PROGRAMMABLE RESISTANCE CARDS

MODELS 69500A THROUGH 69506A

and

MODELS 69510A THROUGH 69513A

OPERATING AND SERVICE MANUAL

FOR CARDS DESIGNATED RUN 1 AND ABOVE*

*For Cards above Run 1
a change page may be
included.

HP Part No. 5950-5983

Printed: January, 1973

SAFETY SUMMARY

The following general safety precautions must be observed during all phases of operation, service, and repair of this instrument. Failure to comply with these precautions or with specific warnings elsewhere in this manual violates safety standards of design, manufacture, and intended use of the instrument. Hewlett-Packard Company assumes no liability for the customer's failure to comply with these requirements.

BEFORE APPLYING POWER.

Verify that the product is set to match the available line voltage and the correct fuse is installed.

GROUND THE INSTRUMENT.

This product is a Safety Class 1 instrument (provided with a protective earth terminal). To minimize shock hazard, the instrument chassis and cabinet must be connected to an electrical ground. The instrument must be connected to the ac power supply mains through a three-conductor power cable, with the third wire firmly connected to an electrical ground (safety ground) at the power outlet. For instruments designed to be hard-wired to the ac power lines (supply mains), connect the protective earth terminal to a protective conductor before any other connection is made. Any interruption of the protective (grounding) conductor or disconnection of the protective earth terminal will cause a potential shock hazard that could result in personal injury. If the instrument is to be energized via an external autotransformer for voltage reduction, be certain that the autotransformer common terminal is connected to the neutral (earthed pole) of the ac power lines (supply mains).

INPUT POWER MUST BE SWITCH CONNECTED.

For instruments without a built-in line switch, the input power lines must contain a switch or another adequate means for disconnecting the instrument from the ac power lines (supply mains).

DO NOT OPERATE IN AN EXPLOSIVE ATMOSPHERE.

Do not operate the instrument in the presence of flammable gases or fumes.

KEEP AWAY FROM LIVE CIRCUITS.

Operating personnel must not remove instrument covers. Component replacement and internal adjustments must be made by qualified service personnel. Do not replace components with power cable connected. Under certain conditions, dangerous voltages may exist even with the power cable removed. To avoid injuries, always disconnect power, discharge circuits and remove external voltage sources before touching components.

DO NOT SERVICE OR ADJUST ALONE.

Do not attempt internal service or adjustment unless another person, capable of rendering first aid and resuscitation, is present.

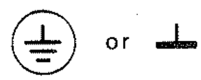
DO NOT EXCEED INPUT RATINGS.

This instrument may be equipped with a line filter to reduce electromagnetic interference and must be connected to a properly grounded receptacle to minimize electric shock hazard. Operation at line voltages or frequencies in excess of those stated on the data plate may cause leakage currents in excess of 5.0 mA peak.

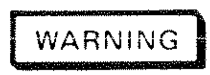
SAFETY SYMBOLS.

Instruction manual symbol: the product will be marked with this symbol when it is necessary for the user to refer to the instruction manual (refer to Table of Contents).

Indicates hazardous voltages.



Indicate earth (ground) terminal.



The WARNING sign denotes a hazard. It calls attention to a procedure, practice, or the like, which, if not correctly performed or adhered to, could result in personal injury. Do not proceed beyond a WARNING sign until the indicated conditions are fully understood and met.

The CAUTION sign denotes a hazard. It calls attention to an operating procedure, or the like, which, if not correctly performed or adhered to, could result in damage to or destruction of part or all of the product. Do not proceed beyond a CAUTION sign until the indicated conditions are fully understood and met.

DO NOT SUBSTITUTE PARTS OR MODIFY INSTRUMENT.

Because of the danger of introducing additional hazards, do not install substitute parts or perform any unauthorized modification to the instrument. Return the instrument to a Hewlett-Packard Sales and Service Office for service and repair to ensure that safety features are maintained.

Instruments which appear damaged or defective should be made inoperative and secured against unintended operation until they can be repaired by qualified service personnel.

SECTION I
GENERAL INFORMATION

1-1 INTRODUCTION

1-2 This instruction manual contains operating and service instructions for Programmable Resistance Cards, Models 69500A through 69506A and 69510A through 69513A. The cards are designed specifically for use in 6936A/6940A Multiprogrammer and 6937A/6941A Multiprogrammer Extender units to produce variable resistance outputs proportional to programmed digital data. The resistance outputs can be used to control programmable power supplies or other devices requiring a variable resistance for control. One model, the 69500A, is supplied without programmable output resistors, thus allowing it to be custom tailored to the user's particular requirements.

1-3 DESCRIPTION

1-4 The output cards are fabricated on a 4½" x 11" printed circuit card. The inner end of the card contains a dual 24 pin (48 pin total) printed circuit plug that can mate with any connector in slots 400 through 414 of a multiprogrammer unit. The variable resistance output is taken from a terminal block located on the outer-end of the card.

1-5 All nine models contain identical address decoding, data storage, and relay switching circuits; but the values of 12 precision resistors installed in an output 12-element precision resistance network, and certain strapping options, vary according to model number.

1-6 When installed in a Multiprogrammer System, the output cards are programmed by a 16-bit word originating at a remote computer or the Multiprogrammer control panel. Twelve of the programmed bits represent data while the remaining four contain the slot address of the output card. The 12 data bits are stored on the output card (when it is addressed) and either energize or de-energize an associated relay. When a logical 1 is programmed in a specific bit position, the resistor in the series element corresponding to that bit position is switched into the circuit; programming a logical 0 in the same bit position short circuits the resistor. The resistors are binary-weighted (the value of each resistor is twice that of the preceding resistor) so that the value of the resistance appearing across the output terminals is proportional to the value of the programmed binary number. The resistance values used on the different model output cards are scaled to be compatible with the programming coefficients of Hewlett-Packard programmable power supplies. The Model 69500A is programmed in a similar manner, but since there are no resistors installed in its output network the programmed bits produce only contact openings and closures.

1-7 MODEL 69500A

1-8 The Model 69500A is supplied without components installed in its output network. The card is capable of producing a programmed variable output (with up to 12-bits of resolution) according to the component values installed in its output network. The Model 69500A could be used, for example, to program a power supply whose programming coefficient is not covered by Models 69501A through 69506A or 69510A through 69513A.

1-9 MODELS 69501A THROUGH 69506A

1-10 Models 69501A through 69506A are used with HP programmable power supplies to produce output voltages (of the power supplies) proportional to programmed digital data. Each model provides a single 12-bit resistance programming channel.

1-11 The following table lists each output card model number and compatible programming coefficient (of HP power supply); the minimum output voltage step produced by a programmed change in the least significant data bit; and the maximum voltage produced when all 12 data bits are programmed to logical 1's.

Output Card Model	Prog. Coef. * of HP Power Supply	Min. Volt. Step for LSB Change	Max. Volt. Out. of HP Power Supply
69501A	200 ohm/volt	10mV	40.95V
69502A	300 ohm/volt	25mV	102.375V
69503A	300 ohm/volt	50mV	204.75V
69504A	1 kilohm/volt	10mV	40.95V
69505A	2 kilohm/volt	10mV	40.95
69506A	2 kilohm/volt	25mV	102.375

*Valid for HP Power Supplies with Option 040.

1-12 MODELS 69510A THROUGH 69513A

1-13 Models 69510A through 69513A are used with HP programmable power supplies to establish current limit points (of the power supplies) according to programmed digital data. Each model provides two identical 6-bit resistance programming channels.

1-14 The following table lists the value of the front panel current control (of the HP Power Supply) that the 6-bit resistance programming channel electrically replaces; the percentage change in potentiometer resistance produced by a programmed change in the least significant data bit of the related 6-bit channel; and the output resistance (in percentage of nominal potentiometer value) produced when all 6 data bits of the same channel are programmed to logical 1's. The resistance output is programmed from 0 ohms to the nominal potentiometer value in 50 steps.

Output Card Model	HP P.S. Current Pot. Value	Min. Res. Step for LSB Change (% of Pot. Value)	Max. Res. (% of Pot. Value)
69510A	200 ohm	2%	126%
69511A	750 ohm	2%	126%
69512A	1k ohm	2%	126%
69513A	1.5k ohm	2%	126%

1-15 SPECIFICATIONS

1-16 Table 1-1 provides detailed specifications applicable to all nine output-card models.

1-17 INTERFACING

1-18 Any output card is automatically interfaced with its associated unit when it is installed in a 400 series slot connector. Once an output card is assigned to a given slot, it assumes the address of that position and will receive programmed data only when that unit and slot are addressed. All operating power and programming bits for the output cards are derived from the multiprogrammer unit.

1-19 Variable resistance outputs of the output cards are taken from a terminal board on the outer-end of the card and wired to the external system. Specific instructions for interfacing the output cards with compatible HP power supplies are given in Section III of this manual.

1-20 ORDERING ADDITIONAL MANUALS

1-21 One manual is shipped with each order. Additional manuals may be purchased from your local Hewlett-Packard field office (see list at rear of this manual for addresses). Specify the model number and HP Part Number shown on the title page.

Table 1-1. Specifications

DATA INPUT: 12-bit binary. VARIABLE RESISTANCE OUTPUT: Accuracy: 0.1% ± 1 ohm of resistance value programmed (Models 69501A through 69506A are supplied with a 10 ohm zero calibration resistor installed in series with the output terminals). Loading: ½ W rating. POWER REQUIREMENTS: (Provided by Multiprogrammer Unit) +12Vdc, 140mA maximum; +5Vdc, 180mA maximum.	PROGRAMMING RELAY DATA: Type: Twelve magnetically shielded, mercury wetted, reed relays. Contact Loading: 1A, 100Vdc. Contact Resistance: Initial 50 milliohms maximum (typically 10 to 25 milliohms). 50 milliohms after rated life (100 x 10^6 operations). SAFETY FEATURE: System enable relay contacts keep output resistance terminals "shorted" until system enable bit is programmed and card is addressed. Feature not provided on Models 69510A through 69513A.

SECTION II
INSTALLATION

2-1 INITIAL INSPECTION

2-2 Before shipment, each programmable resistance card is inspected for mechanical and electrical defects. As soon as the card is received, proceed as instructed in the following paragraphs.

2-3 MECHANICAL CHECK

2-4 If external damage to the shipping carton is evident, ask the carrier's agent to be present when the instrument is unpacked. Check the output card for signs of physical damage. If it is damaged, file a claim with the carrier's agent and notify Hewlett-Packard Sales and Service Office as soon as possible. If it appears to be undamaged, perform the electrical check given in the following paragraph.

2-5 ELECTRICAL CHECK

2-6 Check the electrical performance of the output card as soon as possible after receipt. Section V of this manual contains checkout procedures which will verify operation of the output cards. Refer to the inside front cover of this manual for Certification and Warranty statements.

2-7 REPACKING FOR SHIPMENT

2-8 When shipping an output card, it is recommended that the package designed for it be used. The original packaging material is reusable. If it is not available, contact your local Hewlett-Packard field office to obtain the materials. This office will also furnish the address of the nearest service office to which the output card can be shipped. Be sure to attach a tag to the output card specifying the owner, model number, full serial number, and service required, or a brief description of the trouble.

2-9 OUTPUT CARD INSTALLATION

2-10 Output cards are installed in slots 400 through 414 of a multiprogrammer unit. To install an output card, proceed as follows:

a. Open the hinged front panel of the multiprogrammer unit by turning the recessed screw within the knurled handle counterclockwise.

CAUTION

Always turn off power at the multiprogrammer before installing or removing the output card. If power is not removed, it is possible to short components in the multiprogrammer when installing or removing a card thereby causing possible damage.

b. With the extractor handle on the top and the card components on the right, slide the card into the desired output slot (400 through 414). Note that all output cards are slotted between pins 4 and 5 and all 400 series connectors of the multiprogrammer are keyed between the same points. This makes it virtually impossible to plug an output card in upside down or into any slot other than a 400 series slot.

c. Route all wiring from the output cards through the false-bottom channel and out the back of the unit to the external system. Special wiring considerations are covered in Section III of this instruction manual.

d. As physical installation and wiring are completed for each output card, carefully note and record the following types of information on the installation record card located on the rear of the hinged front panel of the multiprogrammer.

(1) Card type
(2) Application in external system
(3) Flag period, etc.

2-11 ZERO CALIBRATION

2-12 A zero calibration procedure, applicable to Models 69501A through 69506A, is provided in Section V of this manual.

SECTION III
OPERATING INSTRUCTIONS

3-1 DATA INPUT

3-2 The programmable resistance cards are controlled by the multiprogrammer unit in which they are installed. All dc operating power, address and data bits, and control signals are supplied to the output cards through the multiprogrammer main frame connectors in slots 400 through 414. Figure 3-1 illustrates the signals present on all multiprogrammer 400-series connectors.

3-3 PROGRAMMING

3-4 There are three general steps involved in programming an output card. They are:

a. Enabling the output card by programming the system enable (SYE) bit to a logical 1.

b. Addressing the multiprogrammer unit and slot containing the output card.

c. Programming a data word that will produce the desired resistance output.

3-5 It is assummed in the following discussion that the reader is familiar with the definitions and functions of multiprogrammer control and data words. If this is not the case, it is suggested that Section III of the 6940A (or 6936A) Instruction Manual be reviewed before proceeding.

3-6 SYSTEM ENABLE

3-7 The system enable function is applicable to Models 69500A through 69506A, only. An SYE control line is wired to all multiprogrammer 400 series slots. When the system enable function is programmed as part of a control word, the SYE line goes HI. If the card has also been (or is subsequently) addressed with a data strobe, programming SYE on energizes a relay whose contacts open, removing the short across output terminals C and D. The resistance output across terminal C and D then becomes a function of the previously programmed data bits ($\overline{B00}$ through $\overline{B11}$).

3-8 The SYE control circuit also includes a +5V level sensing circuit that initializes the SYE relay to the deenergized state when power is turned on at the multiprogrammer. In addition, the sensing circuit also deenergizes the SYE relay (placing the 10 ohm zero calibrating resistor across output terminals C and D) if the +5V input falls below approximately +4V.

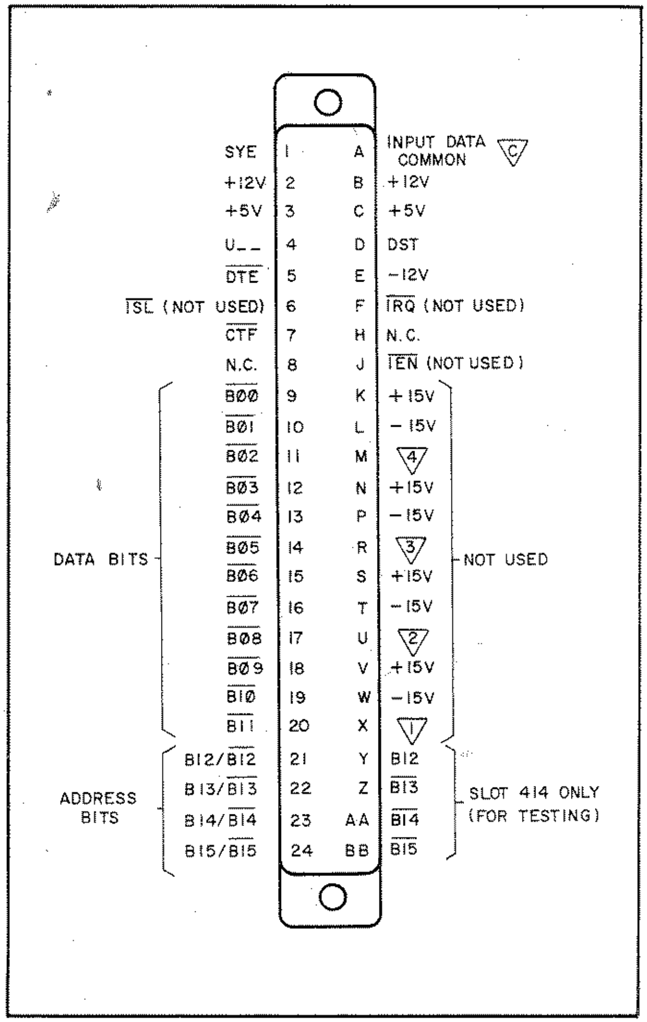


Figure 3-1. Multiprogrammer 400 Series Slot Connector

3-9 ADDRESSING

3-10 An output card is selected to receive new data when its associated address bits (B12/$\overline{B12}$ through B15/$\overline{B15}$ and a unit select line (U--) are all HI. Although both the true and complemented forms of the address bits are represented on Figure 3-1 (e.g. B12 and $\overline{B12}$) only one of the two states is present on each of the four address gate lines when the card is installed in a multiprogrammer slot. For example, if the output card is installed in slot 405, then bits B12 (1), $\overline{B13}$ (2), B14 (4), and $\overline{B15}$ (8) will be present on the address lines;

and all four lines will be HI when a slot 405 is addressed. The U-- line is HI when the associated Multiprogrammer unit is selected as part of a control word. The unit selection is stored by the master unit and it remains in effect until a different unit is selected by a later control word. As mentioned previously, the SYE relay must be energized to enable the card's output across TB1-C and D (Models 69500A through 69506A, only).

3-11 RESISTANCE PROGRAMMING

3-12 Data bits $\overline{\text{BØØ}}$ through $\overline{\text{B11}}$ are stored in the output card storage registers when the card is addressed and data strobed. Each stored data bit controls a relay whose contacts either produce a short circuit or an open circuit across a corresponding programming resistor in a 12-element precision resistance network. The series resistors of the network are binary weighted, with the least significant data bit ($\overline{\text{BØØ}}$) controlling the least significant resistance value. The relationships between a programmed data bit, the corresponding relay state and the condition of the associated programming resistor are:

LOGIC 1 = $\overline{\text{B--}}$, LO = Relay Deenergized = Resistor in Circuit.

LOGIC 0 = $\overline{\text{B--}}$, HI = Relay Energized = Resistor Shorted.

3-13 RESISTANCE PROGRAMMING — VOLTAGE OUTPUT

3-14 Models 69501A through 69506A are used with HP programmable power supplies to produce output voltages (of the power supplies) proportional to programmed digital data. Each model provides a single 12-bit resistance programming channel.

3-15 The following table lists each output card model number and compatible programming coefficient (of HP power supply); the minimum voltage step produced by a programmed change in the least significant data bit; and the maximum voltage produced when all 12 data bits are programmed to logical 1's.

WARNING

When connected to the remote programming terminals of a power supply, the output terminals of a programmable resistance output card will be at approximately the same DC potential of the power supply output voltage. This potential is present even if mainframe power is off, and could represent a shock hazard.

Output Card Model	Prog. Coef. * of HP Power Supply	Min. Volt. Step for LSB Change	Max. Volt. Out. of HP Power Supply
69501A	200 ohm/volt	10mV	40.95V
69502A	300 ohm/volt	25mV	102.375V
69503A	300 ohm/volt	50mV	204.75V
69504A	1 kilohm/volt	10mV	40.95V
69505A	2 kilohm/volt	10mV	40.95
69506A	2 kilohm/volt	25mV	102.375

*Valid for HP Power Supplies with Option 040.

3-16 For all of the above models, the resistance output corresponding to a given programmed number (where $\overline{\text{BØØ}}$ is the LSB and $\overline{\text{B11}}$ is the MSB) can be calculated by multiplying the decimal equivalent of the programmed binary number by the value of the least significant resistor in the 12-element series network. (The resistor values for each model are given in Figure 7-1.)

3-17 The output voltage of the related HP power supply can similarly be calculated by multiplying the programmed number by the minimum step change (in mV) resulting from an LSB change. Sample calculations applicable to the Model 69501A, and assuming a programmed binary number of 000010101010 (170_{10}) are given as follows:

$$R_{OUT} = \text{Prog No.}_{10} \times R_{LSB} = 170 \times 2 \text{ ohms} = 340 \text{ ohms}$$

$$V_{OUT} = \text{Prog No.}_{10} \times V_{LSB} = 170 \times 10\text{mV} = 1.7\text{V}$$

3-18 RESISTANCE PROGRAMMING — CURRENT OUTPUT

3-19 Models 69510A through 69513A are used to establish the current limit points of HP programmable power supplies through use of programmed digital data. Each card provides two identical 6-bit resistance programming channels so that two power supplies can be programmed. Data bits $\overline{\text{BØØ}}$ through $\overline{\text{BØ5}}$ control one channel and $\overline{\text{BØ6}}$ through $\overline{\text{B11}}$ control the second channel. (Bits $\overline{\text{BØØ}}$ and $\overline{\text{BØ6}}$ are the LSB's of their respective channels.)

3-20 The following table lists the value of the front panel current control (of HP Power Supplies) that the 6-bit resistance programming channel electrically replaces; the percentage change in potentiometer resistance produced by a programmed change in the least significant data bit of the related 6-bit channel; and the output resistance (in

percentage of nominal potentiometer value) produced when all 6 data bits of the same channel are programmed to logical 1's. The resistance output is programmed from 0 ohms to the nominal potentiometer value in 50 steps.

Output Card Model	HP Current Pot. Value	Min. Res. Step for LSB Change (% of Pot. Value)	Max. Res. (% of Pot. Value)
69510A	200 ohm	2%	126%
69511A	750 ohm	2%	126%
69512A	1k ohm	2%	126%
69513A	1.5k ohm	2%	126%

3-21 The resistance output corresponding to a programmed 6-bit number can be calculated by:

$$R_{OUT} = \text{Prog. No.}_{10} \times R_{LSB} \text{ of channel}$$

3-22 MODEL 69500A

3-23 This model is supplied without resistors installed in the 12-bit series output element. The choice of components and values is left to the customer, to suit his particular requirements.

3-24 COMMON TIMING FLAG

3-25 A timing flag circuit on each output card produces a $\overline{\text{CTF}}$ pulse that starts when the data bits are first strobed in storage, and lasts for approximately 6msec. The 6msec period is a nominal value provided on all standard programmable resistance output cards. Other $\overline{\text{CTF}}$ periods between 100μsec and 20sec can be obtained by changing the value of capacitor C3, as shown in Figure 7-1; periods less than 100μsec require a modification of the timing flag circuit.

3-26 The purpose of $\overline{\text{CTF}}$ is to prevent the Multiprogrammer from inputting new data to the output card before the relay circuits have had time to complete their previous operation.

3-27 OUTPUT CONNECTIONS

3-28 If the checkout procedures in Section V have not yet been performed, do not proceed with output connections until this has been accomplished.

3-29 RESISTANCE PROGRAMMING — VOLTAGE OUTPUT

3-30 Figure 3-2 illustrates the basic resistance programming connections between a resistance output card (Models 69501A through 69506A) and an HP programmable power supply with Option 040 installed. HP power supplies with Option 040 are calibrated at the factory to produce a voltage output of precisely 0 volts when 10 ohms are connected across their programming terminals. As shown in Figure 3-2, the programmable resistance output cards are equipped with a 10 ohm zero calibration resistor (R26) in series with the programmable 12-

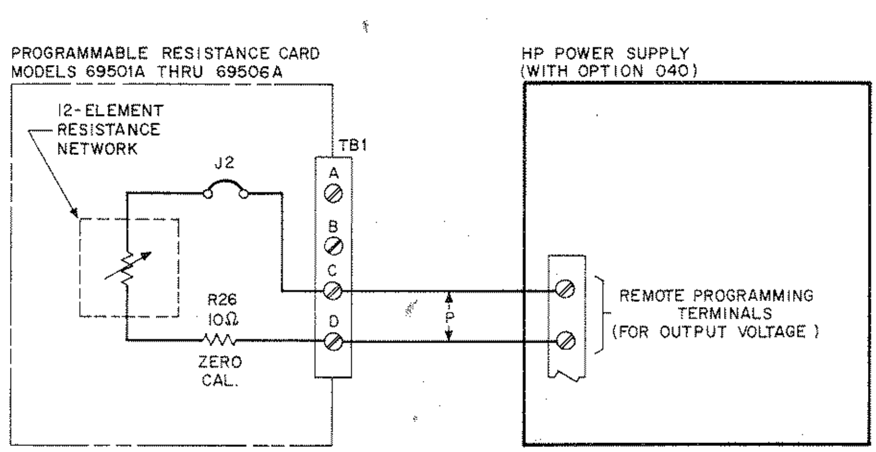


Figure 3-2. Remote Resistance Programming Connections, Voltage Output

element precision resistance network, so that when all logical 0's are programmed into the output card the programming resistance will be 10 ohms and the resulting output of the power supply will be 0 volts.

3-31 Procedures for connecting the programming leads of any output card (Models 69501A through 69513A) to its associated power supply are given as follows:

a. Turn off both the power supply and the multiprogrammer.

b. Using a twisted pair, connect the output of the programmable resistance output card (TB1-C and D) to the remote programming terminals (for voltage output) of the HP programmable power supply. If possible, keep the total resistance of the programming leads below 1 ohm. This can be satisfied by 22 gauge wire for distances between units up to 30 feet (60 feet of wire). Programming lead resistances up to 10 ohms can be accommodated (see zero calibration procedure in Section V) but should be avoided.

c. Perform the power supply load connections and strapping patterns in accordance with the applicable HP power supply instruction manual and its Option 040 appendix.

3-32 RESISTANCE PROGRAMMING — CURRENT OUTPUT

3-33 Figure 3-3 illustrates the resistance programming connections for current limit control of HP programmable power supplies. The connections shown in Figure 3-3 apply to output card Models 69310A through 69313A, only.

3-34 The HP power supplies with Option 040 are calibrated at the factory to produce a 0-ampere current limit for 0-ohms programming resistance. The 10-ohm series resistor used for Models 69501A through 69506A is replaced by a short circuit on output card Models 69510A through 69513A so that when all logical 0's are programmed into the output card, the resulting current limit will be 0-amperes.

3-35 Procedures for connecting the output cards to HP programmable power supplies are given as follows:

a. Turn off the power supplies and the multiprogrammer.

b. Connect output card terminals TB1-A and B(CH 2) to the remote programming terminals (current limit) of one HP power supply, and terminals TB1-C and D (CH 1) to the programming terminals (current limit) of a second HP power supply. Refer to Paragraph 3-31 Step (b) for recommended wire type and size.

c. Perform the power supply load connections and strapping patterns (for current limit) in accordance with the procedures in the applicable HP power supply Instruction Manual and its Option 040 Appendix.

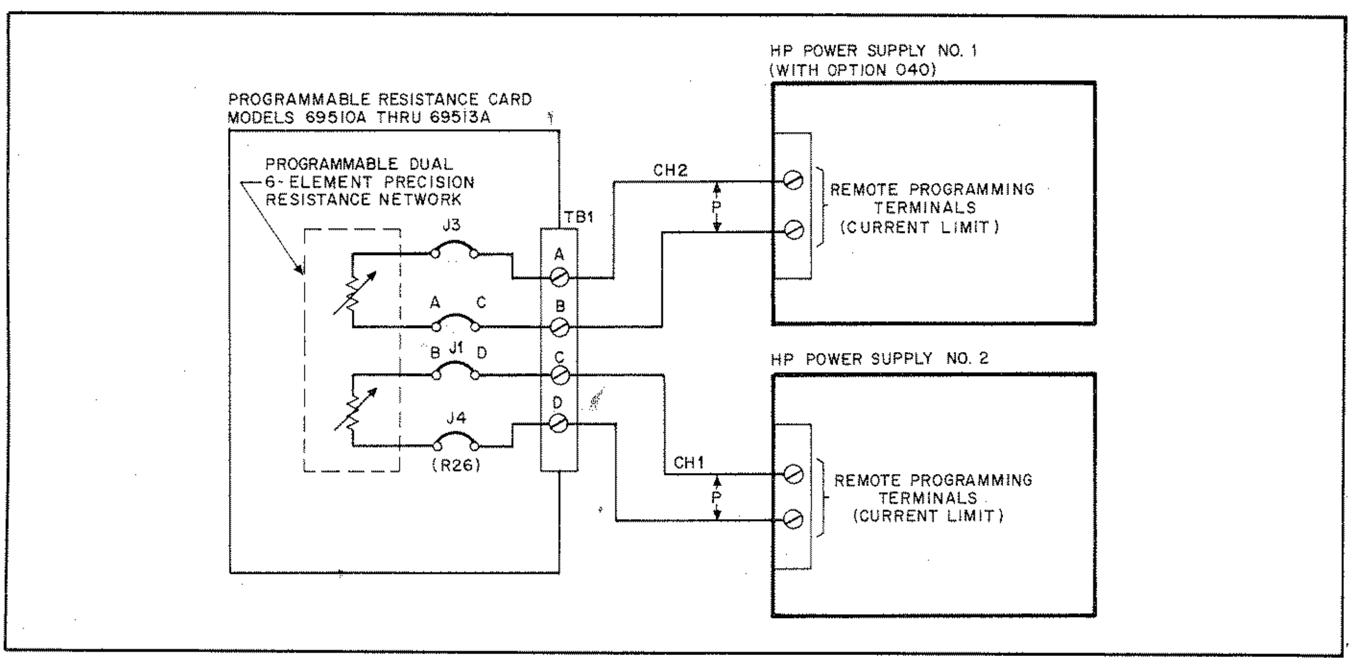


Figure 3-3. Remote Resistance Programming Connections, Current Limit

SECTION IV
PRINCIPLES OF OPERATION

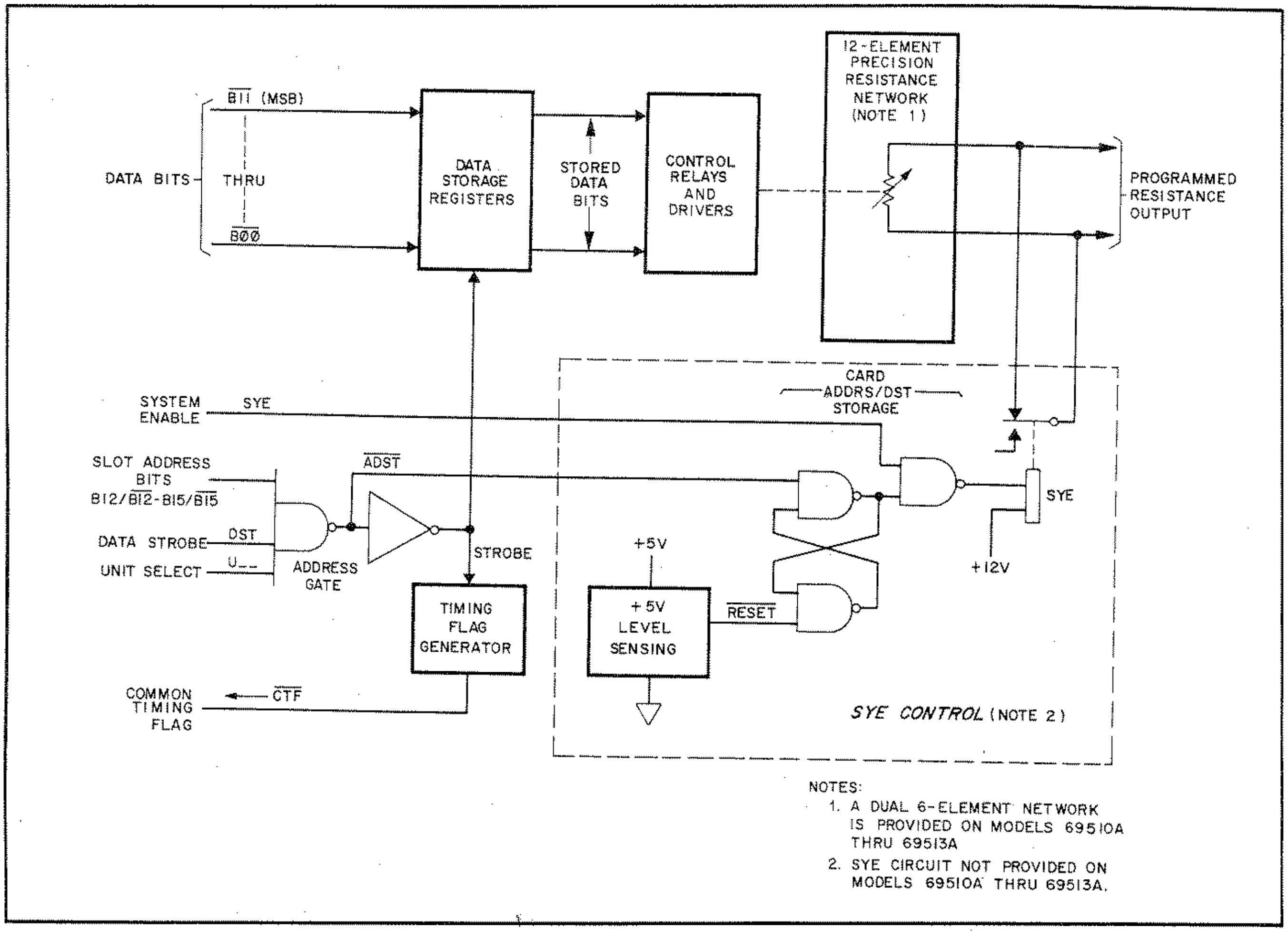


Figure 4-1. Typical Programmable Resistance Output Card, Block Diagram

4-1 INTRODUCTION

4-2 This section contains principles of operation for all programmable resistance output card models. Theory is presented on both a simplified block diagram and a detailed circuit theory level.

4-3 BLOCK DIAGRAM THEORY

4-4 Figure 4-1 is a simplified block diagram of a typical programmable resistance output card. The card consists of an address gate circuit, a strobe amplifier, a 12-bit data storage register, control relays and associated drivers, a 12-element precision resistance network, and a timing flag circuit. An SYE Control Circuit is also provided on Models 69500A through 69506A. When the output card slot is addressed, the address bits all go to the HI state. If the unit containing the card has been selected by a previous control word, U-- is also HI. When a DST pulse appears, the address gate is enabled and passes a strobe pulse to the data storage flip-flops and the timing flag generator circuit. The strobe pulse enters data bits $\overline{B00}$ through $\overline{B11}$ into local storage. The outputs of the storage flip-flops control the data relays which in turn switch programming resistors in and out of the 12-element precision resistance network. The resistors are binary-weighted (the value of each resistor is twice that of the preceding resistor) so that the value of the resistance appearing across

the output terminals is proportional to the value of the programmed binary number.

4-5 The timing flag pulse generator produces a $\overline{CTF}$ pulse that starts at DST and lasts until a timing capacitor within the generator times-out. An SYE Control Circuit is also provided on Models 69500A through 69506A. This circuit holds the card output in the "zero" state (SYE relay deenergized) until the system enable function is programmed. The SYE relay is energized when the output of the address gate ($\overline{ADST}$) sets the card address/DST storage circuit and the SYE bit is programmed to the HI state. The card address/DST storage flip-flop is reset (deenergizing the SYE relay) when power is first turned on or, if the +5V bias falls below approximately +4V.

4-6 DETAILED CIRCUIT ANALYSIS

4-7 Figure 7-1 is a schematic diagram of a resistance output card; it is typical of all models. The tables accompanying Figure 7-1 list the values and strapping configurations for the different models.

4-8 When installed in a Multiprogrammer unit, the output card is programmed by a 16-bit word. Twelve of the bits (BØØ through $\overline{B11}$) represent programmed data, while the remaining four (B12/$\overline{B12}$ through B15/$\overline{B15}$) represent the address of the multiprogrammer slot in which the output card is installed. Although both the true and complemented forms of the address bits are represented on Figure 7-1 (e.g. B12 and $\overline{B12}$) only one of the two states is present on each of the four address gate lines when the card is installed in a multiprogrammer slot. For example, if the output card is installed in slot 405, then bits B12 (1), $\overline{B13}$ (2), B14 (4), and $\overline{B15}$ (8) will be present on the address lines; and all four lines will be HI when slot 405 is addressed. A fifth line, U--, is also part of the addressing scheme and represents a multiprogrammer unit selection.

4-9 SYE CONTROL CIRCUIT

4-10 The SYE control circuit includes the +5V level sensing circuit, the card address/DST storage circuit, relay driver Q3, and relay K2. These circuits control the output of cards used for voltage programming. The output is inhibited (short circuited) under the following conditions: (1) when power is first applied to the multiprogrammer; (2) if a power reduction occurs; (3) if both SYE and the card address (with DST) are not programmed.

4-11 The +5V level sensing circuit (Q8 and Q9 and associated components) shorts the output when power is turned on at the multiprogrammer and, in addition, disables this output if the +5V falls below approximately +4V. This feature is provided to prevent an erroneous output which might occur due to the unpredictable operation of the TTL storage circuits when operated from a supply that is below +4V.

4-12 When power is turned on, +5V is applied across diodes CR4-CR6 and the base-emitter junction of transistor Q9. Q9, therefore, is forward-biased and holds Q8 off. The +5V supply is also applied across R30 and C5. The capacitor cannot charge instantaneously, however, so that the pin 4 input to the address/DST storage flip-flop is held LO to reset the flip-flop. The pin 2 input to NAND gate G1, therefore, is LO and its output is HI. The HI output of G1 is inverted by G2 with the resulting LO input to relay driver Q3 reverse-biasing the transistor. With Q3 off, relay K2 is deenergized and the card output across terminals C and D is shorted (except for R26, the 10Ω zero calibration resistor). After capacitor C5 charges to +3.8V (in approximately 50 msec) the input to the flip-flop is HI.

4-13 The output of the +5V level sensing circuit remains HI until the +5V falls below approximately +4V which is the point at which Q9 is turned off (the voltage applied across CR4-CR6 does not equal the combined drops of these diodes). When Q9 turns off, Q8 is biased on and capacitor C5 rapidly discharges through Q8 to reset the flip-flop (if it was set) and deenergize K2 to disable the TB1-D and -C output as described above.

4-14 Assuming that the +5V does not fall below +4V after power turn on, the pin 4 input of the flip-flop is HI and the flip-flop is controlled by the address gate input at pin 9. When the card is addressed and data strobed, the pin 9 input is LO (for the period of DST) and the flip-flop is set. Thus, the pin 2 input of NAND gate G1 is HI. If SYE has been or is subsequently programmed on, the pin 1 input to G1 is also HI and its output is LO. The LO output is inverted by G2 with its HI output forward-biasing relay driver Q3. Q3 now conducts and energizes K2 to enable the TB1-C and TB1-D output of the card. Thus, the resistance output of the card is connected to the load as long as SYE is on and the card has been addressed and strobed at least once since power was turned on (or since the last power reduction). Of course, if SYE is programmed off, the pin 1 input to G1 is LO and the relay driver turned off by the LO input from G2. Thus, relay K2 is deenergized. Similarly, if power is turned off or the +5V falls below +4V, the relay is deenergized so that after power is restored the card must be readdressed, strobed, and SYE must be present before the output is enabled.

4-15 ADDRESSING

4-16 When the slot and unit in which the output card is housed are addressed, the four address bits and U-- go HI. Data bits $\overline{B11}$ through $\overline{BØØ}$ are also present at this time but are not yet entered into storage. Approximately 4μsec after the programmed word appears, a data strobe pulse (DST) is received by the output-card. The 4μsec delay of DST allows the data lines to settle before the data is stored. When DST appears, it enables NAND gate Z4 which in turn produces a negative pulse the width of DST. Transistor Q2 inverts the negative pulse and applies it to the 12-bit data storage register and the timing flag generator. As previously discussed, the output of Z4 also sets the address/DST storage flip-flop.

4-17 DATA STORAGE

4-18 The 12-bit data storage register is comprised of three four-bit storage flip-flops (Z1, Z2, and Z3). The individual stages are D-type, positive-edge triggered flip-flops. The logical state at the D-input of a flip-flop is transferred to the Q output terminal when the clock terminal (CLK) is strobed by a positive-going pulse.

4-19 When a data bit is programmed to a logical 1 at the computer, the corresponding $\overline{B--}$ data line goes LO. The strobe pulse from Q2 transfers this LO level from the D-input to the Q output. Relay driver Q1 is switched off by the LO level and de-energizes relay K1. When the relay is deenergized, its contacts open and add the value of the associated precision resistor into the 12-element network. The resistors in the 12-element network are binary-weighted, with R1 the least significant.

4-20 TIMING FLAG GENERATION

4-21 The timing flag circuit produces a negative $\overline{CTF}$ pulse that starts at DST and lasts for approximately 6msec. (The 6msec period is a nominal value provided on all standard resistance output cards. Other $\overline{CTF}$ periods between 100μsec and 20sec can be obtained by changing the value of capacitor C3; (periods less than 100μsec require a modification of the timing flag circuit.)

4-22 The purpose of $\overline{CTF}$ is to prevent the multiprogrammer from inputting new data to the output card before the relay circuits have had time to complete their previous operation.

4-23 Before the strobe pulse is generated, the emitter voltage of Q4 is below the turn-on level of SCR CR3. Capacitor C3 is charged positively to approximately 4.1 volts and transistor Q5 is biased on by the emitter voltage of Q7. The LO collector voltage of Q5 cuts off Q6, holding $\overline{CTF}$ at a HI level. (The collector load resistor for Q6 is located on the logic and timing card of the multiprogrammer unit.)

4-24 When the strobe pulse is generated, the emitter voltage of Q4 rises positively and fires the SCR. Capacitor C3 now rapidly discharges through R22 and CR3. With C3 discharged, the current supplied by R21 alone is less than the sustaining current of the SCR, and it cuts off. Capacitor C3 again starts charging toward +5 volts through R21, and after approximately 6msec it has charged to a voltage sufficiently high (approximately 3.2 volts) to overcome the base-emitter diode drops of Q7 and Q5 and the drop across three junction diode CR2. At this time Q5 turns on, Q6 turns off, and $\overline{CTF}$ is reset to the HI state. The circuit can be re-triggered immediately after $\overline{CTF}$ is reset.