Allen Bradley - SLC150 Course

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Unit 4: Sequncer Instructions
Program Structures III

Sequencer Instructions include both the Sequencer Output ---(SQO)--- and the Sequencer Input ---(SQI)---. Both are retentive requiring the use of the Reset instruction. Sequencers instructions are addressed in the range 901-932. Sequencers may have up to 100 steps and can be either time or event driven. To program a sequencer, an understanding of hexadecimal number notation is required.

There are 16 possible combinations of 4 binary bits. Therefore, 16 symbols are required to represent each of the possible 4-bit combinations as shown in the table to the right. Hexadecimal Numbers are base 16 with a single digit used to represent 4 binary (base 2) digits. Since the decimal (base 10) number system has only 10 different symbols to represent a digit, the hexadecimal number system uses letters A through F to represent decimal 10 through 15.

Binary	Hex	Dec
0000	0	0
0001	1	1
0010	2	2
0011	3	3
0100	4	4
0101	5	5
0110	6	6
0111	7	7
1000	8	8
1001	9	9
1010	A	10
1011	B	11
1100	C	12
1101	D	13
1110	E	14
1111	F	15

Binary	Hex	Dec
0000,0000	00	0
0000,0111	07	7
0000,1010	0A	10
0000,1111	0F	15
0001,0000	10	16
0001,0011	13	19
0001,0100	14	20
0001,1111	1F	31
0011,0000	30	48
0100,0001	41	65
0110,1010	6A	106
0111,1011	7B	123
1000,0000	80	128
1001,1101	9D	157
1100,0110	C6	198
1111,1111	FF	255

The Sequencer Output Instruction ---(SQO)--- is used to alter a group of eight outputs or eight internal bits as defined by the group number. The Sequencer Input Instruction ---(SQI)--- is used to examine a group of eight inputs, eight outputs, or eight internal bits. The data for each step of the sequencer is described by a two digit hexadecimal number , because all data is eight bits in length.

External I/O Group Numbers

Bit Addresses	Group#
011-016 (Output) 017-018 (Internal)	0
111-116 (Output) 117-118 (Internal)	1
001-008 (Input)	7
101-108 (Input)	8
009-010 (Input) 109-110 (input)	14

Internal Bit Addresses (SQO or SQI Sequencers)

Bit Addresses	Group Number	Bit Addresses	Group Number
701-708	16	789-796	27
709-716	17	797-804	28
717-724	18	805-812	29
725-732	19	813-820	30
733-740	20	821-828	31
741-748	21	829-836	32
749-756	22	837-844	33
757-764	23	845-852	34
765-772	24	853-860	35
773-780	25	861-868	36*
781-788	26	869-876	37*

***NOTE:** Bit addresses 864 thru 876 apply to special instructions, explained in the following chapters:

Addresses 869-875: Chapter 8.

Addresses 864-868, 876: Chapter 14.

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SQO Instruction:

The Sequencer Output instruction is either time driven or event driven. The Sequencer table defines the operation of the sequencer. A description of each entry in the table follows.

Address = Each sequencer must have a valid address in the range 901-932.

Group Number = The group number defines which group of eight bits can be altered by the SQO instruction.

MASK = The mask is represented as two hexadecimal digits and defines which of the group of eight bits can be altered by the SQO instruction.

DATA = Each sequencer step has eight bits of data which is sent to the 8-bits specified by the group number when the sequencer step is active.

PRESET VALUE = Each step has a preset value which represents tenths of a second for a time driven sequencer and the number of false-true transitions for an event driven sequencer.

Time Driven SQO Instructions operate such that the 8-bit data contained at the active step, is transfered to the masked 8-bits specified in the group number. The sequencer stays at this step until the sequencer rung is true for the number of tenths of a second specified in the Preset Value and then increments to the next step. Each time the sequencer increments a step, the step's data is transferred to the masked 8-bits specified by the group number. After the final step is executed the sequencer returns to step 0 of the sequencer. The *Step Completion Bit* has the same address as the SQO instruction and is On for one scan cycle when a step transition occurs. It is used in a program with Examine On or Examine Off instructions.

Event Driven SQO Instructions operate similar to the time driven SQO, except that the sequencer step number is incremented when the number of false-true transitions equals the Preset Value.

Time Driven SQI Instructions operate such that the 8-bit data contained at the active step, is compared with the masked 8-bits specified in the group number. When the two groups of bits are the same, the *Input Satisfied Bit* will turn On. The input satisfied bit has the same address as the SQI instruction. It is used in the program with Examine On or Examine Off instructions. The sequencer stays at a step until the sequencer rung is true for the number of tenths of a second specified in the Preset Value and then increments to the next step. Each time the sequencer increments a step, the new step's data is compared with the masked 8-bits specified by the group number. After the final step is executed the sequencer returns to step 0 of the sequencer.

Event Driven SQI Instructions operate similar to the time driven SQI, except that the sequencer step number is incremented when the number of false-true transitions equals the Preset Value.

Rung: 001						Time Driven			GEAR SHIFT
I/O Address :	708	707	706	705	704	703	702	701	901
Hex Mask :			3			F			-(SQO)-
Binary Mask :	0	0	1	1	1	1	1	1	GRP 16

Step #	Hex Data	Binary Data								Preset Value
00	38	-	-	1	1	1	0	0	0	0030
01	32	-	-	1	1	0	0	1	0	0030
02	38	-	-	1	1	1	0	0	0	0020
03	18	-	-	0	1	1	0	0	0	0030
04	2C	-	-	1	0	1	1	0	0	0030
05	32	-	-	1	1	0	0	1	0	0030
06	13	-	-	0	1	0	0	1	1	0030

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SQO_SQI Program:

Examine rung 3. The conditions in the upper branch will be used to actuate the sequencer. Move the cursor to the SQO and push the F9 (Instruction Atribute) key. Push the F9 (Edit Sequence) key to examine the sequencer table. Describe the operation of this table. Push <ESC> twice and then toggle switch 1 to activate the sequencer.

Examine rung 4 and describe how the reset functions with the sequencer.

Examine rung 1 and describe the operation of this rung. Examine the time driven SQO 901. Push switch 3 to activate this sequencer. Describe how the reset instruction of rung 2 affects this sequencer.

Turn off switches 1 & 3, turn on switch 5. Describe the operation of the PLC and how the program perform this function.

Rungs 5 through 7 are used to test your ability to count using 3 binary bits (switches 6, 7, and 8). Output 16 will go on when the correct combination of switches is engaged. Switch 9 is used to increment to the next binary number. Switch 10 is used to reset to 000. If you you need help with counting in binary, you can cheat by looking at the 903 SQI sequencer table.

SEQENCER Program

Read the program SEQENCER from the disk and save to the SLC using the PCIS software. This program has a time driven actuation sequence to control a horizontal hydraulic cylinder, and an event driven sequencer with two limit switches at inputs 3 and 4 to control a vertical cylinder. Manual controls are available for all outputs in the program off mode. Both of these program structures are commonly used to control hydraulic solonoid valves.

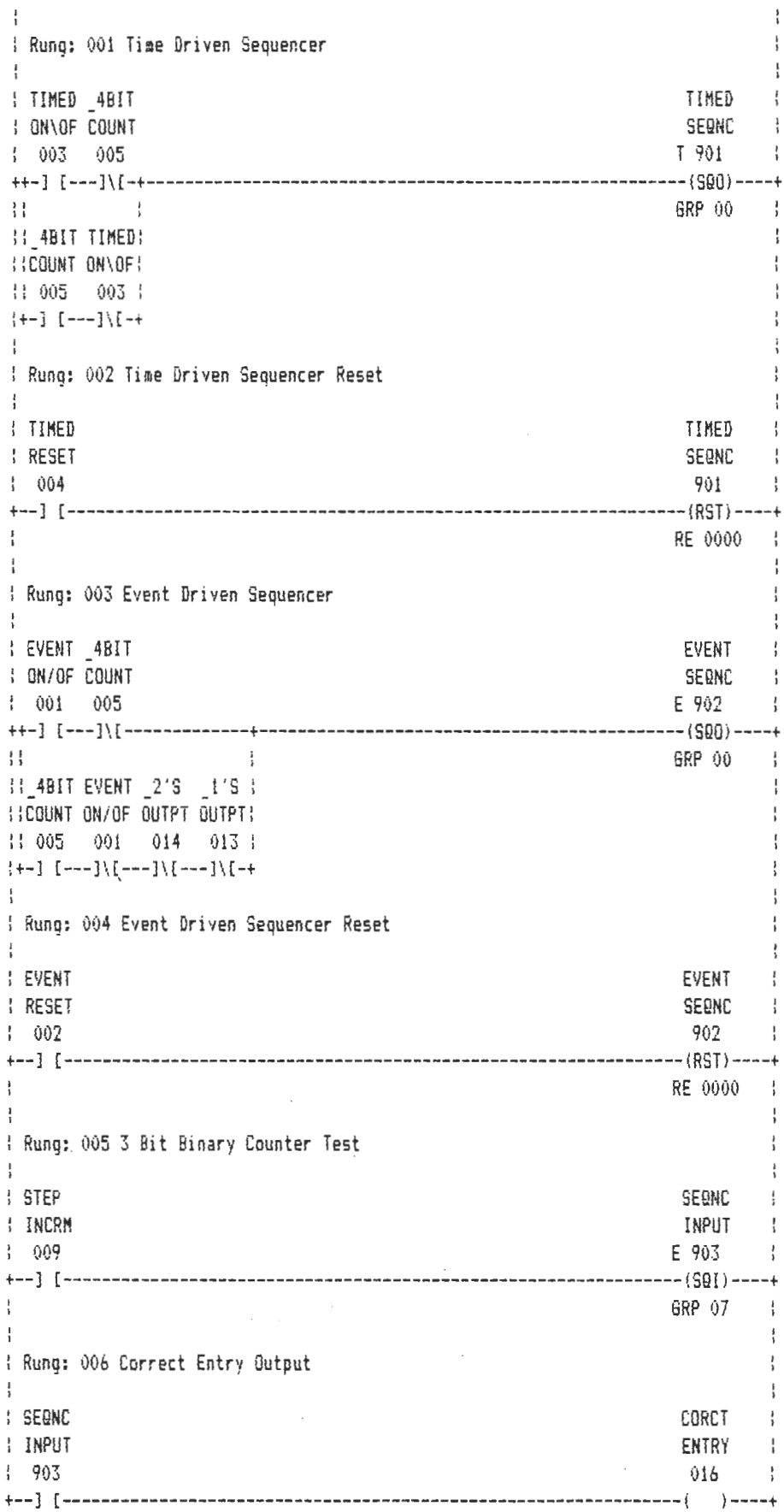
The first and last rungs of the SEQENCER program contain a new output instruction called a Master Control Relay symbolized by ---(MCR)---. When the conditions in the first MCR rung are True, all rungs between the two MCR rungs function normally. When the first MCR rung is False, all outputs are turned Off and accumulator values are saved for counters, timers, and sequencers. This is an ideal instruction to use for shuting off all outputs when an emergency stop condition occurs.

Rungs 2 through 5 actuate the horizontal cylinder in two directions specified as the head and rod end. The sequence is control by the SQO 904 instruction. Move the cursor to the SQO and push the F9 (Instruction Atribute) key. Push the F9 (Edit Sequence) key to examine the sequencer table. Describe the operation of this table. Push <ESC> twice and then toggle switch 1 to activate the sequencer.

Examine rung 3 and describe how the reset functions with the sequencer.

Note how rungs 4 and 5 are used to implement manual and auto control.

Rungs 6 through 11 actuate the vertical cylinder. The SQI instruction in rung 6 is used to examine the state of the two limit switches and the SQO instruction is used actuate the cylinder. Note that rungs 8 and 9 are used to reset the sequencers. Rungs 10 and 11 are used to implement manual and auto control.


Rung: 001 Time Driven Sequencer
TIMED _4BIT
ON\OF COUNT
003 005
TIMED
SEQNC
T 901
(SQO)
GRP 00
_4BIT TIMED
COUNT ON\OF
005 003
Rung: 002 Time Driven Sequencer Reset
TIMED
RESET
004
TIMED
SEQNC
901
(RST)
RE 0000
Rung: 003 Event Driven Sequencer
EVENT _4BIT
ON/OF COUNT
001 005
EVENT
SEQNC
E 902
(SQO)
GRP 00
_4BIT EVENT _2'S _1'S
COUNT ON/OF OUTPT OUTPT
005 001 014 013
Rung: 004 Event Driven Sequencer Reset
EVENT
RESET
002
EVENT
SEQNC
902
(RST)
RE 0000
Rung: 005 3 Bit Binary Counter Test
STEP
INCRM
009
SEQNC
INPUT
E 903
(SQI)
GRP 07
Rung: 006 Correct Entry Output
SEQNC
INPUT
903
CORCT
ENTRY
016
( )

```
|                                                                    |
| Rung: 007 Reset Test Sequencer To Step 0                           |
|                                                                    |
| SQI                                                        SEQNC   |
| RESET                                                      INPUT   |
|  010                                                        903    |
+--] [-------------------------------------------------------(RST)----+
|                                                           RE 0000  |
|                                                                    |
+--------------------- End of Ladder --- Words used = 00063 ---------+
```

Rung: 001 — Time Driven — TIMED SEQNC 901 — (SQO) — GRP 00

I/O Address :	18	17	16	15	14	13	12	11
Hex Mask :			0			C		
Binary Mask :	0	0	0	0	1	1	0	0

Step #	Hex Data	Binary Data	Preset Value
00	00	- - - - 0 0 - -	0010
01	08	- - - - 1 0 - -	0010
02	04	- - - - 0 1 - -	0010
03	0C	- - - - 1 1 - -	0010

Rung: 003 — Event Driven — EVENT SEQNC 902 — (SQO) — GRP 00

I/O Address :	18	17	16	15	14	13	12	11
Hex Mask :			0			3		
Binary Mask :	0	0	0	0	0	0	1	1

Step #	Hex Data	Binary Data	Preset Value
00	00	- - - - - - 0 0	0001
01	02	- - - - - - 1 0	0001
02	01	- - - - - - 0 1	0001
03	03	- - - - - - 1 1	0001

Rung: 005 — Event Driven — SEQNC INPUT 903 — (SQI) — GRP 07

I/O Address :	8	7	6	5	4	3	2	1
Hex Mask :			E			0		
Binary Mask :	1	1	1	0	0	0	0	0

Step #	Hex Data	Binary Data	Preset Value
00	00	0 0 0 - - - - -	0001
01	80	1 0 0 - - - - -	0001
02	40	0 1 0 - - - - -	0001
03	C0	1 1 0 - - - - -	0001
04	20	0 0 1 - - - - -	0001
05	A0	1 0 1 - - - - -	0001
06	60	0 1 1 - - - - -	0001
07	E0	1 1 1 - - - - -	0001

```
|                                                                          |
| Rung: 001 EMERGENCY STOP SWITCH: Turns All Outputs Off when Stop is On   |
|                                                                          |
| EMERG                                                          OUTPT     |
| STOP                                                            OFF      |
|  010                                                                     |
+--]\[-------------------------------------------------------------(MCR)----+
|                                                                          |
| Rung: 002 HORIZONTAL CYLINDER: Actuation Sequence                        |
|                                                                          |
| HORIZ                                                          HORIZ     |
| ON/OF                                                          SEQNC     |
|  001                                                          T 904      |
+--] [-------------------------------------------------------------(SQO)----+
|                                                                GRP 16    |
|                                                                          |
| Rung: 003 HORIZONTAL CYLINDER: Sequencer Reset                           |
|                                                                          |
| HORIZ                                                          HORIZ     |
| ON/OF                                                          SEQNC     |
|  001                                                            904      |
+--]\[-------------------------------------------------------------(RST)----+
|                                                               RE 0000    |
|                                                                          |
| Rung: 004 HORIZONTAL CYLINDER: Rod Actuation Auto/Manual                 |
|                                                                          |
| HORIZ HZROD                                                    HORIZ     |
| ON/OF  BIT                                                      ROD      |
|  001   701                                                      011      |
++-] [---] [-+-----------------------------------------------------(   )----+
||           |                                                             |
||HORIZ HZROD|                                                             |
||ON/OF MANUL|                                                             |
|| 001   006 |                                                             |
|+-]\[---] [-+                                                             |
|                                                                          |
| Rung: 005 HORIZONTAL CYLINDER: Head Actuation Auto/Manual                |
|                                                                          |
| HORIZ HZHED                                                    HORIZ     |
| ON/OF  BIT                                                     HEAD      |
|  001   702                                                      012      |
++-] [---] [-+-----------------------------------------------------(   )----+
||           |                                                             |
||HORIZ HZHED|                                                             |
||ON/OF MANUL|                                                             |
|| 001   007 |                                                             |
|+-]\[---] [-+                                                             |
|                                                                          |
| Rung: 006 VERTICAL CYLINDER: Input Sequencer                             |
|                                                                          |
| VRTCL VRTCL                                                    VRTCL     |
| ON/OF  SQO                                                      SQI      |
|  002   906                                                    E 905      |
+--] [---] [-------------------------------------------------------(SQI)----+
|                                                                GRP 07    |
```

```
|                                                                    |
| Rung: 007 VERTICAL CYLINDER: Output Sequencer                      |
|                                                                    |
| VRTCL VRTCL VRTCL                                          VRTCL   |
| ON/OF  SQO   SQI                                            SQO    |
|  002   906   905                                          E 906    |
+--] [---]\[---] [-------------------------------------------(SQO)----+
|                                                           GRP 16   |
|                                                                    |
| Rung: 008 VERTICAL CYLINDER: Input Sequencer Reset                 |
|                                                                    |
| VRTCL                                                      VRTCL   |
| ON/OF                                                       SQI    |
|  002                                                        905    |
+--]\[-------------------------------------------------------(RST)----+
|                                                           RE 0000  |
|                                                                    |
| Rung: 009 VERTICAL CYLINDER: Output Sequencer Reset                |
|                                                                    |
| VRTCL                                                      VRTCL   |
| ON/OF                                                       SQO    |
|  002                                                        906    |
+--]\[-------------------------------------------------------(RST)----+
|                                                           RE 0000  |
|                                                                    |
| Rung: 010 VERTICAL CYLINDER: Rod Actuation Auto/Manual             |
|                                                                    |
| VRTCL VTROD                                                VRTCL   |
| ON/OF  BIT                                                  ROD    |
|  002   703                                                  013    |
++-] [---] [-+-----------------------------------------------(   )----+
||          | |                                                      |
||VRTCL VTROD|                                                      |
||ON/OF MANUL|                                                      |
|| 002   008 |                                                      |
|+-]\[---] [-+                                                      |
|                                                                    |
| Rung: 011 VERTICAL CYLINDER: Head Actuation Auto/Manual            |
|                                                                    |
| VRTCL VTHED                                                VRTCL   |
| ON/OF  BIT                                                 HEAD    |
|  002   704                                                  014    |
++-] [---] [-+-----------------------------------------------(   )----+
||           |                                                       |
||VRTCL VTHED|                                                       |
||ON/OF MANUL|                                                       |
|| 002   009 |                                                       |
|+-]\[---] [-+                                                       |
|                                                                    |
| Rung: 012                                                          |
|                                                                    |
|                                                                    |
|                                                                    |
|                                                                    |
+--------------------------------------------------------------(MCR)----+
```

End of Ladder --- Words used = 00070

Rung: 002									Time Driven	HORIZ SEQNC
I/O Address :	708	707	706	705	704	703	702	701		904
Hex Mask :			0			3				-(SQO)-
Binary Mask :	0	0	0	0	0	0	1	1		GRP 16

Step #	Hex Data	Binary Data								Preset Value
00	01	-	-	-	-	-	-	0	1	0015
01	02	-	-	-	-	-	-	1	0	0005

Rung: 006									Event Driven	VRTCL SQI
I/O Address :	8	7	6	5	4	3	2	1		905
Hex Mask :			0			C				-(SQI)-
Binary Mask :	0	0	0	0	1	1	0	0		GRP 07

Step #	Hex Data	Binary Data								Preset Value
00	04	-	-	-	-	0	1	-	-	0001
01	08	-	-	-	-	1	0	-	-	0001

Rung: 007									Event Driven	VRTCL SQO
I/O Address :	708	707	706	705	704	703	702	701		906
Hex Mask :			0			C				-(SQO)-
Binary Mask :	0	0	0	0	1	1	0	0		GRP 16

Step #	Hex Data	Binary Data								Preset Value
00	04	-	-	-	-	0	1	-	-	0001
01	08	-	-	-	-	1	0	-	-	0001