



ECET 4530

Industrial Motor Control

Ladder Logic Example Problem

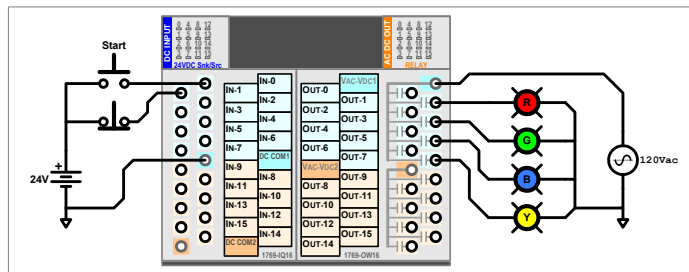
Complex Timer Interaction

1

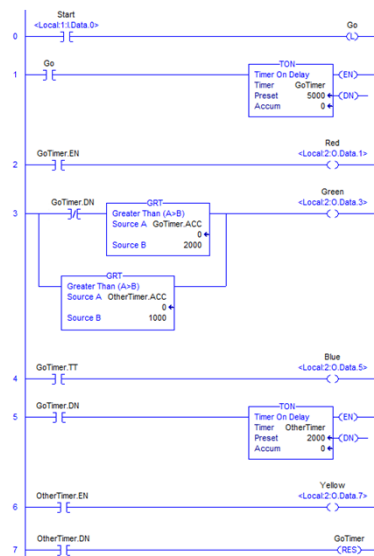


Example Problem

Given the following PLC-based system and the Ladder-Logic program that the PLC is executing:



If the “Start” button is pressed at time $t = 0$, specify the timespans during which each light is “ON” for the first 14 seconds of operation (after the Start button is pressed).

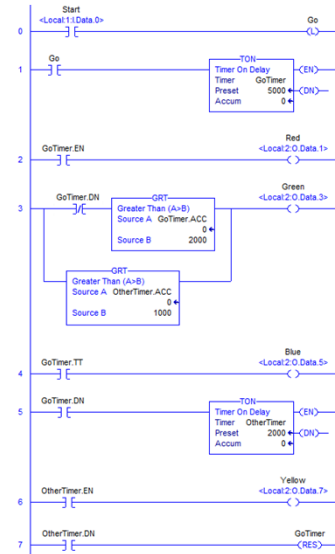


2



Example Problem

Step 1 – Analyze the ladder to determine the Conditions required to Enable or Reset the Timers.



3



Example Problem

Step 1 – Analyze the ladder to determine the Conditions required to Enable or Reset the Timers.

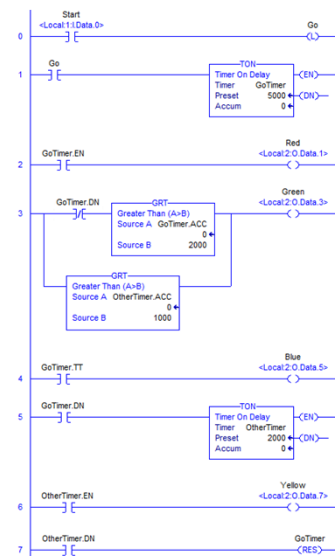
- Rung 1 – GoTimer is Enabled when bit Go = 1.
- Rung 5 - OtherTimer is Enabled when GoTimer.DN = 1 (GoTimer is Done).
- Rung 7 - GoTimer is Reset when OtherTimer.DN = 1 (OtherTimer is Done).

Note that, in the following slides, I will abbreviate:

“GoTimer” as “GT”

and

“OtherTimer” as “OT”

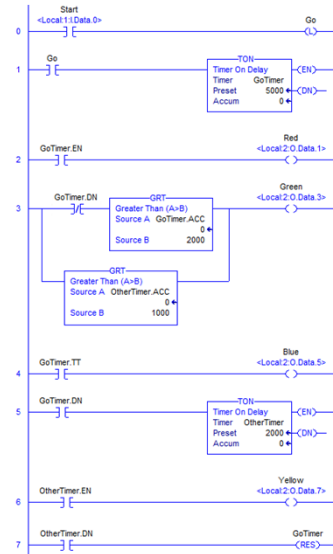


4



Example Problem

Step 2 – Determine the Timing Sequence that occurs once the system is activated (Start is Pressed).



5



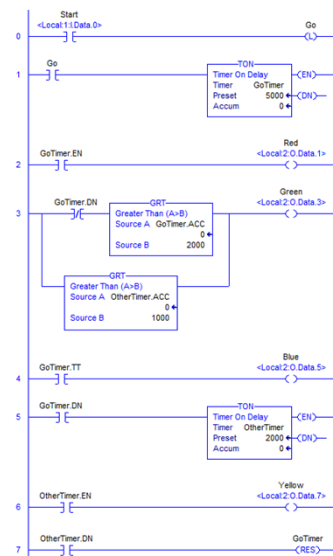
Example Problem

Step 2 – Determine the Timing Sequence that occurs once the system is activated (Start is Pressed).

- At time $t = 0$ sec, Start is pressed \rightarrow the Go bit is set ($Go = 1$) \rightarrow GT is Enabled ($GT.EN = 1$).

Thus, at $t = 0$, GT begins counting from 0 to 5000 (5 sec).

(Note that OT is Disabled while GT is actively counting.)



6



Example Problem

Step 2 – Determine the Timing Sequence that occurs once the system is activated (Start is Pressed).

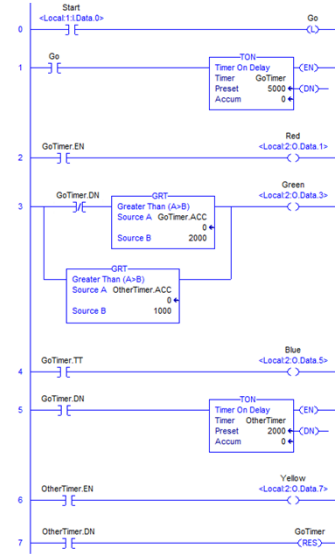
- At time $t = 0$ sec, Start is pressed \rightarrow the Go bit is set ($Go = 1$) \rightarrow GT is Enabled ($GT.EN = 1$).

Thus, at $t = 0$, GT begins counting from 0 to 5000 (5 sec).

- At time $t = 5$ sec, $GT.ACC = 5000 \rightarrow$ GT is Done ($GT.DN = 1$) \rightarrow OT is Enabled ($OT.EN = 1$).

Thus, at $t = 5$, OT begins counting from 0 to 2000 (2 seconds).

(Note that $GT.ACC$ remains at 5000 while OT is counting.)



7



Example Problem

Step 2 – Determine the Timing Sequence that occurs once the system is activated (Start is Pressed).

- At time $t = 0$ sec, Start is pressed \rightarrow the Go bit is set ($Go = 1$) \rightarrow GT is Enabled ($GT.EN = 1$).

Thus, at $t = 0$, GT begins counting from 0 to 5000 (5 sec).

- At time $t = 5$ sec, $GT.ACC = 5000 \rightarrow$ GT is Done ($GT.DN = 1$) \rightarrow OT is Enabled ($OT.EN = 1$).

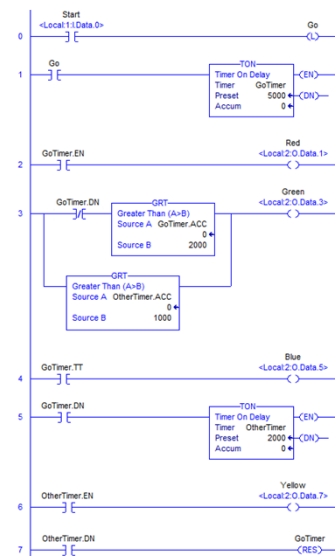
Thus, at $t = 5$, OT begins counting from 0 to 2000 (2 seconds).

- At time $t = 7$ sec, $OT.ACC = 2000 \rightarrow$ OT is Done ($OT.DN = 1$) \rightarrow GT is Reset.

When GT is Reset, $GT.ACC = 0$, $GT.DN = 0 \rightarrow$ OT is Disabled.

When OT is Disabled, $OT.EN = 0$, $OT.ACC = 0$, and $OT.DN = 0$.

Thus, at $t = 7$, GT begins counting again from 0 to 5000 (5 sec).



8



Example Problem

Step 2 – Determine the Timing Sequence that occurs once the system is activated (Start is Pressed).

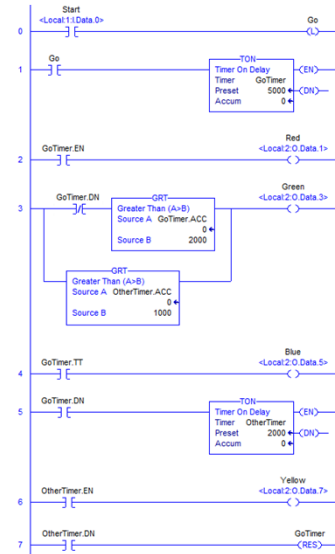
- At time $t = 0$ sec, Start is pressed \rightarrow the Go bit is set (Go = 1) \rightarrow GT is Enabled (GT.EN = 1).
Thus, at $t = 0$, GT begins counting from 0 to 5000 (5 sec).
- At time $t = 5$ sec, GT.ACC = 5000 \rightarrow GT is Done (GT.DN = 1) \rightarrow OT is Enabled (OT.EN = 1).
Thus, at $t = 5$, OT begins counting from 0 to 2000 (2 seconds).
- At time $t = 7$ sec, OT.ACC = 2000 \rightarrow OT is Done (OT.DN = 1) \rightarrow GT is Reset.

When GT is Reset, GT.ACC = 0, GT.DN = 0 \rightarrow OT is Disabled.

When OT is Disabled, OT.EN = 0, OT.ACC = 0, and OT.DN = 0.

Thus, at $t = 7$, GT begins counting again from 0 to 5000 (5 sec).

Since this is equivalent to the conditions at $t = 0$, the process begins again.

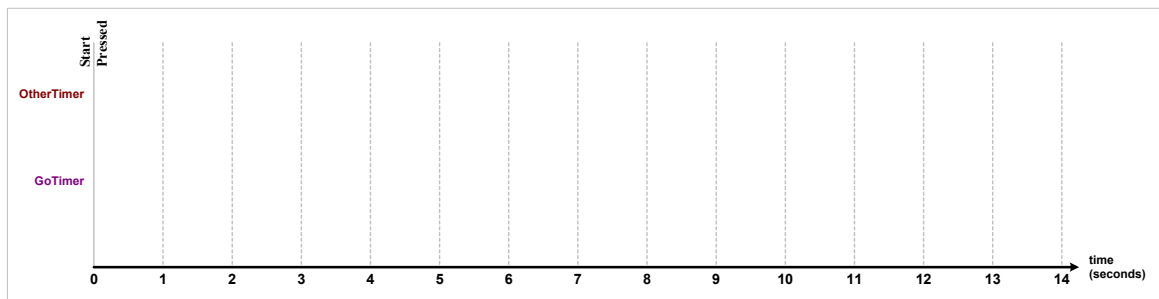


9



Example Problem

Step 3 – Sketch the Timing Sequence that occurs when Start is Pressed.



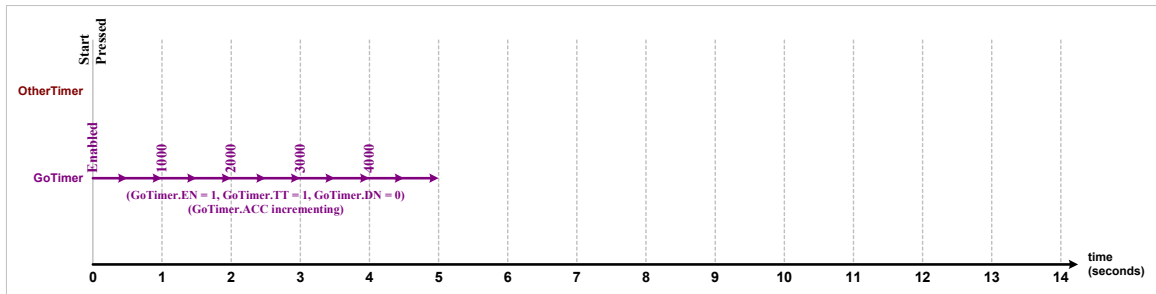
10



Example Problem

Step 3 – Sketch the Timing Sequence that occurs when Start is Pressed.

- At time $t = 0$ sec, Start is pressed \rightarrow the Go bit is set ($Go = 1$) \rightarrow GT is Enabled ($GT.EN = 1$). Thus, at $t = 0$, GT begins counting from 0 to 5000 (5 sec).



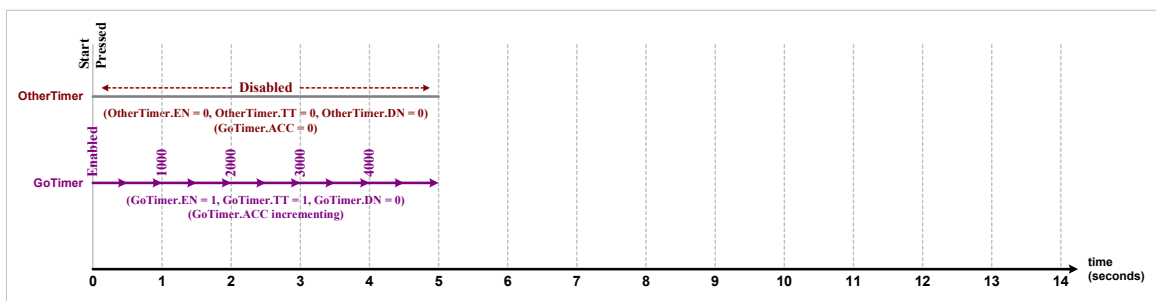
11



Example Problem

Step 3 – Sketch the Timing Sequence that occurs when Start is Pressed.

- At time $t = 0$ sec, Start is pressed \rightarrow the Go bit is set ($Go = 1$) \rightarrow GT is Enabled ($GT.EN = 1$). Thus, at $t = 0$, GT begins counting from 0 to 5000 (5 sec).
During this time (0 sec \rightarrow 5 sec), OT is Disabled.



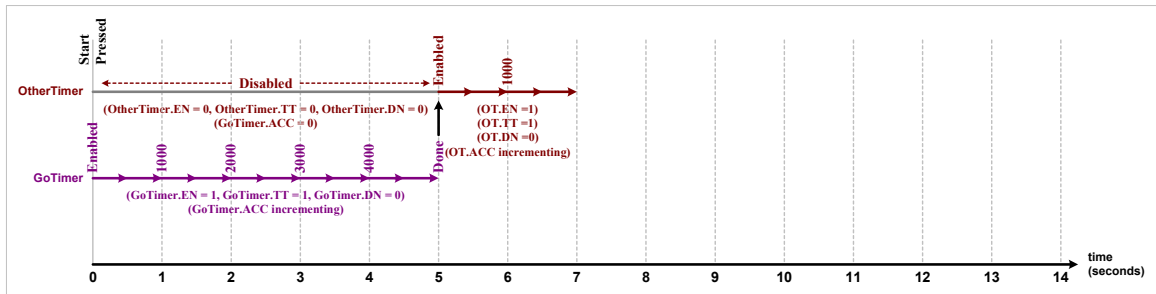
12



Example Problem

Step 3 – Sketch the Timing Sequence that occurs when Start is Pressed.

- At time $t = 5$ sec, $GT.ACC = 5000 \rightarrow$ GT is Done ($GT.DN = 1$) \rightarrow OT is Enabled ($OT.EN = 1$).
Thus, at $t = 5$, OT begins counting from 0 to 2000 (2 seconds).



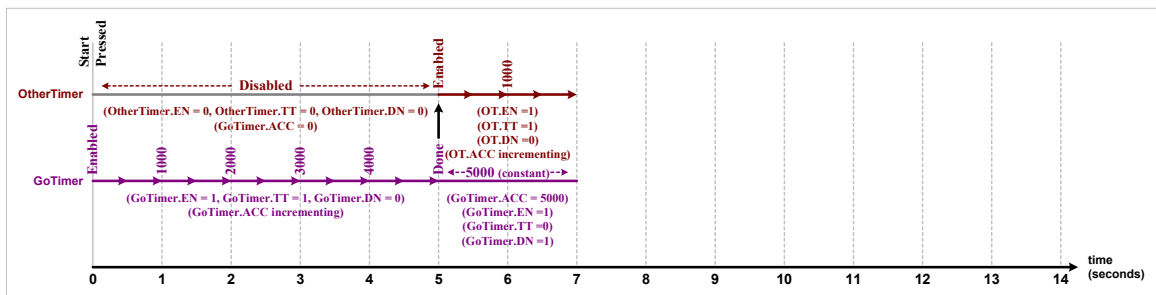
13



Example Problem

Step 3 – Sketch the Timing Sequence that occurs when Start is Pressed.

- At time $t = 5$ sec, $GT.ACC = 5000 \rightarrow$ GT is Done ($GT.DN = 1$) \rightarrow OT is Enabled ($OT.EN = 1$).
Thus, at $t = 5$, OT begins counting from 0 to 2000 (2 seconds).
- During this time (5 sec \rightarrow 7 sec), $GT.ACC$ remains at 5000.



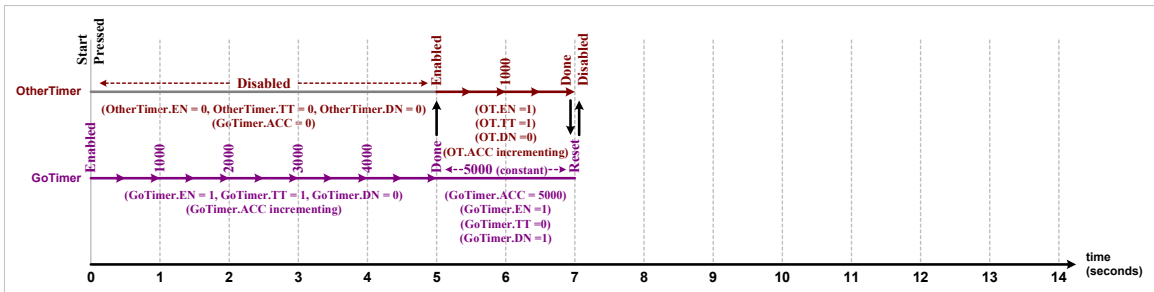
14



Example Problem

Step 3 – Sketch the Timing Sequence.

- At time $t = 7$ sec, $OT.ACC = 2000 \rightarrow OT$ is Done ($OT.DN = 1$) $\rightarrow GT$ is Reset.
When GT is Reset, $GT.ACC = 0$, $GT.DN = 0 \rightarrow OT$ is Disabled.



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Example Problem

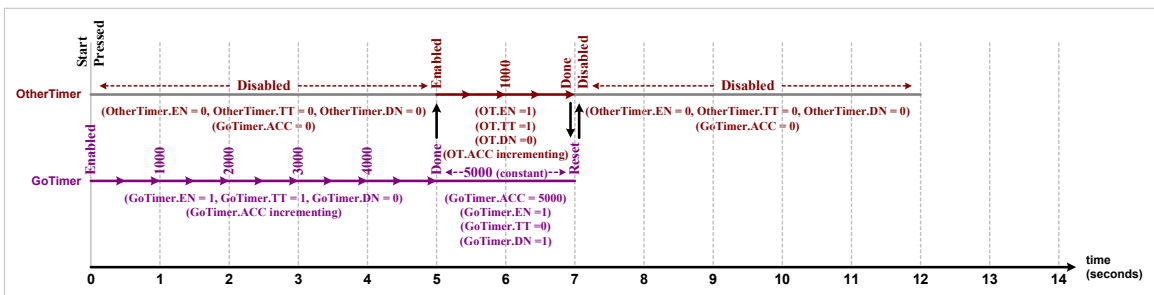
Step 3 – Sketch the Timing Sequence.

- At time $t = 7$ sec, $OT.ACC = 2000 \rightarrow OT$ is Done ($OT.DN = 1$) $\rightarrow GT$ is Reset.
When GT is Reset, $GT.ACC = 0$, $GT.DN = 0 \rightarrow OT$ is Disabled.

When OT is Disabled, $OT.EN = 0$, $OT.ACC = 0$, and $OT.DN = 0$.

(OT will remain disabled until GT is Done again.)

(Note that this also prevents the RES on Rung 7 from resetting GT again.)



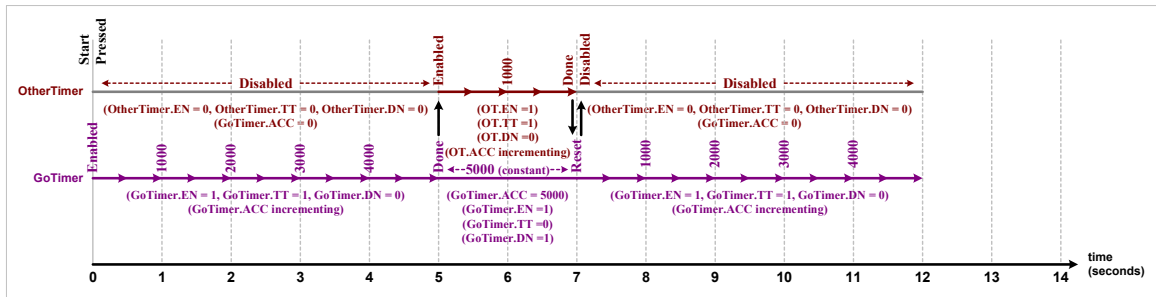
16



Example Problem

Step 3 – Sketch the Timing Sequence.

- At time $t = 7$ sec, $OT.ACC = 2000 \rightarrow$ OT is Done ($OT.DN = 1$) \rightarrow GT is Reset.
- When GT is Reset, $GT.ACC = 0$, $GT.DN = 0 \rightarrow$ OT is Disabled.
- When OT is Disabled, $OT.EN = 0$, $OT.ACC = 0$, and $OT.DN = 0$.
- Thus, at $t = 7$, GT begins counting again from 0 to 5000 (5 sec).



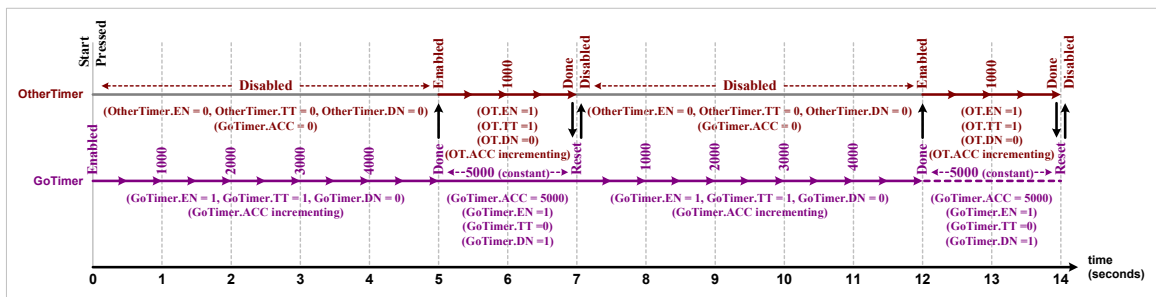
17



Example Problem

Step 3 – Sketch the Timing Sequence.

- At time $t = 7$ sec, $OT.ACC = 2000 \rightarrow$ OT is Done ($OT.DN = 1$) \rightarrow GT is Reset.
- When GT is Reset, $GT.ACC = 0$, $GT.DN = 0 \rightarrow$ OT is Disabled.
- When OT is Disabled, $OT.EN = 0$, $OT.ACC = 0$, and $OT.DN = 0$.
- Thus, at $t = 7$, GT begins counting again from 0 to 5000 (5 sec).
- This is equivalent to the conditions at $t = 0$ when Start was Pressed \rightarrow the process repeats.

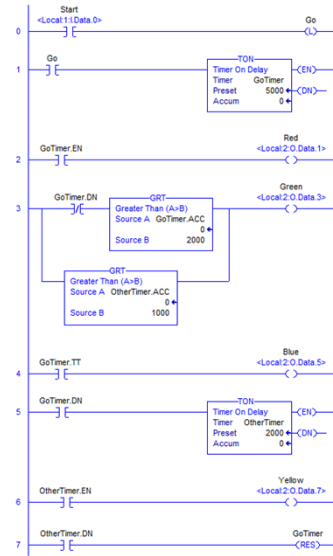


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Example Problem

Step 4 – Determine the Conditions required for each of the Indicator Lamps to become Illuminated.



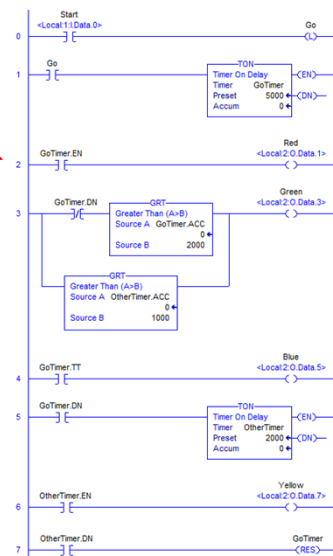
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Example Problem

Step 4 – Determine the Conditions required for each of the Indicator Lamps to become Illuminated.

Red: GT.EN = 1 (GoTimer Enabled)



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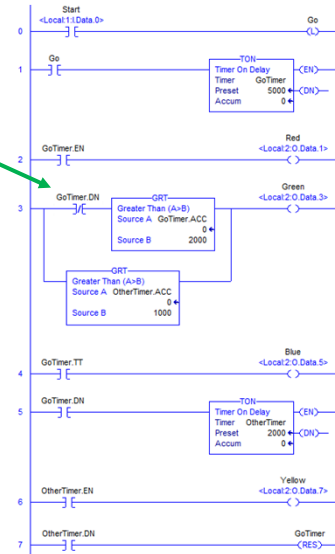


Example Problem

Step 4 – Determine the Conditions required for each of the Indicator Lamps to become Illuminated.

Red: GT.EN = 1 (GoTimer Enabled)

Green: GT.DN ≠ 1 (GoTimer not Done) and GT.ACC > 2000



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Example Problem

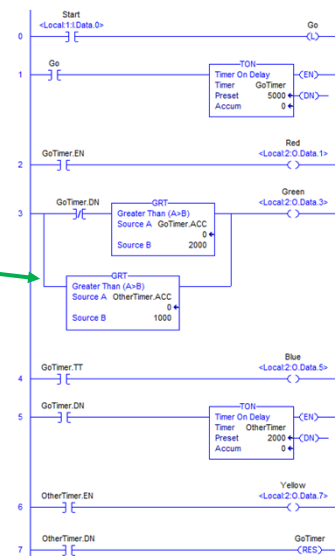
Step 4 – Determine the Conditions required for each of the Indicator Lamps to become Illuminated.

Red: GT.EN = 1 (GoTimer Enabled)

Green: GT.DN ≠ 1 (GoTimer not Done) and GT.ACC > 2000

or

OT.ACC > 1000



22



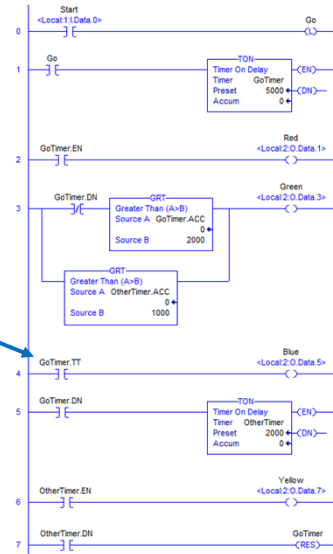
Example Problem

Step 4 – Determine the Conditions required for each of the Indicator Lamps to become Illuminated.

Red: GT.EN = 1 (GoTimer Enabled)

Green: GT.DN ≠ 1 (GoTimer not Done) and GT.ACC > 2000
OR
 OT.ACC > 1000

Blue: GT.TT = 1 (GoTimer is actively counting)



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Example Problem

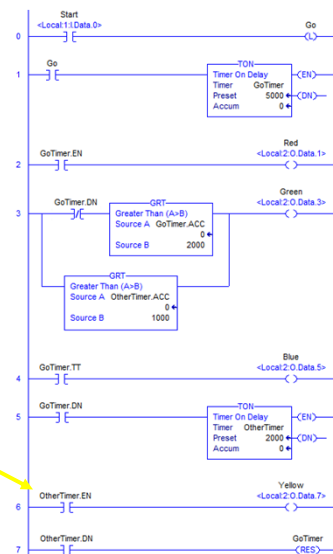
Step 4 – Determine the Conditions required for each of the Indicator Lamps to become Illuminated.

Red: GT.EN = 1 (GoTimer Enabled)

Green: GT.DN ≠ 1 (GoTimer not Done) and GT.ACC > 2000
OR
 OT.ACC > 1000

Blue: GT.TT = 1 (GoTimer is actively counting)

Yellow: OT.EN = 1 (OtherTimer Enabled)

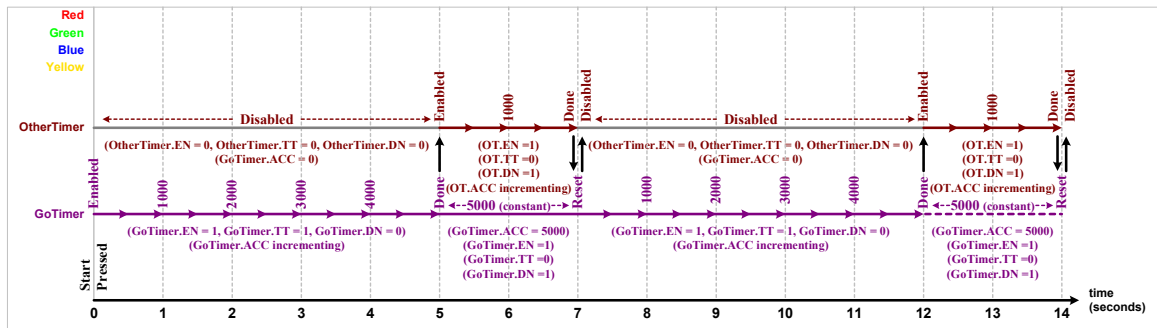


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Example Problem

Step 5 – Based on the timing sequence, determine the times at which the Lamps are Illuminated.



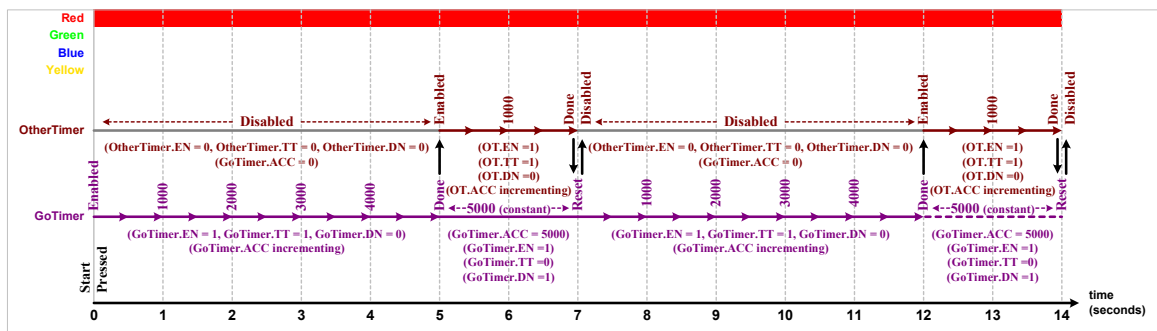
25



Example Problem

Step 5 – Based on the timing sequence, determine the times at which the Lamps are Illuminated.

Red: GT.EN = 1 (GoTimer Enabled)



26

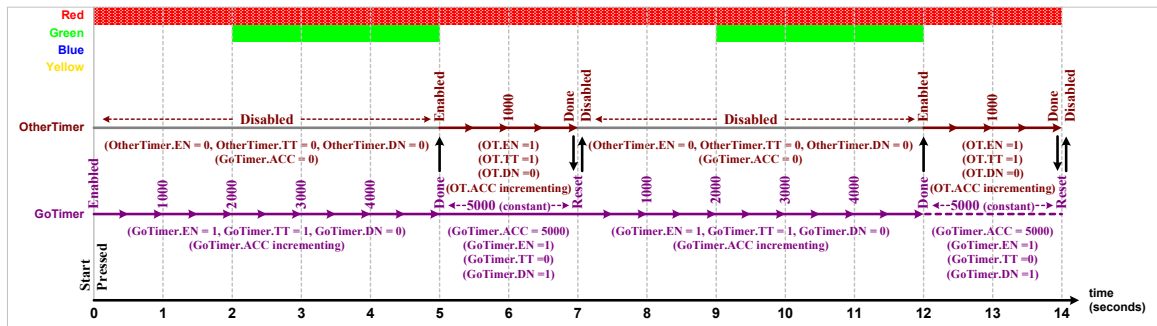


Example Problem

Step 5 – Based on the timing sequence, determine the times at which the Lamps are Illuminated.

Red: $GT.EN = 1$ (GoTimer Enabled)

Green: $GT.DN \neq 1$ (GoTimer not Done) and $GT.ACC > 2000$ or



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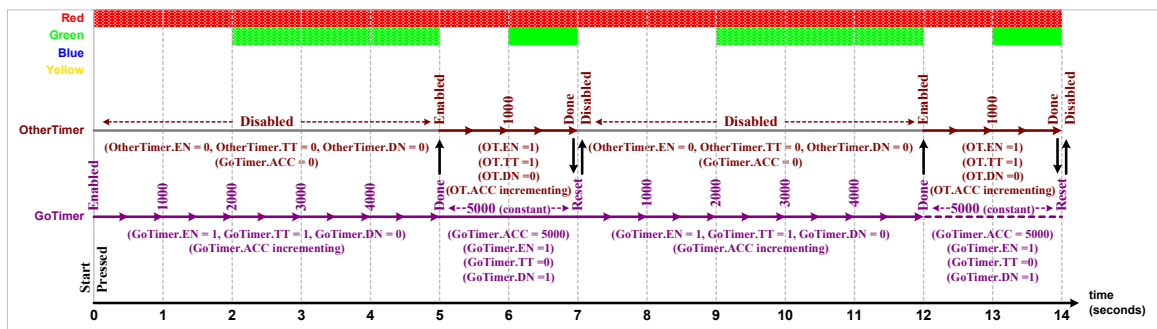


Example Problem

Step 5 – Based on the timing sequence, determine the times at which the Lamps are Illuminated.

Red: $GT.EN = 1$ (GoTimer Enabled)

Green: $GT.DN \neq 1$ (GoTimer not Done) and $GT.ACC > 2000$ or $OT.ACC > 1000$



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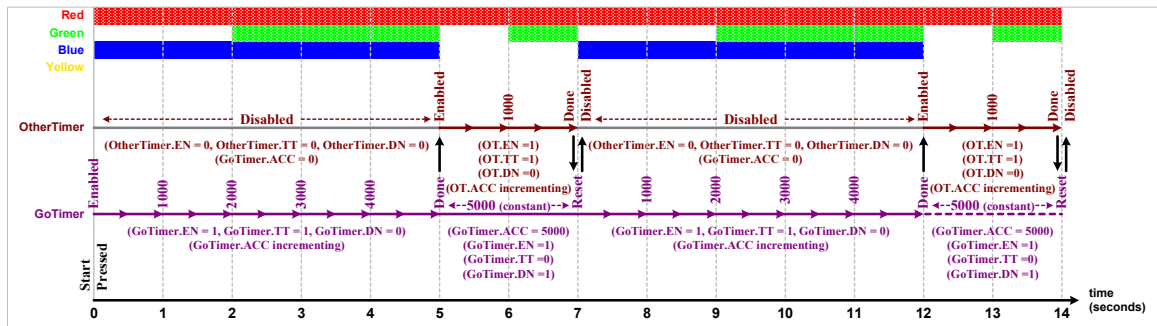
Example Problem

Step 5 – Based on the timing sequence, determine the times at which the Lamps are Illuminated.

Red: $GT.EN = 1$ (GoTimer Enabled)

Green: $GT.DN \neq 1$ (GoTimer not Done) and $GT.ACC > 2000$ or $OT.ACC > 1000$

Blue: $GT.TT = 1$ (GoTimer is actively counting)



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Example Problem

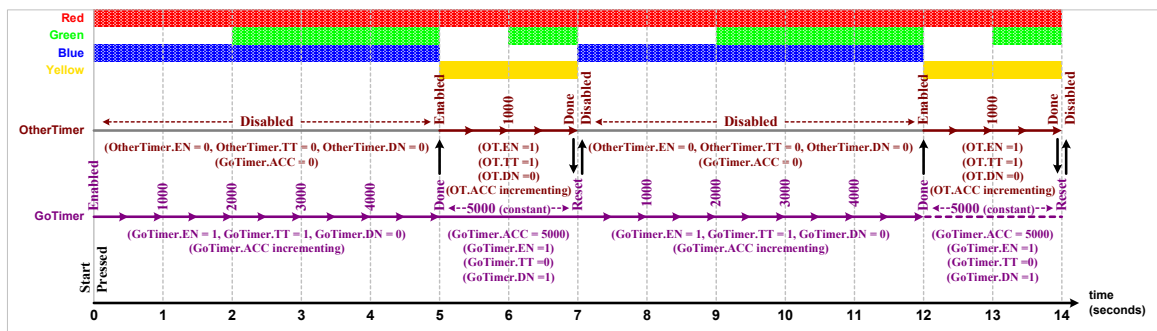
Step 5 – Based on the timing sequence, determine the times at which the Lamps are Illuminated.

Red: $GT.EN = 1$ (GoTimer Enabled)

Green: $GT.DN \neq 1$ (GoTimer not Done) and $GT.ACC > 2000$ or $OT.ACC > 1000$

Blue: $GT.TT = 1$ (GoTimer is actively counting)

Yellow: $OT.EN = 1$ (OtherTimer Enabled)



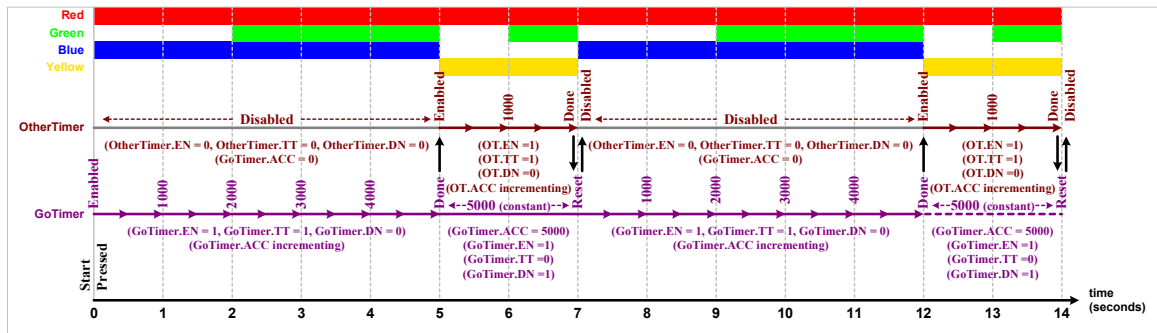
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Example Problem

Step 6 – Specify the timespans during which each light is “ON” in the following table:

timespan (seconds)	0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-11	11-12	12-13	13-14
Red														
Green														
Blue														
Yellow														



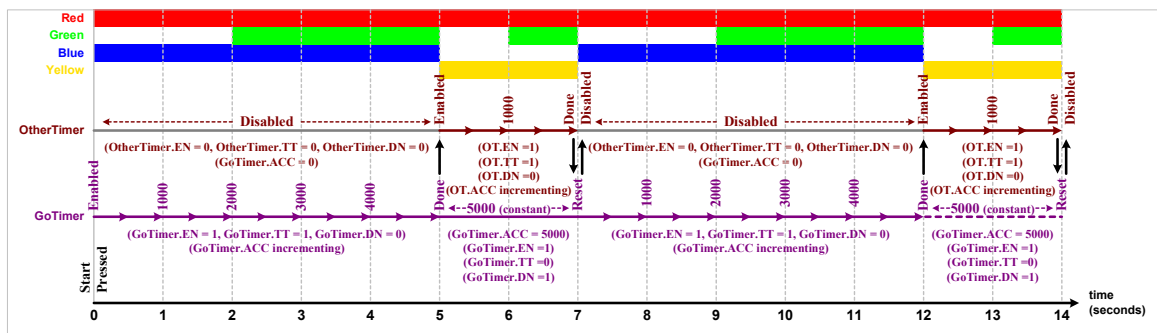
31



Example Problem

Step 6 – Specify the timespans during which each light is “ON” in the following table:

timespan (seconds)	0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-11	11-12	12-13	13-14
Red	On	On	On	On	On	On	On	On	On	On	On	On	On	On
Green														
Blue														
Yellow														



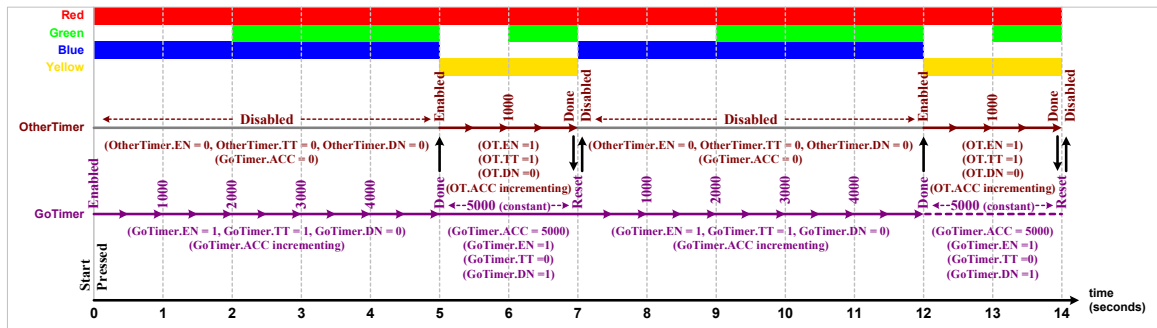
32



Example Problem

Step 6 – Specify the timespans during which each light is “ON” in the following table:

timespan (seconds)	0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-11	11-12	12-13	13-14
Red	On	On	On	On	On	On	On	On	On	On	On	On	On	On
Green			On	On	On		On			On	On	On		On
Blue														
Yellow														



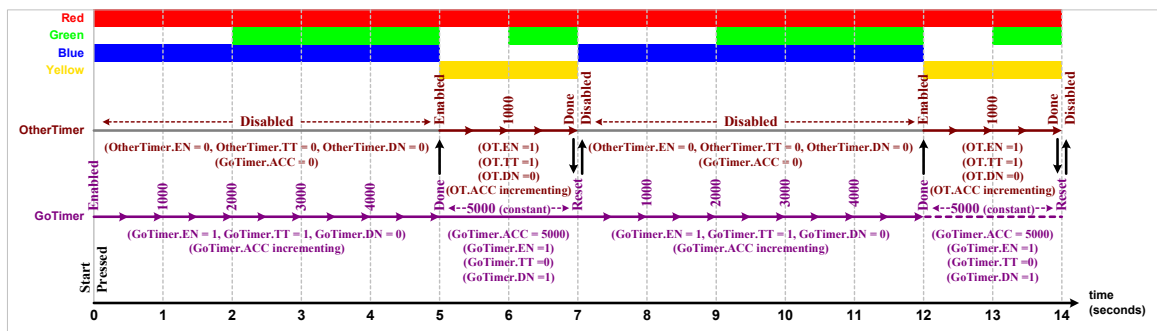
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Example Problem

Step 6 – Specify the timespans during which each light is “ON” in the following table:

timespan (seconds)	0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-11	11-12	12-13	13-14
Red	On	On	On	On	On	On	On	On	On	On	On	On	On	On
Green			On	On	On		On			On	On	On		On
Blue	On	On	On	On	On			On	On	On	On			
Yellow														



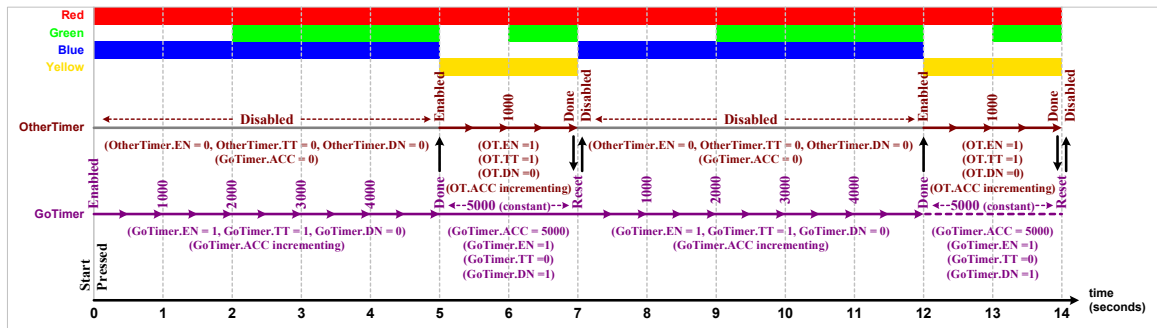
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Example Problem

Step 6 – Specify the timespans during which each light is “ON” in the following table:

timespan (seconds)	0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-11	11-12	12-13	13-14
Red	On	On	On	On	On	On	On	On	On	On	On	On	On	On
Green			On	On	On		On			On	On	On		On
Blue	On	On	On	On	On			On	On	On	On			
Yellow						On	On						On	On



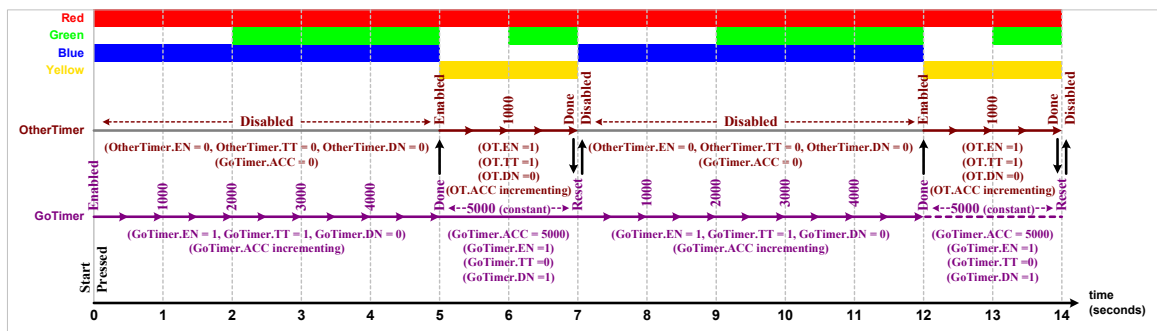
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Example Problem

Step 6 – Specify the timespans during which each light is “ON” in the following table:

timespan (seconds)	0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-11	11-12	12-13	13-14
Red	On	On	On	On	On	On	On	On	On	On	On	On	On	On
Green			On	On	On		On			On	On	On		On
Blue	On	On	On	On	On			On	On	On	On			
Yellow						On	On						On	On



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