VLBA ACQUISITION MEMO #191

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To: VLBA Data Acquisition Group

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Subject: "In-circuit" Component Measurements for BBCs

While it is recommended that all critical resistors and capacitors be checked before assembly it is often useful to be able to re-check components in place without unsoldering them. Many resistors can be measured "in-circuit" with a multimeter because they are isolated - this is the case for the precision resistors in the SSB mixer and filter boards. On the other hand, none of the capacitors can be checked with a simple capacitance meter in-circuit because they are imbedded in various resistive networks. Imbedded components can often be measured using a voltage-to-current transfer [for example, see Ansari, IEEE IM-38, No 4, 922, 1989] via a three-terminal probe. For example, if a very low impedance signal source drives an imbedded capacitor, the signal transfer into a very low impedance detector is uneffected by impedances shunting the ends of the capacitor to ground. The three-terminal probe shown in Figure 1A provides one such method as does the method of Ansari seen in Figure 1B. A variation of this method, shown in Figure 1C, is to measure the frequency which produces a null output. Another method of checking a capacitor is to measure its impedance at a high enough frequency to make the impedance of surrounding components much higher than the impedance of the capacitor. This type of measurement can be made with some component measurement systems like the HP4278A. Recent experience with careful checking of component values and matching mixers (see Acquisition Memo #183) is that the image rejection specification of 26 dB can be met. We should, however, consider obtaining some better component test instruments to make the production and maintenance easier. Also it would be useful to have a BBC available as a "reference" for comparison when another BBC fails to perform to specification.

Attachments (2)

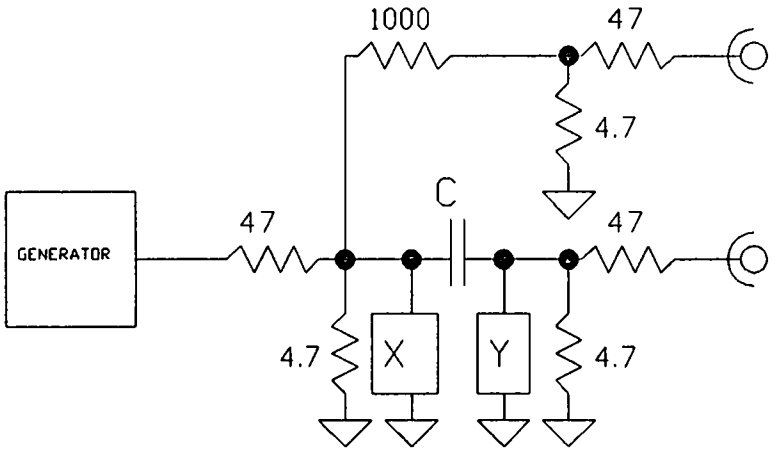


FIG. 1A Outputs are equal when 1/(wc)=1000 and are not sensitive to X and Y

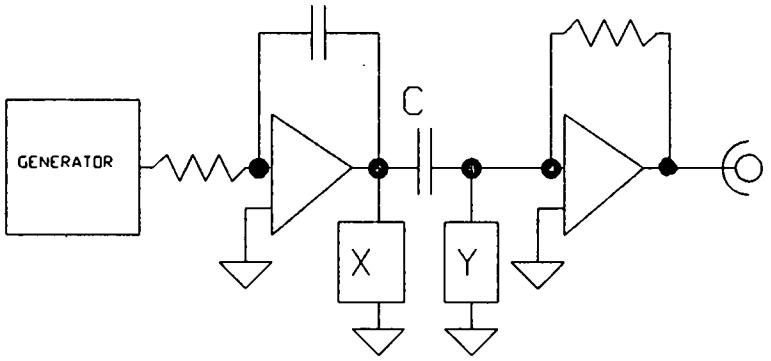


FIG. 1B Ansari method outputs depend only on C and are not sensitive to X and Y

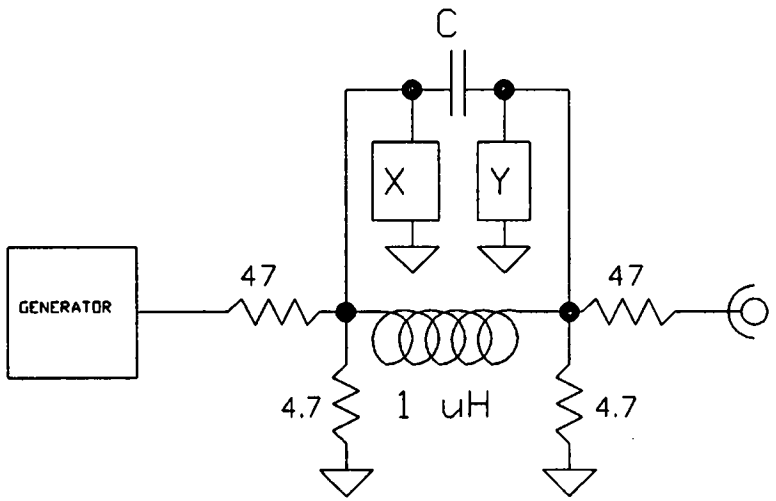


FIG. 1C Output null when $w^2LC = 1$ without dependence on X and Y

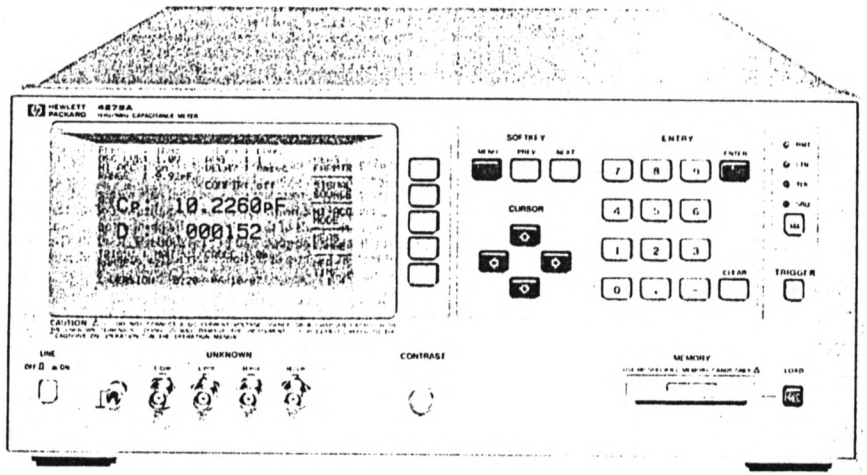
METHODS OF "IN-CIRCUIT" CAPACITANCE MEASUREMENT

COMPONENT MEASUREMENT

1 kHz / 1 MHz Capacitance Meter

Model 4278A

- Measurement Speed: 6.5ms/10ms/21ms
- Measurement Parameters: C-D•Q•ESR•G
- C-D Measurement Accuracy:
  0.07%, 0.0005(1kHz, 21ms)
  0.05%, 0.0002(1MHz, 21ms)
- High Resolution: 6 digit, D:0.00001
- Intelligent Built-in Comparator: 10-bin Sorting



HP 4278A

Description

The HP 4278A 1kHz/1MHz Capacitance Meter is a high speed, highly reliable, precision test instrument aimed at incoming/outgoing capacitor inspection applications on the production line and in quality control. The HP 4278A will improve test efficiency by performing comparative measurements of low to medium value capacitors (up to 200 μF—a range that covers most ceramic and film capacitors) several times faster than previously available capacitance meters.

The HP 4278A's standard measurement frequencies and oscillator output levels are 1kHz/1MHz and from 0.1V to 1V in 0.1V steps, respectively. The HP 4278A's ability to make precision capacitance measurements and to measure low dissipation values will give you an edge in improving the quality of your devices.

The built-in comparator function of the HP 4278A gives you the ability to sort parts into ten bins. A high speed HP-IB interface and an optional handler interface are available for combining the HP 4278A with an automatic handler and an external computer to build a total solution for automatic testing and data acquisition and analysis.

High Speed Measurements

One of the HP 4278A's main features is its selection of high measurement speeds: 6.5ms (153 measurements/sec), 10ms (100 measurements/sec), or 21ms (47 measurements/sec), with a fast settling time. Additionally, the HP 4278A's built-in comparator and high speed HP-IB interface make it possible to construct a measurement system using an automatic handler and an external computer to minimize production test time, and, therefore, cost.

High Accuracy and Resolution

Dissipation factor (D), the parameter measured to determine the quality of capacitors, can be measured with an accuracy of 0.0002 (1MHz) and 0.0005 (1kHz) with a resolution of 0.00001 without degrading measurement speed. The HP 4278A has high capacitance measurement accuracy, 0.05% (1MHz) and 0.07% (1kHz) with 6 full digits of resolution in all measurement ranges, 1pF to 2048 pF (1MHz), and 100pF to 100 μF (1kHz).

The pushbutton zero adjustment function is used to compensate for stray impedance and admittance of the handler and test fixture. The auto calibration function, when used with a capacitance standard, can be used to calibrate the system up to the point of device connection.

Intelligent Built-in Comparator

The intelligent built-in comparator gives the HP 4278A the capability to use nine sets of high and low capacitance values and one set of dissipation limits to sort capacitors into nine bins, according to their capacitance values and whether or not they meet the dissipation limits. Capacitors which are not within the capacitance limits or do not meet the dissipation limits go into the tenth or no-go bin.

All comparator settings can be controlled and monitored using an external computer, and the results of the comparisons can be transferred to a handler interface (optional). All control settings and comparator parameters can be saved on the removable EEPROM memory module (memory card) to facilitate instrument setup and to minimize the chance of an instrument setup error.

Specifications

(refer to data sheet for complete specifications)
Measurement Parameters: C-D•Q•ESR•G
Display: Dot-matrix LCD. Displays measurement values with 4, 5, or 6 digit resolution, control settings, comparator limits, the comparator's decision, self test messages and annunciations.
Measurement Circuit Modes: Parallel and Series
Test Signals:
Frequency: 1kHz and 1 MHz, ±0.02%
Signal Level: 0.1 to 1 Vrms, ±10% (C≤20μF), in 0.1Vrms steps
Measurement Time Modes: SHORT, MEDIUM, and LONG
Measurement Times:

Mode	SHORT	MEDIUM	LONG
Time*	6.5ms	10ms	21ms

* Measurement time includes Settling, Integration (analog measurements), Calculation, and Comparison times.

No additional measurement time is required for measurements performed in an overload (shorted capacitor) condition.

Measurement Range

Measurement Parameter	1 KHz	1 MHz Normal Mode 1 MHz High Accuracy
C	0.001 pF to 200.000 μF	0.00001 pF to 1280.00 pF 0.00001 pF to 2663.00 pF
DF	0.00001 to 9.99999	0.00001 to 9.99999 .000001 to .999999
Q	0.1 to 99999.9	0.1 to 99999.9 20 to 99999.9
G	0.00001 μS to 9.99999S	0.00001 μS to 9.99999 mS 0.00001 μS to 9.99999 mS
ESR	0.000010Ω to 9.99999 MΩ	0.0010Ω to 999.999 KΩ 0.0010Ω to 999.999 KΩ

1. 1kHz Normal Mode: 7 decade ranges 100pF to 100μF full scale. 100% overranging on all ranges, (max. 200000 counts) when D ≦ 0.5.
2. 1MHz Normal Mode: 11 binary ranges, 1pF to 1024pF full scale. 25% overranging on all ranges, when D ≦ 1.
3. 1MHz High Accuracy Mode: Measurement range is ±30% of the user defined nominal value, maximum 2048pF. When D ≦ 0.05.

Measurement Accuracy

It is specified at the UNKNOWN terminals and at the end of standard 1 or 2 meter test leads under the following conditions.
Refer to data sheet for details.
1. Warm Up Time: ≧ 10 minutes.
2. Ambient Temperature is 23 ± 5°C and variance is less than 0.2°C/minute.
3. Test signal level is set to 1 Vrms.
4. Test cable length is 0, 1, or 2 meters (HP 16048A/B/D).
5. Zero OPEN/SHORT compensation has been performed.
6. D ≧0.05 for 1MHz High Accuracy Mode.
   D ≦0.1 for 1kHz and 1MHz Normal Modes.
7. Accuracies are only valid when the measured value is equal to full scall of each range.
8. Accuracy stated in the tables is given for MEDIUM (upper) and LONG (lower) integration times.
9. Accuracy equations are read as follows:
   C: ± (% of reading + % of full scale)
   D: ± (% of reading + absolute D value)
   (C: ± (% of reading + absolute C value) for Table 3)

Table 1 1kHz Measurement Accuracy

C range	C	D
100μF	0.13% + 0.3% 0.07% + 0.025%	0.13% + 0.003 0.065% + 0.0025
100pF - 10μF	0.1% + 0.05% 0.05% + 0.025%	0.1% + 0.001 0.05% + 0.0005

Table 2 1MHz Normal Mode Measurement Accuracy

C range	C	D
256 - 1024pF	0.2% + 0.02% 0.1% + 0.02%	0.2% + 0.002 0.1% + 0.0005
4 - 128pF	0.2% + 0.02% 0.05% + 0.02%	
2pF	0.2% + 0.03% 0.05% + 0.03%	
1pF	0.2% + 0.06% 0.05% + 0.06%	0.2% + 0.004 0.1% + 0.001

Table 3 1MHz High Accuracy Mode Measurement Accuracy

Nominal C + Open Circuit C	C	D
1024 - 2048pF	0.1% 0.1%	0.0007 0.0004
256 - 1024pF	0.1% 0.07%	0.0007 0.0003
4 - 256pF	0.1% 0.05%	0.0007 0.0002
2 - 4pF	0.1% + 0.0004pF 0.06% + 0.0004pF	0.0008 0.0003
0 - 2pF	0.1% + 0.0004pF 0.08% + 0.0004pF	0.0016 0.0006

Trigger Modes: Internal, External, or Manual
Measurement Terminals: Four-terminal pair, guarded
Cable Length Compensation: 0, 1, or 2m
Compensation Function
Zero OPEN/SHORT: Compensation range:R≦20Ω, G≦20μS, and unlimited C and L.
Standard: Improves measurement accuracy by using a standard capacitor as a reference.
Offset: Arithmetic correction of measurement data.
Comparator: Ten-bin sorting for capacitance, and go/no-go testing for D, Q, ESR, and G.
Sorting Modes: Sequential sorting into un-nested bands with absolute limits, and tolerance sorting into nested bands with absolute or percent limits.
Self Test: Checks the HP 4278A's basic operation.
Memory Card: External memory for storing and recalling control settings and comparator limits.

General Specifications

Operating Temperature and Humidity: 0–55°C, 95% RH @ 40°C
Power: 100, 120, 220VAC ± 10%, 240VAC +5 −10%, 48–66Hz, 200VA max.
Dimensions (in mm): Approximately 426(W) by 177(H) by 498(D)
Weight: Approximately 10kg (22lb., standard)

Reference Data

Stability: LONG integration and constant operating temperature.
C ≦ 0.01%/day
D ≦ 0.0001/day
Temperature Coefficient: LONG integration and 23±5°C.
C ≦ 0.01%/°C; 1kHz and 1MHz.
D ≦ 0.0001/°C; 1kHz and 1MHz Normal Mode.
D ≦ 0.00004/°C; 1MHz High Accuracy Mode.
HP-IB Data Output Speed: Maximum 100 bytes/ms, typically 3ms for handshake, depending on the system controller.

Accessories Available

HP 16270A: Memory Card Set	$280
HP 16334A: Tweezer-type Test Fixture for Chip Components	$440
HP 16047A: Direct-coupled Test Fixture	$270 ☎
HP 16047C: Test Fixture	$310 ☎
HP 16048A: Test Leads, BNC (1m)	$330 ☎
HP 16048B: Test Leads, SMC (1m)	$330 ☎
HP 16048D: Test Leads, BNC (2m)	$430
HP 16380A: Standard Capacitor Set	$3010
HP 16380C: Standard Capacitor Set	$4585

Refer to page 283.

Ordering Information

HP 4278A 1kHz/1MHz Capacitance Meter	$7840
Opt W30: 3-year hardware support	$180
Opt 001: 1kHz test frequency only	−$830
Opt 002: 1MHz test frequency only	−$360
Opt 003: 1% frequency shift: prevents possible test signal interference when component test contacts are located close to those of other test units	$0
Opt 009: Delete Manual	−$30
Opt 101: HP-IB compatibility	$240
Opt 201: Handler Interface	$280
Opt 202: Handler Interface	$310
Opt 301: Scanner Interface	$600

☎ Fast-ship product, see page 734.