Novel architectures for GSM/UMTS multi-mode transmitters

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Overview

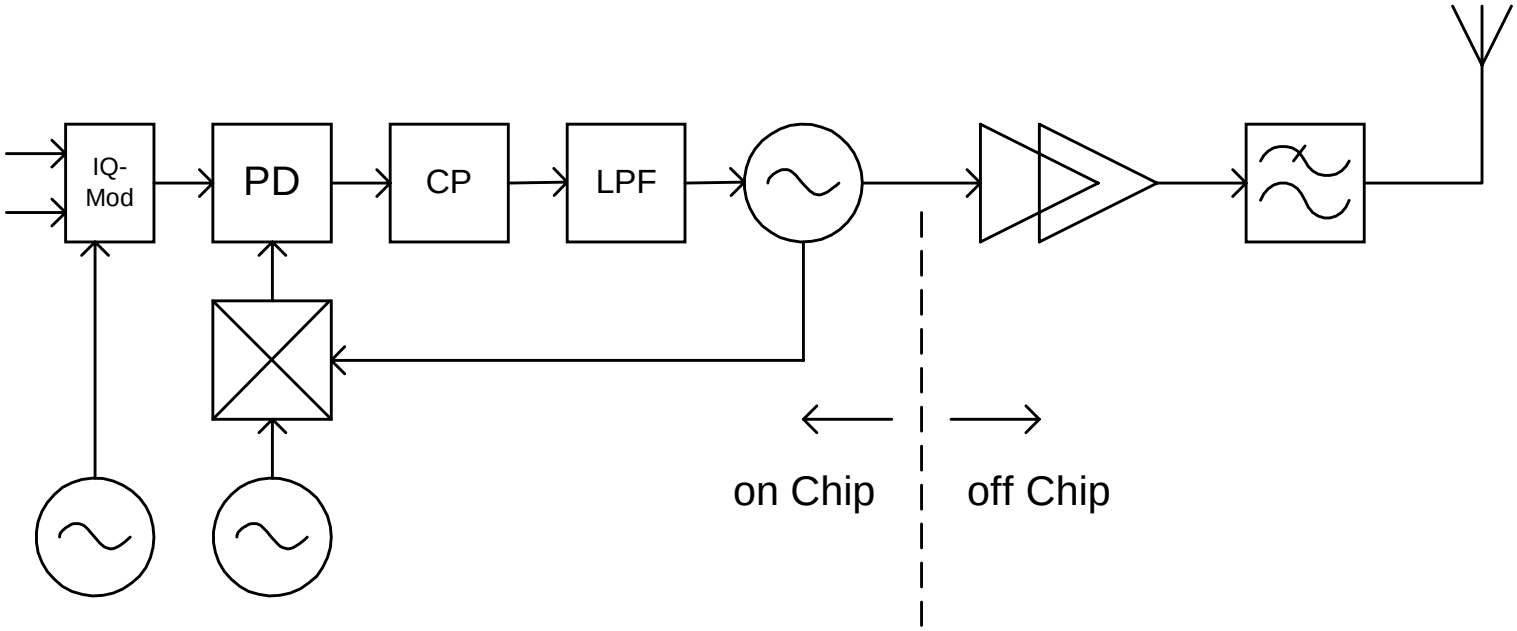
- GSM/UMTS Requirements
- Standard GSM Transmitter Architecture
- Novel GSM Transmitter
- Standard UMTS (FDD) Transmitter Architecture
- Novel Multi-Mode GSM/UMTS Transmitter
- MuMoR Test Circuit

GSM/UMTS IC Requirements

	GSM	UMTS
Modulation	GMSK	CDMA QPSK
Noise	-162 dBc/Hz at 20 MHz	-150 dBc/Hz at 130 MHz (at Transceiver IC, depending on Filters used)

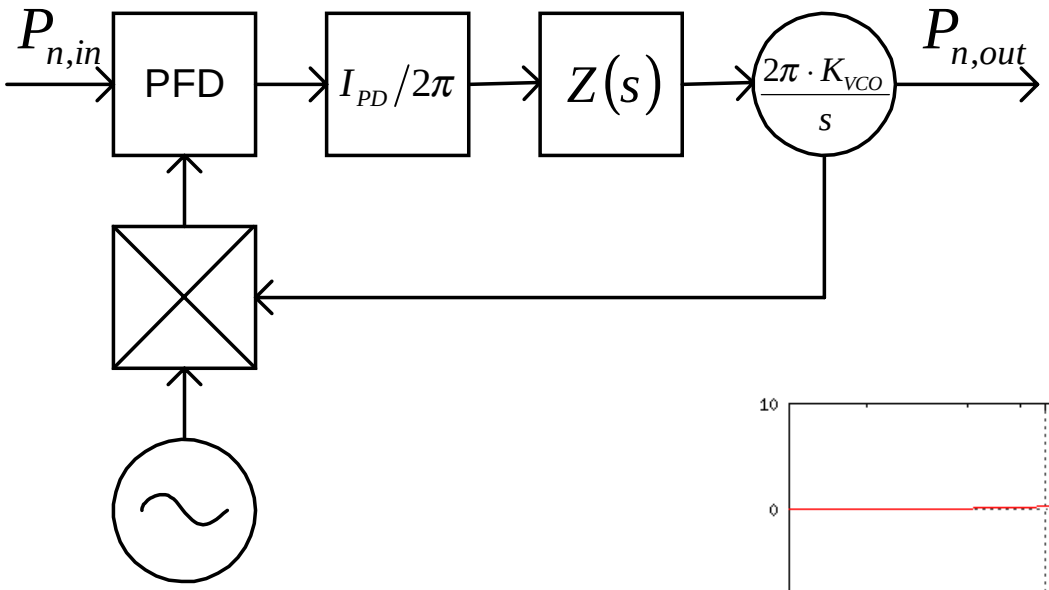
- GSM uses constant envelope modulation
- But GSM has more stringent noise requirements compared to UMTS

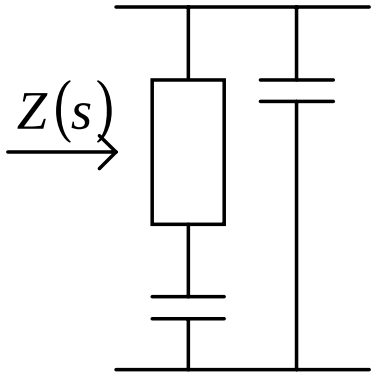
GSM Standard Architecture, Offset-PLL

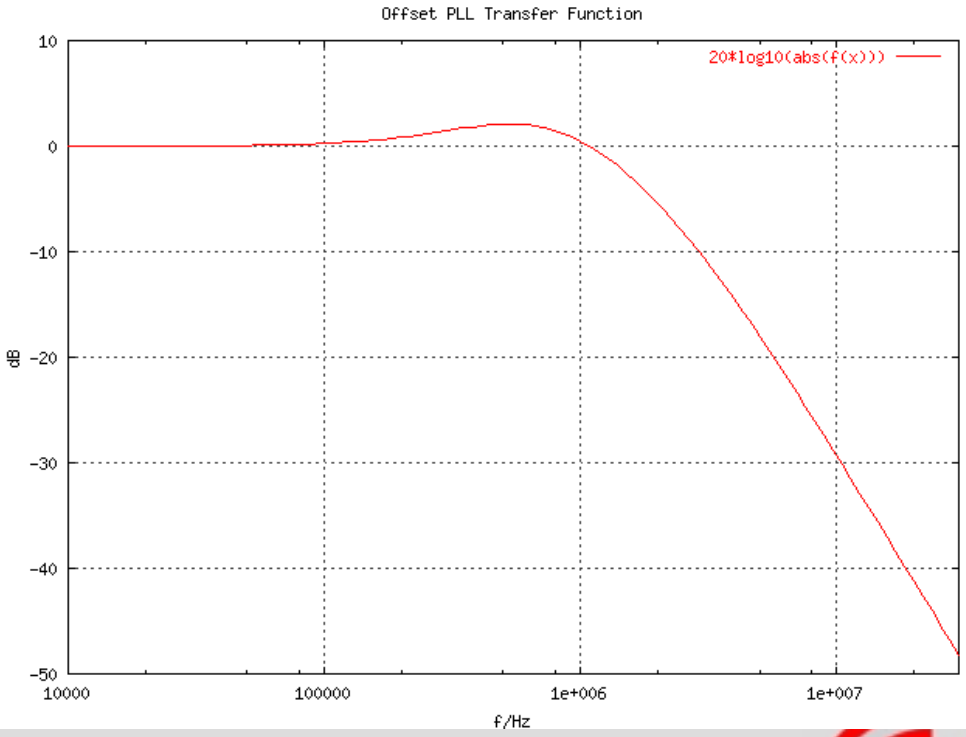


- Signal generation at IF-frequency
- Filtering using Offset-PLL (regulation loop)
  - No external bandpass filters necessary
- Mixer in reference path
  - Also frequency conversion in forward path
  - Two LO signals necessary

GSM Standard Architecture, Offset-PLL



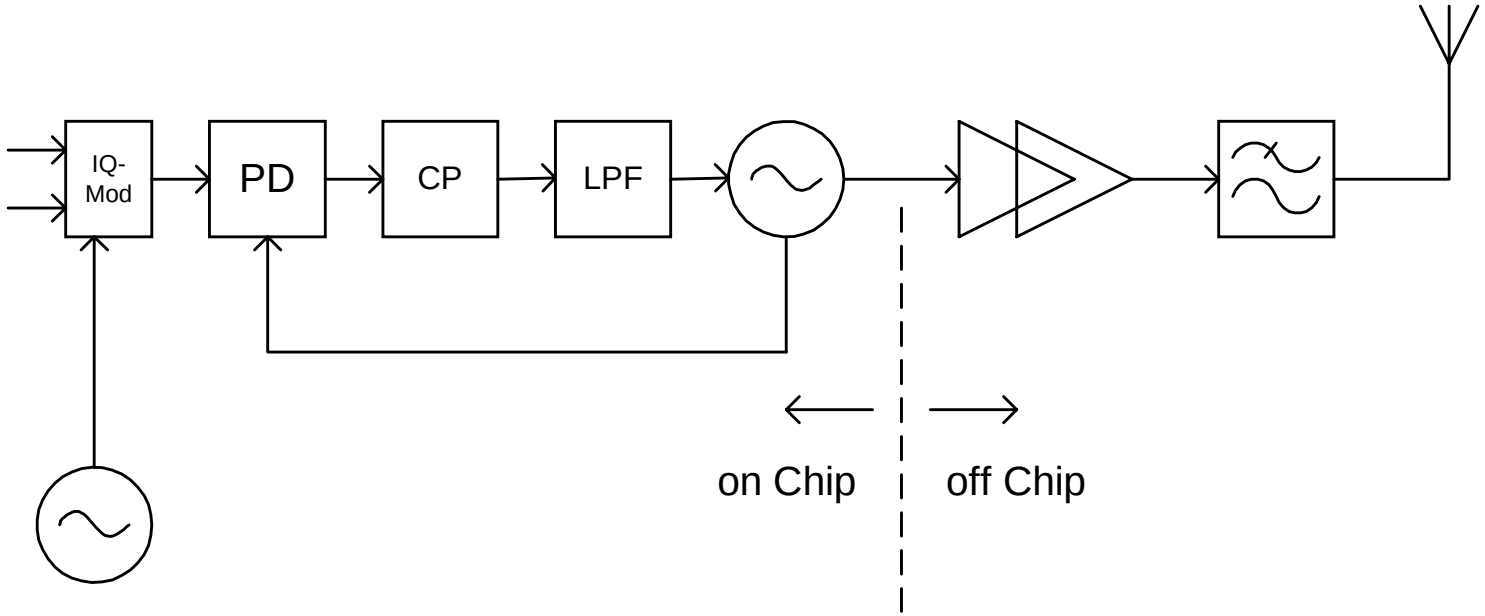




Phase noise transfer function

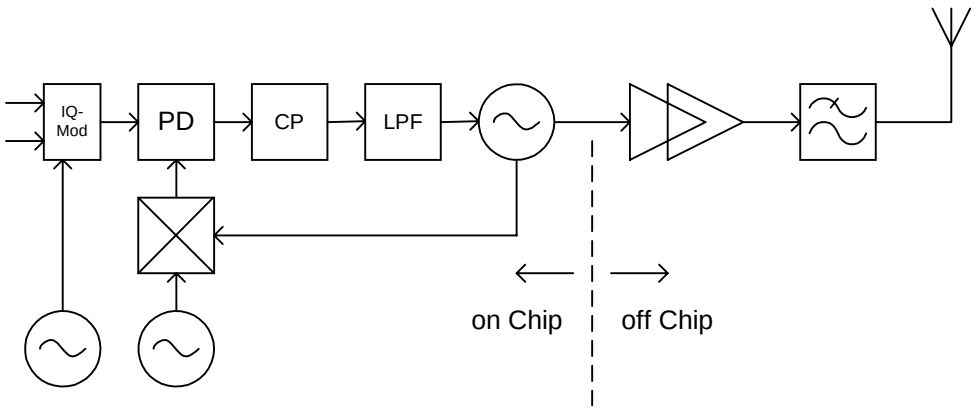
$$\frac{P_{n,out}}{P_{n,in}} = \frac{I_{PD} \cdot Z(s) \cdot K_{VCO}}{s + I_{PD} \cdot Z(s) \cdot K_{VCO}}$$

Novel GSM Architecture, Direct-PLL

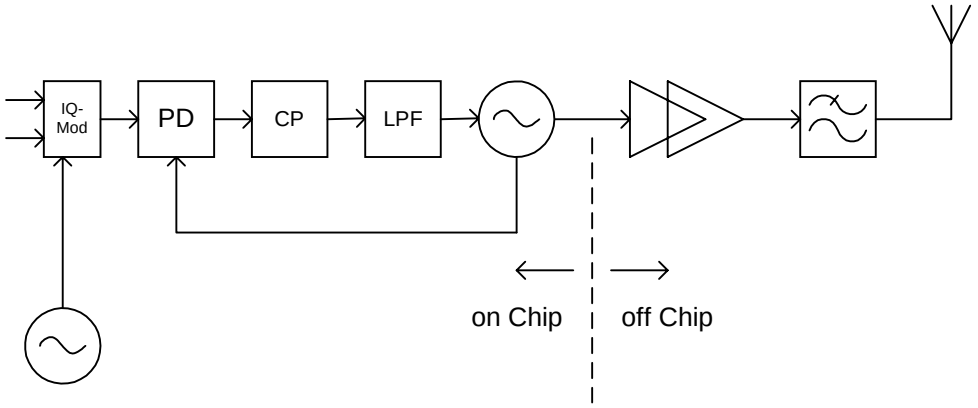


- Signal generation at RF-frequency
- Filtering using Offset-PLL
  - No external bandpass filters necessary
- No mixer in reference path
  - No frequency conversion in forward path
  - One LO signal necessary

Comparison of Direct-PLL and Offset-PLL

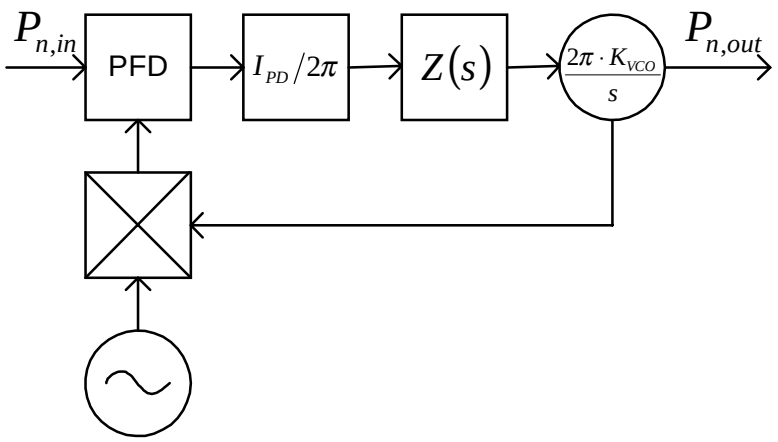


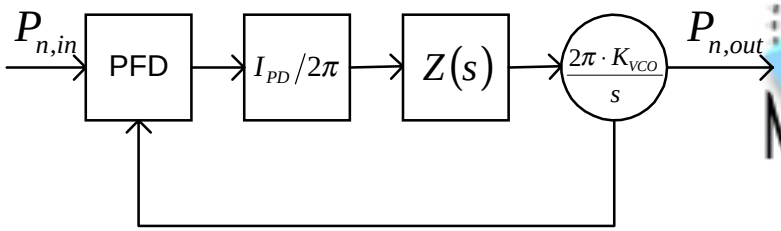
- Frequency conversion avoids LO interference
- Better phase error since signal is generated at IF



- Saved IF-LO and one mixer (cost, power)
- No spurious signals possible
- To avoid LO interference, VCO oscillates on double frequency
- 2 GHz phase detector necessary

Noise filtering of Direct-PLL





- Mixer in Offset-PLL has unity phase transfer function
  - Noise transfer function is identical to Offset-PLL

$$\frac{P_{n,out}}{P_{n,in}} = \frac{I_{PD} \cdot Z(s) \cdot K_{VCO}}{s + I_{PD} \cdot Z(s) \cdot K_{VCO}}$$

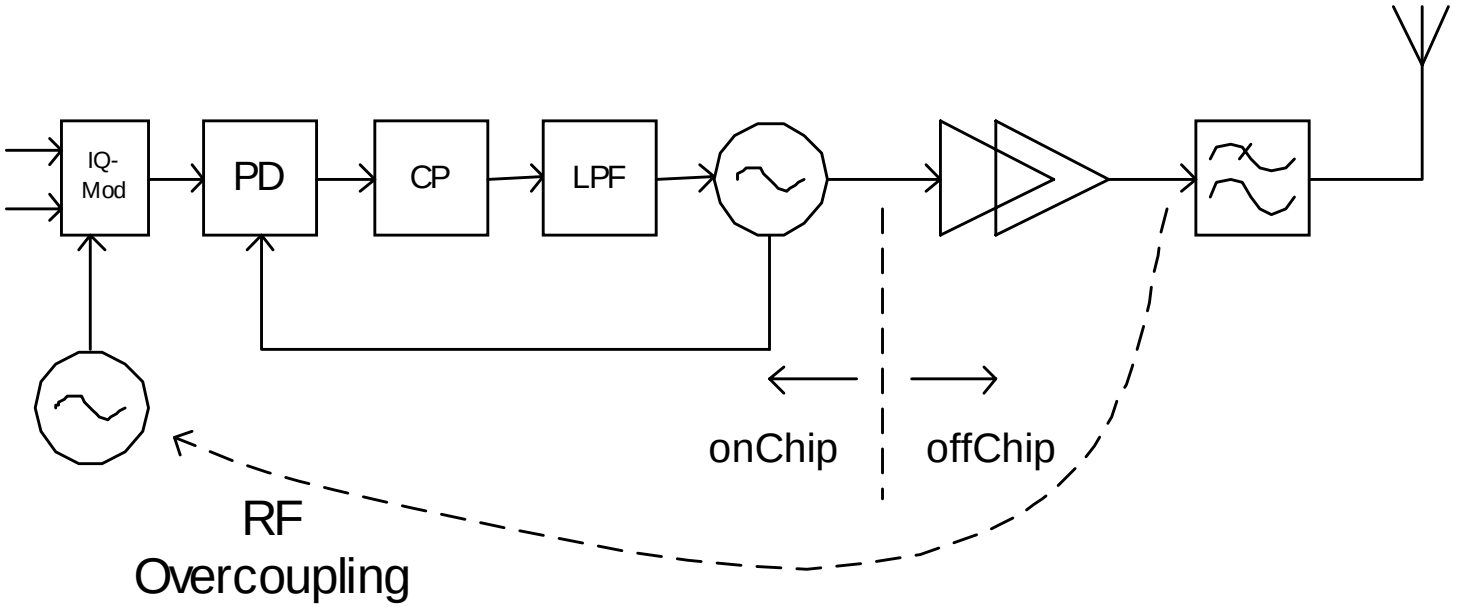
Phase detector for 2 GHz

- With new architecture, the phase detector has to operate at 2 GHz
  - Gilbert Cell Mixer can be used as analogue Phase-Detector (PD)
  - However, additional circuitry is necessary to lock PLL

$$I_{out} = U_{in} \cdot U_{VCO} = \sin(\omega t) \cdot \sin(\omega t + \varphi)$$

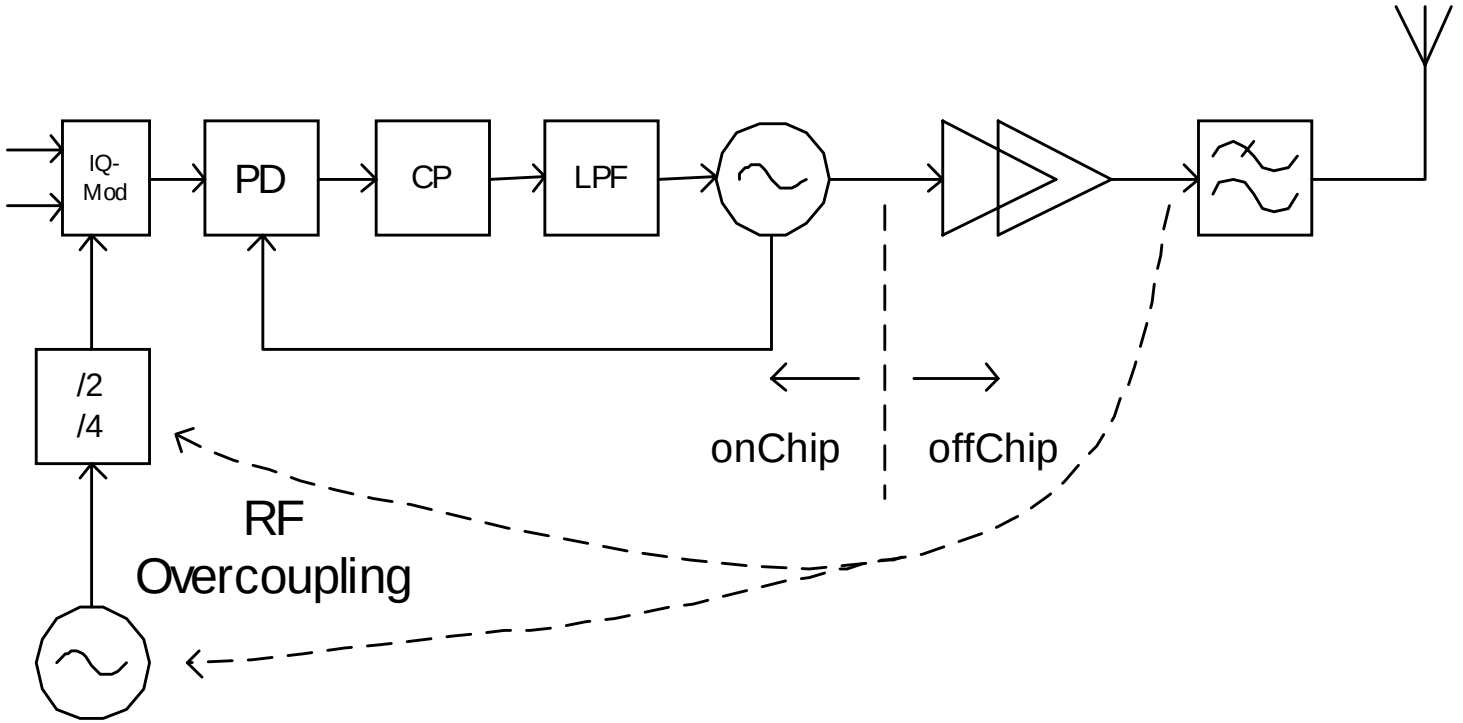
$$I_{out} = \frac{1}{2} \cdot (\cos(\varphi) - \underbrace{\cos(2\omega t + \varphi)}_{RF\,(\,filtered\,)})$$

Potential LO interference with direct PLL



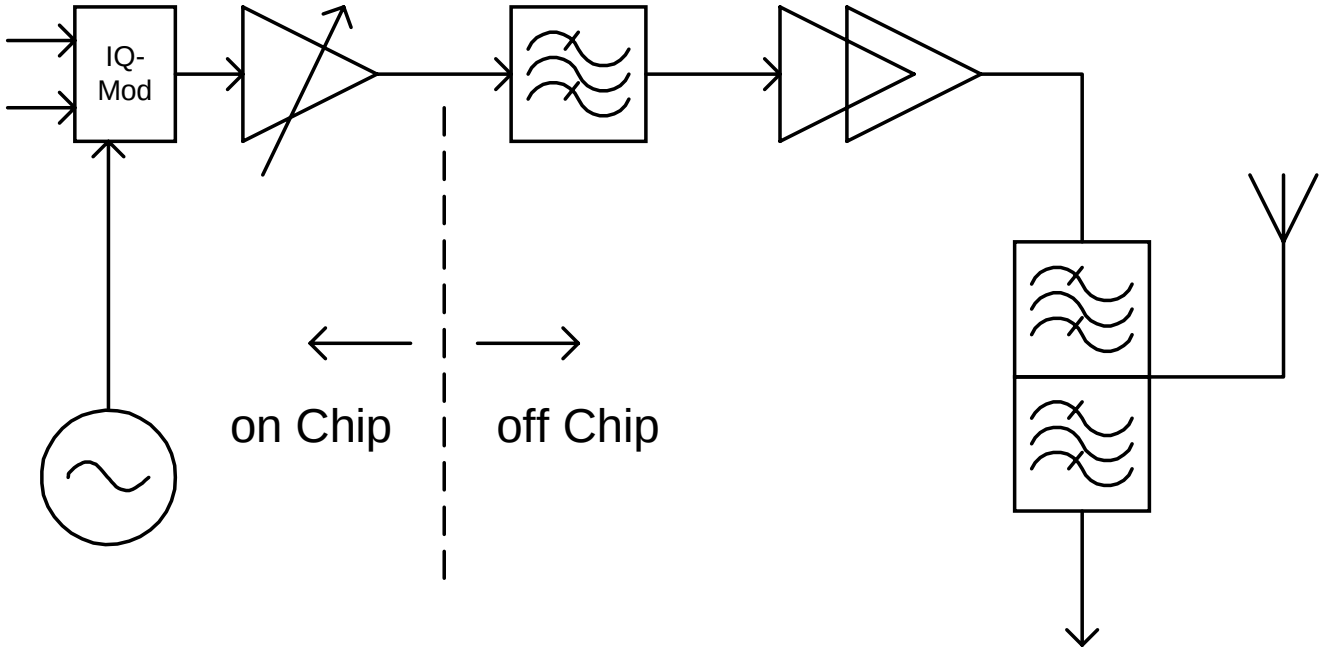
- Modulated Signal from PA output couples to VCO and mixes to low frequency signal
  - High phase noise of synthesizer may result

LO interference mitigation with direct PLL



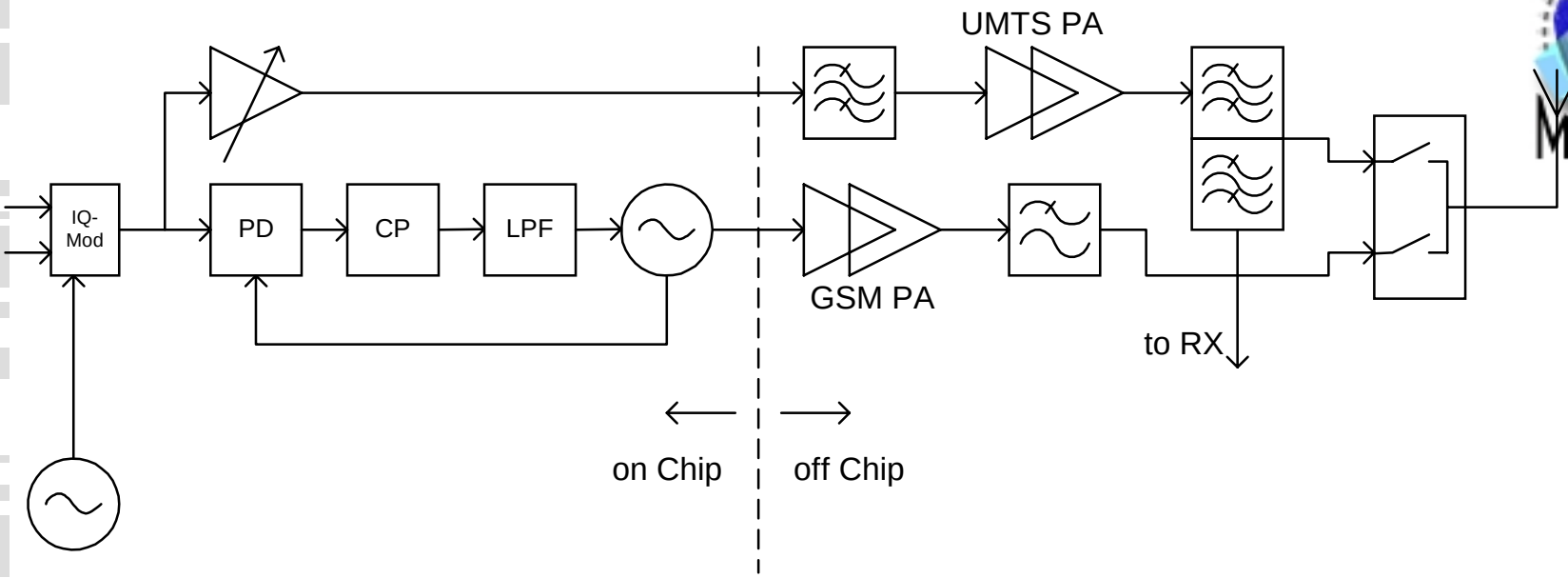
- Only small interference on VCO since signals have different frequencies
- Divider output is usually not sensitive to interference since low frequency signal cannot couple into regulation loop

UMTS Standard Architecture



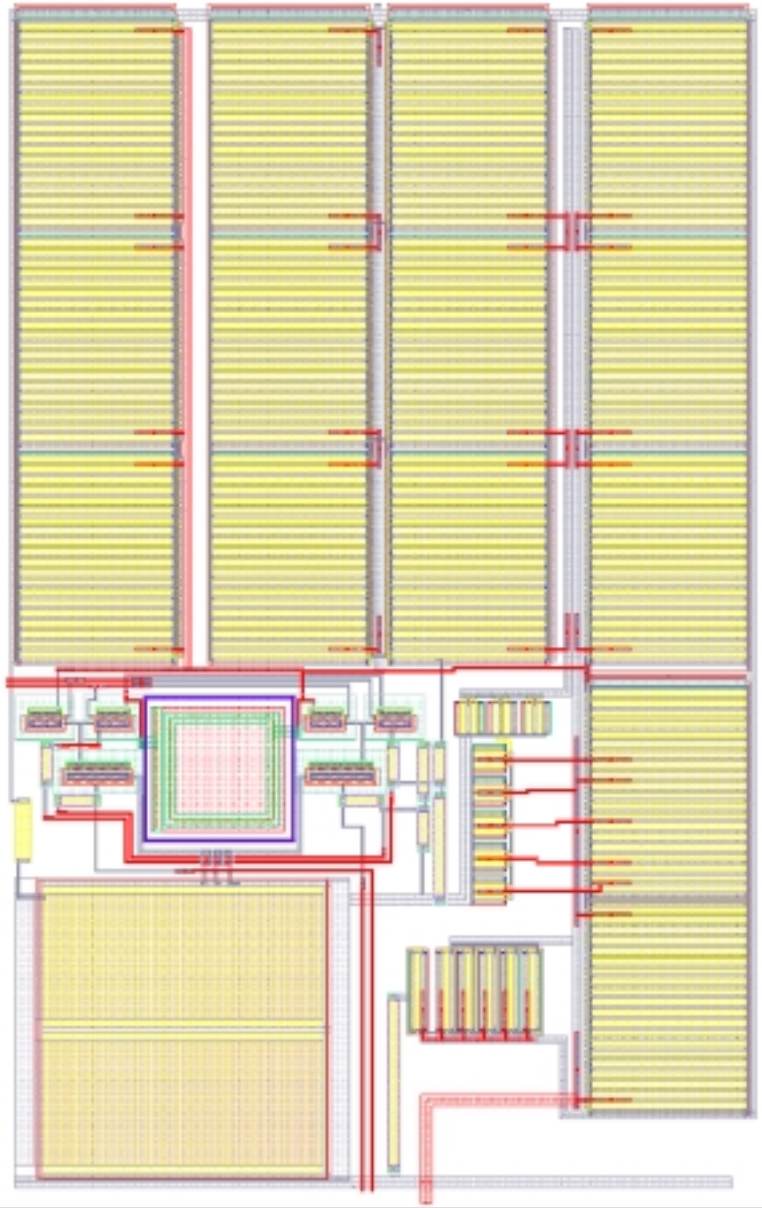
- Direct modulator
- Two bandpass filters
  - Necessary because of FDD
  - Between transceiver IC and PA
  - Duplexer

Multi-Mode GSM/UMTS Transmitter



- Extension of GSM Direct-PLL to Multi-Mode GSM/UMTS Transmitter
- Output of IQ-Modulator is RF (not IF as with Offset-PLL)
  - IQ-Modulator and LO can be used for both modes

MuMoR Test Circuit



- 2 GHz analogue phase detector including charge pump
- Size: 310 × 200 µm
- Current consumption: 5 mA from 2.8 V
- Available: Sep 2004

Overview

- Novel GSM Transmitter architecture
- Novel Multi-Mode GSM/UMTS Transmitter architecture
- Applied for Patent
- Test ICs available Sep 2004

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