

# Pomerači faze reflektivnog tipa

## [13M071MMT] - Milimetarski talasi

student Aleksandar Vuković

Univerzitet u Beogradu  
Elektrotehnički fakultet

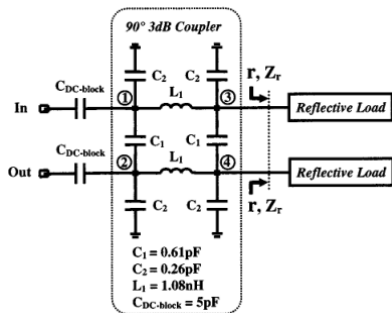
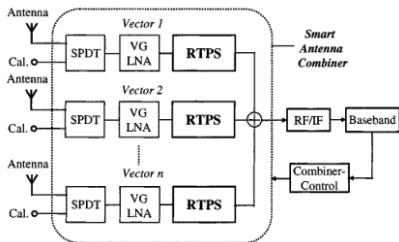
22. 7. 2019.

# Uvod

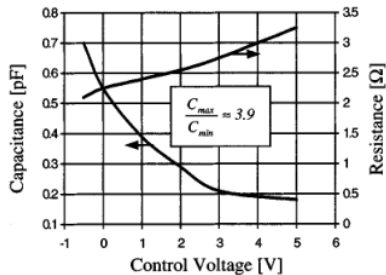
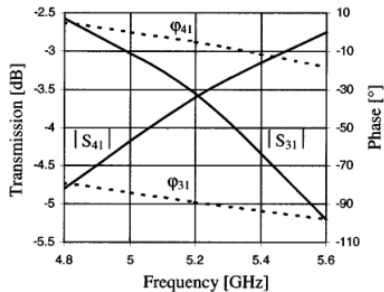
## Sadržaj prezentacije

- ▶ Pomerač faze reflektivnog tipa sa  $360^\circ$  opsegom za *smart* antenske sisteme za C-opseg u  $0.6\ \mu\text{m}$  GaAs MESFET tehnologiji (2002)
- ▶ 16-elementni fazirani niz kao prijemnik za opseg oko 60 GHz u IBM  $0.12\ \mu\text{m}$  SiGe BiCMOS tehnologiji (2011)
- ▶ Pomerač faze reflektivnog tipa sa konstantnim gubicima za oko 24 GHz u  $0.18\ \mu\text{m}$  CMOS tehnologiji (2015)

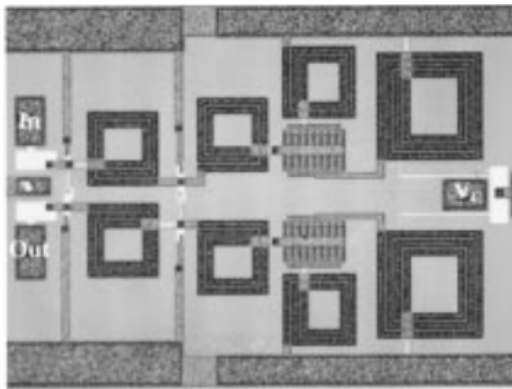
# Prijemnik i hibridni sprežnjak



# S parametri

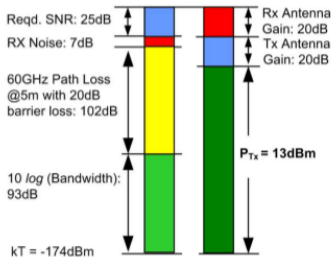
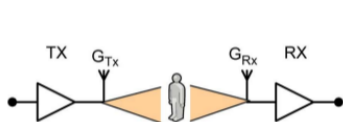


# Lejaut prijemnika

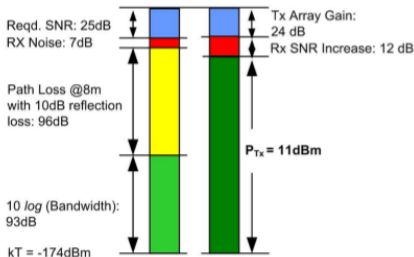
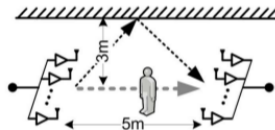


učestanost	5.15 GHz - 5.7 GHz
opseg faznog pomeraja	90° / 360°
gubici	-3.2 dB / -9 dB
varijacija gubitaka	/
S11	/
potrošnja	0
površina na čipu	0.9 mm <sup>2</sup>

# Poređenje bežičnih linkova antenskog elementa i antenskog niza

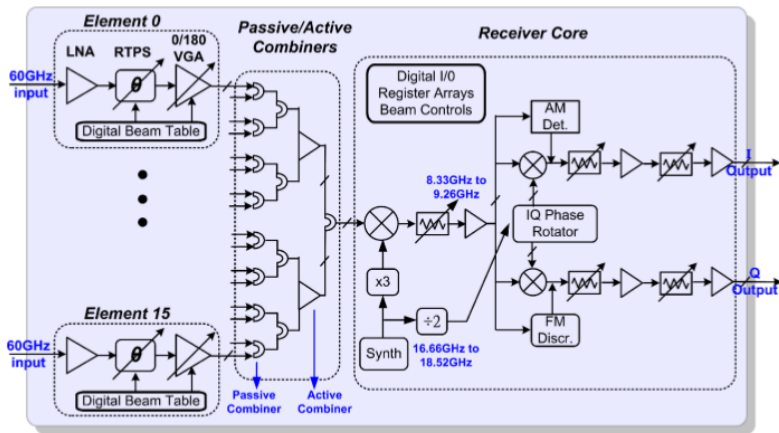


Single-element with high-gain antenna



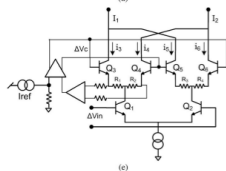
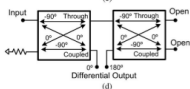
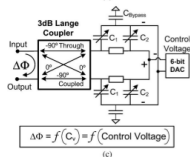
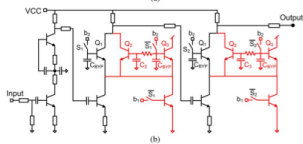
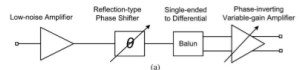
Phased-array Rx and Tx – using reflectors to establish wireless link

# Arhitektura prijemnika



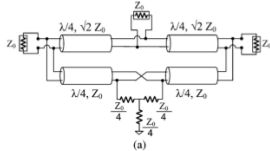


# Arhitektura prijemnika

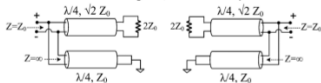


- ▶ a - RF front end
- ▶ b - LNA
- ▶ c - RTPS
- ▶ d - Lange- Lange BALUN
- ▶ e - PIVGA

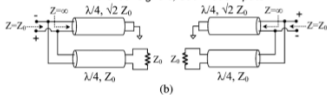
# Gysel kombajner



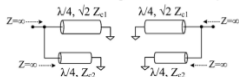
Differential signals, even mode inputs



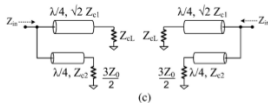
Differential signals, odd mode inputs



Common-mode signals, odd mode inputs

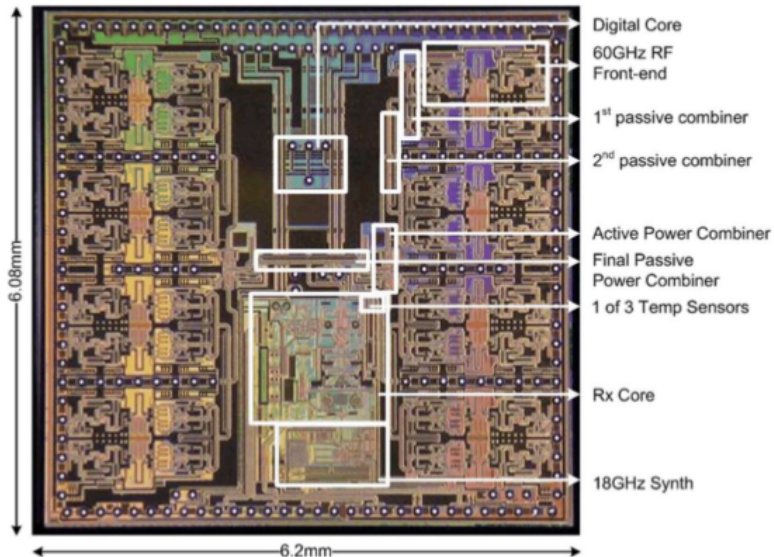


Common-mode signals, even mode inputs



- ▶ a - RF front end
- ▶ b
- ▶ c
- ▶ d

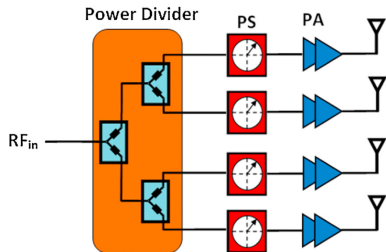
# Lejaut prijemnika fazirani niz



# Pregled rezultata

učestanost	57.2 - 65.9 GHz
opseg faznog pomeraja	360°

# Beamforming predajnik



Specifikacije:

- ▶ varijacija slabljenja u odnosu na fazni pomeraj
- ▶ potrošnja

# Hibridni sprežnjak

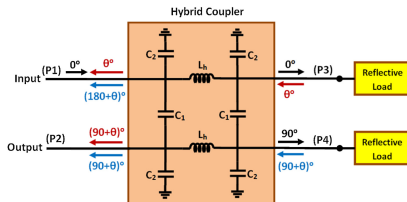
$$\Delta\phi = 2[\tan^{-1}(\frac{Z_{max}}{Z_0}) - \tan^{-1}(\frac{Z_{min}}{Z_0})]$$

Vrednosti "lumped" elemenata:

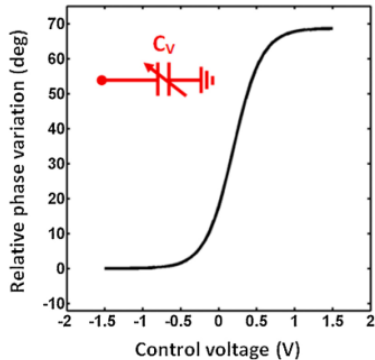
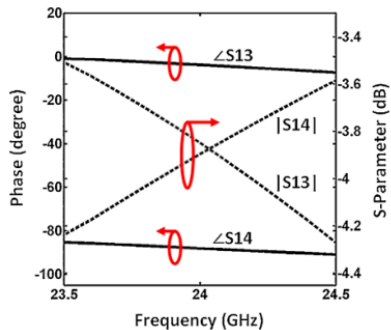
$$L_h = \frac{Z_0}{\sqrt{2}\omega_0}$$

$$C_1 = \frac{1}{\omega_0 Z_0}$$

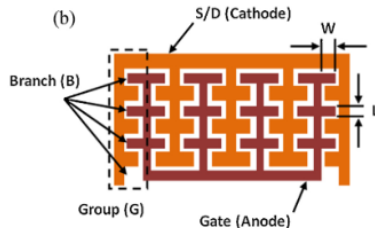
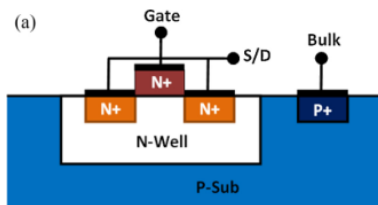
$$C_2 = \frac{1}{\omega_0^2 L_h} - C_1$$



# Rezultati simulacija



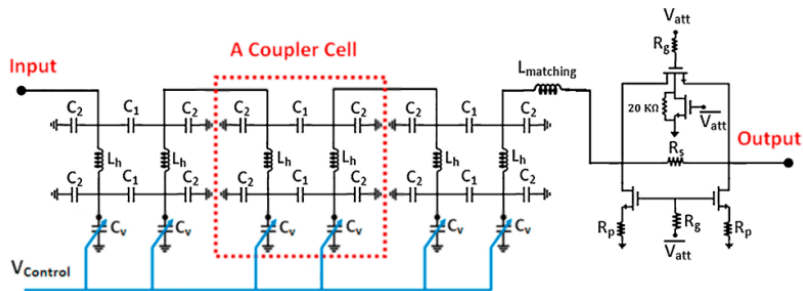
# AMOS varaktor



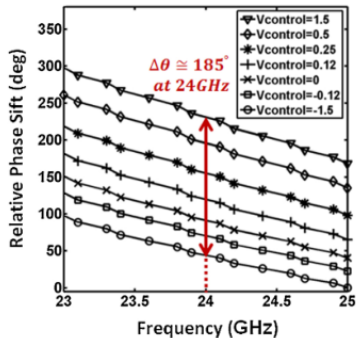
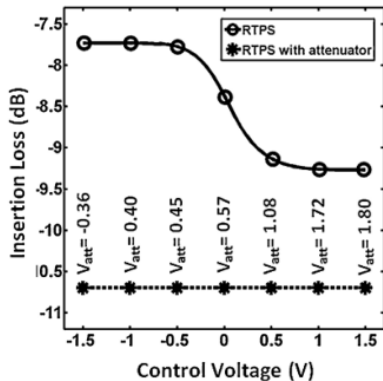
Varaktor ima opseg za podešavanje of 80 fF do 240 fF, sa prosečnom parazitnom otpornošću od  $1.5 \Omega$  i prosečnom parazitnom kapacitivnošću 8 pH.



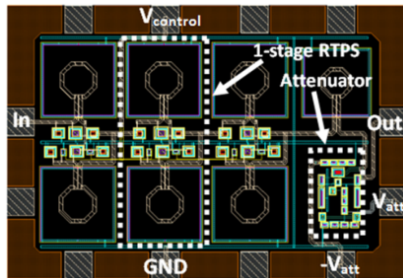
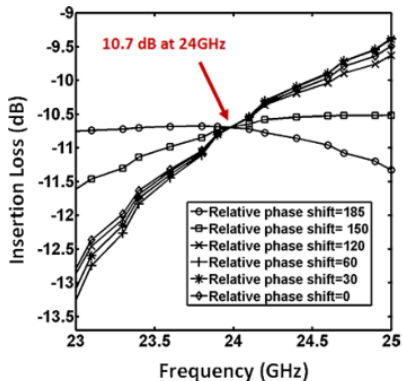
# Shema sprežnjaka i atenuatora



# Rezultati simulacija



# Rezultati simulacija i ležaut



## Pregled rezultata

učestanost	24 GHz
opseg faznog pomeraja	185°
maksimalni gubici	10.7 dB
varijacija gubitaka	0
S11	< 15 dB
potrošnja	0
površina na čipu	0.7 mm <sup>2</sup>

# Dodatno čitanje I



F. Ellinger, R. Vogt, and W. Bachtold.

Ultra compact reflective type phase shifter MMIC at C-band with 360° phase control range for smart antenna combining  
*IEEE J. Solid-State Circuits*, vol. 37, no. 4, pp. 481–486, Apr. 2002.



A. Natarajan, S. Reynolds, M. Tsai, S. Nicolson, J. Zhan, D. Kam, D. Liu, Y. Huang, A. Valdes-Garcia, and B. Floyd.

Fully-Integrated 16-Element Phased-Array Receiver in SiGe BiCMOS for 60-GHz Communications  
*IEEE Journal of Solid-State Circuits*, vol. 46, no. 5, May. 2011.



M. Askari, H. Kaabi, Y. S. Kavian.

A 24 GHz reflective-type phase shifter with constant loss in 0.18  $\mu\text{m}$  CMOS technology  
*AEU - International Journal of Electronics and Communications* 69:1134-1142, May. 2015.