Designing Multicore Microcontrollers

with some help from my friends

By Chip Gracey of Parallax, Inc.
Me after Propeller 1 was finished, working on Propeller 2 – six years ago.
You don’t need fancy accreditations to design your own chips.
Everything you need to know about full-custom chip design is in these two books.
Full-custom design is nitty-gritty, lots of fun. You control EVERYTHING.
RING2 with the 2X shared-drains inverter is FASTER. It has lower parasitic capacitance per drive strength. Neat-O!
An Altera FPGA board I designed to develop Propeller 2 on sits next to a Propeller 1 Demo Board.
Would you believe this took 8 years to make? Every polygon is ours.
Jeff and I at the Micron FIB machine. It modifies chips with an ion beam and tungsten gas – like wire cutters, wire, and solder for sub-micrometer work.
Early forum interaction – I asked questions about what direction to take and the users had lots of great insight on how to improve the Propeller chip.
Someone made this out of a Propeller chip.
### Slot car track monitor and scoreboard.

<table>
<thead>
<tr>
<th>Track</th>
<th>Race Car</th>
<th>Laps Left</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Peter Pettigrew</td>
<td>00:00:00.00</td>
</tr>
<tr>
<td></td>
<td>Team Big Dog</td>
<td>00:00:00.00</td>
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<tr>
<td>2</td>
<td>Hannible Lector</td>
<td>00:00:00.00</td>
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<tr>
<td></td>
<td>Team Slice &amp; Dice</td>
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**Status:** Press Blue Button
Some are more adventurous than others.
Jeff Ledger from the forum started putting on “Unofficial Propeller Conferences”.
The 1st “Unofficial Propeller Conference” was in Ohio.
What a delight to discover the Propeller had attracted all kinds of nice people. If you skimmed an embedded-systems trade show for the kindest people, here’s who you’d get. How did this happen?
Was this some inadvertent filter?
Propeller 2 moves forward with 75-ohm DACs on every pin. Much more analog-friendly.
Now HDTV, thanks to input from an early Propeller Expo attendee.
Schematics. Schematics. Schematics for everything.
Layout effort is becoming overwhelming. Need to do something different!
Verilog and synthesis are the way out of the schematic/layout trap.
8 cogs find their own area within the place-and-route tool.
Our full-custom layout with a big hole in the middle for the blob of 500,000 synthesized gates. Nobody could route such a rat’s nest on his own. The 3,700 signal connections to our custom layout, plus over 2,000 power connections would be the trivial part.
Lots of presenters at a Parallax Expo. Propeller 2 is four years late. Everyone had a great time.
My dad and Bill Henning at a Propeller Expo.
Gatling paintball gun controlled by a Propeller, made by a special-effects artist.
288,000 posts on the main Propeller forum. 7,800 on the early-adopter Propeller 2 forum.
Expensive, but FAST, Altera board - $2495 (that Stratix III chip sells for over $3000!?!)
This is what I was using. We had to buy a new one each year to keep Quartus II current.
New Terasic Altera Cyclone IV boards - $595 (5 cogs) or $79 (1 cog).
Everybody can play with Propeller 2 now, before the silicon is done!
2,291 posts into the “Propeller II update – BLOG” with 282,725 views!
SOME PROPELLER 2 CHIP FEATURES RESULTING FROM FORUM INTERACTION

Code protection using SHA-256/HMAC – open standard which is considered secure (Pedward)

Texture mapping for perspective-correct, lighted, blended polygons - 3D graphics!!! (Andre LaMothe and Roy Eltham)

Multithreading – each cog can now run 4 different programs simultaneously. (Heater, Bill Henning, Ariba, and others)

Friendly boot monitor - no need for a development system if you just want to load some code or poke around. (Potatohead, others)
Security bits are clear.
Welcome, Everyone!

Bits are set!
You’ll get nowhere without a proper signature.

You’ll have to sign your loader if you want to mess with those bits, Sir.

The dreaded code-protect issue finally gets solved, elegantly!
Nasty bug gets discovered and fixed right before a tape-out. Notice that 48 posts occurred in 9 hours between discovering and identifying the bug. Whew!
Thanks to Heater, each cog in the Propeller 2 is now multi-tasking. I was so excited when he thought of this. I worked like mad and 17 days and 964 posts later, it was implemented.
Atomic XOR makes Spin/PASM multitasking compatible. This saved the day.
Ozpropdev made a Space Invaders game on the 1-cog DE0-Nano board.

This is 1/8th of a Propeller 2 running at 3/8ths speed. It even has a background serial monitor.

Too bad we can’t go back to 1978 with a bunch of Propeller chips.

Here is an original Space Invaders motherboard setup.
Here’s a collage of most of the avatars of the forum members who’ve been formative in the Propeller 2’s development. They are from all over the world.
How to wind up with a horse, after all:

- You need a grounded, gut sensitivity about what you are doing. It develops over much time, if you really care.
- You need autonomy to operate. You have to forge that yourself, which usually means working alone, or expecting to.
- Work within a sphere in which you can have control, even if it’s quite limited.
- Others of like mind will eventually join you and you will be able to happily collaborate, without dread of compromise, as you are both free agents. Any less freedom could only produce a donkey. Look at that horse!

It’s said that a camel is a horse designed by committee.
The new Propeller 2 wafers are back, getting packaged. We hope they’re good.
New Propeller 2 die under a microscope.
If the new wafers are good, we’ll have lots of these, at last. Seems a little anticlimactic, doesn’t it?
This is pretty much what a Propeller chip is all about – it’s a handy workshop in which you can build amazing things. I’m really looking forward to getting in there!
THE END

Thank you!