Receiver-Based Equalization for 10GBASE-T

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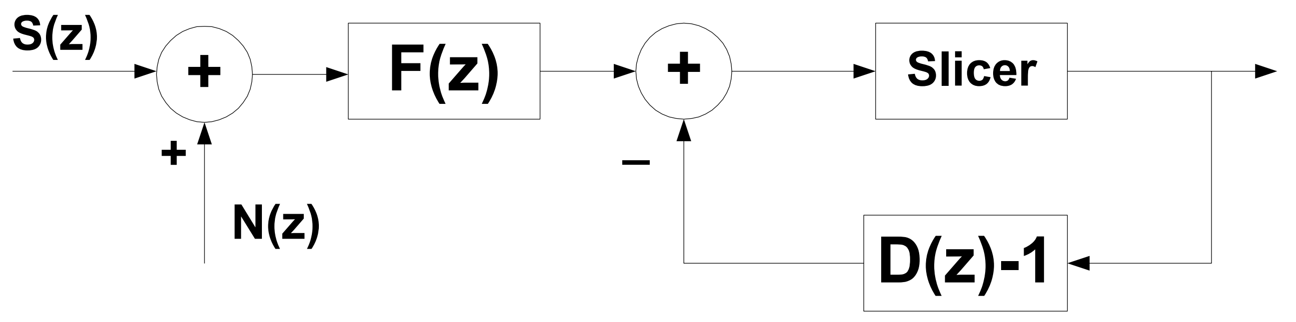
Outline

- Receiver-based DFE processing for low error propagation
- Simulation Results
- Laboratory Results
- Analog Requirements
- Conclusions

Traditional FFE/DFE Configuration



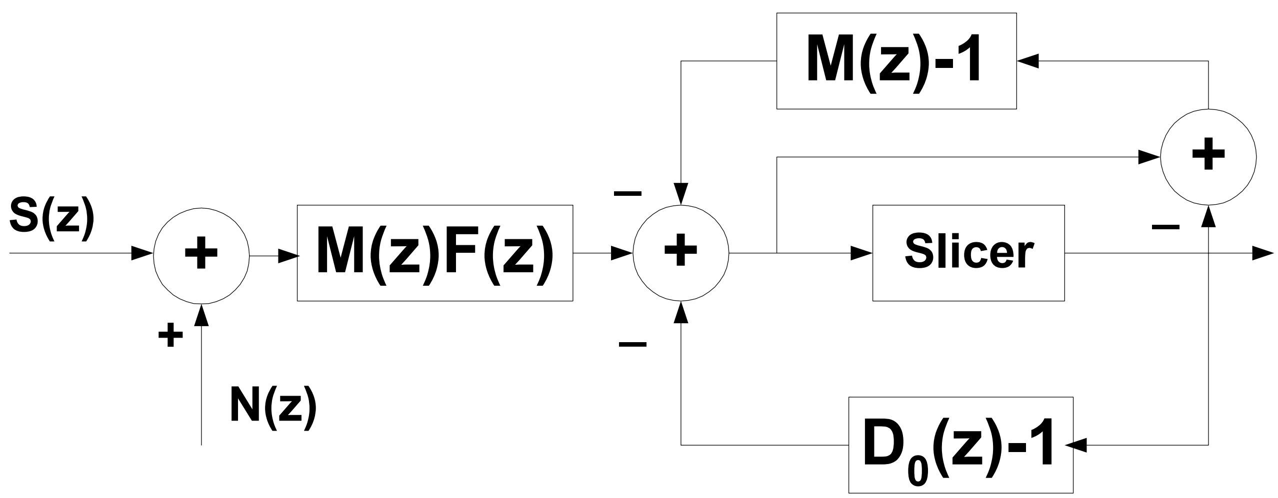
- **Transfer function on the ISI corrupted signal: S(z)**
  - $H_S(z)=F(z)/D(z)$
- **Transfer function on the noise: N(z)**
  - $H_N(z)=F(z)$

Shaping Of The DFE

- Let $D_0(z)=M(z)D(z)$
  - Where: $M(z)$ is a monic minimum phase FIR chosen to shape $D(z)$ such that the number of and amplitude of the coefficients are minimized
- Then
  - $H_S(z)=(M(z)/M(z))\ F(z)/D(z)=M(z)F(z)/D_0(z)$
- Signal transfer function not affected by FFE modification

Stable Inverse Filter

- **Noise transfer function becomes**
  - $H_N(z)=M(z)F(z)$ → Noise enhancement
- **Introduce stable inverse filter for the noise**



- **Resulting noise transfer function reverts to $H_N(z)=F(z)$**

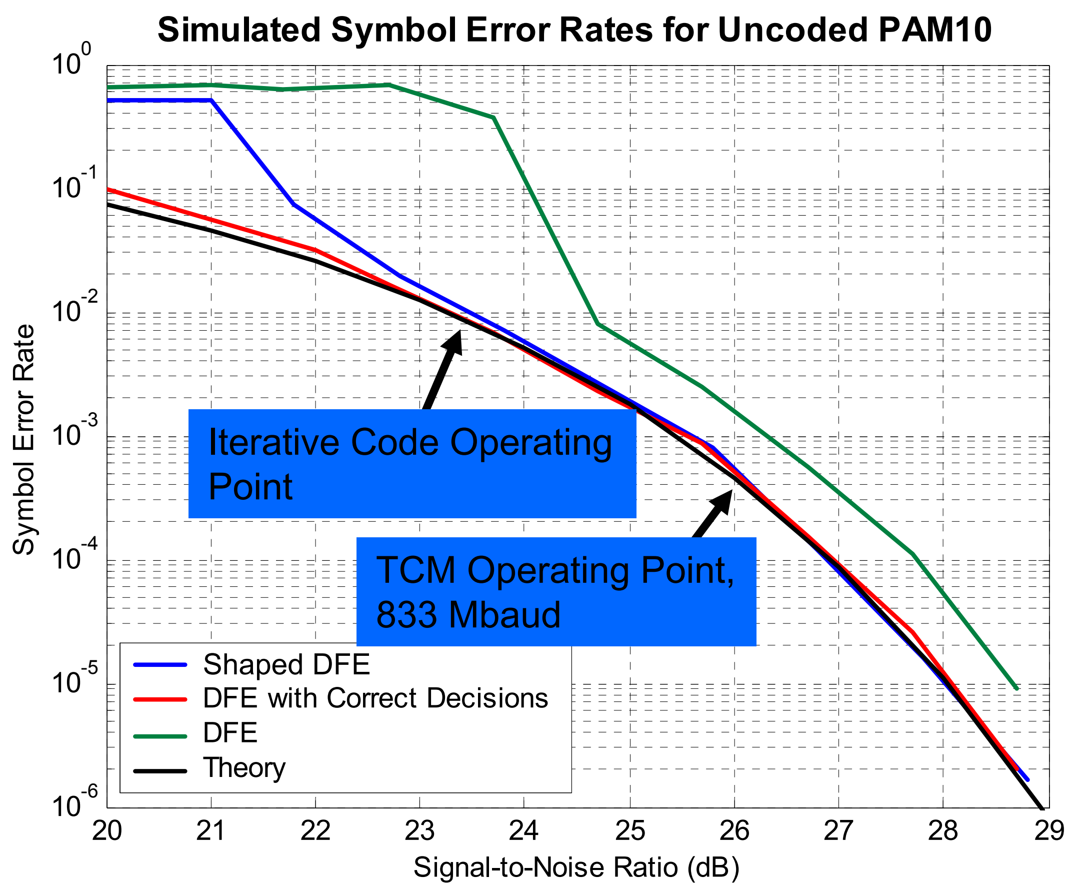
Training/Adaptation

- No coefficient exchange required
- Data mode adaptation straightforward
  - Easily handles channel variations

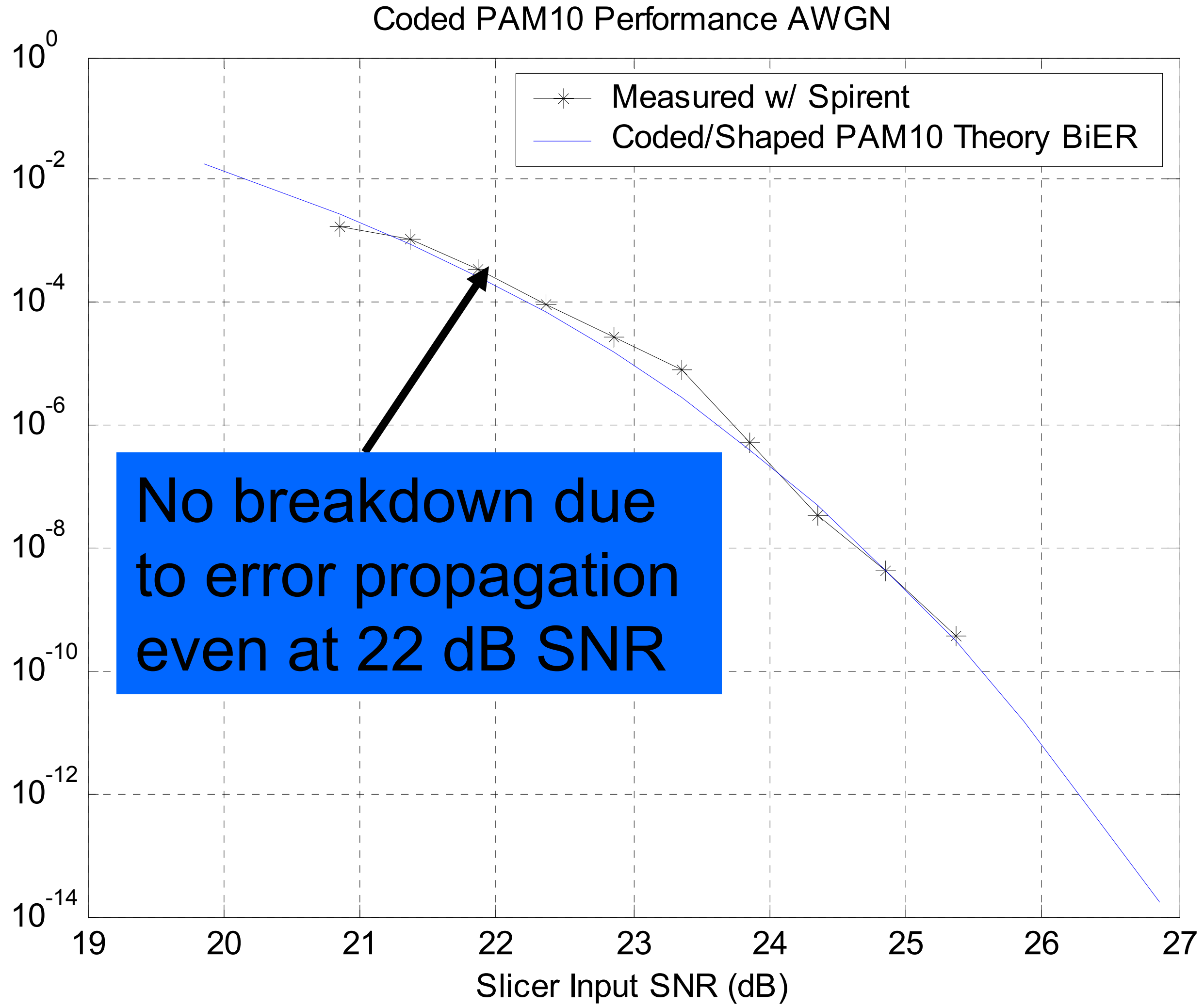
Error Propagation and DFEs

- Most research on DFEs and coded systems is done at BER > 1e-7
- At BER 1e-12, even 8 dB coding gives SER < 1e-2
- MSE from error events is derated by > 20 dB in these cases
- Catastrophic error propagation can be avoided by shaped DFE

Simulation Results



Laboratory Results



Analog Requirements

- Transmitter and receiver linearity requirements:
  - Driven by Echo & NEXT Cancellation (~50-60 dB)
    - Complexity is independent of equalization strategy
- No analog complexity savings or cost relative to TH Precoding
- No change to the transmit spectrum

DSP Costs

- Minimal complexity digital solution
- No additional load on echo/NEXT or FEXT cancellers

Conclusion

- **An all receiver based equalization strategy introduced**
- **Both this approach and the adaptive linear precoder described in “Transmission proposal for 10GBase-T”, G.Zimmerman, March 2004 Plenary can complete a coding/equalization solution utilizing 4D TCM with PAM10**