Research on Key Technologies of Marine Electromagnetic Signal Acquisition

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Abstract: With the intensification of the international situation and the development of the national economy, oil as an important strategic resource has become more and more important. China is a large ocean country with millions of square kilometers of offshore waters, which are rich in coal, oil and natural gas. For the sake of long-term national energy security, it is urgent to develop deep-sea oil and gas exploration technology and exploit deep-sea oil and gas resources. Nowadays, the world is rich in marine oil and gas resources. How to explore marine resources has become an inevitable strategic choice for a country's oil reserves. The ocean is not only rich in oil and gas and mineral resources, but also a natural place for geological research. The sea water movement will produce the induced electromagnetic field, which will affect the subsequent signal processing and geological interpretation results. For the long-term security of national energy, it is urgent to develop the deep-sea oil and gas exploration and marine electromagnetic signal acquisition technology for the exploitation of deep-sea oil and gas resources.

1. Introduction

Over the past decades of reform and opening up, China's national economy has continued to grow rapidly, and the consumption of natural resources has also increased year by year. However, oil is an important strategic energy, the basic product of the nation, and has an important relationship with many parts of the national economy [1]. China is a large ocean country with millions of square kilometers of offshore waters, which are rich in coal, oil and natural gas [2]. With the increase of mining intensity, land mineral resources are decreasing year by year, and marine resources have become a new area of concern. Today, the world is rich in marine oil and gas resources. Exploring marine resources and seizing the first opportunity have become an inevitable strategic choice for a country's oil reserves. China is rich in marine oil and gas resources, and has made great achievements in offshore oil and gas exploration in recent years, but the exploration of deep sea oil and gas is still in its infancy [3]. The marine electromagnetic method stands out among many marine exploration methods, and plays an irreplaceable strategic role in marine resource exploration and subsea oil exploration.

The world's marine oil and gas resources are abundant, and nearly half of the oil and gas resources to be developed are stored offshore. In recent years, the world's marine oil and gas production has continued to increase [4]. The amount of crude oil recovered from the oil and gas reserves that have been developed using oil recovery technology is also considerable. These aspects all indicate that the science and technology of oil and gas exploitation will have greater prospects in the future. 5]. Compared with land, the ocean is covered with highly conductive seawater, which has a severe attenuation of the electromagnetic field. The theory shows that the motion of seawater will produce an induced electromagnetic field. The motion of seawater will produce such typical complex non-stationary and nonlinear noise, which will inevitably affect the subsequent signal processing and geological interpretation results [6]. For the long-term security considerations of national energy, there is an urgent need to develop deep-sea oil and gas exploration and ocean electromagnetic signal acquisition technology to exploit deep-sea oil and gas resources.

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2. Basic Working Principle of Marine Detailed Controlled Source Electromagnetic Exploration

Usually, we call the component whose period is longer than the recording length as the trend item in the test signal. Extracting and eliminating the trend item in the test signal is a very important link in the data processing nowadays. If there is a trend term, on the one hand, it will have a great impact on the correlation analysis in the time domain, and will also cause a great error in the power spectrum analysis in the frequency domain. The same exploration effect can be achieved in homogeneous media regardless of the emitting electrical source or the emitting magnetic source, so the selection of field source does not affect the final interpretation of the underground resistivity structure. Because when a magnetic source emits, under the condition of the same underground structure, the magnitude of the generated electromagnetic field has a linear relationship with the magnitude of the emitted magnetic moment and is directly related to the transceiver distance, the emitted magnetic moment can ideally be made very large [7]. In order to maximize the energy pinned to the seabed, the horizontal electric field transmitter is towed to keep a close distance from the seabed and move at a constant speed at this depth. The emitter is connected with the electric field transmitter and keeps consistent with the moving speed of the transmitter.

For signals, due to band limitation, signal energy is mainly distributed in the low frequency region. Therefore, for noisy signals, the proportion of noise energy is small in the low frequency region and large in the high frequency region. Therefore, the focus of denoising should be on the high frequency region. Figure 1 shows the structure of an ocean electromagnetic signal analysis system.

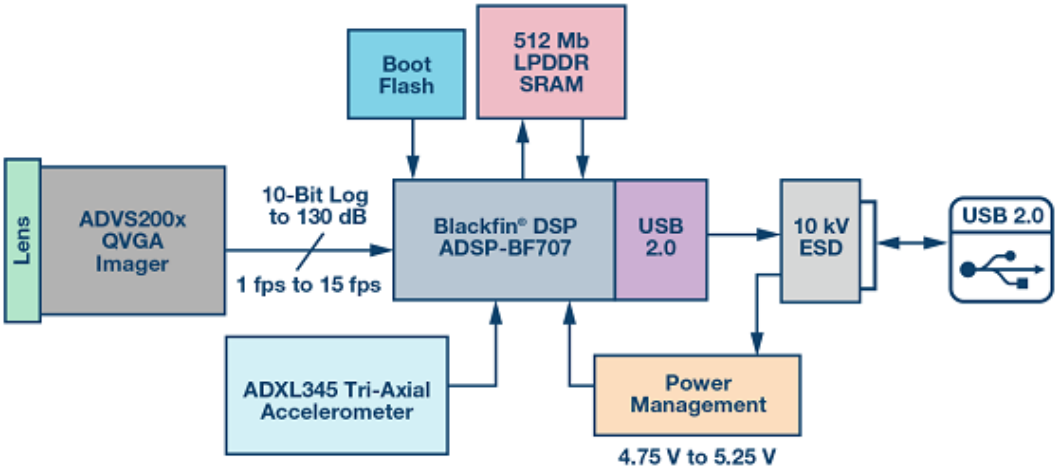

Figure 1 Structure of ocean electromagnetic signal processing and analysis system

The marine detailed controllable source electromagnetic exploration system includes an electric field emission system and an electromagnetic data acquisition system. Since air waves travels at the speed of light in the air and has almost no attenuation, the electromagnetic waves propagating in the water and geological structures are greatly attenuated, so when the depth of seawater is small or the receiving and transmitting distance is short, the effective electromagnetic signals received by the receiver at the seabed are almost submerged by air waves. In order to express a real-time signal x(t), there are many specific manifestations. here, x(t) is taken as the real part of the complex signal and its imaginary part $j\hat{x}(t)$ is reconstructed. Therefore, for x(t), its plural expressions can be recorded as:

$$z(t) = x(t) + j\hat{x}(t) \quad (1)$$

In order to keep the total energy of the original signal constant, the amplitude of the positive frequency spectrum is multiplied by 2. The spectrum of that complex signal z(f) obtain at the positive frequency portion can be expressed as:

$$z(f)=\begin{cases}2X(f), & f>0\\ X(f), & f=0\\ 0, & f<0\end{cases} \quad (2)$$

If H(f) is an odd symmetric step function:

$$H(f)=\begin{cases}1, & f>0\\ 0, & f=0\\ -1, & f<0\end{cases} \quad (3)$$

There are:

$$z(f)=X(f)[1+H(f)] \quad (4)$$

The electric field transmission system comprises a generator, a submarine cable, an electric field transmitter and a transmission electrode. On the other hand, through trend analysis, people can explore its operating state through a larger time scale, and then provide information on changes in operating state of equipment over time, which is helpful to grasp its operating trend as a whole. In practical application, according to the detection accuracy of the receiving device, the attenuation of the signal with the transceiving distance and the requirement of portable instrument system, it is the best choice to reasonably determine the transmitting magnetic moment and transceiving distance. After the transmitter completes its work, the acquisition of the acquisition system can be completed. The data acquisition system is composed of many data acquisition stations which are arranged on the seabed according to certain rules [8]. The generator installed on the ship transmits the voltage to the transmitter on the seabed through submarine cables, and the transmitter generates low voltage and large current signals in a certain frequency range. Air waves is not a wave generated in the air, but a wave propagating from the air, which generally comes out of the emission source, vertically transmits to the interface between air and seawater, then propagates in the air for a period of time, and reaches the receiving device at the interface vertically passing through the air and seawater.

3. Automatic Gain Amplification Design

In the process of marine magnetotelluric survey, because the magnetotelluric signals to be collected are within a certain geographical range and depth range, the dynamic range of the signals, that is, the ratio of the maximum value to the minimum value, will not be very large, and the signal collection channel can meet the requirements of marine magnetotelluric exploration by adopting a fixed increase method. Air waves propagates at the air-sea interface at the speed of light. For receivers with different receiving and transmitting distances, air waves arrives almost at the same time, while the propagation speed of guided waves in high-resistivity reservoirs is much lower than the speed of light, which results in different time for guided waves in air waves and high-resistivity reservoirs to arrive at the same receiver. In marine controlled source electromagnetic exploration, due to the existence of artificial electromagnetic emission sources, and the distance between electromagnetic emission sources and electromagnetic data acquisition stations changes, from far to near, then from near to far.

The scene and content of the video sequence in marine electromagnetic signal acquisition are all changed. It is very difficult to focus when the scene moves rapidly, and sometimes the focus fails. Therefore, in order to enhance the reliability of the focus, it is necessary to ensure that the video focus algorithm is good enough. There are two combinations of multiple digital image windows: series and parallel. The adopted method is a control mode in which a proportion link and a plurality of digital image links are connected in parallel, and each digital image link tracks and controls a signal with a frequency. The system also takes into account the influence caused by the non-linearity of the inverter. The inverter parameters are shown in Table 1.

Table 1 Driver power inverter parameters

Parameter	Numerical
Modulation carrier period (μs)	120
Modulated carrier frequency (kHz)	10
Delay time (μs)	6
Flywheel diode voltage drop (v)	3

Under some strong contrast, the wide dynamic algorithm is used to compress the original data into a dynamic range. In this process, it should be ensured that the wide dynamic image original data has no problem. Because wavelet transform has zoom function and time-frequency localization, it can remove noise and preserve the details of the image, so it can reconstruct high-quality images. Analytic hierarchy process is used to comprehensively evaluate the perceived risks. The relative importance of each factor in the same level with respect to the same factor in the previous level is compared and a pair comparison matrix is constructed. The statistical results are shown in Table 2.

Table 2 Perception layer risk comparison data results

	Residence time	Arrival rate	Visits
Residence time	1	0.45	0.76
Arrival rate	0.86	1	0.58
Visits	0.73	0.49	1

The purpose of the gain adjustment is to expand the dynamic range of the system measurement so that when the signal is small, it can have a large enough amplification factor to ensure that the signal can be detected. According to the requirements of the system, the electromagnetic data acquisition station needs to acquire not only the electromagnetic signals received when the electromagnetic transmitter is working, but also the magnetotelluric signals received when the electromagnetic transmitter is not working, which requires the electromagnetic data acquisition channel to have a large dynamic input range [9]. When the signal is large, try to ensure that the signal does not overflow. If the signal does not overflow as the standard, the same signal may be measured with different gains in practice. Each channel in multiple channels works independently and continuously, so the total amount of data to be stored will be an integral multiple of that of a single channel, increasing the storage capacity index of motor data recorder.

4. Conclusions

In the process of marine magnetotelluric survey, because the magnetotelluric signals to be collected are within a certain geographical range and depth range, the dynamic range of the signals, that is, the ratio of the maximum value to the minimum value, will not be very large, and the signal collection channel can meet the requirements of marine magnetotelluric exploration by adopting a fixed increase method. Because when a magnetic source emits, under the condition of the same underground structure, the magnitude of the generated electromagnetic field has a linear relationship with the magnitude of the emitted magnetic moment and is directly related to the transceiver distance, the emitted magnetic moment can ideally be made very large. The data acquisition system is composed of many data acquisition stations which are placed on the seabed according to certain rules. Air wave greatly interferes with marine electromagnetic signal, and the suppression of shallow sea air wave is an urgent problem to be solved in electromagnetic exploration of marine controllable sources. According to the requirements of the system, the electromagnetic data acquisition station not only needs to collect the electromagnetic signals received when the electromagnetic transmitter is working, but also needs to collect the magnetotelluric signals received when the electromagnetic transmitter is not working.

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