Delta-Sigma Analog-to-Digital Converters

Feedback DAC Design

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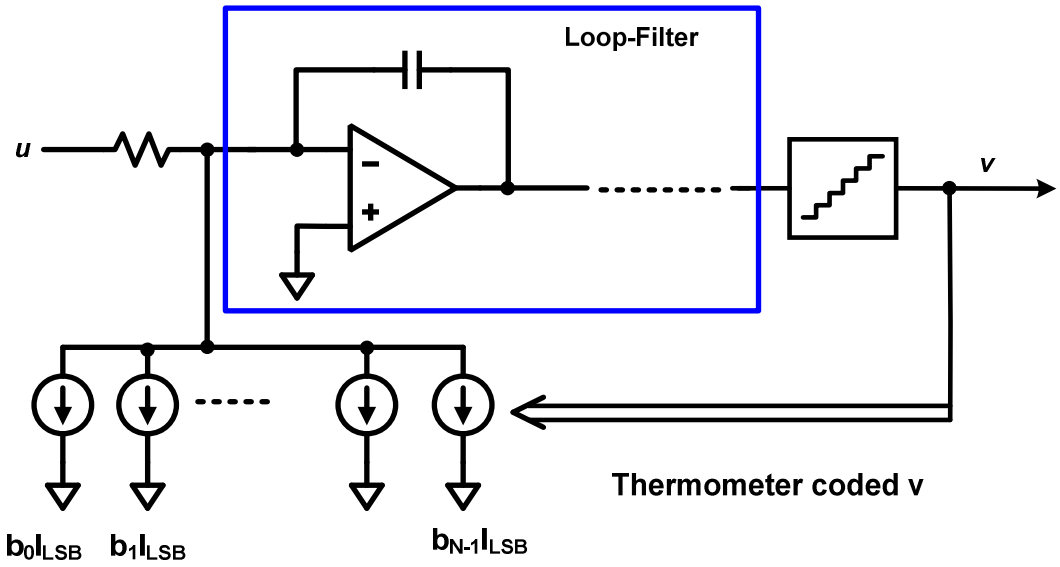
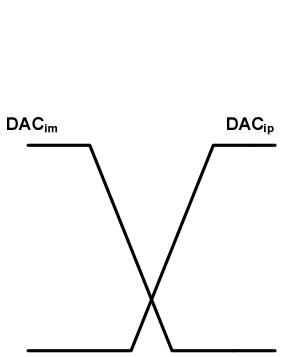
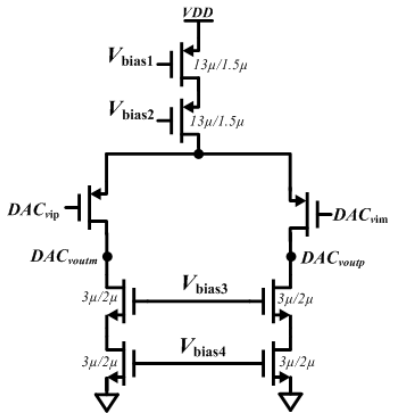
Delta-Sigma ADC

- Array of unit-weighted current steering DACs to pull and push current from the opamp current summing node
- Use high crossover pre-drivers to reduce DAC glitching noise

Feedback DAC Architecture

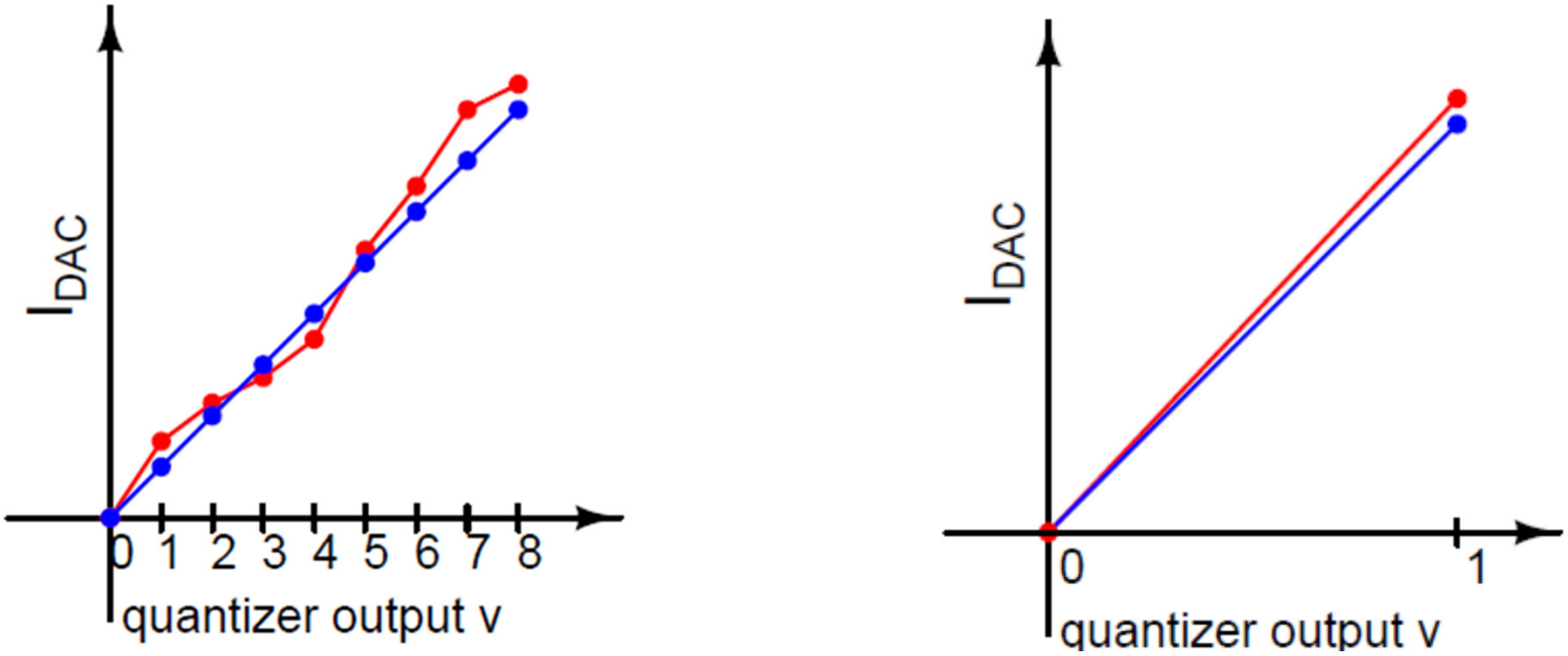






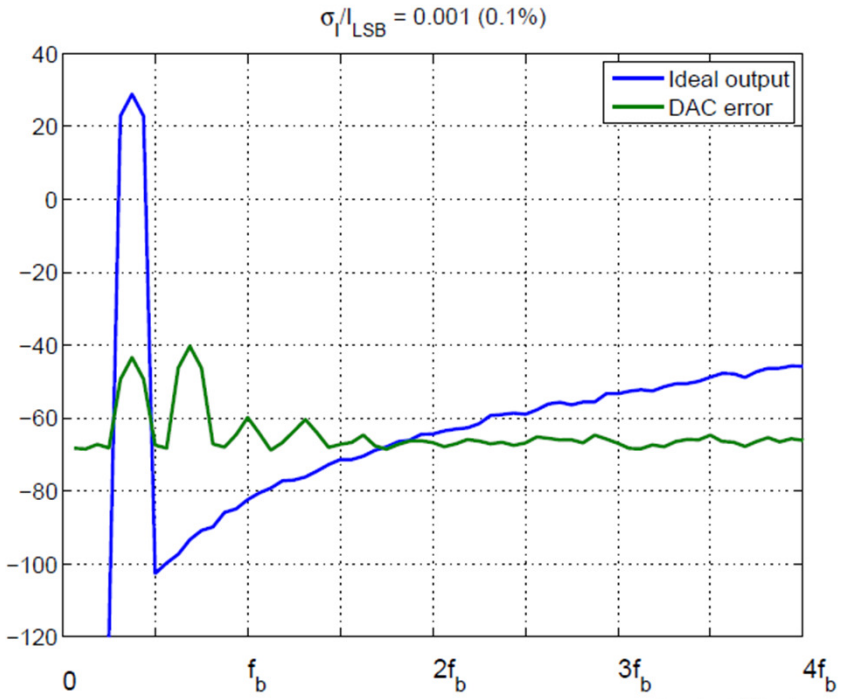
- Array of unit-weighted current steering DACs to pull and push current from the opamp current summing node
- Use high crossover pre-drivers to reduce DAC glitching noise

Feedback DAC Nonlinearity



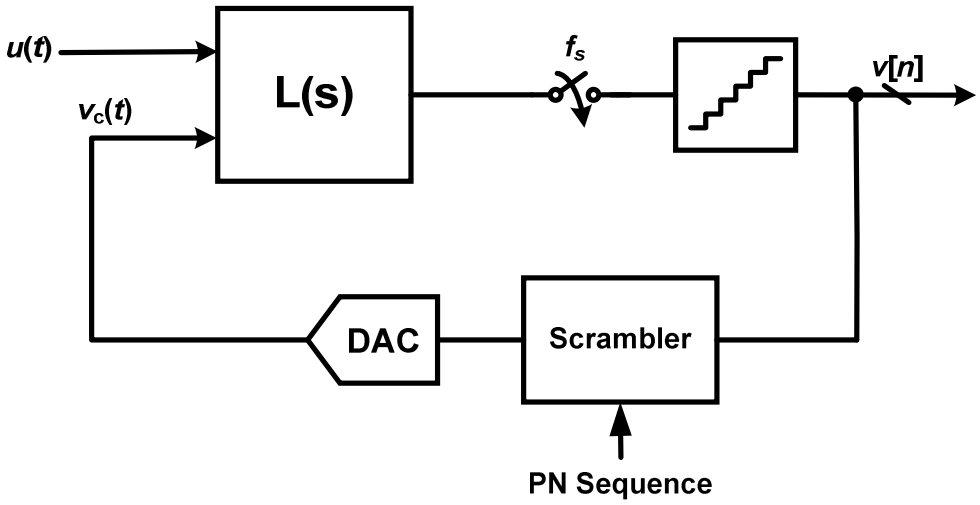
- In a multibit DAC, element mismatch leads to non-linearity
  - *v* is related to the input (*u*) by inverse non-linearity of the DAC
- A single-bit DAC is always linear

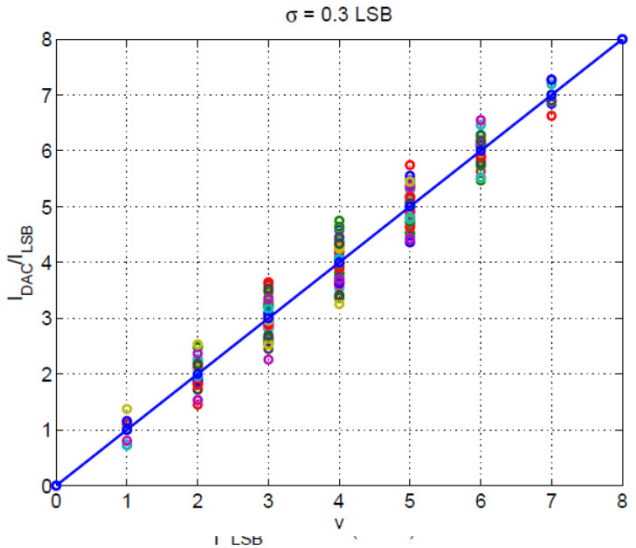
Feedback DAC Nonlinearity

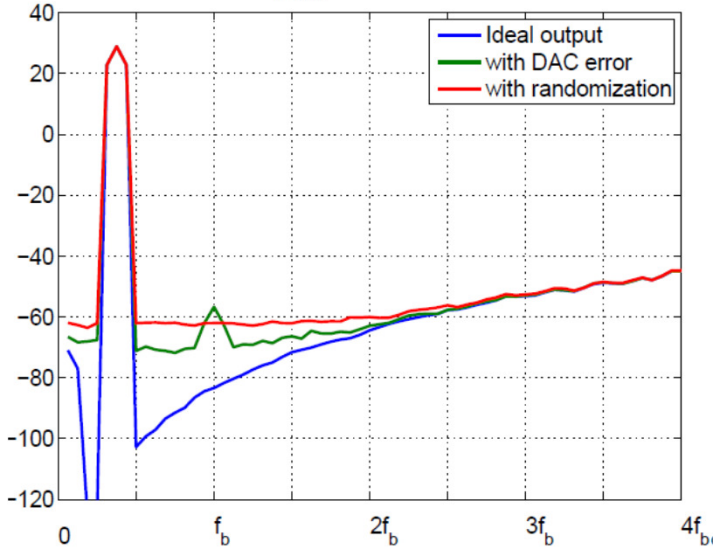


- Leads to distortion
- intermodulation of quantization noise into the signal band

Dynamic Element Matching (DEM)







- Randomize the DAC elements
- Distortion components converted to noise
- Increased noise floor

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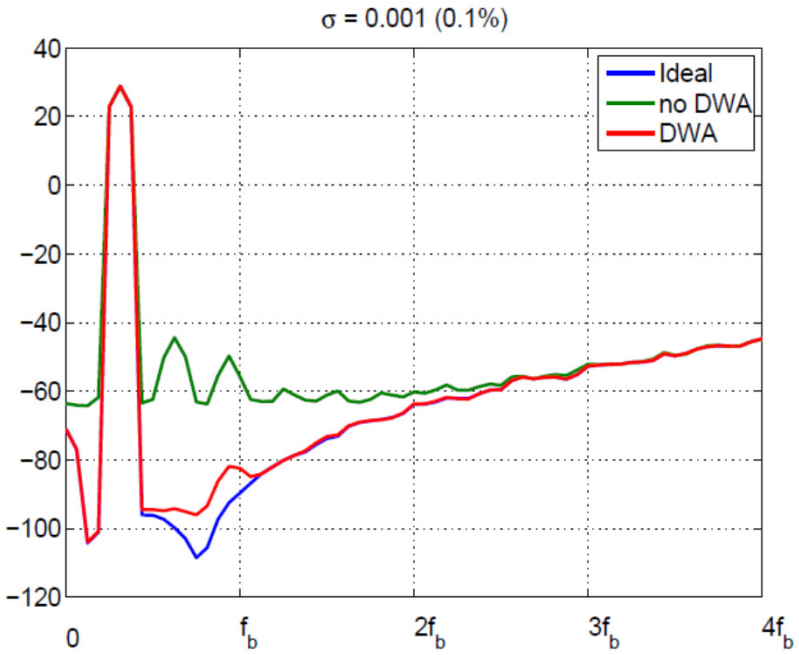
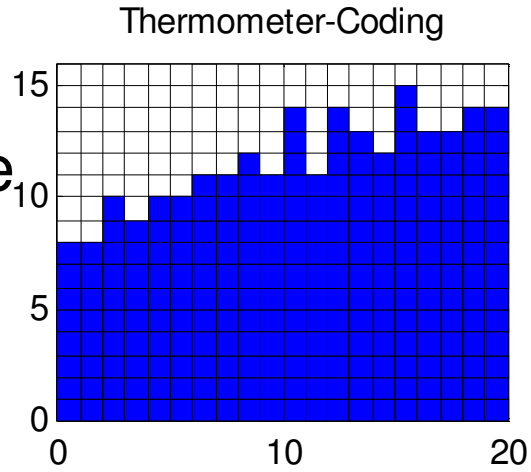
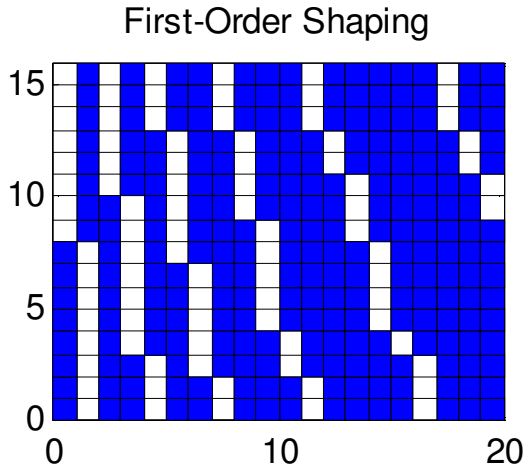
Data Weighted Averaging (DWA)

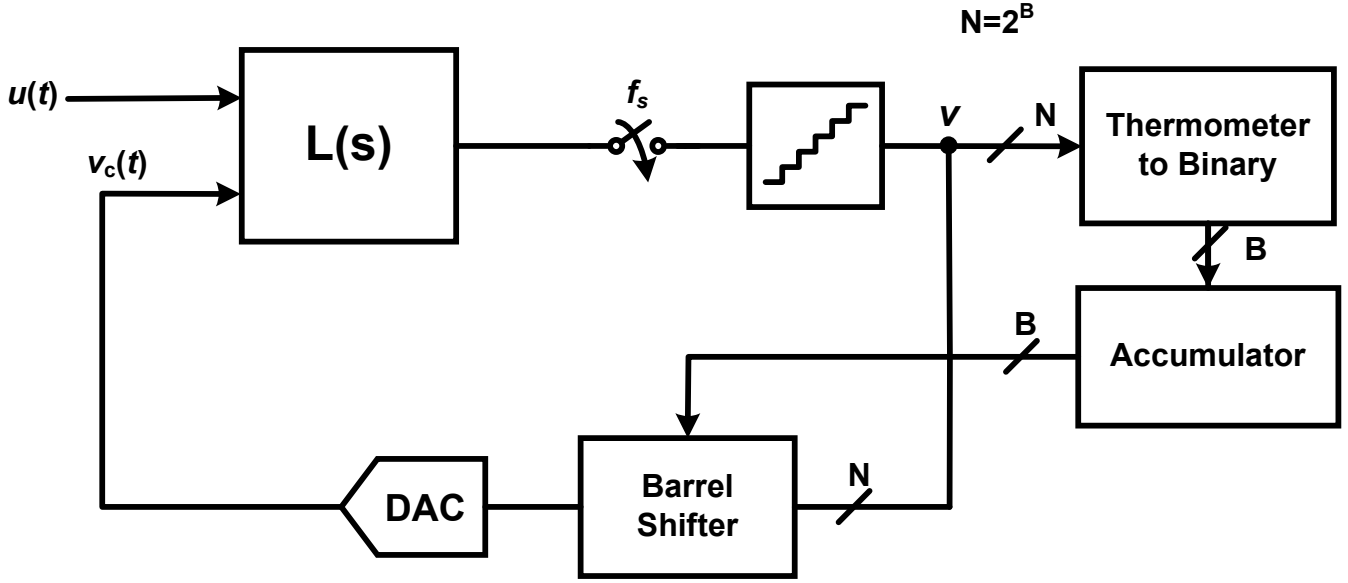
- Cycle through all the current elements as fast as possible
- Accumulate the input code and move the pointer
- First-order mismatch noise shaping





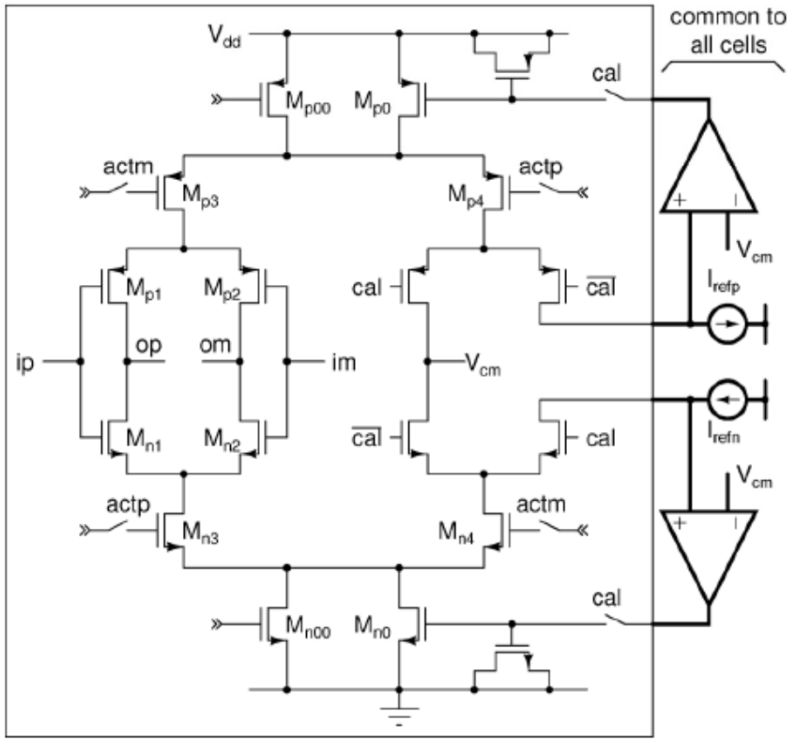


Data Weighted Averaging (DWA)



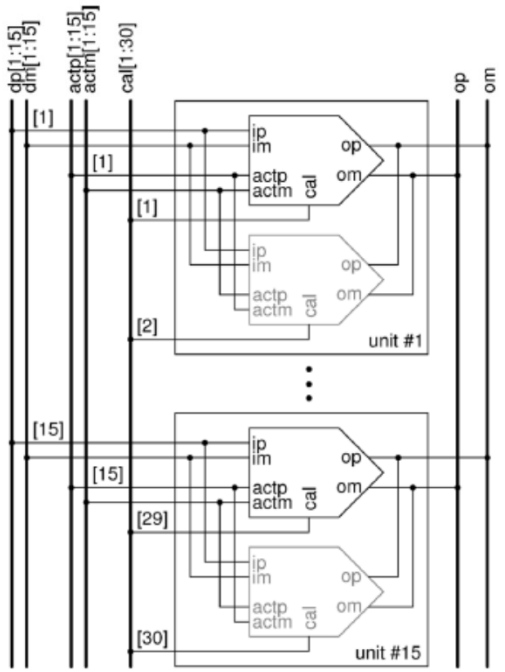
- Barrel shifter delay in the signal path increases loop delay
- Not viable at higher sampling rates (>400 MHz)

DAC Calibration



A 16 MHz BW 75 dB DR CT ΔΣ ADC Compensated for More Than One Cycle Excess Loop Delay

Vikas Singh, Nagendra Krishnapura, Shanthi Pavan, Baradwaj Vigraham, Debasish Behera, and Nimit Nigania



- Digital calibration – estimate element error and subtract from the output
  - Increased Decimation filter complexity
- Analog calibration – calibrate the elements with respect to a master
  - Need to calibrate at every cycle

References

1. R. Schreier, Matlab Delta-Sigma Toolbox, 2009 [Online].

2. S. Pavan, N. Krishnapura, EE658: Data Conversion Circuits Course at IIT Madras [Online].