EXCEL CIRCUIT

QUALITY ASSURANCE

Whitepaper

From PCB Design to Reliable PCBA Delivery

A practical framework for design quality, qualified PCB manufacturing resources, component control, in-house SMT assembly, inspection, traceability, and continuous improvement.

42 Layers	2.4 mil	60 GHz	0.3 mm
PCB DESIGN CAPABILITY	MIN TRACE / SPACE	HIGH-FREQUENCY SUPPORT	MIN BGA PITCH

Document Purpose

This whitepaper explains how Excel Circuit structures quality controls across the full project lifecycle. Project-specific acceptance criteria, inspection levels, testing, reports, and documentation are confirmed during quotation and engineering review.

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Executive Summary

Quality in electronics manufacturing is not a single inspection step. It is the result of controlled decisions made before fabrication, during sourcing, at assembly, and before shipment. Excel Circuit applies a gate-based approach so that design intent, manufacturability, materials, process conditions, workmanship, inspection results, and change history remain connected throughout the project.

Our operating model combines in-house PCB design engineering and in-house SMT assembly with qualified PCB manufacturing resources and component sourcing support. This structure allows the quality plan to begin at the engineering stage and continue through production release rather than relying only on final inspection.

> **Core Principle**
>
> Prevent defects early, detect process drift quickly, preserve traceability, and make acceptance criteria explicit before production.

Whitepaper at a Glance

Section	Focus
1. Quality framework	Responsibility model and quality gates
2. Design quality	Engineering review, DFM/DFA, SI/PI awareness, release control
3. PCB manufacturing	Qualified resource selection, fab documentation, lot controls
4. Component control	BOM risk, approved parts, incoming verification, storage
5. In-house SMT	Stencil, SPI, placement, reflow, AOI/X-ray, workmanship
6. Testing & inspection	Risk-based test strategy and acceptance evidence
7. Traceability & change	Lot history, deviations, NCR/CAPA, revision control
8. Customer handoff	Deliverables, acceptance, continuous improvement

Scope and Responsibility Model

Excel Circuit does not position itself as an owned PCB fabrication factory. PCB fabrication is fulfilled through qualified manufacturing resources selected to match the project technology, material, layer count, impedance, stackup, volume, and delivery requirements. SMT assembly is performed in-house, enabling direct control of assembly process settings, inspection flow, and production feedback.

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End-to-End Quality Framework

The quality plan is organized around stage gates. Each gate defines what must be reviewed, what evidence should be available, and what can block release to the next step. This reduces ambiguity and creates a repeatable path from engineering data to shipped assemblies.

Gate	Primary Controls	Release Evidence
Q0 - Requirement	Project scope, application risk, acceptance criteria, critical dimensions / nets, quantity, lead time	Reviewed requirement set / quotation assumptions
Q1 - Design Release	Schematic / layout review, stackup, constraints, DFM/DFA, BOM readiness, revision freeze	Released Gerber / ODB++, drill, fab notes, BOM, CPL, drawings
Q2 - PCB Fabrication	Supplier fit, material / stackup confirmation, impedance and special process requirements, lot documentation	Fab confirmation, inspection / test evidence as specified
Q3 - Material Readiness	BOM match, substitutions, date / lot codes when required, packaging / MSL checks	Approved material set and deviation record if applicable
Q4 - SMT Process	Stencil / paste setup, SPI, placement verification, reflow profile, AOI, X-ray for hidden joints as required	Process records and inspection result
Q5 - Final Acceptance	Visual inspection, functional / programming / electrical checks as specified, quantity and documentation review	Shipment release package

Risk-Based Quality Planning

Not every product requires the same inspection depth. A simple controller board, a fine-pitch BGA module, a high-frequency RF design, and a high-current power board present different dominant risks. Quality controls should therefore be selected according to failure impact and process sensitivity, not applied as a fixed checklist to every order.

- Higher-risk geometry: fine-pitch BGA, QFN, via-in-pad, HDI structures, dense escape routing.
- Higher-risk electrical behavior: controlled impedance, RF launch structures, DDR / high-speed interfaces, power integrity and thermal current paths.
- Higher-risk materials: moisture-sensitive devices, long-lead / allocated parts, customer-nominated alternates, special laminate systems.
- Higher-risk production conditions: first build, engineering change, supplier change, stencil change, rework, or accelerated delivery.

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Design Quality Starts Before Fabrication

Many production defects originate in ambiguous requirements, incomplete release data, manufacturability conflicts, or late engineering changes. For this reason, the quality process starts with the design package rather than the SMT line.

Engineering Review Focus

Area	Typical Review Items
Schematic / Connectivity	Power domains, interface assumptions, net naming, connector definition, test access, programming requirements
PCB Layout	Clearance, routing topology, reference planes, return paths, via strategy, thermal paths, component orientation and accessibility
Stackup / Impedance	Layer function, dielectric assumptions, target impedance, reference planes, copper weight, fabricator capability alignment
DFM / DFA	Minimum features, annular ring, solder mask, copper-to-edge, panelization constraints, courtyard and assembly spacing
Assembly Data	BOM, CPL / XY, polarity, package mapping, reference designators, special mounting / soldering notes
Release Control	Revision ID, frozen output package, change log, project-specific deviations and customer approvals

Design Capability Envelope

42	2.4 mil	60 GHz	2912
MAX PCB LAYERS	MIN TRACE / SPACE	HIGH-FREQUENCY DESIGN SUPPORT	MAX BGA PIN COUNT

Capability values describe the engineering range that can be supported. Actual manufacturable limits depend on board technology, material, copper weight, stackup, finished thickness, via structure, selected fabrication resource, yield target, and quantity. Final constraints are confirmed per project before release.

> **Quality Rule: Revision Freeze**
>
> Production should start from one controlled release package. Any change after release is logged, impact-reviewed, and approved before the affected lot proceeds.

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Quality Control for PCB Fabrication

Because PCB fabrication is performed through qualified manufacturing resources, resource selection is part of the quality plan. The objective is to match each board to a fabricator with demonstrated capability for its materials, structure, tolerance, impedance, via technology, surface finish, quantity, and delivery expectations.

Resource Qualification and Job Matching

- Capability fit: layer count, HDI structure, blind / buried vias, rigid-flex, heavy copper, RF laminate, controlled impedance, fine features.
- Process fit: surface finish, via filling / capping, depth control, special drilling, copper thickness, solder mask and marking requirements.
- Quality evidence: electrical test coverage, dimensional / visual inspection, impedance data, microsection or coupon evidence when specified.
- Performance history: yield, responsiveness, documentation quality, on-time delivery, corrective-action responsiveness and repeatability.

Critical PCB Item	Typical Control / Evidence
Material / laminate	Confirm manufacturer / type or approved equivalent where specified
Stackup	Fabricator stackup confirmation before build for controlled structures
Impedance	Coupon / TDR evidence when required by drawing or purchase specification
Electrical continuity	Bare-board electrical test according to agreed coverage
HDI / via structures	Process capability review; microsection evidence when project risk requires it
Surface finish	Finish type and thickness requirements confirmed in fabrication notes
Dimensions / outline	Critical mechanical tolerance and connector fit requirements highlighted
Lot traceability	Lot / date / order references retained in the production record where applicable

> **No Factory Overclaim**
>
> Excel Circuit distinguishes between in-house engineering / SMT assembly and qualified PCB fabrication resources. This keeps supplier responsibility transparent while preserving a single project interface for the customer.

Component and In-House SMT Quality

Assembly quality depends on both material integrity and process control. The component plan addresses sourcing risk before materials reach the line, while SMT controls focus on solder paste, placement, thermal process, inspection, and rework discipline.

Component Sourcing Controls

Control	Purpose
BOM normalization	Resolve manufacturer part number, package, value, tolerance, lifecycle and approved alternates
Supplier selection	Prioritize authorized / traceable channels when project requirements call for them
Substitution control	No unapproved functional or package substitution; document customer-approved alternates
Incoming verification	Part number, label, packaging, quantity and visible condition checks; enhanced verification where risk requires
MSL / storage awareness	Protect moisture-sensitive parts and define bake / floor-life actions when applicable
Customer-supplied material	Record received quantity / condition and identify shortages or packaging concerns before build

In-House SMT Process Controls

Process Step	Key Quality Focus
Stencil / solder paste	Aperture suitability, paste condition, print setup, board support
SPI	Paste volume / area / height trends, bridging / insufficiency risk
Placement	Feeder setup, polarity, rotation, package match, first-article verification
Reflow	Thermal profile suitability for board mass and component mix
AOI	Polarity, missing / shifted components, solder joint visibility, bridges and workmanship defects
X-ray	Hidden solder joints such as BGA / selected QFN / bottom-terminated devices when required
Manual / THT	Controlled workmanship, polarity, trim / solder quality, post-process inspection
Rework	Authorized rework method, defect record, re-inspection and disposition

> **First Article Control**
>
> For new or changed builds, the first assembled units should be reviewed against the released documentation before the lot proceeds. This is one of the fastest ways to prevent repeated assembly errors.

Inspection and Testing Strategy

Inspection should generate evidence that is proportional to the project risk and customer acceptance requirements. The exact test package is agreed per project because not every PCB or PCBA requires the same combination of AOI, X-ray, electrical, programming, functional, or dimensional checks.

Typical Inspection Toolbox

Method	What It Helps Verify	Typical Use
Visual / FQC	Workmanship, polarity, markings, damage, cleanliness, quantity	All assemblies / final release
SPI	Solder paste deposition consistency	SMT process monitoring
AOI	Placement, visible soldering defects, polarity, missing parts	SMT assembly
X-ray	Hidden solder joints / voiding / bridges under selected packages	BGA, QFN, bottom-terminated devices as required
Bare-board E-test	Open / short integrity of fabricated PCB	PCB fabrication
TDR / impedance coupon	Controlled impedance result	High-speed / RF where specified
Programming	Firmware loading and device communication	Programmable assemblies when requested
Functional test	Application-level behavior against agreed test method	Where customer provides test procedure / fixture or scope is quoted

Acceptance Criteria

Acceptance criteria must be explicit. Workmanship standards, customer drawings, approved samples, test limits, cosmetic requirements, special cleanliness, and packaging needs should be identified before production. Where an IPC workmanship class is required, the applicable standard and class should be specified in the order or project documentation.

> **Important**
>
> Testing is not automatically implied by assembly. Functional testing, programming, fixture development, environmental screening, or special reporting must be included in the quoted project scope to ensure the required equipment, limits, and evidence are available.

Quality Evidence Package

- Production / inspection result summary as agreed.
- PCB fabrication reports or certificates when specified and available from the selected manufacturing resource.
- X-ray / AOI / impedance or other test evidence when included in the project scope.
- Approved deviation / substitution records, if any.
- Shipment quantity and revision identification.

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Traceability, Change Control, NCR and CAPA

A strong quality system does more than detect a defect. It must make the defect traceable, prevent uncontrolled disposition, identify root cause, and verify that corrective action is effective.

Traceability Structure

Record Layer	Examples
Project	Customer part number, internal project / order ID, quantity, revision, agreed quality plan
Engineering	Released design files, change log, special instructions, approved deviations
PCB	Fabrication source, lot / batch references, stackup / material evidence where applicable
Components	BOM revision, approved alternates, supplier / lot details when required by scope
Assembly	Production batch, line / process records, inspection status, rework record
Shipment	Released quantity, packing / labeling requirements, quality documents supplied

Nonconformance Workflow

Step	Required Action
1. Contain	Stop affected material / lot from moving forward; identify potentially affected units.
2. Record	Document the defect, location, quantity, symptom, evidence and current status.
3. Analyze	Determine likely root cause: design, material, fabrication, assembly, handling, test, or documentation.
4. Disposition	Rework, repair, use-as-is with approval, replace, scrap, or rebuild according to risk and customer requirement.
5. Correct	Implement process / documentation / supplier / design corrective action.
6. Verify	Confirm the corrective action prevents recurrence and update controls where necessary.

Change Control

Changes that can affect fit, form, function, quality, reliability, or production repeatability are impact-reviewed before implementation. Examples include stackup or material changes, component alternates, stencil revisions, critical process changes, and design ECOs. Customer approval is obtained when a change falls outside the agreed specification or approved alternate set.

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Customer Handoff and Continuous Improvement

The final quality gate confirms that the product, documentation, revision, quantity, and agreed test / inspection status are aligned before shipment. The goal is to make the delivery easy to receive, verify, and release at the customer side.

Recommended Project Handoff Package

Project Input from Customer	Quality Output / Confirmation
Gerber / ODB++ / PCB drawing	Fabrication release package and revision confirmation
BOM with manufacturer part numbers	Approved BOM / alternates / sourcing exceptions
CPL / XY / polarity information	Assembly data review and first-article verification
Test procedure / firmware / fixture requirements	Quoted test scope and result evidence
Critical quality characteristics	Highlighted inspection points and acceptance criteria
Packaging / labeling / documentation requirements	Shipment release package aligned to purchase requirements

Quality Metrics We Recommend Tracking

- First-pass yield by product / process stage.
- Defect Pareto by defect type and root-cause category.
- Supplier / fabrication resource nonconformance rate and response effectiveness.
- Rework rate and repeated-defect rate.
- On-time delivery and quality-document completion.
- Customer complaint closure time and recurrence rate.

What Customers Can Expect

Excel Circuit aims to provide one engineering and production interface across PCB design, qualified PCB fabrication resources, component sourcing, and in-house SMT assembly. The practical benefit is faster feedback between design decisions and assembly results, clearer responsibility for project data, and a quality plan that can be adapted to prototype, NPI, and repeat production requirements.

> **For RFQ / NPI Projects**
>
> Share the design package, BOM, quantity, target schedule, test requirements, and any critical quality characteristics. We will use these inputs to define the production route, inspection plan, documentation, and quotation assumptions.