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# Back to Basics

The first thing that struck me was the extreme neatness inside the school building. With it being in Switzerland, I should not be surprised. Yet the Ecole Hoteliere was so clean that it almost could compete with a semiconductor fab. The world's best hospitality management school trains future managers for positions in top hotels and restaurants. Its students undergo a rigorous education program. They familiarize themselves with haute cuisine as well as haute finance. But what surprised me most was their daily drive to improve their basic skills: from their personal attire to cutting vegetables julienne style. Their motto is simple: you can only become a real leader if you excel in the basics.

That simple adage is certainly valid for microelectronics; yet it is too often forgotten. Many young engineers stare at the pundits receiving prizes and titles, and they question how to reach that level. Do top engineers have some special DNA to analyze complex problems? While the youngsters are pondering how to improve their skills, the answer is often in their first-year lectures. The main difference in quality between average and excellent engineers is a deeper level of understanding the basic principles.

For every engineering activity, other principles are relevant. A printed circuit board designer should be familiar with the interaction among the board material, the wiring, the components, and the mounting technology. His excellence depends on his experience with various technologies and correctly interpreting information such as that found in data sheets. That includes knowledge of the component's behavior within the specification range but more so what happens if the part is pushed outside its operating region during switching sequences, power issues, and other unforeseen events.

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In any sort of chip design, the principles of mathematics and physics are indispensable. Mathematical transformations allow different views on the sequence of events. The Fourier frequency transform is the basis of signal filtering, sampling theory, image compression, and many more. Time sequences are interpreted as counts per unit time. To transform from time to frequency, the assumption is used that the signal window can be repeated indefinitely.

That's trivial. Now suppose there is only 1 µs of signal available and no option to stretch into infinity. How accurate can the frequency content then be determined? This simple engineering question reveals a basic transformation constraint: a limited observation period results in limited frequency accuracy. Heisenberg's uncertainty theorem is the quantum mechanical consequence. Many physical and engineering effects are directly related to underlying mathematical theories.

Another vital principle involves a first-order system characterized by a time constant. Any source that fills a container by means of a flow that is proportional to the level difference results in an exponentially declining behavior of the flow. That is true for RC and RL circuits, for heating objects, in financial planning, and in metrological phenomena. Even your toilet tank behaves at some moment as a first-order network.

A time constant is a time delay below the cut-off frequency. The delay equals the time constant, and above the cut-off frequency, the delay is a quarter of the signal frequency period. So a 1-µs time constant delays a 2-mHz or a 10-kHz signal by 1 µs. A complex circuit often reveals its behavior by simply checking the time constants of the nodes that the signal will pass. Automated financial speculation techniques feed the flow of commodity prices (copper, corn, oil) into two separate first-order systems. The decision to buy/sell depends on the sign of the difference between the two first-order systems. The financial know-how is in the choice of the time constants for first-order systems.

Mastering this seemingly simple undergrad material to a deeper level is key for reaching some level of excellence. Electrical engineers should improve their basic skills just as junior hotel managers do: pay attention to them every day!

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