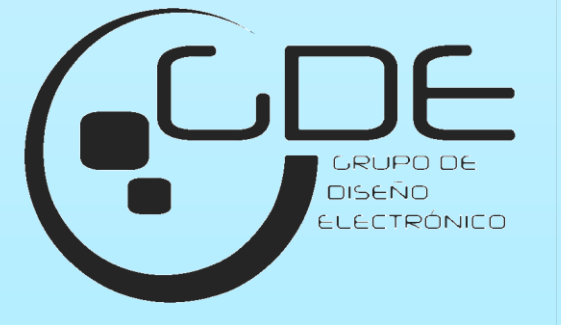


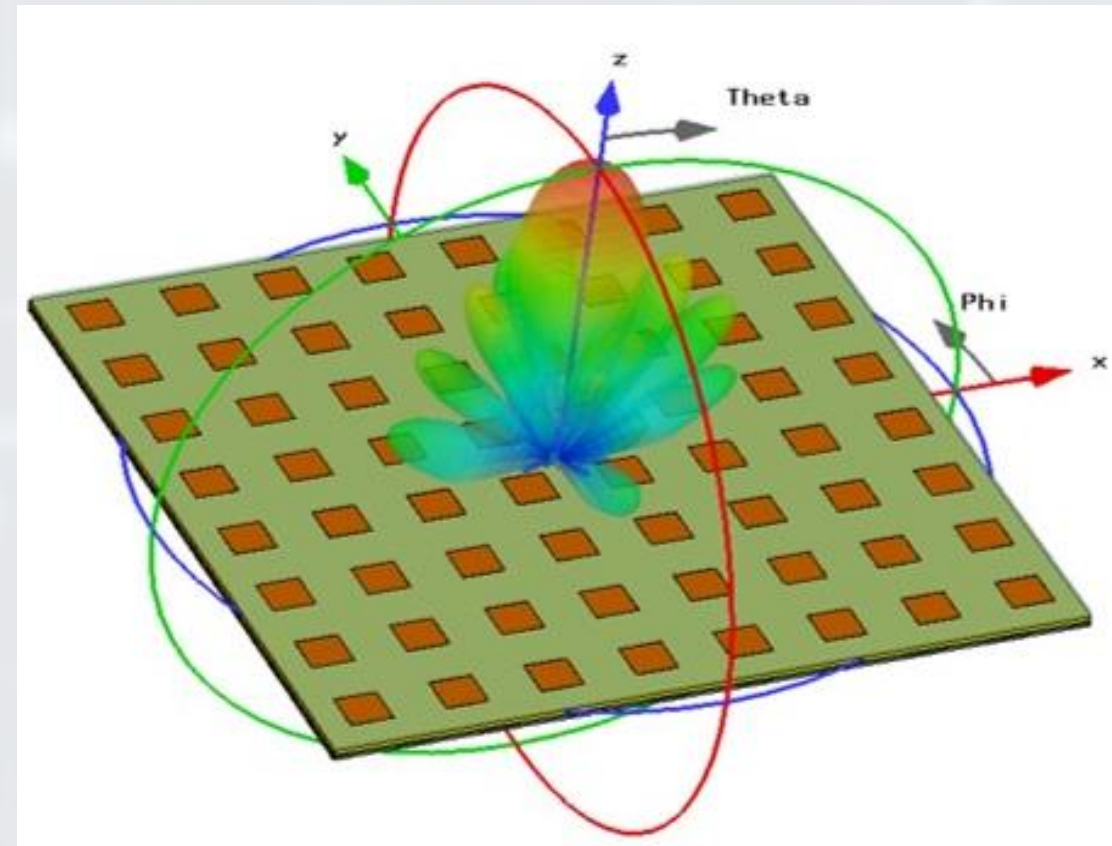
Design of an active a 5-bit digitally programmable phase shifter for hybrid antenna beamformers

Uxua Esteban Eraso, Carlos Sánchez Azqueta, Concepción Aldea Chagoyen y Santiago Celma Pueyo
Grupo de Diseño Electrónico (GDE -I3A) - Universidad de Zaragoza



Millimeter Band:

- ✓ More bandwidth available
- ✓ Less interference and safer
- ✓ Beamforming needed

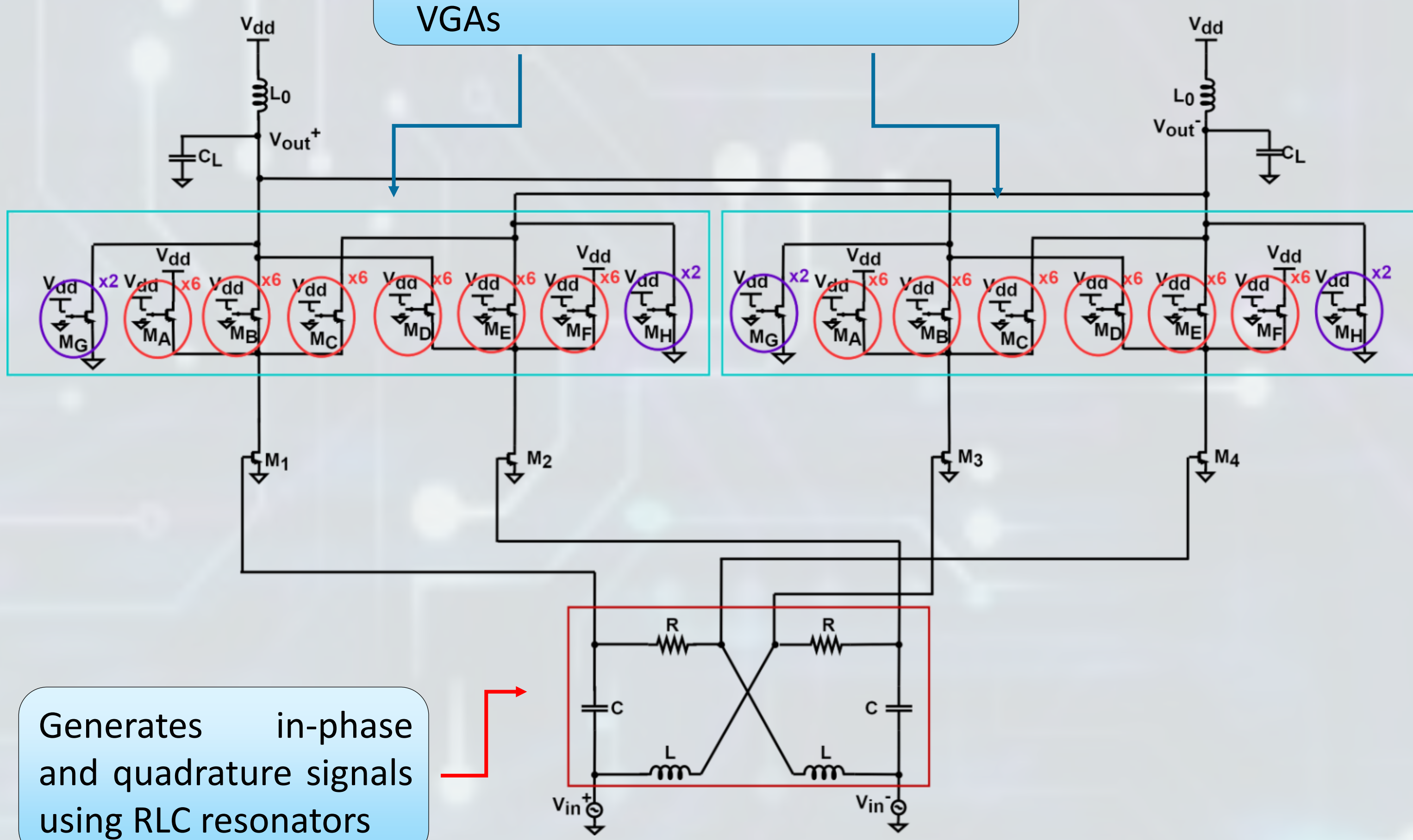


Antenna Arrays:

- ✓ Electronically steerable
- ✓ Multiple beams
- ✓ Faster and cheaper

In-phase and quadrature signals weighted by digitally programmable VGAs

Topology

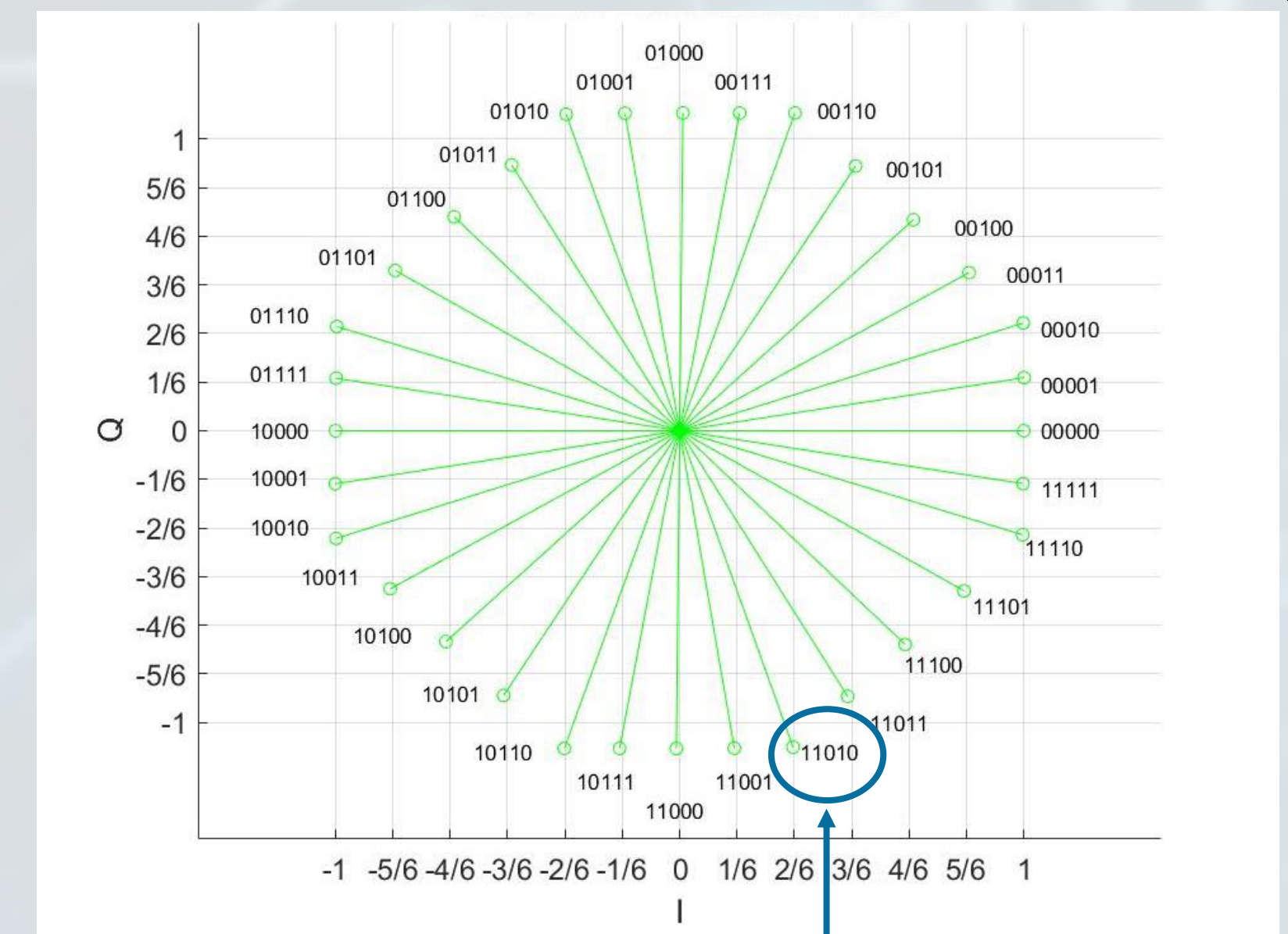
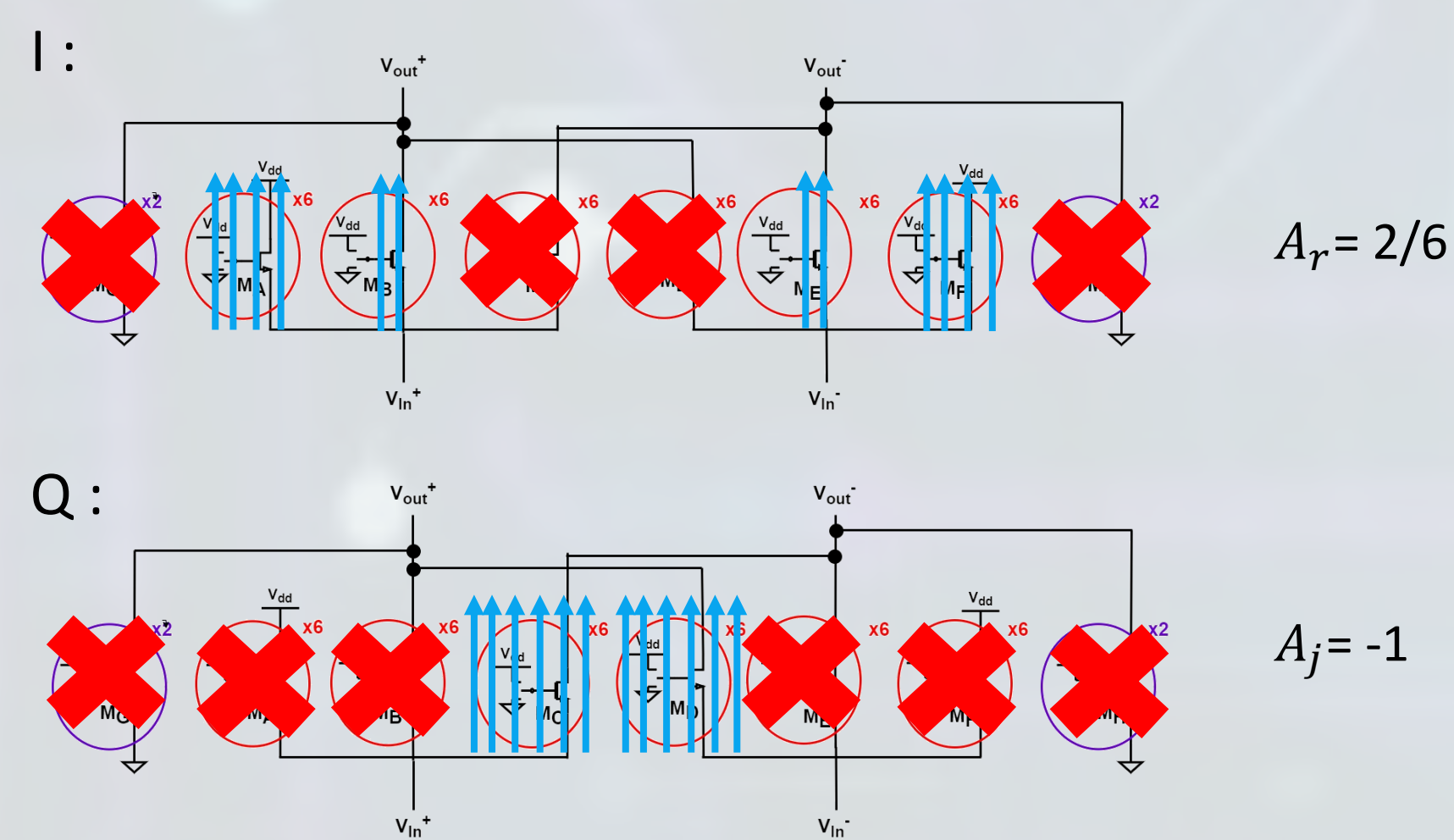


Generates in-phase and quadrature signals using RLC resonators

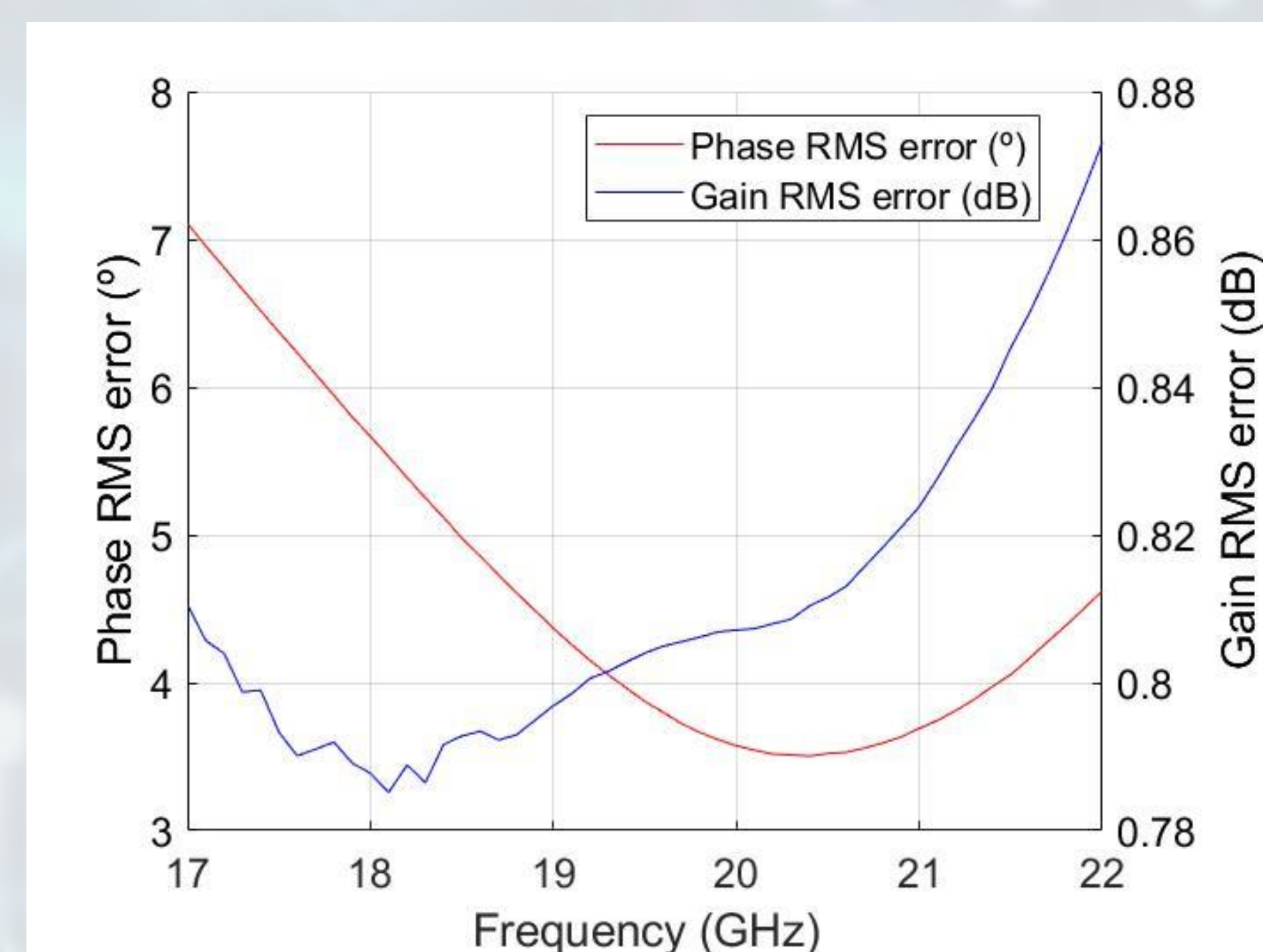
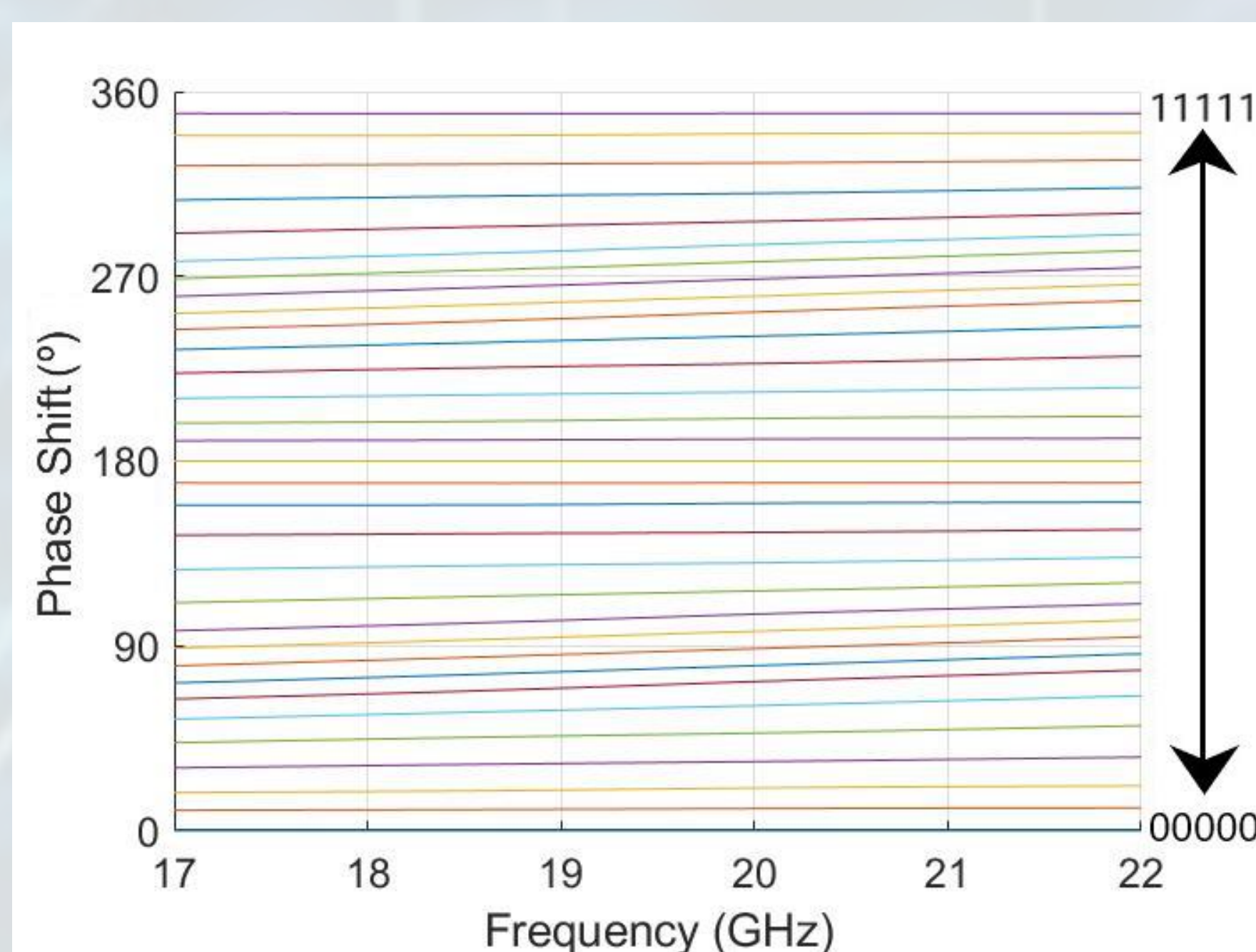
V_{out} phase:

$$\phi = \text{atan}(A_j/A_r)$$

Example:



Results



Frequency (GHz)	Technology / Supply	Resolution	$\Delta\phi_{RMS}$ (°)	ΔA_{RMS} (dB)	S_{11} (dB)	S_{22} (dB)	P_{1dB} (dBm)	Power consumption (mW)
17 - 22	CMOS 65 nm / 1.2 V	5-bits	3.50 - 7.10	0.78 - 0.87	< -10	< -6 @ 18.7- 20.5 GHz	-0.55 ± 0.33 @ 19.5 GHz	9.78 @ 19.5 GHz

Conclusions

- The proposed topology allows to get the desired phase states for active antenna arrays working in millimeter band.
- Dummy transistors are necessary to keep input and output impedances invariant between different configurations.
- This design can be generalizable to other frequency bands and it is compatible with other integration technologies.