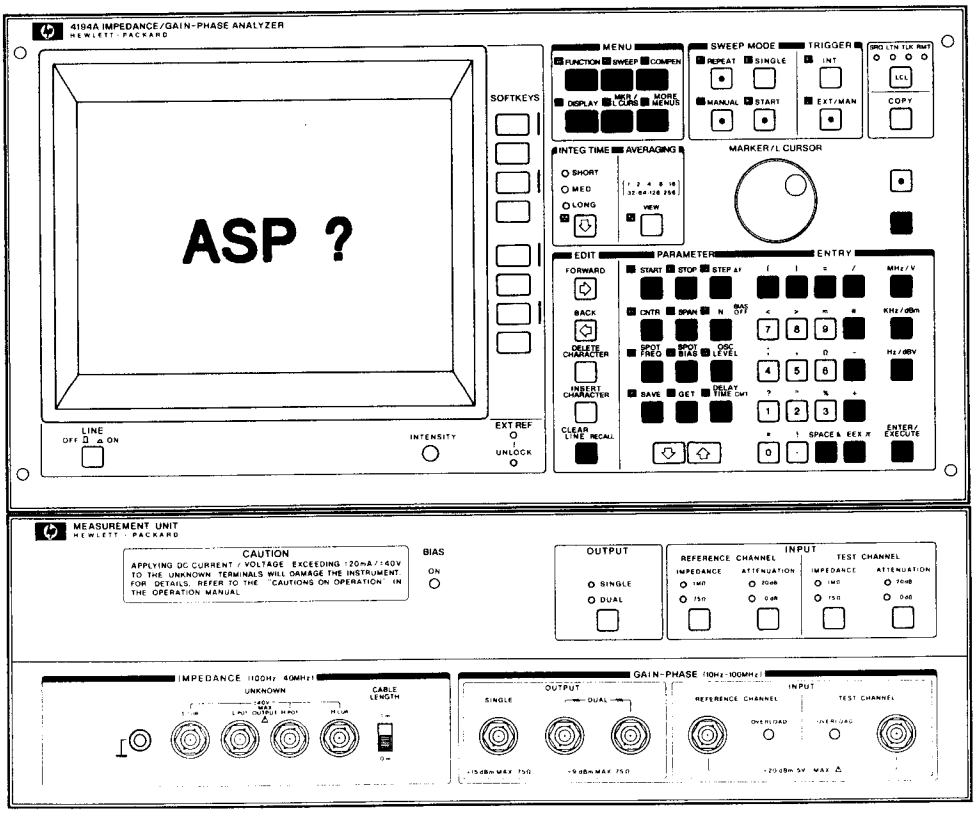
HEWLETT PACKARD

HP 4194A
ASP PROGRAMMING GUIDE



CONTENTS

1. Foreword

Most HP 4194A functions can be controlled easily by using the internal Auto Sequence Program (ASP). ASP increases test efficiency and makes the following possible.

a. Converts raw data to secondary parameters.

The HP 4194A performs this conversion, so it is possible to analyze desired parameters by using the Marker/Line cursor function.

b. Expands the measurement functions.

ASP can be used to perform alternate sweep, spot Group Delay measurements, sweep-timing control, marker tracking etc.

c. Fast automatic Go/No-Go testing of filters and resonators in production.

The HP 4194A performs Go/No-Go testing and outputs the results to an 8 bit I/O port through the rear panel without the need for an external computer. This means you can reduce data transfer time and decrease device test time.

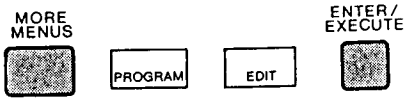
Note

This guide applies to HP 4194A's with Version 2.2 software only.

2. ASP editing basics

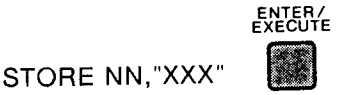
The following is a description of a typical ASP editing session. In this ASP Programming Guide, '**XXXX**' softkey indicates softkeys and **XXXX** key indicates all other keys on the front panel.

(1) Enter the **EDIT** mode.



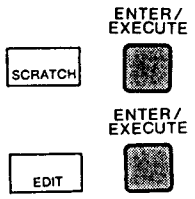
Press the '**QUIT EDITOR**' softkey if the program still remains in the work area. If the program isn't in the work area, go to step(2).

a. If you need the program in the work area, then store it.
[Go to b.]



The program Number is NN and comment is XXX.
[Refer to Figure 1.]

b. Scratch the program in the work area, if you don't need it.
Reenter the **EDIT** mode.




```
                PROGRAM EDITOR
FILE NO:

   10 RST
   20 CMT"MOS C-V  AT 1MHZ"
   30 IMP12;SWP2;SWM2;TRGM2;DPB0;FREQ=1M;OS
   40 START=-5;STOP=5
   50 PAUSE
   60 SWTRG
   70 DTIME=10000
   80 TRIG
   90 DTIME=10
  100 TRGM1

  110 AUTOA
  120 PAUSE
  130 SWP1
  140 END

STORE1,"MOS C-V"_
```

Figure 1

Note

To set the cursor position to a desired line number, key in that line number following '**EDIT**' by pressing the numeric keys on front panel.

If you press the '**EDIT**' softkey and **ENTER/EXECUTE** key in this sequence after an error is detected in an ASP program, the cursor will be set to the program edit line where the error was detected.

If these keys are pressed after you stop the program in progress, the cursor will be set to the program edit line where the '**STOP**' softkey is pressed.

(2) Figure 2 shows the Program Editor Page when no program exists in the ASP work area. ASP is entered by pressing **MENU** keys, hardkeys, and softkeys in sequence, except for the message, register name and equation.

For example, when you want to enter the sweep start command in the program editor page, press the **START** key in the SWEEP MODE so the program command is displayed on the program edit line. You don't have to press each **S**, **W**, **T**, **R**, and **G** keys in the alphabet mode. This line is entered to the work area by pressing the **ENTER/EXECUTE** key.

Softkey labels displayed on the CRT are somewhat different for front panel operation and ASP editing. Refer to the HP 4194A Operating Guide (HP Publication No. 5950-2916) Appendix B, Softkey Tree.

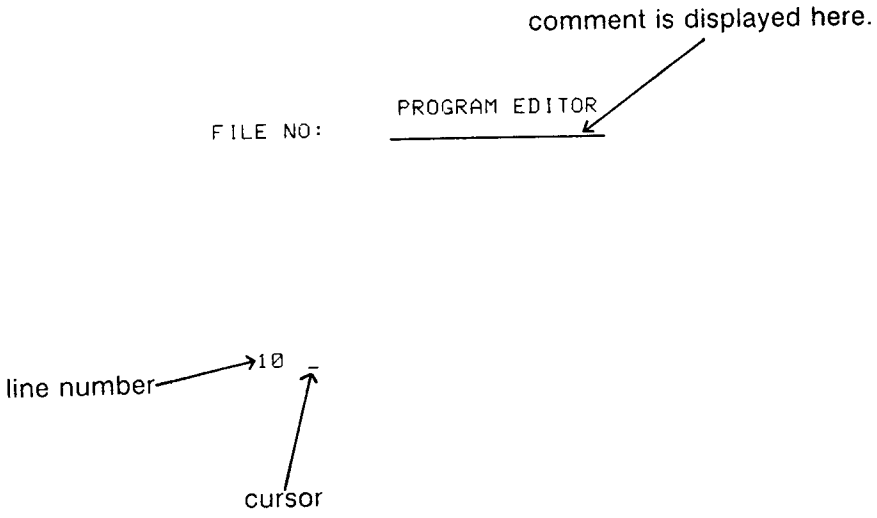


Figure 2

Note

You should insert the **RST** command at the beginning of a program. Otherwise, HP 4194A settings will be the same as before the ASP program is run. Execute the **RST** command before entering the program editor page so you can make sure what parameters are already set. Default setting softkeys are green so you can recognize them easily.

(3) Edit using the menu key.

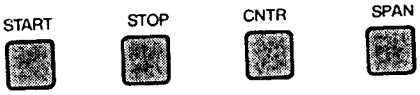
Entering the program as follows will make programming easier.

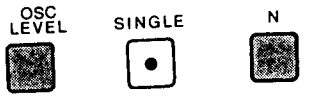
a. Measurement function set up

* Impedance measurement parameter
* Gain-Phase measurement parameter
* Input signal monitor

b. Measurement condition set up

* Sweep parameter (f, OSC LVL, DC-BIAS)
* Sweep type
* Sweep direction
* Programmed points measurement on/off
* Expand markers
* Start/Stop or Center/Span
* OSC Level





c. Compensation

* Compensation mode (All points, Interpolation)
* Calibration
* Open/Short offset
* Phase scale expansion

Do not include the '**ZERO OPEN**', '**ZERO SHRT**', '**0Ω CAL**', '**0S CAL**', '**STD CAL**', and '**OFFSET REF STORE**' commands within a program. Compensation measurement need not be performed with each program execution.

d. Measurement

* Repeat
* Single
* Manual

e. Display

* Display format
* Scale set up and change
* Storage function
* Superimpose function

f. Analysis

[MKR / L CURS]

* Marker analysis
* Line cursor analysis
* Partial analysis

[MORE MENUS] [COPY menu] [EQV CKT]

g. Other

* Auto Sequence Program **EDIT/RUN**
* Screen hard copy
* Equivalent circuit analysis
* Programmed Points measurement set up
* HP-IB define

(4) Quit the **EDIT** mode.

[MORE MENUS] [QUIT EDITOR]

(5) Execute the program.

[RUN]

(6) Debug the program.

'**STEP**' execution is useful for debugging.

(7) Store the program.

[MORE MENUS] [PROGRAM] [STORE]

STORE NN,"XXX" [ENTER/ EXECUTE]

(8) To check if the program was stored, display the stored program catalog.

[CAT]

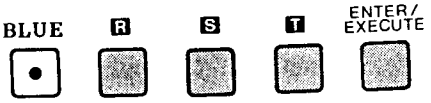
[Example 1]

DUT [1]: 30MHz ceramic resonator

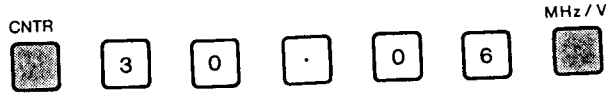
Evaluation parameter : series and parallel resonant frequency and Impedance (|Z|-θ)

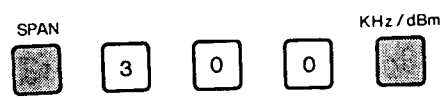
```
10 RST
20 FNC1          ! Impedance

30 CENTER=30.06 MHZ
40 SPAN=300 KHZ
50 SWM2          ! Single sweep
60 ITM2          ! I.T.=Medium

70 OSC=.3 V
80 NOP=201       ! 201 points

90 OPN1          ! Open offset on
100 SHT1         ! Short offset on

110 SWTRG        ! Sweep start

120 ASC2         ! A scale LOG

130 AUTOA        ! Auto scale
140 AUTOB

150 BEEP
160 DISP "PRESS CONT TO ANA"
170 PAUSE
180 MKMXA        ! MKR → MAX(A)
190 PAUSE
200 MKMNA        ! MKR → MIN(A)
210 END
```

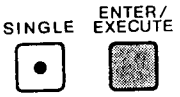
Here shows the key stroke example from line 10 thru line 50.

10 

20 

30 

40 

50 

Fill the rest of lines by following the above examples.

[1] DUT = Device Under Test

3. ASP Applications

In this section, effective use of ASP is explained with some examples. Not only does ASP simplify complicated operations, but it also does the following.

(1) ASP expands the Save function

The HP 4194A has five **SAVE** functions (SAVE 0~4), and these functions can be used within ASP.

(2) Measurement conditions can be changed during a sweep.

Changing the measurement condition during a sweep minimizes measurement time.

```
 10 RST
 20 SWM2;START=1KHZ;STOP=10MHZ;TRGM2
 30 SWTRG
 40 FOR R0=1 TO 100
 50  TRIG
 60 NEXT R0
 70 ITM2;OSC=.4
 80 FOR R0=101 TO 200
 90  TRIG
100 NEXT R0
      .
      .
      .
```

(3) ASP for Peak Tracking function.

This program searches for peak with each new sweep. This is useful for tuning filters.

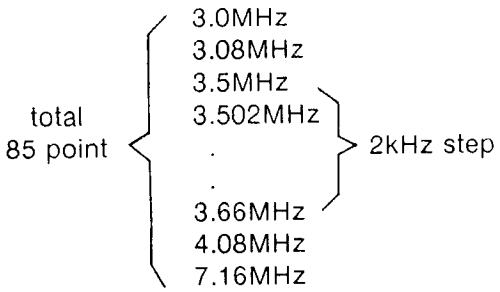
```
10 SWTRG
20 MKMXA
30 GOTO10
40 END
```

Tuning can be done in real time by setting the number of the measurement point from 101 to 201.

e.g. Tuning LC traps.

(4) Programmed Points Tables can be set up by ASP.

When you want to set a Programmed Points Table, as shown below for example, ASP mekes it much easier than to enter each point by using the front panel keys.




```
 10 DISP "TABLE SETTING IN PROGRESS"
 20 PTN=2                          ! Table No.=2
 30 PTCLR                          ! Table clear
 40 POINT=3.0 MHZ                  !
 50 POINT=3.08 MHZ                 !
 60 FOR R0=1 TO 80                 !
 70   R1=R0*2K+3.5M                ! } Table setting
 80   POINT=R1                     !
 90 NEXT R0                        !
100 POINT=4.08 MHZ                 !
110 POINT=7.16 MHZ                 !
120 PTSET                          ! Display the Table
130 BEEP
140 DISP "CHECK THE TABLE"
150 END
```

(5) Complex Matrix operation

The HP 4194A has the capability to perform complex matrix operations. The syntax is as follows.

<V1,V2>=<Equation 1, Equation 2> OP <Equation 3, Equation 4>

V1 and V2 are array or single type variables. OP is an arithmetic operator, (*), (/), (+) and (-). In the < > parentheses, the register or equation which indicates the real part is positioned on the left and the imaginary part is positioned on the right. The result will be stored into the V1 and V2 registers. This operation is performed only in the specified analysis range.

For example,

<RA,RB>=<A,B>-<C,D>

This operation is equal to the following.

RA+jRB=(A-C)+j(B-D)

4. Optimizing ASP

Test time is a very important factor in production. This section explains methods for reducing ASP program execution time.

(1) Use multi-statement program lines when possible.

Memory consumption by a multi-statement program line is less than by a single-statement line, so multi-statement lines reduce interpretation time. You can enter program messages, commands or instructions up to 82 characters per program edit line using a semicolon (;) as the message separator. (The character count of 82 includes line number, separators and spaces.)

```
10 RST                                    ! (Press ENTER/EXECUTE key)
20 IMP12;SWP2;TRGM2;DPB0...
   .
   .
```

Example of a multi-statement line

You can't use the following commands in multi-statement lines.

4194A initialization	RST
sweep	SWTRG, TRIG
copy	COPY
compensation	ZOPEN, ZSHRT, CALY, CALZ, CALSTD
programmed points table	POINT
equivalent circuit	EQDSP, EQCAL, FCHRS
ASP command	LOAD, STORE, PURGE, RUN, CONT, PPAUSE, PSTEP, PSTOP, PROG
ASP statement	IF...THEN, FOR...TO, NEXT, PAUSE, WAIT

statements and commands that not be used on a multi-statement line

The following four statements can be used in multi-statement lines only when they are the last command on a program line.

GOTO, GOSUB, RETURN, END

For example,

50 START=10KHZ;STOP=10MHZ;**GOTO 200**

(2) Turn off the display.

Usually, the screen display is not needed for production testing. Consequently, eliminating the screen display saves time taken up by screen rewriting.

a. Eliminate A and B trace.

Example 10 **DPA0;DPB0**

b. Turn the Marker or Line cursor function off at the end of the line if it is not used.

Example 20 MCF1;MKMXA;R0=MKR;**MCF0**

(3) Enter the constant to the register and compare the measurement value with this register.

The interpreter of the HP 4194A calculates the following by recognizing the constant underlined in Figure 3.

$$(2*10\hat{}1+9*10\hat{}0+9*10\hat{}(-1)+7*10\hat{}(-2)+5*10\hat{}(-3))*10\hat{}6$$

Consequently, if this expression exists in the program loop, it is a large overhead. To avoid this problem, you should set the constant to the register out of the loop, and compare between registers in the program loop as listed Figure 4.

```
100 FOR R0=1 TO 100
200 MKMXA
300 IF MKRA>29.975E6 THEN 700
400 NEXT R0
500 DISP "PASS"
600 GOTO 800
700 DISP "FAIL"
800 END
```

Figure 3

```
 10 R1=29.975E6
100 FOR R0=1 TO 100
200 MKMXA
300 IF MKRA>R1 THEN 700
400 NEXT R0
500 DISP "PASS"
600 GOTO 800
700 DISP "FAIL"
800 END
```

Figure 4

Note

The HP 4194A has an advanced Array variable operating capability. When the element is not defined, all of the elements will be operated on at once. It simplifies and optimizes the program. See examples below.

```
A=E                 ! A(1)=E(1),..,A(401)=E(401)
C=R1*SIN(ATAN(B))   ! C(1)=R1*SIN(ATAN(B(1))),..,C(401)=R1*SIN(ATAN(B(401)))
D=DIF(B)            ! D(1)=DIF(B(1)),..,D(401)=DIF(B(401))
A(10)=E(20)
```

But A > B is equal to A(401) > B(401) operation.

(4) Delete unnecessary commands.

a. Delete **EQDSP**, **PTSET** commands.

b. Delete **GOTO** command following the **THEN** command.

X 100 IF R0<>R1 THEN GOTO 1000

O 100 IF R0<>R1 THEN 1000

c. Make the best use of the current set up.

For example after executing the **RST** command, you don't have to enter **FNC1**, **IMP1**, **SWT1**, **SWP1** etc. command.

For more detailed information refer to Appendix D Default Setting.

d. **AUTO** command is faster than **AUTOA;AUTOB**.

Note

Program readability is contrary to execution speed. So debugging an optimized program is more difficult.

Consequently
1. Write Auto Sequence Programs with single-statements.
2. Debug the program.
3. Rewrite as a multi-statement program.
4. Delete unnecessary commands.
5. Add screen erase commands.

Refer to page 9 for the statements and commands that are not allowed in multi-statement lines.

Appendices

Appendix A

Register Setting Range

Register Name	Value
A,B,C,D,E,F,G,H,I,J RA,RB,RC,RD,RE,RF,RG,RH,RI,RJ,RK,RL OFSTA,OFSTB,OG,OB,SR,SX TYG,TYB,TZR,TZX,TSTDR,TSTDX MYG,MYB,MZR,MZX,MSTDR,MSTDX LCURS,DLCURS EQVR,EQVL,EQVCA,EQVCB	±1E-37 ~ ±9.99999E+37 Res. 6 digits mantissa
Rn,Z	±1E-37 ~ ±9.99999E+37 Res. 12 digits mantissa
AMAX,AMIN,ADIV BMAX,BMIN,BDIV	±1E-37 ~ ±9.999E+37 Res. 4 digits mantissa

IMPEDANCE MEASUREMENT ('IMPEDANCE' mode) :

Register Name	Mode	Value
START,STOP,STEP CENTER,SPAN MANUAL,MKR,SMKR,DMKR FREQ	Frequency	Min. 100.000 HZ Max. 40 000 000.000 HZ *1 15 000 000.000 HZ *2 Res. 0.001 HZ
START,STOP,STEP CENTER,SPAN MANUAL,MKR,SMKR,DMKR OSC	OSC Level	Min. 10.0 mV *3 Max. 1.00 V *3 Min. 10.0 mV *4 Max. 0.50 V *4 Res. 1 % Span 26.0 dB
START,STOP,STEP CENTER,SPAN MANUAL,MKR,SMKR,DMKR BIAS	DC Bias	Min. -40.00 V Max. +40.00 V Res. 0.01 V

*1: Cable Length= 0 m *2: Cable Length= 1 m
*3: Frequency range 100 Hz to 10 MHz (10 MHz inclusive)
*4: Frequency range 10 MHz to 40 MHz

IMPEDANCE MEASUREMENT ('IMP with Z PROBE' mode) :

Register Name	Mode	Value
START,STOP,STEP CENTER,SPAN MANUAL,MKR,SMKR,DMKR FREQ	Frequency	Min. 10.000 HZ Max. 100 000 000.000 HZ Res. 0.001 HZ
START,STOP,STEP CENTER,SPAN MANUAL,MKR,SMKR,DMKR OSC	OSC Level	Min. -65.0 dBm Max. +15.0 dBm Res. 0.1 dB Span 26.0 dB
START,STOP,STEP CENTER,SPAN MANUAL,MKR,SMKR,DMKR BIAS	DC Bias	Min. -40.00 V Max. +40.00 V Res. 0.01 V

GAIN-PHASE MEASUREMENT ('GAIN PHASE' mode) :

Register Name	Mode	Value
START,STOP,STEP CENTER,SPAN MANUAL,MKR,SMKR,DMKR FREQ	Frequency	Min. 10.000 HZ Max. 100 000 000.000 HZ Res. 0.001 HZ
START,STOP,STEP CENTER,SPAN MANUAL,MKR,SMKR,DMKR OSC	OSC Level	Min. -65.0 dBm Max. +15.0 dBm Res. 0.1 dB Span 26.0 dB

Appendix B

Program Code

Note

(1) (*) indicates a selected code as power-on default setting.
(2) (Code=) indicates data write/read type registers.
(3) (@) indicates Read-Only type registers.
(4) (#) indicates battery back-up registers.

1: MENU

1-a : FUNCTION

Code	Function
*FNC1	: Impedance measurement ('IMPEDANCE')
FNC2	: Gain-Phase measurement
FNC3	: Impedance measurement ('IMP with Z PROBE')
	measurement function for impedance
*IMP1	: |Z|- θ
IMP2	: R-X
IMP3	: Ls-Rs
IMP4	: Ls-Q
IMP5	: Cs-Rs
IMP6	: Cs-Q
IMP7	: Cs-D
IMP8	: |Y|- θ
IMP9	: G-B
IMP10	: Lp-G
IMP11	: Lp-Q
IMP12	: Cp-G
IMP13	: Cp-Q
IMP14	: Cp-D
IMP15	: |Z|-Ls
IMP16	: |Z|-Cs
IMP17	: |Z|-Lp
IMP18	: |Z|-Cp
IMP19	: Lp-Rp
IMP20	: Cp-Rp
	measurement function for gain-phase
*GPP1	: Tch/Rch(dB)- θ
GPP2	: Tch/Rch- θ
GPP3	: Tch/Rch(dB)- τ
GPP4	: Rch-Tch(V)
GPP5	: Rch-Tch(dBm)
GPP6	: Rch-Tch(dBV)
	monitor function for impedance
*IVM0	: Off
IVM1	: V(AC)
IVM2	: I(AC)
	monitor function for gain-phase
*GNM0	: Off
GNM1	: Rch(V)
GNM2	: Rch(dBm)
GNM3	: Rch(dBV)
GNM4	: Tch(V)
GNM5	: Tch(dBm)
GNM6	: Tch(dBV)

1-b : SWEEP

	sweep parameter
*SWP1	: Frequency
SWP2	: DC Bias (Impedance measurement Only)
SWP3	: Osc level(V)
SWP4	: Osc level(dBm) (Linear sweep Only)
SWP5	: Osc level(dBV) (Linear sweep Only)
	sweep type
*SWT1	: Linear
SWT2	: Log.
	sweep direction
*SWD1	: Up
SWD2	: Down

1-b : SWEEP(continued)

Code	Function
	programmed point measurement
*PPM0	: Off
PPM1	: On
	o-marker to *-marker sweep
MKEXP	: Execute sweep between markers.

1-c : COMPENSATION

	compensation for impedance measurement
*CMPN1	: Interpolation mode
CMPN2	: All points mode
ZOPEN	: Start open calibration
ZSHRT	: Start short calibration
*OPN0	: Open calibration off
OPN1	: Open calibration on
*SHT0	: Short calibration off
SHT1	: Short calibration on
CALY	: Start 0S calibration
CALZ	: Start 0Ω calibration
CALSTD	: Start 50Ω (standard) calibration
*CAL0	: Standard calibration off
CAL1	: Standard calibration on
*PHS1	: Phase scale to normal mode
PHS2	: Phase scale to expansion mode
	compensation for gain-phase measurement
OFSTR	: Store offset reference
*AOF0	: Data A offset off
AOF1	: Data A offset on
*BOF0	: Data B offset off
BOF1	: Data B offset on
*PHS1	: Phase scale to normal mode
PHS2	: Phase scale to expansion mode

1-d : DISPLAY

	display mode
*DSP1	: X-A&B
DSP2	: A-B
DSP3	: Table
	display function effective for X-A&B mode
AUTOA	: Autoscale A
AUTOB	: Autoscale B
DPA0	: Display data A off
*DPA1	: Display data A on
DPB0	: Display data B off
*DPB1	: Display data B on
*ASC1	: Data A scale to Linear
ASC2	: Data A scale to Log.
*BSC1	: Data B scale to Linear
BSC2	: Data B scale to Log.
AMAX=	: Maximum value for data A scale
AMIN=	: Minimum value for data A scale
BMAX=	: Maximum value for data B scale
BMIN=	: Minimum value for data B scale
ADIV=	: Scale division for data A (Linear scale Only)
BDIV=	: Scale division for data B (Linear scale Only)
GRT0	: Graticule off
*GRT1	: Graticule on
UNIT0	: Unit display off
*UNIT1	: Unit display on
*STRG0	: Storage mode off
STRG1	: Storage mode on

1-d : DISPLAY(continued)

Code	Function
	display function effective for A-B mode
AUTO	: Autoscale A/B both
DPAB0	: Display data A/B both off
*DPAB1	: Display data A/B both on
*ASC1	: Data A scale to Linear
ASC2	: Data A scale to Log.
*BSC1	: Data B scale to Linear
BSC2	: Data B scale to Log.
AMAX=	: Maximum value for data A scale
AMIN=	: Minimum value for data A scale
BMAX=	: Maximum value for data B scale
BMIN=	: Minimum value for data B scale
ADIV=	: Scale division for data A (Linear scale Only)
BDIV=	: Scale division for data B (Linear scale Only)
GRT0	: Graticule off
*GRT1	: Graticule on
UNIT0	: Unit display off
*UNIT1	: Unit display on
*STRG0	: Storage mode off
STRG1	: Storage mode on
	display function effective for Table mode
UNIT0	: Unit display off
*UNIT1	: Unit display on
LINE=	: Top line number (1 to 401)
	superimpose display function effective for X-A&B mode
SPSTR	: Store superimpose data
*SPA0	: Superimpose data A off
SPA1	: Superimpose data A on
*SPB0	: Superimpose data B off
SPB1	: Superimpose data B on
*LMSP0	: Limit-superimpose off
LMSP1	: Limit-superimpose on
	superimpose display function effective for A-B mode
SPSTR	: Store superimpose data
*SPAB0	: Superimpose data A/B both off
SPAB1	: Superimpose data A/B both on

1-e : MKR/LCURS

	marker/line cursor function effective for X-A&B mode
MCF0	: Marker/Lcursor off
*MCF1	: o-marker on
MCF2	: o-marker and *-marker both on
MCF3	: Lcursor on
MCF4	: o-marker/lcursor both on
MCF5	: o-marker and *-marker both on
MKR=	: o-marker setting on X-axis position
MKMXA	: o-marker to maximum point of data A
MKMNA	: o-marker to minimum point of data A
MKMXB	: o-marker to maximum point of data B
MKMNB	: o-marker to minimum point of data B
LCURS=	: Lcursor setting on Y-axis
DLCURS=	: Difference value between o-marker and lcursor on Y-axis
*CUR1	: Lcursor for data A
CUR2	: Lcursor for data B
CRAV	: Lcursor to average point of data
REFRD	: Read o-marker position
WIDTH	: Read difference value of LCURSR and LCURSL
SMKR=	: *-marker setting on X-axis
SRSTR	: Store sweep range
*SWR0	: Partial sweep range off
SWR1	: Partial sweep range on
*ANA0	: Partial analysis range off
ANA1	: Partial analysis range on
ARSTR	: Store analysis range
DMKR=	: Difference value between o-marker and *-marker on X-axis.
	marker/lcursor function effective for A-B and Table modes
MCF0	: Marker/Lcursor both off
*MCF1	: o-marker on
MCF5	: o-marker and *-marker both on
MKR=	: o-marker setting on X-axis
MKMXA	: o-marker to maximum point of data A
MKMNA	: o-marker to minimum point of data A
MKMXB	: o-marker to maximum point of data A
MKMNB	: o-marker to minimum point of data B
SMKR=	: *-marker setting on X-axis
SRSTR	: Store sweep range
*SWR0	: Partial sweep range off
SWR1	: Partial sweep range on
ARSTR	: Store analysis range
*ANA0	: Partial analysis range off
ANA1	: Partial analysis range on

1-f : MORE MENUS

Code	Function
	BASIC program commands for ASP
EDIT	: EDIT--->(line number 1 to 32767)
CAT	: CATalog
LOAD	: LOAD--->(file number 1 to 999)
STORE	: STORE--->(file number 1 to 999),"comment"
PURGE	: PURGE--->(file number 1 to 999)
SCRATCH	: SCRATCH working area
RUN	: RUN
PSTOP	: STOP
PPAUSE	: PAUSE
CONT	: CONTinue
PSTEP	: STEP
QUIT	: QUIT editor
	BASIC program statements for ASP
IF	:
THEN	:
FOR	:
TO	:
NEXT	:
GOTO	:
GOSUB	:
RETURN	:
INPUT	:
OUTPUT	:
WAIT	:
PAUSE	:
BEEP	:
DISP	:
END	:
SEND	:
	HP-IB definition
#ADRS=	: HP-IB address(0 to 30)
	copy function
COPY	: Excute copy(plot/print/dump)
CPYM1	: Plot
CPYM2	: Print
*CPYM3	: Dump
#PSCALE	: Plot scale(left,bottom,right,top)
*SCLP1	: Set plot scale(P1,P2) to normal
SCLP2	: Set plot scale(P1,P2) to graticule base
*PLTF1	: Plot (all)
PLTF2	: Plot (graticule/data both)
PLTF3	: Plot (data only)
SENDPS	: Send plot scale(P1,P2) to plotter
	self test
STSET	: Set up self test page
STN=	: Set self test number
STSTR	: Start self test
STSTP	: Stop self test
STEND	: End self test page
	equivalent circuit
EQDSP	: Display equivalent circuit page
*EQC1	: Select equivalent circuit to A
EQC2	: Select B
EQC3	: Select C
EQC4	: Select D
EQC5	: Select E
EQCAL	: Calculate equivalent circuit parameters
EQVR=	: Equivalent circuit parameter R(Ω)
EQVL=	: Equivalent circuit parameter L(H)
EQVCA=	: Equivalent circuit parameter Ca(F)
EQVCB=	: Equivalent circuit parameter Cb(F)
FCHRS	: Simulate frequency characteristics
	set programmed point table
PTSET	: Set programmed points table page
PTN=	: Programmed points table number(1 to 16)
PTCLR	: Clear programmed points table
PTSWP1	: Sweep parameter to Frequency
PTSWP2	: Sweep parametwr to DC bias
PTSWP3	: Sweep parameter to Osc level(V)
PTSWP4	: Sweep parameter to Osc level(dBm)
PTSWP5	: Sweep parameter to Osc level(dBV)
*LMF1	: Limit for data A
LMF2	: Limit for data B
POINT=	: Programmed point(point,minimum,maximum)
PTSRT	: Sort programmed points table
PTEND	: End programmed points table set-up

2: SWEEP

Code	Function
*WM1	: Sweep mode to Repeat
WM2	: Sweep mode to Single
SWM3	: Sweep mode to Manual point mode
MANUAL=	: Manual point HZ/V/dBm/dBV
SWTRG	: Sweep start trigger

3: TRIGGER

*TRGM1	: Internal trigger mode
TRGM2	: Ext/Manual trigger mode
TRIG	: Measurement trigger for External mode.

4: INTEG TIME

*ITM1	: Integration time to Short (500usec.)
ITM2	: Integration time to Medium (5msec.)
ITM3	: Integration time to Long (100msec.)

5: AVERAGING

NOA=	: Averaging number (1,2,4,8,16,32,64,128 or 256)

6: PARAMETER

START=	: HZ/V/dBm/dBV
STOP=	: HZ/V/dBm/dBV
STEP=	: HZ/V/dBm/dBV
CENTER=	: HZ/V/dBm/dBV
SPAN=	: HZ/V/dBm/dBV
NOP=	: Number of measurement points (2 to 401)
FREQ=	: Spot frequency(HZ)
BIAS=	: Spot bias voltage(V)
OSC=	: Spot osc level(V/dBm/dBV)
SAVE	: Save measurement state(0 to 4)
GET	: Get(recall) measurement state
DTIME=	: Delay time (0 to 1 hour in msec.)
DFREQ=	: Delay aperture(0.50 to 100.00%)
DCOFF	: DC bias off
CMT	: Input comment on display data

7: MEASUREMENT UNIT

*PWS1	: Power splitter to DUAL mode
PWS2	: Power splitter to SINGLE mode
*ATR1	: Reference channel attenuation to 0dB
ATR2	: Reference channel attenuation to 20dB
ZIR1	: Reference channel input impedance to 1MΩ
*ZIR2	: Reference channel input impedance to 50Ω
*ATT1	: Test channel attenuation to 0dB
ATT2	: Test channel attenuation to 20dB
ZIT1	: test channel input impedance to 1MΩ
*ZIT2	: Test channel input impedance to 50Ω

8: OTHERS

Code	Function

instrument initialization

RST : Reset the instrument

Note

The RST command resets the instrument to the power-on default conditions except for the following settings.

1. Sweep mode is set to the Single sweep mode (code : SWM2) and the traces on the screen will be erased.
2. Data registers(A ~ D), general purpose registers (RA ~ RL), all registers for compensation, Rn, Z, and all read-only type registers are not reset.
3. Program WORK AREA is not cleared.

local maximum

LMX(a) : Move the o-marker to the first peak position within the specified range.
Move the *-marker to the last peak position within the specified range.

local minimum

LMN(a) : Move the o-marker to the first valley position within the specified range.
Move the *-marker to the last valley position within the specified range.

Note

1. LMX(a) or LMN(a) is used in connection with the array variables except for X register.
   Example , LMXA, LMNB
2. Select the "Double Marker Mode" (Code :MCF5)
3. When only a peak or valley exists within the specified range, the o-marker moves to maximum or minimum point and *-marker moves to Sweep Start point.
   When no peak or valley exists, the o-marker moves to Sweep Start point and *-marker moves to Sweep Stop point.

array variables

A=	: Register for display data A
B=	: Register for display data B
C=	: Register for superimpose data A
D=	: Register for superimpose data B
#E=	: General purpose register
#F=	: General purpose register
#G=	: General purpose register
#H=	: General purpose register
#I=	: General purpose register
#J=	: General purpose register
RA=	: General purpose register
RB=	: General purpose register
RC=	: General purpose register
RD=	: General purpose register
RE=	: General purpose register
RF=	: General purpose register
RG=	: General purpose register
RH=	: General purpose register
RI=	: General purpose register
RJ=	: General purpose register
RK=	: General purpose register
RL=	: General purpose register

#OFSTA=	: Register to save offset data for display A
#OFSTB=	: Register to save offset data for display B
OG=	: Register to store OPEN offset data in G value
OB=	: Register to store OPEN offset data in B value
SR=	: Register to store SHORT offset data in R value
SX=	: Register to store SHORT offset data in X value
TYG=	: Register to store OS calibration data in G value
TYB=	: Register to store OS calibration data in B value
MYG=	: Resister to store OS calibration data in G value
MYB=	: Register to store OS calibration data in B value
TZR=	: Register to store 0Ω calibration data in R value
TZX=	: Register to store 0Ω calibration data in X value
MZR=	: Register to store 0Ω calibration data in R value
MZX=	: Register to store 0Ω calibration data in X value
TSTDR=	: Register to store 50Ω calibration data in R value
TSTDX=	: Register to store 50Ω calibration data in X value
MSTDR=	: Register to store 50Ω calibration data in R value
MSTDX=	: Register to store 50Ω calibration data in X value
@ X	: Register to store each point of sweep parameter

single variables

Rn=	: General purpose register Rn(n=0 to 99)
Z=	: Register for "Keyboard Input Line" block
@ MON	: Register to store monitor data
@ GONG	: GO/NO-GO result(1=GO,0=NOGO)
@ MKRA	: o-marker reading value on Y-axis for data A
@ MKRB	: o-marker reading value on Y-axis for data B
@ SMKRA	: *-marker reading value on Y-axis for data A
@ SMKRB	: *-marker reading value on Y-axis for data B
@ DMKRA	: Difference value between o-marker and *-marker on Y-axis for data A
@ DMKRB	: Difference value between o-marker and *-marker on Y-axis for data B
@ LCURSL	: Line cursor left reading value
@ LCURSR	: Line cursor right reading value
@ WID	: Difference value between LCURSR and LCURSL

masking status byte

RQS(0) : Mask the status byte(RQS0 means all masked)

data transfer format

*FMT1	: Data format(ASCII mode)
FMT2	: Data format(Binary 64 bit)
FMT3	: Data format(Binary 32 bit)

ASP programming via HP-IB

PROG : Create ASP program via HP-IB

Appendix C

Error Code Numbers

Error code numbers can be read via the HP-IB using " ERR? " command. When an error is detected while an ASP program is in progress the message, "Error NNN in LLLLL", will be displayed instead of the designated error message. NNN indicates an error code number and LLLLL represents the line number where the error was detected.

No.	Error Message
1	(A/B:) ROM check sum error, nnn
2	Back up RAM data lost
3	EEPROM check sum error
4	CPU-(A/B) RAM R/W error, nnnnnnH
5	Undefined symbol
6	Improper numeric expression
7	Out of (1E-37 <--> 9.99999E+37)
8	Improper delimiter
9	Command syntax error
10	Invalid select code number
11	Invalid parameter range
12	Not allowed in LOG sweep
13	LOG swp not allowed in OSC_dB
14	NOP must be 2 to 401
15	Freq. must be 100 to 40MHz
16	Freq. must be 100 to 15MHz
17	Freq. must be 10 to 100MHz
18	Osc must be 10m to 1V or Osc must be -27 to 13dBm or Osc must be -28.8 to 11.2dBm or Osc must be -40 to 0dBV
19	
20	Osc must be -65 to +15dBm or Osc must be 154μ to 1.54V or Osc must be 126μ to 1.26V or Osc must be -76.2 to 3.8dBV or Osc must be -78 to 2dBV
21	Must be 0≤SPAN≤26dB
22	Bias must be -40 to +40V
23	Improper entry unit
24	Sign must be same in LOG swp
25	Can't sweep bias in G/ϕ
26	Can't enter spot bias in G/ϕ
27	Min. Resolution ≤STEP ≤SPAN
28	STEP > SPAN error
29	NOP value too large
30	Not in o & ⋆ MKRS mode
31	Can't set MKR in o REF mode
32	N must be ≥2 in sweep range
33	N must be ≥2 in ana. range
34	
35	Markers not displayed
36	Line cursor not displayed
37	
38	
39	Not allowed in LOG scale
40	Improper scale value
41	
42	
43	Open/Short must be in IMP
44	Open/Short must be in f swp
45	Offset compen must be in G/ϕ
46	Can't change while data exists
47	Box full
48	Number of points full
49	MINIMUM > MAXIMUM error
50	Syntax error in SWEEP POINTS
51	Syntax error in MINIMUM
52	Syntax error in MAXIMUM
53	Not in prog. points measure
54	Programmed points table empty
55	Invalid prog. points table
56	Change function to impedance
57	Change parameter to Z-θ/Y-θ
58	Change sweep to frequency
59	N must be ≥3 in ana. range
60	String buffer full
61	Line number syntax error
62	The same file number exists
63	File number does not exist
64	Directory full
65	Back up memory full
66	No ASP program in memory
67	Not continuable
68	
69	WAIT syntax error
70	GOTO syntax error
71	IF THEN syntax error
72	FOR NEXT syntax error
73	GOSUB RETURN syntax error
74	DISP syntax error
75	OUTPUT syntax error
76	INPUT syntax error
77	Line number not found
78	END statement not found
79	Integer overflow

No.	Error Message
80	Divide by zero error
81	Real math overflow
82	Real math underflow
83	Value range error
84	Invalid SIN/COS argument
85	Invalid LOG/LN argument
86	Invalid SQR argument
87	HP-IB char strings too long
88	Can plot only X-A&B/A-B page
89	Can't print data on this page
90	No save data in backup memory
91	Average must be 2**n (n=0 to 8)
92	Delay aperture 0.5 to 100%
93	Only FREQ & LIN sweep allowed
94	Can't measure τ in prog. point
95	Delay time 0 to 3600000ms
96	AC overload on R ch input
97	AC overload on T ch input
98	DC overload on R ch input
99	DC overload on T ch input
100	AC voltage overload
101	AC current overload
102	DC voltage overload
103	DC current overload
104	Bridge unbalanced
105	Fractional N loop + unlocked
106	
107	(External reference unlock)
108	Fractional N loop - unlocked
109	
110	Out of range in SWEEP POINTS
111	Out of range in MINIMUM
112	Out of range in MAXIMUM
113	Negative data exist in A_REG
114	Can't calculate EQV parameter
115	Not allowed in Zero Span
116	Can't select manual sweep
117	
118	Can't change scale >20 times
119	File number must be 1 to 999
120	Not allowed in prog. measurement
121	Must be 0 $\leq$SPAN $\leq$full range
122	
123	Cable length mismatching
124	Select marker mode
125	Multi statement not allowed
126	Illegal state
127	Not allowed in manual sweep
128	Subscript out of range
129	
130	Calibration must be in IMP
131	Statement too complex
132	Allowed in Z-θ/Y-θ/R-X/G-B
133	INTPOL cal must be in f SWP.

No.	Error Message
200	Write failed
201	Bridge unbalanced
202	Change CABLE LENGTH
203	
204	Freq. must be -20M to 150MHz

Appendix D

Default Setting

SWEEP RANGE :

IMPEDANCE MEASUREMENT ('IMPEDANCE' mode)

Register Name	Frequency(HZ)	DC Bias(V)	OSC(mV)	OSC(dBm)	OSC(dBV)
START	100.000	0.00	10.0	-26.0	-39.0
STOP	*40 000 000.000	0.00	110.0	0.0	-13.0
	*15 000 000.000				
STEP	99 999.750	0.10	1.0	0.2	0.2
NOP	401	101	101	131	131

* 40 MHZ (Cable Length= 0 m) 15 MHZ (Cable Length= 1 m)

IMPEDANCE MEASUREMENT ('IMP with Z PROBE' mode)

Register Name	Frequency(HZ)	DC Bias(V)	OSC(mV)	OSC(dBm)	OSC(dBV)
START	10 000.000	0.00	10.0	-26.0	-39.0
STOP	100 000 000.000	0.00	110.0	0.0	-13.0
STEP	249 975.000	0.10	1.0	0.2	0.2
NOP	401	101	101	131	131

GAIN-PHASE MEASUREMENT ('GAIN PHASE' mode)

Register Name	Frequency(HZ)	OSC(mV)	OSC(dBm)	OSC(dBV)
START	10.000	10.0	-26.0	-39.0
STOP	100 000 000.000	110.0	0.0	-13.0
STEP	249 999.975	1.0	0.2	0.2
NOP	401	101	131	131

Note

(1) CENTER & SPAN can be defined as :

CENTER=(START + STOP)/2
SPAN =(STOP - START)

(2) Relationship between STEP & NOP

$$STEP = \frac{1}{(NOP - 1)} \; (STOP - START)$$

STEP value is rounded to its designated resolution.

$$NOP = \frac{(STOP - START)}{STEP} + 1$$

NOP is rounded to an integer value.

SPOT PARAMETER :

Register Name	'IMPEDANCE'mode	'GAIN-PHASE'mode	'IMP with Z PROBE'mode
FREQ	100 000.000 Hz	100 000.000 Hz	10 000 000.000 Hz
BIAS	0.00 V	0.00 V	0.00 V
OSC	500 mV	0.0 dBm	500 mV

OTHER PARAMETERS :

Register Name	Default Value
NOA	1
NOP	401
DFREQ	0.50 %
DTIME	0 msec

Appendix E HP 4194A ASP Quick Reference

(1) General Command

Note

An (X) in column M indicates statements and commands that can not be used in multi-statement lines.

NAME	Argument	M	Meaning
ANA	0, 1		Analysis range full(0), partial(1)
AOF	0, 1		DATA A offset off(0), on(1)
ARSTR			Store analysis range
ASC	1, 2		DATA A display scale linear(1), log(2)
ATR	1, 2		Reference channel attenuation gain 0dB(1), 20dB(2)
ATT	1, 2		Test channel attenuation gain 0dB(1), 20dB(2)
AUTO			Auto scale on DATA A & B
AUTOA			Auto scale on DATA A
AUTOB			Auto scale on DATA B
BOF	0, 1		DATA B offset off(0), on(1)
BSC	1, 2		DATA B display scale linear(1), log(2)
CAL	0, 1		Calibration off(0), on(1)
CALSTD		X	Calibrate at standard device
CALY		X	Calibrate at 0S
CALZ		X	Calibrate at 0Ω
CAT			Display program catalog
CMPN	1, 2		Compensation mode interpolation(1), all points(2)
CMT	" ", ' '		Input comment data
CMT?			Output comment data to HP-IB
COPY		X	Copy
CPYM	1, 2, 3		Copy mode plotter(1), printer(2), graphic dump(3)
CRAV			Set Line cursor to average on DATA
CUR	1, 2		Line cursor for DATA A(1), B(2)
DCOFF			DC BIAS off
DEG			Set to the degree mode
DISP	Rn		Display general register on system message line
	" ",Rn		
DPA	0, 1		DATA A display off(0), on(1) in X-A&B
DPB	0, 1		DATA B display off(0), on(1) in X-A&B
DPAB	0, 1		DATA A&B display off(0), on(1) in A-B
DSP	1, 2, 3		Display format X-A&B(1), A-B(2), TABLE(3)
EDIT			Edit ASP text from the first line
	line num.		Edit ASP text from the given line
END			(ASP) END
EQC	1...5		Equivalent circuit mode A(1)...E(5)
EQCAL		X	Calculate equivalent circuit parameters
EQDSP		X	Display equivalent circuit
ERR?			Query error code
FCHRS		X	Simulate frequency characteristics
FMT	1, 2, 3		HP-IB output format ASCII(1), IEEE64(2), IEEE32(3)

FNC	1, 2, 3		Function Impedance(1), Gain-phase(2), IMP with Z prove(3)
FOR		X	(ASP) FOR
GET	0..4		Get measurement state
GNM	0..6		Gain monitor off(1),.....,ch-B dBV(6)
GOSUB	line num.		(ASP) GOSUB
GOTO	line num.		(ASP) GOTO
GPP	1..6		Gain-phase parameter
GRT	0, 1		Graticule display off(0), on(1)
ID?			Query identify
IF		X	(ASP) IF
IMP	1..20		Impedance parameter
INPUT	Rn		(ASP) INPUT
ITM	1, 2, 3		Integration time 500µs(1), 5ms(2), 100ms(3)
IVM	0, 1, 2		I/V monitor off(0), V(AC) (1), I(AC) (2)
LMF	1, 2		Limit for DATA A(1), B(2)
LMSP	0, 1		Limit superimpose off(0), on(1)
LMN	(array type)		Set markers to local minimums
LMX	(array type)		Set markers to local maximums
LOAD	1..999	X	Load program
MCF	0..5		Marker line cursor function off(0)..double marker(5)
MKEXP			Markers expand to sweep range
MKMNA			Marker minimum on DATA A
MKMNB			Marker minimum on DATA B
MKMXA			Marker maximum on DATA A
MKMXB			Marker maximum on DATA B
NEXT	Rn	X	(ASP) NEXT
OFSTR			Store offset reference
OPN	1, 2		Open offset calibration off(1), on(2)
OUTPUT	Rn, bb..b		(ASP) OUTPUT
PAUSE		X	(ASP) PAUSE
PHS	1, 2		Phase scale normal(1), expand(2)
PLTF	1, 2, 3		Plot format all(1), grtcl&data(2), data(3)
POINT=	long [real*2]	X	Set Programmed Point [, minimum limit, maximum limit] to Programmed Points Table
PPM	0, 1		Programmed Points measurement off(0), on(1)
PROG	" ", ' '	X	Input program
PTCLR			Programmed Points Table clear
PTEND			Programmed Points Table edit end
PTSET			Programmed Points Table edit
PTSRT			Programmed Points Table sort
PTSWP	1..5		Programmed Points Table's sweep parameter
PURGE	1..999	X	Purge program
PWS	1, 2		Power splitter dual(1), single(2)
QUIT			Quit editor
RAD			Set to the radian mode
REFRD			Reference marker read
RETURN			(ASP) RETURN
REV?			Query revision date
RQS	0..255		HP-IB enable request service
RST		X	Reset
SAVE	0..4		Save measurement state
SCLP	1, 2		Define plot scale on CRT : normal(1), grtcl base(2)
SCRATCH			Scratch working area

SEND	" ", ' '		Send any characters via HP-IB
SENDPS			Send plot scale(P1, P2) to plotter
SHT	0, 1		Short offset calibration off(0), on(1)
SPA	0, 1		Superimpose A recall off(0), on(1)
SPAB	0, 1		Superimpose A&B recall off(0), on(1)
SPB	0, 1		Superimpose B recall off(0), on(1)
SPSTR			Superimpose store
SRSTR			Sweep range store
STB?	0, 1		Query status
STORE	1..999," "	X	Store program [with comment]
STRG	0, 1		Storage display off(0), on(1)
SWD	1, 2		Sweep direction upword(1), downword(2)
SWM	1, 2, 3		Sweep mode repeat(1), single(2), manual(3)
SWP	1, 2, 3, 4, 5		Sweep parameter frequency(1),...OSC level[dBV](5)
SWR	0, 1		Sweep range full(0), partial(1)
SWT	1, 2		Sweep type linear(1), log(2)
SWTRG		X	Sweep start trigger
THEN		X	(ASP) THEN
TO		X	(ASP) TO
TRGM	1, 2	X	Trigger mode internal(1), external(2)
TRIG		X	Programmed external trigger
UNIT	0, 1		UNIT display off(0), on(1)
WAIT	0..655350	X	(ASP) WAIT [msec]
WIDTH			Get LCURSR-LCURSL and store it to WID
ZIR	1, 2		Reference channel input impedance 1MΩ(1), 50Ω(2)
ZIT	1, 2		Test channel input impedance 1MΩ(1), 50Ω(2)
ZOPEN		X	Calibrate zero open
ZSHRT		X	Calibrate zero short

(2) Register

Note

(X) indicates statement and command that can not be multi-statement.
(R) indicates read-only type register.
(S) indicates Back-up register by SAVE function.
(C) indicates CMOS Back-up register.
(E) indicates EEPROM Back-up register.

[Array Type] B:Back-uped M:Multi-statement R:Read-only

Name	Format	B	M	R	Content
A	real*401				DATA A displayed on CRT (yellow)
B	real*401				DATA B displayed on CRT (blue)
C	real*401				Superimpose C displayed on CRT (light yellow)
D	real*401				Superimpose D displayed on CRT (light blue)
E	real*401	C			General purpose
F	real*401	C			General purpose
G	real*401	C			General purpose
H	real*401	C			General purpose
I	real*401	C			General purpose
J	real*401	C			General purpose
MSTDR	real*401				Measured standard calibration data (real)
MSTDX	real*401				Measured standard calibration data (imaginary)
MYB	real*401				Measured 0S calibration data (imaginary)
MYG	real*401				Measured 0S calibration data (real)
MZR	real*401				Measured 0Ω calibration data (real)
MZX	real*401				Measured 0Ω calibration data (imaginary)
OB	real*401				Open offset calibration data (imaginary)
OFSTA	real*401	C			Offset data for A
OFSTB	real*401	C			Offset data for B
OG	real*401				Open offset calibration data (real)
RA	real*401				General purpose
RB	real*401				General purpose
RC	real*401				General purpose
RD	real*401				General purpose
RE	real*401				General purpose
RF	real*401				General purpose
RG	real*401				General purpose
RH	real*401				General purpose
RI	real*401				General purpose
RJ	real*401				General purpose
RK	real*401				General purpose
RL	real*401				General purpose
SR	real*401				Short offset calibration data (real)
SX	real*401				Short offset calibration data (imaginary)
TSTDR	real*401				Theoretical standard calibration data (real)
TSTDX	real*401				Theoretical standard calibration data (imaginary)
TYB	real*401				Theoretical 0S calibration data (imaginary)
TYG	real*401				Theoretical 0S calibration data (real)
TZR	real*401				Theoretical 0Ω calibration data (real)
TZX	real*401				Theoretical 0Ω calibration data (imaginary)
X	long*401			R	Sweep points data

[Others] E:Back-up on EEPROM

Name	Format	B	M	R	Content
ADIV	real	S			DATA A scale / division parameter
ADRS	0..30	C			HP-IB address
AMAX	real	S			DATA A scale maximum parameter
AMIN	real	S			DATA A scale minimum parameter
BDIV	real	S			DATA B scale / division parameter
BIAS	real				Spot DC bias
BMAX	real	S			DATA B scale maximum parameter
BMIN	real	S			DATA B scale minimum parameter
CENTER	long	S			Center
DFREQ	long	S			Group delay aperture of span [%]
DLCURS	real	S			LCURS=MKRA(MKRB)+DLCURS
DMKR	long	S			SMKR=MKR+DMKR
DMKRA	real			R	DMKRA=SMKRA-MKRA
DMKRB	real			R	DMKRB=SMKRB-MKRB
DTIME	int	S			Delay time
EQVCA	real	S			Equivalent circuit parameter Ca
EQVCB	real	S			Equivalent circuit parameter Cb
EQVL	real	S			Equivalent circuit parameter L
EQVR	real	S			Equivalent circuit parameter R
FREQ	real	S			Spot frequency
GONG	0, 1			R	Go/No-Go result
LCURS	real	S			Line-cursor setting
LCURSL	long			R	Line-cursor left reading
LCURSR	long			R	Line-cursor right reading
LINE	1..401				Top displayed line of the table display
MANUAL	long	S			Manual sweep point
MKR	long	S			Marker setting
MKRA	real			R	Marker reading on DATA A
MKRB	real			R	Marker reading on DATA B
MON	real			R	Monitor reading
NOA	2^(0..8)	S			Number of averaging
NOP	2..401	S			Number of sweep points
OSC	long	S			Spot Oscillator level
PSCALE	int*4	C			Plot scale : P1x, P1y, P2x, P2y
PTN	1..16	S			Programmed Points Table number
R0..R99	long				General register
SMKR	long	S			Sub marker setting
SMKRA	real			R	Sub marker reading for DATA A
SMKRB	real			R	Sub marker reading for DATA B
SPAN	long	S			Span
START	long	S			Start
STD	real*2	E	X		Theoretical standard value for calibration
STEP	long	S			Step
STOP	long	S			Stop
WID	long			R	WID=LCURSR-LCURSL
Z	long				Display register
ZOHN	real*2	E	X		Theoretical short value for calibration
ZSIEM	real*2	E	X		Theoretical open value for calibration

(3) Program Control Command

Name	M	Meaning
RUN	X	Program start
CONT	X	Program continue
PSTEP	X	Program step execution
PSTOP	X	Program stop
PPAUSE	X	Program pause

(4) e. t. c.

[Function]

Name	Argument	Identity
ABS	(Expression)	Absolute
AND	(Expression)	Logical AND
ATAN	(Expression)	Arctangent
COS	(Expression)	Cosine
DIF	(Array type)	Differential
EXP	(Expression)	Exponential
LN	(Expression)	Natural logarithm
LOG	(Expression)	Common logarithm
OR	(Expression)	Logical OR
SIN	(Expression)	Sine
SQR	(Expression)	Square root
TAN	(Expression)	Tangent

[Arithmetic operator]

*	Multiplication	
/	Division	
+	Addition	
-	Subtraction	
**	Exponentiation	
=	Equal	
<>	Not equal	
<	Less than	
<=, =<	less or equal	
>	greater than	
>=, =>	greater or equal	
< , >=< , >op< , >	Complex operator	op : *, /, +, -
	(1) <p,q>=<e,e>op<e,e>	p, q is array type register e is expression
	(2) <Rn,Rm>=<s,s>op<s,s>	Rn, Rm is general register s is single type expression

[Constant]

Enn, E+nn, E-nn	Scientific notation
PI	3.14159265359
M	10^6
K	10^3
m	10^-3
U	10^-6
N	10^-9
P	10^-12

[e. t. c.]

,	
;	Multi-command
!	Remark in ASP text
?	Output variable to HP-IB