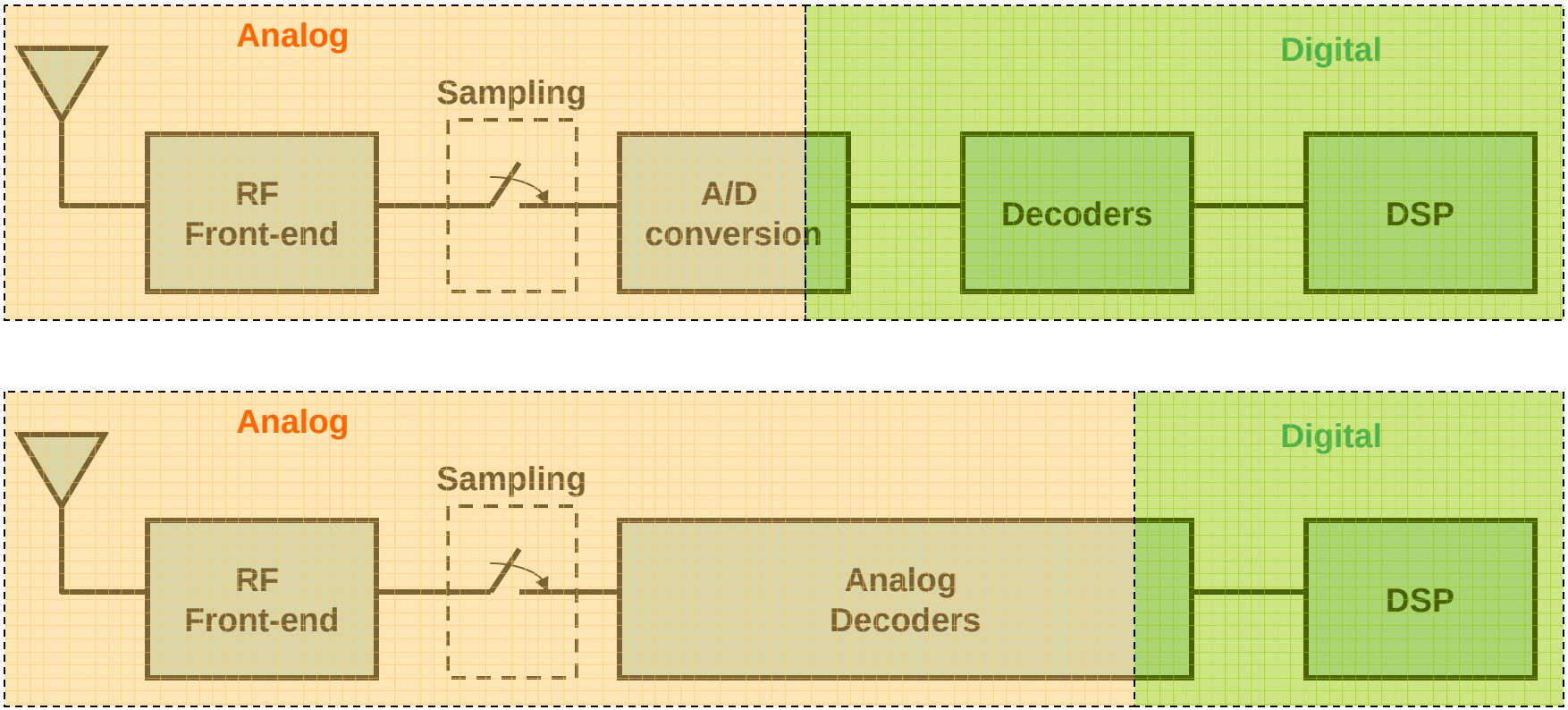
References

C.Kong and S.Chakrabartty*, Analog Iterative Decoders based on Margin Propagation , IEEE Transactions on Circuits and Systems II, pp. 1140-1144, Vol. 54, no. 12, Dec. 2007

P. Kucher and S. Chakrbartty , An Energy-Scalable Margin Propagation-Based Analog VLSI Support Vector Machine, IEEE Symposium on Circuits and Systems (ISCAS'2007), New Orleans 2007

Motivation



Analog decoders: Stretch the boundary between analog-digital domain by combining decoding and data conversion (“Smart data conversion”)

Current Implementations

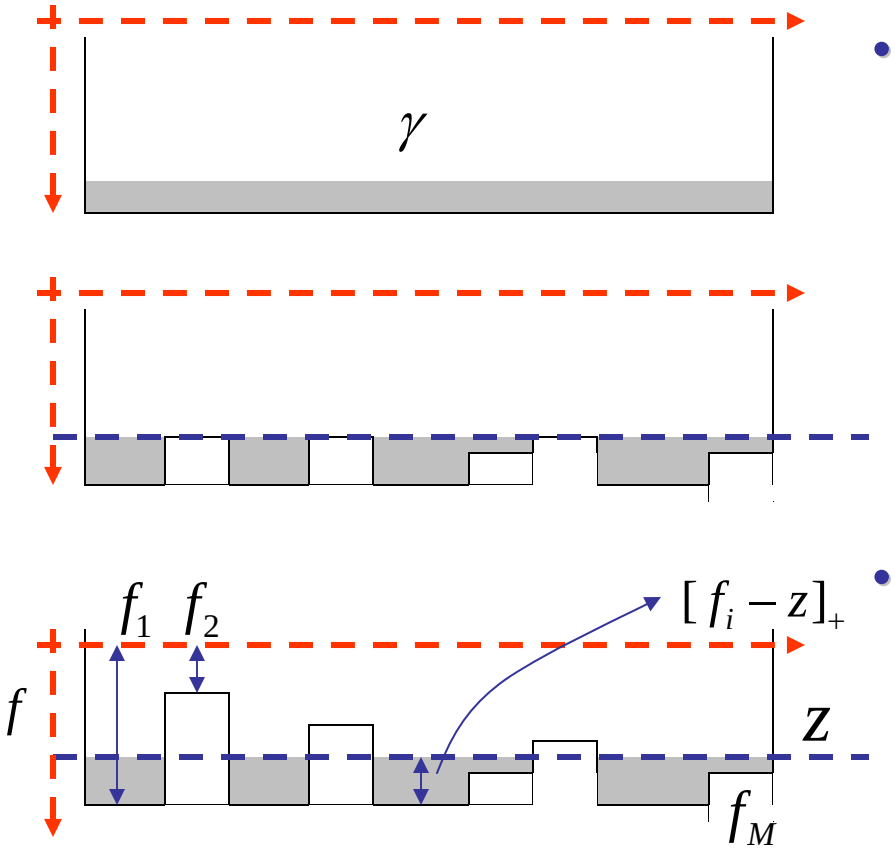
- Underlying principle behind *most* analog decoding implementations is sum-product algorithm using a trans-linear principle (relies on the exponential I-V characteristics).

- For CMOS implementations, the MOS transistors have to be biased in weak-inversion (Loeliger et. al, Winstead et. al).

- Penalty in decoding speed, complexity of sample and hold, temperature dependency.

What is Margin Propagation ?

- The core of margin propagation is margin normalization.



- Margin Normalization is computed using a reverse water-filling criterion

$$\sum_{k=1}^{M} [f_k - z]_+ = \gamma$$

- is the margin normalization factor z

Energy-scalable Computation

(Kucher & Chakrabartty 2006)

- Design energy scalable classifiers which are insensitive to biasing artifacts.

Margin Approximation Technique

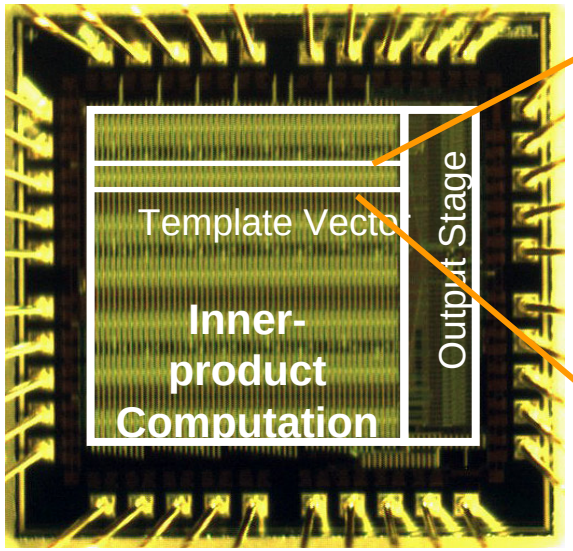
$$z = \log\left(\sum_i e^{f_i}\right) \longleftrightarrow z : \sum_i [f_i - z]_+ = 1$$

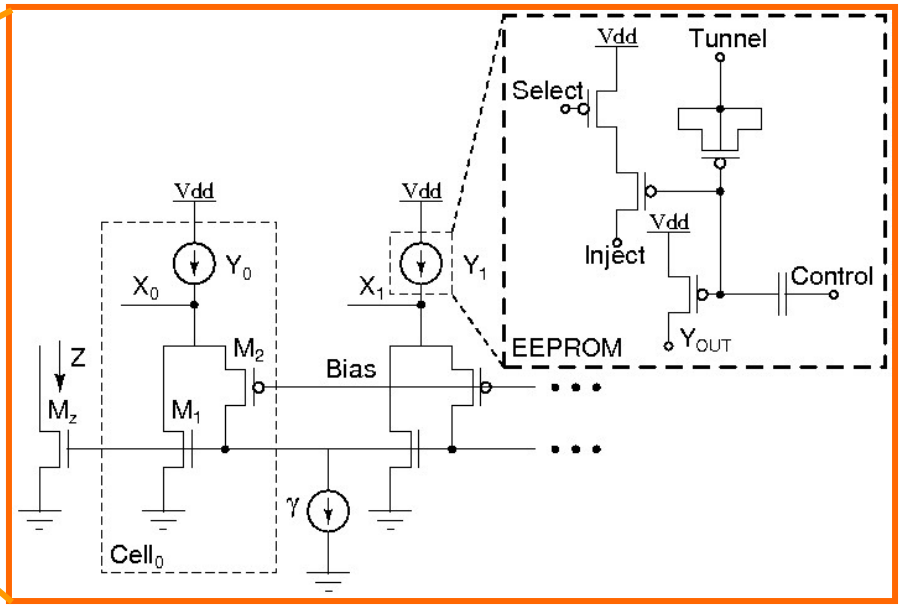
$$\mathbf{w}^T\mathbf{n} \longrightarrow z = \log\left(\sum_i e^{\log w_i + \log n_i}\right) \longrightarrow z : \sum_i [\log w_i + \log n_i - z]_+ = 1$$

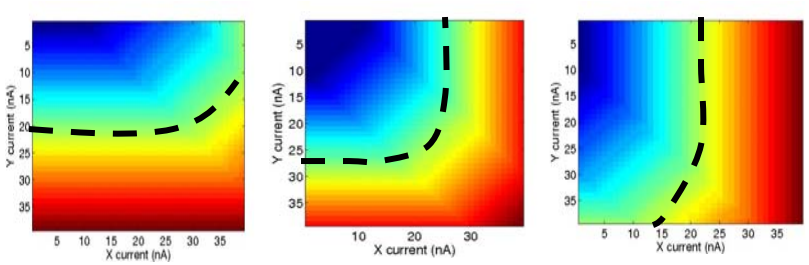
- Requires ONLY addition/subtraction and thresholding – available in all biasing regions/conditions.
- Universally applicable: current/charge mode, CMOS/CCD
- Non-linear operations become linear operations (Powers become multiplication by a constant).

Energy-scalable Classifier

(Kucher & Chakrabartty 2006)







- Non-linear operations become linear.
- Linear operators approximated by “margin normalization”.
- Bias independent and energy scalable operation (350nW @ 40 classification per second).