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Implementation of Reflow Soldering Oven

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Abstract – Soldering is an important and difficult task for custom printed circuit board design especially for integrated circuits that come as chip packages that are impossible to solder by hand. This is particularly true for ball grid arrays (BGA) and small-pitch quad flat packs. If one chooses to design a custom printed circuit board around these chips, then the designer may wish to also purchase a stencil of the designed board that would allow him to squeegee solder paste precisely on the SMD pads. The designer would then carefully place the components on the board, and heat the solder paste with a heat gun or a reflow soldering oven. The problem with reflow soldering ovens is that they are expensive and cost thousands of dollars. So this paper focuses on implementation of reflow soldering oven using normal toaster oven by controlling temperature working of this oven will be same as reflow solder oven so it results in to lower cost model.

Index Terms – Reflow soldering oven, SMD soldering.

1. INTRODUCTION

This paper contains implementation of reflow solder oven by using normal toaster oven. Soldering is an important and difficult task for custom printed circuit board design especially for integrated circuits that come as chip packages that are impossible to solder by hand. This is particularly true for ball grid arrays (BGA) and small-pitch quad flat packs. If one chooses to design a custom printed circuit board around these chips, then the designer may wish to also purchase a stencil of the designed board that would allow him to squeegee solder paste precisely on the SMD pads. The designer would then carefully place the components on the board, and heat the solder paste with a heat gun or a reflow soldering oven. The problem with soldering ovens is that they are expensive and cost thousands of dollars. We have decided to come up with a cheap and working solution to the problem by using a normal toaster oven and controlling it through a microcontroller along with an LCD display that guides the user through the soldering process and constantly provides feedback on the state of the system while reflow soldering.

The input to the system would be via a conventional keypad and would consist of target temperature point at specific times that the user would enter based on the solder paste's recommended temperature profile. The system would interpolate the temperatures for the in-between time intervals and follow the curve generated by the input. The system would also fulfill the appropriate safety requirements and have the capability of aborting the process in case of a mishap. Reflow soldering, like wave soldering, is not a new manufacturing process. The hybrid industry has used and refined the art of reflow soldering for many years. However, with the advent of Surface Mount Technology (SMT), reflow soldering has expanded in the number of types and has been studied, refined and explored as never before. Many different opinions have been expressed about the best process. We have found that the best or optimum process is the solder process which resulted in meeting the goals of reflow soldering for the SMT application. When we have to solder SMD components, they are very small and leads of components are very small to solder. So, these SMD components are very difficult to solder correctly. And it may be damage the components and PCB also. There are few techniques which are used for soldering SMD components like;

1) Hand soldering
2) Hot-Air gun
3) Reflow oven

For hand soldering we have to use binoculars to see the leads of SMD components which are very very small in size, sometimes use of binocular may damage to human eye. And hand soldering do not give accurate soldering. Instead of this technique we use Hot-Air gun technique for soldering of SMD components. But Hot-Air gun technique need more care full observation. Use of Hot-Air gun is very difficult as like hand soldering. It may damage the PCB's and nearby component by high temperature. So reflow is the most convenient method of soldering.

2. BLOCK DIAGRAM

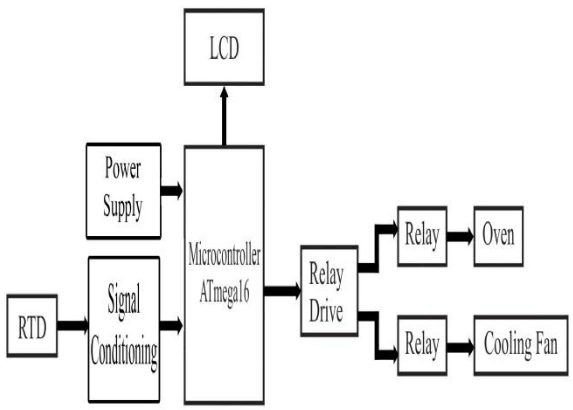

Figure 1. Block Diagram

The system is a microcontroller based system which will be dynamic as far as signaling time is concerned.

The ATmega16 is a controller with High performance, low power AVR 8-bit microcontroller. Advanced RISC architecture. On-volatile program and data memories. On chip analog comparator.40-pin DIP with 32 programmable I/O lines. Operating voltages - 4.5V to 5.5V.Power consumption at 4 MHz, 3V, 35°C.For microcontroller & other circuits power supply circuit is designed using rectifier filter & regulator ICs 7805, 7812 .Which generates 5V&12V voltage.

Micro-controller is connected to relay driver & relay driver is connected to oven & cooling fan. According to change in temperature either fan will be turned on or off.

To sense the temperature of oven RTD is connected inside oven which is used to sense the temperature inside oven further it is connected to microcontroller through signal conditioner circuit. Main task is to maintain temperature of oven in proper way as that of reflow oven which is necessary for proper soldering process. Thus RTD is used to sense temperature According to set point controller controls relay driver so as to maintain proper temperature.

Temperature Profile for Convection Reflow oven is as shown below. There are four stages can be followed in reflow soldering oven system which are mentioned bellow

1. Preheat zone
2 .Thermal soak zone
3. Reflow zone
4 .Cooling zone

This is the main logic used in reflow solder oven.

It is possible implement same technique in conventional oven by controlling temperature as shown in following graph of Temperature profile for convection Reflow oven.

1. Preheat zone:

Maximum slope is a temperature/time relationship that measures how fast the temperature on the printed circuit board changes. The preheat zone is often the lengthiest of the zones and often establishes the ramp-rate. The ramp–up rate is usually somewhere between 1.0 °C and 3.0 °C per second, often falling between 2.0 °C and 3.0 °C (4 °F to 5 °F) per second. If the rate exceeds the maximum slope, damage to components from thermal shock or cracking can occur. Solder paste can also have a spattering effect. The preheat section is where the solvent. In the paste begins to evaporate, and if the rise rate (or temperature level) is too low, evaporation of flux volatiles is incomplete.

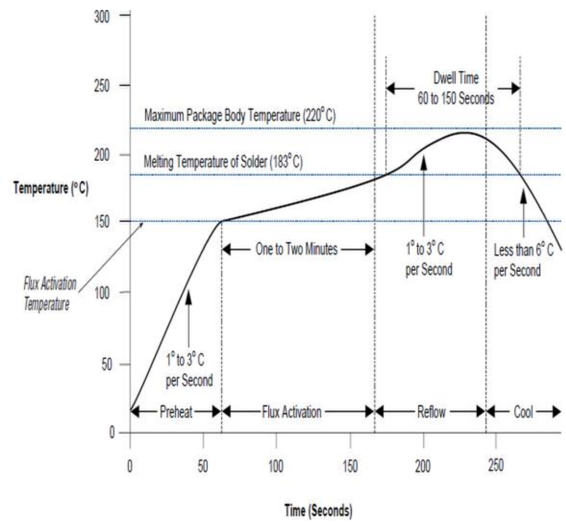

Figure 2: Temperature Profile for Convection Reflow oven

2. Thermal soak zone:

The second section, thermal soak, is typically a 60 to 120 second exposure for removal of solder paste volatiles and activation of the fluxes (see flux), where the flux components begin oxide reduction on component leads and pads. Too high a temperature can lead to solder spattering or balling as well as oxidation of the paste, the attachment pads and the component terminations. Similarly, fluxes may not fully activate if the temperature is too low. At the end of the soak zone a thermal equilibrium of the entire assembly is desired just before the reflow zone. A soak profile is suggested to decrease any delta T between components of varying sizes or if the PCB assembly is very large. A soak profile is also recommended to diminish voiding in area array type packages

3. Reflow zone:

The third section, the reflow zone, is also referred to as the “time above reflow” or “time above liquids” (TAL), and is the part of the process where the maximum temperature is reached. An important consideration is peak temperature, which is the maximum allowable temperature of the entire process. A common peak temperature is 20–40 °C above liquids. This limit is determined by the component on the assembly with the lowest tolerance for high temperatures (The component most susceptible to thermal damage). A standard guideline is to subtract 5 °C from the maximum temperature that the most vulnerable component can sustain to arrive at the maximum temperature for process. It is important to monitor the process temperature to keep it from exceeding this limit. Additionally, high temperatures (beyond 260 °C) may cause damage to the internal dies of SMD components as well as foster intermetallic growth. Conversely, a temperature that isn’t hot enough may prevent the paste from reflowing adequately. Time above liquids (TAL), or time above reflow, measures how long the solder is a liquid. The flux reduces surface tension at the juncture of the metals to accomplish metallurgical bonding, allowing the individual solder powder spheres to combine. If the profile time exceeds the manufacturer’s specification, the result may be premature flux activation or consumption, effectively “drying” the paste before formation of the solder joint. An insufficient time/temperature relationship causes a decrease in the flux’s cleaning action, resulting in poor wetting, inadequate removal of the solvent and flux, and possibly defective solder joints. Experts usually recommend the shortest TAL possible, however, most pastes specify a minimum TAL of 30 seconds, although there appears to be no clear reason for that specific time. One possibility is that there are places on the PCB that are not measured during profiling, and therefore, setting the minimum allowable time to 30 seconds reduces the chances of an unmeasured area not reflowing. A high minimum reflow time also provides a margin of safety against oven temperature changes. The wetting time ideally stays below 60 seconds above liquids. Additional time above liquids may cause excessive intermetallic growth, which can lead to joint brittleness. The board and components may also be damaged at extended times over liquids, and most components have a well-defined time limit for how long they may be exposed to temperatures over a given maximum. Too little time above liquids may trap solvents and flux and create the potential for cold or dull joints as well as solder voids.

4. Cooling zone:

The last zone is a cooling zone to gradually cool the processed board and solidify the solder joints. Proper cooling inhibits excess intermetallic formation or thermal shock to the components. Typical temperatures in the cooling zone range from 30–100 °C (86–212 °F). A fast cooling rate is chosen to create a fine grain structure that is most mechanically sound. Unlike the maximum ramp-up rate, the ramp–down rate is often ignored. It may be that the ramp rate is less critical above certain temperatures however; the maximum allowable slope for any component should apply whether the component is heating up or cooling down. A cooling rate of 4°C/s is commonly suggested. It is a parameter to consider when analyzing process results.

3. HARDWARE SETUP

Hardware setup shows implementation of reflow solder oven using conventional oven. By controlling temperature of conventional oven it is possible to operate it as a reflow solder oven. As mentioned above there are four important zones of temperature. Preheat zone, Thermal soak zone, Reflow zone, cooling zone. Following hardware setup shows oven along with electronic circuit.Temparature of this oven is also controlled in same way & it passes through same temperature zones. This temperature helps solder paste to melt properly & set.

Figure 3: Snapshot of final set up

4. EXPERIMENTAL RESULTS

Following photographs shows results of soldering in oven.

PCB is shown before soldering & after soldering. From results it is clear that if temperature of this oven is accurately controlled quality of soldering is same as that of reflow oven soldering.

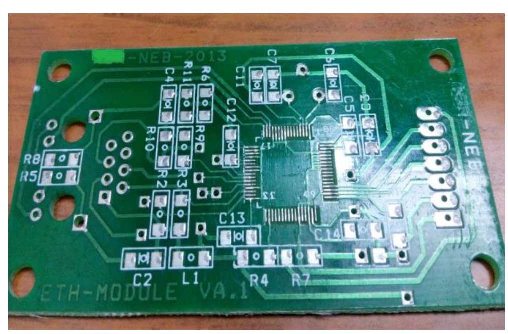

Figure 4: Snapshot of PCB without soldering

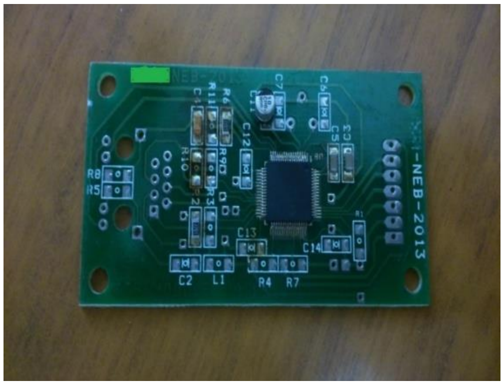

Figure 5: Snapshot of PCB with soldering

5. CONCLUSION

This system is best alternative for reflow solder oven as it is cost effective & affordable as compared to reflow solder oven. Quality of soldering is approximately same as that of reflow oven. Maximum flexibility to allow soldering a large number of circuits with minimum changeover time. It can be very useful in small scale industries to solder SMD components.

REFERENCES

[1] “Infrared Reflow Soldering Re-examined” Philip Zarrow - SMTA ’88 Proceedings
[2] Design and Construction of a Reflow Soldering Oven Solomon Gebre, Keith E. Johnson, William Joshua Russell, and Clement Sung-Jay SunUWEE Technical Report Number UWEETR-2006-0010 June 16, 2006 Department of Electrical Engineering University of Washington Box 352500 Seattle, Washington 98195-2500
[3] “Fluorinert Liquids, Vapor Phase Condensation Heating Reference” 3M, Industrial Chemical Products Division
[4] “Temperature Profiles: The Key for Proper Surface Mount Assembly Process Control” John Maxwell - CARTS ’88 Proceedings
[5] “Desiccant Packaging of Moisture Sensitive Electronic Devices” Joseph M. Williams - SMART IV Proceedings
[6] “Moisture Induced Cracking in Plastic Encapsulated Surface Mount Components during Solder Reflow Process” R. Lin, E. Blackshear, P. Serisky
[7] “Moisture Effects on Susceptibility to Package Cracking in Plastic Surface Mount Components" S.F. Gordon, W. Huffman, K. Yee, et al
[8] “Selectron Criteria for Infrared ReflowSoldering Systems” P. Zarrow - SMART IV Proceedings
[9] “Concerns in Wave and Infrared Soldering of Surface Mount Assemblies” Don Elliott, SMTA ’88 Proceedings 10. “Moisture Induced Plastic IC Package Cracking” Surface Mount Council, Package Cracking Task Force
[10] “Wave Solder Process for Surface Mount Applications” KEMET F-2101 J. Bergenthal
[11] “Surface Mount Mounting Pad Dimensions and Considerations” KEMET F-2100 J. Bergenthal
[12] “Soldering in Electronics” R.J. Klein Wassink; Electrochemical Publications
[13] “Vapor Phase curing of Polymer Thick Film Resistors and Conductors” A. Schultheiss, R.S. Briggs, Dr. P. Srinvasan; Expo SMT ’88 Proceedings
[14] “What’s New In Vapor Phase” D. Linmon; Expo SMT ’88 Proceedings
[15] “Processing Considerations for Surface Mount Connectors” M. Jackson; Expo SMT ’88 Proceedings