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OPERATION OF AGS SWICS INCORPORATING AN 8085 MICROPROCESSOR

I. INTRODUCTION

In order to relieve the AGS PDP-10 computer from the problems associated with reading and calculating parameters from SWIC data every AGS pulse, an Intel Corp. 8085 microprocessor is used to acquire the data from the DATACON SWIC scanner. After calculating the mean and sigma of a beam profile, the microprocessor places the result back in the memory of the SWIC scanner. These parameters can thus be read by the AGS operations computer in one read (32 bits) as opposed to 16 reads (or 3.2 msec) and then performing the number crunching to derive the same mean and sigma.

II. HARDWARE DESCRIPTION

The AGS SWIC system is described in other reports.[1,2] However, for completeness, a brief review of the system will be presented. The ionization charge collected by the individual SWIC wires is stored in a capacitor module consisting of 32 equal capacitors. A solid state 32 channel multiplexer and sample and hold module scans the 32 capacitor voltages and generates a video display of a beam profile every 15 msec. This represents e.g. the horizontal profile. The same is done for the vertical profile. These signals are amplified, buffered and distributed to the various experimenter users, to the main control room, to the closed circuit cable TV system, and to the AGS PDP-8/10 control computer via a DATACON SWIC scanner card. This card requires a start trigger, a stop trigger and a 10 kHz clock signal, as well as control signals from the DATACON crate controller. The card then generates (at a rate of once per 300 μsec) count signals for the solid state 32 channel multiplexer, for the sample and hold, and for the two on-board 8-bit A/D converters (one for the horizontal plane and another for the vertical). The A/D 8-bit output for each channel is then transferred to an octal 32-bit (recirculating type) static shift register (memory). During the 5.4 msec gap in the 15 msec scanning cycle, the PDP-10 can read the contents of the memory and then use the data to calculate and display, or plot, the beam parameters for that AGS pulse. This requires a total number of

computer reads of : $2 \times \frac{1 \text{ read}}{32 \text{ bits}} \times \frac{8 \text{ bits}}{\text{wire}} \times 32 \text{ wires} = 16$ reads (or approximately 3.2 msec) for each SWIC. The large number of reads and calculations for every AGS pulse places a large burden on the PDP-10 computer and is therefore not usually done every pulse.

By interposing the microprocessor between the DATACON A/D converter and the memory chips we affect a small (but reversible) modification to the existing hardware. At the same time we utilize all the existing system which results in a very economical modification. We chose to use the 8085 prototype kit (SKD-85) which has a 2K on-board monitor, a 2K programmable memory, and 512 words of RAM memory. The system can be expanded to include more memory, but it has been found to be adequate for the existing program.

Physically the modifications include:

1. removal of the 3 memory chips from the DATACON scanner board and placing them on the μP board,

2. addition of an 8085 prototype kit mounted in a DATACON crate slot (incorporates local front panel displays and keyboard),

3. addition of 4 flat ribbon cables--3 to transfer the A/D data to the μP board and to return the data; 1 to provide timing information,

4. burn the program into a PROM.

III. 8085 μP DESCRIPTION

A. 8085 Program

The program was written in the 8085 assembly language. It uses 1700 words of the 2K available. The program is basically interrupt driven. The SWIC scanner A/D ready signal serves as an interrupt to the 8085 to read in the channel number and the x and y magnitudes of the SWIC. The μP then stores the data in a temporary buffer (numbered 2800-281F for x, and 2820-283F for y). Basically, the 8085 is doing this all the time on a continuous basis. The SWIC scanner interrupts the 8085 every 300 μsec. The other interrupt (presently provided by a predet trigger at the end of the beam spill) tells the μP to calculate the mean and sigma.

The 8085 sets up a flag and waits until the 32nd channel data is obtained in the latest cycle and then proceeds to the calculation phase. The program first moves the input data to another area (locations 2840-287F). The following quantities are then calculated:

1. SUM = sum of amplitude of the 32 channels.

2. $\Sigma\iota \cdot \chi_\iota$ = sum of [channel ι * amplitude of the ι^{th} channel].

3. $\Sigma\iota^2 \cdot \chi_\iota$ = sum of [channel ι^2 * amplitude of the ι^{th} channel].

Then, the mean is:

$$\text{Mean} = \frac{\Sigma\iota \cdot \chi_\iota}{\text{SUM}}$$

and the sigma is:

$$\text{sigma} = \sqrt{\frac{\Sigma\chi_\iota(\iota - \text{Mean})^2}{\text{SUM}}} = \sqrt{\frac{\Sigma\iota^2 \cdot \chi_\iota}{\text{SUM}} - (\text{Mean})^2}$$

The sums, items (2) and (3) are calculated to 24 bit accuracy. The elapsed time for all the calculations is 50 msec. The results are stored in the original SWIC scanner memory buffers using the following format:

Bit No.	1 – 9	10 – 16	17 – 25	26 – 32
	x mean	x sigma	y mean	y sigma

Bit No.	33 – 48	49 – 64
	x sum	y sum

The actual SWIC mean value is obtained by dividing the displayed x mean or y mean by 10. (9 bits, max. = 51.1.) The actual SWIC sigma value is obtained by dividing the displayed x sigma or y sigma by 10. (7 bits, max. = 12.7.) The DATACON buffers can be read anytime during the spill except when the 8085 is transferring the calculated data to them (< 1 msec). For the purpose of debugging and checking, a switch option was provided (Switch No. 3 - Table I) such that the raw input data is sent to the DATACON instead of the mean and sigma.

B. Operation and Options

When the μP is first powered up, the 8085 front panel displays show "8085", as follows:

		8	5	DATA FIELD (used to display SIGMA)
		8	0	ADDRESS FIELD (used to display MEAN)

The procedure for starting the system is:

1. press "RESET"
2. press "GO"
3. type in 0800 (which is the program starting location)
4. press "EXEC".

The program should begin executing. To test this, if the "VECTINTR" button is pressed, the front panel LEDs should flash. If the predet trigger interrupt is functioning, the LEDs should flash automatically every AGS cycle. When the LEDs flash, the data field and the address field displays should change. This indicates that the 8085 μP is functioning correctly.

Since we incorporate only one local display, a front panel DIP switch is utilized to select the different parameters to be displayed. Table I lists the switches, their status and the options.

The switch position No. 8 option was added to provide some means of correcting errors in the calculations that are caused by a malfunctioning SWIC wire (shorted) or a bad electronics channel. When the option is enabled (ON) the program checks the storage locations 2880 to 28BF (one location for each wire: 2880 to 289F for the x plane wires 1-32, and 28AØ to 28BF for the y plane wires 1-32). If the content of any address is "1" then the value of the data for that wire is replaced by a value consisting of the average of the two adjacent wires.

TABLE I

Switch No.	Status	Display Option
1	ON	MEAN AND SIGMA
1	OFF	SUM
2	ON	Y PLANE
2	OFF	X PLANE
3	ON	SEND DATACON RAW DATA
3	OFF	SEND DATACON MEAN AND SIGMA
4 - 6		NOT USED
7	ON	SUBTRACT FROM EACH CH. THE AVG. OF CH'S 2 & 31
7	OFF	NO SUBTRACTION
8	ON	DO EXTRAPOLATION
8	OFF	NORMAL CALCULATION

REFERENCES

1. Instrumentation for the Slow Extracted Beams, R. Witkover, BNL Internal Report AGS Div. 76-1.

2. AGS SWIC Systems, BNL EP&S Division Technical Note, to be published.