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Voltage Regulating Distribution Transformers as new Grid Asset

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Abstract

Since 2012 voltage regulation distribution transformers (VRDT), that is distribution transformers equipped with on-load tap-changers, have become a new grid asset in frequent use. While initially started as a means to facilitate the economic integration of renewable energies into public power grids, it has become apparent that there is a multitude of use cases for VRDTs beyond renewables integration and that the technology is not limited to public grids but can also find applications in industrial grids and become part of generation units. The primary driver behind these new found fields of application for distribution transformers with on-load tap-changers is a new generation of such tap-changers which is much more compact and much more economical than traditional tap-changers.

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Keywords: Voltage Regulating Distribution Transformer; On-Load Tap-Changer

1. Introduction

Since 2012 voltage regulating distribution transformers (VRDT), that is distribution transformers equipped with on-load tap-changers, have become a central means for innovative grid planning [1, 2]. As a grid asset they facilitate the economic integration of renewable energies into public power grids, but also find use beyond renewables integration and are not limited to public grids only, but can also find application in industrial grids and become part of generation units.

This paper will introduce the technological concepts and principles that make a distribution transformer a VRDT, link VRDTs to established technology in high-voltage grids, explain how VRDTs interact with the power grids in which they have been deployed and establish the basic control strategies applied in VRDTs. Based on the

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foundations different use cases where VRDTs can be helpful will be explained – from public grids, to industrial ones, to dispersed generation units.

2. VRDTs as Grid Asset

Since their first launch as products available in commercial grade – as opposed to prototypes – in 2012, VRDTs have become an established grid asset for many operators of public and industrial distribution grids. This is obviously due to the benefits they realize in the distribution of electrical energy but also because they follow established principles that have been proven as reliable and stable in power engineering for nearly one hundred years.

2.1. Trusted Technology Transferred into the Distribution Grid

Since nearly a century power transformers in high voltage grids have been equipped with on-load tap-changers to dynamically adjust the voltage of such transformers. The underlying technology had originally been industrialized by Maschinenfabrik Reinhausen and relies on changing the number of active windings of a transformer with an electro-mechanical system.

Figure 1 shows how this proven concept can generally be applied to the distribution grid through a VRDT. A secondary substation, e.g., connecting the 20 kV grid with the 400 V grid, is equipped with a special distribution transformer that comes with an actuator such as an on-load tap-changer that allows changing the voltage of the transformer dynamically under load [1].

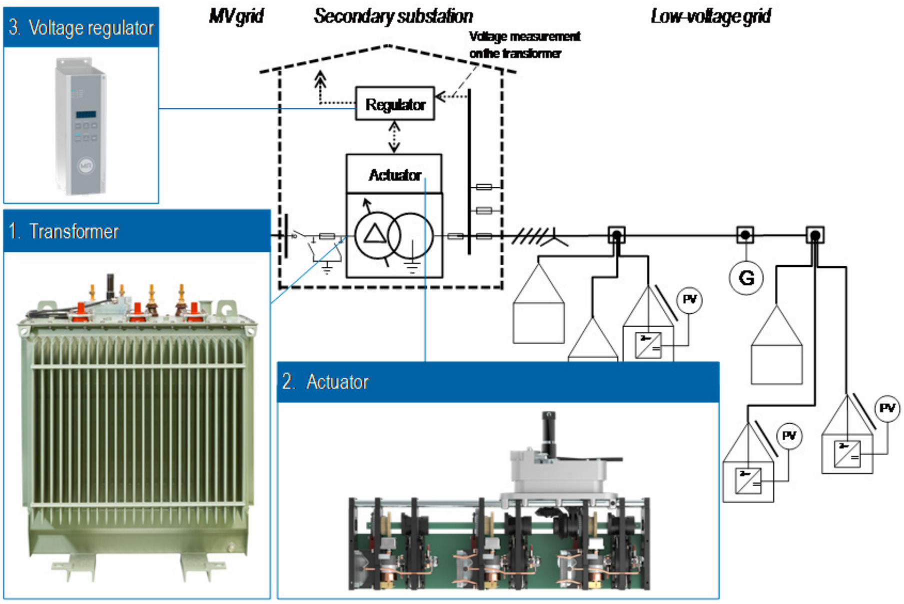

Fig. 1. Layout of the System VRDT.

The market offers different technological concepts for such actuators. Advanced solutions allow an actuator to be installed without having to change the dimensions of the transformer. This is the only way to ensure that a VRDT can be used in all existing secondary substations. Particularly with regard to the large installed base of compact stations, this requirement is a central point for almost all distribution network operators. In addition, an actuator lifespan that corresponds to that of the transformer with no or only minimum maintenance is usually a primary, economically based requirement [1]. This requirement is frequently hard to fulfill for concepts based on power electronics. Moreover, advantageous VRDT concepts facilitate a large regulation bandwidth in that they can