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Review Article

Application Analysis of Digital Signal Processor DSP in Logging Instrument

Jie Lian

Xi'an Research Institute of China Coal Technology and Engineering Group Corp, 710077, Xi'an, Shaanxi, China

Abstract: In today's world, the development of economy has led to the continuous development and evolution of science and technology. Computer technology and large-scale integration technology have been well developed and applied, followed by the technology of digital signal processing DSP production and application. In the field of logging, the application function of this technology plays a key role. It not only allows the imaging logging technology to be further developed, but also enables fast and accurate processing of downhole signals. Therefore, among many logging tools today, digital signal processing DSPs have been widely used, and their functions have been fully utilized. This paper analyzes the application of signal processor DSP in logging instruments. It is hoped that it can play a reference role in the good application and development of logging instruments.

Keywords: *digital signal processor; DSP technology; logging instrument; application*

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Corresponding Author: Jie Lian, Lianjie@cctegxian.com

1 Introduction

In today's rapid economic and scientific development, mining technologies such as coal mining are also in the process of continuous development. Among the applications of logging tools, digital signal processor DSP plays an indispensable role. DSP is a kind of processor that is extremely suitable for application in digital signal processing and operation. It differs from ordinary microprocessor in that its digital processing capability is very powerful, and the amount of computation that can be completed is also very large. Therefore, DSP digital signal processor can effectively meet the requirements of digital processing efficiency in the working process of logging instruments in the modern era.

2 Analysis of the composition of DSP circuits in logging instruments

Among the logging instruments, the DSP digital signal processor is mainly used in the process of collecting and processing the response signal of the logging and controlling the state of the logging instrument. The following figure shows a typical circuit used by the DSP digital signal processor in logging tools, in which input signals can be in various forms[1]. For example, it can realize acoustic logging through the input of waveform signals; it can also realize electrical logging through the input of analog signals; it can also realize radioactive logging through the input of pulse signals.

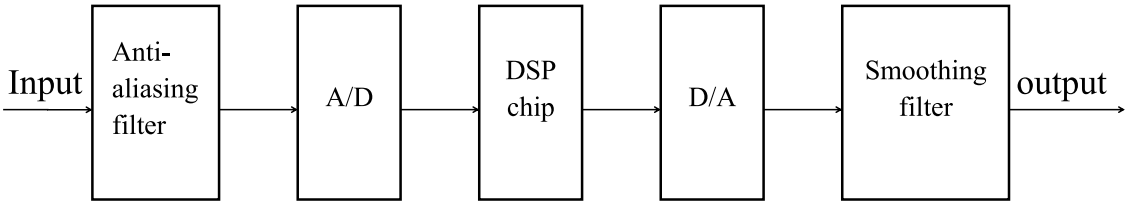

Figure 1. Typical circuit of DSP in logging instrument

First, the input signal is limited and sampled, and then A/D is implemented to make the analog signal realize the transition to the input signal. In order not to lose information, in the sampling process, the sampling frequency should be more than twice the input maximum frequency band limit signal during sampling[2]. The DSP chip input is the digital signal obtained by sampling when the A/D conversion is realized. The DSP chip applies some form to process these digital signals, for example, performing a series of multiply and accumulate operations. After these digital samples are processed, they will again be converted to analog samples by D/A. After the smoothing filter, the obtained analog waveforms are continuous. Of course, what is analyzed here is only a typical example, and in the actual DSP circuit, it does not necessarily have all the components described here. Among the logging instruments, the DSP digital signal processor is only used to process the signal and output it as a digital signal. Therefore, in the logging instrument, the circuit of the DSP digital signal processor does not need to be performed D/A conversion and filtered output[3].

3 The application of DSP circuit in array induction instrument

In the array sensor, signals induced in a plurality of coil sets for reception and a signal as a reference can be collected[4]. In this process, multiple DSP circuits are used in the array sensor, so that the influence of the interference signal can be effectively reduced, and the collected signals can be superimposed and processed. The processing principle is as follows:

The signals generated by the transmitting coils of the instrument have periodicity. When these signals enter the ground layer, each connected coil group can receive the coupled signals, and the relevant information of the formation is included in these signals. However, since these signals have only small amplitude, some useful formation signals are generally unable to be extracted due to signal interference. Based on such a situation, in order to extract the useful signals therein, let the signals of the period 1, 2,…,.until the signals of N can be superimposed on each other, and the DSP circuit can be reasonably applied. Because the signal interference is random, the superposition of the signal can make the real signal clearer. In theory, if the signal is superimposed more often, the resulting signal will have better quality[5]. However, in the actual application process, the register size of the signal superposition result and the speed of the logging will play a decisive role in the number of times the signal is superimposed. For some logging instruments, the signal emission period is less than 100 microseconds, but the DSP acquisition module can achieve 1M sampling per second[6]. And so, when the DSP circuit is applied to this instrument, it can be sampled nearly one hundred times within one emission period of the instrument, and then the sampling signals are superimposed within a certain time range, so that the induced signal is superimposed waveform.

Inside the array sensing instrument, there can be multiple acquisition boards, and each acquisition board will have four DSP acquisition modules. These four modules have the same function. In each acquisition board, the function of the DSP circuit can mainly realize the acquisition of the signal, superimpose the collected signal, and then output the processed signal as a waveform. Inside the DSP2101 signal processor, there is a memory for storing data and a memory for storing programs and the internal RMA can effectively perform the superimposition processing[7]. After the instrument is reset, the circuit used for booting will automatically read the program in the EPROM into the DSP digital signal processor. After the EPROM is read, the EPROM is also in the instrument. There is no corresponding effect, and at the same time it will reduce power consumption and be in an energy-saving mode.

4 The process of DSP digital signal processor to collect and output data

After the signal comes in by the preamplifier, it will be buffer amplified and then enter the A/D converter. Because this converter has a reference function, it can provide a reference level, which allows the input to the signal can be kept within the value of 0 to the reference voltage[8]. When the SMPLCK signal and the START signal are controlled by the main controller for the entire acquisition process, in the DSP processor, START can be used as an interrupt signal when the interrupt signal is toggled from high level to low level, the initialization of the DSP chip can be realized. When the SMPLCK signal transitions from high to low, the A/D conversion is started. When the conversion starts for a few nanoseconds, the EOC level becomes lower and then interrupt occurs once, this will trigger the DSP

to read the data from the previous conversion during the A/D conversion process. When the EOC is re-converted back to high level, the DSP has successfully completed the reading. Therefore, as long as the signal of SMPLCK can always be in a continuous state, the above process of collecting signals will be repeated continuously. At the same time, in the process of DSP chip signal processing, the relevant superposition principle can be used as an effective basis, so that the collected signals can be superimposed and processed to form the signal data of the post-sensing waveform, and then the data is output as a waveform.

Inside the DSP digital signal processor, two processors play a vital role. If one processor has already generated the waveform signal, then the other processor is ready to implement the waveform signal transmission. The DSP controller and the main controller of the instrument can communicate by means of the synchronization rate line port, so that the cache data can be uploaded to the main controller and the data can be successfully sent to the logging system on the ground. After the completion of the transfer of the cached data, a set of internal interrupt signals will be generated, which will end the transmission of data and prepare for the next signal transmission[9].

5 The characteristics of DSP processor chip analysis

5.1 Increase the execution speed of the processor

Inside the DSP chip, a Harvard structure that separates the data from the program is applied. This structure is parallel to the Von Neumann structure used in traditional micro processing, which allows the processor to implement not only in one cycle but also the acquisition of the instruction words in the program memory can achieve the acquisition of the operands in the data storage, so that the processor can achieve a significant increase in its execution speed.

5.2 Increase the processing power of the processor

Because of the Harvard architecture, the pipeline has been widely used in DSP chips, which allows the execution time to be further reduced[10]. For example, in the operation process of the three-stage pipeline, from the value operation to the translation operation to the execution operation, the processing is performed independently, and the processing method can completely overlap the execution of the instructions, thereby further increasing the processing power of the processor.

5.3 Increase the computing speed of the processor

Among the DSP chips, there is a configuration of the dedicated hardware multiplier, which can be configured one or more. In this way, the multiply-add operation and the index operation of the single instruction can be effectively implemented, thereby further improving the computing speed of the processor.

5.4 Increase the processing speed of the processor

The DSP chip provides DSP instructions with special characteristics, such as LTD instruction, MPY instruction and DMOV instruction. During the operation of the processor, these instructions with special characteristics can greatly reduce the number of instructions. In turn, the processing speed of the processor is significantly improved.

5.5 Simultaneous access to the data of two chips

Because of the fast RAM in the DSP chip, in general, the DSP processor can simultaneously access the data of the two chips by means of a separate data bus.

5.6 Realizing real-time and fast processing of signals

Because the special addressing mode is set in the DSP chip, one of the addressing modes has a periodic feature, which can play a circular buffer in the memory of the convolution and related operations. Another way of addressing is called bit-reversed addressing, which is mainly used in FFT operations. Because the DSP chip has such characteristics, the chip can realize the fast calculation of the DSP, so that the signal can be processed in real time and quickly. At the same time, these special addressing modes can also be time-consuming within one instruction cycle. The partial operation is effectively completed.

6 Conclusion

In summary, with the widespread use of DSP digital signal processors in logging instruments, the effective collection and processing of information can be achieved. This new processor successfully replaces the traditional ground acquisition system and achieves significant improvement in functionality. Through the application of the DSP digital signal processor, the signal processing is directly transferred to the downhole

Table 1. List of functions of DSP processor chip

DSP processor chip function	Specific contents
Increase the execution speed of the processor	Apply a Harvard structure that separates data from the program, enabling access to operands in the data store
Increase the processing power of the processor	The Harvard structure is applied, so the pipeline is widely used in the DSP chip, so that the execution time can be further reduced.
Increase the computing speed of the processor	The configuration of the dedicated hardware multiplier can be configured one or more, which can realize the multiply-add operation and the index operation of the single instruction, thereby further improving the computing speed of the processor.
Increase the processing speed of the processor	DSP chip provides processor with special characteristics of DSP instructions, so that the processing speed of the processor is significantly improved
Simultaneous access to the data of two chips	The DSP processor can simultaneously access data from two chips by means of a separate data bus.
Real-time and fast processing of signals is realized	The special addressing mode is set in the DSP chip. One of the addressing modes has periodic characteristics, and the chip can realize the fast calculation of the DSP, so that the signal can be quickly obtained in real time processing

instrument, which greatly improves the timeliness and accuracy of the logging. It can be seen that the application of DSP digital signal processor plays a key role in the improvement of logging efficiency and the guarantee of logging accuracy. It is believed that in the continuous development and transformation of science and technology, DSP digital signal processor will get better development, and realize the full play of its own advantages in more fields.

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