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Hands-On Technical Workshops
by Ron Beaufort

Email PLC Quiz #115 – Answers

Greetings ...

This file contains the answers to our **Email PLC Quiz #115**. This edition is a **Beginner Level** quiz which focuses on the differences between the "Toggle Bit" and the "Force" features of RSLogix software.

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 that you might have.

The following equipment was used during the research and development of this edition of the Email PLC Quiz. Other configurations might possibly give different results.

PLC-5/20E Processor; Series E; Revision D.2
RSLogix5 Software; Version 6.00.00

SLC-5/04 Processor; Series C; OS401
RSLogix500 Software; Version 6.00.00
Note: Most MicroLogix1000 Processors will duplicate the SLC's operation

ControlLogix5555 Processor; Revision 15.4
RSLogix5000 Software; Version 15.00.00

Communication through DF1 Serial Port Connection; 19,200 Baud;
RSLinx Lite Software; Version 2.50.00.20 (CPR 7)

Microsoft Windows 2000 Software; Version 5.00.2195

A number of readers have responded to previous editions of our Email PLC Quizzes with requests for any books that we might have available covering this type of material. At this point in time, we are providing training mainly through our five-day PLC Boot Camp classes. So far we haven't found a satisfactory way to effectively present the same amount of detail in any format other than through face-to-face hands-on training. So no, we're sorry that we don't have any books or other types of training materials to offer - but we thank you very much for asking.

Beginner Level Quiz #115 – Answers to the Questions

Question 1 - Answer 1C
Question 2 - Answer 2B
Question 3 - Answer 3A
Question 4 - Answer 4D
Question 5 - Answer 5C
Question 6 - Answer 6A
Question 7 - Answer 7D
Question 8 - Answer 8B
Question 9 - Answer 9D
Question 10 - Answer 10D
Question 11 - Answer 11B
Question 12 - Answer 12B
Question 13 - Answer 13D
Question 14 - Answer 14D
Question 15 - Answer 15B

While the following material isn't intended to be a full "lesson" on all of the concepts involved, here are some basic ideas that might be helpful in understanding the results of the quiz.

Discussion on the "Toggle Bit" feature

The "Toggle Bit" feature simply reverses the status of a "bit" or, in other words, a "box" located in the processor's memory. Specifically, we are NOT toggling any of the instructions (XIC, XIO, OTE, etc.) which are located in the ladder logic. With that in mind, it should be obvious that Questions 1 through 5 will all have EXACTLY the same results. In simplest terms, toggling at Positions B, C, D, and E will do nothing more – and nothing less – than toggling directly to the Pump's bit in the Output Data Table at Position A.

It is extremely common to see a technician trying to troubleshoot a system by scrolling up and down through the program and toggling each and every instruction (XIC, XIO, OTE, etc.) that bears the address of a "suspected" bit. This is basically the high-tech equivalent of rapping on a series of relays with a screwdriver handle – just to "see if anything changes". The difference is that as long as the same address is being toggled, then all of that scrolling up and down is actually a just waste of time. In short, the technician is simply rapping on the SAME relay over and over.

Recognizing that the "Toggle Bit" operation is ALWAYS applied only to a bit/box in the processor's memory is the key to understanding many of the questions in this quiz – and to systematically troubleshooting a system while other technicians waste their time by using less reliable "hunt-and-peck" methods.

Many technicians believe that a toggle operation always has a TEMPORARY effect that lasts for only one scan. They expect the toggled bit to automatically flip right back to its original state. That's incorrect. Actually the bit will stay in its new toggled state forever – until SOMETHING changes the state again. There are many things that can change the state of a bit. Another toggle operation can do it. Instructions in the ladder logic program can do it. And if the bit happens to have an INPUT address, its status will periodically be updated by the processor - USUALLY at the beginning of every ladder scan. This automatic update of the input bits accounts for the common misconception that says: "You can't toggle an input bit". Actually, yes, you can toggle an input bit, but in most cases it won't stay in its new toggled state for very long.

Discussion on "Forces"

Contrary to popular opinion, the "Force" feature does NOT act directly upon bits (boxes) located in the processor's memory. Instead, the force is applied to either (1) an input "signal" coming into the processor – or (2) to an output "signal" going out of the processor. Specifically, a force is NOT applied directly to a bit in the processor's memory.

Key point: We "toggle" BITS – but we "force" SIGNALS. (Big difference!)

More specifically, input forces are applied (for example) at Positions W and X in Figure 1. Notice that these positions are located UPSTREAM of the bits/boxes on the Input Data Table. On the other hand, output forces are applied (for example) at Positions Y and Z in Figure 1. Notice that these positions are located DOWNSTREAM of the bits/boxes on the Output Data Table. Many technicians fail to realize the simple truth that INPUT forces behave DIFFERENTLY than OUTPUT forces. Let's see why.

First consider that even though forces are NOT applied directly to the bits, it is a fact that INPUT forces DO indeed affect the status of the bits/boxes in the processor's memory. Specifically, forcing an INput signal ON will cause the associated bit/box to take on a status of ONE – regardless of whether the actual field input device (example: a switch) happens to be ON or OFF. IMPORTANT POINT: This means that input forces CAN have an effect on the ladder logic program.

Now consider that OUTPUT forces do NOT affect the status of bits/boxes in the processor's memory. Specifically, forcing an OUTput signal ON will NOT cause the associated bit/box to take on a status of ONE. Yes, the actual field output device (example: a pump) will be energized – but the status (ONE or ZERO) of the bit/box in the processor's memory will still be controlled by the ladder logic program. IMPORTANT POINT: This means that as far as the execution of the ladder logic program is concerned, the output forces do not even exist.

In a nutshell, the status of instructions (XIC, XIO, etc.) in the PLC's program WILL react to INput forces. On the other hand, the status of ladder logic instructions will NOT be affected by OUTput forces.

Notice that this **Beginner Level Quiz #115** covers toggling bits which only have OUTPUT addresses. That's because the processor doesn't periodically "refresh" the output bits the way that it does the input bits. Therefore toggling output bits is much easier for beginners to cut their teeth on. We saved toggling input bits for this month's **Beyond Beginner Quiz #215**.

Discussion on RSLogix5000 “Tool Tips” for Force Items

And now a special word about the screen shots in Figures 4 and 5. As we said earlier, these were taken from Version 15 of RSLogix5000 for a ControlLogix system. One of the main reasons that we used the RSLogix5000 software for these particular pictures was to demonstrate those little “Tool Tips” that pop up when the mouse is held over the “force items” on the screen. (RSLogix5 and RSLogix500 don’t have Tool Tips for their force items.) We need to talk about these little “force item” Tool Tips because they can be quite “misleading” - to say the least.

Consider that pointing the mouse to the word “OFF” at Position D in Figure 4 tells us: “This bit is being forced OFF”. In reality there is NOTHING located at Position D which is being forced at all. (IMPORTANT: The XIC at Position D is NOT a “bit” – it is an “instruction” instead.)

Want proof that nothing at Position D is being forced? We highly recommend that you experiment with a spare system like the one we’re using for this quiz and see for yourself. Try out the situations in Questions 8 through 11 and carefully watch what happens. You will be able to reliably turn the Horn device in the field ON and OFF – as many times as you like – even though the little Tool Tip at Position D firmly assures us that: “This bit is being forced OFF” the whole time.

Based on this, it looks like the nice folks who wrote the RSLogix5000 programming software might have “dropped a stitch” on this one. They’re human too, and we all make mistakes. So is this a trivial matter? Well, it might seem trivial to us while we’re just taking a quiz - but probably not so trivial to a frustrated technician who mistakenly trusts those little Tool Tips while troubleshooting a piece of equipment.

Now take a look at Position C in Figure 4 where another little Tool Tip tells us that the: “Value contains an enabled force”. Try monitoring the “value” of the Pump’s bit in the processor’s memory while you press the Start_Button and then the Stop_Button a few times. The value stored in the Pump’s bit will definitely switch back and forth between ONE and ZERO – and somehow that just doesn’t seem to fit in with what the little pop up Tool Tip is telling us. Another dropped stitch perhaps?

My personal advice is to ignore those little Tools Tips for the “force items” like the ones we’re dealing with. RSLogix5000 makes a lot of use of Tools Tips for many features other than “force items” and usually those work just fine. So how confusing are forces anyway? Notice that even the programmers who write the official software sometimes misunderstand exactly what’s going on with them.

Key "Beginner Level" Concepts Involved in This Quiz

(1) The "Toggle Bit" feature reverses the ONE/ZERO status of a bit in the processor's memory. The bit will remain in its new state until something changes the status again.

(2) A "Force" operation applied to an OUTPUT signal takes place DOWNSTREAM of the Output Data Table. This means that forcing an OUTPUT signal does NOT affect the operation of the ladder logic program. So forcing an output signal either ON or OFF will NOT affect the ONE/ZERO status of the associated output bit. In other words, the ladder logic program will continue to respond exactly as if the OUTPUT force does not exist.

(3) A "Force" operation applied to an INPUT signal takes place UPSTREAM of the Input Data Table. This means that forcing an INPUT signal CAN affect the operation of the ladder logic program. So if the input signal is forced ON, then the ladder logic program will respond to the associated bit's "forced on" status of ONE. If the input signal is forced OFF, then the ladder logic program will respond to the associated bit's "forced off" status of ZERO.

Like most "rules" these have exceptions – but learning these would make a good beginner level starting point. If you'll apply these three concepts to this quiz, you should get the right answer for each and every question.

Survival Tip: Since this beginner level quiz doesn't involve the forcing of inputs, you really only need Key Concepts (1) and (2) to solve all of the questions in this particular quiz.

Beginner Level Quiz #115 – Summing Up

When properly used, the "Toggle Bit" and "Force" features are among the most powerful troubleshooting tools that a PLC technician has at his disposal. Unfortunately most technicians have little or no understanding of exactly how these important features actually work. Even some "Top Gun" PLC technicians with years of experience often rely on "hunt and peck" troubleshooting methods which are based on mistakes and misconceptions.

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 some people find PLC skills so hard 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 at www.ronbeaufort.com.

We hope that you've enjoyed the quiz – and hopefully learned something from it. We've tried to keep the test conditions in our experiments as close as possible to the "normal" conditions that you'll run into while working in the field. But, as they say: "Your mileage may vary." Just remember that there are many factors which can affect the results of any test. That's why it's always best to learn and understand the "nuts and bolts" of why each PLC system acts the way it does – instead of relying on popular "rules of thumb" which might not be accurate in every situation.

If you'd like to discuss any of the material in our PLC Quiz, just contact us and give us a chance to go over it with you. We'll be glad to answer any questions that you might have.