Advantest R6581 Digital Multimeter
Service Manual

Revision 1.6-10/2022

Contents

Revision History

1.3-08/2022: Initial public release.

1.4-09/2022: Added more hardware control commands: ADC integration time, MUX U001, input amplifier, input relays, voltage artifact source setup. Section 14.5 “Resistance transfer adjustment” updated in terms of 100M and 1000M ranges adjustment.

1.5-09/2022: Section 14 “DC Path Factory Calibration” updated.

1.6-10/2022: Fixed “CAL:INT:DCV:HOSEI:STORE” and “CAL:INT:AC:HOSEI:STORE” commands syntax.

1. Overview

Maintenance of the Advantest R6581 digital multimeter is performed in a special mode called "Service mode". The service mode is a set of SCPI commands used in production for diagnostics of the multimeter, its initial setup, evaluation and prediction of the stability of metrological parameters by analyzing calibration logs.

The service mode is not available during normal use of the multimeter and is only activated with a special SCPI command. The state of the service mode is not stored in non-volatile memory and is reset after turning off the power of the device.

All service commands are divided into four function groups:

1) Hardware control.
2) Regular calibration data management.
3) Factory calibration data management.
4) EEPROM Update.

1.1. Hardware control

Hardware control command gives access to low level functions of analog board. This command sends/receives a data packet through internal asynchronous serial interface between digital and analog boards:

WR {#TRG;|#RST;|#RDT;|<packet>|#H<hex_packet>}

Data exchange is carried out in 16-bit packets. Each packet transmitted in the direction to the analog board is a command word that sets the operating mode of FET switches, relays, integrator, counters, etc. In addition to packet transmission, it is possible to set active levels on the RES(et) and TRIG(ger) lines. In the direction to the digital board, the data generated by the ASIC is transmitted.

1.2. Regular calibration data management

Regular calibration data management includes several commands for reading of calibration constants from RAM (all or selectively), writing new values, reading previous calibration results from EPROM, as well as reading a log containing up to 20 latest values of the DMMs internal standards (7,2 V LTZ1000 module and 10 kΩ resistor):

CAL:EXT:ZERO:FRONT:NUMBER?
CAL:EXT:ZERO:FRONT:NUMBER {<begin>,<end>}
CAL:EXT:ZERO:FRONT:RAM {<number>,<value>}
CAL:EXT:ZERO:FRONT:EEPROM:DEF?
CAL:EXT:ZERO:FRONT:EEPROM:NEW?
CAL:EXT:ZERO:REAR:NUMBER?
CAL:EXT:ZERO:REAR:NUMBER {<begin>,<end>}
CAL:EXT:ZERO:REAR:RAM {<number>,<value>}
CAL:EXT:ZERO:REAR:EEPROM:DEF?
CAL:EXT:ZERO:REAR:EEPROM:NEW?
CAL:EXT:DCV:NUMBER?
CAL:EXT:DCV:NUMBER {<begin>,<end>}
CAL:EXT:DCV:RAM {<number>,<value>}
CAL:EXT:DCV:EEPROM:DEF?
CAL:EXT:DCV:EEPROM:NEW?
CAL:EXT:DCV:EEPROM:REF?
CAL:EXT:OHM:NUMBER?
CAL:EXT:OHM:NUMBER {<begin>,<end>}
CAL:EXT:OHM:RAM {<number>,<value>}
CAL:EXT:OHM:EEPROM:DEF?
CAL:EXT:OHM:EEPROM:NEW?
CAL:EXT:OHM:EEPROM:REF?

CAL:INT:DCV:NUMBER?
CAL:INT:DCV:NUMBER {<begin>,<end>}
CAL:INT:DCV:RAM {<number>,<value>}
CAL:INT:DCV:EEPROM:DEF?
CAL:INT:DCV:EEPROM:NEW?
CAL:INT:DCV:RAM?
CAL:INT:OHM:NUMBER?
CAL:INT:OHM:NUMBER {<begin>,<end>}
CAL:INT:OHM:RAM {<number>,<value>}
CAL:INT:OHM:EEPROM:DEF?
CAL:INT:OHM:EEPROM:NEW?
CAL:INT:OHM:RAM?
CAL:INT:AC:NUMBER?
CAL:INT:AC:NUMBER {<begin>,<end>}
CAL:INT:AC:RAM {<number>,<value>}
CAL:INT:AC:EEPROM:DEF?
CAL:INT:AC:EEPROM:NEW?
CAL:INT:AC:RAM?

Commands for reading the results of the previous calibration from the EEPROM are prefixed with DEF. The commands for reading the results of the current calibration from the EEPROM have the NEW prefix. Commands to read the instrument's internal standards log are prefixed with REF.

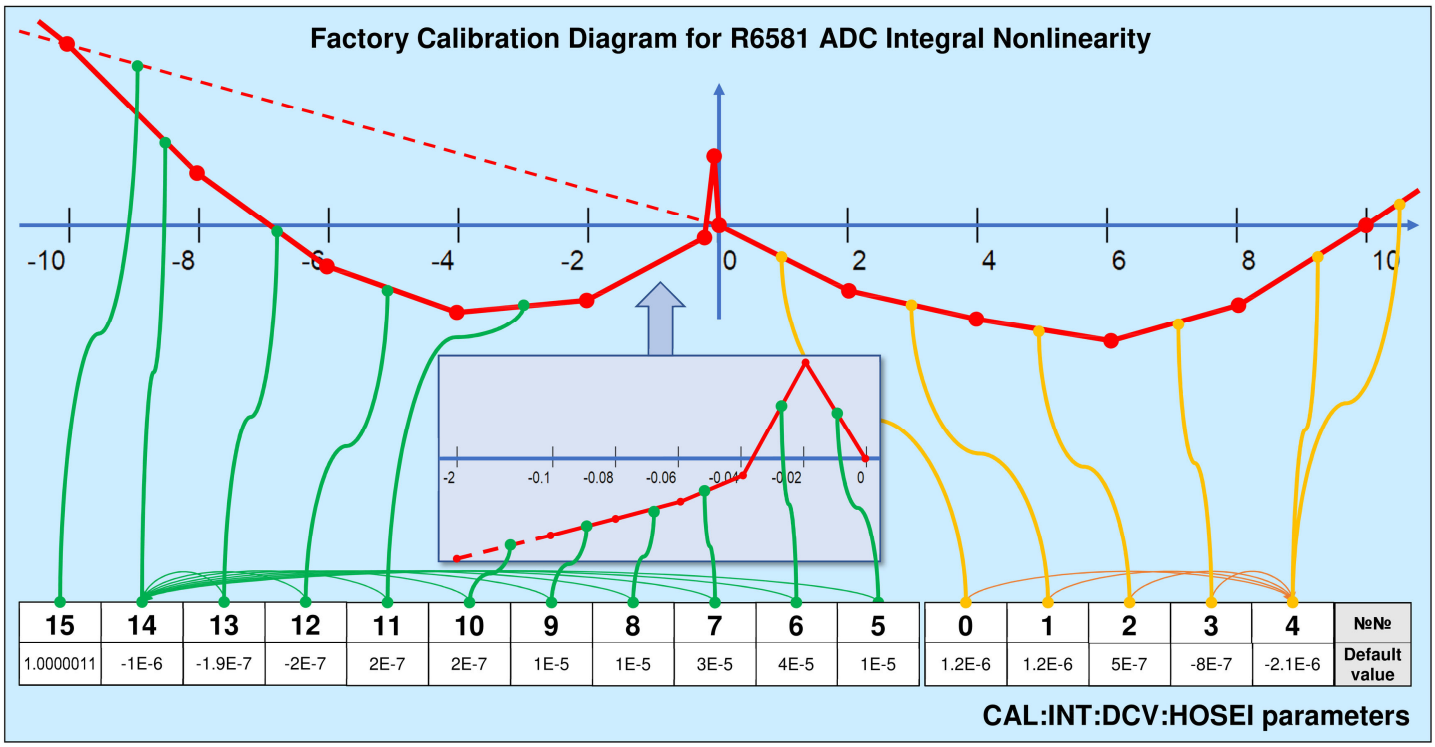
1.3. Factory calibration data management

Factory calibration data management commands (HOSEI commands) are used during the initial setup of the instrument to eliminate small errors that occur in the artifact and internal calibration procedures:

CAL:INT:DCV:HOSEI:NUMBER?
CAL:INT:DCV:HOSEI:NUMBER {<begin>,<end>}
CAL:INT:DCV:HOSEI {<number>,<value>}
CAL:INT:DCV:HOSEI?
CAL:INT:AC:HOSEI:NUMBER?
CAL:INT:AC:HOSEI:NUMBER {<begin>,<end>}
CAL:INT:AC:HOSEI {<number>,<value>}
CAL:INT:AC:HOSEI?

Factory calibration data is divided into two independent blocks: DCV and AC. The DCV factory calibration data block includes:

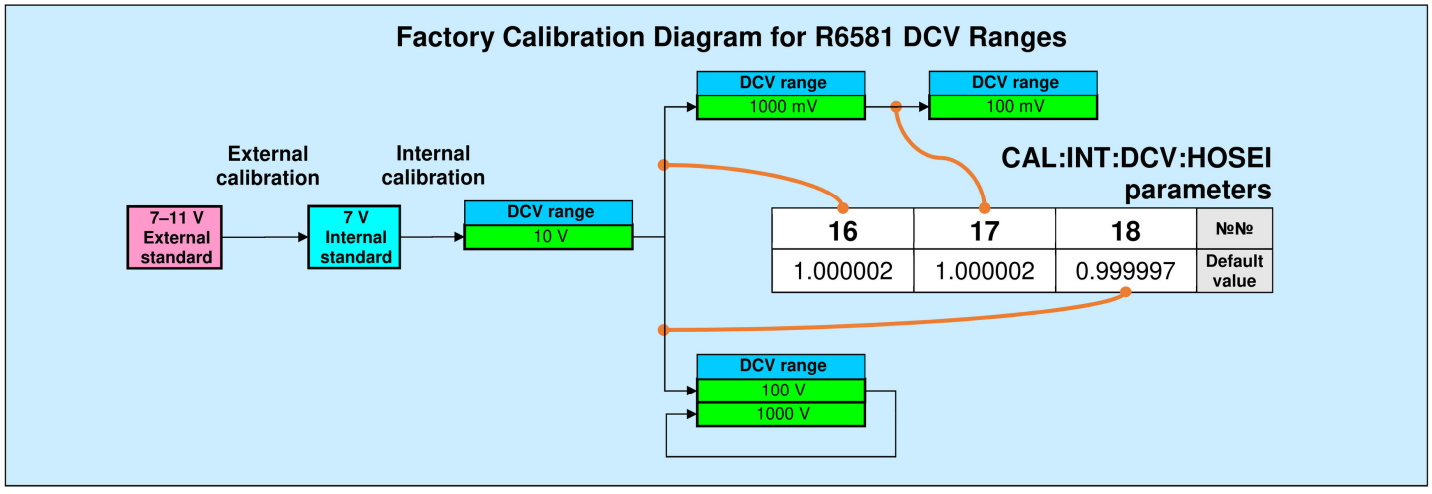
a) 16 coefficients of the correction equations for the integral nonlinearity of the ADC;



15	14	13	12	11	10	9	8	7	6	5	0	1	2	3	4	№№
1.0000011	-1E-6	-1.9E-7	-2E-7	2E-7	2E-7	1E-5	1E-5	3E-5	4E-5	1E-5	1.2E-6	1.2E-6	5E-7	-8E-7	-2.1E-6	Default value

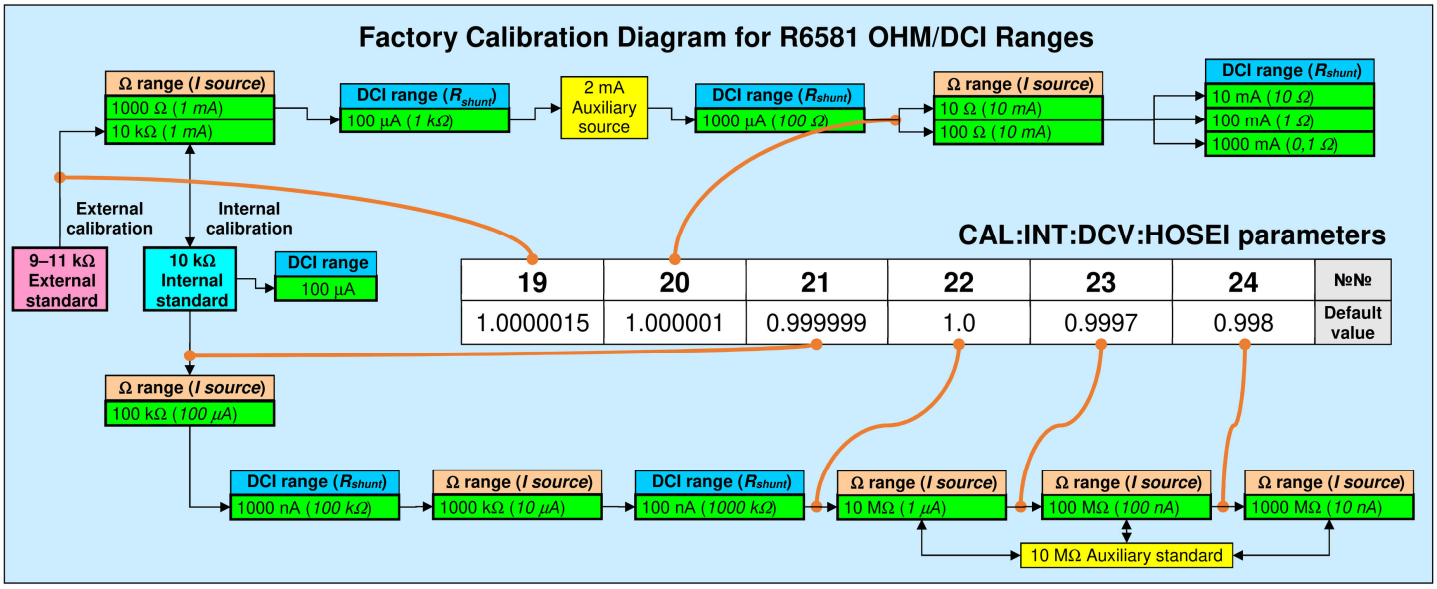
CAL:INT:DCV:HOSEI parameters

b) three coefficients of the equations for correcting errors in transferring the size of a unit of voltage to the measurement ranges of 100 mV, 1000 mV and 100 V during artifact calibration;

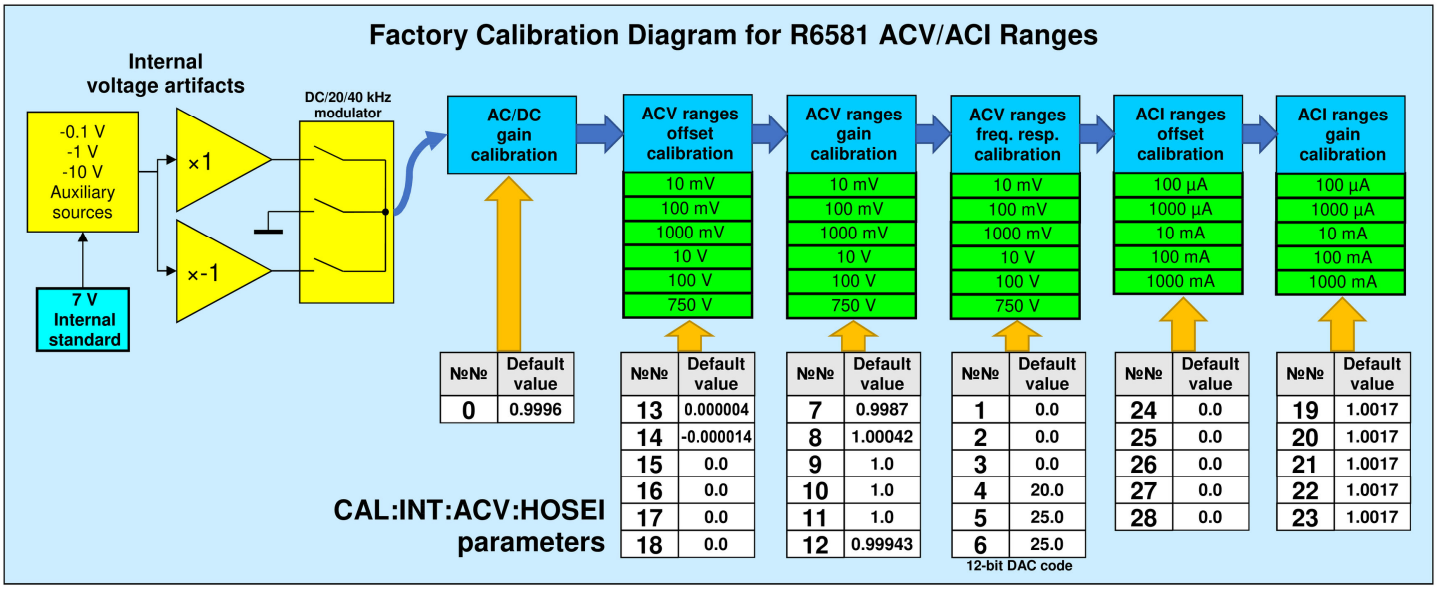


16	17	18	№№
1.000002	1.000002	0.999997	Default value

d) six current sources correction factors with -1 mA, -2 mA, -100 µA, -1000 nA, -100 nA and -10 nA ranges used in resistance/current measurement and internal calibration.



The AC factory calibration data block includes 29 constants used to eliminate internal calibration errors for all ACV and ACI ranges: zero offsets, scales, frequency response linearity, AC/DC gain.



1.4. EEPROM update

Any manual changes to the calibration data in RAM are reversible and are reset when the multimeter is powered off. Saving the edited calibration data in the non-volatile memory is performed using a special type of commands for EEPROM update:

CAL:EXT:EEPROM:STORE {ON|1|OFF|0}
CAL:INT:DCV:HOSEI:STORE {<number>}
CAL:INT:AC:HOSEI:STORE {<number>}

1.5. Command color coding

	Safe (read-only) commands*		Commands requiring caution		Dangerous commands (possible damage to calibration data or hardware)

* For more convenient GPIB output formatting, use the commands:
:SYSTEM:GPIB:DELI:BLOCK CRLF
:SYSTEM:GPIB:DELI:STR CRLF

2. Service Mode Access Control

CAL:EXT:EEPROM:PROTECTION {ON|1|OFF|0}

ON|1 – allows access to protected Service Mode commands
OFF|0 – deny access to protected Service Mode commands

If access to Service Mode is denied, running any of the commands below in this guide will result in a "-113,"Undefined header" error.

3. Front Inputs Zero Calibration Data Management

CAL:EXT:ZERO:FRONT:NUMBER?

Returns a range of calibration constant numbers.

Response example #1	Response example #2	Comments
0, 46	0, 46	Range of calibration records numbers

CAL:EXT:ZERO:FRONT:NUMBER {<begin>,<end>}

Limits the output to the specified range of constants ID (numbers): from <begin> to <end>

CAL:EXT:ZERO:FRONT:RAM {<number>,<value>}

Sets a new <value> for the calibration constant <number>
Example: CAL:EXT:ZERO:FRONT:RAM 2,-0.2E+01

CAL:EXT:ZERO:FRONT:EEPROM:DEF?

Response example #1	Response example #2	Offs	Comments
0 +5.22880000E+03	0 +1.36983000E+04	$0	DCV 100 mV
1 +4.75400000E+02	1 +1.34940000E+03	$8	DCV 1000 mV
2 +4.73000001E+01	2 +1.36800000E+02	$10	DCV 10 V
3 +1.53300000E+02	3 -6.06000000E+01	$18	DCV 100 V
4 +6.29999995E+00	4 -1.05000000E+01	$20	DCV 1000 V
5 -9.64710000E+03	5 -5.08630000E+03	$28	High-Power 4W-Ohm 10 Ω
6 -9.67700000E+02	6 -4.84500000E+02	$30	High-Power 4W-Ohm 100 Ω
7 -9.82000000E+01	7 -5.08000000E+01	$38	High-Power 4W-Ohm 1000 Ω
8 -9.46999999E+01	8 -5.96000000E+01	$40	High-Power 4W-Ohm 10 kΩ
9 -8.98000000E+01	9 -5.65000000E+01	$48	High-Power 4W-Ohm 100 kΩ
10 -1.03400000E+02	10 -6.64000001E+01	$50	High-Power 4W-Ohm 1000 kΩ
11 -9.68000001E+01	11 -6.54000000E+01	$58	High-Power 4W-Ohm 10 MΩ
12 +7.90000000E+01	12 +2.70800000E+02	$60	High-Power 4W-Ohm 100 MΩ
13 +8.17000000E+01	13 +2.69600000E+02	$68	High-Power 4W-Ohm 1000 MΩ
14 -9.68340000E+03	14 -5.78930000E+03	$70	Low-Power 4W-Ohm 100 Ω
15 -9.80900000E+02	15 -5.73600000E+02	$78	Low-Power 4W-Ohm 1000 Ω
16 -9.45400000E+02	16 -6.12500000E+02	$80	Low-Power 4W-Ohm 10 kΩ
17 -9.16000000E+02	17 -6.09500000E+02	$88	Low-Power 4W-Ohm 100 kΩ
18 -9.37800000E+02	18 -6.01600000E+02	$90	Low-Power 4W-Ohm 1000 kΩ
19 +7.96999999E+01	19 +2.62700000E+02	$98	Low-Power 4W-Ohm 10 MΩ
20 +8.14000000E+01	20 +2.52200000E+02	$A0	Low-Power 4W-Ohm 100 MΩ
21 +1.00781068E+07	21 +8.92974210E+06	$A8	High-Power 2W-Ohm 10 Ω
22 +1.00791320E+06	22 +8.92839700E+05	$B0	High-Power 2W-Ohm 100 Ω
23 +1.00762100E+05	23 +8.92503000E+04	$B8	High-Power 2W-Ohm 1000 Ω
24 +1.01268000E+04	24 +9.04310000E+03	$C0	High-Power 2W-Ohm 10 kΩ
25 +1.06030000E+03	25 +1.01910000E+03	$C8	High-Power 2W-Ohm 100 kΩ
26 +1.49400000E+02	26 +2.15700000E+02	$D0	High-Power 2W-Ohm 1000 kΩ
27 +6.81000000E+01	27 +1.42500000E+02	$D8	High-Power 2W-Ohm 10 MΩ
28 +5.09000000E+01	28 +1.29100000E+02	$E0	High-Power 2W-Ohm 100 MΩ
29 +5.33000000E+01	29 +1.31000000E+02	$E8	High-Power 2W-Ohm 1000 MΩ
30 +1.01249170E+06	30 +9.05452200E+05	$F0	Low-Power 2W-Ohm 100 Ω
31 +1.01277400E+05	31 +9.05300000E+04	$F8	Low-Power 2W-Ohm 1000 Ω
32 +1.05730000E+04	32 +1.02420000E+04	$100	Low-Power 2W-Ohm 10 kΩ
33 +1.51510000E+03	33 +2.19910000E+03	$108	Low-Power 2W-Ohm 100 kΩ
34 +6.58700000E+02	34 +1.39460000E+03	$110	Low-Power 2W-Ohm 1000 kΩ
35 +5.48000000E+01	35 +1.22400000E+02	$118	Low-Power 2W-Ohm 10 MΩ
36 +5.25999999E+01	36 +1.36000000E+02	$120	Low-Power 2W-Ohm 100 MΩ
37 +4.28650000E+03	37 +6.50510000E+03	$128	DCI 100 nA
38 +3.89000000E+01	38 +1.43490000E+03	$130	DCI 1000 nA

Response example #1	Response example #2	Offs	Comments
39 +5.07670000E+03	39 +1.46437000E+04	$138	DCI 10 µA
40 +4.72990000E+03	40 +1.45398000E+04	$140	DCI 100 µA
41 +4.48190000E+03	41 +1.44728000E+04	$148	DCI 1000 µA
42 +4.75580000E+03	42 +1.45866000E+04	$150	DCI 10 mA
43 +4.92780000E+03	43 +1.46308000E+04	$158	DCI 100 mA
44 +1.36300000E+03	44 +1.15133000E+04	$160	DCI 1000 mA
45 +3.75880849E+01	45 +3.73871823E+01	$168	Internal temperature, °C
46 2007/02/08 14:11	46 2016/12/12 14:45	$170	Calibration date / time

CAL:EXT:ZERO:FRONT:EEPROM:NEW?

Response example #1	Response example #2	Offs	Comments
0 +6.54720000E+03	0 +1.45054000E+04	$0	DCV 100 mV
1 +6.51800000E+02	1 +1.44220000E+03	$8	DCV 1000 mV
2 +6.62000000E+01	2 +1.46700000E+02	$10	DCV 10 V
3 +1.73300000E+02	3 +2.00000000E+00	$18	DCV 100 V
4 +5.70000005E+00	4 +5.10000002E+00	$20	DCV 1000 V
5 -1.11011000E+04	5 -4.82790000E+03	$28	High-Power 4W-Ohm 10 Ω
6 -1.10230000E+03	6 -4.91700000E+02	$30	High-Power 4W-Ohm 100 Ω
7 -1.12400000E+02	7 -4.68000000E+01	$38	High-Power 4W-Ohm 1000 Ω
8 -1.10700000E+02	8 -5.00000000E+01	$40	High-Power 4W-Ohm 10 kΩ
9 -1.13000000E+02	9 -4.96000000E+01	$48	High-Power 4W-Ohm 100 kΩ
10 -1.11700000E+02	10 -3.84000000E+01	$50	High-Power 4W-Ohm 1000 kΩ
11 -1.18700000E+02	11 -4.76000000E+01	$58	High-Power 4W-Ohm 10 MΩ
12 +4.90000000E+01	12 +2.23500000E+02	$60	High-Power 4W-Ohm 100 MΩ
13 +5.61000000E+01	13 +2.16500000E+02	$68	High-Power 4W-Ohm 1000 MΩ
14 -1.12290000E+04	14 -5.05400000E+03	$70	Low-Power 4W-Ohm 100 Ω
15 -1.08660000E+03	15 -5.19200000E+02	$78	Low-Power 4W-Ohm 1000 Ω
16 -1.08750000E+03	16 -5.00800000E+02	$80	Low-Power 4W-Ohm 10 kΩ
17 -1.02570000E+03	17 -4.76500000E+02	$88	Low-Power 4W-Ohm 100 kΩ
18 -1.04680000E+03	18 -4.73200000E+02	$90	Low-Power 4W-Ohm 1000 kΩ
19 +4.97000000E+01	19 +2.15200000E+02	$98	Low-Power 4W-Ohm 10 MΩ
20 +4.65000000E+01	20 +2.09800000E+02	$A0	Low-Power 4W-Ohm 100 MΩ
21 +6.55610480E+06	21 +6.46637170E+06	$A8	High-Power 2W-Ohm 10 Ω
22 +6.55553700E+05	22 +6.46540000E+05	$B0	High-Power 2W-Ohm 100 Ω
23 +6.55308000E+04	23 +6.46361000E+04	$B8	High-Power 2W-Ohm 1000 Ω
24 +6.60650000E+03	24 +6.60510000E+03	$C0	High-Power 2W-Ohm 10 kΩ
25 +7.25800000E+02	25 +7.92000000E+02	$C8	High-Power 2W-Ohm 100 kΩ
26 +1.26400000E+02	26 +2.13500000E+02	$D0	High-Power 2W-Ohm 1000 kΩ
27 +7.10000000E+01	27 +1.50700000E+02	$D8	High-Power 2W-Ohm 10 MΩ
28 +6.77000000E+01	28 +1.37900000E+02	$E0	High-Power 2W-Ohm 100 MΩ
29 +6.56000000E+01	29 +1.44900000E+02	$E8	High-Power 2W-Ohm 1000 MΩ
30 +6.60437900E+05	30 +6.60254400E+05	$F0	Low-Power 2W-Ohm 100 Ω
31 +6.61105000E+04	31 +6.60270000E+04	$F8	Low-Power 2W-Ohm 1000 Ω
32 +7.19850000E+03	32 +7.96860000E+03	$100	Low-Power 2W-Ohm 10 kΩ
33 +1.23850000E+03	33 +2.12020000E+03	$108	Low-Power 2W-Ohm 100 kΩ
34 +7.14300000E+02	34 +1.52110000E+03	$110	Low-Power 2W-Ohm 1000 kΩ
35 +6.93000000E+01	35 +1.52200000E+02	$118	Low-Power 2W-Ohm 10 MΩ
36 +6.71000000E+01	36 +1.46800000E+02	$120	Low-Power 2W-Ohm 100 MΩ
37 +4.54710000E+03	37 +3.21920000E+03	$128	DCI 100 nA
38 -1.72400000E+02	38 +7.12300000E+02	$130	DCI 1000 nA
39 +2.60280000E+03	39 +9.25270000E+03	$138	DCI 10 µA
40 +2.83970000E+03	40 +9.54140000E+03	$140	DCI 100 µA
41 +2.53160000E+03	41 +9.40020000E+03	$148	DCI 1000 µA
42 +2.66640000E+03	42 +9.01300000E+03	$150	DCI 10 mA
43 +2.49630000E+03	43 +9.10050000E+03	$158	DCI 100 mA
44 -1.57030000E+03	44 +6.25530000E+03	$160	DCI 1000 mA
45 +4.25508707E+01	45 +4.10119317E+01	$168	Internal temperature, °C
46 2022/02/23 03:55	46 2022/05/01 14:05	$170	Calibration date / time

4. Rear Inputs Zero Calibration Data Management

CAL:EXT:ZERO:REAR:NUMBER?

Returns a range of calibration constant numbers.

Response example #1	Response example #2	Comments
100, 146	100, 146	Range of calibration records numbers

CAL:EXT:ZERO:REAR:NUMBER {<begin>,<end>}

Limits the output to the specified range of constants ID (numbers): from <begin> to <end>

CAL:EXT:ZERO:REAR:RAM {<number>,<value>}

Sets a new <value> for the calibration constant <number>
Example: CAL:EXT:ZERO:REAR:RAM 2,-0.2E+01

CAL:EXT:ZERO:REAR:EEPROM:DEF?

Response example #1	Response example #2	Offs	Comments
100 +1.16867000E+04	100 +1.59796000E+04	$0	DCV 100 mV
101 +1.11640000E+03	101 +1.64530000E+03	$8	DCV 1000 mV
102 +1.10700000E+02	102 +1.61500000E+02	$10	DCV 10 V
103 +2.34200000E+02	103 +6.10000000E+01	$18	DCV 100 V
104 +4.90000010E+00	104 -2.00000048E-01	$20	DCV 1000 V
105 -3.53700000E+03	105 +1.50390000E+03	$28	High-Power 4W-Ohm 10 Ω
106 -2.88500000E+02	106 +2.20700000E+02	$30	High-Power 4W-Ohm 100 Ω
107 -3.43000000E+01	107 +2.18000001E+01	$38	High-Power 4W-Ohm 1000 Ω
108 -3.74000000E+01	108 +9.20000005E+00	$40	High-Power 4W-Ohm 10 kΩ
109 -2.58000001E+01	109 +6.50000000E+00	$48	High-Power 4W-Ohm 100 kΩ
110 -3.10000000E+01	110 +1.89000000E+01	$50	High-Power 4W-Ohm 1000 kΩ
111 -2.10000000E+01	111 +1.41000000E+01	$58	High-Power 4W-Ohm 10 MΩ
112 +9.06000000E+01	112 +2.67900000E+02	$60	High-Power 4W-Ohm 100 MΩ
113 +9.11000000E+01	113 +2.59900000E+02	$68	High-Power 4W-Ohm 1000 MΩ
114 -3.75250000E+03	114 +7.85900000E+02	$70	Low-Power 4W-Ohm 100 Ω
115 -2.90500000E+02	115 +1.63300000E+02	$78	Low-Power 4W-Ohm 1000 Ω
116 -3.58700000E+02	116 +1.14900000E+02	$80	Low-Power 4W-Ohm 10 kΩ
117 -3.19000000E+02	117 +1.49600000E+02	$88	Low-Power 4W-Ohm 100 kΩ
118 -3.49900000E+02	118 +2.00600000E+02	$90	Low-Power 4W-Ohm 1000 kΩ
119 +9.18000001E+01	119 +2.67800000E+02	$98	Low-Power 4W-Ohm 10 MΩ
120 +7.59000000E+01	120 +2.65100000E+02	$A0	Low-Power 4W-Ohm 100 MΩ
121 +1.22319295E+07	121 +1.11420439E+07	$A8	High-Power 2W-Ohm 10 Ω
122 +1.22312350E+06	122 +1.11402610E+06	$B0	High-Power 2W-Ohm 100 Ω
123 +1.22272500E+05	123 +1.11376100E+05	$B8	High-Power 2W-Ohm 1000 Ω
124 +1.23352000E+04	124 +1.12844000E+04	$C0	High-Power 2W-Ohm 10 kΩ
125 +1.33580000E+03	125 +1.27930000E+03	$C8	High-Power 2W-Ohm 100 kΩ
126 +2.38000000E+02	126 +2.72500000E+02	$D0	High-Power 2W-Ohm 1000 kΩ
127 +1.26500000E+02	127 +1.74700000E+02	$D8	High-Power 2W-Ohm 10 MΩ
128 +1.16700000E+02	128 +1.67600000E+02	$E0	High-Power 2W-Ohm 100 MΩ
129 +1.12200000E+02	129 +1.63800000E+02	$E8	High-Power 2W-Ohm 1000 MΩ
130 +1.23359170E+06	130 +1.12853060E+06	$F0	Low-Power 2W-Ohm 100 Ω
131 +1.23348500E+05	131 +1.12842700E+05	$F8	Low-Power 2W-Ohm 1000 Ω
132 +1.33407000E+04	132 +1.27905000E+04	$100	Low-Power 2W-Ohm 10 kΩ
133 +2.33210000E+03	133 +2.74680000E+03	$108	Low-Power 2W-Ohm 100 kΩ
134 -1.26600000E+02	134 -1.68200000E+02	$110	Low-Power 2W-Ohm 1000 kΩ
135 +1.26000000E+02	135 +1.71100000E+02	$118	Low-Power 2W-Ohm 10 MΩ
136 +1.23500000E+02	136 +1.57100000E+02	$120	Low-Power 2W-Ohm 100 MΩ
137 +3.50360000E+03	137 +5.39340000E+03	$128	DCI 100 nA
138 +6.83000001E+01	138 +1.12000000E+03	$130	DCI 1000 nA

Response example #1	Response example #2	Offs	Comments
139 +5.13220000E+03	139 +1.19422000E+04	$138	DCI 10 µA
140 +4.82090000E+03	140 +1.17996000E+04	$140	DCI 100 µA
141 +4.73490000E+03	141 +1.15323000E+04	$148	DCI 1000 µA
142 +4.95860000E+03	142 +1.20939000E+04	$150	DCI 10 mA
143 +4.89410000E+03	143 +1.18857000E+04	$158	DCI 100 mA
144 +1.51220000E+03	144 +8.21590000E+03	$160	DCI 1000 mA
145 +3.83407052E+01	145 +3.84857750E+01	$168	Internal temperature, °C
146 2007/02/08 15:13	146 2001/02/22 09:42	$170	Calibration date / time

CAL:EXT:ZERO:REAR:EEPROM:NEW?

Response example #1	Response example #2	Offs	Comments
100 +1.16867000E+04	100 +1.88867000E+04	$0	DCV 100 mV
101 +1.11640000E+03	101 +1.88540000E+03	$8	DCV 1000 mV
102 +1.10700000E+02	102 +1.85400000E+02	$10	DCV 10 V
103 +2.34200000E+02	103 +7.00000000E+00	$18	DCV 100 V
104 +4.90000010E+00	104 +2.90000010E+00	$20	DCV 1000 V
105 -3.53700000E+03	105 +2.55370000E+03	$28	High-Power 4W-Ohm 10 Ω
106 -2.88500000E+02	106 +2.53400000E+02	$30	High-Power 4W-Ohm 100 Ω
107 -3.43000000E+01	107 +3.05000000E+01	$38	High-Power 4W-Ohm 1000 Ω
108 -3.74000000E+01	108 +2.78000000E+01	$40	High-Power 4W-Ohm 10 kΩ
109 -2.58000001E+01	109 +2.35000000E+01	$48	High-Power 4W-Ohm 100 kΩ
110 -3.10000000E+01	110 +3.01000000E+01	$50	High-Power 4W-Ohm 1000 kΩ
111 -2.10000000E+01	111 +1.86000000E+01	$58	High-Power 4W-Ohm 10 MΩ
112 +9.06000000E+01	112 +2.49500000E+02	$60	High-Power 4W-Ohm 100 MΩ
113 +9.11000000E+01	113 +2.48300000E+02	$68	High-Power 4W-Ohm 1000 MΩ
114 -3.75250000E+03	114 +2.29620000E+03	$70	Low-Power 4W-Ohm 100 Ω
115 -2.90500000E+02	115 +2.53400000E+02	$78	Low-Power 4W-Ohm 1000 Ω
116 -3.58700000E+02	116 +2.58400000E+02	$80	Low-Power 4W-Ohm 10 kΩ
117 -3.19000000E+02	117 +2.73500000E+02	$88	Low-Power 4W-Ohm 100 kΩ
118 -3.49900000E+02	118 +2.33500000E+02	$90	Low-Power 4W-Ohm 1000 kΩ
119 +9.18000001E+01	119 +2.38900000E+02	$98	Low-Power 4W-Ohm 10 MΩ
120 +7.59000000E+01	120 +2.40900000E+02	$A0	Low-Power 4W-Ohm 100 MΩ
121 +1.22319295E+07	121 +7.84275060E+06	$A8	High-Power 2W-Ohm 10 Ω
122 +1.22312350E+06	122 +7.84196100E+05	$B0	High-Power 2W-Ohm 100 Ω
123 +1.22272500E+05	123 +7.83948000E+04	$B8	High-Power 2W-Ohm 1000 Ω
124 +1.23352000E+04	124 +8.01400000E+03	$C0	High-Power 2W-Ohm 10 kΩ
125 +1.33580000E+03	125 +9.74500000E+02	$C8	High-Power 2W-Ohm 100 kΩ
126 +2.38000000E+02	126 +2.63400000E+02	$D0	High-Power 2W-Ohm 1000 kΩ
127 +1.26500000E+02	127 +1.84100000E+02	$D8	High-Power 2W-Ohm 10 MΩ
128 +1.16700000E+02	128 +1.82500000E+02	$E0	High-Power 2W-Ohm 100 MΩ
129 +1.12200000E+02	129 +1.83900000E+02	$E8	High-Power 2W-Ohm 1000 MΩ
130 +1.23359170E+06	130 +8.01204600E+05	$F0	Low-Power 2W-Ohm 100 Ω
131 +1.23348500E+05	131 +8.01381000E+04	$F8	Low-Power 2W-Ohm 1000 Ω
132 +1.33407000E+04	132 +9.67850000E+03	$100	Low-Power 2W-Ohm 10 kΩ
133 +2.33210000E+03	133 +2.64360000E+03	$108	Low-Power 2W-Ohm 100 kΩ
134 -1.26600000E+02	134 -1.92800000E+02	$110	Low-Power 2W-Ohm 1000 kΩ
135 +1.26000000E+02	135 +1.93900000E+02	$118	Low-Power 2W-Ohm 10 MΩ
136 +1.23500000E+02	136 +1.81500000E+02	$120	Low-Power 2W-Ohm 100 MΩ
137 +3.50360000E+03	137 +2.41230000E+03	$128	DCI 100 nA
138 +6.83000001E+01	138 +8.72300000E+02	$130	DCI 1000 nA
139 +5.13220000E+03	139 +1.04131000E+04	$138	DCI 10 µA
140 +4.82090000E+03	140 +1.00519000E+04	$140	DCI 100 µA
141 +4.73490000E+03	141 +1.03892000E+04	$148	DCI 1000 µA
142 +4.95860000E+03	142 +1.01105000E+04	$150	DCI 10 mA
143 +4.89410000E+03	143 +1.04810000E+04	$158	DCI 100 mA
144 +1.51220000E+03	144 +7.21060000E+03	$160	DCI 1000 mA
145 +3.83407052E+01	145 +4.10089923E+01	$168	Internal temperature, °C
146 2007/02/08 15:13	146 2022/07/03 15:03	$170	Calibration date / time

5. DCV External Calibration Data Management

CAL:EXT:DCV:NUMBER?

Returns a range of calibration constant numbers.

Response example #1	Response example #2	Comments
200, 203	200, 203	Range of calibration records numbers

CAL:EXT:DCV:NUMBER {<begin>,<end>}

Limits the output to the specified range of constants ID (numbers): from <begin> to <end>

CAL:EXT:DCV:RAM {<number>,<value>}

Sets a new <value> for the calibration constant <number>
Example: CAL:EXT:DCV:RAM 200,+7.2E+00

CAL:EXT:DCV:EEPROM:DEF?

Response example #1	Response example #2	Comments
200 +7.06406674E+00	200 +7.10390038E+00	Internal reference value (7.2 V)
201 +9.99993220E+00	201 +9.99990300E+00	Calibration value of DC voltage standard
202 +3.78879599E+01	202 +3.74692318E+01	Internal temperature, °C
203 2007/02/08 14:26	203 2016/12/12 14:48	External calibration date / time

CAL:EXT:DCV:EEPROM:NEW?

Response example #1	Response example #2	Comments
200 +7.06402041E+00	200 +7.10392292E+00	Internal reference value (7.2 V)
201 +9.99997000E+00	201 +9.99978780E+00	Calibration value of DC voltage standard
202 +3.72955084E+01	202 +4.28177926E+01	Internal temperature, °C
203 2010/02/08 16:02	203 2022/05/01 14:19	External calibration date / time

CAL:EXT:DCV:EEPROM:REF?

Response example #1	Comments
1 +7.06406674E+00 +3.78879599E+01 2007/02/08 14:26	History of 7.2 V internal reference value drift, measured relative to external standard: Voltage / Temperature / Date / Time
2 +7.06402041E+00 +3.72955084E+01 2010/02/08 16:02	
3 +7.06411866E+00 +3.75193054E+01	
4 +7.06411976E+00 +3.71761924E+01	
5 +7.06416113E+00 +3.83118644E+01	
6 -0.00000000E+00 -0.00000000E+00	
7 -0.00000000E+00 -0.00000000E+00	
8 -0.00000000E+00 -0.00000000E+00	
9 -0.00000000E+00 -0.00000000E+00	
10 -0.00000000E+00 -0.00000000E+00	
11 -0.00000000E+00 -0.00000000E+00	
12 -0.00000000E+00 -0.00000000E+00	
13 -0.00000000E+00 -0.00000000E+00	
14 -0.00000000E+00 -0.00000000E+00	
15 -0.00000000E+00 -0.00000000E+00	
16 -0.00000000E+00 -0.00000000E+00	
17 -0.00000000E+00 -0.00000000E+00	
18 -0.00000000E+00 -0.00000000E+00	
19 -0.00000000E+00 -0.00000000E+00	
20 -0.00000000E+00 -0.00000000E+00	

Response example #2	Comments
1 +7.10390038E+00 +3.74692318E+01 2016/12/12 14:48	History of 7.2 V internal reference value drift, measured relative to external standard: Voltage / Temperature / Date / Time
2 +7.10392292E+00 +4.28177926E+01 2022/05/01 14:19	
3 +7.10390038E+00 +3.74692318E+01	
4 -0.00000000E+00 -0.00000000E+00	
5 -0.00000000E+00 -0.00000000E+00	
6 -0.00000000E+00 -0.00000000E+00	
7 -0.00000000E+00 -0.00000000E+00	
8 -0.00000000E+00 -0.00000000E+00	
9 -0.00000000E+00 -0.00000000E+00	
10 -0.00000000E+00 -0.00000000E+00	
11 -0.00000000E+00 -0.00000000E+00	
12 -0.00000000E+00 -0.00000000E+00	
13 -0.00000000E+00 -0.00000000E+00	
14 -0.00000000E+00 -0.00000000E+00	
15 -0.00000000E+00 -0.00000000E+00	
16 -0.00000000E+00 -0.00000000E+00	
17 -0.00000000E+00 -0.00000000E+00	
18 -0.00000000E+00 -0.00000000E+00	
19 -0.00000000E+00 -0.00000000E+00	
20 -0.00000000E+00 -0.00000000E+00	

6. DCV Internal Calibration Data Management

CAL:INT:DCV:NUMBER?

Returns a range of calibration constant numbers.

Response example #1	Response example #2	Comments
400, 406	400, 406	Range of calibration records numbers

CAL:INT:DCV:NUMBER {<begin>,<end>}

Limits the output to the specified range of constants ID (numbers): from <begin> to <end>

CAL:INT:DCV:RAM {<number>,<value>}

Sets a new <value> for the calibration constant <number>
Example: CAL:INT:DCV:RAM 400,-2.4E-10

CAL:INT:DCV:EEPROM:DEF?

Response example #1	Response example #2	Offs	Comments
400 -2.39517626E-10	400 -2.40796641E-10	$0	100 mV ADC scale factor
401 -2.39486278E-09	401 -2.40832447E-09	$8	1000 mV ADC scale factor
402 -2.39562350E-08	402 -2.40903526E-08	$10	10 V ADC scale factor
403 -2.39282400E-07	403 -2.40904379E-07	$18	100 V ADC scale factor
404 -2.39358407E-06	404 -2.40975479E-06	$20	1000 V ADC scale factor
405 +3.82094129E+01	405 +3.72271043E+01	$28	Internal temperature, °C
406 2007/02/09 15:04	406 2016/12/12 15:25	$30	Storing date / time

CAL:INT:DCV:EEPROM:NEW?

Response example #1	Response example #2	Offs	Comments
400 -2.39520454E-10	400 -2.40798721E-10	$0	100 mV ADC scale factor
401 -2.39488326E-09	401 -2.40832540E-09	$8	1000 mV ADC scale factor
402 -2.39564484E-08	402 -2.40903769E-08	$10	10 V ADC scale factor
403 -2.39280521E-07	403 -2.40901372E-07	$18	100 V ADC scale factor
404 -2.39356613E-06	404 -2.40972621E-06	$20	1000 V ADC scale factor
405 +4.43450080E+01	405 +4.44146139E+01	$28	Internal temperature, °C
406 2022/07/03 12:09	406 2022/07/03 12:10	$30	Internal calibration date / time

CAL:INT:DCV:RAM?

Response example #1	Response example #2	Offs	Defaults	Comments
400 -2.39520454E-10	400 -2.40798721E-10	$0	-2.44140625E-10	100 mV ADC scale factor
401 -2.39488326E-09	401 -2.40832540E-09	$8	-2.44140625E-9	1000 mV ADC scale factor
402 -2.39564484E-08	402 -2.40903769E-08	$10	-2.44140625E-8	10 V ADC scale factor
403 -2.39280521E-07	403 -2.40901372E-07	$18	-2.44140625E-7	100 V ADC scale factor
404 -2.39356613E-06	404 -2.40972621E-06	$20	-2.44140625E-6	1000 V ADC scale factor
405 +4.43450080E+01	405 +4.44146139E+01	$28	23.0	Internal temperature, °C
406 2022/07/03 12:09	406 2022/07/03 12:10	$30	' '	Internal calibration date / time

7. DCV Factory Calibration Data Management

CAL:INT:DCV:HOSEI:NUMBER?

Returns a range of calibration constant numbers.

Response example #1	Response example #2	Comments
0, 25	0, 25	Range of calibration records numbers

CAL:INT:DCV:HOSEI:NUMBER {<begin>,<end>}

Limits the output to the specified range of constants ID (numbers): from <begin> to <end>

CAL:INT:DCV:HOSEI {<number>,<value>}

Sets a new <value> for the factory calibration constant <number>
Example: CAL:INT:DCV:HOSEI 1,+1.2E-6

CAL:INT:DCV:HOSEI?

Response example #1	Response example #2	Offs	Defaults	Comments	
0 +1.20000000E-06	0 +1.20000000E-06	$0	0.0000012	Tint >= 10 PLC ADC non-linearity correction by a piecewise linear function*	H_0
1 +1.20000000E-06	1 +1.20000000E-06	$8	0.0000012		H_1
2 +5.00000000E-07	2 +5.00000000E-07	$10	5.0E-7		H_2
3 -8.00000000E-07	3 -8.00000000E-07	$18	-8.0E-7		H_3
4 -2.10000000E-06	4 -2.10000000E-06	$20	-0.0000021		H_4
5 +1.00000000E-05	5 +1.00000000E-05	$28	0.00001		H_5
6 +4.00000000E-05	6 +4.00000000E-05	$30	0.00004		H_6
7 +3.00000000E-05	7 +3.00000000E-05	$38	0.00003		H_7
8 +1.00000000E-05	8 +1.00000000E-05	$40	0.00001		H_8
9 +1.00000000E-05	9 +1.00000000E-05	$48	0.00001		H_9
10 +2.00000000E-07	10 +2.00000000E-07	$50	2.0e-7		H_{10}
11 -2.00000000E-07	11 -2.00000000E-07	$58	2.0e-7		H_{11}
12 -1.90000000E-07	12 -1.90000000E-07	$60	-2.0e-7		H_{12}
13 -4.00000000E-07	13 -4.00000000E-07	$68	-1.9e-7		H_{13}
14 -4.00000000E-07	14 -4.00000000E-07	$70	-0.000001		H_{14}
15 +1.00000050E+00	15 +1.00000080E+00	$78	1.0000011	10 PLC > Tint >= 1 PLC ADC negative scale mult.	H_{15}
16 +9.99997700E-01	16 +1.00000070E+00	$80	1.000002	DCV RAM:$8 1000 mV mult. Correction of transfer error from 10 V to 1 V range	
17 +9.99995000E-01	17 +9.99998000E-01	$88	1.000002	DCV RAM:$0 100 mV mult. Correction of transfer error from 1 V to 100 mV range	
18 +1.00000340E+00	18 +9.99999700E-01	$90	0.999997	DCV RAM:$18 100 V mult. Correction of transfer error from 10 V to 100 V range	
19 +1.00000250E+00	19 +1.00000450E+00	$98	1.0000015	OHM RAM:$18 –1 mA source mult. Correction of transfer error from external resistance standard to 10 kΩ and all lower ranges	
20 +1.00000200E+00	20 +1.00000330E+00	$A0	1.000001	-2 mA aux. source mult. Correction of transfer error from 1 kΩ to 100 Ω range	
21 +1.00000330E+00	21 +1.00000300E+00	$A8	0.999999	OHM RAM:$20 –100 µA source mult. Correction of transfer error from 10 kΩ to 100 kΩ range	
22 +1.00001400E+00	22 +1.00002000E+00	$B0	1.0	OHM RAM:$30 –1000 nA source mult. Correction of transfer error from 1000 kΩ to 10 MΩ range	

Response example #1	Response example #2	Offs	Defaults	Comments
23 +9.99590000E-01	23 +9.99200000E-01	$B8	0.9997	OHM RAM:$38 –100 nA source mult. Correction of transfer error from 10 MΩ to 100 MΩ range
24 +9.98000000E-01	24 +9.97000000E-01	$C0	0.998	OHM RAM:$40 –10 nA source mult. Correction of transfer error from 100 MΩ to 1000 MΩ range
25 2005/03/01 18:02	25 2016/12/12 15:54	$C8		Storing date / time

*Non-linearity correction function pseudocode:

$$
\begin{aligned}
F(x,H) := \;& \text{return } H_{15}\cdot x \text{ if } (x < -10)\\
& \text{return } \left[x - 0.02\cdot(H_5+H_6+H_7+H_8+H_9) - 1.9\cdot H_{10} - 2\cdot(H_{11}+H_{12}+H_{13}) + (x+8)\cdot H_{14}\right]\cdot H_{15} \text{ if } (x \ge -10)\wedge(x < -8)\\
& \text{return } \left[x - 0.02\cdot(H_5+H_6+H_7+H_8+H_9) - 1.9\cdot H_{10} - 2\cdot(H_{11}+H_{12}) + (x+6)\cdot H_{13}\right]\cdot H_{15} \text{ if } (x \ge -8)\wedge(x < -6)\\
& \text{return } \left[x - 0.02\cdot(H_5+H_6+H_7+H_8+H_9) - 1.9\cdot H_{10} - 2\cdot H_{11} + (x+4)\cdot H_{12}\right]\cdot H_{15} \text{ if } (x \ge -6)\wedge(x < -4)\\
& \text{return } \left[x - 0.02\cdot(H_5+H_6+H_7+H_8+H_9) - 1.9\cdot H_{10} + (x+2)\cdot H_{11}\right]\cdot H_{15} \text{ if } (x \ge -4)\wedge(x < -2)\\
& \text{return } \left[x - 0.02\cdot(H_5+H_6+H_7+H_8+H_9) + (x+0.1)\cdot H_{10}\right]\cdot H_{15} \text{ if } (x \ge -2)\wedge(x < -0.1)\\
& \text{return } \left[x - 0.02\cdot(H_5+H_6+H_7+H_8) + (x+0.08)\cdot H_9\right]\cdot H_{15} \text{ if } (x \ge -0.1)\wedge(x < -0.08)\\
& \text{return } \left[x - 0.02\cdot(H_5+H_6+H_7) + (x+0.06)\cdot H_8\right]\cdot H_{15} \text{ if } (x \ge -0.08)\wedge(x < -0.06)\\
& \text{return } \left[x - 0.02\cdot(H_5+H_6) + (x+0.04)\cdot H_7\right]\cdot H_{15} \text{ if } (x \ge -0.06)\wedge(x < -0.04)\\
& \text{return } \left[x - 0.02\cdot H_5 + (x+0.02)\cdot H_6\right]\cdot H_{15} \text{ if } (x \ge -0.04)\wedge(x < -0.02)\\
& \text{return } (H_5\cdot x + x)\cdot H_{15} \text{ if } (x \ge -0.02)\wedge(x < 0)\\
& \text{return } H_0\cdot x + x \text{ if } (x \ge 0)\wedge(x < 2)\\
& \text{return } 2H_0 + x + (x-2)\cdot H_1 \text{ if } (x \ge 2)\wedge(x < 4)\\
& \text{return } 2\cdot(H_0+H_1) + x + (x-4)\cdot H_2 \text{ if } (x \ge 4)\wedge(x < 6)\\
& \text{return } 2\cdot(H_0+H_1+H_2) + x + (x-6)\cdot H_3 \text{ if } (x \ge 6)\wedge(x < 8)\\
& \text{return } 2\cdot(H_0+H_1+H_2+H_3) + x + (x-8)\cdot H_4 \text{ if } (x \ge 8)\wedge(x < 10)\\
& \text{return } (x-10)\cdot H_4 + x \text{ if } (x \ge 10)
\end{aligned}
$$

8. OHM External Calibration Data Management

CAL:EXT:OHM:NUMBER?

Returns a range of calibration constant numbers.

Response example #1	Response example #2	Comments
300, 303	300, 303	Range of calibration records numbers

CAL:EXT:OHM:NUMBER {<begin>,<end>}

Limits the output to the specified range of constants ID (numbers): from <begin> to <end>

CAL:EXT:OHM:RAM {<number>,<value>}

Sets a new <value> for the calibration constant <number>
Example: CAL:EXT:OHM:RAM 300,+10.0000E+00

CAL:EXT:OHM:EEPROM:DEF?

Response example #1	Response example #2	Offs	Comments
300 +9.99977321E+03	300 +9.99952959E+03	$0	Internal reference value (10 kΩ)
301 +1.00000290E+04	301 +1.00000690E+04	$8	Calibration value of reference standard
302 +3.86428613E+01	302 +3.72243752E+01	$10	Internal temperature, °C
303 2007/02/08 15:42	303 2016/12/12 15:17	$18	External calibration date / time

CAL:EXT:OHM:EEPROM:NEW?

Response example #1	Response example #2	Offs	Comments
300 +9.99977321E+03	300 +9.99952959E+03	$0	Internal reference value (10 kΩ)
301 +1.00000290E+04	301 +1.00000690E+04	$8	Calibration value of reference standard
302 +3.86428613E+01	302 +3.72243752E+01	$10	Internal temperature, °C
303 2007/02/08 15:42	303 2016/12/12 15:17	$18	External calibration date / time

CAL:EXT:OHM:EEPROM:REF?

Response example #1	Comments
1 +9.99977321E+03 +3.86428613E+01 2007/02/08 15:42	History of 10 kΩ internal reference value drift, measured relative to external standard: Resistance / Temperature / Date / Time
2 +9.99977321E+03 +3.86428613E+01	
3 +9.99973868E+03 +3.97091317E+01	
4 +9.99973921E+03 +3.67090937E+01	
5 -0.00000000E+00 -0.00000000E+00	
6 -0.00000000E+00 -0.00000000E+00	
7 -0.00000000E+00 -0.00000000E+00	
8 -0.00000000E+00 -0.00000000E+00	
9 -0.00000000E+00 -0.00000000E+00	
10 -0.00000000E+00 -0.00000000E+00	
11 -0.00000000E+00 -0.00000000E+00	
12 -0.00000000E+00 -0.00000000E+00	
13 -0.00000000E+00 -0.00000000E+00	
14 -0.00000000E+00 -0.00000000E+00	
15 -0.00000000E+00 -0.00000000E+00	
16 -0.00000000E+00 -0.00000000E+00	
17 -0.00000000E+00 -0.00000000E+00	
18 -0.00000000E+00 -0.00000000E+00	
19 -0.00000000E+00 -0.00000000E+00	
20 -0.00000000E+00 -0.00000000E+00	

Response example #1	Comments
1 +9.99952959E+03 +3.72243752E+01 2016/12/12 15:17	History of 10 kΩ internal reference value drift, measured relative to external standard: Resistance / Temperature / Date / Time
2 +9.99949833E+03 +4.16726650E+01	
3 +9.99948868E+03 +4.14877170E+01	
4 +9.99952981E+03 +3.73168979E+01	
5 +9.99952959E+03 +3.72243752E+01	
6 -0.00000000E+00 -0.00000000E+00	
7 -0.00000000E+00 -0.00000000E+00	
8 -0.00000000E+00 -0.00000000E+00	
9 -0.00000000E+00 -0.00000000E+00	
10 -0.00000000E+00 -0.00000000E+00	
11 -0.00000000E+00 -0.00000000E+00	
12 -0.00000000E+00 -0.00000000E+00	
13 -0.00000000E+00 -0.00000000E+00	
14 -0.00000000E+00 -0.00000000E+00	
15 -0.00000000E+00 -0.00000000E+00	
16 -0.00000000E+00 -0.00000000E+00	
17 -0.00000000E+00 -0.00000000E+00	
18 -0.00000000E+00 -0.00000000E+00	
19 -0.00000000E+00 -0.00000000E+00	
20 -0.00000000E+00 -0.00000000E+00	

9. OHM Internal Calibration Data Management

CAL:INT:OHM:NUMBER?

Returns a range of calibration constant numbers.

Response example #1	Response example #2	Comments
500, 518	500, 518	Range of calibration records numbers

CAL:INT:OHM:NUMBER {<begin>,<end>}

Limits the output to the specified range of constants ID (numbers): from <begin> to <end>

CAL:INT:OHM:RAM {<number>,<value>}

Sets a new <value> for the calibration constant <number>
Example: CAL:INT:OHM:RAM 500,-9.8E-03

CAL:INT:OHM:EEPROM:DEF?

Response example #1	Response example #2	Offs	Comments
500 -9.80715725E-03	500 -9.85943251E-03	$0	–10 mA current source value
501 -9.80715725E-03	501 -9.85943251E-03	$8	–10 mA current source value
502 -9.80715725E-03	502 -9.85943251E-03	$10	–10 mA current source value
503 -9.80899738E-04	503 -9.86572452E-04	$18	–1 mA current source value
504 -9.80839829E-05	504 -9.87230144E-05	$20	–100 µA current source value
505 -9.80063022E-06	505 -9.86525412E-06	$28	–10 µA current source value
506 -9.81219362E-07	506 -9.87430770E-07	$30	–1 µA current source value
507 -9.81667237E-08	507 -9.87155715E-08	$38	–100 nA current source value
508 -9.84351639E-09	508 -9.83443983E-09	$40	–10 nA current source value
509 +9.99734614E+05	509 +9.99977811E+05	$48	1 MΩ current shunt value
510 +9.99917163E+04	510 +9.99804345E+04	$50	100 kΩ current shunt value
511 +9.99977321E+03	511 +9.99952959E+03	$58	10 kΩ current shunt value
512 +9.99708600E+02	512 +9.99564207E+02	$60	1 kΩ current shunt value
513 +9.99071650E+01	513 +9.98800937E+01	$68	100 Ω current shunt value
514 +1.00059513E+01	514 +1.00097063E+01	$70	10 Ω current shunt value
515 +1.00084819E+00	515 +1.00121618E+00	$78	1 Ω current shunt value
516 +1.00019134E-01	516 +1.00079407E-01	$80	0.1 Ω current shunt value
517 +3.81707628E+01	517 +3.74894282E+01	$88	Internal temperature, °C
518 2007/02/09 15:07	518 2016/12/12 15:57	$90	Internal calibration date / time

CAL:INT:OHM:EEPROM:NEW?

Response example #1	Response example #2	Offs	Comments
500 -9.80686681E-03	500 -9.85531683E-03	$0	–10 mA current source value
501 -9.80686681E-03	501 -9.85531683E-03	$8	–10 mA current source value
502 -9.80686681E-03	502 -9.85531683E-03	$10	–10 mA current source value
503 -9.80865187E-04	503 -9.86449035E-04	$18	–1 mA current source value
504 -9.80799917E-05	504 -9.87267067E-05	$20	–100 µA current source value
505 -9.80022925E-06	505 -9.86597154E-06	$28	–10 µA current source value
506 -9.81203879E-07	506 -9.87508751E-07	$30	–1 µA current source value
507 -9.81666603E-08	507 -9.87276661E-08	$38	–100 nA current source value
508 -9.84202301E-09	508 -9.83615616E-09	$40	–10 nA current source value
509 +9.99839252E+05	509 +1.00003663E+06	$48	1 MΩ current shunt value
510 +9.99941047E+04	510 +9.99824393E+04	$50	100 kΩ current shunt value
511 +9.99977321E+03	511 +9.99952959E+03	$58	10 kΩ current shunt value
512 +9.99708344E+02	512 +9.99559323E+02	$60	1 kΩ current shunt value
513 +9.99072073E+01	513 +9.98800711E+01	$68	100 Ω current shunt value
514 +1.00061834E+01	514 +1.00099565E+01	$70	10 Ω current shunt value
515 +1.00092634E+00	515 +1.00125331E+00	$78	1 Ω current shunt value
516 +1.00013775E-01	516 +1.00081985E-01	$80	0.1 Ω current shunt value
517 +4.42724801E+01	517 +4.44351352E+01	$88	Internal temperature, °C
518 2022/07/03 12:11	518 2022/07/03 12:12	$90	Internal calibration date / time

CAL:INT:OHM:RAM?

Response example #1	Response example #2	Offs	Defaults	Comments
500 -9.80686681E-03	500 -9.85531683E-03	$0	-0.01	–10 mA current source value
501 -9.80686681E-03	501 -9.85531683E-03	$8	-0.01	–10 mA current source value
502 -9.80686681E-03	502 -9.85531683E-03	$10	-0.01	–10 mA current source value
503 -9.80865187E-04	503 -9.86449035E-04	$18	-0.001	–1 mA current source value
504 -9.80799917E-05	504 -9.87267067E-05	$20	-0.0001	–100 µA current source value
505 -9.80022925E-06	505 -9.86597154E-06	$28	-0.00001	–10 µA current source value
506 -9.81203879E-07	506 -9.87508751E-07	$30	-0.000001	–1 µA current source value
507 -9.81666603E-08	507 -9.87276661E-08	$38	-1.0e-7	–100 nA current source value
508 -9.84202301E-09	508 -9.83615616E-09	$40	-1.0e-8	–10 nA current source value
509 +9.99839252E+05	509 +1.00003663E+06	$48	1000000.0	1 MΩ current shunt value
510 +9.99941047E+04	510 +9.99824393E+04	$50	100000.0	100 kΩ current shunt value
511 +9.99977321E+03	511 +9.99952959E+03	$58	10000.0	10 kΩ current shunt value
512 +9.99708344E+02	512 +9.99559323E+02	$60	1000.0	1 kΩ current shunt value
513 +9.99072073E+01	513 +9.98800711E+01	$68	100.0	100 Ω current shunt value
514 +1.00061834E+01	514 +1.00099565E+01	$70	10.0	10 Ω current shunt value
515 +1.00092634E+00	515 +1.00125331E+00	$78	1.0	1 Ω current shunt value
516 +1.00013775E-01	516 +1.00081985E-01	$80	0.1	0.1 Ω current shunt value
517 +4.42724801E+01	517 +4.44351352E+01	$88	23.0	Internal temperature, °C
518 2022/07/03 12:11	518 2022/07/03 12:12	$90	' '	Internal calibration date / time

10. AC Calibration Data Management

CAL:INT:AC:NUMBER?

Returns a range of calibration constant numbers.

Response example #1	Response example #2	Comments
600, 646	600, 646	Range of calibration records numbers

CAL:INT:AC:NUMBER {<begin>,<end>}

Limits the output to the specified range of constants ID (numbers): from <begin> to <end>

CAL:INT:AC:RAM {<number>,<value>}

Sets a new <value> for the calibration constant <number>
Example: CAL:INT:AC:RAM 600,+1.27E+02

CAL:INT:AC:EEPROM:DEF?

Response example #1	Response example #2	Offs	Cal. step / Comments
600 +1.25000000E+02	600 +1.28000000E+02	$0	#1 DAC U508: Amp offset coarse
601 +1.17000000E+02	601 +1.28000000E+02	$8	#2 DAC U508: Amp offset fine
602 +1.41000000E+02	602 +1.28000000E+02	$10	#3 DAC U508: offset comp.
603 +1.05000000E+02	603 +1.28000000E+02	$18	#4 DAC U508: offset comp.
604 +1.75000000E+02	604 +1.28000000E+02	$20	#5 DAC U508: offset comp.
605 +1.05000000E+02	605 +1.28000000E+02	$28	#6 DAC U508: offset comp.
606 +2.15950000E+03	606 +2.04800000E+03	$30	#10 DAC U502: 10mV Range FREQ
607 +2.59800000E+03	607 +2.04800000E+03	$38	#7 DAC U502: 100mV Range FREQ
608 +1.67700000E+03	608 +2.04800000E+03	$40	#13 DAC U502: 1000mV Range FREQ
609 +1.95100000E+03	609 +2.04800000E+03	$48	#16 DAC U502: 10V Range FREQ
610 +2.63200000E+03	610 +2.04800000E+03	$50	#19 DAC U502: 100V Range FREQ
611 +2.63200000E+03	611 +2.04800000E+03	$58	#22 DAC U502: 100V Range FREQ (copying $50)
612 -9.85393998E-02	612 -1.00000000E-01	$60	#27 Internal Gain -0.1V (selfcal source)
613 -9.79860071E-01	613 -1.00000000E+00	$68	#26 Internal Gain -1V (selfcal source)
614 -9.80077814E+00	614 -1.00000000E+01	$70	#25 Internal Gain -10V (selfcal source)
615 -1.00584669E+00	615 -1.00000000E+00	$78	#34 AC/DC Gain (5 iterations)
616 -1.00001216E+00	616 -1.00000000E+00	$80	#36 AC/DC Gain (2 iterations)
617 -9.99948454E-01	617 -1.00000000E+00	$88	#38 AC/DC Gain
618 +2.17862504E-02	618 +2.19780000E-02	$90	#39 10mV Range Gain (calc. only)
619 +1.25000000E+02	619 +1.28000000E+02	$98	#11 DAC U508: Amp offset coarse
620 +9.70000000E+01	620 +1.28000000E+02	$A0	#12 DAC U508: Amp offset fine
621 +1.08913762E-01	621 +1.09900000E-01	$A8	#39 100mV Range Gain (calc. only)
622 +1.25000000E+02	622 +1.28000000E+02	$B0	#8 DAC U508: Amp offset coarse
623 +1.19000000E+02	623 +1.28000000E+02	$B8	#9 DAC U508: Amp offset fine
624 +5.04321182E-01	624 +5.00000000E-01	$C0	#39 1000mV Range Gain (calc. only)
625 +1.25000000E+02	625 +1.28000000E+02	$C8	#14 DAC U508: Amp offset coarse
626 +1.27000000E+02	626 +1.28000000E+02	$D0	#15 DAC U508: Amp offset fine
627 +4.98810247E+00	627 +5.00000000E+00	$D8	#39 10V Range Gain (calc. only)
628 +1.25000000E+02	628 +1.28000000E+02	$E0	#17 DAC U508: Amp offset coarse
629 +1.21000000E+02	629 +1.28000000E+02	$E8	#18 DAC U508: Amp offset fine
630 +5.32103523E+01	630 +5.00000000E+01	$F0	#39 100V Range Gain (calc. only)
631 +1.25000000E+02	631 +1.28000000E+02	$F8	#20 DAC U508: Amp offset coarse
632 +1.23000000E+02	632 +1.28000000E+02	$100	#21 DAC U508: Amp offset fine
633 +1.17025122E+02	633 +5.00000000E+02	$108	#39 750V Range Gain (calc. only)
634 +1.25000000E+02	634 +1.28000000E+02	$110	#23 DAC U508: Amp offset coarse
635 +1.23000000E+02	635 +1.28000000E+02	$118	#24 DAC U508: Amp offset fine
636 +4.56360562E+01	636 +0.00000000E+00	$120	#33 10mV Range
637 +9.12867691E+00	637 +0.00000000E+00	$128	#28 100mV Range
638 +1.97143920E+00	638 +0.00000000E+00	$130	#29 1000mV Range

Response example #1	Response example #2	Offs	Cal. step / Comments
639 +1.99321998E-01	639 +0.00000000E+00	$138	#30 10V Range
640 +1.86850585E-02	640 +0.00000000E+00	$140	#31 100V Range (80-times average)
641 +8.49594117E-03	641 +0.00000000E+00	$148	#32 750V Range (200-times average)
642 +1.00584127E+00	642 +0.00000000E+00	$150	#35 AC/DC Gain
643 -8.64861043E-06	643 +9.99000000E+02	$158	#37 AC/DC Gain
644 -3.70028005E-04	644 +9.99000000E+02	$160	#38 AC/DC Gain
645 +3.79829100E+01	645 +2.30000000E+01	$168	Internal temperature, °C
646 2007/02/09 15:13	646	$170	Internal calibration date / time

CAL:INT:AC:EEPROM:NEW?

Response example #1	Response example #2	Offs	Cal. step / Comments
600 +1.49000000E+02	600 +1.55000000E+02	$0	#1 DAC U508: Amp offset coarse
601 +1.57000000E+02	601 +1.49000000E+02	$8	#2 DAC U508: Amp offset fine
602 +1.41000000E+02	602 +1.43000000E+02	$10	#3 DAC U508: offset comp.
603 +1.05000000E+02	603 +1.05000000E+02	$18	#4 DAC U508: offset comp.
604 +7.30000000E+01	604 +8.50000000E+01	$20	#5 DAC U508: offset comp.
605 +1.03000000E+02	605 +1.01000000E+02	$28	#6 DAC U508: offset comp.
606 +2.13450000E+03	606 +2.14200000E+03	$30	#10 DAC U502: 10mV Range FREQ
607 +2.47400000E+03	607 +2.52100000E+03	$38	#7 DAC U502: 100mV Range FREQ
608 +1.63900000E+03	608 +1.66300000E+03	$40	#13 DAC U502: 1000mV Range FREQ
609 +1.93300000E+03	609 +1.93300000E+03	$48	#16 DAC U502: 10V Range FREQ
610 +2.63000000E+03	610 +2.63700000E+03	$50	#19 DAC U502: 100V Range FREQ
611 +2.63000000E+03	611 +2.63700000E+03	$58	#22 DAC U502: 100V Range FREQ (copying $50)
612 -9.85292264E-02	612 -9.90285082E-02	$60	#27 Internal Gain -0.1V (selfcal source)
613 -9.79846092E-01	613 -9.85294560E-01	$68	#26 Internal Gain -1V (selfcal source)
614 -9.80074257E+00	614 -9.85678013E+00	$70	#25 Internal Gain -10V (selfcal source)
615 -1.00626701E+00	615 -1.00621493E+00	$78	#34 AC/DC Gain (5 iterations)
616 -1.00000430E+00	616 -1.00001883E+00	$80	#36 AC/DC Gain (2 iterations)
617 -9.99072745E-01	617 -9.98997725E-01	$88	#38 AC/DC Gain
618 +2.18151117E-02	618 +2.18192738E-02	$90	#39 10mV Range Gain (calc. only)
619 +1.49000000E+02	619 +1.55000000E+02	$98	#11 DAC U508: Amp offset coarse
620 +1.39000000E+02	620 +1.35000000E+02	$A0	#12 DAC U508: Amp offset fine
621 +1.09114514E-01	621 +1.09091848E-01	$A8	#39 100mV Range Gain (calc. only)
622 +1.49000000E+02	622 +1.55000000E+02	$B0	#8 DAC U508: Amp offset coarse
623 +1.57000000E+02	623 +1.53000000E+02	$B8	#9 DAC U508: Amp offset fine
624 +5.05440418E-01	624 +5.05086560E-01	$C0	#39 1000mV Range Gain (calc. only)
625 +1.49000000E+02	625 +1.55000000E+02	$C8	#14 DAC U508: Amp offset coarse
626 +1.59000000E+02	626 +1.65000000E+02	$D0	#15 DAC U508: Amp offset fine
627 +4.99587560E+00	627 +4.99665901E+00	$D8	#39 10V Range Gain (calc. only)
628 +1.49000000E+02	628 +1.55000000E+02	$E0	#17 DAC U508: Amp offset coarse
629 +1.53000000E+02	629 +1.59000000E+02	$E8	#18 DAC U508: Amp offset fine
630 +5.32601987E+01	630 +5.32507583E+01	$F0	#39 100V Range Gain (calc. only)
631 +1.49000000E+02	631 +1.55000000E+02	$F8	#20 DAC U508: Amp offset coarse
632 +1.53000000E+02	632 +1.59000000E+02	$100	#21 DAC U508: Amp offset fine
633 +1.17128750E+02	633 +1.17104832E+02	$108	#39 750V Range Gain (calc. only)
634 +1.49000000E+02	634 +1.55000000E+02	$110	#23 DAC U508: Amp offset coarse
635 +1.53000000E+02	635 +1.59000000E+02	$118	#24 DAC U508: Amp offset fine
636 +4.55965740E+01	636 +4.55936597E+01	$120	#33 10mV Range
637 +9.11605904E+00	637 +9.11910983E+00	$128	#28 100mV Range
638 +1.96797549E+00	638 +1.96960407E+00	$130	#29 1000mV Range
639 +1.99103107E-01	639 +1.99097145E-01	$138	#30 10V Range
640 +1.86761292E-02	640 +1.86818099E-02	$140	#31 100V Range (80-times average)
641 +8.49231595E-03	641 +8.49512803E-03	$148	#32 750V Range (200-times average)
642 +1.00625298E+00	642 +1.00617126E+00	$150	#35 AC/DC Gain
643 -1.60863294E-04	643 -1.96218909E-04	$158	#37 AC/DC Gain
644 -1.94011139E-03	644 -2.16191860E-03	$160	#38 AC/DC Gain
645 +3.87268896E+01	645 +4.45201540E+01	$168	Internal temperature, °C
646 2022/02/18 14:24	646 2022/07/03 12:19	$170	Internal calibration date / time

CAL:INT:AC:RAM?

Response example #1	Response example #2	Offs	Defaults	Cal. step # / Comments
600 +1.49000000E+02	600 +1.55000000E+02	$0	128.0	#1 DAC U508: Amp offset coarse
601 +1.57000000E+02	601 +1.49000000E+02	$8	128.0	#2 DAC U508: Amp offset fine
602 +1.41000000E+02	602 +1.43000000E+02	$10	128.0	#3 DAC U508: offset comp.
603 +1.05000000E+02	603 +1.05000000E+02	$18	128.0	#4 DAC U508: offset comp.
604 +7.30000000E+01	604 +8.50000000E+01	$20	128.0	#5 DAC U508: offset comp.
605 +1.03000000E+02	605 +1.01000000E+02	$28	128.0	#6 DAC U508: offset comp.
606 +2.13450000E+03	606 +2.14200000E+03	$30	2048.0	#10 DAC U502: 10mV Range FREQ
607 +2.47400000E+03	607 +2.52100000E+03	$38	2048.0	#7 DAC U502: 100mV Range FREQ
608 +1.63900000E+03	608 +1.66300000E+03	$40	2048.0	#13 DAC U502: 1000mV Range FREQ
609 +1.93300000E+03	609 +1.93300000E+03	$48	2048.0	#16 DAC U502: 10V Range FREQ
610 +2.63000000E+03	610 +2.63700000E+03	$50	2048.0	#19 DAC U502: 100V Range FREQ
611 +2.63000000E+03	611 +2.63700000E+03	$58	2048.0	#22 DAC U502: 750V Range FREQ (copying from $50)
612 -9.85292264E-02	612 -9.90285082E-02	$60	-0.1	#27 Internal Gain -0.1V (selfcal source)
613 -9.79846092E-01	613 -9.85294560E-01	$68	-1.0	#26 Internal Gain -1V (selfcal source)
614 -9.80074257E+00	614 -9.85678013E+00	$70	-10.0	#25 Internal Gain -10V (selfcal source)
615 -1.00626701E+00	615 -1.00621493E+00	$78	-1.0	#34 AC/DC Gain (5 iterations)
616 -1.00000430E+00	616 -1.00001883E+00	$80	-1.0	#36 AC/DC Gain (2 iterations)
617 -9.99072745E-01	617 -9.98997725E-01	$88	-1.0	#38 AC/DC Gain
618 +2.18151117E-02	618 +2.18192738E-02	$90	0.021978	#39 10mV Range Gain (calc. only)
619 +1.49000000E+02	619 +1.55000000E+02	$98	128.0	#11 DAC U508: Amp offset coarse
620 +1.39000000E+02	620 +1.35000000E+02	$A0	128.0	#12 DAC U508: Amp offset fine
621 +1.09114514E-01	621 +1.09091848E-01	$A8	0.1099	#39 100mV Range Gain (calc. only)
622 +1.49000000E+02	622 +1.55000000E+02	$B0	128.0	#8 DAC U508: Amp offset coarse
623 +1.57000000E+02	623 +1.53000000E+02	$B8	128.0	#9 DAC U508: Amp offset fine
624 +5.05440418E-01	624 +5.05086560E-01	$C0	0.5	#39 1000mV Range Gain (calc. only)
625 +1.49000000E+02	625 +1.55000000E+02	$C8	128.0	#14 DAC U508: Amp offset coarse
626 +1.59000000E+02	626 +1.65000000E+02	$D0	128.0	#15 DAC U508: Amp offset fine
627 +4.99587560E+00	627 +4.99665901E+00	$D8	5.0	#39 10V Range Gain (calc. only)
628 +1.49000000E+02	628 +1.55000000E+02	$E0	128.0	#17 DAC U508: Amp offset coarse
629 +1.53000000E+02	629 +1.59000000E+02	$E8	128.0	#18 DAC U508: Amp offset fine
630 +5.32601987E+01	630 +5.32507583E+01	$F0	50.0	#39 100V Range Gain (calc. only)
631 +1.49000000E+02	631 +1.55000000E+02	$F8	128.0	#20 DAC U508: Amp offset coarse
632 +1.53000000E+02	632 +1.59000000E+02	$100	128.0	#21 DAC U508: Amp offset fine
633 +1.17128750E+02	633 +1.17104832E+02	$108	500.0	#39 750V Range Gain (calc. only)
634 +1.49000000E+02	634 +1.55000000E+02	$110	128.0	#23 DAC U508: Amp offset coarse
635 +1.53000000E+02	635 +1.59000000E+02	$118	128.0	#24 DAC U508: Amp offset fine
636 +4.55965740E+01	636 +4.55936597E+01	$120	0.0	#33 10mV Range
637 +9.11605904E+00	637 +9.11910983E+00	$128	0.0	#28 100mV Range
638 +1.96797549E+00	638 +1.96960407E+00	$130	0.0	#29 1000mV Range
639 +1.99103107E-01	639 +1.99097145E-01	$138	0.0	#30 10V Range
640 +1.86761292E-02	640 +1.86818099E-02	$140	0.0	#31 100V Range (80-times average)
641 +8.49231595E-03	641 +8.49512803E-03	$148	0.0	#32 750V Range (200-times average)
642 +1.00625298E+00	642 +1.00617126E+00	$150	0.0	#35 AC/DC Gain
643 -1.60863294E-04	643 -1.96218909E-04	$158	999.0	#37 AC/DC Gain
644 -1.94011139E-03	644 -2.16191860E-03	$160	999.0	#38 AC/DC Gain
645 +3.87268896E+01	645 +4.45201540E+01	$168	23.0	Internal temperature, °C
646 2022/02/18 14:24	646 2022/07/03 12:19	$170		Internal calibration date / time

11. AC Factory Calibration Data Management

CAL:INT:AC:HOSEI:NUMBER?

Returns a range of calibration constant numbers.

Response example #1	Response example #2	Comments
0, 29	0, 29	Range of calibration records numbers

CAL:INT:AC:HOSEI:NUMBER {<begin>,<end>}

Limits the output to the specified range of constants ID (numbers): from <begin> to <end>

CAL:INT:AC:HOSEI {<number>,<value>}

Sets a new <value> for the factory calibration constant <number>
Example: CAL:INT:AC:HOSEI 1,+1.01E+00

CAL:INT:AC:HOSEI?

Response example #1	Response example #2	Offs	Defaults	Comments
0 +1.00017000E+00	0 +1.00017000E+00	$0	0.9996	AC RAM:$88 AC/DC Gain mult.
1 +1.50000000E+00	1 +0.00000000E+00	$8	0.0	AC RAM:$30 10mV Range FREQ addon
2 -9.70000000E+01	2 +0.00000000E+00	$10	0.0	AC RAM:$38 100mV Range FREQ addon
3 -1.40000000E+01	3 +0.00000000E+00	$18	0.0	AC RAM:$40 1000mV Range FREQ addon
4 +1.00000000E+01	4 +0.00000000E+00	$20	20.0	AC RAM:$48 10V Range FREQ addon
5 +1.00000000E+00	5 +0.00000000E+00	$28	25.0	AC RAM:$50 100V Range FREQ addon
6 +0.00000000E+00	6 +0.00000000E+00	$30	25.0	
7 +1.00130000E+00	7 +9.96000000E-01	$38	0.9987	AC RAM:$90 10mV Range Gain mult.
8 +1.00097000E+00	8 +1.00070000E+00	$40	1.00042	AC RAM:$A8 100mV Range Gain mult.
9 +1.00035000E+00	9 +1.00015000E+00	$48	1.0	AC RAM:$C0 1000mV Range Gain mult.
10 +1.00021000E+00	10 +1.00000000E+00	$50	1.0	AC RAM:$D8 10V Range Gain mult.
11 +1.00022000E+00	11 +1.00000000E+00	$58	1.0	AC RAM:$F0 100V Range Gain mult.
12 +9.99200000E-01	12 +9.99340000E-01	$60	0.99943	AC RAM:$108 750V Range Gain mult.
13 +6.00000000E-06	13 +0.00000000E+00	$68	0.000004	10mV Range offset
14 +5.00000000E-06	14 +1.70000000E-05	$70	-0.000014	100mV Range offset
15 +2.00000000E-05	15 +0.00000000E+00	$78	0.0	1000mV Range offset
16 -1.00000000E-04	16 +0.00000000E+00	$80	0.0	10V Range offset
17 +2.00000000E-03	17 +0.00000000E+00	$88	0.0	100V Range offset
18 -8.00000000E-02	18 +0.00000000E+00	$90	0.0	750V Range offset
19 +1.00102000E+00	19 +1.00080000E+00	$98	1.0017	ACI 100uA Range Gain mult.
20 +1.00112000E+00	20 +1.00080000E+00	$A0	1.0017	ACI 1000uA Range Gain mult.
21 +1.00099000E+00	21 +1.00080000E+00	$A8	1.0017	ACI 10mA Range Gain mult.
22 +1.00086000E+00	22 +1.00080000E+00	$B0	1.0017	ACI 100mA Range Gain mult.
23 +9.99880000E-01	23 +1.00080000E+00	$B8	1.0017	ACI 1000mA Range Gain mult.
24 +9.00000000E-09	24 +0.00000000E+00	$C0	0.0	ACI 100uA Range offset
25 +1.40000000E-07	25 +0.00000000E+00	$C8	0.0	ACI 1000uA Range offset
26 +6.00000000E-07	26 +0.00000000E+00	$D0	0.0	ACI 10mA Range offset
27 +5.00000000E-06	27 +0.00000000E+00	$D8	0.0	ACI 100mA Range offset
28 +8.00000000E-05	28 +0.00000000E+00	$E0	0.0	ACI 1000mA Range offset
29 2005/03/03 13:46	29 2016/12/12 14:40	$E8		Storing date / time

12. EEPROM Update Commands

CAL:EXT:EEPROM:STORE {ON|1|OFF|0}

ON|1 – sequentially transfers blocks of calibration data from EEPROM:NEW to EEPROM:DEF, from RAM to EEPROM:NEW and updates ":REF" logs and checksums in EEPROM.

CAL:INT:DCV:HOSEI:STORE {ON|1|OFF|0}

Move all DCV:HOSEI factory calibration data from RAM to EEPROM with updated checksum.

CAL:INT:AC:HOSEI:STORE {ON|1|OFF|0}

Move all AC:HOSEI factory calibration data from RAM to EEPROM with updated checksum and starts ACV internal calibration.

13. Hardware Control Commands

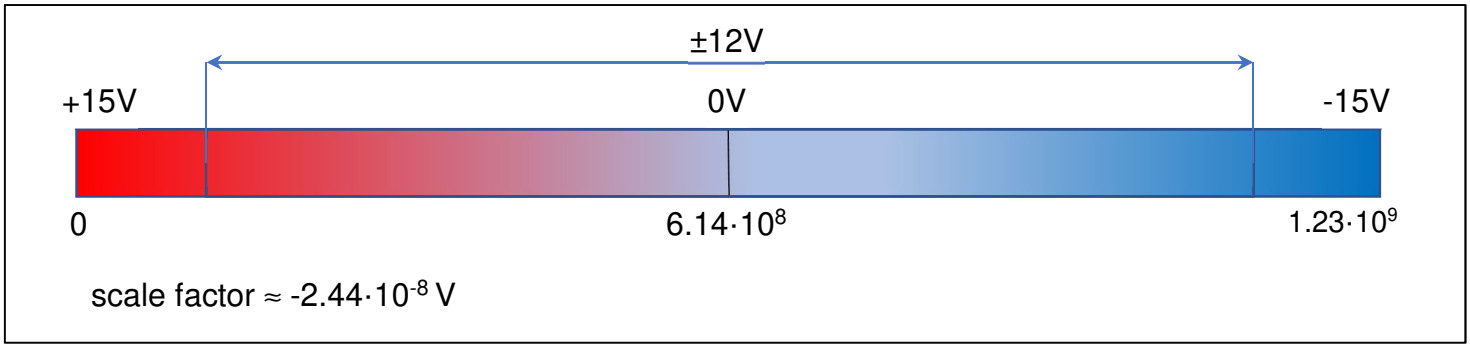
WR {#TRG;|#RST;|#RDT;|<packet>|#H<hex_packet>}

#TRG; – pulse TRIG line (0FFh–>FPGA_Reg11)
#RST; – pulse RES line (0FFh–>FPGA_Reg13)
#RDT; – read 16-bit packet from analog board
packet – a 16-bit packet sent to the analog board (0…65535)
hex_packet – a 16-bit packet sent to the analog board (0…FFFF)

13.1. A/D conversion command sequence

Step	Input string	Action	Output data	Comment
1	:INIT:CONT OFF	Write to DMM		blocking the internal trigger
2	WR #TRG;	Write to DMM		start conversion
3		Wait for conversion end		
4	WR #RDT;	Write to DMM		read higher 16 bit of A/D result
5		Read from DMM	0…65535	16-bit unsigned int
6	WR #H7000	Write to DMM		read lower 16 bit of A/D result
7	WR #RDT;	Write to DMM		
8		Read from DMM	0…65535	16-bit unsigned int

Relationship between input voltage range and ADC output code (PLC10)



scale factor ≈ $-2.44 \cdot 10^{-8}$ V

13.2. ADC integration time setup commands

Index	Tint, s	PLC	Command word #1		Command word #2	
			50 Hz Mains	60 Hz Mains	50 Hz Mains	60 Hz Mains
0	0.000001		$5000		$5400	
1	0.000002		$5001		$5400	
2	0.000003		$5002		$5400	
3	0.000004		$5003		$5400	
4	0.000005		$5004		$5400	
5	0.000006		$5005		$5400	
6	0.000007		$5006		$5400	
7	0.000008		$5007		$5400	
8	0.000009		$5008		$5400	
9	0.00001		$5009		$5400	
10	0.00002		$5250		$5401	
11	0.00003		$5250		$5402	
12	0.00004		$5250		$5403	
13	0.00005		$5250		$5404	
14	0.00006		$5250		$5405	
15	0.00007		$5250		$5406	
16	0.00008		$5250		$5407	
17	0.00009		$5250		$5408	
18	0.0001		$5250		$5409	
19	0.0002		$51A1		$5401	
20	0.0003		$51A1		$5402	

Index	Tint, s	PLC	Command word #1		Command word #2	
			50 Hz Mains	60 Hz Mains	50 Hz Mains	60 Hz Mains
21	0.0004		$51A1		$5403	
22	0.0005		$51A1		$5404	
23	0.0006		$51A1		$5405	
24	0.0007		$51A1		$5406	
25	0.0008		$51A1		$5407	
26	0.0009		$51A1		$5408	
27	0.001		$51A1		$5409	
28	0.002		$51A1		$5411	
29	0.003		$51A1		$5412	
30	0.004		$51A1		$5413	
31	0.005		$51A1		$5414	
32	0.006		$51A1		$5415	
33	0.007		$51A1		$5416	
34	0.008		$51A1		$5417	
35	0.009		$51A1		$5418	
36	0.01		$51A1		$5419	
37	0.02	1	$51A3	$5163	$5420	$5420
38	0.04	2	$51A3	$5163	$5421	$5421
39	0.06	3	$51A3	$5163	$5422	$5422
40	0.08	4	$51A3	$5163	$5423	$5423
41	0.1	5	$51A3	$5163	$5424	$5424
42	0.12	6	$51A3	$5163	$5425	$5425
43	0.14	7	$51A3	$5163	$5426	$5426
44	0.16	8	$51A3	$5163	$5427	$5427
45	0.18	9	$51A3	$5163	$5428	$5428
46	0.2	10	$51A3	$5163	$5429	$5429
47	0.2	20	$51A3	$5163	$5429	$5429
48	0.2	30	$51A3	$5163	$5429	$5429
49	0.2	40	$51A3	$5163	$5429	$5429
50	0.2	50	$51A3	$5163	$5429	$5429
51	0.2	60	$51A3	$5163	$5429	$5429
52	0.2	70	$51A3	$5163	$5429	$5429
53	0.2	80	$51A3	$5163	$5429	$5429
54	0.2	90	$51A3	$5163	$5429	$5429
55	0.2	100	$51A3	$5163	$5429	$5429

13.3. MUX U001 setup commands

Pin	Name	Command	Pin	Name	Command	Pin	Name	Command
1	OHM_HI	$4C05	5	DCI_1A	$4C15	9	-0.1/1/10V	$4C0E
2	OHM_LO	$4C09	6	Temp	$4C19	10	LO	$4C12
3	DCI_0.1uA-1uA	$4C0D	7	DCV	$4C06	11	HI_DIV	$4C16
4	DCI_10uA-0.1A	$4C11	8	+7.2V	$4C0A	12	AC	$4C1A

13.4. Input amplifier setup commands

№	Mode	Command	№	Mode	Command	№	Mode	Command
1	×1	$4401	2	×10	$4402	3	×100	$4404

13.5. Input relays setup commands

№	Name	Command	№	Name	Command	№	Name	Command
K001	HI Rear/Front		K006	HI		K011	-0.1/1/10V	
K002	LO Rear/Front		K007	OHM		K012	PROT	
K003			K008	V_HI		K013	LO-G	
K004	DCI/LO Front	$1801 $1802	K009	DIV	$1804			
K005	DCI/LO Rear		K010	AC_EN				

13.6. Voltage artifact source setup commands

№	Mode	Command	№	Mode	Command	№	Mode	Command
1	-10V	$4420	2	-1V	$4410	3	-0.1V	$4408

13.7. Various command sequences

Packet	Description	Comments
4800	ADC counters reset?	
5C01	Run A/D check 1 waveform	
5C02	Run A/D check 2 waveform	
5C04	Run A/D check 3 waveform	
5C08	Run A/D check 4 waveform	
5C10	Run A/D check 5 waveform	
1008	GUARD relay disable mask	
1010	GUARD relay enable mask	
1020	PROT relay enable mask	
1000	PROT relay disable mask	
1006	Input relay to FRONT mask	
1001	Input relay to REAR mask	
7801	Suspend ADC triggering?	DMM shows 0.000001 and halt
7800	Continue ADC triggering?	DMM continue measurement

14. DC Path Factory Calibration

14.1. Recommended equipment

ADC linearity	DC voltage	Resistance
Programmable DCV source (or DCV source + DMM) with ≤ 0.1 ppm INL at reference points (all ±1 %): -10, -8, -6, -4, -2, -0.1, -0.08, -0.06, -0.04, -0.02, +2, +4, +6, +8, +10 V	Precision DCV sources with short-term instability ≤ 0.1 ppm/10 sec : 100 mV ±1%, 1000 mV ±1%, 10 V ±1%	Resistance standards : 100 Ω ±1% ≤5 ppm/°C (4-wire), 10 kΩ ±1% ≤1 ppm/°C (4-wire), 1000 kΩ ±1% ≤5 ppm/°C (4-wire, shielded), 10 MΩ ±1% ≤10 ppm/°C (2-wire, shielded), 100 MΩ ±1% ≤50 ppm/°C (2-wire, shielded),
Low-thermal shorting plug (OPTIONAL)		

14.2. Enabling access to protected Service Mode commands

CAL:EXT:EEPROM:PROTECTION 1

14.3. ADC linearity adjustment

Input source	Adjustment step / Action / SCPI Command
Low-thermal shorting plug	1. External front and rear zero calibration (OPTIONAL)
–	2. DMM initialization: :INIT:CONT OFF :TRIG:SOUR BUS :ARM:PASS ON :ARM:LAY2:PASS ON :TRIG:PASS ON CONF:VOLT:DC VOLT:DC:RANG 10;NPLC 100 :SENS:VOLT:DC:DIG 8 :SENS:ZERO:AUTO ON
–	3. Resetting of correction factors in RAM: CAL:INT:DCV:HOSEI 0,0 CAL:INT:DCV:HOSEI 1,0 CAL:INT:DCV:HOSEI 2,0 CAL:INT:DCV:HOSEI 3,0 CAL:INT:DCV:HOSEI 4,0 CAL:INT:DCV:HOSEI 5,0 CAL:INT:DCV:HOSEI 6,0 CAL:INT:DCV:HOSEI 7,0 CAL:INT:DCV:HOSEI 8,0 CAL:INT:DCV:HOSEI 9,0 CAL:INT:DCV:HOSEI 10,0 CAL:INT:DCV:HOSEI 11,0 CAL:INT:DCV:HOSEI 12,0 CAL:INT:DCV:HOSEI 13,0 CAL:INT:DCV:HOSEI 14,0 CAL:INT:DCV:HOSEI 15,1
Programmable DCV source (actual voltage): set output to -10 V (X_M10V) set output to -8 V (X_M8V) set output to -6 V (X_M6V) set output to -4 V (X_M4V) set output to -2 V (X_M2V) set output to -0.1 V (X_M0V1) set output to -0.08 V (X_M0V08) set output to -0.06 V (X_M0V06) set output to -0.04 V (X_M0V04) set output to -0.02 V (X_M0V02) set output to 0 V (X_0V) set output to +2 V (X_P2V) set output to +4 V (X_P4V)	4. Obtaining measurement results at reference points using multiple READ? commands with 8x averaging: store result to Y_M10V variable store result to Y_M8V variable store result to Y_M6V variable store result to Y_M4V variable store result to Y_M2V variable store result to Y_M0V1 variable store result to Y_M0V08 variable store result to Y_M0V06 variable store result to Y_M0V04 variable store result to Y_M0V02 variable store result to Y_0V variable store result to Y_P2V variable store result to Y_P4V variable

Input source	Adjustment step / Action / SCPI Command
set output to +6 V (X_P6V) set output to +8 V (X_P8V) set output to +10 V (X_P10V)	store result to Y_P6V variable store result to Y_P8V variable store result to Y_P10V variable
–	5. Normalization of measurement results and calculation of absolute nonlinearity at reference points (in V): SCALE:=(X_P10V-X_0V)/(Y_P10V-Y_0V); OFFS:=X_0V-Y_0V; INL_0V:=Y_0V*SCALE+OFFS-X_0V; INL_P2V:=Y_P2V*SCALE+OFFS-X_P2V; INL_P4V:=Y_P4V*SCALE+OFFS-X_P4V; INL_P6V:=Y_P6V*SCALE+OFFS-X_P6V; INL_P8V:=Y_P8V*SCALE+OFFS-X_P8V; INL_P10V:=Y_P10V*SCALE+OFFS-X_P10V; NOFFS:=(Y_M10V*SCALE+OFFS-X_M10V-INL_0V)/-10; INL_M10V:= Y_M10V*SCALE+OFFS-X_M10V-X_M10V*NOFFS; INL_M8V:=Y_M8V*SCALE+OFFS-X_M8V-X_M8V*NOFFS; INL_M6V:=Y_M6V*SCALE+OFFS-X_M6V-X_M6V*NOFFS; INL_M4V:=Y_M4V*SCALE+OFFS-X_M4V-X_M4V*NOFFS; INL_M2V:=Y_M2V*SCALE+OFFS-X_M2V-X_M2V*NOFFS; INL_M0V1:=Y_M0V1*SCALE+OFFS-X_M0V1-X_M0V1*NOFFS; INL_M0V08:=Y_M0V08*SCALE+OFFS-X_M0V08-X_M0V08*NOFFS; INL_M0V06:=Y_M0V06*SCALE+OFFS-X_M0V06-X_M0V06*NOFFS; INL_M0V04:=Y_M0V04*SCALE+OFFS-X_M0V04-X_M0V04*NOFFS; INL_M0V02:=Y_M0V02*SCALE+OFFS-X_M0V02-X_M0V02*NOFFS;
–	6. Calculation of the coefficients of the nonlinearity correction function: H_0:=(INL_0V-INL_P2V)/2; H_1:=(INL_P2V-INL_P4V)/2; H_2:=(INL_P4V-INL_P6V)/2; H_3:=(INL_P6V-INL_P8V)/2; H_4:=-(H_0+H_1+H_2+H_3); H_5:=(INL_M0V02-INL_0V)/0.02; H_6:=(INL_M0V04-INL_M0V02)/0.02; H_7:=(INL_M0V06-INL_M0V04)/0.02; H_8:=(INL_M0V08-INL_M0V06)/0.02; H_9:=(INL_M0V1-INL_M0V08)/0.02; H_{10}:=(INL_M2V-INL_M0V1)/1.9; H_{11}:=(INL_M4V-INL_M2V)/2; H_{12}:=(INL_M6V-INL_M4V)/2; H_{13}:=(INL_M8V-INL_M6V)/2; H_{14}:=-0.01*(H_5+H_6+H_7+H_8+H_9)-0.95*H_{10}-(H_{11}+H_{12}+H_{13}); H_{15}:=1-NOFFS;
–	7. Updating of correction factors in RAM (where <H_i> is corresponding factor value): CAL:INT:DCV:HOSEI 0,<H_0> CAL:INT:DCV:HOSEI 1,<H_1> CAL:INT:DCV:HOSEI 2,<H_2> CAL:INT:DCV:HOSEI 3,<H_3> CAL:INT:DCV:HOSEI 4,<H_4> CAL:INT:DCV:HOSEI 5,<H_5> CAL:INT:DCV:HOSEI 6,<H_6> CAL:INT:DCV:HOSEI 7,<H_7> CAL:INT:DCV:HOSEI 8,<H_8> CAL:INT:DCV:HOSEI 9,<H_9> CAL:INT:DCV:HOSEI 10,<H_{10}> CAL:INT:DCV:HOSEI 11,<H_{11}> CAL:INT:DCV:HOSEI 12,<H_{12}> CAL:INT:DCV:HOSEI 13,<H_{13}> CAL:INT:DCV:HOSEI 14,<H_{14}> CAL:INT:DCV:HOSEI 15,<H_{15}>
–	8. Saving of correction factors to EEPROM: CAL:INT:DCV:HOSEI:STORE 1

14.4. DCV transfer adjustment

Input source	Adjustment step / Action / SCPI Command
–	1. DMM initialization: :INIT:CONT OFF :TRIG:SOUR BUS :ARM:PASS ON :ARM:LAY2:PASS ON :TRIG:PASS ON CONF:VOLT:DC VOLT:DC:RANG 10;NPLC 100 :SENS:VOLT:DC:DIG 8 :SENS:ZERO:AUTO ON
–	2. Resetting of correction factors in RAM: CAL:INT:DCV:HOSEI 16,1 CAL:INT:DCV:HOSEI 17,1 CAL:INT:DCV:HOSEI 18,1
–	3. Executing of internal DCV calibration (delay ~100 s): :CAL:INT:DCV
DCV source: set output to 1000 mV	4. Setting DMM to 10V range: VOLT:DC:RANG 10
	5. Obtaining measurement result at 1000 mV reference point using READ? commands with 8x averaging: store result to S1V_R10V variable
	6. Setting DMM to 1V range: VOLT:DC:RANG 1
	7. Obtaining measurement result at the same reference point using READ? commands with 8x averaging: store result to S1V_R1V variable
DCV source: set output to 100 mV	8. Obtaining measurement result at 100 mV reference point using READ? commands with 8x averaging: store result to S100mV_R1V variable
	9. Setting DMM to 100 mV range: VOLT:DC:RANG 0.1
	10. Obtaining measurement result at the same reference point using READ? commands with 16x averaging: store result to S100mV_R100mV variable
DCV source: set output to 10 V	11. Setting DMM to 10V range: VOLT:DC:RANG 10
	12. Obtaining measurement result at 10 V reference point using READ? commands with 4x averaging: store result to S10V_R10V variable
	13. Setting DMM to 100V range: VOLT:DC:RANG 100
	14. Obtaining measurement result at the same reference point using READ? commands with 20x averaging: store result to S10V_R100V variable
–	15. Calculation of the coefficients of the transfer error correction equations: H_{16}:=S1V_R10V/S1V_R1V; H_{17}:=S100mV_R1V/S100mV_R100mV; H_{18}:=S10V_R10V/S10V_R100V;
–	16. Updating of correction factors in RAM (where <H_i> is corresponding factor value): CAL:INT:DCV:HOSEI 16,<H_{16}> CAL:INT:DCV:HOSEI 17,<H_{17}> CAL:INT:DCV:HOSEI 18,<H_{18}>
–	17. Saving of correction factors to EEPROM:

Input source	Adjustment step / Action / SCPI Command
	CAL:INT:DCV:HOSEI:STORE 1 CAL:INT:DCV

14.5. Resistance transfer adjustment

Input source	Adjustment step / Action / SCPI Command
–	1. Resetting of correction factors in RAM: CAL:INT:DCV:HOSEI 19,1 CAL:INT:DCV:HOSEI 20,1 CAL:INT:DCV:HOSEI 21,1 CAL:INT:DCV:HOSEI 22,1 CAL:INT:DCV:HOSEI 23,1 CAL:INT:DCV:HOSEI 24,1
–	2. Executing of internal OHM calibration (duration ~170 s): CAL:INT:OHM
10 kΩ resistance standard, 4-wire	3. Setting DMM to 4-wire 10 kΩ range: :CONF:FRES :SENS:FRES:SOUR OCOM :SENS:FRES:SOUR:STAT ON :SENS:ZERO:AUTO ON :SENS:FRES:RANG 10000 :SENS:FRES:NPLC 100 :SENS:FRES:DIG 8
	4. Obtaining measurement result at 10 kΩ reference point using READ? commands with 8x averaging: store result to S10K_BEGIN variable
	5. Running of external calibration (delay ~170 s): CAL:EXT ON CAL:EXT:OHM <S10K_BEGIN> CAL:EXT OFF
	6. Obtaining measurement result at the same reference point using READ? commands with 8x averaging: store result to S10K_END variable
	7. Setting DMM to 4-wire 100 kΩ range: :SENS:FRES:RANG 100E3 :SENS:FRES:SOUR:STAT OFF
	8. Obtaining measurement result at the same reference point using READ? commands with 8x averaging: store result to S10K_R100K variable
100 Ω resistance standard, 4-wire	9. Setting DMM to 4-wire 1000 Ω range: :SENS:FRES:RANG 1000 :SENS:FRES:SOUR:STAT ON
	10. Obtaining measurement result at 100 Ω reference point using READ? commands with 8x averaging: store result to S100_R1K variable
	11. Setting DMM to 4-wire 100 Ω range: :SENS:FRES:RANG 100
	12. Obtaining measurement result at the same reference points using READ? commands with 8x averaging: store result to S100_R100 variable
1000 kΩ resistance standard, 4-wire, shielded	13. Setting DMM to 4-wire 1000 kΩ range: :SENS:FRES:RANG 1E6 :SENS:FRES:SOUR:STAT OFF
	14. Obtaining measurement result at 1000 kΩ reference point using READ? commands with 8x averaging: store result to S1000K_R1000K variable

Input source	Adjustment step / Action / SCPI Command
	15. Setting DMM to 2-wire 10 MΩ range, AZERO on: :CONF:RES :SENS:RES:RANG 10E6 :SENS:RES:NPLC 100 :SENS:RES:DIG 8 :SENS:ZERO:AUTO ON
	16. Obtaining measurement result at the same reference points using READ? commands with 8x averaging: store result to S1000K_R10M variable
10 MΩ resistance standard, 2-wire, shielded	17. Setting DMM to 2-wire 10 MΩ range, AZERO off, PROT off: :SENS:ZERO:AUTO OFF :SENS:RES:PROT OFF
	18. Obtaining measurement result at 10 MΩ reference point using READ? commands with 20x averaging: store result to S10M_R10M variable
	19. Setting DMM to 100 MΩ range, AZERO on: :SENS:RES:RANG 100E6 :SENS:ZERO:AUTO ON
	20. Wait 1 minute for transients to complete. Obtaining one measurement for AZERO refreshing
	21. Setting AZERO off: READ? :SENS:ZERO:AUTO OFF
	22. Obtaining measurement result at the same reference points using READ? commands with 40x averaging: store result to S10M_R100M variable
100 MΩ resistance standard, 2-wire, shielded	23. Obtaining measurement result at 100 MΩ reference point using 20-40 READ? commands with averaging: store result to S100M_R100M variable
	24. Setting DMM to 1000 MΩ range: :SENS:RES:RANG 1000E6
	25. Wait 1 minutes for transients to complete
	26. Obtaining measurement result at the same reference points using READ? commands with 40x averaging: store result to S100M_R1000M variable
	27. Restoring AZERO on, PROT on: :SENS:ZERO:AUTO ON :SENS:RES:PROT ON
–	28. Calculation of the coefficients of the transfer error correction equations: H_{19}:=S10K_END/S10K_BEGIN; H_{20}:=S100_R100/S100_R1K; H_{21}:=S10K_R100K/S10K_END; H_{22}:=S1000K_R10M/S1000K_R1000K; H_{23}:=S10M_R100M/S10M_R10M; H_{24}:=S100M_R1000M/S100M_R100M;
–	29. Updating of correction factors in RAM (where <H_i> is corresponding factor value): CAL:INT:DCV:HOSEI 19,<H_{19}> CAL:INT:DCV:HOSEI 20,<H_{20}> CAL:INT:DCV:HOSEI 21,<H_{21}> CAL:INT:DCV:HOSEI 22,<H_{22}> CAL:INT:DCV:HOSEI 23,<H_{23}> CAL:INT:DCV:HOSEI 24,<H_{24}>
–	30. Saving of correction factors to EEPROM: CAL:INT:DCV:HOSEI:STORE 1

14.6. Exiting from Service Mode

```
CAL:EXT:EEPROM:PROTECTION 0
:INIT:CONT ON
CONF:VOLT:DC
VOLT:DC:RANG 10;NPLC 10
:SENS:VOLT:DC:DIG 8
```

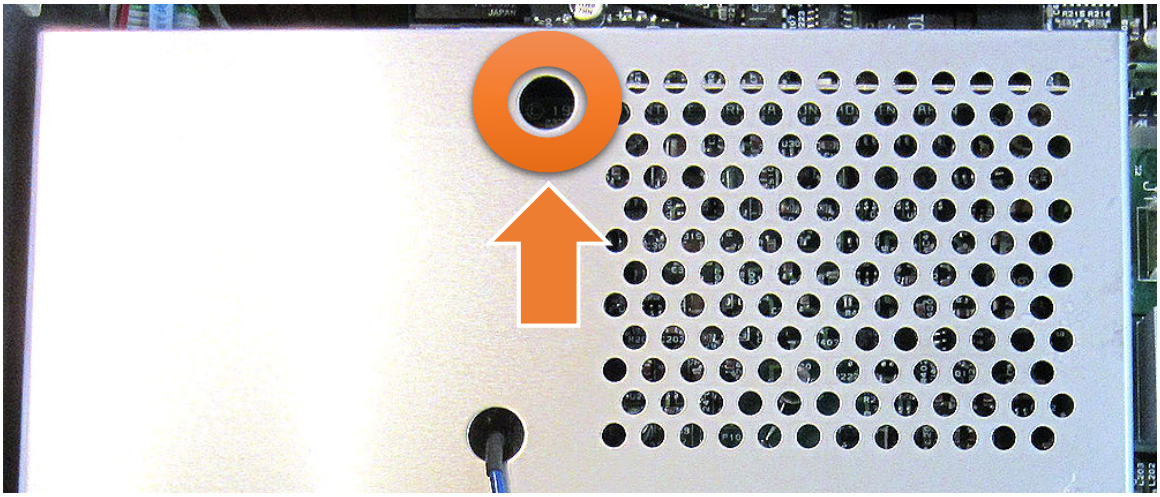
15. AC Path Factory Calibration

The section is in development

15.1. Recommended equipment

AC voltage and current	ACV frequency response	AC/DC gain

15.1. TrueRMS converter offset adjustment



15.2. ACV offset and gain adjustment

15.3. ACV frequency response adjustment

15.4. AC/DC gain adjustment

15.5. ACI offset and gain adjustment