LECTURE #20

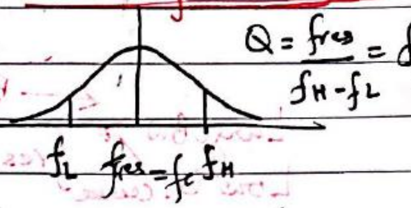
(221) DEMODULATION (CONTD). LECTURE # 20. RADIO RECEIVERS

DEMODULATION CONTD :- RADIO RECEIVERS (Rx)

Q.1 Important Definitions related to Radio Rxs.
Define the following terms related to Radio Rxs:-

(i) Receiver Sensitivity
(ii) Receiver Selectivity
(iii) Receiver Fidelity
(iv) Noise figure (F_n)

Selectivity Q Curve



$$Q = \frac{f_{res}}{f_H - f_L} = \frac{f_{res}}{BW}$$

(i) **Receiver Sensitivity:-**
Receiver Sensitivity of a receiver is defined as its ability to detect weak signals.

(ii) **Receiver Selectivity:-**
Receiver Selectivity is defined as the ability of a Rx to distinguish between two signals close in frequency.

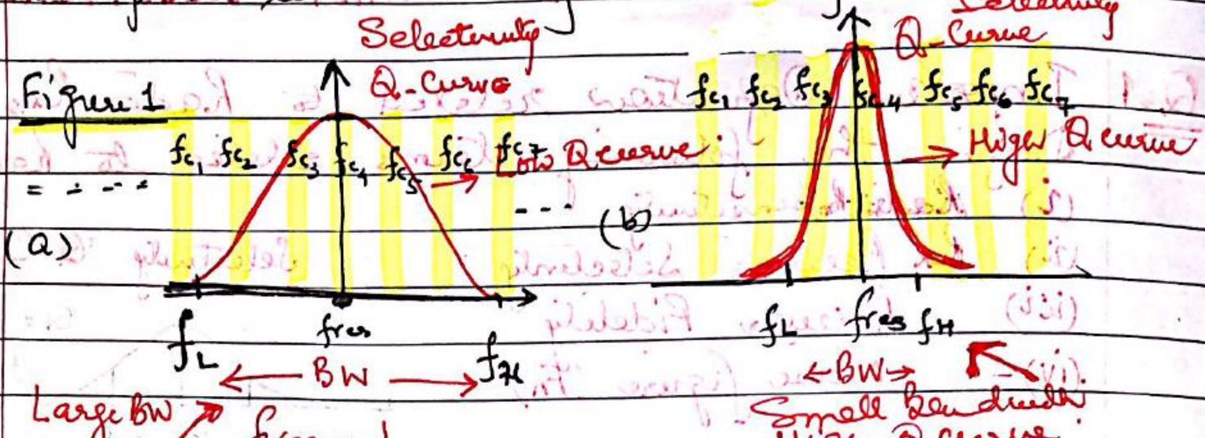
(iii) **Receiver Fidelity:**
Receiver Fidelity is the ability of a Rx to produce an output which is an exact replica (Copy) of the input at the Tx.

(IV) **Noise Figure (F_n)** : $F_n = \frac{(SNR)_o}{(SNR)_i}$; $F_n < 1$ ideally $F_n = 1$

Noise figure of a Rx is the ratio of SNR at output to SNR at input. SNR stands for signal-to-noise ratio. F_n indicates how much noise is introduced by the Rx system as the signals travels from input to output. In other words F_n is the measure of degradation of SNR as the signal travels from input to output. F_n is always < 1.

In figure 1, we may use some illustrations to help in understanding these definitions.

Figure 1



$f_{res} = \frac{1}{2\pi\sqrt{LC}}$

Figure 1(a,b) show Q-curves of a tuned ckt.

$Q = \frac{f_{res}}{BW}$

fres is the resonant frequency.

BW :- bandwidth & Q → Quality factor

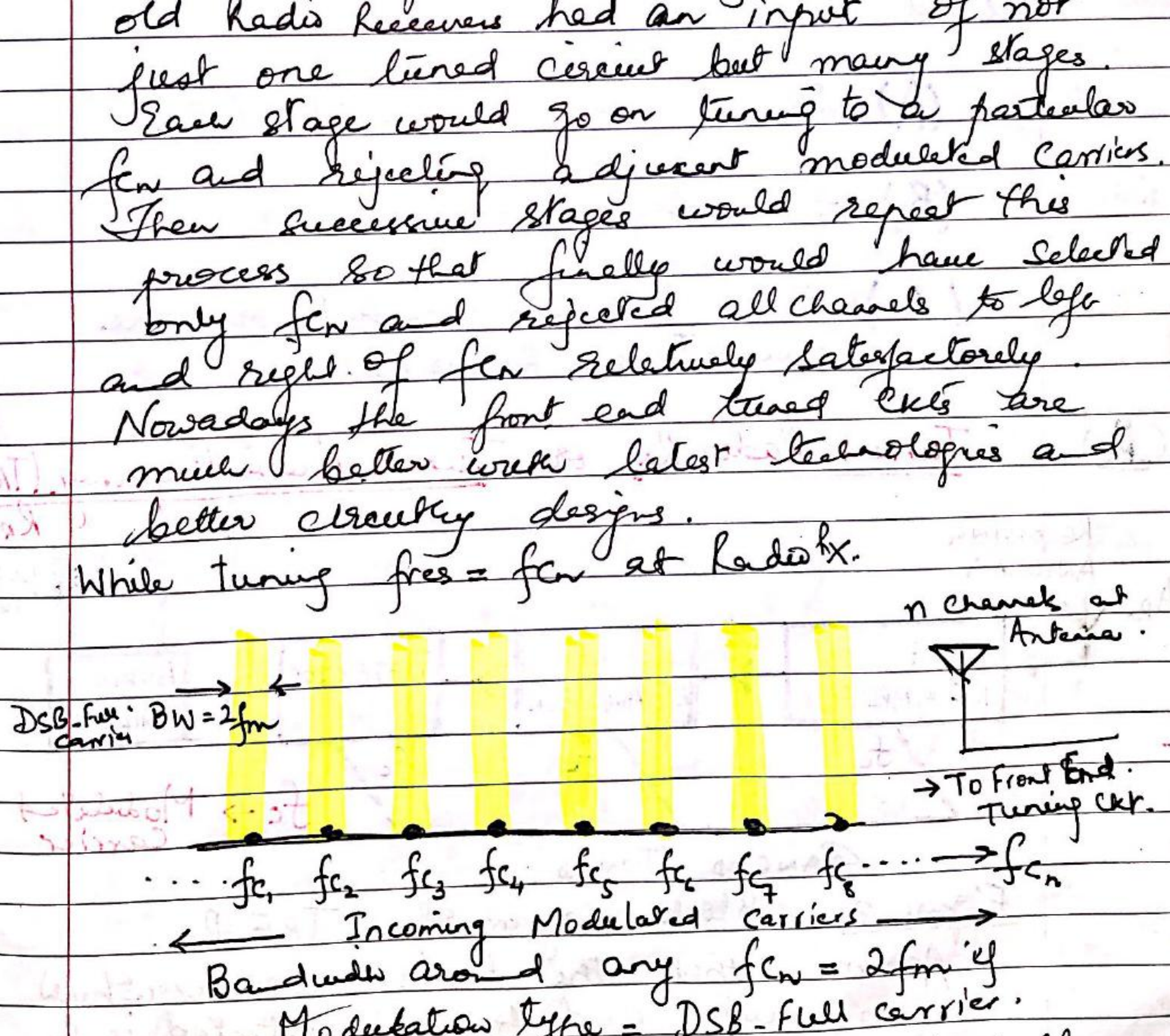
Above figures show that Q curve of Figure 1-a is a low response curve but covers large bandwidth whereas Figure 1-b show a high response curve but covers narrow bandwidth.

From the above two possibilities we shall observe that Figure 1-a Q curve shall offer low sensitivity & low selectivity whereas Figure 1-b Q curve shall offer high sensitivity and high selectivity. Now where bandwidth is concerned then Q-curve of Figure 1-a has larger bandwidth and hence such a tuned circuit will pick up more radio channels at the Rx. front end. Whereas Q curve of figure 1-b has smaller bandwidth and hence will pick up & pass less number of radio channels. Assume modulate radio channels as shown in Fig. The radio channels (shown by green coloured lines) are modulated carriers and have some BW around the respective carriers $f_{c_1}, f_{c_2}, f_{c_3}$ --- f_{c_n}.

If type of modulation is DSB-Full carrier then BW around any $f_{c_n} = 2f_m$.

The design of high Q tuned Ckts is not so easy especially if the modulated incoming carriers f_{c_n} is at a very high position in the spectrum. Therefore it would be much easier to get high Q tuned Ckts at low f_{c_n} (e.g at 100 KHZ) than at high frequency (e.g 1 MHZ). ∴ In early days of Radio Rxs, since it was not an easy task to construct and obtain high Q Ckts, therefore the early old Radio Receivers had an input of not just one tuned circuit but many stages. Each stage would go on tuning to a particular f_{c_n} and rejecting adjacent modulated carriers. Then successive stages would repeat this process so that finally would have selected only f_{c_n} and rejected all channels to left and right of f_{c_n} relatively satisfactorily. Nowadays the front end tuned ckts are much better with latest technologies and better circuitry designs.

While tuning $f_{res} = f_{c_n}$ at Radio Rx.



Bandwidth around any $f_{c_n} = 2f_m$ if Modulation type = DSB-Full carrier.

Figure 2: Assuming n modulated channels received at input of Rx. Any one channel is desired while all others are not.

Q.2.a What are the Different types of Radio Rxs?
Q.2.b Describe Each Type with the help of Block Digs and Give the advantages & Disadvantage of each type.

or

Q.3.a Describe :- Different types of Radio Rxs and
Q.3.b explain how they are able to overcome the disadvantages of their predecessor type?

Ans :- The three main type of Radio Receivers used in AM systems are :-

(A) The Tuned Radio Rx (TRF_Rx)

(B) The SuperHetrodyne Rx

(C) The Double Conversion Rx or the Double-Tuned Radio Rx.

(A). Tuned Radio Rx or Tuned Radio Frequency (TRF) Rx

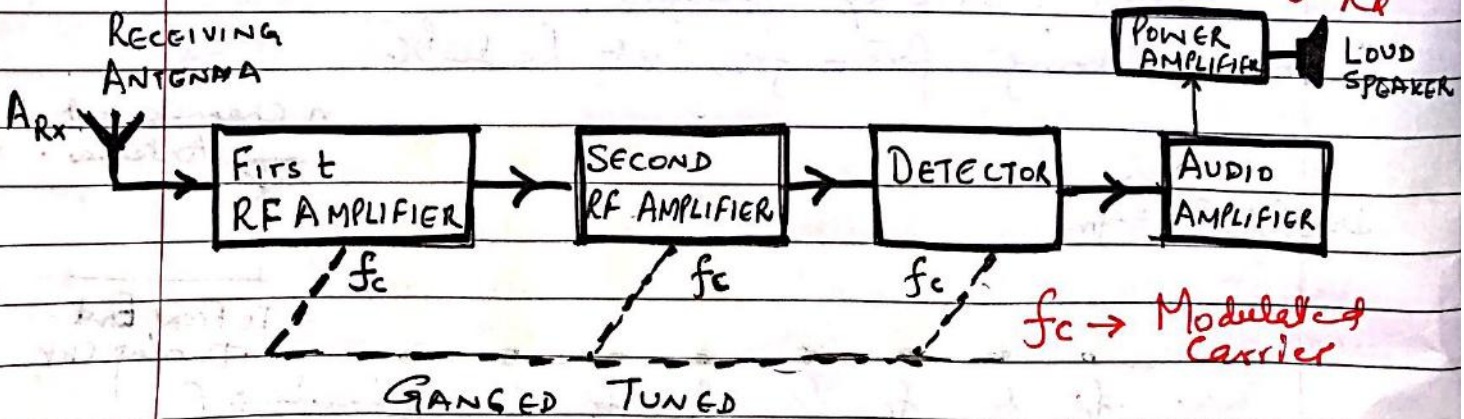


Figure 3: Block Diagram of a TRF_Rx /

Assume that the desired carrier which is modulated and has to be detected is f_c

The block diagram of a TRF-Rx shows that it has a Front-End that comprises of two or more RF Amplifiers. Each RF amplifier is tuned to the incoming desired signal ie the incoming modulated RF carrier (RF → radio frequency). The tuned RF amplifiers successively reject the unwanted adjacent signals (carriers). Collectively these will produce a highly amplified signal at the desired frequency. (ie here f_c).

The selected / tuned frequency (f_c) carries the Modulation. The modulation on f_c is demodulated and hence detected by the Detector. It is the detector that houses the demodulator e.g an envelope detector, Square law Device, or Product demodulator depending on the type of modulation carried by carrier (f_c). Detection is used to extract the modulation (baseband) signal originally carried by carrier (f_c).

General Points of TRF Rx / Merits & Demerits

(1) → The TRF Rx is a simple design but yet it is not widely used.

(2) → It is used mainly for Point-to-Point Communication. It is used by [illegible] being fix-tuned to a particular modulated carrier.

(3) → At the time of its introduction, it offered a great deal of improvement over previously used type of Rxs such as the crystal, regenerative and the super-regenerative Rx.

(4) → TRF-Rx is easy to tune to broadcast modulation frequencies (535 to 1640 kHz). However it poses difficulties at higher frequencies (Why?)

(5) → TRF-Rx suffers from Variation in BW over the tuning range (Why?)

(6) → TRF-Rx suffers from insufficient selectivity at higher frequencies. This means that TRF-Rx poses poor Selectivity at high frequencies (Why?)

Q.4 Give reasons for the statements in points nos. 4, 5 & 6 above with the help of an example.

Q.5 Consider a tuned Ckt required to have a BW of 10KHZ at a $f_{res} = f_c = 535$ KHZ.

Ans.
$$Q = \frac{f_{res}}{BW}$$

$$\therefore Q = \frac{535 \text{ kHZ}}{10 \text{ kHZ}} = 53.5$$

This means that the TRF-Rx requires a $Q = 53.5$ at 535 KHZ and offers a BW of 10KHZ.

Q.6 Repeat above Calculation for $f_{res} = 1640$ KHZ. How much Q is required at this f_{res} for the same BW of 10KHZ.

Ans. Now tuning frequency f_{res} is higher
Here $f_{res} = 1640$ kHZ & BW = 10 kHZ

$$\therefore \text{Required } Q = \frac{f_{res}}{BW} = \frac{1640 \text{ kHZ}}{10 \text{ kHZ}} = 164$$

This means that the TRF-Rx requires a higher $Q = 164$ at 1640KHZ for the same BW = 10KHZ.

Q.7 If $f_{res} = 1640$ KHZ and Q is ~~exceed~~ 120 then how much is BW of the Selectivity Curve. Comment on results.

$$Q = \frac{f_{res}}{BW}; \quad \text{Here } 120 = \frac{1640 \text{ kHZ}}{BW}$$

$$\therefore BW = \frac{1640}{120} \text{ kHZ} = 13.7 \text{ kHZ}$$

Comment on these Results that justify Points 4, 5 & 6.

Point #4 Proved — The solution of these questions show that statement no. 4 is true because as the TRF is tuned from lower frequency of 535 KHZ to 1640 KHZ and if BW offered ($f_H - f_L$) is fixed at 10 KHz the Q required also changes from Q = 53.5 to Q = 164. Therefore higher frequency tuning requires TRF-Rx Q to be higher.

Point #5 Proved — If TRF-Rx is tuned to 535 KHZ and Q = 53.5 for a BW of the Selectivity Response curve of 10 KHZ. Now let TRF-Rx is tuned to higher frequency of 1640 KHZ, then for same Q = 53.5 now the BW of the resulting Selectivity Response Curve will be $Q = \frac{f_{res}}{BW}$, $BW = \frac{f_{res}}{Q}$.

$$BW = \frac{1640\ KHZ}{53.5} = 30.65\ KHZ.$$

Thus even if Q is same at 53.5, and as tuning is changed from $f_{res} = 535$ KHZ to $f_{res} = 1640$ KHZ, then for the low f_{res} BW is 10 KHZ while for higher f_{res} BW = 30.65 KHZ. This means the Selectivity curve also changes. It will be poorly selective at higher frequency for the same Q value.

Point #6 Proved — From above example it is clear that TRF-Rx has poor selectivity at higher tuned frequencies because of larger BW at higher frequencies. Hence point #6 is proved.

Thumbs Rule #01 — In case of a Selectivity Q-Curve, high Q implies high sensitivity whereas small BW implies high selectivity. Normally in Q curves high Q and small BWs should be preferred.

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Thumb Rule: Main problem of TRF Rx is insufficient adjacent frequency rejection (Poor adjacent signal rejection). This is mainly due to large BW and low Q of the selectivity curve.

Another serious problem of TRF-Rx is that Q curve shape varies over the tuning range.

Q.8 What is the Ganged tuned arrangement in the Rxs?

LECTURE # 2 (STARTS HERE)

(B) Super-hetrodyne Receivers

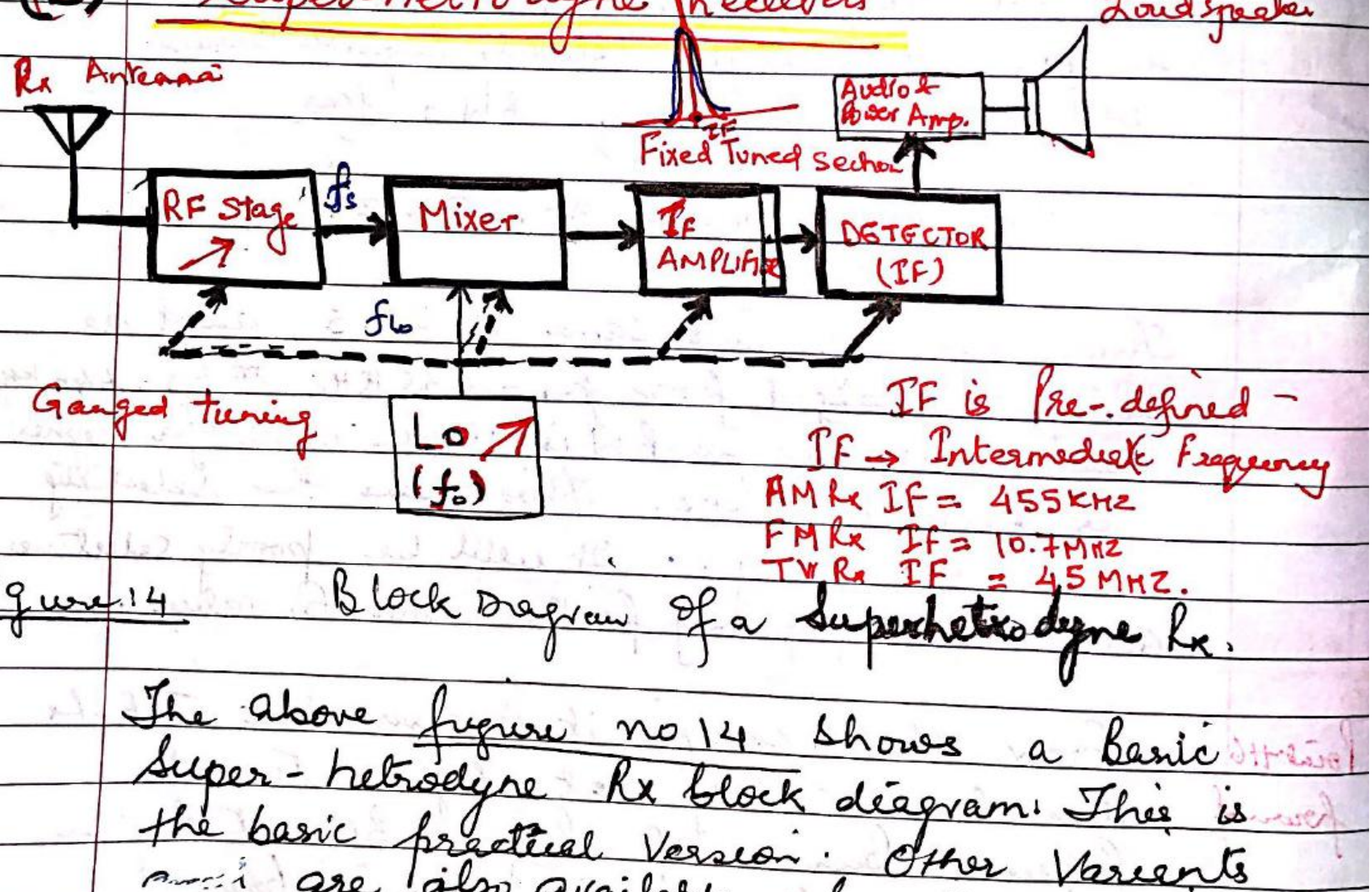

Figure 14 Block Diagram of a Superhetrodyne Rx.

The above figure no 14 shows a basic Super-hetrodyne Rx block diagram. This is the basic practical version. Other variants are also available. Superhetrodyne is used in radio and TV Rxs. This technique allows the Rxs to be tuned to a particular IF (intermediate frequency) even though the front end is variably tuned. This implies