HP 4286A RF LCR Meter

Technical Specifications

Specifications

Specifications describe the instrument's warranted performance over the temperature range of 0°C to 55°C (except as noted). Supplemental characteristics are intended to provide information that is useful in applying the instrument by giving non-warranted performance parameters. These are denoted as *typical*, *typically*, *nominal* or *approximate*. Warm up time must be greater than or equal to 30 minutes after power on for all specifications.

Specifications of the stimulus characteristics and measurement accuracy are defined at the tip of APC-7® connector of 3.5mm-7mm adapter connected to the test head.

Test Signal

Frequency Characteristics

Operating Frequency . . . . 1 MHz to 1000 MHz
A maximum of 10 frequencies can be programmed. An averaging factor can be set at each frequency point.
Frequency Resolution . . . . 10 kHz
Frequency Accuracy . . . . < ±10 ppm @23±5°C

Source Characteristics

Definition of OSC level

- Voltage level : 2 × voltage level across the 50 Ω which is connected to the output terminal. (this level is approximately equal to the level when a terminal is open)
- Current level : 2 × current level through the 50 Ω which is connected to the output terminal. (this level is approximately equal to the level when a terminal is shorted)
- Power level : when terminating with 50 Ω.

OSC Level

Voltage Range . . . . $10\ mV_{rms}$ to $1\ V_{rms}$
Current Range . . . . 200 µA to 20 mA
Power Range . . . . –33 dBm to +7 dBm

OSC Level Resolution

Voltage Resolution

@ 0.22 V < V_{osc} ≤ 1 V . . . . . 2 mV
@ 70 mV < V_{osc} ≤ 220 mV . . . . . 0.5 mV
@ 22 mV < V_{osc} ≤ 70 mV . . . . . 0.2 mV
@ 10 mV ≤ V_{osc} ≤ 22 mV . . . . . 0.05 mV

Current Resolution

@ 4.4 mA < I_{osc} ≤ 20 mA . . . . . 40 µA
@ 1.4 mA < I_{osc} ≤ 4.4 mA . . . . . 10 µA
@ 0.44 mA < I_{osc} ≤ 1.4 mA . . . . . 4 µA
@ 200 µA ≤ I_{osc} ≤ 440 µA . . . . . 1 µA

Power Resolution . . . . . 0.1 dBm

OSC Level Accuracy

Table 1. OSC Level Accuracy at Cable Length = 3 m, 23±5°C

Test Signal Voltage	Frequency Range	OSC Level Accuracy
0.5 V < V_{osc} ≤ 1 V	1 MHz ≤ frequency ≤ 500 MHz	±2 dB
	500 MHz < f ≤ 1000 MHz	+3 dB/–10 dB[1]
0.25 V ≤ V_{osc} ≤ 0.5 V	1 MHz ≤ frequency ≤ 1000 MHz	±2 dB
0.01 V ≤ V_{osc} < 0.25 V	1 MHz ≤ frequency ≤ 1000 MHz	±3 dB

1 Typical data at temperature range is 5 through +40°C

Table 2. OSC Level Accuracy at Cable Length = 3 m, 0°C to +55°

Test Signal Voltage	Frequency Range	OSC Level Accuracy	
		5°C to 40°C	0°C to 55°C
0.5 V < V_{osc} ≤ 1 V	1 MHz ≤ frequency ≤ 500 MHz	±4 dB	±6 dB
	500 MHz < frequency ≤ 1000 MHz	+3 dB/–10 dB[1]	+5 dB/–12 dB[1]
0.25 V ≤ V_{osc} ≤ 0.5 V	1 MHz ≤ frequency ≤ 1000 MHz	±4 dB	±6 dB
0.01 V ≤ V_{osc} < 0.25 V	1 MHz ≤ frequency ≤ 1000 MHz	±5 dB	±7 dB

1 Typical value

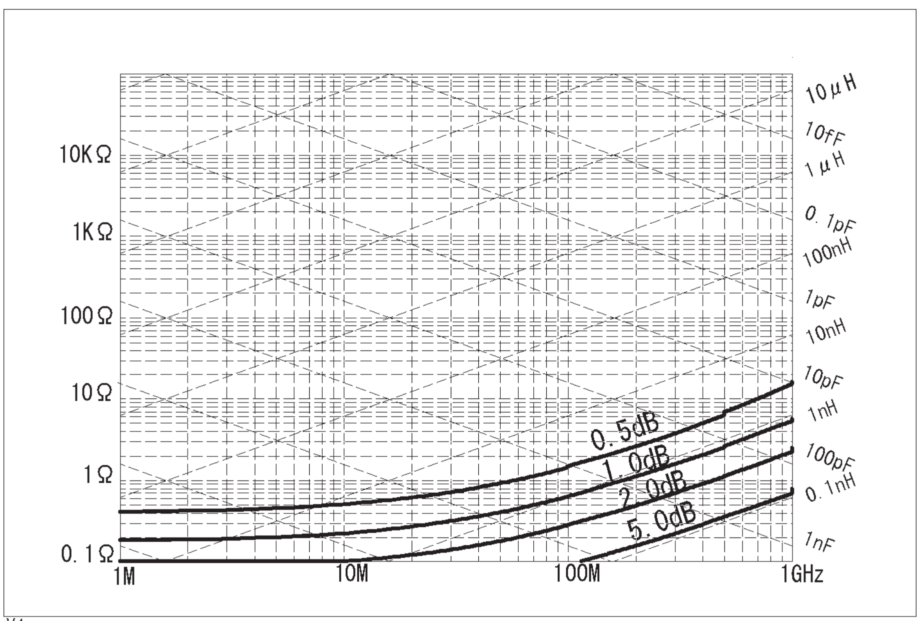
Table 3. OSC Level Accuracy at Cable Length = 1 m, 23±5°C

Test Signal Voltage	Frequency Range	OSC Level Accuracy
0.5 V < V_{osc} ≤ 1 V	1 MHz ≤ frequency ≤ 1000 MHz	±2 dB
0.25 V ≤ V_{osc} ≤ 0.5 V	1 MHz ≤ frequency ≤ 1000 MHz	±2 dB
0.01 V ≤ V_{osc} < 0.25 V	1 MHz ≤ frequency ≤ 1000 MHz	±3 dB

Table 4. OSC Level Accuracy at Cable Length = 1 m, 0°C to +55°

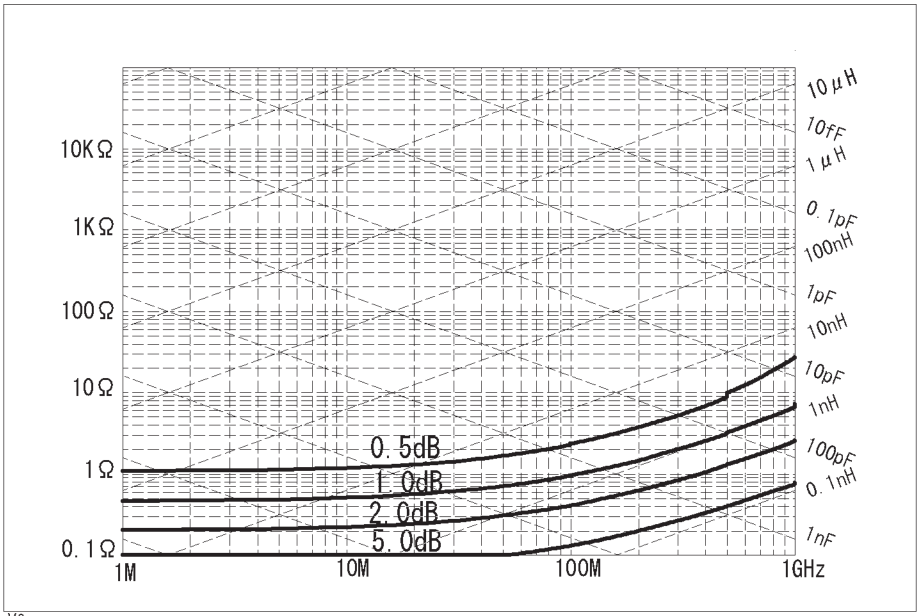
Test Signal Voltage	Frequency Range	OSC Level Accuracy	
		5°C to 40°C	0°C to 55°C
$0.5\ V < V_{osc} \leq 1\ V$	1 MHz ≤ frequency ≤ 1000 MHz	±4 dB	±6 dB
$0.25\ V \leq V_{osc} \leq 0.5\ V$	1 MHz ≤ frequency ≤ 1000 MHz	±4 dB	±6 dB
$0.01\ V \leq V_{osc} < 0.25\ V$	1 MHz ≤ frequency ≤ 1000 MHz	±5 dB	±7 dB

Typical OSC Level Accuracy . . . . 2 times of specification value
Connector . . . . APC-3.5®
Output Impedance . . . . 50 Ω (Nominal Value)
Level Monitor
Monitor Parameters . . . . OSC level (voltage, current)
Monitor Accuracy
Voltage . . . . $20\log(1 + Y_0 \cdot 50 + Z_s/Z_x + E_a\,(\%) / 100)$ [dB] (Typical)
Current . . . . $20\log(1 + Y_0 \cdot Z_x + Z_s/50 + E_a\,(\%) /100)$ [dB] (Typical)
Where,
$\mathbf{E_a}$: depends on measurement frequency and connector type. See measurement accuracy.
$\mathbf{Z_s}$ **and** $\mathbf{Y_0}$: depend on number of point averaging and OSC level. See measurement accuracy
$\mathbf{Z_x}$: Measurement impedance



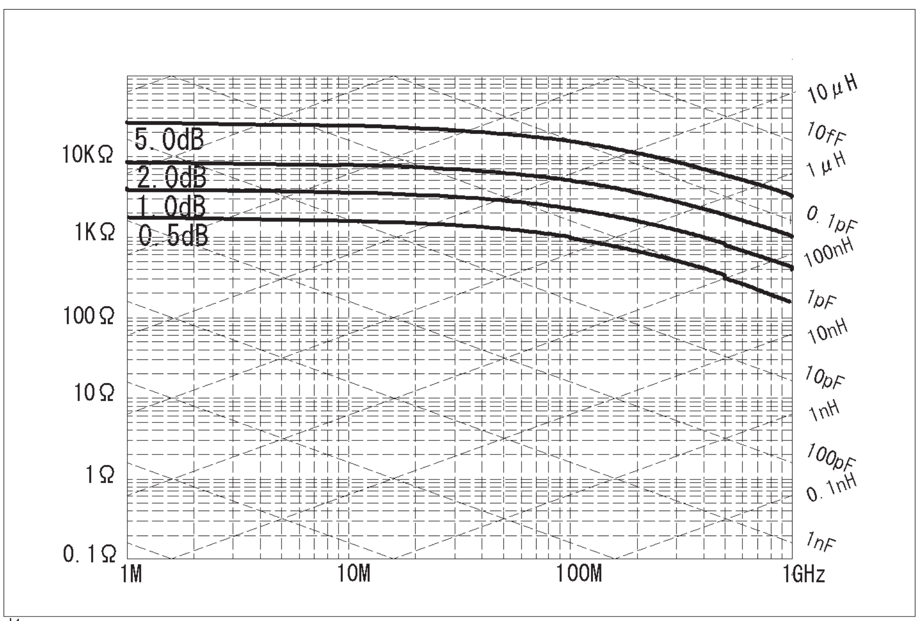
V4

Figure 1. Typical Voltage Level Monitor Accuracy (@N_{av} =8, V_{osc} = 0.2 V)



V2

Figure 2. Typical Voltage Level Monitor Accuracy (@N_{av} =1, V_{osc} = 0.2 V)



I4

Figure 3. Typical Current Level Monitor Accuracy (@N_{av} =8, V_{osc} = 0.2 V)

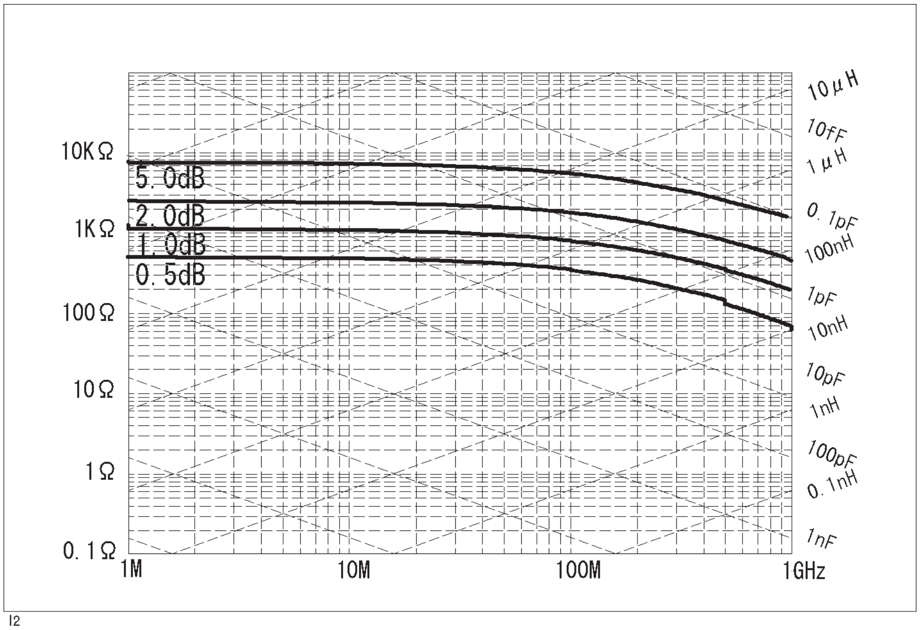


Figure 4. Typical Current Level Monitor Accuracy (@N_{av} =1, V_{osc} = 0.2 V)

Measurement Function

Measurement Parameters

. . . . L_p-D, L_p-Q, L_p-G, L_p-R_p, L_s-D, L_s-Q, L_s-R_s, R-X, |Z|-θ_{rad}, |Z|-θ_{deg}, C_p-D, C_p-Q, C_p-G, C_p-R_p, C_s-D, C_s-Q, C_s-R_s, G-B, |Y|-θ_{rad}, |Y|-θ_{deg}

Measurement Range

Impedance

@ 1MHz, accuracy < 10%, $N_{av} \geq 8$, $V_{osc} \geq 0.2$ V . . . . 200 mΩ to 3 kΩ

Inductance

@ Q < 100, depends on frequency . . . . 1 nH to 100 µH

Contact Check Function

Measurement Current . . . . < 1 mA

List Sweep Characteristics

Sweep Mode . . . . Continuous, Single, Manual
Sweep Direction . . . . Up sweep
Number of Measurement Point . . . . 1 to 10 points
Averaging . . . . Point average
Delay Time . . . . Point delay time, Sweep delay time

Calibration / Compensation Function

Calibration Function . . . . Open/Short/50 Ω calibration, Low loss calibration
Compensation Function . . . . Open/Short/Load compensation, Port extension, Electric length
Calibration Measurement Points

Fixed Cal

This calibration measures the following FIXED points :

1.0	1.03	1.06	1.09	1.12	1.15	1.18	1.21	1.24	1.26
1.29	1.32	1.35	1.38	1.41	1.44	1.47	1.5	1.55	1.6
1.65	1.7	1.75	1.8	1.85	1.9	1.95	2.0	2.1	2.2
2.3	2.4	2.5	2.6	2.8	3.0	3.2	3.4	3.6	3.8
4.0	4.2	4.4	4.6	4.8	5.0	5.5	6.0	6.5	7.0
7.5	8.0	9.0	10	10	12	13	14	15	16
18	20	22	24	26	28	30	33	36	39
42	45	48	51	55	60	65	70	75	80
85	90	95	100	100	120	130	140	150	160
170	180	190	200	210	220	230	240	250	260
270	280	290	300	310	320	330	340	350	360
370	380	390	400	410	420	430	440	450	460
470	480	490	500	510	520	530	540	550	560
570	580	590	600	610	620	630	640	650	660
670	680	690	700	710	720	730	740	750	760
770	780	790	800	810	820	830	840	850	860
870	880	890	900	910	920	930	940	950	960
970	980	990	1000						(UNIT:MHz)

User Cal

SPACEFILL This calibration measures the frequency points that are defined by the list sweep table.

Measurement Accuracy

Conditions of accuracy specifications

- Open/Short/50 Ω calibration must be done. Calibration ON.
- Averaging (on point) factor is larger than 32 at which calibration is done if Cal points is set to USER DEF.
- Measurement points are same as the calibration points.
- Environment temperature is within ±5°C of temperature at which calibration is done, and within 13°C to 33°C. Beyond this environmental temperature condition, accuracy is twice as bad as specified.
- 7 mm connector is used.
- When the analyzer frequency is identical to the transmitted interference signal frequency, refer to "EMC" in "General Characteristics".

Contact Check Measurement Accuracy

@ measurement range : 0.1 Ω to 100 Ω, resolution : 1 mΩ $\pm\{3 + (25\text{m}\Omega/R_{dut} + R_{dut}/10\text{k}\Omega) \times 100\}$ [%]

|Z|, |Y| Accuracy . . . . $\pm(E_a + E_b)$ [%]

θ Accuracy . . . . $\pm\dfrac{(E_a + E_b)}{100}$ [rad]

L, C, X, B Accuracy . . . . $\pm(E_a + E_b) \times \sqrt{(1 + D_x^2)}$ [%]

R, G Accuracy . . . . $\pm(E_a + E_b) \times \sqrt{(1 + Q_x^2)}$ [%]

D Accuracy (ΔD)

@$|D_x \tan\dfrac{(E_a + E_b)}{100}| < 1$ . . . . $\pm\dfrac{(1 + D_x^2)\tan(\frac{E_a + E_b}{100})}{1 \mu D_x \tan(\frac{E_a + E_b}{100})}$

Especially, @ $D_x \leq 0.1$ . . . . $\pm\dfrac{(E_a + E_b)}{100}$

Q Accuracy (ΔQ)

@$|Q_x \tan\dfrac{(E_a + E_b)}{100}| < 1$ . . . . $\pm\dfrac{(1 + Q_x^2)\tan(\frac{E_a + E_b}{100})}{1 \mu Q_x \tan(\frac{E_a + E_b}{100})}$

Especially, @ $\dfrac{10}{(E_a + E_b)} \geq Q_x \geq 10$ . . . . $\pm Q_x^2 \dfrac{(E_a + E_b)}{100}$

Where,

E_a : depends on measurement frequency as follows:

1 MHz≤Frequency≤100 MHz . . . . $0.65 + \frac{0.03}{V_{osc}}$ [%]

100 MHz<Frequency≤500 MHz . . . . $0.8 + \frac{0.03}{V_{osc}}$ [%]

500 MHz<Frequency≤1000 MHz . . . . $1.2 + \frac{0.03}{V_{osc}}$ [%]

E_b : $(Z_s/|Z_x| + Y_0|Z_x|) \times 100$ [%]

V_{osc} : OSC level [V]

Z_x : impedance measurement value [Ω]

Z_s and **Y_o** depend on number of point averaging (N_{av}) and OSC level (V_{osc}) as follows:

Measurement Conditions		Z_s [mΩ]	Y_o [μS]
Number of Point Averaging (N_{av})	**OSC Signal Level (V_{osc})**		
$1 \le N_{av} \le 7$	$0.2\ V \le V_{osc} \le 1\ V$	$50 + 1 \times f_{[MHz]}$	$100 + 0.4 \times f_{[MHz]}$
	$0.01\ V \le V_{osc} < 0.2\ V$	$\frac{0.2}{V_{OSC}} \times (50 + 1 \times f_{[MHz]})$	$\frac{0.2}{V_{OSC}} \times (100 + 0.4 \times f_{[MHz]})$
$N_{av} \ge 8$	$0.2\ V \le V_{osc} \le 1\ V$	$20 + 0.5 \times f_{[MHz]}$	$30 + 0.2 \times f_{[MHz]}$
	$0.01\ V \le V_{osc} < 0.2\ V$	$\frac{0.2}{V_{OSC}} \times (20 + 0.5 \times f_{[MHz]})$	$\frac{0.2}{V_{OSC}} \times (30 + 0.2 \times f_{[MHz]})$

At the following frequency points, instrument spurious characteristics could occasionally cause measurement errors to exceed specified value because of instrument spurious characteristics.

10.71 MHz	17.24 MHz	21.42 MHz	42.84 MHz
514.65 MHz	686.19 MHz		

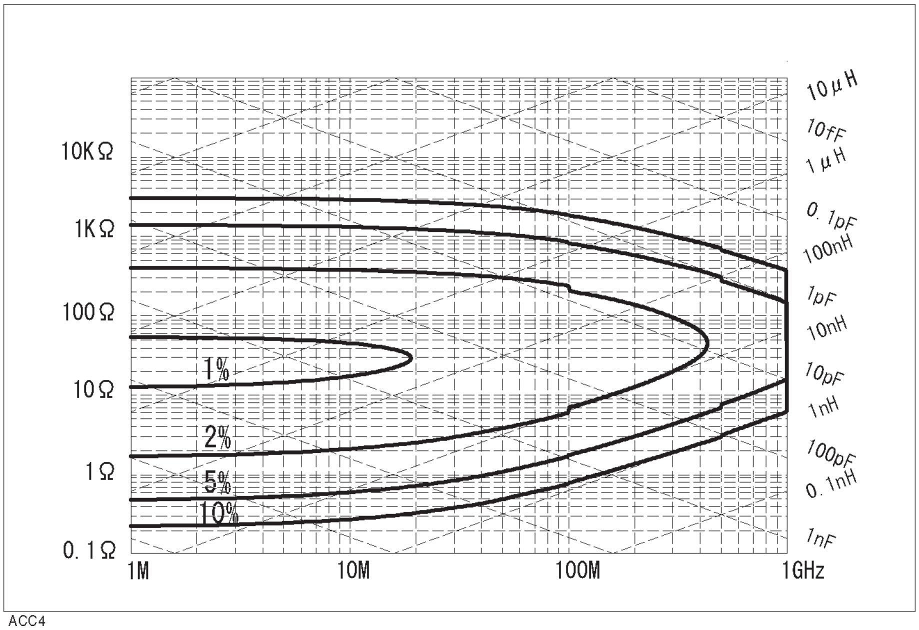


Figure 5. Measurement Accuracy (@N_{av} =8, V_{osc} = 0.2 V)

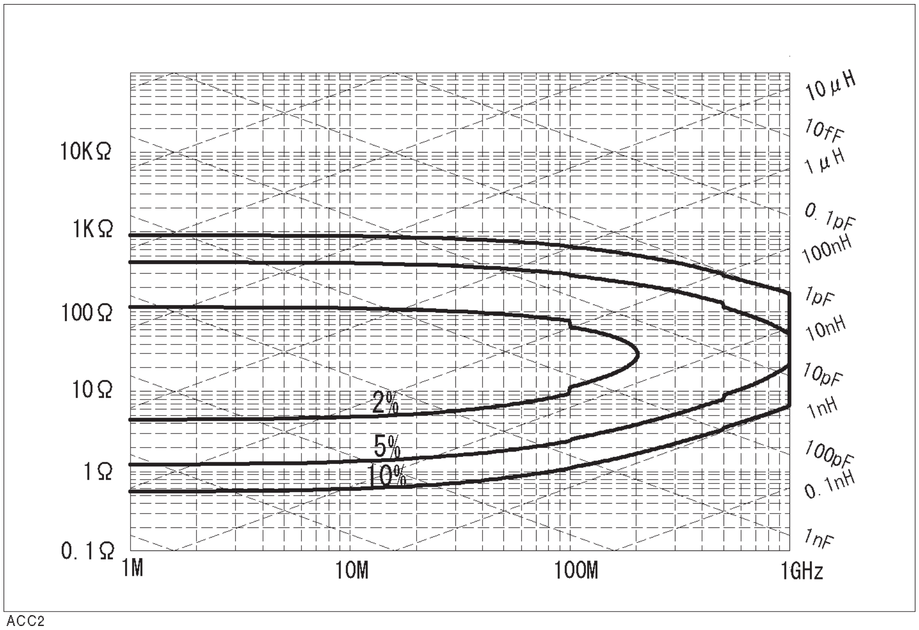


Figure 6. Measurement Accuracy (@N_{av} =1, V_{osc} = 0.2 V)

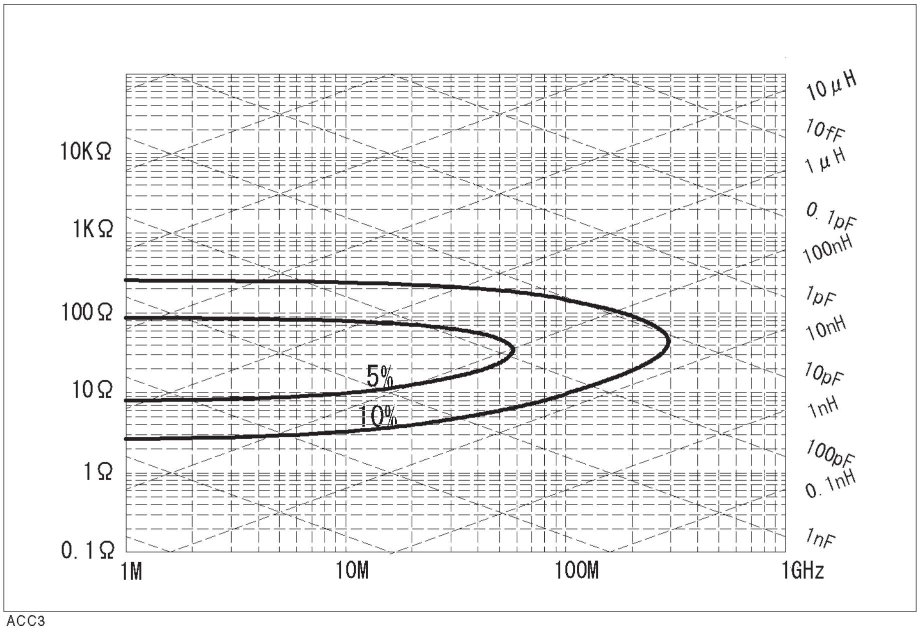


Figure 7. Measurement Accuracy (@N_{av} =8, V_{osc} = 0.02 V)

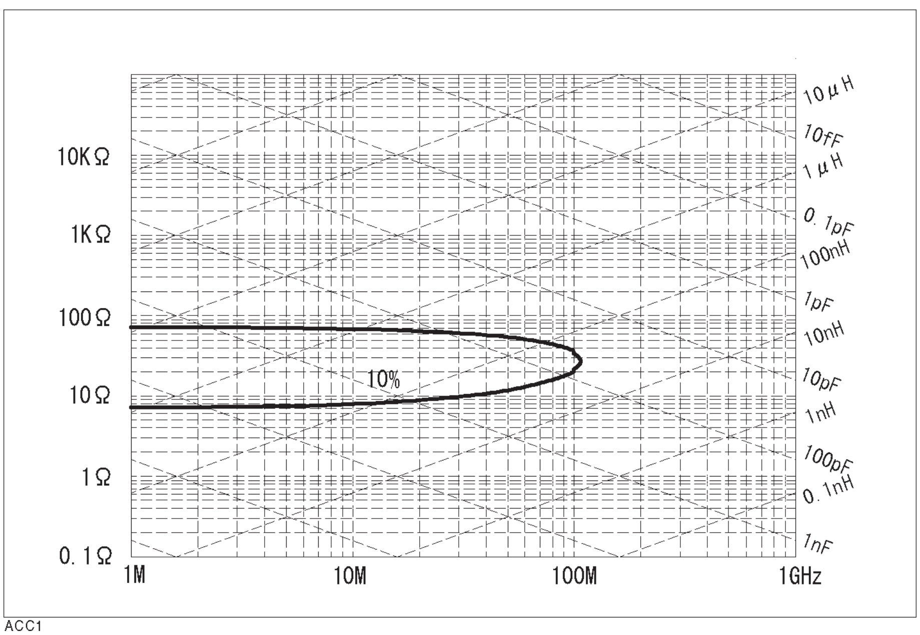


Figure 8. Measurement Accuracy (@N_{av} =1, V_{osc} = 0.02 V)

Typical Measurement Accuracy

Conditions of typical accuracy specifications

- Open/Short/50 Ω calibration must be done. Calibration ON.
- Averaging (on point) factor is larger than 32 at which calibration is done if Cal points is set to USER DEF.
- Measurement points are same as the calibration points.
- Environment temperature is within ±5°C of temperature at which calibration is done, and within 13°C to 33°C. Beyond this environmental temperature condition, accuracy is twice as bad as specified.
- 7 mm connector is used.

|Z|, |Y| Accuracy . . . . $\pm(E_a + E_b)$ [%]

θ **Accuracy** . . . . $\pm\frac{(E_a + E_b)}{100}$ [rad]

L, C, X, B Accuracy . . . . $\pm(E_a + E_b) \times \sqrt{(1 + D_x^2)}$ [%]

R, G Accuracy . . . . $\pm(E_a + E_b) \times \sqrt{(1 + Q_x^2)}$ [%]

D Accuracy (ΔD)

@ $|D_x \tan\frac{(E_a + E_b)}{100}| < 1$ . . . . $\pm\frac{(1 + D_x^2)\tan(\frac{E_a + E_b}{100})}{1 \mu D_x \tan(\frac{E_a + E_b}{100})}$

Especially, @ $D_x \leq 0.1$ . . . . $\pm\frac{(E_a + E_b)}{100}$

Q Accuracy (ΔQ)

@ $|Q_x \tan\frac{(E_a + E_b)}{100}| < 1$ . . . . $\pm\frac{(1 + Q_x^2)\tan(\frac{E_a + E_b}{100})}{1 \mu Q_x \tan(\frac{E_a + E_b}{100})}$

Especially, @ $\frac{10}{(E_a + E_b)} \geq Q_x \geq 10$ . . . . $\pm Q_x^2\frac{(E_a + E_b)}{100}$

Where,

E_a : depends on measurement frequency as follows:

1 MHz≤Frequency≤100 MHz . . . . $0.56 + 0.03\frac{0.03}{V_{osc}}$ [%] *(Typical)*

100 MHz<Frequency≤500 MHz . . . . $0.63 + 0.03\frac{0.03}{V_{osc}}$ [%] *(Typical)*

500 MHz<Frequency≤1000 MHz . . . . $0.70 + 0.03\frac{0.03}{V_{osc}}$ [%] *(Typical)*

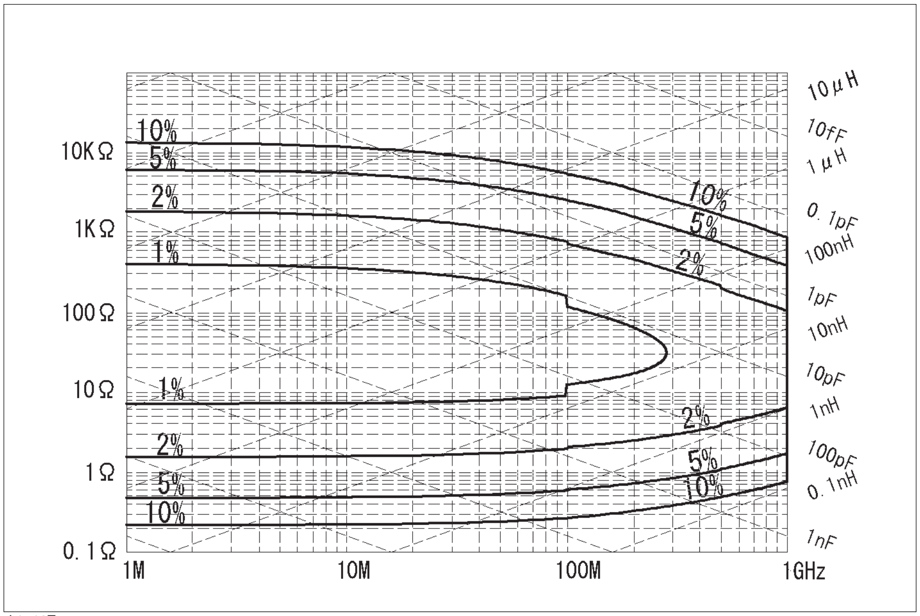
E_b : $(Z_s/|Z_x| + Y_0|Z_x|) \times 100$ [%]

V_{osc} : OSC level [V]

Z_x : impedance measurement value [Ω]

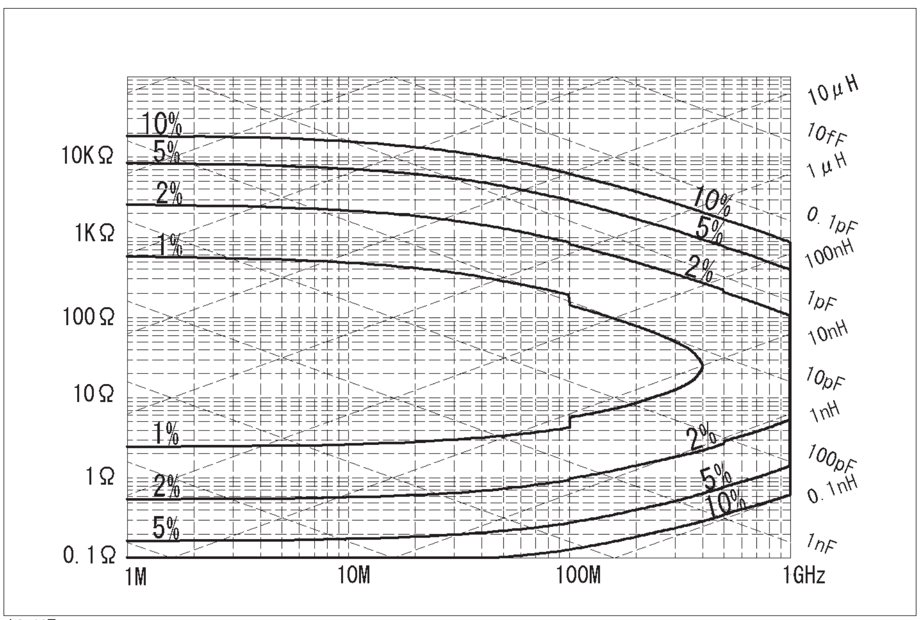
Z_s and **Y_o** depend on number of point averaging (N_{av}) and OSC level (V_{osc}) as follows:

Measurement Conditions		**Z_s [mΩ]**	**Y_o [µS]**
Number of Point Averaging (N_{av})	**OSC Signal Level (V_{osc})**	***(Typical)***	***(Typical)***
$1 \leq N_{av} \leq 7$	$0.2\ V \leq V_{osc} \leq 1\ V$	$20 + 0.05 \times f_{[MHz]}$	$7 + 0.1 \times f_{[MHz]}$
	$0.01\ V \leq V_{osc} < 0.2\ V$	$\frac{0.2}{V_{osc}} \times (20 + 0.05 \times f_{[MHz]})$	$\frac{0.2}{V_{osc}} \times (7 + 0.1 \times f_{[MHz]})$
$N_{av} \geq 8$	$0.2\ V \leq V_{osc} \leq 1\ V$	$7 + 0.05 \times f_{[MHz]}$	$5 + 0.1 \times f_{[MHz]}$
	$0.01\ V \leq V_{osc} < 0.2\ V$	$\frac{0.2}{V_{osc}} \times (7 + 0.05 \times f_{[MHz]})$	$\frac{0.2}{V_{osc}} \times (5 + 0.1 \times f_{[MHz]})$



L1_12T

Figure 9. Typical Measurement Accuracy (@N_{av} =1, V_{osc} = 0.2 V)



L8_12T

Figure 10. Typical Measurement Accuracy (@N_{av} =8, V_{osc} = 0.2 V)

Typical measurement accuracy when open/short/50 Ω/low-loss-capacitor calibration is done

Conditions

- Averaging on point factor is lager than 32 at which calibration is done.
- Cal Points is set to USER DEF.
- Environment temperature is within ±5 °C of temperature at which calibration is done, and within 13 °C to 33 °C. Beyond this environmental temperature condition, accuracy is twice as bad as specified.
- 7 mm connector is used.

|Z|, |Y| Accuracy . . . . $\pm(E_a + E_b)$ [%]

θ Accuracy . . . . $\pm \frac{E_c}{100}$ [rad]

L, C, X, B Accuracy . . . . $\pm \sqrt{(E_a + E_b)^2 + (E_c D_x)^2}$ [%]

R, G Accuracy . . . . $\pm \sqrt{(E_a + E_b)^2 + (E_c Q_x)^2}$ [%]

D Accuracy

@ $|D_x \tan(E_c/100)| < 1$ . . . . $\pm \frac{(1 + D_x^2)\tan(E_c/100)}{1 \mu D_x \tan(E_c/100)}$

Especially, $D_x \leq 0.1$ . . . . $\pm \frac{E_c}{100}$

Q Accuracy

@ $Q_x \tan(E_c/100)$ . . . . $\pm \frac{(1 + Q_x^2)\tan(E_c/100)}{1 \mu Q_x \tan(E_c/100)}$

Especially, $\frac{10}{E_c} \geq Q_x \geq 10$ . . . . $\pm Q_x^2 \frac{E_c}{100}$

Where,

D_x : Actual D value of DUT

E_a, E_b : are as same as E_a and E_b of the measurement accuracy when OPEN/SHORT/50 Ω calibration is done.

E_c $= 0.06 + 0.08 \times \frac{F}{1000}$ (Typical)

F : measurement frequency [MHz]

Q_x : Actual Q value of DUT

Trigger Function

Trigger Source . . . . Internal, Manual, External, Bus

Throughput

For a time from triggering to EOM . . . . $\leq$ 15 msec/point

Display

Type/Size . . . . Monochrome CRT. 7 inch, Text screen only
Resolution . . . . 512 dots × 304 lines

Data Storage

Type . . . . Built-in flexible disk drive, Battery backup SRAM disk memory
Capacity
Built-in flexible disk . . . . 720 kB/1.44 MB
Battery backup SRAM disk memory . . . . 256 kB
Operating time of battery backup SRAM disk memory . . . . 3 days
Disk format . . . . LIF, DOS

Interface

HP-IB

Interface . . . . IEEE 488.1-1987, IEC625, JIS C 1901-1987 standard compatible.
Interface function . . . . SH1, AH1, T6, TE0, L4, LE0, SR1, RL1, PPO, DC1, DT1, C1, C2, C3, C4, C11, E2
Numeric Data Transfer formats . . . . ASCII
32 and 64 bit IEEE 754 Floating point format,
DOS PC format (32 bit IEEE with byte order reversed)
Protocol . . . . IEEE 488.2-1987

Handler Interface

Interface . . . . All output signals are negative logic, opto-isolated open collector outputs.
Output Signals . . . . Sort Judgments (BIN1 to BIN9, AUX_BIN, OUT_OF_BIN, PHI, PLO, SREJ), Contact Check (NO_CONTACT), /FAIL, End Of Analog Processing (INDEX) , End-Of-Measurement (EOM), Power Line Fail (ALARM)
Input Signals . . . . External trigger (EXT_TRIG), Front panel key lock (KEY_LOCK)

Input Output Characteristics

External reference input

Frequency .... 10 MHz±100 Hz (typically)
Level .... > –6 dBm (typically)
Input impedance .... 50 Ω (nominal)
Connector .... BNC female

Internal Reference Output

Frequency .... 10 MHz (nominal)
Level .... 2 dBm (typically)
Output Impedance .... 50 Ω (nominal)
Connector .... BNC female

External trigger input

Level .... TTL Level
Pulse width (Tp) .... > 2 μs (typically)
Polarity .... positive/negative selective
Connector .... BNC female

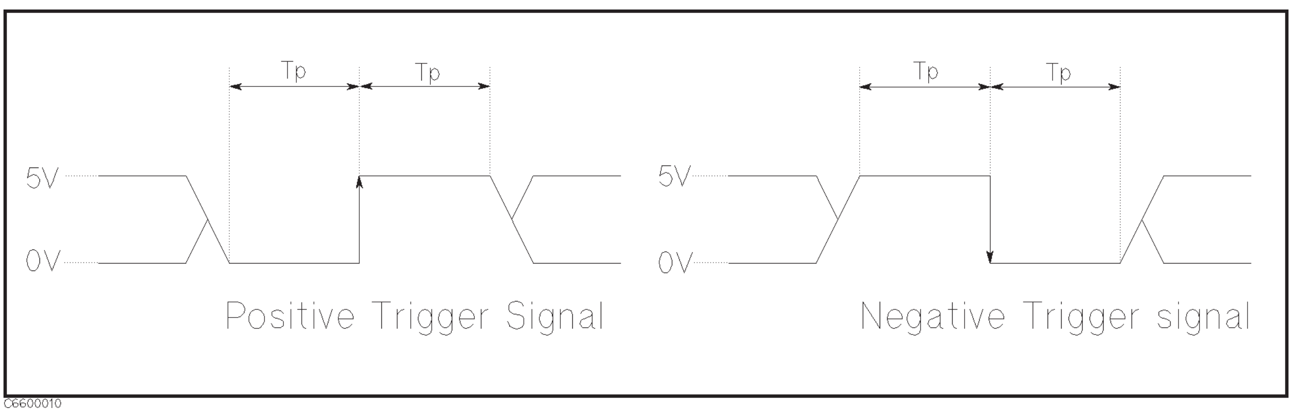


Figure 11. Trigger Signal

General Characteristics

Operation Conditions

Temperature

Disk drive non-operating condition .... 0°C to 55°C
Disk drive operating condition .... 10°C to 50°C

Humidity

@wet bulb temperature <29°C, without condensation

Disk drive non-operating condition .... 15 % to 95 % RH
Disk drive operating condition .... 15 % to 80 % RH

Altitude .... 0 to 2,000 meters
Warm up time .... 30 minutes

Non-operation conditions

Temperature . . . . –40°C to 65°C

Humidity

@wet bulb temperature . . . . 15 % to 95 % RH

Altitude . . . . 0 to 15,240 meters (50,000 feet)

Others

EMC . . . . Complies with CISPR 11 (1990) / EN 55011 (1991) : Group 1, Class A
Complies with IEC 801-2 (1991) / EN 50082-1 (1992) : 4 kV CD, 8 kV AD
Complies with IEC 801-3 (1984) / EN 50082-1 (1992) : 3 V/m
Complies with IEC 801-4 (1988) / EN 50082-1 (1992) : 1 kV Power lines / 0.5 kV Signallines

Note: When tested at 3 V/m according to IEC 801-3/1984, the measurement accuracy will be within specifications over the full immunity test frequency range of 26 to 1000 MHz except when the analyzer frequency is identical to the transmitted interference signal test frequency.

Safety . . . . Complies with EN61010-1:1993 + A2 / IEC61010-1:1990 + A1, A2
Pollution Degree 1
Certifies with CSA C22.2 N0.231-M89

Power requirements . . . . 90V to 132V, or 198V to 264V, 47 to 66 Hz, 500VA max

Weight

Mainframe . . . . 28 kg

Test head . . . . 0.3 kg

Dimensions

Mainframe . . . . 426 (W) × 234 (H) × 537 (D) mm

Test Head . . . . See Figure 12 and Figure 13.

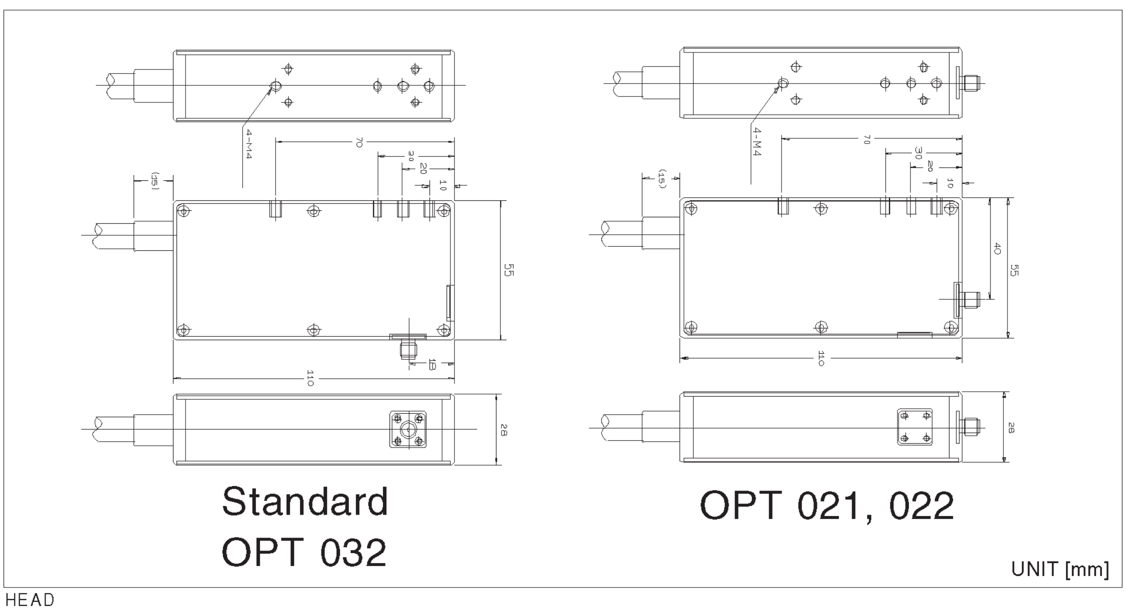


Figure 12. Dimensions of Test Heads (1/2)

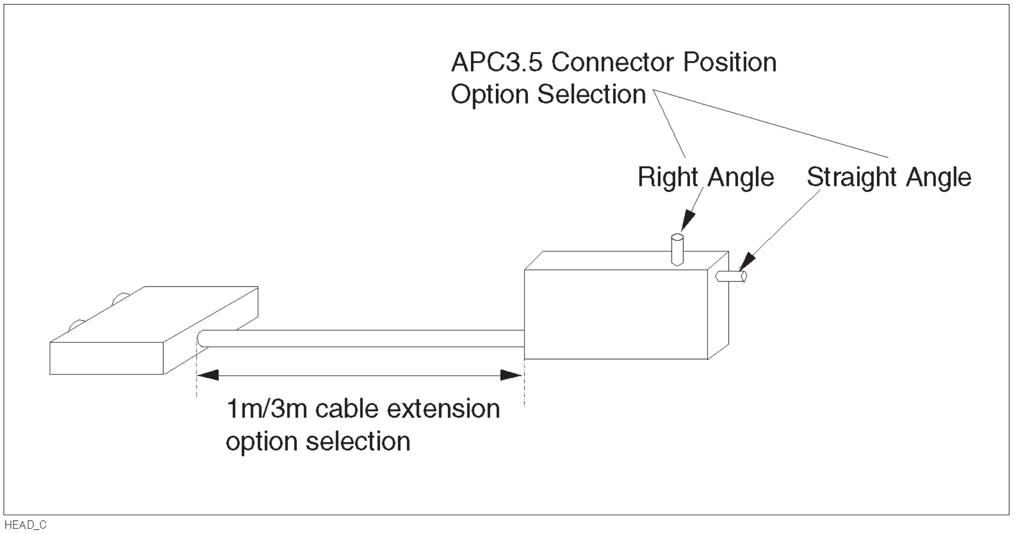


Figure 13. Dimensions of Test Heads (2/2)

Specification for Option 1C2 HP Instrument BASIC

External program Run/Cont input
- **Connector** . . . . . BNC female
- **Level** . . . . . TTL
- **Keyboard connector** . . . . . HP-HIL
- **I/O port** . . . . . 4 bit in/ 8 bit out port, TTL Level

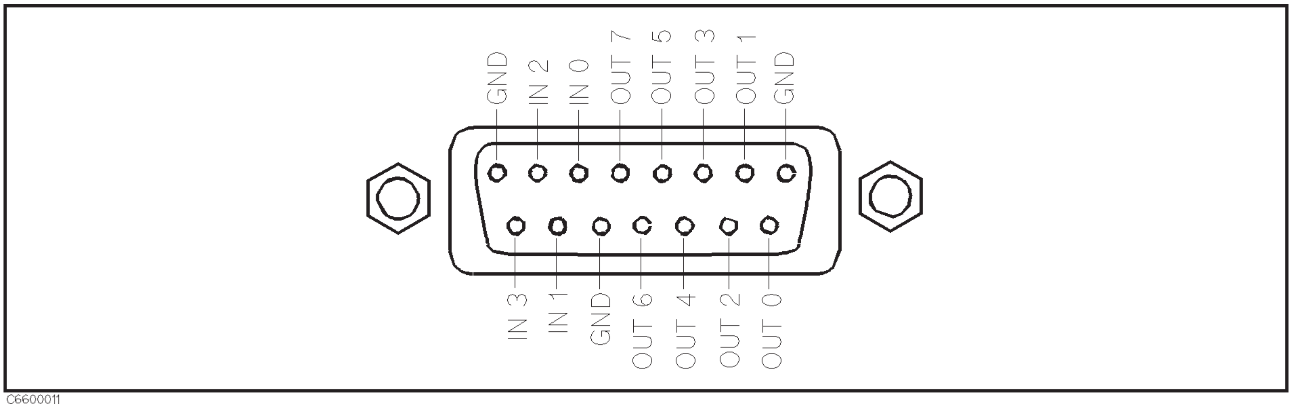


Figure 14. I/O Port Pin Assignment

I/O port pin assignments

Specification for Option 004 Working Standard

Supplied shorting device size
- P/N 16191-29005 . . . . . 1.0 × 0.5 mm
- P/N 16191-29006 . . . . . 1.6 × 0.8 mm
- P/N 16191-29007 . . . . . 2.0 × 1.25 mm
- P/N 16191-29008 . . . . . 3.2 × 1.6 mm

Supplied resistor size
- P/N 5182-0433 . . . . . 1.0 × 0.5 mm
- P/N 5182-0434 . . . . . 1.6 × 0.8 mm
- P/N 5182-0435 . . . . . 2.0 × 1.25 mm
- P/N 5182-0436 . . . . . 3.2 × 1.6 mm

DC resistance of supplied chip resistor . . . . . 51Ω ±0.5 %

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