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Comparison of load inverter topologies in a bipolar LVDC-distribution

J. Rekola and H. Tuusa

Department of Electrical Energy Engineering
Tampere University of Technology
P.O. Box 692, 33101 Tampere, Finland
Phone number: +358 401981519, e-mail: jenni.rekola@tut.fi, heikki.tuusa@tut.fi

Abstract. Low voltage direct current (LVDC) distribution is a new low voltage distribution concept. Potential inverter topologies for a bipolar LVDC 1500 V distribution system are compared. Two- or three-level single-phase half or full bridges or three-phase load inverters can be used in LVDC distribution. Inverters can be connected to 750 V DC or 1500 V DC. The bases of comparison are the size of required LC-filters, voltage and current stresses of the components, capability to operate with reduced DC voltage and feed half-wave rectifying load. Two different LC-filter design methods are used.

According to the simulation results, the most suitable single-phase load inverter topologies connected to 750 V DC are two- and three-level full bridges. The structure of three-level inverters is more complex, but the size of the required passive filter components is just half of the size of the components with two-level inverters.

The difference between LC-filter sizes is not so significant when comparing with two-and three-level inverters connected to 1500 V DC. The maximum voltage stresses of the IGBT-components are $u_{dc}/2$ in three-level inverters but u_{dc} in two-level inverters. Smaller voltage stresses are a remarkable advantage especially at higher voltage levels.

Key words

LC-filter design, LVDC distribution, single-phase inverter, three-phase inverter, three-level inverter

1. Introduction

The structure of the electricity distribution network is changing. There will be more distributed generation and more energy reserves connected to the distribution network [1]. The good power quality is more important nowadays because people are dependent on undisturbed power supply [1]. The low voltage direct current (LVDC) distribution is a new voltage distribution concept which can fulfil these new requirements. Medium voltage is decreased to low voltage by a transformer and rectified to DC. The voltage is converted back to AC near the customer. The Low Voltage Directive 2006/95/EC enables the use of 1500 V DC in power transmission [2]. It is possible to increase the power transmission capacity with the use of DC [1]. Losses of the energy distribution are smaller, because all of the power is active power and there shouldn't be skin effect in DC cables. The target of the system is high cost-efficiency and reliability [1], [3]. The DC system makes it possible to compensate voltage sags and short interruptions in the medium voltage network, and thereby the DC voltage can decrease for example 25 % without any effects on the customer voltage [3].

The structure of the LVDC network is unipolar or bipolar. In the unipolar system, rectifiers and inverters are connected to 1500 V DC as presented in Fig. 1.

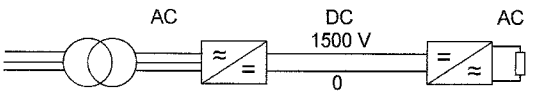

Fig. 1. A unipolar LVDC distribution network

The two voltage levels, ±750V DC, and the neutral are used in the bipolar system. The system can be fed by one rectifier which is connected as a bipolar connection as shown in Fig. 2 or by two rectifiers which are connected as a unipolar way between the positive or negative pole and the neutral. Customers are connected between the positive pole (customer A Fig. 2) or the negative pole (customer B) and the neutral as a unipolar connection, between the positive and the negative poles as a bipolar connection (customer C) or between the positive and negative poles with the neutral connection (customer D) in a bipolar way.

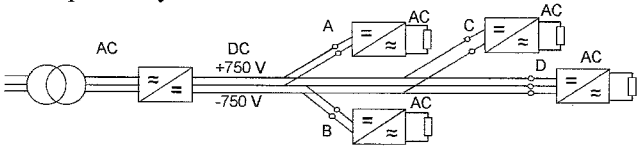

Fig. 2. A bipolar LVDC distribution network