19.1 PRACTICAL TECHNOLOGIES

The combined semiconductor, electronics, and packaging industries develop many exciting and advanced technologies each year. An engineer may be tempted to use the latest and greatest components and assembly techniques on a new project, but careful consideration should go into making such decisions. Relevant constraints for any engineering organization are materials availability and cost, ease of manufacture, development resources, and general risk assessment. These constraints differ among organizations. A large company with extensive experience and support resources has a different view of the world from that of a one-man design shop building microcontrollers. This does not mean that a small organization cannot successfully utilize new technology. It does mean that all organizations must evaluate the practicality of various technologies using constraints that are appropriate for their size and resources.

Materials availability is often a problem, even for large companies, when dealing with cutting-edge technologies or newly introduced products. Cutting-edge technology is, by definition, one that pushes the limits of what is achievable at any given time. Pushing the limits in any discipline generally carries with it the understanding that problems may arise in the early stages of product release. New technologies may also carry higher initial costs while volumes and manufacturing yields are still low. Part of engineering is balancing the risks and benefits of new technologies. When you move into uncharted waters, an occasional setback is almost inevitable. Therefore, the new technology that one may read about in the trade press or see advertised in company literature is not necessarily ready for immediate use.

Aside from the general risk of new products, the economic strength that you represent as a customer has a significant impact on your ability to gain access to these products. If you are a semiconductor company that has just developed a new chip, and you have the staff to support only three initial customers, would you want three large customers or three small customers? Developing relationships with manufacturers and their representatives can assist you in determining when a new technology is practical to use and when it should be allowed to mature further. This applies equally to more mature products. Even components that have been shipping for some time may be subject to availability problems. The term *allocation* is well known to component buyers. In a tight market, vendors will preallocate their manufacturing capacity across a set of key customers to preserve successful business relationships. Even when a product is mature and being manufactured in high volume, a small customer may be unable to purchase it, because it is "on allocation." Allocation problems affect large companies as well in times of increased demand. The semiconductor industry tends to be quite cyclical, moving through phases of supply shortages and softness in demand.

Evaluating the risk of availability is an important step in the component selection process. More mature components are generally easier to obtain. The exceptions to this rule are ICs that have short production lives, such as some microprocessors and memory chips—especially DRAM. The microprocessor and memory markets are highly competitive, and products are sometimes phased out after just a few years. DRAM products are notorious for supply and obsolescence problems after their volumes peak within the first few years of introduction. There are certain bread-and-butter microprocessor and memory ICs that are supported for longer terms. These tend to be products for embedded markets in which semiconductor process technology changes at a slower pace than in the mainstream computer market.

Newer products are often available only through authorized distribution companies. Many mature products can be purchased from catalog distributors. Catalog distributors include Digikey, Jameco Electronics, JDR Microdevices, and Mouser Electronics. Larger engineering organizations with dedicated purchasing staff often prefer to deal with authorized distributors because of more direct access to manufacturers. A small organization may be able to satisfy all or most of its procurement needs with catalog distributors if mature technologies are acceptable.

Manufacturability should be taken into account when selecting components, because it may be impossible to assemble a system without expensive equipment. High-end ICs and electronic components utilize fine-pitch surface-mount technology almost exclusively because of the reduction in parasitics and the increase in signal density. Ball grid array (BGA) packages and 0402/0201 passive components are challenging to properly mount on circuit boards. They require accurate application of solder paste, precise positioning of components, and tightly controlled thermal profiles in solder reflow ovens. Most leaded surface mount components can actually be assembled by hand with a good quality soldering iron, although it may take some time and practice to do this. Ultra fine-pitch components are extremely difficult to assemble by hand in a reliable and repeatable manner, and BGAs are impossible to mount reliably without specialized equipment. These requirements should be taken into consideration according to the manufacturing facilities at your disposal. Organizations willing to spend the money necessary for high-end systems development routinely use BGAs and other advanced packages. Products that must be assembled either by hand (e.g., small prototype runs) or at lower-cost assembly shops that use older equipment must be designed with components that are compatible with these approaches.

More complex digital ICs may require significant development resources whose costs cannot be overlooked. When most digital systems were built from 7400 logic, the development tools required ranged from pencil and paper to a basic schematic capture program. The barrier to entry from a tools purchasing perspective was low and remains low for this class of design. Once a microprocessor is added, things get a little more involved. First, a microprocessor requires boot ROM that somehow must be programmed. EPROM—and now flash—programmers are common development tools in a digital systems lab. (Don't forget to socket the boot ROM rather than soldering it to the PCB, so that it can be removed for programming!) With microprocessors also come software development tools including assemblers and compilers. An assembler is the minimum software tool required to work practically with a microprocessor. Because of their relative simplicity, assemblers can be obtained for little or no cost for most microprocessors. Some manufacturers of embedded microprocessors give away assemblers to promote the use of their products. High-level language compilers (e.g., C/C++) for many microprocessors are also available at little or no cost, thanks to the GNU free software project.

Programmable logic devices require a whole other set of development tools that can get rather expensive, depending on the complexity of the design and which devices are being used. An HDL such as Verilog or VHDL is most commonly used to implement programmable logic, although some engineers still use schematic capture for smaller designs—a practice that was more common in the days of less-complex digital logic. Some PLD manufacturers also support proprietary design entry methods, although this support is more for legacy customers than for new mainstream business. The first step in HDL-based design after writing the logic is to simulate it to verify its operation prior to debugging in the lab. It is much easier to detect a problem in simulation, because all internal logic nodes can be probed, and the circuit can be run at an arbitrarily low speed to observe its operation. Lab debugging requires equipment such as oscilloscopes and logic analyzers to view logic nodes, and less visibility is generally available as compared to a simulation. The next step is synthesis, wherein the language constructs are converted into logic gate representations. Simulation and synthesis tools can cost thousands or tens of thousands of dollars, although some manufacturers offer very low-cost HDL design software for smaller designs. After synthesis, the logic must be mapped and fitted to the specific chip's internal resources. Mapping software is proprietary, based on the type of PLD being used, because each manufacturer's PLD has a different internal structure. This software is provided at low or no cost to customers.

Configuring PLDs once required expensive programming equipment, but most modern CPLDs and FPGAs are now in-circuit programmable via a serial or parallel interface. In fact, most CPLDs and FPGAs use EEPROM or SRAM technology, which makes them almost infinitely reprogramma-