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MMICs & RFICs

How to save money by using custom design GaAs MMICs

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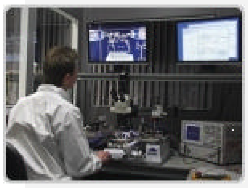

To many people it would seem to defy logic. Surely custom designed MMICs are expensive so how could you possibly save money by using them? Why would anyone try to develop their own custom MMICs when virtually all of the building blocks required in any microwave system are commercially available?

In this article (based on my presentation at the 2010 International Microwave Symposium MicroApps seminar in May 2010) I'll show how being able to specify the exact function of a custom MMIC can help achieve performance improvements in addition to significant unit cost savings versus normal supplier pricing... as long as the volume requirements are sufficient.

Device supplier's cost

In designing your own custom MMIC you would incur many of the same expenses as commercial suppliers, namely the wafer costs, evaluation and qualification costs, test and packaging costs and design team salaries
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However commercial suppliers will also be making a significant expenditure on marketing, advertising, after sales support and the operational cost of selling and distributing their devices to customers. All of this needs to be recouped and will get factored into the component pricing along with a profit margin.

With a custom MMIC these costs can be avoided as you are able to focus on your own needs and making savings on the factors that determine IC production costs, namely wafer price, die area, yield, test and packaging requirements.

Other advantages of custom MMICs

As well as the cost savings, there also are a number of other clear advantages that come from developing custom MMICs, such as the user's ability to specify the exact functionality required, rather than compromising on the closest standard component available in a catalogue.

The custom MMICs can be produced in preferred geographical locations, which can assist in avoiding export restrictions or in addressing security concerns. A custom MMIC also means that you control the pad-out and/or package style and that you, rather than your supplier, can control when your component becomes obsolete.

A custom MMIC pricing example

To prove my argument let's invent an example custom part, say a 4 W, 3-stage, X-band PA. We've undertaken some preliminary design work on this example part and have determined an estimated die area of 9.66 mm² (2.3 mm x 4.2 mm). If fabricated on a process with 150 mm (approximately 6") diameter wafers each wafer would have a total available area of 17,671 mm².

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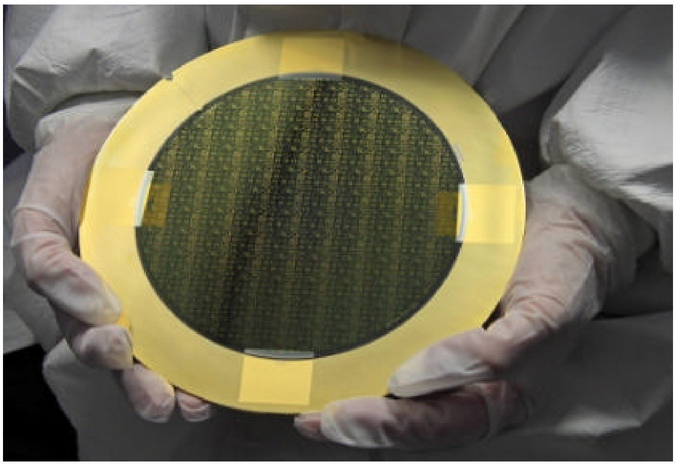

Wafer pricing will depend on the process used and the wafer diameter. Shown is a 6 inch diameter wafer.

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One might assume that this means the number of PA die per wafer would be 1,829 (17,671/9.66) but we need to factor in the area you'll lose at the edge of the wafer to partial die, which would reduce the available wafer area to approximately 16,651 mm².

Approximately 4 to 6 percent of the area is also lost to PCM (Process Control Monitor) sites, which will reduce our available wafer area further to 15.767 mm² and give us 1,632 PA die per wafer — untested!

Yield
Then there are the 'failed die' to consider. Yield is a complex issue and the number of failed die will depend on factors such as defect density, process control, total gate periphery, design centering and the actual pass/fail criteria specified. That said a typical RF yield for the 4W PA in production should be above 80 percent, which therefore gives us over 1,305 working die per 6" diameter wafer.

Wafer cost
Wafer pricing will depend on the process used and the wafer diameter. Modest volume pricing for 6" diameter wafers in a non e-beam process is somewhere between $5000 and $10,000. So if we assume $7,500 then that gives an untested die cost of $5.75. Higher volume usage could obviously drive down the wafer price further.

Testing
It's fair to assume that our bare die parts will require RFOW testing, which will incur costs. Test costs are incurred for all die (pass and fail).

Test costs per die (excluding set up) will vary depending on the number of frequency points tested, complexity of the test setup (i.e. the kit required) and the time taken for each point. For example, a power sweep will be more time consuming and therefore more expensive than s-parameter measurement.

If we assume our PA is tested at 3 frequency points, s-parameters and saturated Pout (only one Pin) then a realistic cost estimate for testing would be $490 per wafer ($0.30 per die). This then bumps our total production cost per die up to $6.12

Amortised costs
Our estimated production cost has so far excluded a number of one-off costs such as design fees, evaluation and qualification costs, prototype wafer run costs and custom mask set costs. These would typically be amortised over the first three years of production with the effect on die costs directly related to the volume/number of parts used. If we assume the additional one-off costs to be amortised are $300,000, this means three years production at 10,000 units per year would add $10 per die for the first three years.

Cost comparison
Through the hypothetical breakdown above, I've concluded that a fully tested custom 4W PA can be produced for an estimated $16.12 per die.

In contrast a review of existing commercially available X-band PA die costs suggests that $60 to $100 would be a typical price for such a part in 1000-off volumes. Of course my custom part does not exist but it very easily could and if it did, would provide the user with significant savings compared to buying commercially available parts.

If the custom part is in production for longer than three years, then the savings will be even greater as the amortised costs will have been covered and the die cost will fall by $10 for all parts built after the third year.

Plextek has successfully designed over 50 full custom GaAs MMICs serving a wide range of applications — including mm-wave ICs for point to point and point to multi-point systems, broadband microwave ICs for ESM systems, multi-band microwave communications products and precision attenuators for instrumentation. These custom MMIC developments have saved our customers money and helped to achieve performance improvements over commercially available alternatives.

For further information: www.plextek.com/rfic.htm.

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