FLUKE®

734A DC Reference Standard

Technical Data

The simple way to maintain and disseminate your volt

The Fluke 734A DC Reference Standard is a direct voltage reference used to maintain the volt in primary and secondary standards laboratories. It consists of four electrically and mechanically independent 732B DC Standards and a rack-width enclosure. Individual 732Bs provide 10V and 1.018V outputs and may be transported easily to remote locations while the reference is maintained in the laboratory. Stability for each output is ±2 ppm per year (10V) and ±0.8 ppm per month (1.018V). Each 10V output can drive up to 12 mA of current to simplify use with instrumentation with low input impedance.

The 734A Reference Standard was designed for laboratories that need to maintain traceability to national standards and to distribute the volt to production, service, calibration laboratories or other remote locations. To simplify shipment, each 732B Standard is small and highly portable. And its 72-hour battery life—which can be extended to more than 130 hours with the optional external battery and charger—means it's practical to ship a 732B across town or around the world.

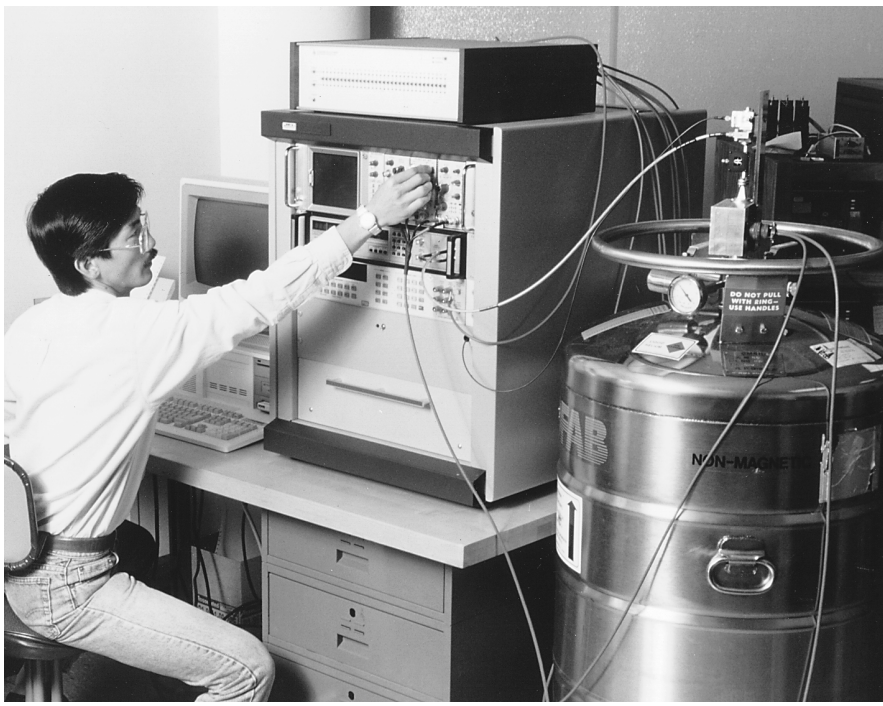
Because each 732B in the 734A Reference Standard is based on the same technology pioneered in the popular 732A—the first standards lab quality 10V electronic reference—you can rely on it to provide the same high stability and predictable drift rate you've come to expect, in a smaller, more portable package.

To simplify support of your 734A, Fluke offers a variety of calibration services to assign values and predicted performance for the 10V output, traceable to national standards and to the Fluke 10V Josephson Array.

Why a four-cell reference?

A four-cell reference is desirable any time you need to maintain and disseminate a reference voltage. At a minimum, three cells are intercompared to detect and identify changes in the output of any one cell. A fourth cell may be used as a spare or to transport the volt to or from remote locations. When it returns to the laboratory, it can be compared to the other three to determine if its output has shifted during transport.

However, there is more to a four-cell reference than four outputs. According to NBS Technical Note 1239, published by the U.S. National Bureau of Standards (now NIST) in 1987, four to six references are required to provide measurement integrity and redundancy, and to minimize the number of measurements required. References must be completely independent of one another. Otherwise, common elements, such as a power supply or oven, might affect the correlation of reference outputs. In addition, with frequent intercomparisons of four cells, you can detect when any one of the cells begins to drift beyond specifications or needs to be repaired.



The Fluke Standards Laboratory offers traceability to its own 10V Josephson Array, an intrinsic standard of voltage, and to national standards.

Each 732B is a stand-alone dc standard with its own power supply, oven, supporting electronics and packaging. Each may be purchased separately, or as a full 734A system, which includes four 732Bs that slide into a rack-width enclosure.

A fractional ppm 10V reference in your lab

With the 734A, it is remarkably simple to establish and maintain a fractional part per million (ppm) primary voltage standard in your laboratory. Over time, with frequent intercomparisons of your four cells, and regular calibrations of one or more cells, you can reduce the uncertainty of your 734A by a factor of three.

From 1984 until the acquisition of our 10V Josephson Array, the Fluke Primary Standards Laboratory maintained its corporate volt in this manner, reducing the absolute uncertainty to ±0.35 ppm traceable to national standards.

Taking your reference to the workload

Standards laboratory operations have changed. In the past, people brought their workload to the standards lab. Today, the functions of the standards lab are being distributed, requiring that many calibrations be performed in the field. The 734A, and its electrically and mechanically independent 732B Standards, was designed to meet that need. The voltage reference remains undisturbed in your laboratory. While at the same time you can distribute the volt to remote locations outside the lab. When the unit is returned to the lab, comparisons can be made to the reference to determine if a shift has occured during the transfer. To maintain traceability to national standards, one cell may be transported to a national lab or other primary standards lab for calibration, again, without disturbing the reference.

Each 732B Standard is relatively light, weighing just 5.9 kg, and its 72-hour battery life provides ample capacity for long shipments. An optional external battery extends that capacity to 130 hours. A special transit case, designed to hold one 732B and an external battery, simplifies transport even further.

The 732B can stand up to a lot of abuse. The inputs can be shorted indefinitely and are protected up to 1100V dc, 25 mA, without damaging the cell or affecting its output.

Ideal support for artifact calibration

Combined with 742A-1 and 742A-10k Resistance Standards, a single 732B makes a tough and compact artifact calibration support package for instruments like the 5700A and 5720A Calibrators from Fluke or the 3458A Multimeter from Hewlett Packard.

Why should you prefer the 734A?

- **Independence.** The 734A is the only standard of its type offering complete mechanical and electrical independence of each of its four standards.
- **Portability.** Each 732B Standard is designed for portability. Each is small, light, rugged and has a long operating battery life.
- **Confidence.** The 732B is based on the proven technology of the Fluke 732A. The 732A was the first standards lab quality electronic reference to gain wide acceptance as a replacement for saturated standard cells. Originally designed for internal transfers of Fluke's corporate volt to the production floor, thousands are now in service worldwide in a variety of applications—from maintaining an institutional reference to transferring values from national labs or privately-operated 10V Josephson Arrays.

The 732B's reference amplifier and resistors are identical to those used in the 732A. But the package is now half the weight, 75% smaller, more rugged and offers greatly extended battery life. The rack-width enclosure provides a convenient way to store cells in your lab. And the internal battery is now a common, off-the-shelf model that can be purchased from a wide range of electronic components suppliers, simplifying your support. Or you can use your own battery, connecting it to the 12-15V dc input on each 732B.

The 734A Reference and 732B Standards are a practical way to maintain and disseminate your volt and to support artifact calibration of instruments like the 5700A and 5720A Calibrators.

The advantages to maintaining your reference at 10V

The primary benefits of maintaining your voltage reference at 10V rather than 1.018V center on efficiency and ease-of-use. At 10V, you can intercompare standards directly with a digital voltmeter. The affects of noise and thermal EMFs are diminished by a factor of 10 compared to standard cells. And with 10V Josephson Arrays becoming more common, working at the 10V level further simplifies the process of establishing traceability. Finally, most modern dc instrumentation today requires a 10V standard for calibration. When you ratio up to 10V from 1.018V, you lose considerable performance.

The 734A supports 1.018V as well

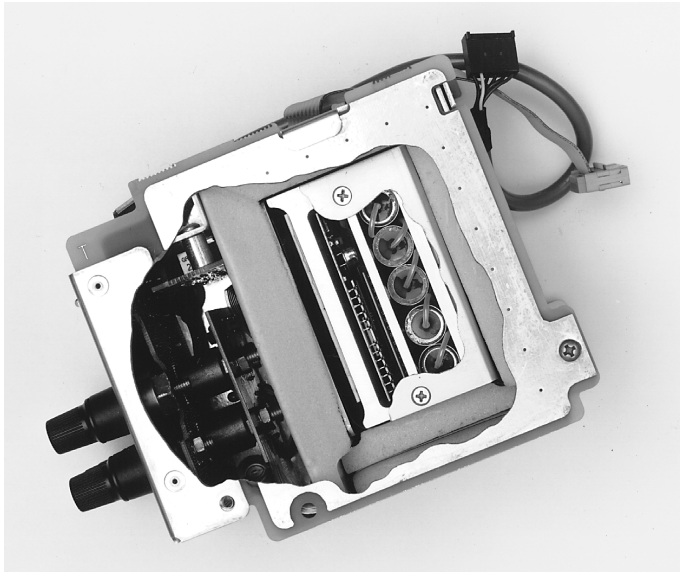
In applications where saturated standard cells are still used, the 1.018V output of each 732B Standard in the 734A Reference greatly simplifies intercomparisons of cell banks. And, like the 10V output, each 1.018V output is completely electrically and mechanically independent to preserve the integrity of your reference. Unlike standard cells, the 1.018V output of the 732B may be used immediately after shipment, eliminating the need to let cells stabilize for an extended period.

Supporting your traceability requirements

Fluke provides the products and services you need to manage your traceability requirements.

The Direct Voltage Maintenance Program consists of four calibration services that can be used separately or in combination depending on your needs. Two of the services are calibrations performed on a new 732B and are offered as options. The remaining two services you perform at your site using a Fluke-owned standard. The resulting data is sent to the Fluke Primary Standards Laboratory for reduction and analysis. Fluke can provide each 732B in your 734A with traceability to both national standards and to the Fluke Josephson Array—an intrinsic standard of voltage.

- **Calibration.** With option 732B-000, we perform an output voltage calibration on your new 732B. Before shipment, your standard is compared to direct voltage standards maintained at Fluke. Your standard, shipped under power, includes a Report of Calibration showing the deviation from nominal and the uncertainty of the calibration.



The Fluke 732B Standard uses the same specially selected zener reference technology pioneered in the popular 732A.

- **Calibration and drift characterization.** Option 732B-100 is similar to the 732B-000 but adds drift rate characterization before shipment. The output voltage is compared to a Fluke Standard for 90 days. Once the drift rate is known, total uncertainty as a function of time is greatly reduced. The projected output voltage is tabulated for 12 months following calibration. Uncertainty of the projection varies linearly from ±0.5 ppm at the time of calibration to ± 1.5 ppm after 12 months. As with the 732B-000, the standard is shipped to you under power.

732B Standards are small, light and rugged. Their 72-hour battery life, which can be extended to 130 hours with the optional external battery and charger, make them ideal for transfer standards.

- **Calibration in your laboratory.** With Option 732B-200, a Fluke-owned and calibrated standard, together with all necessary connecting cables and clear operating instructions is sent to your site for comparison with your reference standard. You make a series of readings over five days and forward the standard to the next laboratory and return the measurement results to the Fluke Standards Laboratory. A value for your reference relative to the Fluke Standard is then assigned. Within one week, a preliminary Report of Calibration is returned to you. Once the standard is returned to Fluke, it is compared to the Fluke Voltage Standard. A final value is assigned to your reference and a final Report of Calibration is sent to you. (*Note: This service is not available in all areas. Contact your local Fluke representative for details.)*

Specifications

Output voltages

Outputs of 10.0V and 1.018V are provided at separate binding-post pairs with the following characteristics:

Stability

Stability for the 732B is specified by the following at a temperature of Tcal ±1°C (15°C ≤Tcal ±35°C):

	Stability (ppm)		
Output Voltage	30 Days	90 Days	1 Year
10V	0.3	0.8	2.0
1.018V	0.8	NA	NA

Noise at output terminals

Output noise is specified for both day-to-day observations and for short-term observations. The former is given by the standard deviation about the regression line of a 90-day regression model. The latter is terms of its rms value in a bandwidth as follows:

Output Voltage	Day-to-Day (S_1) (ppm)	0.01 Hz-10 Hz (ppm)
10V	0.065	0.06 rms
1.018V	0.1	0.3 rms

Output current and impedance

Output Voltage	Output Current	Output Impedance
10V	12 mA*	≤1 milliohm
1.018V	NA	≤1 kohm

* Output current is limited to ≤0.1 mA to realize 72-hour operation under battery power

Output adjustment

10V: 0.15 ppm resolution
1.018V: Set at nominal ±1 mV
No adjustment is provided, however the output value changes when the 10V output is adjusted

Retrace (hysteresis) error

(Constant temperature)
≤0.1 ppm, 10 minute power off
≤0.25 ppm, 1 to 24 hours power off

Stabilization time

(Constant temperature)
For best results, allow a 14-day stabilization period after power has been off for an extended period of time
No power interruption
No stabilization time is required after moving into another environment
Power off <1 hour
1-hour warm up required
Power off 1 to 24 hours
24-hour warm up required

Temperature coefficient (TC) of output

In the temperature range of 15°C to 35°C, the magnitude of TC is bounded by the following:
10V TC ≤0.04 ppm/°C
1.018V TC ≤0.1 ppm/°C

Load regulation

10V output will change less than 1 ppm for a full load change from 0 to 12 mA and less than 0.1 ppm for a load change from 0 to 2 mA

Line regulation

The outputs will change no more than 0.05 ppm for any 10% line voltage change or for the entire operating range of the battery

Output protection

All outputs can be shorted indefinitely without damage to the instrument. The 10V output can withstand voltages from other sources as follows:

1. For voltages ≤220V dc, the unit is protected for up to 50 mA continuous current
2. For voltage ≤1100V dc, the unit is protected for up to 25 mA continuous current or up to 0.6 joules of energy

Environment

	Temp Range (°C)	Relative Humidity (%)	Altitude (feet)
Normal Operation	15-35	15-80	0-6,000
Safe Operation	0-50	15-90	0-10,000
Storage (no batt)	-40-50	non-cond	0-40,000

Compliance with external standards

ANSI ISA-S2
CSA C22.2 #231
IEC 348
IEC 1010
UL 1244

Line power requirements

Voltage	Frequency
90–132V ac	47–63 Hz
180–264V ac	47–63 Hz

Battery operation

When fully charged, the batteries will maintain the 732B for a minimum of 72 hours at 23°C ±5°C, with an output current <0.1 mA.

The batteries are rechargeable in less than 24 hours with a self-contained battery charger.

A rear-panel input has been provided to accept an external 12V battery or equivalent 12V to 15V dc power source.

Isolation

The resistance from any 732B output terminal to earth ground or to the ac mains is at least 10,000 MΩ shunted by less than 1000 pF.

Guard and grounding

Chassis ground terminals are provided on both front and rear panels. Access to the internal guard is provided by a front-panel terminal.

Bibliography of technical references

Emery, Kletke and Voorheis, *A New Approach to Specifying a DC Reference Standard,* Proceedings of the 1992 Measurement Science Conference.

Field, *NBS Technical Note 1239: Solid-State Voltage Standard Performance and Design Guidelines,* Electricity Division, Center for Basic Standards, National Measurement Laboratory, National Bureau of Standards, September, 1987.

Huntley, *A Primary Standard of Voltage Maintained in Solid-State References,* IEEE Transactions on Instrumentation and Measurement, Vol. 1M-36, No. 4, December 1987.

Fluke Corporation, *Technical Information: Fractional PPM Traceability Using Your 732A,* Application Note B0196A, January, 1990.

National Conference of Standards Laboratories, *Array Josephson Junction, Recommended Intrinsic/ Derived Standards Practice,* RISP-1, August, 1991.

Mechanical

	732B	734A
Height	5.3 inches (13.5 cm)	7.5 inches (19.1 cm) with feet 7.0 inches (17.8 cm) without feet
Width	3.9 inches (9.9 cm)	17.0 inches (43.2 cm)
Depth	16.5 inches (41.9 cm)	19.75 inches (50.2 cm)
Weight	13 lb (5.9 kg)	65 lb (29.6 kg)

Explanation of stability verification

Stability for a given period of time is defined as the output uncertainty minus the calibration uncertainty at the 99% confidence level. When the output voltage is characterized by a regression model, stability is given by the following equation:

$$\left| b\left(\frac{P}{365}\right) \right| + S_1 t_1 \sqrt{\left[\frac{S_{ra}\, t_2}{S_1\, t_1}\right]^2 + \left(\frac{1}{n}\right) + \left[\frac{(P-\bar{x})^2}{\Sigma(Xi-\bar{x})^2}\right]}$$

where
- b = slope of regression in ppm/year
- S_1 = standard deviation about the regression (SDEV)
- S_{ra} = SDEV – of data filtered with 7-day moving average filter (MAF)
- P = period of time under consideration in days
- $\bar{x}$ = mean time for regression data
- n = 180 periods (typically 2 measurements per day)
- Xi = ith period
- t_1 = student's t statistic for (n–2) degrees of freedom (typically 2.6)
- t_2 = student's t statistic for $\left[\left(\frac{n}{7}\right) - 2\right]$ degree of freedom (typically 2.81)

Each data point for the computation of the regression parameters is the average voltage of 50 readings taken in a 50-second measurement period.

Ordering information

Models

734A Reference Standard. Includes four 732Bs in a rack-width enclosure. Calibration of each 732B output optional. See Direct Voltage Maintenance Program below.
732B DC Standard. Output calibration optional. See Direct Voltage Maintenance Program below.

Direct Voltage Maintenance Program

732B-000 10V Output Voltage Calibration for one 732B
732B-100 10V Output Voltage Calibration and Drift Rate Characterization for one 732B
732B-200 10V Output Voltage Calibration On Site (U.S. only)
732B-201 Additional 10V Output Voltage Calibration at the same site (U.S. only)

Accessories

734A-7001 Enclosure. Holds up to four 732Bs.
732B-7001 External Battery and Charger
732B-7002 Transit Case. Holds one or two 732Bs or one 732B and one 732B-7001 External Battery and Charger
5440B-7002 Low Thermal EMF Copper Plug-In Cables
Y734A Rack-Mount Kit for 734A or 734A-7001

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