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A MICROPROCESSOR BASED CONTROL AND DATA ACQUISITION SYSTEM FOR PRESSURE MEASUREMENTS IN AN ACOUSTIC WIND TUNNEL

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(1) INTRODUCTION

An experiment to measure the pressure distribution round a tube in a cross-flow in the presence of an intense acoustic field was to be carried out. The compressed air driven wind tunnel had a limited runtime which made manual data logging impractical. An automatic data logging system was therefore designed. A "Nascom 2" microprocessor system was available and was interfaced to control the rotation of the tube and acquisition of data from the pressure transducer system. The interface was designed to enable the data to be viewed on an oscilloscope after each run, and then output in a format suitable for inputting to the mainframe computer (ICL 2970). The data is then analysed on the ICL 2970 and output in graphical form.

(2) DESIGN CONSIDERATIONS

The system was designed around a "Nascom 2" microprocessor system (using a Z80 C.P.U.) with 48K of dynamic R.A.M. Two parallel input/output (P.I.O.) ports were available for control and data transfer and a serial I/O port was available for use with a teletype. The only available method of data transfer between the microprocessor system and the main computer was by means of paper tape. A paper tape punch and reader were interfaced to the microprocessor system to produce computer compatible output. The P.I.O. ports were used in a control mode to reduce the handshake interfacing requirements. The system cost was kept to a minimum and the only peripheral equipment that was used was either already available or inexpensive to purchase or construct.

(3) STEPPER MOTOR CONTROLLER

The stepper motor controller was designed to repeatedly rotate an instrumented tube through a preset angle and take measurements until the tube had been rotated through 360 degrees. The stepper motor controller is independent of the microprocessor system so that the processor was not directly controlling the motor. This would permit the processing or output of data to be carried out while the tube was being rotated to its next position. A variable frequency clock drives a counter which counts down a preset number of cycles (set up on D.I.L. switches) before inhibiting the output from the clock. The inhibit signal triggers a timer which controls the period during which measurements are taken before reloading the counter and turning off the inhibit signal. The output from the clock gate is fed to a further counter which drives the stepper motor decode logic to produce four phases. These signals switch four darlington transistors connected to the motor coils. The number of pulses output each time the programmable counter is loaded governs the angle through which the stepper motor rotates. The acquisition time can be controlled by the microprocessor by switching out the timer and connecting the counter load signal to one of the P.I.O. ports. When the P.I.O. port is strobed the stepper motor rotates through a preset angle and stops. An interrupt in then generated which initiates the acquisition of data. The software to drive the stepper motor controller contains an interrupt handling routine which sets a test byte to zero. This byte is tested in a BASIC subroutine which initiates the acquisition of data when the byte is set to zero. After acquisition is completed bistable 5 loads the programmable counter, activating the stepper motor.

(4) PAPER TAPE PUNCH, READER AND CONTROL

The punch and reader are controlled by P.I.O. B. The 4 M.S.B. of P.I.O. B drive a 4 to 16 line demultiplexer. Seven lines are available as output lines to control other devices and 8 lines are used to toggle 8 J-K bistables. The last line clears the bistables. The buffer data and enable lines are used to switch 9 darlington transistors which directly drive the hole punch relays. Bistable 2 drives a transistor switch which operates the punch clutch release solenoid to punch a character. The paper tape reader is selected by bistable 3 and bistable 4 drives the tape advance solenoid after a character has been read. The software used to drive the punch and reader does not have to run very fast so was written in BASIC for ease of programming. The main routines are as follows:

(a) A delay routine so that data is not transmitted or received faster than the electromechanical relays in the devices can operate.

(b) Output formatting routines which arrange the data in memory in a suitably formatted job for the ICL 2970 when output on tape.

(c) Input formatting routines which allow data from a previous run to be input to the microprocessor for viewing on an oscilloscope.

(d) An output routine which transfers data stored in memory to the punch via P.I.O. A and controls the punch clutch.

(e) An input routine which transfers data from the reader via P.I.O. A to memory and controls the paper advance.

(5) ANALOGUE TO DIGITAL AND DIGITAL TO ANALOGUE CONVERTER

A data acquisition system with a sampling rate of at least 50 kHz was required so that several 3 kHz signals could be acquired using an analogue multiplexer controlled by the processor. An 8-bit data acquisition system was designed with the maximum sampling rate governed by the rate at which the processor could input data to memory. The successive approximation A to D converter is controlled by an 800 kHz clock derived from the 4 MHz microprocessor system clock. This allows the A to D converter to be synchronised with the microprocessor I/O via the parallel ports. The sampling and A to D conversion circuitry is free running. The rate of sampling is preset by D.I.L. switches on a programmable counter. At any time a hold and conversion cycle can be initiated by clearing the programmable counter using a port on P.I.O. B. When a sample is requested the sample and hold gate goes into a hold state and one clock cycle later the A to D conversion is started. Ten clock cycles after the acquire pulse the data is latched ready for transfer to the processor via P.I.O. A. The sample and hold circuitry immediately switches into the sample state as soon as a conversion is complete ready for the next hold state. The maximum sampling rate is 80 kHz. The D to A converter is controlled by Least Significant Bit + 1 (LSB+1) of P.I.O. B. To change the analogue output the data on P.I.O. A is latched onto the D to A latch by strobing LSB+1 of P.I.O. B. The D to A converter drives a buffer amplifier which is connected to the Y input amplifier of an oscilloscope. An appropriate time base frequency is selected manually and the sweep is triggered by bistable 5. This allows the acquired data to be viewed directly on an oscilloscope. The software for the A to D and D to A converters was written in assembler language and converted to machine code using a Z80 assembler. The A to D routine is time dependent and the exact number of clock cycles used in executing each instruction was calculated so that the A to D conversion and processor input via P.I.O. A were synchronised. The A to D routine is a simple loop with an input instruction called from BASIC. The D to A software is a loop with an output instruction and delay routine called from BASIC.

(6) CONCLUSION

A relatively inexpensive and flexible control and data acquisition system for automatically carrying out experiments in a wind tunnel has been designed using the minimum of expensive peripheral equipment.

(7) REFERENCES

1. NASCOM 1980 Nascom Microcomputer Systems Documentation.

2. NATIONAL 1976 National Semiconductor TTL Data Book.

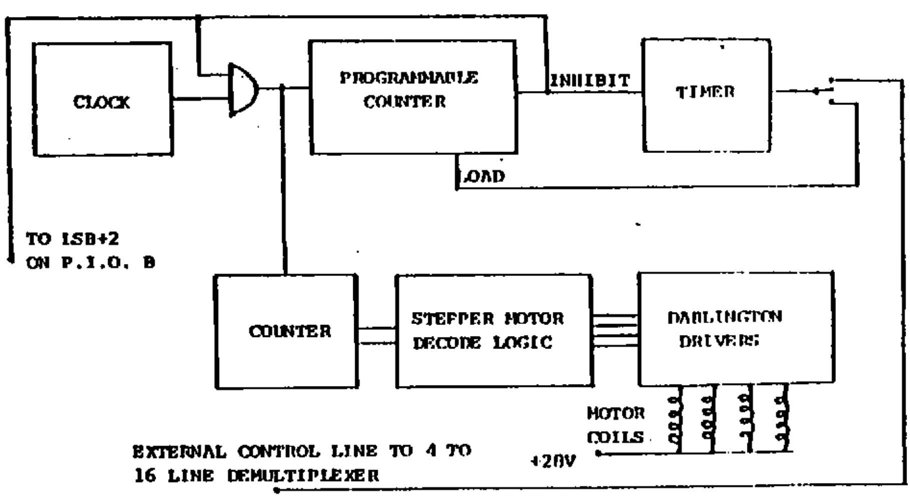

Figure 1: Block Diagram of the Stepper Motor Controller.

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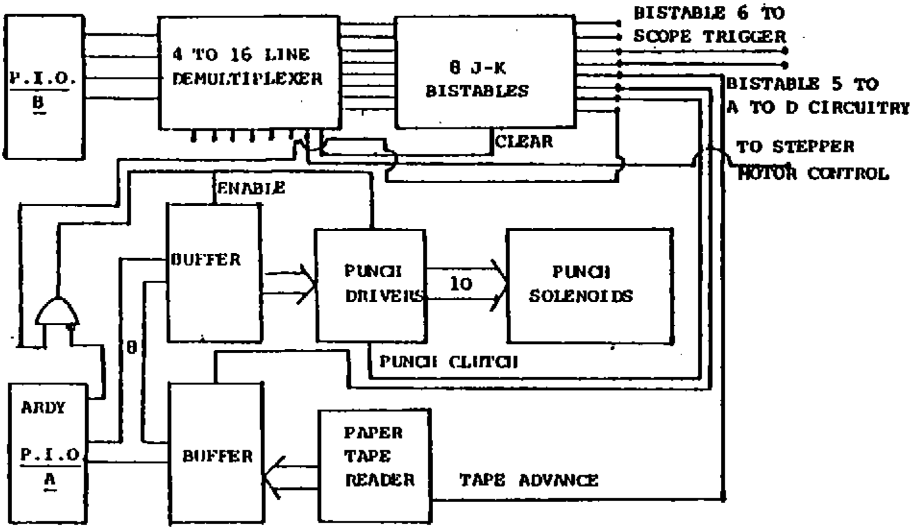

Figure 2: Block Diagram of the Paper Tape Punch and Control Circuitry.

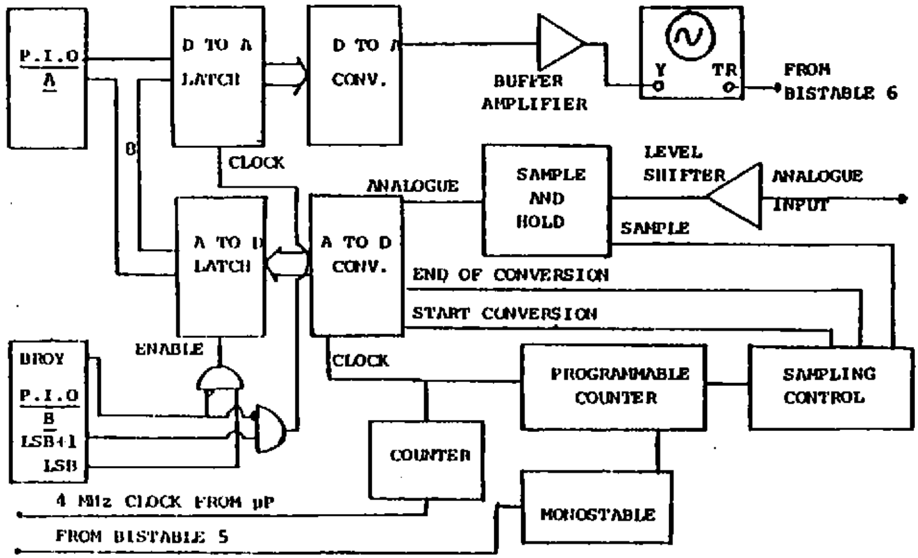

Figure 3: Block Diagram of the A to D and D to A Circuitry.