Simple Timing Signal Analysis Device-XY Mode Displays the Multichannel Shift Waveform

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Abstract. We designed and implemented a simple timing signal analysis device, which displayed multichannel shift waveform without overlapping from left to right on the Oscilloscope screen using X-Y mode as signal input. In order to meet the requirements of high speed sampling rate, we took microcontroller STM32F407VGT6 to collect, storage, analysis signal, and calculate the result wave though high speed DA conversion module to display on the Oscilloscope screen. we took microcontroller STM32F103RB to realize the shift clock circuit and 8-channel digital signal, and adopt the dial-code switch presents the 8-bit trigger word TW. after several test, the signal analysis device could realize the trigger time position adjust at all, time marker line be shifted manually, LED light displayed the status word corresponding to the flag line, and playback two shift cycle timing waveform and other functions simply and efficient. through numerical simulation and experimental analysis, we found that this simple device can greatly display multichannel shift waveform easily and precisely.

Introduction

In recent years, with the increase of the type and number of electronic communication equipment, the failure of the connectivity between the equipment occurs from time to time, which brings great trouble to the equipment operators. Most of the modern communication equipment adopts digital signal to communicate, which puts forward higher requirements on operators' digital logic design ability and digital system analysis ability\textsuperscript{[1]}. In general, people rely on oscilloscope for signal analysis, and the understanding of multi-channel digital signal analysis lacks the support of hardware platform. At present, most simple logic analysis instruments adopt single-chip microcomputer +FPGA mode to realize data display through TFT, which not only increases the product cost but also fails to fully apply the display function of oscilloscope. Therefore, this design USES oscilloscope x-y mode to do signal input, design 8 channels of digital signal storage, display, playback, arbitrary cursor shift and other functions. A simple multichannel timing signal analysis device is implemented. Compared with conventional logic analysis instrument, this device has the advantages of simplicity, low cost, high utilization rate, high accuracy and strong application. the overall design scheme is shown in figure 1.
**Methods**

**Problem Description**

In order to accurately display the multi-channel digital timing signals on the oscilloscope display screen, the basic requirements such as standard test signal acquisition and manual trigger condition setting must be met first. In this process, the two-channel D/A conversion circuit is precisely controlled, and two channels of analog signals are output to the x-y channel of the oscilloscope, and the oscilloscope screen is scanned quickly and orderly, and the multi-channel signals are displayed by using the afterglow effect of the ratio. Therefore, reasonable function module setting and control become the key.

**The Key Logic Module Design Methods**

**Clock and Digital Signal Generation Module.** Clock accurately produced in the role of digital signal control is crucial, this design by STM32F103RBT6 microcontroller as a signal generator, configuration of eight I/O mouth D0 ~ D7 for digital signal output terminal, a clock the clock signal output, internal timer interrupt cycle 10 us, every 10 us raise the interrupt, flip clock IO mouth clock level, produce 100 KHz clock pulse signal. Each interrupt D0 ~ D7 is switched in 8 different state words SW, and every 8 interrupts is a shift cycle, which can display the 8-channel timing waveform at the same time.

**Digital Signal Timing and Master Control Module.** The digital signal timing analysis device and main control module are based on STM32F407VGT6 microcontroller. The microcontroller has the advantages of high integration, FLASH memory on 1 M byte chip, SRAM of 192 K bytes, reset, internal RC, PLL and so on. In addition, the device also includes ART accelerator, 32-bit 7-layer AHB bus matrix, multi-dma controller and so on.

The digital signal timing analysis device can accurately collect complete timing waveform, and the internal high-speed computing unit can process the signal in real time. Because the oscilloscope x-y mode waveform display requires high frequency of input signal, low-frequency signal is easy to cause distortion of display graph. Therefore, STM32F407VGT6 microcontroller conforms to the main frequency requirements of the system, and can well collect and capture the input signal and make the corresponding output control. Its internal high-speed DA conversion analog output can ensure that the
graph input to the oscilloscope (x-y mode) changes continuously without distortion, and the whole control system can run stably.

**Oscilloscope X-Y Channel Display Module.** Oscilloscope X channel waveform voltage determines the distance from the X-axis. The oscilloscope y-channel waveform voltage determines the distance of the spot from the Y-axis. X channel input oblique wave, Y channel cycle input and trigger word matching digital signal waveform can be output on the oscilloscope. In order to display 8 waveforms simultaneously on the oscilloscope, X channel needs to input 8 oblique rising waves, which are respectively used for the complete display of 8 waveforms. The 8 waveforms of Y channel should be handled by lifting pressure, otherwise the spots will be aliased, so the 8 waveforms need to be set on different reference voltages. Oscilloscope time marker line can be set, X channel oblique wave reference voltage can be adjusted.

**Circuit and Program Design**

**8-bit Digital Signal Generator Circuit Design.** The 8-bit digital signal generator circuit is composed of the minimum system board, voltage stabilizing module, USB module, IO port, crystal oscillator, reset and power supply module with STM32F103 as the main chip, realizing a total of 8 digital signals from D0 to D7. The principle is shown in figure 3.

![Figure 3. 8-bit digital signal generator circuit schematic diagram.](image)

**Digital Signal Timing Analysis Device Design.** Digital signal timing analysis device is composed of STM32F103 minimum system board, voltage regulator module, USB module, IO port, crystal oscillator, reset and power supply module to realize the display of digital signal to oscilloscope[3]. The circuit principle is shown in figure 4.

![Figure 4. Digital signal timing analysis device schematic diagram.](image)
Programming Methods

To achieve accurate acquisition of clock and digital signals, analyze the timing sequence of D0 ~ D7 signals, timely respond to the external state and control signals, stabilize the output of analog signals through the oscilloscope x-y channel, and display timing sequence graphics on the oscilloscope. The program flow chart is shown in figure 5.

Results and Discussions

The Test Program and Conditions

The whole test includes hardware and software test. The hardware part is connected to the timing analysis device by the 8-digit digital signal output end and a clock signal. The control panel includes potentiometer, key, dial-code switch, LED light and is connected to the timing analysis unit. The timing analysis device leads out X, Y and GND terminals and connects oscilloscope X and Y channels respectively. Use multimeter, oscilloscope and other instruments to test the hardware connection. After testing, the hardware connection is intact and the modules work normally. The software part displays the result on the built hardware platform, carries on the program adjustment and the revision.
In order to ensure the correct connection of the hardware circuit, power is supplied to the digital signal generator and sequence analysis device respectively, the oscilloscope is opened and set to x-y mode, and the 8-bit effective single-stage trigger word TW is preset through the dial-code switch\(^4\). Adjust the potentiometer, manually shift the time indicator line on the screen, and the LED light displays the indicator line corresponding to the 8-channel digital signal status word SW; Button A sets three trigger time positions; Button B toggles and displays 2 cycles of 8-channel timing waveforms and normal state timing waveforms stored for playback.

**The Test Results and Analysis**

After the test, can be displayed on the oscilloscope at the same time 8 road digital signal sequence, can adjust 8-way digital signal timing the triggering time of the waveform, can choose different trigger mode, can be added on the screen can be manual displacement time marker, with eight lines corresponding LED display time 8 digital signals, to 8 road logic state of the digital signal acquisition and storage, and on the oscilloscope playback two displacement cycle 8-way digital signal\(^5\). The physical diagram of the system test is shown in figure 6.

![Figure 6. The system test physical drawing.](image)

Through testing for many times, can be displayed on the oscilloscope and 8 digital signal sequence, can adjust 8-way digital signal timing the triggering time of the waveform, can choose different trigger mode, can add the manual displacement time marker on the screen, with eight LED display time line 8 digital signals of corresponding time status, to 8 road logic state of the digital signal acquisition and storage, and on the oscilloscope playback two displacement cycle 8-way digital signal. However, there are some individual display waveforms and manual cursor display that cannot achieve absolute "horizontal, horizontal and vertical", because the D/A conversion output has a certain drift, and the D/A conversion output cannot achieve absolute linearity\(^6\).

**Conclusion**

As a typical digital signal analysis and test tool, the simple digital timing analysis device can customize the circuit, upgrade and expand functions, and use x-y mode as the signal input oscilloscope display method. Compared with the oscilloscope channel input method, it can display multiple signals, manual cursor and other practical functions.

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