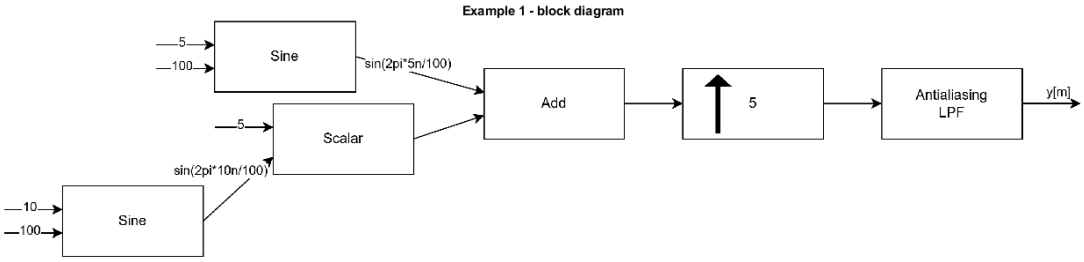
Part 2

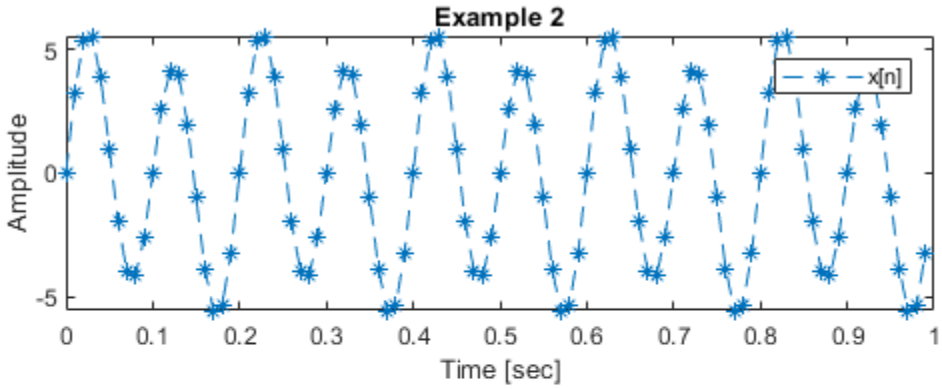
Example 1

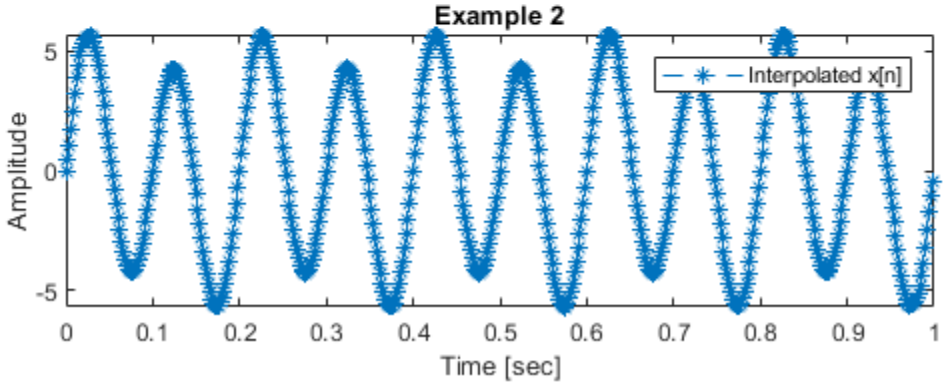
As an input signal we take:

- $y_[n] = sin(2\pi \cdot 5n/N) + 5 * sin(2\pi \cdot 10n/N)$

The interpolation added points that are placed on the original signal, there is no distortion or artifacts because the signal is smooth.







Mean and variance

The mean of the signal is zero (because its integral over 2 sines over 5 and 10 period)

And the variance is:
$1/N \sum^{N} (sin_1 + 5sin_2)^2 = 1/N \sum^{N} sin_1^2 + 25sin_2^2 + 2sin_1 * 5sin_2 = 0.5 + 25 * 0.5 + 0 = 13$

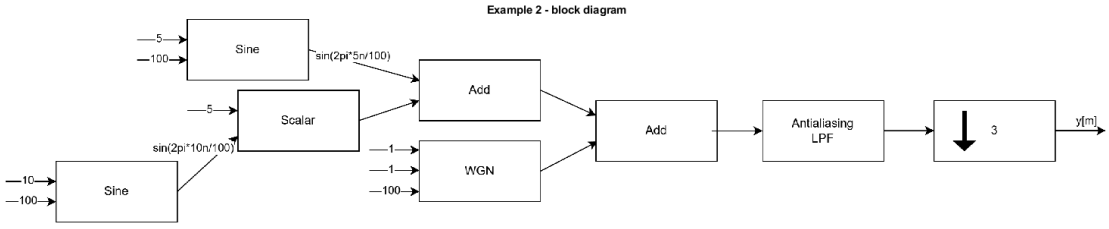
```
x_n_mean =

    2.0428e-16


x_n_var =

    13.1313
```

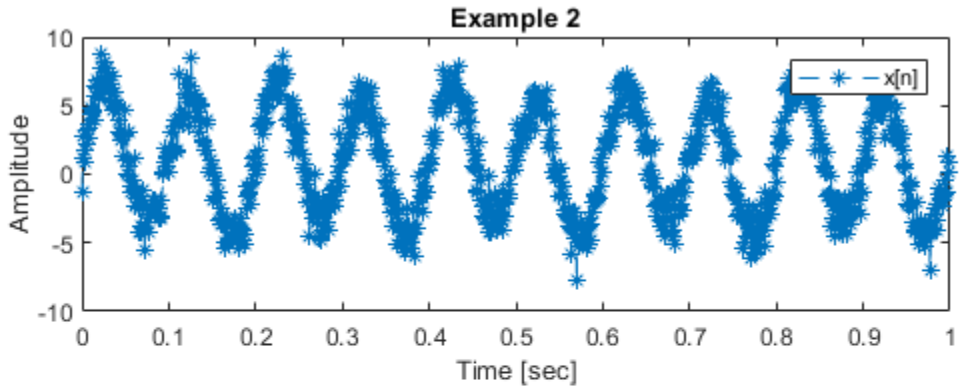
Example 2

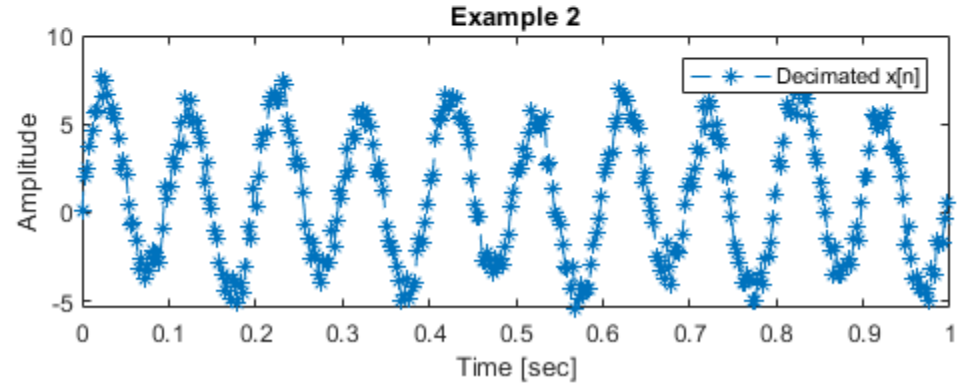
As an input signal we will take the signal from previous example and add additive noise to it:

- $y[n] = sin(2\pi \cdot 5n/N) + 5 * sin(2\pi \cdot 10n/N) + WGN(1,1)$

Additionaly we apply decimation with LPF, as we see it slightly improve distortion because some of the high frequencies filtered out (that was part of WGN).







Mean and variance

The mean of the signal is equal to the mean of noise (because its integral over 2 sines over 5 and 10 period is zeros)

And the variance is:
$1/N \sum^N (sin_1 + 5sin_2 - \mu)^2 = 1/N \sum^N sin_1^2 + 25sin_2^2 + 2sin_1 * 5sin_2 = 0.5 + 25 * 0.5 + 0 = 13$

```
x_n_mean =

    0.9856
```

```
x_n_var =

   14.1176
```

Example 3

Now we will simulate Transmitter-Reciever chain. As an input signal we take:

- $y_1[n] = sin(2\pi \cdot 5n/N)$

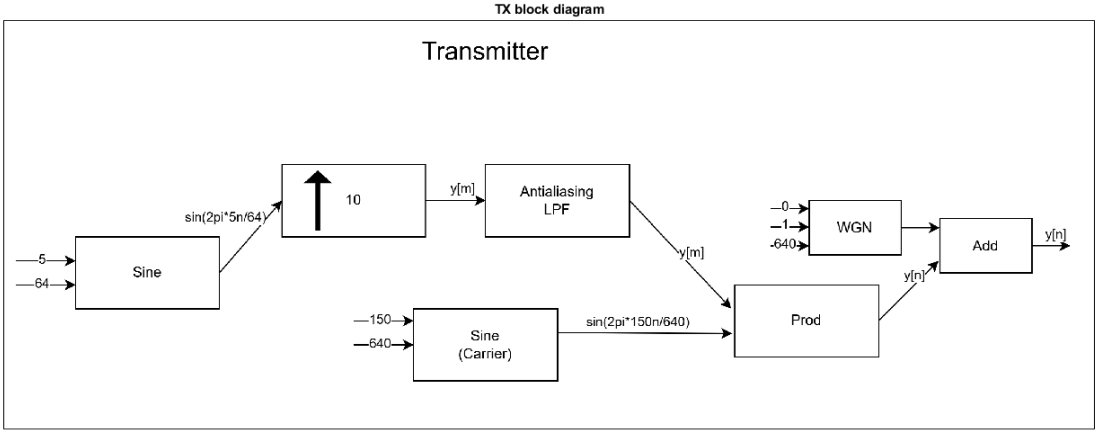
We modulate it using the carrier:

- $y_c[n] = sin(2\pi \cdot 150n/N + pi)$

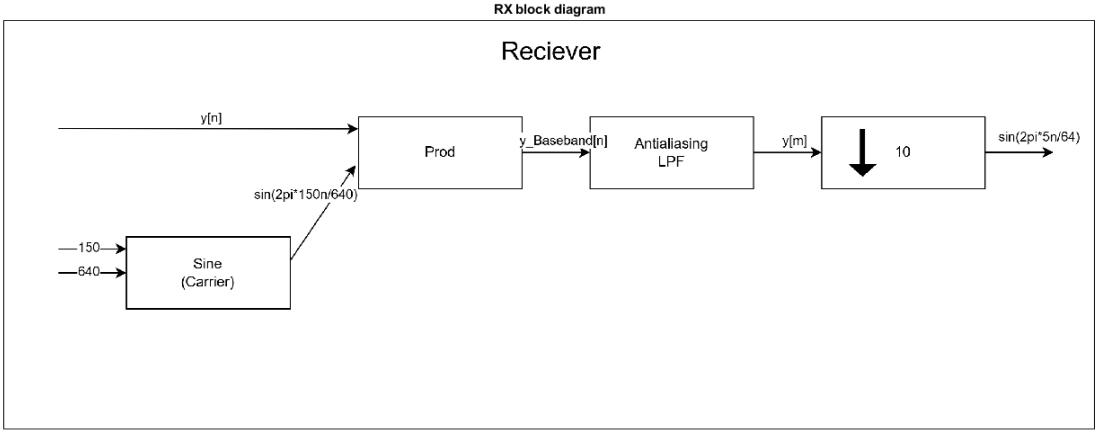
And then, demodulate it using the same carrier.

We suppose that the baseband signal was sampled at low frequency so we interpolate it in order to apply "digital" modulation using prod function from previous section. Afterwards, we decimate the recieved signal.

TX block diagram

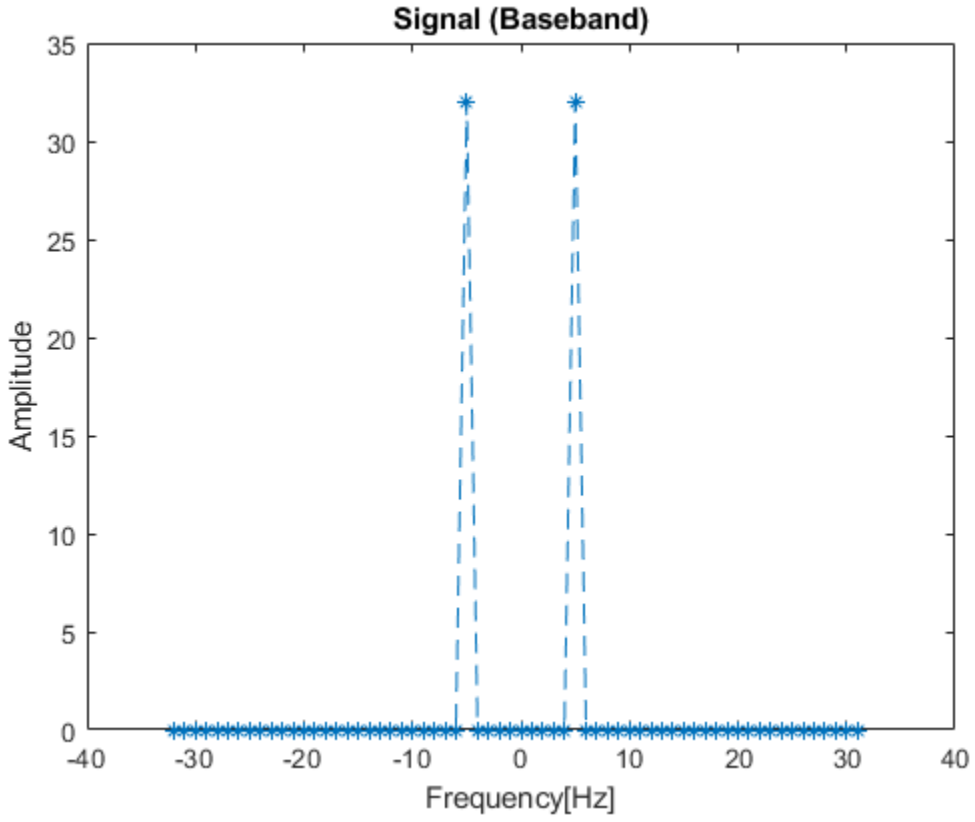


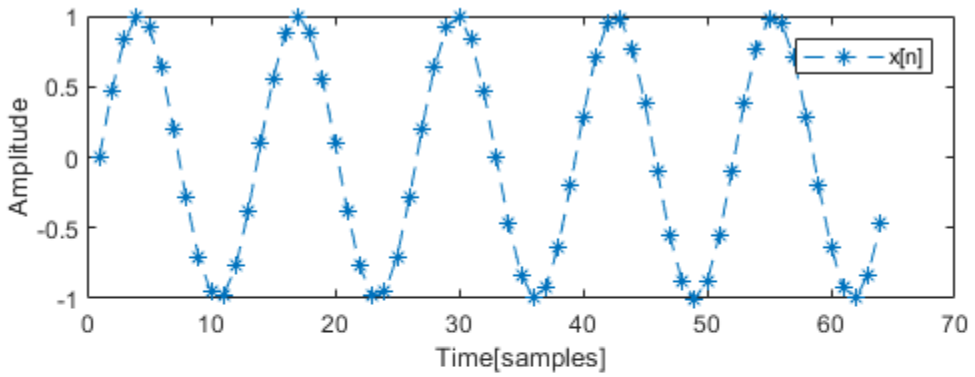
RX block diagram

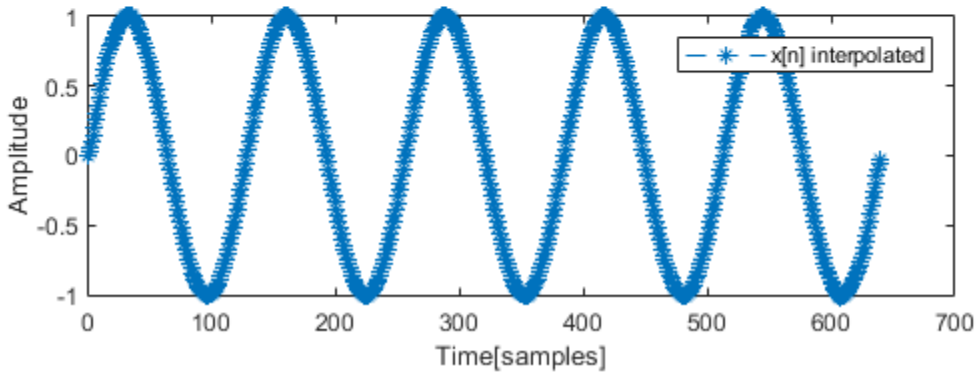


Baseband signal

The signal in baseband composed of 2 deltas at $+-5[Hz]$. The signal has finite BW so the interpolation "added" points on the sine and there is no distortion\artifacts (because the signal is smooth and with finite BW).

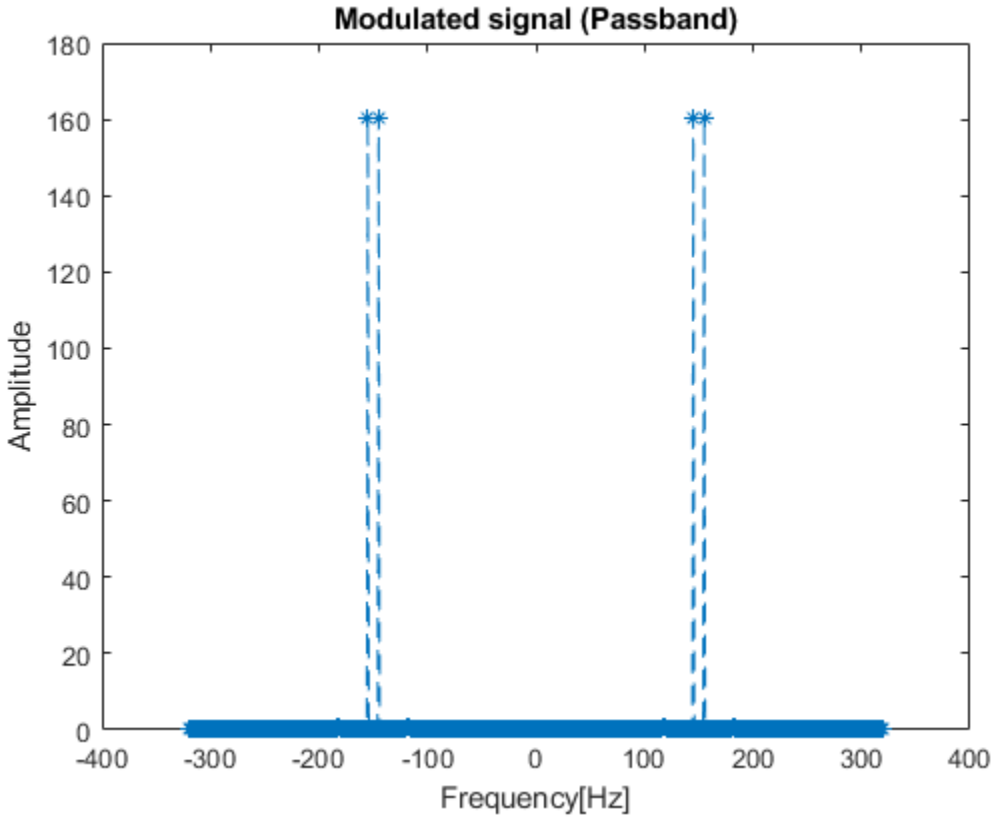

Signal (Baseband)
Amplitude
Frequency[Hz]


x[n]
Amplitude
Time[samples]


x[n] interpolated
Amplitude
Time[samples]

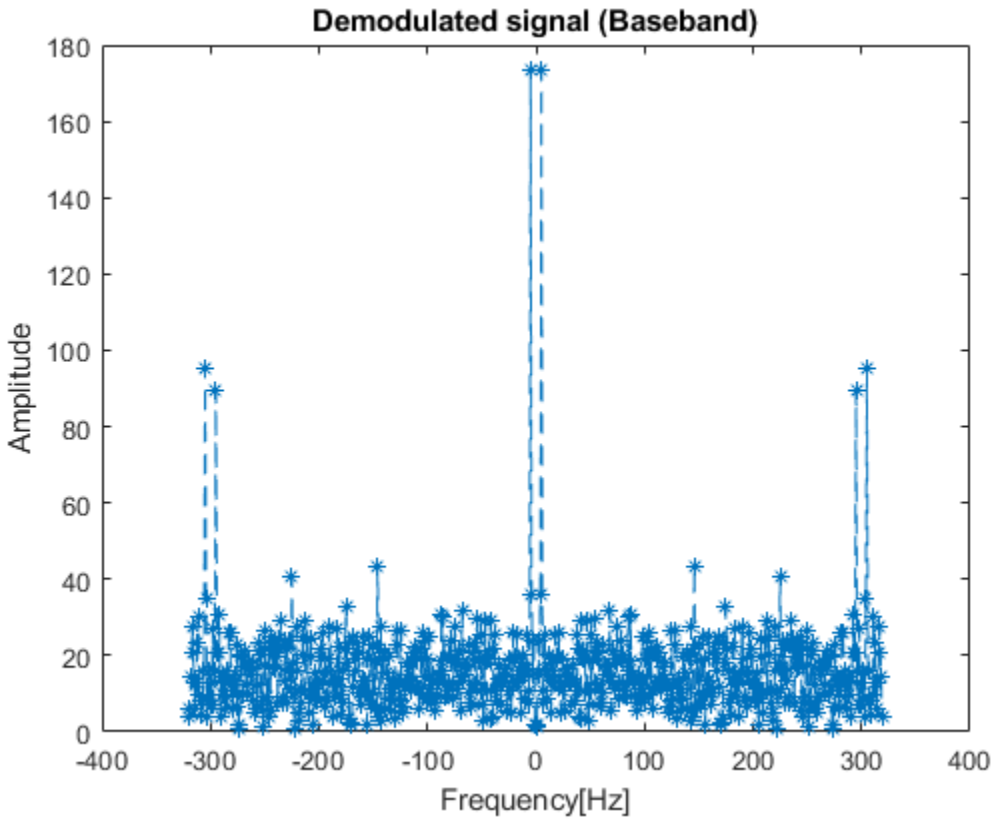
Modulated signal

The modulated signal, composed of 4 deltas at $+-145[Hz]$ and $+-155[Hz]$ because of multiplication between the baseband signal and carrier at $150[Hz]$. Also additive noise were added, so "flat" spectrum in addition to the sine.



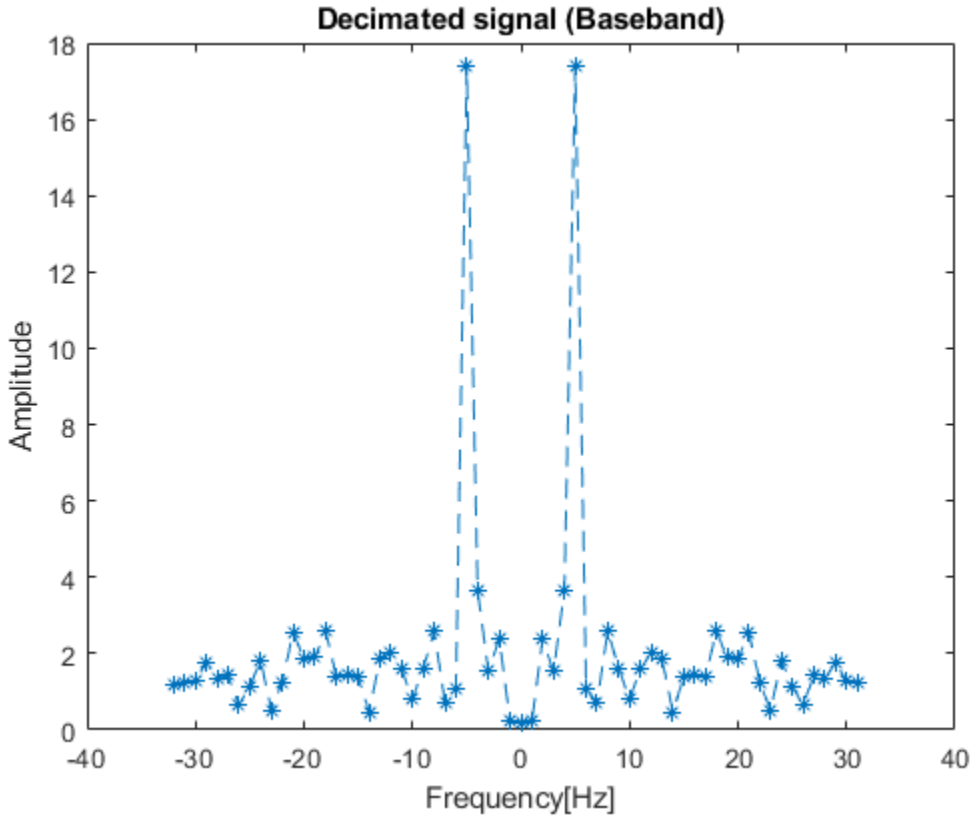
Demodulated signal

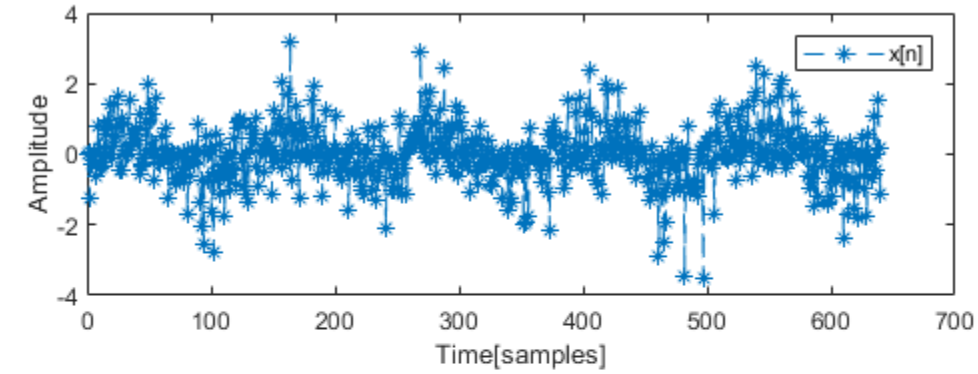
After the demodulation, we get 6 deltas $+-5[Hz]$ and $+-305[Hz]$, $+-295[Hz]$, because of the carrier that created "images" to the desired baseband signal.

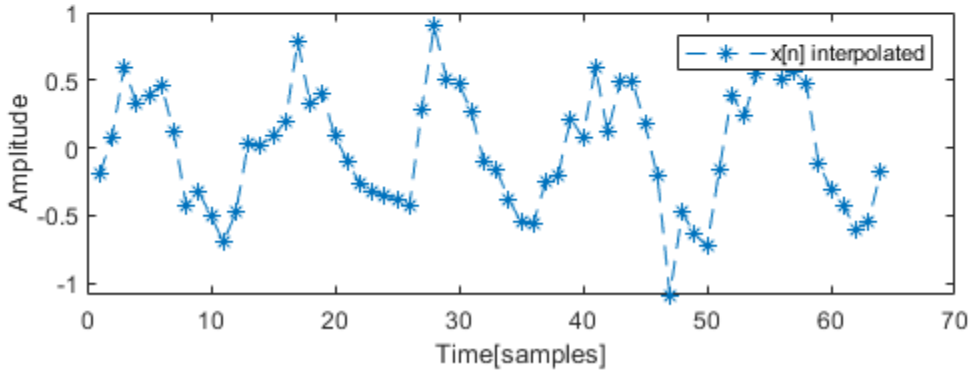


Decimated signal

The desired signal placed around $+-5[Hz]$ so we can decimate the sample rate by 10. The decimation function contains LPF so the "images" were filtered out. Also, we can see that the signal is noised (thats because of the WGN noise). The signal we get after decimation is smoothed and that because of LPF that filter out some of high frequencies (fast uncorrelated changes is due to WGN noise).


Decimated signal (Baseband)
Amplitude
Frequency[Hz]


x[n]
Amplitude
Time[samples]


x[n] interpolated
Amplitude
Time[samples]

Mean and Variance

The mean of the signal is zero (integral over sine over 5 period) The variance is 0.5 (known result because it's mean of squared sine)

```
x_n_mean =

  -1.0235e-16


x_n_var =

    0.5079
```

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