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Single Board Computers: Choosing the Appropriate "Slot One Solution"

Twenty years ago, the thought of an off-the-shelf OEM board that came fully equipped with all necessary computer system functions was not much more than a system designer's dream. Not only was it impossible to fit all necessary functions within the confines of a single board, but a commercial-off-the-shelf (COTS) product could not offer the flexibility to adapt to specific embedded applications. Most applications relied on Using minicomputer technology of the day such as DEC PDP-11's or designs a proprietary system.

The strategy of the 1970's and early 1980's, therefore, centered on the costly and time-consuming task of designing a board from scratch for each integration project or product in a vendors' line. Several factors changed the environment. The emergence of 16bit microprocessors and memory technology allowed for an SBC to fit onto a reasonable board size. The emergence of industry standards such as Multibus provided an electrical and mechanical platform to build a standard board that could be used for different applications. And finally, the emergence of VME with the IEEE 1101.2 mechanical format and pin and socket connectors instead of the more standard gold finger type of connector provided a climate for the standardization of the single board computer. As design priorities changed, the need for a standardized product that could be "customized" for a variety of applications drove the emergence of the single board computer (SBC) marketplace.

As SBC technology advanced the use of field programmable gate array (FPGA) technology allowed more features to be included in the same board size and create the "all-in-one" SBC. The all-in-one SBC provided CPU, memory and I/O all on the same board. Users now had a choice of designing their own SBC or buying a readily available product from one of many suppliers. Concerns about cost and time-to-market have shifted designers' attention to buying commercial off the shelf (COTS) SBCs as the foundation for their systems. They no longer want to design boards, turning to outsourcing to solve specific component challenges. These factors have elevated SBC's from a far-off dream to a reality that is recognized as the "Slot One" solution -- the single most important component of any embedded system.

The wave of support for the single board computer on VME spawned an industry crowded with hundreds of vendors. While the designer is freed from the chains of proprietary systems, the multitude of SBC offerings must be approached with caution and realistic criteria for success. An inappropriate choice of SBC can be as limiting as the proprietary boards of old. While caught up in the COTS momentum, the customer cannot neglect the inherent need to customize performance and functionality to the embedded application. Flexibility in design is the gauge for evaluating and selecting an SBC.

SBC ATTRIBUTES FOR SUCCESS

The process of making choices for system components has evolved with the hardware itself. Single board computer selection, once driven by the choice of processor, now is best approached with an eye toward software. The proliferation of the Windows environment -- the "Wintel juggernaut" -- has opened up opportunities for compatible off-the-shelf software. The end-user customer demanding that the system work in a Windows NT environment, for example, is forcing the integrator to take an overall system approach to design. Software application programs, operating systems and development tools must be readily available to assure ease of integration and expandability. And from the designer's perspective, choosing an SBC platform that supports various operating systems -- Windows NT, Windows 95, QNX and VxWorks -- simplifies the design task for implementing the board in different or mixed applications.

After software compatibility, the consideration for selecting an SBC turn to processor architecture. A designer may have a history and comfort level of VME with a Motorola 68-k processor -- but would be wise to take an objective, forward thinking look at Intel. Historically, the "embedded world" has been driven by the milestones in the workstation market. The fastest chips debut in the workstations and trickle down to the embedded marketplace.

When Sun Microsystems, long the dominant player in the workstation market, switched from Motorola 68-k technology to SPARC technology a demand for SPARC VME boards was created. Several suppliers provided VME boards that used SPARC processors and the functionality of a Sun workstation. With the release of Intel 486 and Pentium processors PC technology-based workstations became the dominant technology in the marketplace. This created a demand for Intel based VME products. The VME products provide 486/Pentium processors as well as common PC functionality and utilize the existing base of software

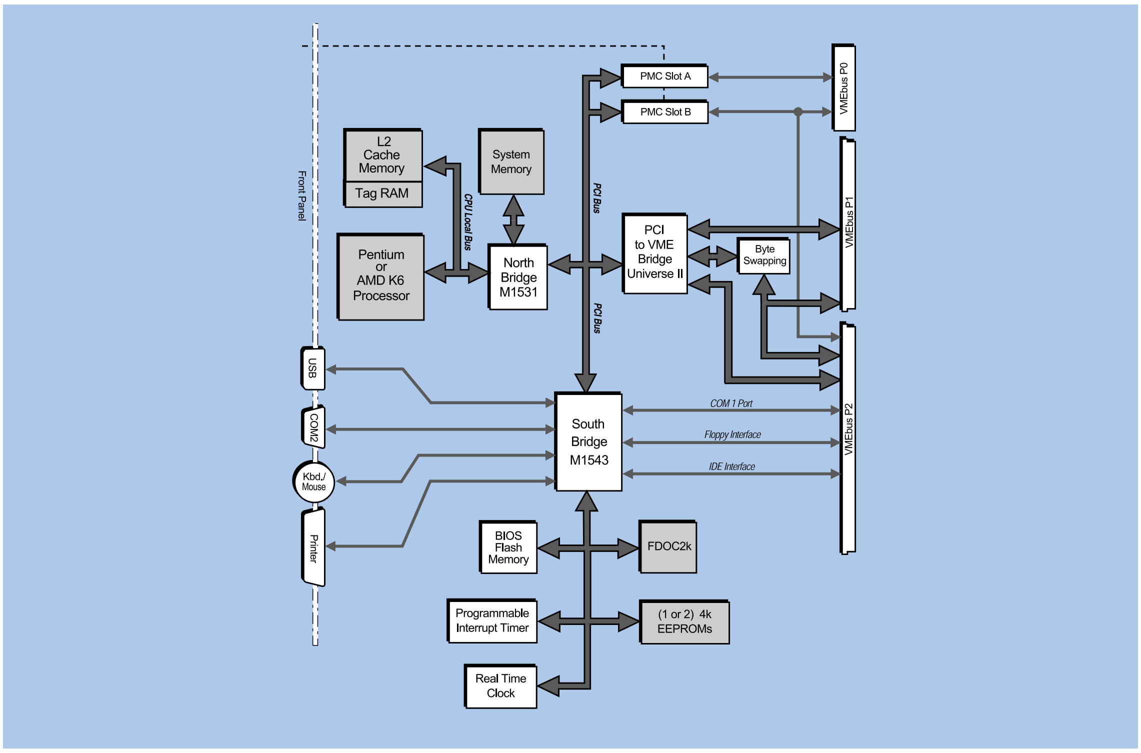

Figure 1. PROTEUS Block Diagram

available for PC architecture workstations.

Development of software (a primary consideration discussed above) is most prevalent on the Intel processor line, and the desktop system market continues to demonstrate its staying power in industrial applications. A lack of foresight in this area can lead to a dead-end solution. For example, if a designer built a system based on Windows NT last year and selected the PowerPC processor, the customer now would be hindered by Microsoft's decision to stop supporting Windows NT in the PowerPC environment. The choice of Intel processor virtually assures system longevity, while a non-mainstream processor can virtually eliminate future upgrade capability.

Additional considerations when implementing an SBC include the feature set required by the customer. Are full workstation features necessary (e.g. disk drives, networking, graphics)? Or, is the primary requirement for basic I/O functionality (e.g. serial, parallel)? Further consideration must be made to expandability of the product. Is there an expansion mezzanine concept for adding features? Mezzanines are critical to system flexibility, facilitating slot-efficient, mix and match I/O via a wide range of available modules. Does it support PMC, PCI, IndustryPack standards or the new PC*MIP specification or is it a custom proprietary implementation? A proprietary mezzanine can be the customer's ultimate obsolescence nightmare, with zero flexibility and limited compatibility.

Finally, the actual operating environment is part of the SBC equation. Are commercial specifications sufficient, or is a ruggedized solution for a harsh environment required? In the latter case, the SBC should be equipped to operate in ranges from minus 40 to plus 51 degrees centigrade. In addition to thermal ruggedization, the board must be mechanically ruggedized to sustain higher vibration and shock environments. A board designed for harsh environment will utilize mechanical stiffeners, larger heatsinks and minimize or eliminate all sockets.

DESIGNS MUST HAVE THE FUTURE IN MIND

Flexibility in single board computers is tied closely to the issue of upgradability. A customer can start with a requirement for 133 MHz performance levels, for example, and then encounter a need for higher speeds and additional memory. Consider an example where an integrator installed a system for a space station simulator that is based on 166 MHz Pentium processors, utilizes 16 boards with 32 MB of memory on each board. While the application might run satisfactorily, the customer realized that there is no headroom in the design, and processor speed is being taxed. A flexible SBC can accommodate the simple addition of processor speed and memory without the hassle of rewriting the software or, in a worst case, buying new boards and starting from scratch. The integrator was able to improve the processor speed to 200 MHz and increase memory to 64 MB and provide more system performance.

SBS Embedded Computers (Raleigh, North Carolina USA) has been in the business of designing single board computers since 1986, when they launched the industry's first Intel-based VME board. The company's focus on flexibility and expandability has driven product development since its inception, and is evident in the latest boards set to be released. As an example of flexibility the SBS Embedded Computers PROTEUS is a third generation Pentium VME product with features for easy customization to different application-specific requirements. The block diagram for the PROTEUS VME product is shown in figure 1.

The concept behind PROTEUS is to address market demand for enhanced I/O functionality and performance in a format that is compatible with other system components. In one scenario, the customer may not have a need for a full range of workstation functions, but may require the flexibility to add I/O modules. For example, PROTEUS could be teamed with a 1553 PMC card to use in an F16 ground test station, an avionics application. With the addition of two Ultra SCSI PMC modules and a 300 MHz AMD K6+ processor a PROTEUS board can be used to build a high performance Windows NT server.

In order to provide the functionality that customers require PROTEUS was designed not as a single product but more as the first in a family of products that can be configured to meet customer requirements. By using VME standards PCI standards and the PMC standard for mezzanine connections the customer is assured that add on features will be available for extending the capabilities of the SBC.

In a different scenario, customers may be looking to upgrade performance in a system that is Motorola 68000-based, while maintaining the system's I/O flexibility. The first incarnation of PROTEUS offers dual PMC slots, processor speeds of up to 300 MHz, up to 128 MB of EDO DRAM, and up to 72MB of Flash Disk-on-Chip, all in a single VME slot. The flexibility of the board allows it to serve as a standalone SBC or as a complementary component in a larger system.

In closing, the important considerations when integrating an SBC start with choosing the software environment to fit the requirement. From there, determine the correct SBC that fits the software environment and provides the features required. Select an SBC that provides the flexibility of I/O and memory expansion as well as one that has a clear upgrade path for performance. By selecting an SBC that has these features, the designer or integrator gains knowledge from the first application that can be used to shorten the time to market on other projects that use the same SBC. Remember that the SBC should be an off-the-shelf product and the added value to the project is the application software that controls the final products. Spend valuable time and resources on optimizing the software and additional custom board development -- not developing an SBC that is already available from multiple vendors. ■

Mr. Peckham is the President of SBS Embedded Computers in Raleigh North-Carolina. He has been at SBS for the past year. Before that Mr. Peckham was Vice President of engineering at a VME board supplier. He has been in the board business for the past 15 years in both the commercial and military markets. He has a BSEE from Northeastern University in Boston MA.