WP104 (v.1.0) January 20, 2000

Xilinx High-volume Programmable Logic Applications in Satellite Modem Designs

Summary

This paper gives an overview of satellite modem technologies and how Xilinx high-volume programmable devices can be used to implementing complex system level glue in satellite modem designs. The Xilinx device families targeted at these high-volume applications include XC9500 CPLDs and Spartan™ FPGAs. Detailed information describing these families can be found on the web at www.xilinx.com.

Introduction

The flow of this document will start with an overview of the satellite modem technology and how the Internet is driving its deployment. This will be followed by an overview of satellite modem technologies and standards. Next examined are the major functional blocks of a satellite modem and an overview of the Application Specific Standard Products (ASSPs) that are used to implement the satellite interface. A Hughes Network Systems using a Spartan device to implement complex system glue in a USB satellite modem design will be illustrated.

While this document focuses on applications of these devices in satellite modem applications, the examples discussed illustrate many of the issues found in other designs. Specifically how to cost effectively interface complex ASSPs with incompatible interfaces. The ASIC vendors have abandoned the traditional solution for this class of problems, the small ASIC, as they moved towards system on chip market. Fortunately for system designers, new classes of low cost PLDs such as the Spartan family have filled this void with devices that replace low density ASICs and retain the time to market advantages of FPGAs.

Overview

Internet users are continuing to demand higher bandwidth access to the net. Both a new class of corporate users and new services are driving this. Corporate users are being brought to the Internet as corporations begin to move away from their private networks. Many are using the Internet to connect remote offices and telecommuters to their corporate LANs using Virtual Private Network (VPN) technologies. High bandwidth access to corporate resources is necessary to maintain the productivity of these remote workers.

New Internet services that are coming on-line also benefit from a higher bandwidth connection to the user. An example includes streaming video, which is an integral part of every on-line news service. Users of on-line shopping services also need greater bandwidth to support the high-resolution images that make an on-line buying decision practical. In the face of this demand analog modem technology has hit the end of the road with the 56K generation of devices.

Satellite modems address the need for increasing Internet access bandwidth by offering download speeds ranging from 400 Kbps to 38 Mbps.

Satellite Modems vs. DSL and Cable Modems

While cable modem or DSL modems have gotten a lot of attention as the next generation of Internet access technology, these technologies are currently limited in their deployment. DSL requires that the subscriber be within 18 thousand wire feet of the central office. Cable modem technology requires a significant upgrade to the head-end equipment within the cable system. Satellite modems only require a clear line of site to the satellite and a standard phone line for the return channel data. For this reason satellite modems not only represent a good option for high speed Internet access, for many people they represent the only option. In terms of deployment, it is estimated that there will be $100 million worth of satellite modems shipped in 1999.

Satellite Modem Technology and Standards

Satellite modems use the same infrastructure that is used to deliver digital television services such as DirectTV. There are three major standards for delivering these services.

DSS (Digital Satellite System)

A proprietary, high-power, digital satellite video technology developed by Hughes. DIRECTV, a DBS service provider owned by Hughes Electronics Corporation, utilizes DSS technology for distribution. As of Q1, 1999 DIRECTV had nearly five million subscribers.

DVB (Digital Video Broadcasting)

A consortium that had developed a set of open, digital video broadcast standards. All DVB systems are based on MPEG-2 audio and video-compression. DVB adds to the MPEG transport stream multiplex, the necessary elements to bring digital broadcast services to the home through cable, satellite and terrestrial broadcast systems.

Primestar

A DBS service provider utilizing proprietary, medium-power, technology. Hughes Electronics Corporation the owner of DIRECTV acquired Primestar in early 1999. At the time of the acquisition, PRIMESTAR had 2.3 million subscribers. At the time of the acquisition Hughes indicated that Primestar’s subscribers would be migrated to DSS technology.

Internet Access via Satellite Modem

Figure 1 illustrates what is involved in providing Internet access via a satellite modem. The complexity of the dataflow within the network is due to the fact that the satellite provides a uni-directional data link.

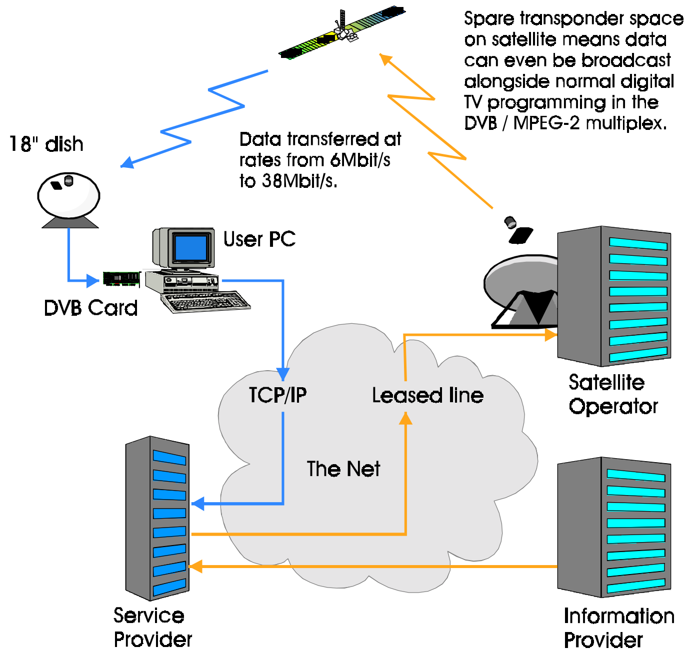

Figure 1: **Internet Access Network Architecture**
(Courtesy of the DVB Project)

User PC

The User PC is a standard personal computer with two network connections. The satellite modem is used to transfer Internet data to the User PC. Data from the User PC destined for the Internet is transferred by way of a telephone connection to the Internet Service Provider.

Internet Service Provider (ISP)

The ISP provides access and routing services for the subscriber. Data coming in from the subscriber over dial up phone connections is routed to the appropriate information provider by way of the Internet. Information coming from the information provider destined for the subscriber is forwarded to the Satellite operator over leased lines.

Information Provider

The information provider is any site providing information resources via the Internet. The satellite data flow issues are transparent to the Information Provider.

Satellite Operator

The Satellite Operator takes data from the ISP and transmits it to the satellite for delivery to the subscriber. This data may be transmitted via dedicated transponders or multiplexed with digital video data.

Satellite Modem Issues

There are two issues that impact the desirability of satellite modems as a means of Internet access.

The first of these is that the bandwidth available from the satellite is shared amongst a large number of users. While each transponder can deliver from 6 to 38 Mbps of data transfer capacity, the DirecPC service only guarantees 144 Kbps to users.

The second issue is that the satellite modems are only capable of receiving data. This has two consequences, the subscriber must use a standard phone line for return data, and as we have seen with this arrangement, considerably complicates the network architecture.

Note that both of these issues are also true of many cable modems.

Satellite Modem Architecture

The functional blocks that make up a satellite modem are illustrated in Figure 2 and include:

- **A Satellite interface** containing the satellite specific link functions.
- **A CPU complex** consisting of the CPU plus RAM and ROM, responsible for configuring and managing the system.
- **A Host Interface** used to connect a modem to the host computer or to a local area network if the modem includes router functionality.

Each of these blocks is typically implemented by a small number of ASSPs. In most cases there are mismatches between the ASSPs used to implement each of these blocks. The system level glue needed to interface these blocks while delivering a product early to market is a key benefit of Xilinx's high-volume FPGA and CPLD products.

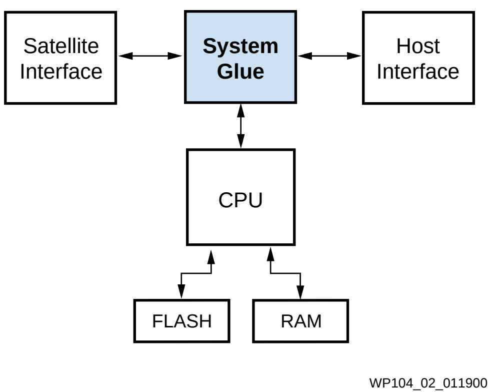

Figure 2: **Satellite Modem Architecture**

The satellite interface consists of two major functional blocks, the tuner and the decoder.

The tuner consists of analog components typically packaged in module form in a shielded metal enclosure. The function of the tuner is to selectively filter and down convert the satellite signal into a quadrature baseband signal. Again note that all of this occurs in analog domain.

The function of the decoder is to provide analog to digital conversion, decoding and forward error correction functions. The decoder is typically implemented as a single ASSP. Figure 3 illustrates the major functional blocks that are included. The decoder is configured and managed by a microprocessor, and as a result these devices include a processor interface in the form of either an 8-bit microprocessor bus or a serial interface such as I^2C.

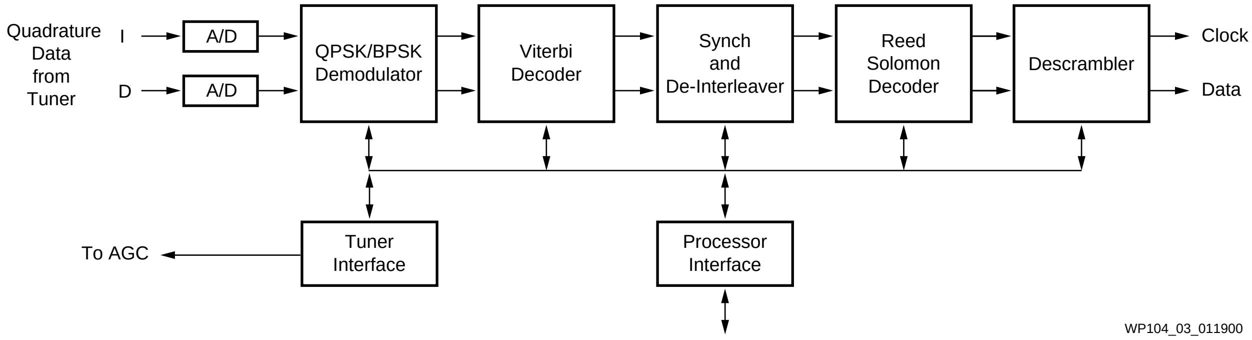

Figure 3: **Decoder Block Diagram**

Satellite Decoder ASSPs

Satellite decoder ASSPs are available from three major vendors as shown in Table 1. While there are minor differences in each of these products, they are all single chip implementations and include all of the needed demodulation, forward error correction, and analog to digital conversion functions.

Table 1: **Satellite Decoder ASSPs**

Supplier	Components	Processor Interface	Standards	Availability
Broadcom	BCM4201 Universal Satellite Receiver	I2C, SPI	DSS, DVB, Primestar	Now
Conexant	HM1211 Demodulator	Serial, Parallel	DVB, DSS	Now
LSI Logic	L64724 Satellite Receiver	Serial, Parallel	DVB, DSS	Now

Host Interfaces

Host interfaces are used on the local side of a modem. This interface is used to connect the modem to a PC, server, or other networking equipment. For an internal modem this interface is the I/O bus of the computer, typically ISA or PCI.

In the past, the most popular interface for external modems has been RS-232. Unfortunately this interface is not fast enough to support the data rates provided by digital modems. As a result, manufacturers of satellite and most other high-speed modems have had to move to other interfaces.

The most popular choice for new external modem designs has been Universal Serial Bus (USB). A key advantage of this interface is that USB has been incorporated into PC core logic for over a year and as a result is included as a standard feature in all new PCs. An external modem that provides a USB interface is attractive since it not only eliminates the need for users to open their systems, but also provides a means of supporting non-PC systems such as the popular iMac. For these reasons this is a popular approach for next generation, satellite modem designs.

For users that are not intimidated by opening up their computer and installing cards, an internal modem is still the most cost-effective solution. The cost of an internal modem will always be lower since there is no need for a case or power supply. In the case of an internal satellite modem the host interface consists of the logic required to glue the CPU local bus and the data stream interface on the satellite decoder to the PCI bus.

Xilinx Satellite Modem Design Win

The Xilinx Spartan series FPGAs were used in the Hughes Network Systems (HNS) DirecPC-USB satellite modem design. This product ships almost 500,000 units a year.

The challenge that HNS was faced with was how to quickly introduce an external satellite modem with a USB interface. Up to this point DirecPC customers only had the option of using an internal PCI modem for their network access. In order to reduce both time to market and development costs HNS wanted to leverage an ASIC they had developed for the PCI card in this new design.

They solved their design challenge with a Spartan XCS20 that they use to implement the required system level glue. The Spartan device implements interfaces for the RISC CPU, the satellite decoder, the USB interface ASSP and their own ASIC. Figure 4 shows a block diagram of their design.

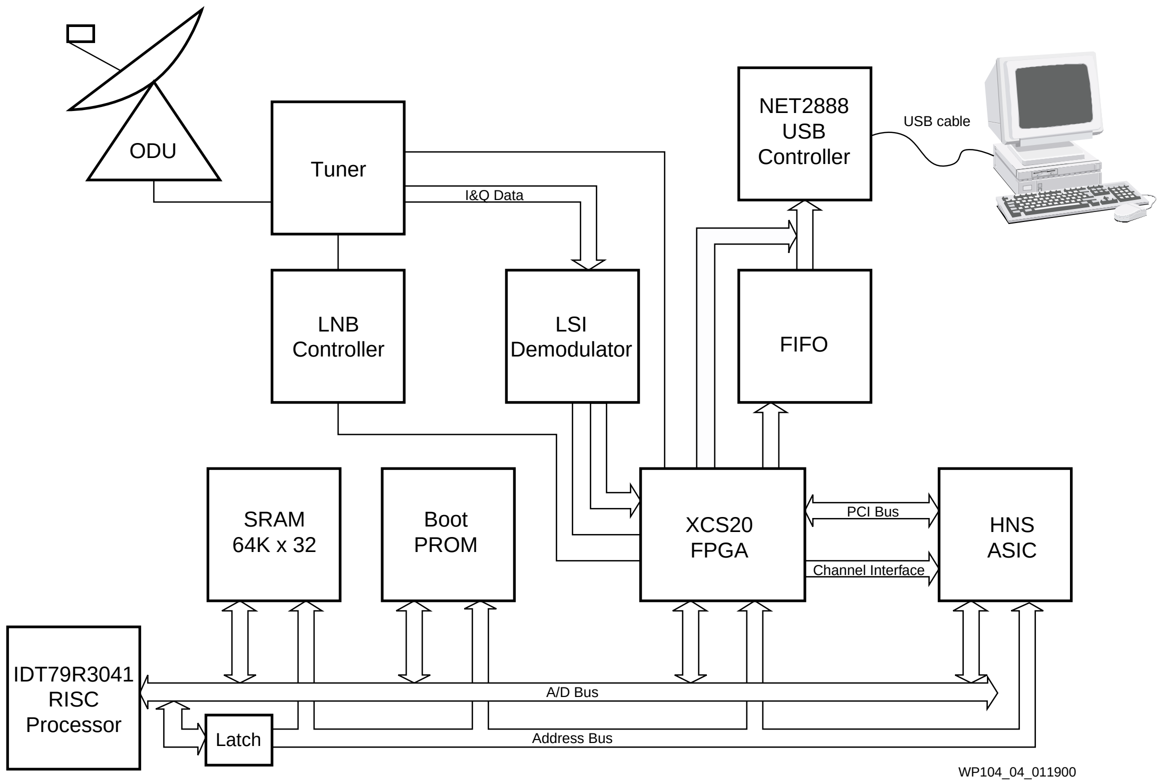

Figure 4: **HNS DirecPC®-USB Receiver Block Diagram**

Functions implemented within the Spartan device include:

- **Processor Interface.** This block contains not only bus state machine logic but also system control registers and a watchdog timer.
- **Data Buffer**. This block buffers data between the satellite decoder and the HNS ASIC.
- **CRC Check**. Incoming packets are checked for errors using a 32-bit CRC polynomial.
- **USB Controller Interface**. This block implements bus arbitration functions for USB DMA requests, control logic for the external data FIFO, and DMA control.
- **PCI interface**. The PCI interface gives the RISC microcontroller access to the control registers with the HNS ASIC and lets it take over the functions that were handled by the host processor in the original PCI card design.

Conclusion

Until satellite modem ASSP manufacturers deliver more highly integrated solutions, designers of these products will be faced with the task interfacing a variety of devices with incompatible interfaces. Xilinx high volume FPGA and CPLD technologies provide system designers with cost effective solutions that retain the traditional PLD time to market advantage.

Revision History

Date	Version	Revision
01/20/00	1.0	Initial Xilinx release