5 Superheterodyne Receiver

Read Z+T Sec. 3.5 pp. 136–139

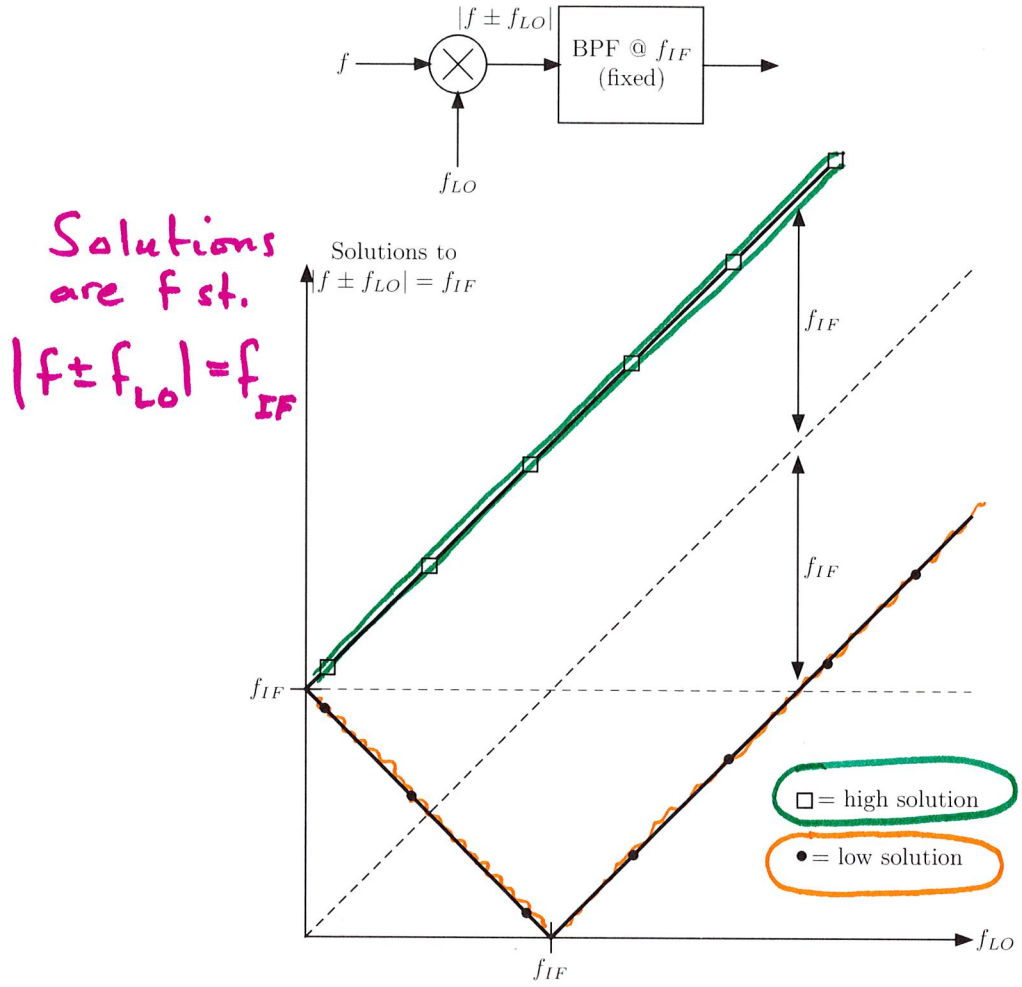
In this section we restrict ourselves to positive frequencies, i.e., f, f_{IF}, and f_{LO} are all > 0.

1. Architecture of SHR is mixer followed by BPF centered at desired IF frequency. Idea is to tune the receiver by varying the frequency f_{LO} of a local oscillator in order to translate desired carrier frequencies to center them on the IF filter.

2. For each choice of f_{LO} there are two frequencies f, which satisfy

$$|f \pm f_{LO}| = f_{IF}$$

and, therefore, would mix to appear in the output of the BPF. The two solution sets vs. f_{LO} are shown in Figure 4.



Solutions are f st. $|f \pm f_{LO}| = f_{IF}$

Figure 4: For a fixed IF frequency f_{IF} and a local oscillator frequency f_{LO} there are always two input frequencies, which are mixed to the IF.

Positive f solutions to $|f \pm f_{LO}| = f_{IF} \iff f \pm f_{LO} = \pm f_{IF}$

$$\iff f = \mp f_{LO} \pm f_{IF}$$

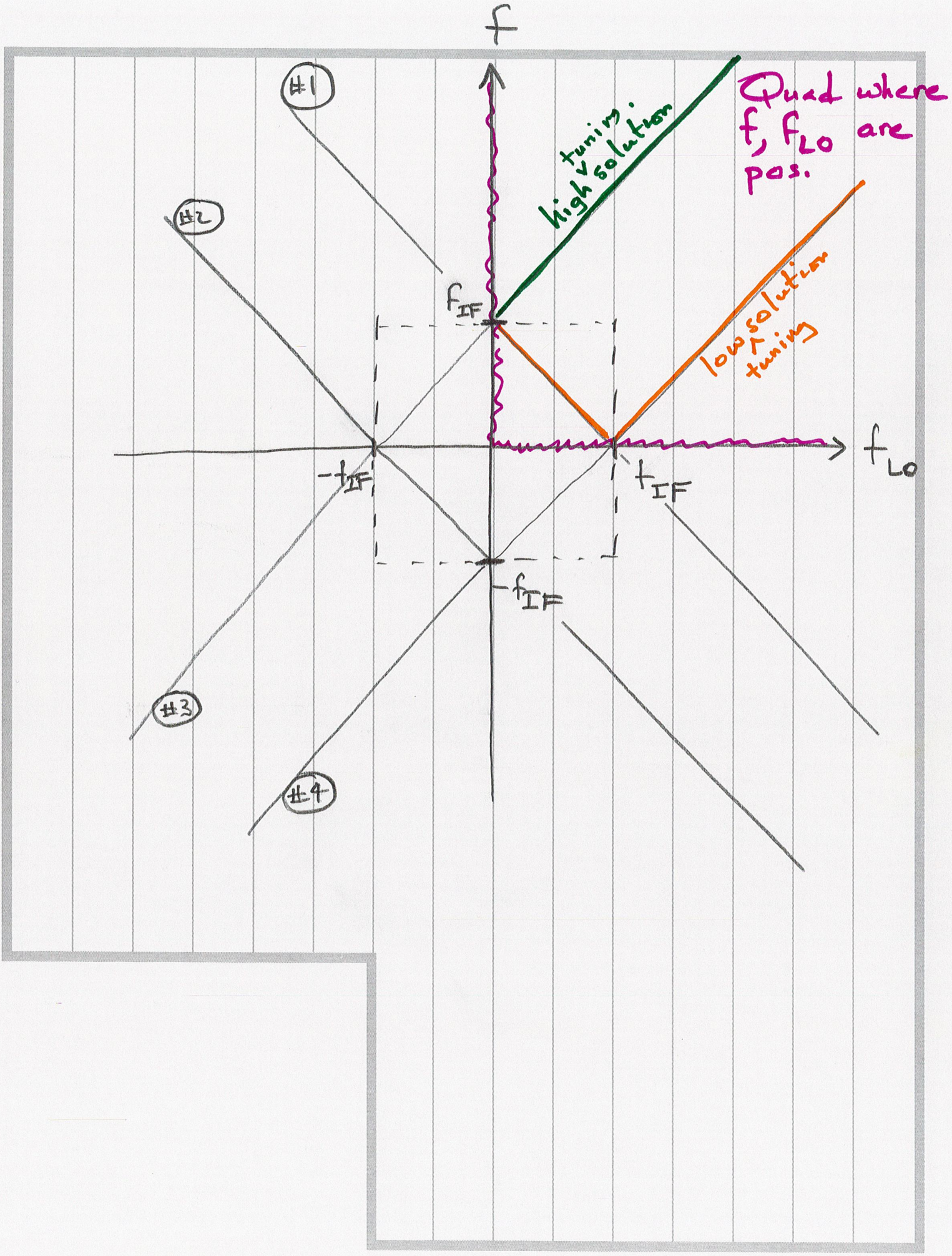
∴ There are 4 cases ...

$$f = -f_{LO} + f_{IF} \quad \#1$$

$$-f_{LO} - f_{IF} \quad \#2$$

$$+f_{LO} + f_{IF} \quad \#3$$

$$+f_{LO} - f_{IF} \quad \#4$$


f
#1
#2
#3
#4
tuning: high solution
Quad where f, f_{LO} are pos.
low solution tuning
f_{IF}
$-f_{IF}$
f_{IF}
$-f_{IF}$
f_{LO}

3. Explanation of operation. Let f_{IF} be a fixed IF frequency and let $f_{desired}$ be the carrier frequency of a signal that we wish to receive in the output of the IF filter. There are two classifications:

   (a) **Upconversion:** $f_{IF} > f_{desired}$. See Figure 5.

   (b) **Downconversion:** $f_{IF} < f_{desired}$. See Figure 6.

4. To prevent both desired and image to appear summed in the output of the BPF a pre-filter must be used to reject the image.

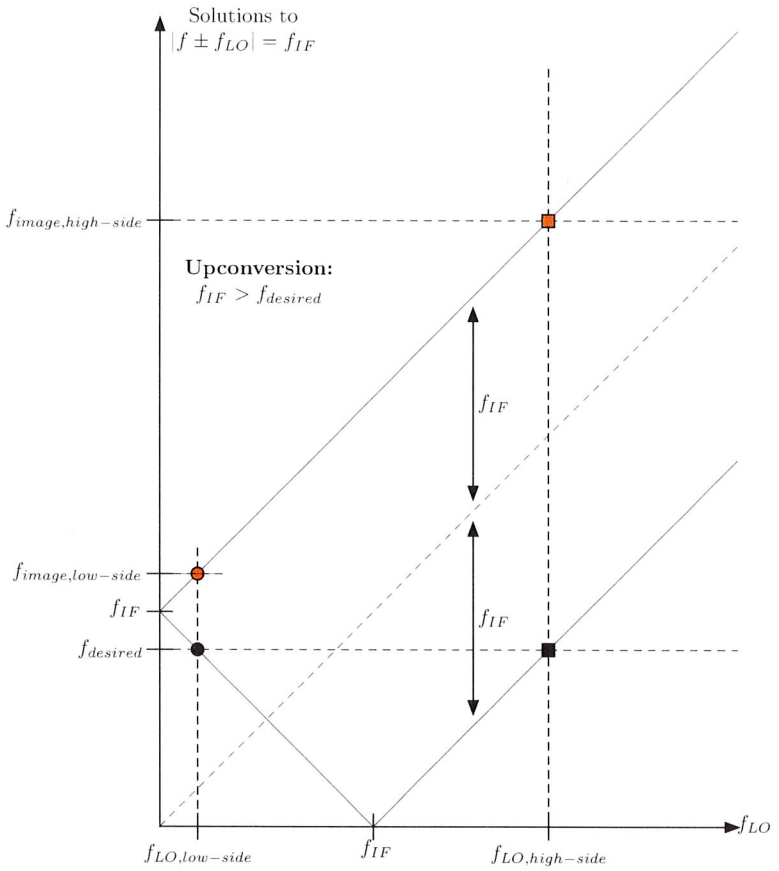


Figure 5: (Upconversion: $f_{IF} > f_{desired}$.) For any $f_{desired}$ there are two choices of LO frequency which will mix it to the IF filter output: $f_{LO,low-side}$ and $f_{LO,high-side}$. Each choice of LO frequency results in an image frequency, which would also appear in the IF filter output.

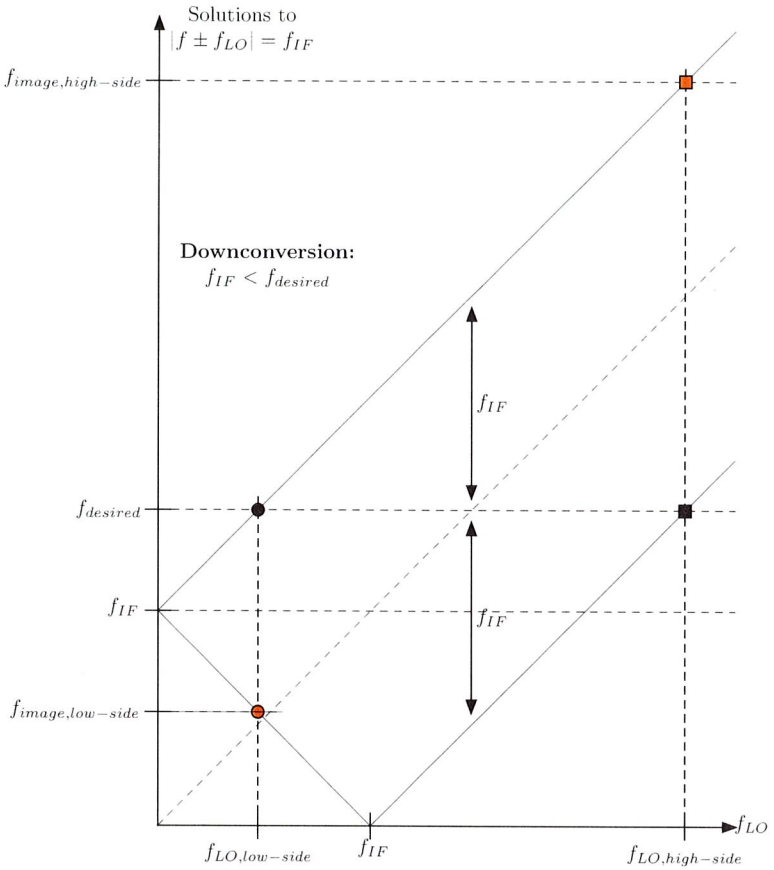


Figure 6: (Downconversion: $f_{IF} < f_{desired}$.) For any $f_{desired}$ there are two choices of LO frequency which will mix it to the IF filter output: $f_{LO,low-side}$ and $f_{LO,high-side}$. Each choice of LO frequency results in an image frequency, which would also appear in the IF filter output.

5. With the SHR architecture one is usually interested in tuning a desired band, e.g., $f_L \leq f_{desired} < f_H$ by varying the local oscillator frequency f_{LO}. This more general case is illustrated in Figures 7 and 8.

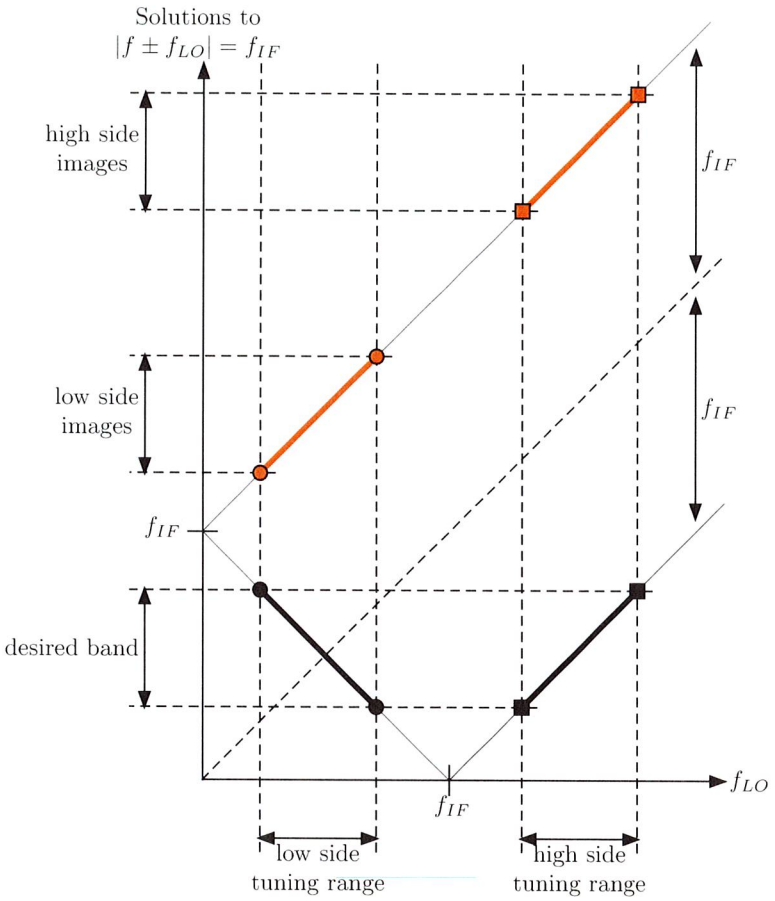


Figure 7: (Upconversion: $f_{IF} > \text{range}(f_{desired})$.)

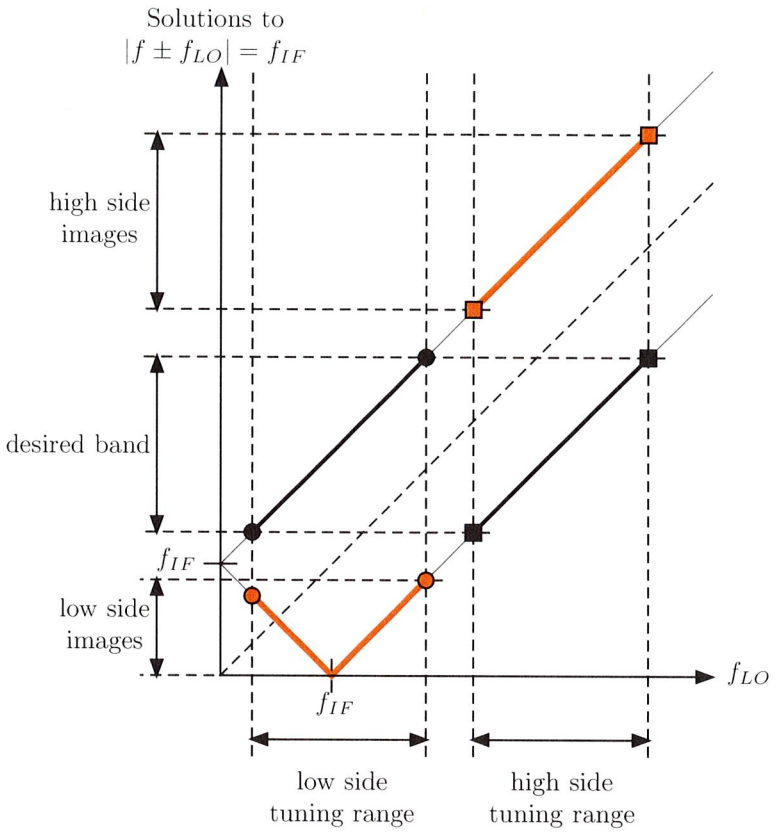


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Figure 8: (Downconversion: $f_{IF} < \text{range}(f_{desired})$.)

6. Sometimes the desired band and the corresponding band of images (either high side or low side images, depending on the tuning scheme) do not overlap. This is the case drawn in Figures 7 and 8. Then a fixed RF prefilter can be used to reject the images.

7. High side tuning has the advantage that is requires the local oscillator to be tunable over a relatively smaller range than does low side tuning. (Relative to the mid point of the required LO frequency range.)

8. The example for AM broadcast band is shown in Figure 9.

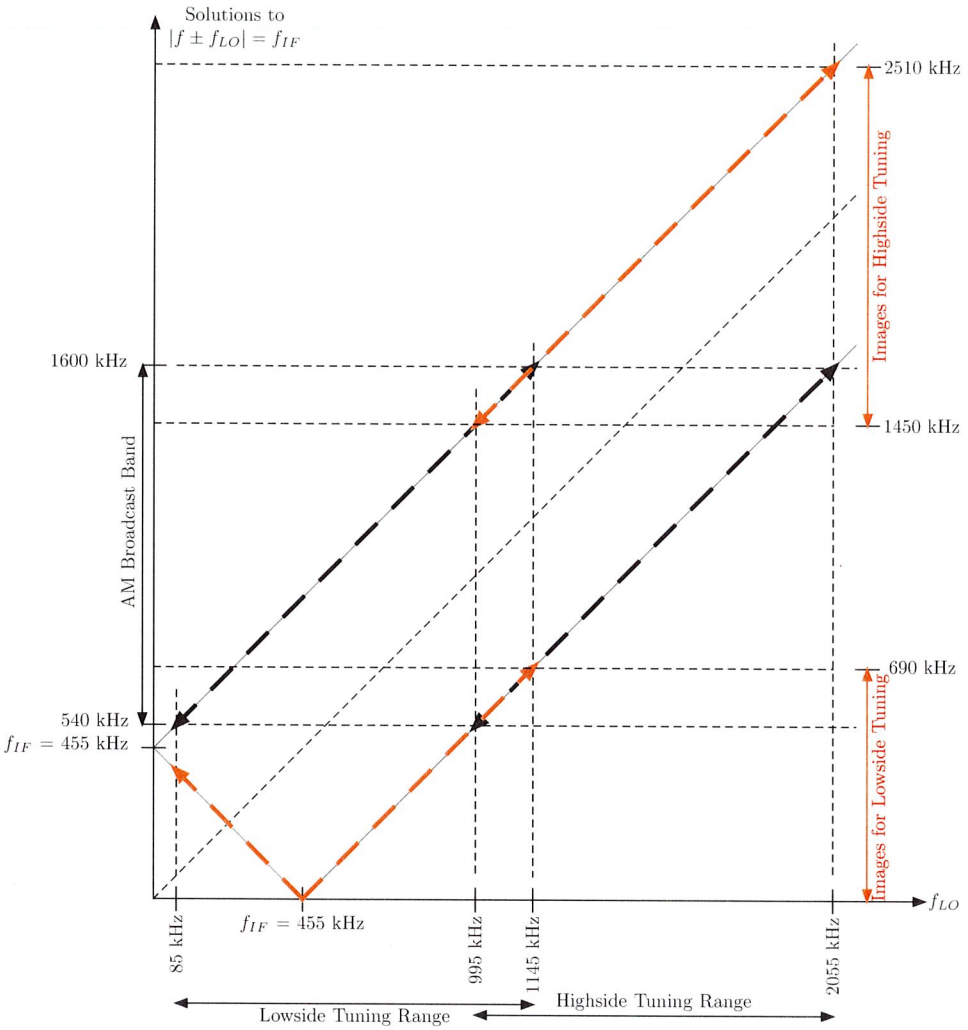

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Figure 9: AM broadcast band for IF frequency 455 kHz.