جامعة قطر
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Department of Electrical Engineering

Development of Instrumentation for High-Precision Angular Position and Speed Measurement

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Abstract

The two main aims of this project are to design an online correction method to correct the imbalances within these sinusoids as well as designing a powerful low-cost converter that is able to extract the angle from the outputs of trigonometric sensors at high accuracy and speed. Throughout the project, two novel online correction techniques were introduced, in addition to a closed loop method. Intensive simulation and implementation was practiced heavily within the project.

Introduction

As technology advanced, the need for more precision becomes critical in many fields. Because of this, precise angular position and speed measurements became crucial in many applications. An example of this is industrial applications like factories automation in which large robotic arms are used in production lines as seen in Figure 1.

The objectives of the project can be briefed in the following points:

- Design, simulate and test an open-loop resolver' s signals correction technique.
- Design, simulate and test an open-loop resolver-to-digital conversion technique.
- Implement a recent closed-loop resolver-to-digital converter and compare the results with the designed open-loop converter.

Figure 1: Robotic arms in an automated factory

Signals Correction

- The most significant causes of errors are amplitude and phase imbalances. A novel method was introduced, and an example of a signal before and after correction can be seen in Figure 2.

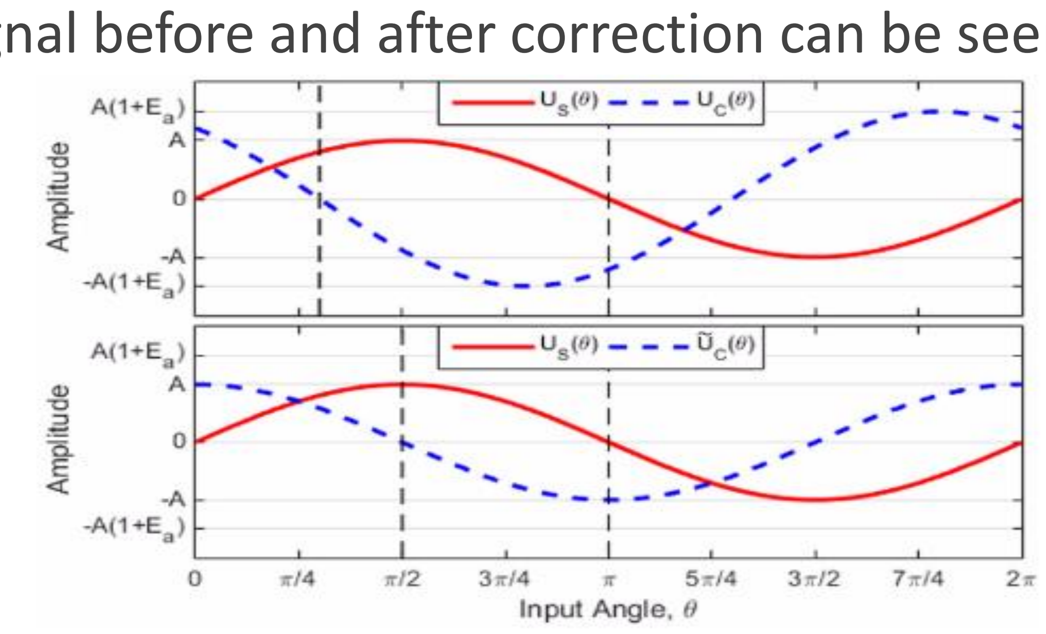


Figure 2: Example of transducer signals before and after balancing

Open Loop

- Adaptive method, as it is independent of the sensor output amplitude.
- Allows the user to compromise between processing speed and results accuracy, depending on the application.

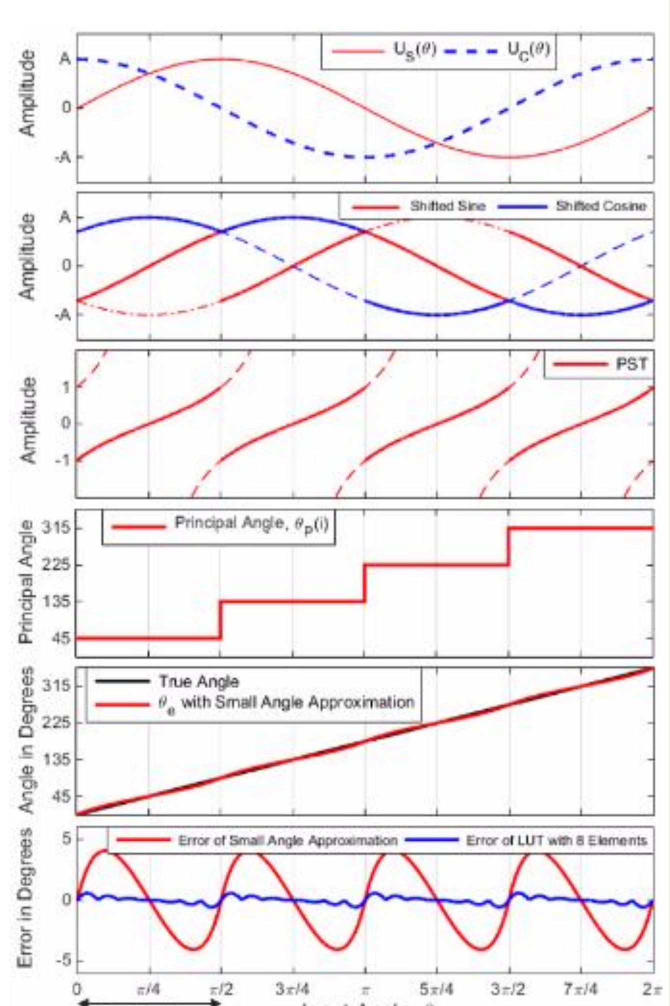


Figure 3: Simulation results for converter with N=4. From top to bottom: The SCS, shifted sine and cosine waves where the solid line portions represent the segments used to determine PST, PST, principal angle in degrees, estimated angle and the residual converter error.

Closed Loop

- Closed loop, PLL, have been successfully implemented. The error was very close to zero in simulation with Simulink.
- The dynamic response was improved using the auxiliary compensator output in the system.

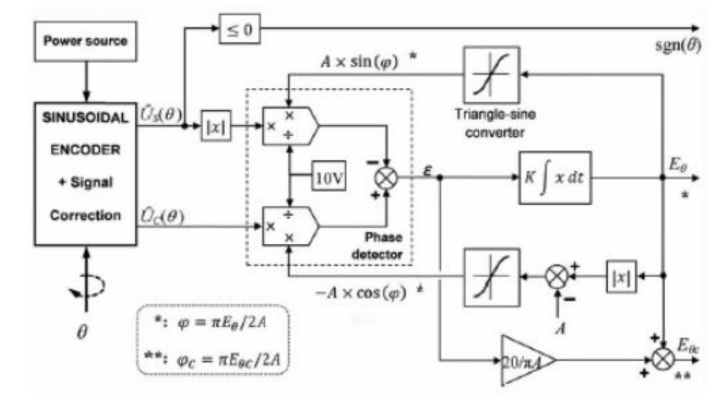


Figure 4: The schematics of the proposed method of the PLL converter

Test Bench

- Real-life test bench was designed in SolidWorks and 3D printed to perfectly align the components, reducing the error.
- Software test bench was made using LabVIEW, allowing the user to set the different testing settings and view the results directly.

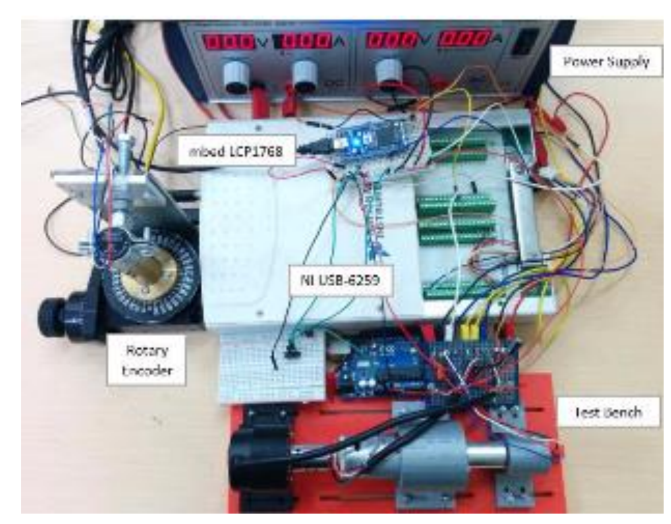
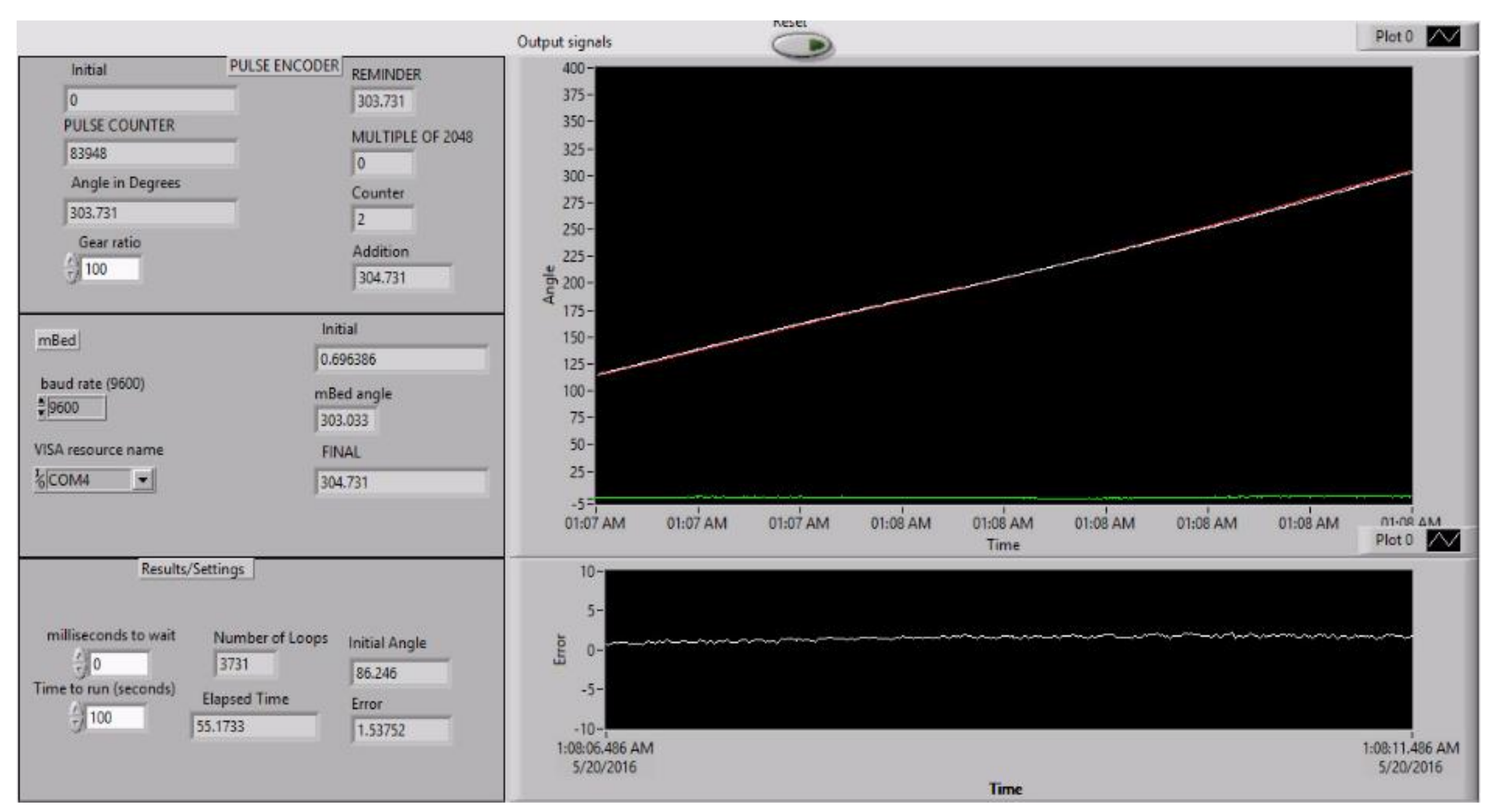


Figure 5: Practical test bench

Results

Figure 6: Results using LabVIEW test bench



- The above figure shows the output results gained using the LabVIEW test bench, with the error displayed against the angle coming from the mbed MCU and the pulse encoder output.

Conclusion and Future Plans

- Implementation was successful across multiple platforms, ranging from the Simulink and LabVIEW simulations to converters programmed on Arduino and mbed MCUs.
- The team is planning to expand the work done, building on the novel methods introduced, and performing more testing with the tools created during the project.

References

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