Project Report

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Course Name: Smart Electronic System Design Paradigm

Instructor: Mr. Kishor Narang

Title: Design of a solution for energy monitoring and harmonic measurement up till 2.5 kHz i.e. 50th harmonic of AC sinusoid.

Team Members: Manoj Gulati [PhD-1327] (2nd Year PhD Student). I will be working on this design individually.

Problem Statement: In this project we are trying to design a system having somewhat similar in functions to power quality analyzer but the goal is to design this using off the shelf components and make the design low cost so that it can be used by community working broadly in smart energy and power quality monitoring.

Scope of the Project: The goal of this project is to design a circuit for sensing harmonics and energy parameters like real power, line voltage, line current and power factor. Some such systems exist for power quality monitoring, having an operational range from 0 Hz - 2.5 kHz (50^{th} Harmonic of AC sinusoid), but they find limited usage due to higher costs (>$2-4000) [1]. Some systems have been designed by NILM community as well for harmonic analysis (up to 50^{th} harmonic) but they are not being commercialized and are limited for lab settings. With this new design we will be able to characterize any given appliance under test (AUT), using both harmonic analysis as well as electrical parameters. These two diverse features can be leveraged for power quality monitoring and appliance level profiling. So far no such work exist in literature which has exploited both of these features jointly. As we have 50 individual feature vectors in case of harmonics, these can be leveraged for the task of appliance profiling efficiently.

One alternate application of this system could be for power quality analysis as our system will be capable to monitor electrical parameters as well as harmonics up to 2.5 kHz so we can do complete power profiling using this system and provide detailed harmonic level details to the end user.

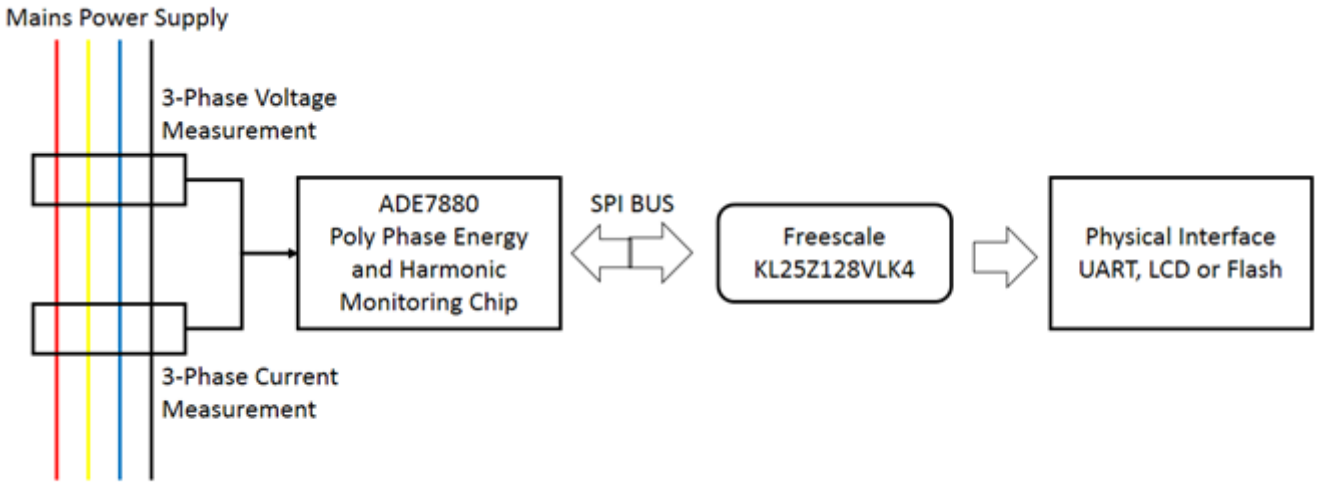
Steps Involved In This Project:

- Starting with a Cortex M0+ processor and learn basic working of GPIO's, communication protocols like SPI, UART, I2C and Ethernet.
- Design a board for ADE7880 Poly-phase Energy measurement chip [2, 3] having harmonic measurement range up to 50^{th} harmonic and a port to extract raw time domain data using sigma-delta ADCs.
    - This involves schematic capture in ORCAD.
    - ERC and DRC checking of layout.
    - Pre-fabrication and post fabrication verification of circuit.
    - Final testing of board after soldering of all components.
- Once the design for ADE7880 board is fabricated this has to be tested thoroughly.
- After getting familiar with peripherals of Cortex M0+, a stable SPI or I2C host implementation has to be done to interface it with ADE7880.

- Data has to be extracted from ADE7880 registers for fetching electrical parameters from ADE7880.
- Based upon timings constraints, we will fetch harmonic data from ADE7880 and match it with any off the shelf power quality measurement product, in order to compare and benchmark our design.
- Some basic analytics can be done using a limited set of appliances to show appliance level data.

NB: This project requires a lot of hardware stuff, which are subjected to be delayed in shipping and fabrication so these delays have to be considered in actual design timeline.

Block Diagram



Block Diagram for energy measurement system with harmonic analysis up to 2.5 kHz

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Components Used: ADE7880, Freescale KL25, ADUM3401, LDO 3V3, 12MHz Crystal OSC, ADR280ARTZ.

Deliverables:

1. As a first step in this timeline I would like show basic working of cortex M0+ processor to have a though understanding of this processor.
2. Second step is to integrate this with ADE7880 board and read registers to fetch electrical parameters and log them in real time on serial terminal/ or serial flash.
3. Third and most important step is to fetch harmonic level data from ADE7880 and display it either on terminal, a graphic LCD and log them in serial flash.
4. One extra step is to compare results from this design with any off the shelf power quality measurement system to benchmark this design.

References

1. http://in.element14.com/fluke/fluke-1735/analyser-power-57v-830v-1a-10a/dp/1272821
2. http://www.analog.com/en/analog-to-digital-converters/energy-measurement/ade7880/products/product.html
3. http://www.analog.com/static/imported-files/data_sheets/ADE7880.pdf