

Date: 1/5/97

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Subject: Path of Least Impedance

In this lab, the fact that current flows in the path of least impedance was investigated. It was found that transmission lines (such as coaxial cables) have an impedance that depends on the frequency. A coaxial cable was connected to a function generator, resistor, and ground strap (between the two ends of the cable). The current was measured through the resistor and strap at various frequencies, holding the voltage source constant.

Based on the information gathered in lab, the current will flow more through the ground strap at lower frequencies, and more through the coaxial cable at higher frequencies.

For low frequencies, a resistor can model the coaxial cable. For frequencies below 10000 Hz, the coaxial cable's impedance varies very little (the current varies very little, and the voltage is, of course, constant). After 10 kHz, the current varies too much for the cable to be represented by a resistor. Therefore 10 kHz is the frequency point for which the model has to change for the cable.

Appendix I - DC Resistances and Currents

Path of Least Impedance

DC Resistances

Inner conductor of coaxial cable:	8.12 Ω
Outer conductor of coaxial cable:	8.25 Ω
Ground Strap:	8.07 Ω
50 Ω Nominal Resistor:	59.01 Ω

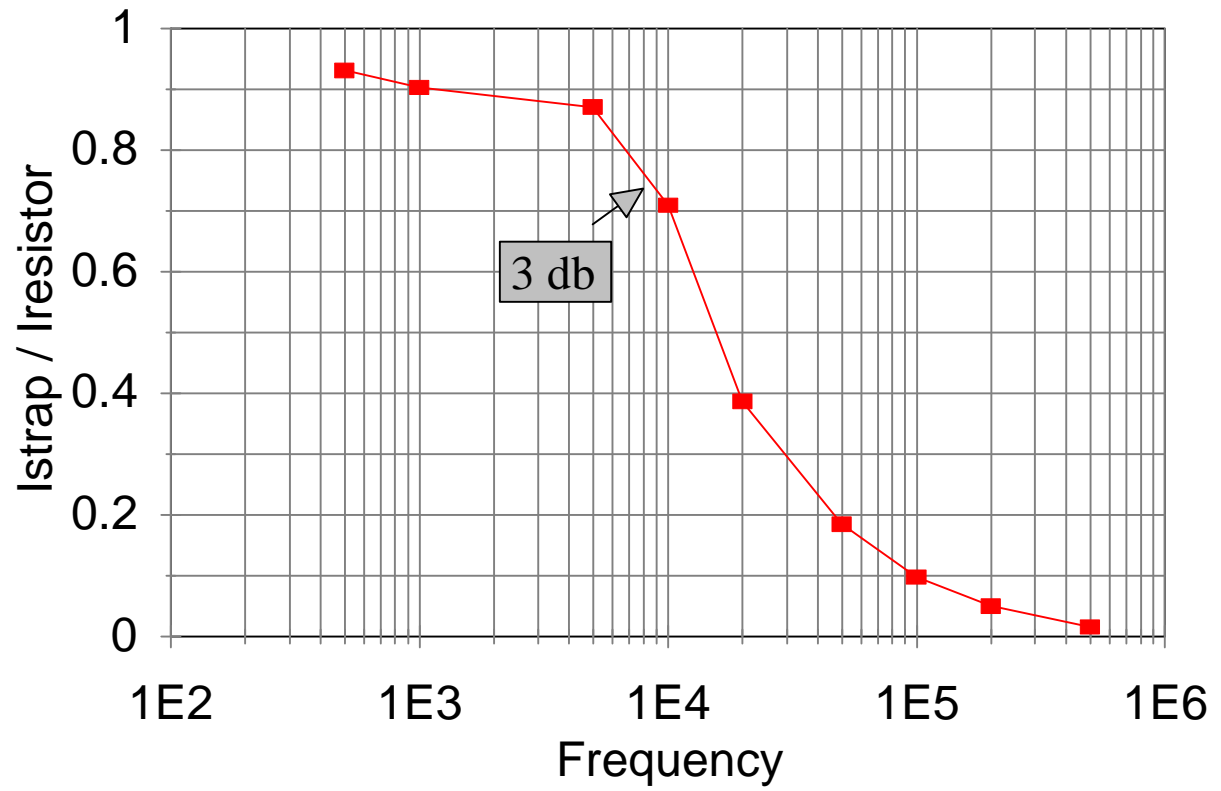
DC Currents vs. Frequencies

f (hz)	I _{strap} (mA)	I _{resistor} (mA)
500	50	50
1000	54	58
5000	56	62
10 k	54	62
20 k	44	62
50 k	24	62
100 k	11.5	62
200 k	6	61
500 k	3	60
1 M	1	60

Appendix II

Path of Least Impedance

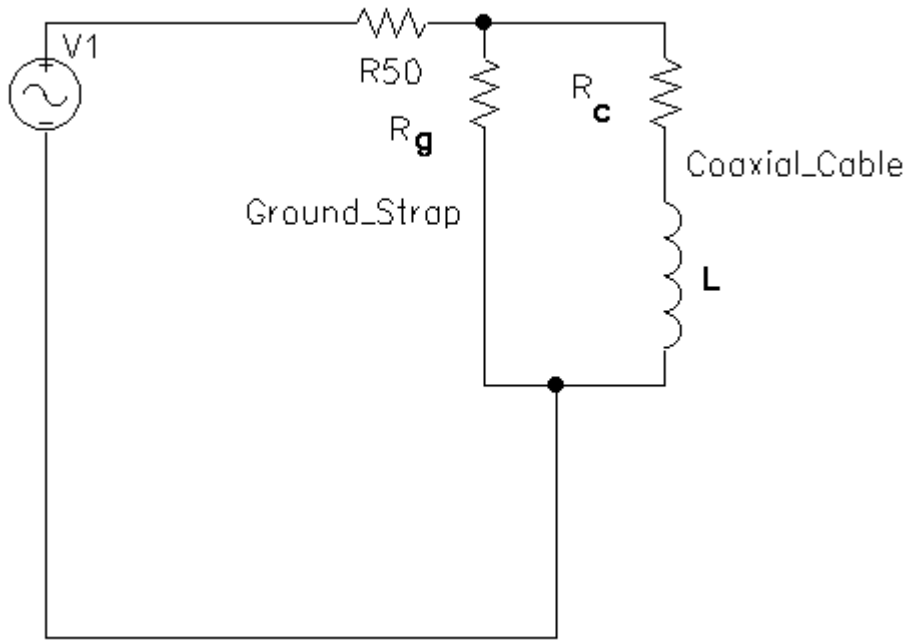
Plot of $I_{strap} / I_{resistor}$ vs. Frequency



Appendix I - Circuit Model

Path of Least Impedance

Circuit Model:



$$I_{\text{ground strap}} = I_{\text{resistor}} * (R_c + j\omega L) / (R_c + j\omega L + R_g) \quad (\text{Current Divider})$$

$$\therefore I_{\text{ground strap}} / I_{\text{resistor}} = (R_c + j\omega L) / (R_c + j\omega L + R_g)$$

$$\therefore I_{\text{ground strap}} * (R_c + j\omega L + R_g) = I_{\text{resistor}} * (R_c + j\omega L)$$

$$\therefore (I_{\text{ground strap}} - I_{\text{resistor}}) * j\omega L = (I_{\text{resistor}} - I_{\text{ground strap}}) * R_c - I_{\text{ground strap}} * R_g$$

$$\therefore \omega = [-R_c - (I_{\text{ground strap}} * R_g) / (I_{\text{ground strap}} - I_{\text{resistor}})] / (j * L)$$

$$\therefore \omega = j * [R_c + (I_{\text{ground strap}} * R_g) / (I_{\text{ground strap}} - I_{\text{resistor}})] / L$$

$$\therefore |f| = 2 * \pi / |\omega| = 2 * \pi * L / [R_c + (I_{\text{ground strap}} * R_g) / (I_{\text{ground strap}} - I_{\text{resistor}})]$$