

A Design of Group Testing System for Mass Hall Sensors

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Abstract—In order to improve the efficiency of detecting mass hall sensors, this article describes a design of group testing system for mass hall sensors which can complete group testing of mass hall sensors' quality one time. The content of group testing includes forward steps, reverse steps, Positive pull power steps, negative pull power steps. The method of testing is based on error deviation testing and linearity calculation using least squares.

Keywords—group testing; mass hall sensor; least squares

I. INTRODUCTION

With the continuous developments of new appliance energy-efficiency standards worldwide, it is necessary to apply a current sensor to monitor and control energy consumption[1]. Hall sensors can detect physical variable such as torque, pressure, stress, position, displacement, speed, acceleration, angle, angular velocity, number of revolutions, etc., and work in harsh environments with high requirements for zero error and linearity under various conditions.

In the past, those hall sensors must be tested in high temperature environment and low temperature environment for a long time and be tested in for modes such as forward steps, reverse steps, Positive pull power steps, negative pull power steps. The zero error and linearity error will be tested in all modes. People must set before those power supply devices and measuring instruments and adjust them and record the measuring result by hand according to designated measuring point which costs a lot time and human work. The product detection cost is high by that way and the production efficiency is low which causes low market competitiveness as result.

In order to improve the efficiency of detecting mass hall sensors, this article describes a design of group testing system for mass hall sensors which can complete group testing of mass hall sensors' quality one time. The content of group testing includes forward stroke, reverse stroke, positive pull power stroke, negative pull power stroke. The method of testing is based on error deviation testing and linearity calculation using least squares.

The design of group testing system for mass hall sensors includes hardware design and software design.

II. HARDWARE DESIGN

A hall sensor includes some parts as Fig1 showing. When the primary current I_p flows through a long wire, a magnetic field is generated around the wire. The magnitude of this magnetic field is proportional to the current flowing through the wire. The generated magnetic field is concentrated in the magnetic ring and passes through the magnetic ring air gap. The Hall element measures and amplifies the output, and its output voltage V_s accurately reflects the primary current I_p [2].

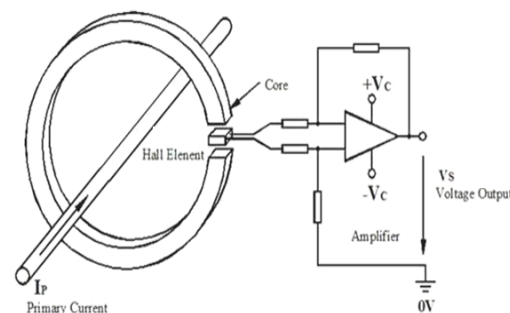


FIGURE I. THE METHOD OF HALL SENSOR TESTING

The hardware of group testing system for hall sensor has some units such as power supply unit, standard current output unit, data measuring unit, hall sensor socket board and computer. The hardware' structure is shown as Fig2.

The power supply unit can offer $+36V$ and $-36V$ for the hall sensor' $+V_c$ and $-V_c$. The standard current output can output from $0A$ to $100A$ for I_p .

The socket board of hall sensor has 80 sockets which can testing 80 hall sensor one time. The data measuring unit can measure 80 hall sensor's voltage output at the same time. The computer controls the power supply and standard current output according to the order specified by the user and collect the measuring data from data measuring unit and save into database. Those hall sensors' quality can be judged by every detection point error and linearity from the saving data.

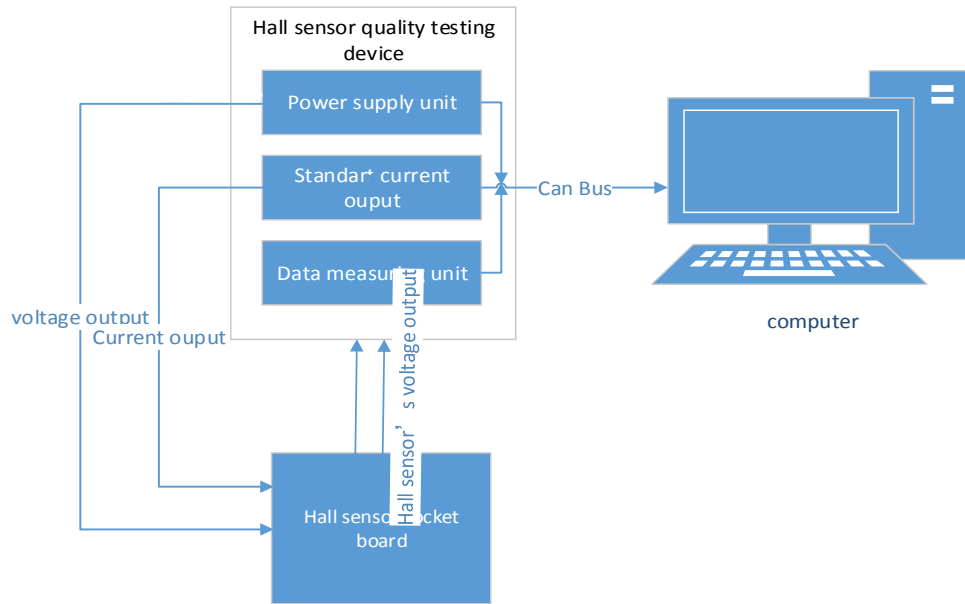


FIGURE II. THE STRUCTURE OF HARDWARE OF GROUP TESTING SYSTEM

III. SOFTWARE DESIGN

The group testing system for hall sensor includes two forms of detection such as Zero error and linearity detection.

A. Zero Error Testing

Zero error is the drift of the zero point where the I_p is 0A [3]. The socket board with 80 hall sensors is put into high temperature box and low temperature box for 7 days with standard power supply and 0A current. The computer collects and saves the testing data according to the specified period and will send a alarm voice and red chart when the zero error beyond the allowable error range.

B. Linearity detection

Linearity means that two variables, "x" and "y" are related by a mathematical equation " $y = cx$," where "c" is any constant number[4]. For hall sensor, "x" is the value of specified current I_p and "y" is the hall sensor's voltage output V_s .

To make the system work, the first step is to set the standard power supply voltage of the Hall sensor, the zero point error limit, the linear standard limit of the forward and reverse stroke, and the positive and negative bias voltage limit. The second step is to set the minimum value, maximum value, and number of the specified current input of the Hall sensor. The points of standard current input is automatically calculated by the computer. For example, the minimum value is 0 and the maximum value is 50A, so the count of the testing points between 0A and 50A divided by 10A is formed according to the calculation formula $(50-0)/10+1=11$, The detection points are 0A, 1A, 2A, 3A, 4A, 5A, 6A, 7A, 8A, 9A, 10A. The stroke current of the above Hall sensor comes from the computer-controlled standard current output unit by digital control and precision current output.

The linear fitting characteristic equation of the Hall sensor is obtained by the least squares method[5], and the maximum fitting error is calculated. The maximum fitting error is divided by the average error of the Hall sensor to obtain the linearity. The formula is as follows:

$$Y=aX+b \quad (1)$$

In formula (1):

Y: the output voltage of the Hall sensor H1;

X: the standard voltage of Hall sensor H1;

a: slope;

b: intercept.

Here, a, b is calculated as follows:

$$a = \frac{\sum_{i=1}^K X_i^2 \sum_{i=1}^K Y_i - \sum_{i=1}^K X_i \sum_{i=1}^K Y_i}{K \sum_{i=1}^K X_i^2 - (\sum_{i=1}^K X_i)^2} \quad (2)$$

$$b = \frac{K \sum_{i=1}^K X_i Y_i - \sum_{i=1}^K X_i \sum_{i=1}^K Y_i}{K \sum_{i=1}^K X_i^2 - (\sum_{i=1}^K X_i)^2} \quad (3)$$

In formula (2) and (3):

X_i is the hall sensor current input value with the i-th standard detection point;

Y_i is the hall sensor voltage output value with i-th standard detection point;

K is the number of detection points;

The linearity Y_L is obtained by follow formula:

$$Y_L = \pm \frac{\Delta L_{max}}{I_{FS}} \quad (4)$$

In formula (4)

ΔL_{max} Is the maximum deviation between the calibration curve and the fitted line.

I_{FS} is the average value of hall sensor rated output.

The computer can save every testing data of the stroke point and print out the final testing result.

C. Group Testing

The group test system can testing the hall sensor with any combination among 4 ways such as forward strode, reverse strode, positive power pull up and negative power pull down.

The forward stroke means positive power giving to +Vc standard voltage such as 12V and -Vc as -12V, and then the standard current unit inputs the Ip following a sequence from 0A to 50A increasing 10A each time in order, and the system collects the Vs output and saves and calculate the data.

The reverse stroke means positive power giving to +Vc standard voltage such as 12V and -Vc as -12V, and then the standard current unit inputs the Ip following a sequence from 50A to 0A decreasing 10A each time in order, and the system collects the Vs output and saves and calculate the data.

The positive power pull stroke means positive power giving to +Vc standard voltage such as 13.2V and -Vc as -12V, and then the standard current unit inputs the Ip following a sequence from 0A to 50A increasing 10A each time in order, and the system collects the Vs output and saves and calculate the data.

The negative power pull stroke means positive power giving to +Vc standard voltage such as 12V and -Vc as -13.2V, and then the standard current unit inputs the Ip following a sequence from 0A to 50A increasing 10A each time in order, and the system collects the Vs output and saves and calculate the data.

IV. SUMMARY

A design of group testing system for mass hall sensors which can complete group testing of mass hall sensors' quality one time. The content of group testing includes forward steps, reverse steps, Positive pull power steps, negative pull power steps. The mothed of testing is based on error deviation testing and linearity calculation using least squares.

ACKNOWLEDGEMENT

This research was financially supported by 2016YFD0702103, 2017YFD0701201-03, 2017GGX30105, 2017GGX30117, 2017YF046, 2017CXGC0213, 2017CXGC0807, 2017CXGC0903, 2018YZ002, 2018YF005-07, 2018CXGC0601.

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