# Super heterodyne receiver



$[A + m(t)] \cos \omega_c t$

$[A + m(t)] \cos \omega_{IF} t$

RF amplifier with bandpass filters tunable to desired $\omega_c$

Frequency converter (mixer)

IF amplifier

Detector
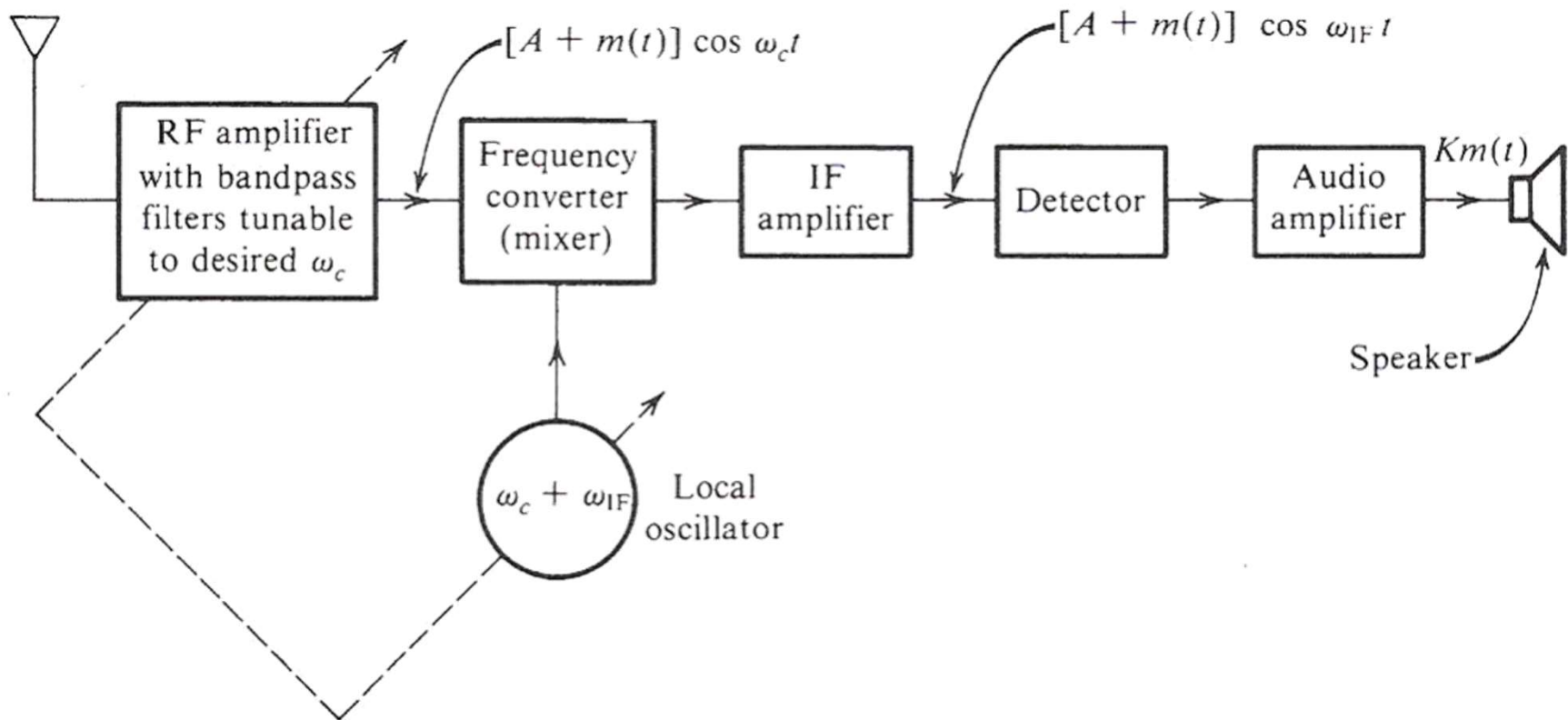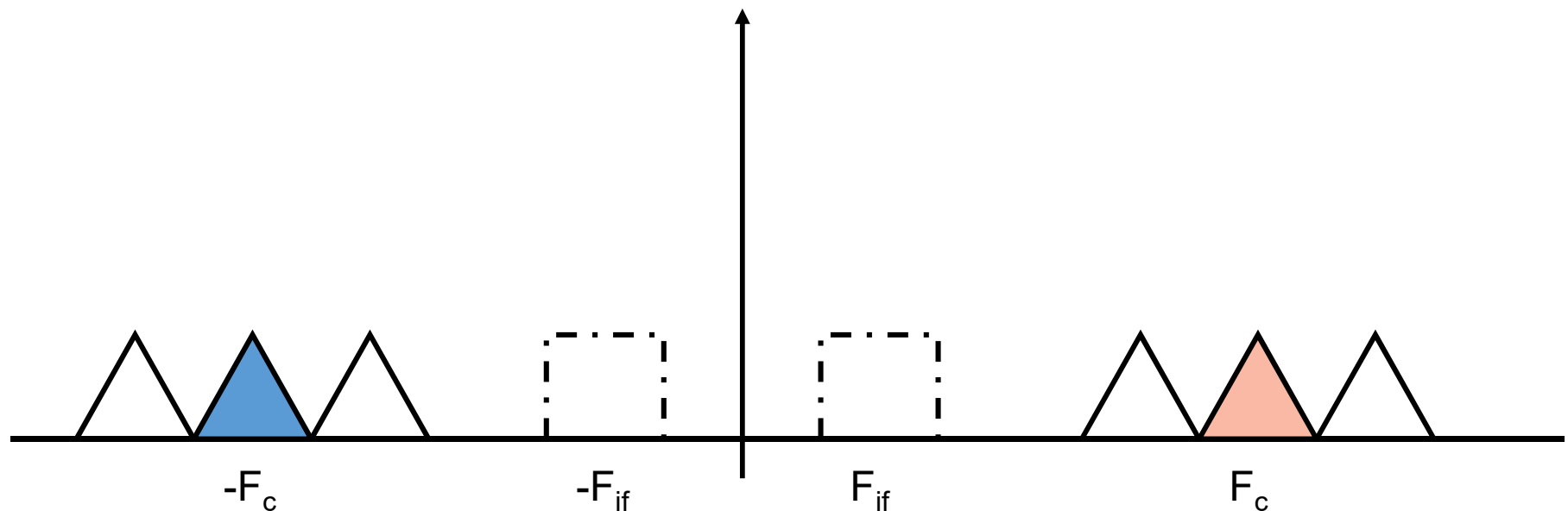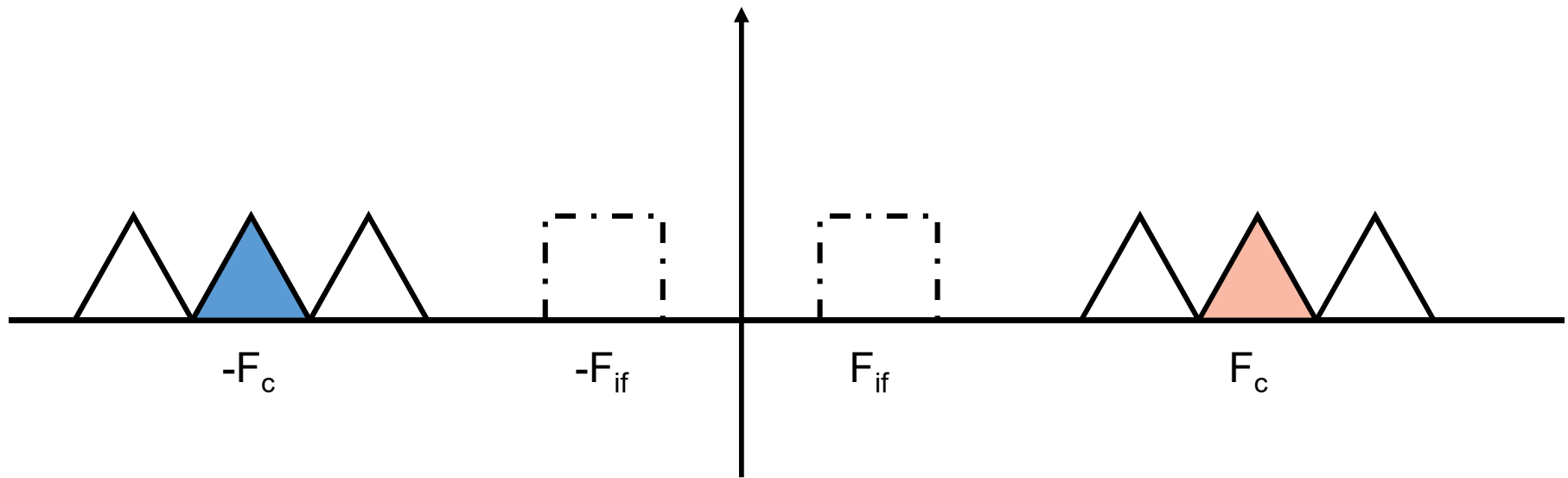
$Km(t)$

Audio amplifier

Speaker

$\omega_c + \omega_{IF}$ Local oscillator

# What is the intermediate frequency $f_{if}$?

- It is fixed frequency located at 455 kHz

- The IF filter is band-pass with center frequency of 455 kHz and bandwidth equal to the bandwidth of one AM channel approximately =10 kHz.
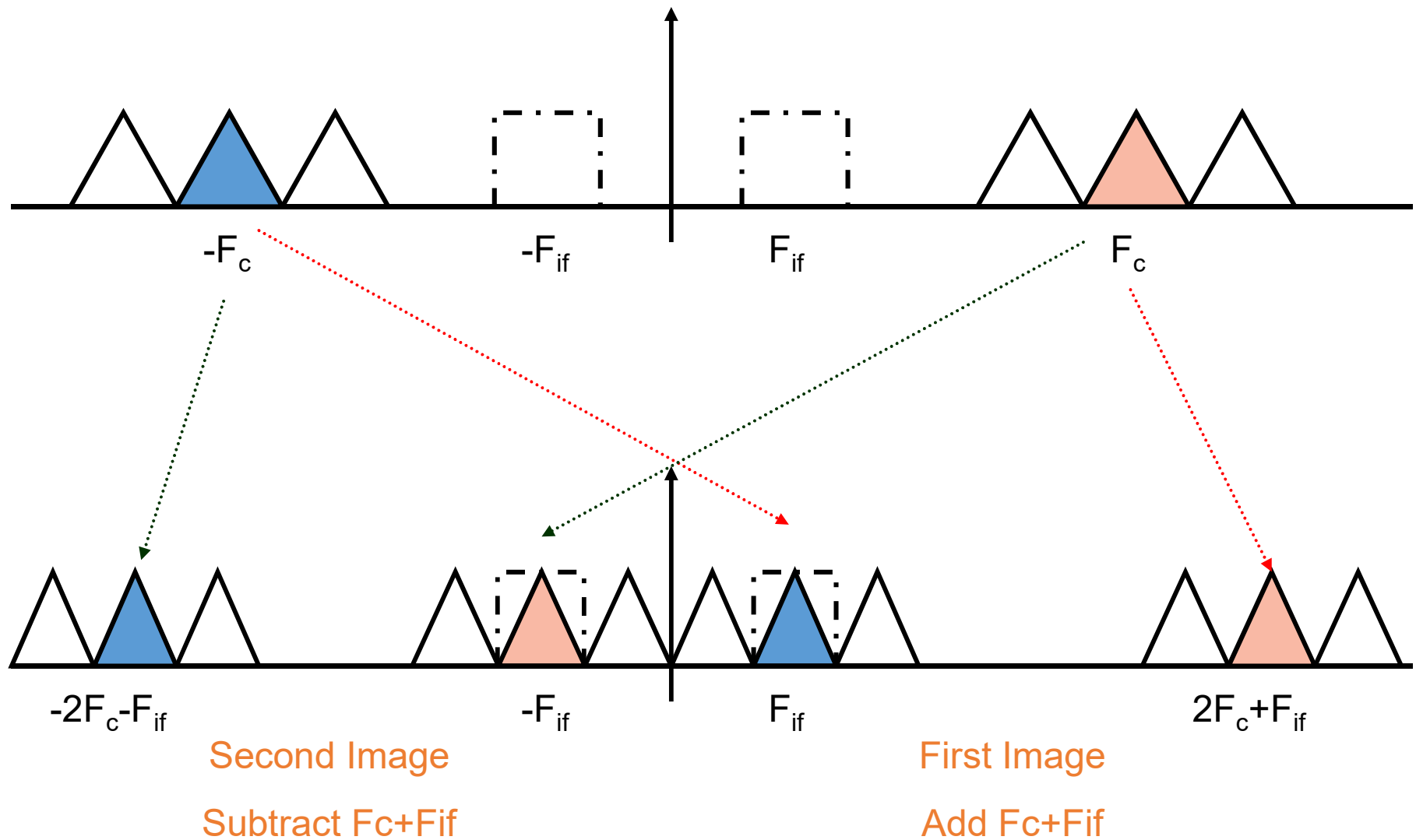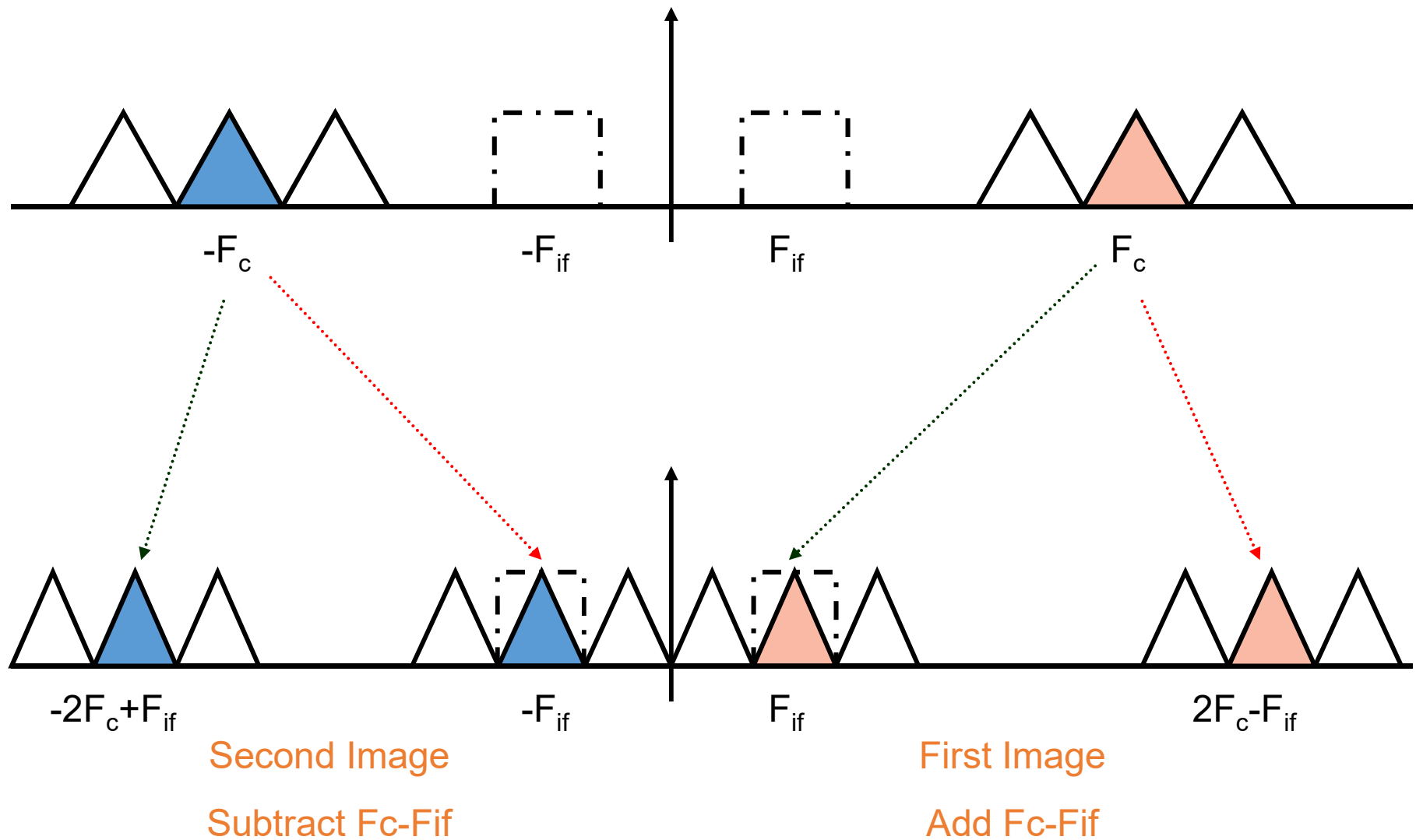
# Why do we need the IF Stage?

- It is too difficult to design a tunable and sharp filter. So we design sharp & fixed filter.

- The channel to be filtered out should first be frequency shifted to the IF frequency by a frequency converter as shown in the super heterodyne Figure

The diagram shows spectral triangles located at $-F_c$ and $F_c$, with dashed rectangular shapes at $-F_{if}$ and $F_{if}$.

Labels on frequency axis: $-F_c$, $-F_{if}$, $F_{if}$, $F_c$

# Up conversion Fc+Fif



$-F_c$

$-F_{if}$

$F_{if}$

$F_c$

$-2F_c-F_{if}$

$-F_{if}$

$F_{if}$

$2F_c+F_{if}$

Second Image

First Image

Subtract Fc+Fif

Add Fc+Fif

# Down conversion Fc-Fif



$-F_c$     $-F_{if}$     $F_{if}$     $F_c$

$-2F_c+F_{if}$     $-F_{if}$     $F_{if}$     $2F_c-F_{if}$

Second Image     First Image

Subtract Fc-Fif     Add Fc-Fif

# Why up conversion is better than down conversion?

**The range of radio station on AM is: 550kHz→1600kHz**
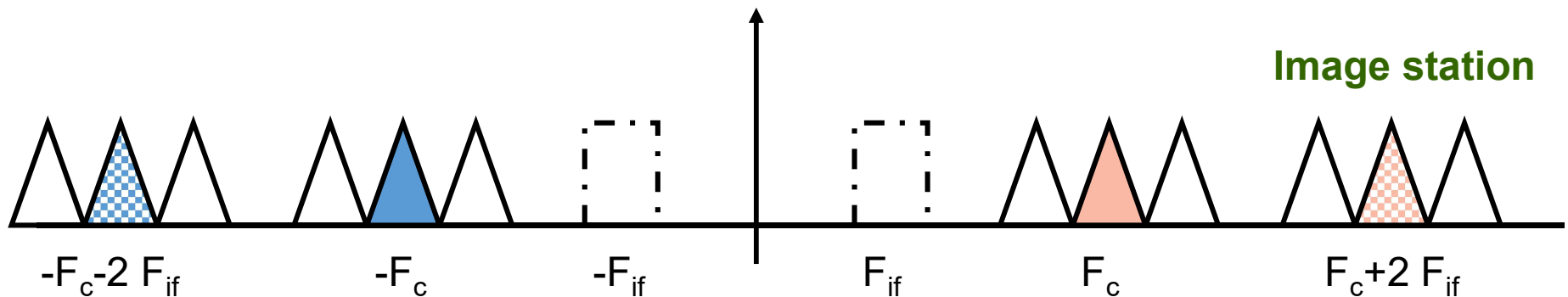
**Up (Fc+Fif): 1005kHz→2055kHz**

**ratio frequency is 1:2**
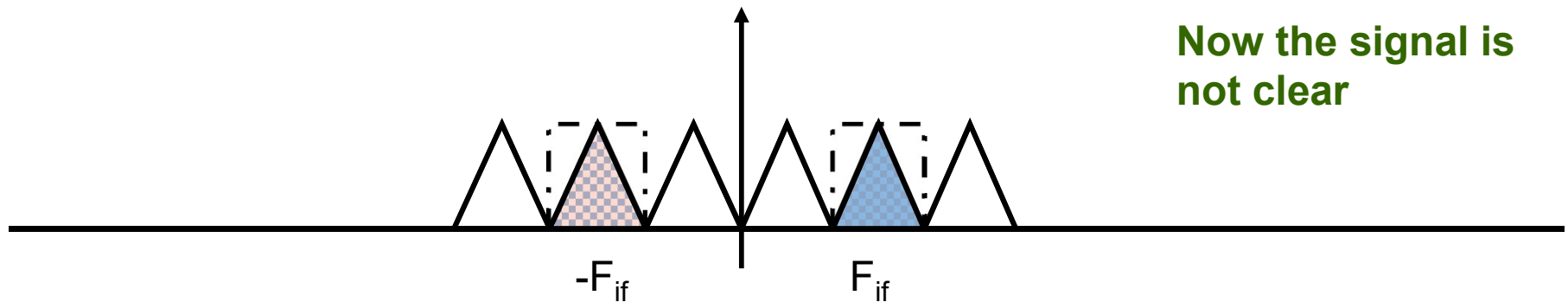
**down (Fc-Fif): 95kHz→1155kHz**

**ratio frequency is 1:12**

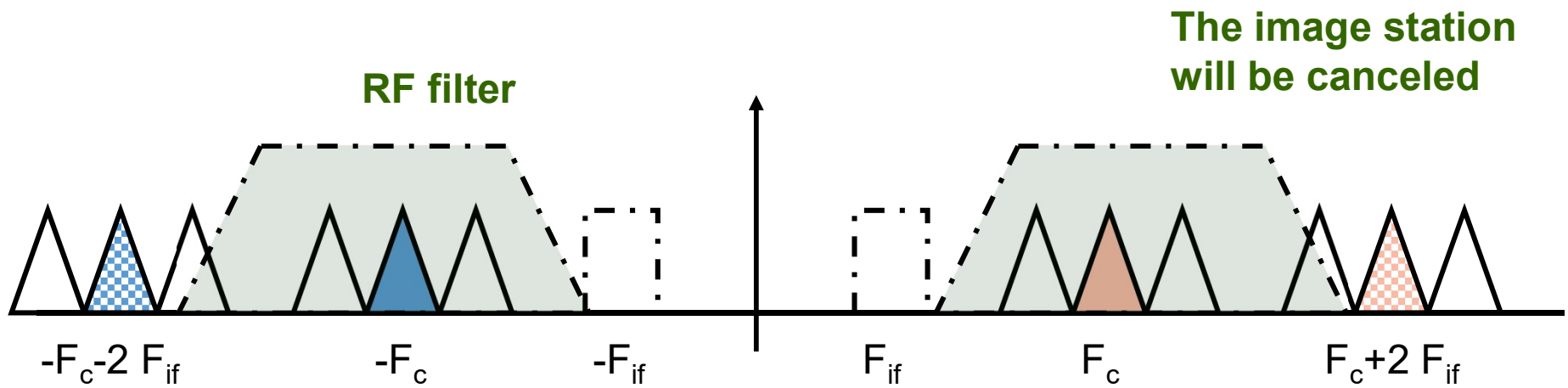**We see the ratio frequency in up conversion is smaller than in down conversion which means it is easier to design.**

# Why we filter at RF stage?



The image station is a station that is spaced by 2*Fif from the desired station as shown in the figure

**RF filter**

**The image station will be canceled**

$-F_c-2\,F_{if}$    $-F_c$    $-F_{if}$    $F_{if}$    $F_c$    $F_c+2\,F_{if}$

**After up conversion**

**Now the signal is clear**

$-F_{if}$    $F_{if}$