Next Generation Wave Solder Process Control
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Many manufacturers take simple temperature profile measurements as their benchmark for process control during the wave soldering process, when in fact there are many more parameters which affect the performance of the process that should also be measured.

Introduction

Wave soldering is a long established process with many parameters that must be controlled to maintain high yields on the production lines.

Many manufacturers take simple temperature profile measurements as their benchmark for process control, when in fact there are many more parameters which affect the performance of the process and should therefore be measured.

In many cases a reflow profiler is used with thermocouples mounted to a test PCB or a simple fixture manufactured from CDM or similar material. This is perfectly valid for measurement of the pre-heater performance or the solder pot temperature; however using simple thermocouples alone to measure PCB to solder wave contact parameters can sometimes produce incorrect results.

Thermocouple are excellent at measuring temperature, however when used to capture contact time or solder wave parallelism from the solder wave they can mask a number of actual problems within the machine setup.

There are four main issues with thermocouples for use in the measurement of contact parameters,

1. The response time is relatively slow to the changes in temperature (see Figure 1), even when fine gauge thermocouples are used we see significant measurement errors with the contact times measured. This is particularly evident when measuring chip waves which typically have very short contact times.

2. Thermocouples will measure a valid contact time even when not actually in contact with the solder wave, we can see in Figure 1 that the red traces has not made actual contact with the wave, but a dwell time would still be registered

3. With the advent of lead free many machines are moving the position of the chip wave and main wave closer together. This makes differentiation of the two waves much more difficult when employing thermocouples as the measurement method and compounds the inherent errors caused by slow response times.

4. It is not possible to measure the solder wave height/PCB immersion depth accurately and repeatable
What are the alternatives?

A simple tempered glass plate has been traditionally used to visually measure the contact area between the PCB and solder wave. When passed through the machine the engineer and visually see the wave shape and take rudimentary measurements.

SolderStar have taken this concept one stage further and produced a special device named the ‘SolderStar WaveShuttle PRO’. Now in its 3rd evolution the WaveShuttle allows the engineer to record digitally not only temperatures from the process but also PCB contact area and wave height from the solder wave.

The WaveShuttle fixture uses SolderStar’s SmartLink interface to extend the use of its reflow data loggers to the special requirements of the wave solder process, crucially two measurement systems are used in parallel combined with special contact sensors to capture all key parameters from the wave solder machine.

What can we measure?

Temperature parameters are automatically decoded from the left and right PCB’s sensors fitted to the WaveShuttle, a solder pot temperature probe is also used to capture accurate solder pot reading. The following temperature parameters are measured:-

- Maximum PCB topside temperatures
- Solder temperature
- DeltaT when the PCB makes contact with wave
- Topside temperature of PCB when makes contact with wave
- Time above liquidus
- Soak times
- Component heating rates
What can we measure? (Continued)

Wave parameters are automatically measured with a 2\textsuperscript{nd} measurement system and contact sensors mounted directly onto the pallet.

The following wave parameters are measured with a single pass,

- Solder Wave Height / PCB Immersion Depth
- Main Wave contact time/length
- Chip Wave contact time/length
- Conveyor Speed
- PCB to Conveyor Parallelism
- Wave Shape

WaveShuttle contact measurement points

The WaveShuttle PRO has contact pins C1–C7 and a Wave Height Sensor array mounted as shown in the diagram below.

The contact pins are mounted flush with the lower edge of the WaveShuttle side rails and are therefore presented to the wave at the same height as the underside of a PCB mounted in the machine conveyor fingers.

Each contact C1–C7 along forms a discrete contact sensor; the wave height array can be calibrated for use with a number of different board thicknesses.

The WaveShuttle measurement system records temperature profile information but also scans all the contacts 100 times per second looking for the solder wave contact. Measurement of the time and duration each contact is connected to the solder wave is recorded. This information is transmitted to the SolderStar PRO data logger at the end of the run and is uploaded to the PC along with temperature profile information for decoding by the PC.
Advantages of this approach

- The contact sensing is virtually instantaneous giving clear and repeatable timings.
- Contacts are sampled **100 times per second** which allows very accurate measurement of contact/dwell times on turbulent chip waves.
- **Only when contacts actually touch is timing triggered.** Thermocouple based systems rely on a heat threshold level to activate timing. This could lead to false triggering and erroneous results.
- The multiple contacts allow timing throughout the wave **front to rear** and **left to right** allowing pot levelling and conveyor angles to be evaluated.
- Conveyor speed measurement accuracy is also dramatically increased.
- Wave height / PCB immersion can be measured.

**Typical Cause & Effects**

Below are some screen captures from the information gathered by the Wave Shuttle PRO device after a pass through the wave solder process.

The increased detail and graphical presentation of captured information allows the engineer to highlight and resolve process problems much more quickly.

**Good Solder Wave Contact Map**

- Red area is voiding detected within the wave
- L/H Side of Main Wave
- Front edge of Main Wave
- Chip Wave
- Main Wave
- Gap between solder pots
**Parallelism Problem**

Problem with wave parallelism  
L/H Side of Main Wave  
-ve parallelism measurement  
+ve parallelism measurement  
Typical causes  
• Solder Pot not level

Main Wave (Single wave machine)

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**Voiding Problem**

Red area indicated % of void detected  
Voids are short periods of time when contact with the wave is lost within the overall contact window. Voiding should be expected on the chip wave plot due to its turbulent nature.  
Typical causes  
• Wave height set to low  
• Baffle blockage  
• Dross build up

Main Wave (Single wave machine)
Contact/Skip Problem

Problem with L/H side of chip wave is detected on C1

Typical causes

• Baffle blockage
Statistical Process Control (SPC)

Once the wave soldering process has been analysed by the WaveShuttle product it is possible for the engineer to measure the effect of adjustments to the wave soldering machine.

Given this information it is a quick procedure to optimise the process and gain control of the many machine variables.

Moving forward from this point the WaveShuttle fixture makes a highly repeatable measurement platform and provides all the necessary tools to analyse the process statistically.

Once a historical log if obtained of the performance within the process by capture of daily runs from the production lines, the trends and Cpk values can automatically be displayed.

WaveShuttle SPC Manager
Summary

Next generation wave soldering tools are now available to allow the engineers controlling the wave soldering process to quickly measure and establish a complete list of measured parameters in a single pass.

Special measurement circuits and sensors are used to capture both temperature profile information and also detailed PCB to wave contact information. Use of graphical display techniques allows the engineer unprecedented insight into the variables evident in the process, plus the cause and effect of making adjustments to these variable.

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About SolderStar

SolderStar is a specialist in the design, development and manufacture of thermal profiling equipment for the lead-free electronics industry. Incorporating state-of-the-art technology and full lead-free protection, SolderStar’s range of instruments and software tools offers leading-edge performance, functionality, heat-resistance and miniaturisation.

SolderStar satisfies all of today’s thermal process control needs, from full-feature high performance product profiling for reflow and wave solder processes, to fully integrated SPC capabilities for continuous quality and process control.

Products are available individually or in packages that are tailor-made to suit the technical and budgetary requirements of all electronics manufacturers, whatever their size and needs and wherever they are in the world.

For more information about SolderStar, visit the company’s website at www.solderstar.com.