Measurement and Analysis of Transient Information Characteristics of IOT Equipment Using Graphical Programming

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Abstract. The switching on and switching off operation of some IOT devices is a complex physical, chemical and mechanical nonlinear transient process, which contains a lot of information. The information has distinction, stability and clear physical meaning. Due to the short time of transient process and the rapid change of waveform and characteristic parameters from time to time, it is difficult for traditional test instruments to capture the characteristics of voltage, current and power consumption in the transient process. Therefore, this paper develops a set of transient characteristic test system of IOT equipment by using the graphical programming software LabVIEW, which realizes the accurate measurement, automatic analysis and display of transient process waveform and characteristic parameters. Taking the operating coil of an electronic product as the test object, the transient characteristics in the whole process of on-off, closing process and breaking process are tested and verified by using the test system, which improves the efficiency of detection and analysis of the performance of IOT equipment.

Keywords: IOT equipment, power consumption test, LabVIEW, transient characteristics.

1. Introduction

The internet of things (IOT) refers to the real-time collection of any object or process that needs monitoring, connection and interaction, and the collection of various required information such as sound, light, heat, electricity, mechanics, chemistry, biology, location, etc. Through various devices and technologies such as information sensors, radio frequency identification technology, global positioning system, infrared sensors, laser scanners, etc. Through all kinds of possible network access, the ubiquitous connection between things and people can be realized, and the intelligent perception, identification and management of goods and processes can be realized. The I am an information carrier based on the internet and traditional telecommunication network. It enables all ordinary physical objects that can be independently addressed to form an interconnected network [1]. The IOT is an extension and expansion of the network based on the internet. It combines all kinds of information sensing devices with the network to form a huge network, realizing the interconnection of people, machines and things at any time and any place. A typical IOT device consists of at least one sensor, one processor and one RF chip. It runs in different states and consumes several nanoamps to several hundred milliamps of...
current in tens of microseconds [2]. It is not easy to accurately detect the voltage, current and power consumption of these devices in different transient states. Their switching on and switching off operation is a complex physical, chemical and mechanical nonlinear process, especially the transient process of closing and breaking, which contains rich information with distinction, stability and clear physical meaning. However, it is difficult to capture the transient characteristic parameters under such complex conditions by using traditional test instruments. Therefore, it is urgent to design a transient characteristic test system for IOT equipment, which can achieve accurate measurement, automatic analysis and intuitive display, so as to improve the detection efficiency.

2. Test system

The test system framework designed in this paper is shown in Figure 1, which is mainly composed of signal detection, acquisition module, upper computer system, etc.

![Figure 1. Design block diagram of test system.](image)

2.1. Signal detection module

The signal detection module mainly processes the analog signal of the system, and outputs the analog voltage and current signal to the secondary side low voltage signal through the hall sensor. This design uses Hall sensor to convert voltage and current signals. It is a modular active electronic sensor. It combines the common transformer with Hall device and electronic circuit. It has the advantages of wide measurement range of common transformer and fast response speed of electronic circuit. It can complete the measurement of DC, AC of different frequencies and pulsating current. The voltage and current sensor based on Hall principle has the following advantages: wide test range, can measure any waveform of current, such as AC, DC, pulsating current, etc; The response speed is fast; Good linearity; The measurement accuracy is high; It is a non-inductive device, the magnetic circuit of the sensor works almost with zero flux, and it is fast compensation when it changes dynamically; Because of the high insulation strength of primary and secondary circuits, it is especially suitable for small capacity test occasions, and it is also very convenient for large capacity system expansion. It also has a very important feature, that is, there is electrical isolation between the primary side and the secondary side, which can protect the secondary equipment and personal safety.

The current type Hall voltage sensor, HCV-25E, is selected for voltage measurement. Its main performance indexes are as follows:

- The rated input current is $10\ mA$ and the rated output is $25\ mA$; The accuracy is 0.5%; Supply voltage is $\pm\ 12-15\ V$; The frequency range is $DC-20kHz$; The working temperature range is $-25^\circ\text{C}$ to $+85^\circ\text{C}$; Response time $\leq 10\ \mu S$; The insulation voltage is $2.5\ kV$; PCB fixed installation is conducive to installation and debugging.

Because the input and output of the Hall voltage sensor are current signals, the input resistance and output resistance should be connected externally. The input resistance generally adopts power resistance
to convert the corresponding input voltage signal into an acceptable current input signal, while the output resistance generally adopts ≤ 50 Ω. The specific wiring is shown in Figure 2.

Figure 2. Wiring diagram of HCV-25E Hall voltage sensor.

The Hall current sensor LA28-NP is selected for current measurement. The current is insulated between primary circuit and secondary circuit. It can be used to measure DC, AC, pulse and mixed current. The measurement range is (0 ~ ±5) A. The specific wiring diagram is shown in Figure 3.

Figure 3. Wiring diagram of LA28-NP.

2.2. Signal acquisition card

Signal acquisition is to convert analog signal into digital signal. The computer expansion card which can realize data acquisition function can be connected to personal computer through USB, PXI, PCI, PCI express, FireWire (1394), PCMCIA, ISA, compact flash and other buses. Data acquisition card is the data transfer station of the whole system, so it is necessary to choose a data acquisition card with excellent performance and easy installation [3]. In this paper, USB 9215 is selected as the acquisition device, and its input analog signal wiring is shown in Figure 4.

Figure 4. Wiring diagram of USB-9215 signal.

USB 9215 data acquisition card has the following characteristics: Four channels synchronous acquisition function; The sampling rate is 20Ks / s, the resolution is 16 bits, the maximum voltage range is (−10 ~ 10) V, and the accuracy range is 5.6 mV; USB bus data transmission, the acquisition card can be easily connected to the USB data line of the computer, so that the signal can communicate with the upper computer. This port connection mode is quite convenient, firm and reliable; The data acquisition
card is attached with driver, which can directly program the register of data acquisition hardware and manage the operation of data acquisition hardware.

2.3. Software design

This system mainly realizes the functions of voltage and current data waveform acquisition, processing, power consumption related parameters analysis and calculation of IOT equipment. The management center of the transient characteristic test system for IOT equipment is shown in Figure 5.

![Figure 5. System management center.](image_url)

Data acquisition design: the core process of data acquisition is to convert the continuous analog signal into discrete digital signal. In the process of test, it is necessary to collect all kinds of waveforms in real time and continuously, and sometimes it is necessary to trigger a special waveform. Therefore, the design of this module should have both the ability of real-time acquisition and monitoring and the function of trigger acquisition for special tasks. The programming process of real-time acquisition includes giving DAQmx task, creating channel, configuring channel, setting sampling clock, starting task, reading task, clearing task, stopping task, etc; In the trigger module, users can choose a variety of trigger types according to their own needs, such as digital signal trigger and analog signal trigger, edge trigger and window trigger, start trigger, pause trigger and reference trigger. Once transient signal appears in the real-time measurement process, a new window will pop up to display the latest captured transient signal.

Waveform analysis and processing design:

1) Digital filtering. Because the test site of IOT equipment is complex, some useless noise signals may be introduced, so digital signal processing is needed after data acquisition to make the system get useful real signals. The function of digital filter is to screen the signal and only let the signal of specific frequency band pass through [4]. Using digital filter technology to develop data signal processing module, not only can solve the shortcomings of traditional hardware filtering method, such as large volume, high investment cost, inconvenient update, but also the software development is simple and practical, which is an effective method to eliminate system interference.

2) Parameter calculation. Although the application of advanced acquisition technology and digital signal processing technology to restore the original signal of measurement, it also needs intelligent analysis and calculation of test parameters. The parameter calculation function of this design has many advantages, such as the automatic parameter calculation function and automatic positioning function between two cursors, which can realize the automatic real-time measurement of voltage, current, power consumption and other parameter.
(3) Waveform analysis. LabVIEW can provide powerful interactive interface design function for the operation panel of analog real instrument. It can convert a large number of measurement data into curves. Waveform analysis has the functions of point-to-point amplification, point to point reduction, X-axis amplification and reduction, Y-axis amplification and reduction, data retrieval and storage, professional report generation, etc.

3. Verification

3.1. Display of measurement system
The main test interface of the transient characteristic test system for IOT equipment is shown in Figure 6. Just pull two cursors to the appropriate position in the software interface, and then click the value to be measured, the calculated value can be displayed in the parameter display box. The parameters show the common experimental data of various test experiments. It includes the effective value, maximum value, minimum value, peak to peak value and working power of voltage and current under the working state of IOT equipment. These parameters are measured by two cursors. First, pull the cursor to the appropriate position, red cursor on the right, blue cursor on the left, and then click the display control to get the measured value.

![Figure 6. Transient characteristic test system for IOT equipment.](image)

3.2. Test verification
Taking the transient characteristic test of an electronic product on and off process of IOT terminal equipment as an example, the feasibility of transient parameter test of the system is verified.

(1) Transient characteristic test of the whole process test
The voltage and current waveforms of the operating coil of the electronic product detected by the test system are shown in Figure 7(a). The top of the figure is the voltage channel, and the voltage unit is $V$; The following is the current channel, the current unit is $mA$; The time unit is $S$. 


Using the developed transient characteristic test system of IOT equipment, these waveforms and parameters can be analyzed and measured. When the two cursors are pulled to the start (blue cursors) and stop (red cursors) positions, the characteristic quantity of the whole process of switching on and off of the operating coil can be automatically measured, as shown in Figure 7 (b).

(a). Working voltage and current waveform.

(b). Numerical simulation of transient characteristics.

**Figure 7.** Transient characteristic test of switching coil during whole process.

(2) Transient characteristic test of closing process

By using the amplification function of the test system, the test waveform of the operation coil of the electronic product in the closing process is selected, and the transient characteristics such as voltage, current, power consumption and time are tested and analyzed, as shown in Figure 8.
(a). Working voltage and current waveform.

(b). Numerical simulation of transient characteristics.

Figure 8. Transient characteristic test of switching coil during closing process.

(3) Transient characteristic test of breaking process

Similarly, the voltage, current, power consumption, time and other transient characteristics of the operating coil of the electronic product during the breaking process are tested, and the analysis results are shown in Figure 9.

It can be seen from the test waveforms and parameters that the effective value of voltage characteristic is 36.44V, the maximum value is 52.62V, the minimum value is -64.93V, and the peak-to-peak value is 117.55V; The effective value of current characteristic quantity is 219.6mA, the
The maximum value is 1944mA, the minimum value is -740.2mA, and the peak-to-peak value is 2684mA. The time characteristic value of the whole process is 792.99ms, in the closing process is 22.72ms, and in the breaking process is 22.64ms; The power consumption characteristic in the whole process is 0.31012W, in the closing process is 0.047044W, and in the breaking process is 0.0007697W.

The waveforms of the instantaneous change process of the switching on and off of the operating coil of the electronic product contain abundant information. In the process of closing and breaking, it has the characteristics of instantaneous, fast and wave beating, especially when start-up, the current suddenly changes, and a large peak is 1944mA; When it stops working, the voltage also has a big peak, which is -64.93V. The transient characteristic parameters obtained from the test will be helpful to analyze the working performance of the electronic product.

4. Conclusion

(1) Based on LabVIEW software, this paper designs a transient characteristic test system for Internet of things equipment, which can realize accurate measurement, automatic analysis and display of transient waveform and characteristic parameters;

(2) Taking the operating coil of an electronic product as the test object, the transient characteristics in the whole process of on-off, closing process and breaking process are tested by using the test system. The transient waveform of the product with rich information in each working stage is analyzed quickly, especially in the process of closing and breaking, which has the characteristics of instantaneous, fast and waveform beating. It is verified that the test system can improve the detection and analysis efficiency of the transient performance of IOT equipment.

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