Esame di Stato di abilitazione alla professione di Ingegnere

Sezione A

Settore dell'Informazione

Prova pratica: Classe 32/S

Tema n. 1

I sessione 2009

Il Candidato supponga di agire come consulente di un laboratorio di Taratura accreditato SIT, quindi operante in conformità ai requisiti della norma internazionale ISO-IEC 17025. Il Laboratorio dispone delle apparecchiature campione indicate nelle appendici A, B, C, D, oltre che dei consueti dispositivi di regolazione della tensione di alimentazione e delle grandezze ambientali e degli opportuni dispositivi elettronici ed informatici. I dispositivi, quando necessario ed opportuno, sono collegabili fra loro mediante il BUS IEEE 488-2. Il Laboratorio opera in condizioni di elevata automazione, in modo da minimizzare l'intervento degli operatori specializzati.

Si vuole sottoporre a verifica di taratura un resistore con le caratteristiche indicate nell'Appendice E. L'incertezza di taratura deve essere inferiore a 10 ppm, cioe' a 1 mΩ

Il candidato progetti un procedimento che permetta di eseguire la verifica di taratura del dispositivo indicato, ed in particolare:

1. Individui le principali condizioni operative ed ambientali per poter eseguire correttamente la verifica.
2. Indichi il procedimento di misura suggerito per eseguire la verifica, progettato in modo da utilizzare al meglio le apparecchiature disponibili, ottenere una elevata automazione delle procedure e una minimizzazione degli operatori specializzati impegnati nella prova. Il procedimento dovra'essere descritto in modo da fornire la base per la stesura della corrispondente procedura tecnica.
3. Esegua una stima dell'incertezza di taratura seguendo le linee guida della norma UNI CEI ENV 13005 (Guida all'espressione dell'incertezza di misura), considerando trascurabile il contributo di incertezza dovuto alle caratteristiche del dispositivo in taratura
4. Indichi le informazioni essenziali che devono essere riportate nel certificato di taratura
5. Individui i principali procedimenti *software* che permettono l'esecuzione automatizzata della verifica e di uno di questi e' invitato a presentare il diagramma di flusso dettagliato
6. Indichi passo per passo l'insieme degli atti che l'operatore dovra' eseguire per l'esecuzione della verifica, mettendo in evidenza gli accorgimenti previsti per individuare/evitare sbagli banali e per salvaguardare la sicurezza degli operatori.

Nel caso in cui siano necessari ulteriori dispositivi, se ne indichino le principali caratteristiche in vista di un acquisto da parte del Laboratorio, giustificando la scelta.

...OMISSIS...

Stability

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:

$$\left| b\left(\frac{P}{365}\right) + 2.65S_1 \sqrt{\left[\frac{S_{ra}}{S_1}\right]^2 + \left(\frac{1}{n}\right) + \left[\frac{\left(\bar{x} + P - x_1\right)^2}{\Sigma\left(X_j - \bar{x}\right)^2}\right]} \right|$$

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 regession data

n = 180 period (typically 2 meassurements per day)

Xj = jth period

X_1 = time at beginning of data

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

Stability for the 732B outputs at 23 ±1°C is specified as follows:

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

Noise at the 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 of a 90-day regression model. The latter is in terms of its rms value in a bandwidth as follows:

Output Voltage	**S_1 (± ppm)**	**S_{ra} (± ppm)**	**Noise (0.01 Hz to 10 Hz (± ppm rms)**
10V	0.068	0.05	0.06
1.018V	0.1	NA	0.03

Output Current and Limits

Output Voltage	**Output Current Limit**	**Output Impedance**
10V	12 mA (Note)	≤ 1 mΩ
1.018V	20 pA	≤ 1 kΩ
Note: Limit output current to ≤ 0.1 mA to realize 72 hour battery operation.		

Output Adjustability

- 10V: 0.15 ppm resolution
- 1.018V: Set at nominal ±1 mV. No adjustment is provided.

The 10V adjustment is done with a set of four decade-control switches with a range of at least 4 mV.

Retrace (Hysteresis) Error

The following table shows the change in 10V output voltage following a power outage (with the battery turned off) with temperature held constant in the normal operating range.

Period that Power is Turned Off	Change in 10V Output Value
10 minutes or less	≤ ±0.1 ppm
10 minutes to 24 hours	≤ ±0.25 ppm

Stabilization Time Requirements

The following information specifies the warmup times required after ac line and battery power has been turned off. The IN CAL indicator will be off, and recalibration will be necessary. The previously specified retrace error specification can be used in the case of brief power interruptions.

With no power interruption:	No stabilization time is required after moving into another environment.
Power off for less than 1 hour:	1-hour warmup required
Power off for 1 to 24 hours:	24-hour warmup required

Electromagnetic Compatibility

This instrument is designed to operate in Standards Laboratory environments where the radio frequency (RF) environment is highly controlled. If used in environments with field strengths >0.18 V/m, there could be errors in measurements.

Temperature Coefficient (TC) of Output

In the temperature range of 15°C to 35°C, the magnitude of the TC is bounded by the following:

- 10V Output: TC ≤ 0.04 ppm/°C
- 1.018V Output: TC ≤ 0.1 ppm/°C

Load Regulation

10V Output Load Change	Maximum 10V Output Change
0 mA to 12 mA (no load to full load)	±1 ppm
0 mA to 2 mA	±0.1 ppm

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 for short periods of time.

Environment

	Temperature Range	Relative Humidity	Altitude
Normal Operation	15°C to 35°C	15% to 80%	0 to 6,000 ft
Safe Operation	0°C to 50°C	15% to 90%	0 to 10,000 ft
Storage (With battery removed)	-49°C to 50°C	Noncondensing	0 to 40,000 ft

Compliance to Standards

ANSI/ISA-S82
CSA C22.2 #231
IEC348
IEC 1010
UL 1244

Line Power Requirements

Line voltage is accepted in the two ranges 90 to 132V and 180 to 264V, at 47 to 63 Hz as shown in the table below. AC line current at 120V ac is 0.13A.

732B Line Voltage Setting	Line Voltage Accepted	Frequency Accepted
100V	90 to 110V	47 to 63 Hz
120V	108 to 132V	47 to 63 Hz
220V	180 to 235V	47 to 63 Hz
240V	225 to 264V	47 to 63 Hz

Battery Operation

When fully charged, the internal batteries will operate the 732B for a minimum of 72 hours at 23 ±5°C, with 0 to 0.1 mA current drain at the 10V output. Model 732B-7001 contains the same battery and charger as Model 732B.

APPENDICE B

CAMPIONI DI RESISTENZA

FLUKE 742A

742A Series

RESISTANCE STANDARDS

Instruction Manual

P/N 850255
September 1988 Rev. 1 4/89

FLUKE

INTRODUCTION

The 742A Series are small, light, rugged resistance standards. The standards require no temperature-controlled air or oil bath. The 742A Series are well suited for use as the following:

- Working standards
- Portable transfer standards
- Calibration support for the Fluke 5700A Calibrator

Stability and temperature coefficients of the 742A Series make them ideal for easy transport to and operation in any working environment within the range of 18 to 28°C. The standards come with six-month and one-year uncertainty specifications. Depending on the accuracy required, a 742A can be recertified at intervals based on either specification.

Each 742A comes with a Report of Calibration and a rear panel label showing the measured value. The rear panel also has a Fluke Primary Standards Lab calibration label, labels that show temperature coefficient alpha and beta centered on 23°C, and the standard's serial number.

NOTE

Refer to "How Temperature Correction Factors are Calculated," further on in this manual for definitions of alpha and beta.

SPECIFICATIONS

Table 1 lists specifications for the available 742A Series Resistance Standards.

Table 1. 742A Series Resistance Standard Specifications

MODEL	NOMINAL RESISTANCE AT 23°C	TIME STABILITY STABILITY		CALIBRATION UNCERTAINTY	MAXIMUM DEVIATION FROM THE 23°C VALUE (18 TO 28°C)	MAXIMUM CURRENT (VOLTAGE)	+1 PPM ERROR ADDER WHEN CURRENT EXCEEDS THE FOLLOWING
		180 DAY	1 YEAR				
742A-1	1Ω	±5.0 ppm	±8.0 ppm	±1.0 ppm	3.0 ppm	500 mA (500 mV)	200 mA
742A-1.9	1.9Ω	±5.0 ppm	±8.0 ppm	±1.0 ppm	3.0 ppm	200 mA (380 mV)	100 mA
742A-10	10Ω	±5.0 ppm	±8.0 ppm	±1.0 ppm	3.0 ppm	100 mA (1V)	20 mA
742A-100	100Ω	±4.0 ppm	±6.0 ppm	±1.0 ppm	3.0 ppm	20 mA (2V)	5 mA
742A-1k	1 kΩ	±4.0 ppm	±6.0 ppm	±1.5 ppm	2.0 ppm	10 mA (10V)	2 mA
742A-10k	10 kΩ	±2.5 ppm	±4.0 ppm	±1.0 ppm	1.5 ppm	3 mA (30V)	600 μA
742A-19k	19 kΩ	±2.5 ppm	±4.0 ppm	±1.5 ppm	2.0 ppm	1.5 mA (28.5V)	600 μA
742A-100k	100 kΩ	±4.0 ppm	±6.0 ppm	±2.5 ppm	2.0 ppm	1 mA (100V)	400 μA
742A-1M	1 MΩ	±6.0 ppm	±8.0 ppm	±5.0 ppm	2.0 ppm	100 μA (100V)	100 μA
742A-10M	10 MΩ	±6.0 ppm	±9.0 ppm	±10.0 ppm	3.0 ppm	20 μA (200V)	20 μA
742A-19M	19 MΩ	±8.0 ppm	±10.0 ppm	±20.0 ppm	4.0 ppm	10 μA (190V)	10 μA

GENERAL SPECIFICATIONS:

Accuracy: The initial resistance is trimmed to ± 2 ppm of nominal. The measured value is printed on the rear panel.

Retrace Error (Hysteresis): 23°C-18°C-23°C cycle: Negligible resistance shift
23°C-28°C-23°C cycle: Negligible resistance shift
23°C-0°C-23°C cycle: <2 ppm resistance shift
23°C-40°C-23°C cycle: <2 ppm resistance shift

Operating Temperature Range: 23 ±5°C

Storage Temperature Range: 0 to 40°C

Report of Calibration: The report of calibration includes a table of resistance values in 0.5° increments from 18 to 28°C.

Size: 8.6 cm H x 10.5 cm W x 12.7 cm L (including binding posts)
(3.4 in H x 4.15 in W x 5 in L (including binding posts))
Binding posts; 2.5 cm (1.0 in)

Weight: 0.68 to 0.91 kg (1.5 to 2.0 lbs), depending on model

DESIGN AND CONSTRUCTION NOTES

The 742A Series are constructed of arrays of Fluke wirewound precision hermetically-sealed resistors. No adjustable resistors of any kind are used.

Each 742A is built with a temperature coefficient near zero at 23° C. To further reduce errors caused by temperature changes, the binding posts are constructed of low-thermal emf material.

FEATURES

Figure 1 shows a front panel view. Table 2 describes binding post functions.

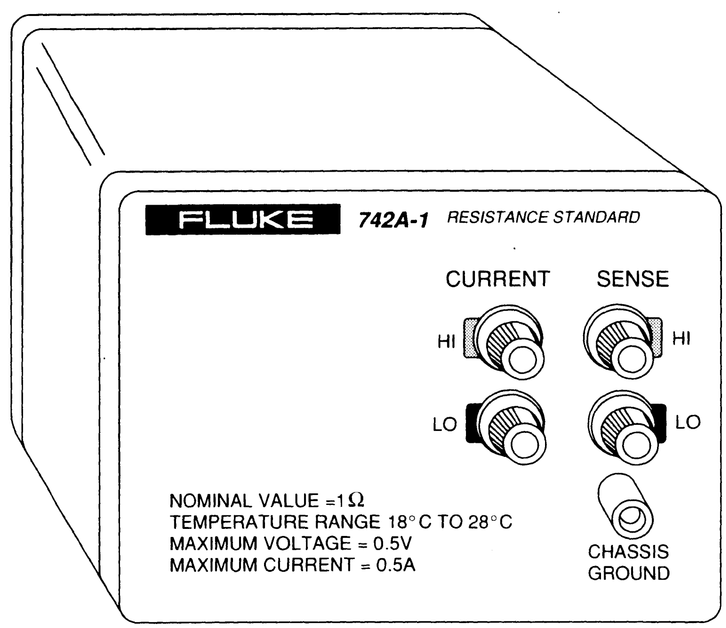


Figure 1. Typical Front Panel View

Table 2. Functions of the Binding Posts

742A BINDING POST	FUNCTION
CURRENT HI	Input for the current source from an ohmmeter
CURRENT LO	Input for the current source from an ohmmeter
SENSE HI	Measurement point for a four-wire ohmmeter
SENSE LO	Measurement point for a four-wire ohmmeter
CHASSIS GROUND	Connected to the case for shielding

Appendix A Specifications

Introduction

The 3458A accuracy is specified as a part per million (ppm) of the reading plus a ppm of range for dcV, Ohms, and dcl. In acV and acl, the specification is percent of reading plus percent of range. Range means the name of the scale, e.g. 1 V, 10 V, etc.; range does not mean the full scale reading, e.g. 1.2 V, 12 V, etc. These accuracies are valid for a specific time from the last calibration.

Absolute versus Relative Accuracy

All 3458A accuracy specifications are relative to the calibration standards. Absolute accuracy of the 3458A is determined by adding these relative accuracies to the traceability of your calibration standard. For dcV, 2 ppm is the traceability error from the Agilent factory. That means that the absolute error relative to the U.S. National Institute of Standards and Technology (NIST) is 2 ppm in addition to the dcV accuracy specifications. When you recalibrate the 3458A, your actual traceability error will depend upon the errors from your calibration standards. These errors will likely be different from the Agilent error of 2 ppm.

Example 1: Relative Accuracy; 24 Hour Operating temperature is Tcal ± 1°C

Assume that the ambient temperature for the measurement is within ± 1°C of the temperature of calibration (Tcal). The 24 hour accuracy specification for a 10 V dc measurement on the 10 V range is 0.5 ppm ± 0.05 ppm. That accuracy specification means:

0.5 ppm of Reading + 0.05 ppm of Range

For relative accuracy, the error associated with the measurement is:

(0.5/1,000,000 x 10 V) + (0.05/1,000,000 x 10 V) = ± 5.5 µV or 0.55 ppm of 10 V

Errors from temperature changes

The optimum technical specifications of the 3458A are based on auto-calibration (ACAL) of the instrument within the previous 24 hours and following ambient temperature changes of less than ±1°C. The 3458A's ACAL capability corrects for measurement errors resulting from the drift of critical components from time and temperature.

The following examples illustrate the error correction of auto-calibration by computing the relative measurement error of the 3458A for various temperature conditions. Constant conditions for each example are:

10 V DC input
10 V DC range
Tcal = 23°C
90 day accuracy specifications

Example 2: Operating temperature is 28°C;

With ACAL

This example shows basic accuracy of the 3458A using auto-calibration with an operating temperature of 28°C. Results are rounded to 2 digits.

(4.1 ppm x 10 V) + (0.05 ppm x 10 V) = 42 µV

Total relative error = 42 µV

Example 3: Operating temperature is 38°C;

Without ACAL

The operating temperature of the 3458A is 38°C, 14°C beyond the range of Tcal ±1°C. Additional measurement errors result because of the added temperature coefficient without using ACAL.

(4.1 ppm x 10 V) + (0.05 ppm x 10 V) = 42 µV

Temperature Coefficient (specification is per °C):

(0.5ppm x 10V + 0.01 ppm x 10V) x 14°C = 71 µV

Total error = 113 µV

Example 4: Operating temperature is 38°C;

With ACAL

Assuming the same conditions as Example 3, but using ACAL significantly reduces the error due to temperature difference from calibration temperature. Operating temperature is 10°C beyond the standard range of Tcal ±5°C.

(4.1 ppm x 10 V) + (0.05 ppm x 10 V) = 42 µV

Temperature Coefficient (specification is per °C):

(0.15ppm x 10V + 0.01ppm x 10V) x 10°C = 16µV

Total error = 58 µV

Example 5: Absolute Accuracy; 90 Day

Assuming the same conditions as Example 4, but now add the traceability error to establish absolute accuracy.

(4.1 ppm x 10 V) + (0.05 ppm x 10 V) = 42 µV

Temperature Coefficient (specification is per °C):

(0.15ppm x 10V + 0.01ppm x 10V) x 10°C = 16µV

Agilent factory traceability error of 2 ppm:

(2 ppm x 10 V) = 20 µV

Total absolute error = 78 µV

Additional errors

When the 3458A is operated at power line cycles below 100, additional errors due to noise and gain become significant. Example 6 illustrates the error correction at 0.1 PLC.

Example 6: operating temperature is 28×C; 0.1 PLC

Assuming the same conditions as Example 2, but now add additional error.

(4.1 ppm x 10 V) t (0.05 ppm x 10 V) = 42 µV

Referring to the Additional Errors chart and RMS Noise Multiplier table, additional error at 0.1 PLC is:

(2 ppm x 10 V) + (0.4 ppm x 1 x 3 x 10 V) = 32 µV

Total relative error = 74 µV

1 / DC Voltage

DC Voltage

Range	Full Scale	Maximum Resolution	Input Impedance	Temperature Coefficient (ppm of Reading + ppm of Range) /º C	
				Without ACAL[1]	With ACAL[2]
100 mV	120.00000	10 nV	>10 GΩ	1.2 + 1	0.15 + 1
1 V	1.20000000	10 nV	>10 GΩ	1.2 + 0.1	0.15 + 0.1
10 V	12.0000000	100 nV	>10 GΩ	0.5 + 0.01	0.15 + 0.01
100 V	120.000000	1 µV	10 MΩ ± 1%	2 + 0.4	0.15 + 0.1
1000 V	1050.00000	10 µV	10 MΩ ± 1%	2 + 0.04	0.15 + 0.01

Accuracy[3] (ppm of Reading (ppm of Reading for Option 002) + ppm of Range)

Range	24 Hour [4]	90 Day [5]	1 Year [5]	2 Year [5]
100 mV	2.5 + 3	5.0 (3.5)+ 3	9 (5)+ 3	14 (10)+ 3
1 V	1.5 + 0.3	4.6 (3.1)+0.3	8 (4)+ 0.3	14 (10)+0.3
10 V	0.5 + 0.05	4.1 (2.6) + 0.05	8 (4) + 0.05	14 (10)+0.05
100 V	2.5 + 0.3	6.0 (4.5) + 0.3	10 (6)+0.3	14 (10)+ 0.3
1000 V[6]	2.5 + 0.1	6.0 (4.5)+ 0.1	10 (6)+ 0.1	14 (10)+ 0.1

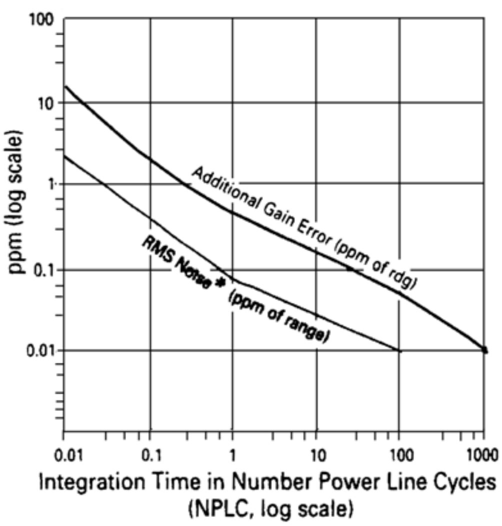
Transfer Accuracy/Linearity

Range	10 Min, Tref ± 0.5ºC (ppm of Reading + ppm of Range)	Conditions
100 mV	0.5 + 0.5	• Following 4 hour warm-up. Full scale to 10% of full scale • Measurements on the 1000 V range are within 5% of the initial meausurement value and following measurement setting. • Tref is the starting ambient temperature. • Measurements are made on a fixed range (>4 min.) using accepted metrology practices
1 V	0.3 + 0.1	
10 V	0.05 + 0.05	
100 V	0.5 + 0.1	
1000 V	1.5+0.05	

Settling Characteristics

For first reading or range change error, add 0.0001% of input voltage step additional error.
Reading settling times are affected by source impedance and cable dielectric absorption characteristics.

Additional Errors



Noise Rejection (dB) [7]

	AC NMR [8]	AC ECMR	DC ECMR
NPLC<1	0	90	140
NPLC>1	60	150	140
NPLC > 10	60	150	140
NPLC > 100	60	160	140
NPLC = 1000	75	170	140

*RMS Noise

Range	Multiplier
0.1V	x20
1 V	x2
10 V	x1
100 V	x2
1000 V	x1

For RMS noise error, multiply RMS noise result from graph by multiplier in chart. For peak noise error. multiply RMS noise error by 3.

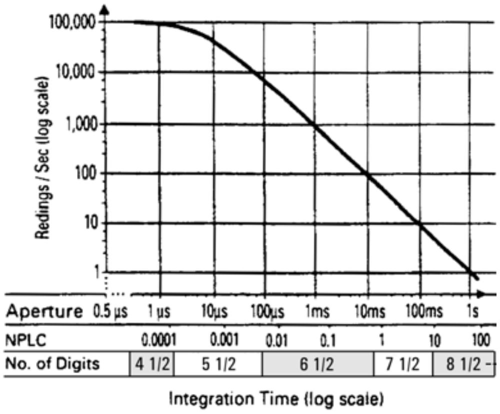
1. Additional error from Tcal or last ACAL ± 1 º C.
2. Additional error from Tcal ±5º C
3. Specifications are for PRESET, NPLC 100.
4. For fixed range (> 4 min.), MATH NULL and Tcal ±1ºC.
5. Specifications for 90 day, 1 year and 2 year are within 24 hours and ±1º C of last ACAL; Tcal ±5ºC, MATH NULL and fixed range.

   ppm of Reading specifications for High Stability (Option 002) are in parentheses.

   Without MATH NULL, add 0.15 ppm of Range to 10 V, 0.7 ppm of Range to 1 V, and 7 ppm of Range to 0.1 V. Without math null and for fixed range less than 4 minutes, add 0.25 ppm of Range to 10 V, 1.7 ppm of Range to 1 V and 17 ppm of Range to 0.1 V.

   Add 2 ppm of reading additional error for Agilent factory traceability to US NIST. Traceability error is the absolute error relative to National Standards associated with the source of last external calibration.
6. Add 12 ppm X $(Vin/1000)^2$ additional error for inputs > 100 V.
7. Applies for 1 kΩ unbalance in the LO lead and ± 0.1% of the line frequency currently set for LFREQ.
8. For line frequency ± 1%, ACNMR is 40 dB for NPLC ≥ 1, or 55 dB for NPLC ≥ 100. For line frequency ± 5%, ACNMR is 30 dB for NPLC ≥ 100.

Reading Rate (Auto-Zero Off)



Temperature Coefficient (Auto-Zero off)

For a stable environment ±1°C add the following additional error for AZERO OFF

Range	Error
100 mV–10 V	5 µV/°C
100 V–1000 V	500 µV/°C

Selected Reading Rates [1]

NPLC	Aperture	Digits	Bits	Readings / Sec A-Zero Off	Readings / Sec A-Zero On
0.0001	1.4 µs	4.5	16	100,000 [3]	4,130
0.0006	10 µs	5.5	18	50,000	3,150
0.01	167 µs[2]	6.5	21	5,300	930
0.1	1.67 ms[2]	6.5	21	592	245
1	16.6 ms[2]	7.5	25	60	29.4
10	0.166 s[2]	8.5	28	6	3
100		8.5	28	36/min	18/min
1000		8.5	28	3.6/min	1.8/min

Maximum Input

	Rated Input	Non-Destructive
HI to LO	±1000 V pk	±1200 V pk
LO to Guard[4]	±200 V pk	±350 V pk
Guard to Earth[5]	±500 V pk	±1000 V pk

Input Terminals

Terminal Material: Gold-plated Tellurium Copper
Input Leakage Current:<20pA at 25°C

1. For PRESET; DELAY 0; DISP OFF; OFORMAT DINT; ARANGE OFF.
2. Aperture is selected independent of line frequency (LFREQ). These apertures are for 60 Hz NPLC values where 1 NPLC = 1/LFREQ. For 50 Hz and NPLC indicated, aperture will increase by 1.2 and reading rates will decrease by 0.833
3. For OFORMAT SINT
4. > 10^{10} Ω LO to Guard with guard open.
5. > 10^{12} Ω Guard to Earth.

2 / Resistance

Two-wire and Four-wire Ohms (OHM and OHMF Functions)

Range	Full Scale	Maximum Resolution	Current Source[6]	Test Voltage	Open Circuit	Maximum Lead Resistance (OHMF)	Maximum Series Offset (OCOMP ON)	Temperature Coefficient (ppm of Reading + ppm of Range) / °C Without ACAL[7]	With ACAL[8]
10 Ω	12.00000	10 µΩ	10 mA	0.1 V	12 V	20 Ω	0.01 V	3+1	1+1
100 Ω	120.00000	10 µΩ	1 mA	0.1 V	12 V	200 Ω	0.01 V	3+1	1+1
1 kΩ	1.2000000	100 µΩ	1 mA	1.0 V	12 V	150 Ω	0.1 V	3+0.1	1+0.1
10 kΩ	12.000000	1 mΩ	100 µA	1.0 V	12 V	1.5 kΩ	0.1 V	3+0.1	1+0.1
100 kΩ	120.00000	10 mΩ	50 µA	5.0 V	12 V	1.5 kΩ	0.5 V	3+0.1	1+0.1
1 MΩ	1.2000000	100 mΩ	5 µA	5.0 V	12 V	1.5 kΩ		3+1	1+1
10 MΩ	12.000000	1 Ω	500 nA	5.0 V	12 V	1.5 kΩ		20+20	5+2
100 MΩ[9]	120.00000	10 Ω	500 nA	5.0 V	5 V	1.5 kΩ		100+20	25+2
1 GΩ[7]	1.2000000	100 Ω	500 nA	5.0 V	5 V	1.5 kΩ		1000+20	250+2

6. Current source is ± 3% absolute accuracy.
7. Additional error from Tcal or last ACAL ± 1° C.
8. Additional error from Tcal ± 5° C.
9. Measurement is computed from 10 M Ω in parallel with input

2 Accuracy[1] (ppm of Reading + ppm of Range)

Range	24 Hour [2]	90 Day[3]	1 Year[3]	2 Year[3]
10 Ω	5+3	15+5	15+5	20+10
100 Ω	3+3	10+5	12+5	20+10
1 kΩ	2+0.2	8+0.5	10+0.5	15+1
10 kΩ	2+0.2	8+0.5	10+0.5	15+1
100 kΩ	2+0.2	8+0.5	10+0.5	15+1
1 MΩ	10+1	12+2	15+2	20+4
10 MΩ	50+5	50+10	50+10	75+10
100 MΩ	500+10	500+10	500+10	0.1%+10
1 GΩ	0.5%+10	0.5%+10	0.5%+10	1%+10

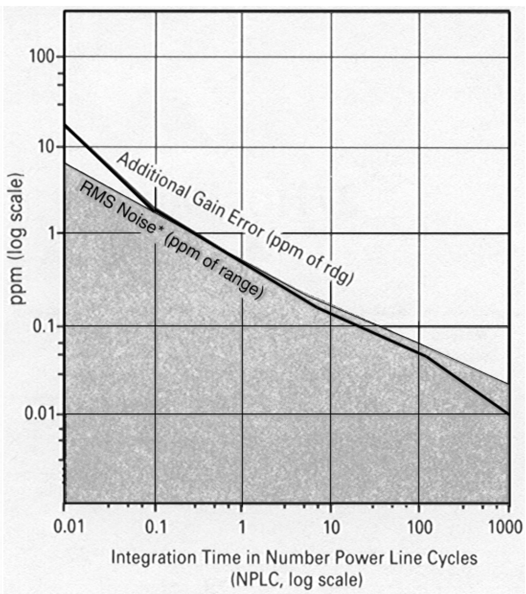
1. Specifications are for PRESET; NPLC 100; OCOMP ON; OHMF.
2. Tcal ± 1°C.
3. Specifications for 90 day, 1 year, and 2 year are within 24 hours and ± 1°C of last ACAL; Tcal ±5°C.

   Add 3 ppm of reading additional error for Agilent factory traceability of 10 KΩ to US NIST. Traceability is the absolute error relative to National Standards associated wifh the source of last external calibration.

Two-Wire Ohms Accuracy

For Two-Wire Ohms (OHM) accuracy, add the following offset errors to the Four-Wire Ohms (OHMF) accuracy. 24 Hour: 50 mΩ. 90 Day: 150 mΩ. 1 Year: 250 mΩ. 2 Year: 500 mΩ

Additional Errors



*RMS Noise	
Range	**Multiplier**
10 Ω & 100 Ω	×10
1k Ω to 100 kΩ	×1
1 MΩ	×1.5
10 MΩ	×2
100 MΩ	×120
1 GΩ	×1200

For RMS noise error, multiply RMS noise result from graph by multiplier in chart. For peak noise error, multiply RMS noise error by 3.

Settling Characteristics

For first reading error following range change, add the total 90 day measurement error for the current range. Preprogrammed settling delay times are for < 200 pF external circuit capacitance.

Selected Reading Rates [4]

			Readings/Sec	
NPLC [5]	**Aperture**	**Digits**	**Auto-Zero Off**	**Auto-Zero On**
0.0001	1.4 µs	4.5	100,000 [7]	4,130
0.0006	10 µs	5.5	50,000	3,150
0.01	167 µs[6]	6.5	5,300	930
0.1	1.66 ms[6]	6.5	592	245
1	16.6 ms[6]	7.5	60	29.4
10	0.166 s[6]	7.5	6	3
100		7.5	36 /min	18/min

4. For PRESET; DELAY 0; DISP OFF; OFORMAT DINT; ARANGE OFF.

   For OHMF or OCOMP ON, the maximum reading rates will be slower.
5. Ohms measurements at rates < NPLC 1 are subject to potential noise pickup. Care must be taken to provide adequate shielding and guarding to maintain measurement accuracies.
6. Aperture is selected independent of line frequency (LFREQ). These apertures are for 60 Hz NPLC values where 1 NPLC=1/ LFREQ. For 50 Hz and NPLC indicated, aperture will increase by 1.2 and reading rates will decrease by 0.833.
7. For OFORMAT SINT

*Teflon is a registered trademark of E. I. duPont deNemours and Co.

Measurement Consideration

Agilent recommends the use of Teflon* cable or other high impedance, low dielectric absorption cable for these measurements.

Maximum Input

	Rated Input	Non-Destructive
HI to LO	± 1000 V pk	± 1000 V pk
HI & LO Sense to LO	± 200 V pk	± 350 V pk
LO to Guard	± 200 V pk	± 350 V pk
Guard to Earth	± 500 V pk	± 1000 V pk

Temperature Coefficient (Auto-Zero off)

For a stable environment ± 1°C add the following error for AZERO OFF. (ppm of Range) /°C

Range	Error
10 Ω	50
100 Ω	50
1 kΩ	5
10 kΩ	5
100 kΩ	1

Range	Error
1 MΩ	1
10 MΩ	1
100 MΩ	10
1 GΩ	100

3 / DC Current

DC Current (DCI Function)

Range	Full Scale	Maximum Resolution	Shunt Resistance	Burden Voltage	Temperature Coefficient (ppm of Reading + ppm of Range) / °C	
					Without ACAL[1]	With ACAL[2]
100 nA	120.000	1 pA	545.2 kΩ	0.055 V	10+200	2+50
1 µA	1.200000	1 pA	45.2 kΩ	0.045 V	2+20	2+5
10 µA	12.000000	1 pA	5.2 kΩ	0.055 V	10+4	2+1
100 µA	120.00000	10 pA	730 Ω	0.075 V	10+3	2+1
1 mA	1.2000000	100 pA	100 Ω	0.100 V	10+2	2+1
10 mA	12.000000	1 nA	10 Ω	0.100 V	10+2	2+1
100 mA	120.00000	10 nA	1 Ω	0.250 V	25+2	2+1
1 A	1.0500000	100 nA	0.1 Ω	<1.5 V	25+3	2+2

Accuracy [3] (ppm Reading + ppm Range)

Range	24 Hour [4]	90 Day [5]	1 Year[5]	2 Year [5]
100 nA[6]	10+400	30+400	30+400	35+400
1 µA[6]	10+40	15+40	20+40	25+40
10 µA[6]	10+7	15+10	20+10	25+10
100 µA	10+6	15+8	20+8	25+8
1 mA	10+4	15+5	20+5	25+5
10 mA	10+4	15+5	20+5	25+5
100 mA	25+4	30+5	35+5	40+5
1 A	100+10	100+10	110+10	115+10

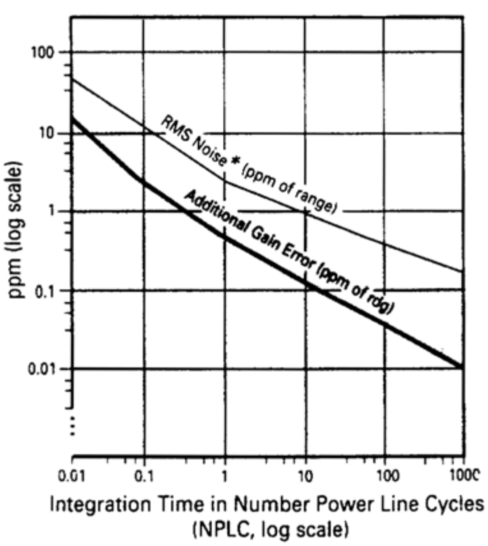
1. Additional error from Tcal or last ACAL±1°C.
2. Additional error from Tcal± 5°C.
3. Specifications are for PRESET; NPLC 100.
4. Tcal± 1°C.
5. Specifications for 90 day, 1 year, and 2 year are within 24 hours and ±1°C of last ACAL; Tcal±5°C

   Add 5 ppm of reading additional error for Agilent factory traceability to US NIST. Traceability error is the sum of the 10 V and 10 kΩ traceability values.
6. Typical accuracy.

Settling Characteristics

For first reading or range change error, add .001% of input current step additional error. Reading settling times can be affected by source impedance and cable dielectric absorption characteristics.

Additional Errors



*RMS Noise	
Range	**Multiplier**
100 nA	×100
1 µA	×10
10 µA to 1A	×1

For RMS noise error, multiply RMS noise result from graph by multiplier in chart. For peak noise error, multiply RMS noise error by 3.

Measurement Considerations

Agilent recommends the use of Teflon cable or other high impedance, low dielectric absorption cable for low current measurements. Current measurements at rates <NPLC 1 are subject to potential noise pickup. Care must be taken to provide adequate shielding and guarding to maintain measurement accuracies

Selected Reading Rates [7]

NPLC	Aperture	Digits	Readings / Sec
0.0001	1.4 µs	4.5	2,300
0.0006	10 µs	5.5	1,350
0.01	167 µs[8]	6.5	157
0.1	1.67 ms[8]	6.5	108
1	16.6 ms [8]	7.5	26
10	0.166 s[8]	7.5	3
100		7.5	18/min

7. For PRESET; DELAY 0; DISP OFF; OFORMAT DINT; ARANGE OFF.
8. Aperture is selected independent of line frequency (LFREQ). These apertures are for 60 Hz NPLC values where 1 NPLC = 1/ LFREQ. For 50 Hz and NPLC Indicated, aperture will increase by 1.2 and reading rates will decrease by 0.833.

Maximum Input

	Rated Input	Non-Destructive
I to LO	±1.5 A pk	<1.25 A rms
LO to Guard	±200 V pk	±350 V pk
Guard to Earth	±500 V pk	±1000 V pk

11 / General Specifications

Operating Environment
Temperature Range: 0°C to 55°C
Operating Location: Indoor Use Only
Operating Altitude: Up to 2,000 Meters
Pollution Rating: IEC 664 Degree 2

Operating Humidity Range
up to 95% RH at 40°C

Physical Characteristics
88.9 mm H x 425.5 mm W x 502.9 mm D
Net Weight: 12 kg (26.5 lbs)
Shipping Weight 14.8 kg (32.5 lbs)

Storage Temperature
–40°C to + 75°C

Warm-Up Time
4 Hours to published specifications

Power Requirements
100/120 V, 220/240 V ±10%
48–66Hz, 360–420Hz (auto sensed)
<30 W, <80 VA (peak)
Fused: 1.5 @ 115 V or 0.5 A @230 V

Cleaning Guidelines
To clean the instrument, use a clean cloth slightly dampened with water.

Warranty Period
One year

Input Terminals
Gold-plated Tellurium Copper

Input Limits
Input HI to LO: 300 Vac Max (CAT II)

IEEE-488 Interface
Complies with the following:
IEEE-488.1 Interface Standard
IEEE-728 Codes/Formats Standard
CIIL (Option 700)

Included with Agilent 3458A:
Test Lead Set (Agilent 34118A)
Power Cord
User's Guide
Calibration Manual
Assembly Level Repair Manual
Quick Reference Guide

Field Installation Kits		Agilent Part Number
Option 001	Extended Reading Memory	03458-87901
Option 002	High Stability Reference	03458-80002
Extra Keyboard Overlays (5 each)		03458-84303

Available Documentation	Agilent Part Number
Product Note 3458A-1: Optimizing Throughput and Reading Rate	5953-7058
Product Note 3458A-2: High Resolution Digitizing with the 3458A	5953-7059
Product Note 3458A-3: Electronic Calibration of the 3458A	5953-7060
Extra Manual Set	03458-90000

APPENDICE D

CALIBRATORE

FLUKE 5720A

1-23. Specifications

The 5700A/5720A Series II Calibrators are verified and calibrated at the factory prior to shipment to ensure they meet the accuracy standards required for all certified calibration laboratories. By calibrating to the specifications in this chapter, you can maintain the high performance level throughout the life of your calibrator.

Specifications are valid after a warm-up period of twice the time the calibrator has been turned off, up to a maximum of 30 minutes. For example, if the calibrator has been turned off for five minutes, the warm-up period is ten minutes.

1-24. Specification Confidence Levels

You calibrator's performance level is ensured by regular calibration to the primary performance specifications, which are provided at both the 99 % and 95 % confidence levels. The 95 % confidence level will provide an accuracy that will often surpass the accuracy requirements for meeting Tag 4 standards, or a coverage factor of 2. Calibration at the 99 % confidence level is also available for those applications that require a confidence factor for the specifications that is higher than 95 %. For information on selecting the confidence level, refer to Chapter 4.

The tables in this chapter provide specifications at both the 95 % and 99 % confidence levels for the 5700A/5720A Series II Calibrators. Included with these tables are operating specifications for using the calibrator with the Wideband AC Module (Option 5700A-03) and the 5725A Amplifier.

1-25. Using Absolute and Relative Uncertainty Specifications

To evaluate the 5700A/5720A Series II coverage of your calibration workload, use the Absolute Uncertainty specifications. Absolute uncertainty includes stability, temperature coefficient, linearity, line and load regulation, and the traceability to external standards. You do not need to add anything to absolute uncertainty to determine the ratios between the calibrator's uncertainties and the uncertainties of your calibration workload.

Relative uncertainty specifications are provided for enhanced accuracy applications. These specifications apply when range constants are adjusted (see "Range Calibration"). To calculate absolute uncertainty, you must combine the uncertainties of your external standards and techniques with relative uncertainty.

1-26. Using Secondary Performance Specifications

Secondary performance specifications and operating characteristics are included in uncertainty specifications. They are provided for special calibration requirements such as stability or linearity testing.

1-27. General Specifications

Warm-Up Time	Twice the time since last warmed up, to a maximum of 30 minutes.
System Installation	Rear output configuration and rack- mount kit available.
Standard Interfaces	IEEE-488, RS-232, 5725A, 5205A or 5215A, 5220A, phase lock in (BNC), phase reference out (BNC).
Temperature Performance	
Operating	0 °C to 50 °C
Calibration	15 °C to 35 °C
Storage	-40 °C to 75 °C
Relative Humidity	
Operating	<80 % to 30 °C, <70 % to 40 °C, <40 % to 50 °C
Storage	<95 %, non-condensing. A power stabilization period of four days may be required after extended storage at high temperature and humidity.
Safety	Designed to comply with UL3111; EN61010; CSA C22.2 No. 1010; ANSI/ISA S82.01-1994
Guard Isolation	20 V
EMI/RFI	Designed to comply with FCC Rules Part 15, Subpart B, Class B; EN50081-1, EN50082-1
ElectroStatic Discharge	This instrument meets criteria C for ESD requirements per EN61326
Line Power	
Line Frequency	47 to 63 Hz; ±10 % 100 V, 110 V, 115 V, 120 V, 200 V, 220 V, 230 V, 240 V
Maximum Power	
5700A/5720A	300 VA
5725A	750 VA
Weight	
5700A/5720A	27kg (62 lbs)
5725A	32kg (70 lbs)
Size	
5700A/5720A	
Height	17.8 cm (7 in), standard rack increment, plus 1.5 cm (0.6 in) for feet
Width	43.2 cm (17 in), standard rack width
Depth	63.0 cm (24.8 in), overall; 57.8 cm (22.7 in), rack depth
5725A	
Height	13.3 cm, (5.25 in)
Width and Depth	Same as 5700A/5720A. Both units project 5.1 cm, (2 in) from rack front.

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1-28. Electrical Specifications

Note

Fluke guarantees performance verification using specifications stated to 99% confidence level.

1-29. DC Voltage Specifications

5720A Series II DC Voltage Specifications

Range	Resolution	Absolute Uncertainty ± 5 °C from calibration temperature [1]				Relative Uncertainty ± 1 °C	
		24 Hours	90 Days	180 Days	1 Year	24 Hours	90 Days
		± (ppm output + μV)					
99 % Confidence Level							
220 mV	10 nV	5 + 0.5	7 + 0.5	8 + 0.5	9 + 0.5	2 + 0.4	2.5 + 0.4
2.2 V	100 nV	3.5 + 0.8	4 + 0.8	4.5 + 0.8	6 + 0.8	2 + 0.8	2.5 + 0.8
11 V	1 μV	2.5 + 3	3 + 3	3.5 + 3	4 + 3	1 + 3	1.5 + 3
22 V	1 μV	2.5 + 5	3 + 5	3.5 + 5	4 + 5	1 + 5	1.5 + 5
220 V	10 μV	3.5 + 50	4 + 50	5 + 50	6 + 50	2 + 50	2.5 + 50
1100 V	100 μV	5 + 500	6 + 500	7 + 500	8 + 500	2.5 + 400	3 + 400
95 % Confidence Level							
220 mV	10 nV	4 + 0.4	6 + 0.4	6.5 + 0.4	7.5 + 0.4	1.6 + 0.4	2 + 0.4
2.2 V	100 nV	3 + 0.7	3.5 + 0.7	4 + 0.7	5 + 0.7	1.6 + 0.7	2 + 0.7
11 V	1 μV	2 + 2.5	2.5 + 2.5	3 + 2.5	3.5 + 2.5	0.8 + 2.5	1.2 + 2.5
22 V	1 μV	2 + 4	2.5 + 4	3 + 4	3.5 + 4	0.8 + 4	1.2 + 4
220 V	10 μV	3 + 40	3.5 + 40	4 + 40	5 + 40	1.6 + 40	2 + 40
1100 V	100 μV	4 + 400	4.5 + 400	6 + 400	6.5 + 400	2 + 400	2.4 + 400

Notes:

DC Zeros calibration required every 30 days.

1. For fields strengths >1 V/m but ≤3 V/m, add 0.01 % of range.

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DC Voltage Secondary Performance Specifications and Operating Characteristics

Range	Stability [1] ± 1 °C 24 Hours	Temperature Coefficient Adder [2]		Linearity ± 1 °C	Noise	
		10 - 40 °C	0 - 10 °C and 40 - 50 °C		Bandwidth 0.1-10 Hz pk-pk	Bandwidth 10 Hz-10 kHz RMS
	± (ppm output + μV)	± (ppm output + μV) / °C		± (ppm output + μV)		μV
220 mV	0.3 + 0.3	0.4 + 0.1	1.5 + 0.5	1 + 0.2	0.15 + 0.1	5
2.2 V	0.3 + 1	0.3 + 0.1	1.5 + 2	1 + 0.6	0.15 + 0.4	15
11 V	0.3 + 2.5	0.15 + 0.2	1 + 1.5	0.3 + 2	0.15 + 2	50
22 V	0.4 + 5	0.2 + 0.4	1.5 + 3	0.3 + 4	0.15 + 4	50
220 V	0.5 + 40	0.3 + 5	1.5 + 40	1 + 40	0.15 + 60	150
1100 V	0.5 + 200	0.5 + 10	3 + 200	1 + 200	0.15 + 300	500

Notes:

1. Stability specifications are included in the Absolute Uncertainty values in the primary specification tables.
2. Temperature coefficient is an adder to uncertainty specifications that does *not* apply unless operating more than ±5 °C from calibration temperature.

Minimum Output .... 0 V for all ranges, except 100 V for 1100 V range

Maximum Load .... 50 mA for 2.2 V through 220 V ranges; 20 mA for 1100 V range; 50 Ω output impedance on 220 mV range; all ranges <1000 pF, >25 Ω

Load Regulation .... <(0.2 ppm of output + 0.1 ppm of range), full load to no load

Line Regulation .... <0.1 ppm change, ± 10 % of selected nominal line

Settling Time .... 3 seconds to full accuracy; + 1 second for range or polarity change; + 1 second for 1100 V range

Overshoot .... <5 %

Common Mode Rejection .... 140 dB, DC to 400 Hz

Remote Sensing .... Available 0 V to ±1100 V, on 2.2 V through 1100 V ranges

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1-32. DC Current Specifications

5720A Series II DC Current Specifications

Range	Resolution	Absolute Uncertainty ±5 °C from calibration temperature [2]				Relative Uncertainty ±1 °C	
		24 Hours	90 Days	180 Days	1 Year	24 Hours	90 Days
	nA	± (ppm output + nA)					
99 % Confidence Level							
220 µA	0	40 + 7	42 + 7	45 + 7	50 + 7	24 + 2	26 + 2
2.2 mA	1	30 + 8	35 + 8	37 + 8	40 + 8	24 + 5	26 + 5
22 mA	10	30 + 50	35 + 50	37 + 50	40 + 50	24 + 50	26 + 50
	µA	± (ppm output + µA)					
220 mA [1]	0.1	40 + 0.8	45 + 0.8	47 + 0.8	50 + 0.8	26 + 0.3	30 + 0.3
2.2 A [1]	1	60 + 15	70 + 15	80 + 15	90 + 15	40 + 7	45 + 7
5725A Amplifier:							
11 A	10	330 + 470	340 + 480	350 + 480	360 + 480	100 + 130	110 + 130
95 % Confidence Level							
	nA	± (ppm output + nA)					
220 µA	0.1	32 + 6	35 + 6	37 + 6	40 + 6	20 + 1.6	22 + 1.6
2.2 mA	1	25 + 7	30 + 7	33 + 7	35 + 7	20 + 4	22 + 4
22 mA	10	25 + 40	30 + 40	33 + 40	35 + 40	20 + 40	22 + 40
	µA	± (ppm output + µA)					
220 mA [1]	0.1	35 + 0.7	40 + 0.7	42 + 0.7	45 + 0.7	22 + 0.25	25 + 0.25
2.2 A [1]	1	50 + 12	60 + 12	70 + 12	80 + 12	32 + 6	40 + 6
5725A Amplifier:							
11 A	10	330 + 470	340 + 480	350 + 480	360 + 480	100 + 130	110 + 130

Note:

Maximum output from the calibrator's terminals is 2.2 A. Uncertainty specifications for 220 mA and 2.2 mA ranges are increased by a factor of 1.3 when supplied through 5725A terminals.

Specifications are otherwise identical for all output locations.

1. Add to uncertainty specifications:

   ±200 x I^2 ppm for >100 mA on 220 mA range
   ±10 x I^2 ppm for >1 A on 2.2 A range

2. For fields strengths >0.4 V/m but ≤3 V/m, add 1 % of range.

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DC Current Secondary Performance Specifications and Operating Characteristics

Range	Stability ±1 °C [1] 24 Hours	Temperature Coefficient [2]		Compliance Limits	Burden Voltage Adder [3] (±nA/V)	Maximum Load for Full Accuracy [4] (Ω)	Noise	
		10 – 40 °C	0 – 10 °C and 40 – 50 °C				Bandwidth 0.1-10 Hz pk-pk	Bandwidth 10 Hz-10 kHz RMS
	± (ppm output + nA)	± (ppm output + nA) / °C					ppm output + nA	nA
220 μA	5 + 1	1 + 0.40	3 + 1	10	0.2	20k	6 + .9	10
2.2 mA	5 + 5	1 + 2	3 + 10	10	0.2	2k	6 + 5	10
22 mA	5 + 50	1 + 20	3 + 100	10	10	200	6 + 50	50
220 mA	8 + 300	1 + 200	3 + 1 μA	10	100	20	9 + 300	500
2.2 A	9 + 7 μA	1 + 2.5 μA	3 + 10 μA	3 [5]	2 μA	2	12 + 1.5 μA	20 μA
5725A	± (ppm output + μA)	± (ppm output + μA) / °C					ppm output + μA	μA
11 A	25 + 100	20 + 75	30 + 120	4	0	4	15 + 70	175

Notes:

Maximum output from the calibrator's terminals is 2.2 A. Uncertainty specifications for 220 mA and 2.2 mA ranges are increased by a factor of 1.3 when supplied through 5725A terminals.

1. Stability specifications are included in the Absolute Uncertainty values for the primary specifications.
2. Temperature coefficient is an adder to uncertainty specifications. It does not apply unless operating more than ±5 °C from calibration temperature.
3. Burden voltage adder is an adder to uncertainty specifications that does not apply unless burden voltage is greater than 0.5 V.
4. For higher loads, multiply uncertainty specification by: $1+\frac{0.1 \times \text{actual load}}{\text{maximum load for full accuracy}}$
5. The calibrator's compliance limit is 2 V for outputs from 1 A to 2.2 A. 5725A Amplifier may be used in range-lock mode down to 0 A.

Minimum Output: .... 0 for all ranges, including 5725A.

Settling Time: .... 1 second for mA and mA ranges; 3 seconds for 2.2 A range; 6 seconds for 11 range; + 1 second for range or polarity change

Overshoot: .... <5 %

Appendice E
Caratteristiche resistore in taratura

Four-terminal resistance

Nominal value: 100 Ω

1 year drift: 2 ppm

Temperature coefficient of resistance: 2 ppm/°C

Maximum dissipation: 1 W

Load coefficient: 6 ppm/W

Se ritenuto necessario, aggiungere altre caratterisctiche del resistore, motivandone la scelta.