

BUILDING REAL-TIME EMBEDDED COMPUTING SYSTEMS

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Abstract

Sundance, a member of Texas Instruments' DSP Third Party Network, is a world leading supplier of single and multiprocessor embedded systems based on DSP/FPGA technology for Real-time applications. It sells COTS (commercial-off-the-shelf) products and SW tools for flexible, modular, scalable and cost effective building blocks and solutions for a wide range of applications such as Medical, Industrial, Military, Telecom and Space.

Introduction

Modularity, flexibility and scalability are design features that keep becoming always more important with the increasing complexity of real-time embedded systems. Besides, the need to build and simulate systems building blocks in a short period of time is essential, so that you can have more time to be focused on algorithms and proof of concepts. Sundance can offer both the above design features with their 'Lego' systems and the tools compatible with Simulink for VHDL ([SMT6040](#) [1]) and DSP ([SMT6050](#) [2]) Code generation.

There is no doubt that high-performance computers and DSPs are increasingly being used to address a diverse range of automation tasks. Sundance has for more than a decade been developing Modules for building scalable DSP processing systems and this technology has allowed to create very fast DSPs boards based on the latest technology from Texas Instruments (such as the 1GHz 64-bit [TMS320C64xx](#) [3] processor), from Xilinx (such as [Virtex-II PRO](#) [4]) and Analog Devices for DAQs chips.

The Modular concept adopted by Sundance more than 15 years ago is constantly allowing a gradual improvement of the part of the system that needs to be enhanced for better performance and still maintain the compatibility with the older generations of DSP, FPGA and Data Acquisition Module.

Sundance philosophy in system design

The essence of Sundance products range covering more than 80 different modules, is a happy marriage: on one hand, the sheer speed and design freedom of a hardware-based approach using FPGAs; on the other, the ability to handle complex high level software using a programmable DSP architecture. What Sundance offers are modular building blocks that give you total flexibility to combine these two powerful approaches in the way best suited to the tradeoffs in your system-level design.

All the systems come with full SW tools for Windows and Linux environment and include also full integration and compatibility with Simulink/Mathworks tools for simulation and DSP/VHDL code generation.

DSP development is supported by the [TI's Code Composer Studio](#)TM [5] and the [3L Diamond RTOS](#) [6], providing effortless parallelization of sequential code and hassle-free control of on-chip resources, like DMA-channels, Host-PC interaction and peripheral interface.

In particular 3L Diamond provides the best tools for fast development of multi-processor DSP projects on systems using one or many C6000s. Compilation, linking and debugging are done using Texas Instruments' Code Composer Studio, to which Diamond adds a comprehensive framework for multi-processor software development.

More in details 3L Diamond offers C6000 users:

- Off-the-shelf solutions to communication, synchronisation, and deadlock problems;
- Built-in drivers for inter-processor communication hardware on supported boards; DSP <--> DSP: you can get up to 400MBytes/sec data transfer rate with the SDB/SHB port whereas you get 20MBytes/sec with commport and with simply a library call!
- Transparent, deadlock-free communication between DSPs, independent of network topology;
- Access to host services, C standard I/O and Windows GUI, from all DSPs in the system;
- Bulk data transfer between the host and any DSP in the system over high-speed inter-processor links, leaving the slow JTAG chain free for debugging;
- A clean simple, easy-to-understand framework for multi-processor software design, proven over more than 15 years of real-world use;
- Unique flexibility to develop multiprocessor software on single-processor hardware and then later deploy on multiprocessor hardware without code changes, re-compilation or re-linking;
- A multi-processor, multi-threading micro-kernel with pre-emptive, priority-based real-time scheduling and a context switch time around 500ns (200MHz CPU);
- Support for networks of mixed C6000 types.

With its large range of COTS products Sundance offers high performance and cost effective solutions in the field of DSP such as Military, Medical, Space Research, Telecommunications, Wireless, Audio, Networking, Imaging/Video, Pattern Recognition, Data Acquisition, Control Systems, Automotive, etc.

Digital signal processing brings the benefits of increased efficiency, higher quality and lower running costs to many manufacturing and industrial organizations.

Sundance products are typically either board level, or conform to defined module and carrier standards. In each case, they are designed to be used either as stand-alone solutions, or in multi-processor systems.

Most of the Sundance's products conform to the TIM (Texas Instruments Module) standard.

The modules are intended to be reusable on different architectures, to be plugged into motherboards (PCI, cPCI, VME, PXI, PC-104, stand-alone, etc. [7]) to build homogeneous systems.

All TIMs are provided with communication ports (up to 20 ports per module and up to 800 Mbytes/sec per port) to allow not only data transfers between two DSPs on to different TIMs, but also between two FPGAs and between an FPGA and a DSP.

The carrier boards provide the environment for the modules to operate and communicate with others and the host machine. Larger systems may be built by using multiple motherboards. This family of carriers features one of the fastest versions of the XDS510 compatible DSP debugging tools using the JTAG chain.

Innovative products

Sundance products family has recently been increased with the creation of very important tools for the new engineers generation. The company is very proud to offer to the market the SMT363-XC2 (Fig. 1), an innovative expansion module that connects DSPs to the Internet. As the first of its kind, the module allows design engineers to quickly and easily Web-enable their DSP-based applications. The new SMT363-XC2 allows a sophisticated collection of DSPs to connect to Ethernet/Internet directly and without the involvement of a host computer. It is now possible for a developer sitting anywhere in the world to develop applications running on a multi-DSP system physically located thousands of miles away as long as there is an internet connection. The application thus developed can be loaded to the DSP hardware and controlled remotely through the Internet/Ethernet. This added functionality is particularly beneficial for applications, such as spectrum analysis systems, digital radios, telecommunications systems and security and military applications, whose usability is enhanced by the added ability to transfer data over the Internet.



Fig. 1 – Picture of the SMT363-XC2

The new design features a Texas Instruments 225 MHz TMS320C6713(TM) DSP, an ARM CPU and a Xilinx Virtex-2 XC2V1000 FPGA. By combining a DSP with the RISC processor, the SMT363-XC2 optimizes the performance of both real-time, processing-intensive tasks, and control functions. The inclusion of the Virtex-2 FPGA brings added flexibility to system designers and can support applications involving high data rate. The module combines a NetSilicon Net-50 ARM chip and an integrated MAC controller for direct connection to an Ethernet network.



Fig. 2 – Picture of the SMT365G

Another very important item that has been added to the broad range of Sundance products is the SMT365G (Fig. 2), based on the new Texas Instrument's 1 GHz TMS320C6416T™ DSP.

“The performance of SMT365G running at 1GHz combined with innovative Sundance support for multi-DSP will open the door for new applications that may have not have seemed possible before”, said Thomas Brooks, C6000 marketing manager, TI.

The SMT365G module has a 1GHz TMS320C6416 DSP; up to 256Mbytes of memory and two million gates Xilinx XC2V2000 Virtex-II FPGA for added flexibility and performance, making this board one of the highest performance COTS hardware or DSP in the market place.

"It took our experienced DSP engineers three years to design a truly scalable MultitDSP hardware system using the first generation of TI's 32-bit 200MHz C6201 DSPs," said Sundance CEO, Flemming Christensen, "But it only took us a few weeks to introduce the first 1-GHz DSP solution to the market and we were pleased to see that all our software worked with very little effort. Codecs running on this latest 1-GHz C6416 DSP technology typically show 10-fold performance increases compared to their 32-bit predecessors."

The SMT365G has two 32-bit Sundance high-speed bus interfaces. This fast data transfer mechanism is used for either IO or Inter-DSP communication, which can be used for pipeline processing of data in applications like radar, medical imaging, image processing or similar high-speed data-processing DSP applications.

Another product, the SMT319 (Fig. 3), which has been nominated for EDN innovation of the year award [8], provides an optimal design and architecture for I/O interfacing, pre-processing, processing and displaying of any type of data including standard and non standard industrial cameras used in Robotics and Automation industries.

SMT319 provides standard NTSC/PAL camera interface both for image acquisition and display. On board FPGA can be used by OEMs for interfacing to non-standard digital data including camera interface such as Camera Link™. Two *Sundance* High Speed Buses (SHBs) at 400 Mbytes/s bandwidth each are fully user programmable and can be configured as synchronous and asynchronous input and/or output interfaces.



Fig. 3 – Picture of SMT319

Pre-processing of data is done in the FPGA and is again fully user programmable. Digital signal processing (1D and 2D FIR filters, FFT) and OEM proprietary algorithms are easily implemented using standard and off the shelf Xilinx and Sundance tools and cores. For additional control, Sundance Modular FPGA Design provides six 8 bit, 20 Mbytes/s bandwidth Communication Ports that could be used as serial links to other modules or as additional input or output controls or data interfaces.

In the processing pipeline, after the FPGA, is a powerful Texas Instruments C6414 600 MHz DSP. Operating on a pre-processed data coming from the FPGA, TI C6414 adds additional processing power and flexibility to the SMT319 module. 32 Mbytes of memory is provided for data storage and assembly.

SMT319 is ideally suited for embedded OEM solution on a stand alone as well as standard and industrial PCI, cPCI and VME platforms. Its flexibility and programmability makes it suitable for any type of application in variety of industries.

What SMT319 offers to the OEMs is innovative combination of functionality, speed, flexibility and scalability / upgradability in a single module available on different OEM platforms. Inherent parallelism in the module's architecture provides OEMs with potential processing power capable of solving any demanding application. Innovative design and provided functionality is enhanced by the fact that SMT319 interfaces to other Sundance modules (A/D, D/A, DSP , FPGAs..) providing OEMs with a single source for their solution.

Conclusion

There is no doubt that systems requirements are many and various and technology is striving to meet them. Sundance is working aiming to help customers by designing standard leading edge hardware, cores and software and to be able to quickly tailor products based on customer demand. Sundance also aims to engineer products and solutions to achieve the most economical implementation without compromising performance.

REFERENCES

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