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The Development of the USB-DMB Receiver

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Abstract

As analog audio systems are changing to digital systems, the DAB (Digital Audio Broadcasting) is expected to provide CD quality audio, various data services with interactiveness and excellent mobile reception ability. The DMB (Digital Multimedia Broadcasting), as more advanced successor of the DAB, adds video capability on the audio and data services. The DAB system assures high quality audio services even when the reception is through portable and mobile receivers. In this paper, USB-DAB receiver and PCI-DMB receiver are designed and implemented. The DAB receiver and the DMB receiver incorporate with PC to make use of computational power and application software of PC. This enables the developed system to be more flexible and to meet various applications easier.

Keywords: *Echo Canceller, NLMS, Pipeline, FPGA, EAB, Synthesis*

I. Introduction

The DAB is called the third generation audio broadcasting that takes over the second generation AM and FM broadcasting. In addition to providing CD quality audio, the DAB promises various data services, interactiveness and excellent mobile reception quality. The DAB will play a major role as new media service that can be realized in various ways such as terrestrial broadcasting, satellite broadcasting, cable or Internet[1,2].

Comparing to existing radio broadcasting, the DAB reduces cost, power consumption and frequency resources through SFN (Single Frequency Network). Since existing radio broadcasting was invented for fixed receiving station, it reveals quality degradation when applied in mobile environment and also requires high power and wide frequency bandwidth. As the next generation audio broadcasting, the DAB employs OFDM (Orthogonal Frequency Division Multiplexing) technology so that it can maintain low noise, high quality audio in downtown areas and high speed mobile environments even with small transmitting power. Thanks to digital communication technology, the DAB provides character service, multimedia service and other various services[3,4].

The DAB system was originally designed for mobile reception of audio signals about 1.5 Mbit/s effective data rate in 1.536 Mhz channel. Currently in Korea, development of the DAB receiver focuses on In-car system and mobile products but it is still in initial stage and doesn't make any distinct results yet. As extent of digital broadcasting technology, the DMB is a kind of multimedia broadcasting and goes one step ahead of the DAB. Sometimes, DAB and DMB are considered as same system and it means the DMB is an advanced type of the DAB. For frequency usage, VHF band (174 ~ 230MHz) will be allocated for terrestrial broadcasting and L-BAND (1452 ~ 1492 MHz) will be allocated for satellite broadcasting[5,6].

For audio and video signal format, the DMB uses the MPEG-4 that is superior to MPEG-2 in compression ratio. MPEG-4 based DMB Receiver offers multimedia information with an excellent audio and video quality to the

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mobile society. Since the DMB has 1.5Mbps transmission bandwidth, SD rate video quality is possiblewith MPEG-4 format and it is believed that the quality has also been proved by tests tried in many countries. In the near future, interactive service and Digital TV service on cellular phone will be possible between customers and broadcasting provides using DMB technology. Recently many researches on DMB receiver has been doing and partly standardization has been achieved. For the road map of the DMB development in Korea, experimental broadcasting was performed based on Eureka-147 standard in 2002 and video transmission in terrestrial broadcasting succeeded for high speed mobile environment of 100 km per hour early in 2003. The KBS (Korean Broadcasting System) company achieved 760kbps rate video transmission using one multiplex of VHF channel number 12 allocated for DAB band. The government decided to allocate the channel number 12 as DMB channel and plans to broadcast DMB nationwide by next year. Commercial service of DMB system based on Eureka-147 standard will start on October2003. In this paper, we tried to show a solution of DMB system. This paper consists of as follows. In chapter 2, how to implement DAB receiver is discussed. The DAB receiver is incorporated with personal computer to borrow powerful computational functionalities from it[7]. In next chapter, the development of DMB receiver is discussed because the DMB is considered as an advanced successor of the DAB. Finally, we conclude this paper in chapter 4.

II. USB-DAB Receiver

Even though theDAB system can be developed as Independent Portable Reciver, it also can be used with other devices such as PDA, cellular phone, or personal computers. In this paper, we incorporate DAB receiver with a personal computer. The PC-based DAB receiver can use both PCI interface and USB interface. Considering covenience for users, USB is more flexible and easy to use so that we implemented the DAB receiver system using USB interface. In Korea, commercial product of DAB using USB interface is not yet on the market and DR BOX1 from Terattac in Germany and Wavefinnder from PSION in Britain have been on market in abroad. The DAB receiver with PC can easily accept digital signals and has advantages in data processing using high performance CPU and in real time data storage using large hard disk drives of PC. For the format of domestic DAB system, Eureka-147 standard was decided and many companies have been doing research to develop fundamental techonologies.

Table 1. Comparisons of Major DAB Standards

Item	Europe Eureka-147	USA IBOC	JAPAN ISDB-TSB	ETRI IBAC
Basic	Muti-Carrier	Muti-Carrier	Muti-Carrier	Muti-Carrier
Modulation	DQPSK/ COFDM	QPSK/ COFDM	DQPSK QPSK 64QAM BST-OFDM	8 PSK, 16QAM/ COFDM
Error Correction	Convolution	Convoluti on (CPCC)	RS + Convolution	RS + Convolu-tio n
Audio Coding	MPEG-1 Layer2	PAC	MPEG-2 AAC	MPEG-2 AAC
Frequency range	30MHz ~ 3GHz	FM/AM Range	TV VHF	FM Range
Bandwidth	1.536MHz	140KHz (Hybrid)	430KHz (1 Segment)	About 482KHz
Data Rate	0.8 ~ 1.7Mbps	128Kbps (Hybrid)	280 ~ 1787Kbps (1 Segment)	About 750Kbps
Standard Date	1995-02	2001	1999	Stop

The Eureka-147 standard uses DQPSK (Differential Quadrature Phase Shift Keying) and OFDM modulation schemes, and adopts Convolutional coding method for error corrections. For the frequency usage, 30MHz ~ 3 GHz frequency range is used and overall specifications were fixed in 1995. Table 1 shows comparisons of major DAB standards.

2.1 Standalone DAB Receiver

Standalone type DAB receiver consists of RF tuner, A/D converter, Baseband DAB chip, D/A converter and MPEG audio decoder. Overall block diagram of the DAB system is

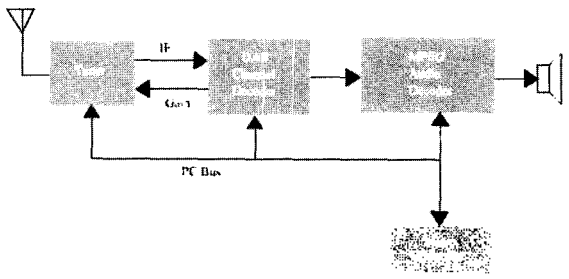

Figure 1. Block Diagram of the Stanalone DAB Receiver

shown in Figure 1.

a. Tuner

Tuner can receive band and L band (1.5Ghz) signals. The RF signals are converted into I and Q signals and the I and Q signals are digitized by the A/D converter. The digital signals are fed to the DAB channel decoder.

Tuner mixes down selected DAB Ensemble to IF (38.912MHz). The Gain control is used to get high ratio of signal to noise at ADC output.

b. DAB Chipset

DAB chip performs channel decoding and source decoding. For channel decoding, it does OFDM demodulation and Viterbi decoding with ETS 300/401. The Viterbi decoer executes an error correction process on the FIC data and the sudio data which is extracted from the demodulated data.

DAB signals that consist of FIC (Fast Information Channel) and MSC (Main Service Channel). For source decoding, the chip contains audio decoder and data decoder. The audio source decoder supports ISO MPEG-1 and MPEG-2. The data decoder supports two independent Packet Mode Decoder.

c. DAC (Digital Analog Converter)

Digital signals from the source decoder go through DAC and are transmitted to speaker. This would be used for standalone typed mobile receiver. The PCM audio data is converted into analog audio signals by the DAC

2.2 Development of the USB-DAB Receiver

The USB-DAB Receiver is developed for the audio broadcast of audio and accompanying data by ETS 300 401. For the implementation of DAB receiver system, Atmel 2739M-B DAB chip that supports ETS 300/401 Eureka-147 standard is used. As DAB tuner, Samsung tuner TDAB10111IA is used and Atmel evaluation kit ADCV22 is used for ADC.

The Analog Digital Converter of the DAB Reciever System, ADCV22 is shown in Figure 2.

For the USB interface with PC, Cypress CY3654 evaluation kit in which IC63723 is used as USB chip. Tuner and B/B board are put together as shown in Figure 3.

Interfaces of the DAB chipset U2739M-B are as follows:

- Source decoder output interface : IIS and SPDIF
- Data decoder output interface : V24, HSSO (High Speed Serial Output)
- Channel decoder output interface : RDI (Receive Data Interface)
  SFCO (Simple Full Capacity Output)
- 10-bit ADC interface
- DSP OAK Core Bootstrap ROM interface
- VCXO (Voltage Controlled Reference Oscillator) interface
- Time De-interleaver SRAM (4Mbit) interface
- HSSO interface, 3 line serial output interface

Figure 4 shows the block diagram of the USB-DAB receiver. Main difference from standalone DAB receiver is a connection to PC through USB interface.

For the communication between PC and DAB receiver, a tunnel is needed for IIC command to be transmitted to the

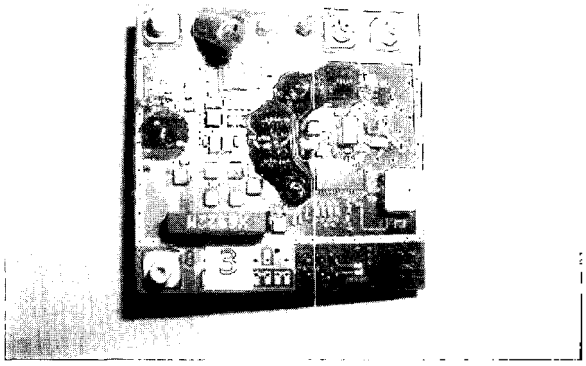

Figure 2. ADC of DAB Receiver System

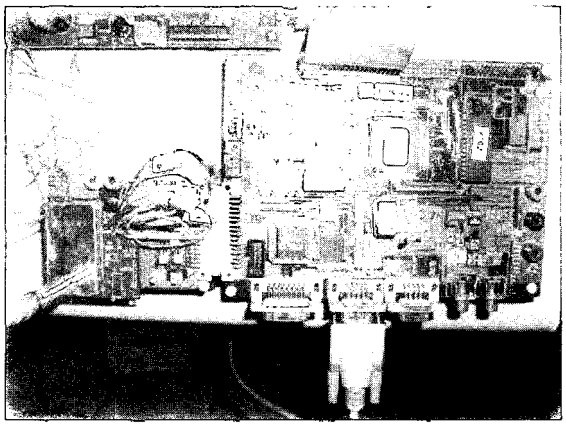

Figure 3. Implementation of Baseband Board with Tuner

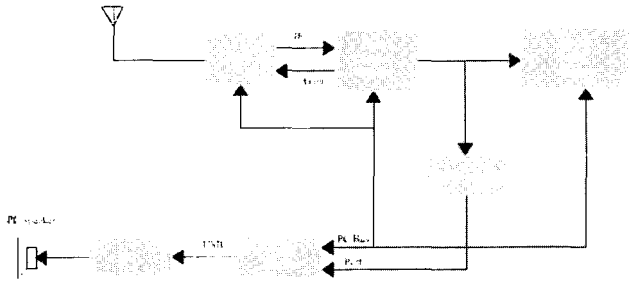

Figure 4. Block Diagram of the USB-DAB Receiver

receiver through USB from PC. USB interfacing methods are classified into four modes based on packet communication types between host PC and USB device. Those four modes are Bulk mode that can retransmit data in case of occurring errors even though it has low priority, Isochronous mode used for transmission with fixed amount of data at fixed time, Interrupt mode for interval transmission of small amount of data, and Control mode for host transmission of setup information.

Figure 5 shows the system that is implemented in four modes described above.

For software, development of USB driver and interface control software between USB interface and DSP controller in DAB side are the main tasks. USB driver installed on PC provides a device-specific interface for main application. DSP as micro-controller is in charge of controlling data bitstream through USB interface. In PC-based DAB system, audio stream decoding is supposed to be done on PC borrowing computational power of Pentium CPU. Actually DSP is believed to be powerful enough to do audio coding in DAB receiver but, considering software usage aspects, it is much flexible and easy to use PC-based codec software.

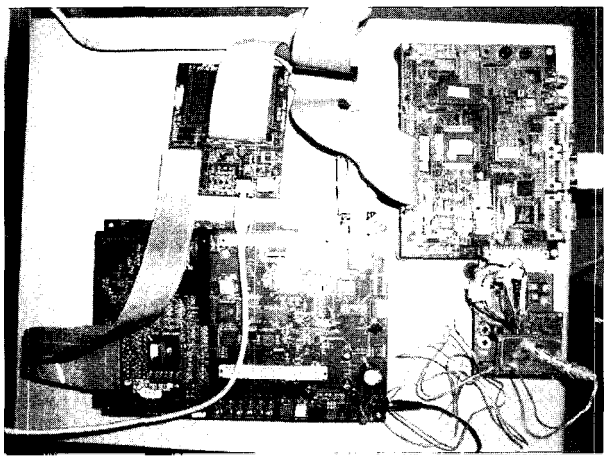

Figure 5. Developed USB-DAB Receiver

III. USB & PCI-DMB Receiver

DMB (Digital Multimedia Broad casting) standard is not yet settled in KOREA, so we propose DMB Receiver that uses existing DAB chip (U2789M-B)

Decoding capability of DAB allows wide range of media contents transmission such as Web pages, animation and Video data. For exmaple, information providing or commercial advertisement are possible in mobile environments such as train or bus.

Therefore DAB is changing to DMB to accommodate various contents besides CD quality audio reception. Video transmission spec adapted for DMB is MPEG-4 384Kbps ~ 500Kbps, Convolution coding and Reed solomon coding for error correction. This enables better quality reception in mobile environments comparing to MPEG-2 of DAB. Currently, transmission protocols are not determined in Korea and we expect that the DMB substitutes DAB in very soon. To meet technological trend, DMB receiver is also developed as shown in Figure 6.

DMB receiver uses Samsung DAB tuner and Atmel U2739M-B for DAB chipset. For other hardware chips, Emblaze ER chipset for MPEG-4 decoding, Conexant Cx23880 for PCI interface and Cypress chipset for USB interface are used. Implementing DMB receiver using existing DAB chipset gives advantages to meet various needs for digital audio development. Especially, switching to MPEG-4 from MPEG-2 provides better quality of data reception in mobile environments.

PCI is faster and tightly coupled with PC so that it can provide more powerful and flexible applications considering developing aspects on PC even though sacrifising some convenients for users. Interfacing the DMB receiver to the PC via the PCI bus involves tunnelling the IIC commands and data over the PCI bus. This is enabled by the PCI interfaces. The PCI logic receives the PCI signals and presents the data received to the application software. The

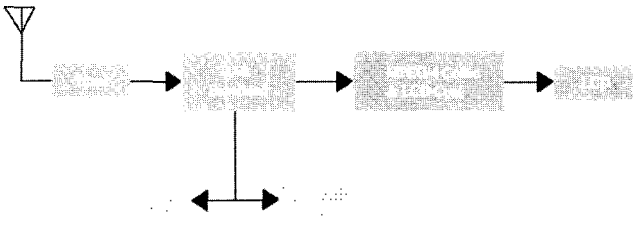

Figure 6. USB & PCI Receiver

applicaion software extracts the IIC commands and data, send them to the IIC master, which is in turn generates the necessary signals on the IIC lines. This operation happens same in using USB interfacediscussed in previous chapter.

Development of DAB chip is still on going and the standard for it is not yet fixed in Korea. Considering this situation, DMB receiver design using existing DAB chips plays an important role in a turning point from DAB to DMB.

IV. Conclusions

As existing radio broadcasting suffers from low reception quality and other new media emerges to substitute for radio broadcasting, it is natural to demand digital broadcasting to compete with them. Digital audio broadcasting is expected to accomplish high quality data reception so that it is enough to compete with other media services. DAB will provide MOT (Multimedia Object Transfer Protocol) application, various Textual Pad services, Traffic Information services and Navigation Aids services. Since the USB-DAB receiver and DMB receiver developed in this paper are based on PC, users can enjoy many additional services such as high quality video service on PC monitor much bigger than LCD of mobile devices and high quality audio with relatively small devices such as PC card installed in PCI in which digital tuner and decoding hardware are contained. With wide spread of internet and PCs, many digital media services are possible and the DAB also plays an important role of this areas. Furthermore, the DAB enables high quality media services in remote sites that are not connected with wired Internet. We believe the DAB receiver and the DMB receiver will create new media applications commercially and technologically.

Currently, any commercial interactive services are not implemented yet and some discussions for how various data services are provided will be necessary. In order for DAB/DMB system to smoothly take over the third generation, there should be information exchange between service providers and customers. In the future, based on USB-DAB receiver and DMB receiver and DMB receiver proposed in this paper, more works will be needed about MOT and PAD for interactive services.

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[Profile]

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NhoKyung Park received the B.S, M.S and Ph.D degree in Electronics form Korea University, Korea, in 1984, 1986 and 1990, respectively. From 1999.3 to 2002.2, he worked as a visiting professor in Information & Communication Engineering, Hoseo university, Asan, Korea. His current research interests include Audio/Video compensation and estimation and chip design, DAB/DMB

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Since 1998, he has been a professor at the department of Information & Communication Engineering in Hoseo university. He has worked in application of system programming to Windows-based system, software development for computer visions and DAB systems. Currently he in interested in Embedded system, especially software developments for lower-powered wirelss communications.