



SELECTIVE SOLDERING – HOW IT HAS EVOLVED TO BECOME AN INTEGRAL METHOD IN TODAY’S MANUFACTURING PROCESSES

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Since regulations were brought in from the European Union’s Waste Electrical and Electronic Equipment (WEEE) and the Restriction of Hazardous Substances (ROHS) to enforce lead-free soldering, the use of selective soldering techniques have increased greatly.

Selective soldering is the method of soldering selectively through-hole (TH) components on a mixed technology assembly, which would otherwise need to be hand soldered, or passed over a wave soldering machine following the soldering of the SMT elements within a reflow oven. It is commonly used where a number of conventional technology components or connectors need to be added to high quality medical, automotive or aerospace SMT assemblies. To combat the potential damage to the surrounding parts on the PCB, the requirement for the selectively soldered region needs to be exact; this resulted in the need for process control technologies to be developed which would ensure the procedure was carried out within a defined production specification.

TH components appear in many complex mixed technology PCB assemblies and several methods of selective soldering are available that address the necessity for site specific TH soldering, including tooled dip soldering systems and programmable mini-wave machines.

The use of selective soldering for lead-free TH soldering applications requiring higher process temperatures has many advantages over other methods like conventional wave soldering due to the potential of increased reliability. Because components are exposed to lower thermal contact during the process it eliminates the potential internal thermal damage.

Some mixed-technology assemblies soldered with standard wave solder equipment would need to use custom designed carriers and masking. However many assemblies, for example, stacked and double-sided SMT assemblies, and even some TH devices, are too complex to be processed this way. The carriers required are also quite complex to produce and may render this approach prohibitively expensive.

If a board assembly cannot run through the wave soldering process, there is an option to hand solder, but this process can be inaccurate and cause failure which would require re-work. It is also prohibited in high reliability applications commonly found in the automotive and military production. To reduce this inaccuracy, specially designed selective soldering systems have been developed.

With the need for selective soldering increasing, SolderStar has developed a dedicated range of process profiling products for the selective processes. These specialised instruments have been developed, in conjunction with a leading global military and aerospace company, to provide a standalone and comprehensive setup and verification tool for their chosen selective soldering process.

This military company was already using the existing Solderstar WaveShuttle PRO system for process control on their conventional wave soldering processes. The measurement of wave contact time, immersion depth, wave parallelism and temperature profile are all required to set up the wave solder machine correctly and these measurements could be captured in one single pass with the WaveShuttle PRO.

Manufactured from 10mm anti-static composite and fitted with durable titanium side rails, the system was designed to work with daily production testing. The measurement fixture also incorporates titanium contact sensors on the underside which captures wave parameter data as it moves through the solder wave, including a true measurement of wave height. Additionally the system measures preheat profiles and solder pot temperatures.

All key process parameters are captured with a single run through the machine. Data is then downloaded via USB or wireless interface for analysis on the engineer’s computer. All parameters can be quickly analysed by using the unique Solderstar Process Checker function showing the good/bad limits to allow periodic process verification to be performed without the need for specialist knowledge.

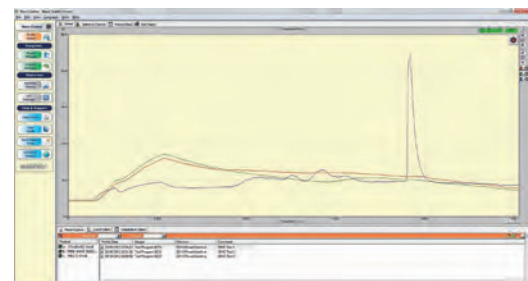


Figure 2. Mini-Wave Software Screen

By capturing data on the temperature profile, as well as solder wave interaction



Figure 1. Mini-Wave Front & Back

parameters in the same pass, it provides medium and large electronics' manufacturers with set up capabilities as well as full, cost-effective SPC of their wave soldering process.

Advantages of the WaveShuttle Pro include:

- It allows for comprehensive parameters measurement with a single pass through a machine
- It is a reliable way to solder in volume
- The titanium contact sensors offer the highest measurement accuracy on wave height, main and chip wave parameters
- Pre-heat and solder pot temperature measurement sensors are included to ensure accuracy
- The 10mm fixture provides a robust platform for daily production testing
- It can be adapted with made-to-measure widths and sensor positions available for fixed width production lines or special applications

Solderstar Smartlink system, it included a dedicated measurement fixture/pallet. This included three arrays of solder contact sensors, including;

- X Speed Sensors – which measure and verify the speed of the X axis of the machine
- Y Speed Sensor – which measure and verify the speed of the Y axis of the machine
- Height Array – Contact sensors that are set at height increments of 0.2mm to 2.4mm to allow the height of the solder 'bubble' to be verified

In addition to these innovations, a pre-heat temperature sensor and a solder temperature probe was added to verify all key parameters in a single pass.

The SolderStar WaveShuttle Selective is now the tool of choice for setup and daily testing of mini-wave selective machines. What made the SolderStar solution unique was the specially configured array of titanium

Other common problems reported by manufacturers was crystallisation occurring in the selective fluxer nozzle resulting in the mis-fluxing of components causing problems with poor wetting or leaving un-activated flux on areas of the assembly. To combat this problem SolderStar developed flux measurement sensors, which can be optionally installed to the measurement fixture. This allows for flux presence and position to be obtained as part of the daily tests.

All parameters can be quickly analysed with the good and bad limits defined easily to allow periodic process verification to be performed without the need for specialist knowledge.

System benefits of this process include:

- Verification X/Y speed and positioning
- Measurement of nozzle solder height
- All titanium wave contact measurement
- A flux measurement option
- Pre-heat and solder temperature measurement sensors
- Custom widths and sensor positions are available for fixed width production lines or special applications

The other main method seen in selective soldering is the multi-wave selective/dip soldering machine, which trades flexibility for increased throughput. With this style of machine custom wave tooling is produced to expose the molten solder selectively to the area required in a single dip. Analysis of the performance of this process needed a different approach as it was found that engineers needed the ability to produce their own analysis sensor configuration to match the tooling design.

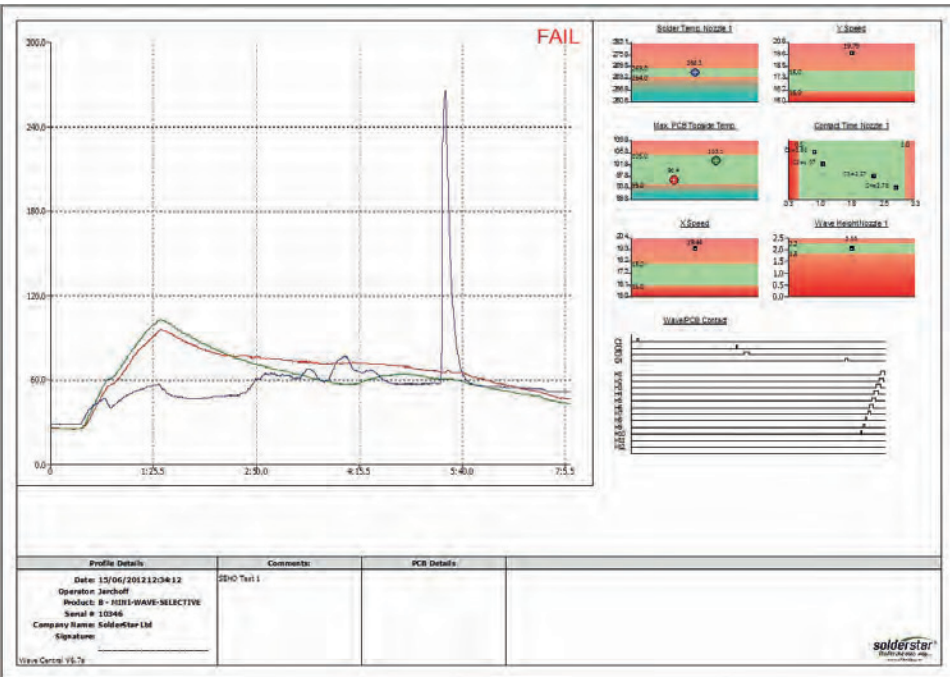


Figure 3. Mini-Wave Test Report

The new system for selective soldering was designed to analyse, improve and gain control of the mini-wave selective soldering process quickly - an important requirement put forward by the military systems manufacturer. The fixture was unique due to it incorporating two measurement systems ensuring that the most comprehensive and repeatable measurement results were obtained.

A new fixture was designed which extended the use of their existing SolderStar datalogger's and could be used on the selective soldering machines. Using the

wave contact sensors arranged on the underside of this measurement fixture to allow quick and comprehensive verification of the machine functionality.

Nozzle strikes on clinched components of the PCB due to PCB warp or general tolerances can result in the positioning mechanism of the machine becoming misaligned. X and Y positioning mechanism and speed on the WaveShuttle Selective are verified by sweeping the selective soldering nozzles between pre-defined datums. A range of stepped contact sensors are employed to allow nozzle wave height measurements to be made and periodically verified.



Figure 4. Multi-Wave Pro

SolderStar's Multi-Wave PRO was developed and comprises compact and flexible instrument design to allow dedicated test fixtures to be produced quickly and cost effectively for multi-wave soldering machines. Measurement sensors are fitted to a customer's specific location, which corresponds to the soldering areas within the multi-wave solder pot tooling, this technique provides contact time and difference data quickly allowing engineers to identify any problem areas within the tool design. Any

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FEATURE CONTINUED...

differences in nozzle to PCB contact can be easily measured providing a powerful platform for process capability analysis, improvement and on-going testing.

Features of this system include:

- Flexible design allowing measurement systems to be installed to multiple fixtures
- Solder Nozzle / PCB Contact Time
- Solder Nozzle Wave Height / Immersion Depth
- Time of first contact delta
- Pre-heat profilers
- Solder pot temperature
- Heating rates

HIGH-SPEED MEASUREMENTS REQUIRED TO YIELD ACCURATE RESULTS

The X/Y speeds in selective soldering machines can be fast which requires a quick responding measurement system to provide accurate and repeatable results.



Figure 5. Multi-Wave Software Screen

The contact sensor system used with SolderStar's development scans every 10 milliseconds and measures digitally to give extremely accurate results.

The innovative contact measurement system relies on a 'Ground' contact to be made to the machine, to detect any contact with a solder wave and it was found that on some mini wave machines the ground was not easily achievable. To combat this a ground pin was produced and placed next to each measurement sensor so repeatable and accurate measurement was always attained.

This measurement and verification is paramount in the soldering process. To produce electronic assemblies without a known thermal profile is detrimental, as you 'cannot manage what you do not measure'. There can be changes in preheat performance, settings can be accidentally edited, or nozzle build up can occur. Also, if the nozzle strikes the PCB during

production, either due to PCB warpage or incorrect machine setting, the X/Y mechanism can be thrown out of alignment and soldering will be off position.

SolderStar's X/Y speed measurement method is performed by programming the machine to sweep from sensor X1 to sensor X2, and a measurement of the time it takes for this process is calculated to verify the speed. The sensors are just 1mm and can be aligned accurately on a CNC machine fixture, allowing for alignment issues to be detected.

Having developed and evolved the selective soldering process with this ground-breaking technology, SolderStar trialed the new system with a customer, who reported all pre-heat and nozzle measurements to be accurate. It was also noted that the wave height measurement was accurate to 0.1mm. But the one area of the machine that was not tested was the fluxing stage. This is notoriously difficult to analyse electronically.

FLUXING-THE DIFFICULTY WITH SELECTIVE SOLDERING PROCESS

Flux facilitates the soldering process and has the primary purpose to clean the components that are to be soldered. To obtain a successful solder any impurity including dirt, oxidation or oil must be removed.

Flux can be removed through mechanical or chemical cleaning, but the increased temperatures required to melt the solder can make the assembly re-oxidize. This can be accelerated as the soldering temperatures increase and can prevent successful soldering.

On a conventional wave solder machine, the entire assembly generally is fluxed, preheated and passed over the solder bath. With selective soldering, only the area to be soldered by the nozzle is fluxed, with dropjet technology to spray small amounts of flux onto the PCB.

As the assembly only comes into contact with the solder nozzle in those places, any flux deposited elsewhere will not be burned off and are left on the assembly, which is not desirable and can cause failures.

The main problems reported in fluxing within the selective process is the X/Y positioning of the fluxer or crystallisation build up in the nozzle resulting in flux being deposited in the wrong areas. This problem is twofold; insufficient fluxing of necessary components resulting in poor soldering, and additionally the potential of un-activated flux seeping under sensitive electronics, producing in-field failures.

After six months of intensive development and trials due to the many types of flux, which all perform differently, SolderStar found a way to prevent this problem. The final solution was a new sensor, manufactured from high temperature thermoplastics, with an embedded stainless steel surface resistance sensors. It was developed as a configurable measurement system which has the option to be trained on different flux compositions, which can detect flux spots of 2mm upwards, a real break-through in the selective soldering process.

SELECTIVE SOLDERING - IS IT THE BEST METHOD?

Selective soldering utilises many of the concepts of other methods, but it benefits from its ability to localise soldering and fluxing with minimal pre-heating required, making it an innovative and unique technique.

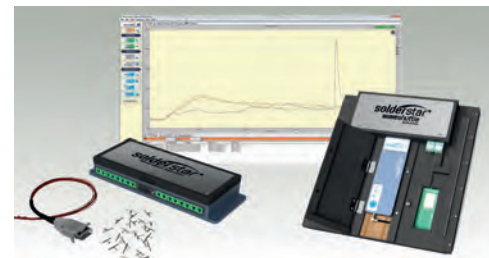


Figure 6. Selective Soldering

The use of selective soldering for lead-free TH and PCB soldering applications includes many advantages over traditional methods like wave soldering, as the thermal shock to sensitive assemblies is potentially reduced. It is a flexible and adaptable process which can be applied to a range of soldering tasks and, with companies like SolderStar developing tools to help setup and further maintain the process to reach specific requirements, it is seen as the answer to many soldering difficulties which are seen more than ever due to the complex designs being manufactured today.

It is now used in the mainstream to give accurate and dependable results in the soldering process and is also used widely in critical assemblies that require precision. It is for this reason that development in this process is ongoing and continues to evolve into a soldering method that is favoured by many.

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