non-system" purposes. With very minor modifications to the circuitry of its front panel indicators, it can be made to function nicely as a free-standing BCD digital voltmeter. Furthermore, it is intended to form the analog to digital link in the eventual hybridization of an analog computer to a small digital computer. Because of these extra purposes, a BCD rather than a binary converter was selected.

Buffer Memory

As shown in Figure 2, the maximum continuous recording rate of a 30 IPS (inches per second) digital recorder writing at a density of 556 BPI (bits per inch, longitudinally) is one character every 60 usec.

Since the Multiverter can produce four characters in 39 usec, and may produce $6\frac{1}{2}$ characters (16 channels) in less than two-thirds of a millisecond, it is clear that some sort of a buffer is needed to temporarily store the Multiverter data output while the individual characters are written onto digital tape. Furthermore, there is the digital tape convention that demands IRC's and so there must be a data accumulator during the "gap time" of a recorder producing computer readable tape.

A 512 byte (= 3 bits) ferrite core memory (FX-12) manufactured by the Ferroxcube Corporation serves this purpose very nicely. Reading or writing a byte in 10 microseconds, it can interleave the storage of a Multiverter data and the retrieval of that data for writing to the digital recorder. Theoretically, 16,667 Multiverter words (4 digits + sign stored as 3 bytes) could be stored and retrieved per second ($16,667 \times 3 \times (10 + 10) \text{ S} = 1 \text{ second}$). This is certainly a sufficient amount of data points for virtually all biological phenomena. In fact, the data rate could be shared among eight or ten channels and the sampling rate would still be sufficiently high for most biological research.

The Multiverter word of Figure 2 is stored as three eight bit words in core. The first word contains the sign and the most significant byte (MSB), the next word, the next two bytes, and the last word the least significant byte (LSB). There is room in the last word for a flag which indicates that it is the last piece of data associated with a single sample data command. This flag is used to insert three characters of binary data point identification into the digital record, irrespective of the number of analog channels converted -- 3, 7,

or 16.

Several additional uses are planned for the core memory. In conjunction with the Multiverter and several D/A (digital-to-analog) converters, the memory will be used as a very flexible time delay generator for the analog computer mentioned above. With little additional electronics, it will be able to provide simultaneously several delays of different durations. The memory will play an important role in an off-line system for plotting digital computer data. Short segments of plotting instructions (such as would be sent to a CalComp incremental plotter) will be read into the core from the playback electronics of a digital tape recorder, which would then halt. The plotting instructions would be taken from the core at a rate compatible with the mechanical plotter. The core would then be reloaded with further commands by reading another plotting record from the tape recorder.

Digital Tape Recorder

The primary specification that the tape recorder must meet is an average writing rate of 10.1 kilocharacters per second. This figure was arrived at by considering the most extreme data rate to be expected of the postural control experiments. The postural stimuli are displacements of a platform on which normal dogs are quietly standing. Their reactions to the displacements constitute the data of the postural control experiments. These data are generally recorded on a seven channel FM analog tape recorder as illustrated in Figure 1. Visual observation of many dogs confirms that dogs will not tolerate fundamental frequencies in excess of 3 hertz. For each

fundamental cycle it is most desirable to record 120 data points (3° phase resolution and frequency components to almost the seventh harmonic). If this were done for each of seven channels and four tape characters were required for each data point (four digits with a sign "overpunched" by setting the A or B bit), the data rate would be $3 \times 120 \times 7 \times 4 = 10,080$ characters/second.

Since high speed tape transports and low cost are not bedfellows, a medium speed (30 IPS) transport (Kennedy Company's DS370R) was selected for the digital recording job. The 10.1 kilocharacters per second requirement dictated a bit density on the tape of 556 BPI. This combination gives a peak data rate of 16.7 KC/second, but the average rates are somewhat below this dependent upon recording block size. Most of the anticipated data rates are substantially below this, so a slower rate of 5.6 KC/second is also available via a two speed capstan motor, which operates at 10 IPS, as well as 30 IPS.

Generally, it is desirable to annotate the data records with some sort of a written comments, such as would be enterable from a Teletype keyboard. Therefore, an incremental transport was chosen for the digital recording job -- it could handle both the high data rates by operating continuously via a capstan, and also could write comments asynchronously with an incremental stepping motor. This incremental mode is also useful for very low data rates, where the asynchronous rate is below the maximum stepping rate of 300 per second.

Although the initial concept of the conversion system did not require playback of the digital tapes, read electronics were pur-

chased along with the tape transport. The principle reason for this was to inexpensively implement the offline digital plotting system mentioned above. It turned out that this was a very fortuitous decision, as it was subsequently necessary to use for data processing a computer that did not have a magnetic tape transport. Thus what started out to be a write only incremental tape recorder is now functioning as well as a low duty computer tape unit. The actual interface was made to an IBM 1130 via its Storage Access Channel (see SAC, Figure 1).

Alphanumeric Annotation

Many hundreds of experiments will be undertaken in the postural control studies. The magnetic tape format desired for these data is illustrated in Figure 3. Each experiment is bracketed off by tape marks, i.e., EOF's. Annotations to the data are recorded as header and trailer records. The header record consists of information such as -- the date, an experiment identification number, the type of experiment, transducer scale factors and offsets, the sampling rate of the conversion, etc. The trailing record might consist of specific conversion information, such as the number of data points sampled, the number of magnetic tape records written, and anything else the investigator may have thought about during the conversion.

By operating the tape recorder in an incremental mode, it is possible to add comment records to the digital tape in an asynchronous fashion from an ASR-33 Teletype keyboard. Figure 3 illustrates both the method of annotation and the details of the coding scheme. Basic-

COMMENT RECORDS

INCREMENTALLY RECORDED AT
556 BPI

THE SIX BITS OF A MAG TAPE WORD ALLOW 64 CHARACTERS. ONLY THE ALPHAMERIC CHARACTERS OF THE ASCII CODE ARE RECORDED BY USING ONLY THE LOWER SIX BITS AND DEMANDING THAT BITS 6 AND 7 BE MUTUALLY EXCLUSIVE.

MAGNETIC TAPE FORMAT

COMPUTER WORD FORMAT

Figure 3.

ally, the first six bits of the ASCII (American Standard Code for Information Interchange) code are recorded into the six data tracks of the seven track magnetic tape.

Teletype units operate serially with the marks and spaces of the code being signalled by the presence or absence of current passing through the unit. Since a digital tape recorder requires parallel information as input, a Teletype unit is not directly compatible with it. Therefore, a serial to parallel conversion must be effected between the two units. A model ASR-33 Teletype was modified to provide parallel operation compatible with RTL logic used throughout the SADDAS electronics.

Control and Formatting Electronics

The integration of the Multiverter, buffer memory, and digital tape recorder into the SADDAS system is accomplished by an electronic log package (a controller) that was specifically designed for this task. The heart and brain of SADDAS, the controller, is illustrated in the Frontispiece as the second rack with handles below the tape recorder. A more detailed illustration of its front panel may be found on the last page of Appendix II: Front Panel Lights and Switches. For a simplified block diagram of its operation, refer to the first schematic in Appendix I: BLOCK DIAGRAM.

The basic design goal was to have a conversion system that was extremely easy to operate. The extent to which this goal was met can be judged by the following operating instructions:

- 1) Turn the system power ON.

- 2) Select DATA mode (other options are TELETYPE mode and COMPUTER mode).
- 3) Place the tape recorder into the WRITE mode and select 10 or 30 IPS.
- 4) Select on the front of the Multivertex the number of analog channels to be converted (1 to 16).
- 5) Set the sampling rate generator to the desired number of samples/second.
- 6) Check that the IPS switch on the controller corresponds to the IPS switch on the tape recorder.
- 7) Push the controller START button to initiate data conversion and the writing of the digital tape.
- 8) Push the controller STOP button to cease data conversion and to bring the tape recorder to a halt.

Briefly, the sequence of events during data conversion is as follows: The controller and the computer interface share the same power supply, as they are never operated simultaneously. Furthermore, they both can control the tape recorder. The selection of the DATA mode (a switch installed in the Tape Recorder electronics rack) gives power and tape control to SADDAS's controller. It also connects the data outputs from the formatting electronics in the controller up to the tape recorder inputs, and also removes from these inputs the parallel data outputs from the Teletype which are used during the incremental (TELETYPE) mode of operation.

The parameters of the conversion, i.e., the tape speed, the number of analog channels to be converted, the sampling rate, when to

start and when to stop are all determined by the data and the interests of the investigator. Therefore, SADDAS cannot make these decisions for him. However, once he has made his choices, the actual conversion proceeds automatically.

Pushing the START button on the controller accomplishes three things: 1) it resets all of the counters, error indicators and format sequencers, 2) it allows sampling commands to pass to the multiverter, and 3) it starts the magnetic tape transport moving with an initial interrecord gap. On each conversion sequence of the Multiverter, the core memory is sequentially loaded with the converted data. Lack of coincidence between the loading and unloading core address counters is an indication that there is information in the core memory that has not been transcribed onto the magnetic tape. When this occurs, and if the core is not loading, the core automatically unloads the information sequentially into the MAG TAPE RECORDER FORMATTER (see lower right of BLOCK DIAGRAM). There it is formatted and written on to the digital tape at a peak rate of either 16.7 or 5.6 KC/second. Whenever the last character of the last channel of a sample point occurs (the core Memory word is flagged for this), the formatter inserts as three characters a 12 bit data point identification number. Periodically, the tape recorder catches up to the data output of the Multiverter. At that time unloading ceases and a filler digit (a binary 12) is written onto the magnetic tape (see Figure 2). Interrecord gaps (a longitudinal check character and three-quarters of an inch of uniformly saturated tape) are inserted automatically after a specified number of characters, both data and

filler digits, have been written. The number of characters, i.e., the record length is selectable by switches that are immediately behind the front panel of the controller. Normally, this number is 4096, but it is settable anywhere from 1 to 4096.

Pushing the STOP button removes the sample and convert commands from the Multiventer, and thus no more data is loaded into the core memory. When all of the core load has been transcribed onto the magnetic tape, there is probably a substantial portion of a tape record left. This is filled with filler digits, and the transport comes to a halt at the next interrecord gap. The investigator then has the option of placing an end-of-file mark (EOF) on the tape, or incrementally writing a comment (by selecting TELETYPE mode), or possibly changing the conversion parameters and continuing to convert data.

For ease of construction and maintenance the SADDAS controller is made out of four by five inch circuit cards which plug into a cage of sockets rack-mounted behind the controller's front panel. The individual cards are mostly socket mounted RTL integrated circuits with some additional semiconductors and passive components. Connections on the cards were made in a point to point fashion with teflon covered wire. Numerous test points and status lights were included in the design, so that any maintenance required could be speedily done.

CIRCUIT DESCRIPTIONS

Block Diagram

The SADDAS Block Diagram is an attempt to simply and schematically relate the multitude of connections (approximately 400) that connect the major components and functional elements of the system. On the North, East, West and South of the logic cards are, respectively, the Multiverter, the core memory, the digital tape recorder, and the controller's front panel. The first three components are free standing units (i.e., not part of the controller) and are suitably displayed as bold blocks. The Sampling Rate Generator is semi-bold as it is a necessary (but external) item. There is a selectable 1, 10, and 60 hertz pulse generator available on the power supply rack, which is used mostly for system test. Normally, for data conversion purposes, a small bench top pulse generator (Tektronix 114) is used.

In the center of the block diagram, the major logic circuits are given functional names. The letters in the upper-right hand corner of these blocks signify the logic card on which the circuit may be found. The broad lines on the sides of these functional blocks keys them to their closest related system component (N, E, S or W).

Parallel data paths are shown as two lines with half-head arrows and an intervening number stating the number of parallel paths. If the parallel data paths are the digitized analog data then the half-arrowed lines are bold, otherwise they are thin-lined. Control and status information are shown with full-headed arrows. Direct control rates solid lines, while indirect control, feedback, and status are only dashed lines.

General Concepts

The electronics in the controller of SADDAS performs two generalized functions:

- 1) Interfacing to and between the electronics of the other system components and
- 2) Sequencing all of the system components so that the right signals, and only the right signals, occur at precisely the right times.

Function 1) is relatively easy to achieve, in that all that must be done is to keep track of polarities, voltage levels, current requirements, impedances, the details of proper grounds, and shielding. Function 2) is substantially more difficult in that there is a great deal of interaction between the system components - certain signals must be generated after specific events, but only if certain conditions are met, etc. The difficulty of the two tasks might be likened to stacking bricks as compared to juggling bricks. To help understand the "juggling act", the following concepts should be born in mind.

Any procedure consists of three parts - a beginning, a middle, and an end. In control instrumentation, circuitry is designed to do those tasks which are necessary during each of these periods. In the case of SADDAS, at the beginning counters and shift registers must be initialized, and the digital recorder must begin moving tape. During the middle, analog data must be sampled, digitized, accumulated temporarily in the buffer memory, retrieved, formatted and written to the tape recorder - all in a coordinated fashion. At the end, data

sampling must stop, the remaining accumulated data must be written out, and the tape transport brought to a halt in the conventional fashion.

The circuitry associated with starting and stopping a conversion can be understood if the characteristics of the multiverter, buffer memory, and tape recorder are known and by some diligent study of the SADDAS schematics. However, the circuitry which coordinates data sampling, converting, accumulating, formatting and writing to the tape recorder requires some additional explanation.

Basically, there must be coordination between two asynchronous timings - the sampling rate applied to the Multiverter, and the writing rate clock for the tape recorder. This problem is compounded by three additional factors. The digitization rate of the Multiverter (approximately 10 microseconds per digit) exceeds the character rate of the tape recorder (60 microseconds). Secondly, the tape recorder cannot continuously record due to the requirement for IRG's. Lastly, the 17 bit digitized output of a Multiverter channel input must be reformatted into the six data bits contained in a seven track tape recorder character.

The electronic solution to these problems follows:

As each channel is sampled and digitized, the 17 bit output of the Multiverter is placed in a 17 bit holding register on Card I. These 17 bits (a sign and four digits) are subsequently formatted for the memory and the tape recorder as follows:

		SIGN				DIGIT 1				DIGIT 2				DIGIT 3				DIGIT 4						LAST	
		+ -		8 4 2 1		8 4 2 1		8 4 2 1		8 4 2 1		8 4 2 1		8 4 2 1		8 4 2 1								CHAN	
																								FLAG	
MVBIT:		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17							*
																									*
1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8		
CORE BYTE 1								CORE BYTE 2								CORE BYTE 3									
		B	A	8	4	2	1	8	4	2	1	8	4	2	1	8	4	2	1						
TAPE CHAR 1								CHAR 2				CHAR 3				CHAR 4									

For loading into the core memory Card I formats the 17 bits into three 8 bit bytes -- the sign and MSD (most significant digit) into the first byte, the next two digits into the second byte, the last digit and an end of sample flag into the last byte. A plus sign is coded as a hexadecimal 2, and the negative sign as a hexadecimal 1, and it occurs only on the last channel of any sample set. These three bytes are selected (i.e., connected from Card I to the buffer memory's interface on Card H) and then loaded sequentially into memory by a three bit shift register (U7, U8, U13) and LOAD circuitry on Card D. This sequence happens for each channel of a sample set in an unbroken fashion; that is, the buffer memory is totally dedicated to loading when Multiverter conversion is in process.

On Card B there is an address coincidence circuit which detects non-coincidence of loading and unloading addresses. This occurs when there has been more data loaded into the memory than has been unloaded. Thus, there is data in the memory that has not yet been retrieved and written to the tape recorder. If the tape recorder is not generating an IRG, and if the Multiverter is not loading the memory, and if there is non-coincidence (U9 and U10 on Card B), then unload memory and write character circuitry is activated (Card D). First a data point iden-

tifier is written onto the tape. As illustrated in Figure 2, the data point identifier is characteristically identified on the tape by having data bits A and B on. The identifier itself consists of three sequentially written hexadecimal digits (= 12 bits) for a total possible count, without repeating, of 4096. These three hexadecimal digits are written under the control of a three bit ID shift register (U16, U17 and U23 on Card D) which sequentially selects (Card E) the appropriate four bits of a 12 bit counter distributed over Cards F and G. The initiation of data point ID writing occurs on Card B where non-coincidence (which makes the COINC line low) initiates the generation of a BYTRST pulse. This initializes the ID shift register (Card D) to select the first of the three hexadecimal digits. The ID shift register establishes and maintains the DIRECT shift signal on Card D. This allows generation of SHIFT pulses (Card B) to carry the ID shift register through its three states. At the completion of writing the data point identifier two events happen. A four bit write shift register (U18, U24, U29 and U34 on Card D) is initialized via the ID shift register C line generating a LDRST signal on Card B. Secondly, via the INDIRECT (indirect) flip-flop on Card D an UNLOAD memory one-shot is triggered on Card B. This causes the memory to be read at the Unload Address (Card G) and the first byte of a channel (sign plus 1st digit) is passed to the mag tape format register on Card E. The bit that is initialized into position 1(01) of the write shift register selects the appropriate data bits out of the format register (bits 3-8) to form the first of four data characters, which is then written to the

tape on the next clock pulse. The **INDIRC** flip-flop is maintained on by **W1** so the second byte is unloaded from memory. When the unload cycle has fetched the second and third decimal digit (**CYCOMP**), the Unload Clock signal (**UNCLK**) that advances the memory's unload address counter is also used in conjunction with the **INDIRC** signal (Card E-U15) to generate a **SHIFT** pulse to advance the write shift register. In position **W2**, the first digit of the second core memory byte now held in the format on register on Card E is written. Since the third digit is already present on Card E a **DIRECT** signal is generated on Card D which causes a **SHIFT** (Card B) to advance the write shift register to **W3**. The third digit is now selected and written. **W3** sets again the **INDIRC** flip-flop, and a core cycle places the third memory byte into the mag tape format register. The **CYCOMP** signal generates **SHIFT**, **W4** is selected, and the last decimal digit is written to tape.

At this point there are two possibilities: either there are more channels of the same data point to be written, or the last channel of a data point was just written. The resolution of these mutually exclusive states is accomplished on Card E with the generation of a **W4N** (normal) or **W4L** (last) signal.

The **W4N** signal calls for additional channels to be written to tape. On card E, **W4N** initiates an **UNLOAD** memory pulse and also causes a **WTRST** signal to reset the write shift register. These are identically the same events that occurred at the completion of writing the data point identifier. Therefore the subsequent process discussed above is repeated and four digits of another channel is written to the

tape recorder.

Eventually the W⁴L signal will be present and if there is non-coincidence of memory load and unload addresses, then the data point ID shift register is reset by the BYTRST pulse developed on Card B. The data point ID is written and at its completion, the C signal from the data point ID shift register initiates a memory UNLOAD via the INDIRC flip-flop on Card D, and also initiates a WRDRST signal on Card B. This is identical to the state initially discussed and also that created by W⁴N above (except that the three characters of a data point ID have been written). The logic then cycles through the three bytes of each channel's conversion if W⁴N's are encountered and inserts data point ID's when W⁴L's are detected.

The data writing process continues until coincidence is reached on Card B. The COINC signal blocks further generation of the BYTRST pulse. Thus the three data point ID characters are not written, more importantly an UNLOAD signal to the memory is not generated by data point ID completion, nor does the WRDRST signal initialize the write shift register. Data transfer has stopped! On Card E a circuit detects that neither data point ID digits nor data digits are being selected. This forces the mag tape formatter into a filler digit state, in which binary 12's are written to the tape.

To gain a more detailed understanding of the SADDAS circuitry, it is suggested that the Block Diagram be thoroughly understood first. Then details of circuit operation can be relatively easily gleaned from the schematics and the circuit functions briefly described in the next section. Liberal use of the Wiring Lists and the Signal Cross Reference in the appendices might make the task somewhat easier.

Circuit Card FunctionsCard A - Record Length Counter and IR Gap Generator

Four basic functions are performed:

- 1) The magnetic tape characters written are counted so that IRG's (inter-record gaps) may be inserted at the end of each data block.
- 2) IRG timing is generated.
- 3) LCC (longitudinal check character) gap timing is generated.
- 4) The number of tape records written is counted for display on the controller front panel.

The Record Length Counter consists of twelve bits and thus has a maximum count of 4096. Four switches on the back of the controller front panel sets the value to which the counter is initialized by the PLCRST signal. The counter counts WRITE signals until it overflows. The OVFLOW signal triggers a one-shot that sets the counter back to its initial value. It also triggers the IR Gap Generator and the LCC Gap Generator.

The IR Gap Generator is a simple one-shot with RC timing. There are two R's which are either open or connected to +3.6 volts in a mutually exclusive fashion. If the FAST line supplies current through the 1.2k resistor, the one-shot timing is 31 milliseconds. If the 3.9k resistor is used, the timing is 108 milliseconds. The IRGAP signal blocks (on Card B) the generation of the WRITE strobe to the tape recorder.

The LCC Gap Generator is a one-shot that operates identically to the IR Gap Generator. The 330/1000 usecond timing determines the

the position of the longitudinal check character trailing the data characters (approximately 5 characters later). The LCCSET signal resets (via Card S) the write-current flip-flops in the tape recorder, the action which actually WRITES the LCC.

The Record Number Counter is a simple counter which is initially set to zero at START time by the RESET signal. It simply counts record length counter overflows (OVTLOS) and displays the results via lights on the controller's front panel.

Card B - Synchronizer and Coincidence Generator

Four basic functions are performed:

- 1) Synchronization of memory unloading and the writing of data point identifiers and the data channel digits.
- 2) Control of the advancement and output gating of the load and unload memory address counters.
- 3) Generation of the WRITE strobe.
- 4) Generation of a memory address coincidence signal.

Synchronization of memory unloading and character writing is discussed in the General Concepts section above.

Memory address counter advancement occurs with the completion of a memory cycle (CYCOMP). The counter which is advanced is determined by an R-S flip-flop (U25) which holds the type of command last issued to the memory. The output gating of the memory address counters is established by Multiverter activity. The INJAM signal (Card I) sets an R-S flip-flop (U1) to the "loading memory" state. That flip-flop stays there until the Multiverter is finished at which time U1 is

reset by the Not LOAD'G signal that is reestablished on Card D by the MVS'YNC signal.

The WRITE strobe is generated by a one-shot (U11) driven by the CLOCK and gated (U6A) by a clocked derivative (U17 and U18) of the IRGAP signal.

The Coincidence Generator compares the state of corresponding flip-flops in the memory load and unload address counters. If any of the nine flip-flops do not agree the memory addresses are different and the coincidence is not achieved (COINC remains low).

Card C - Start/Stop Control and Clock

Four basic functions are performed:

- 1) Initializing all counters, format shift registers and error flip-flops.
- 2) Control of recorder tape motion.
- 3) Gating sampling commands.
- 4) Generation of a precision clock signal.

Resetting of many counters and error flip-flops can be accomplished manually (RSTPB). The Convert flip-flop (U5), set and reset respectively by the START and STOP pushbuttons, also automatically resets all the counters and error flip-flops. In addition the Convert flip-flop triggers a 1.2 millisecond CLEAR one-shot which blocks WRITE Strobe generation (U6A on Card B) while generating (U14 on Card D) pseudo-shift signals to clear out the format shift registers on Card D.

A Forward flip-flop (u2) controls tape motion. It is set by

the Clear one-shot and reset when the last LCC is written. The Data Gate Flip-flop, Coincidence, and the absence of a CLEAR pulse enables this final activity of a SADDAS conversion sequence.

Sampling commands are allowed (U14B) to pass to the Multiverter at the end of the initial IRG initiated by pushing START. Pushing STOP immediately removes sampling commands from the Multiverter. This ultimately will cause coincidence of the load and unload address counters, and thus enable the gate (U6) which will allow the last LCC to stop the tape transport.

The system's master clock (Q2, Q3) is a precision thermally compensated free running multivibrator with a period of 60 microseconds. It triggers a one-shot (U13) which has a selectable duration of 33 or 145 microseconds. In the FAST mode, each cycle of the multivibrator fires the one-shot and thus the 60 microsecond period is maintained. In the SLOW mode every second and third multivibrator period has no effect because the one-shot is already fired. Thus there is effected a 3 times division of the rate giving a period of 180 microseconds which is required for writing 556 cpi tape at 10 IPS. The master clock pulses are shaped by a 30 microsecond one-shot (U15) for generation of the CLOCK and Not CLOCK signals used throughout the controller.

Card D - Data Sampler and Shifters

Five basic functions are performed:

- 1) Cycling of the Multiverter.
- 2) Cycling of memory loading.

- 3) Data formatting of the Multiverter output.
- 4) Data formatting of the data point identifier counter output.
- 5) Data formatting of the core memory output.

Multiverter action is initiated by DDAIPL which triggers the MVSTRT one-shot to sample and convert the first channel. Subsequent channels are sampled by feedback from the multiverter (MVBUSY) triggering a one-shot which is gated by the MVSINC signal. Sampling and conversion of the number of channels selected on the Multiverter front panel proceeds automatically until the MVSINC signal indicates that the first channel is again selected.

Cycling of the memory loading is initiated by MVBUSY, continued through the second and third cycle by the CYCOMP signal, and is finally terminated by a gate (U5B) which allows the CYCOMP signal to pass only if a core format shift register (U7, U8, U13) indicates that there is data to be written.

Data formatting of the Multiverter output is accomplished by this same shift register. Initialized to select the first core byte by the MVJAM signal the register is shifted by a CYCOMP signal to select the second and third bytes.

Data formatting of the data point identifier is accomplished by U16, U17, and U23. Initialized by BYTRST the register selects the first hexadecimal digit. Selection of the second and third digits is effected by a SHIFT signal developed on Card B and discussed in the General Concepts section above.

Data formatting of the core memory output is accomplished by U18, U24, U29, and U34. Operation of this circuit is similar to that of

the data point identifier shift register.

Card E - Magnetic Tape Formatter

Five basic functions are performed:

- 1) Holding of the core memory output.
- 2) Detection of the last channel flag (WHL).
- 3) Gating of the converted data as decimal digits.
- 4) Gating of the data point identifier as hexadecimal digits.
- 5) Generation of a filler digit in the absence of any data to be written.

All of these functions are done in a straightforward manner and can be most easily understood by direct reference to the schematic. The gating functions are accomplished by the mutually exclusive signals W4, W3, W2, W1, C, B and A. In the absence of any of these signals, the character output is defaulted to a binary 12 state by the transistors Q1 and Q2 and associated diodes. During loading of the memory from Multiverter output, the character output is forced to a binary 12 by the signal FORCE developed on Card B.

Card F - Unload Address Counter

Three basic functions are performed:

- 1) Partial generation of the data point identifier.
- 2) Maintenance of the unload memory address.
- 3) Gating of the unload address to the core memory interface.

The last six of the twelve bits of the data point identifier are generated on this card by a simple counter. The first six bits are generated on Card G - Load Address Counter, which is an identical card.

Address maintenance is performed by a simple nine bit counter. Each UNLOAD command generated on Card B generates an UNCLK signal which is the clock input to the counter.

When the unload address is required the NOUNLD line goes low and thus allows gating of the counter output to the memory address circuits.

Card G - Load Address Counter

The operation of this card is identical to that of Card F - Unload Address Counter.

Card H - Memory Interface

Two basic functions are performed:

- 1) Memory address generation by OR'ing the gated outputs of the load address counter and unload address counter.
- 2) Interfacing (buffering) memory control, memory input and memory output signals.

The "boxy" connections on the schematic represents the memory cable which is hard wired to this card. The "arrowed" connections are those of the card's edge connector. The circuitry is straightforward and can be readily understood from the schematic.

Card I - Memory Formatter

Three basic functions are performed:

- 1) Holding of the Multiverter Output.
- 2) Gating of the Multiverter output as bytes for the memory.
- 3) Generation of the last channel flag.

The first two functions are straightforward and can be readily

understood from the schematic. The MWSYNC signal indicates that the Multiverter is looking at the first analog channel. Therefore, the last analog channel is currently in the holding register. Thus, when the third byte (C3) is written the last channel flag (a bit in COME-8) is written by AND'ing MWSYNC and C3.

Card J - Multiverter Interface

One basic function is performed:

- 1) Interfacing (buffering) multiverter input, output, and control signals.

The circuitry is straightforward. Details of the timing may be found in Reference 4.

Card M - Light Drivers

One function is performed:

- 1) Supplying lamp current to the controller's front panel indicator lights.

RTL logic does not have sufficient current capability to drive indicator lights. Therefore, transistors must be used as lamp drivers.

Card N - Error and Status

Three basic functions are performed:

- 1) Tape transport error detection.
- 2) Controller synchronization error detection.
- 3) Supplying lamp current to indicator lights.

Three types of tape errors are detected and locked into R-S error flip-flops. Transport errors (BOT, EOT, Broken tape), parity errors,

and echo check errors are all detected on Card S and pass respectively ENTERR, PARERR and ECODERR signals to the error detection flip-flops.

Synchronisation error checking is performed by U3, U4 and U7. Magnetic tape character 1 (M1) is tested against core byte 1 by checking that byte positions 1 and 2 (MB 1 and MB2) are zeroes. Tape character 4 (M4) is tested against core byte 3 by checking that byte positions 5 and 6 (MB5 and MB6) are zeroes. Magnetic tape characters 2 and 3 (M2 and M3) are tested (U4) against the probable presence of byte 2. The outputs of these tests are strobed by the write one-shot signal WAS. If an inconsistency is detected, the sync error flip-flop U8 is set.

This card also provides the interface transistors to the error and status indicator lights.

Card S - Tape Recorder Interface

Two basic functions are performed:

- 1) Interfacing to the -10 volt negative logic of the Kennedy tape recorder.
- 2) Comparison of the character sent to the recorder with the echo check received from the recorder.

The -10 volt negative logic used in the Kennedy DS370R tape recorder requires transistor level converters to interface with the RTL logic used throughout SADDAS. For the sake of completeness, all tape recorder lines were interfaces even though some of them were not used. Details of the meaning of all signals may be found in Reference 2.

Comparison of the character sent to the recorder with the echo received from the recorder by the character actually written is accomplished by EXCLUSIVE-OR circuits (U3, U4, U5, U6, U7, U10, U11) operating into a seven-input OR circuit (U2 and U9). If there is a mismatch, an ECOMER signal is generated.

RESULTS

Succinctly stated, the results are that SADDAS works. Over 4000 eight cycle trials (each with seven channels) have been digitized, yeilding therefore over 220,000 cycles of digitized data ($4000 \times 8 \times 7$). Each cycle has approximately 150 samples in it, so there has been in excess of 33 million data points digitized ($150 \times 220,000 = 33,000,000$). With four characters per data point, over one-eighth billion digits have been digitized and written to magnetic tape.

Figure 4 is a reduced computer listing of typical SADDAS output - data point identification followed by seven channels of digitized data. The input to all seven channels was a poorly regulated 5 volt power supply that had noise and sixty cycle hum on it, which explains the existence of all positive values of 5000 ± 50 millivolts.

The performance of the system is sufficient to meet the initial design goals. In converting seven channel IRIG (Inter Range Instrumentation Group) magnetic tapes sampling rates in excess of 360 samples per second may be used. This allows three cycle biological data to be sampled at a rate sufficient for 3° phase resolution, as was the initial design goal. When sampling fewer than seven channels, the sampling rate may be progressively increased: e.g., SADDAS will convert one channel at a rate in excess of 2000 samples per second.

REFERENCES

1. Ferroxcube Corporation of America. Core Memory System Series FX-12. Saugerties, New York. 1966. 47 pgs.
2. Kennedy Company. Model DS370R Incremental Magnetic Recorder. Altadena, California. 1966. 65 pgs.
3. Power Designs, Inc. Instruction Manual UPMD-6 Power Supply. Westbury, New York. 1966. 14 pgs.
4. Raytheon Computer. Technical Manual A/D 20-17BCD Multiverter. Santa Ana, California. 1965. 217 pgs.
5. Teletype Corporation. Technical Manual - 32 and 33 Teletypewriter sets. Skokie, Illinois. 1965. 383 pgs.
6. Petersen, Walter A. "A Flexible Data Acquisition and Formatting System for Input to Digital Computers." Section 2-C-2, IEEE Region Six Conference. Institute of Electrical and Electronic Engineers. New York, New York. 1968. 7 pgs.

APPENDIX I

SCHEMATICS

BLOCK DIAGRAM

SCHEMATIC NOTES

CARD A - Record Length Counter and IR Gap Generator

CARD B - Synchronizer and Coincidence Generator

CARD C - Start/Stop Control and Clock

CARD D - Data Sampler and Shifters

CARD E - Magnetic Tape Formatter

CARD F - Unload Address Counter

CARD G - Load Address Counter

CARD H - Memory Interface

CARD I - Memory Formatter

CARD J - Multiverter Interface

CARD M - Light Drivers

CARD N - Error and Status

CARD S - Tape Record Interface

FP - Front Panel Lights and Switches

BUFFER MEMORY

POWER SUPPLIES AND RACK POWER CABLING

+12 VOLT REGULATOR

POWER SUPPLY - LIGHT DRIVER CARD

READ CAGE SWITCH - DATA - TTY - 1130

PULSE GENERATOR CARD

SCHEMATIC NOTES

UNLESS OTHERWISE NOTED:

1. ALL NPN TRANSISTORS: ARE TYPE 2N4275
2. ALL PNP TRANSISTORS: ARE TYPE 2N3906
3. ALL GERMANIUM DIODES: ARE TYPE 'TEK' 6075
4. ALL SILICON DIODES: ARE TYPE CD6538
5. ALL IC GATES: NOR, NAND, INVERTER.

ARE FAIRCHILD μ L914

6. ALL BUFFER AMPLIFIERS: OR

ARE FAIRCHILD μ L900

7. ALL JK FLIP-FLOPS:

ARE FAIRCHILD μ L923

8. ALL EXCLUSIVE OR'S:

ARE FAIRCHILD μ L908

(A)

DATA SAMPLER & SHIFTERS

(D)

TAPE FORMATTER (E)₂

LOAD ADDRESS COUNTER (G)

MEMORY FORMATTER (1)

MEMORY FORMATTER (I)₂

MULTIVERTER INTERFACE

(J)

LIGHT DRIVERS (M)

TAPE RECORDER INTERFACE

(S)

FRONT PANEL

BUFFER MEMORY

SHEET 1 of 2

COMPONENT LOCATION REAR CIRCUIT CARD

BUFFER MEMORY

POWER SUPPLIES & RACK POWER CABLING

± 12V REGULATOR

TRANSISTORS = 2N4275

POWER SUPPLY
LIGHT DRIVER CARD

READ CAGE SWITCH - DATA-TTY-1130

PULSE GENERATOR CARD

APPENDIX II

CARD LAYOUTS and WIRING LISTS

CARD A - Record Length Counter and IR Gap Generator
CARD B - Synchronizer and Coincidence Generator
CARD C - Start/Stop Control and Clock
CARD D - Data Sampler and Shifters
CARD E - Magnetic Tape Formatter
CARD F - Unload Address Counter
CARD G - Load Address Counter
CARD H - Memory Interface
CARD I - Memory Formatter
CARD J - Multiverter Interface
CARD M - Light Drivers
CARD N - Error and Status
CARD S - Tape Record Interface
FP - Front Panel Lights and Switches

Card A - Record Length Counter & IR Gap Generator

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Conn.	Signal	Pin	Ckt.	Ckt.	Pin	Signal	Conn.
FPSW8	RLC-E2	A	in U5	U6 in	1	RLC-E4	FPSW8
				out		RLCARY	A-M
GND	uL923JK	B	in U5	U3 in	2	uL923JK	GND
FPSW7	RLC-U4	C	in U3	U1,U3,U5	3	RESET1	C-12
B-8	WRITE	D	in U1	U1 in	4	RLC-U1	FPSW7
GND	uL923JK	E	in U1	U4 in	5	RLC-E1	FPSW8
FPSW7	RLC-U2	F	in U2	U1 in	6	CLREND	C-D
C-12	RESET1	H	even U	U2,U4,U6	7	uL923JK	GND
FPSW10	RLC-F2	J	in U11	U12 in	8	RLC-F4	FPSW10
GND	uL923JK	K	in U11	U9 in	9	uL923JK	GND
FPSW9	RLC-S4	L	in U9	U7,9,11	10	RESET1	C-12
A-1	RLCARY	M	in U7	U7 in	11	RLC-S1	FPSW9
GND	uL923JK	N	in U7	U10 in	12	RLC-F1	FPSW10
FPSW9	RLC-S2	P	in U8	U8,10,12	13	uL923JK	GND
n.c.		R		U12 out	14	OVFLOW	A-V
FPSW6	FAST	S	in U's	U16 out	15	IRGAP	B-P
FPSW6	SLOW	T	in U's	U14 in	16	PRESET	C-N
n.c.		U	out U14	U13 out	17	OVFLOS	A-CC
A-14	OVFLOW	V	in U13	U13 out	18		n.c.
C-H	LCCGAP	W	out U15		19		n.c.
S-8	LCCSET	X	out U15	Q1 out	20	RLCRST	FPSW's
C-10	IRGAP	Y	out U14	U15 out	21		n.c.
M-S	RNC-5	Z	out U21	U22 out	22	RNC-6	M-T
GND	uL923JK	AA	in U21	U19 in	23	uL923JK	GND
M-P	RNC-3	BB	out U19	U17-22	24	RESET1	C-12
A-17	OVFLOS	CC	in U17	U17 out	25	RNC-1	M-M
GND	uL923JK	DD	in U17	U20 out	26	RNC-4	M-R
+3.6		EE		U20 out	27	RNC-2	M-N
GND		FF		U18,20,22	28	uL923JK	GND

Card B - Synchronizer & Coincidence Generator

71

Conn.	Signal	Pin	Ckt.	Ckt.	Pin	Signal	Conn.
n.c.		A		U6 in	1	CLEAR	C-4
I-9	MVJAM	B in	U1	U1 in	2	LOAD'G	D-12
N-16	SYNCF	C in	U4	U3 out	3	BYTRST	D-10,G-D
D-T	SHIFT	D out	U10	U5 in	4	DIRECT	D-B
G-7	NOLOAD	E out	U7	U2 out	5	NOUNLD	F-7
E-10	FILLER	F in	U8	U8 in	6	W4L	E-23
C-B	FORWRD	H in	U13	U's out	7	COINC	C-8
N-20	WOS	J out	U6	U6 out	8	WRITE	A-D,S-DD
D-L	C	K in	U14	U14 in	9	W4N	E-24
D-AA	INDIRC	L in	U14	U15 in	10	INDIRC	D-23
C-V	CLOCK	M in	U19	U's in	11	CLOCK	C-19
D-17	WRDRST	N out	U15	U12 out	12	FORCE	E-V
A-15	IRGAP	P in	U17	U17 in	13	IRGAP	A-Y
D-12	LOAD'G	R in	U16	U16 in	14	LOAD'G	D-13
H-19	UNLOAD	S out	U20	U18 out	15	WRIT'G	M-Y
H-L	CYCOMP	T in	U30	U25 in	16	LOAD	D-11
E-P,F-M	UNCLK	U out	U30	U30 out	17	LDCLK	G-M
G-P	LDCO-1	V in	U23	U23 in	18	UNCO-1	F-P
G-12	LDCO-2	W in	U22	U22 in	19	UNCO-2	F-12
G-13	LDCO-3	X in	U21	U21 in	20	UNCO-3	F-13
G-X	LDCO-4	Y in	U28	U28 in	21	UNCO-4	F-X
G-19	LDCO-5	Z in	U27	U27 in	22	UNCO-5	F-19
G-20	LDCO-6	AA in	U26	U26 in	23	UNCO-6	F-20
G-EE	LDCO-7	BB in	U33	U33 in	24	UNCO-7	F-EE
G-26	LDCO-8	CC in	U32	U32 in	25	UNCO-8	F-26
G-27	LDCO-9	DD in	U31	U31 in	26	UNCO-9	F-27
+3.6V		EE			27		+3.6V
GND		FF			28		GND

Card C - Start/Stop Control & Clock

72

Conn.	Signal	Pin	Ckt.	Ckt.	Pin	Signal	Conn.
n.c.		A		U7 in	1	RSTPB	FPSW5
B-H	FORWRD	B	out U2		2		n.c.
S-24	FORWRD	C	out SW1	U3 in	3	WMODE	S-AA
A-6	CLREND	D	out U4	U1 out	4	CLEAR	B-1,N-22
D-15	CLEAR	E	out U1	U7 in	5	SYNCF	N-16
FPBNC	COAX	F	in U14	U5 in	6	START	FPSW1
A-W	LCCGAP	H	in U6	U5 in	7	STOP	FPSW2
n.c.		J		U7 in	8	COINC	B-7
n.c.		K			9		n.c.
n.c.		L		U9 in	10	IRGAP	A-Y
n.c.		M			11		n.c.
A-16	PRESET	N	out U12	U8 out	12	RESET1	A-3,etc.
M-Z	DATAG	P	out U9	U10 out	13	RESET2	F's,G's
FPSW3	MPBNO	R	in U13	U13 in	14	MPBNC	FPSW3
n.c.		S		U15 in	15	SYNCSW	N-U
D-2	DSAMPL	T	out U14		16		n.c.
FPSW6	SLOW	U	in U18	U18 in	17	FAST	FPSW6
B-M,D-1	CLOCK	V	out U17		18		n.c.
n.c.		W		U16 out	19	CLOCK	B-11
n.c.		X			20		n.c.
n.c.		Y			21		n.c.
n.c.		Z			22		n.c.
n.c.		AA			23		n.c.
n.c.		BB			24		n.c.
n.c.		CC			25		n.c.
n.c.		DD			26		n.c.
+3.6V		EE			27		+3.6V
GND		FF			28		GND

Card D - Data Sampler & Shifters

73

Conn.	Signal	Pin	Ckt.	Ckt.	Pin	Signal	Conn.
E-23	W4L	A	in U4	U26 in	1	CLOCK	C-V
B-4	DIRECT	B	out U4	U1 in	2	DSAMPL	C-T
N-U	SYNCSW	C	in U1	U2 in	3	MVBUSY	J-18
n.c.		D	out U3	U's in	4	MVSYNC	J-24
H-L	CYCOMP	E	in U5	U1 out	5	MVSTRT	J-DD
H-10	CYCOMP	F	in U5	U20 out	6	CI	I-V
E-7	A	H	out U21	U25 out	7	C2	I-W
E-8	B	J	out U31	U30 out	8	C3	I-X
E-9	C	K	out U35	U7 in	9	MVJAM	I-9
B-K N-	C	L	out U28	U's in	10	BYTRST	B-3
E-11,X	W1	M	out U22	U6 out	11	LOAD	H-20
E-12,19	W2	N	out U27	U10 out	12	LOAD'G	B-R
E-13,W	W3	P	out U32	U9 out	13	LOAD'G	B-14
E-14,17	W4	R	out U33	U12 out	14		n.c.
C-19	CLOCK	S	in U14	U14 in	15	CLEAR	C-3
B-D	SHIFT	T	in U15		16		n.c.
n.c.		U	out U19	U's in	17	WRDRST	B-N
n.c.		V			18		n.c.
n.c.		W			19		n.c.
n.c.		X			20		n.c.
n.c.		Y			21		n.c.
n.c.		Z			22		n.c.
B-L	INDIRC	AA	out U26	U26 out	23	INDIRC	B-10
n.c.		BB			24		n.c.
n.c.		CC			25		n.c.
n.c.		DD			26		n.c.
+3.6V		EE			27		+3.6V
GND		FF			28		GND

Card E - Magnetic Tape Formatter

74

Conn.	Signal	Pin	Ckt.	Ckt.	Pin	Signal	Conn.
G-4	DPID-1	A in	U2		1		n.c.
G-F	DPID-2	B in	U2		2		n.c.
G-C	DPID-3	C in	U1	D's out	3		n.c.
G-5	DPID-4	D in	U1		4		n.c.
G-A	DPID-5	E in	U5		5		n.c.
G-1	DPID-6	F in	U5		6		n.c.
F-4	DPID-7	H in	U4	U's in	7	$\overline{A}$	D-H
F-F	DPID-8	J in	U4	U's in	8	$\overline{B}$	D-J
F-C	DPID-9	K in	U8	U's in	9	$\overline{C}$	D-K
F-5	DPID-A	L in	U8	U6 out	10	FILLER	B-F
F-A	DPID-B	M in	U9	U's in	11	$\overline{W1}$	D-M
F-1	DPID-C	N in	U9	U's in	12	$\overline{W2}$	D-N
B-U	UNCLK	P in	U10	U's in	13	$\overline{W3}$	D-P
n.c.		R out	U22	U's in	14	$\overline{W4}$	D-R
n.c.		S in	U's	U16 out	15	TAPE-1	S-7,M-F
N-16	SYNCF	T in	U6	U16 out	16	TAPE-2	S-6,M-E
n.c.		U in	U6	U17 out	17	TAPE-4	S-5,M-D
B-12	FORCE	V in	U6	U17 out	18	TAPE-8	S-4,M-C
H-21	MEM-1	W in	U3	U18 out	19	TAPE-A	S-3,M-B
H-22	MEM-2	X in	U7	U18 out	20	TAPE-B	S-2,M-A
H-23	MEM-3	Y in	U11	U3 out	21	$\overline{MB1}$	N-21
H-24	MEM-4	Z in	U15	U7 out	22	$\overline{MB2}$	N-Y
H-25	MEM-5	AA in	U19	U26 out	23	$\overline{W4L}$	B-6,D-A
H-26	MEM-6	BB in	U23	U30 out	24	$\overline{W4N}$	B-9
H-27	MEM-7	CC in	U27	U19 out	25	$\overline{MB5}$	N-18
H-28	MEM-8	DD in	U31	U23 out	26	$\overline{MB6}$	N-V
+3.6V		EE			27		+3.6V
GND		FF			28		GND

Card F - Unload Address Counter

75

Conn.	Signal	Pin	Ckt.	Ckt.	Pin	Signal	Conn.
E-M	DPID-B	A	out U5	U6	out 1	DPID-C	E-N
GND	uL923JK	B	in U's	U's	in 2	uL923JK	GND
E-K	DPID-9	C	out U3	U's	in 3	RESET2	C-13
G-1	DPCARY	D	in U1	U1	out 4	DPID-7	E-H
GND	uL923JK	E	in U's	U4	out 5	DPID-A	E-L
E-J	DPID-8	F	out U2	U's	in 6	RESET2	C-13
n.c.		H	in U's	U's	in 7	NOUNLD	B-5
H-C	UNAD-3	J	out U12	U12	out 8	UNCY-3	F-V
GND	uL923JK	K	in U11	U9	in 9	uL923JK	GND
H-B	UNAD-2	L	out U10	U's	in 10	RESET2	C-13
B-U	UNCLK	M	in U7	U8	out 11	UNAD-1	H-A
GND	uL923JK	N	in U7	U9	out 12	UNCO-2	B-19
B-18	UNCO-1	P	out U7	U11	out 13	UNCO-3	B-20
+3.6V		R			14		GND
H-F	UNAD-6	S	out U18	U18	out 15	UNCY-6	F-CC
GND	uL923JK	T	in U17	U15	in 16	uL923JK	GND
H-E	UNAD-5	U	out U16	U's	in 17	RESET2	C-13
F-8	UNCY-3	V	in U13	U14	out 18	UNAD-4	H-D
GND	uL923JK	W	in U13	U15	out 19	UNCO-5	B-22
B-21	UNCO-4	X	out U13	U17	out 20	UNCO-6	B-23
n.c.		Y	in U's	U's	in 21	NOUNLD	B-5
H-K	UNAD-9	Z	out U24	U24	out 22		n.c.
GND	uL923JK	AA	in U23	U21	in 23	uL923JK	GND
H-J	UNAD-8	BB	out U22	U's	in 24	RESET2	C-13
F-15	UNCY-6	CC	in U19	U20	out 25	UNAD-7	H-H
GND	uL923JK	DD	in U19	U21	out 26	UNCO-8	B-25
B-24	UNCO-7	EE	out U19	U23	out 27	UNCO-9	B-26
n.c.		FF	in U's	U's	in 28	NOUNLD	B-5

Card G - Load Address Counter

76

Conn.	Signal	Pin	Ckt.	Ckt.	Pin	Signal	Conn.
E-E	DPID-5	A	out U5	U6	out 1	DPCARY	F-D
GND	uL923JK	B	in U's	U's	in 2	DPID-6	E-F
E-C	DPID-3	C	out U3	U's	in 3	RESET2	C-13
B-3	BYTRST	D	in U1	U1	out 4	DPID-1	E-A
GND	uL923JK	E	in U's	U4	out 5	DPID-4	E-D
E-B	DPID-2	F	out U2	U's	in 6	RESET2	C-13
n.c.		H	in U's	U's	in 7	NOLOAD	B-E
H-3	LDAD-3	J	out U12	U12	out 8	LDCY-3	G-V
GND	uL923JK	K	in U11	U9	in 9	uL923JK	GND
H-2	LDAD-2	L	out U10	U's	in 10	RESET2	C-13
B-17	LDCLK	M	in U7	U8	out 11	LDAD-1	H-1
GND	uL923JK	N	in U7	U9	out 12	LDCO-2	B-W
B-V	LDCO-1	P	out U7	U11	out 13	LDCO-3	B-X
+3.6V		R			14		GND
H-6	LDAD-6	S	out U18	U18	out 15	LDCY-6	G-CC
GND	uL923JK	T	in U17	U15	in 16	uL923JK	GND
H-5	LDAD-5	U	out U16	U's	in 17	RESET2	C-13
G-8	LDCY-3	V	in U13	U14	out 18	LDAD-4	H-4
GND	uL923JK	W	in U13	U15	out 19	LDCO-5	B-Z
B-Y	LDCO-4	X	out U13	U17	out 20	LDCO-6	B-AA
n.c.		Y	in U's	U's	in 21	NOLOAD	B-E
H-9	LDAD-9	Z	out U24	U24	out 22		n.c.
GND	uL923JK	AA	in U23	U21	in 23	uL923JK	GND
H-8	LDAD-8	BB	out U22	U's	in 24	RESET2	C-13
G-15	LDCY-6	CC	in U19	U20	out 25	LDAD-7	H-7
GND	uL923JK	DD	in U19	U21	out 26	LDCO-8	B-CC
B-BB	LDCO-7	EE	out U19	U23	out 27	LDCO-9	B-DD
n.c.		FF	in U's	U's	in 28	NOLOAD	B-E

Card H - Memory Interface

77

<u>Conn.</u>	<u>Signal</u>	<u>Pin</u>		<u>Ckt.</u>		<u>Ckt.</u>		<u>Pin</u>	<u>Signal</u>	<u>Conn.</u>
F-11	UNAD-1	A	in	U5		U5	in	1	LDAD-1	G-11
F-L	UNAD-2	B	in	U4		U4	in	2	LDAD-2	G-L
F-J	UNAD-3	C	in	U3		U3	in	3	LDAD-3	G-J
F-18	UNAD-4	D	in	U2		U2	in	4	LDAD-4	G-18
F-U	UNAD-5	E	in	U1		U1	in	5	LDAD-5	G-U
F-S	UNAD-6	F	in	U1		U1	in	6	LDAD-6	G-S
F-25	UNAD-7	H	in	U2		U2	in	7	LDAD-7	G-25
F-BB	UNAD-8	J	in	U3		U3	in	8	LDAD-8	G-BB
F-Z	UNAD-9	K	in	U4		U4	in	9	LDAD-9	G-Z
D-E, B-T	CYCOMP	L	out	U5		U5	out	10	CYCOMP	D-F
I-11	CORE-1	M	in	U6		U6	in	11		n.c.
I-12	CORE-2	N	in	U7		U7	in	12		n.c.
I-13	CORE-3	P	in	U8		U8	in	13		n.c.
I-14	CORE-4	R	in	U9		U9	in	14		n.c.
I-15	CORE-5	S	in	U11		U11	in	15		n.c.
I-16	CORE-6	T	in	U12		U12	in	16		n.c.
I-17	CORE-7	U	in	U13		U13	in	17		n.c.
I-18	CORE-8	V	in	U14		U14	in	18		n.c.
n.c.		W	out	U23		U10	in	19	UNLOAD	B-S
n.c.		X	out	U22		U15	in	20	LOAD	D-11
n.c.		Y	out	U16		U16	out	21	MEM-1	E-W
n.c.		Z	out	U17		U17	out	22	MEM-2	E-X
n.c.		AA	out	U18		U18	out	23	MEM-3	E-Y
n.c.		BB	out	U19		U19	out	24	MEM-4	E-Z
n.c.		CC	out	U20		U20	out	25	MEM-5	E-AA
n.c.		DD	out	U21		U21	out	26	MEM-6	E-BB
+3.6V		EE				U22	out	27	MEM-7	E-CC
GND		FF				U23	out	28	MEM-8	E-DD

Card I - Memory Formatter

73

<u>Conn.</u>	<u>Signal</u>	<u>Pin</u>	<u>Ckt.</u>	<u>Ckt.</u>	<u>Pin</u>	<u>Signal</u>	<u>Conn.</u>
J-1	MV-1	A	in	U1		1	n.c.
J-2	MV-2	B	in	U2		2	n.c.
J-3	MV-3	C	in	U3		3	n.c.
J-4	MV-4	D	in	U6		4	n.c.
J-5	MV-5	E	in	U7		5	n.c.
J-6	MV-6	F	in	U8		6	n.c.
J-7	MV-7	H	in	U13		7	n.c.
J-8	MV-8	J	in	U12	U10 in	8	MVBUSY J-18
J-9	MV-9	K	in	U11	U9 in	9	MVJAM B-B,D-9
J-10	MV-10	L	in	U17	U's in	10	n.c.
J-11	MV-11	M	in	U16	U15 out	11	CORE-1 H-M
J-12	MV-12	N	in	U22	U15 out	12	CORE-2 H-N
J-13	MV-13	P	in	U21	U20 out	13	CORE-3 H-P
J-14	MV-14	R	in	U27	U20 out	14	CORE-4 H-R
J-15	MV-15	S	in	U26	U25 out	15	CORE-5 H-S
J-16	MV-16	T	in	U32	U25 out	16	CORE-6 H-T
J-17	MV-17	U	in	U31	U30 out	17	CORE-7 H-U
D-6	<u>C1</u>	V	in	U's	U30 out	18	CORE-8 H-V
D-7	<u>C2</u>	W	in	U's		19	n.c.
D-8	<u>C3</u>	X	in	U's		20	n.c.
n.c.		Y				21	n.c.
n.c.		Z				22	n.c.
n.c.		AA				23	n.c.
J-24	MVSYNC	BB	in	U35		24	n.c.
n.c.		CCC				25	n.c.
n.c.		DD				26	n.c.
+3.6V		EE				27	+3.6V
GND		FF				28	GND

1	U1	U2	U3	U4	U5
	U6	U7	U8	U9	U10
	U11	U12	U13	U14	U15
14	U16	U17	U18	U19	U20
15	U21	U22	U23	U24	U25
	U26	U27	U28	U29	U30
28	U31	U32	U33	U34	U35

Card J - Multiverter Interface

79

<u>Conn.</u>	<u>Signal</u>	<u>Pin</u>	<u>Ckt.</u>	<u>Ckt.</u>	<u>Pin</u>	<u>Signal</u>	<u>Conn.</u>
n.c.		A		U3 out	1	MV-1	I-A
n.c.		B		U3 out	2	MV-2	I-B
n.c.		C		U2 out	3	MV-3	I-C
n.c.		D		U2 out	4	MV-4	I-D
n.c.		E		U1 out	5	MV-5	I-E
n.c.		F		U1 out	6	MV-6	I-F
n.c.		H		U6 out	7	MV-7	I-H
n.c.		J		U6 out	8	MV-8	I-J
n.c.		K		U5 out	9	MV-9	I-K
n.c.		L		U5 out	10	MV-10	I-L
n.c.		M		U4 out	11	MV-11	I-M
n.c.		N		U4 out	12	MV-12	I-N
n.c.		P		U9 out	13	MV-13	I-P
n.c.		R		U9 out	14	MV-14	I-R
n.c.		S		U8 out	15	MV-15	I-S
n.c.		T		U8 out	16	MV-16	I-T
n.c.		U		U7 out	17	MV-17	I-U
n.c.		V		U7 out	18	MVBUSY	D-3, I-8
n.c.		W		Q1 in	19		n.c.
n.c.		X		Q3 in	20		n.c.
n.c.		Y		Q2 in	21		n.c.
n.c.		Z		Q4 in	22		n.c.
n.c.		AA			23		n.c.
PWR-8	-12V	BB		U10 out	24	MVSYNC	D-4, I-BB
GND	-12RTN	CC		Q6 in	25		n.c.
D-5	MVSTRT	DD	in Q5	Q7 in	26		n.c.
+3.6V		EE			27		+3.6V
GND		FF			28		GND

Card M - Light Drivers

80

<u>Conn.</u>	<u>Signal</u>	<u>Pin</u>		<u>Ckt.</u>	<u>Ckt.</u>	<u>Pin</u>	<u>Signal</u>	<u>Conn.</u>
E-20	TAPE-B	A	in	Q1	Q1 out	1	DATA-B	FPL-10
E-19	TAPE-A	B	in	Q3	Q3 out	2	DATA-A	FPL-9
E-18	TAPE-8	C	in	Q2	Q2 out	3	DATA-8	FPL-8
E-17	TAPE-4	D	in	Q4	Q4 out	4	DATA-4	FPL-7
E-16	TAPE-2	E	in	Q5	Q5 out	5	DATA-2	FPL-6
E-15	TAPE-1	F	in	Q7	Q7 out	6	DATA-1	FPL-5
F-C	DPID-9	H	in	Q6	Q6 out	7	BYT1-1	FPL-4
F-5	DPID-A	J	in	Q8	Q8 out	8	BYT1-2	FPL-3
F-A	DPID-B	K	in	Q9	Q9 out	9	BYT1-4	FPL-2
F-1	DPID-C	L	in	Q11	Q11 out	10	BYT1-8	FPL-1
A-25	RNC-1	M	in	Q13	Q13 out	11	RECL-1	FPL-20
A-27	RNC-2	N	in	Q10	Q10 out	12	RECL-2	FPL-19
A-BB	RNC-3	P	in	Q12	Q12 out	13	RECL-4	FPL-18
A-26	RNC-4	R	in	Q14	Q14 out	14	RECL-8	FPL-17
A-Z	RNC-5	S	in	Q15	Q15 out	15	RECL-16	FPL-16
A-22	RNC-6	T	in	Q17	Q17 out	16	RECL-32	FPL-15
G-A	DPID-5	U	in	Q19	Q19 out	17	BYT2-1	FPL-14
G-1	DPID-6	V	in	Q16	Q16 out	18	BYT2-2	FPL-13
F-4	DPID-7	W	in	Q18	Q18 out	19	BYT2-4	FPL-12
F-F	DPID-8	X	in	Q20	Q20 out	20	BYT2-8	FPL-11
B-15	WRIT'G	Y	in	Q21	Q21 out	21	WRITEL	FPL-26
C-P	DATAG	Z	in	Q23	Q23 out	22	GATEDL	FPL-25
G-4	DPID-1	AA	in	Q25	Q25 out	23	BYT3-1	FPL-24
G-F	DPID-2	BB	in	Q22	Q22 out	24	BYT3-2	FPL-23
G-C	DPID-3	CC	in	Q24	Q24 out	25	BYT3-4	FPL-22
G-5	DPID-4	DD	in	Q26	Q26 out	26	BYT3-8	FPL-21
n.c.		EE				27		n.c.
GND	+8.5RTN	FF	emitters of all Q's			28	+8.5RTN	GND

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Conn.	Signal	Pin		Ckt.		Ckt.		Pin	Signal	Conn.
N-14	TPERFF	A	in	Q1		Q1	out	1	TPERL	FPL-30
N-15	PARFF	B	in	Q3		Q3	out	2	PARERL	FPL-29
N-13	ECHFF	C	in	Q2		Q2	out	3	ECHE RL	FPL-28
N-16	SYNCF	D	in	Q4		Q4	out	4	SYNERL	FPL-27
S-BB	SPROFF	E	in	U1,U2		Q5	out	5	RUNL	FPL-32
S-AA	WMODE	F	in	U1		Q7	out	6	READYL	FPL-31
J-24	MVSYNC	H	in	Q6		Q6	out	7	FSYNCL	FPL-33
n.c.	Spare	J	in	Q8		Q8	out	8		n.c.
n.c.	Light	K	in	Q9		Q9	out	9		n.c.
n.c.	Drivers	L	in	Q11		Q11	out	10		n.c.
n.c.	"	M	in	Q10		Q10	out	11		n.c.
n.c.	"	N	in	Q12		Q12	out	12		n.c.
S-22	ECOERR	P	in	U6		Q6	out	13	ECHFF	N-C
S-17	XPTERR	R	in	U5		U5	out	14	TPERFF	N-A
S-Z	PARERR	S	in	U9		U9	out	15	PARFF	N-B
FPSW4	ERRRST	T	in	U's		U8	out	16	SYNCF	B-C, N-D
C-15, D-C	SYNCSW	U	out	SW1		U3	in	17	W4	D-R
E-26	MB6	V	in	U3		U3	in	18	MB5	E-25
D-P	W3	W	in	U4		U4	in	19	W2	D-N
D-M	W1	X	in	U7		Q13	in	20	WOS	B-J
E-22	MB2	Y	in	U7		U7	in	21	MB1	E-21
n.c.		Z				U8	in	22	CLEAR	C-4
n.c.		AA						23		n.c.
n.c.		BB						24		n.c.
n.c.		CC						25		n.c.
n.c.		DD						26		n.c.
+3.6V		EE						27		+3.6V
GND		FF						28		GND

Card S - Tape Recorder Interface

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Conn.	Signal	Pin	Ckt.	Ckt.	Pin	Signal	Conn.
n.c.		A	out TRf		1		n.c.
n.c.		B	in Q2	Q4 in	2	TAPE-B	E-20
n.c.		C		Q5 in	3	TAPE-A	E-19
+3.6V	(Inhibit	D	in U1	Q6 in	4	TAPE-8	E-18
n.c.	Step	E	out U1	Q7 in	5	TAPE-4	E-17
n.c.	Motor)	F		Q8 in	6	TAPE-2	E-16
n.c.		H		Q9 in	7	TAPE-1	E-15
n.c.		J		Q3 in	8	LCCSET	A-X
n.c.		K	in TRa		9		n.c.
n.c.		L			10		n.c.
n.c.		M			11		n.c.
n.c.		N			12		n.c.
n.c.		P			13		n.c.
n.c.		R			14		n.c.
n.c.		S		U7 out	15		n.c.
n.c.		T			16		n.c.
n.c.		U		D's out	17	XPTERR	N-R
n.c.		V			18		n.c.
n.c.		W			19		n.c.
n.c.		X	out U15	U15 out	20		n.c.
n.c.		Y	out TRg	TRA in	21		n.c.
N-S	PARERR	Z	out U12	U12 out	22	ECOERR	N-P
C-3,N-F	WMODE	AA	out U13	U13 out	23		n.c.
N-E	SPROFF	BB	out U14	Q12 in	24	FORWRD	C-C
n.c.		CC	out U14	U17 in	25		n.c.
B-8	WRITE	DD	in Q13	U17 in	26		n.c.
+3.6V		EE			27		+3.6V
GND		FF			28		GND

FP - Front Panel Lights and Switches

(FPSW7,8,9,10 behind panel) FPSW1 FPL-31 FPL-32 FPSW2 FPL-33 FPNBC

FPL-1	BYT1-8	M-10	FPL-18	RECL-4	M-11	FPSW1	START	C-6	FPSW7	
FPL-2	BYT1-4	M-9	FPL-19	RECL-2	M-12				4:	RLC-U4 A-C
FPL-3	BYT1-2	M-8	FPL-20	RECL-1	M-13	FPSW2	STOP	C-7	2:	RLC-U2 A-F
FPL-4	BYT1-1	M-7	FPL-21	BYT3-8	M-26				1:	RLC-U1 A-4
FPL-5	DATA-1	M-6	FPL-22	BYT3-4	M-25	FPSW3				
FPL-6	DATA-2	M-5	FPL-23	BYT3-2	M-24	out:	MPBNC	C-14	4:	RLC-E4 A-1
FPL-7	DATA-4	M-4	FPL-24	BYT3-1	M-23	in:	MPBNO	C-R	2:	RLC-E2 A-A
FPL-8	DATA-8	M-3	FPL-25	GATEDL	M-22				1:	RLC-E1 A-5
FPL-9	DATA-A	M-2	FPL-26	WRITEL	M-21	FPSW4	ERRRST	N-T	FPSW9	
FPL-10	DATA-B	M-1	FPL-27	SYNERL	N-4				4:	RLC-S4 A-L
FPL-11	BYT2-8	M-20	FPL-28	ECHEERL	N-3	FPSW5	RSTPB	C-1	2:	RLC-S2 A-P
FPL-12	BYT2-4	M-19	FPL-29	PARERL	N-2				1:	RLC-S1 A-11
FPL-13	BYT2-2	M-18	FPL-30	TPERL	N-1	FPSW6				
FPL-14	BYT2-1	M-17	FPL-31	READYL	N-6	10:	SLOW	A-T,	4:	RLC-F4 A-8
FPL-15	RECL-32	M-16	FPL-32	RUNL	N-5			C-U	2:	RLC-F2 A-J
FPL-16	RECL-16	M-15	FPL-33	FSYNCL	N-7	30:	FAST	A-S,	1:	RLC-F1 A-12
FPL-17	RECL-8	M-14						C-17	FPSW's	RLCRST A-20

APPENDIX III

SIGNAL CROSS REFERENCE

SIGNAL CROSS REFERENCE

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<u>SOURCE</u>	<u>SIGNAL</u>	<u>DESTINATION</u>	<u>SOURCE</u>	<u>SIGNAL</u>	<u>DESTINATION</u>
D-H	<u>A</u>	E-7	M-3	DATA-8	Ken-L, FPL-8
D-J	<u>B</u>	E-8	M-2	DATA-A	Ken-M, FPL-9
MVRTR	BIT1-	Card J	M-1	DATA-B	Ken-N, FPL-10
1-17	BIT17		C-P	<u>DATAG</u>	M-Z
Ken-Z	BOT	Card S	D-B	<u>DIRECT</u>	B-4
Ken-a	Broken Tape	Card S	G-1	DPCARY	F-D
MV-18	BUSY	Card J	G-4	DPID-1	E-A, M-AA
M-7	BYT1-1	FPL-4	G-F	DPID-2	E-B, M-BB
M-8	BYT1-2	FPL-3	G-C	DPID-3	E-C, M-CC
M-9	BYT1-4	FPL-2	G-5	DPID-4	E-D, M-DD
M-10	BYT1-8	FPL-1	G-A	DPID-5	E-E, M-U
M-17	BYT2-1	FPL-14	G-1	DPID-6	E-F, M-V
M-18	BYT2-2	FPL-13	F-4	DPID-7	E-H, M-W
M-19	BYT2-4	FPL-12	F-F	DPID-8	E-J, M-X
M-20	BYT2-8	FPL-11	F-C	DPID-9	E-K, M-H
M-23	BYT3-1	FPL-24	F-5	DPID-A	E-L, M-J
M-24	BYT3-2	FPL-23	F-A	DPID-B	E-M, M-K
M-25	BYT3-4	FPL-22	F-1	DPID-C	E-N, M-L
M-26	BYT3-8	FPL-21	C-T	DSAMPL	D-2
B-3	BYTRST	D-10, G-D			
D-L	<u>C</u>	B-K	N-3	ECHERL	FPL-28
D-K	<u>C</u>	E-9	N-13	ECHFF	N-C
D-6	<u>C1</u>	I-V	Ken-P	ECHO-1	Card S
D-7	<u>C2</u>	I-W	Ken-R	ECHO-2	Card S
D-8	<u>C3</u>	I-X	Ken-S	ECHO-Y	Card S
C-4	<u>CLEAR</u>	B-1, N-22	Ken-T	ECHO-8	Card S
C-E	<u>CLEAR</u>	D-15	Ken-U	ECHO-A	Card S
C-V	<u>CLOCK</u>	B-M, D-1	Ken-V	ECHO-B	Card S
C-19	CLOCK	B-11, D-S	Ken-W	ECHO-W	Card S
C-D	CLREND	A-6	S-22	ECOERR	N-P
FPBNC	COAX	C-F	Ken-Y	EOT	Card S
B-7	COINC	C-8	FPSW4	ERRRST	N-T
I-11	CORE-1	H-M			
I-12	CORE-2	H-N	FPSW6	FAST	A-S, C-17
I-13	CORE-3	H-P	Ken-B	FILEGAP	
I-14	CORE-4	H-R	E-10	FILLER	B-F
I-15	CORE-5	H-S	B-12	FORCE	E-V
I-16	CORE-6	H-T	Ken-F	<u>FORWARD</u>	
I-17	CORE-7	H-U	C-B	<u>FORWRD</u>	B-H
I-18	CORE-8	H-V	C-C	FORWRD	S-24
H-L	<u>CYCOMP</u>	B-T, D-E	MV-45	FRAME1	
H-10	CYCOMP	D-F	N-7	FSYNCL	FPL-33
			M-22	GATEDL	FPL-25
M-6	DATA-1	Ken-H, FPL-5			
M-5	DATA-2	Ken-J, FPL-6	D-AA	<u>INDIRC</u>	B-L
M-4	DATA-4	Ken-K, FPL-7	D-23	<u>INDIRC</u>	B-10
			Ken-A	IRG	Card S
			A-15	IRGAP	B-P

<u>SOURCE</u>	<u>SIGNAL</u>	<u>DESTINATION</u>	<u>SOURCE</u>	<u>SIGNAL</u>	<u>DESTINATION</u>
A-Y	IRGAP	C-10,B-13	MV-43	MPX7SB	Card J
A-W	LCCGAP	C-H	MV-44	MPXLSB	Card J
A-X	LCCSET	S-8	J-1	MV-1	I-A
G-11	LDAD-1	H-1	J-2	MV-2	I-B
G-L	LDAD-2	H-2	J-3	MV-3	I-C
G-J	LDAD-3	H-3	J-4	MV-4	I-D
G-18	LDAD-4	H-4	J-5	MV-5	I-E
G-U	LDAD-5	H-5	J-6	MV-6	I-F
G-S	LDAD-6	H-6	J-7	MV-7	I-H
G-25	LDAD-7	H-7	J-8	MV-8	I-J
G-BB	LDAD-8	H-8	J-9	MV-9	I-K
G-Z	LDAD-9	H-9	J-10	MV-10	I-L
B-17	LDCLK	G-M	J-11	MV-11	I-M
G-P	LDCO-1	B-V	J-12	MV-12	I-N
G-12	LDCO-2	B-W	J-13	MV-13	I-P
G-13	LDCO-3	B-X	J-14	MV-14	I-R
G-X	LDCO-4	B-Y	J-15	MV-15	I-S
G-19	LDCO-5	B-Z	J-16	MV-16	I-T
G-20	LDCO-6	B-AA	J-17	MV-17	I-U
G-EE	LDCO-7	B-BB	J-18	MVBUSY	D-3,I-8
G-26	LDCO-8	B-CC	I-9	MVJAM	B-B,D-9
G-27	LDCO-9	B-DD	D-5	MVSTRT	J-DD
G-8	LDCY-3	G-V	J-24	MVSYNC	D-4,I-BB,N-H
G-19	LDCY-6	G-CC	B-E	NOLOAD	G-7,G-28,G-21
D-11	LOAD	B-16,H-20	B-5	NOUNLD	F-7,F-28,F-21
D-12	LOAD'G	B-R,B-2	A-17	OVFLOS	A-CC
D-13	LOAD'G	B-14	A-14	OVFLOW	A-V
MV-28	LOGIC RETURN	Card	N-2	PARERL	FPL-29
MV-27	LOGIC VOLTAGE	J	S-Z	PARERR	N-S
E-21	MB1	N-21	N-15	PARFF	N-B
E-22	MB2	N-Y	Ken-X	PARITY	Card S
E-25	MB5	N-18		CHECK	
E-26	MB6	N-V	Ken-d	PARITY	Card S
H-21	MEM-1	E-W		GEN	
H-22	MEM-2	E-X	C-N	PRESET	A-16
H-23	MEM-3	E-Y	Ken-K	PWRGND	Card S
H-24	MEM-4	E-Z	N-6	READYL	FPL-31
H-25	MEM-5	E-AA	M-11	RECL-1	FPL-20
H-26	MEM-6	E-BB	M-12	RECL-2	FPL-19
H-27	MEM-7	E-CC	M-13	RECL-4	FPL-18
H-28	MEM-8	E-DD	M-14	RECL-8	FPL-17
MV-46	MODLSB	Card J	M-15	RECL-16	FPL-16
MV-47	MODMSB	Card J	M-16	RECL-32	FPL-15
FPSW3	MPBNC	C-14	Ken-b	REMOTE READ	Card
FPSW3	MPBNO	C-R	Ken-k	REMOTE WRITE	S
MV-41	MPX5SB	Card J			
MV-42	MPX6SB	Card J			

<u>SOURCE</u>	<u>SIGNAL</u>	<u>DESTINATION</u>	<u>SOURCE</u>	<u>SIGNAL</u>	<u>DESTINATION</u>
Ken-E	RESET	Card S	E-19	TAPE-A	S-3, M-B
C-12	RESET1	A-24, H, 3, 10	E-20	TAPE-B	S-2, M-A
C-13	RESET2	F-3, 6, 10, 17, 24	N-14	TPERFF	N-A
		G-3, 6, 10, 17, 24	N-1	TPERL	FPL-30
A-1	RLCARY	A-M			
FPSW8	RLC-E1	A-5	F-11	UNAD-1	H-A
FPSW8	RLC-E2	A-A	F-L	UNAD-2	H-B
FPSW8	RLC-E4	A-1	F-J	UNAD-3	H-C
FPSW10	RLC-F1	A-12	F-18	UNAD-4	H-D
FPSW10	RLC-F2	A-J	F-U	UNAD-5	H-E
FPSW10	RLC-F4	A-8	F-S	UNAD-6	H-F
A-20	RLCRST	FPSW7, 8, 9, 10	F-25	UNAD-7	H-H
FPSW9	RLC-S1	A-11	F-BB	UNAD-8	H-J
FPSW9	RLC-S2	A-P	F-Z	UNAD-9	H-K
FPSW9	RLC-S4	A-L	B-U	UNCLK	F-M, E-P
FPSW7	RLC-U1	A-4	F-P	UNCO-1	B-18
FPSW7	RLC-U2	A-F	F-12	UNCO-2	B-19
FPSW7	RLC-U4	A-C	F-13	UNCO-3	B-20
A-25	RNC-1	M-M	F-X	UNCO-4	B-21
A-27	RNC-2	M-N	F-19	UNCO-5	B-22
A-BB	RNC-3	M-P	F-20	UNCO-6	B-23
A-26	RNC-4	M-R	F-EE	UNCO-7	B-24
A-Z	RNC-5	M-S	F-26	UNCO-8	B-25
A-22	RNC-6	M-T	F-27	UNCO-9	B-26
FPSW5	RSTPB	C-1	F-8	UNCY-3	F-V
N-5	RUNL	FPL-32	F-15	UNCY-6	F-CC
			B-S	UNLOAD	H-19
B-D	SHIFT	D-T			
FPSW6	SLOW	A-T, C-U	D-M	$\overline{W1}$	E-11, N-X
S-BB	SPROFF	N-E	D-N	$\overline{W2}$	E-12, N-19
FPSW1	START	C-6	D-P	$\overline{W3}$	E-13, N-W
MV-50	START	Card J	D-R	$\overline{W4}$	E-14, N-17
MV-49	START	Card J	E-23	W4L	B-6, D-A
	RETURN		E-24	W4N	B-9
Ken-C	STEP	Card S	S-AA	WMODE	C-3, N-F
Ken-j	STEP IN-	Card	B-J	$\overline{WOS}$	N-20
	HIBIT	S	B-N	WRDRST	D-17
Ken-E	STEP PINCH	Card	B-8	WRITE	S-DD, A-D
	ROLLER	S	M-21	WRITEL	FPL-26
FPSW2	STOP	C-7	B-15	WRIT'G	M-Y
N-16	SYNCF	B-C, N-D			
		C-5, E-T	S-17	XPTERR	N-R
N-U	SYNCSW	C-15, D-C			
N-4	SYNERL	FPL-27			
E-15	TAPE-1	S-7, M-F			
E-16	TAPE-2	S-6, M-E			
E-17	TAPE-4	S-5, M-D			
E-18	TAPE-8	S-4, M-C			

APPENDIX IV

OPERATING PROCEDURES

ANALOG TO DIGITAL TAPE CONVERSION SYSTEM
OPERATING PROCEDURE

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I. EQUIPMENT LOCATION AND ABBREVIATIONS:

The Analog to Digital Data Conversion System is located in a single electronics rack organized from top to bottom as follows:

1) Kennedy Tape Recorder Transport	=	TR
2) Kennedy Read Electronics Cage	=	RC
3) 1130 Interface Electronics	=	IF
4) Converter System Controller	=	CV
5) Buffer Memory	=	BM
6) Multiverter A/D Converter	=	MV
7) Analog Input Panel	=	AP
8) Power Supply	=	PS

II. PRELIMINARY SWITCH SETTINGS:

- 1) TR, MV, PS: POWER Sw. OFF.
- 2) TR: READ/WRITE Sw. to READ.
- 3) RC: TRANSPORT/DISABLE Sw. to DISABLE.
- 4) RC: DATA/TTY/1130 Sw. to DATA.
- 5) IF: INTERRUPT/DISABLE Sw. to DISABLE.

III. POWER ON:

- 1) PS: RACK POWER Sw. ON.
- 2) TR: POWER Sw. ON.
- 3) MV: POWER Sw. ON.
- 4) PS: POWER SUPPLY Sw. ON.

IV. READY MULTIVERTER:

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- 1) AP: Connect analog inputs from left to right.
- 2) MV: Select number of channels to be converted on OCTAL CHANNEL SELECT Sw. (Switch Settings = Number - 1; e.g., 7 channels = 006).
- 3) MV: Turn NORM/CALIBRATE Sw. from NORM to CALIBRATE, and then back to NORM.
- 4) CV: Check to see that FRAME SYNC Light is on. If not, cycle NORM/CALIBRATE Sw.(MV) until it comes on.

V. REMOVE DIGITAL TAPE (if necessary):

- 1) RC: FAST FORWARD/REWIND Sw. to REWIND.
- 2) TR: Make sure tape is properly threaded.
- 3) TR: Engage Tape Reel Servos by gently rocking upper reel CCW.
- 4) TR: Push REWIND button; the tape should rewind. If a reflective marker is encountered the tape may stop. Push REWIND again.
- 5) TR: Remove upper tape reel by unscrewing rectangular Reel Lock (CCW) and pulling tape reel from hub.

VI. LOAD DIGITAL TAPE:

- 1) Install tape reel on upper hub. Hold tape reel firmly on hub while turning rectangular Reel Lock CW to lock reel to hub.
- 2) TR: Thread tape directly onto lower reel in a CW fashion. (Moisture on end of tape readily assures that tape end will adhere to lower reel).
- 3) TR: Put 3-4 turns of tape onto the lower reel.
- 4) TR: Draw out 2-3 feet of tape between the reels.
- 5) TR: Gently drape the tape over the white tape guide on the upper tension arm - WITHOUT MOVING IT!!!

- 6) TR: Thread the tape properly through the tape guides, heads and capstans.
- 7) TR: Guide the tape around the lower tension arm and take up the slack with the lower reel.
- 8) TR: ENGAGE TAPE SERVOS by gently rocking upper reel CCW.
- 9) TR: Push READ button.
- 10) TR: Push and hold down LOAD FORWARD button until the tape advances to the first reflective marker, at which time the READ Sw. will disengage and the forward motion will stop.

VII. ADVANCE TAPE PAST PREVIOUSLY WRITTEN FILES (if necessary):

- 1) RC: Set FAST FORWARD/REWIND Sw. to FAST FORWARD.
- 2) TR: Push REWIND button. Tape should advance in forward direction.
- 3) RC: Push STOP button prior to the end of the files to be skipped.
- 4) RC: Change DATA/TTY/1130 Sw. to 1130.
- 5) IF: Push STOP and RESET.
- 6) TR: Set READ SPEED Sw. to 30 IPS.
- 7) RC: Set TRANSPORT/DISABLE Sw. to TRANSPORT to engage capstans.
- 8) IF: Push FORWARD REC. button. The tape should advance to an Inter-Record Gap (IRG). If it doesn't stop within a few seconds hit STOP on the 1130 Interface (IF). The written portion of the tape has been passed over and it will be necessary to backspace to the File Marks by pushing BACKWARD FILE.
- 9) IF: If the tape did stop at an IRG in Step 8, push FORWARD FILE to reach the end of that File. It must be ascertained yet whether the FILE MARK is the last File Mark. By pushing FORWARD REC, and observing the INTERFACE Lights, it is possible to know where the records and File Marks are. If more records are found past the initially found File Mark, it will be necessary to FORWARD FILE again.

- 10) IF: Ultimately the end of the written area on the tape is found. At this point it will be necessary to BACKWARD FILE over the last File Mark as in Step 8.

NOTE: The tape is now positioned for writing, but it is necessary to return the system electronics back to the state at which they were in Section VI, Step 10.

- 11) RC: Set TRANSPORT/DISABLE Sw. to DISABLE.
- 12) RC: Push STOP to disengage the Kennedy READ Mode.
- 13) RC: IMPORTANT: Move DATA/TTY/1130 Sw. to TTY; the READ Mode will automatically come on in the Kennedy Transport.
- 14) RC: Disengage the READ Mode again by pushing STOP.
- 15) RC: Move DATA/TTY/1130 Sw. from TTY to DATA.

VIII. ENGAGE WRITE MODE:

- 1) TR: Turn READ SPEED Sw. to 30 IPS.
- 2) TR: Turn READ/WRITE Sw. to WRITE.
- 3) TR: Push WRITE button, it should light and the tape should advance.
- 4) TR: Insert appropriate number of File Marks by pushing the FILE GAP button. (See Section X, Step 4).

IX. READY CONVERTER SYSTEM:

- 1) CV: Connect up external sampling rate generator and select pulse rate. (1, 10, and 60 pulses are available on Power Supply).
- 2) CV: Push RESET COUNTERS and RESET ERRORS to clear converter. SYNC ERROR Light may remain ON.
- 3) TR: Set READ SPEED Sw. to 10 or 30 IPS as desired.
- 4) CV: Set IPS Sw. to same setting (10 or 30 IPS) as transport.

- 5) BM: Check that the ADDRESS and DATA switches on the BUFFER MEMORY are all DOWN.
- 6) CV: If the magnetic tape records are to be other than 4096 characters plus longitudinal check character, set the Record Length Switches immediately behind the Converter Front Panel to appropriate positions.
- 7) RC: Set TRANSPORT/DISABLE Sw. to TRANSPORT.

X. CONVERTING DATA.

- 1) : Start Analog Input. (E.g., with an FM Tape Recorder start Playback.)
- 2) CV: Push START.
- 3) CV: Push STOP when sufficient ANALOG DATA has been converted.
- 4) TR: Insert File Marks by pushing the FILE GAP button. Three File Marks are suggested at the beginning of new tapes. Two file marks are suggested between files. It is also suggested that three file marks be written at the end of the last file. If that is done, then two file marks will always appear between adjacent files: the BACKWARD FILE discussed in Sec. VII, Steps 8) and 10) will stop the tape between the second and third file marks and subsequent writing of a new file will overwrite the third file mark leaving only two file marks between files.
 File Mark summary:
 - a) 3 at beginning of new tape.
 - b) none at completion of sec. VII.
 - c) 2 between files.
 - d) 3 at completion of data conversion.
 *****READ SPEED Sw. must be at 30 IPS for File Marks*****
- 5) TR: Return READ SPEED Sw. to appropriate position for further conversion.