TRANSIENTS SIMULATOR MODULE USING AN AMPLIFIER OF POTENCY

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Abstract **– This paper proposes a system to simulate the electical transient of a eletrical AC line. This system consists of make a power amplifier that will convert a digital sign, obtained starting from simulations accomplished through the software ATP (Alternative Transients Program), in an analogical sign, so that it is possible to apply it to a load, with the objective of verifying its behavior in conditions of transitory regime. Starting from the transitory simulated, they will be obtained the points (Voltage x Time) that will be converted in an analogical sign, through a data acquisition board. With that sign, the following stage will be to amplify and apply it to the load. In that work it hopes to obtain results to verify the behavior and the levels supported by the loads when they are applied transitory signs. The width of those transitory ones will define the voltage levels supported by the load with the intention of verifying their effects that, in general, they are not supplied by the manufacturers of equipments of the which the consumers claim rewards of damages caused by the suppliers of energy.**

KEYWORDS

Data Acquisition, PWM, Simulation, Transients

I. INTRODUCTION

The proposed work consists of applying a sign originating from a transient generated by the software ATP, through an amplifier and apply to a load, with the objective of verifying his behavior in such conditions [1].

The transients ones simulated in ATP are extracted point to point (Voltage x Time) and converted in an analogical sign, through a data acquisition board. The system will work with a monophase inversor fed with a maximum voltage of (600V) and maximum frequency of answer of 3kHz.

With this work it hope to obtain enough results to verify the behavior of the loads when transients signs are applied, for this the interval of time and the width of those signs will be controlled in order to verify the levels supported by the load. Starting from the obtained results it can or not to prove the transients effects, usually objected by the suppliers of energy and accused of damage the equipments for the consumers.

II. DESCRIPTION OF THE SYSTEM

The system block diagram is presented in the Figure 1.

Where to generate the analogical sign starting from the digital firstly data we will make the simulation of the system in subject in ATP - Alternative Transients Program, of the transient obtained they will be extracted the points that will be transferred for the data acquisition board through a

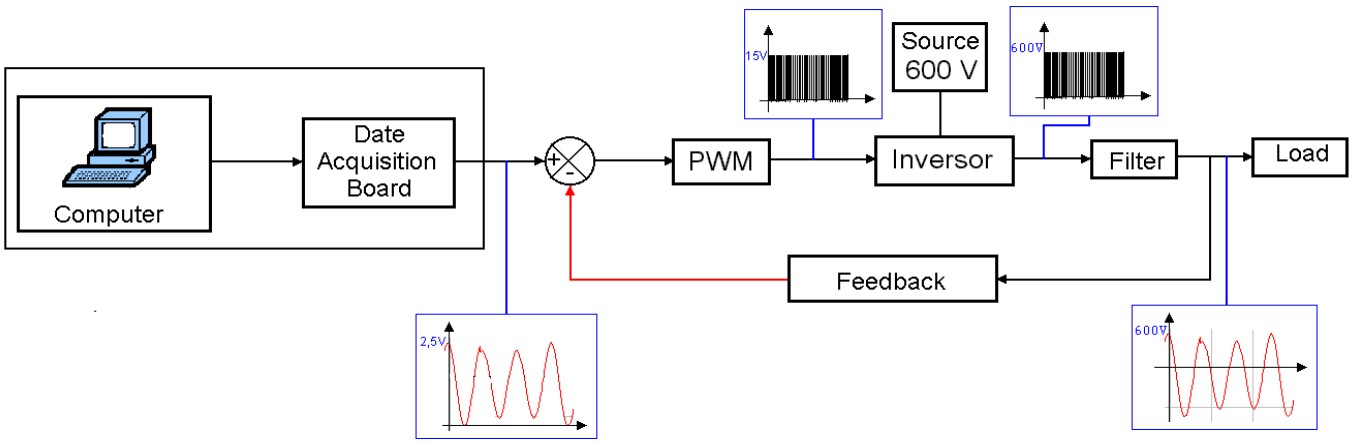

Figure 1 – Diagram of the Transients Simulators Module

control software developed in language C. The data acquisition board will convert the resulting signs of the simulations in analogical signs, those signs can be amplified and applied to the loads to verify his operation due to the application of transients. The values of the output voltage will be of 2,5V with a low current level and the amplifier will work in a strip of voltage of ±600V and in a frequency of up to 3kHz.

The components of the circuit they are described following:

- **Personal computer:** To make the acquisition of data of the simulation in real time and to execute the routines. It was used a Pentium MMX 200MHz processor, with 32Mb of RAM, equipped with a data acquisition board model PCL 818, of Advantech. The control software was developed in language C, in the operating system MS DOS.

- **Pulse Width Modulator - PWM:** responsible for the dispair of the inversor tiristors, the used device is a integrated circuit of control PWM, TL494 that is one of CI's more used for the construction of PWM [8].

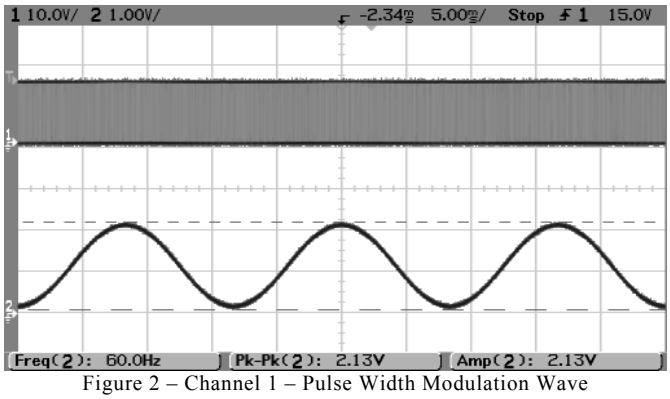

Figure 2 – Channel 1 – Pulse Width Modulation Wave

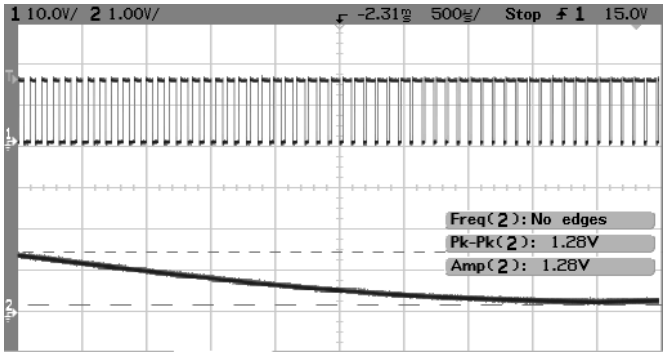

Figure 3 – Detail of the Modulated Wave

At the Figures 2 and 3, we have a waveform at the output of the PWM circuit to a senoidal imput.

- **Conversor AC-AC:** after the modulation the sign will go to the Inversor that converts this sign again for the original form amplified for values around 600 V. This inversor has the amplifier function, substituting a linear amplifier because it consumes less potency than the linear sources.

The used structure is shown at the Figure 4. The bridge H of transistors is the circuit used due to his simplicity and easy implementation. The used transistors are of the type IGBT of the Semikrom code SKT75B12, 75A and 1200V. With the Maximum Switching Time of 20 kHz.

It can be said that this inversor type is formed by four choppers, where the semiconductors conducted to the pairs (D1-D2, Q1-Q2, D3-D4, Q3-Q4).

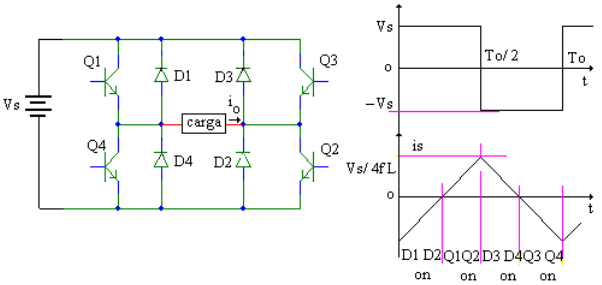

Figure 4 – Monophase Inversor

The output Voltage is given by:

- *Instantaneous:*

$$v_o = \sum_{n=1,3,5,\ldots}^{\infty} \frac{4V_s}{n \cdot \pi} \cdot \mathrm{sen}(n \cdot \omega t)$$

- *Fundamental component*

$$V_1 = \frac{4V_s}{\sqrt{2} \cdot \pi} \therefore V_1 = 0{,}9V_s$$

– *RMS*:

$$V_o = \left(\frac{2}{T_o} \cdot \int_0^{T_o/2} V_s^2 dt \right)^{1/2} \therefore V_o = V_s$$

The control technique used is a PWM escalar. It exists in the waveform in the load a modulated square Voltage. Each group of two transistors of the arm of the inversor they work as unipolars keys of two roads, working synchronized. The keys work the frequency of 15 kHz and the work cycle is controlled and it varies in function to the sign that comes from the microcontroler.

- **Filter**: In the output before feeding the load a lowpass filter of second order was put to eliminate the carrier frequency and to be with the information of low frequency, doing with that the applied sign is the closest the possible of the simulation done of the transient. This filter was projected through Laplace's transformed, starting from the cut frequency wanted we calculated the other parameters of the circuit.

- **Feedback:** responsible for the correction of any distortion that happens in the wave form when certain types of loads are used, it was projected based in an isolation amplifier using a sensor of current of effect Hall.

  Initially the project of the interface was based on the module HP7800, a circuit optocoupler, but soon in the first tests it was possible to notice that this CI was not sufficiently robust to support the variations in the current levels and Voltage applied, then it opted for a change in the circuit, starting to use a transdutor of effect Hall. The made circuit is presented in the Figure 5:

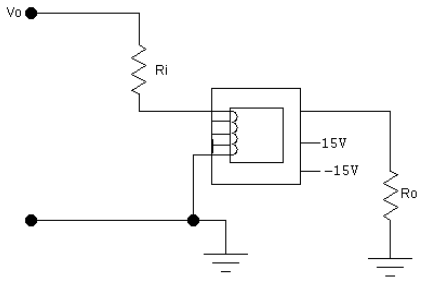

Figure 5 – Transdutor of effect hall

- **Controller PI :** Controller PI makes part of the feedback, the output will be used as input of PWM.

After the obtaining of the Voltage in the output of the circuit reduced for compatible values with the circuit, through the transdutor, it will be necessary to insert a comparator with the original voltage generated by the computer, we made the assembly of the circuit comparator using operational amplifiers. Through the variable resistances regulation we can adjust the gains among a voltage and other.

To proceed we have the circuit of the comparator implemented:

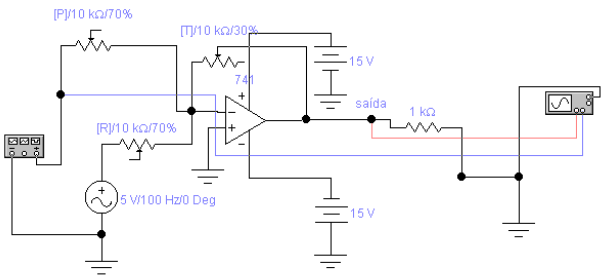

Figure 7 – Voltage comparator to Circuit Feedback.

Through the regulation of the variable resistances we can adjust the gains among a Voltage and other. We have the point that indicates the output of the circuit, this point is that it will be the imput circuit, the form of original wave should be applied to the comparator, together with the output of the circuit (reduced for compatible values with the circuit, through the transdutor of effect hall).

III. EXPERIMENTAL RESULTS

Initially tests were accomplished with forms of sinusoidal waves, to test the amplifier in all answer band, being proven an answer in the band from 0 to 1000 Hz according to Table 1:

TABLE 1
Frequency answer using a sinusoidal sign

Frequency	Voltage	Frequency	Voltage
10	50,16	400	47,751
25	50,193	450	47,718
50	50,16	500	47,751
100	50,028	550	47,685
150	49,995	600	47,19
200	49,968	700	45,738
250	49,968	800	44,649
300	49,632	900	42,57
350	48,642	1000	40,821

To obtain these results they were accomplished two measurements for each frequency and made the averages of the values, the tension to be measured was of 50V RMS, to 60Hz, the used multimeter was one with true RMS what guarantees the safety of the measures.

In the Figure 8 we can prove the final results of the simulation, obtained from an oscilloscope, with sinusoidal waves.

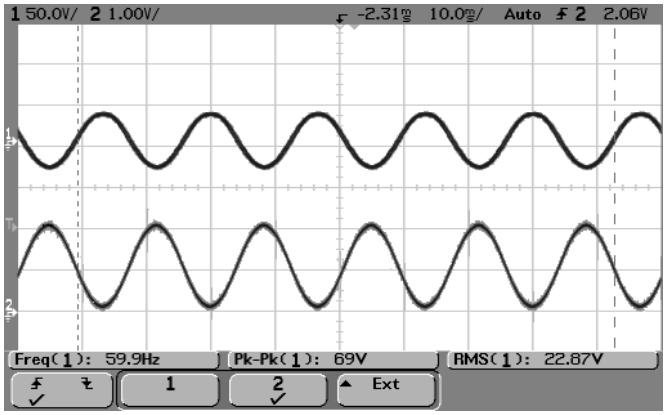

Figure 8 - Channel 1 - Result of the amplifier output
Channel 2 – Reference: 2V.

After the tests with sinusoidal signs, we accomplished tests with simulated signs in ATP, the graph below shows the simulated sign with values of pick of 497,95 and -381,65V.

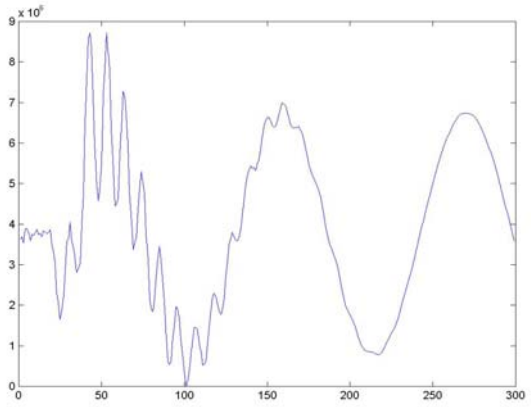

Figure 9 – Transient simulated in ATP

With the sign on the board output we applied to the circuit and we began to increase the source rectifier's voltage for the inversor, the voltage limit that we reached was of 140V with the Voltage variac, for Voltages a little larger than that the high potency caused interference on the Board D/A, provoking mistakes in the program, other happened problem was the incorrect dispair of the controlling drivers of the inversor, this problem might have been caused due to the saturation of PWM, but it could be solved provisorily with a reset switch for the drivers, later the point of operation of PWM will be altered and its operation frequency.

Soon afterwards we accomplished measurements using loads, that are related to proceed:

- 0-50Ω Rheostat, fitting in 50 Ω.
- Wireless phone Panasonic, with source AC/DC 220-110V, 200mA, fitting for 110V.
- Monitor for Computer 14", with source of feeding auto-regulable from 110 to 240V.

In the Figure 10 and 11 we have one of obtained waves, in her we have the two signs: the output of the computer and the output of the amplifier (in bold). The voltage of the board output had already been saved previously and it appears in the graphs just as reference for the output.

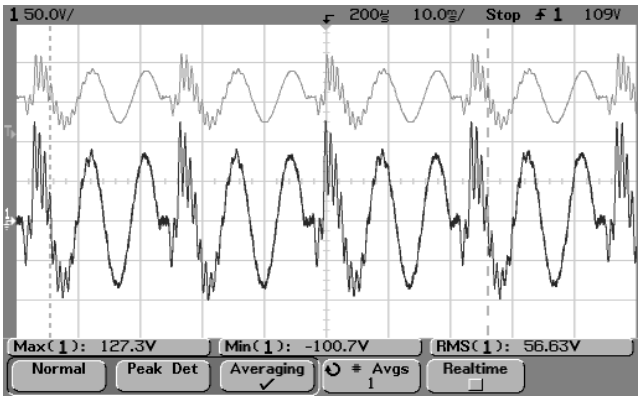

Figure 10 – Transient in the output of the computer and of the amplifier - Wireless phone.

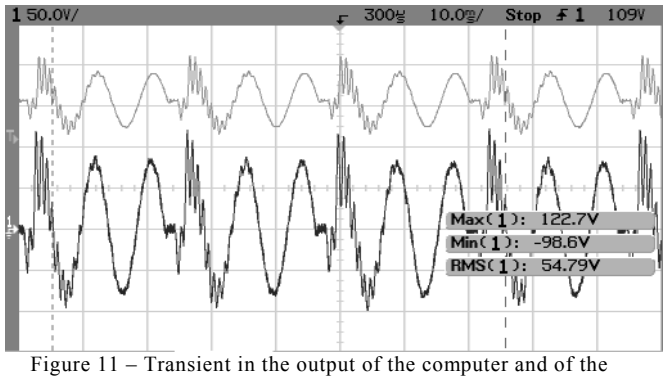

Figure 11 – Transient in the output of the computer and of the amplifier - Monitor.

IV. CONCLUSIONS

We can notice that "Transients Simulator Module" presents a great technological innovation in relation to the common similar Simulators that use linear amplifiers.

In spite of the noise found due to the swicthing of Inversor's tiristors the compensation exists with the perfect reproduction in waveform, what doesn't happen with other simulators that just apply the Voltage in certain angle of the net just allowing a comparison with simulated waveform in ATP.

After having executed the project, they were already initiate tests with different loads, just as having described above, seemingly none of the loads tested up to now presented any evident damage regarding the operation of the same ones, the temperature variation was also analyzed and any detected alteration, some adjustments are still being made so that we can reach larger potency levels and work frequency and to accomplish new tests to come to prove or not the effect of the transients in the loads.

ACKNOWLEDGEMENTS

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