Stereo Radio Signals

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EE 4361 — INTRO TO DIGITAL SIGNAL PROCESSING

***Abstract*—Overall, In this lab overall familiarity with the key parameters and performance of practical RF mixer was gained. The importance of Conversion Loss was shown to be of tantamount significance. The non idealities of mixer's was evident through these precise lab measurements.**

I. INTRODUCTION

THIS lab utilizes the spectrum analyzer, signal generator, and VNA acting as a signal generator to determine the conversion loss of the mixer under test. The VNA is also used to characterize the Mixer's Return Loss. An important aspect of this lab entails accounting for the cable loss present between the signal generator and the mixer LO. This Loss is calculated given the direct measurement with the spectrum analyzer.

II. FORMULATION

Develop and write down the complete analytical formulation of the problem, at the transmitter and at the receiver and, how and why $x_1(n)$ and $x_2(n)$and the gains are obtained in your report.

Starting as analog signals

$$\text{Time Domain}$$
$$x_{1,a}(t) := \text{male speaker}$$
$$x_{2,a}(t) := \text{female speaker}$$

Bandlimited to 5kHz through low pass filtering

$$x_{1,\text{bandlimited}}(t) = x_{1,a}(t) * h_{lp,f_c=5\text{kHz}}(t)$$
$$x_{2,\text{bandlimited}}(t) = x_{2,a}(t) * h_{lp,f_c=5\text{kHz}}(t)$$

Sampling at 16kHz more than double the bandlimited, $F_{s,\text{mic}} = 16 \times 10^3\text{Hz},\ T_{s,\text{mic}} = 1/F_{s,\text{mic}}$ and windowing between 0 and T_F

$$x_1(n) = x_{1,\text{bandlimited}}(t)\Big|_{t=nT_{s,\text{mic}}},\ 0 < nT_{s,\text{mic}} < T_F$$
$$x_2(n) = x_{2,\text{bandlimited}}(t)\ \Big|_{t=nT_{s,\text{mic}}},\ 0 < nT_{s,\text{mic}} < T_F$$

Addition and Subtraction

$$s_1(n) = x_1(n) + x_2(n)$$
$$s_2(n) = x_1(n) - x_2(n)$$

Modulation at $f_{\text{carrier}} = 70\text{kHz}$ and $f_{\text{carrier}} + f_\Delta = 90\text{kHz}$

$$s_{1,\text{modulated}}(n) = s_1(n)\cos\left(\frac{2\pi f_{\text{carrier}}}{F_{s,\text{mic}}}n\right)$$
$$s_{2,\text{modulated}}(n) = s_2(n)\cos\left(\frac{2\pi(f_{\text{carrier}} + f_\Delta)}{F_{s,\text{mic}}}n\right)$$

Addition and Subtraction

$$TX(n) = s_{1,\text{modulated}}(n) + s_{2,\text{modulated}}(n)$$

D/A

$$TX(t) = \sum_{k=-\infty}^{\infty} TX(k)\delta(t + kT_s) * h_{lp,f_c=90\text{kHz}}(t)$$

Lossless Transmission

$$RX(t) = TX(t)$$

A/D with sampling freqency and sample interval $F_{s,\text{receiver}} = 400 \times 10^3\text{Hz},\ T_{s,\text{receiver}} = 1/F_{s,\text{receiver}}$ and windowing between 0 and T_F

$$RX(n) = RX(t)\Big|_{t=nT_{s,\text{receiver}}},\ 0 < nT_{s,\text{receiver}} < T_F$$

Black Box Receiver

$$\text{RECV} := \text{Receiver to be designed}$$
$$\tilde{x}_1(n), \tilde{x}_2(n) = \text{RECV}_1\left(RX(n)\right)$$

III. DESIGN

the RECV operation is given as the below signal processing pipeline.

Demodulation

$$RX_{\text{demodulated, 70kHz}}(n) = RX(n)\cos\left(\frac{2\pi f_{\text{carrier}}}{F_{s,\text{receiver}}}n\right)$$
$$RX_{\text{demodulated, 90kHz}}(n) = RX(t)\cos\left(\frac{2\pi(f_{\text{carrier}} + f_\Delta)}{F_{s,\text{receiver}}}n\right)$$

Filtering

$$s_1(n) = RX_{\text{demodulated, 70kHz}}(n) * h_{lp,f_c=5\text{kHz}}(n)$$
$$s_2(n) = RX_{\text{demodulated, 90kHz}}(n) * h_{lp,f_c=5\text{kHz}}(n)$$

Addition and Subtraction

$$\tilde{x}_1(n) = G_1\left(s_1(n) + s_2(n)\right)$$
$$\tilde{x}_2(n) = G_2\left(s_1(n) - s_2(n)\right)$$
$$G_1, G_2 \to \frac{1}{2}$$

IV. RESULTS

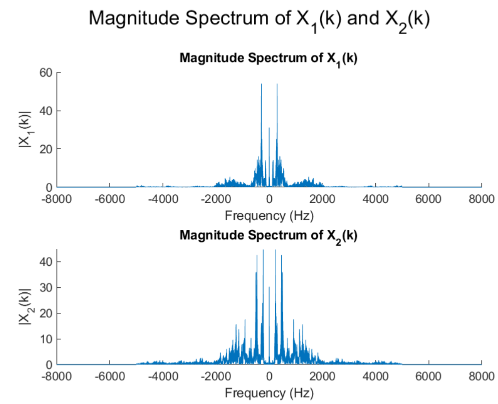

Fig. 1. Magnitude of DFT of Reconstructed Signals $x_1(n)$ and $x_2(n)$

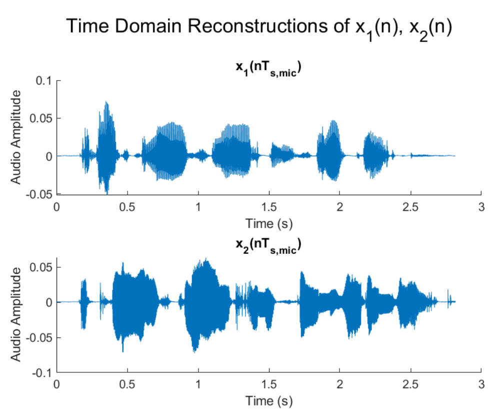

Fig. 2. Time Domain Representation of Reconstructed Signals $x_1(n)$ and $x_2(n)$