HP E1413C

# High-Speed 64-Channel Scanning A/D Converter

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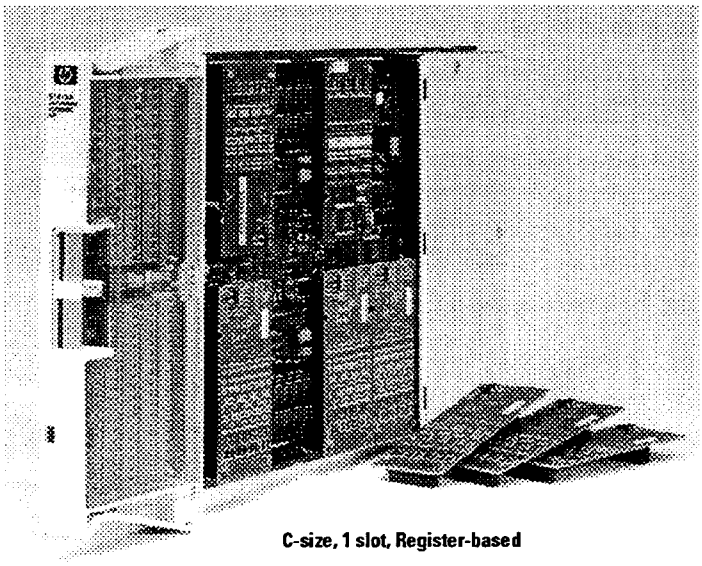
HEWLETT PACKARD

# 64-Channel Scanning A/D Converter

## Technical Data Sheet*
## HP E1413B



C-size, 1 slot, Register-based

- **Multi-function measurement capability**
  **DC Voltage Temperature Resistance Strain**
- **Optional modular signal conditioning plug-on cards**
- **100 kHz measurement rate with mixed functions**
- **Auto-sequenced scan lists**
- **Engineering units conversion at full speed**
- **On-board averaging and hi/lo limit checking**
- **Automatic self-calibration**
- **Built-in self test—*TST**

The E1413B scanning A/D is designed for high performance data acquisition and computer aided test applications where the key requirements are:

- –High speed scanning
- –16-bit resolution
- –High accuracy: .01% of reading
- –4 mV to 16 V full scale voltage input
- –64 Ksample FIFO buffer for block transfers
- –Current value buffer for on-line monitoring

The unique design of this analog sub-system provides a new level of density by combining a 16-bit A/D with a 64 channel differential FET multiplexer in a single C-size slot. Up to eight different Signal Conditioning Plug-ons (SCP's) with eight channels each can be added to the E1413B to provide such capabilities as:

- –Direct input (>100 KHz bandwidth)
- –10 Hz low pass filtering
- –Fixed gain and filter per channel
- –Programmable gain/filter per channel
- –Current sources for resistance, temp
- –Bridge completion and excitation for strain
- –Breadboard card for custom circuits

Channel scans can be made in any order using any function on any channel - all at full speed, including autoranging. Up to four unique scan lists, each with a different sample rate, can be stored in RAM and selected on-the-fly with a single software command. In addition, these scan lists can be automatically sequenced in any order with a unique auto-sequence scan list.

Data transfer speed has been greatly improved because multiple E1413B's can scan in parallel at full speed and then sequentially transfer data over the VXI backplane in D16 or D32 format at rates which match even the fastest embedded VXI computer.

The FIFO RAM is a high speed buffer which stores up to 64 K samples until the controller is ready for efficient block data transfer. For on-line monitoring, the Current Value Table RAM always contains the most recent measured value of each channel in the scan list. This RAM and the FIFO RAM can be accessed asynchronously.

**Data subject to change without notice.*

Averaging can be enabled on a scan basis to provide averaging for each channel over 2 to 256 samples in binary steps. The averaged data goes to both the CVT and the FIFO buffer. The maximum sample rate is >1 KSa/s per channel for 64 channels, although higher rates are possible with fewer channels.

No multiple channels in a scan list and no scan list switching is allowed in order to maintain data identification in the FIFO buffer

Individual high and low limits per channel can be downloaded to the E1413B in engineering units format. If a limit is exceeded, an interrupt or trigger line can be pulled and the limit register can be read to determine the out-of-limit channel. A cumulative mode can be selected which holds the channel number of any out-of-limit reading since the last INIT command. The FIFO buffer can be then read to determine the actual out-of-limit readings.

## Specifications

The following specifications include the SCP and scanning A/D performance together as a unit. Accuracy is stated for a single sample, averaging multiple samples will improve accuracy by reducing noise.

The basic E1413B scanning A/D has a full scale range of ±16 V and five manual or autoranging gains of X1, X4, X16, X64, and X256. An SCP must be used with each eight channel input block to provide input protection and signal conditioning.

**Measurement resolution:**
16 bits (including sign)

**Maximum reading rate:**
100 K samples/sec divided by the number of channels in the scan—for example:

100 K/64 = 1.56 K samples/sec/ch
100 K/16 = 6.25 K samples/sec/ch

**Maximum input voltage:**
normal mode plus common mode

Operating: <±16 V peak
Damage level: >±42 V peak

**Maximum common mode voltage:**
Operating: <±16 V peak
Damage level: >±42 V peak

**Crosstalk:**
referred to X1, 350 Ω source

| | |
|---|---|
| 10 Hz | >135 dB |
| 100 Hz | >115 dB |
| 1 kHz | >95 dB |
| 10 kHz | >75 dB |

**Input impedance:**
Opt 011, 012, 013, 018 and 019
>100 MΩ differential

**Maximum tare cal offset:**
62.5 mV range ±100% of full scale
other ranges ±25% of full scale

**Measurement accuracy:**
90 days, 23 ±1 °C (with *CAL done after 1 hr warm-up and CALZERO done within 5 min.)

**Voltage Measurements**
Opt 011 Direct Input SCP

**Accuracy:**

| Range ± FS | Linearity % of rdg | Offset error | Noise 3 sigma | Noise* 3 sigma |
|---|---|---|---|---|
| 62.5 mV | 0.01% | 5.3 µV | 18 µV | 8 µV |
| 256 mV | 0.01% | 10.3 µV | 45 µV | 24 µV |
| 1.0 V | 0.01% | 31 µV | 110 µV | 90 µV |
| 4.0 V | 0.01% | 122 µV | 450 µV | 366 µV |
| 16.0 V | 0.01% | 488 µV | 1.8 mV | 1.5 mV |

*A/D filter ON (max scan rate—100 samples/sec/ch)

***Temperature coefficients***
Gain: 10ppm/°C
Offset: (0–40 °C) .14 µV/°C
(40–55 °C) .38 µV/°C + .8 µV

**Normal mode rejection:** 0 dB

**Input capacitance:** 80 pF typical

**Common mode rejection:** 0–60 Hz >105 dB

**Voltage Measurements**
Opt 012 10 Hz Lowpass Filter Input SCP

**Accuracy:**

| Range ± FS | Linearity % of rdg | Offset error | Noise 3 sigma | Noise* 3 sigma |
|---|---|---|---|---|
| 62.5 mV | 0.01% | 7.2 µV | 34 µV | 15 µV |
| 256 mV | 0.01% | 12.2 µV | 60 µV | 28 µV |
| 1.0 V | 0.01% | 33 µV | 110 µV | 92 µV |
| 4.0 V | 0.01% | 122 µV | 450 µV | 366 µV |
| 16.0 V | 0.01% | 488 µV | 1.8 mV | 1.5 mV |

*A/D filter ON (max sample rate—>145 µsec–fixed range)

**Temperature coefficients**
Gain: 10ppm/°C
*Offset: (0–30 °C) no additional error*
(30–40 °C) .1 µV/°C
(40–55 °C) .27 µV/°C +2.4 µV

**Normal mode rejection:**
10 Hz lowpass filter (2 pole)
10 Hz -6 dB
50 Hz >23 dB
60 Hz >25 dB

**Common mode rejection:** 0–60 Hz >100 dB

**Voltage Measurements**
Opt 018/019 Fixed Gain/Filter Input SCP

**Accuracy: Opt 018 Fixed gain X16**

| Range ± FS | Linearity % of rdg | Offset error | Noise 3 sigma | Noise* 3 sigma |
|---|---|---|---|---|
| 3.906 mV | 0.01% | 3.8 µV | 3.4 µV | 2.9 µV |
| 15.63 mV | 0.01% | 4.2 µV | 4.1 µV | 3.5 µV |
| on 15.63 mV range at ≥40C | | | 4.4 µV | 3.8 µV |
| 62.5 mV | 0.01% | 4.9 µV | 7.5 µV | 6.3 µV |
| 256 mV | 0.01% | 8.0 µV | 28 µV | 23 µV |
| 1.0 V | 0.01% | 31 µV | 113 µV | 94 µV |

*A/D filter ON (max sample rate—>145 µsec–fixed range)

**Accuracy: Opt 019 Fixed gain X64**

| Range ± FS | Linearity % of rdg | Offset error | Noise 3 sigma | Noise* 3 sigma |
|---|---|---|---|---|
| 3.906 mV | 0.01% | 2.3 µV | 1.7 µV | 1.4 µV |
| 15.63 mV | 0.01% | 2.4 µV | 2.2 µV | 1.9 µV |
| on 15.63 mV range at ≥40C | | | 2.5 µV | 2.2 µV |
| 62.5 mV | 0.01% | 3.0 µV | 7.0 µV | 5.7 µV |
| 256 mV | 0.01% | 8.0 µV | 28 µV | 23 µV |

*A/D filter ON (max sample rate—>145 µsec–fixed range)

**Temperature coefficients**

Gain: 15ppm/°C

Offset: (0–40 °C) .16 µV/°C

(30–40 °C) .18 µV/°C

(40–55 °C) .39 µV/°C + .8 µV

**Normal mode rejection:**

10 Hz lowpass filter (2 pole)

10 Hz -6 dB

50 Hz >23 dB

60 Hz >25 dB

**Common mode rejection (0-60Hz):**

Opt 018 >124 dB

Opt 019 >136 dB

**Voltage Measurements**

Opt 013 Programmable Gain/Filter Input SCP

**Accuracy: Gain of X1**

| Range | Linearity | Offset error | | | | Noise | Noise* |
|---|---|---|---|---|---|---|---|
| ± FS | % of rdg | 2 Hz | 10 Hz | 100 Hz | Filt Off | 3 sigma | 3 sigma |
| 62.5 mV | 0.01% | 12 µV | 8.8 µV | 6.8 µV | 6.3 µV | 45 µV | 26 µV |
| 256 mV | 0.01% | 15 µV | 12.5 µV | 11.2 µV | 10.8 µV | 63 µV | 31 µV |
| 1.0 V | 0.01% | 33 µV | 31.8 µV | 31.3 µV | 31.2 µV | 112 µV | 93 µV |
| 4.0 V | 0.01% | 123 µV | 122 µV | 122 µV | 122 µV | 450 µV | 366 µV |
| 16.0 V | 0.01% | 488 µV | 488 µV | 488 µV | 488 µV | 1.8 mV | 1.5 mV |

*A/D filter ON (max sample rate—>145 µsec–fixed range)

**Temperature coefficients**

Gain: 15ppm/°C (after *CAL)

Offset: add tempco error plus fixed offset to above table

| Temp | Tempco | 2 Hz | 10 Hz | 100 Hz | Filt Off |
|---|---|---|---|---|---|
| (0–30) | .16 µV/°C | 0 µV | 0 µV | 0 µV | 0 µV |
| (30–40) | .18 µV/°C | 13 µV | 9 µV | 1.1 µV | .2 µV |
| (40–55) | .39 µV/°C | 31 µV | 22 µV | 6.4 µV | 1.1 µV |

**Gain of X8**

| Range | Linearity | Offset error | | | | Noise | Noise* |
|---|---|---|---|---|---|---|---|
| ± FS | % of rdg | 2 Hz | 10 Hz | 100 Hz | Filt Off | 3 sigma | 3 sigma |
| 7.8 mV | 0.01% | 4.6 µV | 3.6 µV | 3.2 µV | 3.6 µV | 5.3 µV | 4.5 µV |
| 31.3 mV | 0.01% | 4.7 µV | 3.8 µV | 3.3 µV | 5 µV | 6.9 µV** | 5.9 µV** |
| 125 mV | 0.01% | 6.0 µV | 5.3 µV | 5.0 µV | 14 µV | 14 µV | 12 µV |
| 0.50 V | 0.01% | 16 µV | 16 µV | 16 µV | 56 µV | 56 µV | 46 µV |
| 2.0 V | 0.01% | 61 µV | 61 µV | 61 µV | 225 µV | 225 µV | 188 µV |

*A/D filter ON (max sample rate—>145 µsec–fixed range)

**7.4 µV and 6.3 µV when temp ≥40 °C

**Temperature coefficients**

Gain: 15ppm/°C (after *CAL)

Offset: add tempco error plus fixed offset to above table

| Temp | Tempco | 2 Hz | 10 Hz | 100 Hz | Filt Off |
|---|---|---|---|---|---|
| (0–30) | .16 µV/°C | 0 µV | 0 µV | 0 µV | 0 µV |
| (30–40) | .18 µV/°C | 4.3 µV | 2.7 µV | 1.0 µV | 0.2 µV |
| (40–55) | .39 µV/°C | 13 µV | 22 µV | 6.2 µV | 0.8 µV |

**Gain of X64**

| Range | Linearity | Offset error | | | | Noise | Noise* |
|---|---|---|---|---|---|---|---|
| ± FS | % of rdg | 2 Hz | 10 Hz | 100 Hz | Filt Off | 3 sigma | 3 sigma |
| 3.9 mV | 0.01% | 2.9 µV | 2.3 µV | 2.1 µV | 2.1 µV | 1.6 µV** | 1.3 µV** |
| 15 mV | 0.01% | 3.0 µV | 2.4 µV | 2.2 µV | 2.2 µV | 2.2 µV*** | 1.9 µV*** |
| 62 mV | 0.01% | 3.5 µV | 3.0 µV | 2.9 µV | 2.9 µV | 7.0 µV | 5.7 µV |
| 256 mV | 0.01% | 8.2 µV | 8.0 µV | 8.0 µV | 8.0 µV | 28 µV | 23 µV |

*A/D filter ON (max sample rate—>145 µsec–fixed range)

**1.9 µV and 1.7 µV for 100 Hz filter

***2.5 µV and 1.9 µV when temp ≥40 °C

**Temperature coefficients**

Gain: 15 ppm/°C (after *CAL)

Offset: add tempco error plus fixed offset to above table

| Temp | Tempco | 2 Hz | 10 Hz | 100 Hz | Filt Off |
|---|---|---|---|---|---|
| (0-30) | .16 µV/°C | 0 µV | 0 µV | 0 µV | 0 µV |
| (30-40) | .18 µV/°C | 1.1 µV | 0.2 µV | 0.1 µV | 0.1 µV |
| (40-55) | .39 µV/°C | 6 µV | 1.4 µV | 0.6 µV | 0.6 µV |

**Normal mode rejection:**

2 Hz lowpass filter (2 pole)

2 Hz -3 dB

50Hz >44 dB

60 Hz >45 dB

10 Hz lowpass filter (2 pole)

10 Hz -3 dB

50 Hz >23 dB

60 Hz >25 dB

100 Hz lowpass filter (2 pole)

100 Hz -3 dB

400 Hz >15 dB

**Bandwith:**

Filter Off Mode (2 pole)

Maximum bandwidth

X1 gain (1600/input voltage) Hz

X8 gain (200/input voltage) Hz

X64 gain (25/input voltage) Hz

**Common mode rejection (0 to 60 Hz):**

X1 gain >100 dB

X8 gain >118 dB

X64 gain >136 dB

## Temperature Measurements:

Any of the input SCP's can be used to make temperature measurements with thermocouples, but Options 013, 018, and 019 provide highest accuracy. One 122 µα internal current source is supplied to excite the thermistor reference on the terminal block or an external thermistor or RTD reference.

One of the 64 channels must be used to measure the reference.

Thermistors and RTD's require an input SCP and Option 015 Current Source SCP for excitation.

Engineering units conversion to degrees C are made on-card at full speed.

## Transducer types:

**Thermocouples:** E, E extended, J, K, N, R, S, T (linearized to ITS90 per NIST Monograph 175)

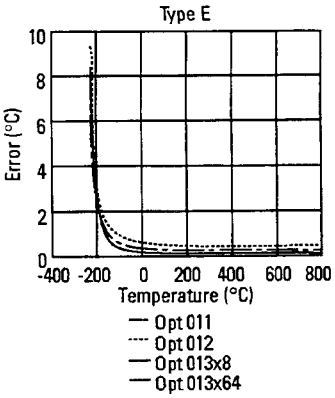
**Thermistors:** 2252, 5 KΩ, and 10 KΩ

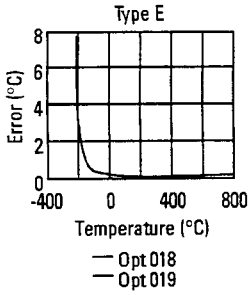
**RTD's:** 100 Ω type 85 and 92

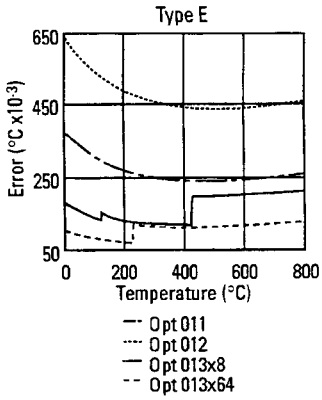
**Measurement range:** -200 to +1500 °C depending on transducer type

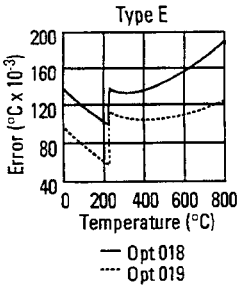
## Temperature accuracy:

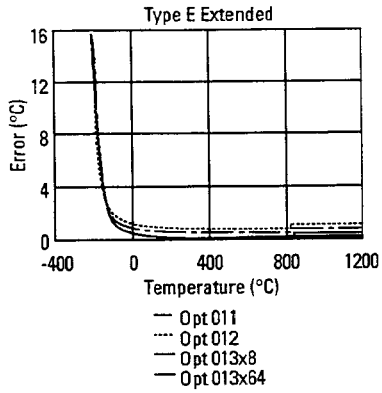
(All measurements for the following specs are made with the A/D filter off.)

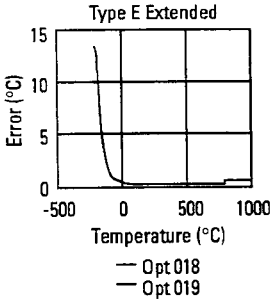


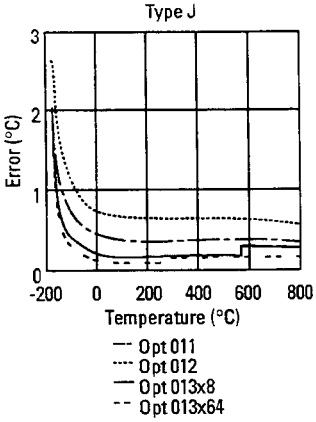



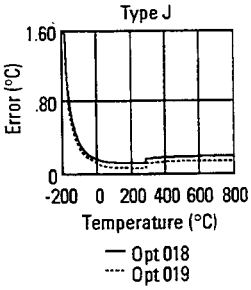



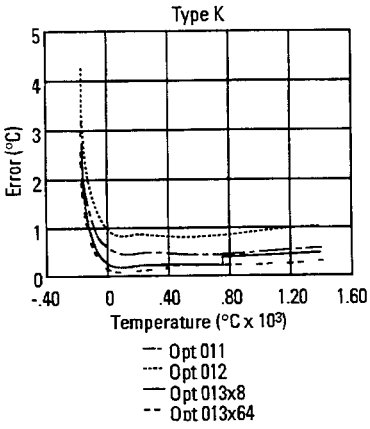



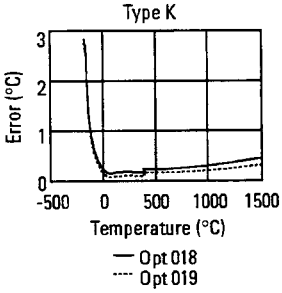



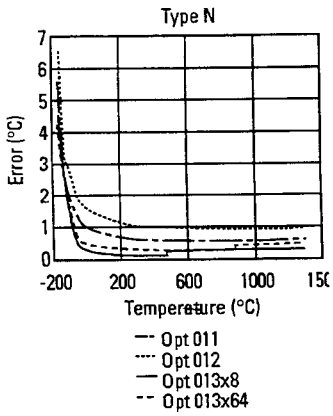



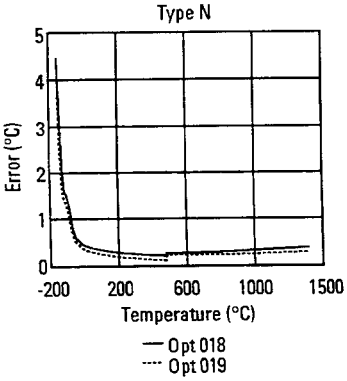



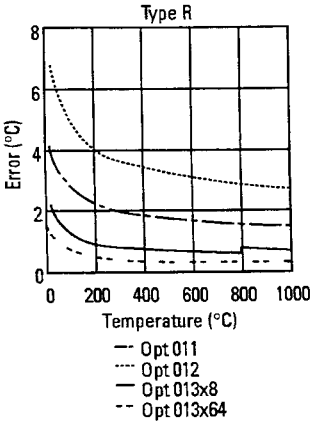



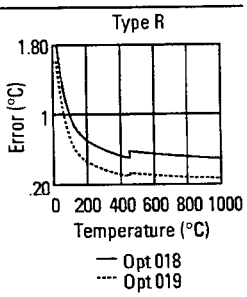



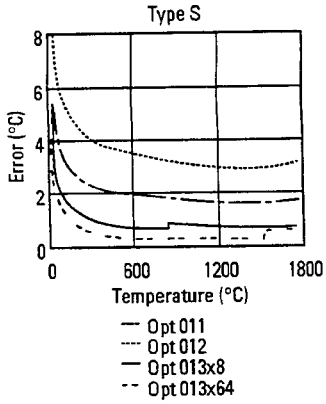



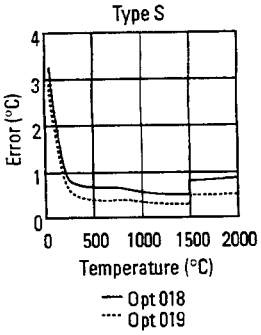



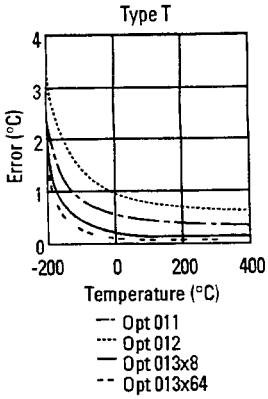



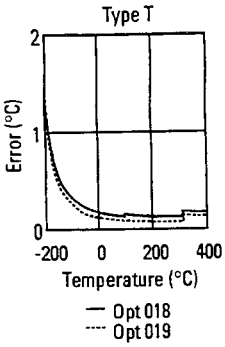



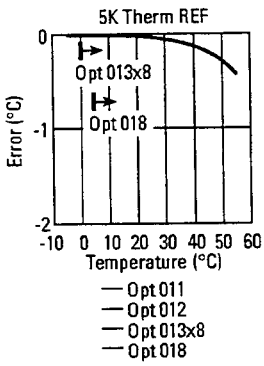



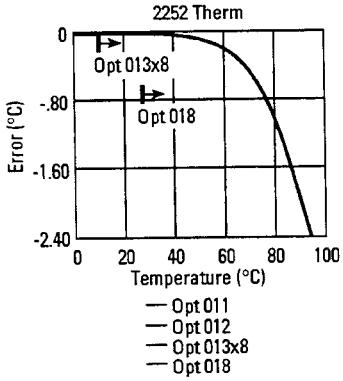


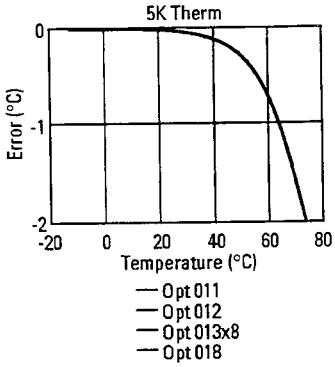



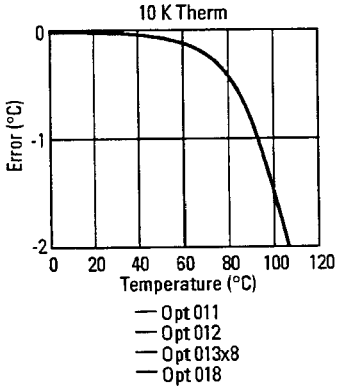



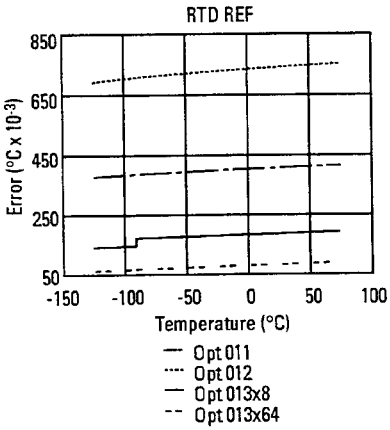



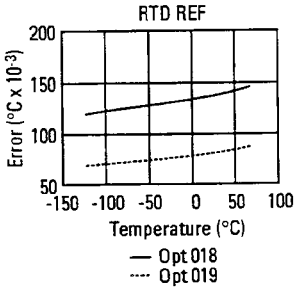



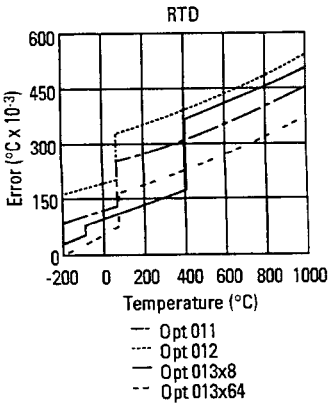



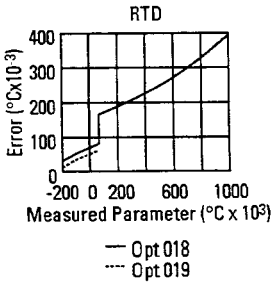



## Strain Measurements

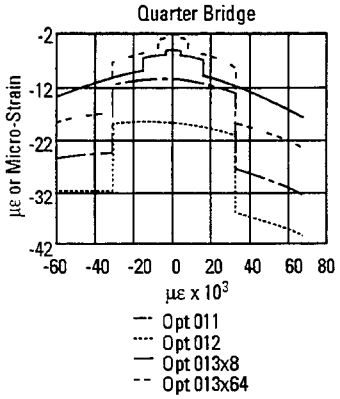
Opt 016/017 Strain Bridge SCP
Internal excitation voltage source: 3.9 V ±0.5 mV
Externally supplied voltages are supported

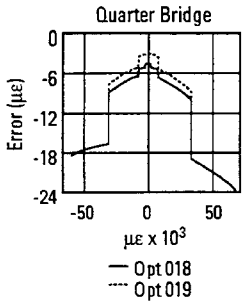
## Completion resistors:

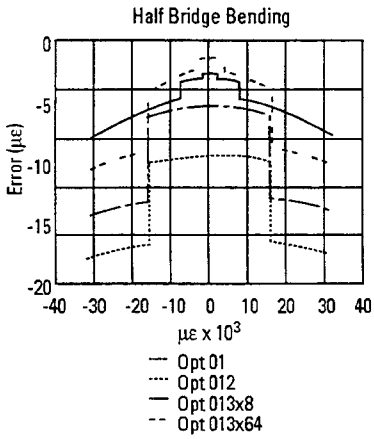
Opt 016 120 Ω ±0.05%
Opt 017 350 Ω ±0.05%

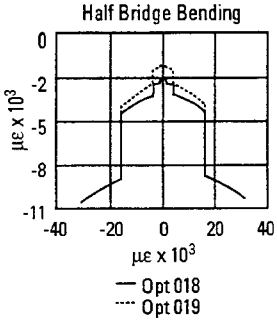
## Measurement accuracy:

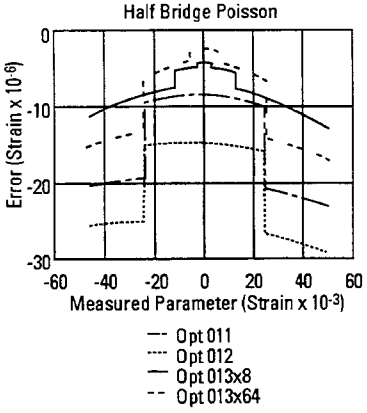
With any input SCP when most sensitive available range is used. (All measurements for the following specs are made with the A/D filter off.)

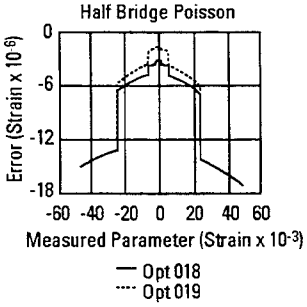


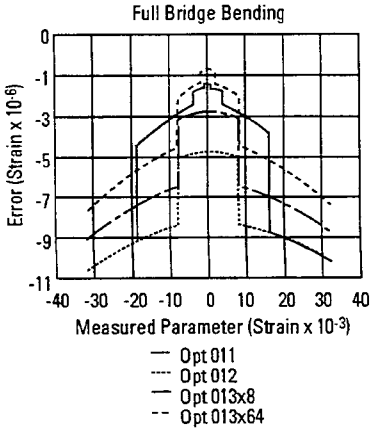



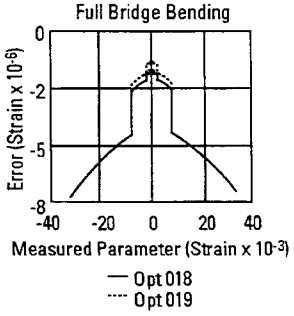



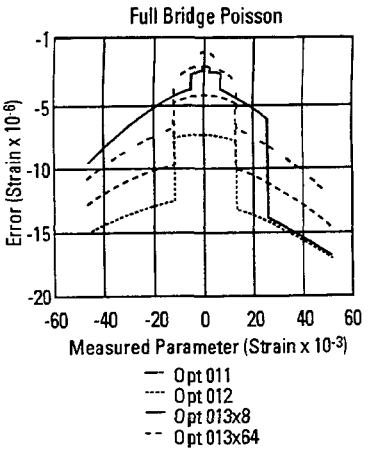



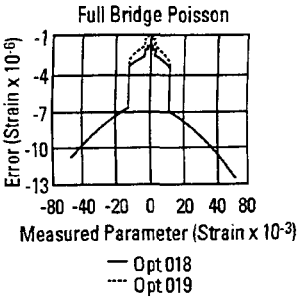



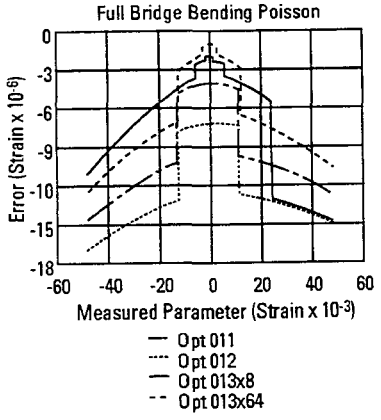



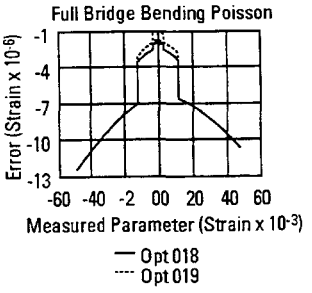






## Resistance Measurements

Opt 015 Current Source SCP

MIN current source:
30.5 µA ±9 µA

MAX current source:
488.3 µA ±60 µA

Measurement accuracy with any input SCP when most sensitive available range is used:

MIN current source:

$$\pm(0.035\% \text{ of rdg} + 0.015\% \text{ of FS} + \frac{\text{rdg} \times 10^8}{\text{rdg} + 10^8})$$

MAX current source:

$$\pm(0.02\% \text{ of rdg} + 0.015\% \text{ of FS} + \frac{\text{rdg} \times 10^8}{\text{rdg} + 10^8})$$

## Other Signal Conditioning

Option 014 Breadboard SCP

Provides six square inches of board space for user-supplied custom circuitry. Up to eight FET mux channels can be accessed. Includes +5 V and ±19 V supplies and overvoltage protection.

### Timing Signals

Scan-to-scan timing and sample-to-sample timing can be set independently.

Scan triggers can be derived from a software command or a TTL level from other VXI modules, internal timer or external hardware.

Multiple E1413B modules can be synchronized at the same rate.using the TTL trigger output from one E1413B to trigger the others.

Multiple E1413B modules can be synchronized at different integer-related rates using the scan timer/N mode.and the TTL trigger output from one E1413B to trigger the others.

### Power Requirements

See the Module Power and Cooling Information Table in the *1994 HP VXI Catalog*.

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Hewlett-Packard
International Sales Branch
Geneva, Switzerland
Telephone: 41 22 780 7111
Fax: 41 22 780 4770


**Printed in USA January 1994**
**5962-8638E**