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Rural Single Wire Earth Return distribution networks – Associated problems and cost-effective solutions

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ABSTRACT

Single Wire Earth Return (SWER) systems are used for supplying electricity at low cost, where electricity supply is required for small populations of people dispersed across wide geographical areas. It is principally used for rural electrification, but is also used for other isolated loads and light rail.

The existing SWER distribution systems have been stretched with the sharp growth of their loads because of customers' change of lifestyle, which has introduced additional load of air conditioning equipment, motors driven by variable-speed drives and inverters. This paper proposes cost-effective solutions to address the problem of voltage regulation and compensation of the unbalancing effect of SWER lines on the three-phase feeder of these lines, which have been exacerbated by this load growth.

To improve the voltage regulation problem, a LV switchable reactor has been designed, a prototype made and tested in the field. Also, an unbalance compensator has been designed to reduce the unbalancing effect of SWER lines. Two case networks have been used to perform simulation studies on the effectiveness of both proposed solutions. At first, a case study is used to demonstrate the impact of a switchable reactor on improving voltage regulation. Then, another case study shows that installation of a switchable reactor and an unbalance compensator simultaneously on a SWER distribution system effectively improves voltage regulation and reduces unbalancing effects.

1. Introduction

Rural electrification has been a long struggle around the globe. Many obstacles had to be overcome before widespread use of rural electric power became practical [1]. There are still many people in the world who are deprived of many advantages of electric energy; about 1.45 billion people (22% of the world population) were deprived access to electricity in 2008 (about 85% of those people lived in rural areas) [2]. Electrification rates remain extremely low in many developing countries, as low as 10% in some African countries, for example, as illustrated in Fig. 1 [2]. Rural electrification is an area in which social justice and equity dictate that there is a need, but political and economic realities are such that the need is often subordinated [3]. The World Bank has been encouraging the expansion of simple systems for rural electrification to reduce the cost of the grid extension [4].

In 1920, Lloyd Mandeno introduced Single Wire Earth Return (SWER) distribution systems in New Zealand. Later in 1947, he published a paper proposing SWER as economic alternative to the standard three-phase distribution systems for rural areas [5]. A brief explanation of SWER systems is provided in [6]. Nowadays SWER distribution systems are used in Australia, New Zealand, South Africa, Canada (Saskatchewan), Brazil, Laos, USA (Alaska) and Iceland. Other countries, for example, Angola, Burkina Faso, Botswana, Namibia, and Mozambique are considering SWER as a means of extending their rural electrification [7]. SWER distribution lines are used extensively in remote parts of these countries as an economic means to deliver electrical energy to small customer loads, scattered sparsely over vast areas. These SWER systems are normally supplied from very long three-phase distribution feeders. In many areas of Australia, rural electrification systems were established by the State Electricity Boards during the 60s, 70s and 80s under community service initiatives.

A SWER line is a unique distribution line that consists of a single conductor, energized at a relatively high voltage, which uses the earth as a return path for load currents, rather than a dedicated neutral or earth conductor. This makes it incredibly simple and economic to construct and it has many advantages due to its small number of components. There are over 150,000 km of SWER lines currently in use in Australia. Individual loads are typically less than 100 kW. Distances between customers can range from less than 1 km up to 25 km.

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