XI JORNADA DE JÓVENES INVESTIGADORES DEL I3A

CMOS design of a phase shifter for 5G/6G active antenna arrays

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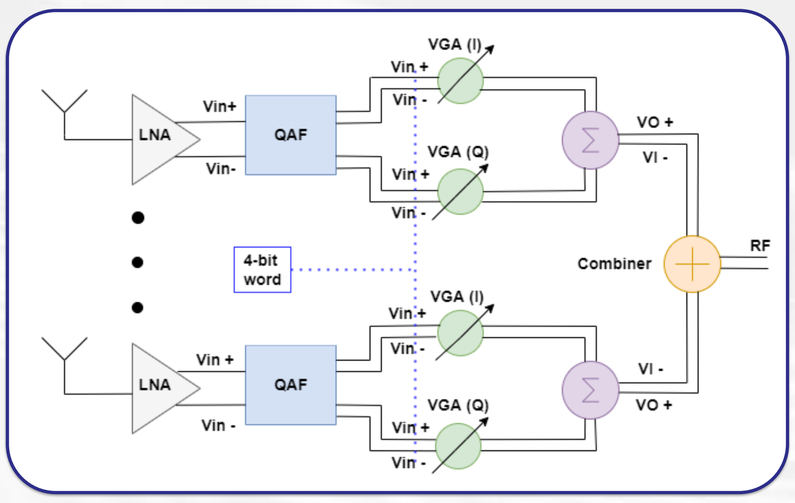
K-band

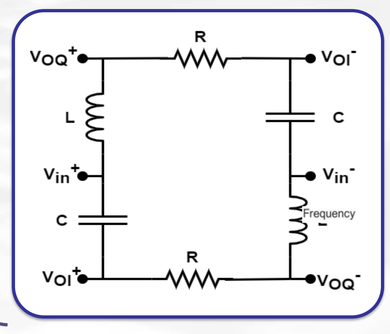
- ✓ Wider bandwidth available
- ✓ Allows the use of **antenna arrays** → ✓ Lower interference with undesired signals; ✓ Electrical steering; ✓ Cheaper and less power consuming
- ✓ Higher data transfer velocity
- ✗ Higher attenuation of the signal

Phase shifter conceptual scheme:

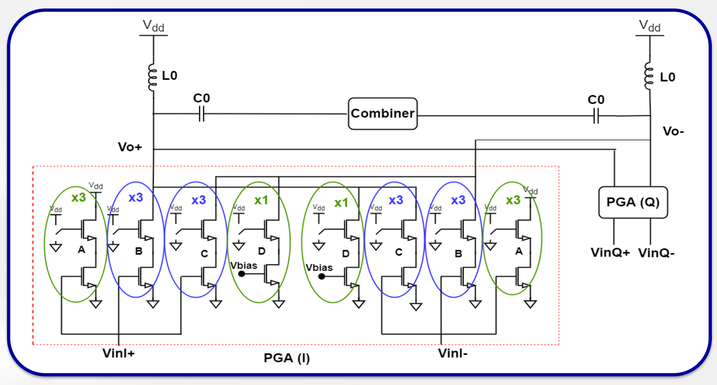


Topology

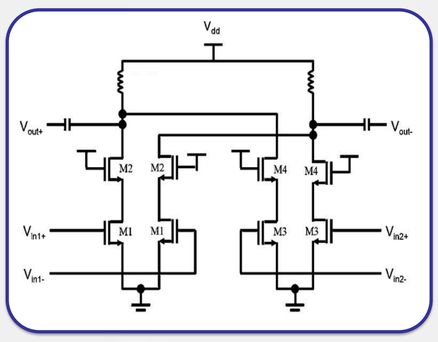
- **Quadrature All-Pass Filter (QAF):** Generates in-phase and quadrature signals
- **Variable Gain Amplifier (VGA):** In-phase and quadrature signals weighed by digitally 4-bit programmable cascade VGAs
- **Power Combiner:** Combines signals coming from different antennas



QAF



VGAs

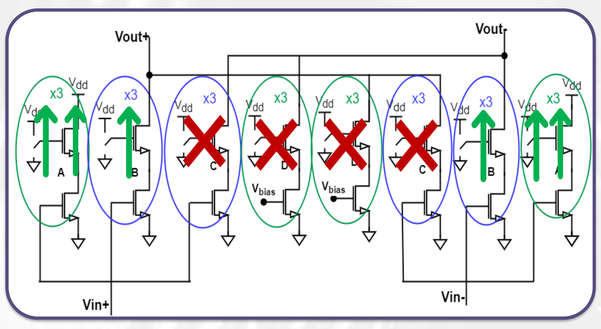


Power Combiner

Operation of a phase shifter

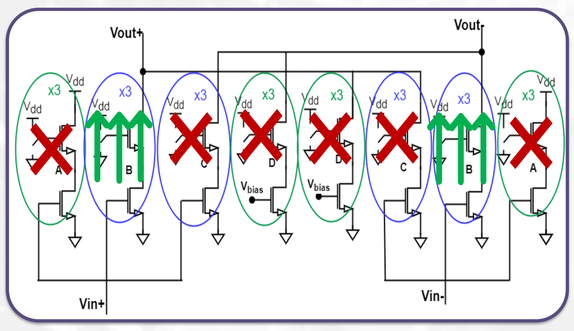
$$\phi = \operatorname{atan}(A_j/A_r) \qquad Gain = \sqrt{A_j^2 + A_r^2}$$

VGA (I)



$A_r = +1/3$

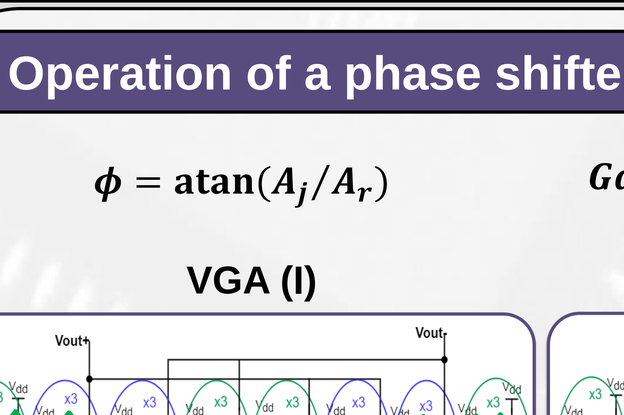
VGA (Q)



$A_j = +1$

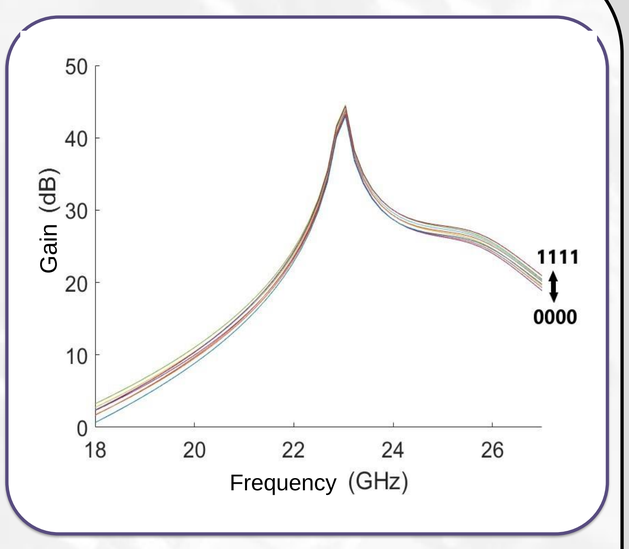
$A_j/A_r = +3$

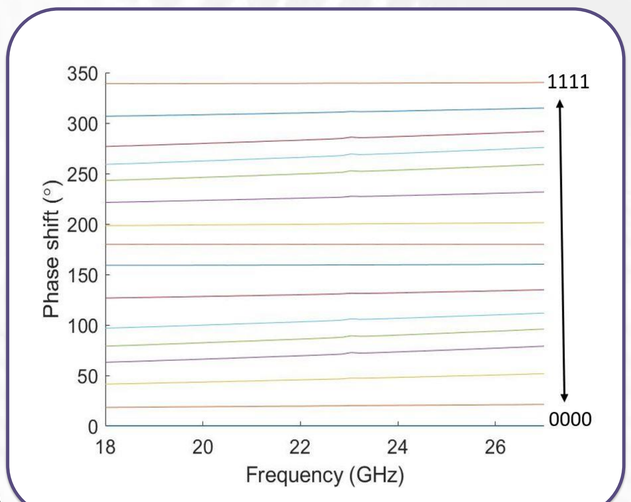
$\phi = 67.5^{\circ}$

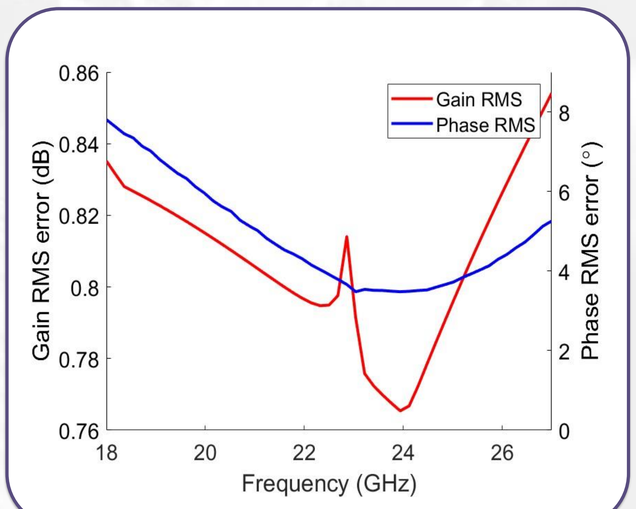


Results

- **Frequency:18-27 GHz**
- **Technology: CMOS 65 nm**
- **$\Delta\phi_{RMS}$ (°): <8°**
- **ΔA_{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.