

## StrainSmart® Data Acquisition System

### MODEL 9000-16-SM FEATURES

- **12 Strain gage channels**, sensors supported:
  - Strain gage (quarter-, half-, and full-bridges)
  - Strain-gage-based transducer
- **4 Plug-in card slots**, available to support:
  - High-level voltage signal
  - Thermocouples
  - Piezoelectric transducers (charge mode and voltage mode)
- **Sampling rates:** 50,000, 25,000, 10,000 and 5,000 samples/second. Analog-to-digital converters (ADCs) over-sample data at 128 times the selected sample rate, and Finite Impulse Response (FIR) filters provide filtering. All ADCs are sampled simultaneously.
- **Expansion to a 48-channel system:** Up to three 9000s can be combined to provide 48 channels of fully synchronized data acquisition (36 strain gage plus 12 configurable).
- **On-board Data Recording:** Supports manual-, time-, and limits-based recording. Pre- and post-trigger data are available for limits-based recording and manually-triggered recording.
- **Self-Calibrating (Optional):** An NIST-traceable MM Part No. A123 voltage calibration card is available as an accessory. This calibration card provides a high-accuracy voltage source that may be used to calibrate the gain and offset of each channel. MM Part No. A123 is removable and interchangeable and it only needs to be present in the Model 9000 during the self-calibration process.
- **Optional analog outputs (Model 9000-16-SM-AO):** Provide an analog output for each of the twelve strain gage channels. Bandwidth DC to 19.8 kHz.

### DESCRIPTION

System 9000 from Micro-Measurements is a versatile, precision data acquisition instrument system intended for dynamic test and measurement applications.

The system includes a scanner with 12 channels of strain-gage-based input and 4 optional input slots (thermocouple, high level and piezoelectric). The scanners may be used separately or up to 3 scanners can be used concurrently for a maximum of 48 fully synchronized channels.

Strain gage channels accept full-, half-, or quarter-bridge configurations and have the required bridge completion components for 120-, 350-, and 1000-ohm bridges. The data is processed in a modern 24-bit digital signal processor and filtering is performed using Finite Impulse Response (FIR), multi-stage filters. This provides excellent noise rejection and stability, and unsurpassed measurement accuracy.

The Model 9000-16-SM Scanner communicates with a host personal computer (PC) via a DHCP auto configured Ethernet connection (required router not included).



Micro-Measurements StrainSmart® software is optimal for configuring, controlling, and acquiring data from the System 9000.

### SUPPORTED SENSORS

- Strain gage (quarter-, half-, and full-bridges)
- Strain-gage-based transducer
- High-level voltage signal
- Thermocouples
- Piezoelectric (voltage and charge mode)

### INPUT CONNECTIONS

Strain gage and high level inputs use eight RJ45 plugs. Shielded wires and shielded connectors are recommended. The thermocouple card accepts both 2- and 3-pin miniature plugs. The piezoelectric card connects through a BNC connector.

### ETHERNET ARCHITECTURE

The Model 9000 communicates over an IEEE-802.3u 100Base-TX Network. Use of the Dynamic Host Configuration Protocol (DHCP) automates the IP address configuration.

### DC OPERATION

The Model 9000 operates on 11-32 VDC power. Power can be sourced from the included power supply, a separate AC-to-DC converter, or a DC supply such as a battery.

### DIGITAL I/O

A digital input and output are provided to interface with external hardware.

### MOUNTING

The Model 9000 can be configured as a stand-alone desktop unit, stacked, or rack-mounted. **A rack-mount kit is available from Micro-Measurements (9000-RM).**

## StrainSmart® Data Acquisition System

### SPECIFICATIONS

#### General

##### Environmental:

**Temperature:** 0° to +50°C

**Humidity:** Up to 90%, non-condensing

##### Enclosure:

**Material:** A356-T6 aluminum casting

##### Dimensions:

3.50 H (3.88 with feet) x 17.19 W x 11.50 D (12.97 including optional 9000-SM-VC card and input cards) inches  
(88.9 x 436.7 x 292.1 mm)

##### Configurations:

Bench-top, stackable, rack-mountable

##### Weight:

13.05 lbs (5.92 kg), without auxiliary plug in cards

#### Power

**Input:** 11-32 VDC, 10 A max

##### Fuse:

10 A Fast-acting blade terminal. (Littlefuse MINI® Blade fuse P/N 0297010 or equivalent)

#### Communication

**Ethernet interface:** 100 Mbit

**Network protocol:** DHCP

#### Data Recording

**Storage type:** Internal SATA solid state drive

**Capacity:** ≥16 GB, max file size is 2 GB

#### Synchronization

**Channel count:** ≤48 channels (3 devices)

##### Configuration:

“Star” topology, max cable length ≤7 ft (~2 m)

### ANALOG CHANNELS

#### Channels

12 Differential inputs  
4 Configurable input slots

#### A/D Converter

**Architecture:** Delta-Sigma ( $\Delta\Sigma$ )

**Resolution:** 24 bits

**Oversampling rate:** 128 times the selected data rate

**Sampling mode:** Simultaneous

#### Data Rates

50,000, 25,000, 10,000 and 5,000 samples/second/channel

#### Analog Anti-Alias Filter

**Type:** Low-pass

**Frequency:** 20 kHz @ -3 dB

**Number of poles:** One

**Topology:** Lowpass RC

#### Digital Filters

**Type:** Finite Impulse response (FIR), two selectable filters provided per sampling rate)

**Table 1. Default Digital Filter Specifications**

$f_{user}$ (Hz)	$f_{pass}$ (Hz)	Passband Peak-Peak Ripple (dB)	Stopband Attenuation (dB)
50,000	12500	0.01	-80
25,000	6250	0.01	-80
10,000	2500	0.01	-80
5,000	1250	0.01	-80

**Table 2. Alternate Digital Filter Specifications**

$f_{user}$ (Hz)	$f_{pass}$ (Hz)	Passband Peak-Peak Ripple (dB)	Stopband Attenuation (dB)
50,000	6250	0.01	-80
25,000	3125	0.01	-80
10,000	1250	0.01	-80
5,000	625	0.01	-80

### STRAIN GAGE INPUTS

#### Channels

**Quantity:** 12

#### Inputs

Software-selectable for S+/S-, Vcal+/Vcal-, or excitation

##### Strain gage:

120  $\Omega$ , 350  $\Omega$ , 1000  $\Omega$  quarter-bridges;  
60  $\Omega$  to 5000  $\Omega$  half- and full-bridges

**Input impedance:** 220 M $\Omega$  nominal each input

**Source current:** ±5 nA per volt excitation

#### Measurement Range and Resolution

**Range:** Depends upon excitation setting (see Table 3)

**Resolution:** 0.5  $\mu\epsilon$  @ GF=2 (0.25  $\mu V/V$ )

**Table 3.  
Strain Gage Measurement Range and Resolution**

Excitation Volts	Typical Measuring Range includes Imbalance	
	± $\mu\epsilon$ @ GF=2	±mV/V
0	77500*	19*
0.25	310000	155
0.5	155000	77
0.75	103000	51
1	77000	38
2	38000	19
3	25000	12
4	77000	38
5	62000	31
6	51000	25
7	44000	22
8	38000	19
9	34000	17
10	31000	15

\* NOTE: Range calculations at zero volts excitation are based upon 1 volt excitation, and are typically used for the quantification of self-generating noise.

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**Input Connector**

8-pin shielded TIA/EIA RJ45 (MM Part No. A114)

**Amplifier**

**Zero temperature stability:**

$\pm 1 \mu\text{V}/^\circ\text{C}$  RTI, after 60-minute warm-up

**DC Gain accuracy and stability:**

$\pm 0.05\%$ ;  $\pm 50 \text{ ppm}/^\circ\text{C}$  (1 year without periodic VCAL)

**Analog input (including full-scale balance):**

**Low range:**  $\pm 38 \text{ mV}$

**High range:**  $\pm 155 \text{ mV}$

**Linearity:**  $\pm 0.02\%$  of full scale

**Common-mode rejection:**  $>90 \text{ dB}$  (DC to 60 Hz)

**Common-mode voltage range:**  $\pm 12 \text{ V}$  typical

**Balance**

**Type:** Software (mathematical)

**Range:**

Full ADC range (actual balance level shifts dynamic measurement range 1:1)

**Excitation**

**Selection:** Software controlled

**Unipolar:** 0 to +10 VDC

**Resolution:** 3 mV

**Accuracy:**  $\pm 10 \text{ mV}$  typical

(Firmware measures excitation variations during arming process)

**Current:** 50 mA max per channel

Over-current limited

Over-current indication

**Load regulation:**  $<0.05\%$  of full scale for 10% to 100% of full scale loads with remote sense

**Temperature stability:**  $\pm 10 \text{ ppm}/^\circ\text{C}$

**Quarter-Bridge Completion**

**Selection:** Firmware controlled

**Accuracy and drift:**

**120  $\Omega$  and 350  $\Omega$ :**  $\pm 0.01\%$ , 5 ppm/ $^\circ\text{C}$  max

**1 k $\Omega$ :**  $\pm 0.01\%$ , 4.5 ppm/ $^\circ\text{C}$  max (socketed)

**Shunt Calibration**

**Selection:** Firmware controlled

**Configuration:**

**Internal QB:** P- to D<sub>120</sub>, P- to D<sub>350</sub>, P- to D<sub>1000</sub>

**External:**

Switched shunt at input connector (Ra, Rb)

**Standard factory installed resistor values:**

Simulates 10000  $\mu\epsilon$  @ GF = 2.0

**5940  $\Omega$   $\pm 0.1\%$ :** Shunts P- to D<sub>120</sub>

**17325  $\Omega$   $\pm 0.1\%$ :** Shunts P- to D<sub>350</sub>

**49500  $\Omega$   $\pm 0.1\%$ :** Shunts P- to D<sub>1000</sub>

**17325  $\Omega$   $\pm 0.1\%$ :** External shunt Ra to Rb

**Resistor sockets:** Tin-plated

**9000-TC THERMOCOUPLE INPUT CARD (OPTIONAL)**

**Channels:**

**Quantity:** 1 per card; 4 cards max

**Inputs**

**Supported thermocouple types:**

J, K, T, E, N, R, S, B

Cold-junction compensation, software-selectable

Open-sensor detection

**Input impedance:** 22 M $\Omega$  nominal each input

**Input Connectors**

Mini-TC with optional earth connection

**Amplifier**

**Zero temperature stability:**

$\pm 2 \mu\text{V}/^\circ\text{C}$  RTI,  $\pm 10 \mu\text{V}/^\circ\text{C}$  RTO, after 60-minute warm-up

**DC Gain accuracy and stability:**

$\pm 0.1\%$ ;  $\pm 30 \text{ ppm}/^\circ\text{C}$

**Zero accuracy and linearity:**  $\pm 0.02\%$  of full scale

**Common mode rejection (DC to 60 Hz):**  $>90 \text{ dB}$

**Common mode voltage range:**  $\pm 12 \text{ V}$  typical

**Measurement Range and Resolution**

**Range:**  $\pm 77.5 \text{ mV}$

**Resolution:**  $1^\circ\text{C}$  min

**Measurement Accuracy**

$\pm 2^\circ\text{C}$  (nominal)

**9000-HL HIGH-LEVEL INPUT CARD (OPTIONAL)**

**Channels**

**Quantity:** 1 per card; 4 cards max

**Inputs**

Differential

**Input impedance:** 220 M $\Omega$  nominal each input

**Input bias current:**  $\pm 0.5 \text{ nA}$  typical ( $\pm 2 \text{ nA}$  max)

**Input Connector**

8-pin shielded TIA/EIA RJ45 (MM Part No. A114)

**Amplifier**

**Zero temperature stability:**

$\pm 2 \mu\text{V}/^\circ\text{C}$  RTI, typical,  $\pm 10 \mu\text{V}/^\circ\text{C}$  RTO, after 60-minute warm-up

**DC Gain accuracy and stability:**

$\pm 0.1\%$ ;  $\pm 30 \text{ ppm}/^\circ\text{C}$

**Zero accuracy and linearity:**  $\pm 0.02\%$  of full scale

**Common-mode rejection (DC to 60 Hz):**  $>90 \text{ dB}$

**Common-mode voltage range:**  $\pm 12 \text{ V}$  typical

## StrainSmart® Data Acquisition System

### Measurement Ranges and Resolution

**Range:** ±10 V

**Resolution:** 100 µV effective

### Excitation

**Selection:** Software controlled

#### Unipolar mode:

**Range:** 0 to +11.997 VDC

**Accuracy:** ±10 mV typical

#### Current:

50 mA max

Over-current/over-temperature protected

#### Load regulation:

<0.05% of full scale (unipolar mode) for a load variation of 10% to 100% of full scale loads (with remote sense)

**Temperature stability:** Better than ±30 ppm/°C

#### Bipolar mode:

**Range:** ±12 VDC (24 VDC total)

**Accuracy:** ±5% of full scale

### 9000-PZ PIEZOELECTRIC INPUT CARD (OPTIONAL)

#### Channels

**Quantity:** 1 per card; 4 cards max

#### Inputs

VM or CM piezoelectric type transducers (switch-selectable)

#### Coupling:

**CM type:** Charge amplifier with software-selectable time constants of 0.5 and 5 seconds.

**VM type:** AC coupling to remove DC bias voltage with high-pass response of 0.1 Hz (-3 dB).

#### Input Connector

Female BNC

#### Amplifier

Gain Accuracy @1KHz: ±0.5%

**Secondary stage DC gain accuracy and stability:** ±0.1% at +23°C; ±25 ppm/°C

### Measurement Ranges and Resolution

#### VM Type transducers range:

0.5 to 29.5 VDC input with measurement ranges of ±14.5 V, ±9.5 V, ±4.7 V, and ±2.3 V

**Resolution:** 1µV

#### Charge type transducers range:

±225,000 pC, ±56,000 pC, ±14,000 pC, ±3,500 pC, and ±875 pC

**Resolution:** 0.1 pC

### Excitation

**Selection:** Software controlled

**Range:** 0, 1, 2, 4, 5, 10 and 20 mA selections for VM type transducers

**Accuracy:** ±3% + (±30 µA) typical at 1 to 20 mA

**Voltage compliance:** 0 to 28 V

**Temperature stability:** ±100 ppm/°C

### A123 VOLTAGE CALIBRATION CARD (OPTIONAL)

#### Accuracy

±100 ppm repeatability, typical;

±250 ppm repeatability, max

#### Drift

1.9 ppm/°C ±0.6 µV/°C typical;

9.4 ppm/°C ±2.1 µV/°C max

#### Resolution

150 µV nominal

#### Voltage Range

±5 V

#### Instrument Calibration

Firmware controlled

#### Calibration voltage:

Supplied by the accessory item MM Part No. A123 voltage calibration card (interchangeable with System 8000)

**Type:** Multi-point, ≥100 samples per point



### DIGITAL INPUT/OUTPUT

#### Quantity

1 input and 1 output

#### Configuration

5 V TTL

Isolated

### ANALOG OUTPUTS (MODEL 9000-16-SM-AO)

#### Channels

**Quantity:** 12 (one per strain gage input channel)

#### Output

**Connectors:** Female BNC Jack (50 Ω)

**Range:** ±10 V (min)

**Load:** 2000 Ω min

**Bandwidth:** DC to 19.8 KHz (-3 dB ±0.25 dB)

**Gain accuracy:** ±1%

**Gain:** Not selectable, depends upon excitation setting (see Table 4)

**Table 4. Analog Output Gain**

Excitation Selection (Volts)	Gain (Volts/Volt)
0-3	257.05
4-10	64.262

NOTE: Software gage factor settings or balance settings have no effect on Analog Output response.

StrainSmart® Data Acquisition System

<b>SYSTEM 9000 OPTIONAL ACCESSORIES</b>		
<b>MM Part Number</b>	<b>Item Description</b>	<b>Notes</b>
<b>COMMUNICATION</b>		
<b>MMA128</b>	Ethernet router (with cable)	Required for communication between your PC and the 9000 <sup>(1)</sup>
<b>MMA129</b>	7', Cat6, shielded, straight-through Ethernet cable	Used for Ethernet communication or synchronization cabling
<b>MMA90</b>	10', Cat5e, unshielded, straight-through Ethernet cable	Used for Ethernet communication <sup>(1)</sup> (should not be used for synchronization cabling)
<b>OPTIONS</b>		
<b>MMA138</b>	9000-HL High Level Input Card	High-level voltage signals $\pm 10$ VDC
<b>MMA139</b>	9000-TC Thermocouple Input Card	Supported J, K, T, E, N, R, S, B types
<b>MMA140</b>	9000-PZ Piezoelectric Input Card	Charge and voltage mode capable
<b>MMA123</b>	Calibration (VCAL) card	Required for on-site calibration
<b>MMA124</b>	Rack-mount kit	Brackets for mounting into an instrumentation rack
<b>SYNCHRONIZATION</b>		
<b>MMA129</b>	7', Cat6, shielded, straight-through Ethernet cable	Used for synchronization cabling between multiple instruments. May also be used for Ethernet communication.
<b>MMA131</b>	2', Cat6, shielded, straight-through Ethernet cable	Used for synchronization cabling between multiple instruments. May also be used for Ethernet communication.
<b>INPUT CONNECTION</b>		
<b>MMA114</b>	RJ45(8) modular plug, shielded	Recommended connector for strain gage and high level inputs. May be used for digital I/O.
<b>MMA106</b>	RJ45(8) modular plug, unshielded	Connector for digital input/output
<b>MMA115</b>	RJ45(8), shielded modular plug crimping tool	Tool used to crimp wires to connector MMA114
<b>MMA108</b>	RJ45(8), unshielded modular plug crimping tool	Tool used to crimp wires to connector MMA106
<b>MMA134</b>	2-Pin miniature plug for type J thermocouple	No shield present
<b>MMA135</b>	3-Pin miniature plug for type J thermocouple	Shield present
<b>MMA136</b>	2-Pin miniature plug for type K thermocouple	No shield present
<b>MMA137</b>	3-Pin miniature plug for type K thermocouple	Shield present
<b>MMA141</b>	Wire clamp for miniature thermocouple plug	
<b>REPLACEMENT PARTS</b>		
<b>MMA123</b>	Fuse, mini blade 32 V 10 A	Replacement item
<b>MMA132</b>	Power supply assembly	Replacement item

**Note 1:** The 9000 requires a DHCP-enabled router for communication with a PC. Part number MMA128 provides a router and a single cable which may be connected to your PC. Each 9000 instrument will require an additional Ethernet cable (MMA90, MMA129, or MMA131).



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