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Hybrid, ASIC, or FPGA: How to Decide Which is Best for Your Aerospace or Defense Application

For the design of boards and systems for embedded applications, engineers are commonly faced with numerous alternatives and trade-offs to consider when selecting the optimal component solution for their specific needs. These alternatives include field programmable gate arrays (FPGAs), application specific integrated circuits (ASICs) and fully integrated hybrid circuits. The selection of one alternative over another can have a profound effect on development costs and timelines, power consumption, performance, design flexibility and recurring cost. This article sheds light on the different design alternatives, and the relative advantages and disadvantages to consider in selecting the best option for optimal system performance, functionality and cost.

Table 1

	FPGAs	Hybrids	ASICs
PC board real estate consumed – without power components or magnetics	Most (including required external components)	Moderate	**Least**
PC board real estate consumed – with power components or magnetics	Most (including required external components)	**Least** (for a fully integrated solution)	Moderate (including required external components)
Mixture of analog and digital circuitry	Limited	**Highest**	High
Integration of power components	Not possible	**Best**	Limited
Power consumption	Most	Moderate	**Lowest**
Proprietary design security	Least	Design dependent	**Most**
Functional non-volatility	Low (for RAM-based FPGAs)	Better	**Best**
Time-to-market	**Lowest**	Moderate	Highest
Development cost	**Lowest**	Moderate	Highest
Design flexibility, ease of modifying	**Most**	Low/Limited	Least
Recurring cost	Moderate	Highest	**Lowest**

FPGA, Hybrid, and ASIC Tradeoffs

FPGAs are commercially available (COTS) devices that can be programmed and reprogrammed, providing design flexibility, as well as relatively faster time-to-market, lower non-recurring engineering (NRE) costs, a simpler design cycle, and lower technical risk. For these reasons, FPGAs are often used for prototyping functions that may later be implemented as ASICs. Additionally, they are beneficial for applications that may require more frequent system updates or potential bug fixes, as they may be re-programmed in the field. FPGAs also offer a high degree of obsolescence mitigation, as firmware code may be ported to next-generation devices or FPGAs from different suppliers.

However, to achieve this high degree of flexibility, FPGAs are typically loaded with many features that may not be required for individual applications, resulting in greater cost, size and power consumption than what would be required for the application. That being said, FPGAs provide a good fit for many aerospace and defense market applications, especially those requiring a great deal of design flexibility and where time-to-market overrides space and power considerations for low-volume applications.

ASICs, on the other hand, are custom manufactured for specific tasks, and offer some major advantages over FPGAs. While they lack the post-production design flexibility of FPGAs, they are generally used in higher volume applications where they offer a lower recurring unit cost, packaging in smaller form factors, and less power consumption. ASICs also provide generally higher speed performance than FPGAs. Furthermore, mixed-signal ASICs are able to combine digital logic, which can include processors, with common analog building blocks, such as voltage references, op-amps, comparators, and A/D and D/A converters.

Compared with many FPGAs, ASICs are non-volatile and provide higher levels of design security for proprietary IP. So while at first glance, FPGA solutions offer flexibility and possible time and cost savings through the use of commercially-available components, in many applications ASIC and hybrid solutions may be required due to environmental conditions, life cycle management and requirements for non-volatility.

Hybrids, which may include FPGAs and/or ASICs, enable the integration of multiple types of technology in highly miniaturized packages. In addition to digital circuitry, these may include high-performance analog circuits such as high-speed/high-accuracy A/D or D/A converters, high power elements such as MOSFETs or IGBTs, and magnetics such as transformers and inductors.

In general, hybrids occupy significantly less board real estate than the corresponding discrete components. In particular, state-of-the-art hybrid construction techniques such as flip-chip and stacked die greatly reduce the size of hybrid microcircuits. Hybrids also reduce manufacturing costs by providing a "turnkey" solution that enables users to purchase, kit, assemble, test and troubleshoot a single component rather than multiple components. In addition, hybrid microcircuits are trimmed and tested as integrated solutions over the required temperature range, thereby eliminating the possibility of mismatches between different components. Further, hermetic hybrids provide higher reliability (MTBF) than discrete components assembled on PC boards.

The selection between FPGAs, ASICs or Hybrids involves multiple tradeoffs. Table 1 shows the advantages and disadvantages of FPGAs, ASICs and Hybrids relative to a series of technical, schedule, and cost-related parameters.

Because of the numerous trade-offs, the choice of using an FPGA, ASIC or Hybrid is highly dependent upon the needs of the application. Some developers have successfully adopted a two-pronged approach, where they will rapidly implement an FPGA solution during prototype development, then convert to an ASIC or Hybrid solution during limited and full-scale production. This allows application developers to prove the technology while minimizing development costs and risks.

Data Device Corporation (DDC), a world leader in the design and manufacture of high-reliability embedded electronic solutions for aerospace and defense systems, as well as industrial applications, offers a wide range of highly optimized Hybrid and ASIC solutions, and offers the capability to provide custom designs incorporating a multitude of technologies. Our highly qualified and experienced team of experts can assist you in the proper selection and design of integrated circuits involving FPGA, ASIC or Hybrid technology. For more information about DDC's design and manufacturing capabilities, or to submit a request for a custom designed solution, please visit our Custom Hybrids and ASICs page.