(C) Double - Conversion Superhetrodyne Rx or Double - Tuned Radio Rx.

Merits :-

(i) The Double-Conversion Rxs allow them to have good adjacent Channel Selectivity.

(ii) For better performance IF should be both low and high. This receiver avoids this compromise by making use of two IFs in same Rx, both high IF & low IF.

(iii) It offers a good image rejection.

Main Application Area :

Double conversion offers no great advantage in broadcast or medium frequency Rx's. However it is essential for Rxs operating in crowded HF and other bands.

Q.18) Draw and explain block diagram of a Double Conversion Rx which could be used for 150 MHZ FM mobile band with following Specifications :-

(i) First IF_1 = 10.7 MHZ.
BandPass (BW) of First IF Amp = 150 KHZ

(ii) Second IF_2 = 465 KHZ
BandPass (BW) of Second IF Amp = 15 KHZ

(iii) Number of incoming Signals Received = 10 Channels/stations
BW of each Channel/Station = 15 KHZ including guard band.

(iv) Desired station f_s centred at 150 MHz.

(v) Stage no. 1 LO frequency $f_{LO_1} = 160.7$ MHz
Stage no 2 LO frequency $f_{LO_2} = 11.165$ MHz

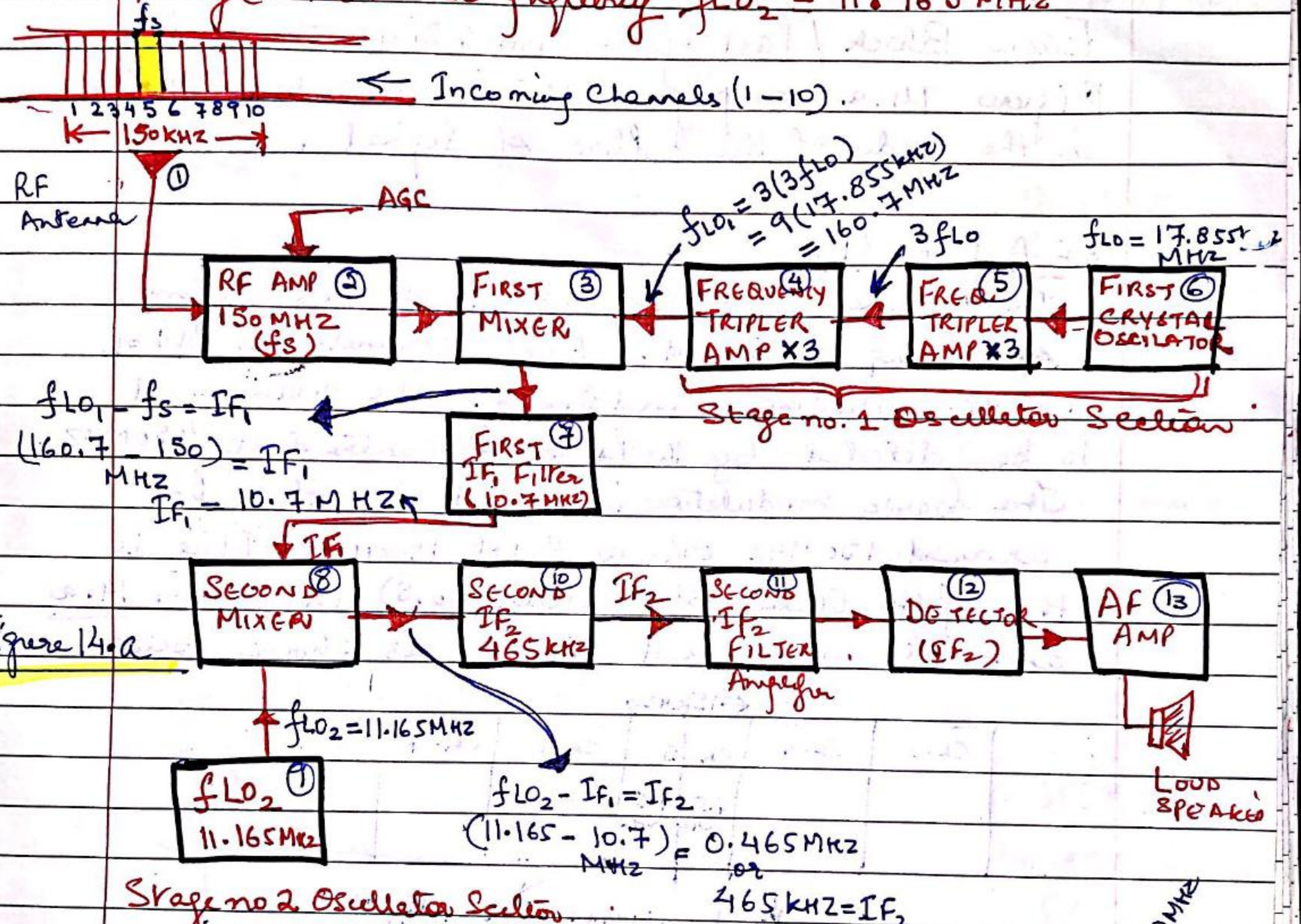
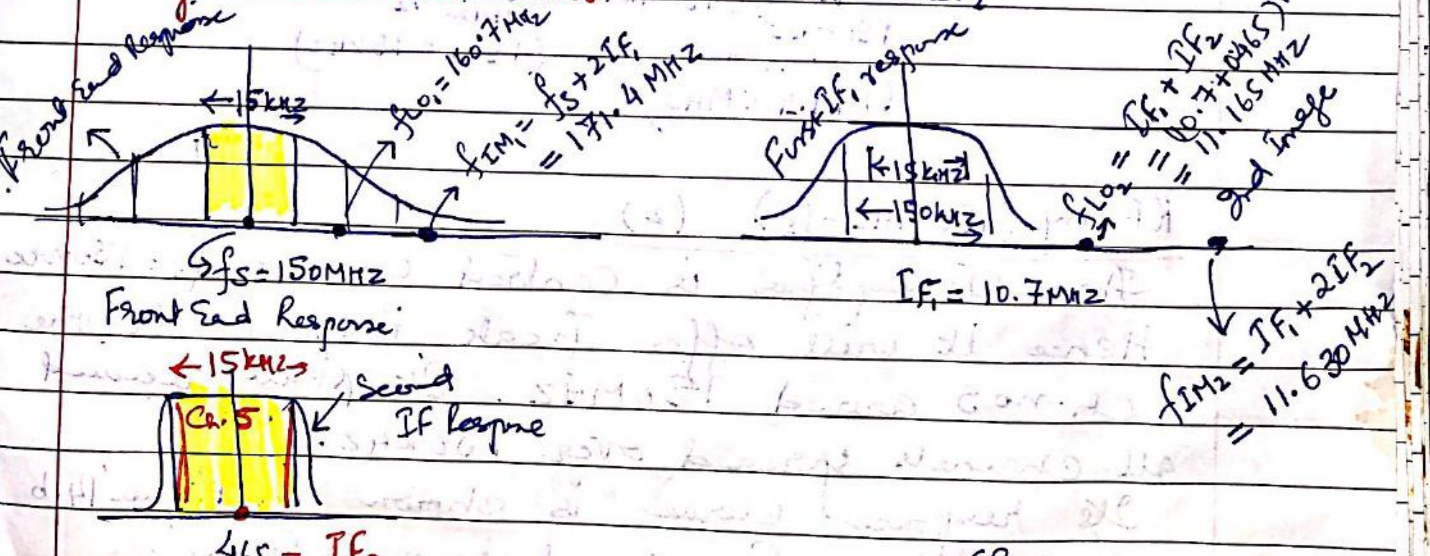


Figure 14.a



(PTO)

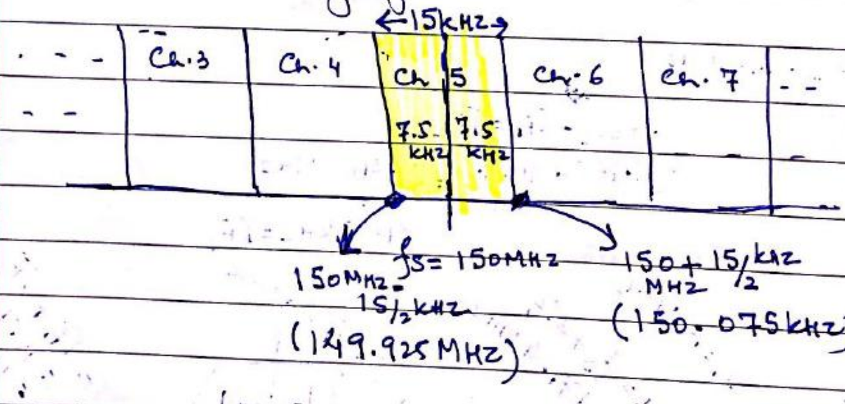
Figure 14.b: Response Curves at various Stages.

Brief Description of function of each block / parts (numbered from 1 to 13).

Each Block / Part of the Block Diag shown in Figure 14.a on page 255 is described briefly in the order of the flow of Signal.

RF Antenna (1)

The Antenna is shown with 10 channels / stations being recieved. Each channel has BW of 15KHZ including Guard Band. The main signal to be detected by the Rx is fs centred at 150MHZ. The basic modulation is carried by this fs around 150 MHZ over a BW of 15KHZ. This is the fifth Channel slot (Channel no.5) in figure 14.a and its magnified view is as shown below



RF Amp (150MHZ - fs) (2)

This RF amplifier is centred around fs = 150MHZ. Hence it will offer peak response to the Ch. no 5 around 150MHZ. It shall recieve all channels spread over 150KHZ. Its response curve is shown in Figure 14.b labeled as Front end response Curve.

Since first stage is designed to offer $f_{LO_1} = 160.7MHZ$

hence first image $f_{IM_1} = f_s + 2\,IF_1$

Here $IF_1 = 10.7\,MHz$

∴ First image freqn $f_{IM_1} = 150\,MHz + 2(10.7\,MHz)$

∴ $f_{IM_1} = 171.4\,MHz$

The spectral position of f_s, f_{LO_1} & f_{IM_1} are all shown in front end response curve of Fig. 14.b.

First Mixer (3)

This is the mixer of stage 1 that received two inputs. These are the 150 MHz centred channel f_s (and adjacent is front end response curve is poor). The second input to mixer is f_{LO_1} generated by oscillator section.

Stage 1 Oscillator section (4, 5, 6).

First crystal oscillator (6) produces $f_{LO} = 17.855\,MHz$

This is passed through two frequency ~~Triplex~~ tripler units (4)(5) so that first stage freq (LO) is

$$f_{LO_1} = 3(3)(17.855)\,MHz$$

$$f_{LO_1} = 160.7\,MHz$$

The Tripler units are used because it is not so easy to generate high frequency oscillations by circuits.

First stage IF_1 filter (7).

This filter is designed to produce high response to first stage $IF_1 = 10.7\,MHz$ over a BW of 150 kHz.

Thus the 10 channels, will pass thro the IF filter. However now modulation which was on fs at 150 MHz is now translated to corresponding modulation on IF_1 at 10.7 MHz. Hence main station (no. 5) modulation is around $IF_1 = 10.7$ MHz over BW of 15 kHz. Around this IF_1 will also be the other channels. This is shown in fig 14(b) by the first IF_1 response curve.

Since pre-defined $IF_2 = 465$ kHz, therefore second stage $f_{LO_2} = 11.165$ MHz

Also we may consider it this way.

$$f_{LO_2} = \underbrace{IF_1}_{\text{Signal in Second stage}} + IF_2 = 11.165 \text{ KHz}$$

$(f_{LO} = f_s + IF)$

$(f_{IM} = f_s + 2\,IF)$.

∴ Second image position is

$$f_{IM_2} = \underbrace{IF_1}_{\text{signal in second stage}} + 2\,\underbrace{IF_2}_{\text{IF of second stage}}$$

IF of second stage → i.e. of second stage.

$$\therefore f_{IM_2} = 10.7\text{MHz} + 0.465\text{MHz}$$

$$f_{IM_2} = 11.630\text{MHz}$$

Even though first image f_{IM_1} was within response curve band pass but that problem is removed by second stage because as seen in figure f_{IM_2} is completely outside the bandpass of first IF_1 response curve centred at 10.7 MHz.

Second Mixer (8)

This mixer hetrodynes IF_1 at 10.7MHZ with second stage LO frequency f_{LO_2} at 11.165MHZ shown in block (9)

Hence $f_{LO_2} - IF_1 = IF_2$

$$\therefore IF_2 = 11.165\,MHZ - 10.7\,MHZ = 0.465\,MHZ.$$

or $\boxed{IF_2 = 465\,KHZ}$

Here also the modulation on Channel no.5 that was now translated to 10.7MHZ is now translated on to a new $IF_2 = 465\,KHZ$. Channel information extends over 15KHZ around 465KHZ. Still there are adjacent Channels picked up by the wide ~~pass~~ Bandpass of previous blocks.

Second IF_2 filter (10)

The adjacent channels are rejected by the second IF_2 filter that should have Bandpass of 15KHZ Centred around 465KHZ so that as shown in Fig 14(b) we are able to get at O/p of this block (10) only the desired Channel no. 5.

Second IF_2 filter Amplifier (11), Detector (12) and AF amplifier (13) are all designed to provide best performance in terms of amplification, demodulation and further amplification around $IF_2 = 465\,KHZ$.

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Important:- Many Communication Rx used for frequency > 30 MHz is FM so the second IF amplifier will be followed by a limiting amplifier and then a frequency discriminator.

IF_1 — This is a high value of 10.7 MHz used for good image response rejection by assuring that the first image frequency is well outside the fixed tuned RF amplifier bandpass

IF_2 — The narrow band pass required for good adjacent Channel rejection is obtained in the second stage which may have value as low as $IF_2 = 100$ KHZ.