

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.



Content

- •SpaceWire links, tokens and time-codes
- •The causes of jitter
- •Experimental verification
- •Reducing jitter
- •Experimental verification
- •Limitations
- •Extension
- Conclusion



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

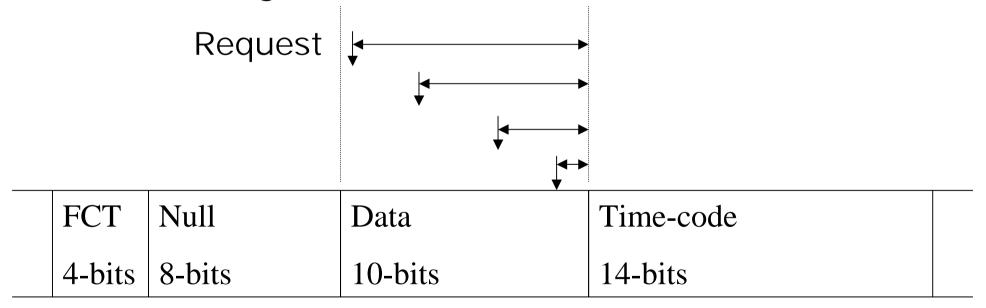
Nulls are sent if there is no higher priority token, to prevent disconnect detection.



The causes of jitter

Transmit – link is busy when time code requested

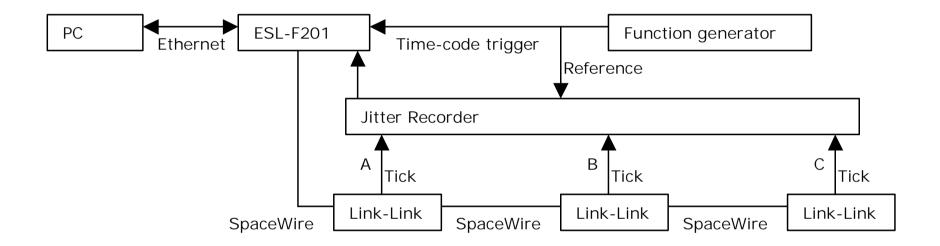
•The time between the request and the timecode being sent varies.



Receive – synchronization to local clock



Experimental verification – test set





Experimental verification – normal link

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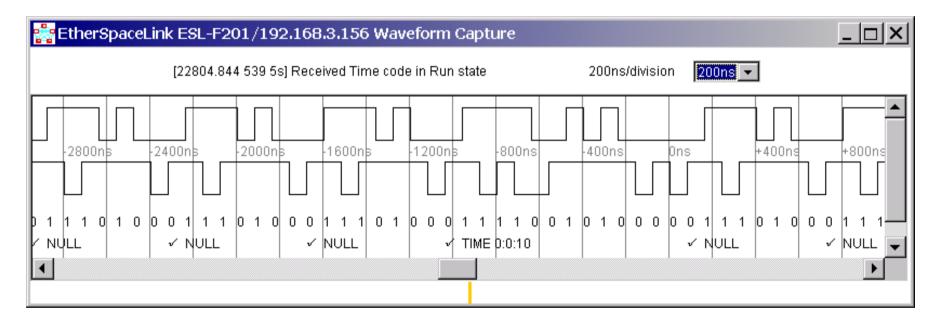
Link speed 12.5Mb/s - bit period = 80ns

Link idling



Reducing Jitter

Normal waveforms



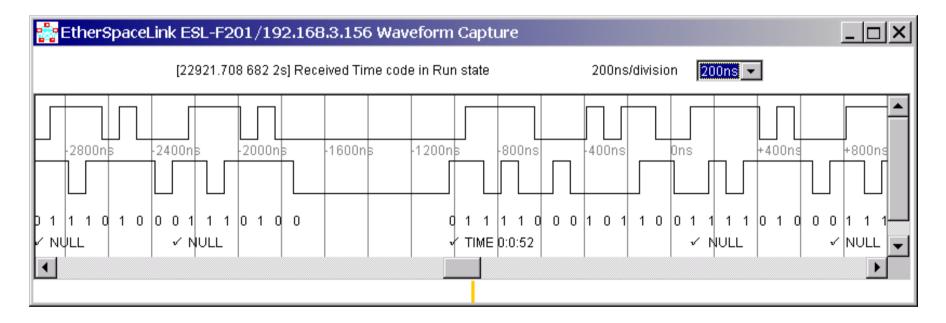
Regular spacing of bits (80ns/bit at 12.5Mb/s)

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



Reducing Jitter (2)

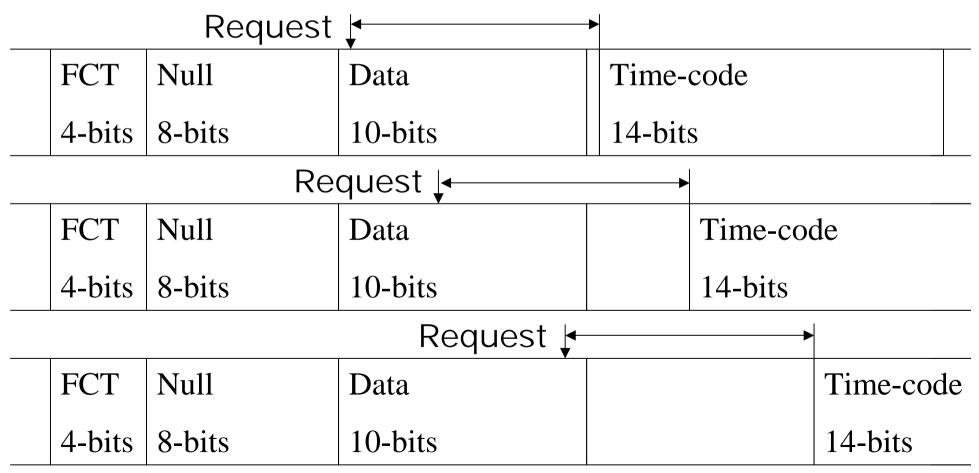
One, or more, bits can be longer than normal





Reducing Jitter (3)

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





Experimental verification – normal link

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

Link idling



Experimental verification – modified link

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

Link idling



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 timecode 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).



Extension

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

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								2	Ons/divisi	on	20ns 🗸									
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-5	800ns	+58	40ns	+58	80ns	+59	20ns	+59	60ns	+6000	Ins	+60	40ns	+60	180ns	+61	20ns	+61	60ns	+6
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Link 1 delayed 3970ns, link 2 delayed 1990ns



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.