K-band

- Wider bandwidth available
- Allows the use of antenna arrays
- Higher data transfer velocity
- Higher attenuation of the signal
- Lower interference with undesired signals
- Electrical steering
- Cheaper and less power consuming

Phase shifter conceptual scheme:

- Quadrature All-Pass Filter (QAF): Generates in-phase and quadrature signals
- Variable Gain Amplifier (VGA): In-phase and quadrature signals weighed by digitally 4-bit programmable cascade VGAs
- Power Combiner: Combines signals coming from different antennas

Operation of a phase shifter

\[ \phi = \text{atan}(A_I/A_R) \]

\[ \text{Gain} = \sqrt{A_I^2 + A_R^2} \]

- VGA (I)
- VGA (Q)

\[ A_I = +1/3 \]
\[ A_R = +1 \]

\[ A_I/A_R = +3 \]

\[ \phi = 67.5^° \]

Results

- Frequency: 18-27 GHz
- Technology: CMOS 65 nm
- \( \Delta \phi_{RMS} (^°) < 8^° \)
- \( \Delta A_{RMS} \) (dB): < 0.86
- Gain (dB): 28.7-30.06 @ 24 GHz

Conclusions

- The 4-bit phase shifter produces the desired phase shift according to the control word.
- This phase states are kept constant in the K-band frequency range.
- Dummy transistors reduce the RMS errors by keeping the input and output impedances constant.