Introduction and Purpose

This note discusses the purposes and uses for the ‘step index’ in conjunction with the Logix Phase Manager instruction. The note suggests numbering conventions and practices that will facilitate consistent and maintainable code. The following will be covered:

• Purpose and use of ‘step indexes’
• Proposed ‘step index’ numbering scheme
• Sequencing phase activity using ‘step indexes’
• Implementing Phase restart logic with ‘step indexes’
• Establishing ‘step indexes’ in routines other than the ‘Running’ state

Purpose, use, and assignment of step indexes

Phase Steps and Step Indexes

‘Phase Steps’ are sequential activity within a phase’s state logic. Take for example the ‘Running’ state of a “Material Addition Phase.” The order and steps this phase might take are:

1. Acquire devices (such as flow meter, valves, and pump)
2. Put devices in ‘Program’ Mode
3. Clear Totalizer
4. Open Valves
5. Start Pump
6. Monitor Flow – wait for set-point to be reached
7. Stop Pump
8. Close Valves
9. Release devices

Therefore ‘step indexes’ provide the step number or index needed to identify various steps (numbers 1-9 in the example above).

Step Index Numbering

There are no product restrictions regarding ‘step index’ values. However, defining and adhering to a standard numbering scheme provides several benefits including:

• Consistent and self-documenting code
• Easier troubleshooting

The following guideline is suggested in Figure 1.

<table>
<thead>
<tr>
<th>Phase State</th>
<th>Step Index Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Running</td>
<td>0 – 2999</td>
</tr>
<tr>
<td>Holding</td>
<td>3000 – 3999</td>
</tr>
<tr>
<td>Restarting</td>
<td>4000 – 4999</td>
</tr>
<tr>
<td>Stopping</td>
<td>5000 – 5999</td>
</tr>
<tr>
<td>Aborting</td>
<td>6000 – 6999</td>
</tr>
<tr>
<td>Resetting</td>
<td>7000 – 7999</td>
</tr>
</tbody>
</table>

Figure 1
Furthermore, ‘step index’ ranges should be defined within at least the ‘Running’ state. The following guideline is suggested in Figure 2.

Therefore, the ideal state index most phases should be found in would be 1500. If this were an agitation phase, the agitator would be running. If this were a material addition phase, the material would be flowing and quantity totalized.

## Phase Step Sequencing

There are no product restrictions regarding phase step sequencing. The following is a suggested method that many users have found easy to use and maintain.

The general concept is:
- If in Step x, then do this
- When these conditions are met, move to Step y

A relay ladder logic (RLL) example of this construct is shown below:

More complex or multiple exit paths can be defined. For example:
When creating the initial design, it is good practice to space step index numbers apart by at least 5, preferably 10 values. This leaves space for additional steps, which are always needed as the project moves through its lifecycle.

Referring to the introduction sample, steps 4 & 5 would look like the following, using the guidelines in this section:
Finally, rung comments should be added. For uniformity, the rung comment could follow the suggested format:

Line 1:  SI = XXXX    Step Title
Line 2:  Step Action
Line 3:  Transition Condition

An example of the completed rung follows:

\[
\begin{align*}
SI &= 1040 \quad \text{Start Pump} \\
\text{Action} &= \text{Start water supply pump} \\
\text{Transition} &= \text{Pump start or fail confirmation}
\end{align*}
\]

**Phase Restart Logic**

**Introduction**

Most phases need to account for a transition from the ‘Running’ state to the ‘Hold’ state and back to the ‘Running’ state. Furthermore, in most cases, a return to the ‘Running’ state does not mean starting the state actions from the beginning.

For example, in the simple sequence, described in the introductory section, if one were to leave ‘Running’ while in Step 6 (adding), go to ‘Hold,’ then return back to ‘Running,’ it would not be desirable to return to the beginning of the sequence and clear the totalizer in Step 3. Instead, one would want to return to Step 4 (open valves) and continue with the addition by opening the valves, starting the pump, and resume adding material.

A recommended approach for handling these reentry conditions is to introduce the concept of ‘HoldIndex.’ The ‘HoldIndex’ is simply the ‘step index’ one wants to return to, if we suddenly left the ‘Running’ state.
Phase Manager Concepts

Before showing examples on how to implement the ‘HoldIndex’, a brief review of the Phase Manager instruction might be helpful. When in a given state, an external command can immediately transition the phase to another state (following the state transition diagram). Phase Manager always resets the ‘step index’ to a configured value (typically 0) when a state transition occurs. For example, if in the ‘Held’ state and the step index were equal to 3030 and then a command to return to the ‘Running’ state were issued, the phase would be in the ‘Running’ state with a ‘step index’ equal to zero.

Implementing a ‘HoldIndex’

The index rung, which is the first rung of the ‘Running’ state logic processes this algorithm:

- Adding an ‘index rung’ which is always the first rung in the ‘Running’ state
- Adding a move instruction to establish a new re-entry point
- Adding a Clear ‘HoldIndex’ command in the resetting state

Index Rung

Implementing the ‘HoldIndex’ to establish desired re-entry points requires three programming actions, those being:

- If the ‘step index’ = 0 (meaning this is the first scan of the ‘Running’ state logic)
- Set the ‘step index’ to XXX (where XXX is the first step of the ‘Running’ logic)
- If the ‘HoldIndex’ > 0, then set the ‘step index’ = ‘HoldIndex’

Simply put, if the ‘HoldIndex’ is greater than zero (meaning a new return point has been established), go to that step. If the ‘HoldIndex’ is = 0, then process the ‘Running’ state logic from the start.

An example of the “Index Rung” follows:

![Index Rung Diagram]
Establishing a New ‘HoldIndex’

Whenever a new, desired, re-entry point is encountered, mark that step as the re-entry step.

Note: This does not have to be “marked” on every step. Only those steps which are the re-entry points should have a “marker.” Referring to the opening example, there would be two re-entry points, those being Step 4 (open valves) and Step 7 (stop pump).

The re-entry point is established with a “Move” instruction, moving the current ‘step index’ into the ‘HoldIndex.’ This in effect says, “If I made it at least this far in the sequence, this is where I would want to return to.”

An example follows:

Clearing the ‘HoldIndex’

The ‘HoldIndex’ must be cleared at the end of the phase’s execution. This should be done in the ‘Resetting’ state, so that the ‘HoldIndex’ is cleared, regardless of the phase exit path (complete, stop, abort).

An example of the ‘HoldIndex’ clear rung, located in the ‘Resetting’ state follows:
Setting ‘Step Indexes’ in other States

As discussed in the previous section, whenever a state transition occurs, the ‘step index’ is set to zero. Therefore, if the “State Index Ranges,” suggested in the opening section, are used, then the user must establish the starting index value.

This is done with a rung, which is always the first rung of the state. An example of the first rung of the ‘Aborting’ state following the conventions suggested in this paper would be:

```
Move
Source   6000
Dest     Step_Index
0
```

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