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Reducing SpaceWire Time-code Jitter

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Introduction

Time codes can be inserted into a SpaceWire data stream but there is some uncertainty in their time of arrival – jitter – of some 10 bit times per link

- 1µs per link at 10Mb/s
- 100ns per link at 100Mb/s

We show how this can be reduced to 10ns (or better) per link.

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Content

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- The causes of jitter
- Experimental verification
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- Experimental verification
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SpaceWire links, tokens and time-codes

A SpaceWire link sends sequences of bits, in units of *tokens*:

EOP	End-of-packet marker	4-bits
EEP	End-of-packet marker	4-bits
FCT	Flow control token	4-bits
ESC	(only as part of compound)	
Data	Byte-wide data	10-bits
ESC-FCT	Null	8-bits
ESC-Data	Time code	14-bits

Nulls are sent if there is no higher priority token, to prevent disconnect detection.

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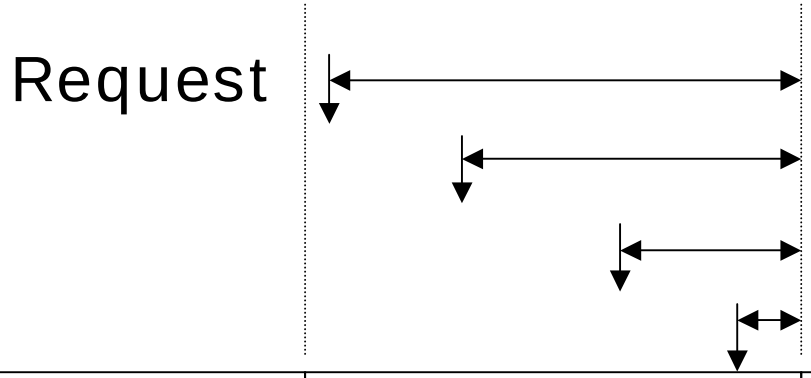
The causes of jitter

Transmit – link is busy when time code requested

- The time between the request and the time-code being sent varies.



	FCT	Null	Data	Time-code
	4-bits	8-bits	10-bits	14-bits

Receive – synchronization to local clock

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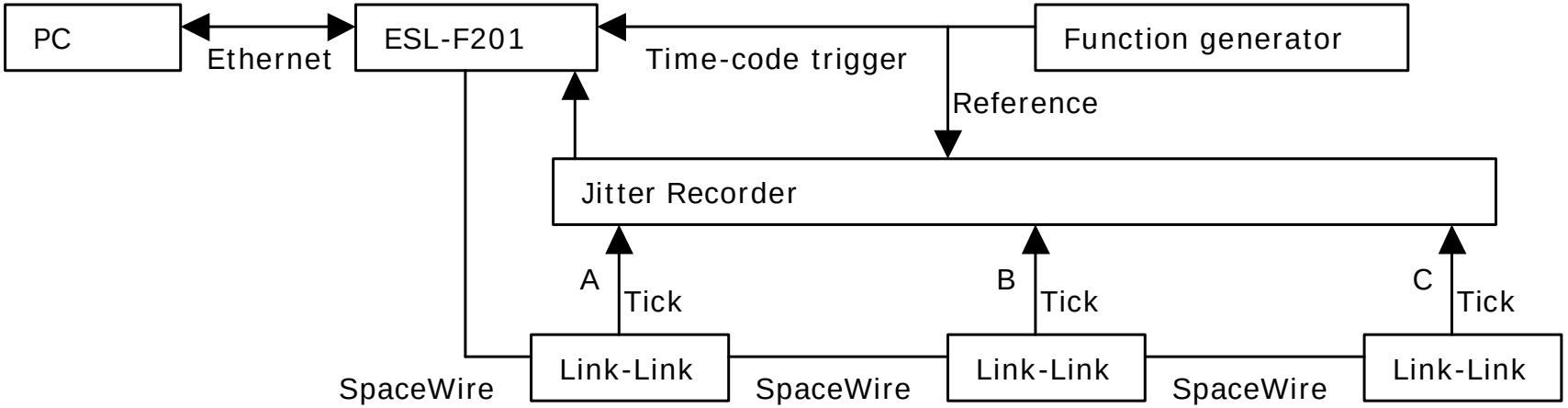
Experimental verification – test set



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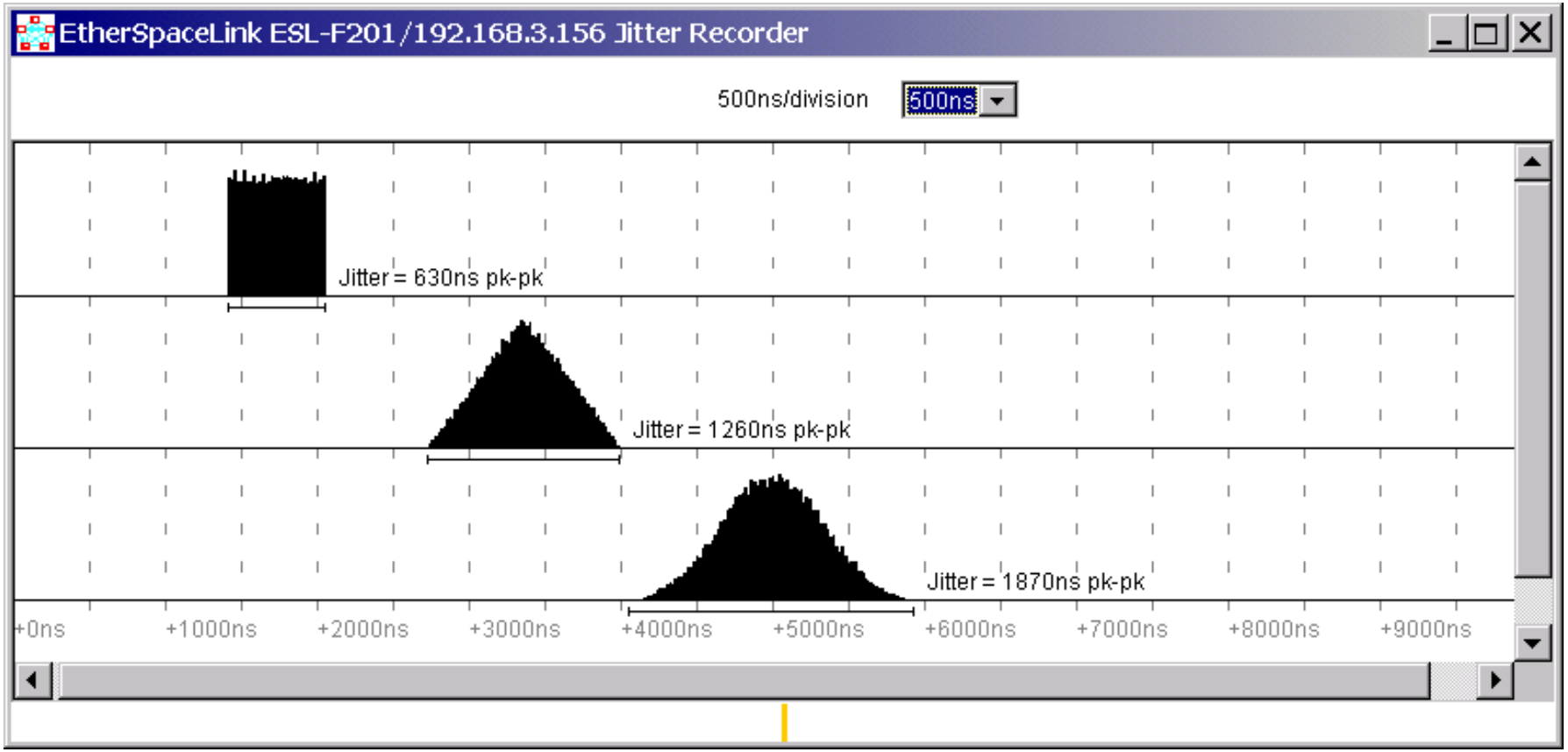
Experimental verification – normal link



Link speed 12.5Mb/s – bit period = 80ns

Link idling

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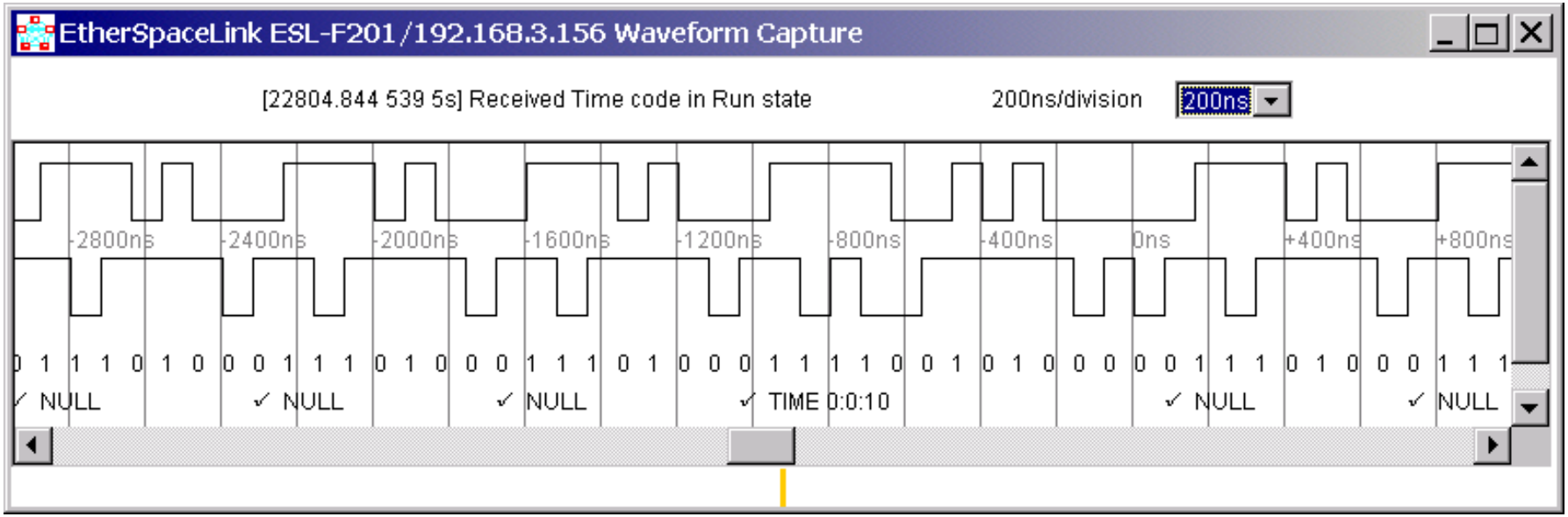
Reducing Jitter

Normal waveforms



Regular spacing of bits (80ns/bit at 12.5Mb/s)

BUT: clock is encoded in this stream (XOR of D and S) therefore, bit period can vary

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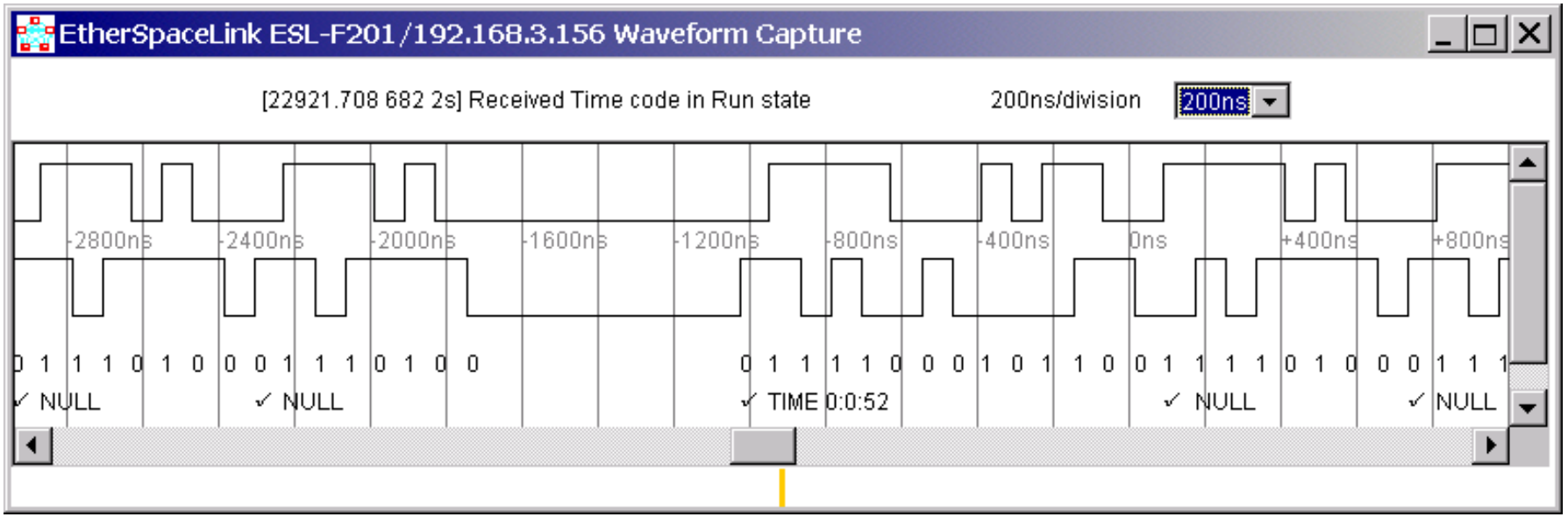
Reducing Jitter (2)

One, or more, bits can be longer than normal



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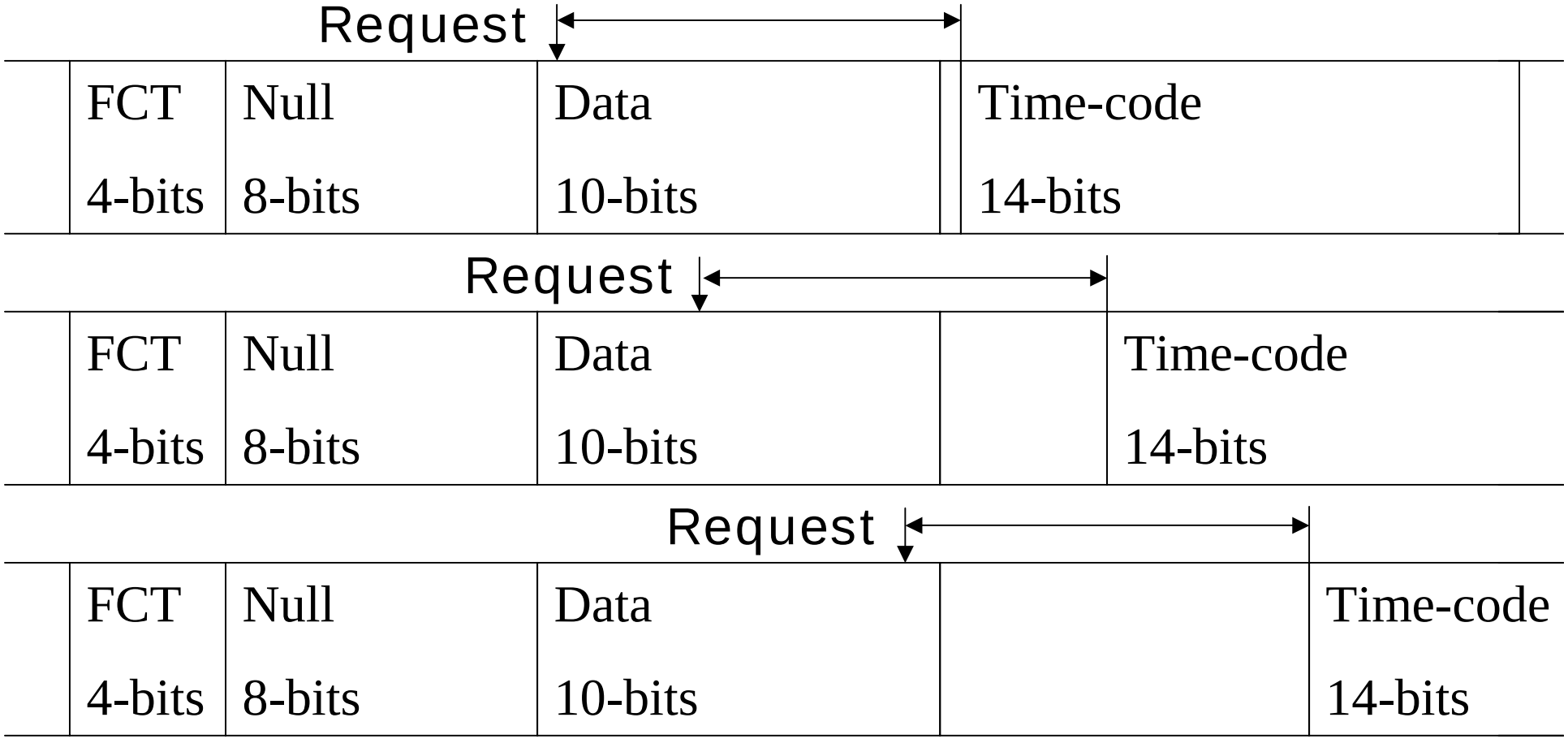
Reducing Jitter (3)

Fix the time between request and time code transmission (to >10-bits)



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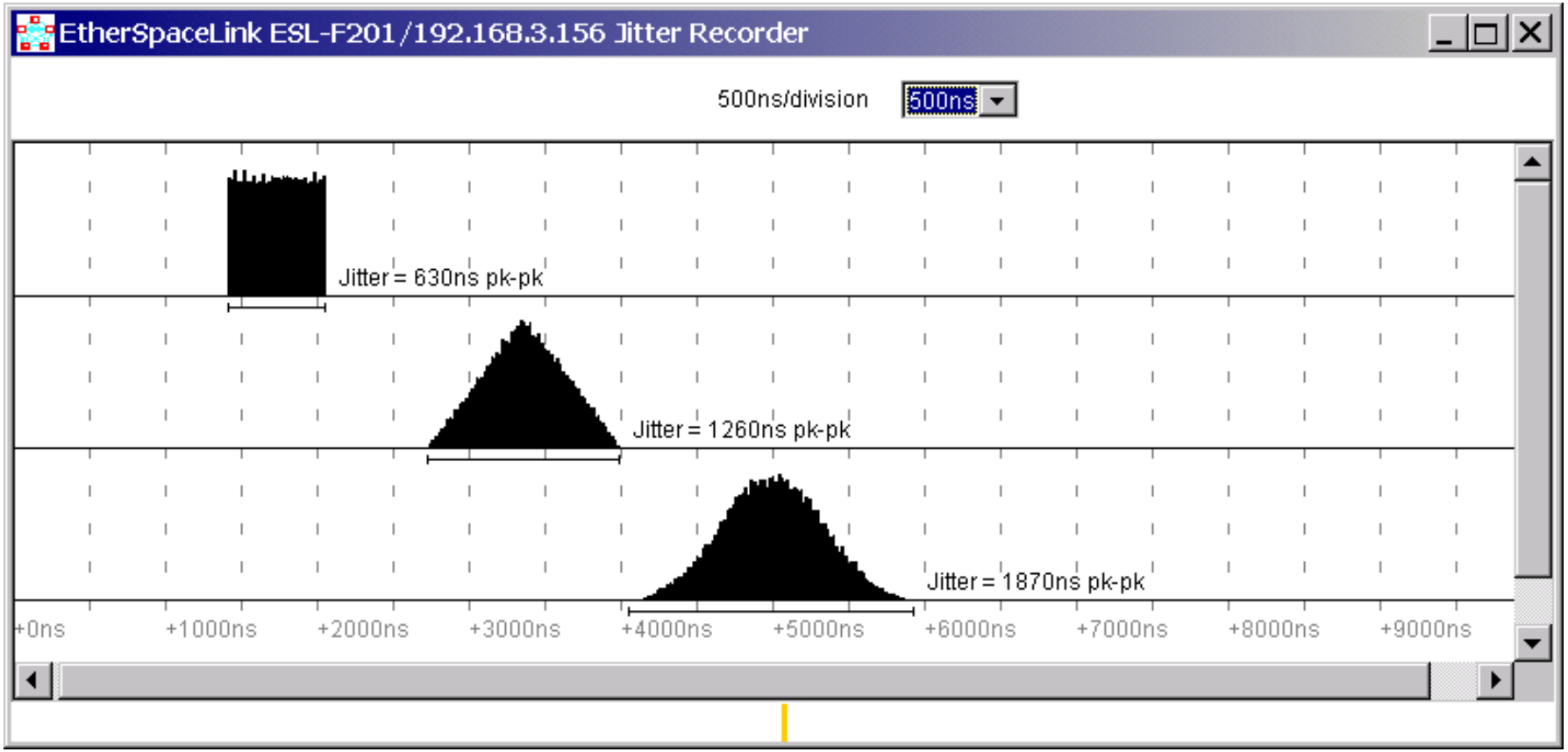
Experimental verification – normal link



Link speed 12.5Mb/s – bit period = 80ns

Link idling

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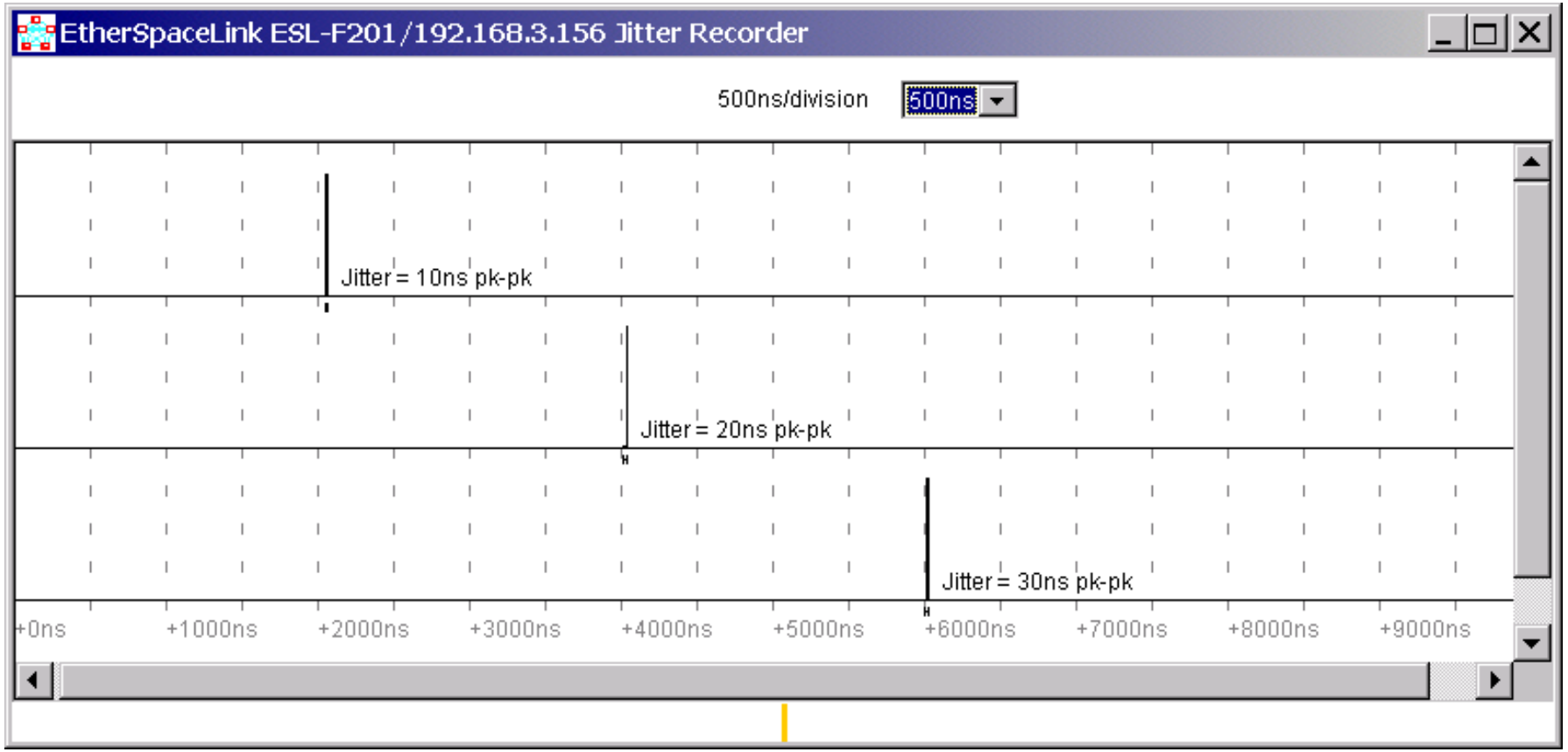
Experimental verification – modified link



Link speed 12.5Mb/s – bit period = 80ns

Link idling

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Limitations

Disconnect detection limits the length of any single bit

- If all the delay is placed before the time code, the minimum link speed is 12.5Mb/s;
- Distributing delays through the bits of the time-code reduces this to below 2.5Mb/s.

Each time-code is 0- to 10-bits longer, a time-code grows from 14- to 19-bits (average).

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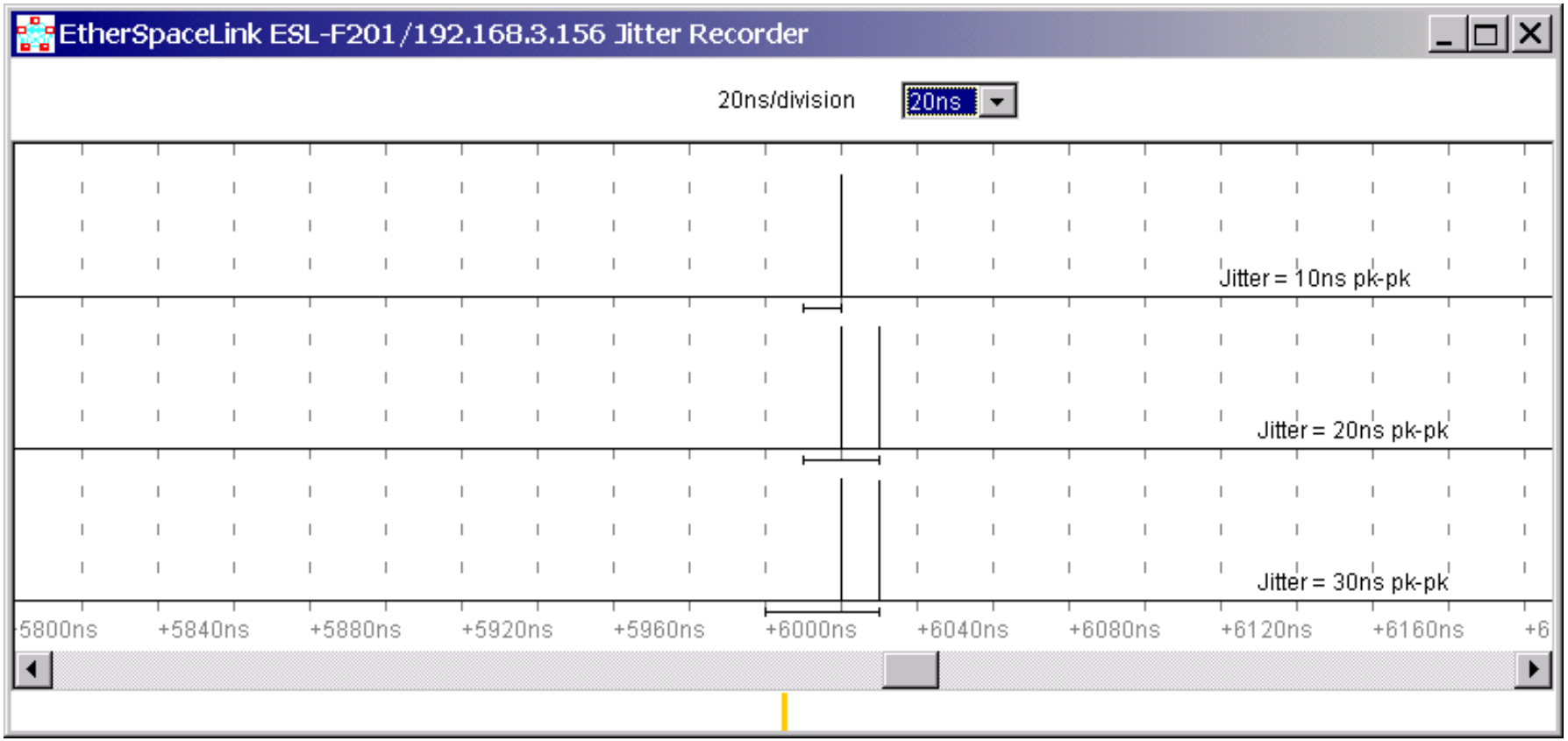
Extension

Early arriving time ticks can be delayed so that all ticks in the system are synchronized.



Link 1 delayed 3970ns, link 2 delayed 1990ns

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Conclusion

- A small change in the link transmitter can give a very significant reduction in time-code jitter.
- The receiver need not be altered, so long as its behaviour is deterministic.
- It is possible to produce accurately synchronized time codes at all nodes in a system.
- This makes time codes easier to use and enables their use in more applications.