(Dataset) Measured self-resonant frequencies of an air-core single-layer solenoid inductor

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This dataset provides measured values of the lowest twenty-two self-resonant frequencies of a solenoid inductor with one end unterminated and the other end driven by a signal generator. The solenoid inductor was made of a single-layer helix of close-wound wire coiled on a hollow cylindrical pipe form.

Solenoid inductors made of a single winding layer (single-layer solenoids) are nonideal electrical components. At low frequencies, such solenoids behave as lossy inductors. At higher frequencies, their behavior is much more complicated.[1] For example, when their terminals are open or grounded, they can exhibit multiple resonances similar to a quarter-wave or half-wave transmission line.[2] Plots of self-resonance data for two solenoids representative of a typical secondary coil in a Tesla coil (or Tesla transformer)[3] are available in Ref. 4. This work provides raw resonant frequency data for a similar solenoid, as described below.

Figure 1 includes a sketch of the experimental setup and a picture of the measured solenoid. A signal generator (BK Precision 4085) drove the bottom of the solenoid with a sine-wave voltage signal of variable frequency while the top was unterminated (open). This arrangement excited both quarter-wave resonances (bottom grounded) and half-wave antiresonances (bottom open) because of the finite generator impedance. Both types of resonances were detected using an oscilloscope with non-contact electric- and magnetic-field probes. The resonant frequency recorded for a given resonance was the driving frequency that maximized the oscilloscope probe signals. No corrections were made for possible perturbations to the resonant frequencies from the probes or generator (e.g., capacitive loading

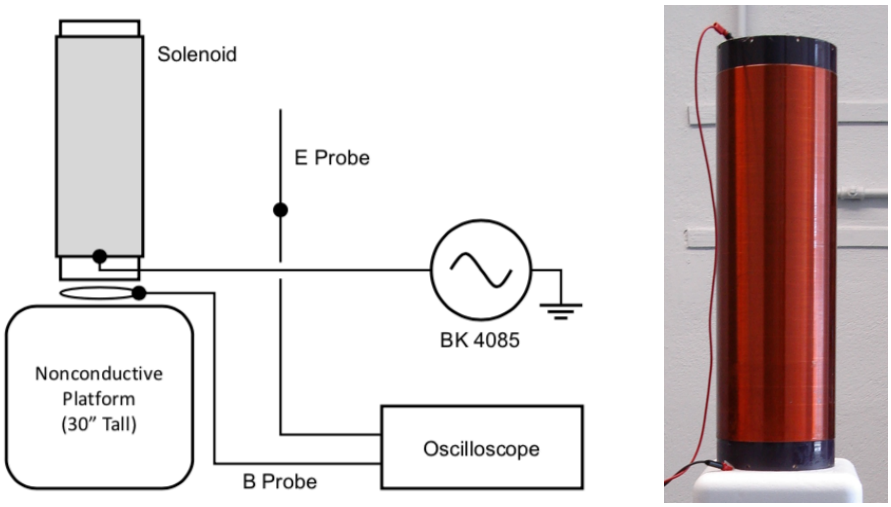

FIG. 1. (Left) Experimental setup for self-resonant frequency measurement. (Right) Picture of the solenoid used with leads attached to measure its inductance.

TABLE I. Measured resonant frequency data. Uncertainties are estimates of experimental error.

Resonance	Frequency MHz	Uncertainty MHz
1	0.3170	0.0002
2	0.743	0.001
3	1.047	0.002
4	1.337	0.002
5	1.614	0.01
6	1.90	0.01
7	2.15	0.01
8	2.43	0.02
9	2.70	0.01
10	2.95	0.01
11	3.22	0.01
12	3.47	0.01
13	3.72	0.01
14	3.98	0.02
15	4.21	0.02
16	4.46	0.02
17	4.71	0.03
18	4.93	0.03
19	5.18	0.03
20	5.45	0.04
21	5.62	0.05
22	5.88	0.05

of antiresonances). The solenoid was kept at least three feet away from any large conductors.

Table 1 lists the resonant frequency data measured in April 2014. The data are also provided in an accompanying tabular data file titled "Solenoid-self-resonances-CU1-2014."

Table 2 lists relevant physical parameters for the solenoid, which was part of a Tesla coil used for lecture demonstrations by the Columbia University Physics Department. It was manufactured by "D&M's High Voltage" of Tampa, Florida, and labeled "6 inch x 20 inch secondary, 22 AWG, 712 turns, 23.35 mH." Its wire was wound around a hollow white plastic pipe that matched PVC schedule 40. The pipe extended about 3 inches below (bottom end) and about 1.5 inches above (top end) the winding, with the visible pipe ends painted black. The interior of the pipe was cleared of insulating baffles and other material. Roughly 2 feet of loose wire at the top was looped and taped to match the winding.

TABLE II. Physical parameters for the single-layer solenoid inductor.

Parameter	Value	Units	Comment
Diameter of winding	0.168 ± 0.002	m	Measured, pipe outer (winding inner) diameter.
Length of winding	0.506 ± 0.002	m	Measured.
Number of turns	712		Manufacturer label.
Wire gauge	22	AWG	Manufacturer label.
Resistance	20.0 ± 0.4	Ohms	Measured, direct current (Ampeg 37SR-A).
Inductance	24.6 ± 1.5	mH	Measured, direct current (Ampeg 37SR-A).

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