

1 Kick-Off Meeting

The kickoff meeting usually takes place in person at Triad's headquarters and lasts 1-2 days. The agenda will include the following: 1) development process overview, 2) project team structure, 3) weekly meeting agenda, 4) overview of scope change process, 5) Milestone and schedule review, and 6) in-depth review of the ASIC development proposal.

2 Specification Development

After the kickoff meeting, the spec development phase begins. The following activities will take place during this phase: 1) detailed review of customer's technical documentation of their system (e.g., schematics, specs, application board circuits, block diagrams, system models), 2) top-down architecture development of the ASIC, 3) creation of the ASIC specification.

During this phase, Triad will hold weekly WebEx meetings with the customer to better understand ASIC requirements. Triad will also begin maintaining an action item log and minutes from each of the weekly meetings. There will be email exchanges and one-on-one phone calls, as needed.

3 Specification Review / Approval

The specification review is the first major milestone after kickoff. The purpose of the review is for Triad and the customer to agree to the first official draft of the ASIC specification. The review itself is typically a half-day meeting where the first draft of the ASIC specification is discussed in detail. This review can usually take place over WebEx.

After the review is completed, and pending any changes to the specification generated from the review, the customer will be asked to sign off on the first draft of the specification. This milestone is especially important, as the ASIC specification is the *controlling technical document* for the project. Once the first draft of the specification is signed off, it will be placed under revision control. Any subsequent changes to the specification must be signed off by both Triad and the customer.

4 Interim Design Review (IDR)

After the specification is signed off at the specification review, the design team will begin to develop all of the IP blocks necessary to build the ASIC. Weekly WebEx meetings with the customer will continue during this phase, with email exchanges and one-on-one phone calls, as needed.

When most of the IP blocks have been captured in schematics or in RTL code, Triad will hold an interim design review (IDR) with the customer. The purpose of the IDR is to present completed schematics and simulation results of most, if not all, of the IP blocks on the ASIC.

The IDR is typically an all-day WebEx meeting where Triad engineers present the following:

- any updates to the specification
- schematics of completed analog IP blocks
- simulation results of completed analog IP blocks
- RTL code of completed digital IP blocks
- simulation results of completed digital IP blocks
- schedule review
- supply chain review
- action items update

5 Critical Design Review (CDR)

Following the IDR, the design team will continue development of the IP blocks necessary to build the ASIC. This activity will include 1) refinement of analog block schematics, 2) simulation of analog blocks over process, voltage, and temperature, 3) refinement of RTL coding of digital blocks, 4) simulation of digital blocks over process, voltage, and temperature, 5) simulations of the full ASIC, 6) physical layout of IP blocks, 7) and physical layout of the top level of the ASIC.

During this phase, weekly WebEx meetings with the customer will continue, with email exchanges and one-on-one phone calls, as needed. The CDR is typically held 4-8 weeks before Triad expects to tape out the ASIC.

The CDR itself is an all-day face-to-face meeting where Triad engineers typically present the following:

- any updates to the specification
- spec compliance based on simulation results
- updated schematics of analog IP blocks, along with simulation results over process, voltage, and temperature
- updated RTL code of digital IP blocks, along with simulation results over process, voltage, and temperature
- ASIC top level layout
- schedule review
- supply chain review
- next steps to get to tapeout
- action items update

6 Release to Fabrication

The next major milestone is release to fabrication, or tapeout. Triad engineering will only release the ASIC for fabrication if a list of checks are completed. Some of the checks included are:

- Simulation, static timing analysis, and formal verification of digital IP
- Top level simulations run with final top level netlist
- Top level layout verification completed (LVS, DRC)
- Bonding diagram verified against ASIC specification and layout of ASIC
- Current revision of ASIC specification signed off by customer

7 Prototype Delivery

Once fabrication of the wafers are completed, the wafer fab will ship the wafers to one of Triad's package assembly suppliers. The assembly house will package enough die from the wafers to provide Triad and the customer with prototype units for use in lab evaluation, production test development, and reliability testing.

The assembly house will then ship the packaged ASIC's to Triad. Triad will typically screen an agreed upon number of packaged ASICs with a manual test routine and ship acceptable ASICs to the customer. The acceptance criteria will usually only include basic functionality at this point.

8 Prototype Evaluation

Both Triad and the customer will evaluate the performance of the ASIC with customer-provided PC boards. Since both parties are using the same board layout, correlation of lab results is achieved with less difficulty.

Triad will verify that the ASIC meets specification by testing and characterizing several ASICs over power supply and temperature. The results of these tests will be placed into a compliance matrix which will highlight any failures of the ASIC to be spec compliant. The compliance matrix will be shared with the customer and compared to the customer's evaluation results.

All specifications that the ASIC fails to meet will be flagged and there will be an agreement between Triad and the customer about how to address the non-compliance.

Also during this phase, production test development will be underway with Triad's test supplier. The production test plan is written by Triad engineering and given to the supplier to implement on their automated test equipment (ATE). The production test plan will provide test coverage sufficient to verify functionality of the ASIC, including any critical specifications that can be tested with the ATE. As ATE is limited in capability in order to deliver high-speed testing, any specifications not tested by ATE will have to be verified by the previously mentioned characterization compliance matrix.

During this phase, quality engineering will initiate reliability testing of the ASIC. This testing will be defined in a reliability plan that has been agreed to by Triad and the customer. Reliability testing includes, at a minimum, ESD and latchup testing.

9 Design Re-work (as necessary)

If the ASIC is non-compliant to the ASIC specification, and both Triad and the customer agree that an ASIC re-design is needed, Triad will initiate re-design of the portions of the ASIC which are not spec compliant. Typically, when the ASIC has been designed as a new via-configurable array (VCA), Triad will be able to only change a single via layer in the layout to successfully re-design the ASIC.

10 Re-spin Critical Design Review (CDR2)

When the re-design has been completed and Triad is within a couple of weeks of tapeout of the second die revision, Triad will host another CDR. This CDR will typically include the following:

- any updates to the specification
- spec compliance based on simulation results
- updated schematics of analog IP blocks, along with simulation results over process, voltage, and temperature
- updated RTL code of digital IP blocks, along with simulation results over process, voltage, and temperature
- schedule review
- supply chain review
- next steps to get to tapeout
- action items update

11 Release to Fabrication

Once the second revision of the ASIC is ready for release to fabrication, or tapeout, Triad engineering will again perform the following checks:

- Simulation, static timing analysis, and formal verification of digital IP (if changed)
- Top level simulations with final top level netlist
- Top level layout verification completed (LVS, DRC)
- Bonding diagram verified against ASIC specification and layout of ASIC
- Current revision of ASIC specification signed off by customer

12 2nd Silicon Delivery

Once fabrication of the wafers are completed, the wafer fab will ship the wafers to one of Triad's package assembly suppliers. The assembly house will package enough die from the wafers to provide Triad and the customer with prototype units for use in lab evaluation, production test development, and reliability testing.

The assembly house will then ship the packaged ASIC's to Triad. Triad will typically screen an agreed upon number of packaged ASICs with a manual test routine and ship acceptable ASICs to the customer.

13 2nd Silicon Evaluation

Both Triad and the customer will evaluate the performance of the ASIC with customer-provided PC boards. Since both parties are using the same board layout, correlation of lab results is achieved with less difficulty.

Triad will verify that the ASIC meets specification by testing and characterizing several ASICs over power supply and temperature. The results of these tests will be placed into a compliance matrix which will highlight any failures of the ASIC to be spec compliant. The compliance matrix will be shared with the customer and compared to the customer's evaluation results.

Special emphasis will be placed on validating that the design changes made for the Si re-spin were successful. Based on Triad's track record, most of the time the single via-layer re-spin is sufficient to address all design problems found in the first prototypes.

Assuming that the ASIC meets specification, production test development will be completed during this phase. Once the production test software and hardware has been signed off by Triad, all future deliveries of the ASIC will go through the production test flow.

Also during this phase, quality engineering will complete all reliability testing of the ASIC. These results will be shared with the customer.

14 Production Release

Production release is an internal milestone for Triad which signals that the ASIC is ready to be shipped to the customer and that the following documents have been released:

- IC Specification
- IC Layout (GDS)
- Bonding Diagram
- Branding Diagram
- Reliability Test Plan
- Manufacturing Plan
- Production Test Plan
- Customer Notification Letter
- Production Documentation Checklist
- Tape and Reel Requirements
- Assembly Build Sheet

We require that the final IC specification be signed by the customer before releasing to production. After production release, the ASIC is turned over completely to the Operations team.