

# **TSN Evaluation Kit**

## **Quick Start Guide**

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## 1. Overview

Thank you for purchasing the TSN Evaluation Kit. Innovasic appreciates your interest our TSN solution. Please contact us at any time to answer questions, help with set-up, or discuss ideas to make integration easy. Helping get your product to market efficiently and effectively is what our support team does best.

## 1.1 TSN Evaluation Kit

The Innovasic TSN Evaluation Kit is configured to provide TSN Gateway functionality in order to quickly assess TSN features and capabilities and better understand how TSN works. From there, it is possible to utilize Innovasic's fido5000 Real-time Ethernet Multi-protocol (REM) Switch chip to provide a TSN solution in your product's application. The figure below shows how the TSN Kit architecture relates to a "partitioned" communication architecture and to an "integrated" communications architecture.



Figure 1- TSN Kit Architecture

Using the TSN gateway functionality allows a non-TSN device to participate in a TSN network without implementing TSN-specific features natively. The TSN gateway has built-in features from the following IEEE specifications:

- 802.1AS, AS-REV Time Synchronization
- 802.1Qbv Scheduled Traffic
- 802.1Qci Ingress Policing
- 802.1CB Seamless Redundancy
- 802.1Qcc Stream Reservation Protocol
- 802.1Qbu / 802.3br Preemption

The TSN gateway comes pre-installed with software that supports 802.1AS, 802.1Qbv, 802.1Qcc, and stream translation. Software updates will be provided to add TSN features and correct any interoperability issues. 802.1Qcc is currently implemented using a webserver, but will ultimately be implemented so the gateway can be configured by a Central Network Controller (CNC),

#### **Network Interface Evaluation Kit Contents:**

- 2-port TSN Ethernet Module
- Standard Ethernet Module
- Baseboard with Power Supply
- RJ-45 Ethernet Cable



Figure 2- TSN Kit Contents

## 1.2 Evaluation Overview

The TSN gateway connects to the TSN cloud as shown in Figure 3 and will synchronize itself with the network using IEEE 802.1AS. In the event there is no master in the TSN network, the gateway can become the master itself. The pre-installed webserver can be used to adjust parameters so the gateway can yield to other masters on the network or force the gateway to become the master on the network.

Once synchronized, the user can define which streams from the standard Ethernet device to translate into the TSN network using the webserver. These streams are "translated" into a format the TSN network can route by tagging the frames with a VLAN tag and assigning a VLAN priority. These streams can then be assigned to queues and then these queues can have "time

windows" assigned to them in order to schedule when the streams can egress onto the network. The assignment of VLAN Priority, queues, and time windows is performed by the using the webserver. An example of how to do this is given as part of this Quick Start Guide.



Figure 3- Evaluation Overview

## 2. Setting up the TSN Evaluation Kit Hardware

This section describes how to setup the hardware provided in the TSN Evaluation Kit so it can be used as a TSN gateway. The next section provides an example of how to connect a standard Ethernet device to a TSN network using the configured TSN gateway. The setup process is simple and should take only a few minutes. From there you can move on to the next section and connect your device to the TSN network. Care should be taken to ensure the modules provided are seated properly and the pins are aligned with the socket.

## 2.1 ESD and Power Supply Considerations

## 2.1.1 Electrostatic Sensitive Device

The hardware should be handled in accordance with proper ESD device-handling techniques. Personnel using this board are advised to use their grounding wrist strap to prevent accidental damage to the hardware.

## 2.1.2 Power Supply and Grounding

A wall adapter power supply is included with your evaluation boards. This supply is 12V, 1A and attaches to the power supply barrel connector. There is also a screw terminal to attach a lab benchtop power supply. For either type of power supply connection, the input voltage to the board must be in the range of 9V to 33V.

## 2.2 Making the Connections

Setting up the hardware is a simple five step process. Evaluation Kit ships with the correct jumpers installed so there is no need to set any jumpers. There is also no need to set any switches.



**Step 1:** Connect the Network Interface Module and the Ethernet Personality Module to the Network Interface Baseboard as shown in Figure 3.

Figure 4 – Baseboard Connections

**Step 2:** Connect the power cable provided in the kit to the "POWER" port. The detailed location of the power port on the baseboard is shown below. Plug the other end of the power cord into a wall socket.



Figure 5 – Power Cable Connection

**Step 3:** Connect one end of an Ethernet cable to the Ethernet Personality Module on the TSN gateway. Connect the other end of the cable to the standard Ethernet device you want to connect to the TSN network. Please note that this end of the Ethernet cable must connect to a single standard Ethernet device and not a network of devices.



Figure 6 – Ethernet Personality Module Connection

**Step 4:** Connect one end of an Ethernet cable to either of the RJ45 jacks on the Network Interface module. The detailed location of the RJ45 jacks is shown below. The other end of the Ethernet cable

connects to a TSN Network. The open port on the Network Interface Module can connect to another TSN device or to any other standard Ethernet device.



Figure 7 – TNS Network Connection

**Step 5:** Apply power to the module by turning the baseboard power switch to the "ON" position. The detailed location of the switch on the baseboard is shown below.



Figure 8 – Power ON Switch location

The resulting setup should look like the picture below.



Figure 9 – Assembled TSN Gateway with Connections

## 3. TSN Network Example

The TSN gateway can bridge any standard Ethernet device onto a TSN network. In order to illustrate how to do this, an example is provided that connects PROFINET Programmable Logic Controller (PLC) to a PROFINET Remote I/O device talking to each other using a TSN network. This example also illustrates standard Ethernet traffic routed across a TSN network using a standard IP camera and a PC. The example setup is shown in the figure below.



Figure 10 – TSN Network Example Configuration

This example uses the contents of two TSN Evaluation Kits. However, the configuration instructions using the webserver are the same whether you want to set up one device or even two or more devices. The physical connections on the TSN side of the network will be different with just a single device, but again, configuring the ports using the webserver are the same.

## 3.1 Configuring a TSN Gateway

Using the assembled TSN gateway resulting from the steps described in Section 2, connect a PC to the end of Ethernet cable connected to the two-port Ethernet connector and your standard Ethernet device to the end of the Ethernet cable connected to the single-port Ethernet connector. In this example, we start by connecting the PROFINET Remote I/O device to the TSN gateway. A diagram of how these connections should look is shown in the figure below.



Figure 11 – Connections for configuring a gateway

On your PC, bring up a web browser and type in *192.168.1.1*. This IP Address is the default IP Address and will cause the web browser to display the webpage from the connected TSN gateway as shown below.

**Please Note**: Because all TSN Gateways ship with the same default MAC address of 12:34:56:78:9A:BC and the same default IP address of 192.168.1.1, only one can be configured on a single network at a time.



*Figure 12 – TSN Gateway Homepage* 

**Please Note**: if you are having issues displaying the webpage, please verify your web browser is a version shown in the table below or newer

Browser	Minimum Required Version
Google Chrome	49
Mozilla Firefox	47
Internet Explorer	11
Opera	39
Microsoft Edge	13

Table 1 – Minimum Required	Browser	Versions
----------------------------	---------	----------

Click on the "Gateway Settings" tab on the left hand side of any webpage to navigate to this page. This webpage is used to setup the IP Address and MAC Address for the TSN gateway as well as setup the MAC address for the standard Ethernet device you wish to connect to a TSN network. The device you are connecting to the TSN network is referred to as the Client and its MAC address is referred to as the Client MAC Address. Click on the "Gateway Settings" tab to navigate to the Gateway Settings page. This page is shown in the figure below.



Figure 13 – Gateway Settings Page for TSN Gateway #1

If you wish to change the MAC address of the TSN gateway on your TSN Network, enter a new MAC Address in the "TSN Gateway MAC Address" field. For this example, the MAC Address for the TSN Gateway has been changed to 78:C6:BB:00:00:50.

**WARNING:** Do not change the value in the "TSN Gateway MAC Address" field to be a Multicast MAC Address. This will cause the device to become inaccessible to a user. A Multicast MAC address has the least significant bit of the first byte set. Hence anything with an odd number for the first byte will be Multicast.

**Please Note:** if you are changing the MAC address, a jumper must be placed on the write protect header of the TSN Gateway.



**Please Note:** if you are changing the MAC address, the TSN Gateway will not use the newly assigned MAC address until after it has been power-cycled.

**Please Note:** if you are using more than one TSN gateway from Innovasic, you MUST provide a unique MAC address for every Innovasic TSN gateway in your network because each TSN Evaluation Kit ships with the same MAC address of 12:34:56:78:9A:BC.

If you wish to change the subnet and / or address of the TSN gateway to meet the needs of your TSN Network, enter a new IP address in the "TSN Gateway IP Address" field.

**Please Note**: after changing the "TSN Gateway IP Address", you will need to enter that address into your browser in order to get back to the webpages for the TSN gateway.

Find the MAC Address for the device connected to the single-port of the TSN gateway. Enter this MAC address in the "Client MAC Address" field on this page. For this example, the MAC address for the ET200S is shown here in the "Client MAC Address" field as 00:1B:1B:57:1F:D2.

**Please Note**: Leave the "Multicast Flooding" box checked for now. This option allows the Client to see all Multicast Ethernet frames on the TSN network in the event the Client application needs access to various Multicast Ethernet frames. Unchecking the box allows "fine tuning" of which Multicast Ethernet frames the Client sees.

Click "Save" after entering data in the fields you have changed.

## 3.2 Verifying Operation of 802.1AS Time Synchronization

Click on the "Time Synchronization (802.1AS)" tab on the left hand side of any webpage to navigate to this page. Most of the fields on this webpage are informational and you can verify the operation of the time synchronization function on the TSN gateway as shown in the figure below. The following describes each of the fields on the webpage.

<u>Sync State</u>, the TSN gateway will report "Synchronized" if it is synchronized to another device that is a better clock source (i.e. a Grand Master) on the TSN network. The TSN gateway will report "Unsynchronized" when it is not synchronized to a master and will report "Grandmaster" if it is providing the master clock source on the TSN network.

Below the "Sync State" status is the status of the two-ports on the TSN side of the gateway. The status of Port 1 and Port 2 are shown and below each port are the following fields:

<u>Port Role</u>: Reports if the port is in "Slave" mode or "Master" mode. If the gateway is not a master, one port will report it is in "Slave" mode while the other port will report it is in "Master" mode. If the gateway is the Grandmaster on the TSN network, then both ports will report they are in "Master" mode.

<u>Port Status</u>: This field reports if the port's connection is "Time Aware" or if it is "Not Time Aware". If there is a connection that can be synchronized then the status is "Time Aware". If there is a connection that cannot be synchronized, the status is "Not Time Aware".

<u>Log Sync Interval</u>: This field allows the user to adjust the rate at which synchronization messages are sent. The value is an integer can range from -5 to +5 which sets the rate between 31.25 milliseconds (2<sup>-5</sup>) to 32 seconds (2<sup>5</sup>). It is recommended to leave the value at its default value of -3.

<u>Line Pdelay\_Req Interval</u>: This field allows the user to adjust the interval between the Pdelay request messages. The value is an integer can range from -5 to +5 which sets the rate between 31.25 milliseconds ( $2^{-5}$ ) to 32 seconds ( $2^{5}$ ). It is recommended to leave the value set at its default value of 0.

<u>Log Announce Interval</u>: This field allows the user to adjust the rate for the interval between announce messages. The value is an integer can range from -5 to +5 which sets the rate between

31.25 milliseconds  $(2^{-5})$  to 32 seconds  $(2^{5})$ . It is recommended to leave the value set at its default of 0.

<u>Line Delay</u>: This field reports the value of the line delay calculated for the cable length of the network connection. This value is reported in ns. In the event the port is "Not Time Aware" or there is no connection to the port, this value will read zero.

The next four items on the page relate to the best master clock source information.

Best Master Clock ID: This field is the 802.1AS Clock Identity of the Best Master to which the TSN gateway is synchronized.

<u>Best Master Priority1</u>, <u>Best Master Priority2</u>, <u>Best Master Steps Removed</u>: these fields are reported for informational purposes related to the Best Master.

The next three items on the page relate to the local clock source information.

Local Clock ID: This field is the 802.1AS Clock Identity of the TSN gateway since it can be the master to a peer on either Port 1 or Port 2.

Innovasic®							
Innovasic TSN Gateway Configuration Tool - Time Synchronization (802.1AS)							
Home Gateway Settings Time Synchronization (802,1AS) Stream Translation	Use this page to monitor Sync State: Grandmaste	ÿ					
Stream Queue Assignment Network Schedule (802.1Qbv)	Port Role: Peer Status: Line Delay: Log Pdelay_Req Interval: Log Sync Interval: Log Announce Interval: Best Master Clock ID: Best Master Priority1: Best Master Priority2: Best Master Steps Remo Local Clock ID: 7 Local Master Priority2: 2 Local Master Priority2: 2 Local Master Priority2: 2 Local Master Priority2: 2	Port 1: Master Not time Aware 0 0 3 0 3 7 8 7 8 7 8 7 8 7 8 7 7 7 7 7 7 7 7 7	Port 2:         Master         Not time Aware         0         -3         0         0:00:50         0:00:50				
ÿ ÿ					© 2016 Innovasic, Inc.		

Figure 14 – Time Synchronization Status for TSN Gateway #1

Local Master Priority1, Local Master Priority2: These fields are used in the Best Master Clock Algorithm (BCMA). By adjusting these values up or down you can change the local clock priority relative to the Best Master's clock priority in order to allow the TSN gateway become the Best Master or prevent it from becoming the Best Master.

The last three items on the page report the status of the time.

Local Time: This field is the value of the local time on the TSN gateway.

Master Time: This field is the value of the Best Master's time.

<u>Time Offset</u>: This field is simply the difference between the Local Time on the TSN gateway and the Master's Time. When the TSN gateway is the Master, the offset is 0.

**Please Note:** If you change the Log Sync Interval, the Local Priority1 or Local Priority2 value, make sure to hit "Save" in order to have the values take effect.

## 3.3 Setting up Stream Translation

Once you have verified time is working properly on the TSN gateway, the next step is to identify which streams from your standard Ethernet device you want to put into the TSN network. Streams not identified for use in a TSN network are automatically classified as "Best Effort" traffic and are handled just like in any other standard Ethernet network – i.e. these streams will not be able to use any of the features of TSN.

The process by which standard Ethernet frames are converted into a format suitable for use in a TSN network is called "Stream Translation". Click on the "Stream Translation" tab on the left hand side of any webpage to navigate to this page. This page is shown in the figure below.

## 3.3.1 Talkers and Listeners

When your standard Ethernet device sends Ethernet messages to another device it is referred to as a "Talker". When your standard Ethernet device receives Ethernet Messages from another device it is referred as a "Listener". This is why on the Stream Translation page you see a set of "Talker Parameters" and a set of Listener Parameters".

It is possible to perform Stream Translation for four Talker Streams. It is also possible to perform Stream Translation on a separate set of four Listener Streams. A checkbox is provided on the page to select how many streams you would like to enable for stream translation. Checking the box will highlight the fields that need to be filled out for the Talker Parameters and Listener parameters.

For the four Talker Streams, it is possible to use 5 different "Methods" to identify the streams coming from the Client in order to translate them into the TSN network. The fields in the Talker Parameters section will change based on the Talker Method selected.

The subsections below describe how to setup Talker and Listener Stream Translation starting with the "Talker Methods" used for Talker Stream Translation.

## 3.3.2 Talker Methods

The five translation methods for identifying Client streams are a unique filter that will match particular Client streams. These methods are identified as:

- Destination MAC Address
- Destination MAC Address AND Priority Code Point of VLAN Tag
- Destination IP Address AND Differentiated Services Code Point (DSCP)
- Destination IP Address AND Protocol and Source Port
- Destination IP Address AND Protocol and Destination Port

The following subsections define the fields looked at for performing the filter match in the stream translation process. If you would like further details on the structure and definition of an Ethernet frame please refer to Wikipedia at the following link:

https://en.wikipedia.org/wiki/IEEE\_802.1Q

#### 3.3.2.1 Destination MAC address

This is the default filter and is the method that is used in this example. The Destination MAC address will be the first 6 bytes that follow the Preamble to any standard Ethernet packet.

The structure of the Ethernet frame and the fields used are highlighted in the figure below. The webpage associated with this Talker Method is shown in the figure that follows.

Preamble	SFD	Destination MAC Address	Source MAC Address	Ethertype	Payload	32-bit CRC
7 bytes	1 byte	6 bytes	6 bytes	2 bytes	46-1500 bytes	4 bytes

Figure 15 – Destination MAC address location in an Ethernet packet

<b>Innovasic</b> <sup>®</sup>									
TSN Evaluation Kit Software Version: 0									
Innovasic TSN Gateway Configuration Tool - Stream Translation									
Home Gateway Settings Time Synchronization (802.1AS) Stream Translation Stream Queue Assignment Network Schedule (802.1Qbv)	Use this page to set up talker and listener stream translation parameters.           Talker Methods         (choose one):           O Destination MAC Address         Destination MAC Address AND Priority Code Point (PCP) of VLAN tag           Destination IP Address AND Protocol AND Source Port         Destination IP Address AND Protocol AND Source Port								
	Talker Parameters:           Streams         On Listener(s) Dest. MAC Addr:           Stream 1:         Ø0:1B:1B:13:44:7C           Stream 2:         Ø0:00:00:00:00:00           Stream 3:         Ø0:00:00:00:00:00           Stream 4:         Ø0:00:00:00:00:00	TSN Dest. MAC Addr (multicast):         VLAN Priority           F1:D0:F1:D0:00:02         7           F1:D0:F1:D0:00:02         0           F1:D0:F1:D0:00:03         0           F1:D0:F1:D0:00:04         0	VLAN         Egress Port.           Dx004         Port 1         Port 2         Both Ports           Dx0000         Port 1         Port 2         Both Ports						
	Stream 4.       □ 00:00:00:00:00         Listener Parameters:         TSN Dest. MAC Addr       VLA         Stream 0.       (multicast)       D:         Stream 1:       ✓ F1:00:F1:D0:00:01       0x0         Stream 2:       F1:D0:F1:D0:00:06       0x0         Stream 3:       F1:D0:F1:D0:00:07       0x0         Stream 4:       F1:D0:F1:D0:00:08       0x0         Save       Save       Save	N Listener Dest. MAC Addr: 105 00:18:18:57:1F:D2 100 00:00:00:00:00 100 00:00:00:00:00 100 00:00:00:00:00	VLAN tag: ① Do not change ① Remove ① Replace VLAN tag with: ② Do not change ② Remove ③ Replace VLAN tag with: ③ Do not change ③ Remove ③ Replace VLAN tag with: ③ Do not change ④ Remove ③ Replace VLAN tag with:						
			@2016 Innovasie Inc						

Figure 16 – Stream Translation Page using Destination MAC Address Talker Method

## 3.3.2.2 Destination MAC address and Priority Code Point of VLAN TAG

Another method is to use the PCP of the VLAN TAG along with the Destination MAC Address to define a stream. The VLAN header is located immediately following the Source MAC Address. The Priority Code Point of the VLAN Tag is 3 bits immediately following the 16 bits for TPID.

The structure of the Ethernet frame and the fields used are highlighted in the figure below. The webpage associated with this Talker Method is shown in the figure that follows.

Preamble	SFD	Destination MAC Addres	S MAC	ource Address	S <b>VL</b>	AN ag	Ethertype	Payload	32-bit CRC
7 bytes	1 byte	1 byte 6 bytes		bytes	4 b	ytes	2 bytes	46-1500 bytes	4 bytes
			TPID	РСР	DEI	VIE	)		
			16 bits	3 bits	1 bit	12 b	its		

*Figure 17 – Destination MAC address and PCP location in an Ethernet packet* 

Innovasic <sup>®</sup>									
TSH Evaluation Kit Software Version: 0									
Innovasic TSN Gateway Configuration Tool - Stream Translation									
Home Gateway Settings Time Synchronization (802.1AS) Stream Translation Stream Queue Assignment	Use this page to set up talker and listene <u>Talker Methods</u> (choose one): Destination MAC Address Destination MAC Address AND Priority Co Destination MAC Address AND Priority Co	<b>r stream tra</b> de Point (PCP)	inslation parameters.						
Network Schedule (802.1Qbv)	Destination IP Address AND Protocol AND     Destination IP Address AND Protocol AND     Destination IP Address AND Protocol AND	Source Port Destination P	ort						
	Talker Parameters:       Streams     On     Listener(s)     Dest. MAC     Addr:       Stream 1:          00:1B:1B:13:44:7C	PCP:	TSN Dest. MAC Addr (multicast): F1:D0:F1:D0:00:02	VLAN VLAN Priority: ID: Egress Port: 7   Dx004   Port 1   Port 2   Both Ports					
	Stream 2:         00:00:00:00:00:00           Stream 3:         00:00:00:00:00:00	0 \$	F1:D0:F1:D0:00:02	0              Dx000              Port 1              Port 2              Both Ports            0              Dx000              Port 1              Port 2              Both Ports					
	Stream 4: 00:00:00:00:00:00	0 \$	F1:D0:F1:D0:00:04	D C Dx000 O Port 1 O Port 2 O Both Ports					
	TSN Dest. MAC Addr <u>Streams</u> On (multicast): Stream 1: Implication F1:D0:F1:D0:00:01	VLAN ID: 0x005	Listener Dest. MAC Addr: 00:1B:1B:57:1F:D2	VLAN tag: Do not change O Remove O Replace VLAN tag with:					
	Stream 2: F1:D0:F1:D0:00:06 Stream 3: F1:D0:F1:D0:00:07	0x000	00:00:00:00:00:00	Do not change     Remove     Replace VLAN tag with:     Do not change     Remove     Replace VLAN tag with:					
	Stream 4: F1:D0:F1:D0:00:08	0x000	00:00:00:00:00:00	O not change O Remove Replace VLAN tag with:					
				© 2016 Innovasic, Inc.					

Figure 18 – Stream Translation Page using Destination MAC address and Priority Code Point of VLAN TAG Talker Method

## 3.3.2.3 Destination IP address and Differentiated Services Code Point

When an Ethernet frame is designated as "IP" in the Ethertype field, an IP Header will immediately follow as the first 19 bytes in the Payload. The Destination IP address is used in conjunction with the Differentiated Services Code Point to define a stream. The DSCP and the Destination IP address can be found as in an Ethernet frame as shown below. The DSCP is the first 6 bits of the second byte in the IPv4 Header. If you would like further details on the structure and definition of an IPv4 within and Ethernet frame please refer to Wikipedia at the following link:

#### https://en.wikipedia.org/wiki/IPv4#Header

The structure of the Ethernet frame and the fields used are highlighted in the figure below. The webpage associated with this Talker Method is shown in the figure that follows.

Preamble	SFD	Destination MAC Address	Source MAC Address	VLAN Tag	Ethertype	Payload	32-bit CRC
7 bytes	7 bytes 1 byte 6 bytes		6 bytes 4 bytes 2 byt			46-1500 bytes	4 bytes

Version / IHL	DSCP / ECN	Length	ldent.	Flags / Frag. Offset	Time to Live	Protocol	Header Checksum	Source IP	Dest. IP
1 byte	1 byte	2 bytes	2 bytes	2 bytes	1 byte	1 byte	2 bytes	4 bytes	4 bytes
	DSCP	FCN							

Figure 19 – Destination IP Address and DSCP location in the IPv4 header

DSCP 6 bits

2 bits

<u>Innovasic</u> <sup>®</sup>											
TSN Evaluation Kit Software Version: (	)										
Innovasic TSN Gateway Configuration Tool - Stream Translation											
Home Gateway Settings Time Synchronization (802.1AS) Stream Translation Stream Queue Assignment Network Schedule (802.1Qbv)	Use this page to set up talker and listen <u>Talker Methods</u> (choose one): <u>Destination MAC Address</u> Destination MAC Address AND Priority C Destination IP Address AND DSCP Destination IP Address AND Protocol ANI Destination IP Address AND Protocol ANI	er stream trar ode Point (PCP) D Source Port D Destination Po	nslation parameters. of VLAN tag rt								
	Talker Parameters:           Streams         On           Listener(s)         Dest. IP Addr:	DSCP:	TSN Dest. MAC Addr (multicast):	VLAN VLAN Priority: ID: Egress Port:							
	Stream 1: 192.108.21.188	3 🗘	F1:D0:F1:D0:00:02	0     0x000     0     Port 1     0     Port 2     0     Both Ports							
	Stream 3: 0.0.0.0 Stream 4: 0.0.0.0	0 \$	F1:D0:F1:D0:00:03	0         ©         Dott 1         Control         Port 2         On the Ports           0         ©         Dx0000         Control         Port 2         On the Ports							
	Listener Parameters: TSN Dest. MAC Addr	VLAN									
	Streams On (multicast): Stream 1: F1:D0:F1:D0:00:01	ID: 0x005	Listener Dest. MAC Addr: 00:1B:1B:57:1F:D2	VLAN tag: O Do not change O Remove O Replace VLAN tag with:							
	Stream 2: F1:D0:F1:D0:00:06 Stream 3: F1:D0:F1:D0:00:07	0x000	00:00:00:00:00:00	Do not change     Remove     Replace VLAN tag with:     Do not change     Remove     Replace VLAN tag with:							
	Stream 4: F1:D0:F1:D0:00:08	0x000	00:00:00:00:00:00	O Do not change O Remove O Replace VLAN tag with:							
	Save										
				© 2016 Innovasic. Inc.							

Figure 20 – Stream Translation Page using Destination IP address and Differentiated Services Code Point Talker Method

#### 3.3.2.4 Destination IP address and Protocol and Source Port

When an Ethernet frame is designated as "IP" in the Ethertype field, an IP Header will immediately follow as the first 19 bytes in the Payload. The Destination IP address is used in conjunction with the Source Port in either the TCP Header or the UDP Header to define a stream. The Protocol field in the IP Header defines the protocol, and if the protocol is TCP or UDP, one of these two headers will immediately follow the IP Header. The Source Port is the first 2 bytes in either the TCP or UDP Header. This is shown in the two figures below. If you would like further details on the structure and definition of a TCP or UDP Header in an IPv4 Header within an Ethernet frame please refer to Wikipedia at the following link:

https://en.wikipedia.org/wiki/Transmission\_Control\_Protocol

https://en.wikipedia.org/wiki/User\_Datagram\_Protocol

The structure of the Ethernet frame and the fields used are highlighted in the figure below. The webpage associated with this Talker Method is shown in the figure that follows.

Preamble	SFD	Destination MAC Address	Source MAC Address	VLAN Tag	Ethertype	Payload	32-bit CRC
7 bytes	1 byte	6 bytes	6 bytes	4 bytes	2 bytes	46-1500 bytes	4 bytes

Version / IHL	DSCP / ECN	Length	Ident.	Flags / Frag. Offset	Time to Live	Protocol	Header Checksum	Source IP	Dest. IP
1 byte	1 byte	2 bytes	2 bytes	2 bytes	1 byte	1 byte	2 bytes	4 bytes	4 bytes

#### Protocol = TCP

Source Port	Dest. Port	Sequence Number	Ack. Number	Data Offset / Res. / Flags	Window size	Header Checksum	Urgency Pointer	Options
2 bytes	2 bytes	4 bytes	4 bytes	2 bytes	1 byte	2 bytes	2 bytes	0-40 bytes

Figure 21 – Destination IP Address, Protocol, and Source Port in TCP Header

Preamble	SFD	Destination MAC Address	Source MAC Address	VLAN Tag	Ethertype	Payload	32-bit CRC
7 bytes	1 byte	6 bytes	6 bytes	4 bytes	2 bytes	46-1500 bytes	4 bytes

Version / IHL	DSCP / ECN	Length	Ident.	Flags / Frag. Offset	Time to Live	Protocol	Header Checksum	Source IP	Dest. IP
1 byte	1 byte	2 bytes	2 bytes	2 bytes	1 byte	1 byte	2 bytes	4 bytes	4 bytes

Protoco	ol = UDP			
Source Port	Dest. Port	Length	Header Checksum	
2 bytes	2 bytes	2 bytes	2 bytes	

Figure 22 – Destination IP Address, Protocol, and Source Port in UDP Header

TSN Evaluation Kit Software Version: 0											
Innovasic TSN Gateway Configuration Tool - Stream Translation											
Home Geteway Settings Time Synchronization (802.1AS) Stream Translation Stream Queue Assignment Network Schedule (802.1Qbv)	Use this page to set up talker and listener Talker Methods (choose one): Destination MAC Address Destination MAC Address AND Priority Coc Destination IP Address AND DSCP Destination IP Address AND Protocol AND Destination IP Address AND Protocol AND	r stream translation paramete de Point (PCP) of VLAN tag Source Port Destination Port	15.								
	Streams     On     Listener(s)     Dest.     IP     Addr.       Stream 1:     I     192.168.21.188	IP Prot: Source Port:	TSN Dest. MAC Addr (multicast): F1:D0:F1:D0:00:02	VLAN         VLAN           Priority:         ID:         Egress Port:           7         ♀         Dx0004         O Port 1         Port 2         O Both Ports							
	Stream 2: 0.0.0.0 Stream 3: 0.0.0.0		F1:D0:F1:D0:00:02 F1:D0:F1:D0:00:03	0         \$ 0x000         Port 1         Port 2         9         Both Ports           0         \$ 0x000         Port 1         Port 2         9         Both Ports							
	Stream 4: 0.0.0.0	UDP 🕶 0 🗘	F1:D0:F1:D0:00:04	0 0x000 O Port 1 O Port 2 O Both Ports							
	TSN Dest. MAC Addr         Stream 0       (multicast):         Stream 1:       ✓ F1:D0:F1:D0:00:01         Stream 2:       F1:D0:F1:D0:00:06         Stream 3:       F1:D0:F1:D0:00:07         Stream 4:       F1:D0:F1:D0:00:08         Save       Save	VLAN         Listener Dest. MA           0x005         00:18:18:57:16           0x000         00:00:00:00:00:00           0x000         00:00:00:00:00           0x000         00:00:00:00:00           0x000         00:00:00:00:00	C Addr: VLAN tag: ED2 Do not chang 0:00 Do not chang 0:00 Do not chang 0:00 Do not chang 0:00 Do not chang	ye Remove Replace VLAN tag with: ye Remove Replace VLAN tag with: ye Remove Replace VLAN tag with: ye Remove Replace VLAN tag with:							
				© 2016 Innovasic, Inc.							

Figure 23 – Stream Translation Page using Destination IP address and Protocol and Source Port

#### 3.3.2.5 Destination IP address and Protocol and Destination Port

When an Ethernet frame is designated as "IP" in the Ethertype field, an IP Header will immediately follow as the first 19 bytes in the Payload. The Destination IP address is used in conjunction with the Destination Port in either the TCP Header or the UDP Header to define a stream. The Protocol field in the IP Header defines the protocol, and if the protocol is TCP or UDP, one of these two headers will immediately follow the IP Header. The Destination Port is the second 2 bytes in either the TCP or UDP Header.

The structure of the Ethernet frame and the fields used are highlighted in the figure below. The webpage associated with this Talker Method is shown in the figure that follows.

	Preamble	e SFD	Des MAC	tination Address	M	Source AC Addres	s	VLA Tag	N g	Ether	type	Pa	yload		32-bit CRC
	7 bytes	1 byte	e 61	bytes		6 bytes 4 bytes 2 bytes 46-1500 bytes					es	4 bytes			
	Version / IHL	DSCP / ECN	Length	Ident.	ا Fra	Flags / ag. Offset	Ti to	ime Live	Prote	ocol	Hea Chec	der ksum	Sourc IP	ce	Dest. IP
	1 byte	1 byte	2 bytes	2 bytes	2	2 bytes	1 k	byte	1 b	yte	2 by	⁄tes	4 byte	es	4 bytes
		Pr	otocol =	ТСР											
	Source Port	Dest. Port	Sequent Numbe	ce Ack er Numl	k. ber	Data Offset / Window Header Urgency Res. / Flags size Checksum Pointer			(	Options					
ĺ	2 bytes	2 bytes	4 bytes	s 4 byt	es	2 byte	s	1	byte	2	bytes	2 k	oytes	0-	40 bytes

Figure 24 – Destination IP Address, Protocol, and Destination Port in TCP Header

Preamble	ole SFD Destination MAC Addres		tination Address	SourceVLANMAC AddressTag		N Ether	type	Payload	32-bit CRC
7 bytes	ytes 1 byte 6 bytes		6 bytes	4 byte	es 2 by	tes 46-	500 bytes	4 bytes	
Version / IHL	DSCP / ECN	Length	Ident.	Flags / Frag. Offset	Time to Live	Protocol	Header Checksu	n IP	Dest. IP

<b>Protocol</b> = U	DP					
	Source Port	Dest. Port	Length	Header Checksum		
	2 bytes	2 bytes	2 bytes	2 bytes	]	

Figure 25 – Destination IP Address, Protocol, and Destination Port in UDP Header

TSN Evaluation Kit Software Version: 0											
Innovasic TSN Gateway Configuration Tool - Stream Translation											
Innovasic TSN Gatev	vay coning	uration 1001 - Stream	Translau	on							
Home	Use this pag	e to set up talker and listene	r stream trar	slation paramete	rs.						
Gateway Settings	Talker Metho	ods (choose one):									
Time Synchronization (802.1AS)	O Destinatio	n MAC Address									
Stream Translation	O Destinatio	n MAC Address AND Priority Co	de Point (PCP)	of VLAN tag							
Stream Queue Assignment	O Destinatio	In IP Address AND DSCP									
Network Schedule (802.1Qbv)	O Destinatio	IN IP Address AND Protocol AND	Source Port								
	🕐 Destinatio	In IP Address AND Protocol AND	Destination Po	rt							
	Talker Param	neters:			TSN Dest. M	AC Addr N	VIAN VIAN				
	<u>Streams</u> On	Listener(s) Dest. IP Addr:	IP Prot: D	est. Port:	(multicast):	F	Priority: ID:	Egress Port:			
	Stream 1: 🗹	192.168.21.188		) 🗘	F1:D0:F1:D	0:00:02	7 🗘 0x004	O Port 1 O Port 2 O Both Ports			
	Stream 2	0000			E1/D0/E1/D	0.00.02	0 ^ 0v000	Dort 1      Dort 2      Dort 2			
	Sucanz.	1 0.0.0.0		· · ·	p 1.00/ 1/2	0.00.02	0 0000	C Forth C Fort2 C Durrons			
	Stream 3:	0.0.0.0	UDP 💌 🛛	) 🗘	F1:D0:F1:D	0:00:03	0 🗘 🗘 0x000	O Port 1 O Port 2 O Both Ports			
								0			
	Stream 4:	1  0.0.0.0	TODP 💌 ju	)	FI:DU:FI:L	00:00:04	U 😴 UXUUU	O Port 1 O Port 2 O Both Ports			
	Listener Par	ameters:									
		TSN Dest. MAC Addr	VLAN								
	Streams On	(multicast):	D:	Listener Dest, MA	C Addr:	VLAN tag:	0.5	Device a V/L @ Ni As a voille			
	Sueann. L	1 F1.00.F1.00.00.01	JOX003	00.10.10.37.11	.02	O Do not change	€ Keniove €	Replace VEANing with			
	Stream 2:	F1:D0:F1:D0:00:06	0x000	00:00:00:00:00	):00	O Do not change	⊙ Remove ○	Replace VLAN tag with:			
							00				
	Stream 3:	FT:D0:FT:D0:00:07	JUXUUU	100:00:00:00:00	):00	O Do not change		Replace VLAN tag with:			
	Stream 4:	F1:D0:F1:D0:00:08	0x000	00:00:00:00:00	):00	O Do not change	• Remove	Replace VLAN tag with:			
	Save										
								© 2016 Innovasic, Inc.			

Figure 26 – Stream Translation Page using Destination IP address and Protocol and Destination Port

#### 3.3.3 Using Listener Parameters

Listener Parameters are used to identify the Ethernet messages to be received from the TSN Network. These parameters are in the section below the "Listener Parameters" on the Stream Translation webpage. Notice that there are no "methods" by which to do this. You simply use the TSN multicast address and the VLAN ID of the stream you want to receive from the TSN Network. In the case of this example, we know the stream coming from the "Talker" we want to "Listen" to is 01:F1:D0:00:00:02 (note that this is a different multicast address than we used for the Talker stream used in the section above). You will see this address in the "TSN Dest. MAC Addr. (multicast)" field under "Listener Parameters" in the figure in the previous section.

We also must supply the Destination MAC address of the Listener. Since the Listener is the Client in this case, it may seem redundant to enter the MAC address of the Client. However, it is possible to have a connection with in the Client that requires a multicast address so this field is provided for that situation. In the case of this example, we simply enter the MAC address of our Client which is 00:1B:1B:57:1F:D2.

The end result will be that any TSN stream with a Destination MAC of 01:F1:D0:00:00:02 and VLAN ID of 0x001 will "untranslated" into a stream with the Destination MAC address of 00:1B:1B:57:1F:D2 and sent to the Client

You can also select how you want to change the VLAN Tag in the "untranslated" stream headed to the Client. It is possible to not change the tag, remove it, or replace it with something else. The purpose of these options is to ensure the VLAN tag is properly handled in VLAN unaware devices or if a device has a specific VLAN tag requirement. In this case, we have chosen to not change the VLAN tag and pass it on as is.

## 3.4 Assigning Streams to Queues

Once you have defined the streams for the client to send to listeners in the TSN network, you assign these streams to queues so the streams can be scheduled at particular times on the network. Click on the "Stream Queue Assignment" tab on the left hand side of any webpage to navigate to this page. The queue assignment is made by selecting the VLAN Priority of the stream and "checking" the queue you want that VLAN Priority assigned to. This is shown on the webpage in the figure below.

TSN Evaluation Kit Software Version: S	<b>asic</b> ®					
Innovasic TSN Gate	way Configura	ation Tool -	Stream Que	eue Assignr	nent	
Home	Use this page to r	nap VI AN priori	ties to the availa	ble queues for b	oth ports and set	the maximum SDU size for each queue.
Gateway Settings						1
Time Synchronization (802.1AS)		Queue u	Queue 1	Queue 2	Queue 3	
Stream Translation			<u> </u>			
Stream Queue Assignment	2	•	<u> </u>	0		
Network Schedule (802.1Qbv)	3	۰	0	<u> </u>	<u> </u>	
	4	•	•	•	<u> </u>	
	5	•	0	<u> </u>	<u> </u>	
	6	•	<u> </u>	<u> </u>	<u> </u>	
	7	•	0	•	0	
	Max SDU (bytes)	1522	1522	1522	1522	
	Save					
					© 2016 Ir	nnovasic, Inc.

Figure 27 – Stream Queue Assignment for TSN Gateway #1

For this example, VLAN Priority 7 has been assigned to Queue 2 and all other VLAN Priorities are assigned to Queue 0.

**Please note**: Queue 0 is the "Best Effort" queue. This means that all traffic that does not have a VLAN tag and considered "Standard Ethernet" gets automatically mapped to Queue 0. So for this example, all traffic that is not VLAN Priority 7 gets queued together with the "Best Effort" traffic. This is also why any standard Ethernet device is compatible with a TSN network – traffic that cannot be mapped to a particular VLAN Priority is simply classified as "Best Effort" traffic.

The next step is to assign a schedule to the queues.

## 3.5 Assign Queues to a Schedule

Click on the "Network Schedule (802.1Qbv)" tab on the left hand side of any webpage to navigate to this page. The schedule is off by default. It must be enabled to activate the schedule. Make sure to "check" the box labelled "Scheduled Traffic Enabled" when you want the defined schedule active on the network. This is shown on the webpage in the figure below.

Setting the schedule is done by defining "windows" within a "Base Period". The default for the "Base Period" is 20ms. You can enter whatever Base Period you want and the resolution is in nanoseconds. For this example, we will set up four windows within the 20ms Base Period. The windows are defined as:

- 1. Window 1 (Entry 0) 0 to 5ms
- 2. Window 2 (Entry 1) -5ms to 10ms
- 3. Window 3 (Entry 2) -10ms to 15ms
- 4. Window 4 (Entry 3) 15ms to 20ms

The next step is to assign queues to these windows. This is done by "checking" the box under the queue you want assigned to that window.

**Please note**: Queue 3 must be enabled at least once during the Base Period. This is because the 802.1AS messages for synchronization are assigned to this queue automatically by the gateway software.

In the figure below you can see the queues have been assigned to the windows as follows:

- 1. Window 1 (Entry 0) 0 to 5ms: Queue 0
- 2. Window 2 (Entry 1) -5ms to 10ms: Queue 1
- 3. Window 3 (Entry 2) 10ms to 15ms: Queue 2
- 4. Window 4 (Entry 3) -15ms to 20ms: Queue 3

TSN Evaluation Kit Software Version: SC000087-000												
Innovasic TSN Gatev	vay C	onfiguration T	oo	- 1	let	wo	rk Schedule (8	802	.10	bv	)	
Home Gateway Settings Time Synchronization (802.1AS) Stream Translation	Use th Sched Base F	nis page to set up IEE uled Traffic Enabled: Period: 2	EE-8	02.1	) vd¢	(sch	eduled traffic).					
Stream Queue Assignment		Port	1				Port	2				
Network Schedule (802.1Qbv)	Entry	Cycle Offset (ns)		oen (		les 03	Cycle Offset (ns)		en (			
	0	0					0					
	1	5000000					5000000					
	2	1000000					1000000					
	3	15000000					15000000					
	4	0					0					
	5	0					0					
	6	0					0					
	7	0					0					
	8	0					0					
	9	0					0					
	10	0					0					
	11	0					0					
	12	0					0					
	13	0					0					
	14	0					0					
	15	0					0					
	Save	•										
										0	B 201	6 Innovasic, Inc.

Figure 28 – Network Schedule for TSN Gateway #1

The assignment of these queues in this example is arbitrary. There may be specific reasons to setup faster cycle times and have multiple queues enable at the same time.

## 3.6 Setting up A Second TSN Gateway

Now that we have one TSN gateway configured we can configure a second one for the purpose of passing schedule traffic back and forth between two standard Ethernet devices. Using a second TSN gateway from another TSN Evaluation Kit, we make the connections as shown in Figure 10 to connect the PROFINET PLC to the TSN Network. The IP Camera is connected, but there is no additional setup since those streams will be handled as "Best-Effort" traffic.

The figures that follow show the configuration of the TSN gateway. Starting with the "Gateway Settings" page, the gateway has been configured with a different TSN Gateway MAC Address, TSN Gateway IP Address, and the Client MAC Address. Compare this webpage with the setting for the ET200S gateway in Figure 13.

TSN Evaluation Kit Software Version: SC0000087-000											
Innovasic TSN Gate	way Configuration T	ool - Gateway Cont	rol and Status								
Home	Use this name to configure	aateway settings									
Gateway Settings		gatemay settings.									
Time Synchronization (802.1AS)	TSN Gateway MAC Address:	78:C6:BB:00:00:60									
Stream Translation	TSN Gateway IP Address:	192.168.21.96									
Stream Queue Assignment	TSN Gateway Subnet Mask:	255.255.255.0									
Network Schedule (802.1Qbv)	Client MAC Address:	00:1B:1B:13:44:7C	J								
	Save										
			(	∋ 2016 Innovasic, Inc.							

Figure 29 – Gateway Settings Page for TSN Gateway #2

The Time Synchronization status for TSN gateway #2 is shown in the figure below. Notice that this gateway is synchronized and that Port 1 is a Slave and Port 2 is a Master. Port 1 is also "Time Aware" whereas Port 2 is "Not Time Aware". This makes sense for our setup because port 1 of this gateway is acting as a slave to the other gateway and is synchronized with it. Compare this webpage with the setting for the ET200S gateway in Figure 14.

**Please note**: The LED on the Network Interface board on this second gateway is flashing yellow. This means that the gateway is a Slave. The LED on the other gateway is flashing red and this means that gateway is the Grandmaster.

Innova	asic	D									
TSN Evaluation Kit Software Version: SC0000087-000											
Innovasic TSN Gate	way Configur	ation Tool - Time S	Synchronization (802	.1AS)							
Home Gateway Settings Time Synchronization (802.1AS)	Use this page to Sync State: Sync	monitor the status of IEEE	-802.1AS time synchronizatio	n.							
Stream Translation Stream Queue Assignment Network Schedule (802.1Qbv)	<ul> <li>Port Role:</li> <li>Peer Status:</li> <li>Log Sync Interval:</li> </ul>	Port 1: Slave Time Aware -3	Port 2: Master Not time Aware -3								
	Best Master Clock Best Master Priori Best Master Priori Best Master Steps	ID:         78:c6:bb:ff:fe:0           ity1:         255           ity2:         248           s Removed:         0	0:00:50								
	Local Clock ID: Local Master Prior Local Master Prior	78:c6:bb:ff:fe:00:00:6 rity1: 255 rity2: 248	0								
	Local Time: 152 Master Time: 152 Time Offset: 69 Save	287.795002514 287.795002583									
				© 2016 Innovasic, Inc.							

Figure 30 – Time Synchronization Status for TSN Gateway #2

The Stream Translation setting for TSN gateway #2 is shown below. Compare this webpage with the setting for the ET200S gateway in Figure 35. Notice that we use the same Talker Method as TSN gateway #1, but this is not a requirement. You can use whatever method is supported by the standard Ethernet device connected.

For the Talker Parameters we use the MAC address of the ET200S because this is the device that we want the PLC to talk to. We use the "TSN Dest. MAC Addr" setup on TSN gateway #1 in the Listener Parameters because this is the multicast stream we want the ET200S to listen to. For the Listener Parameters we use the "TSN Dest. MAC Addr" setup on TSN gateway #1 in the Talker Parameters because this is the multicast stream we want the PLC to listen to.

A summary of the Stream Translation mapping follows the webpage figure below.

TSN Evaluation Kit Software Version: 0													
Innovasic TSN Gateway Configuration Tool - Stream Translation													
Home Gateway Settings Time Synchronization (802.1AS) Stream Translation Stream Queue Assignment Network Schedule (802.1Qbv)	Use this page to set up talker and listener stream translation parameters.           Talker Methods         (choose one):           O Destination MAC Address         O Destination MAC Address AND Priority Code Point (PCP) of VLAN tag           Destination IP Address AND Drotocol AND Source Port         Destination IP Address AND Protocol AND Source Port           Destination IP Address AND Protocol AND Destination Port         Destination IP Address AND Protocol AND Destination Port												
	Talker Parameters:         TSN Dest. MAC Addr: (multicast):       VLAN       VLAN       VLAN       Egress Port:         Stream 1:       00:101:18:157:1F:D2       F1:D0:F1:D0:00:01       7       DX0D0       Port 1       Port 2       Both Ports         Stream 2:       00:00:00:00:00:00       F1:D0:F1:D0:00:02       0       DX0D0       Port 1       Port 2       Both Ports         Stream 3:       00:00:00:00:00       F1:D0:F1:D0:00:03       0       DX0D0       Port 1       Port 2       Both Ports         Stream 4:       00:00:00:00:00       F1:D0:F1:D0:00:04       0       Dx000       Port 1       Port 2       Both Ports         Listener Parameters:       Eistener Parameters:       Eistener Parameters:       Eistener Parameters:       Eistener Parameters:       Eistener Parameters:       Eistener Parameters:												
	Streams       On (muticast):       D:       Listener Dest. MAC Addr:       VLAN tag:         Stream 1:       ✓       F1:D0:F1:D0:00:002       Dx0004       D0:1B:1B:13:44:7C <ul> <li>Do not change</li> <li>Remove</li> <li>Replace YLAN tag with:</li> </ul> Stream 2:       F1:D0:F1:D0:00:00       Dx0000       D0:00:00:00:00       Do not change       Remove       Replace YLAN tag with:         Stream 3:       F1:D0:F1:D0:00:07       Dx0000       D0:00:00:00:00       Do not change       Remove       Replace YLAN tag with:         Stream 4:       F1:D0:F1:D0:00:08       Dx0000       D0:00:00:00:00       Do not change       Remove       Replace YLAN tag with:         Save       Save       Save       Save       Save       Save       Save       Save												
	© 2016 Innovasic, Inc.												

Figure 31 – Stream Translation Page for TSN Gateway #2



*Figure 32 – Stream Translation Mapping* 

The Stream Queue Assignment for TSN gateway #2 is shown in the figure below. Here we mapped the VLAN Priority to Queue 2 just like we did for TSN gateway #1, and all the other priorities are mapped to Queue 0 along with the Best-Effort traffic. This assignment is arbitrary and we could have picked any other queue. Compare this webpage with the setting for the ET200S gateway in Figure 27

TSN Evaluation Kit Software Version: S	<b>asic</b> ®					
Innovasic TSN Gate	way Configura	ation Tool -	Stream Qu	eue Assign	ment	
Home	liee this name to r	nan VI AN priori	ities to the avails	ble queues for b	oth norte and set	the maximum SDII size for each queue
Gateway Settings				ible queues for i		
Time Synchronization (802.1AS)	VLAN Priority	Queue 0	Queue 1	Queue 2	Queue 3	
Stream Translation						
Stream Queue Assignment	2	•	<u> </u>	<u> </u>	<u> </u>	-
Network Schedule (802.1Qbv)	3	•	0	0	0	
	4	۰	0	0	0	
	5	•	•	0	0	
	6	•	0	0	•	
	7	•	•	•	0	
	Max SDU (bytes)	1522	1522	1522	1522	
	Save					
					© 2016 lr	nnovasic, Inc.

Figure 33 – Stream Queue Assignment for TSN Gateway #2

The Network Schedule for TSN gateway #2 is shown in the figure below. The Base Period and schedule windows are the same for TSN gateway #1. This is to ensure that frames can traverse the network without getting queued downstream. It was also done to emulate the cyclic nature of synchronized Industrial networks like PROFINET IRT. In reality you can setup whatever schedule you like to meet the update rate, latency, and jitter requirements for your network.

TSN Evaluation Kit Software Version: SC0000087-000												
Innovasic TSN Gateway Configuration Tool - Network Schedule (802.1Qbv)												
Home Gateway Settings Time Synchronization (802.1AS)	Use th Schede Base F	i <b>s page to set up IEf</b> uled Traffic Enabled: Period: 2	EE-8	02.1	Qbv (	(sch	eduled traffic).					
Stream Queue Assignment		Port	1				Port	2				1
Network Schedule (802 10bv)	Entry	Cycle Offset (ns)	Op	en (	Queu	ies	Cycle Offset (ns)		oen (	Quei	ues	
			Q0	Q1	Q2	Q3		QD	Q1	Q2	Q3	
	0	0					0					
	1	1000000					1000000					
	2	15000000			•		15000000					
		0					0					
	-	0					0					
	6	0					0					
	7	0					0					
	8	0					0					
	9	0					0					
	10	0					0					
	11	0					0					
	12	0					0					
	13	0					0					
	14	0					0					
	15	0					0					
	Save	1										
										0	© 201	6 Innovasic, Inc.

Figure 34 – Network Schedule for TSN Gateway #2

#### 3.6.1 Using Talker Parameters

Talker Parameters are used to identify the Ethernet messages to be sent over the TSN Network. Select one of the methods described in the previous section and fill out the fields to match the criteria of the frames you want to perform stream translation on. In the case of this example, the Destination MAC method is used and the Destination MAC of the device the Client wants to "Talk" to is entered in the field below the "Listener(s) Dest. MAC Addr." heading. This allows the TSN gateway to identify streams with the supplied Destination MAC.

Next, enter a "TSN Dest. MAC Addr." into the field below this heading. This can be any multicast address and Innovasic has chosen to use 01:F1:D0:00:00:01 for this example ("01" is

bolded to distinguish it from the address we will use for the Listener stream later on). The VLAN Priority and VLAN ID fields also need to be filled out.

**Please Note**: The usable range for VLAN ID is 0x003 through 0xFFE. This is because IEEE8-2.1 Q-2011 lists 0x000 through 0x002 and 0xFFF as reserved.

In this example, we have chosen a VLAN Priority of 7 and a VLAN ID of 0x004. The end result will be that any stream with a Destination MAC of 00:1B:1B:13:44:7C will be translated into a stream with the Destination MAC address of 01:F1:D0:00:00:01 and a VLAN ID of 0x004 with at VLAN Priority of 7.

You can also select which port to send out the translated stream onto the TSN network. Which port you choose depends on your topology, but it doesn't hurt anything to send it out both ports if you are unsure. In this case, we have chosen to send the translated stream out both ports.

TSH Evaluation Kit Software Version: 0	asic <sup>∞</sup>		
Innovasic TSN Gatev	way Configuration Tool - Stream	Translation	
Home Gateway Settings Time Synchronization (802.1AS) Stream Translation Stream Queue Assignment Network Schedule (802.1Qbv)	Use this page to set up talker and listener <u>Talker Methods</u> (choose one): Destination MAC Address Destination MAC Address AND Priority Codd Destination IP Address AND DSCP Destination IP Address AND Protocol AND S Destination IP Address AND Protocol AND S	stream translation parameters. 9 Point (PCP) of VLAN tag Source Port Pestination Port	
	Talker Parameters:           Streams         On           Listener(s) Dest. MAC Addr:           Stream 1:         00:1B:1B:13:44:7C           Stream 2:         00:00:00:00:00:00           Stream 3:         00:00:00:00:00:00	TSN Dest. MAC Addr VI (mutticast): Pr F1:D0:F1:D0:00:01 7 F1:D0:F1:D0:00:02 0 F1:D0:F1:D0:00:03 0	AN       VLAN         ority:       D:         Egress Port:       •         Dx0004       •         Port 1       •         Port 2       •         Both Ports         Dx0000       •         Port 1       •         Port 2       •         Both Ports
	Stream 4: 00:00:00:00:00:00	F1:D0:F1:D0:00:04 0	Dx000 O Port 1 O Port 2 O Both Ports
	TSN Dest. MAC Addr <u>Streams</u> On (multicast): Stream 1: Implication: Stream	VLAN ID: Listener Dest. MAC Addr: 0x005 00:1B:1B:57:1F:D2	VLAN tag: • Do not change • Remove • Replace VLAN tag with:
	Stream 2:         F1:D0:F1:D0:00:06           Stream 3:         F1:D0:F1:D0:00:07	Dx000         00:00:00:00:00:00           Dx000         00:00:00:00:00:00	Do not change     Remove     Replace VLAN tag with:     Do not change     Remove     Remove     Replace VLAN tag with:
	Stream 4: F1:D0:F1:D0:00:08	0x000 00:00:00:00:00	O Do not change O Remove O Replace VLAN tag with:
			© 2016 Innovasic, Inc.

Figure 35 – Stream Translation Page for TSN Gateway #1

#### 3.7 Verifying Scheduled Traffic

Once you have implemented the Network Schedule, you can verify the schedule has been implemented using features in Wireshark. First have a Wireshark capture running with a tap in between the devices. Stop the Wireshark capture by clicking on the red square as shown below:

⊿ Ca	pturing fron	n Local Area Connection 4 [W	ireshark 1.12.9	) (v1.12.9-0-gfadb421 fr	om master-'	1.12)]				
<u>F</u> ile	<u>E</u> dit ⊻iew G	<u>io C</u> apture <u>A</u> nalyze <u>S</u> tatistics T	elephon <u>y T</u> ools	<u>I</u> nternals <u>H</u> elp						
0	ا 📕 🔉 🔘	<u>a</u>   B B X 2   9, 4	🔹 🔿 🛜 :		D. 🖭   🗃	K 🗹 🖪	*			
Filter:	~~~~			Expression Clear	Apply Save					
No.	Time	Source		Destination		Protocol	Length Info			
4 5	723 22.93	874300(siemens_57:1f:d2		01:f1:d0:00	:00:02	PNIO	72 RTC1,	ID:0x8000,	Len:	2
4 5	724 22.93	884400(siemens_57:1f:d2		01:f1:d0:00	:00:02	PNIO	72 RTC1,	ID:0x8000,	Len:	- 2
4 5	725 22.93	984300(siemens_57:1f:d2		01:f1:d0:00	:00:02	PNIO	72 RTC1,	ID:0x8000,	Len:	2
4 5	726 22.94	084100(siemens_57:1f:d2		01:f1:d0:00	:00:02	PNIO	72 RTC1,	ID:0x8000,	Len:	- 2
4 5	727 22.941	184300(siemens_57:1f:d2		01:f1:d0:00	:00:02	PNIO	72 RTC1,	ID:0x8000,	Len:	- 2
4 5	728 22.94	284300(siemens_57:1f:d2		01:f1:d0:00	:00:02	PNIO	72 RTC1,	ID:0x8000,	Len:	- 2
4.5	729 22.948	859400(siemens_13:44:7c		01:f1:d0:00	:00:01	PNIO	72 RTC1,	ID:0x8000,	Len:	- 2
4 5	730 22.94	886000(siemens_13:44:7c		01:f1:d0:00	:00:01	PNIO	72 RTC1,	ID:0x8000,	Len:	- 2
4.5	731 22.948	886200(siemens_13:44:7c		01:f1:d0:00	:00:01	PNIO	72 RTC1,	ID:0x8000,	Len:	- 2
4.5	732 22.94	886400(siemens_13:44:7c		01:f1:d0:00	:00:01	PNIO	72 RTC1,	ID:0x8000,	Len:	- 2
4 5	733 22.941	886600(siemens_13:44:7c		01:f1:d0:00	:00:01	PNIO	72 RTC1,	ID:0x8000,	Len:	. 2
4.5	734 22.948	886700(siemens_13:44:7c		01:f1:d0:00	:00:01	PNIO	72 RTC1,	ID:0x8000,	Len:	- 4
4 5	735 22.941	886900(siemens_13:44:7c		01:f1:d0:00	:00:01	PNIO	72 RTC1,	ID:0x8000,	Len:	
4 5	736 22.941	887100(siemens_13:44:7c		01:f1:d0:00	:00:01	PNIO	72 RTC1,	ID:0x8000,	Len:	2
4.5	737 22.94	887300(siemens_13:44:7c		01:f1:d0:00	:00:01	PNIO	72 RTC1,	ID:0x8000,	Len:	- 2
4 5	738 22.94	887400(siemens_13:44:7c		01:f1:d0:00	:00:01	PNIO	72 RTC1,	ID:0x8000,	Len:	2
4.5	739 22.948	887600(siemens_13:44:7c		01:f1:d0:00	:00:01	PNIO	72 RTC1,	ID:0x8000,	Len:	- 2
4.5	740 22.94	887800(siemens_13:44:7c		01:f1:d0:00	:00:01	PNIO	72 RTC1,	ID:0x8000,	Len:	- 2
4 5	741 22.94	888000(siemens_13:44:7c		01:f1:d0:00	:00:01	PNIO	72 RTC1,	ID:0x8000,	Len:	- 2
4.5	742 22.94	888200(siemens_13:44:7c		01:f1:d0:00	:00:01	PNIO	72 RTC1,	ID:0x8000,	Len:	- 2
4 5	743 22.94	888300(siemens_13:44:7c		01:f1:d0:00	:00:01	PNIO	72 RTC1,	ID:0x8000,	Len:	- 2
4 5	744 22.948	896400(siemens_13:44:7c		01:f1:d0:00	:00:01	PNIO	72 RTC1,	ID:0x8000,	Len:	. z,
4.5	745 22.949	984600(siemens_13:44:7c		01:f1:d0:00	:00:01	PNIO	72 RTC1,	ID:0x8000,	Len:	- 2
<										>
🗄 Fr	ame 1: 72	bytes on wire (576 bits	), 72 bytes	captured (576 bits)	on interi	face 0		_		
± Et	hernet II	, Src: Siemens_57:1f:d2	(00:1b:1b:57	:1f:d2), Dst: 01:f1:	:d0:00:00	:02 (01:	F1:d0:00:00:02	)		
<b>⊞</b> 80	2.10 Virtu	ual LAN, PRI: 7, CFI: 0,	ID: 0							
PR	OFINET CY	CIIC Real-Time, RTC1, ID	:0x8000, Len	: 48, Cycle:47914 (	Valid, Pr	nmary,Ok	,Run)			
PR	OFINET IO	Cyclic Service Data Uni	t: 48 bytes							
Us	er Data (	including GAP and RTCPac	aing): 48 by	tes						

Figure 36 – Wireshark Capture

Navigate to "Statistics/I/O Graph".

<u>í</u> c	apturing	from L	ocal Area Conne	ctio	n 4 [Wireshark 1.12.	9 (v1	.12.	9-0-gfadb421 from master	-1.12)]				
<u>F</u> ile	<u>E</u> dit <u>V</u> ie	w <u>G</u> o	<u>Capture</u> <u>A</u> nalyze	Sta	atistics Telephony <u>T</u> ools	Interr	nals	Help					
0	•		BBX	Y	<u>S</u> ummary				🤹 🗹 🐔	* 🛱			
-					Comments Summary								
Filter					Show address resolution		E:	xpression Clear Apply Save	9				
No.	Tim	e	Source		Protocol Hierarchy			Destination	Protocol	Length Info			
1	9397 9.	879473	3000 siemens	£	) Conversations			01:f1:d0:00:00:02	PNIO	72 RTC1.	ID:0x8000.	Len:	2
1	9398.9.	87947	5000 siemens_		Endpoints			01:f1:d0:00:00:02	PNIO	72 RTC1,	ID:0x8000,	Len:	- 2
1	9399 9.	880443	3000 siemens_		Packet Lengths			01:f1:d0:00:00:02	PNIO	72 RTC1,	ID:0x8000,	Len:	- 2
1	9400 9.	881443	3000 siemens_	1.	IO Graph			01:f1:d0:00:00:02	PNIO	72 RTC1,	ID:0x8000,	Len:	- 2
1	9401 9.	882451	LOOO Siemens_	-	To arapit			01:f1:d0:00:00:02	PNIO	72 RTC1,	ID:0×8000,	Len:	- 4
1	.9402 9.	88345	0000 siemens_	-	Conversation List	•		01:f1:d0:00:00:02	PNIO	72 RTC1,	ID:0×8000,	Len:	2
1	.9403 9.	88932	5000 siemens_	1	Endpoint List	•	· I · ·	01:f1:d0:00:00:01	PNIO	72 RTC1,	ID:0×8000,	Len:	2
1	.9404 9.	889683	3000 siemens_	1	Service <u>R</u> esponse Time	•	·   -	01:f1:d0:00:00:01	PNIO	72 RTC1,	ID:0×8000,	Len:	2
1	.9405 9.	88968	6000 Siemens_	1-	2011			01:f1:d0:00:00:01	PNIO	72 RTC1,	ID:0×8000,	Len:	2
1	9406 9.	88968	7000 Siemens_	1	Zamest			01:f1:d0:00:00:01	PNIO	72 RTC1,	ID:0×8000,	Len:	2
1	.9407 9.	88968	3000 Siemens_	-	ANCP			01:f1:d0:00:00:01	PNIO	72 RTC1,	ID:0×8000,	Len:	- 2
1	.9408 9.	889691	LOOO Siemens_	-	BACnet			01: <del>1</del> :d0:00:00:01	PNIO	72 RTC1,	ID:0×8000,	Len:	2
1	.9409 9.	88969.	2000 Siemens_		Collectd			01:f1:d0:00:00:01	PNIO	72 RTC1,	ID:0x8000,	Len:	- 4
1	.9410 9.	889694	4000 Stemens_	l	Compare			UI:TI:dU:UU:UU:UI	PNIO	72 RICL,	ID:0x8000,	Len:	- í
1	.9411 9.	88969	5000 Stemens_ Zooo stemens	j 🖻	Flo <u>w</u> Graph			01:51:40:00:00:01	PNIO	72 RICL,	ID:0x8000,	Len:	1
1	.9412 9. 0413 0	88969.	7000 Stemens_		HART-IP			01:51:40:00:00:01	PNIO	72 RICL,	ID:0x8000,	Len:	1
1	.9413 9. 0414 0	88969	3000 Siemens_		HTTP	•	· I · ·	01:11:00:00:00:01	PNIO	72 RICL, 72 RICL	ID:0x8000,	Len:	1
1	.9414 9. 0415 0	00070	JOOO Siemens_ 3000 siemens		ONC-RPC Programs			01:11:00:00:00:01	PNIO	72 RICL, 72 RICL	ID:0x8000,	Len:	1
1	.9413 9. 0416 0	22070	1000 Siemens_		Sametime	•	·	01:f1:d0:00:00:01	PNIO	72 RTC1,	ID:0X8000,	Len:	. 1
1	0/17 0	99970	4000 Stemens_ 6000 Siemens		TCP StreamGraph	- F		01:f1:d0:00:00:01	PNIO	72 RTC1,	TD:0x8000,	Len:	1
1	9417 9. 9418 9	88970	3000 Siemens_ 3000 Siemens		UDP Multicast Streams			01.f1.d0.00.00.01	PNTO	72 RTC1,	TD:0x8000,	Len:	1
1	9410 9. 9419 9	890441	3000 Stemens_ 3000 Siemens		WLAN Traffic			01.f1.d0.00.00.01	PNTO	72 RTC1,	TD:0x8000,	Len:	2
		000111	Jugo Diemento_	1-	TO CLARKER				1112.0	r to rectany	1010/00000,	La Call I I	
					IP Statistics								-
± F	rame 1:	72 by	ytes on wire		BOUTP-DHCP		une la la	d (576 bits) on inter	tace 0	Ca. 10. 00. 00. 00			
E	thernet	II, 1	Src: Siemens_	57:	:1†:d2 (00:1b:1b:5	/:1†:	:dZ)	, Dst: 01:+1:d0:00:00	):02 (01:	+1:d0:00:00:02	)		
± 8	UZ.IQ V	nrtua	I LAN, PRI: 7	, C	LF1: U, ID: U		40		danana ol	Dum)			
ΨP	ROFINET	Cycl.	ic Real-Lime,	R1	nci, id:ux8000, Le	1: 4	+8,	Cycle:47914 (Valid, Pr	imary, ok	, kunj			
E E	CON DOT	- 10 Cj	genne Service Sluding CAR s	Da nd	ntenneling), 48 bytes	d oc							
U	ser bat	a (in	ciuding GAP a	na	RICPadding): 48 b	yces							

Figure 37 – I/O Graph Selection

Enter the destination MAC address as a filter for each of the I/O Graphs. For this example the MAC addresses used were the Multicast Addresses for the listener/talker streams. Change the

style to FBar and the Tick Interval to 0.001sec. This will then show something like the screen in the figure below.



*Figure 38 – Wireshark Graph of the example schedule* 

Because we have the same schedule for both of the streams and these streams were placed in the same queue, both colors depicting the streams may not be displayed. This is the case in the figure above. One way to see both streams is to place them into different schedule windows.

This is shown in the figure below. The stream for the TSN gateway #2 was changed from what was originally implemented in Figure 34 to the schedule below.

TSN Evaluation Kit Software Version: SC0000087-000												
Innovasic TSN Gateway Configuration Tool - Network Schedule (802.1Qbv)												
Home Gateway Settings	Use th	is page to set up IE	EE-80	02.10	) vd¢	sch	eduled traffic).					
Time Synchronization (802.1AS) Stream Translation	Base F	Period: 2	000	000	)		ns	2				
Stream Queue Assignment Network Schedule (802.1Qbv)	Entry	Cycle Offset (ns)	1 Op	en (	Queu	es	Cycle Offset (ns)		en (	Quei	ies	
	0	0			Q2		0			Q2		
	1	5000000					5000000					
	2	1000000					1000000					
	3	15000000					15000000					
	4	0					0					
	5	0					0					
	6	0					0					
	7	0					0					
	8	0					0					
	9	0					0					
	10	0					0					
	11	0					0					
	12	0					0					
	13	0					0					
	14	0					0					
	15	0					0					
	Save											
										6	9 201	6 Innovasic, Inc.

Figure 39 – Modified Schedule for TSN Gateway #2

After modifying the schedule according to the figure above, the traffic has moved to the different schedule windows. This can be seen in the figure below for 01:F1:D0:00:00:01 (shown in black)

and 01:F1:D0:00:00:02 (shown in red). Using Figure 28 and Figure 39 you can verify the traffic shown in black is separated from the traffic in red by 10ms.



Figure 40 – Wireshark Graph of the modified schedule

## 3.8 Using the TSN gateway in any TSN Network

This concludes the example for setting up the TSN gateway. With the settings available in the webserver on the TSN gateway, it is possible to configure the gateway of any TSN network requirements where that network is utilizing 802.1AS and 802.1Qbv.

As new TSN features are added or there are updates to existing TSN features, check with Innovasic to get the new software. Details for updating the software for the TSN gateway to enable these new features or updates are provided in Appendix A.

## 4. Revision History

The table below provides the sequence of revisions to document IA221160923.

Date	Revision	Description	Page(s)
October 17, 2016	00	Initial Release	NA
November 16, 2016	01	Added LED behavior, updated screenshot, added a field for AS description, added a note about only configuring one gateway at a time.	11, 14- 15, 46- 47
November 22, 2016	02	Added a warning about changing the TSN Gateway's MAC address to Multicast.	13

## 5. Appendix A – Updating the TSN Gateway Software

The TSN Gateway Kit comes loaded with the latest TSN Gateway application software and firmware at the time of shipment. It is advised that the user update the TSN Gateway application software and firmware as necessary. The latest release of the TSN Gateway application software and firmware can be found at Innovasic's Developer Portal.

To get the most recent software, refer to the picture below and perform the following steps:

- 1. Log In to the Developer Portal
- 2. Click on the Network Interface tab on the left-hand side
- 3. Click on the "Software for Network Interface" sub option
- 4. Click on the Download button below "TSN Gateway REM Switch Network Interface Software"
- 5. Agree to the Terms and Conditions



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Document #: IA221160923-02 UNCONTROLLED WHEN PRINTED OR COPIED Once you have downloaded the TSN Gateway software, the directory structure should appear as shown.

Name	Date modified	Туре
퉬 BoardConfig	9/28/2016 12:48 PM	File folder
퉬 Bootloader	9/28/2016 12:48 PM	File folder
Jan TSN	9/28/2016 12:48 PM	File folder
🐌 Web	9/28/2016 12:48 PM	File folder
TSN_Gateway_Loader.bat	9/28/2016 12:48 PM	Windows Batch File

The files that need to be loaded with the Ethernet bootloader and their locations in the zip file are shown in the following table:

File	Location
TSN_Gateway.load	TSN
sfs_data.load	Web

Web

*Table 2 – Load File Names* 

The Ethernet Bootloader is used to program a module with a given .load file. The following instructions show an example of how to update the software using the Ethernet Bootloader.

sfs\_bat.load



- First install a jumper on the bootloader header of Innovasic's baseboard.
- Verify that a TFTP server is running on your PC (A sample TFTP server is provided in the "Tools and Docs" download from Innovasic's website).
  - Make a note of the IP address being used by the TFTP server, in this example it will use 192.168.21.100.
- Then create a static arp table entry using a command prompt.
  - The arguments for the arp table entry are the MAC address of the module and the IP address you wish to assign the module.
  - All of Innovasic's modules are preloaded with a default MAC address of 12-34-56-78-9A-BC.
  - The IP address for this example will be 192.168.21.105

- From a command line enter the command arp -s 192.168.21.105 12-34-56-78-9A-BC and press enter (Note the IP Address is arbitrary and the only constraint is that it needs to be on the same subnet as the NIC you are using on your PC).
- Enter the command arp –a and verify the MAC and IP address are present in your arp table.
- Ping the module by typing ping 192.168.21.105
  - The first ping will time out followed by 3 successful pings.
- Establish a telnet session with the module.
  - o Type "telnet 192.168.21.105"

You have now accessed the Ethernet bootloader. Load each of the software components by means of the load command

- Type "load 192.168.21.100 TSN\_Gateway.load
- o Type "load 192.168.21.100 sfs\_data.load
- Type "load 192.168.21.100 sfs\_bat.load

The bootloader will display the following success message after successfully loading any of the .load files.



Your module has now been updated with the most recent version of the TSN Gateway software.

# 6. Appendix B – Behavior of the RapID Platform LEDs for the TSN Gateway

The TSN Gateway has LED behavior that is specified according to the following image and tables.



Table 3 – Behavior of LEDs

MOD LED	System Status	
	Not Participating in a gPTP	
Off	network	
	Participating in a gPTP	
Steady Red	network as a grandmaster	
	Participating in a gPTP	
Steady Green	network not as a grandmaster	
	Standby (waiting to enter Run	
	Mode. Only seen at power-up	
Flashing Green	or reset)	

NET LED	System Status
	No Stream Translations have
	been Configured and
	scheduled traffic is not
Off	enabled
	At least one Stream
	Translation has been
Steady Red	configured
	Scheduled Traffic has been
Steady Green	enabled
	At least one Stream
	Translation has been
	configured and Scheduled
Steady Yellow	Traffic has been enabled

Debug LED	System Status	
Off	The system is not in run mode	
	The system has entered run	
Flashing Red	mode	

## 7. For Additional Information

The Innovasic Support Team is continually planning and creating tools for your use. Visit http://www.innovasic.com for up-to-date documentation and software. Our goal is to provide timely, complete, accurate, useful, and easy-to-understand information. Please feel free to contact our experts at Innovasic at any time with suggestions, comments, or questions.

Innovasic Support Team 5635 Jefferson St. NE, Suite A Albuquerque, NM 87109 USA

(505) 883-5263 Fax: (505) 883-5477 Toll Free: (888) 824-4184 E-mail: support@innovasic.com Website: http://www.Innovasic.com

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