SECTION 6
INTRODUCTION TO LADDER LOGIC

This section describes the basic ladder logic that is used in programming the Micro 84 PC. The elements used in Ladder Logic programming include relay contacts, coils, references, registers, and function blocks. The controller's logic is structured into networks, and programmed into the Micro 84 PC via a P190 Programmer. The controller scans each network and solves the logic which controls the input to other logic in the program, or controls an output (i.e., turning ON a switch, stopping a process, resetting a meter, etc.).

6.1 NETWORKS

A network is a set of interconnected logic elements which represents all, or part of the user's Micro 84 PC program. Each network has a maximum width of 7 columns and a maximum height of 4 rows (see Figure 6-1)

A network can contain any combination of relay contacts, coils, counters, timers, and arithmetic function blocks. The logic can fill the entire network area or just a portion of it.

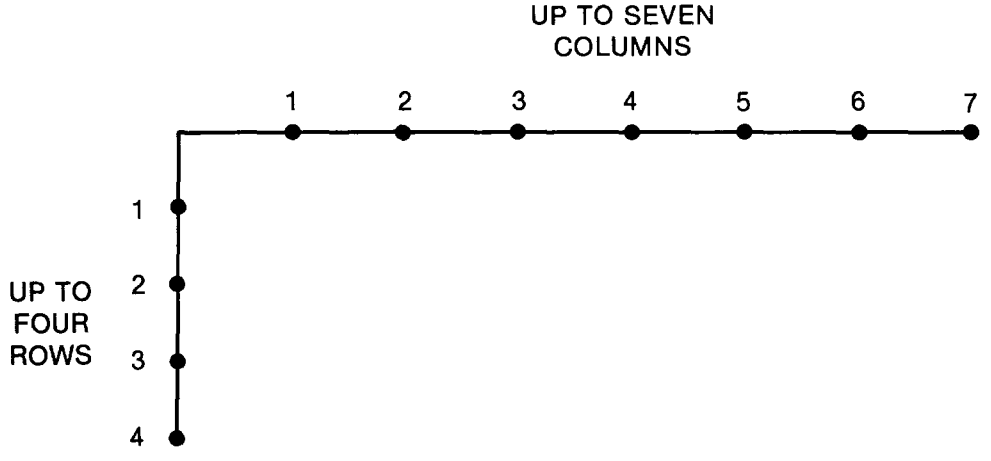


Figure 6-1. Network Parameters

6.2 SOLVING NETWORK LOGIC

The MICRO 84 function is to "solve" the ladder logic networks. To do this, it "scans" the various elements of a network, checking the state of each input element (are contacts open or closed, etc.) and setting the status of the output coils accordingly. In performing its scan of a network, the MICRO 84 first checks the status of the left-most COLUMN of elements from the top row to the bottom row, and then proceeds COLUMN by COLUMN to the right, until the entire network is "solved". An element in Row 3, Column 4 is scanned (and solved) before an element in Row 1, Column 6. The output of the first element can be used as input to the second element. Figure 6-2 illustrates the sequence the controller uses in solving a network.

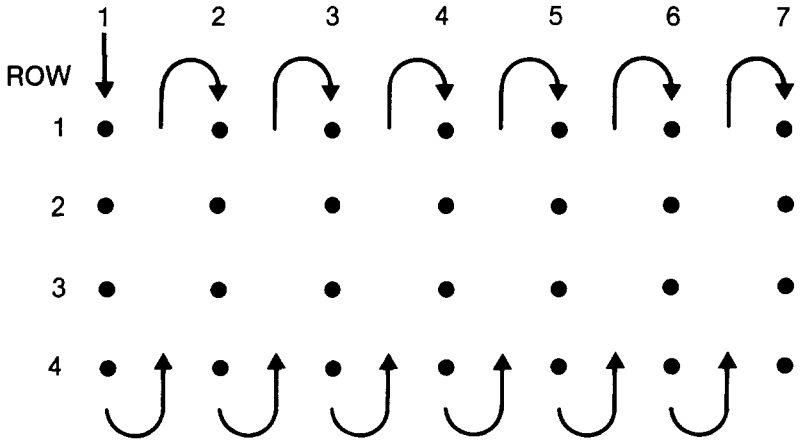


Figure 6-2. Network Solving Sequence

The MICRO 84 solves a network in a particular fixed sequence. You can arrange the logic elements so that the status of a coil can be used as discrete input to a contact in a column to the right of the coil (see Figure 6-3). The status of a coil also can be used as discrete input to another network.

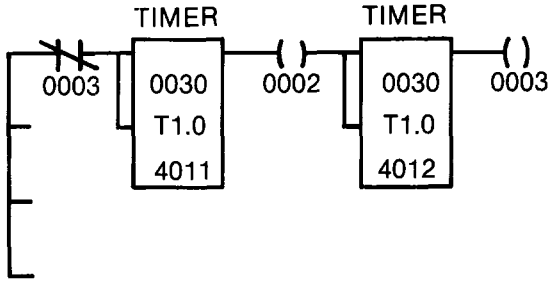


Figure 6-3. Coil Used As Discrete Input

6.3 REFERENCES

Four digit reference numbers are used to identify relay contacts, coils, inputs, outputs, latches and registers. There are four types of references. Each type has a different code digit to identify it; this digit is the first of four consecutive digits. The reference types and their functions are listed in Table 6-1.

Table 6-1. References

0XXX — Coil/Discrete Output

- A discrete (ON/OFF) signal that is controlled by logic.
- Can be used to drive a real output through an output module. Can be used only once in the program.
- Can be used internally to drive one or more contacts in user logic. Can be used many times in the program.

1XXX — Discrete Input

- Status of the input is controlled by an input module.
- Used to drive contacts in user logic.
- Can be used repeatedly in the program.

2XSS — Sequencer Contact or Relay.

- X refers to the specific 400X register controlling the sequencer.
- SS refers to the step number in 2XSS Sequencer
- Used to control a contact
- Used to provide step information.

3XXX — Input Register

- A numerical input from an external source (i.e., thumbwheel, analog signal, or high speed counter).
- Sixteen consecutive discrete signals.

4XXX — Holding/Output Register

- Used to store numerical information in the controller.
- Can output numerical information to an output module.

NOTE

These numbers refer to actual registers or discretes within the controller that contain numerical values or ON/OFF conditions. An X is any digit, 0 through 9; however, it may have a specific limit (for example, maximum 6) as designated in the configuration table.

6.4 PROGRAMMING FUNCTIONS

The MICRO 84 Programmable Controller has the ability to program or simulate the operation of relay contacts, timers, sequencers, counters, and arithmetic functions. All programming is done on the basic format of up to seven elements in each horizontal row or rung. A network can be a single rung, two rungs, or up to four rungs. Relay type elements occupy a single node position within a network and non-relay type elements (counters, timers and arithmetic operations) occupy two vertically oriented node positions within a network.

Data is entered directly into the memory of the controller (it is not stored in the programming panel). If AC line power is interrupted prior to completion of the programming, the data entered is retained. No additional operations are required; the data you enter is the data stored for use by the controller.

Network elements can be added, deleted, or changed at any time using the programming panel. The logic changes do not interrupt the controller's operation. In addition, the effect of any coil (input or output) on system operation can be tested by simulating inputs and outputs using the MICRO 84's disable feature.

The basic programming elements are the contacts, coils, and connectors shown below:

6.5 RELAY CONTACTS

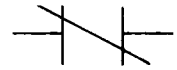
The relay contact is the basic programming element. It can be referenced to either a logic coil (0XXX), a discrete input (1XXX), or a sequencer (2XSS). The contact is opened (no power passing through) or closed (power passing through) when a certain condition exists (such as, logic coil is energized or de-energized; input signal is ON or OFF).

Relay contacts can be normally open or normally closed.

6.5.1 Normal Contacts

The two most commonly used contacts are:

Normally Open (NO) Contact 

Normally Closed (NC) Contact 

When the coil or discrete input is ON, the normally open (NO) contact is closed and passes power, and the normally closed (NC) contact is open and does not pass power.

When the coil or discrete input is OFF, the NO contact is open and does not pass power, and the NC contact is closed and passes power. See Table 6-2.

Table 6-2. Normally Open and Normally Closed Contacts

	NO Contact	NC Contact
Coil or Discrete Input is ON	passes power	does not pass power
Coil or Discrete Input is OFF	does not pass power	passes power

6.5.2 Inserting Contacts

A relay contact is inserted into a program by placing the cursor over the desired location, keying a reference (0XXX, 1XXX, or 2XSS) into the Assembly Register (AR) and pressing the appropriate relay contact software label key.

To change the type of relay contact, place the cursor over the contact to be changed and press the desired software label key. To change the reference numbers below a contact, position the cursor over the contact, enter a new value into the AR, and press the ENTER key.

6.6 VERTICAL AND HORIZONTAL SHORTS

Vertical and horizontal shorts are straight line connections between contacts.

Vertical shorts are used to connect contacts and function blocks one above the other in a network. Vertical shorts can also be used to connect inputs or outputs in a function block to create either/or conditions. When two contacts are connected by vertical shorts, a vertical short on each side, power is allowed to pass through if either, or both, contacts receive power.

To enter a vertical short, place the cursor to the left and above the reference for the short, and press the VER OPEN/VER SHORT software label key. A vertical short is cleared (or opened) by pressing the VER OPEN software label key and the SHIFT key. If a vertical short is used in combination with other logic elements, the vertical short must be entered first.

Horizontal shorts are used in combination with vertical shorts to expand logic within a network without breaking the power flow. They can be used to create either/or conditions using basic relay contacts. For example, if one line of logic contains two relay contacts, and the line below it only contains one contact, a horizontal short can be placed beside the single contact. (See Figure 6-4.)

A vertical short is used to connect the horizontal short to the top logic line. Power passes through to energize the coil, if the two top contacts are energized, or if the bottom contact is energized.

To enter a horizontal short, place the cursor over the reference desired for the short and press the "------" software label key. To clear a horizontal short, press the DELETE NODE label key on the P190 Programmer.

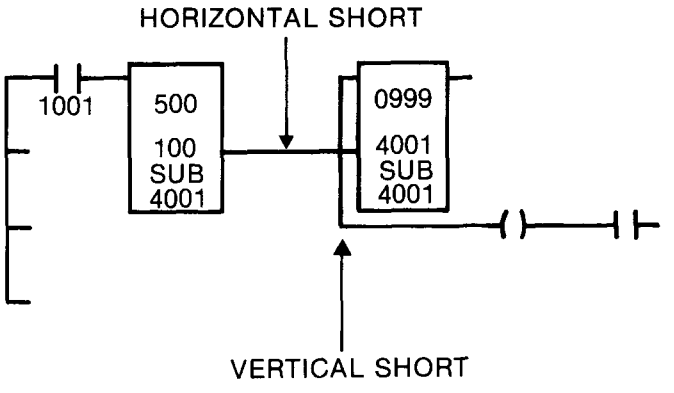


Figure 6-4. Shorts

6.7 COILS

A coil is used to activate logic within a program, and/or to control an output circuit. It is represented by a 0XXX reference number and either of two symbols:

A Normal, Non-retentive Coil, ———( )———, is turned OFF if power is removed and later restored (power cycle).

A Latched, Retentive Coil, ———(L)———, retains its previous state through a power cycle.

NOTE

A normal, non-retentive, disabled coil retains its disabled state through a power cycle.

Coils can be located in any column of a network. Each 0XXX reference can be used as a coil only once, but can be referenced to any number of relay contacts.

A logic coil is inserted into a program the same way as a relay contact. The cursor can be directly beside the last logic element in a row. When the COIL software label key (———( )——— or ———(L)———) is pressed, the coil is inserted. The only reference allowed is a 0XXX reference, unlike relay contacts which allow 0XXX, 1XXX, or 2XSS references.

6.8 DISABLE/ENABLE

Any logic coil or discrete input in a program can be disabled, and forced ON or OFF, from the P190 keyboard. DISABLE separates the state of the coil/discrete input from control of the PC logic. DISABLE/ENABLE is used for debugging and wiring I/O devices and allows you to test the changes before you actually change your existing logic.

Disabling a coil or input causes the programmed logic to bypass that particular coil or input. Use of the FORCE ON and FORCE OFF software label keys allow you to control the state of that particular coil or input. Memory Protect must be OFF.

To disable a coil or input, follow the instructions below:

1. Ensure that Memory Protect is OFF on the P190 Programmer.

2. Go to the Logic Functions software label keys (———( )———, ———| |———,———| |———,etc.) and press the NEXT MENU software label key.

3. Position the cursor over the desired coil on the logic screen.

4. Press the DISABLE and FORCE ON and FORCE OFF software label keys, as desired.

To disable a coil without displaying it on the logic screen:

1. Press the Change Screen key on the P190 keyboard.

2. Press the PART REF software label key.

3. Enter the coil reference number or discrete innput reference number in the Assembly Register (AR).

4. Press the GET COL/GET REF software label key or the ERASE/GET key.

5. Press DISABLE and FORCE ON/FORCE OFF as desired.

The reference number appears at the cursor position with its state, ON or OFF, and the following software labels appear:

GET COL GET REF	PREV REF NEXT REF	ERASE COL ERASE REF	RELEASE HOLD	ENABLE	DISABLE	FORCE ON	FORCE OFF

Press the FORCE ON or FORCE OFF software label keys to change the state of the coil or input. Press the ENABLE software label key to enable the coil or input. If the coil or input is enabled, it cannot be forced ON or forced OFF; it retains the state it had when the ENABLE software label key was pressed.

Disabling a coil or input causes the programmed logic to bypass that coil or input. Use of the FORCE ON and FORCE OFF software label keys allow you to control the state of a specific coil or input from the P190. Memory Protect must be OFF.

WARNING

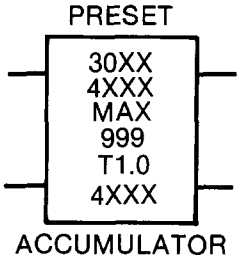
Disabling a coil does not disconnect AC or DC power at the corresponding output module. The coil's state determines power flow. This may cause personal injury if a coil, assumed to have been disabled, changes state while a repair is being made.

6.9 TIMERS

Two timer rates are provided in the MICRO 84: one second and one tenth of a second. These internal timers can be used to create as many logic program timers as are necessary.

The timer content is not lost due to a power failure.

The one second timer (T1.0) is used to measure times between 1 second and 999 seconds. The one tenth of a second timer (T0.1) is used to measure times between 0.1 second and 99.9 seconds. The format of the timer element is shown below:



Input 1
The timer is activated when power is connected to Input 1. A normally open contact is usually in this input line.

Input 2
The timer is enabled (able to be activated) when power is connected to Input 2 and is reset when power is removed. A normally closed contact is usually in this input line.

Preset
The upper element of the timer (preset) is used for setting the time period in seconds, or in tenths of seconds, that is to elapse before Output 1 is activated. The preset can be a fixed value (up to 999) or a register. When the preset is a register (reference number 3XXX or 4XXX), the content of the register (a value up to 999) is used as the preset value. This register may be used by all timers having the same preset value.

Accumulated Time
The lower element of the timer must be a register (reference number 4XXX) in which the actual (accumulated) time is stored. This "holding" register must be unique for this timer.

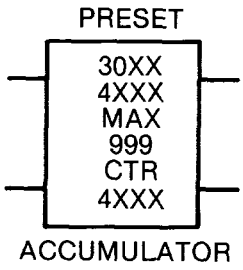
Output 1
Output 1 is a normally open circuit that becomes a closed circuit when the accumulated time equals the preset time. Remains closed until the timer is reset or until the equality no longer exists.

Output 2
Output 2 is a normally closed circuit that becomes an open circuit when the accumulated time equals the preset time. Remains open until the timer is reset or until the equality no longer exists.

6.10 COUNTERS

The MICRO 84 contains circuits that simulate event counters. The counter increases its value by one whenever the input signal goes from OFF (de-energized) to ON (energized). Only on this positive transition (OFF to ON) is the count increased. Even if the input signal remains ON for several hours, it represents only one transition from OFF to ON and is thus only one count.

The format of the counter element is shown below:



The counter functions the same as the timer except that the preset value and the value being accumulated in the lower register are in terms of the number of times an event has occurred rather than the amount of time that has elapsed.

6.11 CASCADING TIMERS AND COUNTERS

Timers and counters can be interconnected or cascaded to satisfy any required logic (see Figure 6-5). As many timers and counters as necessary can be placed within a network limited only by the 4 x 7 logic element format.

Two timers (or counters) can be placed in series (interconnected) by using output 1 of one timer as input 1 to a second timer. These two timers allow twice as much time to be measured; they are cumulative in effect.

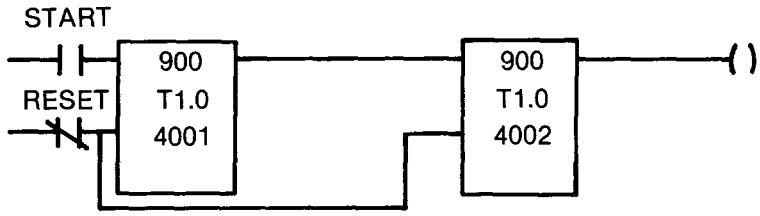


Figure 6-5. Interconnecting Timers

Timers and counters can also be cascaded to, in effect, multiply their range. Figure 6-6 illustrates a timer/counter network that produces a time-of-day clock measuring time in hours and minutes.

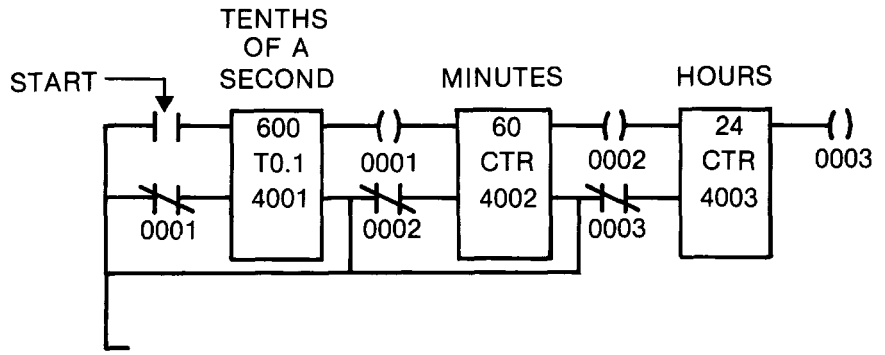
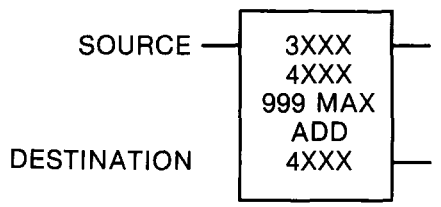


Figure 6-6. Time-of-Day Clock

6.12 ARITHMETIC OPERATIONS

The arithmetic operations consist of addition and subtraction.

The format of the arithmetic operations is shown below:



Input
The arithmetic operation is performed when power is connected to the input. The input circuit is normally open.

Preset
The upper element of an arithmetic operation is a preset value. The preset can be a fixed value (up to 999) or a register. When the preset is a register (reference number 3XXX or 4XXX), the content of the register (a value up to 999) is used as the preset value.

Holding Register
The Holding Register holds the result of another logic operation (reference number 4XXX). This value is added to the preset value.

Result Register
The Result Register holds the result of the values in the preset and holding registers. This register number is assigned by the Micro 84 and is always the Holding Register plus one (4XXX + 1). Be sure when you assign a holding register reference number, that the next consecutive reference number is available for use by the controller.

Output 1
The status of the output is determined by the result of the arithmetic process.

Output 2
The status of the output is determined by the result of the arithmetic process.

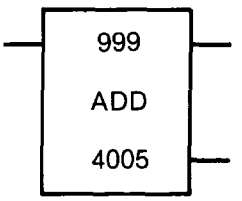
NOTE

An output is energized only if the input is also energized. When power is removed from the input, the output is de-energized.

6.12.1 Addition

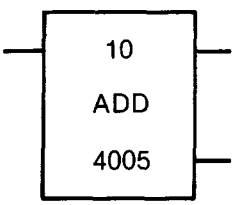
The addition function adds the preset value to the contents of the holding register and stores the result in the result register. The result register is an implied register (the holding register plus one), automatically assigned by the PC. Based on the results of the addition, one of two output conditions exists:

- If the sum exceeds 999, output 1 is energized (Output 2 is de-energized) and the remainder (the sum minus 1000) is stored in the result register.



		4005		4006	
999	+	20	=	19	
				(1019)	

- If the sum is less than 999, Output 2 is energized (Output 1 de-energized).



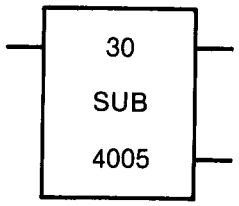
		4005		4006	
10	+	20	=	30	

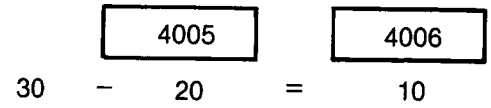
The result register contains only the result of the latest calculation.

6.12.2 Subtraction

The subtraction function compares the value in the preset with the value in the holding register and places the value of the difference in the result register. The result register is an implied register (the holding register plus one), automatically assigned by the PC. Based on the results of the compare, one of three output conditions exists:

- If the preset is greater than the holding register, Output 1 is energized.
- If the preset is less than the holding register, Output 2 is energized.
- If the preset is equal to the holding register, both Output 1 and Output 2 are energized.





6.13 SEQUENCERS (DRUM PROGRAMMERS)

The MICRO 84 Programmable Controller can be used to produce a drum type programmer on a circumferential row-by-row (sequencer) basis. Each circumferential row can operate independently or dependently with reference to the surrounding rows. The controller can contain up to eight sequencers with up to sixteen contacts for each. Reference numbers for sequencer contacts start with the digit 2 and are in the form 2RXX. The significance of the remaining three digits of a sequencer contact reference number is as follows:

Sequencers are controlled by the value XX (01-16) that is contained in a sequence register R (reference numbers 1-8, that is, 4001-4008).

Sequencer Register Reference Number: 400R

Sequencer Contact Reference Number: 2RXX

R = 1 through 8 (Sequencer reference register number 4001-4008)

XX = 01 through 16 (Sequencer contact number)

Sequencer operation is controlled by a numeric value (1 through 16) placed in a specific sequencer register (4001-4008) by any of the non-relay devices such as a counter, timer, or arithmetic operation. The value placed in the sequencer reference register results in a single sequencer contact (2RXX) being energized (contact closes). All other contacts are de-energized. Look at the logic in Sequencer example, Figure 6-7. This circuit sequentially energizes contacts (and consequently the attached coils) 2101 through 2108. The sequential contacts are made at 20 second intervals (see Figure 6-8).

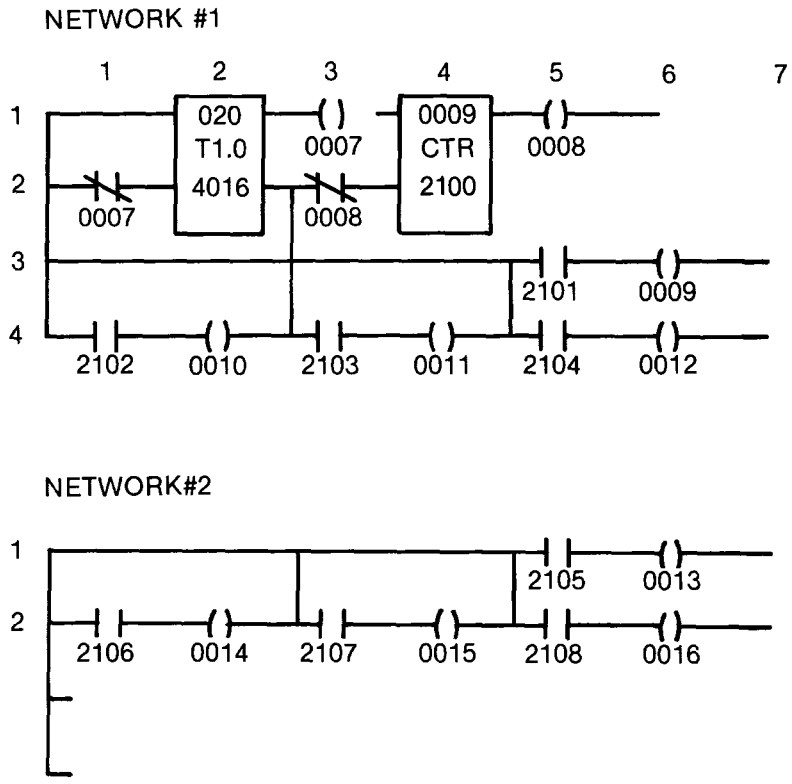


Figure 6-7. Sequencer Example

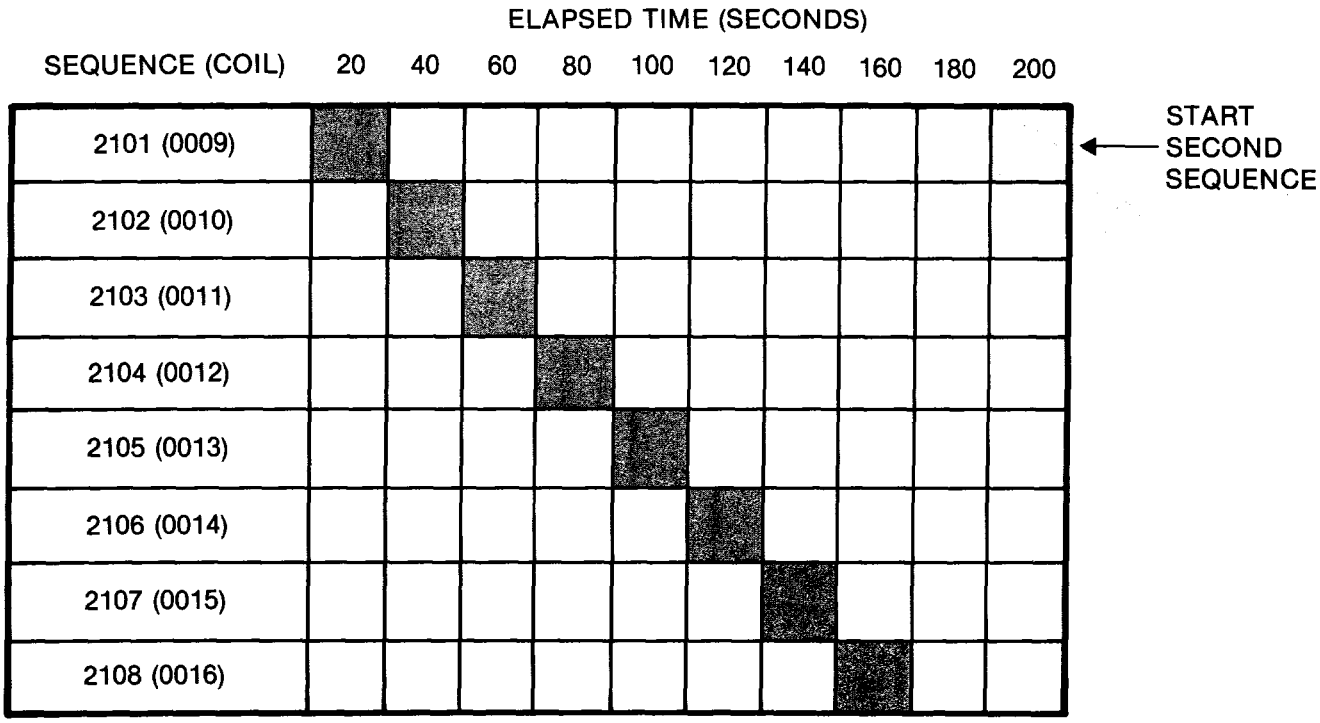


Figure 6-8. Elapsed Time In Seconds.

To create the Sequencer networks illustrated in Figure 6-7 press the PROGRAM software label key, followed by the PROCEED software label key. This loads the programmer operations. Once this is done, you can perform the step by step instructions shown below.

Press NETWORK ED software label key.

Press CREATE NET software label key.

Press ——— software label key.

Press —→ software label key.

Press T1.0 softare label key.

Key 20 into the AR.

Press ENTER.

Press ↓

Key 4016 into the AR.

Press ENTER.

Press ↓

Press →

Key 7 into the AR.

Press —( )— software label key.

Press CTR software label key.

Key 9 into the AR.

Press ENTER.

Press ↓

Key 40001 into the AR.

Press ENTER.

Press ↑

Press →

Key 8 into AR.

Press —( )—

Press → three times to return cursor to Row 1, Column 1.

Press ↓

Key 7 into the AR.

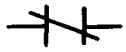
Press —|/|—

Press →

Press VER SHORT.

Press →

Key 8 into AR.

Press 

Press → , twice.

Press ↓

Press ———

Press →

Press ———

Press VER SHORT.

Press →

Press ———

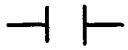
Press →

Press ———

Press VER SHORT.

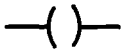
Press →

Key 2101 into the AR.

Press 

Press →

Key 9 into the AR.

Press 

Press → twice.

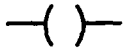
Press ↓

Key 2102.

Press 

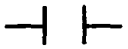
Press →

Key 10 into AR.

Press 

Press →

Key 2103 into the AR.

Press 

Press →

Key 11 into the AR.

Press —( )—

Press →

Key 2104 into the AR.

Press —| |—

Press →

Key 12 into the AR.

Press —( )—

To place this network into the PC, key the network number into the AR and press the REPL NET software label key.

Using the same software label keys as in the above example, enter Network #2, illustrated in Figure 6-7 by yourself.