Development of New Portable Equipment for Prototyping and Evaluation on Speech and Audio Signal Processing Applications

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Abstract
For researchers and engineers working on speech or audio signal processing, to implement and evaluate processing algorithms on specific devices such as DSP or FPGA is necessary for realizing real time signal processing applications. Furthermore, evaluation of algorithms in real world environment is very important. However, conventional evaluation boards are not portable or quality of sound interface is not enough.

For evaluation in real world, we developed new portable equipment for prototyping and evaluation on speech and audio signal processing. It is a light and small box, which works with a rechargeable battery. This equipment includes a DSP and a FPGA, and audio interface up to 4-channel input and output. Furthermore, connected via USB interface, this equipment can be controlled from PC.

As a sample application, we developed a prototype of hearing aid system on this equipment. The system conducts frequency independent amplitude compression in order to compensate for hearing loss. We can carry this equipment anywhere, so this prototype system is convenient for evaluation in daily life environment.

1. Introduction
Recently, advanced signal processing applications like speech recognition, audio encoding, or active noise control have been implemented on LSI or DSP, not only for research but also for consumer products. For research and development of these applications, evaluation in real-world environment in early stage is needed. Nevertheless, most of evaluation systems for signal processing algorithm are too heavy. Some evaluation boards are light enough, but they need AC power supply and have poor signal processing power.

To meet the demand for evaluation in real world environment, we developed a portable device “PHASE Model SP-100”.

2. Features
SP-100 has enough performance for signal processing prototyping. SP-100 is a laptop-PC size box, which includes electrical board, rechargeable battery, PC interface and sound interfaces.

Main features of SP-100 are:
- Enough signal processing power for prototyping
- Multi channel audio interface
- PC interface (USB 1.1)
- Portability

Sample system setup and block diagram are shown in Figure 1 and Figure 2 respectively.

Figure 1: Example of evaluation system setup (SP-100 connected to a laptop PC via USB cable).

Figure 2: Block diagram of SP-100.

2.1. FPGA/DSP
SP-100 contains a TMS320C6711 DSP and a VIRTEX XCV1000E FPGA. Each can deliver up to 900 MFlops of DSP processing power and up to 1 Million gates. The configuration data of FPGA and firmware of DSP are stored in Flash Memory, which can be updated.

SP-100 consists of two boards, main board and daughter board. The DSP and FPGA are mounted on the daughter board that makes SP-100 upgradeable by replacing the daughter board.
2.2. Audio interface
Specifications of audio interface are shown in Table 1.

Table 1: Specifications of audio interface

<table>
<thead>
<tr>
<th>Feature</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sampling Frequency</td>
<td>48/44.1/32/16/8 (kHz)</td>
</tr>
<tr>
<td>Analog Input</td>
<td>Line: 4ch / Mic: 4ch</td>
</tr>
<tr>
<td>Analog Output</td>
<td>Line: 4ch, Phone: 2ch</td>
</tr>
<tr>
<td>Digital Input/Output</td>
<td>Optical</td>
</tr>
<tr>
<td>S/N ratio</td>
<td>88dB (1kHz)</td>
</tr>
<tr>
<td>Dynamic range</td>
<td>84dB (1kHz)</td>
</tr>
</tbody>
</table>

2.3. SDRAM for PCM data storage
SP-100 has 32 Mbyte SDRAM which allows users store PCM data up to 33 minutes sound data for monaural 8kHz sampling or 83 seconds sound data for 4-channel 48kHz sampling. The SDRAM is useful for reproduction of test sounds and recording sound data.

2.4. PC interface (USB 1.1)
SP-100 can be connected to PC via USB cable and controlled from PC. The USB connection allows users:

- Control parameters of processing in DSP or FPGA
- Transfer PCM data from SP-100 to PC and vice versa
- Update FPGA configuration data and DSP firmware.

2.5. Portable/Light weight
SP-100 is portable and works with built-in battery up to 4 hours. In addition, it is light enough to carry and small enough to be packed in a small computer bag. The weight and dimension of SP-100 are:

- Weight: 1.0kg
- Dimension: 238(W), 192(D), 40(H) (mm)

3. Sample Application
In order to demonstrate the effectiveness of SP-100, we developed a hearing aid system as a sample application.

3.1. Purpose
For researchers studying hearing aids, evaluation in daily life environment is important. In order to evaluate hearing aid processing algorithm, we designed a portable prototype system of hearing aids on SP-100.

3.2. System setup
The system setup of prototype hearing aid system is shown in Figure 3. Subjects listen to processed sound and evaluate quality of processed sound. Thanks to portability of SP-100, evaluation can be done in any places. Parameters of processing are adjustable from PC. Test sounds are provided from PC or audio inputs.

3.3. Signal processing
Processing method for the hearing aid prototype system is multi-band amplitude compression that is widely used for digital hearing aids. The block diagram is shown in Figure 4.

In this example, signal processing is implemented on the FPGA as specific digital circuits, though it can be implemented on DSP.

4. Conclusions
This paper introduced the development of portable equipment for prototyping and evaluation for signal processing applications. It contains powerful DSP and FPGA, and multi-channel audio interface. Moreover, its portability enables us evaluate signal processing algorithms in real world environment.

5. Acknowledgements
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