DNP3 Router

Radio Network Setup

Technical Application Note

A-DNP3R

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aparian

CONTENTS

1. Preface 3
1.1. Purpose of this Document 3
1.2. Additional Information 3
1.3. Support 3
2. Application Description 4
2.1. Simple Network 4
2.2. Simple Repeater Network 4
2.3. Redundant Repeater Network 5
2.4. Routed Repeater Network 6
3. Setup – DNP3 Router 8
3.1. Timeouts 8
3.2. Delay Times 8
3.2.1. Reply Wait Time (Outstation) 9
3.2.2. Confirm Delay Time (Master) 9
3.2.3. Inter-Mapping Delay Time (Master) 10
3.2.4. Repeater Delay (Outstation) 11
3.3. Repeater/Routed Table 12
4. Radio Network Considerations 14
4.1. Events 14
4.2. Security 14
4.3. BaudRate 14

1. PREFACE

1.1. PURPOSE OF THIS DOCUMENT

This document will assist the user to setup a radio network using Aparian's DNP3 Router.

1.2. ADDITIONAL INFORMATION

The following resources contain additional information that can assist the user with the module installation and operation.

Resource	Link
Slate Installation	http://www.aparian.com/software/slate
DNP3 Router User Manual DNP3 Router Datasheet Example Code & UDTs	http://www.aparian.com/products/dnp3router
Ethernet wiring standard	www.cisco.com/c/en/us/td/docs/video/cds/cde/cde205_220_420/installation/guide/cde205_220_420_hig/Connectors.html
CIP Routing	The CIP Networks Library, Volume 1, Appendix C:Data Management
DNP3	http://www.dnp.org
Slate Installation	http://www.aparian.com/software/slate

1.3. SUPPORT

Technical support will be provided via the Web (in the form of user manuals, FAQ, datasheets etc.) to assist with installation, operation, and diagnostics.

For additional support the user can use either of the following:

Contact Us web link	www.aparian.com/contact-us
Support email	support@aparian.com

2. APPLICATION DESCRIPTION

The Aparian DNP3 Router can be used in various radio network applications. The DNP3 Router provides various parameters and functionality that will assist the user in low-bandwidth radio network applications. There are also certain recommendations that the user should consider when implementing DNP3 on a radio network.

The diagrams below show examples of typical network configurations.

2.1. SIMPLE NETWORK

In this network the DNP3 Master can communicate with all the DNP3 Outstations directly.

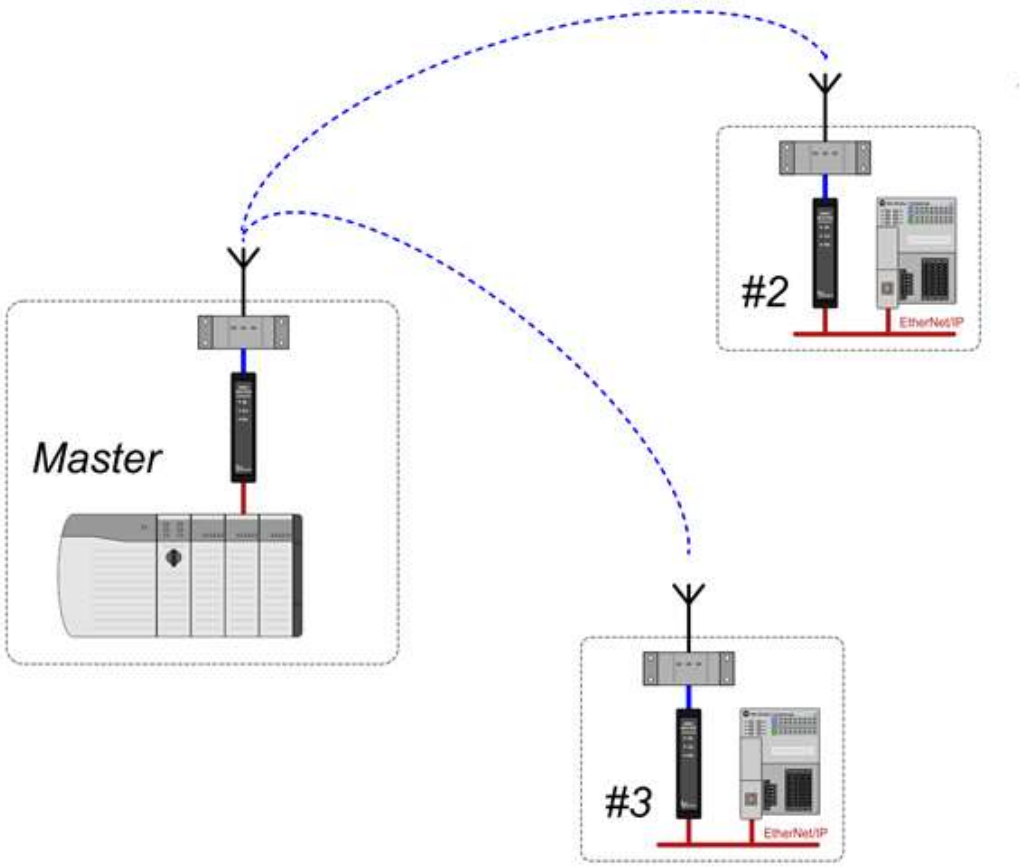


FIGURE 1 - SIMPLE RADIO NETWORK

2.2. SIMPLE REPEATER NETWORK

In this network the DNP3 Master cannot communicate with all the DNP3 Outstations directly. This may be due to excessive distance or obstructions to the radio communication. In this

instance the DNP3 Router (when in Outstation Mode) can be configured to act as a repeater for other DNP3 Outstations allowing the DNP3 Master to communicate with all DNP3 Outstations.

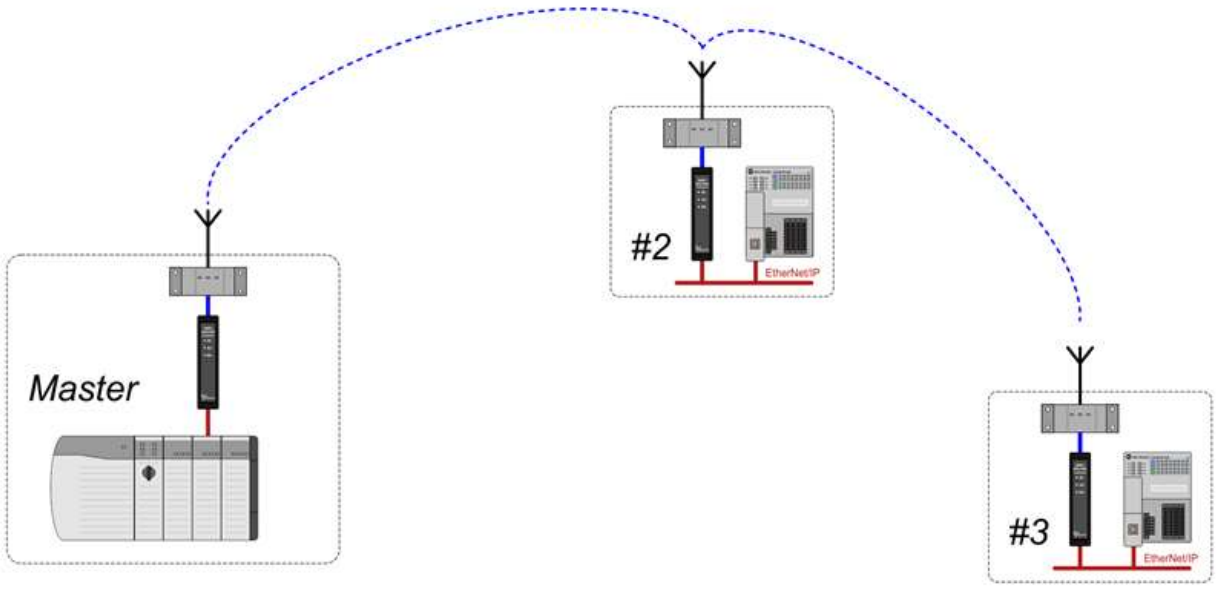


FIGURE 2 - SIMPLE RADIO WITH REPEATER NETWORK

2.3. REDUNDANT REPEATER NETWORK

In this network the DNP3 Master cannot communicate with all the DNP3 Outstations directly. This may be due to excessive distance or obstructions to the radio communication. In this instance more than one DNP3 Router (when in Outstation Mode) can be configured to act as a repeater for other DNP3 Outstations allowing the DNP3 Master to communicate with all DNP3 Outstations in a redundant manner (i.e. if one of the repeating nodes is unavailable then the network will still operate).

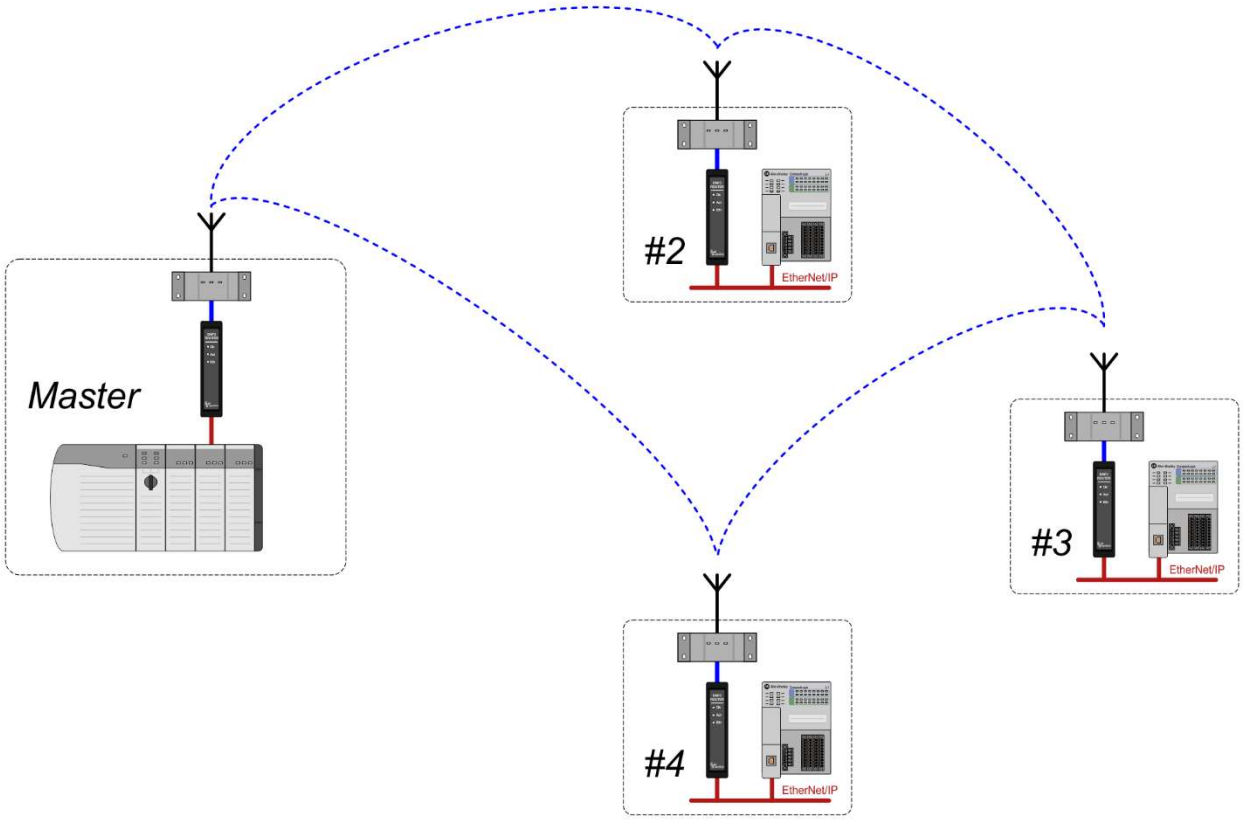


FIGURE 3 - REDUNDANT RADIO WITH REPEATER NETWORK

2.4. ROUTED REPEATER NETWORK

In this system there are multiple DNP3 Outstations on different radio networks (operating on a different frequency or modulation), such that nodes on network A cannot communicate directly with nodes on network B. The DNP3 Router can be configured (in Outstation mode) to relay a message from network A to network B (and vice versa) via another DNP3 Router over Ethernet. This will allow the DNP3 Master to communicate with all DNP3 Outstations (over various radio networks) without needing a radio interface for each radio network.

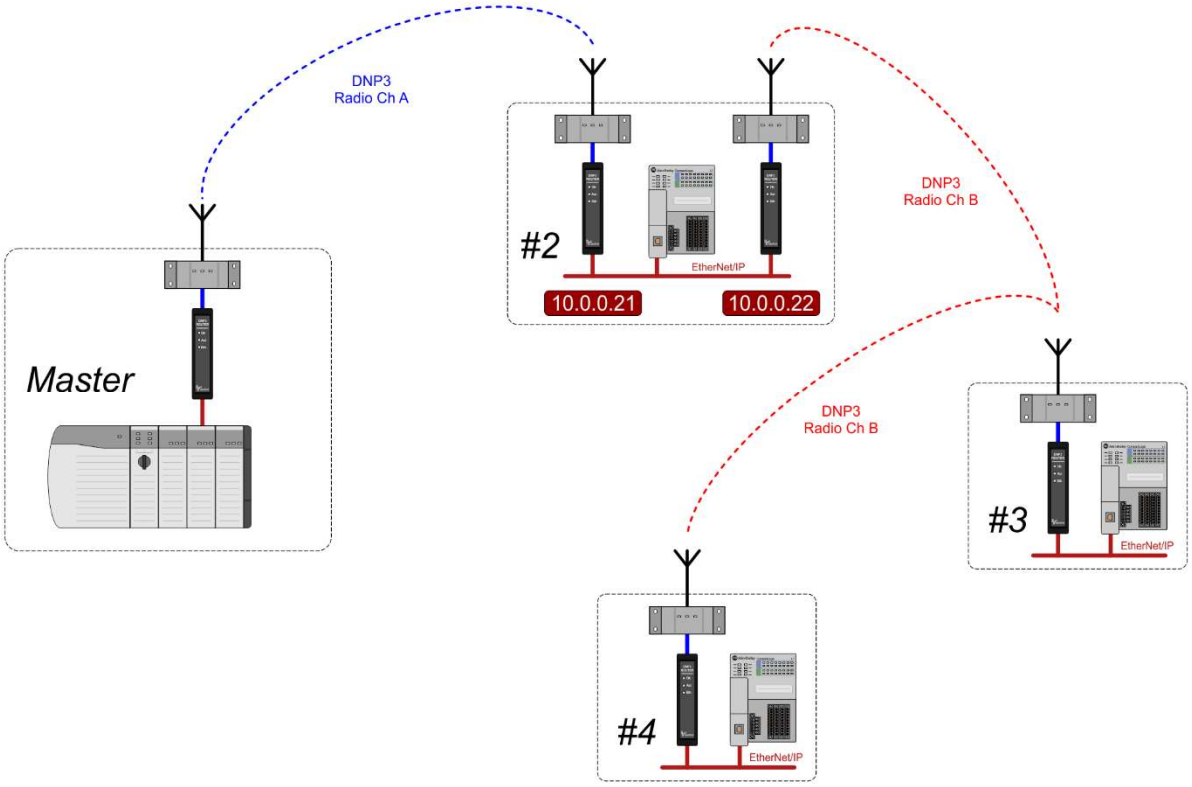


FIGURE 4 - REPEATER NETWORK OVER VARIOUS RADIO NETWORKS

3. SETUP – DNP3 ROUTER

The following sections describe the configuration required for setting up a DNP3 Router in a radio network with message repeaters and routers.

3.1. TIMEOUTS

Radio networks generally have larger message transaction delay times when compared to conventional wired networks. This may typically be attributed to the radio transmit and receive switching and collision avoidance deadtime, etc. Also, many radio networks use a low baud rate which means the message transmission rate is slower.

Repeaters will add additional delays depending on how many repeating hops are in the system.

For these reasons, the *Timeout* setting in the DNP3 configuration settings must be increased to allow for the increased transaction time. The value defaults to 500ms which in many radio applications making use of repeaters may not be sufficient.

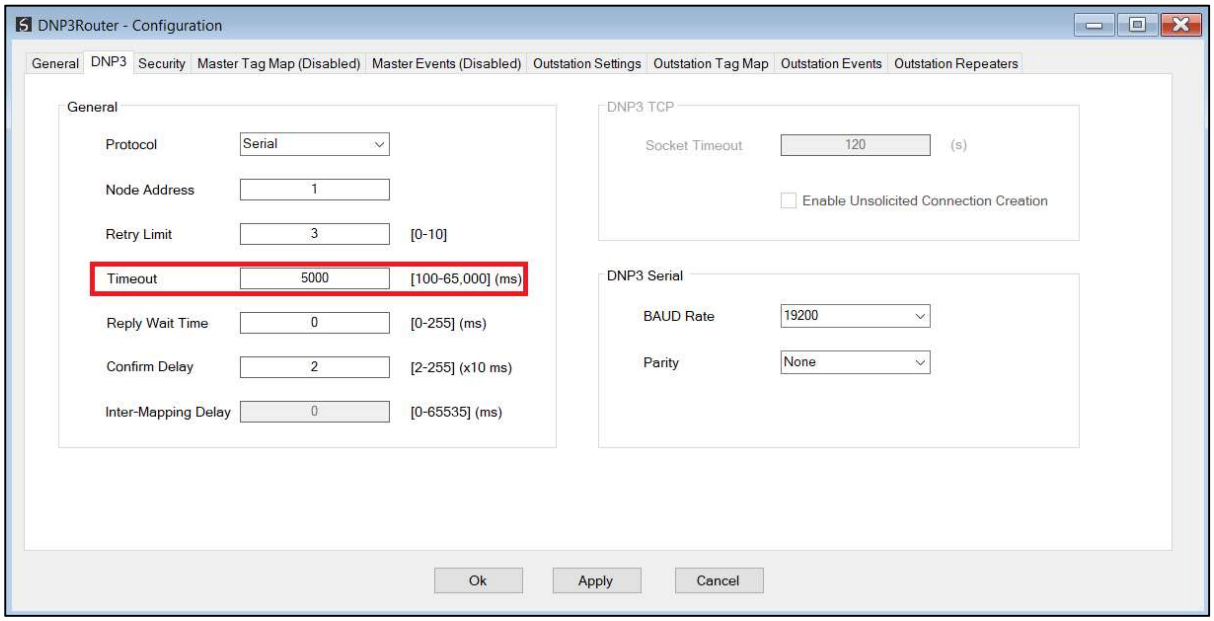


FIGURE 5 – TIMEOUT SETTING

3.2. DELAY TIMES

To ensure there is no packet collisions when sending and receiving DNP3 packets, the DNP3 Router has numerous configurable delays allowing the user to customize the module for each specific application.

3.2.1. Reply Wait Time (Outstation)

The *Reply Wait Time* setting will allow the DNP3 Router outstation to delay the response to a specific request. This can be used to allow the radio sufficient time to switch between transmit and receive or to allow for some quiet time between the request and the response.

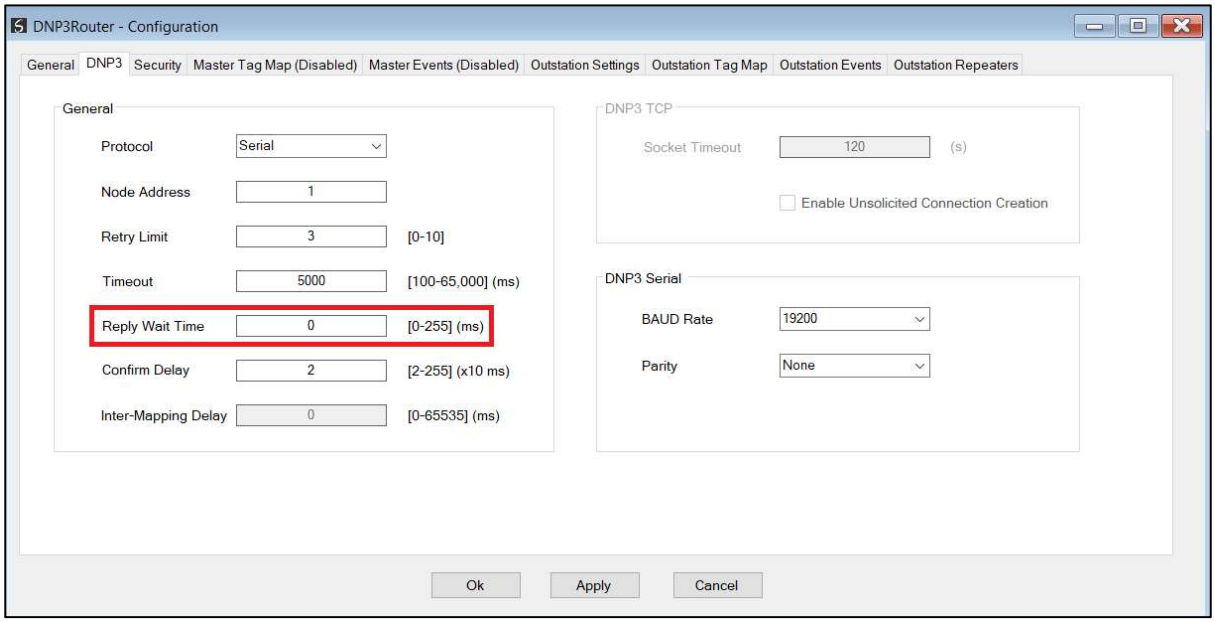


Figure 6 – Reply Wait Time

3.2.2. Confirm Delay Time (Master)

When the DNP3 Router (in Master mode) has been configured for events, then this setting will allow the DNP3 Master to delay the DNP3 Confirm message after receiving events from a DNP3 Outstation. This is particularly useful in architectures where repeaters are used, because the repeaters might have a repeat delay configured. If there is no confirm delay then, in certain situations, there will be very little quiet time between messages which can lead to collisions.

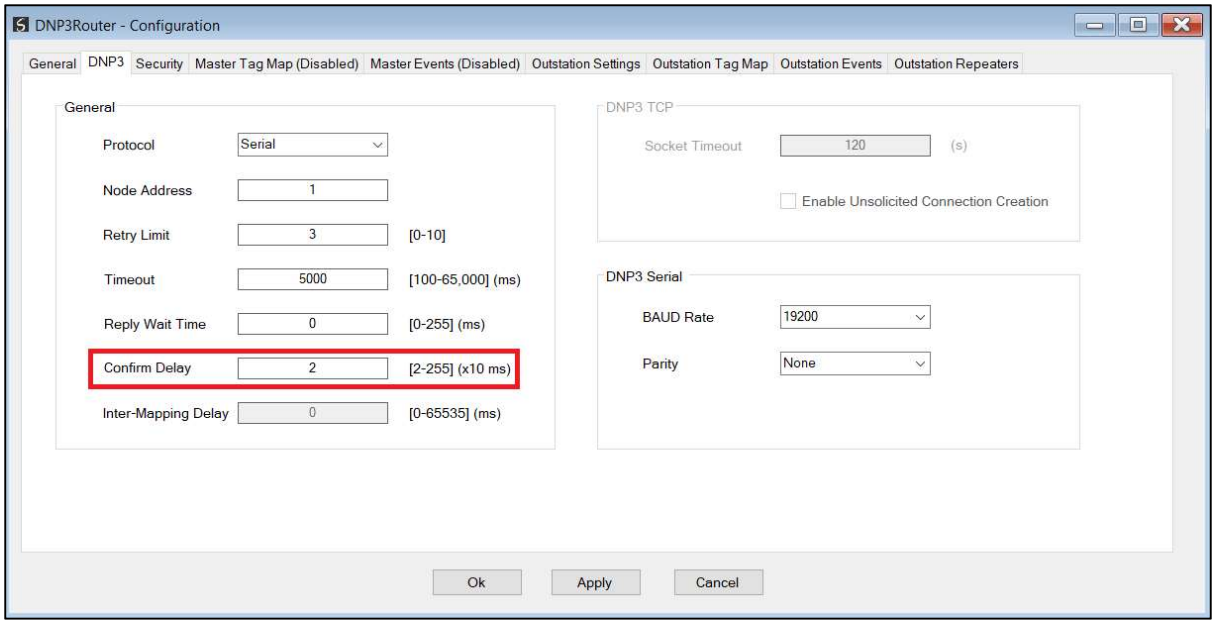


FIGURE 7 – CONFIRM DELAY

3.2.3. INTER-MAPPING DELAY TIME (MASTER)

The *Inter-Mapping Delay Time* allows the user to add a quiet time between executing mapped items configured in the Master Tag Map. This can be used to avoid message collisions in redundant repeating architectures. For example, when redundant repeaters are used the DNP3 Master will normally send the next mapped item request the moment the response is received. In this situation the redundant repeater might send the last response at the time the DNP3 Master is sending the request for the next mapped item.

The *Inter-Mapping Delay Time* setting will also allow the DNP3 Router (in Master mode) to provide some quiet time when unsolicited events have been configured for the DNP3 Outstation. See section 4 for recommendations when using unsolicited events in a radio network.

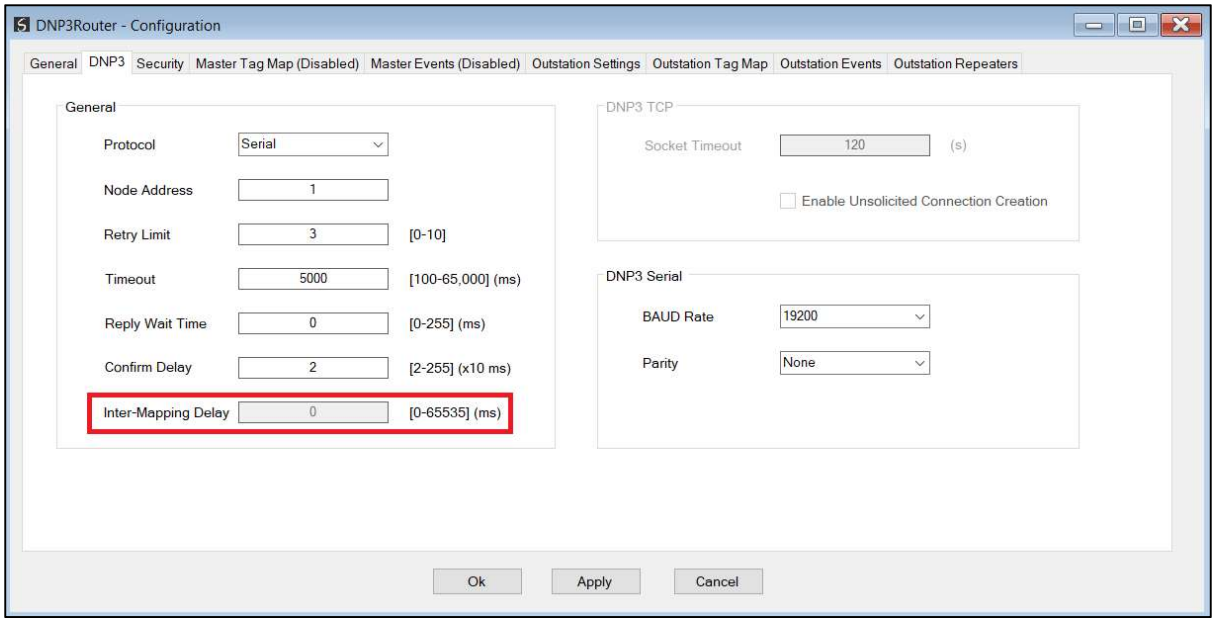


FIGURE 8 – INTER-MAPPING DELAY

3.2.4. REPEATER DELAY (OUTSTATION)

When configuring the repeater table in the DNP3 Router (in Outstation mode) then it is recommended that the user add a delay. This delay will allow the repeated message to be delayed before resending it. This is useful because certain radios need some time to switch between receiving and transmitting (and vice versa). It will also allow the user to configure redundant repeaters with different delay times ensuring that there are no message collisions.

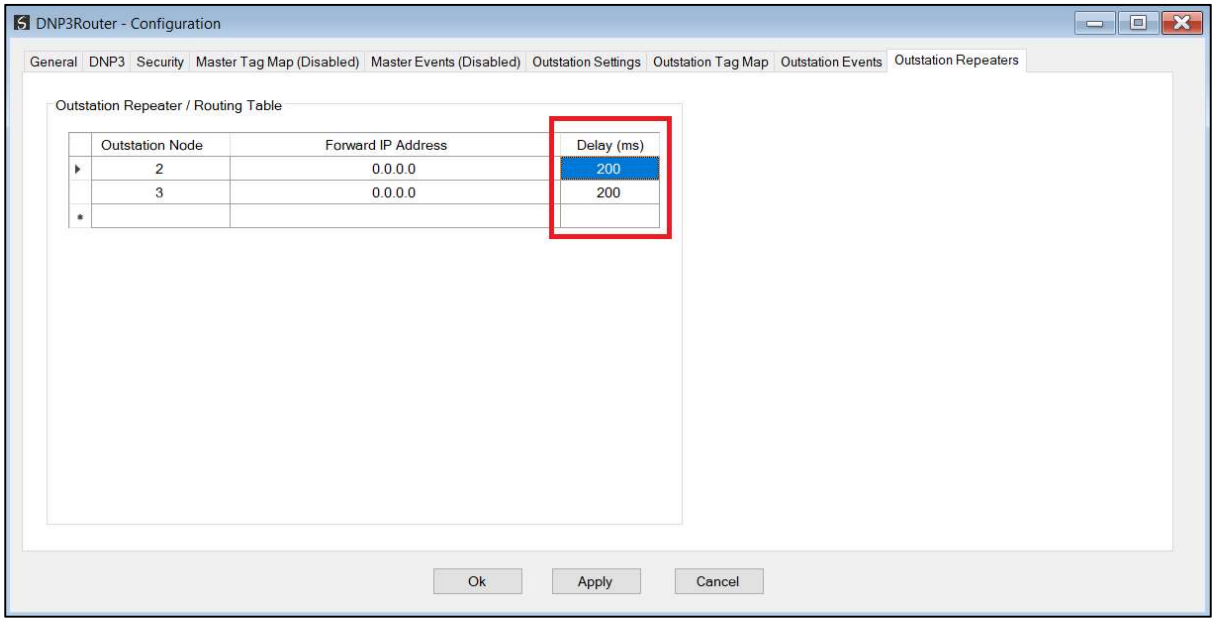


FIGURE 9 – REPEATER DELAY

3.3. REPEATER/ROUTED TABLE

The repeater table is used by the DNP3 Router Outstation to repeat messages received from the DNP3 Master or another DNP3 Outstation. The table consists of a Node number, Forward IP Address, and a Delay.

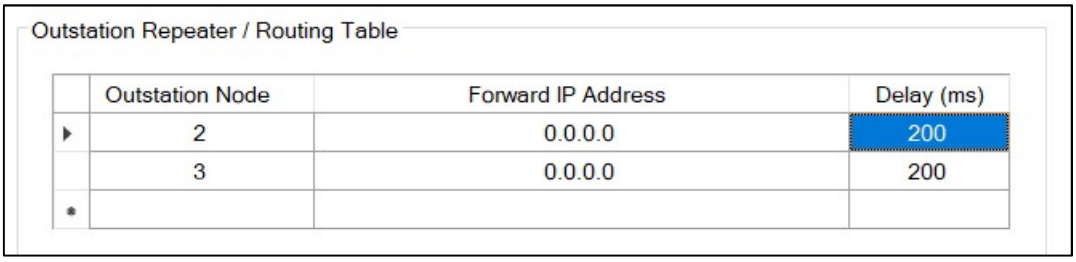


FIGURE 10 – REPEATER DELAY

Outstation Node
This setting is used to instruct the DNP3 Router which messages must be repeated. If the node number appears in either the Source or Destination address, then the message will be repeated.

Delay
The delay is used to allow quiet time between when the DNP3 Outstation (which is acting as a repeater) receives the message and when it re-transmits the message. As previously mentioned, this is useful because certain radios need some time to switch between receiving and transmitting (and vice versa).

The delay can also be used when repeaters are setup in a redundant architecture. When referring to figure 3, if station #2 and station #4 (or station #3) can see each other and the repeat delay times are the same, then the repeated packet will be corrupted because both #2 and #4 will repeat the message at the same time. In this instance the user needs to ensure that the repeat delay is such that there are no two nodes sending at the same time.

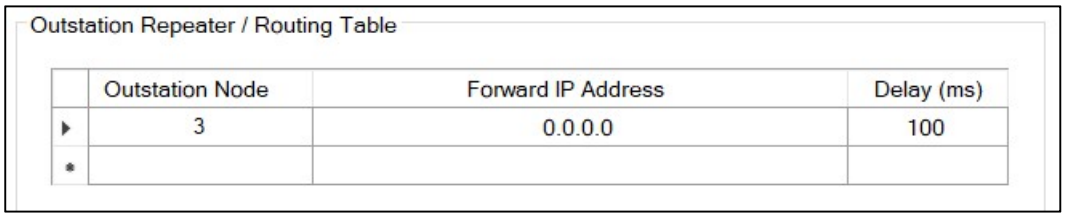
Below is an example of how to configure the repeating delay when using a redundant architecture.

Note it is assumed that the message sending time is less than 100ms.

Node	0ms	100ms	200ms	300ms	400ms	500ms	600ms	700ms	800ms	900ms	1000ms
1 (Master)	Req Node 3				Done				Done		
2		Req Node 3		Resp Node 1				Resp Node 1			
3			Resp Node 1				Resp Node 1				
4						Req Node 3					

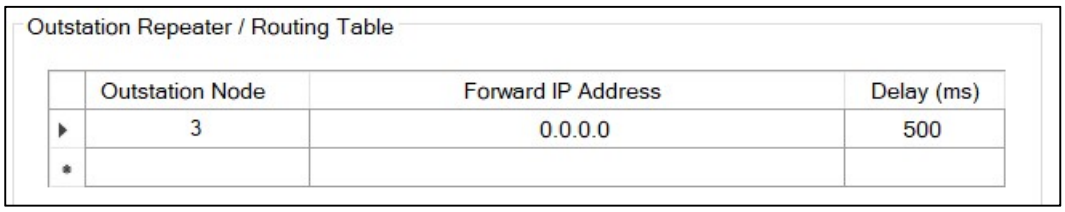
FIGURE 11 – REPEATER DELAY CONFIGURATION IN REDUNDANT ARCHITECTURE

In this case the repeating delay for node 2 will be 100ms while for node 4 it will be 500ms.


Outstation Repeater / Routing Table

	Outstation Node	Forward IP Address	Delay (ms)
▶	3	0.0.0.0	100
*			

FIGURE 12 – REPEATER TABLE CONFIGURATION FOR NODE 2


Outstation Repeater / Routing Table

	Outstation Node	Forward IP Address	Delay (ms)
▶	3	0.0.0.0	500
*			

FIGURE 13 – REPEATER TABLE CONFIGURATION FOR NODE 4

Forward IP Address

This address is used to determine to which DNP3 Router the message must be forwarded (see figure 4) to repeat on a different radio network. If the routed message functionality is not being used, then 0.0.0.0 must be entered.

4. RADIO NETWORK CONSIDERATIONS

The following considerations must be taken into account when implementing radio networks with DNP3.

4.1. EVENTS

When using DNP3 Events the DNP3 Master can either unload events by polling the DNP3 Outstations or by enabling Unsolicited Messages for the DNP3 Outstations.

When using unsolicited messages, it is always a possibility that the DNP3 Master sends a request or another DNP3 Outstation sends a response at the time another DNP3 Outstations wants to send an unsolicited message. In this scenario both the Master/Outstation transaction as well as the Unsolicited Response will be corrupted, and both will have to be retried. When using unsolicited responses, it is recommended to have lots of quiet time on the network to minimize the chance of having message collisions. This can be achieved by configuring the delays shown in section 3 to allow for quiet time on the radio network.

When using the polling method there is no additional risk of message collisions because the DNP3 Master controls when this poll will be sent.

4.2. SECURITY

When enabling security, it is important to note that the message exchange is a four-step process and not just two-steps (request and receive). This is due to the authentication process and therefore the user may need to increase the message timeout to accommodate the higher transaction time.

Even when using Aggressive mode (which reduces the authentication exchange back to a two-step process), the initial transaction will still be a four-step process.

4.3. BAUDRATE

When setting up the radio network the user must always consider the baud rate of the radio network. This will determine how much time is needed for a request-receive transaction and will, in most cases, be the bulk of the time needed per transaction.

For example, using a Baudrate of 4800 means that 600 bytes can be continuously sent per second (4800 bits / 8 = 600 bytes). This means that if the user requests 50 Analog Inputs with status (which equals 200 bytes without the normal DNP3 packet overhead), the response will take approximately 333ms. When adding the DNP3 packet overhead the response from the DNP3 Outstation will be over 400ms.



NOTE: When troubleshooting the DNP3 Radio network it might be useful to check the DNP3 packet capture, specifically the times, at various repeating nodes to determine if the network is operating as expected.