The Mighty MOSFET
by
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This handout explains the story behind this OLLI class, and provides a way to review the slides plus additional information – a lot more.

For my entire adult life, and for a fair part of my childhood, I've been fascinated by computers. Learning how they work, and then making them work has been a passion. For years, while I was doing various practical things with computers at various jobs, I thought about how I could share my enthusiasm for this marvelous technology with others.

To most people, computers are the ultimate black box. At least since the personal computer revolution in the 1980s, almost everyone has learned to use computers – like we learn to drive a car, or operate a television – without really understanding anything about how that inanimate object manages to do so much to serve – and sometimes annoy – us. We may appreciate the things computers can do, without much thought about how they do them.

For me, having an understanding of what is going on inside the box makes me appreciate computers even more. I am frankly amazed that such an intricately designed machine can even work. And even more amazed that they have become such a pervasive presence in our lives. Computers are built from layers upon layers of invention, and like a coral reef, they have developed into something worthy of awe and wonder. This has taken decades, and the combined contributions of countless individuals.

With this mindset, I've often considered trying to write down what I know about how computers are built, so that others might be able to share in my appreciation. I envisioned a book that would start with the basics, and work up through the layers of technology. At each layer, I would explain just enough to give an intuitive feel for that layer; how that particular piece of technology was built from the lower layers, and how it was, in turn, used to build something slightly more complex. Continuing up through the layers, the whole beautiful picture would emerge.

Given that computers are built out of microelectronics based on silicon – which is also the primary component of sand – the title of this potential book came to me quickly: *Computers from the Ground Up*.

For many years, the book was just something to think about, though. I had plenty of real work to do, for which various companies paid me, throughout a rewarding career creating and using these complex machines. As the 50 year anniversary of my first paying job working with computers approached, and noting that it coincided with what the Social Security Administration informed me was my "Full Retirement Age," I decided that perhaps it was time to give this retirement thing a try.

That approaching date was in mid-2020, so I did a fair amount of planning and preparing to retire at that time, getting my personal finances in a position to sustain my wife and me without a regular paycheck coming in, wrapping up my part of current work projects, and starting to think about what I would do once the daily grind of work was no longer consuming most of my time.

I did follow through on my plans to retire in mid-2020, but of course, there was a little thing called the Covid pandemic raging at just that time. Most of my thinking about what to do with my time after

retiring involved traveling to exciting places, or otherwise finding new and different things to do. Instead, like the rest of the country, and much of the world, I was hunkered down at home – nowhere to go, and not much to do.

It did not take too many days of that before the idea of spending some time writing that book I had always dreamed about came to the forefront – so off I went, starting with chapter one, and just plowing on through.

Soon, the book started taking shape. My goal was to make it accessible to general audiences with no previous computer engineering background, but with sufficient detail so that each step up the ladder of technology could be understood well enough that a reader would be able to conclude, "Yes, I see how that works, now."

I had a basic table of contents worked out. The first half of the book would be about computer hardware, and the second half about software, and just thinking about the topics to be covered, I thought that the two halves would be roughly equal in length.

After a few months of work, a first draft of the first half was nearing completion, and I was ready to take a break. Also, in 2021, some things started reopening, and other opportunities appeared.

This gave me a chance to step back and look at what I had written so far. I generally liked it, but I realized there was a problem. My book was intended to give someone who just had a healthy curiosity about computers some basic information about how they were built and worked. The first half of the book seemed to accomplish that goal for the hardware aspects of computers, and it had just about the right level of detail, in my opinion. It was also 172 pages long.

I had to ask myself, if I completed this book, and it turned out to be 350 pages long, would anyone who just wanted to satisfy their general curiosity about computers be likely to pick it up? I was coming to the conclusion that while I still thought people would be interested in understanding more of what I knew about computers, this book might not be the best way to educate them.

Then, in the fall of 2021, OLLI at UNT resumed in-person classes. I had heard of OLLI at UNT earlier in 2021, and was anxious to check it out. I've been hooked since attending my first OLLI class, and it is now a big part of what I am doing with my retirement. Regularly attending 30 or more classes a semester, you'll see me often learning more about things I've never really studied before: literature, opera, history, music, and more.

After the first semester, it occurred to me that maybe OLLI also presented an opportunity to approach my dream of sharing my passion for computer technology with others. The students I was meeting seemed to be the naturally curious type, and there did not appear to be a lot of classes offered that focused on teaching the fundamentals behind modern technology.

So, with some trepidation, I filled out the form to propose a course that I thought might be interesting. I was excited when it was selected to be part of the spring 2022 semester. Encouraged by the reception it seemed to get from the OLLI community, I proposed a second course in the summer, which had a little bit more challenging material, and then offered to teach each of these again in the fall.

After that much warm up, I took a deep breath, and proposed this course, "The Mighty MOSFET" for the spring 2023 semester. It is taken pretty directly from my book draft. Obviously, it does not cover

as much material as is contained in the 172 pages I wrote, but I believe (and hope) that it will introduce some of the marvels of modern computer technology, by answering some questions about, “What is really going on in there?” at the lowest physical layers.

“The Mighty MOSFET” was actually a chapter title in the book, which I liked so much, I used it for the course title, although the course covers information adapted from a few chapters both before and after that one.

My hope is that students will be able to absorb enough information in 90 minutes to develop a decent intuitive feel for how electronic switches (called MOSFETs) work and are constructed in integrated circuits, how those switches can be arranged to perform basic logic functions, and how these logic building blocks can perform the sorts of operations that computers need to do.

But, to present that, I necessarily need to cover quite a bit of material pretty quickly. I think it will be possible to get that basic understanding, but I also suspect that some will likely feel that they need to look at the materials more closely and think through some things I’ll be describing to really “get it.”

So, with the optimistic belief that at least some who hear my presentation might be motivated to want to improve their understanding more fully, I’m offering two resources that you can download and study at your leisure.

However, I do NOT recommend that you download and look at these before the class. Please give me the opportunity to introduce this information to you in person, and then if you want to deepen your understanding, use the links below.

If you are reading this handout online, you may be able to just click on the link, or possibly “ctrl-click” on a link, to start the download. If that doesn’t work, you should be able to copy the link into any web browser to request the file download.

The first link downloads a PDF file with all the slides presented in the class, along with my “speaker’s notes” reminding me of what I intend to say. As you’ll see in the class there are animations on some of these slides, which of course you won’t see on the static download, but after seeing it live, it may be helpful to be able to go back to some of the key points and dig in further. There are 79 slides, and there is one page per slide, so if you decide to print it out, be sure you have plenty of paper on hand!

https://drive.google.com/uc?export=download&id=1KCHo5Iiv4-m9SOPg5Z_A8xkOUwtzx2mj

The second link will download a PDF of my draft of the first half of “Computers from the Ground Up.” All 172 pages of it. If you are *really* inspired, and want to go through it, you are welcome to do so. My main request is that if you do decide to do this, please contact me at “david.mckinley@mail.com” and let me know what you thought of the (half) book. Maybe some day I’ll get back to it again, and your honest feedback would be invaluable.

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Finally, please do reach out to me by email at “david.mckinley@mail.com” or grab me next time you see me at any OLLI class or function, if you have further questions, or would just like to talk about any of this stuff further.