Structures for LTI systems (3)

Signal flow graphs

Definitions

- A signal flow graph is a network of directed branches that connect at nodes.
- It is equivalent to block diagrams which we are already familiar with, except for a few notational differences
- Can be used to find the transfer function between any two variables (not just the input and output).

Basic elements of a signal flow graph

Nodes in signal flow graphs represent ***variables*** (in our case, DT signals)

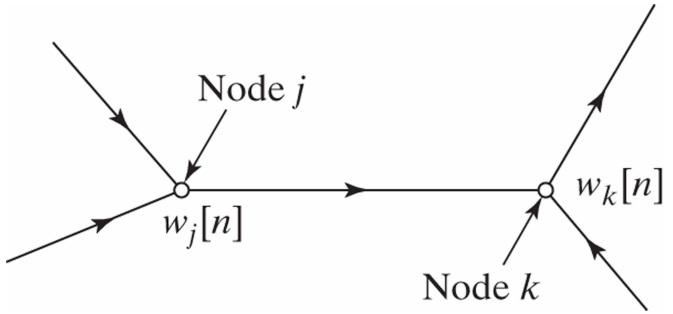
Branches link nodes together (always with a direction specified by the arrowhead)

The output of a branch is always a linear transformation of the input of the branch (in linear signal flow graphs)

-multiplication with a constant

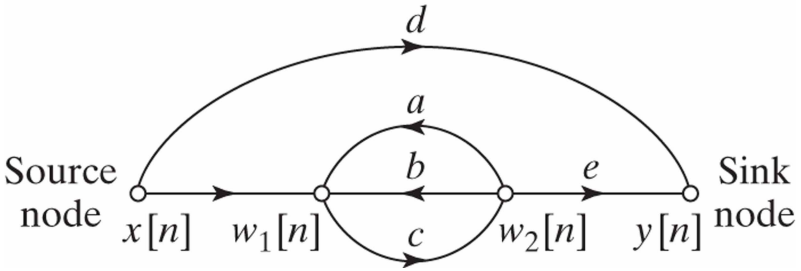
-identity transformation

-delay

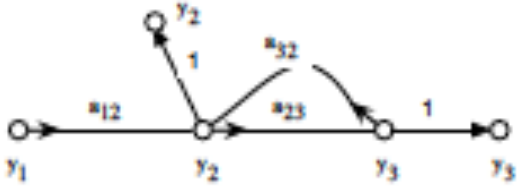


- The value carried by a specific node is the sum of all branches coming into it.
- "Summing" nodes (for two or more entering branches)
- "Branching" nodes (for one entering branch and two or more exiting branches)

Basic elements of a signal flow graph (cont'd)

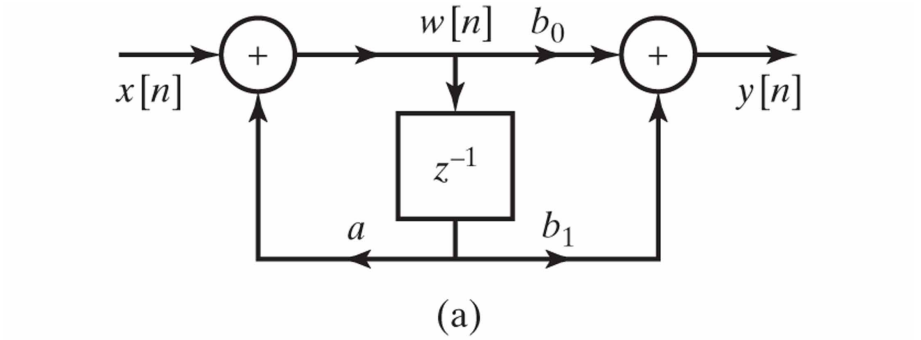


- Two special types of nodes:
  - ***Source nodes*** are nodes that have no entering branches; they represent the injection of external inputs (signal sources) into the graph.
  - ***Sink nodes*** are nodes that have only entering branches; they are used to extract outputs from a graph.
    - Any variable can be made into an output by adding a sink via a branch with identity transformation

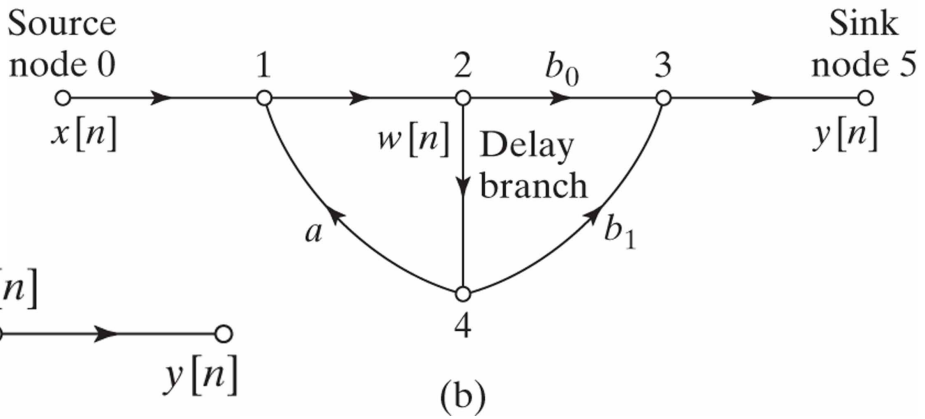


From block diagrams to flow graphs

Figure 6.10 (a) Block diagram representation of a 1st-order digital filter. (b) Structure of the signal flow graph corresponding to the block diagram in (a).



(a)



(b)

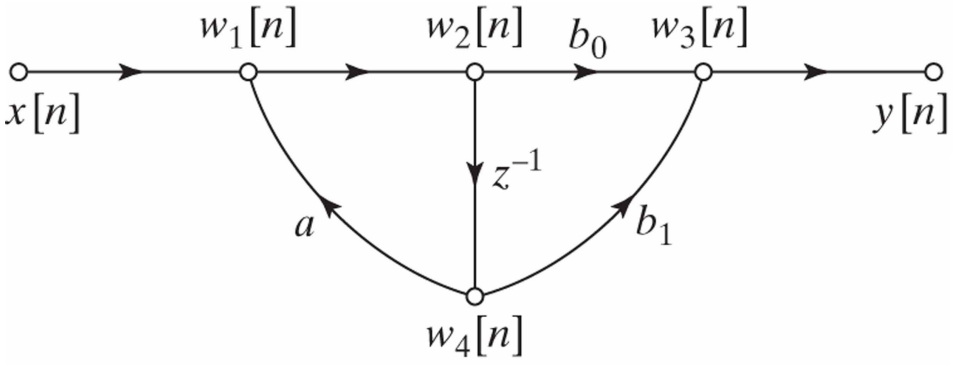
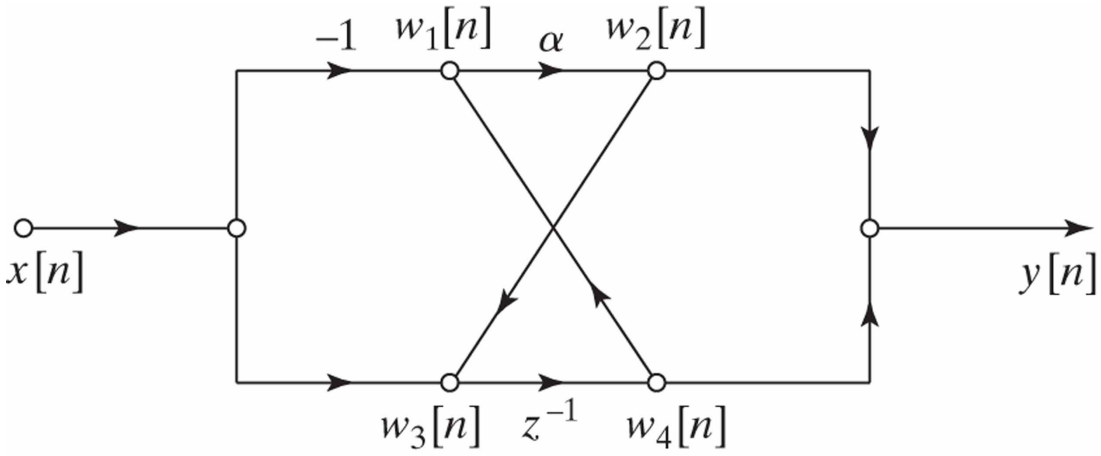


Figure 6.11 Signal flow graph of Figure 6.10(b) with the delay branch indicated by z^{-1}.

Signal flow graph representations of LTI systems

- The signal flow graph representation of a LTI system is not unique.
- For any given rational system function, equivalent sets of difference equations and network structures (flow graphs) exist.
- In practical implementations, factors such as number of multipliers and adders, regularity of the structure, and coefficient quantization are taken into account when deciding which network structure (flow graph) to use.

Derivation of a direct from structure from a flow graph expressed in a non-standard form



Steps:

- From the signal flow graph, we write down the set of difference equations representing the graph (one equation for each node variable)
- Translate this set of equations in the Z-domain
- Find the system function as the ratio Y(z)/X(z)
- Draw the direct form I flow graph

Example 1

- Problem 6.2. Determine the difference equation that relates x[n] to y[n] in the following signal flow graph.

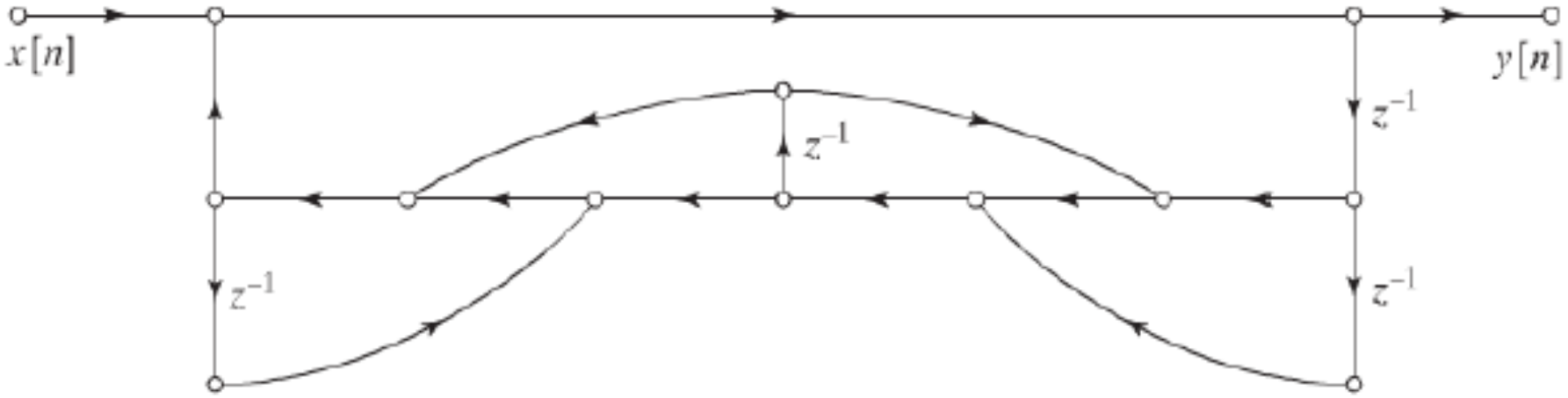
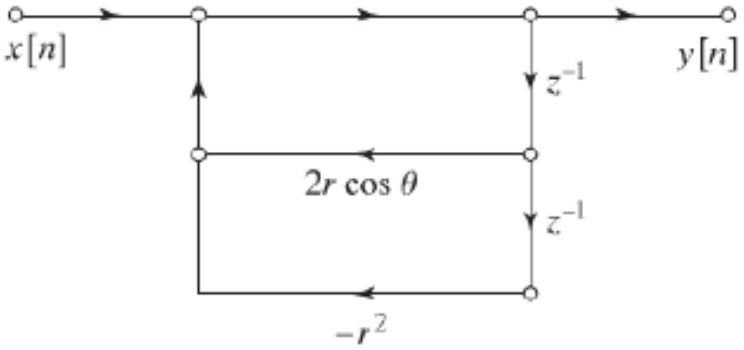


Figure P6.2

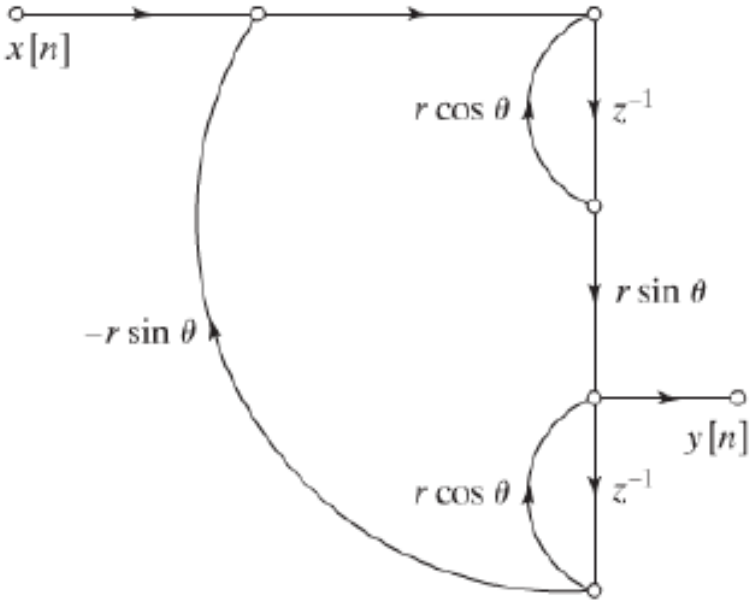
Example 2

- Problem 6.1 (textbook). Determine the system functions that correspond to each of the two flow graphs. Show that these system functions have the same poles./



Network 1

(a)



Network 2

(b)