E-Poster

DC-biased high-power impedance measurement system for planar magnetic core up to 50 MHz

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Abstract

This paper discusses the measurement methodology of a planar PwrSoc magnetic core at higher frequencies and higher power. A DC-biased impedance measurement system usable up to 50 MHz, AC 10 A, DC-bias 5 A is designed. High-frequency wires on measurement PCB board are provided with impedance matching to 50 Ω, whose dimension is so designed to carry the rated AC and DC currents. Stray-impedance at high frequencies is calibrated accurately by means of extensively utilizing a function of commercially available impedance analyzer. Leaded radial inductors, wire-wound inductors and chip inductors ranging from 10 nH to 10 μH in market are applied for measurements. The measured data agreed well with the published data sheet, and it is found that the developed system has a potential to be used up to >100 MHz range.

Brief Description and Figures

A. Objective

Planar magnetic core measurement technology directs toward higher frequency and higher power ranges to develop better PwrSoc, and measurement up to 20 MHz has been demonstrated [Ref. Jef Thone, Mike Wens "Large-signal inductor loss measurement on integrated inductors", e-poster, PwrSOC 2014]. In this work, a DC-biased impedance measurement system usable up to 50 MHz, AC 10 A, DC-bias 5 A is studied.

B. Design of DC-biased high-power impedance measurement

As shown in Fig.1, DC signal from DC generator will be superimposed at the DUT with amplified AC signal from impedance analyzer (4294A, Agilent Tech.) through power amplifier (NF 4020, NF Corp., et al) and therefore the DC-bias characteristics of DUT can be measured through the impedance analyzer. The voltage and

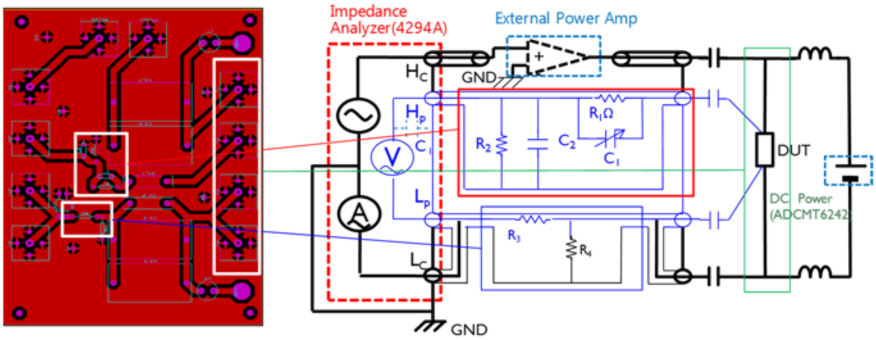


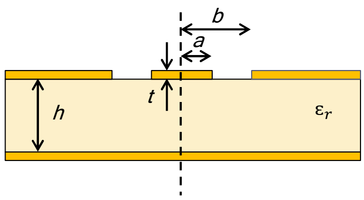
Fig. 1. DC-biased high-power impedance measurement system

current dividing circuit are attached to the impedance analyzer for high power inductor measurement; division ratios are 51:1 for voltage and 101:1 for current, respectively.

C. Impedance matching design for PCB

Impedance matching to 50 Ω is provided for on-PCB wires to decrease stray impedance and accordingly to improve the measurement accuracy. CAD software (Proteus 8 Professional) is used to design coplanar waveguide on the typical FR-4 PCB as shown in Fig. 2. Completed wiring layout is shown in the left side in Fig. 1.

Grounded CPW cross section



Grounded CPR design

$$Z_0 = \frac{60\pi}{\sqrt{\varepsilon_{eff}}} \frac{1}{\frac{K(k_3)}{K(k_3')} + \frac{K(k_4)}{K(k_4')}}$$

$$\varepsilon_{eff} = 1 + q_2(\varepsilon_r - 1)$$

K(m): Complete elliptic integral of the first kind

	Value	unit
ε_r	4.7	
h	1.6	mm
a	1.36	mm
b	2.90	mm
Z	50	ohm
f	1000	MHz
1/4λ	40.618	mm

Signal line width: 2a=2.72 mm
Signal-groud gap; b-a=1.54 mm

Fig. 2. CPW design in FR-4 PC

D. Results and Discussion

Fig. 3 shows the completed measurement board connected to the fixture (16047E, Agilent). Test inductors are leaded radial inductors, wire-wound inductors and wire wound molded chip inductors ranging from 10 nH to 10 μH in market (TDK TSL0709, SLF10145 and LFC32, respectively). All the measured data were agreed well with the data sheet in the published

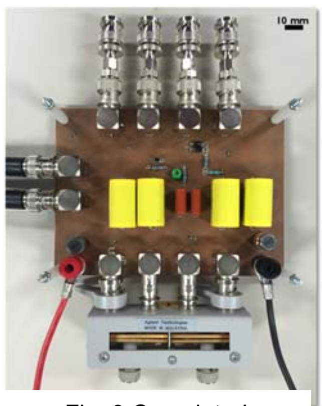
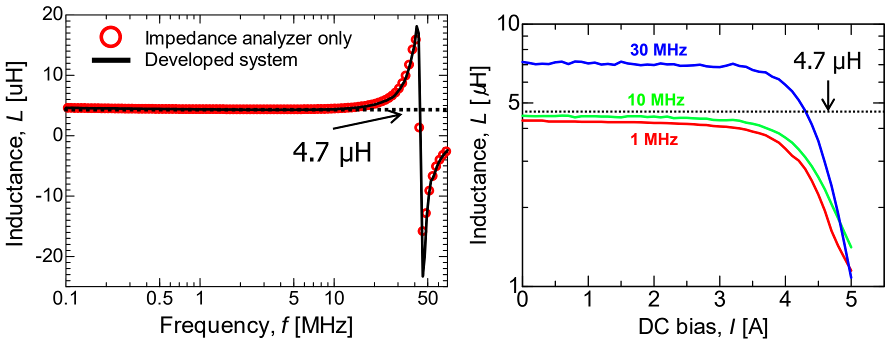
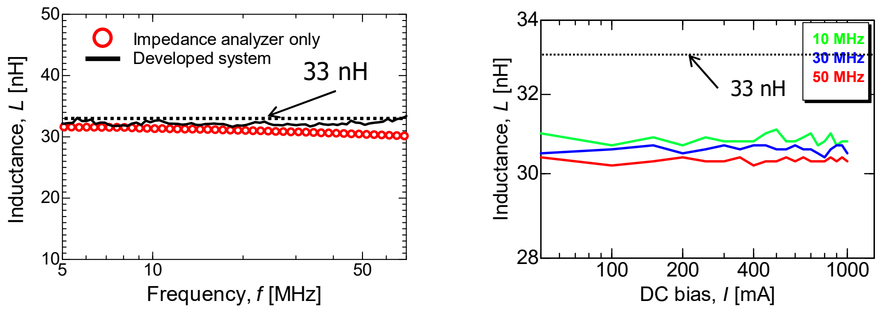


Fig. 3 Completed measurement board



(a) Frequency dependence of inductance, (b) DC-bias characteristic
Fig. 4 Lead inductor, 4.7 µH:



(a) Frequency dependence of inductance, (b) DC-bias characteristic
Fig. 5 Chip inductor, 33 nH:

frequency and DC -bias current ranges. Representative data are shown in Fig. 4 and Fig. 5. A 4.7-µH leaded inductor resonated at 40 MHz and the inductance is flat up to DC 4 A. A 33-nH chip inductor will not resonate up to 100 MHz while small peak is seen at 70 MHz, indicating that >100 MHz measurement would be possible soon by reducing the stray impedance of the PCB.

Key Contributions

A DC-biased impedance measurement system for planar magnetic core has been developed usable up to 50 MHz, AC 10 A, DC-bias 5 A. Measured data of typical inductors demonstrated the validity of the proposed methodology, and potential >100 MHz measurements.

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