Application Note: Creating Easy Links for RTMoE with Unidrive M700

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The Unidrive M700 has the ability to transmit and receive both synchronous and non-synchronous messages over Ethernet via the RTMoE (Real Time Motion over Ethernet) communication protocol developed by Control Techniques. This protocol allows for drive to drive communications to be quickly and reliably configured using standard Ethernet cabling with the FFM Ethernet, an SI Ethernet option module, or an MCi210 module. Drive clock synchronization is achieved using the Precision Time Protocol (PTP), otherwise known as IEEE1588 V2 over Ethernet. This protocol uses tuneable clocks running on each drive that will synchronize to a selected master clock on the network in order that all drives will know the same time on the system at any given instant. Using PTP, these clocks can be synchronized to a jitter of less than 1 us, and through Easy Links a user currently can run message cycle frequency times as low as 1 ms.

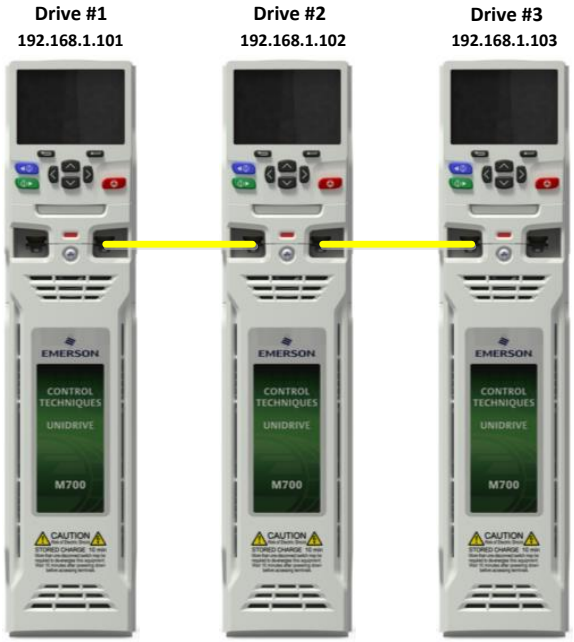
This application note will outline the minimum setup for creating both synchronous and non-synchronous links using "Easy Links" with either the FFM Ethernet on the Unidrive M700/702, an SI Ethernet (On M70x), or with an MCi210 on an M70x. Using Easy Links in Menus 10 and 11 of an Ethernet or MCi210 module allows a user to map drive-to-drive communications from the keypad, Unidrive M Connect, or from a pre-existing parameter file or macro. The example shown in this note will outline both how to configure a cyclic, synchronous links (i.e. master position reference, synchronous speed reference) as well as a cyclic, non-synchronous links (i.e. status word, control word). The configuration of these links only requires 2 drives to be on the network, but this note will show examples with 3 drives to illustrate wider network situations. Also, this example will show some generic drive exchange locations (application parameters, drive status values, etc.) that likely would be changed for different applications.

Additionally, this example utilizes the following revisions of software and firmware:

1. Unidrive M700 Firmware: 1.13.02.00
2. SI Ethernet Firmware: 1.06.01.04
3. MCi210 Firmware: 1.05.04.26
4. Unidrive M Connect: 2.06.00

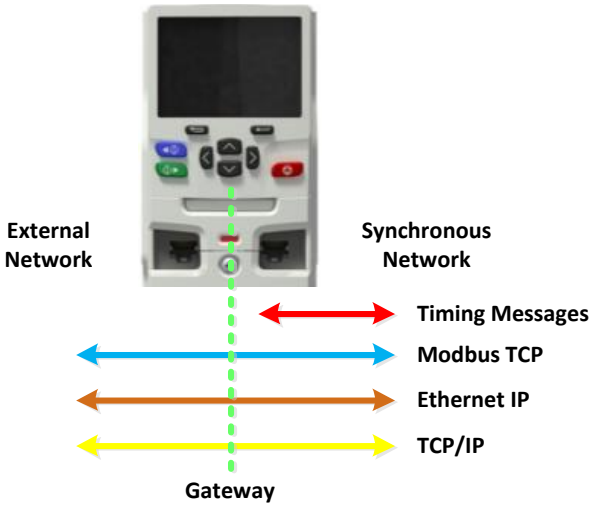
For this example, three Unidrive M700 drives will be networked together in a daisy chain topology using the FFM module (Onboard Ethernet). These drives are denoted as Drive #1 (IP 192.168.1.101), Drive #2 (IP 192.168.1.102), and Drive #3 (IP 192.168.1.103) (if assistance is required in setting up the IP Addresses on network modules, please consult the *SI Ethernet User Guide*). This system will utilize cyclic links, both synchronous and non-synchronous, which will be used to pass real time position and speed

references along with blocks of status and control information. With the Easy Links available on the Ethernet module, each drive has the capacity to transmit (Tx) up to 3 different blocks of data as well as receive (Rx) up to 3 different blocks of data. Each block can contain up to 10 contiguous parameters (16 or 32 bit) which can be structured in Menu 0 of the drive for appropriate blocking in the case their actual parameter locations are scattered throughout the drive.



Before configuring each link for each drive, since this example will utilize network synchronization, it is important to configure the network to affectively support synchronization. There are several parameters that are necessary to understand and to configure properly to ensure predictable network and drive behavior on a synchronous Ethernet network:

1. When a network is synchronized, there are synchronization messages sent alongside the user configured information (i.e. parameter exchange). If another network that does not support these types of timing messages is exposed to them, it can interrupt that external network. A gateway can be configured on the drive that is exposed to an external network to "filter" out these messages so that they do not interfere with the other network. By setting **Gateway Mode (4.02.015)** to **"Gateway"**, this filter is put in place between the 2 Ethernet ports on the switch, so that these timing messages can only exist on the right side of the switch network, but not on the left. This will allow other protocols to pass through (i.e. Modbus TCP) but not the timing messages when looking right to left at the Ethernet switch. This should only be changed for the drive that is exposed to an external network, where all other drives have this setting as **"Switch"**. In this case, Drive #1 will be considered to be connected to and external network. See the following graphic:

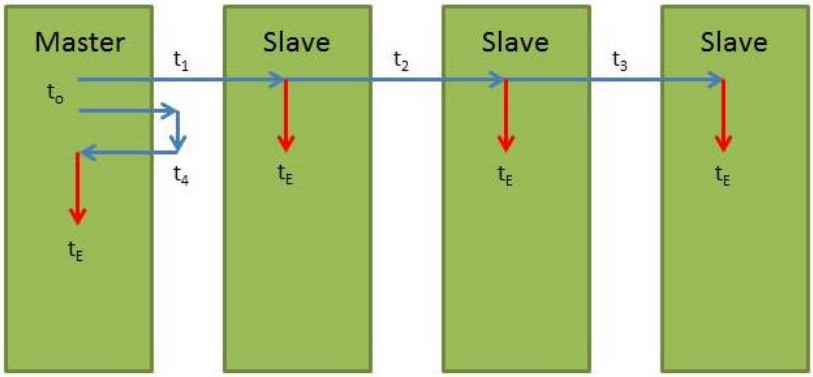


2. In order for any drive on a network to know which set of drive clocks to be synchronized to, it must have a virtual local area network (VLAN) configured. Separate networks can be synchronized that are hard wired together, as long as they have unique VLAN allocations on the network. For this example, a single VLAN identifier will be used, so all drives should have **VLAN Enable (4.02.030)** set to **"ON"** and their **Drive VLAN ID (4.02.031)** set to **"0"**. This allows the Ethernet modules to identify to which network they should be synchronized. In this case, that identifier will be "0".

3. After a network is configured and reset, it attempts to identify which Ethernet module on the network will act as the "Grandmaster Clock", or in other words, the clock to which all other Ethernet modules should synchronize to. The goal is that each clock in each Ethernet module on the network is ticking with the same value of absolute network time. The Grandmaster Clock selection can be manually selected, or can be left up to the drives on the network to arbitrate and choose on their own which clock will be the Grandmaster. For this example, the latter case will be employed, so **Preferred Sync Master (4.11.001)** can be set to a value of **"1"** on all drives. This will give all Ethernet modules equal opportunity to be chosen as the Grandmaster Clock. Note that the drive that becomes the Grandmaster Clock does not need to be the position or logic master on the system; this is only for *network synchronization*.

4. Finally, **Easy Mode Maximum Network Delay (4.11.030)** gives a *synchronous* message being sent and received an execution time *relative to the absolute time that the message was sent by the sending drive*. Since the drives are synchronized to a Grandmaster Clock, each drive on the RTMoE network knows exactly what the current absolute time is at any given time. When a message is sent by a drive, it is sent with a time stamp of exactly when it was sent, as well as information on when to execute (write) the information to the target drive, which is what **Easy Mode Maximum Network Delay** (**4.11.030)** defines. This is the vehicle that allows the information to be executed at the exact same time on the network, not matter when it is

received. If the time it takes for a message to get from the sender to the receiver exceeds the value in **4.11.030**, the Ethernet module will trip. For this example it is recommended that this parameter is set to **"3 ms".** The message timing with this delay is illustrated in the following graphic, where the blue arrows show the flow of information over Ethernet, and the red arrows show the execution (writing) of the information. This illustration is shown with 4 drives to help better understand this process:



In this drawing, t_o is the absolute time that the message is sent from the master drive. T_1, t_2, t_3, and t_4 are the times it takes the messages to get their destinations (e.g. 100us, 500us, 700us, and 900us respectively). T_E is the execution time of that message, and is equal to t_o + **4.11.030**. Even though the transmission times t_1, t_2, t_3, and t_4 may be different, t_e will be the same in all four of the drives. To summarize another way, although the time between the receipt of the message and the execution of the message may be different for each drive in the network, the absolute timing for execution according to the grandmaster clock will be the same for each drive.

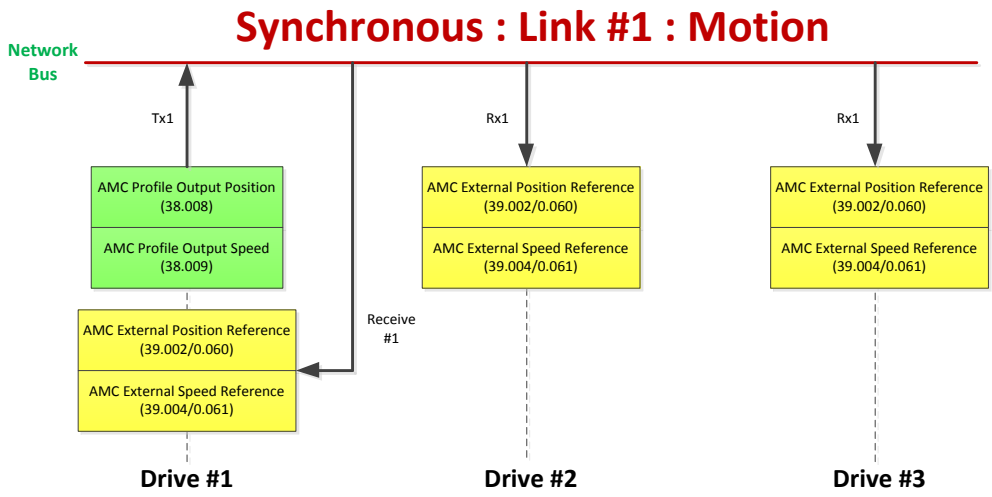
5. After the above settings are configured appropriately for each drive, turn **Reset** (24.007) to **"On"** to allow these changes to take effect in the module. For this example, these changes are summarized in the table below:

	Drive #1	Drive #2	Drive #3
Gateway Mode (4.02.025)	Gateway	Switch	Switch
VLAN Enable (4.02.030)	On	On	On
VLAN ID (4.02.031)	0	0	0
Preferred Sync Master (4.11.001)	1	1	1
Easy Mode Maximum Network Delay (4.11.030)	3 ms	3 ms	3 ms

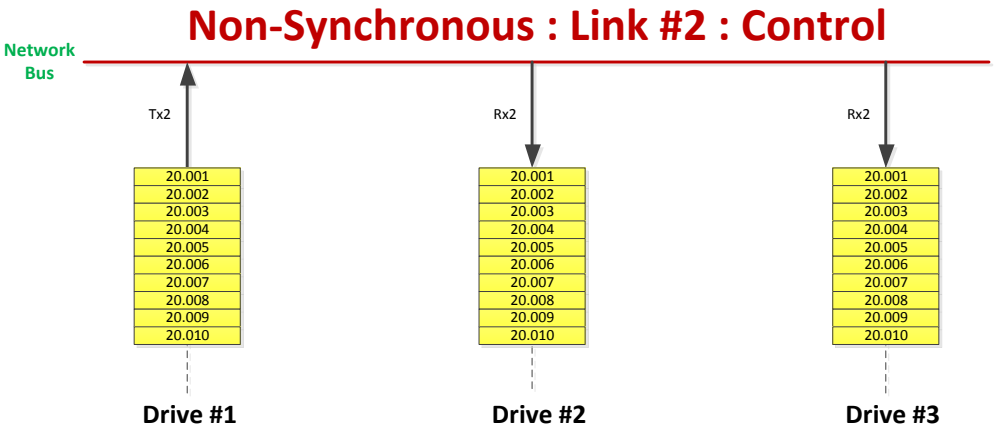
With the network now prepared, the individual links can now be configured. It is easiest to configure these links using Unidrive M Connect, but this can also be performed through the keypad. In this example, Drive #1 will act as the motion master on the system, sending a synchronized speed and position reference to the other two drives. In addition to this, Drive #1 will send a "control block" of data to the other drives, and the other drives will each return a "status block" of data back to Drive #1. Each link that gets transmitted from a drive will have a "Link Number" attached to it, so that as it goes out to the network bus, it can be identified by that ID and received into another drive, or back into the transmitting drive. This configuration is important, as it allows transmitted links to be identified and selected from the network bus from any drive that has access to the network and is a part of the same VLAN.

First, the synchronous link that will be generated from Drive #1 will include the **AMC Profile Output Position (38.008)** and the **AMC Profile Output Speed (38.009)** that are produced from the AMC profile generator. This is a common way to utilize the profile generating capabilities of the AMC and synchronously send the results to a synchronous motion network (use of the AMC is covered in other literature, and will not specifically be addressed here, as this note is designed primarily to assist a user in setting up and using Easy Links). Once this information is transmitted, it should be received into all drives (back onto itself and to the other two drives on the network) into the **AMC External Position Reference (39.002)** and the **AMC External Speed Reference (39.004)**. Since multiple registers must be sent and received as a contiguous block, sending 38.008 and 38.009 is simple, but receiving into 39.002 and 39.004 means that these must be tied to consecutive registers elsewhere in the drive. This is done by using Menu 22 to tie 39.002 to 0.060, and 39.004 to 0.061. With this configuration, the receiving link can be written for 2 consecutive registers, starting at parameter 0.060. This will use the Tx1 link for

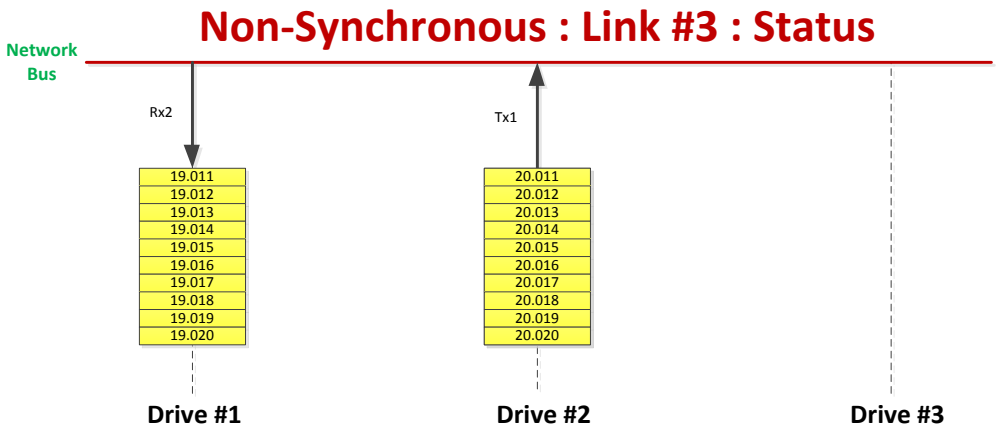
Drive #1, the Rx1 link for Drive #1, the Rx1 link for Drive #2, and the Rx1 link for Drive #3. The graphic for Link #1 is shown below:



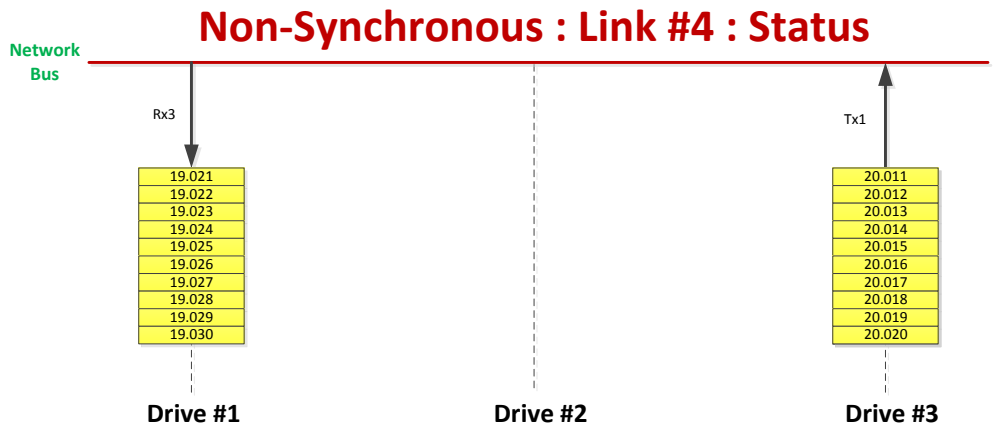
For Link #2, Drive #1 will broadcast 10 parameters (20.001 – 20.010) to the network bus, and Drive #2 and Drive #3 will receive them into parameters 20.001 – 20.010. This block of data can act as a control block on the system to send other commands that do not need to be synchronized on the network. This will use the Tx2 link for Drive #1, the Rx2 link for Drive #2, and the Rx2 link for Drive #3. The graphic for this link is shown below:



For Link #3, Drive #2 will broadcast 10 parameters (20.011 – 20.020) to the network bus, and Drive #1 will receive them into parameters 19.011 – 19.020. This block of data can act as a status block from Drive #2 to Drive #1, and potentially could also be picked up by Drive #3 if desired. In this case this link will use the Rx2 link for Drive #1, and the Tx1 link for Drive #2. The graphic for this link is shown below:



For Link #4, Drive #3 will broadcast 10 parameters (20.011 – 20.020) to the network bus, and Drive #1 will receive them into parameters 19.021 – 19.030. This block of data can act as a status block from Drive #3 to Drive #1, and potentially could also be picked up by Drive #2 if desired. In this case this link will use the Rx3 link for Drive #1, and the Tx1 link for Drive #3. The graphic for this link is shown below:



Once the flow of information is understood for each of the links that will be setup, the specific link settings can be entered into the drive through Unidrive M Connect, through a parameter file, or through the keypad. Before entering in the Easy Link settings, it is important to first understand the settings that will be associated with a transmitting link, as well as a receiving link. For these examples, Tx1 and Rx1 will be examined, but these setting descriptions will apply to all transmit links (Tx1, Tx2, and Tx3) as well as all receiving links (Rx1, Rx2, and Rx3) on all drives. The associated graphics are taken from Unidrive M Connect to better illustrate these settings.

1. **Transmitting Link Settings (Tx1, Tx2, and Tx3)**

4.10.010	**Tx1 Link Profile**		**Std**
4.10.011	**Tx1 Link Number**		**0**
4.10.012	**Tx1 Source Parameter**		**0.00.000**
4.10.013	**Tx1 Parameter Count**		**0**
4.10.014	**Tx1 Link Transmission Type**		**Unicast**
4.10.015	**Tx1 Destination Address**		**0.0.0.0**
4.10.016	**Tx1 Message Rate**		**0 ms**

a. ***Tx1 Link Profile (4.10.010)****:* This can be set to either **"Std"** or **"Sync".** With a setting of **"Std",** this link will become a cyclic, non-synchronous transmission of information from the drive to the network. With a setting of **"Sync",** this link will become a cyclic, synchronous transmission of information from the drive to the network. If this setting is set to **"Sync",** the drive receiving this link must have the same setting for its Rx link.
b. ***Tx1 Link Number (4.10.011):*** This is the link identifier value, and for the link to be valid it must be greater than 0. When a link number is attached to a transmitting link, it allows other receiving links to find that link on the network bus by the link number.
c. ***Tx1 Source Parameter (4.10.012):*** The source parameter is the memory location on the drive or in a slot module where the transmitting block of data will start from.
d. ***Tx1 Parameter Count (4.10.013):*** The parameter count is the number of contiguous parameters that should be included in the block of data to be sent, starting at the Tx1 Source Parameter location. This can be a value between 1 and 10.
e. ***Tx1 Link Transmission Type (4.10.014):*** This will define how the transmitting link directs its parameters out onto the network. There are 3 options available for this setting:
    i. **Unicast:** Determine a single IP address to where the information can be received.
    ii. **Multicast:** Determine a set of destinations to where the information can be received.
    iii. **Broadcast:** The transmitting information can be picked up by any destination on the VLAN. For this example, Broadcast will be the setting that is employed.

f. ***Tx1 Destination Address (4.10.015):*** This defines the IP Address of the desired destination of the link. When the Transmission Type is set to "Broadcast" this will become a mask of 255.255.255.255 to allow any destination.

g. ***Tx1 Message Rate (4.10.016):*** The message rate is the cyclic frequency that the information will be transmitted to the network. This value can be set anywhere from 1 to 100 ms. A lower value will create more traffic on the network, and a higher value will decrease frequency on the network. For synchronous links (Sync), it is common to us a value of 1 ms, for non-synchronous links (Std) it is common to use a value of 10 ms.

2. Receiving Link Settings (Rx1, Rx2, and Rx3)

4.10.040	**Rx1 Link Profile**		**Std**
4.10.041	**Rx1 Link Number**		**0**
4.10.042	**Rx1 Destination Parameter**		**0.00.000**
4.10.043	**Rx1 Parameter Count**		**0**
4.10.044	**Rx1 Source Type**		**Direct**
4.10.045	**Rx1 Timeout**		**100 ms**
4.10.046	**Rx1 Timeout Action**		**Trip**
4.10.047	**Rx1 Timeout Event Destination**		**This slot**
4.10.048	**Rx1 Timeout Event Type**		**No Event**

a. **Rx1 Link Profile (4.10.040):** This can be set to either "Std" or "Sync". With a setting of "Std", this link is assuming a cyclic, non-synchronous reception of information from the network to the drive from a transmitting link. With a setting of "Sync", this link will become a cyclic, synchronous reception of information from the network to the drive. If this setting is set to "Sync", the drive sending this link must have the same setting for its Tx link.

b. **Rx1 Link Number (4.10.041):** This link number must match the link number of the transmitting information from a drive to the network in order to receive that information.

c. **Rx1 Destination Parameter (4.10.042):** The destination parameter is the beginning memory location in the drive or slot module that the block of information being received should be written to.

h. **Rx1 Parameter Count (4.10.043):** The parameter count is the number of contiguous parameters that will be read from the block of data to be sent, with the writing of the data starting at the Rx1 Destination Parameter location. This can be a value between 1 and 10.

d. **Rx1 Source Type (4.10.044):** The source type defines how the information is being taken from the network into the receiving drive. There are 3 possible settings for this parameter:

i. **Direct:** This is used if the transmitting link is set to “Broadcast” or “Unicast”.
ii. **Multicast:** This is used to match the multicast setting of the transmitting link, so that the drive is able to access those parameters on the network.
iii. **Local:** This is used if the drive is receiving a link that it is transmitting from itself. This is useful in synchronization schemes, as it allows a drive to synchronize the reception of information with other drives on the network when the sender (originator) of the information is itself.

e. **Tx1 Timeout Responses (4.10.045 – 4.10.048):** For the purposes of this example, these do not need to be discussed. If more information is needed for these parameters, the *SI Ethernet User Guide* should be consulted.

With these understandings in place, to creating each link according the prior illustrations can be done with the following settings. Note that the following settings would also work for testing with only 2 drives if the settings for Link #4 are disregarded, along with any settings for Drive #3. The settings below are shown for each link from Unidrive M Connect:

1. Synchronous Link #1 : Motion

Drive #1 : Tx1

4.10.010	Tx1 Link Profile		Sync	
4.10.011	Tx1 Link Number		1	
4.10.012	Tx1 Source Parameter		0.38.008	AMC Profile Output Position
4.10.013	Tx1 Parameter Count		2	
4.10.014	Tx1 Link Transmission Type		Broadcast	
4.10.015	Tx1 Destination Address		255.255.255.255	
4.10.016	Tx1 Message Rate		1 ms	

Drive #1 : Rx1

4.10.040	Rx1 Link Profile		Sync	
4.10.041	Rx1 Link Number		1	
4.10.042	Rx1 Destination Parameter		0.00.060	AMC External Position Reference
4.10.043	Rx1 Parameter Count		2	
4.10.044	Rx1 Source Type		Local	
4.10.045	Rx1 Timeout		100 ms	
4.10.046	Rx1 Timeout Action		Trip	
4.10.047	Rx1 Timeout Event Destination		This slot	
4.10.048	Rx1 Timeout Event Type		No Event	

Drive #2 and Drive #3 : Rx1

4.10.040	Rx1 Link Profile		Sync	
4.10.041	Rx1 Link Number		1	
4.10.042	Rx1 Destination Parameter		0.00.060	AMC External Position Reference
4.10.043	Rx1 Parameter Count		2	
4.10.044	Rx1 Source Type		Direct	
4.10.045	Rx1 Timeout		100 ms	
4.10.046	Rx1 Timeout Action		Trip	
4.10.047	Rx1 Timeout Event Destination		This slot	
4.10.048	Rx1 Timeout Event Type		No Event	

2. Non Synchronous Link #2 : Control

Drive #1 : Tx2

4.10.020	Tx2 Link Profile		Std	
4.10.021	Tx2 Link Number		2	
4.10.022	Tx2 Source Parameter		0.20.001	Application Menu 3 Read-write Integer 1
4.10.023	Tx2 Parameter Count		10	
4.10.024	Tx2 Link Transmission Type		Broadcast	
4.10.025	Tx2 Destination Address		255.255.255.255	
4.10.026	Tx2 Message Rate		10 ms	

Drive #2 and Drive #3 : Rx2

4.10.050	Rx2 Link Profile		Std	
4.10.051	Rx2 Link Number		2	
4.10.052	Rx2 Destination Parameter		0.20.001	Application Menu 3 Read-write Integer 1
4.10.053	Rx2 Parameter Count		10	
4.10.054	Rx2 Source Type		Direct	
4.10.055	Rx2 Timeout		100 ms	
4.10.056	Rx2 Timeout Action		Trip	
4.10.057	Rx2 Timeout Event Destination		This slot	
4.10.058	Rx2 Timeout Event Type		No Event	

3. Non Synchronous Link #3 : Status

Drive #1 : Rx2

4.10.050	Rx2 Link Profile		Std	
4.10.051	Rx2 Link Number		3	
4.10.052	Rx2 Destination Parameter		0.19.011	Application Menu 2 Read-write Integer 11
4.10.053	Rx2 Parameter Count		10	
4.10.054	Rx2 Source Type		Direct	
4.10.055	Rx2 Timeout		100 ms	
4.10.056	Rx2 Timeout Action		Trip	
4.10.057	Rx2 Timeout Event Destination		This slot	
4.10.058	Rx2 Timeout Event Type		No Event	

Drive #2 : Tx1

4.10.010	Tx1 Link Profile		Std	
4.10.011	Tx1 Link Number		3	
4.10.012	Tx1 Source Parameter		0.20.011	Application Menu 3 Read-write Integer 11
4.10.013	Tx1 Parameter Count		10	
4.10.014	Tx1 Link Transmission Type		Broadcast	
4.10.015	Tx1 Destination Address		255.255.255.255	
4.10.016	Tx1 Message Rate		10 ms	

4. Non Synchronous Link #4 : Status

Drive #1 : Rx3

4.10.060	Rx3 Link Profile		Std	
4.10.061	Rx3 Link Number		4	
4.10.062	Rx3 Destination Parameter		0.19.021	Application Menu 2 Read-write Integer 21
4.10.063	Rx3 Parameter Count		10	
4.10.064	Rx3 Source Type		Direct	
4.10.065	Rx3 Timeout		100 ms	
4.10.066	Rx3 Timeout Action		Trip	
4.10.067	Rx3 Timeout Event Destination		This slot	
4.10.068	Rx3 Timeout Event Type		No Event	

Drive #3 : Tx1

4.10.011	Tx1 Link Number		4	
4.10.012	Tx1 Source Parameter		0.20.011	Application Menu 3 Read-write Integer 11
4.10.013	Tx1 Parameter Count		10	
4.10.014	Tx1 Link Transmission Type		Broadcast	
4.10.015	Tx1 Destination Address		255.255.255.255	
4.10.016	Tx1 Message Rate		10 ms	

Once these settings are in place, all parameter settings should be saved in the drive before continuing. In order to restart the Easy Links network with the new settings, it is best to reset each Ethernet module individually through setting **Reset** (24.007) to **"On"**. Once the network comes into synchronization, a few parameters can be observed for network status as described below:

1. ***Tx Link Status (4.10.019, 4.10.029, 4.10.039):*** This will show the status of transmitting links on each drive if they are enabled. Consulting the Unidrive M Parameter Reference Guide is helpful in diagnosing network issues through this parameter.
2. ***Rx Link Status (4.10.049, 4.10.059, 4.10.069):*** This will show the status of receiving links on each drive if they are enabled. Consulting the Unidrive M Parameter Reference Guide is helpful in diagnosing network issues through this parameter.
3. ***Cyclic Messages Per Second (4.10.004):*** This parameter will display the number of messages (Rx and Tx) per second in the module.
4. ***Synchronization Jitter From Grandmaster (4.11.006):*** This parameter will display the real time jitter of the local network clock to the Grandmaster Clock (in nanoseconds). If the local clock is the Grandmaster Clock, this value will be 0.

This example shows how to execute both synchronous and non-synchronous data transfer along the same network using Easy Links for Real Time Motion Control over Ethernet (RTMoE). Again, although this note describes a network for 3 drives, the above settings would also work for testing with only 2 drives if the settings for Link #4 are disregarded along with any settings for Drive #3. Easy links provide a high performance and reliable replacement for applications that were using CTNet and CTSync, and give users the opportunity to maximize onboard network capabilities of the Unidrive M700.