



DOES IT MATTER HOW ENGINEERS IN OTHER COUNTRIES ARE USING REFERENCE DESIGNS? THE ANSWER IS A RESOUNDING "YES."



Reference designs WORLDWIDE: UNDERSTANDING THE IP IMBALANCE

BY NICHOLAS CRAVOTTA • CONTRIBUTING TECHNICAL EDITOR

With the rising complexity of silicon and software design, it has become critical for component vendors to supply more information than just a data sheet to get engineers started on their designs. Reference designs are important ways for companies to pass on IP (intellectual property) relevant to the effective use of their products. The term "reference design" itself is a fairly ambiguous term and can even take on different meanings within the same silicon company (see **sidebar** "Defining reference design" at the Web edition of this *Global Report* at www.edn.com/global). For example, a company's FAEs (field-application engineers) serving North America may use the term to refer to a paper schematic or an evaluation board with limited application software. FAEs from the same company working in Asia, however, may use the term to refer to a fully designed product, perhaps missing external plastics, that is ready for mass production (see **sidebar** "MTK pioneers complete designs and garners de facto monopoly in handsets," also at www.edn.com/global).

Some companies claim that they create reference designs to demonstrate their expertise and market leadership. The reality is that reference designs are all about selling components used in the design. Reference designs require sig-

nificant expense to create, and this expense limits the number of designs that any company can offer.

How countries around the world use reference designs directly influences which ones a company will create and,

more important, how they will use them to generate design wins. Component vendors make deliberate decisions about where they target their reference designs, thus placing engineers in different countries in competition with each other in a way that directly impacts their access to a vendor's engineering and support resources. In other words, the uneven flow of IP is changing the global engineering landscape.

GLOBAL TRENDS

It's difficult to track trends for the use of reference designs in regions of the world. After all, it's a fine line between describing a trend and perpetuating a stereotype. How a company approaches the acquisition of IP depends greatly upon its size, maturity, region, and culture. For example, China, with its lower cost of labor, focuses more on the BOM (bill-of-materials) charges than on the NRE (nonrecurring-engineering) charges. The opposite situation can be true in North America, where engineers are willing to program in C to save design time but at the expense of a larger program memory and a higher performance, more expensive processor. Across Asia, companies

are open to reference IP from IP cores for chip design to complete system designs. Speed in bringing just enough features to market is key (see **sidebar** “Reference designs: What separates Asia from the rest?” at www.edn.com/global).

It's always dangerous to generalize, but if you had to describe each country in only a few words, the following trends and stereotypes might suffice. For example, NIH (not-invented-here) companies, which those in North America typically are, have a great deal of internal experience on which to fall back. These engineers focus on one application in contrast to a component vendor's engineers, who develop application-specific IP for relatively unrelated designs from project to project. As such, the NIH engineers can produce optimal designs. Some reference materials are nice to have, especially for accounting for the obscure and frustrating nuances of a component, but they serve only as launching points for more sophisticated designs. This approach typically maximizes performance and the number of features but incurs the greatest investment and overhead.

In “after-the-fact” environments, such as Japan, engineers are also experienced and create superior products. However, they like to have comprehensive reference designs available not to build upon but to compare with their own designs. They like to work out all the details for themselves, which, like taking the time to solve a puzzle rather than looking at the answer, stretches their skills and improves their mastery of the technology (see **sidebar** “Japanese engineers focus on original designs and customization” at www.edn.com/global). They don't want to repeat what others have done, but they want to see how they've done it. The reference design acts as a final check, perhaps revealing only minor idiosyncrasies in component specs that the engineers overlooked.

The distributed-IP-design model, typical of the United Kingdom, focuses on IP management at the distributor level. European distributors typically add value and increase profits by providing not only chips, but also complete subsystems that designers can drop into a design with limited modifications. In effect, distributors act as IP brokers between component companies and OEMs. This ap-



A Texas Instruments digital-camera reference design comes complete with a camera lens and a sensor.

proach can significantly impact component selection. Although NIH-focused engineers may resist such offerings, some distributors in North America are beginning to explore this approach. To learn about one European system house that always begins designing before reference-design availability, see **sidebar** “Getting to market first precludes a wait for a reference design” at www.edn.com/global.

Some companies, such as those in Taiwan, take an “as-is” approach, taking reference designs mostly as the component vendors supply them. Their goal is minimal investment and fastest time to market. In some cases, an ODM (original-design manufacturer) stands between component vendors and OEMs. ODMs take on the burden of understanding an application market as well as related silicon, software, and system issues. ODMs work with component vendors to create their own reference designs, which they then sell to OEMs that want to quickly get to market. For example, an ODM may create a fairly complex digital-camera design. The ODM then sells this design to multiple OEMs, which personalize the design, perhaps by creating only the external plastics or introducing a differentiating feature, such as antishake or red-eye removal (see **sidebar** “Reference software” at www.edn.com/global).

In another environment, such as India, application engineers with little real-world experience don't always have the luxury of leisurely earning their expertise. Instead, they act as “sponges,” learning on the job. In these environ-

ments, not making mistakes is critical for employment. These engineers consume reference designs, poring over boards and schematics, trying to soak up whatever knowledge they can while still producing designs as quickly as possible.

In contrast, the Chinese design environment is more of a “chop shop.” The focus is on adapting reference designs for end products and minimizing costs. Reference designs by nature are somewhat generic so that you can apply the IP you capture in them across a wide range of applications. Reference designs drive sales of components, so the more customers who can use the design, the better. This approach recognizes that a reference design probably isn't as cost-effective as it could be and brings up images of an “engineer” ripping components off the reference board until it stops working and reducing it to its bare essentials. Swapping lower tolerance or alternative components is also common.

MARKETING BY EDUCATING

To increase sales, reference designs must meet the critical needs of engineers in education and reduction of overall design cycles (see **sidebar** “Pitfalls” at www.edn.com/global). For companies that don't care about adding their own IP or advanced features, time to market is everything (see **sidebar** “Reference designs open doors in Taiwan”). “The more of a turnkey design they can start with, the quicker they can realize product, though the Asia market is progressively becoming more self-sufficient,” says Steve



Marsh, strategic-marketing manager for the digital-signal-controller division at Microchip (www.microchip.com). “If we could do form factor, that would be even better for this subset of customers.” A speedy, successful design is critical to the survival of these companies. “They want to be able to say that they’ve done a particular application so they can claim expertise with the technology to their next potential customer,” says Marsh.

Even Korea is proving a fertile market for ready-for-market reference designs (see sidebar “Reference designs improve but don’t always offer full performance” at www.edn.com/global). In addition, some reference-design creators don’t exhaustively test their designs, limiting their usage.

System companies that lack expertise in certain key areas may take evaluation boards to production. This “de-

sign” methodology quickly produces results but provides little long-term gain or understanding of why the design works. Users can repeat the design but cannot easily build on it as they could have if they had taken the time to understand it. Countries with younger, less experienced engineers are beginning to recognize this fact. For example, India and China each want to be the design center of the world, with the fastest service

REFERENCE DESIGNS OPEN DOORS IN TAIWAN

Mike Pan, Taiwan Bureau Chief, EDN Asia

Given the complexity and cost of system-design challenges that R&D engineers are facing, IC vendors provide their customers with reference designs that reduce time to reaching volume production by enabling manufacturability. Simplifying the path toward production is especially important for the Taiwanese electronics industry, which excels at low-cost mass production. “It is impossible for us to use a chip in our system if it comes with no reference design,” says Allen Su, a senior engineer at Powercom Co Ltd, a provider of power-protection products, such as solar-cell, solar-panel, and UPS (uninterruptible-power-supply) products.

Many sources, such as chip vendors, distributors, and VARs (value-added resellers), are available for reference design in the industry. But the robustness of reference designs varies from company to company. “Some provide us only a data sheet and associated rules used in designing PCBs [printed-circuit boards] based on the chip, while others

are more general-purpose, targeting diverse customers. Both engineers report that they must make significant efforts to meet their application requirements if they want to adopt these designs. “Foreign IC vendors can probably do a customized reference design for their first-tier customers but not for everybody,” says Su.

Chen also has experienced insufficient support by an international IC vendor. The company used such vendors for DSP sources but later found that it could not adapt the operating system with the selected DSP product and that the product was too costly. To address these problems, the company developed its own SOC (system on chip), which is an unusual approach among system makers in the Taiwanese market. In addition to improved performance, the SOC offers flexibility, according to Chen.

Both Su and Chen believe that products from local IC makers are more complete than offerings from foreign chip suppliers. The reason for this superiority could be that local IC vendors leverage a geographical advantage and learn precisely what their customers want. Moreover, the Taiwanese vendors offer competitive costs and speak the same native language.

To fill the gap with small to mid-sized system makers in Taiwan, foreign IC makers cooperate with local distributors or VARs to promote their products. Actel, for example, recently announced a reference design in Taiwan to enable intelligent system- and power-management imple-

mentations. “To better support our local customers, we had expended our sales network by working closely together with local distributors and VARs,” says Rick Lain, the company’s director of sales for the Asia-Pacific region. “We have three VARs in Taiwan to deliver more specific solutions based on our chip to its targeted customer.”

Distributors are other active sources of reference designs. “The mindset of our development in reference design differs from that of IC vendors,” points out TW Lin, vice president of R&D and the field-application-engineering department at Zenitron Corp, a distributor of semiconductor and electronic components. “Business is business. IC vendors’ reference designs always focus on how to let their chip perform better. In contrast, our focus is on manufacturability.” Sometimes, the company provides almost a prototype or board ready for mass production, according to Lin.

Reference designs from IC vendors, especially from foreign IC vendors, are not available for manufacturing, says Lin. “For example, if an IC vendor bases its chip on a six-layer PCB, then we have to convert it into a four-layer PCB and find cheaper replacements for other components on the board. Meanwhile, we also take care of issues such as EMI [electromagnetic interference], signal integrity, and other electronic characteristics,” he says. “All we have done is assist our customers in reducing the cost and accelerating the time to market for their products.”

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offer a more complete solution,” says Aren Chen, a supervisor of the R&D division at Vivotek Inc, a manufacturer of IP (Internet Protocol)-surveillance and multimedia-communication products, including network cameras, video servers, and recording software.

Both Su and Chen agree that reference designs from foreign companies



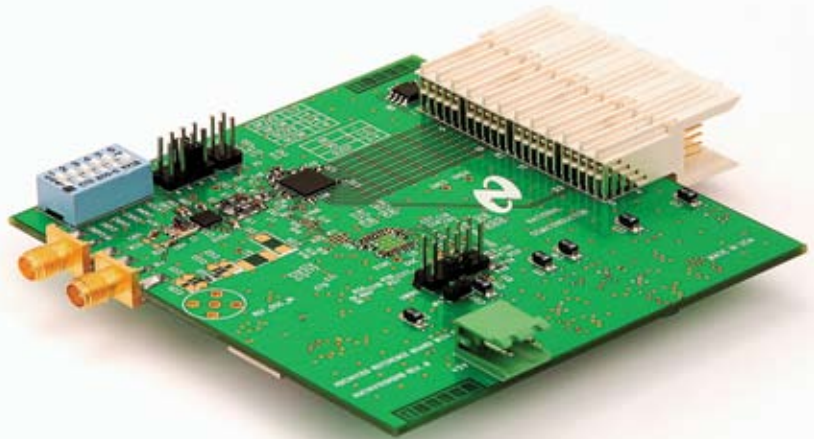
and output. They continue to push for turnkey, black-box designs. They would be even happier if the form factor were also complete. But don't believe the stereotype that all they are doing is copying. These companies are soaking up information as fast as other companies can ship it to them.

India, for example, is experiencing tremendous growth. Estimates place the number of new engineering openings at 10,000 each year, which sounds like a lot until you consider that the pool of applicants competing for these positions exceeds 300,000. "Engineering offers young people a chance to escape the lower caste," says Rick Zarr, worldwide-technology-partnership-marketing manager at National Semiconductor (www.national.com), "and they rely heavily upon reference designs to fill the many gaps in their experience."

From this perspective, "engineering outsourcing" is a misnomer because engineering is more than just copying someone else's design. "Innovation, insight, and experience are hard things to export," says Zarr. "American culture is quite diversified, and this affects the way American engineers solve problems." However, in addition to learning the basics of engineering, these other countries are discovering what it takes to be innovative. They also understand that, if they do something well, they not only make a great deal of money, but also get the chance to do it again tomorrow.

The perception that the United States is a think tank and the rest of the world is the think tank's manufacturing arm is dangerously naïve, especially when you consider that the fully burdened cost of an engineer in North America is about \$250,000, whereas that for an engineer in India with a master's degree in electrical engineering is about \$45,000. Design houses in India are not shy about investing in the infrastructure and expertise they need to compete and aggressively leverage their salary advantage.

For component vendors, these inexperienced engineers represent a tremendous opportunity, which they can capitalize on through reference designs. Rather than teach how to solve problems using general concepts, which they can apply anywhere, they can teach problem solving using components. In other words,



National Semiconductor's ADC14V155KDRB high-IF-receiver reference-design board enables immediate evaluation of a high-dynamic-range IF-sampling application.

instead of showing an engineer how to lay a trace or hold impedance constant, they provide a Gerber file that supplies the necessary trace. The file teaches the engineer something about traces but perhaps not enough to give the engineer the confidence to bring in a different component. In such a case, components in a reference design are more than just suggestions or recommendations. They lead to design wins and direct sales.

Reference designs also cover for lack of distributor expertise. The more product lines distributors take on, the less time they have to learn about—and pitch—each part. Reference designs open the door to innovative ways of helping distributors effectively sell parts.

Some companies offer bevvies of reference designs for downloading from their Web sites. The application-specific knowledge these resources share is also component-specific, so there is a value in working even with smaller design houses, because they are learning to use a subset of the components on the market. Engineers with a mandate to produce quickly tend to design with what they already know. Reference designs effectively seed this market.

Reference designs are not simply about showing engineers how to design around a component, such as a processor. In fact, for secondary-component vendors, reference designs can be their most powerful marketing tools. Consider a company evaluating a digital chip that has little idea of how to implement any associated analog circuits. If it selects the digital chip, the company will most likely also go with the secondary components in a reference design that makes up the ana-

log support circuitry. The same situation applies to RF subsystems, power supplies, assembly-level algorithms, and whatever other expertise a company lacks.

Many component vendors leverage associated design wins through cobranding with noncompetitive suppliers. Jointly developing a reference design reduces investment cost and increases the overall exposure of a design because multiple companies and distributors distribute the reference design. Also, cobranding increases the number of reference designs a company is associated with, a factor that some companies believe indicates market leadership. Partnerships can range from developing application notes together to creating whole portions of a production-ready design.

UK distributors execute another form of cobranding by combining suppliers to create reference designs. "Distributors are looking for ways to increase profits by adding value beyond simply supplying components," says Alan Hutton, partnership manager for Europe at National Semiconductor. "More and more, they are accomplishing this by providing complete subsystems."

Selling systems through cobranding has many advantages. First, it spreads the investment of creating the reference design among several vendors. Second, it enables vendors to highlight features that their customers may not understand well. For example, a design may benefit from implementing dynamic-voltage scaling on the main processor. Because a relatively inexpensive microcontroller manages scaling, it may seem more complicated to implement than it is to someone unfamiliar with the technology. By



having the scaling as part of the reference design, an engineer can experiment with it firsthand and see its potential benefits. Additionally, the implementation may reveal useful “best practices” or show how to reduce the number of required front-end components.

If the engineer likes the feature, the processor vendor wins because this factor may help lead the customer to select this component. At worst, another customer gets educated on the technology behind the feature. And the engineer can implement the feature with no additional design expense because it is possible to just lift the dynamic-voltage-scaling circuit straight from the reference design.

This win is key for the other vendors involved in creating the reference design because it helps tie secondary components to the selection of a primary component. It becomes a system sale rather than a tool sale of a single component, which distributors like because they can sell several parts at once. Although an engineer could select the main processor and choose different components to implement dynamic-voltage scaling, it is tempting just to take the entire subsystem because someone else has specified all the components.

Component vendors or distributors sometimes team up with local design houses to create region-specific reference designs. For example, these vendors and distributors will use regional vendors as sources for secondary components on a board. If the secondary components come from a foreign or more expensive source, this approach significantly reduces the value of the reference design. The effectiveness of cobranding in China, India, and the United Kingdom, however, can have a negative impact for other countries. When China and India ask for reference designs, they purchase components. The NIH attitude of requiring a reference design just to look at a part and not necessarily buy it yields fewer returns. Additionally, because NIH engineers tend to trust their own designs more than those from component vendors, the sale of secondary components is less certain. Ideally, these engineers don't want to depend on reference designs.

As a result, cobranding tends to be more effective in China and India, prompting companies to focus their ef-

forts at those companies from which they get a better return. This factor potentially impacts worldwide engineering outsourcing. As more design decisions and sales move offshore, so does a company's focus of its limited design resources. To some degree, the refusal of NIH engineers to demand and use more comprehensive reference materials leads to a shrinking willingness of component companies to provide them any.

THE KNOWLEDGE GAP

The competitive edge that engineers gain from specialized knowledge is shrinking and will continue to do so for many mainstream applications. Reference designs that supply basic hardware and software functions make it possible for smaller players to enter markets with a relatively small up-front investment.

COBRANDING TENDS TO BE MORE EFFECTIVE IN CHINA AND INDIA.

“Reference designs, especially software algorithms and libraries in our case, are key enablers to help accelerate product time to market,” says Richard Fischer, applications-engineering manager for the digital-signal-controller division of Microchip. “If we provide a complex algorithm, either for a vertical application or for a horizontal technology, this gives us a broader base of customers for our processors.”

Providing more of the overall design or subsystem continues to play an ever-growing role in selling silicon. “It's one thing to say what a customer should achieve as it relates to performance; it's another to actually walk in the shoes of the customer by designing a complete system and realizing that performance for yourself,” says Kanika Carver, digital-imaging marketing manager at Texas Instruments (www.ti.com). “These system-level designs are much more complex than first imagined, requiring system-level IP versus components. The more we provide of the complete solution, the more we learn, and the more effective the silicon and software we can offer.”

Differentiation, therefore, no longer focuses on the product level, but on the

functional level. Differentiation continues to refine, narrowing down to specialized feature support or extreme cost cutting. In this way, reference designs also narrow the gap between mature companies, which focus on developing most of their own technology, and aggressively agile companies, which focus on carving away a small portion of large markets for themselves.

Reference designs enable more companies to work with complex technology and create viable products. It's not that IP is disappearing from those that possess it but rather that it is trickling down faster than it ever has before. Not everyone is thrilled about the increase in shared IP. For example, a GPS (global-positioning-system)-module manufacturer has made significant investment in developing designs. Understandably, the company may be unhappy when an RF-silicon vendor wants to further educate its customers with a production-ready reference design.

This prospect can be either exciting or disturbing. India is hungry and learning fast, and everyone wonders what impact that thirst for knowledge will have on the engineering establishment, because the power in a technocracy is based on limited access to knowledge. A major shift is in progress, with countries such as India working to acquire expertise and the ability to provide quality comparable with that from other countries.

For all the talk about a global economy, most companies still focus primarily on preserving their own pieces of the market pie. Is an equal distribution of engineering expertise good for the world, for each country, or for a particular company? Outsourcing has long been a volatile topic. Is it possible for India to pull itself up the technology ladder without pulling someone else down?

Electronic design continues to become more complicated, and the number of layers of companies involved in a design continues to increase. There is room for more players in the design process than ever before. And, given the size and the myriad distinct demands of the global market, there is also more room to specialize. **EDN**

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Note for Pete: You don't have to do these sidebars.

DEFINING REFERENCE DESIGN

Nicholas Cravotta, Contributing Technical Editor

The term “reference design” can apply to a wide range of materials available to educate engineers and accelerate design cycles. Definitions of some of the terms surrounding reference designs follow:

- **Data sheet:** A data sheet describes the specifications of a component. Although essential, data sheets typically represent theoretical or projected limits whose accuracy varies upon many real-world factors.

- **Application note or white paper:** Transferring IP (intellectual property) using an application note or white paper is attractive because companies can produce these publications without completely engineering a design. They can discuss concepts and show block diagrams. They are worth more when you can map them to a development board.

- **Virtual reference design:** With these designs, rather than receive a board, developers have access to a schematic and list of recommendations. Virtual materials are appealing because anyone can download a file, and manufacturing limits the number of hardware boards that are available.

- **Demo board:** The demo board is primarily a vehicle for powering up a device and exploring the first level of its capabilities. It usually has just enough components to turn on the device and communicate with it. Imagine considering the purchase of a car: You could look at the engine and kick the tires but could not take the car out of the lot.

- **Evaluation platform:** To evaluate a component requires the ability to use and stress all or most of its features. Typically, evaluation boards or modules have additional support circuitry and limited software to enable testing of all modes of operation in a fashion that is close to but not the same as it would be in a

real-world application. If the user is not going to use certain features or modes, you can remove some of this circuitry. If this product were a car, you'd be driving it around the block.

- **Web bench:** This relatively new design-and-marketing tool provides a modeling environment in which developers can test component configurations. Engineers have access to hosted simulation environments or an evaluation board that they can easily configure and access through the Internet. Web benches can “demonstrate” the abilities of a component and provide fairly specific information about how to configure and program the device; engineers can then use this information to produce a production design. Evaluation through a Web bench is also more accessible to many engineers because it takes only a few minutes to see whether you want to explore further. Compare this approach with a hardware-based board, which may require hours to set up and configure.

- **Reference system:** This system is a complete working system that enables real-world operation, testing, and stressing of the components used in the design. Full reference manuals, application software, and demos that illustrate the performance of the system in the best possible light are usually available. Often, you can get a complete schematic, although manufacturers assume no liability for any errors in the design. If this were a car, you'd be taking it home for a month and fiddling under the hood.

- **Production-ready design:** This type of reference design shows how the component solves a problem. You use it as the foundation for final product design. If it were a car, all you'd change is the nameplate and the available colors.

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REFERENCE SOFTWARE

Nicholas Cravotta, Contributing Technical Editor

Although software is as important as hardware, the industry still perceives hardware as a cost incurred with every unit, whereas it sees software as a relatively fixed cost regardless of the units made. NIH (not-invented-here) OEMs approach software as an intellectual-property investment, which also serves as a barrier to entry for new companies wanting to enter a market. These OEMs aren't interested in getting lots of software from component vendors because more software more quickly erodes the value of the software investment they have already made. If they look at software at all, it's to confirm that they missed no critical details or that their implementation is superior.

For aggressive Chinese and Indian companies, which focus on time to market, software is truly the major barrier. Even though engineers are less expensive, the time that software takes to develop is what matters. For these companies, the availability of off-the-shelf software is important.

Software has the advantage of being easy to create in a modular fashion. You can encapsulate intellectual property as smaller elements, such as an EEPROM driver, to complete subsystems, such as a motor controller or complete TCP/IP (Transmission Control Protocol/Internet Protocol) stack with an embedded Web server. An API (application-programming interface) hides most implementation details. Software is also

flexible in performance and pricing. For example, a low-speed modem may be free, and a high-performance modem may require a licensing fee. Additionally, if you pay for software, it often comes as source code, providing another learning opportunity for engineers.

Having access to a foundation of software based on comprehensive libraries or a network of third-party-software suppliers reduces the number of touch points in a reference design. "Companies in China and Taiwan aren't as concerned about adding their own special sauce as [they are about] how quickly they can realize the end product," says Kanika Carver, digital-imaging-marketing manager at Texas Instruments (www.ti.com). "For the supplier, it's all about how many design variables you can remove." For example, a camera design implements image-capture, compression, and storage functions. Advanced features, such as antishake or high-definition-video recording may not be readily available, however. The questions engineers ask themselves are: How many pieces are left, and how many can I acquire or design?

Reducing the number of companies an engineer must consult with also increases value. Rather than dealing with software from multiple companies, an engineer could use a reference design that integrates all the software and makes it easier to begin and complete design.

JAPANESE ENGINEERS FOCUS ON ORIGINAL DESIGNS AND CUSTOMIZATION

Takatsuna Mamoto, Editor in Chief, EDN Japan

Japanese engineers tend not to use reference designs. *EDN Japan* asked an engineer who is involved in circuit design for printers about using reference designs. The engineer replied, "It is our policy not to use reference designs. To get an advantage against competing products in performance, function, and production cost, we have to work out circuit designs with original ideas."

In another case, an engineer involved in digital still cameras said, "To win from a business perspective, we have to fully optimize our design. For instance, we must fine-tune the PCB [printed-circuit-board] design, minimizing the number of layers used in the design and maximizing the performance characteristics of the product. We simply

can't use a reference design in such projects."

On the other hand, an engineer who is involved in module design in power-supply manufacturing said, "It is most exciting for us to carefully select suitable electronic components one by one and develop the final products using them to realize overall characteristics."

Taking a broad look at electronic manufacturers in Japan, you can see a gradual movement to potentially use reference designs. Today, however, Japanese engineers generally like custom-oriented design, though they may compare their work with reference work. So, the Japanese market shows slower acceptance than the global marketplace in the practical use of reference designs.

GETTING TO MARKET FIRST PRECLUDES A WAIT FOR A REFERENCE DESIGN

Graham Prophet, Editor, EDN Europe

Pace Micro Technology (www.pacemicro.com), a UK-based developer of digital-TV-delivery technologies and a supplier to the pay-TV industry worldwide, designs and manufactures set-top boxes, personal video recorders, and media gateways for subscription access to TV services through satellite, cable, and IP (Internet Protocol). Its areas of expertise, therefore, take in the latest HD (high-definition) video-decoding standards, encryption of both content and secure-payment systems, and reception and demodulation of multiple digital-signal types, and other factors. Its profile as a leading-edge supplier to the field means that it also must look ahead to the TV-service industry's emerging business models and be ready with product designs for a rapidly moving consumer market.

Pace, as a company that works in the consumer-product market with rapid design cycles, has a unique approach to reference designs. "There are two basic approaches to the ways companies use reference designs," says Nadeem Ullah, Pace's silicon-business specialist. "The first is to regard them as a demonstration that the chip or chip set does actually work—that it has the functionality claimed for it. The second approach is to take that design that the silicon vendor has presented, package it, and take it directly to production. Pace's approach is the first one: We use it as a demonstrator.

"As a leading-edge set-top-box manufacturer, we are working closely with our silicon vendors. [When a new chip is in design], we don't wait for the IC vendor to get its first silicon to production; we will already be working on our own product design. The silicon vendor will be developing its reference design to show the chip working, but that board design will typically be large and bulky with many test points."

Pace bases its PCB (printed-circuit-board) design on the chip specifications, so production is well-advanced. "Our boards will typically be ready when the silicon is: We can—and do—take the chip maker's first silicon as soon as it is available and fit it to our boards," Ullah says, noting that in Pace's market, it cannot afford to wait for the supplied reference design to appear. "There have been cases where [Pace] has supplied one of our initial PCBs to the chip vendor to carry out driver development, as our board design has gone faster than theirs."

The issue of software development for a new chip is critical. At this stage, around the time of first silicon, initial software drivers for the new design are typically not ready, and the IC vendors' reference designs are the vehicles on which Pace develops these designs, Ullah notes.

As an example of the cooperation he describes, Ullah

cites the introduction of the company's DS810KP, which it supplied to service provider Premiere (www.premiere.de) in Germany to launch the first DVB-S2 H.264 HD service; the product also supports MPEG-2 standard-definition decoding and DVB-S. Pace supplied the product to meet a fixed deadline: Units had to be in the field for the Football (Soccer) World Cup in Germany in 2006, and Pace delivered them in December 2005. Central to the design is an MPEG-4-decoder chip that was the subject of the kind of cooperation between Pace and its silicon suppliers that Ullah says typifies Pace's development process. Waiting for the chip maker's reference design, he implies, would have made it unlikely that those soccer matches would have been on viewers' screens in high definition.

Complete reference designs, ready to take to production, "do fall on our doorstep," Ullah says, "but we don't pick them up. We leave that approach to the smaller, low-cost, high-volume-product makers: Today, [in the set-top-box market], they are typically the suppliers of volume, free-to-air, low-selling-price boxes."

However, Ullah adds, the chip makers will have done their due diligence in their reference designs, on issues such as layout. "We do take onboard any critical layout points that are apparent and put them into our own PCB designs. But, for a company such as Pace that is selling products in many different markets and has to conform to the regulations that apply in those markets, there's a lot of key work that's not part of the standard reference design. Safety and EMC [electromagnetic compatibility] are two of those areas. For example, in its reference design, the silicon vendor will likely not have fully worked through issues such as radiated clocks as a source of EMI [electromagnetic interference]."

With this close relationship to its key silicon suppliers, does Pace use any "classic" ASICs? Ullah says no. The cost is prohibitive, but the chips and chip sets the company employs "are ASICs in the sense that they are very specific to a particular market—for example, set-top boxes with conditional access. They are characterized by more and more integration. We leave that aspect to the silicon suppliers," Ullah says. How does the company achieve sufficient differentiation for its products in the market? "The chip set is only one aspect of the design and the feature set," Ullah observes. "Product features come from the integration of software with the chip set, and, with our closer relationship with our chip suppliers, we do influence what goes into the chip set. In our sector, it's all about getting those features into the market first!"

MTK PIONEERS COMPLETE DESIGNS AND GARNERS DE FACTO MONOPOLY IN HANDSETS

Jeff Lu, Executive Editor, EDN China

The concept of a reference design was exclusive to a handful of semiconductor vendors when the concept first emerged, but it has become part of the standard offering that any semiconductor vendor that wants to do business in China must provide. Chinese vendors especially rely on reference designs in consumer electronics. "It is not that we do not devote more resources to design on our own. Rather, neither the boss nor the market gives us time," says a Shenzhen-based handset-design engineer.

One Chinese handset designer, MTK Inc (MediaTek, www.mediatek.com.tw), has over the past few years had a profound impact on the attitude of the local vendors toward reference designs. By today's standards, many traditional semiconductor companies, including many international companies, provide incomplete reference designs because they provide only a hardware reference based on their chip sets. Such designs often lack optimization for commercial use. Moreover, these designs generally lack supporting software, so developers must undertake software development or deal with third-party-software vendors.

MTK's business model, in the words of Oliver Xu, a principal analyst at Gartner (www.gartner.com), is "buy one, get one free," meaning that vendors bundle software with chip hardware. Customers need to pay only for the chips, because the software is free. In the case of a mobile handset, a design team with an MTK reference design must design only the user interface and shells.

MTK's move dramatically lowers the technical threshold of handset design. It means that players can enter the mobile-phone market in China, assuming they sufficiently resolve investment, manufacturing, and sales-channel issues. China's huge mobile-phone

market becomes an incubator for these emerging mobile-phone companies. More than 70 vendors in China now have handset-manufacturing licenses, and many "underground" vendors without licenses are conducting activities in the market.

Xu estimates that MTK had a market share of 40% in China's mobile-phone market in 2006. Many industry insiders estimate that MTK has a higher market share, which translates into a de facto monopoly.

"In Japan, we need to sell only chips," says Frank Liu, marketing manager of emerging multimedia-process vendor C2 Microsystems (www.c2micro.com). "Usually, we do not know what products designers will develop with these chips. Yet, in China, to sell chips, we must provide total solutions covering hardware plus software."

Certainly, MTK's model also has produced a negative impact on Chinese consumer-electronics vendors: undifferentiated products. When you open the shell of competing products, you will find that the components inside are the same. This lack of differentiation spells at least two risks for IC customers: They can survive only through price competition, and they rely excessively on a single vendor.

Some homegrown-semiconductor vendors are looking to establish new business models to break MTK's monopoly. Chipnuts (Shanghai, www.chipnuts.com), recently introduced a smart-handset-design platform. Unlike MTK, Chipnuts integrates different vendors' software and hardware products on the platform, leaving more choices for the design engineer's customers. "We hope that each link of the industry chain can capitalize on our platform," says Jun Zhan, vice president of Chipnuts.

PITFALLS

Nicholas Cravotta, Contributing Technical Editor

With up-front investment so high, component vendors want to get as much impact as they can from a reference design, so they choose an application that isn't specific, making designs somewhat generic. But generic designs, by definition, require compromise and efficiency trade-offs. For example, getting a motor to spin is relatively straightforward. But working with the characteristics of a motor and increasing performance by adapting algorithms require an understanding of the basic design. Thus, a cursory use of a reference design—that is, using it as is—and receiving a time-to-market advantage tends to reduce quality, increase BOM (bill-of-materials) costs, or both.

Just because a reference design is available does not mean it is the component vendor's most appropriate part for an application. Certain processors, for example, sell better in certain countries. The most likely candidates for worldwide sales, then, are the components that have the largest market share or more widespread

branding. As a consequence, you are more likely to see a reference design for a low-range to midrange digital camera using a part that is available worldwide than you are for a higher end camera using a chip primarily limited to use in North America.

Language and cultural differences introduce significant barriers to design, as well. Vendors don't translate all documentation, so a reference design is less accessible and therefore less effective when they export them to other countries. If most of a company's reference designs target China, for example, an imbalance in the distribution of intellectual property will result.

Language barriers and time zones also make it difficult for engineers to get help understanding a reference design or making custom modifications. In these instances, design centers play large roles in increasing the effectiveness of reference designs because they provide more easily accessible personal support.

REFERENCE DESIGNS IMPROVE BUT DON'T ALWAYS OFFER FULL PERFORMANCE

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In Korea, reference designs greatly affect the success of product development. Because the reference design can minimize design risks and enhance the reliability of end applications as well as reduce a development period, the reliance on such designs is escalating. Recently, the quality of chip vendors' reference designs has improved greatly. The vendors are providing more detailed and diverse information, ranging from detailed specs of the parts in use to complete schematics of the designs. The vendors often supply these reference designs in virtually the same form factors as the end application requires.

"The latest reference designs have excellent quality in both software and hardware, and the functional verification is already complete," says Jongowan Kim, senior researcher of the application-technology laboratory at the telecommunication R&D center of Samsung Electronics (www.samsung.com). "So, reference designs are being used for developing almost all products."

Reference designs are also helpful when design teams move to a new chip or processor platform. "Since I have been working on a development project based on microprocessors for the first time, I have encountered difficulties," says Seongu Kim, assistant manager at the multimedia R&D center of Hyundai Autonet. The company uses reference designs for microprocessors to develop the terminals of Hyundai Motor Co (<http://worldwide.hyundai-motor.com>). "But the reference design has been very helpful," he says. But Kim also indicated that "the detailed descriptions of each part of the design and appropriate software have been lacking."

Seokjin Pang, assistant manager for the hardware team at the R&D center of Kiryung Electronics (www.kiryung.co.kr), uses a reference design based on the Texas Instruments (www.ti.com) TMS320DM270 for the

S-DMB (satellite-digital-multimedia-broadcasting) application for vehicles. "Since data provided by chip vendors are used for references for establishing the basics, partial modification is inevitable, considering the variety and reality of end applications," he says. "But the use of reference design ranges from 50 to 90%, depending on the application."

The evolution of reference designs has also greatly affected the development environments of manufacturers. Also, the quality of reference designs is an important criterion for selecting a chip. "As the lifetime of products gets shorter, pressure on reducing a development period is getting stronger," says David Yoon, chief engineer at the mobile-communication laboratory of LG Electronics (www.lge.com). "If an excellent reference design is used, products could be developed with minimum R&D personnel in addition to the reduction of the development period. So, it is a very important resource for enterprises. Since the advance verification of a reference design has been done and the know-how of chip vendors has been confirmed, it is very helpful for engineers to review a reference design and to make the most of it," he says.

However, a reference design can have limitations as a chip-focused demonstration board. "For most of the reference designs, tests for each case are not performed in actual environments," says Kyung-Fan Shin, senior engineer at the overseas HSDPA (high-speed-downlink-packet-access)-development group of Pantech (www.pantechusa.com). "So, products frequently cannot be used since some functions are not implemented properly. Often, the design is modified or a separate chip is used. Chip vendors need to verify reference designs in more diverse environments."

REFERENCE DESIGNS: WHAT SEPARATES ASIA FROM THE REST?

Denice Cabel and Stephen Las Marias, EDN Asia

Despite Asia's growing high-technology development, industry observers still perceive the region to be good only in low-cost design and development work. This situation is mainly due to the Asian market environment, in which most companies focus on developing cheap and quickly produced products. In line with this scenario, reference designs in developing such products in Asia vary greatly compared with the United States or Europe.

Asian engineers' use of reference designs in IC design sets them apart from their Western counterparts. "Many customers in Asia would apply reference designs as turnkey solutions due to time-to-market pressures and the lack of design resources," says Jack Chen, senior application engineer of the general-products division at Xilinx Asia Pacific (www.xilinx.com).

Jerald Tatel, applications manager of NXP Semiconductors (www.nxp.com), agrees. "Market segments that are low-tech and high-volume in production prefer mass-market reference designs that can be produced cheaply and quickly, with minimum or no specification requirements for quality," he says. He also notes that today's fast-paced consumer-product cycles are pushing suppliers to not only compete to be the first to introduce unique products in the market, but also race against shortening market-demand periods. "This market condition translates into the reference-design requirements of 'having just enough features and being ahead of everybody else,'" he says.

The top driver for using reference designs in Asia is most likely time-to-market pressure. Reference designs help shorten the time engineers spend on designing a product by supplying the required basic information. "Besides showing the capabilities and value propositions of the main device, reference designs also enable interested customers to launch their products faster to the market, as they can reuse around 70% of the work that has been done on the reference designs," says Lai Chong Yeap, application manager for sales and market-

ing at NXP Semiconductors. Yeap says that another obvious difference between reference designs made in Asia and those from other regions is the type of external peripherals or components each market uses. "I think it is easier to get support from various silicon or component vendors in Asia, as compared to Europe; hence, those types of components are more likely to be used in Asian reference designs," says Yeap.

WHAT ENGINEERS LOOK FOR

Design engineers in Asia look for robust feature support in reference designs. "An effective reference design should be applicable in real product integration and provide a key idea in overcoming a technical challenge. It should have detailed documentation, a timing-analysis report for critical paths, and an abundance of IP [intellectual-property] cores," says Chen.

Ease of use for hardware and software development, use of the correct form factor, total BOM (bill-of-materials) costs, and the future expandability of features are among the factors that Yeap claims make reference designs effective. "Reference designs should show all the value propositions of the main application IC and the features that are tailored to meet market requirements and customer requirements of the targeted applications," he says.

Yeap explains that the main application IC is the most important component among all features of a reference design. He says that 80% of the focus is on the main application IC. "For example, if the main application IC targets portable-audio-video applications, we must ensure that the main application IC of the reference design contains features such as audio and video codecs and performance support, acceptable file-transfer speeds to and from a PC, and power performance during audio and video playback," he says. "The reference design must be able to show the main capabilities of the main application IC and fulfill close to actual product requirements."

Reference designs should also be flexible and expandable. According to Tatel, it is difficult to predict and make provisions in the reference designs for emerging peripherals. Ideally, a design should be extensible to support new features driven by the converging applications and the need to integrate more features into one product. When you couple this need with fast time-to-market requirements, he says, “the only solution seems to be to cater to expandability features on your reference platform.”

Tatel also mentions that his team recently faced a technical issue with one of its USB devices, which it implemented in an automotive system. “Four parties were involved: a tier-one supplier, the main SOC [system-on-chip] supplier, the software vendor, and NXP,” says Tatel. “Our reference design was flexible enough to be configured to work with another FPGA that simulates the behavior of the main SOC. This [situation] allowed us to pinpoint the cause of the fault, debug, and work out a solution. Our tier-one supplier and main SOC supplier were also able to confirm our findings using a similar reference setup.”

Xilinx’s Chen faced a technical problem when he was using a UART controller as an interface to debug an FPGA. “The availability of a reference design helped me to achieve my objective within a shorter period of time,” he says. Like the ICs that the semiconductor vendor is trying to sell, the reference board must be able to differentiate itself with one or two applications that vendors can develop in combination with devices from other vendors. “For example, my team created a novel application developed on a single video DSP to process two video streams in parallel,” says Tatel. “In combination with an FPGA configured as a video demultiplexer or splitter, we created a new ‘dual-video’ experience for users.” He also believes that reference designs are important for verification and testing. “Previously, I worked as a product developer,” he says. “In that function, it is important to verify the performance specification of a device before

implementing it in a design. Also, with development cycles getting shorter, we need to achieve designs that are functional the very first time. Even after the implementation, reference designs are kept as performance benchmarks in case there are some contentious points during the development and mass-production stages and even beyond that.”

IMPROVING REFERENCE-DESIGN OFFERINGS

Besides offering faster time-to-market capabilities to manufacturers, reference-design makers should also be up to the challenge of providing expansion ideas to their reference designs. “If a customer calls and says, ‘We have this new feature in mind and are now studying how to implement this feature in the current reference platform,’ we should be ready with ‘expansion ideas’ both in hardware and software. We can then offer to execute such customized solutions for their specific requirements, in a collaborative manner to further lock in the customer,” says Tatel.

Without question, the chip companies see reference designs as competitive advantages in acquiring and retaining customers. “Providing a dedicated or focused team to develop the reference design will allow the customer to achieve a faster time to market without making too many major modifications before launching the product,” says Yeap. According to Chen, companies should provide detailed documentation and test reports to help customers evaluate the reference designs and make the designs easy to use with minimal parameters.

Providing documentation and support kits will allow customers to set up, demonstrate, evaluate, and customize settings and applications to suit their unique needs, says Tatel. “The key element here is the simplicity and completeness of the support kit, such that customers will find it very easy and comfortable to work with. Of course, we also provide all information and avenues for them to seek assistance if needed.”