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Design of SMD PCBA for ADE7169 based single phase power meter / Noradilah Auyob.

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Bachelor of Electrical Engineering (Industrial Power)

May 2010

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"I hereby declare that I have read through this report entitle Design of SMD PCBA for ADE7169 Based Single Phase Power Meter and found that it has comply the partial fulfillment for awarding the degree of Bachelor of Electrical Engineering (Industrial Power)"

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DESIGN OF SMD PCBA FOR ADE7169 BASED SINGLE PHASE POWER METER

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A report is submitted in partial fulfillment of the requirements for the degree of Bachelor of Electrical Engineering (Industrial Power)

Faculty of Electrical Engineering

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2010

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"I declare that this report entitle Design of SMD PCBA for ADE7169 Based Single Phase Power Meter is the result of my own research except as cited in the references. The report has not been accepted for any degree and is not concurrently submitted of any other degree"

Signature :.....

Author : NORADILAH BINTI AUYOB

Date : 22 APRIL 2010

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To my beloved mother Jamaliah binti Abdul Rahman and father Auyob bin Adon

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ABSTRACT

Single phase power meter is use to measure current, voltage and power in single phase system. The purpose of this project is to Design SMD PCBA for Single Phase Power Meter Circuit Using ADE7169. This Printed Circuit Board (PCB) layout based on ADE7169 will have high accuracy, reliability and low power losses that can give an efficient measurement relate to the utility tariff. Methodology of this project is literature review, design the circuit using PCB software and fabricate the design layout. Expectation of this project is the PCB layout can complete design without any error problem and the layout have been etch. Finally, the PCBA can provide excellent performance in measurement for our billing at home.

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ABSTRAK

Meter kuasa satu fasa digunakan untuk mengukur arus, voltan dan kuasa dalam sistem satu fasa. Tujuan utama projek ini dilakukan ialah untuk merekabentuk PCBA untuk meter kuasa satu fasa yang dapat memberikan bacaan yang tepat, betul dan berfungsi sepenuhnya dilengkapi dengan paparan bacaan secara digital. Untuk menyiapkan projek ini, metodologi yang di lakukan ialah dengan membuat kajian ilmiah dan membina litar dengan menggunakan perisian PCB dan melakukan simulasi untuk memastikan litar berfungsi seperti yang telah direkabentuk. Jangkaan keputusan dalam projek ini adalah himpunan bagi papan litar bercetak boleh berfungsi apabila komponen selesai dihimpunkan di atas papan. Akhir sekali, himpunan papan litar bercetak tadi boleh digunakan dengan baik dalam pengukuran kuasa di dalam rumah

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CHAPTER 1

INTRODUCTION

Chapter 1 give an overview of Design of SMD PCBA for ADE7169 Based Single Phase Power Meter, the objective of the project are stated clearly. There are few problem statements that explain about the existing problems which is eventually lead to this project development. The methodology explains briefly about the project flow. The scope of work which consisting of hardware and software development is being discussed in this chapter as well.

1.1 Basic Power Meter

An electricity meters operate by continuously measuring the instantaneous voltage (volts) and current (amps), instantaneous power (watts) which is then integrated against time to give energy used (joules and kilowatt-hours). The single-phase electronic electricity meters are usually designed for active energy measurement for direct connection in single-phase in 2-wire network low voltage with frequency 50Hz or 60Hz which is used especially in rural areas. There are two types of power meter:

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1.1.1 Analog power meter

Analog power meter is also known as electromechanical meter that has a spinning disc and a mechanical counter display. The most common type of electricity meter is the Thomson electromechanical induction watt-hour meter, invented by Elihu Thomson in 1888. This type of meter operates by counting the revolutions of a metal disc that rotates at speed proportional to the power drawn through the main fuse box. The number of revolution is thus proportional to the energy usage.

This metallic disc has two operated coil. One of the coils function is to produces a magnetic flux in proportional to the voltage and the other produces magnetic flux in proportion to the current. The field of the voltage coil is delayed by 90 degrees using a lag coil. (Fleming J.A, 1914) Thus, it produces eddy currents in the disc and the effect is such that a force is exerted on the disc in proportion to the product of the instantaneous current and voltage. A permanent magnet exerts an opposing force proportional to the speed of rotation of the disc and will stopping its spin after power has been removed.

The amount of energy represented by one revolution of the disc is denoted by the symbol *Kh* which is given in units of watt-hours per revolution. The value 7.2 is commonly seen. Using the value of *Kh*, one can determine their power consumption at any given time by timing the disc with a stopwatch. If the time in seconds taken by the disc to complete one revolution is *t*, then the power in watts is $P = \frac{3600 \cdot Kh}{t}$. This method can be used to determine the power consumption of household devices by switching them on one by one.

In an induction type meter, creep is a phenomenon that can adversely affect accuracy of power measurement. It is occurred when the meter disc rotates continuously with potential applied and the load terminals open circuited. The Figure 1.1 shows the analog power meter.

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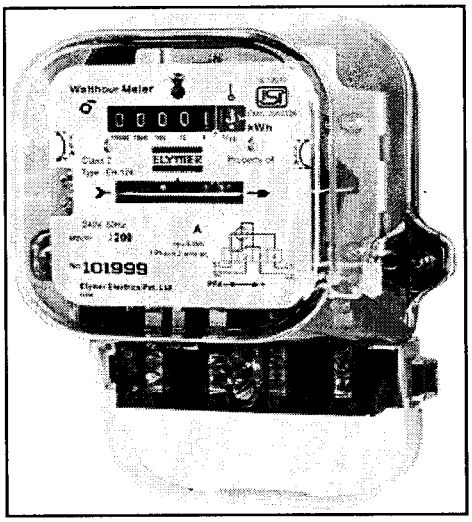

Figure 1.1: Analog Power meter

1.1.2 Digital Power Meter.

Electronic meters measure energy using highly integrated components, such as the ADE516x, ADE556x, ADE716x, ADE756x, and ADE77xx families of energy measurement ICs. These devices digitize the instantaneous voltage and current via a high-resolution sigma-delta ADC. Computing the product of the voltage and current gives the instantaneous power in watts. Integration over time gives energy used, which is usually measured in kilowatt hours (kWh). The energy data is displayed on a liquid-crystal display (LCD). The ADE ICs have been tested using an accelerated life test. The results proved the ADE performance to be accurate and reliable for 60 years. Figure 1.2 shows the digital power meter.

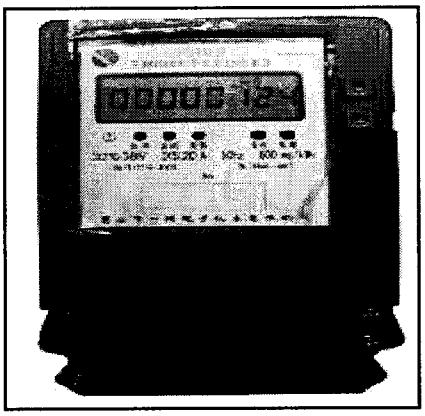

Figure 1.2: Digital Power Meter

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1.1.3 Advantages of Digital Power Meter

Electronic meters have high accuracy over a wide current dynamic range, are able to handle higher currents, have low power consumption, and are reliable and robust (stable over time and temperature). (Kaplan.R, 2003) Electronic meters also offer several benefits. In addition to measuring instantaneous power, they can measure other parameters such as power factor and reactive power. Data can be measured and stored at specific intervals, allowing the utility to offer price plans based on time-of-day of usage. In addition, electronic meters are not influenced by external magnets or orientation of the meter itself, so they are more tamper-proof than electromechanical meters. Electronic meters are also highly reliable. (Harney.A, 2009)

1.2 Problem Statement

Locally designed and low cost electronic power meter with high accuracy is not readily available. Another problem is most of the power meter use generic microcontroller which is complicated and not accurate and have limited power measurement variable.

1.3 Objectives

The objectives of this project are:

i. To study about the PCB design software
ii. To understand about PCB circuit design
iii. To design the Single Phase Power Meter of SMD PCBA using ADE7169 circuit.

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1.4 Scope

The scope of this project is to design single phase power meter of SMD PCBA using ADE7169. This meter will use the digital concept provide with Liquid Crystal Display (LCD), energy mesurement unit, battery management and Real-Time Clock (RTC).

1.5 Thesis Outline

1.5.1 Chapter 1 – Introduction

This chapter is about the introduction of Design of SMD PCBA for ADE7169 Based Single Phase Power Meter. The basic power meter was already explained and clearly about specification for this project. Then, know about the types of power meter and its advantages.

1.5.2 Chapter 2 – Literature Review

This chapter is explain about the Printed Circuit Board (PCB), software and the Integrated Circuit (IC) that to use in this project. The Theoretical Study will be discussing on some related theories and explanations on each equipment used in this project. Fact and finding is the formal process to collect and capture the entire information about system, system requirements and system preferences. In addition, information source can be gathered in formal sources and informal sources. For formal sources the information can be gathered from books, journal, research papers, encyclopedias, newspapers, magazines, handbooks, thesis, bibliographies and World Wide Web (WWW).

1.5.3 Chapter 3 – Methodology

This section will describe the flow of this project. It is an important criterion for this project. This chapter discussed about procedures that will use in this

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project. It begins by choosing a topic of project, research and finally completing by developing the system. The purpose in this chapter is to implement this system smoothly and follow the planning that has been decided.

1.5.4 Chapter 4 – Result

This chapter will be discussing about the result that is obtained from the project

1.5.5 Chapter 5 – Analysis and discussion of the result.

As the result is present, the analysis and discussion of the result will be discussed in this chapter.

1.5.6 Chapter 5 – Conclusion and recommendation

This chapter are consists two subtopics which are the conclusion as well as the recommendation towards this project. To develop this project, it must be considered to the research element as the main point.

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CHAPTER 2

LITERATURE REVIEW

In this chapter, there are two main subtopics which are Related Previous Project and Theoretical Study. The Related Previous Project gives some review on several previous projects. In addition, the Theoretical Study will be discussing on some related theories and explanations on each equipment used in this project. Fact and finding is the formal process to collect and capture the entire information about system, system requirements and system preferences. Fact and finding is most crucial to the system planning and system analysis phase. It helps to learn about the vocabulary, problems, opportunities, constraints, requirements and priorities of a business and a system.

Resource of information should be collected from variety source. Information source can be gathered in formal sources and informal sources. For formal sources the information can be gathered from books, journal, research papers, encyclopedias, newspapers, magazines, handbooks, thesis, bibliographies and World Wide Web (WWW). For formal information sources it includes contact with peers, colleagues, supervisor and the user of the system. As a whole, the literature review draws on the knowledge, culture, methodology and theories of the topic.

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2.1 Printed circuit Board (PCB)

A printed circuit board (PCB) is interconnects electronic components without discrete wires as shown in Figure 2.1. It used to mechanically support and electrically connect electronic components using conductive pathways, or traces, etched from copper sheets laminated onto a non-conductive substrate. It is also referred to as printed wiring board (PWB) or etched wiring board. A PCB populated with electronic components is known as a printed circuit board assembly (PCBA) as shown in Figure 2.2. Printed Circuit Boards (PCB) are primarily an insulating material used as base, into which conductive strips are printed. The base material is generally fibreglass, and the conductive connections are generally copper and are made through an etching process. (Kia.B, 2005)

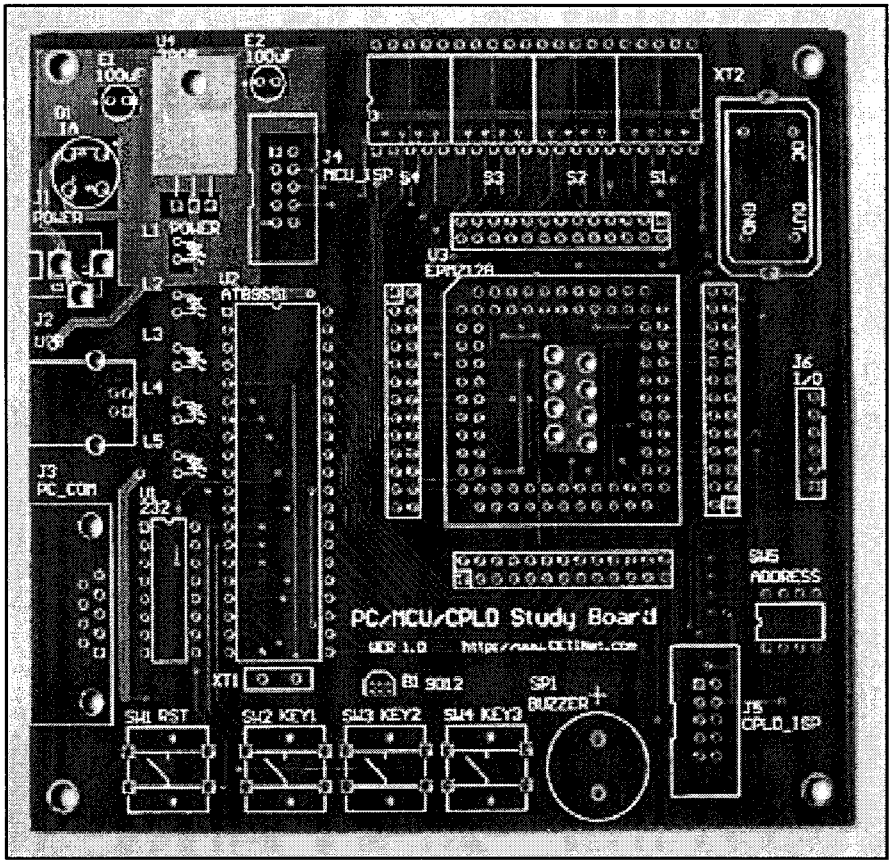

Figure 2.1: Printed Circuit Board (PCB)

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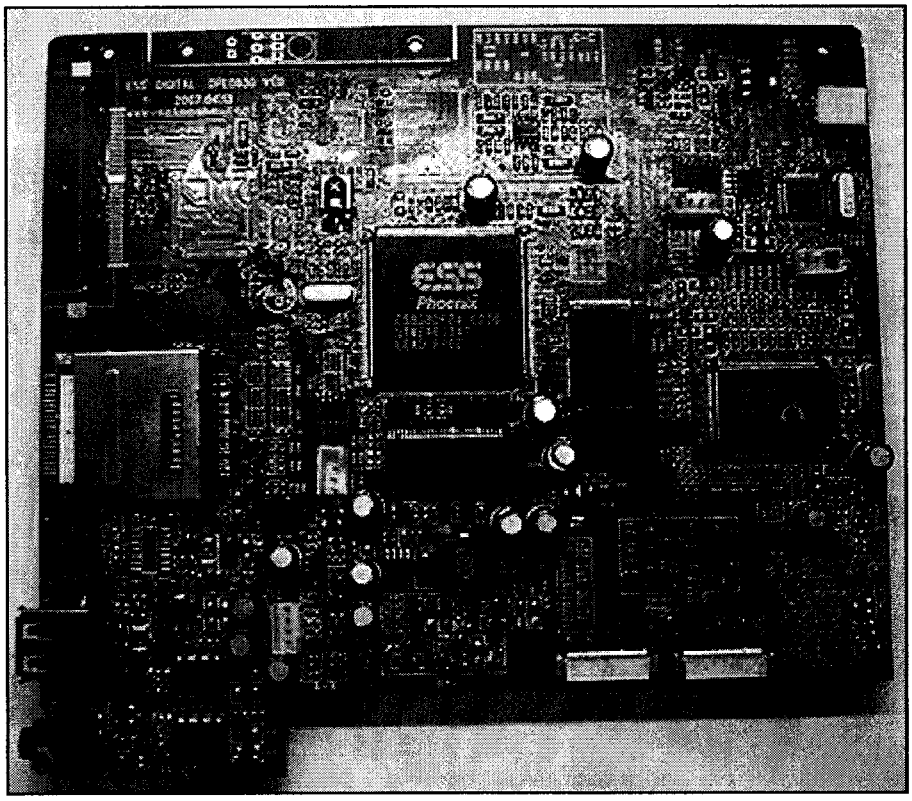

Figure 2.2: Printed Circuit Board Assembly (PCBA)

2.1.1 PCB design layer

There are three major types of printed circuit board construction which is single-sided, double-sided and multi-layered. Single-sided boards have the components on one side of the substrate. When the number of components becomes too much for a single-sided board, a double-sided board may be used. Electrical connections between the circuits on each side are made by drilling holes through the substrate in appropriate locations and plating the inside of the holes with a conducting material. The third type, a multi-layered board, has a substrate made up of layers of printed circuits separated by layers of insulation. The components on the surface connect through plated holes drilled down to the appropriate circuit layer. This greatly simplifies the circuit pattern. (Kia.B, 2005)

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2.1.2 The Printed Circuit Board (PCB) Layout

The connections on the PCB should be identical to the circuit diagram, but while the circuit diagram is arranged to be readable, the PCB layout is arranged to be functional, so there is rarely any visible correlation between the circuit diagram and the layout. (Clydy.F, 2007)

PCB layout can be performed manually (using CAD) or in combination with an Autorouter. The best results are usually still achieved using at least some manual routing simply because the design engineer has a far better judgement of how to arrange circuitry. Surprisingly, many autorouted boards are often completely illogical in their track routing. The program has optimised the connections, and sacrificed any small amount of order that may have been put in place by manual routing. Generally autorouted boards are somewhat harder for a technician to repair or debug, for this reason. Historically, PCBs used to be laid out by drawing or using stick on paper shapes on mylar film for manual routing.

The CAD PCB layout consists of several layers, for illustration often the layers will be coloured and compressed into the one overlay image. When doing layout boards, try to use actual size check plots at some stage during the design process. Most overlays need to be printed out enlarged to show the detail, but an actual size print, with mounting holes and possibly cut outs, is a great check tool. The print itself can be placed inside the actual enclosure, to see how it will be positioned in relation to other parts and place components up against the pad markings as a quick idiot-check of dimensions.

Took a bit of effort into the PCB design which is the quality of design can make a difference. The width of the tracks is a trade-off based on current flow, space available, size of parts, and electromagnetic interference. The track layout is a similar trade-off that also picks when to dodge from one side of the board to the other to avoid an obstacle, but overall normally aims to find the shortest regular path between the connected points. Given the impedance, susceptibility, and signal

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on tracks, the loop area is another trade-off that is considered as the design procedures

2.1.3 The process of manufacturing the PCB board

Figure 2.3 below shows the process of manufacturing the PCB board.

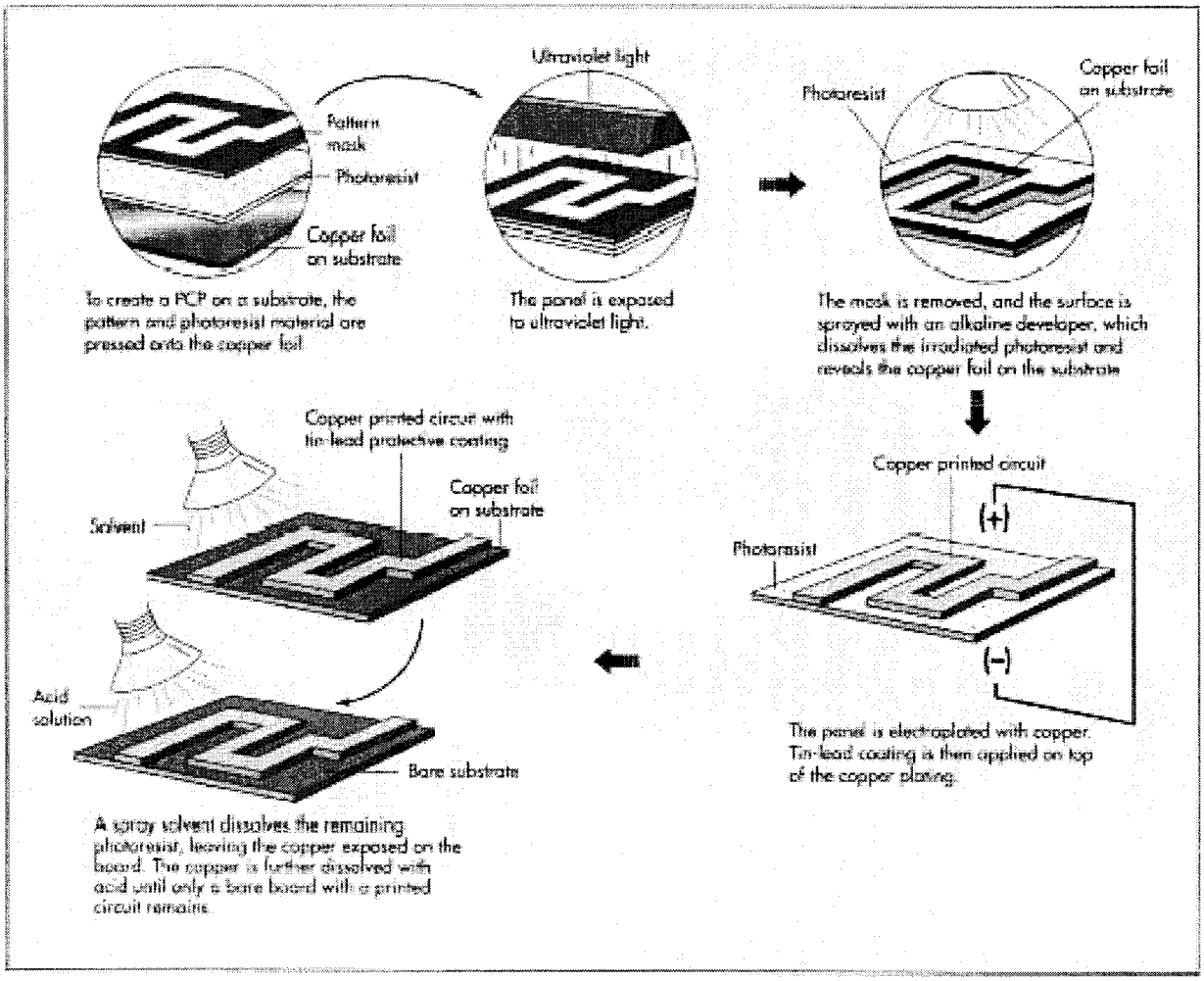

Figure 2.3: Process to manufacturing the PCB board

1) Woven glass fiber is unwound from a roll and fed through a process station where it is impregnated with epoxy resin either by dipping or spraying. The impregnated glass fiber then passes through rollers which roll the material to the desired thick-nests for the finished substrate and also remove any excess resin.

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