Evaluation Susceptibility of Equipment against Voltage Sags: Lamp, Contactor and Variable Speed Drive

Surya Hardi[1], R. Harahap[1], S. Achmad[1] and Rohana[2]
[1]*Department of Electrical Engineering, Universitas Sumatera Utara, Medan, Indonesia*
[2]*Department of Eletrical Engineering,University of Muhammadyah Sumatera Utara, Medan, Indonesia*

Keywords: Equipment testing, voltage sags, susceptibility standard curve.

Abstract: Information about susceptibility of equipment against voltage sags is important in order to avoid system production drop out. Recently many electrical equipment are develop by using electronic components for energy saving. The electronic components have been recognizing as susceptible against voltage sags. This paper presents test results of susceptible equipments to voltage sags which are fluorescent and mercury vapor lamps, contactors and variable speed drives. A Schaffner Proffline 2100 electromagnetic compatibility (EMC) has been used to create voltage sag characteristics. Magnitude and duration are considered as main characteristics for testing. Point on wave of sag initiation was considered for testing contactor only. Therefore VSDs are three phase, they were test againt voltage sag types I, II and III. The test results were evaluated by comparing with sensitivty of standard curve availablesuch as ITIC, SEMI F47 and immunity curves recommended by IEEE P1668^{TM} 2014.

1 INTRODUCTION

Voltage sags are one of power quality problems, which are interesting in power system. They can cause a serious effect on the equipment performance degradation. When the equipment is supplied by voltage sags may result in disruption, malfunction, tripping undesired and even damage. Finally, apparent economic losses can occurred on consumers. Susceptibility of equipment is depending on voltage sag qualities and equipment types. Magnitude and duration of voltage sags are main characteristics and other characteristics are symmetrical and unsymmetrical of voltage sags, phase shift angle, point on wave (POW) of sag initiation, etc. Voltage sags are resultedfrom short circuit faults in power system and others are large motor starting and transformer energizing.

There are some ways to asses susceptibility of equipment against voltage variation among others is mentioned power acceptability curve designed by CBEMA viz. computer business equipment manufacturers association in (Heydt et al. 2001). But available specifically for voltage sags is Semiconductor equipment and material institute (SEMI-F47).Last is standard curve recommendedby(IEEE P1668^{TM}, 2014). The standards are a method to evaluate ride through of equipment to voltage sags, whichdistinguishfor one phase load and three-phase load. Availability susceptibility curve of equipment individually become crucial. Because from the curve can be known ride through of equipment when voltage sag occurs whether the equipment in operation and malfunction/trip region. These information can be get from manufacturer, but it is infrequently or by other way via laboratory testing. This paper is to evaluate testing results of equipment sample such as lamps, contactors and variable speed drives (VSDs). Those equipment are legitimated as susceptible against voltage sags. Results obtained were constructed in a susceptibility curve and then compared with susceptibility standard curve.

2 STANDARD CURVES RELATED TO EQUIPMENT SUSCEPTIBILITY

The CBEMA is earlier standard is named power acceptability curve was introduced in 1980. The curve is has become standard guidance within

Hardi, S., Harahap, R., Achmad, S. and Rohana, .
Evaluation Susceptibility of Equipment against Voltage Sags: Lamp, Contactor and Variable Speed Drive.
DOI: 10.5220/0008886800730078
In *Proceedings of the 7th International Conference on Multidisciplinary Research (ICMR 2018)* - , pages 73-78
ISBN: 978-989-758-437-4

industry to asses susceptability of automatic data processing to voltage change in short duration (Heydt et al. 2001). But it has been applied in many equipment. The curve is dispalyed in Figure 1.

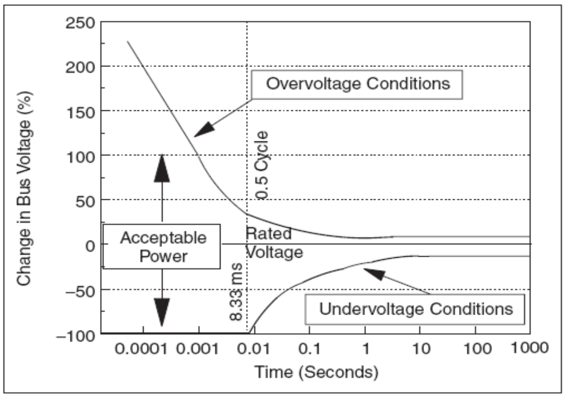

Figure 1:ITIC curve.

This curve explains equipment susceptibility against voltage variation significantly is influenced by sag magnitude and duration.

In 1996, CBEMA curve was redesigned and was called (ITIC), information technology industry council curve is documented in (IEEE Std. 1346, 1998). This curve is almost similar with old CBEMA and the different is more piecewise so that easy to digitize. SEMI F47 is the first time recommends susceptibility curve specific to voltage sag (SEMI F47). ITIC and SEMIF47curves are plotted simultaneously such as in Figure 2.

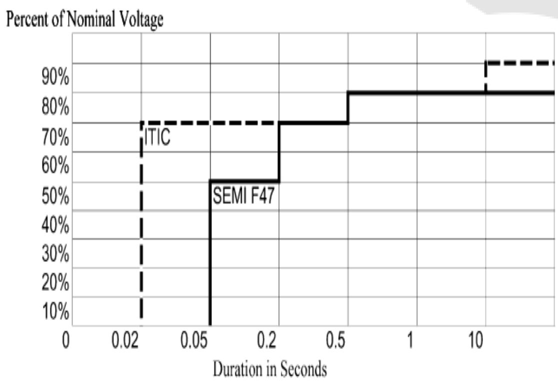

Figure 2: SEMI F47 and ITIC curves.

It can be seen that the duration of dip is less than 0.2 seconds, the SEMI curve is under ITIC curve and it is stricter than ITIC. Several equipments pass the ITIC requirement but not pass for the SEMI F47 requirement curve border.

From Figure2, it can be seen that ITIC has four knee points which are (75%; 20 ms), (75%; 50ms) and (80%;50ms), (80%, 100ms) and whereas SEMI F47 has five knee points which are (50%;50ms), (50%; 200ms) and (75%;200ms), (75%; 200ms), (75%; 500ms). Those curves can be used for three phase and single phase equipment without distinguish. Generic shape of SEMI F47 has been applied by some researchers to asses susceptibility of adjustable speed drive among of found in (Hardi Surya et al. 2013 and DjokicS. Z et al. 2005).

IEEE P1668^{TM} 2014 recommended immunity test for three phase equipment categorized as type I, type II and type III. These categorizes base on amount of phase voltage dropping. Susceptibility curves are shown in Figure 3 and Figure 4. Those can be seen that the curves are more simple compared with earlier curve because they have three knee points respectively.

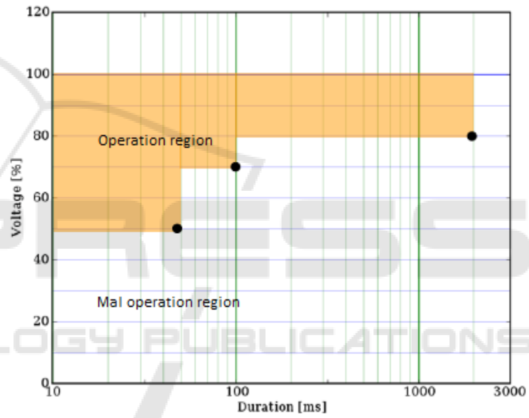

Figure 3:Susceptibility standard curve for voltage sagtype I and type II.

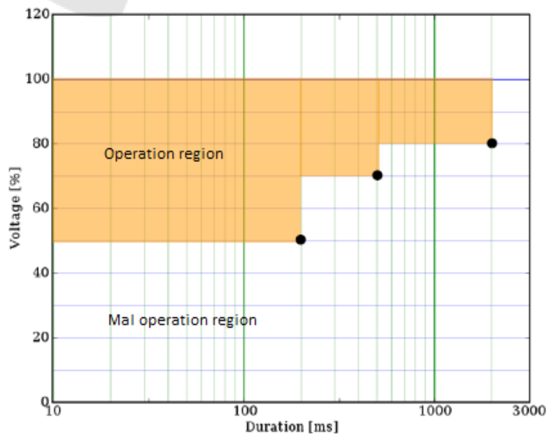

Figure 4:Susceptibility standard curve for voltage sags type III.

3 FACILITY AND EQUIPMENT TESTED

3.1 Facility

Schaffner Proffline 2100 electromagnetic compatibility (EMC) is equipment capable for generating the waveform required. It has 3x3kVA power rating atvoltage magnitude in ranges 0-300Vrms/phase. The equipment can produce kind of power quality problems and one of them is as voltage sag generator (VSG). Voltage sag chracteristic is set via personal computer (PC). There are two types out put available of the equipment i.e. single phase and three phase. Photo of the equipment tester is shown in Figure 5. This equipment available at laboratory in Universiti Malaysia Perlis (UniMAP) and has been used for testing of equipmentsusceptibility.

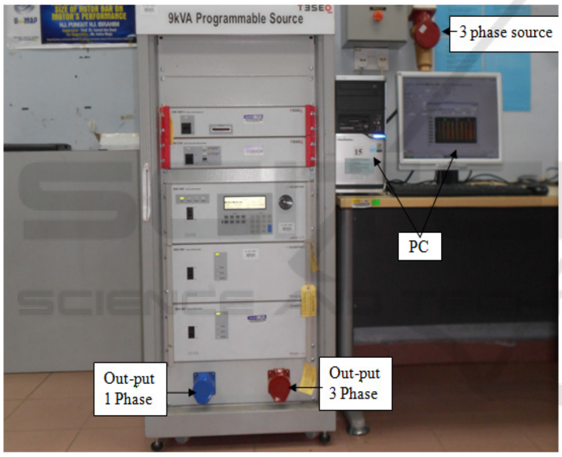

Figure 5: Photograph of Schaffner 2100 EMC.

3.2 Equipment Tested

There are three sensitive equipment tested against voltage sag i.e. lamps, contactors and VSDs.

3.2.1 Lamps

In general the lamps can be extinguished when supplied with voltage sag, except incandescent lamp. Both types of lamps such as fluorescent (FCL) lamp with electronic ballast and mercury vapor lamp many are widely used people with efficiency reason.

Electronic ballast uses a switch-mode power supply to modify the input fundamental frequency voltage to a much higher frequency voltage typically in the range of 25 to 40 kHz.

The mercury vapor lamp (MVL) is a high intensity discharge lamp. It uses an arc through mercury vaporization in a high pressure tube to generate greatly light bright which is obtained straight from it is own arc. The lamps need high voltage at first start. They also are developed from electronic components therefore susceptible against voltage sags.

3.2.2 Contactors

AC contactor is an electromagnetic device that acts when the electromagnetic coil is connected to a voltage source. Current will flow through the coil induces a magnetic field consequnce spring attract for closingits contacts. Magnetic force produced is influenced by the voltage magnitude. When the supply voltage is decreased or interrupted, the springposition is back to initial position so the contact keeps in open position. Contactors take large current starting instants to close it contact is compared with small current in operation condition.

Contactors are recognized also as susceptible against voltage sags. Motor get energy supply form utility via contactor. When contactor is subjected voltage sags, it may trip so that connection between motor and contactor disconnected.

3.2.3 Variable Speed Drives

Variable speed drives (VSDs) is many found industrial sectors for controlling speed of an electric motor. Rotational speed variation of the motor is not expected, particularly in industry process. Because can cause damage in end product. VSD is fabricated from electronic components consequently it is susceptible toward voltage sag (Petronijevic et al. 2010). It can trip if is supplied by certain low voltage level in fixed sag duration. Specs ofthe equipment tested are summarized as in Table 1.

Table 1:Specs of the equipment tested.

Type	Lamp	Contactor	VSD
Rated	FCL with Ballast electronic 240V AC, 36W	C(1) 240V, 20A	VSD (1) 3 phase, 0.5 HP, 380-450V, 400Hz.
	Mercury vapor lamp 240V AC 250W	C(2) 240V, 20A	VSD (2) 3 phase 1.5kW, 380- 450 V, 500Hz

3.2.4 Testing Procedure

The equipment was connected to VSG for generating voltage sags. Out-put voltage of VSG was set from 90% up down 0% of nominal voltage with step 2.5%. Sag duration of 10ms was progressively increased until the equipment trip/switch off. If the equipment is not trip, proceeds for another voltage sag level, record the equipment trip or not. The lamps take into account sag magnitude and duration only, because POW is not influenced on the Lamp. But the POWof sag initiation was considered in contactor testing. Because the VDF is three phase, it was tested for voltage sags types I, II and III such as recommended.

4 RESULT AND DISCUSSION

Magnitude and duration of voltage sags are main characteristics used for testing of three types of equipment namely; lamps, contactors and variable speed drives.

4.1 Lamp Testing

Two types of lamps were used for testing viz. Fluorescent lamp (FCL) and Mercury vapor lamp(MVL).Waveform example of voltage supplied and current drawn by FCL lamp is shown in Figure 6. This Figure shows the lamp was supplied by voltage sag of 20% and 200ms in duration which it in tripping condition. It can be seen during sag, the current is zero and while end of the voltage sag, the current extremely increased.

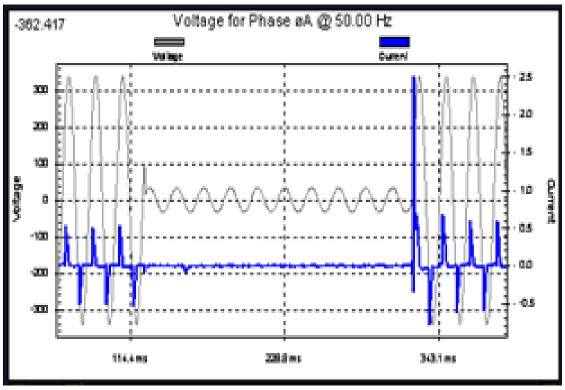

Figure 6: Voltage and current waveform for sag of 20% and 200ms in duration.

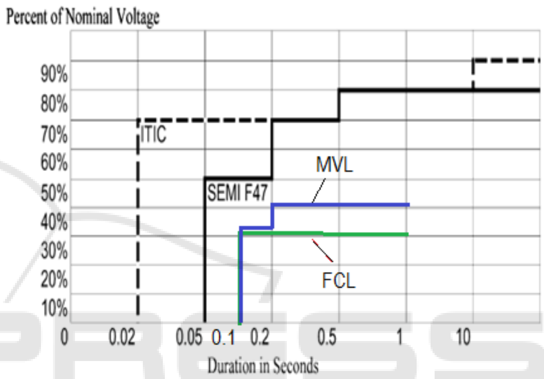

Figure 7:Susceptibility curves for MVL and FCL lamps.

Susceptibilties of the lamps is shown in Figure 7. MVL lamp is more sensitive than FCL lamp and it trips is starting at voltage level 40% whereas FCL sensitive voltage level at 30%. Even so the lamps meet standard required because they curve lines are far below standard curves.

4.2 Contactors Testing

Two contactors from distinct manufacturer, which have same rated, were used in the testing. The voltage and current waveform when the contactor C1 subjected to voltage sag of 40% in 100ms duration. Figure 8 shows the contactor is tripping condition. Earlier study considered other characteristics of voltage sag such as POW of sag initiation was studied by (Jeong et al.2007) in simulation model and(S. Hardi and I. Daut, 2010) in experimental test. In this paper the POW considered from 0° until 90° in step 15°. The most sensitive test results only are displayed in this paper which the contactors was supplied by voltage sags with 60° POW. The curves resulted such as in Figure 9.

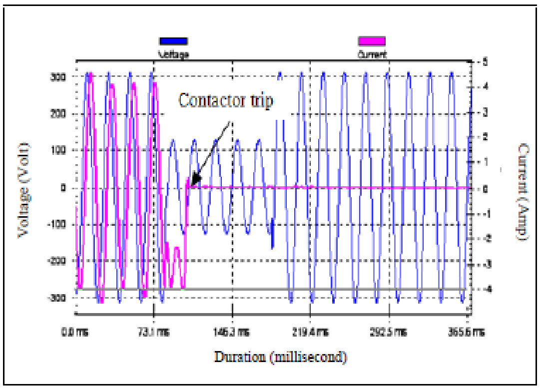

Figure 8: Voltage sag of 40% and current waveform throughcontactorC1.

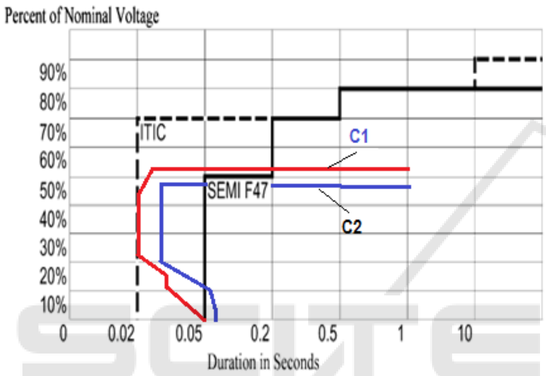

Figure 9: Susceptibility curve for contactor C1 and C2.

From Figure 9, it can be seen that there are some testing points from 20ms to 50ms are above curve line of SEMI F47. It means the contactors are not meeting the standard curve but pass for ITIC standard. For other POWs, the contactors are satisfying curve standards. The result is not prensented in this paper. Contactor C1 begins to trip at voltage level 52.5% and below for duration around 30ms. Contactor C2 less sensitive compared with contactor C1. It starts to trip at voltage level 47.5% and duration of 30ms above.

4.3 Variable Speed Drives Testing

Three phase VSDs of distinct rated power and distinct brand were used for testing against voltage sag types I, II and III. Difference these types are based on number of phases dropping and phase angle shift. Voltage sag type I, only single phase the voltage drops and voltage sag type II, two phases voltage drop and phase shift occured. Voltage sag type III, third phase voltage drop and there is no phase shift. Test results of VSD subjected to voltage sags are shown in Figure 10 and Figure 11. Voltage sag type I did not cause VSD trip hence susceptibility curve is not presented.

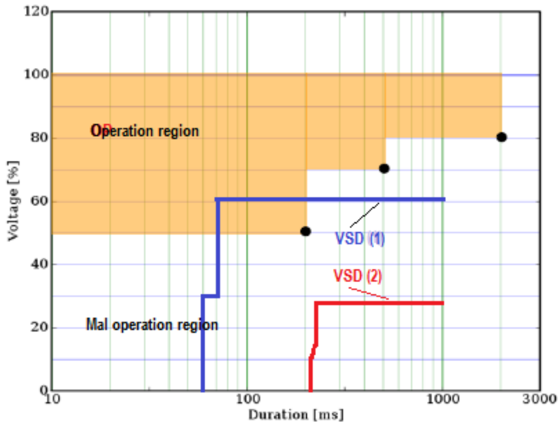

Figure 10:Susceptibility curve of VSDs caused by voltage sag type II.

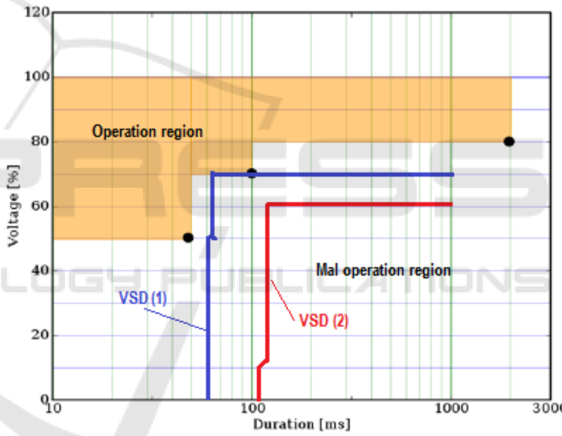

Figure 11. Susceptibility curve of VSDs caused by voltage sag type III.

Figures 10 and 11 show susceptibilities of VSD(1) are higher than VSD(2). This is because distinct in VSD capacitance design as energy saving and setting over current or under voltage protection of the ASD (Stockman, 2003 and Pedra et al.2005).VSD(2) is not passing for voltage sag type II, because some of the curve lines are in operation region. But it satify standard curve for testing type III.

5 CONCLUSIONS

Difference fabrication of equipment gives susceptibility different results. In general susceptibility of the equipment is within tolerance limit, except for contactors. This is because susceptible contactors was presented has highest susceptibility at 60º POW. But it passes for ITIC standard curve. VSD (1) is more susceptible than VSD (2). It is not get through when subjected to voltage sags type II and trip at voltage level of 60% below, 80ms in duration.

REFERENCES

Djokic S. Z., J. Desmet, G. Vanalme, J. V. Milanovic´, and K. Stockman., 2005. Sensitivity of personal computers to voltage sags and short nterruptions,"*IEEE Trans. Power Del.*, vol. 20, no. 1, pp. 375–383.

Hardi Surya, Daut I., Nisja I. and Rohana. 2013. Effect of Voltage Sag Types on AC Motor Drive: Test Result. Journal of Environmental Research And Development Vol. 7 No. 4A, April-June. Pages 1615-1621.

Heydt, G.T., Ayyar R and Thallam R. 2001. Power Aceptabilty. IEEE Power Engineering Review, September. Pages:12-15.

IEEE Std. 1346-1998. Recommended Practice for Evaluating Electric Power System Compability with electronics Process Equipment.

IEEE P1668™.2014. IEEE Trial-Use Recommended Practice for Voltage Sag and Short Interruption Ride-Through Testing for End-Use Electrical Equipment Rated Less than 1000 V.

Jeong, S.W., Lee G.J. and Gim J.H. 2009. The Study on the Characteristics of Operating Limits of AC Contactor during Voltage Sag. Transmission & Distribution Conference & Exposition: Asia and Pacific, IEEE Conference Publications. Pages: 1 – 4.

Pedra, J., Corcoles F. and Suelves F.J., 2005. Effect ofBalanced and Unbalanced Voltage Sags on VSI-FED Adjustable Speed Drives. IEEE Trans. On Power Delivery, Vol. 20. No. 1, January. Pages: 224 – 233.

Petronijevic M., Veselic B., Mitrovic N., KosticV.,Jeftenic B. 2010. Comparative study of unsymmetrical voltage sag effects on adjustable speed induction motordrives. IET Elect. Power Appl., Vol. 5. Issue 5, pages: 432-442.

SEMI F47 available at: *https: //www.powerstandards.com/tutorials/what-is-semi-f47*

Stockman, K. ,D'hulsterF., Verhaege, K. and Didden, M., 2003.Ride through of Adjustable Speed Drives During Voltage Dips. Electric Power system Research 66 Pages: 49-58.

Surya Hardi and I.Daut., 2010. Sensitivity of Low Voltage Consumer to Voltage Sags. The 4International Power Engineering and Optimization Conf. (PEOCO2010), Shah Alam, Selangor, MALAYSIA: 23-24 June. Pages:396-401.