A New Type of the VLF High Voltage Generator

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***Abstract* — The purpose of this paper is about a new design and construction of a very low frequency (VLF) high voltage generator. The VLF generates a sinusoidal waveform at 0.1 Hz. It consists of two main parts, a modulation unit and a high voltage switching unit. The modulation unit is compared the 0.1 Hz sinusoidal waveform and the 10 kHz triangular waveform. It makes the unipolar control signal for the high voltage switching unit from high voltage direct current (HVDC) to the sinusoidal VLF generator with the high voltage low pass filter. This VLF high voltage generator will be used for cable testing in IEEE 400.2 standard, Guide for Field Testing of Shielded Power Cable Systems Using Very Low Frequency (VLF).**

***Index Terms* — VLF generator, HVDC modulation**

I. INTRODUCTION

The problem associated with testing field aged cable using DC and AC high voltage test equipment has some disadvantages. The AC high voltage transformer is large, heavy and expensive even with resonant test sets [1]. While testing by DC high voltage needs a very high voltage so it causes some damage on the insulation of the cable. Therefore, the VLF transformer is represented to solve these problems.

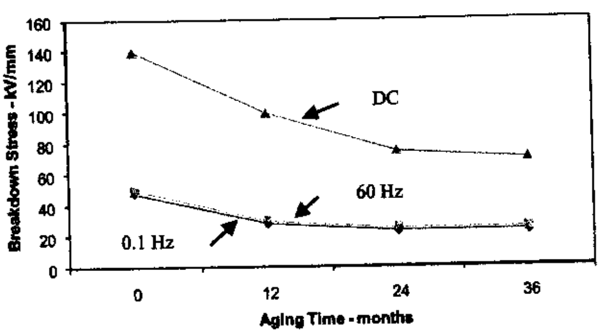

Figure 1. Comparison of AC, DC, and VLF breakdown voltage.

As shown in Figure 1. The magnitude of the VLF breakdown voltage test at 0.1 Hz and the AC breakdown voltage test at 60 Hz are less than the DC breakdown voltage test. The effect of the VLF test has damage on the XLPE cable less than do tests with DC and AC at 60 Hz test. The VLF at 0.1 Hz field proof tests have been developed based on evaluation of laboratory aged XLPE insulated cable [2].

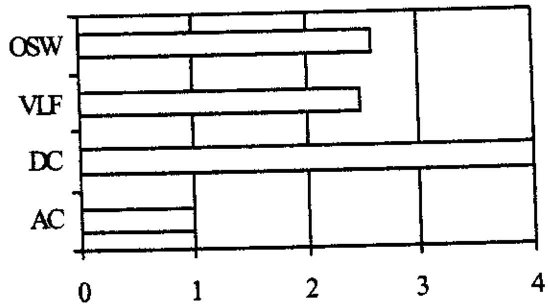

Figure 2. Comparison of AC, DC, VLF and OSW breakdown voltage during water-tree detection.

From comparison of breakdown voltage of cable under AC, DC, very-low frequency (VLF) and oscillating wave (OSW) voltages that shown in Figure 2. This indicates that OSW is the equal of VLF in terms of the size of the test equipment and water-tree detection capability. However, VLF has a better soundness capability. It is therefore concluded that VLF is the most suitable waveform for use in voltage withstands testing of water-tree cable [3].

Table 1 Suitability of selected waveforms in voltage withstand tests

Waveform	Scale of equipment	Water-tree detection	Soundness
AC	●	☺	☼
DC	☺	●	●
OSW	☼	☼	●
VLF	☼	☼	☺

☺: Suitable ☼: OK ●: Unsuitable

The most suitable waveform for using in voltage withstands tests is the very-low frequency (VLF) field test method [4]. The VLF method proof that it is helpful and simple method which gets a good indication in global condition and gets a loss value as the leakage current measurement in conjunction. It is concluded that only the VLF proof test technology to measure directly the approximate leakage current. The suitability of selected waveforms in voltage withstand tests with scale of equipment, water-tree detection capability, and soundness tests that represented by the table1.

The high voltage test equipment with sinusoidal waveform is produced from modulated with the desired VLF frequency at 0.1 Hz. The schematically is shown in Figure 3. This is a simplified method to use in diagnostic

III. Circuit Description

The basic idea of the new modulation circuit is shown in Figure 7. It has two parts of the circuit, the modulation unit and the switching unit. The modulation unit is used to generate sine wave at 0.1 Hz and triangle wave at 10 kHz into the total signal. This total signal is used to drive the switching in part of switching unit.

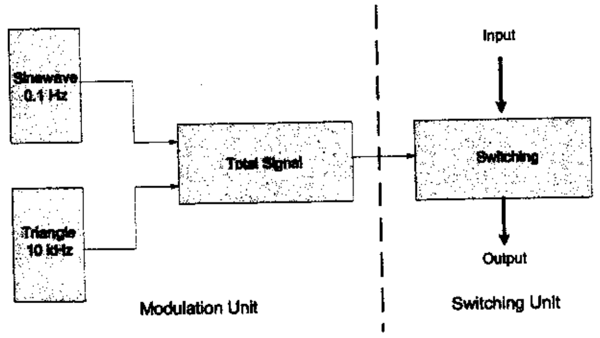

Figure 7. The diagram of the single-phase inverter implemented.

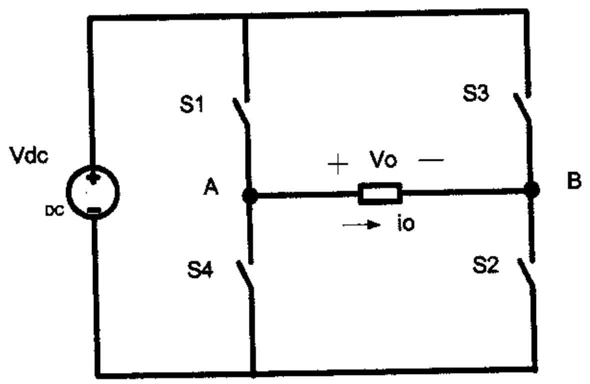

Figure 8. The switching unit.

The switching unit used a full-bridge circuit as a dc-to-ac inverter that is shown in Figure 8. One of the full-bridge inverter (square-wave) is the unipolar modulation scheme. It is easy to change to sinusoid output waveform [9].

IV. Experiment

The diagram of the single-phase inverter implemented has two parts of the circuit, the modulation unit and the power switching unit. The modulation system part contained an AC variable voltage source, a full-wave rectifier, a switching unit and a modulation unit. The high voltage transformer part contained a VLF transformer that used to generate a sinusoidal very low frequency at 0.1 Hz. The shaded part is the control circuit contained the microcontroller for creates pulse with modulation (PWM) control signals.

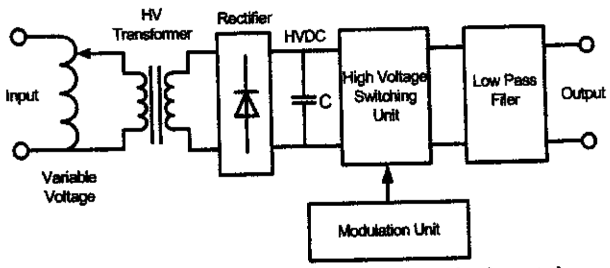

Figure 9. The diagram of the single-phase inverter implemented.

The basic idea of the new design is shown in Figure 9. The input power for the system is obtained from normal 220 V 50 Hz source. Output voltage amplitude is controlled in the usual fashion, represented by the variable autotransformer. The output voltage of this transformer has increased by 1 to 65 with high voltage (HV) transformer. The HV transformer is stepped up voltage to full wave rectifier for producing a high voltage direct current (HVDC) to the high voltage switching unit. The high voltage capacitor used to confirm the HVDC has less any ripple or noise.

The high voltage switching unit is generated a high voltage unipolar modulation waveform. It has two frequencies in each period that is a high frequency at 10 kHz and a low frequency at 0.1 Hz. The high voltage low pass filter between the power switching unit and the output is reduced the 10 kHz out from the output to an acceptable VLF sinusoidal waveform at 0.1 Hz.

The schematic diagram for the power circuit is shown in Figure 10. The four module of IGBT are used for full bridge switching devices. The IC gate driver is used to drive the group of IGBT in the upper and lower gate as a single-phase inverter. The single-phase diode bridge rectifier of the HVDC link is connected to the single-phase AC power supply, 220V, 50Hz to provide a constant DC source to the inverter. The high voltage capacitor is used to filter any ripple of HVDC from the diode bridge rectifier. The high voltage resistor is helped to discharge DC voltage from the high voltage capacitor after unused the HVDC power source.

The low-pass filter scheme is used RC filter type for high voltage filter in this circuit because it can be cut-off at very low frequency which used capacitance lower than LC filter type. In this paper is designed cut-off frequency at 1 Hz for low-pass filter of the high voltage unipolar modulation waveform.

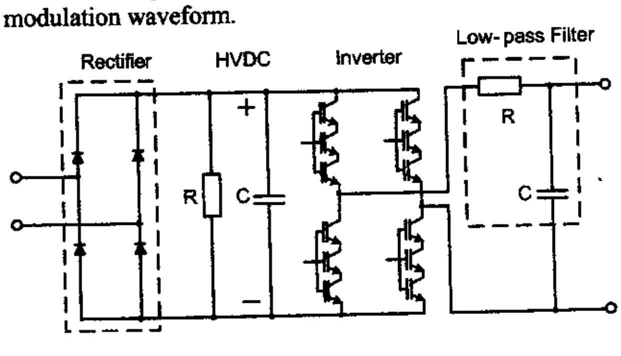

Figure 10. The schematic diagram for the power circuit.

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INDEX TERMS

- **IEEE Terms**
  DC generators , Frequency , HVDC transmission , Low pass filters , Low voltage , Power cables , Power generation , Signal generators , System testing , Voltage control

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- **Author Keywords**
  HVDC modulation , VLF generator

REFERENCES

1. S.Chotigo and S.seesanga, ECTI-CON2007 Conference Inc. "Modulation Circuit for VLF Transformer" Mae Fah Luang University, Chiang Rai, Thailand.

2. G.S. Eager, C.Katz, B.Fryszczyn, J. Densley, B.S. Bernstein. "High Voltage VLF Testing of Power Cable" IEEE Transactions on Power Delivery, Vol.12, No.2, April 1997.
   Abstract |Full Text: PDF (720KB)

3. Katsumi Uchida, Yoichi Kato, Masahiko Nakade, Daisuke Inoue, Hiroyuki Sakakibara and Hideo Tanaka. "Estimating the Remaining Life of Water-Treed XLPE Cable by VLF Voltage Withstand Tests" Furukawa Review, No.20 2001.

4. Henning Octjen, "Principals and Field Experience with the 0.1 Hz VLF Method regarding the Test of Medium Voltage Distribution Cables", IEEE International Symposium on Electrical Insulation Conference, September 2004, pp. 376-379.

5. Richard Reid Senior Member High Voltage, Inc. "High Voltage VLF Test Equipment with Sinusoidal Waveform" 0-7803-5515-6/99/$10.00© 1999 IEEE.

6. Wei Xinlao, Wang Yonghong, Chen Qingguo, Ma Sen. "A New Type of VLF High Voltage Generator Used for On-site Tests of Power Cables" Properties and Applications of Dielectric Materials, May 25-30, 1997, Seoul, Korea.

7. Gnerlich, H. R., "Field Testing of HV Power Cables: Understanding VLF Testing." IEEE Electrical Insulation Magazine, vol. 11, no. 5, pp. 13-16, Sep./Oct. 1995.
   Abstract |Full Text: PDF (400KB)

8. Moh, S. C., "Very low frequency testing-Its effectiveness in detecting hidden defects in cables,"2003 CIRED (17th International Conference on Electricity

Distribution), Barcelona, Paper 84, May 12-15,2003.

9. Mohan, Undeland, Robbins. Power Electronics. 2 nd ed. USA: Prentice-Hall, Inc., 1993.

10. IEEE 400.2 standard, "Guide for Field Testing of Shielded Power Cable Systems Using Very Low Frequency (VLF)", 2004.