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Raspberry PI PICO Based UPFC/APFC System

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***Abstract*—The Unified Power Flow Controller and automatic power factor correction systems are vital elements of present-day electrical grids. Here, I aim to develop the integration of these functionalities Enhancement of the electricity quality and reduction of losses while also offering a robust solution for controlling power in real time is the major target of the work. The research is constructed on consideration of the problem, its objectives, design, implementation and results of the project, including its strengths andweaknesses.**

I. INTRODUCTION

maintains efficiency and reliability; contemporary power networks struggle and adapt to growing demands. Optimized efficiency in power flow and rectification of the power factors has never been more required. Unified power flow controllers (UPFCs) and Automatic power factor correction (APFCs) are two of the most important technologies that respond to this need.
By integrating UPFC with APFC functionalities, the project achieves accurate control of voltage levels, impedance and phase angles while improving the power quality associated with high reactive power losses.
A combination of these systems is energy efficient and (relatively) cost effective and real-time interaction allows for power management across electrical networks. As a means of this project, the Rasp Pi Pico is employed.

II. PROCEDURE FOR PAPER SUBMISSION

A. Integrated systems of Unified Power Flow Controller and Automatic Power Factor Correction are a solution to some of the modern challenges that present themselves before the electrical grid, through real-time control on power flow through voltage, phase angle, and impedance regulation on power transmission while improving efficiencies and stability on the power distribution side. Meanwhile, power quality is addressed by the reduction of reactive power and raising the power factor. This project seeks to integrate the two systems using a low-cost and flexible microcontroller, the Raspberry Pi Pico, in an efficient and scalable solution for industrial, renewable, and small-scale power grids.System Design and Architecture
The system design is composed of several components working together to provide efficient power management. The Raspberry Pi Pico is at the heart of the system, serving as the central controller. It interfaces with voltage and current sensors, which collect real-time data from the grid. The microcontroller processes this information to control the output through relays and capacitors that correct the power factor and stabilize the voltage. The entire system operates dynamically, adjusting in real-time to varying load conditions, ensuring optimal energy distribution and improving grid stability.
Key Components and Modules
Raspberry Pi Pico (Microcontroller): It serves as the central processing unit which receives data from the sensors and issues control signals to the relays and capacitors.
Voltage and Current Sensors: It measures the electrical parameters in the grid, giving real-time data for power factor correction and voltage control.
Relays: These switch the capacitors in the APFC system to supply the reactive power compensation and correct the desired power factor.
Capacitors: Used to compensate for the reactive power, thus upholding the power factor in the system.
tPower Supply: Supplies the required voltage for feeding the Raspberry Pi Pico and other accompanying circuitries.

Display: An LCD or digital display brings real-time information about system variables such as voltage, current, and power factor.

III. UNITS

Use either SI (MKS) or CGS as primary units. (SI units are strongly encouraged.) English units may be used as secondary units (in parentheses). This applies to papers in data storage. For example, write ―15 Gb/cm^2 (100 Gb/in^2). ‖ An exception is when English units are used as identifiers in trade, such as ―3½ in disk drive. ‖ Avoid combining SI and CGS units, such as current in amperes and magnetic field in oersteds. This often leads to confusion because equations do not balance dimensionally. If you must use mixed units, clearly state the units for each quantity in an equation.
The SI unit for magnetic field strength H is A/m. However, if you wish to use units of T, either refer to magnetic flux density B or magnetic field strength symbolized as μ0H. Use the center dot to separate compound units, e.g., ―A·m^2. ‖

IV. HELPFUL HINTS

A. Figures and Tables

Block Diagram Components and Connections:
1. Raspberry Pi Pico (Microcontroller)
the central processing unit that controls the entire system, processes input data from sensors, and sends control signals to relays and capacitors.
2. Power Supply
Supplies the required power to the Raspberry Pi Pico, sensors, and other components. It should be able to supply both DC for the microcontroller and AC for the motors and relays.
3. LCD (Display)
Displays real-time values such as power factor, voltage, and current. The Raspberry Pi Pico interfaces with the LCD to output these values.
4.Relay1, Relay2, Relay3
oThese relays control the capacitors in the APFC system. The Raspberry Pi Pico will trigger them to adjust the reactive power compensation dynamically.
5.Capacitor1, Capacitor2, Capacitor3
oUsed for reactive power compensation. Capacitors are controlled via relays to improve the power factor at different load conditions.
6. Switch Box (230V AC Supply)
This connects the AC input, usually taken from the grid or the mains supply. The switch box may be used as a switch ON/OFF system for the whole device or to distribute power to motors.
7. Signal Sensor Module
Measures values such as current, voltage, and phase angle. The sensor transmits this information to the Raspberry Pi Pico where it is processed for control.
8. CT (Current Transformer) Motor1, Motor2, Motor3
These are the industrial or load-side equipments monitored by the system. These motors can be controlled by Raspberry Pi Pico, or alternatively, the raspberry pi pico may respond to their operational status by changing the UPFC and APFC settings according to the required action. Each of the motors will have a corresponding current transformer that measures the electrical current flowing through them.

B. References

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Smart Power Flow Management Using UPFC in Modern Grids - Discusses advanced control algorithms for UPFC in grid-connected systems, including methods to reduce total harmonic distortion. MDPI, 2022【32†source】.

V. PUBLICATION PRINCIPLES

1.Raspberry Pi Pico-Based Unified Power Flow Controller and Automatic Power Factor Correction System The system works in a dynamic manner, constantly changing the power parameters in real time to enhance power quality and energy efficiency and stabilize voltage. Here is a technical breakdown of how the system operates:

Getting Started: Power Supply and Initial Setup

2. A 230V AC supply enters the Switch Box that energizes the arrangement. This power is shared with different components including Raspberry Pi Pico, Signal Sensor Module and Motors (CT Motor1, Motor2, Motor3) and Relays/Capacitors.

No Signal Detection or Data Gathering

3.Signal Sensor Module (SSM) which rotates and monitors the electrical parameters of the system

VI. CONCLUSION

This project demonstrates a Unified Power Flow Control/Automatic Power Factor Corrector System designed with Raspberry Pi Pico. This project showcases how inexpensive microcontrollers also like the Raspberry Pi Pico can tackle big problems of power management such as power factor correction, voltage stabilization, energy efficiency, etc. The controller system has automatically monitored and controlled the quality of the power used for the real-time system and is adaptive in nature for the current market of power electronics since it can improve the power quality and minimize the energy losses to a greater extent while also providing a scalable solution for a variety of applications including industrial PSs and renewable energy (RE) grids. This is useful in showing how simple hardware and software can go a long way in making power management solutions more optimized, reliable, and sustainable.

VII. APPENDIX

APFC: ACTOMATIC POWER FACTOR CORRECTION
IOT: INTERNET OF THINGS
PFC: POWER FACTOR CORRECTION
PWN: PULSE WIDTH MODULATION
UPFC: UNITIED POWER FLOW CONTROLLER

VIII. ACKNOWLEDGMENT

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