A Transmission-Line-based Phase Shifter for High-Speed, Ultra-Low-Power N-PSK Transmitters

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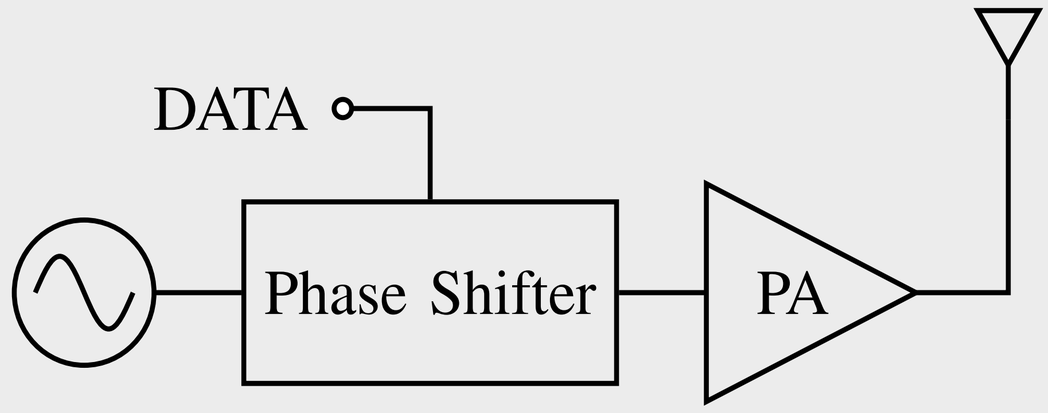
Motivation: Enabling Future Ultra-Low-Power Polar Transmitter

- Polar Transmitter
  - lower power consumption, prefer APSK over QAM
  - Especially Interesting for OFDM signals
- Direct Digital Modulation
  - No upconverters, simpler architectures
  - No High-Performance Data Converters

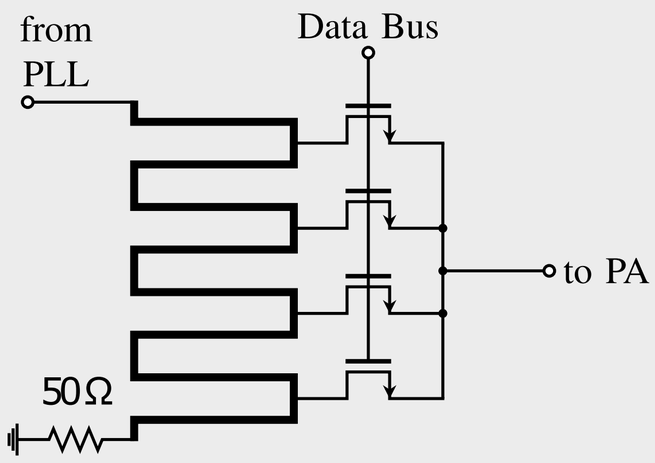


Phase Shifter Concept

- Transmission-Line Elements
  - Coplanar Waveguides
  - Length optimized for λ/4
- MOSFET Switches
  - Slight capacitive Load, but negligible
- Fully-Passive Structure
- Element Length:

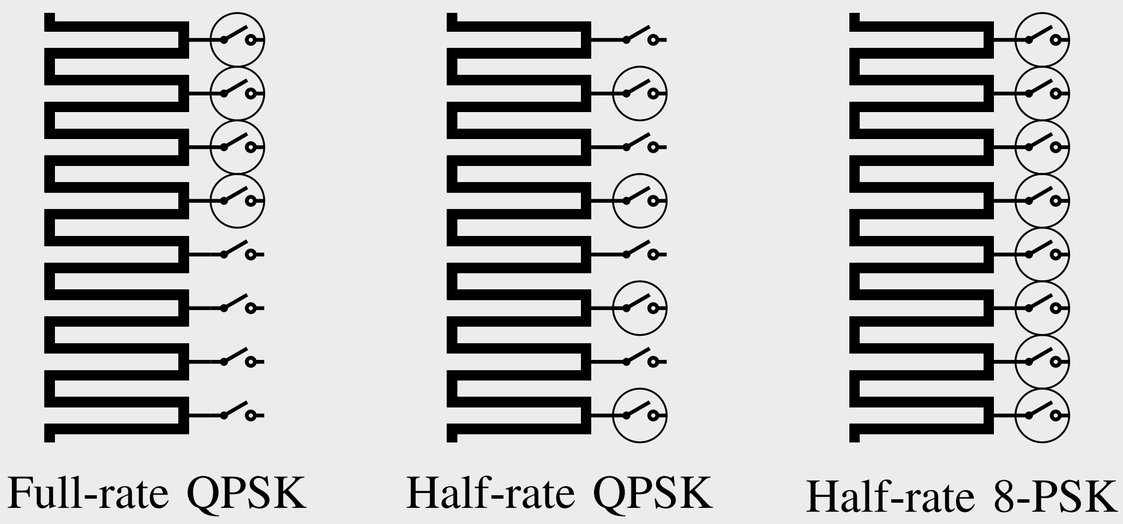
$$L_t = \frac{1}{2^{N_{max}}} \cdot \frac{c_0}{f_{c,max} \cdot \sqrt{\varepsilon_r}}$$

Nmax: Number of bits for modulation format
fcmax: Carrier Frequency



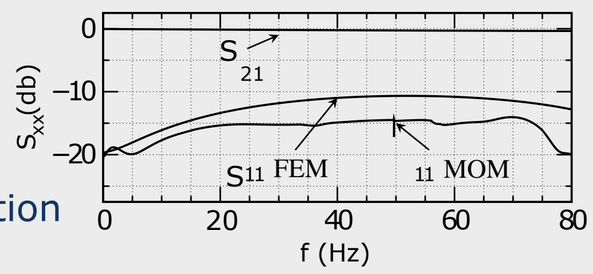
Modulation Formats

- More Transmission Line Elements
  - Four Elements for QPSK, eight for 8-PSK etc.
  - Selection of Modulation Format by Switches
  - More complex Modulation with lower carrier frequencies

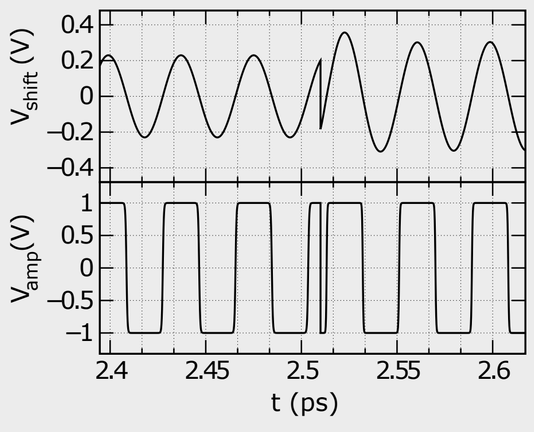


Simulated Waveforms

- S-Parameters
  - Momentum and FEM-Simulation
  - Virtually no loss
  - Acceptable Reflection



- Phase-Shifted Waveforms
  - Waveforms before and after saturating Amplifier
  - Phase Modulation without Amplitude Variation



Implementation with Summing Tree

- 22 nm FDSOI Technology
- High-Q RF-Capable Top Metal
- Structure covered by Ground Shield
- Total Size: 325 µm x 165 µm

Simulation Results for different Modulation Formats

- Pseudo-Random Bit-Stream input
- Saturation Amplifier after Phase Shifter (behavioural Model)
- Virtually no power consumption
  - Power Amplifier has high power comsumption, but this is true is for all transmitter