ACTIVE NETWORK SYNTHESIS

ACTIVE NETWORK SYNTHESIS

- IC technology immensely influences the design of networks for voice and data comm.
- It enables the realization of these n/ws with small-size and low cost resistors,capacitors and active elements .
- They eliminate the need for inductors which are relatively bulky and expensive.
- Active R-C n/ws further give advantages such as :
  - (a) Standardusation and modularity of design
  - (b) Switchability
  - (c) Ease of manufacture
  - (d) Better performance vis-a-vis cost
  - (e) Much useful with computer aids
- A wide range of n/ws and filters using active R-C n/ws have been developed during the last two decades.

Elements used in active N /Ws

- Resistors
- Capacitors
- Active Elements like
  - (a) Op-amp (operational amplifier
  - (b) Gyrators
  - (c) Generalized Impedance Converters
- A Controlled Source is considered a basic active element .The are classified as under:
  - (i) Current controlled current source (cct)- Transistor
  - (ii) Voltage controlled current source (VCT)– Field EffectTransistor
  - (iii) Voltage controlled voltage source (VCT)– op amp
  - (iv) Current controlled voltage source

Operational Amplifier

- Also known as **Op amp.** It is designed to sense the difference
- between the voltage signals applied at its two i/p terminals
- (i.e., $V_b - V_{a)},$ multiply by a voltage gain A and cause the resulting voltage A $(V_b - V_a)$ to appear at o/p terminal.
- **Characteristics of Ideal op – amp**

(a) Infinite voltage gain

(b) Infinite bandwidth

(c) Infinite input impedance

(d) Zero output impedance

(e) Zero drift (parameter not changing with temp)

(f) Infinite slew rate (o/p voltage change occurs simultaneous with the i/p voltage change)

(g) Zero common mode gain (the op-amp gives only to the difference signal $V_b - V_a$ and so ignores any signal common to both inputs. i.e if V_b= Va = 1V then an ideal op-amp has zero common mode gain or equivalently infinite common mode rejection.)

Active Components

- Gyrator : It is a 2-port device which is becoming an integral part of active filter design and inductor simulation . It is a non reciprocal device.
- A gyrator is characterised by the terminal relationships

$V_1 = - r_1 I_2$

$V_2 = - r_2 I_1$

If $r_1 = r_2$, the power delivered to the gyrator is zero. Such a device is called passive lossless one and is called an ideal gyrator.

If $r_1 \neq r_2$, the power can be made negative and then the device is called an active gyrator. It is also considered as an impedance inverter.

2-port parameters of gyrator are

$z_{11} = 0 \quad z_{22} = 0$, $\quad y_{11} = 0 \quad y_{22} = 0$

$z_{12} = - r_1 \quad z_{21} = r_2$, $\quad y_{12} = g_2 \quad y_{21} = - g_1$

Filters

- A **filter** is a device that passes electric signals at certain frequencies or frequency ranges while preventing passage of others .Filters are used in wide range of applications esuch

  (a) Modem and speech processing

  (b) Channel selection in telephone central offices

  (c) Data acquisition systems

  (d) System power supplies

  Types of Filters

  (i) Low Pass Filter (LPF)

  (ii) High Pass Filter (HPF)

  (iii) Band Pass Filter (BPF)

  (iv) Band Stop Filter (BSF)

  Band Pass Filter can be realized by connecting LPF and HPF in Series.

  Band Stop Filter can be realized by connecting LPF and HPF in Parallel.

decibels

- Decibels are represented by dBs
- Decibels are the unit of power.
- **Power gain in dB = 10 log(P_2 / P_1)**

ex input power = 1 w and output power = 100w

Then gain in dBs = 20dBs [10 log (100 / 1)]

- **In terms of voltage**
- **gain = 20 log(V_2 / V_1)**

ex input voltage = 1 V and output Voltage = 100V

Then gain in dBs =40 dBs [20 log(100 / 1)

Attenuation is reverse of Amplification

3 dB reduction means power has attenuated by half

Active Filters

- Advantages of Active R-C filters :

  (i) Bulky inductors are not used .only R,C and op-amps are used. This saves cost ,makes the design more compact and reduces the loss.

  (ii) Increased circuit reliability , because all the processing can be automated.

  (iii) The design process is simpler than that for passive filters.

  (iv) They have high gain , inherently high input impedance with low output impedance.

  (v) The can realize a wider class of functions.

  (vi) They are easily compatible with IC circuits due to absence of inductor in the circuit.

  (vii) Improvement in performance because high quality components can be realized readily.

  (viii) A reduction in parasites , because of the smaller size.

Low Pass Filter

- $(v_0 – v) / R_2 = (v-0)/R_1$
  or $v = v_0 / [1 + (R_2 / R_1)]$ (1)
  $(v_i – v) / R = v / [1 / sc]$ or
  $v = v_i / [1 + RCs]$ (2) From eq (1) and (2)
  $v_0 / [1 + (R_2 / R_1)] = v_i / [1 + RCs]$
  or $v_o / v_i = [1 + (R_2 / R_1)] / [1 + RCs]$ (3)
  Gain of the op-amp circuit is
  $A_0 = v_0 / v = 1 + (R_2 / R_1)$ (4) From eq (3) and (4)
  $H(s) = v_o / v_i = A_0 / [1 + RCs]$
  $= A_0 / [1 +s / w_0]$
  This is the transfer function of First Order Active Low Pass Filter.
  $w_0 = 1 / RC$ represents the cut – off frequency.

Hence for given cut-off frequency w_0 and assumed C , the value of R can be evaluated . Similarly , for arbitrary gain A_0 = and some value of R_1 , the value of R_2 can be obtained and hence first

order active low pass filter can be designed.

High Pass Filter

- $(v_0 - v) / R_2 = (v-0)/R_1$
  or $v = v_0 / [1 + (R_2 / R_1)]$ (1)
  $(v_i - v) / [1 / sc] = v / R$ or
  $v = v_i / [1 + (1/ RCs)]$ (2) From eq (1) and (2)
  $v_0 / [1 + (R_2 / R_1)] = v_i / [1 + RCs]$
  or $v_o / v_i = [1 + (R_2 / R_1)] / [1 +1/ RCs]$ (3)
  Gain of the op-amp circuit is
  $A_0 = v_0 / v = 1 + (R_2 / R_1)$ (4) From eq (3) and (4)
  $H(s) = v_o / v_i = A_0 / [1 +1/ RCs]$
  $= A_0 / [1 + 1/(s / w_{0)}] = A_{0(}(s / w_{0)} / [1 + (s / w_0)]$
  Which is the transfer function of First Order Active High Pass Filter.
  $w_0 = 1 / RC$ represents the cut – off frequency.

Hence for given cut-off frequency w_0 and assumed C , the value of R can be evaluated . Similarly , for arbitrary gain A_0 = and some value of R_1 , the value of R_2 can be obtained and hence first order active high pass filter can be designed.

The interchanging of R and C in low pass filter results in first order high pass filter.

Band Pass Filter

Active LPF is in Series with active HPF

$f_1 = 1 / 2 \;\; R_1 \, C_1$ high frequency cut-off of LPF

$f_2 = 1/ \;\; 2 \;\; R_0 \, C_0$ low frequency cut-off of HPF

Band Stop Filter

- Active LPF is in Parallel with active HPF

- Low frequency cut –off of HPF $f_2 = 1 / 2\ R_h C_h$

- High frequency cut –off of LPF $f_1 = 1 / 2\ R_l C_l$

- The final op-amp stage acts as a summer.