# Supporting niche service needs at a regional level—a case study

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*Regional electronics manufacturing services (EMS) providers are not simply being asked to provide a full range of traditional EMS services. Their business focus often drives them in directions not found widely in higher volume EMS providers. One example is Clover Electronics. It has developed strong capabilities in LCD backlight design and LCD customization to address the needs of customers whose volumes or specific application needs do not align with available off-the-shelf product. This article will look at the SMT process control challenges inherent in manufacturing the printed circuit board assemblies (PCBAs) used in these programs. It will also look at key issues in process control in the final integration process.*

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## Introduction

Regional EMS providers fill critical niches in their customers' supply chains by handling hard-to-outsource programs or highly specialized low-to-medium volume assembly processes. Clover Electronics (Atlanta, GA) has focused on the market requiring high performance displays for applications such as communications, gaming, security, traffic signage, etc.

Most LCD manufacturers look for annual production quantities in the hundreds of thousands for custom application development. Typically, niche applications have annual quantities in the 5K-30K per year range. To address this issue, this contractor buys commercial off-the-shelf LCDs and customizes them for specific customer requirements. Such customizations can include improved optical performance: most likely an increase in luminance and reliability. The off-the-shelf unit almost always requires the contractor to disassemble the unit where a number of modifications can be made with the aim of meeting a specific customer requirement. CCFL backlights are generally replaced with a PCBA strip of ultra bright LEDs manufactured by the contractor. Additionally, in some applications the diffuser stack is modified with specialty films to enhance light output. In other applications, the exterior of the display is ruggedized or otherwise modified to meet customer requirements. These ruggedized displays may have to withstand hostile environmental factors such as blowing sand, heat, humidity, altitude and boot kick or drop tests. For these requirements the LCDs are modified to include anti-reflective coated films or cover glass, thick kick-plate glass or privacy films.

## Production differences

Larger displays, such as those used in highway signage, often use through-hole technology PCBAs. These larger panels may be 2 ft x 1 ft in overall dimensions. A production challenge in these larger footprint products is that wave conveyor speed must be increased to deal with the heat during wave. On one project, the assembly was consistently run through the wave at 4X normal speed to minimize the heat on the board, resulting in no solder joint quality issues.

The LED strip used in smaller display backlights is normally 100% SMT, although there may be wire attachment post-SMT. The production challenge is that LEDs have lenses that are sensitive to heat and handling damage. As a result, it is important to maintain proper thermal profiles during reflow and minimize handling during production and any work-in-process movement between production areas. The lens that is used on ultra bright LEDs is made of a silicon type material and can easily be knocked off with improper handling. In this contractor's case, carriers are used for the strips and the process is completely inline from paste deposition through the oven.

Comparatively, smaller (less bright) LEDs use an inverted type lens inside the case, and there is no problem with them in terms of reflow characteristics for leaded or RoHS compliant applications.

Additionally, SMT LEDs don't have leads outside the body of the component and are similar to QFNs and leadless chip carrier (LCC) products. Instead, they have pads under the component with three leads. One lead is for heat dissipation and the

*"The production challenge is that LEDs have lenses that are sensitive to heat and handling damage."*

other two are for actual electrical contact.

PCB substrate selection is important. Ultra bright LEDs require additional heat sinking. This is typically done using an aluminum backed PCB. This is usually a very thin FR4 material bonded to a thin sheet of aluminum. Another option is an FR4 substrate with a specific via-hole pattern that distributes heat more efficiently. There is usually a cluster of 8-13 vias around the heat sink pad near the LED. This layout is more common in high-powered silicon devices.

There is a 1:1 aperture ratio for the spacing of the paste placement on the board. The 1:1 land pattern allows an ample amount of paste to be deposited. It is important to make sure that via holes aren't too close to the solder pads for the LEDs and that an ample amount of solder mask is present to minimize the solder wicking into the via holes.

Actual volume component placement is identical to other SMT components. Most LEDs are packaged on tape and reel. Prototypes are typically hand placed.

From a reflow standpoint, forced air convection ovens with eight zones are ideal because the heat and subsequent outgassing can be controlled better with a larger number of zones. Ovens with three to five zones do not offer as much control. When heat is not properly controlled the outgassing of solder can cause massive voids. This leads to problems with high frequency lines because the void acts a conductor. Additionally, a large void reduces the current carrying capability of that joint.

This contractor uses a Heller eight-zone forced air convection oven with KIC process optimization software. The process window is initially defined by determining the intersection among solder specifications, the substrate specifications and component tolerances. Thermocouples are attached to a sample product and a manual profile is run which can be compared against the process window. In the case of ultra bright LEDs on PCB strips, additional thermocouple probes are used to better monitor the heat distribution pattern across the board as it goes through the oven.

The software generates a Process Window Index (PWI), a single number that indicates how the process fits the defined process window. The lower the number, the closer the process is towards the center of the process window. The size of the process window and capabilities of the reflow oven determine how low the number can be and facilitates the development of robust thermal profiles in tighter process windows.

*Volume component placement for LED assemblies is identical to other SMT components.*

SMT LEDs are much more robust with a tightly controlled temperature profile. Even small variations can create issues. For example, in one production lot, a blower was failing intermittently in the oven. The oven wasn't signaling the failure, but some boards were not completely soldered. The KIC monitoring system made it easy to identify the zone with the temperature fluctuation and identify the blower that was failing.

Cleaning can be an issue. An aggressive flux is used in the reflow process, requiring the use of an aquatic type of wash in the cleaning process. The water must be high enough in temperature and pressure to wash the flux out between the LED and board.

The final assembly process of the modified LCD, defined by an optics engineer, requires highly skilled labor and is performed in a class 100 cleanroom to prevent contamination within the optical stack of the assembly.

Functional test equipment is usually supplied by the customer so that testing is performed under 'field-test' conditions. In addition to visual inspections, luminance, color and uniformity measurements are often collected. A challenge is that there may be variance in color and/or brightness among production lots of the same LED. In some cases, this is unacceptable in the final application, but in others the slight variance is not an issue. Where variance may be a problem, production lots are sequenced to component lots.

## Conclusion

LCD manufacturing uses many traditional EMS production capabilities. At the same time, it does require a stronger focus on process control, thermal profiling, the minimization of handling, and a clean room environment. Highly skilled operators at final assembly and specialized engineering support are also required. With those elements in place, a wide range of specialized LCD applications can be supported.

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