A Sigma-Delta Based Open-Loop Frequency Modulator

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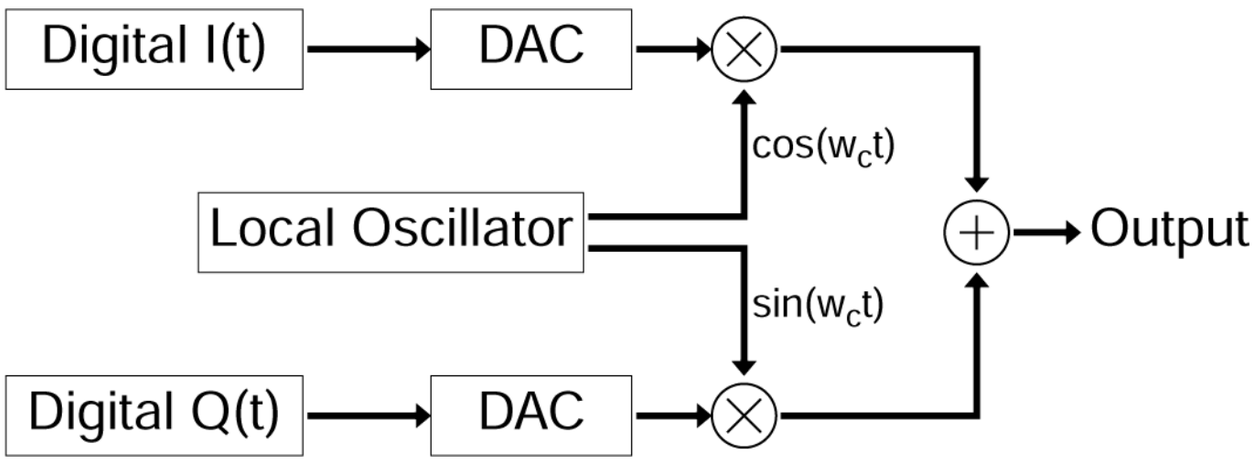
ABSTRACT

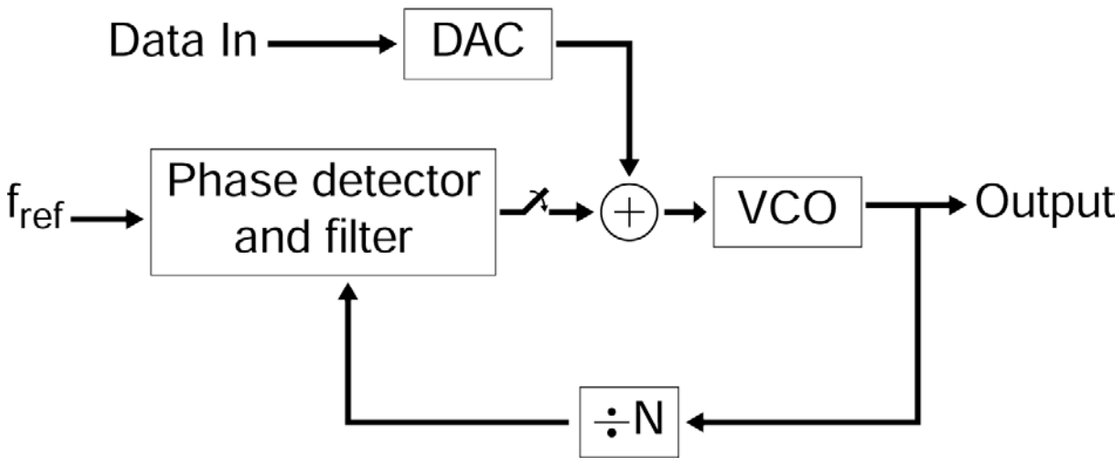
A constant-envelope, continuous phase modulation architecture is presented in which a sigma-delta modulator is combined with an open-loop modulator. Compared to existing architectures, Σ–Δ based open-loop modulation can be implemented with minimal analog circuitry. The architecture is demonstrated with a discrete implementation performing frequency modulation at a carrier frequency of 120 MHz. By increasing the Σ–Δ modulation frequency, the quantization noise is filtered out by the VCO and disappears beneath the measurement noise floor.

Existing Architectures

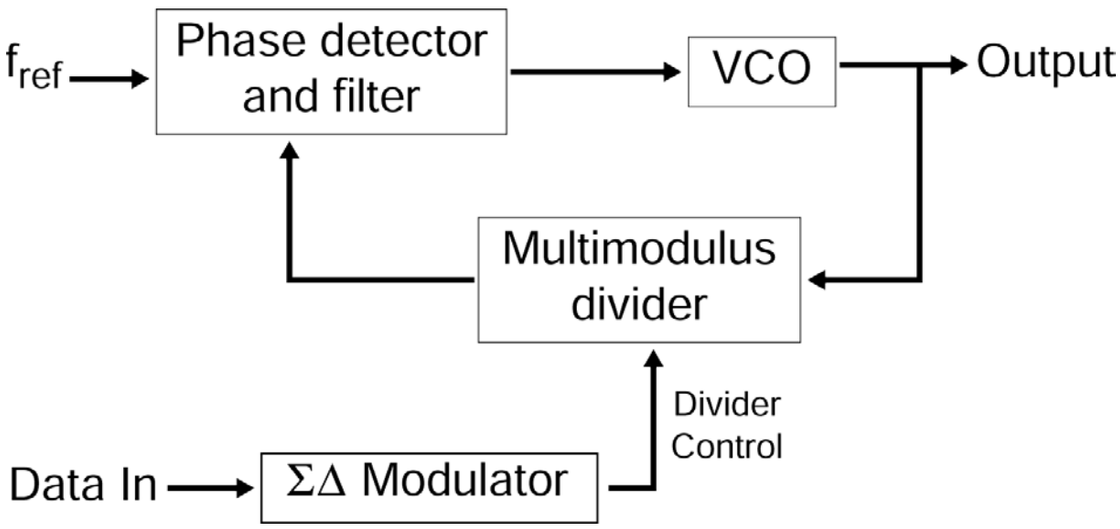
Quadrature Modulation



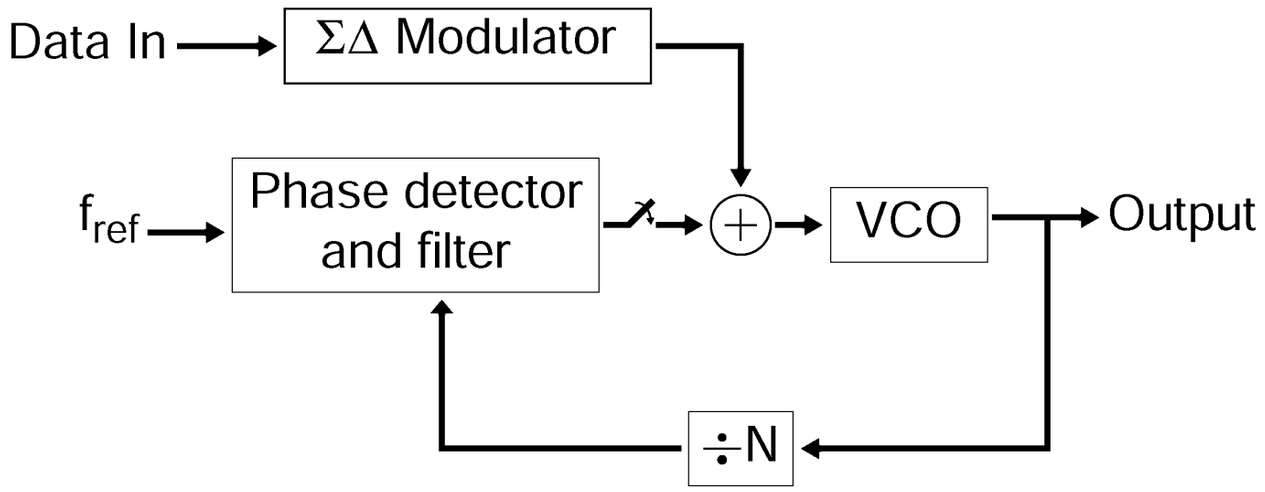
Open-Loop Modulation



Modulated Synthesis



PROPOSED ARCHITECTURE



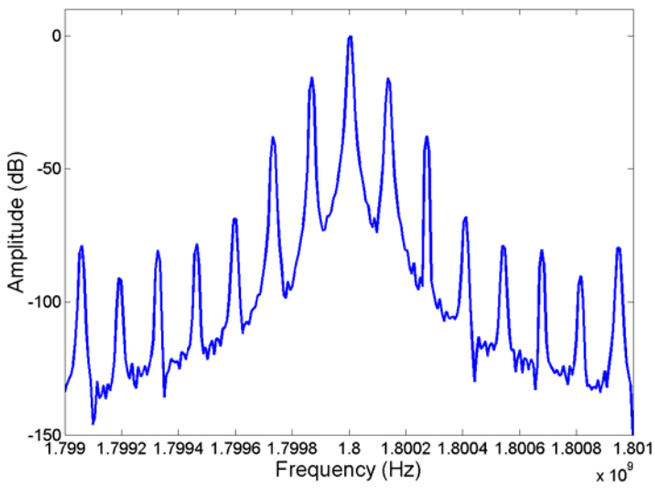
ADVANTAGES:

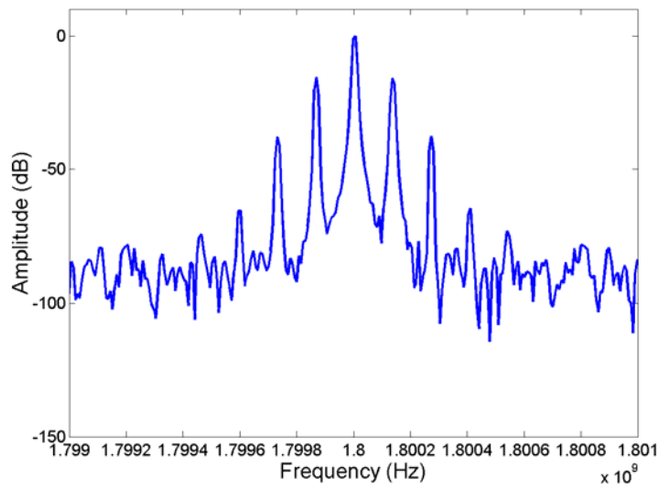
- ☺ Simple to implement
- ☺ Low power consumption
- ☺ Tuning linearity of VCO can be ensured

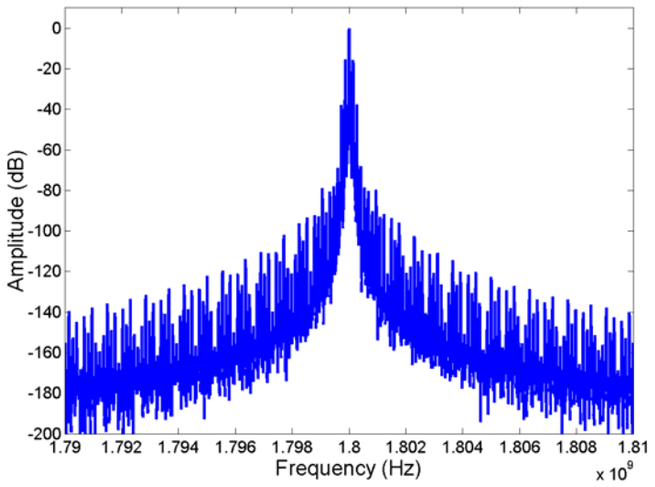
DISADVANTAGES:

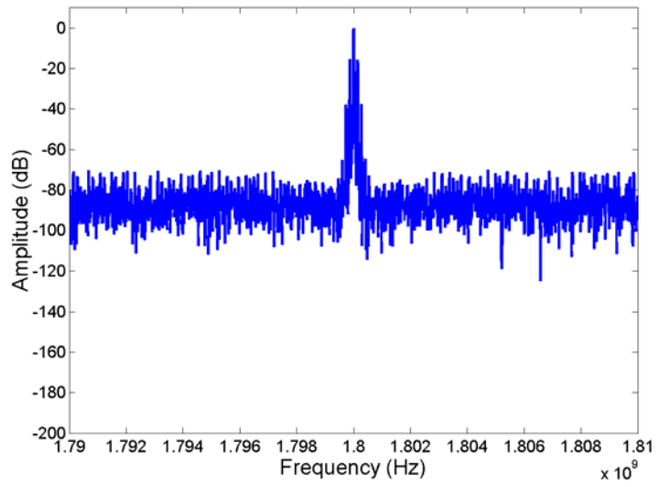
- ☹ Σ–Δ quantization noise must be filtered out before transmission
- ☹ PLL must periodically stop transmission to lock to carrier frequency (in an open-loop configuration)

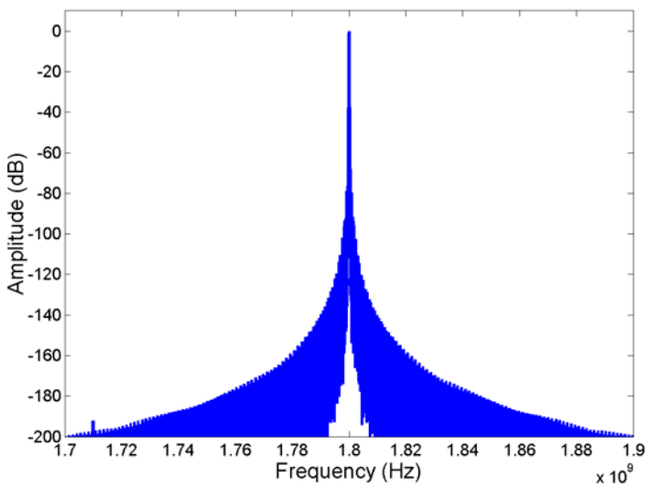
Frequency Analysis

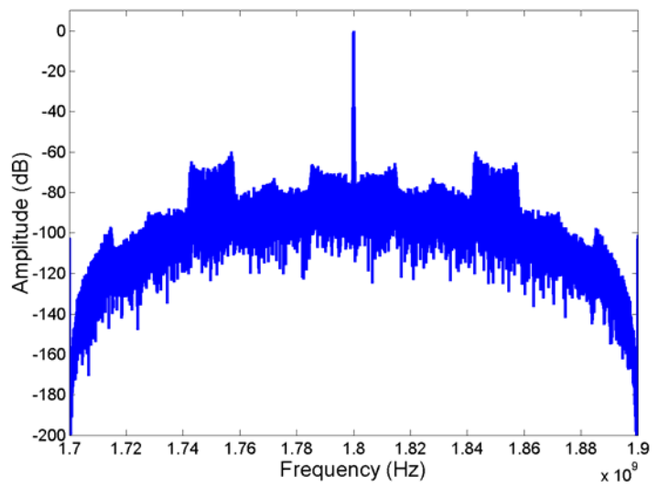










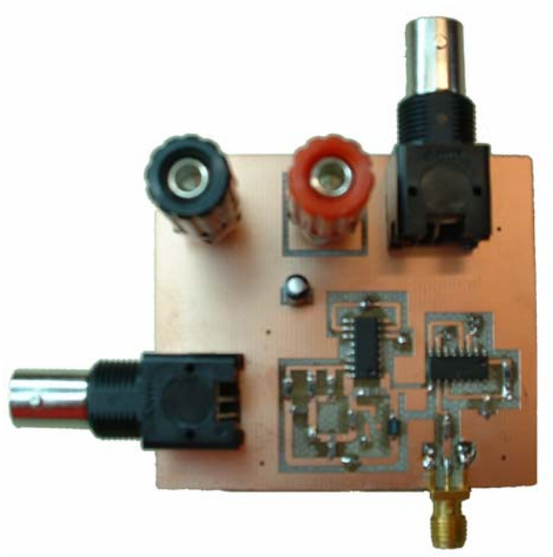


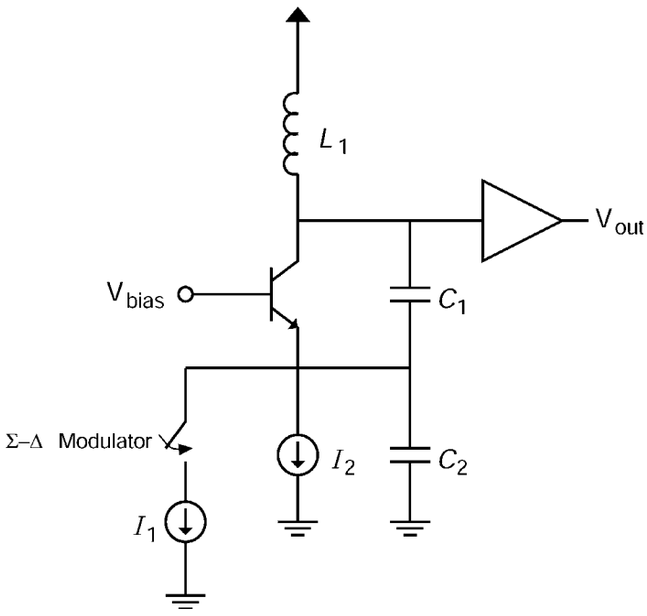
GMSK Modulation

Σ–Δ Based GMSK Modulation
(Σ–Δ clocked at 100 MHz)

→ Identical frequency spectrum near carrier

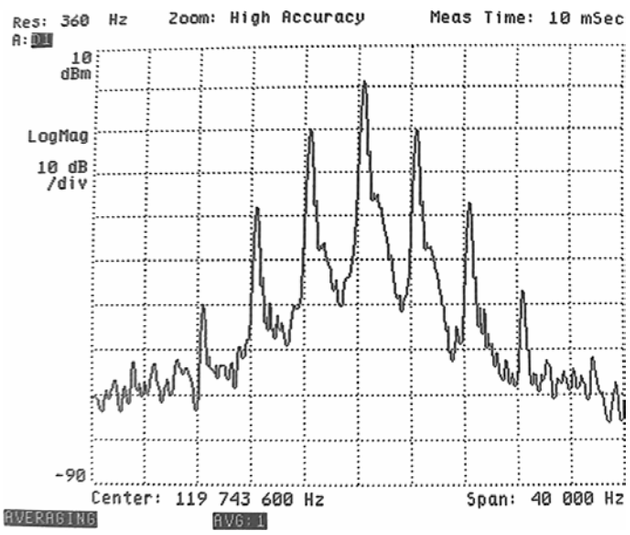
EXPERIMENTAL RESULTS



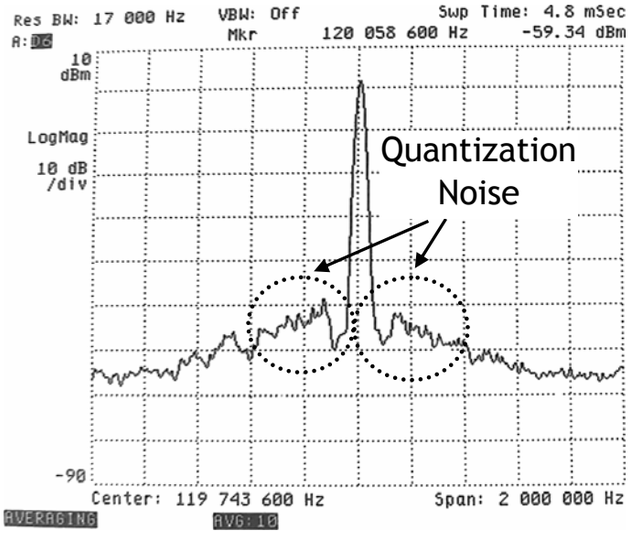


→ Implementing FM modulation

Frequency Spectrum with Σ–Δ clocked at 1 MHz

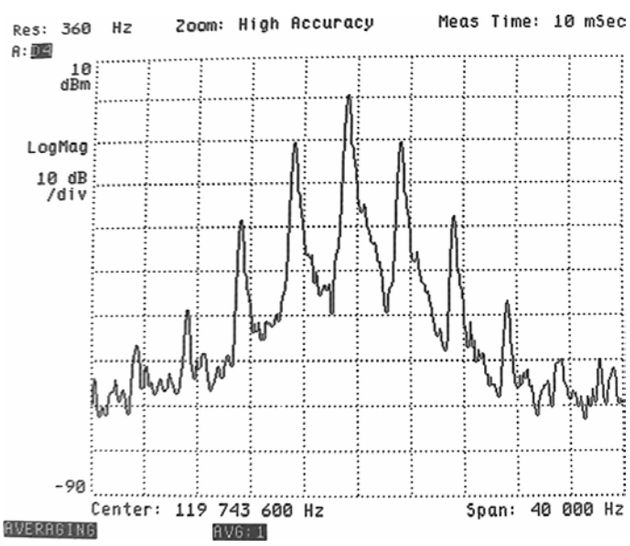


Narrowband

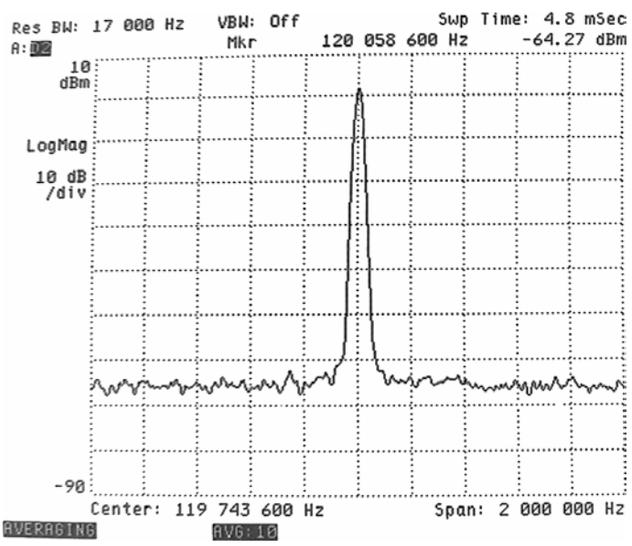


Wideband

Frequency Spectrum with Σ–Δ clocked at 10 MHz

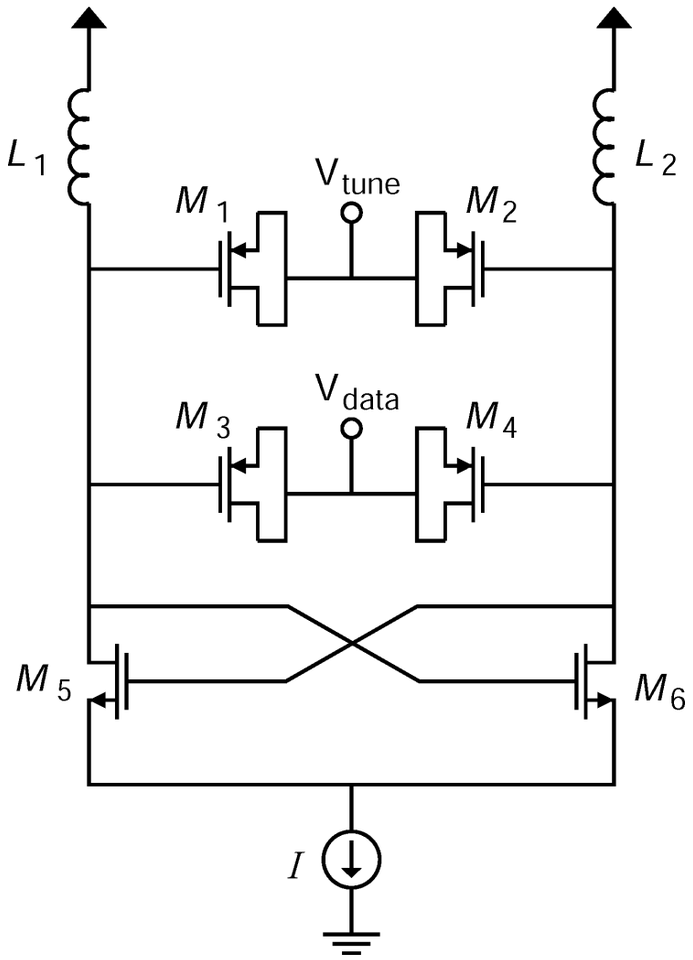


Narrowband



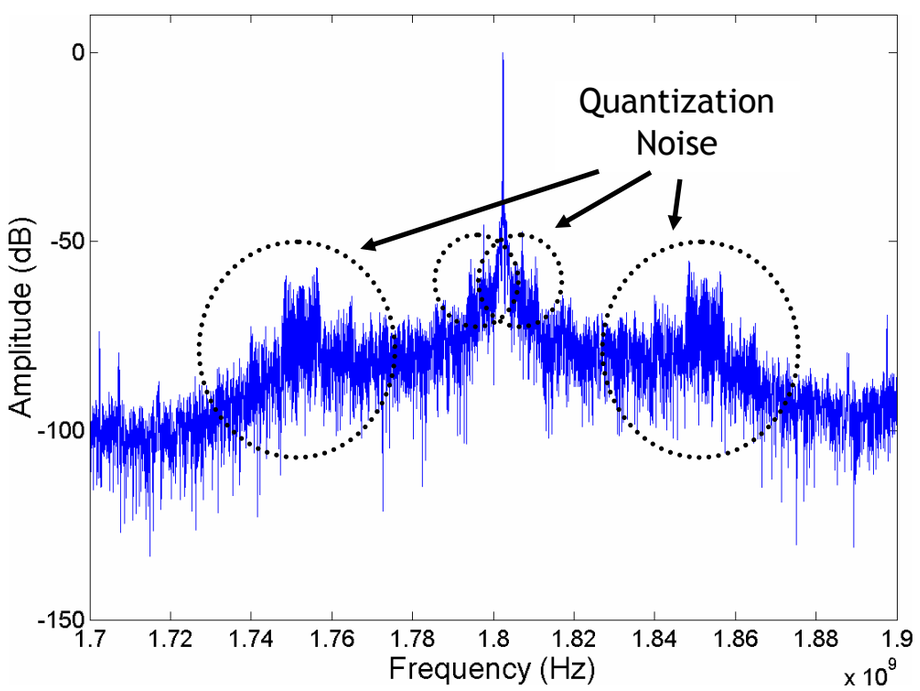
Wideband

Circuit Simulations

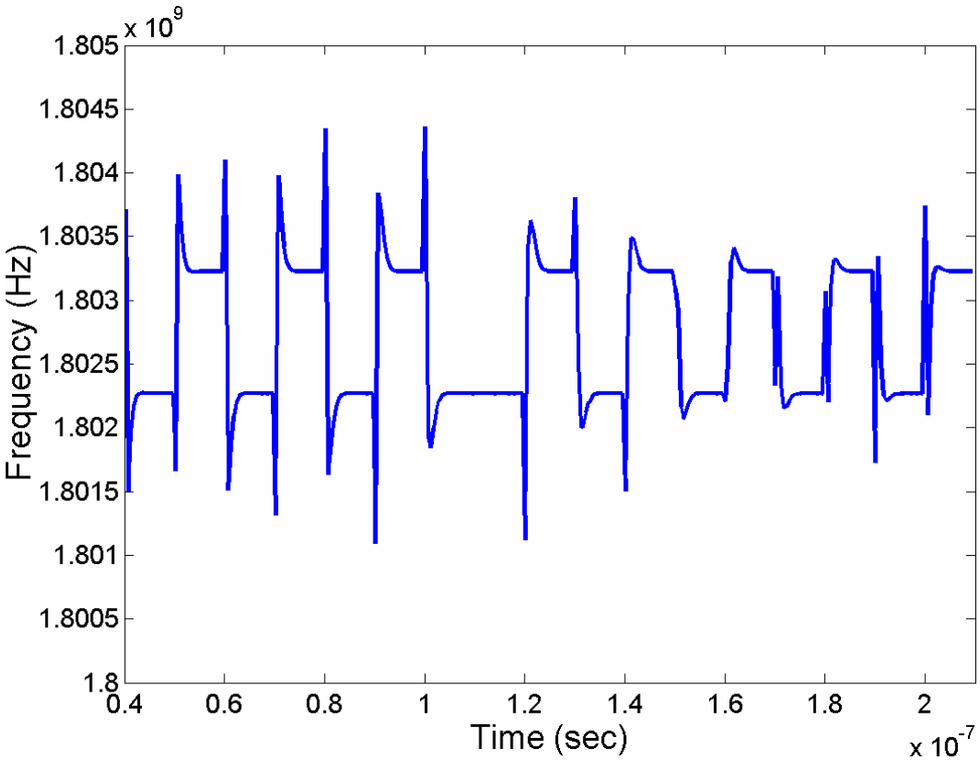


→ Implementing GSMK modulation for a GSM cellphone at 1.8 GHz

Frequency Spectrum with Σ–Δ clocked at 100 MHz



Instantaneous frequency response of VCO



→ Switching time affects bandwidth of VCO