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CHARACTERIZATION OF METAL HALIDE LAMPS UNDER SAG VOLTAGES

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ABSTRACT

This paper presents a methodology for characterization of metal halide lamps regarding voltage sags. Initially, a sag generator was designed and implemented. Then, a testing scheme was proposed, in order to analyze the behavior of a type of Metal Halide lamp under this type of event. Finally, taking as reference the standard SEMI F-47, a characteristic curve was constructed, showing the operating region of the lamp.

KEYWORDS: Voltage sag; Sag generator; Metal halide lamps; Immunity test.

CARACTERIZACIÓN DE LUMINARIAS TIPO HALURO METÁLICO ANTE EVENTOS SAG

RESUMEN

Este artículo plantea una metodología para la caracterización de luminarias de haluro metálico, ante eventos sag. Inicialmente, se diseñó y construyó un generador de eventos sag. Luego, se planteó un esquema de pruebas, que fue utilizado para analizar el comportamiento de un tipo de luminarias de alta densidad de descarga tipo *Metal Halide*, ante eventos sag. Finalmente, tomando como referente el estándar SEMI F-47, se realizó la construcción de una curva característica que muestra la región de operación de la luminaria.

PALABRAS CLAVES: Evento Sag; generador sag; luminarias de haluro metálico; pruebas de inmunidad.

CARACTERIZAÇÃO DE LÂMPADAS TIPO HALURO METÁLICO ANTE EVENTOS SAG

RESUMO

Este artigo apresenta uma metodologia para a caracterização de lâmpadas de haluros metálicos, ante eventos sag. Inicialmente, foi desenhado e construído um gerador de eventos sag. Logo foi planteado um esquema de provas que foi

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usado para analisar o comportamento de um tipo de lâmpadas de alta densidade de cargas tipo Metal Halide ante eventos sag. Finalmente, tomando como referência o padrão SEMI F-47, realizou-se a construção de uma curva característica que mostra a região operacional da lâmpada.

PALAVRAS-CHAVE: Evento sag; Gerador sags; Lâmpadas de haluros metálicos; Provas de imunidade.

1. INTRODUCTION

Voltage sags, also known as dips, are sudden reductions, short in duration, of the magnitude of the standard electric tension signal. Such magnitude can vary between 10 and 90% of the voltage (International Electrotechnical Commission 2006; Markiewicz & Klajn, 2004). These sags are generally produced because of short-circuit failures or the implementation of large charges such as electric engines and can affect the functioning of devices sharing connection circuits of said charges, including when they occur with a duration of less than 100 ms (Dorr et al., 1995; Yim-Shu Lee et al., 2009; Sedighnejad & Jalilian, 2010).

The negative effects of voltage sags are mainly evidenced in devices such as computers, speed regulators, machines for the control of industrial processes and high-intensity discharge lamps (Perez Fernandez 2006; Vargas López, 2005). The high-intensity discharge (HID) lamps most used in public lighting applications or locations with a high affluence of people are the high pressure sodium and metal halide lamps. Both types of lamps present high levels of sensibility before short duration voltages sag and swells. These, which regularly occur in the electricity distribution grids,cause power outages in lamps lasting 5 to 15 minutes, while a new ionization process for re-starting takes place (Diaz et al., 2007; Dorr et al., 1995).

The characterization of the behavior of a machine before a voltage sag can be made through a voltage acceptability curve. Currently, the existing standards for the achievement of said curves are the following: CBEMA, ITIC and the SEMI F-47 Standard (Thallam & Heydt 2000).

This article presents a methodology for the application of immunity tests to metal halide lamps upon voltage sags. The single-phase voltage sag generator designed and developed to this end is based on the timed introduction of an inductive load which causes the sinking in the lamp's power supply voltage signal. The results of the characterization are presented using the designed sag generator for the set of 3 metal halide 400W lamps.

2. VOLTAGE SAG GENERATOR STRUCTURE

The main purpose and function of the voltage sag generator is to temporarily introduce an inductive-type charge which will generate an overcurrent in the power source. Said inductive charge will cause a decrease in the tension signal during a pre-established time lapse. The voltage sag generator contains three main stages (**Figure 1**):

- Control stage: defines the start of the disturbance and the duration of the event.
- Commutation stage: allows the commutation between the nominal power voltage and the voltage disturbance.
- Inductive charge: in charge of triggering the sinking of the voltage when temporarily introduced in the lamp's power circuit. The temporary introduction of said charge is done through the commutation stage.

The characteristics of each one of the stages that make up the system are described below:

a) Control stage:

According to the definition of the IEEE 1159 regulation, an instantaneous short-term voltage sag is the entire sinking between 0.1 and 0.9 p.u., with a duration between 0.5 and 30 cycles (less than 500ms and 60 Hz) (Committee 2009). As such, the control system was designed to define the times of interruption injected to the lamp's power in the mentioned operation interval. The control circuit that should act as a temporized switch works within a range of 1ms and 800ms.

To generate the interruptions, an MC68HC08JL3 micro-controller was used (MOTOROLA 2005). The firmware was developed in language C, used as a software code-warrior compiler. The operation of the circuit control allows:

Increase or decrease in the time of sag duration in 1ms steps. For this, circuit control adjustment switches S1 or S4 are used. The interruption time chosen can be seen in a liquid crystal display (LCD, DISP1). Once the time has been chosen, the action must be executed through S3. This way, the interruption will automatically end once the time established by the user is reached. Figure 2 shows the schematic diagram and the control system prototype.

Figure 1. Structure of the voltage sag generator

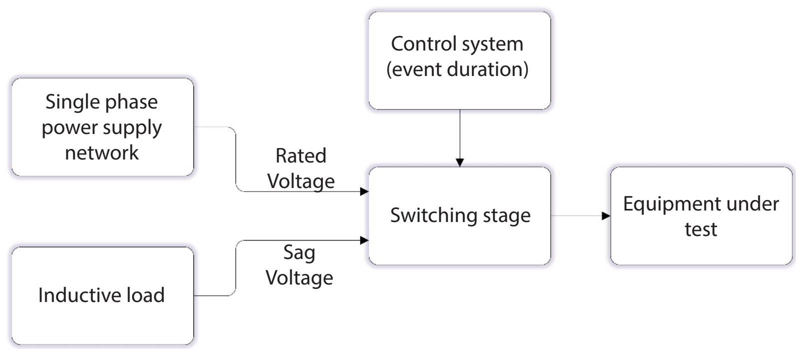
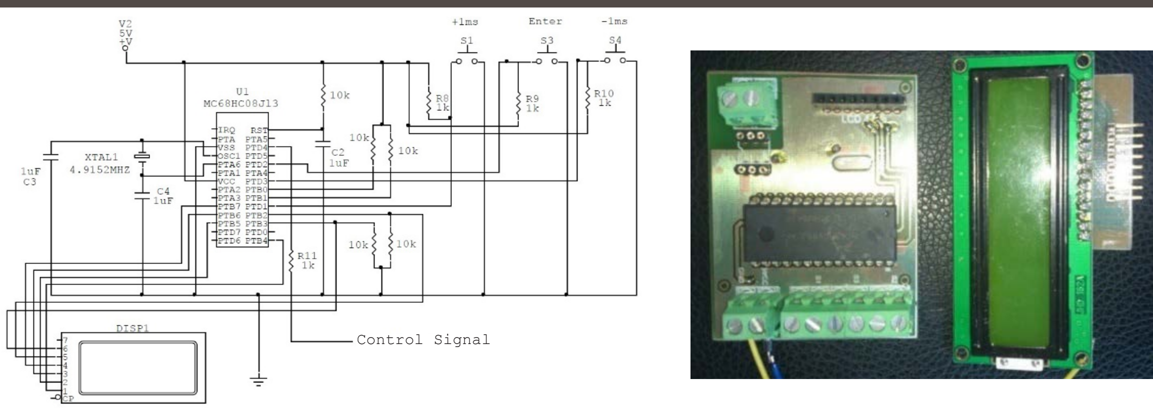


Figure 2. Control circuit



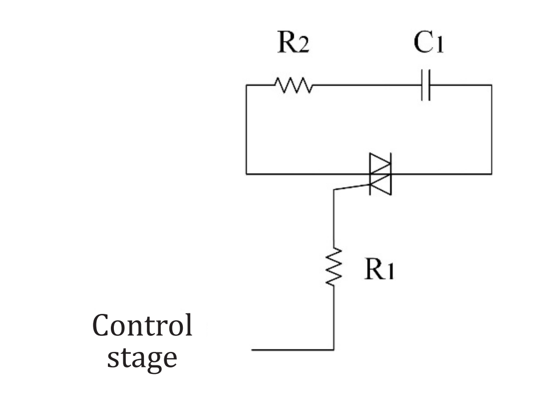
(a) Schematic diagram

(b) Prototype

b) Commutation stage:

In order to achieve the temporary inductive input and output that will generate the sinking of the electric tension signal, a phase-control thyristor was used. Its characteristics are defined according to the maximum charge values in which a current limitation device can operate. For this case, an ST180S (International Rectifier, 2003) reference was used. The commutation circuit protector was developed from a SNUBBER grid. The SNUBBER condenser was achieved using resonance criteria see (**Figure 3**). An optocoupler was used as the interface between the control and power stages.

Figure 3. Commutation circuit



c) Inductive charge:

Given that a variable inductive charge that allows the realization of considerable testing is required to develop the characterization of the machine tested, single-phase VARIAC was chosen, The VARIAC used has 18 variable charge positions (from 5mH to 280mH) (Ci-Effe-Gin.d.).

3. TESTING METHODOLOGY

In order to measure the impact of the sag on a device, in this case metal halide lamps, it is necessary to identify the sinking levels and duration of the voltage sags that cause the sudden power outage of the 400W Metal Halide type lamp. The method proposed in this paper is based on the following stages:

- Design and implementation of a voltage sag generator which will allow the device's behavior to be evaluated (See numeral 2).
- Technical tests and recording of results that determine different sinking levels and the duration of the sags which cause sudden power outages in the lamp.
- Characteristic curve based on the levels and duration of sags which cause sudden power outages using the variables used in the SEMI F47 Standard.

The assembly for the development of technical tests can be seen in **Figure 5**, where the following elements are present:

1. Isolated single-phase transformer - 110/220V (600W).
2. Standard electronic ballast (Reference ICF2S26H1LD).
3. Machine tested: 400W metal halide lamp.
4. FLUKE 435 (Fluke Corporation 2008) power quality analyzer, responsible for the measurement of generated sags.
5. Control of sag duration stage.
6. Inductive charge (variac).

Before starting tests, it is necessary to leave the lamp on during 30 minutes. This is the minimum time required to obtain maximum density.

The test is developed by initially selecting the first Variac charge positions, then adjusting, in 1ms, the duration time of the circuit control interruption. Once these conditions are met, the voltage sag is generated from the control system. The control system sends the command to the commutation stage in charge of introducing the inductive charge. If the lamp suffers a power outage, the event is registered using the gridanalyzer. If the device being tested does not fail, the duration of the event is increased by 1ms and the test is repeated.

Figure 4. Assembly for testing

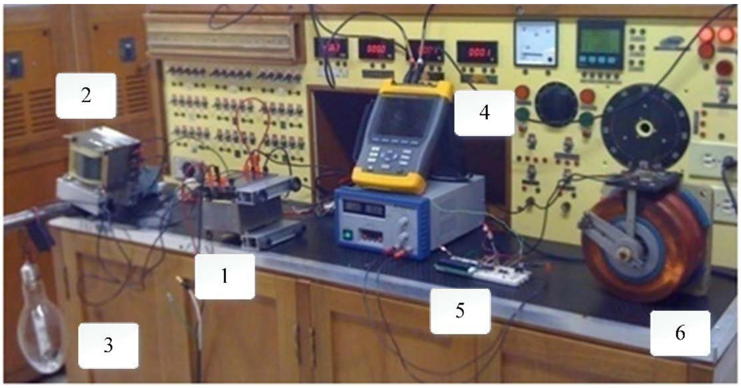
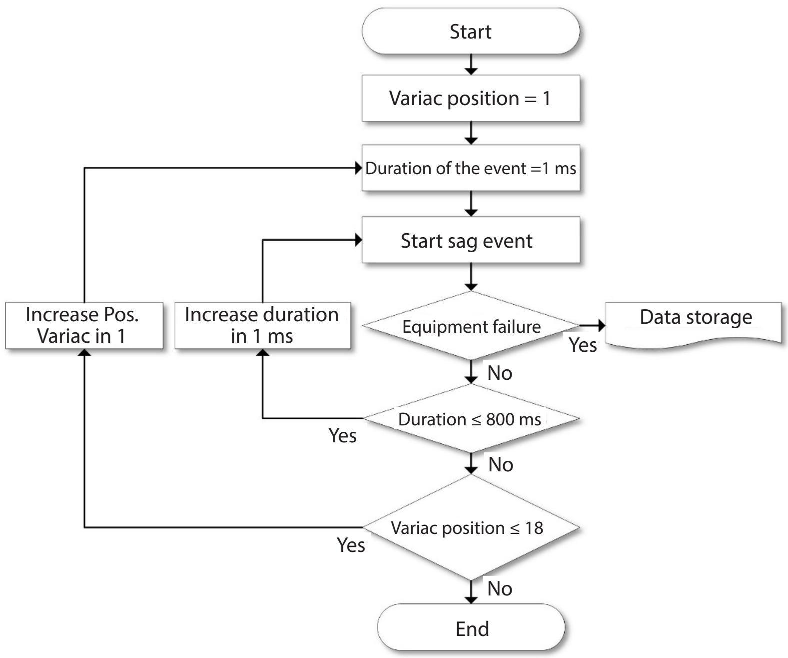


Figure 5. Test scheme



After each power outage of the lamp, there is a wait time of no less tan 10 minutes in order to begin the new test. This, for the purpose of stabilizing the functioning of the lamp and allowing for the reestablishment of the ionization and lighting intensity.

In the case that the lamp does not turn off, it is important that the time interval between samples be less than 1 minute. This time is required in order to reach a stabilization of the lamp ionization.

Once the limit of the duration of the sag generator has been reached, the variac is taken to the next position. This, in order to modify the value of the inductive charge. Then, the new control circuit interruption time is adjusted to 1ms in order to initiate the new test. The test scheme is shown in **Figure 5.**

The data obtained from the 18 positions and the different event duration times allow for the construction of a behavior curve for the lamp before generated voltage sags.

4. RESULTS AND DISCUSSION

The proposed test scheme was used to evaluate the behavior of three (3) high discharge 400W metal halide lamps. For each lamp, 3 test routines were run.

The data for the construction of the curve stem from the magnitude of the configured Variac charge, the measured tension at the moment of the event and the duration time of each one of the sags that caused the power outage of the lamp.

For the construction of the characteristic curve, the data for the tension fall during the event versus the voltage sags duration time are taken into account, complying with the established parameters in the SEMI F47 Standard and the CBEMA curve. It is important to clarify that the Variac used does not present a linear displacement (percentage of variation of the inductance).

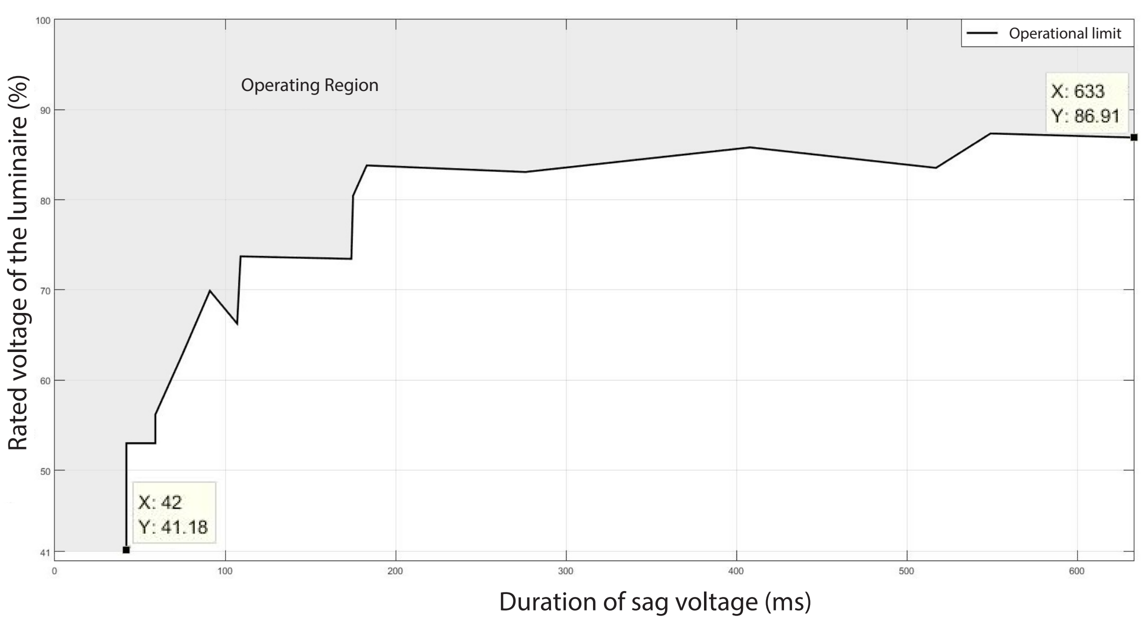
Figure 6 shows the characteristic curve obtained. In said figure, the region of operation for the analyzed lamps is shown. The SEMI F47 Standard was used as a reference.

From **Figure 6**, it is evident that upon greater duration of the event, the lamp is more prone to power outages because of the occurrence of a voltage sag. In addition, for short durations, a much greater sinking magnitude is required for the lamp to turn off.

Stemming from the obtained characterization, one can establish the operative region of the analyzed lamp (shaded region). This indicates that the device being tested can work under the presence of sags whose characteristics of magnitude and duration are above the one indicated. The region with a failure risk indicates that the device is exposed to a power outage and it will affect its the normal functioning.

Given the range of the variac work, it was not possible to analyze voltage sags with a duration lesser tan 42ms.

Figure 6. Characterization curve of 400W Metal Halide lamps



In order to achieve characterizations of other types of charges with the equipment designed, it is necessary to take the power of the grid to which the charge is connected into account for the purpose of designing the adequate required source.

5. CONCLUSIONS

A low-cost, simple voltage sag generator was implemented, with variables both in voltage magnitude and duration times of the event.

A methodology for the characterization of metal halide lamps upon voltage sags was proposed. The curve uses the variables for the Standard SEMI F47 (duration of the event versus percentage of the nominal voltage). The procedures of applied trials and the proposed characterization method in this paper is replicable on other electric and electronic devices.

The data obtained allows for the evaluation of the behavior of a 400W Metal Halide lamps upon the occurrence of voltage sags in the power supply of the signal. The analysis of the characteristic curve constructed evidences the joint influence between the variables of the duration of the event and the magnitude in the occurrence of power outages in the type of lamp analyzed.

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