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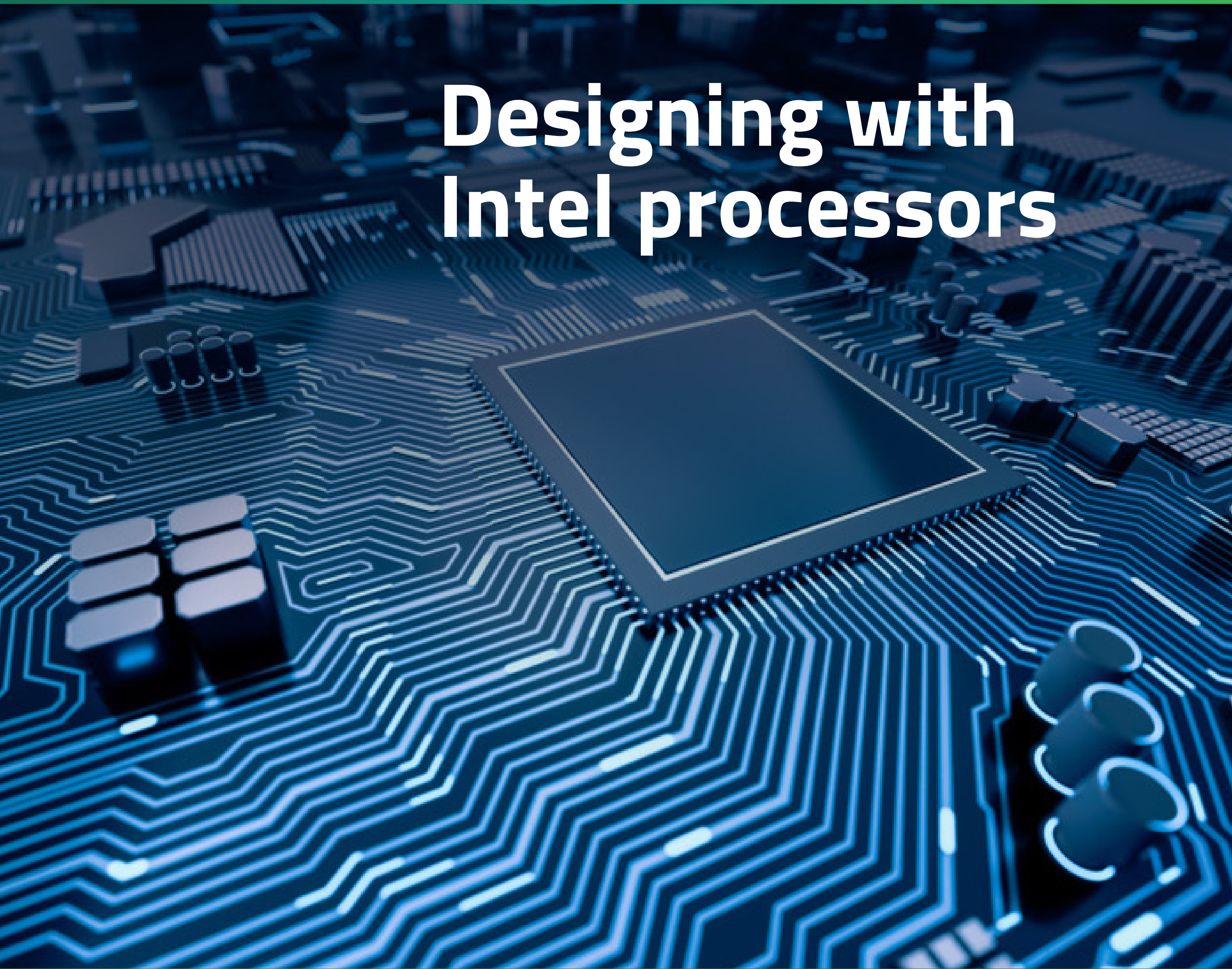
Designing with Intel processors



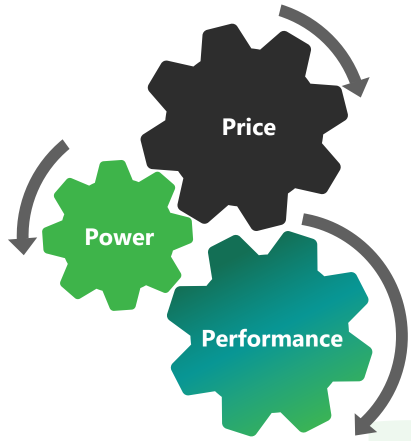
Introduction

When we think of a processor, the first brand that comes to our mind is Intel. Undoubtedly, Intel has been a leader in the processor segment since the inception of the very first processor. Today, Intel processors/ chipsets are used in a variety of products - be it Single board computers, Gaming systems, Personal computers, Servers, Networking equipment, Laptops, Gateways or even Wearable devices. Out of the various segments, Intel enjoys the maximum market share in the computing segment. The label 'Intel inside' on a product is one that instills confidence in any potential buyer. In this article, let us try to understand what it takes to design a board with a high-end Intel processor.

Choosing the right processor

The first step to success while designing a sophisticated board with cutting-edge features is indeed choosing the right processor. The processor selection should be wisely done as any claw back could have serious consequences. There are several factors that needs to be considered before finalizing on the processor. However, for most of the designs, selecting a processor largely depends on the 3 Ps – Performance, Power consumption and Price.

The 3 Ps are closely interdependent – Higher the performance, greater would be the power consumption and higher would be the cost. After studying the key product requirements, a designer should shortlist a few processors that satisfies all the product features. The three Ps of each processor should be analyzed and the best processor should be chosen for the design.



Processor Performance

Traditionally, the performance of a processor was evaluated based on its clock frequency or the number of instructions it can execute per second. Today, the processors are much more complex in nature and several other factors also needs to be considered to effectively judge the overall performance of a processor - Clock frequency, number of cores, cache memory, overclocking are some of them. Also, the application/ use case the processor is intended to serve plays a significant role in determining the processor's performance. For instance, a processor with higher clock frequency may not fare as well as a processor with more number of cores/ threads when considered for an application that involves multi-tasking. Several benchmarking tools are available which compares the various parameters of a processor and ranks them. This could be a useful reference for a designer to rely upon for judging the processor performance.

Processor base frequency: This continues to be an important factor while selecting a processor. Processor base frequency specifies the rate at which a processor's core operates. It is often represented in Giga Hertz (GHz). Higher the frequency, better would be the performance.

Number of processor cores: A core is an independent processing unit within a processor chip. As there are more number of cores, processor can execute more number of tasks in parallel, thereby increasing the performance.

Cache memory: The small amount of memory located on the processor's die which can be accessed much faster when compared to the external RAM placed outside the processor chip. More the cache memory, more efficient is the processor.

Turbo boost: Turbo boost enabled processor allows its clock frequency to be increased above the base frequency when demanding tasks are being executed for a short duration of time.

Hyperthreading: A thread is a sequence of instructions to be processed by the CPU. Processors that support hyperthreading technology can execute multiple threads on each core simultaneously, thus improving the processorthroughput with threaded software.

Below is a comparison of 7th Generation Intel Core processor with respect to some of the parameters that directly affects processor performance.

Processor	i3 7100E	i3 7100U	i5 7440EQ	i5 7300U	i7 7820EQ	i7 7600U
Vertical Segment	Embedded	Mobile	Embedded	Mobile	Embedded	Mobile
# of Cores/ Threads	2/ 4	2/ 4	4/ 4	2/ 4	4/ 8	2/ 4
Base Frequency	2.9 GHz	2.40 GHz	2.9 GHz	2.60 GHz	3.0 GHz	2.8 GHz
Cache	3 MB	3 MB	6 MB	3 MB	8 MB	4 MB
External Memory	64 GB	32 GB	64 GB	32 GB	64 GB	32 GB
TDP	35 W	15 W	45 W	15 W	45 W	15 W
Turbo Frequency	-	-	3.60 GHz	3.50 GHz	3.70 GHz	3.90 GHz
Hyper-threading	Yes	Yes	No	Yes	Yes	Yes

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Design Challenges/ Considerations

Designing boards with complex processors always encounter certain obstacles. In fact, each PCB design poses some unique design challenge. When It comes to designing an x86 board, there could be some additional challenges related to BIOS or thermal that a designer will have to address.

Real Estate availability & Placement challenges	First step towards an efficient PCB layout would be the placement of key components. Often, due to mechanical constraints, the PCB form factor would be such that adequate room is not available to place all components in the desired manner. Designers will have to place the components judiciously without affecting the product's overall quality/ performance.
Routing	A high end Intel processor will invariably have several high-speed interfaces such as DDR, PCIe, SATA etc.. Providing adequate clearance, length matching the signals, maintaining the specified characteristic impedance, minimizing stub lengths etc are mandatory to achieve acceptable performance. Violations could adversely affect the functionality, emissions and even reliability of the product.
Power Sequencing & Power Delivery	Intel processors generally would have multiple power rails/ domains. Each interface/ signal will be linked to one of the power domains. Care should be taken by the designer to ensure that no signal (unless permitted) is driven when its corresponding power rail is in an OFF state. Also, the power rails would need a specific power-up and power down sequence. Failing to follow these could result in boot issues, higher power consumption or even reliability issues. The power planes should also be carefully laid avoiding necks to ensure a proper power delivery.
Thermal Issues	TDP of a processor represents the average power it dissipates under a defined workload. When this is exceeded, the processor would start to throttle by reducing its base frequency or safely shutdown to prevent a permanent damage. An OEM would like the product to support widest possible temperature range. To improve the thermal performance, the designer should design an efficient heat spreader/ cooling solution. Also, he should select components with low thermal resistance and provide maximum copper coverage in the power planes.
Vast Docume-ntation	Intel processors are associated with exhaustive documentation which gets frequently updated. Going through each document thoroughly is vital for an unambiguous design.

Best Practices

A set of guidelines and best practices should be followed for any design to be successful. Due to the sheer complexity involved, it is imperative to adhere to the best practices even more for an Intel processor based design. Failing to do this would make testing challenging, would increase the time to market and escalate the overall development cost.

Reviews

It is essential to do a detailed design review at every stage of design cycle for a first-time-right product. The design review should cover all aspects of design. Wherever the documentation is not clear, it is important to approach the vendor and get it clarified.

Adherence to guidelines

Intel provides guidelines for all signals/ interfaces – design guidelines, placement guidelines, routing guidelines etc. There would be instances where due to certain design constraints some of the guidelines cannot be followed. In such cases, designer must perform a detailed design analysis and take a call on how to proceed. At times, it might be necessary to do a signal integrity analysis for high speed interfaces to ensure the design would meet its desired performance.

Component selection

Components chosen in the design should be after evaluating the cost, availability and life cycle. An alternate component should be identified wherever possible, which can be used as a replacement in case the chosen part becomes unavailable or obsolete.

Testability

A good design ought to have sufficient test points on critical signals which would prove to be very useful during the board bring up, not having them may adversely impact the project schedule. Also, for boards with Intel processors, providing a provision for ITP-XDP tool on the board will be quite helpful during the board-bring up.

Proper documentation

It is important to ensure that there is no ambiguity in the requirements including Software and BIOS related at the beginning of the design phase. Any misinterpretation of the requirement or a requirement considered to be trivial, might severely impact the project schedule and costs. Also, it is very important to document the minute design details with utmost clarity for future reference.

Conclusion

Designing a complex PCB involving a high-end processor is always a challenge. Shrinking time to market, stiff BOM cost targets and stringent regulatory certification requirements adds to the woes faced by the OEMs. To reduce this burden, it makes perfect sense for the OEMs to off-load the design and development to a reliable partner with niche expertise in product development. This not only helps the OEM to realize a better-quality product, but it also accelerates the time to market and save costs. In this approach, the onus of executing the design, right from selecting the processor up to regulatory certification shifts to the design house. A design house will be better prepared to handle the design challenges by leveraging the best design practices from their vast expertise. For a product to be successful, it is not sufficient that it is well conceptualized, equally important is its execution!

Author Bio

Ajay Menon is a Senior Hardware Engineer with hands on experience in all phases of product development cycle. He has extensive experience working with x86/ ARM based designs and has designed several products including SBC, SOMs, Servers, Gateways, Industrial systems, Telecom devices etc. He holds a bachelor's degree in Electronics & Communication Engineering and Master's degree in Digital Design & Embedded Systems.

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