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Making the Build-or-Buy Decision—Balancing Cost, Time and Performance

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When deciding to use standard products, custom products or pursue in-house designs, time-to-market pressures and staff capabilities are key considerations

In this era of standards-driven design, chip sets and reference designs, you might think that the classic build-or-buy decision is rarely an engineering issue. Although it may have changed in its details, the decision process remains an important part of any engineer's job. Some of you may suggest that it is more "how much to build" than whether or not to build, but the decision process remains the same.

In some cases, the build-or-buy decision has gotten harder, due to more choices. For example, should a circuit be constructed using standard building-block ICs, a standard-cell ASIC, a semi-custom IC, or a full-up fabricated IC for large-scale production.

To examine this subject, we'll take several common functional subsystems and discuss the options and tradeoffs for each.

Semiconductor Circuit Functions

For the operational function of a new design, the extreme "build" end of the spectrum is probably a collection of catalog ICs that provide the required features at an acceptable level of performance, supported by occasional discrete semiconductors for specific power, control and signal functions. I think nearly all engineers are familiar with this method, since college lab experiments work this way, proof-of-concept and prototypes are typically built this way, as are many small-quantity manufactured products.

Many high performance designs use a building-block approach, since a common tradeoff versus higher integration is the ability to obtain maximum performance. Noise, dynamic range and crosstalk performance is usually somewhat less in a highly-integrated IC when compared to a more-or-less optimized device with simpler functionality.

When the higher-integration options have performance that is acceptable for the application, and quantities will justify the initial engineering costs, there are many options available in terms of engineering complexity, development time, initial engineering and setup costs and, of course, the range of performance.

To begin the investigation, an engineer often starts with performance, since certain minimum acceptable specifications may dictate the material, process type and semi- versus full-custom design choices. CMOS, silicon, SiGe, GaAs and other processes offer a wide range of available frequency range, noise figure, dynamic range, power consumption and other key parameters.

Once the choice is made for a certain type of semiconductor process (or maybe just narrowed down), the decision-making shifts to more practical matters—development software usability and its proven results, support from the vendor's staff, estimated time to various development milestones, initial cost versus amortized cost, etc. These non-circuit choices almost always have a greater effect on a successful outcome than the potential performance of the chosen process!

Entire books have been written on the subject of IC design. Once the choice has been made to examine the semi- or full-custom options, a short note like this is no longer useful, so we will move on to another subsystem.

Filters

This is easily the most-discussed build-or-by circuit element in my experience. Compared to the cost of individual components, a manufactured filter is expensive at low to moderate quantities. Even at high volumes, the filter may represent the single most costly device in the bill of materials.

But engineering time is expensive, too, and the range of filter specifications is wide. Often, an engineer is simply not well enough versed in filter design to obtain the level of electrical, environmental and reliability performance that an experienced vendor of filter products can offer. At the highest performance—narrow bandwidths, critical passbands/stopbands or flat delay characteristics—the decision is almost always to adjust the design to accommodate a standard filter, or perhaps to obtain a semi-custom filter adapted from a standard product.

Another line of discussion is eliminating filters from the circuit, or reducing their performance requirements to easily-obtained levels. Direct conversion is a well-known technique that eliminates a lot of filters by moving signal processing complexity into the digital portion of the radio. In an earlier day, block up- and down-conversion accomplished a similar task, eliminating much of the front-end filtering.

As microwave frequencies go higher, the choice is often whether to implement the filter on the main circuit board using a stripline or microstrip design, or whether to move the filter inside the package with the semiconductor device, thus minimizing the requirement for high-precision etching of a high-performance microwave board material.

Because there are many companies capable of providing filters to a customer's specification, the build-or-buy decision is usually limited to simple filters and projects with small quantities.

Test Accessories

Testing is another area of engineering that involves the widest possible range of frequencies, functions and performance requirements. Some accessories for testing are both common and inexpensive, such as attenuators, cables, directional couplers, power dividers, etc.

These individual test components are assembled by the engineering staff into various test configurations during the development process. But when it comes time for production testing, the decision is whether to build similar assemblies for the production line (including calibration, maintenance and support), or have a specific assembly manufactured by an outside vendor. While both approaches are common, there are plenty of vendors that are well-known for providing specialized assemblies with the necessary switching, coupling, filtering, terminating and other requirements.

I think engineers will always build simple test setups for lab use unless time pressures prevent it. In an increasingly integrated product design environment, it is one area where they can still do some hands-on work that's not at a keyboard.

Power Amplifiers

Like filters, the range of frequencies and performance parameters for power amplifiers is vast. Thus, it is impossible for a power amplifier specialist company to offer everything that a customer might need. Likewise, a company might only have a competent power amplifier designer for the specific range of products they have made for a long time.

In the case of power amplifiers, it is clear that most build-or-buy decisions are made at the beginning of the design process. In my experience, there is rarely any gray area in this decision—it is clear from the beginning whether they have the time and personnel resources to even consider an in-house design.

"One-Shot" Products

I have been involved in several projects where a vendor has been contracted to assemble a single custom system, perhaps a communication including antenna(s) plus various amplifiers, filters and switching. Many times, it is easy to assemble such a system from off-the-shelf modules and components.

Often, however, there is some aspect of the system that is not supported by a standard product, due to the frequency involved, or a special performance requirement. This is when the build-or-buy decision is made. It may not always be clear whether to allocate in-house engineering time to build that system block, or have a vendor of similar products provide a custom component, often with substantial engineering charges.

Actually, in most cases like this, great effort is made to locate a previously unknown vendor who can provide the missing part as a standard or easily adapted product.

A Note on Reference Designs

A related issue is whether to design "from scratch" or simply use one of the reference designs available for the product being considered. This is often discussed with the help of the marketing department, who can add the concepts of, "What do our customers expect?" and, "What will set us apart from our competition."

These type of build-or-buy decisions at the beginning of the design process are becoming more common. The availability of copiable reference designs has grown exponentially in recent years and has enabled the rapid development cycle needed for high-volume manufacturing.

Although the build-or-buy decision is still a significant part of engineering, particularly when making products at less than consumer-level quantities, it seems clear that the "build" decision is often considered "the last resort."