An Universal Parallel Sonar Signal Processing System

Lifu You, Enfang Sang and Jingyi Zhao

Dept. of Underwater Acoustic Engineering, Harbin Engineering University, Harbin 150001, P.R.China

Abstract: Parallel processing technology is more and more applied in modern sonar system. An universal parallel signal processing module is developed, which is based on VME bus, and comprised of four TMS320C40 digital signal processors. It is convenient to get more powerful processing system. As examples, some basic sonar processing algorithm such as FFT, beamforming have been implemented using this module. The results show that this module is suitable for many kinds of sonar system.

INTRODUCTION

Sonar signal processing remains the most complicated branch in the field of signal processing due to such reasons as the complexity, temporal and spatial variabilities of underwater acoustic channels. With the increasing of ocean exploitation and underwater defense demands, it has become a very urgent task to accelerate the overall development of our state-of-the-art sonar technology. The main trend of modern sonar hardware technology is comprehension, digitalization and modularization. The probability of realization mainly lies in the rapid development and progress of modern computer technology, DSP technology and parallel processing theory. Modulization design is the main trend of modern electronic system. It brings more flexibility, easy to be expanded and programmable. A successful electronic module can be applied to different systems without any changes, this eliminates the same work to do repeatedly. This trend is influencing the sonar system design. The sonar data real-time processing system must take advantage of the most powerful digital signal processors and have flexibility which can meet the demands of different situations. The module used in the system should be designed under standard computer bus in order to cooperate with other products.

The TMS320C40 is a 32 bit floating point DSP built on TMS320C30. It has the following features to support parallel processing:

- Six bi-directional communication ports for high speed interprocessor communication.
- Two identical external data and address buses supporting shared memory systems and high data rate single-cycle transfers.
- Six channel self-programmable DMA coprocessor for concurrent I/O and CPU operation.

In order to take advantage of the TMS320C40’s parallel processing features and provide powerful sonar signal processing module, a module is developed which is based on VME bus and four chips of TMS320C40 are integrated.

SYSTEM OVERVIEW

The structure of this TMS320C40 parallel processing module is showed in Figure 1. Four chips of TMS320C40 are connected using communication ports. Each TMS320C40 has 128Kx32bit RAM on its local bus. 128Kx32bit shared memory is on the TMS320C40s' global bus, and the arbitration logic is designed to ensure that each TMS320C40 has the equal chance to access to the shared memory and VME bus. The shared memory can also be addressed by the VME bus. This feature ensures that when more than one module are used on VME bus, each TMS320C40 can also access to the shared memory on the other module, which means this module can be used to get more powerful parallel processing system easily. The remaining communication ports of the TMS320C40s can also be used to link TMS320C40s on different modules. This module can complete 1.1billion operations per second and have 200MFLOPS. It can be easily used with other VME bus products to get a real-time sonar signal processing system.
PERFORMANCE BENCHMARKS

A parallel 1-D FFT has been implemented on this module using hyper-cube topology. Table 1 shows the timing benchmark results and the parallel speedup and efficiency are shown in table 2.

TABLE 1. FFT Timing (ms)

<table>
<thead>
<tr>
<th>Number of Points</th>
<th>64</th>
<th>128</th>
<th>256</th>
<th>512</th>
<th>1024</th>
<th>2048</th>
<th>4096</th>
</tr>
</thead>
<tbody>
<tr>
<td>one TMS320C40</td>
<td>0.095</td>
<td>0.2</td>
<td>0.47</td>
<td>1.0</td>
<td>2.26</td>
<td>9.18</td>
<td>19.99</td>
</tr>
<tr>
<td>four TMS320C40s</td>
<td>0.055</td>
<td>0.10</td>
<td>0.20</td>
<td>0.41</td>
<td>0.86</td>
<td>1.76</td>
<td>3.71</td>
</tr>
</tbody>
</table>

TABLE 2. Parallel Speedup and Efficiency of FFT

<table>
<thead>
<tr>
<th>Number of Points</th>
<th>64</th>
<th>128</th>
<th>256</th>
<th>512</th>
<th>1024</th>
<th>2048</th>
<th>4096</th>
</tr>
</thead>
<tbody>
<tr>
<td>Speedup</td>
<td>1.7</td>
<td>2.0</td>
<td>2.37</td>
<td>2.5</td>
<td>2.6</td>
<td>5.2</td>
<td>5.4</td>
</tr>
<tr>
<td>Efficiency</td>
<td>0.43</td>
<td>0.52</td>
<td>0.6</td>
<td>0.62</td>
<td>0.66</td>
<td>1.3</td>
<td>1.34</td>
</tr>
</tbody>
</table>

SUMMARY

The TMS320C40 parallel signal processing module presented here is suitable for many kinds of sonar systems. FFT timing benchmarks show that good processing ability can be achieved with this module. Also the beamforming and wavelet processing ability are under testing.

ACKNOWLEDGMENTS

This work is supported by National Underwater Acoustic Technology Laboratory of China.

REFERENCES