Errata

Document Title: Testing Switching Power Supplies (AN 339-14)

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HP References in this Application Note

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Application Note 339-14

TESTING SWITCHING POWER SUPPLIES

USING THE HP 4194A

INTRODUCTION

Here are some suggestions on how to use the HP 4194A Impedance/Gain-Phase analyzer to test and troubleshoot Switching Power Supplies and the components used to build them.

This information will be useful to:

- Switching Power Supply Manufacturers (QA, Production, R&D Lab)
- Power Supply Design Engineers (Lab)
- Component Manufacturers who supply components to Switching Power Manufacturers.

MEASUREMENT NEEDS

Switching power supplies are becoming increasingly popular due to their high efficiency (thus lower operating temperature), lower volume, and lower weight than linear supplies. Switching frequencies are being pushed higher as engineers shoot for further reductions in weight and volume, and for increased efficiency. The characteristics of components used in switching power supplies are specified by most manufacturers at much lower frequencies than are used in switching power supplies, so the true characteristics of capacitors, transformers, and inductors must be tested at the actual frequency of operation. The following measurements are used to properly select, evaluate, and test switching power supply components and circuits.

Component Measurement Needs

- *Impedance* at frequency of operation
- *Self-resonance frequency* of inductors and capacitors

Circuit Measurement Needs

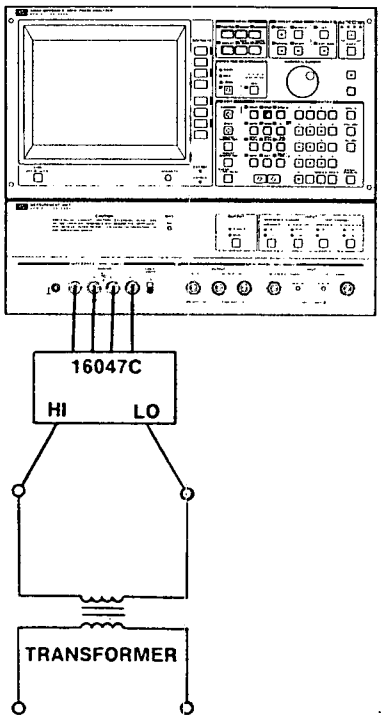
- Loop Gain/Phase measurement (Open and Closed Loop) for stability analysis
- Frequency response signature analysis for historical analysis when troubleshooting and product/component consistency analysis

MEASUREMENT SOLUTIONS

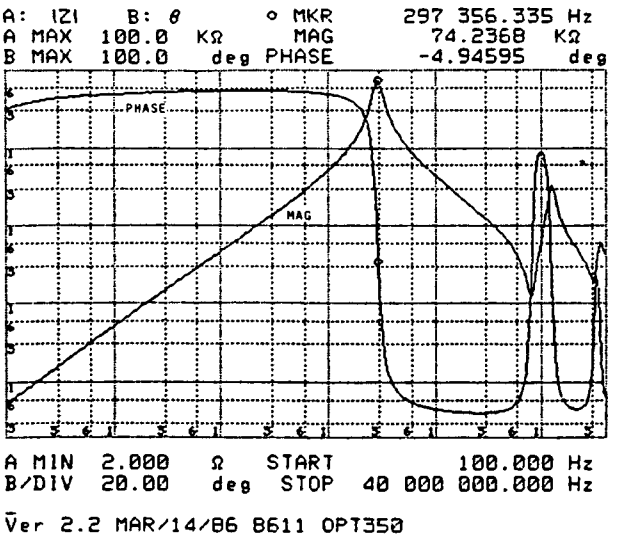
- HP 4194A

EXAMPLE 1: Measuring a Transformer's Self-resonance Frequency

Example 1 shows the measurement of the self-resonance frequency and the frequency response of a switching Power supply's transformer.



Measurement Setup



Sample Measurement Results

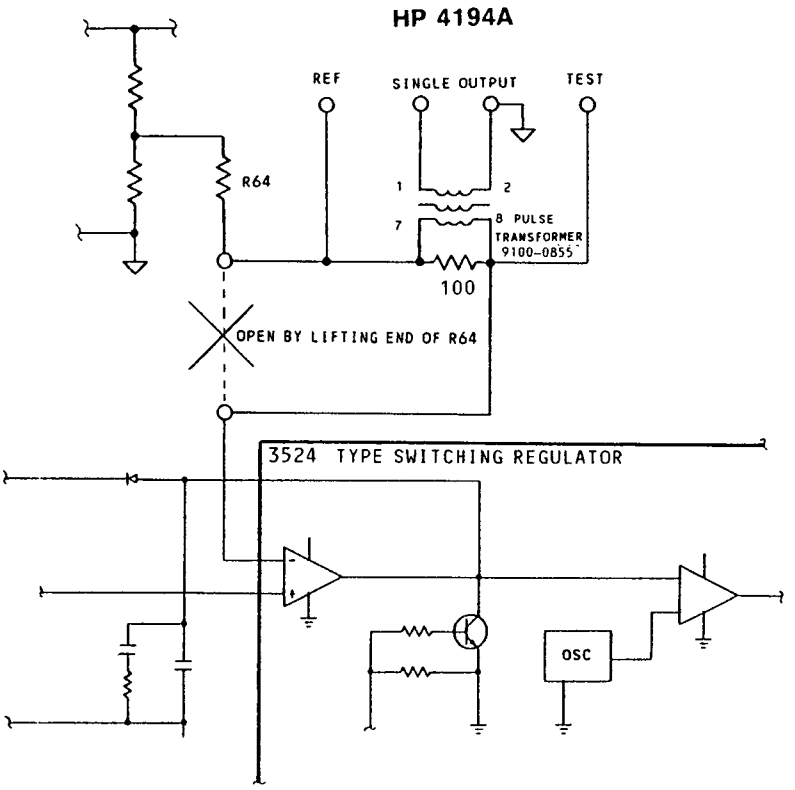
Figure 1. Transformer Self-Resonance Frequency Measurement

In the following example an isolation transformer is used between the power line and the switching power supply under test. **THINK SAFETY AT ALL TIMES!** Ten to one oscilloscope probes are used for the REF and TEST channel inputs, and a straight through cable which is made up using COAX cable is used for the OUTPUT signal from the HP 4194A.

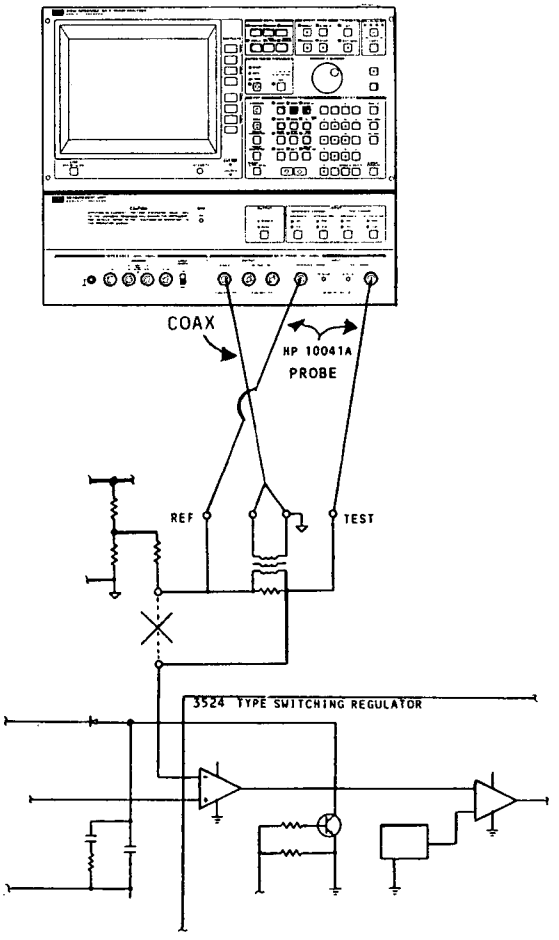
EXAMPLE 2: Switching Power Supply's Frequency Response Characteristics

Frequency response characteristics can be used in the design/development phase and in production test phase. In the design phase, components and circuits must be checked to ensure adequate gain-phase margins for stable operation. In the production phase, programmed limit testing can be used to verify that production units are within design limits. Wrong valued capacitors and inductors, defective capacitors and inductors, and defective transformers are some of the things that can cause frequency response variation in a switching power supply circuit.

The following figure shows a partial circuit diagram and the test setup used to test a switching supply based on the popular 3524 series switching regulator control IC. The output of the error amplifier is not brought directly out of the 3524 IC, so an alternative scheme of injecting the signal and connecting the REF and TEST inputs using a wide-band pulse transformer is shown. An injected test signal level of 0.2 V was used to obtain a good signal to noise ratio while at the same time not over driving the circuit to the point of trashing it. Notice what is happening at 50 Hz (the line frequency at which this test was conducted) and at around 58 kHz, the switching frequency.



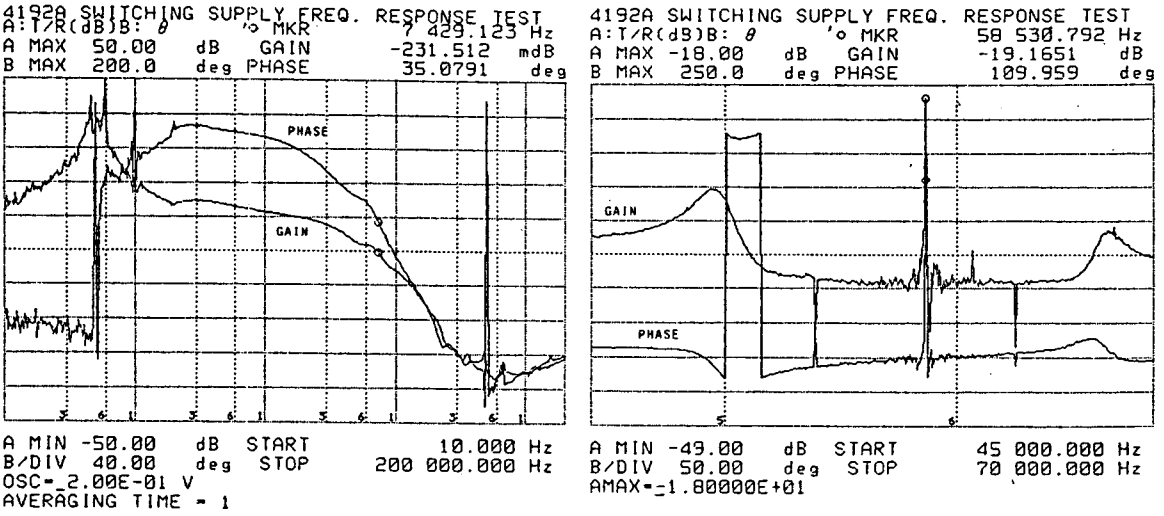
Switching Power Supply Circuit Diagram and Test Setup



Measurement Setup

Figure 2. Circuit Frequency Response Characteristics

Open-loop Gain-Phase characteristics measured under closed-loop conditions.



Frequency Response **Zoomed In At Switching Frequency**

Figure 3. Circuit Frequency Response Characteristics

SUMMARY

The design, evaluation, and testing of today's high frequency switching power supplies is much more effective (quality, time to market, cost) when sophisticated, yet easily used test equipment is brought to bare on the problem. In addition to the usual measurement techniques, the HP 4194A is flexible and powerful enough to allow the user to develop new and innovative measurements. Frequency response measurement can be used in a lab environment and as an automated test in a production line environment, and when using the HP 4194A frequency response measurement becomes a simple everyday measurement tool. The frequency response of a switching power supply is the signature of the circuit, and a change in the signature indicates a change (or problem) in the components within the circuit. Frequency response measurement normally requires several carefully setup instruments to perform, but with the HP 4194A you get everything in one instrument.

The HP 4194A offers powerful solutions for designing and testing switching power supply components and circuits. The problem of determining the properties and characteristics of components at frequencies outside of the normally specified values is critical to success in the highly competitive switching power supply market.

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.

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