Lab1: Power in home appliances

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***Abstract*—This report presents the design and implementation of a security box and a dimmer circuit using DIACs and TRIACs. The reader also can find the validation review with the theoretical model seen in class.**

***Keywords*—Current, Power, Power Factor, Voltage, Waveform.**

I. INTRODUCTION

The main purpose of this practice is to perform an analysis on the wave form and measurements of three different type of load. Inside the security box there is a fuse to protect the equipment from any shortcut. We used a shunt resistor of 1 Ω and 10 W to measure current dividing the voltage by 1 to obtain the actual current value. All electronics devices are composed of resistances, capacitors and inductances, a soldering iron is a resistive linear load, they require heat to work. The voltage measured would be the same as the source but the current will vary depending on the power consumption of the device. We expect the same waveform for the voltage and current and no phase shift between them.

A drill would be an inductive linear load, based on the fact that motors are made of inductive coils. It should be a phase shift between voltage and current. The laptop is a nonlinear load, the voltage waveform would be the same but we expect a different shape for the current [1].

The second part consists on designing and developing an AC controller made of DIACs and TRIACs. This kind of circuit is able to change the RMS voltage on the terminals of a linear load by manipulating the firing angle of the TRIAC using a potentiometer. The load will not be linear anymore because of the electronic circuit resultant of the resistive load in series with the AC controller.

II. PROCEDURE AND RESULT ANALYSIS

A. Power Computations

The purpose of this practice is to measure the power consumption on electrical home devices, such as a laptop, a drill and a soldering iron. Taking into account that they work with high values of voltage and current compared with previous labs, precautions were taken in order to protect the devices and our integrity. The Figure 1 shows the circuit proposed by the teacher to measure voltage and current safely.

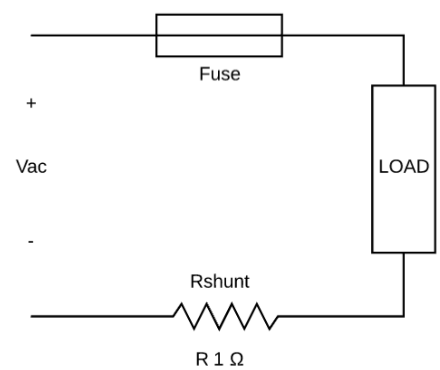

Fig. 1. Circuit Diagram.

V_{ac} represents the 120 Vrms sine wave obtained from the university phase line, *Fuse* represents a 3A circuit breaker, *Load* represents the load and *Rshunt* represents the 1 Ω and 10 W power resistor. We chose a small value for the resistor to do not affect the functioning of the circuit.

The gauge of the wire was selected depending on maximum current needed by the higher power load according to electrical parameters of each device. Current values of devices are shown on the Table I. Based on this, AWG 14 wire was selected to build the power meter, because it is able to conduct a maximum of 15 A_{rms}. In addition to this,

TABLE I
POWER AND CURRENT VALUES OF EACH DEVICE.

Device	Power (W)	Voltage (V_{rms})	Current (A_{rms})
Solderin Iron	40	120	0.33
Drill	130	120	1.08
Laptop	140	120	1.16
Light Bulb	70	120	0.58

the circuit uses a 3A fuse to protect load and wires of high currents.

The circuit is inside a 4x4 box with a fuse holder to change the breaker, 4 measuring terminals; the white one for neutral, green one for ground and both black one for phase. The box is shown in the Figure 2.

Fig. 2. Circuit box.

For this practice three different loads are chosen to analize their voltage and current waveform: a soldering iron like resistive load, a drill like inductive load and a laptop like non-linear load. These loads are conected to an electrical outlet, using the power meter. Owing to high electrical network inertia, the voltage waveform do not depend on the load. For this reason, the voltage signal is similar in all measurings. However, current waveform depend on impedance load and voltage, and the first parameter is realted to load features. Therefore, the power analysis will be centered on current waveform.

1) Solderin Iron (resistive load): The current waveform is a pure sine signal and it does not present any distortion and between voltage and current there are not phase difference. This is an important feature from resistive loads and it can be observed in the Figure 3.

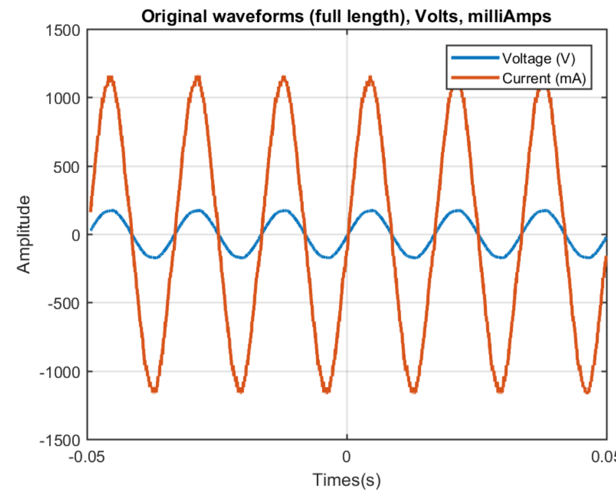

Fig. 3. Voltage and current waveforms of a resistive load.

Additionally, in a resistive load, product between current and voltage always is positive, this means that soldering iron is a power consumer and it is not able to supply energy.

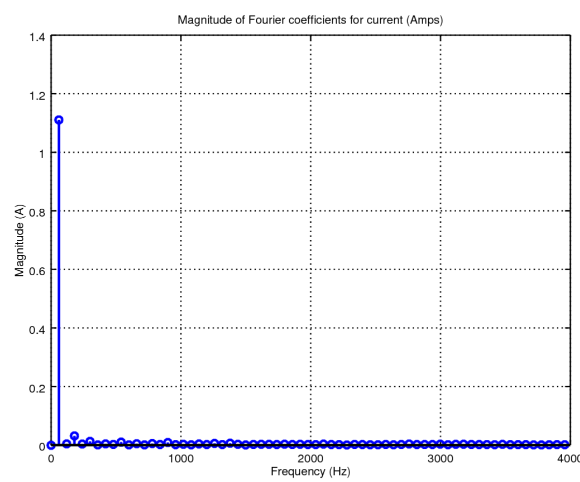

Fig. 4. Furier current coefficients for resistive load.

Listing 1. Output for resistive load.

```
T      =     0.0167  s
f0     =    59.9520  Hz
Vrms   =   123.3322  V
Irms   =     0.7860  A
S      =    96.9336  VA
Pavg   =    96.8309  W
P      =    96.8309  W
Q      =    −1.8282  VAR
D_fast=      4.0701  VA
D      =     4.0562  VA
```

```
PF      =     0.9989
THD_V   =     1.8878  %
THD_I   =     4.0154  %
```

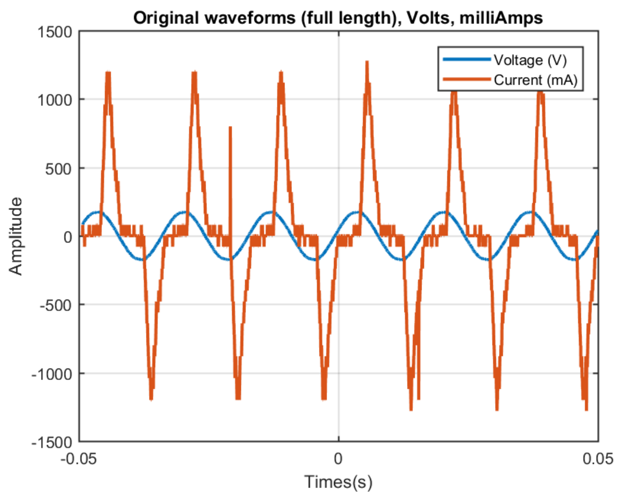

Fig. 5. Voltage and current waveforms of a inductive load.

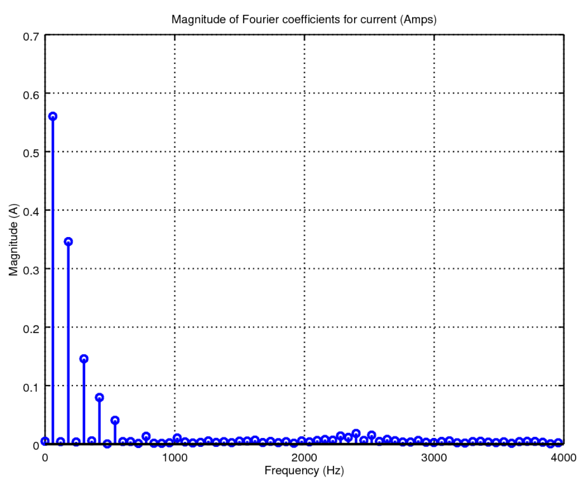

Fig. 6. Furier current coefficients for inductive load.

Listing 2. Output for inductive load.

```
T       =     0.0167  s
f0      =    59.9520  Hz
Vrms    =   123.8850  V
Irms    =     0.4831  A
S       =    59.8537  VA
Pavg    =    30.4372  W
P       =    30.4372  W
Q       =    38.7767  VAR
D_fast=      33.9472  VA
D       =    33.9434  VA
PF      =     0.5085
THD_V   =     1.8561  %
THD_I   =    69.7550  %
```

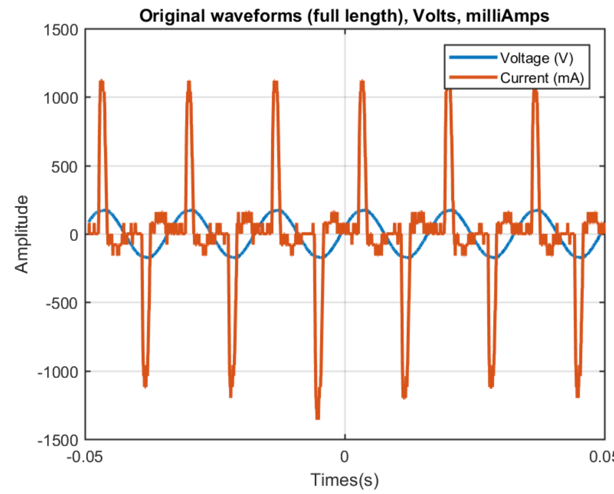

Fig. 7. Voltage and current waveforms of a non-linear load.

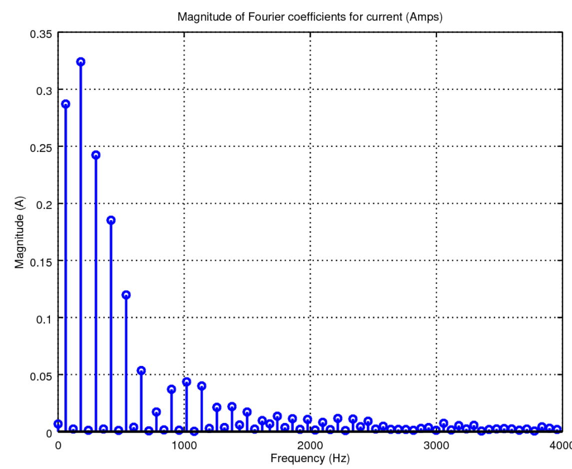

Fig. 8. Furier current coefficients for non-linear load.

Listing 3. Output for non-linear load.

```
T       =     0.0167  s
f0      =    59.9520  Hz
Vrms    =   124.3447  V
Irms    =     0.3916  A
S       =    48.6915  VA
Pavg    =    23.9965  W
P       =    23.9965  W
Q       =    −5.7979  VAR
D_fast=      41.9692  VA
D       =    41.9644  VA
PF      =     0.4928
THD_V   =     2.2668  %
THD_I   =   164.9239  %
```

B. AC contoller

For the second part of the practice, we have to propose a circuit using thyristors to control the amount of power delivered to the light bulb. The input is the 120 V AC and the output is an AC waveform where there is a delay angle before triggering the AC voltage. The phase control is done with a potentiometer. The circuit designed is shown in the Figure 9.

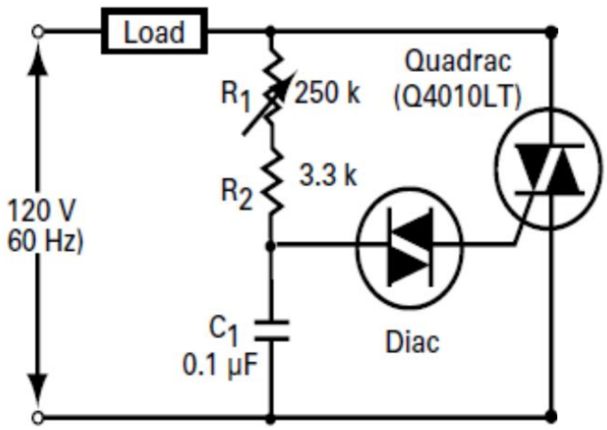

Fig. 9. AC controller circuit.

III. CONCLUSIONS

The resistive load shows a power factor of almost 1. The inductive load has a curly current shape, thanks to the type of motor being used in the drill. The non-linear load shows a kinky wave shape that depends on the circuit inside the electronic device.

Power computations let us understand better the circuits, taking into account the meaning behind the power factor and the different kinds of power related to a circuit.

The dimmer allows us to regulate the power taken by the light bulb. Taking into account that a light bulb is resistive, the effectiveness depends on the efficiency voltage and effective current.

The circuit is controlling the AC power to the light bulb by switching on and off during the positive and negative regions of the input sinusoidal signal. During the negative part of the input signal, the same type of response will be obtained since both the DIAC and TRIAC can be triggered in the reverse direction. Varying the resistance R, it is possible to control the driving angle. [3]

About inductive and non-linear loads, you shouldn't use the dimmer circuit, because both rely on the PF and the voltage and current wave shape.

As we learned in class, electronic devices, such as, DIACs and TRIACs let us build circuits to control the power taken by a resistive load.

REFERENCES

[1] H. Kopka and P. W. Daly, *A Guide to LaTeX*, 3rd ed. Harlow, England: Addison-Wesley, 1999.