Parameter Selection of Dynamic Reactive Power Compensator (DRPC)

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ABSTRACT

This poster presents the complete simulation study of a Dynamic Reactive Power Compensator (DRPC), which is one of the Flexible Alternative Current Transmission System (FACTS) devices. Continuous and smooth reactive power compensation will improve the power system performance. This brings down voltage fluctuation, power loss in the transmission system and threat on instability while reducing the kVA demand. Further the transmission lines can be utilized to transmit more active power while improving the reliability of the supply. A control system for DRPC has been developed; simulated using EMTDC/PSCAD program and results are provided.

INTRODUCTION

Increasing population and industrialization created a large electricity demand. Industries consume large amount of reactive power mainly due to induction machines [1, 2]. The reactive power consumption reduces the power factor of the load center, power transfer capability of the transmission lines while causing under voltage problems [1]. Reactive power compensation improves the power system performance in many ways such as improving the power factor, boosting the voltage, enhancing the power transfer capability, controlling the power oscillations and improving the system stability [3-6]. Correct choice of power electronic devices and its control is thus mandatory to achieve effective and efficient performance. This presentation discusses VAr Compensation Using a FACTS device named as DRPC. This is the first study in Sri Lanka carried out to develop and implement a DRPC.

METHODOLOGY

The feasibility of the proposed system was studied at the Faculty of Engineering, University of Peradeniya.

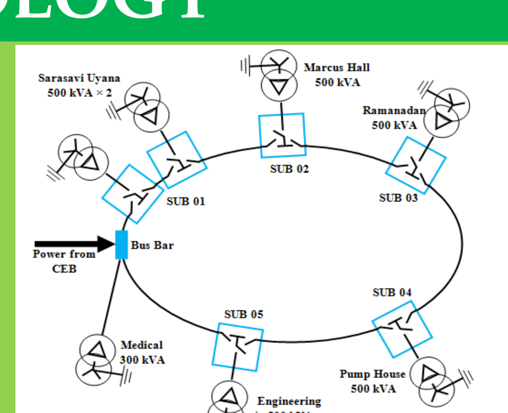

Figure 1: 11 kV underground ring network of the University of Peradeniya

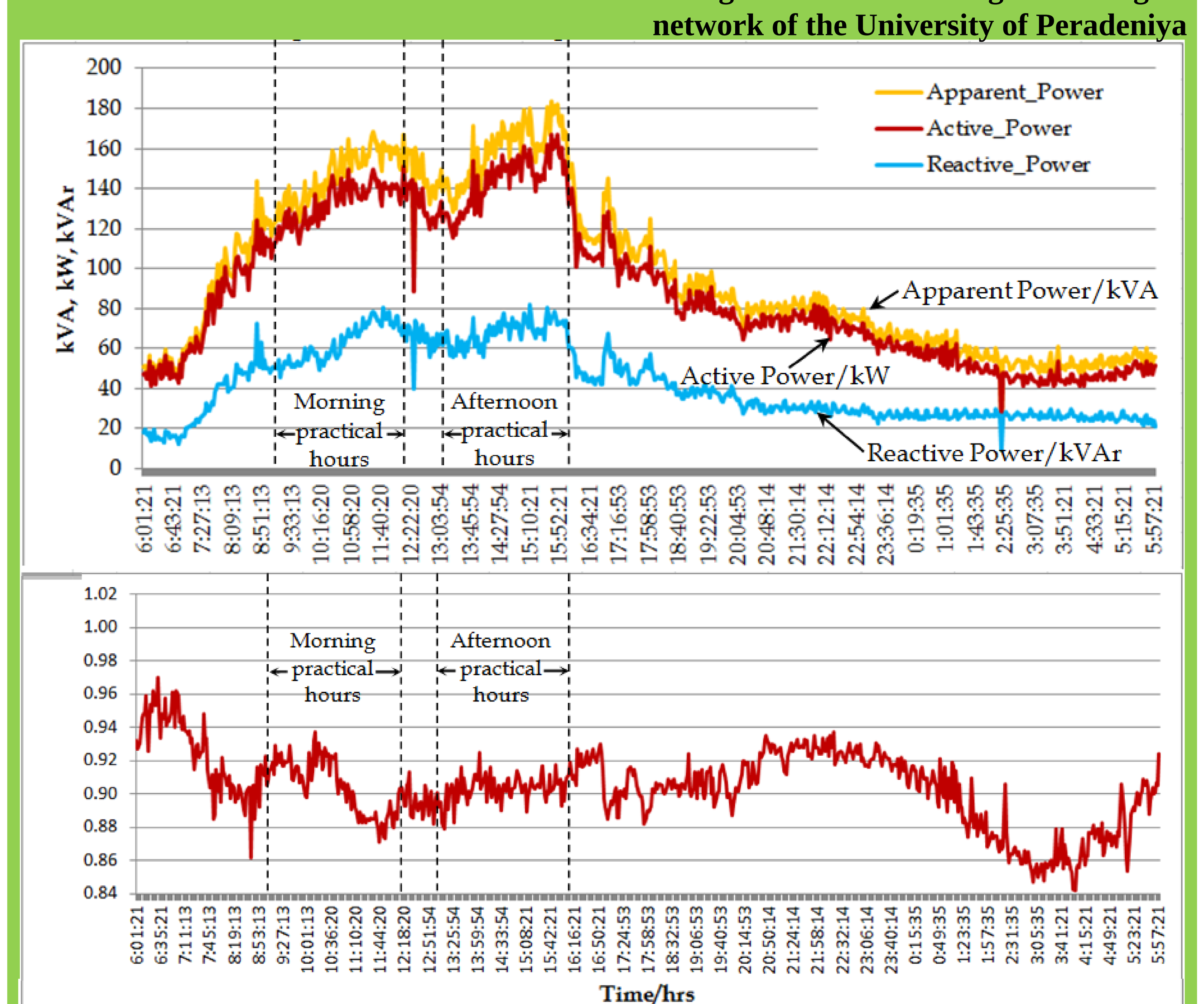

Figure 2: Power flow from Engineering Faculty transformer

Power flow measurement clearly shows that Engineering faculty consumes a peak reactive load of 85 kVAr twice a day, falling in the practical hours. The power factor is varying in the range between 0.84 and 0.97.

The design was focused to supply a fixed reactive power of 20 kVAr using filter capacitors and a maximum of 90 kVAr. Variable reactive power compensation was done by controlling the Breaker Switched Capacitors (BSCs) together with the Thyristor Controlled Reactors (TCRs). Filter inductor values were calculated to filter the mentioned harmonics. TCR inductor value was calculated to compensate for one of the three equal BSCs.

A Dynamic Reactive Power Compensator model was developed using EMTDC/PSCAD tool. The Engineering Faculty transformer and the upstream network were modeled as an AC voltage source with impedance. The loads were modeled using variable resistor and variable reactors.

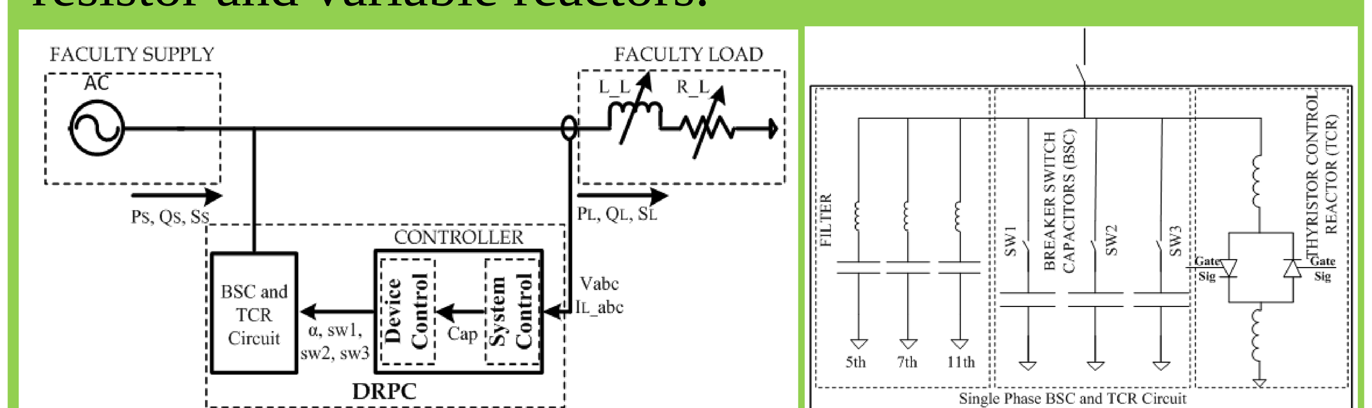

Figure 3: (a) Simulated DRPC model, (b) Single Phase BSC and TCR circuit

The DPRC controller consists two sections namely (i) system level controller and the (ii) device level controller.

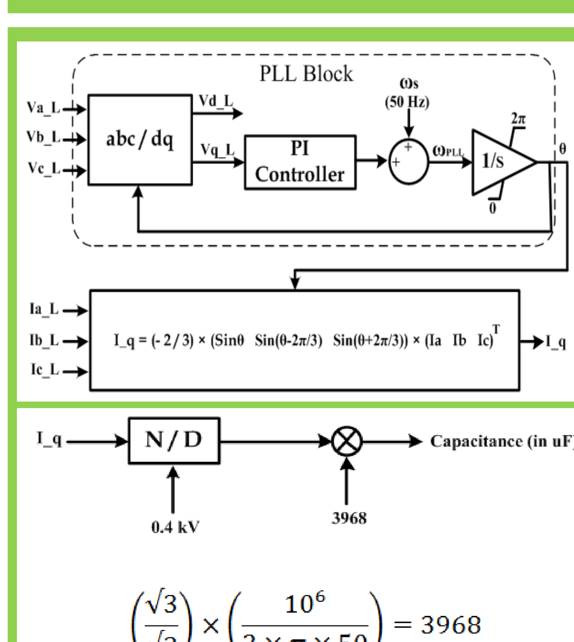

Figure 4: System level control

Three phase voltage vector Phase Locked Loop (PLL) was used to track the system frequency angle theta (θ) [7]. Further in the controller model d-q transformation was used to find the Quadrature-Phase component of the load currents (Iq_L) feed forward controller was to find the capacitor value.

Depend on the reactive power demand the breaker switches are operated to supply the reactive power to the load. Thyristor firing angles were controlled to vary smoothly the reactive power supplied by DRPC.

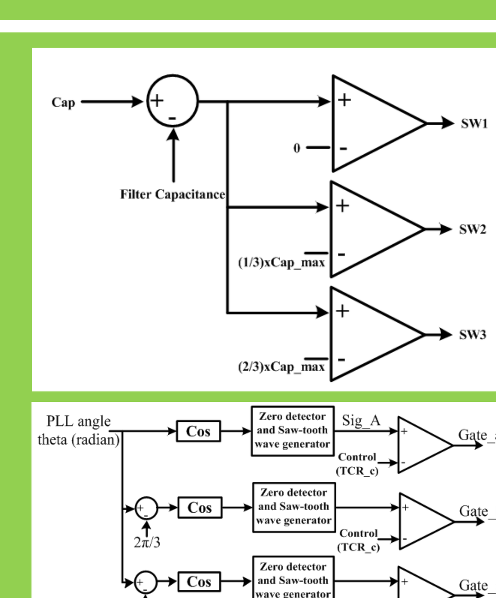

Figure 5: Device level control

RESULTS

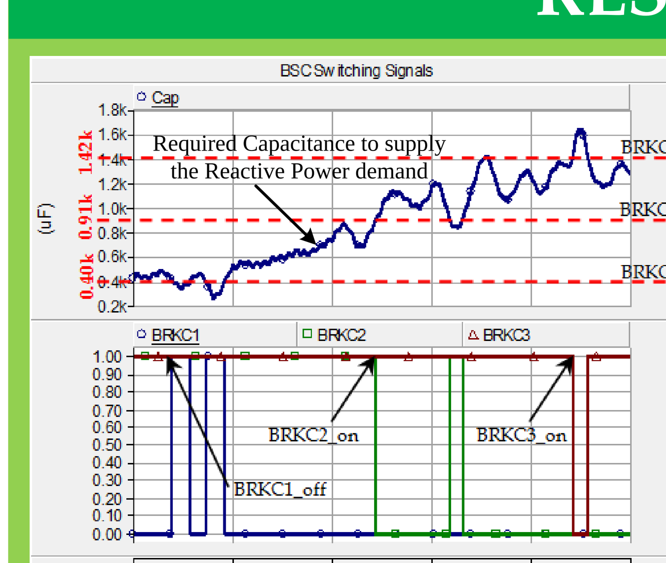

Figure 6: BSC switching signal generation

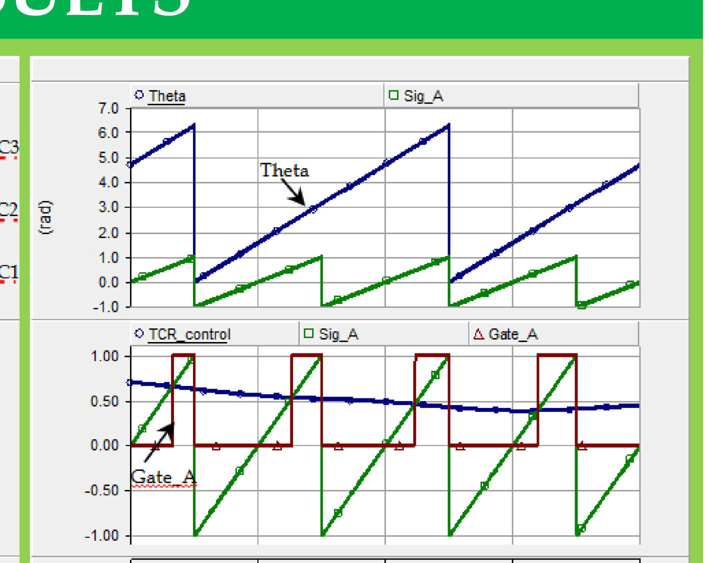

Figure 7: TCR control and Gate signals

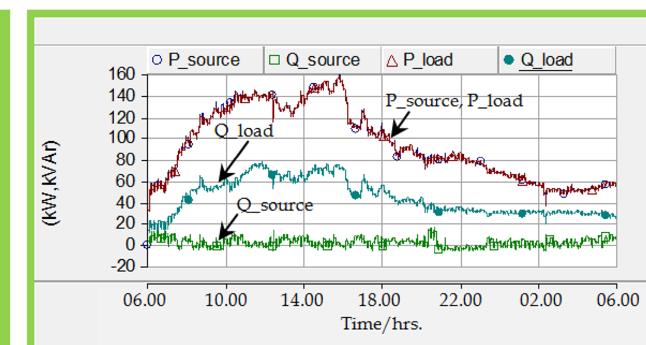

Figure 8: Simulated load variation

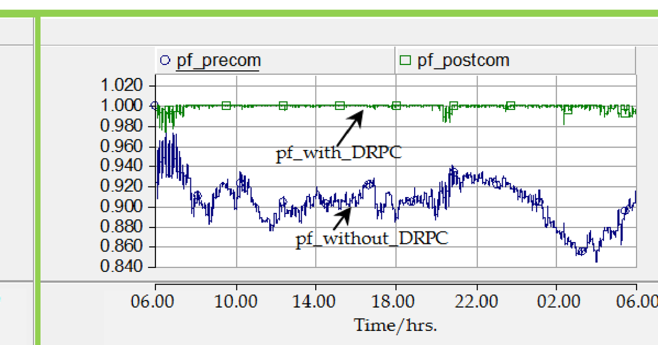

Figure 9: Simulated power factor variation

The load power variation and power factor variation (pf_without_DRPC) obtained from simulation are matched with the measured information. This confirmed that the load model is correctly developed in the simulation. The reactive power consumed from the source is shown as zero. This confirms the total reactive power consumed by the load is supplied by the DRPC. The proposed DRPC improves the power factor towards unity.

DRPC reduces the peak kVA demand nearly from 180 to 160. Thus in terms of electricity bill reduction (with the current kVA demand charge of 850 rupees [8]), is 17000 rupees per month. In addition to this the stress on the 11 kV ring network is also reduced.

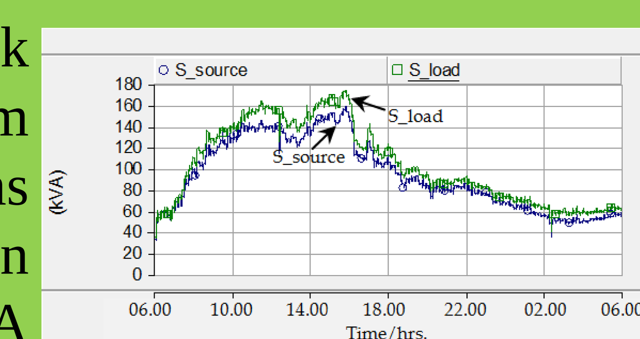

Figure 10: Apparent power comparision

DISCUSSION

Simulation results confirm that the reactive power drawn from the source is kept at zero by the controlled DRPC injection. Addition to the power factor improvement, always a reactive power compensator boosts the bus bar voltage. Since the kVA charges are high, reduction in kVA demand will reduce the electricity bill by a considerable amount. As a result the money saved will payback the cost of implementation. More to this peak shaving of the kVA demand helps the utility to supply power with comparatively less line losses.

This research will give a motivation to implement DRPC locally made in Sri Lanka with low cost. Further this study and endurance will boost further application of DRPC, built locally under proper guidance and customization to user demands, so that CEB can apply this modern application to boost the voltage profile at the load centers where applicable. Therefore the distribution lines can be extended effectively to electrify the rural areas of the country.

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