The Design Of The Ultrasonic Nondestructive Testing System Based On The EMAT

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Abstract. This paper introduces a kind of based on the electromagnetic acoustic transducer (EMAT) metal pipeline detection system, fusion of two dimensional orientation, shape unique technological innovation, implementation of various metal pipe wall corrosion situation of rapid, accurate, fully automated non-destructive testing.In the aspect of hardware design, single-chip microcomputer control was achieved by C language programming the launch of the pulse signal. Pulse signal was sent to launch circuit, ultrasonic signal. Design of preamplifier, controllable gain amplifier two-stage amplifier circuit for receiving signal is amplified. Including data acquisition circuit detection circuit and A/D conversion circuit, single chip microcomputer and the LabVIEW platform via A serial port communication agreement. In the aspect of software design, the design of the EMAT pipe nondestructive testing system based on LabVIEW human-computer interaction interface.

Key words: EMAT; Ultrasound; Non-destructive testing; Pipeline detection;

1 Introduction

In petroleum, chemical industry, urban water supply industry, pipeline transport network is an essential part of, and most of the pipeline facilities, is fast approaching its design life.Due to pipe used for a long time in all kinds of high temperature and high pressure medium, the corrosion of pipeline corrosion and fatigue, creep, hydrogen and other aging damage and degradation problems are more serious.This means that in view of the pipe nondestructive flaw detection is very important. Conventional NDT techniques are a serious deficiencies: detection for point by point scanning process, thus cannot be effectively used in the current industrial scale. And based on the pipeline cleaning robot, the pipeline internal detection system in operation and cost and expensive equipment complex, only applies to large trunk pipeline detection.Vehicular electromagnetic acoustic transducer (EMAT) metal pipeline detection system design from the outer wall of pipeline, make the whole equipment simple structure[1,2].And run in the pipe trunk pipeline detection equipment, compared to the system of manufacture and running cost low, easy to operate. For various types of

enterprises, therefore, various grades of pipeline, provide low cost, reliable pipeline testing services.

2 System design

The basic principle of ultrasonic detection is through ultrasonic wave ACTS on the detected object, according to the ultrasonic propagation in the medium of sound velocity, attenuation, impedance, reflection, transmission, scattering and other physical properties test. And test equipment, such as work piece to make defect evaluation. Design a set of EMAT[5,6] nondestructive testing system based on virtual instrument, in addition to the necessary hardware, such as the EMAT transducer, control circuit, ultrasonic emitting circuit, ultrasonic receiving circuit, data acquisition circuit, power circuit, all through the computer software is used to realize the function, achieve the greatest degree of saving hardware resource, reduce cost[3].

### 2.1 Design of the hardware in the system

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2.1.1 EMAT transducer design

EMAT transducer design is the core component of detection system, it can realize the conversion of electrical energy into mechanical energy, the stand or fall of transducer design directly affects the stability of detection system.EMAT transducer mainly has three parts: coil, magnets, the tested parts.By changing the excitation coil in the direction of current or change the coil relative to the position of the magnet magnetic field which is formed by the formation of different types of waveform, such as longitudinal wave and transverse wave, surface wave, Lamb wave and SH wave, etc.

2.1.2 Control circuit design.

Using model AT89C52[7]single chip microcomputer as the core controller of the system.The smallest circuit of single-chip computer work, namely the center MCU control module and a clock circuit and reset circuit.Choose internal clock design, through the button to reset circuit design, the work of the single chip microcomputer minimum circuit.Take EA can make the high level + 5 v, namely let EA = 1, the program starting from the internal ROM.As shown in figure 1 is the normal work of the single chip microcomputer minimum circuit design.
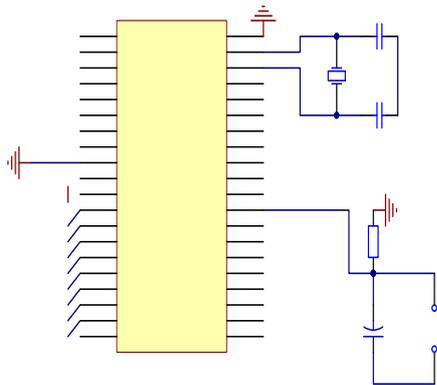

Figure 1. Minimum Working Circuit of Single Chip Unit

Crystal oscillation circuit, single chip microcomputer to normal work, is in accordance with the unified clock pulse in the sequence of operation. To produce the clock pulse, the need for oscillator and clock circuit.Internal oscillator, microcontroller through an external crystal vibration circuit, constitute the internal clock of self-excited oscillation circuit. The pulse frequency is determined by the external crystals, it is to determine the work speed of the single chip microcomputer, but crystal frequency could not choose too high, too high will reduce the stability of single chip microcomputer.In general, the MCU crystal frequency cannot be more than 25 MHZ. In order to improve the stability of the crystal oscillation circuit, eliminate higher harmonic oscillation circuit produced affect the normal work of the single chip microcomputer, in even a pin connected to two capacitance between XTAL1 and XTAL2 C16 and C17.

The design selected 30 pf as C16 and C17 capacitance values.

Reset circuit, through the reset, the CPU and other components in the system are in the same initial state then SCM from the initial state began to work. From figure 1, you can see, this topic design using the key level reset circuit, through the reset button to press to make it through the resistor connected with power supply. To finish the RST pin 1, reset.

2.1.3 Ultrasonic signal transmission circuit design

Launch circuit by the host control pulse signal through the photoelectric isolation, via the transistor Q1 and Q2, Q3 after push-pull amplifier circuit to drive, in order to improve the transient response of Q4.Control pulse signal to Q4 after push-pull amplifier circuit drive control.In order to reduce the excitation pulse width, it is necessary to shorten the pulse signal along the falling edge and the rising time, selects the superior performance of MOS devices to meet the requirements.Choose high power field effect MOS tube APT10050B2VR, It is a new generation of high voltage n-channel enhancement field effect tube.It provides faster switching speed, low leakage, up to 1000 v drain-source voltage, pulse drain current of 84 a, maximum allowable by constant current for 21 a, can satisfy the fastest high-power output high frequency pulse signal of the high strength requirement.As shown in figure 2, Q4 drain by R6 by high pressure.Used in the design of 600 v high voltage dc power supply.When Q4 deadline, capacitor C4 in under the action of high voltage power supply, the R6 charge to 600 v;Q4 is conduction, C4 by Q4, R7 discharge, produced in the R8 excitation probe of high voltage pulse signal.R8 is the biggest variable resistance of 10000 ohms.We can change the R8 resistance of the resistance to alter the strength of the high voltage pulse signal.The greater the resistance, the voltage, the greater the load on the R8 produced by high voltage pulse intensity.
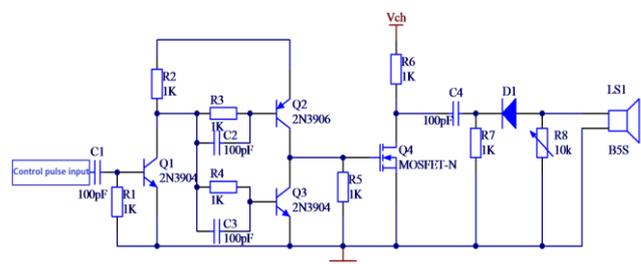
Figure 2. Launch Circuit

2.1.4 Ultrasonic signal receiving circuit design

Design using diode switch characteristics, using a diode [8]in parallel circuit of signal amplitude limit, to filter out high voltage pulse signal.Selection of resistance value of 50 KΩR9, greater than the launch R8, adjustable resistance in the circuit to avoid receiving circuit loading effect on transmission circuit.Choose has larger forward current diode D2 and D3 two-way limiter circuit,

eliminate transmission circuit of high voltage pulse, avoid its receiving into the back-end receiving circuit interference, the experimental results show that the output of this limiter circuit can achieve the anticipated effect of this design.
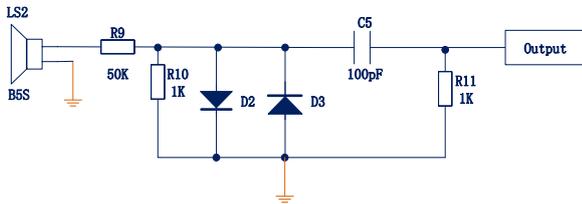

Figure 3. Ultrasonic Amplitude Limit Circuit

2.1.5 Preamplifier circuit

In this system design of the preamplifier circuit, J2 ultrasonic echo signals AD797 in-phase input terminal 3, C3, R3, R1, R2 constitute a negative feedback network and C3 capacitance value depends on the size of the signal gain.This time we design, R1 resistance of 10 ohms, R2 resistance is 400 ohms, R3 resistance of 100 ohms, C3 capacitance value of 33pF.Through calculating amplifier gain for 39 times, can be drawn from the noise of 0.98 nV/Hz.Pin 4 and pin 7-5 v and + 5 v power supply, through the two capacitor C1 and C2 in parallel, can expand the dynamic bandwidth, pin 4 can all use the same multiple shunt capacitor technology.The voltage signal preamplifier AD797 after output via pin 6 to the back of the controllable amplifier circuit.
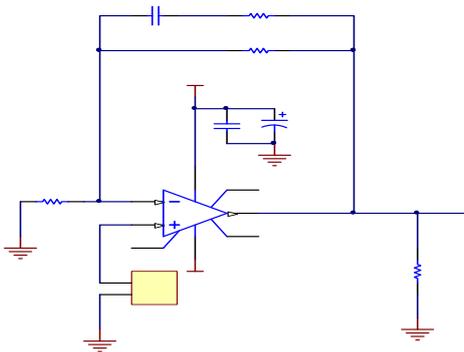

Figure 4. Diagram of Pre-amplication

2.1.6 Controllable amplifying circuit

As shown in figure 5, the 3rd pin EMAT ultrasonic echo signal received through the pre-amplifier chip AD797 amplified, the output signal which is amplifying by the AD603 chip will be output from the pin VOUT.The VOUT pin and FDBK pin connection with variable resistor R13, by changing the resistance of R13,They can be easily to choose the appropriate gain range.By adjusting the R14 variable resistance of the resistance to change the size of the gain control voltage, so as to achieve the aim of the magnification fine-tuning.
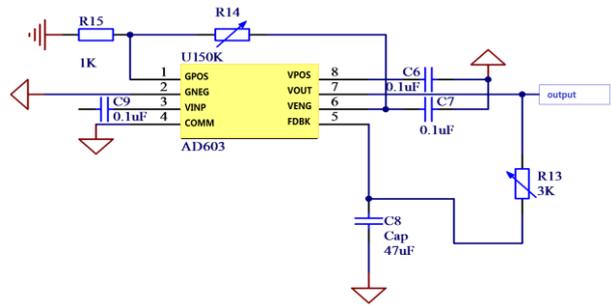

Figure 5. Controlled Amplifier Circuit

2.1.7 Ultrasonic signal acquisition circuit design

As shown in figure 6, the circuit is mainly composed of AD810, AD8036, LH033, AD810 of four integrated op-amp.Among them, the detection before in-phase amplifier composed of AD810 chip for buffer.AD810 was initially developed for multimedia an operational amplifier.It has high conversion rate, wide band, the signal distortion is small, low noise very many superior performance, so is especially suitable for as a buffer amplifier of buffer ultrasonic signal detection circuit.Finally complete the detection process of EMAT ultrasonic echo signal through AD810 chip pin 6 output to A/D conversion circuit.
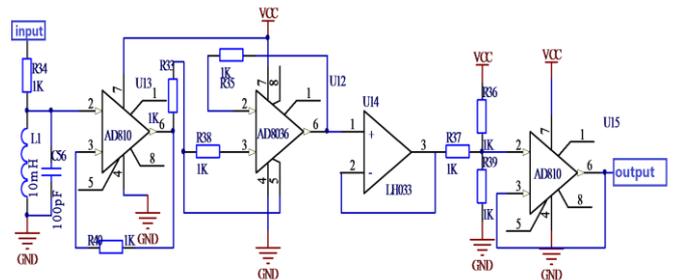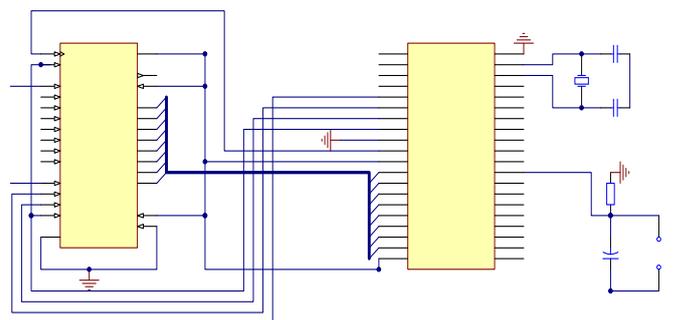

Figure 6. Buffer Detection Circuit

2.1.8 A/D conversion circuit

The design of A/D conversion[9] circuit using classic ADC0809 as A/D conversion chip.Connection with ADC0809 AT89C52 as shown in figure 7.

Figure 7. Analog/Digital Conversion Circuit

Process: first enter three address, and 1, will be ALE to address in the address latch;This address decoding strobe road one of the analog input to the comparator;Start up along the reset the successive approximation register;After the falling edge start A/D conversion, EOC output signals become low, indicating conversion is ongoing, until to complete A/D conversion, EOC is A high level, the result data have been deposited in the latch.When the OE input high electricity at ordinary times, output three states door open, convert the result of digital output onto the data bus。

2.1.9 Serial communication circuit
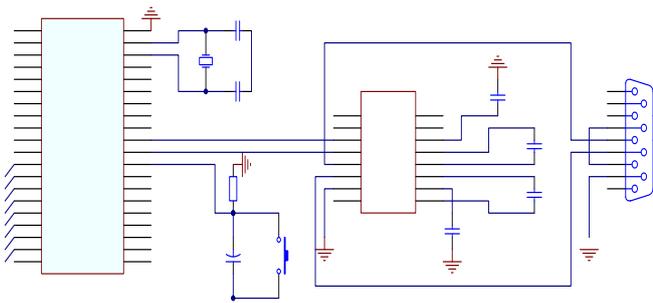
Figure 8. Serial Port Transmission Circuit

EMAT electromagnetic ultrasonic nondestructive testing system commonly used RS232 and MAX232 chip is used to realize serial transmission.RS232 is set by the American electronics industry association of asynchronous transmission standard interface.Because RS232 compatible with TTL level does not need to use the level conversion circuit to realize high and low level transformation.This design chooses MAX232 chip.MAX232 chip connection with AT89C52 single-chip computer as shown in figure 8.

2.2 PC software design of the system

In the design of serial port communication LabVIEW and microcomputer.VISA first call a Serial Port communication configuration node function Configure Serial Port to a Serial Port parameters Settings, including Serial Port resource allocation, set the baud rate for 9600, setting no check, 8 data bits, 1 stop bit, software and hardware such as shaking hands is prohibited.Initialization is completed, the use of VISA Read child nodes of the Write, VISA function to send and receive data.But at the time of receiving data, note that before calling VISA Read function, you need to use the VISA Bytes at Serial Port to query the number of Bytes of data in the data buffer, if does not accord with to Read number of Bytes, then wait.Until the TimeOut or buffer in bytes is equal to the number of bytes to Read.In addition, you can through the VISA, the Set I/O Buffer

Size to Set the Size of the Buffer.Under special circumstances, can through the VISA Flush the I/O Buffer child nodes to empty Buffer data.To send and receive data, through the VISA Close function over a serial port communication.

System software, on the whole, including data acquisition, DAC spectrum analysis and waveform display, defect parameters measurement[10], record keeping and reading and so on five big modules, specific steps are as follows:

• Repeat option Controls > > Numeric > > Digital Control eight times, amend the name led by wave position respectively, the first wave amplitude, faults and defects the amplitude, frequency of filter type, filter, filter order and wave velocity.

• Repeat option Controls > > Numeric > > Digital Indicator twice, will name change for defect location, defect rate, respectively.

• Select Controls > > Boolean > > Stop Button and amend the name to Stop.

• Select Controls > > Graph > > XY Graph.XY Graph can draw out the non-uniform sampling data, and some plane curve.In view of the advantages of using XY Graph as defects in the design curve display.

• On the Graph popup menu Visible Items > > Cursor Legend, display vernier Legend plate.The default cursor legend plate have two cursors, can use the positioning tool to drag it any corner of the make it expand or narrow, needs to show the number of cursors.

Program flowchart is mainly composed of the following parts: the ultrasonic signal acquisition, filter module, wave detection module and data analysis module.Among them, the ultrasonic signal acquisition module by calling StartVI and Con - FIG VI, AI StartVI and AI ReadVI node implementation;Butterworth filter selected FilterVI child nodes to achieve;Wave detection module by calling the Peak Detector VI function;Defect analysis module according to the calculation formula of choosing appropriate arithmetic unit functions to achieve.Defect location calculation formula, which represents the ultrasonic wave velocity.First of all, subtracter function called, will launch wave and defect location code as input, the corresponding time difference.It then calls the multiplier function, will be on the output and 0.5.Then call the multiplier, will output a result with ultrasonic speed by code.Finally will output operation and display the results of pipeline defect location code is linked together, defect position can be calculated and displayed in the interface.Defect rate = defect amplitude value/first amplitude value, called divider, a defect amplitude value, amplitude value of the corresponding code as input, the output sent to the front panel display.

3 Conclusion

Choose single chip microcomputer as the core controller, using C language programming.Single chip microcomputer as a series of square wave pulse through driving circuit to produce high strength of the pulse signal of ultrasonic transducer.Receiving circuit design of

the preamplifier and controllable amplifier two-stage amplifier circuit for receiving of weak ultrasonic signal is amplified.Including data acquisition circuit detection circuit, A/D conversion circuit design.LabVIEW graphical programming based development platform, to achieve a PC and single-chip serial communication, PC via serial control microcontroller, the microcontroller serial transmission of data collected by the host computer for processing.After the relevant tests, the system design with high performance, scalability, maintainability, and other characteristics.It also has a strong practical.

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