MagneMotion

A Rockwell Automation Company

SYNC IT Sample Logic Application Note

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MagneMotion, Inc.
A Rockwell Automation Company
139 Barnum Road
Devens, MA 01434
USA

Phone: +1 978-757-9100
Fax: +1 978-757-9200

www.magnemotion.com

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About This Document

This document is an Application Note.

Purpose

This document describes the MMI_SyncSampleLoop sample logic operating theory, setup, and options in general terms. More detailed explanations of each routine are provided as comments in the sample code. This logic is applicable to MagneMover LITE and QuickStick systems that use SYNC IT™ controllers.

Reference Documents

- 990000447 – LSM Synchronization Option User's Manual
- 990000769 – Allen Bradley MMI_sample_loop Sample Logic Application Note

Definitions, Acronyms, and Abbreviations

Table 1 provides common terminology for use with SYNC IT™.

Table 1: Sync IT Terminology

Term	Definition
Sync Box	SYNC IT™ controller

Overview

This document describes the SYNC IT™ Sample Logic Version 2.0.0. The MMI_SyncSampleLoop.ACD logic from this release expands upon the MMI_sample_loop.ACD sample logic described in the Allen Bradley MMI_sample_loop Sample Logic Application Note. Some of the sample loop routines have been modified for use with sync, while others are unchanged. Additional tasks, programs, and routines have been developed for use with sync.

This sample logic contains examples of several ways to take and release sync control of vehicles. One routine contains a vehicle-based state machine where each vehicle cycles through the states. This state machine first takes and releases sync control from a stop, then takes and releases sync control during motion. Another routine contains a state machine which takes all vehicles on the track under sync control together.

Layout

This sample logic project is configured for a continuous sync loop of 4 SYNC IT™ controllers (sometimes referred to as Sync Boxes) for 20 Axes. The system layout is shown in Figure 1, which displays the Paths and Nodes, as well as the Sync Box locations on the track. This layout contains more Nodes than the minimum required for this layout to illustrate a multi-Path system example.

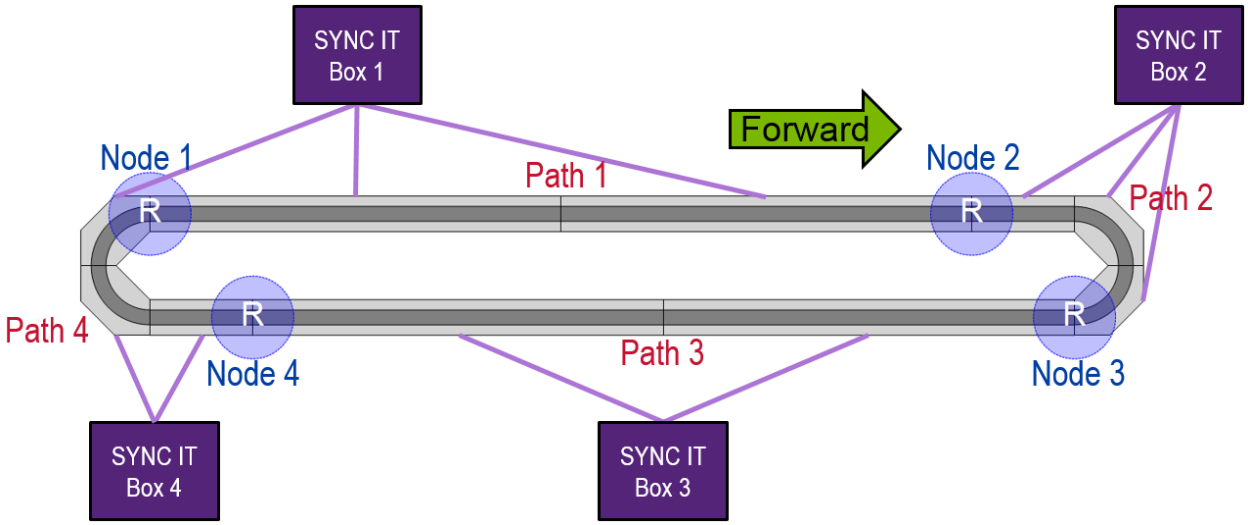

Figure 1: Sync Sample Loop Layout

New Programs and Routines

Multi-Zone Mode

Multi-Zone Mode is an example of taking and releasing sync control of a vehicle both from a stop and during motion. Vehicles are taken under sync control at a station, and a Motion Axis Move (MAM) is used to command them to the next station where they are released from sync control. A Motion Axis Jog (MAJ) is then used to match the virtual axis to the vehicle's asynchronous speed and sync control is taken. A Motion Change Dynamics (MCD) is used to change the axis (and therefore vehicle) speed. Sync control is released while the vehicle is in motion and the vehicle continues back to the first station.

Since the sample loop is one complete Sync Zone, the converted vehicle data from the Sync Boxes uses a position starting at 0 and ending at the full track length. The Path and Position format of vehicle location is also used at times. Figure 2 displays the Path and Position as well as converted vehicle data formats for the start and end positions of the MAM and MAJ in Multi-Zone Mode.

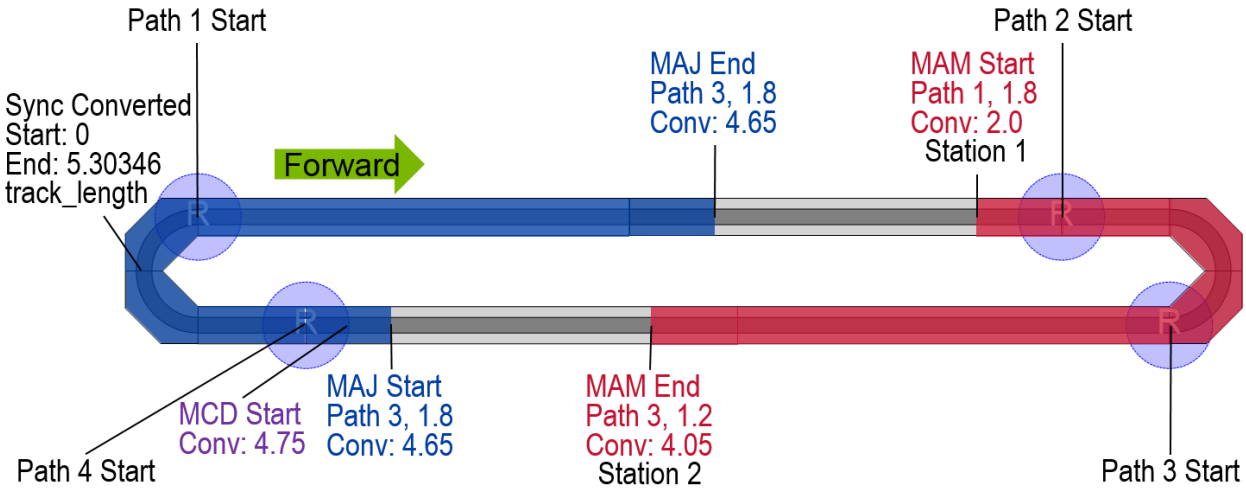

Figure 2: Sync Sample Loop Multi-Zone Mode

The station manager and vehicle manager of the MMI_sample_loop.ACD are utilized to ensure the vehicle always has an underlying asynchronous order. This mode also utilizes the Motion Axis Stop (MAS) and Motion Redefine Position (MRP) motion instructions to stop and align virtual axes to vehicle positions. Multi-Zone Mode is a vehicle-based state machine, meaning that each vehicle moves independently through the states.

Continuous Mode

Continuous Mode is an example of taking sync control of all vehicles at the same time and moving them together. Continuous Mode uses a MAS and MRP to stop all the axes and align them to the vehicle positions on the track. An equal spacing between vehicles is calculated and a MAM is used to move vehicles to the initial positions shown in Figure 3 and Figure 4. Axes 02-20 use a Motion Axis Gear (MAG) to gear to Axis 01. A MAJ is used to jog Axis

01, therefore moving all vehicles together. This mode also uses the station manager and vehicle manager to ensure vehicles have underlying asynchronous orders.

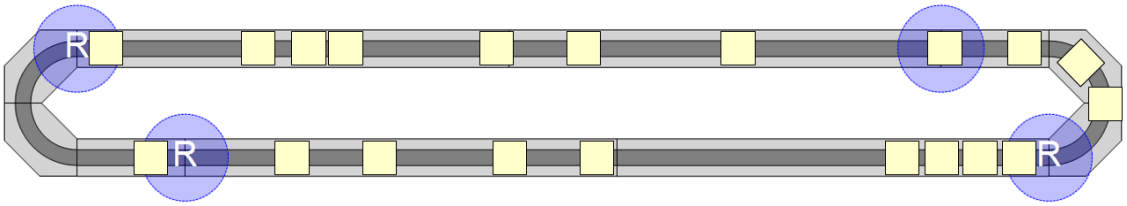

Figure 3: Continue Mode Before Initial Positions

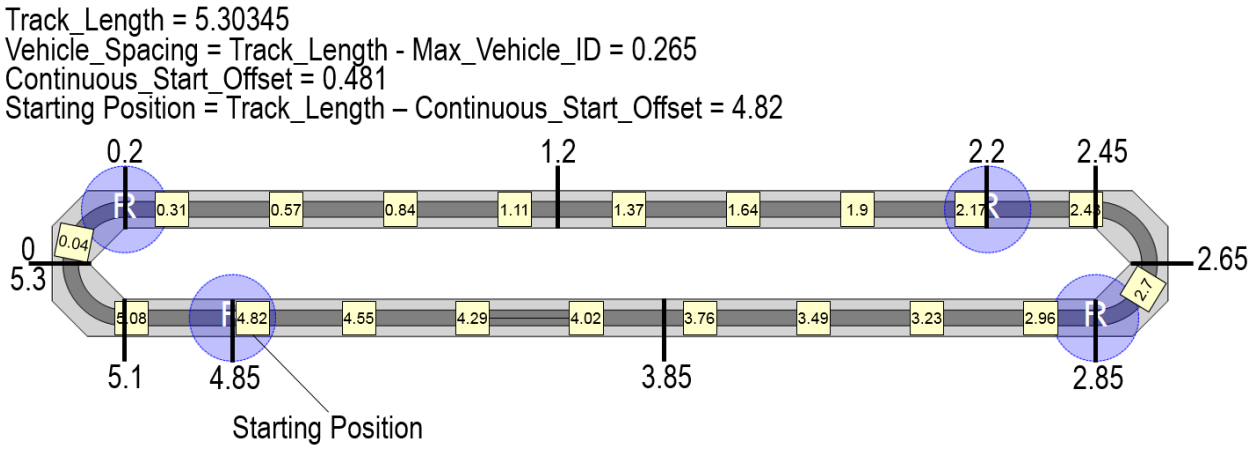

Figure 4: Continuous Mode Vehicle Initial Positions

Sync Dashboard, Axis Unwind, and Init Sync

The Sync Dashboard routine allows the user to configure their sync application. Parameters such as mode, station locations, velocities, and direction can be configured there.

Axis Unwind is a structured text routine to set the Position Unwind for all axes.

The Init Sync routine is called from the Cold Start Service to configure the Sync Box data and clear the tags used for sync control.

Motion Managers

A new program has been added to the main task for managing Motion Instructions (MAM, MAJ, etc.). This program contains routines where each Motion Instruction can be enabled on a per axis basis or for all axes. User Defined Types (UDTs) have been created to contain the tag inputs to each Motion Instruction. For example, the user can set the MAS deceleration rate (SYNC_MAS[v].decel_rate) and then execute the MAS for the vehicle. The user can also execute a Motion Instruction for all axes together. This approach allows for the indirect addressing of Motion Instructions despite that motion axes cannot be indirectly addressed.

Profile Task

The Profile Task now contains all direct communications with the Sync Boxes. The Convert Feedback routine (previously titled Utilities in some versions of sync sample logic) is called from the Main Routine of the Profile Task.

Out Slot Assignment uses a new helper routine (R02A_OutSlotAvailable) to determine the lowest available output slot on a Sync Box for vehicles entering the range of the Box. It also clears the output slot once the vehicle is out of range.

The Take Sync Control routine manages sending the Vehicle ID to the output slot on the Sync Box and taking sync control. The user can now toggle a bit within the sync state machine of either mode to take or release sync control of a vehicle and this routine will handle the process. It also handles maintaining sync control as a vehicle traverses multiple Sync Boxes.

Profiles to Motor uses several AOIs to populate the axis, vehicle, and profile information into an array of Sync Box data. This array is then copied to the Sync Box Output Data for each Sync Box at the end of the Main Routine of the Profile Task.

Instructions

Taking Sync Control

This sample logic has simplified the process of taking and releasing sync control of a vehicle. The process for taking sync control of a vehicle includes sending the Vehicle ID to the output slot on the Sync Box, latching the Use Host Profile bit for that slot, and checking that the Under Sync Control status bit reflects that the vehicle is using the host profile. Two new tags have been implemented to help perform this task. Both tags are arrays of bits where the index is the Vehicle ID.

Latching out_slot_to_sync_box[v] moves v's Vehicle ID into the output slot that R02_OutSlotAssignment has assigned for the vehicle. Unlatching out_slot_to_sync_box[v] moves zero into the Vehicle ID location of the slot that v was assigned. It also unlatches the Use Host Profile bit for the slot.

If use_host_profile[v] is latched while out_slot_to_sync_box[v] is latched, then the Use Host Profile bit for the slot is latched for the vehicle. Unlatching use_host_profile[v] unlatches the Use Host Profile bit for the slot, releasing sync control of the vehicle.

Figure 5 is an example of latching the use_host_profile[v] bit within the Multi-Zone Mode state machine. In state 35, the use_host_profile[v] bit is latched. In state 40, the Under Sync Control bit is checked to ensure the vehicle is now using the Host Profile before proceeding.

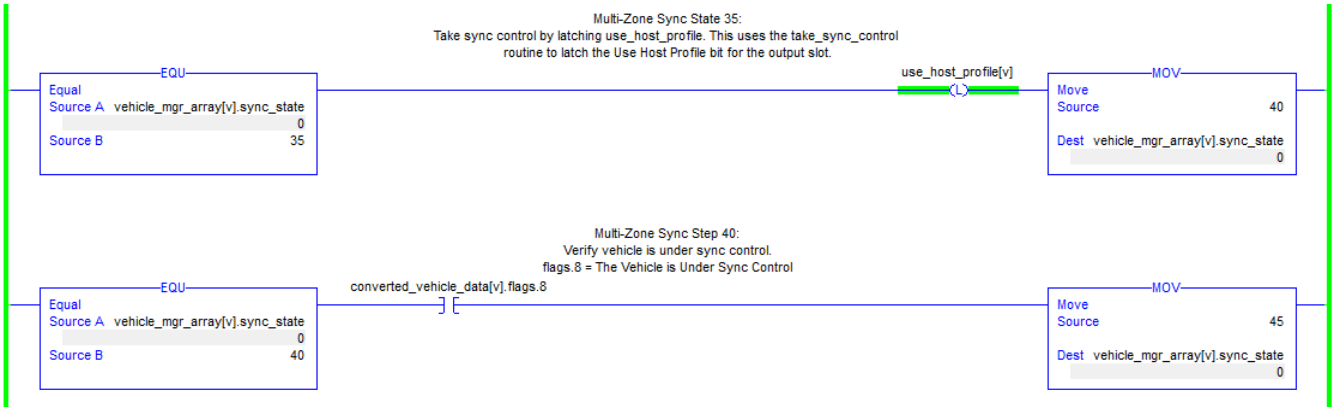

Figure 5: Take Sync Control

Using Motion Managers

The new Motion Mangers allow the user to configure and execute Motion Instructions from the state machine. Each Motion Instruction is enabled by latching the execute bit of the associated UDT. The example from the Multi-Zone Mode shown in Figure 6 executes an MRP. State 25 sets the current vehicle position from the converted vehicle data to the desired MRP position. State 25 also latches the execute bit and checks that the MRP is enabled. Sate 30 checks that the MRP successfully initiated.

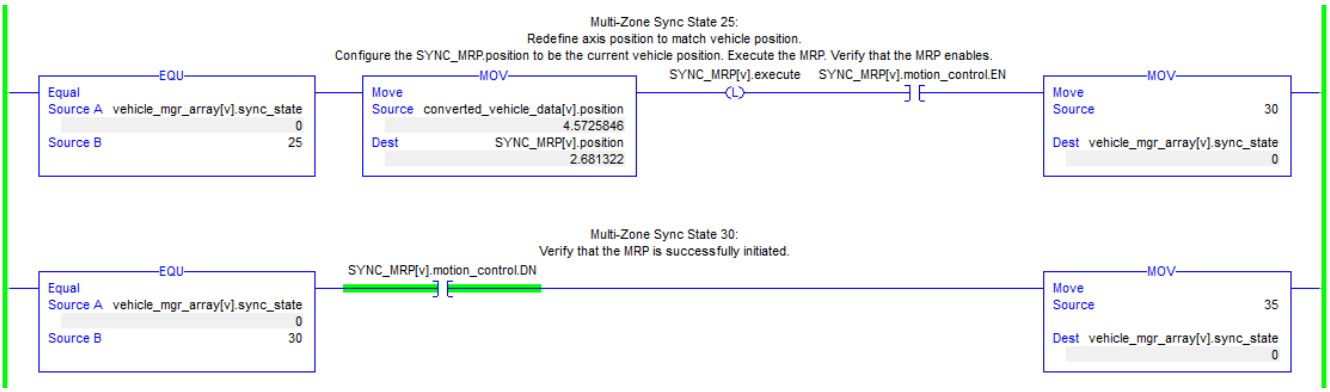

Figure 6: Execute Motion Instruction for Indivudal Axis

The example in Figure 7 is from the Continuous Mode to MRP all axes to all vehicle positions. Step 30 sets the MRP position to the converted vehicle data position of all vehicles. Step 35 executes an MRP for all vehicles at the same time. Step 40 then checks that the MRP is successfully initiated before proceeding.

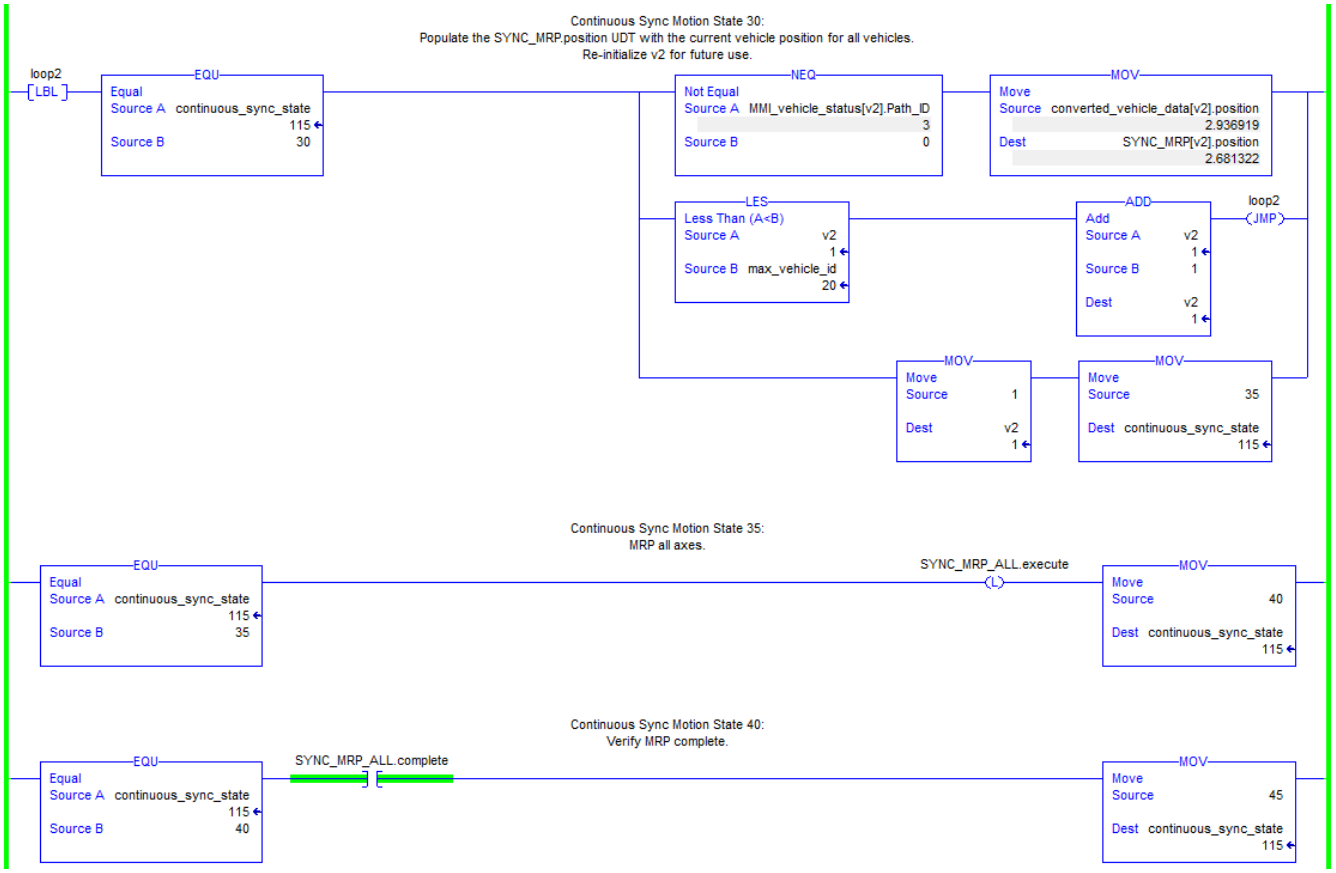

Figure 7: Execute Motion Instruction for all Axes

Modifications for Different Layouts

Table 2 outlines the locations and types of modification required to run this sample logic for a different system layout.

Table 2: Modifications for Different Layouts

T00_MainTask	
P01_MMISample	
R00_MainRoutine	No changes required.
R01_SyncDashboard	Configure the application parameters per system design.
R02_ColdStartService	No changes required.
R02A_InitConstants	Set the constants in rung 6 for your system size (ex. max_path_id).
R02B_InitStations	Configure additional stations if desired. Station parameters for stations 1-4 are set in the Sync Dashboard.
R02C_AxisUnwind	Add or remove axes per system design.
R02D_InitSync	Configure per system layout. Add or remove Sync Boxes per system design.
R02E_NextCommandCount	No changes required.
R03_MsgService	No changes required.
R04_HLCLinkMonitor	No changes required.
R05_StationProcessing	Modify station depart conditions as desired.
R06_StationMgr	No changes required.
R07_VehicleMgr	No changes required.
R08_SyncModeMultizone	Modify process as desired.
R09_SyncModeContinuous	Modify process as desired.
P02_MMISyncMotionManager	
R00_MainRoutine	No changes required.
R01_MASManager	Add or remove axes per system design.
R02_MRPManager	Add or remove axes per system design.
R03_MAMManager	Add or remove axes per system design.
R04_MAGManager	Add or remove axes per system design.
R05_MAJManager	Add or remove axes per system design.
R06_MCDManager	Add or remove axes per system design.
T01_ProfileTask_P01_10ms	
P01_MMISyncControl	
R00_MainRoutine	Add or remove Sync Boxes per system design.
R01_ConvertFeedback	Add or remove Sync Boxes per system design.
R02_OutSlotAssignment	Add or remove Sync Boxes per system design.
R02A_OutSlotAvailable	No changes required.
R03_TakeSyncControl	Add or remove Sync Boxes per system design.
R04_ProfilesToMotor	Add or remove Sync Boxes and axes per system design.
Motion Groups	
MotionGroup00_MMI	Add or remove axes per system design.
AOIs	
AOI_MM_Sync_Output_Format	Modify the motor start and end locations and wrap conditions per system design. Add or remove Sync Boxes per system design.

AOI_MMI_Sync_Motion_IO	If the system is a loop and the last motor on the last Sync Box is not Motor 2, change Motor_2_End_Point in rung 2 to be the end point of last motor. The wrap condition currently wraps the end of Motor 2 on the Wrap_end motor with the start of Motor 1 on the Wrap_start motor.
UDTs	
UDT_MM_SyncBoxOutput	Add or remove Sync Boxes per system design.
UDT_MM_SyncBoxOutSlot	Add or remove Sync Boxes per system design.
UDT_MM_VehiclesPerPathArray	Expand UDT_MM_VehicleData for more vehicles per system design.
Controller Tags	
Configure the Communication Path for tags of type MESSAGE to point to the HLC IP Address. Expand array sizes for more components as needed per system design.	
I/O Configuration	
Configure PLC I/O per system design. Configure IP Addresses of Generic Ethernet Modules to be the IP Address of the Sync Boxes.	

Appendix

Multi-Zone Mode State Machine

Table 3: Multi-Zone Mode State Machine

Sync State	Multi-Zone Mode	Next State	Use Host Profile	Out Slot to Sync Box
200	Stop all axes.	-	-	-
0	No operation. A vehicle arrival at Station 1 will move this to state 5.	-	-	-
5	Vehicle has arrived at Station 1. Stop the motion axis (MAS).	10	U	U
10	Confirm the axis is stopped.	15	U	U
15	Confirm the motor is the vehicle master and the vehicle signal is good.	20	U	U
20	Start sending data to the output slot on the Sync Box.	25	U	L
25	Redefine axis position to match vehicle position (MRP).	30	U	L
30	Verify that the MRP is successfully initiated.	35	U	L
35	Take sync control.	40	L	L
40	Confirm the vehicle is under sync control.	45	L	L
45	Configure and send a move command to Station 2 (MAM).	50	L	L
50	If sync control drops for more than 10 milliseconds, move to state 200. When the MAM is complete, move to state 55.	200 or 55	L	L
55	Release sync control.	60	U	L
60	Verify the Under Sync control bit is off.	65	U	L
65	Stop sending data to the output slot on the Sync Box.	70	U	U
70	Jog the axis at the async speed and acceleration (MAJ).	75	U	U
75	Verify the MAJ successfully initiated.	80	U	U
80	Wait for the vehicle to cross the jog start position.	85	U	U
85	Redefine axis position to match vehicle position (MRP).	90	U	U
90	Verify that the MRP is successfully initiated.	95	U	L
95	Start sending data to the output slot on the Sync Box.	100	U	L
100	Confirm the motor is the vehicle master and the vehicle signal is good.	105	L	L
105	Take sync control.	110	L	L
110	Confirm the vehicle is under sync control.	115	L	L
115	Wait for the vehicle to cross the jog change speed position.	120	L	L
120	Change the vehicle to the sync speed (MCD).	125	L	L
125	Verify that MDC is successfully initiated.	130	L	L

Sync State	Multi-Zone Mode	Next State	Use Host Profile	Out Slot to Sync Box
130	If sync control drops for more than 10 milliseconds, move to state 200. When the vehicle is between the MAJ end and MAM start positions, move to state 135.	200 or 135	L	L
135	Release sync control.	140	U	L
140	Verify the Under Sync control bit is off.	145	U	L
145	Stop sending data to the output slot on the Sync Box.	0	U	U

U – Bit is Unlatched

L – Bit is Latched

Continuous Mode State Machine

Table 4: Continuous Mode State Machine

State	Continuous Mode	Next State	Use Host Profile	Out Slot to Sync Box
200	Stop all axes.	-	-	-
0	No operation. Wait for the end of Cold Start Service to move to state 5.	-	-	-
5	Stop all axes (MAS).	10	U	U
10	Verify all axes are stopped.	15	U	U
15	Start sending data to the output slots on the Sync Boxes for all vehicles.	20	U	L
20	Confirm the motor is the vehicle master for all vehicles.	25	U	L
25	Confirm the motor is the vehicle signal is good for all vehicles.	30	U	L
30	Populate the MRP with the current vehicle position for all vehicles.	35	U	L
35	MRP all axes to the vehicle positions.	40	U	L
40	Confirm all MRPs complete.	45	U	L
45	Take sync control of all vehicles.	50	L	L
50	Confirm all vehicles are under sync control.	55	L	L
55	Command all vehicles to Station 3 for an underlying async order.	60	L	L
60	Sort all vehicles by path.	65	L	L
65	Confirm sort is complete, Initialize variables for initial position order calculations.	70	L	L
70	Calculate the spacing for the initial positions for the first path.	75	L	L
75	Repeat spacing calculation for all other paths.	80	L	L
80	Populate the MAM with the initial positions for all vehicles.	85	L	L

State	Continuous Mode	Next State	Use Host Profile	Out Slot to Sync Box
85	MAM all vehicles to their initial positions.	90	L	L
90	Confirm the MAMs complete.	95	L	L
95	Populate the MAG for Axes 02-20.	100	L	L
100	MAG Axes 02-20 to Axis 01.	105	L	L
105	Confirm MAG successfully initiated for Axes 02-20.	110	L	L
110	Configure and execute a MAJ for Axis 1.	115	L	L
115	If sync control drops for more than 10 milliseconds, move to state 200.	200	L	L

U – Bit is Unlatched

L – Bit is Latched

More Information

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Revision History

Ver.	Change Description
00	Initial release

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Local Technical Support Phone Numbers	Locate the phone number for your country.	http://www.rockwellautomation.com/global/support/get-support-now.page
Direct Dial Codes	Find the Direct Dial Code for your product. Use the code to route your call directly to a technical support engineer.	http://www.rockwellautomation.com/global/support/direct-dial.page
Literature Library	Installation Instructions, Manuals, Brochures, and Technical Data.	http://www.rockwellautomation.com/global/support/direct-dial.page
Product Compatibility and Download Center (PCDC)	Get help determining how products interact, check features and capabilities, and find associated firmware.	http://www.rockwellautomation.com/global/support/pcdc.page

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Rockwell Otomasyon Ticaret A.Ş., Kar Plaza İş Merkezi E Blok Kat:6 34752 İçerenköy, İstanbul, Tel: +90 (216) 5698400

www.rockwellautomation.com

Power, Control and Information Solutions Headquarters

Americas: Rockwell Automation, 1201 South Second Street, Milwaukee, WI 53204-2496 USA, Tel: (1) 414.382.2000, Fax: (1) 414.382.4444
Europe/Middle East/Africa: Rockwell Automation NV, Pegasus Park, De Kleetlaan 12a, 1831 Diegem, Belgium, Tel: (32) 2 663 0600, Fax: (32) 2 663 0640
Asia Pacific: Rockwell Automation, Level 14, Core F, Cyberport 3, 100 Cyberport Road, Hong Kong, Tel: (852) 2887 4788, Fax: (852) 2508 1846