

A Scalable Software-Defined Radio Development System

Sundance enters the SDR fray with a Xilinx-based platform.

by Flemming Christensen
Managing Director
Sundance
Flemming.C@sundance.com

There has been a strong push in the past few years to replace analog radio systems with digital radio systems. The Department of Defense Joint Tactical Radio System program shifted the emphasis on the development of software-defined radio (SDR) to the forefront of research and development efforts in the defense, civilian, and commercial fields.

Although it has existed for many years, SDR technology continues to evolve through newly funded ventures. The “holy grail” of SDR is its promise to solve incompatible wireless network issues by implementing radio functionalities as software modules running on generic hardware platforms. Future SDR platforms will comprise hardware and software technologies that enable reconfigurable system architectures for wireless networks and user terminals.

Although new SDR-based systems are purported to be highly reconfigurable and reprogrammable right now, the truth is that SDR hardware platforms are still in their early development stages. Many issues must still be resolved, including reconfigurable signal processing algorithms, hardware and software co-design methodologies, and dynamically reconfigurable hardware. Overall, the main key issues for SDR embedded system platforms are flexibility, expandability, scalability, reconfigurability, and reprogrammability.

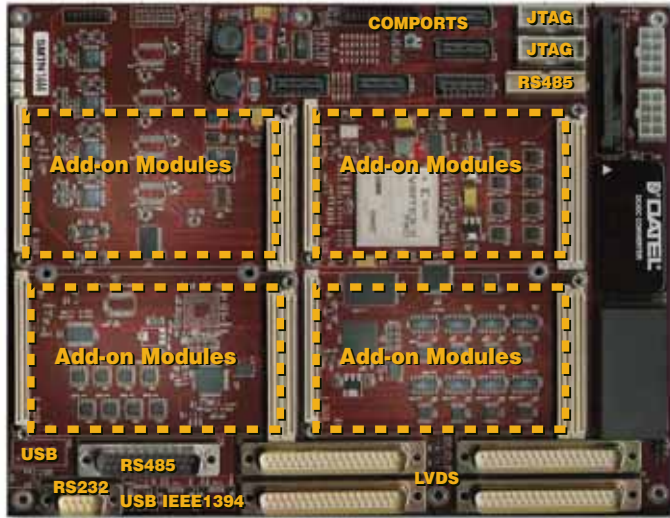


Figure 1 – The SMT148

Meeting the Challenge

SDR is characterized by a decoupling between the heterogeneous execution platform, based on hardware functions together with DSP and MCU processors, and the applications through abstraction layers.

One of the approaches for meeting the complexity demands of third-generation systems is to use multi-core systems where a DSP and a microcontroller work together with an FPGA-based hardware coprocessor. With its embedded IBM™ PowerPC™, the Xilinx® Virtex-II Pro™ FPGA is rapidly becoming a solution that embeds and tightly couples reconfigurable logic and a processor in the same device.

Sundance, a developer of advanced system architectures for high-performance signal processing applications, has focused on designing FPGA-based development platforms that address an SDR OEM's wish list. Our challenge was to design a system that would provide the scalability SDR systems require.

The Embedded System Controller

The SMT148 (Figure 1) is one of many development systems Sundance has launched recently. Aimed specifically at SDR, the SMT148 is a fully configurable and expandable waveform development environment that meets the many requirements of SDR developers. This entry-level, stand-alone system enables radio designers to investigate and experiment with the

many configurations of multi-channel software programmable and hardware-configurable digital radio.

The SMT148 has at its heart a powerful embedded system controller that leverages the Xilinx Virtex-II Pro FPGA with its embedded PowerPC 405 processor (Figure 2). As an embedded system controller, the role of the Virtex-II Pro device is to manage the reconfiguration

of the add-on modules, especially when downloading. Reconfiguration means switching between modes or updating a hardware/software component.

In the global functioning of the SMT148, you can download many kinds of software (high-level applications, protocol stacks, low-level signal processing algorithms) and employ several methods to

download software. The eight RocketIO™ transceivers on the Virtex-II Pro device enable high-speed data transfer to additional SMT148 or Virtex-II Pro add-on modules.

Downloads can leverage a powerful I/O architecture that includes the popular FireWire, USB interfaces, LVDS interfaces, and JTAG for debugging and downloads. Data flows into the FPGA and is managed by a Sundance program written for the embedded PowerPC before processing. Figure 3 is the C code comprising the data flow and RocketIO PowerPC program.

Scalable, Reconfigurable Embedded Processors

Scalability is addressed through four add-on module sites, and you can partly resolve the requirements of dynamic reconfiguration by adding additional Xilinx-based FPGA modules. All add-on modules communicate through the Virtex-II Pro device, which also manages two 32-bit microcontrollers that enable communications with most widely used standards.

With the RocketIO transceivers connected to differential pair connectors, you can connect FPGA systems directly

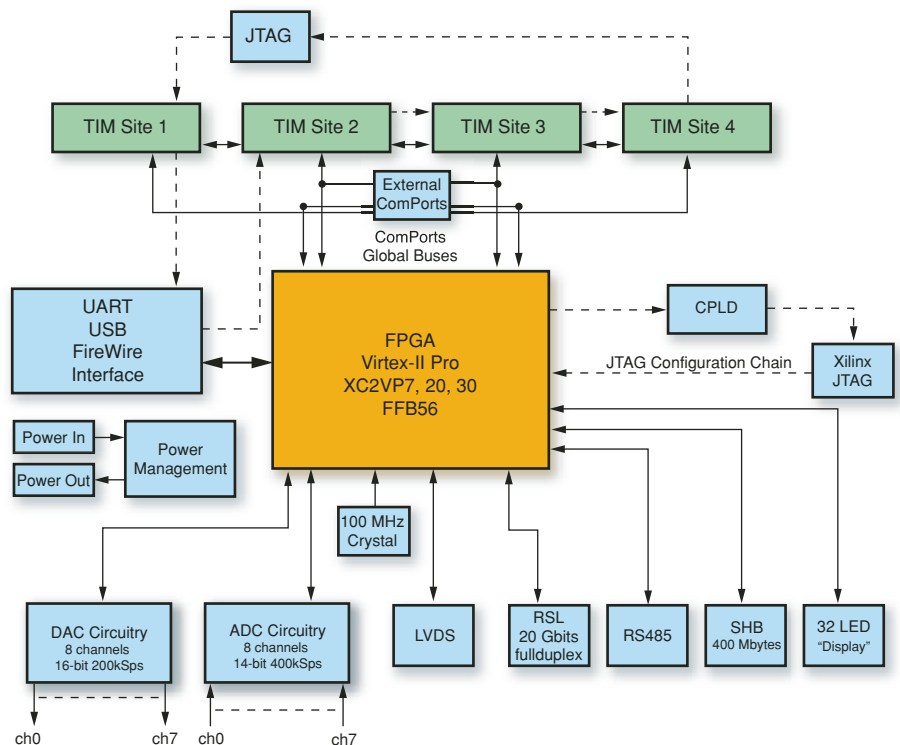


Figure 2 – SMT148 systems architecture

through simple cable connections supporting more than 2 Gbps data rates.

The SMT148 leverages the Xilinx Virtex-II Pro block RAM configuration to generate FIFOs for the RocketIO transceivers, add-on modules communication ports, and a high-speed bus, as well as the embedded PowerPC code. The single high-speed bus allows parallel data transfer to and from a wide range of high-speed ADC/DAC modules.

When we designed the SMT148, we understood that one of the many challenges OEMs would face in developing JTRS-compliant platforms was the availability of interchangeable and networked processing nodes. The availability of processing nodes aims to meet the expandability and scalability requirements in complex waveform applications.

The SMT148 meets this availability challenge with a network of daughter sites that

topology neatly harmonized to the Xilinx architecture.

Fully interconnected and configurable through their communication ports, these add-on sites are also connected to the embedded Virtex-II Pro FPGA. The availability of a network of add-on sites removes the main expandability restrictions often associated with other platforms, and offers the OEMs a highly compact design and development tool.

More importantly, this scalable system architecture makes the SMT148 a perfect development platform with which to resolve the many issues related to the implementation of multiple radio functionalities in a single environment. These can be addressed as multiple software modules running on Sundance's reconfigurable hardware platform.

IP Cores

Sundance takes advantage of the high-performance DSP acceleration capabilities and flexible connectivity that the Virtex-II Pro FPGA provides by supporting developers with a family of software tools and IP cores.

The SMT148 I/O flexibility enables you to rapidly investigate and experiment with features of the Virtex-II Pro FPGA as well as those of developed IP cores from Sundance. These include multi-tap complex filters, Viterbi decoders, encoders, a complete transmitter, QAM mapper, multi-phase pulse shaping filter, multi-phase cascaded integrator comb (CIC) interpolation filter with a fixed interpolation rate, multi-phase numerical-controlled oscillator (NCO), and multi-phase digital mixer.

Conclusion

Developing, testing, and implementing SDR IP cores is simplified with the Sundance SMT148 platform. You can now focus on developing additional IPs without worrying about peripheral processing or I/O devices, as these are simply off-the-shelf add-on IP blocks.

For more information, please visit www.sundance.com.

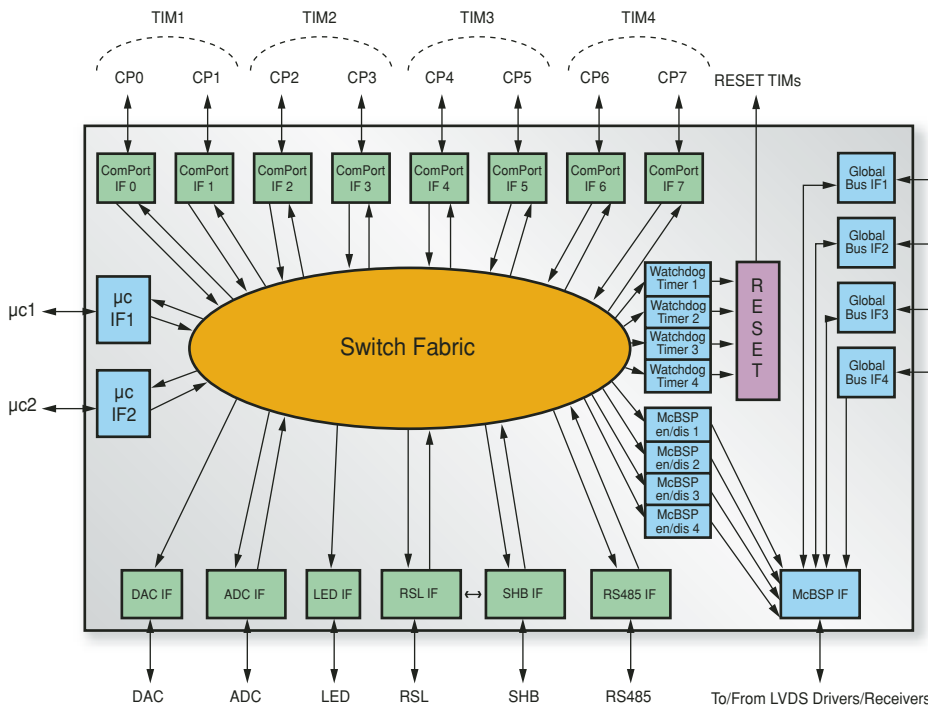


Figure 3 – Interconnections diagram of the digital modules inside the SMT148

Data rates on this port are in excess of 100 MHz (400 Mbps), and are useful for transferring sampled 16-bit I and Q. Processing data streams can take place either in the embedded PowerPC in the Virtex-II Pro device or throughout an array of other add-on Virtex-II Pro FPGA-based modules with embedded PowerPC.

The FPGA on the SMT148 carrier card is connected to many different devices and therefore has many internal interfaces that allow it to exchange data or commands with the external world. All interfaces are reset at power on when applying a manual reset. Figure 4 shows the interconnections between the digital modules inside the FPGA.

you can use for additional resources such as signal processors, reconfigurable computing modules, and Sundance's large family of add-on modules. These add-on modules include a variety of embedded system options such as reconfigurable modules with tightly coupled Virtex-II Pro FPGAs and DSPs, digital and analog converters, data conversions, transceivers, and I/Os of all types.

Designed for Developers

Powered by an external supply, the SMT148 platform has an impressive topology that accepts input signals from various sources through a network of multi-pin connectors. High-speed I/O channels support the additional nodes in a network