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Troubleshooting Ethernet Network Issues When Using Integrated Motion

Kinetix and Powerflex Technical Support

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Introduction

Integrated Motion on the Ethernet/IP Network adds in another layer of troubleshooting ability

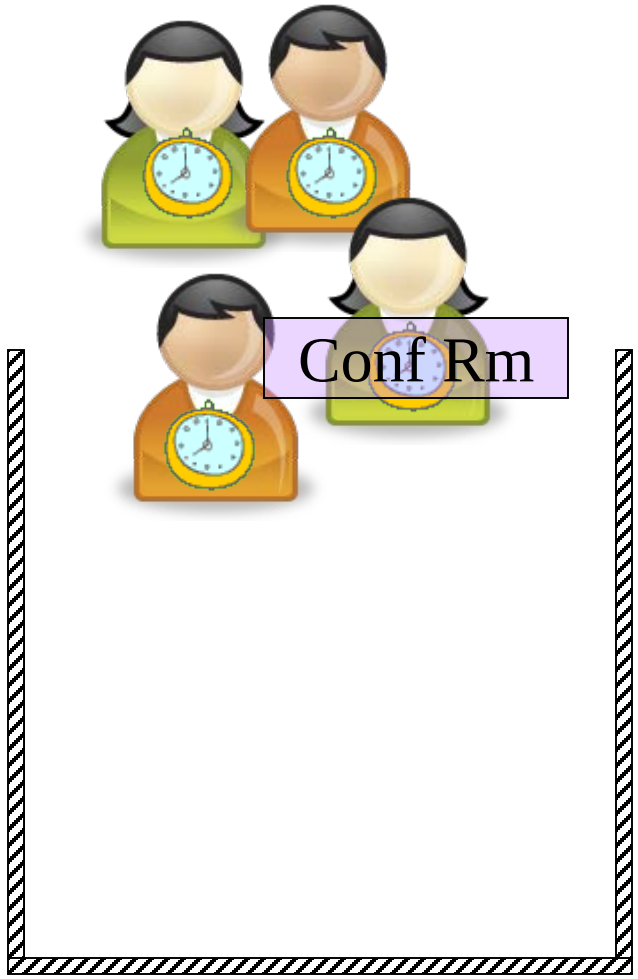
- The Integrated Motion Ethernet/IP Network is crucial to transmission and receiving of drive to controller and controller to drive information.
- This session is going to start at the beginning of the evaluation of this network in terms of the most common calls that technical support receives.
- There will be future sessions regarding intermediate and possibly even advanced troubleshooting and recommendations for Integrated Motion on the Ethernet/IP Network. I'm going to ask for your input on EXACTLY what you'd want to see by giving you my email address.

Agenda

The Integrated Motion on Ethernet/IP Network can be very simple or very complex based on plant layout. You HAVE to start with the basics or can get lost very easily in the troubleshooting process.

- The Integrated Motion on Ethernet/IP Big Picture
  - What is going on behind the scenes?
- Define the Integrated Motion Network
  - A simple hand sketch and cabinet layout can tell all.
- The difference between a configuration issue vs actual network fault.
- Use of Studio 5000 in search of the different issues.
- Knowledgebase articles written for the user to guide in the evaluation.

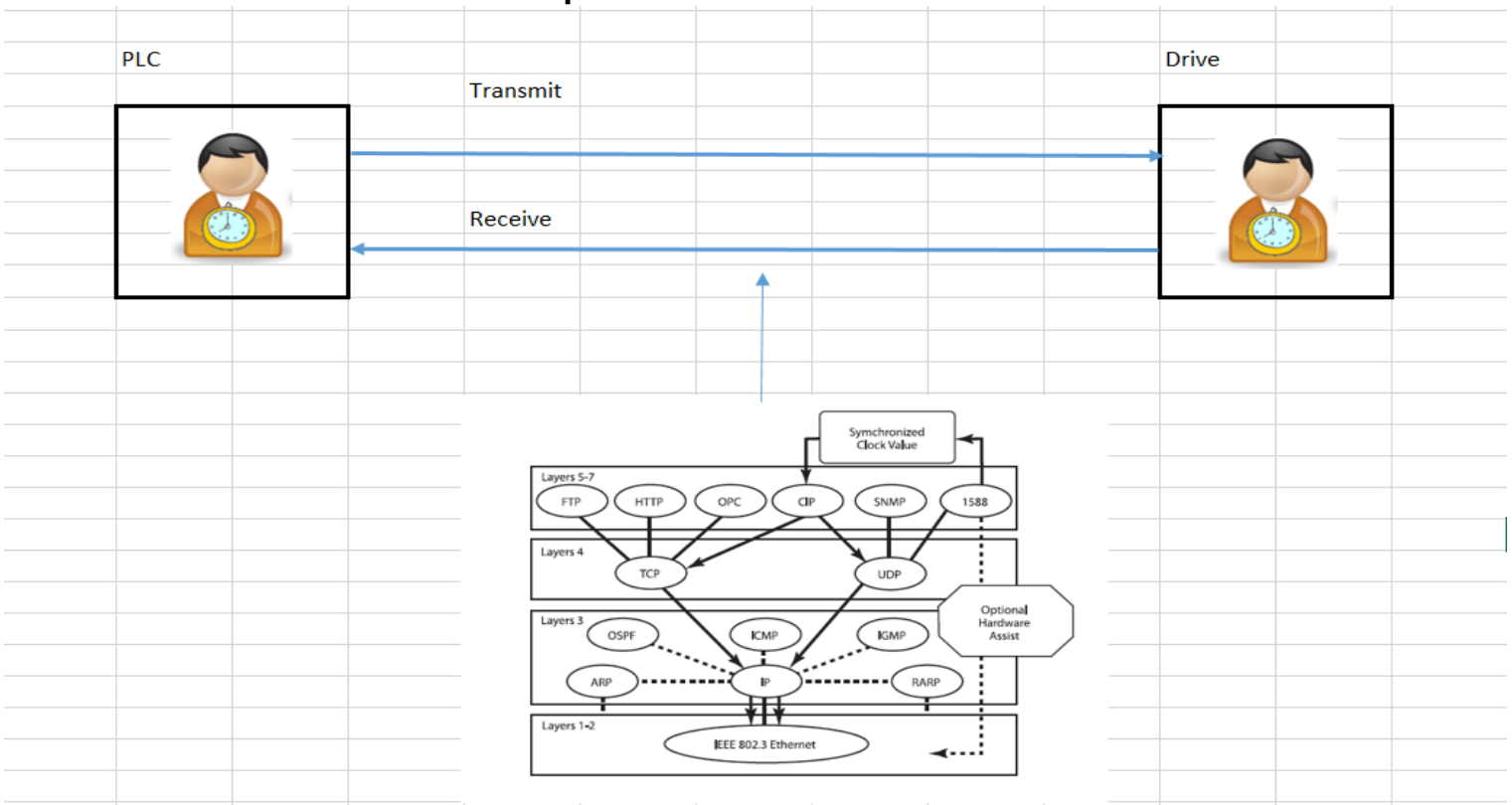
The ‘thought’ behind Integrated Motion on Ethernet/IP



- CIP Motion coordinates devices in a manner that’s similar to our own methods for coordinating meetings and events
  - All members (devices) have clocks to compare time to an absolute base and scale
  - A destination (position) is targeted for the event
  - A time (timestamp) is set for when the event shall occur
  - A message is sent to each member (device) to meet at the given place at the pre-determined time
    - Not all messages might arrive at precisely the same time!
    - …But all members arrive in the proper position at the proper time for the meeting to take place!

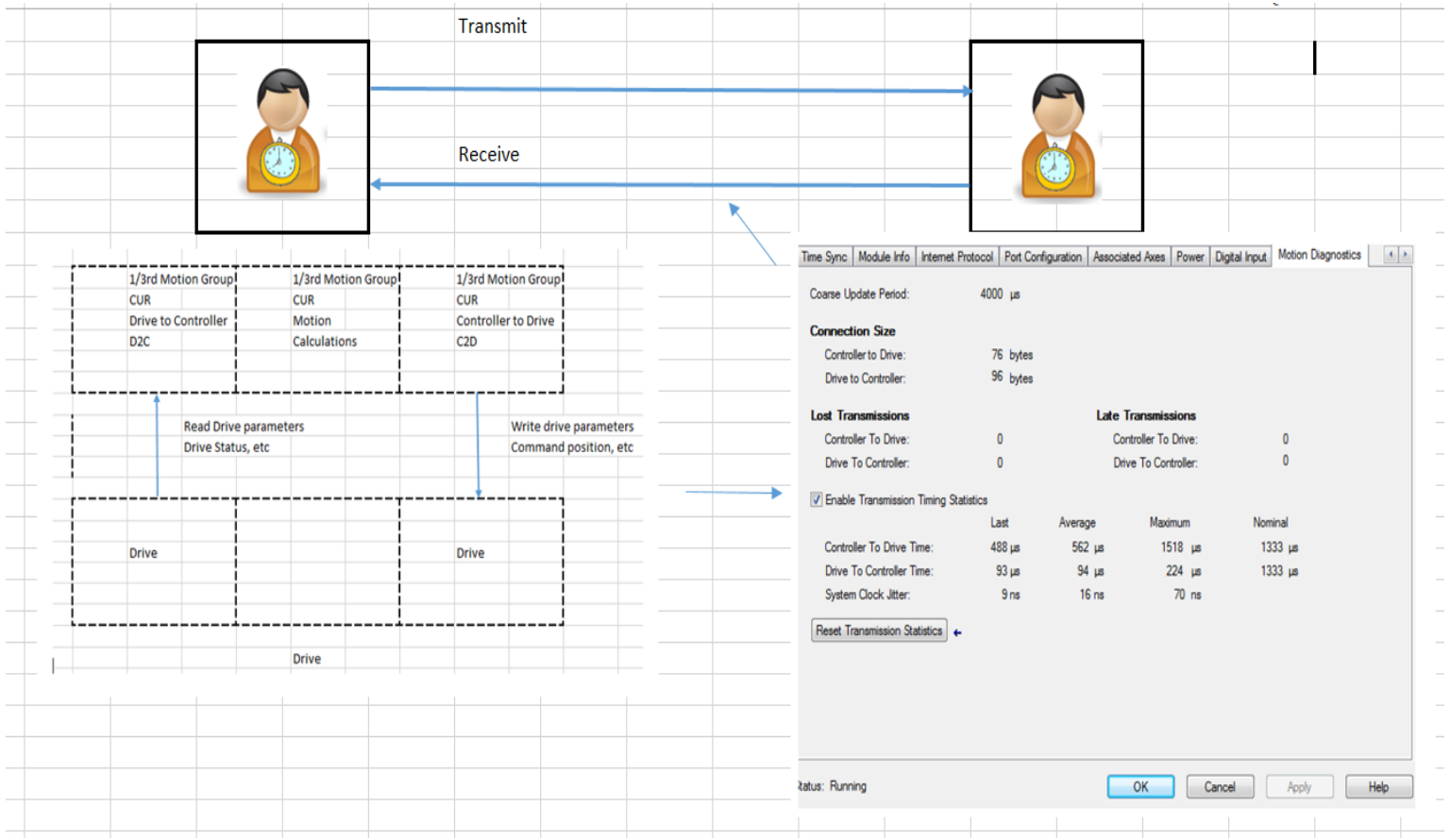
The BIG(or small) Picture

- CIP Motion does not schedule the network to create determinism.
- Instead, CIP Motion delivers the timestamp and data for execution as part of the packet data.
- This allows motion devices to plan and follow positioning path information according to a pre-determined execution plan.



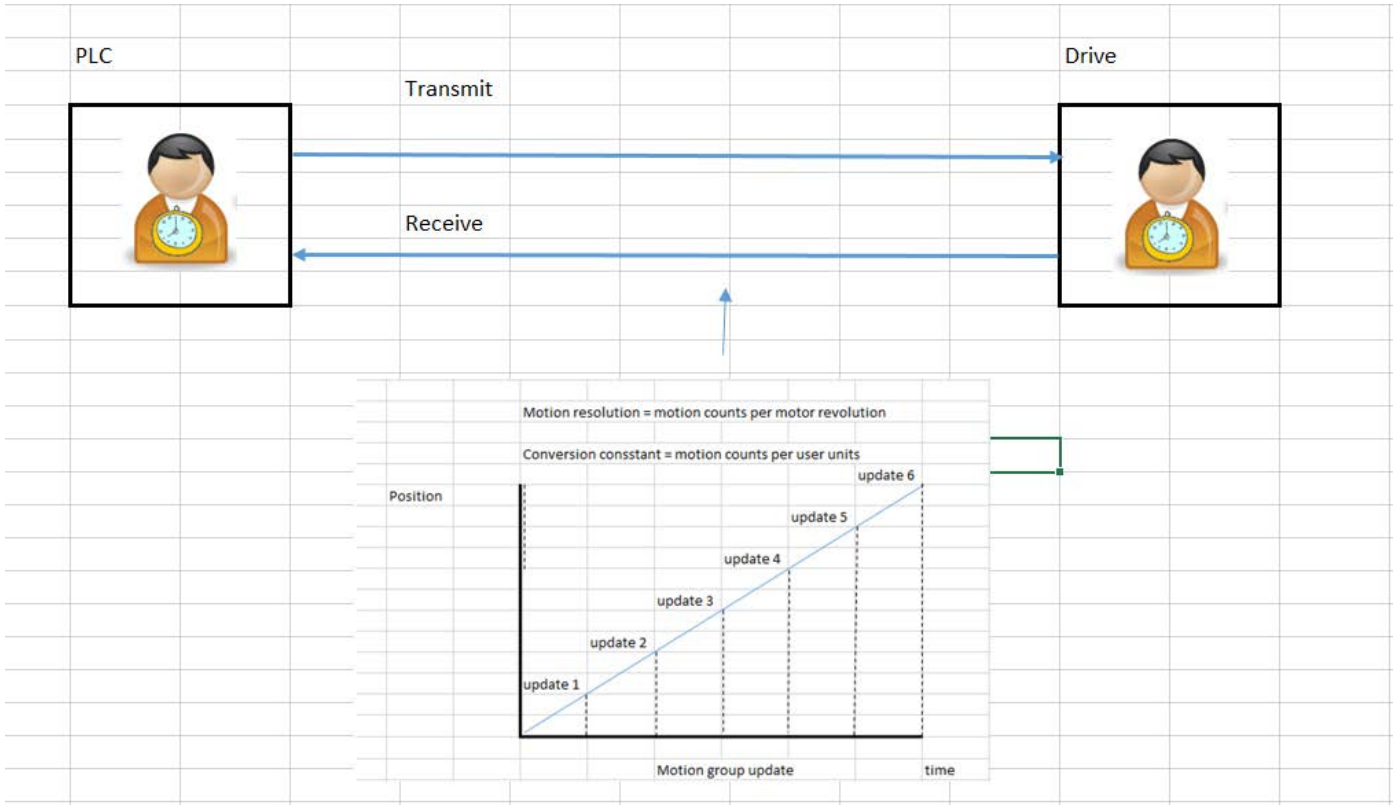
- The Ethernet Network layer uses CIP and IEEE1588 Time Synchronization(what they call PTP) for the PLC packet data
- The Transmission Control Protocol does the ordering and the checking of the packet quality
- The User Datagram Protocol carries the information of the timestamp and the motion planner position, for instance

The BIG(or small) Picture



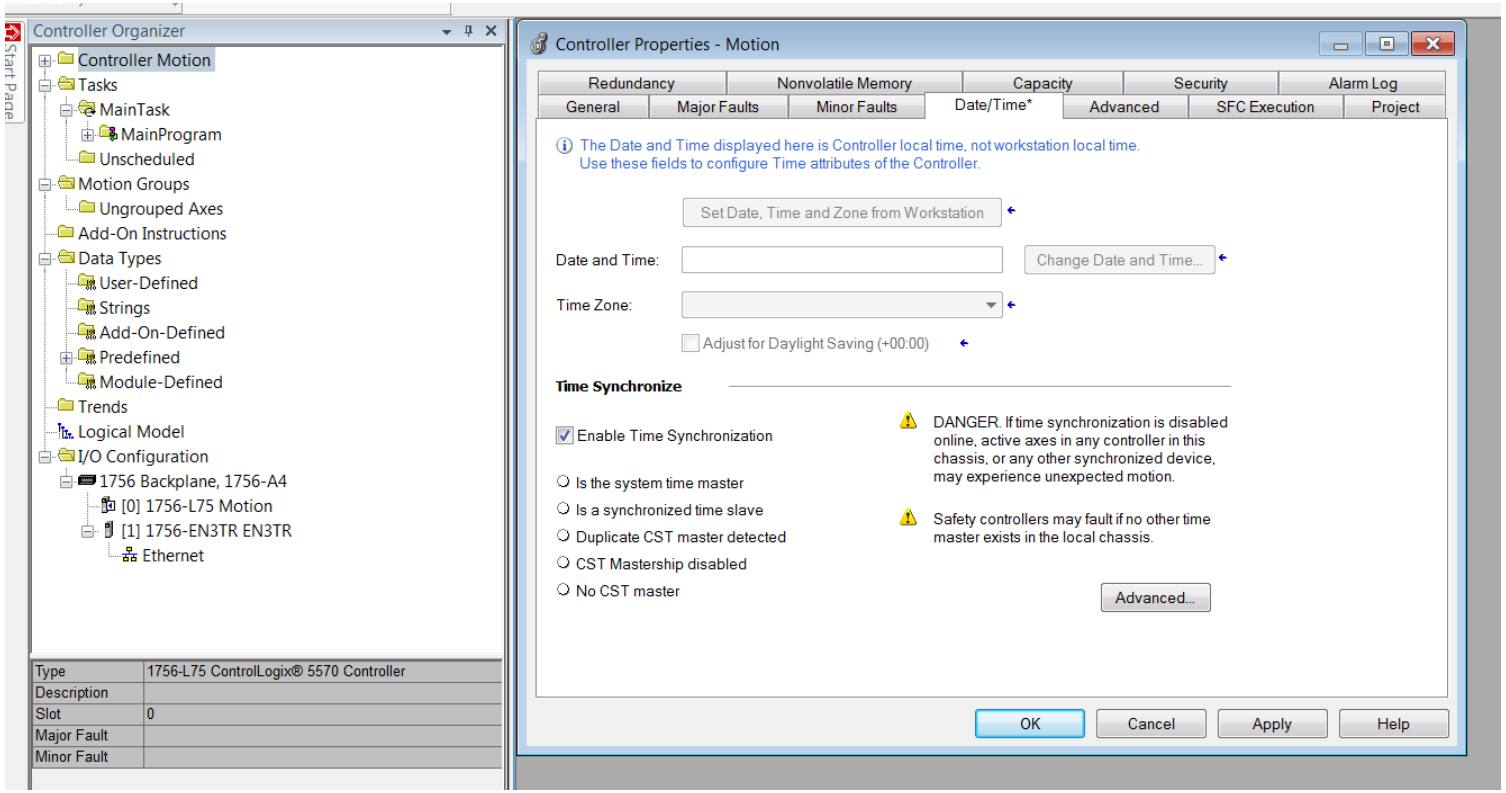
- Each Drive configured for Integrated Motion for Ethernet/IP has a name:S for evaluating, typically over TCP, packet quality
- Controller to Drive(C2D)
- Drive to Controller(D2C)
- This is the 1 cycle model or legacy. 2 cycle model used with L8x controllers improves
- ADD TN

The BIG(or small) Picture



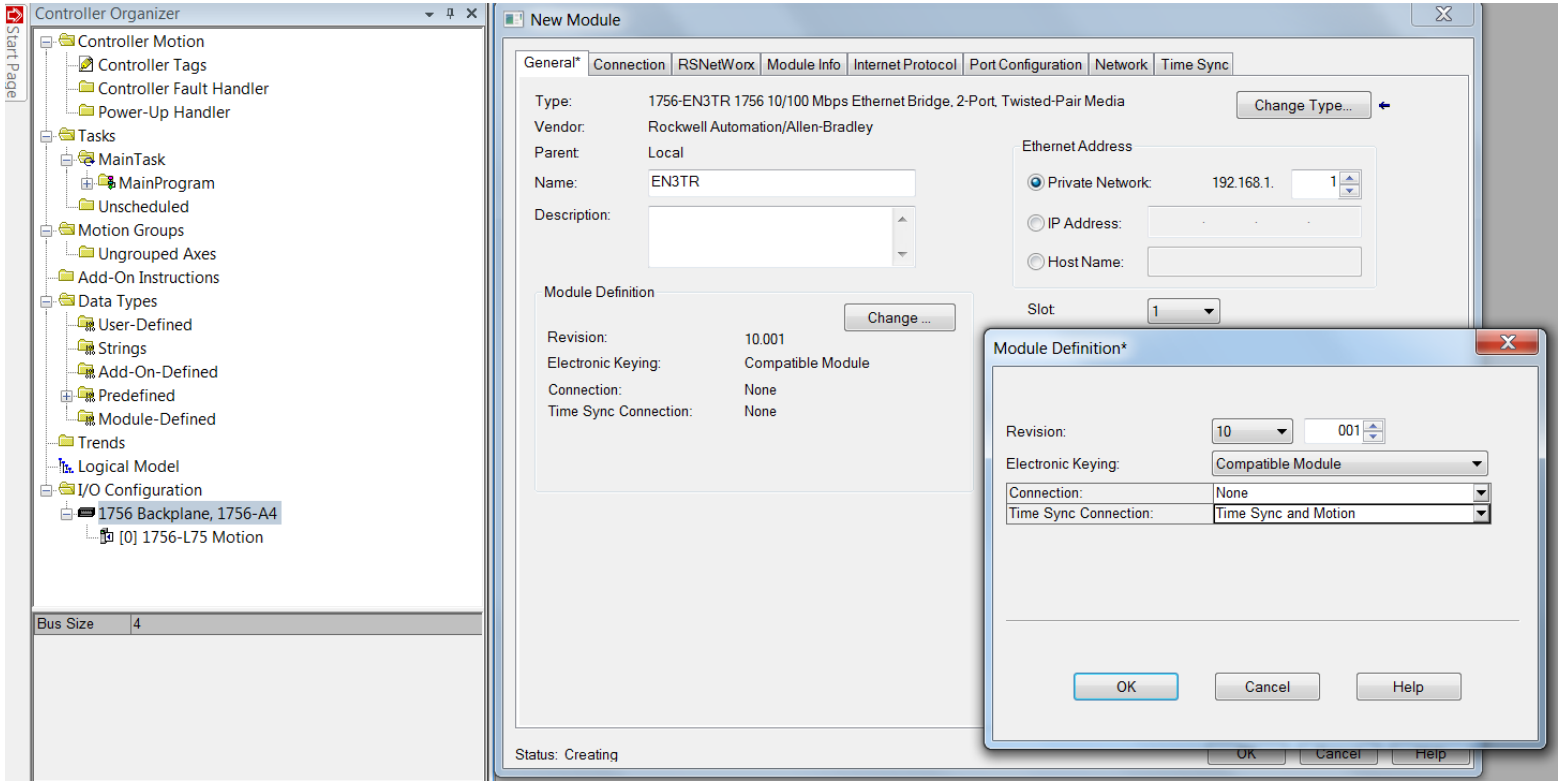
- Each Drive configured for Integrated Motion then gets assigned for use in the Motion Planner by associating what is called axis cip drive with the actual Drive:S module.
- There is the link and difference from the module and the axis
- The motion planner plots out the coarse updates ahead of time
- There is RIDETHROUGH in the motion planner so missed packets can be late or lost and not affect criitical position performance

In Studio the key configurations that support the model



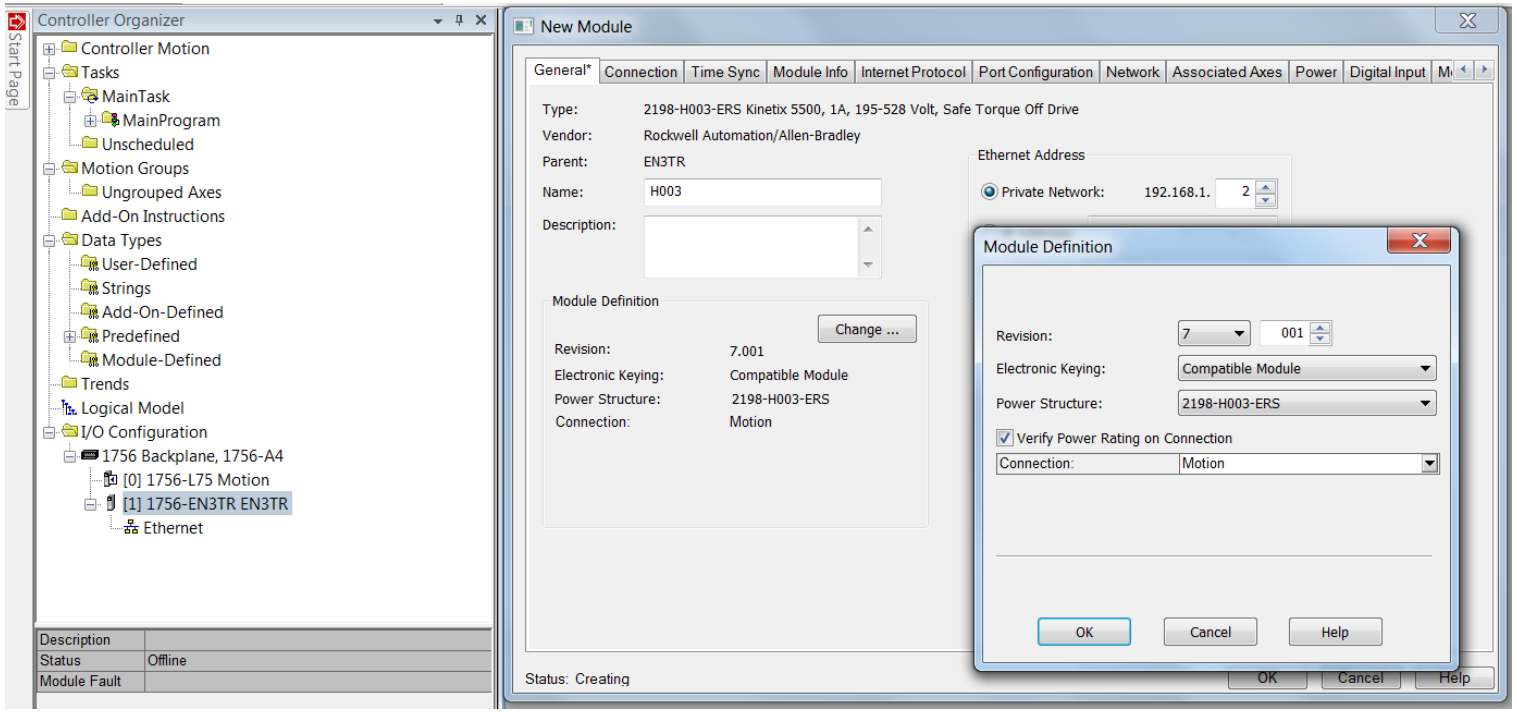
- The controller needs to support Integrated Motion on Ethernet/IP1756-L6/7/8 with and without safety, 1769-LxxERM, 5069
- https://rockwellautomation.custhelp.com/app/answers/detail/a_id/869248
- http://literature.rockwellautomation.com/idc/groups/literature/documents/sg/1756-sg001_-en-p.pdf
- http://literature.rockwellautomation.com/idc/groups/literature/documents/sg/1769-sg001_-en-p.pdf
- MUST set the Time Synch request. This is overhead so if not needed, do not check.

In Studio the key configurations that support the model



- The ControlLogix platform uses the Ethernet media to set the number of axes. For instance, the 1756-EN3TR can do 128 position axes.
- https://rockwellautomation.custhelp.com/app/answers/detail/a_id/40784/page/1
- For CompactLogix the controller enabling time synch and motion automatically enables the Ethernet port for this as it is hermetic.
- In this ControlLogix platform, enable the Time Synch and Motion ability in order to be able to select the components that are allowed on this network

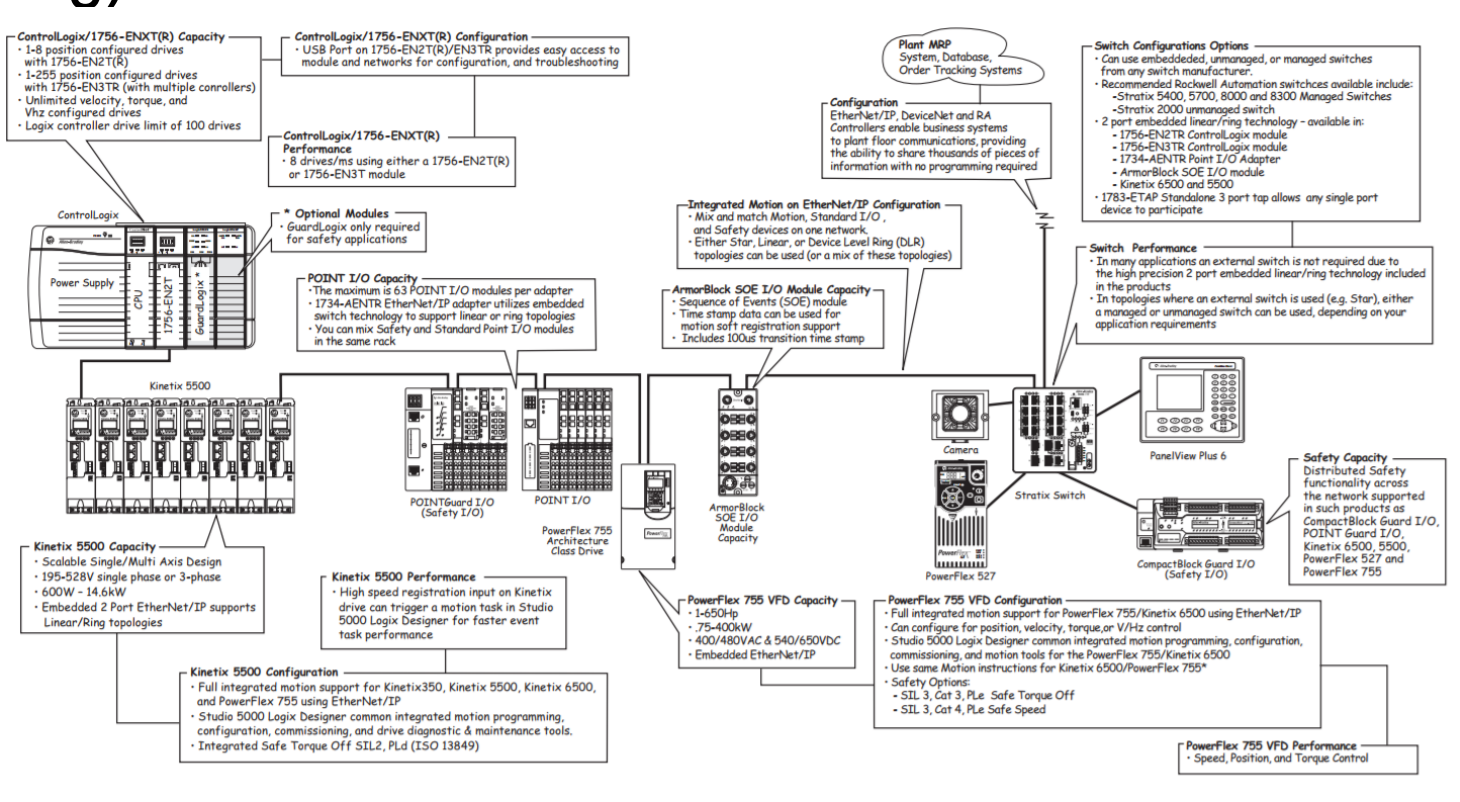
In Studio the key configurations that support the model



- Note the 'Parent' module listed as the EN3TR
- The Connection indicates what the data packets from the controller to drive
  - CIP connections
    - 1 for Motion Only
    - 2 for Safety Only
    - 3 for Motion and Safety
  - https://rockwellautomation.custhelp.com/app/answers/detail/a_id/1058859
  - You can go to the EN3TR webpage to know this as well

The Integrated Motion Network

- An Integrated Motion Network consists of a processor (with time stamp ability and motion instruction ability) normally through Ethernet medium(cabling) to a local switch to the drives/IO/Panelview, etc.

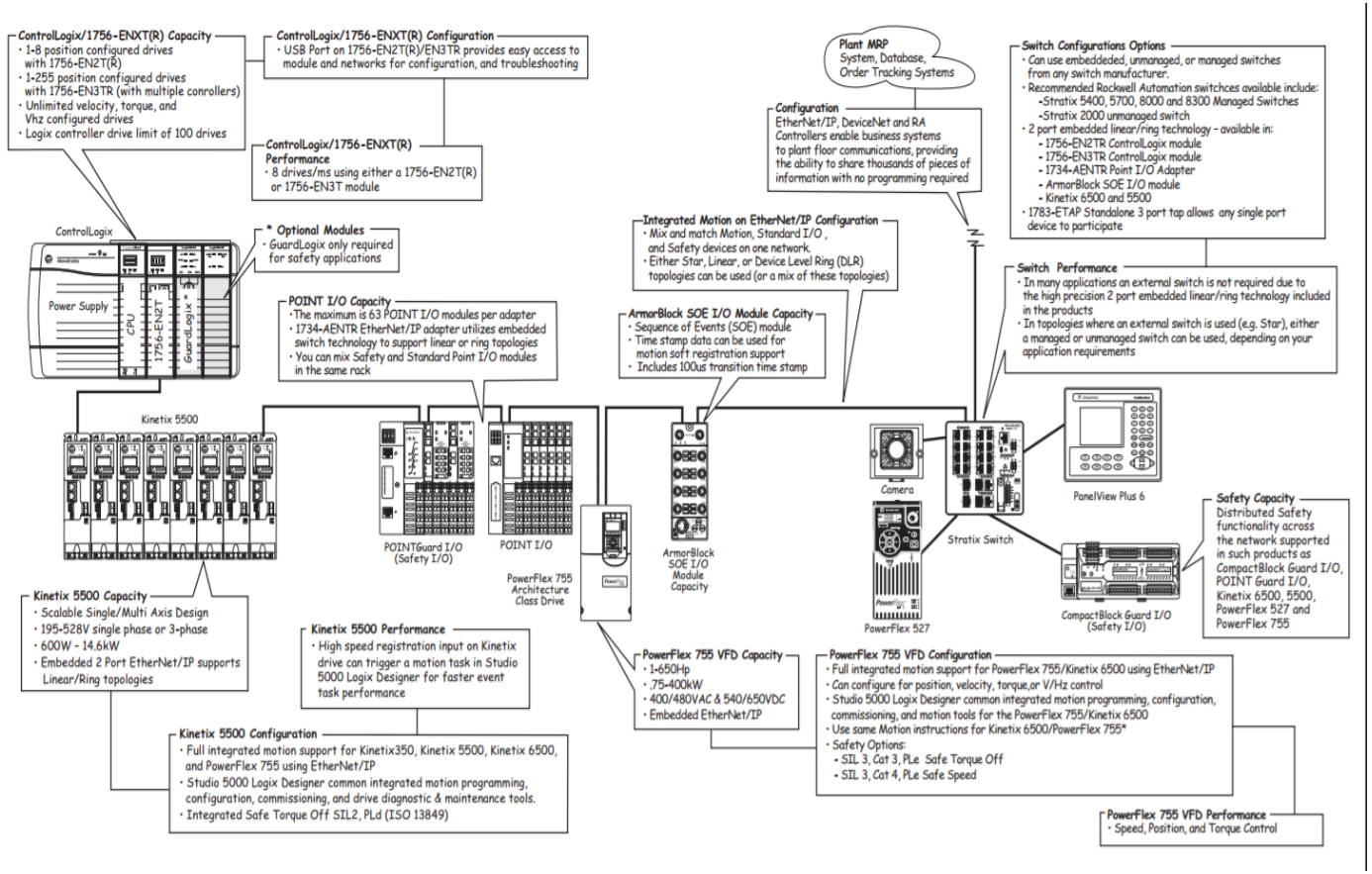


The Integrated Motion Network

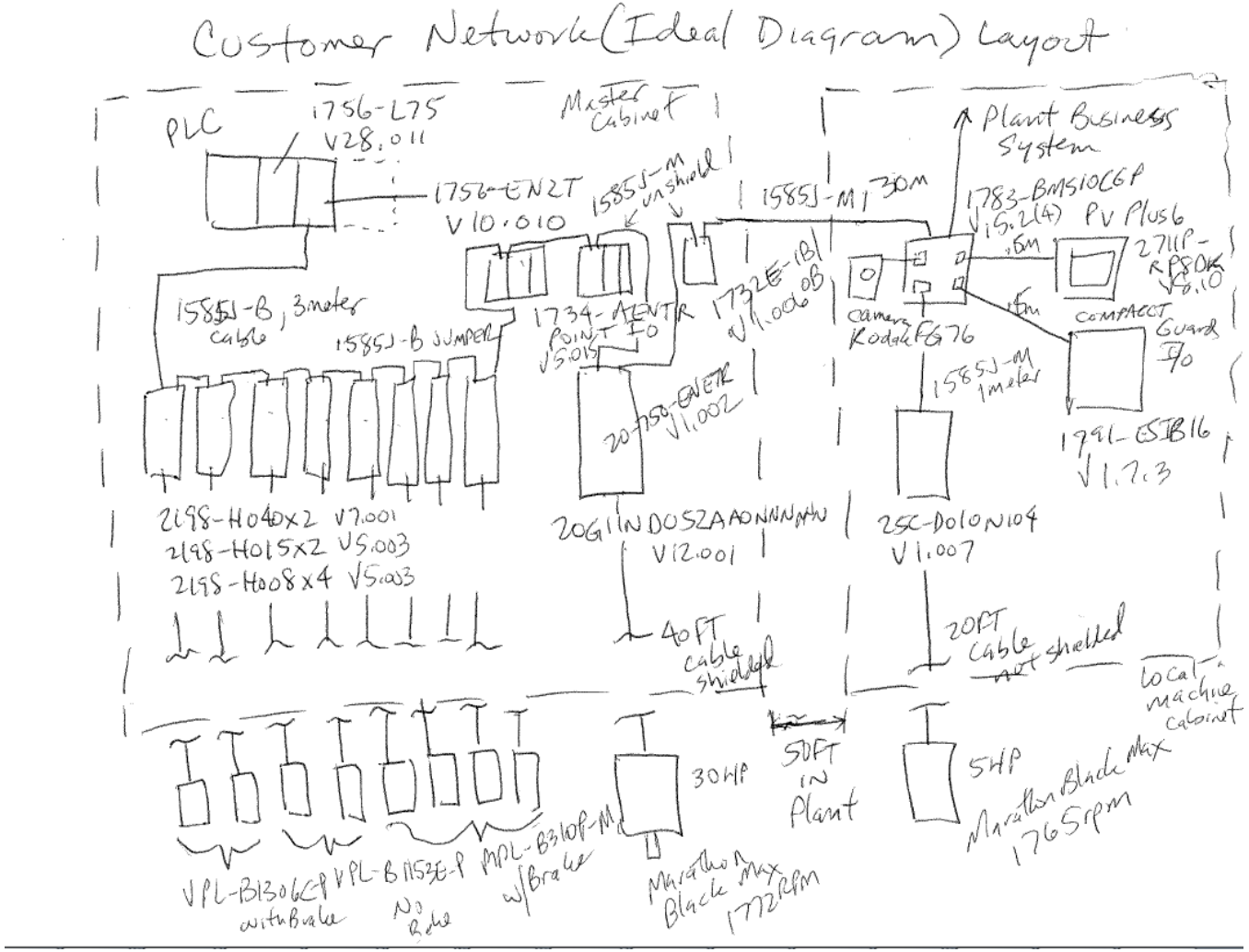
- No two motion systems are alike (regardless of what is reported, there can always be some difference in network traffic, component mounting, wire routing, etc.
- A network diagram showing the layout on the Ethernet is the best way for one to understand possible issues whether configuration or fault.
- In the previous slide, an application configuration note showing tested and proven systems can give the end user an example of best placement and network usage. http://literature.rockwellautomation.com/idc/groups/literature/documents/qr/iasimp-qr019_-en-p.pdf
- The example drawing is great but step back and let's take the same diagram into something even more useful for technical support and others to evaluate possible reported issues and get to faster resolution.

The CAD type drawing

- The CAD drawing is a great representation of the system network.



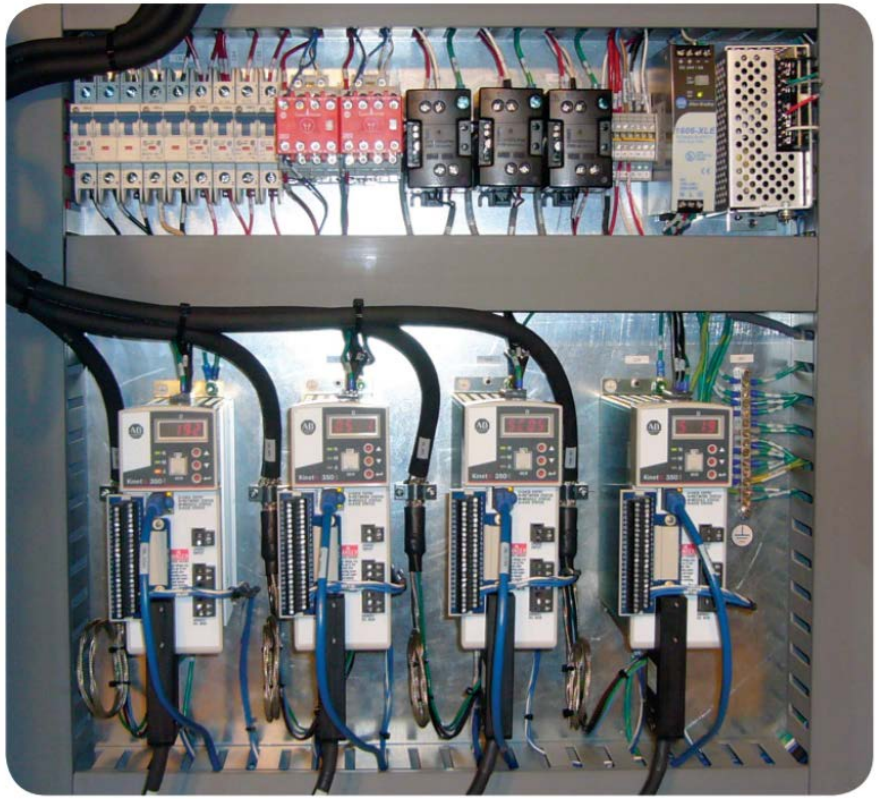
A simplified, more detail hand sketch



- Defines that there are two cabinets
- Notice revision levels of all catalog numbers
- 1585J shielded and unshielded cable being used
- Use of drive to motor unshielded cable
- Distance between 2 cabinets
- Switch at the local cabinet level for plant business data capture
- Others – just a few examples

A Picture of the Cabinet layout

- The network diagram does not do all justice in defining where problems could lie. Get a jpg or photo of the cabinet(s) with open doors to see possible issues.



- The cabinet layout shows the routing of the Ethernet cabling, the IO cabling, the power cabling, the feedback wiring, etc.
- The workmanship or care taken to ensure layout puts clean power vs dirty power in the proper place
- Other items

Integrated Motion on Ethernet/IP Network Summary

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- Paint the picture with as much detail as possible:
  - The network layout including the Ethernet media
  - Define the revisions of all the components
  - The panel or cabinet layout
  - Discover any event that causes an issue and if repeatable and how often
- That leads to the evaluation of what could be wrong even before you do all of the aforementioned work. What actual is wrong with the network?

How to identify a configuration issue in Integrated Motion on Ethernet/IP?

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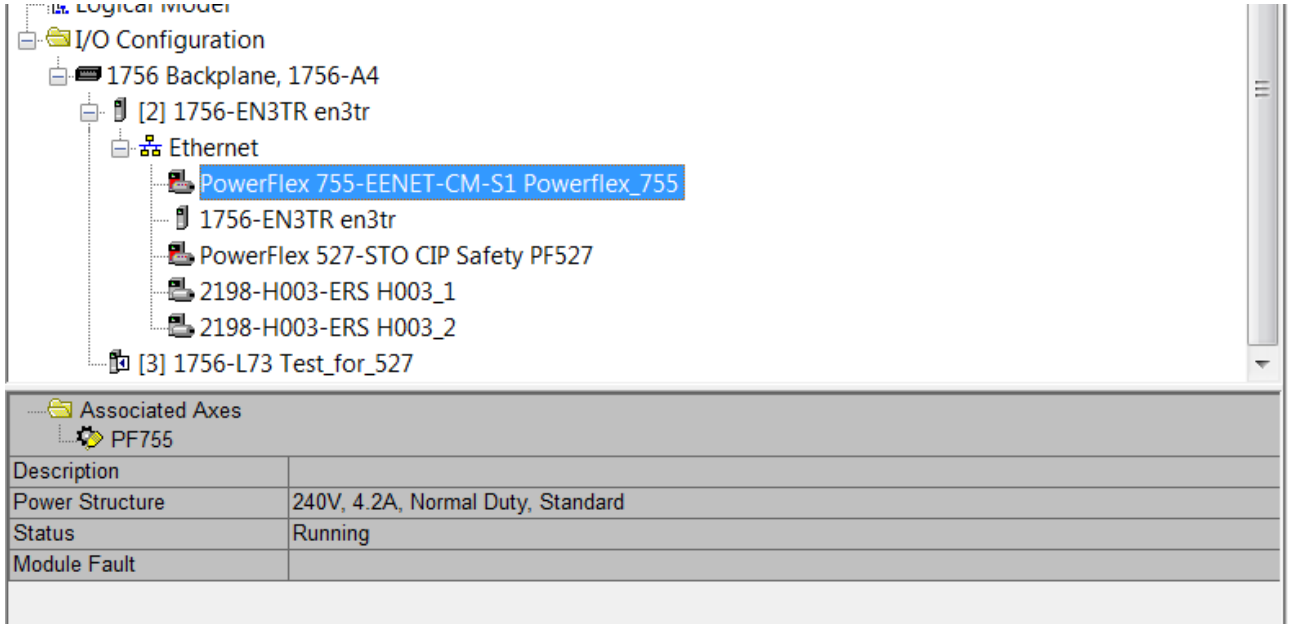
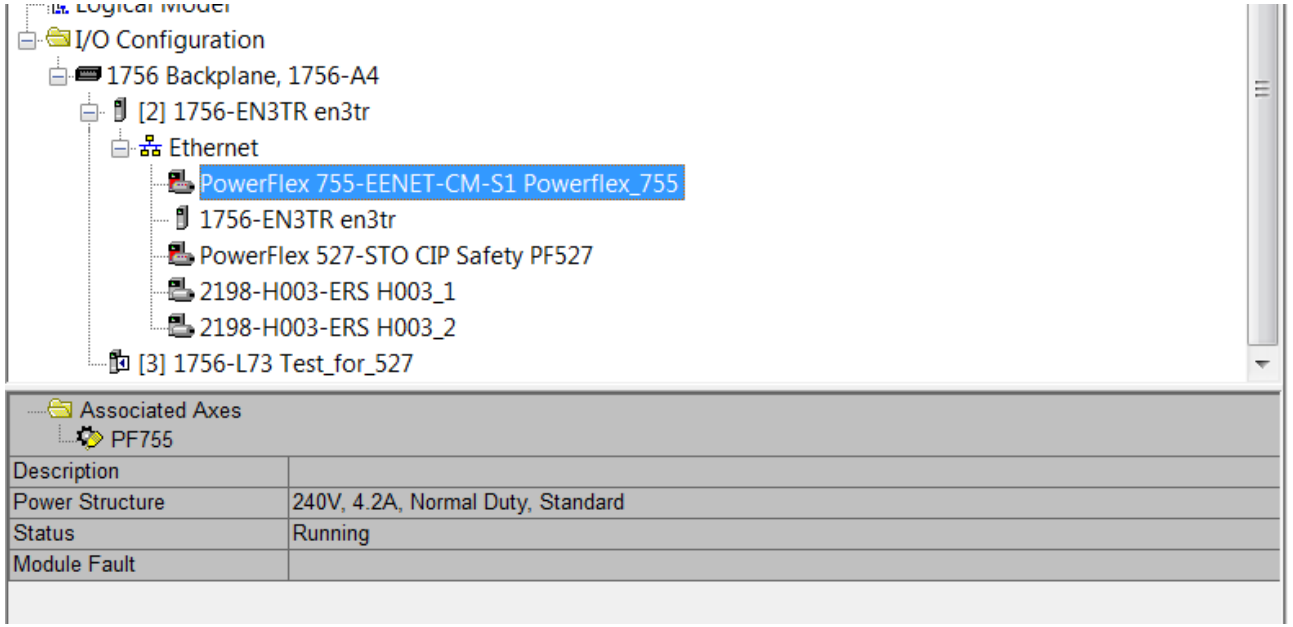
- When you get asked if the system is a new system in the OEM in-house or a new system that worked at the OEM but now is having an issue at the end user or this system had been running for 5 years before having any issue, there really is a reason:
  - New system normally points to configuration issue:
    - Axis cip drive in the controller organizer IO tree does not have a running connection status on power up.
    - Axis cip drive in the motion group is not in a stopped state ready for some type of motion command.
    - Installation issues or possible design improvement.
  - New system that worked at the OEM but on the End User floor, there are issues:
    - Same as above.
    - Note the OEM disconnected components in travel or connections may have loosened.
    - Network plug into an end user information system – may or may not have been simulated before
  - Existing system that had been working for 5 years but now there are issues:
    - These can be tougher to pin point system culprits.
    - The same evaluation of the IO tree running status then the motion group cip state still holds much value

A Configuration vs Network Fault



- Use Studio for startup or consistent program evaluation of a configuration issue.
- Always go to the IO tree to find if there is a running connection BEFORE going to the Motion Group to check on the Axis CIP Drive CIP State
- Left mouse click the drive to highlite. The quick view should pop up as shown
- Do this for all the axis in the related motion group
- What are typical faults in the connection status?

IO Module Fault not allowing RUNNING Status



- Powerflex 755 normally wrong power structure, IO cards, etc
  - https://rockwellautomation.custhelp.com/app/answers/detail/a_id/114363
- Powerflex 527 normally safety TUNID signature and not out of the box
  - https://rockwellautomation.custhelp.com/app/answers/detail/a_id/758322
- Kinetix 5500/5700/6500 wrong power configuration/bus sharing group
  - https://rockwellautomation.custhelp.com/app/answers/detail/a_id/578285

Module Fault

- Termed Module Fault because they are related to the Drive:S module.
- Programmatically always check Axis Fault→Module Fault→Bit 1
- https://rockwellautomation.custhelp.com/app/answers/detail/a_id/768604
- https://rockwellautomation.custhelp.com/app/answers/detail/a_id/481830
- https://rockwellautomation.custhelp.com/app/answers/detail/a_id/1041106
- https://rockwellautomation.custhelp.com/app/answers/detail/a_id/768603

Axis Fault Bits

Usage	Access	T	Data Type	Default	Min	Max	Semantics of Values
Required - All	GSV[1]	T	DINT	-	-	-	Bitmap 0 = PhysicalAxisFault 1 = ModuleFault 2 = ConfigurationFault 3 = GroupFault 4 = MotionFault 5 = GuardFault 6 = InitializationFault 7 = APRFault 8 = Safety Fault 9…31 = Reserved

The Axis Fault Bits attribute is a collection of basic fault types associated with the axis. Each valid axis fault type is assigned a bit in this word. Any fault condition associated with a given fault type will result in the setting of the appropriate axis fault bit.

Each bit in the Axis Fault Bits attribute represents a roll-up of the associated fault types. One or more faults of a given fault type result in the associated bit of the Axis Fault Bits attribute being set.

RUNNING Module Status = Good Connection but issue in Motion Group

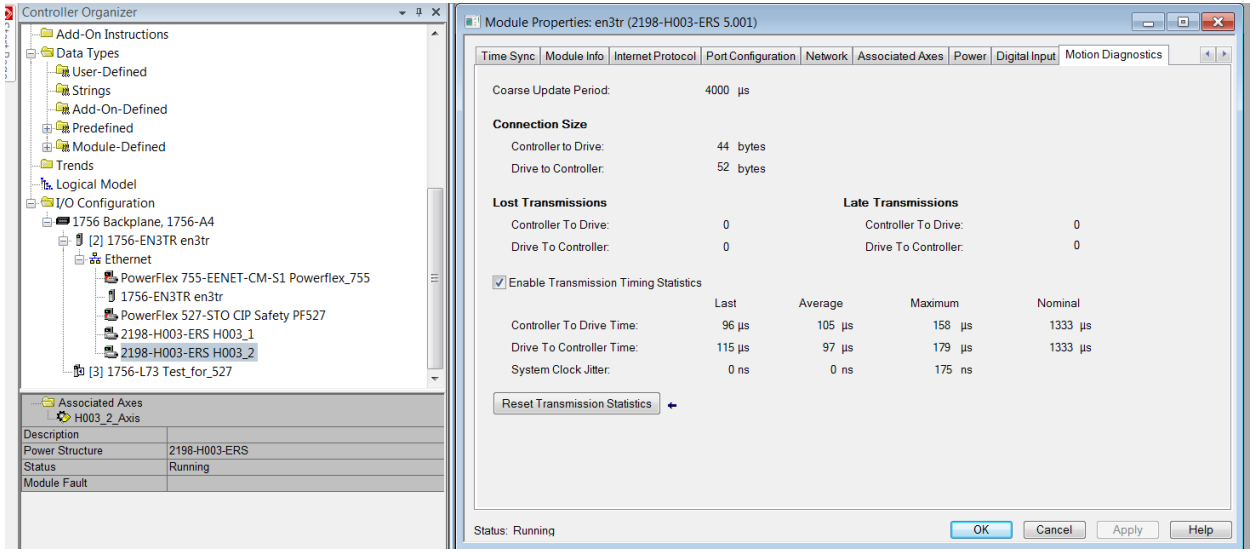
Current State	Event	Conditions	Next State
Off	Power Up		Self Test
Self Test	Self Test Complete		Initializing
Initializing	Initialization Fault		Major Faulted
Initializing	Initialization Complete		Pre-Charge
Shutdown	Major Fault		Major Faulted
Shutdown	Shutdown Reset		Pre-Charge
Pre-Charge	Shutdown		Shutdown
Pre-Charge	Major Fault		Major Faulted
Pre-Charge	Bus Up		Stopped
Start Inhibited	Shutdown		Shutdown
Start Inhibited	Major Fault		Major Faulted
Start Inhibited	Inhibits Cleared		Stopped
Major Faulted	Fault Reset	SD = 1	Shutdown

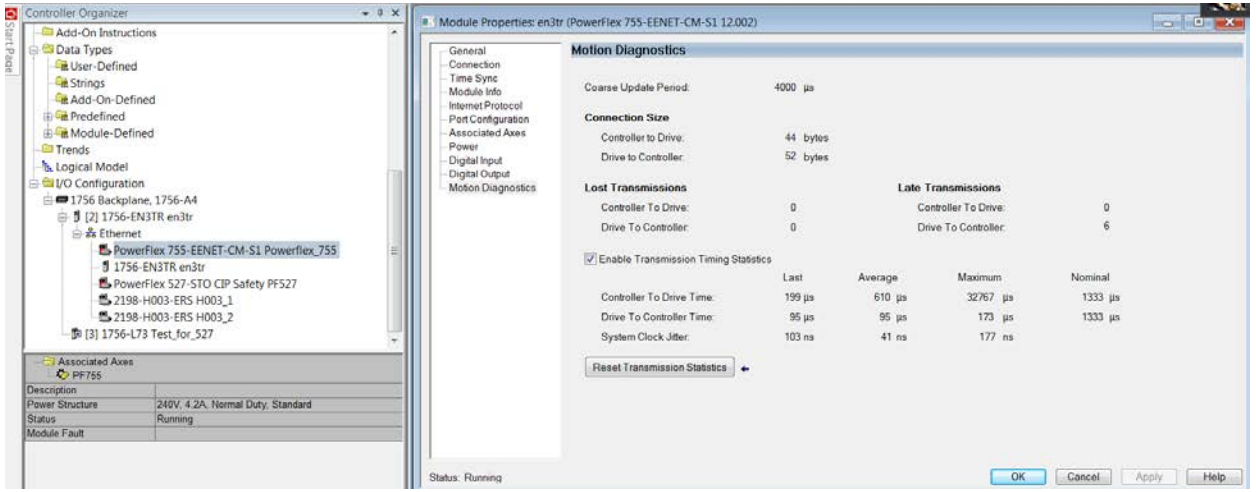
- http://literature.rockwellautomation.com/idc/groups/literature/documents/rm/motion-rm003_-en-p.pdf
- What the different cip states the axis can be in? The Initialization State is Unconnected→Configuring→Synchronizing→Waiting for Group. Then typically Pre-charge→Start Inhibited→Stopped

RUNNING Module Status = Good Connection but issue in Motion Group

- Unconnected – check the IO configuration first. May have no power to the drive
- Configuring – Based on the specific drive there usually is an axis cip drive module configuration fault
- Synchronizing – Normally you don't stick here as this is where the clocks of the grandmaster and slave drives are synchronizing up.
- Waiting for Group – This axis may be configured fine but the planner wants to see all the axis in the motion group on power up else the other axis will wait for the group
- Pre-charge – All state configurations but no dc bus power recognized and stuck in pre-charge state
- Start Inhihibited – typically the last state before stopped. Safe off could inhibit the drive from allowing current to the motor
- Stopped – waiting for action by the motion planner. ALWAYS a good idea to have CIP Axis State =2 before commands

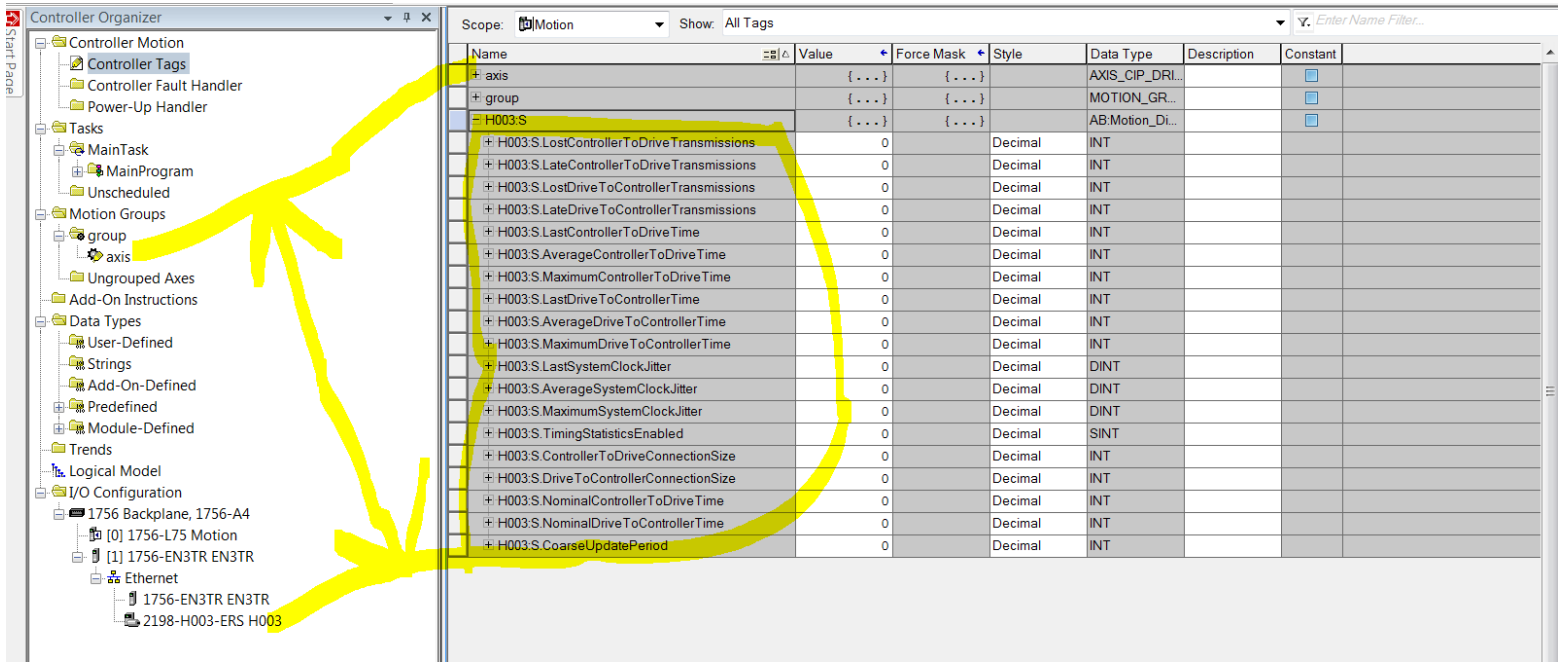
Motion Timing Statistics





- Powerflex 527, Powerflex 755, Kinetix 350, Kinetix 6500, Kinetix 5500 and Kinetix 5700 are different architectures and clock performance will differ
  - Therefore the clock jitter and skew can differ
- The C2D and D2C connection sizes differ from drive to drive
- The late and lost packets can differ from drive to drive

In Studio the key configurations that support the model



- Supporting the ‘Picture’ discussion
- The Kinetix 5500 under the EN3TR creates the Kinetix 5500:S which are the module statistics of the TCP checking of packet quality
- The Axis in the Motion Group then is associated to this Kinetix 5500 so the planner knows on where to send position information, for instance
- These are not enabled all the time basically for system overhead. They are for troubleshooting needs.

Network related faults are really Module Faults

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Module Fault Bits

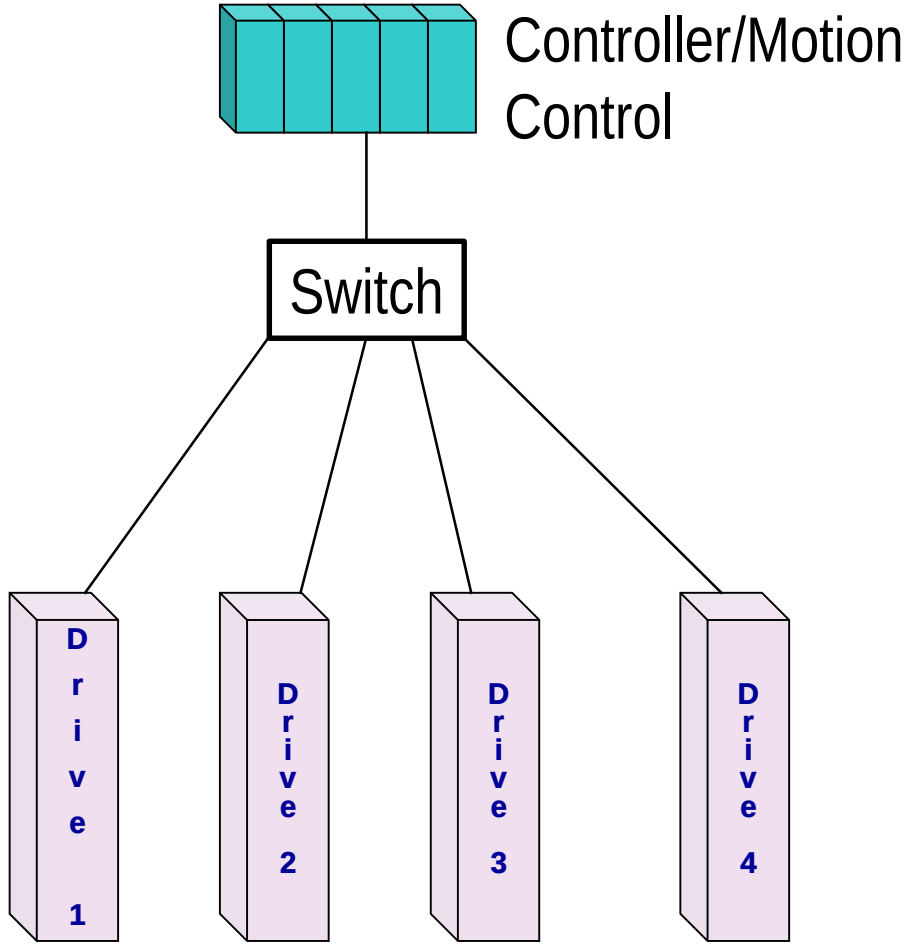
Usage	Access	T	Data Type	Default	Min	Max	Semantics of Values
Required - All	GSV	T	DINT	-	-	-	Enumeration 0 = Control Sync Fault 1 = Module Sync Fault 2 = Timer Event Fault 3 = Module Hard Fault 4 = Reserved 5 = Reserved 6 = Module Conn. Fault 7 = Conn. Format Fault 8 = Local Mode Fault 9 = CPU Watchdog Fault 10 = Clock Jitter Fault 11 = Cyclic Read Fault 12 = Cyclic Write Fault 13 = Clock Skew Fault 14 = Control Conn. Fault 15 = Control Clock Sync Fault 16 = Module Clock Sync Fault 17 = Logic Watchdog 18 = Duplicate Address 19…31 = Reserved

Most Frequent Module Faults?

- There's a good tech-note with technical information on most of these faults and other communication faults. https://rockwellautomation.custhelp.com/app/answers/detail/a_id/1047243/page/1
- These are the most frequent ones seen:
  - Control Sync Fault
  - Module Sync Fault
  - Module Conn Fault
  - Control Conn Fault
  - Clock Jitter Fault

Analogy of a Control/Module Sync Fault

- The Control Sync Fault bit attribute is set when the Logix controller detects that several consecutive connection updates from the motion module have been missed. This condition results in the automatic shutdown of the associated motion module. The Logix controller is designed to `ride-through' a maximum of four missed position updates without issuing a fault or adversely affecting motion in progress. Missing more than four position updates in a row constitutes a problematic condition that warrants shut down of the motion module. This bit is cleared when the connection is re-established
- Module Sync Fault would be very similar only the drive posting since it is not receiving or does not think it is getting data from the controller
  - If the motion diagnostics show C2D and D2C updating more than 1 per minute, it may be the motion group CUR is too stringent.
  - Find a zero point of the machine or daily time stamp and if these faults occur is it based on a machine function, switch or contactor turn on, etc.
  - Notice if just a C2D or D2C reaches the maximum 32767 usec buffer. For instance, inhibiting a drive or the connection status from the controller to the drive will cause this to clamp to that value.
  - https://rockwellautomation.custhelp.com/app/answers/detail/a_id/494592 is a helpful tool for the Control and Module Sync Faults.



Module/Control Conn Fault

- Module Conn Fault means the module no longer is in good C2D messaging from the controller.
- It is possible the Ethernet cable broke but use the module entry status to determine if there is a connection or not.
  - https://rockwellautomation.custhelp.com/app/answers/detail/a_id/768603
- This fault means the motion packet transmission receive is shutdown. These can normally follow Control/Module Synch Fault.
- Experience shows that these can happen if the drive goes into a ‘freeze’ state. Drive is not sure what next commands to follow.
- Same thought on Control Conn Fault only opposite direction

Clock Jitter Fault

- The Motion Diagnostics page indicates the module has experienced a period of approximately 40 seconds of very high clock variance. Somewhere on the realm of approximately 10,000 ns
- Each drive module has a different clock therefore the clock accuracy will be different. Not easy to compare the drives.
- Can be caused by a multitude of events such as a processor wall clock change. New technologies are being evaluated to have this done as the motion system is operating however, today, the recommendation is to inhibit the drive module before changing the clock then uninhibit which asks the drive and controller to synchronize back up
- Power cabling and network cabling not segregated. Drive start or turn on then increases jitter average, maximum?
- Network system layout. Local switch to plant systems where the clock synchronization could be affected. That is just too much in a visual ability.

Summary

- The Integrated Motion Ethernet/IP Network is crucial to transmission and receiving of drive to controller and controller to drive information.
  - Integrated Motion on Ethernet/IP needs to have all devices synchronized.
- This session hit on a few points on network layout, the integrated motion packets, module configuration and faults.
- https://rockwellautomation.custhelp.com/app/answers/detail/a_id/1041751 is a good knowbase that can give topology and layout recommendations when using Integrated Motion on Ethernet/IP.
- I'd like to get your input on a more in-depth session with actual architectures that would help all users better size and incorporate Integrated Motion on Ethernet/IP.
- pjmicech@ra.rockwell.com with those suggestions for a possible intermediate and advanced session with regards to this topic. Also if you have any specific questions or issues in an existing system.

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Thank You

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