PLL and Oscillators

Component
École Nationale Supérieure d'Électrotechnique d'Électronique d'Informatique d'Hydraulique et des Télécommunications

In brief

- **Ametys Code:** N7EE06B
- **Open to exchange students:** Yes

Presentation

Objectives

By the end of this course, students will be able to:

Understand the fundamental principles of phase-locked loops (PLLs) and oscillators.

Identify the different types of phase detectors and their areas of application.

Master the role and operation of voltage-controlled oscillators (VCOs) and charge pumps in a PLL.

Analyze the dynamics of the loop in capture mode and locked mode, as well as the conditions for stability.

Design and characterize loop filters in relation to the overall performance of the PLL (bandwidth, noise, lock time).

Understand the principle of positive feedback oscillators, harmonic and LC oscillators, and the concept of negative resistance.

Be familiar with quartz oscillators and their frequency stability characteristics.

Description

1. General introduction to PLLs and oscillators

Reminder of synchronization and frequency generation requirements in electronic systems.

Basic architecture of a phase-locked loop (PLL): phase detector, loop filter, voltage-controlled oscillator (VCO), frequency divider, charge pump.

Areas of application: telecommunications, data conversion, processor clocks, RF circuits.

2. Phase detectors and associated circuits

Phase multiplier: analog operation.

XOR detector: logical approach and simple applications.

Flip-flop detector: sequential phase detection.

PFD (Phase-Frequency Detector): detailed operation, linearity, wide capture range.

Charge Pump: current-voltage conversion, imbalance effects, and impact on phase noise.

3. Loop filter and PLL dynamics

Structure and role of the loop filter: integrator, active/passive low-pass filter.

Analysis of the PLL in locked mode: stability, phase margin, frequency response.

Analysis of the PLL in capture mode: transient dynamics, phase acquisition.

Concepts of bandwidth, lock time, and jitter.

4. Voltage-controlled oscillators (VCO)

Principle of operation of the VCO.

Voltage/frequency relationship and linearity.

5. Principles of autonomous oscillators

Oscillation conditions and positive feedback.

Harmonic and LC oscillators: topologies, stability, spectral purity.

The concept of negative resistance: energy interpretation and practical implementation.

Quartz oscillators: resonance principle, frequency stability, app

Pre-requisites

Signal transistors and power components

Transistor amplifier circuits

Continuous linear systems automation

Methods for analyzing electrical circuits