HEWLETT PACKARD

Application Note 339-11

Filter Test for Production and Incoming Inspection

– HP 4194A Impedance/Gain-Phase Analyzer –

INTRODUCTION

The HP4194A Impedance/Gain-Phase Analyzer can quickly and easily evaluate a filters transmission characteristics. The following information is useful for production and incomming inspection testing of ceramic, crystal, LC, hybrid and active filters.

MEASUREMENT DESCRIPTION AND MAJOR CONCERNS

Filter manufacturers and end users need to perform fast and accurate filter testing to increase throughput and reduce evalutation cost. First, they need to quickly perform transmission measurements like gain, phase and group-delay. They also need to derive filter parameters such as insertion loss, ripple, 3dB/6dB bandwidth, center frequency, spurious level and frequency (refer to figure 1 for typical filter parameters). Finally, they must decide if these parameters meet the test limits. All of these operations must be automated inorder to quickly and accurately test filters.

Filter testing must also be automated inorder to reduce the chance of operator or measurement setup error. The test instrument should automatically measure and perfrom checks, plus provide an output of the test results.

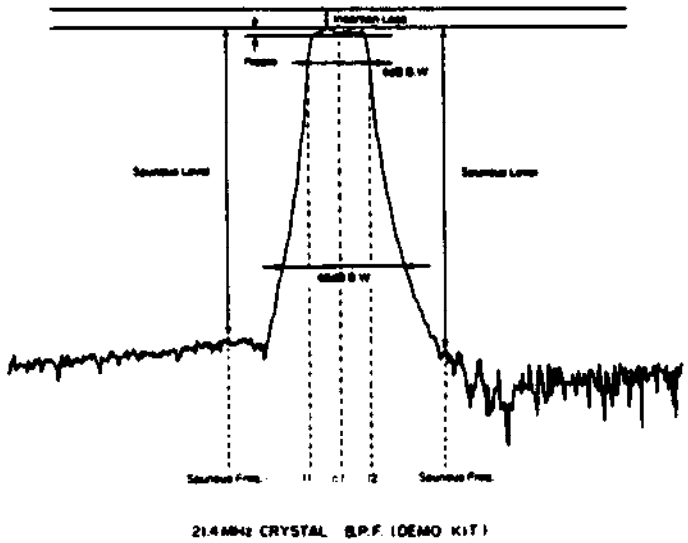


Figure 1. Typical Band Pass Filter Parameters

HP 4194A SOLUTION

Fast Transmission Measurement

The HP 4194A can perform fast gain, phase and group-delay measurements from 10Hz to 100MHz. The analyzer has a Programmable Points Measurement (PPM) function that allows you to select which frequency points to measure during the sweep. This function optimizes filter measurement speed by reducing measurement points outside the passband region and concentrating them in the passband region. A program points sweep can be setup in the HP 4194A's PPM table and stored in the analyzer's non-volitile memory (refer to figure 2) Inaddition, the measurement speed per point is 3.5 ms, making the HP 4194A fast and efficient for transmission measurements.

PROGRAMMED POINTS TABLE 2

SWEEP:FREQUENCY(Hz) LIMIT FOR DATA A

N	SWEEP POINTS	MINIMUM	MAXIMUM
1	21 365 000.000	-9.99999E+37	9.99999E+37
2	21 375 645.000	-9.99999E+37	9.99999E+37
3	21 380 000.000	-9.99999E+37	9.99999E+37
4	21 385 000.000	-9.99999E+37	9.99999E+37
5	21 390 000.000	-9.99999E+37	9.99999E+37
6	21 391 250.000	-9.99999E+37	9.99999E+37
7	21 394 000.000	-9.99999E+37	9.99999E+37
8	21 396 000.000	-9.99999E+37	9.99999E+37
9	21 398 000.000	-9.99999E+37	9.99999E+37
10	21 400 000.000	-9.99999E+37	9.99999E+37
11	21 402 000.000	-9.99999E+37	9.99999E+37
12	21 406 000.000	-9.99999E+37	9.99999E+37
13	21 408 000.000	-9.99999E+37	9.99999E+37
14	21 408 575.000	-9.99999E+37	9.99999E+37
15	21 416 000.000	-9.99999E+37	9.99999E+37
16	21 420 000.000	-9.99999E+37	9.99999E+37
17	21 425 550.000	-9.99999E+37	9.99999E+37
18	21 430 000.000	-9.99999E+37	9.99999E+37
19			

Figure 2. Program Points Measurement table for program points sweep.

Automatic Filter Parameter Evaluation

The HP 4194A can automatically derive filter parameters using its graphic analysis and Auto Sequence Program (ASP) functions. The graphic analysis functions such as marker and line-cursor can be used to obtain insertion loss, ripple, 3dB/6dB bandwidth, center frequency, spurious level/frequency and others.

Automated filter testing can be performed without a computer by using an ASP program. ASP is a basic like program that you can write in the HP 4194A to control all the measurement and graphic analysis functions to automatically derive filter parameters. In addition, an ASP program can check if the test results match the test limits, determining if the device passes or fails. An example of an ASP filter test program is shown in figures 3a,b,c,d.

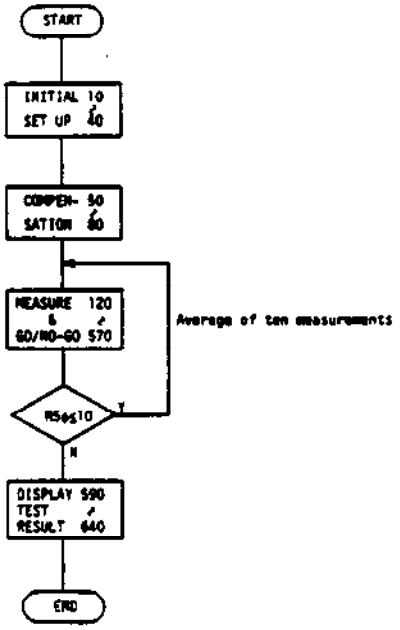
```
 2 RST
 4 R90=-5;R98=-1;R50
 6 R81=21.3995M
 8 R91=21.4005M
10 R92=15K
12 R93=2
14 R94=35K
16 R95=60
18 R96=21.384M
20 R97=60
21 R98=21.416M
22 R60=21.3M
24 R61=21.5M
26 R65=10
28 CNT"21.4 MHz CRYSTAL B.P.F. TEST"
30 FNC2;GPP1;ATR2;HOP=25;OPB0;SWMZ;AMAX=0;AMIN=-130
40 START=R60;STOP=R61;GOTO 90
50 DISP "MAKE THRU CAL,THEN PRESS CONT";BEEP
60 PAUSE
70 SWTR6
80 OFSTR(AOF)
90 DISP "CONNECT OUT,THEN PRESS CONT";BEEP
100 PAUSE
110 FOR RS0=1 TO R65
120  SWTR6
130  ANA0;MCF1;MKMXA;R0=-MKRA;R9=MKR;DLCURS=-40;MCF4;R35=LCURSL;R36=LCURSR;MC
140  MCF1;MKR=R9;DLCURS=-65;MCF4;R4=LCURSR-LCURSL;MCF0
150  MCF1;DLCURS=-6;MCF4;R2=LCURSR-LCURSL;R1=SQR(LCURSR*LCURSL);MCF0
200  MKR=R35;$MKR=$START;MCF$;ARSTR;ANAI;LMK(A);MCF0
210  IF $MKR<STOP THEN GOTO 270
220  IF MKR>START THEN GOTO 250
230  RS=-R0-MKR;R6=MKR;GOTO 300
250  $MKR=START;MCF$;ARSTR;MKMXA;R5=-R0-MKRA;R6=MKR;MCF0;GOTO 300
270  MKR=START;MCF$;ARSTR;MKMXA;R5=-R0-MKRA;R6=MKR;MCF0
300  MKR=R36;$MKR=STOP;MCF$;ARSTR;LMK(A);MCF0
310  IF MKR>START  THEN GOTO 340
320  R7=-R0-$MKRA;R8=$MKR;GOTO 400
340  $MKR=STOP;MCF$;ARSTR;MKMXA;R7=-R0-MKRA;R8=MKR;MCF0
400  MKR=LCURSL;$MKR=LCURSR;MCF$;ARSTR;LMK(A);MCF0
410  IF $MKR<STOP  THEN GOTO 440
420  R3=0;GOTO 500
440  MCF$;ARSTR;MKMA;R3=-R0-MKRA;MCF0
500  IF R0>R90 OR R3>R93 THEN GOTO 570
510  IF R1<R81 OR R7>R91 THEN GOTO 570
520  IF R2<R92 OR R4>R94  THEN GOTO 570
530  IF R5<R95 OR R7<R97 THEN GOTO 570
540  IF R6>R96 OR R8<R98 THEN GOTO 570
550  DISP "PASS";GOTO 580
570  DISP "FAIL";BEEP
580 NEXT RS0
590 DISP ""
600 DISP "PRESS CONT TO SEE PARA.VALUE";BEEP
610 PAUSE
620 START=!0 HZ ;STOP=!6 HZ ;HOP=9
630 OSP3;UNIT0
640 A(1)=-R0;A(2)=R1;A(3)=R2;A(4)=R3;A(5)=R4;A(6)=R5;A(7)=R6;A(8)=R7;A(9)=R8
650 DISP "END";BEEP
660 END
```

Figure 3a. Filter Test ASP program

REGISTER DEFINITION

Line	Register	Parameter	Test Limit
4	R90	Insertion Loss	> -5dB
6	R81	Min. Center Frequency	21.3995 MHz
8	R91	Max. Center Frequency	21.4005 MHz
10	R92	6 dB Bandwidth	>15 KHz
12	R93	Ripple	< 2 dB
14	R94	65 dB Bandwidth	< 35 KHz
16	R95	Spurious Level (left)	> -60 dB
18	R96	Spurious Frequency (left)	< 21.384 MHz
20	R97	Spurious Level (right)	> -60 dB
21	R98	Spurious Frequency (right)	> 21.416 MHz
22	R60	Start Frequency	
24	R61	Stop Frequency	
26	R65	Number of Measurements	

Figure 3b. Filter Test ASP program register definition.



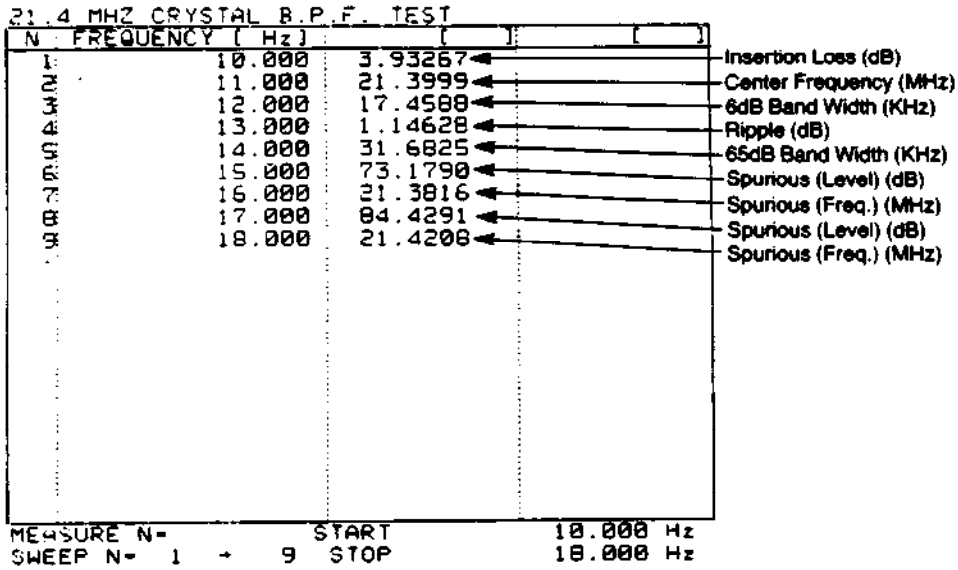


Figure 3d. Filter Test ASP program test result output.

Quick GO/NO-GO Filter Testing

The HP 4194A can also perform automatic Go/No-Go filter testing by using its limits function. Minimum and maximum test limits can be set for each sweep point when using the PPM sweep mode (refer to figure 4). A special register in the HP 4194A will indicate if one or more measurement exceeds the program test limits. This register can be read quickly by an ASP program. An example of an ASP Go/No-Go test program is shown in figures 5a,b.

BAND PASS FILTER (PROG PTNS)
PROGRAMMED POINTS TABLE 2

N	SWEEP POINTS	SWEEP FREQUENCY(Hz)	LIMIT FOR DATA A MINIMUM	MAXIMUM
1	21	365 000.000	-1.35000E+02	-9.50000E+01
2	21	375 645.000	-1.35000E+02	-8.00000E+01
3	21	380 000.000	-1.05000E+02	-6.00000E+01
4	21	385 000.000	-9.00000E+01	-4.00000E+01
5	21	390 000.000	-5.45000E+01	3.00000E+00
6	21	391 250.000	-4.00000E+01	3.00000E+00
7	21	394 000.000	-1.50000E+01	3.00000E+00
8	21	396 000.000	-1.50000E+01	3.00000E+00
9	21	398 000.000	-1.50000E+01	3.00000E+00
10	21	400 000.000	-1.50000E+01	3.00000E+00
11	21	402 000.000	-1.50000E+01	3.00000E+00
12	21	406 000.000	-1.50000E+01	3.00000E+00
13	21	408 000.000	-4.00000E+01	3.00000E+00
14	21	408 575.000	-4.55000E+01	3.00000E+00
15	21	416 000.000	-9.17500E+01	-4.00000E+01
16	21	420 000.000	-1.00000E+02	-6.00000E+01
17	21	425 550.000	-1.35000E+02	-8.00000E+01
18	21	430 000.000	-1.35000E+02	-9.50000E+01
19				

Figure 4. Program Points Measurement table with minimum and maximum test limits

```
10 !
20 !   *** GO/NO-GO FILTER TEST ***
30 !
35 CMT"GO/NO-GO FILTER TEST"
40 BEEP
45 RST              ! RESTART
50 SWM2             ! SINGLE SWEEP
60 FNC2             ! GAIN-PHASE
70 OSC=-3 DBM
80 AMAX=5;ADIV=12.5
90 DPB0                    ! PHASE DISP OFF
100 PTSET;PTN=2;PTEND ! SET PPM #2 ON
110 PPM1
120 LMSP1                  ! LIMITS ON
130 SWTR6                  ! START MEAS
140 R0=GONG                ! READ GONG REG
150  IF R0=1 THEN GOTO 500
160    DISP "FAIL"         ! FAILED TEST
165    BEEP
170    WAIT 100
180    END
190 !
500  DISP "PASS"           ! PASSED TEST
510  BEEP
515  WAIT 100
520 END
```

Figure 5a. GO/NO-GO Filter Test ASP program (this program uses the PPM table in figure 4).

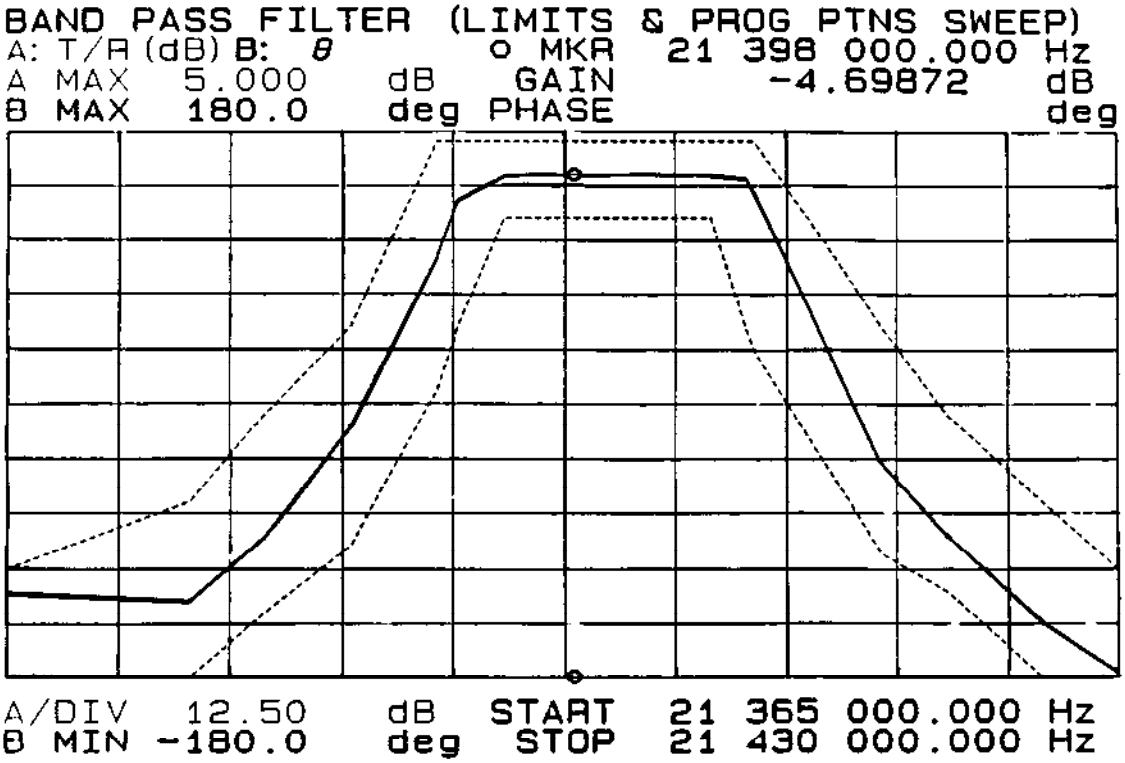


Figure 5b. GO/NO-GO Filter Test measurement display (with minimum and maximum limits)

CONCLUSION

The HP 4194A is very well matched for testing filters. It performs fast transmission measurements using the Program Points Measurement sweep and can quickly calculate filter parameters using the marker and line-cursor functions. All these operations can be automated and filter parameters checked using an ASP program. Finally, by using the HP 4194A's limits function, you can also perform fast ASP GO/NO-GO filter testing.

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