Research Journal of Applied Sciences, Engineering and Technology 7(20): 4196-4199, 2014
DOI:10.19026/rjaset.7.788
ISSN: 2040-7459; e-ISSN: 2040-7467

Submitted: March 23, 2013 Accepted: February 25, 2014 Published: May 20, 2014

Research Article

The Research on Anti-scaling Based on Electromagnetic Fields

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Abstract: Electromagnetic scaling is a kind of physics method of anti-scaling. An Anti-scaling instrument that generates electromagnetic fields to prevent scaling is designed in this study. The two important functions of the instrument are as follows: The output of a single frequency signal and its frequency and voltage can be changed manually; the output of a swept-frequency signal, from 0 to 21 kHz. The instrument is composed of a signal generator and coils in which electromagnetic fields are induced. The production of the signal mainly depends on the chip of CD4046B CMOS Micro power Phase-Locked Loop. According to the principle of electromagnetic induction, the signal from the signal generator flows though coils which induce changed magnetic fields, then the magnetic fields effect the microstructure of water, the aim of anti-scaling is achieved. The experiment shows that the equipment effectively reduces scaling.

Keywords: Anti-scaling, electromagnetic field, phase-locked loop, swept-frequency

INTRODUCTION

Scale deposits can damage industrial and mining equipment. This causes technical and economic problems. Chemical anti-scaling solutions are not entirely satisfactory because they can reduce the life of the equipment and cause environmental problems. However, an anti-scaling instrument that generates electromagnetic fields to prevent scaling is economical and environmentally friendly. Variable electromagnetic fields can be induced by different types of signal. As the voltage fluctuation of square wave is strong, the electromagnetic fields induced may effect stronger disturbance to the ions and molecules in the hard water (Higashitani *et al*., 1988). Moreover, many scientific research institutions locally and internationally have widely confirmed that the electromagnetic fields induced by square wave can combat scale more effectively than other types of waves (Liu, 1999; Chen *et al*., 2009; He *et al*., 2010; Wang and Cheng, 2004; Higashitani *et al*., 1993). We have researched a kind of electromagnetic field anti-scaling instrument which can produce fixed frequency and swept-frequency square waves. The production of the signal mainly depends on the chip of CD4046B CMOS Micro power Phase-Locked Loop. Both voltage and frequency ranges can be adjusted, according to requirement. It can combat different forms of water scaling. Experimental results indicate that it does not only prevent scaling.

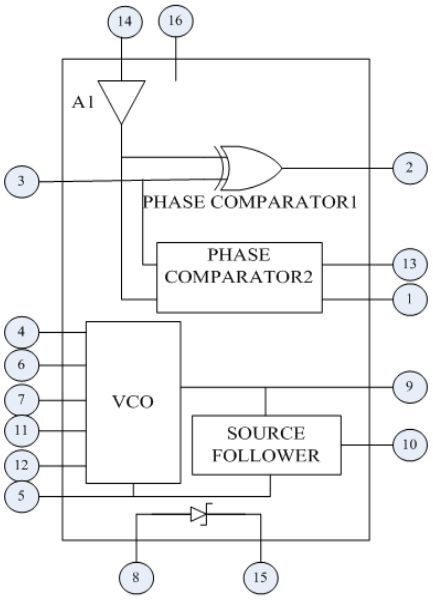

Fig. 1: The internal structure of CD4046

MATERIALS AND MOTHODS OF MARKING ANTI-SCALING INSTRUMENT

The instrument internal structure of CD4046: The important instrument should be introduced. The CD4046 Micro-power Phase-Locked Loop is an integrated circuit. Its power consumption and frequency drift are very low. The highest operating frequency is

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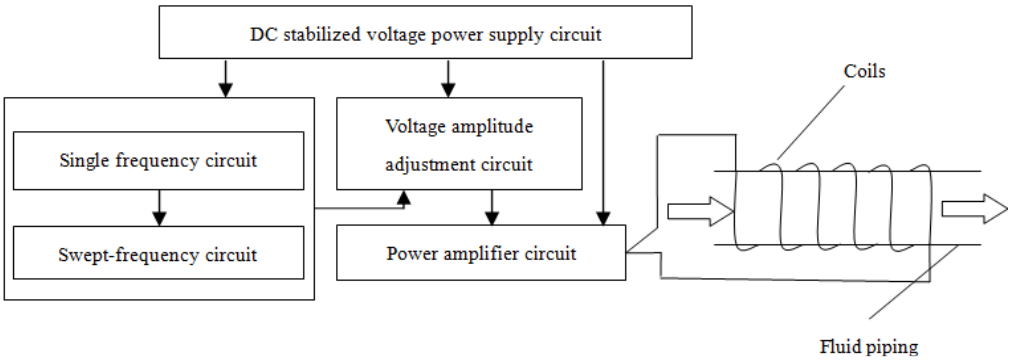

Fig. 2: The structure of anti-scaling instrument

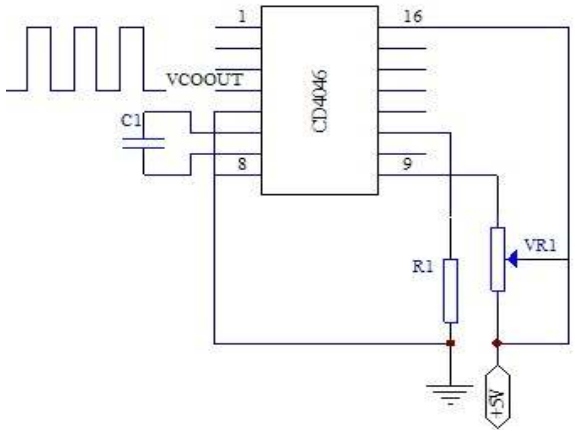

Fig. 3: The single frequency circuit

1.4 MHz. The power voltage (VDD) is 5V~15V. The internal structure of it is described, Fig. 1. Its Phase-Locked Loop consists of a low-power, linear Voltage-Controlled Oscillator (VCO) and two different phase comparators having a common signal-input amplifier and a common comparator input. A 5.2V zenerdiode is provided for supply regulation if necessary (Cho *et al*., 1997; Thackery, 1980; Epstein, 1983).

The structure of anti-scaling instrument: The anti-scaling instrument consists of signal generator and coils which electromagnetic fields are induced, Fig. 2. The winding of coils around a pipe constitutes a solenoid. According to the principle of electromagnetic induction, the signal from the signal generator flows though coils inducing magnetic fields and achieving the goal of anti-scaling. The strength of the magnetic fields are determined by the size of the coils. We suggest the design of coils should be appropriate to enable the instrument combat effectively.

The signal generator is composed of the following:

- The DC stabilized voltage power supply circuit
- A single frequency circuit
- A swept-frequency circuit
- A voltage amplitude adjustment circuit
- A power amplifier circuit

The DC stabilized voltage power supply circuit: The signal generator circuit needs two sets of DC stabilized voltage power supply units, ±15V and ±5V. The main components are: 15V transformer, rectifier bridge, voltage stabilizer (78 and 79 series), electrolytic capacitor (470 μF/50V and 47 μF/25V) and ceramic capacitor. Because the principle of DC stabilized voltage power supply is simple, there is no redundancy.

The single frequency circuit: The CD4046 Phase-Locked Loop unit adopts the RC linear Voltage-Controlled Oscillator (VCO). It requires one external capacitor C_1 and one or two external resistors R_1 or R_2 as charge and discharge elements. Resistor R_1 and capacitor C_1 determine the frequency range of the VCO and resistor R_2 enables the VCO to have a frequency offset if required. The VCO is a kind of current control oscillator. It requires the charge current of capacitor C_1 is proportional to the control voltage so that the oscillation frequency is proportional to the control voltage too (Xing *et al*., 2006). When the control voltage of VCO is 0, the frequency of output signal is the lowest. If the control voltage is equal to the supply voltage VDD, the frequency of output will increase to the highest range. The range of oscillation frequency is up to R_1, R_2 and C_1. Because the charging and discharging of it all depends on the same capacitor C_1, the output is a symmetric square wave. Generally, the highest frequency of CD4046 is 1.2 MHz (VDD = 15V) (Lee and Cho, 2002). If VDD<15V, the highest frequency range will be reduced. The design of the CD4046 Phase-Locked Loop single frequency unit is illustrated, Fig. 3.

The 16 base pin connects with the +5V DC stabilized voltage power supply. The VCO voltage controller (9 base pin) connects with 470 KΩ potentiometer, so that the voltage and the frequency of output (4 base pin) can be changed. The 12 base pin is a vacant terminal which means that R_2 is infinite. The lowest output frequency f_1 is 0. The capacitor between 6 and 7 pin is 4700 PF. Resistor R_1 is 10 KΩ. The circuit will output square waves when its 9 pin connects with 5V power supply. The range of frequency is 0~21 KHz. Amplitude is 0~5V. The single frequency square

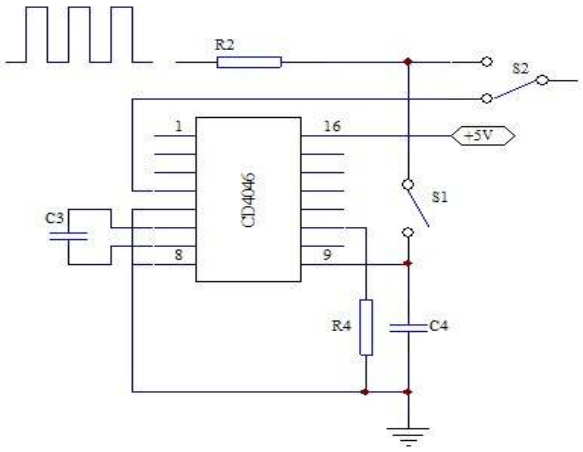

Fig. 4: The swept-frequency circuit

wave whose frequency can be changed manually is outputted.

The swept-frequency circuit: The swept-frequency circuit works out by CD4046. It can be divided into two parts. One of them outputs the single frequency signal from last circuit, the other one outputs the swept-frequency signal. The transition of these two functions is performed by switches S1 and S2. S1 controls the output of triangular waves so that the swept-frequency waves can be achieved; S2 controls whether single frequency signal or swept-frequency signal can be output.

The circuit of swept-frequency is similar to the single frequency circuit. An integrator is added to the VCO (9 pin) before the output of single frequency signal are inputted by the next CD4046 chip, Fig. 4. When S1 is turned on, the capacitor C_2 charges and then discharges. The single frequency square wave signal is turned into a triangular wave signal. This enables the voltage to change continuously, in cycles. Then the 4 pin will output a swept-frequency signal. According to calculations, the highest frequency is 21 kHz. The output range of swept-frequency is 0~21 KHz. Amplitude is 0~5 V.

The voltage amplitude adjustment circuit: The voltage amplitude adjustment circuit primarily consists of comparator (LM393) and precision operational amplifier (4558). The LM393 does reverse proportion computation so that the signal from the last circuit is changed into a bipolar signal. The operational amplifier (4558) can amplify the voltage signal from LM393 and adjust the range of voltage amplitude. According to calculations, the reverse magnification coefficient is about 0~2. Theoretically, the amplitude of the output square wave can be changed from 0~±10 V.

The power amplifier circuit: The circuit of the power amplifier is simple. Low power triode transistors (9012) and (9013) constitute the B complementary output

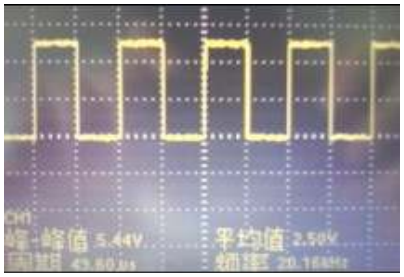

Fig. 5: Single frequency signal

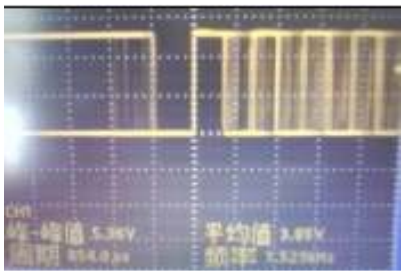

Fig. 6: Swept-frequency signal

amplifier circuit. The DC driver power (VCC) of amplifier circuit is 15 V. When the output square wave locates the positive half cycle triode transistor 9013 is activated and begins operating. At the same time the triode transistor 9012 is cut-off. When the output square wave locates the negative half cycle triode transistor 9012 is activated and begins operating, so the triode transistor 9013 is cut-off. Because triode transistor works in the state of collector the current is amplified and the voltage remains the same.

RESULTS AND DISCUSSION

The anti-scaling instrument is designed to meet requirements. It can output the square waves and swept-frequency waves. The two styles of signals are performed by switches. Both voltage and frequency can

be adjusted. The output signals are illustrated, Fig. 5 and 6. The single frequency electromagnetic fields can not prevent scaling effectively in water treatment. The swept frequency signal can produced frequency-conversion electromagnetic fields, it should be used for anti-scaling and de-scaling.

CONCLUSION

Changed frequency anti-scaling instrument can produce the electromagnetic fields which frequency can be changed in a certain range. The operating voltage of instrument is 220 V, the range of frequency is 0~20 kHz. This kind of anti-scaling technology is appropriate for different forms of water. It has a wide range of applications and a very good development prospect.

ACKNOWLEDGMENT

This study is supported by the "The Natural Science Foundation of Heilongjiang Province" (F201211).

REFERENCES

Chen, C., Y. Wang and Y.Z. You, 2009. Design of electromagnetic field descaling instrument based on FPGA. Instrument Tech. Sensor, (08): 36-02.

Cho, Y.I., C.F. Fan and B. Choi, 1997. Theory of electronic anti-fouling technology to control precipitation fouling in heat exchangers. Int. Commun. Heat Mass, 24(6): 757-770.

Epstein, N., 1983. Thinking about heat transfer fouling: A 5*5Matrix. Heat Transfer Eng., 4(1): 43-56.

He, J., Z.Z. Zhao, Y.H. Li, G.C. Bai and H.Y. Zhao, 2010. Research status and progress in scale inhibition and removal by physical technology. Ind. Water Treatment, (09): 05-05.

Higashitani, K., A. Kage, S. Katamura, K. Imai and S. Hatade, 1988. Effect of magnetic field on formation of iron on calcium carbonate nucleation and growth. Langmuir, (5): 861-867.

Higashitani, K., A. Kage, S. Katamura, K. Imai and S. Hatade, 1993. Effect of a magnetic field on formation of $CaCO_3$ particles. Colloid Interface Sci., 156(4): 90-95.

Lee, S.H. and Y.I. Cho, 2002. A study of physical water treatment technology to mitigate the mineral fouling in a heat exchanger. Ph.D. Thesis, Drexel University, Philadelphia.

Liu, R., 1999. A study of fouling in a heat exchanger with an application of an electronic anti-fouling technology. Ph.D. Thesis, Drexel University, Michigan USA.

Thackery, P.A., 1980. The cost of fouling in heat exchanger plant. Effluent Water Treat., 20: 112-115.

Wang, X.L. and S.K. Cheng, 2004. Scaling analysis and its applications of electrostatic micromotors. Harbin Inst. Technol., 11(02): 177-04.

Xing, X.K., C.F. Ma, Y.C. Chen, Z.H. Wu and X.R. Wang, 2006. Electromagnetic anti-fouling technology for prevention of scale. J. Cent South Univ., T., 01: 68-74.