Spark-Gap Tesla Transformer

1 Introduction

I built two secondary coils: Small coil D25.4/H119 (Diameter=25.4mm and Height=119mm) and Medium coil D73/H228. I experimented with the spark gap, and observed that a series spark gap is better in terms of power handling, noise, and spark discharge length. The capacitance is very important. It should be able to pump a high current, so a low ESR and a low inductance pulse type capacitor is required.

2 Small Coil D25.4/H119

The specs are given below.

Table 1. Small Coil, 25.4/119

Secondary coil form	PVC
Winding height of secondary coil	119.0 mm
Diameter of secondary coil	25.4 mm
Wire diameter for secondary coil	0.275 mm (0.25 mm diameter + %10 enamel coating)
Aspect ratio	4.69:1
Spacing between windings	0.0 mm
Secondary turns	432
Secondary wire length	34.53 m
Secondary inductance	0.91 mH
Approximate resonant frequency	3699 KHz
Secondary quarter wave long resonant frequency	2172 KHz
Secondary self capacitance	2.03 pF
Top load capacitance required for quarter-wave long coil	3.86 pF
Primary capacitance	352 pF (Jar)
Primary tuning range	12-16 μH

I tested this coil with two different primary caps. First I constructed a water filled jar cap using aluminum foil as shown in Fig. 3, and measured its capacitance as 352pF. The estimated voltage rating was about 20KV. I run a bunch of tests by varying the supply voltage, changing the spark gap configuration, and putting different discharge terminals. A series spark-gap configuration involving four or more gaps gives the best performance. However, the total gap spacing must not be larger than 5-6mm to protect the primary capacitor. A series arrangement is quieter. The streamers emanating from the discharge terminal are quite visible in the dark. And I measured a spark discharge of about 3-3.5cm using a grounded rod. The estimated voltage output was about 70KV. The coil and the streamers are shown in Fig. 2 and 3, respectively.

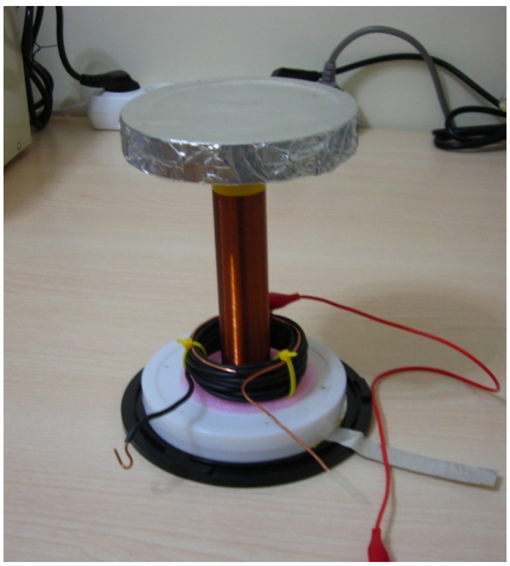

Fig. 1. My first Tesla transformer. The secondary coil form is a 25.4 mm diameter PVC pipe. The secondary winding is 119mm high. AWG30 wire has been used. The primary coil has an inductance of about 15μH.

Fig. 2. Streamers emanating from the secondary terminal. A light bulb is acting as a plasma globe.

Fig. 3. A simple jar capacitor, easy to manufacture and cheap. The lower value of the capacitance has some advantages. First, since the HV supply charges the capacitor rapidly, the spark-gap firing rate is very high compared to a larger capacitor version. Second, since the accumulated charge is low, the risk of electrical shock is also low.

Fig. 4. Series spark gap arrangement.

Then I tested the same secondary using a 2.53nF/16KV MMKP array as shown. Primary inductor was replaced too. Since the cap has been increased, a much lower primary inductance was needed. The spark length was about 4.5-5 cm. However, the spark gap firing rate has been reduced. A higher current is needed from the HV transformer..

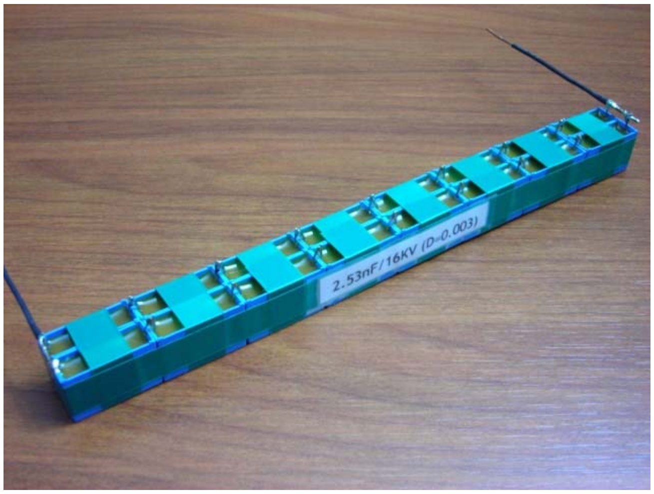

Fig. 5. Primary cap 2.53nF/16KV.

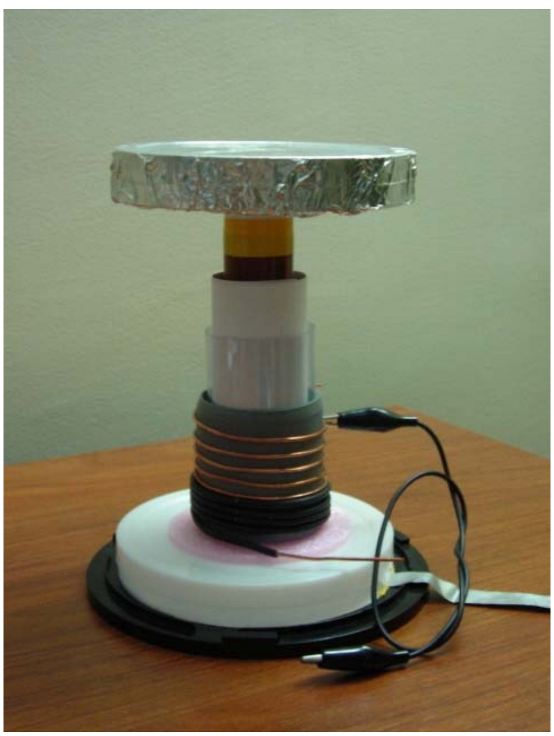

Fig. 6. The new primary for the 2.53nF cap.

3 Medium Coil

Table 2. Medium Coil, 73/227

Secondary coil form	PP (Polypropylene)
Winding height of secondary coil	228.0 mm
Diameter of secondary coil	73.0 mm
Wire diameter for secondary coil	0.275 mm (0.25 mm diameter + %10 enamel coating)
Aspect ratio	3.12:1
Spacing between windings	0.0 mm
Secondary turns	829
Secondary wire length	190.14 m
Secondary inductance	13.82 mH
Approximate resonant frequency	619 KHz
Secondary quarter-wave long resonant frequency	394 KHz
Secondary self capacitance	4.78 pF
Top load capacitance required for quarter wave long coil	7 pF
Primary capacitance	8.4nF/15KV (MMKP array of 4 strings, each string has 6 caps each 10nF/2500V)
Primary tuning range	18-25 μH

Fig. 7. The medium coil.

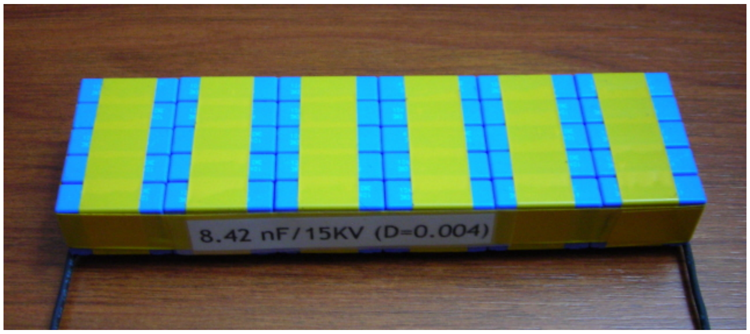

Fig. 8. MMKP array of 8.42nF/15KV.

This transformer is very powerful. For a spherical door knob discharge terminal, it was tuned at about 7.5uH, and 15cm long sparks have been observed.

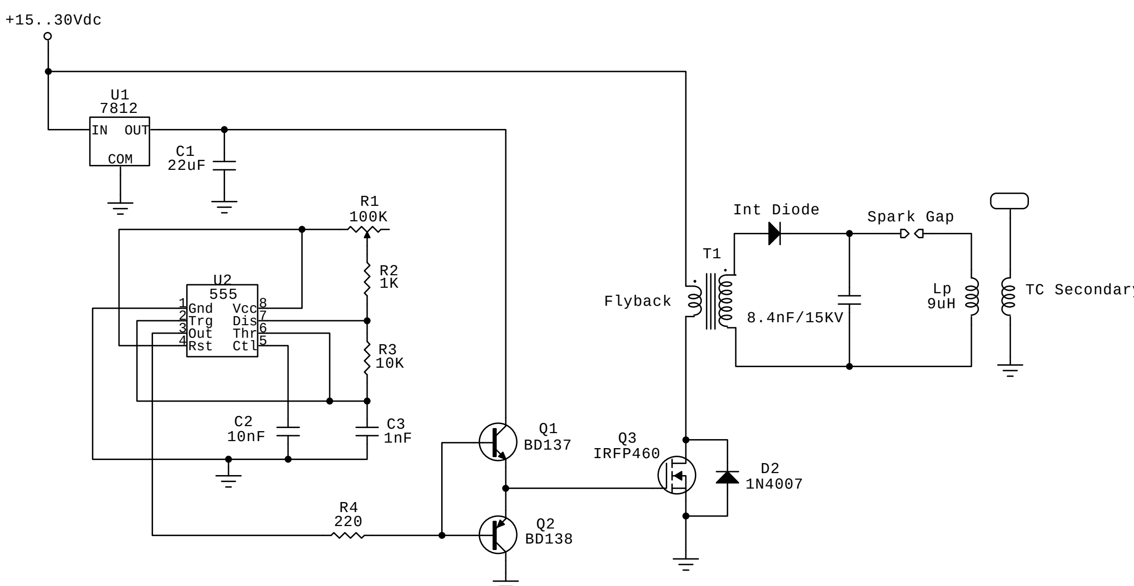

Fig. 9. The circuit. Flyback primary has 20 turns.

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