Analog & Digital Communication

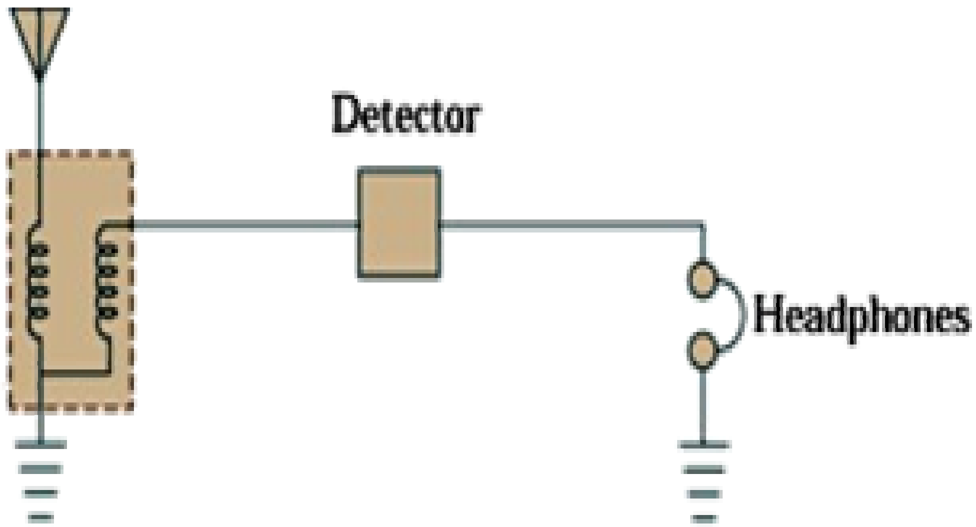
UNIT I

Tuned Radio Frequency Receiver

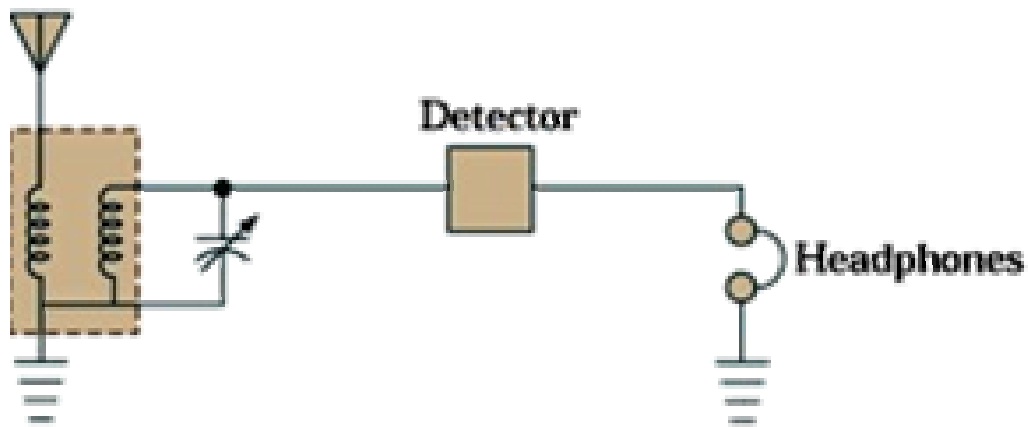
Outline

- Basic Receiver
- TRF block diagram
- Advantages
- Disadvantages

Basic receiver -1

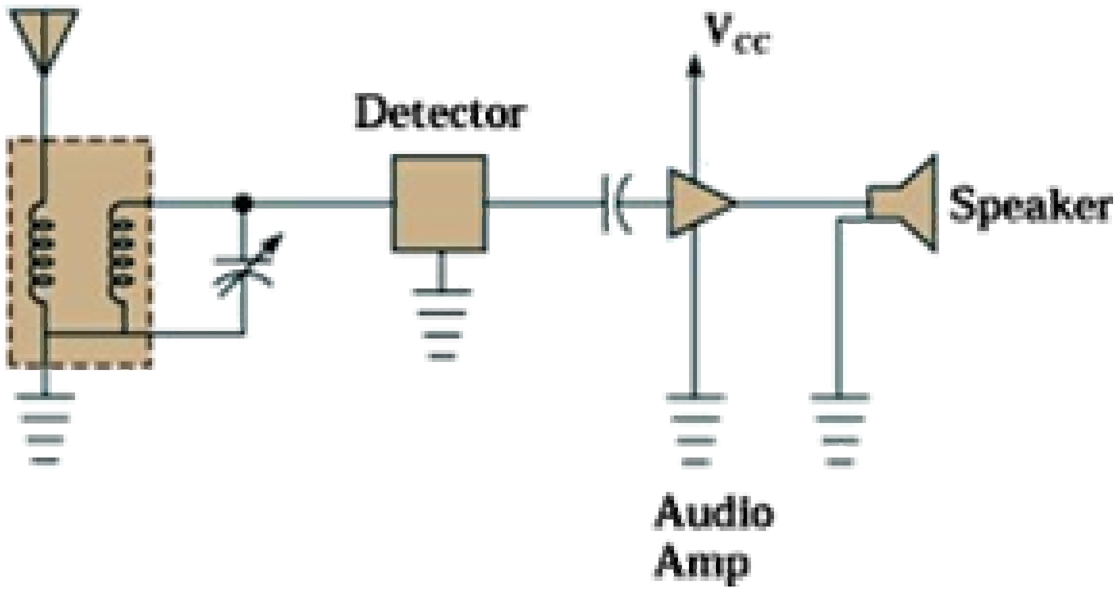


Basic receiver -2



If there are many stations then add one tuning circuit which selects a particular station

Basic receiver-3

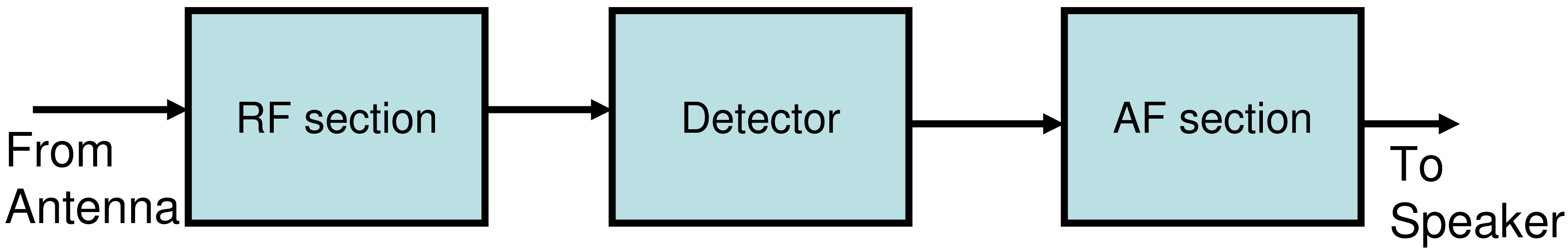


If the power from antenna is not sufficient then add an audio amplifier

Receivers

- Coherent receivers
  - Synchronous receivers
  - Carrier frequencies generated in the receiver and used for demodulation
- Non-coherent receivers
  - Asynchronous receivers
  - No frequencies are generated in receiver for demodulation purpose

Non-coherent tuned radio frequency receiver (TRF)



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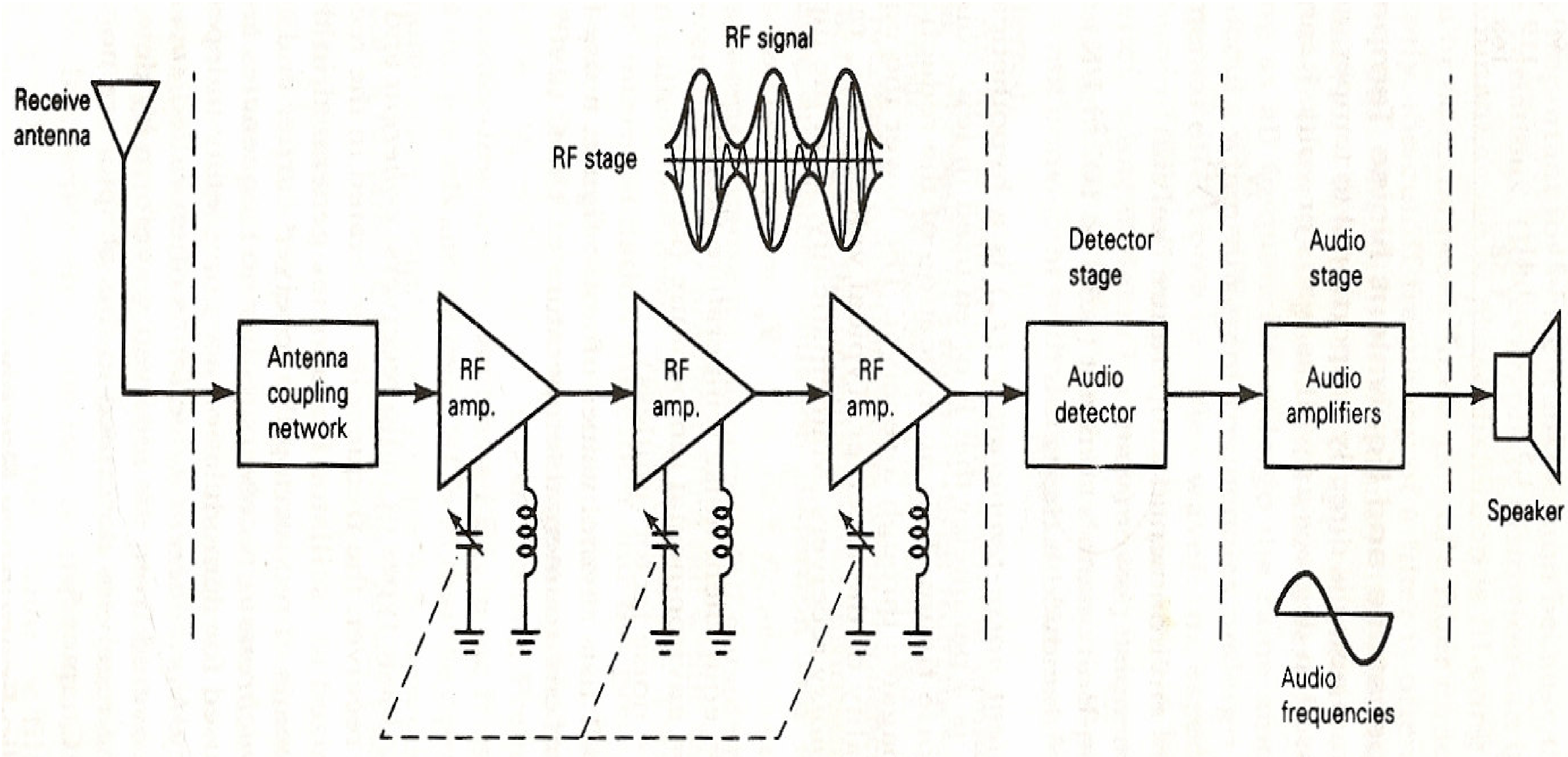
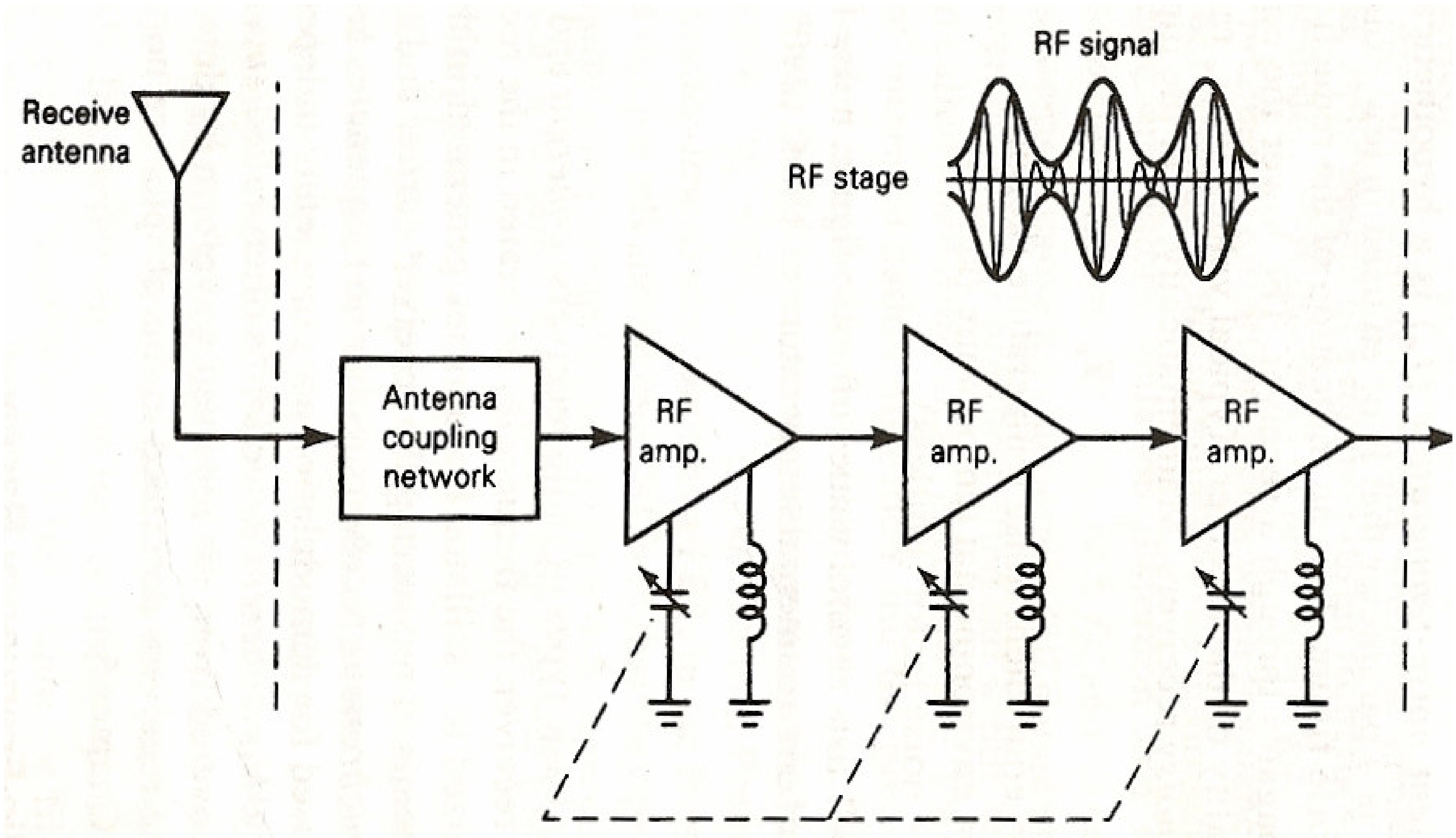
Non-coherent tuned radio frequency receiver (TRF)



TRF

- One of the earliest type of AM receivers
- Simplest in nature
- Three sections
  - RF stage
  - Detector stage
  - Audio stage

RF stage

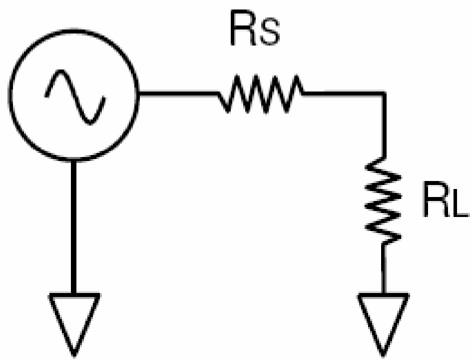

RF signal
Receive antenna
RF stage
Antenna coupling network
RF amp.
RF amp.
RF amp.

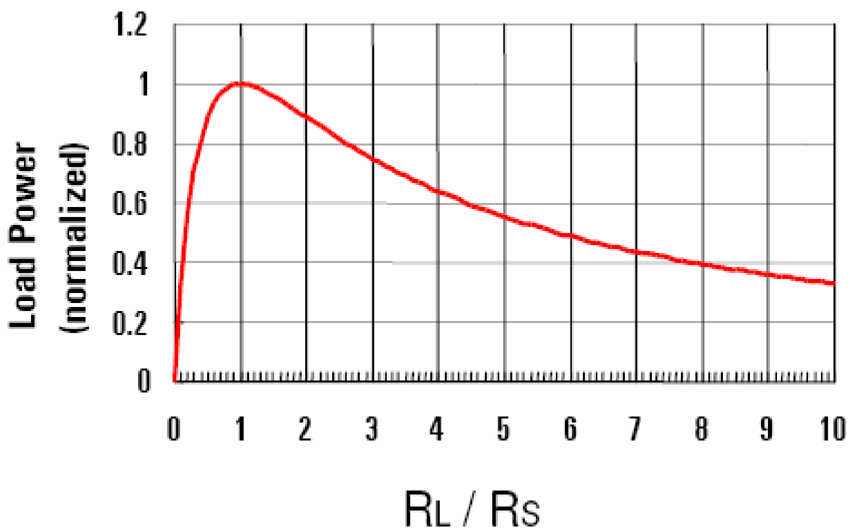
RF Stage

- Two to three RF amplifiers
- One matching (coupling) network
  - To match antenna impedance with amplifier input impedance

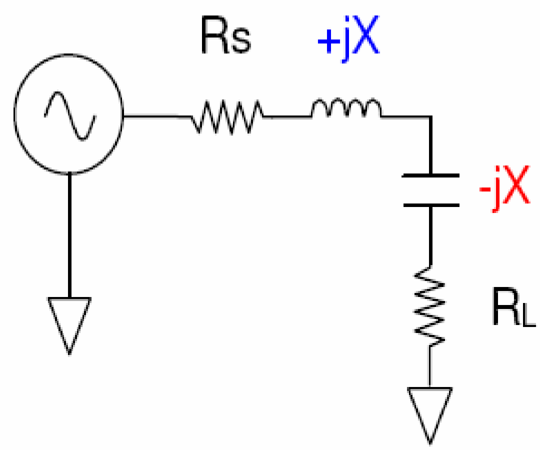
May be skipped from here

Power Transfer Efficiency





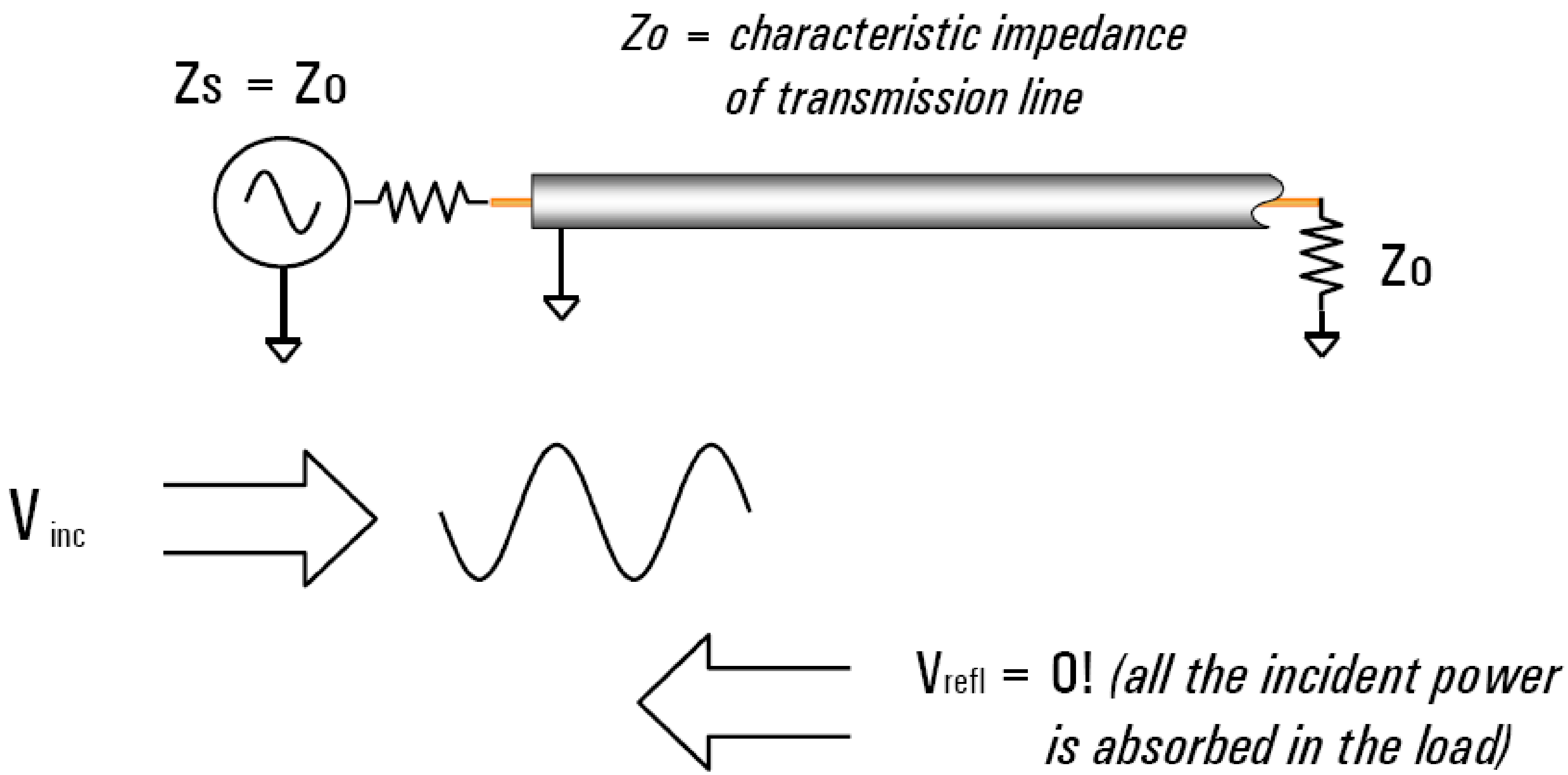
For complex impedances, maximum power transfer occurs when $Z_L = Z_S^*$ (conjugate match)



Maximum power is transferred when $R_L = R_S$

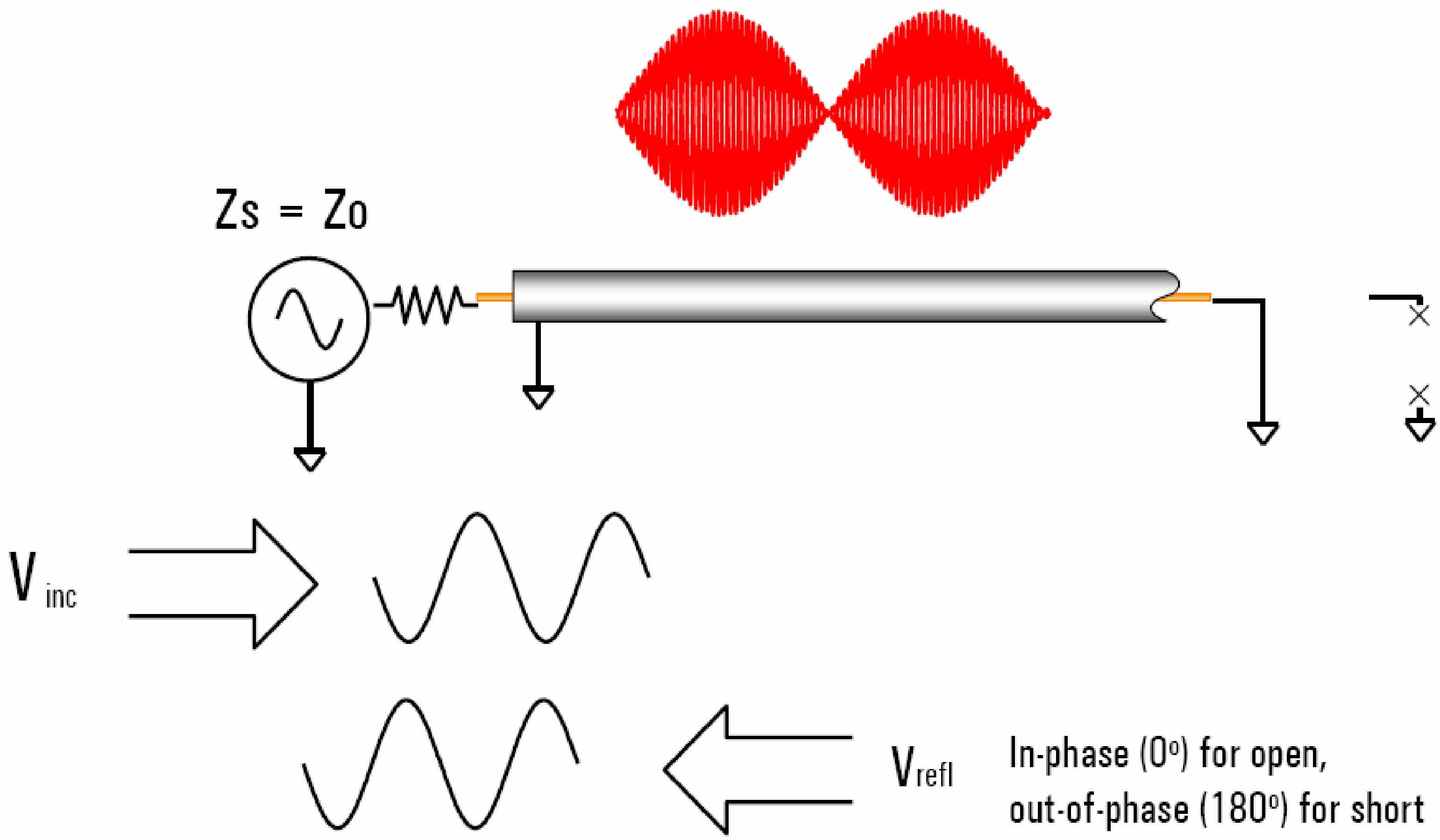
- Low frequencies
  - wavelengths >> wire length
  - current (I) travels down wires easily for efficient power transmission
  - measured voltage and current not dependent on position along wire
- High frequencies
  - wavelength » or << length of transmission medium
  - need transmission lines for efficient power transmission
  - matching to characteristic impedance (Zo) is very important for low reflection and maximum power transfer
  - measured envelope voltage dependent on position along line

Transmission Line Terminated with Zo



For reflection, a transmission line terminated in Zo behaves like an infinitely long transmission line

Transmission Line Terminated with Short, Open

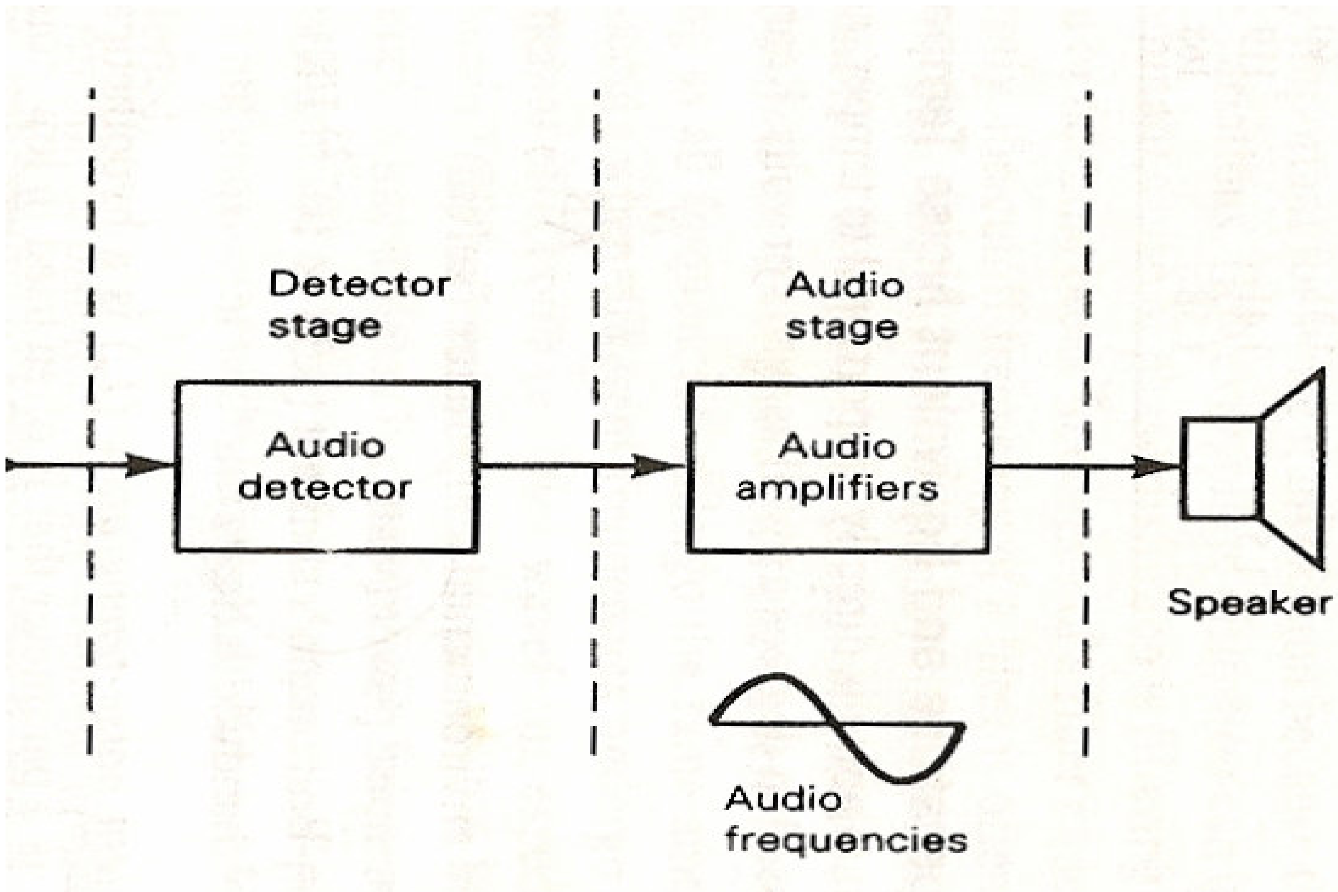


For reflection, a transmission line terminated in a short or open reflects all power back to source

..here

Detector and audio stage

From
RF amp

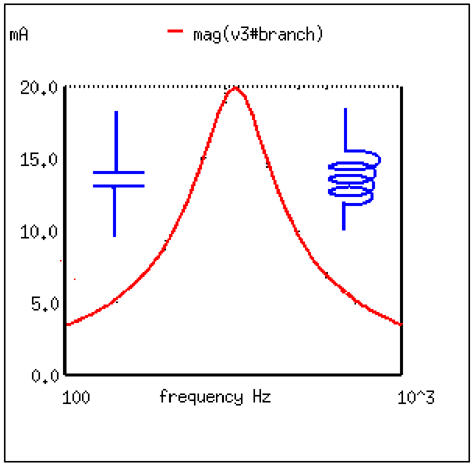


Advantages of TRF

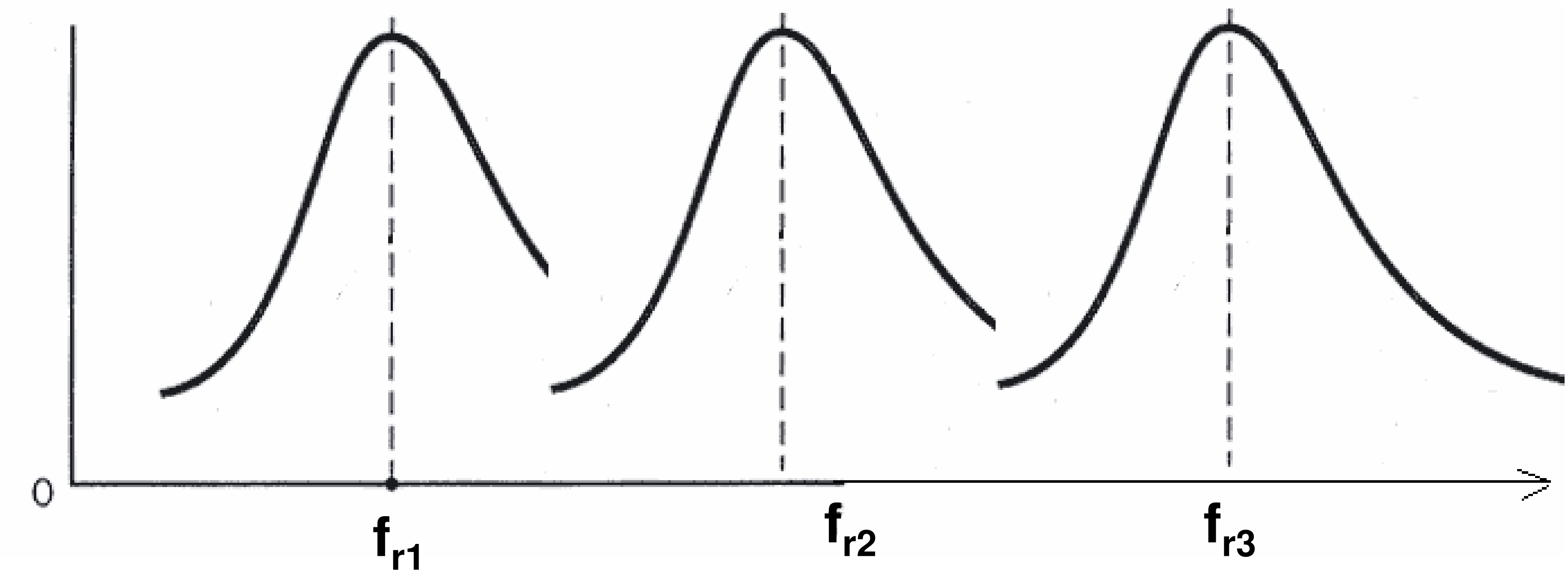
- Simple
- High sensitivity

Problem of tuning to different frequencies

$$resonantFreq = \frac{1}{2\pi\sqrt{LC}}$$

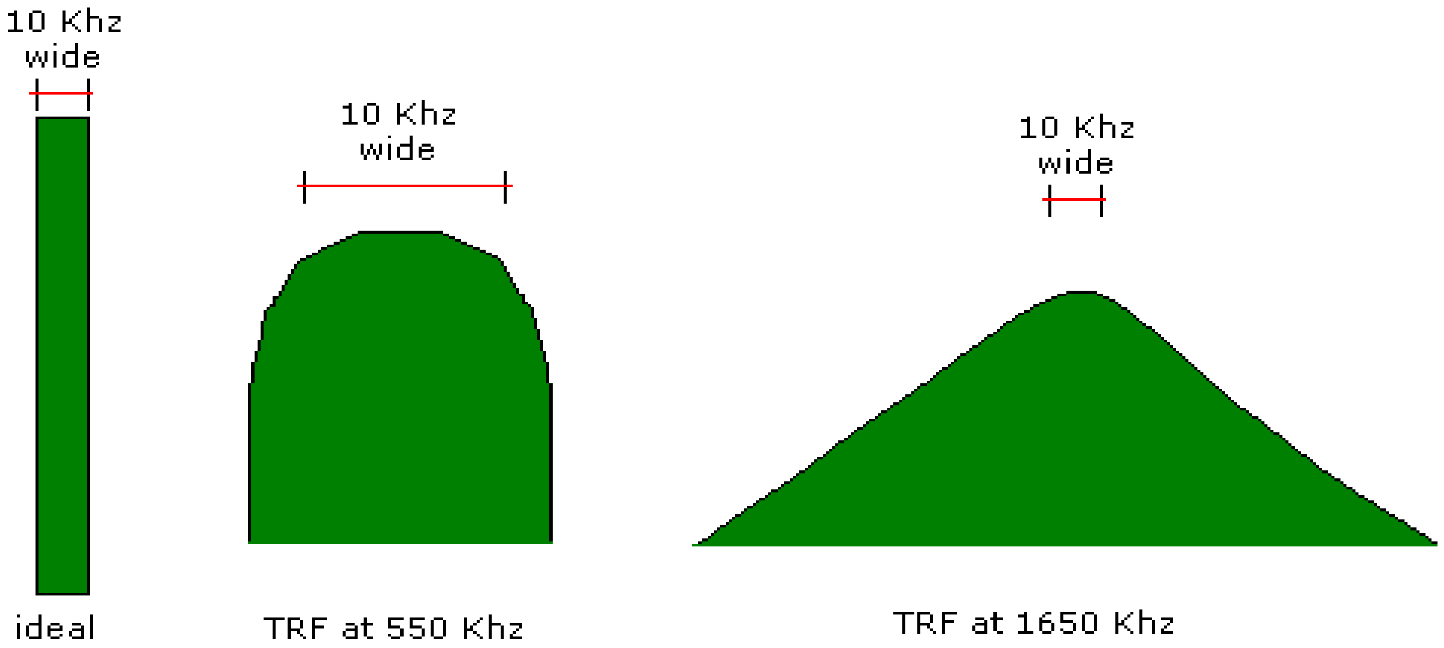


By changing L or C we can change resonant Frequency from f_{r1} to f_{r2} to f_{r3}



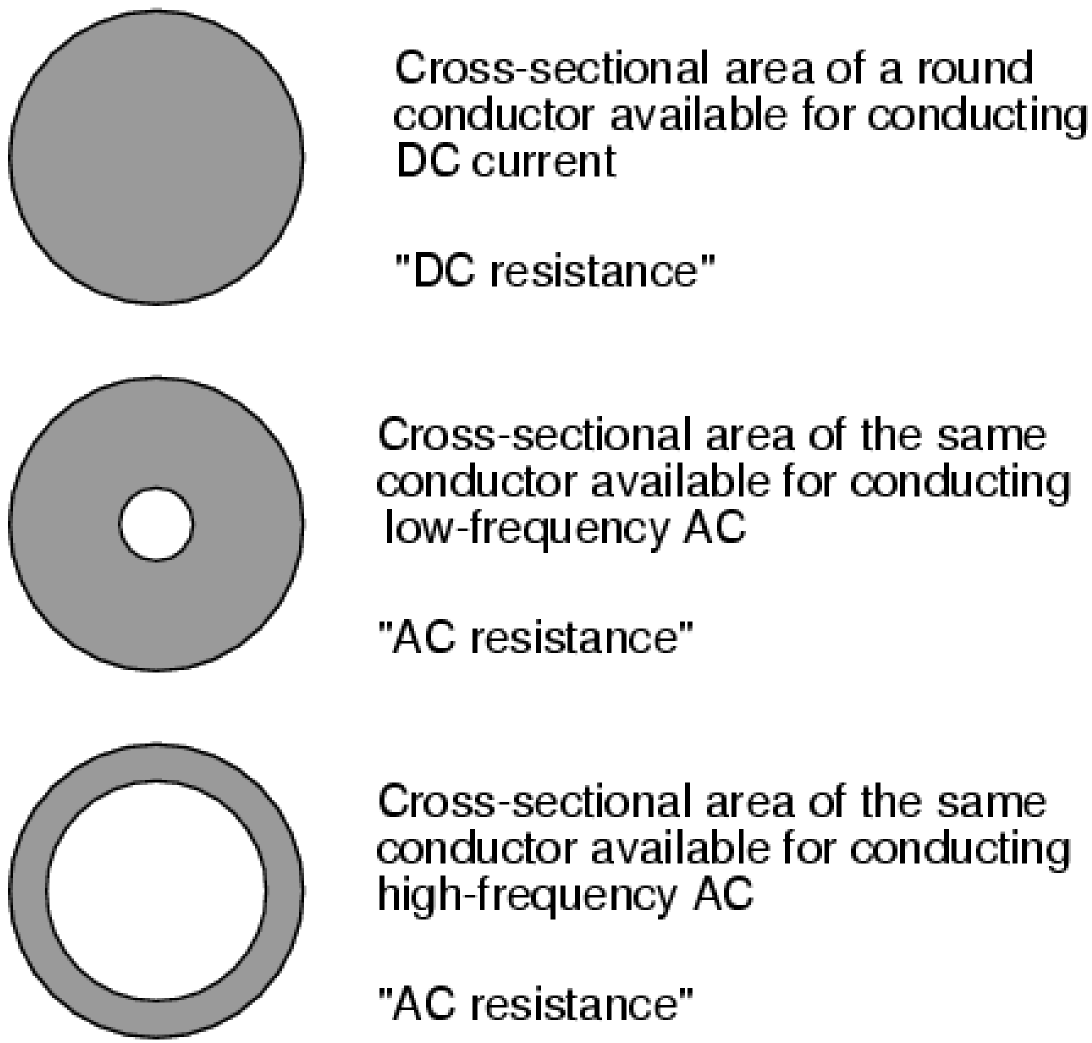
But what happens to bandwidth?

- Bandwidth inconsistent
  - When tuned over large frequencies



Skin effect

- At radio frequencies, current flow is limited to outer most area of a conductor
- Therefore area for current flow decreases
- Higher the frequency lesser the area available
- Resistance increases with frequency
- Quality factor of resonance circuit decreases
  - Bandwidth increases (f/Q)


Cross-sectional area of a round conductor available for conducting DC current
"DC resistance"
Cross-sectional area of the same conductor available for conducting low-frequency AC
"AC resistance"
Cross-sectional area of the same conductor available for conducting high-frequency AC
"AC resistance"

- For lower frequency narrower bandwidth
- As frequency increases bandwidth broadens

Instability

- Multistage RF amplifiers easily get into oscillation mode

<u>Solution</u>

- Stagger tuning
  - Tune each amplifier to different frequency slightly above or below center frequency

Non-uniform gain

- Amplifier gain is not constant for all the frequencies

Conclusion

TRF is suitable for single channel, low frequency application

Example

- For an AM commercial broadcast band receiver (535KHz to 1605 KHz) with an input Q-factor of 54, determine the bandwidth at the low and high ends of the spectrum

Answer

- Bandwidth of the tank circuit at 535 KHz is equal to 535 KHz/54 = 10 KHz
- Bandwidth of the tuned circuit at 1605 KHz is equal to 1605 KHz/54 = 29.63 KHz
- -3dB bandwidth at lower end of spectrum is 10 KHz
- But at the higher end of the spectrum it is three times more i.e. 30 KHz

Answer

- Suppose we want to achieve 10 KHz bandwidth at 1605 KHz, then Q factor of tank circuit should be 1605 KHz/10 KHz, Q=160
- Q factor of 160 will give -3 dB band width of 10 KHz at 1605 KHz
- But at, 540 KHz?
- -3 dB bandwidth is 540 KHz/160=3.4 KHz
- Too narrow bandwidth information is lost

- Instead of being shaped like a page they tended to look more like a flat sand hill.
- The reason for this is it is exceedingly difficult or near impossible to build LC Filters with impressive channel spacing and shape factors at frequencies as high as the broadcast band.