Proposal of Power Supply Module for the Electromagnetic Field Probe

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Abstract. *This article deals with a proposal of power supply for autonomous electromagnetic field probe. The probe consists of three parts: control electronics, electromagnetic fields sensor and power supply. In this article we deal with power supply of the probe analysis and synthesis. We analyze the impact of the power supply part on the measurement error of the electromagnetic field. Result of an analysis will be dependency of the measurement error on the distance of segments which serves as a power supply for probe. Based on this values will be possible defined the overall dimensions of the electromagnetic field probe.*

Keywords: Power Supply, Sensor, Electromagnetic Field Probe, Minimum Distance, Near-Field

1. Introduction

It is necessary propose adequate power supply for device during proposal of electrical equipment. Some equipment has special requirements considering at their construction or function. Our proposed equipment is autonomous electromagnetic (EM) field probe. This probe will measure one or several vector components of the electric field intensity in the near-field region from source of the EM field [1]. The EM field probe consists of electric small sensor(s), control electronics (e.g. operational amplifier, μProcessor, etc.) and power supply. Proposed EM field probe must be autonomous in terms of power supply. The power supply will be designed as a device taking energy from measured EM field. This device will insert in to the near distance from source of EM field. Intensity of electric (magnetic) field reached high value in the near-field region [2]. We know that electric current is generated with EM field in the near area of the antenna from reciprocity theorem [2]. We use elementary electric dipole as an antenna. This component converts electric field intensity to the induced voltage at the end of the dipole. The dipole alone is not good version of power supply. We must to propose electrical component, which provide sufficient power supply for EM field probe. Our device can influence measured EM field in its surroundings. We must verify the effects proposed power supply on the measurement EM field.

2. Conception of power supply

In this part will be proposed power supply for EM field probe. Dipoles convert electric field intensity to the induced voltage at the end of the dipole. The length of the dipole must be significantly less than the wavelength of the EM field. The dipole alone is not enough for power supply of the probe. For the purposes of increasing input voltage are used different types of voltage multiplier [3], [4]. In our proposal we focused on the cascade multiplier (*Cockcroft-Walton* multiplier) as shown in Fig. 1.

A cascade multiplier is an electric circuit with an AC input and DC output of roughly twice the peak input voltage. They are a variety of voltage multiplier circuit and are often, but not always, a single stage of a general form of such circuits. The term is usually applied to circuits consisting of rectifying diodes *D* and capacitors *C* only, other means of doubling voltages are not included. Output of cascade multiplier is theoretically an integer times the

AC peak input, for examples, 2, 3, or 4 times the AC peak input. Thus it is possible to get 200 V DC from a 100 V peak AC.

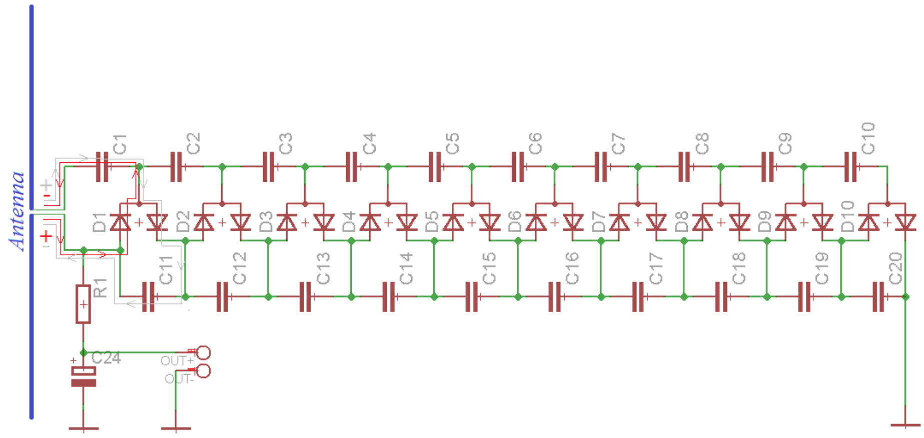


Fig. 1. Cascade multiplier (*Cockcroft-Walton* multiplier)

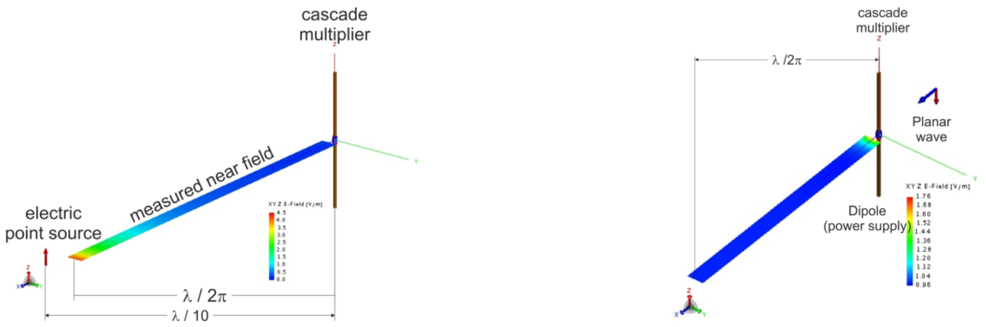
Principle of the cascade multiplier is simple. At the time when the AC input (antenna) reaches its positive polarity on anode of the first diode in D_1 (D_1 is double diode) is allowing current from the capacitor C_1 back into the input (red line). Capacitor C_1 is charged to the voltage peak of source, $U_{c1} = \sqrt{2}u$. Where u is input AC signal. When the same AC signal reverses polarity, current flows through the second diode in D_1 filling up the capacitor C_{11} with both the positive end from AC source u and the first capacitor U_{c1} (grey line). Second capacitor is charged to the voltage $U_{c11} = \sqrt{2}u + U_{c1} = 2\sqrt{2}u$. With each change in polarity of the input, the capacitors add to the upstream charge and boost the voltage level of the capacitors downstream, towards the output on the right. The output voltage, assuming perfect conditions, is twice the peak input voltage multiplied by the number of stages in the multiplier. Cascade multiplier has 10 stages which are showed in Fig. 1.Each stage containing two capacitors and two diodes. That means on the output will be an integer 10 times the AC peak input, $U_{OUT} = 10\sqrt{2}u$ [4]. As a diode we use Schottky zero bias diode, therefore we neglected voltage losses on the diode.

The DC/DC converter is connected at the output from the cascade multiplier thereby that voltage from power supply reaches the required level. Capacitor C_{24} is to store the voltage from cascade multiplier. Proposed *cascade multiplier* consists of electric short dipole, Cockcroft-Walton multiplier and DC/DC converter.

3. Impact of power supply on the EM field measurement

The existing an interaction between the cascade multiplier and EM field sensor because there are located close to each other. The impact of the cascade multiplier (proposed power supply) is significant only when large current flow from power supply. In our case proposed EM field probe is powered by current 3 mA. Quantifying the change of the electric field intensity caused by the influence of the cascade multiplier in the near EM field is main task of this article part. EM simulation software FEKO was used for calculate it. In the software FEKO was created a first model where the source of the EM field is *electric point source*. The values of the electric field intensity denote as E_1 depended of x coordinate was simulated, Fig. 1a. The value E_1 are not influencing by cascade multiplier. In the next step, insert cascade multiplier into the model. Cascade multiplier is represented by a loaded electric short dipole Fig. 1a. Get the values of the electric field intensity in the vicinity of the cascade multiplier. These values denote as E_{pws1}.

In the FEKO was created a second model where the source of the EM field is *planar wave*. The values of the electric field intensity denote as E_2. Insert cascade multiplier into the model. Cascade multiplier is represented by a loaded electric short dipole, too Fig. 1b. Get the values of the electric field intensity in the vicinity of the cascade multiplier. These values denote as E_{pws2}. Distance between cascade multiplier and source of EM field was $\lambda/10$, in both cases. Both models were supplied with electric field intensity from 0.5 V/m to 100 V/m.



a) Model 1- *electric point*　　　　b) Model 2 - *planar wave*

Fig. 2. Measuring impact of cascade multiplier to the measurement

4. Results

The measurement error was calculated for electric field intensity with cascade multiplier. This error we get from equation:

$$\delta_{Ex} = \frac{E_{pwsx} - E_x}{E_x} 100\% \tag{1}$$

Index *x* represents the number of the model. In figure Fig. 3(for *electric point source*) and Fig. 4 (for *planar wave source*) we see dependence of the measurement error δ_{Ex} on the distance from cascade multiplier.

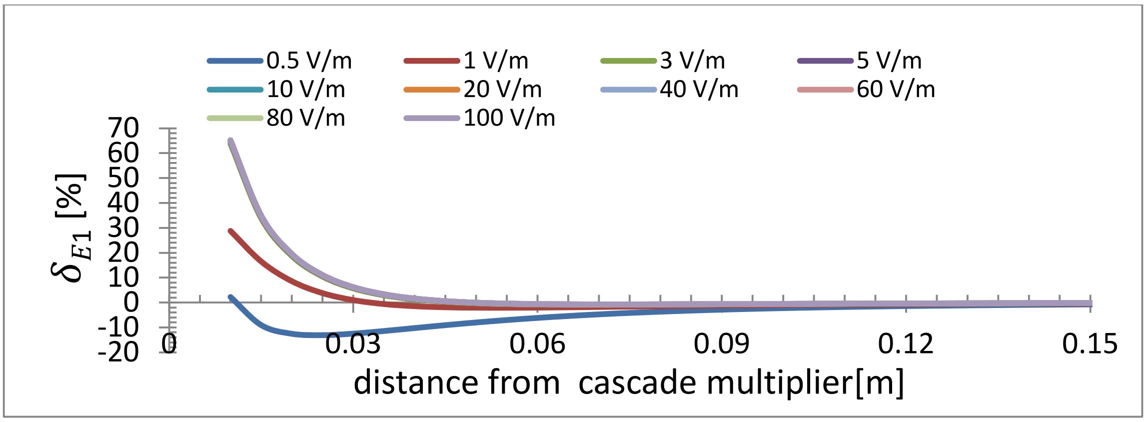


Fig. 3. Dependence of the error δ_{E1} on the distance from cascade multiplier (*electric point source*)

The dipole which represents cascade multiplier flowing current and that generated EM field in the vicinity of the dipole. This EM field influence value of the electric field intensity in the close to the cascade multiplier. In the figure Fig. 3 we can see that to the sustained value of electric field intensity occurs after exceeding distance 10 cm from cascade multiplier. In this case is as a source of EM field used *electric point*. Measurement error δ_{E1} is same for values of electric field intensity greater than 3 V/m. Dependence of the measurement error on the distance from cascade multiplier for *planar wave* is shown in figure Fig. 4. The EM field close to the cascade multiplier reached different value of electric field intensity as when has not been there. In figure Fig. 4 we can see that to the sustained value of electric field intensity occurs after exceeding distance 5 cm from cascade multiplier. Measurement error δ_{E2} is almost same for all values of electric field intensity.

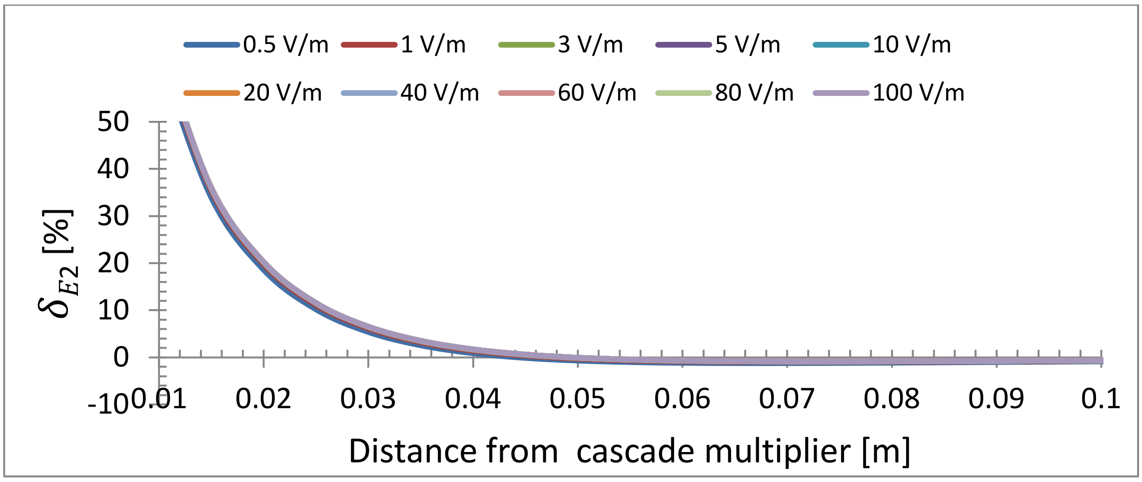


Fig. 4. Dependence of the error δ_{E2} on the distance from cascade multiplier (planar wave)

5. Conclusions

In this article we deals with proposal of power supply for EM field probe. Proposed power supply is powered from measured EM field. Proposed power supply consists from cascade multiplier (*Cockcroft-Walton multiplier*), dipole and DC/DC converter. We were dealing with examination of influence cascade multiplier to the EM field measurement. Conclusion is that minimal distance proposed EM field probe must be 10 cm from the cascade multiplier. Measured EM field is not affected with cascade multiplier in this distance.

Acknowledgements

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