Errata

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HP References in this Application Note

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A/N 339-6

Static Head Testing for Disk Drives

— HP 4194A Application Information —

Introduction

This application sheet describes how to use the HP 4194A Impedance/Gain-Phase Analyzer to perform static disc drive magnetic head testing. This information is useful to;

* Magnetic Head Manufacturers (LAB, QA, PRODUCTION)
* Disc Drive Manufacturers (LAB, QA)

Problem

Magnetic Head manufacturers need to test their magnetic heads both in R&D and Production. Testing in R&D gives a company insight for new designs and helps improve their products. Testing in Production increases productivity and achieves higher device volume with device consistency. Proper testing insures that magnetic heads are shipped conforming to their specifications, increasing customer satisfaction.

Disc Drive manufacturers need to test their magnetic heads in QA (Receiving Inspection). The cost of replacing a bad magnetic head grows considerably as the drive proceeds through the production process. QA removes magnetic heads that don't perform to their specifications before being placed in the Head Disc Assembly (HDA), reducing production cost.

Measurement Requirements

Magnetic heads are like inductors and can be characterized in a like manner. They are usally analyzed using a static and dynamic test. The static tests (which this paper will only deal with) are made by measuring impedance parameters while sweeping either the frequency or the ac test signal level (See Table 1).

Table 1

Static Head Impedance Measurement Parameters

* |Z| and phase vs frequency
* Self-resonant impedance and frequency
* L vs frequency, L vs ac test signal level
* C vs frequency, C vs ac test signal level

Measurement Solution

The HP 4194A Impedance/Gain-Phase Analyzer and HP 41941A/B Impedance Probe can make all the necessary static head measurements. The analyzer can accurately measure |Z|, L, C and other impedance parameters. It can perform these impedance measurements while either sweeping frequency (100Hz to 100 MHz) or ac signal level (10mVrms to 1Vrms). Many features found in the HP 4194A give it the flexibility and versatility needed in todays fast paced disc drive marketplace. As an example:

Color CRT

This allows you to display impedance measurements and graphic analysis functions like markers and line-cursors to easily determine the resonant frequency. Comparing this benefit to a standard digital LCZ meter is like comparing an oscilloscope to a voltmeter. They both give you readings, but an instrument with a CRT gives you correlation between points.

Auto Sequence Programming (ASP)

Automatic static head tests are made possible with the HP 4194A's ASP capability. ASP is a basic-like program that you can write in the HP 4194A to control the analyzer's operation without a computer. ASP programs can be stored in the instrument and turned into a one button test solution. Or, if a computer is used, it can off-load much of the work a computer has to do.

Equivalent Circuit Modeling

This function can be used to approximate or simulate the frequency characteristics of three and four element circuit models. Two of the HP 4194A's circuit models are used for coils to approximate the frequency characteristics of a magnetic head (Figure 1). These frequency characteristics are influenced by several factors: 1) Loss from the coils and core material (expressed as either series or parallel resistance - depending on the amount of loss), 2) Distributed capacitance between coils (expressed as parallel capacitance), and finally 3) Self-inductance of the magnetic head.

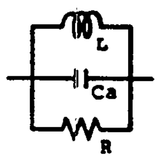
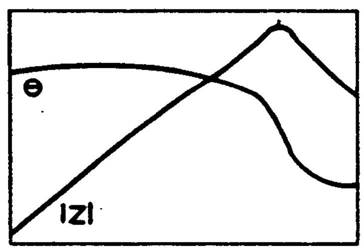
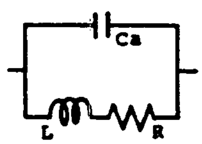
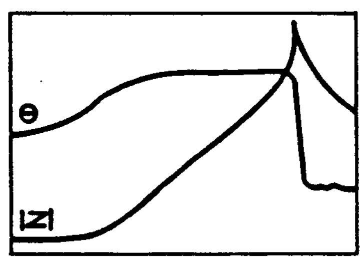
CIRCUIT MODEL	EQUIVALENT CIRCUIT	EQUIVALENT CIRCUIT ELEMENTS	IMPEDANCE AND PHASE SHAPE
CKT A		L = Self-Inductance Ca = Distributed Capacitance of Coil R = Core Loss (large loss)	
CKT B		L = Self-Inductance Ca = Distributed Capacitance of Coil R = Core Loss (less loss than CKTA)	

Figure 1: HP4194A Equivalent Circuit Models for Magnetic Heads

To approximate the elements of the magnetic head's equivalent circuit model, you make a frequency swept impedance and phase measurement, then find the self-resonant frequency (Figure 2). Next select the appropriate equivalent circuit model (CKT A or B) by choosing the model that will most closely produce the same impedance and phase frequency characteristics (Figure 1). Finally, execute the equivalent circuit's parameter function to calculate the parameter values for the selected model (Figure 3).

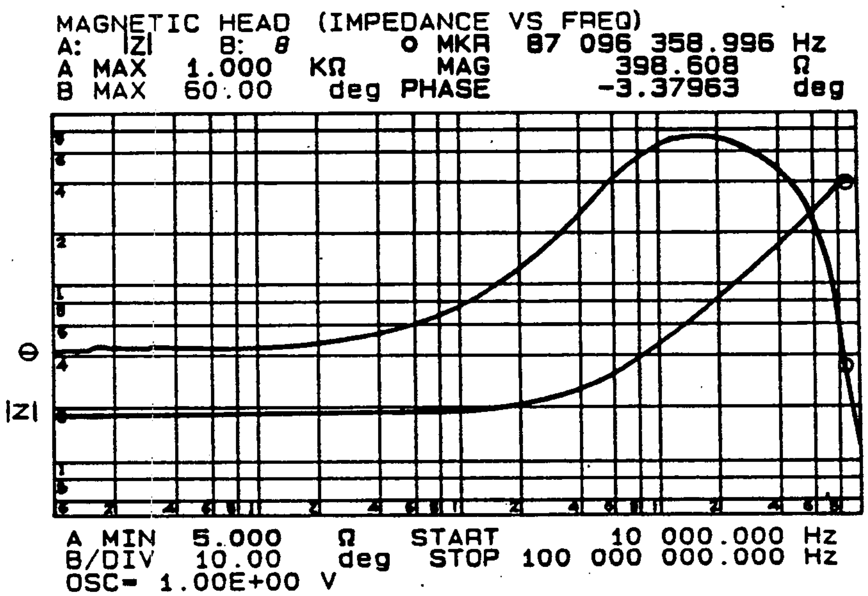


Figure 2: Self-Resonant Frequency of a Magnetic Head

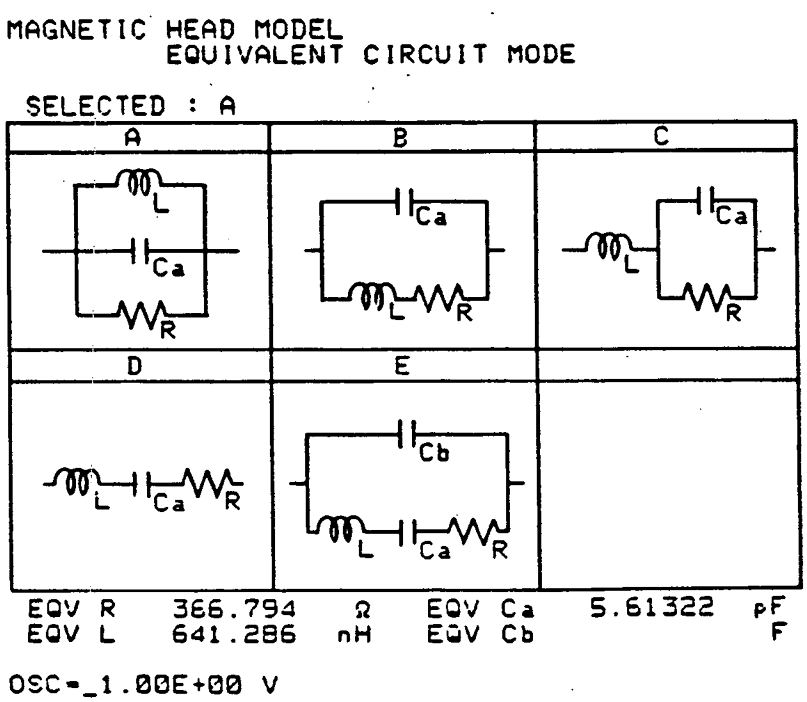


Figure 3: Equivalent Circuit Calculation (CKT A)

To simulate the frequency characteristics for a magnetic head, select the appropriate equivalent circuit model (use the same rules as in the "approximation" procedure). Then enter the values for each equivalent circuit element and execute the frequency simulation function. The simulated frequency characteristics will be displayed on the color CRT. If a measurement was made prior to performing the simulation, the actual result will be displayed together with the simulated result (Figure 4).

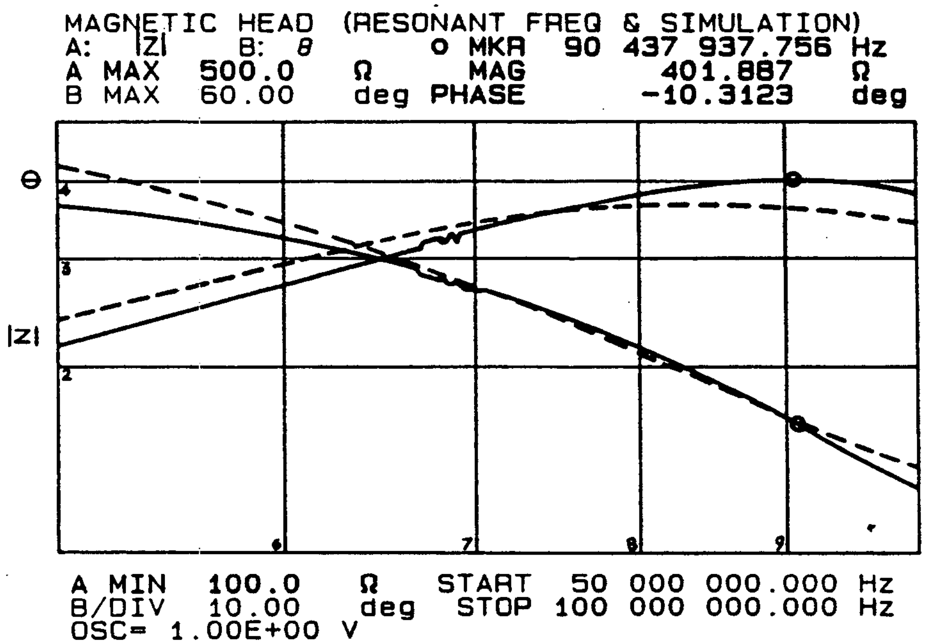


Figure 4: Actual (solid line) and Simulated (dash line) measurement of a Magentic Head

Applications For Using the Equivalent Circuit Function

1) R&D : The equivalent circuit models can help you design magnetic heads and magnetic head circuits. You can simulate designs and operations in assembled circuits by defining each term in the equivalent circuit model and observe how the frequency characteristics are influenced by the parasitic impedance elements. After the magnetic head is designed or assembled in a circuit, the design values of the equivalent circuit elements can be compared with the actual measurement using the approximation function. This allows R&D engineers to evaluate their designs better than before.

2) Incomming Inspection and Production Test : You can also use the Equivalent Circuit function to perform GO/NO-GO testing in production or incomming inspection. Good magnetic heads can be characterized by obtaining reference R, C and L values of a coil's equivalent circuit model. Comparing these characterized values against measurement values of other heads (via an ASP program or computer) allows you to quickly check whether a device is good or bad.

3) <u>Process Monitoring</u> : The Equivalent Cirucit function also allows you to monitor the production process of magnetic heads. If a bad head is found, you can find out what went wrong in the production process via the changes in the equivaelnt circuit values. For example, a change in the self-inductance (L) value can indicate a coil is shorted or open in a magnetic head. A change in capacitance (C) can be due to a change in the coil's shape or distance between coils. A different resistance value can reflect a problem with the core material, since R is dependent on core loss.

Conclusion

The HP 4194A is well matched for static magnetic head testing. It has a broad frequency range and good impedance accuracy. The color CRT and graphic analysis functions makes it easy to analyze your device. Equivalent Circuit function allows you to analyze magnetic heads better. Also, ASP allows you automate your measurements without using a computer (Figure 5 is an example ASP program for performing statice magnetic head testing).

```
  2 CMT"         *** MAGNETIC HEAD TEST ***"
  5 RST
  7 FNC3;CAL0        ! Z-PROBE IMPED FUNCT
 10 CMT"CALIBRATION OPERATION"
 12 DISP "CONNECT 41941A/B Z-PROBE"
 15 BEEP
 17 PAUSE
 20 DISP "CONNECT 0 OHM TO Z-PROBE"
 22 BEEP
 25 PAUSE
 27 CALZ
 30 DISP "CONNECT 0S TO Z-PROBE"
 32 BEEP
 35 PAUSE
 37 CALY
 40 DISP "CONNECT 50 OHM TO Z-PROBE"
 42 BEEP
 45 PAUSE
 47 CALSTD
 50 CAL1
 52 DISP "CONNECT FIXTURE TO Z-PROBE"
 54 BEEP
 56 PAUSE
 60 DISP "OPEN-CIRCUIT FIXTURE"
 70 BEEP
 80 PAUSE
 85 ZOPEN
 90 DISP "SHORT-CIRCUIT FIXTURE"
 95 BEEP
100 PAUSE
110 ZSHRT
120 OPN1;SHT1
130 CMT"MAGNETIC HEAD
    (IMPEDANCE & PHASE VS FREQ)"
135 DISP "CONNECT DUT TO FIXTURE"
140 BEEP
142 PAUSE
160 IMP1;DSP1
170 PPM0;SWP1
180 SWT2
200 ASC2
205 IMP1
210 SWTRG
212 AUTOA;AUTOB
214 MKMXA
220 BEEP
230 DISP "PRESS CONT"
240 PAUSE
245 CMT"SELF-RESONANT FREQUENCY"
250 START=40 MHZ
260 ITM2
270 SWTRG
280 AUTOA;AUTOB
290 MKMXA
300 BEEP
310 DISP "PRESS CONT"
320 PAUSE
330 CMT"MAGNETIC HEAD EQUIVALENT
    CIRCUIT ANALYSIS"
340 EQDSP
350 EQC1
360 EQCAL
370 BEEP
380 DISP "PRESS CONT"
390 PAUSE
400 CMT"MAGNETIC HEAD SIMULATION"
410 FCHRS
420 BEEP
430 DISP "DONE !!!"
440 END
```

Figure 5: ASP Program for Static Magnetic Head Test