University of Tehran
College of Engineering
School of Electrical and Computer Engineering

Digital Communications Lab

Dr.Olfat

Prelab 3 - Part II

Soroush Mesforush Mashhad

SN:810198472

Aban 01

Contents

Abstract

In this prelab we shall study the conversion of lowpass and band-pass signals to eachother, we shall study a realistic model of this conversion which has amplitude and phase errors.

1 Conversion of Lowpass Equivalent of Bandpass signals

1.1 Unideal conversion to lowpass equivalent

As we know the lowpass equivalent of a bandpass signal is extracted from the following equation.

$$x_{lp}(t) = x_i(t) + jx_q(t)$$

Now, we shall review the ideal conversion to freshen our minds.

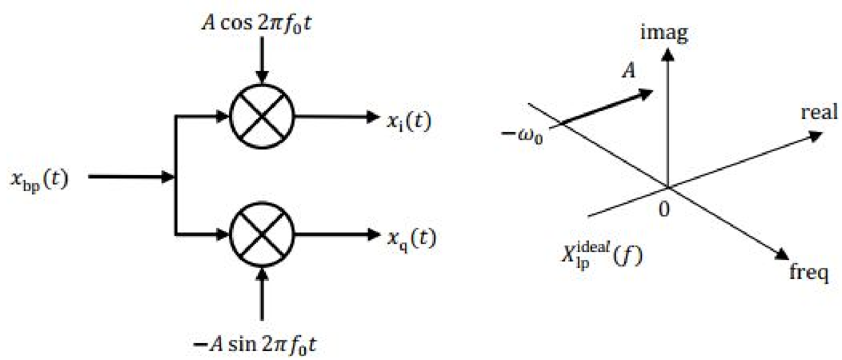

Figure 1: Ideal Structure

In this structure we can easily deduce:

$$x_{lp}(t) = Ax_{bp}(t)\cos(2\pi f_0 t) - jAx_{bp}(t)\sin(2\pi f_0 t) = Ax_{bp}(t)e^{-j2\pi f_0 t}$$

In the unideal realization of our structure, the quadrature part of the signal consists of two errors, amplitude (α) and phase(φ).

For this case we have the following.

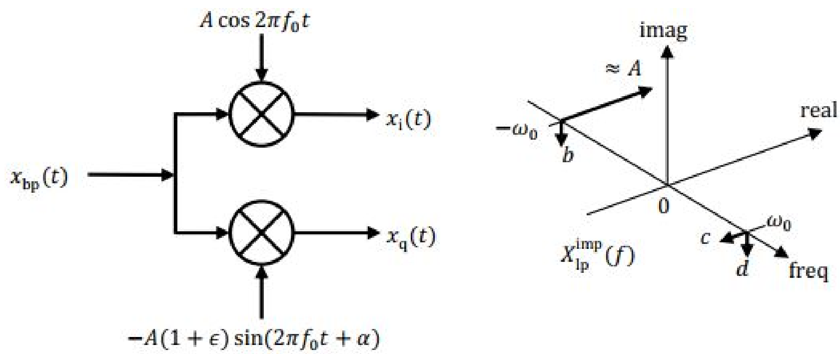

Figure 2: Unideal Structure

In this structure we can deduce:

$$x_{lp}(t) = Ax_{bp}(t)\cos(2\pi f_0 t) - jA(1+\varepsilon)x_{bp}(t)\sin(2\pi f_0 t+\alpha)$$

From trigonometry, we can rewrite the above term as:

$$x_{lp}(t) = Ax_{bp}(t)\cos(2\pi f_0 t) - jA(1+\varepsilon)x_{bp}(t)\left(\sin(2\pi f_0 t)\cos(\alpha)+\cos(2\pi f_0 t)\sin(\alpha)\right))$$

Now we use the exponential terms of the sin(.) and cos(.) function.

$$x_{lp}(t) = \frac{A}{2}x_{bp}(t)\left(e^{j2\pi f_0 t}+e^{-j2\pi f_0 t}\right)$$
$$-j\frac{A}{2}x_{bp}(t)\left(\frac{(\varepsilon+1)\cos(\alpha)}{j}\left(e^{j2\pi f_0 t}-e^{-j2\pi f_0 t}\right)+(\varepsilon+1)\sin(\alpha)\left(e^{j2\pi f_0 t}+e^{-j2\pi f_0 t}\right)\right)$$

Now we use the Fourier transform to go into the frequency domain, hence we have:

$$\mathscr{X}_{lp}(f) = \frac{A}{2}\left[\left(1-e^{j\alpha}(\varepsilon+1)\right)\mathscr{X}_{bp}(f-f_0)+\left(1+e^{-j\alpha}(\varepsilon+1)\right)\mathscr{X}_{bp}(f+f_0)\right]$$

It is obvious to us that $(1 - e^{j\alpha}(\varepsilon + 1))$ is undesirable and $(1 + e^{-j\alpha}(\varepsilon + 1))$ is desirable, so to find the range of ε and α we set one of them to zero and find the range of the other respectively, so we shall have:

$$P = \frac{1 - (1+\varepsilon)e^{j\alpha}}{1 + (1+\varepsilon)e^{-j\alpha}}$$

$$if\ \varepsilon = 0 \longrightarrow P = \left|\frac{1 - e^{j\alpha}}{1 + e^{j\alpha}}\right| \leq 0.001 \longrightarrow 0.0006\pi \leq \alpha \leq 1.999\pi$$
$$if \alpha = 0 \longrightarrow P = \left|\frac{\varepsilon}{2 + \varepsilon}\right| \leq 0.001 \longrightarrow |\varepsilon| \leq 0.002$$