**C O V E N T R Y**

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| Faculty of Engineering and Computing  Department of Aerospace, Electronic and Electrical Engineering  6040CEM Individual Project Realization  Software-based Control System and Validation Model for Voltage Source Inverter  Student Name: Wong Jun Jie  Student ID (CU): 11843544  Supervisor: Chai Yoon Yik  Submitted in partial fulfillment of the requirements of the Degree of Bachelor of Electrical and Electronic Engineering  **Session: Apr 2024** |

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# Introduction

In the search for a sustainable energy future, the necessity for innovative and cost-effective solutions is more important than before. As countries around the world work to fulfill this demand, the focus on renewable energy technology has been growing. Malaysia is on the path of a major change in its energy policy and market dynamics, pushed in large part by the government's commitment to promoting renewable energy use. This thesis addresses a significant gap in the Malaysian market: the development of locally produced photovoltaic (PV) power inverters that are complying with national policies and market demands.

Currently, most PV power inverters in Malaysia are imported and not designed to the local environment or market requirements. The gap has become more significant as government policies support the deployment of renewable energy technologies, increasing demand for PV-related power systems. The lack of locally developed solutions creates a unique opportunity for Malaysian businesses to innovate and compete in this rapidly growing sector.

The primary goal of this project is to develop a fundamental framework that allows for rapid development of power conversion systems. This includes motor control and other applications that need AC power control and generation, which are critical for maximizing the efficiency and efficacy of renewable energy systems. The project's technological focus is on developing a software-based control system with digital signal processors (DSP) or microprocessors. This system can also be used as a validation model for the development of voltage source inverters, which are required to convert direct current (DC) from PV panels into usable alternating current (AC).

This thesis will explore the design, development, and testing of this model, emphasizing its potential to be adapted for various applications within the renewable energy sector. By doing so, it aims to not only fill a critical market gap but also contribute to the global effort towards energy sustainability.

### Problem Statement:

To achieve sustainable energy future, innovative and affordable solutions are in need as the current market does not have any available system that is suitable to local market. With the increased demand and government policy adaptation to promote renewable energy usage, a solution for Malaysia will be a hotcake in the next few years.

### Problem Analysis:

Currently Most of the PV Power Inverters are imported and do not have any solution that is developed specifically locally. As the government policy changes will increase the demand of the PV-related Power System solution, this has created a market and opportunity for local companies to develop a solution that is both competitive and innovative with first-class performance.

### Project Objective:

This project is aimed to design a foundation, or model which will allow rapid development for Power Conversion System, as well as Motor Control and other applications which apply AC Power Control and Generation.

### Technical Objective:

Software-based (DSP/microprocessor) Control System and validation Model for Voltage source Inverters Development:

* Total Harmonic Distortion of the Output Waveform (THD%) < 5%
* Active and Reactive Power Control
* Single Phase Power Exchange Control with Three Phase Power Exchange Capabilities.

# Literature Review

System Overview

System Diagram

## Synchronous Reference Frame based Control.

Fundamental Concepts: Describe the synchronous reference frame (SRF) technique and its role in enhancing the performance of power converters and AC motor drives.

Benefits in Power Systems: Explore the advantages of SRF-based control in managing and synchronizing with the grid, particularly for renewable energy integration.

## Clarke Park Transformation

Overview and Theory: Introduce the mathematical foundation and purpose of Clarke and Park transformations in electrical engineering, particularly in the context of simplifying the analysis of three-phase circuits by converting them to a two-axis coordinate system.

Application in Power Electronics: Discuss how these transformations are used in the control of AC motors and inverters, highlighting their importance in achieving accurate and efficient control in power conversion systems.

## Positive, Negative and Zero Sequence

Positive and Negative and Zero

## How Positive and Negative Sequence affects the overall systems.

Definition and Impact: Explain what positive, negative, and zero sequence components are and their significance in power systems.

Influence on System Performance: Analyze how these components affect the stability, fault tolerance, and overall efficiency of electrical systems.

## Power Injection

Concept and Techniques: Review methods of power injection in power systems, focusing on renewable energy sources.

System Integration Challenges: Discuss the challenges and solutions related to integrating high levels of renewable energy into the grid, emphasizing power quality and stability.

## Design Software (MATLAB Simulink)

# Methodology

## Grid Information Extraction

Voltage SRF

Current SRF /w Controller

## PLL Loop Tuning

PLL Tuning for the Gain

## PI Synchronous Reference Frame Control

Reference Injection

Output Transformation

## PI controller Gain Tuning (Include in the PI synchronous discussion)

## Reference Generation

Id and Iq reference Generation

## Ideal Grid /w Load Testing

LCL and load current

## Reference Id generation Algorithm (Comparing it with other papers)

Integration type

# Result and Analysis

## PLL Response under Different Tuning

For this Testing, we will test PLL with different Gain Value. We will obtain the response of the PLL to track grid frequency from 55Hz to 50Hz (Grid Frequency). We will also analyze the ωt behavior under different gain.

Change Kp, Ki ,Kd from the system

## Output Waveform across Different Power Reference (for THD%)

In this testing, we will determine output power and the THD% of the Output Current under different power reference (assuming no power limit on the DC Link with stiff voltage regulation)

Pref = 0, 500 , 1000 , 2000, 3000, check THD and waveform

## PI response under different Kp and Ki (need to find a way to express the findings)

This testing will determine the reference current behavior under different Kp and Ki. The Current reference will be following the last test of the system.

Response Under the condition

Kp : 0.25, 0.5, 1 @ Ki = 1

Ki: 0.25, 0,5, 1 @ Kp = 1

## Transient Response During Startup of the System between

This testing will determine the transient on different injection point from grid current and grid voltage.

Voltage Reference, Current Reference feed into the logic.

Refence Generation

Testing under different mode (equivalent output Power from DC link Capacitor or pow

# Conclusion and Future Recommendations

The Use of the DDSRF

Negative Sequence Reference Frame

Three Phase DC Link Design

# Reference/Bibliography

Meow