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Modeling of A Power Balance of A Three-Phase High Voltage Power Supply For Microwaves Generators With One Magnetron By Phase

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Abstract

This work treats the study of the power balance of a three-phase high voltage power supply for microwaves generators with one magnetron by phase, used in various industrials applications, from its modeling with Matlab-Simulink. The modeling of this new three-phase power supply passes by the modeling and the dimensioning of its own HV three-phase transformer. The design of this power supply uses three π quadruple models equivalents of new three-phase transformer with magnetic shunt of each phase. Every one supplies at its output a voltage doubler cell composed of a capacitor and a diode that in its output supplies only one magnetron. This system was tested with the help of Mtalab Simulink code, the voltage and current curves obtained by simulation are compared with those obtained by experimental of conventional power supply using a single phase transformer for one magnetron. Then we will determine the average power emitted by each magnetron, and establish the balance of the power microwave generator by computing the performance that must be identical to that obtained from experimental.

Keywords: energy balance; power supply; three-phase transformer; average power.

Introduction

Fig. 1 shows the setup of the new three-phase high voltage power supply of microwaves generators with one magnetron by phase. This scheme is composed of a new three-phase transformer, supplying by phase a cell doublers composed of capacitor and o diode, each cell supplies at its output a single magnetron.. The aim of this article is to determine the energy balance of this new three-phase power supply from its modeling with MATLAB SIMULINK. The paper is organized as follows: on the first step we presented the equivalent model of a new three-phase transformer. This model will be integrated in overall scheme of the power supply to be adapted for the modeling of the entire system using MATLAB SIMULINK code. The voltage and current curves obtained by simulation compared with those obtained experimentally by a conventional power supply using a single-phase transformer for one magnetron [1-6]. In the second step we study the power balance of this new three-phase power supply by determining the value of the instantaneous power curve, this lead to establish the average power emitted by each magnetron, next we will establish the energetic balance of the power microwave generator by computing their performance that must be identical to that obtained experimentally.

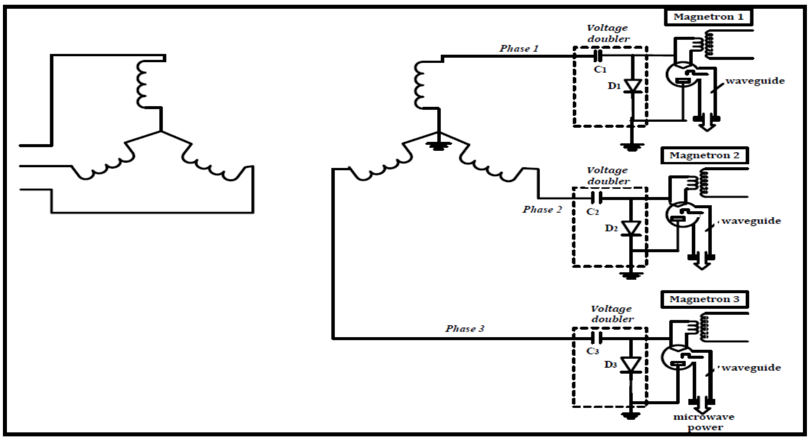


Figure 1: Three-Phase Power Supply For Magnetron By Phase

Modeling of The Three-Phase Power Supply

Description of The Model

Moreover, in our previous work [7]-[8], we have treated the modeling of a new three-phase power supply for one magnetron. In our design of this new three-phase transformer with magnetic shunts, we use an armored structure tetrahedron type (Fig. 2) to represent the equivalent magnetic circuit of the transformer, which will undoubtedly allow to reduce the congestion and the volume of this new device and makes it more economical [7].

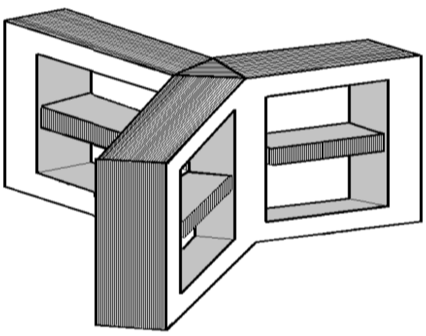


Figure 2: Equivalent Magnetic Circuit of The Three-Phase Transformer With Magnetic Shunt

The three-phase high voltage transformer is presented by its equivalent scheme referred to secondary (Fig.3). Everything happens as if each phases of the new three-phase HV transformer with magnetic shunts, is composed of an ideal transformers; each one supplying a π quadruple model [9]-[10] composed of inductive elements L'p on the primary side, and LS on the secondary side and L'Sh on the shunts side. This π quadruple model appears more convenient to study the functioning of the transformer with the help of MATLAB SIMULINK code. Each inductive elements of this model were determined from the geometrical dimensions of the transformer, everyone is represented by its characteristic Φ(*i*) according to the relation L(i)= n2Φ(*i*) /i where the quantity n2Φ(*i*) and its currents i can be determined from the curve B(H) of the material used and the geometrical dimensions of the transformer using the relation: n2*Φ(*i*)=n2*B*S and i=(H*l)/n2. each nonlinear inductance is implemented in MATLAB-SIMULINK code with a block which we introduce the points of the magnetization curve of the used material; After that we will replace each nonlinear inductance its equivalent block diagram mentioned above in the overall scheme of the new power supply (figure 3) to be suitable for the modeling of the whole device.

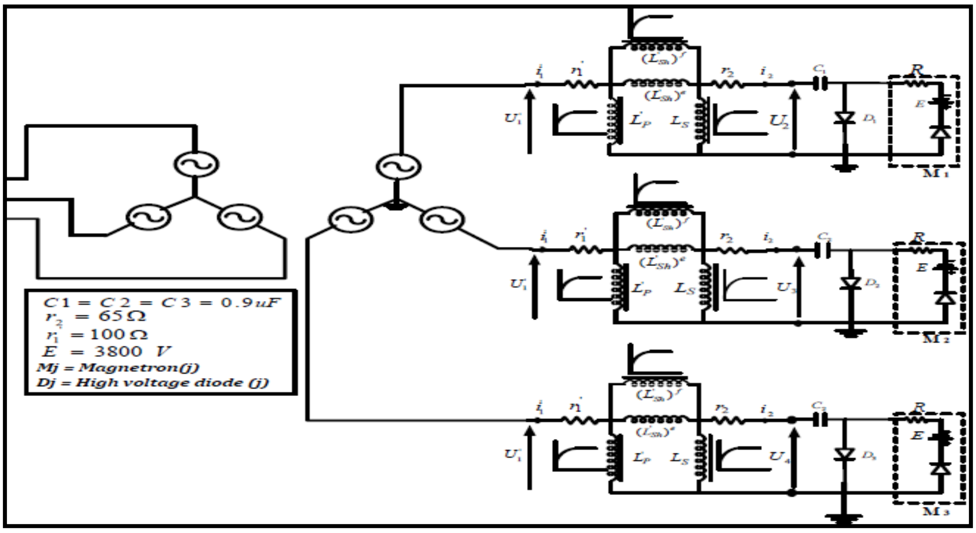


Figure 3: Three-Phase Power Supply Simulated By MATLAB SIMULINK Code

Simulation Results of The Nominal Functioning of The New Three Phase Power Supply For One Magnetron By Phase

By using the π quadruple model of the new transformer, we have validated the nominal functioning of this power supply. The simulation of the proposed system is carried out on the MATLAB version 7.10.0 (2010a) using the sim power system (SPS) toolbox and discrete step solver of 1e-5. Fig.5 shows the results obtained from this simulation. We compare in (Fig.4) and (Fig.5), the simulation results obtained by Matlab-Simulink with that obtained by experimental in the same conditions (nominal operation) [1]-[2]-[3]

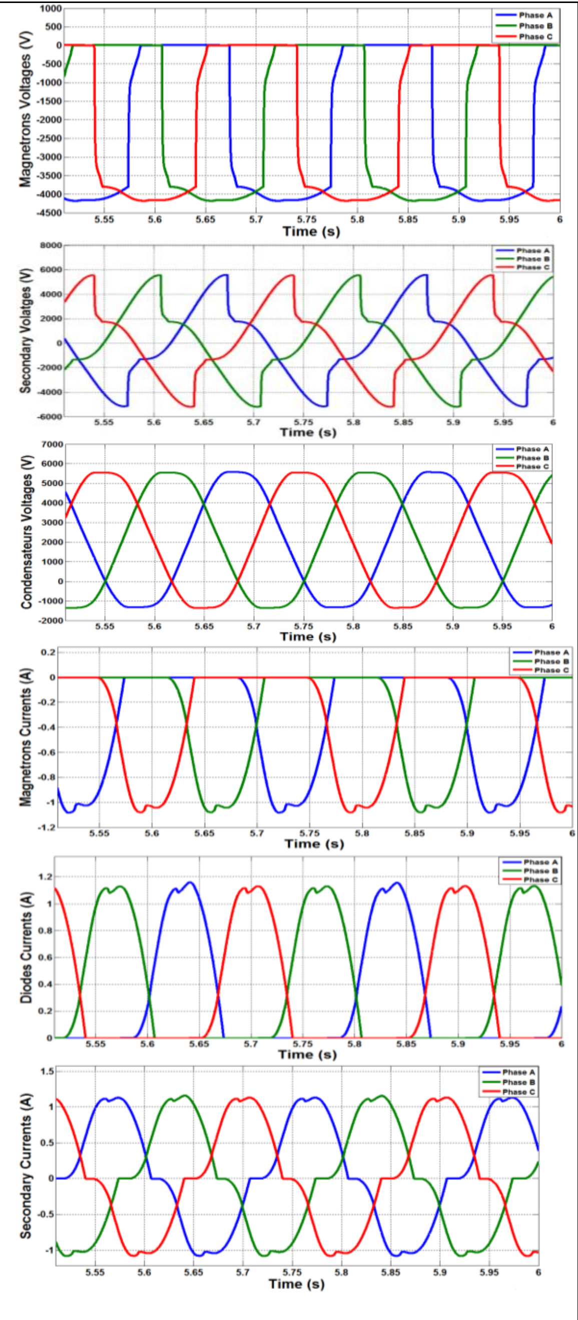


Figure 4: Simulation with MATLAB SIMULINK: Forms of currents and voltages waves

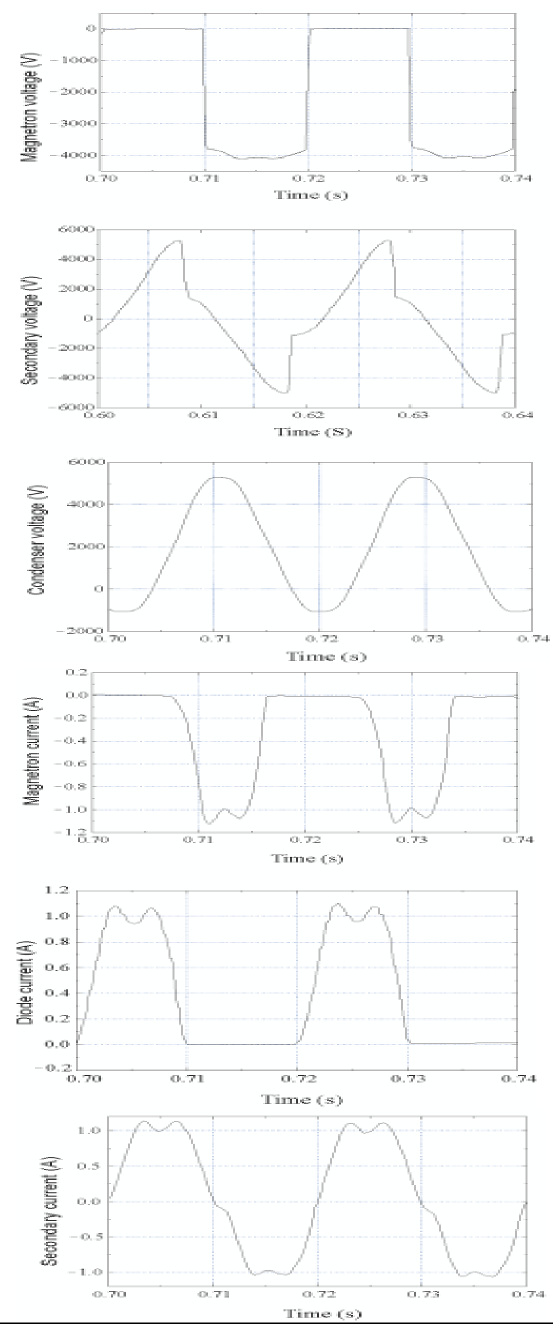
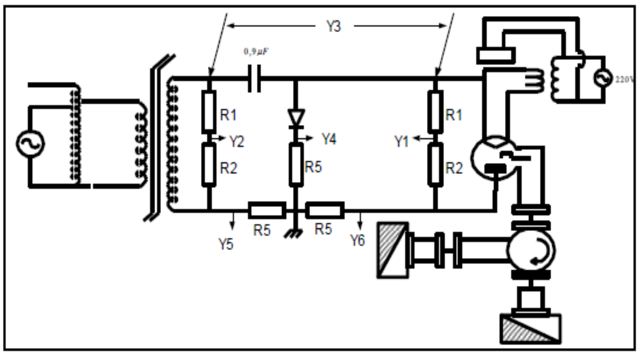


Figure 5: Experimental Waveforms of Currents And Voltages (Nominal State)

From the Fig.4 and Fig.5 we see that the signals obtained from simuation are curves of varios size, periodic, non sinusuiadal and dephaysing by (2π/3) between them, which confirms the absence of interaction between magnetrons. these signals are in good accordance with those obtained by experiemental and simulation of a conventionnel power supply using a single phase transformer for one magnetron [4].

Fig.6 shows the experimental setup for Measuring of the Characteristics Current and Voltage of the high voltage Power Supply for Magnetron in Nominal Operation. This test was performed in the department of electrical engineering of higher School of Technology in Agadir (Morocco). The tests were performed during nominal operation of the magnetron power supply [11]-[12].



Y1 : magnetron voltage,
Y2 : secondary voltage,
Y3 : condensator voltage,
Y4 : diode current,
Y5 : secondary current,
Y6: magnetron current,
R1= 10MΩ, R2=10 KΩ,
R3=22 Ω

Figure 6: Experimental Set up for Measuring of the Characteristics:Current and Voltage of the Power Supply HV for Magnetron inNominal Operation

Energy Balance of The New Three-Phase Power Supply and Its Performance

In this part we will validate the nominal functioning of this new three-phase power supply by computing the instantaneous power curves of each magnetron, this lead to establish the average power of each magnetron (fig.7). This indicates that the transformer delivers an average power equal to 3821 watts. That is to say there will be 1273 watts for each magnetron. Witch confirms full power operation of the new three-phase power supply with one magnetron by phase. The curves obtained by simulation with MATLAB SIMULINK code are the same forms of that obtained by experimental of a conventional power supply using a single phase transformer with magnetic shunt (fig.8).

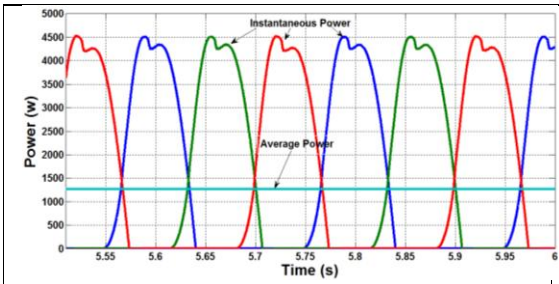


Figure 7: Average power and instantaneous power obtained by Matlab-Simulink for a three-phase power supply

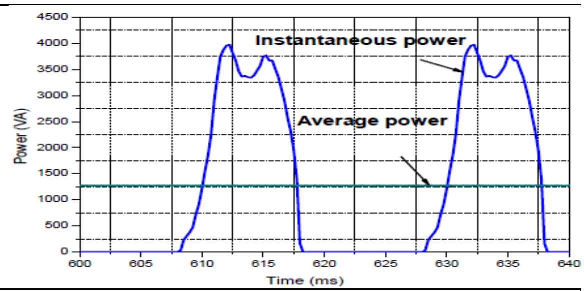


Figure 8: Average power and instantaneous power obtained by experimental of a single-phase power supply

From the curves of power obtained, we can therafater deduce the performance of this new three-phase power supply which is 92%, namely and 93% experimental, either. We note that the namplate of the single phase transformer indicate an apparente power on the order 1650 V with a factor of primary power 0.825.

$$\eta_{Matlab\text{-}simulink} = \frac{P_s}{P_e} = \frac{3821}{4142} = 0.92 \qquad \eta_{Experimetal} = \frac{1275}{1650*0.825} = 0.93$$

We see that the performance obtained by MATLAB SIMUINK corresponding to the new three-phase power supply is identical to that obtained from experimental of a conventional power supply using a single phase transformer for one magnetron

Conclusion

The originality of this paper resides in the study of the power balance of a new three-phase power supply. The power curve obtained by simulation is verified with sufficient approximation to that experimental one.

In this paper we have established the energetic balance of the power microwave generator by computing their performance which is identical to that obtained from experimental for a conventional power supply using a single phase transformer for one magnetron.

As perspectives, this work can be extended for the study of the energetic balance of new three-phase or six-phase power supply for several magnetrons by phase

Appendix

During this work, we have taken as reference the following geometrical dimensions of the three-phase transformer HV with magnetic shunts:

- The width of the non-wound core: a = 25 mm
- The width of the magnetic circuit: b = 120 mm
- Number of stacked sheets of the shunt: n3 = 18
- Number of turns in the primary: n1 = 224
- Number of secondary turns: n2 = 2400
- Height of the sheet stack of shunts: h = 0.5 n3.
- Surface of the core: S1 = S2 = a.b
- Surface of shunt: S3 =h.b
- Thickness of the air gap: e = 0.75 mm

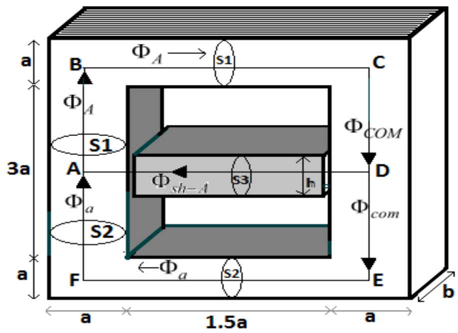


Figure 9: Geometry of Transformer With Magnetic Shunt (Phase A As Example)

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