Active Filter with Integrated Flywheel

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1. Introduction

Power quality is becoming an increasingly important aspect of power supply. Not only the number of perturbing power electronic devices is rising, but also an increasing number of sensitive loads can be observed. Due to this fact, power quality has to be observed very carefully to avoid malfunctions of devices and, consequently, the interruption of industrial processes. Power quality is not only important in the industry but in the supply of households as well e.g. light flicker caused by frequent voltage variations must be avoided.

2. Purpose

To reduce supply perturbations a combination of an active filter with a flywheel system is presented. This device compensates any deviation of the voltage shape from the sinusoidal waveform by exchange of energy with the grid. The amount of energy provided by the flywheel is sufficient to fulfill an additional UPS-function for at least 20 s at full power. When a fault in the supply grid is detected, the system is able to disconnect the sensitive load from the grid within 10 ms. This disconnecting time is short enough to prevent most of the sensitive loads from malfunction.

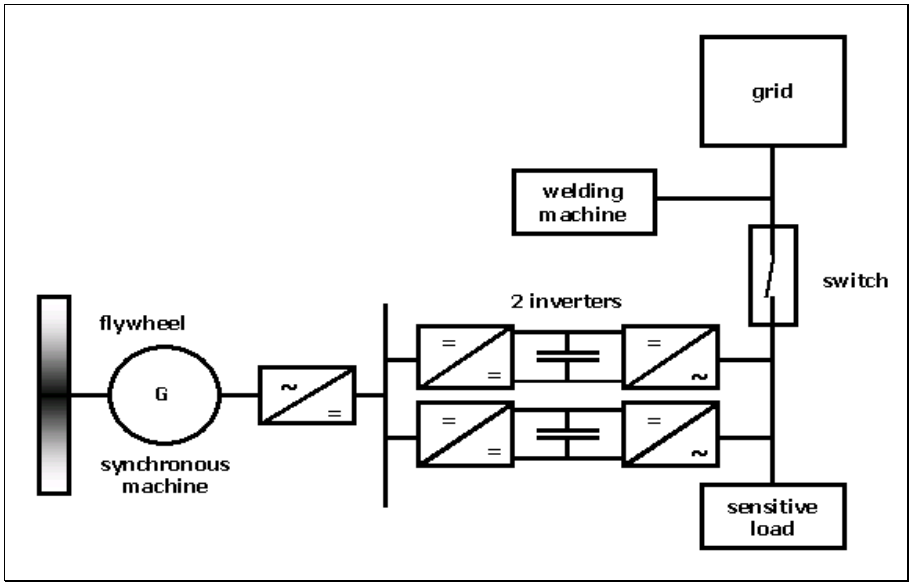

figure 1: schematic of system

3. Background

The system was designed for a multifunctional application. In this special case which is described here the welding machines of a small company connected to the public supply medium voltage grid are producing flicker. Welding machines and the distribution transformers supplying the low voltage grids for individual homes are connected to

the same line. The strengthening of the grid at that point is neither desired nor economically realizable at the moment. Thus, another solution to this problem was found with this active filter system.

4. Technical data

The heart of the system is formed by two inverters that are capable of active filtering. The energy for the ups functionality is stored in a flywheel. The flywheel is a POWERBRIDGE which is manufactured by Piller GmbH, Germany. Within the range of rotation speed from 1800 to 3600 rpm the POWERBRIDGE is able to store 16.5 MWs of energy. The flywheel has a vertical axis and rotates in a helium atmosphere to reduce losses caused by air turbulence. The axis is connected to a synchronous generator that converts the kinetic energy into electric energy. The AC voltage of the synchronous generator is rectified and provided on a DC bus bar. The two inverters are connected to this DC bus bar by a DC/DC chopper. They are used to regulate the voltage level for the inner DC link,

figure 2: POWERBRIDGE, POWERFORMER 400, container system

a huge capacitor bank. The voltage is then transformed to AC and fed into the coupling point. The inverters are POWERFORMER 400 also manufactured by Piller GmbH. These are four quadrant inverters using 6 pulse IGBT technology. The power of 400 kW each is controlled by a sophisticated controller board. It provides the ability of active filtering by an instantaneous voltage control. The complete system is integrated in a 20 ft container. Therefore the system becomes a mobile solution.

5. Results

The first results of the system are shown in the diagrams below.

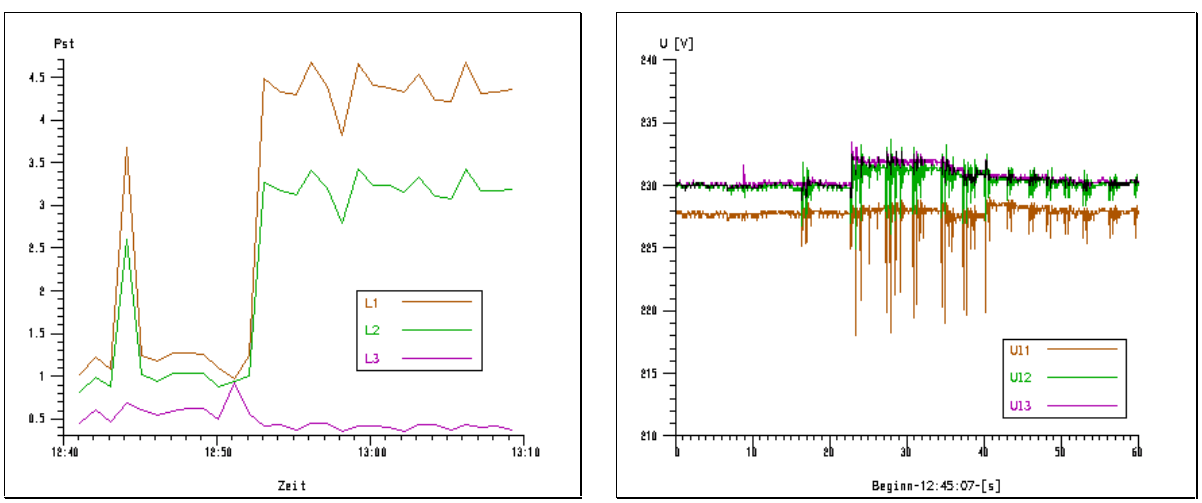

figure 3: flicker value and voltage over time

The left one shows the flicker value over time. Up to 12:52 the filter is operating. In this time the flicker value is below or slightly above the allowed value. When the filter stops operating the flicker value rises increasingly in phases L1 and L2 where the welding machine is connected to. The peak at 12:44 was caused by an interruption in filter operation. In the right diagram the voltage in the three phases is shown over one minute. The filter again stops operating at second 22 and restarts at second 41. In this time the voltage dips are approximately three times deeper. In operation the filter limits the voltage dips to nearly 3 volts.

6. **Partners and funding**

The system is a project of four partners: team GmbH, Herten, Germany is working in the fields of data technology, measurement and energy services and is doing the voltage quality measurement during the monitoring phase of the system. Piller GmbH, Osterode, Germany, as a manufacturer of static and dynamic ups systems has delivered the hardware and adjusted the control to get the system work. RWE Energie AG, Essen, Germany, as a major german utility is the power provider at the place where the system is installed. EUS GmbH, Gelsenkirchen, Germany, is a consulting and engineering company for the electricity supply industry and is improving the active filter control for the system. The project is funded by the Landesinitiative Zukunftsenergien, a project of the german federal country of Northrhine-Westphalia.