SLAC-PUB-3204
September 1983
(A)

INTELLIGENT MIRROR MONITOR AND CONTROLLER FOR SYNCHROTRON RADIATION BEAM LINES*

by
X. L. Xu †
Stanford Linear Accelerator Center
Stanford University, Stanford, California 94305
and
J. Yang
Stanford Synchrotron Radiation Laboratory, Stanford, California 94305

Abstract

A microprocessor-based, stand-alone mirror monitor and control system has been developed for synchrotron radiation beam lines. The operational requirements for mirror position and tilt angle, including the parameters for controlling the number of steps, direction, speed and acceleration of the driving motors, may be programmed into EPROMS. The instruction sequence to carry out critical motions will be stored in a program buffer. A manual control knob is also provided to fine tune the mirror position if desired. A synchronization scheme for the height and tilt motions maintains a fixed mirror angle during insertion. Absolute height and tilt angle are displayed. Electronic (or programmable) tilt angle limits are provided to protect against damage from misalignment of high power beams such as focussed wiggler beams. A description of mirror drives with a schematic diagram is presented. Although the controller is made for mirror movers, it can be used in other applications where multiple stepping motors perform complex synchronized motions.

Introduction

Devices such as targets, collimators, slits and mirrors which are installed in beam lines at SSRL require precise remote positioning and monitoring under computer control. Since 1973, these and similar applications have been handled by several kinds of home-made and commercial stepping motor controllers. New instruments being installed at SSRL require complex motor control and synchronization. Recent advances in microprosser-based stepping motor controllers have made these devices attractive choices for new applications.

The mirror mover on a new beam line at SSRL uses two paired stepping motors (one pair for translation, the other pair for inserton) to control mirror height and tilt angle. The Intelligent Mirror Monitor and Controller (IMMC) is aimed at meeting new beam line needs for multiple stepping motors and their synchronized operation. The system schematic diagram is shown in Figure 1. Here, two identical IMMCs are used for the mirror control system. Their difference is only the programs stored in EPROMs for their own positioning. The clockwise (CW) and counterclockwise (CCW) mechanical limits provide the signals to the microprocessor in IMMC for over travel protection.

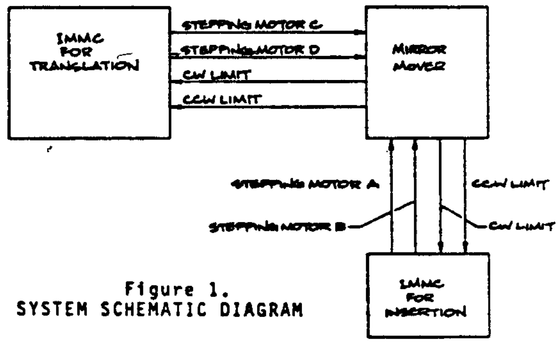

Figure 1.
SYSTEM SCHEMATIC DIAGRAM

The IMMC uses the single chip 8-bit microprocessor CY512 (Cybernetic Micro Systems' product) which has the following features:

1. Built in numerical control firmware to simplify programming.
2. Frees host processor by off-loading programs for each independent stepping motor.
3. Software direction and hardware/software start/stop control.
4. Absolute and relative positioning modes.
5. Programming in either ASCII or BINARY code.
6. Ramp-up/slew/ramp-down, step inhibit operation and selection.
7. 4000 pps maximum stepping rate (with 6 MHZ crystal).
8. 25 high level commands.
9. Sequences of high level commands stored internally in a program buffer and executed on command.
10. Ability to down load programs.

For convenient and flexible control operation, the system will work in a stand-alone mode.

System Description

Figure 2 shows the overall configuration of the system. Central to the design is the microprocessor CY512. This microprocessor has the ability to receive and process commands, to generate the desired timing sequences, and to drive the stepping motors.

Twenty five high level language commands (see Table 1) are available for programming. Tables 2,3 and

(Submitted to the Third National Conference on Synchrotron Radiation Instrumentation, Brookhaven National Laboratory, New York, September 12-14, 1983)

*Work supported by the Department of Energy, contract number DE-AC03-76SF00515.
†University of Science and Technology of China, Hefei, P.R.C. (Visiting Scholar at SLAC and SSRL).

4 are listings of programs which perform the three standard mirror operation: (1) insert mirror into the beam; (2) adjust the mirror height and (3) adjust the mirror tilt angle. These programs are stored in EPROM memory and selected.

The program may be selected using the "PRESET ADDRESS" or "SPEED SELECT" switches, and a push button "START" is used download the program into the microprocessor's buffer memory (see Figure 3). The BUSY/READY signal from the microprocessor synchronizes the load process, one byte at a time, until the end of the program (termination symbol OFFH) is needed. The end of the program then inhibits further program loading

Table 1
CY512 Command Summary

ASCII CODE	NAME	INTERPRETATION	BYTES STORED
A	Athome	Set current location as absolute zero	1
B	Bitset	Set programmable output line high	1
C	Clearbit	Reset programmable output line low	1
D	Doitnow	Begin program execution	1
E	Enter	Enter program code	1
F	Factor	Set facter parameter for step rate	2
G	Go	Begin relative stepping operation	1
H	Halfstep	Set halfstep mode of operation	1
I	Initialize	Turn off step drive lines, reset controller	1
J	Jump	Go to specified program buffer location	2
L	Loop	Repeat program segment for specified count	3
N	Number	Set number of steps to be taken (relative)	3
O	Offset	Set next stepper drive signal value	2
P	Position	Set and step to target position (absolute)	3
Q*	Quit*	Stop saving program, enter command mode. Also quit stepping. * never followed by ")"	1
R	Rate	Set step rate parameter	2
S	Slope	Set ramp rate for slew mode operation	2
T	Loop Til	Loop "Til" dowhile line goes high	1
U	Until	Stop execution until wait line is low	1
V	Verify	Verify internal buffer contents	2
W	Wait	Stop executing until wait line is high	1
X	eXpend	Time delay for specified milliseconds	3
+	CW	Set clockwise direction	1
-	CCW	Set counterclockwise direction	1
0	Command	Stop program execution, enter command mode	1

until the load process is restarted by setting the program start address. The microprocessor executes the program immediately after completion of the load process.

Manual operation is enabled when the MANUAL/AUTO switch is lever-locked in the MANUAL position. A front panel knob is provided to fine tune the mirror positions. It allows the motors in one-step operation mode in either clockwise or counterclockwise direction.

Three digital display meters are used to indicate the absolute mirror position (height at front, height at rear, tilt angle).

To protect against inadvertent mirror misalignment, the mirror mover contains the following:

1. Mechanical limit switches and stops to prevent over travel of all motions which may stress vacuum parts.
2. Two operational modes:
   a) Auto mode-- It is controlled by operator for adjusting mirror to proper position by means of selecting different programs to move the mirror to one of several preset positions.
   b) Manual mode-- Single-step, front panel knob control only.
3. Programmable limits for the tilt angle prevent the beam from striking the beam pipe. The limits are preset on DIP switches and compared with mirror's tilt value in real time. If exceeded, an inhibit signal will stop all motions.

Also, a two-position toggle switch on the front panel is provided to inhibit any mirror motion regardless of limit conditions.

Acknowledgement

The authors are grateful to Dr. H. Winick, deputy director of the Stanford Synchrotron Radiation Laboratory for his encouragement during this study. This work is supported by the U.S. Department of Energy through their support of SSRL and SLAC.

Table 2
H Speed Programs

Program 1 ASCII Commands	Program 1 BINARY Codes	Program 2 ASCII Commands	Program 2 BINARY Codes
I)	49 00	I)	49 00
E)	45 00	E)	45 00
+)	2B 00	-)	2D 00
N 100)	4E 02 64 00	N 100)	4E 02 64 00
R 240)	52 01 F0	R 240)	52 01 F0
S 50)	53 01 32	S 50)	53 01 32
F 1)	46 01 01		
G)	47 00	G)	47 00
X 500)	58 02 F4 01	X 500)	58 02 F4 01
L 10,7)	4C 02 0A 07	L 10,6)	4C 02 0A 06
0)	30 00	0)	30 00
Q	51	Q	51
D)	44 00	D)	44 00
Stopper	FF	Stopper	FF

Table 3
M Speed Programs

Program 3 ASCII Commands	Program 3 BINARY Codes	Program 4 ASCII Commands	Program 4 BINARY Codes
I)	49 00	I)	49 00
E)	45 00	E)	45 00
+)	2B 00	-)	2D 00
N 10)	4E 02 0A 00	N 10)	4E 02 0A 00
R 150)	52 01 96	R 150)	52 01 96
S 10)	53 01 0A	S 10)	53 01 0A
		F 1)	46 01 01
G)	47 00	G)	47 00
X 500)	58 02 F4 01	X 500)	58 02 F4 01
L 10,6)	4C 02 0A 06	L 10,7)	4C 02 0A 07
0)	30 00	0)	30 00
Q	51	Q	51
D)	44 00	D)	44 00
Stopper	FF	Stopper	FF

Table 4

L Speed Programs

Program 5		Program 6	
ASCII Commands	BINARY Codes	ASCII Commands	BINARY Codes
I)	49 00	I)	49 00
E)	45 00	E)	45 00
+)	2B 00	-)	2D 00
N 1)	4E 02 01 00	N 1)	4E 02 01 00
R 1)	52 01 01	R 1)	52 01 01
S 1)	53 01 01	S 1)	53 01 01
F 1)	46 01 01	F 1)	46 01 01
G)	47 00	G)	47 00
X 1000)	58 02 E8 03	X 1000)	58 02 E8 03
L 10,7)	4C 02 0A 07	L 10,7)	4C 02 0A 07
O)	30 00	O)	30 00
Q	51	Q	51
D)	44 00	D)	44 00
Stopper	FF	Stopper	FF

Table 5

Program Map in EPROM (2716)

000	Program 0 for insertion or translation
070	Program 5 for low speed CCW
080	Program 3 for medium speed CCW
0D0	Program 1 for high sped CCW
120	Program 2 for high speed CW
140	Program 4 for medium speed CW
180	Program 6 for low speed CW
7FF	

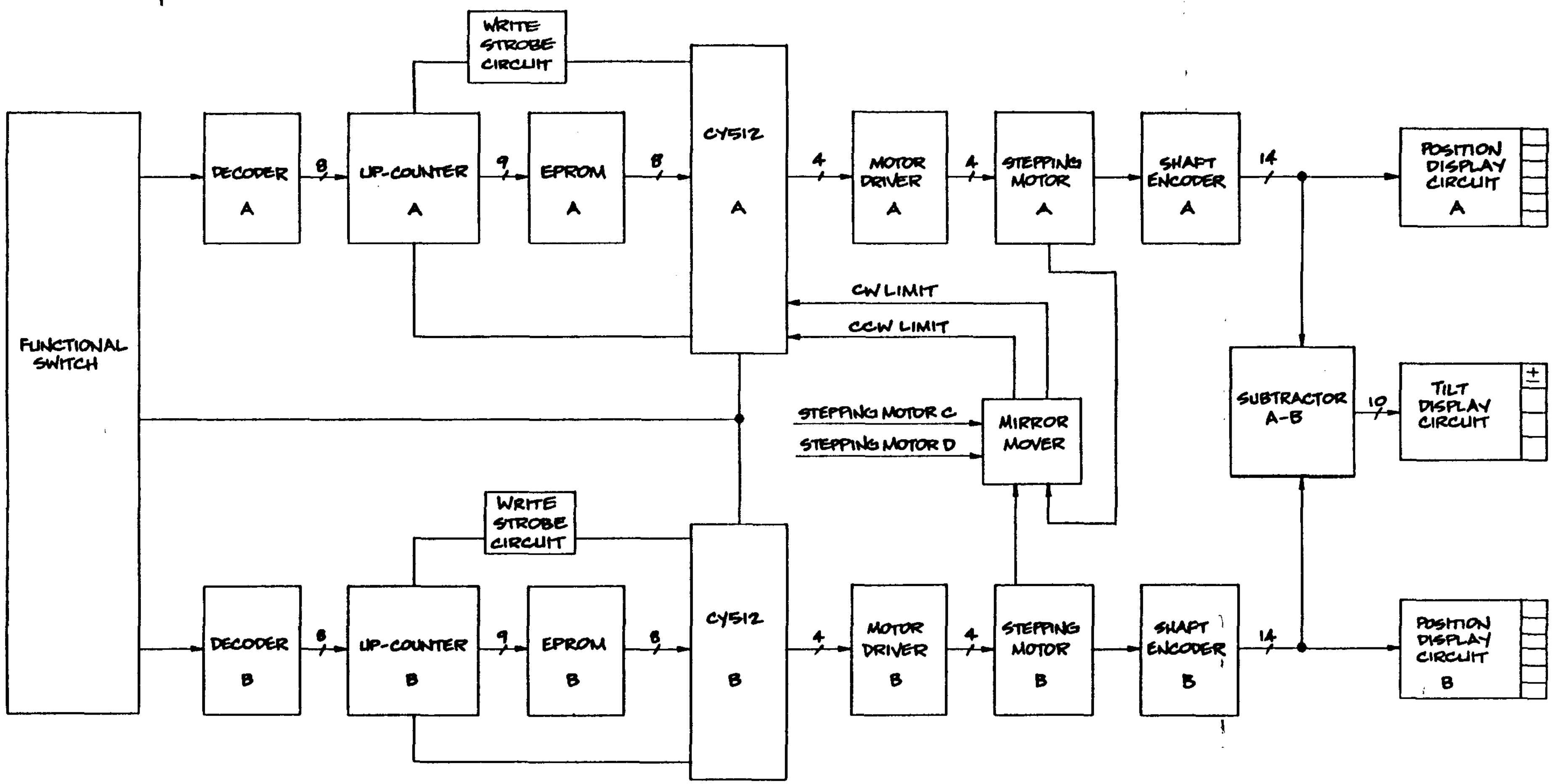

FIGURE 2
IMMC BLOCK DIAGRAM

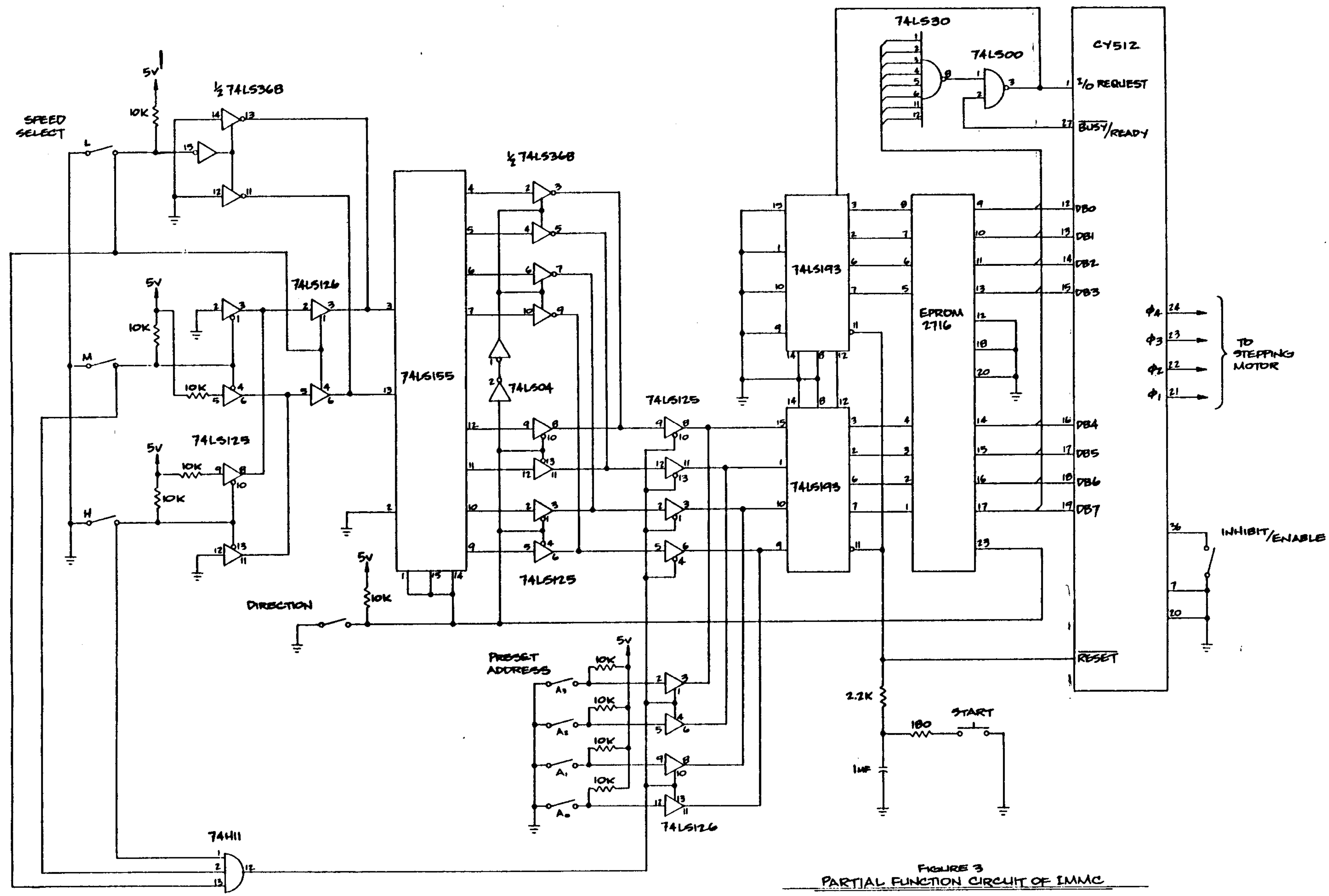

FIGURE 3

PARTIAL FUNCTION CIRCUIT OF IMMC