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TAPECLIP SYSTEM SPECIFICATION

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1.0 SCOPE

1.1 This specification establishes the requirements for the design, fabrication, testing, delivery and installation of the NASA/ARC TAPECLIP System. The TAPECLIP system is a semi-automatic closed-loop ionogram processor operating from analog magnetic tape that will be used for processing sounder telemetry data from the Topside Sounder Satellites.

2.0 APPLICABLE DOCUMENTS

The following documents form a part of this specification to the extent specified herein.

2.1 X-533-62-142 - NASA/GSFC Operations Plan 7-62 Swept Frequency Topside Sounder (Canada) S-27 September 1962.

2.2 X-513-65-454 - NASA/GSFC Operations Plan 13-65 International Satellites for Ionospheric Studies (ISIS-X) November 1965.

2.3 Spacecraft Description ISIS-X (Alouette B/DME-A) November 1965.

2.4 ISIS 'A' Technical Plan, February 1968.
ISIS Project Office
Defense Research Telecommunications Establishment
Ottawa, Canada

2.5 NASA/GSFC OPPLAN 13-68 ISIS-A.

2.6 Study Report, Part I - Engineering study and preliminary design of instrumentation for the Scaling and Editing of Ionograph Data. Prepared for NASA/ARC by Astrodata, Inc., September 1967.

2.7 IBM 1800 Data Acquisition and Control System Installation Manual - Physical Planning
File Number 1800-15
Form A26-2922-4

2.8 IBM 1800 Data Acquisition and Control System Configurator
File Number 1800-00
Form A26-5919-4

2.9 IBM System/360 Model 50 Functional Characteristics
File Number S360-01
Form A22-6898-1

2.10 IBM System/360 Component Description
IBM 2250 Display Unit Model 1
File Number S360-03
Form A27-2701-1

3.0 GENERAL SYSTEM REQUIREMENTS

3.1 System Description

The TAPECLIP system shall be a semi-automatic closed-loop ionogram processor operating from analog magnetic tape. Data to be reduced by the TAPECLIP system shall be topside sounder data recorded on 1/2-inch, 7-track magnetic tape from the Alouette I, Alouette II, ISIS-A, and ISIS-B satellites. This system is an expansion of the FILMCLIP system which is presently operational at NASA/ARC. Consequently, the TAPECLIP system must interface with existing hardware and software.

The FILMCLIP system is a film-oriented, closed-loop ionogram processor for reducing virtual depth-frequency h'(f) topside sounder ionograms recorded on 35 mm film to electron density profiles N(h). A functional block diagram of the FILMCLIP system is shown in figure 1. A functional block diagram of the subject TAPECLIP system is shown in figure 2. The combined TAPECLIP and FILMCLIP system is shown in figure 3.

The combined systems shall provide for a convenient man/machine interface so that an operator has complete control of the various processing modes all the way from manual step-by-step processing to as fully automatic processing as data quality will permit.

3.1.1 Telemetry Formatting Subsystem

This subsystem performs the function of converting analog sounder telemetry data on magnetic tape to a digital format that can be stored conveniently in computer memory. Frequency modulated sounder video data is demodulated by an FM subcarrier discriminator, corrected for zero offset and scale factor, and digitized by the ADC at a rate to provide sampling at each 5 KM of virtual depth below satellite height.

The clock pulses controlling the ADC are derived from a reference frequency on the analog magnetic tape by means of a phase-locked time base generator. Timing information on the analog magnetic tape is converted to digital form by the time code translator and is available to the computer with millisecond resolution. For Alouette II, frequency marker information is recorded on a separate tape track from the sounder video. Frequency marker FM data is demodulated by a separate FM subcarrier discriminator. Frequency markers are identified by the frequency marker detector which generates a computer interrupt to store the time of occurrence of each frequency marker.

For ISIS-A, time and frequency marker data are subcommutated on word 3 of the PCM channel. A PCM decom is provided to output all PCM data to the 1800 computer. Bit 7, word 3 is separately decommutated and output to the timing code generator.

Sounder video line and frame sync pulses control the formatting of digital data in computer memory so that the computer knows the magnitude, time of occurrence, transmit pulse frequency, and virtual depth of each data sample in memory.

A test oscilloscope shall be provided in the Telemetry Formatting Subsystem for monitoring the sounder video signal during operation and for viewing other significant waveforms in the subsystem, when trouble-shooting operational problems or during maintenance periods.

3.1.1.1 Analog Magnetic Tape Playback Machine

The telemetry data from the topside sounder satellites is recorded on 1/2-inch magnetic tape. These analog magnetic tapes are the source of input data to the TAPECLIP system and are played back on the Analog Magnetic Tape Playback Machine at speeds of X1, X2, or X4 equivalent real time.

3.1.1.2 Timing Subsystem

The timing subsystem is comprised of a time code translator, tape search and control unit, timing code generator, and minor time converter. Timing information on the analog magnetic tape is converted to digital form by the time code translator and is available to the computer with millisecond resolution. The tape search and control unit permits automatic tape search to a preselected start and stop time on the analog magnetic tape. The timing code generator provides a time code for use when there is no time code on the analog magnetic tape or when the quality of the time code on the tape is so poor that it is not readable.

When processing data from the spacecraft tape recorder on the ISIS-A satellite, decoded ISIS-A time is input to the timing code generator where it is converted to the NASA 36-bit code for subsequent processing by the time code translator.

Timing from ISIS-A data can be obtained from more than one track of the magnetic tape as follows:

a. NASA 36-bit code, amplitude modulated on a 1 kHz carrier, is recorded on track 6.

b. ISIS-A time on word 3 bit 7 of the PCM channel is recorded on track 4. ISIS-A time derived from the PCM decom is input to the timing code generator where it will be converted to the NASA 36-bit code for subsequent processing by the time code translator.

c. ISIS-A time derived from playback of the spacecraft magnetic tape recorder will be telemetered in the PCM signal on a 93 kHz FM subcarrier, which will be direct recorded on track 5. In this mode the output of FM Subcarrier Discriminator #2 will provide the input signal for the PCM decom. ISIS-A time then will be processed as described in b.

d. Replayed ISIS-A time (clock data) consisting of a 46.08 kHz carrier signal amplitude modulated by a 240-bps time code (4X real time) is also recorded on track 5 along with the 93 kHz FM subcarrier described in c. This signal will not be processed by the TAPECLIP system.

3.1.1.3 FM Discriminator Section

This section receives frequency modulated signals from playback of analog magnetic tape and provides demodulated sounder video data to the zero and scale correction unit. Frequency marker data from the Alouette II satellite is recorded on a separate tape track. Data from this channel is demodulated for input to the frequency marker detector.

ISIS-A PCM data derived from playback of the spacecraft tape recorder will be telemetered on a

93 kHz FM subcarrier and recorded on track 5. In this mode, data from this channel is demodulated for input to the PCM decom.

3.1.1.4 Phase-Locked Time Base Generator

This unit is a phase-locked frequency synthesizer operating from a reference frequency on magnetic tape. Inputs to this unit at X1 real time shall be the following reference frequencies:

a. 10 kHz from Track 2
b. 50 kHz from Track 2
c. 11.52 kHz from the PCM decom

The unit generates a clock frequency proportional to tape speed to control the sampling rate of the ADC. The unit also provides a separate 1 kHz carrier frequency to the timing code generator for use in processing the ISIS-A time code and for accruing time when a usable NASA 36-bit time code signal is not available from the magnetic tape.

3.1.1.5 Analog-to-Digital Converter (ADC)

The ADC receives analog sounder video data from the zero and scale correction unit and provides an 8-bit analog-to-digital conversion at a rate determined by the clock frequency coming from the phase-locked time base generator. The clock frequency to tape playback speed is such that the ADC samples the sounder video data in 5 KM increments of virtual depth. At X1 playback speed, the ADC clock frequency is 30,000 pps.

3.1.1.6 Line, Frame Synchronizer

The frame synchronizer recognizes the frame sync pulse on the sounder video signal at the start of each ionogram frequency sweep and generates a computer interrupt which resets the line sequence number counter in the 1800 Computer to zero.

The line synchronizer recognizes the line sync pulse on the sounder video signal at the time the satellite transmitter pulse occurs, and generates a computer interrupt which resets the range increment number counter in the 1800 Computer to zero.

3.1.1.7 Zero and Scale Correction

The sounder video signal is ac coupled before being recorded at the ground receiving station on a wide-band FM channel on analog magnetic tape. The zero and scale correction unit restores the dc component to the sounder video signal and provides scale or gain correction to normalize the signal amplitude to match the full scale range of the ADC.

3.1.1.8 Frequency Marker Detector

The frequency marker detector receives data from the FM data channel and generates a computer interrupt at the time of occurrence of each frequency marker pulse. Upon receipt of each interrupt, the computer stores a time word, so that when the time for all the frequency markers has been received the information is available to determine the satellite transmitter frequency for each line of sounder video data.

3.1.2 Computer Subsystem

The Computer Subsystem provides control for the TAPECLIP system and, after scaling is complete, computes the N(h) profile.

3.1.2.1 IBM 1800 Computer

The IBM 1800 Computer is a process controller which accepts digitized sounder video and timing data as well as interrupts from various sources such as the following:

a. Frame sync pulses
b. Line sync pulses
c. Frequency marker pulses
d. Operator inputs
    1. Scaling control
    2. Keyboards
    3. Light pen

The 1800 interacts with portions of the telemetry formatting subsystem in a way which simplifies the performance requirements of these sections over what might otherwise be necessary with a less versatile computer. The 1800 Computer structures data for the CRT ionogram display, and handles data to and from the 2250 Graphic Display Unit. A high-speed data link couples the 1800 Computer to the 360 Computer, so that effectively the 360 Disc Memory is available to the 1800. With a planned installation of an IBM 2314 disc drive on the 360 Computer, the available memory will be large enough to store the digitized sounder video data from a complete pass of the satellite over the ground receiving station, which represents the data from up to 32 complete ionograms. The data transfer rate is such that the system can accept data played back from analog magnetic tape at 4X the speed at which it was recorded.

3.1.2.2 IBM 360/50 Computer

The 360 Computer performs the complex N(h) and inverse h'(f) computations and transfers data to and from the 1800. Final data is stored on digital magnetic tape for subsequent off-line plotting and printing, or alphanumeric data can be listed on the line printer.

3.1.2.3 Software Section

All computer software shall be written by a separate NASA/ARC contractor. It shall be the responsibility of the vendor to provide the necessary software guidance and support to this contractor so that the additional software for the TAPECLIP system can be written and made operational in an efficient and timely manner.

3.1.3 Display Subsystem

The Display Subsystem provides visual outputs from the machine to the operator, and also provides the means by which the operator communicates with the system.

3.1.3.1 CRT Ionogram Display Unit

The CRT Ionogram Display Unit provides a visual display to the operator for all or a portion of an ionogram. This display contains so-called fixed and variable data to provide a maximum of visual information for the operator. The fixed data will be an electronic image equivalent of a film ionogram. The variable data will comprise the movable cursor character, scaled or computed data points, and the 3-line A-scan display on the right-hand side of the CRT.

3.1.3.2 IBM 2250 Graphic Display Unit

The 2250 provides capability for displaying scaled and computed data points on a preselected coordinate system. The coordinate system might be all or a portion of an ionogram for an h'(f) display of virtual depth as a function of frequency and time. Alternatively, the display might be the N(h) profile of electron density as a function of true height. The programmed function keyboard provides means for operator control of the various modes of operation of the system. The alphameric keyboard provides means for operator entry of data to the system. The light pen provides another means of interaction between the operator and the machine. The 2250 also provides for display of alphameric characters for coordinate annotation as well as for displaying numeric values of range, frequency, and time representing the coordinate position of the scaling cursor character.

3.1.3.3 Scaling Cursor Control Unit

The Scaling Cursor Control Unit provides a means for operator control of the scaling cursor character which appears on both the 2250 and the CRT Ionogram Display Unit. This character can be positioned anywhere in the display coordinate system. Its function is determined by an operator key selection on the 2250 programmed function keyboard.

3.1.3.4 Scaling Converter

The scaling converter provides the analog-to-digital interface between the Scaling Cursor Control Unit and the 1800 Computer. This is an existing unit that is also part of the FILMCLIP system.

3.2 System Design Philosophy

3.2.1 Design Criteria

The design criteria specified in this document are requirements that can be readily met with present day state-of-the-art technology. It is not intended that the proposed system is the only one that will meet the requirements of the desired objective. The intent is to allow a degree of engineering latitude wherever possible in order to take maximum advantage of engineering creativity.

3.2.2 Expansion Capability

The TAPECLIP system shall have the growth and expansion capability to meet the additional data reduction requirements of future ISIS satellites as well as being able to adapt to changing requirements as new ideas and techniques in programming and operating procedures are developed. The system design of both hardware and related software shall be implemented in such a way that the system can be economically expanded. Except for the magnetic tape machine, equipment cabinets shall not be more than three-quarters full to allow room for future expansion. It is desired that future expansion of the TAPECLIP system be implemented in such a way as to minimize interruption of operations at that time.

3.2.3 System Flexibility

System configuration and setup controls shall be arranged in a convenient and logical manner in accordance with good human engineering principles. These controls shall be located on a panel in a cabinet near the analog magnetic tape machine. The TAPECLIP system will require two operators minimum for efficient operation in the specified configuration; one at the main control console at the 2250 and the other to handle the analog magnetic tapes, load the tape machine, and otherwise take care of setup and tape queuing tasks, etc. This is independent of the IBM 360 operators who may be running jobs in the background even though TAPECLIP is operating in the foreground with top priority.

3.2.4 System Accuracy

The performance specification for each section or any subsystem within the specification shall be met without regard to other system components included in the data path or to any considerations dependent on configuration. The system accuracy shall be as high as reasonable economy and technical feasibility permit.

3.3 Operational Philosophy

The TAPECLIP system is designed for use in a production facility and shall be capable of retiring a backlog of accumulated data tapes and film ionograms as well as maintaining pace with the rate at which present and future Topside Sounder Satellites are transmitting data. As a minimum performance design goal, the system shall be capable of processing the bulk of the topside sounder data from one satellite.

The console operator is an essential link in the TAPECLIP system. Consequently, the man-machine interface shall be designed in such a way that it can efficiently utilize the operator's unique capability to interpret display patterns. She can then inform the machine what to do next via function keys, controls, switches, or light pen, etc. It is desired that the system operate essentially fully automatic when processing thin line nonambiguous ionograms. Yet, when the more difficult ionograms are processed, the operator can preempt control at whatever level she desires down to a step-by-step manually controlled sequence.

The primary objective in the design of the TAPECLIP system is to provide a system in which the particular capabilities of the man and machine are most efficiently utilized. Information requested by the operator should be displayed with minimum delay. The display should respond to her instructions with minimum delay in order not to distract her from concentrating on the primary pattern recognition and processing task. The TAPECLIP operating system will be basically a well-structured multiprogramming operating system which can function in a number of different modes as determined by the operator, which will depend on the problems encountered in processing a given ionogram.

3.4 Operational Modes

The various operational modes of the TAPECLIP system will be dependent on both the hardware configuration and the organization of the software. The data to be reduced will be topside sounder data recorded on magnetic tape from the Alouette I, Alouette II, ISIS-A, and ISIS-B satellites. Different operational configurations will be required when reducing data from each of these satellites. In addition, it is required that the system operate at playback speeds of X1, X2, and X4 equivalent real time with data from each of the above satellites.

In one mode it may be desirable to play back only one ionogram at a time in forward time sequence. In another mode the operator may wish to load data from all 32 ionograms in a pass of the satellite into the 2314 Disc File associated with the IBM 360 Computer. When so-called thin line ionograms are being reduced, a "fully" automatic mode is desired in which the computer performs all of the functions of scaling selection, then performs the N(h) computation and presents the results for operator approval. At the other end of the scale, a step-by-step manual mode will be required when the operator is working with the difficult high altitude ionograms that contain multiple traces, spread echoes, resonance smears, etc. In between these extremes an intermediate semiautomatic mode of operation will be desired. Complete flexibility in the various operational modes with convenience in changing from one to another is required.

4.0 PERFORMANCE REQUIREMENTS

4.1 Analog Magnetic Tape Machine

Data input to the TAPECLIP system is provided by playback from analog magnetic tape. The analog magnetic tape machine shall be a Sangamo Model 4712 1/2 inch, 7-track tape machine. This machine will be supplied by NASA/ARC. Certain modifications shall be made to the machine to provide operation at any one of three selectable speeds. The vendor shall be responsible for having the machine modified to meet the additional specifications required.

The analog magnetic tape machine shall meet the manufacturer's published specifications for this unit.

4.1.1 Playback Speeds

There shall be three switch selectable playback speeds of 15, 30, and 60 ips.

4.1.2 Playback Amplifiers

There shall be four direct-reproduce amplifiers with electrically switchable amplitude and phase equalizers for playback speeds of 15, 30, and 60 ips. These will be used on Tracks 2, 3, 5 and 6. A PCM reproduce amplifier shall also be provided for use on Track #4.

The voice reproduce amplifier is presently wired to a playback head that reads a narrow track on the edge of the magnetic tape. This amplifier should be reconnected to operate from the playback head on Track #1 with an appropriate pad interface to compensate for the difference in playback signal level between Track #1 and the edge track.

4.1.3 Manual Control

The tape machine shall be controlled manually from the transport front panel.

4.1.4 Tape Search

The tape transport shall be capable of operating with a tape search and control unit (timing section).

4.2 Timing Subsystem

The timing subsystem reads the NASA 36-bit time code on playback from magnetic tape and provides a time-of-year input to the IBM 1800 Computer with milli-second resolution.

In tape search mode, the operator can preset the desired times to start and stop playback. The timing subsystem will then control the analog magnetic tape machine to locate on tape the time code corresponding to the preset start time. When the selected segment of tape reaches the preset stop time, the tape machine automatically stops and all auxiliary outputs are removed.

The time code generator performs a dual function as follows:

a. ISIS-A time, derived from bit 7, word 3 of the PCM channel, is an input to the time code generator. The generator shall convert the ISIS-A time code to the NASA 36-bit code amplitude modulated on a 1 kHz carrier.

b. In the event a usable NASA 36-bit time code is not available from the analog magnetic tape, the generator shall generate the time code synchronized to an external 1 kHz carrier signal derived from the phase-locked time base generator. In this mode the time code generator is preset to the time indicated on the tape log sheet and then the time code is advanced in 1 ms increments by the 1 kHz carrier.

4.2.1 <u>Time Code Translator</u>

The time code translator shall be an Astrodata Model 5220-200 NASA time code translator. This unit will be supplied by NASA/ARC. In addition to the standard parallel BCD outputs, an auxiliary 16-bit parallel binary output shall be provided representing milliseconds. This auxiliary output shall recycle once per minute and have a full range count of decimal 59999. Major time is defined as days, hours, and minutes. Minor time is defined as seconds and milliseconds. A complete time word will occupy three 1800 computer words as follows:

a. Days as three 4-bit BCD words, right adjusted.

b. Hours and minutes as four 4-bit BCD words.

c. Milliseconds from 0 to 59999 decimal as a 16-bit binary word.

Major time in BCD is read in on demand of the 1800 computer. Minor time in binary is read in once per line at the time of zero range, and also at the time of occurrence (leading edge) of frequency markers.

All digital outputs shall properly interface with the IBM 1800 digital input channel. The unit shall accept a "ready" signal from the 1800 computer and provide a "sync" signal when major time is to be transferred to the 1800. The unit shall meet the "sync" and "ready" signal specifications for the 1800.

The time code translator shall meet the manufacturer's published specifications for this unit. A Model 5220-200 data sheet is included in the appendix.

4.2.2 Tape Search and Control Unit

The tape search and control unit shall be an Astrodata Model 5224-100. This unit shall be supplied by NASA/ARC. The tape search and control unit provides automatic search of the analog magnetic tape and will locate the selected start time at both forward and reverse speeds. Start and stop times are preset by the operator using switches located on the front panel of the unit. The tape search and control unit shall control the analog magnetic tape machine from time information derived from the time code translator.

Capability for tape search forward and stop shall be provided when the time code input to the time code translator is derived from the time code generator.

The tape search and control unit shall meet the manufacturer's published specifications for this unit. A Model 5224-100 data sheet is included in the appendix.

4.2.3 Time Code Generator

The time code generator shall accept an external 1 kHz carrier frequency and generate a NASA 36-bit 100-pps code amplitude modulated on a 1 kHz sinusoidal carrier. In another mode of operation, the time code generator shall accept the ISIS-A 60-pps time code as a serial pulse train and convert it to the above NASA 36-bit code.

The NASA 36-bit time code format is shown in figure 8. The ISIS-A time code format is shown in figure 9. The time code generator shall meet all performance specifications at X1, X2 and X4 playback speeds. The following specifications relate to X1 playback speed.

4.2.3.1 Performance Specifications

a.	Input A:	ISIS-A time code serial pulse train from the PCM decom.
b.	Input B:	1 kHz square wave derived from the phase-locked time base generator.
c.	Input Impedance:	Greater than 10K ohms to ground.
d.	Logic Levels:	Binary 1 = +3 to +5 volts Binary 0 = 0 to +0.45 volts
e.	Error Bypass:	The unit shall have a synchronization mode which permits the operator to select the bypass of 0, 1, 2, or 3 consecutive ISIS-A time words which may be decoded erroneously.

f. Synchronization: The difference in time between the ISIS-A time code and the converted NASA 36-bit time code shall be less than 1 ms.

g. Serial Time Code Output: NASA 36-bit 100-pps time code amplitude modulated on a 1 kHz sinusoidal carrier.

h. Front Panel Controls and Indicators:

(1) Time Code Start

(2) Time Code Stop

(3) Reset (clear all registers)

(4) Digital display of time in the output registers for day of year, hours, minutes, and seconds by wide angle "NIXIE" tubes

(5) Thumbwheel digital switches for each digit of time of day, hours, minutes, and seconds for presetting start time.

(6) Error bypass switch as described in (e).

(7) Mode switch to select operation from ISIS-A time or to generate the NASA 36-bit code synchronously with the external 1 kHz carrier.

i. Output Amplitude: Adjustable from 0 to 10 volts peak-to-peak.

j. Load Impedance: Nominal 600 ohms unbalanced to ground.

k. Output Impedance: Less than 50 ohms for frequency components up to 10 kHz.

l. Harmonic Distortion: Less than 2% referred to a 1 kHz carrier at 10 volts peak-to-peak.

m. Mark-to-Space Ratio: Nominally 3:1, adjustable from 2:1 to 4:1.

4.2.4 Minor Time Converter

The Minor Time Converter receives, from the Astrodata 5220-200 Time Code Translator, five digits of parallel BCD (8-4-2-1) time representing seconds and milliseconds, and a 1 kpps clock signal, and converts this to a 16-bit binary output for parallel input to the IBM 1800 computer.

The minor time output shall be a logical extension of major time and shall recycle once per minute, synchronized to the advance of the units of minutes digit within 0.2 ms.

Input signal logic levels shall be compatible with the 5220-200 Time Code Translator. Output signal logic levels shall be compatible with the digital input channel of the 1800 computer.

The unit shall accept a "ready" signal from the 1800 computer and provide a "sync" signal when minor time is to be transferred to the 1800. The unit shall meet the "sync" and "ready" signal specifications for the 1800.

It is not required that the minor time converter be built as a separate unit. If desired, it may be included as a logical function in the time code generator package.

4.3 FM Discriminator Section

The FM Discriminator Section consists of two FM subcarrier discriminators. One discriminator operates on standard IRIG ±40 percent wideband channels and is used to demodulate the sounder video data. The other discriminator is used with Alouette II to demodulate frequency marker data and with ISIS-A for demodulation of PCM data received on playback from the spacecraft tape recorder. Each discriminator shall be able to operate at three different playback speeds that are X1, X2, and X4 equivalent real time.

In the following subsections, the subcarrier center frequencies and low pass filter corner frequencies are specified for each of the three playback speeds.

In response to this specification, the vendor shall supply the location of all poles and zeros in the bandpass and low pass filters, including those representing the loop transfer function, and show that these will meet both the frequency response and time delay specifications.

4.3.1 Wideband FM Subcarrier Discriminator

4.3.1.1 Performance Specifications

a. Subcarrier Center Frequencies: 27 kHz, 54 kHz, 108 kHz

b. Frequency Deviation: ±40%

c. Input Signal Level: 10 mv to 2v rms

d. Input Impedance: More than 10K ohms shunted by less than 50 pf

e. Deviation Polarity: Switch selectable + or -

f. Output Voltage: Bandedge voltage continuously adjustable from ±1 volt to nominal ±11 volts. Output voltage linear to ±120% of any bandedge voltage up to ±10 volts. A calibrated 10-turn dial shall be direct reading in bandedge voltage within 2% of full bandwidth voltage.

g. Output Frequency Response: DC to 50 kHz or as limited by the response of low pass filters.

h. Output Current: Not less than 20 ma at any output voltage up to ±12v.

i.	Short Circuit Protection:	No circuit damage from an output short circuit at any output voltage up to maximum limiting voltage.
j.	Output Impedance:	Less than 0.1 ohms at DC; less than 10 ohms at low pass filter corner frequency
k.	Output Voltage Limiting:	Nominal 130% of bandedge voltage for any bandedge voltage from ±1v to ±10v.
l.	Output Current Limiting:	Nominal 130 ma at any setting of the bandedge volts control.
m.	Capacitive Loading:	Up to .002 μfd
n.	Carrier Feedthru:	With 10 volts DC output at lower bandedge frequency, the carrier feedthru shall be less than 20 mv p-p with specified low pass filters.
o.	Output Noise:	With 20 mv rms input signal at center frequency, the output noise shall be less than 8.5 mv rms for a gain setting of 10v at bandedge deviation, and a 3-sigma probability of less than 40 mv p-p with specified low pass filters.

p. Loss of Signal: An internal loss-of-signal threshold adjustment shall be provided. With loss of signal, an 1800 computer interrupt shall be generated.

q. Recovery from Loss of Signal: Limited only by the rise time of the low pass response of the discriminator.

r. Recovery from Out-of-Band Signal: Limited only by the rise time of the low pass response of the discriminator.

s. Static Nonlinearity: Less than 0.05% of full bandwidth, best straight line up to maximum deviation.

t. Harmonic Distortion: Less than 1.0% rms distortion of a $\pm$40% deviation signal at any intelligence frequency from DC to specified low pass filter corner frequency.

u. Output Zero Stability: Less than 0.05% of full bandwidth for 24 hours after a 15 minute warmup.

v. Deviation Sensitivity Stability: Less than 0.1% of full bandwidth for 24 hours after a 15 minute warmup.

w. Amplitude Modulation Rejection: Less than 1.0% of full bandwidth peak transient for a 20 db step change in subcarrier amplitude at center frequency with specified low pass filters.

x. Line Voltage Sensitivity: Less than ±0.2% of full bandwidth change in zero or deviation sensitivity for a 10-volt change in line voltage.

y. Meter(s):

(1) Input meter function, logarithmic scale, minimum 60 db dynamic range.

(2) Output meter function, direct reading in percent bandedge from zero center

z. Data Loss Indicator: Indicator shall indicate loss of signal.

aa. Bandedge Volts Control: 10-turn potentiometer with calibrated 10-turn vernier dial.

ab. Zero Adjust Control: Multiturn potentiometer with screwdriver slot for adjustment.

ac. Test Points:

(1) Output Signal

(2) Signal Ground. Signal ground shall be separated from chassis ground.

(3) Input Signal

ad. Power Supply: The regulated power supply shall be self-contained.

ae. Power Supply Voltage: Nominal 115v AC, 60 Hz.

af. Operating Temperature Range: 5°C to 50°C with circulating air.

ag. Relative Humidity: Up to 90% without condensation

ah. Low Pass Filters:

(1) Corner frequencies* 10 kHz, 20 kHz, 40 kHz

(2) Response, maximally flat time delay.

The pole positions of the low pass filters shall be supplied by the vendor.

*The LPF corner frequency is defined as the frequency at which the 0 db line and asymptotic attenuation slope on a logarithmic frequency scale intersect.

(3) Attenuation beyond cutoff shall be asymptotic to a minimum 42 db/octave slope.

(4) Filters can be switch selectable or plug in from the front panel.

ai. Channel Selection: Subcarrier center frequencies of 27 kHz, 54 kHz, and 108 kHz can be switch selected or provided by separate channel selectors which plug in from the front panel.

4.3.2 PROPORTIONAL BANDWIDTH FM SUBCARRIER DISCRIMINATOR

4.3.2.1 Performance Specifications

a. Subcarrier Center Frequencies and Deviations: 30 kHz, 60 kHz, 120 kHz, ±7.5% deviation; 23.25 kHz, 46.5 kHz, 93 kHz, ±25% deviation

b. Input Signal Level: 2 mv to 2 volts rms, up to 12 volts p-p, FM multiplex input

c. Input Impedance: Greater than 10,000 ohms shunted by less than 50 pf

d. Deviation Polarity: Switch selectable + or -

e. Input Selectivity: The bandpass filter response shall be down less than 3 db at bandedge and more than 30 db at 3 times bandedge deviation. Time delay variation thru the bandpass filter from LBE to UBE shall be less than ±2.0%

f. Output Voltage: Bandedge voltage shall be continuously adjustable from ±1 volt to nominal ±11 volts, and linear to ±120% of any bandedge voltage up to ±10 volts. A calibrated 10-turn dial shall be direct reading in bandedge volts within 2% of full bandwidth voltage.

g.	Output Frequency Response:	DC to 50 kHz, or as limited by the response of the loop and low pass filters
h.	Output Current:	Not less than ±20 ma at any output voltage from ±1 volt to ±12 volts
i.	Short Circuit Protection:	No circuit damage from an output short circuit at any output voltage up to maximum limiting voltage
j.	Output Impedance:	Less than 0.1 ohm at DC, and less than 10 ohms at low pass filter corner frequency
k.	Output Voltage Limiting:	Nominal 130% of bandedge voltage for any bandedge voltage up to ±10 volts
l.	Output Current Limiting:	Nominal 130 ma at any setting of the bandedge volts control
m.	Capacitive Loading:	Up to 0.002 μfd
n.	Carrier Feedthru:	With 10 volts DC output at lower bandedge frequency, the carrier feedthru shall be less than 20 mv p-p with specified low pass filters.
o.	Output Noise:	With 20 mv rms input signal at center frequency, the output noise shall be less

than 5 mv rms at MI=5 and 8.5 mv rms at MI=1 for a gain setting of 10 volts at bandedge deviation, and a 3-sigma probability of less than 40 mv p-p with specified low pass filters.

p.	Loss of Signal:	An internal loss-of-signal theshold adjustment shall be provided. With loss of signal, an 1800 Computer interrupt shall be generated.
q.	Recovery from Loss of Signal:	Shall not exceed the rise time of the low pass response of the loop and low pass filters by more than 5 ms.
r.	Recovery from Out-of-Band Signal (either data or reference):	Shall not exceed the rise time of the low pass response of the loop and low pass filters by more than 5 ms.
s.	Static Nonlinearity:	Less than 0.05% of full bandwidth, best straight line up to maximum deviation
t.	Harmonic Distortion:	Less than 1.0% rms distortion with MI=5 low pass filter and less than 2.0% rms distortion with MI=1 low pass filter
u.	Output Zero Stability:	Less than $\pm 0.01\%$ of center frequency for 24 hours after a 15 minute warmup

v.	Deviation Sensitivity Stability:	Less than ±0.1% of full bandwidth for 24 hours after a 15 minute warmup
w.	Amplitude Modulation Rejection:	Less than 1.0% of full bandwidth peak transient for a 20 db step change in subcarrier amplitude at center frequency with specified low pass filters
x.	Line Voltage Sensitivity:	Less than ±0.2% of full bandwidth change in zero or deviation sensitivity for a 10-volt change in line voltage
y.	Meter(s):	(1) Input meter function, logarithmic scale, minimum 60 db dynamic range (2) Output meter function, direct reading in percent bandedge from zero center
z.	Data Loss Indicator:	Indicator shall indicate loss of signal
aa.	Bandedge Volts Control:	10-turn potentiometer with calibrated 10-turn vernier dial
ab.	Zero Adjust Control:	Multiturn potentiometer with screwdriver slot for adjustment

ac. Test Points:
(1) Output Signal
(2) Signal Ground. Signal ground shall be separated from chassis ground
(3) Input Signal

ad. Power Supply: The regulated power supply shall be self-contained

ae. Power Supply Voltage: Nominal 115v AC, 60 Hz

af. Operating Temperature Range: 5°C to 50°C with circulating air

ag. Relative Humidity: Up to 90% without condensation

ah. Low Pass Filters, MI = 5:
(1) Corner frequencies* 450 Hz, 900 Hz, 1800 Hz
(2) Response, maximally flat time delay
(3) Attenuation beyond the corner frequency shall be asymptotic to a minimum 18 db/octave slope
(4) Filters can be switch selectable or plug in from the front panel

*The LPF corner frequency is defined as the frequency at which the 0 db line and asymptotic attenuation slope on a logarithmic frequency scale intersect.

ai. Low Pass Filters, MI = 1:

(1) Corner frequencies*
6 kHz, 12 kHz, 24 kHz

(2) Response, maximally flat time delay

(3) Attenuation beyond the corner frequency shall be asymptotic to a minimum 30 db/octave slope. The poles of the phase locked loop filter shall be combined with the poles of the low pass filter to provide a composite 5-pole LPF. The frequency input to voltage output transfer function of the phase locked loop demodulator shall contain no zeros.

aj. Channel Selectors:

Center frequencies and deviations as specified in (a). Channel selectors can plug in thru the front panel or be switch selectable.

4.4 PHASE-LOCKED TIME BASE GENERATOR

Reference frequencies of 10 kHz or 50 kHz are recorded on a separate track on the analog magnetic tape at the ground receiving station. For ISIS-A data, the reference frequency may alternatively be the PCM bit rate of 11.52 kHz derived from the PCM decom. On playback, the time base generator converts the input reference frequency to the appropriate clock frequency which controls the ADC to sample the sounder video data every 5 km of virtual depth. At X1 playback speed of 15 ips, the clock frequency is 30 kHz. In addition, an auxiliary 1 kHz square wave output signal shall be provided as a carrier input to the time code generator.

The ADC clock pulses shall be capable of being phase reset at time zero, to each line sync pulse within ±0.5 km of zero range.

The generator shall be capable of operating at playback speeds of X1, X2, and X4 equivalent real time.

An input bandpass filter shall be used when the reference frequency is derived from magnetic tape. Bandpass filters shall be provided for each of these two reference frequencies at each of the three playback speeds.

The frequency input to frequency output transfer function shall have a pair of complex poles in the S-plane with a damping ratio of .866 and no zeros in the numerator term.

The vendor shall provide a functional block diagram, detailed description, and a linear model analysis showing how the specified transfer function is to be implemented.

4.4.1 Performance Specifications

a. Reference Frequencies:	10 kHz, 50 kHz, 11.52 kHz, X1, X2, X4
b. Bandpass Filter Center Frequencies (f_c):	10 kHz, 50 kHz, X1, X2, X4
c. Input Signal Level:	10 mv to 2v rms
d. BPF Selectivity:	Down less than 3 db at frequencies $f_c(1 \pm .075)$, and down more than 24 db at frequencies $f_c(1 \pm .225)$.
e. Time Delay Variation:	Less than $\pm 2\%$ between the frequencies $f_c(1 \pm .075)$.
f. Loop Corner Frequencies (f_n):	see below
g. Loop Damping Ratio:	0.866 $\pm 5\%$
h. Phase Jitter:	With fixed reference frequency input of 100 mv rms or more, the phase jitter on the ADC clock frequency due to carrier feedthru modulation of the phase-locked VCO shall be less than $\pm 2\%$.

Loop Corner Frequencies (f_n):

Ref. Freq.	f_n X1, X2, X4
10 kHz	800 Hz
50 kHz	800 Hz
11.52 kHz	120 Hz

The tolerance on f_n is $\pm 10\%$.

i. Phase Reset: At time zero for each line sync pulse the phase of the ADC clock pulses shall be reset to equivalent range zero ± 0.5 km.

j. ADC Clock Pulse Output:

(1) Logic levels
Binary 1 = +3 to +5 volts
Binary 0 = 0 ± 0.45 volts

(2) Rise time less than 0.5 μs from 10% to 90% of full amplitude

(3) Pulse width 2 ± 0.5 μs measured at half amplitude

(4) Current sufficient to drive the ADC input

k. 1 kHz Output:

(1) 50% duty cycle square wave $\pm 0.5\%$

(2) Logic levels
Binary 1 = +3 to +5 volts
Binary 0 = 0 ± 0.45 volts

(3) Rise time less than 1.0 μs from 10% to 90% of full amplitude

(4) Current sufficient to drive the time code generator input

4.5 Analog-to-Digital Converter Subsystem

The ADC subsystem accepts the analog sounder video signal from the zero and scale correction unit and clock pulses from the phase-locked time base generator and digitizes the sounder video signal with 8-bit resolution at a maximum rate of 120,000 samples per second at X4 playback speed. Two 8-bit bytes are then packed into a 16-bit word for parallel input to the 1800 Computer. Following a line sync pulse, byte 1 represents the relative sounder video signal amplitude at range 5 KM, byte 2 at range 10 KM, etc. Sixteen-bit computer word 1 is made up of bytes 1 and 2, word 2 contains bytes 3 and 4, etc.

The ADC Subsystem consists of a sample-and-hold amplifier, analog-to-digital converter, and data output unit.

4.5.1 Sample-and-Hold Amplifier

The sample-and-hold amplifier tracks the incoming analog sounder video signal until an ADC clock pulse activates the hold cycle. The analog voltage at the time of the clock pulse is then held constant long enough to be converted to an equivalent numerical value by the ADC. The sample-and-hold amplifier then resumes the tracking mode.

4.5.1.1 Performance Specifications

a.	Gain:	+1.0 $\pm$.05%
b.	Sample-and-Hold Offset:	$\pm$.05% f.s. (5 mv)
c.	Noise:	Less than 0.5 mv RMS
d.	T.C. Offset:	$\pm$.005%/°C f.s.
e.	T.C. Gain:	$\pm$.005%/°C f.s.
f.	Offset Stability:	$\pm$.05% f.s. for 30 days
g.	Gain Stability:	$\pm$.01% f.s. for 30 days
h.	Input Voltage:	$\pm$10v ($\pm$15v max.)
i.	Input Impedance:	Greater than 10 megohms in parallel with less than 50 pf
j.	Output Voltage:	$\pm$10v ($\pm$15v max.)
k.	Output Impedance:	Less than 0.5 ohms in series with less than 20 μh
l.	Output Current:	Sufficient to drive the ADC input
m.	Settling Time from Hold to Track:	Less than 5 μsec to .05% f.s.

n. Hold Decay Rate: Less than 10 mv/ms

o. Frequency Response: Flat within ±.05% f.s. DC to 50 kHz

p. Aperture Uncertainty: 100 ns

q. Trigger Input: Compatible with ADC

r. Operating Temperature Range: 5° to 50°C

4.5.2 Analog-to-Digital Converter

The ADC digitizes the analog sounder video signal with 8-bit resolution at the time of each clock pulse and outputs the digital values to the data output unit.

4.5.2.1 Performance Specifications

a. Input Voltage: ±10v f.s. (±15v max.)

b. Input Impedance: Not less than 1K ohms

c. Digitize Command (clock pulse): Digitizes with clock pulse at +3 to +5v. Does not digitize with clock pulse at 0 to +0.45v. 0.5 μsec max. delay to start conversion.

d. Number of Bits: 8

e. Conversion Time: 5 μsec max.

f.	Accuracy:	±0.5% f.s. including quantizing error
g.	Output Code:	2's complement
h.	Busy Signal:	Binary 1 = Converter off Binary 0 = Converter digitizing
i.	End of Conversion:	Binary 1
j.	Output Logic Levels:	Compatible with data output unit and sample-and-hold amplifier.
k.	Stability:	0.1% f.s. for 30 days
l.	Temperature Coefficient:	±.01%/°C
m.	Operating Temperature Range:	5° to 50°C

4.5.3 Data Output Unit

The data output unit accepts two 8-bit bytes from the ADC and packs these into a 16-bit word for parallel input to the 1800 Computer. The unit accepts a pulse from the line synchronizer and uses this to identify byte 1, word 1 at the beginning of each line. The unit accepts a "ready" signal from the 1800 and generates a "sync" signal when data is to be transferred. The output logic levels of the unit shall be compatible with the input signal requirements of the 1800 high-speed digital input channel. The logic levels shall be compatible with the ADC.

4.6 Line, Frame Synchronizer

The beginning of an ionogram is identified by a frame sync pulse of 7 ms duration in the sounder video data in Alouette I and Alouette II, and 16.67 ms in ISIS-A and ISIS-B. The occurrence of the trailing edge of the frame sync pulse will generate a computer interrupt to reset the line sequence number counter to zero, and also read in major time from the time code translator. The sounder video formats for the Alouette I, Alouette II, and ISIS-A satellites are shown in figures 4, 5, and 6, respectively. A summary of video formats of the Canadian Scientific Satellites is shown in figure 7.

A line sync pulse occurs at the beginning of each line of sounder video data. Time zero, t_o, for each line shall be the trailing edge of the line sync pulse at the telemetry zero level. The occurrence of the line sync pulse shall generate a computer interrupt to reset the range increment number counter to zero. At time t_o the phase of the ADC clock pulses shall also be reset to coincide with zero range.

The 1800 Computer shall be programmed to generate windows for both frame and line sync pulses after "lock" has been acquired. The windows shall be available for use in discriminating against false sync pulses.

Provision shall be made for manually initiating a start frame pulse if for some reason the frame synchronizer is unable to identify the frame sync pulse.

In another mode of operation, the operator shall be able to enter, on the alphameric keyboard, an estimated time of year for the occurrence of the frame sync pulse. With the tape playback started prior to this time, the computer shall be able to generate a synthetic frame sync pulse at the pre-set time input from the Time Code Translator, which will enable the telemetry formatting subsystem to load the sounder video data for that particular ionogram into computer memory.

For the case where frame lock has been acquired, in processing the pass of a satellite, a mode of operation shall be provided for the computer to output a synthetic frame sync pulse at the estimated time the frame sync pulse should have occurred in the frame sync window.

The vendor shall provide a description of the operation of the line and frame synchronizer in sufficient detail to permit evaluation of the operational techniques proposed. System response to a missing line sync pulse(s) shall be described. Assume not more than two consecutive missing line sync pulses.

4.7 Zero and Scale Correction Unit

The Zero and Scale Correction Unit shall provide DC restoration of the ac-coupled video signal and normalized gain so that the maximum peak-to-peak video signal is compatible with the full scale range of the ADC.

Telemetry scale calibration (gain) and zero reference pulses for Alouette II, ISIS-A, and ISIS-B video signals occur just prior to the line sync pulse, as shown in figure 7. No gain or zero reference pulses are provided on Alouette I (S-27) video signals.

Zero correction shall be generated for each line of sounder video data unless a missing line sync pulse occurs. The full scale amplitude of the sounder video signal remains reasonably constant so that it is really only necessary to compute the scale level once per ionogram. The scale setting should be computed by averaging the values of at least 10 telemetry scale pulses.

The vendor shall describe in detail the operation of the zero and scale correction unit with video signals from Alouette II, ISIS-A, and ISIS-B. Zero and scale correction of video signals from Alouette I must be handled in a somewhat different manner since no telemetry zero and scale calibration pulses are provided. How this is to be accomplished shall be described in adequate detail.

4.7.1 Performance Specifications

a. Input Voltage: $\pm$10v f.s.

b. Input Impedance: Greater than 100K ohms in parallel with less than 50 pf

c.	Zero Offset Range:	An input signal within the range +10v to -10v shall be adjusted to 0v output
d.	Zero Offset Resolution:	0.1% of full bandwidth as provided by a 10-bit DAC
e.	Gain Range:	An input signal within the range 3v to 10v shall be adjusted to 10v output
f.	Gain Resolution:	As provided by a 10-bit register, giving 1000 increments of gain
g.	Output Voltage:	±10v f.s.
h.	Output Current:	Sufficient to drive the ADC subsystem
i.	Frequency Response:	Flat from DC to 50 kHz ±.05%

4.8 - Frequency Marker Detector

On magnetic tapes from Alouette II, frequency markers are recorded as a frequency modulated subcarrier on a separate track from the sounder video signal. During playback this frequency marker signal is demodulated by a separate FM subcarrier discriminator and applied to the input of the frequency marker detector. The frequency marker detector unit generates a computer interrupt for each frequency marker, causing the computer to store the time of occurrence of the leading edge of the frequency marker pulse to the nearest millisecond. The frequency marker pulses are width coded on Alouette II, and this information can be used to identify the calibration frequencies these pulses represent, if so desired.

On Alouette I,ISIS-A, and ISIS-B, the frequency markers are superimposed on the sounder video signal. On Alouette II, the frequency markers can be switched by ground control to occur on the sounder video signal. The vendor shall describe in detail how these frequency markers are identified and stored in computer memory.

4.9 PCM SUBSYSTEM

The PCM subsystem accepts serial PCM data from ISIS-A at 11.52 kbps, X1 playback speed, and outputs the words in the frame in a packed format of two 8-bit bytes per computer word. The subsystem also outputs the ISIS-A time code to the time code generator, and a square wave at the bit rate to the phase locked time base generator.

The PCM subsystem consists of a PCM signal conditioner, a PCM decommutator, and a PCM data output unit. The subsystem shall operate at playback speeds of X1, X2, and X4 equivalent real time.

4.9.1 PCM Signal Conditioner

The PCM signal conditioner accepts the input serial PCM data which may be degraded by error signals such as noise, jitter, bandwidth limiting, rate variations, and ac or dc baseline offset, and reconstructs the serial data and the bit rate clock.

The unit shall be an EMR Model 2720-02 PCM Signal Conditioner with selectable filter-sample and reset-integrator detectors. The unit shall operate from serial PCM data coming from either the PCM read amplifier in the analog magnetic tape machine or from FM subcarrier discriminator #2 when PCM data is on the 93 kHz subcarrier at X4 playback speed. The unit shall operate at bit rates of 11.52 kbps, 23.04 kbps, and 46.08 kbps.

4.9.2 PCM Decommutator

The PCM decommutator accepts the regenerated serial NRZC signal and the bit rate clock pulse trains from the PCM signal conditioner and generates frame sync, word sync, and a square wave signal at the bit rate for input to the phase locked time base generator. Parallel 8-bit words are output to the PCM data output unit. Bit 7, word 3 is separately decommutated and output to the time code generator.

4.9.2.1 Performance Specifications

a.	Input Signal:	Compatible with PCM signal conditioner
b.	Input Bit Rate:	11.52 kbps, 23.04 kbps, 46.08 kbps
c.	Word Length:	8 bits per word
d.	Frame Length:	24 words per frame
e.	Frame Rate:	60/sec at X1 playback
f.	Frame Sync Pattern:	Words 1 and 2, octal 004727
g.	Frame Sync Modes:	Search, check, and lock as shown in figure 10

(1) The number of bit errors may be independently set to any number from 0 to 7 for each of the three modes.

2

(2) The check mode length may be set to check 0-10 successive frame sync patterns before entering the lock mode.

(3) The lock mode length may be set to detect 1-10 consecutive missing sync patterns before returning to the search mode.

h. Logic Levels: Binary 1 = +3 to +5v
Binary 0 = 0 to 0.45v

i. Bit Sync Output:
(1) 50% duty cycle square wave at the input bit rate
(2) Current and rise time compatible with the phase locked time base generator

j. Decoded Time Output:
(1) Bit 7, word 3
(2) Sync pulse to identify the time of occurrence of bit 7, word 3
(3) Current and rise time compatible with the time code generator

k. Word Output:
(1) 8-bit parallel
(2) Current and rise time compatible with the PCM data output unit

4.9.3 PCM Data Output Unit

The PCM data output unit accepts two 8-bit bytes from the PCM decom and packs these into a 16-bit word for parallel input to the 1800 Computer. Following frame sync, 16-bit computer word 1 is made up of PCM words 3, 4, computer word 2 contains PCM words 5, 6, etc., and word 11 contains PCM words 23, 24. The unit accepts a "ready" signal from the 1800 and generates a "sync" signal when data is to be transferred. The output logic levels of the unit shall be compatible with the input signal requirements of the 1800 high-speed digital input channel. The input logic levels shall be compatible with the PCM decom.

4.10 CRT Ionogram Display Unit

The purpose of the CRT Ionogram Display Unit is to provide a means of visual communication from the computer to the operator. An electronic ionogram picture is displayed on the CRT under program control using the digitized sounder video data in computer memory. The minimum acceptable CRT screen size shall be 6 inches vertical by 8 inches horizontal.

4.10.1 Operating Modes

The operator shall be able to select a variety of display modes to meet the needs of closed loop ionogram processing. The following modes shall be provided:

a. Complete ionogram display

b. Expanded display of any portion of the time or frequency (horizontal) axis up to 10 times, i.e., any 0.1 portion of the time scale can be expanded to fill the full horizontal width of the screen.

c. Expanded display of any portion of the virtual depth (vertical) axis up to 10 times, i.e., a range of 500 KM can be expanded to fill the full vertical height of the screen.

   A detailed description of how scale expansion is implemented shall be given.

d. A movable scaling cursor character shall be displayed on the electronic ionogram picture. The coordinates of the scaling character in frequency and range shall be continuously displayed in digital form in engineering units on the IBM 2250 graphic display unit. The position of the scaling character shall be controlled by the operator via the scaling cursor control unit.

e. An A-Scan display showing three lines of video data shall be provided on the right hand side of the CRT screen as shown in figure 11. The middle A-Scan line displayed shall be the line on which the scaling cursor character is positioned. The other two lines shall be the preceding and following lines. As the position of the scaling character is changed, the A-Scan display shall change accordingly.

   A duplicate scaling cursor character or a horizontal line segment shall be positioned on the middle A-Scan line at the same range as the scaling cursor character as shown in figure 11. With an expanded range scale display, the A-Scan display shall expand vertically the same as the ionogram display.

   An echo pulse on the A-Scan display shall be shown with deflection to the right for increasing pulse amplitude. Full scale echo pulse amplitude shall cause a deflection of up to 1 cm from the mean value of the video zero level. The deflection sensitivity shall be adjustable so that the maximum amplitude of a full scale echo pulse can be adjusted from 0.25 cm to 1.0 cm.

The average spacing between the three A-Scan lines shall be adjustable from 0.25 cm to 1.0 cm. The horizontal position of the middle A-Scan line shall be adjustable over a range of 4 cm from the far right edge of the usable CRT display.

f. The ionogram picture shall contain up to a 4-level gray scale including "black." An equivalent half-tone picture shall be equally acceptable.

The three threshold levels separating the four gray scale regions shall be individually adjustable as parameter inputs from the alphameric keyboard. The operator shall have the option to input only one or two threshold levels instead of three. The position of the threshold levels referred to a selected line shall be displayed on the 2250 as described in h.4.e of this section. The method of implementing these features shall be described.

g. The CRT ionogram display shall be linear in time along the horizontal scale, and linear in range along the vertical scale.

h. A calibrated coordinate system shall be established on the 2250 graphic display unit which has the same scale factor as the ionogram on the CRT ionogram display unit. Annotated tick marks for frequency markers and range markers shall be provided in a manner similar to that used in the FILMCLIP System. A scaling cursor character shall be displayed on the 2250 in the same relative position as the related character appears on the CRT ionogram display. In effect, the two displays are similar in some respects, but differ to the following extent:

1. The CRT display unit contains the essential video detail of a film ionogram except for frequency and range markers. There is no alphameric annotation on this display.

2. The 2250 display provides the same coordinate system but has no sounder video signal representation. This display includes annotated tick marks for frequency and range markers. An alphameric display in engineering units of the coordinate position of the scaling cursor character appears near the bottom of the screen. In effect, the position of the scaling cursor character is direct reading in frequency, range and time.

3. The types of data that shall be capable of being displayed on the 2250 and alternatively superimposed on the electronic ionogram on the CRT display unit are as follows:

    a. Scaled X, O, Z-traces

    b. Computed X, O, Z-traces

    c. Exit frequencies of X, O, Z-traces

    d. Frequencies and maximum range of significant resonances including f_N, f_T, f_H, $2f_H$, $3f_H$, etc.

    e. Computed or scaled X, O, Z-traces of previously processed ionograms in a pass

4. The types of displays that would be unique to the 2250 are as follows:

    a. Computed N(h) profile on a coordinate system calibrated in engineering units

    b. Computed contour plots of N(h) and h(N) vs satellite position

    c. Diagnostic messages

    d. Operator instructions in manual modes

e. An expanded (in amplitude) A-Scan display of a line selected by the position of the scaling cursor character on which can be superimposed the three grey scale threshold levels as dashed vertical lines in any combination of one, twos or three.

4.10.2 Scaling

Scaling is the operation of identifying the coordinates of points of interest in an ionogram. Some of the features of interest are outlined in the following:

a. Locus of points identifying the X-trace

b. Locus of points identifying the 0-trace

c. Locus of points identifying the Z-trace

d. Exit frequencies of the X, 0, and Z traces

e. Frequencies of significant resonances including f_N, f_T, f_H, $2f_H$, $3f_H$, etc.

4.10.3 Scaling Modes

Some of the scaling modes to be implemented using the X-trace as an example, are as follows. A similar capability shall be provided for the 0 and Z traces:

a. Individual points along the X-trace identified by manual positioning of the scaling cursor character. From 15 to 30 points may be selected.

b. Manual selection of a set of points along the X-trace to serve as a correlation model for identification of the X-trace in digital form in computer memory.

c. Prediction of the correlation model by interpolation or extrapolation of data from other ionograms.

d. A smooth curve fit of any of the sets of data points in (a) through (c).

It shall be possible to temporarily superimpose on the CRT ionogram display any of the scaled traces in (a) through (d).

4.11 Scaling Cursor Control Unit

The Scaling Cursor Control Unit provides a means for operator control of the position of the scaling cursor character on both the CRT ionogram display unit and the 2250 graphic display unit.

The scaling cursor control unit shall be a position control device in which the relative position of the scaling cursor character on the CRT shall be proportional to the position of the operator controlled stylus on the scaling cursor control unit.

The scaling cursor control stylus shall be movable anywhere within an area of approximately 8 inches vertical by 10 inches horizontal. The control stylus shall remain at any coordinate position within this area when the operator removes her hand.

The guides which support the stylus shall offer negligible reaction force to the operator when she is curve tracing the X-trace with the scaling character on the CRT ionogram display.

The movement of the stylus shall produce an approximately 1:1 corresponding motion of the scaling cursor character on the CRT ionogram display. With an expanded frequency and/or range scale of up to 10 times on the CRT ionogram display, the relative 1:1 motion of the stylus and scaling character shall be automatically maintained. A detailed description of how the scaling cursor control unit is to be implemented shall be given.

The scaling cursor control unit shall interface with the existing scaling converter in the FILMCLIP System. The output from the scaling cursor control unit shall be two analog voltages, one proportional to the vertical component of the stylus position and the other proportional to the horizontal component. The lower left stylus position shall be the 0,0 voltage position.

The human engineering aspects of the scaling cursor control unit shall be given careful consideration in order to provide a control unit that is convenient and natural for an operator to use. The operator shall be able to scale any of the traces by executing a continuous coordinated motion of the right arm and hand, guiding the control stylus while watching the scaling character of the CRT ionogram display. The vendor shall provide a detailed description of how the human engineering aspects of the TAPECLIP System are to be implemented.

4.12 Scaling Converter

The Scaling Converter accepts two analog input voltages, 0 to +10 volts full scale, representing the X-Y coordinate position of the Scaling Cursor Control Unit or the relative positions of the horizontal and vertical crosshairs on the OSCAR-F Film Reader, and digitizes them in alternate sequence. These values are further multiplexed with the numerical representation of the Switchbox setting, which is part of the FILMCLIP system, and input to the IBM 1800 Computer in a 1, 2, 3 sequence. The Scaling Converter is now an operational component of the FILMCLIP system, but it shall be relocated in one of the equipment cabinets of the TAPECLIP system. The vertical panel space required for the Scaling Converter is 21 inches. A functional block diagram of the unit is shown in figure 12.

A switch controlled relay shall be provided to switch the analog voltage inputs to the Scaling Converter between the Scaling Cursor Control Unit and the OSCAR-F Film Reader.

4.13 Test Oscilloscope

A test oscilloscope shall be provided in the Telemetry Formatting Subsystem for monitoring the sounder video signal during operation and for viewing other significant waveforms in the subsystem, when trouble-shooting operational problems or during maintenance periods. The unit shall be a Tektronix Type RM 564 split screen storage oscilloscope with a Type 3A6 dual trace plug-in amplifier and a Type 2B67 time base unit. The scope shall be mounted in one of the cabinets at a convenient viewing height with an input signal selector switch panel-mounted directly below it. Three separate rotary selector switches for the A and B vertical amplifier inputs and external sync input shall be provided. A variety of output waveforms and sync signals from subsystems in the TAPECLIP system shall be wired into the selector switches. The choice of signals to be brought into the switch panel will be based on recommendations of the vendor and discussions with NASA/ARC personnel.

4.14 Software

All computer software for the IBM 1800 Computer, 2250 Display Unit, and 360/50 Computer shall be written by a separate NASA/ARC contractor. It shall be the responsibility of the vendor to provide the necessary software guidance and support to this contractor so that the additional software required for the TAPECLIP system can be written and made operational in an efficient and timely manner. The vendor shall prepare software specifications for the various computer control and display functions that are required, for the telemetry formatting subsystem, and for the display subsystem. Software specifications shall consist of functional descriptions and/or flow diagrams of operations and computations to be performed by the IBM 1800 Computer and the IBM 2250 Display Unit.

5.0 GENERAL DESIGN REQUIREMENTS

The TAPECLIP system shall be designed, fabricated, tested, delivered and installed in accordance with the requirements of this specification. The system shall be built to best commercial practices and shall be designed utilizing off-the-shelf items wherever possible, either manufactured by the vendor or commercially available from other sources. The requirements of this specification are detailed only to the extent considered necessary to obtain the desired mechanical, electrical, visual, and operational characteristics.

5.1 Electrical Requirements

5.1.1 System Power

The system shall operate from a primary power source of 115 volts ac, 60 Hz, 3-wire, single phase. Primary power shall be controlled by means of a circuit breaker of proper capacity that will disconnect the system from the line in the event a serious fault occurs within the system. Power shall also be controlled from a single circuit switch mounted on each peripheral unit.

A duplex power receptacle per rack shall be built into the system on a separate breaker. Each separate receptacle shall be capable of handling 15 amperes.

If power supplies, peripheral units, or other system components are critical to $\pm 10\%$ power line variations, ac line regulators and/or filters shall be furnished as part of this contract to maintain specified system accuracy.

The system shall have separate ac and dc power distribution panels. Fuses shall be provided where necessary for circuit protection.

5.1.2 Power Supplies

All power supplies used in this system shall be short circuit protected to withstand shorted outputs without damage for an extended period of time. All power supplies shall be provided with voltmeters and shall have voltage test points.

5.1.3 Circuit Module Form Factor

All electronic circuitry shall be packaged on the minimum number of printed circuit board sizes consistent with economic considerations for ease of maintenance and reduced spare part complements. All circuitry, except display tubes, shall be solid state. Silicon monolithic integrated circuits shall be used.

5.1.4 System Logic Description

All cards shall represent an advanced approach to implementing the logic design of digital systems. The circuit designs and packaging shall be derived from extensive prior experience. Circuit designs shall permit logic design to be implemented with a minimum number of rules. In all cases, the electrical circuit design, card design, and card production shall reflect the most conservative and reliable approaches.

5.1.5 Test Points

Test points shall be located wherever convenient on the front of all cards and shall represent significant circuit outputs.

5.1.6 Wiring and Cabling

All wiring and cabling used in the system shall conform to best commercial practices. Cables and harnesses shall be firmly supported to prevent undue stresses on the wires or connector terminals. Intra-system wiring and connecting cables shall be routed through wiring ducts and isolated to minimize noise and transient pickup. Wiring shall be protected by grommets when passing through holes in sheet metal.

The preferred method of wire termination for control and other circuits, as applicable, shall be the use of terminal lugs, wire wrap, crimp, and solder.

5.1.7 Cable Harness

Wherever practical, insulated conductors shall be tied to form a neat cable harness. Power lines and signal lines shall be bundled separately.

5.1.8 Connections

All input and output electrical connections shall be identified. Cables shall be installed with sufficient space so that connectors can be connected or disconnected without interference from other cabling or hardware.

5.1.9 Connectors

All connectors for proper interface between the TAPECLIP system and the existing FILMCLIP system shall be provided by the vendor. The vendor shall supply mating connectors wherever required. Cable connectors shall not require disassembly of the system for accessibility. All cable connectors shall have grips adjusted to prevent strain on solder connections. The connectors shall be labeled and keyed so that they cannot be incorrectly mated.

5.1.10 Grounding, Electrical Bonding

A grounding and electrical bonding scheme shall be developed and implemented for the TAPECLIP system that will satisfactorily meet both performance and personnel safety requirements.

A chassis ground shall be provided on the assemblies. All metal parts within the equipment shall be bonded so that the dc resistance between the ground point and any metal structural part shall be less than 0.1 ohm. The chassis ground point shall be clearly labeled "GROUND POINT."

5.1.11 Soldering

Soft solder shall be used for soldering electrical connections. Soldering procedures shall conform to best commercial practices.

5.1.12 Electromagnetic Interference Control

In the design of the TAPECLIP system, electromagnetic interference control shall be implemented to the extent that the system is compatible within itself.

5.2 Mechanical Requirements

5.2.1 Modular Construction

System design for packaging shall be based upon the use of individual printed circuit cards and/or assemblies which are replaceable functional elements. The circuit cards shall be fabricated of epoxy glass laminate with through connections being either plate-thru or eyelet. The subassemblies shall be completely wired and rack mounted.

5.2.2 Accessibility

All electronic circuitry packaged in logic trays shall be accessible from the front of the system.

Digital logic assemblies and rack-mounted equipment without front access shall be mounted on slides.

5.2.3 Enclosures

All equipment shall be housed in cabinets with a maximum overall height of 6 feet and a width and depth of approximately 2 feet. Convenience outlets (115v, 60 Hz) shall be provided on each cabinet. The system cabinets shall be designed for installation and operation on a computer floor (2 ft x 2 ft squares).

Equipment cabinets shall not be more than three-quarters full in order to provide room for future expansion.

5.2.4 Compatibility and Interchangeability

Provisions shall be made for compatibility between and within subsystems so that requirements for special impedance and voltage level matching elements are minimized.

All parts of the system having the same part numbers shall be mechanically and electrically interchangeable without selection.

5.2.5 Workmanship and Materials

All materials used in the system shall be new, undamaged and the best grade for the purpose intended. Layout of parts, switches, lights, controls, etc., is left to the discretion of the vendor and shall be arranged for maximum convenience for operation and maintenance. All items produced shall conform to good workmanship standards. Particular attention shall be paid to cleanliness, neatness and thoroughness of soldering, wiring, impregnation of coils, marking of parts and assemblies, plating, painting, riveting, machine screw assembly, welding and brazing. All mechanical parts shall be free from burrs and sharp edges.

The vendor shall provide and maintain a manual of workmanship standards that is available to all production, inspection, and test personnel.

5.2.6 Maintenance Aids

To aid in maintenance, the logic state of significant circuits shall be displayed by means of indicating lamps. Plug-in unit-type construction of all electronic circuitry shall be used. Easily accessible test points shall be provided on all electronic plug-in circuitry where practical, and for all power supplies and regulators. Front panel test points shall be provided for all functions that require frequent monitoring. The equipment shall be constructed such that all parts are easily accessible from only one side (top or one side) of the logic trays for servicing. Wiring, drawings, and corresponding physical components shall be properly labeled. Operational schematics shall be in the form of logic drawings. All logic functions (gates, flip-flops, etc.) and their associated inputs and outputs shall be identified.

5.2.7 Special Tools

A set of any special tools required for system operation, calibration, or maintenance shall be provided. The set shall include necessary extender modules and cables. Examples of special tools are wire wrap and unwrap tools, AMP tab insertion and removal tools, AMP tab crimpers, logic card extractors, etc.

A reasonable supply of spare fuses, AMP tabs, etc., shall be supplied with the system for use during acceptance testing and initial operation of the system.

5.2.8 Limited Life Items

The use of material and articles with limited life characteristics shall be avoided. Where such items must be used, they shall be marked to indicate, by date or frequency of use, the beginning and expected end of useful life. Adequate procedures shall be employed to control items of this nature, to ensure their removal and replacement on a regularly scheduled basis. The use of any item with limited life characteristics requires prior approval from NASA/ARC.

5.2.9 Fail-Safe Design

The system shall be designed in such a way that a failure of any subsystem shall not cause a failure in any other subsystem or in the total system.

5.2.10 Component Identification

Components such as transistors, diodes, capacitors, resistors, and integrated circuits shall be identified on the printed circuit cards by etching, silk-screening, or ink stamping. The component identification shall be in agreement with schematic designations on the drawings.

5.2.11 Painting

All cabinets and front panels of the system shall be painted per FED-STD-595. The colors shall be determined at a later date.

All materials shall be compatible with the environments to which the system will be exposed. The metals shall possess adequate corrosion-resistant characteristics or shall be suitably protected to resist corrosion.

5.2.12 Dissimilar Metals

The use of dissimilar metals shall be avoided wherever practicable. Where it is necessary that dissimilar metals be assembled and used in contact with each other, an interposing material compatible to each shall be used. Dissimilar metals are defined in Standard MS-33586A.

5.3 Human Engineering

Principles of good human engineering shall be employed in the design of the TAPECLIP system. The following aspects shall be considered:

a. Human body sizes and effective muscular force applications
b. Workplace arrangement and layout
c. Presentation of visual data
d. Manual control characteristics
e. Maintenance considerations
f. Environmental considerations
g. Personnel safety

5.3.1 Personnel Safety

Maximum safety shall be provided to personnel installing, operating, and maintaining the system. Provisions shall be made to prevent personnel from coming in contact with rotating or reciprocating parts, or with potentials in excess of 40 volts.

5.4 Environmental Requirements

The system shall withstand the environmental conditions that will be encountered in shipment to NASA/ARC.

The system shall operate continuously under the following environmental conditions:

a.	Temperature	+60°F to +80°F
b.	Relative Humidity	Up to 90% without condensation

5.5 Maintainability

The vendor shall design the system for optimum maintainability. These objectives shall include but not necessarily be limited to the following technical and operational considerations:

Design so that all faults can be isolated and corrected within one hour following shutdown due to failure in 90% of all cases.

Design so that all faults can be isolated to an accessible removable assembly or component.

Design so that scheduled servicing, replacement of parts, and adjustments shall not be required during any 8-hour period and shall not take longer than 4 hours to be accomplished.

Design so that fuses, if used, shall be readily accessible.

Where required for checkout or maintenance, extender cards and cables shall be provided by the contractor.

Standardized components requiring minimum lubrication, adjustment, cleaning, and protection shall be used wherever standardization does not penalize the system in either performance or reliability.

The system shall incorporate self-testing capabilities wherever possible.

The physical arrangement of components shall be such that they can be readily inspected, serviced, and adjusted without removing the component and with minimum disturbance to other parts. Sequential assembly and subsequent disassembly arrangements of detailed parts shall be avoided wherever possible.

Design so that inspection, service, adjustment and replacement may be accomplished using a minimum of standard and special tools or support.

Provide adequate test points to facilitate malfunction isolation and the connection of calibration instrumentation.

5.6 Reliability Objectives

The system shall be of such design and construction that the mean time between failure shall be 500 hours or more. A failure shall be defined as any malfunction which prevents normal operation of the system.

6.0 QUALITY ASSURANCE PROVISIONS

The vendor shall, as a minimum, establish and maintain an effective inspection system in accordance with NASA quality publication NPC-200-3.

7.0 INSTALLATION

The system shall include all necessary items for installation except utility services which shall be furnished by NASA/ARC. Installation instructions necessary to enable NASA to provide the proper space and facilities at the installation site shall be furnished not later than 30 days in advance of the estimated delivery date of the system.

The entire TAPECLIP system, including all NASA-furnished equipment except the IBM equipment, shall be installed by the system contractor according to a schedule arranged with NASA/ARC. Interfacing of the system with the IBM 1800 Computer shall be done with the assistance of IBM Customer Engineers. Moving of the system from the Government's receiving station to the installation site shall be accomplished by NASA. The vendor shall notify a representative of NASA/ARC when acceptance tests are to begin. The installation period, which is the time interval between delivery and notification of readiness for acceptance testing, shall be no longer than 2 weeks.

8.0 ACCEPTANCE TESTING

The vendor shall submit an acceptance test procedure 30 days prior to the acceptance test. The acceptance test shall prove that the system conforms to all requirements of this specification. The acceptance test shall demonstrate specified performance of the system in each of the operational modes.

The vendor shall provide all special test equipment required to perform the acceptance tests.

9.0 SPARE PARTS LIST

The vendor shall supply a recommended spare parts list within 60 days after formal acceptance of the system.

10.0 PROGRESS REPORTS

The vendor shall submit separate monthly progress reports of all work accomplished during each month of contract performance. Reports shall be in narrative form and brief and informal in content. Five (5) copies of the report shall be submitted. Monthly progress reports shall include:

1. A quantitative description of overall progress. The vendor shall project system progress outlining a complete set of design, development, fabrication, and purchasing milestones, including beginning and ending date of each milestone.

2. An indication of any current problems which may impede performance, with proposed corrective action

3. A discussion of the work to be performed during the next monthly reporting period

10.1 Report Period

During the period of performance of this contract, the contractor shall submit the monthly reports on or before the 15th day of the month succeeding that covered by the report. The final report shall be submitted prior to the expiration of the period of performance of the contract. All reports shall be submitted to the contracting officer at NASA/ARC.

11.0 SYSTEM INSTRUCTION MANUALS

The instruction manual shall be divided into five sections as follows:

Section I - Description

Section II - Operation

Section III - Principles of Operation

Section IV - Maintenance

Section V - Drawings

11.1 Section I shall be written in clear semitechnical exposition setting forth the following:

a. Purpose and capabilities of the system

b. Physical description of system construction

c. Operational features and characteristics of the system

d. A list of the accessory items provided with the system

e. An index of all documentation pertinent to operation and maintenance of the system

11.2 Section II shall describe in clear language how the system is operated. It shall provide operating instructions for each possible mode of operation of the system. These instructions shall be written in a logical sequential manner to provide all the step-by-step information necessary for an untrained user to properly operate the system.

11.3 Section III shall include but not be limited to the following topics which shall be described in technical detail:

a. Conventions followed in major unit designations, circuit card numbering, system wiring, etc., and the related drawings and documentation

b. A functional description of circuit cards in the system

c. Detailed discussions of each logic diagram presented in logical order by signal flow. Each logic diagram discussed in Section III shall be reproduced by photo offset process and shall be included in the manual.

11.4 Section IV shall include but not be limited to the following where applicable:

a. Preventive maintenance measures

b. Precautions to be observed in system maintenance

c. A list of test equipment required for system maintenance

d. A suggested troubleshooting procedure

e. Suggestions on circuit card repair

f. A list of spare circuit cards recommended to support 1 year of system operation

11.5 Section V shall include every electrical drawing used in system construction. This will include schematics and assembly drawings of every printed circuit card. In addition, charts showing the location of each circuit card in the system shall be included. Wire lists shall be included if other drawing information does not document system cabinet wiring.

11.6 Makeup and Composition

The instruction manual shall be printed on bond paper. The number of fold-out pages (11 in. x 17 in.) shall be held to a minimum. The binders shall be plainly labeled giving the name of the system and the name of the system manufacturer. In the event that the size of the system manual makes it impractical to be contained in one volume, the various volumes of the manual shall be appropriately labeled. The number of volumes shall be minimized to the greatest extent reasonable.

Prefatory matter shall be identical in all volumes and shall clearly indicate where the volume break is made.

11.7 Delivery of Manuals

Six (6) copies of the final instruction manual shall be delivered within 60 days after acceptance of the TAPECLIP system by NASA/ARC.

11.8 Preliminary Manuals

Four (4) preliminary copies of the instruction manual shall be provided when the system is delivered.

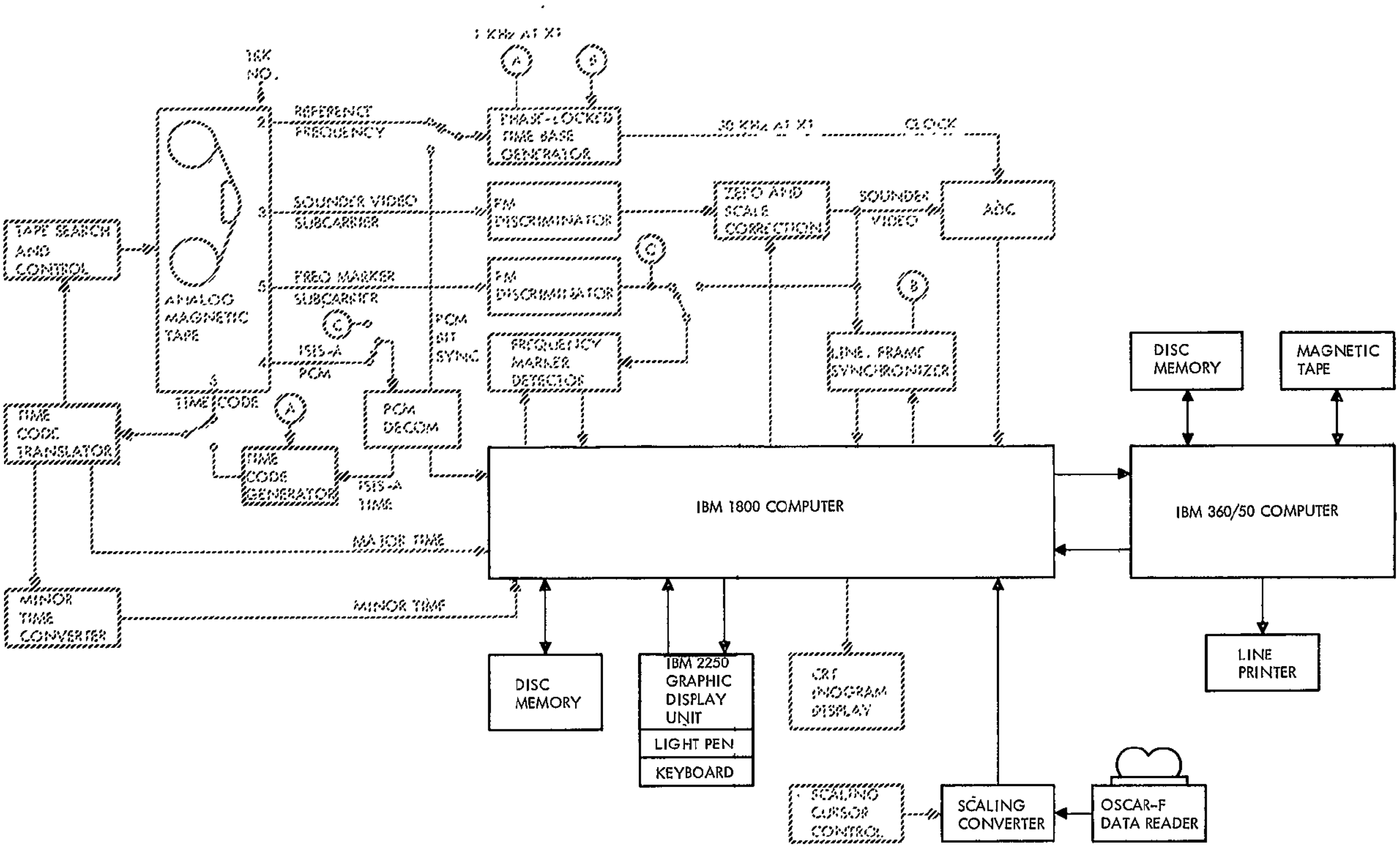


FIGURE 1 NASA/ARC FILMCLIP SYSTEM

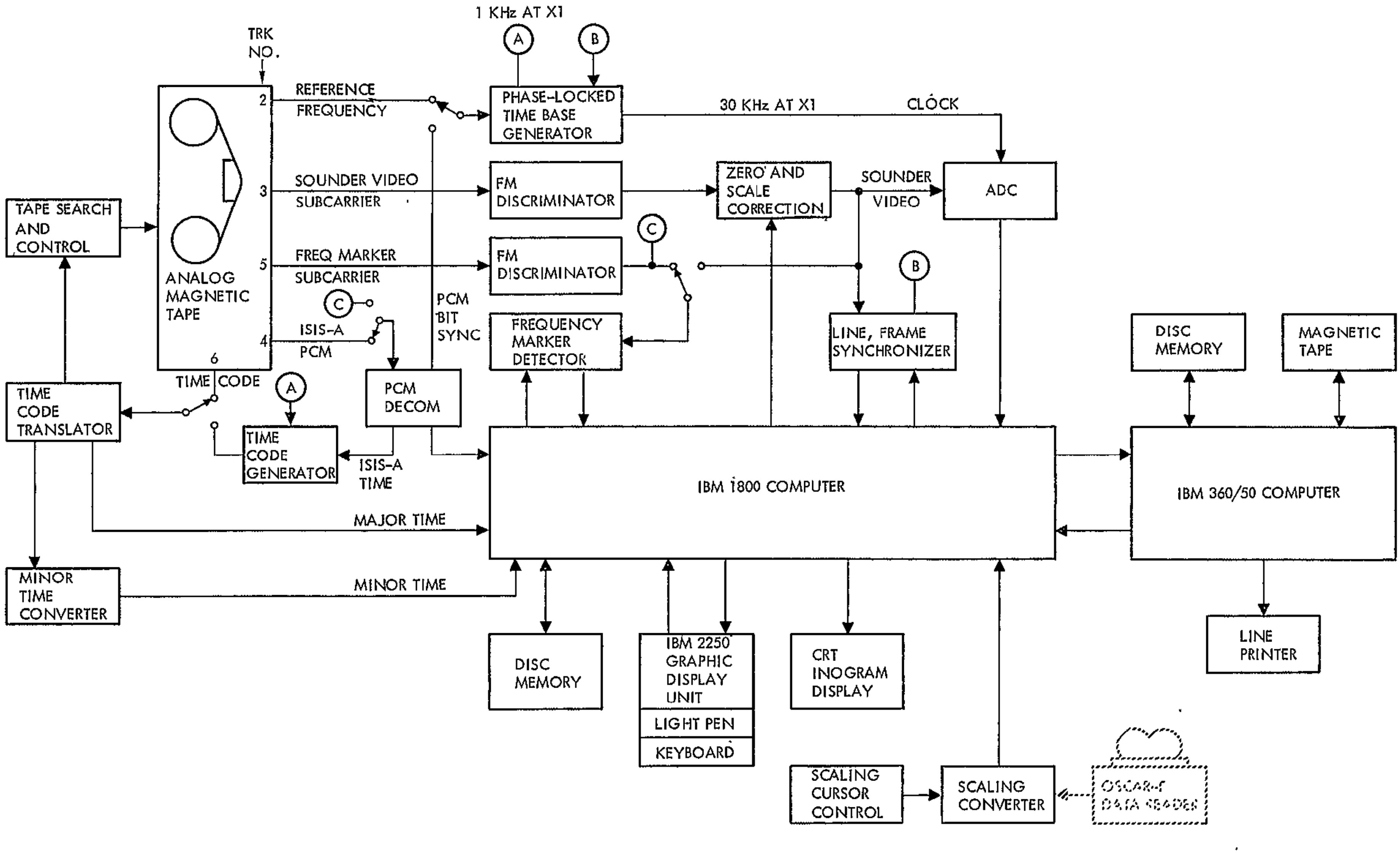


FIGURE 2 NASA/ARC TAPECLIP SYSTEM

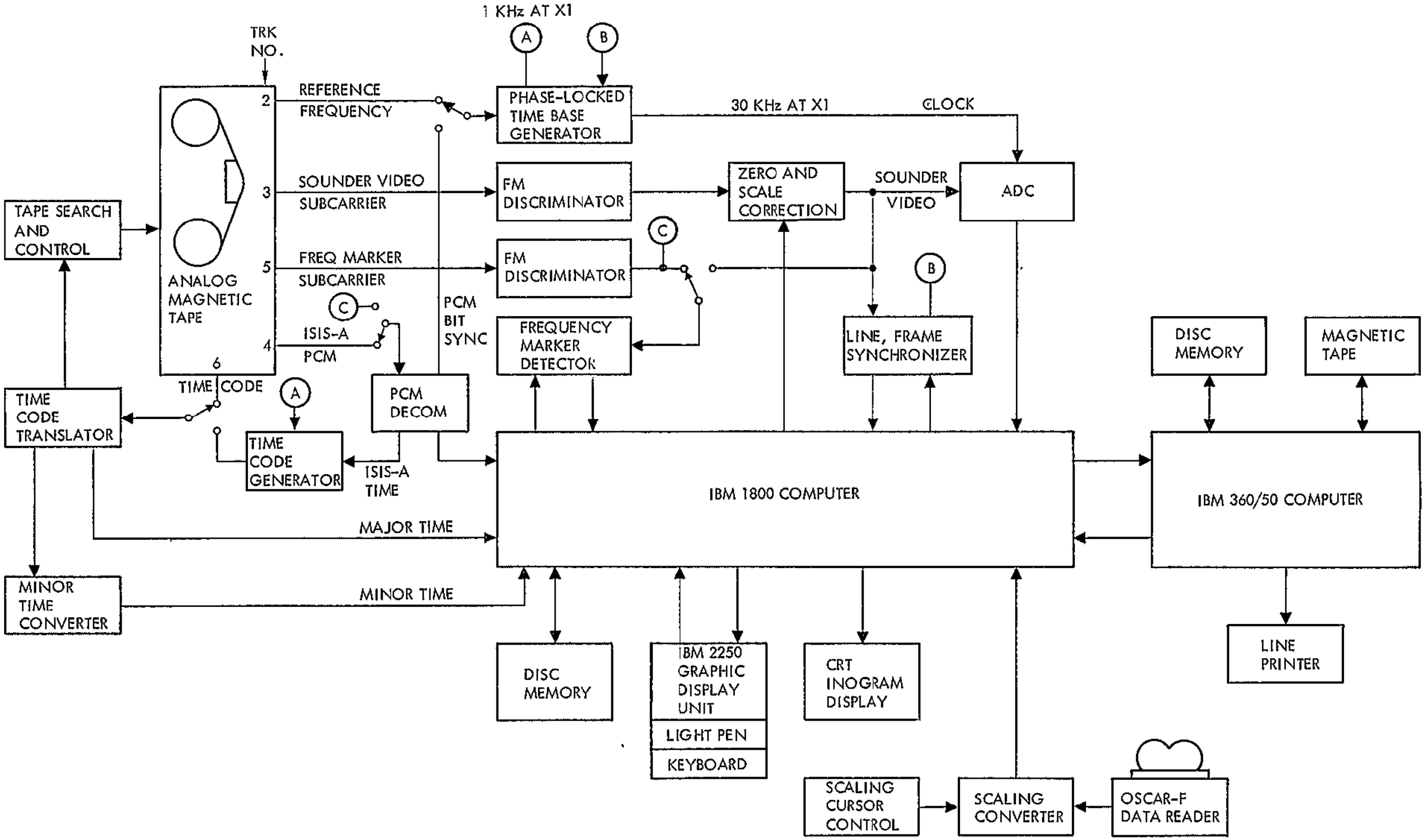


FIGURE 3 NASA/ARC COMBINED TAPECLIP AND FILMCLIP SYSTEM

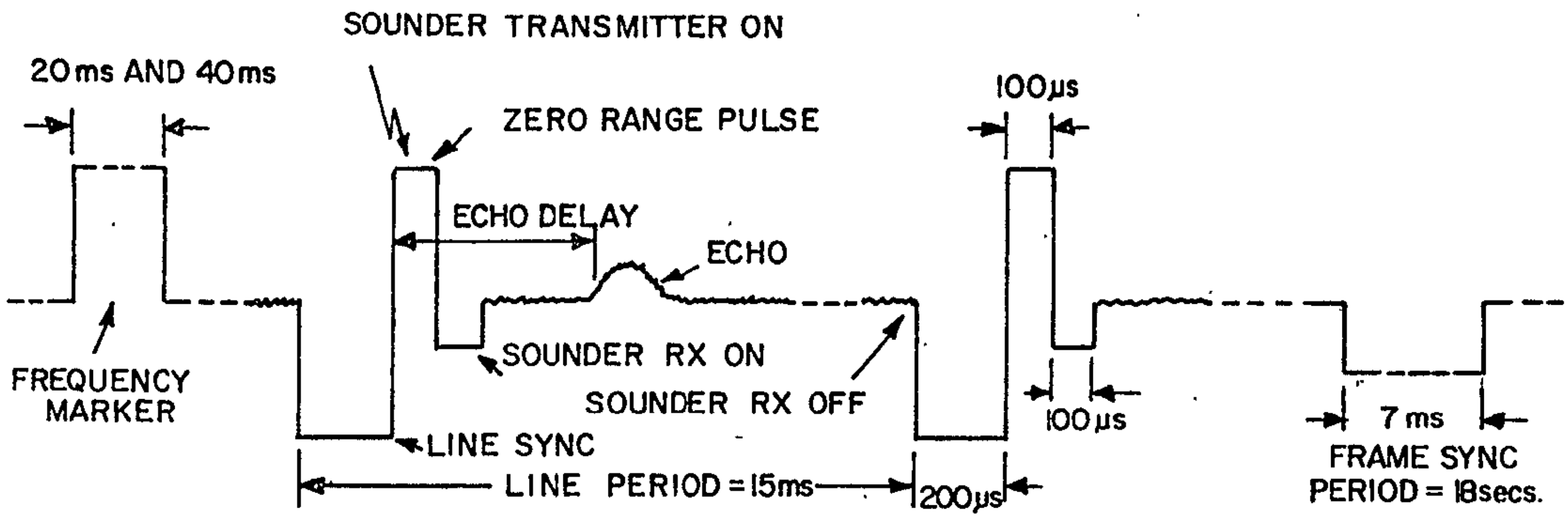


FIGURE 4. ALOUETTE I SOUNDER VIDEO FORMAT

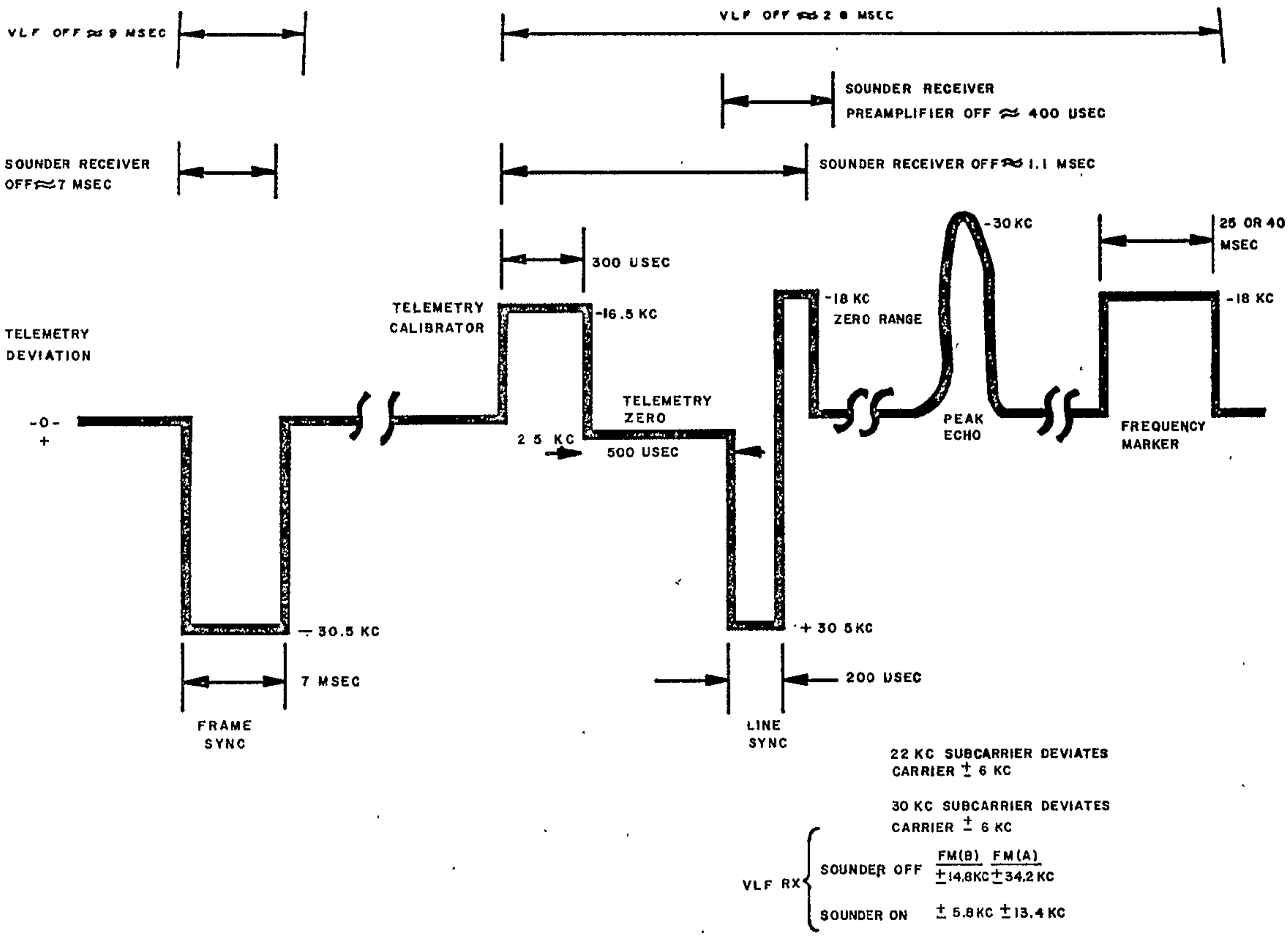
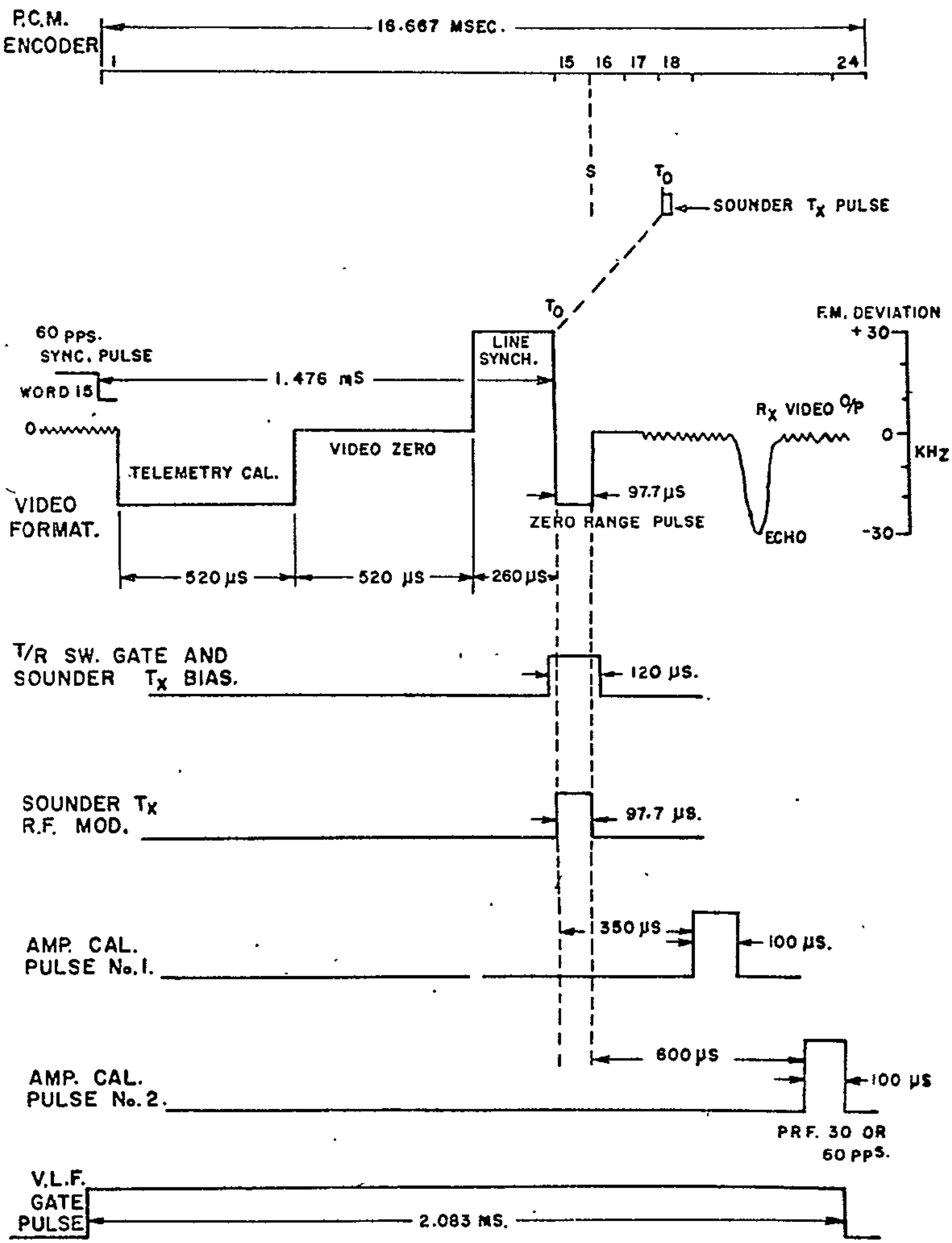


FIGURE 5. ALOUETTE II SOUNDER VIDEO FORMAT

ONE WORD = 1/24 x 16.6667 MSec. = 0.6944 MSec.



ISIS-A

FIGURE 6. SOUNDER TIMING AND VIDEO FORMAT

VIDEO FORMATS OF CANADIAN SCIENTIFIC SATELLITES

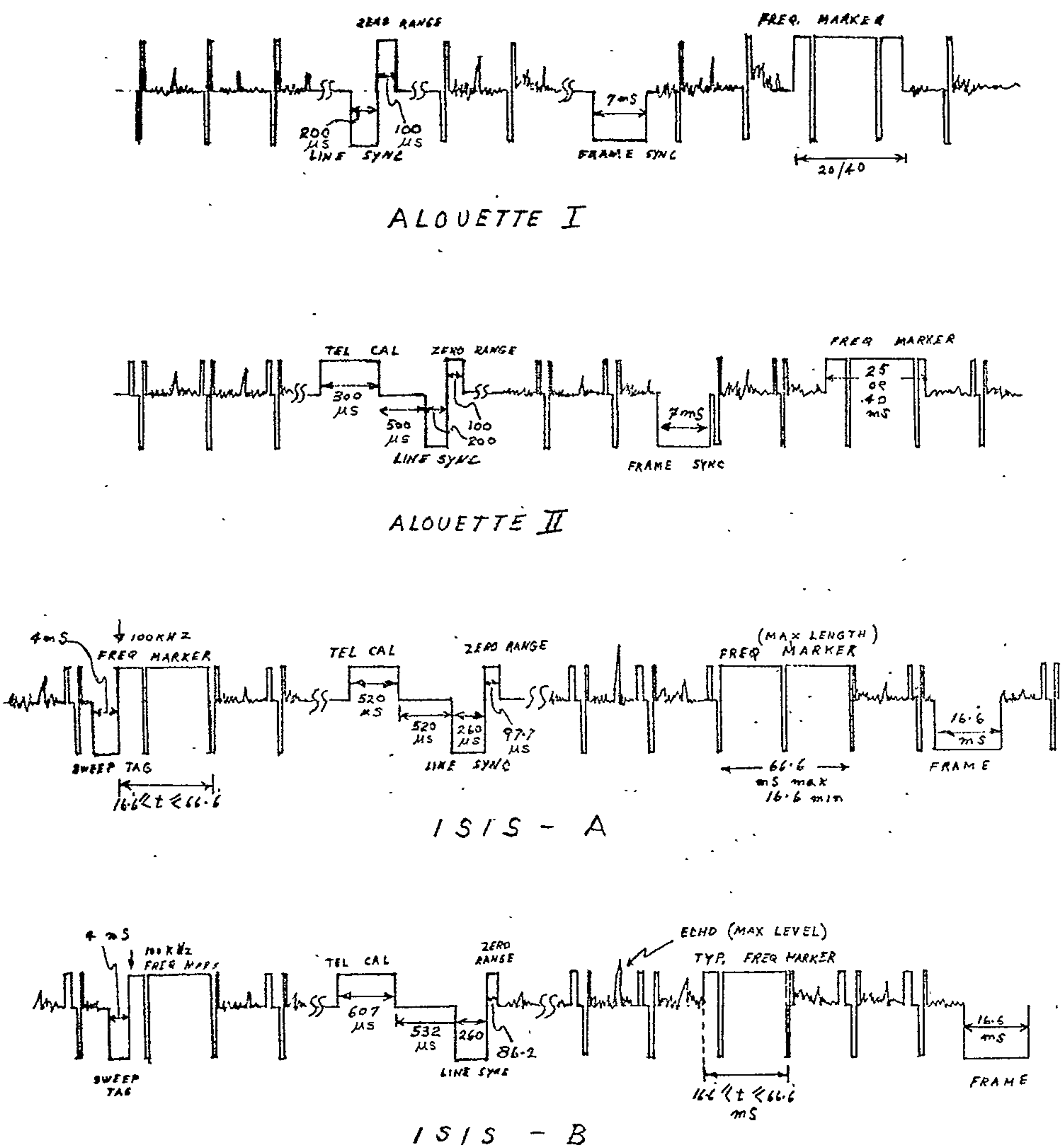


FIGURE 7

The NASA 36 Bit Time Code is a 100 pps pulse width modulated time code This code may be used to amplitude modulate a 1000 cps sine wave carrier

The code is composed of a Reference Marker and nine sub code words, which describe time of year in seconds, minutes, hours and days Each sub code is weighted in binary coded decimal fashion The leading edge of all pulses are precisely spaced at 10 milliseconds intervals The Time Frame is completed by 100 pps index markers and by index markers occurring every 100 milliseconds from 100 milliseconds to 900 milliseconds

The frame Reference Marker is described by five binary one's followed by a binary zero The leading edge of the binary zero is the reference time

The Time Frame provides for the insertion of control functions for identifying the recording station

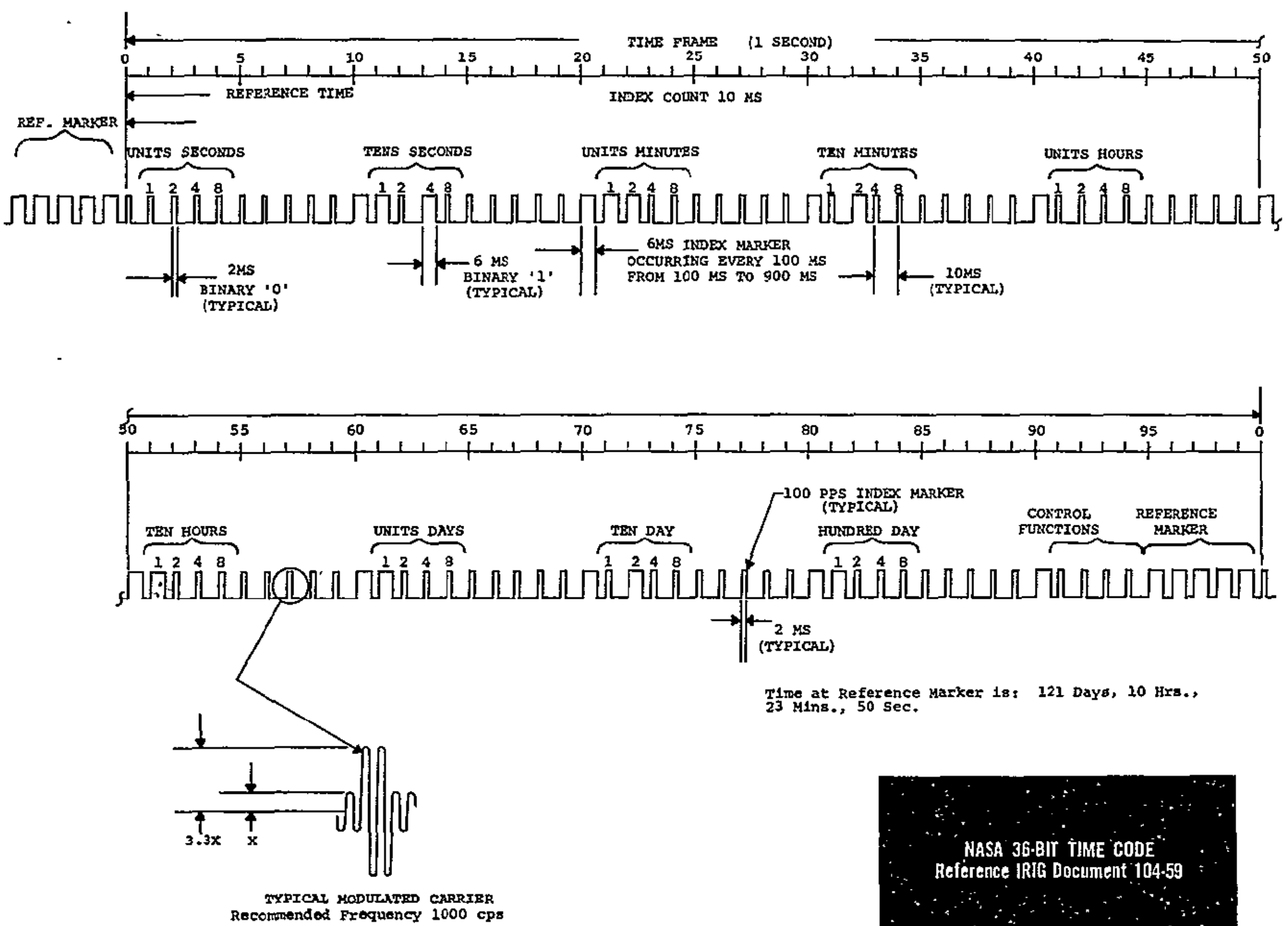


FIGURE 8. NASA 36-BIT TIME CODE

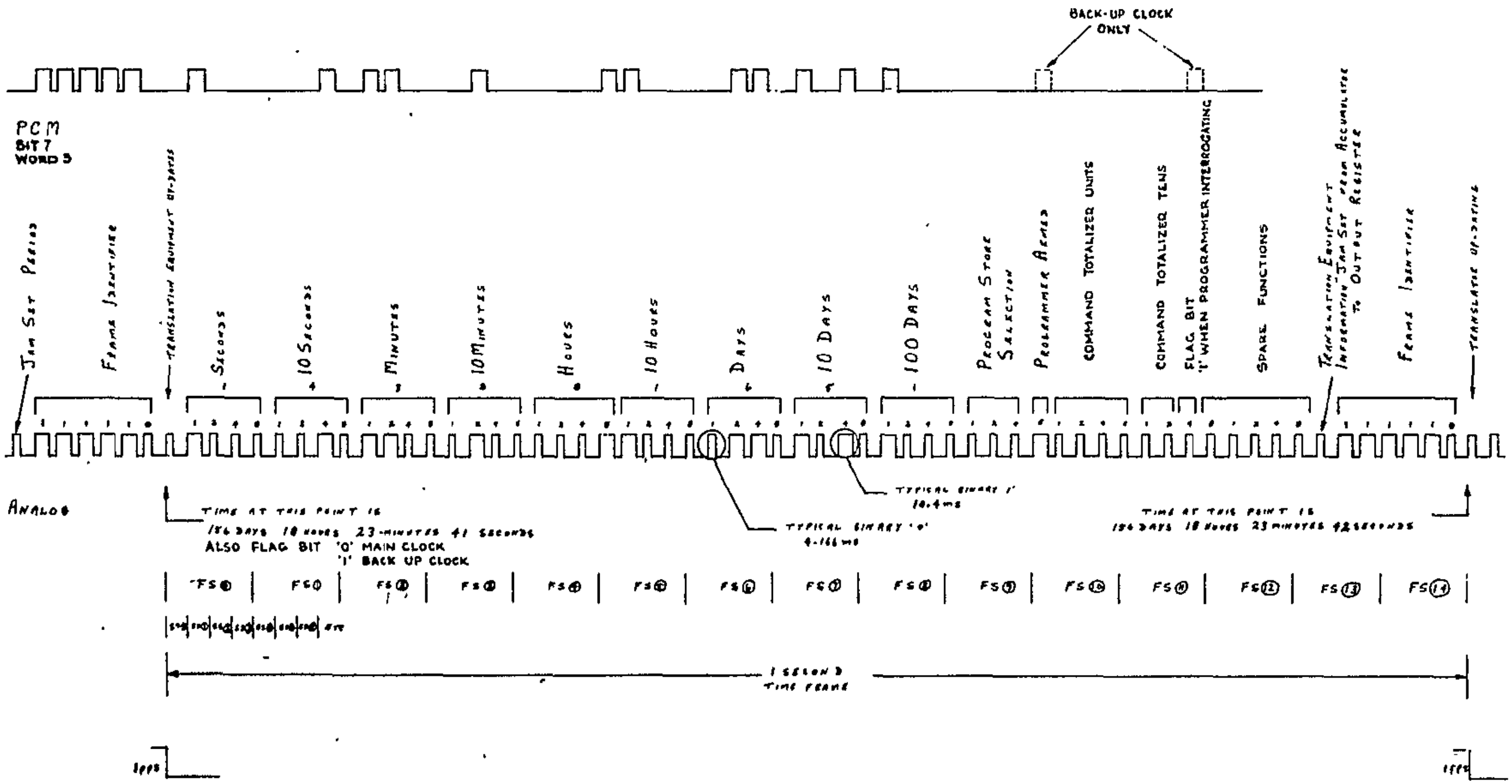


FIG. 9. 60 pps BCD TIME FORMAT PCM AND ANALOG CHANNELS.

ISIS A'.

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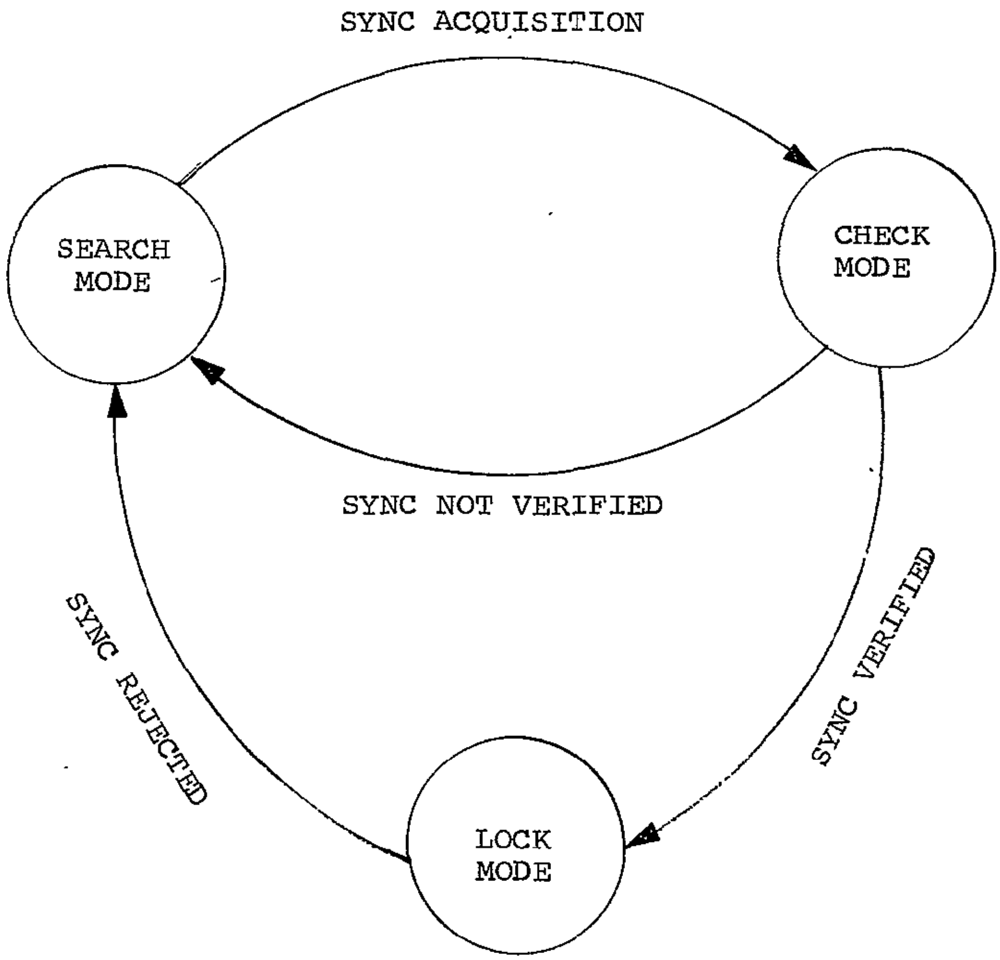


SYNC ACQUISITION - Sync pattern detected with number of bit errors less than or equal to N.

SYNC NOT VERIFIED - Sync pattern detected with number of bit errors greater than M.

SYNC VERIFIED - Sync pattern detected with number of bit errors equal to or less than M, P times in succession.

SYNC REJECTED - Sync pattern detected with number of bit errors greater than Q, R times in succession.

NOTE: M,N,Q = 0-7
P = 0-10
R = 1-10

FIGURE 10. PCM FRAME SYNCHRONIZATION CRITERIA

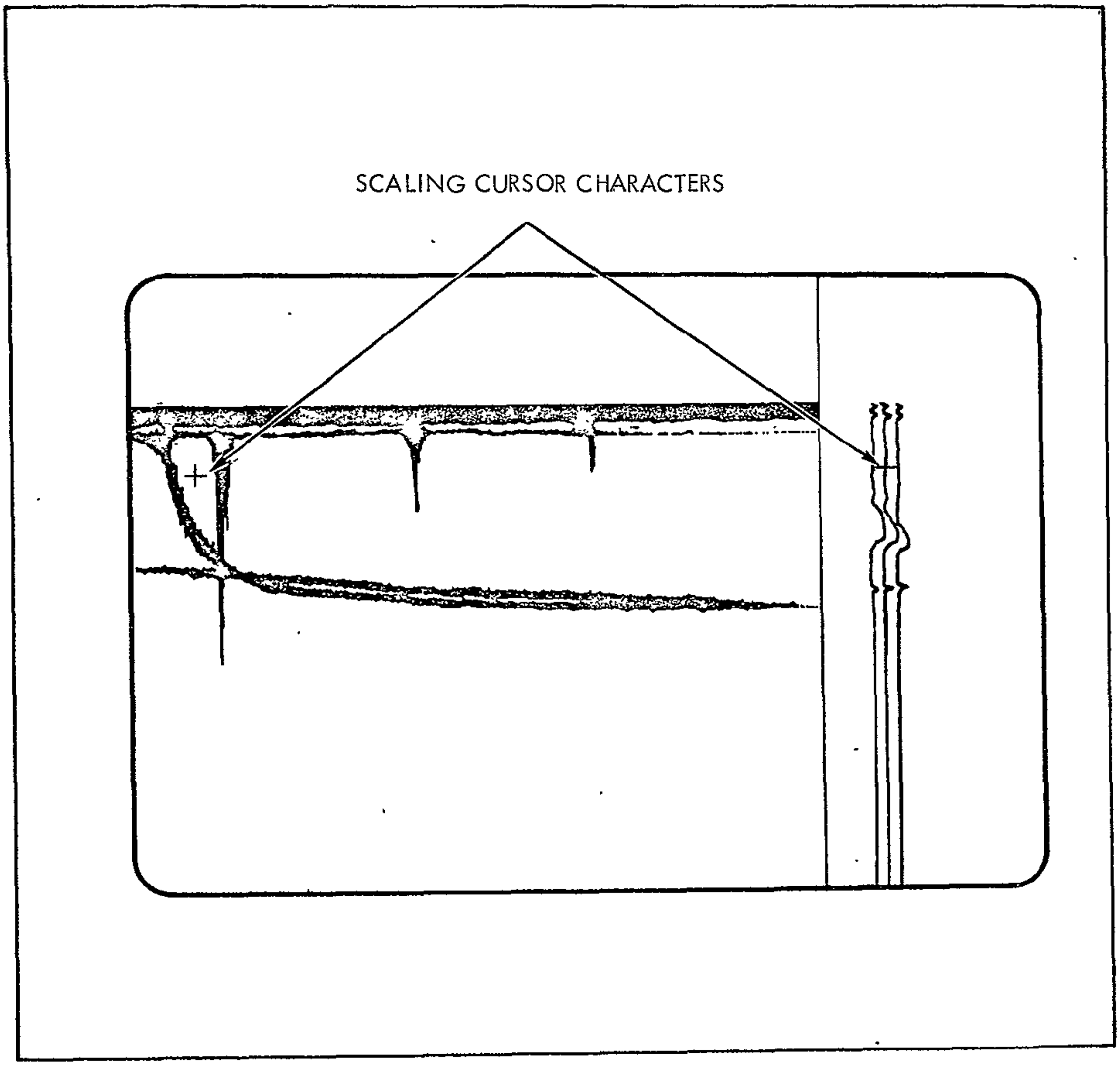


FIGURE 11. EXPANDED IONOGRAM DISPLAY WITH A-SCAN AUGMENTATION

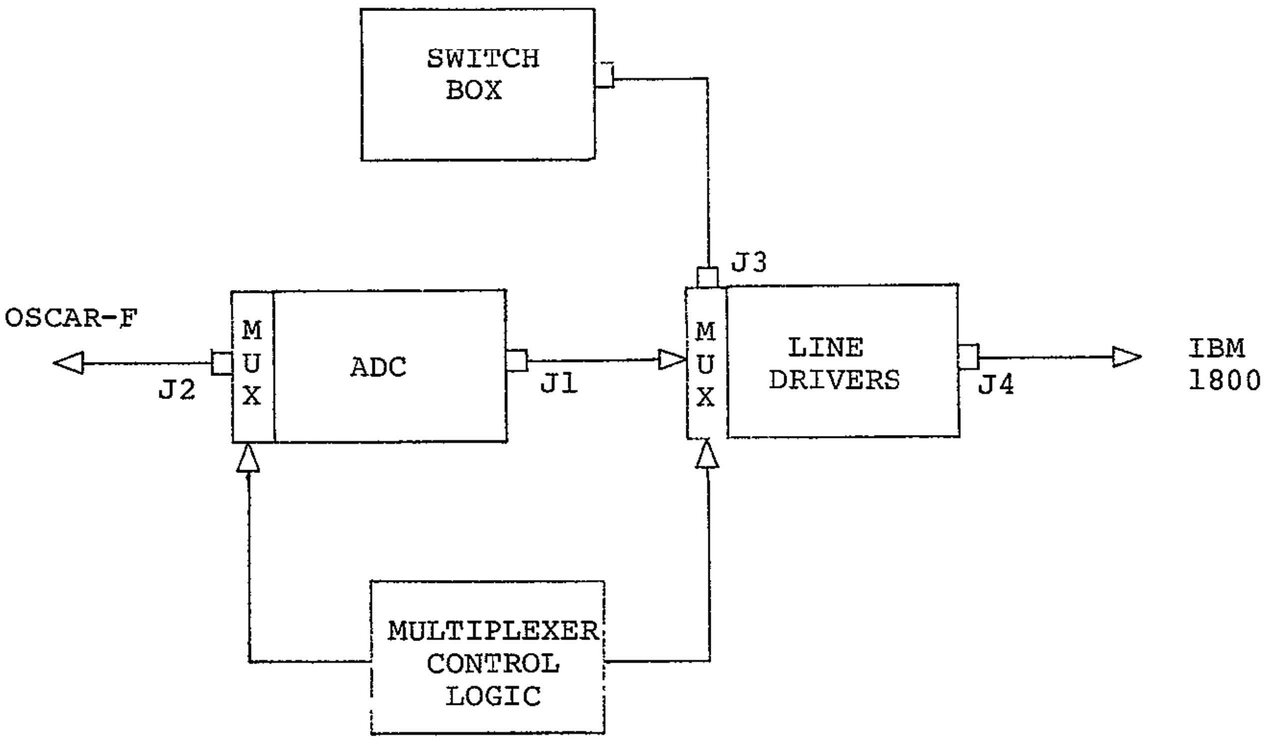


FIGURE 12. SCALING CONVERTER

APPENDIX A

List of Items to be Supplied by the Vendor

1. FM discriminators
2. Frequency marker detector
3. Phase-locked time base generator
4. Zero and scale correction
5. ADC
6. Line, frame synchronizer
7. PCM decommutator
8. Time code generator
9. Minor time converter
10. CRT ionogram display unit
11. Scaling cursor control unit
12. Control panels
13. Test oscilloscope
14. Equipment cabinets
15. Interconnection cabling between cabinets and to the IBM 1800 Computer
16. Installation
17. Acceptance test procedures
18. Perform final acceptance test
19. Instruction manuals
20. Software guidance and liaison with NASA/ARC contractor
21. Integration of NASA/ARC supplied equipment, including necessary modifications and responsibility for seeing that the equipment meets the performance specifications of the original manufacturer.

APPENDIX B

List of Items to be Supplied by NASA/ARC

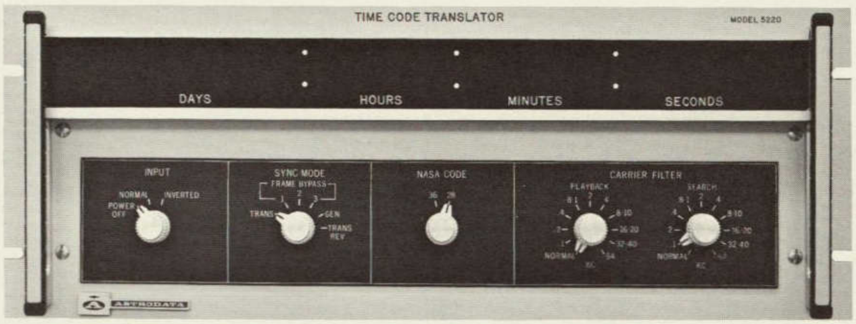
1. IBM 360/50 Computer and associated peripheral equipment
2. IBM 1800 Computer and associated peripheral equipment
3. Additional 1800 digital input channels required by the TAPECLIP system
4. IBM 2250 Graphic Display System
5. Sangamo Model 4712 Analog Magnetic Tape Machine
6. Astrodata Model 5220 Time Code Translator
7. Astrodata Model 5224 Tape Search and Control Unit
8. Site preparation, including floor space, partitions if necessary, and furniture
9. Electrical power including main power switch and circuit breakers
10. Software contractor to program the TAPECLIP system

ASTRODATA

MODEL 5220 NASA TIME CODE TRANSLATOR

bulletin

5220-200A



PART NUMBER 5220-200

features

- ALL SOLID-STATE
- MANUAL AND AUTOMATIC TAPE SEARCH COMPATIBILITY
- ADJUSTMENT-FREE INPUT CIRCUITRY
- WIDE BANDWIDTH, HIGH SENSITIVITY
- HIGH RELIABILITY
- DECIMAL DISPLAY
- PARALLEL AND SERIAL OUTPUTS

APPLICATION

The Model 5220 NASA Time Code Translator is used in Telemetry and Data Reduction systems where it is necessary to read time codes from magnetic tape. Since the unit can translate two of the standard NASA formats, it may also be used in data acquisition applications where different codes are required for changing resolution requirements.

The unit is most efficient when decoding time codes from magnetic tape, either at reduced or accelerated speeds, as is the case in manual or automatic tape search. For manual positioning of the tape prior to data reduction, either the front panel display can be used, or a Model 5575 Time Interval Preset can be connected to detect a desired time increment. For completely automatic tape search, the unit can be connected to a Model 5224 Tape Search and Control Unit. This allows the tape to be searched from any position to locate a preset Start and Stop time.

Parallel and serial outputs are provided for use by external data systems.

Solid-State Reliability

The majority of the logic of the Model 5220 uses silicon semiconductors to provide more efficient and reliable operation. All circuitry is mounted on glass-epoxy etched circuit cards, and test points provide access to all critical points in the circuitry.

Wide Dynamic Input Range

For high-speed tape search, the input circuits of the Model 5220 have an extremely wide operating range. This means adjustment-free operation for all applications. The dynamic operation provided includes amplitude from **20 millivolts to 50 volts peak-to-peak,** frequency from **50 cps to 240 kcps,** and modulation ratios from **2:1 to 6:1.** No manual adjustment is needed within the above ranges.

Built-in noise rejection is provided both for the analog signals as well as the digital process. To achieve greater accuracy where required, the noise rejection may be varied by internal adjustments.

SPECIFICATIONS

INPUT

Input Time Code (Switch Selectable): (1) NASA 36-Bit Format, 1 kc carrier
(2) NASA 28-Bit Format, 100 cps carrier

Input Characteristics

AGC Range: 0.020 volts to 50 volts pp (Mark)

Carrier Frequency Range: 50 cps to 240 k cps or 240 times speedup

Frequency Response: ±3 db, 15 cps to 300 k cps

Modulation Ratio (PAM): Automatic operation for Mark-to-space ratios from 2:1 to 6:1; manual adjustment to 10:1

Input Resistance: 5000 ohms shunted by 20 pf

OUTPUTS

Visual Display: The translated time-of-year (days, hours, minutes and seconds) is displayed in decimal form by wide-angle, long-life, Super "NIXIE" tubes.

Remote Display: Up to 3 remote displays (ASTRODATA Part #6520-900 or equal) may be operated from the remote display output.

Parallel Output (Logic): Twelve digits of parallel BCD (8-4 2-1) representing days, hours, minutes, seconds, and milliseconds.
Logic levels:
Binary "0" 0 +0 −0.3 volts
Binary "1" −7 ±1 volt
Maximum Loading: 1800 ohms to ground or Model 5224 Tape Search Control Unit and 5000 ohms external load to ground. (0.005 amperes to a negative source.)

Pulse Rate Outputs (1-to-1 playback, 1 kc code carrier)

Frequency: 1,000 pps; 100 pps; 10 pps; 1 pps.

Amplitude: − 7 ±1 volts base line to 0 +0 −0.3 volts.
(Positive-going transition "on-time.")

Rise Time: Less than 1.0 microsecond.

Fall Time: Less than 4.0 microseconds.

Maximum Load: 1000 ohms-to-ground resistive, 1800 pf capacitive.

Duty Cycle: 1000 pps at 50% (all others 80%).

Serial Code Output: The input code is provided from the output of the AGC amplifier at 8 ±2 volts pp (filtered) from a source impedance of 6 k ohm.

SPECIAL FEATURES

Carrier Filters: Ten band-pass filters may be selected by two front panel rotary switches. One switch selects the proper filter for tape playback speed. The second switch selects the proper filter for search speeds, when used in conjunction with a Tape Search and Control Unit. An additional switch position permits by-passing the filter. A rear panel switch allows for inserting external filters via a connector on rear of the unit. Center frequencies of the band-pass filters are: 100, 200, 400, and 800/1000 cps; 2, 4, 8/10, 16/20, 32/40 and 64 k cps. When operating with a Tape Search and Control Unit automatic selection of either the search or playback filter is made during the corresponding operational mode.

Synchronization Mode (Error By-pass): Permits the operator to select the by-pass of 0, 1, 2, or 3 consecutive time words which may be decoded erroneously, or to operate as a generator accrueing time from the input carrier frequency. This feature operates in either the forward or reverse search modes.

Single Cycle Drop-Out Protection: Noise or drop out of a single cycle or less (carrier frequency) occurring on the input will not affect the decoding process.

Noise Rejection (Zero Axis): Internal control allows selection of high or low noise rejection depending upon application. No spurious axis crossings will occur with peak-to-peak signal to peak-to-peak noise ratios of 14 db on high range and 20 db on low range throughout full frequency range.

Milliseconds By-Pass: A switch on rear of panel allows the by-pass of the minor time counter when decoding tapes or signals with extremely severe noise.

FRONT PANEL CONTROLS

Power and Carrier Polarity (INPUT): Applies power and allows operator to compensate for phase inversion of the input code carrier (Rotary Switch).

Code Selector: Selects input code: NASA 36-Bit or NASA 28-Bit (Rotary Switch).

Playback Filter: Selects proper band-pass filter commensurate with time code carrier frequency and ratio of recorded to playback tape speed (Rotary Switch).

Search Filter: Selects proper band-pass filter commensurate with time code carrier frequency and ratio of recorded to search tape speed (Rotary Switch).

Synchronization Mode: Selects frame error by-pass and manual "Read Reverse" mode (Rotary Switch).

ENVIRONMENT

Temperature Range: 0°C to +55°C

Humidity: Up to 95% relative

POWER: 95 to 135 volts ac, 50 to 400 cps.
65 watts approximately (117 volts).

CONNECTORS: All input and output connectors are located on the rear panel. All multi-pin connectors are provided with mating connectors.

SIZE

Mounting: The unit mounts in any standard 19-inch relay rack.

Panel: 7 inches high by 19 inches wide.

Chassis: 17.25 inches wide by 6.9 inches high by 14.37 inches deep.

WEIGHT: 40 pounds.

FINISH: Federal Standard 595, Light Blue Color #25526. Other finishes may be specified by purchaser at no additional cost.

MANUALS: Two (2) copies of the installation, operation, and maintenance handbook are furnished with the system.

ANCILLARY EQUIPMENT: 5575 Time Interval Preset
5000-100 DC Code — Fail-Safe Unit
5224 Tape Search and Control Unit
6520 Remote Display
6330 Serial Code Generator

ASTRODATA INC.

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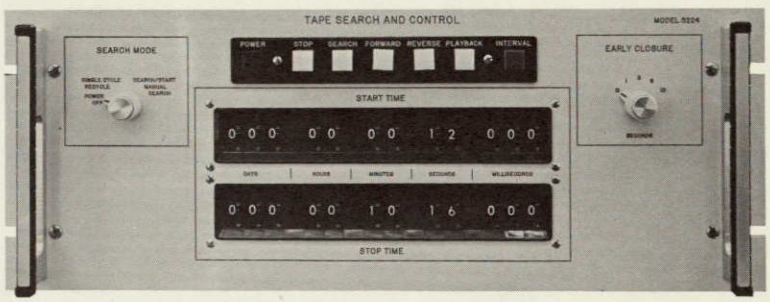
ASTRODATA

MODEL 5224 TAPE SEARCH AND CONTROL UNIT

bulletin

5224A



PART NUMBER 5224-100

features

- **COMPLETELY AUTOMATIC CONTROL OF ANALOG MAGNETIC TAPE TRANSPORT**
- **AUXILIARY OUTPUTS FOR CONTROL OF DATA REDUCTION PROCESSES**
- **MULTIPLE SEARCH MODES FOR WIDER APPLICATIONS**
- **ADJUSTMENTS FOR BEST SEARCH OPERATIONAL CHARACTERISTICS**
- **RESOLUTION TO 1 MILLISECOND**

APPLICATION

The model 5224 Tape Search and Control Unit is used in data reduction applications where complete automatic search of magnetic tape is desired. Time resolution — days, hours, minutes, seconds and milliseconds — is available. Multiple search modes provide the necessary flexibility for all data reduction applications. Internal adjustments are provided for further refinements of the search operation. The tape need not be positioned at any known point prior to operation since the unit will locate the selected start time at both forward and reverse speeds.

GENERAL DESCRIPTION

The Model 5224 Tape Search and Control Unit accepts parallel inputs from time code translator units such as the ASTRODATA Model 5220 Universal IRIG Translator, the Model 6220 Universal Time Code Translator, or the Model 5400 Time Code Translator/Generator. The Model 5224 uses these inputs to supply control outputs for automatically controlling a magnetic tape transport for high speed search in both the forward and reverse directions.

"START" and "STOP" times are pre-set by the operator with switches located on the front panel of the unit. After the operator selects a portion of tape to be played back, he actuates the "START" switch. The system will then automatically search the magnetic tape at high speed to locate the selected "START" time. "START" time is always located in the high-speed reverse mode. The transport is then stopped and programmed into the forward playback mode.

"START" time is again detected, but at the controlled forward playback speed. This ensures high resolution and accuracy for all auxiliary outputs, thus reducing the possibility of ambiguities in the data reduction systems.

The unit proceeds to "STOP" time where all auxiliary outputs are removed and the tape transport is stopped. The Model 5224 then awaits further manual instructions, or recycles, depending on the choice of modes.

Four basic models are available:

Part No. 5224-100: 12-digit pre-set "START" and "STOP" time selectors. Days-Hours-Minutes-Seconds-Milliseconds. (Illustrated).

Part No. 5224-101: 9-digit pre-set "START" and "STOP" time selectors. Days-Hours-Minutes-Seconds.

Part No. 5224-102: 9-digit pre-set "START" and "STOP" time selectors. Hours-Minutes-Seconds-Milliseconds.

Part No. 5224-103: 6-digit pre-set "START" and "STOP" time selectors. Hours-Minutes-Seconds.

The following specifications describe Part No. 5224-100 and, with the exception of time resolution, are applicable to all other part numbers.

SPECIFICATIONS

INPUT: Parallel BCD (1-2-4-8) representing time-of-year in days, hours, minutes, seconds and milliseconds.

CONTROLS

Search Mode: A rotary switch is provided for control of system mode of operation. The following modes are provided:

Recycle: Searches for the pre-set interval, plays back the selected data and repeats this cycle until stopped.

Single Cycle: Searches for the pre-set interval and plays back the selected data. When the pre-set "STOP" time is reached, the tape transport will automatically stop.

Search/Start: Searches for the time frame that is three time frames less than the pre-set "START" time. When this frame is reached, the tape transport will automatically stop.

Manual Search: Plays back data contained on the magnetic tape. This mode inhibits automatic tape search. "START" and "STOP" switches are activated so that all auxiliary outputs are supplied during this mode.

Pre-Set Start: Twelve decimal thumbwheel switches are provided for the manual pre-selection of the day, hour, minute, second and millisecond of the interval "START" time to be searched for.

Pre-Set Stop: Twelve decimal thumbwheel switches are provided for the manual pre-selection of the day, hour, minute, second and millisecond of the interval "STOP" time to be searched for.

Tape Transport Manual Control: The following indicator type pushbuttons actuate the automatic search sequence and manually control the tape transport playback unit:
"Start Search"
"Fast Forward"
"Fast Reverse"
"Drive Playback"
"Stop"

OUTPUTS

Tape Transport Control: Momentary (or latching) contact closures/openings are provided for automatic control of the following functions of the tape transport unit:
"Search"
"Playback"
"Fast Reverse"
"Fast Forward"
"Stop"

Parallel BCD Code: The input connector is parallel to an output connector to permit "Daisy Chain" of translator output to additional equipment.

Auxiliary Outputs: Two Form "C" (DPDT) contact operations are provided as outputs during the playback interval. Contacts are rated at 2 amps at 32 volts dc resistive.
Early operation of two form "C" (DPDT) contacts are provided, front panel adjustable from 3 to 13 seconds (typical on 1-second time frame) prior to "START" time. This early operation allows external recording devices to be started and to attain speed prior to "START" time. The contacts have the same rating as above.

1. DC Level Shift — -9 ± 1 volt shift from 0-volt baseline during the playback interval. Maximum load is 1,000 ohms to ground.
2. Start Pulse — Positive 8-volt pulse from 0-volt baseline at "Start" time.
3. Stop Pulse — Positive 8-volt pulse from 0-volt baseline at "Stop" time.

Start and Stop pulses are 3 ± 1 microsecond duration into 1,000 ohms to ground.

CONNECTORS: Multi-conductor, interconnecting cable to the Time Code Translator is furnished; length, 4 feet. Multi-pin mating connector is furnished for connection to tape transport. All other outputs are by means of BNC-type connectors.

INDICATORS

Power: ON/OFF

Search Lit during search mode

Interval: Lit during playback interval

SPECIAL FEATURES: Adjustable (internal) time delays are incorporated for best search operations dependent on the type of tape transport used.

1. Transport Inhibit — Adjustable delay from 1 to 20 seconds allows compensation for the time required by the transport to stop in the fast forward or fast reverse speeds.
2. Translator Inhibit — Adjustable delay from 1 to 10 seconds inhibits the translator from reading after start of tape transport to allow operating speed to be reached. This protects the system from the possibility of false reading due to settling time of the reproduce amplifiers.

When searching for "START" time, either in forward or reverse directions, the unit forces the tape past the desired time before stopping the transport. The "time detector" derives signals which indicate "greater than," "equal to" or "less than." Therefore, the unit ensures that the indicated time is true before altering the search operation. This protects against false "starts" and "stops" which cause unreliable system operation.

POWER: 95 to 135 volts, 50/400 cps. 25 watts (117 volts).

ENVIRONMENT

Temperature Range: 0°C to +55°C

Humidity: Up to 95% relative

SIZE

Mounting: The unit mounts in standard 19-inch relay rack.

Panel: 7 inches high.

Chassis: 17 inches wide x 6.9 inches high x 15⅜ inches deep.

WEIGHT: 25 pounds.

FINISH: Federal Standard 595, Light Blue color #25526. Other finishes may be specified by purchaser at no additional cost.

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LITHO IN U.S.A.

4700 RECORDER/REPRODUCER

CONFIGURATION

for

SERIAL NUMBER

365

MODEL NUMBER

4711	
4712	X
4741	
4742	
4744	
4784	

TAPE WIDTH

Dual Width	
1/4 Inch	
1/2 Inch	X
1 Inch	
1 1/2 Inch	
2 Inch	

TAPE THICKNESS

1.0 Mil	
1.5 Mil	X

REEL DIAMETER

10 1/2 Inch	
14 Inch	X

ELECTRONIC SPEEDS

120 ips	
60 ips	
30 ips	X
15 ips	
7 1/2 ips	
3 3/4 ips	
1 7/8 ips	
15/16 ips	

HEADS

Interleaved	X
Inline	

SERVO TYPE

Capstan Frequency	X
Capstan Synchronous	
(200 kc Osc.) Tape Synchronous	X

DIRECT ELECTRONICS (QUANTITY)

Record	4
Reproduce	4

FM ELECTRONICS (QUANTITY)

Record	3
Reproduce	3

DIGITAL ELECTRONICS (QUANTITY)

Record	
Reproduce	

VOICE

Edge Track A or B	X
Multiplex	

LOOP CAPABILITIES	
IRIG 17KC/60CPS REFERENCE	
ERASE CAPABILITIES	
SHUTTLE CONTROL	X
WOW AND FLUTTER COMPENSATION	
VU METER	
IRIG 60 CPS SERVO	X

MAGNETIC HEAD CHARACTERISTICS
for
TAPE TRANSPORT SERIAL NO. 365

HEAD	PART NO.	SERIAL NO
RECORD	852090	605
REPRODUCE	850360	602
RECORD/REPRODUCE		

TAPE TYPE Reeves-HRMB/B
TRACK NUMBERING FORMAT Ampex
BIAS BOARD SERIAL NO. 224
VOICE BOARD SERIAL NO. 132

BIAS FREQUENCY 1.2mc
BIAS CURRENT 22.5
SIGNAL CURRENT 0.25

Track No.	Direct Rec'd Serial No.	Direct P/B Serial No.	Equalizer Bd. Serial No.	FM Osc. Serial No.	FM Demod Serial No.	FM Filter Bd. Serial No.	Bias Current (ma)(rms)	Direct Record Current (ma)(rms)	FM Rec'd Current ~~(ma)~~ mv (rms)
1				265	156		7.4	0.80	0.34
2				266	157		5.4	0.80	0.32
3				267	158		6.5	0.80	0.36
4	150	152					5.0	0.65	
5	151	153					6.8	0.60	
6	152	154					5.8	0.60	
7	153	155					7.1	0.57	

CHAPTER I

GENERAL INFORMATION

1-1. SCOPE OF INSTRUCTION MANUAL .

a. PURPOSE. - This manual contains the operating instructions for the Sangamo 4700 Recorder/Reproducer. These instructions include descriptive material, installation instructions, operating procedures, operational theory and operator's maintenance. Because of the various possible 4700 Recorder/Reproducer configurations, the operator should thoroughly familiarize himself with the specific system received. The particular 4700 Recorder/Reproducer configuration as delivered is shown by a table located inside the front cover of the accompanying manual. The optimum magnetic head characteristics for head or heads supplied with the particular recorder/reproducer are also listed, following the configuration sheet. Four models of the 4700 Recorder/Reproducer are produced by the Sangamo Electric Company, Springfield, Illinois - 4711, 4712, 4741, and 4742. These machines differ only in the area of signal handling electronics and in the type of magnetic heads used. The 4711 and 4712 Recorder/Reproducers employ plug-in speed dependent circuits that require changing for each change of tape speed, indicated by the third digit one (1) of the model number. The 4741 and 4742 Recorder/Reproducers are automatically switched when tape speed is changed for the corresponding speed dependent circuit, indicated by the third digit four (4) of the model number. The difference between series 11 and series 12 or between series 41 and series 42 occurs in the frequency handling capabilities. If the last digit of the model number is one (1) the direct electronics are capable of recording and reproducing frequencies between 100 cps and 100 kc at 60 ips tape speed. If the last digit of the model number is two (2) the direct electronics are capable of recording and reproducing frequencies between 250 cps and 250 kc at 60 ips tape speed. More exact specifications can be found in paragraph 1-3

b. SUPPLEMENTARY INFORMATION - A separate Maintenance Instructions manual can be provided, and contains such information as system wiring diagrams, complete systems parts list, theory of operation of the plug-in assemblies, and schematic diagrams.

1-2. GENERAL DESCRIPTION.

a. GENERAL. - The Sangamo 4700 Recorder/Reproducer consists of six major assemblies: a control panel, an ac control box, a power supply drawer, a tape transport panel, a vacuum panel, and a plug-in module chassis (signal bay). These six assemblies are called out in Figures 1-2, 1-3 and 1-4.

b DESCRIPTION. - The Sangamo 4700 Recorder/Reproducer is a completely transistorized unit that offers the operator maximum reliability and data accuracy Employing a unique vacuum tensioning and cleaning system, precise tape tension is maintained at the head while cleaning the tape to reduce drop-outs and oxide build-up A totally new concept in capstan drive ensures the greatest accuracy possible in recording and reproducing tapes No mechanical coupling is made between the capstan and the necessary drive mechanism An eddy current clutch isolates the capstan from unwanted drive mechanism noises and ensures smooth tape handling. The capstan drive is covered in greater detail in Chapter IV.

c. CAPABILITIES. - The Sangamo 4700 Recorder/Reproducer utilizes an open loop tape deck that offers the capability of reel-to-reel or loop operation on the same deck without making any mechanical changes Eight tape speeds are standard on the 4700 - 120, 60, 30, 15, 7-1/2, 3-3/4, 1-7/8 and 15/16 inches per second (ips). When tape synchronous speed control is used, two lower speeds can be achieved for long-term operation. Running speeds may be changed during operation with speed synchronization achieved in less than three seconds. The tape transport is designed to accept either 1.0 or 1.5 mil.tape in 1/4 to 2-inch width. Field conversion from one tape width to another is easily accomplished with a tape width change kit. Direct, FM, Digital, and Voice electronics are all available for the Sangamo 4700 Recorder/Reproducer.

1-3. GENERAL SPECIFICATIONS.

a. TAPE TRANSPORT CHARACTERISTICS.

Reel Size	Precision or NAB, 10-1/2 or 14 inch
Reel Locks	Non-detachable, quick acting, 20° turn to lock and unlock
Tape Width	
Reel-to-Reel	1/4, 1/2, 1, 1-1/2 or 2 inch
Continuous Loop	1/2, 1, 1-1/2 or 2 inch
Tape Thickness	1.0 or 1.5 mil base may be used interchangeably (0.65 mil base on special order)
Tape Speeds	120, 60, 30, 15, 7-1/2, 3-3/4, 1-7/8, 15/16 ips, all electrically selectable
Stop and Start Time	Less than 5 seconds for 120 ips; less than 3 seconds for all other record/reproduce speeds for tape widths to one inch
Tape Speed Accuracy	±0.25% of nominal at 120, 60, 30, 15 and 7-1/2 ips; ±0.50% at 3-3/4, 1-7/8 and ±0.75% at 15/16 ips with capstan frequency speed control
Search	Bidirectional, continuously variable from 40 to 150 ips; also controlled at 120 ips
Rewind/Fast Forward Speed	850 feet per minute, nominal
Controls	Illuminated push-buttons for control of: Power, Tape Reset, Record Ready, Operate, Fast Forward, Fast Reverse, Tape Sense, Search, Stop, (Optional)-Fill Bin, Shuttle, Tape control indicate light; rotary switch for Tape Speed; optional Tape Path switch
Tape Loop Operation (optional)	6-250 feet for speed of 60, 30, 15, 7-1/2, 3-3/4 and 1-7/8 ips; 70 ft maximum for 120 ips; no loop operation at 15/16 ips

b. TAPE SYNCHRONOUS CONTROL SPECIFICATIONS.

Speed Control Correction Rate	±20% speed change per second without loss of synchronism at 60 ips
Speed Control Range	±10% of nominal tape speed at 60 ips
Instantaneous Time Displacement Error	less than ±5 microseconds at 60 ips (over a ten record interval)
Record-to-Reproduce Accuracy	±0.0004% (crystal oscillator stability)

c. DIRECT RECORD/REPRODUCE SPECIFICATIONS.

Input Sensitivity	0.1 to 25.0 volts rms, adjustable with input attenuator to produce optimum record level

Nominal Input Level . . . . 1.0 volts rms

Input Impedance. . . . . 20,000 ohms unbalanced to ground

Frequency Response

4711 and 4741 . . . . 100 cps to 100 kc ±3 db at 60 ips
100 cps to 125 kc ±3 db at 60 ips

4712 and 4742 . . . . 250 cps to 250 kc ±3 db at 60 ips
250 cps to 300 kc ±3 db at 60 ips

Signal-to-Noise Ratio (using IRIG heads)

4711 and 4741 . . . . ≥ 38 db (35 db with 125 kc bandwidth limit)

4712 and 4742 . . . . ≥ 30 db (25 db with 300 kc bandwidth limit)

Harmonic Distortion. . . . . less than 1.0% third harmonic of 1000 cps at 60 ips

Output Level — 1 volt rms at optimum record level

Output Current

4711 and 4712 . . . . ±10 ma peak

4741 and 4742 . . . . ±14 ma peak (See Note 1.)

Output Impedance

4711 and 4712 . . . . less than 100 ohms unbalanced to ground

4741 and 4742 . . . . less than 50 ohms unbalanced to ground (See Note 1.)

d. FM RECORD/REPRODUCE SPECIFICATIONS.

Input Sensitivity. . . . . ±0.5 to 50 volts peak, adjustable with input attenuator for ±40% deviation

Nominal Input Level . . . . ±1.4 volts peak

Input Impedance . . . . 20,000 ohms unbalanced to ground

Frequency Deviation. . . . . ±40%

Output Impedance

4711 and 4712 . . . . less than 100 ohms unbalanced to ground

4741 and 4742 . . . . less than 25 ohms unbalanced to ground (See Note 1.)

Output Level

4711 and 4712 . . . . ±2 volts peak into 200 ohm load

4741 and 4742 . . . . ±4 volts peak into 75 ohm load

Output Current

4711 and 4712	±10 ma peak
4741 and 4742	±50 ma peak (See Note 1.)

Frequency Response

4711 and 4741	
Flat amplitude filter	dc to 10 kc ±0.5 db at 60 ips (±40% carrier deviation) dc to 20 kc ±0.5 db at 60 ips (±20% carrier deviation) on special order
Linear phase filter	dc to 10 kc +0.5 db, -3 db at 60 ips (±40% carrier deviation) dc to 6 kc ±0.5 db at 60 ips (±40% carrier deviation)
4712 and 4742	
Flat amplitude filter	dc to 20 kc ±0.5 db at 60 ips (±40% carrier deviation) dc to 40 kc ±0.5 db at 60 ips (±20% carrier deviation) on special order
Linear phase filter	dc to 20 kc +0.5 db, -3 db at 60 ips (±40% carrier deviation) dc to 12 kc ±0.5 db at 60 ips (±40% carrier deviation)

Center Frequency

4711 and 4741	54 kc at 60 ips
4712 and 4742	108 kc at 60 ips

Signal-to-Noise Ratio

4711 and 4741	
Flat amplitude filter	1/2 inch - ≥ 46 db at 60 ips 1 inch - ≥ 48 db at 60 ips
Linear phase filter	1/2 inch - ≥ 45 db at 60 ips 1 inch - ≥ 47 db at 60 ips
4712 and 4742	
Flat amplitude filter	1/2 inch - ≥ 44 db at 60 ips 1 inch - ≥ 45 db at 60 ips
Linear phase filter	1/2 inch - ≥ 43 db at 60 ips 1 inch - ≥ 44 db at 60 ips

DC Drift	less than 1.0% full scale per 10°F after 10 minute warmup
DC Linearity	within 1.0% of full scale, referenced to best straight line
Distortion (total harmonic)	less than 1.0% for 60 to 7 1/2 ips; less than 1.5% for 3 3/4 to 15/16 ips

Transient Response (at 60 ips)

Flat amplitude filter (±0.5 db)

4711 and 4741	Rise time - 36 microseconds (between 10% and 90% points) Overshoot - less than 15%
4712 and 4742	Rise time - 18 microseconds (between 10% and 90% points) Overshoot - less than 15%

Linear phase filter

4711 and 4741	Rise time - 36 microseconds (between 10% and 90% points) Overshoot - less than 2%
4712 and 4742	Rise time - 18 microseconds (between 10% and 90% points) Overshoot - less than 2%

e. DIGITAL RECORD/REPRODUCE SPECIFICATIONS.

(1) PCM

Input Signal

Amplitude	1 volt (min.), peak to peak
Clip Level	-2 to +2 volts, continuously adjustable through zero
Polarity	Plus, minus, or plus and minus
Input Impedance	20,000 ohms (min.) shunted by 100 pf (max.)
Input Signal Rise Time	any

Maximum Bit Rate

4741 or 4711	550 bits per inch, at a typical drop out rate of 1×10^7
4742 or 4712	1100 bits per inch, at a typical drop out rate of 1×10^7
Output Impedance	75 ohms or less
System pulse coincidence	±1.6 microseconds

(2) PDM

Input Signal Amplitude	1 volt (min.) peak to peak
Input Impedance	20,000 ohms (min.), shunted by 100 pf (max.)
Record Transfer Characteristic	differentiation with 10 microsecond time constant
Reproduce Transfer Characteristic	reconstructs original rectangular pulse train
Output Impedance	100 ohms (max.)
Nominal Output Level	20 volts peak to peak across 1000 ohms resistive load

Output Pulse Rise and Fall Times	2 microseconds (max.) from 10% to 90% amplitude
Range of Adjustment of Missing Pulse Reset Circuit	100 to 1000 microseconds
System Performance	
Minimum Pulse Length.	less than 100 microseconds at 15 ips; 75 microseconds at 30 and 60 ips
Pulse Accuracy.	±2 microseconds or better

1-4. OPTIONAL FEATURES.

Tape Synchronous Speed Control

Voice Annotation (either multiplexed with a data track or as a separate edge track)

Erase Capabilities

Tape Loop Operation

Shuttle Control

IRIG (Inter-Range Instrumentation Group) 17kc/60cps Reference Oscillator

Preset Delayed Stop

Wow and Flutter Compensation

Remote Control

Mobile Dolly

Monitor Oscilloscopes

NOTE 1. - Models 4741 and 4742 are shipped with the following specifications:

DIRECT

(1) Output Current ±8 ma peak

(2) Output Impedance less than 75 ohms unbalanced to ground

FM

(1) Output Current ±50 ma peak maximum into 33 ohm load

(2) Output Impedance less than 75 ohms unbalanced to ground

To achieve those values as stated in the General Specifications, remove the direct reproduce (AP) board from each DIRECT/FM module. Replace the 47 ohm resistor with a wire jumper between the stand-offs in series with pin A located at the terminal end of each AP board. The 47 ohm resistor is supplied in the output to prevent possible transistor damage if the output is shorted for a prolonged period at an elevated high operating temperature.