Our Passion on Popularization of RISC-V

Tony Xu @Nuclei System Technology
About Us

Nuclei System Technology, is a leading RISC-V core IP company in China. We focus on RISC-V core IP R&D, growing RISC-V market and ecosystem with our partners. We provide solutions based on RISC-V to help the customers to reach the success by accelerating the innovation.
The estimated value of total IC demand in China Mainland in 2018 is

83.49 Billion USD, CAGR 22.9%

The value of total IC demand in world in 2018 is 401.625 Billion USD**, the percentage of Chinese IC market of world IC market is

20.78%

Source: *SEMI China 5,740 (¥ RMB, **WSTS autumn 2018
## China Market Overview

The sales value of the domestic IC companies distributes in 8 domains as below:

<table>
<thead>
<tr>
<th>Domain</th>
<th>Company Number</th>
<th>%</th>
<th>Sales Value Billion USD</th>
<th>Company Number</th>
<th>%</th>
<th>Sales Value Billion USD</th>
<th>Growth Rate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Communication*</td>
<td>266</td>
<td>46.24%</td>
<td>13.09</td>
<td>307</td>
<td>40.62%</td>
<td>15.23</td>
<td>16.34%</td>
</tr>
<tr>
<td>Consumer</td>
<td>610</td>
<td>23.24%</td>
<td>6.58</td>
<td>783</td>
<td>23.95%</td>
<td>8.98</td>
<td>36.46%</td>
</tr>
<tr>
<td>Computer</td>
<td>85</td>
<td>6.59%</td>
<td>1.87</td>
<td>109</td>
<td>13.95%</td>
<td>5.23</td>
<td>180.18%</td>
</tr>
<tr>
<td>Multimedia</td>
<td>72</td>
<td>9.02%</td>
<td>2.55</td>
<td>75</td>
<td>7.33%</td>
<td>2.75</td>
<td>7.59%</td>
</tr>
<tr>
<td>Smart Card</td>
<td>62</td>
<td>7.15%</td>
<td>2.02</td>
<td>71</td>
<td>5.36%</td>
<td>2.01</td>
<td>-0.72%</td>
</tr>
<tr>
<td>Navigation</td>
<td>23</td>
<td>0.32%</td>
<td>0.09</td>
<td>28</td>
<td>0.22%</td>
<td>0.08</td>
<td>-7.56%</td>
</tr>
<tr>
<td>Analog</td>
<td>180</td>
<td>3.50%</td>
<td>0.99</td>
<td>210</td>
<td>5.50%</td>
<td>2.06</td>
<td>108.04%</td>
</tr>
<tr>
<td>Power IC</td>
<td>82</td>
<td>3.94%</td>
<td>1.12</td>
<td>115</td>
<td>3.07%</td>
<td>1.15</td>
<td>3.30%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>1380</strong></td>
<td><strong>28.31</strong></td>
<td><strong>1698</strong></td>
<td></td>
<td></td>
<td><strong>37.49</strong></td>
<td></td>
</tr>
</tbody>
</table>

*IoT, Networking, Phone
RISC-V in China

Momentum is growing in China for RISC-V, many companies are asking for RISC-V.

- Shanghai government issued a 2-years-policy (July.1st.2018-June.30th.2020) to provide financial support to the companies related to RISC-V in China.

- **CRVIC** (China RISC-V Industry Consortium) and **CRVA** (China Open Instruction Ecosystem (RISC-V) Alliance) together aggregate the industrial and academic resources to accelerate the growth of RISC-V ecosystem in China.
Our Passion on RISC-V

Open Source RISC-V Core Hummingbird E203

The First and the second RISC-V books in Chinese

Running Social Network Media

Perseveringly Sharing our Thought on RISC-V
Hummingbird E203

- First open source RISC-V core project in China
- Written in Verilog HDL according to industry level standard
- Well documented with rich demos
- Two books and FPGA development board
- Widely used in research, education and evaluation
Hummingbird E203

A hummingbird may be small, but it has all its vital organs. So does the Hummingbird E203.
Hummingbird E203
# RISC-V Processor Design

## Part 1. Overview of CPU and RISC-V

<table>
<thead>
<tr>
<th>第一部分</th>
<th>CPU 与 RISC-V 综述</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 章</td>
<td>一文读懂 CPU 之三生三世 ——2</td>
</tr>
<tr>
<td>2 章</td>
<td>大道至简——RISC-V 架构之魂 ——29</td>
</tr>
<tr>
<td>3 章</td>
<td>乱花渐欲迷人眼——盘点 RISC-V 商业版本与开源版本 ——46</td>
</tr>
<tr>
<td>4 章</td>
<td>开源 RISC-V——蜂鸟 E200 系列 超低功耗 Core &amp; SoC ——54</td>
</tr>
</tbody>
</table>

## Part 2. How to Design a CPU with Verilog

<table>
<thead>
<tr>
<th>第二部分</th>
<th>手把手教你使用 Verilog 设计 CPU</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 章</td>
<td>先见森林，后观树木——蜂鸟 E200 设计总览和顶层介绍 ——65</td>
</tr>
<tr>
<td>6 章</td>
<td>流水线不是流水账——蜂鸟 E200 流水线介绍 ——78</td>
</tr>
<tr>
<td>7 章</td>
<td>万事开头难吗——切从取指令开始 ——88</td>
</tr>
<tr>
<td>8 章</td>
<td>一鼓作气，执行力是关键——执行 ——117</td>
</tr>
<tr>
<td>9 章</td>
<td>善始者实繁，克终者盖寡——交付 ——161</td>
</tr>
<tr>
<td>10 章</td>
<td>让子弹飞一会儿——写回 ——170</td>
</tr>
<tr>
<td>11 章</td>
<td>哈弗还是比亚迪——存储器架构 ——178</td>
</tr>
<tr>
<td>12 章</td>
<td>黑盒者的窗口——总线接口 单元 BIU ——203</td>
</tr>
<tr>
<td>13 章</td>
<td>不得不说的故事——中断和异常 ——217</td>
</tr>
<tr>
<td>14 章</td>
<td>最不起眼的，其实是最难的——调试机制 ——246</td>
</tr>
<tr>
<td>15 章</td>
<td>动如脱兔，静如处子——低功耗的诀窍 ——260</td>
</tr>
<tr>
<td>16 章</td>
<td>工欲善其事，必先利器—— RISC-V 可扩展协处理器 ——276</td>
</tr>
</tbody>
</table>

## Part 3. RTL Simulation and Running Software on FPGA SoC

<table>
<thead>
<tr>
<th>第三部分</th>
<th>使用 Verilog 进行仿真和在 FPGA SoC 原型上运行软件</th>
</tr>
</thead>
<tbody>
<tr>
<td>17 章</td>
<td>冒个烟先——运行 Verilog 仿真测试 ——292</td>
</tr>
<tr>
<td>18 章</td>
<td>套上壳子上路——实现 SoC 和 FPGA 核心 ——302</td>
</tr>
<tr>
<td>19 章</td>
<td>画龙点睛——运行和测试软件示例 ——321</td>
</tr>
<tr>
<td>20 章</td>
<td>是骡子是马？拉出来遛遛——运行测试程序 ——332</td>
</tr>
</tbody>
</table>

## Appendix. Details of RISC-V

<table>
<thead>
<tr>
<th>附录部分</th>
<th>RISC-V 架构详述</th>
</tr>
</thead>
<tbody>
<tr>
<td>附录 A</td>
<td>RISC-V 架构指令集介绍 ——342</td>
</tr>
<tr>
<td>附录 B</td>
<td>RISC-V 架构 CSR 存储器介绍 ——374</td>
</tr>
<tr>
<td>附录 C</td>
<td>RISC-V 架构的 PLIC 介绍 ——384</td>
</tr>
<tr>
<td>附录 D</td>
<td>存储器映射背景介绍 ——392</td>
</tr>
<tr>
<td>附录 E</td>
<td>存储器原子操作指令背景介绍 ——397</td>
</tr>
<tr>
<td>附录 F</td>
<td>RISC-V 指令编码列表 ——400</td>
</tr>
<tr>
<td>附录 G</td>
<td>RISC-V 伪指令列表 ——404</td>
</tr>
</tbody>
</table>
RISC-V Embedded Development

第 1 章 进入 32 位时代，谁能成为下一个 8051 ………………… 1
第 2 章 开源蜂鸟 E203 超低功耗 RISC-V Core 与 SoC ……… 25
第 3 章 大道至简——RISC-V 架构之魂 ………………………… 29
第 4 章 RISC-V 中断和异常 …………………………………… 43
第 5 章 开源蜂鸟 E203 MCU SoC 总体介绍 ………………… 59
第 6 章 开源蜂鸟 E203 MCU SoC 外设介绍 ………………… 78
第 7 章 开源蜂鸟 E203 MCU 开发板与调试器 ………………… 143
A Processor Design Book Becomes One of Best-Selling Technical Books in China First Time!
Social Network Media

We are running WeChat Subscription Account (微信公众号) to use the power of social network media for RISC-V.
In Facing of Doubt, We Choose to Start a Business to Show RISC-V can be Mainstream!
Nuclei System Technology

We are a RISC-V Core IP company, and focus on AIoT area.
Nuclei System Technology

- Nuclei System Technology was founded in 2018, and quickly became a leading RISC-V Core IP company in China.
- Focus on R&D of RISC-V Core IP and related solutions, and to be enabler of local RISC-V ecosystem.
- Growing rapidly, and finished more than more than ten million RMB angel round funding.
- Vice chairman of CRVIC, and also the member of CRVA.
Nuclei System Technology

**N200/N22 (32bit)**
- Cortex-M0
- Cortex-M0+
- Cortex-M3
- Cortex-M4F
- Cortex-M7

**NXXX(32bit)**
- Cortex-R4
- Cortex-R5
- Cortex-A5
- Cortex-A7

**NXXX(64bit)**
- Cortex-A53
- Cortex-A35
- Cortex-A55

**Supporting RISC-V Vector Instructions**

**ARM Helium Vector Extension**
Nuclei + Andes

Open is the key of RISC-V! Comparing to mainstream processor, RISC-V is not perfect, so we have to work side by side to R&D competitive products and make ecosystem better.
Nuclei + Andes

N22 is the result of tight engineering cooperation between Nuclei and Andes. Now, we are working on

- New features: DSP, FPU, ACE
- Optimization: Smaller gate count (the target is 12K~13K in minimal configuration)
Nuclei + Andes

N22 can be configured to satisfy customers' different requirements

**Simple Controller**
- Minimum Configuration
- • V5e: RISC-V compliant RV32EC
  • AndeSight IDE with Toolchain

**IoT Controller**
- Normal Configuration
- • V5/V5e: RISC-V compliant RV32IMAC/RV32EMAC
  • AndeSight IDE with Toolchain

**Smart Controller**
- Full Configuration
- • V5/V5e: RISC-V compliant RV32IMAC/RV32EMAC
  • Optional DSP ISA, FPU and ACE features
  • AndeSight IDE with Toolchain
N22+DSP Preliminary Result

**Dot Product of the Q15 Complex Vector** (smaldrs, smalxda, wexti) - 4.07x

**Q15 FIR Filter** (kmabb) - 3.86x

**Q31 FIR Filter** (kmmac.u) - 3.36x

**Convolution of the Q15 Vectors** (smalbb, wexti, sclip32, pkbb16, smalda, smalxda, maxw) - 3.98x
N22+FPU Preliminary Result

Whetstone Benchmark (MWIPS/MHz)

- **Cortex-M4F**
- **N22+FPU**

**Single-Precision**
- N22+FPU: 1.806
- Cortex-M4F: 1.09

**Double-Precision**
- N22+FPU: 1.366


Next Step

● Extending new features for our ultra low power product line, and optimizing to make higher quality.
● Developing a higher performance processor soon.
● Having more partners to build a more solid ecosystem and develop China market together.
Do You Want to Be Our Partner?
Please Contact Me

Tony Xu

tonyxu@nucleisys.com
THANKS!