



shipment schedule. The IC manufacturer works as a partner, as part of your manufacturing flow, to deliver what you need, when you need it.

### THE CUSTOM IC DEVELOPMENT PROCESS

The process of developing a custom IC can proceed in several different ways. It depends on how much of the engineering effort you choose to undertake and how much you want a design house or the IC manufacturer to do.

At one end of the spectrum, you can do all the IC design work, and the IC manufacturer will provide only the manufacturing of the IC. This method, often called “customer-owned tooling” (COT), requires that you have IC design expertise and the appropriate CAE/CAD tools in-house. Although the tools and expertise can be very expensive, companies that do many custom IC designs sometimes find this to be the best option because it gives them full control over their IC design.

At the other end of the spectrum, a semiconductor manufacturer can execute the entire process from specification development and chip design through manufacturing. In this model, engineers from the chip manufacturer meet with you to understand your requirements and develop a specification for the custom IC. Once the specification is agreed upon (usually similar to a catalog part datasheet), IC designers begin the process of designing the circuitry.

The execution of most design programs falls somewhere in between these extremes. Often, the equipment manufacturer will develop a specification and provide it as a starting point for the IC manufacturer. The bottom line is that you can do as little or as much of the process as you want.

Often, a chip manufacturer has existing silicon IP blocks that can be leveraged for your design. For example, if your custom IC needs a linear voltage regulator, it is likely that there is a library of several preexisting designs to choose from that would meet the requirements of your design. This re-use decreases design time and risk because circuits that have been used in other

IC designs have already been built and characterized.

The design process is typically very interactive. Design tradeoffs—often issues of performance versus cost—are made with your involvement. Design reviews are held at multiple times during the development process to ensure that the design really does meet your technical requirements, while still being as cost-effective as possible.

### CHOOSING A CUSTOM IC DEVELOPMENT PARTNER

You have many choices when selecting a partner to provide a custom IC solution. There are small design houses that do just the chip design, and leave it to you to source the fabrication of your part. There are also full-service semiconductor companies, such as Texas Instruments, that design and manufacture ICs entirely in-house. Working with a company such as TI, which operates its own wafer manufacturing, helps facilitate a smooth transition to mass production without “finger-pointing.”

Often the best place to start is to talk with a company that already makes catalog parts with similar functionality to what you are trying to integrate. For example, if you want to build a custom audio part, contact companies that have a comprehensive existing audio product offering to discuss your requirements. This way you have access to the expertise and silicon IP that the company has already built in that area.

### DEVELOPMENT COSTS AND SCHEDULE

The cost and amount of time it takes to develop a custom IC varies dramatically depending on the complexity of the device. Even a simple full-custom analog IC development can be more than a million dollars. This level of investment makes a custom IC practical only if production volumes (and consequently cost savings) are high, which is often the case for consumer products.

Development expenses include the engineering effort to design the chip, as well as fixed costs incurred to start wafer production, chip testing, and packaging. Usually these payments are called “non-recurring engineering,” or NRE payments.

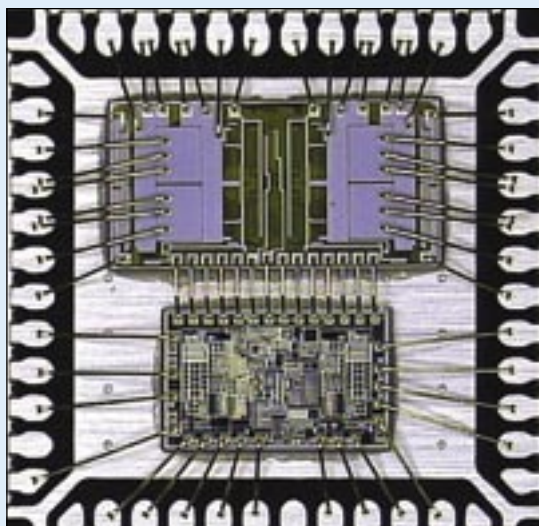
Depending on the nature of the business, IC manufacturers may require full or partial payment for development expenses at various times during the development program. Every program is different and is evaluated based on the individual business case for each custom part.

Development time depends on the complexity of the design and the amount of IP re-use that the IC manufacturer can do. For a simple design that uses mostly existing IP, or for modification of an existing chip, first samples can sometimes be delivered as soon as four months from the time the design effort begins, and mass production can start two or three months later. A complex design that requires several silicon manufacturing passes easily can take over a year to complete.

### CONCLUSION

Obviously, undertaking a custom IC development takes a considerable commitment, both on your part and on the part of the partners you choose. Nevertheless, in many cases it can be the best option for your consumer electronic equipment design. **M<sup>3</sup>**

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**FIGURE 2: Two separate ICs die mounted into one package.**