

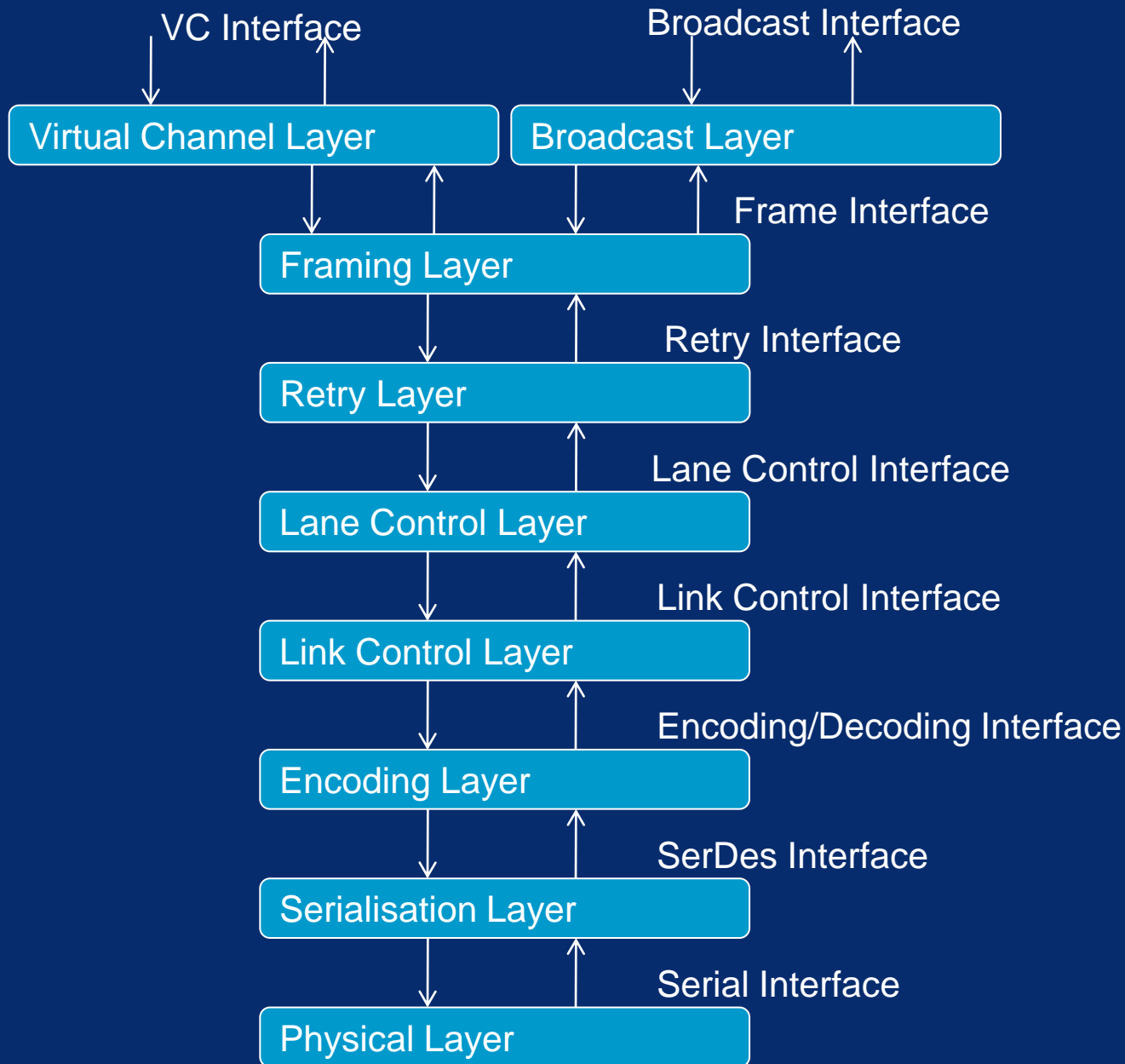
SpaceFibre CODEC: Use of the TLK2711-SP

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SpaceFibre Overview





SpaceFibre Layers

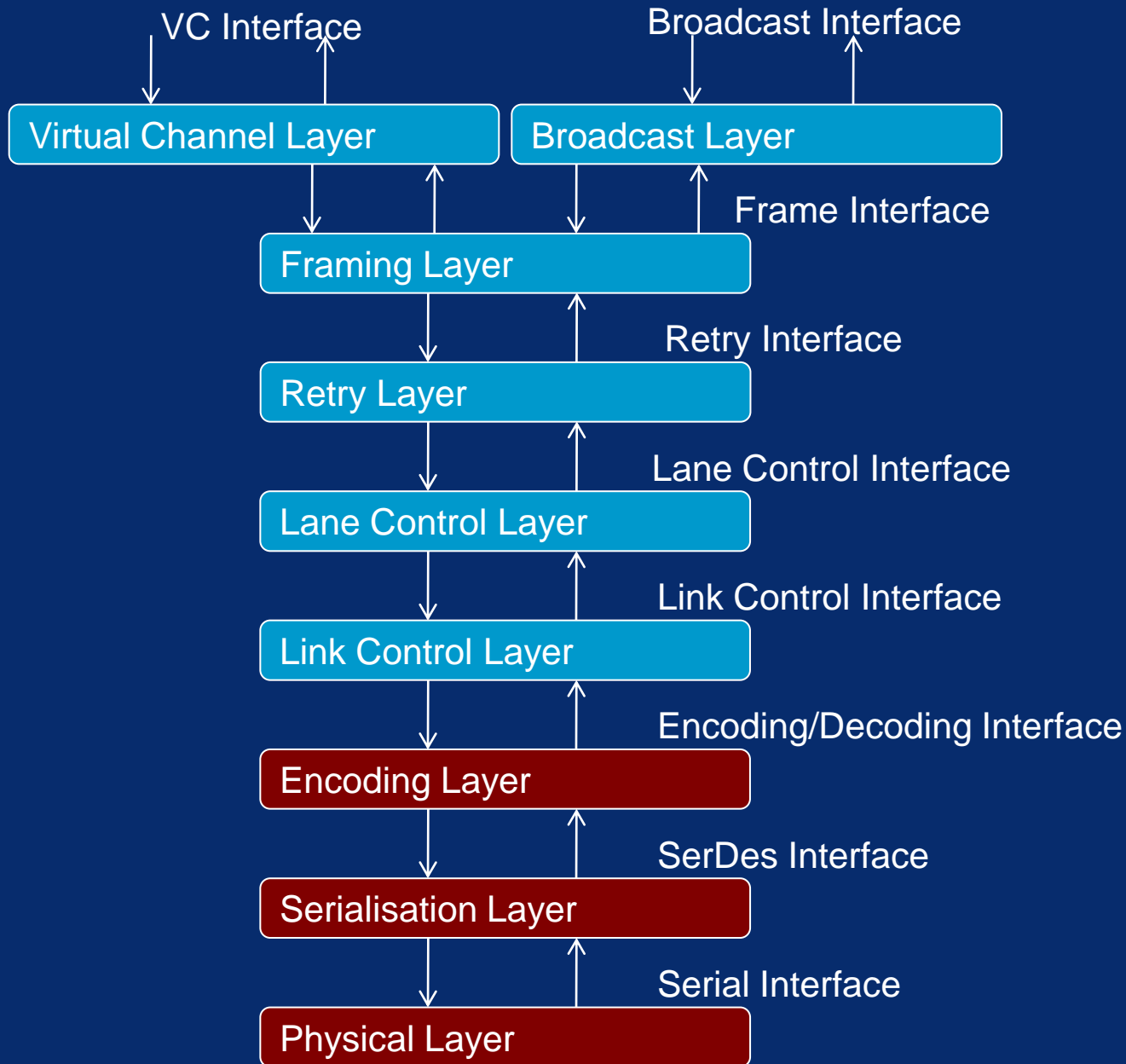
- **Virtual Channel:**
 - Quality of service and flow control
- **Broadcast:**
 - broadcasts short messages across network
- **Framing:**
 - Frames information to be sent over link
 - Scrambles SpaceWire packet data
- **Retry:**
 - Recovers from transient and persistent errors



SpaceFibre Layers

- **Lane Control:**
 - Runs several SpaceFibre links in parallel
 - Provides higher data throughput and redundancy with graceful degradation
- **Link Control:**
 - Link initialisation, error detection and re-initialisation
- **Encoding/Decoding:**
 - Encodes data into symbols for transmission
- **Serialisation:**
 - Serialises SpaceFibre symbols
- **Physical:**
 - Fibre optic or copper medium.

SpaceFibre and TLK2711-SP



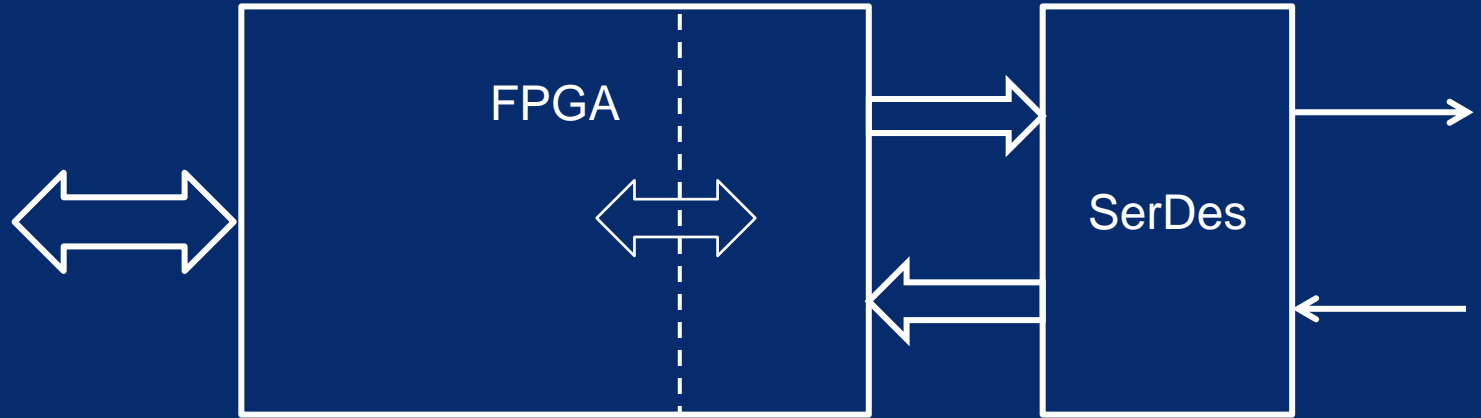


Spaceflight Implementation

- How can we implement this today
 - For flight applications
 - Avoiding several years of chip development and qualification effort?
- Difficult bit is the SerDes
 - Runs at high speed
 - Requires analogue phase-locked loop
- Solution: use existing radiation tolerant SerDes and FPGA
- Possibly Xilinx if the MGTs are radiation tolerant?



Flight Implementation



Encoding

Application
Logic

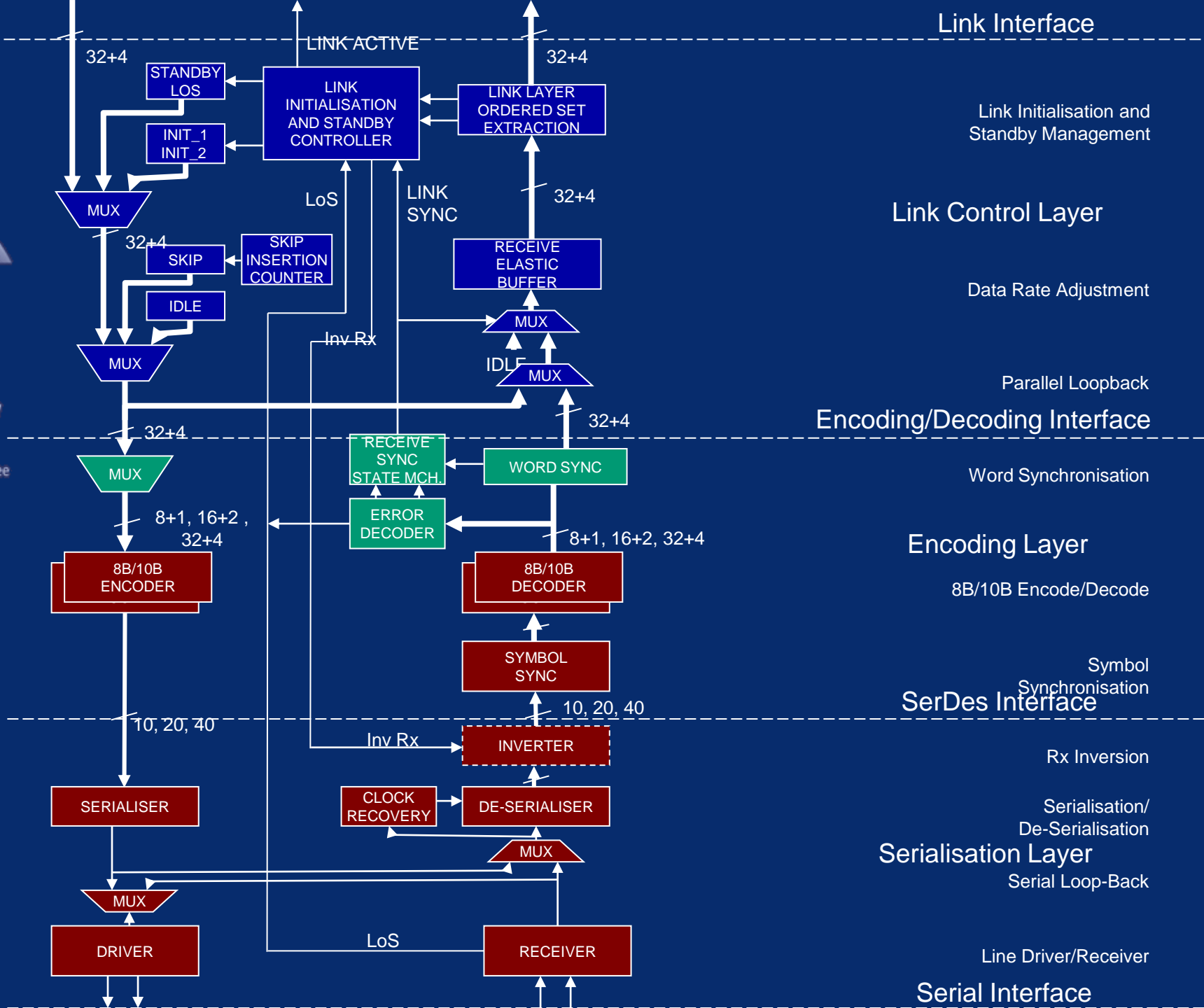
Link Control
Lane Control
Retry
Framing
Virtual Channels
Broadcast Channel

Serialisation



TLK2711-SP

- TLK2711-SP
 - Radiation tolerant SerDes
 - Includes 8B/10B encoder/decoder
 - Runs at 2.5 Gbits/s
 - 2 Gbit/s actual data rate
 - Combined with a radiation tolerant FPGA
 - Can be used to implement radiation tolerant SpaceFibre interface
- Problem: incompatible with draft SpaceFibre standard!
- SpaceFibre specification modified to be able to use this device
- Also possible to use other SerDes devices





8B/10B Coding

- Zero DC bias:
 - same number of ones and zeros
- 10-bit symbols representing
 - 8-bit data codes
 - Some control codes, K-codes
 - Codes use
 - 5 ones and 5 zeros
 - 4 ones and 6 zeros
 - 6 ones and 4 zeros
 - Characters with different number of 1s and 0s have two possible codes to preserve DC bias

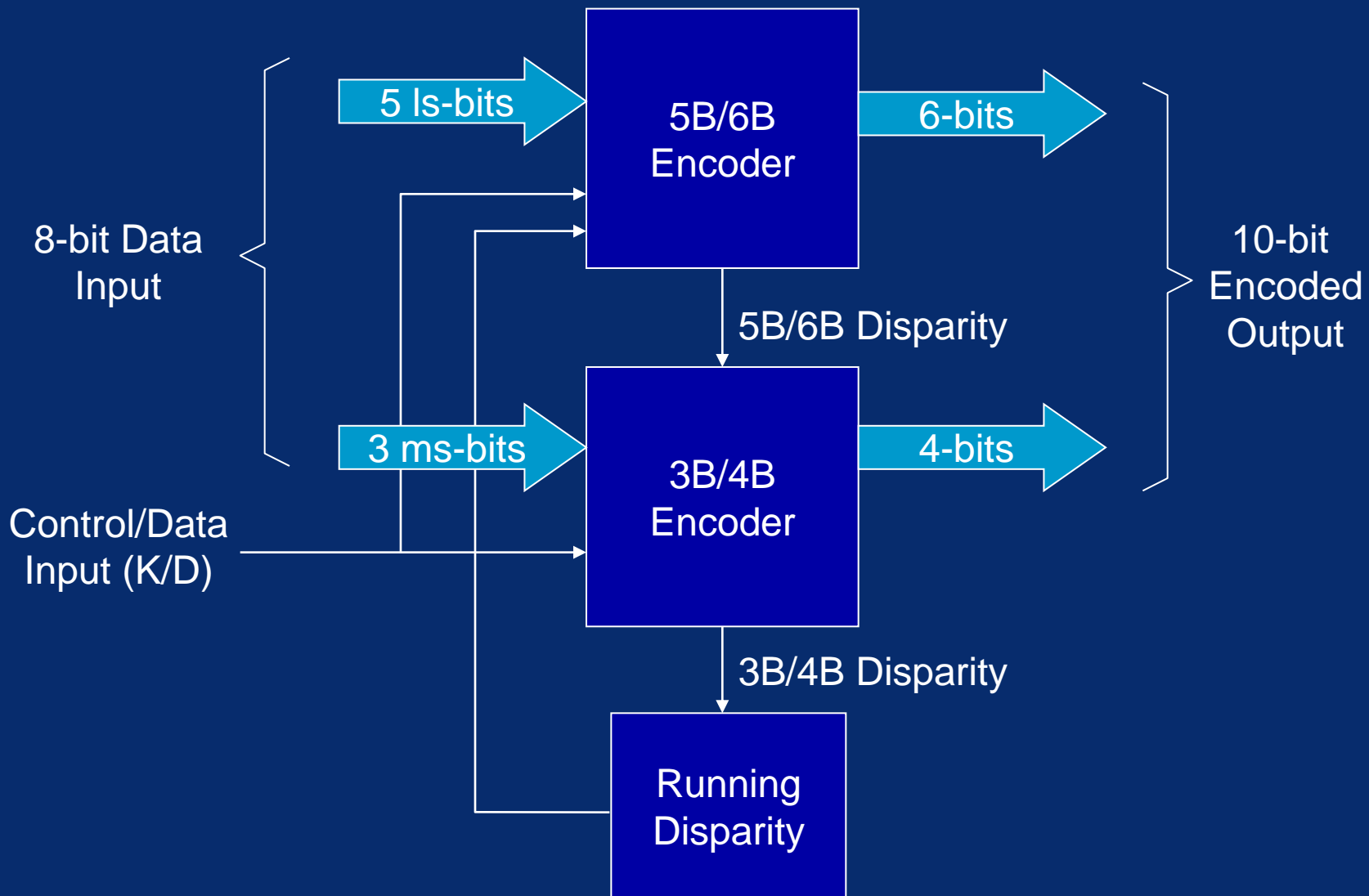


8B/10B Coding

- Ensures sufficient bit transitions for clock recovery
 - No more than 5 consecutive ones or zeros
- All characters encoded with 10-bits giving constant bit and character rates, simplifying transmitter and receiver
- Unused codes can be used to detect link errors



8B/10B Encoder



Part of 5B/6B Encoding Table

Input		Output	
Data Input	Data bits 43210 (EDCBA)	Current Running Disparity -ve abcdei	Current Running Disparity +ve abcdei
D00.y	00000	100111	011000
D01.y	00001	011101	100010
D02.y	00010	101101	010010
D03.y	00011	110001	
D04.y	00100	110101	001010
D05.y	00101	101001	
D06.y	00110	011001	
D07.y	00111	111000	000111
D08.y	01000	111001	000110
D09.y	01001	100101	
D10.y	01010	010101	

3B/4B Encoding



Input		Output	
Data Input	Data bits 765 (HGF)	3B/4B Disparity -ve fghj	3B/4B Disparity +ve fghj
D/Kxx.0	000	1011	0100
Dxx.1	001	1001	
Kxx.1	001	0110	1001
Dxx.2	010	0101	
Kxx.2	010	1010	0101
D/Kxx.3	011	1100	0011
D/Kxx.4	100	1101	0010
Dxx.5	101	1010	
Kxx.5	101	0101	1010
Dxx.6	110	0110	
Kxx.6	110	1001	0110
Dxx.7	111	1110/0111	0001/1000
Kxx.7	111	0111	1000



8B/10B Control (K) Codes

Input Special Character Name	Output	
	Current Running Disparity -ve	Current Running Disparity +ve
K28.0	001111 0100	110000 1011
K28.1	<u>001111</u> 1001	<u>110000</u> 0110
K28.2	001111 0101	110000 1010
K28.3	001111 0011	110000 1100
K28.4	001111 0010	110000 1101
K28.5	<u>001111</u> 1010	<u>110000</u> 0101
K28.6	001111 0110	110000 1001
K28.7	<u>001111</u> 1000	<u>110000</u> 0111
K23.7	111010 1000	000101 0111
K27.7	110110 1000	001001 0111
K29.7	101110 1000	010001 0111
K30.7	011110 1000	100001 0111



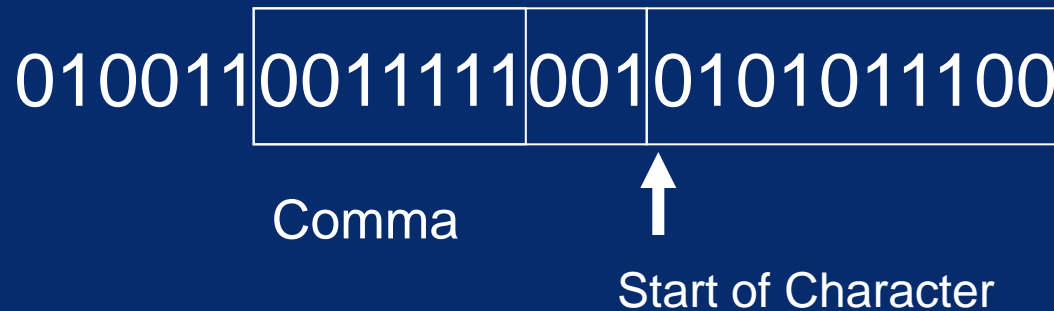
Symbol synchronisation

- 8B/10B Comma Pattern
 - Three control codes contain a unique 7-bit pattern
 - 0011111 or 1100000
 - Does not occur in data codes
 - Cannot be produced by combining any data code or other control code
 - Pattern is known as the comma pattern
 - Widely used for character synchronisation

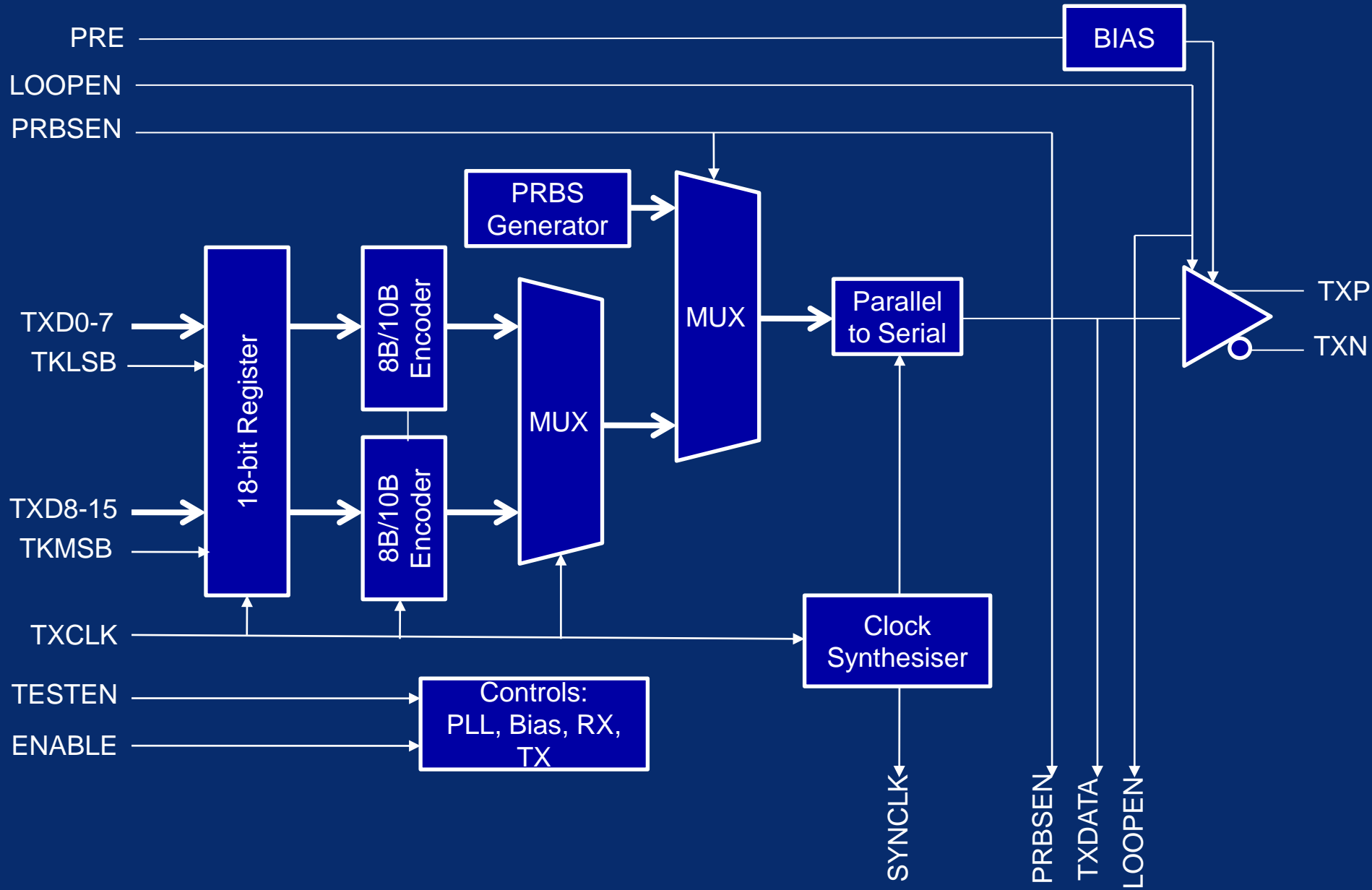


Symbol synchronisation

- Commas
 - Used to detect the character boundaries in the serial bit stream
 - Contain unique seven bit sequences
- Plus Comma
 - 0011111
- Negative Comma
 - 1100000
- Example

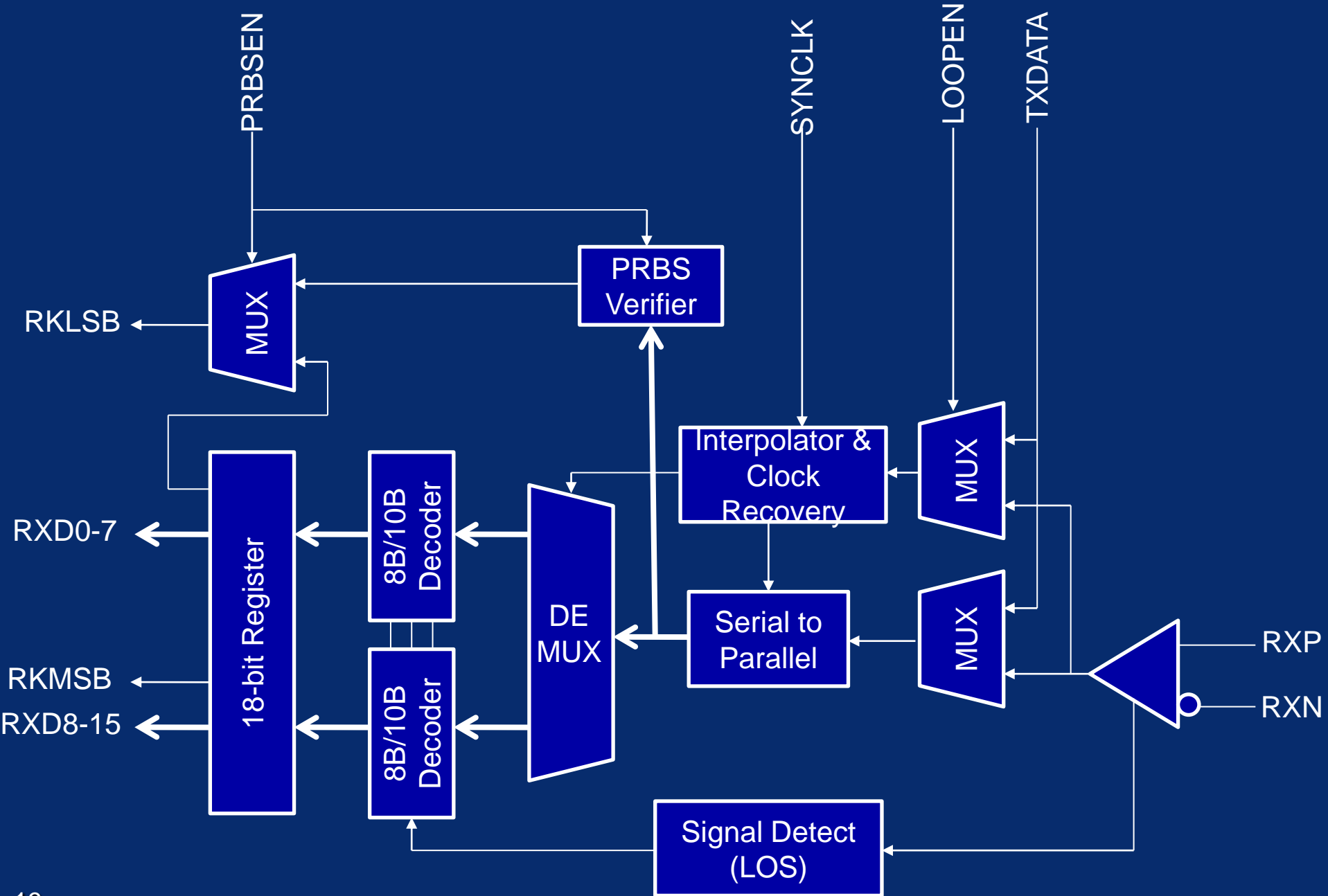


TLK2711-SP Transmitter



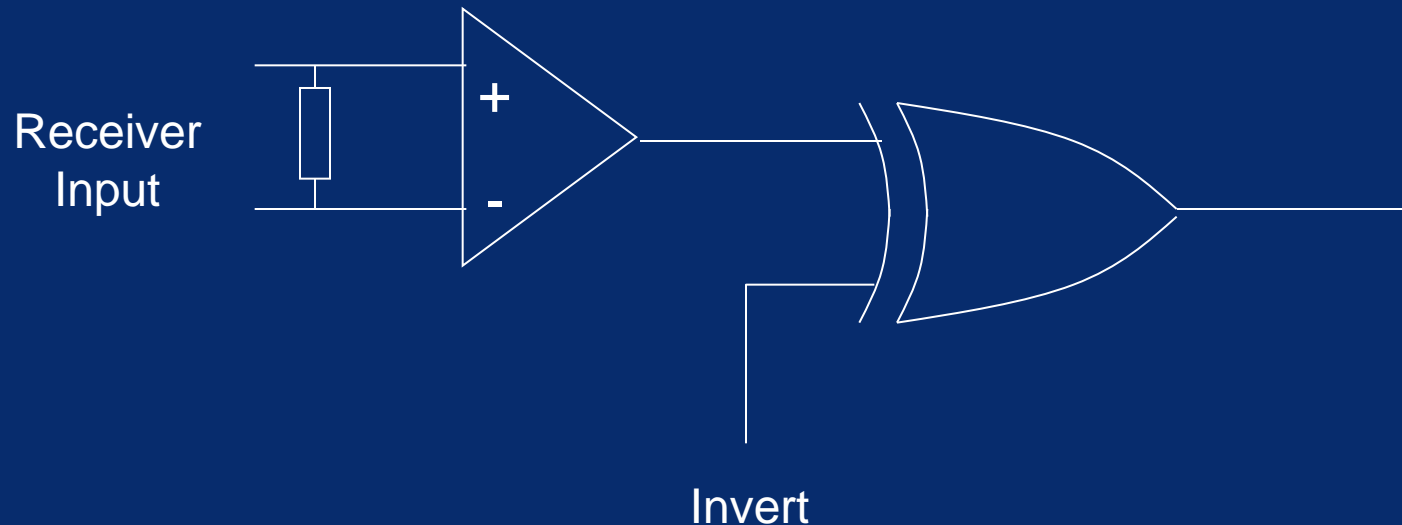
To RX

TLK2711-SP Receiver



TLK2711 Compatibility with SpaceFibre

- Changing receive polarity
 - To simplify high-speed PCB layout
 - And improve signal integrity
 - Include change of polarity on receiver input
 - Detect polarity
 - Swap polarity if required





TLK2711 Compatibility with SpaceFibre

- Bit stream inversion
 - TLK2711 does not support bit inversion
 - Bit inversion is useful to help PCB layout
 - SpaceFibre makes bit inversion mandatory for new devices
 - But permits legacy devices like TLK2711 to not implement bit inversion
- Detecting inversion
 - INIT1 and IDLE control words have valid bitwise inverse symbols
 - Can then detect if direct or inverse INIT1's being received
 - If inverse, change polarity of receiver



TLK2711 Compatibility with SpaceFibre

- Bit synchronisation
 - Bit and symbol synchronisation performed inside TLK2711
 - Status information not provide
 - Impact on receive synchronisation state machine
 - Now uses reception of valid symbols to indicate bit and symbol synchronisation

TLK2711 Compatibility with SpaceFibre

- Symbol synchronisation
 - Does not support symbol synchronisation on negative disparity commas
 - Link might never synchronise, depending on data being sent

Symbol	Comma	Data	Data	Data	Comma	Data	Data	Data
Ones/zeros	diff	diff	same	same	diff	diff	diff	diff
Disparity	-ve	+ve	-ve	-ve	-ve	+ve	-ve	+ve

↑
↑
 Not Sync'ed Not Sync'ed

TLK2711 Compatibility with SpaceFibre

- Solution to Symbol Synchronisation
 - During initialisation
 - Use pairs of control words both starting with comma
 - Comma has +ve or -ve disparity
 - First control word has only symbols with same number of 1s and 0s after the comma

Symbol	Comma	Data	Data	Data	Comma	Data	Data	Data
Ones/zeros	diff	same	same	same	diff	?	?	?
Disparity	-ve	+ve	+ve	+ve	+ve	-ve	?	?
	↑ Not Sync'ed				↑ Sync'ed			

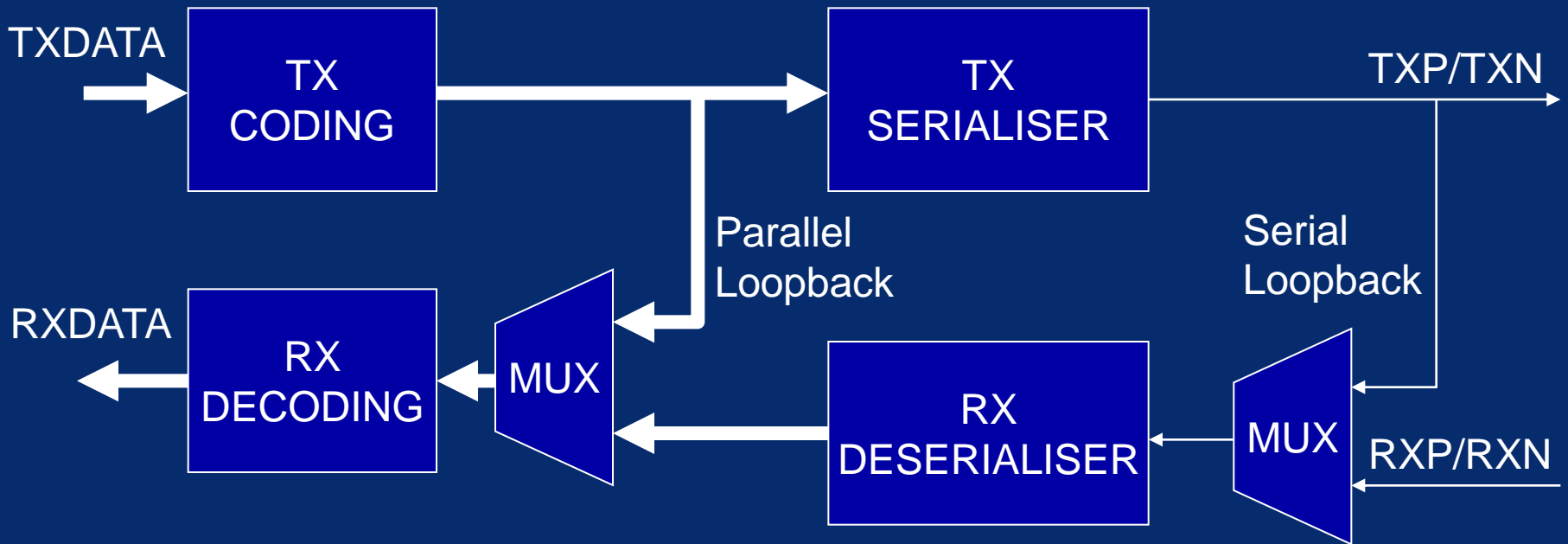


TLK2711 Compatibility with SpaceFibre

- Solution to Symbol Synchronisation
 - During initialisation
 - Polarity is not known
 - INIT1 and IDLE control words have valid bitwise inverse symbols
 - These bitwise inverse symbols are chosen to also have same number of 1s and 0s
 - So if bit stream is inverted can still synchronise

Loopback

- Normal operation
- Internal parallel loopback
- Internal serial loopback





TLK2711 Compatibility with SpaceFibre

- Parallel loopback
 - Not implemented in TLK2711
 - It does provide serial loopback
 - SpaceFibre makes parallel loopback optional
 - Serial loopback is mandatory



TLK2711 Compatibility with SpaceFibre

■ Interface

- Interface to TLK2711 is 16-bits data + 2 D/K bits
 - i.e. two symbols wide
- SpaceWire uses control and data words
 - Four symbols wide
 - 32-bits + 4 D/K bits
- Need to be multiplexed over TLK2711 interface
- SpaceFibre specification permits 8+1, 16+2, or 32+4 wide interfaces to be used



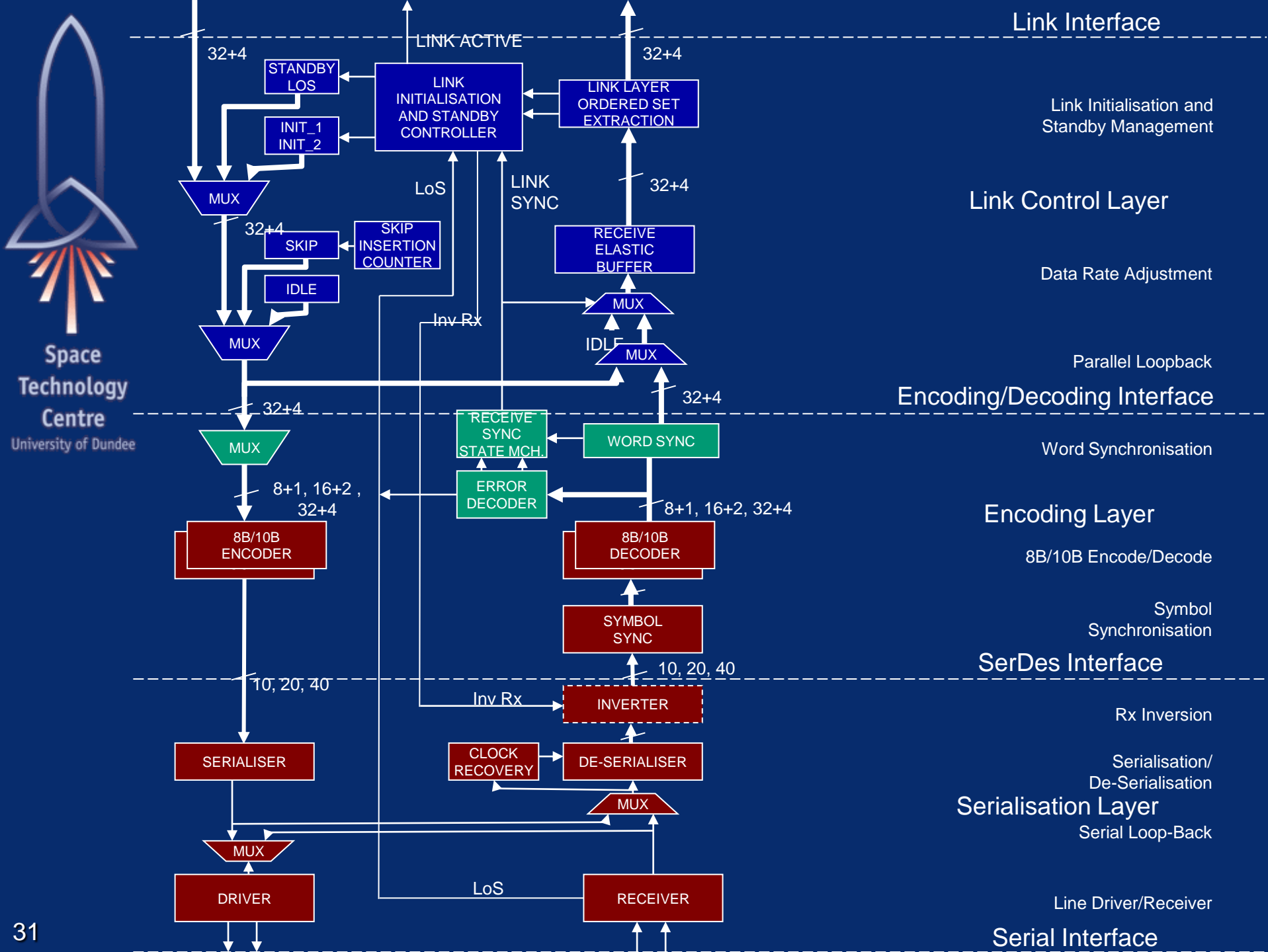
TLK2711 Compatibility with SpaceFibre

- Error indication
 - TLK2711 indicates error detected by receiver by output of a K0.0 code
 - Which is not a valid K-code
 - Decoder needed to decode this K-code into an error signal



TLK2711 Compatibility with SpaceFibre

- Line drivers and receivers
 - TLK2711 uses Voltage Mode Logic (VML)
 - SpaceFibre specifies Current Mode Logic (CML)
 - To improve conducted emissions
 - Can translate from VML to CML using resistor network





Revised SpaceFibre Architecture

- Interface to lower layers
 - Compatible with different serialiser/de-serialiser devices
 - May be necessary to adapt specific device to this common interface
- Encoding/decoding interface
 - Transfer control and data words
 - Encoding
 - 8B/10B encoding into groups of four symbols
 - Decoding
 - Symbol synchronisation
 - 8B/10B decoding
 - Word synchronisation to from control and data words

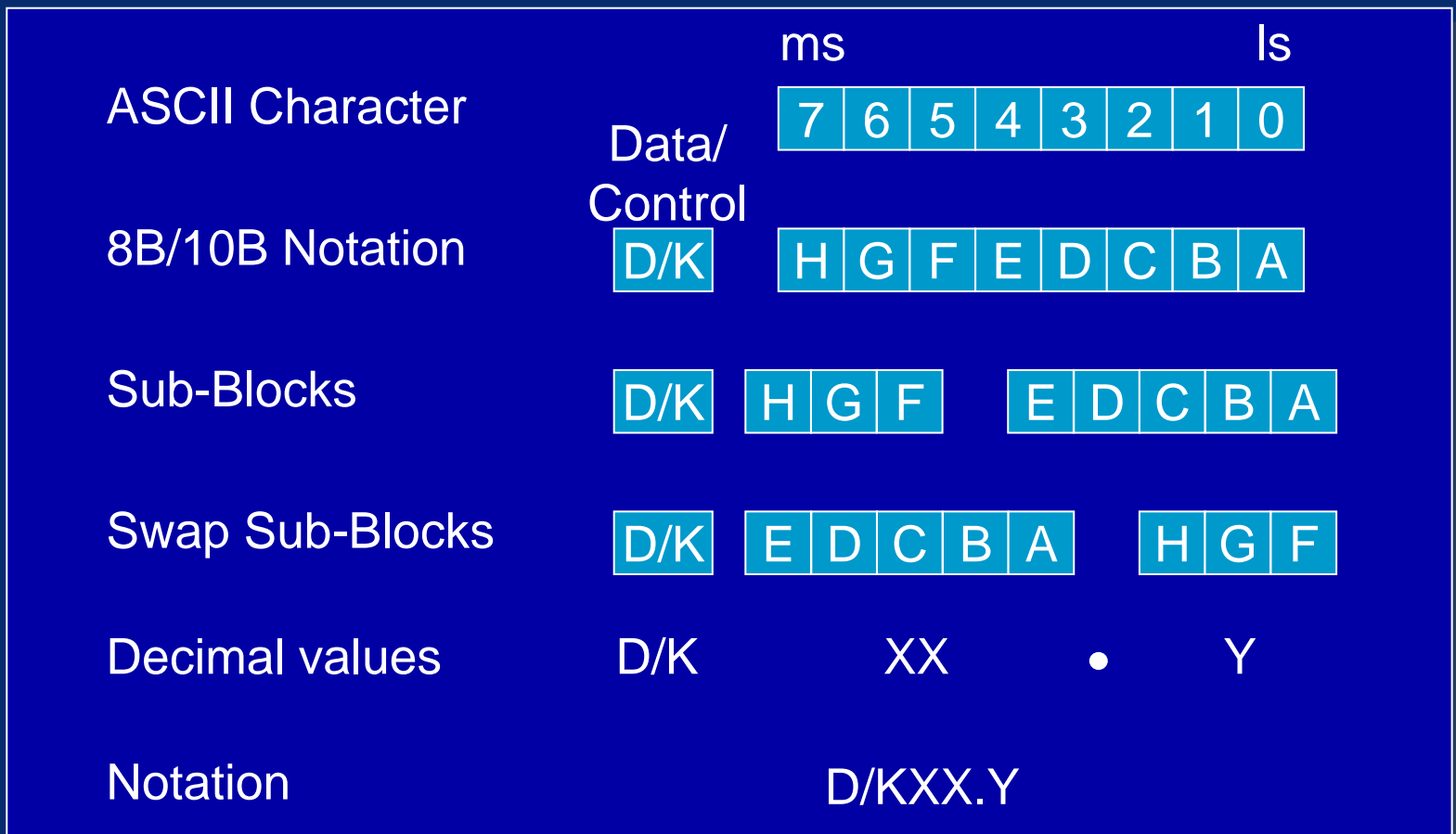


Conclusions

- SpaceFibre designed to meet needs of future spacecraft
 - High data-rate
 - Quality of service
 - FDIR
- TLK2711-SP is a radiation tolerant SerDes
 - Which includes 8B/10B encoding/decoding
- Can be used as lower level of SpaceFibre
- Enables immediate implementation of flight qualified SpaceFibre design
- SpaceFibre specification modified to be able to use TLK2711-SP



8B/10B Notation





8B/10B Notation Examples

	1 0 1 0 1 1 0 0										
D	1 0 1 0 1 1 0 0										
D	1 0 1			0 1 1 0 0							
D	0 1 1 0 0					1 0 1					
D	12			•	5						
D12.5											

	1 0 1 1 1 1 0 0										
K	1 0 1 1 1 1 0 0										
K	1 0 1			1 1 1 0 0							
K	1 1 1 0 0					1 0 1					
K	28			•	5						
K28.5											