Research and development of automatic sampling instrument control system

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Abstract: During the test of medical and chemical process, operators need to precise and repeated sampling operation of various liquid frequently. This paper designs a kind of automatic sampling control device based on PLC and the stepper motor's, and introduces the hardware and software structure of the system. This system can realize the pre washing, accurate positioning, sample number and sample volume settings, and has a touch screen for man-machine interface, which can be widely used in the field of precise experimental sample needs.

Introduction

Trace liquid sample devices in 1956, by the German Institute of physiological and chemical research scientist Schnitger invention. The trace liquid sample injector from the earliest development to today, not only adds the sample accuracy to be more accurate, but also the kind is also richer. In our country, the trace liquid sampler and the development of a late start, and most of all from abroad or forming Chemiluminescence analyzer with matching sampler, for the production of specifically applicable to independent application of the micro liquid injector is almost absent. Therefore, research and design the suitable to China's clinical medical diagnosis instrument micro liquid sample adding device is the trend of the development of the industry of medical diagnosis.

Traditional plus sample control system with 8 bit or 16 bit single chip microcomputer is given priority to, more integration is not high, low reliability, friendly man-machine interface is not the disadvantage [1]. For this reason, this article is based on luoyang LanFei PLC and MCGS touch screen, designed a new type of automatic add sample instrument, equipment operation simple, reliable, friendly interface, it can be finished at the same time more group reagent and sample.

Overall design

The control system is reliazed by a plurality of step motor.position and speed of stepper motor, by the number and frequency of pulse transmited to the stepping motor. The three stage is used in step motor, namely step starting with acceleration, uniform motion process when arriving in expectations, stops with the deceleration process, to ensure the stable operation of the stepper motor[2]. In the software programming, the control device uses software protection measures. when it detect that the stepper motor is running or input value exceeds the set range, the input data value is invalid, and the corresponding window is pop-up , to remind the operator.

The whole system control process

This system through the touch screen is sending the task sequence, and monitoring and sample status, and gives the corresponding prompt. System according to specific tasks, add sample before, touch screen pipe cleaning command, plus sample motor control and sample arm long point location, peristaltic pump according to the upper machine set of cleaning pipe to wash, wash finished, PC appear "dialog" pipe is clean; In PC set a number of sets of sample to add the number of sample tube and, after click "add sample orders", add the sample arm stretched out to add sample position, and to add sample tube movement to the set position, peristaltic pump plus sample set quantitative start and set by touch screen, a set of sample is completed, the XY plane stepper motor control to stay sample tube move another sample position, and in turn, the complete recovery, touch screen pop up[3], but the complete recovery experiment "prompt dialog box.

back to the origin, after flushing pipe, another batch of reagent and sample can be operation; The armband for Luke 9 sample needle, 9 kinds of reagent and sample can be performed at the same time, of course, also can choose only one kind of reagent sample add operation. System is equipped with the stop button, no matter under what circumstances, press the stop button, the system of all equipment in the stop state. The sample diagram of the control system of the machine As shown in figure 1.

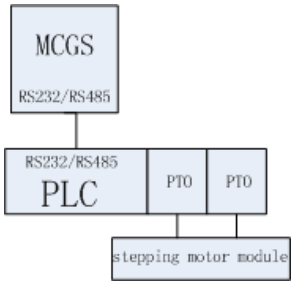

Fig.1: the diagram

Control system hardware design

The system hardware consists three parts:

i)A power of two phase stepping motor and its drive control sample to stay single pipe or tube of the tube, to realize the motion control of x, y plane;

ii) A small power of two phase stepping motor and its drive control and sample arm extended or retracted, realize the Z axis movement.

iii)Touch screen via a serial port to send signals to luoyang LanFei PLC, open, stop the peristaltic pump, complete and accurate control of sample weight.

In luoyang LanFei YF0H series CPU module is the core of the whole control system, the high speed counter module comes with 3 road, 2 road PWM output or the office, with a RS485 serial interface. A built-in Modbus - RTU communication protocol (can be used as the host, also can be used as the machine), support for the Modbus can connect any HMI man-machine display terminal; Configuration 2 pieces YF0A - regarding the module at the same time, each module provides 2 axis positioning control of output pulses (+), each axis has 2 road origin capture input[4]. Choose 2 HB3525dDstepper motor drive, this drive has 4 files and so on Angle of constant torque subdivided, bipolar constant current drive high performance stepping drive, driving voltage range, DC12 36 v, with one power supply. Adaptation under 2.0 A current, 57 mm outside diameter under various types of two-phase hybrid stepping motor.

Stepper motor is applied to make operation can achieve high control precision, factory default whole step from the Angle of 1.8 degrees. After using 2 HB3525Dd stepper driver, fractionizing eight times, through further subdivided, can improve the motion precision and accuracy.

Table 1 is the control system of PLC I/O allocation table, the input signal including the system start, stop, stop arm, and x, y plane stepper motors inching control signal. Related to the stepper motor control signals: x, y plane movement arm the origin, the origin signal and out of limit switch signal are all connected to YF0A -PTO the office module. The output signal is mainly three way stepper motor regarding output signals and direction, system operation instructions, etc. PC MCGS and there are many soft contact and soft light to control the operation of the system and state.

Control system software development

PLC program development

EasyLad programming software has a variety of programming mode, online debugging, at any time can be change the operating mode (programming/operation), monitor, register each of a state. The control process of the whole system is shown in figure 2.

By using multiple module pulse train output function library EPTO_S. Yf (multi module S curve of the pulse train output acceleration and deceleration) can easily complete the positioning control, the library can support eight modules, 16 shaft point-to-point positioning control. The function library contains several functions as follows:

i) DRVAE absolute positioning function;

ii) DRVIE relative positioning function;

iii)motor DRVSE stop function;

iv)read the current position of the motor function RdCPosE;

v)back to zero ZRNE function;

vi)inching function JOGE;

vii)read the state of the motor marked function RdDRVF;

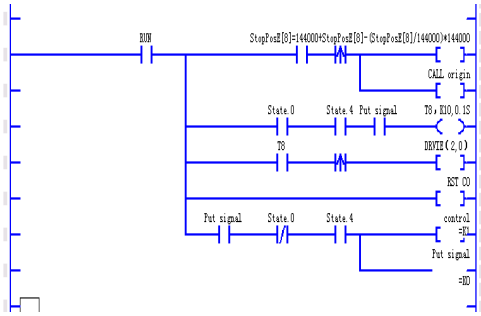

Fig.2 :The Demonstration program

In the normal use function library EPTO_S yf, must define the following global symbol:

Array of StopPosE [16] : type or DINT. Stops the absolute position of each shaft motor (unit: pulse number).

PTO_DirE: type of DM or INT. Each bit for each axis motor, to OFF away from the origin to ON close to the origin (0 ~ + up coordinate)

PLC program in accordance with the structured programming ideas to organize each function.

Initialization function Init: complete system initialization, than color melamine tray long arms, long points, and self-checking system function is normal.

Wash rinse function: complete sample plus sample before and needle and reagent pipe flushing operation.

Add Sample function Sample: complete batch, grouping arm long point, etc.

PC program development

PC Beijing kunlun pass Thai MCGS touch-screen. The product offers a standard Modbus RTU- a serial port communication, can be directly with luoyang LanFei YF0H series connection, CPU simplify programming work.

The main monitoring interface includes parameter setting, function test,calibration and test, system of charging and discharging liquid, system cleaning, liquid emptying, help button, realize the function of dilution,liquid, titration and liquid etc..

Parameter setting interface realizes the operating frequency of the peristaltic pump, pipe diameter and database setting,by implementation of related configuration using direct input digital or scroll mode[6].

Monitoring menu as shown in figure 3. the picture is the control interface, due to the limited length, related parameters setting of the interface is no longer listed.

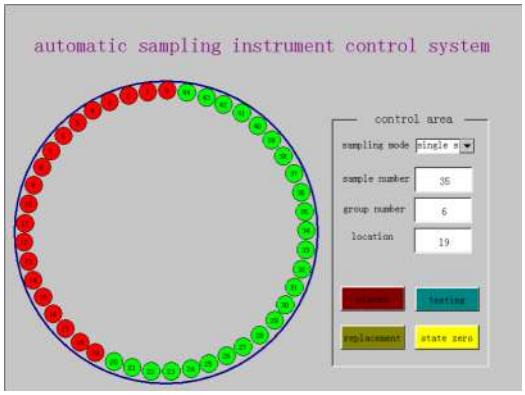

Fig.3: sample control interface

Results and analysis

The statistical average value of each batch of V, Variance and the accuracy of S, and further calculate the precision of the system CV. The formula is as follows:

$$\bar{\nu}=\frac{\sum_{i=1}^{k}\nu_i}{k} \quad (1)$$

$$\sigma=\sqrt{\frac{\sum_{i=1}^{k}(\nu_i-\bar{\nu})^2}{k-1}} \quad (2)$$

$$S=\frac{|C_i-\bar{\nu}|}{\bar{\nu}} \quad (3)$$

$$CV=\frac{\sigma}{\bar{\nu}} \quad (4)$$

Tab1.Experimental results

	5ml	10ml	20ml	30ml	40ml
measurement data	5.12	10.32	20.21	29.77	39.68
	4.98	10.21	19.82	29.89	39.69
	4.99	9.96	19.93	30.42	40.32
	5.12	9.98	20.37	30.53	39.79
	5.11	10.23	19.88	29.71	40.31
mean deviation	5.064	10.14	20.042	30.064	39.958
deviation	0.012	0.506	0.751	0.834	0.875
accuracy	7.23%	16.1%	23．6%	38.7%	32．6%
precision	1.42%	1.51%	1.22%	1.27%	0.82%

After the automatic sampling instrument is completed,it should be widely used in biochemical analyzer. To test the instrument, determine the actual sampling device sampling precision, and is able to complete the task, and meet the requirement of practical use. Direct measurement of sample amount on the micro liquid sample by the volume is very difficult, weight method is used by measuring sampling precision.

To statistics Each batch average $\bar{v}$,variance σ and the accuracy S, and furtherly calculate accuracy CV of system. The calculation formula is as follows:

The above data compare with the general standard, parameters are as follows:

i) 1 ~ 5% range: accuracy ± 3%, accuracy ⩽ 1.5%

ii) 5 ~ 30% range: accuracy ± 1.2%, accuracy ⩽ 0.5%

3) 30 ~ 100% range: accuracy ± 1%, accuracy ⩽ 0.2%

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