Importance of Wave Height Measurement in Wave Solder Process Control

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It is still common place to simply capture temperature profile measurements as a benchmark for wave soldering process control, when in fact there are many more parameters which must be controlled to obtain maximum performance from this dynamic soldering process.

Introduction

Wave soldering is a long established process which yields both high quality soldering and throughput if set up and controlled effectively. Machines and the related processes have evolved, but largely the individual elements of fluxing and pre-heating, which is followed by one or two solder baths has stayed the same.

Simple temperature based measurement of the process has been used over the years by utilising existing profiling instruments designed primarily for use on the SMT reflow ovens. Additionally, high temperature glass plates were passed through the machines by the engineer to view the wave to PCB contact area with the human eye. The glass plate method is highly informative, but still relies heavily on human judgment, as the measurement is a visual snapshot and not easily recorded.

In many cases, engineers construct a simple fixture with thermocouples mounted to a test PCB, this is perfectly valid for the 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 produce inaccurate results.

Thermocouples are excellent at measuring temperatures; 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 set-up.

The importance of Solder Wave Height

The wave solder process has a variety of settings that must be adjusted by the operator. This can directly impact the soldering performance. The pre-heat and solder temperature set-points are established using the techniques already discussed, but contact time, conveyor speed and wave height are all inter-related and more difficult to measure accurately.

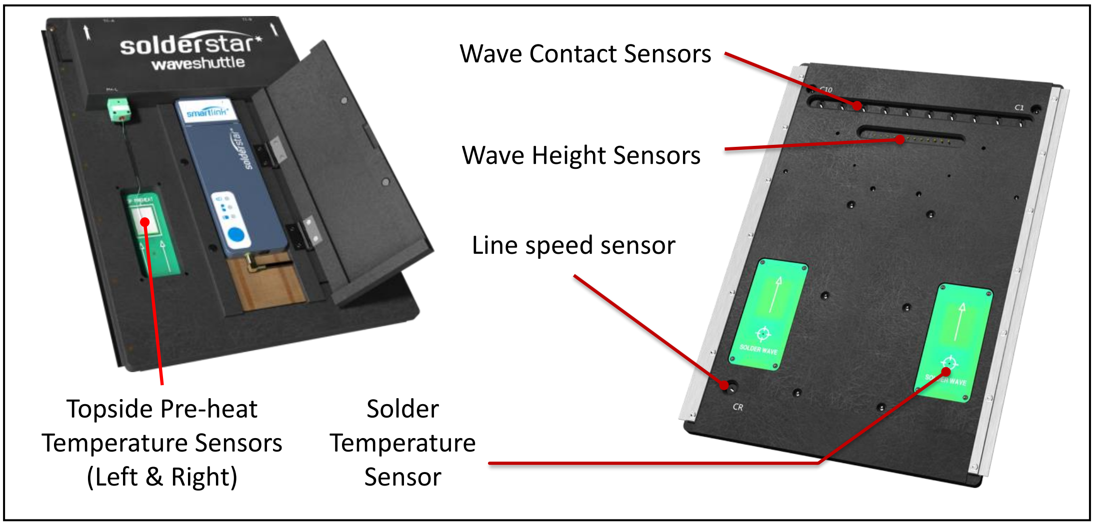
The industry ‘rule of thumb’ for PCB to solder wave contact time of 2 – 4 seconds is commonly used, but this key parameter is influenced by both conveyor speed and the height of the solder wave. Incorrect contact times will result in poor solder penetration within the though-hole joints.

An increase or decrease in solder wave height will result in contact time variations. To correctly ensure this parameter is controlled fully, the height of wave , the speed and the resultant contact times need to be measured independently. Previously this has only been possible through mechanical methods which are not a practical technique in the production environment. Other methods using a temperature sensor yield are only an estimation of these important parameters and cannot therefore be relied upon.

The SolderStar Solution

SolderStar has developed a special device called the WaveShuttle PRO to help in accurately measuring the process control of wave soldering machines. This specialised instrument allows the engineer to digitally record the temperatures from the process, and also the contact information and wave height from the wave solder process in a single pass of the machine.

The WaveShuttle fixture features the unique Solderstar SmartLink interface which allows a standard profiling datalogger device to extend its use to the special requirements of the wave solder process. Crucially, *two* measurement systems are used in parallel, combined with special titanium contact sensors to capture all key parameters from the wave solder machine.



WaveShuttle measurement technique

The WaveShuttle PRO uses two independent and specialised circuits for temperature and wave contact measurement. Temperature profiles are captured using traditional thermocouple sensors, but contact sensing is performed by an array of titanium sensors which are scanned 100 times per second ensuring measurements are both accurate and repeatable.

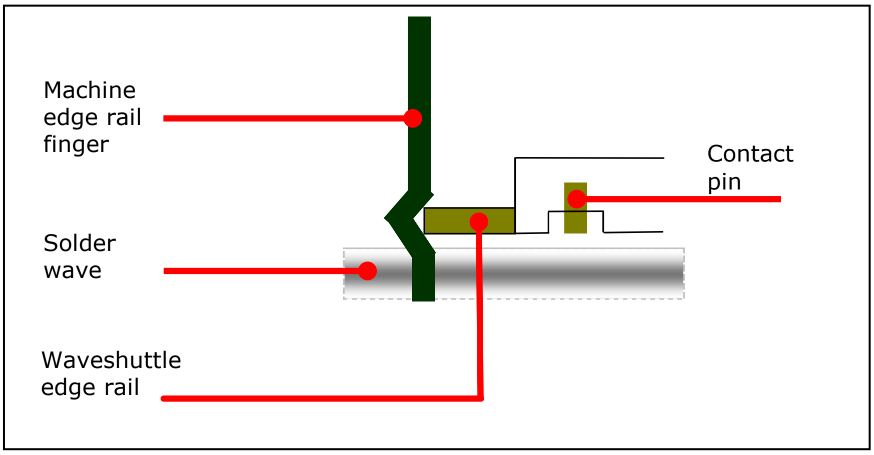
A line array of sensors are positioned on the front of the measurement fixture to give contact information across the whole working width of the solder wave. These sensors also allow measurement of the PCB to Wave parallelism.

Additionally, stepped wave height contacts are positioned during the process to allow this crucial parameter to be measured reliably. These sensors are adjustable to set at a different height at the time of manufacture, with tolerances of +/- 0.1mm achievable.

A rear sensor is also fitted to allow independent verification of the line speed of the machine.

The edge rails fitted to the WaveShuttle form the electrical ground connection of each of the contacts. Each contact along with the edge rail forms a discrete electrical switch circuit (Figure 2), which operate when contact with the solder and the contact pin is made. This results in a true contact detection method.

Figure 2:



Advantages of this approach

- Only when contacts actually touch the solder wave, is timing triggered. Thermocouple-based systems rely on a heat threshold level to activate timing. This leads to false triggering and erroneous results
- Wave height can now be accurately measured
- Contacts are sampled 100 times per second which allows for a very accurate measurement of contact/dwell times on turbulent chip waves.
- The multiple contacts ensures timing throughout the wave front to rear, and left to right, allowing pot levelling and conveyor angles issues to be evaluated.
- Conveyor speed measurement accuracy is also dramatically increased
- Another advantage of accurate timing data of solder contact is the ability to calculate key temperature parameters with improved repeatability.

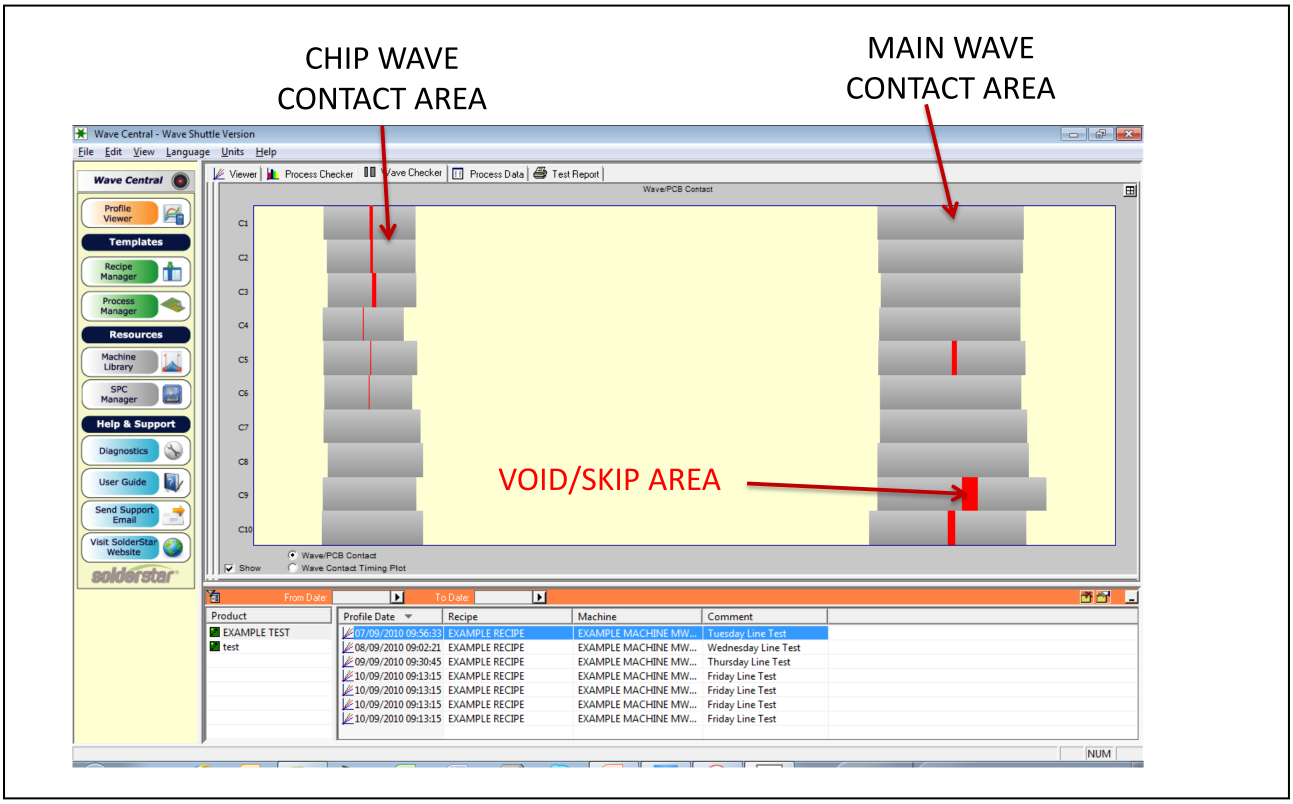
All key temperature parameters are automatically decoded from the left and right PCBs fitted to the WaveShuttle system also benefit from a specially designed solder pot temperature probe which is used to capture accurate solder pot readings.

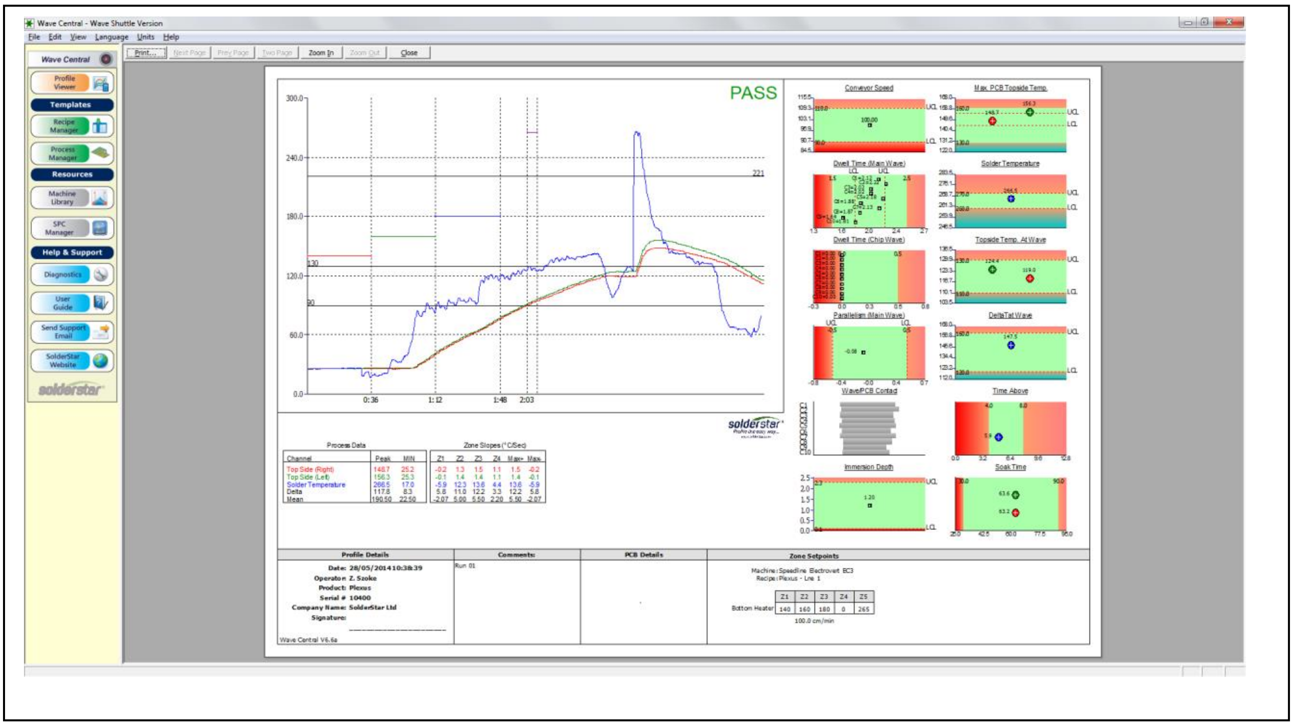
Wave to PCB Contact Measurement – ‘Digital Glass’ technology

Solderstar has long recognised that using graphical approaches to present data gathered by its instruments to users is the most effective way to communicate measurements.

Wave to PCB contact measurement is taken from the underside titanium contacts and the rapid scanning circuitry. The result is a detailed timing plot of actual activity in terms of solder wave contact.

Not only can the contact time be measured to an accuracy of 0.01 seconds, but also a graphical view can be displayed of the actual contact area, the wave positions and any area of voiding.





What parameters can be measured in a single pass?

Wave Parameters measured:

- Wave Height / Immersion depth
- Main Wave contact time/length
- Chip Wave contact time/length
- PCB to Conveyor Parallelism
- Conveyor Speed

Temperature Parameters:

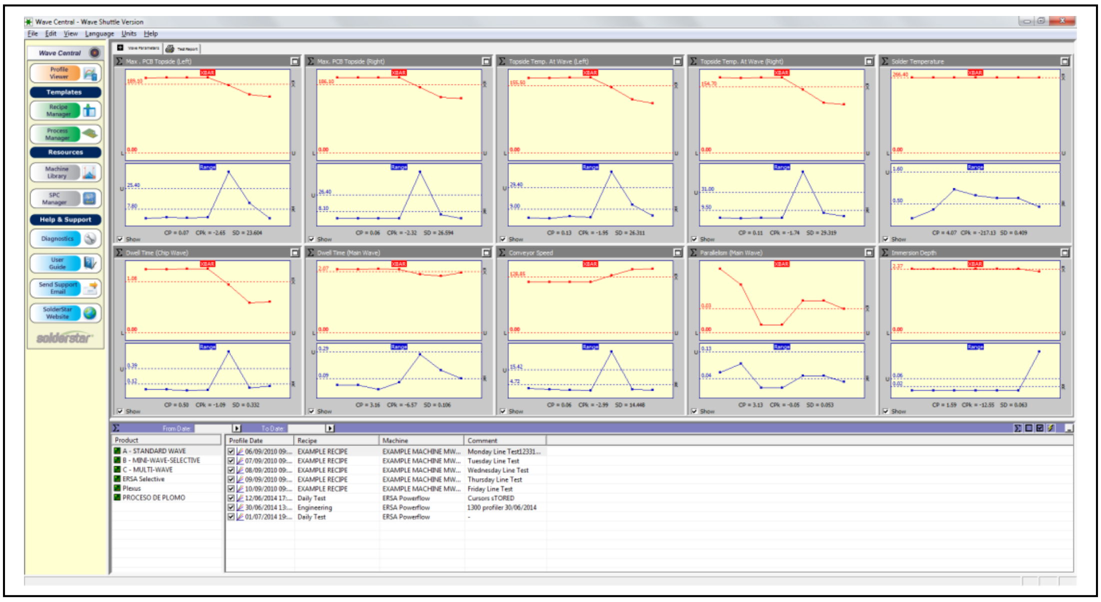
- Maximum PCB topside temperatures
- Solder temperature
- DeltaT when the PCB makes contact with wave
- Topside temperature of PCB when in contact with the wave
- Time above liquidus
- Soak times
- Component heating rates

Statistical Process Control (SPC)

The SolderStar WaveShuttle makes it possible for the engineer to measure the effect of adjustments to the wave soldering machine. Given this information, it is a quick procedure then to optimise the process and gain control of the many machine variables.

This captured production data uses the SPC tools built into the Solderstar software allowing the engineer to analyse the process statistically.

Xbar and Range charts can quickly be plotted to gain an insight into process stability and highlight any process trends allowing preventative action to be taken before production quality is impaired.



Conclusion

Wave soldering measurement techniques used by many engineers simply rely on temperature measurement sensors,by utilising existing profiling instruments designed primarily for use on the SMT reflow ovens. Measurements taken using temperature measurement alone does not represent a true picture of the process capability. New measurement methods and technologies employed in products such as the WaveShuttle PRO , are widely accepted as a step forward and the correct way to control this process with increased confidence.There are methods to ensure the measurement of the wave soldering process is captured and accuracy is ensured, whether it is the wave height or speed measurement to key temperature parameters and improved repeatability.

The responsibility for the process no longer falls on the shoulders of the engineer, it can now be measured precisely with the use of specially designed equipment that ensures quality of the soldering performance, resulting in a traceable and accurate final process.