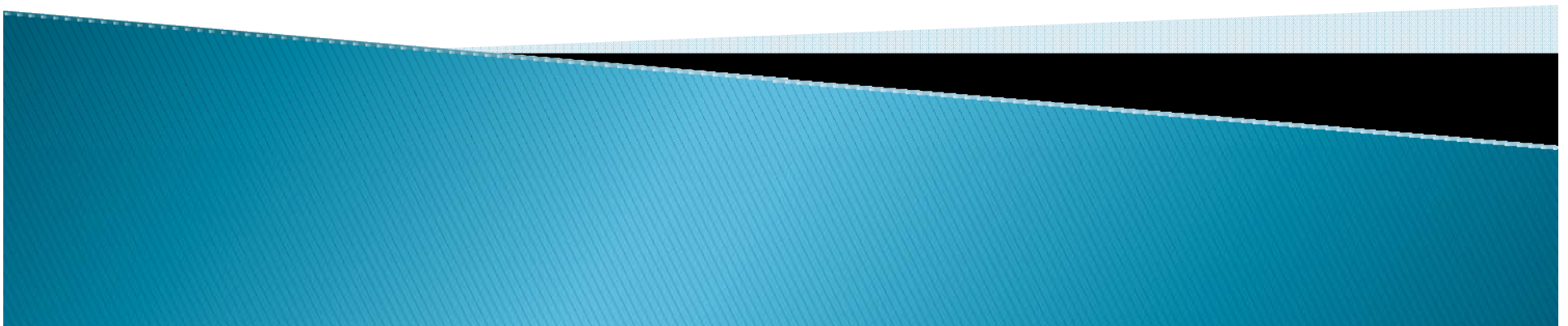


# SpaceWire-RT prototyping

Demonstration

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# Prototyping Features

## ▶ Performance

- RTC: 250 $\mu$ s timeslot, 6 data packets of 256B (76Mbit/s) per source-destination pair.

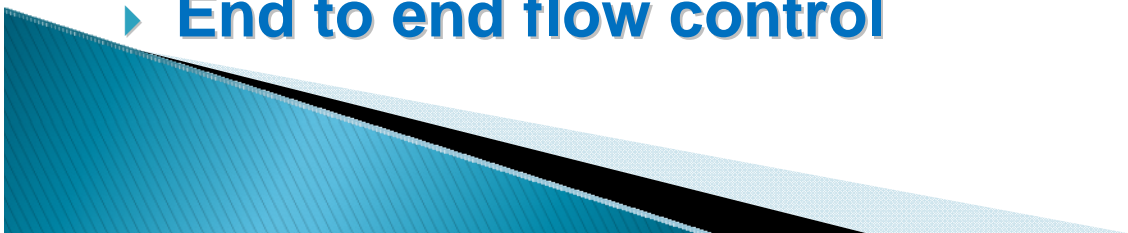
## ▶ Fault tolerant

- Desynchronization tolerant: late arrival of acknowledges
- Automatic retrials: configurable
- Alternative paths: same bandwidth in case of a path failure.
- Graceful degradation: Multiple paths per channel dependent on timeslot used.
- TimeCode error tolerant: Go silent if local clock mismatches

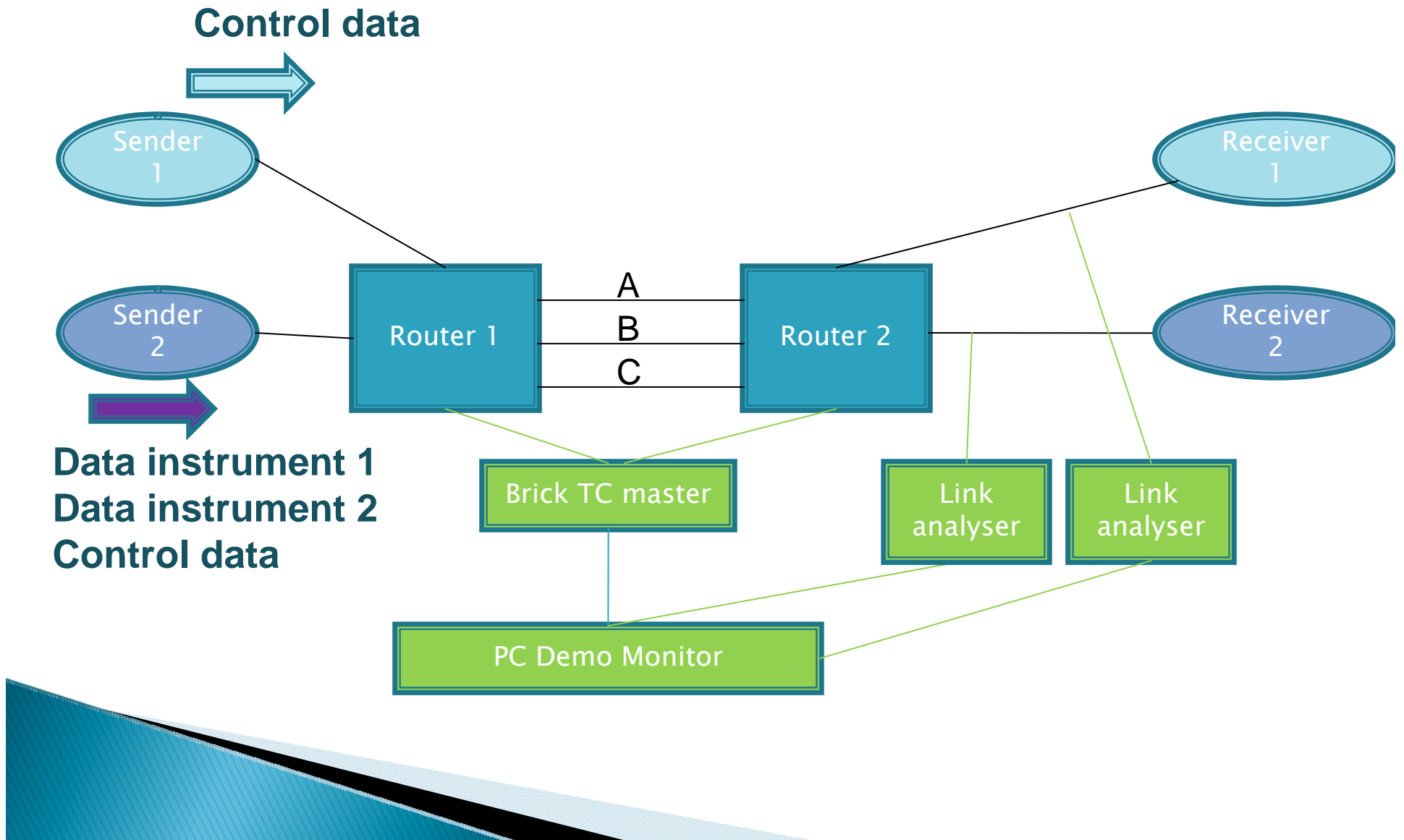
## ▶ Priorities

- **Bandwidth allocation** of each channel
- Higher priority channels use bandwidth of others when not used

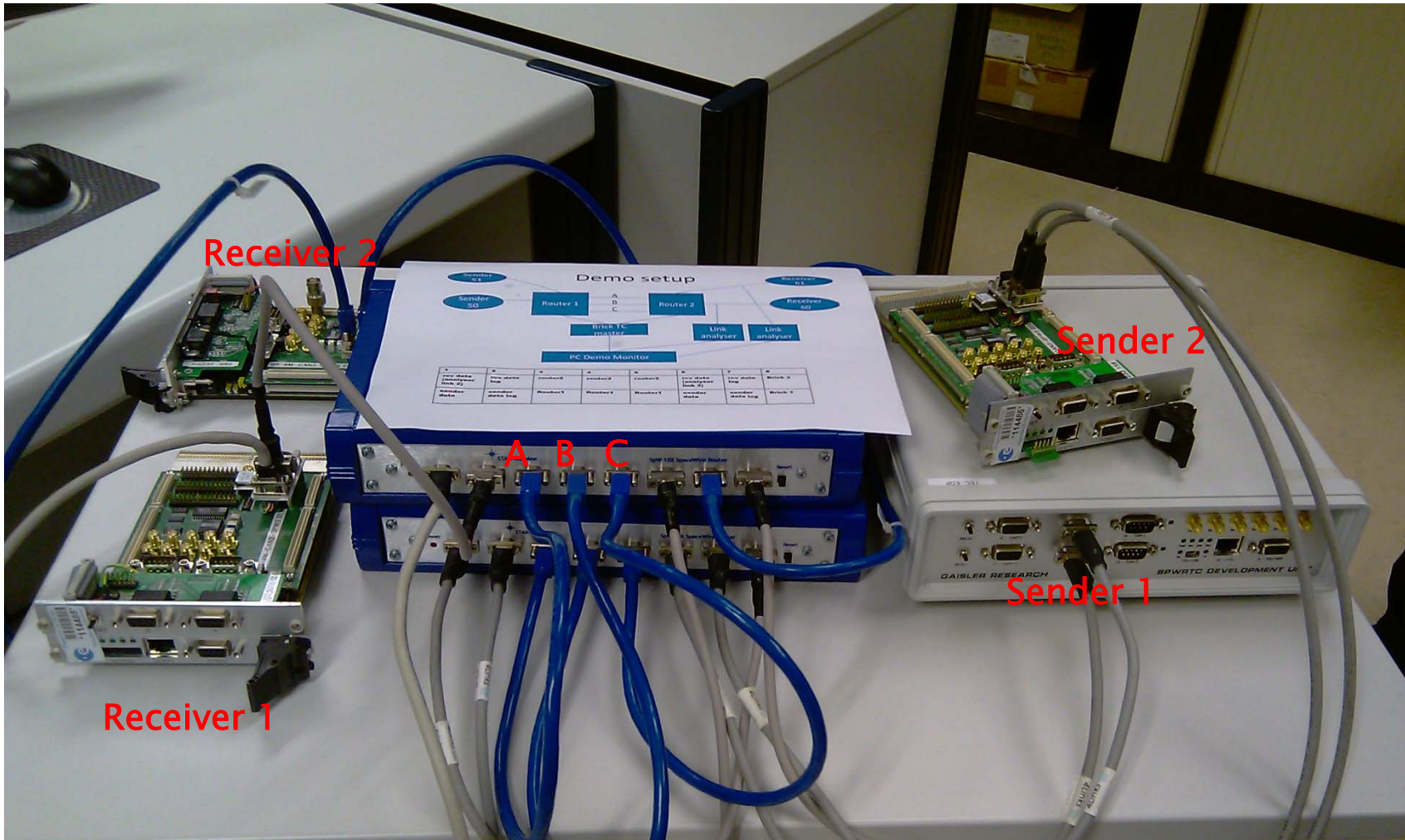
## ▶ End to end flow control



# Demo Topology



# Demo Topology



# Demo Objectives

- ▶ **See SpaceWire-RT working**
  - Packet types, end to end flow control, scheduling...
- ▶ **Use of Spare bandwidth**
  - When receiver does not have buffer space for one instrument, the other instrument use its bandwidth
- ▶ **Fault tolerant, graceful degradation**
  - All payload and control data is immune to sporadic parity bit errors or a single link failure.
  - Control data is immune to 2 link failures
  - Reduced bandwidth for Payload data when 2 link failures



**Show functions, not performance**



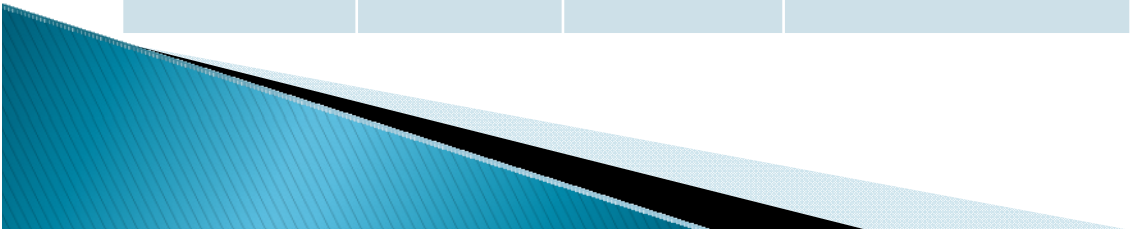
# Demo Configuration

## Sender 1









Ch number	Type	Priority	% bandwidth	1 error	2 errors
1	Control	Highest	1.65%	OK	OK
2	Data 1	Normal	49%	OK	Bandwidth reduced
3	Data 2	Normal	49%	OK	Bandwidth reduced

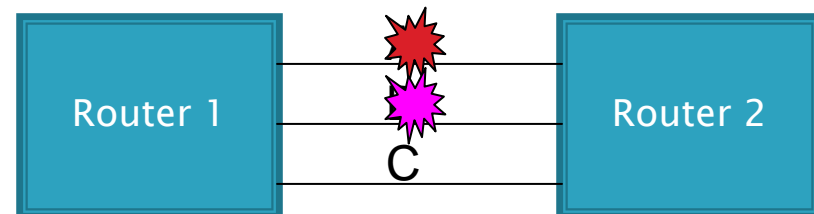
## Sender 2

Ch number	Type	Priority	% bandwidth	1 error	2 errors
1	Control	Highest	1.65%	OK	OK



# Demo Configuration (2)

Slots	Sender>Rcv	Channels High Priority->Low	Path Primary   redundant
0	1->1	1, 2, 3	   C
0	2->2	1	
1	1->1	1, 3, 2	   C
1	2->2	1	
2	1->1	1, 2, 3	   
2	2->2	1	C
3	1->1	1, 3, 2	   C
3	2->2	1	



# Support Slides



# Demo network monitor

Stop

## Sender

	Messages sent	retries	msgs/sec		status	errors
Control channel	255	0	32	Path 1	Primary path	0
Data channel 1	8532	0	1050	Path 2	Primary path	0
Data channel 2	8575	0	1056	Path 3	Primary path	0

## Receiver

	Messages rcv	Message size		status
Control channel	255	256	stop	Return path 1 Primary path
Data channel 1	8531	1536	stop	Return path 2 Primary path
Data channel 2	8574	1536	stop	Return path 3 Primary path

**Data Channel 2 stopped  
Increase data rate of ch 1**

## Demo network monitor

Stop

### Sender

	Messages sent	retries	msgs/sec		status	errors
Control channel	1896	0	32	Path 1	Primary path	0
Data channel 1	65963	0	1824	Path 2	Primary path	0
Data channel 2	58257	0	0	Path 3	Primary path	0

### Receiver

	Messages rcv	Message size		status
Control channel	1895	256	stop	Return path 1 Primary path
Data channel 1	69034	1536	stop	Return path 2 Primary path
Data channel 2	58255	1536	start	Return path 3 Primary path

# Demo network monitor

Stop

## Sender

	Messages sent	retries	msgs/sec
Control channel	3372	0	27
Data channel 1	137544	1	1019
Data channel 2	70144	1	1023

	status	errors
Path 1	Primary path	0
Path 2	Redundant path	0
Path 3	Redundant path	0

## Receiver

	Messages rcv	Message size	
Control channel	3372	256	stop
Data channel 1	156262	1536	stop
Data channel 2	70175	1536	stop

	status
Return path 1	Primary path
Return path 2	Redundant path
Return path 3	Redundant path

## Link A & B fails

RT demo Monitor

### Demo network monitor

Stop

### Sender

	Messages sent	retries	msgs/sec
Control channel	4603	0	32
Data channel 1	175083	1	538
Data channel 2	112127	1	1088

	status	errors
Path 1	Redundant path	0
Path 2	Redundant path	0
Path 3	Path disabled	5

### Receiver

	Messages rcv	Message size	
Control channel	4604	256	stop
Data channel 1	193785	1536	stop
Data channel 2	112158	1536	stop

	status
Return path 1	Redundant path
Return path 2	Redundant path
Return path 3	Redundant path

## TimeCode received

Time Delta	End A Event	End A Error	End A Delta	End B Event
500,100 µs	TIMECODE [04]		500,100 µs	NULL
7,260 µs				NCHAR [04]
80 ns				NCHAR [01]
60 ns				NCHAR [FE]
60 ns	NULL		7,460 µs	NCHAR [03]
60 ns				NCHAR [FE]
60 ns				NCHAR [01]
60 ns				NCHAR [FF]
60 ns				NCHAR [FF]
80 ns				NCHAR [00]
60 ns				NCHAR [00]
60 ns				NCHAR [00]
40 ns				NCHAR [00]
80 ns				NCHAR [00]
60 ns				NCHAR [00]
60 ns				NCHAR [00]
80 ns	NULL		760 ns	NCHAR [00]
60 ns				NCHAR [00]
400 ns				EOP
123,620 µs	NCHAR [FE]		124,080 µs	
100 ns	NCHAR [03]		100 ns	NULL
100 ns	NCHAR [FE]		100 ns	
100 ns	NCHAR [92]		100 ns	NULL
100 ns	NCHAR [02]		100 ns	NULL
100 ns	NCHAR [01]		100 ns	
100 ns	NCHAR [00]		100 ns	
100 ns	NCHAR [EF]		100 ns	NULL
100 ns	NCHAR [00]		100 ns	NULL
100 ns	NCHAR [01]		100 ns	
100 ns	NCHAR [02]		100 ns	
100 ns	NCHAR [03]		100 ns	
100 ns	NCHAR [04]		100 ns	
100 ns	NCHAR [05]		100 ns	NULL
100 ns	NCHAR [06]		100 ns	
100 ns	NCHAR [07]		100 ns	
100 ns	NCHAR [08]		100 ns	
24,840 µs	EOP		24,840 µs	NULL
260 ns	NCHAR [FE]		260 ns	
100 ns	NCHAR [03]		100 ns	
100 ns	NCHAR [FE]		100 ns	NULL

Time Delta	End A		
260 ns	<b>(NUM=5) SPW-RT Packet (DATA)</b>		
	Destination Address: FE		
	Format: Data Packet		
	Source Address: FE		
	Channel: 2		
	Sequence: 5		
	00 FF 18 19 1A 1B 1C 1D		
	1E 1F 20		
28,440 µs	EOP (28,440 µs)	28,440 µs	
100 ns	<b>(NUM=6) SPW-RT Packet (DATA)</b>	100 ns	
	Destination Address: FE		
	Format: Data Packet		
	Source Address: FE		
	Channel: 2		
	Sequence: 6		
	00 52 50 51 52 53 54 55		
	56 57 58		
28,040 µs	EOP (28,040 µs)	28,040 µs	
124,000 µs			<b>(NUM=2) SPW-RT Packet (SACK)</b>
			Path Address: 4 1
			Destination Address: FE
			Format: SACK Packet
			Source Address: FE
			02 06 B0
520 ns			EOP (520 ns)
81,360 µs			<b>(NUM=3) SPW-RT Packet (SBFCT)</b>
			Path Address: 3 1
			Destination Address: FE
			Format: SBFCT Packet
			Source Address: FE
			FF FF 00 00 00 00 00 00
			00 00 00
1,840 µs			EOP (1,840 µs)
124,360 µs	<b>(NUM=7) SPW-RT Packet (DATA)</b>	332,080 µs	
	Destination Address: FE		
	Format: Data Packet		
	Source Address: FE		
	Channel: 3		
	Sequence: 1		
	00 3F 00 01 02 03 04 05		
	06 07 08		
26,440 µs	EOP (26,440 µs)	26,440 µs	
280 ns	<b>(NUM=8) SPW-RT Packet (DATA)</b>	280 ns	
	Destination Address: FE		
	Format: Data Packet		
	Source Address: FE		
	Channel: 3		

## Packet types

## Flow control channel 3

Time Delta	End A	
80 ns	<b>(NUM=5) SPW-RT Packet (DATA)</b>	
	Destination Address: FE	
	Format: Data Packet	
	Source Address: FE	
	Channel: 2	
	Sequence: AD	
	00 97 18 19 1A 1B 1C 1D	
	1E 1F 20	
28,520 µs	EOP (28,520 µs)	28,520 µs
100 ns	<b>(NUM=6) SPW-RT Packet (DATA)</b>	100 ns
	Destination Address: FE	
	Format: Data Packet	
	Source Address: FE	
	Channel: 2	
	Sequence: AE	
	00 3A 50 51 52 53 54 55	
	56 57 58	
28,140 µs	EOP (28,140 µs)	28,140 µs
123,380 µs		<b>(NUM=3) SPW-RT Packet (SACK)</b>
		Path Address: 4 1
		Destination Address: FE
		Format: SACK Packet
		Source Address: FE
		02 AE 66
520 ns		EOP (520 ns)
80,960 µs		<b>(NUM=4) SPW-RT Packet (SBFCT)</b>
		Path Address: 3 1
		Destination Address: FE
		Format: SBFCT Packet
		Source Address: FE
		FF F0 00 00 00 00 00 00
		00 00 00
1,860 µs		EOP (1,860 µs)
125,320 µs	<b>(NUM=7) SPW-RT Packet (DATA)</b>	332,040 µs
	Destination Address: FE	
	Format: Data Packet	
	Source Address: FE	
	Channel: 2	
	Sequence: AF	
	00 40 00 01 02 03 04 05	
	06 07 08	
26,440 µs	EOP (26,440 µs)	26,440 µs
280 ns	<b>(NUM=8) SPW-RT Packet (DATA)</b>	280 ns
	Destination Address: FE	
	Format: Data Packet	
	Source Address: FE	
	Channel: 2	



# Redundant path used

80 ns	<b>(NUM=14) SPW-RT Packet (DATA)</b>	80 ns	
	Destination Address: FE		
	Format: Data Packet		
	Source Address: FE		
	Channel: 3		
	Sequence: 2E		
	00 A4 50 51 52 53 54 55		
	56 57 58		
28,220 $\mu$ s	EOP (28,220 $\mu$ s)	28,220 $\mu$ s	
124,980 $\mu$ s			<b>(NUM=7) SPW-RT Packet (SACK)</b>
			Path Address: 5 1
			Destination Address: FE
			Format: SACK Packet
			Source Address: FE
			03 2E AE
			EOP (540 ns)
540 ns			<b>(NUM=8) SPW-RT Packet (SBFCT)</b>
81,100 $\mu$ s			Path Address: 5 1
			Destination Address: FE
			Format: SBFCT Packet
			Source Address: FE
			FF FF 00 00 00 00 00 00
			00 00 00
			EOP (1,400 $\mu$ s)
1,400 $\mu$ s			
124,160 $\mu$ s	<b>(NUM=15) SPW-RT Packet (DATA)</b>	332,180 $\mu$ s	
	Destination Address: FE		
	Format: Data Packet		
	Source Address: FE		
	Channel: 2		
	Sequence: 62		
	00 BF 50 51 52 53 54 55		
	56 57 58		
26,420 $\mu$ s	EOP (26,420 $\mu$ s)	26,420 $\mu$ s	

# Graceful degradation

Status Counters

Characters/Events Per Second

	End A	End B
Signaling Rate	100,005 MHz	160,007 MHz
Disconnect Error	0	0
Parity Error	0	0
Credit Error	0	0
Escape Error	0	0
Char Sequence Error	0	0
Data Character	3.179.754	67.389
EOP Character	11.999	3.999
EEP Character	0	0
FCT Character	8.923	398.968
NULL Character	8.511.981	19.715.168
Time-code Character	2.000	0

Clear Freeze

Data Character	2.383.978	64.754
EOP Character	8.996	4.000
EEP Character	0	0
FCT Character	8.594	299.119
NULL Character	9.508.367	19.768.386
Time-code Character	2.000	0

# Path disabled when error

		<b>(NUM=145) SPW-RT Packet (SBFCT)</b>
		Path Address: 5 6
		Destination Address: FE
		Format: SBFCT Packet
		Source Address: FE
		FF 00 00 00 00 00 00 00
		00 00 00
		EOP (2,240 μs)
<b>(NUM=19) SPW-RT Packet (DATA)</b>	3,99794 ms	
Destination Address: FE		
Format: Data Packet		
Source Address: FE		
Channel: 1		
Sequence: 91		
00 91 00 01 02 03 04 05		
06 07 08		
EOP (26,440 μs)	26,440 μs	
		<b>(NUM=146) SPW-RT Packet (SACK)</b>
		Path Address: 5 6
		Destination Address: FE
		Format: SACK Packet
		Source Address: FE
		01 91 8E
		EOP (840 ns)
		<b>(NUM=147) SPW-RT Packet (SBFCT)</b>
		Path Address: 4 6
		Destination Address: FE
		Format: SBFCT Packet
		Source Address: FE
		FF 00 00 00 00 00 00 00
		00 00 00
		EOP (3,040 μs)
		<b>(NUM=148) SPW-RT Packet (SACK)</b>
		Path Address: 4 6
		Destination Address: FE
		Format: SACK Packet
		Source Address: FE
		42
		EOP (1,120 μs)
		<b>(NUM=149) SPW-RT Packet (SBFCT)</b>
		Path Address: 3 6
		Destination Address: FE
		Format: SBFCT Packet
		Source Address: FE
		FF 00 00 00 00 00 00 00
		00 00 00
		EOP (2,220 μs)

