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Research on Speed Measurement System Based on DSP

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Abstract: In this study, a TMS320LF2407 Digital Signal Processor (DSP)-based data acquisition, processing and communication system is described. The system makes full advantage of the high-speed and high-performance processing ability of the DSP chip, as well as its interior integrates two event management modules EVA and EVB and it composes of the Determination of electrical machinery rotational speed instrument with the photoelectric encoder, which can measure the rotational speed of the electrical machinery directly. The data transfer between Serial Communication Interface (SCI) module which is integrated by its interior with the computer can be displayed on the computer terminal in real time. The level conversion chip interface chip makes use of MAX3221 which is from MAXIM company in the United States. Experimental results show the feasibility of the design.

Key word: Digital signal processor, DSP 2407, photoelectric encoder, rotational speed measurement

PRINCIPLE OF A PHOTOELECTRIC ENCODER

A photoelectric coder (Deng *et al*., 2007) is a sensor, which converts mechanical geometry displacement on the output shaft into pulse or digital value through photoelectric conversion. This is one of the most widely used sensors currently. The working principle of the photoelectric coder as shown in the figure, which there carve many nonopaque and opaque lines regularly on the disc and there put a light-emitting element and a photosensitive element on both sides of the disc. When the disc rotation, the light flux by the photosensitive element received changes with the nonopaque lines and the reshaped waveform which is into pulses and there is the phase flag on the output by photosensitive element turns code wheel, which outputs a pulse for each revolution. In addition, the code wheel provides two pulse signal phase which are different of 90° for judging the direction of rotation. As shown in Fig. 1.

The photoelectric encoder is susceptible to interference, therefore, in addition it will ground normally and ground wire is reliable grounding of the photoelectric encoder output line. Like the other encoder, the accuracy of the optical encoder determines the accuracy of the photoelectric encoder. Therefore, we not only require the indexing of code wheel precise, but also should it require to have steep edge alternately in a dark place in order to reduce noise which is caused by the logic "0" and "1" of mutual conversion. This requires optical projection precise and material for the code wheel, which must be the fine material. The simple forward and reverse circuit of photoelectric encoder is shown in Fig. 2.

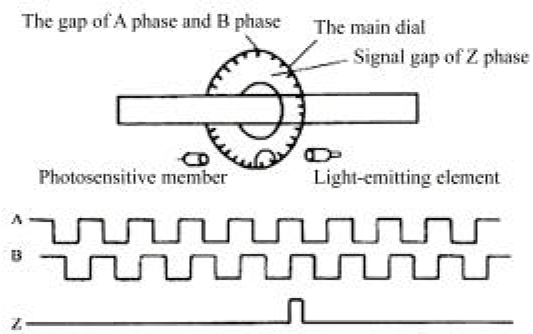

Fig. 1: Principle of a photoelectric encoder

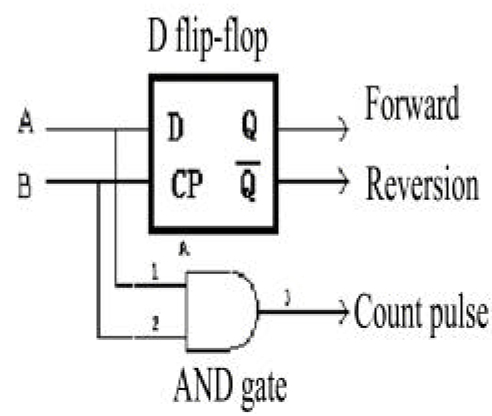

Fig. 2: Simple forward and reverse circuit of photoelectric encoder

The resolution of the output pulse optical encoder is the main indicators of its performance. The resolution is

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the number of the pulses output when the circle rotates a circle. We often subdivide its pulse in order to improving the resolution of the optical encoder. The subdivision method is both software and hardware. The hardware circuit is used widely because of its timely response and high reliability. The optical encoder output pulse gets combination through AB phase pulse rising and falling edges. The count pulse frequency and optical encoder output pulse frequency is the same if only use a phase rising edges to count. It can get twice as many the count pulse of the output pulse frequency of the photoelectric encoder if you use both A phase pulse rising and falling edges. The original pulse frequency can be increased by four times if you use A and B phase pulse rising and falling edge at the same time.

DESIGN OF HARDWARE CIRCUIT OF THE SYSTEM

Hardware part refers to the DSP chip TMS320LF2407 (Peng, 2000) as the core of data acquisition circuit and peripheral interface circuit Fig. 3.

TMS320LF2407 is one kind of 16-bit of Digital Signal Processing (DSP) (Chen and Zhang, 1999) chip with stronger controlled functions by TI Company produced which is the highest market share in the world. The TMS320LF2407 uses high-performance static CMOS technology, which makes the power supply voltage down to 3.3 V and reduces the power consumption of the controller. The 30 MIPS's speed of execution makes the instruction cycle shortened to 33 ns (30 MHz), which greatly improving the real-time control ability of the controller. In addition to TMS320LF2407`s high-speed CPU core, the chip also integrates two Event Manager (EV) module, A/D conversion (ADC) module controller local area network (CAN) module, serial communication interface (SCI) module and 16 bits serial peripheral interface (SPI) module, etc.

Each EV module has an orthogonal encoder pulse circuit. The detection logic of each EV module in the direction of the orthogonal encoder pulse circuit which of the two sequences is a pilot sequence and then it generates the direction input signal as the counting direction of the general-purpose timer 2 or 4 input direction. General-purpose timer counts up if the CAP1/QEP1 (CAP4/QEP3 for EVB module) input is pilot sequence. General-purpose timer counts down if the CAP2 / QEP2 (CAP5/QEP4 for EVB module) input is pilot sequence.

Two-row orthogonal to both edges of the input pulse counts by the orthogonal encoder pulse circuit. Thus, four times the clock frequency is generated for each input sequence and this clock is used as a general-purpose timer 2 or 4 of the input clock.

You can input pulse orthogonal coding in the encoding and counting pins/QEP1 CAP1 and CAP2/QEP2 (for EVA module) or CAP4/QEP3 and CAP5/QEP4 (for the EVB module) after the circuit is enabled. Orthogonal encoder pulse circuit can be used to connect

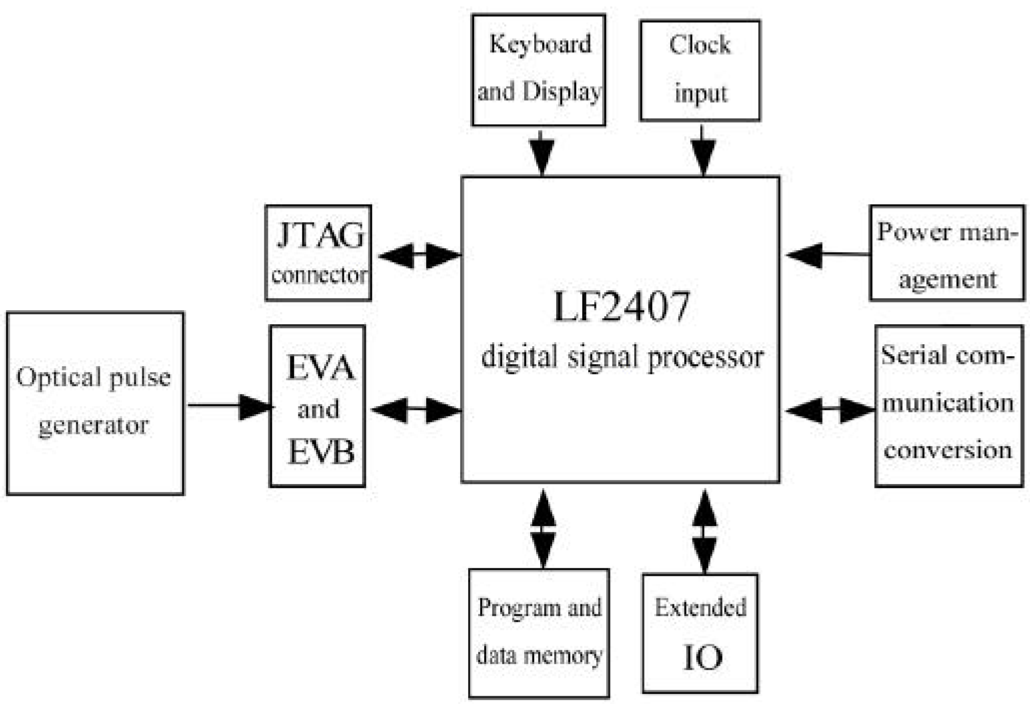

Fig. 3: Diagram of hardware structure

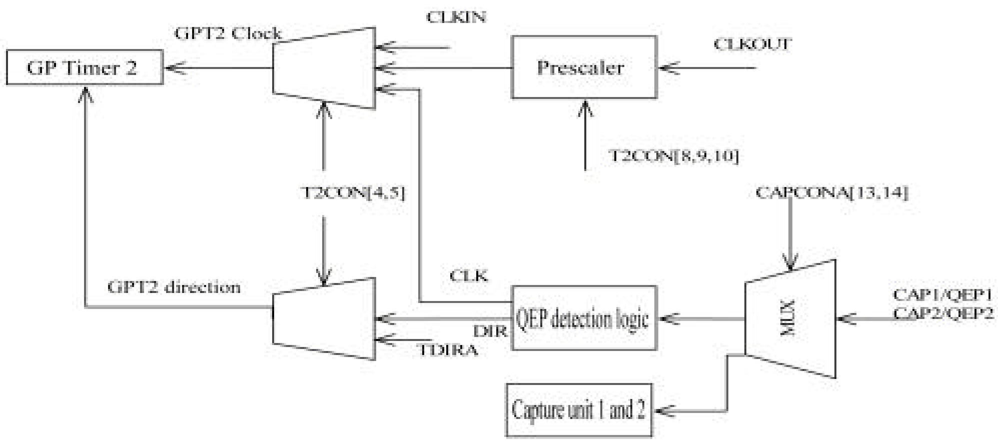

Fig. 4: Structure diagram of the orthogonal coded

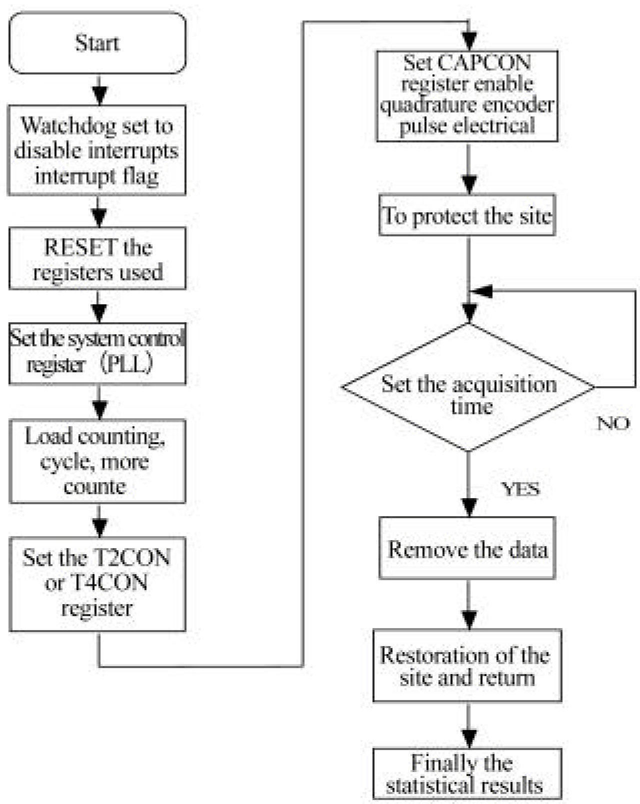

Fig. 5: Flow chart of data acquisition and processing system program

optical encoder to obtain information such as location and rate of rotating machinery. The corresponding capture pin will be prohibited, if you can make orthogonal coded pulse circuits. EVA module QEP block diagram is shown in Fig. 4. It is the same as the EVB module.

Demanding TMS320LF2407 peripheral devices based on the requirements and corresponding peripheral circuit mainly includes: Expansion of power management, clock input, the program and data memory, serial communication interface level converter, analog-to-digital conversion reference voltage and the input signal transform, JTAG emulation interface and IO expansion slot module design. Figure 5 is the hardware block diagram of the whole system.

The hardware circuit requires two supply voltage: 3.3 and 5 V. 3.3 V is a TMS320LF2407 DSP core and IO voltage and write-voltage of 5 V is for FLASH. This article selects regulated power supply provides the+5 V power to supply voltage, which chooses TI company's DC/DC conversion chip TPS7333 and will transform a single+5 V input into a single+3.3 V output for the system power supply. The internal frequency of TMS320LF2407 is 30 MHZ. It selects frequency 15MHZ active crystal as the system input clock and the clock generator chip integrates Phase-Locked Loop (PLL) technology and the external oscillation frequency second harmonic, resulting in a very stable internal clock. System works normally because of the right offer of the power supplying voltage and input clock. The following is introduced in accordance with the direction of the input signal process selection and working status of other modules (Chen and Zhang, 1999). We use the SN75173 which is produced by TI Company and can be differential signals A+, A-, B+, B-conversion orthogonal encoder pulse A, B in order to make the differential output of the encoder could be used.

The CPU of TMS320LF2407 analyses it in accordance with a predetermined algorithm calculation and arrives at a final result. The system extends the 64 K words of external program memory and 64 K words of external data memory in order to be able to more quickly process large amounts of data and convenient in simulation debugging. The calculated results are displayed in real-time on the computer terminal by the TMS320LF2407 Serial Communication Interface (SCI) (Zong *et al*., 2010) module and the computer data transmission.

The system uses asynchronous serial communication. In addition to solve the speed error test data format transfer, the Universal Asynchronous Receiver/Transmitter (UART) communication have to solve a fundamental problem in the communication master and slave must be in accordance with uniform electrical and physical interface standard to connect, such as signal level, the signal definition cable characteristics must be uniform standards. We must carry out the conversion of the electrical and physical interface between the electrical and physical interface standard if the primary inconsistent. When DSP and computer serial port connecting, because the former is TTL level (5 V or 3.3 V) and the latter is the RS-232 (15 V) level so the two are not compatible and must connect by level switch. The MAXIM company level conversion chip is chosen and used as TMS320LF2407 and computer serial communication interface chip MAX3221.

TMS320LF2407 chip provides the logic to scan the JTAG circuit to facilitate the simulation debugging. Emulator communicates with TMS320LF2407 JTAG port which can access the DSP resources including on-chip registers and storage area via a 14-pin connector. So it provides a real-time hardware emulation and debugging environment which is ease of system software debugging. In addition, important pin of DSP chip TMS320LF2407 are raised to enhance the versatility of the system can be developed and portability.

DESIGN OF SYSTEM SOFTWARE

Software design refers to on the basis of the hardware circuit, realizing the algorithm in the form of programs and then realizes the function of the particle counter. Software design of the entire system consists of two parts: (1) Using the standard C language and assembly language to program and realizing the motor speed and position determination and serial communication between the DSP and the computer, (2) Using the Visual Basic language to program for computer and realizing the serial communication between the computer and the DSP and the computer will display the output.

DSP data acquisition and processing procedures: Data acquisition part of the first set up EVA (or EVB) registers, the required value is loaded into the general-purpose timer 2 (or 4) count, cycle and compare register; Set the T2CON (4) register, the general-purpose timer 2 (or 4) is set to directional increase/down counting mode, take the quadrature encoder pulse circuit as a clock source and enable the general-purpose timer 2 (or 4); Set register CAPCONA (CAPCONB) to make orthogonal pulse circuit can be connected. Regular time to read out the value of T2CNT (or T4CNT), then T2CNT divided by 4, is the number of turns of the motor this time.

DSP data acquisition processing program flow chart is shown in Fig. 4.

Computer virtual panel program: The motor speed and position measurement results display output on the computer through the serial communication between the DSP SCI module and computer. The virtual instrument panel is developed with the visual controls of Visual Basic 6.0 on the computer. The operator can use the mouse and keyboard to complete most of the operation. The time of the data acquisition can be set in the user interface.

CONCLUSION

The quadrature encoder pulse circuit united timer in the using DSP2407 EV module can measure the position and speed of the motor, can reduce the peripherals and can improve the reliability of the system. It can also use the serial communication between DSP2407SCI module and computer or microcontroller to send out the results, in order to analyze and reference. In practice can simplify design, reduce development time and improve system efficiency and reliability, to get twice the result with half the effort.

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