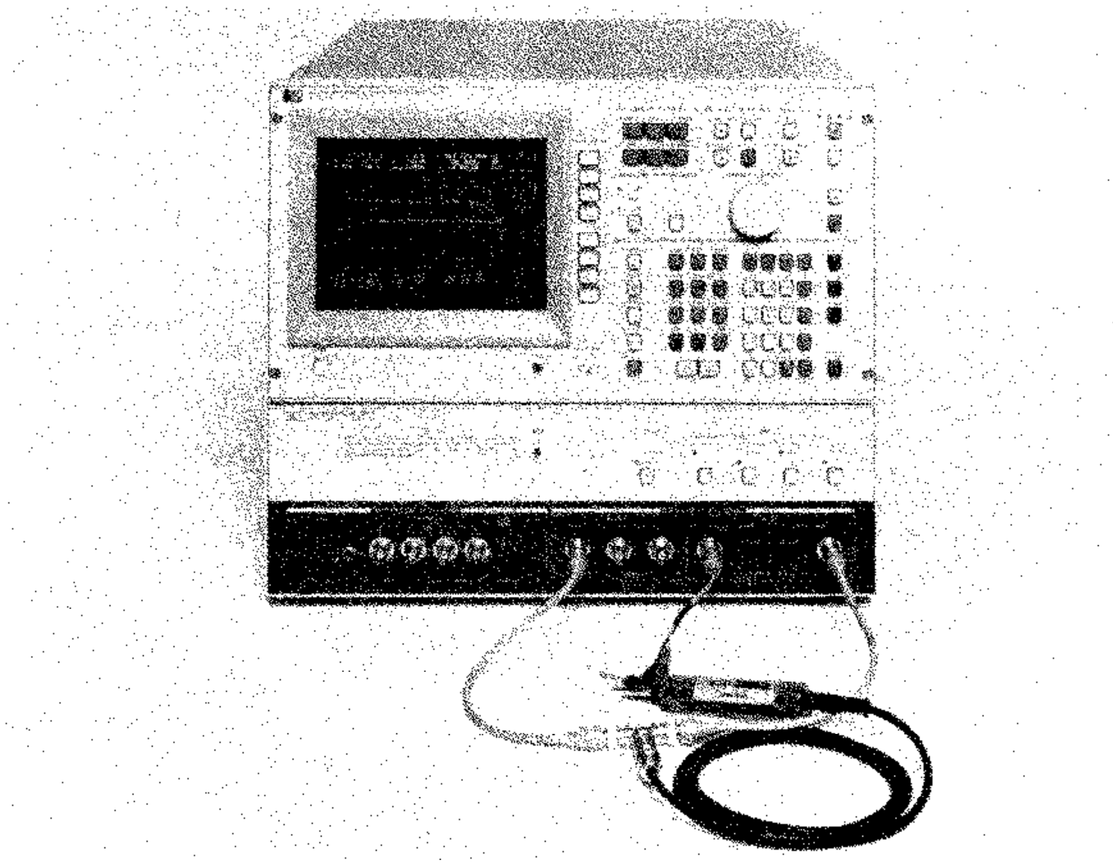
HEWLETT PACKARD

Application Note 339-7

Efficient Evaluation of LISNs and Voltage Probes for EMI Tests

- HP 4194A Impedance/Gain-Phase Analyzer -



Introduction

Electro-Magnetic Interference (**EMI**) is a factor that must be taken into considered when designing electrical and electronic products. Some of the sources of EMI in electronic equipment are reference clocks, switching power supply circuits, and logic signals on bus lines. It is especially necessary to consider EMI generated by computers and computer peripherals. Electronic equipment manufacturers need to invest in EMI test equipment, because EMI is a difficult design problem that must be addressed.

The HP 4194A Impedance/Gain-Phase Analyzer eases the EMI design task by reliably and efficiently measuring impedance and transmission characteristics as required to evaluate EMI. Furthermore, to comply with future needs, impedance measurements can be made at frequencies up to 100MHz by combining the HP 4194A with the HP 41941A/B Impedance Probe Kit. This application note describes cost effective EMI evaluation of Line Impedance Stabilization Networks (**LISNs**) and voltage probes used for noise voltage testing.

Measurement Problems and the Solutions Offered by the HP 4194A

* Necessity for Evaluating LISNs and Voltage Probes

LISNs and voltage probes are used for noise voltage testing and are specified in the VDE 0876 standard (EMI testing techniques in the Federal Republic of Germany).

However, when a LISN or voltage probe are used in operational environment, sometimes the test results exceeds the limits set by the standards due to the radiation from the equipment used in the test being at a resonant frequency of some part of the LISN or voltage probe circuit. The impedance and resonance characteristics of LISNs and voltage probes used for noise voltage testing must be determined to obtain correct results.

* The HP 4194A covers the 10kHz to 30MHz frequency range

To evaluate LISNs and voltage probes, impedance measurements referenced to ground and transmission characteristic measurements in the 10kHz - 30MHz range are required, which usually requires two or more instruments to perform this tasks. The inconveniences that result because the use of multiple instruments, such as the discontinuity in frequency characteristic curves, has always been a problem.

The HP 4194A offers the best solution for making LISN and voltage probe measurements. Precise measurements are possible over a wide frequency range for making transmission measurements, and for making accurate (±1.5%), impedance measurements of grounded devices, thus improving the reliability and accuracy of measurements.

* The HP 4194A Performs Data Processing and Analysis Functions

In the past to analyze measurement data, a system with an external controller was required. The HP 4194A has an internal 16-bit computer for fast data processing. Analysis is carried out using the HP 4194A's color graphics CRT. Evaluation and measurement can be performed quickly, increasing efficiency and thereby lowering cost.

Lisn Performance Evaluation

A LISN consists of the test equipment needed to set up a test circuit in conjunction with the Equipment Under Test (EUT) and a receiver. The LISN also provides the measurement terminals as shown in Figure 1. The circuit from points 1-1' to 2-2' is the LISN (the strict definition of an LISN does not include the low-pass filter (LPF)). The LISN will directly affect the measurement results if it produces any electrical noise or has any resonate points. Therefore, periodic performance evaluation, under EMI test conditions, of the LISN to minimize induced errors is a must for performing reliable EMI tests. The test parameters of the LISN are artificial main impedance, isolation of the low pass filter, and receiver coupling.

1. Input Impedance (Artificial Main Impedance)

The impedance characteristics at 1-1' should be:

$$Z = \frac{R \times j\omega L}{R + j\omega L} \quad \pm 20\%$$

$$= 50\Omega \pm 20\%$$

$$R = 5\ [\Omega]$$
$$L = 50\ [\mu H]$$

These parameters can be quickly measured and displayed in high resolution graphics on the HP 4194A's CRT. Figure 2 shows some typical measurement results and the close matching to the reference curve specified in the VDE 0876 standard. The allowable impedance range, shown by the dotted lines, can be easily displayed using the HP 4194A's internal named Auto Sequence Program (ASP) programming function, which is a programming language similar to BASIC. Figure 3 shows the program listing for the ASP program used for this measurement.

In this example, a peak is detected at around 20MHz. This peak is acceptable, because it is within the range specified, however, this peak should be noted as a characteristic of the LISN. Using the marker and associated softkey, peak values can be quickly obtained either manually or automatically.

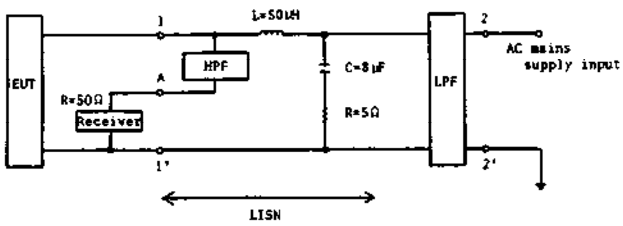


Figure 1. Simplified LISN Circuit

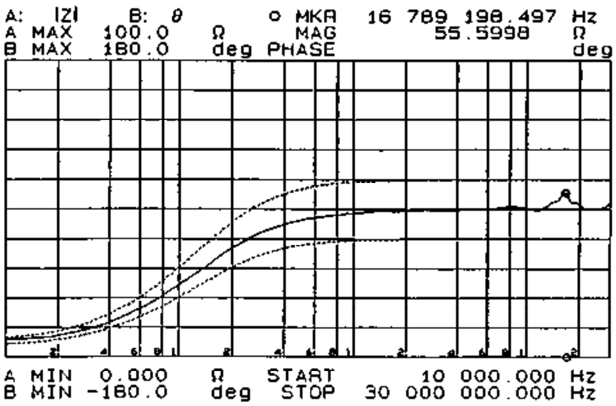


Figure 2. Input Impedance Evaluation

```
10 ! ##### LISN TESTING #####
20 RST
30 BEEP
40 FNC3;SWT2;DPB0
50 START=10 KHZ
60 STOP=30 MHZ
70 AMIN=0;AMAX=100
80 BEEP
90 DISP "CALCULATING LIMIT DATA"
100 RD=X                 ! FREQUENCY
110 RA=50/(3025+9.8696E-8*RD*RD)
120 RB=SQR(75625+30077E-8*RD*RD+97.4E-16*RD**4)
130 RC=RA*RB             ! IDEAL CURVE
140 RE=RC*1.2            ! IDEAL CURVE + 20%
150 RF=RC*.8             ! IDEAL CURVE - 20%
160 DISP "DRAWING LIMIT LINE"
170 PTN=1
180 PTCLR
190 LMF1
200  FOR R1=1 TO 401
210  POINT=RD(R1),RF(R1),RE(R1)
220  NEXT R1
230 PPM1;LMSP1
240 BEEP
250 DISP "SET LISN TO MEASURE"
260 PAUSE
270 DISP "MEASURING"
280 SWTRG
290 IF GONG=1 THEN DISP "PASS!"
300 IF GONG<>1 THEN DISP "FAIL!"
310 BEEP
320 END
```

Figure 3. ASP for Input Impedance Evaluation

2. Isolation of the Low Pass Filter

The transmission characteristics between 2-2' and A-1' in Figure 1 should be ≤ -40dB. This measurement is to evaluate the suppression level of the LPF through which the RF signal passes to the receiver. Typical measurement results are shown in Figure 4. In this example, frequencies below 100kHz are not within the -40dB specification. The marker of the HP 4194A is quite helpful for detecting the point of intersection of the gain curve and the -40dB line.

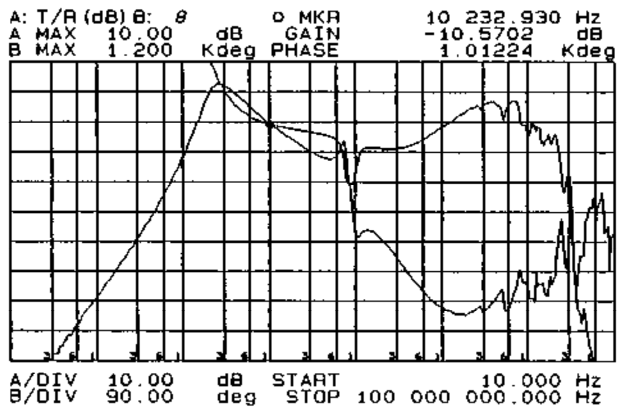


Figure 4. Isolation of Low Pass Filter

3. Receiver Coupling

The transmission characteristic between 1-1' and A-1' in Figure 1 should be approximately 0dB. The purpose of this measurement is to evaluate the loss between the EUT and the receiver terminals, the lower the loss, the better. Typical measurement results in Figure 5 shows -0.135dB at 10kHz and -3.5dB at 30MHz. The 4194A's marker function is very useful for obtaining detailed analysis information.

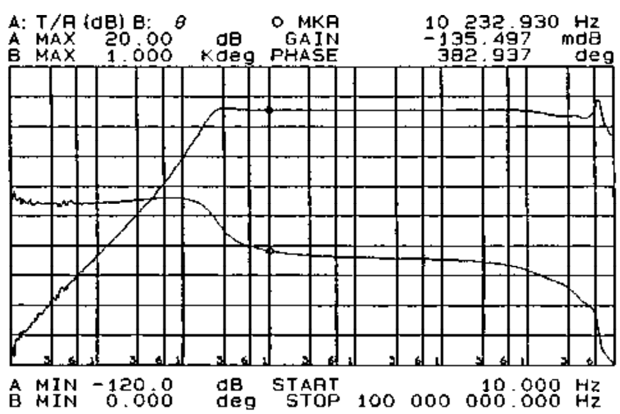


Figure 5. Receiver Coupling

Voltage Probe Performance Evaluation

Voltage probes are used to measure noise at recorder terminals, battery cables, and shield conductors of floating BNC terminals, etc. Figure 6 shows a simplified circuit of a voltage probe. Voltage probe evaluation measurements must take into consideration errors due to losses within the voltage probe, so the measurement data must be compensated by subtracting out the probe's loss. This loss is referred to as the compensation factor. The main purpose of voltage probe evaluation is to analyze losses by measuring the transmission characteristics of the probe.

Typical measurement results for a 1500Ω voltage probe is shown in Figure 7. As the curve shows, the compensation factor is approximately 30dB. Measurement results using this probe, therefore, need to be compensated by adding 30dB. The increases in the low frequency region due to the filter in the voltage probe should be added into this compensation factor to obtain the true noise characteristics of the EUT. The HP 4194A's table display is helpful when looking at values of measurement data and compensation factors in a numerical display.

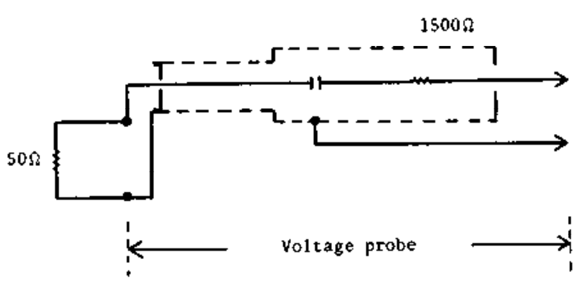


Figure 6. Simplified Voltage Probe Circuit

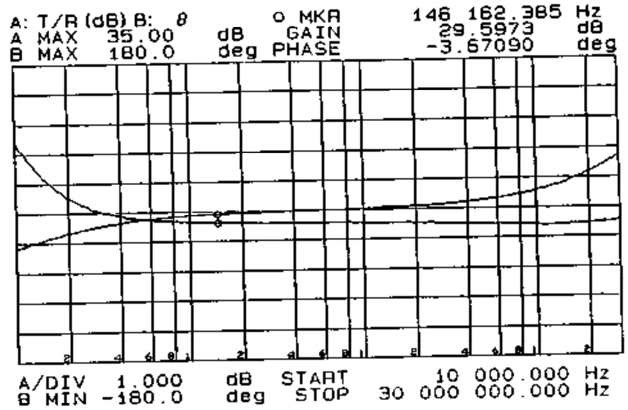


Figure 7. Voltage Probe Loss

Conclusion

In addition to the above evaluations, impedance measurements are becoming significantly more important when noise due to resonances in the circuits or circuit networks is a major source of EMI. Using the HP 4194A and HP 41941A/B which can perform grounded impedance measurements, you can reduce radiation from circuits by measuring the circuit impedance and shifting the resonance points of the circuits as need be.

The HP 4194A and HP 41941A/B with their wide measurement capabilities, analysis and programming functions will make your life a lot easier when testing, troubleshooting, and designing for **EMI**!

For more information, call your local HP sales office listed in the telephone directory white pages. Ask for the Electronic Instrument Department, or write to Hewlett-Packard. **U.S.A.** - P.O. Box 10301, Palo Alto, CA 94303-0890. **Europe** - Hewlett-Packard S.A., P.O. Box 529, 1180 AM Amstelveen, The Netherlands. **Canada** - 6877 Goreway Drive, Mississauga, L4V 1M8, Ontario. **Japan** - Yokogawa-Hewlett-Packard Ltd., 3-29-21, Takaido-Higashi, Suginami-ku, Tokyo 168. **Far East** - Hewlett-Packard Asia Headquarters, 47/F China Resources Building, 26 Harbour Road, Wanchai, Hong Kong. **Australasia** - Hewlett-Packard Australia Ltd., 31-41 Joseph Street, Blackburn, Victoria 3130 Australia. **Latin America** - Hewlett-Packard Latin America Headquarters, 3495 Deer Creek Rd., Palo Alto, CA 94304. For all other areas, please write to: Hewlett-Packard Intercontinental Headquarters, 3495 Deer Creek Rd., Palo Alto, CA 94304.

Printed in Japan **May, 1987** **5950-2922**