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**Saturn IB/V - Instrument Unit**

**Technical Manual**

# Instrumentation System Description

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IBM No. 65-966-0021

(S-IU-202 Thru 204/501 Thru 503)



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UNIT INSTRUMENTATION SYSTEM DESCRIPTION  
(S-IU-2-02 THROUGH 204/501 THROUGH 503)  
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**TECHNICAL MANUAL**

**SATURN IB/V INSTRUMENT UNIT  
INSTRUMENTATION SYSTEM DESCRIPTION**

**(S-IU-202 THRU 204/501 THRU 503)**

Prepared under Contract

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by

International Business Machines Corporation

Federal Systems Division

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## PREFACE

This manual provides complete system-level description of the Instrumentation System (measurements and telemetry) for the Saturn Launch Vehicle Instrument Unit. This manual is intended to be used for Instrumentation System familiarization as well as a detailed training and reference document.

The airborne Instrumentation System is provided to monitor conditions and events on the launch vehicle and transmit the information to ground receiving stations. The system comprises the equipment necessary to sense, prepare, and transmit the information from the launch vehicle, and the launch complex equipment to support these operations. The Instrumentation System is used both during prelaunch checkout and flight of the launch vehicle.

Information in this manual will help support detailed trouble-shooting of the system during launch checkout but will not support trouble-shooting of malfunctioning components. For more detailed information refer to the documents in the List of Related Documents.

Section I of this manual gives the general concept of instrumentation as used by the Instrument Unit. The purpose and general function of the system are explained with emphasis on the fundamental electronic and mechanical techniques used to obtain the desired results. This section is oriented to personnel with little or no familiarity with basic instrumentation.

Section II contains a general description of the physical and functional characteristics of each Instrumentation System component. The functional description is limited to an explanation of the methods used by a component to accomplish its function, without stating details of the exact interior workings of the component. This level of detail will enable technical personnel to understand the function of the component within the system.

Section III shows how the separate components function together to form the Instrumentation System. The various airborne and launch complex functional loops are explained without going to the level of component detail given in Section II. Emphasis is placed on the relationship between the launch vehicle and launch complex components. This section will enable technical personnel to understand how the system accomplishes its role in the overall mission.

This edition contains information covering Saturn IB Launch Vehicles 202 through 204, Saturn V Launch Vehicles 501 through 503, and Launch Complexes 34, 37, and 39. Information for subsequent vehicles will be added. As this is not a historical document, information covering expended vehicles will be deleted as convenience dictates.

The following symbols are used in this technical manual to denote differences between IU Instrumentation System configurations:

- A** Applies to S-IU-202 only.
- B** Applies to S-IU-203 and 204 only.
- C** Applies to S-IU-501, 502, and 503 only.

### LIST OF RELATED DOCUMENTS

The following manuals have been published under NASA contracts as source and reference information on IU systems and/or components.

Title	Number		Published Date	Changed Date
	IBM	MSFC		
Saturn IB/V Instrument Unit Structure Repair Manual	65-966-0011H	III-5-510-1	1 September 1965	
Auxiliary Power Distributors	65-966-0013H	III-5-510-2	1 October 1965	
Power Distributor	65-966-0014H	III-5-510-3	1 October 1965	
Emergency Detection System Distributor	65-966-0015H	III-5-510-4	1 October 1965	
Control Distributor	65-966-0016H	III-5-510-5	1 October 1965	
Measuring Distributors	65-966-0017H	III-5-510-6	1 October 1965	
56 Volt Power Supply	65-966-0018H	III-5-510-7	1 October 1965	1 May 1966
5 Volt Measuring Voltage Supply	65-966-0019H	III-5-510-8	1 October 1965	
Saturn IB/V Instrument Unit Switch Selector, Model II	66-966-0001	III-5-510-9	1 February 1966	
Saturn IB/V Instrument Unit Component Handling Equipment Description and Operating Instructions	66-966-0005	III-5-510-10	1 February 1966	
Saturn IB/V Instrument Unit C-Band Radar Transponder Set SST-135C	66-966-0008	III-5-510-11	31 July 1964	1 March 1966
Saturn IB/V Instrument Unit Control Accelerometer	66-966-0012	III-5-510-12	1 March 1966	
Saturn IB/V Instrument Unit Control-EDS Rate Gyro Package	66-966-0013	III-5-510-13	1 March 1966	
Saturn IB/V Instrument Unit Control Signal Processor	66-966-0014	III-5-510-14	1 March 1966	
Saturn IB/V Instrument Unit Flight Control Computer	66-966-0015	III-5-510-15	15 March 1966	
Saturn IB/V Instrument Unit Instrumentation System Description	65-966-0021	III-5-509-1	1 June 1966	

LIST OF RELATED DOCUMENTS (Cont)

Title	Number		Published Date	Changed Date
	IBM	MSFC		
Saturn IB/V Instrument Unit Navigation, Guidance, and Control System Description	66-966-0003	III-5-509-2	1 February 1966	
Saturn IB/V Instrument Unit System Test Reference Manual Volume I Control System Volume II Guidance System Volume III ST-124M-3 Inertial Stabilizer System	66-966-0004	III-5-509-3	1 March 1966	
Saturn IB/V Instrument Unit System Description and Component Data	66-966-0006	III-5-509-4	1 March 1966	
Saturn IB/V Instrument Unit Environmental Control System Description	66-966-0009	III-5-509-5	15 March 1966	
Apollo-Saturn Emergency Detection System Description	66-966-0010	III-5-509-6	1 March 1966	

The following documents contain source and reference information on the IU Instrumentation System and/or components.

Number	Title
106-65	Inter-Range Instrumentation Group (IRIG) Telemetry Standards
40M33021	SA-202 Instrument Unit Electrical Schematics
40M33041	SA-203 Instrument Unit Electrical Schematics
50M10670	S-IU-501 Instrumentation Program and Components (IP&C)
50M12030	S-IU-202 Instrumentation Program and Components (IP&C)
50M12393	S-IU-203 Instrumentation Program and Components (IP&C)
50M12394	S-IU-204 Instrumentation Program and Components (IP&C)
50M66501	Maintenance and Instruction Manual for Telemetry Oscillator Assembly Models A1, A2, and A3
50M66503	Maintenance and Instruction Manual for Model B1 Telemetry Oscillator Assembly
50M66505	Maintenance and Instruction Manual Model I Radio Frequency Assembly
50M66506	Maintenance and Instructions for Model 270 Time Division Multiplexer
50M66508	Maintenance and Instruction Manual for Model II and Model IIA Telemetry Calibrator

LIST OF RELATED DOCUMENTS (Cont)

Number	Title
50M66509	Maintenance Instructions for Multiplexer Model 245
50M66510	Maintenance and Instruction Manual for SS/FM Telemetry Assembly
50M66511	Maintenance and Instructions for SS/FM Top Deck Assembly
50M66512	Maintenance Instructions for Pulse Code Modulation Digital Data Acquisition Subsystem Assembly (PCM/DDAS) Model 301
50M66513	Maintenance Instructions for Remote Digital Submultiplexer
50M66514	Maintenance Instructions for PCM/RF Assembly Model CT-19B
50M66515	Maintenance and Instruction Manual for Model II Radio Frequency Assembly (Analog)
50M66516	Maintenance and Instruction Manual for Model II Radio Frequency Assembly (Digital)
50M66528	Maintenance and Instruction Manual for SS/FM Demultiplexer Assembly
60C09058	Saturn Antenna Systems SA-202
60C09075	Saturn IB Instrumentation Systems Description SA-201 through 205
6009047	S-IU-502 Instrumentation Program and Components (IP&C)
6009048	S-IU-503 Instrumentation Program and Components (IP&C)
7910128	SA-204 Instrument Unit Electrical Schematics
7910137	S-IU-501 Instrument Unit Electrical Schematics
7910138	S-IU-502 Instrument Unit Electrical Schematics
7910139	S-IU-503 Instrument Unit Electrical Schematics
D5-15338	Saturn V Instrumentation System Description Launch Vehicle SA-501
ETR-TR-65-9	AFETR Instrumentation Handbook
None	SA-202 Saturn Technical Information Handbook
None	SA-203 Saturn Technical Information Handbook
None	Saturn IB and V Instrumentation Checkout Procedures for Digital Data Acquisition System Models DRS-1, DRS-2, DRS-3, and TRS-1
None	S-IU Flight Measurements Manual, Saturn IB Vehicles



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# SECTION I

## SYSTEM INTRODUCTION

### 1-1 PURPOSE OF SYSTEM

The Instrument Unit Instrumentation System is provided to monitor conditions and events aboard the launch vehicle and furnish this information to ground receiving stations (see Figure 1-1). The ground stations use this information (1) prior to launch to assist in checkout of the launch vehicle, (2) during flight for immediate determination of launch vehicle condition, and (3) after flight as a scientific record.

All major components for the system are located in the Instrument Unit. Most of the major components are mounted on Thermal Conditioning Panels and make use of the Environmental Control System. The only system components not located in the Instrument Unit are some transducers used for monitoring other portions of the launch vehicle.

Monitored information from the launch vehicle is sent to checkout equipment at Kennedy Space Center as well as a world-wide network of monitoring stations. Prior to launch, the information is radiated to ground receiving stations at KSC for checkout of the Instrumentation System. Some of the information is also sent through wiring to the launch site electrical support equipment for recording, visual display, and for use in automatic checkout of the launch vehicle. During flight, the information is radiated to a world-wide network of monitoring stations that use the data for immediate determination of launch vehicle status.

Information sent to the ground is generally recorded as well as monitored. Magnetic tape recorders and paper recorders are used. These recordings are used for scientific evaluation of the mission.

The Digital Data Acquisition System (DDAS) converts instrumentation information into a form readily usable by the launch vehicle automatic checkout equipment. The DDAS can also visually display the information to assist in immediately analyzing

vehicle status. Information sent through the DDAS can be recorded for future use.

The ground receiving stations receive the radiated signals from the launch vehicle and decode the signals to regain the individual conditions or events being monitored. This information is visually displayed to assist in determination of launch vehicle status.

To achieve the particular purpose of each Apollo/Saturn Vehicle, there are variations in the IU Instrumentation System. These variations depend on the mission plan and flight test requirements of the launch vehicle. As new Instrumentation System components become proven, redundancy in later launch vehicles will be decreased. As confidence in the overall launch vehicle increases, instrumentation requirements decrease. In general, as the Apollo/Saturn Vehicle progresses from the development phase to the operational phase, the amount of measurements taken and the number of Instrumentation System components will decrease. This section will not detail the different configurations of the Instrumentation Systems for each Instrument Unit.

### 1-2 GENERAL FUNCTION OF SYSTEM

The on-board Instrumentation System consists of the equipment needed to sense vehicle conditions (measurements) and transmit this information (telemetry) from the launch vehicle. Figure 1-2 shows typical data flow through the Instrumentation System. Data flow is through the following functional stages:

- Source
- Conditioning
- Distribution
- Multiplexing
- Modulation
- Storage
- Transmitting
- RF equipment

Measurements originate from transducers, electrical pick-offs, and computer data. If necessary,

these signals are conditioned to a voltage range acceptable to the modulation stage before being distributed to the proper multiplexing or modulation equipment. Some measurements go through a multiplexing (time-sharing) stage to increase the data handling capacity of the system. All measurements are then converted to some form of modulation that will subsequently deviate a Frequency Modulation (FM) transmitter carrier. The FM outputs can be recorded on magnetic tape for delayed transmission.

All modulated measurements are then transmitted by one of four telemetry transmitters. The pulse code modulation output is also converted to a medium range frequency (mf) and sent to the ground via the umbilical. During flight, the transmitter outputs are coupled onto a single line, routed through a switch, divided between two antennas, and broadcast to the ground. In prelaunch checkout, the switch may route these coupled vhf signals through a load, and then to the ground via the umbilical.

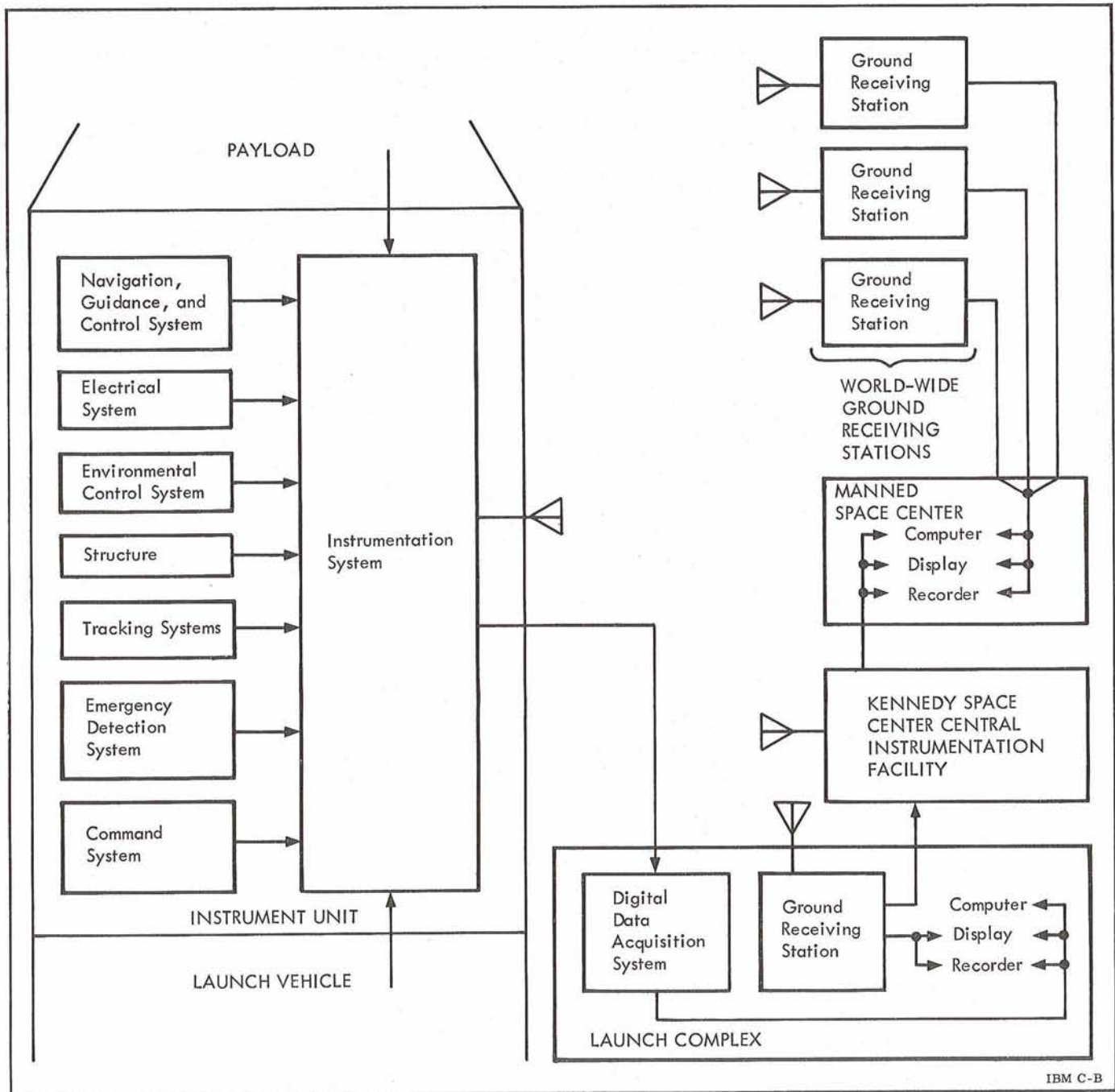
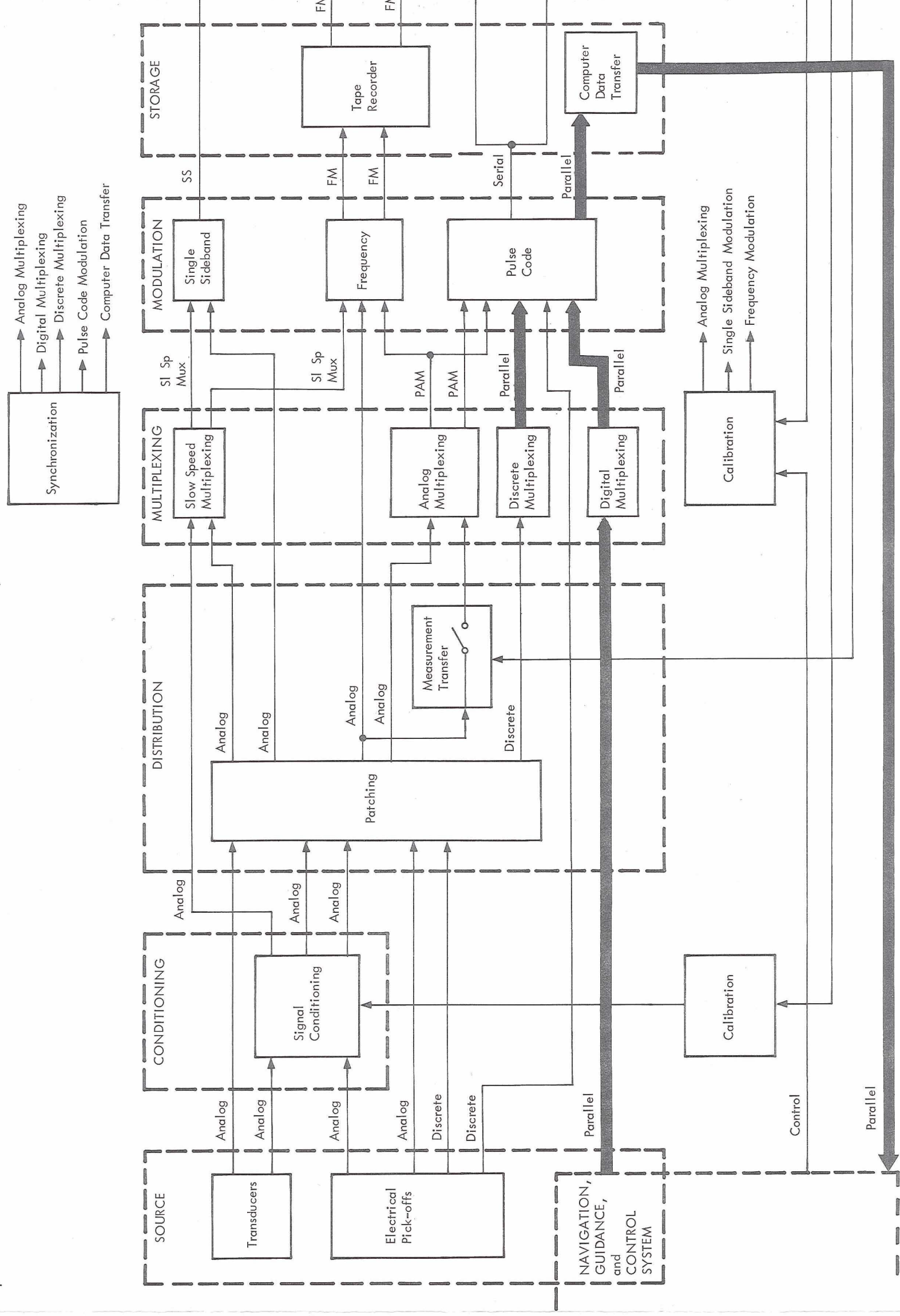


Figure 1-1. Instrumentation System Functional Interface

Measurements ————— Teleme



2

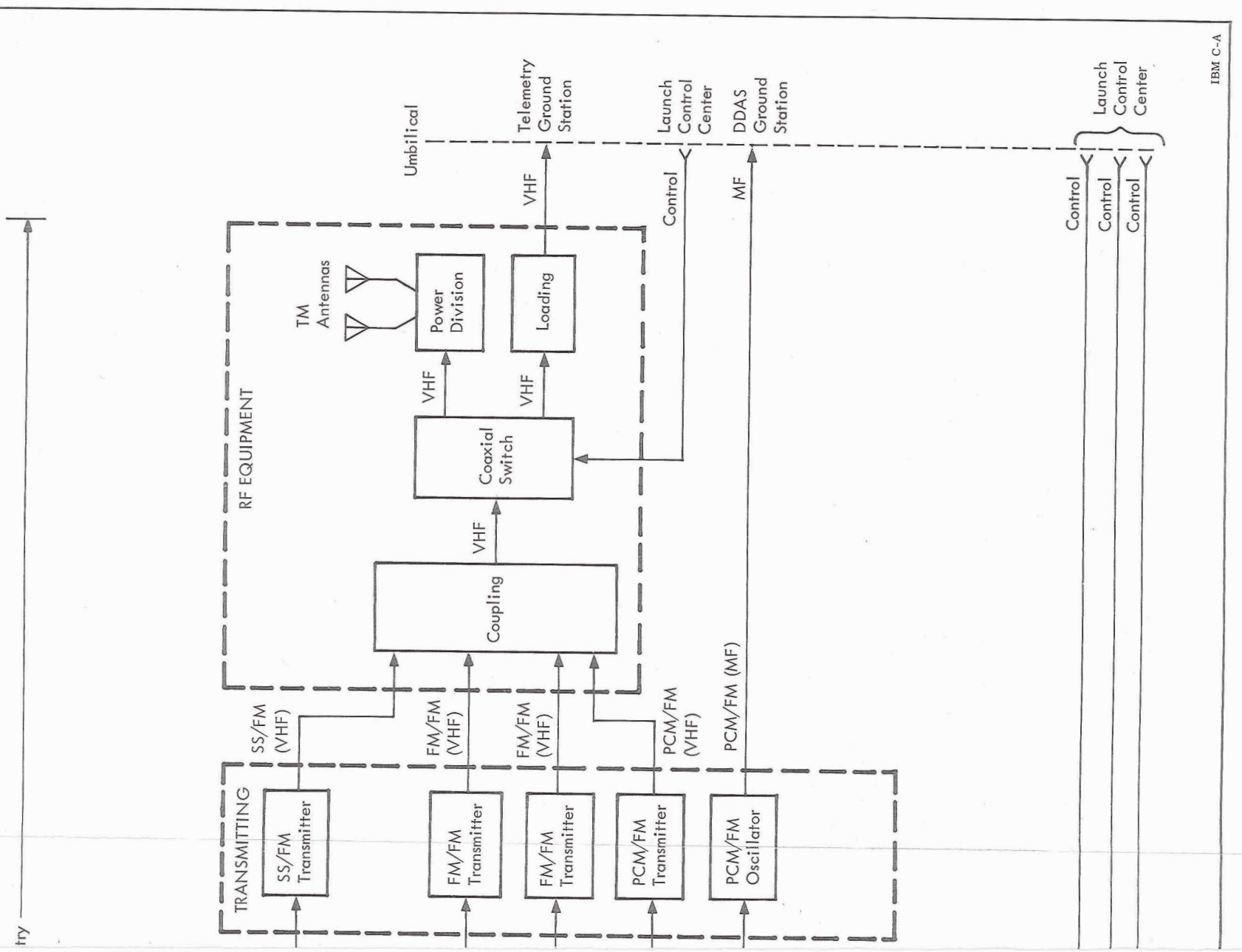


Figure 1-2. Instrumentation System Functional Data Flow

Synchronization equipment is provided to ensure that the multiplexing and modulation stages are operating in phase with each other.

Some stages of measurement data flow may be selected for automatic on-board calibration. The calibration is controlled from the ESE prior to launch and by the Navigation, Guidance, and Control System during flight.

### 1-3 SOURCE

Many conditions and events from the launch vehicle guidance, control, propulsion, tracking, and other systems are monitored by the Instrumentation System. Typical conditions and events are:

Temperature	Gyro precession
Pressure	Vehicle attitude
Vibration	Computer digital information
Acceleration	Electrical power
Acoustic	RF power
Flow rate	Relay position
Position	Stage separation
Current	Frequency
Voltage	Angular velocity

All measurements must be in electrical form to be processed by subsequent stages of the system. Measurements that are already in electrical form (electrical pick-offs) are furnished directly to the next functional stage. Measurements that are not in electrical form use transducers to convert the mechanical conditions to electrical conditions for use by subsequent stages.

Several hundred measurements are transmitted by the system. To achieve the best combination of reliability, effectiveness, and cost, different processes are used to sense and transmit these measurements. A functional description of these processes follows.

Each measurement, after it is in electrical form, is classed in one of three categories. These categories are:

- Analog Data - An electrical signal that is instantaneously proportional to the measurement being monitored. The actual data may be represented by either the voltage, frequency, or both, of the signal.

- Discrete Data - An electrical signal representing, by a voltage level, either mode of a two-mode signal, for example, the presence or non-presence of a voltage.
- Digital Data - A series of electrical binary data pulses that, when decoded, represents a series of discretes, an analog signal, or information from a computer. When this type of data is presented as a group of digital pulses existing simultaneously, it is referred to as parallel digital data.

All measurements, after they are in electrical form, come from one of three sources. They are furnished from transducers, electrical pick-offs, or computer data.

#### Transducers

Each transducer's electrical output is proportional to the mechanical condition it monitors. The following types of conditions are converted by transducers:

Acceleration	Convected heat
Mechanical position	Radiated heat
Liquid or gas pressure	Sound
Rate of liquid flow	Vibration

Some transducer outputs require signal conditioning prior to acceptance by the modulation equipment.

#### Electrical Pick-Offs

Electrical signals picked off directly from monitored equipment are in the form of varying voltage levels, varying current levels, varying frequencies, or discrete voltages. Discretes require no signal conditioning, but some of the other signals do require conditioning.

#### Computer Data

Computer data from the Navigation, Guidance, and Control System is fed directly to the digital multiplexing stage. This binary information is in parallel digital format.



#### 1-4 CONDITIONING

Signal conditioning is a process of adapting the individual measurement signal to the modulation stage. Incoming signals may be in any electrical form but they are all converted to a proportional signal in the range acceptable to the modulation stage. Signal conditioning also serves to electrically isolate the sensors from subsequent equipment. Measurements that have been signal conditioned are distributed to the multiplexing stage or directly to the modulation stage.

#### 1-5 DISTRIBUTION

The distribution stage serves to route measurements to the appropriate multiplexing or modulation stage. While some signals are wired directly from the sensor to a multiplexing stage, the majority are routed through a patch-board arrangement. This patch-board arrangement lends flexibility to the system by allowing measurement broadcast channels to be changed without modification to the vehicle. During flight, some measurements that have passed their usefulness are automatically switched out and replaced with new measurements. This function serves to increase the measurement capacity of the system. During prelaunch checkout, those few measurements that go through FM modulation without being multiplexed are also switched to analog multiplexing to allow checkout via the DDAS equipment.

#### 1-6 MULTIPLEXING

Multiplexing is a process of periodically sampling measurements at a fast rate while ensuring that no intelligible data is lost. The many samples in a preselected sequence are sent to the modulation equipment to allow the system to handle more data. This method of multiplexing is called time-share multiplexing. Another method of multiplexing, called frequency multiplexing, is used in the modulation stage. Analog, slow-speed, discrete, and digital multiplexing are used in the multiplexing stage.

##### Analog

Analog multiplexing is a method of sequentially sampling (time-sharing) many low-frequency analog measurements, giving an output train of amplitude varying pulses (pulse amplitude modulation). This sampling (see Figure 1-3) is done by electronically switching from one measurement to the next, similar to a mechanical commutator. This Pulse Amplitude Modulation (PAM) is a repeating train of narrow,

fixed-width pulses, each pulse being an instantaneous sample of an analog measurement. This method is used with data that has low-frequency response (less than 25 Hz) requirements. When an analog multiplexer is used with FM/FM, the process is called PAM/FM/FM.

##### Slow-Speed

Slow-speed multiplexing sequentially samples many high-frequency analog measurements at a relatively slow rate (see Figure 1-3). The output consists of a series of electrical pulses with the voltage and frequency of each pulse representing the instantaneous voltage and frequency of an analog signal. These long samples (several seconds each) are sequentially furnished to the modulation stage. Slow-speed multiplexing is also a time-sharing method, but as the samples are each several seconds long it can be used with data that has very high-frequency response requirements.

##### Discrete

Discrete multiplexing is a method of sequentially sampling many discrete measurements and giving an output in parallel digital format. Groups of unassociated discretions are accepted and converted to parallel outputs for use by pulse code modulation (see Figure 1-3). These parallel outputs are furnished to the pulse code modulation stage. This low-frequency response, high-accuracy method is used with PCM.

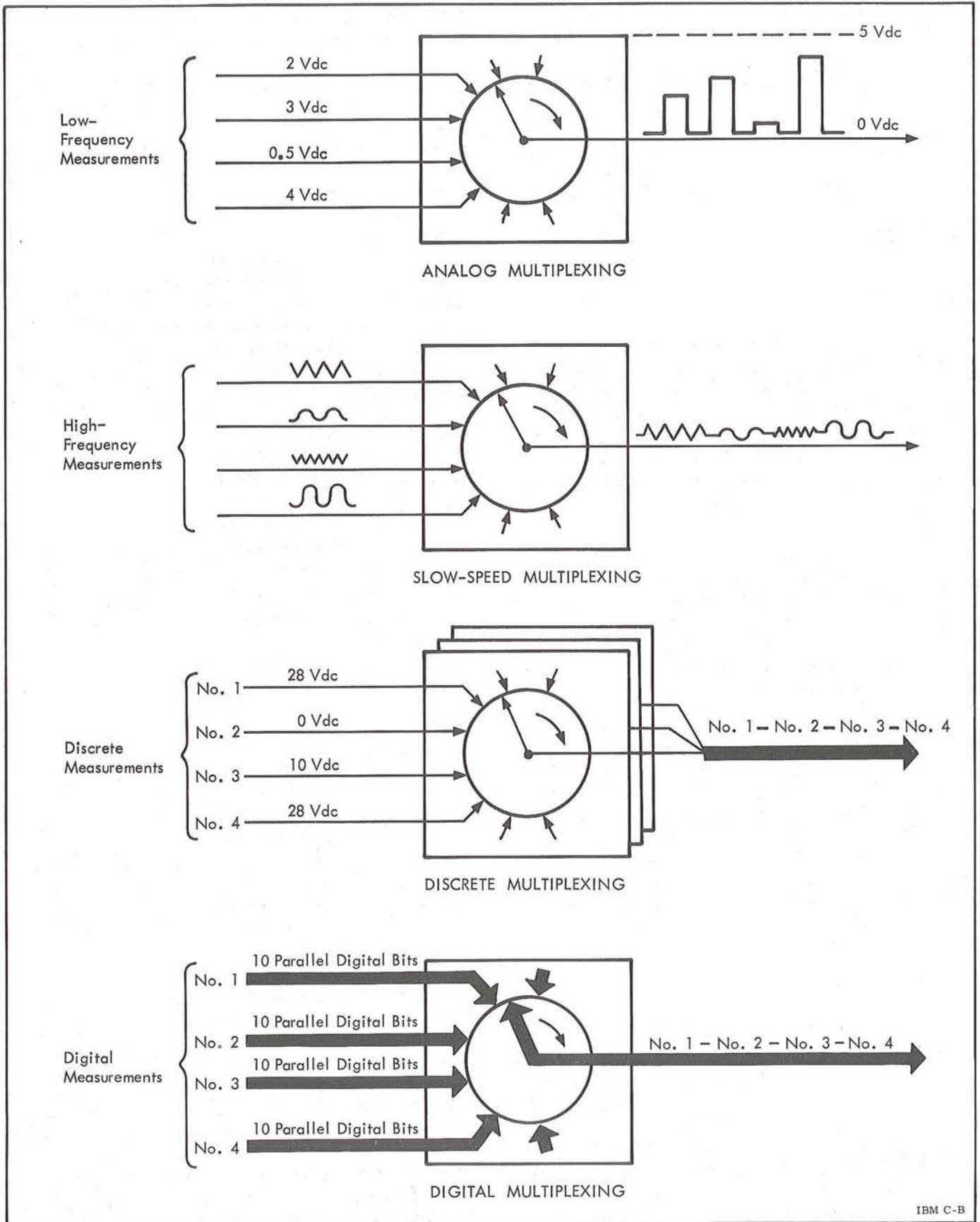
##### Digital

Digital multiplexing is a method of sequentially sampling many Navigation, Guidance, and Control System input pulses that are in parallel computer-word form (see Figure 1-3). The input pulses are formatted into parallel outputs acceptable by pulse-code modulation. This low-frequency response, high-accuracy method is used with PCM.

#### 1-7 MODULATION

The purpose of the modulation stage is to convert all measurements or multiplexed data to a form that can modulate an FM transmitter. Three types of telemetry transmitter modulation techniques are used to transmit the large number of measurements, with their different requirements for frequency response and amplitude accuracy. Frequency response requirements can be approximately categorized as follows:

Low response . . . . .	Less than 5 Hz
Medium response . . . . .	Up to 50 Hz



IBM C-B

Figure 1-3. Multiplexing Techniques

High response . . . . . Up to 1000 Hz  
Very high response . . . . . 30 Hz to 3000 Hz

Accuracy requirements can be approximately categorized as follows:

Low accuracy . . . . . Allowable error of over 4%  
Medium accuracy . . . . . Allowable error of 2 to 4%  
High accuracy . . . . . Allowable error of less than 2%

### Frequency

FM accepts individual and multiplexed (PAM and slow-speed) analog measurements and transforms them into individual frequency information outputs mixed into a single output (see Figure 1-4). This method of modulation is also called frequency multiplexing. Several voltage controlled oscillators (sub-carrier oscillators) are used, with one analog measurement or one multiplexed pulse train modulating each one.

To increase measurement handling capacity, the mixed outputs of several low-frequency subcarrier oscillators are used as inputs to one high-frequency oscillator thus freeing those same low frequencies for use by other low-frequency subcarrier oscillators. These frequency-modulated signals are then mixed and amplified for output to an FM/FM transmitter.

The FM technique can have high-frequency response but only medium accuracy, at best. FM/FM can realize high-frequency response when the higher frequency subcarrier oscillators are used. If the lower frequency subcarrier oscillators are used, the FM/FM technique can only attain medium response. Due to the signal-to-noise characteristics of the technique, FM/FM will deliver only medium accuracy. Use of an analog multiplexer will detract from the frequency response.

### Single Sideband

Single Sideband (SS) modulation is a method of combining several high-frequency analog measurements or slow-speed multiplexed measurements into a composite output without causing excessive bandspread of the transmitter carrier to be modulated (see Figure 1-4). Each input is subjected to a process of modulation and filtering to emerge as information in a fixed frequency band. The emerging signal is instantaneously proportional in frequency and amplitude to

the input signal. The outputs of several fixed bands are mixed and sent to the input of an FM transmitter.

The SS technique has a very high-frequency response with medium-amplitude accuracy. Use of a slow-speed multiplexer can increase the amount of measurements carried without adversely affecting the frequency response. This is because each sample is for a relatively long time.

### Pulse Code

Pulse Code Modulation (PCM) accepts parallel digital, PAM, and discrete inputs, and transforms this data into an output train of serial digital data (see Figure 1-4). Discrete and PAM inputs are converted to parallel digital pulses and temporarily stored for integration with the parallel inputs. The parallel data is integrated in a preselected sequence. The integrated data is then serialized into a repeating train of binary digital pulses. This serial train is the modulation for an FM vhf transmitter and for an mf oscillator.

The PCM/FM technique has a low-frequency response but gives high accuracy. The frequency response is low because PCM is a sampling method. The accuracy is high because of the high signal-to-noise ratio.

## 1-8 STORAGE

The purpose of the storage stage is to store, or assist in storing, instrumentation data for later transmission to ground receiving stations. Two methods of data storage are used. One method employs a magnetic tape recorder/reproducer for storage of analog data. The other method uses a unit that transfers PCM data into the Navigation, Guidance, and Control System digital computer for future transfer back to the telemetry transmitting equipment.

### Tape Recorder

The function of the tape recorder is to record, and reproduce for rebroadcast, information that would otherwise be lost during retro-rocket fire at S-IB/S-IVB separation. During flight, both outputs of the FM modulation stage are routed through the tape recorder to the two FM/FM transmitters. Just before retro-rocket fire, a signal from the Navigation, Guidance, and Control System causes the tape recorder to start recording these FM modulation signals until after retro-rocket burnout. Another signal from the Navigation, Guidance, and Control System then

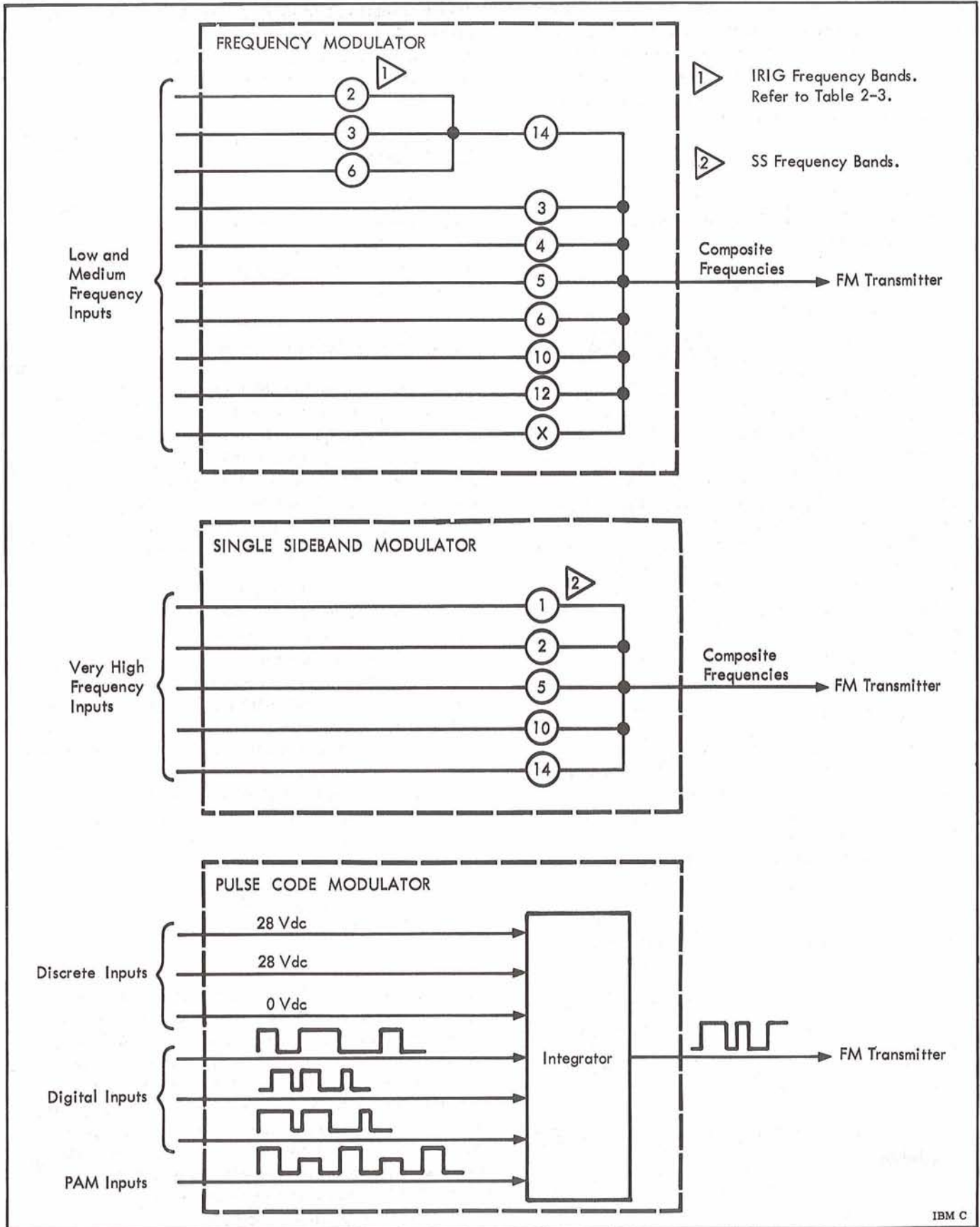


Figure 1-4. Modulation Techniques

causes the tape recorder to play the recording into the two FM/FM transmitters. Retro-rocket fire interferes with the broadcast signals by ionizing the air around the antennas causing these vhf signals to become excessively noisy or completely blocked from transmission to the ground.

#### Computer Data Transfer

The function of computer data transfer is to furnish PCM data to the Navigation, Guidance, and Control System digital computer for storage. This storage function takes place during the orbital portion of a mission while the IU is not within range of a ground telemetry receiving station. When the IU again comes within range of a receiving station, the stored data is transferred into the digital multiplexing stage for transmission through the antennas.

The program of the Navigation, Guidance, and Control System selects the individual PCM measurements and the instant they are to be transferred into the digital computer. The complete output of the PCM modulation stage, in parallel digital format, is provided for computer data transfer. On command from the Navigation, Guidance, and Control System, selected parallel digital words are compressed and stored in the digital computer. When the IU comes within range of the next receiving station, the stored data, along with timing information, is sent through digital multiplexing to pulse code modulation for transmission.

#### 1-9 TRANSMITTING

Four vhf transmitters and one mf oscillator are used to transfer measurement data to the ground. The four FM vhf transmitters receive inputs from the modulation stage and send their outputs to the ground via antennas. The transmitters are functionally identical. The PCM mf oscillator accepts data from PCM modulation and transfers the data to the ground via the umbilical.

#### Single Sideband/Frequency Modulated (SS/FM) Transmitter

The SS/FM transmitter receives the mixed signals from SS modulation and furnishes an output to the rf equipment. The incoming signal is first used to modulate the FM transmitter circuit, then amplified, filtered, and sent to the rf equipment.

#### Frequency Modulated/Frequency Modulated (FM/FM) Transmitters

The two FM/FM transmitters are physically identical; they each receive a separate signal from

FM modulation and furnish an output to the rf equipment. The incoming signal is first used to modulate the FM transmitter circuit, then amplified, filtered, and sent to the rf equipment.

#### Pulse Code Modulated/Frequency Modulated (PCM/FM) Transmitter

The PCM/FM transmitter receives serial PCM data and furnishes an output to the rf equipment. The incoming PCM data frequency modulates the FM transmitter circuit, then is amplified, filtered and sent to the rf equipment.

#### PCM/FM Oscillator

The PCM/FM oscillator receives the same input as the PCM/FM transmitter and furnishes an mf output through coaxial cable to DDAS equipment. The incoming PCM data frequency modulates a voltage controlled oscillator. This FM carrier is transformer coupled to a coaxial cable for delivery to the ground DDAS equipment via the umbilical. This data path is used for prelaunch checkout only.

### 1-10 RF EQUIPMENT

The rf equipment receives the transmitter rf outputs and broadcasts them in an omni-directional pattern about the launch vehicle roll axis. The transmitter outputs are coupled into a single line and sent to a divider which splits the power between two antennas. The radiated signals are monitored by ground receiving stations. By using a coaxial switch and load, the transmitter outputs can be sent to the telemetry ground station without being radiated through the antennas.

### 1-11 SYNCHRONIZATION

Synchronization control is used to keep the multiplexing and modulation equipment operating in the proper relationship with each other. The timing signal for synchronization control originates in an oscillating crystal whose output is changed to several different frequencies. These frequencies are used to control the different operating rates for analog multiplexing, digital multiplexing, discrete multiplexing, pulse code modulation, and computer data transfer. Synchronization is necessary to ensure that each pulse of information is routed to the proper circuit at the time it is supposed to be there.

## 1-12 CALIBRATION

Several portions of the Instrumentation System are equipped with circuits that permit calibration signals to be applied. These calibration signals are applied to the measurements portion and the telemetry portion. At the receiving stations the normal broadcast data is compared to the calibrated broadcast data to determine system accuracy.

In the strict sense of the word, this is not a true calibration. The calibrated circuits are not adjusted or compensated for drift or other error. Instead, a preset precise input signal is applied to these circuits to cause a calculated output. Comparison (at the receiving stations) of the actual output to the calculated output will determine the amount of circuit error. When the determined error is applied to the actual signal, the circuit is, in effect, calibrated.

### Measurements

Each signal conditioning measurement channel may be calibrated by providing the channel with a pre-

set simulated input. The type of measurements simulation input varies with the type of channel being calibrated. Channels may be calibrated singly or in groups. The channel selection and mode application are controlled from the ESE and are used only during prelaunch checkout.

### Telemetry

Selected channels through the analog multiplexing, single sideband modulation or frequency modulation stages may be calibrated by application of a simulated input. This calibration signal consists of several preset voltages through the input range of the modulation stages. For prelaunch checkout, the selection and application of calibration signals are controlled from the Launch Control Center. During flight, the calibration signals are controlled by the Navigation, Guidance, and Control System program.

## SECTION II

# COMPONENT DESCRIPTION AND FUNCTIONS

### 2-1 AIRBORNE EQUIPMENT

The airborne Instrumentation System consists of those major components listed in Table 2-1 and the transducers listed in Table 2-2. These items are all installed in the Instrument Unit near the locations indicated in the tables. The following paragraphs describe the airborne components.

#### 2-2 5 V SUPPLY

The 5 V Supply is a dc-to-dc converter that furnishes highly regulated transducer operating power and calibration reference voltage. The unit accepts unregulated 28 Vdc from the IU Electrical System, converts the 28 Vdc to a precise 5 Vdc, and distributes the 5 Vdc (via the Measuring Distributors) to the IU and other stage potentiometer transducers, all Measuring Racks, the TM Calibrator, F1 and F2 Telemeters, and F1 and F2 Mux. The 5 V Supply is the source power for all transducer originated measurements and the reference voltage for telemetry calibration. The 5 V Supply can provide up to 1 ampere of continuous current and will not be harmed by a short circuit on the output.

#### Construction

This transistorized 5 V Supply weighs 3 pounds. The unit is 2 inches high, 5 inches wide, and 5 inches long.

#### Function

The unregulated dc input is filtered (see Figure 2-1) and fed to the input regulator for removal of input variations. The then-regulated voltage is applied to the oscillator which generates a full-wave, 4 kHz signal and serves as a source isolation stage. The oscillator output is full-wave rectified, filtered, and sent to the output regulator. The precise 5 Vdc from the output regulator is filtered to remove RF interference as well as any lower frequencies. The output of the 5 V Supply is fed to Measuring Distributor A3 for distribution.

### 2-3 TRANSDUCERS

Transducers are used to convert mechanical or electrical energy into a proportional electrical energy form that can be used by the Instrumentation System. The transducers used in the IU transform mechanical movements, fluid and gas pressures, temperatures, fluid flow rates, and electrical power into electrical signals acceptable by the system. Most transducers are part of the Instrumentation System and are attached to the component being monitored. Some few transducers are an integral part of the component being monitored and for the purpose of this manual they are considered voltage pick-offs.

The Instrumentation System for IU-203 contains several transducers that are not found on other vehicles. These transducers are located in the nose cone as well as in the IU and are used to monitor acceleration, sound level, temperature, pressure, and liquid level for experiments peculiar to the mission of IU-203. Due to the lack of available data and limited use of these transducers, this technical manual does not contain descriptive information about them.

#### Pressure Transducers

A pressure transducer converts a fluid or gas pressure into a proportional electrical signal. Two types of pressure transducers are used (see Figure 2-2). Both types require 5 Vdc excitation from the 5 V Supply and use a potentiometer to produce the proportional output. Neither type is more than 4 inches in the longest dimension. As the output signal is already between 0 and 5 Vdc, no signal conditioning is required.

**Bourdon Tube** - The bourdon tube pressure transducer consists of a bourdon tube enclosed in an evacuated chamber. One end of the tube is connected to the pressure being measured and the other end to a potentiometer in the transducer. An increase in pressure in the bourdon tube causes it to start to straighten out, thus moving the potentiometer. Since the chamber is evacuated to 0 psia, any pressure over

Table 2-1 . List of Major Airborne Components

Common Nomenclature	Formal Nomenclature	Model	Reference Designator		Location
			IB	V	
5 V Supply	5 Volt Measuring Voltage Supply		602A16	602A16	12
Measuring Rack Selector	Measuring Rack Selector		601A400	601A400	1
Measuring Rack A401	Measuring Rack		601A401	601A401	2
Measuring Rack A402			601A402	601A402	1
Measuring Rack A403			602A403	602A403	11
Measuring Rack A404			602A404	602A404	13
Measuring Rack A405			602A405	602A405	9
Measuring Rack A406			602A406	602A406	15
Measuring Rack A407			602A407	602A407	14
Measuring Rack A408			602A408	602A408	14
Measuring Rack A409			602A409	602A409	15
☐ Measuring Rack A669				603A669	23
Measuring Distributor A3	Measuring Distributor		602A3	602A3	10
Measuring Distributor A4	Measuring Distributor		602A4	602A4	13
TM Calibrator	Telemetry Calibrator	II	602A437	602A602	13
TM Calibrator Controller	Telemetry Calibrator Power and Control Assembly		602A566	602A603	13
Slow Speed Mux	Slow Speed Multiplexer Assembly	245	602A442	602A598	11
F2 Mux	F2 Multiplexer Assembly	270	602A567	602A592	†10
P1 Mux	P1 Multiplexer Assembly	270	602A446	602A593	† 9
☐ RDSM	Remote Digital Submultiplexer	1-D	603A431		17
☐ RDM-J	Remote Digital Multiplexer	410		603A599	17
RDM-K	Remote Digital Multiplexer	410	603A455	603A594	18
☐ S1 Telemeter	S1 Telemeter Assembly		602A440		11
☐ S1 Telemeter	S1 Telemeter Assembly	601		602A596	11
F1 Telemeter	F1 Telemeter Assembly	B-1	602A439	602A588	12
F2 Telemeter	F2 Telemeter Assembly	A-3	602A443	602A590	10
PCM/DDAS Telemeter	PCM/DDAS Telemeter Assembly	301	602A420	602A595	12
CIU	Computer Interface Unit	501	603A447	603A605	17
Tape Recorder	Airborne Tape Recorder	101	602A419	602A604	11
☐ S1 Transmitter	S1 RF Transmitter Assembly	I	602A441		11
☐ S1 Transmitter	S1 RF Transmitter Assembly	II		602A597	11
☐ F1 Transmitter	F1 RF Transmitter Assembly	I	602A438		12
☐ F1 Transmitter	F1 RF Transmitter Assembly	II		602A589	12
☐ F2 Transmitter	F2 RF Transmitter Assembly	I	602A444		9
☐ F2 Transmitter	F2 RF Transmitter Assembly	II		602A591	9
☐ P1 Transmitter	P1 PCM/RF Transmitter Assembly	CT-19B	602A421		13
☐ P1 Transmitter	P1 PCM/RF Transmitter Assembly	II	602A571	602A600	13
☐ UHF Transmitter	UHF PCM/RF Transmitter Assembly	III		603A601	24
☐ RF Coupler	Telemetry RF Coupler	432	602A445		9
☐ RF Coupler ††	Telemetry RF Coupler	451		602A641	9
Coaxial Switch	Coaxial Switch		601A563	601A563	4
Coaxial Termination	Coaxial Termination		601A564	601A564	4
Power Divider	Telemetry Power Divider	221	601A436	601A436	4
☐ TM Antenna	Telemetry Antenna	219	602A452		10
☐ TM Antenna	Telemetry Antenna	219	603A453		22
☐ TM Antenna	Telemetry Antenna	223	602A580	602A580	10
☐ TM Antenna	Telemetry Antenna	223	603A581	603A581	22

†Locations reversed for  
☐ configuration.

††Model 432 used on IU-501.



Table 2-2. List of Transducers

Measurement Number	Transducer Type	Reference Designator	Location
A2-603	Accelerometer (force-balance)	603A463	21
A3-603		603A464	21
☐A6-603	Microphone Source Follower Temperature gage (thermistor)	603A465	21
☐A7-603		603A466	21
B1-601		601A471	1
B1-601		601A472	1
C6-601		601A467	6
C9-601		601A470	6
C10-601		601A473	6
C11-601		601A474	6
C12-601		601A475	6
C13-601		601A476	6
C15-601		601A477	6
C16-603		603A478	22
C17-603		603A479	21
C18-602		602A480	10
C19-601		601A481	4
C20-601		601A482	3
C21-603		603A483	21
C22-602		602A484	15
C23-603		603A485	19
C24-603		603A486	19
C25-602	602A487	9	
C26-601	601A488	7	
C27-603	Temperature gage (resistance thermometer)	603A489	22
C28-603		603A490	22
C29-603	Temperature gage (thermistor)	603A491	22
C30-603		603A492	22
C31-603		603A493	21
C35-601		601A495	7
C36-601		601A496	5
C37-601	Temperature gage (resistance thermometer)	601A415	4
C38-601		601A416	2
C39-602		602A411	10
C40-602		602A412	9
C41-602		602A413	16
C42-602		602A414	14
C43-603		603A417	21
C44-603		603A418	20
C58-602		602A503	12
C59-602		602A504	12
C60-602		602A505	10
☐AC61-602		602A506	13
☐AB C71-601		601A608	6
☐BC C72-602		602A582	13
☐C73-603		603A583	24
C74-602		602A584	11
☐C82-601		601A608	6

Table 2-2 . List of Transducers (Cont)

Measurement Number	Transducer Type	Reference Designator	Location	
D10-603	Pressure gage (bourdon tube)	603A525	22	
D11-603	Pressure gage (bellows)	603A526	21	
D17-601		601A511	6	
D18-601		601A512	7	
D24-601		601A573	6	
D25-601		601A574	6	
E7-603		Pressure gage (bourdon tube)	603A519	21
E8-603		Accelerometer (piezoelectric)	603A520	21
E9-603			603A521	21
E10-603			603A522	24
E11-603			603A523	24
E12-603			603A524	24
E13-603	603A530		24	
E14-603	603A531		18	
E15-603	603A532		18	
E16-603	603A533		18	
E17-603	603A534		18	
E18-602	602A535		9	
E19-602	602A536		9	
E20-603	603A537		22	
E21-603	603A538		22	
E22-602	603A539		16	
E23-602	602A540		16	
E26-603	603A541		19	
E27-603	603A542		19	
E28-603	603A543		19	
F1-601	Flowmeter		601A547	6
F2-601		601A548	6	
F3-601		601A549	5	
F4-603		603A550	20	
F5-603		603A551	21	
F6-602		602A552	16	
F7-601		601A553	4	
F8-603		603A554	19	
F9-602		602A555	9	
F10-601		601A556	6	
F11-603		603A557	21	
AJ25-602		VSWR measuring unit (model 220)	602A448	10
BC J25-602	VSWR measuring unit (model 225)	602A642	10	
AJ26-602	VSWR measuring unit (model 220)	602A448	10	
BC J26-602	VSWR measuring unit (model 225)	602A642	10	
AJ27-602	VSWR measuring unit (model 220)	602A448	10	
BC J27-602	VSWR measuring unit (model 225)	602A642	10	
AJ28-602	VSWR measuring unit (model 220)	602A448	10	
BC J29-602	VSWR measuring unit (model 225)	602A642	10	
AJ29-602	VSWR measuring unit (model 220)	602A448	10	
BC J29-602	VSWR measuring unit (model 225)	602A642	10	
AJ30-602	VSWR measuring unit (model 220)	602A448	10	
BC J30-602	VSWR measuring unit (model 225)	602A642	10	
AJ31-602	VSWR measuring unit (model 220)	602A448	10	

Table 2-2. List of Transducers (Cont)

Measurement Number	Transducer Type	Reference Designator	Location
BC J31-602	VSWR measuring unit (model 225)	602A642	10
A J32-602	VSWR measuring unit (model 220)	602A448	10
BC J32-602	VSWR measuring unit (model 225)	602A642	10

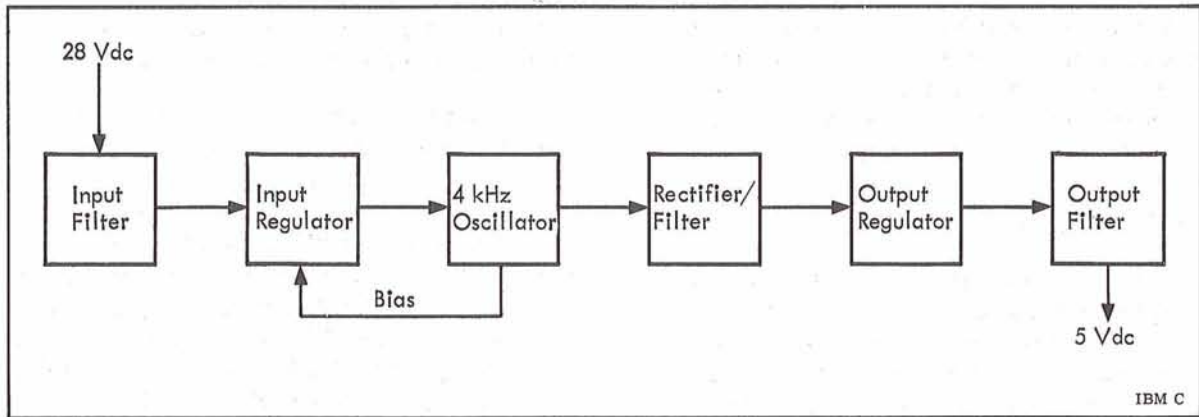


Figure 2-1. 5 V Supply Functional Diagram

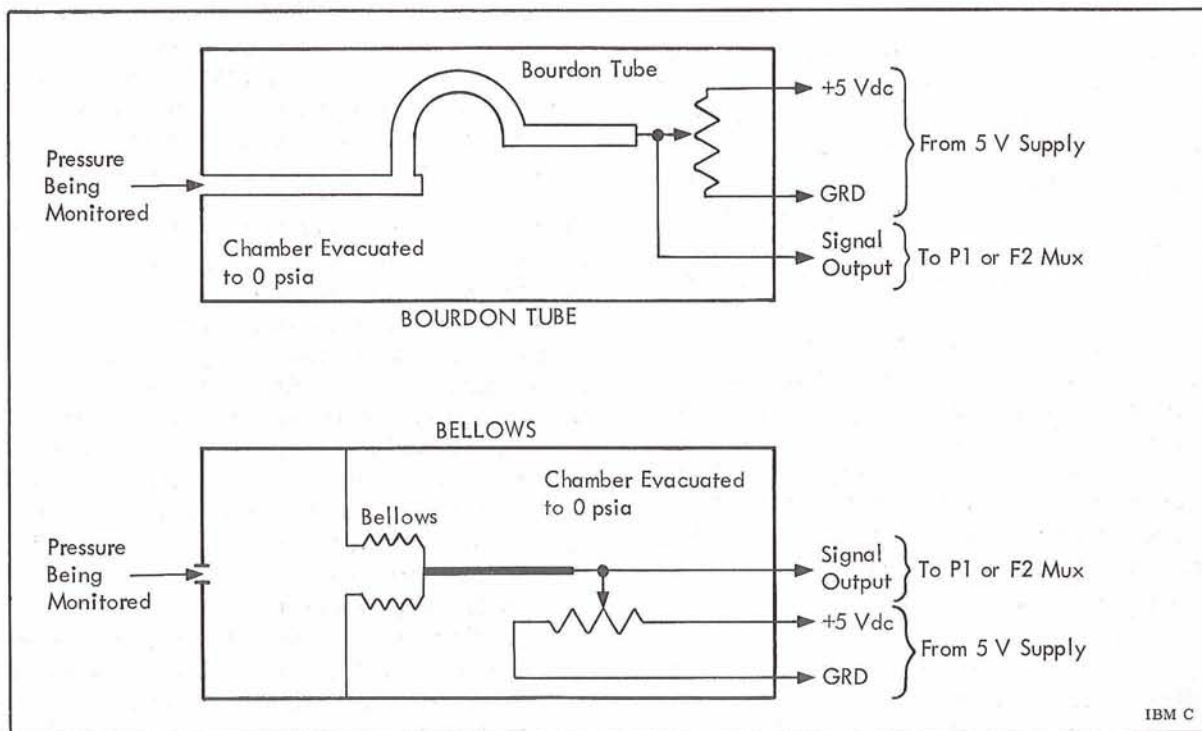


Figure 2-2. Pressure Transducers Functional Diagram

this will cause the potentiometer to move and produce a change in the output electrical signal.

**Bellows** - The bellows pressure transducer consists of two chambers separated by a bellows. One chamber is evacuated to 0 psia and the other is connected to the pressure being measured. The bellows is connected to a potentiometer in the transducer thus converting any pressure change to a change in the output signal.

A variation in the bellows type is also used. The variation consists of connecting the evacuated chamber to another pressure source instead of evacuating it. The resultant output signal represents a differential between the two pressures.

#### Temperature Transducers

A temperature transducer converts a fluid or gas temperature into a proportional electrical signal. Two types are used. Both types consist of a resistance that changes proportionally with the temperature being measured. The outputs of both types must be signal conditioned to form a 0 to 5 Vdc signal. The signal conditioning is accomplished by letting the resistive element of the transducer be one leg of a balanced bridge circuit in a dc amplifier signal conditioning module.

**Thermistor** - The resistance of the thermistor type transducer decreases as the temperature being measured increases. It is useful for measuring temperatures that vary in the rather narrow range of  $-4^{\circ}\text{F}$  to  $+212^{\circ}\text{F}$  ( $-20^{\circ}\text{C}$  to  $+100^{\circ}\text{C}$ ). The transducer is built in the form of a probe, with the sensing element in the tip. The tip extends into the fluid or gas being measured. The probe is not more than 3 inches long.

**Resistance Thermometer** - The resistance of the resistance thermometer transducer increases as the temperature being measured increases. It is useful for measuring temperatures that vary in the rather wide range of  $-373^{\circ}\text{F}$  to  $+482^{\circ}\text{F}$  ( $-225^{\circ}\text{C}$  to  $+250^{\circ}\text{C}$ ). The transducer is built in the form of a probe, with the sensing element in the tip. The tip extends into the fluid or gas being measured. The probe is not more than 3 inches long.

A variation of the resistance thermometer is also used. Instead of being built in the form of a probe, the sensing element is in a thin, flat shape. The element is physically bonded to the surface of the unit being measured and is sensitive to conducted heat. The transducer is not more than 1 inch square.

#### Acceleration Transducers

An acceleration transducer converts the frequency and quantity of a one-axis acceleration into a single electrical signal. The frequency of the acceleration is represented by the frequency of the electrical signal and the quantity is represented by the amplitude. Two types of acceleration transducers are used (see Figure 2-3). The outputs of both types must be signal conditioned to form a 0 Vdc to 5 Vdc signal. Both types receive operating power from the associated Measuring Rack module. Neither type is more than 3 inches in the largest dimension.

**Force-Balance Accelerometer** - The force-balance accelerometer uses a pendulum to produce an output signal. An applied acceleration causes a movement of the pendulum in relation to the position detector. The position detector inductively senses the amount and direction of this movement and produces a proportional electrical signal. This signal is amplified and fed to the restoring coil. The restoring coil forces the pendulum to return to its original position. Since the signal to the restoring coil is proportional to the applied acceleration, this signal is used for the accelerometer output. As the actual movement of the pendulum is minute, angular displacement about the pivot is disregarded and the movement is considered linear along the sensitive axis. Force-balance accelerometers are used to sense low-frequency vibrations or continuous acceleration. They are used in conjunction with servo accelerometer signal conditioning modules. The force-balance accelerometer is attached by bolts to the structure being measured for acceleration.

**Piezoelectric Accelerometer** - The piezoelectric accelerometer uses the piezoelectric effect of a crystalline structure to produce an output signal. An applied vibration in the sensitive axis causes a flexing of the mass. As the crystal is bonded to the mass, the crystal is subjected to compression-tension forces. These forces cause the crystal to generate a small electrical signal proportional to the frequency and quantity of the vibration. This electrical signal is fed through an emitter follower that serves as an impedance matching device. The piezoelectric accelerometer is used in conjunction with an ac amplifier signal conditioning module. Prior to launch, the accelerometer and subsequent components can be calibrated by applying a 400 Hz signal to the crystal. Piezoelectric accelerometers are insensitive to continuous acceleration and are used to measure vibrations in the range of 50 Hz to 3000 Hz. The transducer is bolted to the structure being measured for vibration.

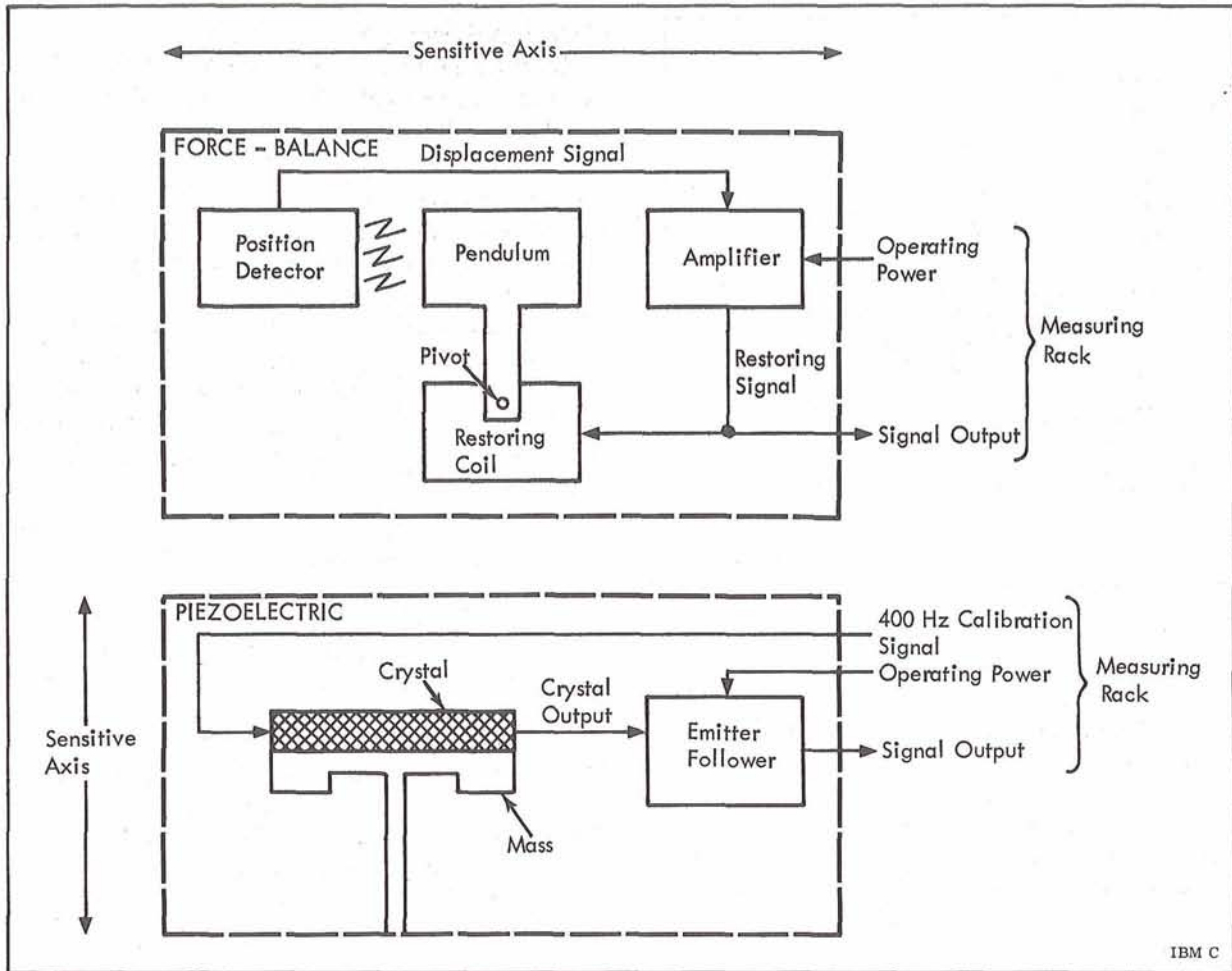


Figure 2-3. Acceleration Transducers Functional Diagram

### Flow Rate Transducers

A flowmeter converts the rate of flow of a fluid (amount per unit time) within a pipe into an electrical signal. The rate of flow is represented by the frequency of the signal. The output signal must be signal conditioned to form a 0 Vdc to 5 Vdc signal. The flowmeter is assembled into the pipe carrying the fluid being measured. Flowmeters come in several sizes with the largest not more than 4 inches in its longest dimension. Most flowmeters are equipped with a mechanical locking device to prevent damage to the turbine during purge operations.

The flowmeter casing (see Figure 2-4) consists of a short piece of pipe the same size as the piping being measured. Within the casing is a free-turning turbine. External to the casing is a winding surrounded by a permanent magnetic field. Fluid pumped through the piping and flowmeter causes the turbine to turn at a rate directly proportional to the

velocity of the fluid. Guide tubes reduce fluid turbulence caused by the turbine. The metal turbine blades disturb the magnetic field, thus inducing a current into the winding. This current is changed each time a turbine blade disturbs the magnetic field. The frequency of the current change is proportional to the turbine speed which is proportional to the fluid velocity. The ac signal output is sent to a dc amplifier signal conditioning module or to a frequency to dc converter signal conditioning module.

### Acoustic Transducers

An acoustic transducer converts a sound into a proportional electrical signal. The transducer consists of two pieces -- a microphone and a source follower (see Figure 2-5). The output signal must be signal conditioned to form a 0 Vdc to 5 Vdc signal. As sound is a movement of air molecules, an acoustic transducer can operate only in the atmosphere.

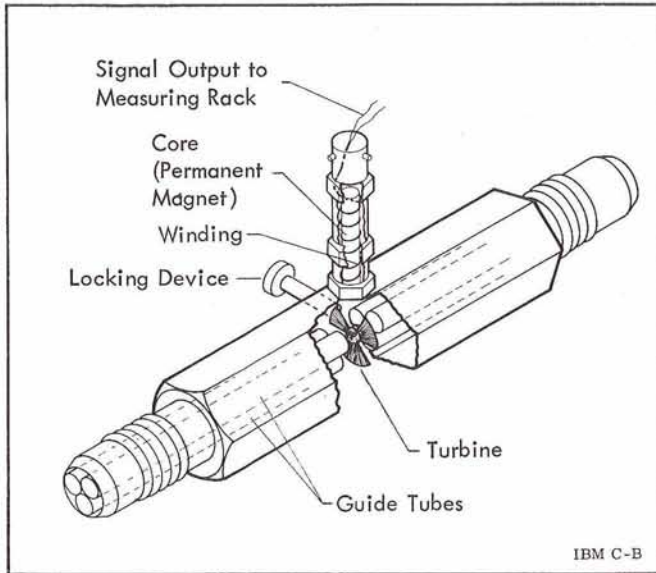


Figure 2-4. Flow Rate Transducer Functional Diagram

**Microphone** - The microphone uses the piezoelectric effect of a crystalline structure to produce an output. The unit is sensitive to sound pressure levels of 110 db to 190 db in the frequency ranges of 50 Hz to 3150 Hz. The microphone consists of a crystal solidly bonded to a mass with a sound-sensitive diaphragm attached to the crystal. The microphone is mounted directly to the structure with the diaphragm facing the area to be measured for sound. Sound pressure applied to the diaphragm causes it to vibrate and this vibration causes compression-tension forces to be felt by the crystal. The crystal generates a small electrical signal proportional to the applied sound pressure. The amplitude of the signal represents the db level and the frequency represents the frequency of the sound. The electrical output of another crystal/mass assembly (which is mounted opposite the first) is coupled directly to the output of the first. Unwanted

crystal outputs induced by structural vibrations are thus cancelled out and are not felt on the microphone output. The output of the microphone is coupled via coaxial cable to the source follower.

**Source Follower** - The source follower electrically isolates and increases the current of the microphone output. The source follower is a transistorized unit less than 3 inches in its longest dimension. The source follower receives operating power from the Measuring Rack. The output of the source follower is routed to an ac amplifier signal conditioning module. Prior to launch, the source follower and subsequent components can be calibrated by application of a 400 Hz signal.

RF Power Transducers

The VSWR measuring unit is the only rf power transducer used. It contains eight coupler assemblies, each of which measures the transmitted or reflected power of a telemetry transmitter. Each of the eight output signals from the unit is low-level dc and is fed to a dc amplifier signal conditioner module. The **A** VSWR measuring unit (model 220) is less than 6 inches in its longest dimension. The **BC** VSWR measuring unit (model 225) is 4 inches high, 9 inches wide, and 13 inches long.

A typical rf input signal (see Figure 2-6) is in the frequency range of 230 MHz to 260 MHz, with 22 watts of power. Each measurement is inductively picked off by a coupling loop inserted into the electromagnetic field about the input signal conductor. The loop is inserted so as to be sensitive to energy traveling in one direction only, therefore, one loop is necessary for transmitted power monitoring and another loop for reflected power monitoring. A crystal detector rectifies the voltage in each pickoff line.

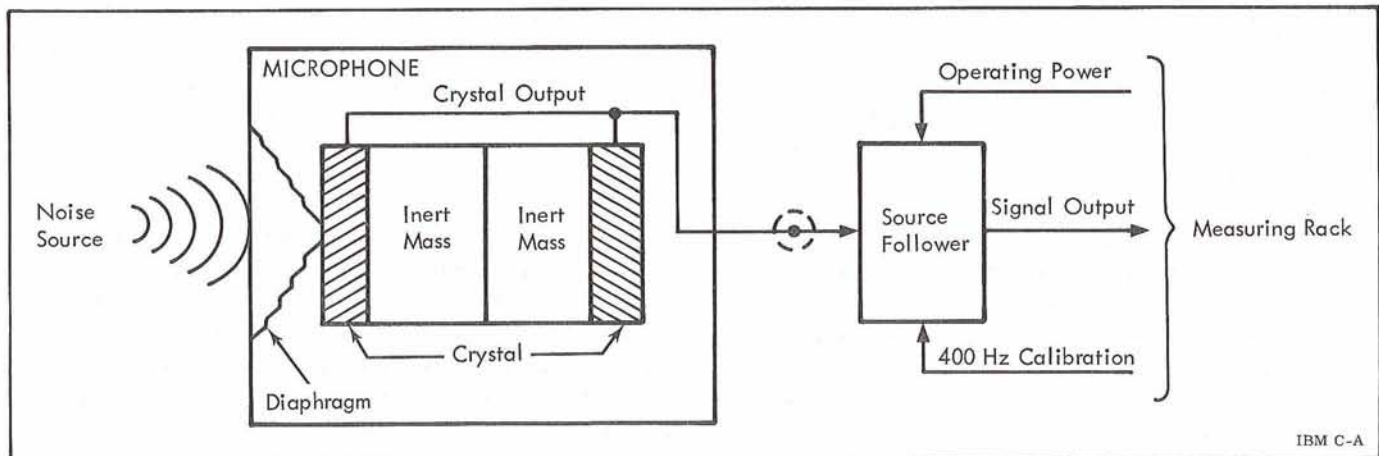


Figure 2-5. Acoustic Transducer Functional Diagram

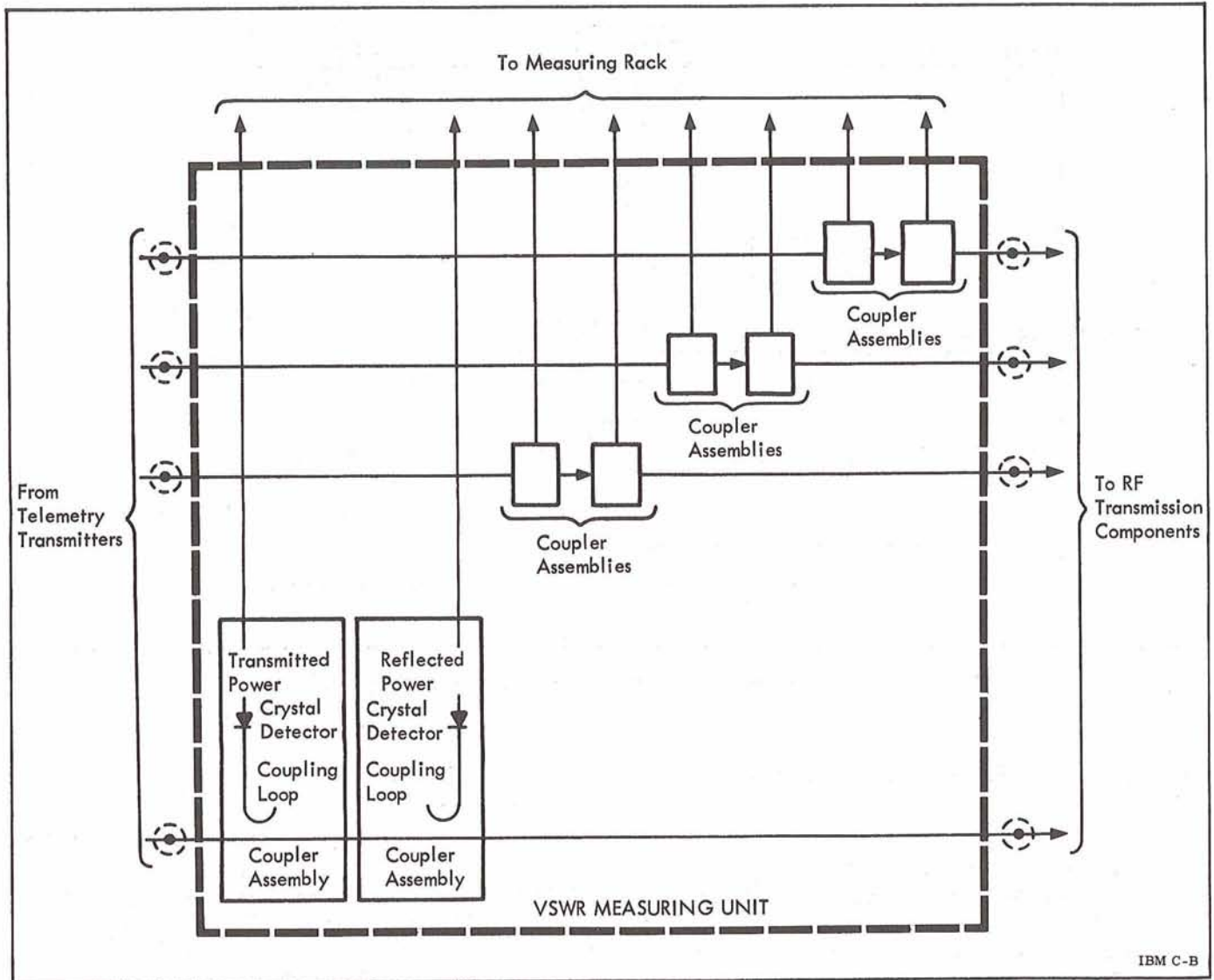


Figure 2-6. RF Power Transducer Functional Diagram

#### 2-4 MEASURING RACK SELECTOR

The purpose of the Measuring Rack Selector is to decode Measuring Rack selection commands from the ESE, select the rack or racks to be calibrated, and pass on ESE calibration commands to the selected Rack or Racks. The Measuring Rack Selector is used only during prelaunch checkout. The unit is capable of calibrating up to 14 Measuring Racks.

##### Construction

The Measuring Rack Selector is made of welded sheet aluminum and uses transistorized plug-in modules. The unit is 5 inches high, 5 inches wide, 5 inches long, and weighs 3 pounds.

##### Function

The three selection commands (rack, channel, and mode) are always furnished simultaneously to the Measuring Rack Selector. The commands are present for a period of 40 milliseconds.

The mode select command (see Figure 2-7) is presented to the Measuring Rack Selector as a binary coded signal on two lines. The command is isolation-amplified before being sent to all Measuring Rack channel selectors. The three possible output commands from the isolation amplifier are: (1) HIGH calibration command, (2) LOW calibration command, or (3) neither HIGH nor LOW (RUN command). The input mode select command also starts a synchronizing network that enables the decoded rack selector

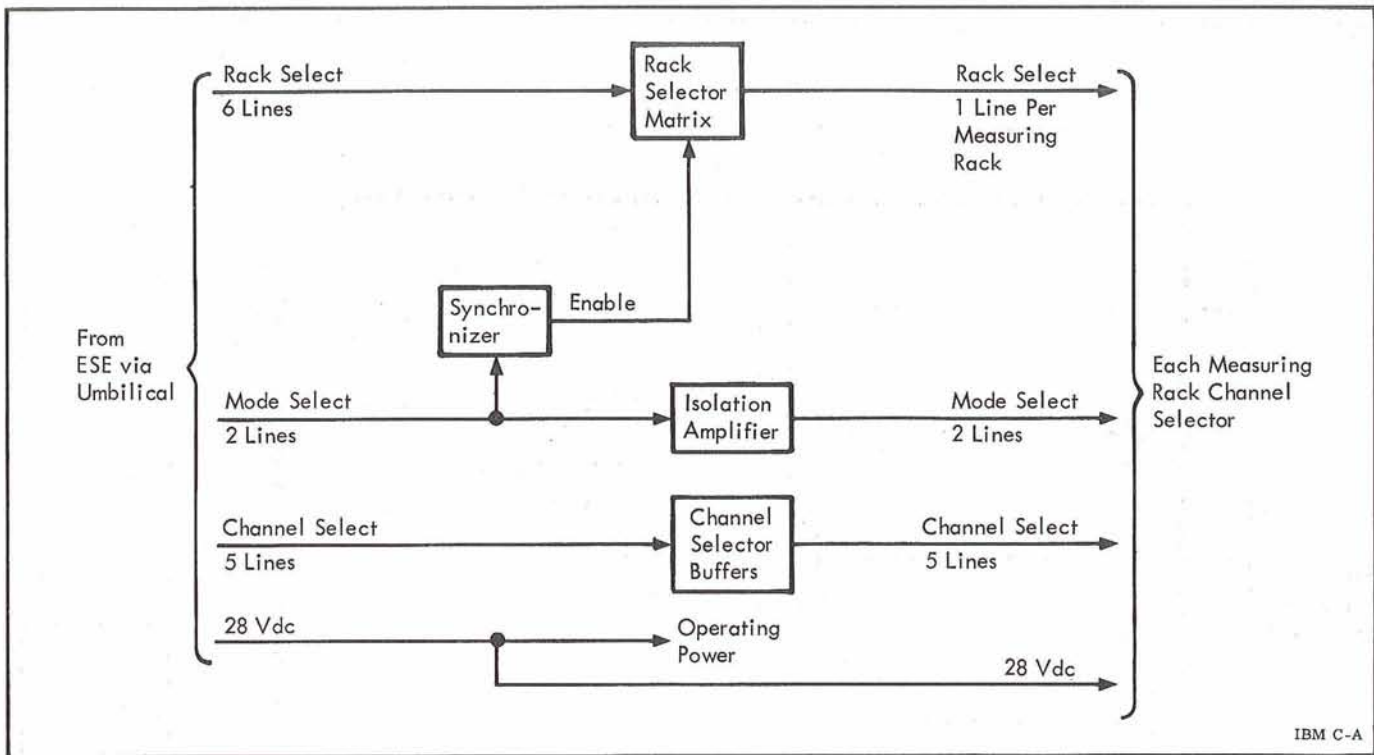


Figure 2-7. Measuring Rack Selector Functional Diagram

command to be sent to the applicable Measuring Rack or Racks.

The rack select command is presented to the Measuring Rack Selector as a binary coded signal on six lines. The command is enabled by the mode select command, and is decoded by the rack selector matrix. The calibration command output of the matrix consists of removing the single 28 Vdc command that is normally sent to each Measuring Rack. The 28 Vdc is removed from the Rack or Racks being calibrated.

The channel select command is presented to the Measuring Rack Selector as a binary coded signal on five lines. The five lines are buffered before being sent on to all of the Measuring Rack channel selectors for decoding.

The Measuring Rack Selector operates on 28 Vdc power from the ESE. When this power is first applied, an internally generated clear pulse resets all internal circuitry. The unit also forwards this power on to each of the channel selectors in the Measuring Racks.

## 2-5 MEASURING RACKS

The purpose of the Measuring Racks is to house the channel selectors and signal conditioning modules. Each Measuring Rack contains two channel selectors, plug-in slots for 20 signal conditioning modules, and the wiring necessary to route the electrical signals to these modules (see Figure 2-8).

A Measuring Rack is 7 inches high, 10 inches wide, and 13 inches long. It weighs 21 pounds with all plug-in modules. The unit is not pressurized and affords easy access to the modules.

Any of the several types of signal conditioning modules can be used in any of the Measuring Rack channel slots. Each slot is furnished the same complement of power, signal, and command wiring. Each signal conditioning module is wired to accept its required signals.

Signal conditioning modules receive calibration commands through the channel selectors. Some types of modules accept calibration commands in both the HIGH mode and the LOW mode while others can accept only HIGH.



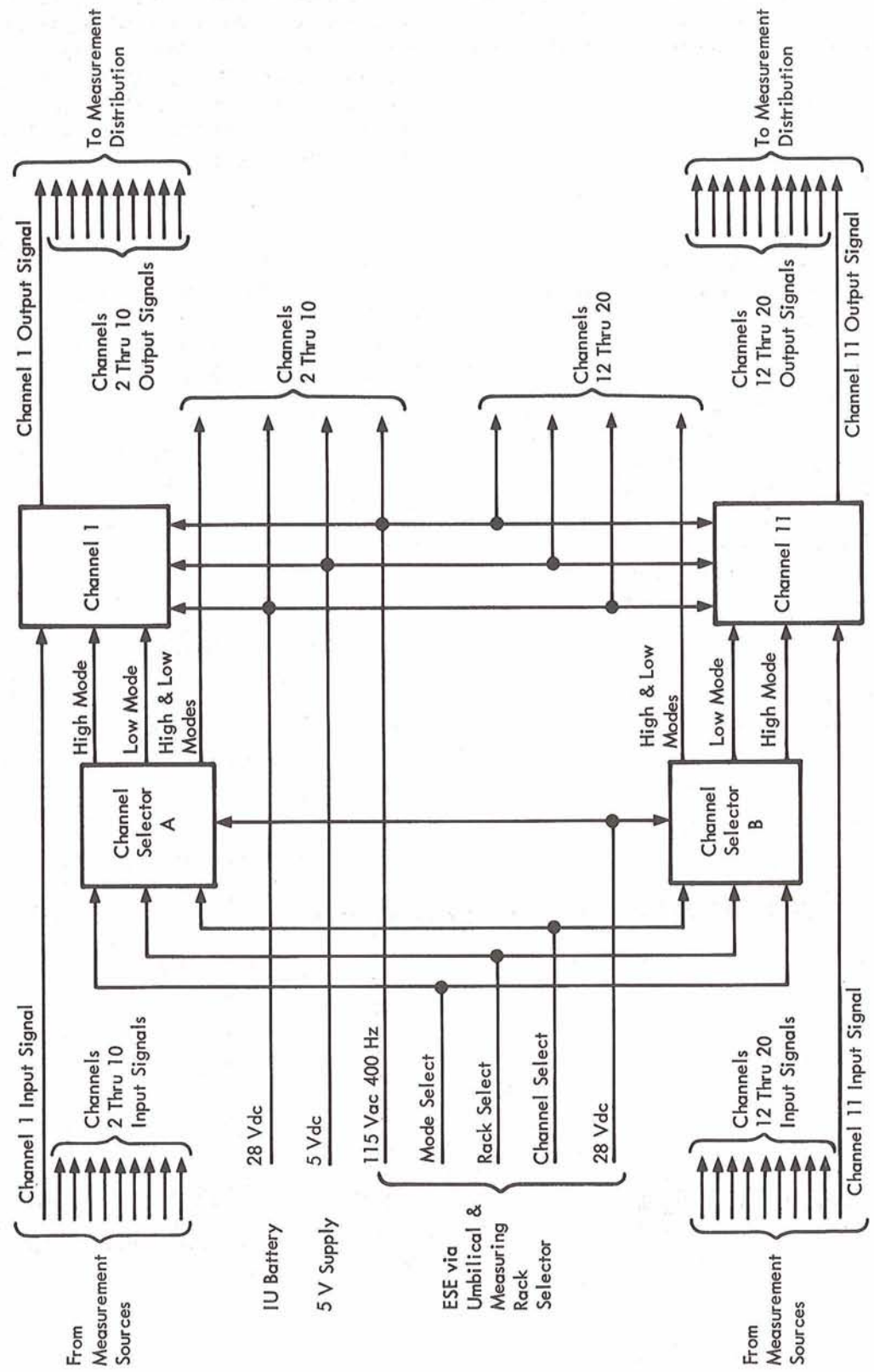


Figure 2-8. Measuring Rack Functional Diagram

Each of the seven types of signal conditioning modules is used to condition a different type of measurement signal. These modules and the channel selector modules are listed and described in the following paragraphs.

- Channel selector A
- Channel selector B
- DC amplifier
- AC amplifier
- Servo-accelerometer, Type 363
- Servo-accelerometer, Type 364
- Servo-accelerometer, Type 365
- Frequency-to-dc converter
- Frequency measuring adapter

Channel Selector

The channel selector decodes the calibration commands and selects the Measuring Rack channel or channels to be calibrated. Each Measuring Rack has two of the units: channel selector A and channel selector B. Both channel selectors are identical except that A decodes commands for channels 1 through 10, and B decodes commands for channels 11 through 20. The channel selector operates on 28 Vdc from the Measuring Rack Selector.

All commands to the channel selector (see Figure 2-9) come through the Measuring Rack Selector. All three commands (rack select, channel select, and mode select) are necessary to cause the channel selector to send a calibrate command to a channel or

channels. The rack select command consists of the removal of a 28 Vdc signal. The channel select command consists of a five-line, binary coded signal. The HIGH mode command and LOW mode command each consist of a 28 Vdc signal. The channel selector can cause either one channel or all 10 channels to be calibrated in the HIGH mode or the LOW mode. The mode signal to a channel consists of a 28 Vdc signal.

Each channel mode selector is a latch circuit that retains its output even though the input commands have been released. To release the calibrate commands to the channels, a RUN mode command must be sent. This command consists of the proper rack and channel signals to the channel select matrix, but no HIGH or LOW mode signal input. The enable signal to the channel mode selector without an accompanying HIGH or LOW signal will cause it to return to a no-output state. The latching circuit is also released when operating power is removed from the module.

DC Amplifier

The dc amplifier module converts dc measurement signals or low-frequency ac measurement signals into a 0 Vdc to 5 Vdc range. The dc amplifier module physically consists of two parts: a range card and a fixed gain amplifier. The range card plugs into the amplifier portion. Different types of range cards are selected to adapt the measurement signal to the fixed amplifier.

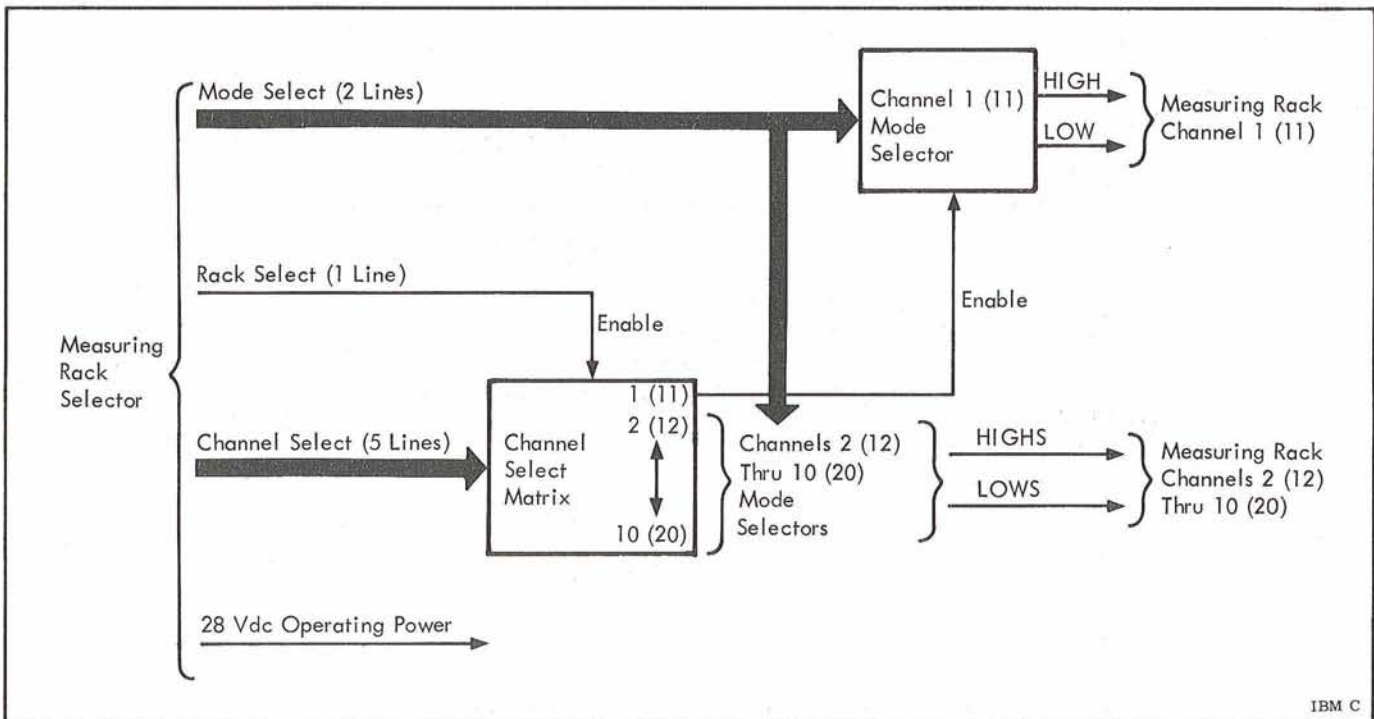


Figure 2-9. Channel Selector Module Functional Diagram

Range cards are individually tailored to particular measurements but all range cards fall into two general categories. The voltage divider range card transforms an input voltage into a proportional 50 mV range. The bridge range card monitors varying resistive networks and transforms the varying resistance into a proportional 0 Vdc to 50 mVdc range. Bridge range cards are used with resistive-type temperature transducers. The transducer is the variable leg of the bridge.

Regulated power used by the range card and the amplifier is generated on the amplifier portion. The 28 Vdc power from the IU Electrical System (see Figure 2-10) is first regulated to 18 Vdc. The 18 Vdc is used by all active stages on the amplifier portion. The dc-to-dc converter uses the 18 Vdc to generate 15 Vdc for the output regulator. The output regulator provides a precise 10 Vdc to the range card for use by the bridge network and the calibration network. Another product of the dc-to-dc converter is an 8 V peak-to-peak square wave at 10 kHz. This square wave is sent to the modulator and demodulator for use in the amplification process.

The input signal to a dc amplifier module is first routed straight through the amplifier portion to the range card. The range card conditions the signal to a 50 mV range and sends it back to the amplifier portion for amplification to a 5 V range. The amplified signal is then routed back to the range card for addition of bias voltage if necessary. From the range card the signal is returned to the amplifier portion and on out to the measurement distribution equipment. The following paragraphs give more details of signal flow using the two types of range cards.

- Voltage Divider Range Card - The input is first sent to a voltage divider network to bring the signal to a coarse 50 mV range. If the input signal contained an excessively high frequency, a bridge rectifier is used to reduce the signal to its amplitude component only. The signal then goes through a normally enabled gate to the gain adjust network to become a precise 50 mV range. If the input to the module was a dc signal, the voltage at this point will be 0 Vdc to 50 mVdc. If the input was an ac signal, the voltage at this point will be  $\pm 25$  mVac peak-to-peak.
- Bridge Range Card - The input in this case is a varying resistance that is the

variable leg of a bridge network on the range card. An adjustable 10 Vdc from the amplifier portion is used for operating power of the bridge. Adjustment of this 10 Vdc controls the span of the bridge's output 50 mVdc range. Adjustment of another leg of the bridge sets the lower edge of the range at 0 Vdc.

The 50 mV signal from either type of range card is then fed through the low-pass input filter on the amplifier portion. Either a 20 Hz or a 1000 Hz low-pass filter may be used. This filter governs the frequency response of the entire module. The signal is then modulated at 10 kHz, amplified by a factor of 100, demodulated, and filtered to remove any ripple. If the original input signal was dc, the voltage at this point will be 0 Vdc to 5 Vdc. If the original input signal was ac, the voltage range at this point will be approximately  $\pm 2.5$  Vac peak-to-peak.

The signal next goes back to the range card and there, if the signal is ac, through a bias network. This network adds the necessary bias voltage (approximately 2.5 Vdc) from the 5 V Supply to ensure that the full scale range of the ac signal is between 0 Vdc and 5 Vdc. The bias network is not used for dc signals. Due to the limitations imposed by the input filter, the signal at this point will be dc or ac not exceeding a frequency of 1000 Hz. The signal is then routed back out through the amplifier portion and then to the measurement distribution equipment.

Calibration commands from the channel selector actuate relay gates on the amplifier portion of the module which in turn control the circuits on the range card. The HIGH calibration command disables the normal measurement signal on the range card and causes the range card to generate a precise dc voltage near the upper band edge of the particular range card's output. The LOW calibration command does the same except the resulting dc signal is near the lower band edge.

#### AC Amplifier

The ac amplifier module converts the amplitude of a high-frequency measurement signal into a proportional 0 Vdc to 5 Vdc range. The ac amplifiers are used with piezoelectric accelerometers and acoustic transducers. The ac amplifier module physically consists of two parts: a range card and a fixed gain amplifier. The range card plugs into the amplifier portion and all range card inputs/outputs go through the amplifier portion. Different value range

cards are selected to adapt the measurement signal to the fixed amplifier. The module also furnishes regulated operating power and a calibration voltage to the transducer.

A typical measurement signal is (see Figure 2-11) routed through the amplifier portion to a voltage divider on the range card. The voltage divider used is selected to reduce the signal voltage to a proportional 50 mV peak-to-peak signal. The signal is then fed to a band-pass filtering network on the amplifier portion that limits the signal frequency to a range of 25 Hz to 4500 Hz. This signal is then voltage amplified by a factor of approximately 100 before being sent to the bias network on the range card. A 2.5 Vdc bias voltage from the 5 V Supply is added to give an output signal with the original frequency and a range of 5 V peak-to-peak, centered around 2.5 Vdc. This ensures that the signal remains within the limits of 0 Vdc to 5 Vdc. The output signal is distributed to the telemetry equipment.

Prior to launch, a 115 Vac 400 Hz calibration voltage is constantly applied to the module. An isolation circuit on the amplifier portion reduces the voltage to 5 Vac. The 5 Vac is furnished to an adjustable voltage divider on the range card. The voltage divider is adjusted to provide a signal out of the transducer that is 90 percent of its full scale amplitude output. From the voltage divider, the calibration signal is fed to a normally disabled gate on the amplifier portion. A HIGH calibration mode command will enable the gate and allow the calibration voltage to be sent to the transducer. The LOW calibration mode command is not used by this module.

#### Servo Accelerometer

The servo accelerometer module transforms the output of a force-balance accelerometer into a 0 Vdc to 5 Vdc output signal and furnishes operating power to the force-balance accelerometer. Two types of servo accelerometer modules are used. For the purpose of this manual they are designated type 363, type 364, and type 365. Types 364 and 365 are identical except that the polarity of the input signal is reversed.

Type 363 - The input signal from the accelerometer is of a single polarity in the range of 0 to 1.5 mA (see Figure 2-12). The signal goes through a loading network where the current-intelligent data is changed to voltage-intelligent data. An adjustment here ensures that the full scale output of the accelerometer is represented by 5 Vdc. Calibration commands are not used with this module.

Types 364 and 365 - The input signal from the accelerometer is of a dual polarity in the range of -0.25 mA to +0.25 mA (see Figure 2-12). The signal first goes through a normally enabled gate to the loading network where the current-intelligent data is changed to voltage-intelligent data. An adjustment here ensures that the full scale outputs of the accelerometer are represented by a range of 5 V. The signal then goes through the bias network where enough voltage (2.5 Vdc) is added to ensure the output signal to be in the range of 0 Vdc to 5 Vdc. The amount of voltage added is adjustable. A HIGH calibration command removes the input signal, thus allowing only the bias voltage to appear at the output. The LOW calibration command is not used with this module.

#### Frequency-to-DC Converter

The purpose of the frequency-to-dc converter module is to change frequency-intelligent measurement signals from flowmeters into proportional 0 Vdc to 5 Vdc signals. The range of the unit is adjustable to allow full scale output (5 Vdc) to represent any full scale input from 100 Hz to 600 Hz. An output of 0 Vdc always represents 0 Hz input. The unit operates on 28 Vdc power.

The input from the flowmeter (see Figure 2-13) is first processed through the low-pass filter to eliminate unwanted frequencies and excessive voltages. The signal is then amplified by a factor of approximately 50 before being sent to the wave shaping circuit. The output of the wave shaping circuit is a 15 V peak-to-peak square wave at the input frequency. The range of the unit is adjusted by varying the duration of the square wave pulses. The square wave is then fed to the averaging network which operates on the principle of capacitive charge time. The capacitive averaging network electrically averages the frequency and pulse duration of the square wave to produce a proportional 0 Vdc to 5 Vdc signal. The output filter reduces ripple on the output signal to a negligible value.

A 115 Vac 400 Hz calibration voltage is constantly applied to the unit's calibration signal generator prior to launch. This generator produces a 1.2 V peak-to-peak 100 Hz square wave that is fed to the input of the calibration gate. A calibrate command enables the gate and allows the 100 Hz square wave to be added to any existing signal from the transducer. The calibration command is a HIGH mode command. The LOW calibration mode is not used by this module.

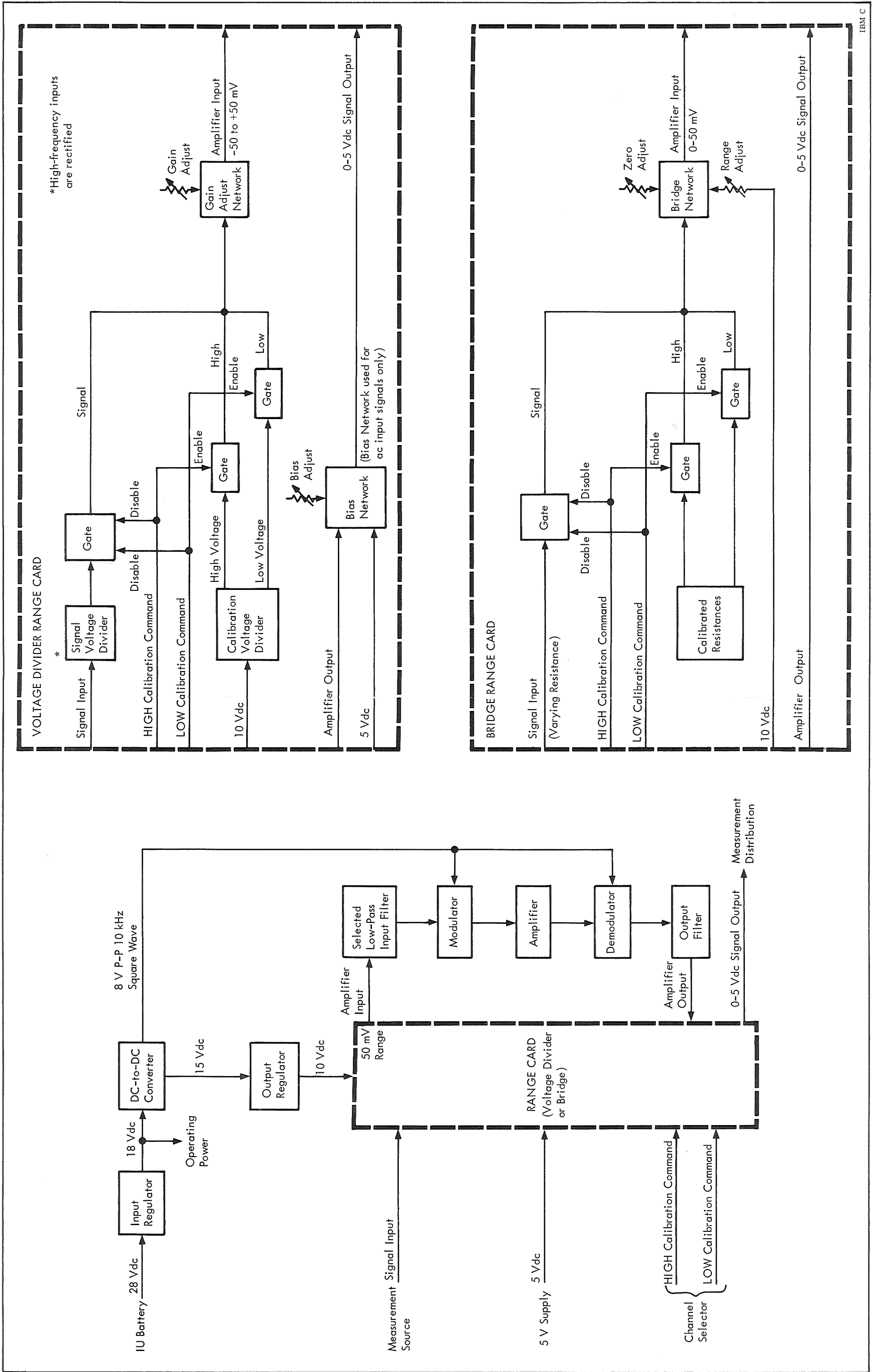


Figure 2-10. DC Amplifier Module Functional Diagram

Frequency Measuring Adapter

The purpose of the frequency measuring adapter module is to precisely monitor the frequency of a 400 Hz signal. Operating power for the module is 28 Vdc. The frequency measuring adapter is physically larger than the other signal conditioning modules and takes up space in the Measuring Rack that could be occupied by two normal size modules.

Variations of the 400 Hz input signal of up to 0.1 Hz can be detected by the module. The input signal (see Figure 2-14) is frequency amplified by a factor of 200 and then sent to the mixer stage. The frequency-divided output of a crystal oscillator is furnished to the mixer as a reference frequency of 79,980 Hz. The band-pass transformer will pass only the difference between the two frequencies, which is normally 20 Hz. An increase in the 400 Hz input

of 0.1 Hz will cause a 40 Hz output from the band-pass transformer. A decrease of 0.1 Hz will cause an output of 0 Hz. The voltage out of the band-pass transformer is fixed at approximately 5 Vac. A 2.5 Vdc bias voltage is then added to the signal to put the signal in the 0 Vdc to 5 Vdc range acceptable by the telemetry equipment.

Calibration commands are not used with the frequency measuring adapter.

2-6 MEASURING DISTRIBUTORS

The two Measuring Distributors are used to distribute instrumentation measurements to preselected telemetry channels and to distribute the calibration voltage from the 5 V Supply. The distributors are built in a patch-board arrangement to provide for easy rerouting of signals that flow through the distributors.

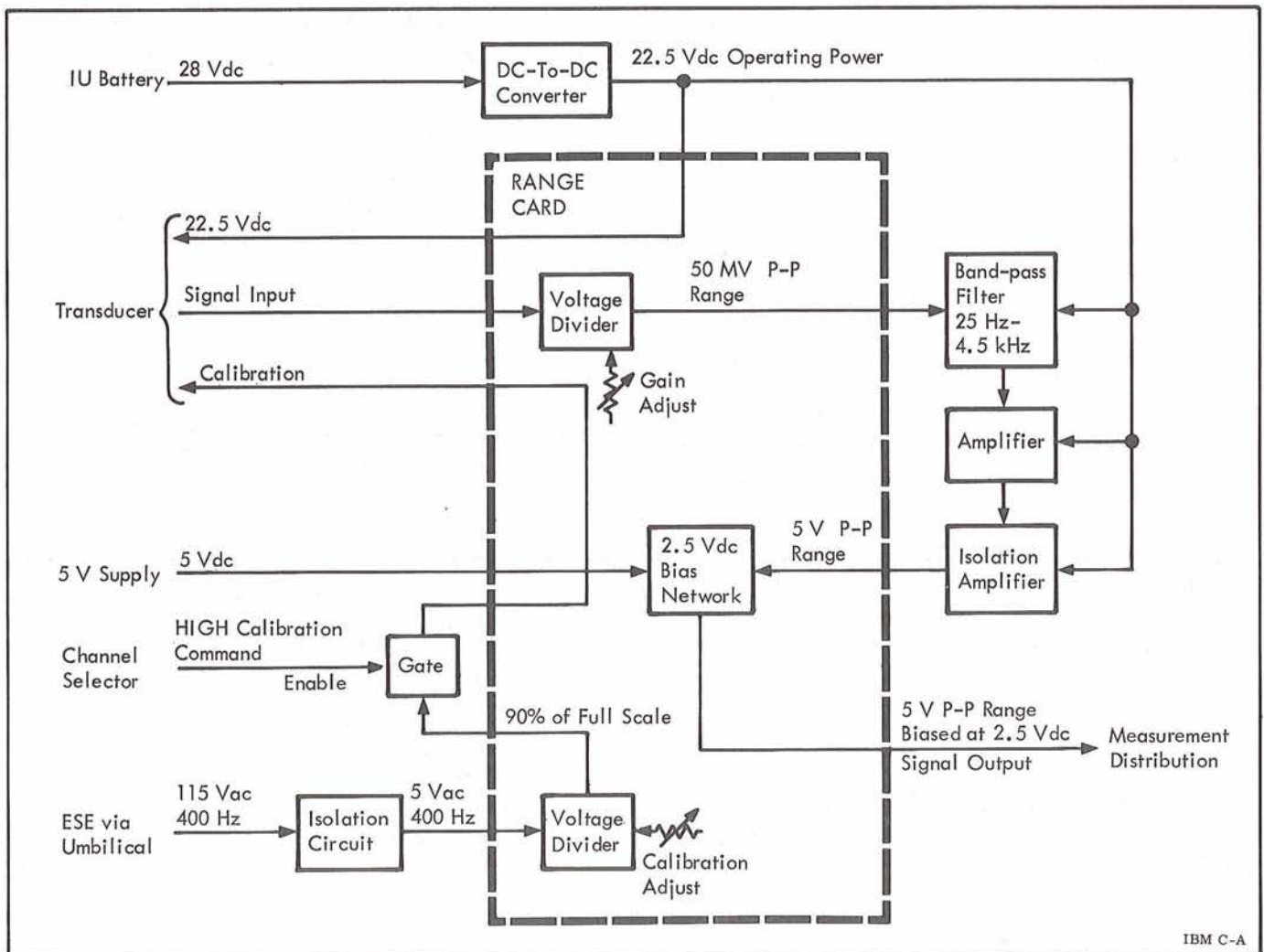


Figure 2-11. AC Amplifier Module Functional Diagram

Construction

Each Measuring Distributor case is made of magnesium and contains relays, resistors, and electrical wiring. The unit uses a relief valve to maintain positive internal pressure of 6 psi over atmospheric environment. The Measuring Distributor is 6 inches high, 13 inches wide, 13 inches long, and weighs 21 pounds. The Measuring Distributor is shock mounted to the cold plate.

Function

Almost all instrumentation measurements are routed through the patch-board arrangement of a Measuring Distributor before being sent to the telemetry equipment. This allows the data on telemetry channels to be manually changed with a maximum of speed and a minimum of disturbance to airborne circuitry. Resistors are placed in the lines of some measurements to limit the voltage to the telemetry equipment or to isolate the Instrumentation System from the equipment being measured.

Through the use of relays, the Measuring Distributor places different stage measurements on the same telemetry channels. This is done by de-

energizing a relay that is energized prior to stage separation (see Figure 2-15). Prior to launch, this function can be controlled from the ESE to assist in checkout.

Prior to launch, relays in the Measuring Distributor can switch measurements that are on F1 or F2 Telemeter paths only, to PCM telemeter channels. Normally, these PCM channels are occupied by other measurements or are grounded to prevent noise. From the PCM/DDAS Telemeter these measurements are then hardwired to the DDAS ground station to assist in checkout of the launch vehicle.

The Measuring Distributors also serve as the only distribution paths for the 5 Vdc from the 5 V Supply. This power is routed to all components that require it for calibration and all components that use it for transducer operating power.

2-7 TELEMETRY CALIBRATOR CONTROLLER

The TM Calibrator Controller is provided as an interface for the TM Calibrator. The controller isolates all power and command inputs to the TM Calibrator as well as routing all outputs from the TM

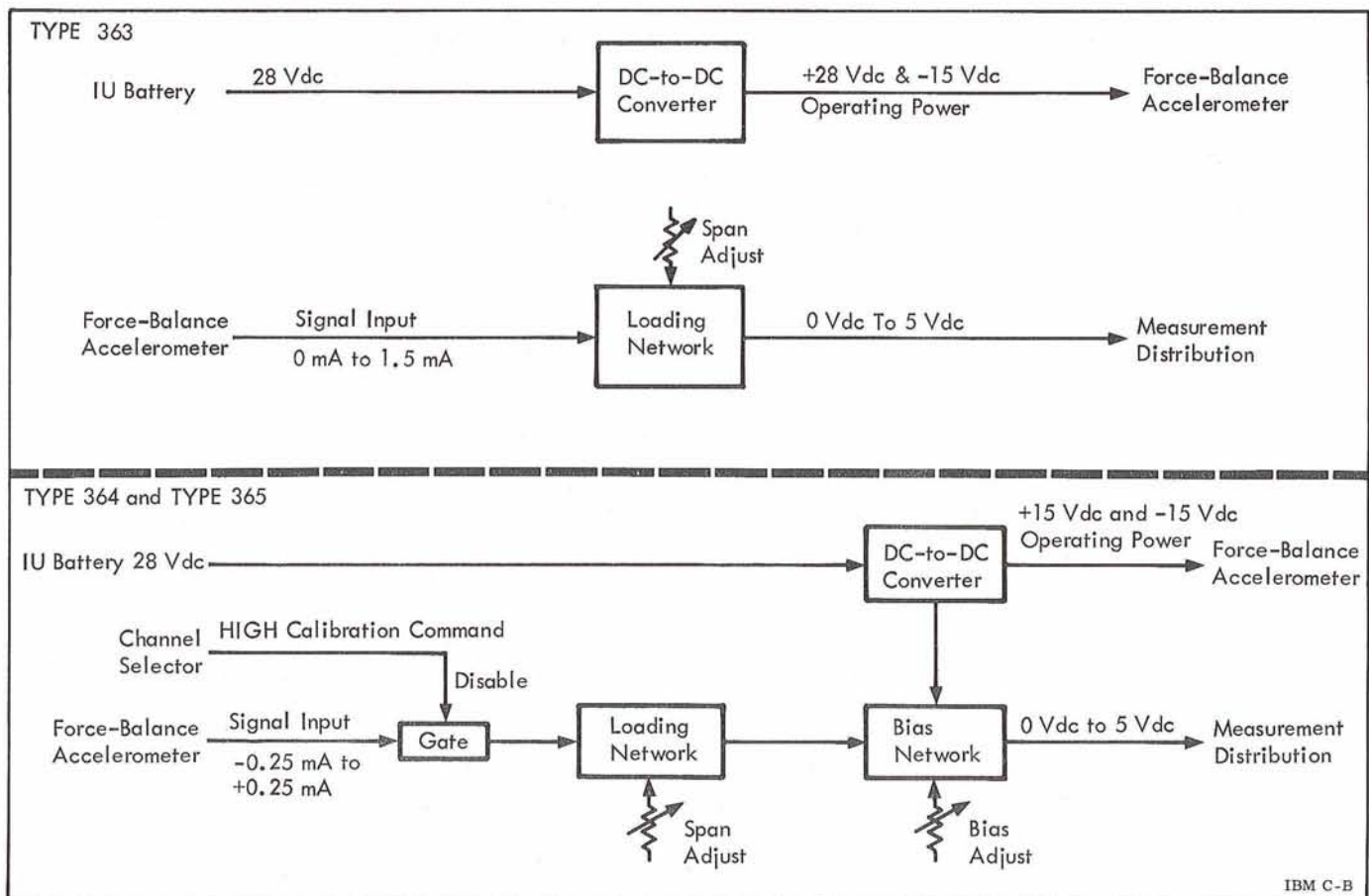


Figure 2-12. Servo Accelerometer Module Functional Diagram

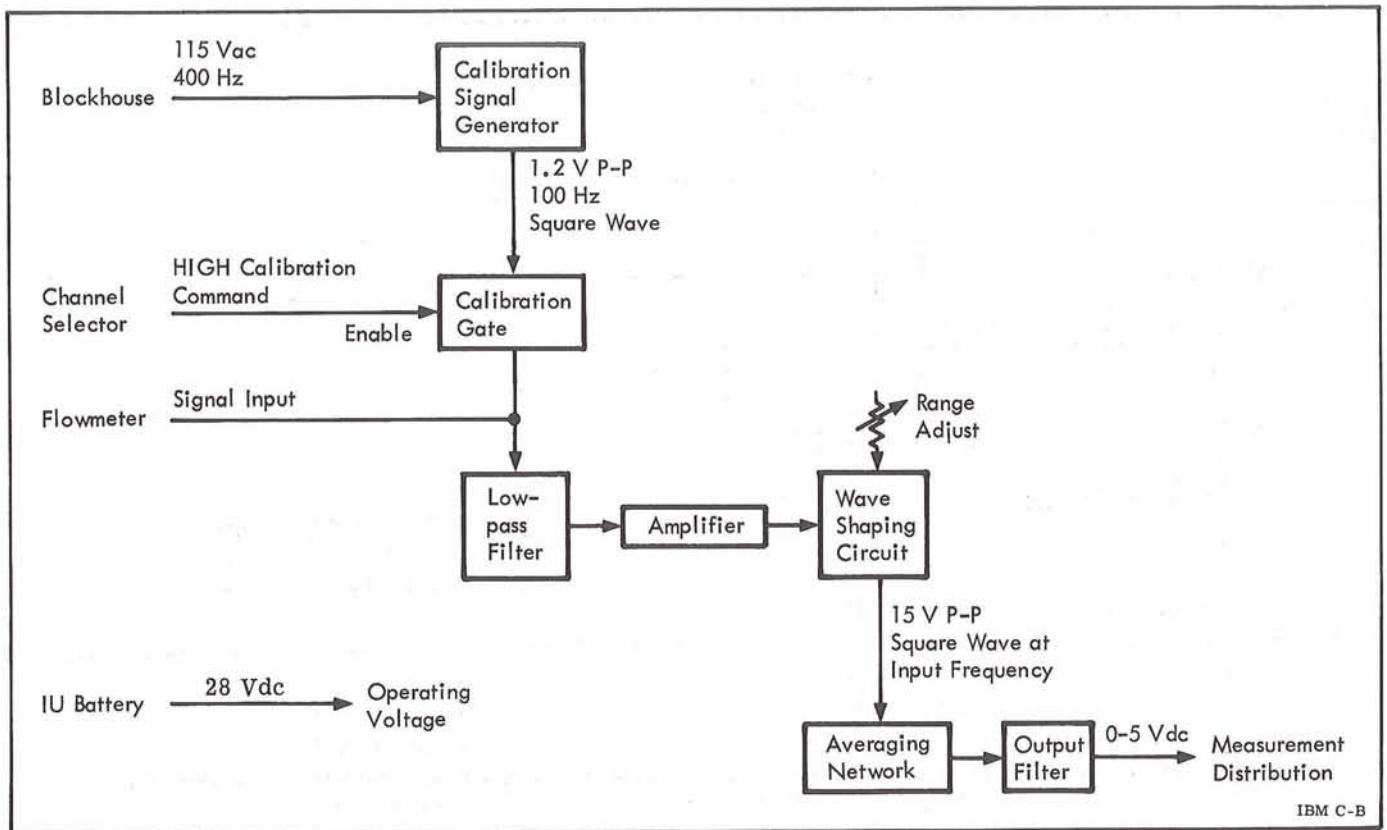


Figure 2-13. Frequency-to-DC Converter Module Functional Diagram

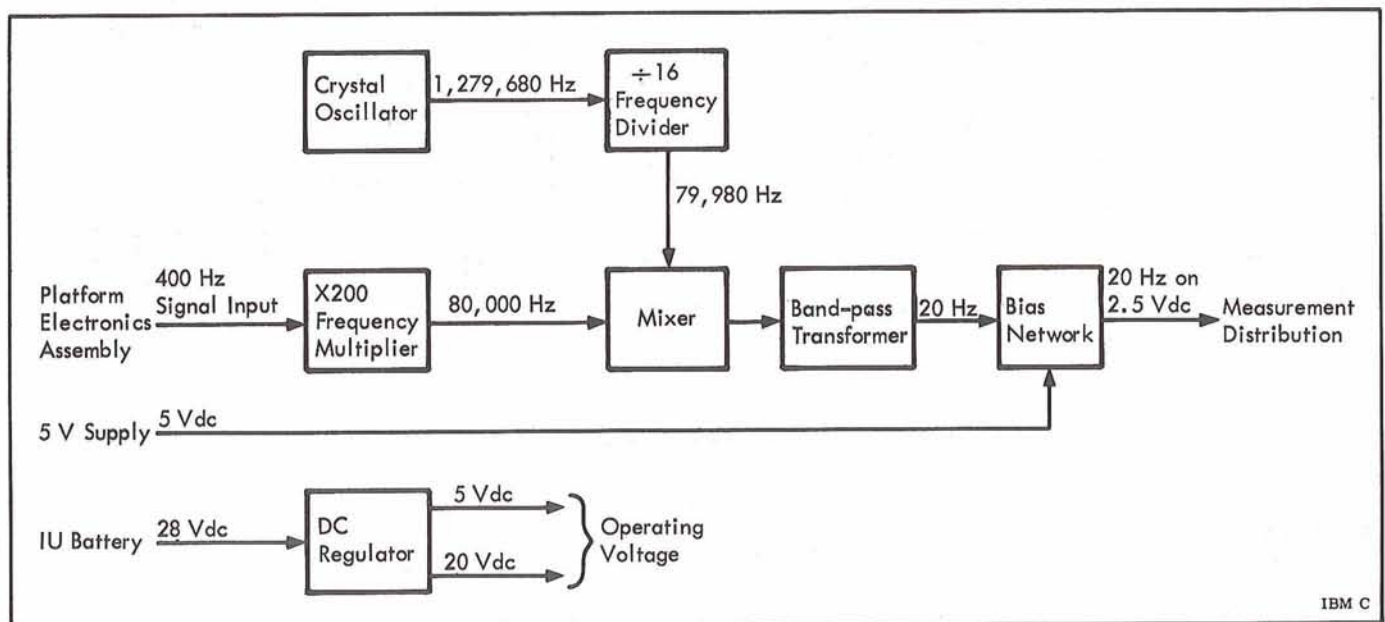


Figure 2-14. Frequency Measuring Adapter Module Functional Diagram



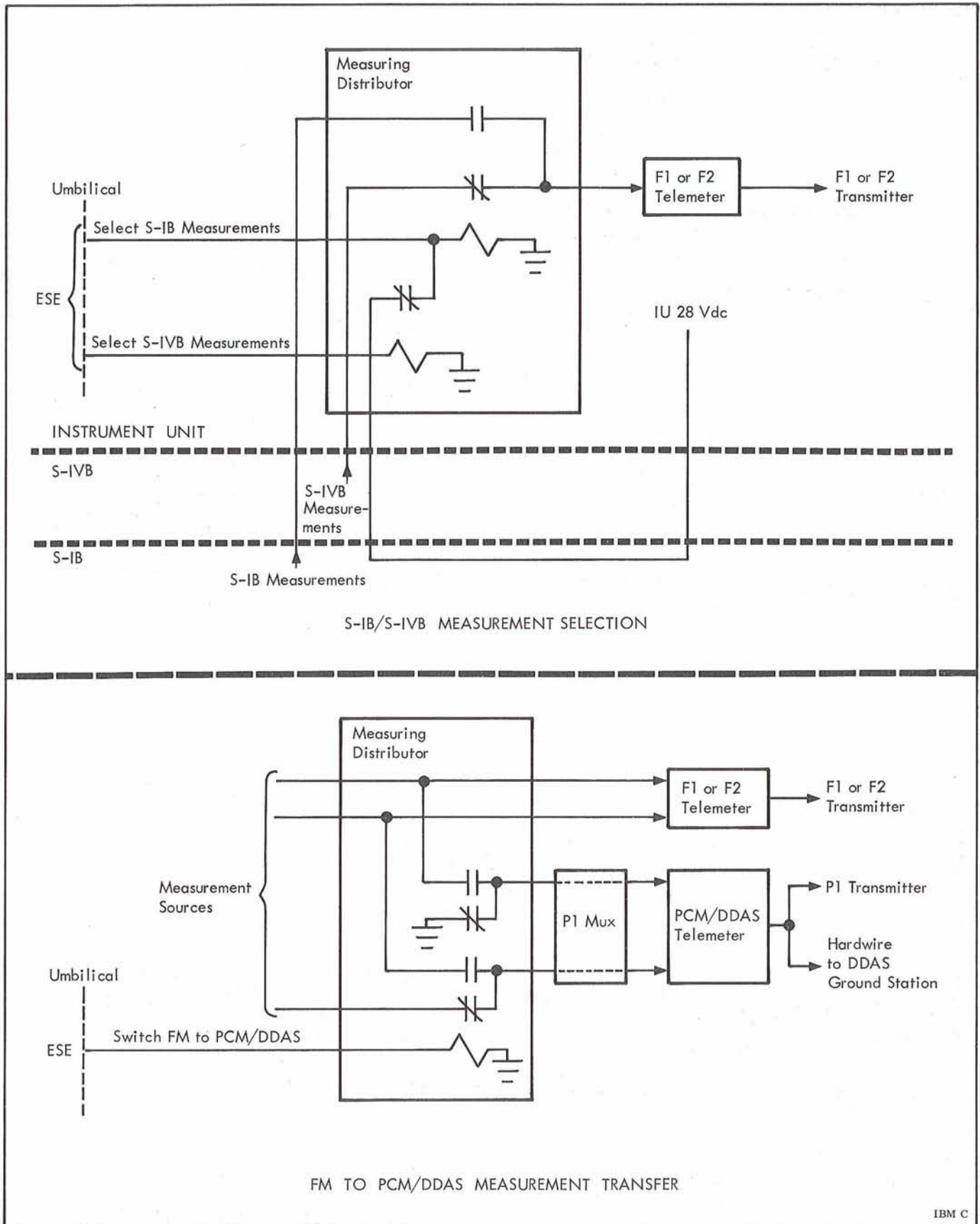


Figure 2-15. Typical Measuring Distributor Switching Functional Diagram

Calibrator. As the operation of the two units are completely interdependent, refer to paragraph 2-8 for a more complete functional description of the TM Calibrator Controller.

#### Construction

The TM Calibrator Controller has a magnesium case and uses plug-in modules. The unit is 6 inches high, 6 inches wide, 5 inches long, and weighs 4 pounds.

### 2-8 TELEMETRY CALIBRATOR

The model II, type 1, TM Calibrator provides calibration signals to all telemetry components requiring calibration for data comparison. All electrical connections to the TM Calibrator are routed through the TM Calibrator Controller, therefore the functional description must include both of these components. These two units are referred to as the Calibrator-Controller Assembly. The Calibrator-Controller Assembly is operated during flight and prior to launch. The Calibrator-Controller Assembly is capable of calibrating up to three single sideband telemeters and six FM telemeters or model 270 multiplexers. For ease of explanation, full use is assumed.

#### Construction

The TM Calibrator has a magnesium case and uses plug-in modules. The unit is 6 inches high, 6 inches wide, 5 inches long, and weighs 5 pounds.

#### Function

The Calibrator-Controller Assembly contains three main functional circuits (see Figure 2-16). Although the three circuits are interdependent, they have separate outputs. The output selection circuit selects the component to be calibrated and sends a 28 Vdc calibrate enable signal to that component. The voltage stepper circuit generates and selects the calibration voltage to be sent to the FM telemeters. The single sideband telemeter calibration circuit generates the inflight calibration signal and selects whether this signal or an ESE generated signal will be applied to the single sideband telemeters.

The Calibrator-Controller Assembly is operated in either the preflight mode (K3 energized) or the inflight mode (K1 or K2 energized). In the preflight mode, the voltage and duration of the calibration signal to the FM telemeters is controlled from the blockhouse. In the inflight mode, the Calibrator-Controller Assembly enables and calibrates the single sideband telemeters, FM telemeters, and model 270 multiplexers in a preset sequence.

**Output Selection Circuit Function** - The output selection circuit consists of those components from the control flip flop to the output OR gates, inclusively. A start calibration command from K1 or K2 enables the output relay drivers and sets the control flip flop. The control flip flop advances the 7-point sequence generator to step 1, enables the 7-point sequence generator input gate to accept signals from the 5-point sequence generator and enables the clock input gate in the 5-point sequence generator. In step 1, the 7-point sequence generator causes the relay matrix and gate to issue calibrate command 1 through the enabled relay driver. This supplies a calibrate enable command to one FM telemeter or model 270 mux and one single sideband telemeter. Each time the voltage stepper circuit completes a 0 to 5 Vdc sequence, it sends a signal through the 7-point sequence generator input gate to advance the sequence generator to select the next calibrate command to be issued. The start calibration command must be present for at least 4.2 seconds to ensure that the relay drivers remain enabled during the entire calibration sequence. The output selection circuit is not used during the preflight mode.

**Voltage Stepper Circuit Function** - The voltage stepper circuit consists of those components from the voltage comparator to the unity gain amplifier, inclusive. In the preflight mode K3 is energized, allowing the preflight levels from the blockhouse to control the output of the voltage comparator. The voltage comparator also receives a feedback from the output of the unity gain amplifier. The only possible output from the unity gain amplifier is one of the five steps of the calibration signal (0.00, 1.25, 2.50, 3.75, or 5.00 Vdc). If the voltage from the unity gain amplifier is not the same as the voltage from the blockhouse, the comparator sends a signal to enable the 5-point sequence generator gate, another signal to enable the clock input gate, and another signal through the conditioning stage to advance the 5-point sequence generator to the first step. With the clock input gate enabled, the clock issues pulses at 140-millisecond intervals. Each clock pulse advances the 5-point sequence generator to select the next voltage level. Each time the 5-point sequence generator passes the 5-volt level, it commands the 7-point sequence generator to issue the next calibration command. The 5-point sequence generator sends a command through the calibration matrix to the signal divider to produce the desired 0 to 5-volt level. The signal divider uses the precise 5 Vdc from the 5 V Supply as a supply voltage to be divided as necessary. The output is fed through the unity gain amplifier to the FM telemeter calibrate bus. This output is also fed back to the

comparator, and as long as the output does not equal the commanded voltage, the comparator will cause the circuit to continue stepping through the 0 to 5 Vdc range. Therefore, if a cycle command (200 percent of 5 Vdc) is sent from the blockhouse, the circuit will keep stepping. One complete stepping sequence is 700 milliseconds long.

In the inflight mode K3 is not energized, thus allowing 28 Vdc to be applied to the voltage comparator. This inhibits the preflight levels and makes a constant no-compare condition in the voltage comparator. When a calibration sequence is started in the output selection circuit, that circuit enables the clock input gate. This allows the 5-point sequence generator to step continuously until the inflight calibration sequence is complete, that is, six consecutive 5-point sequences.

Single Sideband Telemeter Calibration Circuit Function - A 1700 Hz, 1-volt peak-to-peak calibration signal is constantly generated by an oscillator circuit and furnished to the normally open contacts of K5. Whenever the output selection circuit selects a single sideband telemeter for calibration, K5 is closed allowing the calibration voltage to be applied to all three single sideband telemeters. During prelaunch mode, the blockhouse can select all three single sideband telemeters for calibration through K4 without using the output selection circuit. When this is done, a calibration signal consisting of a 1-volt peak-to-peak sine wave swept from 3000 Hz to 0 Hz is furnished from the blockhouse through the Calibrator-Controller Assembly, to calibrate the single sideband telemeters.

## 2-9 F2 MULTIPLEXER AND P1 MULTIPLEXER

Each of these units is a model 270 mux. The model 270 mux is a two-stage multiplexer that sequentially monitors many inputs signals, and produces two parallel repeating pulse trains, with each pulse a sample of an input signal (PAM). The input signals must be preconditioned to a range of 0 to 5 Vdc. The sampling rate is governed by sync signals from the PCM/DDAS Telemeter.

### Construction

The model 270 mux has an aluminum alloy case containing plug-in printed circuit cards. The unit weighs 21 pounds. It is 6 inches high, 11 inches wide, and 13 inches long.

### Function

The model 270 mux is basically a 30 channel component. Channels 1 through 27 of these 30 primary channels are data channels, 28 is the frame

identification channel, and 29 and 30 are amplitude reference channels. Primary channels 1 through 23 can be submultiplexed with 10 subchannels each. This gives the model 270 mux the capability of accepting  $23 \times 10 + 4$  or 234 different measurements. Channels 29 and 30 carry a precise 5 Vdc reference level and are bridged together to form a constant amplitude and location reference.

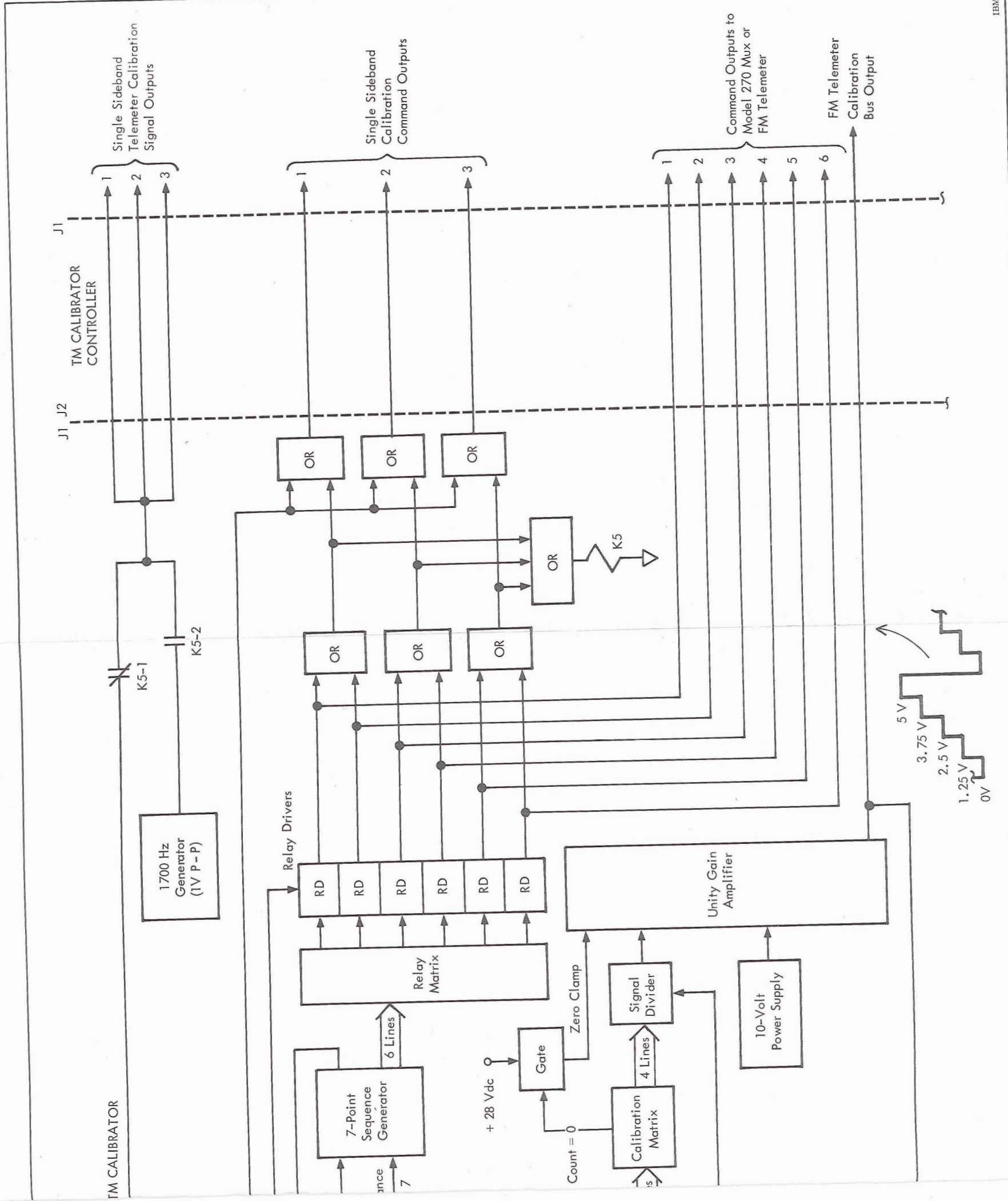
Primary channels 1 through 30 are repeatedly monitored in sequence (see Figure 2-17). One complete sequence constitutes a frame. Primary channels 1 through 23 each introduce a different subchannel into the frame for 10 consecutive frames. These 10 frames are a master frame. Primary channel 28 is held to a zero output level except during frame 10, when a 5 Vdc level is inserted. This change in reference level provides master frame identification. One master frame is necessary to sample all 234 inputs to the model 270 mux.

When commanded from an external source, the model 270 mux will perform a calibration sequence. Upon receipt of a calibrate command, the internal calibrator generates a 5-step series of precise voltages at levels of 0 Vdc, 1.25 Vdc, 2.50 Vdc, 3.75 Vdc, and 5 Vdc. At the start of the next master frame, each step is applied for the duration of one master frame (83.3 milliseconds). These stepped voltages are applied to the output isolation amplifier and replace the pulse train from the main multiplexer that is normally routed through the isolation amplifier. An inhibit calibration signal from the sync circuit stops the calibration during channels 28, 29, and 30, allowing the frame identification pulses to pass. After the five master frames of calibration the circuit is reset and is ready for the next calibration command.

The isolation amplifier accepts inputs from the main multiplexer and the calibrator and forms these inputs into two parallel pulse trains, one train with a pedestal, and one train without. The voltage range of the pulse train without pedestal is 0 Vdc to 5 Vdc. The voltage of each pulse of the pulse train with pedestal is reduced to 76 percent of the input voltage and then the pedestal of 1.2 Vdc is added to each pulse. The pedestal ensures that there is always a minimum of 1.2 Vdc on each pulse.

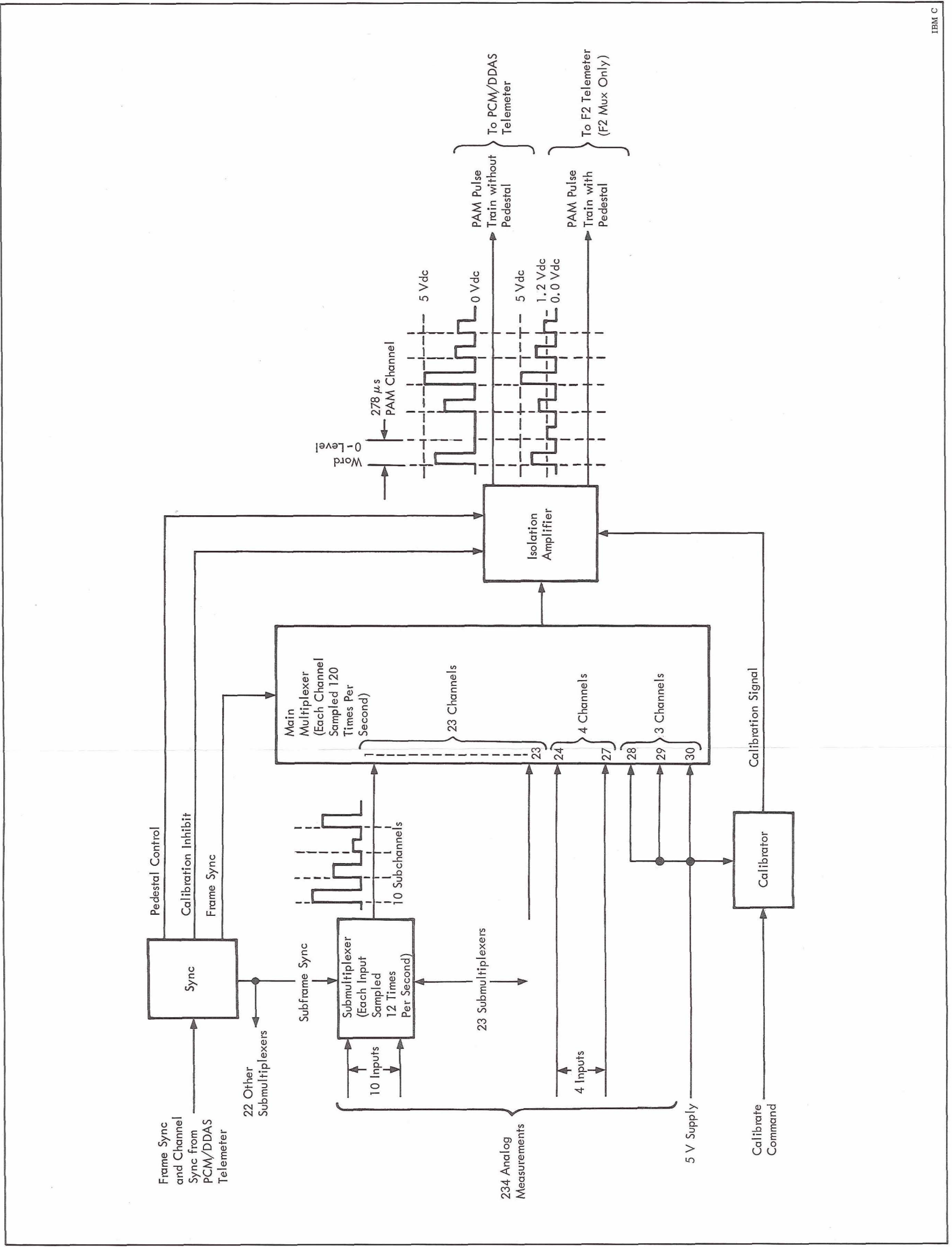
The two pulse trains, one with pedestal and one without, are provided to satisfy the input requirements of subsequent equipment. Pedestal is used with the FM telemetry path because of the characteristics of the ground station decommutation equipment. This

2



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Figure 2-16. Calibrator-Controller Assembly Functional Diagram



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Figure 2-17. F2 and P1 Multiplexer Functional Diagram

equipment will not synchronize if several sequential pulses happen to be at 0 Vdc. The pedestal is unnecessary in PCM telemetry.

Each channel output has a 50 percent duty cycle. This means that half of the channel contains data while the other half has not data (zero level). This produces an output pulse train of fixed-width pulses with the zero-level space between the pulses being the same width as the pulses.

Channel sync signals furnished to the two model 270 mux are 180 degrees out of phase. This results in the output signal of F2 Mux lagging the output of P1 Mux by one-half of a channel time or 139 microseconds. The duty cycle of P1 Mux (A-time) occurs during the non-duty cycle of the F2 Mux (B-time) preceding channel. This means that while the duty cycles of the two Mux occur at the same rate, they do not occur at the same time. For S-IU-202, the channel sync signals are reversed so that F2 Mux operates in A-time and P1 Mux operates in B-time.

Channel sync and master frame sync signals are furnished to the model 270 mux from the PCM/DDAS Telemeter. For F2 Mux on S-IU-204 and S-IU-501 through S-IU-503, the sync signals come from the S-IVB PCM/DDAS Telemeter. Channel sync signals are pulses occurring at a rate of 3600 per second. Master frame sync signals are pulses occurring at a rate of 4 per second. These sync signals cause the model 270 mux to operate with the following characteristics:

- Master frame
  - Rate: 12 per second
  - Length: 83.3 milliseconds
  - Contents: 10 frames
- Frame
  - Rate: 120 per second
  - Length: 8.33 milliseconds
  - Contents: 30 PAM channels
- Channel
  - Rate: 3600 per second
  - Length: 278 microseconds
  - Contents: One 139-microsecond data pulse and 139 microseconds of zero level

## 2-10 REMOTE DIGITAL MULTIPLEXER

The model 410 Remote Digital Multiplexer (RDM) accepts up to 100 bits of digital data, tempo-

rarily stores them as ten 10-bit words, and sends the words in a repeating sequence to the PCM/DDAS Telemeter. The unit is pre-programmed to determine the order of monitoring the inputs and the order of sending the words to the PCM/DDAS Telemeter. The RDM is synchronized with the PCM/DDAS Telemeter to cause the output words to appear at the instant the PCM/DDAS Telemeter is programmed to accept them.

Two RDM units, RDM-J and RDM-K, are used in the IU (except for S-IU-201 through S-IU-204 where only RDM-K is used). RDM-K receives only the 40-bit digital word from the LVDA. RDM-J replaces the RDSM used on S-IU-201 through S-IU-204 and receives various discrete and digital signals.

### Construction

The RDM has a magnesium case containing plug-in printed circuit cards. The unit is 6 inches high, 11 inches wide, 10 inches long, and weighs 16 pounds.

### Function

The 100 input bits (see Figure 2-18) are grouped into ten 10-bit groups and each group is routed to a magnetic core storage register (MCR). Write commands from the program patch to the individual MCR's cause the groups to be stored as 10-bit words. The write commands to the MCR's can be programmed to occur in sequence or simultaneously, depending on the time relationship desired between the measurements being monitored.

The read commands from the program patch determine the order in which the ten MCR outputs will be furnished to the parallel storage register. The read sync pulse ensures that each word is shifted to the parallel storage register at the right word time.

The parallel storage register receives a clear command just prior to receiving each new data word (7200 times per second). The 10-bit data word is then stored momentarily in ten parallel flip flops. Each word is stored just long enough to be read as a PCM word by the PCM/DDAS Telemeter.

Programming of the RDM is done by wiring the program patch to transform sync pulses into read and write commands. Programming may cause selected words to appear more than one time in the output sequence, thus increasing sampling rate. Any RDM word may be sent to the PCM/DDAS Telemeter more than once per PCM frame.

RDM-K also has the function of updating its data source. The LVDA furnishes to RDM-K a 40-bit computer word which is written into four MCR's simultaneously. After the word has been written into the MCR's, a delayed reset pulse is sent back to the LVDA to cause a new word to be transferred into its output buffer register. This updates the LVDA before RDM-K accepts new data. This updating occurs 240 times per second.

2-11 **AB** REMOTE DIGITAL SUBMULTIPLEXER

The model 1-D Remote Digital Submultiplexer (RDSM) accepts up to 100 discrete measurements and gates them in groups to the PCM/DDAS Telemeter. Commands from the PCM/DDAS Telemeter determine the order that the groups are sent out and the RDSM is synchronized with the PCM/DDAS Telemeter to ensure the output groups appear at the instant the PCM/DDAS Telemeter is programmed to accept them.

Construction

The RDSM has a magnesium case containing plug-in printed circuit cards. The unit weighs 13 pounds. It is 7 inches high, 7 inches wide, and 11 inches long.

Function

The 100 discrete inputs (see Figure 2-19) are routed in groups of 10 to ten 10-bit digital gates. The order in which the ten digital gates are enabled is determined by the PCM/DDAS Telemeter. As a digital gate is enabled its input signals are routed through as a 10-bit parallel digital word. Each digital word is momentarily stored in the parallel storage register long enough to be read as one PCM word by the PCM/DDAS Telemeter. Just before a new word is sent to the parallel storage register a reset command resets the flip flops in the parallel storage register.

Commands from the PCM/DDAS Telemeter cause the output words to appear in sequence, one through ten, at a rate of 120 words per second. One word may be read out of the RDSM per PCM/DDAS Telemeter frame, therefore, it takes ten frames to read out all ten RDSM words.

2-12 PCM/DDAS TELEMETER

The model 301 PCM/DDAS Telemeter is an encoder-multiplexer assembly that will accept and time-integrate PAM analog signals, discrete signals, and digital signals into a single output. The single

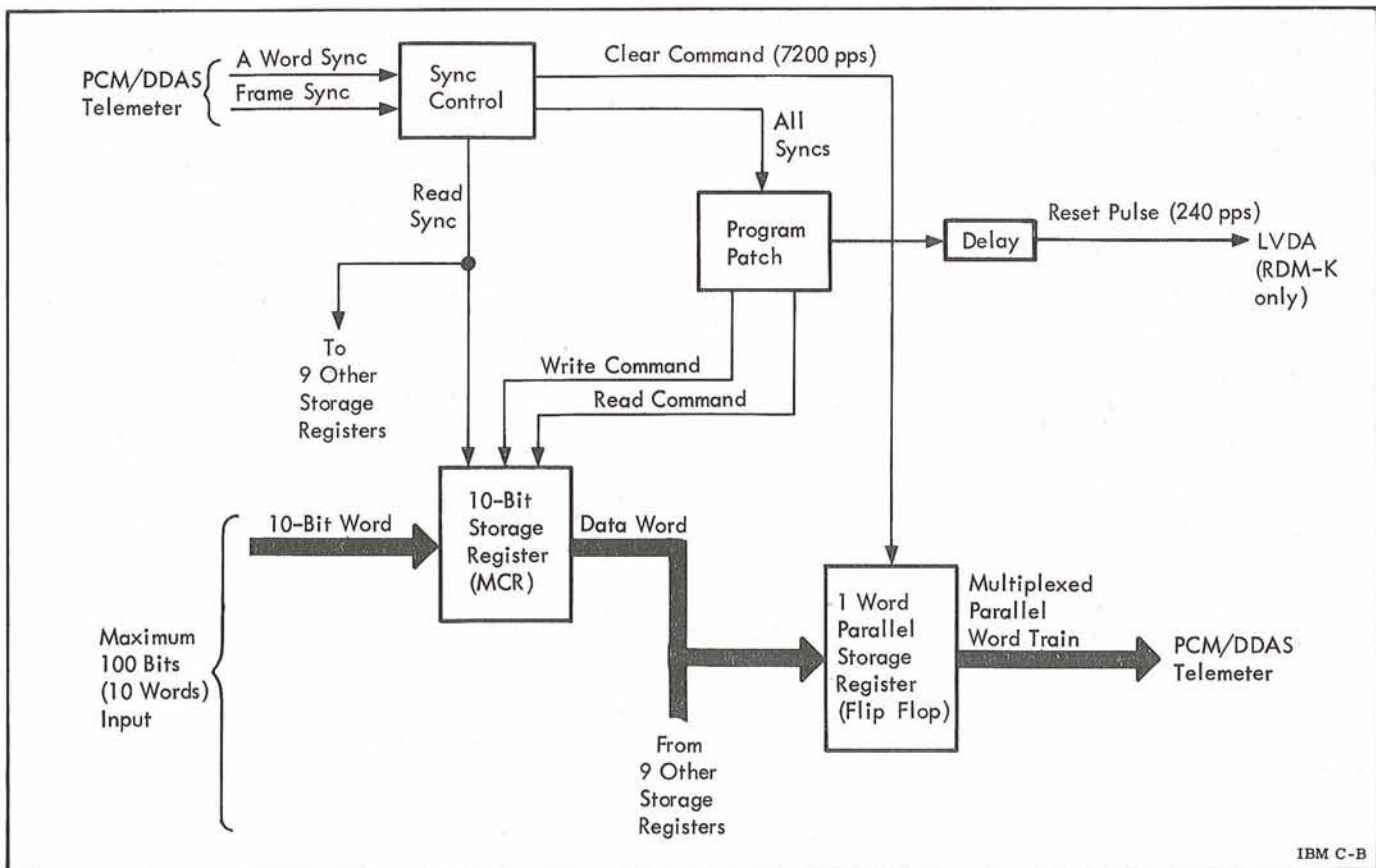


Figure 2-18. Remote Digital Multiplexer Functional Diagram

output is furnished to other components in three different forms. The PCM/DDAS Telemeter is also the key component for synchronization, housing the master electronic clock.

The three forms of the PCM/DDAS Telemeter output are:

- A serial, digital pulse train that is sent to an FM transmitter for broadcast to ground receiving stations.
- A series of parallel, digital 10-bit groups that is sent to the CIU for transfer to the LVDC.
- A 600 kHz FM carrier, modulated by the serial pulse train, that is sent to the ground ESE via the umbilical.

### Construction

The PCM/DDAS Telemeter has a magnesium case containing plug-in printed circuit cards. The unit weighs 27 pounds. It is 9 inches high, 9 inches wide, and 13 inches long.

### Function

Up to six model 270 multiplexers' PAM analog pulse trains can be accepted by the unit, although only two are used on the IU. The pulse trains are all time-integrated (see Figure 2-20) with each other and the individual pulses are encoded into 10-bit digital data. The encoded pulses are then available for multiplexing with discrete and digital inputs as 10-bit words.

Sync signals from the PCM/DDAS Telemeter cause each model 270 mux to operate in either A-time or B-time. Up to three mux can operate in each time. Sync signals to the PAM mux selector cause it to alternately scan the A-time and B-time inputs. If more than one mux is used during A-time or B-time, a different mux pulse train will be selected on each scan. The output of the PAM mux selector is an interlacing of the 50 percent duty cycles of the A-time and B-time mux pulse trains. A complete scan of one A-time channel and one B-time channel takes 278 microseconds, or 139 microseconds per data word.

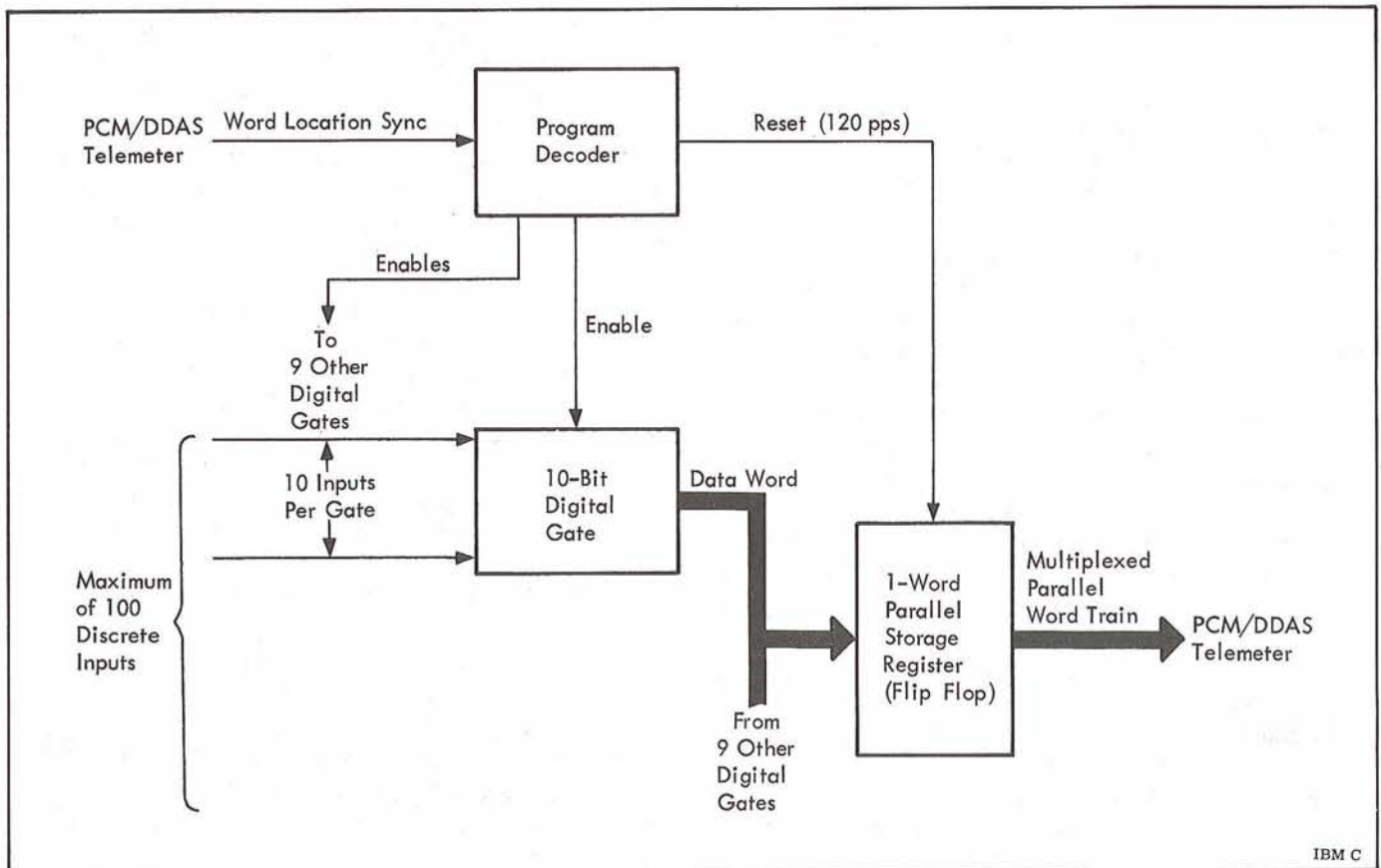


Figure 2-19. **AB** Remote Digital Submultiplexer Functional Diagram



The analog-to-digital encoder is synchronized to encode each word as the word is furnished by the PAM mux selector. Each analog word is encoded into a 10-bit digital word and stored in parallel form for transfer to the encoder gate.

The read sync pulse to the encoder gate causes each stored word to be transferred through the encoder gate to the parallel storage register, providing an inhibit pulse is not present at the encoder gate.

Digital inputs come from the RDM and the RDSM. Each digital signal is a standard parallel 10-bit word. Sync signals to the multiplexers cause their outputs to be available at the time the PCM/DDAS Telemeter is programmed to accept them. These digital inputs are furnished to the input of a digital gate. A separate read command from the program patch to each digital gate will route that gate's input through to the parallel storage register. A read sync pulse ensures that the parallel storage register receives the digital gate output at the proper word time. The read command also inhibits the encoder gate for that word time, allowing only the digital gate output to be sent to the parallel storage register.

Discrete inputs originate in numerous places. They are handled by the PCM/DDAS Telemeter in groups of 10. Each group is routed to a magnetic core storage register. A write command from the program patch determines the point in time that the group will be stored in the storage register. A read command from the program patch shifts this parallel output into the parallel storage register as a 10-bit digital word. A read sync pulse ensures that it is shifted at the right word time. The read command also inhibits the encoder gate output that would otherwise be sent to the parallel storage register.

The frame identifier transforms the sync signals into three unique 10-bit words that are inserted in the sequence to identify the frames and master frames. These three words are placed in word-times 29B, 30A, and 30B of each frame. The logic level of these words are reversed each 30th frame to identify the end of a master frame. As the frame identifier sends identification words to the parallel storage register, it also inhibits the output of the encoder gate.

Programming of the PCM/DDAS Telemeter is accomplished by wiring the program patch to transform word location pulses into read and write commands. The program patch constantly receives

timing count pulses, occurring at the various frame and word rates. Pre-wiring of the program patch uses these word location counts to generate the read and write commands, and route the commands to the desired digital gates and storage registers. These commands cause the digital gates and storage registers to accept and transfer their inputs to the parallel storage register at selected times in the format. Programming may cause selected words to appear at more than one time in the output sequence, thus increasing the sample rate.

These data words from the digital gates and storage registers override the data words from the encoder gate. Frame identification words also override the words from the encoder gate. The multiplexed input to the parallel storage register, then, consists of the encoded analog words, in the sequence supplied by the model 270 multiplexers, with digital-originated, discrete-originated, and frame identification words substituted at preselected points. The output of the parallel storage register is sent directly to the Computer Interface Unit and to the serializer. A clear command resets the flip flops before each new word is sent to the parallel storage register.

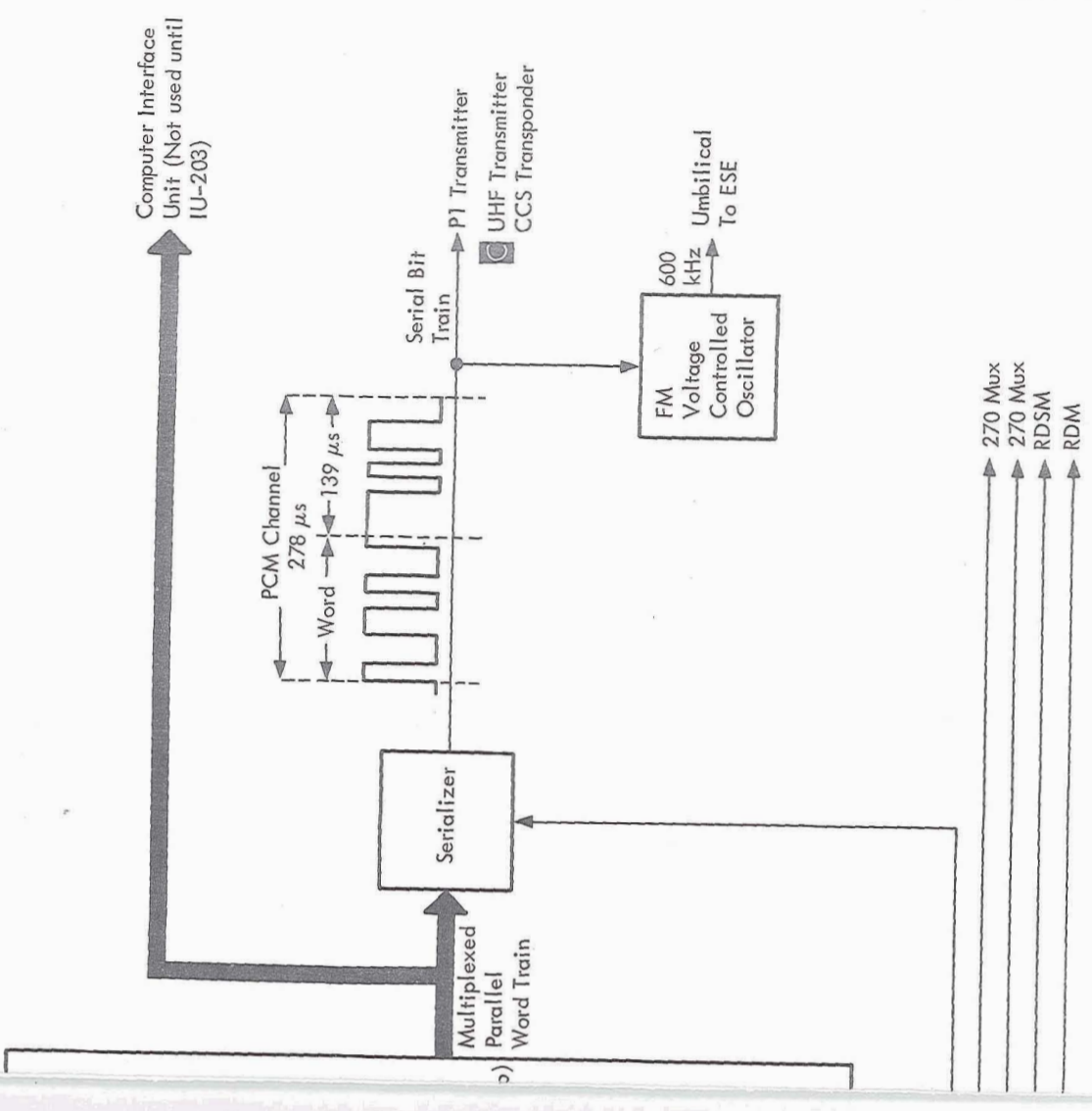
The serializer accepts the 10-bit parallel word and gates the bits out sequentially starting with the most significant bit of each word. This pulse train is inverted and re-inverted, producing dual, opposing pulse trains. The dual pulse trains are sent to the P1 Transmitter as a "push-pull" type modulation. One of the pulse trains is sent to the FM voltage controlled oscillator. The pulse trains are NRZ (non-return to zero), that is, there is no return to zero level between the bits.

The voltage controlled oscillator produces a 600 kHz FM carrier that is modulated by the serial NRZ pulse train. The modulated carrier is transformer coupled to a coaxial cable that is routed through the umbilical and then to DDAS receiving equipment. This signal is demodulated, demultiplexed, and decoded, to recreate the original measurements. These measurements can be displayed on meters, or recorded, or used as command verifications in the automatic checkout equipment.

The output of the PCM/DDAS Telemeter is a repeating format with the characteristics listed below. One master frame (1800 word times) contains a sampling of all inputs to the unit and the frame identification words necessary for the ground receiving equipment to locate specific words within the format.



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IBM C-C

Figure 2-20. PCM/DDAS Telemeter Functional Diagram

- Master frame
  - Rate: 4 per second
  - Length: 250 milliseconds
  - Contents: 30 frames
- Frame
  - Rate: 120 per second
  - Length: 8.33 milliseconds
  - Contents: 30 channels
- Channel
  - Rate: 3600 per second
  - Length: 278 microseconds
  - Contents: 2 words
- Word
  - Rate: 7200 per second
  - Length: 139 microseconds
  - Contents: 10 digital bits
- Bit
  - Rate: 72,000 per second
  - Length: 13.9 microseconds
  - Contents: Logic '1' or '0'

## 2-13 COMPUTER INTERFACE UNIT

The model 501 CIU assists in the transfer of telemetry data to the LVDA/LVDC for storage. All instrumentation data from the PCM/DDAS Telemeter is furnished to the CIU, and on request from the LVDA/LVDC, selected words of this data are transferred to the LVDA/LVDC for storage. As the LVDA/LVDC and PCM/DDAS Telemeter are components of two non-synchronous systems, the CIU acts as a buffer between them.

The CIU is used only after orbital insertion, while the vehicle is not within range of any ground receiving station. When the vehicle comes within range of a ground station, the data stored by the LVDA/LVDC is returned to the PCM telemetry equipment for broadcast to the ground.

The CIU is not used on S-IU-201 or S-IU-202.

### Construction

The CIU has a magnesium alloy case containing plug-in printed circuit cards. The unit weighs 12 pounds. It is 6 inches high, 11 inches wide, and 10 inches long.

### Function

All synchronization inputs to the CIU are furnished by the PCM/DDAS Telemeter (see Figure 2-21). The sync inputs cause the sync control circuit to generate the word location addresses in sync with the PCM/DDAS Telemeter. These addresses are used to check the data addresses requested by the LVDA and to gate the requested words through the CIU at the time they appear in the PCM format.

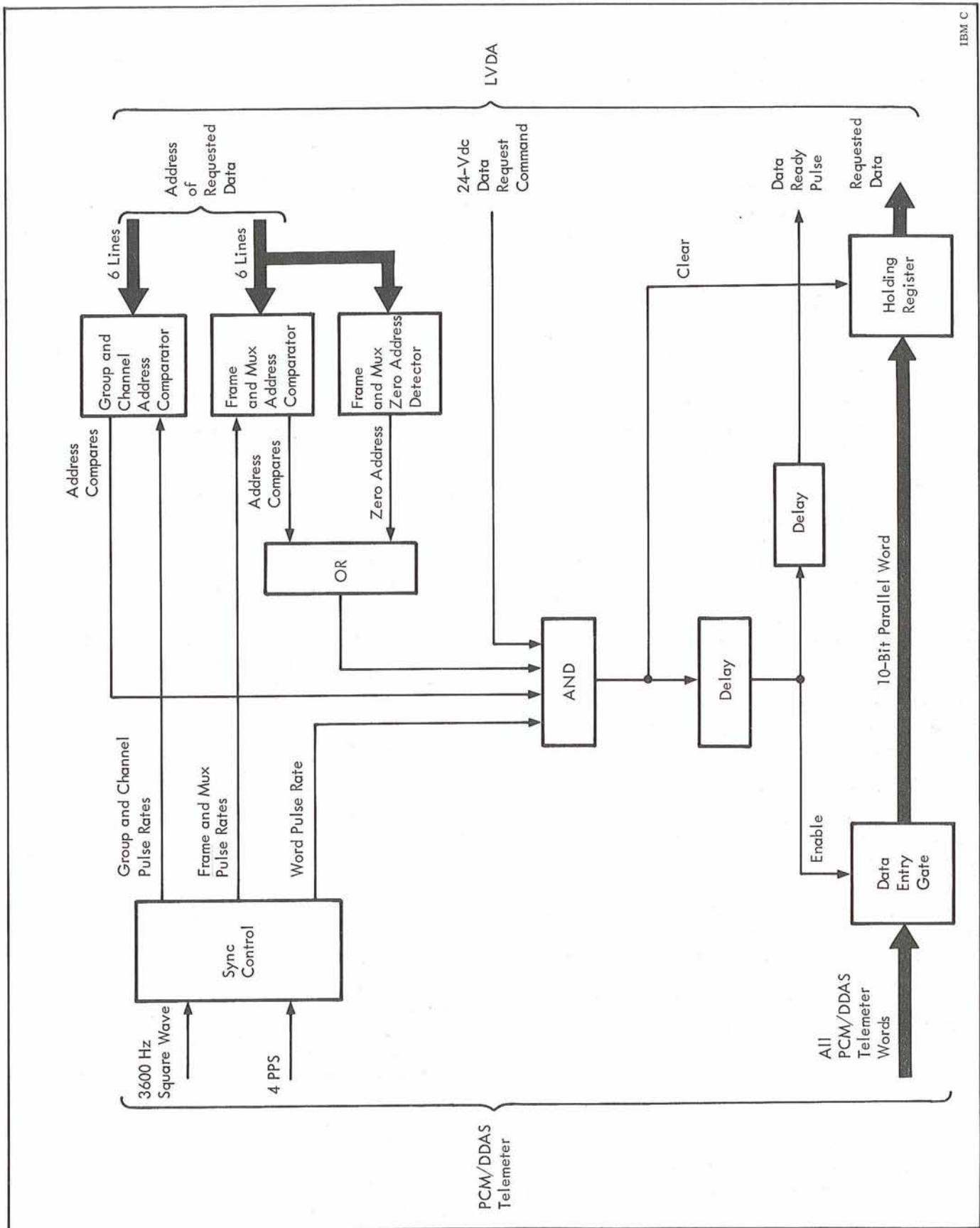
The complete PCM data format from the PCM/DDAS Telemeter is furnished to the data entry gate in the CIU. The data is furnished in parallel format, one word at a time. A word will pass through the data entry gate only when requested by the LVDA.

The data request from the LVDA consists of 12 parallel lines of coded address and one 24 Vdc data request command. The requested address is checked by the address comparators to ensure that the address is valid. The address comparators will not give an output compare signal until the address of the requested word actually occurs in the PCM format. Thus, nearly a complete PCM master frame (250 milliseconds) might have to pass before the addresses compare. If a frame and mux zero-address is sent, the addressed group and channel word of every frame will be gated into the holding register when the data request is present. The data request command must be present longer than the duration of a PCM master frame to ensure passage of the requested word.

The data request command, the address compare signals, and pulses occurring at the PCM word rate, are ANDed together to cause the requested data to be transferred. The output of the AND gate is a pulse for each word of requested data. An output pulse first clears the output holding register of previous data. After a short delay, the data entry gate is enabled and the requested word is transferred into the holding register. After another short delay, a data ready pulse is sent to the LVDA. The data ready pulse causes the LVDA to accept and process the parallel word that is being presented to it by the holding register. This word will also remain in the CIU holding register until the next pulse from the AND gate.

## 2-14 F1 TELEMETER AND F2 TELEMETER

F1 Telemeter and F2 Telemeter are each an FM telemeter that is provided to convert analog measurement signals into proportional frequency-intelligent



IBM C

Figure 2-21. Computer Interface Unit Functional Diagram

signals for subsequent modulation of an FM transmitter. All input signals must be pre-conditioned to a 0 Vdc to 5 Vdc range. Input signals come to F1 and F2 Telemeters from transducers, measurement racks, measurement distributors, and multiplexers. The F1 Telemeter (model B-1) can accept a total of 27 input signals and the F2 Telemeter (model A-3) can accept a total of 19 input signals. The outputs of F1 and F2 Telemeters are furnished to the tape recorder prior to being routed to two FM transmitters.

### Construction

Each Telemeter has a magnesium case containing plug-in printed circuit cards. F1 Telemeter weighs 18 pounds and F2 Telemeter weighs 14 pounds. F1 Telemeter is 6 inches high, 10 inches wide, and 11 inches long. F2 Telemeter is 4 inches high, 8 inches wide, and 15 inches long. F2 Telemeter is pressurized to 20 psia.

### Function

The sub carrier oscillators (SCO) are the units within each Telemeter that convert the analog inputs into frequency-intelligent data. Each SCO is a voltage controlled oscillator that is set at a precise frequency range. The frequency output will shift up to the high limit as the input signal (see Figure 2-22) increases to 5 volts. The frequency output will shift down to the low limit as the input signal decreases to 0 volts. Thus, the output frequency of each SCO is set to be linearly proportional to an input of 0 to 5 Vdc. A low-frequency ac signal can be an input to an SCO if the signal is first biased at mid-range (2.5 Vdc).

Frequencies and operations of SCO channels are controlled by a government agency, the Inter-Range Instrumentation Group (IRIG). These controls were established for several reasons. Among them are:

- To ensure that transmitting equipment frequencies and receiving equipment frequencies are compatible.
- To eliminate possible interference between different systems.
- To set manufacturing standards.
- To facilitate the transfer of data between government test ranges.

Table 2-3 lists the frequencies, deviations, and frequency responses of all IRIG standard SCO

channels. The channel numbers are convenient ways to refer to specific bands. The listed frequencies are the center, upper, and lower limit of each channel. Deviation is the amount, in percentage, that the upper and lower frequency limits are set from center. Frequency response is the highest input frequency that can be accepted by a channel (due to that channel's frequency and deviation limits) and be reproduced without significant loss of data. Inputs of higher frequency can be accepted, but at a corresponding loss of accuracy.

Channels used in F1 and F2 Telemeters are flexible and may be easily changed. The specific channels used were chosen to meet the needs of the system. Three different modulation processes using the IRIG channels, are used by the Telemeters.

A typical data input is routed through an SCO and then joined with the other channel outputs. These signals are then sent through an isolation amplifier and the composite signal can then be used to deviate an FM transmitter. This process, using one SCO to modulate an FM carrier, is referred to as frequency modulation/frequency modulation (FM/FM).

Another typical data input is routed through a low-frequency SCO, joined with several other low-frequency SCO outputs, and routed to an isolation amplifier. This composite output is then used as the input to one high-frequency SCO. This process, using two SCO stages to modulate an FM carrier, is referred to as frequency modulation/frequency modulation/frequency modulation (FM/FM/FM).

The third process uses the output pulse train of a model 270 mux as the input for one high-frequency, high-deviation SCO. This process is called pulse amplitude modulation/frequency modulation/frequency modulation (PAM/FM/FM).

The voltage output (pre-emphasis) of each SCO is factory-adjusted to overcome inherent noise problems and yet not affect the adjacent SCO's. Generally, the higher frequency SCO's require a higher voltage output to overcome noise. Pre-emphasis determines the amount of rf carrier deviation to be effected by the individual SCO.

The output isolation amplifier for F2 Telemeter provides a differential output, but the F1 Telemeter has a single-ended output.

All channels in each Telemeter (except the PAM/FM/FM channel) may be calibrated by applying

a known voltage instead of the normal input signal to the SCO. All channels are calibrated during prelaunch checkout but only selected channels are calibrated during flight. The PAM/FM/FM channel is never calibrated because its input, the multiplexer pulse train, is periodically calibrated. Some channels are not calibrated during flight because the data they transmit must not be interrupted, even momentarily.

Calibration is started by an external command which causes the SCO inputs to be transferred to an externally controlled calibration bus. The different voltages applied to the calibration bus are 0.0, 1.25, 2.50, 3.75, and 5.0 Vdc. These known voltages will produce a known frequency shift of the SCO, allowing normal data to be compared to calibrated data to determine the SCO accuracy.

The calibration relay of each SCO is wired to a calibration YES bus or NO bus. During prelaunch checkout, a calibration command from the ESE will transfer to the calibration bus those SCO relays connected to the YES bus and the NO bus. The ESE then determines the calibration voltages applied to the bus and the length of time they are applied.

During flight, only those SCO relays connected to the YES bus can be transferred to the calibration bus. The inflight calibration command and the calibration voltages come from the TM Calibrator. The calibration command switches the YES SCO inputs to the calibration bus for 700 milliseconds. During this time, the TM Calibrator applies one stepped sequence of the calibration voltage levels to the calibration bus.

## 2-15 TAPE RECORDER

The model 101 Tape Recorder records and stores, for future transmission, that instrumentation information that would otherwise be lost due to atmospheric ionization during retro-rocket fire. The Tape Recorder is operated on command from the Navigation, Guidance, and Control System and can record approximately 180 seconds of 300 Hz to 120 kHz information on two tracks of 1/4-inch tape. The outputs of F1 Telemeter and F2 Telemeter are recorded on the two tracks of this magnetic tape recorder.

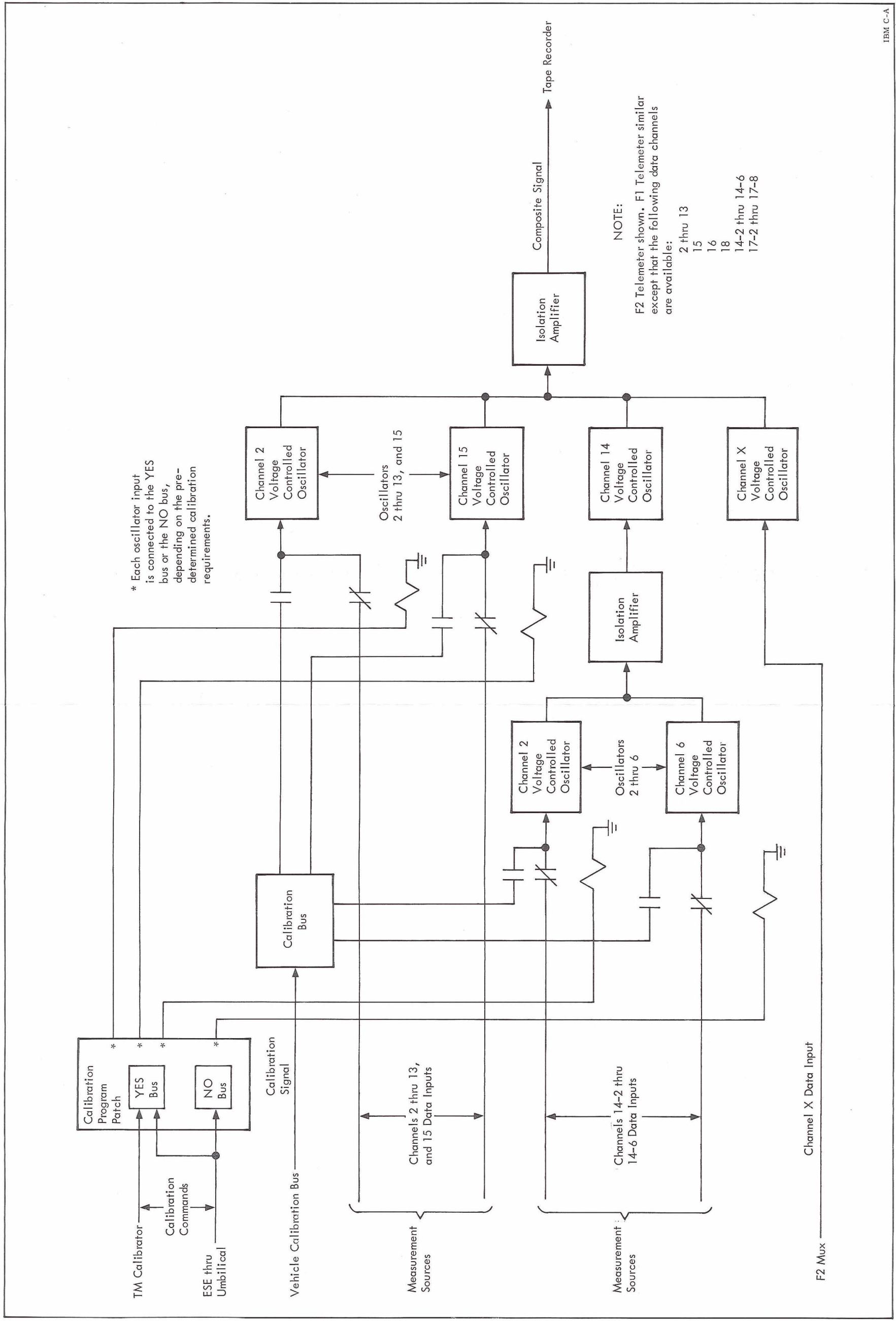
### Construction

The Tape Recorder is a reel-to-reel type recorder containing a removable tape magazine and transistorized plug-in modules. It is 3 inches high, 9 inches wide, 10 inches long, and weighs 10 pounds. The unit is pressurized to 20 psia.

### Function

The operating modes of the Tape Recorder are selected by application or absence of commands (see Figure 2-23). The recorder has a capability of five different modes.

- Ready Mode. The recorder is in this mode if source voltage has been applied, tape transport is not operating, and the tape is at the beginning of its run. A ready to record signal is sent to the ESE.
- Standby Mode. The recorder is in this mode if source voltage has been applied, tape transport is not operating, and the tape is in any position except the beginning.
- Record Mode. The recorder is placed in this mode by a record command. As it is recording, all previous data on the tape is erased. Recording will continue until the record command is removed or the recorder runs out of tape. If the command is removed or the tape runs out, the recorder will automatically revert to the standby mode. Recording speed is 60 inches per second.
- Reverse Playback Mode. The recorder is placed in this mode by a reverse playback command. The tape is driven in the direction opposite to the recording direction and the recorded data is furnished, in reverse time sequence, to the RF transmitters. This playback will continue until the command is removed or the recorder runs out of tape. If the tape runs out, the recorder will automatically revert to the ready mode. If the command is removed, the recorder will revert to the standby mode. No data is erased during this mode. Reverse playback speed is 60 inches per second.
- Forward Playback Mode. The recorder is placed in this mode by a forward playback command. The tape is driven in the same direction as the recording direction and the recorded data is furnished, in proper sequence, to the RF transmitters. This playback will continue until the command is removed or the recorder runs out of tape. If the command is removed, the recorder will revert to the standby mode. No data is erased during this mode. Forward playback speed is 60 inches per second.



IBM C-A

Figure 2-22. F1 and F2 Telemeter Functional Diagram



Table 2-3. IRIG Subcarrier Frequencies and Deviations

Channel (Band)	Center Frequency (Hz)	Lower Limit (Hz)	Upper Limit (Hz)	Deviation (percent)	Frequency Response† (Hz)
1	400	370	430	±7.5	6.0
2	560	518	602	±7.5	8.4
3	730	675	785	±7.5	11.0
4	960	888	1,032	±7.5	14.0
5	1,300	1,202	1,398	±7.5	20.0
6	1,700	1,572	1,828	±7.5	25.0
7	2,300	2,127	2,473	±7.5	35.0
8	3,000	2,775	3,225	±7.5	45.0
9	3,900	3,607	4,193	±7.5	59.0
10	5,400	4,995	5,805	±7.5	81.0
11	7,350	6,799	7,901	±7.5	110.0
12	10,500	9,712	11,288	±7.5	160.0
13	14,500	13,412	15,588	±7.5	220.0
14	22,000	20,350	23,650	±7.5	330.0
15	30,000	27,750	32,250	±7.5	450.0
16	40,000	37,000	43,000	±7.5	600.0
17	52,500	48,560	56,440	±7.5	790.0
18	70,000	64,750	75,250	±7.5	1050.0
19	93,000	86,025	99,975	±7.5	1395.0
A††	22,000	18,700	25,300	±15	660.0
B	30,000	25,500	34,500	±15	900.0
C	40,000	34,000	46,000	±15	1200.0
D	52,500	44,620	60,380	±15	1600.0
E	70,000	59,500	80,500	±15	2100.0
F	93,000	79,050	106,950	±15	2790.0
X†††	70,000	49,000	91,000	±30	4200.0

† Frequency response is based on a deviation ratio of five.

†† Increased deviation bands A through X may be employed by omitting other bands of that center frequency and the following bands:

<u>Band Used</u>	<u>Omit Bands</u>
A	13, 15, and B
B	14, 16, A, and C
C	15, 17, B, and D
D	16, 18, C, and E
E	17, 19, D and F
F	18 and E
X	16, 17, C, and D

††† Utilized for PAM/FM/FM and is not a standard IRIG channel.

While in the record mode, a precise 120 kHz speed compensation signal is applied to each of the two channels in addition to the data being recorded. This signal is used by the ground receiving stations to detect possible tape speed deviations.

While in either playback mode, the outputs of F1 Telemeter and F2 Telemeter are interrupted to enable the signal being played back to be sent to the F1 Transmitter and F2 Transmitter. The inputs to the transmitters are not interrupted during record mode.

2-16 SLOW SPEED MULTIPLEXER

The purpose of the model 245 Slow Speed Mux is to time-share up to 80 high-frequency measurements to increase the measurement capacity of the telemetry equipment. The inputs may come from transducers, signal conditioners, or other sources. These inputs are multiplexed into 17 output channels which may be sent to the S1, F1, or F2 Telemeter.

Construction

The Slow Speed Mux has a magnesium case containing plug-in printed circuit cards. The unit weighs 13 pounds. It is 3 inches high, 8 inches wide, and 11 inches long.

Function

Each of the 16 output channels (see Figure 2-24) may contain samples of 1, 2, 4, or 5 input signals. This is accomplished by placing a mux in each channel that will time share 1, 2, 4, or 5 inputs. Except for the 1-input channel, all input signals must be in the range of 0 to 5 V. As the 1-input channel is merely a wire running straight through the component, it will accept and pass any input signal.

The Slow Speed Mux operates on a frame rate of 1 frame per 12 seconds. During 1 frame, each of the 16 different channel multiplexers makes one

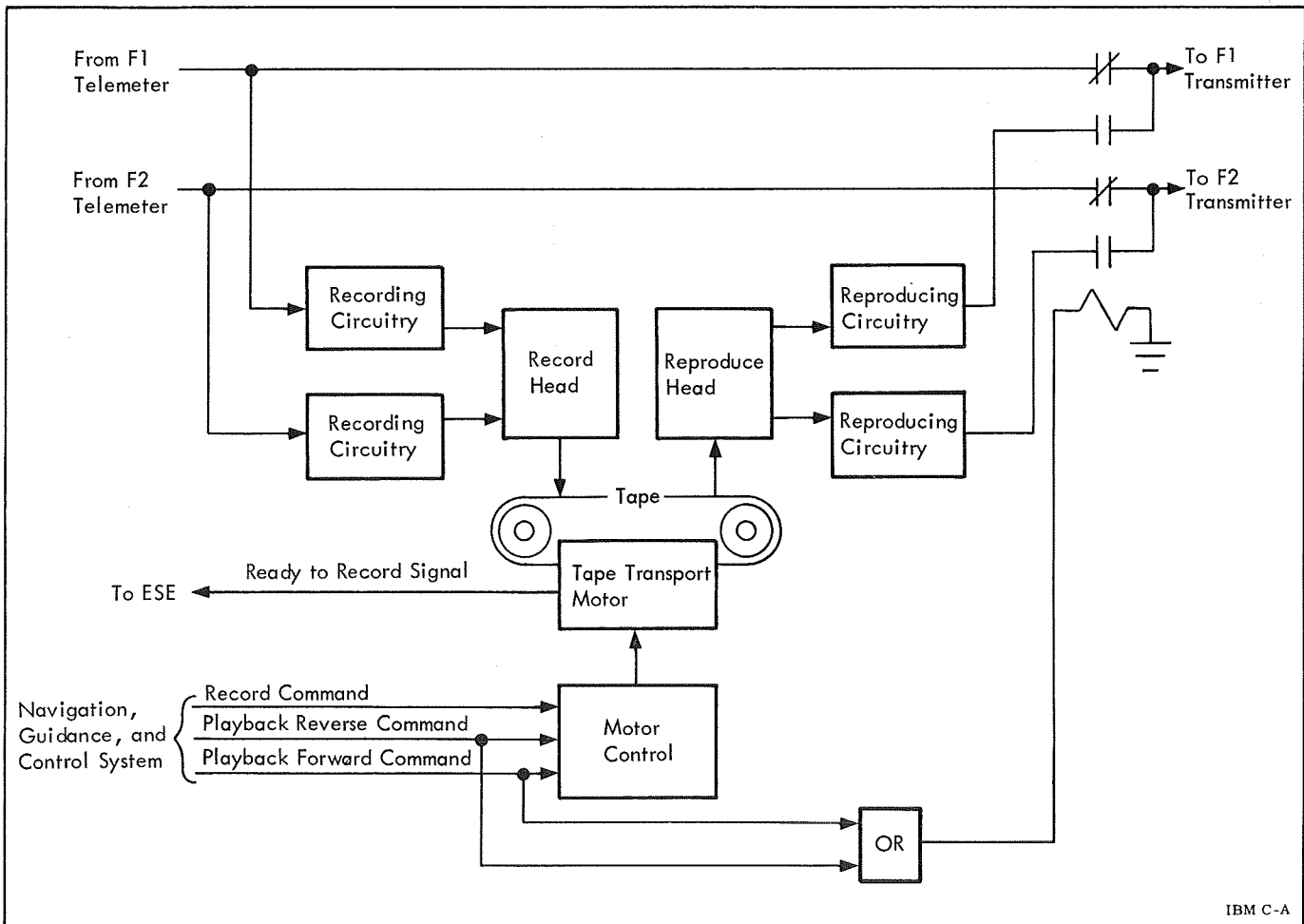
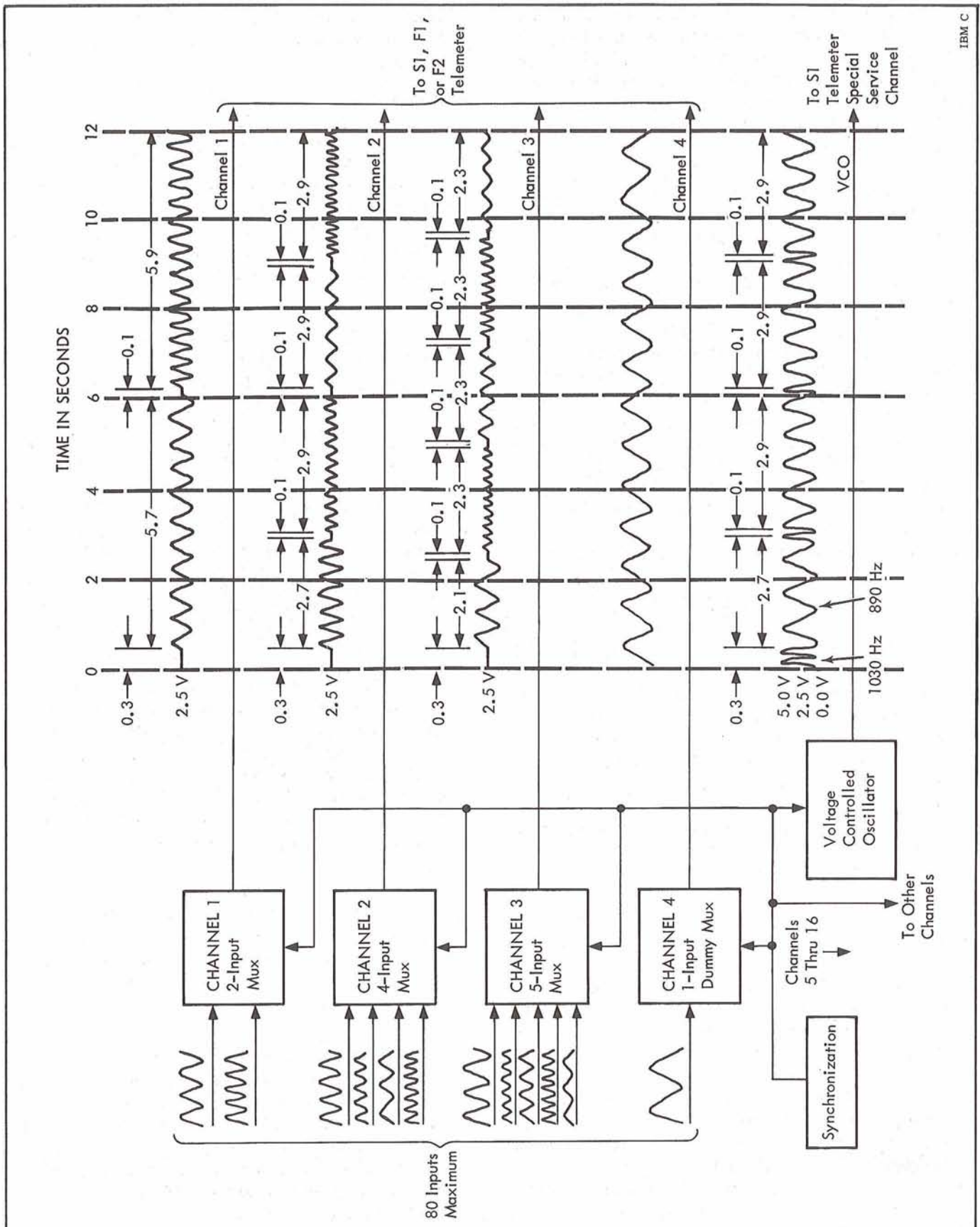


Figure 2-23. Tape Recorder Functional Diagram



IBM C

Figure 2-24. Slow Speed Multiplexer Functional Diagram

sample of each of its inputs. A 2.5 Vdc signal location pulse is inserted between the samples to aid in showing where a new sample starts. This pulse is 100 milliseconds long except between the last and first samples. Between the last and first samples the 2.5 Vdc pulse is 300 milliseconds long to show that a new frame is beginning.

A multivibrator furnishes the basic timing signal within the synchronization circuit. This timing signal triggers other multivibrators which produce the sync signals necessary to cause the multiplexers to sample at the proper rate and the voltage controlled oscillator to develop the proper sync frequencies.

The voltage controlled oscillator is a multivibrator circuit that provides two sync frequencies along with the multiplexed channels to assist in data reduction. These sync frequencies are controlled by the synchronization circuit. The two frequencies are 890 Hz and 1030 Hz - the lower and upper limits of IRIG subcarrier band 4. The 1030 Hz signal is present when the 2.5 Vdc signal location pulse is applied to the four-input multiplexer. The 890 Hz signal is present at all other times.

## 2-17 S1 TELEMETER ASSEMBLY

The S1 single sideband Telemeter provides 17 modulation channels of wide-frequency-band data to an FM transmitter. Measurement data is sent through 15 of these bands while the other 2 are used for synchronizing signals. The channels are spaced in a manner to produce a nominal bandwidth to the transmitter while retaining high frequency response. The single sideband modulation method is used to improve the measurement handling capacity of the transmitter.

The **C** configuration S1 Telemeter is a model 601.

### Construction

**AB** S1 Telemeter has a magnesium case containing plug-in printed circuit cards. The unit weighs 18 pounds. It is 6 inches high, 10 inches wide, and 10 inches long.

The **C** configuration S1 Telemeter is made up of an **AB** configuration unit with a type III top deck assembly mounted on the top. The top deck assembly houses a dc-to-dc converter which furnishes the 28 Vdc power to the bottom assembly, and an isolation amplifier for the output of the bottom assembly. The top deck assembly has a magnesium case containing

plug-in modules. The model 601 unit is 10 inches high, 10 inches wide, 10 inches long, and weighs 23 pounds.

### Function

All 15 data channels (see Figure 2-25) are identical except for their individual carrier frequencies, so channel 1 will be discussed as a typical data channel. S1 Telemeter also has a special service channel that is used to transmit synchronization information for the Slow Speed Mux. This channel will be discussed separately.

Measurement data input signals must be in the range of 30 Hz to 3000 Hz, 0 volts to 5 volts peak to peak. The data input may be a single measurement or a multiplexed group of signals.

The frequency synthesizer derives all carrier frequencies used by the unit from the output of a 910 kHz crystal oscillator. The output of the oscillator is divided and keyed to produce the necessary frequencies. One of the outputs is a 455 kHz signal that is sent to the first modulator of each channel and is used as the first carrier frequency for each channel. Another output is a spectrum of frequencies harmonic to 4.74 kHz that is sent to the filter set. The third output is a pilot signal of 75.83 kHz sent to the first summing amplifier.

The pilot signal is sent to the ground receiving stations and used there as an amplitude reference to approximate the amplitude of each data channel. The pilot signal amplitude is preset so that when the amplitude is reconstructed at the receiving stations, the gain of the agc can be determined. The frequency of 75.83 kHz is used because it is higher than the highest data channel carrier frequency.

The filter set selects 15 of the nonharmonic frequencies sent to it from the frequency synthesizer. Each second modulator of all 15 data channel receives a different one of these frequencies. The second modulators use these frequencies as the second carrier frequencies for each channel.

The typical channel accepts its input through the normally enabled data gate. The signal is then routed to the first balanced modulator for mixing with the 455 kHz first carrier frequency. The sum and difference frequencies (upper and lower) sidebands resulting from this amplitude modulation process are then sent to the band-pass filter. The band-pass filter allows only the sum frequency (455 kHz + data frequency) to go to the second modulator.

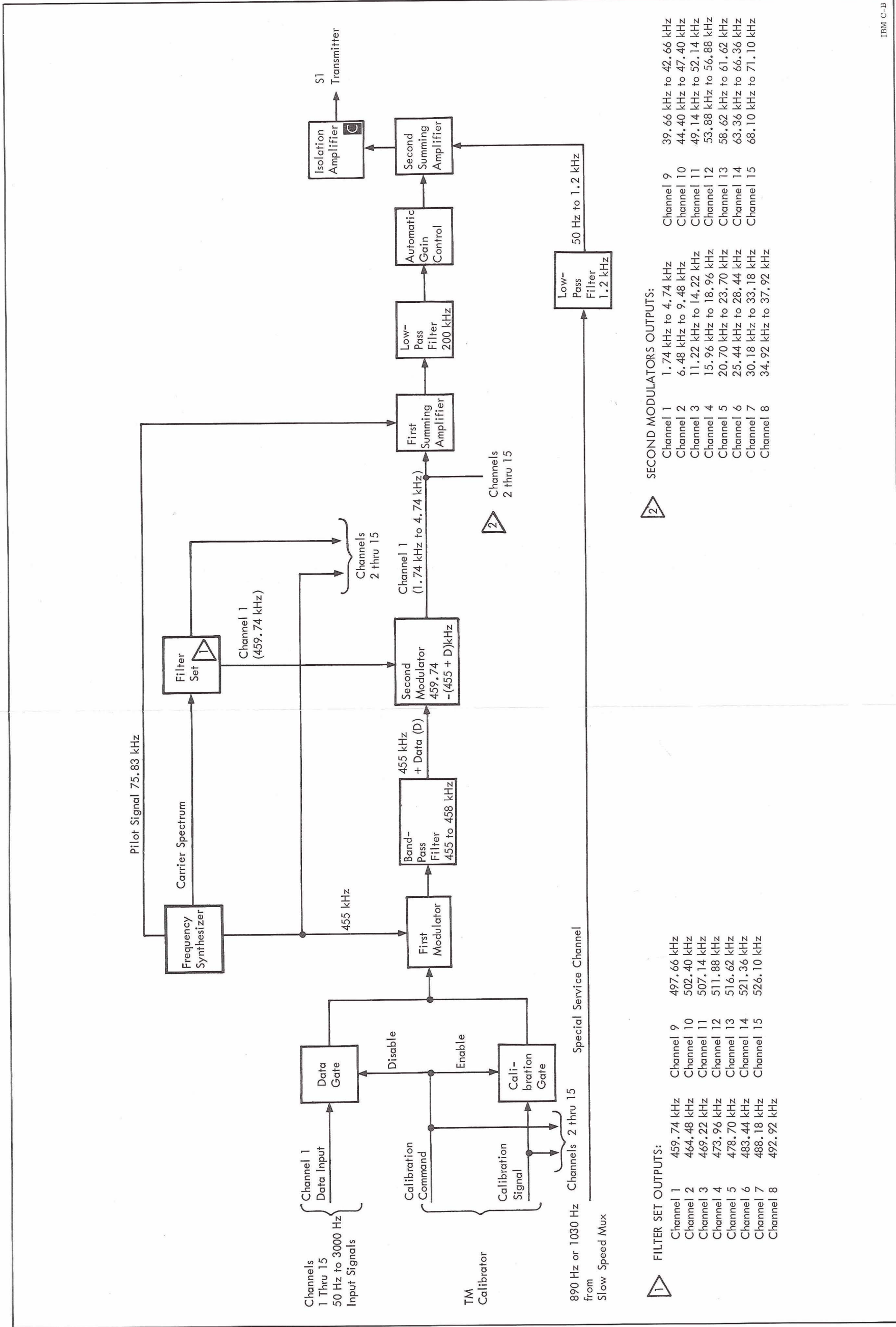


Figure 2-25. S1 Telemetry Functional Diagram

The second balanced modulator mixes this sum frequency with the second carrier frequency (459.74 kHz for channel 1) to produce new sum and difference frequency bands. The difference band for channel 1 is 1.74 kHz to 4.74 kHz with the input data frequency represented in this band by 4.74 kHz minus the input data frequency. The difference bands of all 15 channels are 3.0 kHz wide with a guard frequency of 1.74 kHz between the bands. The sum bands are later filtered out so are of no importance.

The 15 data inputs have not been translated into 15 different frequency bands. These 15 signals are then bussed to a common point and routed to the first summing amplifier along with the pilot tone. The 16 combined frequencies are then furnished to the low-pass filter where the sum frequencies generated by the second modulators are eliminated. The low-pass filter output goes to an automatic gain control circuit that keeps the composite signal at a constant maximum amplitude regardless of input variations. The controlled composite signal is then provided to the second summing amplifier.

The special service channel allows a non-translated frequency to be added to the 15 data channels and the pilot signal. The input signal is sent through a low-pass filter that limits the frequency to a band lower than the lowest data channel. This channel is used for the synchronizing signal from the Slow Speed Mux.

**AB** The second summing amplifier accepts the composite signal and the output of the special service channel, adds them together and provides them to the S1 Transmitter. This output modulation signal consists of 17 different frequencies: 15 data channel outputs, the pilot signal, and the special service channel output.

**C** The second summing amplifier accepts the composite signal and the output of the special service channel, adds them together, and provides them to the isolation amplifier. The gain of this adjustable amplifier is set at unity. The isolated output signal is then sent to the S1 Transmitter as a modulation

input. This modulation signal consists of 17 different frequencies: 15 data channel outputs, the pilot signal, and the special service channel output.

S1 Telemeter can be calibrated on command from the TM Calibrator during flight or prelaunch checkout. The 28 Vdc command from the TM Calibrator disables the data input to each channel and enables the calibration gate in each channel. This allows a precise calibration signal to be sent to the first modulator instead of the normal measurement data. During flight, the calibration signal is 1.7 kHz, 1 volt peak-to-peak. During prelaunch checkout, the calibration signal is a 0 Hz to 3000 Hz, 1 volt peak-to-peak sweeping frequency and is supplied by the ESE.

#### 2-18 **AB** S1, F1, and F2 RF TRANSMITTERS

These model I, type IV, FM transmitters are identical except for carrier frequency and use. They accept modulating frequencies from S1, F1, and F2 Telemeters respectively. Each transmitter uses a combination of solid-state devices and vacuum tubes to transmit through the RF transmission components. The unit is pressurized to 20 psia.

#### Construction

The transmitter has an aluminum alloy case containing plug-in modules. The unit weighs 13 pounds. It is 3 inches high, 9 inches wide, and 10 inches long. The case is equipped with cooling fins.

#### Function

Each transmitter accepts frequency-intelligent data (see Figure 2-26) from a frequency modulation telemeter or a single sideband telemeter. The unit contains dc-to-dc converter circuitry to produce regulated power for the transmitter and power amplifier subassemblies. The incoming signal is first applied to the solid-state transmitter assembly. The output carrier from the transmitter subassembly is then processed through the power amplifier and low-pass output filter. The carrier has a power of 22 watts and a deviation of 125 kHz. Center frequencies for the

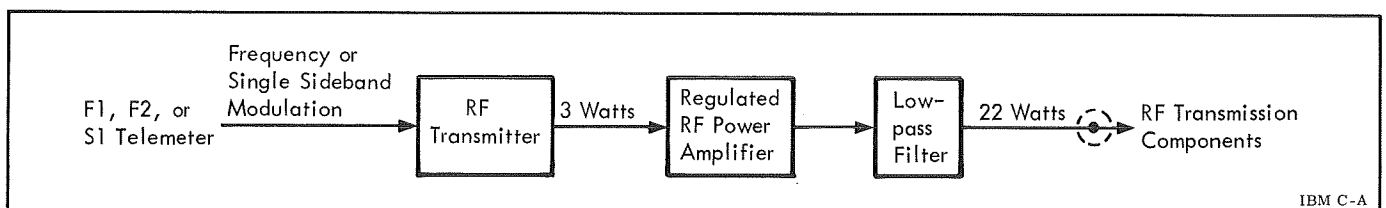


Figure 2-26. **AB** S1, F1, and F2 Transmitter Functional Diagram

transmitters are: S1 - 259.7 MHz; F1 - 250.7 MHz; and F2 - 245.3 MHz.

2-19 **C** S1, F1, AND F2 RF TRANSMITTERS

These model II, type IV, FM transmitters are identical except for carrier frequency and use. They accept modulating frequencies from S1, F1, and F2 Telemeters respectively. Each transmitter uses a combination of solid-state devices and vacuum tubes to transmit through the RF transmission components. The unit is pressurized to 21 psia.

Construction

The transmitter has an aluminum alloy case containing plug-in modules. The transmitter has all solid-state circuitry except for the vacuum tube power amplifier module. The unit is 4 inches high, 11 inches wide, 13 inches long, and weighs 15 pounds. The case is equipped with cooling fins.

Function

Each transmitter accepts frequency-intelligent data (see Figure 2-27) from a frequency modulation telemeter or a single sideband telemeter. The input from the telemeter is first routed through a differential signal adapter or a dummy signal adapter. The differential signal adapter is used only on the F2 Transmitter to adapt the differential output signal of F2 Telemeter to the requirements of the transmitter module. The unchanged signal is then fed through an external connector to the tape recorder. This same signal is then returned by the tape recorder and is used as modulation by the transmitter module. The transmitter module responds with a change in the output frequency of its crystal-controlled carrier in proportion to the input modulation. The power of this signal is then amplified and filtered to result in a carrier of 20 watts and 125 kHz deviation. Center frequencies for the transmitters are: S1 - 259.7 MHz; F1 - 250.7 MHz; and F2 - 245.3 MHz.

2-20 **A** P1 PCM/RF TRANSMITTER

The model CT-19B P1 PCM/RF Transmitter uses the PCM pulse train from the PCM/DDAS

Telemeter as modulation for a vhf carrier. The unit uses a combination of solid-state devices and vacuum tubes to transmit through the RF transmission components.

Construction

The chassis is cast aluminum in the form of an inverted T and acts as a heat sink for the subassemblies. The four subassemblies are each in an aluminum case that is bolted to the chassis. The vhf transmitter subassembly has cooling fins. The P1 Transmitter is 7 inches high, 7 inches wide, 9 inches long, and weighs 15 pounds.

Function

The double-ended pulse train from the PCM/DDAS Telemeter is first fed to a shaper circuit (see Figure 2-28). The shaper forms a pulse train of uniform rise and fall times, and filters out unwanted signals. The pulse train then modulates an FM oscillator that has a center frequency of 9 MHz. The crystal oscillator determines the transmitter frequency. It generates a frequency that is 1/2 the desired output frequency minus 9 MHz (118.55 MHz). The outputs of the FM oscillator and crystal oscillator are then mixed to form a modulated signal of 127.55 MHz. The signal is then frequency doubled and power amplified to form a carrier of 255.1 MHz at 15 watts with a modulation excursion of  $\pm 36$  kHz.

The transitions between the levels of the PCM/DDAS Telemeter binary output are what cause the P1 Transmitter carrier to be deviated. A transition in the positive direction produces a deviation at the high band edge and a transition in the negative direction produces a deviation at the low band edge.

2-21 **BC** P1 PCM/RF TRANSMITTER

The model II P1 PCM/RF Transmitter uses the PCM pulse train from the PCM/DDAS Telemeter as modulation for a vhf carrier. The unit is all solid-state circuitry except for the regulated tube-type power amplifier.

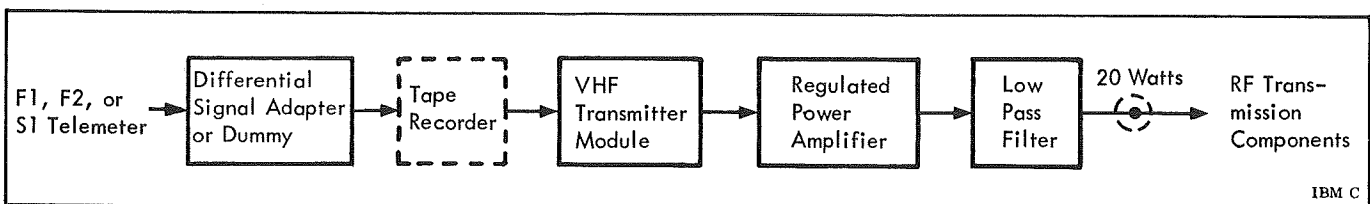


Figure 2-27. **C** S1, F1, and F2 Transmitter Functional Diagram

transmitters are: S1 - 259.7 MHz; F1 - 250.7 MHz; and F2 - 245.3 MHz.

2-19 **C** S1, F1, AND F2 RF TRANSMITTERS

These model II, type IV, FM transmitters are identical except for carrier frequency and use. They accept modulating frequencies from S1, F1, and F2 Telemeters respectively. Each transmitter uses a combination of solid-state devices and vacuum tubes to transmit through the RF transmission components. The unit is pressurized to 21 psia.

Construction

The transmitter has an aluminum alloy case containing plug-in modules. The transmitter has all solid-state circuitry except for the vacuum tube power amplifier module. The unit is 4 inches high, 11 inches wide, 13 inches long, and weighs 15 pounds. The case is equipped with cooling fins.

Function

Each transmitter accepts frequency-intelligent data (see Figure 2-27) from a frequency modulation telemeter or a single sideband telemeter. The input from the telemeter is first routed through a differential signal adapter or a dummy signal adapter. The differential signal adapter is used only on the F2 Transmitter to adapt the differential output signal of F2 Telemeter to the requirements of the transmitter module. The unchanged signal is then fed through an external connector to the tape recorder. This same signal is then returned by the tape recorder and is used as modulation by the transmitter module. The transmitter module responds with a change in the output frequency of its crystal-controlled carrier in proportion to the input modulation. The power of this signal is then amplified and filtered to result in a carrier of 20 watts and 125 kHz deviation. Center frequencies for the transmitters are: S1 - 259.7 MHz; F1 - 250.7 MHz; and F2 - 245.3 MHz.

2-20 **A** P1 PCM/RF TRANSMITTER

The model CT-19B P1 PCM/RF Transmitter uses the PCM pulse train from the PCM/DDAS

Telemeter as modulation for a vhf carrier. The unit uses a combination of solid-state devices and vacuum tubes to transmit through the RF transmission components.

Construction

The chassis is cast aluminum in the form of an inverted T and acts as a heat sink for the subassemblies. The four subassemblies are each in an aluminum case that is bolted to the chassis. The vhf transmitter subassembly has cooling fins. The P1 Transmitter is 7 inches high, 7 inches wide, 9 inches long, and weighs 15 pounds.

Function

The double-ended pulse train from the PCM/DDAS Telemeter is first fed to a shaper circuit (see Figure 2-28). The shaper forms a pulse train of uniform rise and fall times, and filters out unwanted signals. The pulse train then modulates an FM oscillator that has a center frequency of 9 MHz. The crystal oscillator determines the transmitter frequency. It generates a frequency that is 1/2 the desired output frequency minus 9 MHz (118.55 MHz). The outputs of the FM oscillator and crystal oscillator are then mixed to form a modulated signal of 127.55 MHz. The signal is then frequency doubled and power amplified to form a carrier of 255.1 MHz at 15 watts with a modulation excursion of  $\pm 36$  kHz.

The transitions between the levels of the PCM/DDAS Telemeter binary output are what cause the P1 Transmitter carrier to be deviated. A transition in the positive direction produces a deviation at the high band edge and a transition in the negative direction produces a deviation at the low band edge.

2-21 **B** P1 PCM/RF TRANSMITTER

The model II P1 PCM/RF Transmitter uses the PCM pulse train from the PCM/DDAS Telemeter as modulation for a vhf carrier. The unit is all solid-state circuitry except for the regulated tube-type power amplifier.

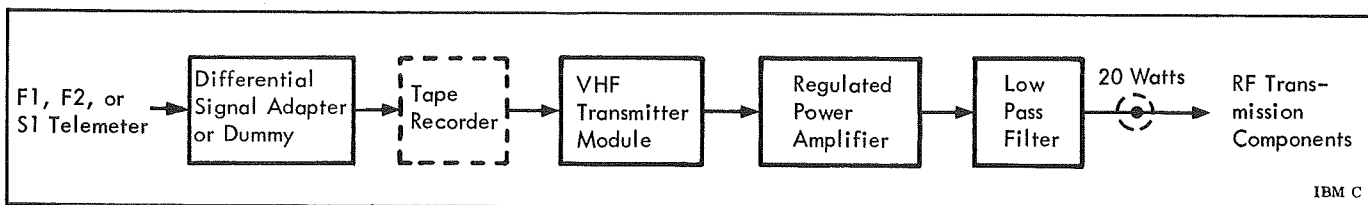


Figure 2-27. **C** S1, F1, and F2 Transmitter Functional Diagram



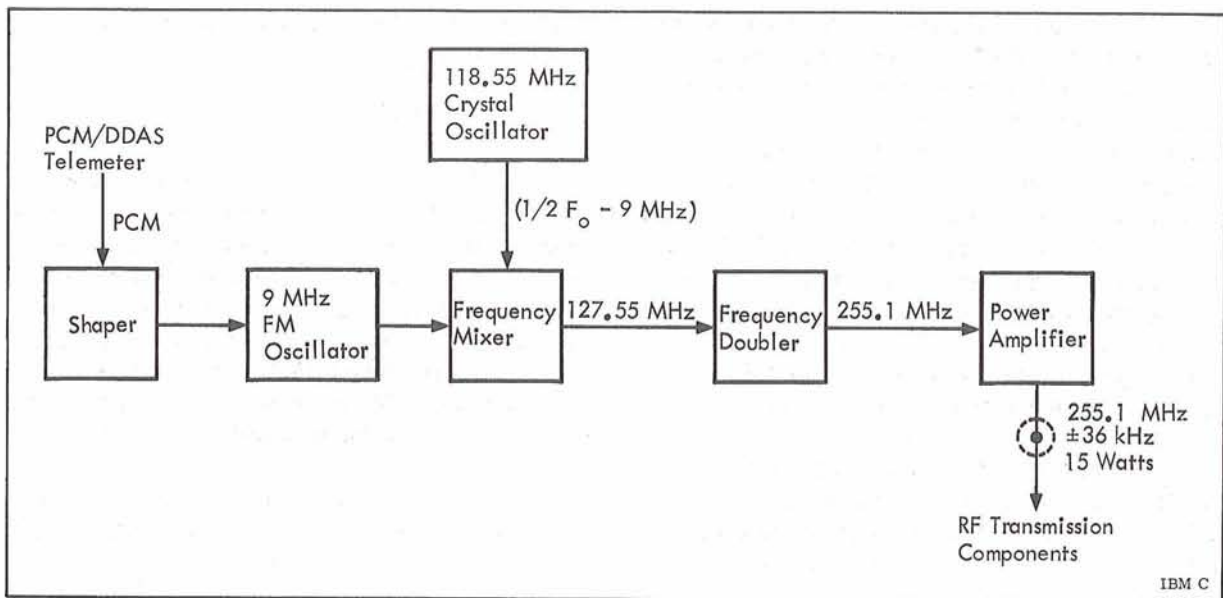


Figure 2-28. A P1 Transmitter Functional Diagram

Construction

The P1 Transmitter has an aluminum alloy case containing plug-in modules. The unit is 4 inches high, 11 inches wide, 13 inches long, and weighs 18 pounds. The case is equipped with cooling fins. The unit is pressurized to 6 psig.

Function

The double-ended pulse train from the PCM/DDAS Telemeter is first fed to the PCM signal conditioner in the P1 Transmitter (see Figure 2-29). This module translates the positive-going and negative-going input excursions into corresponding positive and negative output voltages. This flip-flop circuit maintains the positive or negative voltage output until it is changed by the next input excursion of the opposite polarity. These positive or negative voltages are fed through a jumper plug before being used as the modulation to the transmitter module. The jumper plug is located on an external connector that could furnish the signal to a tape recorder.

The positive level of the two-level input causes the crystal-controlled transmitter module to transmit at its high-band edge, and the negative level at its low-band edge. The power of this carrier is

then amplified and filtered to remove the upper harmonics and spurious frequencies. This results in a carrier of 255.1 MHz with a power of 20 watts.

2-22 C UHF RF TRANSMITTER

The model III UHF Transmitter uses the PCM pulse train from the PCM/DDAS Telemeter as modulation for a uhf carrier. The unit transmits through the CCS RF transmission components.

Construction

The UHF Transmitter has an aluminum-magnesium alloy case containing wired-in modules. The signal adapter module is externally mounted on the case of the unit. The UHF Transmitter is 3 inches high, 5 inches wide, and 15 inches long, exclusive of the signal adapter module which is less than 4 inches in its longest dimension. The unit weighs 19 pounds. All solid-state circuitry is used except for the traveling wave tube power amplifier.

Function

The PCM binary NRZ input from the PCM/DDAS Telemeter first goes to the signal adapter to

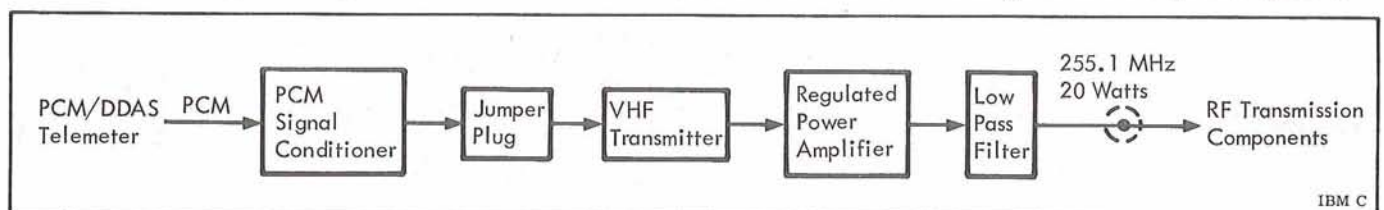


Figure 2-29. BC P1 Transmitter Functional Diagram

reduce the voltage to a range acceptable to the exciter section (see Figure 2-30). The signal adapter is sensitive to only positive or negative excursions of the input. A positive excursion results in a positive output which remains until a negative excursion is felt. A negative excursion results in a negative voltage output which remains until a positive excursion is felt. These two levels cause the 25 MHz VCO to be biased at either its upper or lower band edge. The 25 MHz VCO output goes to the balanced mixer, along with a 164 MHz signal from the crystal oscillator. These two frequencies are summed and sent through a band-pass filter as a modulated 189 MHz carrier. Components in the exciter section are selected to produce the desired output center frequency. The 189 MHz signal is multiplied by a factor of 12, amplified, and filtered to emerge as a 20-watt output at 2277.5 MHz.

### 2-23 RF TRANSMISSION COMPONENTS

The RF transmission components (see Figure 2-31) transfer the carrier signals from the four VHF telemetry transmitters to ground receiving stations. The signals may be radiated through antennas or carried by coaxial cable through the umbilical. The components are the RF Coupler, Coaxial Switch, Coaxial Termination, Power Divider, and two TM Antennas. Although there is an input to the TM RF Coupler of over 80 watts, the antennas only radiate a total of approximately 40 watts. This loss of power

is inherent in the RF transmission components and coaxial wiring.

#### Telemetry RF Coupler

The RF Coupler uses tuned cavities to selectively pass the signals to be coupled. Each carrier input passes through a resonant cavity that is tuned to 1/4 wavelength of the carrier center frequency. The four carriers are then capacitively coupled together and routed to the Coaxial Switch. Since each cavity is tuned to a different center frequency, only the selected carrier frequency may pass. The RF Coupler is sealed at atmospheric pressure.

The RF Coupler used on Saturn IB is a model 432. It is 5 inches high, 4 inches wide, 12 inches long, and weighs 3 pounds.

The RF Coupler used on Saturn V is a model 451. It is 7 inches high, 8 inches wide, 13 inches long, and weighs 11 pounds. For S-IU-501, a model 432 is used instead of a model 451.

#### Coaxial Switch

The Coaxial Switch routes the composite carrier signals either through the antennas or through the coaxial termination. The switch is spring loaded to the antenna position and can be controlled only through the umbilical. Therefore, after umbilical

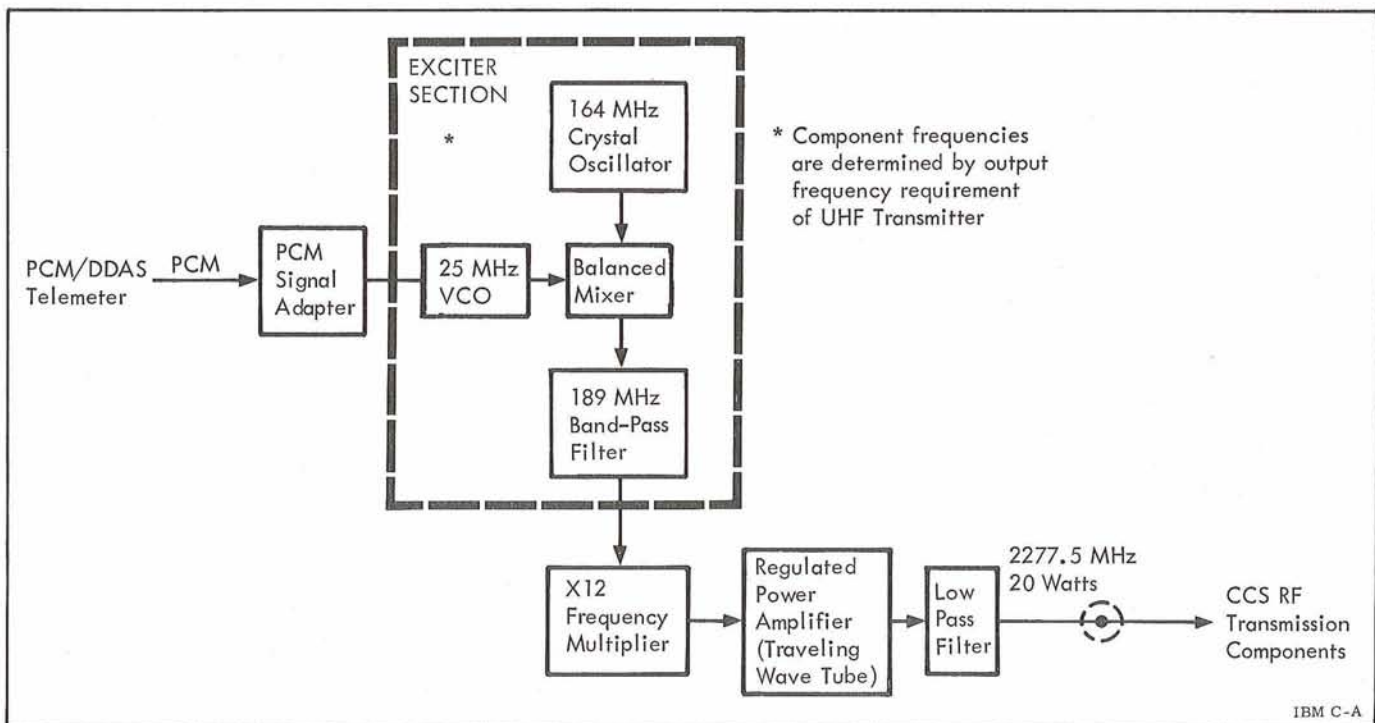


Figure 2-30. UHF Transmitter Functional Diagram

disconnection, it can only be in the antenna position. The Coaxial Switch is less than 4 inches in its longest dimension and weighs 1 pound. The unit is sealed at atmospheric pressure.

Telemetry Power Divider

The model 221 Power Divider equally divides the composite carrier signal from the Coaxial Switch and routes this signal to the two TM Antennas. The Power Divider also provides impedance matching. The unit is 2 inches high, 3 inches wide, 9 inches long, and weighs 1 pound.

Telemetry Antennas

The two TM Antennas (model 219 for S-IU-202, and model 223 for all others) radiate the telemetry carrier to ground receiving stations. They are stub antennas mounted 180 degrees apart on the external surface of the IU to provide an omni-directional pattern about the launch vehicle roll axis. Each antenna is 5 inches high, 7 inches wide, 15 inches long, and weighs 6 pounds.

Coaxial Termination

The Coaxial Termination is used during pre-launch checkout to allow the telemetry transmitters

to broadcast their information without radiating through the antennas. The termination receives its input through the normally open contacts of the Coaxial Switch. The input rf signal is dissipated and grounded through a load resistor. A small coil inserted into the electromagnetic field around the load resistor inductively picks off a small portion of the input signal. This low-wattage signal is then routed to ground receiving stations through the umbilical. The unit is 4 inches high, 5 inches wide, 12 inches long, and weighs 4 pounds.

**2-24 LAUNCH COMPLEX EQUIPMENT**

The Instrumentation System launch complex equipment consists of that equipment necessary to (1) control and calibrate airborne instrumentation components, (2) receive and decode instrumentation data, and (3) record and display the decoded instrumentation data. Much of this equipment is shared with other systems therefore this manual covers only the instrumentation function of the equipment.

Instrumentation System equipment for each launch complex consists of the IU Measuring & Tracking Panel, Telemetry Ground Station, Measuring Station, and analog recorders in the firing room of the Launch Control Center (LCC). For Saturn IB, this equipment is located at Launch Complex 34 and

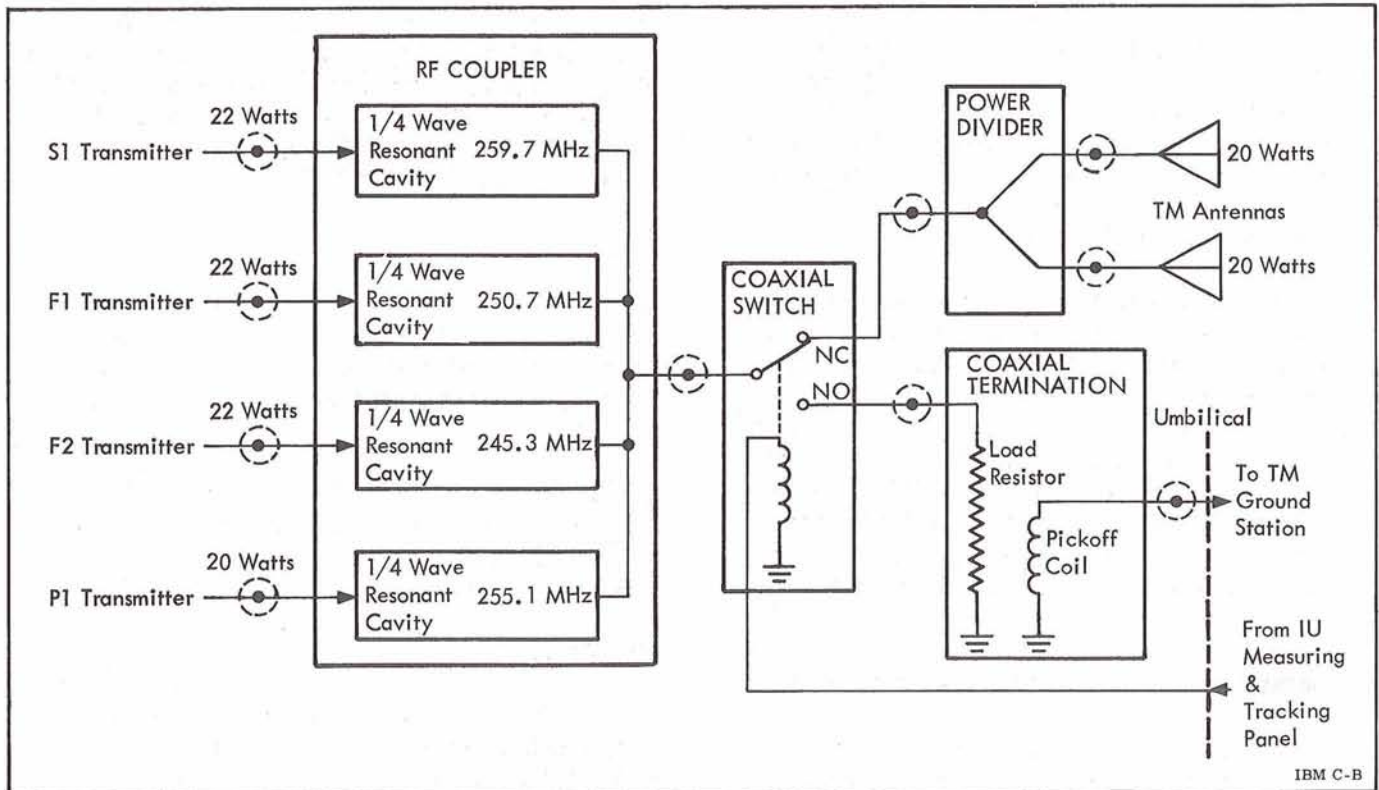


Figure 2-31. RF Transmission Components Functional Diagram

Launch Complex 37, and for Saturn V it is located at Launch Complex 39. Figures 2-32 and 2-33 show how the Instrumentation System relates to other equipment within and without the launch complex. The Saturn IB and Saturn V launch complexes use different types of equipment for the Instrumentation System, but functionally they are almost identical.

The Central Instrumentation Facility (CIF), located on Merritt Island, is the main instrumentation data receiving station for KSC. This facility houses the myriad equipment necessary to receive and decode data from the many space programs. CIF can interchange data with the Manned Spacecraft Center in Texas and Marshall Space Flight Center in Alabama. The LCC DDAS Station and Telemetry Ground Station are linked with CIF via a two-way carrier transmission system. The LCC and CIF interchange the outputs of the telemetry receivers.

Each launch complex has an area equipped with test gear to bench-check and repair airborne telemetry components. Coaxial connections are provided to the Telemetry Ground Station to enable that station to be used in component checkout. At LC-34 this area is located in the Support Building, at LC-37 it is in the Service Structure, and at LC-39 it is in the same LCC room with the Telemetry Ground Station.

#### 2-25 IU MEASURING & TRACKING PANEL

The IU Measuring & Tracking Panel (see Figure 2-34) furnishes manual power control and status display of the Instrumentation System and Tracking System airborne components. The panel is located in an electrical equipment rack in the LCC Firing Room. This technical manual will not discuss the Tracking portion of the panel.

The controls and indicators on this panel perform the functions listed in Table 2-4. The panel is used during checkout and launch to manually control the airborne components. It is used in place of, or to augment automatic checkout by the Launch Computer Complex. To enable automatic checkout, the switches on the panel are set to the AUTO position. This allows the Launch Computer Complex to control the functions of the panel. Most of the status indications are supplied to the panel via telemetry and/or DDAS.

#### 2-26 SATURN IB TELEMETRY GROUND STATION

The Saturn IB Telemetry Ground Station, located downstairs in the LCC, receives, decodes,

and displays all instrumentation data from the launch vehicle. It has a receiver for each telemetry link in the IU, S-IVB, and S-IB. The remainder of the decoding and display equipment is shared by the three stages. The station is used to check out the on-board instrumentation equipment and to support the pre-launch checkout of the launch vehicle. This technical manual will describe only the IU functions of the Telemetry Ground Station.

The station consists of 15 racks of signal processing and test equipment. The station has a liberal complement of plug-in and switch-operated patch panels to allow any signal to be routed to any place that it might be necessary. Many pieces of rack-mounted test equipment are included in the station to test the incoming signals and the station processing equipment. Only general signal processing paths are described by this technical manual.

The station can receive the vhf telemetry rf signals via the hardline coax through the umbilical, or from the helix antenna mounted on the LCC roof (see Figure 2-35). The signals are attenuated as necessary and furnished to all receivers. An rf path is also furnished from the telemetry component checkout area to assist in bench checks of airborne components. The uhf telemetry rf signal is supplied via the RF Racks.

A receiver reverses the function performed by a telemetry transmitter. Each receiver supplies several outputs, taken from different stages within the receiver. These signals range from the if. stage output, down in frequency to the demodulated or video output.

#### IF. Output

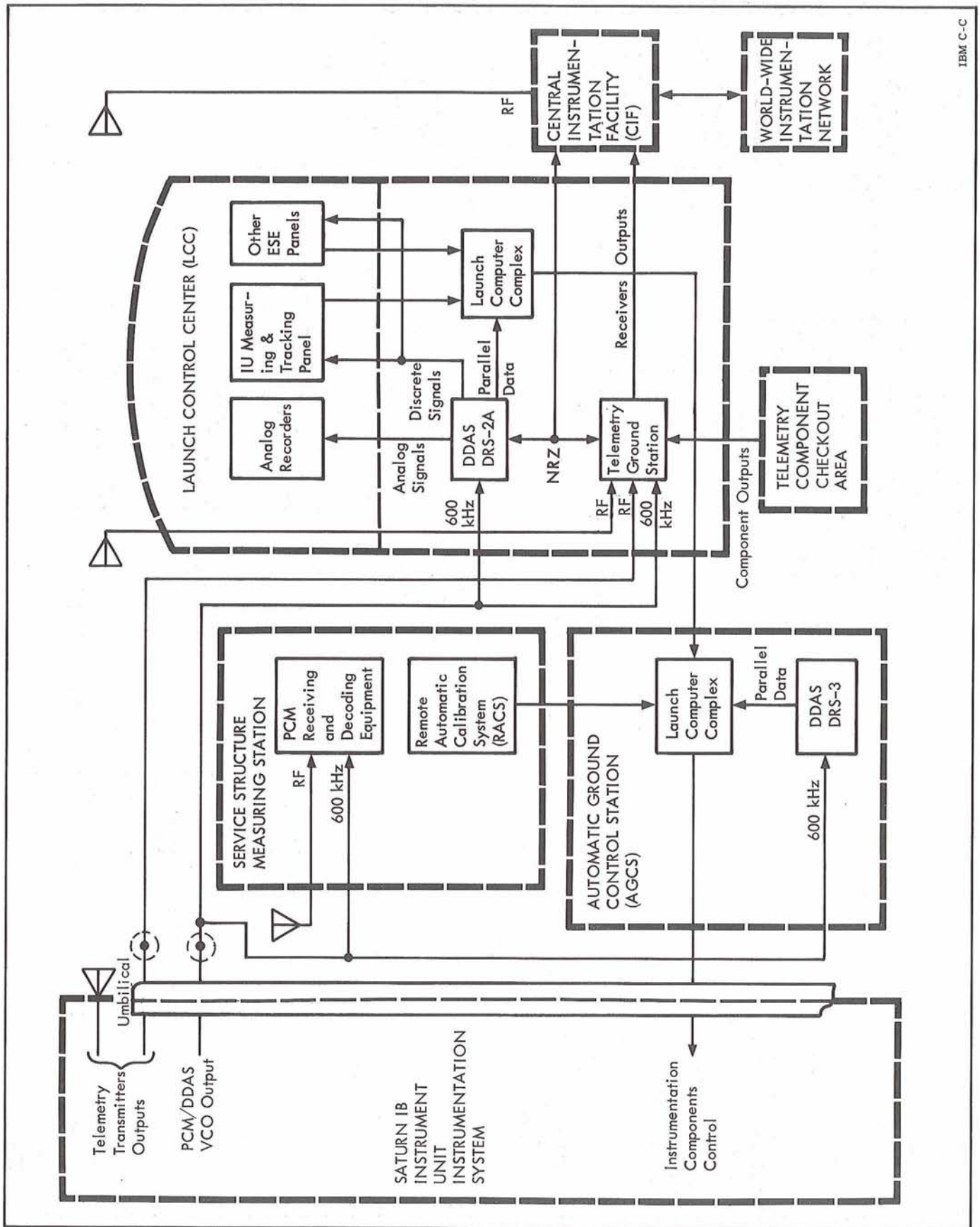
The if. output is taken from the 30 MHz intermediate frequency stage. This signal is sent to test equipment that evaluates and displays the characteristics of the incoming rf signal.

#### AGC Output

The agc output is a dc signal that is proportional to the input signal strength. These signals are routed to display meters.

#### Pre-D Output

The pre-d output is the down-converted pre-detection signal which has a center frequency of 450 kHz. The pre-d signal is sent to the tape



IBM C-C

Figure 2-32. Saturn IB Launch Complex Instrumentation Equipment Block Diagram

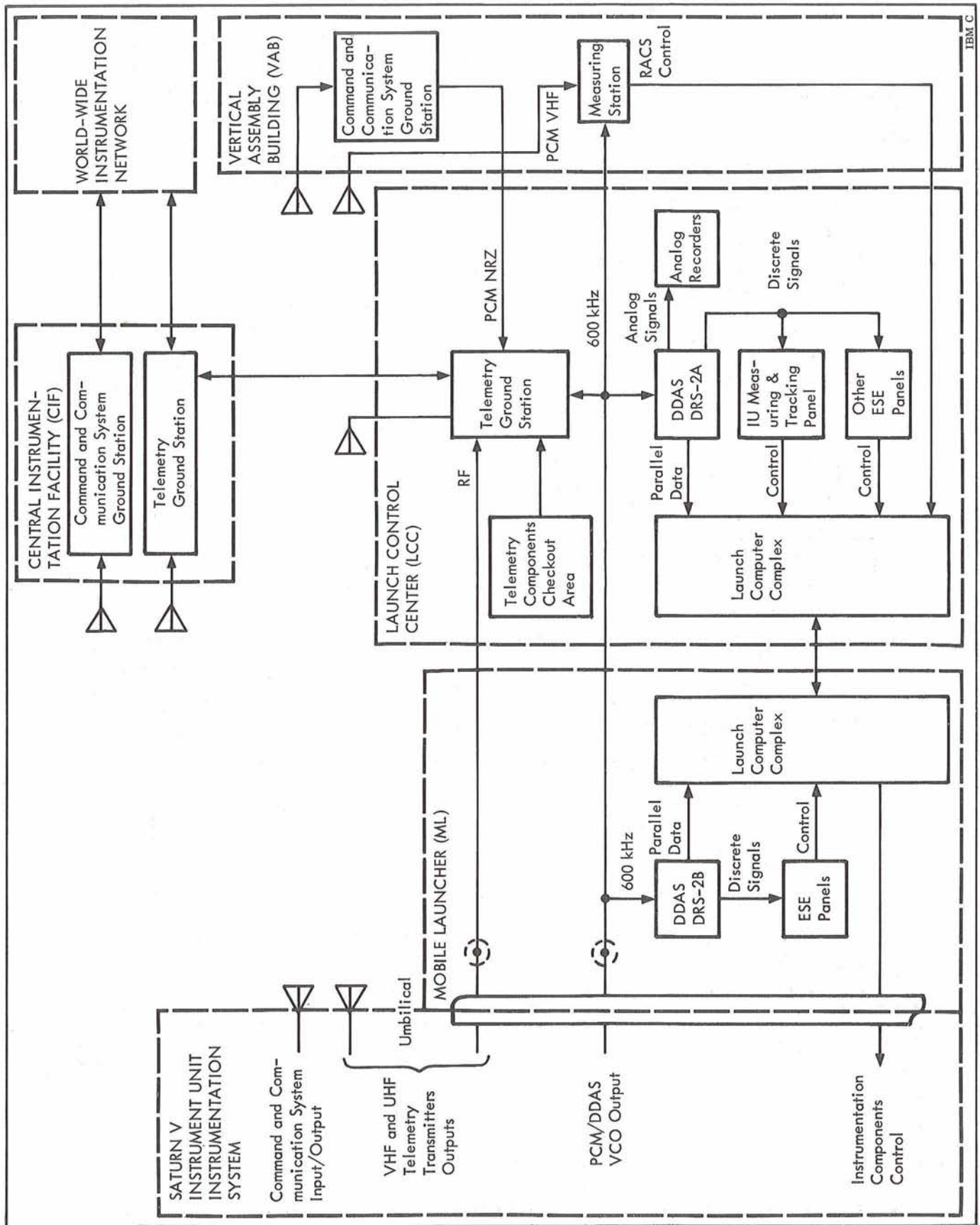


Figure 2-33. Saturn V Launch Complex Instrumentation Equipment Block Diagram

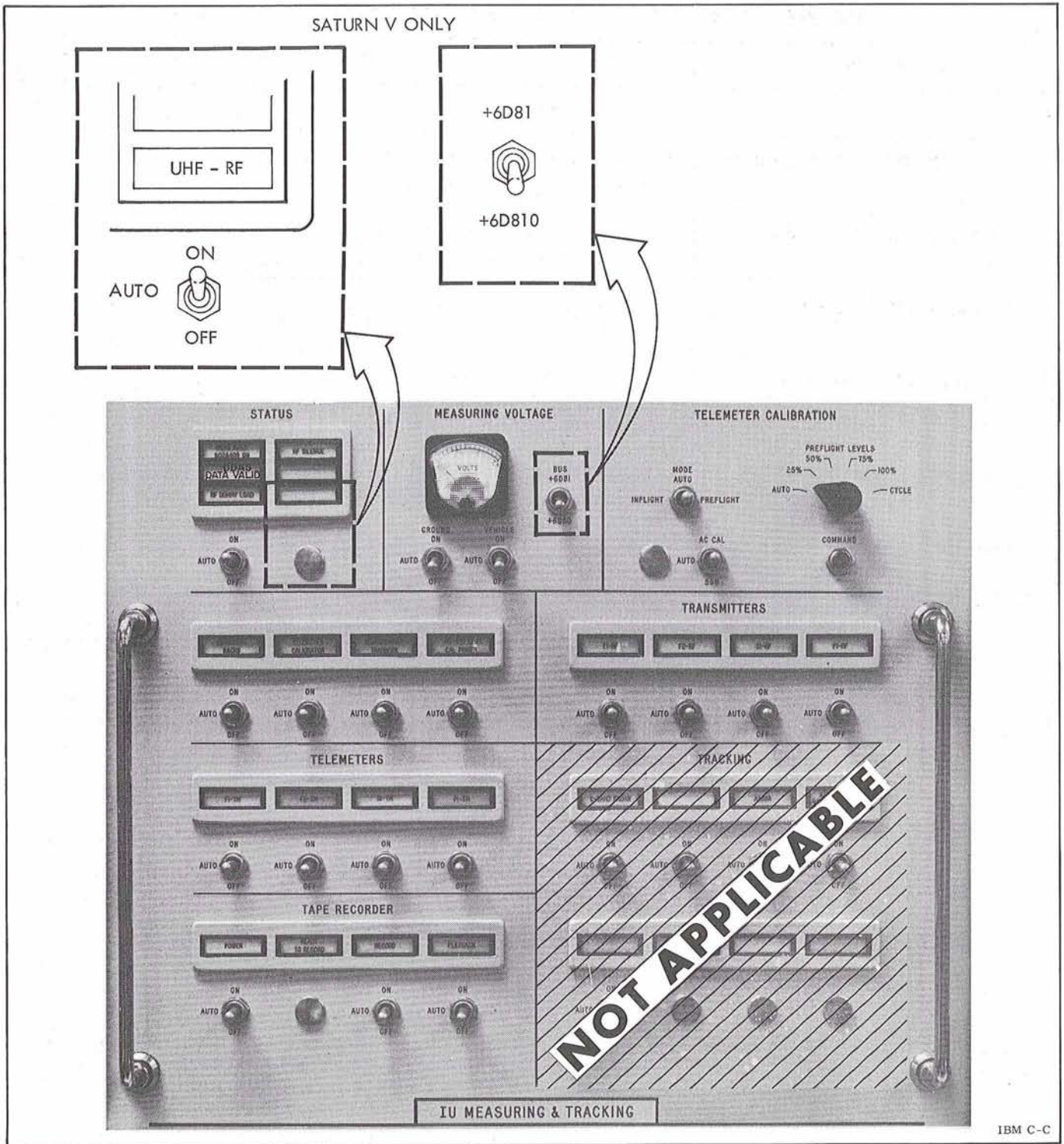


Figure 2-34. IU Measuring & Tracking Panel

Table 2-4. IU Measuring & Tracking Panel Control and Indicator Functions

Control or Indicator	Function
STATUS	
<p>MEAS RACK 602A408 ON indicator</p> <p>DDAS DATA VALID indicator</p> <p>RF DUMMY LOAD switch</p> <p>RF DUMMY LOAD indicator</p> <p>RF SILENCE indicator</p> <p><input type="checkbox"/> UHF-RF switch</p> <p><input type="checkbox"/> UHF-RF indicator</p>	<p>*Lights green indicating that 28 Vdc operating power has been applied to Measuring Rack A408.</p> <p>Lights green indicating that the DDAS ground station is synchronized with the input data.</p> <p>Switches the transmitter outputs to the Coaxial Termination instead of the TM Antennas.</p> <p>Lights green indicating that a command has been sent to the Coaxial Switch to switch the transmitter outputs to the Coaxial Termination instead of the TM Antennas.</p> <p>Lights red indicating that power to all airborne transmitting components has been disabled.</p> <p>Controls 28 Vdc operating power to UHF Transmitter.</p> <p>*Lights green indicating that 28 Vdc operating power has been applied to UHF Transmitter.</p>
MEASURING VOLTAGE	
<p>GROUND switch</p> <p>VEHICLE switch</p> <p>BUS switch</p> <p>Voltmeter</p>	<p>Controls 5 Vdc power to ESE recording and receiving equipment.</p> <p>Controls 28 Vdc operating power to the 5 V Supply.</p> <p>Selects the input to the voltmeter. *The +6D81 position monitors the airborne measuring voltage. The +6D80 (Saturn IB) position monitors the ESE measuring voltage. The +6D810 (Saturn V) position monitors the ESE measuring voltage.</p> <p>Monitors the voltage of either airborne or ESE measuring voltage.</p>
TELEMETER CALIBRATION	
<p>MODE switch</p> <p>AC CAL - SSB switch</p>	<p>Selects the mode of operation for airborne telemetry calibration. The INFLIGHT position allows the normal inflight calibration to be performed on command. The PREFLIGHT position allows telemetry calibration of individual airborne components to be controlled manually from the panel.</p> <p>During preflight calibration, selects whether calibration of F1 and F2 Telemeters or S1 Telemeter will be performed. The AC CAL position allows a 100 Hz signal to be applied to the VCO channels in F1 and F2 Telemeters. The SSB position allows a sweeping signal of 0 to 3000 Hz to be applied to the S1 Telemeter channels.</p>



Table 2-4. IU Measuring & Tracking Panel Control and Indicator Functions (Cont)

Control or Indicator	Function
PREFLIGHT LEVELS switch	During preflight calibration, selects the percentage of 5 Vdc to be applied to F1 and F2 Telemeters. The CYCLE position allows a continuously stepping voltage to be applied.
COMMAND pushbutton	Initiates the calibration commands that have been selected by the other switches.
MEASURING RACKS switch	Controls 28 Vdc operating power to all Measuring Racks.
MEASURING RACKS indicator	*Lights green indicating 28 Vdc operating power has been applied to Measuring Racks A401 through A407 and A409.
TELEMETER CALIBRATOR switch	Controls 28 Vdc operating power to the TM Calibrator and TM Calibrator Controller.
TELEMETER CALIBRATOR indicator	*Lights green indicating 28 Vdc operating power has been applied to the TM Calibrator and TM Calibrator Controller.
MEASUREMENT TRANSFER switch	Controls measurement routing relays in Measuring Distributors A3 and A4. Airborne measurements that are normally transmitted by F1 or F2 Telemeters are switched to the DDAS path for use by ground checkout equipment. When in the ON position, measurements are removed from DDAS path.
MEASUREMENT TRANSFER indicator	*Lights green indicating F1 and F2 Telemeter measurements have been switched to DDAS.
AC 400 CPS CAL POWER switch	Applies an ESE 115 Vac, 400 Hz signal to the Measuring Racks for use in measurements calibration.
AC 400 CPS CAL POWER indicator	Lights green indicating the ESE 115 Vac, 400 Hz signal has been sent to the Measuring Racks.
TRANSMITTERS	
F1-RF switch	Controls 28 Vdc operating power to F1 Transmitter.
F1-RF indicator	*Lights green indicating that 28 Vdc operating power has been applied to F1 Transmitter.
F2-RF switch	Controls 28 Vdc operating power to F2 Transmitter.
F2-RF indicator	*Lights green indicating that 28 Vdc operating power has been applied to F2 Transmitter.
S1-RF switch	Controls 28 Vdc operating power to S1 Transmitter.
S1-RF indicator	*Lights green indicating that 28 Vdc operating power has been applied to S1 Transmitter.
P1-RF switch	Controls 28 Vdc operating power to P1 Transmitter.

Table 2-4. IU Measuring & Tracking Panel Control and Indicator Functions (Cont)

Control or Indicator	Function
P1-RF indicator	*Lights green indicating that 28 Vdc operating power has been applied to P1 Transmitter.
<b>TELEMETERS</b>	
F1-TM switch	Controls 28 Vdc operating power to F1 Telemeter.
F1-TM indicator	*Lights green indicating that 28 Vdc operating power has been applied to F1 Telemeter.
F2-TM switch	Controls 28 Vdc operating power to F2 Telemeter and F2 Mux.
F2-TM indicator	*Lights green indicating that 28 Vdc operating power has been applied to F2 Telemeter and F2 Mux.
S1-TM switch	Controls 28 Vdc operating power to S1 Telemeter and Slow Speed Mux.
S1-TM indicator	*Lights green indicating that 28 Vdc operating power has been applied to S1 Telemeter and Slow Speed Mux.
P1-TM switch	Controls 28 Vdc operating power to PCM/DDAS Telemeter, P1 Mux, RDM-K, RDSM ( <b>AB</b> ), RDM-J ( <b>C</b> ), and CIU ( <b>BC</b> ).
P1-TM indicator	*Lights green indicating that 28 Vdc operating power has been applied to PCM/DDAS Telemeter, P1 Mux, RDM-K, RDSM ( <b>AB</b> ), RDM-J ( <b>C</b> ), and CIU ( <b>BC</b> ).
<b>TAPE RECORDER</b>	
POWER switch	Controls 28 Vdc operating power to the airborne Tape Recorder.
POWER indicator	*Lights green indicating that 28 Vdc operating power has been applied to the Tape Recorder.
READY TO RECORD indicator	Lights green indicating that the airborne Tape Recorder's tape is at the beginning of the reel.
RECORD switch	Command the airborne Tape Recorder to start recording in a forward direction.
RECORD indicator	*Lights green indicating that a record command has been sent to the tape recorder.
PLAYBACK switch	Commands the airborne Tape Recorder to play back in a reverse direction.
PLAYBACK indicator	*Lights green indicating that a forward playback command has been sent to the Tape Recorder.

Table 2-4. IU Measuring & Tracking Panel Control and Indicator Functions (Cont)

Control or Indicator	Function
TRACKING  (Not applicable to this technical manual)	
*Indication is routed from the airborne Instrumentation System to the IU Measuring & Tracking Panel through telemetry and/or DDAS.	

recorder and can be patched to the CIF interface. The signal can also be sent to a pre-d demodulator and used in place of the video output.

Video Output

The detected video is the final output of the receiver. This signal is processed through subsequent demodulating/decoding equipment in the station and is routed to the CIF interface. The signal may be sent to the tape recorder.

The video output from the receiver will follow one of three general signal processing paths. The particular path depends on whether the data originated as PCM/FM data, FM/FM data, or SS/FM data.

PCM/FM Data

The PCM/FM receiver video output is the same as the telemetry output of the PCM/DDAS Telemeter. This NRZ signal is fed to the TRS-1 DDAS station to regain the identity of the individual measurements. If a 600 kHz demodulator is used, the TRS-1 can receive the DDAS output from the vco in the PCM/DDAS Telemeter.

A patching arrangement will allow the video NRZ to be furnished to the LCC DDAS Station, or the NRZ from the LCC DDAS Station to be fed to the TRS-1. This allows both stations to operate during prelaunch or postlaunch.

The TRS-1, in effect, reverses the functions of the PCM/DDAS Telemeter, P1 and F2 multiplexers, the RDM, and the RDSM. This station is assembled to supply only analog measurement outputs. These measurements can be furnished to analog paper recorders or displayed for real time readout.

FM/FM Data

The FM/FM receiver video output is the same as the output from F1 Telemeter or F2 Telemeter. The video signal is sent to frequency discriminators and, if necessary, to PAM decommutation equipment. The discriminators reverse the functions of the F1 and F2 Telemeters. The discriminators provide analog measurement signals to the recording and display equipment or a PAM pulse train that is the same as F2 Multiplexer output. The pulse train can be fed to the synchronizer for recording or display as a pulse train, or through a decommutator for recording or display as individual measurements.

2-27 SATURN V TELEMETRY GROUND STATION

The Saturn V Telemetry Ground Station, located in room 2P10 of the LCC, receives, decodes, and displays all instrumentation data from the launch vehicle. The station is used to check out the on-board IU, S-IVB, S-II, and S-IC instrumentation equipment and to support the prelaunch checkout of the vehicle. This technical manual will describe only the IU functions of the Telemetry Ground Station.

The station consists of signal processing and test equipment physically divided into six separate groups or modules. There is a module for equipment that is used only with the IU, a module each for the S-IVB, S-II, and S-IC, a module for equipment that is common to all stages, and a module to house the equipment that interfaces between the station and the Central Instrumentation Facility. Except for this physical division, the station is very similar to the Saturn IB Telemetry Ground Station. Figure 2-36 is a functional diagram of the Saturn V station.

SS/FM Data

The SS/FM receiver video output is the same as the output from S1 Telemeter. This video signal

is sent to the SS/FM demultiplexer which, in effect, reverses the function of S1 Telemeter. The SS/FM demultiplexer supplies the 15 data channels and the special service channel. The special service channel carries time correlation data for the switching functions of the Slow Speed Mux. This signal is sent through a special discriminator to detect the switching data. The switching data and measurement data are sent on to the display and recording equipment.

#### 2-28 SATURN IB MEASURING STATION

The Saturn IB Measuring Station, located in the service structure, monitors, calibrates, and records all launch vehicle measurements. The Measuring Station has a receiver for each stage of the launch vehicle that will receive and demodulate that stage's PCM/FM output and DDAS output. This allows the station to receive the PCM data via the DDAS or rf paths. The station also contains the RACS equipment to send calibration commands to the Measuring Racks and verify that the calibrated measurement is correct. This technical manual will describe only the IU functions of the Measuring Station.

Measurements that cannot be transmitted by DDAS, that is SS/FM and FM/FM measurements, must be monitored and calibrated manually. This is done by using portable test equipment in the launch vehicle, and calibrating each measurement separately. This portable equipment is located at the Measuring Station when not in use.

The functions of the station can be performed automatically by the SDS 910 Computer (see Figure 2-37). This computer can cause the RACS to send calibration commands to the onboard measurements. The P1 receiver/demodulator will receive the measurements' calibrated outputs and furnish them to the DDAS station in NRZ serial form. This NRZ digital data is broken down to the individual measurements by the DDAS station. Selected measurements can be displayed on meters or recorded on analog recorders.

The DDCS serves as a reference for each measurement. It contains the voltage level that each measurement should read when calibrated. When the SDS 910 Computer receives the calibrated data from the DDAS station, it compares this to the data from the DDCS. If the calibrated data is not at the proper level, the computer delivers a printout of the erroneous measurement.

#### 2-29 SATURN V IU MEASURING STATION

The Saturn V IU Measuring Station, located on level 27 of the VAB, monitors, calibrates, and records all IU measurements. There are Measuring Stations on other levels for the other vehicle stages. Each Measuring Station can handle its respective stage of a vehicle in any high-bay position or on any LC-39 launch pad. The IU Measuring Station can receive the P1 telemetry rf link and the DDAS link. The station also contains the RACS equipment to send calibration commands to the Measuring Racks and verify that the calibrated measurement is correct.

The functions of the station can be performed automatically by the Launch Computer Complex (see Figure 2-38). This computer can cause the RACS to send calibration commands to the onboard measurements. The P1 receiver/demodulator will receive the measurements' calibrated outputs and furnish them to the DDAS station in NRZ serial form. This NRZ digital data is broken down to the individual measurements by the DDAS station. Selected measurements can be displayed on meters or recorded on analog recorders. If the calibrated data is not at the proper level, a printout of the erroneous measurement is delivered.

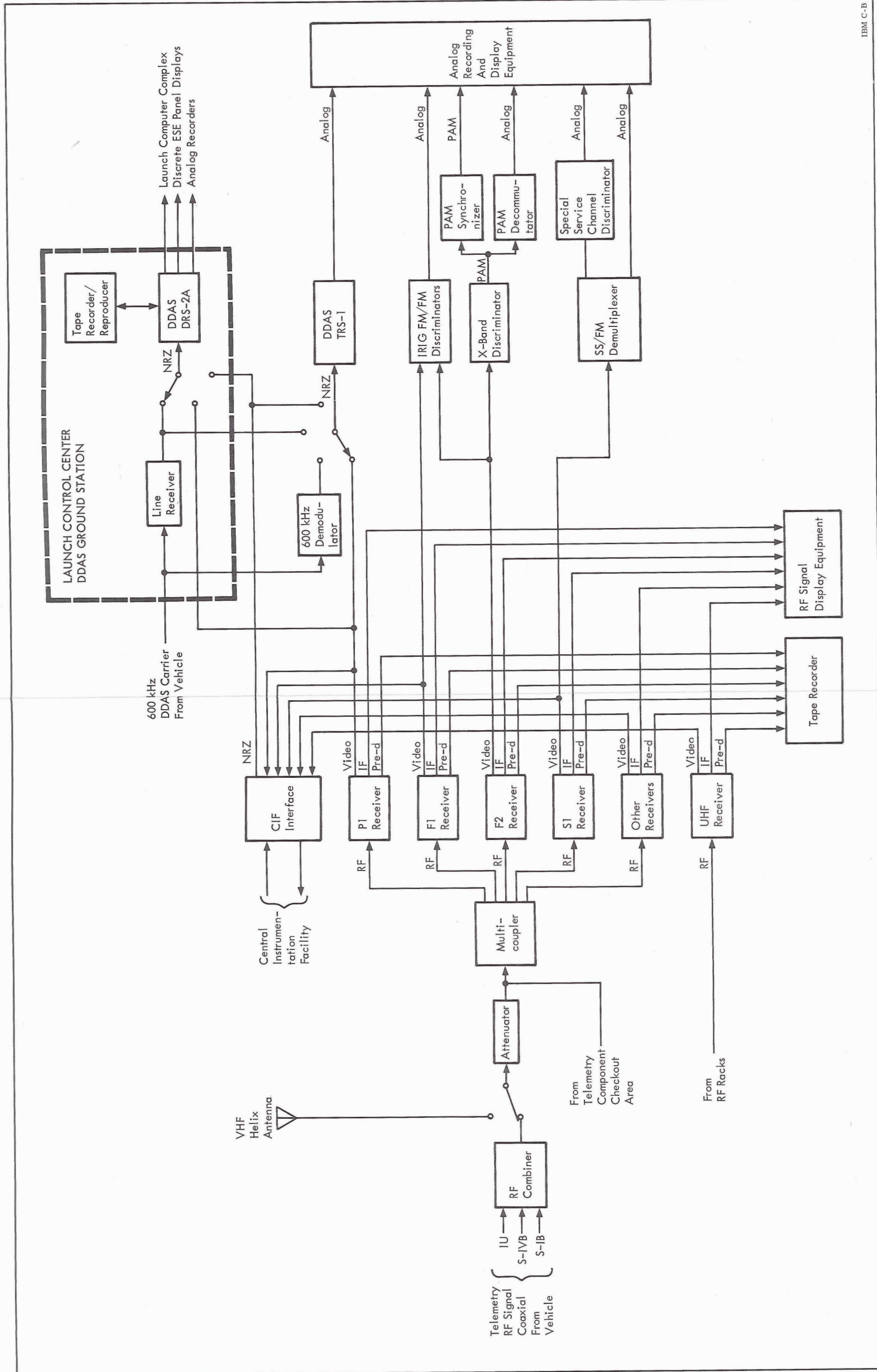
The Saturn V RACS equipment is physically different from the Saturn IB equipment but it performs the same function.

#### 2-30 SATURN IB REMOTE AUTOMATIC CALIBRATION SYSTEM (RACS) EQUIPMENT

The Saturn IB RACS equipment provides a means of manually performing the measurements calibration. This equipment can select any channels of the airborne Measuring Racks, and cause those channels to be stimulated by a known input. This function is normally performed by the Launch Computer Complex, but can be performed manually to check out individual measurement channels.

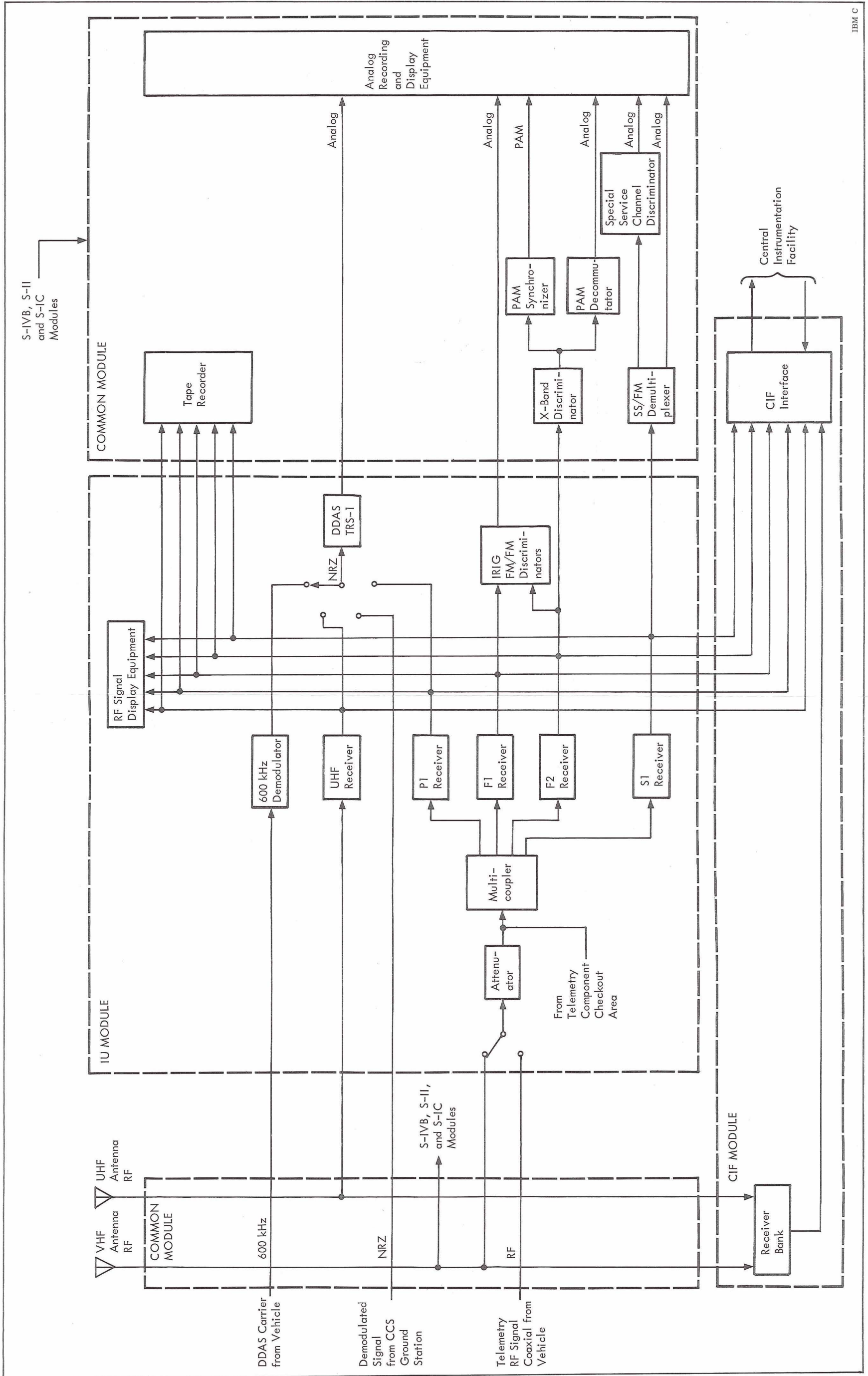
The RACS equipment consists of two main portions - the RACS Control Panel for commanding the operation, and the RACS Display Panel for observing the status of the Measuring Rack channels as commanded from the RACS Control Panel.

The RACS Control Panel has a calculator-type keyboard (see Figure 2-39) that enables rapid selection of individual channels to be calibrated. Keys in the RACS section are depressed to select one or all Measuring Racks to be subject to calibration. Keys



IBM C-B

Figure 2-35. Saturn IB Telemetry Ground Station Functional Diagram



IBM C

Figure 2-36. Saturn V Telemetry Ground Station Functional Diagram

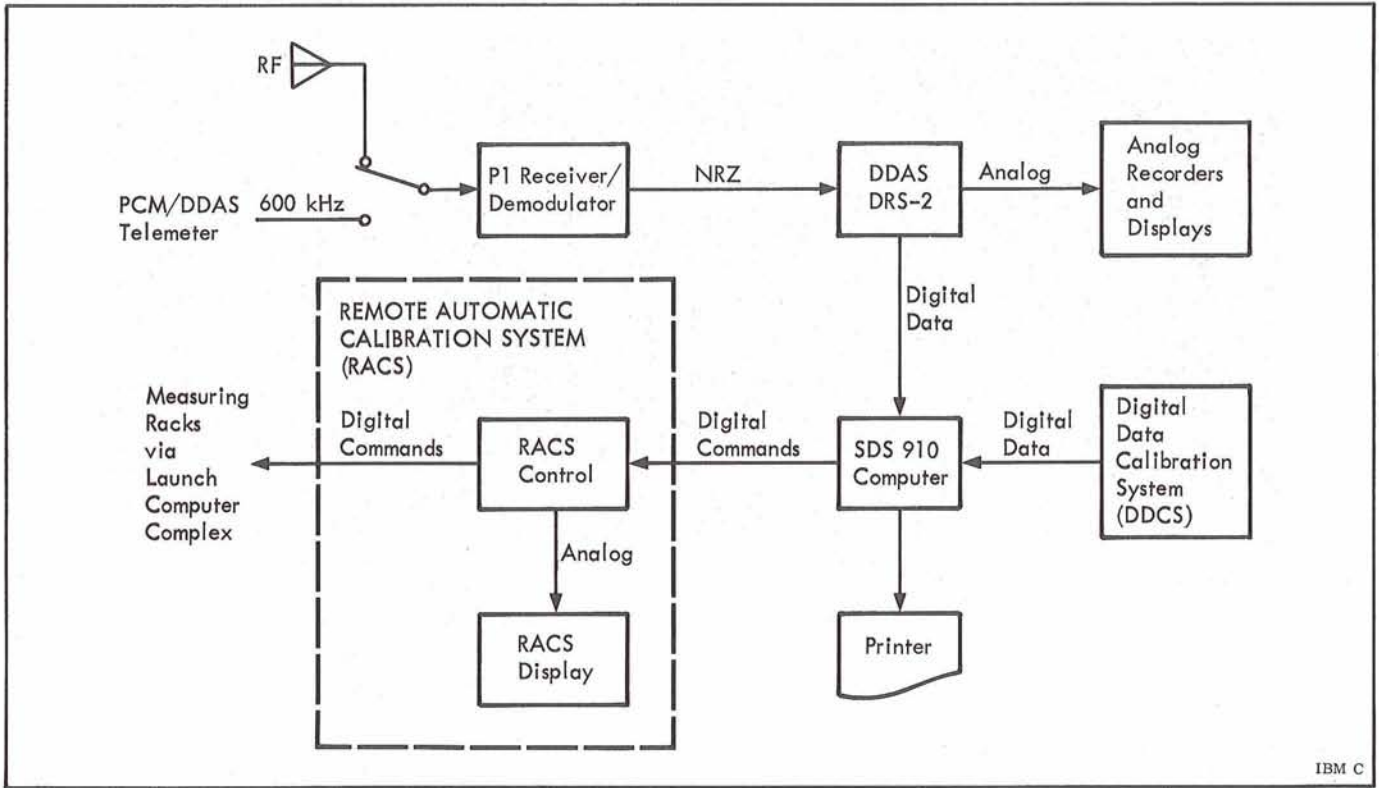


Figure 2-37. Saturn IB Measuring Station Functional Diagram

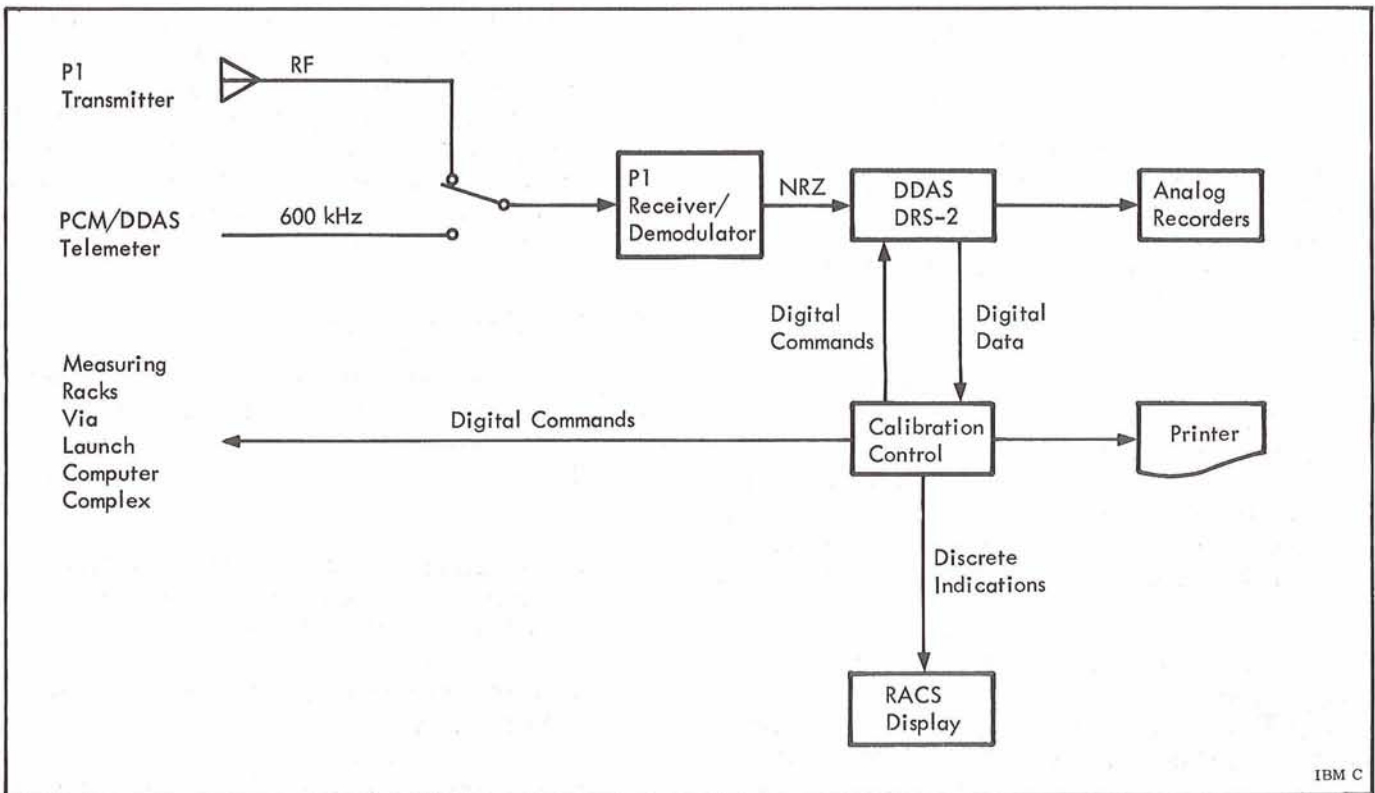


Figure 2-38. Saturn V Measuring Station Functional Diagram

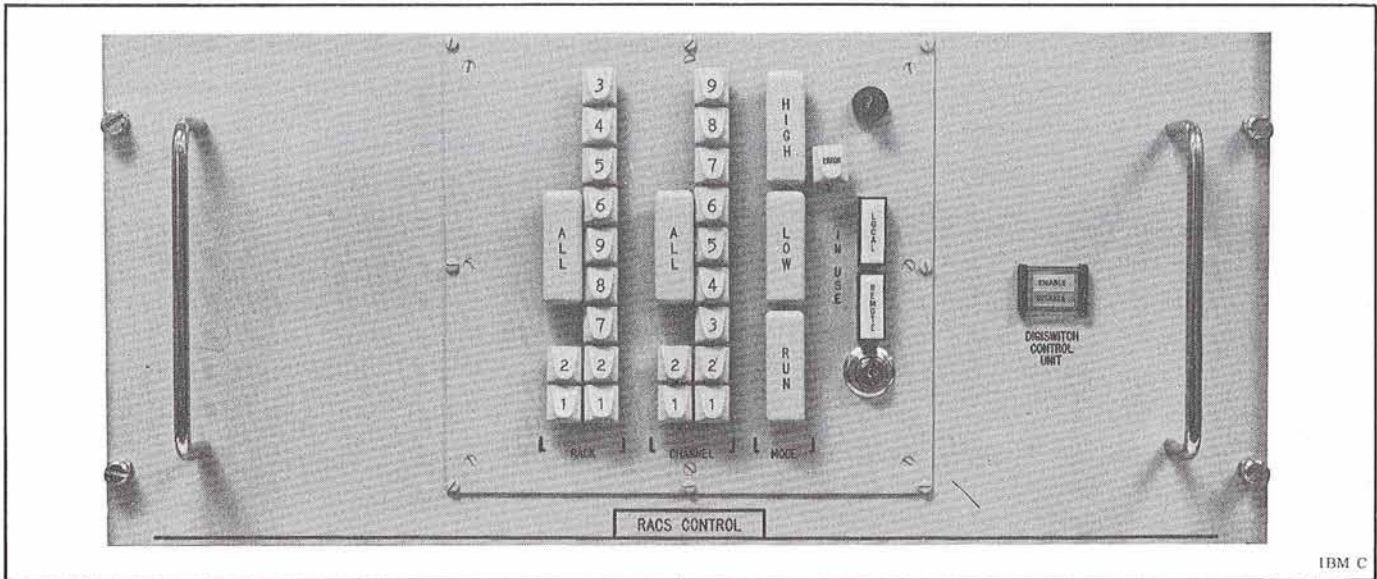


Figure 2-39. Saturn IB RACS Control Panel

in the CHANNEL section are depressed to select one channel or all channels to be subject to calibration. Keys in the MODE section are depressed to select the mode of calibration for the selected Measuring Rack channels. A rack or channel setup error can be corrected by depressing the ERROR key and re-entering the correct rack and channel information before depressing a mode key.

As more than one RACS Control Panel can be used at the launch complex, an IN USE indicator will light if the RACS is in use, and will show whether the panel being observed is in use (LOCAL) or another panel (REMOTE). The observed panel is electrically disabled if the REMOTE indicator is lit.

All three commands must be selected before the calibration command will leave the RACS Control Panel. This is ensured by letting the mode command also enable the other two commands. After a command is sent, the panel resets itself in approximately 0.25 seconds and is ready for a new selection.

The RACS Display Panel consists of a matrix of indicators that display the mode status of each channel in all Measuring Racks. This panel displays the status that the channels should be in, as commanded from the RACS Control Panel or the Launch Computer Complex.

## 2-31 DIGITAL DATA ACQUISITION SYSTEM (DDAS) GROUND STATIONS

A DDAS Ground Station receives PCM data from the airborne PCM/DDAS Telemeter and processes this data into a form readily usable by other portions of the ESE checkout and launch equipment. The station is assembled in several configurations to meet different input and output requirements. Several different configurations are used at the launch complexes to support IU operations. Either all or part of these launch complex stations may at times be used to support other than IU operations, but the following discussion is limited to IU support functions.

### General Functional Description

A DDAS Ground Station may be assembled to receive serial PCM data, PCM/FM data, or both (see Figure 2-40). Possible inputs to a station are as follows:

- An NRZ serial train of PCM digital data that has been previously demodulated by a receiver external to the station.
- A 600 kHz carrier modulated by the PCM NRZ serial train.
- A telemetry frequency carrier modulated by the PCM NRZ serial train.



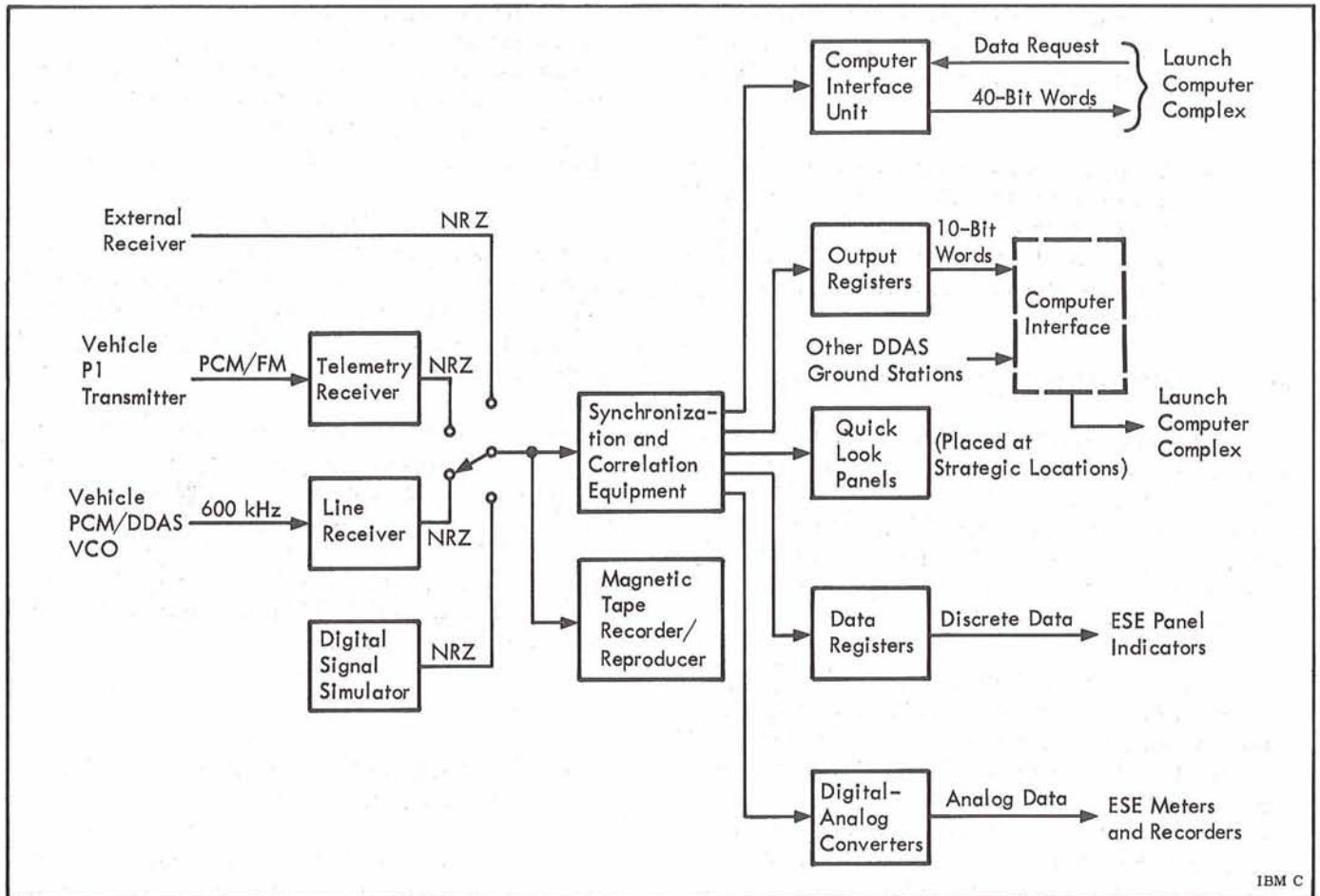


Figure 2-40. Typical DDAS Ground Station Functional Diagram

The station is assembled with the necessary receivers and input selector switching to meet the particular requirements. All stations contain a digital signal simulator for use in checkout and setup of the station.

After the input data is put into NRZ format, it is fed through the synchronization and correlation equipment. This equipment reshapes the input signal, derives data address, and provides serial and parallel data for use by the output devices.

A magnetic tape recorder/reproducer may be used with the station. This unit can be used to record an NRZ input signal for future playbacks. The recorder/reproducer can also be loaded with a test tape and used as input device to test the DDAS station.

A DDAS Ground Station can provide several forms of serial and parallel data outputs for use by the Launch Computer Complex and visual displays.

Again, the station is assembled to meet the particular requirements. An individual station will provide some, but not all, of the outputs listed below:

- The computer interface unit will shift parallel 40-bit words into the Launch Computer Complex when the words are specifically requested by the Launch Computer Complex.
- The output registers shift all station input data into an external computer interface as parallel 10-bit words for use by the Launch Computer Complex.
- Quick look panels are placed at strategic locations in the launch complex and allow the operator to manually select and observe any 10-bit PCM word, in both its digital and analog form.

- The data registers are programmed to select specific discrete data from the PCM format and forward that data to ESE panel indicator lamps.
- The digital-analog converters are programmed to select specific words from the PCM format, return the words to their analog forms, and forward the analog signals to display meters and instrumentation recorders.

#### Specific DDAS Ground Station Configurations

The four DDAS Ground Stations used to support the IU at each launch complex are very different in their uses. While these stations are referred to by model number, each one has been altered so that it no longer has the exact configuration implied by the model number. The four stations have the characteristics and uses explained below.

Launch Control Center Model DRS-2A - The purpose of this station is to feed IU data into the Launch Computer Complex and to furnish analog and discrete data to recorders and ESE display panels. The station can receive a 600 kHz carrier with its line receiver, or a previously demodulated NRZ signal, and record this signal on an associated tape recorder. Output registers, quick look panels, data registers, and digital-analog converters are used for output devices.

Telemetry Ground Station Model TRS-1 - The main purpose of this station is to furnish analog and quick look outputs for use in checkout of the Instrumentation System. The station can receive only a previously demodulated NRZ signal and uses quick look panels and digital-analog converters as output devices. The station can also be used to check the validity of the outputs from the Launch Control Center DDAS Station.

Measuring Station Model DRS-2 - This station is used to test the outputs of specific measurements and does not feed the Launch Computer Complex. It can receive a 600 kHz or telemetry frequency carrier. For output devices it uses output registers, data registers, and digital-analog converters.

AGCS Model DRS-3 (Saturn IB) - This station's only function is to feed IU data into the Launch Computer Complex. It has an associated line receiver to transform the 600 kHz input into an NRZ form and uses output registers and quick look panels for output devices.

ML Model DRS-2B (Saturn V) - This station feeds IU data into the Launch Computer Complex and furnishes discrete and analog signals to ESE consoles in the ML. The station's only input is the 600 kHz from the IU PCM/DDAS VCO which is demodulated by a line receiver. Output registers, quick look panels, data registers, and digital-analog converters are used for output devices.

#### 2-32 LAUNCH CONTROL CENTER ANALOG RECORDERS

The LCC analog Recorders, located in the firing room record several hundred analog measurements. As well as being recorded on paper, these measurements can be read in real time from the recorders. The recorders can be operated manually, or automatically by the Launch Computer Complex.

The analog measurements are furnished to these recorders from the LCC DDAS Station. The measurements selected to be routed to the recorders are those considered vital enough to require visual monitoring during launch. Most of the measurements pertain to the status of the IU but a few of them are readouts of ESE associated with the IU.

## SECTION III

# SYSTEM FUNCTIONS AND DATA FORMATTING

### 3-1 SYSTEM FUNCTIONS

The airborne and launch complex equipment operate together to perform functions that contribute to the end result of transmitting launch vehicle data to ground receiving stations. Examples of these functions are: airborne data flow, airborne component power control, calibration, and tape recorder control. The following paragraphs describe the functions of the Instrumentation System. Unless otherwise noted, the descriptions apply to Saturn-IB and Saturn V.

#### 3-2 AIRBORNE MEASUREMENT DATA FLOW

All airborne measurements originate at transducers or electrical pick-offs and are transmitted from the vehicle by those paths specified in Figure 3-1. This illustration shows all components and all possible paths that the airborne measurements may follow. For the routing of a specific measurement, refer to the Instrumentation Program and Components document for the vehicle in question.

#### 3-3 MEASUREMENTS CALIBRATION

The purpose of measurements calibration is to assist in determination of measuring equipment accuracy. This is done by providing signal conditioning modules with known, precise inputs in place of the normally monitored measurement signals. The normally monitored signals are compared to the calibrated signals to determine the exact degree of measuring equipment accuracy. Since measurements calibration is controlled from the ESE, it is used during prelaunch checkout only.

##### General

Calibration commands (see Figure 3-2) can originate either automatically from the Launch Computer Complex or manually from the Remote Automatic Calibration System (RACS) control panel. Three commands are necessary to calibrate any measurement channel. They are:

- Rack select command -- This command selects any one Measuring Rack or all nine Measuring Racks for calibration.
- Channel select command -- This command selects any one channel or 20 channels in a Measuring Rack for calibration.
- Mode select command -- This command selects the HIGH, LOW, or RUN mode of calibration for the channels being calibrated. The RUN mode is an absence of HIGH or LOW and results in no calibration signal applied to the modules.

These three commands enable a variety of calibration configurations. The configurations are in the following categories:

- One Measuring Rack, one channel (HIGH or LOW)
- One Measuring Rack, all channels (HIGH or LOW)
- All Measuring Racks, one channel each (HIGH or LOW)
- All Measuring Racks, all channels each (HIGH or LOW)

The status of the commands to each Measuring Rack is displayed on the RACS display panel.

##### Function

Assurance that all three commands will be issued simultaneously from the RACS control is obtained by allowing the mode command to enable the other two commands. The RACS control resets after 250 milliseconds and is ready for the next set of commands. The Launch Computer Complex can be programmed to simulate the output of the RACS control.

The three commands are routed through the umbilical to the Measuring Rack Selector. This unit decodes the rack select command and sends an enable to the Measuring Racks being calibrated. It also routes the channel select and mode select commands to all of the Measuring Racks.

Each Measuring Rack contains channel selectors that receive and decode the three commands, and

sends a HIGH or LOW calibration command to the Measuring Rack channel or channels being calibrated. The particular signal conditioning modules that may be placed in these channels use the calibration modes in the following manner:

- DC amplifier --- HIGH and LOW
- AC amplifier --- HIGH
- Servo accelerometer --- HIGH
- Frequency to dc converter --- HIGH
- Frequency measuring adapter --- Neither

A 115 Vac, 400 Hz voltage is used to furnish the known calibration input to the ac amplifier modules and frequency to dc converter modules. This voltage is supplied through the umbilical. The Measuring Racks are connected in series to receive this voltage.

The dc amplifier modules and servo accelerometer modules convert and use 28 Vdc from the Electrical System to generate a known calibration signal.

### 3-4 TELEMETRY CALIBRATION

The purpose of TM calibration (see Figure 3-3) is to assist in determination of telemetry equipment accuracy. This is done by furnishing selected telemetry equipment with known, precise inputs in place of the normally broadcast measurements signals. The normally broadcast signals are compared to the calibrated broadcast signals to obtain the exact degree of telemetry equipment accuracy.

TM calibration is used during flight and pre-launch checkout. During flight, TM calibration is controlled by the program of the LVDC. For prelaunch checkout, TM calibration is automatically controlled by the Launch Computer Complex or manually by the IU Measuring & Tracking Panel.

Two components and special circuitry in other components provide TM calibration. The two components are the TM Calibrator and the TM Calibrator Controller. Special circuits to accept calibration inputs are located in F2 and P1 Multiplexers, F1 and F2 Telemeters, and S1 Telemeter.

The TM Calibrator and TM Calibrator Controller function together to furnish and control the calibration inputs to the telemetry components. These

two units together are referred to as the Calibrator-Controller Assembly. The Calibrator selects the calibration signal level and selects the component to be calibrated. The Controller furnishes regulated power to the Calibrator and also serves as an interface unit, routing and isolating all signals to and from the Calibrator.

The Calibrator-Controller Assembly furnishes six outputs for calibration of model 270 multiplexers or FM telemeters, and three outputs to calibrate single sideband telemeters. Each of these units that are to be calibrated contain circuitry to accept the calibration command and apply the calibrated signals to their individual data channels. While up to nine components can be calibrated by the Calibrator-Controller Assembly, the full capability is not used. For clarity of explanation, this description of operation assumes that full capability is used.

To increase system flexibility, all inputs and outputs of the Calibrator-Controller Assembly are routed through a Measuring Distributor. This allows the inputs and outputs to be patched to selected telemetry equipment without modification to launch vehicle wiring.

During prelaunch checkout, the calibration capabilities are greatly expanded. Any of several preflight calibrations may be selected in addition to the normal inflight calibration.

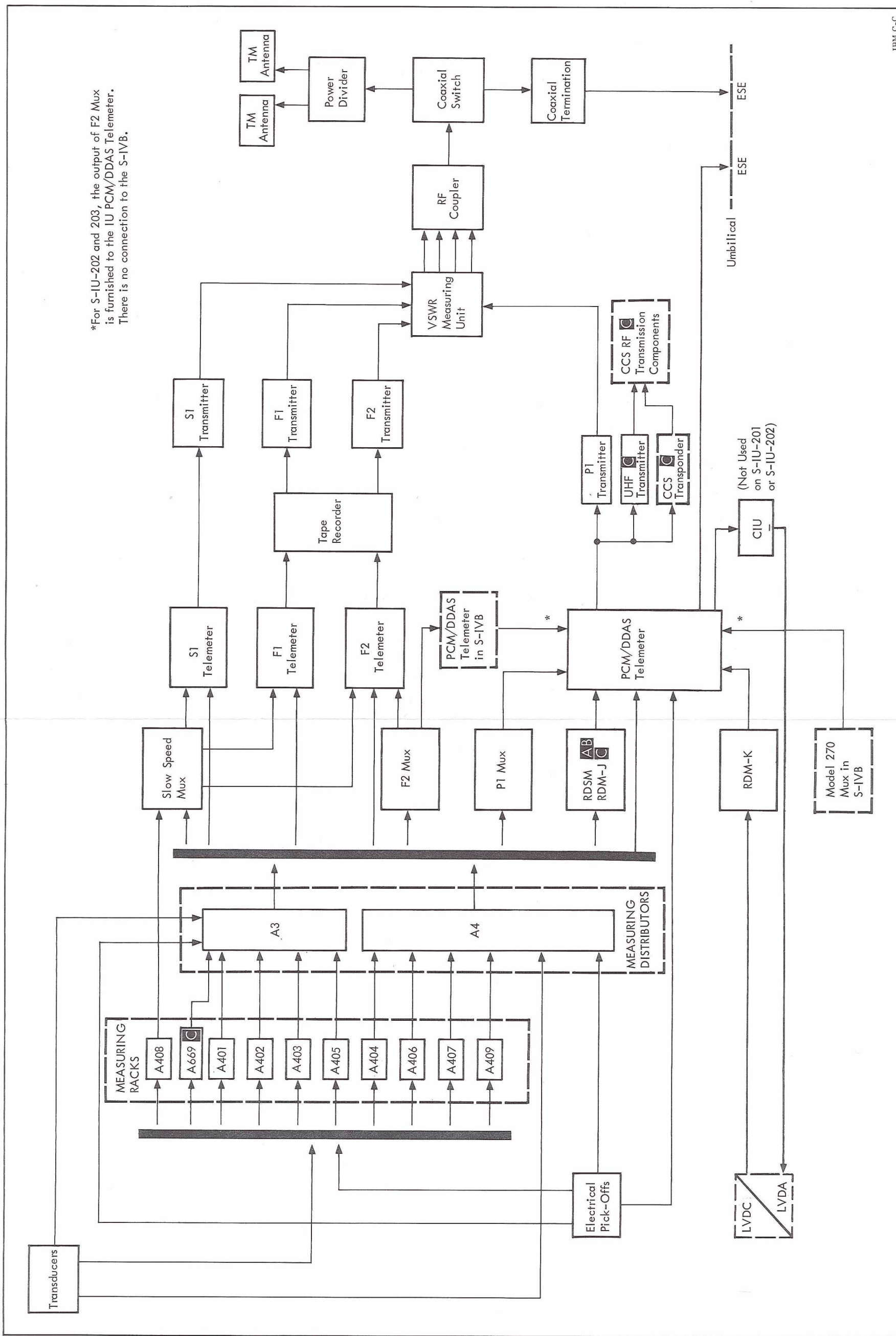
The equipment is operated in either the inflight mode or the prelaunch mode. During inflight mode, the telemetry equipment is calibrated by preset signals in a preset sequence when commanded to do so by the LVDC program. During prelaunch mode, the LVDC command may be simulated or variable calibration signals may be furnished to the telemetry equipment.

#### Inflight Mode

During flight, upon receiving a 4.2-second, 28 Vdc command from the LVDC, the Calibrator-Controller Assembly will:

- Furnish one 0 to 5 Vdc calibration signal in 1.25 Vdc steps, to be sent to the FM telemeters being calibrated.
- Furnish 28 Vdc commands that are used to enable FM telemeters to receive calibration signals or initiate a calibration sequence in the model 270 multiplexers.

\*For S-IU-202 and 203, the output of F2 Mux is furnished to the IU PCM/DDAS Telemeter. There is no connection to the S-IVB.



IBM C-C

Figure 3-1. Airborne Measurements Data Flow

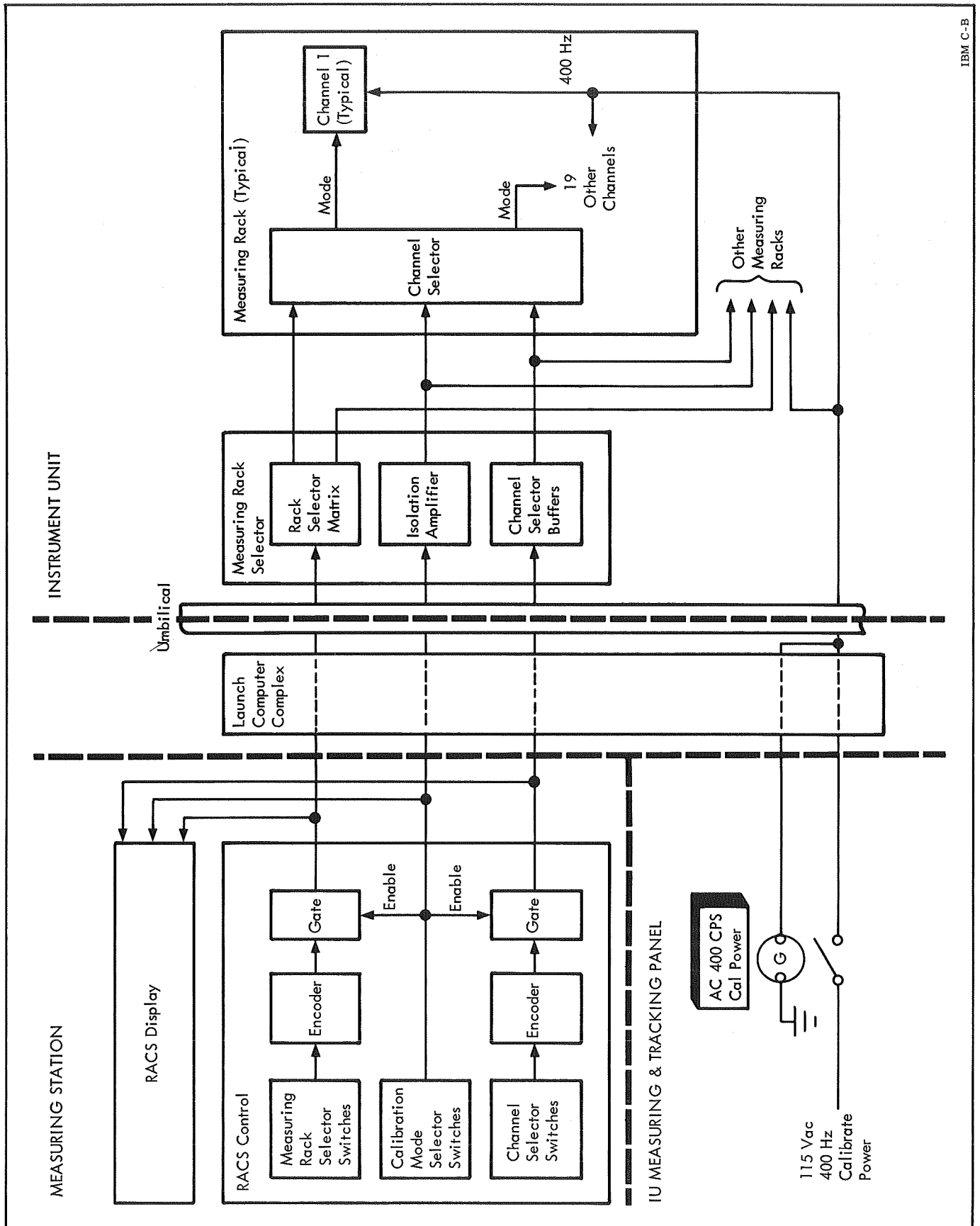


Figure 3-2. Measurements Calibration Functional Diagram

- Furnish a 28 Vdc command that enables the single sideband telemeters to receive calibration signals.
- Furnish a 1700 Hz calibration signal to the single sideband telemeters being calibrated.

The equipment uses 28 Vdc from the vehicle power supply and 5 Vdc from the 5 V Supply. The 5 Vdc is used for the precise 0 to 5 Vdc calibration signal sent to the FM telemeters. The 28 Vdc is regulated by the Controller and used for operating power for the Calibrator and the 28 Vdc enable signals sent to calibrate the telemetry equipment.

The inflight calibration start command originates in the LVDC (see Figure 3-3) and is routed through the Switch Selector to a clock circuit in the Calibrator-Controller Assembly.

The clock starts a voltage divider and stepper circuit which produces a precise 0 to 5 Vdc, stepped voltage output. This sequentially stepped output goes from 0.00 to 1.25 to 2.50 to 3.75 to 5.00 and back to 0.00 in a period of 700 milliseconds. The stepped voltage runs through six sequences and is fed to the calibration bus for distribution to the FM telemeters. Each time the stepped voltage finishes a sequence, the output selector circuit advances to select the next telemeter or mux to be calibrated.

When an FM telemeter is selected for calibration, the 28 Vdc signal from the Calibrator-Controller Assembly energizes a relay circuit in the telemeter assembly. This relay inhibits the normal measurement data for 700 milliseconds and substitutes the stepped calibration voltage present at the calibration bus. This calibration is performed only on those FM telemeter channels patched to the YES bus. When another unit is selected for calibration, the relay returns to its original position and normal measurement data is once more allowed to flow to the oscillator channels.

When a model 270 mux is selected for calibration, the 28 Vdc signal from the output selector starts an automatic circuit in the mux. This automatic circuit inhibits the normal measurement data input and substitutes an internally generated, stepped 0 to 5 volt signal like the signal generated by the Calibrator-Controller Assembly. When a mux receives the calibrate command, the calibration sequence is delayed until the start of the next mux master frame. Each voltage step is held for one master frame, thus requiring five master frames

or approximately 400 milliseconds for a complete calibration sequence. The mux then returns the normal measurement data to its data channels.

While the multiplexers and FM telemeters are being calibrated, the Calibrator-Controller Assembly also selects and calibrates the single sideband telemeters. The Calibrator-Controller Assembly produces a 1700 Hz, 1 volt peak-to-peak calibration signal. Single sideband telemeters are selected and calibrated with the 1700 Hz signal similar to the method used for the selection and calibration of the FM telemeters. A calibration sequence for a single sideband telemeter lasts the time necessary for two multiplexers or FM telemeters to be calibrated, that is, 1400 milliseconds. Normal measurement data is then allowed to return to the data channels of the single sideband telemeter.

#### Prelaunch Mode

During prelaunch mode the calibration equipment, while being controlled from the LCC can:

- Simulate the inflight calibration start command from the LVDC.
- Transfer the calibration bus to ESE control and supply an ESE generated calibration signal.
- Select single sideband telemeters for calibration and supply an ESE generated calibration signal.
- Connect the data input of all FM telemeters to the calibration bus.
- Control the output of the Calibrator-Controller Assembly to allow any step of the 0 to 5 Vdc calibration signal to be applied to the calibration bus.

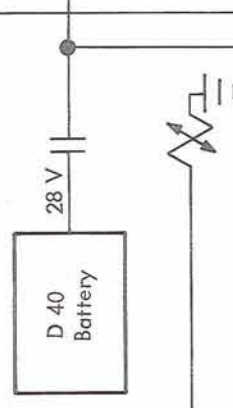
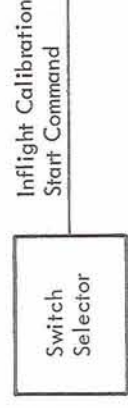
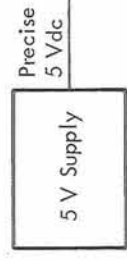
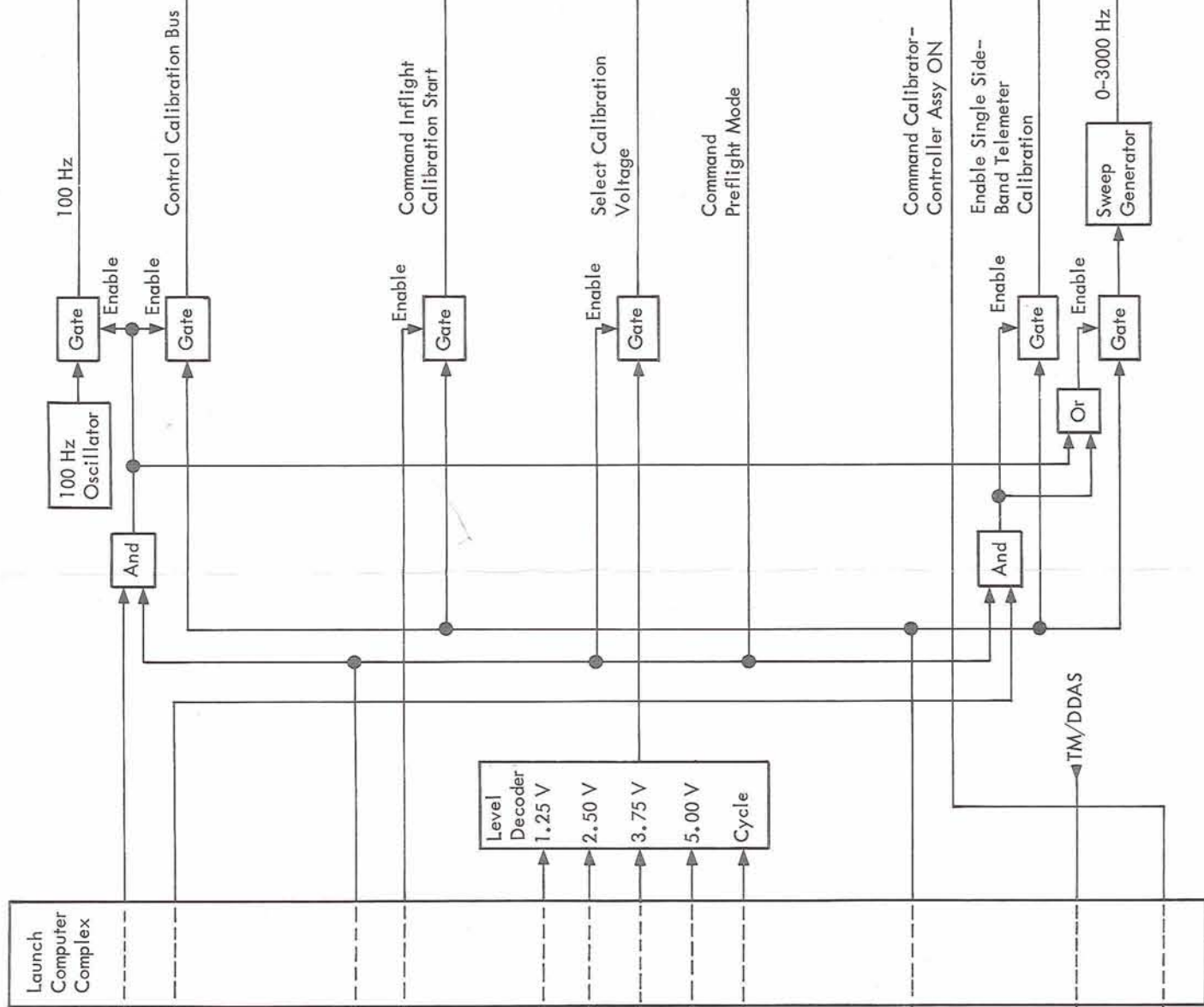
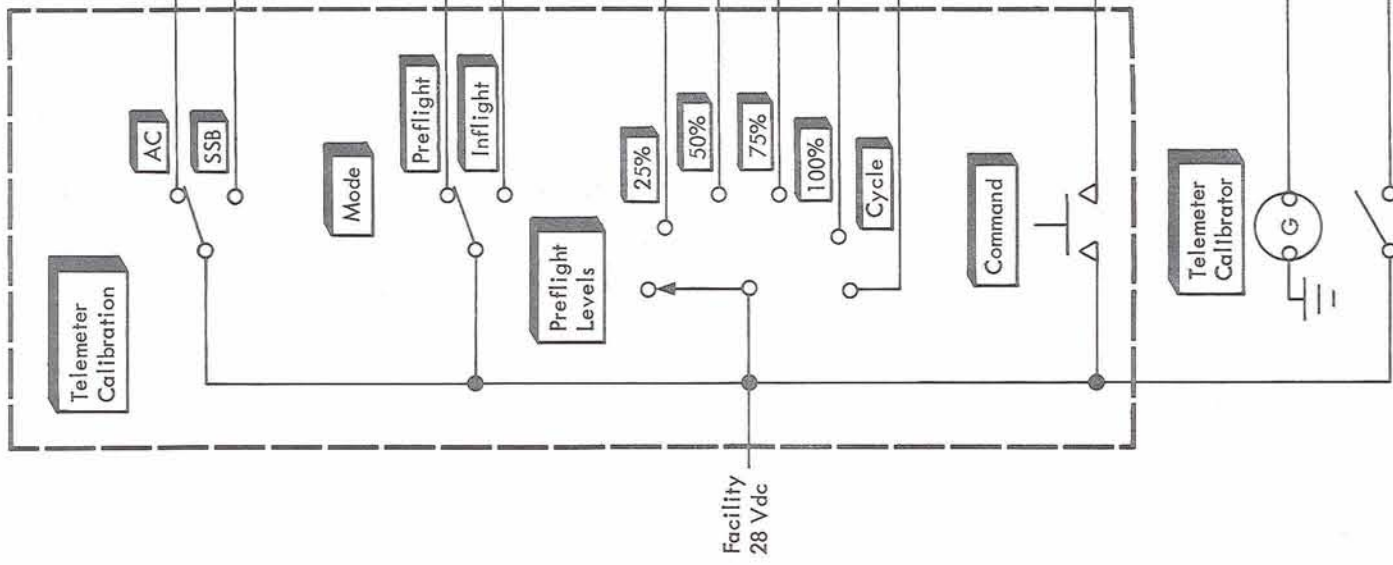
The airborne equipment uses the same 28 Vdc and 5 Vdc power used in the inflight mode. During prelaunch mode, however, the 28 Vdc may be switched OFF, thus turning OFF the Calibrator-Controller Assembly.

An inflight calibration start command simulation signal may be originated by the ESE. This signal is fed to an OR circuit in the Calibrator-Controller Assembly and starts the same calibration sequence that is started by the inflight calibration start command from the LVDC. This signal must be present for at least 4.2 seconds to keep the output drivers enabled.

IU MEASURING & TRACKING PANEL

INSTRUMENT UNIT

Umbilical



TM/DDAS



2

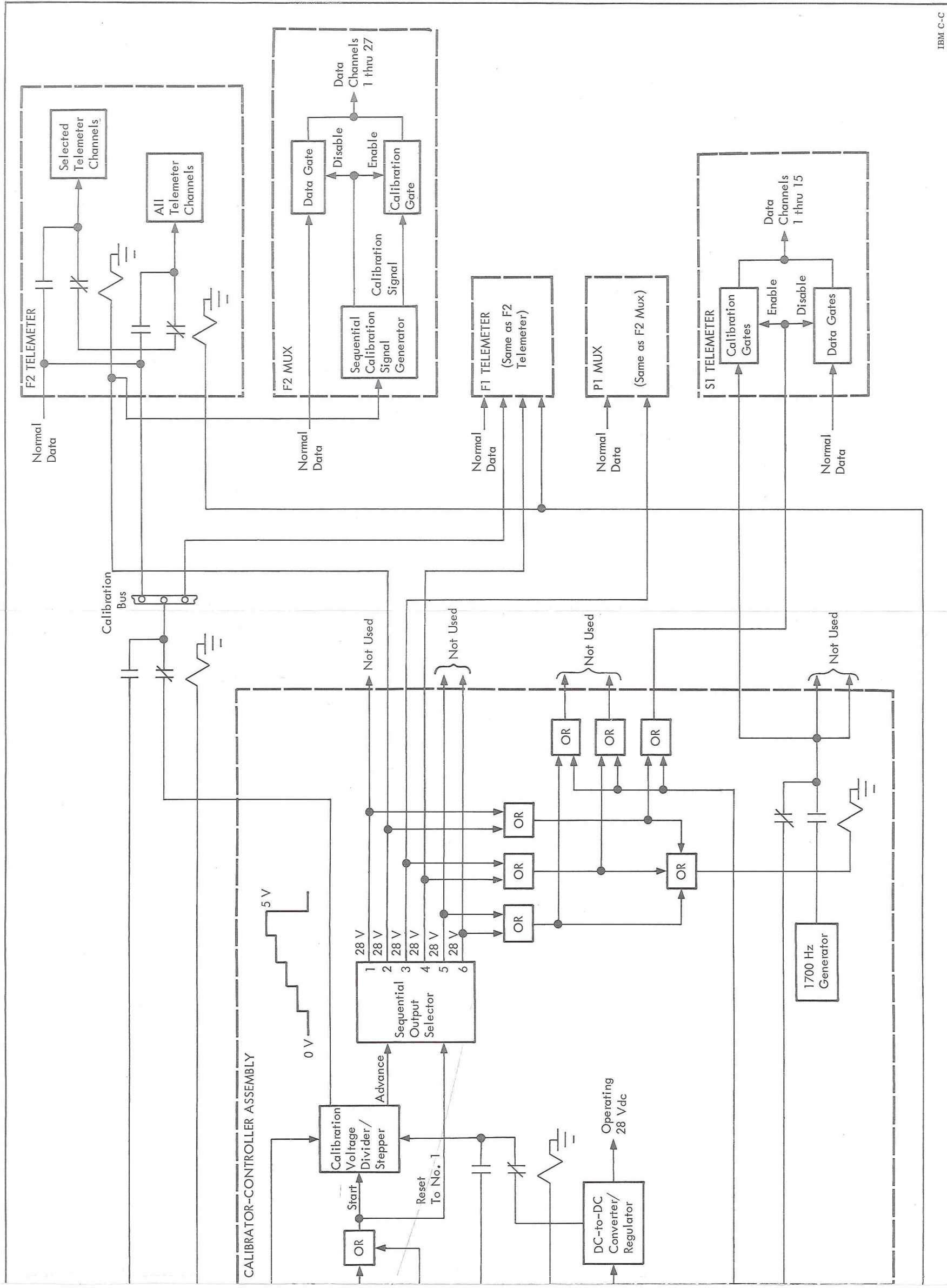


Figure 3-3. Telemetry Calibration Functional Diagram

The Calibrator-Controller Assembly's signal to the calibration bus may be switched out and substituted by an input from the ESE. This input is a 100 Hz signal with the primary purpose of calibrating those FM telemeter channels that carry frequency-intelligent measurement data.

A command from the ESE can cause the single sideband telemeters to be switched to the calibration bus in the Calibrator-Controller Assembly. A sweeping 0 to 3000 Hz calibration signal is then applied to the bus from the ESE. This 1 V peak-to-peak signal sweeps from 3000 Hz to 0 Hz to 3000 Hz in a 10 second period.

Application of a preflight calibration mode command causes those FM telemeter channels connected to the YES bus and the NO bus to be switched to the calibration bus. This command also allows the 0 to 5 Vdc calibration voltage from the Calibrator-Controller Assembly to be completely controlled from the ESE.

After the preflight calibration mode command has been sent, the 0 to 5 Vdc output is under the complete control of the ESE. The ESE may select any of six possible signals to be supplied by the Calibrator-Controller Assembly to the calibration bus. Any of the five voltage steps or a continually stepping voltage may be selected. Each of these six signals may be applied to the calibration bus for as long as desired.

#### ESE Control

Five switches on the IU Measuring & Tracking Panel provide manual control of TM calibration during checkout. Using these switches, inflight TM calibration can be simulated or a variety of checkout modes can be selected.

Power is applied to the Calibrator-Controller Assembly by the TELEMETER CALIBRATOR switch, and verification that power has been applied to the unit is returned to the associated indicator via telemetry or DDAS.

The MODE switch selects whether inflight calibration will be simulated or one of the variety of preflight checkout modes enabled.

The AC-SSB switch, in the AC position, enables a 100 Hz calibration signal to be applied to each VCO in the FM telemeters. In the SSB position, it enables a 0 to 3000 Hz calibration signal to be applied to the single sideband telemeters. This switch is operable only in the preflight mode.

The PREFLIGHT LEVELS switch operates only in the preflight mode and selects the calibration voltage level for Calibrator-Controller Assembly to apply to each FM telemeter VCO.

The COMMAND pushbutton causes the calibration mode that has been set up by the four TELEMETER CALIBRATION switches to be applied to the telemetry equipment.

#### 3-5 TELEMETRY COMPONENTS POWER CONTROL

Prior to launch, all telemetry components are manually ON-OFF controlled from the IU Measuring & Tracking Panel (see Figure 3-4). The components can also be automatically controlled by the Launch Computer Complex. All of the relays shown in the IU are self-latching so they will stay closed after umbilical disconnection.

When the relays are closed, the airborne components are powered by the IU Electrical System. Prior to launch, the Electrical System generally uses facility power instead of the batteries.

Discrete indications of the status of the airborne components are sent to the IU Measuring & Tracking Panel via PCM telemetry or DDAS. These discrete signals control lights associated with the controlling switches.

When necessary during checkout, the Test Conductor can ensure that rf silence is maintained by withholding operating power from some of the telemetry components. This power can be withheld from all telemetry transmitters, and all telemeters and multiplexers except those needed to transfer data through the DDAS coaxial path.

For S-IU-204 only, a command from the Switch Selector turns OFF operating power to the S1 Transmitter. The command is sent after the S1 Transmitter has ceased to broadcast useful data. This function prevents rf interference with other systems.

#### 3-6 MEASURING RACKS POWER CONTROL

The 28 Vdc operating power to the Measuring Racks and Measuring Rack Selector can be applied automatically by the Launch Computer Complex or manually by the IU Measuring & Tracking Panel (see Figures 3-5 and 3-6). The power to the Measuring Racks will remain applied after umbilical disconnection because of latching relays, but power to the Measuring Rack Selector (and subsequently to the channel selectors) can only be used during checkout.

One signal through the telemetry or DDAS path causes the MEASURING RACKS indicator to show that power has been applied to Measuring Racks A401 through A407 and A409. Another signal causes the MEAS RACK 602A408 ON indicator to light.

A command from the Switch Selector turns OFF the operating power to Measuring Rack A408. This is done to conserve the airborne batteries. The command is sent during flight, after the measurements going through that rack have ceased to represent meaningful data.

### 3-7 MEASURING VOLTAGE DISTRIBUTION AND CONTROL

There are two different measuring voltage systems, one in the IU and one in the IU ESE. Both systems can be automatically controlled by the Launch Computer Complex or manually controlled from the IU Measuring & Tracking Panel. A voltmeter on this panel will monitor the voltage of either of these distribution systems.

#### Vehicle Measuring Voltage

The vehicle measuring voltage originates in the 5 V Supply (see Figure 3-7) and is routed through the Measuring Distributors to the necessary components. This 5 Vdc is used for potentiometer transducer operating power, in telemetry calibration, and as signal conditioning bias voltage.

The measuring voltage is furnished to the potentiometer transducers which use a percentage of the 5 Vdc as their output signal. In addition to the IU potentiometer transducers, the measuring voltage is supplied to those transducers in other stages that furnish signals to the IU Instrumentation System.

The measuring voltage is sent to the Calibrator-Controller Assembly to be converted into the telemetry calibration signal.

Measuring voltage is sent to all Measuring Racks and distributed to all 20 channels in each Measuring Rack. The measuring voltage is used by ac and dc amplifier modules for signal biasing. AC measurement signals that are normally centered around 0 Vdc must be biased at 2.5 Vdc to place them in the range acceptable by the telemetry equipment.

The measuring voltage furnished to F2 and P1 Mux is used as amplitude reference pulses and as frame identification pulses.

Measuring voltage is supplied to F1 and F2 Telemeters but is not used by these units.

The vehicle measuring voltage is monitored and returned to the ground by the telemetry and DDAS paths. It can be measured by the voltmeter on the IU Measuring & Tracking Panel when the BUS switch is in the +6D81 position.

#### Ground Measuring Voltage

The ground measuring voltage originates in an ESE 5 Vdc power supply. This voltage is distributed to measurement recorders and other instrumentation equipment that use it as a calibration standard voltage.

The voltage is controlled from the IU Measuring & Tracking Panel and can be measured by the voltmeter on that panel when the BUS switch is in the +6D80 position (+6D810 position for Saturn V).

### 3-8 TAPE RECORDER OPERATION

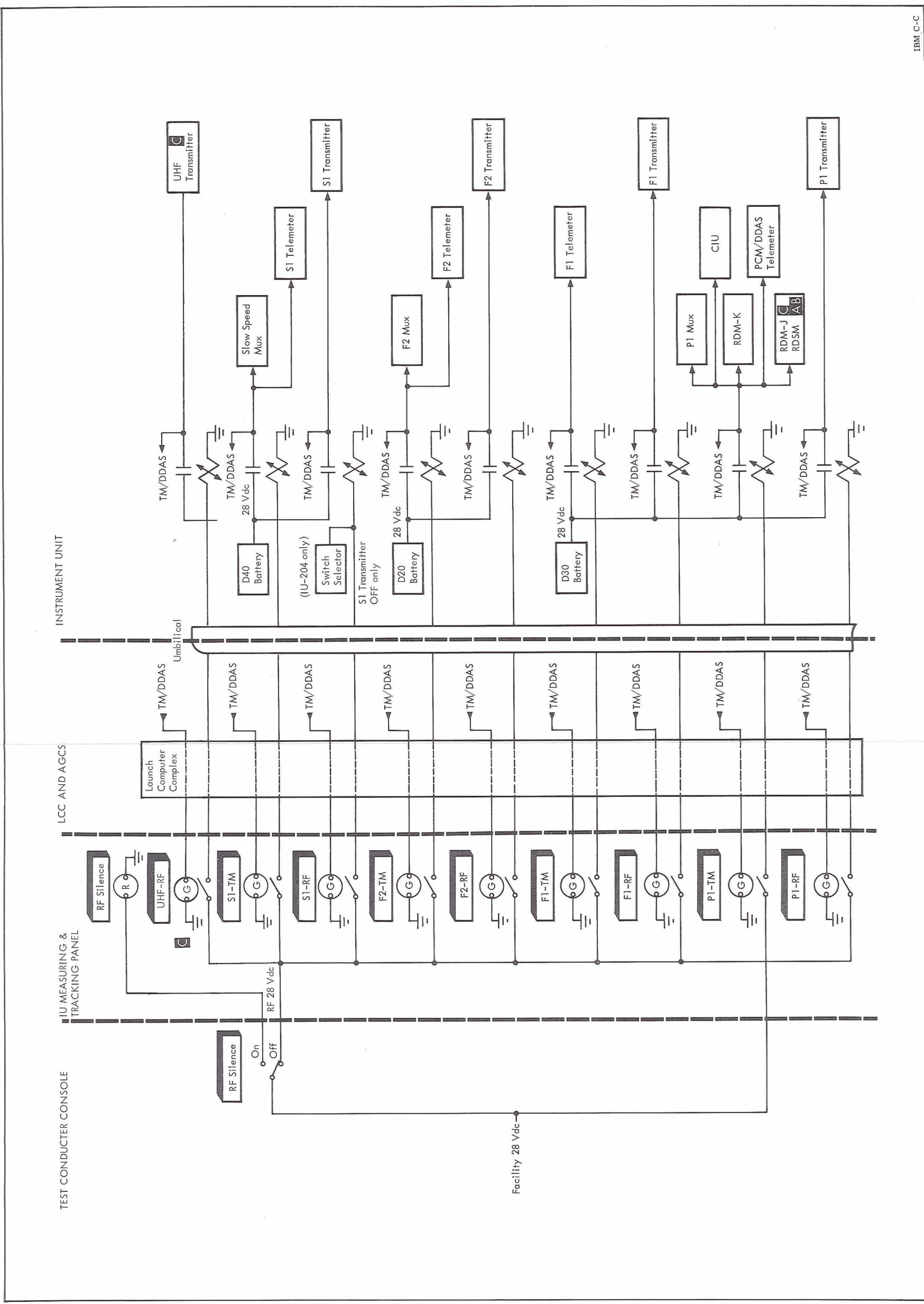
During checkout, the Tape Recorder is operated manually from the IU Measuring & Tracking Panel or automatically by the Launch Computer Complex. During flight it is operated by commands from the LVDC through the Switch Selector.

Prior to launch, 28 Vdc power is applied to the Tape Recorder by the ESE (see Figure 3-8). The POWER and READY TO RECORD indicators will light indicating that the Tape Recorder is ready for operation. After launch, a command from the LVDC will cause the Tape Recorder to record the outputs of F1 and F2 Telemeters during retro-rocket fire. Near the end of IU operation, commands from the LVDC cause the Tape Recorder to play back its recorded data first in reverse and then forward. During either playback mode, the data still being furnished by F1 and F2 Telemeters is not sent to the rf components.

During prelaunch checkout, the record and reverse playback commands can be sent to the Tape Recorder from the IU Measuring & Tracking Panel through the Switch Selector. The indicators on the panel are lighted by status signals sent back to the ESE via PCM telemetry or DDAS.

### 3-9 MEASUREMENT PATHS

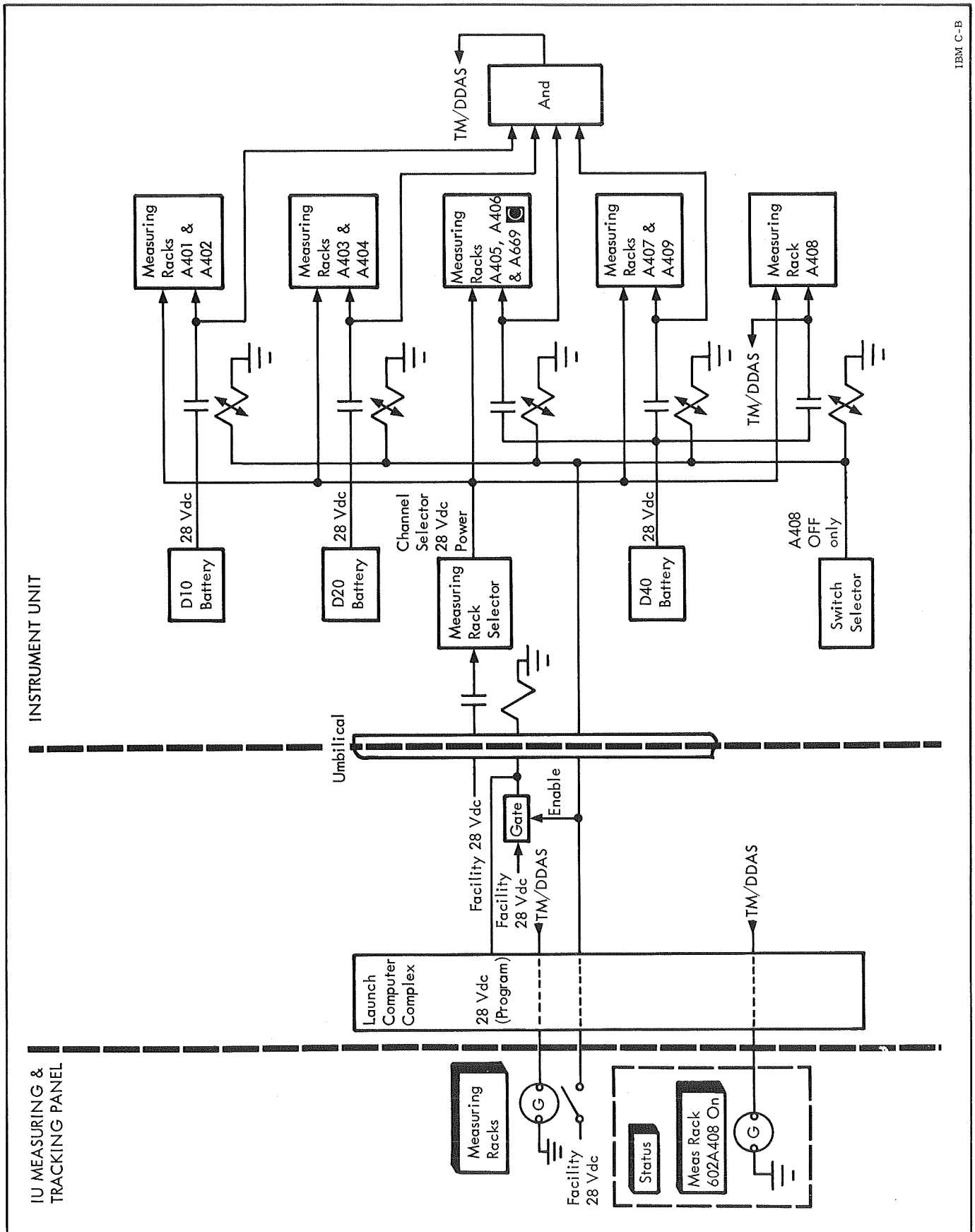
Figure 3-9 shows all combinations of measurement sources, signal conditioning modules, and



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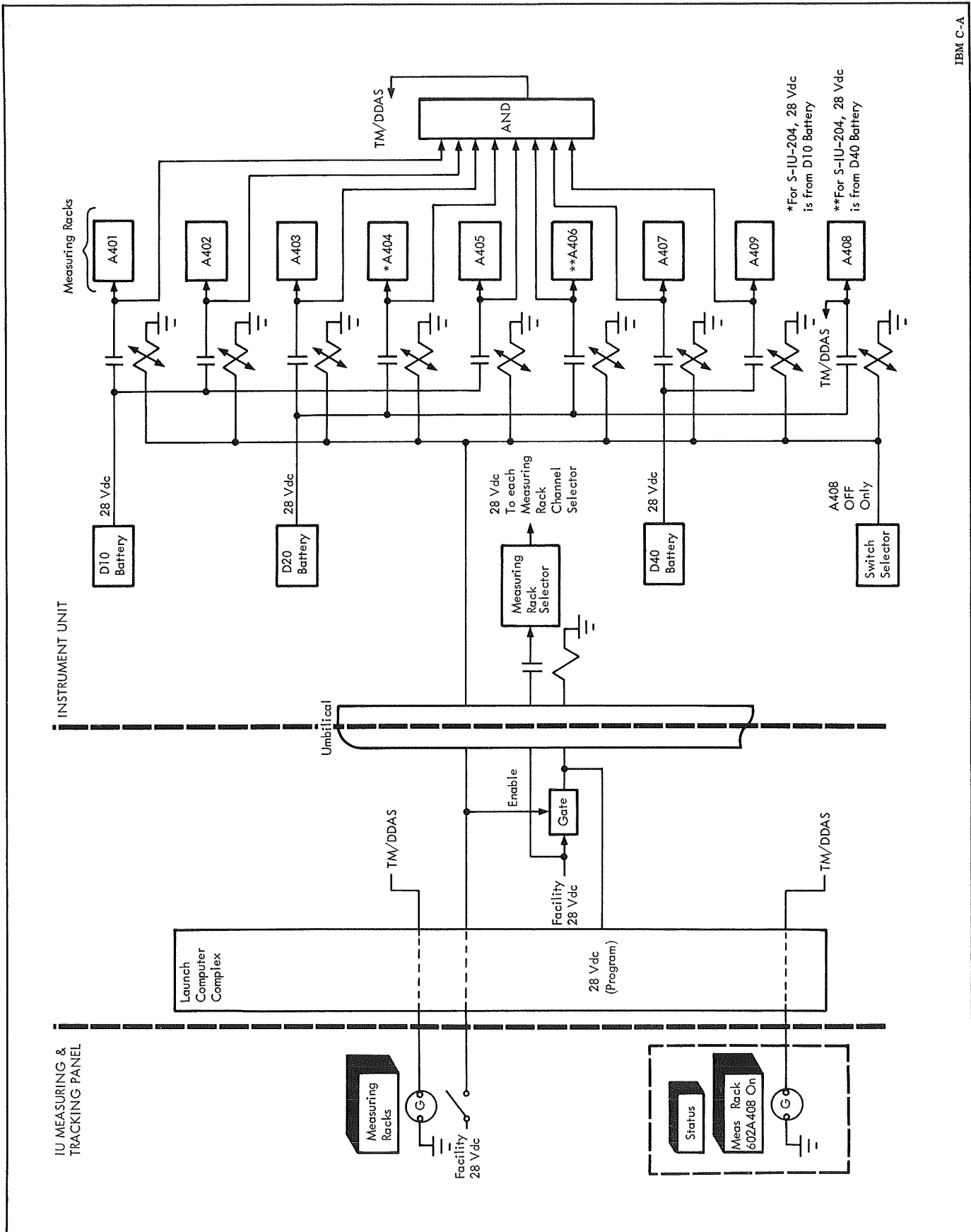
Figure 3-4. Telemetry Components Power Control Functional Diagram

Changed 15 April 1966



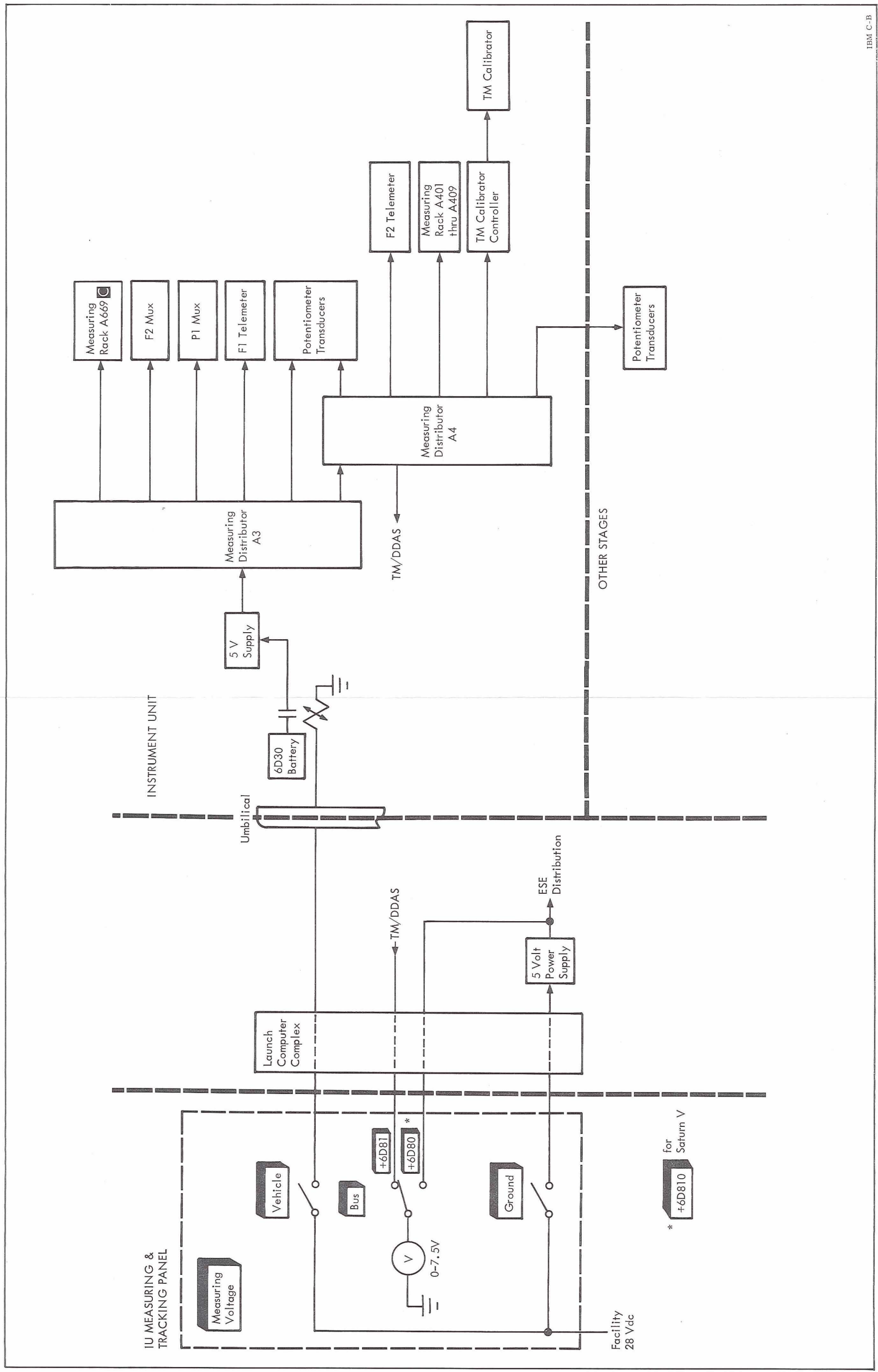
IBM C-B

Figure 3-5. AC Measuring Racks Power Control Functional Diagram



IBM C-A

Figure 3-6. **B** Measuring Racks Power Control Functional Diagram



IBM C-B

Figure 3-7. Measuring Voltage Distribution and Control Functional Diagram

telemetry channels that are used in the Instrumentation System. They are grouped by type of measurement sources and show the types of signal conditioning and telemetry paths that are necessary for each type of pickup.

### 3-10 STAGE MEASUREMENT SELECTION

Stage measurement selection permits better utilization of telemetry channels by allowing individual telemetry channels to carry measurements from each stage (see Figures 3-10 and 3-11). This is accomplished by a relay network in Measuring Distributor A4 that switches the telemetry channel inputs from expended stage measurements to active stage measurements at separation. These measurements all pertain to engine deflection and are transmitted through PCM telemetry. During prelaunch checkout, they are switched to DDAS by measurement transfer.

This function can be simulated during pre-launch checkout by the Control Computer Input Substitute Panel. A command from this panel that selects a stage for operation will actuate the relay network in Measuring Distributor A4 and will also direct the measurements to the corresponding Engine Deflection Panel. These panels use the measurements to present a display of engine status.

### 3-11 MEASUREMENT TRANSFER

Measurement transfer permits some measurements, that are normally transmitted through FM telemetry, to be sent to the LCC through PCM telemetry or DDAS. The DDAS path is normally used and this allows IU checkout to proceed without the necessity of turning on the telemetry transmitters.

Relays in Measuring Distributors A3 and A4 that can be controlled only by the IU Measuring & Tracking Panel (or Launch Computer Complex) provide measurement transfer (see Figure 3-12). Measurements that normally go through F1 and F2 Telemeters only, are paralleled through the PCM/DDAS Telemeter also by measurement transfer relays. These PCM channels are normally occupied by other measurements or grounded inputs.

### 3-12 TELEMETRY PATHS

Measurement data from the telemetry equipment is transferred to the Launch Complex by three different paths. The routing and use of these paths are controlled by the ESE (see Figure 3-13).

The antenna path broadcasts the outputs of all telemetry transmitters (referred to as links) through the TM Antennas to ground receiving stations. At the launch complex, these stations are the Measuring Station and the Telemetry Ground Station. From the Telemetry Ground Station, the demodulated P1 link can be furnished to the LCC DDAS Station. The antenna path is the only path used after launch. This mode of operation is called open loop.

The Coaxial Switch, which can be manually controlled from the IU Measuring & Tracking Panel, transfers the transmitter links from the TM Antennas to the Coaxial Termination. The Coaxial Termination dissipates most of this high wattage signal. The remaining low wattage signal is routed through the umbilical via coaxial wiring to the Telemetry Ground Station. The demodulated P1 link can be furnished to the LCC DDAS Station. This path, using the Coaxial Termination, can be used during prelaunch checkout only and is referred to as closed loop.

The DDAS output from the PCM/DDAS Telemeter consists of the same data that is sent to the P1 Transmitter, but on a different carrier. The DDAS link has a carrier of 600 kHz, modulated by the PCM NRZ pulse train. The DDAS link, on coaxial wiring, leaves the IU through the umbilical and is furnished to the DDAS Station in the AGCS. This station demodulates the signal for its own use and also amplifies the 600 kHz carrier for use by the Measuring Station DDAS Station, the LCC DDAS Station, and the DDAS Station used in the Telemetry Ground Station. This path can be used during prelaunch checkout only.

### 3-13 LAUNCH COMPUTER COMPLEX INTERFACE

Virtually all Instrumentation System command and monitor functions are controlled by the Launch Computer Complex. Commands from the ESE to the vehicle are routed through the Launch Computer Complex and may be duplicated by this computer. Discrete vehicle indications monitored by the airborne Instrumentation System are sent to the DDAS Ground Station for distribution to ESE indicators and the computer. Figure 3-14 shows a typical command and monitor function with the tie-in to the computer.

A Tape Recorder ON or OFF command is routed through the computer before actuating a latch-type relay in the vehicle. The computer may originate the ON or OFF commands for automatic checkout. If a command is issued manually, the relay in the vehicle will remain in the commanded position until the other command is sent. Placing the switch to AUTO after sending an ON or OFF command will not remove the command.



The instrumentation discrete measurement that monitors power application to the Tape Recorder is sent to the ESE via telemetry or the DDAS path through the umbilical. In either case, the discrete measurement is routed through the DDAS Ground Station and associated signal conditioner to the TAPE RECORDER POWER indicator. The signal also leaves the DDAS Ground Station as part of a computer input word and is furnished to the computer.

### 3-14 COMPUTER DATA TRANSFER

Computer data transfer is divided into two categories: transfer of PCM telemetry data into the LVDC for storage (data compression), and transfer of LVDA/LVDC computer word data into PCM telemetry for transmission to ground receiving stations (data transmission).

#### Data Compression

Data compression is used only after insertion of the IU into earth orbit. At times, after insertion, the IU is not within range of a ground station. During these times, PCM data is processed through the CIU into the LVDA/LVDC for examination and storage. The data to be sent to the LVDC, and the time it is to be sent, are pre-selected by the program of the LVDC. This program usually selects most of the data processed by the PCM/DDAS Telemeter, including all mission control measurements. This data, along with other data originating in the LVDA/LVDC, is stored until the IU comes within range of the next ground station, whereupon, the data is sent out through the RDM-K to the PCM/DDAS Telemeter for transmission.

The compressed data is not used by the LVDC for computations. It is only stored until transmitted when the IU is within range of a ground station.

The data compression routine starts just after loss of the first ground station and occurs only while the IU is not over a ground station. To obtain data from the CIU, the LVDC generates a signal that consists of 12 lines of address and 1 line with a 24 Vdc request command (see Figure 3-15). The address specifies to the CIU the location of the requested word in the PCM format. The request command inhibits the normal (real-time) telemetry data transmission flow from the LVDA to the RDM-K and is also sent to the CIU to be ANDed with the address. When the requested word appears in the PCM format, it is gated through the CIU holding register and on into the LVDA. The CIU then generates a data ready pulse that causes the LVDC to perform a CIU Interrupt Sub-

routine to compress and store the data. The data ready pulse also releases the inhibit that was placed on real-time data transmission flow from the LVDA to the RDM-K. Thus, LVDA transfer of data to the RDM-K is inhibited for as long as it takes the CIU to locate the requested word in the PCM format. This will be a maximum of 250 milliseconds which is the length of one PCM master frame.

Data is compressed by two methods: (1) amplitude compression, in which a regularly sampled quantity is stored only when its voltage amplitude deviates by more than a prescribed amount from a standard, or (2) time compression, in which desired quantities are stored at prescribed intervals as they are read or computed. Data to be compressed is furnished by the CIU path or other sources in the LVDA/LVDC.

Data compression is not used on S-IU-201 or S-IU-202.

#### Data Transmission

Transmission of data from the LVDA/LVDC occurs by control of the LVDC program. This data consists of either the real-time information being processed by the LVDA/LVDC or data that has been stored by the data compression function. The selection of real-time or compressed data is controlled by the LVDC program and coincides with the proximity of the IU to a receiving station. Only real-time data is selected until after orbital insertion. After insertion, while the IU is not within range of a ground station, data transmission from the LVDA to the RDM-K is inhibited by the data compression function. This inhibit must take place because the data compression function uses some of the same LVDA/LVDC circuitry used by the data transmission function. Each time the IU comes within range of a receiving station, real-time data and compressed data are alternately selected for transmission during each second.

Data transmission consists only of that information that is transferred from the LVDA to the RDM-K as a 40-bit word and does not consist of those analog and discrete measurements that are furnished to the Instrumentation System by other paths.

Of the 40 bits in the word that is parallel transferred from the LVDA, 26 bits are data, and the other 14 signify source and identification of the data. The RDM-K accepts the parallel 40-bit word, momentarily stores it as four 10-bit words, and then sends a

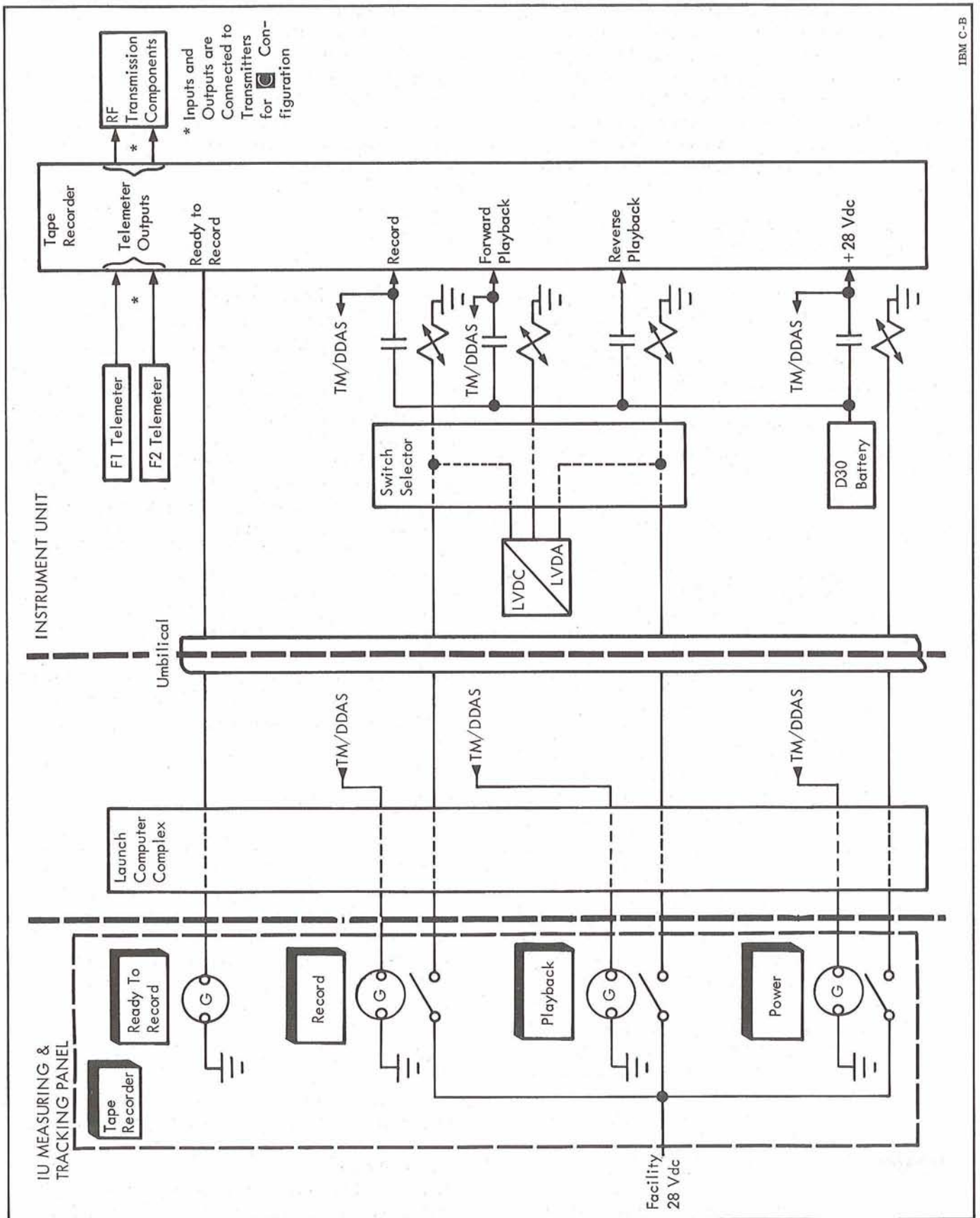


Figure 3-8. Tape Recorder Operation Functional Diagram

reset pulse to the LVDA to make a new 40-bit word available (see Figure 3-15). The four 10-bit words are furnished sequentially, in parallel format, to the PCM/DDAS Telemeter at a rate of twice each PCM frame, or 240 times per second. As the reset pulse from the RDM-K causes the 40-bit LVDA word to change at the same rate, this gives a sample rate of 240 times per second with each sample representing new information.

### 3-15 **C** COMMAND AND COMMUNICATION SYSTEM INTERFACE

In addition to being broadcast through the TM Antennas, the PCM telemetry data is also furnished to the airborne Command and Communication System (CCS) for transmission to ground receiving stations. The PCM data is sent to CCS by two different methods: one is the output of the UHF Transmitter and the other is the NRZ data right out of the PCM/DDAS Telemeter. In all cases the data is the same, as it is the serial output from the PCM/DDAS Telemeter.

#### UHF Link

The output of the UHF Transmitter is furnished as the input to the three-way PCM Coaxial Switch (see Figure 3-16). The output of this switch is controlled through the Switch Selector by the program of the LVDC. Two of the output paths go to separate circuits within the PCM Directional Antenna. These two circuits allow an output beam spread of 40 degrees or 70 degrees. The third output path from the PCM Coaxial Switch goes through the Hybrid Ring and on to the CCS/PCM Omnidirectional Antennas. The choice between these three paths is governed by the distance of the IU from Earth.

#### CCS Down-Link

The NRZ output of the PCM/DDAS Telemeter is also furnished directly to the transmit section of the CCS Transponder as a modulation source. This transmit section generates the CCS down-link rf carrier that is sent to the CCS Power Amplifier. The amplified carrier is next furnished to the CCS Coaxial Switch from where it follows a path similar to the UHF telemetry carrier described in the preceding paragraph. An inhibit signal from the Switch Selector can turn OFF the down-link signal to eliminate interference between the CCS Transponder and similar transponders in the spacecraft.

#### CCS Up-Link

Interrogation pulses and discrete commands are furnished to the receive section of the CCS Transponder through the CCS Receiving Antennas and CCS

Power Divider. This up-link signal supplies data to the transmit section and is also demodulated for use by the Command Decoder. This audio signal is decoded by the Command Decoder and furnished to the LVDC/LVDA to initiate a variety of functions. The command verification output from the Command Decoder is sent back to the ground station through PCM telemetry. Receiving station equipment compares the command verification signal to the command that was actually sent to ensure that the proper command was received by the IU.

### 3-16 DATA FORMATTING

The data format is the relationship of the telemetry channels within the output of each of the telemeters. This relationship is determined by the configurations of the multiplexers and telemeters used in the Instrumentation System. The output of a particular telemeter unit may consist of data channels that are time-shared, frequency-shared, or a combination of both. The following paragraphs explain the data formatting characteristics of each of the components and list the data format for each Instrument Unit.

By design, the data format can easily be changed at any time prior to launch. The data formats given in this manual are for training purposes only. To ensure accurate information, consult the appropriate IP&C and other engineering documentation.

#### 3-17 F2 MUX FORMAT

The F2 Mux is a time-sharing device with one analog output at any given instant. Refer to paragraph 2-9 for a functional description of this unit. The unit's 30 channels can be continuous (each input monitored 120 times per second) or contain a X10 sub-multiplexer (each input monitored 12 times per second). Table 3-1 lists the channel configurations of each F2 Mux.

#### 3-18 P1 MUX FORMAT

The P1 Mux is a time-sharing device with one analog output at any given instant. Refer to paragraph 2-9 for a functional description of this unit. The unit's 30 channels can be continuous (each input monitored 120 times per second) or contain a X10 sub-multiplexer (each input monitored 12 times per second). Table 3-2 lists the channel configurations of each P1 Mux.

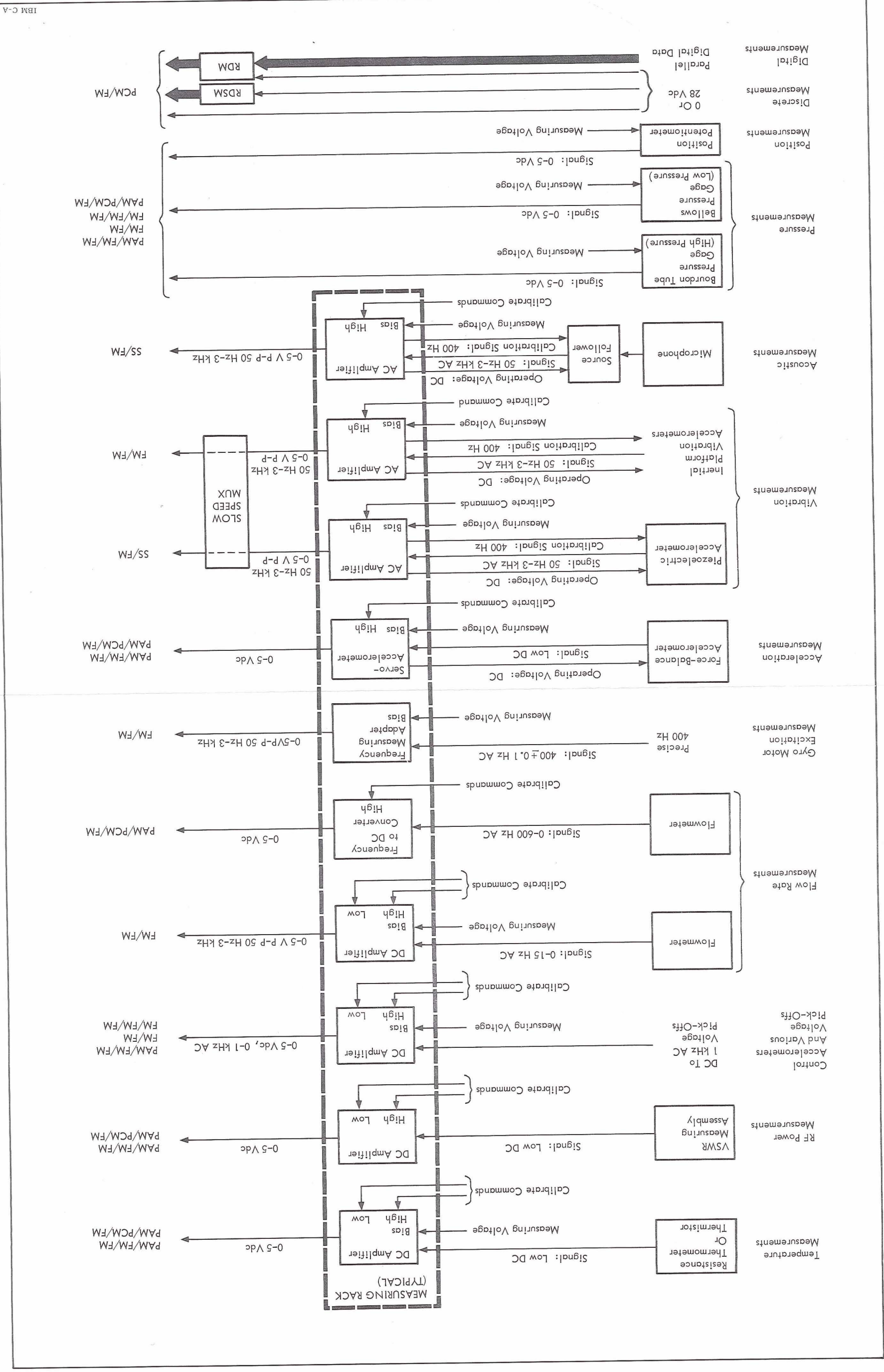
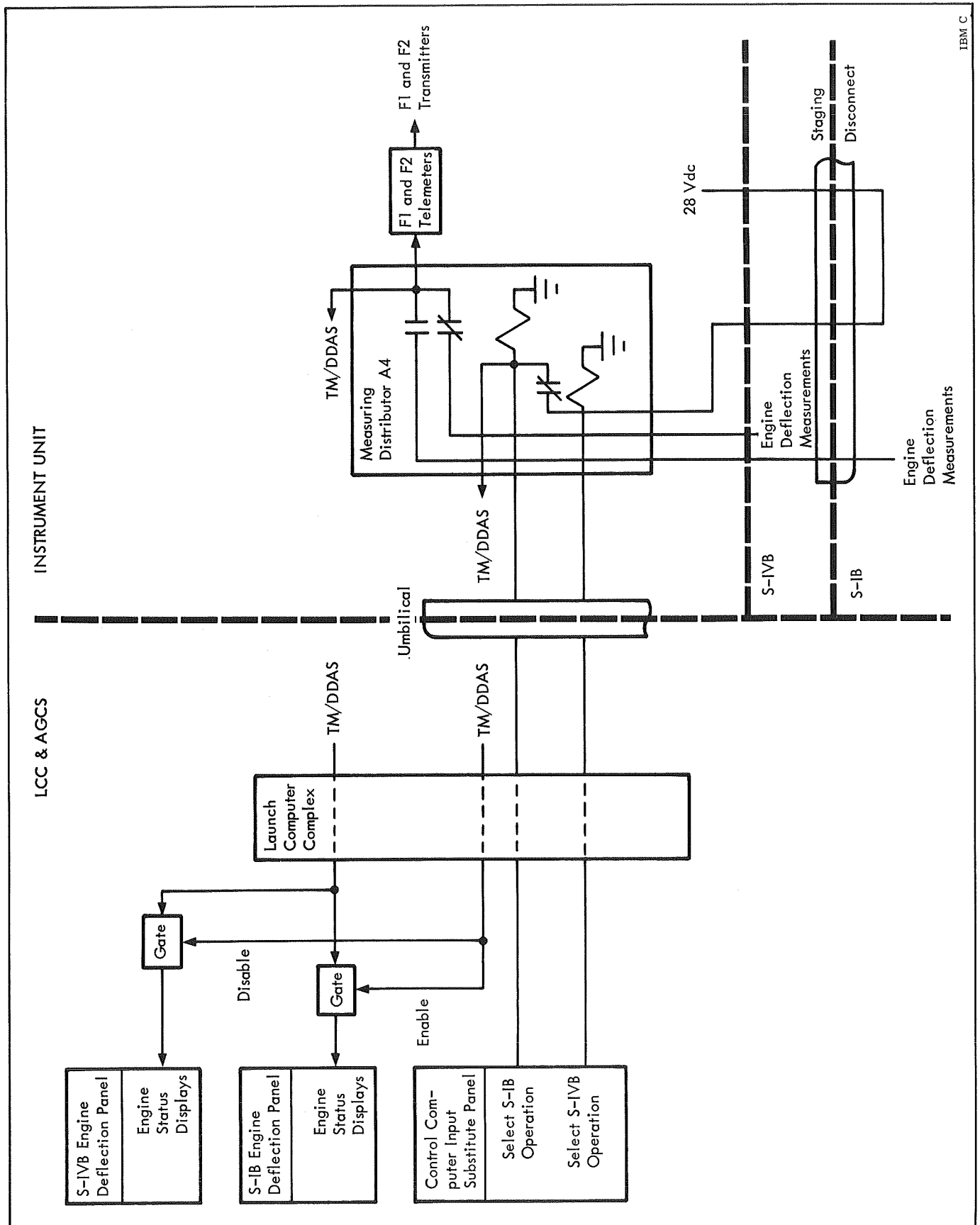


Figure 3-9. Measurement Routing Paths Functional Diagram



IBM C

Figure 3-10. Saturn IB Stage Measurement Selection Functional Diagram

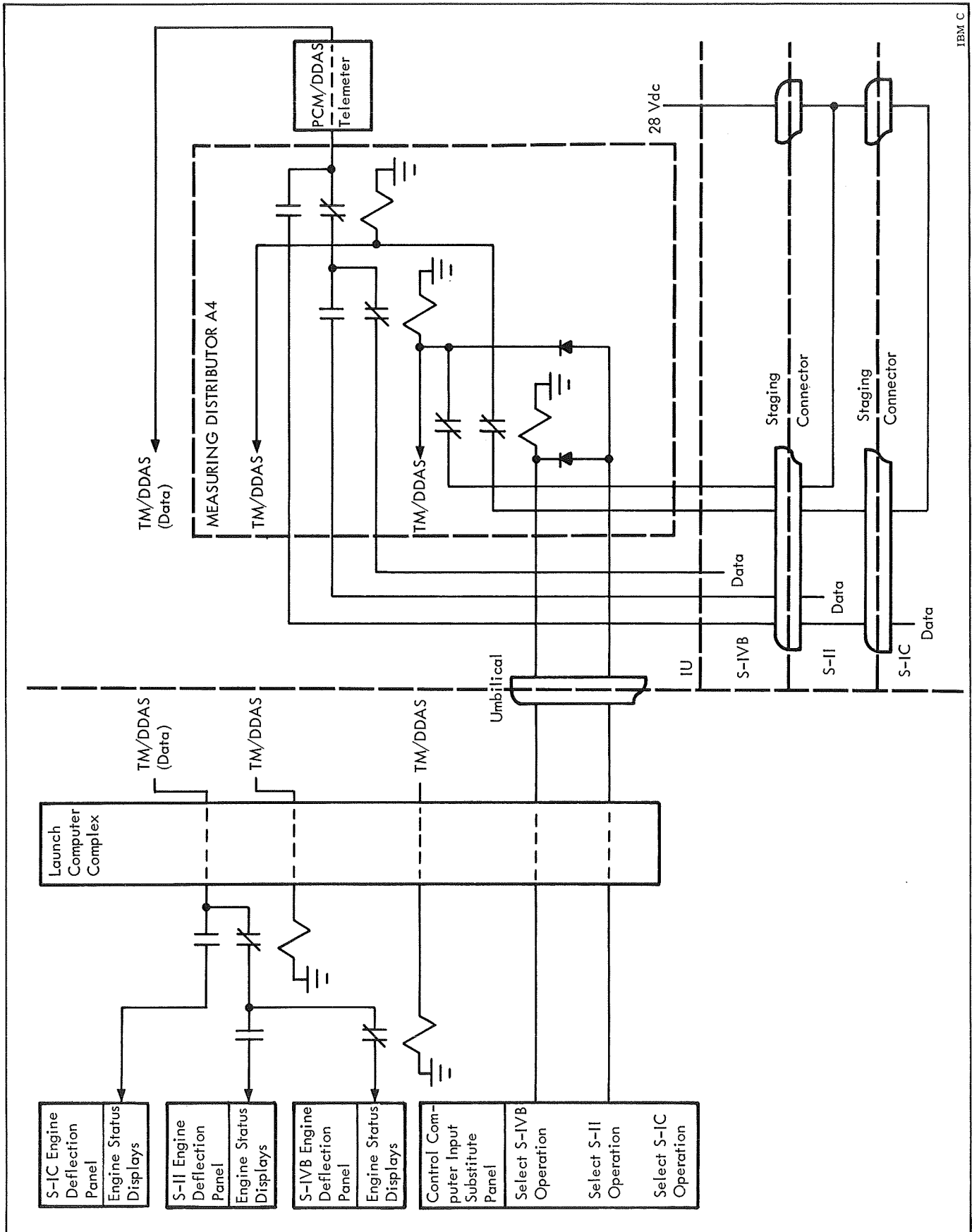
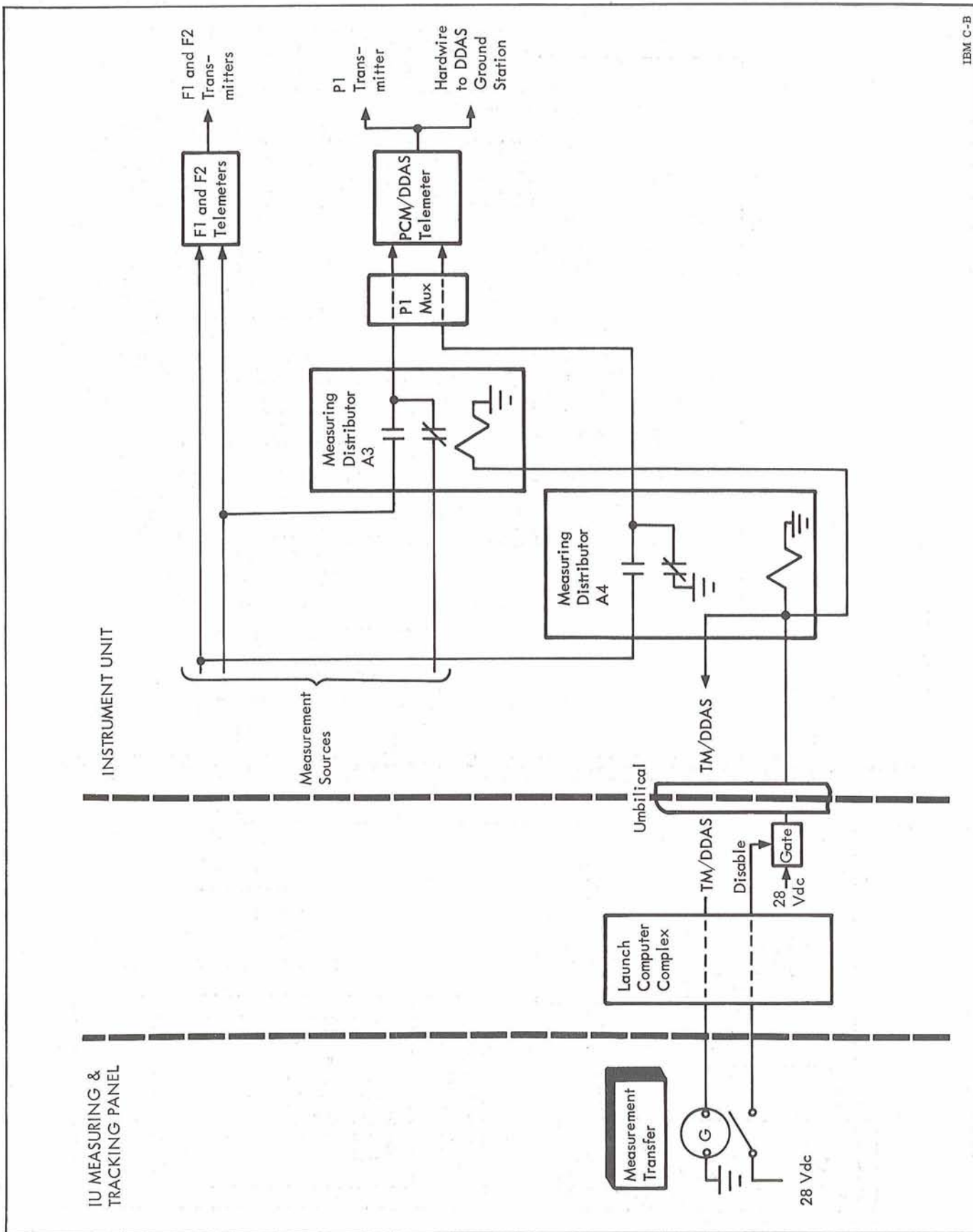


Figure 3-11. Saturn V Stage Measurement Selection Functional Diagram



IBM C-B

Figure 3-12. DDAS Measurement Transfer Functional Diagram

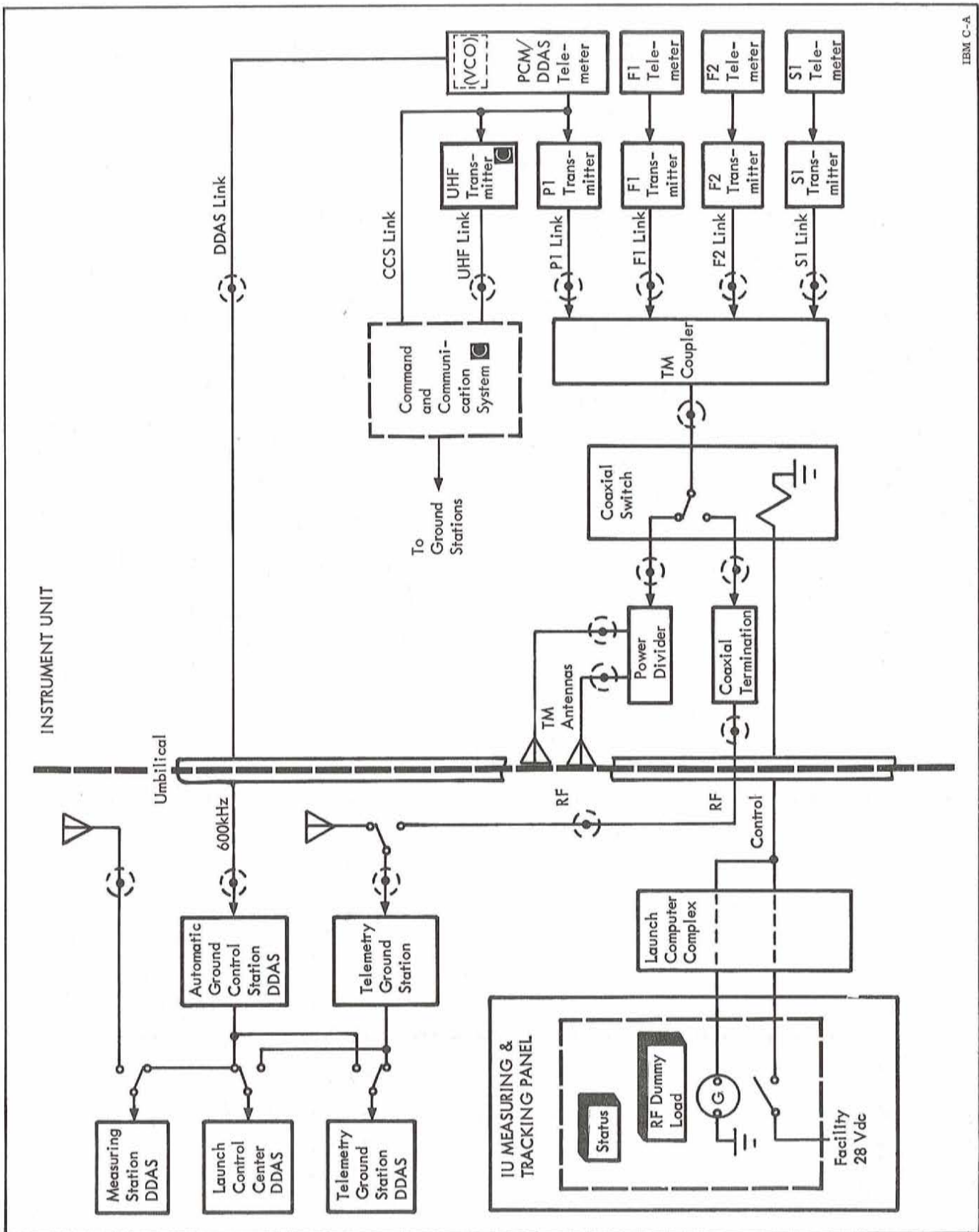
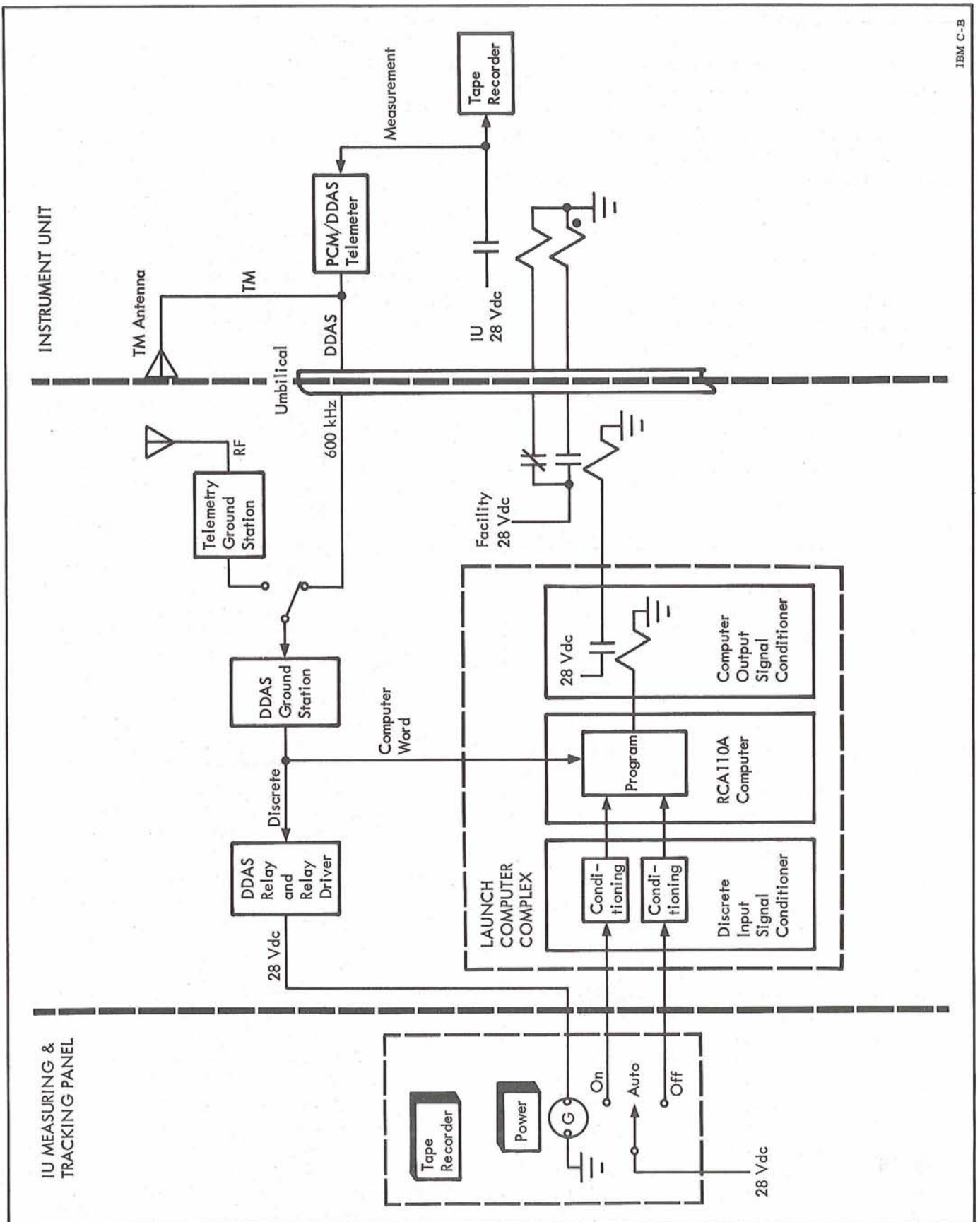


Figure 3-13. Telemetry RF Signal and DDAS 600 kHz Signal Flow Control Functional Diagram





IBM C-B

Figure 3-14. Typical Instrumentation System to Launch Computer Complex Interface Functional Diagram

3-19 RDM-K FORMAT

RDM-K is a time-sharing device with one parallel word output at a given instant. Refer to paragraph 2-10 for a functional description. Even though RDM-K has a ten-word capability, its output may consist of only a few of these words. The output presentation is dependent on the internal programming of the unit. Table 3-3 lists the word sequence of RDM-K.

3-20 RDM-J FORMAT

RDM-J is a time-sharing device with one parallel word output at a given instant. Refer to paragraph 2-10 for a functional description. Even

though RDM-J has a ten-word capability, its output may consist of only a few of these words. The output presentation is dependent on the internal programming of the unit. Table 3-4 lists the word sequence of RDM-J.

3-21 RDSM FORMAT

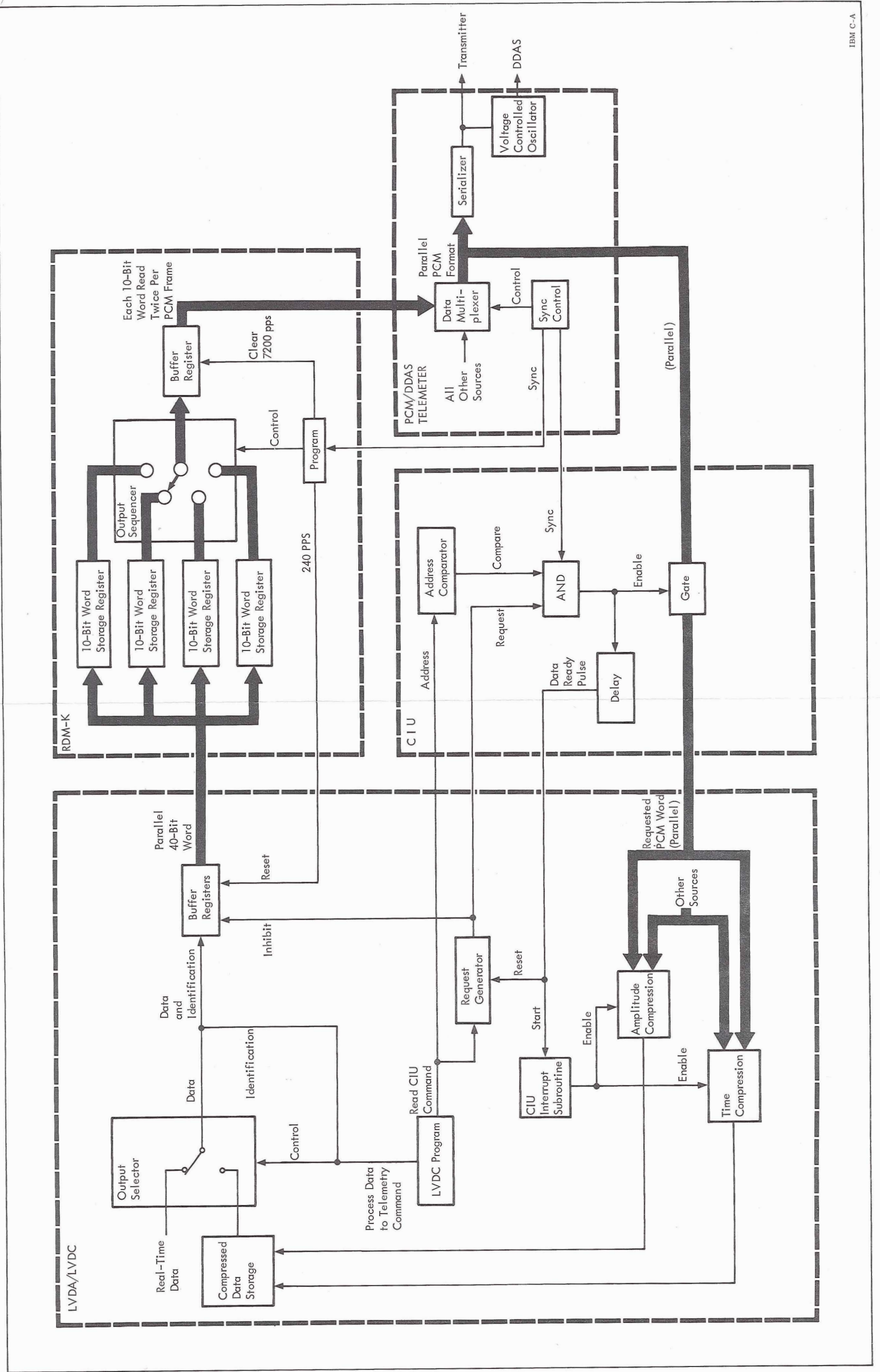
The RDSM is a time-sharing device with one parallel word output at a given instant. Refer to paragraph 2-11 for a functional description. The output of the RDSM consists of 10 separate, parallel words, with each word made up of separate discrete signals. These words are gated out to the PCM/DDAS Telemeter sequentially, one through ten, at a rate of one per PCM frame.

Table 3-1. List of F2 Mux Channel Configurations

Channel	Used on S-IU-	
	202	203 thru 204 and 501 thru 503
1	Continuous	X10 submux
2	X10 submux	X10 submux
3	X10 submux	X10 submux
4	X10 submux	X10 submux
5	Continuous	X10 submux
6	Continuous	X10 submux
7	X10 submux	Continuous
8	Continuous	Continuous
9	Continuous	Continuous
10	X10 submux	X10 submux
11	Continuous	Continuous
12	Continuous	Continuous
13	Continuous	Continuous
14	X10 submux	Continuous
15	Continuous	X10 submux
16	Continuous	Continuous
17	Continuous	X10 submux
18	Continuous	Continuous
19	Continuous	X10 submux
20	Continuous	Continuous
21	X10 submux	Continuous
22	Continuous	X10 submux
23	Continuous	Continuous
24	Continuous	Continuous
25	Continuous	Continuous
26	Continuous	Continuous
27	Continuous	Continuous
28	Identification	Identification
29	Identification	Identification
30	Identification	Identification

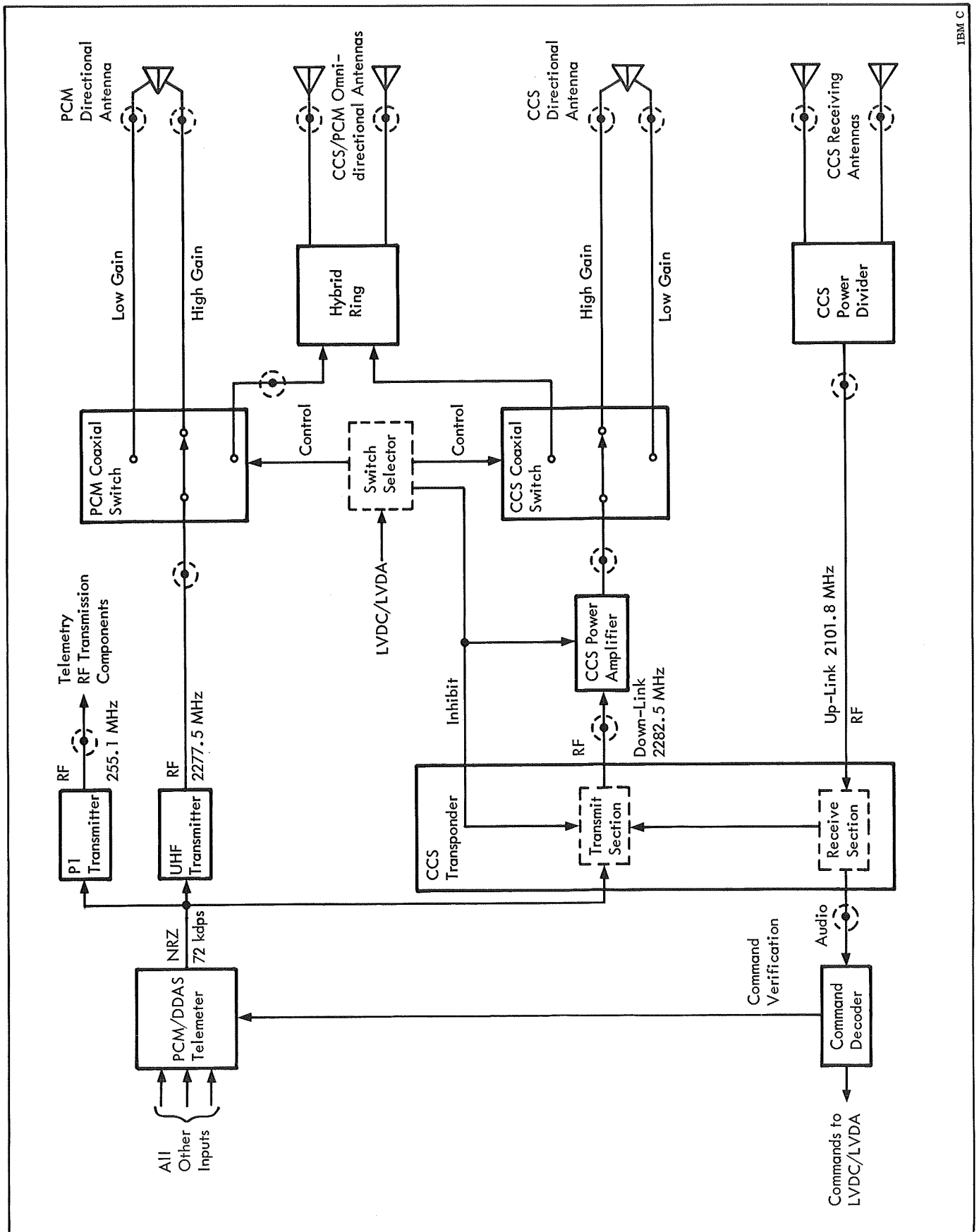
Table 3-2. List of P1 Mux Channel Configurations

Channel	Used on S-IU		
	202	203	204 and 501 thru 503
1	X10 submux	X10 submux	X10 submux
2	X10 submux	X10 submux	X10 submux
3	X10 submux	Continuous	Continuous
4	X10 submux	X10 submux	X10 submux
5	X10 submux	Continuous	Continuous
6	X10 submux	Continuous	Continuous
7	Continuous	X10 submux	Continuous
8	Continuous	Continuous	Continuous
9	Continuous	Continuous	Continuous
10	X10 submux	Continuous	Continuous
11	Continuous	Continuous	Continuous
12	Continuous	Continuous	Continuous
13	X10 submux	Continuous	Continuous
14	Continuous	X10 submux	X10 submux
15	Continuous	Continuous	Continuous
16	Continuous	Continuous	Continuous
17	X10 submux	Continuous	Continuous
18	Continuous	X10 submux	X10 submux
19	X10 submux	Continuous	Continuous
20	Continuous	Continuous	Continuous
21	Continuous	Continuous	Continuous
22	X10 submux	Continuous	Continuous
23	Continuous	Continuous	Continuous
24	Continuous	Continuous	Continuous
25	Continuous	Continuous	Continuous
26	Continuous	Continuous	Continuous
27	Continuous	Continuous	Continuous
28	Identification	Identification	Identification
29	Identification	Identification	Identification
30	Identification	Identification	Identification



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Figure 3-15. Computer Data Transfer Functional Diagram



IBM C

Figure 3-16. Command and Communication System Interface Functional Diagram

3-22 PCM/DDAS TELEMETER FORMAT

The PCM/DDAS Telemeter is a time-sharing device with an output of one digital bit at any given instant. Refer to paragraph 2-12 for a functional description. The output of the unit consists of a repeating train of serial, digital data that, when re-constructed, makes up analog words, discrete events, and digital words.

Up to 10 digital words can be accepted by the unit and placed in the output format in word times that would otherwise be occupied by analog input data from the model 270 multiplexers. Each word can be programmed to appear more than once in the output format. Figure 3-17 shows a PCM master frame and Table 3-5 lists the combination of digital gate cards and magnetic core storage register cards used in the format of each PCM/DDAS Telemeter.

3-23 F1 TELEMETER FORMAT

The F1 Telemeter is a frequency-sharing device with an output of several frequency-shared signals at any given instant. Refer to paragraph 2-13 for a functional description. The output consists of the signals from several voltage controlled oscillators mixed onto a single wire. Table 3-6 lists the SCO channels used by each F1 Telemeter.

3-24 F2 TELEMETER FORMAT

The F2 Telemeter is a frequency-sharing device with an output of several frequency-shared signals at any given instant. Refer to paragraph 2-13 for a functional description. The output consists of the signals from several voltage controlled oscillators mixed onto a single wire. Table 3-7 lists the SCO channels used by each F2 Telemeter.

3-25 SLOW SPEED MUX FORMAT

The Slow Speed Mux is a time-sharing device with an output of 16 different channels at any given instant. Refer to paragraph 2-15 for a functional description. Each of the 16 different output channels may be made up of up to five separate high-frequency inputs. Table 3-8 lists the channel configurations of each Slow Speed Mux.

3-26 S1 TELEMETER FORMAT

The S1 Telemeter is a frequency sharing device with an output of several frequency-shared signals at any given instant. Refer to paragraph 2-16 for a

functional description. The output consists of the signals from several tuned modulators mixed onto a single wire. This unit is not programmable.

Table 3-3. List of RDM-K Output Word Sequences

Input Word	Output Word Sequence
1	Not used
2	Not used
3	Not used
4	1
5	2
6	3
7	4
8	Not used
9	Not used
10	Not used

Table 3-4. List of RDM-J Output Word Sequences

Input Word	Output Word Sequence
1	1
2	2
3	3
4	4
5	5
6	6
7	7
8	8
9	9
10	10

Table 3-5. List of PCM/DDAS Telemeter Digital Card Configurations

Input Word	Card Type		
	S-IU-202	S-IU-203	S-IU-204 and 501 thru 503
1	MCR	MCR	MCR
2	Dummy	MCR	MCR
3	MCR	MCR	MCR
4	MCR	MCR	Dummy
5	MCR	MCR	Dummy
6	MCR	MCR	Dummy
7	MCR	Dummy	Dummy
8	Digital Gate	Digital Gate	Digital Gate
9	Dummy	Dummy	Dummy
10	Digital Gate	Digital Gate	Digital Gate

Table 3-6. List of F1 Telemeter Channel Configurations

Possible Channels*	Used on S-IU-				
	202	203	204	501	502 & 503
2					
3		x			
4	x	x	x	x	x
5	x	x			
6	x	x	x	x	x
7	x	x	x	x	x
8	x	x	x	x	x
9	x	x	x	x	x
10	x	x	x	x	x
11	x	x	x	x	x
12	x	x	x	x	x
13	x	x	x	x	x
14-2	x	x	x		x
14-3		x	x		
14-4	x	x	x	x	x
14-5	x				
14-6	x	x	x	x	x
15					
16	x	x	x	x	x
17-2					x
17-3				x	x
17-4	x	x	x	x	x
17-5	x	x	x	x	x
17-6	x	x	x		
17-7	x	x	x	x	x
17-8	x	x	x	x	x
18	x	x	x	x	x

\*Refer to Table 2-3 for frequencies.

Table 3.7. List of F2 Telemeter Channel Configurations

Possible Channels*	Used on S-IU-			
	202	203	204	501 thru 503
2	x	x	x	x
3				
4	x	x	x	
5	x	x	x	x
6	x	x	x	x
7	x	x	x	x
8	x	x	x	x
9	x	x	x	x
10	x	x	x	x
11	x	x	x	x
12	x	x	x	x
13	x	x	x	x
14-2			x	
14-3				
14-4		x		x
14-5	x	x	x	x
14-6	x	x	x	x
15	x	x		
X	x	x	x	x

\*Refer to Table 2-3 for frequencies.

Table 3-8. Slow Speed Mux Channel Configurations

Channel	S-IU-202	S-IU-203	S-IU-204 and 501 thru 503
1	2-input mux	2-input mux	2-input mux
2	2-input mux	2-input mux	2-input mux
3	2-input mux	2-input mux	2-input mux
4	2-input mux	2-input mux	2-input mux
5	2-input mux	2-input mux	2-input mux
6	2-input mux	2-input mux	2-input mux
7	2-input mux	2-input mux	2-input mux
8	2-input mux	2-input mux	2-input mux
9	2-input mux	2-input mux	2-input mux
10	Dummy mux	2-input mux	Dummy mux
11	4-input mux	4-input mux	4-input mux
12	4-input mux	4-input mux	4-input mux
13	4-input mux	4-input mux	4-input mux
14	4-input mux	4-input mux	4-input mux
15	4-input mux	4-input mux	Dummy mux
16	Dummy mux	Dummy mux	Dummy mux

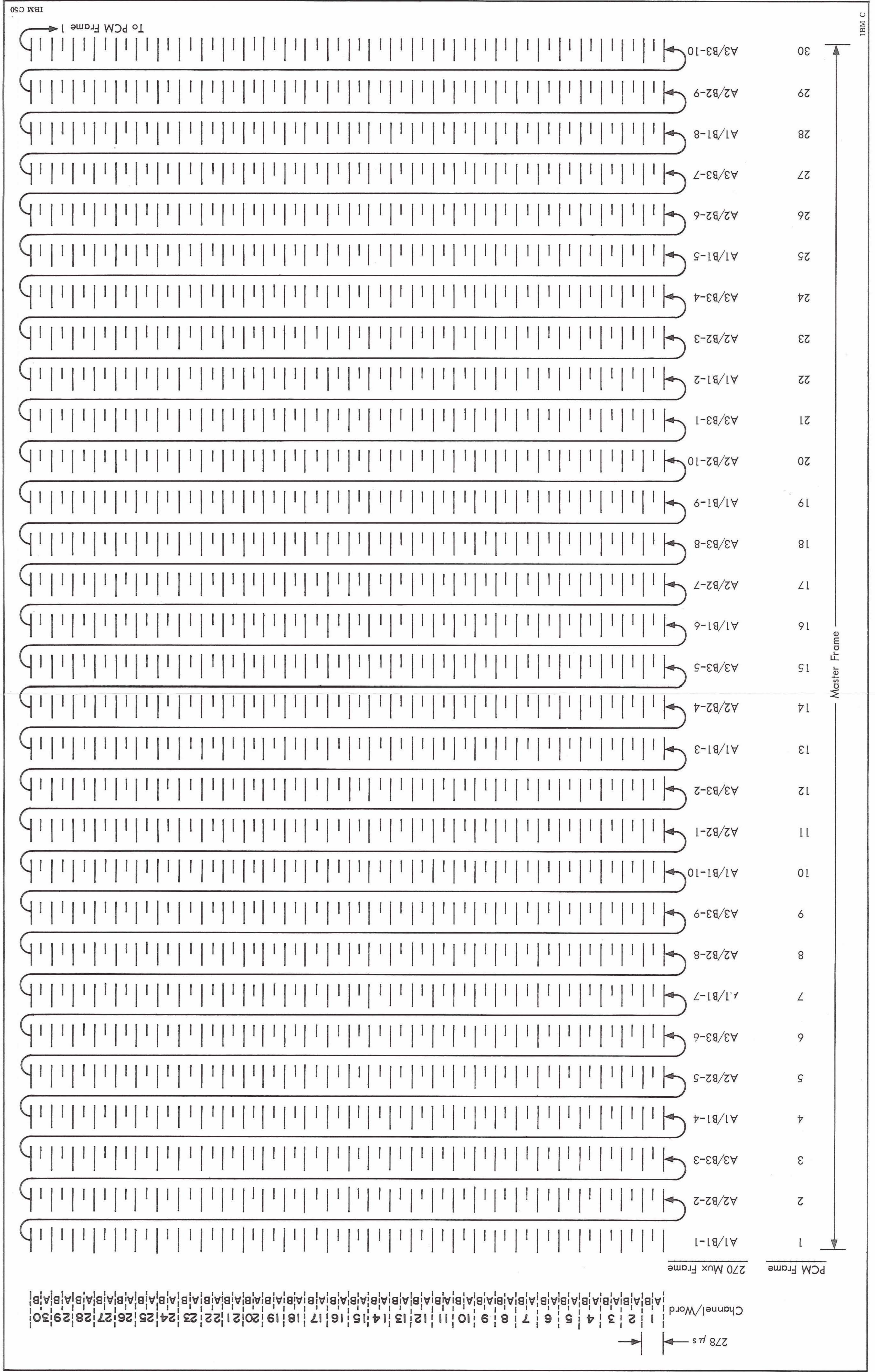


Figure 3-17. PCM Channel Identification Chart

## SPECIAL SYMBOLS

The following symbol definitions are for those symbols used in this manual that the reader may not be familiar with.



Placarded Nomenclature. Data in the box is given exactly as it appears on the equipment.



Latching Relay (schematic). Requires two commands: one to latch and another to unlatch. The dot indicates the last coil that has been energized.



Latching Relay (simplified). Requires two commands: one to latch and another to unlatch. Unlatch command is not shown.



Parallel Data Flow. Parallel lines carrying binary digital data or binary discrete data. Signifies ten lines unless otherwise indicated.

**A**

S-IU-202 Effectivity. The accompanying information pertains to S-IU-202 only.

**B**

S-IU-203 and S-IU-204 Effectivity. The accompanying information pertains to S-IU-203 and S-IU-204 only.

**C**

S-IU-501, 502, and 503 Effectivity. The accompanying information pertains to S-IU-501, 502, and 503 only.



## GLOSSARY

AGCS:	Automatic Ground Control Station.
ANALOG DATA:	An electrical signal that is instantaneously proportional to the measurement being monitored.
BPS:	Bits per second.
DDAS:	Digital data acquisition system.
DDCS:	Digital data calibration system.
CIF:	Central Instrumentation Facility at KSC.
CIU:	Computer Interface Unit.
DIGITAL DATA:	A series of electrical binary data pulses that represents a series of discrete signals, an analog signal, or information from a computer.
DISCRETE DATA:	An electrical signal representing, by a voltage level, either mode of a two-mode signal.
ESE:	Electrical support equipment.
FR:	Firing Room (Saturn V Blockhouse).
HZ:	Hertz, cycles per second.
IP&C:	Instrumentation Program and Components List.
IRIG:	Inter-Range Instrumentation Group.
IU:	Instrument Unit.
LVDC:	Launch Vehicle Digital Computer.
LCC	Launch Control Center (Saturn IB Blockhouse).
LVDA:	Launch Vehicle Data Adapter.
MF:	Medium frequency.
ML:	Mobile Launcher.
MUX:	Multiplexer.
PAM:	Pulse amplitude modulation.
PARALLEL DATA:	A group of digital data pulses existing simultaneously.
PCM:	Pulse code modulation.
RACS:	Remote Automatic Calibration System.
RDM:	Remote Digital Multiplexer.
RDSM:	Remote Digital Submultiplexer.
SCO:	Subcarrier oscillator.
SS:	Single sideband.
SSB:	Single sideband.
TM:	Telemetry, telemeter.
TMA:	Thermal mounting adapter.
VAB:	Vertical Assembly Building.

GLOSSARY (Cont)

VCO: Voltage controlled oscillator.

WORD: Unit of data 139 microseconds long.  
May consist of an analog electrical  
signal or ten bits of digital data.

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