ECE615 Mixed-Signal IC Design

Lecture 18 Slides: ΔΣ Architectures

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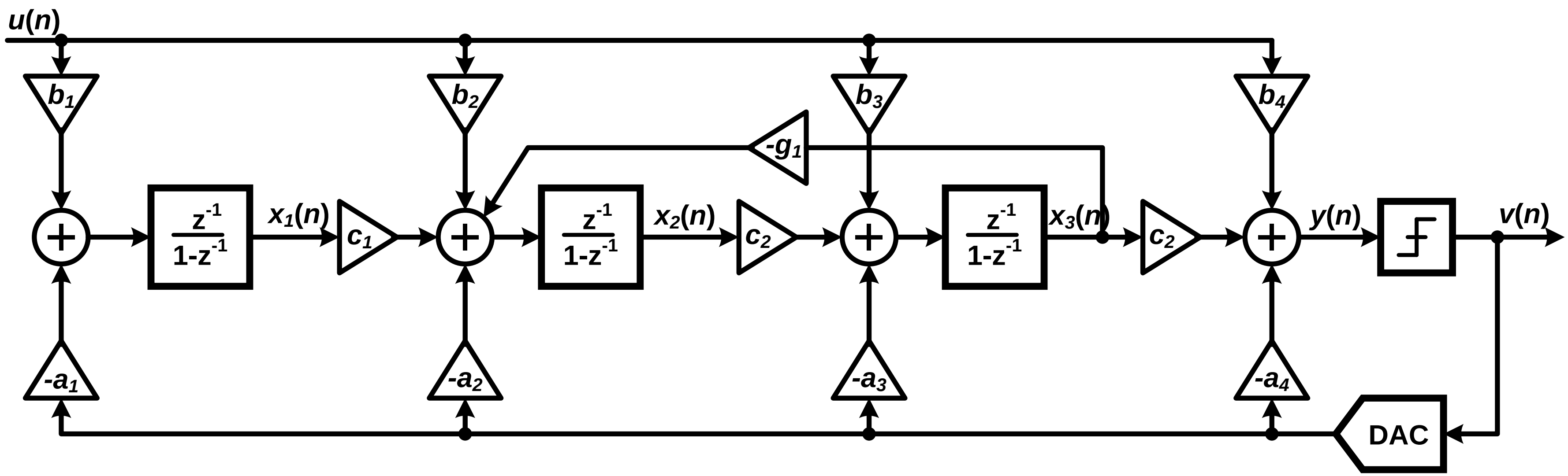
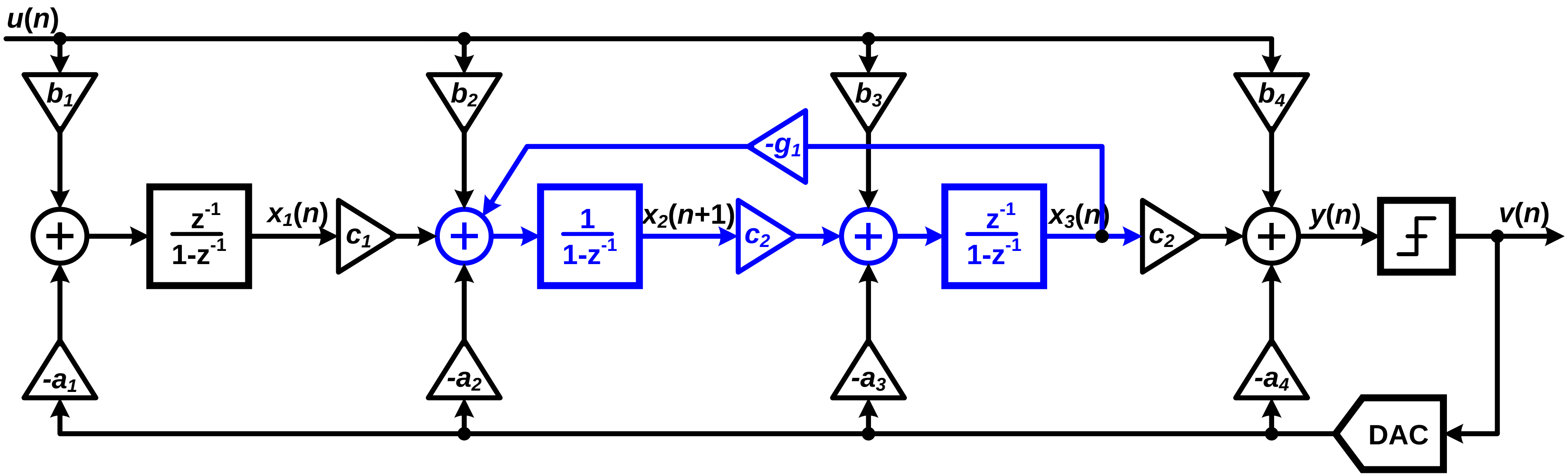
CIFB (Cascade of Integrators with Distributed Feedback)



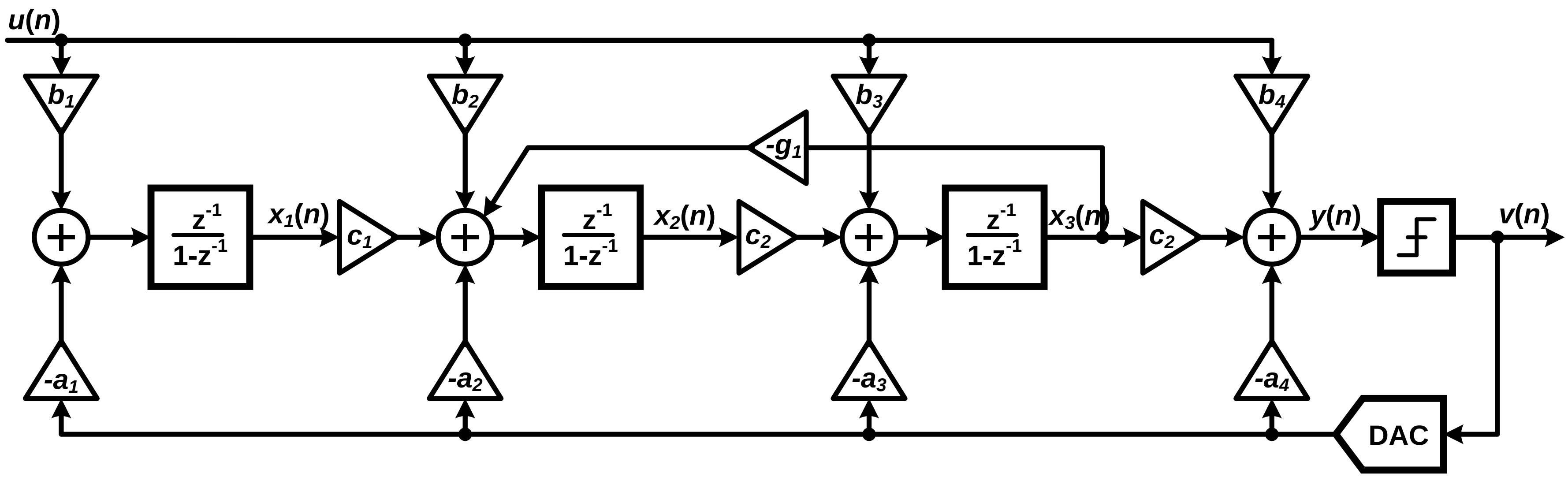
- Cascade of delaying integrators:
  - Feedback coefficients **a**'s realize the zeros of L_1 and thus the NTF and STF poles.
  - Feed-in coefficients **b**'s determine zeros of L_0 and thus the STF zeros.
  - State scaling coefficients **c**'s are used for dynamic range scaling.
  - Implements Butterworth NTF.

CRFB (Cascade of Resonators with Distributed Feedback)



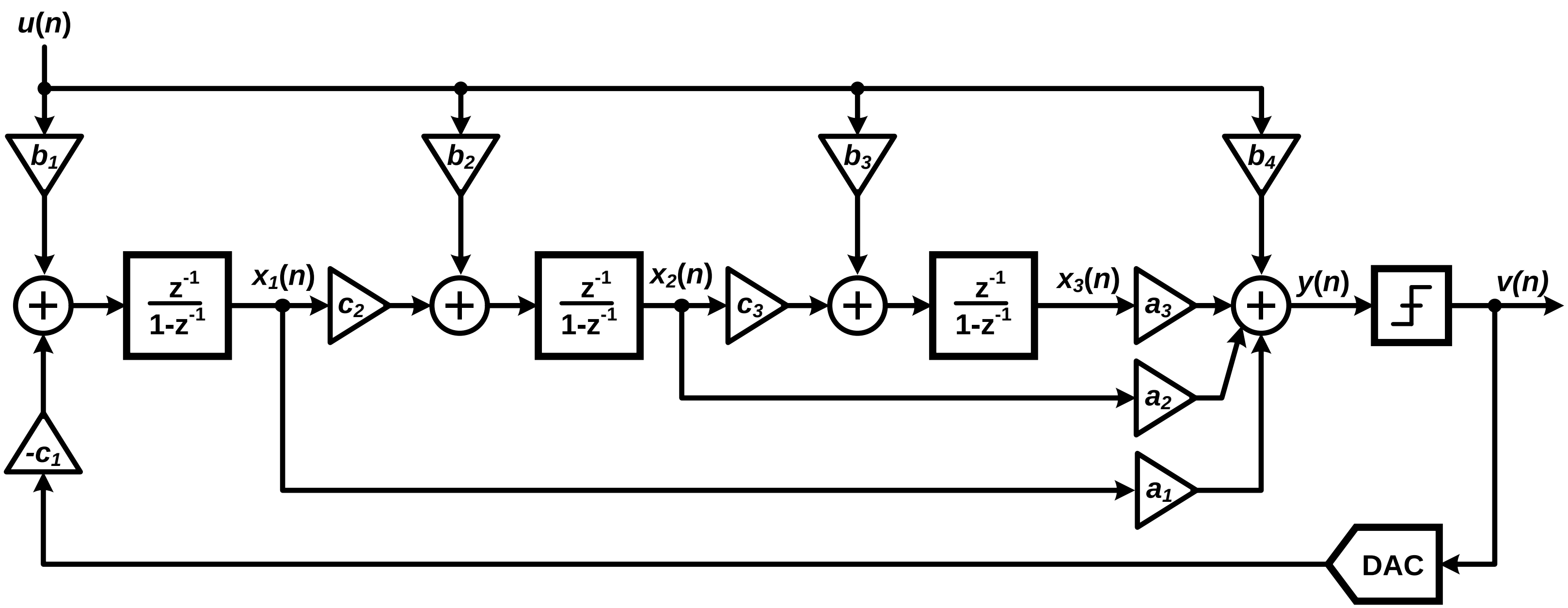
- Combine a non-delaying and a delaying integrator with local feedback around them, to form a stable resonator.
  - Local feedback coefficients **g**'s realize the complex zeros in the NTF.
  - Implements NTF with complex zeros. $z_i = e^{\pm j\sqrt{g_1}}$
- For odd-order, use an integrator in the front to avoid noise coupling due to g.

CIFB with Resonators



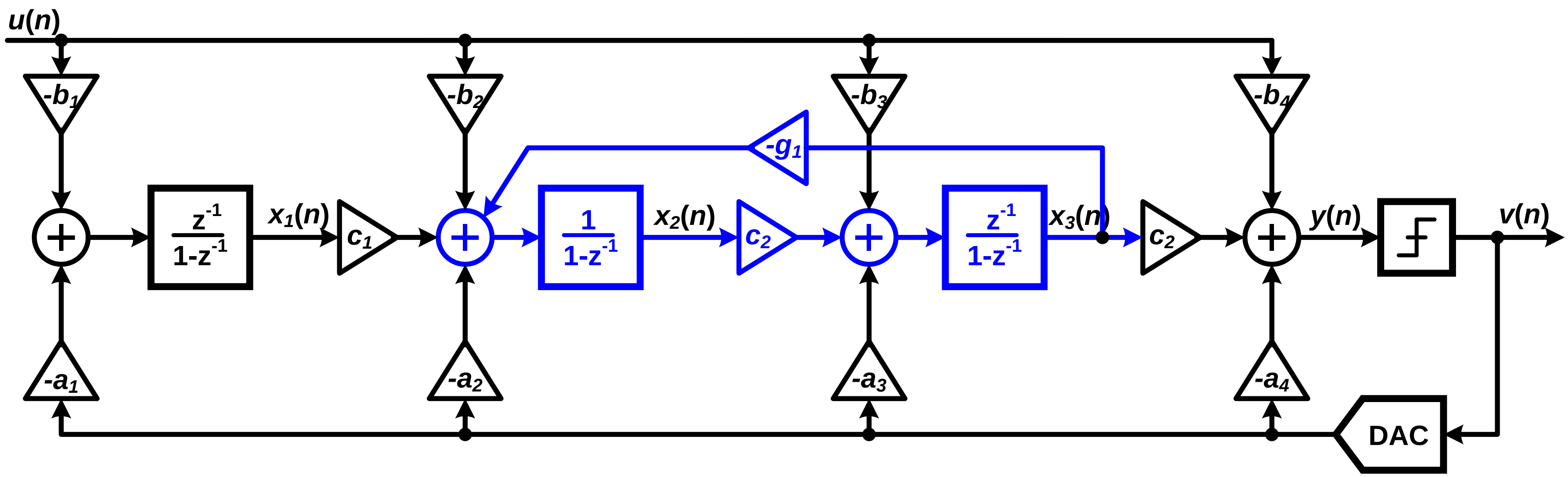
- A resonator can also be formed with two delaying integrators
  - Resonator poles outside the unit circle. $z_i = e^{1 \pm j\sqrt{g_1}}$
  - Locally unstable but works fine in a stable loop-filter.
- Relaxes settling requirements on the op-amps and implements complex NTF zeros.

CIFF (Cascade of Integrators with Feed-Forward Summation)



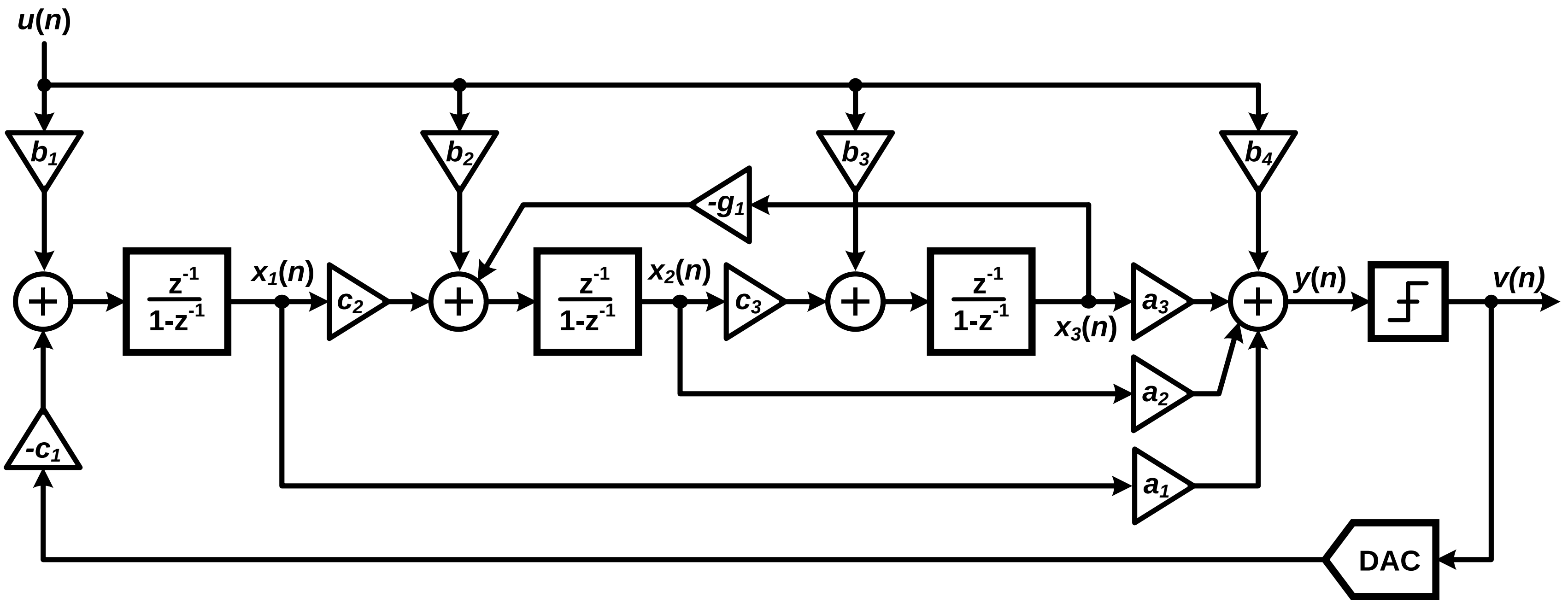
- Cascade of delaying integrators:
  - Feedforward coefficients **a**'s realize the zeros of L_1 and thus the NTF and STF poles.
  - Feed-in coefficients **b**'s determine zeros of L_0 and thus the STF zeros.
  - State scaling coefficients **c**'s are used for dynamic range scaling.
  - Implements Butterworth NTF.

CRFF (Cascade of Resonators with Feed-Forward Summation)



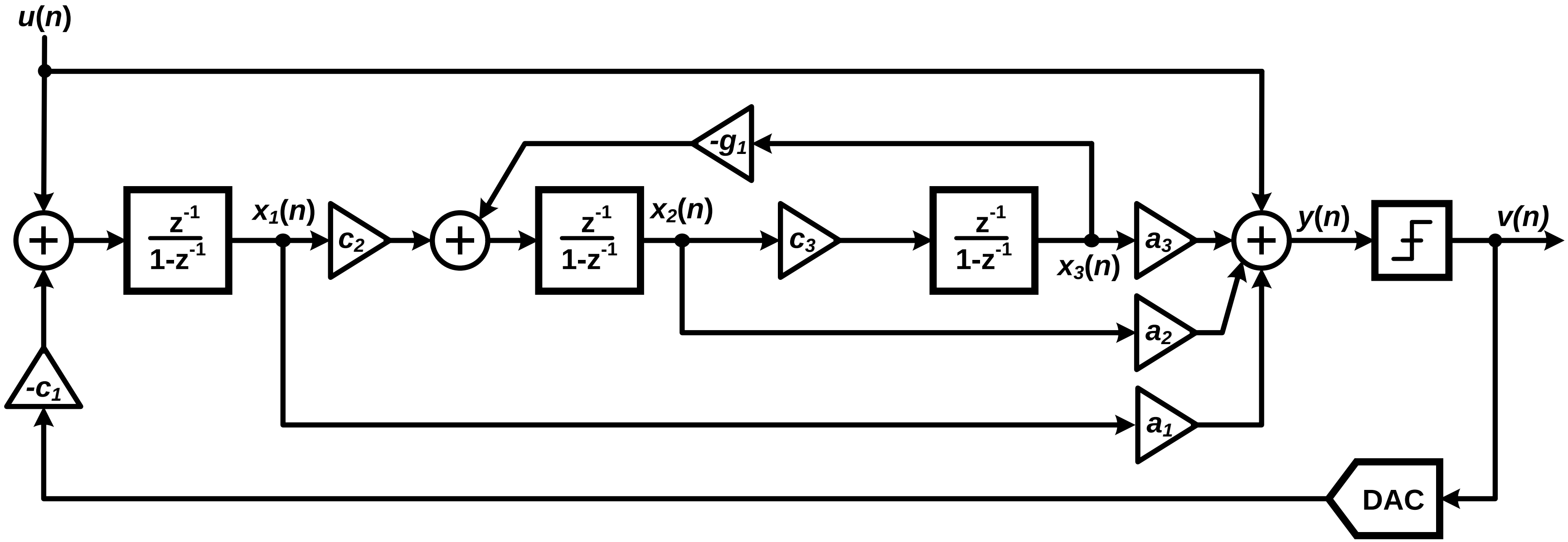
- Use resonators with feedforward summation.
  - Local feedback coefficients **g**'s realize the complex zeros in the NTF.
  - Implements NTF with complex zeros. $z_i = e^{\pm j\sqrt{g_1}}$
- For odd-order, use an integrator in the front to avoid noise coupling due to g.

CIFF with Resonators



- Uses resonators formed with two delaying integrators.
  - Resonator poles outside the unit circle. $z_i = e^{1 \pm j\sqrt{g_1}}$

Low-Distortion CIFF Topology



$$b_1 = b_{N+1} = 1$$

$$STF(z) = 1$$