HEWLETT PACKARD

Digital to Analog Voltage Converter Card Model 69720A, and Digital to Analog Current Converter Card Model 69721A

Preliminary Instruction Manual

SERIAL NUMBERS

This manual applies directly to cards with serial numbers prefixed as follows:

Model	Prefix
69720A	1909A
69721A	1918A

For cards with serial prefixes above those listed, a manual change page may be included.

Manual Part No. 5950-1836
Microfiche Part No. 5950-1837

Printed: January 1980

HP Computer Museum
www.hpmuseum.net

For research and education purposes only.

MANUAL CHANGES

Model 69720A Digital to Analog Voltage Converter Card and Model 69721A Digital to Analog Current Converter Card

Manual HP Part No. 5950-1836

Make all corrections in the manual according to the errata below, then check the following table for your card serial number and enter any listed change(s) in the manual.

Model 69720A

SERIAL		MAKE CHANGES
Prefix	Number	
2024A	0451-up	1

Model 69721A

SERIAL		MAKE CHANGES
Prefix	Number	
2030A	0156-0215	1
2052A	0216-0415	1,2
2147A	0416-up	1,2,3

CHANGE 1:

Make the following changes to the parts list and schematic diagram:

Delete transistor Q3 and resistor R65.
Change U29 to IC SN74LS33, HP Part No. 1820-1209.

These changes (See Figure 1) prevent the card from remaining enabled when the mainframe power supply crowbars.

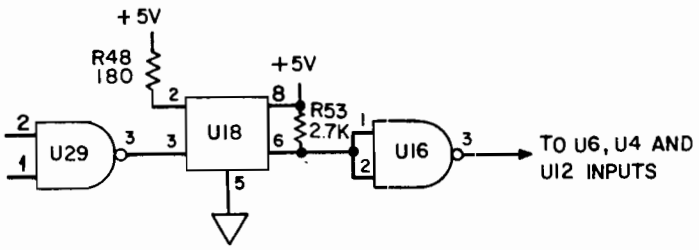

Figure 1. Card Enable Circuit Changes

Jumper options W31 through W35 have been added (See Figure 2) to facilitate factory installed specials for the following non-standard ranges:

69720A: ±5V, ±2.5V, +10V, +5V
69721A: ±10mA, ±5mA, +20mA, +10mA

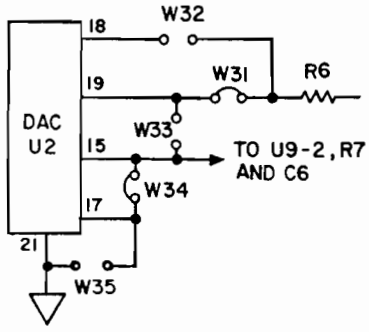

Figure 2. Jumper Additions

CHANGE 2:

On schematic and in parts list for the 69721A card, change resistors R24,R25 to 100K, HP Part No. 0699-0762.

ERRATA

The standard 69790A (1k), Option 002 69790A (2k), and Option 004 69790A (4k) Memory cards have been replaced by the 69790B (standard 4k) Memory Card. The 69790B uses low power CMOS RAM chips and draws only 1.2A from the +5 V supply. Consequently, there are no current loading restrictions and the +5 V power supply loading considerations described in paragraphs 4-2 through 4-10 no longer apply. A 6942A or 6943A mainframe can be filled with eight 69790B assemblies that occupy all 16 I/O slots (each 69790B requires two slots). Any combination of the existing I/O card models (69700A through 69790B) can now be installed in a mainframe without overloading the +5 V supply.

▶ CHANGE 3:

On schematic and in parts list for the 69721A card, change capacitors C20,C24, C26-32 to .1μF, HP Part No. 0160-4722, qty 7.

12-7-81

Digital to Analog Voltage Converter Card Model 69720A, and Digital to Analog Current Converter Card Model 69721A

1-1 GENERAL DESCRIPTION

1-2 This manual covers the 69720A Digital-to-Analog Voltage Converter and the 69721A Digital-to-Analog Current Converter cards.

NOTE

All statements herein apply to both models unless specifically noted.

1-3 The 69720A Digital-to-Analog Voltage Converter card provides a high-speed bipolar output voltage from twelve bits of data supplied either through the mainframe backplane or through the card's external edge connector. Its output range is −10.24 through +10.235 volts at up to 5 milliamps, and the voltage value of its LSB is 5 millivolts.

1-4 The 69721A Digital-to-Analog Current converter card has the same voltage output capabilities as the 69720A card except that the current rating of its voltage output is 4 milliamps. In addition to its voltage output, the 69721A has a bipolar −20.48 to +20.47mA current output with a voltage compliance of 11 volts and an LSB value of 10 microamps. Its voltage and current outputs track each other and are not independently programmable.

1-5 The analog outputs of both models are isolated from digital data common so that grounded loads and loads floating at up to 250V dc or ac above ground can be controlled.

1-6 Cycling a D/A card transfers to the card's second rank of storage the data previously stored in its first rank and converts this data to an analog voltage or current. The card can be cycled either through a programmed instruction or an External Trigger signal. External triggering allows analog output changes to be synchronized by external events. Dual rank storage on the card allows two or more cards to have their outputs updated simultaneously, either by a programmed instruction or by an External Trigger signal.

1-7 The card's output can be driven to zero voltage or current by pulling an External Enable input low via a TTL low logic level or a contact closure. When the TTL signal goes high or the contacts open, the output returns to the value stored in the second rank.

1-8 By supplying data from a 69790A Memory card to the D/A card's external data input, single-shot or repetitive waveforms with up to 4096 voltage or current steps can be generated at rates up to 100,000 steps per second.

1-9 As many as 16 D/A Voltage Converters or D/A Current Converters may be used in a single mainframe.

NOTE

Both models of cards are shipped with their power supply jumpers arranged to select ± 18V Isolated Mainframe Supply 1, which can power only up to 12 D/A Voltage Converters or up to 10 D/A Current Converters. Depending on power supply loadings and isolation requirements, it may be necessary to change the power supply jumpers on some cards to power them from one of the other two ± 18V isolated mainframe supplies or from external isolated supplies. (See paragraphs 4-13 through 4-17 for information on the ± 18V isolated mainframe supplies and Section 9 for instructions on changing the cards' power supply jumpers.)

2-1 BLOCK DIAGRAM

2-2 Figure 1 is a block diagram of the Model 69720A Digital-to-Analog Voltage Converter and the Model 69721A Digital-to-Analog Current Converter. (The portion of the diagram enclosed by a dashed line applies only to the Model 69721A).

3-1 SPECIFICATIONS

Voltage Output:

Model 69720A: −10.240V to +10.235V, at up to 5mA load current.
Model 69721A: −10.240V to +10.235V, at up to 4mA load current.

Current Output:

Model 69721A: −20.48mA to +20.47mA, at up to 11V load compliance voltage.

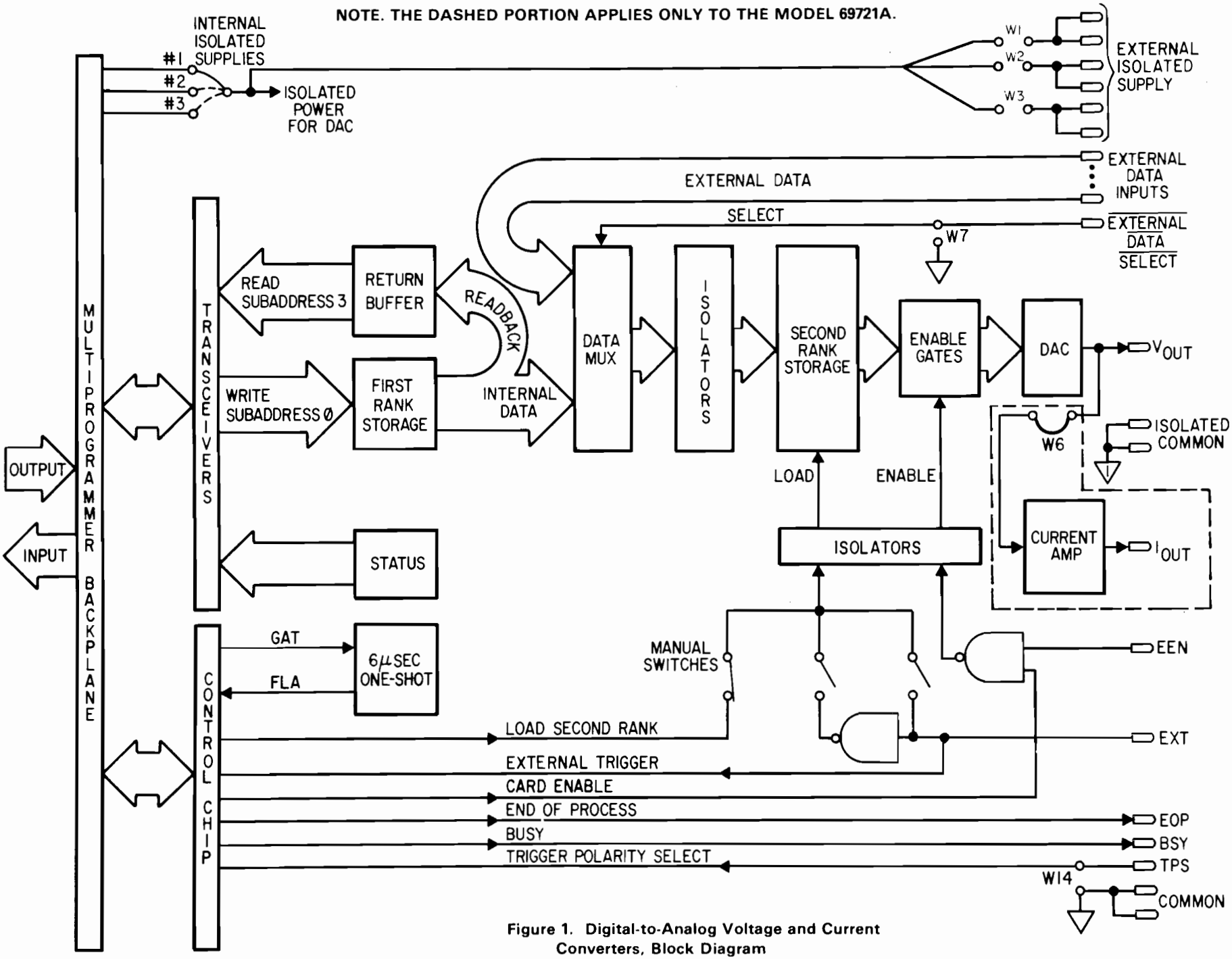

Figure 1. Digital-to-Analog Voltage and Current Converters, Block Diagram

Voltage Accuracy: At 20-30°C ambient temperature outside mainframe,
for 24 hours: 5mV
for 90 days: 15mV.

At 0-55°C ambient temperature outside mainframe,
for 24 hours: 15mV
for 90 days: 25mV

Current Accuracy (Model 69721A):
At 20-30°C ambient temperature outside mainframe,
for 24 hours: 10μA.
for 90 days: 30μA.

At 0-55°C ambient temperature outside mainframe,
for 24 hours: 40μA
for 90 days: 60μA

Voltage Resolution: 5mV

Current Resolution (Model 69721A): 10μA.

Voltage Output Conversion Time: Voltage output settles within 5mV of final value in less than 6μs.

Current Output Conversion Time (Model 69721A): Current output settles within 10μA of final value in less than 10μs.

Voltage Output Ripple and Noise: Less than 3mV p-p, 20Hz to 20MHz.

Current Output Ripple and Noise (Model 69721A): Less than 6μA p-p, 20Hz to 20MHz.

Output Protection: Voltage output can withstand indefinite short circuit. Current output on model 69721A can withstand indefinite short or open circuit.

Voltage Rating: Voltage between any analog output pin and ground must not exceed 250Vdc or ac.

External Digital Inputs:
12-bit, two's complement data input.
Inputs are low power Schottky TTL.
Logical 1 = 2.0 to 5.25V
Logical 0 = 0 to 0.5V
An external circuit must sink 1mA in the low state.

For the characteristics of the card's other inputs and outputs, see Section 7.

Temperature Range:
0°C to +70°C operating in mainframe (allows 15°C internal rise when operating in mainframe at up to +55°C ambient); −40°C to +80°C storage.

Dimensions:
299.72mm x 132.08mm/11.8" x 5.2"

4-1 INSTALLATION

4-2 I/O Card Power Supply Considerations

4-3 To power its I/O cards, a 6942A or 6943A mainframe contains two unisolated supplies with outputs of +5 volts and ±12 volts, and three isolated ±18-volt supplies. The current each of these supplies has available to I/O cards is as follows:

+5V Supply	12.8A
+12V Supply	2.0A
−12V Supply	1.5A
+18V (No. 1)	1.0A
−18V (No. 1)	0.6A
+18V (No. 2)	0.4A
−18V (No. 2)	0.25A
+18V (No. 3)	0.2A
−18V (No. 3)	0.15A

The following paragraphs describe the restrictions that power supply considerations may sometimes impose on the card complement of an individual mainframe.

NOTE

If an individual mainframe or extender does not include any of the following models, then any 16 cards can be installed in it without regard for current limitations.
69720A Digital-to-Analog Voltage Converter
69721A Digital-to-Analog Current Converter
69751A Analog-to-Digital Converter
*69775A Counter/Totalizer Card**
69790A Memory Card (Option 002, 2048 words)
69790A Memory Card (Option 004, 4096 words)
(Each model 69790A Memory card assembly consists of two cards that occupy two of the 16 slots in a mainframe.)

*Include the Counter card in the above list only if its power supply jumpers have been changed to power its count and count enable input circuits from one of the ±18V isolated supplies in the mainframe.

If a mainframe is to include any of the above models, then observe the restrictions described below to keep current drains within allowable limits. The restrictions on the card complement of a mainframe fall into two categories:

(a) those caused by the extra loading of the +5V supply by Option 002 or Option 004 Memory cards, and

(b) those that affect how the cards that require isolated power are assigned to the three ±18V supplies that provide it.

4-4 Memory Cards and the +5V Supply

4-5 All I/O cards use +5V power, but model 69790A Memory cards use substantially more than the other models. A standard Memory card with a capacity of 1024 16-bit words uses 1.6 amps, an Option 002 Memory card with a 2048-word capacity uses 2 amps, and an Option 004 Memory card with a 4096-word capacity uses 2.6 amps. In contrast, the other I/O card models require between 350 and 750 milliamps from the +5V supply. The +5V supply can supply up to 12.8 amps to the I/O cards. *Consequently, unless a mainframe includes one or more Option 002 or Option 004 Memory cards, you can use any combination of card models to fill the 16 card slots of a mainframe without having to be concerned about the loading on the +5V supply.* (Regardless of option, each Memory card assembly consists of two cards that occupy two card slots.)

4-6 Standard Memory Card. The standard 1024-word Memory card assembly draws 1.6 amps from the +5V supply. Eight 2-card assemblies fill a mainframe and use all of the 12.8 amps available. If fewer standard Memory cards are used, any unoccupied slots can be filled by any types of cards except Memory cards.

4-7 Option 002 Memory Card. The 2048-word Option 002 Memory card draws 2.0 amps from the +5V supply. Thus all but 800 mA of the available current is used if only six 2-card assemblies are installed in a mainframe. One or two cards of other types can be included in the remaining four card slots if their currents total 800 mA or less. The remaining two or three slots, in this instance, would have to be left vacant. (Table 1 lists the currents that the I/O cards draw from the +5V supply.)

4-8 If fewer than six Option 002 Memory card assemblies are installed in a mainframe, then refer to Table 1, add the currents for all the cards in the mainframe, and, if necessary, leave as many as three slots vacant to keep the total current from exceeding 12.8 amps.

4-9 Option 004 Memory Card. The 4096-word Option 004 Memory card draws 2.6 amps from the +5V supply. Thus all of the available current is used if only five 2-card assemblies are installed in a mainframe. (Actually five assemblies draw 13 amps, slightly over the 12.8-amp limit.) So six card slots must be left vacant if five Option 004 assemblies are installed.

4-10 If fewer than five Option 004 Memory card assemblies are installed in a mainframe, then refer to Table 1, add the currents for all the cards in the mainframe, and leave vacant as many slots as necessary to keep the total current from exceeding 12.8 amps.

4-11 The Unisolated ±12V Supply

4-12 Only two card models use power from the ±12V supply in the mainframe. The 69771A Digital Input/Analog Comparator uses 20 mA from the positive output and 40 mA from the negative output. The 69775A Counter/Totalizer uses 120 mA from the positive output and 15 mA from the negative output. *No possible combination of cards can overload the ±12V supply.*

NOTE

A Counter card is powered from the unisolated ±12V supply only if it is not necessary to photoisolate its count and count enable inputs. If photoisolation is required, jumpers must be changed on the card to power its input circuits from one of the three ±18V supplies in the mainframe or from an external isolated supply.

Table 1. I/O Card Current Drain from +5V Supply

Current Drain from +5V Supply	I/O Card Models
350 mA	69770A Isolated Digital Input Card 69771A Digital Input/Analog Comparator
400 mA	69720A Digital-to-Analog Voltage Converter 69721A Digital-to-Analog Current Converter 69731A Digital Output Card 69751A Analog-to-Digital Converter 69776A Interrupt Card
650 mA	69700A through 69706A Resistance Output Cards 69730A Relay Output Card
750 mA	69735A Pulse Train Output and Stepping Motor Controller 69736A Timer/Pacer Card 69775A Counter/Totalizer Card
1.6A	69790A Memory Card (Standard)
2.0A	69790A Memory Card (Option 002)
2.6A	69790A Memory Card (Option 004)

4-13 The Isolated ±18V Supplies

4-14 The mainframe contains three ±18V supplies with isolated outputs. This ±18V power is required by the analog circuits of

69720A Digital-to-Analog Voltage Converters,
69721A Digital-to-Analog Current Converters, and
69751A Analog-to-Digital Converters.

The 69775A Counter/Totalizer card can also use ±18V power if jumpers on the card are changed to connect to one of these isolated supplies instead of using the unisolated ±12V supply that is normally connected. The Counter card must have its

count and count enable circuits powered from an isolated supply if photoisolated operation is required.

4-15 Three separate isolated supplies are provided in a mainframe so that individual cards or groups of cards can be electrically isolated from each other when necessary. All four models of cards that can use ± 18V isolated power are equipped with jumpers than can select any one of the three supplies or an external isolated supply connected to the card's external edge connector. The three models of D/A and A/D converters, however, all have their jumpers arranged to select ± 18V supply no. 1 when they are shipped. Since the cards' current requirements are such that no more than 12 D/A Voltage Converters, or 10 D/A Current Converters, or 6 A/D Converters, or 8 Counter cards can be installed in the same mainframe and powered from supply no. 1 without overloading it, the jumpers on some cards must be changed if the total load exceeds that available from supply no. 1 or if some cards must be powered from separate supplies to isolate them from each other.

4-16 Here are the current ratings of the three ± 18V supplies and the current requirements of the four card models that use isolated mainframe power.

	Positive Output	Negative Output
± 18V Supply No. 1	1.0A	0.6A
± 18V Supply No. 2	0.4A	0.25A
± 18V Supply No. 3	0.2A	0.15A

	Positive Input	Negative Input
69720A D/A Voltage Converter	80 mA	40 mA
69721A D/A Current Converter	100 mA	50 mA
69751A A/D Converter	150 mA	80 mA
69775A Counter /Totalizer	120 mA	15 mA

Power supply loading calculations can be based just on the figures for the positive supply outputs and card requirements. If these are within limits, the negative supply loadings are also within limits.

4-17 For a particular card model, the jumpers that are used to select one of the three ± 18V supplies or an external isolated supply are identified in a later section of the applicable manual.

4-18 I/O Card Installation

CAUTION

To prevent an accidental short from damaging a card or a mainframe, always turn off the Multiprogrammer before installing or removing I/O cards.

4-19 To install an I/O card in a 6942A Multiprogrammer or 6943A Extender mainframe:

1. Remove the rear cover from the mainframe by operating its four quarter-turn fasteners.
2. Positioning the card with its handle to the bottom and its components to the right, slide it into the desired card cage slot (0-15) until it touches the connector. (A notch in the card edge and keys in the I/O slot connectors prevent a card from being installed upside down or in a slot other than those intended for I/O cards.)

NOTE

Memory card assembly 69790A consists of two cards interconnected by a cable and occupies two adjacent slots in the mainframe.

3. Rotate the card handle downward until it engages the groove at the bottom of the I/O slot, and then rotate it upward to push the card into the connector.
4. Wire the card's edge connector assembly following the instructions given in Chapter 2 of the 6942A User's Guide.
5. As each card is installed and wired, record the following information:
   a. Card type
   b. Application in external system
   c. The card's main address (its slot number plus 100 times the frame address selected by the mainframe's frame address switch)
   d. Card subaddresses
   e. Data format parameters (data type, LSB value, and number of bits)
6. Install rear cover on Multiprogrammer unit.

5-1 EXTERNAL CONNECTIONS

5-2 The pin assignments of the input and output signals available at the card's external edge connector are shown in Figure 2. (The lettered pins are on the component side of the card). One dual 36-pin edge connector is supplied with each I/O card for interfacing field wiring to the card. Instructions for making up the mating connector and hood assembly are provided in Chapter 2 of the 6942A User's Guide.

6-1 CHECKOUT

6-2 Chapter 7 of the 6942A User's Guide contains several illustrative programs that can be used to verify that the card is operational.

7-1 EXTERNAL INPUT AND OUTPUT SIGNALS

7-2 This section describes the functions of the card's external terminals at edge connector J2, describes the input and output signals that can be connected there, and explains the use of any jumpers that affect the functioning of these inputs and outputs. Figure 3 shows the locations of the jumpers on the card. The card is shipped with all jumpers arranged as shown in this figure. (**Jumper W6** is omitted in the model 69720A and included in the model 69721A. **Jumper W21** is used only for testing the card.)

7-3 Analog Outputs

7-4 The card's analog voltage output is available between J2-W and isolated common at J2-21 and -Y. The 69721A's current output is available between J2-19 and isolated common. Detailed information on these outputs is provided in Section 3. Since the card's D/A converter requires input data in two's complement form to produce its bipolar output, the card is shipped with its data type jumpers arranged to select the data type in which programmed positive or negative decimal numbers are stored on the card in two's complement form (data type 1).

7-5 External Digital Inputs

7-6 The card accepts digital data from the mainframe backplane or through its external edge connector. An external data source is selected by pulling the card's $\overline{\text{External Data Select}}$ input to a low logic level, shorting it to ground, or by installing **jumper W7**. If data is to be supplied from an external device, the 12 digital input lines indicated in Figure 2 are used. Data common is at J2-36 and -rr. For the card to function over its full bipolar output range, negative input data must be supplied in two's complement form.

Logical 1 = 2.0 to 5.25V
Logical 0 = 0 to 0.5V
The driving signal must sink 1mA in the low state.

7-7 $\overline{\text{External Data Select}}$

7-8 The $\overline{\text{External Data Select}}$ input is used to select either backplane or external data inputs to the card. To select the external inputs, pull this input low with a low logic level or with a short to ground or install **jumper W7**.

High = 2.0V to 5.0V (or no connection)
Low = 0.0V to 0.5V (or short to ground)
The driving signal must sink 3mA in the low state.

7-9 External Trigger (EXT)

7-10 A logical true signal at the card's External Trigger input cycles the card. The logic sense of the card's External Trigger input depends on the logic state of its Trigger Polarity Select input or the presence or absence of **jumper W14**.

High = 2.0V to 5.0V (or no connection)
Low = 0.0V to 0.5V (or short to ground)
The driving signal must sink 1mA in the low state.

7-11 Trigger Polarity Select (TPS)

7-12 The logic sense of the card's External Trigger input is determined by the logic state of its Trigger Polarity Select input or the presence or absence of **jumper W14**. (**W14** is not installed when the card is shipped.) If the Trigger Polarity Select input is at a high logic level or unconnected, the card is triggered by a low-to-high transition at the External Trigger input. If the Trigger Polarity Select input is at a low logic level, shorted to ground, or if **jumper W14** is installed, the card is triggered by a high-to-low transition at the External Trigger input.

High = 2.0V to 5.0V (or no connection)
Low = 0.0V to 0.5V (or short to ground)
The driving signal must sink 1mA in the low state.

7-13 External Enable (EEN)

7-14 The voltage (and current) output of a card can be externally driven to zero by pulling the External Enable pin low via a low level TTL signal or contact closure.

High = 2.0V to 5.0V (or no connection)
Low = 0.0V to 0.5V (or short to ground)
The driving signal must sink 1mA in the low state.

7-15 Busy (BSY)

7-16 This signal goes high while the card is busy performing its operation.

High = 3.7V while sourcing 200μA.
Low = 0.5V while sinking 7mA.

7-17 End of Process (EOP)

7-18 This output signal goes high to indicate that the card has completed its operation. It can be used to trigger an external device or another I/O card. The EOP output signal is not a fixed-width pulse but is instead a positive level that remains high until reset low after a minimum of 2 microseconds.

High = 3.7V while sourcing 200μA.
Low = 0.5V while sinking 7mA.

7-19 External Bias

7-20 External bias input terminals are provided at the edge connector (see Figure 2). If an external supply is used, the mainframe isolated power supply jumpers must be removed and the external supply jumpers installed as described in Section 9 of this Manual.

8-1 DATA TYPES AND LSB VALUES

8-2 Each card model is manufactured with jumpers that are positioned to specify the data type and the LSB value that become effective for that card when the system is first energized. D/A Converter cards are shipped with data type and LSB jumpers **W15 through W20** and **W8 through W13** arranged as indicated in Tables 2 and 3, assigning the card a data type in which data programmed in decimal form is stored on the card in two's complement form and establishing 5 millivolts as the LSB value for voltage outputs using the Model 69720A or 10 microamps as the LSB value for current outputs using the Model 69721A.

8-3 The card's data type and LSB jumpers can be repositioned to select one of the other data types and LSB values listed in Tables 2 and 3, thus making a different data type or LSB value effective at system turn-on. Changing the jumpers to select data type 7, for example, permits output voltages or currents to be programmed by octal data. (This of course would restrict the programmer to using the octal equivalent of the desired two's complement output.)

8-4 As an alternative to changing the jumpers on the card, it is also possible to program a card's data type and LSB to be different from those established by its jumpers by using a Set Format (SF) instruction. Any of the data types of Table 2 can be used, but programmed LSB values are not limited to those in Table 3. Any desired LSB value between 0.001 and 65.535 can be programmed. This allows the user to express programmed data in units appropriate to the process to which the card is dedicated. A Set Format instruction also allows the user to set maximum limits on programmed data. (See Chapter 5 of the 6942A User's Guide for instructions on using the Set Format instruction.)

Table 2. D/A Converter Card, Data Type Jumpers

DATA TYPE CODE	DESCRIPTION	JUMPER ARRANGEMENT					
		W18	W19	W20	W15	W16	W17
1*	PROGRAMMED POSITIVE OR NEGATIVE NUMBER IS STORED ON CARD IN TWO'S COMPLEMENT FORM	0	0	0	1	1	1
2	PROGRAMMED POSITIVE OR NEGATIVE NUMBER IS STORED ON CARD IN SIGN-MAGNITUDE FORM	0	0	1	1	1	0
3	PROGRAMMED POSITIVE NUMBER IS STORED ON CARD IN UNSIGNED BINARY FORM	0	1	0	1	0	1
4	(SPECIAL AUTORANGE CODE USED ONLY WITH 69736A TIMER/PACER CARD)						
6	PROGRAMMED POSITIVE NUMBER IS STORED ON CARD IN UNSIGNED BCD FORM	1	0	1	0	1	0
7	PROGRAMMED OCTAL INTEGER IS STORED ON CARD IN UNSIGNED BINARY FORM	1	1	0	0	0	1

1= JUMPER IN 0= JUMPER OUT

*When the card is shipped, its jumpers are arranged to select the starred data type when power is applied to the system.

Table 3. D/A Converter Card, LSB Jumpers

LSB CODE	LSB VALUE	JUMPER ARRANGEMENT					
		W12	W13	W11	W9	W10	W8
0	0.001	0	0	0	1	1	1
1	0.025	0	0	1	1	1	0
2	0.1	0	1	0	1	0	1
3	0.5	0	1	1	1	0	0
4	0.01	1	0	0	0	1	1
5	0.05	1	0	1	0	1	0
6	0.005	1	1	0	0	0	1
7	1.0	1	1	1	0	0	0

1= JUMPER IN 0= JUMPER OUT

Notes

1. The model 69720A is shipped with its LSB jumpers arranged to select an LSB value of 0.005 so that its output voltage can be directly programmed in volts with a 5-millivolt resolution.
2. The model 69721A is shipped with its LSB jumpers arranged to select an LSB value of 0.01 so that its output current can be directly programmed in milliamps with a 10-microamp resolution. As the model 69721's current output is programmed over its −20.48 to +20.47 milliamp range, its output voltage tracks it proportionally over its −10.24 to +10.235 volt range.

9-1 ISOLATED POWER SUPPLIES

9-2 The ±15V bias voltage for the card's D/A converter and output amplifier circuits can be obtained from a mainframe isolated supply or from an external isolated supply. As shipped from the factory, a D/A card's power supply jumpers are connected to use isolated power from ±18V Supply 1 in the mainframe. (Regulators on the card reduce the voltage to ±15 volts.) Since four card models are shipped with jumpers connecting ±18V Supply 1, it is necessary to consider power supply loading and your isolation requirements and to change power supply jumpers on some cards if required. I/O card current requirements and ±18V power supply current capabilities are given in paragraph 4-16.

9-3 Mainframe Isolated Power Supplies

9-4 The isolated ±18V supplies in the mainframe are designated 1, 2, and 3. For maximum flexibility, they have

three different nominal current capacities: Supply 1 is rated at 1 amp, Supply 2 is rated at 400 milliamps, and Supply 3 is rated at 200 milliamps. For the purpose of planning the loading of these supplies, each D/A Voltage Converter card can be considered to be an 80-milliamp load and each D/A Current Converter card can be considered to be a 100-milliamp load. Thus a single mainframe can accommodate up to 16 D/A Voltage Converters with Supply 1 powering up to 12, Supply 2 powering up to 5, and Supply 3 powering up to 2. A mainframe can accomodate up to 16 D/A Current Converters with Supply 1 powering up to 10, Supply 2 powering up to 4, and Supply 3 powering up to 2. See paragraph 4-16 for the current drains of the other cards that can use these isolated ±18V supplies. Table 4 lists the D/A card jumper connections for each of the ±18V isolated supplies.

9-5 External Isolated Power Supplies

9-6 A regulated or unregulated external isolated supply can be used to power the card's D/A converter and output amplifier circuits. If a regulated supply with ±15V outputs is used, the on-board ±15V regulators are bypassed by installing **jumpers W4 and W5** (see Table 4). A regulated or unregulated supply with ±17.7 to ±19.9 volt outputs can be used if the on-board regulators are made operational by removing **jumpers W4 and W5**.

10-1 CALIBRATION PROCEDURES

10-2 Separate calibration procedures are provided in this section for model 69720A and 69721A cards. The card is calibrated and ready for use when shipped, but calibration may be required if the card's output(s) are observed to exceed specification accuracy limits. The sample test program in Chapter 7 of the 6942A User's Guide can be used to check the card. The card must be recalibrated following the replacement of components in the D/A voltage converter, the voltage output amplifier, or the current output amplifier.

10-3 Equipment Required

1. Digital voltmeter with minimum accuracy of 0.005% of reading (HP model 3455A or equivalent).
2. Desktop computer with HP-IB interface (model 9825, 9835, or 9845; with 98034A HP-IB Interface card).
3. Precision resistor, 500 ohms ±0.005% (needed to calibrate model 69721A only).

10-4 Test Set-up

10-5 Install the 69720A or 69721A card in slot 1 of a 6942A mainframe with no other cards installed, or else mount it on a 6942A PC Board Extender card (HP part no. 5060-2792) installed in slot 1. Connect the controller to the Multiprogrammer through the 98034A HP-IB Interface card.

10-6 Model 69720A Calibration Procedure

1. Connect the DVM across the 69720A card's voltage output between pins J2-W (+) and J2-Y (common).
2. Energize the 6942A and the DVM and allow them to warm up for at least 20 minutes.

Table 4. D/A Converter Card, Isolated Power Supply Jumpers

		JUMPER W1	W2	W3	W4	W5	W22	W23	W24	W25	W26	W27	W28	W29	W30
MAINFRAME ISOLATED POWER SUPPLIES	±18V SUPPLY 1*	0	0	0	0	0	0	0	0	0	0	0	1	1	1
	±18V SUPPLY 2	0	0	0	0	0	0	0	0	1	1	1	0	0	0
	±18V SUPPLY 3	0	0	0	0	0	1	1	1	0	0	0	0	0	0
EXTERNAL ISOLATED POWER SUPPLIES	REGULATED OR UNREGULATED ±17.7V TO 19.9V	1	1	1	0	0	0	0	0	0	0	0	0	0	0
	REGULATED ±15V **	1	1	1	1	1	0	0	0	0	0	0	0	0	0

1 = JUMPER IN 0 = JUMPER OUT

*When the card is shipped, its power supply jumpers are connected to use isolated power from ±18V power supply no. 1 in the mainframe.

**Using a ±15V external isolated supply to power the 69721A D/A Current Converter instead of a nominal ±18V supply may reduce the card's current output compliance voltage to less than 11 volts.

3. Program the card's output to its negative full-scale value of −10.240 volts by programming an Output Parallel instruction as follows:

9825A Controller

```
0: wrt 723,"OP,1,-10.240T"
```

9835/45 Controllers

```
10  OUTPUT 723;"OP,1,-10.240T"
```

4. Adjust voltage offset potentiometer R10 for a DVM display of −10.240 volts.
5. Program the card to its positive full-scale value of +10.235 volts by programming:

9825A Controller

```
0: wrt 723,"OP,1,10.235T"
```

9835/45 Controllers

```
10  OUTPUT 723;"OP,1,10.235T"
```

6. Adjust voltage gain adjust potentiometer R4 for a DVM display of +10.235 volts.
7. Program the card to negative full-scale again and repeat the procedure starting at step 4, if required.

10-7 Model 69721A Calibration Procedure

1. Connect the DVM across the 69721A card's voltage output between pins J2-W (+) and J2-Y (common).
2. Energize the 6942A and the DVM and allow them to warm up for at least 20 minutes.
3. Program the card to its negative full-scale current of −20.48 milliamps by programming an Output Parallel instruction as follows:

9825A Controller

```
0: wrt 723,"OP,1,-20.48T"
```

9835/45 Controllers

```
10  OUTPUT 723;"OP,1,-20.48T"
```

4. Adjust voltage offset potentiometer R10 for a DVM display of −10.240 volts.
5. Program the card to its positive full-scale current of +20.47 milliamps by programming:

9825A Controller

```
0: wrt 723,"OP,1,20.47T"
```

9835/45 Controllers

```
10  OUTPUT 723;"OP,1,20.47T"
```

6. Adjust voltage gain adjust potentiometer R4 for a DVM display of +10.235 volts.
7. Program the card to its negative full scale current again and repeat the procedure starting at step 4, if required.
8. Connect the 500-ohm 0.005% resistor between current output pins J2-19 and J2-21.
9. Program the card for zero output:

9825A Controller

```
0: wrt 723,"OP,1,0T"
```

9835/45 Controllers

```
10  OUTPUT 723;"OP,1,0T"
```

10. Record the voltage displayed on the DVM.
11. Move the DVM's positive lead from the voltage output at J2-W to the current output at J2-19.
12. Adjust current offset potentiometer R17 for a DVM display equal to the one recorded in step 10.

NOTE

If the resistor used is not within 0.005% of 500 ohms, adjust for a DVM display based on the actual resistor value as follows:

$$V_{DISPLAYED} = \frac{R_{ACTUAL}}{500} V_{RECORDED}$$

13. Program the card to its positive full-scale current of +20.47 milliamps by programming as in step 5.
14. Adjust current gain adjust potentiometer R15 for a DVM display of +10.235 volts. (Adjust for 10.235 volts multiplied by $R_{ACTUAL}/500$ if resistor is not within 0.005% of 500 ohms.)
15. Program the card to its negative full-scale current of −20.48 milliamps by programming as in step 3.
16. Check the DVM display for a reading of −10.240 volts. (Check for reading of −10.240 volts multiplied by $R_{ACTUAL}/500$ if resistor is not within 0.005% of 500 ohms.) If further adjustment is required, repeat steps 9 through 16.

11-1 TRIGGER DELAY BYPASS SWITCHES

11-2 Most of the system's I/O cards can be cycled through an external trigger input to the card, but in some applications the 20 microsecond delay between the trigger signal and the D/A card's cycling does not allow sufficiently close synchronization with the external event. Switches on the D/A

card allow it to be triggered externally with a delay of only 7 microseconds if it can be assumed that the external trigger will not occur while the card is being cycled through software.

WARNING

Only one of the three switches, designated S2-1, -2, and -3, should be closed at a time.

11-3 **S2-1** is normally closed, allowing the card to be cycled either through software or through an external trigger. With S2-1 closed, the 20 microsecond delay is in effect for external triggers.

11-4 If **S2-2** is closed, the external trigger input is actuated by a positive-going signal and the delay is reduced to 7 microseconds. With this switch closed, the card can be cycled only through an external trigger and not through software.

11-5 If **S2-3** is closed, the external trigger input is actuated by a negative-going signal and the delay is reduced to 7 microseconds. Again, the card can be cycled only through an external trigger and not through software.

11-6 It is not necessary to install or remove **jumper W14** to change the external trigger's input logic sense when S2-2 or S2-3 is closed.

12-1 SCHEMATIC DIAGRAM

12-2 Figure 4 is a schematic diagram of the 69720A D/A Voltage Converter and of the 69721A D/A Current Converter.

13-1 REPLACEABLE PARTS TABLE

13-2 Tables 5 and 6 are the replaceable parts tables for the 69720A D/A Voltage Converter and the 69721A D/A Current Converter.

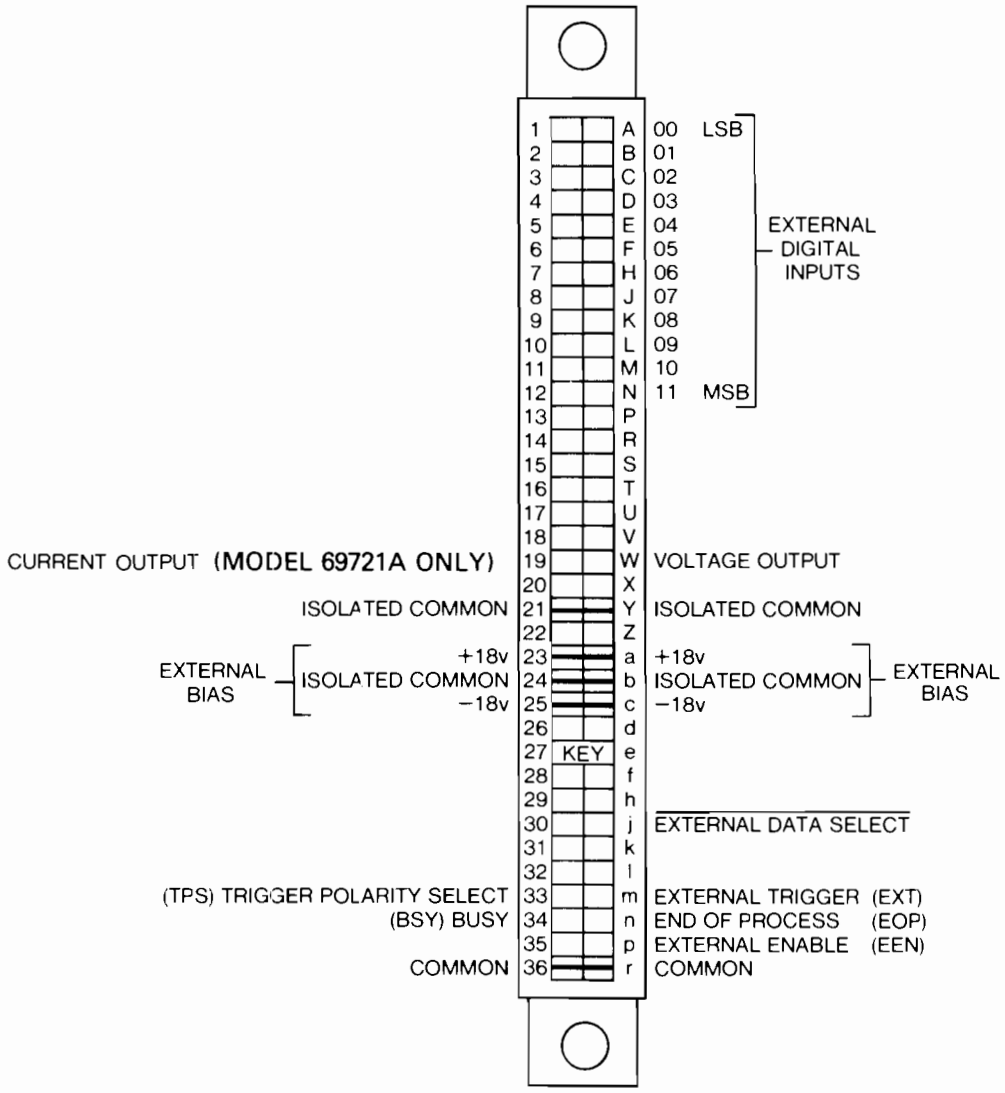

Figure 2. Digital-to-Analog Voltage and Current Converters, External Edge Connnector

NOTE. JUMPER W6 IS OMITTED IN THE MODEL 69720A AND INCLUDED IN THE MODEL 69721A.

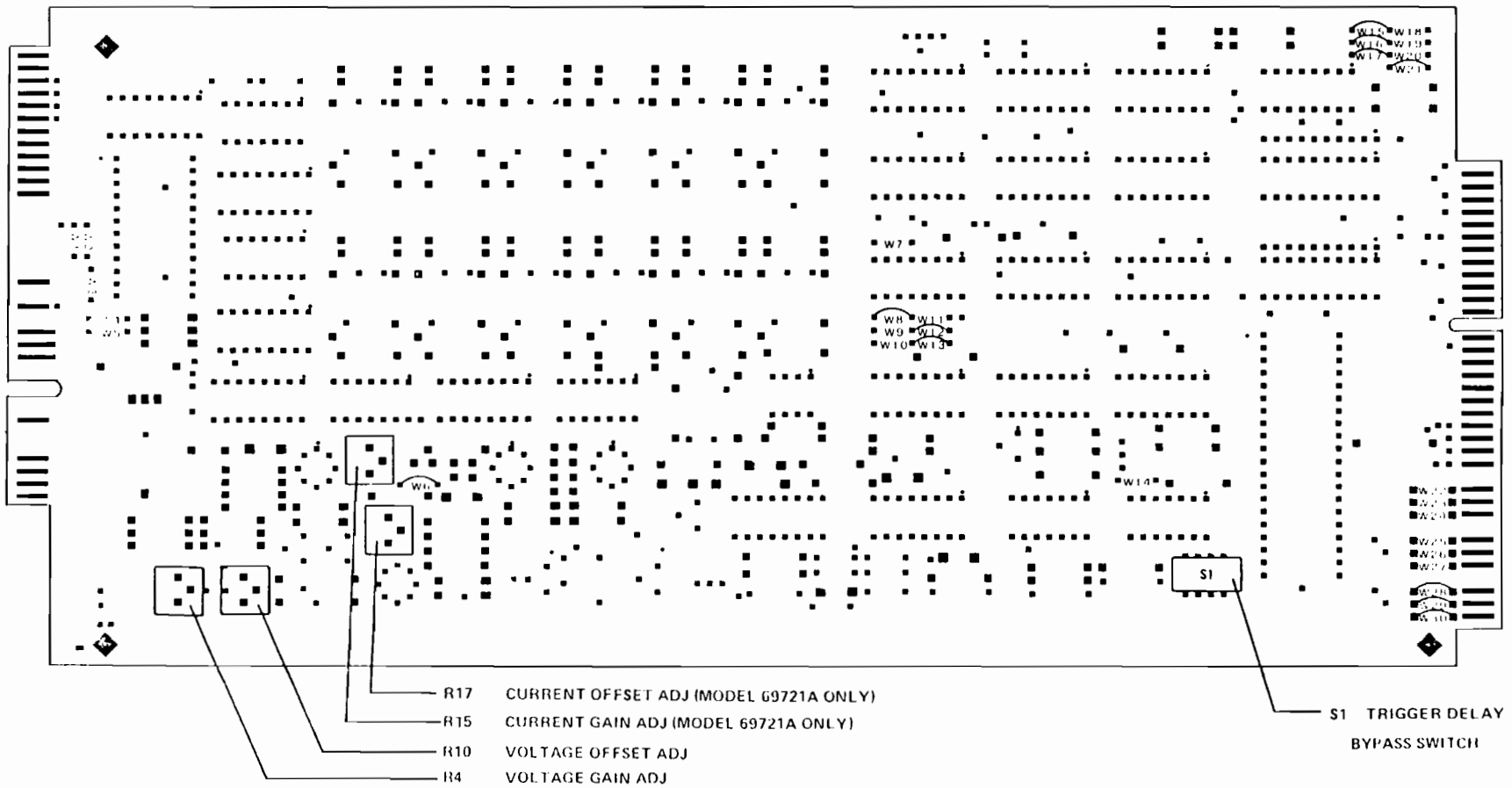

Figure 3. Digital-to-Analog Voltage and Current Converters, Jumper Locations

NOTE: THE INDICATED PORTION OF THE SCHEMATIC APPLIES ONLY TO THE MODEL 69721A.

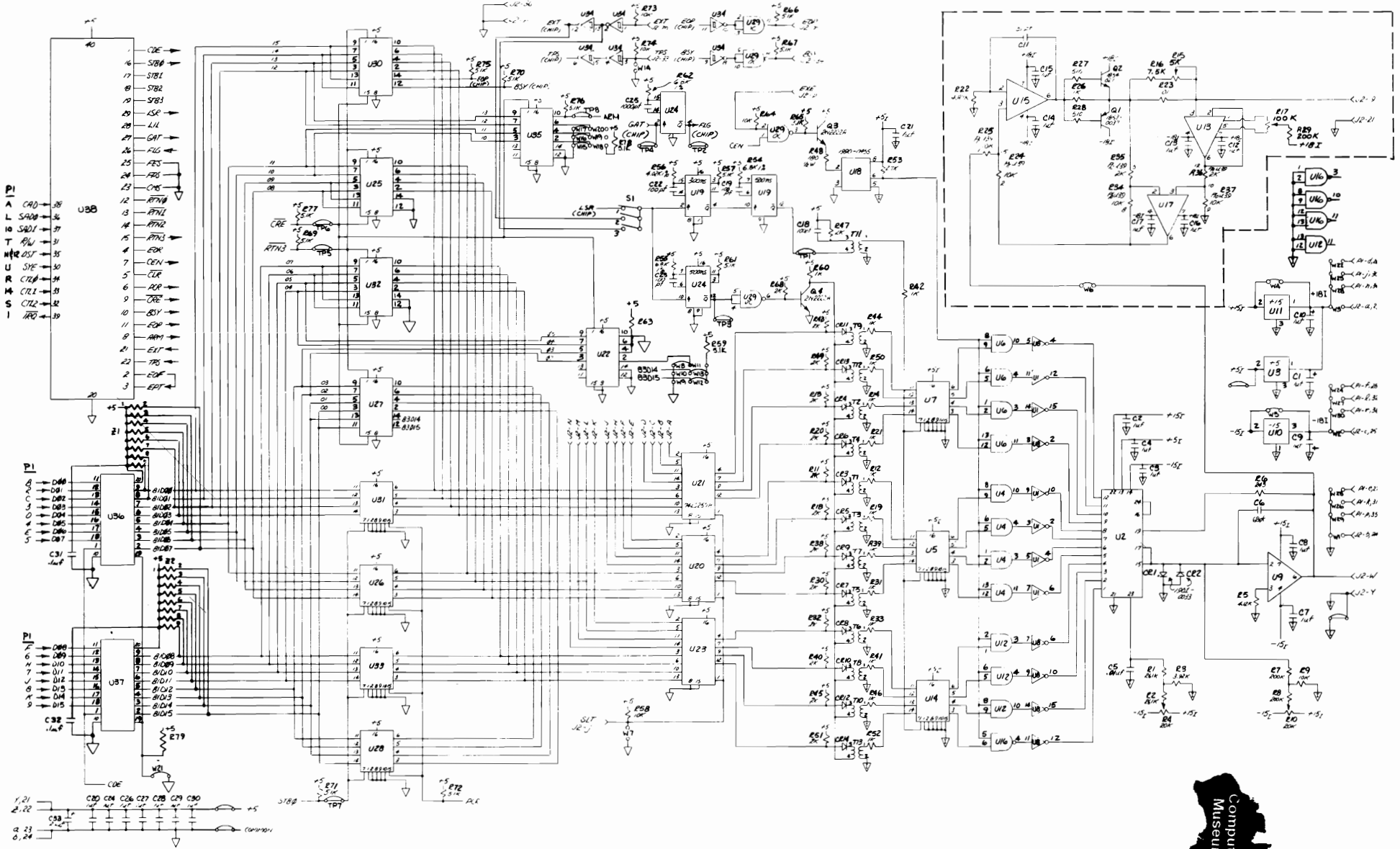

Figure 4. Digital-to-Analog Voltage and Current Converters, Schematic Diagram

Table 5. Replaceable Parts, Model 69720A

CIRCUIT REFERENCE	STOCK NO.	DESCRIPTION	QTY
C005	0150-0093	CAP .01UF +80	1
C002-4,7,8,21	0160-0127	CAP 1UF 20% 25V	6
C006	0160-0949	CAP 68PF 5% 300V	1
C025	0160-2735	CAP 1000PF 5%	1
C018,19,22,23	0160-3070	CAP 100PF 5%	4
C020,24,26-32	0160-4722	CAP .1UF +80	9
C001,9,10,33	0180-0291	C-F 1UF 35V	4
R012,14,19,21,31,33,39,41,42,SEE X	0683-1025	RES 1K 5% .25W	14
R044,46,50,52,60	0683-1025X	CON'T CIR REF	
R058,63,64,73,74,79	0683-1035	RES 10K 5% .25W	6
R011,13,18,20,30,32,38,40,43,SEE X	0683-2025	RES 2K 5% .25W	14
R045,47,49,51,68	0683-2025X	CONCT CIR REF	
R053	0683-2725	RES 2.7K 5% .25W	1
R057,59,61,65-67,69-72,75-78	0683-5125	RES 5.1K 5% .25W	14
R054,55,62	0683-6825	RES 6.8K 5% .25W	3
R048	0686-1815	RES 180 5% .5W	1
R001,2	0698-3455	RES 261K 1%	2
R005	0698-3493	RES 4.12K 1%	1
R056	0698-3558	RES 4.02K 1%	1
R006	0757-0408	RES 243 1% .125W	1
R003	0757-0435	RES 3.92K 1%	1
R009	0757-0442	RES 10K 1% .125W	1
R007,8	0757-0472	RES 200K 1%	2
REF (U38)	1200-0552	SKT-IC 40-CONT	1
REF(U2)	1200-0634	SOCKET-IC	1
Z001,2	1810-0280	NETWORK-RES SIP	2
U002	1813-0094	HYBRID; D/A	1
U016	1820-0949	IC MC14011CP	1
U029	1820-1198	IC SN74LS 03 N	1
U034	1820-1416	IC SN74LS 14 N	1
U019,24	1820-1437	IC SN74LS221N	2
U020,21,23	1820-1438	IC SN74LS257N	3
U004,6,12	1820-1486	IC CD4081BY	3
U005,7,14,26,28,31,33	1820-1544	IC CD4076BCU	7
U001,8	1820-1746	IC MC14049	2
U036,37	1820-2075	IC SN74LS245N	2
U022,25,27,30,32,35	1820-2257	IC MC14503BCP	6
U038	1820-2302	IC-CONTROL CHIP	1
U003	1826-0144	IC 7805C	1
U011	1826-0274	IC 78L15A	1
U010	1826-0281	IC V RGLTR	1
U009	1826-0528	IC 356B	1
Q003,4	1854-0477	XSTR NPN 2N2222A	2
CR001-14	1901-0033	DIO-GEN PRP	14
U018	1990-0455	OPTO ISOLATOR	1
R004,10	2100-0558	RES-TRMR 20K 10%	2
S001	3101-2368	SW-RKR 4-1A	1
T001-13	5080-1924	XFMR-PULSE	13

STOCK NO.	DESCRIPTION	QTY
1251-6056	KEYING PLUG	1
1251-6059	CONN PC EDGE	1
1480-0059	PIN-ROLL .062	1
5950-1836	MNL-OPER & INST	1
TPPNR-13927	CONN HOOD	1
TPPNR-14071	EYLT-SLDR,BG	1
TPPNR-14072	CONT-BAG	1

Table 6. Replaceable Parts, Model 69721A

CIRCUIT REFERENCE	STOCK NO.	DESCRIPTION	QTY
C005	0150-0093	CAP .01UF +80	1
C002-4,7,8,12-17,20,21,24,26-32	0160-0127	CAP 1UF 20% 25V	21
C006	0160-0949	CAP 68PF 5% 300V	1
C025	0160-2735	CAP 1000PF 5%	1
C018,19,22,23	0160-3070	CAP 100PF 5%	4
C011	0160-4457	CAP 51PF 5% 300V	1
C001,9,10,33	0180-0291	C-F 1UF 35V	4
REF(Q1,2)	0340-0453	INSUL XSTR	2
R012,14,19,21,26,31,33,39,41 SEE X	0683-1025	RES 1K 5% .25W	15
R042,44,46,50,52,60	0683-1025X	CON'T CIR REF	
R058,63,64,73,74,79	0683-1035	RES 10K 5% .25W	6
R011,13,18,20,30,32,38,40,43,SEE X	0683-2025	RES 2K 5% .25W	14
R045,47,49,51,68	0683-2025X	CONCT CIR REF	
R053	0683-2725	RES 2.7K 5% .25W	1
R027,28	0683-5115	RES 510 5% .25W	2
R057,59,61,65-67,69-72,75-78	0683-5125	RES 5.1K 5% .25W	14
R054,55,62	0683-6825	RES 6.8K 5% .25W	3
R048	0686-1815	RES 180 5% .5W	1
R001,2	0698-3455	RES 261K 1%	2
R005	0698-3493	RES 4.12K 1%	1
R056	0698-3558	RES 4.02K 1%	1
R035,36	0698-3950	RES 2K .01% .3W	2
R022	0698-4444	RES 4.87K 1%	1
R024,25,34,37	0699-0289	RES 10K .01%	4
R023	0699-0291	RES 101 .1%	1
R006	0757-0408	RES 243 1% .125W	1
R003	0757-0435	RES 3.92K 1%	1
R016	0757-0440	RES 7.5K 1%	1
R009	0757-0442	RES 10K 1% .125W	1
R007,8,29	0757-0472	RES 200K 1%	3
REF(U38)	1200-0552	SKT-IC 40-CONT	1
REF(U2)	1200-0634	SOCKET-IC	1
REF(Q1,2)	1205-0011	HT-DSPR	2
Z001,2	1810-0280	NETWORK-RES SIP	2
U002	1813-0094	HYBRID; D/A	1
U016	1820-0949	IC MC14011CP	1
U029	1820-1198	IC SN74LS 03 N	1
U034	1820-1416	IC SN74LS 14 N	1
U019,24	1820-1437	IC SN74LS221N	2
U020,21,23	1820-1438	IC SN74LS257N	3
U004,6,12	1820-1486	IC CD4081BY	3
U005,7,14,26,28,31,33	1820-1544	IC CD4076BCU	7
U001,8	1820-1746	IC MC14049	2
U036,37	1820-2075	IC SN74LS245N	2
U022,25,27,30,32,35	1820-2257	IC MC14503BCP	6
U038	1820-2302	IC-CONTROL CHIP	1
U003	1826-0144	IC 7805C	1
U011	1826-0274	IC 78L15A	1
U010	1826-0281	IC V RGLTR	1
U009,15	1826-0528	IC 356B	2
U013,17	1826-0672	IC	2

CIRCUIT REFERENCE	STOCK NO.	DESCRIPTION	QTY
Q001	1853-0037	XSTR PNP SI	1
Q002	1854-0271	XSTR NPN SI	1
Q003,4	1854-0477	XSTR NPN 2N2222A	2
CR001-14	1901-0033	DIO-GEN PRP	14
U018	1990-0455	OPTO ISOLATOR	1
R004,10	2100-0558	RES-TRMR 20K 10%	2
R017	2100-3214	RES-TRMR 100K	1
R015	2100-3252	RES VAR 5K 10%	1
S001	3101-2368	SW-RKR 4-1A	1
T001-13	5080-1924	XFMR-PULSE	13
	1251-6056	KEYING PLUG	1
	1251-6059	CONN PC EDGE	1
	1480-0059	PIN-ROLL .062	1
	5950-1836	MNL-OPER & INST	1
	TPPNR-13927	CONN HOOD	1
	TPPNR-14071	EYLT-SLDR,BG	1
	TPPNR-14072	CONT-BAG	1