Phase-coded automotive radar

Automotive radar penetration is expected to increase exponentially in the coming decade. Under these circumstances, interference between radar systems is likely to be become a practical problem. Spread spectrum techniques (phase-coded radars) promise to mitigate the effect of interferences; as of today, on the other hand, it is known that a large portion of these radars will operate with the fast-chirp-sequence technique. It is therefore important to quantify the problem of interference between fast-chirp-sequence radars, and to determine if and to what extent the use of spread-spectrum techniques can alleviate the interference problem. It is also relevant to determine if fast-chirp-sequence radars will (likely) migrate towards pure phase-coded systems in the future, or a hybrid solution combining fast-frequency chirps with phase coding is likely to become a next de-facto standard, as both fast-chirp and phase coding may have practical, complementary features.

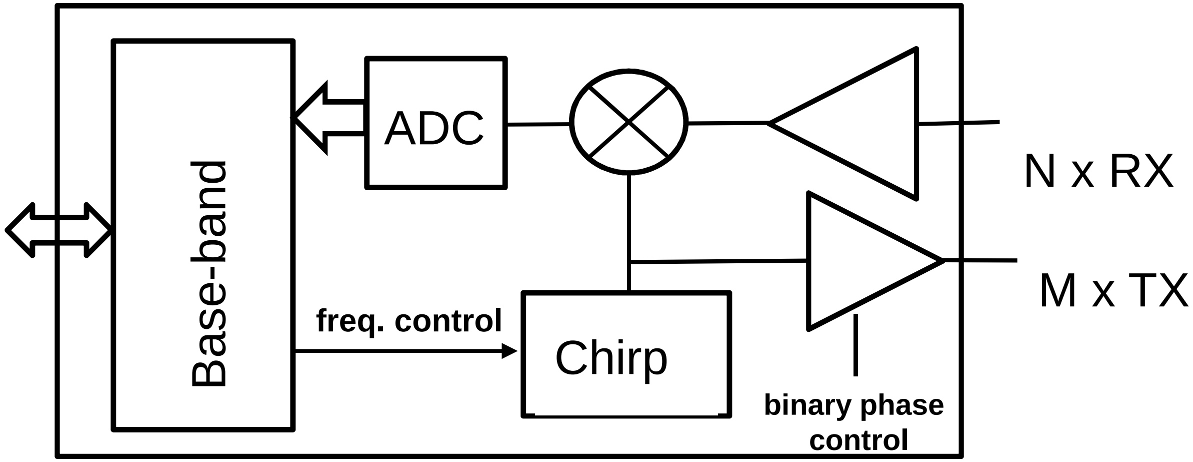
In this thesis, a benchmark of phase-coded, fast-chirp sequence, and hybrid phase-coded/fast-chirp sequence will be presented. The work will deliver system models (for example in matlab) for estimation of the deleterious effect of interference from these type of systems into each other. An overview of phase-coded radar literature will be presented, and a complete signal path shall be proposed (e.g. dimensioning ADC sampling rate and ENOB requirement , BB signal processing implementation, etc…) The theoretical study will be complemented by practical validation on fast-chirp sequence, and possibly also on hybrid phase-coded/fast chirp sequence, hardware test set-up.

Interference rejection techniques

- Random frequency hopping and delays between acquisition sequences.
- Binary Phase Modulation (BPM):
  - Random phase code per ramp to spread signal.
  - Vary phase change rate (“chip rate”) per ramp.
  - De-spread on receive to select channel.
- Electronic protection: for some ramps, chirp LO only with TX off, listen to environment. Still need phase coherent CPI timing.
- Interference avoidance: GPS-synchronized chirps across autonomous vehicles.
- Front-end key requirements: TX binary phase control and chirp start control on GPIO lines

NXP radar evolution: today

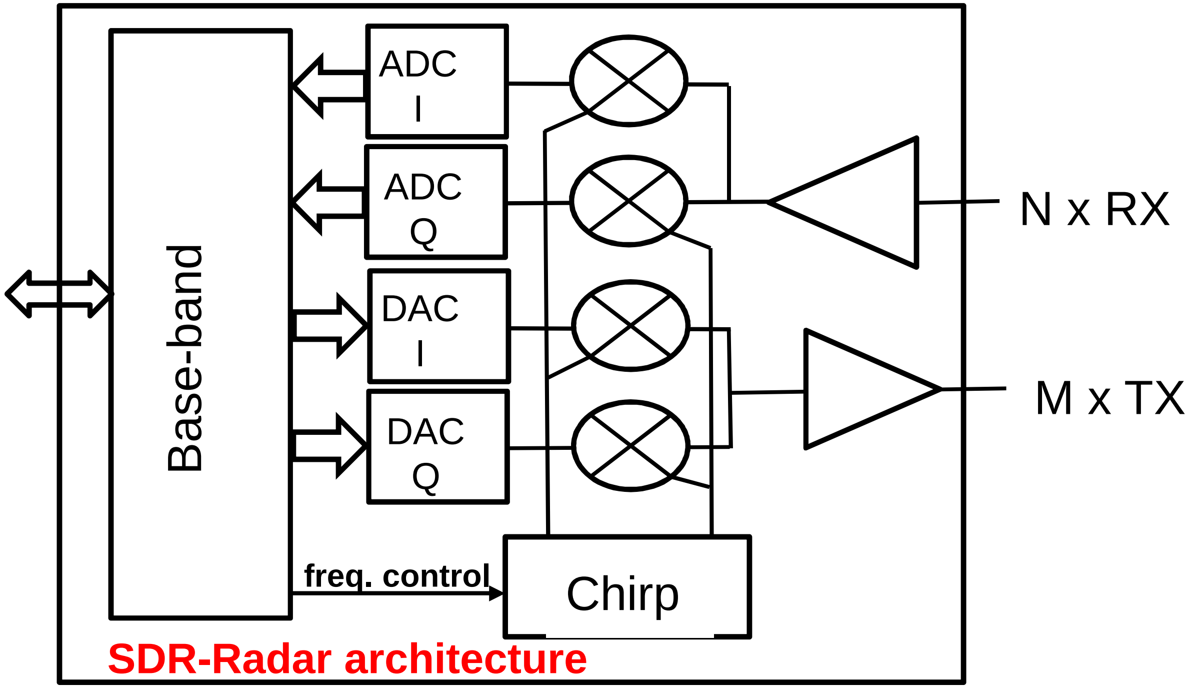
Dolphin/ORCA architecture



+ ultimate cost-effective fast-chirp FMCW system

- limited waveform flexibility for interference suppression → limited radar signature possibilities
- expansion towards TX analog-beam steering requires mmWave phase shifters in TX path → natural evolution to I/Q transmitters, see next slide

NXP radar evolution: software-defined radar



+ ultimate software-defined automotive radar architecture:

→ supports fast-chirp FMCW system as legacy

→ full waveform design flexibility for interference suppression → radar signature possible

→ natural evolution towards TX analog-beam steering solution: DACs can be used for DC phase control for beam-steering, as well as phase modulation or frequency offset insertion on top of FMCW, many other things ….