ANDEEN-HAGERLING

AH 1100 Capacitance Standard Frame **AH 11A** Fused-Silica Capacitance Standard

The World's Most Stable Capacitance Standards[1]

The AH 1100 capacitance standard frame containing from one to four AH 11A fused-silica capacitance standards provides reference capacitors of unexcelled stability. The inherent stability of this system when subjected to mechanical or thermal shock makes it the ideal transfer standard for capacitance. The built-in precision temperature controllers make it a simple, reliable system to use. These are the only standards currently sold that are sufficiently accurate to calibrate the AH 2500A capacitance bridge to the limits of its specifications.

Outstanding Features

- ***Any*** capacitance value in the range from below 1 pF up to 115 pF may be ordered.
- Stability of larger capacitors is better than 0.3 ppm/year.
- Temperature coefficient of the capacitance with respect to changes in ambient temperature is less than 0.01 ppm/°C.
- Hysteresis resulting from temperature cycling is less than 0.05 ppm.
- Hysteresis resulting from mechanical shock is less than 0.05 ppm.
- AC voltage coefficient is less than 0.003 ppm/volt.
- DC voltage coefficient is less than 0.0001 ppm/volt.
- Power line sensitivity is less than 0.0003 ppm per 1% change in power line voltage.

- Dissipation factor is less than 0.000 003 tan delta.
- Three year warranty
- The user-selected capacitance value is set at the factory to a NIST traceable accuracy of 2 ppm at 1 kHz.
- The built-in precision oven in each AH 11A uses a dual temperature sensor system which provides increased reliability and confidence.
- The AH 1100 frame provides monitoring of critical temperature control parameters such as the differences within the dual temperature sensors in each standard.
- Each AH 11A standard can be easily removed from the AH 1100 frame. Their small size and light weight make them easy to ship for calibration.
- Shipping is simple since continuous temperature control of the ovens is not needed to maintain the stability specification.
- The fused-silica element is hermetically sealed in dry nitrogen.
- Three-terminal BNC connections minimize connector costs and number of cables.

[1] in commercial production.

BRIEF HISTORY

Capacitance standards using fused silica as a dielectric have been investigated at NBS (now NIST) for many years. Some particularly thorough research was done in the early 1960's by Cutkosky and Lee[2]. They constructed two versions of fused-silica based capacitors and characterized most of the important features of these standards. The set of twelve that they created contained several standards which were exceptionally stable. These and several later ones have been used ever since as the primary capacitance standards of the United States. These primary standards are calibrated on a regular basis against the calculable capacitor at NIST. The latter is now the ultimate reference.

[2] R. D. Cutkosky and L. H. Lee, Improved Ten-Picofarad Fused Silica Dielectric Capacitor, J. of Res. of the National Bureau of Standards - C., Vol. 69C, No. 3, July-Sept. 1965.

BASIC DESIGN

AH 1100 Frame

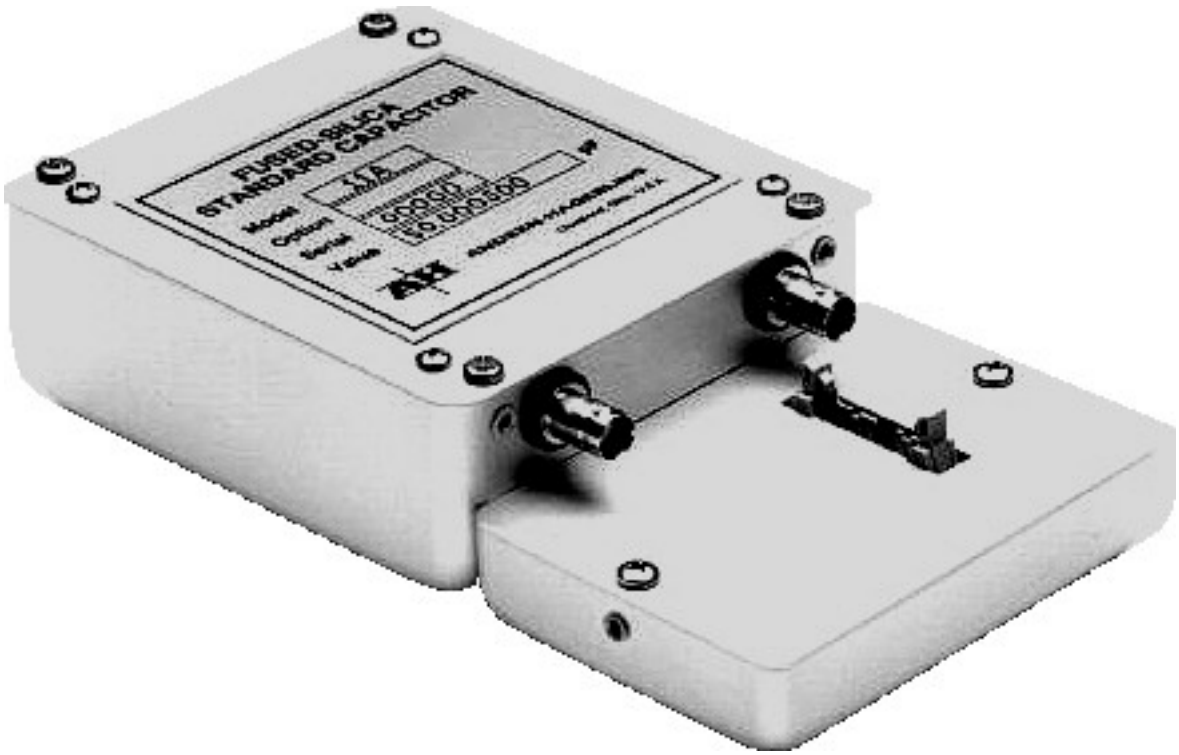
The AH 1100 frame consists of a 3.5 inch (8.9 cm) high, standard width, bench-top or rack-mountable frame. This frame can hold up to four AH 11A fused-silica capacitance standards. The frame provides the electrical power to operate the precision temperature-controlled oven that is part of each AH 11A. The frame also provides the metering circuits that monitor internal power voltages and temperatures. A three-terminal connection to each standard is made independently from pairs of BNC connectors on the front of the AH 1100. The AH 1100 also contains extra space to accommodate several optional features that will be available in the future.

AH 11A Standard

Each AH 11A standard has, as its basic element, a fused-silica disk which is used to form a set of capacitors having values that are binary weighted. Factory selection of the appropriate capacitors from this set allows the AH 11A to be offered in a wide range of very accurately set values. Final trimming of the value is achieved by a small adjustment to the temperature of the oven. This method avoids the introduction of a separate trimming capacitor with its associated instabilities. Thus the dielectric of the AH 11A is very nearly 100% solid fused silica.

The fused-silica disk is hermetically sealed in a copper chamber that is thermally well insulated from the outside case of the AH 11A. The temperature of this chamber is measured by two precision temperature sensors, connected to two totally independent monitoring circuits. The *average* of the output voltages produced by these two circuits is used to control the temperature of the copper chamber. The *difference* in these output voltages may be selected for display on the front panel of the AH 1100 frame. As the standard ages, this difference should remain near zero. The smaller the difference, the greater the confidence in the stability of the oven temperature.

Each AH 11A incorporates the temperature measurement and control circuitry needed for its oven. Connection from the AH 11A to the AH 1100 frame is made with three connectors: two BNC and one 16 pin.



The AH 11A standard

FEATURES

User-Selected Values

AH 11A capacitance standards can be ordered with any value from below 1 pF up to 115 pF. Furthermore, if the application for which the original value was purchased becomes obsolete, the AH 11A can be returned to the factory and set to a totally new value for a nominal cost.

Traditionally, capacitance values for transfer of higher echelon calibration values have been chosen to be several parts per million above 10, 100 and 1000 pF. The AH 11A can be ordered with values such as these for 10 and 100 pF. For applications requiring calibration of an AH 2500A capacitance bridge, values near 100 pF are preferred to those near 10 pF. In fact, for calibration of an AH 2500A at a single value, Andeen-Hagerling recommends using an AH 11A standard having a value of 99.99950 pF. This is 5 ppm below 100 pF. Values slightly below 10, 100, or 1000 are preferred to those above since this allows the capacitance bridge to most conveniently display an additional digit. Otherwise, the exact choice of values should be based on convention, personal preference, and standardization among groups that are exchanging calibration values.

Applications of User-Selected Values

- **Calibration of a Range**

For end applications requiring the measurement of a narrow range of values, one may desire one or more standards that fall within that range of values. Such application-specific standards can substantially increase confidence in the accuracy of measurements made within that range of values. An example might be fuel gauging where the capacitance values representing “full” and “empty” are useful calibration points since they represent the limits of the range being measured.

- **Calibration of a Set**

For end applications requiring the measurement of a well defined set of values, the possession of a set of standards whose values equal the nominal values within the application set can substantially increase confidence in the accuracy of measurements made near values in that application set. Especially, for volume applications, this may allow using lower cost capacitance meters to achieve a given accuracy. The ability of the AH 11A to be set to any value makes such strategies possible to a degree of accuracy never before attainable.

- **Deviation Measurements**

The ability to precisely set the value of the AH 11A allows it to serve as a reference capacitor against which an unknown capacitance is compared. This configuration allows differential capacitance measurements to be made that can be simultaneously very fast and very accurate.

- **Linearity Measurements**

Possession of a set of only four standards in a 1, 2, 4, 5 or similar sequence allows high precision linearity calibrations to be made over one decade of values. In this example, a set having 10, 20, 40, and 50 pF standards can be used to form parallel combinations that create every decade capacitance value from 10 to 120 pF. The addition of one more value to the set such as 1, 1, 2, 4, 5 allows the set to be self-checked for internal consistency.

Monitoring

The AH 1100 frame incorporates a panel meter with a three-and-one-half digit LED display to monitor internal parameters whose stability is critical to the stability of the capacitance values. This meter can read the most important power supply voltages at the press of a button. The meter also reads the difference in the readings taken by the pair of temperature sensors in each AH 11A. For convenience, these differences are reported in units of ppm of the capacitance value. Although the temperature of the AH 1100 chassis is not critical, its temperature may also be read by the panel meter. In addition, each AH 11A standard has an associated LED on the AH 1100 front panel that will flash if control of the oven temperature is lost, even briefly.

Ease of Shipping

AH 11A standards may be sent for calibration by shipping the entire AH 1100 frame containing up to four standards. Alternatively, if the calibrating lab has an AH 1100 frame, then only the AH 11A standards that are to be calibrated need be sent. These are easily removed by removing the top cover of the AH 1100, disconnecting three cables from each AH 11A, and loosening four mounting screws. The calibrating lab installs the AH 11A in that lab's AH 1100 frame to perform the calibration.

The AH 1100/11A system is much more impervious to its environment than other capacitance standards. The AH 1100 and AH 11A's can be shipped in a well cushioned box comparable to that used to ship other precision instruments. With such packaging, no other special handling requirements are necessary.

The small thermal hysteresis of the AH 11A means that it does not need to be shipped at its operating temperature. This eliminates the need to include heavy batteries in its shipping container.

Stability during Shipping

As a result of the AH 11A's resistance to thermal and mechanical shock, the expected changes in the capacitance value due to shipping are more than two orders of magnitude smaller than with Invar plate, gas dielectric capacitors. This can eliminate the all too common problem where the Invar plate standard that just returned from the national primary calibration laboratory has changed by 20 or more ppm during shipping even though its calibration papers say it should be good to 5 ppm.

Storage

While accurate measurements can only be made with the AH 1100/11A under power and with stable oven temperatures, this is only necessary while measurements are actually being made. When not in use, these standards can be left on the shelf with the power off and may have better long term stability under such conditions.

Temperature Range

The operating temperature range for the AH 1100/11A system is wider than for other capacitance standards and does not require a carefully controlled laboratory environment.

AH 1100/11A SPECIFICATIONS

Range of capacitance values that can be ordered: Any value from below 1 pF up to 115 pF.

Accuracy of initial setting: 2 + 1/C ppm at 1 kHz where “C” is the value of the 11A in pF.

Stability in ppm per year: 0.3 + 1/C ppm/year

Temperature coefficient relative to a change in ambient temperature: 0.01 ppm/°C

Hysteresis from temperature cycling: 0.05 ppm

Hysteresis from mechanical shock: 0.05 ppm

AC voltage coefficient: 0.003 ppm/volt rms at 1 kHz

DC voltage coefficient: 0.0001 ppm/volt

Sensitivity to power line voltage changes: 0.0003 ppm per 1% change in power line voltage

Dissipation factor: less than 0.000 003 tan delta

Maximum allowable applied voltage: 250 volts peak

Warm up time from power-on: 30 minutes

Operating temperature range: 10° to 40° C

Storage temperature range: -40° to +75° C

Humidity: 0 to 85% relative humidity, non-condensing

Power requirements: 40 watts max. during power-on, 20 watts after power-on

Power frequency: 48 to 440 Hz

Power voltage ranges: 85 to 115, 102 to 138, 187 to 253 and 204 to 276 volts rms

AH 1100 packaging: The AH 1100 frame is 3.5 inches (8.9 cm) high and 15 inches (38.1 cm) deep behind the front panel. Hardware for rack mounting and a bail for bench top use are provided.

Weight of AH 1100 only: 15 pounds (7 kg)

AH 11A packaging: 4.45 wide by 8.0 long by 2.0 inches high (11.3 wide by 20.3 long by 5.1 cm high).

AH 11A weight: 1.5 pounds (0.7 kg)

Safety: Designed in accordance with UL1244, IEC348, and BS4743

Radiated emissions: Designed to meet FCC and VDE class A requirements

Warranty: The AH 1100 and AH 11A are covered by a three year warranty. Forward and return shipping is covered during the first three months of the warranty period.

Note: Specifications are subject to change without notice.

Ordering Information	**Order Number**
AH 1100 Capacitance Standard Frame	AH 1100
AH 11A Fused-Silica Capacitance Standard	AH 11A-(*value in pF*)

For questions regarding these products, possible applications, the location of your nearest sales representative, or ordering information:

Call: 440-349-0370 **Fax: 440-349-0359**

E-mail: info@andeen-hagerling.com

ANDEEN-HAGERLING, INC.

31200 Bainbridge Road
Cleveland, Ohio 44139-2231 U.S.A.

Home | AH 2700A Bridge | AH 2500A Bridge | AH 1100/11A Standard | AH DCOAX Cable | Reader Response Form