Life cycle of an Embedded IC from concept to end user

Dhanunjay Nalla
IC Staff Test Engineer
Recapitulation

➢ What is an IC?
  • Integrate several circuits on a single substrate

➢ What is the need of an IC?
  • To save space on devices/gadgets. PC vs Tablet vs Smart phone

➢ What is an Embedded IC?
  • Make the device ready to use. IC -> device -> FW -> OS -> Apps

➢ What is the importance of an Embedded IC?
  • Growing needs of the human being to become ...
Dear Vikram Sir,

Thank you very much for arranging the session.

Please find the presentation attached herewith and please do not hesitate to reach me for any clarification/questions.

Wish you a great week ahead and Happy festival season.

Thanks & Regards,
Dhanunjay Nalla

On Fri, 23 Oct 2020 at 16:53, Vikram Kulkarni (Dr.) <Vikram.Kulkarni@nmims.edu> wrote:

Dear Mr. Dhanunjay,
Semtech Neuchatel, Switzerland.

I heartily welcome you to deliver the lecture on "Embedded systems" tomorrow i.e, 24-10-2020 between **1pm to 2pm** Indian Standard Time.

You can join the lecture with the following MS-Teams code or code

Team code: **qipw3dh**

https://teams.microsoft.com/l/team/19%3a6cf40683deb9448e992d4f1f9ebbf4a8%40thread.tacv2/conversat...
He is currently working for Semtech Neuchatel, Switzerland as a Staff Test Engineer.

Prior to this role he worked for Advantest SAS, Grenoble France as an Application Engineer from 2016 to 2019 and at Cypress Semiconductors pvt. Ltd., Bangalore India as a Senior Test Engineer from 2012 to 2016.

He is a co-author for,


Thanking you.

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Thanks and Regards

Dr. Vikram Kulkarni
Assistant Professor,
Dept. of Information Technology,
Mukesh Patel School of Technology, Management, and Engineering,
NMIMS Deemed University, Mumbai campus,
Maharashtra, India.

Ph. +91 9952566338, 9492010124
Office: +91-22-45024733

Alternate Email: vikram.msrao@gmail.com

Personal Website: https://vikrammsrao.wixsite.com/vikram
Employer Website: https://engineering.nmims.edu/faculty-and-research/faculty-profile/vikram-kulkarni/
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Stages of IC life

- Concept
- Specifications
- Design & Layout
- Verification
- Tape out
- Fabrication
- Firmware
- Characterization and testing
- Qualification and Release
- Manufacturing
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Engage with the customer(s) to get their needs
• Mobile carrier company needs a radio to support 5G standards
• Other one is looking for a hexa-deca (16) core processor for next gen smartphone
• Another one is looking for xyz ...

Get fascinated to your specifications / design

Marketing team will be more active at this stage

Feedback to the design team from the customers
• About the requirements from the customer
• Specifications

Keep track of the expected “future” demand from customer
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Specifications

➢ Design team gets an idea on the device specifications
➢ Decide to design new one or to reuse existing (with improvements)
➢ Assume, new design is needed
➢ Prepare floor plan
➢ Block level specifications.
  • Ex: Need a 16 - core processor to run at 4 GHz
  • 5G radio : support many bands, different speeds
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Design & Layout

➢ Synthesis the block level specifications into sub blocks / IP level
  • Ex: Need 16x1 / 8x2 / 4x4 IPs for a 16-core processor
➢ Assume, you need to use 16 x 1-core IP.
➢ Design 1-core IP that can run at 4 GHz.
➢ Interconnect all cores to get to the necessary block
➢ When the transistor level design is ready, prepare the layout
➢ Run the simulations again on the layout.
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Verification

➢ Verify the design is functioning as per the expectations & matching the specifications
➢ Simulations on the design level
➢ Use test benches to model the blocks (in addition to the actual design)
➢ Feedback the results to the design until expected block is ready
➢ Could use FPGA to mimic the device
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Tape out

- Once the design is ready, all simulations are ready, verification is complete
- Send the layout metal masks & die floor plan, foot prints etc to foundry
- Prepare:
  - HW for test, reliability, characterization
  - Test / characterization program
  - FW
  - Validation -> test cases for FW
  - Customer code
- Get ready for wafer / packages.
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Fabrication

- Wait for the foundry to deliver the wafers together with the wafer attribute data
- WAT data is very important to identify the device behaviour before testing
- Fab-deviations, process variations are caught by WAT.
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Firmware

- IC is getting ready, what is next?
- How do you verify / test / use the bare IC?
- Prepare the FW before the devices arrives
- The software that controls the device functionality

Two types:
- Permanent FW: store in ROM, load before tapeout.
  - One time yet lot of effort
- Flexible FW: Store in Flash, load anytime, as many times as you want
  - Need to integrate Flash, one time investment, reap the fruits forever
  - Often is used to re/cover the design issues
Firmware

- Language: ASM, C, few other
- Requirements: Minimum, efficient, real time, stable, easy to read ...
- Errors: are very expensive
  - A good FW can make bring life to a scrap device
  - A very small error can turn $tn product into scrap
- Minimize processor activity, ex: battery powered devices
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Characterization & Testing

- Wafers are ready, if needed, assemble the devices into the packages.
- For wafer test, need to be ready with the Test/Characterization programs.
- Bulk testing - ATE is needed.
- Characterization – Bench setup (DPS, VI, OSC, AWG, ...) / ATE
- Need to have the proper hard ware (PCB, sockets, Probe card etc) before starting test / char
- On ATE, need to have the test program
- Char – Sweep the device behaviour across PVT corners to find the pass-fail boundary and values for all specifications at this boundary
- Device is meeting all specifications → proceed for bulk testing
  - If not, go back to design and repeat
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- Manufacturing
Qualification & Release

➢ Bulk Testing:
  • Prepare and debug the production test program – must be on an ATE
  • Test wafers (6”, 8”, 10”, 12”) / Packages (DIP, QFN, SOIC, BGA, WLCSP, …)

➢ Reliability Tests:
  • Make sure device life time is as per the design expectations
  • Perform stress tests, to avoid field failures

➢ Once devices pass through Reliability test, freeze the test program and submit for the Test houses (in-house testing or OSATs)

➢ Six Sigma, Gaussian distribution

➢ Statistical Analysis of test results
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Manufacturing

➢ Once the device pass all Reliability tests, it is the time to sell
➢ Fab will produce the wafers
➢ Test house performs testing WT or FT
➢ Operation team will take care of the post release activities.
➢ Sell to customers : direct or distributor
➢ Zero inventory:
  • Take orders with a lead time
  • Fabricate, Test & Sell within the lead time
  • No extra expenses in maintaining the inventory
  • No available finished good in the inventory
  • Need to have the fab, test, assembly houses available all the time
How this could help you?

<table>
<thead>
<tr>
<th>Role</th>
<th>Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Program Manager</td>
<td>Business administration with strong electronic background</td>
</tr>
<tr>
<td>Design Engineer</td>
<td>Design &amp; layout, must have deep understanding of transistor level circuits</td>
</tr>
<tr>
<td>Verification Engineer</td>
<td>Verification, Deep understanding of transistor level together with HDLs</td>
</tr>
<tr>
<td>Product Engineer</td>
<td>Thorough understanding of processes from transistor level to package part</td>
</tr>
<tr>
<td>Test / Characterization Engineer</td>
<td>Thorough understanding of transistor level circuits, ATE knowledge &amp; HL languages</td>
</tr>
<tr>
<td>System Engineer</td>
<td>Knowledge of HDL, block level understanding of circuits</td>
</tr>
<tr>
<td>Software / FW Engineer</td>
<td>Register level understanding of a circuit &amp; low level languages</td>
</tr>
<tr>
<td>Validation Engineer</td>
<td>Block level understanding &amp; high level languages</td>
</tr>
<tr>
<td>(Field) Application Engineer</td>
<td>Block level understanding &amp; low level + high level languages, 20% travelling</td>
</tr>
<tr>
<td>Marketing</td>
<td>Business administration with Electronic background</td>
</tr>
<tr>
<td>Failure Analysis Engineer</td>
<td>Block level &amp; register level understanding, FA instruments</td>
</tr>
<tr>
<td>Other cross functional roles</td>
<td>To facilitate all the above roles to ease the execution of their job</td>
</tr>
</tbody>
</table>
Questions?