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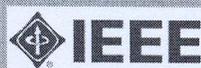
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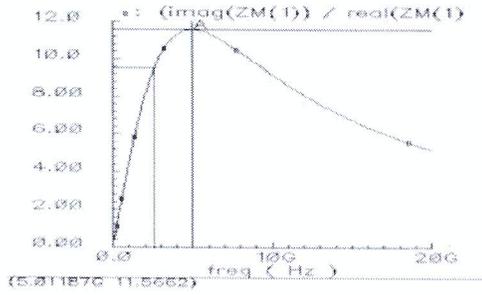


Fig. 4. Q factor as a function of frequency of inductor SP011S200T.

Colpitts VCO's core transistor  $M1$  is represented by 4 parallel connected "modnrf" NMOS transistors. The capacitance of  $C3$  and  $C4$  is formed by 16 parallel connected "cpolyrf" capacitors with values equal to 1 pF.

TABLE 1. THE VALUES OF INDUCTOR, FEEDBACK CAPACITORS, AND CORE TRANSISTOR SIZE OF COLPITTS VCO CORE

VCO core	L [nH]	C1 [fF]	C2 [fF]	C3=C4 [pF]	M1-W/L [ $\mu\text{m}$ ]
	1.1	18x330	16x330	16x1	4x(200/0.35)

The schematic of buffer topology is shown in Fig. 5. The output of Colpitts VCO is the drain voltage of transistor  $M1$  ( $V_{DM1}$ ), which is connected to input ( $Buffer\_in$ ) of the buffer stage. Block circuit of Colpitts VCO and buffer simulated with Cadence is shown in Fig. 6.

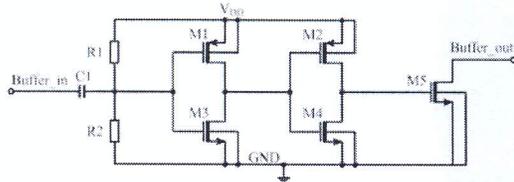


Fig. 5. Schematic of buffer.

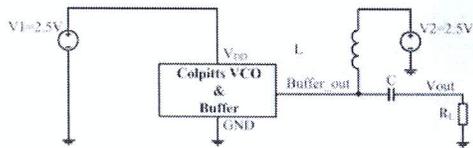


Fig. 6. Simulated Colpitts VCO and buffer block circuit.

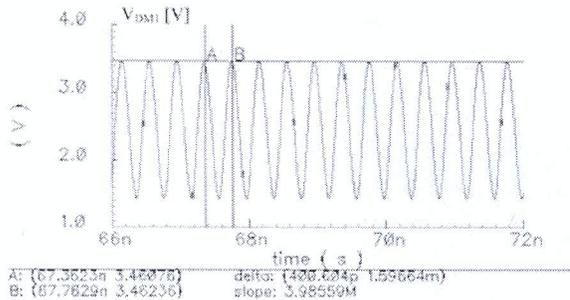


Fig. 7. Drain voltage waveform of transistor  $M1$   $V_{DM1}$ .

The value of load resistor  $R_L$  of the block circuit shown in Fig. 6, is equal to 50  $\Omega$ . Simulated waveforms of output voltage of Colpitts VCO ( $V_{DM1}$ ) are presented in Fig. 7 and Fig. 8.

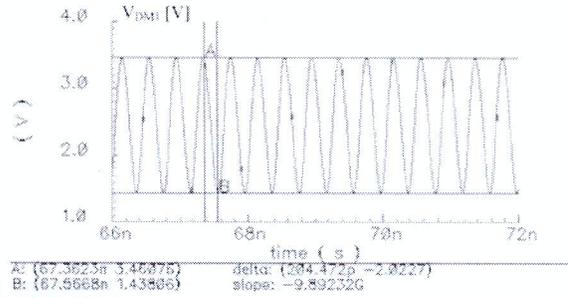


Fig. 8. The peak-to-peak voltage of  $V_{DM1}$ .

As can be seen from Fig. 7 the frequency of Colpitts VCO core's output voltage is equal 2.5 GHz. The peak-to-peak voltage of  $V_{DM1(p-p)}$  equal to 2.02 V could be seen in Fig. 8. The simulated waveforms of output voltage  $V_{out}$  of designed Colpitts VCO and buffer block circuit, shown in Fig. 6, are presented in Fig. 9 and Fig. 10.

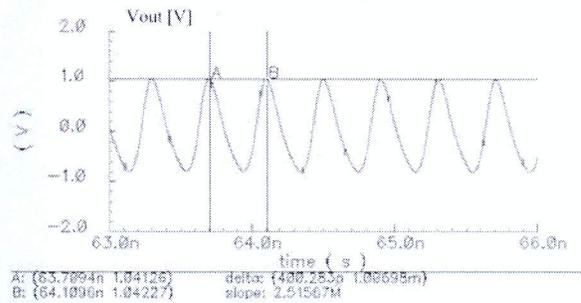


Fig. 9. The simulated waveform of output voltage  $V_{out}$ .

As can be seen respectively from Fig. 9 and Fig. 10 frequency of oscillation  $f_o$  of Colpitts VCO is equal to 2.5 GHz, while output peak-to-peak voltage  $V_{out(p-p)}$  is equal to 1.83 V.

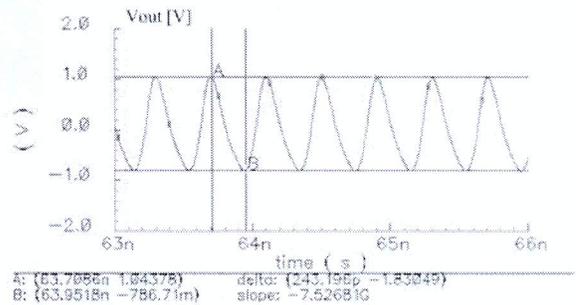


Fig. 10. The peak-to-peak voltage of  $V_{out}$ .

The drain current waveform of core transistor  $M1$  ( $I_{DM1}$ ) is shown in Fig. 11.

TABLE 2. THE MAIN PARAMETERS OF COLPITTS VCO

Colpitts VCO	$f_o$ [GHz]	$V_{DM1(p-p)}$ [V]	$V_{out(p-p)}$ [V]	$I_{DM1(p-p)}$ [mA]
	2.5	2.02	1.83	45.23

The value of peak-to-peak current  $I_{DM1(p-p)}$  is equal to 45.23 mA. The main obtained parameters of the designed Colpitts VCO are summarized in Table. 2.

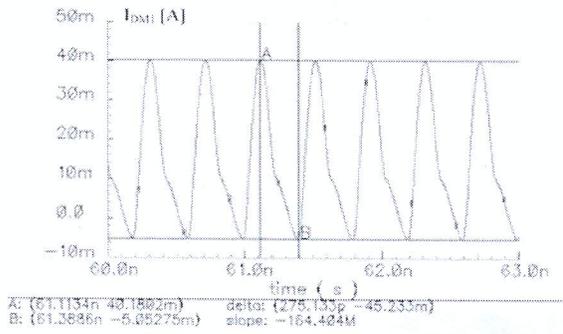


Fig. 11. The waveform of drain current of transistor M1 ( $I_{DM1}$ ).

**B. Phase noise and frequency tuning of designed Colpitts VCO**

The phase noise of the oscillators degrades the dynamic range of the receivers [7]. If voltage controlled oscillators have low phase noise, the signal-to-noise ratio of the desired signal can be improved. According to the theory the phase noise can be expressed by [7]:

$$L_{total} \{ \Delta\omega \} = 10 \cdot \log \left[ \frac{P_{sideband} (\omega_0 + \Delta\omega, 1Hz)}{P_{carrier}} \right], \quad (2)$$

where  $P_{sideband}$  is the single sideband power at the frequency offset  $\Delta\omega$  from the carrier with a measurement bandwidth of 1 Hz.  $P_{carrier}$  is the total power under power spectrum. The obtained phase noise characteristic of the Colpitts VCO is shown in Fig. 12.

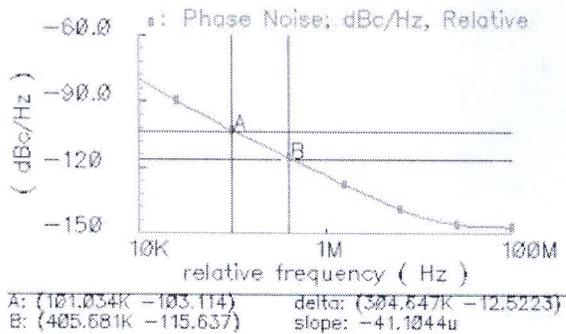


Fig. 12. Phase noise characteristic of designed Colpitts VCO.

The simulated phase noise is equal to -103 dBc/Hz at a 100 kHz offset from 2.5 GHz carrier when Colpitts VCO drawing 20 mA current from a 2.5 V power supply.

TABLE 3. PHASE NOISE OF COLPITTS VCO

Colpitts VCO	Phase Noise @ 100kHz [dBc/Hz]	Phase Noise @ 400kHz [dBc/Hz]
	-103	-115.6

The phase noise at a 400 kHz offset from 2.5 GHz carrier is equal to -115.6 dBc/Hz. The obtained phase noise results of the designed Colpitts VCO are summarized in Table. 3.

The frequency tuning of the investigated Colpitts VCO is performed using MOS varicap “cvar”, available in the library *PRIMLIB* of the AMS 0.35  $\mu\text{m}$  technology. This voltage controlled capacitance component is connected in parallel with capacitor  $C1$  of the VCO core shown in Fig. 3. The schematic of Colpitts VCO core with varicap is illustrated in Fig. 13.

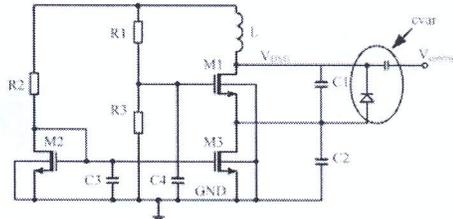


Fig. 13. Schematic of Colpitts VCO core with varicap.

The frequency of oscillation  $f_o$  of the investigated Colpitts VCO as function of control voltage  $V_{control}$  applied to varicap “cvar” is investigated. The obtained results are presented in Table 4.

TABLE 4. FREQUENCY OF OSCILLATION OF COLPITTS VCO AS FUNCTION VCONTROL

$V_{control}$ [V]	Colpitts VCO $f_o$ [GHz]
0	2.5
0.5	2.4
1	2.35
1.5	2.34
2	2.31
2.5	2.2

The dependence of  $f_o$  as function of control voltage  $V_{control}$  is graphically presented in Fig. 14.

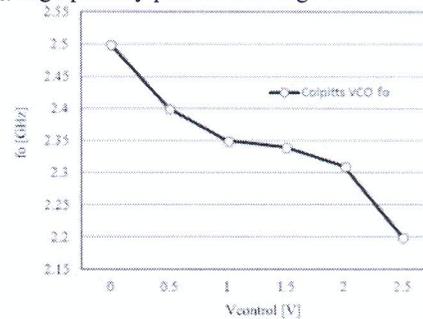


Fig. 14. Frequency of oscillation  $f_o$  of Colpitts VCO as function of control voltage  $V_{control}$ .

The received simulation results show that  $f_o$  of Colpitts VCO can be adjusted from 2.5 GHz to 2.2 GHz, when the control voltage  $V_{control}$  is changed from 0 V to 2.5 V. The simulated waveform of the voltage  $V_{DM1}$ , when  $V_{control}$  is equal to 2.5 V, is presented in Fig. 15. In this particular

case frequency of oscillation  $f_o$  of Colpitts VCO is equal to 2.2 V.

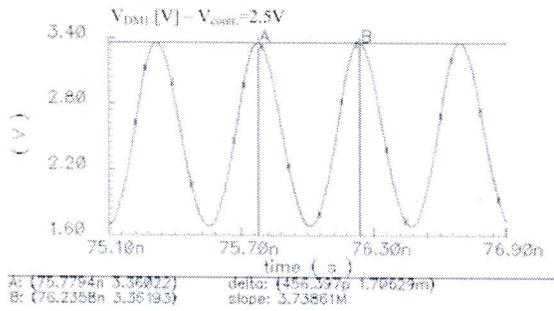


Fig. 15. The waveform of  $V_{DM1}$  when  $V_{control}$  is equal to 2.5 V.

The layout of Colpitts VCO, designed on AMS SiGe BiCMOS 0.35  $\mu\text{m}$  technology, is presented on Fig. 16.

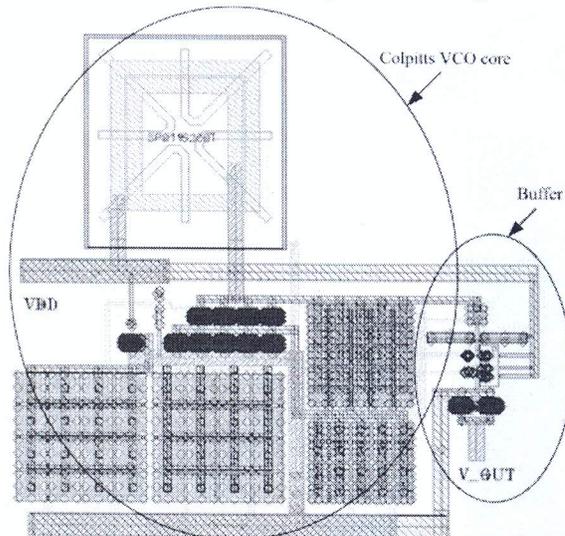


Fig. 16. The layout of Colpitts VCO designed on SiGe BiCMOS 0.35  $\mu\text{m}$  technology.

The occupied silicon area of Colpitts VCO and buffer designed on AMS SiGe BiCMOS 0.35  $\mu\text{m}$  technology is 0.73x0.69  $\text{mm}^2$ .

### III. CONCLUSION

In this paper is presented Colpitts VCO designed on 0.35  $\mu\text{m}$  technology. The phase noise of the investigated circuit is equal to -103 dBc/Hz at a 100 kHz offset and -115.6 dBc/Hz at a 400 kHz offset from 2.5 GHz carrier frequency. The frequency of oscillation  $f_o$  of Colpitts VCO can be adjusted from 2.2 GHz to 2.5 GHz, when the control voltage  $V_{control}$  is changed in the range between 2.5 V and 0 V. The obtained results show that Colpitts VCO can be used for wireless communication applications.

### ACKNOWLEDGEMENT

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