Transform your production process enforcement and control to the next level and measure your quality and yield with consistency with the Optel Process Enforcement and Quality Management solution.

Optel’s solution provides process and quality traceability at the circuit assembly level, improving internal operations management, creating customer conformance certifications and delivering management and customer reporting.

The management of tracking numerous circuit assembly jobs is challenged by variations in the production process steps required by different assemblies. Challenges like lead free, automated and hand assembly, testing and coatings drive the need to automatically validate the correct routing and enforce each PCB follows the route for its work order.

Address Customer Process Conformance
Respond to increasing customer demands for process traceability, quality data and certificates of process conformance. Optel Process and Quality Traceability solution will enable new business opportunities to be pursued and improved retention of existing business through better customer satisfaction.

Optel’s manufacturing execution system for production process enforcement addresses internal needs and external customer demands for process enforcement, traceability and quality management to the circuit assembly serial number level.

Drive Continuous Process Improvement
Imagine achieving the level of production process traceability controls and reporting needed to win business from demanding clients as well as the control you need internally to drive continuous process improvements.

The Optel Process Enforcement solution incorporates circuit assembly serialization and controls each work order’s process routing steps providing production process control precision from PCB serialization through shipping. Optel’s integrated factory solution improves quality and yield through process enforcement.

Optel process enforcement includes operations spanning the SMT line, hand assembly line, rework, QC, testing, pack and shipping.

**Optel Quality Management**
The Quality Management component provides quality traceability data, and statistical process control, test data and defect logging, and reporting.

Now track defects through their lifecycle from detection through rework and back through re-inspection by circuit assembly serial number.

Optel’s Quality Management tools capture and manage defect and repair data collection, yield data and first article inspection. Quality and yield traceability reporting includes defects, repairs, testing, DPMO and yield data for circuit assemblies to the serial number level for supervisors, management and customer reporting.

**Web Reporting for External Customers**
Deliver high value process traceability and quality management data reporting in real-time via Optel’s secure Web process and quality reporting system.

The Optel Web Reporting system, Optel Reporter, allows internal and external customers to securely login to a portal with your company logo and obtain reports by work order, circuit assembly number or serial number. Customers can see completed jobs and jobs in process at each production step.

Additionally the sales or management team can set the appropriate level of external reporting detail needed for each customer or internal user.

**System Goals**
The overall system goals for the Optel Process Enforcement, Traceability and Quality Management solutions are:

- Project and new product introduction production design and planning checklist signoff management
- Production process enforcement, validation and verification
- Process traceability – capturing and reporting process
parameters for each routing step for each panel or serial number circuit assembly

• Minimize defects and improve quality consistency
• Certify process conformance for customers

Assembly Line Process Enforcement/Traceability

The Optel Process Enforcement and Traceability solution covers the electronic assembly line portion of the manufacturing operations from PCB and panel serialization through shipment.

The assembly line process enforcement is enabled by placing electronic scanners at strategic points along the assembly line to scan serial numbers of board assemblies and panels allowing the operations to tie activity to these assemblies and their work orders. The information collected is managed, tracked and stored in Optel’s database providing a central consistent shop floor repository of information for operating, management and reporting of entire plant operations for all Optel solutions.

Process Data Collection
The Optel system collects data throughout the manufacturing production lines via hand-held scanners or fixed location scanners. Process data is also collected from selected machine interfaces. The process data collection provides for the following:

• PCB circuit assembly serial numbers are scanned at various data collection points during the assembly, test, and box build processes
• Electronic work order job travelers are available on line to anyone working on the project
• Process traceability and enforcement reports are available on line and in real time
• Circuit assemblies by serial number are prevented from being shipped unless all routing operations have been completed
• Quality data is collected for failures and repairs providing yield, DFMO and quality metrics

Figure 1 is a high level diagram that illustrates placement of scanners and computers for collecting data and managing the processes.

By placing scanners at key locations serialized assemblies’ movement through the lines and across the floor can be tracked and enforced.

Serialization
Serialization of each panel and PCB are critical to make the process enforcement and traceability a reality. The key points on the Optel serialization are:

• Each panel and PCB on the panel is bar coded
• Bar code prefix and number of digits are defined
• Panel bar code should be placed on one side and PCB bar codes on the other side of the panel
• For panel level operation scans, operator can scan either panel bar code or any of PCB bar codes
• Panel and PCB bar codes are tied to work order

Two sample bar codes both using 2D technology formatting are illustrated in Figure 2. The first image is a small label for use with boards with limited free space and a larger one that allows inclusion of text.

As an example of Optel Panel serialization, Figure 3 shows the mapping of the panel bar code to the circuit bar code. Operators can print the next bar codes, reprint a bar code or print the panel list.

Define Custom Routings by Work Order
Optel Process Enforcement allows custom routings for different types of customer’s jobs or by work order down to the panel side to be defined and managed. Thus each customer job can be assigned the exact operational steps and routing needed, no more and no less than required.
Focus on continuous process improvements and as improvements are discovered and implemented including new equipment or new processes, the Optel Process Enforcement allows the new operations to be added to the operational routings inventory for new jobs. Routing can be defined as a single pass operation which must run in place in its routing order or a multiple pass enforced operation such as a wash, which needs to occur in its routing order place but can be performed multiple times. Figure 4 illustrates the Optel Process Routing Manager screen.

**Figure 4 - Optel Process Routing Management Screen**

“The BOM Check”
- Define checklist items like Fiducials by operation like Placement
- Signoff start and completion of checklist items
- Monitor design checklist progress by project

The Design Traveler checklist signoff screen is illustrated in Figure 5.

**Figure 5 - Design Traveler Checklist**

**Design Traveler**
The Design Traveler provides project design checklists to insure all the design steps, customized by assembly, are signed off and completed from schematic to achieve deliverables. The Design Traveler enables users to:
- Create design traveler checklist by assembly number and revision
- Define design department organization and access/approvals
- Define operation categories within operations like

**Electronic Work Order Job Traveler**
Electronic Work Order Job Travelers in Optel replace manual paper job travelers as illustrated in Figure 6 and accompany the work order job from planning through production shipping. The Work Order Traveler and can be accessed from any Optel station on the plant floor and from supervisor’s and manager’s office computers.

**Figure 6 - Optel Work Order Electronic Job Traveler**

Optel Work Order Travelers provide electronic signoff and status monitoring throughout the plant and across the process steps for all work order jobs. This eliminates lost or missing paper job travelers and represents a permanent
record based on Optel’s factory floor data base repository. The Optel Work Order Electronic Job Traveler provides an electronic checklist signoff for sales data, production planning, kitting and assembly/test through shipping. Process traceability status reports by circuit assembly serial number are available in real time from PCB serialization step to throughout the production process steps.

**Process Enforcement Kiosk Data Collection**

Kiosk type data collection is part of the Optel’s Process Enforcement. Operations such as board wash, selective soldering, functional tests, wave solder and hand wash use Optel’s Process Enforcement Kiosk application for scanning, recording and enforcing panel’s or circuit assembly’s process movement.

### Automated Electronic Assembly - SMT

Optel Process Enforcement Kiosk station can collect scans from multiple scanners used for multiple operations improving affordability.

Example process traceability functionality for the automated SMT line is listed below:

- Prints bar codes for PCB and panel serialization
- Captures board serial numbers entering line
- Verifies correct solder paste and stencil are used for current job, and assigns solder paste parameters to each serial number and monitors solder paste expiration date
- Insures solder paste TACK time not exceeded by panel/circuit assembly serial number before entering pick and place machines
- If Optel Material Management solution is also installed, automated assembly material traceability is enabled to the circuit assembly serial number
- Includes SMT Visual Inspection and SMT hand-placement station
- Captures defects and repair data during visual inspection through rework and back to inspection
- Supports electronic first article inspection/sign off
- Verifies correct oven profile is selected for current job and all pre-reflow oven processes completed before allowing panel to enter reflow oven
- Records actual oven profile for each serial number circuit assembly

As desired the conveyor for the SMT line can be locked/unlocked by Optel to additionally enforce process step movement.

**Screen Printer Setup Verification**

Using the correct screen printer setup is a critical step in the process enforcement. Optel provides screen printer setup verification tied to work order and top or bottom side of the board as is shown in the screen capture in Figure 7.

**Figure 7 - Optel Screen Printer Setup Verification Screen**

Optel Process Enforcement allows operators to perform additional functions such as scan solder paste for type and TACK time tracking.

Screen Printer Setup Verification benefits:

- Capture solder paste date code, lot code, expiration date, received date and model number at receiving and bar code with a license plate
- Prevent from using wrong solder paste or stencil and includes solder paste and stencil bar coding
- Capture solder paste TACK time on the line
- Allow for capturing screen printing cycle time and machine utilization

An example bar code for solder paste container is illustrated in Figure 8.

**Figure 8 - Optel Solder Paste Container Bar Code Label**

**Stencil Traceability**

Optel Process Enforcement supports managing Stencil Traceability. The key features are:

- Capture Stencil assembly number, side, vendor, and received date are at receiving
• Bar code Stencil with a unique license plate ID
• Assignment of Stencil to multiple assemblies allowed
• Make Stencil obsolete and list of obsolete stencils is maintained
• Maintain Stencil usage history per screen printer and assembly
• Management and retrieval of Stencil storage capabilities are optional

An example of the Stencil bar code label is illustrated in Figure 9.

**Figure 9 - Optel Stencil Bar Code Label Example**

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**Hand Placement and Visual Inspection**

Optel Enforcement, Traceability and Quality Manager solution addresses the needs for Hand Placement at SMT and Visual Inspection stations. Example process coverage includes:

- Operator scans panel, places components, and visually inspects the board
- If defects are found, they are logged using Optel’s defect tracking, sent to repair operation and the repair information is saved
- If the panel passes inspection, operator enters PASS event, Optel checks whether reflow profile on the oven matches assembly number
- If all checks are satisfied, Optel enables movement of panel into the reflow oven
- A mechanical stud can be installed in front of oven to prevent operator from pushing panel into the reflow oven in case panel is not scanned, does not pass inspection, or profile is not valid

**Reflow Oven Traceability**

To address the Reflow Oven on the SMT line, the Optel Process Enforcement solution collects data from the oven and matches it to the circuit assembly/work order being processed.

- Reflow oven zone profile is verified for each panel before panel allowed to enter
- Reflow oven temperature and humidity data is collected for each zone for each panel as it enters the oven

**Manual Slide Line and Wave Solder**

The hand place manual slide line and wave solder steps are covered by the Optel process enforcement.

Functionality covers:

- Panels are scanned as they enter manual assembly line
- Performs setup verification and material traceability data collection (optional)
- Defect collection and yield calculation performed at the final inspection station

The Optel support for Manual Slide Line and Wave Solder is illustrated in Figure 10.

**Figure 10 - Optel Supports Manual Slide Line and Wave Solder**

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**Testing**

Optel supports several types of testing for process routing enforcement and collecting test results for test and quality information tracking.

**Test Data Collection and Test Reports**

The Optel Quality Manager can optionally collect test data from flying probe machines, in circuit testers, customer test systems (processing their log outputs) and from hand testing.

**Flying Probe**

Optel Process Enforcement and Traceability provides support for Flying Probes such as:

- Saves machine test results each time complete board is tested
- In case board fails, operator typically re-tests just the failed point and if circuit board passes, Optel tracks and records data for each pass, fail and retest for each serial number
- If board fails retests, operator typically performs manual test and if that fails, a defect is logged into Optel and board is sent to the rework area

**Quality Management**

The Optel Quality Manager provides test results reporting to help manufacturing operations and management improve and track the business. Optel Quality Manager collects defect information, addressing repair conditions, provides defect code management, and provides quality metrics reporting
including highlighting hot spots on boards with frequent defects and providing reference for defect codes.

The primary Quality Manager screen views are:

- **Job View** – for associating work orders/jobs/serial numbers/components
- **Defect Tracking** – allows entering defects, looking for hot spots and supporting first article
- **Yield** – provides information regarding board assembly or higher level assembly yields
- **Reports** – provides quality reports
- **Alarms** – provides quality alarms and threshold setting administration
- **First Article Inspection** – provides functionality for first article inspection

**Defect Tracking and Defect Data Collection**
The Optel Quality Manager provides for defect inputs from quality inspections and repair and for defect tracking. An example Defect Data Collection screen is illustrated in Figure 11 as a graphic interface to allow input of the defect and its parameters such as:

- Status
- Defect
- Component PN
- Reference designator
- Operation
- Quantity
- Log time
- Component placement on board

**Quality Reports by Serial Number**
The Optel Quality Manager provides a series of quality reports. An example list of reports follows:

- DPMO (defects per million operations) for a project
- DPMO for multiple projects
- DPMO for an operation
- DPMO for a package
- Pareto chart
- Yield for an operation
- Yield for a project
- Yield for multiple projects
- Pareto analysis of defect data
- Tracking feeder errors on pick and place machines in real time using P-Chart

An example of a quality report is the Pareto Chart, which is illustrated in Figure 12.

**Figure 12 - Quality Reports - Pareto Chart**

**Yield Data Display and Data Collection**
The Optel Quality Manager provides the ability to display yield data and provide for yield data collection as illustrated in Figure 13 for a Post-Reflow Visual Inspection.

**Figure 13 - Yield Data - Collection and Real-time Status**

operations. For example the SMT Yield Data screen shows yield results by work order, assembly part number and
revision and provides statistics for:
- Total assemblies
- Passed
- Failed
- Scrapped
- Balance
- Yield Percent

Yield data screen serves as an input screen for an operations station, in this case allowing the Post-Reflow Visual Inspection operator to input Pass, Fail or Scrap.

**First Article Inspection**
The Optel Quality Manager provides support for First Article Inspection with details for each component part number, package, manufacturing install operations, quantity and graphical board location diagram.

An example screen shot of the Optel Quality Manager with the First Article Inspection view is illustrated in Figure 14.

*Figure 14 - Optel Quality Manager - First Article Inspection*

The functionality provided for first article inspection by Optel Quality Manager is:
- Paperless with graphic interface
- Check boxes for each component
- Electronic sign-off
- LCR component test collection with results assigned to each component in the report (optional)

**Control for Each Serial Number and Each Operation**
PCB serial numbers are scanned at various data collection points during the assembly, test, and box build processes.

**Serial Number Tracking**
The Optel Process Enforcement, Traceability and Quality Manager solution provides for board serial number tracking and process enforcement at various data collection points during the assembly, test, and box build processes. Optel Process Enforcement ties quality information and defects to serial numbers. An example screen shot of Optel Process Traceability report displaying a circuit assembly by serial number process traceability for the screen printer operation is illustrated in Figure 15.

*Figure 15 - Optel Serial Number Traceability by Job*

**Rework**
Rework is also supported as part of the Optel Process Enforcement and Traceability solution. Key Rework functionality supported is:
- Rework follows same approach as other projects
- Boards are received by the shipping department
- Project is defined and rework routing assigned to the project based on the rework type
- If component replacement is involved, purchase order is issued for components
- Materials department needs to be aware of project and that the components have been ordered
- When components are received, they are kitted to the rework work order
- Rework project is then traced the same way as the case with complete board build

**Pack and Shipping**
The Optel Process Enforceability also supports pack and ship with functionality for:
- Verify each circuit assembly by serial number successfully passed all required process operations as required by the process route defined for the work
order at pack

- Assign packing slip number to each serial number
- Print Certificate of Conformance
- Print test results
- Prevent from shipping if the customer is flagged as "do not ship"
- Print tracking number if non-company courier

Report on Job Execution / Quality Via Web
Keep customers informed about their job status and quality. A job execution and quality reporting application, as illustrated in Figure 16 provides a Web interface for both internal and external customers to access only their information about their work orders and jobs in real time based on permissions.

The reporting provides routing production status for work orders, circuit assemblies or specific serial number boards including drill down to quality and yield information. Reports are available for internal users and reports to customers can be permissioned by customer allowing appropriate information as needed.

Figure 16 - Optel Circuit Reports for External Customer Reporting

Obtain reports by work order, by circuit assembly, by serial number and filter by date range. Reports span high level routing status, defects, repairs, cycle times, quality, yield, DFMO and Pareto Analysis. Select a work order and drill down to each routing operational step and to circuit assembly PCB serial numbers.

Process Enforcement, Traceability and Quality Management Solution Benefits

Select Process Enforcement, Traceability and Quality Manager Solution Benefits follow:

- Complete control over all processes and ability to quickly react to out-of-control processes
- Reduce DPMO, increase yields and better product quality
- Process and quality traceability for each circuit assembly serial number
- Decrease lead times
- Increase equipment utilization
- Better communication with customers and ability to predict order completion time
- Implementation of fundamental concept of lean manufacturing: getting job done right first time
- When integrated with Optel Solutions for Material Management and Component Traceability and Lean Manufacturing solutions, the genealogy for routing process operation steps, components, moisture sensitive materials, repairs, defects, cycle times, yield and machine performance is all captured to the circuit assembly board serial number level
- Optel database with complete view of all information for all Optel solutions allow integrated management, control and reporting
- Achieve quality standards for certifications
  - FDA Department of Health and Human Services 21 CFR Part 11 Electronic Records; Electronic Signatures
  - FDA Department of Health and Human Services 21 CFR Parts 808, 812, and 820 Medical Devices; Current Good Manufacturing Practice (CGMP)

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COMPANY CONTACT INFORMATION
Optimal Electronics Corporation
8716 N. Mopac, Suite #230
Austin, TX 78759
(512) 372-3415 HQ   214-295-4199 Sales
www.optelco.com   sales@optelco.com

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