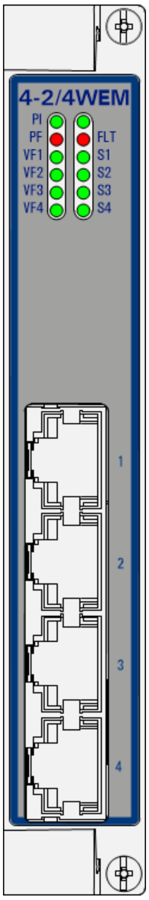
User Manual

Installation
Dragon PTN
Interface Module PTN-4-4WEM-L



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1. INTRODUCTION

1.1 General

This document is valid as of Dragon PTN Release 4.0DR.

This document describes the PTN-4-4WEM-L interface module which can be used to interconnect leased line modems, PABXs... via the Dragon PTN Network. This module provides 4 RJ45 ports to transport analogue voice signals between 300 - 3400Hz with a maximum level of 5dBm. These ports are balanced voice ports with an impedance of 600Ω. The used transportation mode is point-to-point 4-Wire voice (2-Wire = future support).

Besides the analogue voice interface, each port also provides an E&M interface (=future support). E&M (=Ear and Mouth) is a signaling mechanism between telephone switches.

Verify the 'Dragon PTN Bandwidth Overview' manual (Ref. [100] in Table 1) to see in which node and Interface Module slot this Interface Module can be used.

This Interface Module converts the analogue voice from a voice link into MPLS-TP packets over the Dragon PTN network, and vice versa. The destination Interface Module must also compensate for possible jitter and network delays to keep everything synchronized. A packetized TDM service is called a Circuit Emulation Service (=CES). A maximum of 4 CESs (1 per port) can be configured per PTN-4-4WEM-L Interface Module.

The main supported features are:

- Packetizing of analogue voice;
- Balanced voice ports, 600Ω impedance; Sample rate 8Khz;
- Services
  - CESoPSN (=CES over Packet Switched Network) → 2W/4W Voice;
  - Hitless Switching / Single Path ;

A general 4Wire Voice example can be found in the figure below:

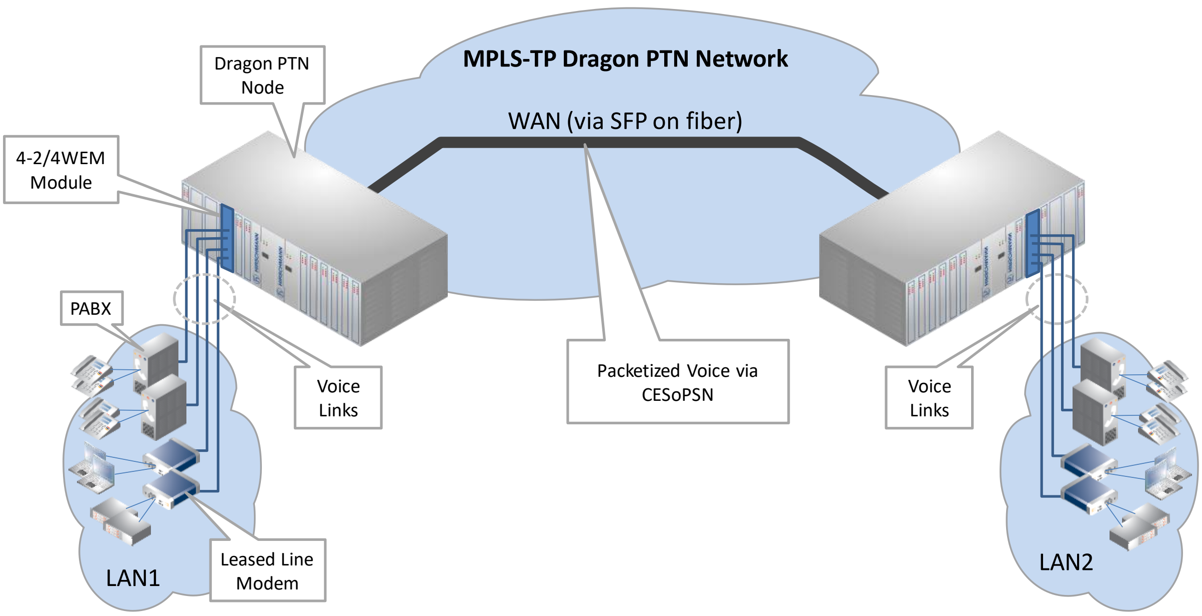

Figure 1 General 4Wire Voice Example

1.2 Manual References

Table 1 is an overview of the manuals referred to in this manual. All these manuals can be found in the HiProvision (=Dragon PTN Management System) Help function.

Table 1 Manual References

Ref.	Manual	Title
[1]	UM_BasicConfig_Dragon-PTN_and_HiProvision-Operation_Rel_4-0DR_1019_en.pdf	Dragon PTN and HiProvision Operation
[2]	IG_Dragon-PTN_Installation-and-Operation_02_1019_en.pdf	Dragon PTN Installation and Operation
[4]	IG_Dragon-PTN_PTN-CSM310-A_02_1019_en.pdf	Dragon PTN Switching Module: PTN-CSM310-A
[5]	IG_Dragon-PTN_General-Specifications_01_1019_en.pdf	Dragon PTN General Specifications
[100]	UM_Dragon-PTN_Bandwidth-Overview_01_1019_en.pdf	Dragon PTN Bandwidth Overview

2. MODULE DESCRIPTION

2.1 Front Panel

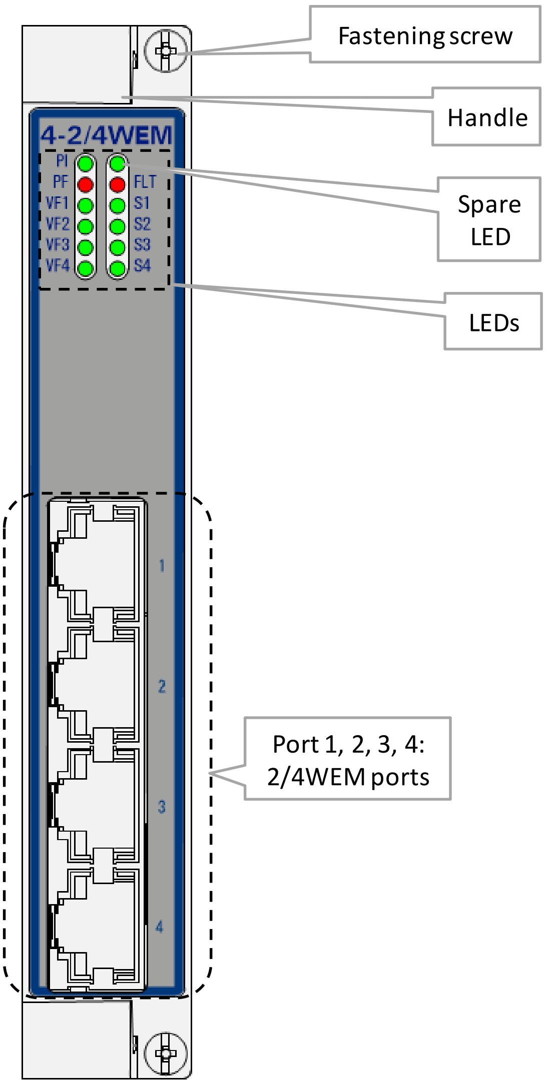

Figure 2 Front Panel

2.1.1 Insert/Remove Module into/from Node

See ‘Dragon PTN Installation and Operation Manual’ Ref.[2].

2.1.2 LEDs

The meaning of the LEDs depends on the mode of operation (= boot or normal) in which the Interface Module currently is running. After plugging in or rebooting the Interface Module, the Interface Module turns into the boot operation, see Table 2. After the module has gone through all the cycles in the table below (=rebooted successfully), it will turn into the normal operation, see LEDs in Table 3.

Table 2 LED Indications In Boot Operation

Cycle	PI	PF	FLT	VF[1..4]	S[1..4]
1	x	---	Slow blinking	---	---
2	x	---	Fast blinking	---	---
3	x	---	---	---	---
4	x	---	x	x	x
x : LED is lit / --- : LED is not lit; The sub cycle times may vary. The entire boot cycle time [1→4] takes approximately 2 minutes.					

Table 3 LED Indications In Normal Operation

LED	Color	Status
PI (=Power Input)	Not lit, dark	+12V power input to the board not OK
	Green	+12V power input to the board OK
PF (=Power Failure)	Not lit, dark	power generation on the board itself is OK
	Red	power generation on the board itself is erroneous
FLT (=FauLT)	Not lit, dark	no other fault or error situation, different from PF, is active on the module
	Red	a fault or error situation, different from PF, is active on the module
VF<n> (=Voice Frequency)	Not lit, dark	No service programmed on port<n>
	Lit, Green	Programmed service is operational on port<n>
	Blinking, Green	Service programmed but no data received on backplane (=network) side
S<n> (=future) (=E&M Signaling)	Not lit, dark	E wire (from E&M) on the front side (LAN) is not active
	Lit, Green	E wire (from E&M) on the front side (LAN) is active

2.1.3 Voice RJ-45 Ports and Cables

The PTN-4-4WEM-L module provides four of these ports and each port connector has eight pins. See the table and figure below for an overview and description.

- 4 Wire mode: the signals are transmitted over the transmit pair (TxA-TxB) and received from the receive pair (RxA-RxB);
- 2 Wire mode (=future): the signals are transmitted and received over the receive pair (RxA-RxB);

- CAT5E shielded cables must be used to connect the RJ-45 ports;

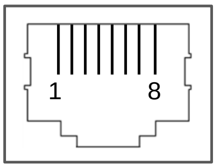

Figure 3 Voice RJ-45 Connector

Table 4 Voice RJ-45 Connector: Pin Assignments

Pin Number	Description	Input/Output
1 (=future)	E (Ear)	Input
2 (=future)	M (Mouth)	Output
3	TxA (Transmit A)	Output
4	RxA (Receive A)	Input
5	RxB (Receive B)	Input
6	TxB (Transmit B)	Output
7 (=future)	SG (Signal Ground)	---
8 (=future)	SB (Signal Battery)	---

2.2 Functional Operation

2.2.1 General

An application network (e.g. LAN1) can be connected to the MPLS-TP Dragon PTN network via one of the 4 voice interface ports. The PTN-4-4WEM-L module can interface with 4 voice lines. In Figure 1, a common functional setup is shown.

In Figure 4 below, a more detailed functional setup is shown. A LAN1 network interfaces the Dragon PTN node via the voice ports on the PTN-4-4WEM-L module. The PTN-4-4WEM-L converts this traffic into Ethernet traffic on the backplane. The Central Switching Module (= CSM, see Ref. [4],[4b] in Table 1) converts this Ethernet traffic into packetized Voice MPLS-TP and transmits it via an Ethernet Interface Module (e.g. 4-GC-LW) onto the Dragon PTN MPLS-TP network. The packetizing of the voice input occurs via CES: CESoPSN (see §2.2.3) technique.

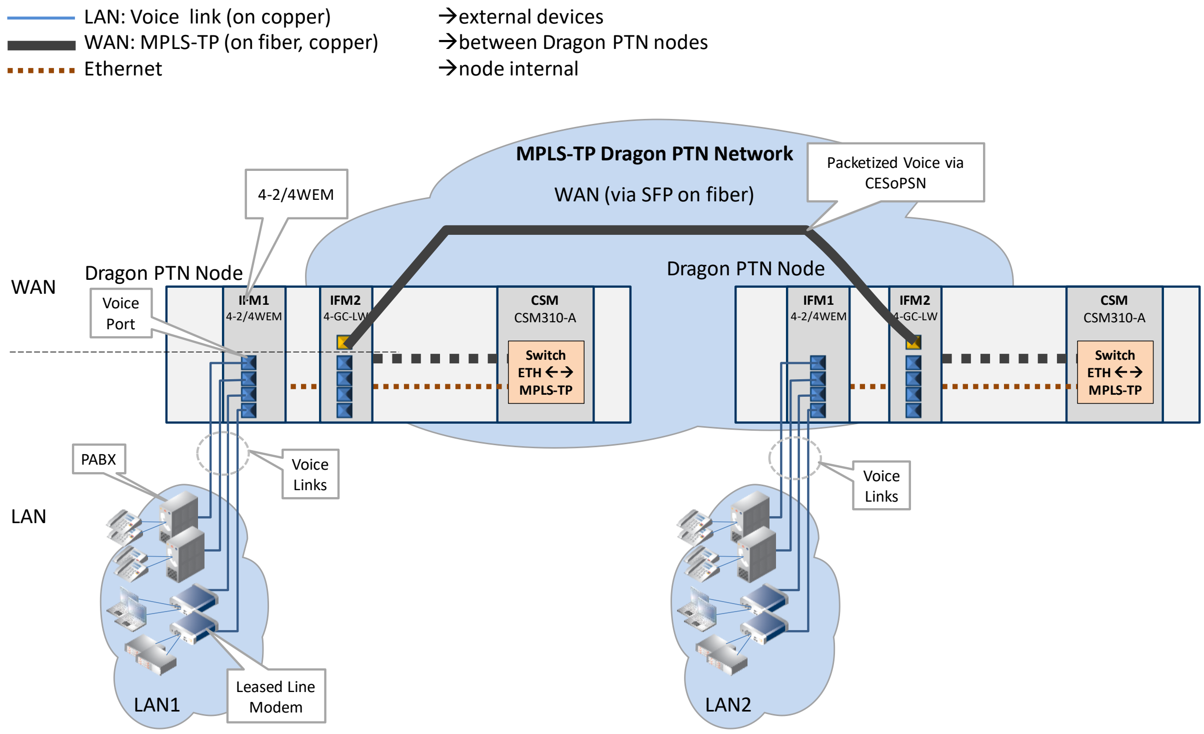

Figure 4 Detailed Function Voice Example

2.2.2 Services

A point-to-point '2W/4W Voice' service can be configured in HiProvision via creating a Circuit Emulation Service (=CES) with protocol type '2W/4W Voice'. The incoming analogue signal will be sampled at a rate of 8 kHz. The digitized voice data will be encapsulated in TDM packets which will be sent over the Dragon PTN network as Ethernet packets. Following parameters are needed per service:

- CES: Service Type: Circuit Emulation;
  - Protocol: 2W/4W Voice;
  - Usage is always CESoPSN;
  - optional: Hitless Switching;
  - optional: Single Path;

2.2.3 CES: CESoPSN (Point-to-Point)

CESoPSN (=Circuit Emulation Service over Packet Switched Network)

CESoPSN is a point-to-point service between two voice ports that uses the timeslots of an E1 frame to transport the data over the MPLS-TP Dragon PTN network. One such service can be configured per port. This service transports the voice data into the first timeslot and the E&M signaling (=future) in the second timeslot of an E1 frame.

The destination module will receive the transported timeslots from the Dragon PTN network and regenerate the voice data and the E&M signaling (=future) from it to finally output it on its voice port.

Each end-point or port must be located in a different node.

2.2.4 CES: Hitless Switching

Hitless Switching is a feature within CESoPSN that provides a safe redundant connection where no data or synchronization is lost when switching from the active to the backup path or vice versa, e.g. because of cable break. The total delay over the network remains nearly constant during switch-over. Redundancy via Hitless Switching is obtained via completing the list below:

- creating two independent point-to-point tunnels without protection;
- setting the Hitless Switching on at service creation time in HiProvision.

NOTE: See Ref.[1] for the creation of tunnels and services;

On the source side, with Hitless Switching enabled, the Interface Module duplicates each packet on a second tunnel (e.g. Tunnel y, see figure below). Each packet also contains a 16 bit sequence number. Different tunnels mean different paths through the network, with each path its own delay. Different delays result in a slow and a fast path.

On the destination side, with Hitless Switching enabled, the Interface Module buffers the fastest path and forwards packets from the slowest path on the voice link. Packets will be processed according a packet sequence number.

Hitless Switching is a redundant mechanism but differs from Protection Switching, see the table below for an overview. So if redundancy is needed in the service, either choose Hitless Switching or Protection Switching, mixing up both mechanisms is not allowed. Depending on the choice, settings must be done at tunnel creation time and/or service creation time.

When Hitless Switching has been enabled, the CES can only start up with two links up, coming out of a two-links-down situation (except when Single Path has been enabled, see §2.2.5).

See §2.2.6 for a delay comparison within CES depending on the enabled sub features, see also further on.

Table 5 Difference Between Protection and Hitless Switching

	Protection Switching	Hitless Switching
required tunnel type	1 point-to-point tunnel	2 point-to-point tunnels
tunnel protection type	1:1;	none; the redundancy is created via two independent point-to-point tunnels.
service parameter	Hitless Switching = disabled	Hitless Switching = enabled
at switch-over	possible data loss	no data or synchronization loss
total delay	less than hitless switching	more than protection switching

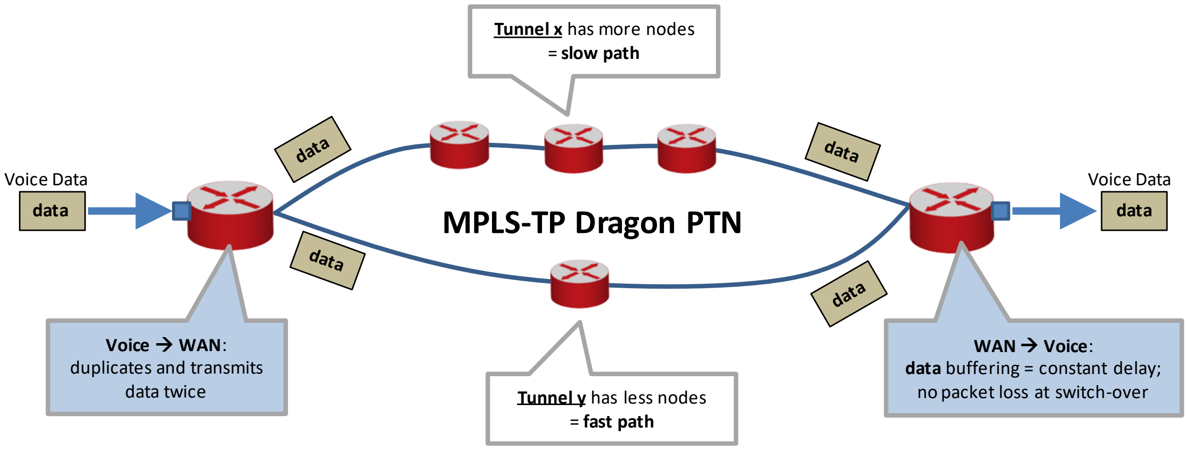

Figure 5 Hitless Switching

2.2.5 CES: Single Path

The Single Path feature is a sub feature of Hitless Switching (see §2.2.4). It influences the start-up behavior of the Hitless Switching mechanism:

- enabled: The CES can already start up with only one link up, coming out of a two-links-down situation; this setting results in bigger delays because of bigger buffers.
  - if the fastest path came up first:
    - the CES starts up according to the fastest path;
    - possible CES interrupt or minor packet loss when the slowest path comes up later on;
  - if the slowest path came up first:
    - the CES starts up according to the slowest path;
    - no CES interrupt or packet loss when the fastest path comes up later on;

See §2.2.6 for a delay comparison within CES depending on the enabled sub features, see also further on.

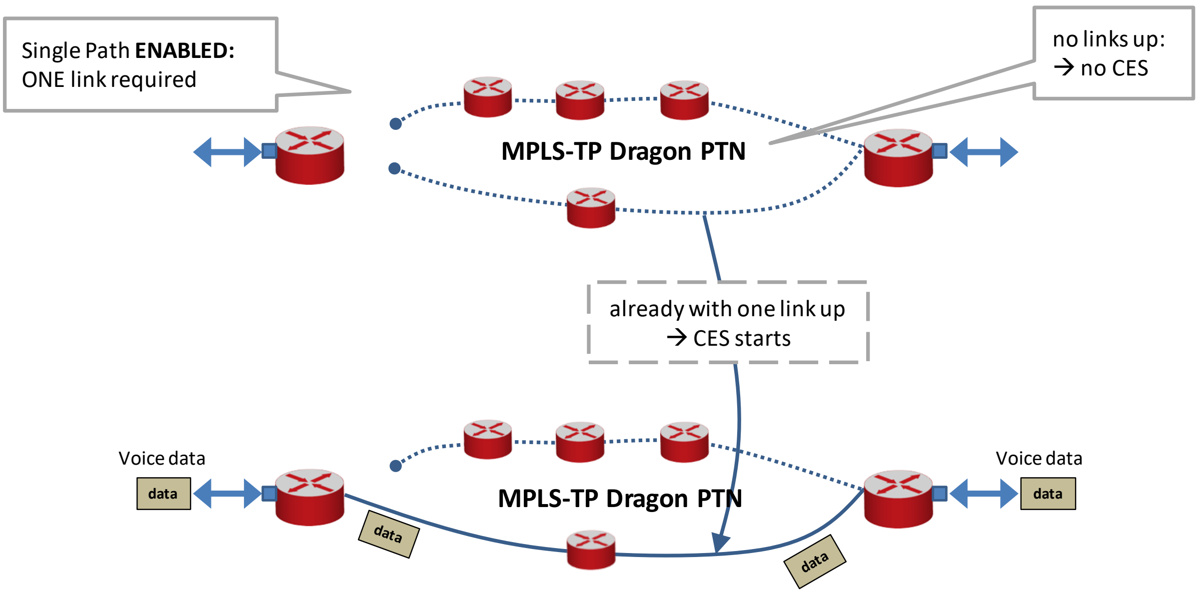

Figure 6 Single Path Enabled

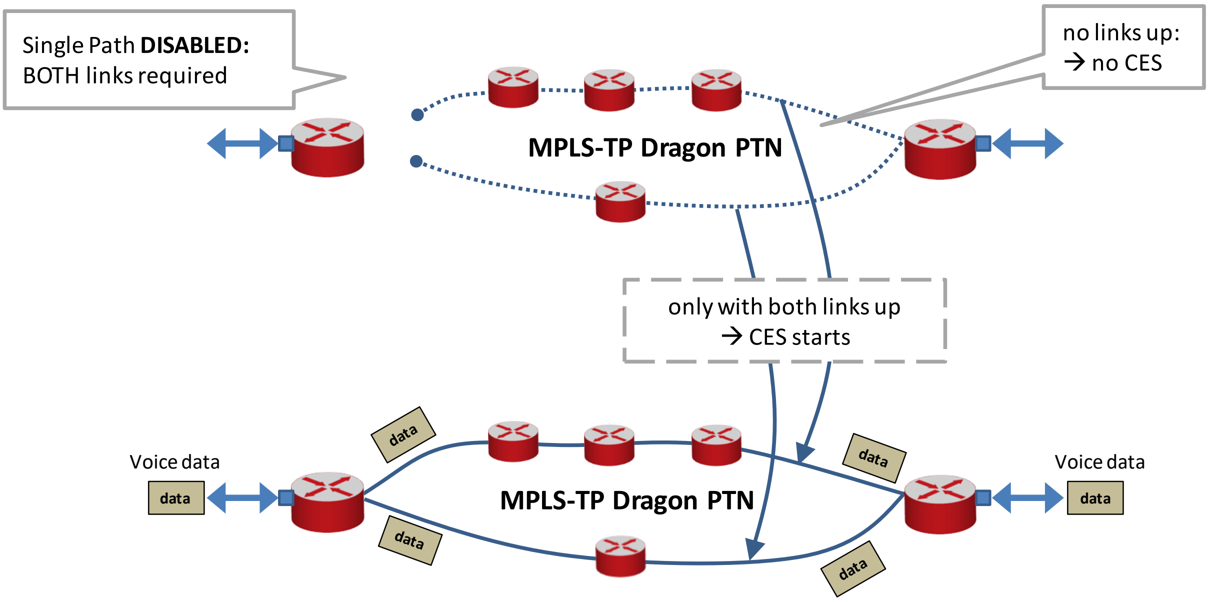

Figure 7 Single Path Disabled

2.2.6 CES: Delay Comparison in CES Features

Table 6 Delay Comparison in CES (Features)

CES	Hitless Switching	Single Path	Resulting Delay
X	---	---	lowest
X	X	---	medium
X	X	X	highest
X = enabled; --- = disabled			

2.2.7 I/O with the Central Switching Module (=CSM)

The PTN-4-4WEM-L module receives traffic via its front panel ports and converts this into Ethernet traffic which is forwarded to the CSM via the backplane. The CSM does all the processing on this data (synchronization, CRC checks, conversions, switching…). The CSM converts this data into MPLS-TP packets and transmits it via a WAN port (on an Interface Module that supports WAN) onto the WAN. On the destination side, the same processing occurs in reverse order.

2.2.8 Synchronization / Clock Distribution / Network Timing

CAUTION: Make sure to configure/verify the clocking parameters below.

The Dragon PTN network provides a number of mechanisms to perform synchronization / clock distribution / network timing per CES. The CSM synchronizes all the included Interface Modules in the node.

The application endpoints in a 'Circuit Emulation: 2W4W Voice' service can communicate in a synchronized way. Which method can be used depends on:

- The 'Clock Source' setting of port1, this setting will be taken as common setting for the entire Interface Module. 'Clock Source' settings of port2, 3 and 4 in HiProvision will be ignored;
- SyncE availability in the endpoint nodes;

The figures below show relevant end-to-end clocking configurations for this Interface Module. The PRC (=Primary Reference Clock) is a very stable high quality clock that can be used as a reference clock delivered via SyncE to the node:

- A, D = Application ports;
- B, C = Interface Module front ports;

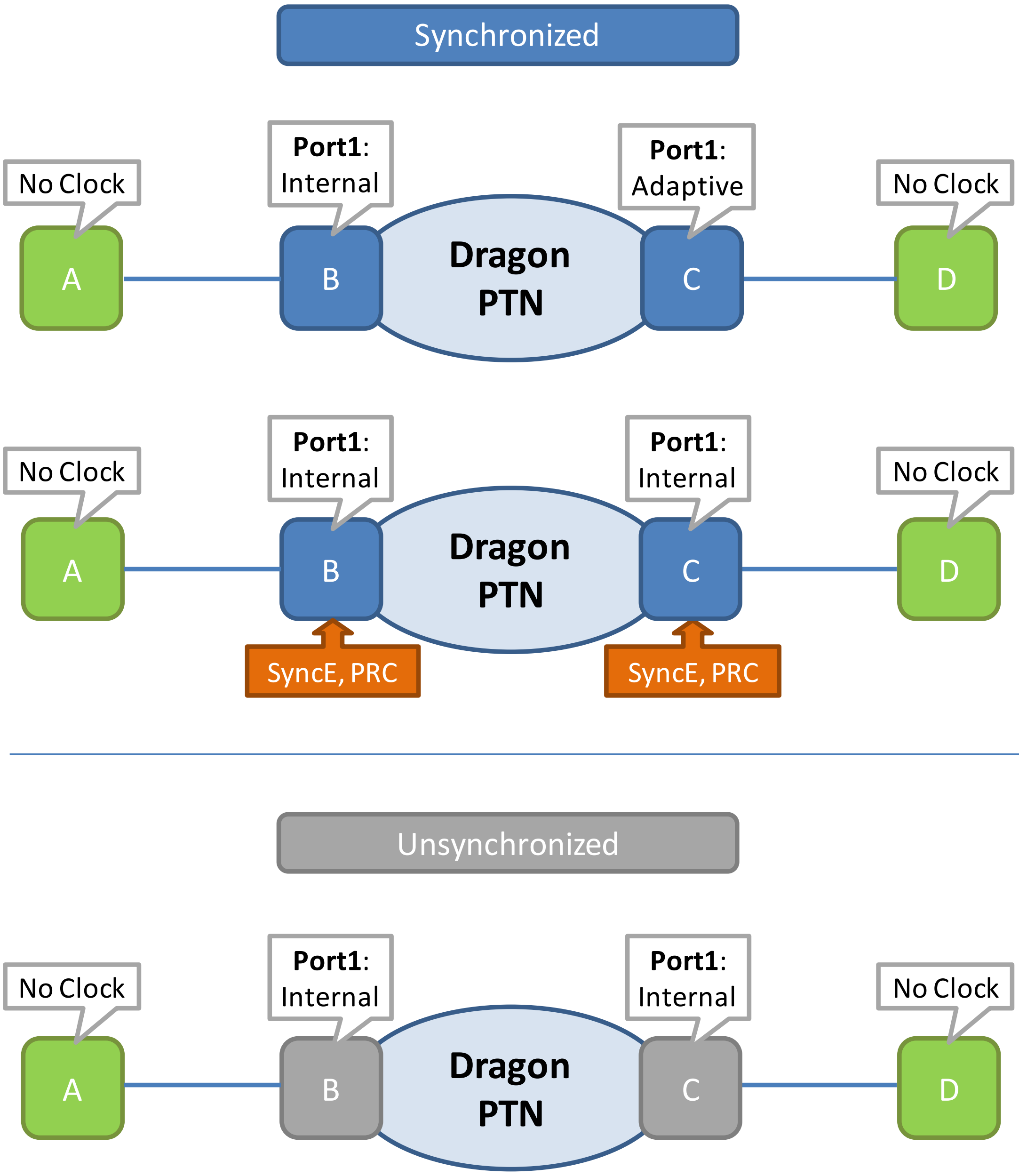

Figure 8 4-2W4WEM Clocking/Synchronization Overview

Table 7 Clocking Parameters on Port & Service Level

Port A: Clock Source	Port B: Clock Source Port1	Port C: Clock Source Port1	Port D: Clock Source	Description
Synchronized				
'No Clock'	'Internal Clock'	'Adaptive/ Differential'	'No Clock'	Node (B) transmits packets to node (C) based on an Internal Clock. This clock is delivered by the local oscillator on the Interface Module. Node (C) recovers the clock from the incoming packet stream from the network and uses it to encode/decode data streams. All the ports of an Interface Module in 'adaptive' mode (→port1='adaptive') operate as a slave.
'No Clock'	'Internal Clock' + SyncE	'Internal Clock' + SyncE	'No Clock'	Both nodes (B) and (C) encode/decode the data stream to/from the end applications based on the 'Internal Clock' on the Interface Module. This clock is delivered by the CSM and is based on a PRC delivered via SyncE.
Unsynchronized				
'No Clock'	'Internal Clock'	'Internal Clock'	'No Clock'	Both nodes (B) and (C) encode/decode the data stream to/from the end applications based on the 'Internal Clock' on the Interface Module. This Internal clock is delivered by the local oscillator on the Interface Module. The service will be stable 15s after the service startup. Though, the clocks of both sides are not synchronized. Sooner or later, one of the transmit buffers will overflow or run dry, resulting in a reset of the buffers. This reset will cause a minimal loss of data.

NOTE: SyncE: See the manuals in Ref.[1] and Ref.[4], [4b] for more detailed information;

2.2.9 Selftest: Tone Generation/Level Metering

Selftests can be performed via test tone generation/level metering in CESes, e.g. when configuring or troubleshooting a CES.

CAUTION: enabling selftests disables or disturbs normal service traffic on a port!

For more information and configuration settings, see 'Test and Loopback' in Ref.[1] in Table 1.

2.3 Onboard Interfaces

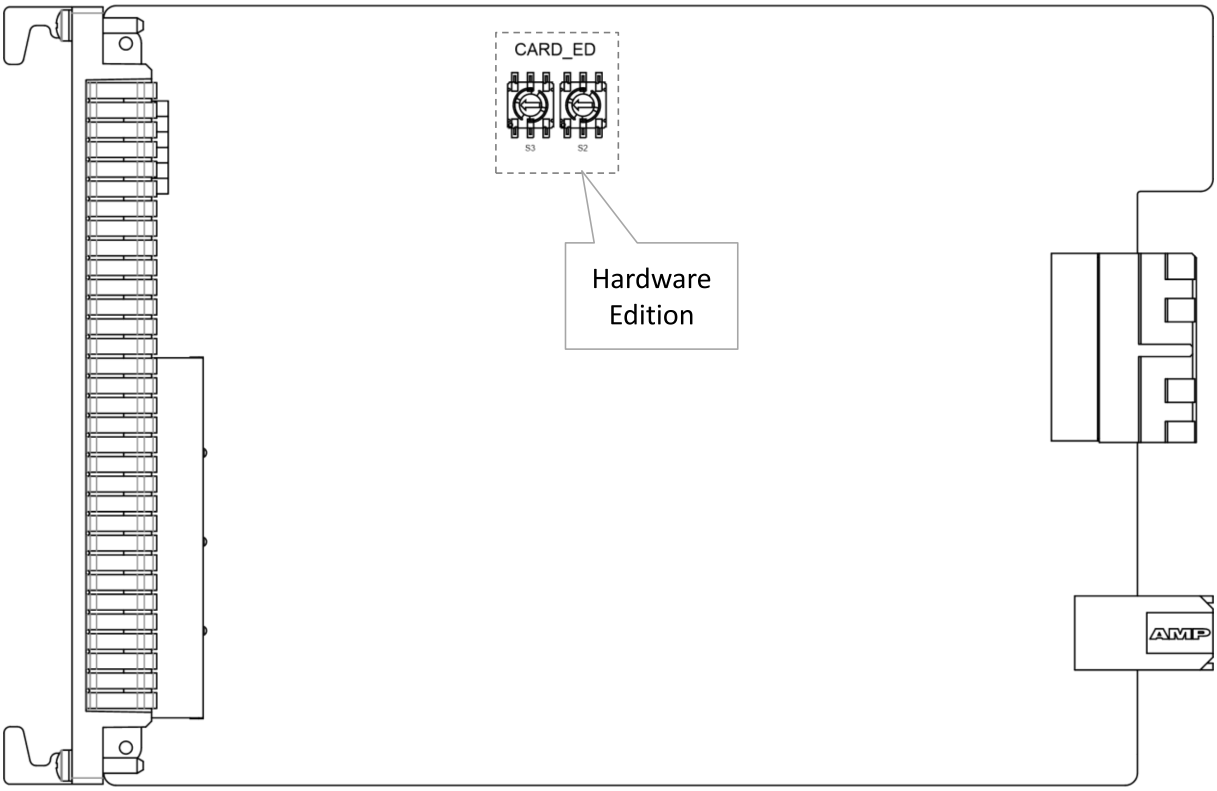

Figure 9 PTN-4-4WEM-L: Side View

2.3.1 Straps

No user relevant straps.

2.3.2 DIP Switches

a. Hardware Edition

The Hardware Edition (labeled as CARD_ED) (see Figure 10) is set in decimal code using rotary switches S2 to S3 (=most significant). It can be read out as well via HiProvision. This edition has been factory set and MUST NOT BE CHANGED!

Example: Setting S3='0' and S2='5' indicates Hardware Edition '5' (dec).

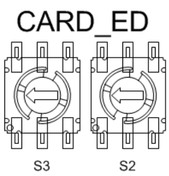

Figure 10 Hardware Edition

3. TDM FRAMES/PACKET FOR CES

3.1 General

In a CES service, the amount of TDM Frames per Ethernet packet is an important setting because it influences the amount of consumed bandwidth and delay through the network. The more TDM Frames/Packet, the less bandwidth is used but the bigger the total delay through the network.

In HiProvision, it can be configured how many TDM Frames/Packet can be encoded.

- Default TDM Frames/Packet = 4;
- Maximum TDM Frames/Packet, no Hitless Switching: 24;
- Maximum TDM Frames/Packet, Hitless Switching: 10;

3.2 Bandwidth

If only one TDM frame per packet is encoded, it generates a lot of header information (due to small Ethernet packet sizes) on the network resulting in a lot of consumed bandwidth. Encoding more frames into one packet will decrease the amount of header information and as a result the consumed bandwidth as well. As of 8 frames per packet and higher, the bandwidth consumption stabilizes towards the minimum bandwidth consumption. See the graph below.

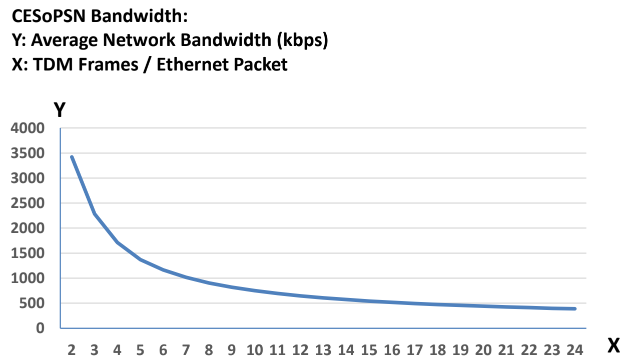

Figure 11 CESoPSN Bandwidth

3.3 Delay

3.3.1 General

The total delay between two end points over the Dragon PTN network depends on:

- **P** (=Packetization Delay): Delay to encode Serial input into MPLS-TP packets;
- **Path Delay**: Delay from source to destination over the MPLS-TP network path; can be measured by HiProvision via OAM delay measurement for the specific service; Path Delay = Delay external network (if any) + 5µs/km + 10µs/node;
- **DP** (=Depacketization Delay): Delay to decode MPLS-TP packets into Serial output;
- **DPh**: Extra Depacketizing Delay due to hitless switching;
- **Total Delay** = Total Network delay between two Serial applications;
- **Total Delay** = (Packetization + Path + Depacketization + Hitless Switching) Delay;

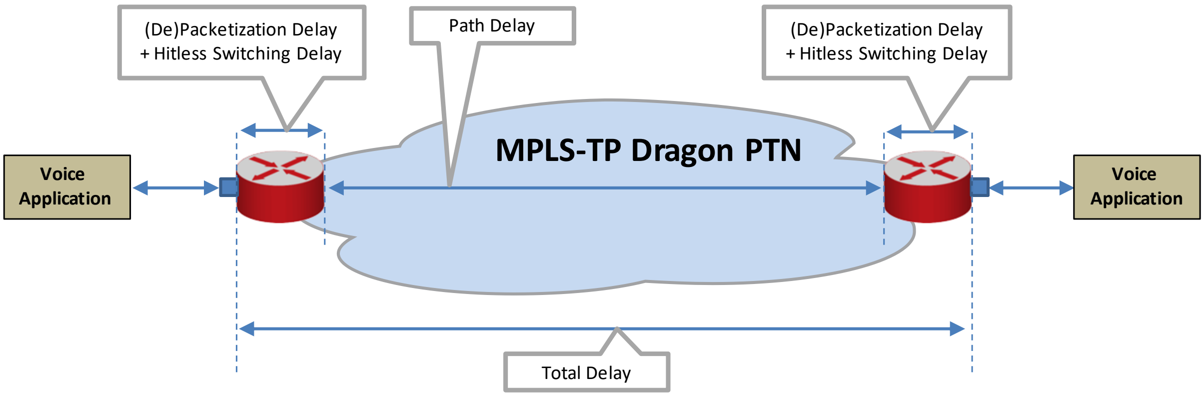

Figure 12 Delays

3.3.2 Delay Parameters

These delays in §3.3.1 depend on the selected service in HiProvision and its configured delay parameters. HiProvision offers the delay parameters listed below to tune the delay.

CAUTION: If you are not familiar with these parameters, keep the default values.

- **TDM Frames per Packet**: The lower the value, the lower the delay.
- **Jitter Buffer Size (µs)**: advice: Set this value to 'Packetizing Delay + expected peak-to-peak jitter (µs)'; The default peak-to-peak jitter could be 250 µs; The expected peak-to-peak jitter (µs) must be measured in the network. If the packetizing delay 'P' <2000 µs, set the buffer size to at least 2000 µs. If the packetizing delay 'P' > 2000 µs (e.g. 2500 µs), set the buffer size to at least e.g. 2500 µs.

CAUTION: By default, the jitter buffer will reset once for optimal processing 15 seconds after a change in the service occurs. This reset will cause a minimal loss of data. See 'jitter buffer' in the 'Dragon PTN and HiProvision Operation' Manual (=Ref. [1]) for more information.

- **Maximum Network Path Delay Difference (µs)** (only for Hitless Switching): advise: Set this value to '(Two Paths nodes difference)*10 + expected peak-to-peak jitter (µs)'. If path1 has 17 nodes and path2 has 8 nodes, this is a difference of 9 nodes. You could set MaxNetwPathDelayDiff = 9*10 + 250 = 340 µs;

3.3.3 Estimated Delay Calculation and Formulas

Table 8 shows formulas to calculate an estimated delay. Once you have the desired estimated delay, fill out the parameter values in HiProvision, which shows the calculated 'P+DP+DPh'.

Table 8 Estimated Delay Formulas

Delay	No Hitless Switching	Hitless Switching
P	TDMFramesPerPacket * 125	
Path Delay	measured by HiProvision	
DP	(JitterBufferSize – P) / 2	
DPh	0	2P + MaxNetwPathDelayDiff + 1087
Total	P + Path Delay + DP + DPh	

3.3.4 Estimated Delay Examples

Find some example values below. Fill them out in the formulas to find the estimated total delay:

- TDMFramesPerPacket = 10
- Pathdelay (measured by HiProvision) = 500 µs
- JitterBufferSize = 4000 µs
- MaxNetwPathDelayDiff = 340 µs

Table 9 Estimated Delay (µs) Examples

Delay	No Hitless Switching	Hitless Switching
P	**10** * 125 = 1250	
Path Delay	**500**	
DP	(**4000** – 1250) / 2 = 1375	
DPh	0	2*1250 + **340** + 1087 = 3927
Total	1250 + 500 + 1375 + 0 = **3125 µs**	1250 + 500 + 1375 + 3927 = **7052 µs**

3.4 Tuning CES = Tuning TDM Frames/Packet

Tuning the CES is mainly done by tuning the TDM Frames/Packet parameter. Tuning this parameter is a trade-off between bandwidth and delay. The more bandwidth is consumed the less the resulting network delay and vice versa. This tuning is application dependent. Check out whether bandwidth or delay is critical for an application or network. Based on these findings, bandwidth and delay parameters can be tuned.

Some examples according the information in §3.2 and §3.3:

- if bandwidth is not a problem, and a small delay is wanted → 1-3 TDM frames/packet;
- if less bandwidth is required and delay is not important → at least 4 TDM frames/packet;
- if less bandwidth and a small delay are wanted → 5 .. 10 TDM frames/packet.

4. MODULE SPECIFICATIONS

4.1 General Specifications

For general specifications like temperature, humidity, EMI... see Ref.[5] in Table 1.

4.2 Other Specifications

Table 10 Other Specifications

Description	Value
Weight	0.24 kg / 0.5 lb
MTBF	84 years at 25°C/77°F
Power Consumption	7.2W (measured at 25°C/77°F, with data transport)
Module Size	width: 20.32 mm / 0.8 inches height: 126 mm / 4.96 inches depth: 195 mm / 7.68 inches

4.3 Ordering Information

- PTN-PTN-4-4WEM-L : (future support)

5. ABBREVIATIONS

CE	Conformité Européenne
CESoPSN	Circuit Emulation Service over Packet Switched Network
CSM	Central Switching Module
EMI	Electromagnetic Interference
ERR	Error
FLT	Fault
GND	Ground
IEEE	Institute of Electrical and Electronics Engineers
LAN	Local Area Network
LVD	Low Voltage Directive
LT	Line Termination
MTBF	Mean Time Between Failures
NT	Network Termination
OAM	Operations, Administration and Maintenance
PF	Power Failure
PI	Power Input

PME	Physical Medium Entities
PRC	Primary Reference Clock
PTN	Packet Transport Network
S	E&M Signaling
SCTE	Serial Clock Transmit External
TRx	Transmit
TTC	Terminal Timing Clock
TxD	Transmit Data
VF	Voice Frequency
WAN	Wide Area Network