1 Python implementation: Radar signal and target detection!

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Objective of Python script:

1. Maximum range a radar can detect with respect to bandwidth and intermediate frequency.
2. Distance measurement of 3 targets with their Intermediate frequencies observed by the radar signals.
3. Measurement of Doppler velocities of different targets with respect to their Doppler frequencies.
4. Measurement of maximum velocity that a sensor can detect
5. Measurement of velocity resolution depending on chirp rate.

1.1 Standard radar operation parameters.

In [45]:
```python
# Radar signal operation specifications
f_low = 70*10**9 # Lower frequency of Radar operation in Hz
f_high = 90*10**9 # Higher frequency of Radar operation in Hz
chirp_slope = 300*10**12 # hz/second
c= 3*10**8 # in m/s

# Calculation of center frequency
f_c = round((f_low + f_high)/2, 3)
f_c_GHz = f_c/(10**9)
print('The center frequency in GHz, fc = ',f_c_GHz,'GHz')

# Calculation of wavelength
Lambda = c/f_c # in meter
Lambda_mm = Lambda*10**3 # in mellimeter
print('Wavelength, Lambda = ', Lambda_mm,'mm')

# Calculation of Bandwidth
BW = f_high - f_low # in Hz
BW_GHz = BW/10**9
print('Bandwidth in GHz, BW = ', BW_GHz,'GHz')

# Calculation of Chirp rate
chirp_rate = BW/chirp_slope
print('Chirp rate = ', chirp_rate, 'seconds')
```

```
The center frequency in GHz, fc =  80.0 GHz
Wavelength, Lambda =  3.75 mm
Bandwidth in GHz, BW =  20.0 GHz
Chirp rate =  6.666666666666667e-05 seconds
```

1.2 Maximum range to be detected, Distance of targets from radar.

In [46]:
```python
import math

c= 3*10**8 # in m/s
f_c = 80*10**9 # center frequency of operation in Hz
range_resolution = 0.5 # meter
chirp_time = 20*10**(-6) # second
BW_IF = 18*10**6 # Intermediate mx frequency in Hz.

BW = c/(2*range_resolution) # Bandwidth required for the given reange resolution.
R_max = math.ceil((c *chirp_time*BW_IF)/(2*BW)) # maximum range detected by the radar sensor.

print('Maximum range detected by the radar sensor = ',R_max,'meter')

If = [1*10**6, 5*10**6, 20*10**6] #Intermediate frequencies corresponding to targets 1 to 3, in Hz

for i in range(3):
    r = math.ceil((c*chirp_time*If[i])/(2*BW)) # Distance of targets from the radar sensor.
    if r < R_max:
        print(f'Distance of target{i+1} from the radar sensor = ',r,'meter')
    else:
        print(f'The target{i+1} at distance {r} meter can not be detected by the radar.')
```

```
Maximum range detected by the radar sensor =  180 meter
Distance of target1 from the radar sensor =  10 meter
Distance of target2 from the radar sensor =  50 meter
The target3 at distance 200 meter can not be detected by the radar.
```

1.3 Maximum velocity detection, Relative Doppler velocity, Velocity resolution.

In [47]:
```
c = 3 *10**8      # m/sec
f_c = 77 * 10**9   # Hz
range_resolution = 0.5  # m
chirp_time = 20 *10**(-6)  # seconds
chirps_per_frame = 128

Lambda = c / f_c # Wavelength in meter
fd = [0, 4* 10**3, -4* 10**3, 8* 10**3] # radar Doppler frequency for targets 1 to 4, in Hz.

# Calculation of relative Doppler velocities of different targets
for i in range(4):
    v = round((fd[i]*Lambda)/2, 2) # relative Doppler velocity of targets 1 to 4, in m/s
    print(f'Relative Doppler velocity of the target{i+1} = ', v,'m/s')

# Maximum velocity that a sensor can detect for the given chirp time, in m/ses
v_max_detect = round(Lambda/(4 * chirp_time), 2)
print('Maximum velocity that a sensor can detect for the given chirp time = ', v_max_detect, 'm/sec')

#Velocity resolution in m/sec. And effect of chirp rate on Velocity resolution.
v_resolution = round(Lambda / ( 2*chirps_per_frame*chirp_time), 3)
print('Velocity resolution of radar = ', v_resolution,'m/sec')

chirps_per_frame_double = 2*chirps_per_frame
v_resolution_with_double_chirp_rate = round(Lambda / ( 2*chirps_per_frame_double*chirp_time), 3)
print('Velocity resolution of radar after doubling the Chirps per frame = ', v_resolution_with_double_ch
```

```
Relative Doppler velocity of the target1 =  0.0 m/s
Relative Doppler velocity of the target2 =  7.79 m/s
Relative Doppler velocity of the target3 =  -7.79 m/s
Relative Doppler velocity of the target4 =  15.58 m/s
Maximum velocity that a sensor can detect for the given chirp time =  48.7 m/sec
Velocity resolution of radar =  0.761 m/sec
Velocity resolution of radar after doubling the Chirps per frame =  0.38 m/sec
```

In [ ]:
```

```