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Comparison of NRZ and Duobinary Receivers with and without Precoding

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Statement of Problem

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- **Goal**: Derive a common transmitter for use with either an NRZ or a duobinary receiver.
- Implementation complexity and error propagation discussed for following 4 cases:

Duobinary receiver *without* Tx precoding	Duobinary receiver *with* Tx precoding
NRZ receiver *without* Tx precoding	NRZ receiver *with* Tx precoding

Transmitter with Precoder

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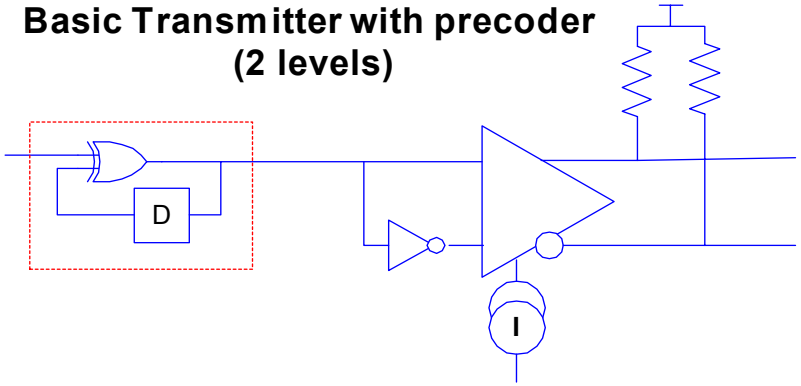
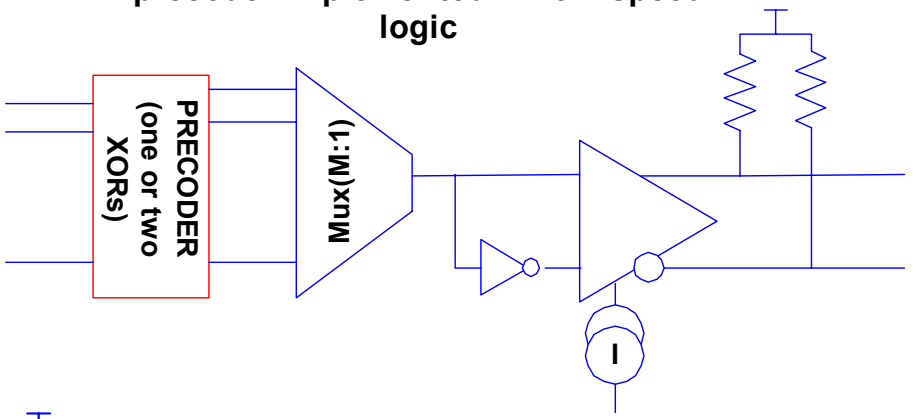
- Transmitter with precoder
  - Precoder in Tx simplifies duobinary decoding in Rx and avoids error propagation
  - Precoder can also be implemented in parallel at lower speeds

Basic Transmitter with precoder (2 levels)

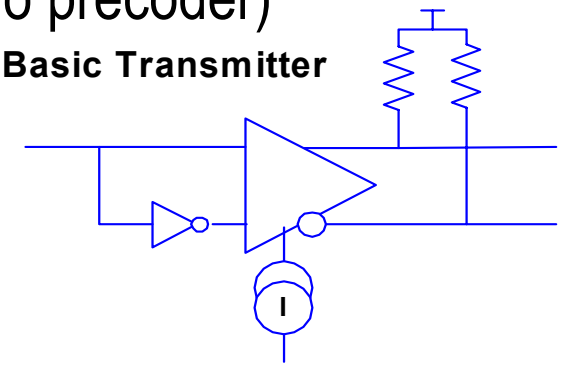


Basic Transmitter (2 levels) with precoder implemented in low-speed logic



- Basic Transmitter (no precoder)

Basic Transmitter



Duobinary Receiver without Tx Precoding

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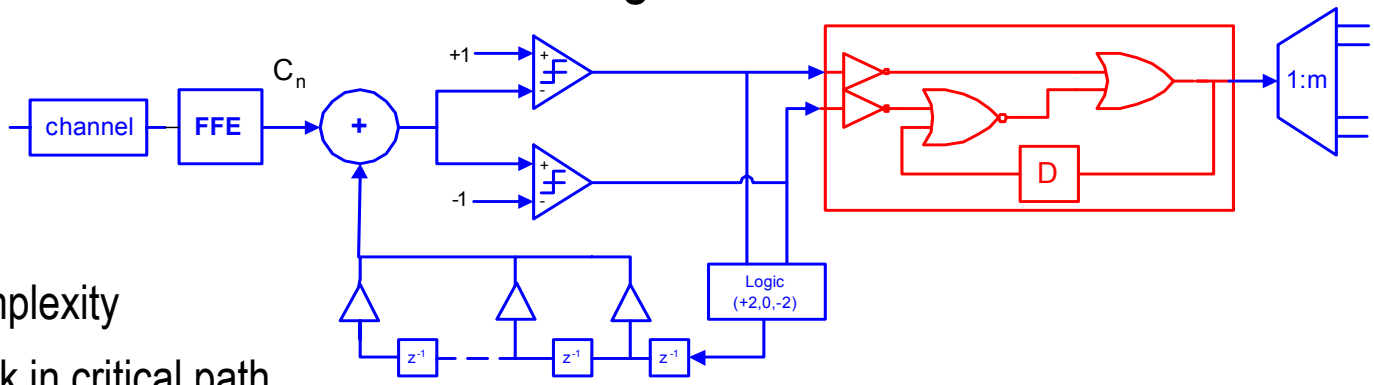
- Duobinary Decoder without Tx Precoding



  - Decoder complexity
    - Feedback in critical path
    - Can be implemented in parallel with lower speed logic -> requires an additional mux
    - 2 levels of logic + feedback path < 1 Tclk
  - Unbounded error propagation due to feedback in decoder
    - Error burst determined by # of consecutive '0's at C_n; e.g. 1 error propagates 4 errors

Original Stream	-1 1 1 –1 1 –1 1 1 1 –1 –1 –1
C_n	-2 0 2 0 0 0 0 2 2 0 –2 –2
C_n + error	-2 0 2 2 0 0 0 2 2 0 –2 –2
Decoded Stream	-1 1 1 1 -1 1 –1 1 1 -1 –1 -1

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Duobinary Receiver with Tx Pre-Coder

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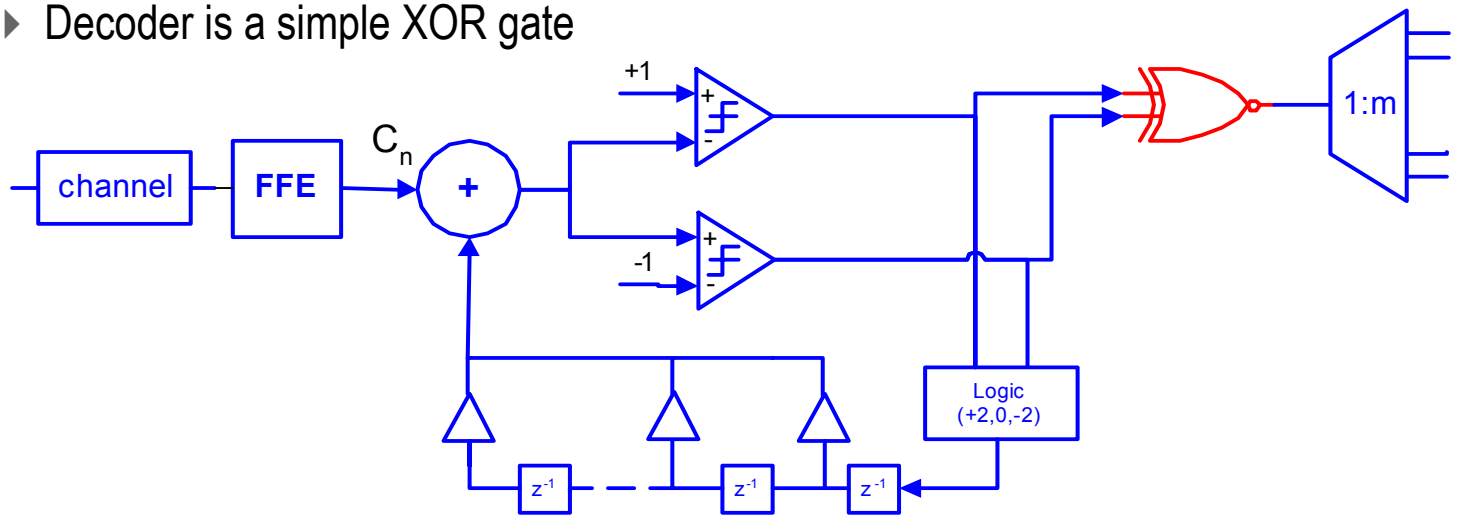
- Duobinary Rx with Tx Precoding
  - Decoder is a simple XOR gate



  - No error propagation

Original Stream	-1 1 1 –1 1 –1 1 1 1 –1 –1 –1
C_n (with precoding)	-2 0 0 -2 0 +2 0 0 0 -2 –2 –2
C_n + error	-2 0 0 -2 +2 +2 0 0 0 0 –2 –2
Decoded Stream	-1 1 1 –1 -1 –1 1 1 1 1 –1 –1

NRZ Receiver with precoding

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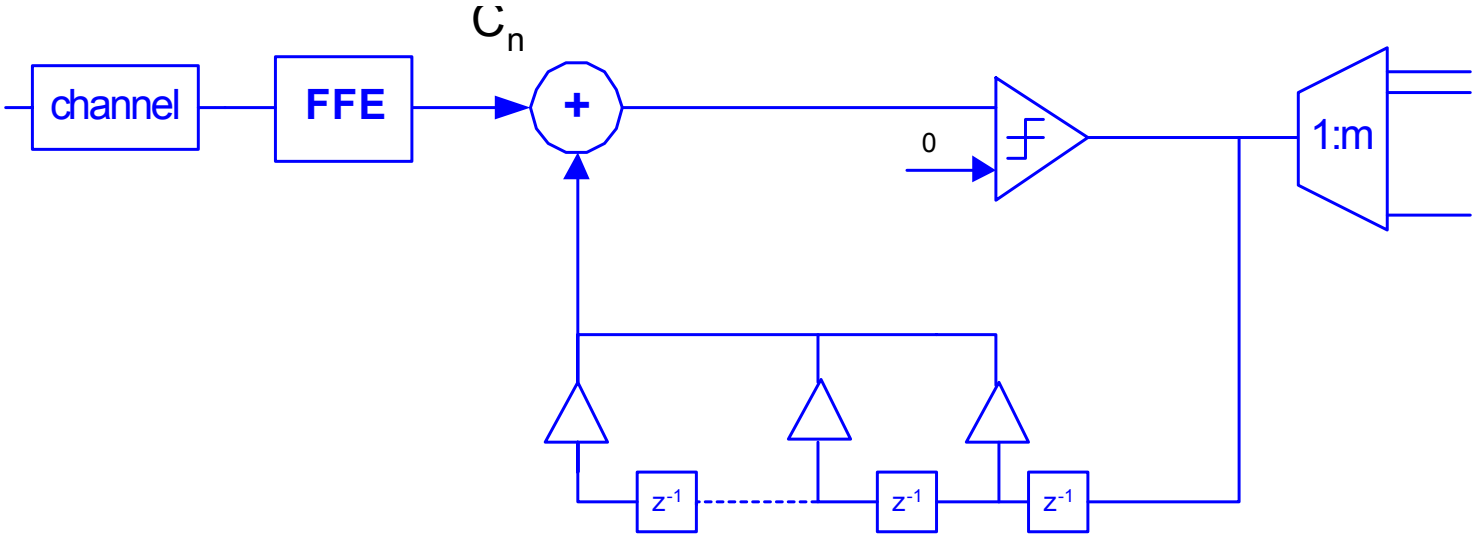
- NRZ receiver without Tx precoding



  - Classic NRZ receiver - no error propagation

NRZ Receiver with Tx precoding

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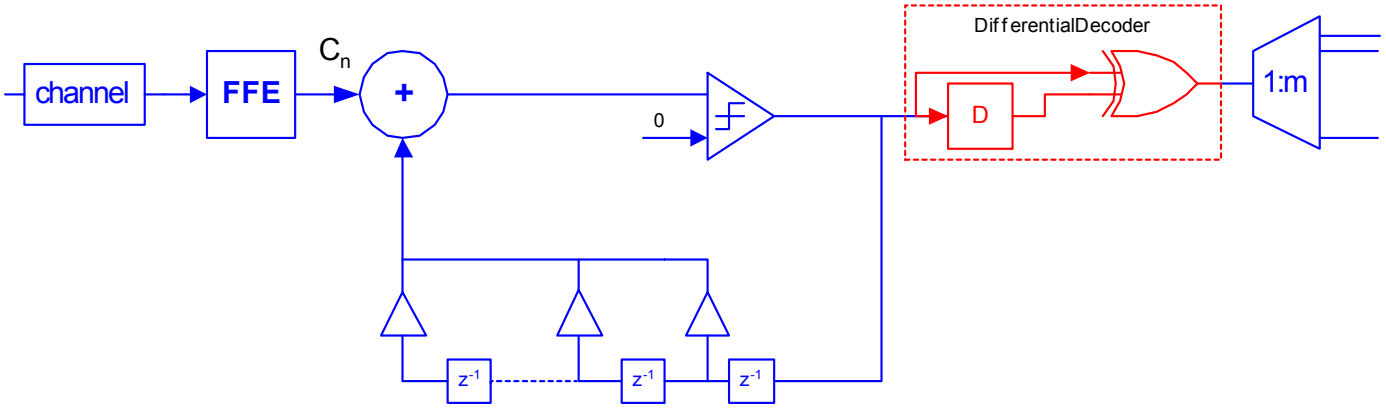
- NRZ receiver with Tx precoding
  - Requires a differential decoder to undo the Tx precoder



  - Bounded error propagation due to XOR and delay-element (limited to 2 bits)

Original Stream	-1 1 1 –1 1 –1 1 1 1 –1 –1 –1
C_n (with precoding)	-1 1 –1 –1 1 1 -1 1 –1 –1 –1 –1
C_n + error	-1 1 –1 1 1 1 -1 1 –1 –1 –1 –1
Decoded Stream	-1 1 1 1 0 –1 1 1 1 –1 –1 –1

Conclusion / Recommendation

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- Normative two-level transmitter must include a precoder
  - In the duobinary receiver
    - Eliminates unbounded error propagation
    - Decoder is a simple XOR gate
  - In the NRZ receiver
    - Trivial differential decoder required
    - Error propagation limited to 2 bits
- Approach provides maximum flexibility in receiver design options while minimizing overall circuit complexity in Tx and Rx