# Measurement and Control Peripherals

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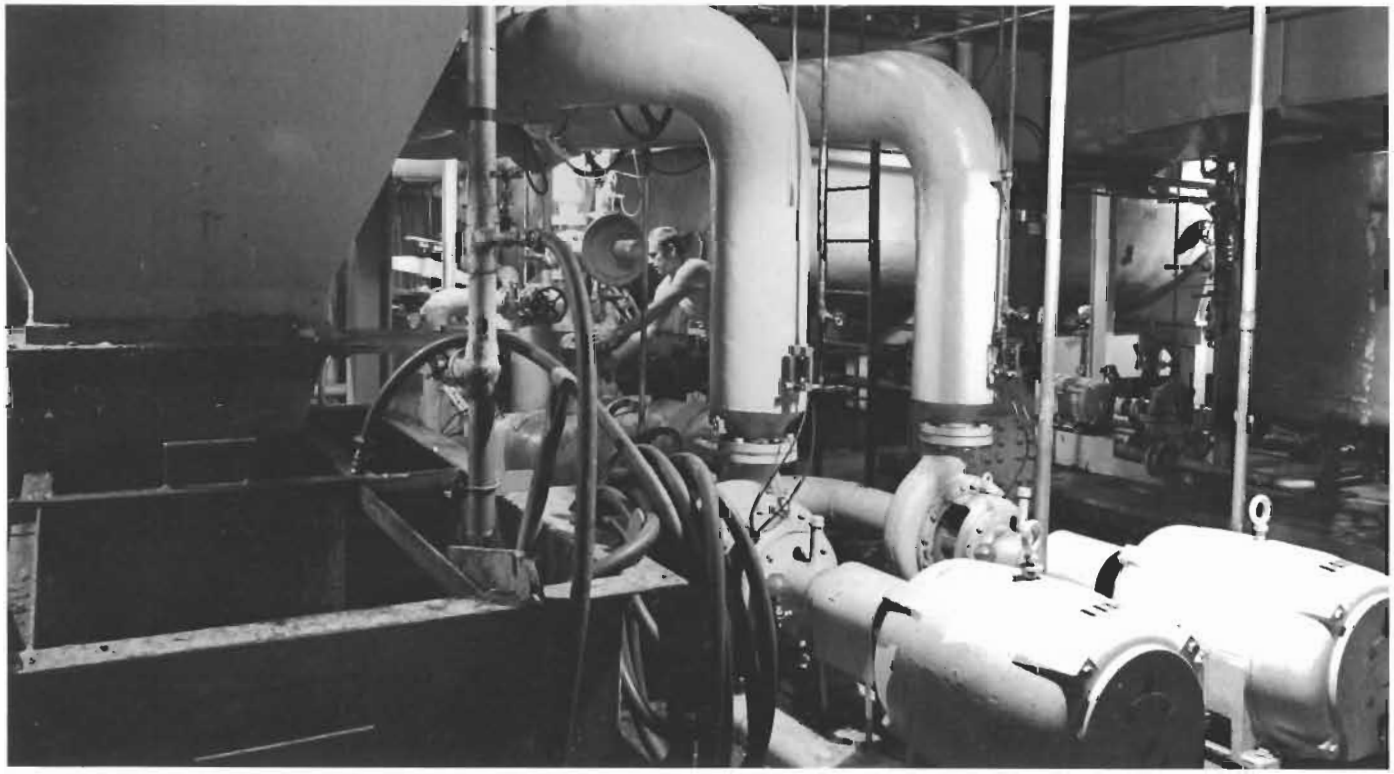
## Stations and subsystems for measurement and control applications

Technical Data



# Introduction

This document contains technical data and specifications for Hewlett-Packard products that are used in scientific or industrial measurement and control applications. The products contained in this data book are listed in the table of contents shown below. Ordering and configuring information for these products are contained in the HP 9603R and HP 9611R Configuring Guide, HP Literature Request Number 5952-8507. These products are used with controllers, such as HP 2100S Computers, HP 21MX Computers, HP 96MX Series Computer Systems or HP 1000 Series Computer Systems. Consult with your HP Sales Representative for technical data and ordering information for controllers and related peripherals.

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# Scientific Measurement and Control Station

model 9603R

Technical Data 9/76

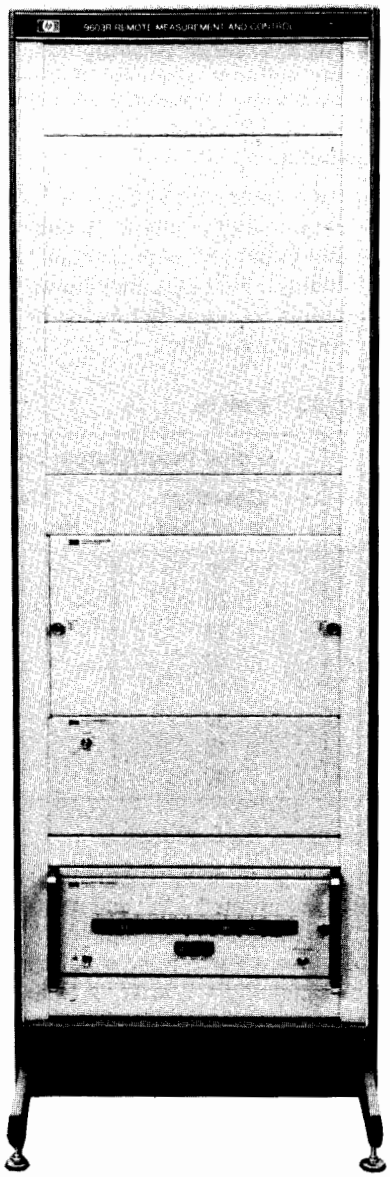
## Features

- **12-Bit, 45 kHz analog-to-digital Converter**
- **16 to 528 high or low level inputs**
- **12 to 1080 digital I/O signal lines**
- **Operation up to 3 km (10,000 ft.) away from computer/ controller**
- **Up to 8 local/remote stations**
- **Sensor-Based DAS Library routines**
- **Extended ISA FORTRAN support**

## Description

The HP 9603R Scientific Measurement and Control Station that is used with HP 2100S Computers, HP 21MX/E Computers, HP 96MX series Computer Systems, or HP 1000 series Computer Systems in data acquisition and control applications, where analog and digital input/output signal interfacing to external sources are required. It consists of an analog and digital input/output subsystem (HP 2313B) together with a communication subsystem which provides serial communication to one of the aforementioned computers up to 3 km (10,000 ft.) away via hardwired, twisted pair cables.

The 9603R also includes a cabinet housing the analog input/ output subsystem. Optionally the 9603R can be interfaced locally to the computer for higher throughput or analog and digital input/output signal interfacing close to the computer.





## Specifications

**Analog Input/Output Capacity**

| Cabinet Expansion Option | Analog Input/Output Subsystem | |
|---|---|---|
| | Capacity: No. of Cards | Capacity: No. of Inputs |
| none | 7 | 112 |
| none | 7 | 112 |
| 050 | 19 | 304 |
| 050 | 31 | 496 |
| 051 | 19 | 304 |
| 051 | 19 | 304 |
| 052 | 7 | 112 |
| 052 | 7 | 112 |

HP 12751A High-Level Multiplexer: 16 differential/32 single-ended inputs/card, up to ±10.24V fs, up to 45,000 chan/sec or samples/sec/chan.
HP 12761A Solid-State Low-Level Multiplexer: 16 differential inputs/card, programmable ranges ±10 to 800 mV fs, CMV to 10V peak, up to 8,000 chan/sec, up to 50 samples/ sec/chan.

# Specifications

HP 12760A Relay Low-Level Multiplexer: 16 differential inputs/card, programmable ranges ±10 mV to 200 mV fs, CMV to 200V peak, up to 125 chan/sec, up to 20 samples/sec/chan.
HP 12757A Dual 12-Bit Digital-Analog Converter: two 0 to ±10.24V fs, 20 mA analog outputs per card, 5 mV resolution, up to 15,000 points/sec.
HP 12755A Programmable Pacer: precision programmable decade multiple intervals from 1 $\mu$s to $10^7$ $\mu$s times programmable multiple from 1 to 255, 0.01% accuracy, 50 ns aperture with high-level multiplexer.

*Note: For detailed specifications on the analog I/O subsystem and its plug-ins, other than data rates, see the HP 2313B Analog I/O Subsystem data sheet, HP Literature Request Number 5952-8511.*

### Analog I/O Expanders

HP 12764A First Expander: adds 12 spaces for analog input/output cards (up to 192 inputs or 16 outputs).
HP 12765A Second Expander: adds another 12 spaces (or 24 spaces total including first expander above) for another 192 inputs/16 outputs (or up to 384 inputs or 32 outputs total including the first expander).

### Digital Input/Output Capacity

| Cabinet Expansion Option | Digital Input/Output Subsystem | |
|---|---|---|
| | Capacity: No. of Cards | Capacity: No. of I/O Lines |
| none | 15 | 180 |
| none | 30 | 360 |
| 050 | 30 | 360 |
| 050 | 30 | 360 |
| 051 | 45 | 540 |
| 051 | 60 | 720 |
| 052 | 75 | 940 |
| 052 | 90 | 1080 |

### Digital I/O Subsystem Plug-In Modules

HP 91202A 12-Bit Digital Inputs: 12 digital input chan/card, available in direct and isolated TTL, and contact closure input versions.
HP 91205A 12-Bit Event Sense Interrupt Input: 12 digital input chan/card receive equal, greater, or less than comparison to reference word, interrupts if comparison condition is satisfied, contact closure input.
HP 91221A 12-Bit Pulse Counter: up and down count inputs for count of external pulses up or down to/from 4095 at pulse rates to 200 kHz, available in TTL or contact closure level input versions.
HP 91201A 12-Bit Digital Outputs: 12 digital output chan/card, available in TTL, and contact closure output versions.
HP 91220A Stepping Motor Control: generates clockwise or counterclockwise outputs, up to 2047 step pulses, available with TTL or 12V output.
HP 91208A Programmable Timer: generates output gate pulse from jumper-selectable, decade multiple 1 $\mu$s to $10^5$ $\mu$s intervals times programmable multiple from 1 to 4095 (a range of 1 $\mu$s to 6.8 minutes), TTL output level.
HP 91209A Frequency Reference: generates decade-multiple square wave outputs from 1 Hz to 100 kHz for pacing external instruments, counter timing, or recorder timing marks, available with open collector transistor output.
HP 91026A Digital-Analog Current Converter: one 0 to 20.475 mA output per card, 0 to 10.5V compliance, 12-bit resolution.*
HP 91207A Digital-Analog Voltage Converter: one 0 to ±10.24V, 5 mA output per card, 12-bit resolution.*

* *Requires addition of voltage regulator in digital I/O subsystem or extender in which it is used.*

*Note: For detailed specifications on the digital I/O subsystem and its plug-ins, other than data rates, see the HP 91063A Digital I/O Subsystem data sheet, HP Literature Request Number 5952-8513.*

### Digital I/O Expanders

HP 91140A Digital I/O Extenders: adds 15 card slots for 12-bit I/O cards. Up to 15 Digital I/O Extenders can be added for a total of 240 I/O card slots and 2880 digital I/O channels.

### Analog and Digital I/O Throughput Rates

Throughput rates for analog-to-digital measurements and digital input/output vary with the length of the serial data communication cable through which the 9603R exchanges control and data information with its master system, as follows:

| Cable Length | | Maximum Analog Input/Output Throughput Rate (points/sec) Via | | | | Maximum Digital I/O Rate (points/sec) |
|---|---|---|---|---|---|---|
| | | High-Level Multiplexer | Low-Level Multiplexer | | Dual D-A Converter | |
| Meters | Feet | | Solid-State | Relay | | |
| 3.66* | 12* | 45,000* | 8000* | 125* | 15,000* | |
| | | 2500 | 2000 | 125 | 2000 | 1250 |
| 180 | 600 | | | | | |
| | | 2250 | 1750 | 100 | 1750 | 500 |
| 360 | 1200 | | | | | |
| | | 2000 | 1500 | 100 | 1500 | 500 |
| 600 | 2000 | | | | | |
| | | 2000 | 1500 | 100 | 1500 | 500 |
| 1200 | 4000 | | | | | |
| | | 1500 | 1000 | 100 | 1000 | 450 |
| 1600 | 5400 | | | | | |
| | | 1000 | 750 | 100 | 750 | 370 |
| 2200 | 7300 | | | | | |
| | | 600 | 500 | 100 | 500 | 285 |
| 3000 | 10000 | | | | | |

* *with Option 200*

*Note: These rates are attainable under the following conditions in RTE-II/RTE-III:*

1. *System clock running.*
2. *No other system activity except remote I/O requested by a single program.*
3. *No programs in any active list except the program requesting I/O in I/O suspend list.*

# Specifications

### Precautions

Protective devices may be required in some applications involving cabling to remote stations. Consult with your local authorities on the proper installation of Class 2 (communication, remote control, signal) circuits, prior to deployment of the remote station(s).

### Power Requirements

Remote Station Cabinet: 220V ±10%, 60 Hz, split-phase or 230V ±10%, 50 Hz, single-phase AC.
Per Analog I/O Subsystem or Expander: 115/230V ±10%, 50 or 60 Hz, 400 VA, maximum.
Per Digital I/O Subsystem or Extender: 115/230V ±10%, 50 or 60 Hz, 460W, maximum.

### Operating Conditions

o° to 40°C (+32° to 104°F) ambient temperature.

### Master System Memory Usage (Words$_{10}$)

For Analog I/O:
- RTE Driver: 540 words
- RTE-B Device Subroutines:
  - For Analog Input: 600 words
  - For Analog Output: 105 words
- RTE-C/RTE-II/RTE-III Device Subroutines:
  - For Analog Input: 475 words
  - For Analog Output: 174 words

For Digital I/O:
- RTE Driver: 940 words
- RTE-B Device Subroutines:
  - For Digital I/O: 371 words
  - For Event Sense: 244 words + 13 words for each Event Sense Interrupt Card
  - For Analog Output: 90 words
- RTE-C/RTE-II/RTE-III I.S.A. FORTRAN Device Subroutines and Programs:
  - For Digital I/O: 320 words
  - For Event Sense: 523 words + 13 words for each Event Sense Interrupt Card
  - For Bit Manipulation: 140 words
  - For Frequency: 160 words
  - For Stall Alarm: 70 words
  - For each Digital I/O Subsystem (local and remotes): 32 words
  - For each Digital I/O Card: 1 word

### Heat Dissipation

Per Analog I/O Subsystem and Expander: 1366 BTU/hr, maximum.
Per Digital I/O Subsystem and Extender: 1570 BTU/hr, maximum.

### Physical Dimensions

Cabinet: 64.22 in. (1632 mm) high, 30 in. (762 mm) deep, 21 in. (533 mm) wide (per bay).

### Weight

Per Analog I/O Subsystem and Expander: 48.5 lb. (22 kg).
Per Digital I/O Subsystem Extender: 38 lb. (17.3 kg).
For One-Bay Cabinet: 148 lb. (73.1 kg).
For Two-Bay Cabinet: 271 lb. (122.9 kg).

## ORDERING INFORMATION

**HP 9603R** Remote Scientific Measurement and Control Station, consisting of:
1. 2313B-001 Analog I/O Subsystem.
2. Remote Microcircuit Interface.
3. One-bay, 56-inch cabinet, 220V, 60 Hz, split-phase power.
4. Instruction manuals.
5. 91220A DAS Utility Library.

### Options

| | |
|---|---|
| 006 | 12764A Analog I/O Expander (first 12-slot addition to analog I/O subsystem) |
| 007 | 12765A Analog I/O Expander (second 12-slot addition to analog I/O subsystem) |
| 008 | 12751A High-Level Multiplexer Card |
| 020 | 02313-60007 Single-ended input cable for high-level multiplexer |
| 021 | 02313-60008 Differential input cable for high-level multiplexer |
| 009 | 12761A Solid-State Low-Level Multiplexer |
| 010 | 12760A Relay Low-Level Multiplexer |
| 022 | 02313-60026 Differential input cable for low-level multiplexer |
| 011 | 12755A Programmable Pacer |
| 013 | 12757A Dual 12-Bit Digital-to-Analog Converter |
| 015 | 230V, 50 Hz operation of remote station |
| 050 | Second cabinet bay for first and second analog I/O expanders |
| 051 | Second cabinet bay for first analog I/O expander and two digital I/O extenders |
| 052 | Second cabinet bay for four digital I/O extenders |
| 200 | Delete remote serial subsystem, add local microcircuit interface |
| 201 | 91220A-20 DAS Utility Library on minicartridge |
| T17 | 91063A Digital I/O Subsystem |
| T19 | 91063A-001 Digital I/O Susbystem with Remote Microcircuit Interface |
| T18 | 91140A Digital I/O Extender |
| J10 | 91202A Digital Input, ground true TTL |
| J11 | 91202A-002 Digital input, ground false TTL |
| J12 | 91202A-001 Digital Input, ground true, +6V to +14V false |

**Options (continued)**

J14 91203A-003 Isolated Digital Input, ground false, +25V to +50V true
J15 91203A-001 Digital Output, ground false TTL
J16 91203A Isolated Digital Input, ground true TTL
J17 91205A Event Sense Interrupt Input, open true, closure false
K04 91201A Digital Output, ground true TTL
K11 91201A-001 Digital Output, ground false TTL
K05 91204A Relay Output
K14 91220A Stepping Motor Output
J20 91208A Programmable Timer
J21 91209A Frequency Reference
J22 91221A 12-Bit Pulse Counter
I20 91206A Digital-to-Analog Current Converter
I21 91207A Digital-to-Analog Voltage Converter
I28 91132A Voltage Regulator (for use with I20 or I21

**Prerequisite Items**

91226B Remote Communications Subsystem (required for linking 9603R to RTE-B/C/II/III based 96MX systems).
91226B-020 Remote Communications Subsystem (required for linking 9603R to RTE-B/C/II/III based HP 1000 series systems).

**Specifications subject to change without notice.**

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For more information, call your local HP Sales Office or East (301) 948-6370 • Midwest (312) 677-0400 • South (404) 434-4000 • West (213) 877-1281. Or write: Hewlett-Packard, 1501 Page Mill Road, Palo Alto, CA 94304. In Canada: 275 Hymus Blvd., Point Claire, Quebec. In Europe: Hewlett-Packard, P.O. Box 85, CH-1217 Meyrin 2, Geneva, Switzerland. In Japan: Yokogawa-Hewlett-Packard, 1-59-1, Yoyogi, Shibuya-ku, Tokyo, 151.



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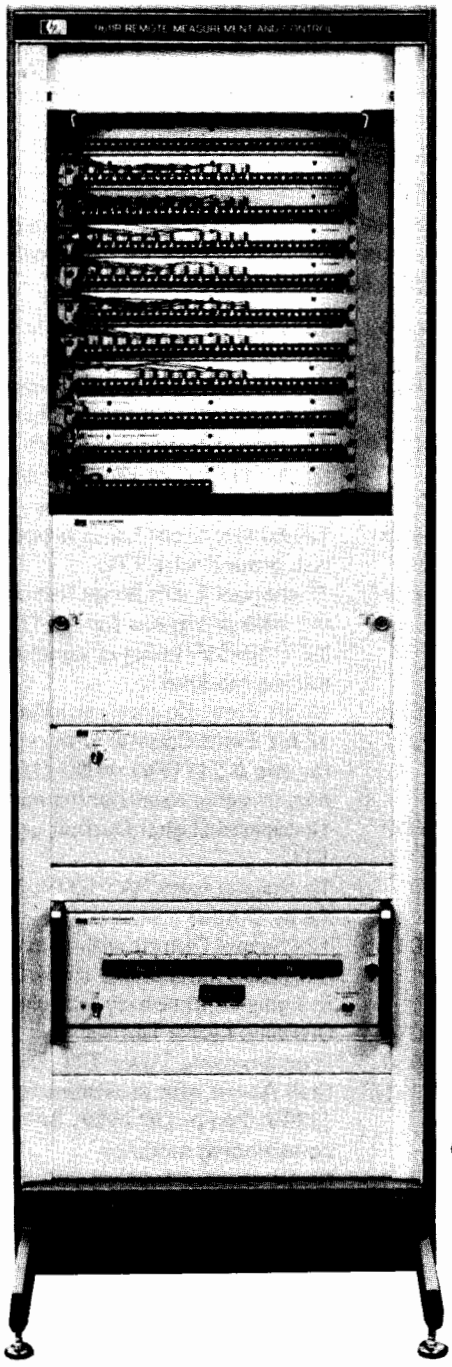
# Industrial Measurement and Control Station

model 9611R

Technical Data 9/76

## Features

- **16 to 528 analog inputs**
- **12 to 900 digital I/O signal lines**
- **Full range of signal conditioning for analog and digital I/O encountered in the industrial environment**
- **Provision for screw-terminal connection assemblies**
- **Operation up to 3 km (10,000 feet) from computer/controller**
- **DAS Utility Library**
- **ISA FORTRAN extension support**



## Description

The HP 9611R is an Industrial Measurement and Control Station for a computer-based data acquisition and control applications where digital and analog input/output to machine/process sources, control actuators, and indicator panels are some distance from the computer.

The 9611R contains most signal conditioning options to meet a wide variety of conditions encountered in industrial data acquisition and control applications.

The base station is intended to be remote from the computer, however, an optional interface is available when the application demands close proximity of the 9611R to the computer.

The base 9611R consists of a 91063A-001 Digital I/O Subsystem with a remote communication subsystem that provides a serial communication to HP 2100S Computers, HP 21MX/E Computers, HP 96MX series Computer Systems, and HP 1000 series Computer Systems up to 3 km (10,000 feet) via twisted pairs.

The 9611R also contains a one-bay cabinet with power supply tray with 5 VDC power required by some of the signal conditioning options, together with provisions for screw-terminal connection assemblies for field wiring from transducers/control actuators.

Optionally the 9611R can accommodate analog I/O lines with the HP 2313B Analog I/O Subsystem; this together with the digital I/O subsystem can be remotely located from the aforementioned computer/controllers.

### Digital Input/Output Capacity

| Remote Station Enclosure Size | Digital I/O Subsystem | |
|---|---|---|
| | Capacity: No. of Cards | Capacity: No. of I/O Lines |
| 1 Bay | 15 | 180 |
| 2 Bay | 15 | 180 |
| | 15 | 180 |
| | 30 | 360 |
| | 45 | 540 |
| 3 Bay | 45 | 540 |
| | 60 | 720 |
| | 75 | 900 |

### Digital I/O Subsystem, Plug-In Cards, and Signal Conditioning Modules

Each of the digital input/output plug-in cards listed include screw-terminal connection assemblies with applicable provisions for signal conditioning modules.

| | |
|---|---|
| HP 91203A-010 | 12-channel Isolated Status Input, ground-true TTL |
| HP 91203A-011 | 12-channel Isolated Status input for 25-50 VDC inputs for contact closures |
| HP 91222A-011/ 012 | 12-channel Status Input with provision for AC (117V) or DC (10-55V) plug-in signal conditioning modules |
| HP 91205A-010 | 12-channel Event Sense Interrupt Input, ground-false TTL |
| HP 91205A-011/ 012 | 12-channel Event Sense Interrupt Input with provisions for AC (117V) or DC (-10-55V) plug-in signal conditioning modules |
| HP 91221A-010 | 12-bit Event Counter, ground-false TTL |
| HP 91221A-011 & 012 | 12-bit Event Counter with provisions for one AC (117V) or DC (10-55V) plug-in signal conditioning module |
| HP 91201A-010 | 12-channel Digital Output, ground-true TTL |
| HP 91204A-010 | 12-channel form "A" 100V, 1A (20W) Relay Output |
| HP 91223A-011/ 012 | 12-channel Output with provisions for AC (230V, 2A) or DC (55V, 2A) plug-in signal conditioning modules |
| HP 91220A-010 | Stepping Motor Output |
| HP 91208A-010 | Programmable Timer TTL Output |
| HP 91208A-011/ 012 | Stall Alarm with provisions for AC (230V, 2A) or DC (55V, 2A) signal conditioning modules |
| HP 91212A | Single channel Isolated 230V, 2AAC Output signal conditioning module |
| HP 91213A | Single-channel Isolated 0-55V, 2A Output signal conditioning module |
| HP 91207A-010 | 12-bit D/A Voltage Converter |
| HP 91206A-010 | 12-bit D/A 0-20 mA Output Converter |
| HP 91210A | Single-channel Isolated 117 VAC input signal conditioning module |
| HP 91211A | Single-channel Isolated 10-55 VDC signal conditioning module |

### Digital I/O Expanders and Auxiliary Power Supplies

| | |
|---|---|
| HP 91140A | Digital I/O Expander allows up to 15 I/O digital plug-in cards |
| HP 91113A | 48V, 2A power supply for common power to DC signal conditioning modules |

*Note: For detailed specifications on the digital I/O subsystem and its plug-ins, other than throughput rates, see the HP 91063A Digital I/O Subsystem data sheet, HP Literature Request Number 5952-8513.*

### Analog Input/Output Capacity

| Remote Station Enclosure Size | Analog I/O Subsystem | |
|---|---|---|
| | Capacity: No. of Cards | Capacity: No. of Inputs |
| 1 Bay | 7 | 112 |
| 2 Bay | 19 | 304 |
| | 31 | 496 |
| | 19 | 304 |
| | 7 | 112 |
| 3 Bay | 31 | 496 |
| | 19 | 304 |
| | 7 | 112 |

### Analog I/O Subsystem Plug-In Cards

Connection Assembly: Each of the analog I/O plug-in cards listed includes a screw-terminal assembly for connection of inputs or outputs.

HP 12751A High-Level Multiplexer: 16 differential inputs per card, up to ±10.24V fs, 45,000 samples/sec/chan.

HP 12761A Solid-State Low-Level Multiplexer: 16 differential inputs per card, programmable ranges ±10 to 800 mV fs, CMV to 10V peak, up to 8000 chan/sec, up to 50 samples/sec/chan.

HP 12760A Relay Low-Level Multiplexer: 16 differential inputs per card, programmable ranges ±10 mV to 200 mV fs, CMV to 200V peak, up to 125 chan/sec, up to 20 samples/sec/chan.

HP 91224A Solid-State Analog Input Current Multiplexer: 16 inputs per card, program-selectable 2.5 to 200 mA fs ranges, CMV to 10V peak, 500-2000 chan/sec, up to 50 samples/sec/chan.

HP 91225A Relay Analog Input Current Multiplexer: 16 inputs per card, program-selectable 2.5 to 100 mA fs ranges, CMV to 200V peak, 100-125 chan/sec, up to 20 samples/sec/chan.

HP 12757A Dual 12-Bit Digital-Analog Converter: Two 0 to ±10.24V fs, 20 mA analog outputs per card, 5 mV resolution, up to 15,000 points/sec.

*Note: For detailed specifications on the analog I/O subsystem and its plug-ins, other than throughput rates, see the HP 2313B Analog I/O Subsystem data sheet, HP Literature Request Number 5952-8511.*

### Digital and Analog I/O Throughput Rates

Throughput rates for digital and analog I/O vary with the length of the serial data communication cable through which the 9611R exchanges control and data information with its master system, as follows:

| Cable Length | | Maximum Analog Input/Output Throughput Rate (points/sec) Via | | | | Maximum Digital I/O Rate (points/sec) |
|---|---|---|---|---|---|---|
| | | High-Level | Low-Level Multiplexer | | Dual D-A | |
| Meters | Feet | Multiplexer | Solid-State | Relay | Converter | |
| 3.66* | 12* | 45,000* | 8000* | 125* | 15,000* | |
| 180 | 600 | 2500 | 2000 | 125 | 2000 | 1250 |
| 360 | 1200 | 2250 | 1750 | 100 | 1750 | 500 |
| 600 | 2000 | 2000 | 1500 | 100 | 1500 | 500 |
| 1200 | 4000 | 2000 | 1500 | 100 | 1500 | 500 |
| 1600 | 5400 | 1500 | 1000 | 100 | 1000 | 450 |
| 2200 | 7300 | 1000 | 750 | 100 | 750 | 370 |
| 3000 | 10000 | 600 | 500 | 100 | 500 | 285 |

** with Option 200*

*Note: These rates are attainable under the following conditions in RTE-II/RTE-III:*

1. *System clock running.*
2. *No other system activity except remote I/O requested by a single program.*
3. *No programs in any active list except the program requesting I/O in I/O suspend list.*

### Master System Memory Usage ($Words_{10}$) for

For Digital I/O:
- RTE Driver: 940 words
- RTE-B Device Subroutines:
  - For Digital I/O: 371 words
  - For Event Sense: 244 words + 13 words for each Event Sense Interrupt card
  - For Analog Output: 90 words
- RTE-C/RTE-II/RTE-III I.S.A. FORTRAN Device Subroutines and Programs:
  - For Digital I/O: 320 words
  - For Event Sense: 523 words + 13 words for each Event Sense Interrupt card
  - For Bit Manipulation: 140 words
  - For Stall Alarm: 70 words
  - For Frequency and Totalizing: 160 words
  - For each Digital I/O Subsystem (local and remotes): 32 words
  - For each Digital I/O card: 1 word

For Analog I/O:
- RTE Driver: 540 words
- RTE-B Device Subroutines:
  - For Analog Input: 600 words
  - For Analog Output: 105 words
- RTE-C/RTE-II/RTE-III Device Subroutines:
  - For Analog Input: 475 words
  - For Analog Output: 174 words

### Precautions

Protective devices may be required in some applications involving cabling to remote stations. Consult with your local authorities on the proper installation of Class 2 (communication, remote control, signal) circuits, prior to deployment of the remote station(s).

### Power Requirements

Remote Station Cabinet: 220V ±10%, 60 Hz, split-phase, or 230V, 50 Hz, single-phase, AC.
Per Digital I/O Subsystem or Extender: 115/230V ±10%, 50-60 Hz, 400 VA, maximum.
Per Analog I/O Subsystem or Expander: 115/230V ±10%, 50-60 Hz, 460W, maximum.

### Operating Conditions

0° to 40°C (+32° to 104°F)

### Heat Dissipation

Per Digital I/O Subsystem and Extender: 1570 BTU/hr, maximum.
Per Analog I/O Subsystem and Expander: 1366 BTU/hr, maximum.

### Physical Dimensions

Cabinet: 66.22 in. (1632 mm) high, 30 in. (762 mm) deep, 21 in. (533 mm) wide (per bay).

### Weight

Per Digital I/O Subsystem and Extender: 38 lb. (17.3 kg).
Per Analog I/O Subsystem and Expander: 48.5 lb. (22 kg).
For One-Bay Cabinet: 148 lb. (73.1 kg).
For Two-Bay Cabinet: 271 lb. (122.9 kg).
For Three-Bay Cabinet: 374 lb. (178.6 kg).

### ORDERING INFORMATION

**9611R** Remote Industrial Measurement and Control Station, consisting of:

1. 91063A-001 Digital I/O Subsystem.
2. Remote Microcircuit Interface.
3. One-bay, 56-inch cabinet, 220V, 60 Hz, split-phase power, top cable entry, and lockable front and rear doors.
4. Provision for 7 analog and 15 digital I/O options with screw-terminal field terminations.
5. 62005E 5V, 2A Power Supply for signal conditioning modules.
6. Instruction manuals.
7. DAS Utility Library.

# Specifications

**Options**

021 91203A-010 12-Channel Status Input, ground-true TTL
022 91205A-010 12-Channel Event Sense Interrupt Input, ground-false TTL
023 91221A-010 12-Bit Event Counter, ground-false TTL
024 91222A-011 12-Channel Status Input with provision for AC signal conditioning modules
025 91205A-011 12-Channel Event Sense Interrupt Input with provision for AC signal conditioning modules
026 91221A-011 12-Bit Event Counter with provision for AC signal conditioning module
027 91210A One-Channel Isolated AC input signal conditioning module (up to 117 VAC)
029 91222A-012 12-Channel Status Input with provision for DC signal conditioning modules
030 91205A-012 12-Channel Event Sense Interrupt Input with provision for DC signal conditioning modules
031 91221A-012 12-Bit Event Counter with provision for DC signal conditioning modules
032 91211A One-Channel Isolated DC input signal conditioning module (10-55 VDC)
020 91208A-010 Programmable Timer Card (TTL)
033 91201A-010 12-Channel Output, ground-true TTL
034 91204A-010 12-Channel Relay Output
036 91220A-010 Stepping Motor Output
037 91223A-011 12-Channel Output with provision for AC solid-state relay modules
038 91208A-011 Stall Alarm with provision for AC solid-state relay modules
039 91212A One-Channel Isolated AC Solid-State Relay Module (up to 250 VAC)
040 91223A-012 12-Channel Output with provision for DC solid-state relay modules
041 91208A-012 Stall Alarm with provision for DC solid-state relay modules
042 91213A One-Channel Isolated DC Solid-State Relay Module (up to 55 VDC, 2A)
045 91140A Digital I/O Extender
043 91207A-010 Digital-to-Analog Voltage Converter
044 91206A-010 Digital-to-Analog Current Converter
046 91123A Voltage Regulator (for use with 043/044)
071 91131A 48V, 2A Power Supply for common power to DC signal conditioning modules (115V, 60 Hz)
072 91131A-015 48V, 2A Power Supply for common power to DC signal conditioning modules (230V, 50 Hz)
100 Adds remote Analog I/O Subsystem
001 91110A High-Level Multiplexer
002 91111A Solid-State Low-Level Multiplexer
003 91112A Relay Low-Level Multiplexer
004 91224A Solid-State Analog Input Current Multiplexer
005 91225A Relay Analog Current Input Multiplexer
008 91113A Dual 12-Bit Digital-to-Analog Converter
015 230V, 50 Hz operation of remote station
053 Substitute bottom cable entry for top cable entry in 9611R cabinet
050 Second cabinet bay for two Analog I/O Expanders, top cable entry
051 Second cabinet bay for one Analog and one Digital I/O Extender, top cable entry
052 Second cabinet bay for two digital I/O Extenders, top cable entry
054 Second cabinet bay for two Analog I/O Expanders, bottom cable entry
055 Second cabinet bay for one Analog and one Digital I/O Extender, bottom cable entry
056 Second cabinet bay for two Digital I/O Extenders, bottom cable entry
060 Third cabinet bay for two Digital I/O Extenders, top cable entry
061 Third cabinet bay for two digital I/O Extenders, bottom cable entry
200 Delete remote communications subsystem
201 DAS Utility Library on minicartridge
203 Adds Analog I/O Subsystem (2313B-001) with local interface

**Prerequisites Items**

91226B Remote Communications Subsystem (required for linking 9611R to RTE-B or RTE-II/III based 96MX series systems).
91226B-020 Remote Communications Subsystem (required for linking 9611R to RTE-B/C or RTE-II/III based HP 1000 series systems).

**Specifications subject to change without notice.**

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For more information, call your local HP Sales Office or East (301) 948-6370 • Midwest (312) 677-0400 • South (404) 434-4000 • West (213) 877-1281. Or write: Hewlett-Packard, 1501 Page Mill Road, Palo Alto, CA 94304. In Canada: 275 Hymus Blvd., Point Claire, Quebec. In Europe: Hewlett-Packard, P.O. Box 85, CH-1217 Meyrin 2, Geneva, Switzerland. In Japan: Yokogawa-Hewlett-Packard, 1-59-1, Yoyogi, Shibuya-ku, Tokyo, 151.



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# Analog I/O Subsystem, Expanders, and Related Plug-Ins

model 2313B

Technical Data 9/76

## Features

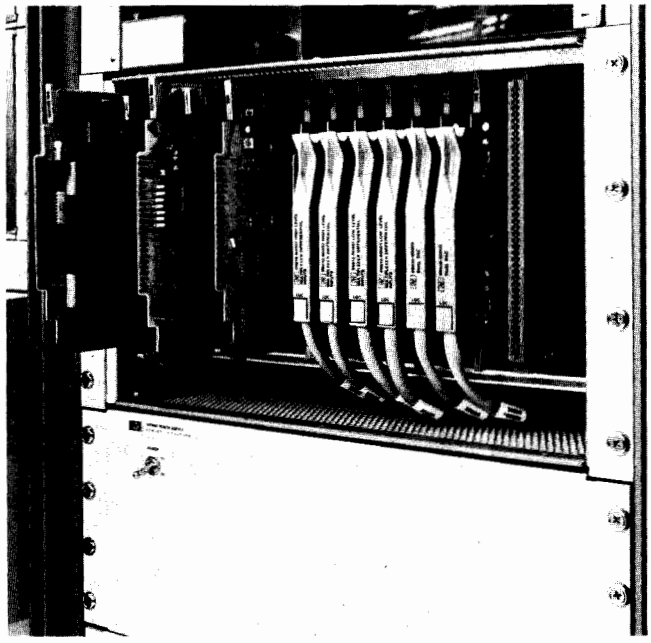
- **12-bit resolution**
- **Analog I/O plug-ins available with screw-terminal industrial connection assemblies**
- **High-level (±10.24V fs), solid state S.E. or diff. analog input at scanning speed up to 45 kHz**
- **Low-level (±10 mV to 800 mV fs, solid state analog input at scan rates to 8 kHz, signal plus CMV ≤ 10V**
- **Low-level (±10 mV to 200 mV fs), relay analog input at scan rates to 150 Hz, 200V CMV**
- **Solid-state or relay switched 2.5, 5, 10, 20, 25, 50, and 100mA analog current input multiplexing (industrial version only)**
- **High-accuracy 12-bit (±10.24 V, 20mA) analog outputs**
- **Plug-in pacer available for precision timing of analog I/O**
- **Input/output capacity expandable to 528 differential analog inputs or 44 analog outputs, or combination of inputs and outputs**
- **Field expandable**
- **Software drivers and interface routines for BCS, RTE-B, RTE-C, and RTE-II/III operating systems.**

## Description

The 2313B Analog I/O Subsystem consists of control, sampling, and analog-to-digital conversion modules in a mainframe providing at least two spaces for analog I/O plug-ins. It also includes a separate power supply, a computer interface card with interconnecting cable, and software appropriate to the operating system in which the subsystem is used. It is designed for rack-mounted operation only. The 2313B is standard in the 9603R. Measurement and Control Station is offered for the addition of analog I/O capability to other systems configured around HP 96MX System Controllers, HP 21MX, HP 2100S, or HP 1000 series Computers.

### EXPANDABILITY AND CAPABILITIES

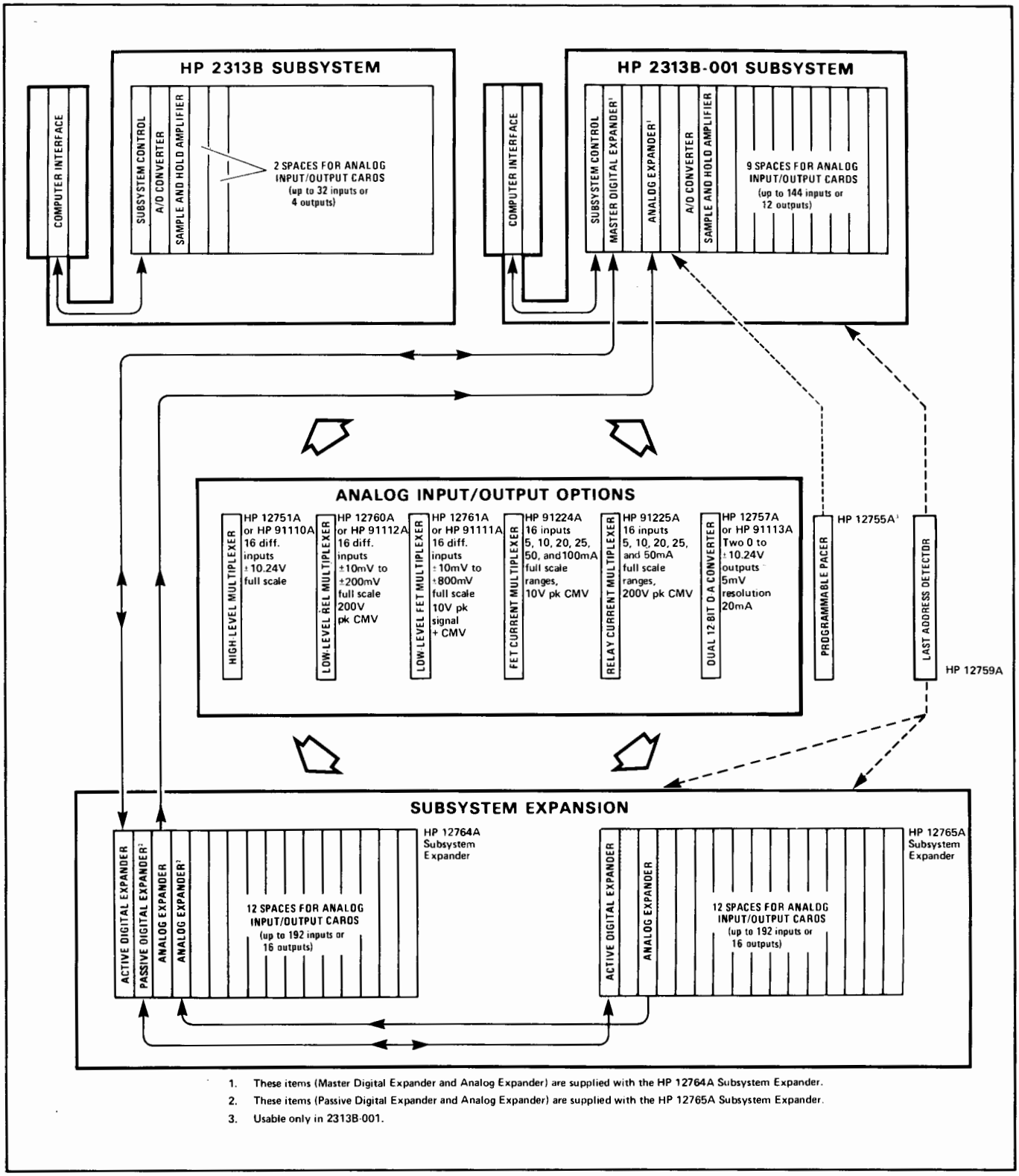
The expandability and capabilities of the HP 2313B subsystem are summarized in Figure 1 on the next page.



**Easily Installed**

With the user's choice of appropriate analog I/O cards, the subsystem is a complete package, virtually ready to use as soon as it is delivered. Simply rack mount the subsystem, plug one interface card into the computer, and connect the cable. The subsystem needs only to be integrated into the software operating system (BCS, RTE-B, RTE-C, or RTE-II/III) of the computer to be ready for programmed operation. When it is ordered as part of a complete system, the subsystem installation and integration into the computer system is accomplished at the factory.

In addition to the driver software used in normal operation, the subsystem includes a unique verification program. This is an interactive program in which the operator commands any mode of operation via the system's keyboard input unit. An easy-to-follow printout or display of the results is provided. Because it is extensive and easy to use, this program can substitute for application programming during the early stages of system development. It will thus save time and effort, at the same time confirming correct operation of the subsystem.




1. These items (Master Digital Expander and Analog Expander) are supplied with the HP 12764A Subsystem Expander.
2. These items (Passive Digital Expander and Analog Expander) are supplied with the HP 12765A Subsystem Expander.
3. Usable only in 2313B-001.

Figure 1. HP 2313B Subsystem and Related Options

# Specifications

## SUBSYSTEM SPECIFICATIONS

**Resolution**
12 bits, including sign; LSB = 5 mV.

**Full Scale Input**
+10.235V to -10.24V.

**Input/Output Capacity**
In Standard 2313B: Two card spaces.
In 2313B-001: Nine card spaces.
In 12764A/12765A: Each expander adds 12 card spaces.

**Operating Conditions**
0° to 35°C (32°to 95°F) ambient, allowing for 15°C (27°F) temperature rise inside system or remote station cabinet.

**Operational Prerequisite**
Rack mounting is a prerequisite for operation of the 2313B subsystem and analog I/O expanders.

**Power**
Voltage: 115/230V ±10%, switch selectable.
Frequency: 50 to 60 Hz.
Power Consumption: 400 VA, maximum, per subsystem and expander.
Interface: 0.05A (-2V), 1.1A (+4.5V) drawn from computer or I/O extender.

**Computer I/O Channels**
One serves the subsystem and all expanders.

**Heat Dissipation**
1366 BTU/hr. maximum possible per 2313B or 12764A or 12765A expander.

**Physical Characteristics**
Panel Height: 21 inches (534 mm) per subsystem or expander.
Weight: 48.5 lb. (22 kg) per subsystem or expander.

**Programmable Operating Modes**
Single-Channel Mode: Subsystem repeatedly measures a single analog input channel, or repeatedly outputs the analog of the digital value of a single location in the computer's memory, at a rate determined by the driver or the plug-in pacer.
Block Scan Mode: Subsystem measures analog input channels, or outputs the analog of digital values in the computer's memory, in a sequence determined by addresses from a buffer in memory, at the rate determined by the driver or the plug-in pacer.
Sequential Mode: Subsystem measures consecutive analog input channels, or outputs the analog of digital values from consecutive locations in the computer's memory, at a rate determined by the driver or the plug-in pacer.

## HARDWARE SUPPLIED

HP 2313B Analog I/O Subsystem:
1. Mainframe chassis with control card, sample-and-hold amplifier, analog-to-digital converter, and space for two analog I/O cards.
2. Power supply.
3. Extender card and operating and service manual.
4. Microcircuit (computer) interface card and cable.

HP 2313B option 001 Analog I/O Subsystem: increases capacity of mainframe chassis to nine analog I/O card spaces, plus space for a plug-in programmable pacer, and connection cards to 12764A analog I/O expander.

HP 12762A Field Upgrade Kit: provides parts to convert standard 2313B to 2313B option 001.

HP 12764A First Analog I/O Subsystem Expander:
1. Mainframe chassis with analog and digital expander cards and space for 12 analog I/O cards.
2. Analog and digital I/O expander cards used in 2313B-001 mainframe.
3. Ground cable.
4. Power supply.

HP 12765A Second Analog I/O Subsystem Expander:
1. Mainframe chassis with analog and digital expander cards and space for 12 analog I/O cards.
2. Analog and digital I/O expander cards used in 12764A mainframe.
3. Ground cable.
4. Power supply.

## SOFTWARE SUPPLIED

Verification Routine
Optional Software (one of the following driver/interface routine options):
S30 BCS driver and FORTRAN/ALGOL driver interface.
S50 RTE driver and FORTRAN/ALGOL driver interface.
S60 RTE driver and RTE-B driver interface.

## ORDERING INFORMATION

HP 2313B Analog I/O Subsystem.
HP 2313B-001 Analog I/O Subsystem.
HP 12762A Analog I/O Capacity Field Upgrade Kit.

*NOTES:*
*A. The analog I/O specifications of the subsystem differ with the plug-in used; see the specifications for the 127XXA and 91XXXA plug-ins in the remaining pages of this data sheet for throughput rates, accuracies, aperture times, etc.*
*B. The 91XXXA series plug-ins are only for 9611R Industrial Measurement and Control Stations. These include screw-terminal customer connection assemblies, and assume 9611R cabinet mounting provisions for those assemblies.*
*C. The 2313B analog I/O specifications differ in remote stations. See the 9603R and 9611R data sheets.*

## HP 12751A/91110A HIGH-LEVEL MULTIPLEXER SPECIFICATIONS

**Hardware Supplied**
HP 12751A High-Level Multiplexer:
1. High-level multiplexer card.
2. Mating connector.

HP 02313-60007 Single-Ended Input Cable:
1. 16-foot cable, terminated with high-level multiplexer mating connector at one end, unterminated at source end.

HP 02313-60008 Differential Input Cable:
1. 16-foot cable, terminated with high-level multiplexer mating connector at one end, unterminated at source end.

HP 91110A High-Level Multiplexer, Industrial Version:
1. High-level multiplexer card.
2. Screw-terminal connection assembly.

**Number of Inputs**
16 differential or 32 single-ended (single-ended operation applies only to 12751A, not to 91110A which is limited by its connection assembly to 16 differential inputs).

**Full Scale Input**
+10.235V to -10.240V.

**Overall Accuracy of Multiplexer, S&H, and ADC**
With Respect To: source used for calibration.
Conditions: source resistance $< 100$ ohms.
Factors Included: 3 sigma noise; linearity, offsets, 8-hour stability; gain, calibration transfer, and dynamic response errors; and effects of ±10% line voltage variation and ±5°C variation from calibration temperature.
Accuracy: ±0.09% fs ±1/2 LSB (subsystem without expanders); 12764A expander adds ±0.05 fs and 12765A expander adds ±0.06% fs.
Temp. Coefficient: ±0.0026% fs/°C.
Long-Term Drift: ±0.06% fs, maximum, in 30 days.

**Throughput Rate to Buffer**
To 45 kHz using Direct Memory Access (DMA), assuming no interrupts from higher priority devices, no other machine cycles used for DMA, no more than one level of indirect addressing, and no chaining of indirects in non-DMA operations. Includes high-level multiplexer switching, S&H sampling, and ADC conversion times. To 10 kHz in BCS-based system not using DMA.

**Aperture Time**
50 nanosec, peak-to-peak time variation, reading-to-reading if subsystem is paced by HP 12755A Programmable Pacer. Includes S&H aperture and pace pulse jitter.

**Source Resistance**
1 kΩ, maximum, balanced or unbalanced.

**Input Impedance**
Selected Channel: $> 5$ MΩ shunted by $< 60$ pF (1 HLMPX card); $> 3.3$ MΩ shunted by $< 70$ pF (9 HLMPX cards); $> 2$ MΩ shunted by $< 120$ pF (33 HLMPX cards in fully-expanded subsystem).
Non-Selected Channel: $> 50$ MΩ shunted by $< 10$ pF.
Power Off: $> 500$ kΩ, all channels.

**Pumpout Current Offset**
Offset due to HLMPX switching transients stored on input cable capacitance $< 1000$ pF: $< 0.05\%$ fs at 45 kHz, with 500Ω source resistance, ±10.3V inputs (differential + common mode), 528 inputs in subsystem.

**Crosstalk Rejection**
Between Inputs to Same HLMPX Card: 80 dB.
Between Inputs to Different HLMPX Cards: 120 dB.
Conditions: dc to 1 kHz, 1 kΩ source resistance.

**Common Mode**
Rejection: 80 dB, dc to 60 Hz, 1 kΩ source resistance, using differential input.
Return: $\leqslant$ (10 kΩ + 10 μH) with up to 125 feet of HP part number 8120-1781 input cable for differential inputs. To 10Ω maximum + 10 μH, maximum, low to power common, for single-ended inputs.

**Maximum Input**
For Rated Accuracy: ±10.5V differential + common mode, or ±10.24V high-to-common, single-ended input.
Without Damage: up to ±15V, any input line to chassis.

**Weight**
HP 12751A: 2 lb. (0.91 kg).
HP 91110A: 4.5 lb. (2.05 kg).

## HP 12760A/91112A RELAY LOW-LEVEL MULTIPLEXER SPECIFICATIONS

**Hardware Supplied**
HP 12760A Relay Low-Level Multiplexer:
1. Relay low-level multiplexer card.
2. Mating connector.

HP 02313-60026 Differential Input Cable:
1. 16-foot cable, terminated with multiplexer mating connector at one end, unterminated at source end.

HP 91112A Relay Low-Level Multiplexer, Industrial Version:
1. Relay low-level multiplexer card.
2. Screw-terminal connection assembly.

**Number of Inputs**
16 differential inputs per multiplexer card.

**Input Ranges**
±10 to 200 mV

**Overall Accuracy of Multiplexer, S&H, and ADC**
With Respect To: source used for calibration.
Conditions: sample rates up to 20 samples per second per channel.
Factors Included: 3 sigma noise; linearity; offsets; 8-hour stability; gain, calibration transfer, and dynamic response errors; and effects of ±10% line voltage variation and ±5°C variation from calibration temperature.
Accuracy and Temp. Coefficient by Input Ranges:

| Input Ranges | Overall Accuracy* (% fs ±1/2 LSB) | Temp. Coeff. (% fs/°C) |
|---|---|---|
| ±10 mV | ±0.29% | ±0.0054% |
| ±20 mV | ±0.22% | ±0.0054% |
| ±40 mV | ±0.17% | ±0.0054% |
| ±80 mV | ±0.16% | ±0.0054% |
| +100 mV | ±0.15% | ±0.0064% |
| +200 mV | ±0.14% | ±0.0064% |

**Figures listed refer to overall accuracy of subsystem without expanders; HP 12764A expander adds ±0.05% fs and HP 12765A expander adds ±0.06% fs to these figures.*

**Aperture Time**
1 millisec, peak-to-peak time variation, reading-to-reading if paced by HP 12755A Programmable Pacer. Includes variation in LLMPX switching, S&H aperture, and pace pulse jitter.

**Throughput Rate to Buffer**
To 150 channels/second for succession of measurements on same input range; 20 samples per second, maximum, on any one input channel for rated accuracy.

**Source Resistance**
To 1 kΩ, maximum, balanced or unbalanced.

**Input Resistance**
> 4 MΩ, power on or power off.

**Crosstalk Rejection**
Signal: 120 dB between differential inputs, dc to 1 kHz, 1 kΩ source.
Common Mode: 120 dB, dc to 60 Hz, up to 1 kΩ source unbalance.

**Common Mode Rejection**
115 dB, dc to 60 Hz, up to 1 kΩ unbalance, up to 10 Hz sample rate.

**Input Filter Characteristics**
Two pole, low-pass RC, 12 dB/octave slope, -6 dB ±1.5 dB at 0.75 Hz, -60 dB at 60 Hz for each input channel.

**Input Switching**
Mercury-wetted relay switches transfer differential input signals via "flying capacitor".

**Maximum Input**
Signal: ±0.3V between differential lines.
Common Mode: ±200V peak between any pair of differential input lines and subsystem chassis.

**Overvoltage**
Greater than +5V to -0.3V between any pair of differential input lines may destroy filter capacitors and resistors of overloaded channel. No additional damage up to ±200V peak.

**Overload and Open Channel Recovery**
Multiplexer recovers to specified accuracy on the next channel after differential input of 10 times programmed range (within limits of overvoltage specification) or after an open input channel.

**Weight**
HP 12760A: 4 lb. (1.82 kg).
HP 91112A: 6.5 lb. (2.95 kg).

## HP 12761A/9111A SOLID-STATE LOW-LEVEL MULTIPLEXER SPECIFICATIONS

**Hardware Supplied**
HP 12761A Solid-State Low-Level Multiplexer:
1. Solid-state low-level multiplexer card.
2. Mating connector.

HP 02313-60026 Differential Input Cable:
1. 16-foot cable terminated with multiplexer mating connector at one end, unterminated at source end.

HP 91111A Solid-State Low-Level Multiplexer, Industrial Version:
1. Solid-state low-level multiplexer card.
2. Screw-terminal connection assembly.

**Number of Inputs**
16 differential inputs per multiplexer card.



**Input Ranges**
±10 to 800 mV, see list under Overall Accuracy.

**Overall Accuracy of Multiplexer, S&H, and ADC**
With Respect To: source used for calibration.
Conditions: sample rates no greater than those specified.
Factors Included: 3 sigma noise; linearity; offsets; 8-hour stability; gain, calibration transfer, and dynamic response errors; and effects of ±10% line voltage variation and ±5°C variation from calibration temperature.
Accuracy and Temp. Coefficient by Input Ranges:

| Input Ranges | Overall Accuracy* (% fs ±1/2 LSB) for Sample Rates To 20 Hz | 50 Hz | Temp. Coeff. (% fs/°C) |
|---|---|---|---|
| ±10 mV | ±0.33% | ±0.38% | ±0.0054% |
| ±20 mV | ±0.28% | ±0.31% | ±0.0054% |
| ±40 mV | ±0.23% | ±0.26% | ±0.0054% |
| ±80 mV | ±0.19% | ±0.21% | ±0.0054% |
| ±100 mV | ±0.17% | ±0.19% | ±0.0064% |
| ±200 mV | ±0.15% | ±0.16% | ±0.0064% |
| ±400 mV | ±0.14% | ±0.16% | ±0.0064% |
| ±800 mV | ±0.14% | ±0.15% | ±0.0064% |

**Figures listed refer to overall accuracy of subsystem without expanders; HP 12764A expander adds ±0.05% fs and HP 12765A expander adds ±0.06% fs to these figures.*

**Aperture Time**
2 μsec, peak-to-peak time variation, reading-to-reading if subsystem is paced by HP 12755A Programmable Pacer. Includes variation in LLMPX switching, S&H aperture, and pace pulse jitter.

**Throughput Rate to Buffer**
Multiplex Rate: to 8000 channels/second for succession of measurements on same input range, using Direct Memory Access (DMA); assumes no interrupts from higher priority devices, no other machine cycles used for DMA, no more than one level of indirect addressing, and no chaining of indirects in non-DMA operations.
Sample Rate: to 50 samples/second, maximum, on any one channel, for rated accuracy.

**Source Resistance**
To 1 kΩ, maximum 100Ω maximum unbalance for rated accuracy.

**Input Resistance**
Power On: > 5 MΩ.
Power Off: > 10 kΩ.

**Crosstalk Rejection**
Between Inputs to Same LLMPX Card: > 100 dB.
Between Inputs to Different LLMPX Cards: > 140 dB.
Conditions: dc to 1 kHz, 1 kΩ source, 10V peak difference between inputs.

**Common Mode Rejection**
> 100 dB, dc to 60 Hz, exclusive of filter attenuation, up to 1 kΩ source unbalance.

**Input Filter Characteristics**
Two pole, low-pass RC, 12 dB/octave slope, -6 dB ±1.5 dB at 5 Hz, -30 dB at 60 Hz for each input channel.

**Maximum Input**
Total voltage (differential signal plus common mode) cannot exceed 10V peak between any input line and any other input line, or between any input line and ground. Greater than 10V differential may destroy filter capacitors.

**Overload and Open Channel Recovery**
Multiplexer recovers to specified accuracy on the next channel after differential input up to 10 times the programmed range (within limits of maximum input specification) or after an open input channel.

**Weight**
HP 12761A: 2 lb. (0.91 kg).
HP 91111A: 4.5 lb. (2.05 kg).

## HP 91224A SOLID-STATE ANALOG INPUT CURRENT MULTIPLEXER ASSEMBLY SPECIFICATIONS

**Hardware Supplied**
HP 91224A Solid-State Analog Input Current Multiplexer Assembly:
1. Solid-state low-level multiplexer card.
2. Screw-terminal connection assembly with a signal conditioning circuit board containing 16 precision 4 ohm current-to-voltage conversion resistors, each protected by a 1/8A fuse.

**Applicability**
HP 9611R Industrial Measurement and Control Stations only.

**Input Ranges**
2.5 to 200 mA, see list under Overall Accuracy.

**Overall Accuracy of Signal Conditioning, Multiplexer, S&H, and ADC**
With Respect To: source used for calibration.
Conditions: sample rates no greater than those specified.
Factors Included: tolerances of current-to-voltage conversion circuits; 3 sigma noise; linearity; offsets; 8-hour stability; gain, calibration transfer, and dynamic response errors; and effects of ±10% line voltage variation and ±5°C temperature variation from 25°C.
Accuracy and Temp. Coefficient by Input Ranges:

| Input Ranges | Overall Accuracy* (% fs ±1/2 LSB) for Sample Rates To 20 Hz | 50 Hz | Temp. Coeff. (% fs/°C) |
|---|---|---|---|
| 2.5 mA | ±0.53% | ±0.58% | ±0.0104% |
| 5.0 mA | ±0.48% | ±0.51% | ±0.0104% |
| 10 mA | ±0.43% | ±0.46% | ±0.0104% |
| 20 mA | ±0.39% | ±0.41% | ±0.0104% |
| 25 mA | ±0.37% | ±0.39% | ±0.0114% |
| 50 mA | ±0.35% | ±0.36% | ±0.0114% |
| 100 mA | ±0.34% | ±0.36% | ±0.0114% |
| 200 mA | ±0.34% | ±0.35% | ±0.0114% |

**Figures listed refer to overall accuracy of subsystem without expanders; HP 12764A expander adds ±0.05% fs and HP 12765A expander adds ±0.06% fs to these figures.*

**Aperture Time, Throughput Rate to Buffer, Common Mode Rejection, Crosstalk Rejection, Input Filter Characteristics, Maximum Input, and Overload and Open Channel Recovery**
Specifications same as HP 12761A/91111A Solid-State Low-Level Multiplexer, pages

**Weight**
5 lb. (2.27 kg).

## HP 91225A RELAY ANALOG INPUT CURRENT MULTIPLEXER ASSEMBLY SPECIFICATIONS

**Hardware Supplied**
HP 91225A Relay Analog Input Current Multiplexer Assembly:
1. Relay low-level multiplexer card.
2. Screw-terminal connection assembly with a signal conditioning board containing 16 precision 4 ohm current-to-voltage conversion resistors, each protected by a 1/8A fuse.

**Applicability**
HP 9611R Industrial Measurement and Control Stations only.

**Input Ranges**
2.5 to 100 mA, see list under Overall Accuracy.

**Overall Accuracy of Signal Conditioning, Multiplexer, S&H, and ADC**
With Respect To: source used for calibration.
Conditions: sample rates up to 20 samples per second per channel.
Factors Included: tolerances of current-to-voltage conversion circuits; 3 sigma noise; linearity; offsets; 8-hour stability; gain, calibration transfer, and dynamic response errors; and effects of ±10% line voltage variation and ±5°C temperature variation from 25°C.
Accuracy and Temp. Coefficient by Input Ranges:

| Input Ranges | Overall Accuracy* (% fs ±1/2 LSB) | Temp. Coeff. (% fs/°C) |
|---|---|---|
| 2.5 mA | ±0.49% | ±0.0104% |
| 5.0 mA | ±0.42% | ±0.0104% |
| 10 mA | ±0.37% | ±0.0104% |
| 20 mA | ±0.36% | ±0.0104% |
| 25 mA | ±0.35% | ±0.0114% |
| 50 mA | ±0.34% | ±0.0114% |
| 100 mA | ±0.34% | ±0.0114% |

**Figures listed refer to overall accuracy of subsystem without expanders; HP 12764A expander adds ±0.05% fs and HP 12765A expander adds ±0.06% fs to these figures.*

**Aperture Time, Throughput Rate to Buffer, Common Mode Rejection, Crosstalk Rejection, Input Switching, Input Filter Characteristics, Maximum Input, and Overload and Open Channel Recovery**
Specifications same as HP 12760A/91112A Relay Low-Level Multiplexer, pages

**Weight**
7 lb. (3.18 kg).

## HP 12757A/91113A DUAL 12-BIT DIGITAL-TO-ANALOG CONVERTER SPECIFICATIONS

**Hardware Supplied**
HP 12757A Dual 12-Bit Digital-to-Analog Converter (DAC):
1. Dual 12-bit DAC card.
2. Mating connector.
3. Dual-DAC test routine.

HP 91113A Dual 12-Bit Digital-to-Analog Converter (DAC), Industrial Version:
1. Dual 12-bit DAC card.
2. Screw-terminal connection assembly.
3. Dual-DAC test routine.

**Number of Outputs**
Two outputs per DAC card.

**Output**
Signal: +10.235V to -10.240V, 0 to 20 mA, short circuit proof.
Load Regulation: ±0.05% fs, maximum, 0 to 20 mA.
Load Capability: resistance > 500Ω, capacitive load to 0.002 μF will not cause instability.
Resolution: 5 mV.
Accuracy at 25°C (77°F): ±0.025% fs, 0 to 5 mA output.
Temp. Coefficient: ±400 μV/°C (±222 μV/°F), maximum.
Stability: 1.5 mV, maximum total drift for 24 hours, after 1 hour warmup.
Settling Time: 50 μsec, maximum to within ±0.05% of final value.
Effective Data Rate: 15,000 conversions/second via Direct Memory Access (DMA).
Ripple and Noise: 2 mV p-p, maximum in 0 to 100 kHz bandwidth. Transients with 10 mV peak amplitude, and 2 μsec duration may occur when either channel is programmed.

**Remote Grounding**
"Low" output lead may be grounded remotely, provided ground voltage does not differ from system ground by more than ±2V. (DAC output voltage plus common mode voltage must be between +10.235V and -10.240V).

**Display Interface**
Blanking Pulses: +10V to -10V, high, and +1V to -1V low.
Blanking Pulse Duration: 250 nsec/4 μsec, jumper selectable.
Display Erase: NPN transistor closure to ground for 1 second; 25V maximum open circuit, 16 mA, maximum sink.
External Flags: TTL compatible and +10V inputs.

**Relative Usage Per Subsystem**

| In HP 2313B-001: | | In HP 12764A/65A: | |
|---|---|---|---|
| Number of | | Number of | |
| Dual-DAC Cards | Other Cards | Dual-DAC Cards | Other Cards |
| 6 | 0 | 8 | 0 |
| 5 | 2 | 7 | 2 |
| 4 | 3 | 6 | 3 |
| 3 | 5 | 5 | 5 |
| 2 | 6 | 4 | 6 |
| 1 | 8 | 3 | 8 |
| 0 | 9 | 2 | 9 |
| | | 1 | 11 |
| | | 0 | 12 |

**Weight**
HP 12757A: 2 lb. (0.91 kg).
HP 91113A: 4.5 lb. (2.05 kg).

## HP 12755A PROGRAMMABLE PACER SPECIFICATIONS

**Hardware Supplied**
HP 12755A Programmable Pacer card.

**Sample-Sample Timing**

| Interval Range | Resolution | Frequency Range |
|---|---|---|
| 1 to 255 μs | 1 μs | 1 MHz to 3.92 kHz |
| 10 to 2550 μs | 10 μs | 100 kHz to 392 Hz |
| 0.1 to 25.5 ms | 100 μs | 10 kHz to 39.2 Hz |
| 1 to 255 ms | 1 ms | 1 kHz to 3.92 Hz |
| 10 to 2550 ms | 10 ms | 100 Hz to 0.39 Hz |
| 0.1 to 25.5 sec | 100 ms | 10 Hz to 0.039 Hz |
| 1 to 255 sec | 1 sec | 1 Hz to 0.0039 Hz |
| 10 to 2550 sec | 10 sec | 0.1 Hz to 0.00039 Hz |

**Subsystem Aperture**
Depends upon multiplexer used; see specifications for HP 12751A/91110A, 12760A/91112A, and 12761A/91111A multiplexers.

**Accuracy of Pace Interval**
Within ±0.01% of programmed interval.

**External Start Delay**
200-500 nsec to first pace pulse after External Start signal crosses trigger threshold.

**External Input Signals***
Names: External Start/Stop and External Clock inputs.
Thresholds: +1.5 to 2.0V, positive-going/+0.6 to 1.1V, negative-going.
Hysteresis: 0.4 to 1.4V.

**Start-Stop**
Phase: slide switch selects polarity of external start-stop signals.
Contact Closure: grounding one pin (0 to +0.4V) starts pacer; grounding a different pin (0 to +0.4V) stops pacer.

**External Output Signals***
Names: pace pulse (500 ns at pace rate) and Pace Gate (square wave at half pace rate) outputs.
Levels: +2.0-5.25V high; 0 to +0.8V low.
Line Loading: 48 mA sink in low state/1.2 mA source in high state.
Isolation: External pace pulse output is provided from a driver that is isolated by a TTL gate from the internal pace pulse line which drives the 2313B-001 subsystem.

**Weight**
2 lb. (0.91 kg).

**External signals are input to, and output from, the front connector of the programmable pacer card.*

## HP 12759A LAST ADDRESS DETECTOR SPECIFICATIONS

**Application**
Roll-over reset of analog input channel addressing to the first address used in sequential mode. It is required in BCS-based system for running more than one complete scan of a sequence of channels in response to one call to the driver.

**Exclusion**
The last address detector is not supported in the RTE-B system.

**Weight**
2 lb. (0.91 kg).

**Specifications subject to change without notice.**

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For more information, call your local HP Sales Office or East (301) 948-6370 • Midwest (312) 677-0400 • South (404) 434-4000 • West (213) 877-1281. Or write: Hewlett-Packard, 1501 Page Mill Road, Palo Alto, CA 94304. In Canada: 275 Hymus Blvd., Point Claire, Quebec. In Europe: Hewlett-Packard, P.O. Box 85, CH-1217 Meyrin 2, Geneva, Switzerland. In Japan: Yokogawa-Hewlett-Packard, 1-59-1, Yoyogi, Shibuya-ku, Tokyo, 151.



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5952-8511

HEWLETT hp PACKARD

# Plug-In 20 kHz* Analog-to-Digital Interface Subsystem

model 91000A

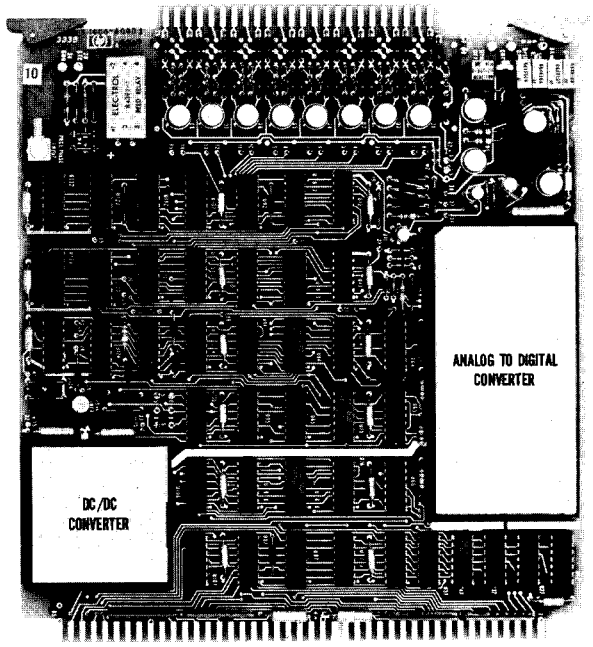
Technical Data 9/76

## Features

- **Complete subsystem on a computer interface card**
- **8 differential/16 single-ended input channels**
- **Software compatible with larger (2313B) Analog I/O Subsystem**

## Description

The 91000A is a complete, ±10.24V fs analog input subsystem for HP 1000 Model 31 or Model 81 Computer Systems, HP 96MX System Controllers, HP 21MX, or HP 2100S Computers. It includes interface and control logic, sample-and-hold amplifier, ADC, and input multiplexer with capacity for 16 single-ended or 8 differential inputs.




## Specifications

**Resolution**
12 bits, including sign; LSB=5 mV.

**Full Scale Input**
+10.235V to −10.24V.

**Number Of Inputs**
8 differential or 16 single-ended.

**Maximum Sample Rate**
To 20,000 channels per second*

**Sample-And-Hold**
"Hold" strobe is delayed 150 nsec from trailing edge of page pulse; aperture (total jitter with respect to pace pulse) is less than 250 nsec.

**External Pace Pulse Input**
+4.5V ±0.5V, 1.5μs ±0.5μs pulse referenced to 0 ±0.5V baseline, 100Ω source.

**Overall Accuracy**
±0.1% fs ±1/2 LSB at 25°±5°C, ±0.004% fs/°C over 0° to 55°C range of ambient temperatures outside of computer. These absolute accuracy specifications include 3 sigma noise; linearity, offset, gain, and dynamic response errors; and ±10% line voltage variation effects on the entire subsystem (multiplexer, sample-and-hold amplifier, and analog-to-digital converter).

**Input Impedance**
>5 mΩ (power on), 1 kΩ ± 10% (power off).

**Maximum Input**
±10.5V diff. + common mode, or high-to-computer chassis (S.E. inputs); ±10.24V high-to-common (S.E. inputs) for rated accuracy; up to ±15V, any input line to computer chassis without damage.

**Source Resistance**
To 1kΩ, balanced or unbalanced.

**Crosstalk And Common Mode Rejection**
>80 dB, dc to 100 Hz, using differential input.

**Computer I/O Channels Required**
One.



**Interface Current Required**

| −2V | +4.5V |
|---|---|
| 0.065A | 2.4A |

**Memory Required For RTE Driver and Device Interface Routines**
900 bytes for driver, plus 760 bytes for FORTRAN/ALGOL device interface, or 1250 bytes for BASIC device interface.

**Weight**
4 lb (1.8 kg)

**This is a hardware rate subject to response degradation that depends on other activity in the system; actual rates achieved will vary accordingly.*

# Specifications

## HARDWARE FURNISHED

1. A-to-D Interface (91000-60001).
2. Mating connector kit (02313-60010).
3. Coaxial connector (1250-1223).

## SOFTWARE FURNISHED

A-to-D interface verification routine on punched tape (91000-60002).

## SOFTWARE USED

The 91000A A-to-D Interface uses DVR62 and device interface routine R2313, included with the 92066A RTE Measurement and Control Drivers Package.

## MANUALS FURNISHED

1. Interface service manual (91000-930001).
2. Operating and programming manual (91000-93003).

## ORDERING INFORMATION

91000A A/D Interface Card

**Options**

005: Single-Ended Input Cable (91000-60005).

006: Differential Input Cable (91000-60004).

## INSTALLATION

Installation of the 91000A is the responsibility of the customer. HP installation assistance is provided on request, at prevailing rates.

**Specifications subject to change without notice.**

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HEWLETT hp PACKARD

# Digital I/O Subsystem — model 91063A

# Digital I/O Extender and Digital I/O Plug-Ins — model 91140A

Technical Data 9/76

## Features

- **Capacity expandable from 15 to 240 12-bit I/O card slots (up to 2880 digital I/O channels)**
- **Uses only one computer I/O channel**
- **Wide choice of digital I/O capabilities**
- **Software supplied for HP 2100S computers and 9600MX series computer systems**
- **Easily installed and serviced**

## Description

The 91063A Digital I/O Subsystem consists of a 6940A Multiprogrammer and interface for 2100 series Computers. It is standard in the 9611R Industrial Measurement and Control Station and is offered for the addition of digital I/O capability to the 9603R Scientific Measurement and Control Station.

### Expandability

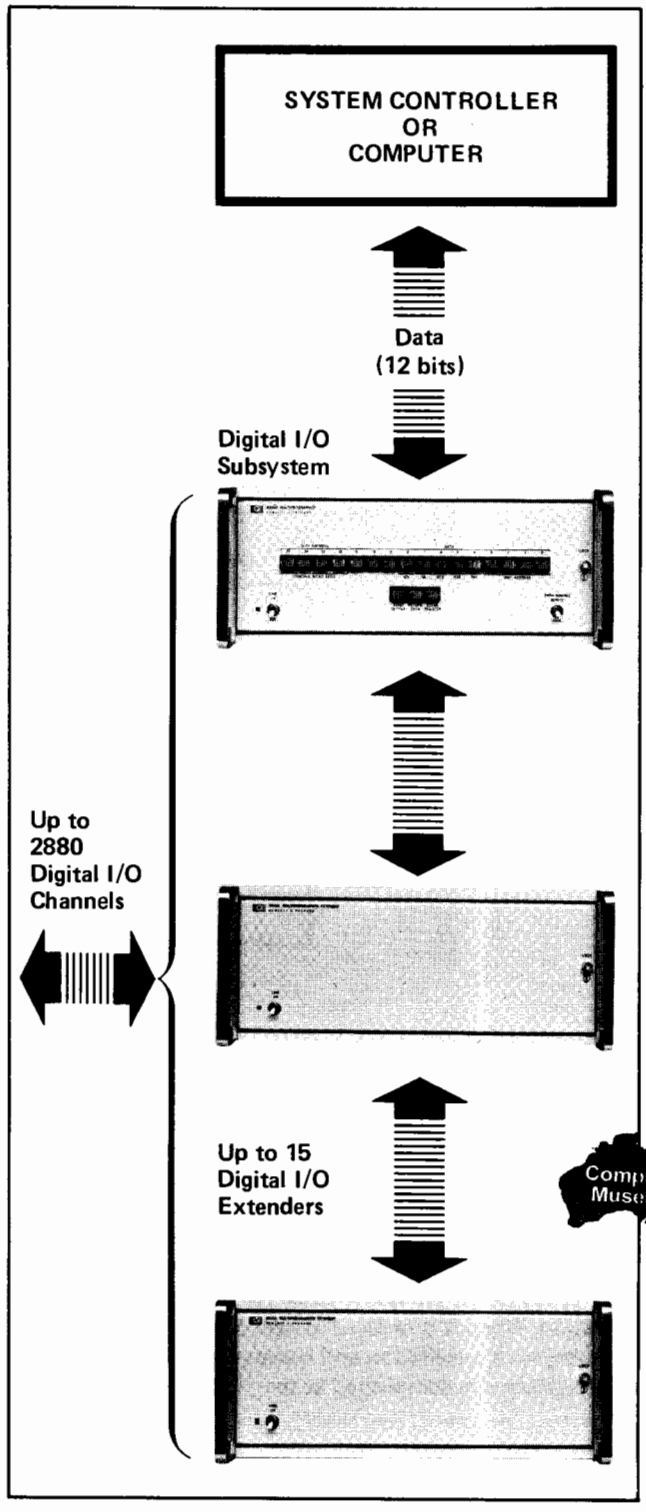
The basic capacity of the subsystem is 15 card slots for 12-bit I/O cards. Through the addition of 91140A digital I/O extenders, this capacity can be increased to 240 I/O card slots (15 in the subsystem mainframe and 15 more in each of 15 I/O extenders). The entire digital I/O subsystem connects to the computer via a single 16-bit microcircuit duplex register interface.

### Wide Choice of Capabilities

Subsystem capabilities are offered as modular plug-in cards, including 12 channel status inputs, 12-channel event sense inputs, and event counter input. Both solid-state and relay contact outputs providing 12-channel capacity are offered. Other digital output choices include a stepping motor controller, a programmable timer, a stall alarm, and a frequency reference. The subsystem can also be equipped with both digital-to-analog current and voltage converters, each providing 12-bit resolution.

### Industrial Connections and Signal Conditioning

The digital I/O subsystem plug-ins can be equipped with screw-terminal connection assemblies (option 010), which simplify connection of digital inputs and outputs. In their basic form, the screw terminals of these industrial connection assemblies connect directly to the input or output pins of the digital I/O subsystem plug-in modules, through the standard mating connector. However, voltages switched by external contact closures are sometimes incompatible with the



relatively low levels that are acceptable to the digital I/O subsystem input plug-ins. Similarly, the digital output signals available from the output plug-ins may not provide the drive required to energize controlled devices. To accommodate the fullest range of industrial requirements, two other versions of the connection assembly are offered, each providing a printed circuit board on which can be installed solid-state, plug-in ac or dc signal conditioning modules. These modules provide photo-isolated connection of digital inputs and outputs as shown in Figures 1 and 2. In addition to isolation, the signal conditioning provides for interfacing with the wide range of ac and dc digital I/o voltages normally encountered in the real world. This adaptability simplifies application of the digital I/O subsystem to user's needs.

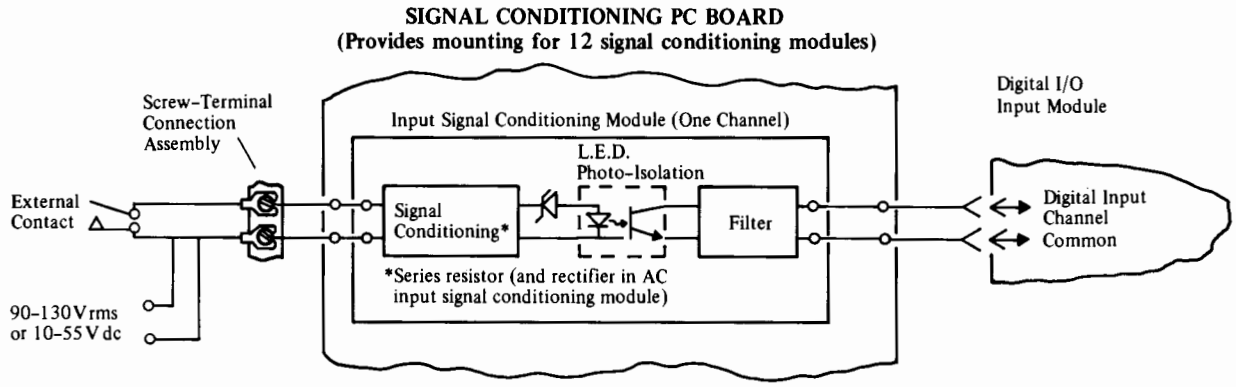



**Figure 1. Digital Input Signal Conditioning**

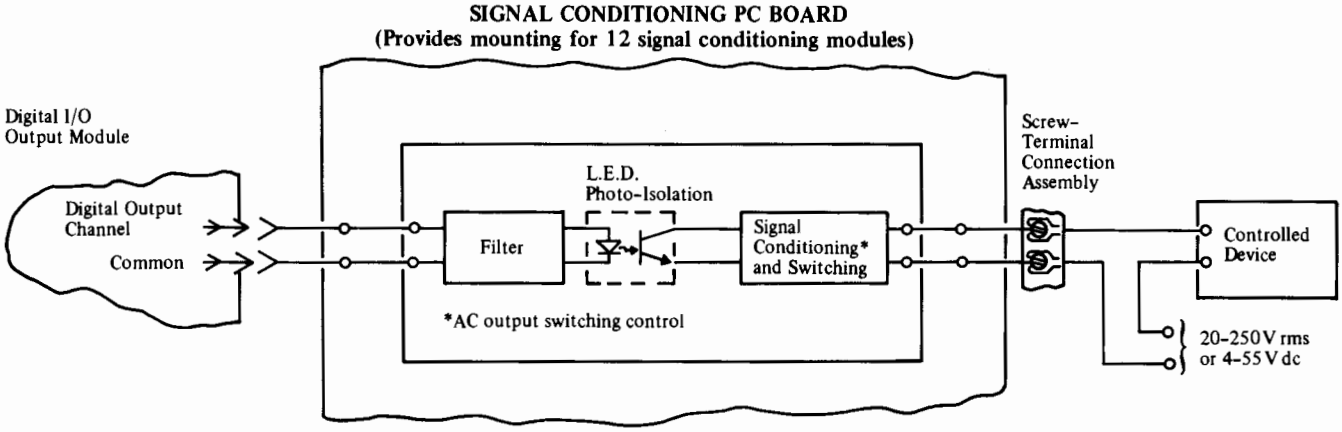



**Figure 2. Digital Output Signal Conditioning**

### Easily Installed

With the user's choice of appropriate digital I/O cards, the subsystem is a complete package, virtually ready to use as soon as it is delivered. Simply rack mount the subsystem, plug one interface card into the computer, and connect the cable. The subsystem then needs only to be integrated into the software operating system (BCS, RTE-B, RTE-C, or RTE-II/III) of the computer to be ready for programmed operation. When it is ordered as part of a complete system, the subsystem installation and integration into the computer system is accomplished at the factory.

### Easily Serviced

On-line diagnostics provide for remote checkout of the digital I/O subsystem. In the event of a malfunction, manual entry switches on the panel of the subsystem mainframe can be used to simplify and speed fault isolation. With these switches, any desired bit pattern can be sent to any card in the subsystem or any extender connected to it. Input states can be brought in from one channel and sent to another channel as part of a check on overall operation. This helps to quickly isolate a system malfunction to the digital I/O subsystem, interface, or computer, and helps to localize faults within the subsystem. Front panel access to all cards speeds completion of replacements or repairs when necessary.

# Specifications

## SUBSYSTEM and EXTENDER SPECIFICATIONS

**Card Positions**
15 in subsystem and each extender, up to 240 total with 15 extenders.

**Maximum Data Resolution**
12 bits.

**Data Transfer Rate**
20,000 digital words/sec, maximum.

**Operating Conditions**
0° to 40°C (32° to 104°F) ambient, allowing for 15°C (27°F) temperature rise inside system cabinet.

**Power**
Voltage: 115/230V ±10%, switch selectable.
Frequency: 48 to 440 Hz.
Power Consumption: 460W per subsystem and extender.
Microcircuit Interface: 0.05A (−2V) and 1.1A (+4.5V) drawn from computer or I/O extender.

**Heat Dissipation**
1570 BTU/hour per subsystem or extender at maximum power consumption.

**Computer I/O Channels**
One serves the subsystem and up to 15 extenders.

**Physical Characteristics**
Panel Height: 8-3/4 inches (222 mm) per subsystem and extender, including 1-3/4 inch blank panel space required for proper ventilation.
Weight: 38 lb. (17.3 kg) for subsystems, 34 lb. (15,4 kg) for each extender.

**Subsystem Controls**
Line On: Applies primary AC power.
Data Source: Selects remote/local.
16-Bit Switches: Enter words and address them to specific plug-in slot.
Load Output: Enters 16-bit switch pattern into the subsystem.
Clear Register: Clears all bits previously entered via the 16-bit switches.
Return Data: Generates a flag to computer, signaling data available on the return data lines.

**Extender Controls**
Line On: Applies primary AC power.

## HARDWARE SUPPLIED

HP 91063A Digital I/O Subsystem:
HP 6940A Multiprogrammer, including AC power cable, 1-3/4 inch (45 mm) blank panel, and rack mounting assembly.
HP 12566B Interface Kit, including interconnecting cable.

HP 91140A Digital I/O Extender:
HP 6941A Multiprogrammer Extender, including AC power cable, 1-3/4 inch (45 mm) blank panel, and chaining cable.

## SOFTWARE SUPPLIED

Diagnostic and Test Tapes
Optional Software (one of the following subsystem driver/interface routine options):

| | |
|---|---|
| S30 | BCS driver and FORTRAN/ALGOL driver interface |
| S50 | RTE driver and FORTRAN/ALGOL driver interface |
| S60 | RTE driver and RTE-B driver interface |

## SUBSYSTEM ORDERING INFORMATION

HP 91063A Digital I/O Subsystem.
HP 91140A Digital I/O Extender.

## HP 91201A DIGITAL OUTPUT CARD SPECIFICATIONS

**Data Output**
Capacity: 12 bits.
"1" State: 0 to 0.3V, 32 mA max. sink current.
"0" State: +4.5 to 5V/+12V, jumper sel., 1k ohm source.

**Gate Output**
Low State: 0 to 0.3V, 32 mA max. sink current.
High State: +4.5 to 5V/+12V, jumper sel., 1k ohm source.
Interpretation: Change in level indicates data is present on output lines; signal reverts to original state at start or end of external device response period, as selected by jumper.

**Flag Input**
Low State: 0 to 0.5V, 15 mA max. source current.
High State: +2.4–5V.
Duration: 2 μsec, minimum.
Interpretation: Change in level indicates external device has received data; return to original level indicates external device has completed response period. Gate Output can be connected directly to Flag Input.

**Option 001**
Substitutes positive-true, ground-false logic (same data output levels) for ground-true, positive-false logic of standard 91201A Digital Output Card.

**Option 010**
Adds screw-terminal connection assembly for use in HP 9611R Measurement and Control Station.

## HP 91202A DIRECT DIGITAL INPUT CARD SPECIFICATIONS

**Data Input**
Capacity: 12 bits.
"1" State: 0 to 0.8V, 6 mA max. source.
"0" State: +2 to +5V, 1k ohm.

**Gate Output**
Low State: Saturation, 50 ohms, 11 mA max. sink.
High State: Cut off, 1k ohm, maximum.
Interpretation: Low state signals readiness for data from external source.

**Flag Input**
Low State: 0.08V, 6 mA max. source.
High State: †2 to +5V, 1k ohm.
Interpretation: High to low change indicates external device busy; return to high state indicates input is ready.

**Option 001**
Substitutes "1" level = 0 to 1V, 15 mA max. source and "0" level = +6 to +14V for standard data input levels; 40 mA max. sink for low state and cut off, 10k ohms, max. for high state of gate output; and 0 to 1V, 15 mA max. source for low state and +6 to +14V high state of flag input.

**Option 002**
Substitutes ground-false, positive-true logic (same data input levels) for ground-true, positive-false logic of standard 91202A Direct Digital Input Card.

## HP 91203A ISOLATED DIGITAL INPUT CARD SPECIFICATIONS

**Data Input**
Capacity: 12 bits.
"1" State: 0 to 0.4V.
"0" State: +3.5 to +6V, 3 mA min. current.
Isolation: Up to 100V between data input lines and subsystem/extender common.

**Option 001**
Substitutes ground-false, positive-true logic (same data input levels) for ground-true, positive-false of standard 91203A Isolated Digital Input Card.

**Option 002**
Substitutes "1" level = +25 to 50V, 3 mA min. current and "0" level = 0 to 0.4V for standard data input levels.

**Option 003**
Substitutes "1" level = 0 to 0.4V and "0" level = +25 to +50V, 3 mA min. current for standard data input levels.

**Option 010**
Adds screw-terminal connection assembly for use in HP 9611R Measurement and Control Station. (Available only with standard HP 91203A Isolated Digital Input Card, not with option 001, 002, or 003.)

## HP 91204A RELAY OUTPUT CARD SPECIFICATIONS

**Data Output**
Capacity: 12 normally-open contact pairs.
"1" State: closes contacts.
"0" State: opens contacts.
Operation Times: 3.5 millisec pull-in/release.

**Contact Ratings**
Type: Mercury wetted contacts.
Voltage: 100V dc or 100V rms, maximum.
Current: 1.0A switching.
Power: 20W, maximum.
Life: Over $100 \times 10^6$ operations/contact at full rating.
Resistance: 0.05Ω, max. throughout rated life.

**Operating Position**
Vertical in subsystem or extender; tilt of subsystem or extender must not exceed 30° in any direction.

**Option 010**
Adds screw-terminal connection assembly for use in HP 96MX systems.

## HP 91205A EVENT SENSE INTERRUPT CARD SPECIFICATIONS

**Applicability**
Event sense interrupt card is usable only in HP 91063A subsystem mainframe, not in 91140A extender.

**Data Input**
"1" State: Contact open, >1 MΩ to common.
"0" State: Contact closed, <100Ω to common.
Integration Time: 10 millisec.
Capacity: 12 bits.

**Basis of Interrupt**
External data is compared to reference word, interrupt is issued to computer based on one of the following jumper-selected choices:
1. External data equal to reference word.
2. External data not equal to reference word.
3. External data less than reference word.
4. External data greater than reference word.

**Option 010**
Adds screw-terminal connection assembly for use in HP 9611R Measurement and Control Station

**Option 011**
For use in HP 9611R Measurement and Control Station. Adds screw-terminal connection assembly with mounting for 91210A AC input signal conditioning modules, which provide for 95-130V rms ac input.

**Option 012**
For use in HP 9611R Measurement and Control Station. Adds screw-terminal connection assembly with mounting for 91211A DC input signal conditioning modules, which provide for 10-55V dc input.

## HP 91206A DIGITAL-to-ANALOG CURRENT CONVERTER SPECIFICATIONS

**Output**
Signal: 0 to 20.475 mA.
Compliance: 0 to 10.5V, output referenced to −15V (isolated).
Load Regulation: 2 μA, maximum over compliance range.
Resolution: 5 μA.
Accuracy: ±2.5 μA over entire compliance range at 25° ±5°C (77° ±9°F).
Temp. Coeff: ±0.6 μA per °C (±0.34 μA per °F).
24-Hour Stability: 1.5 μA max. drift after 1 hour warmup.

**Programming Speed**
10 μsec for digital transfer to card +30 μsec max. settling to within 5 μA of final value.

**Ripple and Noise**
2 mV p-p, maximum, dc to 400 kHz.

**Remote Grounding**
Either output lead may be grounded remotely, provided external ground-to-system ground differential is no more than 100V.

**Prerequisite**
One 91132A Voltage Regulator is required in each 91603A subsystem or 91140A extender containing a 91206A Digital-to-Analog Current Converter.

**Option 010**
Adds screw-terminal connection assembly for use in HP 9611R Measurement and Control Station.

## HP 91207A DIGITAL-to-ANALOG VOLTAGE CONVERTER SPECIFICATIONS

**Output**
Signal: +10.235V to −10.240V, 0 to 5 mA, short circuit proof.
Load Regulation: ±3 mV, maximum, 0 to 5 mA.
Resolution: 5 mV.
Accuracy: ±5 mV, 0-5 mA output at 25° ±5°C (77° ±9°F).
Temp. Coeff: ±600 μV/°C (±333 μV/°F).
24-Hour Stability: ±1.5 mV max. drift after 1-hour warmup.

**Programming Speed**
10 μsec for digital transfer to card, +30 μsec max. settling to within 5 mV of final value.

**Ripple and Noise**
2 mV p-p, maximum, dc to 400 kHz.

**Prerequisite**
One 91132A Voltage Regulator is required in each 91063A subsystem or 91140A extender containing a 91207A Digital-to-Analog Voltage Converter.

**Option 010**
Adds screw-terminal connection assembly for use in HP 9611R Measurement and Control Station.

## HP 91208A PROGRAMMABLE TIMER, STALL ALARM CARD SPECIFICATIONS

**Output**
Interval: Variable from 1 μsec to 409.5 sec, using combination of programmable increments from 1 to 4095 and choice of decade-multiple periods from x1 μsec to $x10^5$ μsec, selectable by 91204A Relay Card, or by fixed jumpers.
Timing Accuracy: 0.01% of programmed interval ±100 nsec.
Levels: Positive-true and negative-true TTL, each capable of driving 10 TTL standard loads.

**Option 010**
Adds screw-terminal connection assembly for use in HP 9611R Measurement and Control Station.

**Option 011**
For use in HP 9611R Measurement and Control Station. Adds screw-terminal connection assembly with mounting for 91212A AC solid-state relay modules, which provide for switching of 20-250V rms ac.

**Option 012**
For use in HP 9611R Measurement and Control Station. Adds screw-terminal connection assembly with mounting for 91213A DC solid-state relay modules, which provide for switching of 4-55V dc. Includes 200V, 3A inductive overshoot suppression diodes at the outputs.

## HP 91209A FREQUENCY REFERENCE CARD SPECIFICATIONS

**Output**
Type: Square wave.
Frequencies: 1, 10, and 100 Hz and 1, 10, and 100 kHz.
Accuracy: 0.01% of nominal frequency.
Drivers: Open collector with 50 mA sink capability. Pullup resistor to +5V/+12V on card, or external supply to +30V can be added. Each output can drive up to three count inputs on separate 91221A Event Counter Cards.

**Inhibit**
Contact closure or low-state TTL logic level between inhibit line and common turns off the oscillator.

## HP 91210A AC INPUT SIGNAL CONDITIONING MODULE SPECIFICATIONS

**Applications**
Up to 12 of these modules may be used with option 011 digital input cards to provide photo-isolated connection of AC inputs.

**Input**
Signal Voltage: 95 to 130 VAC rms at 47-63 Hz.
Load: 5.5-10 mA rms at 120 VAC.
Impedance: 18k ohms.

**Operation Times**
13 millisec typical turn-on/turn-off.

**Isolation When Mounted**
Dielectric Strength, Input to Output: 250V rms at 60 Hz.
Insulation Leakage Immunity: input current to 2 mA rms (typical) will not cause turn-on.

## HP 91211A DC INPUT SIGNAL CONDITIONING MODULE SPECIFICATIONS

**Application**
Up to 12 of these modules may be used with option 012 digital I/O input cards to provide photo-isolated connection of DC inputs.

**Input**
Signal Voltage: 10 to 55 VDC.
Load: 10 mA ±25%.

**Operation Times**
2.5 millisec typical turn-on/turn-off.

**Isolation When Mounted**
Dielectric Strength, Input to Output: 250V rms at 60 Hz.
Insulation Leakage Immunity: input current to 3 mA DC will not cause turn-on.

## HP 91212A AC SOLID-STATE RELAY MODULE SPECIFICATIONS

**Application**
Up to 12 of these solid-state relay modules may be used with option 011 digital output cards to provide photo-isolated AC switching.

**Output**
Voltage Rating: 20 to 250 VAC rms, 47-63 Hz.
Current Rating: 10 mA, min., to 3A, max., continuous; surge to 80A, max., for 16 millisec.

**Switching Mode And Turn-On/Turn-Off**
Module switches on only when line voltage crosses zero, switches off only when load current crosses zero. Turn-on takes 1/2 cycle (8.3 ms) maximum; turn-off takes one cycle (16.6 ms maximum at 60 Hz).

**Dielectric Strength, Input to Output**
500 VAC rms at 60 Hz.

## HP 91213A DC SOLID-STATE RELAY MODULE SPECIFICATIONS

**Application**
Up to 12 of these solid-state relay modules may be used with option 012 digital output cards to provide photo-isolated DC switching.

**Output**
Voltage Rating: 4-55 VDC.
Current Rating: Up to 1.5A continuous, unidirectional.
Saturation Voltage Drop: 2V at 2A.

**Operation Times When Mounted**
Turn-on: 500 μsec maximum.
Turn-off: 3.0 millisec maximum.

## HP 91220A STEPPING MOTOR CONTROL CARD SPECIFICATIONS

**Application**
This card generates pulses to either of two outputs, which are connected to the clockwise and counter-clockwise inputs of a user supplied stepping motor controller, such as SLO-SYN ST 1800B or Foxboro 137W.

**Output**
No. of Pulses: programmable from 1 to 2047.
Pulse Frequency: nominally 100 Hz, adjustable between 10 Hz and 2 kHz by changing components on card or connecting external resistor.
Low Level: 0 to 0.5V, 50 mA max. sink.
High Level: +4.75 to +5.25V or +12V unregulated, jumper selectable.
No. of outputs: Two program-selectable, one for clockwise drive, the other for counter-clockwise drive.

**Flag Output**
TTL high indicates output count is in progress (busy state); low indicates ready state.

**Option 010**
Adds screw-terminal connection assembly for use in HP 9611R Measurement and Control Station.

## HP 91221A EVENT COUNTER CARD SPECIFICATIONS

**Application**
This card counts up or down in the range of 0 to 4095. Carry and borrow pulses generated when count goes above 4095 or below 0 permit counters to be cascaded. When used with the 91208A Programmable Timer or the 91209A Frequency Reference, the Event Counter may be used to measure frequencies or time intervals. A preset feature provides for counting a pre-determined number of events without intermediate polling by the computer.

**Input**
Type: +5V, +12V, +24V, or contact closure pulse inputs for both up and down counting.
Frequency: to 10 kHz square wave (software limited).
Minimum Pulse Width: 2.5 μsec.
Maximum Rise Time: 5 μsec.
Enable Inputs: Open circuit or TTL high = enable; short circuit or TTL low = disable.
Common Mode Tolerance: up to 100V rms, max.

**Outputs**
Counter Output: 12 bit binary; drive capability is one TTL standard load.
Carry Output: TTL output goes high when count is incremented above 4095; drive capability is ten standard TTL loads.
Borrow Output: TTL output goes high when count is decremented below zero; drive capability is ten standard TTL loads.

**Option 010**
Adds screw-terminal connection assembly for use in HP 9611R Measurement and Control Station. Provides all connections except counter output.

**Option 011**
For use in HP 9611R Measurement and Control Station. Adds screw-terminal connection assembly with mounting for 91210A AC input signal conditioning modules, which provide for 95-130V rms ac digital input. Limits input count frequency to 20 Hz and requires 30 millisec signal duration. Provides all connections except counter output.

**Option 012**
For use in HP 9611R Measurement and Control Station. Adds screw-terminal connection assembly with mounting for 91211A DC input signal conditioning modules, which provide for 10-55V dc input. Limits input count frequency to 200 Hz and requires 3 millisec minimum pulse duration; provides all connections except counter output.

## HP 91222A 12-BIT AC/DC STATUS INPUT SPECIFICATIONS

**Application**
For use in HP 9611R Measurement and Control Station to receive ac or dc digital inputs via ac or dc input signal conditioning modules. Must order either option 011 or 012.

**Digital Input**
Capacity: 12 bits.
"1" State: 95-130V rms ac (w/option 011 and 91210A AC signal conditioning modules) or 10-55V dc (w/option 012 and 91211A DC signal conditioning modules).
"0" State: Open circuit.

**Option 011**
Equips 91222A Status Input with screw-terminal connection assembly with mounting for 91210A AC input signal conditioning modules, which provide for 95-130V rms ac digital input.

**Option 012**
Equips 91222A Status Input with screw-terminal connection assembly with mounting for 91211A DC input signal conditioning modules, which provide for 10-55V dc digital input.

## HP 91223A 12-BIT AC/DC DIGITAL OUTPUT SPECIFICATIONS

**Application**
For use in HP 9611R Measurement and Control Station to switch ac or dc digital outputs via ac or dc solid-state switch modules. Must order either option 011 or 012.

**Digital Output**
Capacity: 12 bits.
"1" State: Switches "on" 20-250V rms ac (w/option 011 and 91212A AC solid-state switch modules) or 4-55V dc (w/option 012 and 91213A DC solid-state switch modules).
"0" State: Open circuit.

**Option 011**
Equips 91223A Digital Output with screw-terminal connection assembly with mounting for 91212A AC solid-state switch modules, which provide for switching of 20-250V rms ac digital output.

**Option 012**
Equips 91223A Digital Output with screw-terminal connection assembly with mounting for 91213A DC solid-state switch modules, which provide for switching of 4-55V dc digital output. Includes 200V, 3A inductive overshoot suppression diodes at the outputs.

**Specifications subject to change without notice.**

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For more information, call your local HP Sales Office or East (301) 948-6370 • Midwest (312) 677-0400 • South (404) 434-4000 • West (213) 877-1281. Or write: Hewlett-Packard, 1501 Page Mill Road, Palo Alto, CA 94304. In Canada: 275 Hymus Blvd., Point Claire, Quebec. In Europe: Hewlett-Packard, P.O. Box 85, CH-1217 Meyrin 2, Geneva, Switzerland. In Japan: Yokogawa-Hewlett-Packard, 1-59-1, Yoyogi, Shibuya-ku, Tokyo, 151.

DIGITAL I/O SUBSYSTEM, DIGITAL I/O EXTENDER AND DIGITAL I/O PLUG-INS 9/76

Printed in U.S.A. (06)
5952-8513

HEWLETT hp PACKARD

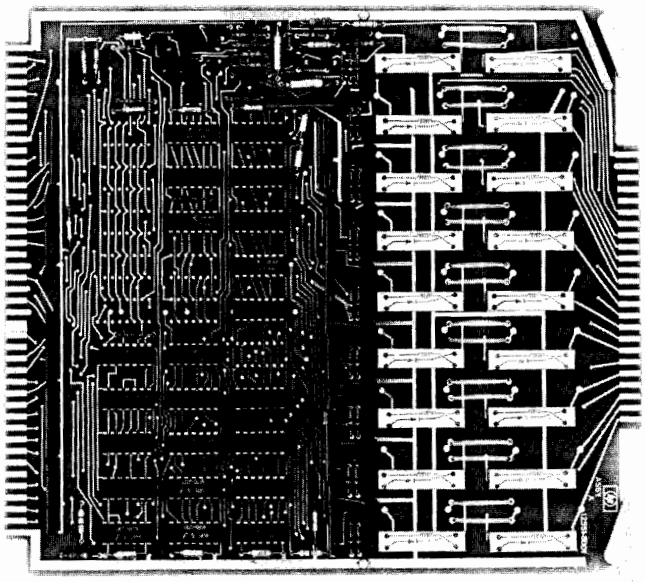
# 16-Bit Relay Output Register

model 12551B

Technical Data 10/76

## Features

- **16-bit output used separately or in combination to control from 1 to 16 devices**
- **Floating contact closures for flexible use of output bit states**
- **Power-on initialization predetermines intial states of all relays**
- **Command-interrupt logic provides two-way communication**



## Description

The Relay Register provides 16 floating contact closures which can be used for controlling one device, or be subdivided in any combination to control several devices. The voltages switched through the relay contacts can differ from each other, and from computer ground, by as much as 100V peak. Contacts can be connected in series, parallel, or in series-parallel, with or without diode isolation.

### Power On Preset

Turn-on of computer power automatically presets register flip-flops that store the output bit states for the various relays. The presets are applied separately to the register flip-flops for bits 15 through 8 and those for bits 7 through 0, as shown in Figure 1. Hard-wired jumper connections to each group of eight flip-flops determine whether all the flip-flops in a group will be set, closing the respective relay contacts, or cleared, allowing the relay contacts to open. *Initialization assures that the states of all relays are known immediately after power turn-on,* which is particularly desirable when power supplies are being programmed. This feature also saves initialization instructions that might otherwise be required in computer programs.

### Output Operations

An Output instruction (OTA or OTB) transfers 16 data bits from the computer A- or B-Register to the storage register flip-flops, in turn energizing the corresponding relays through transistor driver circuits, closing the relay contacts.

The relays retain their states unless changed by the next OTA or OTB instruction. Relay contacts close or open within 1 millisecond following transfer of new bit states to the storage register on the card.

### Read-Back Operations (with Option 001)

The bit states applied to the relays can be read back into the computer A- or B-register by an Input instruction (LIA or LIB). The read-back capability also permits any part of a program to determine the state of the relays at any given time.

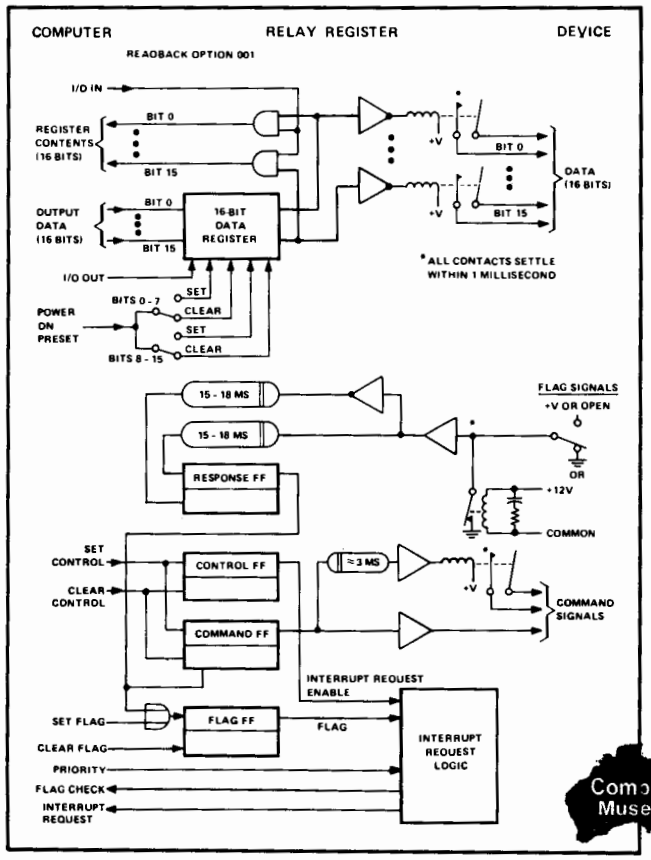



Figure 1

# Description
(Continued)

**Command-Interrupt Capability**

In addition to the 16-bit relay output, the Relay Register is equipped with command and interrupt logic that makes possible a two-way exchange of control and status or request information between the computer and controlled equipment. Typically, the computer will use the command logic to 'tell' a controlled equipment that new data has been entered in the Relay Register. The controlled equipment will normally use the interrupt logic to 'ask' the computer for the next data word to be transferred via the Relay Register.

The command output is generated in response to a Set Control (STC) instruction in the program. This instruction sets the Control and Command flip-flops (Figure 1), enabling the interrupt request logic in addition to activating the command output. There is a choice of two command outputs, which can be used individually or simultaneously. One of the outputs comes from a ground-referenced driver transistor and the other is an isolated (floating) contact closure that can be used as flexibly as any of the 16 sets of relay contacts that make up the output data.

An interrupt request is generated in response to a flag signal from the controlled equipment. This signal sets the Response flip-flop, which clears the Command flip-flop and activates the interrupt request logic when it has been enabled by the set output of the Control flip-flop. As shown in Figure 1, the Relay Register provides an isolated flag input to a relay coil as well as a ground-referenced input to a driver transistor. (The +12V input to the relay coil need not be referenced to computer ground.) Energizing the relay coil grounds the input line to the driver transistor, which sets the Response and Flag flip-flops. Where the isolation provided by the relay coil input is not needed, an external circuit closure to ground has the same effect.

# Specifications

**Relay Contacts**
States: All contacts are normally open when power is off; contacts close individually in response to '1' bit states from computer.

Maximum Power: 10W peak or continuous, per contact.

Maximum Voltage: 100V peak or continuous across open contacts, between output connector pins, and with respect to computer ground on the register card.

Maximum Current: 500 mA per contact, peak or continuous.

Life: 10 million operations under rated load.

Resistance: 0.1Ω at 100 mA (higher and lower current).

Protection: Mounting positions are provided for connecting contact protection resistors in series with the contacts of all the relays.

Settling Time: 1 millisecond, maximum, for pull-in or drop-out.

**Data Output**
(16 floating relay contacts, with ratings as specified above)

'1' Level: Contact closed.

'0' Level: Contact open.

Power-on Preset: Register is normally wired to preset all data relays open. Upon request at time of ordering, register will be wired to preset bits 15 through 8 or bits 7 through 0 open, or all bits closed when power is turned on.

**Command Output, Ground-Referenced**
'1' Level: 0V, 12 mA current sink.
'0' Level: +12V through 10 kΩ.

**Command Output, Isolated**
(Floating relay contact, with ratings as specified above)

'1' Level: Contact closed.
'0' Level: Contact open.
Delay: 3 milliseconds nominal.

**Response (Flag) Input, Isolated**
Normal: 12V, 15 mA to relay coil.
Set Flag: No input to relay coil.
Response Delay: 15 milliseconds, nominal.

**Response (Flag) Input, Ground-Referenced**
Normal: 0V, 12 mA current sink from NPN transistor.
Set Flag: Open Circuit.
Response Delay: 15 milliseconds, nominal.

**Interface Current Supplied By The Computer**
Interface Kit 12551B:
0.24A (+12V), 0.39A (−2V), 0.6A (+4.5V)
Interface Kit 12551B-001:
0.24A (+12V), 0.59A (−2V), 1.1A (+4.5V)

**Weight** Net: 17 oz. (482 g)

## ORDERING INFORMATION

Order by Interface Kit Number
Interface Kit 12551B, consisting of:
1. Relay Output Register (without read-back option), Part No. 12551-6001.
2. Connector Kit, 48 pin, Part No. 02116-6178.

Interface Kit 12551B-001, consisting of:
1. Relay Output Register (with read-back option), Part No. 12551-6002.
2. Connector Kit, 48 pin, Part No. 02116-6178.

## INSTALLATION

Installation of the HP 12551B is the responsibility of the customer. HP installation assistance is provided on request, at prevailing rates.

**Specifications subject to change without notice.**

For more information, call your local HP Sales Office or East (301) 948-6370 • Midwest (312) 677-0400 • South (404) 434-4000 • West (213) 877-1281. Or write: Hewlett-Packard, 1501 Page Mill Road, Palo Alto, CA 94304. In Canada: 275 Hymus Blvd., Point Claire, Quebec. In Europe: Hewlett-Packard, P.O. Box 85, CH-1217 Meyrin 2, Geneva, Switzerland. In Japan: Yokogawa-Hewlett-Packard, 1-59-1, Yoyogi, Shibuya-ku, Tokyo, 151.



Printed in U.S.A. (06)
5952-8514

HEWLETT hp PACKARD

# 16-Bit Duplex Register

model 12554A

Technical Data 10/76

## Features

- **Versatile operation in 16-bit input and 16-bit output storage, plus control and interrupt logic**
- **Off-the-shelf interface to meet most computer interface needs**
- **Easy to program using HP Assembly language**

## Description

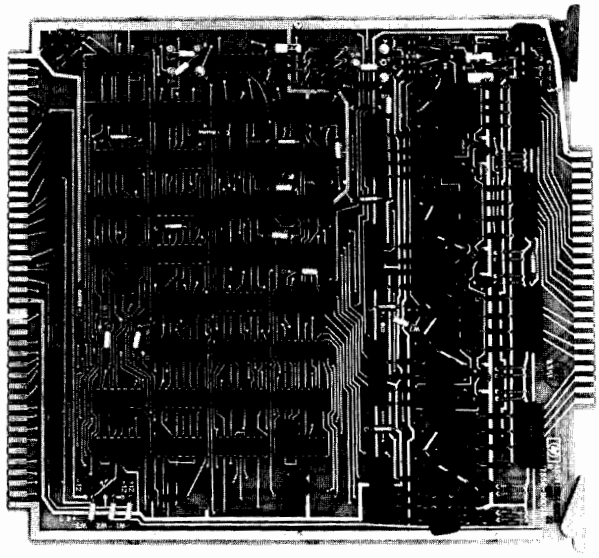
The Hewlett-Packard Duplex Registers enable you to interface HP computers to exchange input and output information with most digital output measurement devices. And, you can have a single interface card with 8-bit or 16-bit storage registers, depending on your application. Adding a duplex register to your HP computer is quick and easy — merely plug the duplex register card into a computer I/O slot and connect a cable. Although each duplex register is designed as a general purpose interface, it has many of the same features as other HP interface cards designed for specific peripheral devices. Included are 8- or 16-bit input and output storage registers which provide temporary storage during data transfer, plus control and interrupt logic. Also provided is a device command line to the external equipment and a flag (action completed) response line from the external device. These functions are shown in the simplified logic diagram. Input operations, output operations, and combined input/output operations are possible between the computer and the external device when interfaced through either duplex register.

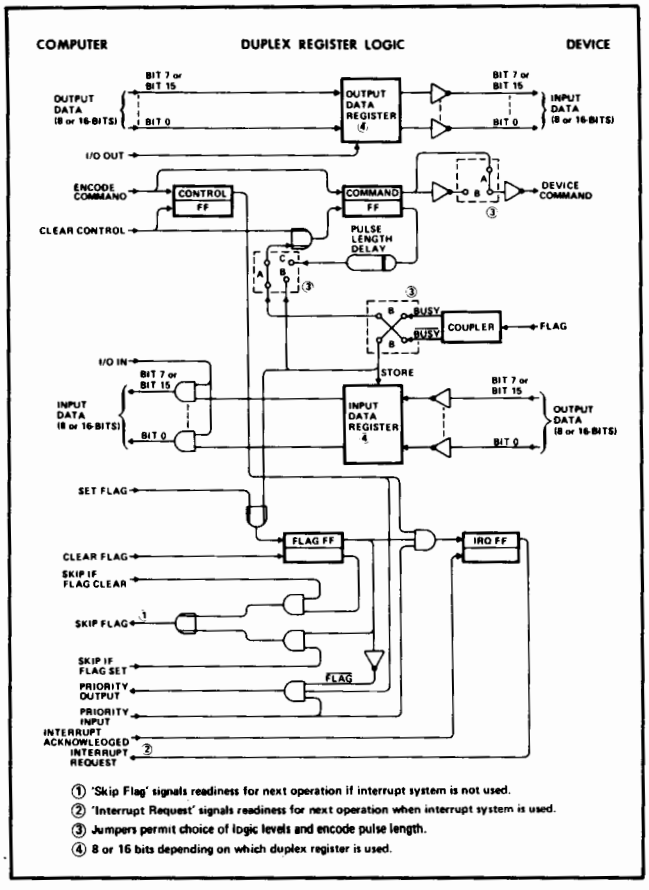
### Input Operations

When the external device is ready to supply data to the computer, it must supply a flag signal to the duplex register. This signal enters data into the input data register and sets up a request for service (Interrupt Request, or Skip Flag if interrupt system is not being used). The computer responds with an input instruction (and resulting I/O In signal) that enters the input data into the computer A- or B-register.

### Output Operations

An output instruction and an accompanying I/O Out signal from the computer transfers 8 or 16 data bits (depending on which register is used) from the computer A- or B-register to the output data register on the card. These bits are then applied to the external device without further intervention by the computer. The next step is issuance of a device command by the computer which "tells" the external device that the data is ready to be acted upon.





# Description

When the external device is ready for the next data word it simply returns the flag signal to the duplex register. This signal sets up a request for service (Interrupt Request, or Skip Flag if interrupt system is not being used.) The computer responds by outputting the next 8 (or 16) bits of data and a device command.

### Combined Input/Output Operations

Each duplex register includes two independent registers which allow a two-way flow of information between the computer and an external device. A typical combined input/output operation would be output of control information to a measuring device that measures data from several input channels. The output register would provide control information to the external device and the input register would accept the results of the measurements. If the external device is a printer, data is transferred through the output register and status information is read back into the input register.

### Direct Memory Access Operations

When coupled through the Direct Memory Access (DMA) section of an HP computer, the duplex registers can handle inputs from A-to-D Converters or outputs to telemetry command links at high data rates. The basic duplex registers are capable of 100,000 8- or 16-bit transfers per second.

# Specifications

| | DUPLEX REGISTER CARD Part No. 12554-60023 (16 bits) Part No. 12597-6001 (8 bits) (Pos In/Pos Out) | DUPLEX REGISTER CARD Part No. 12554-60024 (16 bits) Part No. 12597-6002 (8 bits) (Neg In/Neg Out) |
|---|---|---|
| OUTPUT LEVELS<br>"1" state<br>"0" state | 0 to +0.5V, 12 mA sink max.<br>+12V, 10K source | -12V, 10K source<br>0 to -0.5V, 12 mA sink max. |
| INPUT LEVELS<br>"1" state<br>"0" state | 0 to +0.5V, 12 mA sink max.<br>+8V | -8V<br>0 to -0.5V, 12 mA sink max. |
| BIAS AND IMPEDANCE | +8V through 700 ohms | -8V through 700 ohms |
| DEVICE COMMAND OUTPUT | Command signal to external device:<br>1. Indicates data is ready in Output Register<br>2. Is terminated by a device Flag signal input | |
| DEVICE FLAG INPUT | External device command to interface card:<br>1. Strobes data to Input Storage Register<br>2. Sets interface-card Flag FF | |

### Interface Current Supplied By The Computer

| Interface Kit | +12V | -12V | -2V | +4.5V |
|---|---|---|---|---|
| 12554A | 0.023A | 0.03A | 0.06A | 1.11A |
| 12554A-01 | 0.025A | 0.25A | 0.06A | 1.11A |
| 12597A | 0.05A | 0.02A | 0.05A | 0.75A |
| 12597A-01 | 0.02A | 0.05A | 0.05A | 0.75A |

(Note: An auxiliary HP Power Supply may be necessary for installations which use several I/O devices with high-current requirements. Consult your nearest HP Field Sales Office.)

### Duplex Card Dimensions

Width: 7-3/4 inches (196,8 mm)
Height: 8-11/16 inches (220,7 mm)

### Interface Kit Weight

Net weight: 18 oz (675 gm)

### ORDERING INFORMATION

HP 12554A Interface Kit, consisting of:

16-Bit Duplex Register Interface Card, Part No. 12554-60023 (Positive in/Positive out)

Connector Kit (for interconnect cable), Part No. 02116-6178.
Test Connector, 24-pin, Part No. 1251-0332

HP 12554A-01 Interface Kit, consisting of:

16-Bit Duplex Register Interface Card, Part No. 12554-60024 (Negative in/Negative out)

Connector Kit (for interconnect cable), Part No. 02116-6178
Test Connector, 24-pin, Part No. 1251-0332

### INSTALLATION

Installation of the HP 12554A is the responsibility of the customer. HP installation assistance is provided on request, at prevailing rates.

**Specifications subject to change without notice.**

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Printed in U.S.A. (06)
5952-8515

HEWLETT hp PACKARD

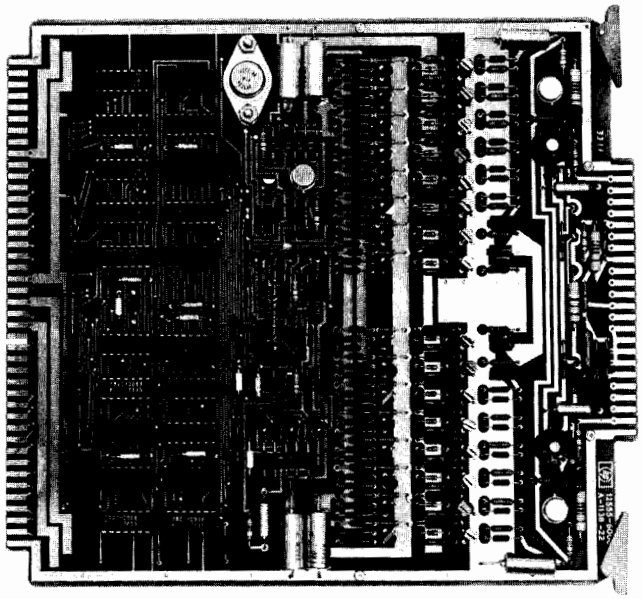
# Digital-to-Analog Converter

model 12555B

Technical Data 10/76

## Features

- **Continuous, rapid graphical display of data using conventional oscilloscopes**
- **Rapid graphical display of large amounts of semi-static data using storage-type oscilloscopes**
- **Plotting of graphical data using an analog X-Y plotter to obtain low-to-medium resolution point plots**
- **Providing programmed voltage references for use in programming power supplies**



## Description

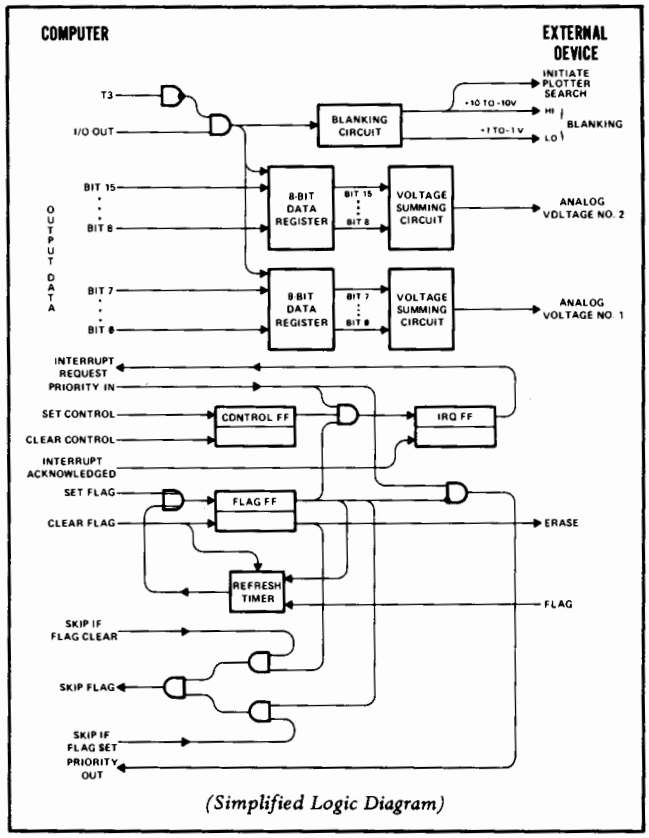
The D-A Converter provides two analog outputs ranging between 0 and +10 volts. Resolution of each channel is 8 bits. Blanking and "erase" signals are also provided by the D-A Converter for use with oscilloscopes and X-Y plotters. D-A Converter operation may be under program control or Direct Memory Access (DMA) with Dual Channel Port Controller (DCPC).

The Dual 8-Bit D-A Converter consists of the D-A Converter card and a connector kit, which together form Interface Kit 12555B. The D-A Converter card can be plugged into any computer Input/Output slot. It contains control and interrupt logic, and a timer for use in maintaining a graphical display on conventional oscilloscopes and to determine erase signal duration in storage-type oscilloscope operation. Two summing networks on the card convert the digital data from the computer to the two analog output voltages. Additionally, two voltage levels are provided by the D-A Converter card as blanking signals for conventional oscilloscopes. The blanking signal turns off the electron beam after a point has been excited so that the beam is not observed between that point and the next point to be excited. During use of the D-A Converter card with storage-type oscilloscopes, an erase signal can be made available to remove the existing display on the oscilloscope screen when a new pattern is to be displayed.

The two analog voltages can also be connected to X-Y plotters for graphic display of data.

When used with oscilloscopes or X-Y plotters, the D-A Converter card will cause a unique point in a 256-by-256 array to be displayed or plotted.

The D-A Converter card can be used with Direct Memory Access in 2100 or with the Dual Channel Port Controller in the 21MX for analog outputs at high data rates.




*(Simplified Logic Diagram)*

# Description

**Analog Voltage Outputs**

Output operations to obtain the two analog voltages from the D-A Converter are *very simple.* A Load A (LDA) or a Load B (LDB) instruction, followed by an Output instruction is all that is required to program the two analog output voltages from a data word in memory. The Output instruction transfers 16 bits from the computer A- or B-register to the data register of the D-A Converter card.

These bits then enter the voltage summing circuits of the card where the analog voltages are formed and made available to the external device. Analog Voltage No. 1 is formed by bits 0 through 7 from the computer A- or B-register and Analog Voltage No. 2 is formed by bits 8 through 15. The magnitude of each analog output voltage is given by 10N/255, where N is the decimal value represented by the combination of bits in each group of 8 bits from the computer.

# Specifications

## ANALOG OUTPUT VOLTAGES

| | |
|---|---|
| Voltage Range: | 0 to +10V nominal (full scale accuracy: ±100 mV) |
| Zero Offset: | ±40 mV (1 count) |
| Linearity: | To ±40 mV within one machine cycle from the end of the Output (OTA/B) program instruction. |

## BLANKING PULSES

**Blanking Pulses**

| | |
|---|---|
| High: | +10 to -10 volts (nominal) |
| Low: | +1 to -1 volt (nominal) |
| Pulse length: | 2 memory cycles (2114/2115/2116) or 2 instruction times (2100, 21MX) |
| Erase Signal: | Transistor closure to ground |

**Current Requirements (Max.)**

| | |
|---|---|
| +4.5V Supply: | 2.4A |
| -2V Supply: | 1.08A |
| +12V Supply: | 0.5A |
| -12V Supply: | 0.36A |

## PHYSICAL CHARACTERISTICS

**Dimensions:**
Width: 8-11/16 in. (220.7 mm)
Height: 7-3/4 in. (196.8 mm)
Weight: 17 oz. (482 g)

**Terminated Cables**

The use of 75 ohm coaxial cables terminated with 75 ohm resistive loads is recommended for cable runs of more than 15 feet when used with high speed devices, such as oscilloscopes (Analog output voltages then = 0 to about 5V).

## HARDWARE SUPPLIED

**Interfact Kit 12555B, consisting of:**

1. Dual 8-Bit D-to-A converter card, HP Part No. 02116-6198.
2. Connector Kit, 24-Pin, HP Part No. 02116-6264

## ORDERING INFORMATION

12555B D-to-A Converter Kit

## INSTALLATION

Installation of the HP 12555B is the responsibility of the customer. HP installation assistance is provided on request, at prevailing rates.

**Specifications subject to change without notice.**

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For more information, call your local HP Sales Office or East (301) 948-6370 • Midwest (312) 677-0400 • South (404) 434-4000 • West (213) 877-1281. Or write: Hewlett-Packard, 1501 Page Mill Road, Palo Alto, CA 94304. In Canada: 275 Hymus Blvd., Point Claire, Quebec. In Europe: Hewlett-Packard, P.O. Box 85, CH-1217 Meyrin 2, Geneva, Switzerland. In Japan: Yokogawa-Hewlett-Packard, 1-59-1, Yoyogi, Shibuya-ku, Tokyo, 151.



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5952-8516

HEWLETT hp PACKARD

# 40-Bit Register

model 12556B

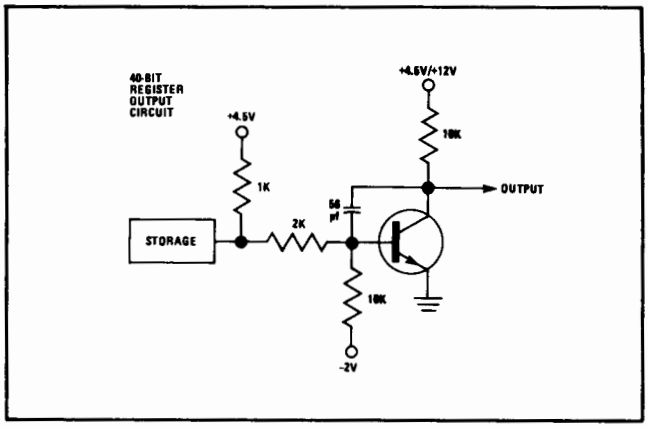
Technical Data 10/76

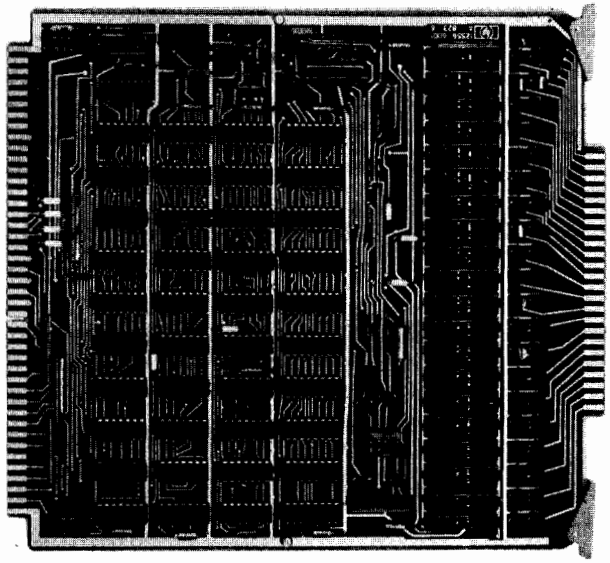
## Features

- **40 bit (10 BCD digit) capacity**
- **Choice of ASCII or binary assembly modes**
- **Includes recorder command-holdoff interface**

## Description

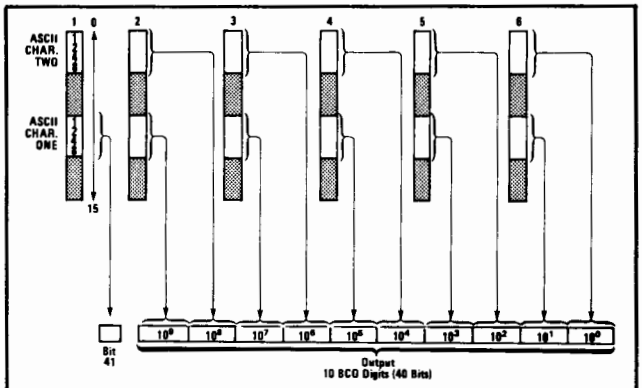
The 12556B is an output interface with 40-bit capacity for driving program input lines of non-HP-IB stimulus or measuring instruments, control panel indicators or control lines, or HP model 5055A or 5050B Digital Recorders connected to HP 96MX or HP 1000 Model 31 or Model 81 Computer Systems.



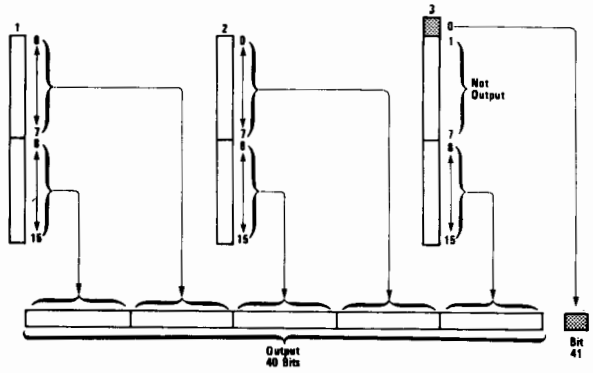



### ASSEMBLY OF OUTPUT

The 40-bit register offers a choice of ASCII and binary output modes. In ASCII mode, the register assembles the BCD portion of ASCII characters from six words (12 bytes) in computer memory, as shown in Figure 1, to form a 41-bit output (10 BCD digits plus control bit). In binary mode, the register output is assembled from three words (six bytes) or memory, as shown in Figure 2.




*Output Assembly in ASCII Mode*
*Figure 1*




*Output Assembly in Binary Mode*
*Figure 2*

# Specifications

**Data Output**
No. of Bits: 40 data bits and one control bit.

"1" Level: +12V/+4.5V, jumper-selectable, through 10kΩ.

"0" Level: 0V, 10 mA max. current sink.

**Reference Voltages**
Positive: +9V/+3.33V, jumper-selectable, 110Ω impedance.

Negative: +1V/+0.37V, jumper-selectable, 44Ω impedance.

**Command Output**
Standard: 50 μs pulse from <+1V to +7.8V.

Option 002 Negative Command: 50 μs pulse from >+5V/+7.8V, jumper-selectable, to <+1V. May be changed to positive command by changing jumper.

**Flag (Positive Hold-Off) Input From External Device**
Standard: +7V to +15V, 2.3 mA, minimum, from -0.7V or open circuit state. Return to ground or open circuit state sets flag.

Option 002: +4.5V to +15V, 2.2 mA, minimum, from -0.7V or open circuit state. Return to ground or open circuit state sets flag.

**Status (Negative Hold-Off) Input From External Device**
-3V to -30V, 0.61 mA, minimum, from +5V open circuit state. (This input from 5050A/B recorder remains in hold-off state when recorder is out of paper.)

**Output Presetting**
Power On: turn-on of computer power presets all output bits to "0" state.

Programmed: All output bits can be program-preset to either "1" or "0".

**Override Timer**
Timing: sets flag after 300 milliseconds if external device has not returned flag.

Status: bit 3 to input bits is set if override timer has set flag.

**Output Assembly Modes**
ASCII Mode: bits 11-8 and 3-0 from 16-bit computer words are assembled to form the output (see Figure 1).

Binary Mode: All bits of 16-bit computer words form the output, most significant bit first.

Mode Selection: by jumpers and programming.

**Computer I/O Channels Used**
One.

**Interface Current Required**
0.01A (-12V), 0.08A (-2V), 0.9A (+4.5V), 0.15A (+12V).

**Memory Required For RTE Driver**
500 bytes; 640 bytes when called from Multi-User Real-Time BASIC.

**Prerequisite**
The performance test routines must be read into the system via the 12925A Punched Tape Reader Subsystem; therefore the HP 1000 Model 31 or Model 81 Computer System must have the punched tape reader before it can use the 12556B 40-Bit Register.

## HARDWARE FURNISHED

1. 40-Bit Register, positive true (12556-6002).
2. Mating connector kit (5060-8339).

## SOFTWARE FURNISHED

Output Register Test Routine on punched tape (20348-60001).

## SOFTWARE USED

The 40-Bit Register uses driver DVR54, included with the 92066A RTE Measurement and Control Drivers Package.

## MANUAL FURNISHED

Interface Manual (12556-9002).

## ORDERING INFORMATION

**Options**

001: Substitutes cable (02547-6040) for connection to 5050A/B, 5055A, or 562AR Digital Recorder in place of mating connector kit.

002: Replaces standard positive true 40-Bit Register, interface manual, and test routine with:

1. 40-Bit Register, ground true (12556-60022).
2. Test connector (12556-60023).
3. Test cable (12556-60024).
4. Output register diagnostic routine on punched tape (29026-60001).
5. Interface manual (12556-90028).

## INSTALLATION

Installation of the 12556B is the responsibility of the customer. HP installation assistance is provided on request, at prevailing rates.

**Specifications subject to change without notice.**

HEWLETT hp PACKARD

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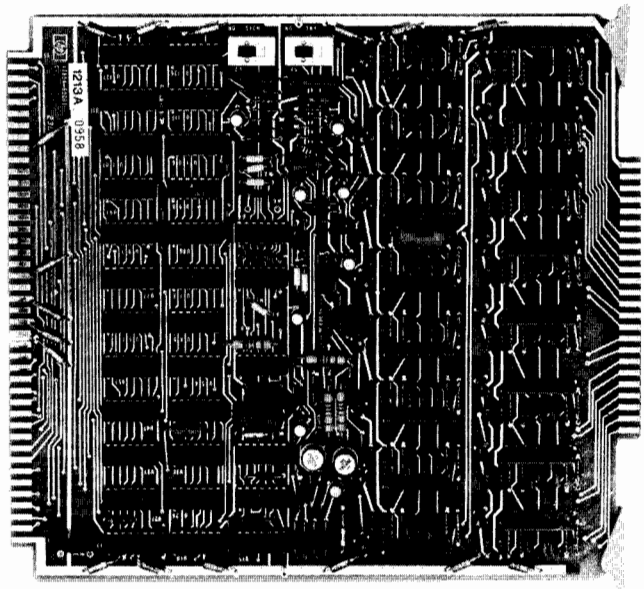
# Data Source Interface

model 12604B

Technical Data 10/76

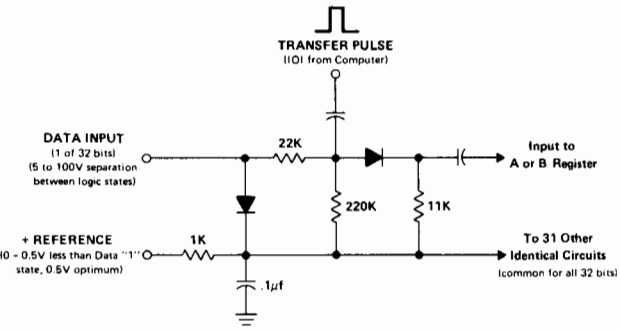
## Features

- **32 bit (8 BCD digit) capacity**
- **Wide-range of referenced input logic levels (-100V to +100V)**
- **Provides measurement triggering signals to data source**

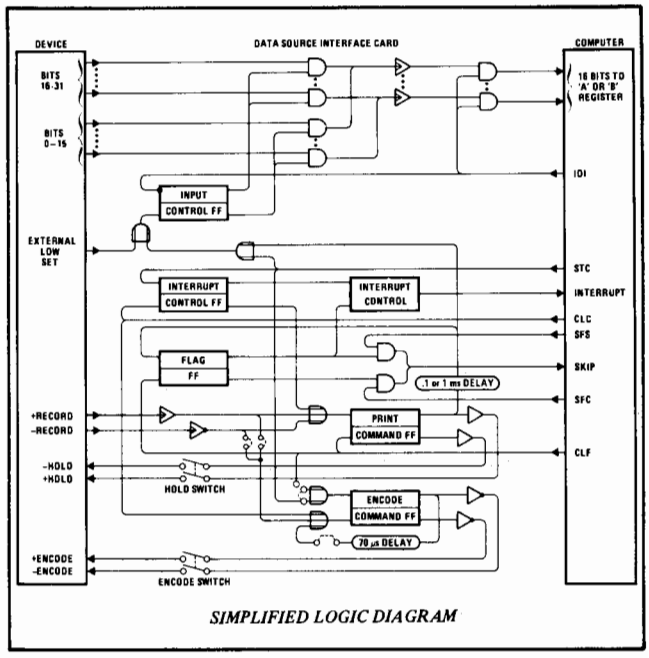


## Description

The HP 12604B is a non-HP-IB measuring instrument Data Source Interface (DSI) card with 32-bit capacity. As such, it can transfer up to 8 BCD digits from counters, DVMs, etc., to HP 2100S Computers, HP 21MX Computers, HP 96MX series Computer Systems, or HP 1000 series Computer Systems. Referenced capacitive coupling (see circuit diagram) accommodates logic levels between -100V and +100V, making the DSI a universal interface for connecting a digital instrument with digital output to the aforementioned computers.




*DATA INPUT CIRCUIT DIAGRAM*




*SIMPLIFIED LOGIC DIAGRAM*

## Specifications

**Data Input**

Range of Levels: between -100V and +100V.

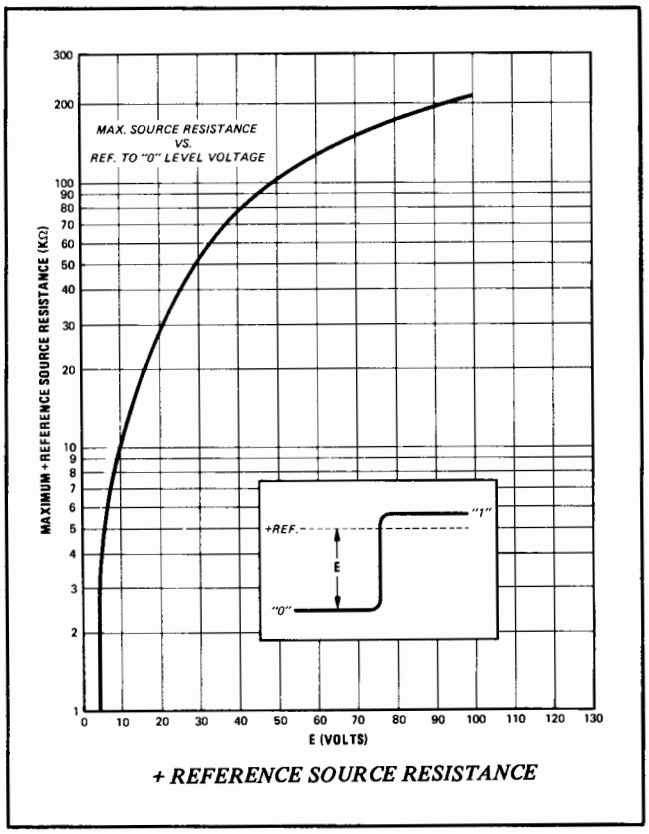
"1" State: 5V (min.) to 100V (max.) more positive than "0" state.

Line Settling Delays: 0.1 or 1 ms, jumper-selected.

**Transfer Rate**

Up to 1000 readings/sec. with 0.1 ms line settling delay.

**+Reference**
0.5V less positive than "1" state (see *+Reference Source Resistance* diagram below).




*+ REFERENCE SOURCE RESISTANCE*

**Control**
+Encode: shift from -12V (through 10kΩ) to ground.

-Encode: shift from +12.5V (through 9kΩ) to ground.

Pulsed Encode: 60-80 μs duration, jumper-selected.

+Hold: +17V through 1kΩ (10 mA max.).

-Hold: -11V through 2.2kΩ (10 mA max.).

Record Command: +4.5V to +24V (or -4.5V to -24V), 20 μs (min.) pulse, ac-coupled.
External Low Set: +4.5V logic pulse to set for first 16 bits input (not required for normal operation.

**Computer I/O Channels Used**
One.

**Interface Current Required**
0.024A (-12V), 0.35A (-2V), 1.1A (+4.5V), 0.01A (+12V), 0.037A (+30V).

**Memory Required For RTE Driver**
200 bytes; 440 bytes when called from Multi-User Real-Time BASIC.

**Prerequisite**
The performance test routine must be read into the system via the 12925A Punched Tape Reader Subsystem; therefore the HP 1000 Model 31 or Model 81 Computer System must have the punched tape reader before it can use the 12604B Data Source Interface.

## HARDWARE FURNISHED

1. Data Source Interface (12604-60001).
2. Mating connector kit (5060-8339).

## SOFTWARE FURNISHED

Data source interface diagnostic on punched tape (20337-60001).

## SOFTWARE USED

The Data Source Interface uses driver DVR40, included with the 92066A RTE Measurement and Control Drivers Package.

## MANUAL FURNISHED

Interface manual (12604-90002).

## ORDERING INFORMATION

12604B Data Source Interface.

**Options**
001: Cable (12604-60002) to 2402A/2401C IDVM in place of mating connector.

002: Cable (02116-6153) to older HP counters in place of mating connector.

003: Cable (12604-60008) to newer integrated circuit HP counters in place of mating connector.

005: Cable (12604-60007) to 3450B DVM in place of mating connector.

## INSTALLATION

Installation of the 12604B is the responsibility of the customer. HP installation assistance is provided on request, at prevailing rates.

**Specifications subject to change without notice.**

For more information, call your local HP Sales Office or East (301) 948-6370 • Midwest (312) 677-0400 • South (404) 434-4000 • West (213) 877-1281. Or write: Hewlett-Packard, 1501 Page Mill Road, Palo Alto, CA 94304. In Canada: 275 Hymus Blvd., Point Claire, Quebec. In Europe: Hewlett-Packard, P.O. Box 85, CH-1217 Meyrin 2, Geneva, Switzerland. In Japan: Yokogawa-Hewlett-Packard, 1-59-1, Yoyogi, Shibuya-ku, Tokyo, 151.



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# Sensor-Based DAS Utility Library

model 92400A

Technical Data 9/76

## Features

- **Software routines and functions for sensor-based data acquisition and control applications**
- **Callable from FORTRAN, ALGOL, HP Assembly** language
- **Some functions programmable in HP Real Time BASIC**
- **Supplied on paper tape or minicartridge**

## Description

The implementation of computer-automated data acquisition and control systems often involves special data and signal processing functions. To minimize user's time, effort, and cost investment in providing these additional functions, Hewlett-Packard has a modular library of routines and functions for sensor-based data acquisition and control applications. These are based on many years of HP experience with sensor-based data acquisition applications.

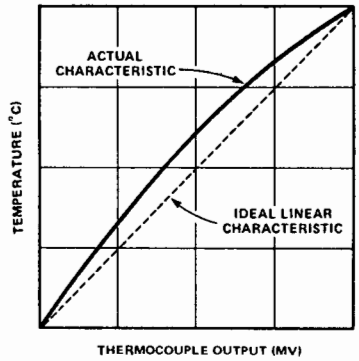
The different capabilities available from this library are summarized below. More detailed information on the individual capabilities is provided in subsequent pages of this data sheet. All of the routines in the library are callable from FORTRAN, ALGOL, and HP Assembly language. All of the routines except Code Conversion, Curve Fitting, and the Integer routines of the Statistical Analysis Packare are also callable from HP Real-Time BASIC.

| DAS Utility Library Package | Capability |
|---|---|
| Thermocouple Linearization Package | Converts thermocouple voltage to °F or °C, with correction for thermocouple non,linearity, for Type J, K, and T thermocouples, in -250° to 1600°F (-150°C to 900°C) range, providing ±0.5°F/±0.3°C accuracy. |
| Humidity Package | Calculates vapor pressure from dew point temperature, relative humidity, or wet and dry bulb temperatures, and calculates relative humidity from dew point temperature or wet and dry bulb temperature, with 1% accuracy. |
| Statistical Analysis Package | Calculates mean, standard deviation, and histogram from fixed or running data. |
| Code Conversion Package | Converts ASCII to EBCDIC or BCD and vice versa. |
| Curve Fitting Package | Performs least squares error curve fit of user's data to choice of six different standard functions. |
| Interpolation Package | Performs first- and second-order interpolation of uniformly-spaced or randomly-spaced data. |
| Integration Package | Performs numerical integration of first- and second-order fixed data or running data. |

**Thermocouple Linearization Package**

The Thermocouple is the most commonly used and least costly type of temperature sensor. Thermocouples are available in a number of different types of materials and are adaptable to nearly any mounting geometry. However, one of the problems that must be dealt with in the utilization of thermocouples is the non-linearity of their temperature-to-output voltage characteristic (Figure 1).

The Thermocouple Linearization Package deals with the problem of non-linearity for three popular types of thermocouples. It provides voltage-to-temperature conversion accuracy of ±0.5°F (±0.3°C) for the thermocouples and temperature ranges listed below, for 32°F (0°C) and 150°F (66°C) reference temperatures.




THERMOCOUPLE NON-LINEARITY
Figure 1.

| Type | Thermocouple Material | Temperature Range |
|---|---|---|
| J | Iron-Constantan | −250°F to +1400°F (−160°C to +760°C) |
| K | Chromel-Alumel | −30°F to +1600°F (−35°C to +870°C) |
| T | Copper-Constantan | −250°F to +750°F (−250°C to +400°C) |

Linearization Method

The Thermocouple Linearization Package converts voltage to temperature and corrects for non-linearity through a combination of table look-up and first- and second-order curve fit interpolation techniques. The data used has been calculated from reference tables made available in mid-1971 by the National Bureau of Standards, and supercedes N.B.S. circular # 561.

Source Language

The Thermocouple Linearization Package is written entirely in FORTRAN. The functions of the package are well documented so that they may be easily modified to operate over narrower temperature ranges, thereby minimizing table look-up and calculation overhead associated with temperature conversion.

Functions Provided

The Thermocouple Linearization Package provides the functions listed below:

| FORTRAN II | FORTRAN IV | BASIC | ALGOL | Assembly | Subroutines and Functions | |
|---|---|---|---|---|---|---|
| X | X | X | X | X | FECON | Converts Iron-Constantan thermocouple output voltage to °C/°F with correction of non-linearity. |
| X | X | X | X | X | CRALM | Converts Chromel-Alumel thermocouple output voltage to °C/°F with correction of non-linearity. |
| X | X | X | X | X | CUCON | Converts Copper-Constantan thermocouple output voltage to °C/°F with correction of non-linearity. |

For Iron-Constantan Thermocouples (FORTRAN): `FECON(V,M,I)`
For Iron-Constantan Thermocouples (BASIC): `100 FECON(V,M,E,T)`
For Chromel-Alumel Thermocouples (FORTRAN): `CRALM(V,M,I)`
For Chromel-Alumel Thermocouples (BASIC): `100 CRALM(V,M,E,T)`
For Copper-Constantan Thermocouples (FORTRAN): `CUCON(V,M,I)`
For Copper-Constantan Thermocopules (BASIC): `100 CUCON(V,M,E,T)`

*Thermocouple Output (Volts)*
*Mode (Units & Ref. Jct. Temp.)*
*+1 = °F at 32°F reference*
*+2 = °F at 150°F reference*
*−1 = °C at 0°C reference*
*−2 = °C at 150°F reference*
*Error**
*Temperature (°F or °C)***

** Error parameter = −1 for thermocouple output out of bounds; otherwide = 0*

*** Temperature °F or °C (parameter in HP Real-Time BASIC calls only; "T" is not used in FORTRAN function call)*

Program Example

To determine and print out temperature in °C from Chromel-Alumel (type K) thermocouple output voltage with ice point (0°C) reference, the CRALM function would be used, as follows:

**Programmed from FORTRAN**

```
      T=CRALM(V,-1,I)
      IF(I)10,200,10
   10 WRITE(1,20)T
   20 FORMAT("EXHAUST TEMP=" F6.1 "DEG C")
      *
      *
  200 ERROR ROUTINE
```

**Programmed from Real-Time BASIC**

```
100 CRALM(V,-1,E,T)
110 IF E<0 THEN 500
120 PRINT "EXHAUST TEMP= ";T
    *
    *
500 REM ERROR ROUTINE
```

Memory Requirements and Execution Times

| Routine | Memory Req'd $Words_{10}$* | Execution Time (maximum) |
|---|---|---|
| FECON | 217 | 1.2 millisec |
| CRALM | 220 | 1.2 millisec |
| CUCON | 137 | 1.4 millisec |

**Not including standard library routines used by the linearization routines.*

**Humidity Package**

Humidity significantly affects engine performance, so its measurement and control is highly important in engine testing. Humidity also affects the rate and result of reactions, so it must be dealt with in process control and labs as well. To assist programs that must handle humidity relationships, the functions in the Humidity Package calculate vapor pressure and relative humidity from wet/dry bulb temperatures or dew point temperature. Vapor pressure may also be calculated from relative humidity. These calculations give ±1% of actual pressure in vapor pressure calculations.

Basis of the Humidity Package

The calculations of the humidity package are based on data published in the *Handbook of Chemistry and Physics,* and include interpolation between published values.

Source Language

The Humidity Package is written entirely in FORTRAN. The functions of the package are well documented, so that they may be easily modified or extracted and applied in a wide variety of applications.

Functions Provided

The Humidity Package provides the functions listed and described below:

| FORTRAN II | FORTRAN IV | BASIC | ALGOL | Assembly | Subroutines and Functions | |
|---|---|---|---|---|---|---|
| X | X | X | X | X | PPDWP | Calculates vapor pressure from dew point temperature. |
| X | X | X | X | X | PPRH | Calculates vapor pressure from relative humidity. |
| X | X | X | X | X | PPBLB | Calculates vapor pressure from wet and dry bulb temperatures. |
| X | X | X | X | X | RHDWP | Calculates relative humidity from dew point temperature. |
| X | X | X | X | X | RHBLB | Calculates relative humidity from wet and dry bulb temperatures. |

*(Continued)*

For Vapor Pressure (mm Hg) from Dew Point Temperature

(FORTRAN): `VAPOR = PPDWP(T,I)`

(BASIC): `CALL PPDWP(T,E,V)`

*Dew Point Temperature**

*Error***

*Vapor Pressure (mm Hg)†*

For Vapor Pressure (mm Hg) from Relative Humidity

(FORTRAN): `VAPOR = PPRH(T1,H,I)`

(BASIC): `CALL PPRH(T1,H,E,V)`

*Dry Bulb Temperature**

*Relative Humidity (0 to 100%)*

*Error***

*Vapor Pressure (mm Hg)†*

For Vapor Pressure (mm Hg) from Wet and Dry Bulb Temperatures

(FORTRAN): `VAPOR = PPBLB(T1,T2,P,I)`

(BASIC): `CALL PPBLB(T1,T2,P,E,V)`

*Dry Bulb Temperature**

*Wet Bulb Temperature**

*Barometric Pressure (> 0 mm Hg)*

*Error***

*Vapor Pressure (mm Hg)†*

For Relative Humidity (%) from Dew Point Temperature

(FORTRAN): `HUMD =RHDWP(T1,T,I)`

(BASIC): `CALL RHDWP(T1,T,E,H)`

*Dry Bulb Temperature**

*Dew Point Temperature**

*Error***

*Relative Humidity (%)†*

For Relative Humidity (%) from Wet and Dry Bulb Temperatures

(FORTRAN): `HUMD =RHBLB(T1,T2,P,I)`

(BASIC): `CALL RHBLB(T1,T2,P,E,H)`

*Dry Bulb Temperature**

*Wet Bulb Temperature**

*Barometric Pressure (> 0 mm Hg)*

*Error***

*Relative Humidity*

* *All temperature must fall within 32° F to 212° F/0° to 100° C range.*

** *Error parameter = -1 for other parameter out of bounds; otherwise = 0.*

† *Parameter used in HP Real-Time BASIC calls only; "V" or "H" as last parameter is not used in FORTRAN function call.*

Program Example

To determine the relative humidity when the dry bulb temperature is 72°F, the wet bulb temperature is 60°F, and the barometric pressure is 760 mm of mercury, the RHBLB function would be used as follows:

**Programmed in FORTRAN**

```
    H=RHBLB(72.,60.,760.,I)
    IF(I)200,10
 10 WRITE(1,20)H
 20 FORMAT("REL.HUM.=" 4.1 "%")
    *
200 ERROR ROUTINE
```

**Programmed in Real-Time BASIC**

```
100 RHBLB(72.,60.,760.,E,H)
110 IF E<0 THEN 750
120 PRINT "REL.HUM.= ";H
    *
    *
750 REM ERROR ROUTINE
```

*Note A: Temperatures in °C are stated as negative values to distinguish them from °F temperatures; for example 10°C would be entered as -10.*

*Note B: The IF branching to the error routine is required to take care of out-of-bounds input to the RHBLB function.*

Memory Requirements and Execution Times

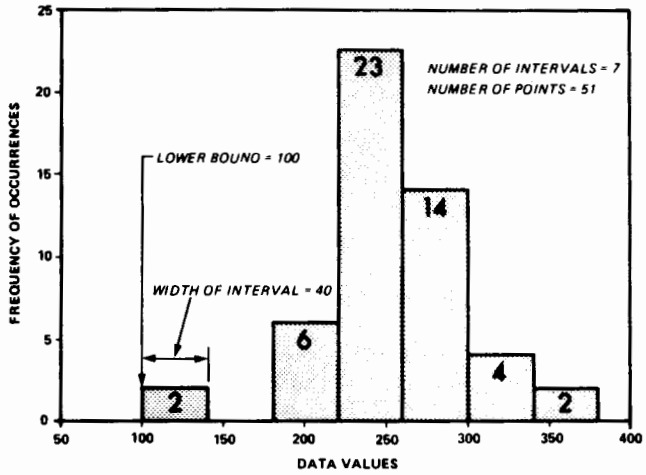
| Routine | Memory Req'd Words$_{10}$* | Execution Time (maximum) |
|---|---|---|
| PPDWP | 94 | 2.6 millisec |
| PPRH | 21† | 3.2 millisec |
| PPBLB | 66† | 3.8 millisec |
| RHDWP | 41† | 5.9 millisec |
| RHBLB | 44† | 7.1 millisec |

* *Not including standard library routines used by the Humidity Package.*

† *Additional memory used by PPRH, PPBLB, RHDWP, and RHBLB; those routines also use the PPDWP routine (94 words).*

**Statistical Analysis Package**

In many applications, particularly testing applications, it is often desirable to analyze the statistical properties of data, such as mean value, standard deviation, and frequency distribution (Histogram, Figure 2) of data values. The Statistical Analysis Package performs the required calculations for all of these statistical functions for fixed and for running data, in real (floating point) and in integer form.




HISTOGRAM EXAMPLE
Figure 2.

Routines Provided

The Stastical Analysis Package provides the routines listed and described below:

| FORTRAN II | FORTRAN IV | BASIC | ALGOL | Assembly | Subroutines and Functions | |
|---|---|---|---|---|---|---|
| X | X | X | X | X | STATF | Calculates mean and standard deviation of fixed array of real data. |
| X | X | X | X | X | STATI | Calculates mean and standard deviation of fixed array of integer data. |
| X | X | | X | X | HISTF | Generates histogram of fixed array of real data. |
| | | X | | | HISTB | Generates histogram of fixed array of real data. |
| X | X | | X | X | HISTI | Generates histogram of fixed array of integer data. |
| X | X | | X | X | INTLF | Initializes for recording of running real data. |
| | | X | | | INTLB | Initializes for recording of running real data. |
| X | X | | X | X | INTLI | Initializes for recording of running integer data. |
| X | X | | X | X | RCRDF | Records running real data. |
| | | X | | | RCRDB | Records running real data. |
| X | X | | X | X | RCRDI | Records running integer data. |
| X | X | X | X | X | REPRT | Reports mean and standard deviation and number of data points after recording of running data. |

For Fixed Data the Statistical Analysis Package provides the following four routines:

Mean and Standard Deviation —
- from real data (FORTRAN) — `CALL STATF(ARRAY,NPTS,RMEAN,STDEV)`
- from real data (BASIC) — `CALL STATF(A(1), N, R, D)`
- from integer data (FORTRAN) `CALL STATI(IARAY,NPTS,RMEAN,STDEV)`

*Real or integer array of data to be analyzed*
*Number of elements in the array*
*Arithmetic Mean of the data*
*Standard Deviation of the data from the Mean*

Histogram —
- from real data FORTRAN `CALL HISTF(ARRAY,NPTS,START,DELTA,NHIST,I,IERR)`
- from real data (BASIC) `CALL HISTF(A(1), N, S, W, N(1), I, E)`
- from integer data (FORTRAN) `CALL HISTI(IARAY,NPTS,ISTRT,IDLTA,NHIST,I,IERR)`

*Real or integer lower bound of Histogram*
*Real or integer value of width of each interval in Histogram*
*Array containing frequency counts of Histogram*
*Number of intervals in Histogram*
*Error parameter**

For Running Data the Statistical Analysis Package provides the following five routines:

To initialize for recording running:
- real data (FORTRAN) — `CALL INTLF(ITYPE,WORK(,START,DELTA,NHIST,I))`
- real data (BASIC) — `CALL INTLB( M, W(1) , S, W, N(1), I )`
- integer data (FORTRAN) — `CALL INTLI(ITYPE,WORK(,ISTRT,IDLTA,NHIST,I))`

*Mode of recording running statistics*

*ITYPE (or M) < 0 for Histogram only*
*= 0 for Histogram, Mean, and Standard Deviation*
*> 0 for Mean and Standard Deviation only*

*Other variables have same meaning as in calls shown previously.*

*Real array used to accumulate running statistics and for mode and bound information. WORK (or W(1) is dimensioned by 3 for ITYPE (or M) >0, by 5 for integer data with ITYPE ≤ 0, by 6 for real data with ITYPE (or M) ≤ 0.*

** 0 for no error, or the number of out-of-bound points. If I is negative, IERR (or E) gives negative count of out-of-bound points; If I is positive, IERR (or E) gives out-of-bound data counts in first and last interval of Histogram with positive count for out-of-bound points.*

*(Continued)*

**Curve Fitting Package**

In many applications it is advantageous to be able to characterize data as being representative of a specific mathematical function. Such characterization makes possible a sort of shorthand representation of large volumes of data from relatively few samples, minimizing storage and data rate requirements and promoting efficient utilization of system resources. The Curve Fitting Package performs least square error curve fitting of user's data to the six standard functions listed below, under 'Routine Provided'. As part of this procedure, it calculates the maximum error and standard error of the data with respect to the function against which the data is being checked.

Source Language

The Curve Fitting Package is written entirely in FORTRAN. The routine is well documented so that it may be easily modified to test additional or different functions.

Routine Provided

The Curve Fitting Package provides the following routine:

| FORTRAN II | FORTRAN IV | BASIC | ALGOL | Assembly | Subroutines and Functions | |
|---|---|---|---|---|---|---|
| X | X | X | X | X | CRVFT | Fits user's data to any of six different standard functions. |

To fit user's data to any of six different functions;

(FORTRAN) ——CALL CRVFT(ITYPE,XARAY,YARAY,N,A,B,ERRMX)

(BASIC) ——CALL CRVFT( I, X, Y, N,A,B, E )

*Function to be fit*

*1 is: Y=A*X+B* *4 is: Y=X/(B*X+A)*
*2 is: Y=B+A/X* *5 is: Y=B*EXP(A*X)*
*3 is: Y=1/(A*X+B)* *6 is: Y=B*A**A or B*X↑A*

*Array of independent, real variables*

*Array of dependent values to be fit, which correspond to independent variables in XARAY*

*Number of points in XARAY*

*"A" coefficient for best least square error fit*

*"B" coefficient for best least square error fit*

*Absolute value of maximum error of the user data with respect to the selected curve fit function*

Program Example

To find the best fit for some empirical data (in arrays STIM and RESP) to a standard curve, the CRVFT routine might be employed as follows:

```
      DIMENSION A(6),B(6),ERRMX(6),ERRST(6),STIM(100),RESP(100)
      *
      *
      DO 10 I=1,6
      CALL CRVFT(I,STIM,RESP,100,A(I),B(I),ERRMX(I),ERRST(I))
   10 CONTINUE
```

Memory Requirement and Execution Time

| Routine | Memory Req'd $Words_{10}$* | Curve No. | Execution Time (milliseconds) |
|---|---|---|---|
| CRVFT | 611 | 1 | 2.5 + 1.4 X N** |
| | | 2 | 2.5 + 1.7 X N** |
| | | 3 | 2.5 + 1.8 X N** |
| | | 4 | 2.5 + 1.7 X N** |
| | | 5 | 2.5 + 1.8 X N** |
| | | 6 | 2.5 + 8 X N** |

* *Not including standard library routines used by the Curve Fitting Package.*

** *Where N is the number of points in the XARAY table.*

### Interpolation Package

Through the use of interpolation, it is possible to derive many values from a relatively few samples, minimizing storage and data rate requirements. This is particularly valuable when it is desired to plot data, as shown in Figure 3. The solid line in Figure 3 is a linear plot of the equation $y = x^2/20$ for $x$ values of zero, 10, and 20 and the corresponding $y$ values of zero, 5, and 20. The dashed line plots the $y$ values corresponding to $x$ values of zero, 2, 4, 6, 8, 10, 12, 14, 16, 18, and 20, showing how closely second-order interpolation of additional $x,y$ coordinates can approximate the true shape of the parabolic function. The Interpolation Package provides First-order (linear) Interpolation from either uniformly-spaced or randomly-spaced data and Second-order Interpolation from uniformly-spaced or randomly-spaced data.

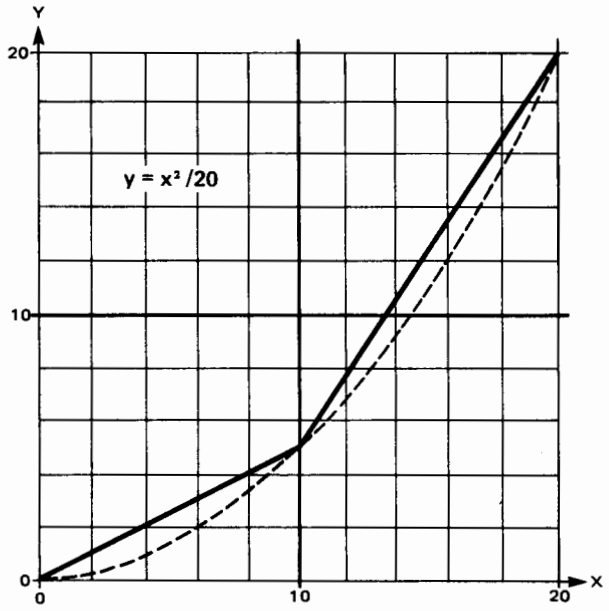
Definitions and Requirements

**Uniformly-spaced data** refers to uniformly-spaced values of $x$, from which values of $y$ result that will be uniformly-spaced if they follow a first-order, or linear, function or not uniformly spaced if they follow a second-order, or parabolic, function.

**Randomly-spaced data** refers to values of $x$ which are not uniformly spaced, but which are in strict ascending monotonic order, with corresponding values of $y$. Interpolation from randomly-spaced data requires that the data be arranged in ascending order of $x$ and corresponding $y$ values prior to attempting interpolation.

Source Language

The Interpolation Package is written entirely in FORTRAN and is well documented so that it may be easily modified to satisfy special needs.




INTERPOLATION EXAMPLE
Figure 3.

Functions Provided

The Interpolation Package provides the following functions:

| FORTRAN II | FORTRAN IV | BASIC | ALGOL | Assembly | Subroutines and Functions | |
|---|---|---|---|---|---|---|
| X | X | X | X | X | FRSTU | Performs first-order interpolation of uniformly-spaced data. |
| X | X | X | X | X | SCNDU | Performs second-order interpolation of uniformly-spaced data. |
| X | X | X | X | X | FRSTR | Performs first-order interpolation of randomly-spaced data. |
| X | X | X | X | X | SCNDR | Performs second-order interpolation of randomly-spaced data. |

For Uniformly-Spaced Data

First-Order Interpolation (FORTRAN)—`VALUE = FRSTU(X,YARAY,N,START,DELTA,IERR)`
First-Order Interpolation (BASIC)—`CALL FRSTU(X,Y(1), N, S, D, E, Y)`
Second-Order Interpolation (FORTRAN)—`VALUE = SCNDU(X,YARAY,N,START,DELTA,IERR)`
Second-Order Interpolation (BASIC)—`CALL SCNDU(X,Y(1), N, S, D, E, Y)`

*Argument value of function to be interpolated (x value of y = F(x))*
*Array of y values on which interpolation is based*
*Number of values in the array*
*x value which corresponds to first value in YARAY (or Y(1))*
*Spacing between function argument (x) values, corresponding to values in YARAY (or Y(1))*
*Error (-1 if X is within range of YARAY (or Y(1)); otherwise is set to 0*
*Interpolated y value**

** Y is a parameter in Real-Time BASIC calls only; it is not used in FORTRAN calls.*

For Randomly-Spaced Data

```
First-Order Interpolation (FORTRAN) ———— VALUE = FRSTR(X,YARAY,XARAY,N,IERR)
First-Order Interpolation (BASIC) ———— CALL   FRSTR(X,Y(1), X(1), N, E,    Y)
Second-Order Interpolation (FORTRAN) ——— VALUE = SCNDR(X,YARAY,XARAY,N,IERR)
Second-Order Interpolation (BASIC) ———— CALL   SCNDR(X,Y(1), X(1), N, E,    Y)
```

*Array of function argument values corresponding to function values in YARAY; values in XARAY must be in strict ascending order.*

*Interpolated y value**

** Y is a parameter in Real-Time BASIC calls only; it is not used in FORTRAN calls.*

Program Example

To plot a smooth curve of 50 points from only 10 randomly-spaced *x* values in YARAY, the SCNDR function might be used as follows:

**Programmed from FORTRAN**

```
      DIMENSION XARAY(10),YARAY(10)
      *
      *
      X=XARAY(1)
      DO 10  I=1,50
      X=X+.02*(XARAY(10)-XARAY(1))
      Y=SCNDR(X,YARAY,XARAY,10,IERR)
      WRITE(11) 1,1,X,Y
   10 CONTINUE
```

**Programmed from Real-Time BASIC**

```
100 DIM X(10),Y(10)
    *
    *
300 FOR X=X(1) TO X(10) STEP .02*(X(10)-X(1))
310 SCNDR(X,Y(1),10,E,Y)
320 PRINT X,Y
330 NEXT X
```

Memory Requirements and Execution Times

| Routine | Memory Req'd $Words_{10}$* | Execution Time (millisec, max.) |
|---|---|---|
| FRSTU | 97 | 1.2 |
| SCNDU | 126 | 1.8 |
| FRSTR | 116 | 0.8 + 0.07 X N** |
| SCNDR | 159 | 2.0 + 0.07 X N** |

* *Not including standard library routines used by the Interpolation Package.*

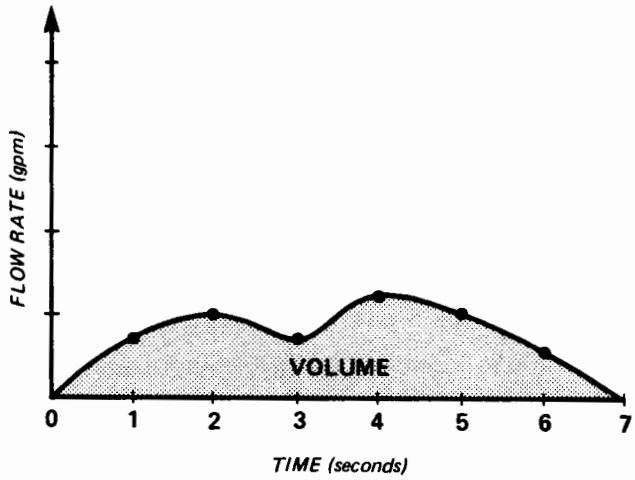
** *Where N is the number of points in the XARAY or YARAY table.*

**Integration Package**

Among the practical problems confronting the data acquisition and control systems user are the summation of data from a few samples and the reduction of the effects of noise. The solution to both of these problems is aided by the Integration Package. The Integration Package gives the area under a curve through either first-order (linear) or second-order numerical integration, from either fixed or running data.

Summation of Data

Summation of data is useful in process control and bulk material handling applications because flow rate integrated over time gives the total volume of a gas, liquid, or granular material sent to a process stage or put into a package (Figure 4).




VOLUME = $\int$ FLOW RATE (gpm)

Figure 4.

### Noise Reduction

Noise reduction is desirable in every application. When the integral of several data points is averaged, the noise component of the data tends to be reduced by the averaging process, while the average value of the data over the integration interval remains unchanged.

### Integration Method

The integration package uses the trapezoidal rule for first-order (linear) integration and Simpson's method for second-order integration.

### Source Language

The Integration Package is written entirely in FORTRAN and is well documented so that it may be easily modified to satisfy special requirements.

### Functions and Routines Provided

The Integration Package provides the following functions and routines:

| FORTRAN II | FORTRAN IV | BASIC | ALGOL | Assembly | Subroutines and Functions | |
|---|---|---|---|---|---|---|
| X | X | X | X | X | FAREA | Performs numerical integration of a fixed array of data. |
| X | X | X | X | X | STRTA | Initializes for integration of running data. |
| X | X | X | X | X | AREA | Computes latest value of running integral. |

For numerical integration of an array of data (FORTRAN): `AREA = FAREA(DATA,N,DX)`
For numerical integration of an array of data (BASIC): `CALL FAREA(D(1),N,I, A)`

*Array of real data to be integrated*
*Number of elements in array*
*Interval between points to be integrated*
*DX (or I) < 0 for second-order integration*
*DX (or I) > 0 for first-order (linear integration*
*Area under the curve**

To initialize for numerical integration of running data (FORTRAN): `AREA = STRTA(WORK,DX,Y1)`
To initialize for numerical integration of running data (BASIC): `CALL STRTA(W(1),I, Y1)`

*Real array used for working storage*
*Interval between points to be integrated*
*First point in running integral*

To compute new current value of running integral (FORTRAN): `AREA = AREA(D,WORK)`
To compute new current value of running integral (BASIC): `CALL AREA(D,W(1), A)`

*Next point to be included in the integral*
*Real array used for working storage*
*Area under the curve**

** Parameter in HP Real-Time BASIC calls only: "A" parameter is not used in FORTRAN function calls.*

*Note: A different array is needed for each variable to be integrated. WORK (or W(1)) is dimensioned by 3 for first-order integration and by 4 for second-order integration.*

Program Example

To determine the total volume of a fluid passing through a pipe, the flow rate can be integrated with respect to time, at 10-second time intervals, by using the STRTA routine and the AREA function as follows:

**Programmed from FORTRAN**

```
      DIMENSION WORK(4)
      *
      CALL STRTA(WORK,-10.,FLOW)
      *
      * (FLOW RATE MEASUREMENT
      *  EVERY 10 SECONDS)
      *
      VOLUM=AREA(FLOW,WORK)
      *
      * (STATEMENTS USING VOLUM)
      *
```

**Programmed from Real-Time BASIC**

```
100   DIMENSION W(4)
      *
300   STRTA(W(1),-10,F)
      *
      * (FLOW RATE MEASUREMENT
      *  EVERY 10 SECONDS)
      *
500   AREA(F,W(1),V)
      *
      * (STATEMENTS USING V)
      *
```

Memory Requirements and Execution Time

| Routine | Memory Req'd Words$_{10}$* | Order | Execution Time (milliseconds) |
|---|---|---|---|
| FAREA | 175 | First<br>Second | Approx. 7 for 100 points |
| STRTA | 59 | | 0.5 |
| AREA | 114 | First<br>Second | 0.6<br>1.1 |

**Not including standard library routines used by the Integration Package.*

## ORDERING INFORMATION

The Sensor-Based DAS Utility Library is ordered as HP 92400A, Option 020, which is the entire seven utility packages described in this data sheet. Each utility package will include the following software and documentation.

1. Relocatable Binary Tape
2. Source Program Tape
3. Source Program Listing
4. User's Manual
5. Programmer's Reference Manual

The Sensor-Based DAS Utility Library can also be ordered as Option 201 to the HP 9603R Scientific Measurement and Control Station or the HP 9611R Industrial Measurement and Control Station. In Option 201, the DAS Utility Library software is provided on minicartridge instead of paper tape.

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SENSOR-BASED DAS UTILITY LIBRARY 9/76

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# I.S.A. FORTRAN Extension Package

model 92413A

Technical Data 9/76

## Description

The I.S.A. FORTRAN Extension Package is a set of FORTRAN routines that meet the Instrument Society of America (I.S.A.) standard S61.1-1972, as well as certain additional, special-purpose routines not covered by the specification. Four of the routines described by the specification, STOP, IOR, IAND, and INOT, are not included in the package because they are already part of the standard libraries. This package is summarized below.

Although the routines in the 92413A package are intended for use only by FORTRAN programs in RTE-C, RTE-II, or RTE-III systems, similar capabilities are included in the RTE-B and Multi-User Real-Time BASIC Libraries to the extend indicated in the BASIC column in the table below.

### ORDERING INFORMATION

Order the I.S.A. FORTRAN Extension Package as HP 92413A.

| FORTRAN II | FORTRAN IV | BASIC | Subroutines and Functions | |
|---|---|---|---|---|
| | | | Executive Interface Routines | |
| X | X | B | START | Starts a program immediately, or after a specified time delay. |
| X | X | B | TRNON | Starts a program at a specified time. |
| X | X | B | WAIT | Suspends execution of a program for a specified interval. |
| | | | Analog Input Using 2313B Analog I/O Subsystem | |
| X | X | | AISQ | Requests analog input from a series of sequential channels; AISQW adds wait for completion. |
| X | X | | AIRD | Requests analog input from a series of channels in arbitrary order; AIRDW adds wait for completion. |
| X | X | B | AISQF | Requests analog input from a series of sequential channels with wait for completion and output in real instead of integer form. |
| X | X | B | AIRDF | Requests analog input from series of channels in arbitrary order with wait for completion and output in real instead of integer form. |
| | | | Analog Output Using 2313B Analog I/O Subsystem or 91063A Digital I/O Subsystem | |
| X | X | | AO | Requests analog output of integer data to specified analog output channels; AOW adds wait for completion. |
| X | X | B | AOF | Requests analog output of real data with wait for completion. |
| | | | Digital Input/Output Using 91063A Digital I/O Subsystem | |
| X | X | B | DI | Requests input of specified number of digital words written into specified array via designated array of digital I/O channels; DIW adds wait for completion. |
| X | X | | DOM | Requests output of a specified number of digital words, read out of a specified array via a designated array of digital I/O channels, with output set for a specified time; DOMW adds wait for completion. |
| X | X | B | DOL | Requests output of a specified number of digital words, read out of a specified array via a designated array of digital I/O channels, with output set until it is changed; DOLW adds wait for completion. |

B *Identifies routine in Real-Time BASIC library similar to the routine listed here as part of 92413A I.S.A. FORTRAN Extension Package.*

| FORTRAN II | FORTRAN IV | BASIC | Subroutines and Functions | |
|---|---|---|---|---|
| | | | Bit Manipulation | |
| X | X | B | IEOR | Requests Exclusive OR of two integers. |
| X | X | B | ISHFT | Shifts a digital word a specified number of bit positions left or right. |
| | | | Event Sense | |
| X | X | | EVSNS | Establishes or removes a linkage between a given event and a program. |
| | | | Auxiliary Analog I/O Subsystem Routines | |
| X | X | B | NORM | Initializes the 2313B Analog I/O Subsystem. |
| X | X | B | SGAIN | Sets gain of low-level multiplexer channels. |
| X | X | B | RGAIN | Reads gain of low-level multiplexer channels. |
| X | X | B | PACER | Sets subsystem pace rate. |
| | | | Special Digital I/O Subsystem Functions | |
| X | X | | FREQ | Measures frequency using digital I/O timer and pulse counter plug-in cards. |
| X | X | | PSET | Presets pulse counter to specified count and sets up interrupt when counter has counted down the preset number of pulses; the interrupt can event schedule a program through the EVSNS routine. |
| X | X | | STEP | Advances a stepper motor "N" steps clockwise or counterclockwise, using the stepping motor control card; STEPW adds wait for completion. |
| | | | Stall Alarm Program | |
| X | X | | STALL | Prevents issuance of an alarm contact closure while the system continues to reschedule it, resetting a programmable timer card in the digital I/O subsystem. The digital I/O subsystem must also continue to function. |

B *Identifies routine in Real-Time BASIC library similar to the routine listed here as part of 92413A I.S.A. FORTRAN Extension Package.*

**Specifications subject to change without notice.**

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To record running real data (FORTRAN) — `CALL RCRDF(DATA,WORK,IERR[,NHIST])`

To record running real data (BASIC) — `CALL RCRDB( A,  W(1),  E,   N(1) )`

To record running integer data (FORTRAN) — `CALL RCRDI(IDAT,WORK,IERR[,NHIST])`

*Real or integer data to be recorded*

*NOTE: Parameters enclosed in brackets [ ] are optional; they are needed only when ITYPE (or M) ≤ 0, selecting Histogram output.*

*Other variables have same meaning as in calls shown previously.*

To report Mean and Standard Deviation and Number of samples after recording of running data:

(FORTRAN) — `CALL REPRT(WORK,RMEAN,STDEV,NUM)`

(BASIC) — `1250 REPRT(W(1),  R,  D,  N1)`

*Number of samples*

** 0 for no error, or the number of out-of-bound points. If I is negative, IERR (or E) gives negative count of out-of-bound points; If I is positive, IERR (or E) gives out-of-bound data counts in first and last interval of Histogram with positive count for out-of-bound points.*

Source Language

The Statistical Analysis Package is written entirely in FORTRAN. The routines of the package are well documented, so that they may be easily modified or extracted and used in a different form.

Program Examples

To product a histogram from a fixed array of real data (ARRAY), with bounds of 10 and 80 and seven cells, each 10 units wide, the HISTF routine would be used as follows:

**Programmed in FORTRAN**

```
      DIMENSION ARRAY(100),NHIST(7)
      *
      *
      CALL HISTF(ARRAY,100,10,10,NHIST,-7,IERR)
      IF(IERR)200,10,
   10 NORMAL DATA PROCESSING PATH
      *
      *
  200 ERROR ROUTINE FOR OUT-OF-BOUND DATA
```

**Programmed in Real-Time BASIC**

```
100 DIMENSION A(100),N(7)
    *
    *
300 HISTF(A(1),100,10,10,N(1),-7,E)
310 IF E#0 THEN 900
320 REM NORMAL PATH
    *
    *
900 REM ERROR ROUTINE FOR OUT-OF-BOUND DATA
```

*Note: Data outside the bounds are not counted because negative number (-7) is used for the value of I.*

To maintain running data statistics on a real parameter (DATA) in a system and derive the Mean, Standard Deviation, and a Histogram with lower bound of -10 and 15 intervals of width 0.5, the INTLF, RCRDF, and REPRT routines would be used as follows:

**Programmed in FORTRAN**

```
      DIMENSION NHIST(15),WORK(6)
      *
      *
      CALL INTLF(0,WORK,-10.,.5,NHIST,15)
      *
      *
      CALL RCRDF(DATA,WORK,IERR,NHIST)
      *
      *
      CALL REPRT(WORK,RMEAN,STDEV,NUM)
```

**Programmed in Real-Time BASIC**

```
100 DIMENSION N(15),W(6)
    *
    *
300 INTLF(0,W(1),-10,.5,N(1),15)
    *
    *
400 RCRDF(A,W(1),E,N(1))
    *
    *
500 REPRT(W(1),R,D,N1)
```

Capacity of Statistical Analysis Package

Up to 32,767 data points can be recorded by the running statistics routines RCRDF and RCRDI. The maximum count allowable in any Histogram interval is 32,767.

Memory Requirements and Execution Times

| Routine | Memory Req'd $Words_{10}$* | Execution Time (For 100 points) |
|---|---|---|
| STATF | 79 | 20 millisec |
| STATI | 79 | 20 millisec |
| HISTF | 98 | 21.8 millisec |
| HISTI | 99 | 10.2 millisec |
| INTLF | 93 | 3.4 millisec |
| INTLI | 89 | 3.4 millisec |
| RCRDF | 145 | 0.85 millisec |
| RCRDI | 160 | 0.8 millisec |
| REPRT | 63 | 1.3 millisec |

** Not including standard library routines used by the Statistical Analysis Package.*

### Code Conversion Package

When a large central data base from various small computer-automated data acquisition systems is desired, it may be necessary to accomplish at least some data processing off-line on another computer facility. This is done by recording the data to be processed on IBM-compatible magnetic tape in a code recognizable by the computer that is to do the processing. The Code Conversion Package provides the following code translations to satisfy off-line processing needs:*

ASCII to BCD (7-channel) or EBCDIC (9-channel code
BCD or EBCDIC code to ASCII

Characteristics

In conversion from EBCDIC (8-bit code) to ASCII (7-bit code), and from ASCII to BCD, some undefinable characters may be encountered. Whenever this occurs, the highest-order bit (bit 7) of the undefined character is set to 1, and bits 0 through 6 will be the same as the original input (EBCDIC or ASCII). It is thus possible to detect the undefinable characters and have an indication of the original character. There are no lower-case characters in BCD, so the Code Conversion Package translates lower-case ASCII to upper-case BCD to preserve as much information content as possible.

Routines Provided

The Code Conversion Package provides the following code translation routines:

| FORTRAN II | FORTRAN IV | BASIC | ALGOL | Assembly | Subroutines and Functions | |
|---|---|---|---|---|---|---|
| X | X | | X | X | ASCEB | Converts ASCII to EBCDIC. |
| X | X | | X | X | EBCAS | Converts EBCDIC to ASCII. |
| X | X | | X | X | ASCBC | Converts ASCII to BCD. |
| X | X | | X | C | BCDAS | Converts BCD to ASCII. |

For converting ASCII to EBCDIC — `CALL ASCEB(NCHAR,NSORC,NDEST)`
For converting EBCDIC to ASCII — `CALL EBCAS(NCHAR,NSORC,NDEST,IERR)`
For converting ASCII to BCD — `CALL ASCBC(NCHAR,NSORC,NDEST,IERR)`
For converting BCD to ASCII — `CALL BCDAS(NCHAR,NSORC,NDEST)`

*Integer number of characters to be converted*
*Array containing characters to be converted*
*Destination array for converted characters (may be same as NSORC for conversion in place or different for conversion into a different area of core)*
*Number of characters which had no translation*

* *ASCII = American Standard Code for Information Interchange*
*EBCDIC = Extended Binary Coded Decimal Interchange Code*
*BCD = Binary Coded Decimal*

Program Example

To convert input buffer NSORC from ASCII to EBCDIC and output the converted NSORC buffer to a different device, the ASCEB routine would be used as shown in the following sequence of FORTRAN statements:

```
DIMENSION NSORC(40)
READ(7)NSORC
CALL ASCEB(80,NSORC,NSORC)
WRITE(8)NSORC
```

Memory Requirements and Execution Times

| Routine | Memory Req'd $Words_{10}$* | Approximate Execution Time |
|---|---|---|
| ASCEB | 99 | 50 microsec per character |
| EBCAS | 67 | |
| ASCBC | 103 | |
| BCDAS | 167 | |

* *Not including standard library routine used by the Code Conversion Package.*

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