

CONFIGURING  
SIGMA SYSTEMS  
USING  
SYSTEM INTERFACE UNITS

by

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## I. INTRODUCTION

The Systems Interface Units (SIU's) were conceived and developed in order to enable an individual to configure and price systems in the field.

There are several specific facets of SIU activity that should be noted:

- 1) There is no "Free Systems Engineering" policy for Sigma systems. The cost of integrating SIU's into a Sigma system is included in the price of the SIU.
- 2) When analog instruments are used in a Sigma system, cabinets, power supplies, cables, and connectors must be added to the systems price. There is no additional engineering charge for the integration of this equipment.
- 3) There is no additional charge for checkout using SDS standard systems methods and the SIU handler programs.
- 4) Engineering and Programming charges will be added for the design, integration, and checkout of any special item in a Sigma system.
- 5) All special programming requirements will be checked with Systems Programming and priced in accordance with their recommendations.
- 6) Installation will be made by Customer Service. Any unusual systems engineering installation requirements or testing will be charged to the customer.
- 7) Control and approval is from the Regional Applications Manager.
- 8) A copy of the systems proposal is to be submitted to the appropriate systems marketing manager.
- 9) All quotations of nonstandard equipment such as "Black Box Interfaces" will be generated by Systems and Applications in response to a Field Request or RPQ per Sales Manual Procedures.

## II. SYSTEM CONFIGURING AIDS

To enable a person to configure systems using SIU, that individual should be familiar with the following SDS publications.

- Computer Reference Manual
- SIU Brochure (64-28-01)
- Multiplexer Brochure (64-55-09)
- Analog/Digital Converter Brochure (64-55-07)
- Digital/Analog Converter Brochure (64-55-08)
- SDS Market Support Manual (Sections 64-56-XX)
- SIU Technical Manuals
- SIU Proposal Sections

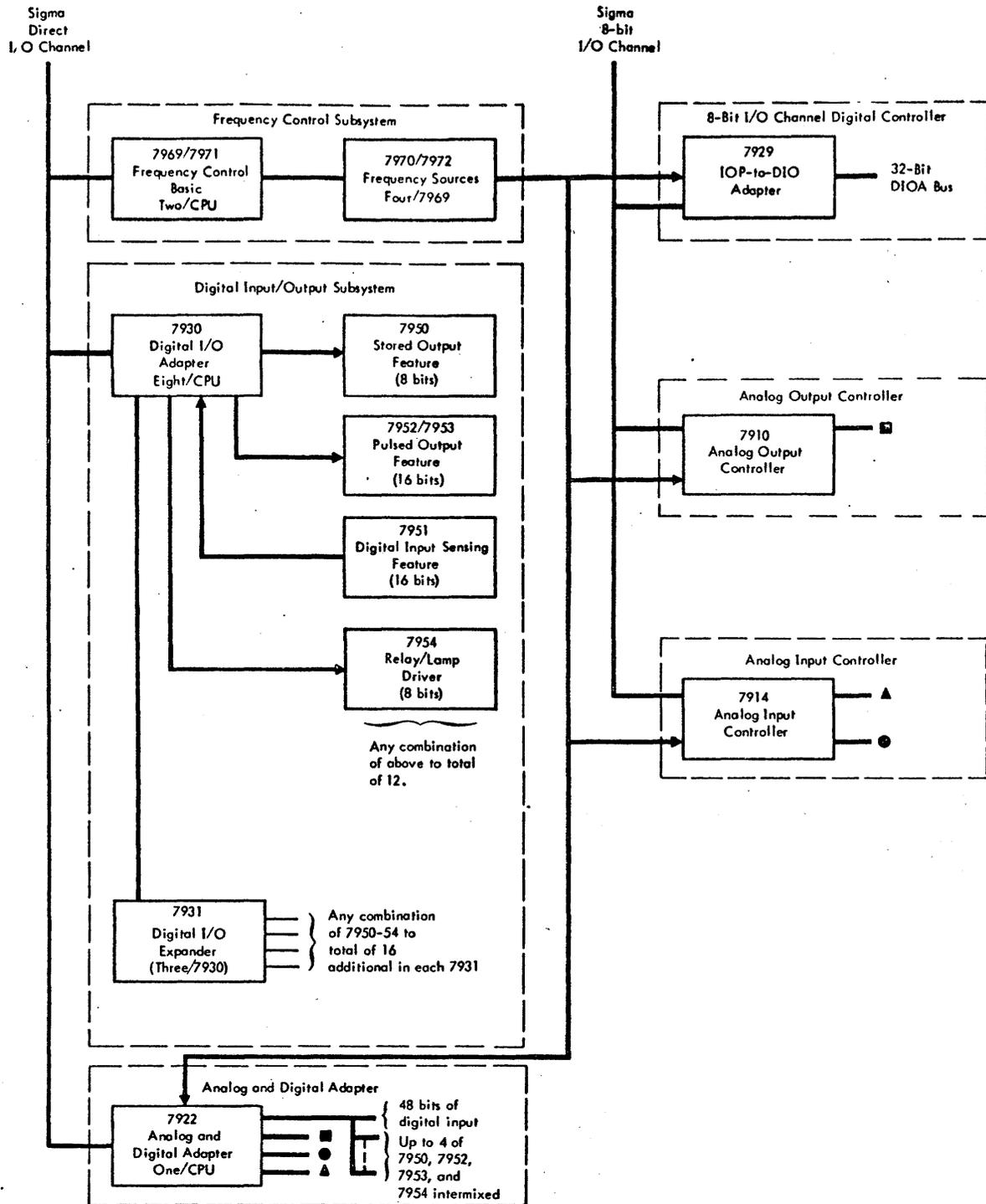
This brochure has been produced in order to enable an individual to use the preceding information to completely configure and price an SDS system using Sigma computers and System Interface Units. This publication is not intended to take the place of the manuals noted previously. If additional aid should be required in configuring a system, please feel free to contact the writer directly.

### III. WHY SIU'S

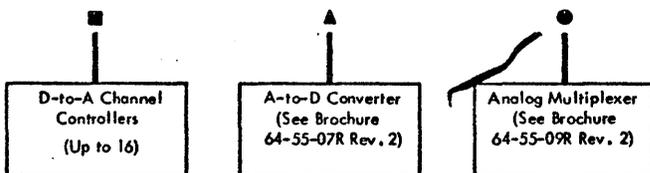
The SDS System Interface Units through standardization of design offer an economical means for connecting and controlling a wide range of analog and digital devices to a Sigma computer.

Through standardization, SIU's offer:

- ease and speed of system design
- user-oriented software
- comprehensive documentation
- concurrent foreground/background processing
- present and future flexibility
- maintenance programs
- lower costs



The following units can be attached to the Analog and Digital Adapter, Analog Output Controller, and Analog Input Controller as indicated.



**Sigma System Interface Unit Configuration**

#### IV. 7914 ANALOG INPUT CONTROLLER

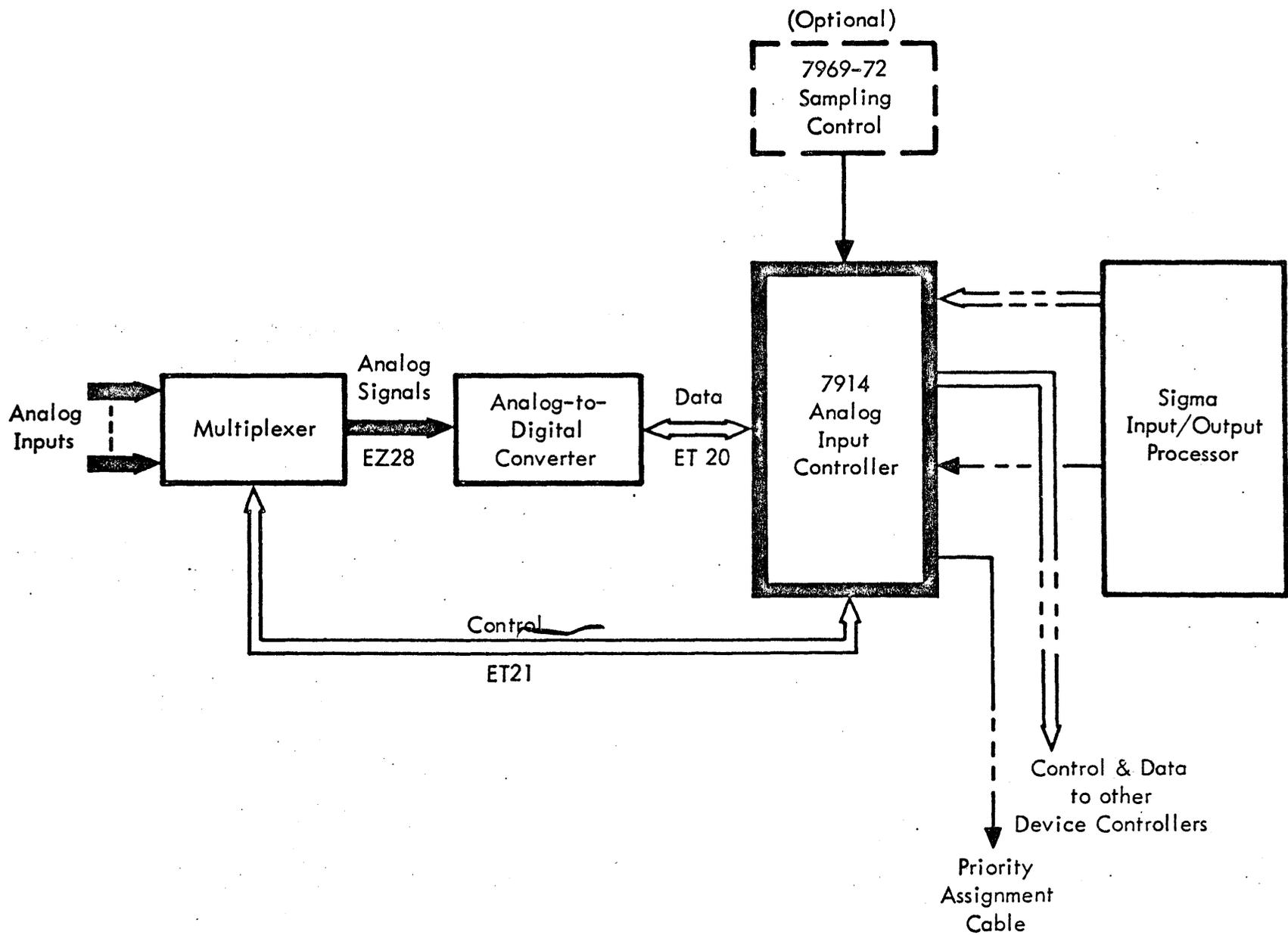
The SDS Model 7914 Analog Input Controller offers a flexible, economical means for connecting analog-to-digital conversion equipment to Sigma computers. Under control of this unit, analog inputs can be sampled randomly or sequentially via program control. Once initiated, analog-to-digital conversions proceed independent of the Sigma central processor.

The Model 7914 controller connects directly to the 8-bit I/O interface of a Sigma computer, where it uses one channel position. Each 7914 provides the interface and control necessary to operate one high-speed analog multiplexer and one analog-to-digital converter.

The operational performance of an analog input system depends upon the interaction of the 7914, the multiplexer, the sample-and-hold amplifier (if one is used), and the analog-to-digital converter. Information about these analog instruments is presented in Section X of this brochure.

In figuring accuracy, it is important to make the distinction between calibratable and noncalibratable error in the determination of overall system performance. The nonrandom errors can be minimized through calibration techniques. Calibratable errors, in general, are systematic; noncalibratable errors are random, or unpredictable. It is suggested that a calibration run be made immediately prior to the use of a data system. The tare values from the calibration run are then transferred to the computer, where appropriate compensatory calculations reduce the calibratable (nonrandom) error to a negligible value. A system with the stability to maintain its condition (relative to any systematic error) between calibration runs can realize the advantage of such a calibration procedure. With the distinction between calibratable and noncalibratable errors in mind, the merit of a data system depends largely upon the noncalibratable (noise) errors.

The Model 7914 Analog Input Controller is programmed with standard Sigma input/output instructions (SIO, TIO, HIO, TDV, and AIO). Eight user-set toggle switches on the 7914 determine the device address to be used in I/O instructions.

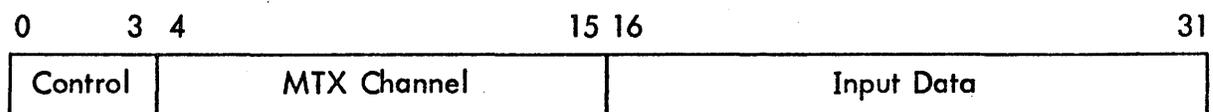


Utilization of the 7914 Analog Input Controller

Control of the 7914 is dependent upon the program stored in the Sigma computer. An I/O Command Doubleword is placed in the register for the selected I/O channel. This IOCD contains the memory address of the first byte to be output, the number of bytes to be transferred, and certain control information.

Two program-selectable modes of operation are possible with the Model 7914: the normal (or random) mode, in which the computer supplies a new multiplexer address before each conversion, and the automatic mode (for sequential or burst operation), in which the computer supplies a multiplexer channel address for the first conversion only and the 7914 then generates subsequent addresses.

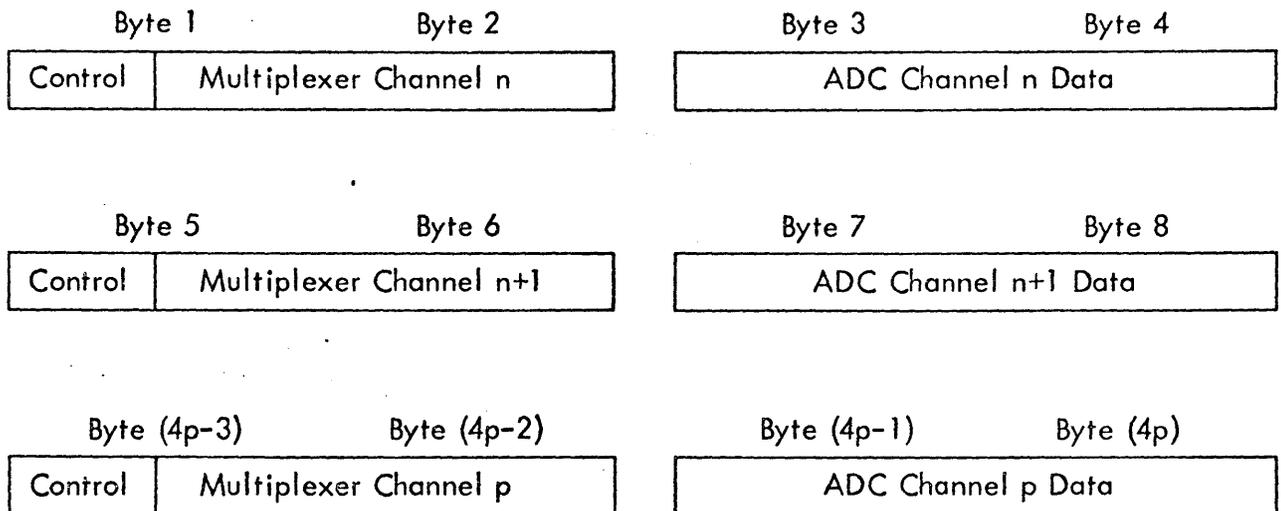
The format of a 7914 instruction is shown in the following example.



Bit	Function
0	"0" = random "1" = sequential
1	"0" = maximum rate "1" = under control of external signal
2	"0" = increment address "1" = address unchanged
3	"0" = no action "1" = burst mode

In the random mode, after the 7914 receives its start order (SIO), it accesses the first two bytes of an IOCD-specified list in memory. Then the multiplexer selects the specified channel and commands the ADC to begin conversion. When the multiplex-conversion cycle

is complete, the digital result is stored in memory in the two byte positions following those accessed for the operation. This process repeats until the program-specified number of analog samples has been obtained. For the random mode, the program list for one record would appear as shown in the accompanying example, where  $p$  is the number of channels.

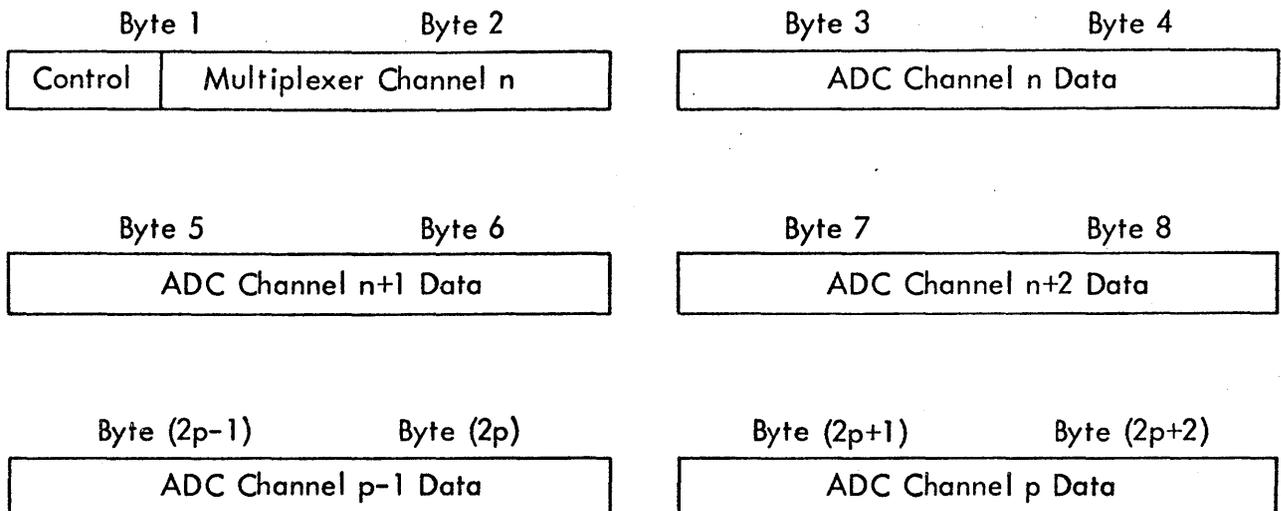


In the sequential mode, channel addresses are generated for subsequent conversions in one of two ways, specified under program control:

- By incrementing the present address by one before each conversion. When the HX35 Sample-and-Hold Amplifier is used, the multiplexer channel address is incremented as soon as the previous conversion has been initiated, thereby increasing the sampling rate by an "overlap" mode of operation.
- By maintaining the same address for all conversions in a group. In this case, the 7914 need not wait for multiplexer settling before it initiates another conversion, since the channel address has not changed.

The first two bytes obtained by the 7914 have the same format as those in the normal mode (i. e., 4 bits of control and 12 bits of multiplexer address). Thereafter, converted digital data is packed into successively higher byte pairs until the program-specified number of analog samples has been obtained. The control bits in the first byte determine whether the multiplexer address for each conversion is incremented by one (sequential operation)

or remains the same (burst operation). For either sequential mode, the program list for one record would appear in memory as shown in the following example, where p is the number of channels.



The multiplexer selects channels in sequence by channel number; however, any section of the multiplexer "list" can be selected for readout. The 12-bit field indicates the starting channel number, and the IOCD specifies the number of sequential channels to multiplex.

The speed of the 7914 depends upon the computer to which it is connected; the multiplexer, sample-and-hold, and ADC used; the mode and rate of operation; and the user's software construction (single data value, block of values, or ping-pong tables).

The 7914's various operating modes are described in detail in the SIU brochure and the standard proposal section. In the normal (random) mode, the data-in service cycle immediately follows the data-out service cycle. The service cycles follow the completion of the multiplex/conversion cycle. The maximum sampling rate can be determined from:

$$\text{Random Sampling Rate} = \frac{1}{T_r}$$

$$\text{where } T_r = t_{mu} + t_{sh} + t_{ad} + t_{dc} + t_{iop}$$

In the automatic (sequential) mode, the data-out cycle of two bytes is followed by a series of two-byte data-in cycles. The service cycles occur during analog-to-digital conversion. The maximum sampling rate can be determined from:

$$\text{Sequential Sampling Rate} = \frac{1}{T_s}$$

$$\left. \begin{array}{l} \text{where } T_s = t_{mu} + t_{dc} \\ \text{or } T_s = t_{sh} + t_{ad} \\ \text{or } T_s = t_{dc} + t_{iop} \end{array} \right\} \text{Use whichever is largest}$$

This assumes the use of a sample-and-hold amplifier and operation in an overlap mode. If the system does not utilize a sample-and-hold amplifier, then:

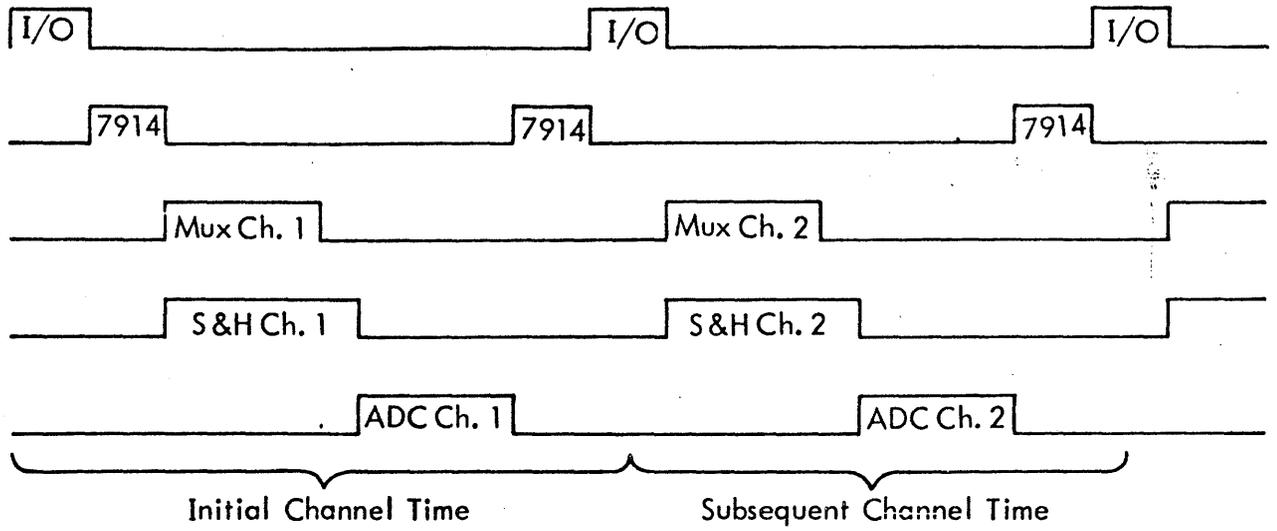
$$T_s = t_{mu} + t_{ad}$$

Values for substitution in the above equations are given in the following table. If any device is not present (e. g., sample-and-hold), the settling time for that item should be omitted from the equation.

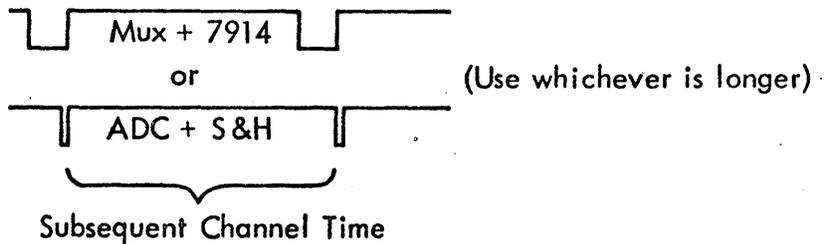
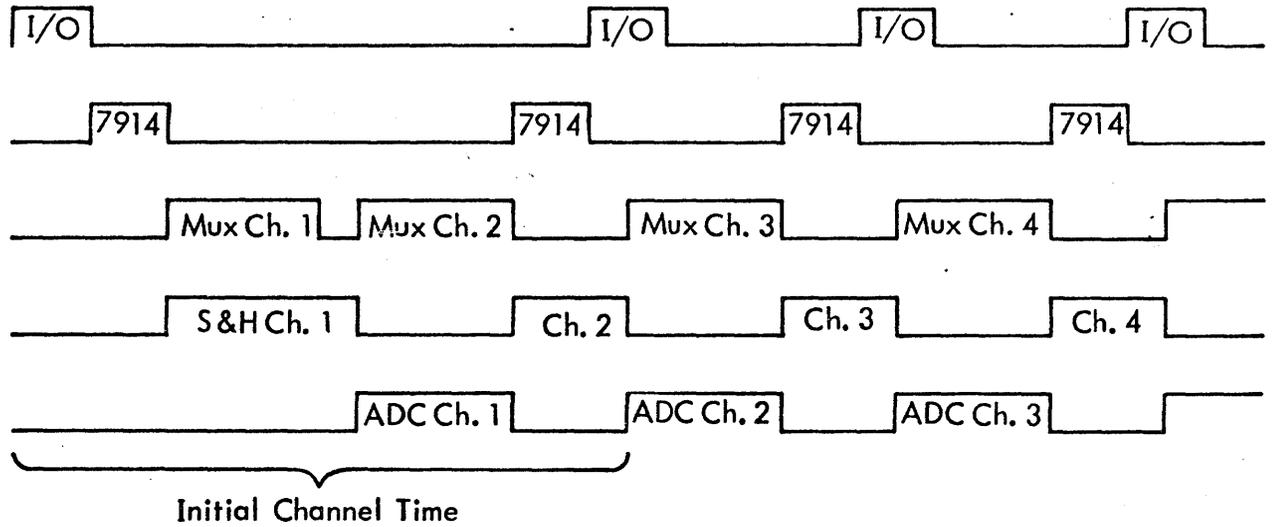
Table 1. Time Values for Sampling Rate Calculations

Symbol	Time	Description
$t_{mu}$	32.0 $\mu$ sec	Multiplexer settling time
$t_{sh}$	11.0 $\mu$ sec	Sample-and-hold settling time
$t_{ad}$	33.3 $\mu$ sec	AD20-11 conversion time
$t_{ad}$	75.0 $\mu$ sec	AD20-14 conversion time
$t_{ad}$	18.5 $\mu$ sec	AD30-12 conversion time
$t_{ad}$	5.2 $\mu$ sec	AD35 conversion time
$t_{ad}$	6.0 $\mu$ sec	AD35-SH conversion time
$t_{dc_r}$	7.0 $\mu$ sec	For 7914 in random mode
$t_{dc_s}$	4.0 $\mu$ sec	For 7914 in sequential mode
$t_{iop}$	12.0 $\mu$ sec	For Sigma 2
$t_{iop}$	14.4 $\mu$ sec	For Sigma 5 with integral IOP
$t_{iop}$	10.8 $\mu$ sec	For Sigma 5/7 with multiplexor IOP

Random Mode (with Sample & Hold)



Sequential Mode (with overlap using Sample and Hold)



Input Timing Charts for the 7914

## V. 7910 ANALOG OUTPUT CONTROLLER

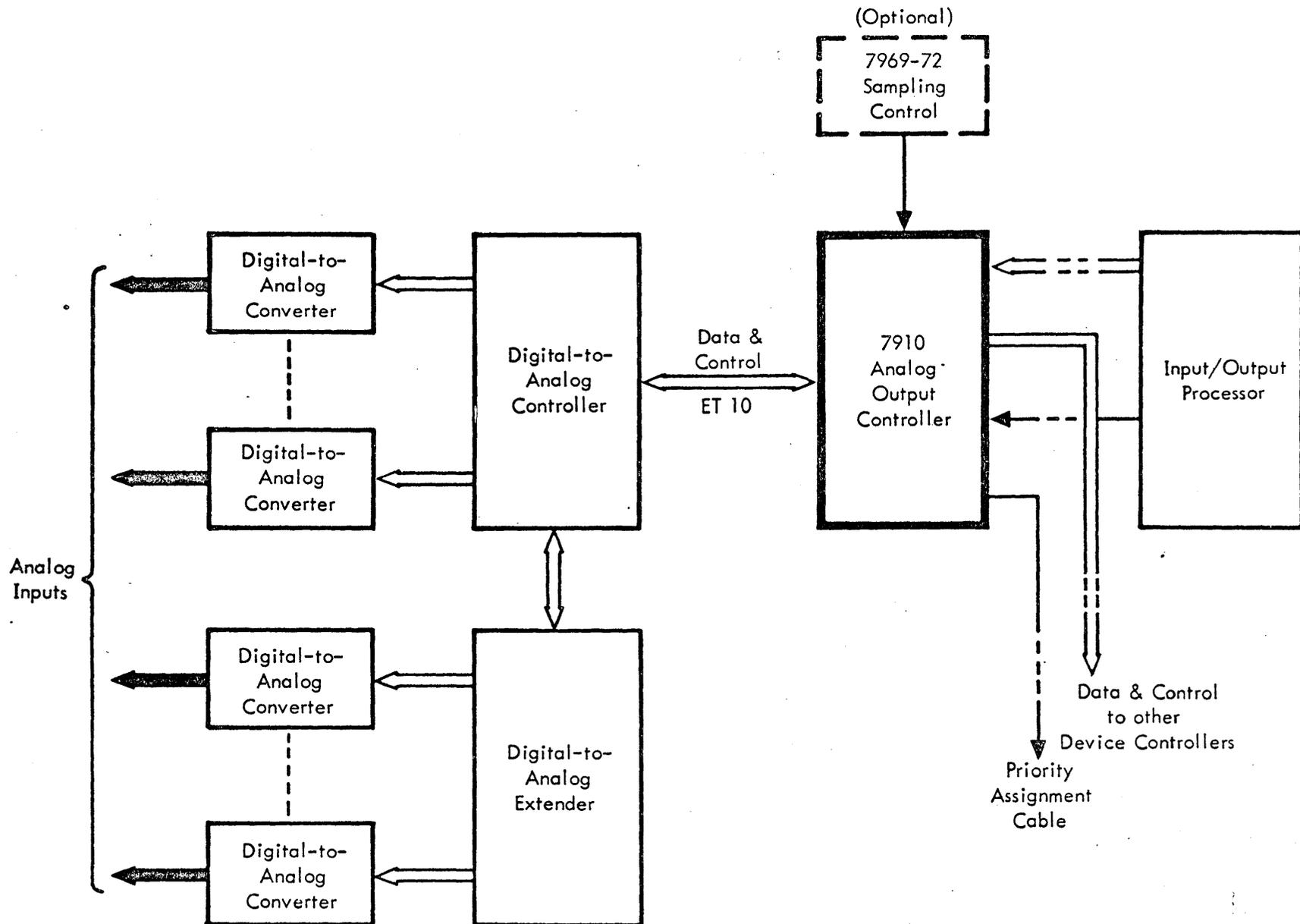
The SDS Model 7910 Analog Output Controller offers a flexible, economical means for connecting digital-to-analog conversion equipment to Sigma computers. Under control of this unit, analog outputs can be varied randomly, sequentially, or simultaneously under program control. Once initiated, digital-to-analog conversions proceed independently of the Sigma central processor.

The Model 7910 controller connects directly to the 8-bit I/O interface of a Sigma computer, where it uses one channel position. Each 7910 provides the interface and control necessary to operate 16 SDS digital-to-analog controllers. The number of digital-to-analog conversion channels controlled is dependent upon the controller selected. Information about the digital-to-analog converters is presented in Section X of this brochure.

The analog output controller is programmed with standard Sigma input/output instructions (SIO, TIO, TDV, HIO, and AIO). Eight user-set toggle switches on the 7910 determine the device address to be used in I/O instructions.

Control of the 7910 is dependent upon the program stored in the Sigma computer. An I/O Command Doubleword is placed in the register for the selected I/O channel. This IOCD contains the memory address of the first byte to be output, the number of bytes to be transferred, and certain control information. Two program-selectable modes of operation are possible with the 7910.

- Mode 1. The computer transfers the digital equivalent of the desired analog signal through the 7910 to the first-rank register of the selected digital-to-analog converter. This data is immediately transferred to the second-rank register, causing a new analog output signal to appear on that channel.
- Mode 2. Similar to Mode 1, except that transfer to the second-rank register occurs only after an entire group of first-rank registers has been loaded. This transfer causes new analog outputs to be generated simultaneously from all second-rank registers in the group.

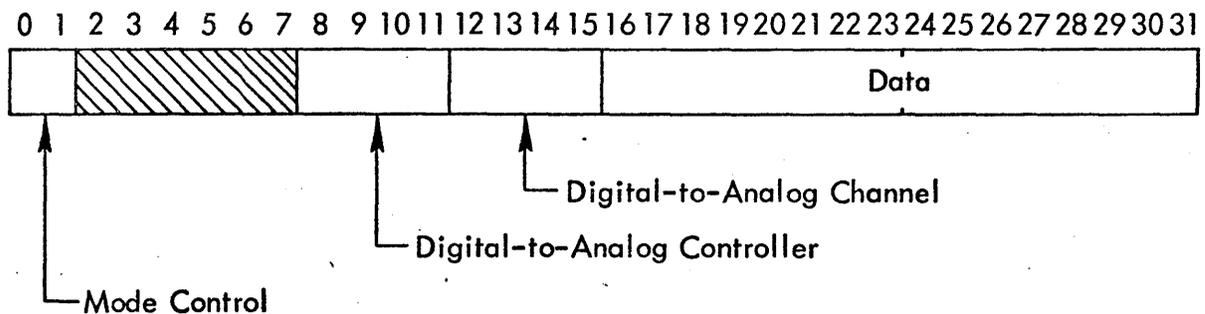


Utilization of the 7910 Analog Output Controller

The actual transfer pulse can be generated either by the 7910 or by an external source. In the latter case, the optional SDS frequency control subsystem (SDS Models 7969-7972) can be used to provide the external transfer pulse. Operating in this way, the system can cause specific groups of analog outputs to change randomly, sequentially, or simultaneously at regular, prespecified intervals.

In operation, after the 7910 receives its start order (SIO), it accesses the first four bytes of an IOCD-specified list in memory. As shown in the following example, four bytes of information are required for each conversion: one control byte, one digital-to-analog address byte, and two digital data bytes. In Sigma 5 and Sigma 7, these are all contained in one word. In Sigma 2, the data bytes are in the word following the control and address.

The format of a 7910 instruction is shown in the accompanying example:



<u>Bit</u>	<u>Function</u>
00	Load the first-rank register of the addressed converter but perform no other action.
01	Load the first-rank register of the addressed converter, and then transfer the first-rank register contents to the second-rank register in all converters connected to the 7910, thus altering their analog output. (NOTE: If the first-rank register of a particular converter has not been changed since the last transfer, there is no change in its analog output.)

<u>Bit</u>	<u>Function</u>
11	Load the first-rank holding register of the addressed converter, but inhibit all further operations of the 7910 until an external transfer signal occurs. This signal causes the first-rank register contents to be transferred to the second-rank register in all converters connected to the 7910.

The input rate of the 7910 depends upon the computer to which it is connected and the digital-to-analog converter used. The maximum speed can be determined from:

$$\text{Rate} = 1/T$$

$$\text{where } T = t_{iop} + t_{dc}$$

The values for substitution are shown in Table 2.

Table 2. Time Values for Input Rate Calculations

Symbol	Time	Description
$t_{iop}$	10.2 $\mu\text{sec}$	For Sigma 2
$t_{iop}$	9.5 $\mu\text{sec}$	For Sigma 5 with integral IOP
$t_{iop}$	8.8 $\mu\text{sec}$	For Sigma 5/7 with multiplexor IOP
$t_{dc}$	3.0 $\mu\text{sec}$	For 7910

## VI. 7930/7931 DIGITAL INPUT/OUTPUT SUBSYSTEM

The SDS Model 7930/7931 Digital Input/Output subsystem provides an extremely flexible means of providing most digital signals required by Sigma computer users. The following units make up the subsystem:

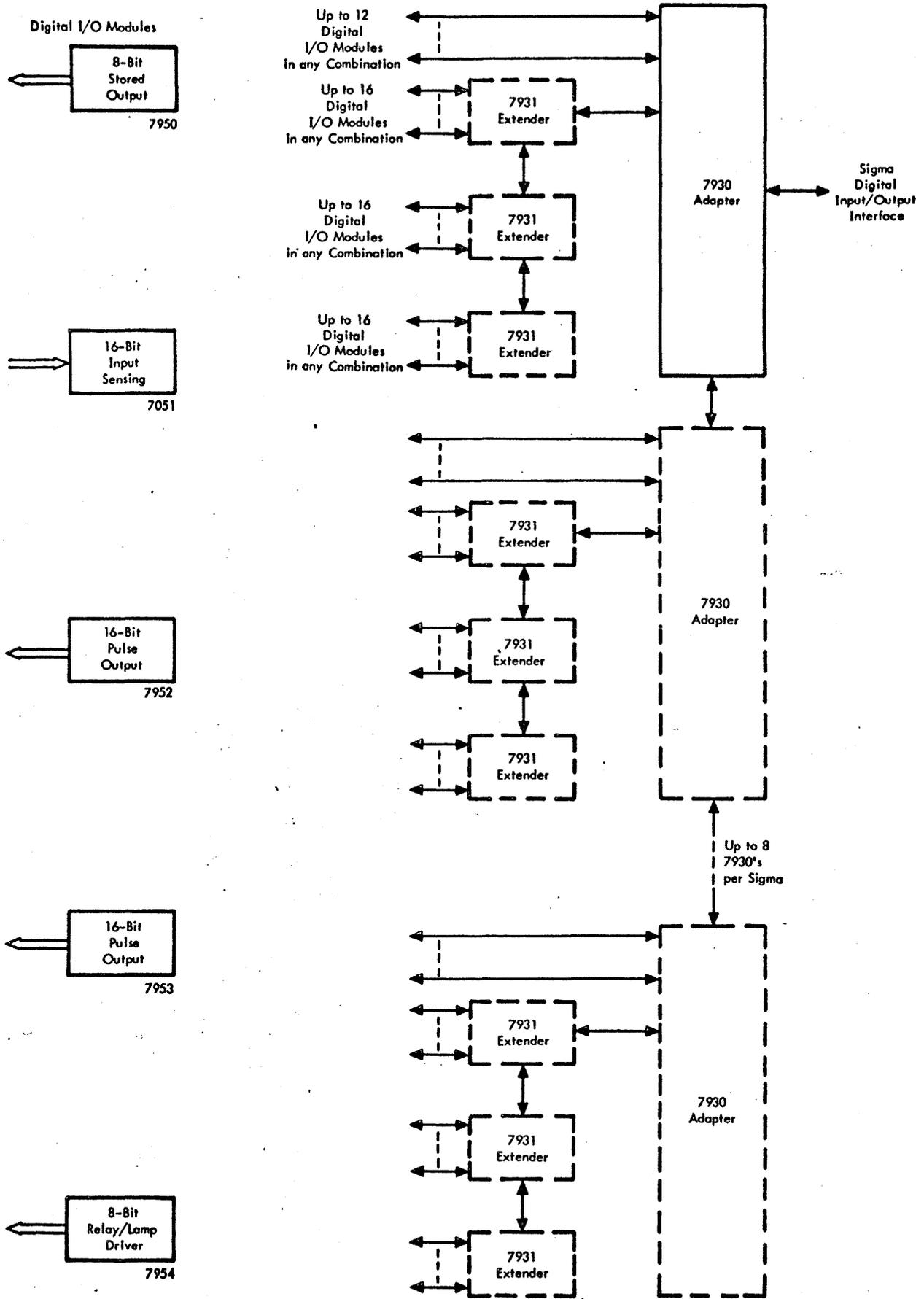
7930	Digital Input/Output Adapter
7931	Digital Input/Output Extender
7950	Stored Digital Output (8 outputs)
7951	Digital Input (16 inputs)
7952	Pulsed Digital Output (16 0-volt pulses)
7953	Pulsed Digital Output (16 +4-volt pulses)
7954	Relay/Lamp Driver (8 outputs)

The 7930 connects to the Direct Input/Output (DIO) interface of the computer. An "External Interface Feature" (8070 for Sigma 2 and 8270 for Sigma 5) is required on Sigma 2 and 5. The Sigma 7 contains the "External Interface Feature" as a standard item.

Up to eight 7930's may be connected to the DIO interface. Bits 4-6 of the address/control word select which 7930 is requested. A switch card within the 7930 enables the user to specify the address of each 7930. The 7930 contains three Control Channels. Each Control Channel can accommodate four Model 795x digital I/O modules. Bits 8-11 of the address/control word are used to select the desired Control Channel.

Up to three 7931's may be attached to each 7930. Each 7931 contains four Control Channels. Each Control Channel can accommodate four Model 795x digital I/O modules. Bits 8-11 of the address/control word select the desired Control Channel, as shown in the following discussion.

To configure a digital input/output subsystem, it is important to understand just how the 7930/7931 functions. Operation of the subsystem is under control of the Sigma computer, via Read Direct (RD) and Write Direct (WD) instructions.



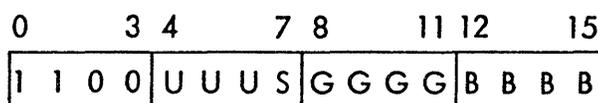
7930 Digital Input/Output Subsystem

During an RD instruction execution, the CPU presents a 16-bit address, receives 32 (or 16) bits of data for entry into the computer, and indicates to the external device that an RD is currently being executed. Information is transferred via the direct I/O bus.

Similarly, during a WD instruction execution, the CPU presents a 16-bit address, transmits a 32-bit (or 16-bit) data word from the computer, and indicates to the external device that a WD is currently being executed. Information is transferred via the direct I/O bus.

In the Sigma 2, data to or from the DIO line is placed in the A register. In the Sigma 5 and 7, data to or from the DIO line is placed in the register designated by the instruction. When an RD instruction is used it is important to store the present contents of the register, since the incoming data will over-write the existing information.

The format of the 16-bit address/control word is:



X'C'

<u>Bit</u>	<u>Function</u>
0 - 3	always a hexadecimal "C"
4 - 6	select one of eight 7930's
7	sub-multiplex control bit; determines whether the first or the second 8 bits of a 16-bit digital I/O module are to be used.
8-11	select one of fifteen 32-bit-wide control channels (three in the 7930 and four in each possible 7931). Each channel accommodates four digital I/O modules.
12-15	select one or more digital I/O modules connected to the selected control channel; a one in bit 12 gates signals to the first digital I/O module, a one in bit 13 gates signals to the second module, ones in both bits 12 and 13 gate signals to modules 1 and 2, etc.

The 7930/7931 subsystem has been designed to operate from both the 16-bit DIO of the Sigma 2 and the 32-bit DIO of the Sigma 5 or 7. When the subsystem is used with the Sigma 5 or 7, the 32-bit DIO lines are connected directly to the Control Channel. When it is used with the Sigma 2, the 16-bit DIO lines are connected to Control Channel lines 0-15 and paralleled with Control Channel lines 16-31 respectively.

## VII. 7922 ANALOG AND DIGITAL ADAPTER

The SDS Model 7922 Analog and Digital Adapter offers an economical means of connecting a wide range of analog and digital devices to a Sigma computer to provide a flexible data acquisition and control system.

The capabilities of the 7922 enable it to:

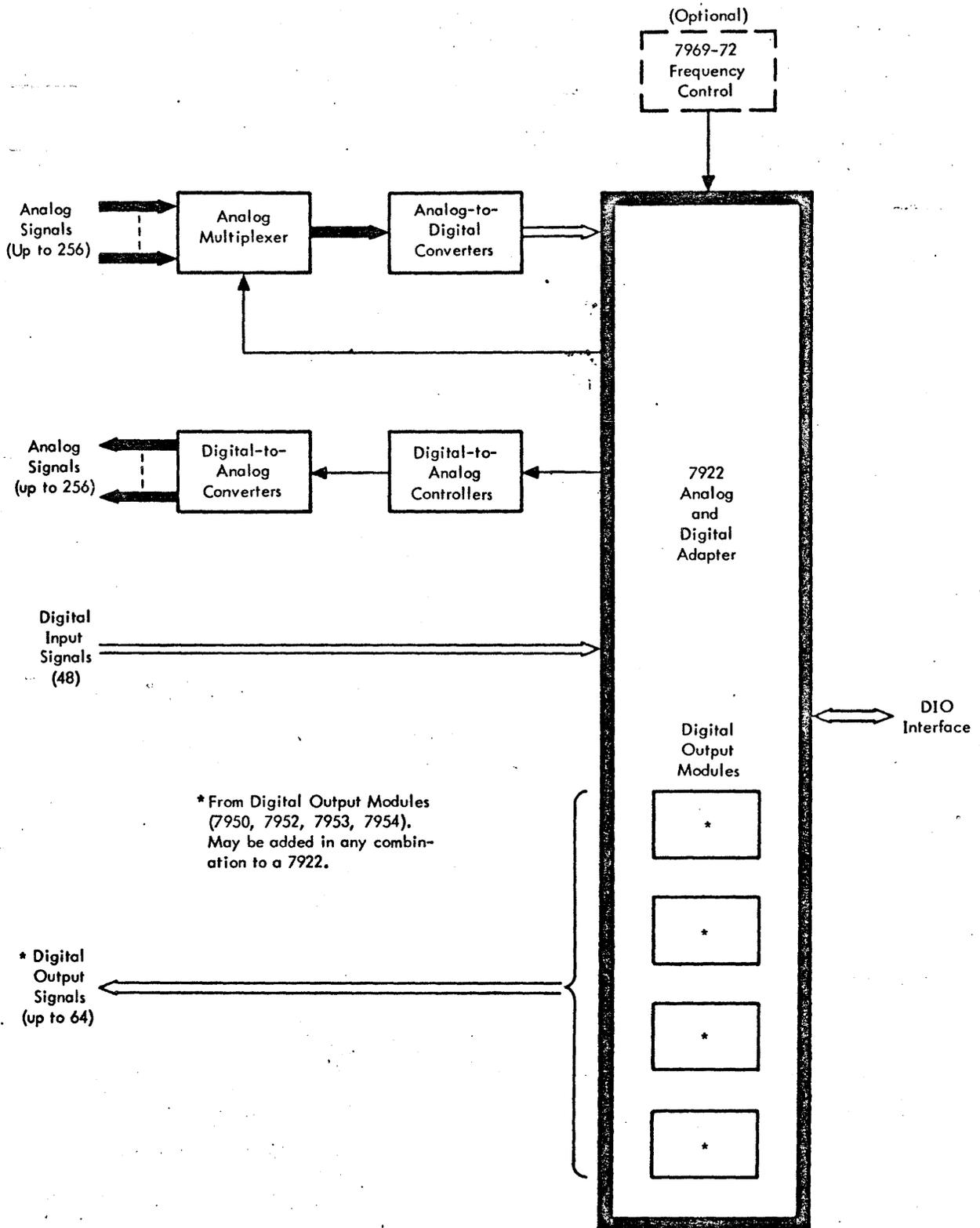
- control a 256-channel analog signal multiplexer,
- input data from an analog-to-digital converter
- control up to 256 channels of digital-to-analog conversion
- input 48 digital signals
- provide up to 32 stored digital output signals, or up to 64 pulsed digital outputs

The 7922 connects to the Digital Input/Output Interface (DIO). An "External Interface Feature" 8070 or 8270 is required on the Sigma 2 or 5. (The Sigma 7 contains the "External Interface Feature" as a standard item.) Only one 7922 may be connected to the DIO.

The 7922 is controlled by the Sigma computer using Read Direct (RD) and Write Direct (WD) instructions. The 7922 has basically four modes of operation.

- Analog Input (RD instruction)
- Analog Output (WD instruction)
- Digital Input (RD instruction)
- Digital Output (WD instruction)

During an RD instruction execution, the CPU presents a 16-bit control word to the 7922 which then selects the desired input function (Analog Input or Digital Input) and receives the resulting bits of data (16 maximum) into the computer. Information is transferred via the direct I/O bus.

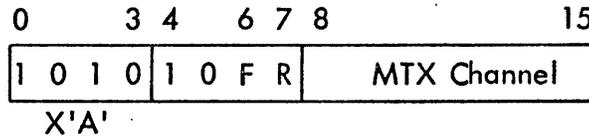


Utilization of the 7922 Analog and Digital Adapter

During a WD instruction execution, the CPU presents a 16-bit control word to the 7922 which then selects the desired output function (Analog Output or Digital Output) and transmits a 16-bit data word from the computer to the selected converter or output module. Information transfer is via the direct I/O bus.

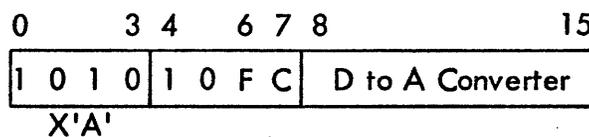
In the Sigma 2, data to or from the DIO is placed in the A register. In the Sigma 5 or 7, data to or from the DIO is placed in the register designated by the instruction. (When using an RD instruction it is important to store the present contents of the register as the incoming data will over-write the existing information.)

Analog input control word (RD) format:



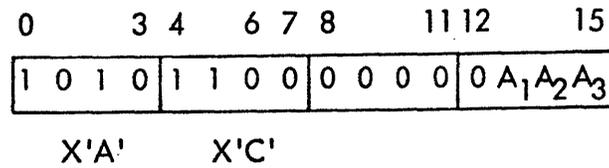
<u>Bit</u>	<u>Function</u>
6	"0" = digitize now "1" = wait for external signal to digitize
7	"0" = digitize channel defined by bits 8-15 "1" = digitize previously selected channel

Analog output control word (WD) format:



<u>Bit</u>	<u>Function</u>
6	"0" = update DAC now "1" = wait for external signal to update DAC(s)
7	"0" = load first rank D to A registers "1" = transfer all data in first rank register to second rank registers

Digital input control word (RD) format:

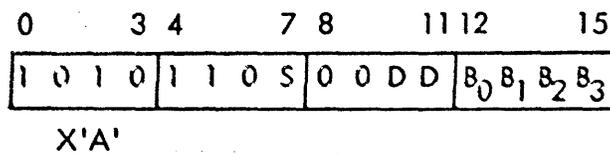


Bit

Function

13-15      Selects which one of three 16-bit words are to be input

Digital output control word (WD) format:



Bit

Function

7      Selects first or second 8 bits of 16-bit I/O modules

10-11      Selects pulse duration of 7952-3 digital I/O modules

12-15      Selects which digital I/O modules are to be used  
 (B<sub>0</sub> or B<sub>1</sub>; B<sub>0</sub> & B<sub>1</sub>; B<sub>2</sub> or B<sub>3</sub>; or B<sub>2</sub> & B<sub>3</sub>)

### VIII. 7969-7972 FREQUENCY CONTROL SYSTEM

The SDS Frequency Control System uses standardized equipment to provide frequency control and clocking signals for the SDS Sigma System Interface Units. The system enables the SIU's to perform operations at regular prespecified intervals, selected manually or under program control.

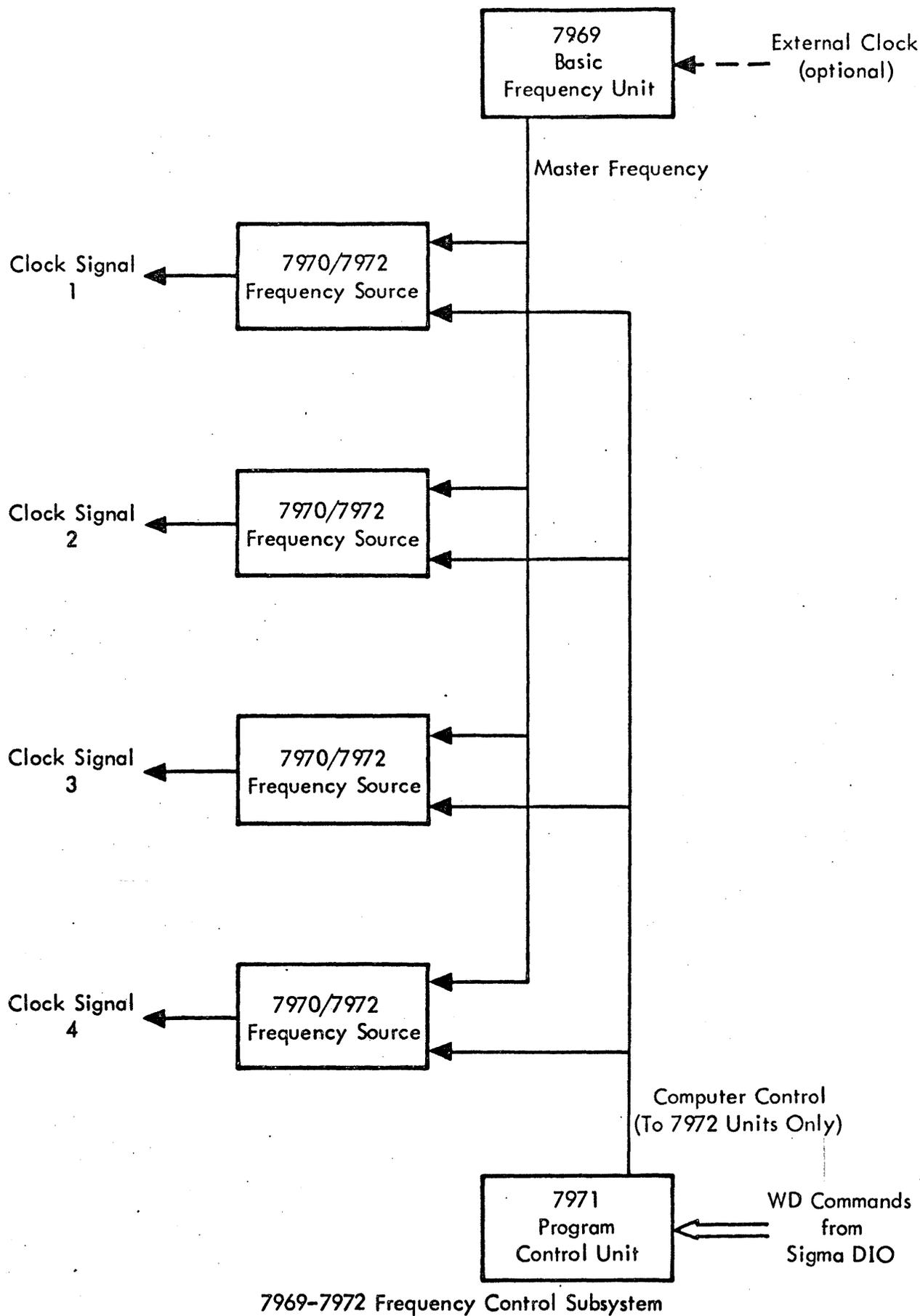
The Frequency Control System can contain the following elements:

- Model 7969 Basic Frequency Unit
- Model 7970 Manual Frequency Source
- Model 7971 Program Control Unit
- Model 7972 Programmed Frequency Source

The Model 7969 Basic Frequency Unit is the basis of the Frequency Control System. It consists of an MT12 Mounting Chassis that contains its own integrated circuitry plus space to plug in the 7970's, 7971's, and 7972's. The 7969 contains the basic clock for the system, which is a crystal-controlled oscillator normally supplied with a 1.28-Mhz crystal. (The crystal plugs in; other frequency crystals from 1 Mhz to 2 Mhz may be specified.) The master clock for the 7970's and 7972's is obtained from a binary divider chain connected to the oscillator. Toggle switches enable the customer to select the desired master frequency. The range of master frequencies is shown in Table 3.

Table 3. Range of Master Frequencies

Crystal	Switch						
	1	2	3	4	5	6	7
	(In KHz)						
1.00 MHz (minimum)	500	250	125	62.5	31.25	15.625	7.8125
1.28 MHz (supplied as standard)	640	320	160	80.0	40.0	20.0	10.0
2.00 MHz (maximum)	1,000	500	250	125.0	62.5	31.25	15.625



The Model 7971 Program Control Unit provides the necessary interconnection between the Frequency Control System and the Sigma computer. The 7971 connects to the DIO interface and requires an external interface feature (Model 8070 or 8270) for Sigma 2 and 5, respectively. Sigma 7 contains this feature as a standard item. Two 7971's can be connected to a Sigma computer. Each 7971 is used in conjunction with one 7969, and can control up to four 7972's.

The 7971 routes Write Direct (WD) commands from the computer to set the comparison register in the program-selected 7972. In addition, the WD command can turn the output clock of the selected 7972 on or off.

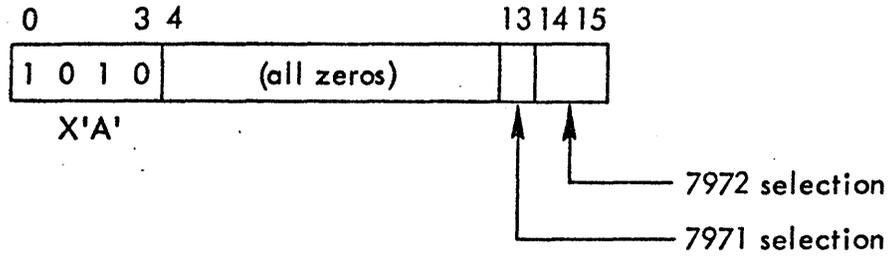
The Model 7970 Manual Frequency Source contains an 8-bit counter which counts the selected master frequency. This count is compared to the settings of eight manual toggle switches. When the counter value equals switch value, an output pulse is generated and the counter is reset. The output frequency,  $f_o$ , is:

$$f_o = \frac{\text{master frequency}}{N+1} \quad \text{where } 4 \leq N \leq 255$$

The Model 7972 Programmed Frequency Source contains a 12-bit counter which counts the selected master frequency. This count is compared to the value of a 12-bit holding register set from the computer's DIO interface through the Model 7971 Program Control Unit. When the counter value equals the register value, an output pulse is generated and the counter is reset. The output frequency,  $f_o$ , is:

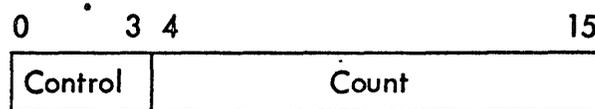
$$f_o = \frac{\text{master frequency}}{N+1} \quad \text{where } 4 \leq N \leq 4095$$

The WD control word has the following format:



<u>Bit</u>	<u>Function</u>
0 - 3	always a hexadecimal "A"
4-12	always zeros
13	selects one of two 7971's
14-15	selects one of four 7972's

The data associated with the WD control word has the following format:



<u>Bit</u>	<u>Function</u>
0	0 = output frequency enabled 1 = output frequency disabled
1	0 = load holding register with "count" and start counting 1 = load holding register with "count", output a pulse, and start counting
2-3	Unused
4-15	Count

## IX SIU INSTALLATION DATA

The following table contains information about SIU installation data, encompassing: identification of unit, physical description, installation location, and cabling connections.

Table 4. Installation Data

Name of Unit	Physical Description	Where Installed	Internal Cabling to Sigma *	SIU to Device Cabling†
Analog Input Controller (7914)	One chassis†	Sigma I/O cabinet, any chassis position	Four cables to 8-bit I/O system bus (Model ET10)	One ET20 from 7914 to A-to-D converter; one ET21 from 7914 to multiplexer
Analog Output Controller (7910)	One chassis	Sigma I/O cabinet, any chassis position	Four cables to 8-bit I/O system bus (Model ET10)	Two ET10s from 7910 to first DA35 or DA36; two ET10s from each DA35 or 36 to next DA35 or 36
Analog and Digital Adapter (7922)	One chassis	Sigma I/O cabinet, any chassis position	Three cables to Sigma direct I/O bus (Model ET10)	Same as 7910 and 7914 for analog instruments; similar to 7930/31 for digital signals
IOP-to-DIO Adapter (7929)	One chassis	Sigma I/O cabinet, any chassis position	Four cables to 8-bit I/O system bus (Model ET10)	Four ET10s to external devices(s), plus one ET10 to 7970/7972 or other frequency source.
Digital I/O Subsystem (7930, 7931, 7950, 7951, 7952, 7953, 7954)	7930, 7931: one chassis each. 7950, 7951, 7952, 7953, 7954: one module each	7930s and 7931s each occupy a single chassis position in a Sigma I/O cabinet. 7950, 7951, 7952, 7953, and 7954 plug into 7930 or 7931 as required	7930: four cables to Sigma direct I/O bus or to 7929 bus (Model ET10)†† 7931: two cables to 7930 7950, 7951, 7952, 7953, 7954: none	Customer-fabricated cables using ZT15 cable plug modules
Frequency Control Subsystem (7969, 7970, 7971, 7972)	7969: one control chassis; accommodates one 7971 and four 7970s or 7972s	7969 occupies one chassis position in a Sigma I/O cabinet. 7970, 7971, and 7972 plug into 7969 as required	7969/7970/7972: none 7971: three cables to Sigma direct I/O bus (Model ET10)††	One ET10 from each destination to next destination

\* Cables listed in this column are provided free as part of normal unit installation.

† Cables between these system interface units and terminal devices must be purchased separately.

‡ Chassis are standard SDS 32-module card cages.

†† Three cables only for Sigma 2.

## X. SDS ANALOG INSTRUMENTS USED WITH SIU'S

The accompanying two charts list the analog instruments used with the Models 7910, 7914, and 7922 Systems Interface Units.

In configuring a system using analog instruments, it is particularly important that the required cabinets, power supplies, cables, etc., be included.

The input rate and accuracy to be quoted for an analog system can be readily compiled from the charts. Note, however, that the accuracy can be improved by taking a calibration run immediately prior to using the data acquisition system and then using the Sigma computer to make the appropriate compensatory calculations.

### Characteristics of Analog Instruments Used with Sigma SIU's

Model Number	Instrument Description	Remarks	Prerequisites	SIU	Error (1)	Noise (3σ) (2)	Revolution	Time	Drift per °C	Power Units (3)	Space Units (4)	Cable SIU (5)	I/O Connectors	Comments
MU55	Multiplexer (MTX) Controller	Controls 32 MTX Channels Will house up to 8 SX4		7914 7922						5	1	ET 21		Transformer coupling required
MU56	Multiplexer (MTX) Controller	Controls 96 MTX Channels Will house up to 8 SX4		7914 7922						5	1	ET 21		Transformer coupling required
MU57	Multiplexer (MTX) Controller	Controls 224 MTX Channels Will house up to 8 SX4		7914 7922						5	1	ET 21		Transformer coupling required
MU75	Multiplexer Extender	Will house up to 8 SX4 32 MTX Channels	MU56 MU57							5	1			Includes cable to connect extender to another extender or multiplexer controller
MU77	Multiplexer Extender	Will house up to 16 SX4 64 MTX Channels	MU56 MU57							5	2			Includes cable to connect extender to another extender or multiplexer controller
SX40	Multiplexer Switch Card	4 Channels/Card	MU--		±0.2% (10-volt)	±0.04%		32 μsec per channel	400 μV	1			ZX 13	Mounts in MU-- multiplexers
SX41	Multiplexer Switch Card	4 Channels/Card Adjustable offset and gain	MU--		±0.01% (10-volt)	±0.04%		32 μsec per channel	400 μV	1			ZX13	Mounts in MU-- multiplexers

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Model Number	Instrument Description	Remarks	Prerequisites	SIU	Error (1)	Noise (3σ) (2)	Revolution	Time	Drift per °C	Power Units (3)	Space Units (4)	Cable SIU (5)	I/O Connectors	Comments
AD20-11	Analog-to-Digital Converter	To incorporate Sample & Hold, add HX35		7914 7922	±0.05% ±1/2 lsb	±0.008%	11 bits (incl. sign)	33 μsec per conversion	100 μV	10	1	ET 20	BNC	Transformer coupling required. Use an EZ28 cable to connect ADC to multiplexer.
AD20-14	Analog-to-Digital Converter	To incorporate Sample & Hold, add HX35		7914 7922	±0.01% ±1/2 lsb	±0.008%	14 bits (incl. sign)	75 μsec per conversion	100 μV	10	1	ET 20	BNC	Transformer coupling required. Use an EZ28 cable to connect ADC to multiplexer.
AD30-12	Analog-to-Digital Converter	To incorporate Sample & Hold, add HX35		7914 7922	±0.025% ±1/2 lsb	±0.025%	12 bits (incl. sign)	18.5 μsec per conversion	100 μV	10	1	ET 20	BNC	Transformer coupling required. Use an EZ28 cable to connect ADC to multiplexer.
AD35	Analog-to-Digital Converter			7914 7922	±0.01% ±1/2 lsb	±0.012%	15 bits (incl. sign)	5.2 μsec per conversion	negligible		1	ET 20	BNC	Use an EZ28 cable to connect ADC to multiplexer.
AD35-SH	Analog-to-Digital Converter	Similar to AD35 but includes S&H		7914 7922	±0.02% ±1/2 lsb	±0.012%	15 bits (incl. sign)	6 μsec per conversion	negligible		1	ET 20	BNC	Use an EZ28 cable to connect ADC to multiplexer. Cannot function in an overlap mode. Aperture time = 50 ns.
HX35	Sample & Hold Amplifier	Mounts in AD-- series ADC	AD--		±0.01%	±0.04%			100 μV					Aperture time 100 ns 11 μsec settling time. Mounts in AD--.

## Characteristics of Analog Instruments Used with Sigma SIU's

Model Number	Instrument Description	Remarks	Prerequisites	SIU	Error (1)	Noise (3#) (2)	Resolution	Time	Drift per °C	Power Units (3)	Space Units (4)	Cable to SIU (5)	I/O Connectors	Comments
DA35-9	Digital-to-Analog Controller	Will house up to 16 DX15		7910 7922						5	1	2 ET10		A PT10 power supply is required for each 8 DAC controllers.
DA35-15	Digital-to-Analog Controller	Will house up to 5 DX16 - 27		7910 7922						5	1	2 ET10		A PT10 power supply is required for each 8 DAC controllers.
DA36-15	Digital-to-Analog Controller	Will house up to 12 DX16 - 27		7910 7922						5	2	2 ET10		A PT10 power supply is required for each 8 DAC controllers.
DX15	Digital-to-Analog Converter	Output ±10V	DA35-9		±0.2%	±0.03%	9 bits	5 μsec	700 μV	1			BNC	Mounts in DA35-9. DAC conversion time is negligible. Settling time to 0.1% of final value is 5 μsec.
DX16	Digital-to-Analog Converter	Output ±10V	DA35-15 DA36-15		±0.025%	±0.03%	12 bits	7 μsec	100 μV	1			BNC	Mounts in DA35-15 or DA36-15. DAC conversion time is negligible. Settling time to 0.01% of final value is 7 μsec.
DX17	Digital-to-Analog Converter	Output ±10V	DA35-15 DA36-15		±0.015%	±0.03%	15 bits	7 μsec	100 μV	1			BNC	Mounts in DA35-15 or DA36-15. DAC conversion time is negligible. Settling time to 0.01% of final value is 7 μsec.
DX26	Digital-to-Analog Converter	Output ±100V	DA35-15 DA36-15		±0.025%	±0.03%	12 bits	100 μsec	1 MV	1			BNC	Mounts in DA35-15 or DA36-15. DAC conversion time is negligible. Settling time to 0.01% of final value is 100 μsec. Customer must furnish +135Vdc and -135Vdc power supplies.
DX27	Digital-to-Analog Converter	Output ±100V	DA35-15 DA36-15		±0.015%	±0.03%	15 bits	100 μsec	1 MV	1			BNC	Mounts in DA35-15 or DA36-15. DAC conversion time is negligible. Settling time to 0.01% of final value is 100 μsec. Customer must furnish +135Vdc and -135Vdc power supplies.

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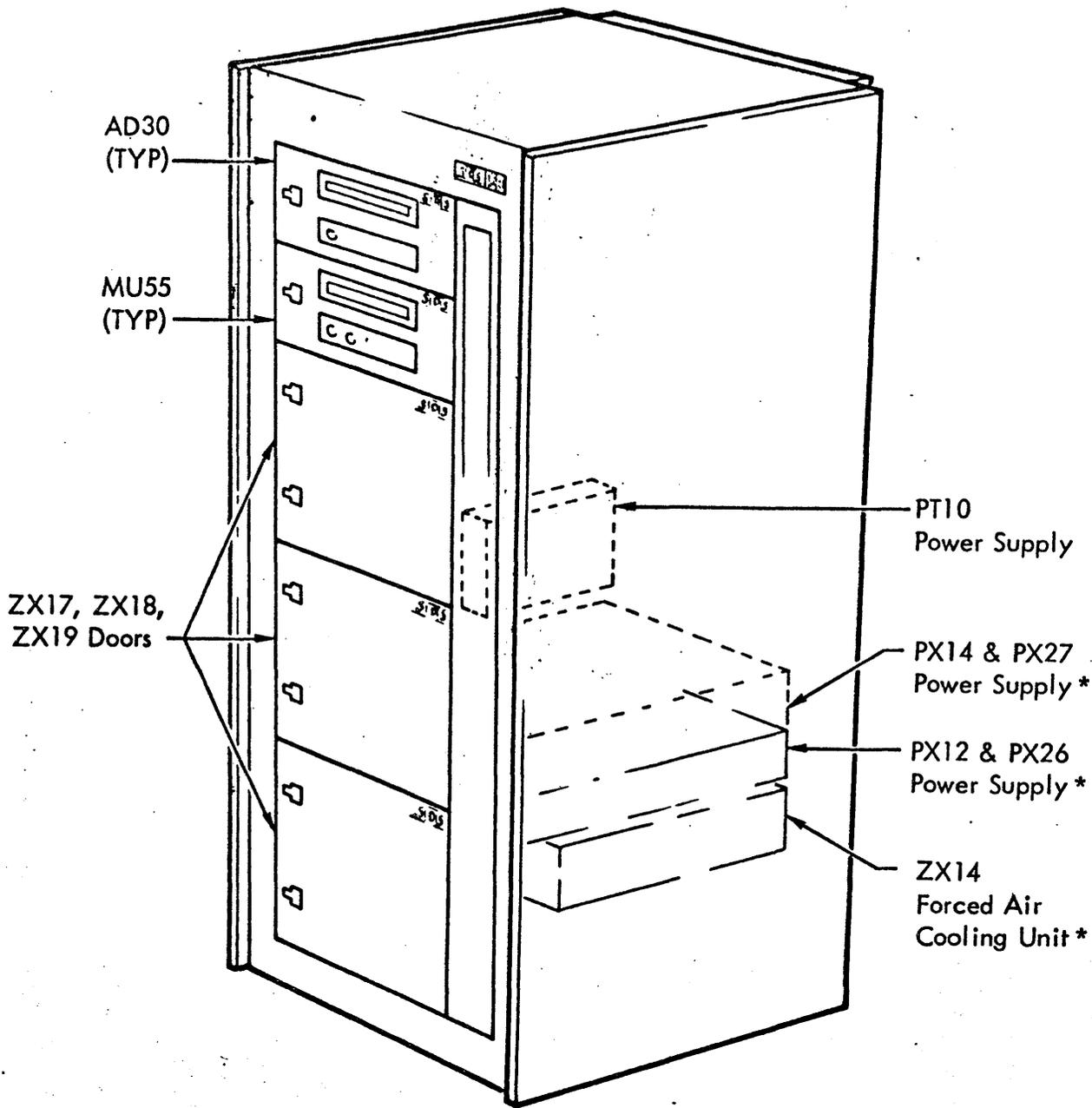
### Notes

- Total system accuracy is obtained by adding the sum of the errors of the individual items making up the system plus the square root of the summation of squares of the noise of the individual items.  

$$\text{Accuracy} = \sum \text{errors} [(MTX) + (S\&H) + (ADC)] + \sqrt{\sum \text{noise} [(MTX)^2 + (S\&H)^2 + (ADC)^2]}$$
- See note (1).
- SDS analog instruments do not contain their own power supplies and cannot use Sigma computer power. PX26 and PX12 or PX27 and PX14 must be provided. The PX26 and PX12 provides 20 power units. The PX27 and PX14 provides 80 power units.
- SDS analog instruments, their required power supplies, and a ZX14 cooling unit, mount in Model 8910 cabinets. The 8910 provides 8 space units. The power supply and cooling unit take up 2 units. ZX17 or ZX19 doors should be used to cover any open front panel space. The ZX17 covers 1 space unit. The ZX19 covers 2 space units.
- Cabling between Sigma SIU's and SDS analog instruments must be added and priced into a system.

### Cross Reference

- SIU information is contained in SDS brochure 64-28-01.  
 Data on configuring systems is found in Section 64-56-XX of the Market Support Manual.  
 Multiplexer information is contained in SDS brochure 64-55-09.  
 Analog-to-Digital Converter information is contained in SDS brochure 64-55-07.  
 Digital-to-Analog Converter information is contained in SDS brochure 64-55-08.



\* Power Supply and Cooling Unit  
Mount from Rear

Mounting of Analog Instruments in an 8910 Cabinet