UNIVERSIDADE FEDERAL DO PARÁ
INSTITUTO DE TECNOLOGIA
FACULDADE DE ENGENHARIA DA COMPUTAÇÃO E TELECOMUNICAÇÕES

Estudo e Implementação de Técnicas para Sincronismo em Sistemas de Telecomunicações

Gabriel Peixoto de Carvalho

BELÉM - PARÁ

2016

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Gabriel Peixoto de Carvalho

Estudo e Implementação de Técnicas para Sincronismo em Sistemas de Telecomunicações

Trabalho de Conclusão de Curso apresentado para obtenção do grau de Engenheiro em Engenharia da Computação, do Instituto de Tecnologia, da Faculdade de Engenharia da Computação e Telecomunicações.

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Este trabalho foi julgado adequado em __/__/____ para a obtenção do Grau de Engenheiro da Computação, aprovado em sua forma final pela banca examinadora que atribuiu o conceito ____________.

____

Prof. Aldebaro Barreto da Rocha Klautau Junior

ORIENTADOR

____

Prof. Wilson Pacheco Ferreira

COORIENTADOR

____

Prof. Francisco Carlos Bentes Frey Muller

MEMBRO DA BANCA EXAMINADORA

____

Eng. Igor Mesquita de Almeida

MEMBRO DA BANCA EXAMINADORA

____

Prof. José Augusto de Lima Barreiros

DIRETOR DA FACULDADE DE ENGENHARIA DA COMPUTAÇÃO E TELECOMUNICAÇÕES

Dedico este trabalho aos meus pais e ao meu irmão, os quais desempenharam um papel inigualável em minha educação.

Agradecimentos

Igor Antonio Auad Freire

Viva como se você fosse morrer amanhã. Aprenda como se você fosse viver para sempre.

Mahatma Gandhi

Lista de Siglas

1. ADSL - *Linha de assinante digital assimétrica*

Lista de Símbolos

b	Taxa agregada de bits alcançável para o sistema

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Abstract

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Introdução

Capítulo 2

Carrier Recovery

Carrier recovery is a processes used in coherent demodulation where the phase and the frequency of the transmitter carrier wave are recovered by the receiver and thus after having such information it is possible to extract the information in the transmitted signal.
Considering that the phase and frequency of the transmitted wave probably will be affected by noise, it is not a straight-forward method, it includes filtering and usually feedback systems to correct the erros in phase or frequency caused by the noise.
This chapter aims in the brief exploration of some techniques used for carrier recovering, such as Phase locked loops, costas loop and others.

2.1 Phase-Locked Loop (PLL)

Phase-locked Lopp is a kind of feedback system, which has been extensively used in communications sytems and other applications which require frequency synthesis.
The Phase-Locked Loop is composed by three basic components 2.1:

1. A phase detector (PD).

2. A loop filter.

3. A voltage-controlled oscillator (VCO).

As it can seen in the figure 2.1 the phase-locked loop is a feedback system whose main goal is to make the output signal the same as the input signal. Basically the phase detector compares the phase of the input signal against the pahse of the VCO output, then the PD output is inputed in the loop filter whose output is the voltage that controls the VCO. The output of the phase detector is the phase error between the input signal and the VCO and the output of the loop filter outputs the control voltage to the VCO.

When the loop is locked, teoretically, the output frequency is the same as the input frequency, but to maintain the control voltage necessary to lock it is needed a nonzero output to the phase detector, thus the pll operates with some phase error, but this tends to be small.

Pll makes simple to syntethize frequencies with a pll and do operations of analog modulation and demodulation, these applications willbe briefly discussed later.

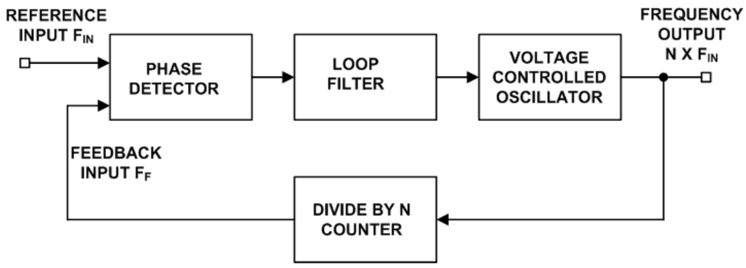

Figura 2.1: Basic PLL scheme

2.1.1 PLL Fundamentals

Considering a basic pll scheme as shown in figure 2.2 we can see that the input signal has a pahse of $\theta_i(t)$ and the VCO output has a phase of $\theta_o(t)$. Assuming that the loop is locked and the phase detector is linear, the ouput of the PD is proportional to the phase difference between its inputs, thus,

$$v_d = K_d(\theta_i - theta_o) \tag{2.1}$$

where k_d is the PD gain factor and its unity is volt/radian.

The v_d is filtered by the loop filter, supressing noise and high frequency signal components, the filter also contributes for the determination of the dynamic performance of the loop. The filter transfer function is given by $F(s)$.

Frequency output of the VCO is determined by the input v_c and since frequency is the derivative of the phase, the operation in the VCO can be described by,

$$L[\frac{d\theta_o(t)}{dt}] = s\theta_o(s) = K_o V_c(s) \tag{2.2}$$

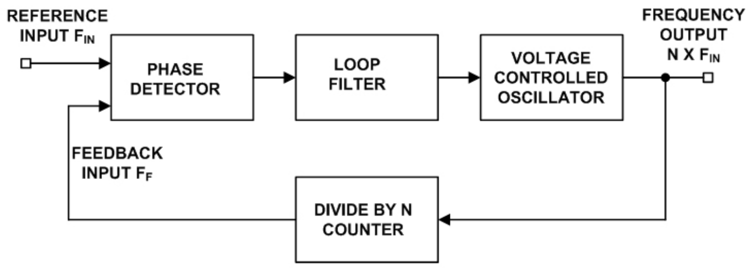

Figura 2.2: PLL

we can see that the output of the VCO is linearly related to the integral of the control voltage.

Using laplace notation it is possible to stablish some basic equations to describe the loop components behavior,

$$V_d(s) = K_d[\theta_i(s) - \theta_o(s)] \tag{2.3}$$

$$V_c(s) = F(s)V_d(s) \tag{2.4}$$

$$\theta_o(s) = \frac{k_o V_c(s)}{s} \tag{2.5}$$

The combination of these equations 2.3 2.4 2.5 results in the basic loop equations:

$$H(s) = \frac{\theta_o(s)}{\theta_i(s)} = \frac{K_o K_d F(s)}{s + K_o K_d F(s)} \tag{2.6}$$

$$\frac{\theta_i(s) - \theta_o(s)}{\theta_i(s)} = \frac{\theta_e(s)}{\theta_i(s)} = \frac{s}{s + K_o K_d F(s)} = 1 - H(s) \tag{2.7}$$

$$V_c(s) = \frac{sK_d F(s)\theta_i(s)}{s + K_o K_d F(s)} = \frac{s\theta_i(s)}{K_o} H(s) \tag{2.8}$$

Where:

- $H(s)$ is the closed-loop transfer function
- θ_e is the phase error

Based on the equantions which describe the behavior of the components in the phase-locked loop we can classify the pll based on the order of the transfer function associated with the loop. This classification is based upon the nunmber of perfect integrators ($\frac{1}{s}$) present in the transfer function.

- First order loop.
- Second order loop.
- Third and higher order loop.

2.1.1.1 First Order Loop

The first order loop is the simplest implementation of a phase-locked loop, where the loop filter is ommited, thus $F(s) = 1$

$$H(s) = \frac{K_o K_d}{s + K_o K_d} = \frac{K}{s + K} \tag{2.9}$$

Where:

- $K = K_o K_d = K_v$;

2.1.1.2 Second Order Loop

The second order loop

2.1.1.3 Third an Higher Order Loops

2.1.2 PLL Components

2.1.3 tracking

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