Digital design of high-precision magnetic field for hydrogen maser

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***Summary*—Hydrogen maser is the time and frequency reference source of metrology, punctuality and scientific research in China, and it is the core equipment of national important projects such as deep space exploration, navigation and positioning. In this paper, a scheme to realize the digitization of magnetic field of hydrogen atomic clock is presented. We first design a simple programmable precise current source. And then we use a microprocessor-based intelligent control algorithm to automatically find the maximum power point corresponding to the output voltage of the single-chip microcomputer. Finally, the constant output voltage. In the actual test process, we designed the constant current source circuit output current step quantity can achieve 5uA high precision, spectrum analyzer sampling efficiency and the control system work accuracy is very high.**

Keywords—magnetic field; constant current source circuit; digitization; spectrum analysis; maximum operating power point

I. INTRODUCTION

Hydrogen maser has the advantages of high frequency stability and low frequency drift. It has been widely used in the deep space exploration, navigation systems and frequency calibration. The quantum transition of hydrogen atoms and its signal detection are realized in the cavity-blub assemble of the hydrogen maser. Atomic transition signal amplitude of hydrogen maser directly determines the system signal to noise ratio, and thus affects system performance, which makes cavity-bulb assemble one of the most important parts of hydrogen maser. Straight solenoid is widely used in cavity-bulb assemble of hydrogen maser to generate the constant magnetic field for atomic transition.

The current of the straight solenoid is completed by applying voltage and matching digital dials with different resistance values. At present, We use the manual method to dial the digital dial, and there are big human factors that the signal we dialed is strong or weak is based on experience. The power point we actually used before may only be a relatively large value. Moreover, in view of the artificial dialing, the number of digits of the dial is limited, and the stepping amount of the digital dial is rather large. It will inevitably introduce a variety of transition frequency signal noise, affect the signal to noise ratio of the output frequency signal of the hydrogen maser, and ultimately has an impact on the hydrogen maser frequency stability. Here we show a digital design of the magnetic field of the hydrogen maser.

II. METHODS

First, the microprocessor outputs a PWM square wave whose duty cycle gradually increases from 0 to 1 in steps of 1/65535 to the high-precision current source circuit. Then the precision current source passes through a second-order low-pass filter, multiplexer, and operational amplifier. The magnetic field coil of the hydrogen maser generates a constant weak magnetic field by applying a micro current. The magnetic field provides the quantization direction for the transition of the hyperfine structure energy level, so that the transition $[F=1, m_F=0] \leftrightarrow [F=0, m_F=0]$ (σ transition) is achieved. The output frequency signal of the hydrogen maser is sampled by the host computer design system and processed by real-time images, and then handed over to the microprocessor to control and compare the power of the output frequency signal. Finally, based on the intelligent control algorithm, real-time search and comparison of the maximum power point together with its corresponding output voltage, determine the maximum output signal power point, effectively improve the signal to noise ratio. Consequently it can improve the frequency stability of the hydrogen maser.(Fig.1)

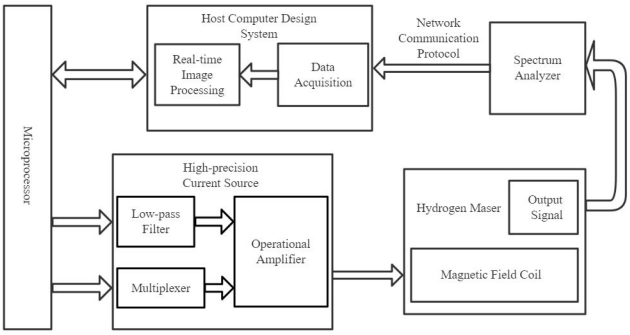

Fig.1 system structure diagram

III. CONCLUSIONS

On the whole, the small resolution and high-precision magnetic field design has a wide range of applications. It can not only be used in hydrogen maser, but also universally applicable to the environments that require high-precision magnetic fields. It can also be combined with other new technical means to further optimize the design of the magnetic field. In the future, we will continue to improve its output current accuracy and reduce the system response time.