Ron Beaufort Training, LLC
5900 Core Avenue, #102
Charleston, SC 29406
843-437-1883 www.ronbeaufort.com

Hands-On Technical Workshops
by Ron Beaufort

Email PLC Quiz #110 – Questions

Greetings ...

This edition of our "Email PLC Quiz" contains questions intended for technicians at a "**Beginner**" level. As always, the primary objective of the quiz is to cover useful skills for technicians who troubleshoot systems controlled by Allen-Bradley PLCs.

PLEASE NOTE: If you would rather not receive more "Email PLC Quizzes" like this one, just reply to this email with the word "remove" in the subject line. On the other hand, if you know someone who might find this type of information useful, please feel free to forward this email to them.

IMPORTANT: Due to size and bandwidth considerations, this edition of the "PLC Quiz" is being sent as an email attachment. If you have trouble opening the attachment, you may download the entire file (in an easy to print PDF format) from our website at www.ronbeaufort.com - look in the "Sample Lessons" section. Answers to the quiz are also available as a separate file. Absolutely no registration or visitor information is ever required for access to our website.

Also, if you'd like to discuss the information contained in any of our quizzes, please feel free to contact us. We'll be glad to answer any questions you might have.

Please keep in mind that this material is intended only for use with the PLC-5, the SLC-500, and the ControlLogix families of Allen-Bradley PLC processors. You should also keep in mind that there may be certain important differences in operation between these three processor families. For example, information pertaining to a PLC-5 system might not be directly applicable to the SLC-500 or to the ControlLogix platforms. In simple terms, all Allen-Bradley processors do NOT function in exactly the same way.

We'd also like to say "thank you" to all of you who have contacted us and asked for future editions of our PLC Quizzes – and who have recommended your friends and associates to be added to our email list. Based on all of the comments we've received so far, it seems that we're meeting our goal of making our quizzes: (1) entertaining, (2) thought provoking, and (3) educational. We've also been pleased to hear about the "spirited" debates over our previous editions that have taken place around the maintenance shops. We'd like to say a special "thank you" for all of your excellent suggestions for topics to be covered in our future editions. We'll definitely try to get around to those in the months ahead.

Good luck on the quiz ...

Beginner Level Quiz – Number 110

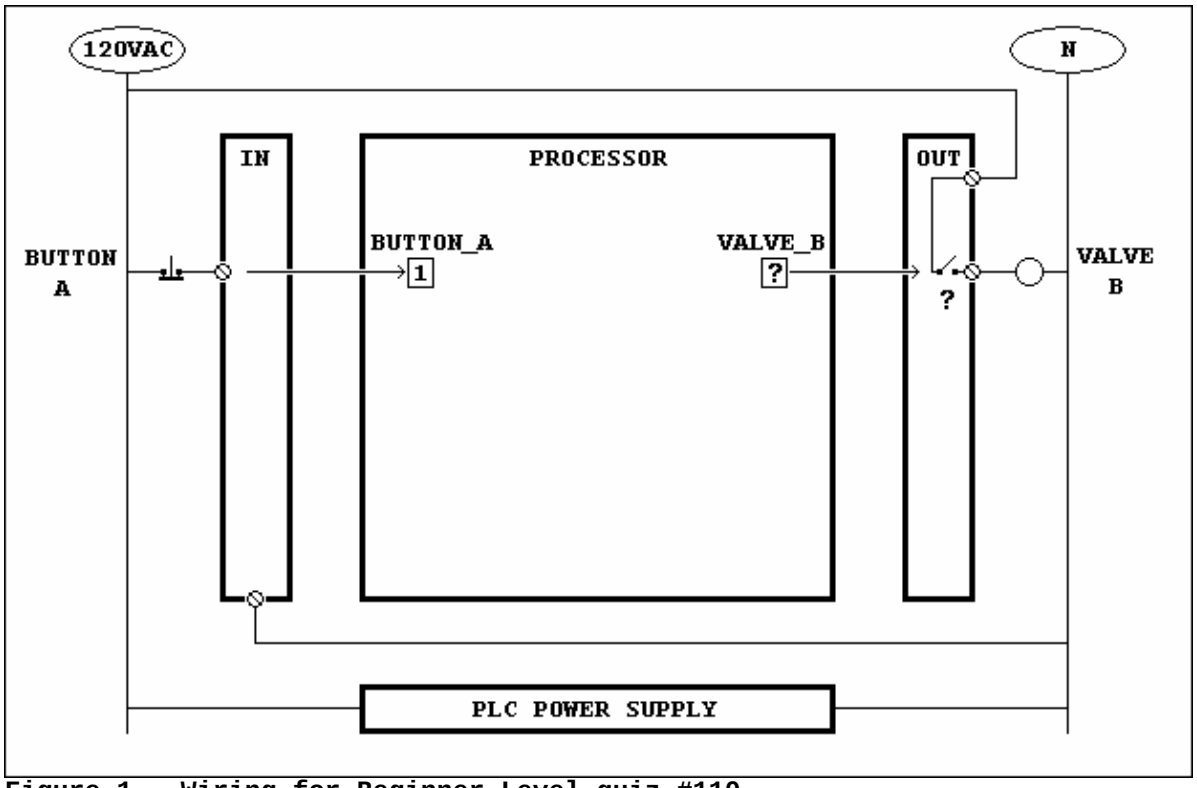

Figure 1 – Wiring for Beginner Level quiz #110

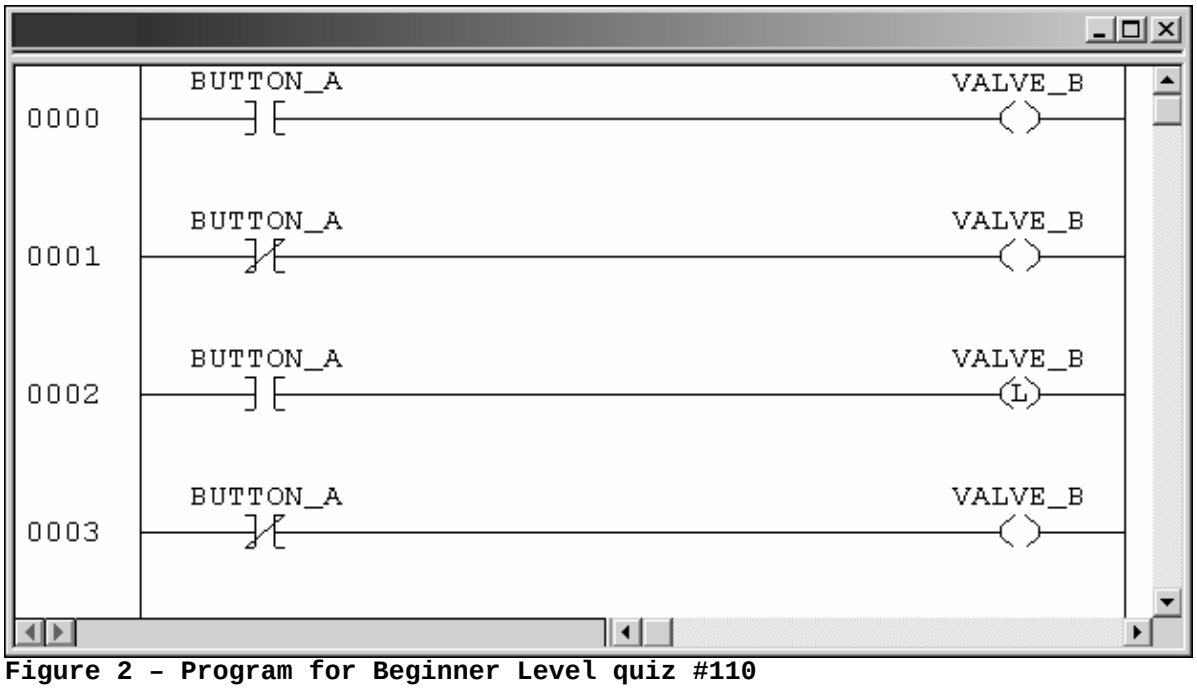

Figure 2 – Program for Beginner Level quiz #110

Figure 1 shows the wiring for a simple control system. The field device "VALVE_B" is a common solenoid valve with a standard 120 volt AC coil. The PLC output module uses relay-type contacts. This is not a solid-state TRIAC type module. All of the wiring and field devices are in good condition. There are no burned-out bulbs, broken wires, bad switches, etc. BUTTON_A is wired for normally-closed operation and will not be pressed at any time during the exercise.

Figure 2 shows the entire ladder logic program. These rungs are being properly scanned as in a normal simple program. This is not an STI or any other type of subroutine file. The processor's key will be left in the Run position throughout the entire exercise.

Be sure to read each answer carefully – and then pick the one which BEST answers the question. Actually the problems are quite simple – it's the answers which can make things seem so confusing. Even students with several years of experience often arrive at our "PLC Boot Camp" classes with serious misconceptions about how PLC ladder logic really works. All of the incorrect answers below are based on some of the most popular of those mistaken ideas. In other words, we didn't just "make up" a series of wrong answers to make the quiz more challenging. All of the confusing material below is taken directly from what many technicians incorrectly believe to be true – and what some PLC training schools actually teach to their students on a day-to-day basis. Be alert.

Beginner Level Quiz – Number 110

For an SLC-500 system ...
Question 1: Will VALVE_B in the field be ON, OFF, or CHATTERING?

For a PLC-5 system ...
Question 2: Will VALVE_B in the field be ON, OFF, or CHATTERING?

For a ControlLogix system ...
Question 3: Will VALVE_B in the field be ON, OFF, or CHATTERING?

Answer A: VALVE_B in the field will be ON ... because the program has been improperly written using the same "input" (BUTTON_A) on multiple rungs – and each rung controls the same output ... this arrangement is the ladder logic equivalent of a multiple "OR" statement (much like four electrical switches wired in parallel) ... with this arrangement, if ANY switch is TRUE then VALVE_B will be turned ON in the field ... some of the rungs are programmed with BUTTON_A in its ON condition - and some of the rungs show BUTTON_A in its OFF condition ... with this improper configuration, we're guaranteed that TRUE (active) logic will always be able to reach some of the rung outputs ... in other words, at least two "switches" will always be ON ... this means that VALVE_B in the field will always be ON ...

Answer B: VALVE_B in the field will be OFF ... because improperly programming the same output address (VALVE_B) on this many rungs in a row will force the PLC into a "recursive loop" which will FAULT the processor ... due to the FAULT condition, the processor will instantly shut down and ALL of its field outputs (including VALVE_B) will be turned OFF ...

Answer C: VALVE_B in the field will be ON ... because, as shown in Figure 1, BUTTON_A has been field wired for normally-closed action ... rungs 0000 and 0002 have been incorrectly programmed by showing BUTTON_A with normally-open action ... since this programmed action doesn't match the actual field wiring, the processor will simply ignore these two improperly programmed rungs – and they'll have no effect on the operation of the output device ... that leaves us with only two rungs (0001 and 0003) to actually control VALVE_B ... each of these active rungs correctly shows BUTTON_A as a switch wired with normally-closed action ... BUTTON_A is NOT being pressed, so the status of its bit is ONE or ON or TRUE ... this means that rungs 0001 and 0003 are both TRUE – and so VALVE_B in the field will be turned ON ...

Answer D: VALVE_B in the field will be ON ... because first the TRUE condition of rung 0000 will cause VALVE_B to turn ON ... rung 0001 is a FALSE rung ... FALSE (inactive) rungs cannot affect an output which has previously been turned ON by a TRUE (active) rung ... so the FALSE logic of rung 0001 can't change the status of VALVE_B – and the output remains ON ... next the TRUE condition of rung 0002 will "latch" VALVE_B ON ... then, since FALSE (inactive) rungs are "outranked" by TRUE (active) rungs, rung 0003 can't change the status of VALVE_B – and VALVE_B in the field will be ON ...

Answer E: VALVE_B in the field will CHATTER ... specifically, it will usually be OFF – but occasionally it will pulse ON very briefly at random times ... because the TRUE condition of rung 0000 will cause a ONE to be written into the bit for VALVE_B ... and then the FALSE condition of rung 0001 will cause a ZERO to be written into the bit for VALVE_B ... and then the TRUE condition of rung 0002 will cause a ONE to be written into the bit for VALVE_B ... and then the FALSE condition of rung 0003 will cause a ZERO to be written into the bit for VALVE_B ... this same action will be repeated scan after scan ... the status of the bit for VALVE_B will be rapidly changing back and forth between ONE and ZERO ... as the output module receives these conflicting ON and OFF signals, the result will be that VALVE_B in the field will occasionally chatter rapidly ON and OFF ...

Answer F: VALVE_B in the field will be ON ... because rung 0002 has been programmed using an OTL (Latch) instruction ... latches are "retentive" ... this means that once the bit for VALVE_B has been latched ON, it will always retain its ON status - until an OTU (Unlatch) instruction is used to turn the bit back OFF ... notice that there is no OTU (Unlatch) instruction anywhere in the program – and until this flaw is corrected, there is no way that VALVE_B can ever be UNLATCHED ... the input condition of rung 0002 is TRUE ... as soon as the processor executes this rung (even once), the bit for VALVE_B will be LATCHED in its ON state ... then the rest of the rungs in the program will have no effect on VALVE_B, since none of them contain the OTU (Unlatch) command necessary to turn the bit back OFF ... so the field output VALVE_B will remain ON ...

Answer G: VALVE_B in the field will be OFF ... because first the TRUE condition of rung 0000 will cause a ONE to be written into the bit for VALVE_B ... and then the FALSE condition of rung 0001 will cause a ZERO to be written into the bit for VALVE_B ... and then the TRUE condition of rung 0002 will cause a ONE to be written into the bit for VALVE_B ... and then the FALSE condition of rung 0003 will cause a ZERO to be written into the bit for VALVE_B ... the status of the bit for VALVE_B will be rapidly changing back and forth between ONE and ZERO ... since the status of the output bit is only sent to the output module after all of the ladder rungs have been executed, the output module only receives the ZERO status from the bit as written by rung 0003 ... so VALVE_B in the field will be OFF ...

Answer H: we cannot tell for certain whether VALVE_B in the field will be ON or OFF ... because essentially what we have here is a “double-coil” program - that actually has FOUR coils trying to control a single output in the field ... in poorly written programs like this one, the processor’s scan is too fast, too random, and too unpredictable to be systematically analyzed ... all we can say for certain is that VALVE_B will definitely NOT be chattering ... beyond that, the system must be tested under actual operating conditions to see whether VALVE_B will be ON or OFF in the field ...

Answer I: VALVE_B in the field will be OFF ... because before each scan cycle, the processor compiles the entire ladder logic program – and finds that there are four rungs all trying to control the same output (VALVE_B) in the field ... since this “double-coil effect” would give an ambiguous (indefinite) outcome, the processor selects only the LAST rung in the ladder and uses it to perform the control – so “the last rung wins” ... specifically, the processor simply ignores the other three (extra) rungs each time the program is scanned – and rungs 0000 through 0002 are not even executed ... when the last rung (rung 0003) is executed, the XIO (Examine If Open) instruction finds that the input (BUTTON_A) is NOT open ... this makes the rung’s input condition FALSE – and the OTE (Output Energize) instruction turns VALVE_B in the field OFF ...

Answer J: VALVE_B in the field will be ON ... because Allen-Bradley processors always execute their ladders by going “top to bottom – left to right” ... by following that pattern, on rung 0000 the processor evaluates the XIC (Examine If Closed) as a FALSE condition – since the “open” symbol programmed for BUTTON_A does NOT match the button’s actual “closed” condition in the field ... then on rung 0001 the processor evaluates the XIO (Examine If Open) as a TRUE condition – since the “closed” symbol programmed for BUTTON_A DOES match the button’s actual “closed” condition in the field ... then on rung 0002 the processor evaluates the XIC as a FALSE condition – since the “open” symbol programmed for BUTTON_A does NOT match the button’s actual “closed” condition in the field ... then on rung 0003 the processor evaluates the XIO as a TRUE condition – since the “closed” symbol programmed for BUTTON_A DOES match the button’s actual “closed” condition in the field ... at this point, the processor has finished with the first “top to bottom” pass – and found that the “final” (effective) status of BUTTON_A is TRUE ... now the processor moves “left to right” for the pass down the output side of the ladders ... first on rung 0000 the processor executes the OTE (Output Energize) using the final TRUE evaluation of BUTTON_A – and turns VALVE_B ON ... then on rung 0001 the processor executes the OTE using the final TRUE evaluation of BUTTON_A – and again turns VALVE_B ON ... then on rung 0002 the processor executes the OTL (Output Latch) using the final TRUE evaluation of BUTTON_A – this time “latching” VALVE_B ON ... then on rung 0003 the processor executes the OTE using the final TRUE evaluation of BUTTON_A – and again turns VALVE_B ON ... the processor’s “top to bottom – left to right” scan sequence is now finished, with the result that VALVE_B in the field will be ON ...

Summing up Beginner's Level Quiz #110

As we said before, the reason that the "wrong" answers to our quizzes seem so confusing is that they are based on the same common misconceptions that many technicians believe to be true. Unfortunately much of this material "sounds right" even though it happens to be totally wrong. The fact that these wrong ideas are so commonly believed and so widely circulated helps explain why many people find PLC skills difficult to master. If you're interested in how our "PLC Boot Camp" classes are specifically designed to weed out and correct these types of mistakes and misconceptions, you can find a lot of detailed information on our website.

Also, there is an abbreviated lesson included in the Answer file for this quiz. All of the skills required to systematically analyze simple problems like those in our quiz are fully covered in less than one hour on Monday morning of the five-day class. Our students are then repeatedly drilled through additional practice sessions as they learn to apply their skills while solving increasingly difficult exercises as the class proceeds.

The answers for the quiz are available for downloading from our company website at www.ronbeaufort.com – look in the "Sample Lessons" section. Absolutely no registration or visitor information is ever required for access to any part of our website.

Also, if you'd like to discuss the information contained in any of our quizzes, please feel free to contact us. We'll be glad to answer any questions you might have.