HEWLETT **hp** PACKARD

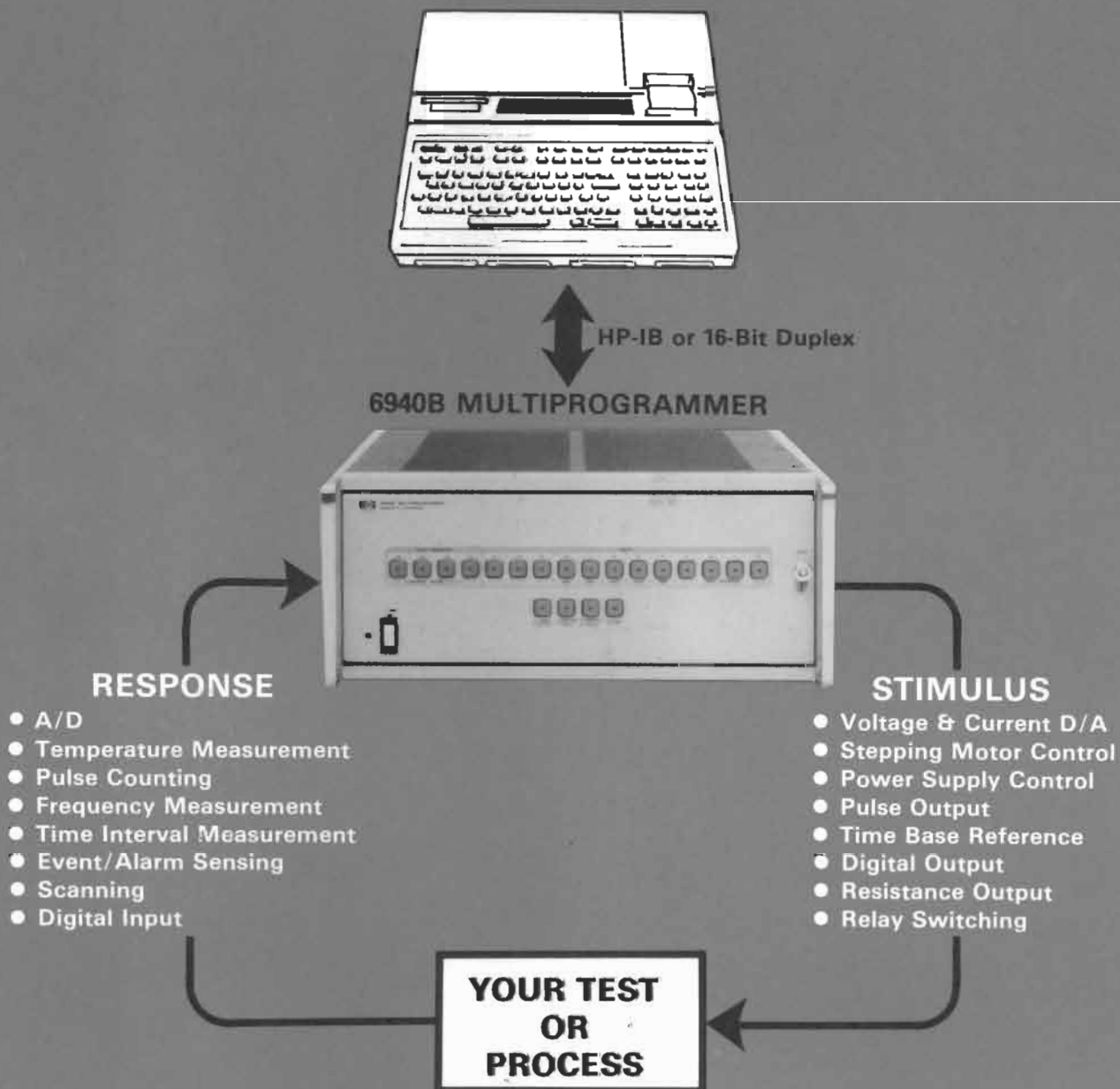# MULTIPROGRAMMER

Model 6940B, 6941B

Technical Data, June 1979

... a versatile I/O expander & converter for automatic test & control

THE 6940B MULTIPROGRAMMER...
YOUR KEY TO SUCCESSFUL
AUTOMATIC TEST AND CONTROL

With the 6940B Multiprogrammer, Your HP Desktop or Mini Computer Becomes a Reliable, Easy-to-Use Automatic Test or Control System

HP-IB or 16-Bit Duplex

6940B MULTIPROGRAMMER

RESPONSE
- A/D
- Temperature Measurement
- Pulse Counting
- Frequency Measurement
- Time Interval Measurement
- Event/Alarm Sensing
- Scanning
- Digital Input

STIMULUS
- Voltage & Current D/A
- Stepping Motor Control
- Power Supply Control
- Pulse Output
- Time Base Reference
- Digital Output
- Resistance Output
- Relay Switching

YOUR TEST OR PROCESS

MULTIPROGRAMMER FEATURES

- Digital data storage is on plug-in cards to reduce controller processing overhead.
- Pacing can be accurately controlled internally or externally.
- Functions can be controlled individually or in groups.
- The system can be programmed to a neutral state in case of emergency.
- The controller can be interrupted when digital lines change state.
- All analog inputs and outputs are isolated from data common.

HP Computer Museum
www.hpmuseum.net

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Contents

Model Number Index

Computer Museum

CAPABILITIES

STIMULUS

Alphabetical Index

Programmable DC Voltage and Current
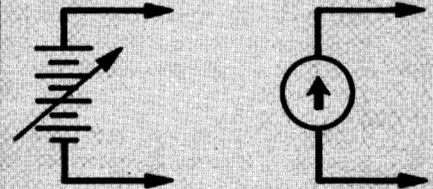
The output voltage (up to 100V) and current (up to 1000A) of forty different HP power supplies can be programmed to provide bias in automatic test systems or control of electromechanical process equipment.
Cards Used: Resistance Output, 69501A – 69513A.

Digital-to-Analog Conversion
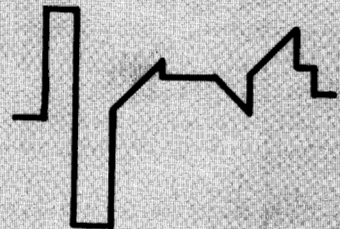
Twelve-bit voltage and current DAC's for strip chart, x-y, and analog tape recordings as well as control of analog programmable instruments and process control devices with 0-5 volt or 4-20mA inputs.
Cards Used: Voltage DAC, 69321B; Quad DAC, 69322A; Current DAC, 69370A; Voltage Regulator, 69351B.

Time and Frequency Reference
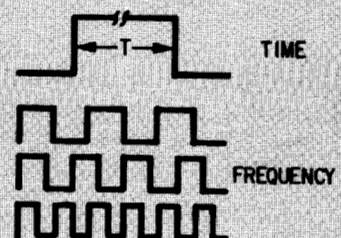
TIME

FREQUENCY

One-shot timing pulses, programmable from 1μsec to 40 days, and crystal-controlled pulse trains in fixed frequencies of 1, 10, 100, 1K, 10K, and 100KHz serve as time-base references for control, measurement, and data acquisition equipment.
Cards Used: Timer, 69600B; Frequency Reference, 69601B.

MEASUREMENT	CONTROL	ACQUISITION

Temperature Measurement
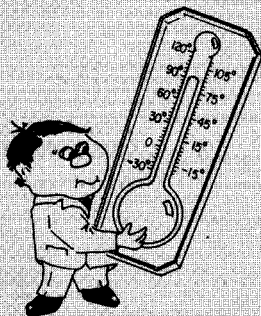
Temperature measurements are easy with the 69423A Low Level A/D and Scanner. Simply wire up to six thermocouples per card to the card edge connector. Reference junction temperature can be read from channel 7 on the card.

Cards Used: Low Level A/D and Scanner, 69423A; Voltage Regulator, 69351B

Stepping Motor Control
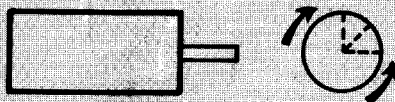
One computer word to card produces from 1 to 2047 square-wave pulses at either of two outputs (CW or CCW) to control motor translators. Output pulses are also used for pulse-train update of supervisory control stations.

Cards Used: Stepping Motor Control, 69335A.

Scanning and Input Multiplexing
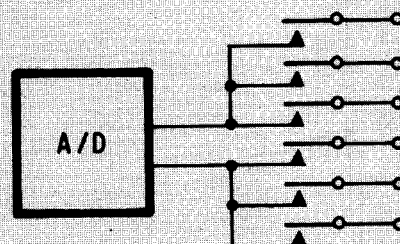
Simple single-ended switches or multi-wire scanner matrices are formed by interconnecting relays on a Relay Output/Readback Card. The relay output card scanners act as input multiplexers for A/D, Pulse Counter, and Digital Input Cards.

Card Used: Relay Output/Readback, 69433A.

Voltage, Current and Resistance Measurements
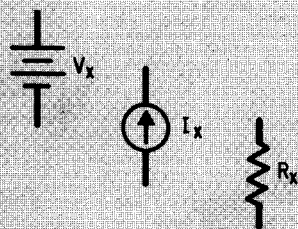
The 69422A High Speed A/D card measures voltages in the presence of 100V of common mode noise. Connecting a resistor across the input permits current measurement for 4-20mA current loops used in process control. Combine voltage monitor and current DAC cards for resistance measurements.

Cards Used: A/D, 69422A; Current DAC, 69370A; Voltage Regulator, 69351A.

Digital Output and Switching

SOLID STATE OUTPUTS

RELAY MATRIX
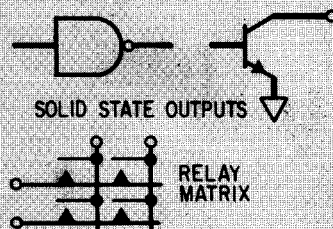
Twelve-bits of data in TTL, open collector, or SPST relay-contact form provide digital control of instruments, indicators, and solid-state AC relays.

Cards Used: TTL, 69331A; Open Collector, 69332A; Mercury-wetted Relay, 69330A; Relay Output/Readback, 69433A.

Event Sensing

FULL
IN
OUT
STOP
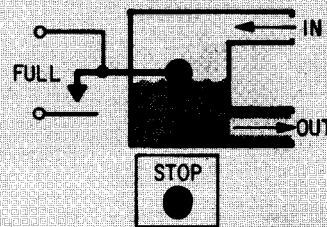
It is often necessary for a system to respond quickly to alarm conditions, operator intervention or other requests for immediate service. This service request is made via a program interrupt generated by either an event sense or a process interrupt card.

Cards Used: Event Sense, 69434A; Process Interrupt, 69436A.

Pulse Counting Preset and Up/Down

UP
OUT
DOWN
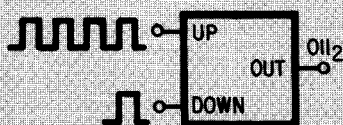
Counter may be preset to any value within count range of 0 to 4095. The program can examine the counter without disturbing the counting process (read-on-the-fly).

Cards Used: Pulse Counter, 69435A.

Time Interval Measurement

START
CLOSE
OPEN
STOP
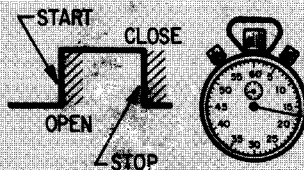
Elapsed time between two events can be measured in the range of 10µsec to 1 hour by counting a known frequency over the unknown interval. The program divides the accumulated count by the known frequency to determine the interval.

Cards Used: Pulse Counter, 69435A; Frequency Reference, 69601B.

Digital Input

$+8.001$

017700_8

Digital input cards accept 12 bits of data from digital measuring instruments, push-buttons, switches, relays, and other digital devices in the form of logic levels or contact closures. Digital data sources with more than 12 bits of data use several digital input cards.

Cards Used: Digital Input, 69431A; Isolated Digital Input, 69430A.

Multiprogrammer buil
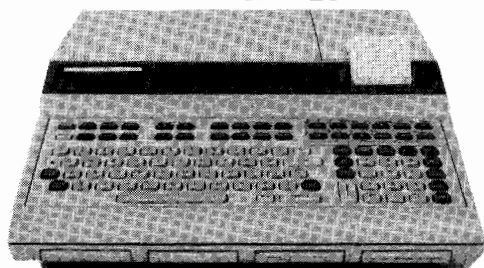
Use your HP Desktop Computer or HP Minicomputer as the system controller that programs each plug-in card in the Multiprogrammer and Multiprogrammer Extender mainframes to control, measure, and monitor system variables.

HP-1000

INTERFACE KITS

Include hardware and software for operating the Multiprogrammer from HP-IB or 16-bit I/O cards in HP computers.

59500A INTERFACE is for computers with HP-IB I/O.

14550B INTERFACE is a 16-bit parallel interface for HP minicomputers.

98032A (Option 040,340, or 440) is for HP Desktop Computers with 16-bit I/O capability.
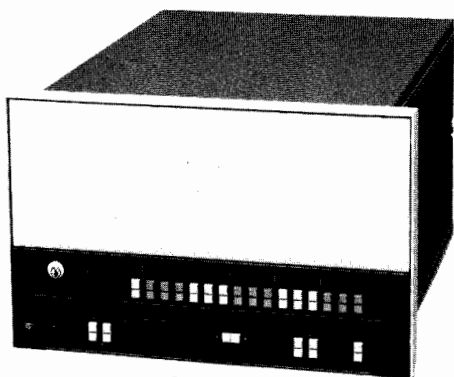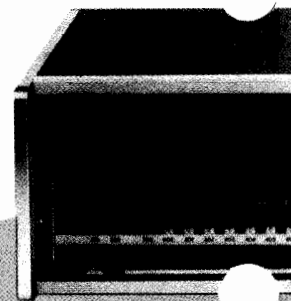
Programmab
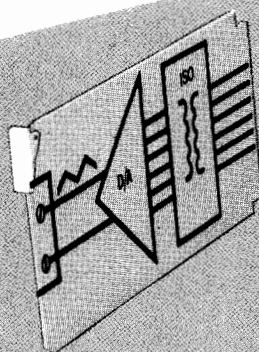
FREQUENCY REFERENCE
(Not Shown)

69601B – Provides six separate square wave outputs derived from a 1MHz crystal. Often used with 69435A counter cards for time interval measurements.

D/A CONVERTERS
(12-Bit Resolution)

69321B-Voltage D/A −10 to +10V @ 0.5mA, 5mV accuracy.
69322A-Voltage D/A 4-channel, 20mV accuracy.
69370A-Current D/A 0-20mA @0,10.5V, 5µA accuracy.
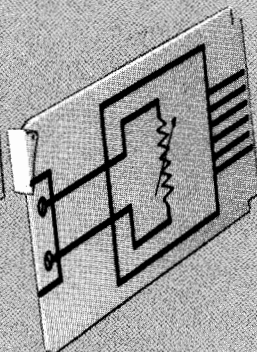
RESISTANCE PROGRAMMING

69501A-69513A – Single 12-bit or dual 6-bit channels for resistance programming of HP power supplies.

TEMPERATURE MEASUREMENT

69423A-Monitors up to 6 channels of thermocouple input. Has a seventh channel for automatic reference junction compensation.
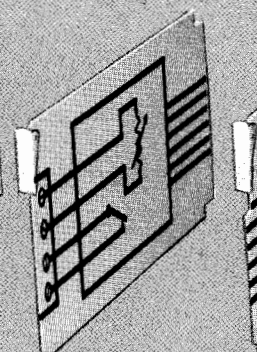
DIGITAL OUTPUTS
(12-Bits)

69331A – TTL/DTL logic levels.
69332A – Open Collector drivers.
69330A – Relay Register. Isolated SPST N.O. mercury-wetted contacts.
69433A – Relay Output/Readback.

STEPPING MOTOR CONTROL

69335A – Used to drive stepper motor and pulse-update type controls. Can be programmed to generate from 1 to 2047 pulse outputs to either of two terminals.
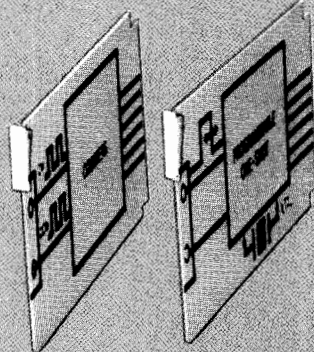
TIMER

69600B – Can be programmed to generate crystal controlled, one-shot timing pulses. Time increment is variable from 1µsec to 40 days.

4

ding-block components

6940B MULTIPROGRAMMER
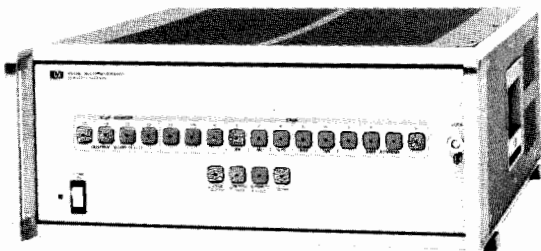
Controls the bidirectional transfer of data between the computer and the plug-in cards (shown below) installed in the 6940B Multiprogrammer and the 6941B Extender Mainframes. The 6940B has a basic 15-channel (plug-in card) I/O capacity.

Up to 30 meters separation

6941B EXTENDERS
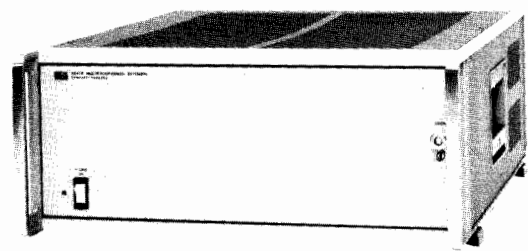
Each Extender mainframe accommodates up to fifteen programmable plug-in cards. Up to fifteen extenders can be chain-cabled together to obtain up to 240 individually addressable I/O channels. Extenders may be separated from one another by up to 30 meters.

6940B/6941B MAINFRAME (Door Removed)

le I/O cards
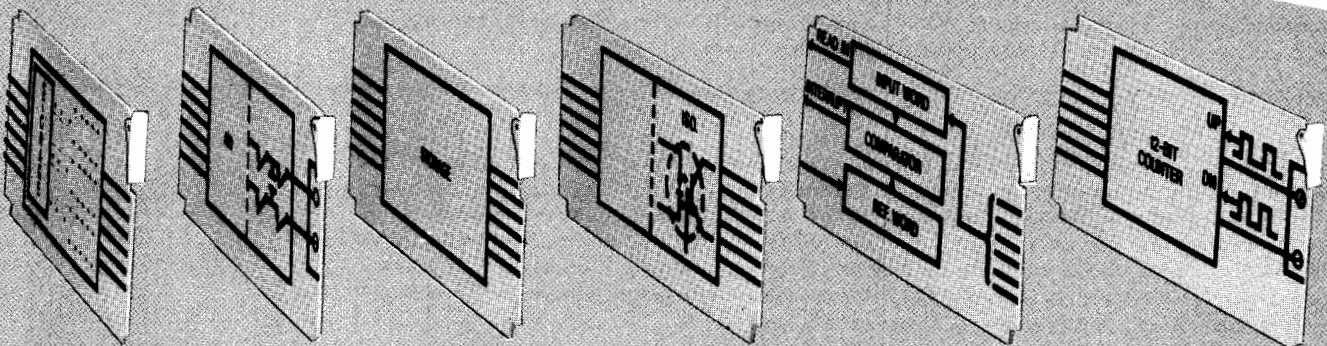
DESIGN YOUR OWN
69500A – Series Element.
69380A – Breadboard Output.
69480A – Breadboard Input.
69280A – Breadboard

DIGITAL INPUT
69431A – Monitors 12 lines of TTL, DTL, or contact closure logic. Gate/Flag circuits included for exchanging control signals with user's device.

EVENT SENSING
69434A – Compares digital input with reference data stored on card. An interrupt is generated when data sets do not match.
69436A – Generates an interrupt on positive and/or negative transitions of any of 12 input lines and stores the event.

HIGH SPEED A/D
69422A-Converts dc input voltage (± 100, ± 10, ± 1, ± 0.1V) to equivalent 12-bit 2's complement digital word for computer reading.

ISOLATED DIGITAL INPUT
69430A – Monitors 12, independent, 12V inputs. All input lines are isolated. Eight options available to accommodate a wide range of inputs.

PULSE COUNTING
69435A – Counts pulses up or down in a range of 0 to 4095. Carry and borrow pulses are generated to permit cascading of cards. Counters can be pre-set.

APPLICATIONS

The Multiprogrammer provides flexible and convenient I/O expansion and conversion capability for computers and calculators. This versatility has made the Multiprogrammer an important part of many different types of automatic systems.

Production Testing

I. C. Testing

Functional testing of digital integrated circuits involves the use of 69331A Digital Output Cards to establish pre-determined logic states at the inputs to the device, and 69431A Digital Input Cards to read the device outputs back to the controller for comparison with expected results. Analog I.C.'s are stimulated with programmed voltage levels from the 69321B Digital-to-Analog Voltage Converter or 69370A Digital-to-Analog Current Converter and measured with the 69422A High Speed A/D Card. These tests are often performed on semiconductor wafers as part of the I.C. manufacturing process, and repeated on the packaged I.C. for final inspection.
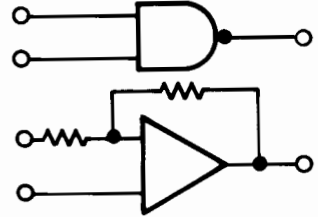
Electronic Subassembly Testing

The digital and analog inputs and outputs of the Multiprogrammer are connected through fixtures to printed circuit modules, cables, and other assemblies such as D/A and A/D converters, filters, and oscillators for incoming inspection, production, calibration, and troubleshooting. During the test, 69501A Resistance Output cards control the outputs of DC Power Supplies that bias the subassembly. Adjustment of critical circuits is performed by a 69335A Stepping Motor Control Card that operates a motor, translator, and flexible shaft as an automatic screwdriver. Multiconductor cables are tested for continuity, with 69331A Digital Output and 69431A Digital Input Cards.
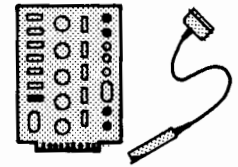
Electromechanical Component Testing

A wide variety of tests on relays and solenoids are performed with Multiprogrammers, including operational tests in which the 69332A Open Collector card applies power to the coil, and 69431A Digital Input Cards check for proper contact action. Hysteresis in the relay is often measured by generating a staircase function from a programmable power supply under control of a 69501A Resistance Output Card. Time delays are measured with a 69435A Counter Card and 69601B Frequency Reference Card. Contact and coil resistance at various current levels are measured by using a 69370A Digital-to-Analog Current Converter or Constant Current DC Power Supply and the 69422A High Speed D/A Card. Production tests of other electromechanical devices such as process control valves, flowmeters, tachometers, gauges, switches, and detectors are performed with Multiprogrammer-based automatic systems.
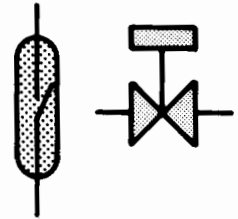
Instrument Quality Control Testing

Complete instruments such as modular power supplies are checked for conformance with line and load regulation, accuracy, transient response, and other specifications by using the Multiprogrammer to control programmable loads through 69321B Digital-to-Analog Voltage Converter Cards, to set the sampling time of a DVM with a 69600B Programmable Timer Card, and to control an AC line regulator with 69330A Relay Output Cards. Digital panel meters, setpoint controllers, and other instruments with digital or analog inputs or outputs are tested for accuracy, linearity, and operation under stress conditions with Multiprogrammer systems that save time and improve product quality.
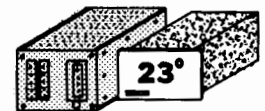
Research and Development

Environmental Testing

Multiprogrammer I/O cards are not only capable of operating analog and digital instruments under environmental test and measuring their performance, but are also well suited to control of environmental chamber parameters such as temperature, pressure and humidity during the test cycle. In other types of environmental testing, such as operation of shake tables for small structures, and control of hydraulic rams for large structures and vehicles, 69321B Digital-to-Analog Voltage Converters are programmed to synthesize the waveforms that simulate actual transportation and shock conditions. Designers can alter parameters during the lab test to analyze the effect of severe stresses and abusive treatment. Temperature of the test chamber and various parts of the unit can be measured with the 69423A, Low Level A/D and Scanner.
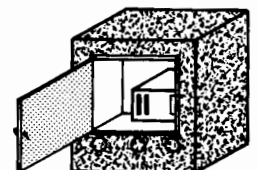
Margin Testing

Today's markets demand increased attention to reliability and margins of safety in early stages of product development. The flexibility and convenience of the Multiprogrammer make it a valuable tool in the laboratory to perform repetitive tests on prototypes under simulated worst-case electrical, mechanical, and thermal conditions. At the completion of the development phase, the Multiprogrammer lab system becomes a cost-effective solution for automatic testing of the new unit on the production line.
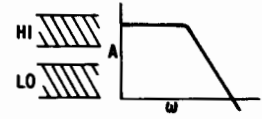
Life Testing

Automatic control of life tests with the Multiprogrammer saves labor and reduces the possibility of human error; also, automatic control ensures impartial and repeatable test conditions. The 69600B Programmable Timer card is often used to initiate each portion of the test sequence at precise intervals.

The 69331A Digital Output Cards operate solid-state AC and DC switches that replace conventional relays for automatic programmed disconnect of faulty units during the test. Power supplies under control of the 69501A Resistance Output card vary electrical bias for units under test. Up to 2,880 digital inputs or outputs can be controlled or monitored with a chain of one 6940B Multiprogrammer and fifteen 6941B Multiprogrammer Extenders for large scale life testing.
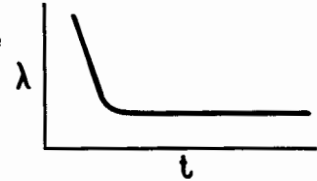
Component Evaluation

Frequently, product designers must evaluate a number of similar components from a number of potential suppliers to select the best parts for their product. The ease with which the Multiprogrammer can be reconfigured with various plug-in cards enables a design engineer to quickly construct versatile test sets for thorough evaluation of electrical, electronic, and electromechanical components. The equipment used for vendor qualification in the lab can be used later in production for automatic incoming inspection of the components.
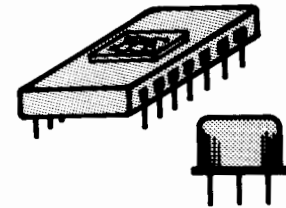
Monitoring and Control

Power Management

Power companies calculate demand charges on the basis of peak power consumed. Connection of the 69435A Counter Card to the contact outputs of the wattmeter and connection of the 69434A Event Sense Card to the time interval contact at the wattmeter provide the information needed to sense an impending abnormal peak interval and temporarily shut down sheddable loads such as heating and ventilating equipment. Temperature is measured with the 69423A Low Level A/D and Scanner. 69331A Digital Output cards are used to operate solid-state AC switches or electromechanical interposing control circuits for the sheddable loads. When the demand charge portion of the total energy bill is not large enough to justify investment in a demand-limiting system, the Multiprogrammer can be used in a system that automatically turns off loads when they are not needed.
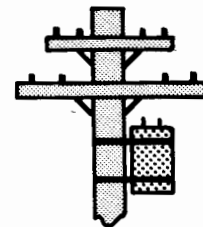
Process Automation

Multiprogrammer capabilities are used to interface with conventional process controllers by using the 0-20mA output of the 69370A Digital-to-Analog Current Converter Card or pulses from the 69335A Stepping Motor Control Card to adjust the setpoint in supervisory control systems. Multiprogrammers are also used in direct digital control systems where conventional analog control loops are replaced by Multiprogrammer analog and digital I/O cards operating with a software algorithm for proportional, rate, and reset control. The flexibility and expandability of the Multiprogrammer is particularly useful for pilot plant automation and process experiments that may require many changes in configuration during installation and development of the final system.
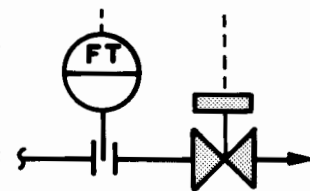
Data Acquisition and Signal Distribution

Data acquisition systems employ a 69433A Relay Output Card as scanner for routing analog signals to the 69422A High Speed A/D Card for measurement. Temperature can be measured with the 69423A Low Level A/D and Scanner. Digital Input Cards monitor DC logic levels directly, or are connected to optically isolated signal conditioners for monitoring 115 and 230Vac signals. Control signals up to 100 volts DC or AC rms are distributed directly to the process with 69433A or 69330A Relay Output Cards, while 69331A Digital Output Cards control solid-state AC or DC relays for controlling voltages above 100 volts. The Multiprogrammer mainframes can be separated by up to 100 feet (30 meters), so that proper location of mainframes used for scanning and distribution can significantly reduce cabling costs to sensors and indicators.
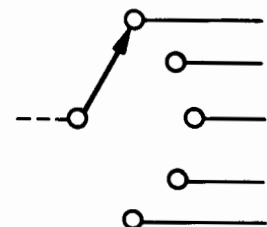
HARDWARE

Convenience

(1) Local Switch Register - An important aid in system checkout and troubleshooting, these switches permit manual programming of all Multiprogrammer output, input and control functions. Fault isolation to a functional area of the system (computer, multiprogrammer, or external devices), as well as mainframe and plug-in card troubleshooting can all be accomplished from the 6940B front panel.

(2) AC Power Module — Selects either 100, 120, 220, or 240Vac, 48-440Hz as power source. A safety interlock makes it impossible to change the AC voltage selection without first removing the power cable.

(3) Logic Probe Connector — Provides 5Vdc power for operating HP logic probes.

(4) Cable Channel — All cabling between the multiprogrammer plug-in cards and external devices are routed through this channel and out the back of the mainframe.

(5) Extractor Handles With ID — Facilitate easy removal of cards from mainframe. The card designation is stamped on the handle.

(6) Molded Edge Connector — Supplied with most I/O cards for convenience in wiring to external devices.

(7) DC Power Supplies — Power for all plug-in cards, including four isolated ±15 volt supplies for up to 15 analog I/O cards, are built in to the mainframes, regulated by the 69351B.

Modularity

(8) Cable-Together Mainframes — Up to fifteen 6941B Extender mainframes can be chain-cabled on to a 6940B Multiprogrammer to obtain up to 240 programmable I/O slots.

(9) Plug-In I/O Cards — Up to 15 I/O cards can be programmed through each mainframe. The cards can be mixed in any order and type.

(10) Keyed Mainframe Connectors — Prevent cards from being plugged into wrong connectors.

Operating Features

(11) Emergency Shutdown — Many models of output cards can be simultaneously set to a safe state (output shorted or opened) under program control.

(12) Turn-On Preset — Most output cards are set to an initial (safe) state upon power turn-on.

(13) Synchronized Outputs — Multiple analog and digital output cards can be programmed to output data in synchronized groups.

(14) Computer Interrupt — Most input cards can request interrupt service from the computer.

(15) Automatic Timing — Output cards that control relatively slow devices like stepping motors, solenoids, and power supplies can be programmed to interrupt the computer when the output has been completed.

(16) Isolation — Pulse Transformers or optically coupled isolators on some plug-in cards avoid ground loops.
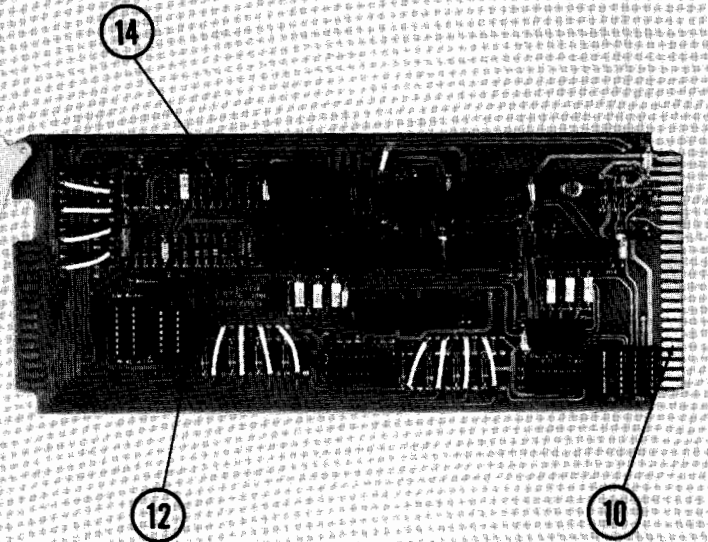
Typical Input Card
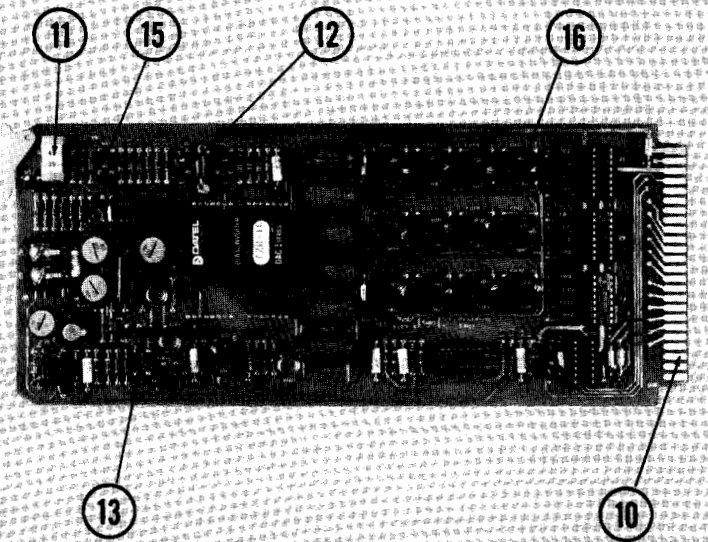
Typical Output Card

Front View of 6940B

Rear View of 6940B
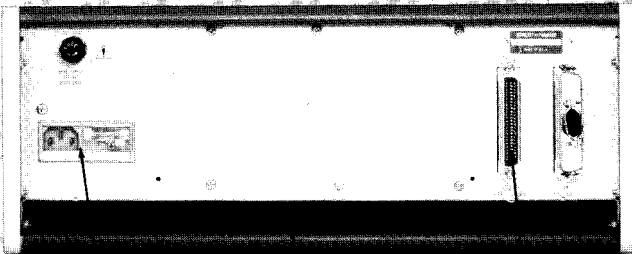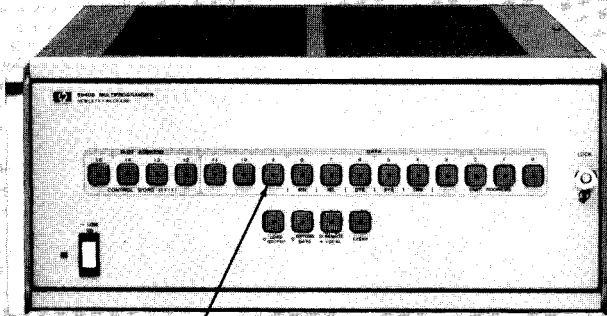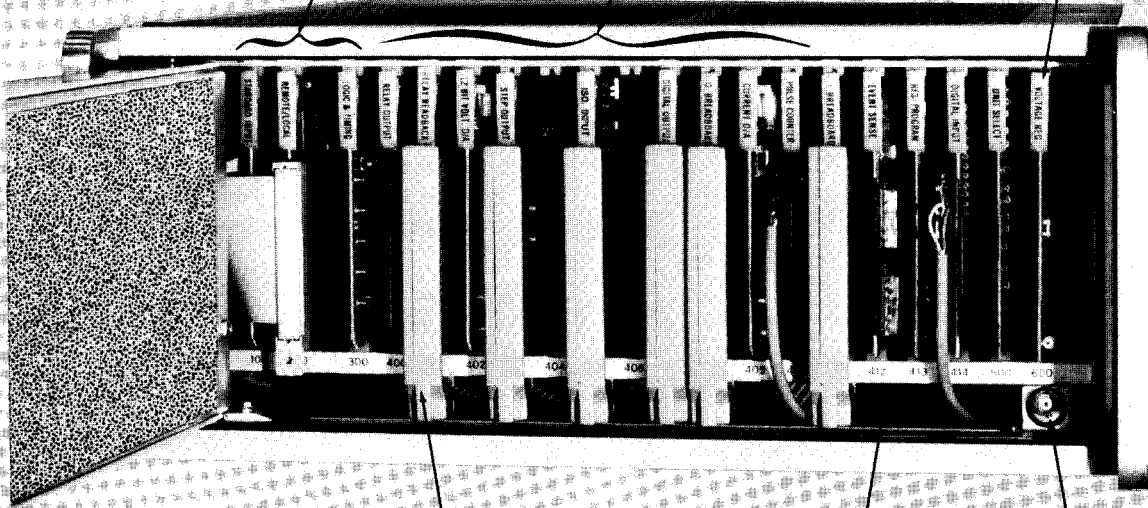
6940B with Door Open

CONTROLLERS FOR THE 6940B

Here are some of the HP Computers used with the 6940B - (See also configuration checklist on page 58).

9825S

The 9825S features 23K bytes of user read-write memory, a 32 character LED display, a 16 character printer, and a tape cartridge drive. The 9825S is programmed in the HPL language. It interfaces with the 6940B via 16-bit duplex or HP-IB. A Software Library (model 14556A) and Throughput Analysis (AN 282-1) are also available with the 9825S.
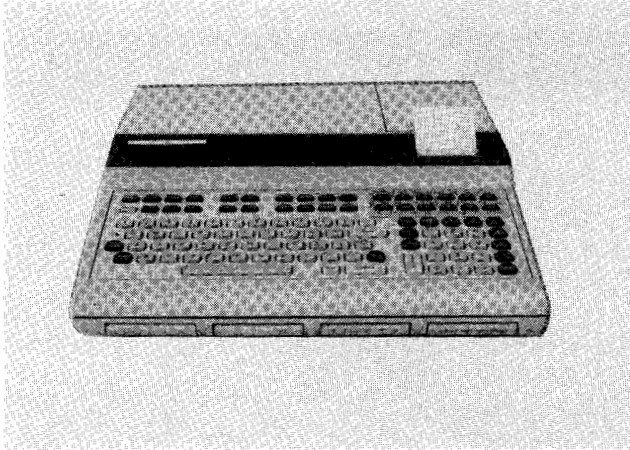
9835

The 9835 features a 12" CRT, up to 246K bytes of user read-write memory, and a tape cartridge drive. The 9835A can be programmed using BASIC or assembly language. It interfaces with the 6940B via 16-bit duplex or HP-IB.
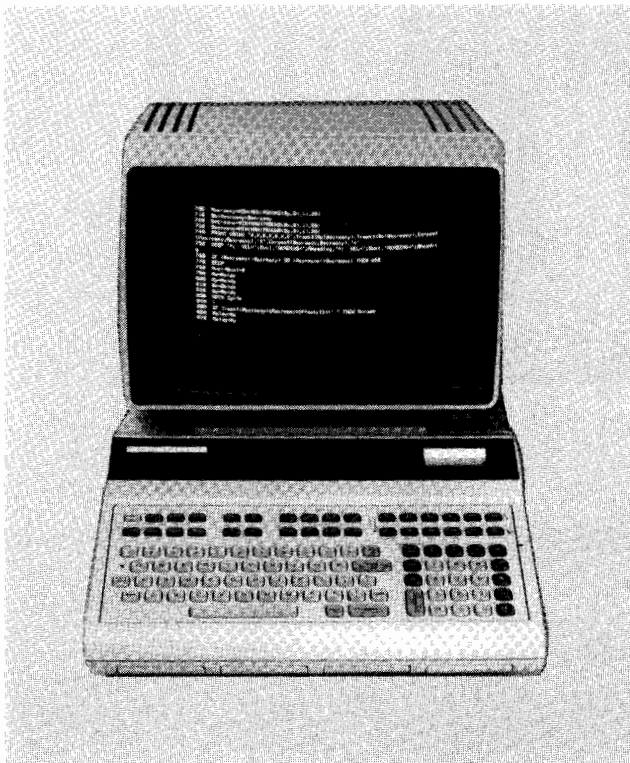
9845

The 9845 features a 12" CRT with full graphics, an 80 character line printer, dual tape cartridge, and 62K bytes of user read-write memory. The 9845 is programmed in BASIC. It interfaces with the 6940B via 16-bit duplex or HP-IB.
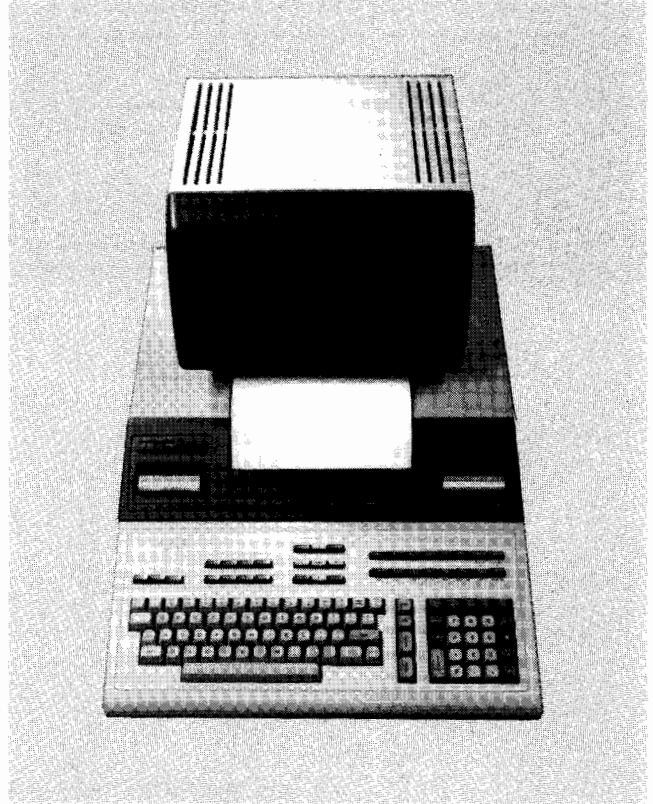
HP-1000

The HP-1000 computer system offers a multiple user and multiple station operating system, high speed and performance, and up to 2048K bytes of read-write memory. BASIC, FORTRAN, and assembly language may be used with the HP-1000. Interfacing with the 6940B may be done via 16-bit duplex or HP-IB.
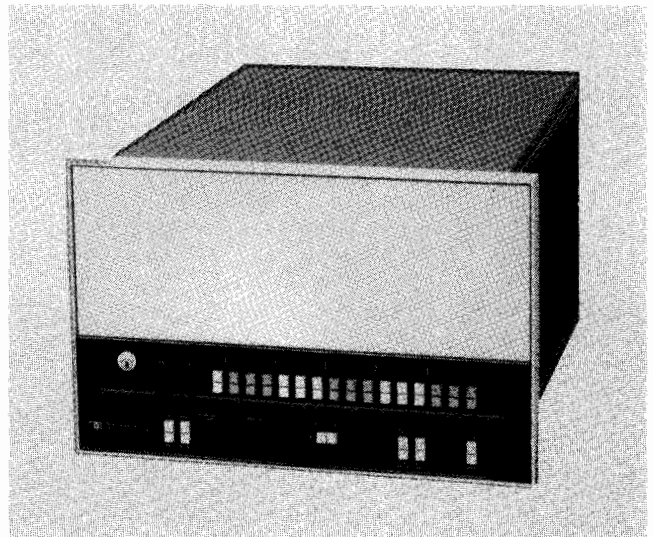
LEARNING TO OPERATE THE 6940B

14556A Software Library
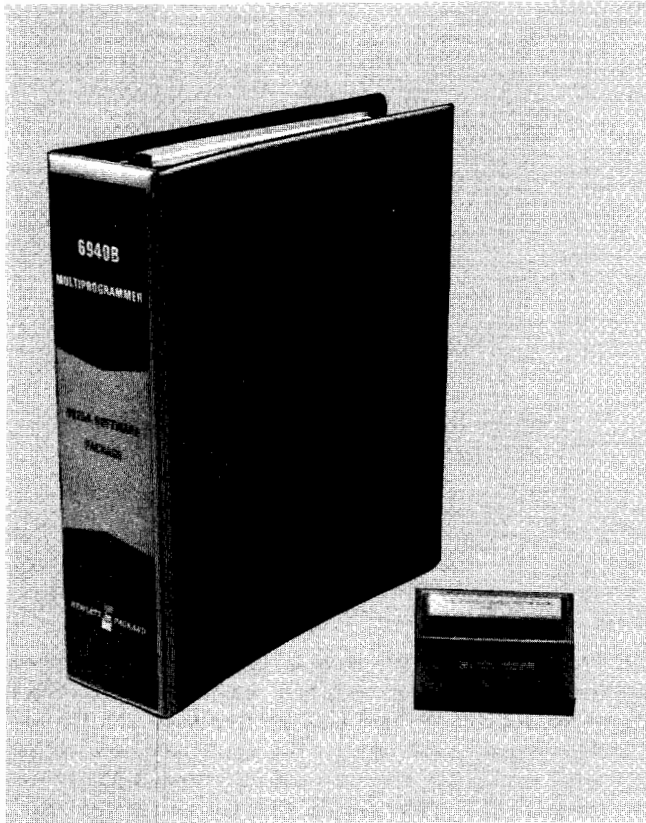
The 14556A Software Library offers 9825 users a simplified way to operate the Multiprogrammer. Simply select from the 40 high level routines, those which you would like to use. The Autoloader will load these from the Library tape and append them to your program ready for your use.

To read analog voltage, the program will look like this:

```
0: cll 'Analog Input' (5,X)
1: prt X
2: end
```

The voltage from the A/D Card in slot 5 of the Multiprogrammer is printed as a decimal value.

The Library tape contains routines for both HP-IB and 16-bit duplex systems. It comes complete with an easy-to-use manual with step by step instructions on the tape's use.

The following routines are contained on the Library Tape:

Auto Loader
File Lister
Analog Input
Single Ended Scan

Double Ended Scan
Frequency Measurement
Time Interval
Voltage Serial Output
Voltage Parallel Output
Current Serial Output
Current Parallel Output
Timer Pulse
Relay Output
Motor Output
J Thermocouple
T Thermocouple
E Thermocouple
R Thermocouple
S Thermocouple
Thermocouple Reference
B Thermocouple
K Thermocouple
Set Counter
Read Counter
Serial Output
Parallel Output
Simple Output
Interrupt Output
Serial Input
Parallel Input
Simple Input
Clear Unit
Arm
Serial Poll
Recycle
Disarm
Time Out
Reference Word

LEARNING TO OPERATE THE 6940B (Cont.)

Multiprogrammer Training Course
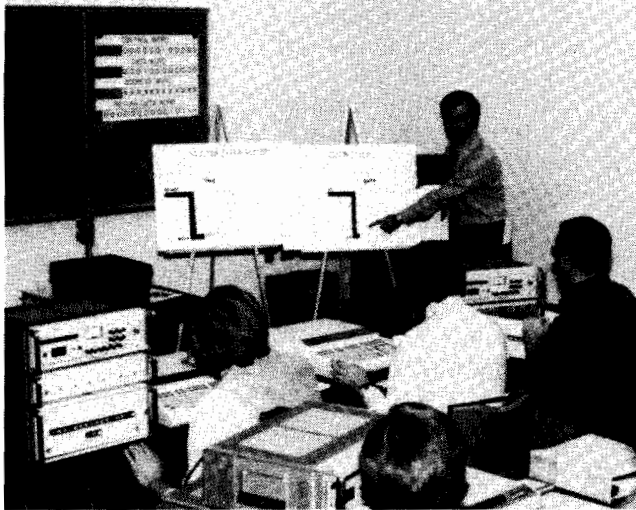
The fastest way to learn to use the 6940B Multiprogrammer is to enroll in the Multiprogrammer Training Course, given once a month at Hewlett-Packard's New Jersey Facility. At the Multiprogrammer School you will receive three days of in-depth training from Multiprogrammer experts. The school also gives you the chance to ask the experts questions regarding your particular application. The school offers a hands-on approach to get you programming the 6940B fast.

For more information, ask your Field Engineer for data sheet 5952-4026.

Throughput Analysis
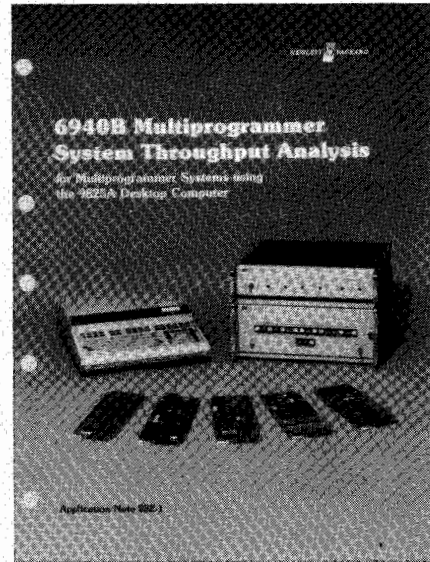
To find out how much time is required for all various Multiprogrammer operations when operated with a 9825A computer, ask your HP Field Engineer for a copy of AN 282-1, "System Throughput Analysis". This application note will tell you what throughput rates you will encounter, whether you are using HP-IB or 16-bit duplex. Also included in AN 282-1 are the throughput rates when using the 14556A Software Library.

Comprehensive Users Guide
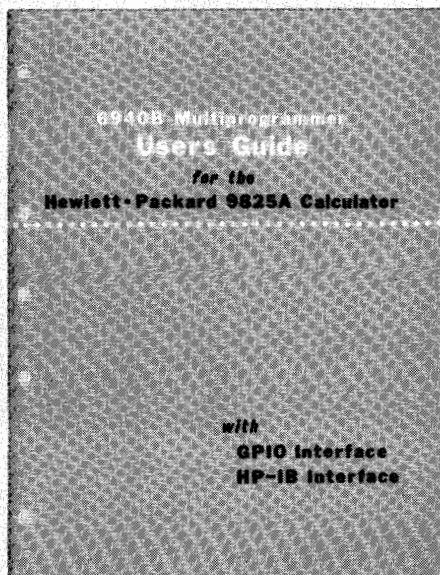
Each desktop computer interface kit for the 6940B Multiprogrammer is shipped with a Users Guide to help get you started on your own. Examples are given showing how to use each Multiprogrammer plug-in card. For the advanced programmer, the Guides also show how to use techniques such as high speed input and output and subprogram writing. Also included are chapters on operating theory and number theory.

INTERFACING

HP-IB: 59500A Multiprogrammer Interface Kit
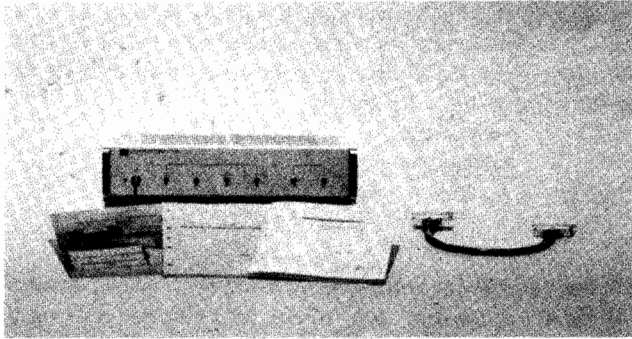
The 59500A Multiprogrammer Interface Kit converts the serial ASCII alphanumerics of the HP-IB to the 16-bit parallel format required by the 6940B/6941B Multiprogrammer.

The kit includes:

1. 59500A Interface Unit
   Dimensions:

3 1/4"H	16 3/4"W	18 1/4"D
(82.6mm)	(425.5mm	(463.6mm)

   Weight: 12 lbs. (5.4kg.)
   Power requirements:
   100/120/220/240Vac (selectable 48-440Hz, 15W.

2. Chaining cable model 14541A for connection to 6940B Multiprogrammer. (Up to 100 feet on special order.)

3. 59500A operating and service manual.

4. An HP-IB Multiprogrammer User's Guide that includes a tutorial description of Multiprogrammer operation, a discussion of the functions of the 59500A Interface Kit, installation instructions, diagnostic software, programming fundamentals, utility subroutines ,number theory, and sample programs for every plug-in card.

NOTE: *The HP-IB cable that connects the 59500A to the HP-IB controller or other HP-IB instruments is NOT provided in the 59500A Interface Kit. Refer to page 58 for cable information.*
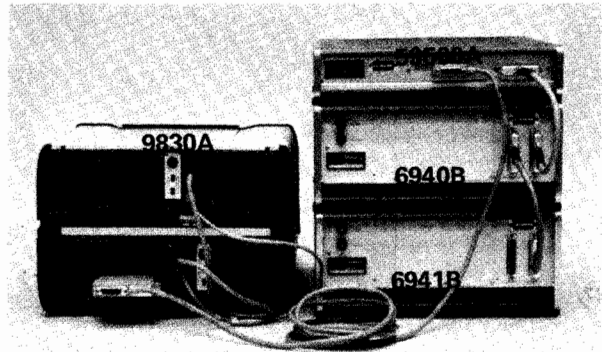
Typical HP-IB Multiprogrammer with one 6941B Extender Unit.

For Desktop Computers and Minicomputers using the HP-IB, the 59500A will interface the Multiprogrammer to the bus. By using the HP-IB, you need not dedicate an I/O port of your computer to the Multiprogrammer, rather only one of 31 possible bus addresses is required. You also have the benefit of using an international standard: IEEE 488.

The HP-IB cable length is restricted to 2 meters times the number of devices, or 20 meters, whichever is less. For distances greater than this, the HP 37201A HP-IB Extender may be used. The 37201A extends the HP-IB up to 1km using twisted-pair wire or unlimited distance when modems are used.
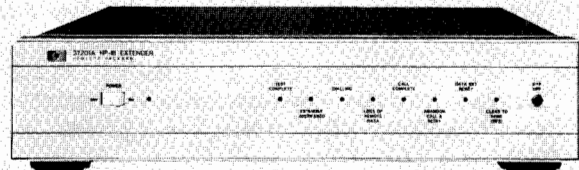
37201A HP-IB Extender

98032A: 16-bit Duplex for HP Desktop Computers
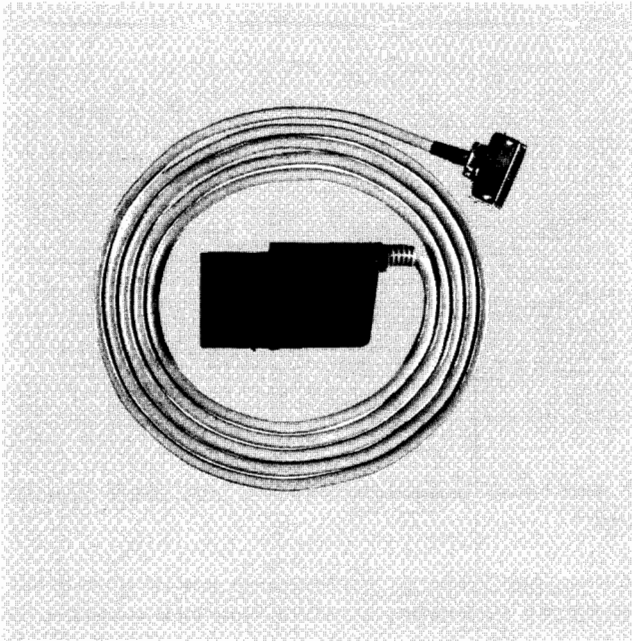
For HP Desktop Computers with 16-bit duplex capability, the 98032A Interface may be used to connect the 6940B with the computer. An option must be specified so that you get the proper interface for your system:

Desktop Computer	16-Bit Duplex Interface
9825	98032A opt 040
9835	98032A opt 340
9845	98032A opt 440

A Users Guide with programming examples, installation and operation instructions, and theory is included with each 98032A.

The length of the 98032A cable is 15 feet. The cable comes ready to plug into the desktop computer and the 6940B.

14550B: 16-bit Duplex for HP-1000 Computer System

This kit provides all the equipment necessary to install, verify, and operate a 6940B Multiprogrammer with an HP-1000 Computer.

The kit includes:

1. A specially modified 12566B Ground True Microcircuit Interface Card, tested with logic sense jumpers in proper positions for the Multiprogrammer. This is a 16-bit duplex register card that plugs into the HP computer. Hardware manuals, a test connector and a software verification routine for the Microcircuit card are provided in the kit.

2. The 14540A Multiprogrammer-to-12566B 12-foot cable with service manual. (Up to 100 feet on special order.)

3. A 69431A Digital Input Card with option 095, 69331A Digital Output Card, 14550-60001 Slot Verification Cable, and 14910A Complete Diagnostic. This equipment is used to completely test the digital paths between the computer and the Microcircuit card, 14540A cable, Multiprogrammer Mainframe, 14541A Chaining Cables, 6941B Multiprogrammer Extenders and each Multiprogrammer plug-in I/O slot. The diagnostic also tests the front panel lamps and switches by interfacing with the operator.

4. Instructions that allow you to completely test the Interface Kit and Mainframes. On-site installation by hp is not included with the kit. The kit is designed to help you become familiar with the Multiprogrammer as you install it and verify its operation.

5. The following software and manuals are provided with the kit and may be ordered separately:

Name	Part Number
RTE DVR 61 REV 840	14907-60001
RTE LIBRARY REV B	14912-60001
Verification REV B	14910-60001
Manual	14550-90022
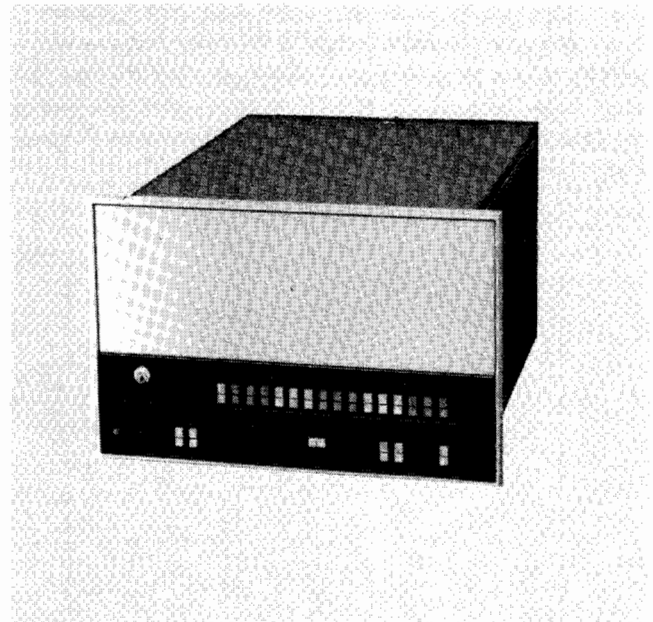
Connector Assembly Model 14555A
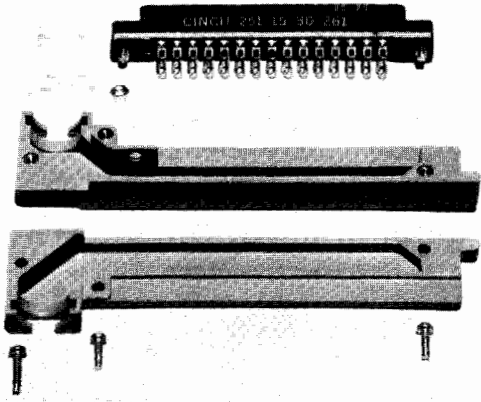
This assembly connects digital I/O cards with external signals. One 14555A is provided with each digital I/O plug-in.

62413A Cooling Unit
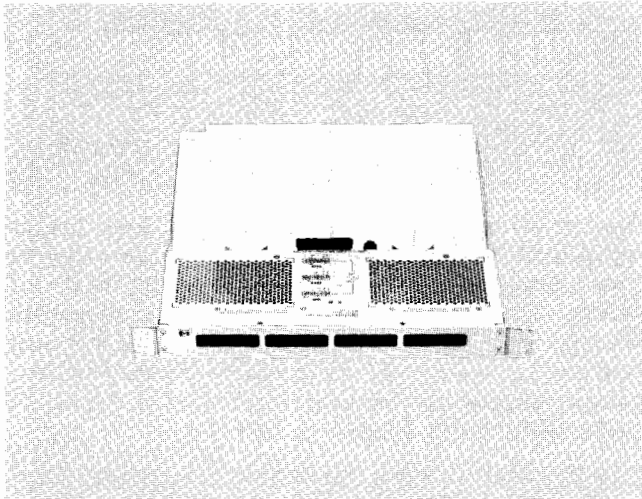
The 62413A Cooling Unit is not necessary in most Multiprogrammer applications, but is a convenient 1 3/4-inch high, 45 CFM fan for use in equipment racks where temperatures would otherwise exceed 55°C. Refer to page 17 of OEM Modular Power Supply Brochure HP #5952-3979 for specifications.

Rack Slides for HP Cabinets

To mount the 6940B or the 59500A in an HP cabinet, you will require one adapter and either a fixed or a pivot slide pair:

6940B:	Adapter: 1490-0721
	Pivot Slides: 1490-0719
	Fixed Slides: 1490-0714
59500B:	Adapter: 1490-0722
	Pivot Slides: 1490-0719
	Fixed Slides: 1490-0714

Pocket Programmer, Model 14533B
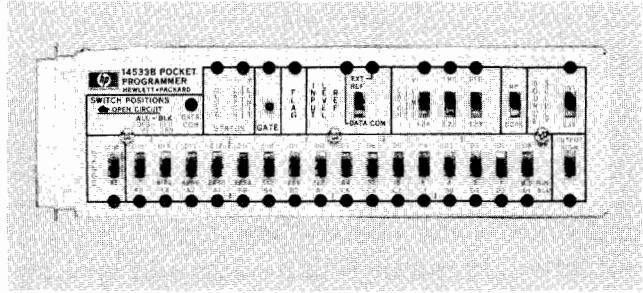
The Pocket Programmer is used to check the digital input/output connector J1 of the 6940B Multiprogrammer Mainframe.

Changes in the manual switch positions on the Pocket Programmer are visible on the front panel of the 6940B and the outputs of the 6940B proximity switches are available at test points on the Pocket Programmer.

Pocket Programmer Cable, Model 14534A
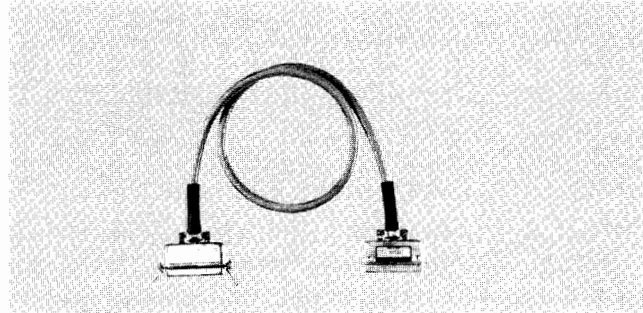
The Pocket Programmer plugs directly into the rear of the Multiprogrammer. The 3-foot 14534A Extender Cable is a convenience that allows you to operate the Pocket Programmer in front of the 6940B.

Main Input Cable Assembly, Model 14540A
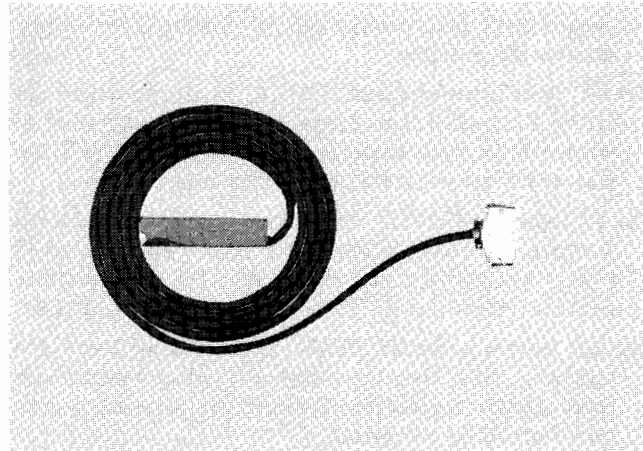
The 12-foot (up to 100 feet on special order) cable connects the Multiprogrammer to the specially Modified Ground True 12566B Microcircuit Cad. This cable is included in the 14550B Interface Kit.

OPERATING FEATURES

Input/Output Expansion

The Multiprogrammer expands a single 16-bit input, 16-bit output register of a computer or calculator to control up to 240 12-bit input or output channels. Four types of 16-bit words are exchanged between the computer and the Multiprogrammer to achieve this expansion:

A CONTROL WORD is sent from the computer to the Multiprogrammer to select one of several output or input modes of operation, and to specify which mainframe (in the chain of one 6940B Multiprogrammer Mainframe and up to 15 6941B Multiprogrammer Extender Mainframes) is to respond to subsequent words from the computer. The four most significant bits in a control word are always logical 1's. The Multiprogrammer stores the unit address portion of a control word that specifies one of the 16 mainframe units, and also stores the mode information contained in bits 4-8 of the CONTROL WORD.
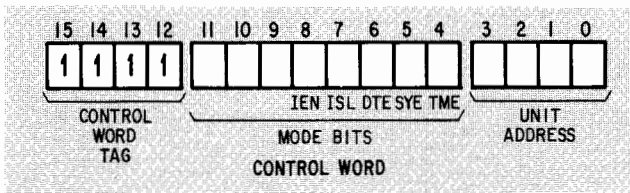
Bits 0, 1, 2, 3: **Unit Address.** This selects which unit in a chain of up to 16 will receive the data words that follow.

Bit 4: **Timing Mode Enable (TME).** When programmed to a logical 0, data is transferred to the Multiprogrammer at the maximum possible rate. When programmed to a logical 1, the computer waits until Multiprogrammer cards have finished their operations before proceeding to program the next data transfer.

Bit 5: **System Enable (SYE).** Programming SYE to logical 1 enables the outputs of most models of output cards to assume their programmed values. Setting SYE to zero disables the outputs.

Bit 6: **Data Transfer Enable (DTE).** By programming this bit to a logical 1, any pre-programmed combination of output cards, such as those needed to drive an X-Y display will simultaneously update their output data.

Bit 7: **Input Select (ISL).** Programming this bit to a logical 1 allows subsequently addressed input cards to send 12 bits of input data to the computer. This bit is programmed to a logical 0 when output cards are to be addressed.

Bit 8: **Interrupt Enable (IEN).** When this bit is set to a logical 1, cards that have interrupt capability and have been armed to generate interrupts are allowed to send interrupts to the computer.

Bits 12, 13, 14, 15: These bits are all logical 1's to distinguish CONTROL WORDS from the other types of words.

A DATA WORD is sent from the computer to an output card in the particular mainframe unit that was selected by a previous CONTROL WORD. The four most significant bits of the DATA WORD represent the slot address of the output card that will store the other 12 bits of the DATA WORD. The slot address of an output card is determined by its physical location in one of the 15 input/output slots in each mainframe.
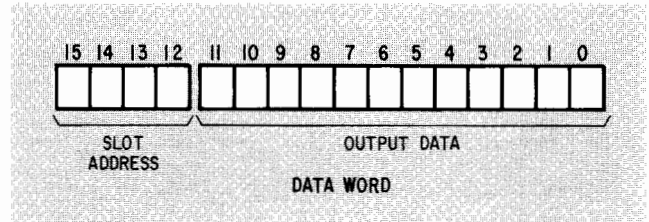
The data portion of the DATA WORD is stored on the output card to establish the desired magnitude of digital or analog output in the form of contact closures, bit patterns, pulses, resistance, voltage or current.

An ADDRESS WORD selects a slot that holds an input card in the mainframe unit specified by the previous CONTROL WORD. Only the four most significant bits of an ADDRESS WORD are used to specify the physical slot location of the input card. The 12 least significant bits are ignored by the input card in the input mode.
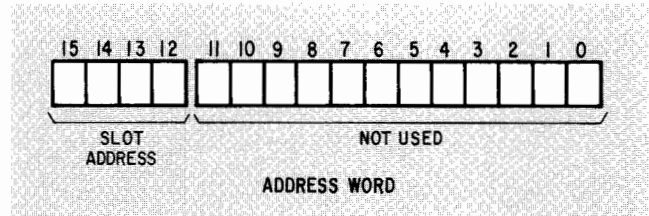
When an input card is addressed from the computer output register with an ADDRESS WORD, it sends data back to the input register of the computer with a RETURN DATA WORD. The 12 least significant bits of this word contain the input data. If this input card is the one that had generated an interrupt to the computer (via the Multiprogrammer flag line), the most significant bit of the RETURN DATA WORD bit 15 will be a logical 1.
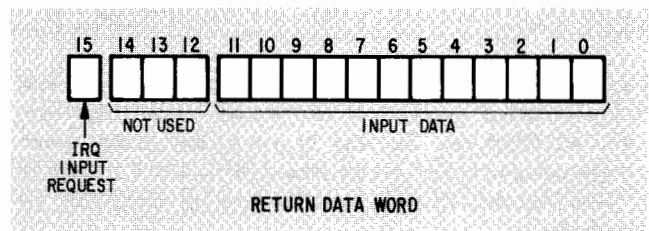
To summarize, the Multiprogrammer makes input/output expansion possible by accepting CONTROL WORDS to select mainframes and the modes of operation, DATA WORDS to select and control output cards and ADDRESS WORDS to select input cards that send data back to the computer with RETURN DATA WORDS.

Noise Immunity

Systems using the Multiprogrammer may often be located in electrically noisy environments, such as manufacturing plants. The Multiprogrammer deals with this situation in two ways: first, the maximum data transmission rate 50 microseconds per transmission) is fast enough to allow efficient operation with most computers and output devices, but

yet is not so fast that extreme noise sensitivity is a problem. Second, the particular method of data transfer employed (Gate/Flag) greatly reduces noise sensitivity.

A typical data transmission sequence utilizing the Gate/Flag method is as follows: first, the data lines are set at the computer to represent the data word being transmitted (these lines are set in the dc sense and do not carry pulses). Second, the Gate ("encode") line is set at the computer to indicate the presence of valid data and to request that it be stored. The Multiprogrammer then waits about 5 microseconds to insure that all data lines have settled firmly into their assigned states. Next, the data lines are sampled within the Multiprogrammer and the bits are stored on the selected output card. In response, the Multiprogrammer immediatley sets its Flag output to inform the computer that the data has been received and stored. Since all information is being sent as dc level changes through band-limited input circuits, and since the data is sampled at a particular instant of time, the system is relatively insensitive to externally introduced noise pulses.

Internal Storage

The design of hardware for a computer controlled system often has a direct bearing on the relative ease with which the associated computer programs can be written. Since the cost of writing programs can represent a significant portion of the system cost, saving programming time can be as important as reducing the hardware cost. As a means of saving programming time, the Multiprogrammer System incorporates a 12-bit storage register on each output card; this register maintains the last data word transmitted and therefore allows the program writer to forget about an output channel once he has set it. Data is needed from the computer only when one of the output cards is to be set to a new value.
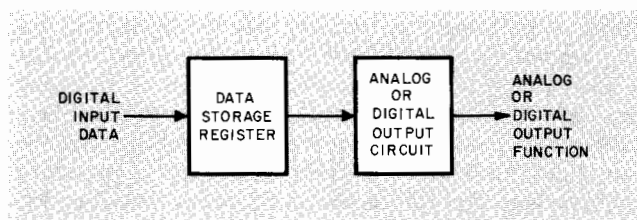
Many of the digital input cards also have internal storage. Some input cards such as the Isolated Digital Input card have no storage so that "live" or real-time inputs can be continuously monitored by the computer.

Dual Rank Storage

A common problem in high speed systems is the difficulty of simultaneously updating output channels. The voltage and current D/A cards provide dual-rank storage to handle this problem. With these cards, a previously set output value can be maintained on the output by means of one data register while new data is stored in another register. Transfer of the stored data to the output is accomplished by making use of the control word. The seventh least significant bit in the word is assigned the name, "Data Transfer Enable" (DTE). When this bit is set to 1, a signal is sent through the system which causes all cards having dual-rank storage to transfer the new data into the second storage reg-

ister, thus simultaneously changing the outputs of all such cards to the previously stored new values.
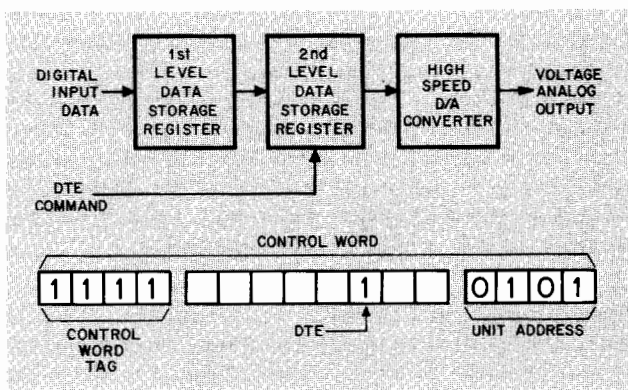
System Protection

A common characteristic of instruments for generating stimuli and control is that of a high potential for causing damage. Consider a power supply programmed by the Multiprogrammer to provide 5 volts for microcircuits. If it erroneously gets set to 15 volts during system turn-on, it will cause mass destruction. The Multiprogrammer system contains a controlled system turn-on function to handle this problem.

Each output card is provided with a protection circuit that keeps the card output in a safe state until a special command is transmitted by the controlling computer, regardless of the data stored on the card. For example, resistance cards (used to program power supplies) are provided with a normally closed pair of relay contacts connected directly across the output terminals. When the relay is not energized, the output of the card (and thus the power supply output) is maintained safely at zero. A single data line running throughout the system controls this relay and similar protective devices on other output cards; the line is automatically set to the safe (0) state at initial system turn-on. The computer controls this line by again making use of the control word. The sixth least significant bit in this word is assigned the name, "System Enable" (SYE). When this bit is set to 1, all the output cards in the system are enabled. Thus it is possible to preset the data stored on each of the cards to the desired initial value and then activate the entire system by transmitting a single control word.
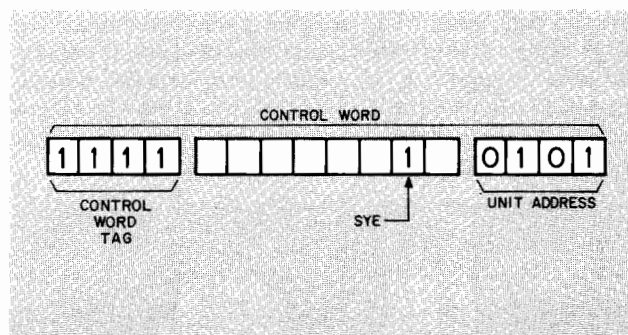
The System Enable function also provides protection against various other system failures. In addition to being under computer control, the SYE bit is automatically set to the safe (0) state if input power is removed from the system, if the data input cable is unplugged, or if the internal mainframe power supply crowbars.

Automatic Timing

In a typical test system, the test program follows the sequence of first setting test conditions (supply voltages, load conditions, etc.), and then causing appropriate measurements to be made. This sequence ordinarily requires the computer programmer to know how much time is required to set up the outputs so he can prevent any measurements from being made before the system is ready. However, in the Multiprogrammer System, the timing is a function of the hardware and not a concern of the programmer.

This is accomplished as follows: The resistance output, stepping motor and D/A cards are provided with adjustable timing circuits that are triggered whenever the card outputs are programmed. The timing period can be set to match the response time of almost any device that might be connected to the Multiprogrammer. The relay and digital output cards are provided with Gate outputs (a contact pair and a logic level line, respectively) for triggering an external timing circuit.

After one or more output cards have been programmed with DATA WORDS, the computer sends a CONTROL WORD with bit 4, TME, Timing Mode Enable, turned on. The flag line from the Multiprogrammer to the computer will now indicate when the programmed outputs have timed out.
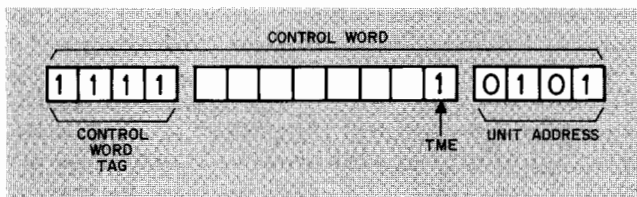
Isolation

In many cases, it is desirable to provide analog output signals which do not share a common ground with the data input. A particulary necessary requirement for such isolation occurs when power supplies are controlled by a D/A card. Depending on which of the power supply's output terminals is grounded, it is possible to end up with the common side of the analog output connected to the high voltage output of the power supply. The Multiprogrammer eliminates this problem by providing complete isolation between analog outputs and data inputs. This isolation is achieved through the use of relays or pulse transformers, depending on the particular card. In addition, four isolated bias supplies are provided in each mainframe to independently power the output circuitry of up to four groups of analog output or input cards with a separate ground for each group if desired.
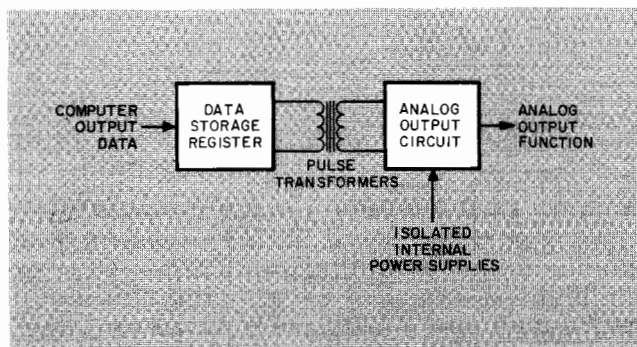
Optically coupled isolators in the Isolated Digital Input card enable monitoring of active circuits at potentials that are referenced above or below computer ground.
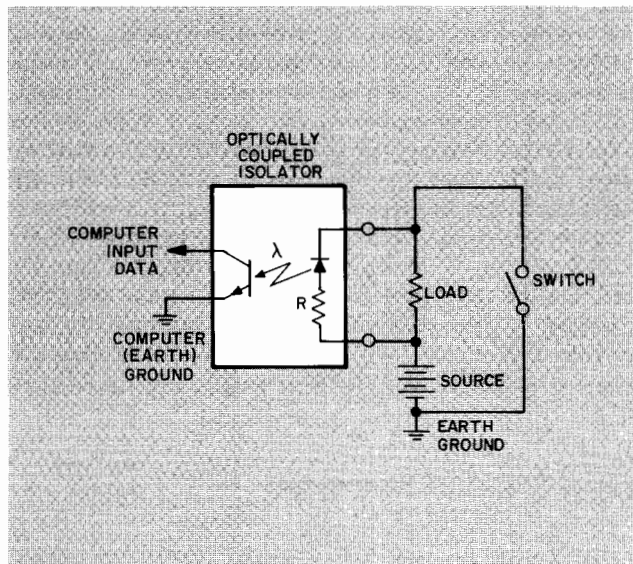
Polling and Interrupting

Many types of digital inputs are initiated by the computer. To read the status of switches in a network under test, for example, the computer issues a control word with ISL, Input Select bit 7 on, and then sends an address word to a digital input card. The Multiprogrammer then sends the data to the computer using a return data word. This is called "polling".

However, polling is not practical for certain types of alarm inputs or momentary or transient inputs. When rapid system response to a digital input is necessary, continuous rapid polling may consume inordinate amounts of computer time, and is an unnecessary burden for the software program author. To solve these problems, the Multiprogrammer uses plug-in cards like the Event Sense card to generate a computer interrupt via the Multiprogrammer flag when digital inputs being monitored change state. A control word with IEN, Interrupt Enable, and TME, Timing Mode Enable both turned on is an important part of the procedure that enables the Event Sense card to interrupt. Only when an interrupt is detected is the computer required to poll the cards, resulting in considerable savings of both computer time and software writing effort.

Troubleshooting

A primary aid in troubleshooting is the manual switch register on the front panel of the Multiprogrammer. These 19 switches permit entering data by hand; this allows the computer and computer program to be eliminated as possible trouble sources. In addition to data entry, the front panel switches allow manual duplication of all normally computer controlled functions. As a result, this feature is useful not only in troubleshooting but also in initial checkout of a system.

SPECIFICATIONS

(Data Subject to Change)
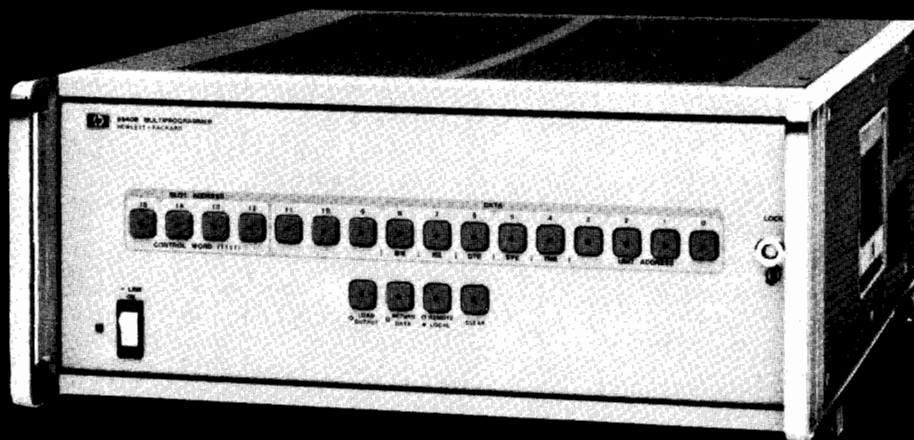
MULTIPROGRAMMER AND EXTENDER MAINFRAMES

6940B Multiprogrammer
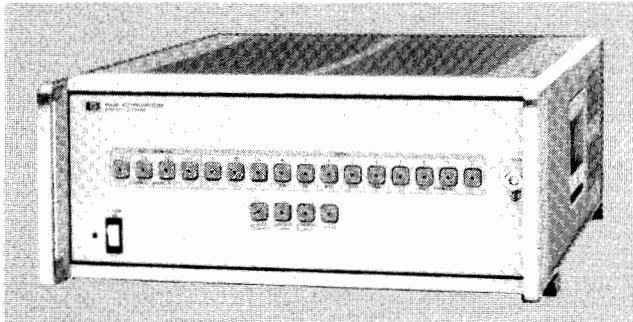
Plug-in I/O Card Positions: Maximum of 15 plug-in output or input cards per mainframe. Side-hinged front panel provides access to card slots.

Data Input and Output Connectors: Two 50-contact, rear-mounted, female ribbon connectors. The connector for the computer or calculator is shown below.
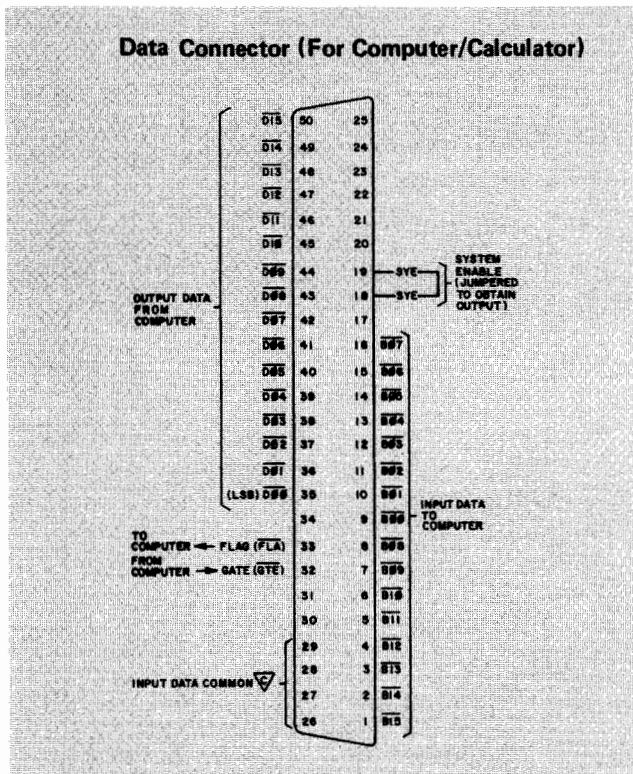
Data Connector (For Computer/Calculator)

Data Transfer Rate: 20K words/sec.

Maximum Data Resolution: 12 bits per plug-in card.

Operating Position: Limited to maximum of 30° displacement from horizontal in any direction when using output cards with mercury wetted relays. These cards include: 69330A, 69433A, and 69500-69513A.

Accessories Furnished: Data Input Plug (HP Part No. 1251-0086), PC Board Extender Card (HP Part No. 5060-7901).

Cooling: Natural convection.

Temperature Range: 0°C to +55°C operating, −40°C to +75°C storage.

Power: 100/120/220/240Vac (selectable), +5%, −10%, 48 to 440Hz, 230 watts.

Front Panel Controls: Power ON/OFF switch and indicator lamp, REMOTE/LOCAL switch for selecting computer or manual control, and 19 switches for manual data entry and control.

Interfacing: A 6940B mainframe equipped with the standard interface card is designed to interface with binary sources employing TTL or DTL microcircuit logic. Information regarding interfacing kits containing the necessary hardware and software to interface the 6940B with HP computers is found in the interface section of this brochure.

Receiver Specifications: The 6940B receiver circuit used for each of the 16 data bits and the Gate input is shown below with its specifications.

VOLTAGE POLARITY: ABOVE 0 VOLTS.
LOGIC LEVELS: HIGH = +2.0 TO 5.5VDC.
LOW = 0 TO +0.8VDC.
I_{SOURCE} = 19mA MAXIMUM WITH 0V INPUT.
I_{SINK} = 2.6mA MAXIMUM WITH +5.5VDC INPUT.
E_{OC} = +3.5VDC (NOMINAL) WITH INPUT OPEN.
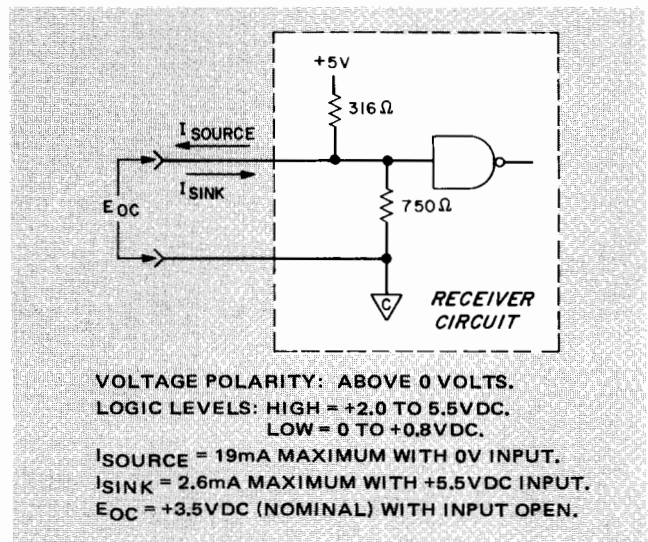
Driver Specifications: The 6940B driver circuit used for the Flag output and the 16 monitor bits is shown below with its specifications.

VOLTAGE POLARITY ABOVE 0 VOLTS.
LOGIC LEVELS: HIGH = +2.4 TO +5.0VDC.
LOW = 0 TO +0.4VDC.
I_{SOURCE} = 2.5mA AT +2.4VDC OUTPUT.
I_{SINK} = 43mA AT 0.4V

Computer Museum
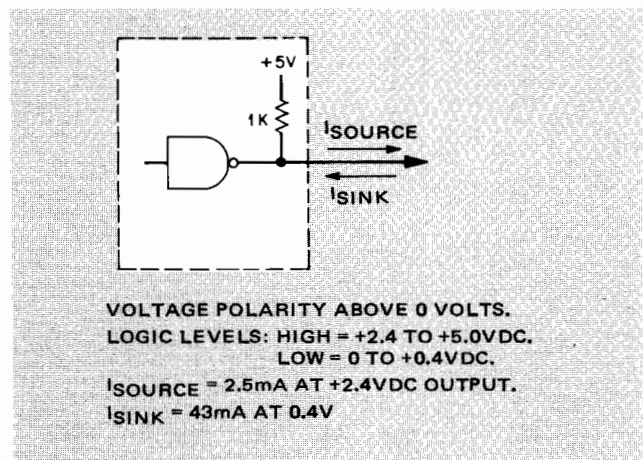
Weight (without plug-in I/O cards): 35.0 lbs. (15.9 kg) net, 43.0 lbs. (19.5 kg) shipping.

Dimensions:
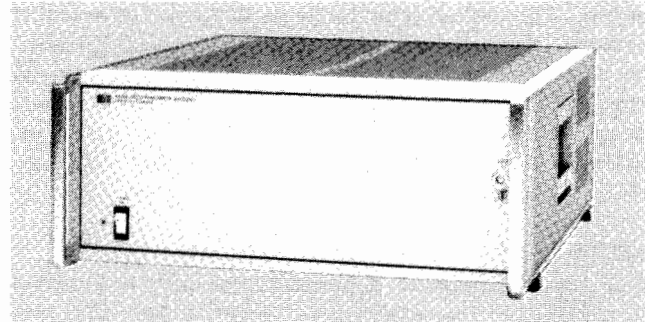
Options Available

For 6940B & 6941B

Option 910: Extra operating and service manual (one manual supplied per instrument)

Option 908: Rack Mounting Kit

Chaining Cable, Model 14541A
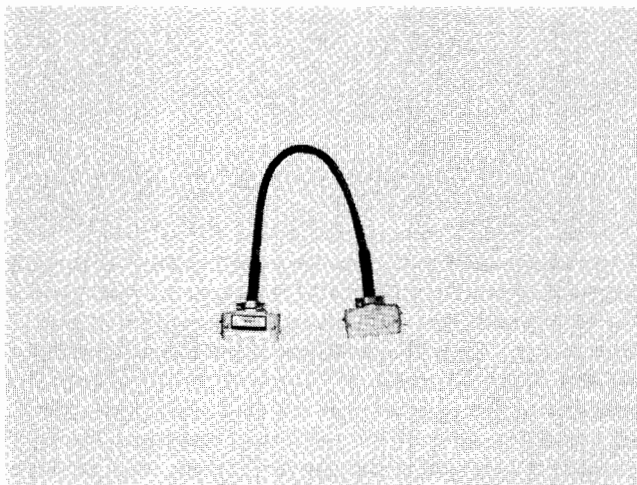
The 14541A Chaining Cable connects 6940B to 6941B mainframes and connects 6941B to other 6941B mainframes. Standard length is 18 inches. Extra length cables up to 100 feet (30 meters) are available on special order.

6941B Extender

Plug-in I/O Card Positions: Maximum of 15 plug-in output or input cards per mainframe. Side-hinged front panel provides access to card slots.

Data Transfer Rate: 20K words/sec.

Maximum Data Resolution: 12 bits per plug-in card.

Operating Position: Limited to maximum of 30° displacement from horizontal in any direction when using output cards with mercury wetted relays. These cards include: 69330A, 69433A, 69500-69513A, and 69325A-69328A.

Accessories Furnished: PC Board Extender Card (HP Part No. 5060-7901).

Cooling: Natural convection.

Temperature Range: 0°C to +55°C operating, −40°C to +75°C storage.

Power: 100/120/220/240Vac (selectable), +5%, −10%, 48 to 440Hz, 230 watts.

Front Panel Controls: Power ON/OFF switch and indicator lamp.

Interfacing: 6941B Extender mainframes are designed to be operated only in conjunction with a 6940B mainframe; all interfacing for the system is accomplished in the latter mainframe.

Weight (without plug-in I/O cards): 33.5 lbs. (15.2 kg) net, 40.3 lbs. (18.3 kg) shipping.

Dimensions: Same as 6940B

Rear View of 6940B/6941B

ANALOG OUTPUT

69321B D/A Voltage Converter Card

This is a 12-bit D/A with voltage output in the range of ± 10V at 5mA. The card can control analog instruments, drive analog recorders, stimulate units under test, and generate user defined waveforms under software control. The card features emergency shutdown and dual rank storage for simultaneous outputs. If more than ± 10 volts at 5mA is required, the output of the 69321B can be boosted with an HP 6827A Power Supply/Amplifier.

69322A Quad D/A Voltage Converter Card

Four voltage outputs of 10-bits resolution each are provided by the 69322A. The outputs are ± 10 volts at 5mA. This card offers a lower cost alternative to the 69321B where multiple outputs of only 10-bit resolution are required. The dual rank storage feature is not available on this card. The four outputs on the card are referenced to the same common which is isolated from the data common.

69370A D/A Current Converter Card

The 0-20mA current output of this card operates electro-mechanical actuators, stimulates semiconductors, and acts as a signal for resistance measurement with an A/D Card. For currents higher than 20mA, power supplies under control of the 69510A-69513A Resistance Output Cards are an alternative to the 69370A.

69500A-69513A Resistance Output Cards

These cards control a variety of unipolar DC power supplies with outputs up to 100 volts and 1000 amps. The outputs of all power supplies are isolated from ground and from each other by the relay/resistor network on these cards.

69351B Voltage Regulator Card

One 69351B Voltage Regulator Card must be inserted in the Voltage Regulator slot in any 6940B Multiprogrammer or 6941B Multiprogrammer Extender Mainframe to provide isolated ± 15 volt power supplies through the backplane for all the 69321B D/A Voltage 69322A Quad DAC, 69422A and 69370A D/A Current Cards used in that mainframe. Isolation of the analog input and output cards powered by the 69351B Voltage Regulator Card is often necessary for proper system operation. The following paragraphs explain why isolation is important.

Computers are designed with the digital I/O data common line (the reference wire for all electrical interface signals) wired to the third conductor in the AC power cord, the earth ground conductor. The data common line at earth ground potential runs through the HP-IB or 16-bit duplex interface cable to the 6940B Multiprogrammer backplane. Some plug-in cards such as the 69431A Digital Input Card and the 69331A Digital Output Card bring the data common line out to the card edge connector. It is standard practice in most, if not all, computer and calculator systems to have the data common line for all *digital* I/O connected to earth ground at *only* one point through *only* one wire to achieve maximum immunity from noise on the digital signal lines. However, *analog* I/O must often be isolated from earth ground as shown by the examples below.

The diagram below shows a non-isolated digital-to-analog converter being used to stimulate a unit under test which has been grounded to protect the people operating the system.
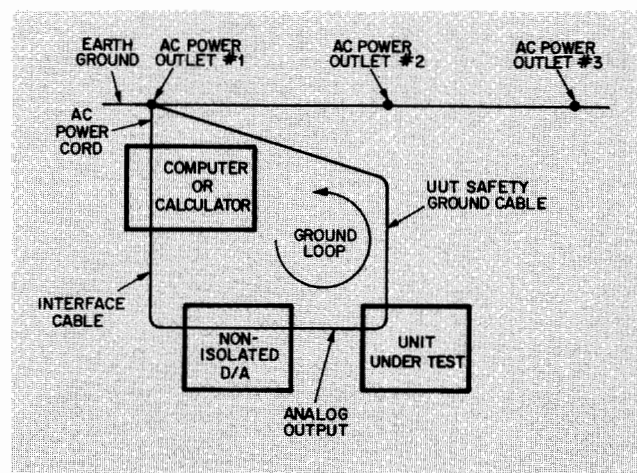
The use of a non-isolated D/A in this system has formed a low resistance (perhaps 500 milliohms) path through the computer, D/A, and unit under test. Stray magnetic fields will induce circulating currents that appear as noise on the output of the D/A and in the unit under test.

If the unit under test is grounded at a second electrical outlet as shown below, the same noise problem and increased probability of a more serious problem exist.
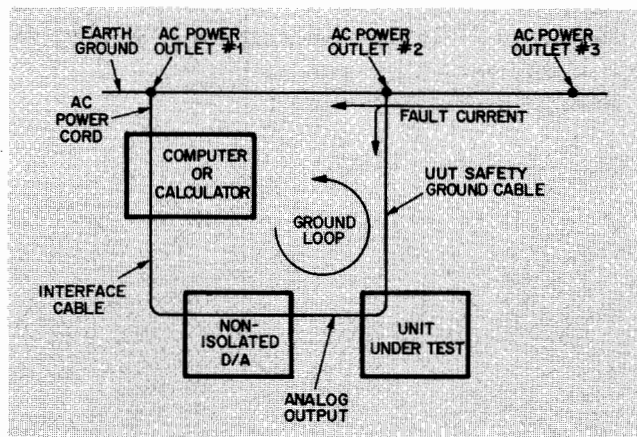
If for some reason a fault occurs at outlet number three, a very large amount of current (up to thousands of amps for a few milliseconds) can surge down the ground conductor to earth ground. Since the resistance of the ground conductor between outlet #2 and outlet #1 can be comparable to the resistance of the path through the UUT, non-isolated D/A, and computer, some of the AC current created by the fault at outlet #3 will surge through the system, with possible damage to equipment or injury to personnel. The isolation of digital lines on 69321B Voltage D/A, 69322A Quad DAC, 69370 D/A Current Converter, 69422A High Speed A/D, 69423A Low Level A/D and Scanner and isolation of the power supplies by the 69351B Voltage Regulator prevents formation of these ground loops.

D/A Voltage Converter Card
Model 69321B
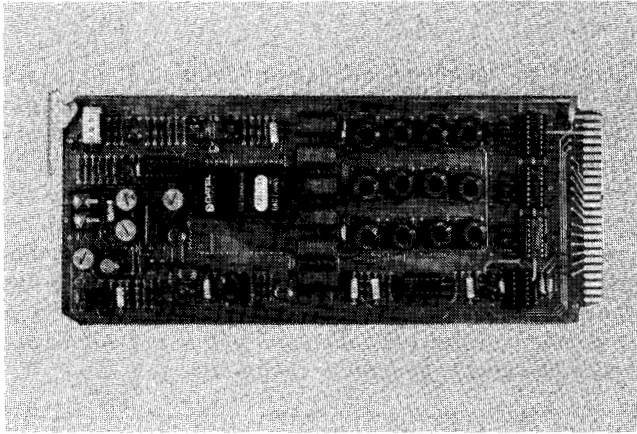
This card provides a high speed, bipolar output voltage that is the analog of the digital input data. Dual-rank storage, a feature that allows all D/A cards in a system to change their outputs simultaneously, is provided on 69321B cards.

Voltage Regulator Card, Model 69351B must be used in each mainframe in which one or more of these output cards are used. Because the Voltage Regulator Card contains four isolated supplies, up to four analog outputs in any one mainframe can have isolated grounds; any additional outputs must share a common ground connection with one of the four isolated outputs. Jumpers on the 69321B connect the card to any one of the four isolated supplies in the mainframe.
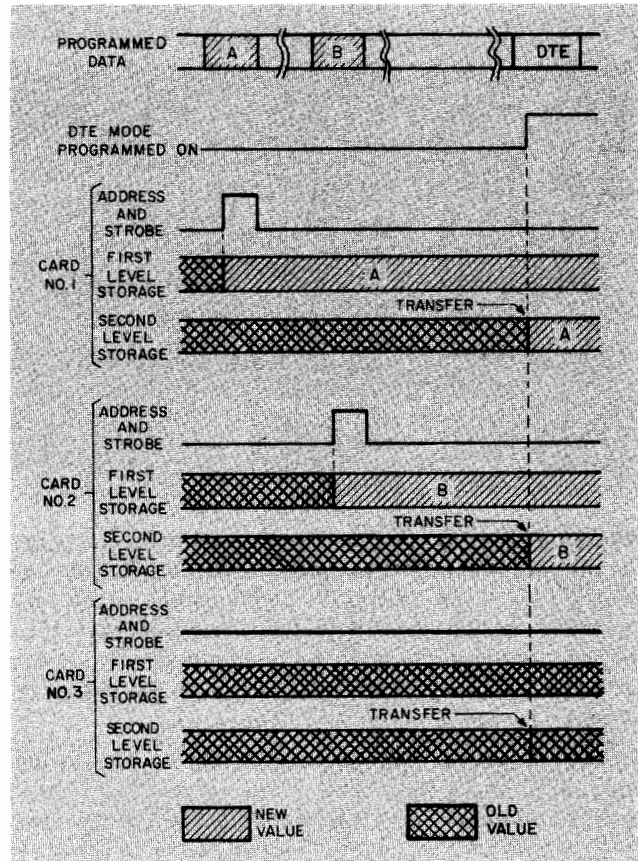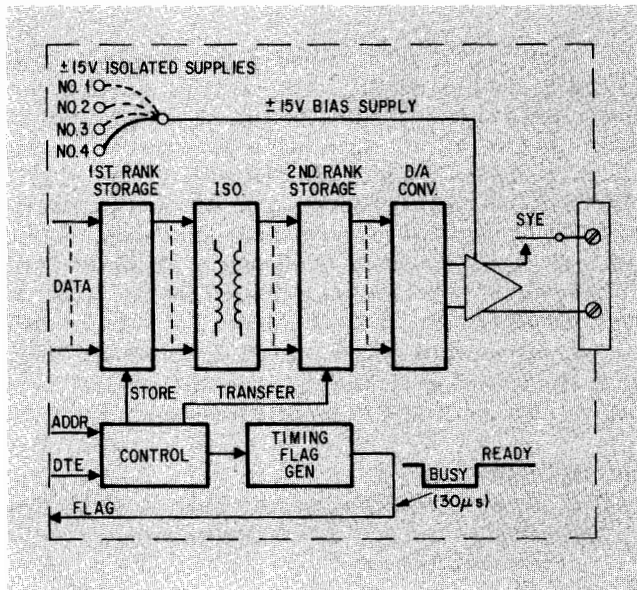
Control Signals:

SYE: System enable relay contacts hold output open until SYE is programmed on and the card is addressed.

DTE: The second rank of storage and thus, the output on all 69321B cards is updated to the value stored in the first rank when DTE is programmed on.

TME: Allows timing flag signals from cards to control "busy" period of Multiprogrammer flag to computer. The timing flag period on the D/A cards is 30μsec. Refer to Operating Features Section for details.

DTE Timing Diagram

Data Input: 12-bit data word representing output voltage in 2's complement form.

Output: −10.240V to +10.235V with through-zero programming.

Minimum Step Change (Resolution): 5mVdc.

Accuracy: 5mV at 25°C ±5°C, when delivering 0-5mA.

Programming Speed: Digital data transfer to card: approximately 10μsec. Analog voltage conversion: 30μsec maximum to within 5mV of final value.

Load Regulation: 3mV maximum at output terminals for a load change of 5mA.

Ripple and Noise: 2mV p-p maximum, DC to 400kHz.

Temperature Coefficient: 600μV/°C from 15°C to 55°C.

Stability: 3mV maximum total drift for 24 hours after 1 hour warm-up.

Output Protection: Can withstand indefinite short circuit.

Breakdown Voltage: Potential difference between any one output terminal and chassis ground must not exceed 100 Vdc or 100V rms.

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.

Operating Position: Any (no restrictions).

Output Terminals: Two-contact terminal block (size 6 spade).

Quad D/A Voltage Converter Card
For 6940B Multiprogrammer
Model 69322A
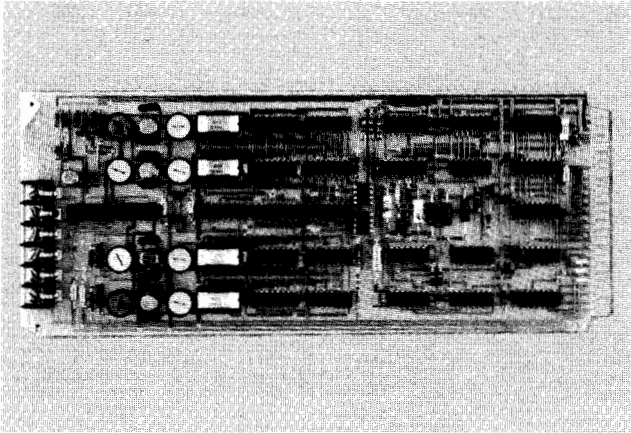
This card provides four individually programmable, bipolar output voltages that are the analog of the digital data input. Two of the 12-input data bits specify which output is programmed and the remaining 10-bits represent the desired output voltage. The card's four outputs share a common ground connection which is isolated from the data input ground.

Voltage Regulator Card, Model 69351B, must be used in each mainframe in which one or more of the 69322A cards are used. Because the Voltage Regulator Card contains four ±15V isolated supplies, up to four 69322A cards in any one mainframe can have isolated grounds. Remember, however, that the four outputs on individual 69322A cards share a common ground connection. Jumpers on the 69322A connect the card to any one of the four isolated supplies in the mainframe. Each Quad D/A card will draw 100mA from the isolated ±15V supply.
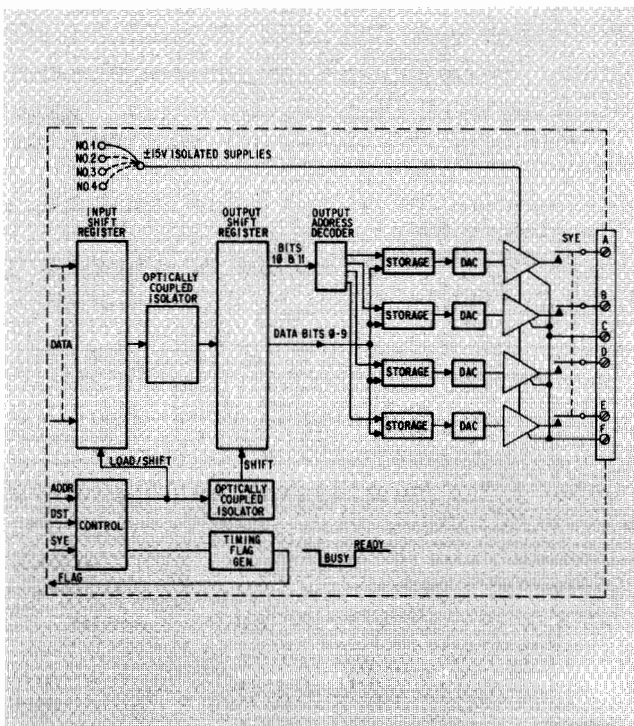
Each of the four individually programmable output circuits on the 69322A card consists of a 10-bit storage latch and a 10-bit digital-to-analog converter (DAC). When the card is addressed and data strobed (DST), bits 0-9, representing the desired bipolar output voltage, are transferred into the storage latch specified by bits 1Ø and 11. The latch will retain this data until it is selected again and reprogrammed with new data. The associated DAC converts bits 0-9 into the equivalent output (−10.24V to +10.22V). The data bit configuration required to program each output and the corresponding output terminal are as follows:

Output No.	Output Terminal **	Data Bits *		
		11	1Ø	9 (MSB) → Ø (LSB)
1	A	Ø	Ø	
2	B	Ø	1	Represent Bipolar
3	D	1	Ø	Output Voltage (2's
4	E	1	1	Complement Coding)

* Ø - programmed off
1 - programmed on

** Analog output ground (common) terminals C and F are isolated from the data input ground (common).

The −10V to +10V programmable output voltages available at each of the four outputs on the card can be used to control or test a variety of analog devices. Quad D/A Cards are often used in control applications that require voltage signals to change at programmed intervals of time. Up to 160 Quad D/A cards (up to 10 per mainframe) provide up to 640 D/A's (4 per card) which can be individually controlled from a single chain of Multiprogrammer Mainframes. The time interval between programmed changes can be as short as 100µsec or as long as desired. The time intervals can be established by using a 69600B Programmable Timer Card or by reading a clock made from a 69435A Pulse Counter Card and a 69601B Frequency Reference Card.

Control Signals:

SYE: System enable relay contacts hold the card's four outputs open until SYE is programmed on and the card is addressed.

TME: Allows timing flag signals from cards to control "busy" period of Multiprogrammer flag to computer. The timing flag period on Quad D/A cards is 100µsec.

ADDR: Selects card that receives the voltage programming data.

DST: Transfers programmed data into the selected output storage latch.

Specifications: *The following are performance character-istics of the 69322A which are warranted.*

Data Input: 12-bit word (2 output address bits, 10 data bits). The 10-data bits represent the output voltage in 2's complement form.

Output: 4-individually programmable outputs; −10.24V to +10.22V at 5mA.

Minimum Step Change (Resolution): 20mVdc (LSB).

Accuracy: ±20mV at 25°C ± 3°C.

Programming Speed: Digital data transfer to selected output: 60μsec.

Analog Voltage Conversion: 30μsec maximum for a 0 to ± full scale change (to within 20mV of final value).

Load Regulation: 3mV maximum at each output when delivering 0-5mA.

Isolation: 100Vdc between data input lines and analog output terminals.

Temperature Coefficient: 2mV/$^\circ$C from 0-70°C.

Output Protection: Card can withstand an indefinite short circuit (one output at a time).

Breakdown Voltage: Potential difference between any output terminal and chassis ground must not exceed 100Vdc or 100V rms.

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.

Operating Position: Any (no restrictions).

Output Terminals: Six-contact terminal block.

Ripple and Noise: 2mV p-p typical.

Stability: 2mV (typical) total drift for 24 hours after 1/2 hour warmup.

Output Current: Maximum output current is 5mA over the 0-70°C temperature range. However, when the ambient temperature is maintained at 25°C, the maximum output current is typically 10mA.

Quad D/A Applications

Process Control

The 69322A outputs can be used to control flow valves and analog displays. The DAC is also often used to control other process control equipment such as function generators. Special waveforms necessary in some processes may be created by calculator software and the 69322A.

Production Testing

Analog signals from the DAC can be used to automatically test analog IC's, A/D converters, and IF strips. The DAC's can also control programmable loads used in automatic testing.
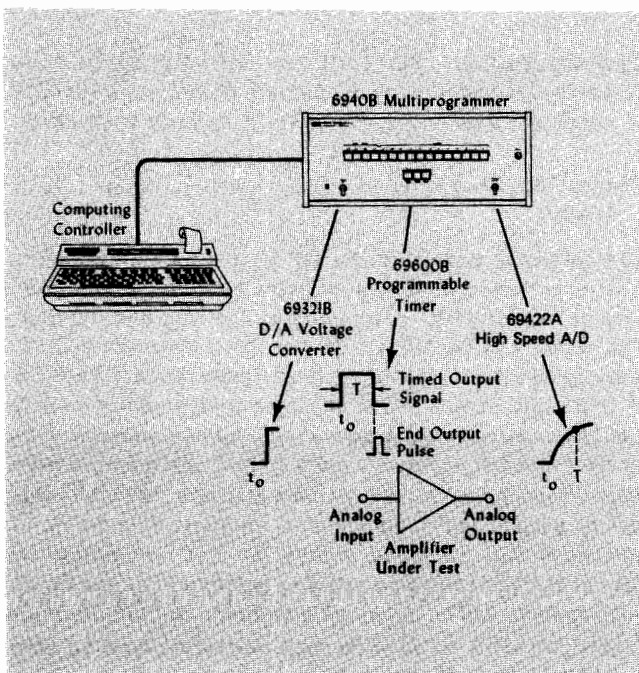
R & D

In the lab, environmental chambers and shake tables can be controlled with the help of 69322A supplied synthesized waveforms. The analog outputs are also used in margin testing and component evaluation.

In the classroom, various electronic functions can be demonstrated with the 69322A and the Multiprogrammer system.

Data Acquisition and Logging

Strip chart recorders and plotters use the outputs of the 69322A to drive their analog inputs.
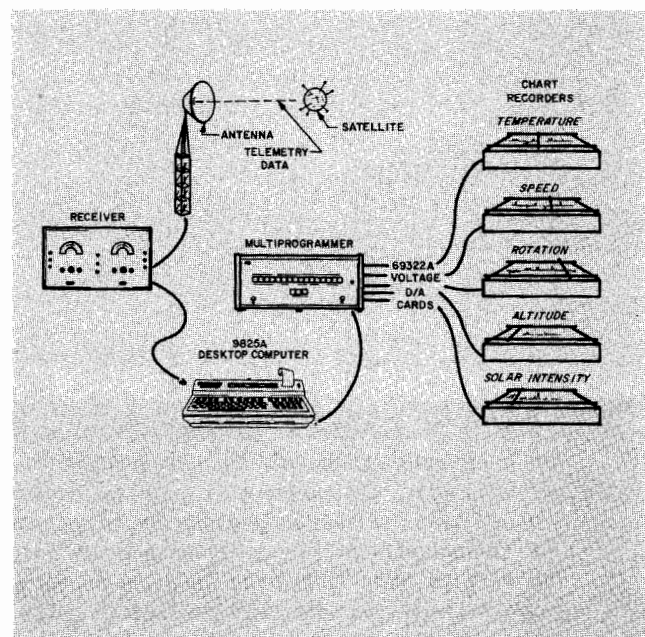
Resistance Output Cards
Models 69500A-69513A
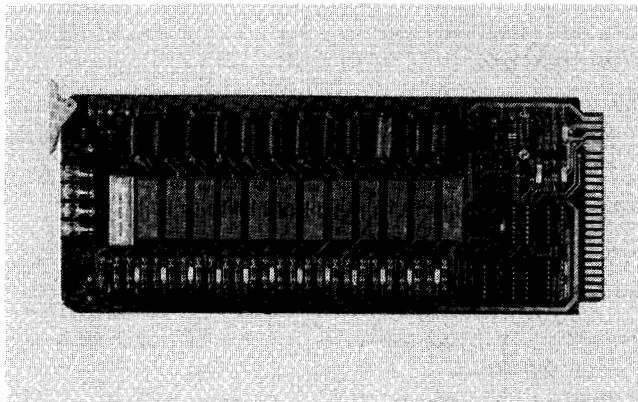
These cards provide a programmed value of resistance as their output. Twelve magnetically shielded, mercury-wetted, reed relays select the resistance values by modifying the value of a series string of high-accuracy, binary weighted resistors. A maximum of 15 Resistance Output cards may be used in any one mainframe.

Model 69500A is supplied without output resistors. Customers may select and load their own resistors. Models 69501A—69506A are single output, 12-bit resolution cards designed to program the voltage output of a single HP power supply equipped with Option 040. Models 69510A—69513A are dual output, 6-bit resolution cards designed to program the current outputs of two HP power supplies equipped with Option 040.
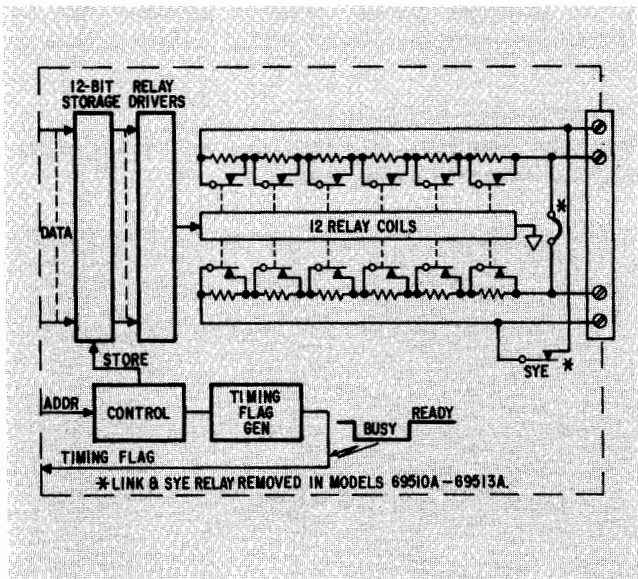
Control Signals:
 SYE: Used on Models 69500A-69506A only. Output terminals are shorted until SYE is programmed on.
 TME: Allows timing flag signals from cards to control "busy" period of multiprogrammer flag to computer. The period of the timing flag on each card may be adjusted from 100μsec to 20sec by changing components on the card. Refer to Operating Features Section for details.

Data Input: 12-bit binary. Logical 1 = resistor in circuit; logical 0 = resistor short circuited.

Output Channels: Models 69500A—69506A, one 12 element, variable resistance channel. Models 69510A—69513A, two independent, 6 element, variable resistance channels.

Resistance Output and Resolution:

MODEL	MAX. RESISTANCE (ohms)	RESOLUTION (ohms)
69500A	unloaded	——
69501A	8,190	2
69502A	30,712.5	7.5
69503A	61,425	15
69504A	40,950	10
69505A	81,900	20
69506A	204,750	50
69510A	252	4
69511A	945	15
69512A	1,260	20
69513A	1,890	30

Accuracy: 0.1% of resistance value programed $+2, -0$ ohms.

Power Rating: All resistors are 1/8 watt, 5ppm/$^\circ$C TCR.

Programming Speed: Digital data transfer to card: approximately 10μsec. Analog resistance conversion: 6msec maximum.

Breakdown Voltage: Potential difference between any one output terminal and chassis ground must not exceed 100 Vdc or 100V rms.

Temperature Range: $^\circ$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.

Operating Position: Cards are mounted vertically in mainframe. The use of mercury-wetted relays limit tilt to 30° maximum displacement from vertical in any direction.

Output Terminals: Four-contact terminal block (size 6 spade).

The following table lists the HP dc power supplies which have been tested for operation with the Multiprogrammer. Option number 040 is assigned to these power supplies. The option (as performed by the factory) consists of (1) special calibration, and (2) protection checkout. The former procedure insures (by addition or adjustment of calibration controls) that the power supply can be accurately set to zero and the maximum rated output voltage or current when programmed by the Multiprogrammer; the latter procedure insures (by modifications of internal circuitry, if necessary) that the power supply will not be damaged by the rapid, repetitive programming possible with the Multiprogrammer. Other HP power supplies under 100 volts not listed in the table are available with modifications equivalent to Option 040 on special order.

Multiprogrammer Resistance Card Selection Table

Use this table to select appropriate cards for the model 6940B Multiprogrammer when controlling output voltage or current of specific power supplies equipped with Option 040.

HP POWER SUPPLY			VOLTAGE PROGRAMMING			CURRENT PROGRAMMING		
Volts	Amps	Model	Resistance Card	Volt/Step	Accuracy ‡	Resistance Card §	Amp/Step	Accuracy ‡
0-7.5	0-5	6281A	69501A	10mV	1% ± 20mV	69501A	10mA	10% ± 65mA
0-8	0-1000	6464C	69501A	10mV	1.0% ± 5mV	69501A	2A	1.0% ± 2A
0-10	0-2	6113A	69504A	10mV	0.1% ± 2mV	69512A	40mA	◊
0-10	0-10	6282A	69501A	10mV	1% ± 20mV	69501A	20mA	10% ± 65mA
0-10	0-20	6256B	69501A	10mV	1.0% ± 10mV	69510A	0.4A	10% ± 85mA
0-10	0-50	6259B	69501A	10mV	1.0% ± 8mV	69510A	1A	10% ± 65mA
0-10	0-100	6260B	69501A	10mV	1.0% ± 10mV	69510A	2A	10% ± 205mA
0-16 or 0-18	0-600 / 0-500	6466C	69501A	10mV	1.0% ± 5mV	69501A	3A	1.0% ± 2A
0-20 / 0-40	0-0.6 / 0-0.3 Dual Output; Dual Range	6205B	2 Each 69501A	10mV	1% ± 20mV	Current Limit Not Adjustable		
0-20	0-1	6111A	69504A	10mV	0.1% ± 2mV	69512A	20mA	◊
0-40	0-1	6114A ††	69505A	10mV	.025% ± 1mV	69512A	40mA	2% ± 5mA
0-20	0-3	6284A	69501A	10mV	1% ± 20mV	69513A	60mA	10% ± 60mA
0-20	0-3	6253A *	2 Each 69501A	10mV	1% ± 20mV	69513A	60mA	10% ± 60mA
0-20	0-10	6263B	69501A	10mV	1.0% ± 9mV	69512A	0.2A	10% ± 50mA
0-20	0-20	6264B	69501A	10mV	1.0% ± 10mV	69510A	0.4A	10% ± 85mA
0-20	0-50	6261B	69501A	10mV	1.0% ± 8mV	69510A	1.0A	10% ± 65mA
0-24	0-3	6224B	69501A	10mV	1.0% ± 15mV	69513A	60mA	10% ± 35mA
0-25	0-1	6220B	69502A	25mV	1% ± 50mV	69512A	20mA	10% ± 20mA
0-25	0-2	6227B *	2 Each 69501A	10mV	1% ± 25mV	69512A	40mA	10% ± 15mA
0-36	0-300	6469C	69501A	10mV	1.0% ± 5mV	69501A	0.6A	1.0% ± 1A
0-40	0-0.5	6112A	69504A	10mV	0.1% ± 2mV	69512A	10mA	◊
0-40	0-1.5	6289A	69501A	10mV	1% ± 20mV	69511A	30mA	10% ± 30mA
0-40	0-1.5	6255A*	2 Each 69501A	10mV	1% ± 20mV	69511A	30mA	10% ± 30mA
0-40	0-3	6265B	69501A	10mV	1.0% ± 7mV	69512A	60mA	10% ± 12mA
0-40	0-5	6266B	69501A	10mV	1.0% ± 8mV	69512A	0.1A	10% ± 20mA
0-40	0-10	6267B	69501A	10mV	1.0% ± 8mV	69512A	0.2A	10% ± 30mA
0-40	0-30	6268B	69501A	10mV	1.0% ± 8mV	69510A	0.60A	10% ± 40mA
0-40	0-50	6269B	69501A	10mV	1.0% ± 8mV	69510A	1.0A	10% ± 65mA
0-50	0-0.5	6220B	69502A	25mV	1% ± 25mV	69512A	10mA	10% ± 10mA
0-100	0-0.4	6115A ††	69506A	25mV	.025% ± 1mV	69511A	15mA	2% ± 5mA
0-50	0-1	6228B *	2 Each 69502A	25mV	1% ± 25mV	69512A	20mA	10% ± 15mA
0-50	0-1.5	6226B	69502A	25mV	1.0% ± 15mV	69511A	30mA	10% ± 18mA
0-60	0-1	6294A	69502A	25mV	1% ± 50mV	69512A	20mA	10% ± 20mA
0-60	0-3	6271B	69502A	25mV	1.0% ± 6mV	69512A	60mA	10% ± 12mA
0-60	0-15	6274B	69502A	25mV	1.0% ± 7mV	69512A	0.3A	10% ± 50mA
0-64	0-150	6472C	69502A	25mV	1.0% ± 25mV	69501A	0.3A	1.0% ± 1A
0-100	0-0.75	6299A	69502A	25mV	1% ± 15mV	69511A	15mA	10% ± 15mA

§ The 69501A card has only one output channel but is used for current programming of certain high current supplies.

‡ The accuracy specification refers to the combination of the power supply and the programming card; it includes the effects of load, line and internal temperature changes in the supply.

◊ These supplies are constant voltage/current limit, rather than constant voltage/constant current.

†† No special Option 040 modifications are necessary for these supplies.

* Dual Output.

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D/A Current Converter Card
Model 69370A
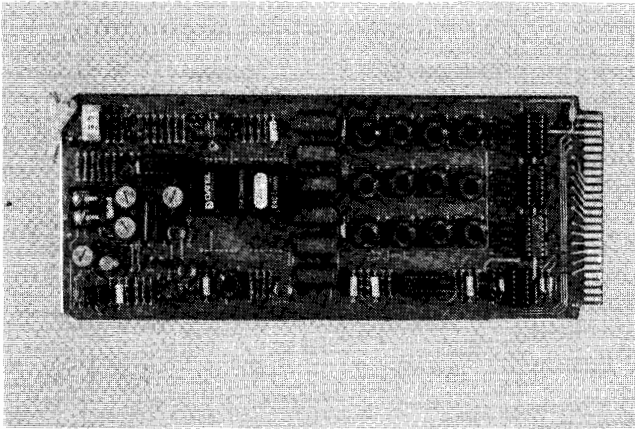
This card provides a high speed, constant current output that is the analog of the binary digital input data. The card provides dual-rank storage, a feature that allows all D/A cards in a system to change their outputs simultaneously. The DTE timing diagram on page 24 also applies to the 69370A.

Voltage Regulator Card, Model 69351B must be used in each mainframe in which one or more of these output cards are used. Because the Voltage Regulator Card contains four isolated supplies, up to four analog outputs in any one mainframe can have isolated grounds; any additional outputs must share a common ground connection with one of the four isolated outputs. Jumpers on the 69370A interconnect each card with any one of the four isolated supplies in the mainframe.

The 0-20mA current output of the 69370A is designed for test or control of devices with input impedances of up to 500 ohms. Many types of electrical-to-mechanical, -hydraulic, or -pneumatic converters utilizing 1-5 or 4-20mA inputs can be controlled by the 69370A.
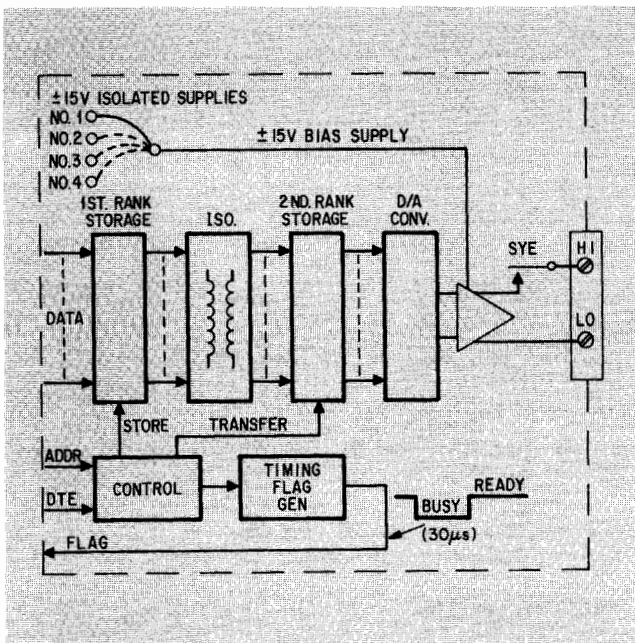
The 69370A Current D/A Converter Card and the 69321B Voltage D/A Converter Card are often used in control appli-

cations that require voltage or current signals to change at programmed intervals of time. In automatic test systems, the application is frequently called arbitrary waveform generation. The waveforms can be used to control instruments, operate the unit under test, or act as supervisory signals that control stresses during a life test. Up to 240 independently controlled D/A's (up to 15 per mainframe) can be controlled from a single chain of Multiprogrammer Mainframes. The time intervals between programmed changes of the D/A's can be as short as 50 microseconds (if the computer or calculator can program outputs at 50μsec speeds) or as long as desired (seconds, hours, even months). The time intervals can be established by using the 69600B Programmable Timer or by reading a clock made from a 69435A Pulse Counter Card and a 69601A Frequency Reference

Control Signals:

SYE: System enable relay contacts hold output open until SYE is programmed on and the card is addressed.

DTE: The second rank of storage on all 69370A cards is updated to the value stored in the first rank when DTE is programmed on. See timing diagram on preceeding page.

TME: Allows timing flag signals from cards to control "busy" period of Multiprogrammer flag to computer. The timing flag period on the D/A cards is 30μsec. Refer to Operating Features Section for details.

Data Input: 12-bit data word representing output current in binary form.

Output: 0 to 20.475mA, at up to 10.5V.

Minimum Step Change (Resolution): 5μA

Accuracy: 5μA at 25°C ±5°C when delivering up to 10.5V.

Programming Speed: Digital data transfer to card, approximately 10μsec. Analog output conversion: 30μsec maximum to within 5μA of final value.

Transients: Less than 2μA.

Load Regulation: 3μA maximum at output terminals for a load change from 0-10.5 volts.

Ripple and Noise: 2μA p-p maximum.

Temperature Coefficient: 600nA/°C from 15°C to 55°C.

Stability: 3μA maximum total drift for 24 hours after 1 hour warm-up.

Output Protection: Can withstand indefinite short or open circuit.

Breakdown Voltage: Potential difference between any one output terminal and chassis ground must not exceed 100 Vdc or 100V rms.

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

Operating Position: Any (no restrictions).

Output Terminals: Two contact terminal block (size 6 spade).

Voltage Regulator Card
Model 69351B

±15 Volt Jumpers
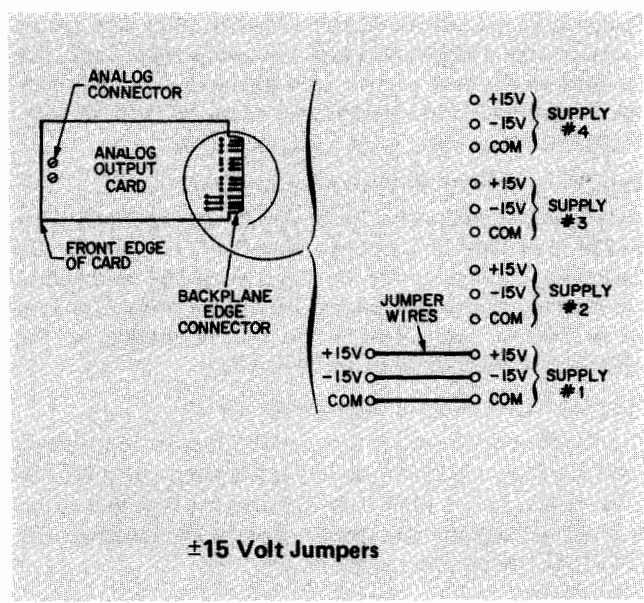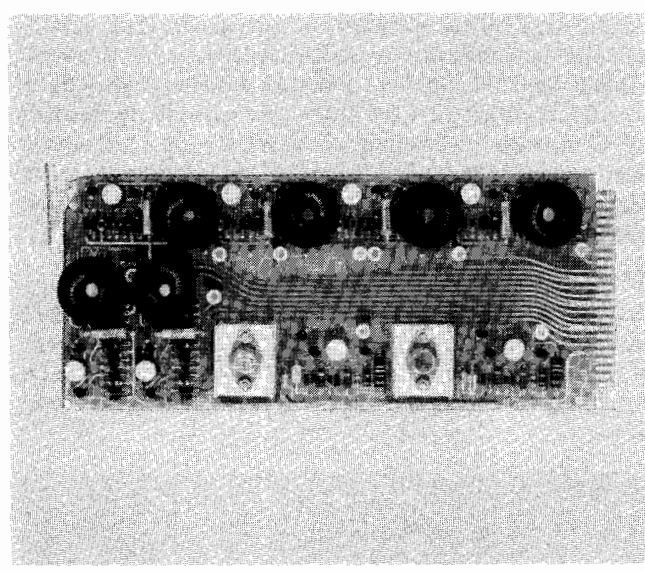
This card provides four regulated, isolated bias supplies for the following analog cards: 69321B D/A Voltage, 69322A Quad DAC, 69370A D/A Current, 69422A High Speed A/D, and 69423A Low Level A/D and Scanner. One voltage regulator must be used in each mainframe in which one or more of these analog cards are used. The regulator card is inserted in a slot reserved for this purpose in each mainframe, and does not take up an I/O card slot.

The 69351B Voltage Regulator outputs are routed via the Multiprogrammer backplane to all 15 I/O card slot connectors when the 69351B is inserted in the slot reserved for it, adjacent to the 15 plug-in I/O card slots. The current output capability of each of the four + 15 volt supplies is shown in the table below.

Power Supply	#1	#2	#3	#4
Rating	750mA	150mA	150mA	150mA

The current used by each of the five types of plug-in cards that require the 69315B Voltage Regulator Card are shown below. below.

The analog cards (69321B, 69322A, 69370A, 69422A, and 69423A) have three jumpers at the backplane edge of the board that you position to select the ± 15V supply that will operate the card.

Plug-in Card	Current Requirement
69321B	47mA
69322A	100mA
69370A	47mA
69422A	140mA
69423A	70mA

As shipped from the factory, 69321B D/A Voltage Cards, 69322A Quad D/A Voltage Cards, 69422A High Speed A/D, and 69423A Low Level A/D and Scanner are jumpered to supply 1. The 69370A D/A Current Cards are jumpered to supply 4.

These factory installed jumper positions should be changed if: (1) more that three 69370A D/A Current Cards are to be put in the same mainframe or (2) more than five 69422A High Speed A/D Cards are to be put in a mainframe or (3) more than ten 69423A Low Level A/D and Scanner Cards are to be put in a mainframe or (4) more than seven 69322A Quad D/A Voltage Converter Cards are to be put in a mainframe or (5) you need the cards isolated from each other.

When jumpers are changed, the current required from each supply should not exceed its rating, and the following points must be observed.

Combining A/D's and D/A's in One Mainframe:

1. 69370A cards should not be operated from those ± 15V supplies that are connected to other analog cards: (ie. 69321B, 69322A, 69422A, and 69423A). The LO terminal of the 69370A is connected to the − 15V output, but the LO terminal of the other analog cards are connected to the ± 15V common output. In the event of the 69370A is connected to the same ± 15V supply, a fuse will blow on the 69351B Voltage Regulator Card. Spare plug-in fuses are located on the card.

2. This isolated ± 15V supply that is connected to an analog card becomes referenced to the common input of that card. If other cards are operated from this same ± 15V supply, they also will be referenced to this common input.

29

ANALOG INPUT

Temperature Measurement

Temperature measurements using thermocouple wire can be made with the 69423A Low Level A/D and Scanner Card. This card has six channels of input, plus a seventh reference channel. This seventh channel eliminates the need for an ice bath. The 69423A data sheet is on pages 34 and 35.

General Low Level Voltage Measurement

Voltages in the range of ±20mV may be measured using the 69423A Low Level A/D and Scanner Card. For general purpose voltage measurement, the input signals are attached to the six input terminals. Source impedance should be kept below 500Ω for best results in this type of application. The 69423A data sheet is on pages 34 and 35.

General High Level Voltage Measurement

The 69422A High Speed A/D is the Multiprogrammer Analog Input Card for monitoring signals in the ranges of ±100mV, ±1V, ±10V, and ±100V. This card features high speed—up to 33,000 conversions per second—and 12-bit resolution. The 69422A data sheet is on pages 32 and 33.

A/D Per Channel Capability

Up to eight 69422A High Speed A/D's may be placed in a mainframe without using any external power supplies. All of the A/D's will be isolated from data common, but all eight cards will not be isolated from each other. The cards can be grouped into four sets, with each set being isolated from each of the other sets. Each extender mainframe can contain its own 69351B Voltage Regulator which provides power to additional sets of isolated A/D's located in those extender mainframes.

Multiplexed A/D Capability (Scanning)

By using a 69433A Relay Card with the 69422A High Speed A/D, 12 single-ended or 6 double-ended signals can be scanned. Up to fourteen 69433A Relay Cards can be used in the same mainframe with one 69422A A/D for 168 single-ended, or 84 two-wire multiplexed channels. A 12-channel, single-ended scanner is shown below.
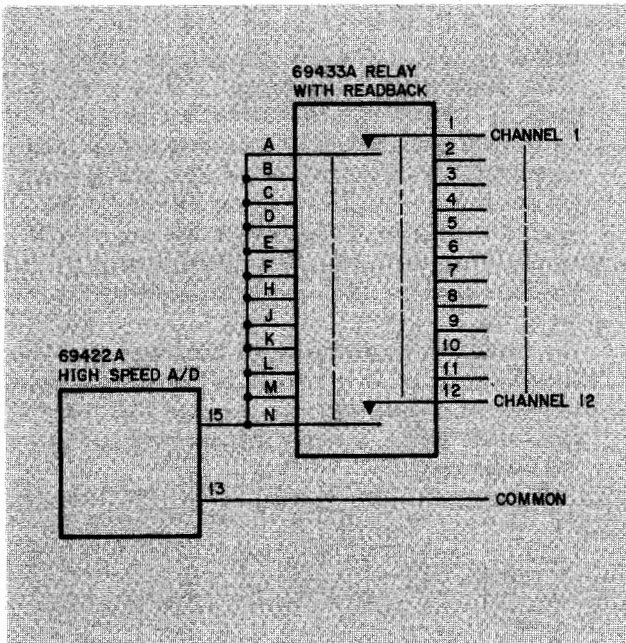
Channel capacitance at 100kHz is 10pF open, 25pF closed, and 20pF interchannel. Frequency response is flat to within ±0.2dB from DC to 1MHz. Crosstalk is better than −60dB from DC to 1HMz with a 50 ohm open channel termination and better than −30dB from DC to 1MHz with a 1 megohm open channel termination. Thermal offset voltages are ±100 microvolts per relay. Relay resistance is less than 300 milliohms.

Waveform Analysis and AC Measurement

Time-varying waveforms and transients of less that ±102V peak are mreasured with the 69422A High Speed A/D paced by the 69601B Frequency Referency when using the 16-bit duplex interface. The configuration of this operation is shown below.
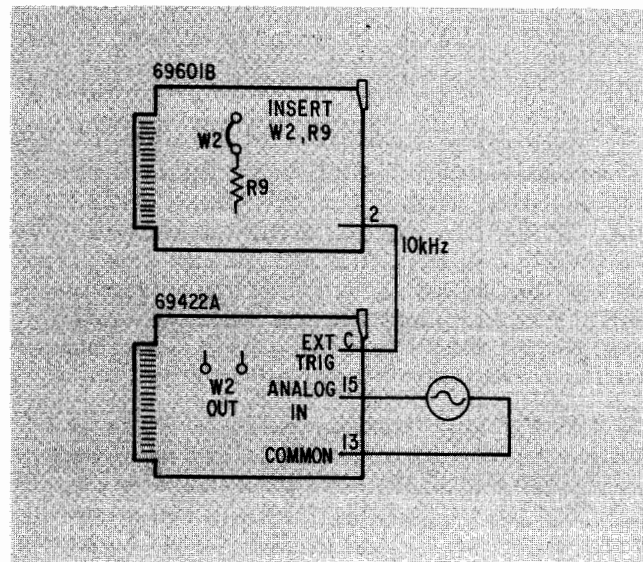
The configuration shown takes a sample every 100μsec. Using the 69601B, samples can alternatively be taken at the following intervals: 1ms, 10ms, 100ms, 1s. The high speed waveform digitization is possible only when using the 16-bit duplex interface, it is not possible with HP-IB. This is because the buffered transfer capability of the 16-bit duplex interface is used.

Paced A/D Measurements

An easily implemented technique for making voltage measurements with the 69422A High Speed A/D Card at programmable intervals of time is to use the 69600B Programmable Timer Card to hold off the computer program between readings. The time intervals can be as short as 7 milliseconds or as long as 47 days. The Timer Card can generate an interrupt, if desired, at the end of each interval.

Simultaneous Readings With Several A/D's

Simultaneious readings (within ±1μs) by 69422A High Speed A/D's are initiated by providing a 1μs (min) TTL pulse at the external trigger input (pin C) of the cards. External triggering of several High Speed A/D Cards is particularly useful in fault analysis applications where an external pulse signals the onset of an error or emergency condition that demands immediate and simultaneous measurements.

Delayed Simultaneous Readings

The 69600B Programmable Timer is used as a programmable delay for the triggering of simultaneous measurements with up to eight High Speed A/D Cards.
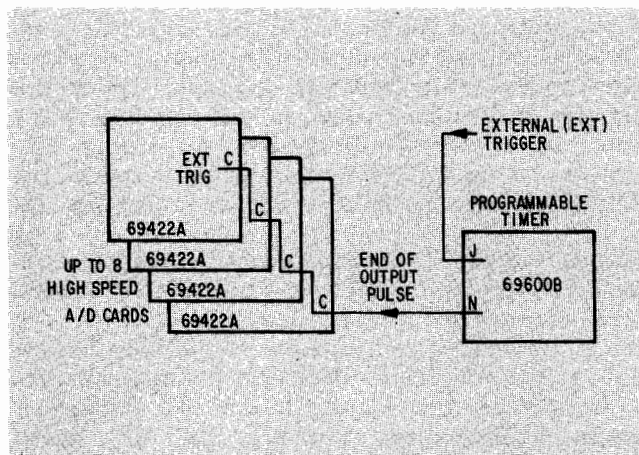
The End of Output Pulse (pin N) on the 69600B in connected to the External Trigger input (pin C) of each High Speed A/D Card. The program presets the 69600B to the desired delay time, but the timer does not begin to time out until it receives a program command or an external trigger (EXT) signal.

Current Measurement

The current flowing in circuits under test and in analog control loops can be measured if the circuit can (or does already) include a resistor of suitable ohmic value, accuracy, and temperature coefficient. The input impedance of the 69422A High Speed A/D is $10^{10}\Omega$, which means that the resistor used for sensing current can be up to 100KΩ without losing ac-

curacy. The accuracy of this resistor should be 1% or better, including drift due to self-heating in the resistor. The current is measured by using software to divide the voltage reading in volts by the resistor value in ohms. The accuracy of the measurement is the sum of the accuracy and drift of the resistor plus the absolute accuracy specification on page 33 plus the ratio of the resistor to the input impedance of the 69422A High Speed A/D Card.

Resistance Measurement

Resistance measurements can be made with the 69422A High Speed A/D and the 69370A D/A Current Card. The combination becomes a digitally programmable two-wire or four-wire ohmmeter.

Accuracy of Resistance Measurements

Resistance Being Measured	A/D Voltage Range	Accuracy
100KΩ	10	6%
10KΩ	10	1%
1KΩ	10	0.3%
100Ω	1	0.2%
10Ω	0.1	0.2%

Four terminal connections are required for resistances less than 100Ω. For measurements of high-current, low-resistance contacts, 10% accuracy measurements in the milliohm region are possible when constant current power supplies with OP-tion 040 (see page 27) provide 10 amps or more to contacts under test that are monitored with the 69422A High Speed A/D.

Hi Speed A/D
Voltage Converter Card
Model 69422A
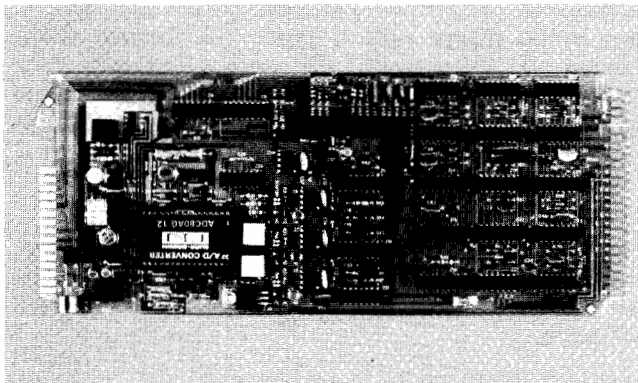
This card monitors bipolar dc voltages in one of four ranges, ±100mV, ±1V, ±10V, or ±100V, and returns a 12-bit, digital word to the controller to indicate the magnitude and sign of the measured voltage. Three manually settable range switches select the ±100mV, ±1V, or ±10V range. Input voltages in the ±100V range are connected to the card's divide-by-ten attenuator.

Instructions for modifying and recalibrating the card for other bipolar and unipolar ranges are provided in the Operating and Service manual.

The card uses a high performance sample/hold amplifier and successive approximation A/D converter which provide a high conversion speed and excellent accuracy characteristics. The dc input voltage is guarded to maintain high input impedance.
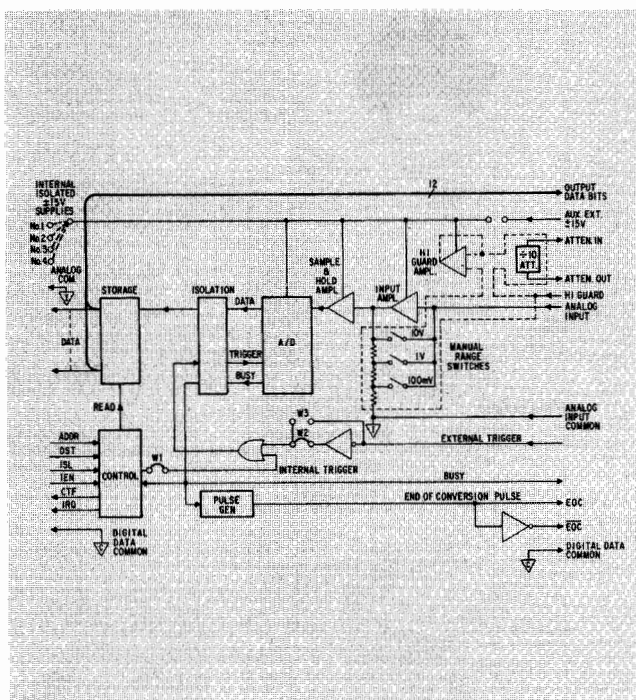
Up to 20,000 voltage readings per second can be transferred from the card to the computer through the Multiprogrammer Mainframe. The readings can be initiated by program commands or by an external trigger signal applied to the card edge connector. Data is also available at the card auxiliary output data bits on the front edge connector for transfer to external data receivers at up to 33,000 readings per second. The 69422A can interrupt the computer when data is ready.

Voltage Regulator Card, Model 69351B, must be used in each mainframe in which one or more 69422A cards are used. Because the Voltage Regulator Card contains four ±15V isolated supplies, up to four 69422A cards in any one mainframe can have isolated grounds. Jumpers on the 69422A card connect to any one of the four isolated supplies in the mainframe. Each High Speed A/D card will draw 140mA from an isolated ±15V supply in the 6940B mainframe. Up to eight 69422A cards can be used in a single Multiprogrammer Mainframe using all four of the internal ±15V supplies. Up to 15 cards can be used per mainframe by supplying external ±15V bias at the card edge connector.

Multiprogrammer Control Interface Signals:
   ADDR, DST, and ISL: Commands card to take reading (converts and stores) if internal trigger jumper is installed.
   ADDR: Puts converted data on Multiprogrammer backplane.
   ADDR and ISL: Allows controller to read in data.

Interrupt Mode (External Trigger Jumper installed, Internal Trigger Jumper removed)

   To arm card for computer interrupt:
      Individual arm — ISL on, ADDR, DST.
      Batch arm — IEN on
   Program Interrupt mode:
      IEN and TME: Enables all armed input cards to operate in interrupt mode. The 69422A card will generate an interrupt when external trigger is received and conversion is completed.
   To poll for interrupting cards:
      The controller polls each input card, examining the state of bit 15 (IRQ) of each return word. Bit 15 will be true if the addressed card requested an interrupt. The controller should read in the 12 return data bits from any addressed input card whose associated IRQ bit is true.

Input Voltage Ranges
   Attenuator Input:
      ±100V (+102.35 to −102.40V), 50mV resolution

Switch Selectable:
±10V (+10.235 to −10.240V), 5mV resolution
±1V(+1.0235 to −1.024V), 500μV resolution
±100mV (+0.10235 to −0.10240V), 50μV resolution

Static Accuracy:

	Accuracy	
Output Range	20 - 30°C	0 - 50°C
100mV, 1V, 10V	±0.15% of f.s.	±0.4% of f.s.
100V	±400mV	±750mV

Conversion Time:
30μsec (33k conversions per sec) for external data output.
50μsec (20k conversions per sec max.) through Multiprogrammer Backplane.

Dynamic Characteristics:
Settling Time: To within 0.01% of step change for a step equal to 50% of the full scale range (e.g., a 10 volt step on the 10 volt range). The settling time includes settling times of the input amplifier and sample/hold amplifier and the slew rate limiting effects.

Range	Max. Settling Time
100mV	40μsec
1V	16μsec
10V	15μsec
100V	1msec

Aperture Time: Less than 200 nanoseconds
Delay with respect to external trigger: Less than 1μsec.

Isolation:
100Vdc between analog circuits and data common.

Input Impedance:
100mV, 1V, 10V Ranges: 10^{10} ohms shunted by 15pF
100V Range: 10^6 ohms shunted by 20pF

Common Mode Rejection:
With 1 ohm in low input lead
120dB @ 60Hz
80dB @ 10kHz
With 1k ohm in low input lead
60dB @60Hz
20dB@ 10kHz

External Digital Inputs and Outputs
Data Outputs:
12 bits positive true 2's complement binary data. Low power Schottky TTL outputs.

External Trigger:
Positive or negative true (jumper selectable) 1μsec (min.) pulse. Low power Schottky TTL input: 0.5mA sink required.

End of Conversion Outputs:
0.5 to 2μsec wide negative true pulse. Low power Schottky TTL output.

Busy:
Indicates that the conversion cycle is in progress. Approximately 25μsec wide negative true pulse. Low power Schottky TTL output.

**Temperature Range:** 0°C to 70°C operating in mainframe (allows +15°C internal rise in mainframe at up to +55°C ambient); −40°C to +80°C storage.
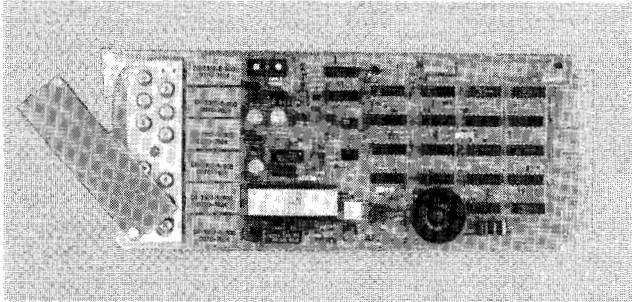
Operating Position:
Any (no restrictions).

Output Connector: One 15-pin dual (30-pin total) edge connector. Mating female connector assembly supplied (HP Part No. 14555A). This connector accommodates up to 15 wires with outside diameters of up to 66 mils each.
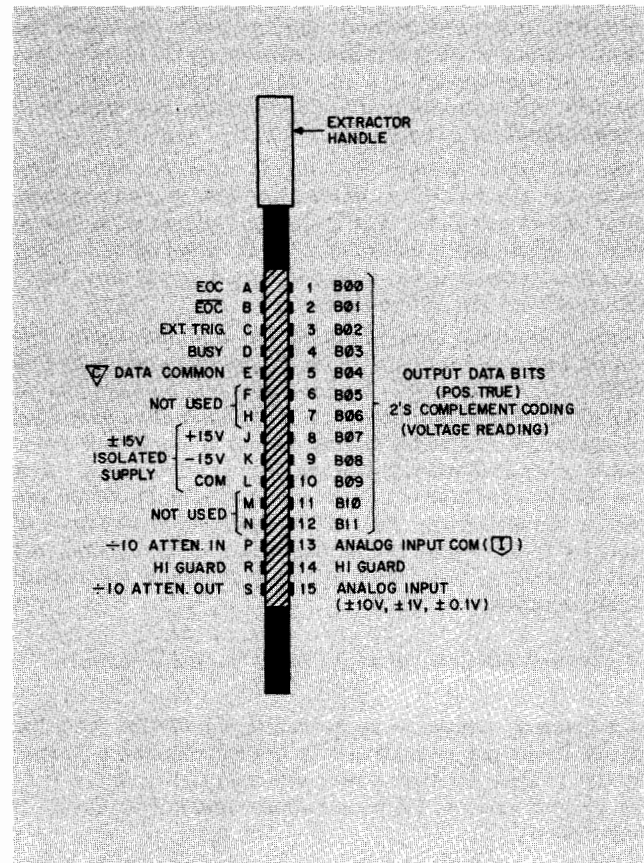
Low Level A/D and Scanner
Model 69423A

Six channels of thermocouples or other low level dc sources in the range of ±20mV can be monitored with this card. The card returns a 12 bit digital word to the controller to indicate the sign and magnitude of the measured voltage on the selected channel. The selection of either the unipolar or bipolar range and the desired channel are programmable from the controller.

The signal being measured passes through an amplifier into a multiple slope integrating A/D. The excellent noise rejection 60Hz is achieved by controlling the A/D integration period with a crystal controlled oscillator. An option is available for 50Hz environments. Low thermal EMF reed relays are used to select one of the six input channels.

A seventh channel on the card is used to read back the temperature of the isothermal input terminal block. Use of this seventh channel eliminates the need for an ice bath in thermocouple applications with the 69423A. Instead of using the ice bath, the reference junction temperature is automatically compensated for in software.

This card, which is especially useful in thermocouple applications, can also be used in general low level dc input applications. When using this card in general purpose dc measurement of applications best results will be obtained by keeping source impedance below 500Ω and normal mode noise plus signal below 110% of full scale.

Voltage Regulator Card, Model 69351B, must be used in each mainframe in which one or more 69423A cards are used. The 69351B has its own slot in the mainframe and does not take up one of the 15 I/O slots. Because the Voltage Regulator Card contains four ±15V isolated supplies, up to four 69423A cards in any one mainframe can have isolated grounds. Jumpers on the 69423A card connect to any one of the four isolated supplies in the mainframe. Each 69423A will draw 70mA from an isolated ±15V supply in the mainframe. Up to 15 69423A's can be used per mainframe by using all four of the internal ±15V supplies.

Using the 69423A Low Level A/D and Scanner

The simplest method of programming the 69423A from the 9825A Desktop Computer is with the HPL Software Library, Model 14556A. To take a temperature measurement a software call is made to the proper library routine from the Software Library.

For example, if a type T thermocouple is wired to channel 2 of a 69423A in slot 6 of the 6940B Multiprogrammer, the program would look like this:

```
cll 'T Thermocouple' (6.2, A)
prt A
end
```

The temperature at the thermocouple is printed as a decimal number of degrees Celsius. For more information on the Software Library, see page 11.

Using the 69423A Low Level A/D and Scanner Without the 14556A Software Library

A sequence of control words and data words must be sent from the controller to the 6940B Multiprogrammer to read back data from the 69423A.

A control word is sent with the ISL mode bit off to put the 6940B into output mode. If an indication is desired to notify the controller when the 69423A has completed its reading, the TME mode bit may also be programmed on. One of the seven input channels on the 69423A is selected by sending a data word to the 6940B.

To read the converted data back into the controller, the Multiprogrammer is first put into input mode by turning on the ISL mode bit with another control word. The 69423A is selected for readback with an address word and the controller stores the data returned in the return data word.

The Operating and Service Manual explains each of these steps in detail and shows how to convert the thermocouple and reference voltages into degrees Celsius. Examples in the manual show how to program the 69423A from the 9845, 9835, 9825, and HP1000 controllers.
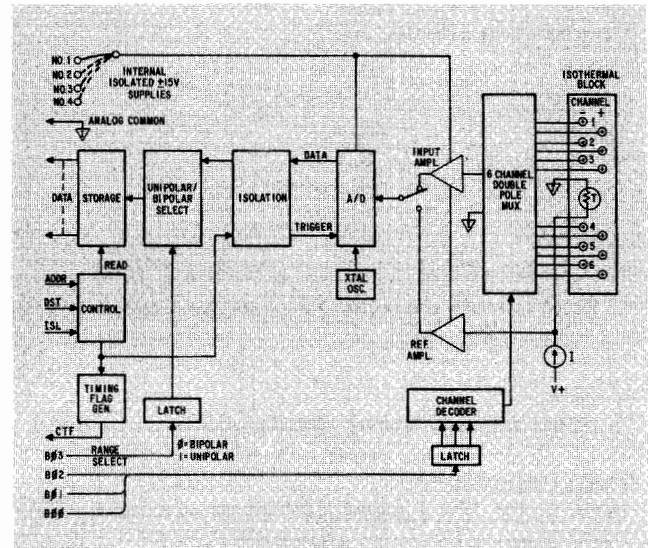
Input Ranges:

Standard	0 to 20mV; 5μV LSB
	±20mV; 10μV LSB
Option 050	0 to 50mV; 12.5μV LSB
	±100mV; 25μV LSB
Option 100	0 to 100mV; 25μV LSB
	±100mV; 50μV LSB

Resolution: 12 bits

Accuracy:

Standard	±40μV @25°C ±5°C
Option 050	±100μV @25°C ±5°C
Option 100	±200μV @25°C ±5°C

Temperature Coefficient:

Standard	1μV/°C @0 to 70°C
Option 050	2.5μV/°C @0 to 70°C
Option 100	5μV/°C @0 to 70°C

Conversion Time: 140ms (155ms Option 005) max.

Input Resistance: 500KΩ min.

Max. Normal Mode Voltage: ±20 volts

Isolation Voltage: 20Vdc or 40Vdc (no restriction)
50Vdc or 100Vdc (when the 69423A's use internal power supplies to which no other plug-in card types are connected. Jumpers allow analog I/O cards to be connected to any of the four internal power supplies.)

Normal Mode Rejection: For signal plus noise less than 110% of full scale.
60Hz ±0.1% > 50 dB
50Hz ±0.1% > 50 dB (Option 005)

Effective Common Mode Rejection: For common mode voltages up to 100V p-p.
1Ω imbalance in low lead.
60Hz ±0.1% > 120 dB
50Hz ±0.1% > 120 dB (Option 005)
dc > 120 dB

Reference Junction Accuracy: 1°C

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

System Accuracy in Thermocouple Applications

The following table shows accuracies to be expected from systems consisting of the 69423A Low Level A/D and Scanner in the 6940B Multiprogrammer and using the 14556A Software Library with the 9825A Desktop Computer. These accuracy figures include error from both hardware and software sources. The 14556A Software Library Manual indicates the proper values for the constants in the temperature utility routines that should be used with the desired temperature range. In cases where the temperature to be measured will not go below the reference temperature (usually 20-30°C), the unipolar range of the 69423A may be used for greater resolution.

Accuracy may be improved by approximately a degree Celsius by going to special accuracy thermocouple wire. The sources of error are approximately 85% hardware related and 15% software related.

Thermocouple Type	Unipolar/ Bipolar Scale	Range	Resolution	System Accuracy Using 14556A Software Library	
				Not Including Thermo Wire	Including Thermo Wire (Standard Wire)
J	Uni	30 to 400°C[1]	0.1°C	±2°C	±4.2°C
K	Bi	−200 to 400°C[1]	0.2°C	±2.6°C	±4.8°C
	Uni	30 to 400°C[1]	0.1°C	±2.6°C	±4.8°C
T	Bi	−200 to 400°C	0.2°C	±2.3°C	±(2.3°C + 2%)
	Uni	30 to 400°C	0.1°C	±2.3°C	±(2.3°C + 0.75%)
E	Bi	−200 to 300°C[1]	0.2°C	±2.8°C	±5.0°C
	Uni	30 to 300°C[1]	0.1°C	±2.3°C	±4.5°C
R,S	Uni	30 to 1700°C	1.0°C	+16-13°C	+18-15°C
B	Uni	800 to 1700°C	0.7°C	±7°C	±(7°C + ½%)

[1]These ranges can be increased by a factor of 2.5 (decreasing the resolution and the accuracy not including thermocouple wire by 2.5) and a factor of 5 (decreasing the resolution and the accuracy not including thermocouple wire by 5%) by options 050 and 100 respectively.

HP Model Number	Description	Prerequisite
69423A	Low Level A/D and 6 channel scanner plus reference channel	6940B Multiprogrammer 69351B Voltage Regulator
Option 005	50Hz Option	
Option 050	50mV full scale	
Option 100	100mV full scale	

FUNCTIONAL CARDS

69600B Programmable Timer Card (One-Shot)

This card can be used to hold off computer operation for a programmable period of time when making periodic readings or generating outputs at specific intervals. The card can also be used to supply a one-shot output or to interrrupt the computer at programmable times.

69601B Frequency Reference Card

The output from this card is a crystal-controlled square wave which is used to pace A/D measurements. The square wave outputs are available for external use.

69435A Pulse Counter Card

This card totalizes logic level or contact closure pulses. Count up and count down inputs are provided. The count can be read without disturbing the counting process, and the counter can be preset under software control. As a totalizer, the 69435A is used to count objects on production lines, to accummulate counts from AC power meters, and to monitor units under test.

69335A Stepping Motor Control Card

This card produces a programmable number of pulses at either of two outputs to drive stepping motor translators, and other actuators and converters that respond to pulse train inputs. The pulse outputs of this card are also used in testing sequential logic circuitry and subassemblies.

Frequency Measurement

The 69435A Pulse Counter Card is paired with the 69600B Timer Card as shown on page 37 to measure frequency. Frequencies up to 200 KHz can be measured with this set-up. Signals from industrial drivers such as flowmeters, tachometers, contact closures, and cam operated switches are well suited to this application.

Time Interval Measurement

The 69435A Pulse Counter Card is paired with the 69601B Frequency Reference Card to measure time intervals. This set-up is shown on page 37. The resolution of this arrangement is from 10 μs to 1 second in 6 decades. The range can be expanded from 4095 times the resolution to 17 million times the resoution by adding another Pulse Counter Card. Programmable ranging can be added by using a 69433A Realay Card to access different frequency outputs of the 69601B Frequency Reference Card.

Time of Day

By driving the 69435A Pulse Counter Card with the 69601B Frequency Reference Card, an elapsed time clock can be implemented. this set-up is shown on page 37. With two 69435A's the resolution is from 10 μs (max count is 2.8 minutes) to 1 second (maximum count is 194 days).

Frequency and Time Applications

TOTALIZER
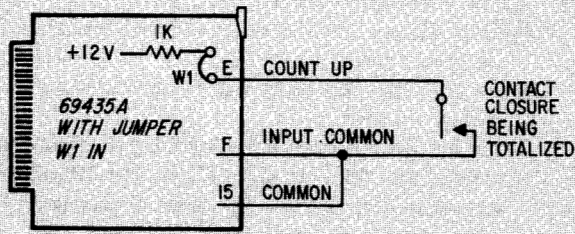
THREE 4-BIT COUNTERS
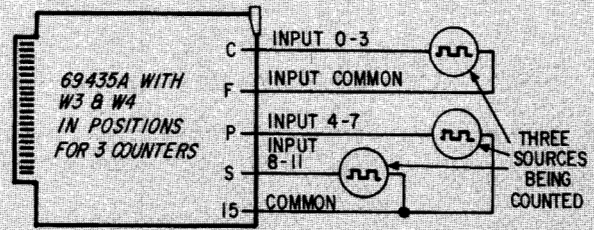
UP/DOWN COUNTING
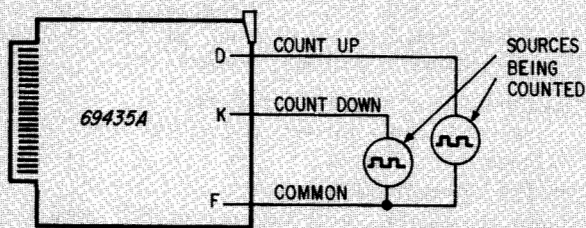
NOTE: COUNT UP AND DOWN INPUTS MUST NOT BE COINCIDENT. TO COUNT COINCIDENT PULSES, USE TWO 69435A'S.

PRESET COUNTER
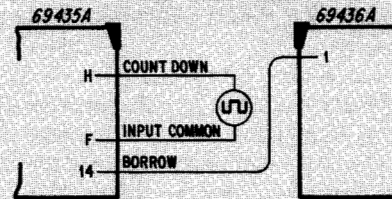
The 69435A is loaded with the preset count value using a data word. The 69436A generates an interrupt when the preset value is reached. Any of the 12 positive edge detectors may be used. (The carry output may be connected in the same manner in order to permit unlimited counting capability from one card.)

FREQUENCY MEASUREMENT
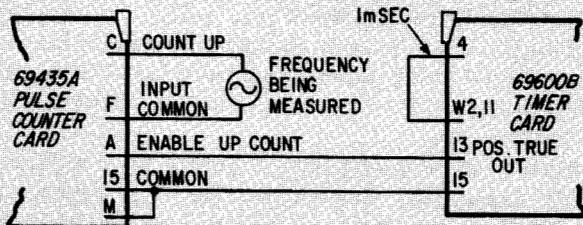
THE 69600B TIMER ENABLES THE COUNTER FOR A PROGRAMMED PERIOD OF TIME. THE CONTROLLER DIVIDES THE COUNT BY THE TIME TO DETERMINE FREQUENCY.

TIME INTERVAL MEASUREMENT
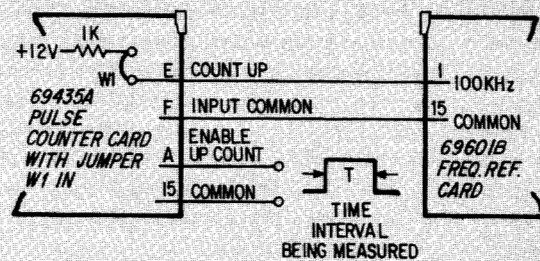
THE CONTROLLER DIVIDES THE TOTAL COUNT BY THE FREQUENCY OUTPUT OF THE 69601B TO DETERMINE THE TIME INTERVAL

CASCADED COUNTERS
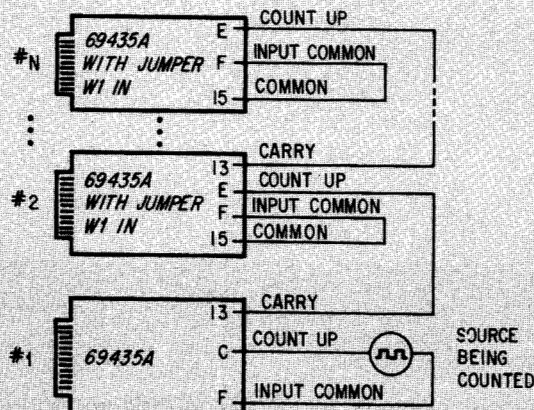
COUNTER #1 HOLDS THE 12 LEAST SIGNIFICANT BITS OF THE BINARY COUNT WORD; COUNTER #N HOLDS THE 12 MOST SIGNIFICANT BITS.

ELAPSED TIME CLOCK

TIME INCREMENTS CAN BE 10μSEC. TO 1SEC; THE CLOCK CAN BE PRESET; TOTAL COUNT CAN BE EXTENDED BY CASCADING COUNTERS.

Programmable Timer Card
Model 69600B

This card generates a crystal-controlled one-shot output and end of output pulse each time it is commanded by the program. The duration of the output is determined by the combination of two factors: (1) the number of programmed time increments, from 1 to 4095; and (2) the selected period of the increments, from 1μsec to 0.1sec. Period selection can be accomplished by fixed jumpers on the 69600B card or brought under program control by using a 69330A Relay Output Card. The timed output and end of output pulse are available in both positive-true and ground-true form. One or more (up to 15) timers may be used in a mainframe to either hold off or interrupt the computer or calculator program for the purpose of pacing input or output operations with other plug-in cards or instruments. Known-interval outputs generated by this card can be connected to the count enable input of 69435A Pulse Counter Cards as a period-reference for frequency measurements. The output of the 69600B can be used to turn off a normally-on relay or circuit that is connected to an audible alarm, safety interlock switch, or other "fail-safe" circuit. At regular intervals, the computer or calculator re-programs the 69600B to disable the fail-safe circuit. If, for any reason, the controller does not re-program the 69600B as scheduled, the fail-safe circuit is activated at the end of the previously programmed timer interval. This is commonly known as a watchdog timer or stall alarm.
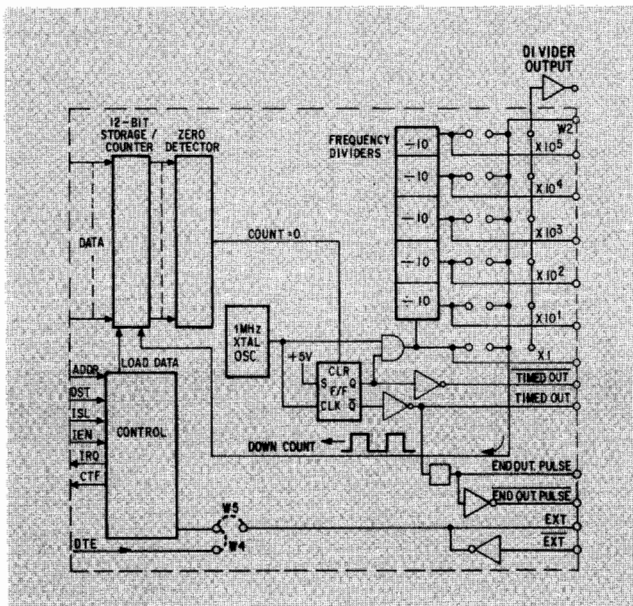
Control Signals:
To load binary number representing desired number of time increments:
ISL off: Allows controller to output data to card.
ADDR: Selects card to receive increment count data (in binary form).
DST: Strobes programmed increment count into storage on card.
DTE on: Allows output to begin immediately upon receipt of DST. If DTE is off; the 69600B card will store data but will not begin output until DTE is turned on in a subsequent control word, thus permitting the 69600B output to be synchronized with outputs from other cards having the DTE function. With jumper W4 out and W5 in, outputs stored on the card may be initiated by an external trigger signal (EXT). As shipped from the factory both functions are disabled, but may be enabled via manually selectable jumpers.

To arm card for computer interrupt:
Individual arm — ISL on, ADDR, DST
Batch arm — IEN on
To poll for interrupting cards:
ISL on; ADDR. Note the state of IRQ. If true, that card has requested an interrupt.

Timed Output Duration: 1 to 4095 programmable increments. The period of each increment is jumper selectable in six decades from $X1\mu$sec to $X10^5\mu$sec (or 1 to 4095μsec to 0.1 to 409.5sec). Longer periods are available on special order.
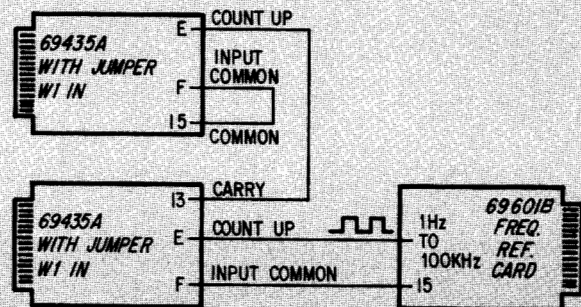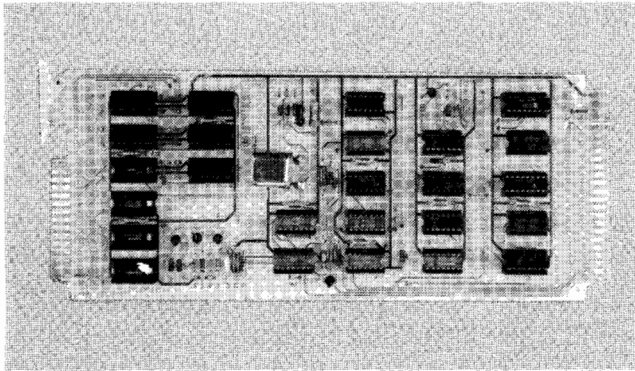
End of Output Pulse Duration:

Output Drivers: Outputs available in positive-true and ground-true form. Each output can drive 10 TTL standard loads, or 10 count enable inputs of 69435A pulse counter cards.

Accuracy: 0.01% of programmed time interval ±100nsec.

Output Connector: One 15-pin dual (30-pin total) edge connector. Mating female connector assembly supplied (HP Part No. 14555A). This connector accommodates up to 15 wires with outside diameters of up to 66 mils each.
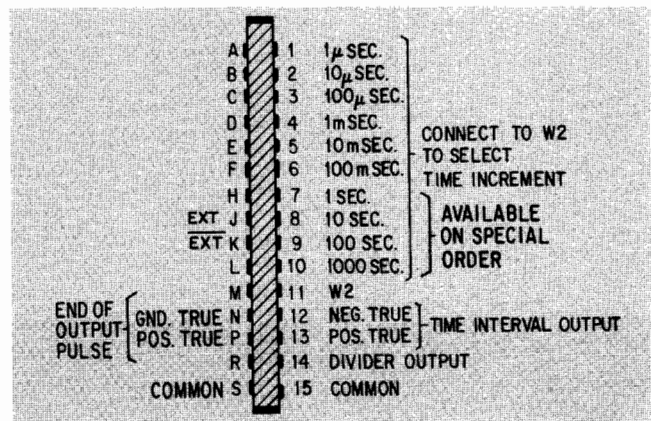
Temperature Range: $0°$ to $70°C$ operating in mainframe (allow $+15°$ internal rise when operating in mainframe at up to $+55°C$ ambient); $-40°C$ to $+80°C$ storage.

Operating Position: Any (no restrictions).

Frequency Reference Card
Model 69601B
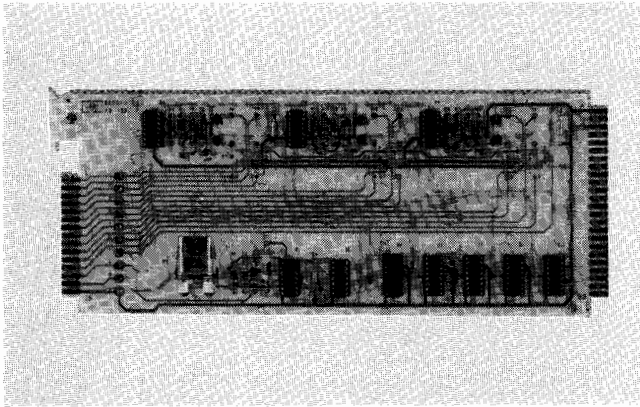
This card provides six square-wave outputs at fixed frequencies from 1Hz to 100kHz, derived from a 1MHz crystal. The outputs may be turned off with the low state of an external TTL logic gate or external contact closure between the inhibit line (pin 13) and common (pin 15).
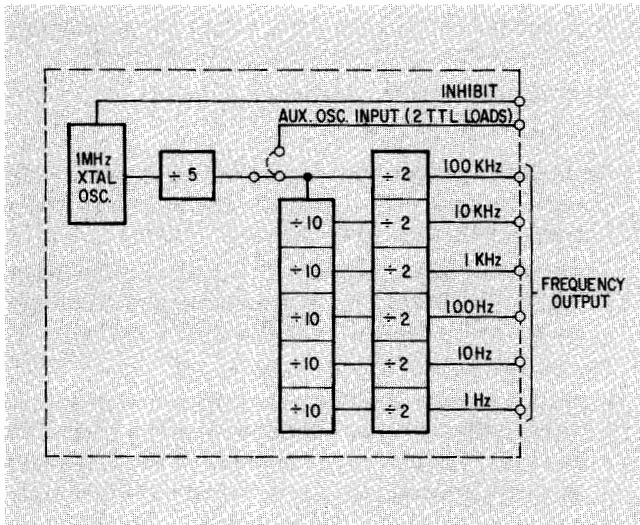
The 69601B Frequency Reference Card is used in conjunction with the 69435A Pulse Counter Card for measurement of time intervals. In this application, each of the six outputs of the 69601B can drive up to three count inputs on separate 69435A Pulse Counter Cards. The time interval signal being measured is connected to the enable line of the counter.

The outputs of the 69601B are suitable for other applications such as pacing external A/D and D/A converters and serving as a time base for event markers on strip chart recorders.

To use the 69601B as a frequency divider for TTL signals, the internal oscillator is replaced with an external source at the auxiliary oscillator input, pin 14.

Fixed Output Frequencies: 1Hz, 10Hz, 100Hz, 1kHz, 10kHz, 100kHz.

Accuracy: 0.01% of nominal frequency.

Inhibit Line: A contact closure or low state TTL logic level applied between pin 13 and common (pin 15) turns off the oscillator.

Output Drivers: Supplied as open collector outputs with 50mA sink capability. A pullup resistor to +5V, +12V, or an external supply up to 30V can be added to each output.
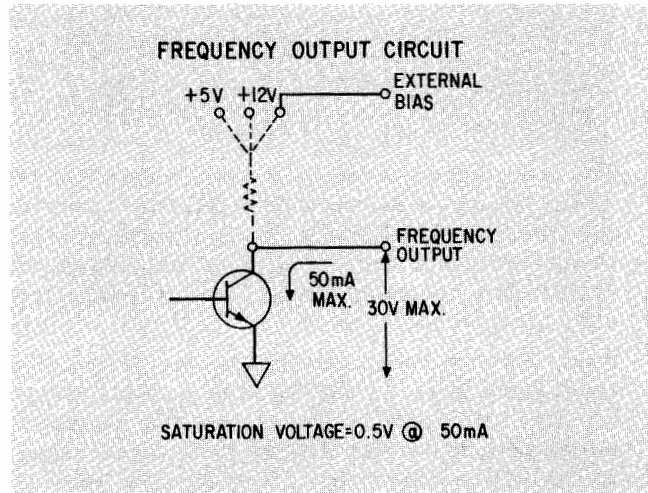
FREQUENCY OUTPUT CIRCUIT

SATURATION VOLTAGE=0.5V @ 50mA

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

Operating Position: Any (no restrictions).

Output Connector: One 15-pin dual (30-pin total) edge connector. Mating female connector assembly supplied (HP Part No. 14555A). This connector accommodates up to 15 wires with outside diameters of up to 66 mils each.

A	1	100KHz
B	2	EXT. BIAS (100KHz)
C	3	10KHz
D	4	EXT. BIAS (10KHz)
E	5	1KHz
F	6	EXT. BIAS (1KHz)
H	7	100Hz
J	8	EXT. BIAS (100Hz)
K	9	10Hz
L	10	EXT. BIAS (10Hz)
M	11	1Hz
N	12	EXT. BIAS (1Hz)
P	13	INHIBIT
R	14	AUX. OSC. INPUT
S	15	COMMON

NOT USED

EXTRACTOR HANDLE
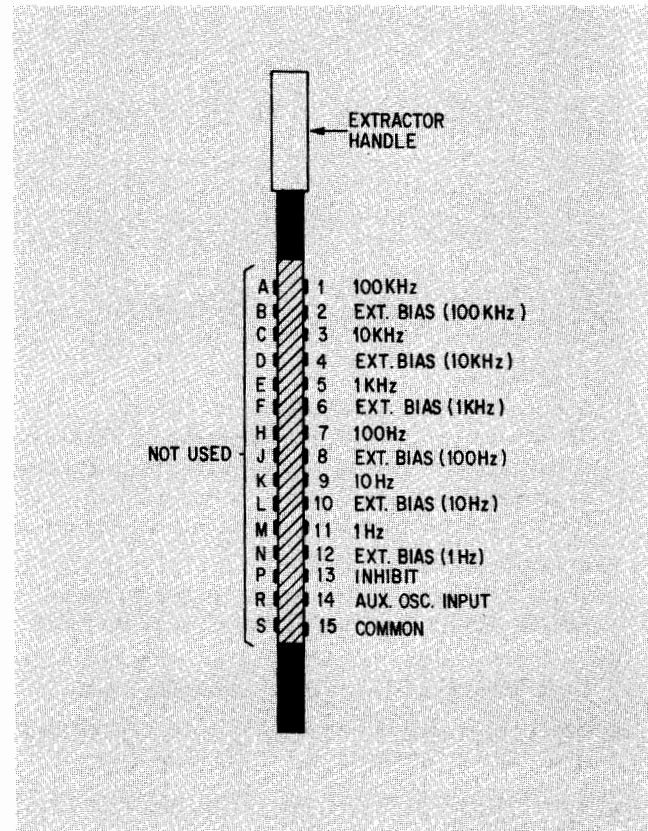
Pulse Counter Card
Model 69435A

This card will count pulses, up or down, in the range of 0 to 4095. A carry or borrow pulse is generated as the count goes above 4095 or below 0. These pulses allow multiple counter cards to be cascaded for greater counting capability or they can serve as alarm signals. The card can also be used as a pre-set counter.

Separate enable lines associated with the UP and DOWN count inputs allow the 69435A to be used as a frequency counter. This is done by simply connecting a known time interval signal to the enable line and the unknown frequency to the related count input. Programmable Timer Card 69600B can be used as a time interval reference for the 69435A. The complement of the frequency measurement technique permits time interval measurements. In this case, a known-frequency pulse train is connected to the up-count line and a pulse of unknown duration is connected to the up-enable line. Duration measurements with up to 5μsec resolution are possible using this technique.
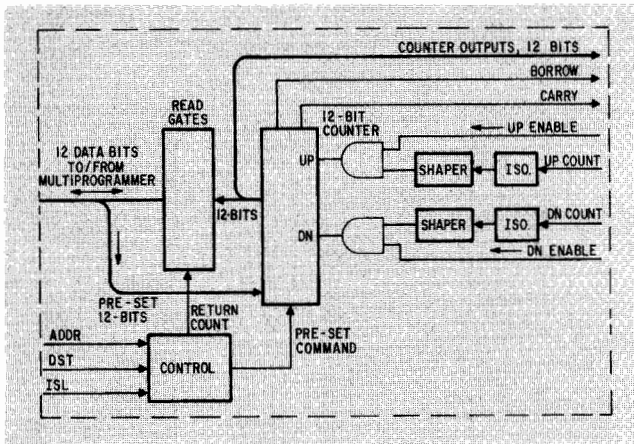
Control Signals:

In output mode to preset counter:

ISL off: Allows computer to output data to card.

ADDR: Selects card to receive preset count (in binary form).

DST: Strobes programmed data into storage on card.

In input mode to read in count:

ISL on: Allows computer to read in data from card.

ADDR: Selects card to input count (in binary form).

Carry Output: Goes HI when count is incremented above 4095. Drive capability is 10 TTL standard loads.

Borrow Output: Goes HI when count is decremented below zero. Drive capability is 10 TTL standard loads.

Counter Outputs: 12-bit binary. Drive capability is 1 TTL standard load.

Input Receivers:

NOTE: PADS ARE PROVIDED FOR POTENTIOMETER AND SERIES RESISTOR TO ACCOMMODATE NON-STANDARD VOLTAGE INPUTS.
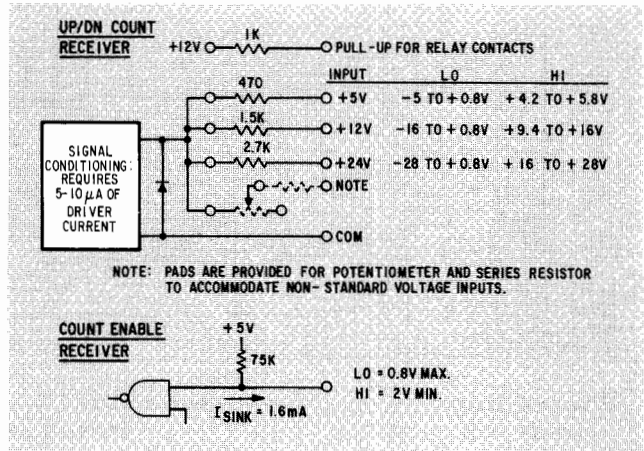
Enable Receivers: Open circuit or TTL HI = Enable, short circuit or TTL LO = Disable.

Input Count Frequency: Up to 200kHz square wave. Other wave shapes can be counted providing the Rise Time is < 5μsec. (Slower rise times can be accommodated by making minor component changes on the card.)

Minimum Pulse Width: 2.5μsec.

Maximum Rise Time: 5μsec.

Breakdown Voltage: Potential difference between isolated input terminals B through L and chassis ground must not exceed 100Vdc or 100Vrms.

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

Operating Position: Any (no restrictions).

Input Connector: One 15-pin dual (30-pin total) edge connector. Mating female connector assembly supplied (HP Part No. 14555A). This connector accommodates up to 30 wires with outside diameters of up to 44 mils each.
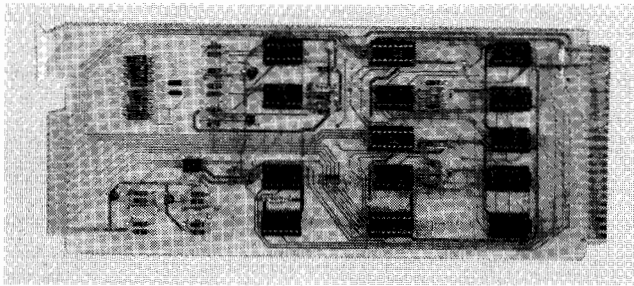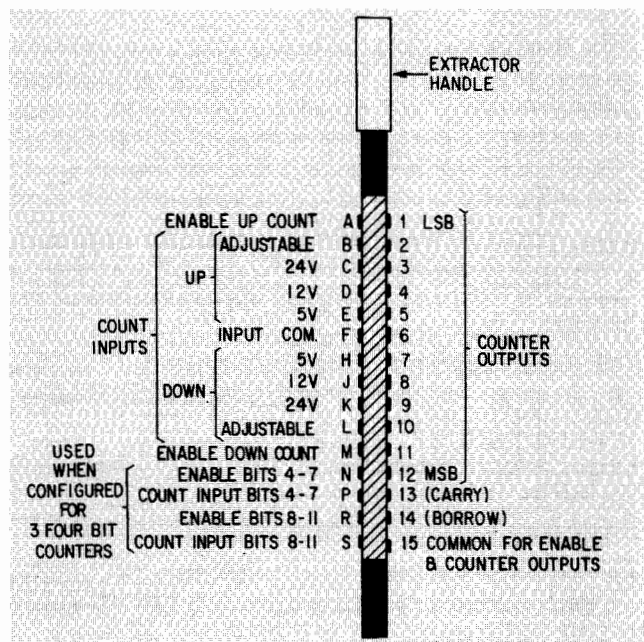
Stepping Motor Control Card
Model 69335A
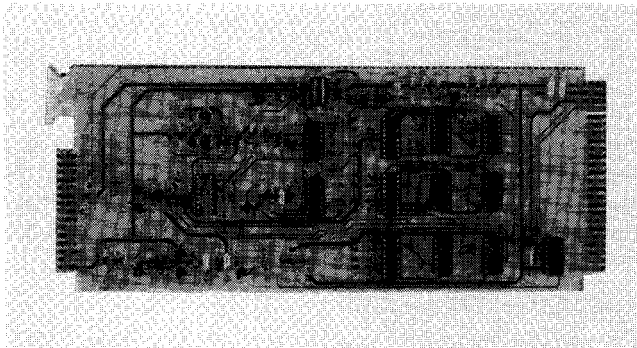
The 69335A can be programmed to generate from 0 to 2047 square wave pulses at either of two output terminals of the card. The user may also configure the card to program from 0 to 4095 square wave pulses. When applied to a stepping motor translator (such as the Superior Electric Co. ST101) these pulses are converted to clockwise and counterclockwise drive pulses for an associated stepping motor. The square wave outputs of the 69335A can also be used for pulse-train update of supervisory control stations.

External Flag Output: Signal is available at pin 13 when jumper W5 is in position B. A HIGH level (+2.4 to 5.0V) indicates that an output count is in progress ("busy" state). A LOW level (0 to 0.5V, 16mA sink) specifies the "ready" state.

Control Signals:
  SYE: Prevents card from generating pulses until SYE is programmed on.
  TME: Allows flag signals from cards to control busy period of Multiprogrammer flag to computer.

Data Input: 11-bit binary (B00-B10) specifies total number of steps from 1 to 2047. 1 bit (B11) specifies direction of rotation

Drive Pulse Outputs:

Drive Pulse Frequency: Nominally 100Hz. Can be adjusted from 10Hz to 2kHz by changing R or C value on card or connecting external programming resistor across pins 4-6. When externally programmed, frequency can be calculated by $f = \dfrac{10^7}{Rp}$

Output Connector: One 15-pin dual (30-pin total) edge connector. Mating female connector assembly supplied (HP Part No. 14555A). This connector accommodates up to 15 wires with outside diameters of up to 62 mils each.


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.

DIGITAL OUTPUT

69331A Digital Output Card

This general purpose output card has discrete transistor outputs that can provide 5 or 12 volt logic levels to instruments, solenoid drive circuits, and solid-state AC switches. The card has storage for 12 output bits, power-on preset circuits, system enable/disable capability, and gate/flag handshake capability to ensure orderly transfer of data to external digital devices.

69332A Open Collector Output Card

The 69332A can switch more voltage and current than the 69331A Digital Output Card. The Open Collector Output Card does not use the SYE capability, and its outputs are random at power-on.

69433A Relay Output with Readback Card

This is the card to use for analog scanning applications. Timing circuits on the card assure that the relays are closed before a measurement is taken with an A/D card. The ability to read back contact status means that subroutines can check the state of the contacts before programming a change. Distribution trees and matrices can be easily wired with this card. No external handshaking is available with the 69433A.

69330A Relay Output Card

The gate/flag handshake capability of this card make it useful for controlling instruments that are programmed with contact closures. Handshaking guarantees that the twelve data relays have had sufficient time to operate before the gate relay is actuated.

Breadboard Output Card

For user-designed output circuit mounting, refer to the Breadboard Card section on page 53.

Digital Output Card
Model 69331A
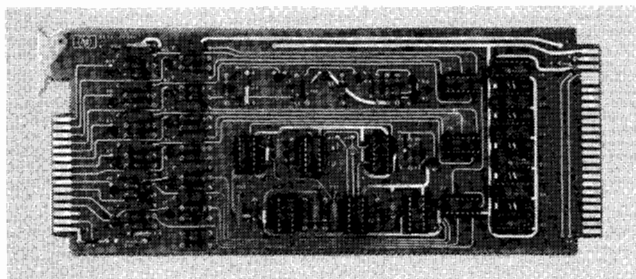
This card provides 12 bits with TTL/DTL-compatible logic levels as its output. The card uses the Gate/Flag timing method of digital data transfer. A maximum of 15 Digital Output cards may be used in any one mainframe.
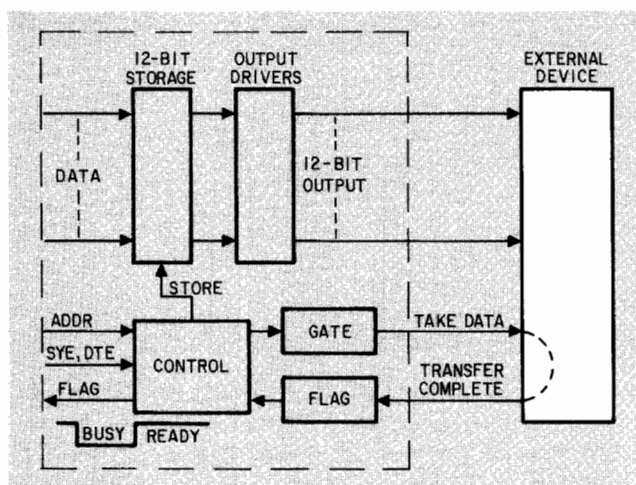
Data Input: 12-bit binary. Logical 1 = low output; logical 0 = high output. Option 073 reverses the sense of the outputs.

Digital Outputs:

LOW: 0 to 0.5Vdc, sink 32mA maximum
HIGH: +4.75 to 5.25Vdc (open circuit),
1 kilohm source impedance.
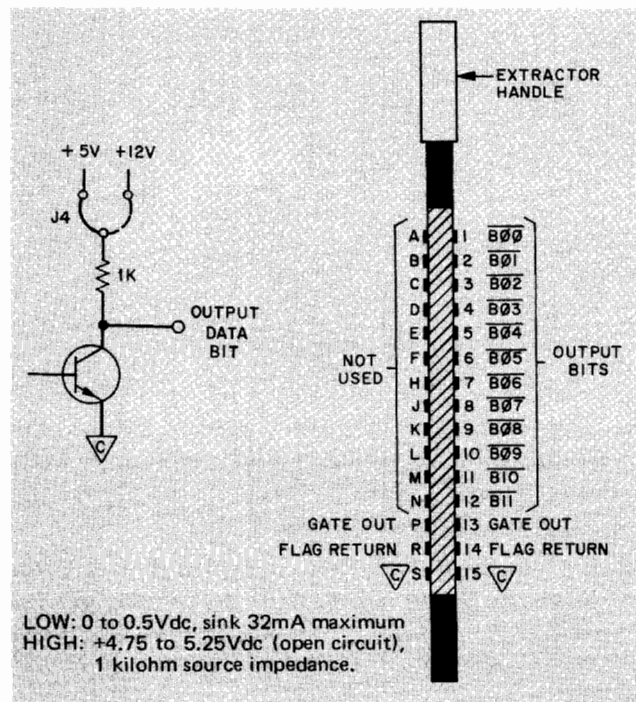
Control Signals:

SYE: Holds all digital outputs in the logical 0 state until SYE is programmed on. With SYE on, the card will respond to programmed data.

DTE: Part of programming sequence that generates a signal to tell the external device to accept the digital outputs of the 69331A. The device signals back to the 69331A that the transfer is complete via a device flag.

TME: Allows flag signals from cards to control "busy" period of Multiprogrammer flag to computer. Refer to Operating Features Section for details.

Gate Output: A HIGH (+2.4 to 5.0V) to LOW (0 to +0.5V, 32mA sink) transition of the GATE OUTPUT signals the external device to read the digital outputs of the 69331A.
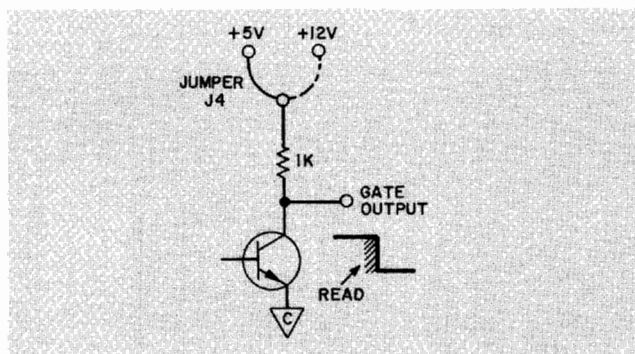
Flag Input: A LOW (0 to 0.5V) to HIGH (+2.4 to 5.0V) transition of the flag input signals the 69331A that the data transfer to the external digital device is complete.

Isource = 15mA MAX
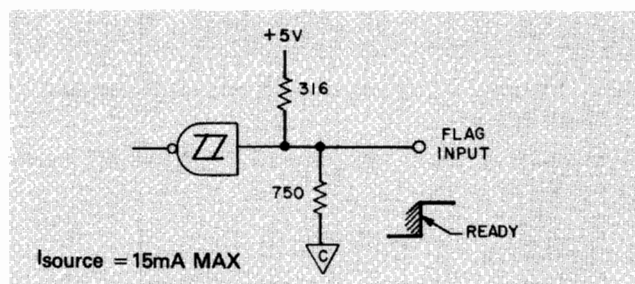
NOTES:

1. Gate and flag logic senses are the same for the standard 69331A and the 69331A with Option 073.

2. If the gate/flag feature is not used, a jumper should be connected between the gate-out and flag-in pins of the 69331A.

3. If a pulse is used to drive the Flag Input, the pulse width must be 2μs minimum.

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.

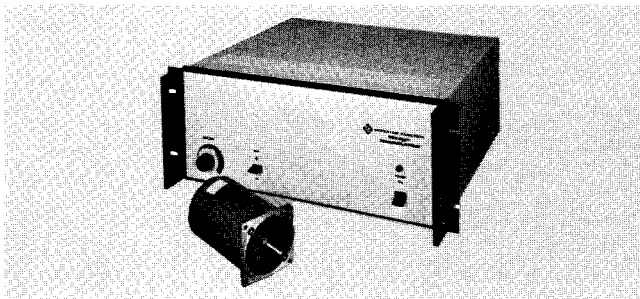**Operating Position:** Any (no restrictions).

Output Connector: One 15-pin dual (30-pin total) edge connector. Mating female connector assembly supplied (HP Part No. 14555A). This connector accommodates up to 15 wires with outside diameters of up to 62 mils each.

Open Collector Output Card
Model 69332A
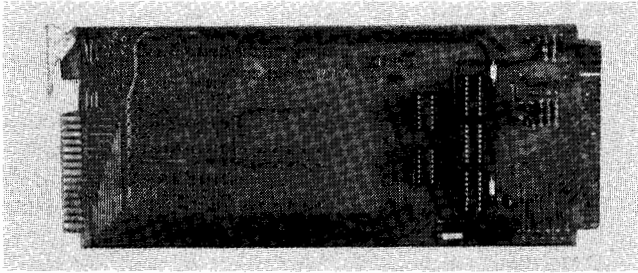
This digital output card is designed to drive lamps and relay coils utilizing an external dc power source. Digital storage circuits on the cards allow a single computer I/O channel to control up to 2,880 lamps or relay coils with a chain of 16 Multiprogrammer mainframes. Twelve IC buffers on the card act as switches for voltages up to 30 volts dc and currents up to 40mA.
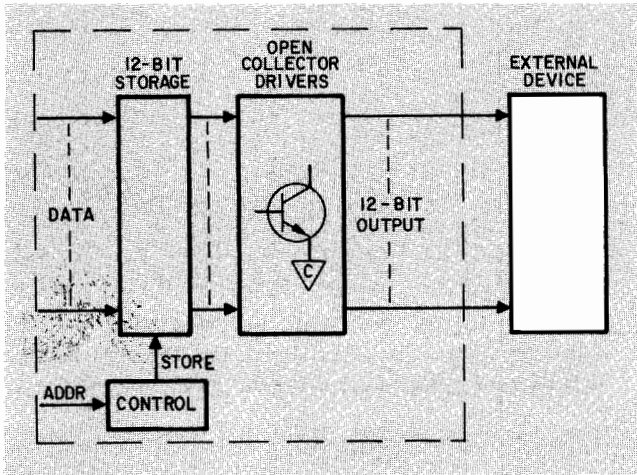
Control Signals: SYE and Flag functions are not used on Model 69332A.

Data Input: 12-bit binary. Logical 1 = driver ON; logical 0 = driver OFF.

Digital Output:

* IT IS IMPORTANT TO USE ONLY AN ISOLATED POWER SUPPLY BECAUSE THE COMMON ��AT THE 69332A IS CONNECTED TO EARTH GROUND THROUGH THE COMPUTER.

Output Circuit Ratings: 30 volts dc breakdown, 40mA maximum sinking capability. Reverse protection or free-wheeling diodes must be placed across relay coils or other inductive loads to prevent inductive voltage kicks from damaging the 69332A.
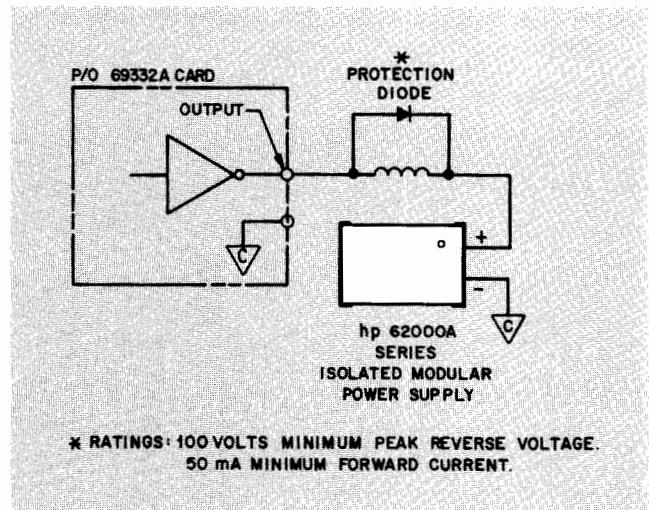
* RATINGS: 100 VOLTS MINIMUM PEAK REVERSE VOLTAGE. 50 mA MINIMUM FORWARD CURRENT.

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

Operating Position: Any (no restrictions).

Output Connector: One 15-pin dual (30-pin total) edge connector. Mating female connector assembly supplied (HP Part No. 14555A). This connector accommodates up to 15 wires with outside diameters of up to 62 mils each.

Relay Output with Readback Card
Model 69433A
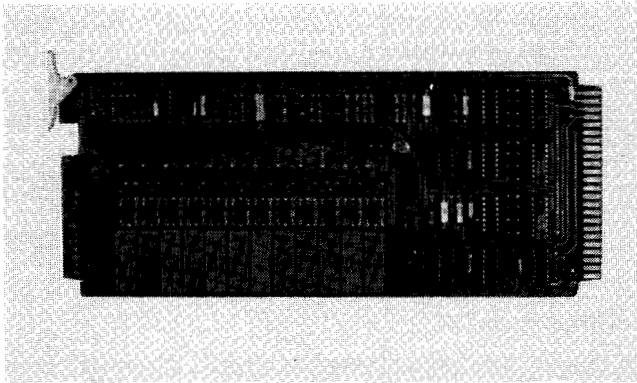
This card provides the same basic 12, independent, SPST, mercury-wetted normally open contact pairs as the Model 69330A Relay Output Card. In addition, the 69433A Relay Output/Readback Card allows the computer to examine the status of the relay coil drive circuits on the card, before and after the contacts are actually changed. The external gate and flag relays used on the 69330A are omitted from the 69433A.
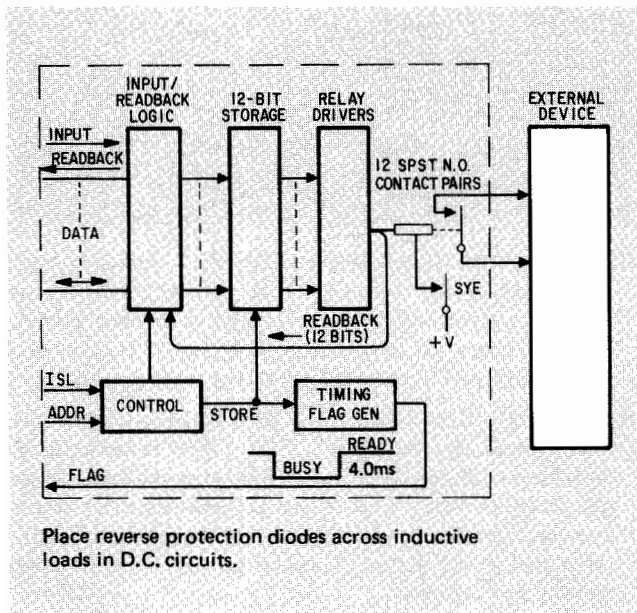
Place reverse protection diodes across inductive loads in D.C. circuits.

Control Signals:

SYE: Holds relays in deenergized state until SYE is programmed on. With SYE on, the relays will respond to programmed data.

ISL: Allows computer to read-in status of relay driver outputs. Refer to Operating Features Section for details.

TME: Allows flag signals from cards to control "busy" period of Multiprogrammer flag to computer. Refer to Operating Features Section for details.

Data Input: 12-bit binary. Logical 1 = contact pair closed; logical 0 = contact pair open. (This relationship can be reversed by the user if required.)

Data Readback: 12 bits, logical 1 = relay driver ON; logical 0 = relay driver OFF.

Relay Data:

Type: Twelve form A (SPST normally open), magnetically shielded, mercury-wetted reed relays.

Pull-in Time: 3.5msec

Release Time: 3.5msec

Contact Resistance: 300 milliohms maximum at full loading over rated life (10^8 operations).

Contact Loading: 100Vdc or ac 1.0A switching, 28VA maximum.

Thermal Offset: ±100 microvolts maximum per relay.

Channel Capacitance: 10pF open, 25pF closed, 20pF channel to channel, where a channel is any two adjacent reley contacts.

Frequency Response: Flat to within ±0.2dB from DC to 1MHz.

Crosstalk: Better than −60dB from DC to 1MHz with 50 ohm terminations.
Better than −30dB from DC to 1MHz with 1 megohm terminations.

Digital Outputs:

Breakdown Voltage: Potential difference between any one output terminal and chassis ground must not exceed 100 Vdc or 100V rms.

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.

Operating Position: Cards are mounted vertically in mainframe. The use of mercury-wetted relays limit tilt to 30° maximum displacement from vertical in any direction.

Output Connector: One 15-pin dual (30-pin total) edge connector. Mating female connector assembly supplied (HP Part No. 14555A). This connector accommodates up to 30 wires with outside diameters of up to 44 mils each.
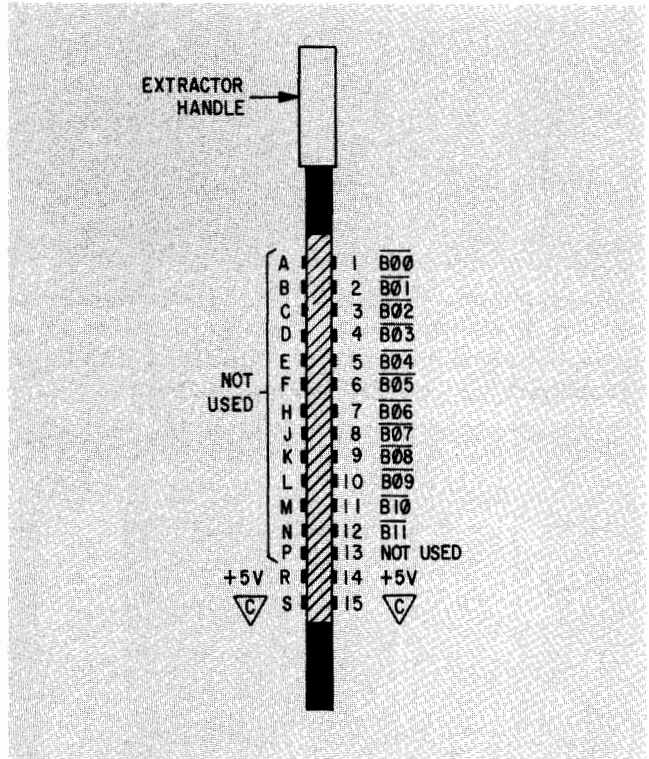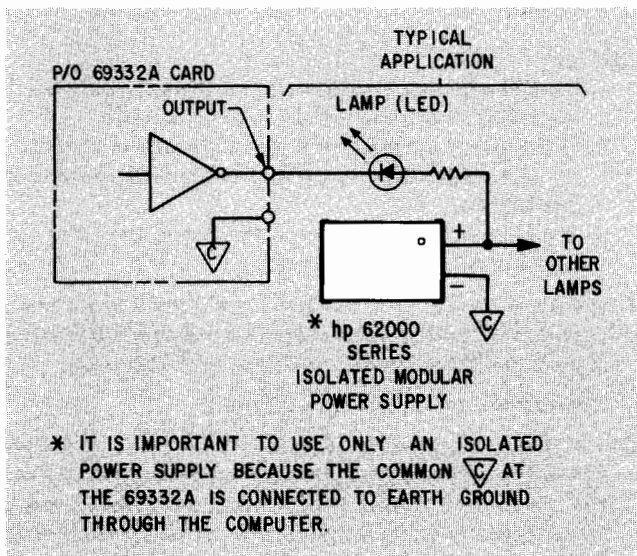
Relay Output Card
Model 69330A
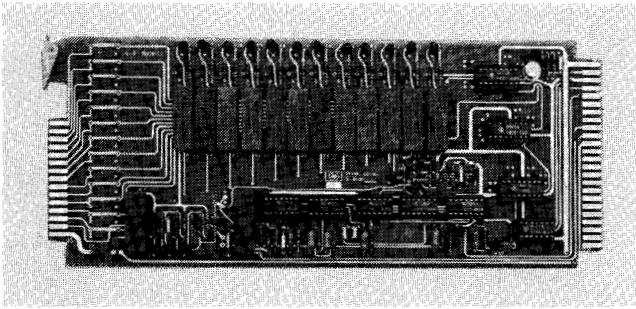
This card provides 12, independent, SPST, normally open mercury-wetted contact pairs. A maximum of 15 cards may be used in any one mainframe ($12 \times 15 = 180$ independent sets of contacts available for switching functions). Two additional relays are provided for external circuit Gate/Flag operation.
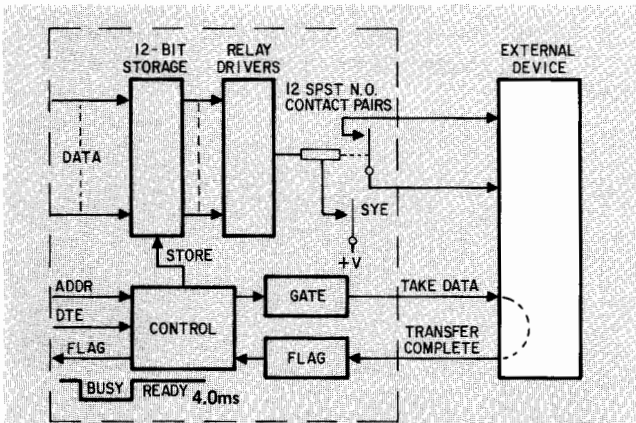
Place reverse protection diodes across inductive loads in D.C. circuits.

Control Signals:

SYE: Holds relays in deenergized state until SYE is programmed on. With SYE on, the relays will respond to programmed data.

DTE: Part of programming sequence that generates a gate signal to tell the external device to accept the digital outputs of the 69330A. The device signals back to the 69330A that the transfer is complete via a device flag.

TME: Allows flag signals from cards to control "busy" period of Multiprogrammer flag to computer. Refer to Operating Features Sections for details.

Data Input: 12-bit binary. Logical 1 = contact pair closed; logical 0 = contact pair open. (This relationship can be reversed by the user if required.)

Relay Data:

Type: Twelve form A (SPST normally open), magnetically shielded, mercury-wetted reed relays.

Pull-in Time: 3.5msec

Release Time: 3.5msec

Contact Resistance: 300 milliohms maximum at full loading over rated life (10^8 operations).

Contact Loading: 100Vdc or ac 1.0A switching, 28VA maximum.

Thermal Offset: ±100 microvolts maximum per relay.

Channel Capacitance: 10pF open, 25pF closed, 20pF channel to channel, where a channel is any two adjacent relay contacts.

Frequency Response: Flat to within ±0.2dB from DC to 1MHz.

Crosstalk: Better than −60dB from DC to 1MHz with 50 ohm terminations.
Better than −30db from DC to 1MHz with 1 megohm terminations.

Digital Outputs:

NOTE: IF GATE AND FLAG ARE NOT NEEDED FOR HANDSHAKING WITH AN EXTERNAL DEVICE, CONNECT PIN P TO 15 AND CONNECT PIN 13 TO 14.
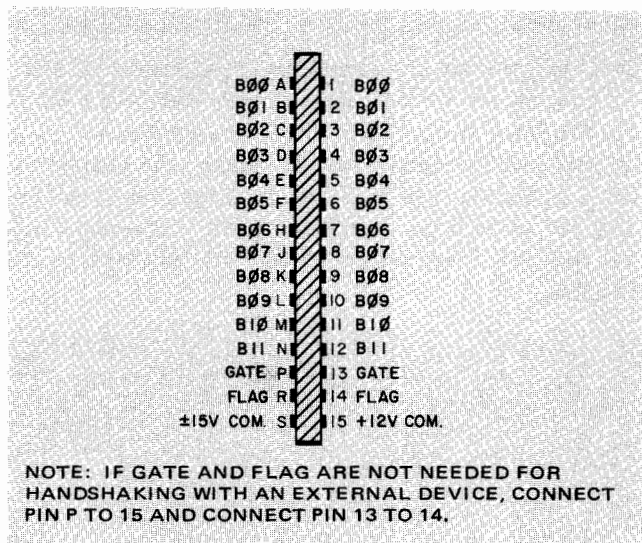
Device Command (Gate) Output: One SPST, normally open or normally closed (user selectable) contact pair. Change in contact status indicates data is present on card output. Contacts revert to original status either at start or end (user selectable) of external device response period.

Device Signal (Flag) Input: Can be either contact closure (sink 15mA maximum) or 12Vdc ±20% (source 15mA maximum). Presence of signal indicates external device has received data. End of signal indicates external device has completed response period. If external Flag input signal is not desired, Gate output can be connected directly to Flag input.

Breakdown Voltage: Potential difference between any one output terminal and chassis ground must not exceed 100 Vac or 100V rms.

Temperature Range: 0°C to $+70^{\circ}$C operating in mainframe (allows $+15^{\circ}$C internal rise when operating in mainframe at up to $+55^{\circ}$C ambient); -40°C to $+80^{\circ}$C storage.

Operating Position: The card is mounted in the mainframe with the relays vertical. The use of mercury-wetted relays limits tilt to 30° maximum displacement from the vertical in any direction.
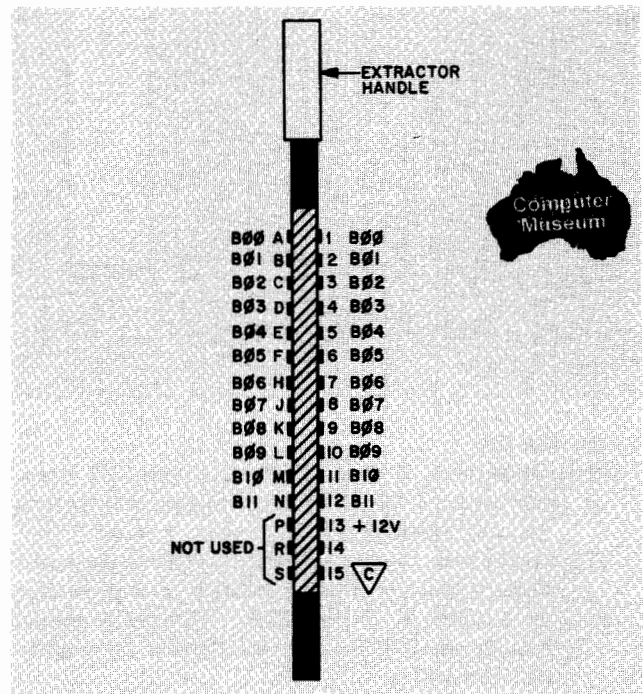
Output Connector: One 15-pin dual (30-pin total) edge connector. Mating female connector assembly supplied (HP Part No. 14555A). This connector accommodates up to 30 wires with outside diameters of up to 44 mils each.

DIGITAL INPUT

69430A Isolated Digital Input Card

When digital signals in a test or process must remain isolated from ground and from each other, the 69430A Isolated Digital Input Card is used. The external digital lines must be capable of supplying at least 3mA to each optically coupled isolator on the 69430A. The card has no storage or gate/flag handshake capability.

69431A Digital Input Card

This is the general purpose input card that has storage, gate/flag handshake capability, and the ability to interrupt the computer when the flag line is set by the external device. The card is used to read data from digital instruments, switches, IC's, contacts, and other digital data sources.

Gate/Flag Handshaking

Handshaking is necessary in many digital input operations where an orderly exchange of data is important. For example, suppose a computer is to be programmed to read a BCD number that an operator at a test station has set on a thumbwheel switch register. The interface must be made in a manner that ensures that the computer does not read the register at the moment the operator is changing the switches. One way to accomplish this is to connect the gate line of the 69431A Digital Input Card to a light emitting diode lamp next to the thumbwheel, and to connect the flag line of the 69431A to a pushbutton next to the thumbwheel. The 12 data bits of the 69431A (and bits from as many other 69431A's as necessary for large numbers) are connected to the BCD outputs of the thumbwheel. First, the computer addresses the Digital Input Card, causing the gate lamp to light as a signal that the

operator may now change the thumbwheel settings. After changing the thumbwheels, the operator pushes the flag pushbutton to let the computer know he's ready. Pressing the flag pushbutton automatically stores data on the 69431A, turns off the gate lamp (because the computer has not yet read the new data) and can even interrupt the computer if the program has been written to respond to the interrupt. Handshaking is not always necessary in switch reading and other digital input applications, but is nearly always used for reliable communication between digital instruments and computers. When not used, the gate and flag on the 69431A Digital Input Card are simply wired together in the card edge connector.

Reading More Than 12 Bits of Data Simultaneously

Each Digital Input Card is a 12-bit card, but several cards can be used when 16, 24, 32, or any number of bits are to be read in parallel. One way to make sure that data is simultaneously stored on a group of 69431A Digital Input Cards is to connect all their flag lines together.

Breadboard

For user-designed input circuit mounting, refer to the Breadboard Card section on page 53.

Interrupt

When computer time cannot be wasted waiting for an input or event to occur, the interrupt systems of the Multiprogrammer and the computer may be used. Refer to page 50 for information on this topic.

Isolated Digital Input Card
Model 69430A
(Must Specify One Option When Ordering)

Data Input (from external device): 12-bit binary.

The resistor R (in illustration below) in each input circuit determines the voltage levels that the 69430A will monitor. One of the following standard options or a special option may be selected by the user. External device must supply 3mA minimum.

LO Level	HI Level	HI appears as Logical 1 (Option)	LO appears as Logical 1 (Option)
0 to 0.4V	3.5 to 6V	073	069
0 to 0.4V	6 to 12V	087	084
0 to 0.4V	12 to 25V	088	085
0 to 0.4V	25 to 50V	089	086
0 to −0.4V	−3.5 to −6V	073	069
0 to −0.4V	−6 to −12V	087	084
0 to −0.4V	−12 to −25V	088	085
0 to −0.4V	−25 to −50V	089	086

Ground loops are one of the most persistent and annoying problems in automatic test and control systems. The 69430A Isolated Digital Input Card breaks the path of potential ground loops by using photoisolators in each input line.

Isolation between the ac earth-grounded I/O and external circuitry is necessary when the circuits being monitored are biased by power supplies that are isolated from ac earth ground (for safety or noise immunity purposes) or that are floating up to 100 volts dc above ac earth ground.

Since the need for isolation arises from power supply grounding circumstances, the card is designed to monitor only circuits that are active, not passive. Simple relay contacts that have no connection to a power supply are inherently isolated, and there is no further need for isolation. Relay contacts that are "dry" (i.e. no voltage or current) are monitored with 69431A or 69434A cards. "Dry" contacts cannot be monitored with the 69430A.

The card may be ordered with any of eight different options. These options allow the 69430A to be used with inputs having either ground-true or positive-true logic sense and to accommodate a wide range of logic levels.

R	OPTION
390Ω	069,073
1.5K	084,087
3.6K	085,088
8.2K	086,089

SUGGESTED CONFIGURATION TO DRIVE THE 69430A INPUTS WITH TTL SIGNALS
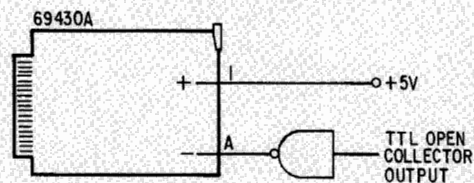
Breakdown Voltage: Potential difference between any input terminal and chassis ground must not exceed 100 Vdc or 100V rms.

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

Operating Position: Any (no restrictions).

Input Connector: One 15-pin dual (30-pin total) edge connector. Mating female connector assembly supplied (HP Part No. 14555A). This connector accommodates up to 30 wires with outside diameters of up to 44 mils each.

Control Signals:
ADDR: Card reads-in 12-bits from external device when unit (mainframe) and card addresses are issued.
ISL: Allows computer to read-in data.
TME, SYE: Not used with 69430A.

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Digital Input Card
Model 69431A
(Must Specify One Option When Ordering)

This card allows the computer to read 12 bits of logic level or contact closure data that is referenced to the computer logic common (ac earth ground). Inputs may be stored on the card or examined live. Gate/Flag circuits are provided on each 69431A to allow external input devices to use the interrupt system of the computer.

The card may be used to examine digital inputs at a point in time selected by the computer program (dedicated input mode) or by an external device connected to the flag line (interrupt search mode).
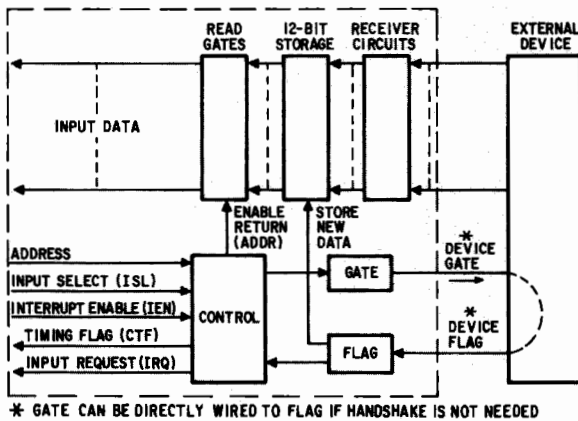
Control Signals:

In Dedicated Input Mode:

ISL on: Allows computer to read in data.

ADDR: Puts stored input data on Multiprogrammer backplane.

DEVICE GATE: Tells external device that computer is ready to read in new data.

DEVICE FLAG: Updates 12-bit storage register with new data for read in.

TME/CTF: Coordinates computer-device input cycle.

Interrupt Search Mode:

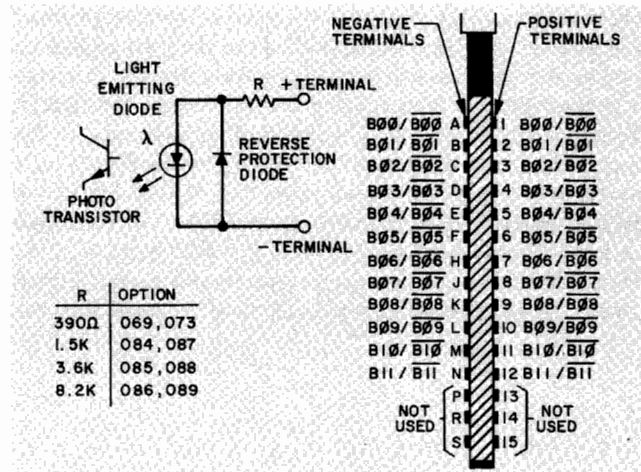IEN and TME: Activates all input cards. The cards in turn generate an output gate signal to tell the external devices that the computer is ready to accept input data.

ISL and ADDR: The computer polls each input card, examining the state of bit 15 (IRQ) of each return word. Bit 15 will be true if the addressed card requested an interrupt. The computer should read in the 12 return-data bits from any addressed input card whose associated IRQ bit is true.

Data Input (from external device): 12-bit binary. One of three standard Options (070, 069, and 073) may be selected to monitor different types of digital inputs.

	LOGICAL 1	LOGICAL 0
OPTION 069 GROUND TRUE	0 TO 0.8V	2 TO 5V
OPTION 073 POSITIVE TRUE	2 TO 5V	0 TO 0.8V

Device Command (Gate) Output: A high-to-low transition signals the device that the card is ready to receive new data. Signal levels for the three options are:

OPTIONS 073 and 069: HI = 2.0 to 5.0V; LO = 0 to 0.8V.

OPTION 070: HI = 8 to 13V; LO = 0 to 0.5V.

Device Signal (Flag) Input: A low-to-high transition of the flags' trailing edge causes the input card to store the digital input data from the device. Signal requirements for the three options are:

OPTION 070: HI = 6 to 14V or open contact; LO = 0 to 1V or closed contact.

OPTIONS 069 and 073: HI = 2.0 to 5V; LO = 0 to 0.8V.

A 5μs (minimum) wide pulse may be used to drive the Flag input.

Input Connector: One 15-pin dual (30-pin total) edge connector. Mating female connector assembly supplied (HP Part No. 14555A). This connector accommodates up to 15 wires with outside diameters of up to 62 mils each.
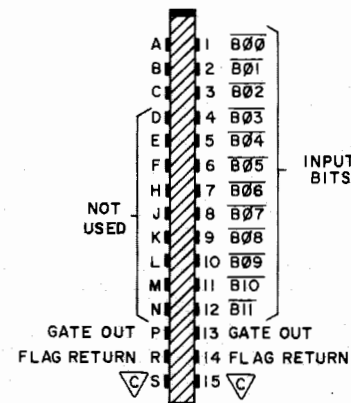
Option 095: Inputs compatible with 69331A.

Option 096: Logic levels and sense are compatible with the digital outputs of 69421A and 69435A cards.
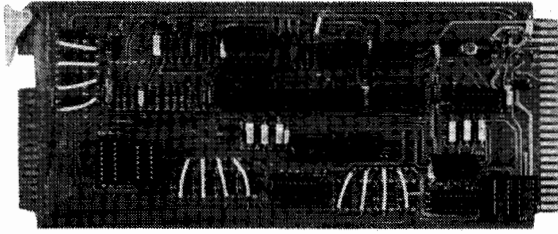
Temperature Range: 0°C to 70°C operating in mainframe (allows +15°C internal rise when operating in mainframe at up to +55°C ambient); −40°C to +80°C storage.

Operating Position: Any (no restrictions).

INTERRUPT CARDS

When to Use Interrupts

When an input is expected to occur at an unpredictable time, the interrupt systems of the Multiprogrammer and computer may be used rather than forcing the computer to waste time waiting for the input. When the input is ready, the Multiprogrammer tells the computer to stop what it is doing and service the input. Interrupts may also be used to notify the computer of emergency conditions, requiring immediate attention.

During the time while the Multiprogrammer is programmed to listen for interrupts, it cannot perform any other operations. If you want the Multiprogrammer to do something else while it is still listening for interrupts, you must temporarily disable the interrupt system to perform the operation. In most cases, the cards will catch interrupts that occur during this period and save them until the interrupt system is re-enabled. In the case of the 69434A Event Sense Card however, only events that occur while the interrupt system is enabled are detected. The other interrupt cards can be programmed to store interrupts even when the interrupt system is disabled.

69434A Event Sense Card

This card interrupts the computer when the 12-bit digital external word being monitored is unequal to the 12-bit reference word stored on the card by the computer. Jumpers on the card can be positioned to generate the interrupt when the external word is unequal to, equal to, greater than, or less than the 12-bit reference word. Filters on each input line make the card ideal for use in relay contact monitoring applications. The card has storage for 12 external lines. The interrupting bit (or bits) are identified. This card is for word-oriented contact closure events, while the 69436A Process Interrupt Card is for bit-oriented TTL events.

69436A Process Interrupt Card

This card interrupts the computer when any one or more of twelve lines being monitored change state. The card has storage for 12 external lines. Up to 24 lines can be monitored by one 69436A if identification of the interrupting line is not needed. The card stores data that lasts for 100 nanoseconds or more. The interrupting bit (or bits) are identified. The card can be programmed to store events which occur while the interrupt system is off. This card is for bit-oriented TTL events, while the 69434A Event Sense Card is for word-oriented contact closure events.

69422A High Speed A/D Card

This card can be programmed to interrupt the computer when it is externally triggered to take a reading. The 69422A data sheet is on page 32.

69431A Digital Input Card

A flag signal from an external device can be used to generate an interrupt with this card. The 69431A data sheet is on page 49.

69600B Timer Card

This card can be programmed to generate an interrupt when the programmed time interval expires. The 69600B data sheet is on page 38.

Output Cards

The Multiprogrammer can also be set up to interrupt the computer when output operations (such as turning a stepper motor) complete.

Event Sense Card
Model 69434A
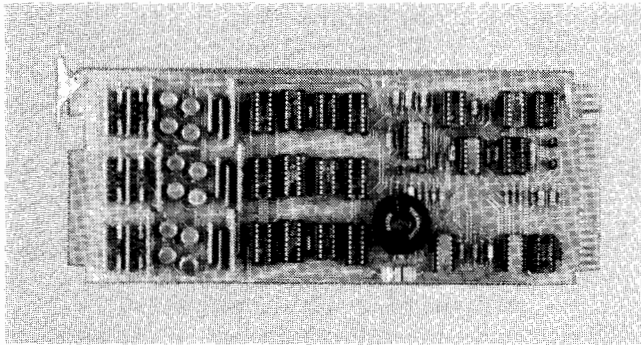
This card monitors up to 12 external contact closures and interrupts the computer when one or more contacts change state with respect to 12 reference bits stored on the card. Jumpers on the card allow the user to reconfigure the card to interrupt when the 12 bits being monitored are equal to, not equal to, greater than, or less than a programmed 12-bit reference pattern stored on the card. This flexibility allows the Multiprogrammer to act as an alarm sensor, freeing the computer to perform other tasks during non-alarm conditions.

Signal conditioning circuits for each input line discriminate between bona fide contact changes and noise or contact bounce.

See page 50 for more on the 69436A versus the 69434A.
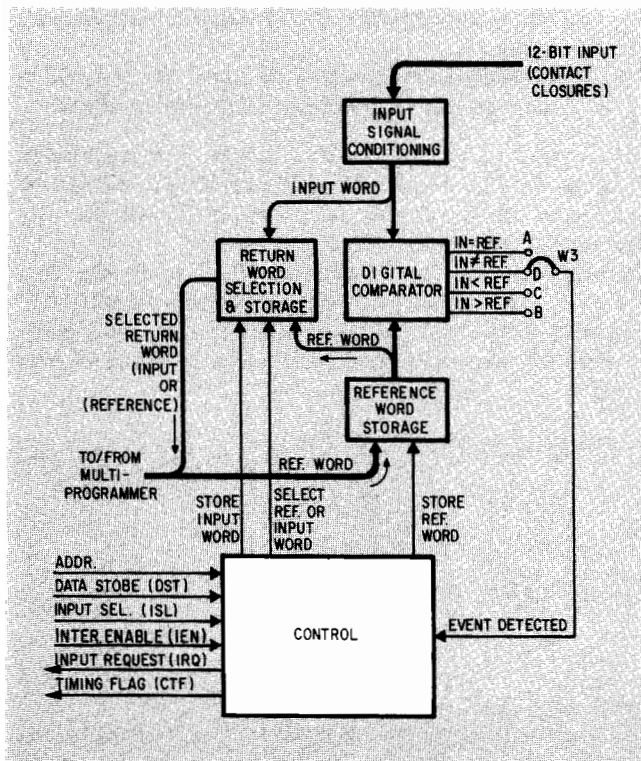
signals involved in each step is listed along with the associated step.

(1) Load reference word into storage registers on addressed event sense card (ISL and TME off).

(2) Activate card (ISL on, TME off) so that it can generate a computer interrupt when an event takes place and the multiprogrammer is set to the interrupt enable mode.

(3) Program interrupt enable mode (IEN and TME on, ISL off).

(4) Detect an event and notify the computer of this condition (flag to computer goes busy).

(5) Program the interrupt search mode (IEN and TME off, ISL on).

(6) Poll event sense cards (by issuing card addresses without a computer gate) and note the state of bit 15 (IRQ) of the return word. Bit 15 will be true if the addressed card had previously sensed an event. The computer should accept the 12 return-data bits from any addressed event sense card whose associated IRQ bit is true.

Digital Inputs: The 69434A is designed to monitor contact closures or openings lasting at least 20 milliseconds and to filter out contact bounce and noise lasting less than 5 milliseconds.

Event sense detection is based on system consideration such as number of event sense cards, operating system and processing programs utilized.
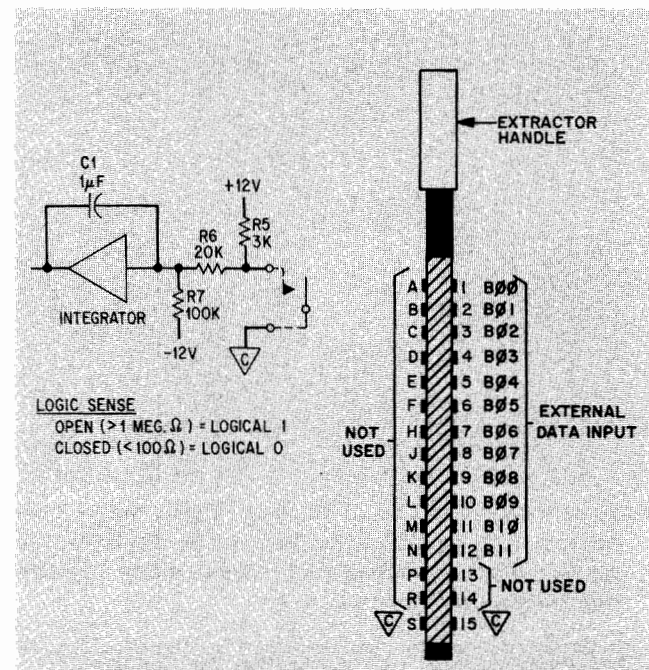
Temperature Range: 0°C to +70°C operating in mainframe (allows +15°C internal rise when operating in mainframe at up to +55°C ambient); −40°C to +80°C storage.

Operating Position: Any (no restrictions).

Input Connector: One 15-pin dual (30-pin total) edge connector. Mating female connector assembly supplied (HP Part No. 14555A). This connector accommodates up to 15 wires with outside diameters of up to 62 mils each.

Control Signals:

The following steps outline a typical programming sequence used to load a reference word into an event sense card, activate the card, sense an event, poll for the interrupting card, and read in the data from that card. The state of the control

Process Interrupt Card
Model 69436A

This card provides TTL and open collector compatible edge detectors; one positive and one negative for each of 12 storage latches. Logic transitions lasting 100nsecs or longer are detected, stored, and used to generate an interrupt signal to be sent to the controller. The 69436A can monitor up to 24 input lines (from other cards or from external sources), providing a high speed interrupt when any line makes an appropriate transition. If an input line is connected to more than one edge detector, software routines permit the controller to determine the polarity of the interrupting transition.

See page 50 for more on the 69436A versus the 69434A.
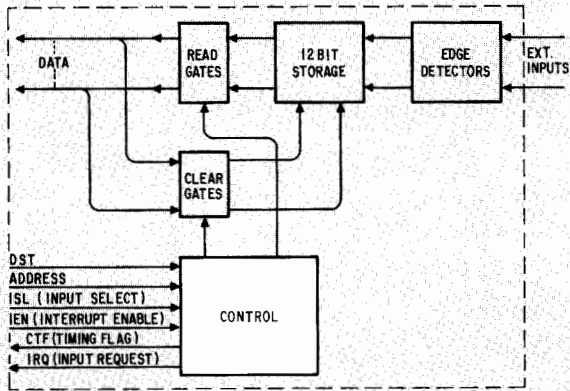
External Inputs (From Logic Circuits): Twelve inputs from external TTL or open collector circuits. Each input is connected to a corresponding positive and/or negative edge detector circuit on the card.
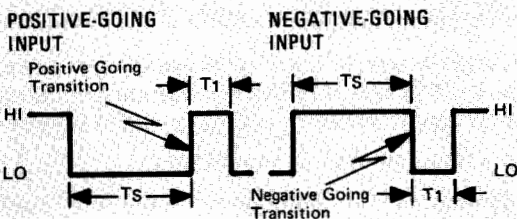
Logic Levels: HI = 2.5V (min) to +5.25 (max)
               LO = OV (min to + 0.4V (max)

Rate of Rise: 5V/μsec minimum
Rate of Fall: 5V/μsec minimum
Set Up Time (T_S): Input must remain LO (HI for negative-going input) for a minimum of 1.0μsec before it switches HI.

Pulse Duration (T_1): 0.1μsec minimum.

External Input Circuit Current Sink:
   When connected to a positive or a negative edge detector circuit: may sink 0.5mA max at logic HI (5.25V)
                         must sink 2.6mA min at logic LO (OV)
   When connected to a positive and a negative edge detector circuit: may sink 1.0mA max at logic HI (5.25V)
                         must sink 4.4mA min at logic LO (OV)

Control Signals:
   Output Mode (ISL, IEN, TME off, ADDR true):
      a. Initialize card by sending a data word with logical ones in bit positions B00 thru B11; or
      b. Reset card by sending a data word with logical ones in the bit positions where transitions were detected; or
      c. Disarm card by sending a data word with logical zeros in bit positions B00 thru B11.
   Input Mode (ISL on, ADDR true):
      a. Input data to controller; or
      b. Arm card by sending DST
   Interrupt Mode (IEN, TME on):
      a. Allows card to control CTF and interrupt the controller.
      b. Arms card automatically if jumper W6 is installed (the 69436A card is shipped with W6 installed).

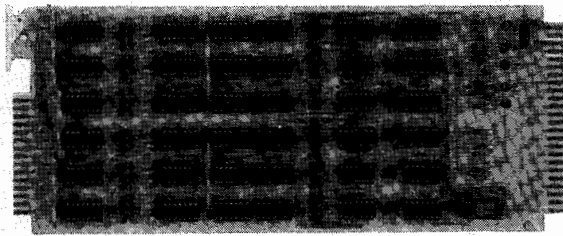**Temperature Range:** 0° to 70°C operating in mainframe (allow +15°C internal rise when operating in mainframe at up to +55°C ambient); —40°C to +80°C storage.
Operating Position: Any (no restrictions).
**Output Connector:** One 15-pin dual (30-pin total) edge connector. Mating female connector assembly supplied (HP (HP Part No. 14555A). This connector accommodates up to 30 wires with outside diameters of up to 44 mils each.
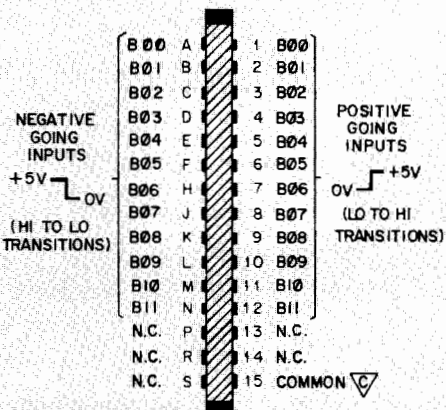
BREADBOARD CARDS

General

Each breadboard card has space on it for mounting custom user-designed circuitry. The various power supplies of the Multiprogrammer may be tapped through the breadboard cards to power external circuitry.

The major differences between the three breadboard models are as follows:

- 69480A - Has input buffer gates for driving the 6940B backplane with input data.
- 69380A - Has output storage buffers for using backplane output data to drive external or custom circuits.
- 69280A - Has no circuits at all, only a generalized grid pattern.

Power Limitations

The following limits should be observed for each breadboard card to ensure that the current drawn from the $+5V$, $+12V$, and $-12V$ power supplies will not exceed the maximum current.

Power Supply	Maximum Current Per Mainframe	Maximum Current Per Card
$+5V$	3A	200mA
$+12V$	2.7A	180mA
$-12V$	750mA	50mA

Power consumption from the $\pm 15V$ supplies must be kept to the limits shown in the following table.

Power Supply	#1	#2	#3	#4
Rating	750mA	150mA	150mA	150mA

The other Multiprogrammer cards which use these $\pm 15V$ supplies draw current from the supplies as shown in the following table.

Plug-in Card	Current Requirement
69321B	47 mA
69322A	100 mA
69370A	47 mA
69422A	140 mA
69423A	70 mA

Breadboard Card
Model 69280A
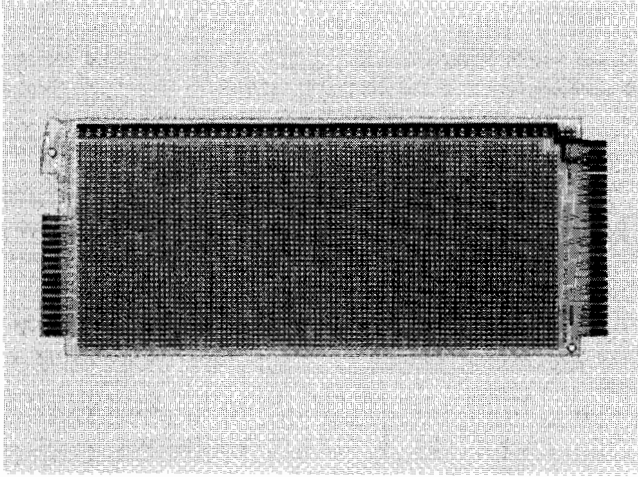
For Mounting Custom Circuitry

The HP 69280A Breadboard offers Multiprogrammer owners a generalized grid pattern for the mounting of custom circuitry used with the Multiprogrammer. Resistors, IC's, capacitors, and other types of components can be mounted on the 9½" x 4" grid area of the card. The grid area is composed of plated through holes spaced 0.1" apart. The holes are connected by traces in groups of 3 to facilitate point-to-point wiring of components on card. Up to thirty signal/power lines may be connected to the board through the connector supplied.

Such circuits as input amplifiers, active and passive filters, level converters low level signal conditioning, and special relay configurations may be mounted on this card. UP to 60 16-pin IC packages can be installed on the card with ample space to run wiring. The drilled holes are 0.044" in diameter and will accommodate most low power components.

For Accessing The Power Supplies Of The Multiprogrammer

Through the 69280A, the various power supplies of the 6940B Multiprogrammer can be tapped to power external circuitry. These power supplies are the +5V, +12V, and −12V supplies, tied to the controller common, and the four ±15V supplies, isolated from the controller common.

The supplies can be used to drive the circuits mounted on the breadboard card or can be brought through the output connector to the outside world. To use the ±15V supplies, the HP 69351B Voltage Regulator Card must be installed in slot 600 of the mainframe. The +5V and ±12V supplies require no additional cards.

Power consumption from the +5V, +12V and −12V supplies should be kept to the limits shown in the Tables on page 53 to ensure that the ratings of these supplies will not be exceeded, regardless of the number of breadboard cards installed in the mainframe. If external power is dissipated on the card, you should verify that the temperature within the mainframe is no more than 15°C above the ambient temperature outside the mainframe. The 62413A Cooling Unit may be used when necessary.

Dimensions: (all are nominal)
Overall: 114.30mm x 279.40mm/ 4.5" x 11.0"
Custom Component Mounting Area: 234.95mm x 107.95mm/9.25" x 4.25"
Max.Component Height Off Card: 10.16mm/0.4"
Grid Hole Size: 1.118mm/.044"
Grid Hole Spacing: 2.54mm/.100"

Maximum Trace Current: 5 Amps

Maximum Voltage: 100V dc or 100V rms between chassis ground and any point on the card.

Operating Position: Any (no restrictions)

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.)

Output Connector:
One 30-pin dual contact edge connector supplied. HP model number 14555A. This connector accommodates up to 15 wires with outside diameters up to 62 mils each or up to 30 wires with outside diamters up to 44 mils each.

Signals Available on Card:
All Multiprogrammer backplane signals are available unbuffered on the card. All power supplies in the Multiprogrammer are also available on this card. To use the ±15V supplies, the HP 69351B Voltage Regulator Card is required.

Breadboard Output Card
Model 69380A
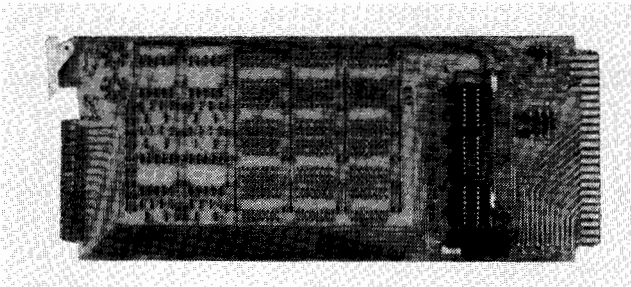
User-designed output circuits can be mounted on this card to implement a special function that is under computer control through the Multiprogrammer. The card is supplied with storage flip-flops and address decoding circuits. The SYE, DTE, and common flag lines are buffered on the card for interaction with custom circuits. General-purpose printed circuit patterns on the card allow the user to mount up to twelve 16-pin dual in-line packages, and approximately 30 other transistors, resistors, capacitors, or other small electronic components. The components are interconnected by the user with point-to-point hand-soldered wiring. The internal Multiprogrammer +5V, +12V, and −12V power supplies are available for use on the card, and the four isolated ±15V supplies are available when the 69351B Voltage Regulator Card is installed in the Multiprogrammer Mainframe.

To ensure that the current drawn from the +5V, +12V, and −12 volt power supplies will not exceed the maximum current, regardless of the number of custom-made cards the user installs in the mainframe, each card should be designed to draw less than the values shown in the tables on page 53 Also, the user should verify that temperatures within the mainframe remain at less than 15°C above ambient temperature outside the mainframe if external power is dissipated on the card. The 62413A Cooling Unit shown on page 15 can be used when necessary.

Typical Applications

- Parallel-to-Serial Converters
- Latching Relay Outputs
- Form-C Relay Outputs
- Logic Window Control
- Programmable Amplifiers
- Line Driver Outputs
- Buffer Memory
- D/F Converter
- Non-Linear DACS
- Multiplying DACS
- Code Converters
- TTY Interface

Digital Outputs

Digital Outputs: The twelve digital outputs from three low power quad bistable latches (SN 74L75N) are available at the edge connector.

Logical 1 = 2.4V min. @ 200μA output
Logical 0 = 0.4V max., sinking 8mA

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:
Overall: 114.30mm x 279.40mm 4.5″ x 11.0″ (nominal)
Customer Component Mounting Area: 76.20mm x 117.80mm 3″ x 7″ (nominal)
Max Component Height off Card: 10.16mm 0.4″ (nominal)

Output Connector: One 30-pin dual contact edge connector supplied. HP Part No. 14555A. This connector accomodates up to 15 wires with outside diameters up to 62 mils each, or up to 30 wires with outside diameters up to 44 mils each.

Breadboard Input Card
Model 69480A
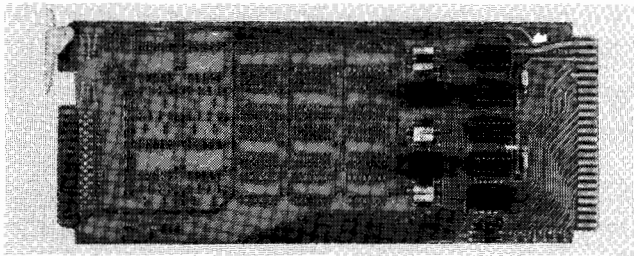
User-designed input circuits can be mounted on this card to implement a special monitoring function with the Multiprogrammer. The card is supplied with address decoding circuits. The ISL, IEN, interrupt request, data strobe, and common flag lines are buffered on the card for interaction with custom input circuits. General-purpose printed circuit patterns on the card allow the user to mount up to twelve 16-pin dual in-line packages, and approximately 30 other transistors, resistors, capacitors, or other small electronic components. The components are interconnected by the user with point-to-point hand-soldered wiring. The internal Multiprogrammer (+5V, +12V, and −12V) power supplies are available for use on the card and the four isolated ±15 volt supplies are available when the 69351B Voltage Regulator Card is installed in the Multiprogrammer Mainframe.

To ensure that the current drawn from the +5V, +12V, and −12 volt power supplies will not exceed the maximum current, regardless of the number of custom-made cards the user installs in the mainframe, each card should be designed to draw less than the values shown in the tables on page 53. Also, the user should verify that temperatures within the mainframe remain at less than 15°C above ambient temperature outside the mainframe if external power is dissipated on the card. The 62413A Cooling Unit shown on page 15 can be used when necessary.

Typical Applications

- Serial-to-Parallel Converters
- Shaft Position Encoders
- Threshold Detectors
- Go/No Go Logic Testing
- Code Converters
- Limit Switches
- TTY Interface
- Line Driver Inputs

Digital Inputs:
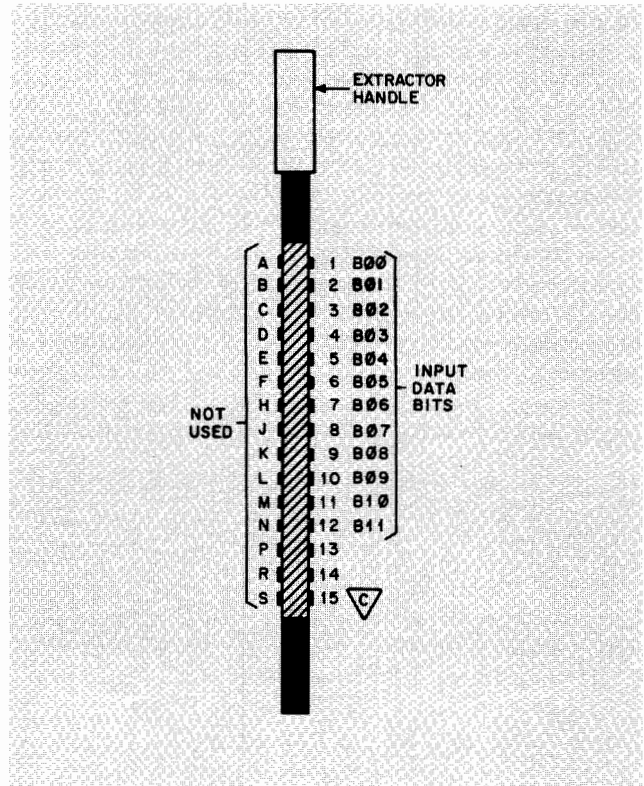
Digital Inputs: The twelve digital inputs to three open collector quad two-input nand gates (SN 7438N) are available at the edge connector.

Logical 1 = 2V min. @ 40μA output.
Logical 0 = 0.8V max., sinking 1.6mA.

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.
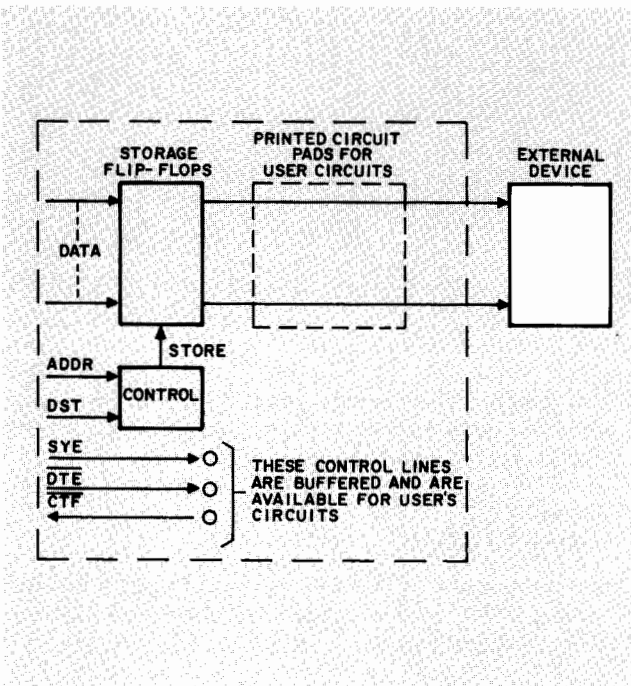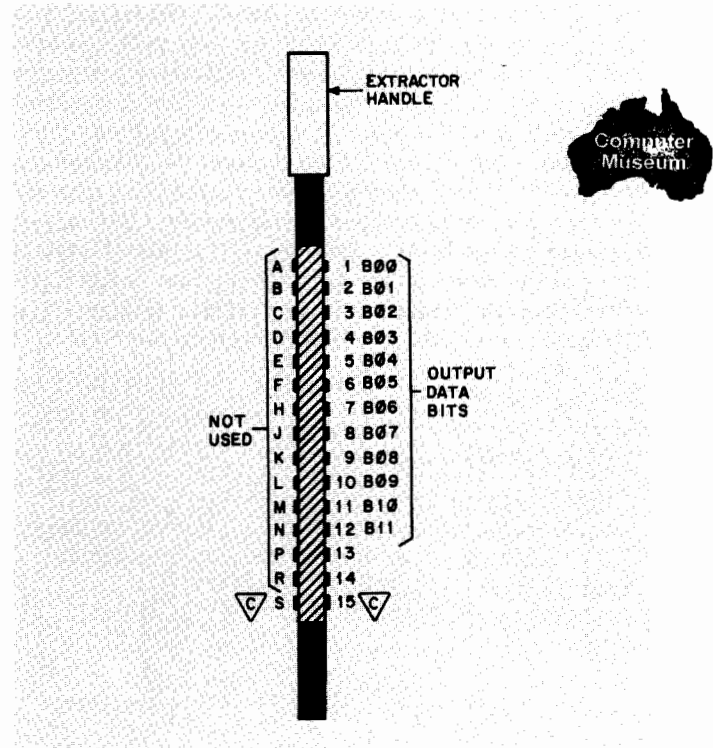
Dimensions:
Overall: 114.30mm x 279.40mm 4.5" x 11.0" (nominal)
Customer Component Mounting Area: 76.20mm x 117.80mm 3" x 7" (nominal)
Max Component Height off Card: 10.16mm 0.4" (nominal)

Input Connector: One 30-pin dual contact edge connector supplied. HP Part No. 14555A. This connector accomodates up to 15 wires with outside diameters up to 62 mils each, or up to 30 wires with outside diameters up to 44 mils each.

SERVICE KIT
Model 14551A

The HP Model 14551A Multiprogrammer Service Kit is a diagnostic and service aid for the Hewlett-Packard Model 6940A/B Multiprogrammer subsystems. It is used by HP field offices in support of service contracts, and by users with a need for the shortest possible down time.

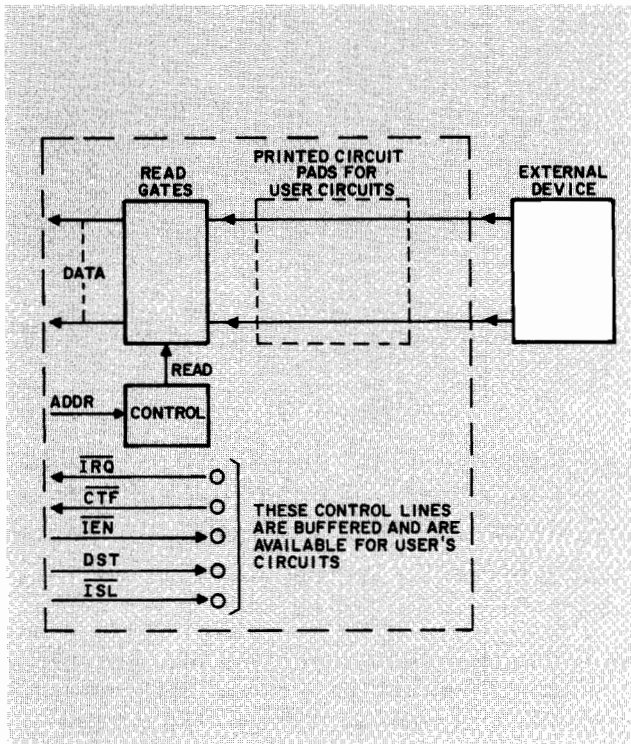Like the Multiprogrammer itself, the standard kit is flexible and can be specifically configured to meet each user's needs. The 14551A contains a selection of the most frequently needed replacement assemblies and spare parts, and documentation for trouble isolation. It allows Multiprogrammer users to make most repairs on-site, with resulting minimum down time.

The 14551A is designed to be used with an HP computer in the HP 1000 series, a 9825A desktop computer, or by the 6940B operating alone in the LOCAL mode.

The standard 14551A Service Kit consists of an attache-type case containing:

- 6940B A2, A3, and A5 mainframe plug-in cards.
- Parts for modifying these cards so that they may be used in a 6940A mainframe if desired.
- Various quantities of 38 different selected components for these cards and the mainframe assemblies.
- Programs and instructions on a 9825A tape cartridge for HP-IB verification of the mainframe and all currently available input and output cards; 16-bit duplex mainframe verification routines.
- A paper tape for HP-1000 series computer verification of the mainframe.
- A 69331A Output Card and a 69431A option 095 Input Card for these tests.
- A LED test card and connecting cables for HP-IB card verification.
- A 5060-7901 extender card, an instruction manual for the 6940B and 14551A, operating note, parts list.
- Several additional slots are provided in the case for spare input or output cards.

Dimensions: The 14551A is 46 cm wide by 38 cm deep by 14 cm high (18 in. by 15 in. by 5-1/2 in.). Net weight is 5 kg. (11 lbs.). Shipping weight is 8 kg. (17 lbs.).

Accessory Available: A 69330A Relay Output Card facilitates testing of 69430A cards other than option 069.

Special Configurations: The spare parts in the standard 14551A Kit are also used on some input and output cards. Additional parts and cards can be supplied to support any combination of cards and extenders, by a program that eliminates duplication. See your HP Field Engineer for more information on special configurations.

Special Kit: Your HP Field Engineer can supply you with the special kit quotation form.

Configuration Checklist

This checklist will help you compile a complete list of the equipment necessary to configure your system.

1. Controller

Model No.	Roms	Interface
9825S	98213A/14A/16A 98210A (Note: these are included with the 9825S)	16-bit duplex: 98032A opt 040 OR HP-IB: 98034A and 59500A
9835A or 9835B	98332A	16-bit duplex: 98032A opt 340 OR HP-IB: 98034A and 59500A
9845A or 9845S	98432A or opt 32('	16-bit duplex: 98032A opt 440 OR HP-IB 98034A and 59500A
HP 1000		16-bit duplex: 14550B (Contains software drivers and hardware interface) OR HP-IB: 59310B and 59500A

2. Additional HP-IB Cables (for HP-IB systems only)

☐ The 98034A comes with a cable and connector for the first instrument to be connected to the bus. Additional instruments require one of the following cables:

10631A	HP-IB cable	1m (3.3 ft)
10631B	HP-IB cable	2m (6.6 ft)
10631C	HP-IB cable	4m (13.2 ft)

3. Mainframes

☐ 6940B: Holds up to 15 I/O Cards plus one 69351B Voltage Regulator Card.

☐ 6941B and 14541A: For each additional set of 15 I/O Cards

4. Plug-in Cards

☐ One option for logic level and logic sense must be specified when ordering 69431A Digital Input Cards or 69430A Isolated Digital Input Cards.

☐ One 69351B Voltage Regulator card must be placed in each 6940B or 6941B Mainframe that contains one or more 69321B Voltage DAC, 69322A Quad DAC, 69370A Current D/A, 69422A High Speed A/D, or 69423A Low Level A/D and Scanner.

5. Extra Manuals

☐ One operating and service manual is provided with each product. To order additional manuals, specify option 910 at additional cost.

6. Rack Mount Hardware

☐ To order rack mounting hardware for 6940B and 6941B, specify option 908 at additional cost.

7. Extra Plug-in Card Connectors

☐ One 30-pin connector assembly model 14555A is provided with each plug-in I/O card (except models 69321B, 69370A, 69423A, and 69500A through 69513A, which have screw terminal blocks). Model 14555A Connector Assembly is available for separate purchase. Unterminated 15-conductor cable, HP Part No. 8120-1903 is convenient for use with the 14555A connectors. Two 15-conductor cables can be used in each connector hood. Order the wire by the foot.

8. Software Library

☐ For 9825 systems, the 14556A contains routines for simplified Multiprogrammer Operation.

9. Customer Training Seminar

☐ 6940B Option M32 for three days of hands-on training with the 6940B Multiprogrammer and any of these controllers: 9825, 9835, or 9845.

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