Errata

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HP References in this Application Note

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Impedance Testing Using Scanner

- HP 4284A Precision LCR Meter -

INTRODUCTION

Today component manufacturers need higher productivity and component yields in order to supply lower cost products with faster delivery and higher reliability to compete against very tough competition. Consequently, most component manufacturers require impedance testing using a scanner to improve productivity and to control the quality of their products. But many systems were designed without considering the influence of residual errors specific to scanning systems. The HP 4284A Precision LCR Meter with the Option 301 Scanner Interface has a correction function for a scanning system. This application note describes solutions to the problem of scanning system residual error by comparing a conventional system to an improved system using the HP 4284A. Also this note covers how to design an ideal scanning system.

SCANNING MEASUREMENT PROBLEMS AND SOLUTIONS

This section describes problems, solutions and typical results of using a scanning system to measure components. Part one of this section shows the results of measuring 100 capacitors using the experimental scanning system shown in figure 1. The results show some of the problems of using a scanning system with a conventional LCR meter. Part two shows the results of measuring a capacitor at each channel to analyze what causes the problems, the results makes clear two problems of a conventional systems. And part three shows a solution using the HP 4284A's correction function for a scanning system. Then a practical example of measuring 100 samples is described.
Problems Using a Conventional Scanning System

The measurement results obtained using a scanner does not always correspond with the values obtained without a scanner. Figure 2 shows the measurement results of measuring 100 capacitors (typical value is 3300 pF) at a measurement frequency of 1 MHz and a oscillator level of 1 V. The scanner system is an experimental system which uses OPEN/SHORT correction and a conventional scanner. The results looks inaccurate because the distribution is wider and some dissipation factor values are negative. Figure 3 shows the measurement results when using the HP 4284A with the HP 16047C Multipurpose Test Fixture to measure the same 100 capacitors. The results shown in figure 3 can be roughly regarded as the actual distribution of the 100 samples. A comparison between them suggests that using a scanner causes this difference. The distribution in measurement values shown in figure 2 is greater than the one shown in figure 3 and some of the D measurement

Figure 1. Experimental Scanning System

Figure 2. Measurement Results Using OPEN/SHORT Correction

(a) Capacitance

R̅ = 3195.15pF
S.D. = 135.575

(b) Dissipation Factor

R̅ = -0.0102
S.D. = 0.01148

Figure 3. Measurement Results Using the HP 16047C

(a) Capacitance

R̅ = 3257.46pF
S.D. = 27.0668

(b) Dissipation Factor

R̅ = 0.00338
S.D. = 9.76152
values in figure 2 are negative. It seems that the distribution in the measurement value using a scanner is greater than the actual value and that the dissipation factor values tend to be offset to a negative value. The scanner located between fixture and LCR meter has some errors that a conventional LCR meter cannot reduce.

Tracking Down the Error Source

Figure 4 shows the measurement results using a six channel scanner to measure the same capacitor at each channel. The measurement is made with a conventional OPEN/SHORT correction, where the correction measurement data obtained at one of the six channels. The center black dot in figure 4 is the reference value measured using the HP 16047C Multipurpose Test Fixture connected directly to the HP 4284A. The reference capacitance value is 3210 pF and the dissipation factor is 0.00045. Figure 4 clearly shows the two problems of a scanning system using the conventional correction function.

One of problems is the discrepancy in measurement value between each channel. The OPEN/SHORT correction function can reduce errors caused by residuals and stray capacitance of the scanning system. However the OPEN admittance and SHORT impedance of each channel are different from channel to channel because the cable length and the arrangement of parts between the LCR meter and the fixture are different for each channel branch. The reason why this discrepancy occurs is that a conventional LCR meter can store only one set of data for correction.

The other problem is the negative dissipation factor. Figure 4 shows that some scanner measurement values are offset from the reference value to a negative value even if the OPEN/SHORT correction is used. The OPEN/SHORT correction cannot reduce this error because the error is caused by a complicated phase shift of the test signal in the scanner.

Figure 4. Problems Using a Scanner

Figure 5 shows measurement results when the HP 4284A's MULTI-correction mode and OPEN/SHORT/LOAD correction are used. A detailed discussion is given in the next.
MULTI-Correction Mode

When the Option 301 Scanner Interface is installed, the HP 4284A can minimize the discrepancy in measurement values between the scanner measurement channels with its MULTI-correction mode function. With this option, the HP 4284A can store a complete set of correction data (OPEN/SHORT/LOAD) for up to 128 channels. All the data is stored in the HP 4284A's non-volatile memory, therefore it is not necessary to transfer data from the controller to the HP 4284A (the data is not lost when the HP 4284A is turned off). Figure 5-(a) shows the measurement results when using OPEN/S-HORT correction in MULTI-correction mode, less measurement discrepancy.

OPEN/SHORT/LOAD Correction

The discrepancy in measurement data can be minimized by using the MULTI-correction function, but the negative dissipation factor problem is still not solved. The OPEN/SHORT/LOAD correction functions built into the HP 4284A will solve this problem. Figure 5-(b) shows the measurement results when using OPEN/SHORT/LOAD correction in the MULTI-correction mode. The results show that the error in dissipation factor is reduced and that all measurement values are close to the reference value.

The OPEN/SHORT/LOAD correction requires OPEN, SHORT, and working standards. The working standard should have good stability and its characteristics should be accurately known and close to the value to be measured. To measure the characteristics of a working standard, use the HP 4284A with a multipurpose test fixture such as the HP 16047A/C.

Confirmation Measurement

Figure 6 shows the confirmation measurement results for the same 100 capacitors used before and with the OPEN/SHORT/LOAD and MULTI-correction mode. The measurement results shown in figure 6 closely matches those in figure 3. This demonstrates that these correction functions are effective in reducing errors due to the scanning system.

DESIGNING A SCANNING SYSTEM

This section describes how to design a scanning system to measure components using an LCR meter.

Reviewing Specifications

When you design a scanning system, you have to select the scanner and the cable configuration. To do this, you should clarify your measurement requirements (specifications) for the system. For example, it is impossible to measure a 10 pF capacitor with 0.1% accuracy when using a scanner that has 100 pF of stray capacitance. Specifications to review are measurement accuracy, the DUT measurement frequency, and the number of scanner channels. The measurement accuracy requirement will determine the maximum residual and stray capacitance allowed in the scanning system. The measurement value and the test frequency requirements are determined by the cable configuration. The number of channels determines the type of scanner you should select.

![Graph](image)

Figure 6. Improved Measurement Results
Consideration for Residuals

The OPEN/SHORT/LOAD compensation function of the HP 4284A can reduce most of the errors due to the scanning system. It, however, cannot zero out the errors if the residuals in the system are too great. Residuals consist of series impedance and parallel admittance that exist in the scanner and the interconnecting cables up to the DUT. To find these residual values, refer to the data sheets of the scanner and cables used, or directly measure them by measuring with the DJT terminals OPEN and SHORTed.

The series impedance and parallel admittance values should be less than 1/100 of the DUT’s value. For example, when a 100 pF capacitor is measured at 1 MHz, the series impedance should be less than 16 ohms (2.5 micro Henrys in inductance) and the parallel admittance should be less than 6.3 micro Siemens (1 pF in capacitance). If the residuals in your system exceed (or are estimated to exceed) the limits, try minimizing the residuals by adopting a 4-terminal configuration, changing the wires to shielded cables, and guarding the test fixture.

Selecting Cable Configuration and Scanner

The cable configuration used for a scanner depends on the impedance value to be measured. There are five cable configurations used to measure impedance as shown in Figure 7. Figure 7 shows the appropriate cable configurations for the impedance ranges to be measured. The 3-terminal, 5-terminal, or 4-terminal pair are recommended for high impedance measurements, and the 4-terminal or 4-terminal pair are recommended for low impedance measurements. But if the impedance of a test device is in the mid-range impedance values, the 2-terminal configuration can be used. Using the 2-terminal configuration lets you have the maximum number of measurement channels with the minimum number of instruments, thus lower system cost. Using the 4-terminal pair configuration will achieve the highest accuracy over a wide impedance measurement range at a higher system cost.

After you determine the cable configuration you can select a scanner. As table 1 shows, the maximum number of channels depends the cable configuration and the scanner used. Using Hewlett Packard’s scanners (for example, the HP 3488A or HP 3235A) makes the design of a system easy because they are controlled via HP-IB, plus many kinds of switching modules are provided.

<table>
<thead>
<tr>
<th>Table 1. Channels Available vs Cable and Scanner Configuration</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Recommanded Impedance Range</strong></td>
</tr>
<tr>
<td><strong>Cable Config.</strong></td>
</tr>
<tr>
<td>3488A with opt. 010</td>
</tr>
<tr>
<td>3488A with opt. 012</td>
</tr>
<tr>
<td>3235A + 34504A</td>
</tr>
</tbody>
</table>

* connecting in series
** connecting in series and using 2 scanners
*** connecting in series and using 5 scanners
Figure 7. Cable Configurations

Note:
Only the combination of the HP 3235A with the HP 34504A can provide a 4-terminal-pair configuration. To configure a 4-terminal-pair, both the inner and outer conductors must be switched ON and OI-F.
Programming

After the hardware specifications of the system are fixed, you can write a control program to take measurement and correction data. The HP 4284A requires a controller to use the MULTI-correction mode. Program 1 lists a sample program. This program controls the HP 4284A with Option 301, and the HP 3488A with Option O10, and scans six channels when using the 2-terminal configuration. You can modify this program to suit your measurement system and scanner needs. The following procedure describes how to use this sample program.

If you apply a high DC or AC current to scanner, the measuring sequence should be modified as follows.

1. Turn off the test signal or bias
2. Switch channels
3. Apply the test signal or bias
4. Measure

This program scans six channels to make correction data measurements. While the program is running a message will be displayed on the controller’s screen.

(STEP 1) Select function

The following message is displayed on the screen when the program starts.

SELECT FUNCTION
(1) MEASUREMENT
(2) CORRECTION?

This is asking if you want to take correction data or make a measurement. If you select to take correction data, you should type 1 and press the controller’s RETURN key. If your select MEASUREMENT, then you should press 2 and press the RETURN key.

(STEP 2) Select correction method

After pressing RETURN key in step (1), the following message is displayed.

SELECT CORRECTION METHOD TO BE USED IN MEASUREMENT
(1) OPEN/SHORT CORRECTION
(2) OPEN/SHORT/LOAD CORRECTION

Select the correction method to be used in the measurement. You should select 1 or 2 and press the RETURN key.

(STEP 3) Selection correction mode to be used for measurement

After the RETURN key is pressed the following message will be displayed:

SELECT CORRECTION MODE
(1) SINGLE (2) MULTI

You should select 1 or 2 and press the RETURN key. The next step depends on the selection of STEP 1 (getting correction data or measuring device).

If you chose to measure, the system starts scanning and measuring the devices. If you chose to get correction data, the program proceeds to STEP 4.

Figure B. Flow Chart of Sample Program
(STEP 4) Measure the OPEN correction data for each channel

The following message will be displayed on the screen:

CH1 OPEN MEASUREMENT
OPEN TEST TERMINALS OF CH1,
THEN PRESS CONTINUE KEY

After this message is displayed, you should open the test terminal for channel 1 and press the CONTINUE softkey of the controller to measure the open admittance. When you press the CONTINUE key, the HP 4284A starts measuring the open admittance of channel 1 and displays the following message:

OPEN MEASUREMENT IN PROGRESS

If you select the MULTI-correction mode, you should repeat the same procedure for channels 2 to 6.

After the measurement is completed the next message is displayed.

(STEP 5) Measure SHORT correction data for each channel

CH.1 SHORT MEASUREMENT
SHORT TEST TERMINALS OF CH1,
THEN PRESS CONTINUE KEY

After this message is displayed, you should short the test terminal of channel 1 and press the CONTINUE softkey of the controller to measure the short impedance. When you press the CONTINUE key, the HP 4284A starts measuring the short impedance of channel 1 and displays the following message.

SHORT MEASUREMENT IN PROGRESS

If you select MULTI-correction mode, you should repeat the same procedure for channels 2 to 6.

After measuring, if you chose the OPEN/SHORT/LOAD correction, the program will proceed to STEP 6. If you did not select OPEN/SHORT/LOAD correction, the program will proceed to STEP 7.

(STEP 6) Measure LOAD correction data for each channel

CH.1 LOAD MEASUREMENT
CONNECT A STANDARD TO TEST TERMINALS OF CH1, THEN PRESS CONTINUE KEY

After this message is displayed, connect the standard device to the test terminals of channel 1 and press CONTINUE key. The HP 4284A will start to measure the device and display the following message.

LOAD MEASUREMENT IN PROGRESS

After the measurement is complete, the following message is displayed.

CH.1 STANDARD VALUE SETTING
INPUT STANDARD VALUE OF A

Type in the standard's value of A (A means first parameter)

INPUT STANDARD VALUE OF B

Type in the standard's value of B (B means the second parameter and press the RETURN key. The following message will be displayed.

STANDARD VALUE
A= xxxxxx, B= xxxxxx, OK?
(1) YES (2) NO

If the value is wrong, type 2 and press the RETURN key. You can re-enter the standard value (xxxxxx means the standard value that you entered). If you chose YES (type 1 and press the RETURN key), getting the correction data for channel 1 finishes. If you select the MULTI-correction mode, you should repeat the same procedure for channels 2 to 6. After getting all the correction data, the following message will be displayed.

CORRECTION IS COMPLETED.

DO YOU WANT TO CONTINUE TO MEASURE?
(1) YES (2) NO

To start scanning, select YES (type 1 and press the RETURN key). To exit the program, select NO (type 2 and press the RETURN key).

(STEP 7) Scanning measurement

This program scans six channels to measure and display the measurement data on the screen.
Typical Measurement Results

Figure 9 shows sample results of a scanning measurement using the HP 4284A and the HP 3488A. All measurements in Figure 9 use the OPEN/SHORT/LOAD correction and the MULTI-correction mode. The sample devices are capacitors and inductors. Figure 9-(a) shows the results of measuring high value capacitors, figure 9-(b) shows the results of measuring low value capacitors and figure 9-(c) shows the results of inductance measurement. The results shows that the measurement results are not influenced by the scanner, hence the OPEN/SHORT/LOAD correction and the MULTI-correction mode are effective for all impedance ranges.

CONCLUSION

The HP 4284A with Option 301 has powerful correction functions for reducing the errors that a conventional LCR meter can not reduce when making scanning measurements. The HP 4284A is an outstanding LCR meter to use for obtaining accurate scanning system impedance measurement results.

(a) High Capacitance

<table>
<thead>
<tr>
<th>CAPACITANCE [uF]</th>
<th>DISSIPATION FACTOR</th>
</tr>
</thead>
<tbody>
<tr>
<td>REFERENCE VALUE</td>
<td></td>
</tr>
<tr>
<td>CHANNEL 1</td>
<td>910.870</td>
</tr>
<tr>
<td>CHANNEL 2</td>
<td>909.658</td>
</tr>
<tr>
<td>CHANNEL 3</td>
<td>909.702</td>
</tr>
<tr>
<td>CHANNEL 4</td>
<td>909.659</td>
</tr>
<tr>
<td>CHANNEL 5</td>
<td>909.463</td>
</tr>
<tr>
<td>CHANNEL 6</td>
<td>910.748</td>
</tr>
</tbody>
</table>

(Test Frequency 100Hz Osc. level 1V)

(b) Low Capacitance

<table>
<thead>
<tr>
<th>CAPACITANCE [pF]</th>
<th>DISSIPATION FACTOR</th>
</tr>
</thead>
<tbody>
<tr>
<td>REFERENCE VALUE</td>
<td></td>
</tr>
<tr>
<td>CHANNEL 1</td>
<td>9.60644</td>
</tr>
<tr>
<td>CHANNEL 2</td>
<td>9.63423</td>
</tr>
<tr>
<td>CHANNEL 3</td>
<td>9.64935</td>
</tr>
<tr>
<td>CHANNEL 4</td>
<td>9.63341</td>
</tr>
<tr>
<td>CHANNEL 5</td>
<td>9.69686</td>
</tr>
<tr>
<td>CHANNEL 6</td>
<td>9.61032</td>
</tr>
</tbody>
</table>

(Test frequency 1kHz Osc. level 1V)

(c) Inductance

<table>
<thead>
<tr>
<th>INDUCTANCE [uH]</th>
<th>DISSIPATION FACTOR</th>
</tr>
</thead>
<tbody>
<tr>
<td>REFERENCE VALUE</td>
<td></td>
</tr>
<tr>
<td>CHANNEL 1</td>
<td>91.1340</td>
</tr>
<tr>
<td>CHANNEL 2</td>
<td>90.9654</td>
</tr>
<tr>
<td>CHANNEL 3</td>
<td>91.3405</td>
</tr>
<tr>
<td>CHANNEL 4</td>
<td>91.2980</td>
</tr>
<tr>
<td>CHANNEL 5</td>
<td>91.2880</td>
</tr>
<tr>
<td>CHANNEL 6</td>
<td>91.2962</td>
</tr>
</tbody>
</table>

(Test frequency 1kHz Osc. level 10mA)

Figure 9. Measurement Results
Program 1. Sample Program

1000 ****************************
1010 14284 APPLICATION NOTE 363-6
1020 * IMPEDANCE TESTING USING SCANNER
1030 ****************************
1040 DIM A(1:100), D(1:100), Wk(1:100)
1050 1060
1070 H13484A*717
1080 H3484A\789
1090 Freq=1.25S
1100 *Meas_function*="CPD"
1110 Corr_function*="Meas_function"
1120 "Load corr. function is CP-D"
1130 A=Meas_function(1,2)
1140 B=Meas_function(3,3)
1150 1160 Open_ch(1)="OPEN1"
1170 Open_ch(2)="OPEN2"
1180 Open_ch(3)="OPEN3"
1190 Open_ch(4)="OPEN4"
1200 Open_ch(5)="OPEN5"
1210 Open_ch(6)="OPEN6"
1220 Close_ch(1)="CLOSE1"
1230 Close_ch(2)="CLOSE2"
1240 Close_ch(3)="CLOSE3"
1250 Close_ch(4)="CLOSE4"
1260 Close_ch(5)="CLOSE5"
1270 Close_ch(6)="CLOSE6"
1280 Open_all_ch=OPEN1, OPEN2, OPEN3, OPEN4, OPEN5, OPEN6
1290 1300 Measurement=0
1310 Correction=1
1320 Open_short=0
1330 Open_short_load=1
1340 Single=1
1350 Multi=1
1360 1370 A=sum
1380 B=sum
1390 A=sum
1400 B=sum
1410 1420 Work=0
1430 PRINT CHRM(12)
1440 PRINT "SELECT FUNCTION (1) MEASUREMENT (2) CORRECTION"
1450 INPUT "TYPE NUMBER AND PRESS RETURN KEY",Work
1460 IF Work=1 THEN Function=Measurement
1470 IF Work=2 THEN Function=Correction
1480 IF Function=Correction THEN 1500
1490 1500 Work=0
1510 PRINT CHRM(12)
1520 PRINT "SELECT CORRECTION METHOD TO BE USED IN MEASUREMENT"
1530 PRINT "(1) OPEN/SHORT (2) OPEN/SHORT LOAD"
1540 INPUT "TYPE NUMBER AND PRESS RETURN KEY",Work
1550 IF Work=1 THEN Correct_su=OPEN_short
1560 IF Work=2 THEN Correct_su=OPEN_short_load
1570 IF Work=1 AND Work=2 THEN 1620
1580 1590 Print "SELECT CORRECTION MODE (1) SINGLE (2) MULTI"
1600 PRINT "TYPE NUMBER AND PRESS RETURN KEY",Work
1610 IF Work=1 THEN Correct_mode=Single
1620 IF Work=2 THEN Correct_mode=Multiply
1630 IF Work=1 AND Work=2 THEN 1620
1640 1650 IF Correct_su=OPEN_short THEN Correct_su=OPEN/SHORT LOAD
1660 IF Correct_su=OPEN_short_load THEN Correct_su=OPEN/SHORT LOAD
1670 IF Correct_mode=Multi THEN Correct_mode=MULTI
1680 1690 OUTPUT H4284A="RESET"
1700 OUTPUT H4284A="OPEN,ALL"
1710 OUTPUT H4284A="FREQ",FREQ
1720 OUTPUT H4284A="FUNCTION",Meas_function
1730 OUTPUT H4284A="CORRELATION",CORR_function
1740 OUTPUT H4284A="INITIALIZE" 4284A
1750 OUTPUT H4284A="TRIG MODE"
1760 OUTPUT H4284A="CORRELATION",ST "F!"
1770 OUTPUT H4284A="CORRELATION",ST "I"
1780 OUTPUT H4284A="DISP/PAGE MEAS"
1790 OUTPUT H4284A="CHملك"
1800 OUTPUT H4284A="FUNCTION MEASUREMENT" Measurement or correction
1810 FOR Ch=1 TO Nach-1
1820 CH=VAL(CH)
1830 PRINT CHRM(12)
1840 PRINT "CH","CH&AS" OPEN MEASUREMENT"
1850 PRINT "OPEN TEST TERMINALS OF CH&CH"
1860 PRINT "OPEN MEASUREMENT"
1870 PRINT "START OPEN MEAS. (2) SKIP CH, "CH&AS"
1880 Work=0
1890 INPUT "TYPE NUMBER AND PRESS RETURN KEY",Work
1900 IF Work=1 AND Work=2 THEN 1990
1910 OUTPUT H4284A=Close_ch(CH)
1920 OUTPUT H4284A="FREQ",FREQ
1930 OUTPUT H4284A="FUNCTION",Meas_function
1940 OUTPUT H4284A="INITIALIZE" 4284A
1950 OUTPUT H4284A="CORRELATION",CORR_function
1960 OUTPUT H4284A="CORRELATION",CORR_function
1970 ADDENDUM Event_reg=0?
1980 IF ADDENDUM Event_reg=0 THEN 2060
1990 OUTPUT H4284A=Close_ch(CH)
2000 OPEN skip_ch
2010 IF Correct_mode=Single THEN Short_meas
2020 NEXT Ch
2030 Short_meas:
2040 FOR Ch=1 TO Nach-1
2050 CH=VAL(CH)
2060 PRINT CHRM(12)
2070 PRINT "CH","CH&AS" SHORT MEASUREMENT"
2080 PRINT "SHORT TERMINALS OF CH&CH"
2090 PRINT "START SHORT MEAS. (2) SKIP CH, "CH&AS"
2100
Sample Program (Continued)

2100 Work=0
2110 INPUT "TYPE NUMBER AND PRESS RETURN KEY", Work
2120 IF Work<>1 AND Work<>2 THEN 2210
2130 IF Work=2 THEN Short_skip_ch
2140 OUTPUT Hp3488a(close_ch(#Ch))
2150 OUTPUT Hp4284a("CORR=USE "VAL#(Ch)"
2160 PRINT "SHORT MEASUREMENT IN PROGRESS"
2170 OUTPUT Hp4284a("CORR=SPOT:"#Dia"
2180 OUTPUT Hp4284a("STAT:OPEN/EVENT"
2190 ENTER Hp4284a(Event_reg)
2200 IF BINAND(Event_reg,1)=0 THEN 2200
2100 OUTPUT Hp3488a(open_ch(#Ch))
2210 Short_skip_ch:
2220 IF Correct_mode=Single THEN Load_meas
2340 NEXT Ch
2350 Load_meas:
2360 IF Correct_sum=Open_short THEN Skip_load
2370 FOR Ch=1 TO NoCh
2380 Ch=VAL#(Ch)
2390 PRINT CHR$(12)
2400 PRINT "CH,"CH#" LOAD MEASUREMENT"
2410 PRINT "CONNECT A STANDARD TO THE TEST TERMINALS OF CH"#Ch
2420 PRINT "(1) START LOAD MEAS. (2) SKIP CH,"#Ch"? 7"
2430 Work=0
2440 INPUT "TYPE NUMBER AND PRESS RETURN KEY", Work
2450 IF Work<>1 AND Work<>2 THEN 2440
2460 IF Work=2 THEN Load_skip_ch
2470 OUTPUT Hp3488a(close_ch(#Ch))
2480 OUTPUT Hp4284a("CORR=USE "VAL#(Ch)"
2490 PRINT "LOAD MEASUREMENT IN PROGRESS"
2500 OUTPUT Hp4284a("CORR=SPOT:"#Dia"
2510 OUTPUT Hp4284a("STAT:OPEN/EVENT"
2520 ENTER Hp4284a(Event_reg)
2530 IF BINAND(Event_reg,1)=0 THEN 2510
2540 OUTPUT Hp3488a(open_ch(#Ch))
2550 PRINT CHR$(12)
2560 PRINT "CH,"CH#" STANDARD VALUE SETTING"
2570 PRINT "INPUT STANDARD VALUE OF A""
2580 INPUT "TYPE VALUE AND PRESS RETURN KEY", Ref_a
2590 PRINT "INPUT STANDARD VALUE OF B""
2600 INPUT "TYPE VALUE AND PRESS RETURN KEY", Ref_b
2610 PRINT "STANDARD VALUE ="";Ref_a,"" Ref_b"
2620 INPUT "TYPE NUMBER AND PRESS RETURN KEY", Work
2630 IF Work<>1 AND Work<>2 THEN 2630
2640 IF Work=2 THEN 2650
2650 OUTPUT Hp4284a("CORR=SPOT:"#Dia"
2660 Load_skip_ch:
2670 IF Correct_mode=Single THEN End_correction
2680 NEXT Ch
2690 Skip_load:
2700 OUTPUT Hp3488a(open_ch(#Ch))
2710 END_correction:
2720 PRINT CHR$(12)
2730 PRINT "CORRECTION IS COMPLETED."
2740 Work=0
2750 INPUT "DO YOU WANT TO CONTINUE TO MEASURE? (1) YES (2) NO", Work
2760 IF Work<>1 AND Work<>2 THEN 2750
2770 IF Work=1 THEN Measurement
2780 IF Work=2 THEN END_correction
2790 Measurement:
2710 PRINT CHR$(12)
2720 PRINT "CORR= "Correct_sum"," MODE= "Correct_mode
2730 FOR Ch=1 TO NoCh
2740 OUTPUT Hp3488a(close_ch(#Ch))
2750 OUTPUT Hp4284a("CORR=USE "VAL#(Ch)"
2760 PRINT "INITIALIZE HP 4284A"
2770 OUTPUT Hp4284a("STRG"
2780 PRINT Hp4284a(Event_reg)
2790 ENTER Hp4284a(Event_reg)
2800 A(Ch)=VAL#(Work(#Ch)
2810 B(Ch)=VAL#(Work(#Ch)
2820 PRINT "CH,"Ch#"=";A(Ch),B(Ch)=";B(Ch)
2830 INPUT A_sum=A_sum(A(Ch)
2840 B_sum=B_sum(B(Ch)
2850 OUTPUT Hp3488a(open_ch(#Ch))
2860 NEXT Ch
2870 PRINT
2880 PRINT A_sum=SUM#(A)
2890 B_sum=SUM#(B)
2900 OUTPUT Hp3488a(open_ch(#Ch))
2910 NEXT Ch
2920 PRINT
2930 PRINT A_sum=SUM#(A)
2940 B_sum=SUM#(B)
2950 OUTPUT Hp3488a(open_ch(#Ch))
2960 NEXT Ch
2970 PRINT
2980 PRINT A_sum=SUM#(A)
2990 B_sum=SUM#(B)
3000 FOR Ch=1 TO NoCh
3010 A(Ch)=A(Ch)+B(Ch)
3020 B(Ch)=B(Ch)+B(Ch)
3030 NEXT Ch
3040 FOR Ch=1 TO NoCh
3050 A(Ch)=SQR(A(Ch))
3060 B(Ch)=SQR(B(Ch))
3070 PRINT A()" AVE.=";A(Ch),B()" AVE.=";B(Ch)
3080 PRINT A_sum=SUM#(A)
3090 B_sum=SUM#(B)
3100 FOR Ch=1 TO NoCh
3110 END