Fieldbus

Application Note 155

This application note outlines the fieldbus options available for *Triamec* devices. While the primary focus is on *Tria-Link*, our proprietary fieldbus solution, *EtherCAT* is also discussed. Additionally, this documentation includes information on drive-to-drive data exchange and the *Tria-Link* monitor.

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Owner fm

1 Introduction to Fieldbus Types for Triamec Devices

The two fieldbus options for *Triamec* Devices are *EtherCAT* and *Tria-Link*, a bus developed by *Triamec*. *Triamec* servo drives support either *EtherCAT* or *Tria-Link*. We generally recommend using *EtherCAT,* but it is advantageous to use *Tria-Link* if the following features are required:

- Direct drive to drive communication (e.g. axis compensation depending on the position of other axes)
- Integration into custom client application (TAM API)
- *Tria-Link* Master Mode: A servo drive in *Tria-Link Master Mode* can be used to connect multiple drives to each other and to upper level control. The master servo drive then connects directly via Ethernet to an industrial PC. (e.g. wafer stage) via TAM API.
- 10kHz path planner coupling (direct feed)

2 EtherCAT

In contrast to the *Tria-Link*, the cyclic data is defined at boot time and cannot be changed later. This makes debugging through the fieldbus less flexible than with the *Tria-Link*. However, customers may still use the USB or Ethernet interface for debugging within *Triamec TAM System Explorer*.

Exchange of cyclic data between slaves is less flexible than with *Tria-Link* and is not supported. More information is found in [2].

3 Tria-Link

Tria-Link is a bus developed by *Triamec*. *Tria-Link* servo drives can be connected with the other *Triamec* devices and must form a **ring topology** with the *Triamec* PCI-Adapter (also called "*Tria-Link adapter*") or the *Master Drive*. *Tria-Link* is *not* supported with *EtherCAT* drives. A *Tria-Link* ring system can support up to 48 drives. Use quality Cat. 5E or 6, double shielded, standard Ethernet cables.

For the communication media *Triamec* recommends using Cat. 5E or 6, double shielded, standard Ethernet cables. The cable should be shielded at least once externally to mitigate electromagnetic interference (EMI) in environments with potential electrical noise.

3.1 Connection from PC to Tria-Link

There are **two different configurations of *Tria-Link*** depending on the intended use:

- *Tria-Link* with *Tria-Link* PCI adapter card: for machines that require TwinCAT or Direct Feed, e.g. most wafer stages
- *Tria-Link* Master Mode: for machines that do NOT require TwinCAT or Direct Feed

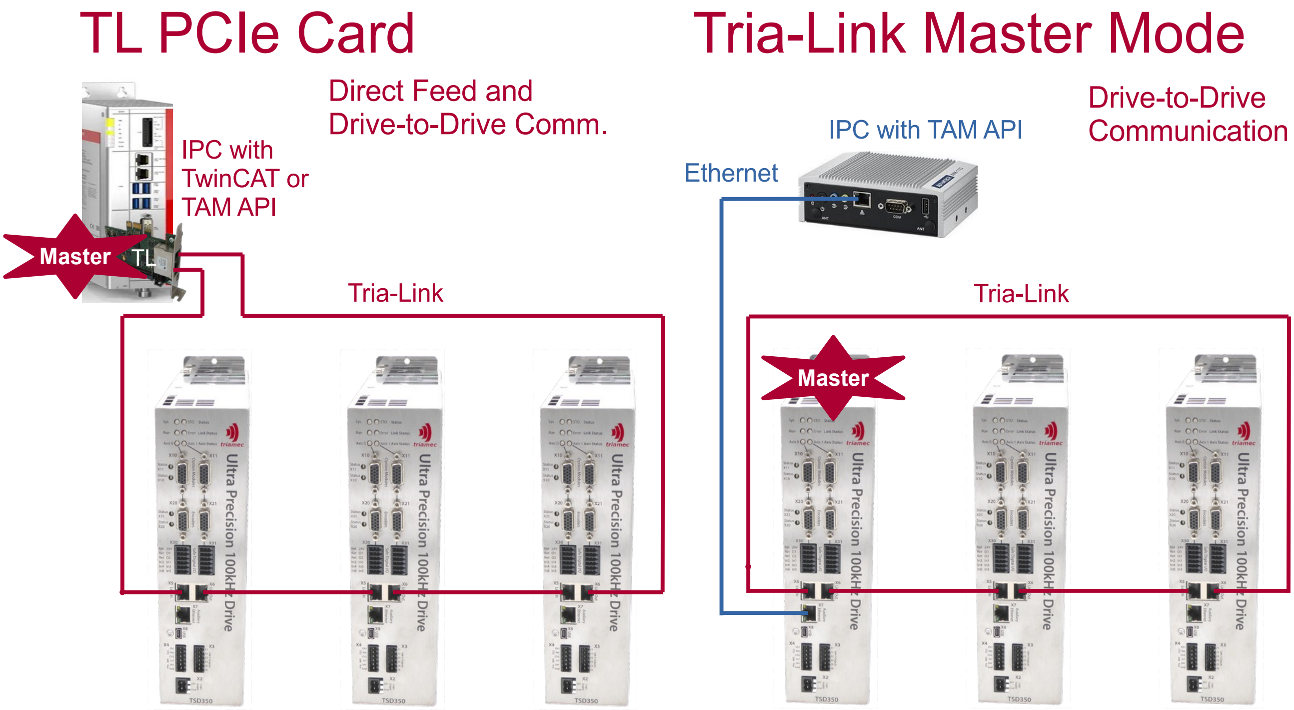


Figure 1: Tria-Link with third party control system (left) versus Tria-Link using a drive in Master Mode with a Bridge Mode access (right)

3.1.1 Tria-Link with PCI adapter card

The adapter card can be used **either** with a high-level **control system** (e.g. *TwinCAT*, TAM API software, etc) or with the ***TAM System Explorer* via PCI**, but not both at the same time. The *Tria-Link PCI adapter card* has to be installed on the *PC*.

To grant the *TAM System Explorer* access via PCI: Choose **File > Preferences > Startup > Acquired Adapters** and set one of the following values:

- *Triamec* devices over PCI
- *Triamec* devices w/o Ethernet
- All *Triamec* devices

3.1.1.1 Bridge Mode and USB Observer

There are two options to access the *Tria-Link* ring with the *TAM System Explorer* **while** other applications (e.g. TwinCAT) use the *Tria-Link* adapter.

- Use an ***USB Observer*** by connecting via USB to the *Tria-Link* adapter card. The USB cable can be attached to the adapter card without interrupting the system.
- ***Bridge Mode***: Access a *Tria-Link* device with Ethernet and use the device as a bridge between *Ethernet* and *Tria-Link*. The mode may be activated on one drive only in a *Tria-Link* ring, using General.Parameters.Bridge set to Ethernet. If this mode is not activated, the PC has access only to the connected drive.

Note To use Bridge Mode, all drives in the *Tria-Link* ring must have a firmware version >= 4.6.0.

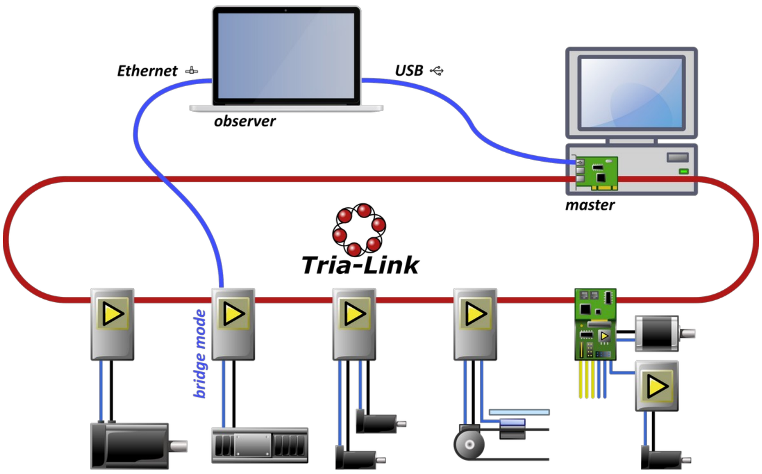


Figure 2: Tria-Link system with an observer PC

With the *TAM System Explorer* running on the observer PC, one can observe any drive signals online, even while the master application (e.g. TwinCAT) is running.

> **Note** If the USB cable is connected to the *observer PC*, no extra configuration is needed when operating *TAM System Explorer* with an USB Observer. **File > Prefereces > Startup > Acquired adapters** should be set to ***Triamec* Devices over USB** in this case. This prevents the *TAM System Explorer* from accessing the PCI board that is already occupied by the control system.

3.1.2 Tria-Link Master Mode

In *Tria-Link* Master Mode a **servo-drive can act as the master** and other drives can be connected directly to each other. The master servo drive can then be connected via Ethernet to an industrial PC running **TAM API**.
Tria-Link Master Mode is available with **firmware release 4.23.3 or higher** to all TSD and TSP-series servo drives.

Follow these few steps to set up *Tria-Link* Master Mode:

1. There **must be no** TL card in the ring
2. Choose a drive to be accessed as the Bridge Mode drive from Ethernet and set:
   General/Parameters/TriaLinkMaster = True
   General/Parameters/Bridge = Ethernet
3. Save the configuration permanently onto the drive
4. Restart the TAM System Explorer by selecting **File > Restart This Application** if it's the first time setting up Master Mode.

Then all drives should be visible via the Ethernet connection of the drive that is in **Bridge Mode** (see Figure 1).

> **Note** **Only one drive** inside a *Tria-Link* ring system can be in **Master Mode.** The same drive has to be in Bridge Mode for accessing all drives in the *Tria-Link* ring system.

3.2 Tria-Link Monitor

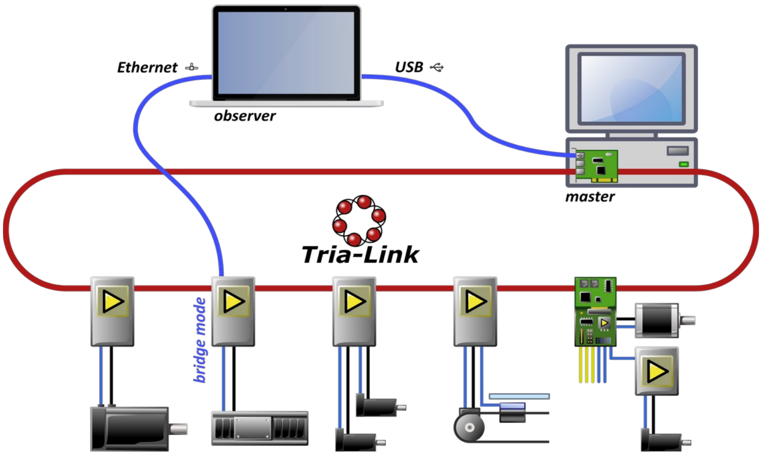
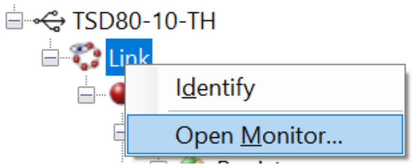


Figure 3: Tria-Link System with Observer PC

The *Tria-Link Monitor* is exclusively available for the *Tria-Link* fieldbus. It is a tool embedded in the *TAM System Explorer* to debug the *Tria-Link* fieldbus. To start the it, **right-click** the ***Tria-Link*** node and select **Open monitor...**



Note It is recommended to use the tool while connected to the *Tria-Link* as an observer to debug a running machine.

3.2.1 Displayed Information

The *Tria-Link Monitor* displays a table with all devices in the *Tria-Link* ring.

3.2.1.1 Station

Order Code and SN of the participants in the *Tria-Link***.**

If the link is observed by USB, the device where USB is connected will show up twice. One of the two entries is the USB observer.

3.2.1.2 Order

The values index the order of the participants in the *Tria-Link***.**

This column is only visible in the debug build. It is calculated from the absolute difference of the two values in the local bus register 2: phase count ring 1+2 (1 incr = 10ns). The participants are sorted according to this value in the *Monitor*. This is useful to make an exact statement in case of cable breaks.

3.2.1.3 Address

The values are the unique number within the *Tria-Link* **used for communication**.

In a *TwinCAT* system, these addresses are used for identification. In such setups, the address is made persistent on the device.

When several stations have the same address, communication with these devices will be severely impacted. There will be only one entry in the *Monitor*, but it's undefined from where its values are read. Initializing the link will remedy this situation.

3.2.1.4 Publishers, Subscribers

The values show which channels are in use.

Channels enable drive-to-drive data exchange (refer to chapter 3.3) and are set up in the General.Parameters.TriaLink registers.

All publishers should be matched by at least one subscriber. While an unsatisfied subscriber will cause an error on that device, unmatched publishers will go unnoticed. An unmatched publisher indicates a configuration error which itself might be the cause for a dependent function not to work as intended.

3.2.1.5 Stream

Stream1 and Stream2 count direction-dependent erroneous path planner data.

Most common cause are problems with the higher-level controller, such as jitter or CNC task exceeds.

3.2.1.6 PPM

The values show the difference of the quartz clock to the reference clock.

PPM denotes *Parts per Million*. The reference is always the TL card (*Bus Master*) and should have the value 0.

3.2.1.7 CRC

CRC1 and CRC2 count direction-dependent erroneous packets.

Tria-Link packets are marked with a *CRC* when sent to the ring.

3.2.1.8 Frame

Frame1 and Frame2 count direction-dependent faulty frames.

A *Frame* is the unit circulating with 10kHz on the *Tria-Link*. There are two *Frames* per clock, one in each direction. A *Frame* consists of 33 *Tria-Link* packets, plus timestamp with its own *CRC*. The middle of the timestamps of receipt of *Frame1* and *Frame2* is used to synchronize the participants.

3.2.1.9 Gap

Gap1 and Gap2 count direction-dependent missing/invalid Ethernet IPGs*.

A *Gap* represents the *Interpacket Gap*. In short, *IPG* is a pause between two *Frames*.

3.2.1.10 RxErr

RxErr1 and RxErr2 count direction-dependent defective/lost packets.

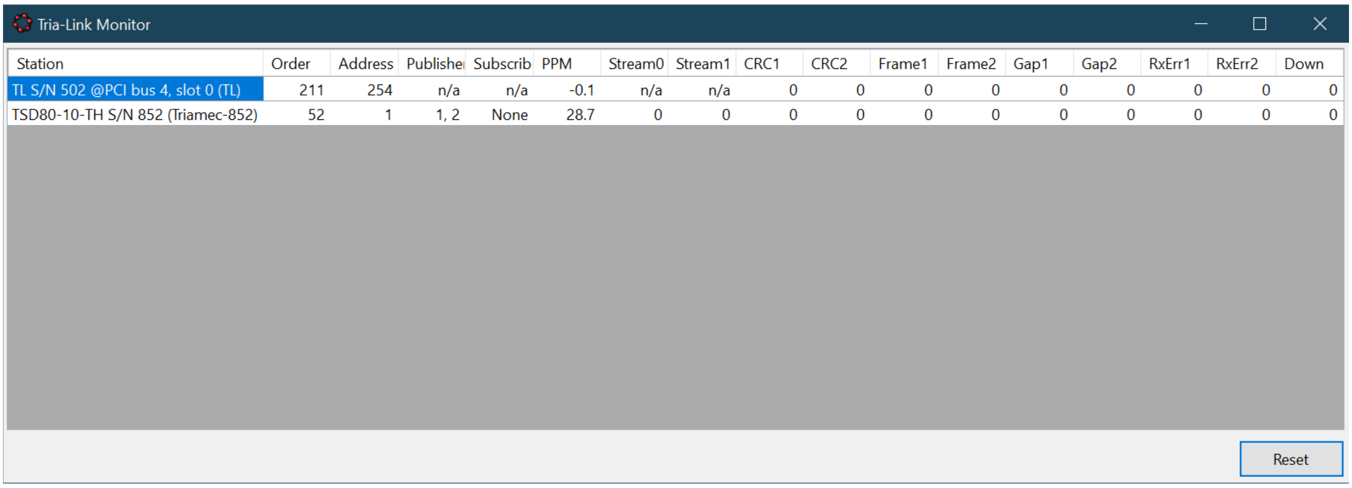
These counters are directly forwarded from the *MII* of Ethernet. A packet that gets corrupted on the *physical* counts up the *MII* Error. *RxErr* values indicate electrical problems (cable or EMC).

3.2.1.11 Down

Down increments if a participant had to be resynchronized to the link.

Usually in this case all participants are resynchronized and therefore the whole column counts up.

3.2.2 Interpretation



Station	Order	Address	Publishe	Subscrib	PPM	Stream0	Stream1	CRC1	CRC2	Frame1	Frame2	Gap1	Gap2	RxErr1	RxErr2	Down
TL S/N 502 @PCI bus 4, slot 0 (TL)	211	254	n/a	n/a	-0.1	n/a	n/a	0	0	0	0	0	0	0	0	0
TSD80-10-TH S/N 852 (Triamec-852)	52	1	1, 2	None	28.7	0	0	0	0	0	0	0	0	0	0	0

The counters gain importance from left to right. While the *Monitor* is open, each increment is also logged. This allows a temporal analysis.

We start on the far right:

1. *Down* counter may already be at 1 when the link was rebuilt for the test (e.g. machine reboot).
2. If *Down* continues to increment without user action, there are serious problems.
   - Possibly defective devices in the ring.
     - Serious electrical problems (cable break, etc.).
     - Customer program provokes recurring ring boot.
3. *RxErr* values:
   - increment regularly → cable or EMC
   - count abruptly, irregularly → cable or EMC
   - count only when motors enabled → suspect EMC, grounding problems
   - count up in pairs of two participants → suspect cable issues in between the two participants
4. values further left are often consequential errors of *RxErr*.
5. check *PPM* (exclude crystal problems):
   - Nominal hardware is tuned to <25 *PPM*.
   - Differences >50 *PPM* to reference are suspicious.

3.2.2.1 Additional Information

- Column index suffix refer to the running direction of packets on the ring.
  All columns with suffix 1 represent one direction.
  All columns with suffix 2 represent the opposite direction.
- The direction with respect to the order of the participants (or also physical direction) is unknown.The maximum value in all counters is 255, whereas *PPM* is not a counter.

3.3 Drive to Drive Data Exchange

Triamec Motion AG products are capable of drive-to-drive data exchange with a 10kHz rate. This feature is available only in a *Tria-Link* fieldbus setup.

The main purpose is to send data directly to where it is used, cyclically and without detours. This is key to complex applications where multiple devices exchange process relevant data.

This chapter describes how to setup such data exchange and its specification.

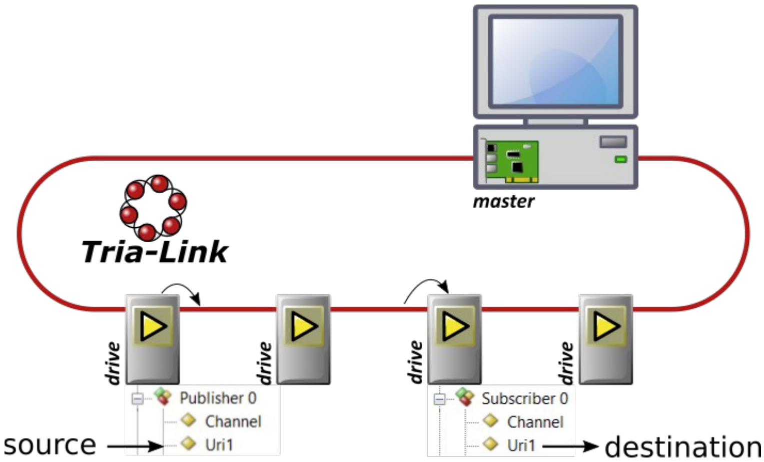


Figure 4: Drive-to-Drive data exchange concept

3.3.1 Configuration

The method described in the following is called the *Tria-Link* channel method. Data can be sent flexibly from publisher to subscribers. We first describe the channel concept and then how to setup the publisher and the subscriber settings.

3.3.1.1 Payload and Channels

The data is exchanged using packets of data. These packets of data have the following properties.

- The packets are exchanged at a fixed rate of 10 kHz.
- Each packet contains a payload of 6 values.
- Value types can be mixed within one packet.
- A standard value is either a 32-bit integer or a 32-bit float.
- Any two of these values can be combined to a 64-bit double or 64-bit integer.

The header of these packets identifies the packet as a *Tria-Link* channel packet with a channel identifier.

- One drive can publish 4 channels concurrently.
  This gives a maximum of 24 values sent out cyclically per drive.
- One drive can subscribe up to 3 channels concurrently.
  This gives a maximum of 18 values received cyclically per drive.
- 16 Channels are allowed on the *Tria-Link* concurrently.
  This gives a total of 96 values exchanged on the *Tria-Link*.

The channel identifier is unique on the *Tria-Link* ring and can be chosen by the customer from a pool of sixteen available identifiers. If two drives publish data using the same channel identifier, an error is generated on the subscriber side. Data can be received by more than one subscriber concurrently. This can be used, i.e. to publish one analog input signal from one drive to multiple drives that use this data.

3.3.1.2 URI Address

The data exchanged between publisher and subscribers can be specified flexibly.

- Any register value of a drive can be published, but preferably registers from the category Signals.
- Subscriptions are restricted to the following registers.
  - Any Commands register.
  - Any Application register, preferably working with the Variables category.

Each register in a drive has a unique address, called the *URI Address*. This address is used to specify:

- the source on the publisher drive, and
- the destination on the subscriber drive.

3.3.1.3 Setting up the publisher

Any drive that is set up to send data is called a publisher. Navigate to one of the four publishers of this drive at General.Parameters.Trialink.Publishers[], figure Figure 5.

Register	Actual	Prepare	Unit	Description
Channel	Disabled	Disabled	-	Specify to which channel the data should be published
Uri1	General/Signals/DcBusVoltage	General/Signals/DcBusVoltage	-	The address of the source register
Uri2		dcbusc	-	The address of the source register
Uri3				
Uri4				
Uri5				
Uri6			-	The address of the source register

General/Signals/DcBusCurrent
General/Signals/DcBusCurrentSquared
General/Signals/DcBusCurrentSquaredMax

Figure 5: Tab view of a publisher
The Uri addresses are entered with help of an auto completion list.

The channel is currently Disabled, which means it will not publish data to the *Tria-Link*. Now choose one of the 16 global channel identifiers in the register Channel. This must be unique over the whole *Tria-Link* bus.

Any six registers of the drive can now be specified for being published on this channel. Set up the registers Uri1 to Uri6 by committing an *URI Address*. The data will be copied from the specified registers and sent to the *Tria-Link*.

Special case for 64-bit values

All channels are defined to carry six slots of 32 bits. To share 64-bit floating point values or 64-bit integer values two 32-bit slots are required. This is automatically set up and indicated as you choose a 64-bit register, as indicated in figure Figure 6.

Register	Actual
Channel	Channel1
Uri1	Axes[0]/Signals/PathPlanner/Position
Uri2	- Reserved for previous 64-bit Register -
Uri3	Axes[0]/Signals/PathPlanner/Velocity
Uri4	Axes[0]/Signals/PathPlanner/Acceleration

Figure 6: 64-bit registers occupy two slots

3.3.1.4 Setting up the subscriber

Any drive that is setup to receive data is called a subscriber. Navigate to one of the three subscribers of this drive at General.Parameters.Trialink.Subscribers[]. A subscriber inherits the same registers as a publisher and therefore looks the same (Figure 5).

The Channel is set to Disabled, if not used. To receive data from the *Tria-Link*, choose one of the 16 global channel identifiers in the register Channel. This must be a channel that is active on a publisher drive.

Any six registers of the subscriber drive can now be specified in Uri1 to Uri6. The data received on the defined channel will be copied from the *Tria-Link* and saved to the destination registers.

3.3.2 Timing

The *Tria-Link* has the advantage of direct drive-to-drive data exchange with low latency. The *Tria-Link* has a 10kHz communication rate and therefore also the direct drive-to-drive data exchange is bound to this rate.

The data exchange always takes one full communication cycle of 100µs. New data is always propagated in the next cycle from the moment it is ready. Referring to cycles, the following steps apply (see also Figure 7):

- The data is set and ready to publish in cycle 0.
- It is then transmitted to all subscribers in cycle 1.
- Finally the data is ready to use from the start of cycle 2.

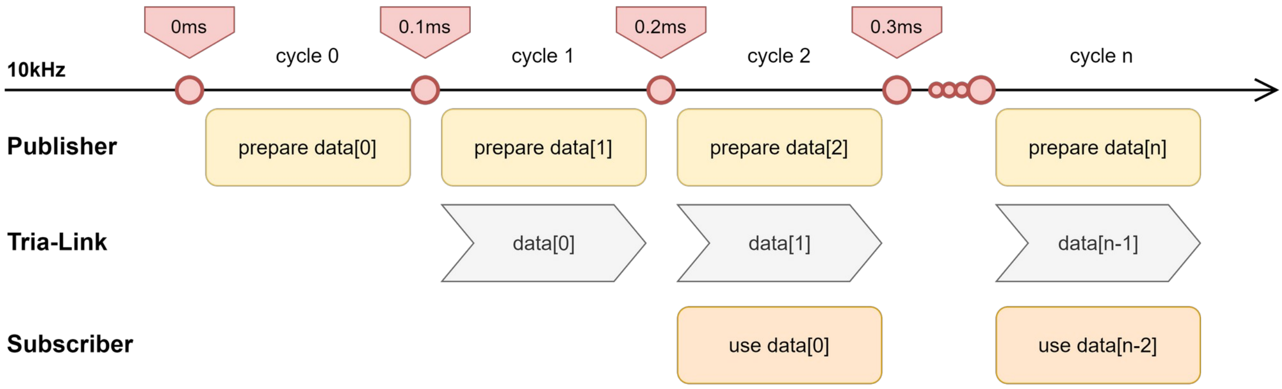


Figure 7: Timing in drive-to-drive data exchange

The same timing rules apply for round trips or man in the middle processing. To process data on an other drive and send it back it will take two transmission cycles and one process cycle in between. This results in 3 cycles delay.

Note Subscribed data is ready to use in the register at the start of the cycle. It is possible to read new data, process it and publish the result within the same cycle.

3.3.3 Monitoring

In order to review the channel setup, bring up the *Tria-Link* Monitor (chapter Error: Reference source not found) as shown in Figure 8. In a sane configuration, each channel in use must occur in both publisher and subscriber columns.

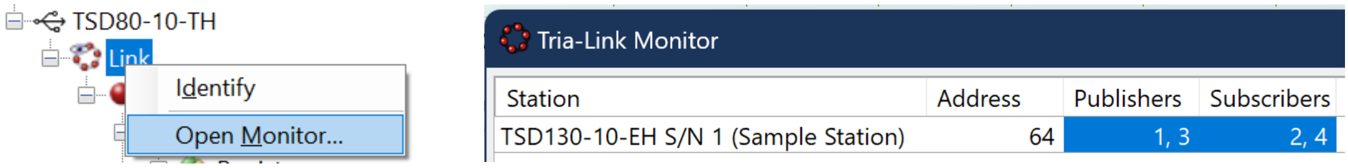


Figure 8: The Tria-Link Monitor allows to check all configured channels in one view.
In this example, there is only one station publishing on channels 1 and 3, and getting values from channels 2 and 4.

References

[1] "Servo Drive Setup Guide", ServoDrive-SetupGuide_EP025.pdf, *Triamec Motion AG,* 2024.
[2] "Installation Guideline", ETG1600_V1i0i2_G_R_InstallationGuideline.pdf, *EtherCAT* Technology Group, 2024.
[3] "Ethernet Interface", AN123_Ethernet_EP006.pdf, *Triamec Motion AG*, 2024

Revision History

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001	2025-01-13	fm	Initial edit: Full integration of AN146 and AN142 into AN155

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