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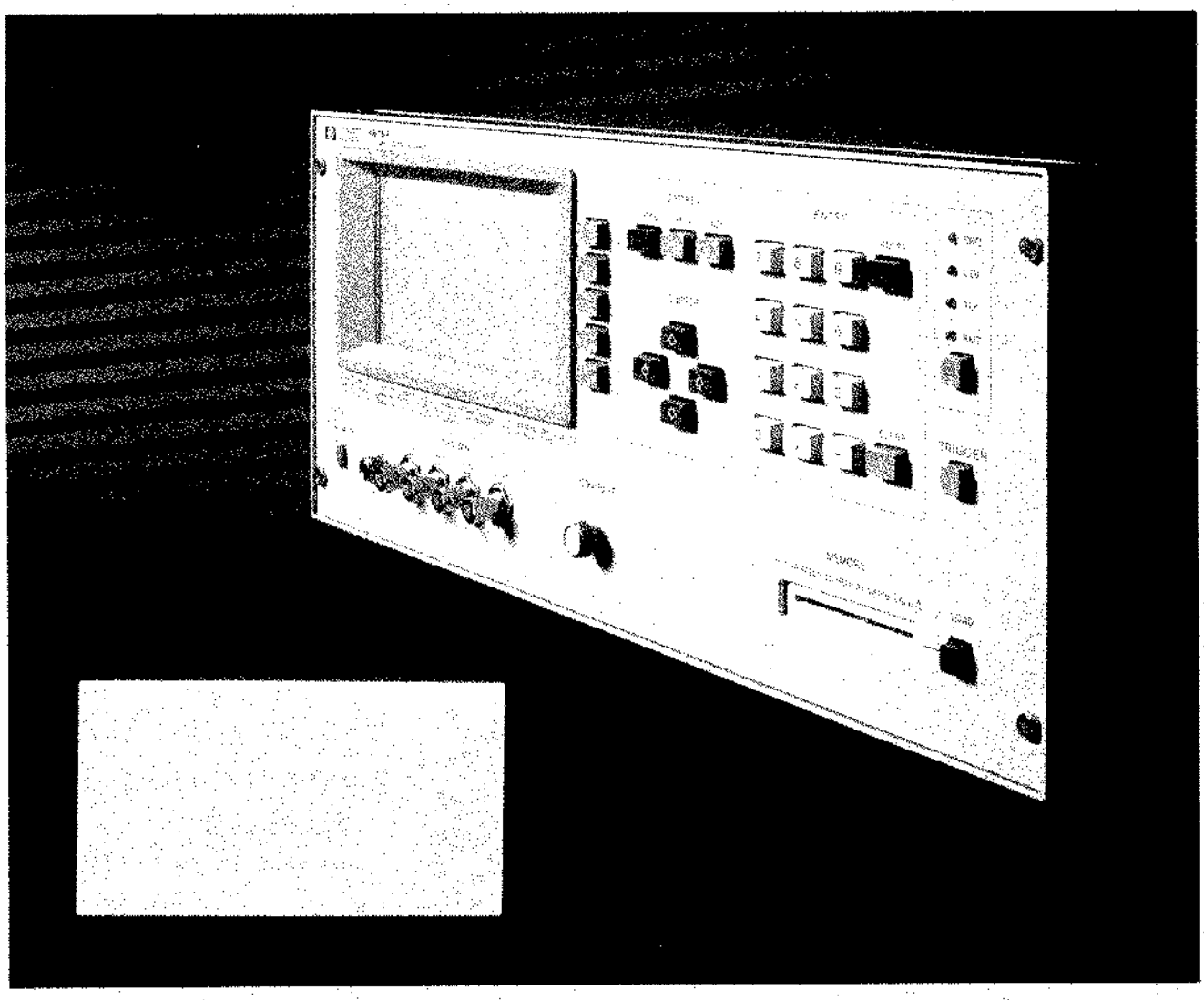
HP 4278A 1 KHz/1 MHz Capacitance Meter

HEWLETT PACKARD

HP-IB SYSTEMS

Exceed Todays Capacitor Test Requirements

Technical Data



- 1 KHz and 1 MHz Testing
- Accuracy with High Throughput
- High Resolution and Stability

HP 4278A 1 KHz/1 MHz Capacitance Meter

Enhances Testing Efficiency and Capacitor Quality

The HP 4278A 1 KHz/1 MHz Capacitance Meter is ideally suited for the production line, quality assurance, incoming/outgoing inspection, and research and development. Capable of measuring capacitance, dissipation factor, quality factor, equivalent series resistance, and conductance at 1 KHz and 1 MHz, the HP 4278A can test most ceramic, film, and mica capacitors.

Accuracy, Resolution, and Throughput

The HP 4278A has an impressive set of accuracy, resolution, and throughput specifications to reduce testing cost and improve component quality. With a C accuracy of 0.05%, a DF accuracy of 0.0002, and DF resolution of 0.000001 at 1 MHz, the HP 4278A exceeds today's low DF and low ppm level testing requirements. At 1 KHz, the C and DF accuracies are equally impressive at 0.075% and 0.0005, respectively. All measurement parameters; C, DF, Q, ESR, and G have six digits of resolution.

To reduce test time and improve testing efficiency, the HP 4278A's most accurate measurement time is a mere 21 ms. This translates into a throughput of over 171,000 parts per hour. If an even higher throughput is required, the 6.5 ms measurement time yields a throughput of 553,000 parts per hour.

The HP 4278A fast short-circuit recovery system improves throughput even more. Normal operation is resumed the instant the shorted device is removed. This means the handler can always be operated at full speed and capacitors will always be sorted into their proper bin.

Increase Production Versatility While Reducing Cost

No longer do you need to perform the expensive and time consuming task of switching different bridges in and out of your test systems. The HP 4278A allows you to select either test frequency, 1 KHz or 1 MHz, via the softkeys. To increase production efficiency even more, the memory card feature allows the operator to quickly set up the entire instrument in a matter of seconds.

The test signal level is variable from 0.1 Vrms to 1.0 Vrms in 0.1 Vrms steps and complies with all international test standards.

Reduce Operator Errors

One of the most important objectives in production test, is the elimination of erroneous control and comparator settings. To help eliminate this problem, the HP 4278A's large LCD display provides precise information on control settings, measurement data, and comparator limits. To improve this process even more, the memory card is capable of setting all control and comparator limits with a simple push of a button.

Simple Integration with a Handler

To facilitate the integration of the HP 4278A into your test system, optional handler and high speed HPIB interfaces are available. Standard with every HP 4278A is the advanced comparator with sequential and tolerance sorting capability, the new working standard compensation, and new data offset functions.

KEY SPECIFICATIONS

Measurement Parameters	C, DF, Q, ESR, G		
Number of Display Digits	4, 5, or 6 digits (selectable)		
Test Frequency		1 KHz	1 MHz*
Measurement Range	C	0.001pF-200.000 μF	0.00001 pF-2663.00 pF
	D	0.00001-9.99999	0.000001-0.999999
Measurement Accuracy	C	0.075%	0.05%
	D	0.0005	0.0002
Measurement Time	6.5 ms/10 ms/21 ms		
Test Signal Level	0.1 Vrms to 1.0 Vrms in 0.1 Vrms Steps		
Test Cable Length	0, 1, and 2 meters		
Comparator Function	Primary Measurement Parameter: 10 BINS Secondary Measurement Parameter: HIGH/IN/LOW		

*1 MHz High Accuracy Mode

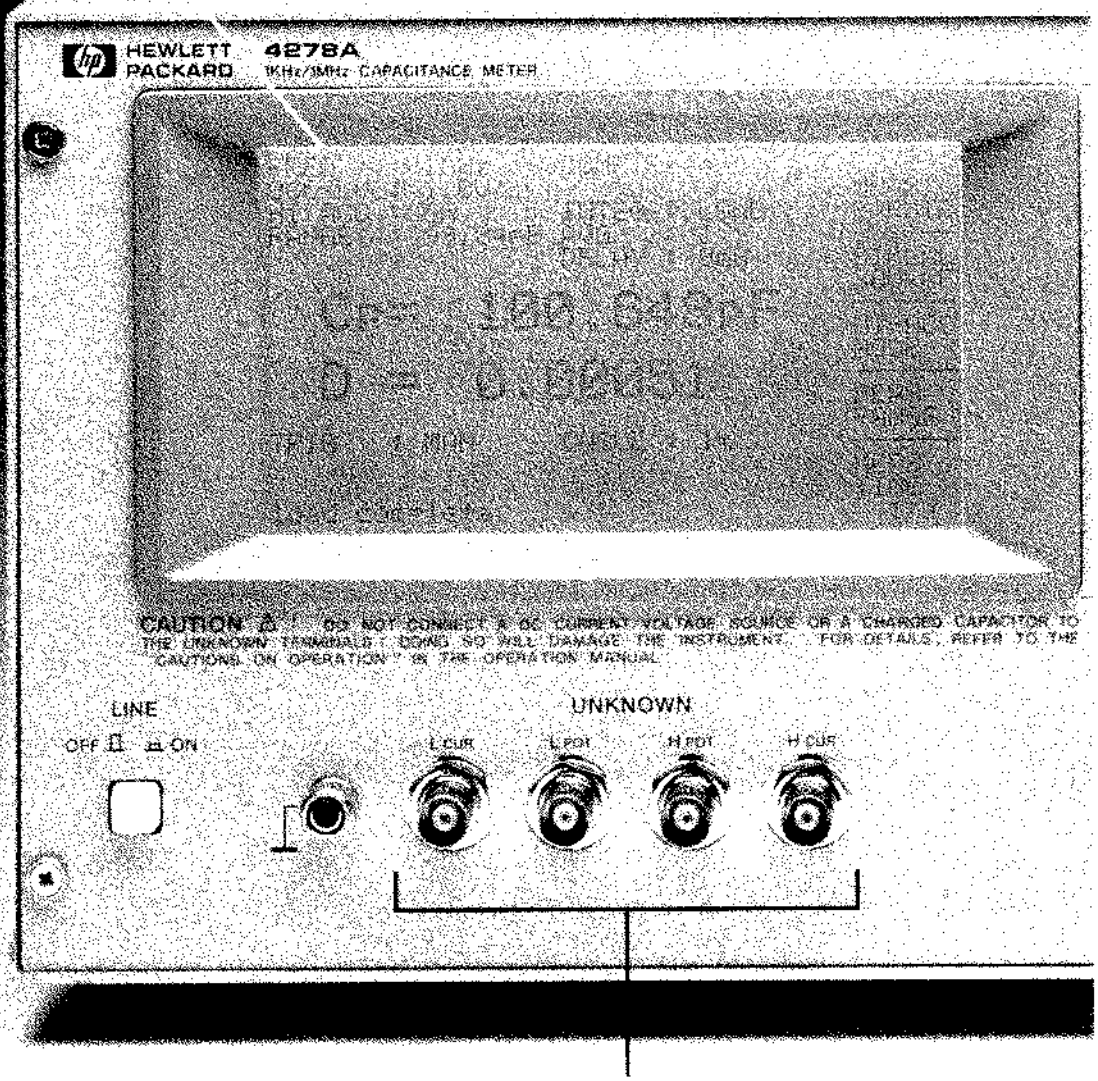
HP 4278A 1 KHz/1 MHz Capacitance Meter

LARGE LCD DISPLAY

For easy viewing of measurement results, instrument settings, and bin information.

MENU AND SOFTKEYS

Fast and convenient instrument setup.



FOUR TERMINAL PAIR MEASUREMENT

Eliminate measurement errors due to mutual inductance, stay admittance, and residual impedance in the test cabling and fixturing.

HANDLER INTERFACE (Option 201)

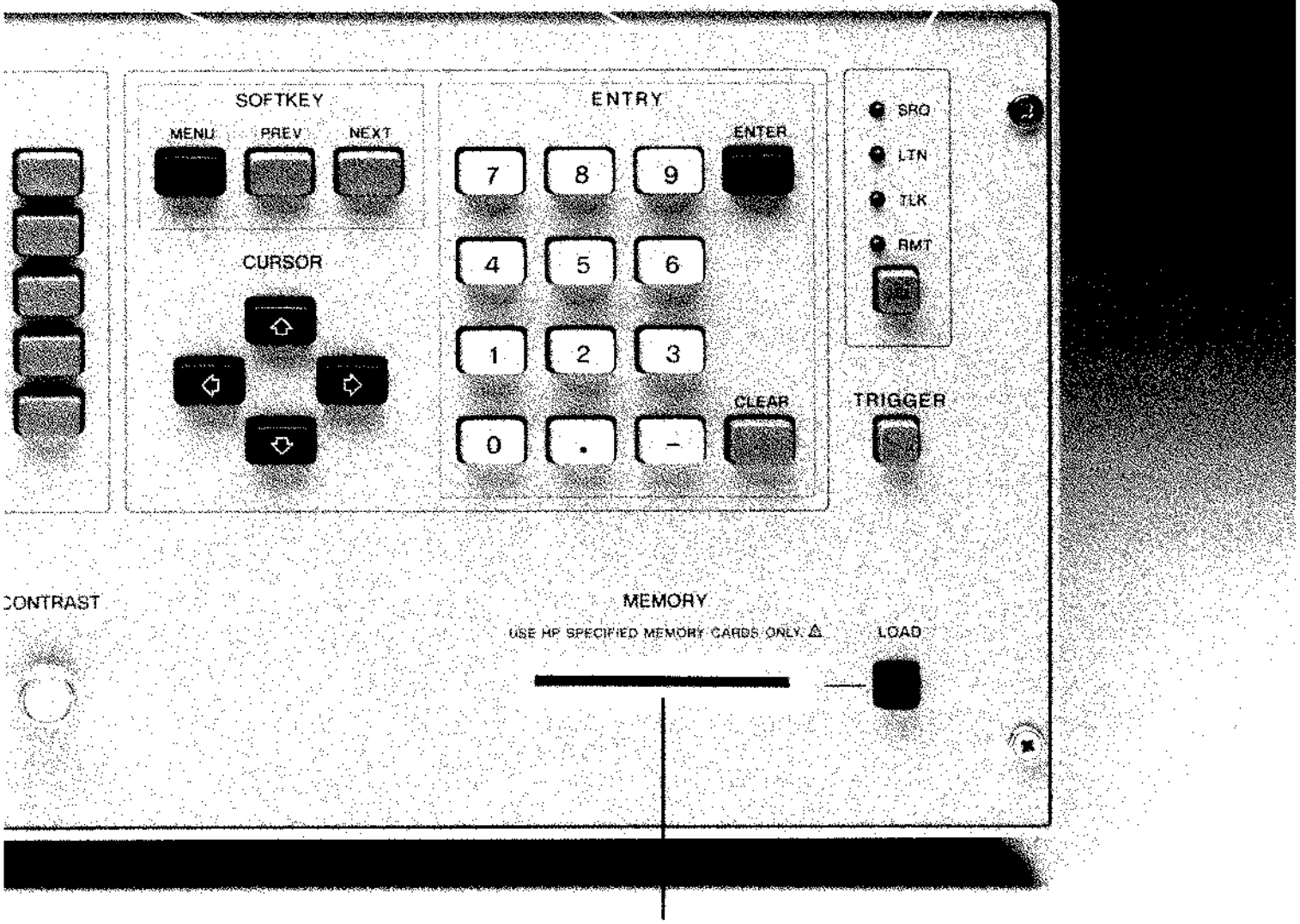
Connect the HP 4278A with your favorite handler for reliable high throughput testing.

NUMERIC KEYPAD

Enter bin settings quickly and easily.

HPIB (Option 101)

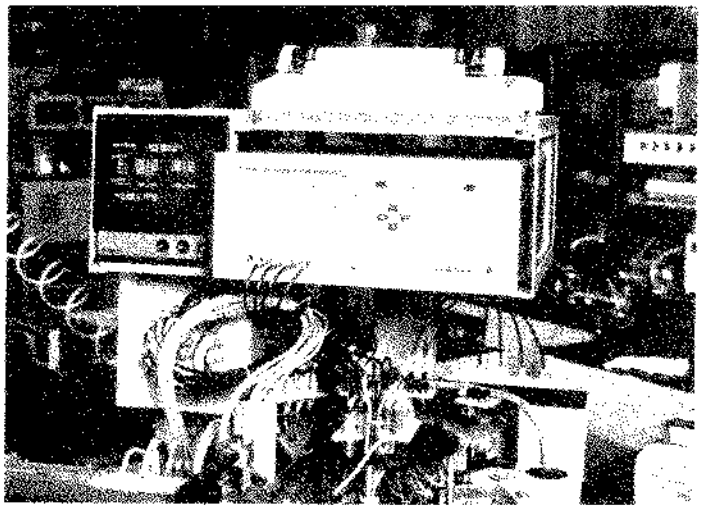
High speed data logging and instrument control are now possible with HPIB.



MEMORY CARD

Eliminate setup errors and idle time between production runs by loading all instrument setting and bin information using the memory card.

Applications

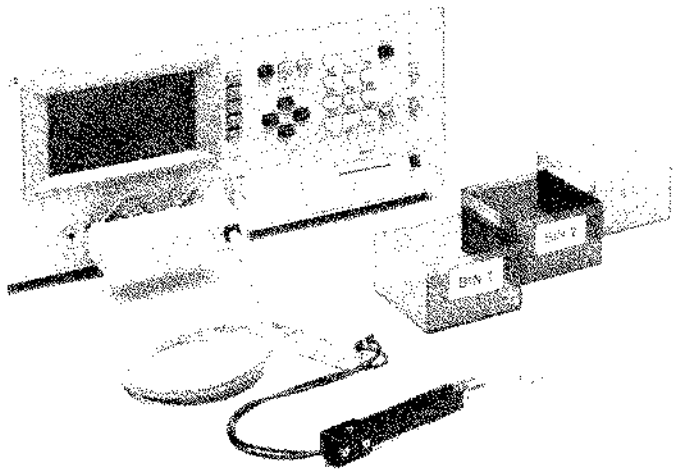


Automated Production Testing

No longer do you have to sacrifice system throughput to obtain accurate C and DF measurements. The HP 4278A's HIGH ACCURACY mode is ideally suited for today's and tomorrow's stringent C and DF production testing requirements. The measurement time in the High Accuracy mode is a mere 21 ms. A faster 10 ms measurement mode can be selected for those applications requiring only moderate C and DF testing limits.

To improve operator efficiency and minimize errors, the entire instrument setup including bin limit information can be easily set using the memory card.

A flexible multiple bin sorting capability, digital handler interface, advanced automatic calibration and compensation functions, and high speed HPIB operation make for easy system integration.



Manual Production Testing

For those short production runs where high cost automatic handlers are not appropriate, the HP 4278A's advanced design and powerful features make it an ideal tool for manual measurement. The HP 4278A's large clear LCD display is capable of presenting measurement data and bin information in a format that helps speed the sorting operation. The handler interface output lines can also be used to control bin indicators.

Both HP and customer/application specific test fixtures can be used with the HP 4278A. The easy to use compensation functions can eliminate any test fixture's stray parasitics from the measurement data and thus improve measurement accuracy. Another unique feature of the HP 4278A is the Status Display page. By reviewing the test fixture's stray parasitics, the operator can quickly determine if the test fixture is good or needs replacement.

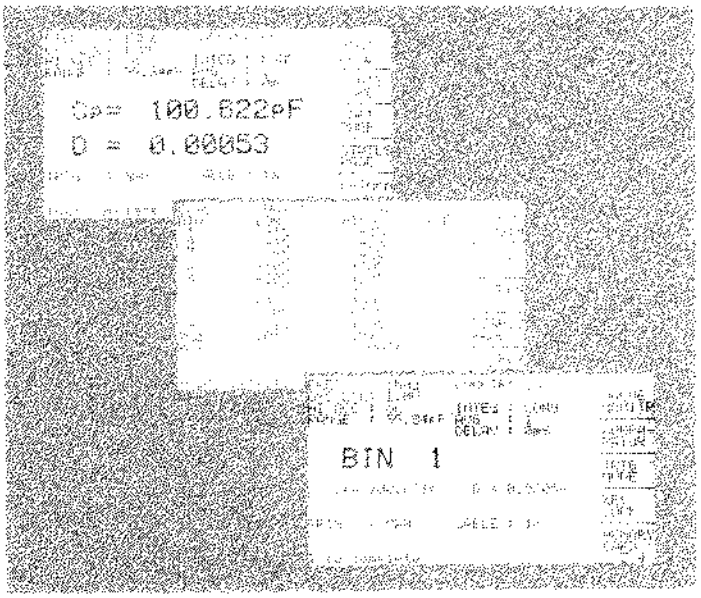


Quality Assurance Research and Development

The HP 4278A's high accuracy, 1 ppm resolution, and high stability makes it an excellent choice for Quality Assurance, and Research and Development. At 1 MHz, the DF accuracy is an amazing 0.0002 while the DF resolution is an incredible six digits (0.000001) or 1 part per million. Capacitance accuracy is equally impressive, 0.05% and 0.075% at 1 MHz and 1 KHz, respectively.

For quality assurance applications, the HP 4278A will allow you to meet or exceed the ever tightening quality control standards. The internal data storage and HPIB capability also allows for data manipulation and statistical analysis.

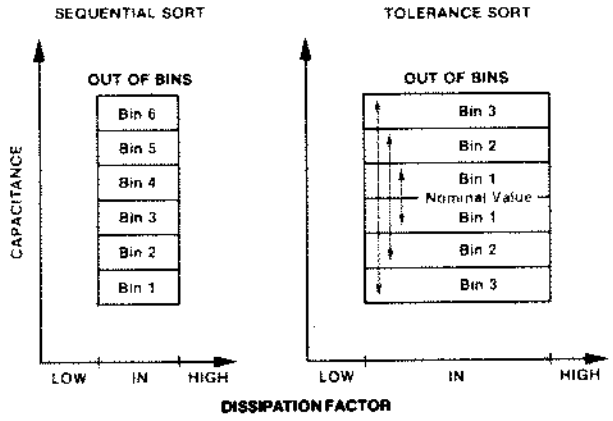
In R&D, the HP 4278A's DF resolution of 0.000001 is essential when developing and evaluating new low dissipation factor capacitors and materials.



Simple Operation and Large LCD Display

All of the measurement parameters and functions can be set or selected using the MENU and softkeys. The numeric key pad, enter, clear, and cursor keys are designed for quick and convenient data entry. To change or set a comparator limit, simply move the cursor to the proper location in the Limit page, clear the entry, and enter the new value. Selecting either the 1 KHz or 1 MHz test frequency is equally simple.

The large clear LCD display allows you to quickly review the instrument's state and measurement data. The HP 4278A can also display data in many different formats. To the left, we see the Measurement, Limit, and Sorting Page displays. The Measurement Page highlights the C-DF measurement results and provides information on the instrument's settings. The Limit Page clearly displays all of the comparator settings and bin counts. The Sorting Page displays bin decisions and is ideally suited for MANUAL PRODUCTION TESTING AND SORTING.

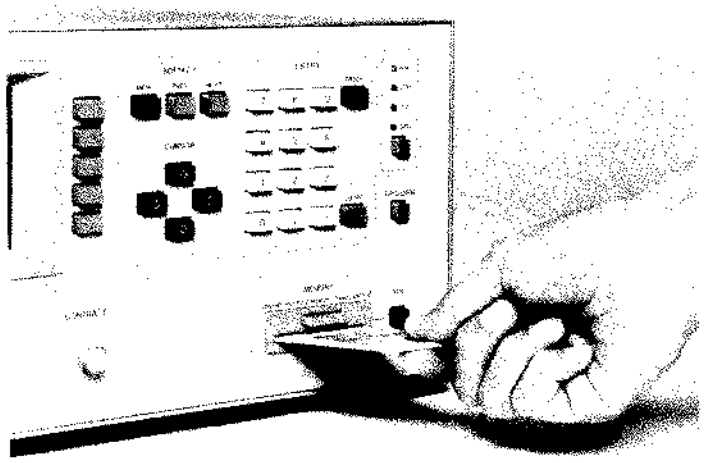


Intelligent Go/No-Go Sorting

The HP 4278A's built-in comparator can sort capacitors into a maximum of 10 bins. Two limit setting modes are available; sequential and tolerance. In the sequential mode, the upper and lower limits for the bins are set. For the tolerance mode, a nominal value is set and the variation from the nominal value is used to determine the bin limits.

In addition, the HP 4278A has several new built-in features. The bin count function tracks the number of components sorted into each bin for statistical quality control. Components which pass the DF test but fail the C test can be sorted into the AUXILIARY BIN. And the comparator allows you to choose either C or DF/Q/ESR/G as the primary sorting parameter.

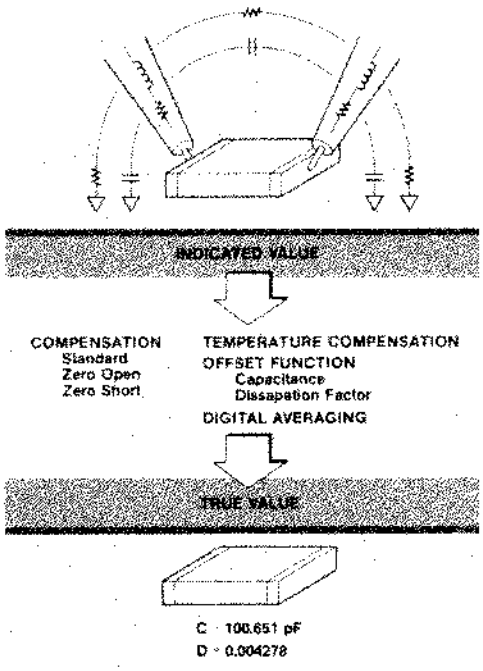
All of these new features combine to make the HP 4278A's built-in comparator the most advanced and easy to use in the industry.



Quick Instrument Setup

The memory card can eliminate all instrument setup errors and minimize the idle time between production runs, thus improving production quality and efficiency. The entire HP 4278A measurement set up including bin limit information can now be stored and loaded using the new memory card feature.

To operate, simply insert the memory card into the slot and press the load key. The card can now be removed and used to setup other HP 4278As.

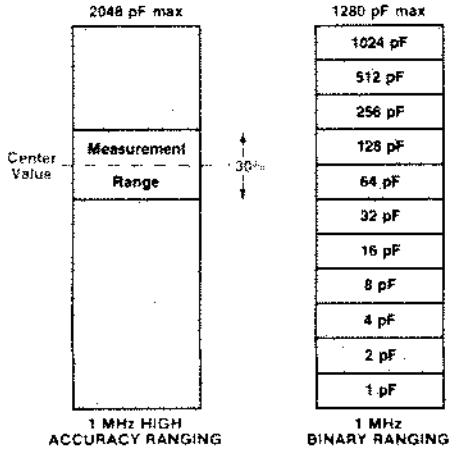


Improve Accuracy and Repeatability

The new working standard compensation function improves measurement accuracy. By using YOUR capacitor standard as a reference, all measurement results are now relative to your standard. This improves measurement accuracy and repeatability.

The other advanced compensation features of the HP 4278A can eliminate all of the system errors introduced by the test leads, scanners, and the handler test head. The zero open and short compensation functions are used to cancel the parasitics in the system fixturing. The new TEMPERATURE compensation minimizes internal conversion errors. The new OFFSET function allows the user to offset the measurement results by a user defined value.

All of these advanced compensation functions combine to produce the most accurate and repeatable measurements results possible.

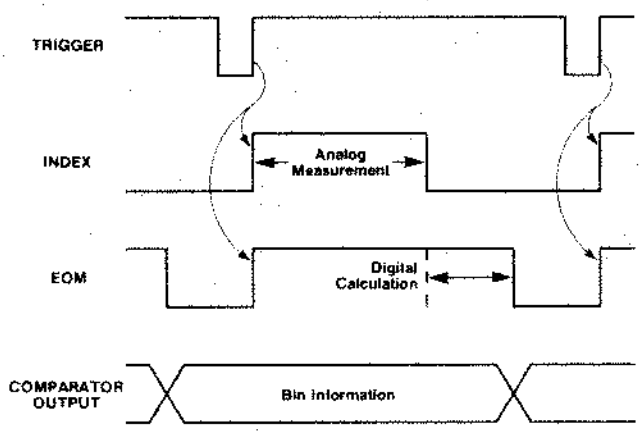


Precision Measurements Over Entire Range

To achieve a C accuracy of 0.05% and a DF of 0.0002 at 1 MHz, the HP 4278A features a new full scale measurement ranging technique. To use this new high accuracy ranging, the user only needs to enter a center value, the measurement range will then be ±30% of the center value. Any component outside this range, will automatically be sorted into the OUT of BINS.

In addition, a new binary auto ranging mode has been developed for general purpose 1 MHz testing. The full scale measurement range changes in binary steps from 1 pF to 1024 pF to optimize measurement accuracy.

So whatever your testing requirements are, the HP 4278A has been designed to provide you the most accurate and repeatable measurement results possible.



Handler Interface (Option 201)

The HP 4278A's handler interface is compatible with the HP 16064A Comparator (used with the HP 4276A and HP 4277A LCZ Meters). To maintain highly reliable sorting, optically isolated open collector drivers are used on all output signals.

For those future applications requiring the use of the HP 4278A 6.5 ms high speed measurement capability, an INDEX signal is provided to optimize handler, scanner, and meter timing. Many measurement status indicators are also provided for Statistical Quality Control applications.

Specifications

MEASUREMENT FUNCTIONS

Measurement Parameters:
C (capacitance), DF (dissipation factor), Q (quality factor), ESR (equivalent series resistance), G (conductance).

Combinations:

Parallel	C-DF, C-Q, C-G
Series	C-DF, C-Q, C-ESR

Ranging: Auto and Manual

Trigger: Internal, External and Manual

Delay Time: Programmable delay from the trigger command to the start of the measurement, 0 to 1000 ms in 1 ms steps.

Measurement Terminals: Four Terminal Pair

Test Cable Length: 0, 1, and 2 meters

Integration Time: Short, Medium, and Long

Averaging: 1, 2, 4, . . ., 128, and 256, programmable.

TEST SIGNAL

Test Frequency and Accuracy: 1 KHz and 1 MHz, ±0.02%

Signal Level and Accuracy: 0.1 to 1.0 Vrms in 0.1 Vrms steps, ±10% for C < 20 μF

DISPLAY

LCD Dot-matrix type display. Capable of displaying: measured values, control settings, comparator limits and decisions, self test messages, and annunciations.

COMPENSATION FUNCTIONS

Zero OPEN/SHORT: Compensation range: R ≤ 20Ω,G ≤ 20 μS, and unlimited C and L.

Standard: Improves measurement accuracy by using a standard capacitor as a reference.

Offset: Arithmetic correction of measurement data.

COMPARATOR FUNCTION

Sorting Modes:
Sequential is unnested with absolute upper and lower limits. Tolerance is nested bands with absolute or percent limits. Both sequential and tolerance are for the primary sorting parameter (C or DF/Q/ESR/G), maximum of 10 bins. HIGH/IN/LOW is for the secondary sorting parameter (DF/Q/ESR/G or C).

Decision Outputs: Bin number, Auxiliary bin, Out of Bins, and rejection status.

Bin Count: Maximum count of 999999 for each bin.

OTHER FUNCTIONS

Memory Card: Removable memory device to store and recall all control and limit information.

Self Test and Auto Calibration:
Softkey or HPIB controllable. Provides a means to confirm proper operation and calibrate the HP 4278A using the HP 16380A/C Standard Capacitors.

GENERAL SPECIFICATIONS

Operating Temperature and Humidity: 5°C to 45°C, ≤95% RH at 40°C

Storage: -20°C to 60°C

Power Requirements: 100/120/220V ± 10%, 240V -10% to +5%, 48 to 66 Hz, 200 VA (max)

Size: 426(W) x 177(H) x 498(D)mm

Weight: Approx. 15 kg (33 lb.)

OPTIONS

Option 003: 1% test frequency shift. Prevents possible test signal interference from other 1 KHz and 1 MHz signal sources.

Option 101: HP-IB Interface.

All controls settings, measured values, self-test results, and comparator information. Data output time is a maximum 10 μsec/byte (depends upon controller). Handshake time is typically 2 to 3 ms using a HP 9826/36.

Option 201: Handler Interface.

All output signals are negative logic, optically isolated open collectors. Output signals include: bin number, out of bins, rejection status, index, measurement complete, and alarm. All input signals are optically isolated. Input signals include: keylock and external trigger.

SUPPLEMENTAL PERFORMANCE CHARACTERISTICS

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; 1 KHz and 1 MHz.
D ≤ 0.0001/°C; 1 KHz and 1 MHz Normal Mode.
D ≤ 0.00004/°C; 1 MHz High Accuracy Mode.

Settling Time: Test frequency, test signal level, and range (manual and remote): 100 ms

Input Protection:
Internal circuit protection, when a charged capacitor is connected to the Unknown terminals. The maximum capacitor voltage is:

$V_{max} = \sqrt{2/C}$ where: Vmax ≤ 1 KV and C is in Farads.

MEASUREMENT TIME

Total Measurement Time = Measurement Time + Display Time

Measurement Time

Mode	Settling Time	Analog Measurement	Digital Computation	Measurement Time
SHORT	1 ms	1.7 ms	4 ms	6.5 ± 0.5 ms
MEDIUM	1 ms	5.4 ms	4 ms	10 ± 1 ms
LONG	1 ms	13.6 ms	6 ms	21 ± 1 ms

Display Time

Measurement Page (typical)	Limit Page*	Sorting Page (typical)	Status Page
5 ms	0 ms	2.4 ms	0 ms

* Typically 2 ms when bin count data is displayed.

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	0.00001Ω to 9.99999 MΩ	0.001Ω to 999.999 KΩ
		0.001Ω to 999.999 KΩ

MEASUREMENT RANGE NOTES:

1. 1 KHz Normal Mode: 7 decade ranges 100 pF to 100 μF full scale. 100% overranging on all ranges, (max. 200000 counts) when D ≤ 0.5.
2. 1 MHz Normal Mode: 11 binary ranges, 1 pF to 1024 pF full scale. 25% overranging on all ranges, when D ≤ 1.
3. 1 MHz High Accuracy Mode: Measurement range is ±30% of the user defined nominal value, maximum 2048 pF. When D ≤ 0.05.
4. G and ESR ranges depend on the capacitance value.
5. All parameters have six digits of resolution.

MEASUREMENT ACCURACY

Is specified at the UNKNOWN terminals and at the end of standard 1 or 2 meter test leads under the following conditions.

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 1 MHz High Accuracy Mode.
   D ≤ 0.1 for 1 KHz and 1 MHz Normal Modes.

All accuracy tables provide SHORT, MEDIUM AND LONG integration accuracy equations.

SHORT
MEDIUM
LONG

1 KHz MEASUREMENT ACCURACY SPECIFICATIONS

C RANGE (Cf)	MEASUREMENT PARAMETERS					
	C		DF		G	ESR
	% of reading	% of full scale	% of reading	Absolute value	Absolute value	Absolute value
100 μF	0.19% 0.13% 0.07%	3.7α²% 0.3α²% 0.25α²%	0.19% 0.13% 0.065%	0.037α 0.003α 0.0025α	(12+231α)Cx μS (8.2+19α)Cx μS (4.1+16α)Cx μS	(0.3/Cx+0.06)Ω (0.21/Cx+0.005)Ω (0.1/Cx+0.004)Ω
10 μF						
1 μF	0.15%	0.3%	0.15%	0.006/α	(9.4Cx+19Cf) μS	(0.24+0.48/α)/Cx Ω
100 nF	0.1%	0.05%	0.1%	0.001/α	(6.3Cx+3.1Cf) μS	(0.16+0.08/α)/Cx Ω
10 nF	0.05%	0.025%	0.05%	0.0005/α	(3.1Cx+1.6Cf) μS	(0.08+0.04/α)/Cx Ω
1 nf						
100 pF						

NOTES:

1. Accuracy equations are read as follows
   C: ±(% of reading + % of full scale)
   D: ±(% of reading + % of absolute D value)
   G: ±(absolute G value)
   ESR: ±(absolute ESR value)
2. Cx = C reading in μF
   Cf = C range (100 μF, 10 μF, . . ., 0.0001 μF)
   α = Cx/Cf if α ≥ 1, let α = 1
3. 100 μF range accuracy is only specified when α > 0.2
4. Additional error due to temperature. Multiply the measurement accuracy by the temperature factor.

Temp. °C	5	18	28	45
Factor	x2	x1	x2	

1 MHz NORMAL MODE MEASUREMENT ACCURACY SPECIFICATIONS

C RANGE (Cf)	MEASUREMENT PARAMETERS							
	C		DF		G		ESR	
	% of reading	% of full scale	% of reading	Absolute value	% of reading	Absolute value	% of reading	Absolute value
1024 pF	0.3%	0.4%					0.3%	480Cf/Cx² Ω
512 pF	0.2%	0.02%					0.2%	320Cf/Cx² Ω
256 pF	0.1%	0.02%					0.1%	80Cf/Cx² Ω
128 pF			0.3%	0.005/α	0.3%	(0.019Cx+0.025Cf) μS		
64 pF			0.2%	0.002/α	0.2%	(0.013Cx+0.0013Cf) μS		
32 pF	0.3%	0.4%	0.1%	0.0005/α	0.05%	(0.0031Cx+0.0013Cf) μS		
16 pF	0.2%	0.02%					0.3%	480Cf/Cx² Ω
8 pF	0.05%	0.02%					0.2%	320Cf/Cx² Ω
4 pF							0.05%	80Cf/Cx² Ω
2 pF	0.3% 0.2% 0.05%	0.4% 0.03% 0.03%			0.3% 0.2% 0.05%	(0.019Cx+0.05) μS (0.013Cx+0.0038) μS (0.0031Cx+0.0038) μS		
1 pF	0.3% 0.2% 0.05%	0.8% 0.06% 0.06%	0.3% 0.2% 0.1%	0.006/α 0.004/α 0.001/α	0.3% 0.2% 0.05%	(0.019Cx+0.05) μS (0.013Cx+0.0025) μS (0.0031Cx+0.0025) μS	0.3% 0.2% 0.1%	960/Cx² Ω 640/Cx² Ω 160/Cx² Ω

NOTES:

1. Accuracy equations are read as follows:
   C: ±(% of reading + % of full scale)
   D: ±(% of reading + absolute D value)
   G: ±(% of reading + absolute G value)
   ESR: ±(% of reading + absolute ESR value)
2. Cx = C reading in pF
   Cf = C range (1 pF, 2 pF, . . ., 1024 pF)
   α = Cx/Cf
3. Additional error due to temperature. Multiply the measurement accuracy by the temperature factor.

Temp. °C	5	8	18	28	38	45
Factor	x3	x2	x1	x2	x3	

1 MHz HIGH ACCURACY MODE MEASUREMENT ACCURACY SPECIFICATIONS

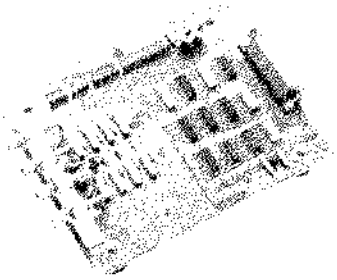
Nominal C value + Open Circuit C	MEASUREMENT PARAMETERS				
	C		DF	G	ESR
	% of reading	Absolute value	Absolute value	Absolute value	Absolute value
1024 - 2048 pF	0.4% 0.11% 0.11%	0 0 0	0.004 0.0007 0.0004	0.025Cx μS 0.0044Cx μS 0.0025Cx μS	640/Cx Ω 110/Cx Ω 64/Cx Ω
256 - 1024 pF	0.4% 0.11% 0.07%	0 0 0	0.004 0.0007 0.0003	0.025Cx μS 0.0044Cx μS 0.0019Cx μS	640/Cx Ω 110/Cx Ω 48/Cx Ω
4 - 256 pF	0.4% 0.11% 0.05%	0 0 0	0.004 0.0007 0.0002	0.025Cxμ S 0.0044Cx μS 0.0013Cx μS	640/Cx Ω 110/Cx Ω 32/Cx Ω
2 - 4 pF	0.4% 0.1% 0.06%	0 0.0004 pF 0.0004 pF	0.004 0.0008 0.0003	25Cx nS (3.8Cx+2.5) nS (0.63Cx+2.5) nS	640/Cx Ω 130/Cx Ω 48/Cx Ω
0 - 2 pF	0.2% 0.1% 0.08%	0.002 pF 0.0004 pF 0.0004 pF	0.008/Cx 0.0016/Cx 0.0006/Cx	(13Cx+13) nS (3.8Cx+2.5) nS 3.8 nS	1270/Cx² Ω 260/Cx² Ω 96/Cx² Ω

NOTES:

1. Accuracy equations are read as follows:
   C: ±(% of reading + absolute C value)
   D: ±(absolute D value)
   G: ±(absolute G value)
   ESR: ±(absolute ESR value)
2. Cx = C reading in pF
3. Range is the nominal capacitance value + open circuit capacitance. When the nominal capacitance value plus open circuit capacitance is equal to the range limit values, use the lower ranges' accuracy specifications.
4. Additional error due to temperature. Multiply the measurement accuracy by the temperature factor

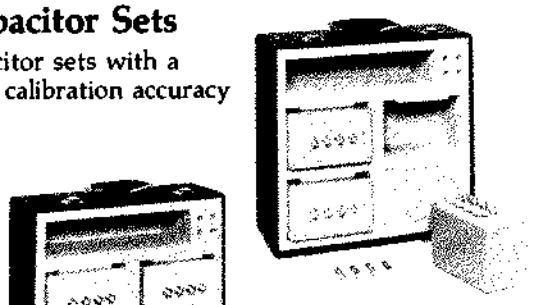
Temp. °C	5	8	18	28	38	45
Factor	x3	x2	x1	x2	x3	

Accessories



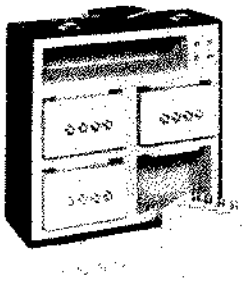
16380A/C Standard Capacitor Sets

Four terminal pair standard capacitor sets with a total range of 1 pF to 1 μF and a calibration accuracy of ±0.01%.



04278-65001 Handler Simulator

Four channel scanner designed to test the Handler Interface Option 201. A 1 meter digital interface cable is included.



Ordering Information

HP 4278A 1 KHz/1 MHz Capacitance Meter .....

Furnished Accessories:

04278-89001: Memory Card (1 ea.)

Options:

Opt 001: 1 KHz Test Frequency Only .....
Opt 002: 1 MHz Test Frequency Only .....
Opt 003: 1% Test Frequency Shift .....
Opt 101: HPIB Interface .....
Opt 201: Handler Interface .....

Opt 009: Delete Operating Manual .....
Opt 907: Front Handle Kit .....
Opt 908: Rack Mount Kit .....
Opt 909: Rack Flange and Handle Kit .....
Opt 910: Additional Operating Manual .....

Accessories:

04278-89001: Memory Card (1 ea.)
04278-61100: Memory Card Set (Contains 10 Memory Cards)
04278-65001: Handler Simulator
04278-65003: Test Program

For more information, call your local HP sales office listed in your telephone directory or an HP regional office listed below for the location of your nearest sales office. Ask for the Electronic Instrument Department.

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