Reliability Enhancement of Industrial Capacitor Banks Through Smooth Engagement to the Grid

Problem statement

Most industries with inductive loads, resulting in a lower power factor due to inductive loads. In order to maintain a better power factor, capacitor banks are used in the industry. These capacitor banks are having lesser lifetime due to adverse effects of transient voltages and currents. mainly owing to transients generated due to capacitor bank Energization and switching.
Lack of proper grid engagement in existing methods; the switch or connector module which connects capacitor banks to the grid, can be considered as one of the main reason for this.

Aims and Objectives

- Analyze how different capacitor banks behave due to different transient voltages and other harmful effects and analyze the effects from the capacitor bank to the power system, and the power system to the capacitor bank.
- Proposing a smooth engagement or switching process of capacitor banks to the grid which does not facilitate harmful effects to capacitor banks.

Project Methodology

Using the information of an industrial application (36 stories building) model of this existing power system and medium voltage industrial power network which is referred to in a research paper was designed in the MATLAB Simulink software.

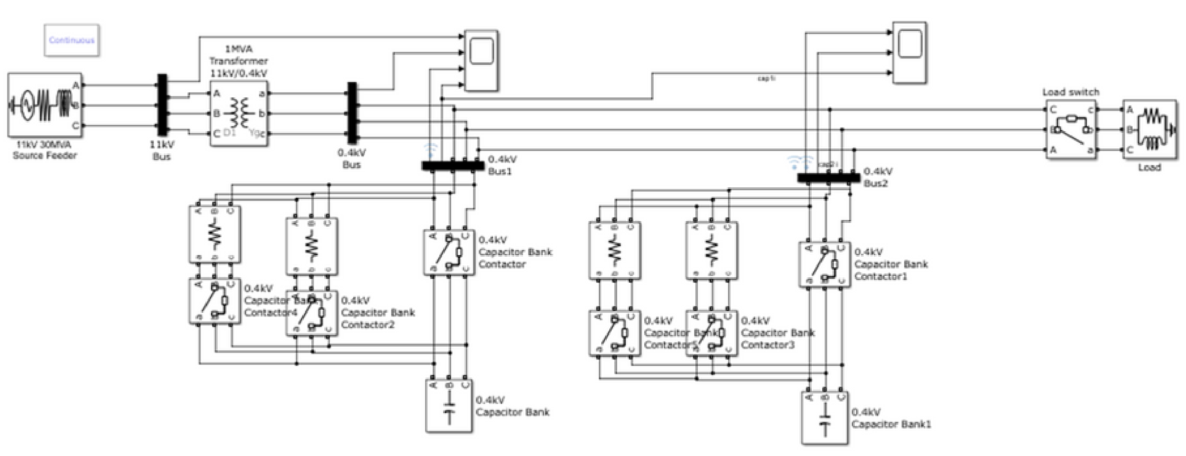

Figure 1 - Pre-Insertion Intermediate step Switching solution model (WTC Common Area Power System)

Potential solution tests for the intermediate Step Switching mechanism (an advancement of the existing pre-Insertion resistor protective mechanism) was developed and parameters were optimized according to the low-voltage and Medium voltage power models to mitigate switching / energization inrush transients in the power system.

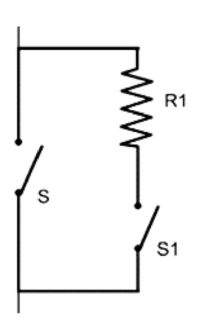

Figure 2 - The basic structure of PIR mechanism

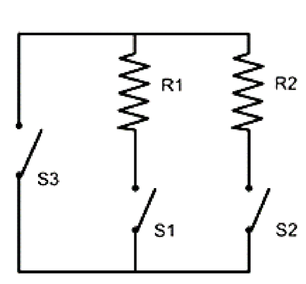

Figure 3 - The basic structure of the PIRIS

Capacitor banks switch sizing and usage of Electro Magnetic relays also were analysed.

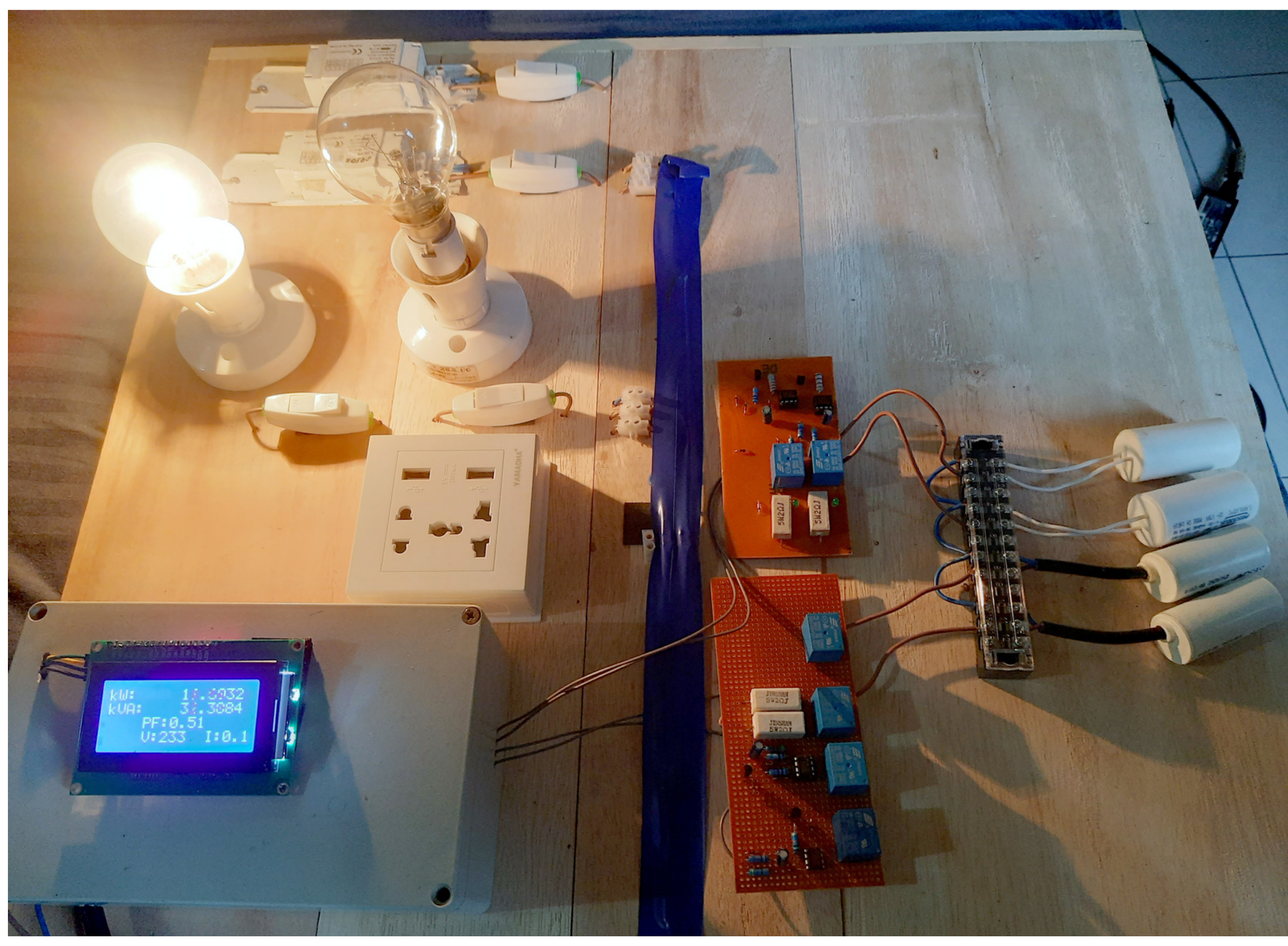

Figure 4 -Implemented prototype

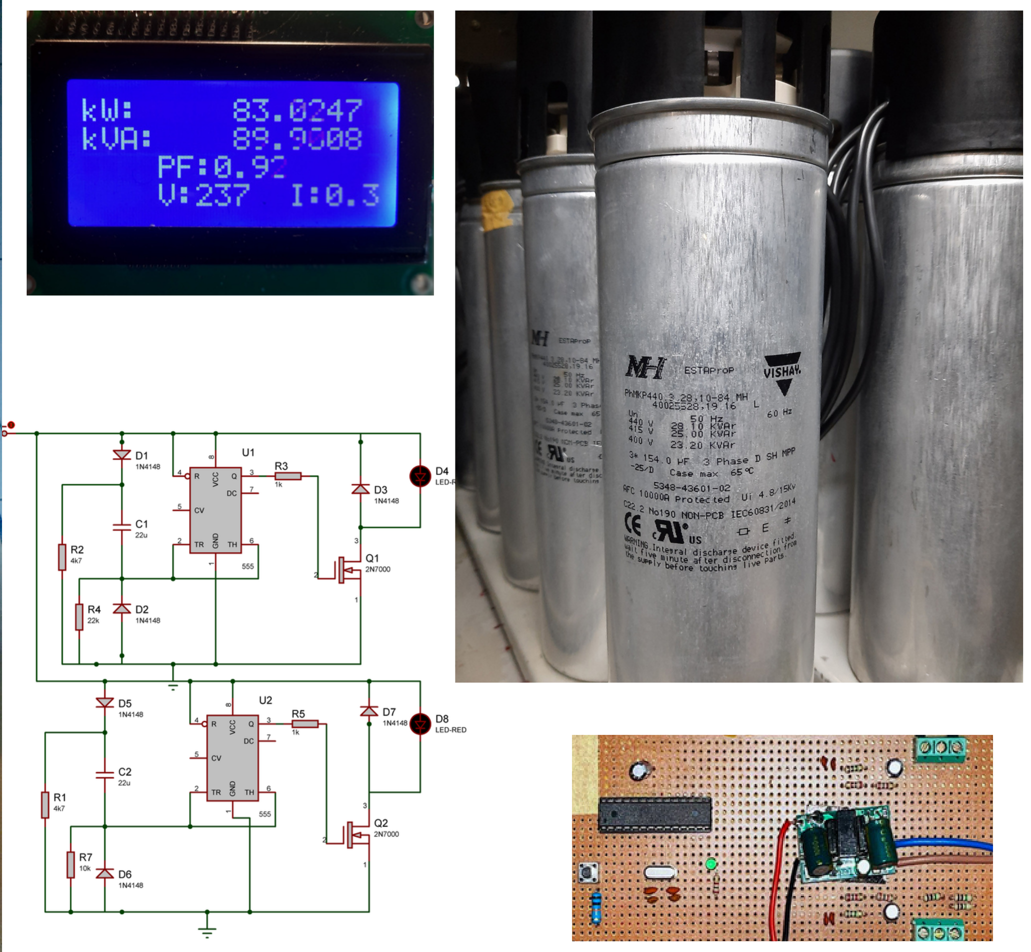

Figure 5 - Controlling Circuitry

Prototype

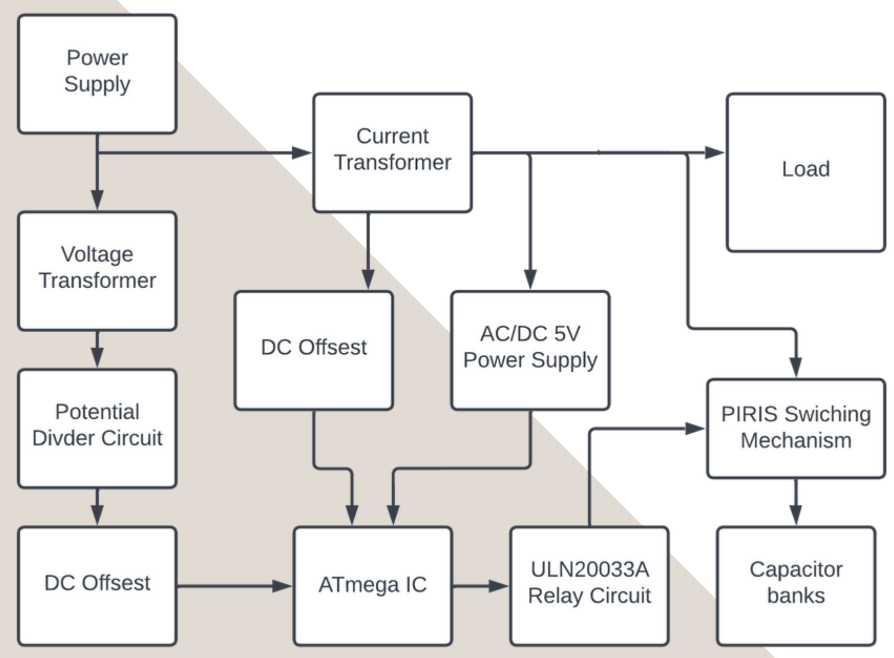

Figure 6 : Prototype block diagram

To demonstrate the real world application on the proposed mechanism the above prototype is designed and implemented.

Problems and Challenges

- Typical load variations that occur in power systems were difficult to obtain in real time.
- Determining accurate parameters of transmission cables and other power equipment in simulations of the reference power models
- Practical implementation of the proposed solution in industrial parameter scale

Individual Contribution

Table 1 - Individual Contributions

Janitha Mendis	Thisum Kariyawasam
Research and literature review on Existing Protective measures	Research and literature review on Power system transients
Researching the emerging protective mechanisms	Researching the emerging protective mechanisms
Designing simulation models	Designing simulation models
Analysis of WTC power system	Simulations on capacitor bank switching scenarios (Mainly on Low voltage)
Simulations on capacitor bank switching scenarios (Mainly on Medium voltage)	Solution testing and results analysis
Solution testing and results analysis	Implementation of prototype
Designing and PCB Etching	Prototype system program
Troubleshoot and Testing	Troubleshoot and Testing

Results and Analysis

The proposed PIRIS mechanism was tested in comparison with No-protection and PIR method in the MATLAB Simulink models of the WTC and medium voltage power systems. The following results were obtained.

Table 2 - Back to Back Switching scenario Results

	Low voltage		Medium Voltage	
Transient	Voltage	Current	Voltage	Current
No Protection	419.9 V	26.19 kA	29.3 kV	8577 A
Pre insertion	381.3 V	15.52 kA	22.5 kV	1066 A
Proposed solution	360.6 V	10.70 kA	22.1 kV	532 A

Here, 31% and 50% of current, 5.42% and 1.7% of voltage transients were further mitigated respectively in WTC and Medium voltage power system models.
In order to optimize the results, graphs were obtained by varying the resistor values and switching durations.

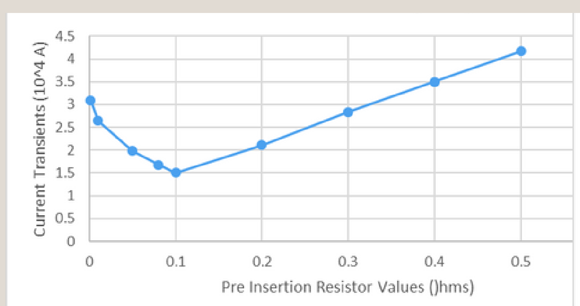

Figure 7: Peak inrush current Vs Pre insertion resistance (WTC)

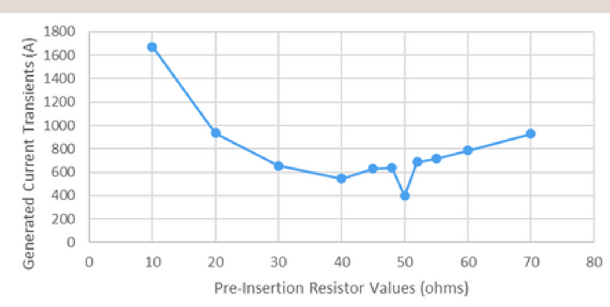

Figure 8: Peak inrush current Vs Pre insertion resistance (Medium Voltage)

Conclusion

With the above-demonstrated results, it can be concluded that the proposed mechanism is successful and has good potential as an Industrial solution. The implemented prototype is capable of detecting power factor and correcting them automatically.

References

- Switching Transients due to a Power Factor Correction Capacitor Bank in LV Power System and Their Comparison with Lightning Impulses S. G. Mohammad1, C. Gomes2*, M. R. Mehijou3, 2019
- I. Nisja, M. Zoni et al., \Study of capacitor bank switching transient in distribution network," in MATEC Web of Conferences, vol. 248. EDP Sciences, 2018, p. 02004.
- S. A. Ali, \Capacitor banks switching transients in power systems," Energy Science and Technology, vol. 2, no. 2, pp. 62{73, 2011.

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