MASTER

A Digital Spectrometer Scan Controller*

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Abstract

An electronic device for control of a stepping motor scanned spectrometer is described. The device digitally displays wavelength, stops a scan at a preset wavelength and remotely controls a strip chart recorder. The primary utility of the device is in obtaining precise wavelength reproducibility in recorded spectra.

I. Introduction

In performing experiments in our laboratory, it was found necessary to have a spectrometer scanning system which would give good wavelength reproducibility in recorded spectra. For this purpose one must be able to reset as precisely as possible the wavelength at which a scan is begun, and to synchronize the starting times and scan speeds of the spectrometer and recorder. The device described here achieves these requirements and greatly facilitates the acquisition of spectra. It has been built in our laboratory and functioning as described herein for the past six months.

II. General description of function

The spectrometer scan controller slaves two devices, an HS50D Superior Electronics stepping motor and a Heath/Schlumberger model SR204 strip chart recorder. The stepping motor is powered by a Superior Electronics STM1800B translator board. The board advances or reverses the motor one step for each input pulse to the board. The scan controller produces and counts these pulses and drives an LED display which reads wavelength directly to the nearest $0.1 \text{ \AA}$. The motor gearing is such that each pulse to the motor advances the spectrometer $5/96 \text{ \AA}$.

The SR204 recorder is used in this system since it has remote control capabilities. The paper drive is a stepping motor run from an internal 50Hz square wave. The motor can also be driven from an external clock. By using the scan controller to produce the pulses for both the spectrometer stepping motor and the recorder stepping motor, their scan speeds will be synchronized. The recorder servo drive, pen lift and scan functions can also be controlled externally by applying TTL inputs to a rear panel connector. A TTL high input enables the particular front panel control

and a low input disables it. Thus to synchronize the beginning of the recorder scan with the spectrometer scan, the recorder front panel controls are set to scan and the controller enables the recorder functions at the same time as a spectrometer scan is initiated. A switch on the controller disconnects the inputs to the recorder to allow free scanning if desired.

Before going into the various parts of the circuitry in more detail, there are some other features of the scan controller which should be described. The main counting chip has a built-in comparator. This comparator is loaded with a wavelength and when the scan has reached this wavelength it will stop automatically. Limit switches are mounted at each end of the sine bar to prevent damage to the grating drive mechanism. The closing of either of these switches stops the scan and the controller will not allow a subsequent scan to be initiated in the same direction. The scan controller also places wavelength marks on the recorded spectrum. This permits accurate wavelength interpolation.

III. Description of circuitry

A) IC's used

With noted exceptions the IC's are 14 or 16 pin DIP packages of the CMOS logic family. In the figures simple gates are shown as discrete devices with no pin-outs given. Power and ground connections are not shown but the IC's used follow the normal convention (pin 14 or 16 is power, 7 or 8 is ground). The gates used are as follows:

2 input And:	4011, 14 pin, 4 per IC
2 input And:	4081, 14 pin, 4 per IC
3 input And:	4073, 14 pin, 3 per IC
2 input Or:	4071, 14 pin, 4 per IC
3 input Or:	4075, 14 pin, 3 per IC
Inverters :	4009, 16 pin, 6 per IC
Buffers :	4010, 16 pin, 6 per IC

Pin 1 on the 4009's and 4010's is an auxiliary voltage input. The voltage of a high output from all of the inverters or buffers on the IC is determined by the voltage applied to this pin. Those buffers and inverters wired to give 5 v. (TTL) outputs rather than 12 v. (CMOS) outputs have a 5 v. power connection indicated in the figures.

The more complicated IC's used are:

4027:	J-K Master-Slave Flip-Flop, 16 pin, 2 per IC
4020:	14 Stage Ripple-Carry Binary Counter, 16 pin
4089:	Binary Rate Multiplier, 16 pin
4029:	Presetable Up/Down Counter, 16 pin
K1100A:	Motorola 5.24288 MHz Crystal Oscillator (TTL)
74107:	J-K Master-Slave Flip-Flop, 14 pin, 2 per IC (TTL)
MK50395:	Mostek 6 Decade Counter/Decoder, 40 pin

The MK50395 counter deserves detailed description. The counter section holds six decades. Only five are used here. When the up/down input, pin 40, is high, it counts up. When pin 40 is low, it counts down. The count can be cleared to zero by applying a high to pin 20. The count is decoded digit by digit and is available as a seven segment output for an LED and as a binary coded decimal (BCD) output. The seven segment outputs a-g, pins 4-10, are used here. Digit strobe outputs D1-D6, pins 24-29, are available for multiplexing. The strobe frequency is set by the capacitor

between power and pin 21. The frequency used here is 10 KHz. The counter can be loaded to any number by bringing the counter load input, pin 31, high. The digits are loaded with thumbwheel switches, each inputting at pins 16-19. The loading is multiplexed with the digit strobes. The compare register is loaded at inputs 32-35 by bringing pin 30 high. When the counter content is equal to the comparator content, a high output appears at pin 23. The clock input is at pin 36. Counting is inhibited by a high applied to pin 37.

B) Power supply and translator board

Fig. 1 shows the power supply and translator board connections. The transformer, power resistors, capacitors, rectifier and translator board are all available from Superior Electronics. They make up the basic circuit needed to drive the HS50D stepping motor. Both positive and negative voltages (app. 20 v.) are used. The positive goes to pin P and the negative to N of the translator board. The +20 v. is also used as input to voltage regulators. The 5 v. regulator powers TTL circuitry. One of the 12 v. regulators powers CMOS circuitry and the other is used exclusively to power the LED's. One small 40 v. power supply is not shown.

The S and R inputs to the translator board are for the incoming pulses which trigger stepping. Input S is for decreasing the wavelength and R is for increasing. Negative going pulses of moderate magnitude are needed. We use a 0 to -20 v. square wave with app. 1 msec fall time.

C) Main frequency dividing circuit

Fig. 2 shows the main frequency dividing circuit. The scan speeds produced are 1000, 500, 200, 100, 50, 20, 10, 5 and 2 Å/min. With 5/96 Å/sec.

this requires stepping frequencies of 320, 160, 64, 32, 16, 6.4, 3.2, 1.6 and .64 Hz. The counter however must receive different frequencies if one count of the counter is to be $0.1 \text{ \AA}$. These frequencies are $2 \times \frac{1}{3} \times \frac{200}{256} \times v_s$, where v_s is the frequency of the stepping motor. By successive divisions of the output from the K1100A oscillator, the nine frequencies given above, and double these frequencies, are produced. The numbers beside the leads in Fig. 2 are the frequency of the square wave at that point. The outputs are run to S1 which selects the scan speed desired. The switch sends the frequency at "CK" toward the translator board, and double this frequency, at "CK'", to a dividing circuit in the main control section. This last circuit takes $\frac{1}{3} \times \frac{200}{256}$ of this frequency and sends it to the counter.

D) Main control circuit

In Fig. 3 the 2N6037 transistor to the left of the MK50395 is used to generate a voltage pulse which sets various Flip-Flops (F-F's) to desired initial states when the controller is powered up.

The two F-F's on the 4027 marked "A" in Fig. 3 control whether or not scan is allowed. This is because pin 1 of 4027A must be high for CK' pulses to get through gate 1 and on toward the counter, and for CK pulses to get through gate 2 or gate 3 and on toward the translator board. Lamps indicate whether or not a scan is in progress. Pin 1 is also inputted to the recorder remote inputs, so the recorder scan start (and stop) is synchronous with that of the spectrometer. Pin 1 of 4027A is set high, i.e. a scan is initiated, by depressing S3. Switch S2 determines the scan direction. It simultaneously sets the up/down input of the counter to the

proper voltage level and enables CK pulses to get through either gate 2 or gate 3 and on to the proper input of the translator board.

A scan is stopped by applying a reset to pin 4 of 4027A. This sets pin 1 low and leaves the F-F's in their original configurations. The reset can be applied by: using the preset wavelength limit, depressing an immediate stop button or hitting a spectrometer limit switch. The origins of these resets can be seen by referring to Fig. 3.

The wavelength marker is derived from the five 4029 IC's above and to the right of the counter. The clock pulses inputting the counter also input this frequency dividing chain. Outputs are taken which go high every 25, 100 and 500 Å. The desired output is selected by S10 and is used to temporarily close a relay switch. The relay grounds the input to the recorder when closed, so a narrow mark is placed on the recorded spectrum at the desired wavelength spacing. Switch S11 determines whether or not the marker circuit operates.

Fig. 4 shows the multiplexing circuits for the LED wavelength display and the BCD thumbwheel switches. The same set of thumbwheel switches is used for loading either the counter or the comparator depending on which of the counter's load inputs is brought high (S4 or S5 of Fig. 3).

A more detailed description of the operation of the circuitry is available from the authors upon request.

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Figure Captions

Fig. 1: Power supply and translator board connections.

Fig. 2: Main frequency dividing circuit.

Fig. 3: Control circuit.

Fig. 4: Multiplexing circuits.