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SOLAR BASED ELECTRONIC FENCING

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ABSTRACT

This paper introduces fundamental concepts of electric fence technology, presents a new design method for a livestock electric fence energizer circuit and impulse transformer as well a mathematic analyze of the circuit. A new expression for design single impulse transformers for this kind of application is presented who has different project criteria from conventional transformer applications. The Energizer equipment is rounded about many concepts, safety standards and data performance that are discussed. An electric circuit prototype of Electric Fence Energizer Equipment for livestock use was implemented and the results are showed. This work is based on a study developed in a Master Thesis.

I. INTRODUCTION

Nowadays the use of electric fence for control and content livestock are having a large application in almost all countries of the world. Electric Fence was starting to use in the thirties and nowadays is used in all world in little and big farms. Brazil, like the major exporter of beef cattle is a great consumer of this technology. Big farms with large areas of control need electric fences energizers of large capacity to keep high voltage in all its extension. But not much information about safety use and project is presented in papers and available for consumers and manufacturers as well electric fences characteristics. There are in Brazil many manufacturers of this kind of equipment, but these manufacturers use empiric rules to design this kind of equipments. This work intends to be a starting point to change this reality involving the academic researchers in the study of this problem. The different parts of the fence are shown in Fig. 1. The electric fence presents the following parts: Energizer, Wire, Isolation and Ground.

II. OPERATION

The current flow on the fence is showed in Fig. 2. When the cattle touch the wire the circuit is closed and the electric impulse current generated by the Energizer flows through the body. In practical experiences is evidenced that the cattle doesn’t transpose the fence for a peak voltage higher than 2 kV measured where cattle touches the wire. For a fence with this peak voltage the livestock xperiments a panic sensation and don’t return to touch the wire.

The simplified electric circuit for the fence circuit is showed on Fig. 2 too. This circuit was modeled from results obtained through measurements in a real fence [1]. The Z0 is the characteristic impedance of the fence line and were

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in some cases the conductor capacitive and inductive reactance is more expressive than the conductor resistance. This impedance may be calculated in the same way that for a power line. In this study was observed that the reflection phenomenon is important to calculate the peak voltage in the fence because this effect can boost the peak voltage value in the system. The reduced voltage produced by faults in insulators produce reflections in the fence line that reduces the peak voltage on the fence.

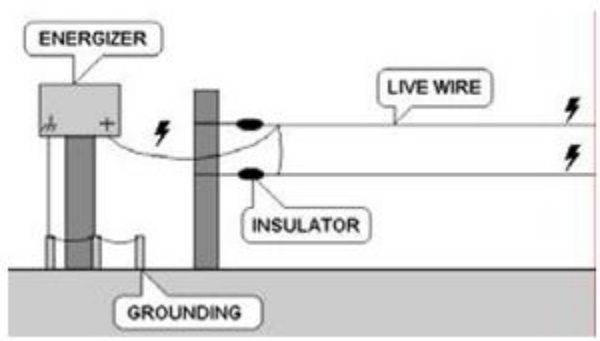

Fig. 1: Parts of the Electric Fence.

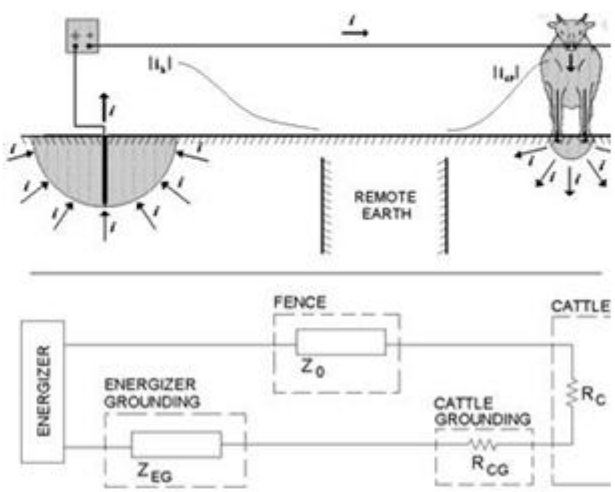

Fig. 2: Current flow (path) in a fence circuit at the cattle touch momentand the simplified equivalent electric circuit.This electric circuit modeled is very useful to estimate the peak value of voltage and the dissipated energy in the cattle in the worst case – the end of the fence. It was evidenced that the energizer grounding and the fence line impedance need to

be projected appropriated because they are the main design parameters and causes a reduction of the peak voltage in the cattle body who touches the fence at t he end. It was observed too that the grounding of the hoofs of cattle is expressive comparing to the cattle body resistance. This voltage divider reduces the voltage and energy in the cattle body. The main grounding will depend in soil resistivity and in some cases a grounding wire in the fence will be necessary, even in small fences with few kilometers The resistance of the body of the cattle is assumed to be 175 Ω for impulse current and for a

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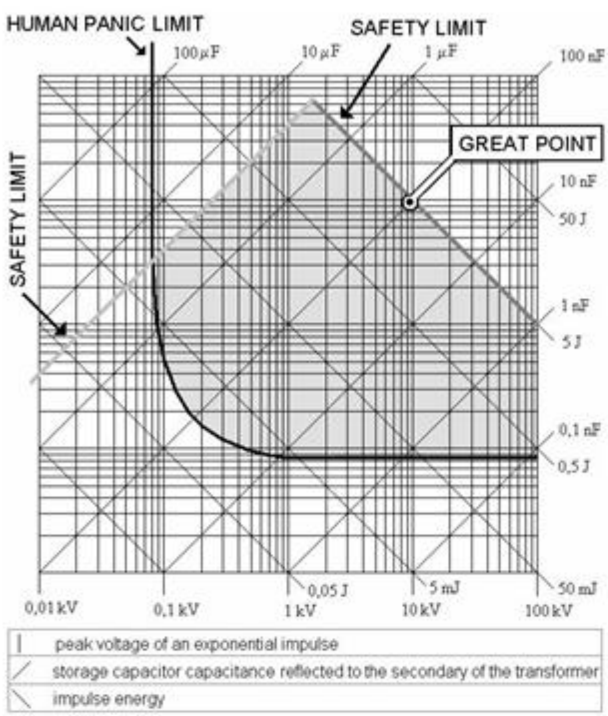
nose to the hoofs path [2]. This data is important to preview the voltage applied in the cattle that will depend of the wire impedance and the ground impedance. For human beings the resistance for impulse current is 500 Ω for the hand to the feet path. This data is important to the safety energy limits described in the standard IEC 60335-2-76 [3].

III. SAFETY ASPECTS

All safety information is important to develop an Electricv Fence Energizer circuit. Is very relevant a correct understanding of electric characteristics of this circuit and the produced reaction of the electric shock derived from it. In the TABLE 1 is listed the mainly safety aspects provided by standard IEC 60335-2-76 [3]. The technical report IEC 60479-2 (chapter 6) [4] shows safety limits for single impulse waveform based on experiments presented in specialized bibliography. There are other two main standards for safety requirement for energizers: the UL-69 edited by Underwriters Laboratories (UL) and the DIN VDE 0131 and DIN VDE 0669 edited by the Deutsche Elektrotechnische Kommision (DKE)

The energy discharged in the load is lower than the energy stored in the capacitor of the energizer circuit. The value of the discharged energy of an energizer will depend of the value of the load. So, it is possible that, an energizer with more the 5 J stored in the capacitor may accomplish the standard requirement for the energy impulse discharge.

The Fig. 3 presents a graphic that describes the safety limits and the panic limits of an exponential impulse discharged in the human body. This graphic presents a gray painted area where the values of peak voltage and duration of the impulse cause a panic sensation. This graphic was created using parametric limits values presented by IEC 60479-2 [4] and IEC 60335-2-76 [3] standard and can be used as reference for an energizer project.



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An energizer designed to produce an electric impulse in a 500 Ω load with the peak voltage value and the energy value according to the "great point" of the graphic of the Fig. 3 will reach the maximum efficacy for this condition, within safety limits. An exponential impulse may be considered and circuit losses are ignored to obtain a correct relation between the values presented in this graphic.

IV. ENERGIZER

The Electric Fence Energizer converts the electrical energy,which normally comes from the electrical utility, batteries or solar PVs in an electric impulse with limited energy associated according to safety limits. The electric circuit is divided in two parts as shown in Fig 4: Supply Circuit and Impulse Generator Circuit.

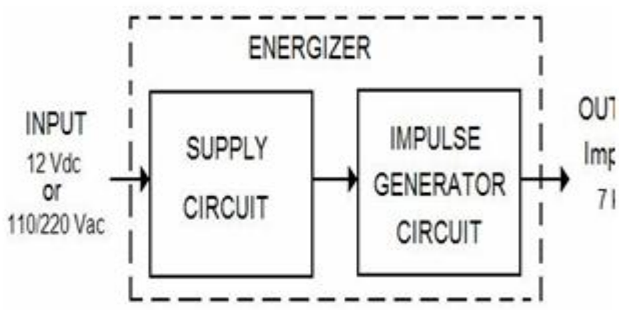

Fig. 4: Electric Fence Energizer

V BLOCK DIAGRAM

The supply circuit provides a DC link to charge th storage capacitor C1. Two usual supply circuits are illustrated in Fig. 5 to exemplify. One is a conventional power supply, 127/220 Vac 50/60 Hz, grid connected (a) and the other one is a 12 V battery associated with a fly back converter (b). Both circuits are used in commercial equipments to raise the input voltage around 300 to 600 Vdc.

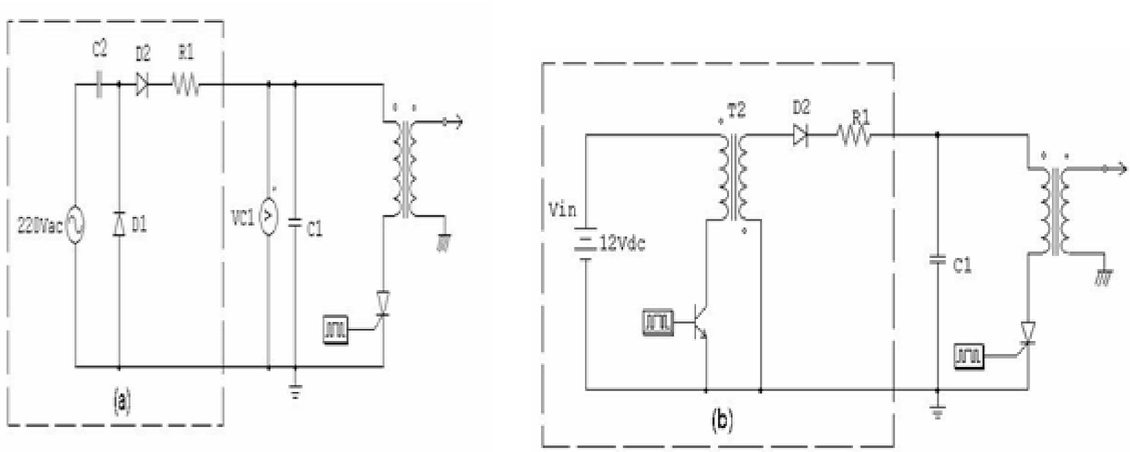

Fig. 5: (a) Means supply – voltage duplicator, (b) Battery supply – Fly Back CC-CC Converter

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Impulse Generator Circuit - IGC

The Impulse Generator Circuit - IGC (Fig. 6) consists in a Discharging Impulse Magnetizer circuit. This impulse generation circuit is present in almost all commercial energizers. The transformer T has two main functions to provide electrical isolation – according IEC60335-2-76 [3] requirement - and boosts the input voltage. This element is normally present in commercial circuits with turn ratio around 1:10. It will depend of the charge voltage of the capacitor and the desired peak voltage of the electrical impulse produced in the fence. The transformer secondary is connected to the wire of the fence and to the ground electrodes. The capacitor C1 is the energy storage element, to charge this capacitor the circuit has about one second. The switch is usually implemented by a thyristor S that provide the discharge of the capacitor. The resistor R1 limits the current of the supply in the charging of C1 and in the discharging of C1. The operation circuit is divided in two stages: Charge Capacitor Stage - stage 1 (Fig. 7) and Discharge Capacitor Stage - stage 2 (Fig. 8).

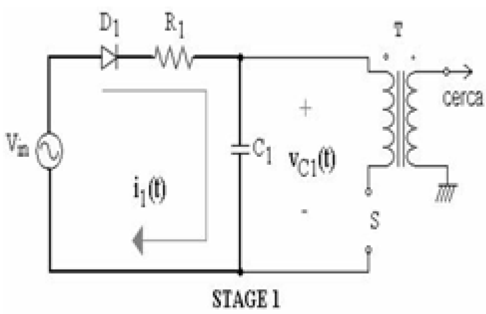

Fig. 7:Charge of the capacitor – stage 1.

In the impulse magnetizer circuit, the transformer T needs to be modeled with the leakage and magnetizing parametersc (Fig. 9) because the relative high frequency of the harmonics [5] of the impulse generated by the discharge of the capacitor C1.

Because of the low value of the load RL reflected to the primary, the RSE value of the capacitor C1 needs to be modeled too.

V. ENERGIZER DESIGN PROCEDURE

To design the IGC is important to know the behavior of the vs(t) waveform and ip(t) waveform as well as they respective peak values. This information is useful to design the transformer, to define the thyristor parameters and know the energy dissipated in the 500 Ω load. Both curves can be obtained trough computer simulation or analytic analysis. However the development of the mathematic expressions of the IGC results in a complex work. With

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some conditions the circuit can be reduced to a series RLC circuit so the expressions for vs(t) and ip(t) can be easily obtained. To this simplification be correct, the reactance of the magnetizer inductance Lm for the di/dt applied by the capacitor C1 discharge may be at least ten times higher than the resistance RL according to the equation (1). The fc is the characteristic frequency of the current impulse.

f L R c m 2.π . . ≥10. (1) With the condition above the amount of the peak value of the current ip(t) flowing in Lm can be neglected (Fig. 10). VI. CONCLUSION The information presented in this paper shows important safety requirements for energizer circuit design. A presentation of the electric fence circuit model based on transmission line theory and propagation waves was showed. It was presented a panic standard graphic that is a useful tool for electric fence energizer design. The measured results of the prototype show clearly that this kind of circuit is appropriate to be used as Electric Fence Energizer because it complies with the standard safety requirements and shows that the circuit analysis and the circuit design of the circuit and of the transformer are appropriate. The measured results validate the design method however an improve of the this design procedure is necessary to obtain better results. With the continuation of this work and improvement of the design method and implementation materials a commercial version will be designed. So this study has a fundamental importance to increase the knowledge in this kind of circuit that is not approached by power electronics bibliography.

VI. CONCLUSION

The information presented in this paper shows important of Safety.

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