Realization Techniques

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- The IIR filter can be realized in many forms. They are

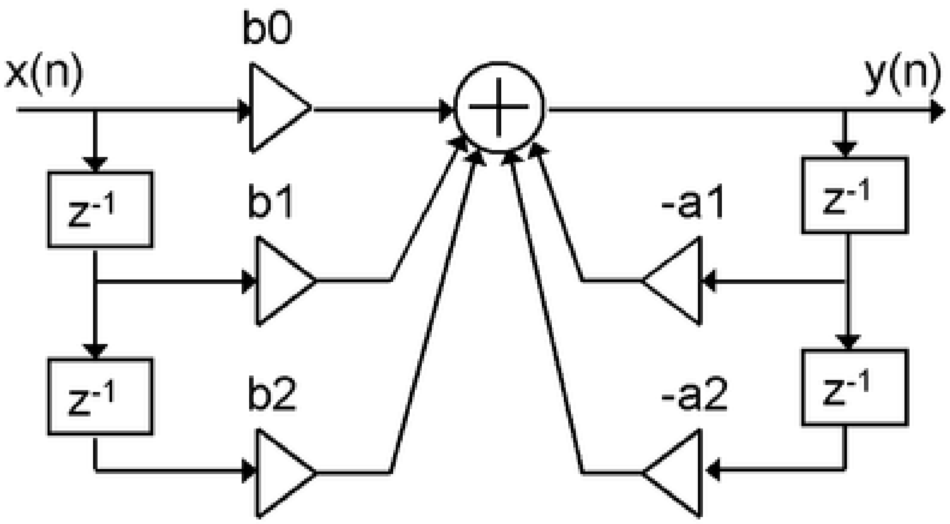
  (i) Direct form – I realization
  (ii) Direct form – II realization
  (iii) Cascade form
  (iv) Parallel form

Direct form – I realization:

Let us consider an LTI recursive system described by the difference equation,

$$H(z) = \frac{Y(z)}{X(z)} = \frac{\sum_{k=0}^{M} b_k z^{-k}}{1 + \sum_{k=1}^{M} a_k z^{-k}}$$

$y(n) = - a_1 y(n-1) - a_2 y(n-2) - \ldots\ldots - a_N y(n-N) + b_0 x(n) + b_1 x(n-1) + b_2 x(n-2) + \ldots\ldots + b_M x(n-M)$



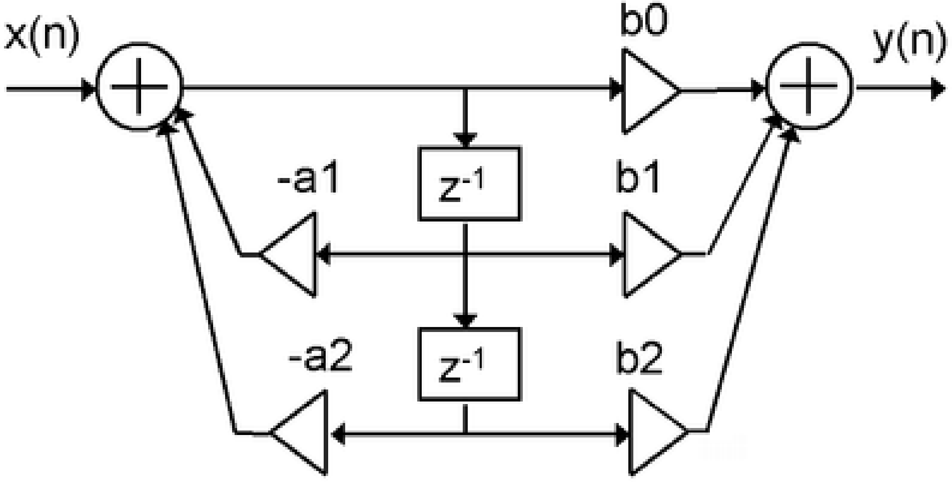
Direct form – II realization:

Let us consider an LTI recursive system described by the difference equation,

$$y(n) = b_0 w(n) + b_1 w(n-1) + b_2 w(n-2) + \ldots\ldots + b_M w(n-M)$$

where $w(n) = x(n) - a_1 w(n-1) - a_2 w(n-2) - \ldots\ldots - a_N y(n-N)$

Then the equation can be realized as,

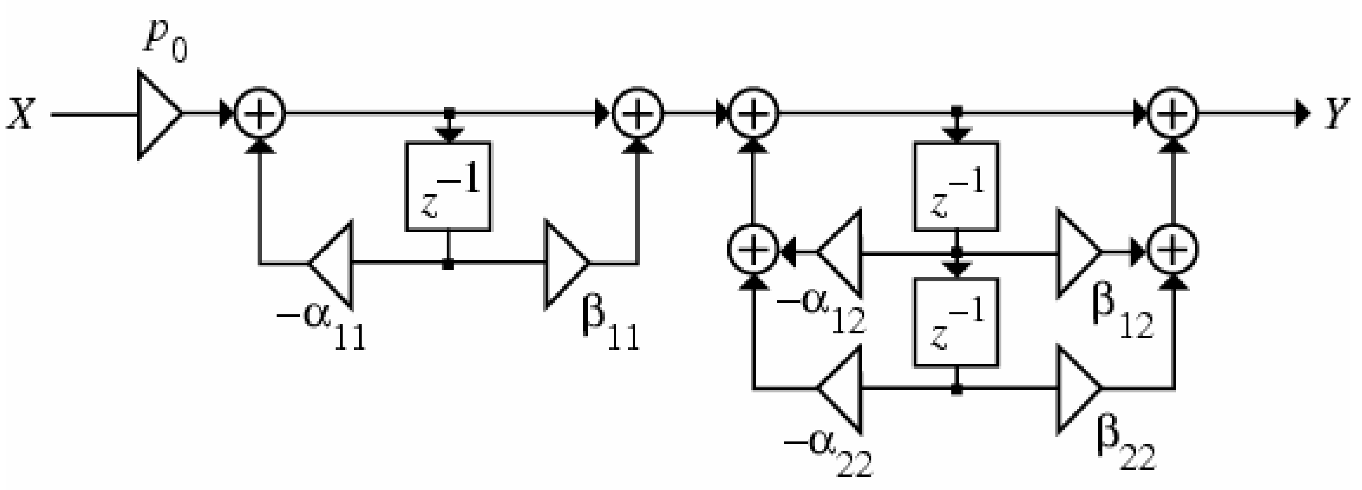


Cascade form:

Let us consider an IIR system with system function,

$H(z) = H_1(z)\ H_2(z)\ \ldots.\ H_k(z)$

Now realize each $H_k(z)$ in direct form II and cascade all structures.



Parallel form structure:

A parallel form realization of an IIR system can be obtained by performing a partial expansion of

$$H(z) = c + \sum_{k=1}^{N} \frac{c_k}{1 - p_k z^{-1}}$$

where p_k are the poles of the filter.

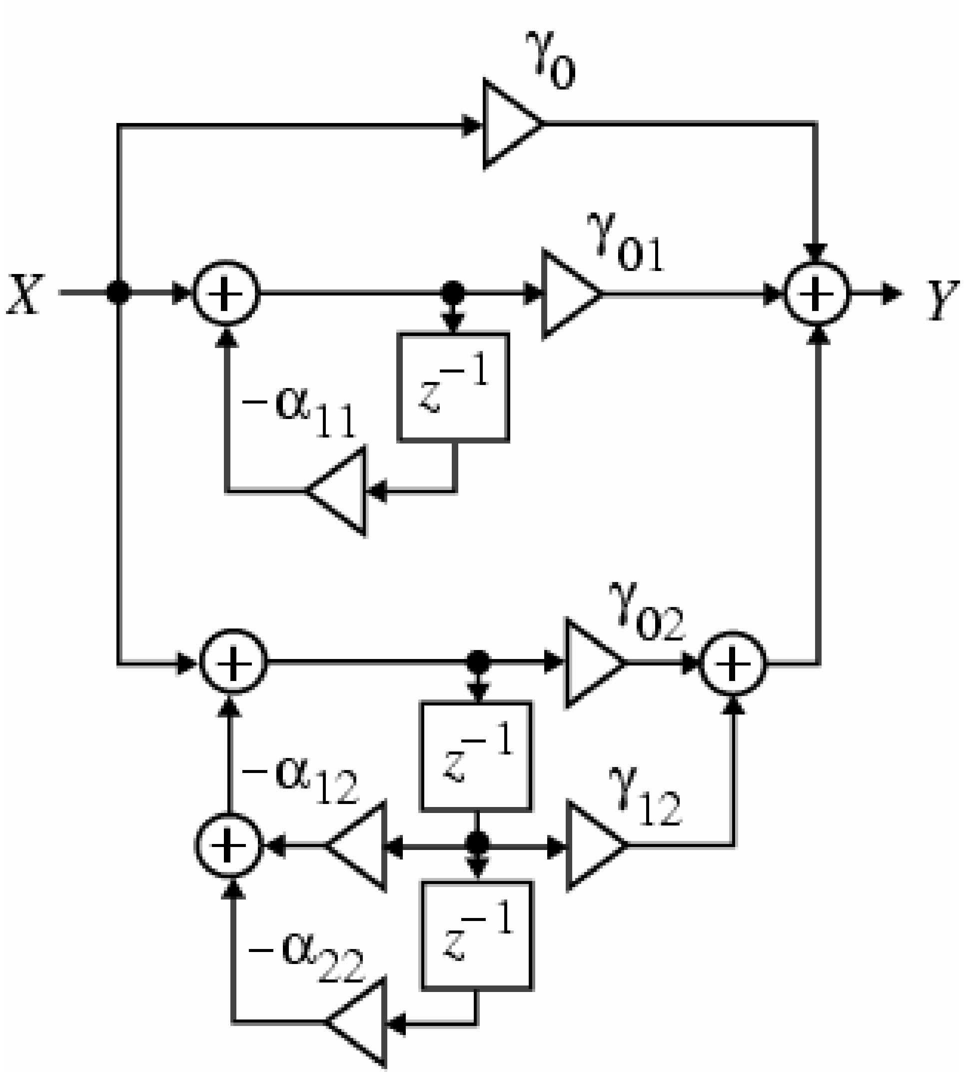
Then H(z) can be written as

$$H(z) = c + \frac{c_1}{1 - p_1 z^{-1}} + \frac{c_2}{1 - p_2 z^{-2}} + \text{.........} + \frac{c_N}{1 - p_N z^{-1}}$$

$$H(z) = \frac{Y(z)}{X(z)} = c + H_1(z) + H_2(z) + \text{.......} + H_N(z)$$

and

$$Y(z) = c + H_1(z)X(z) + H_2(z)X(z) + \text{.......} + H_N(z)X(z)$$



γ_0
γ_{01}
X
Y
z^{-1}
$-\alpha_{11}$
γ_{02}
z^{-1}
$-\alpha_{12}$
γ_{12}
z^{-1}
$-\alpha_{22}$