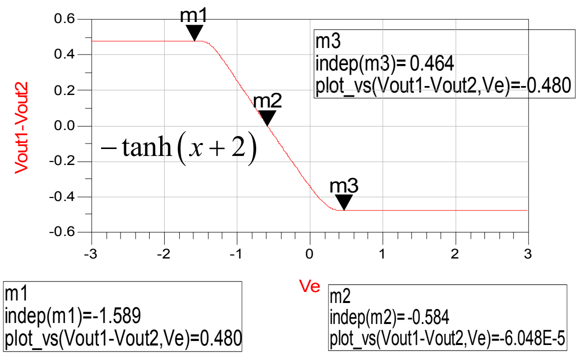


Fig.7 The voltage transfer curves, which corresponds to-tanh($x$+1), +tanh($x$-2), +tanh($x$+5) and -tanh($x$+2)

Referring to the curves of figure 7, the voltage limits $V_{emin}$ and $V_{emax}$ are determined. The maximum and minimum value of each voltage transfer curve and offset voltage $V_{Offset}$, correspond to those theoretically calculated.

The four voltage transfer curves and their sum are shown in figure 8.

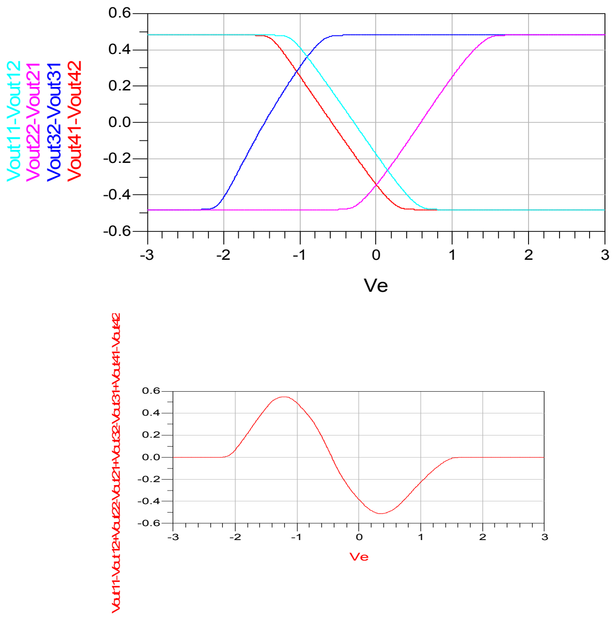


Fig.8 Sum of the four voltage transfer curves

We note from figure 8, the sum of four voltage transfer curves, which correspond to -tanh($x$+1), +tanh($x$-2), +tanh($x$+5) and -tanh($x$+2) are approximated to a Gaussian monocycle pulse.

### 3.2.5 Temporal Study of NMOS Transistors Differential Pairs

The temporal study of a NMOS transistors differential pair is obtained by applying to the input a rectangular voltage of 5V amplitude and 400MHz frequency.

The temporal response of four differential pairs of the figure 9 corresponding to -tanh($x$+1), +tanh($x$-2), +tanh($x$+5) and -tanh($x$+2) are obtained by choosing the voltage $V_2 = V_{Offset}$ of table 2.

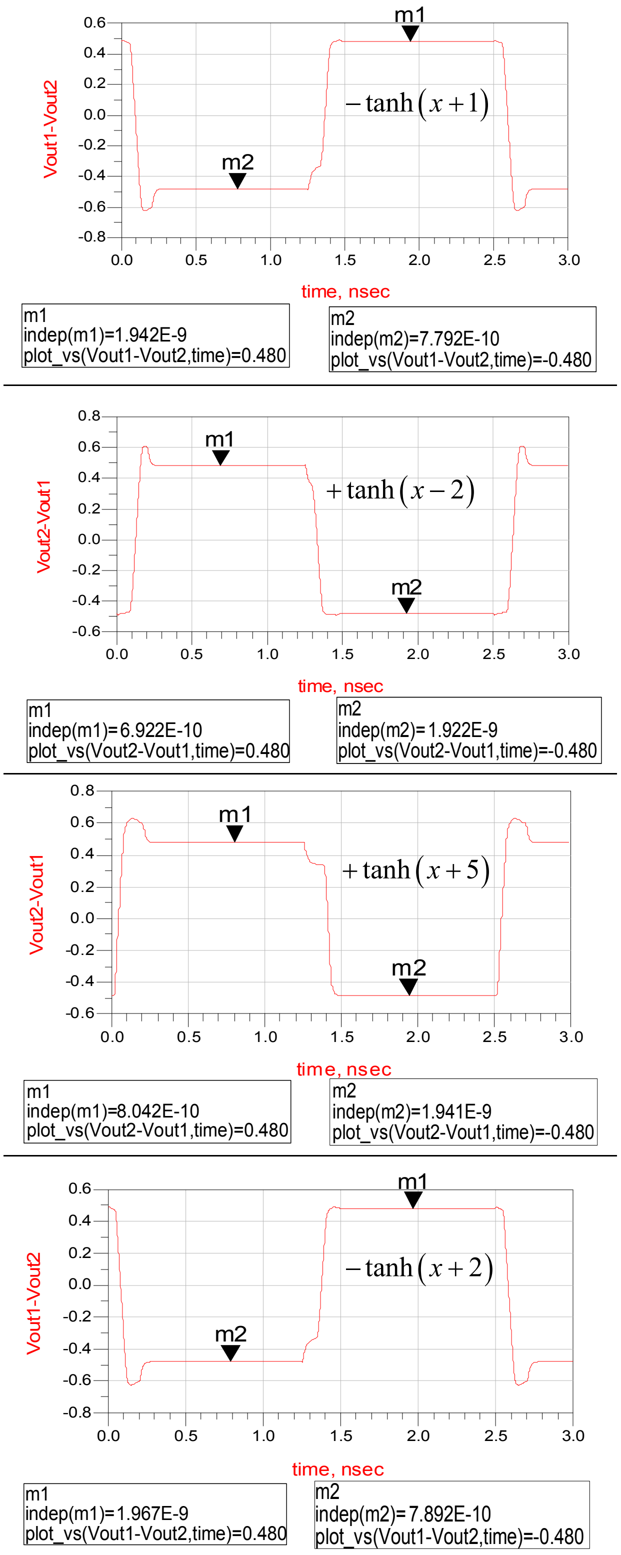


Fig.9 Temporal response of four differential pairs

According to the curves of figure 9, we note that the temporal response of four NMOS transistors differential pairs saturate the values theoretically calculated $V_{o\,min}$ = -0.480 V and $V_{o\,max}$ = 0.480 V.

### 3.2.6 Simulations of the Monocycle Pulse Generator

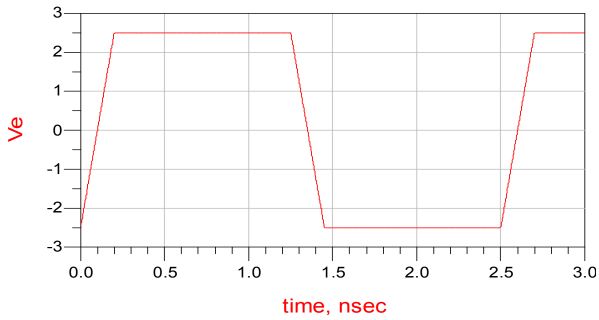
The monocycle pulse generator in figure 5 is formed by the parallel association of four NMOS transistors differential pairs that are already studied and it is powered to its input by a rectangular voltage generator of frequency 400 MHz which represents the repetition frequency of the series of Gaussian monocycle pulse. Thus, the curves below show the simulation results obtained with the circuit of figure 5 using the software ADS (Advanced Design System). These results are obtained by using the transistor model AMS 0.35µm and the ideal components of the library ADS for the rectangular signal source and current sources.

- Temporal study

The temporal study of the monocycle pulse generator allows us to describe the characteristics of the pulses generated in amplitude and frequency terms.

After simulations on the optimization of various parameters of the polarization circuit, we took current sources of 2.4mA, a drains biasing of 2.5V and a rectangular source with amplitude about 5V peak to peak and rise time of the order 200 ps.

The monocycle pulse generator creates at its output a series of Gaussian monocycle pulse with frequency of 400 MHz, the results are mentioned in figure 10.



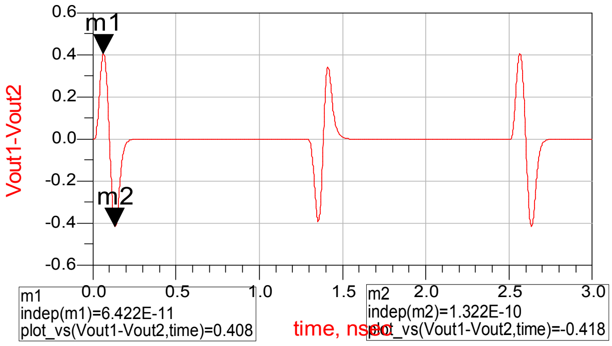


Fig.10 Simulations results of circuit monocycle pulse generator

The first curve in figure 10 represents the rectangular signal applied to the input circuit and the second curve represents the sequence of monocycles pulses generated. We note that pulses are triggered at each rising or falling front. We also note that monocycles pulses generated with rising fronts begin with the positive semi-cycle (what we call the pulse in phase). In contrast the monocycles pulses generated with falling fronts begin with the negative semi-cycle (what we call the pulse in opposition of phase). We then deduce that the sequence of pulses generated is consisted of the succession of pulses in phase and opposition of phase. However, these pulses have the same temporal width and almost the same magnitude as shown in figure 10.

A single Gaussian monocycle pulse is shown in figure 11:

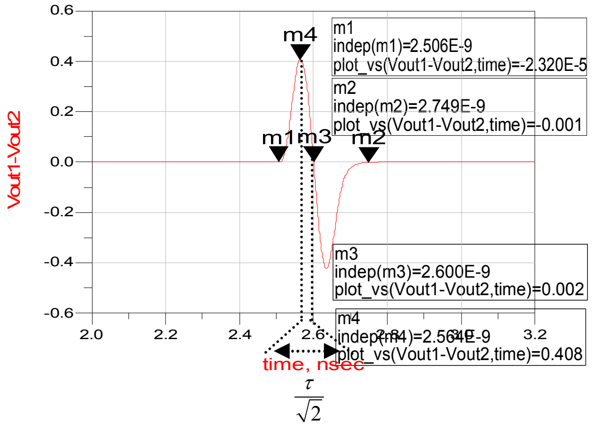


Fig.11 A single Gaussian monocycle pulse

According to figure 11, the period of the Gaussian monocycle pulse is $T_m = 0.243ns$, therefore the monocycle frequency is $f_{monocycle} = \frac{1}{T_m} = 4.115GHz$ corresponds to the theoretical frequency which is about $4.1GHz$.

The curve in figure 11 reached its maximum for $t = \frac{\tau}{\sqrt{2}} = 0.036ns$ [13], so the constant that allows to adjust the pulse width is $\tau = 0.0509ns$. The center frequency of the Gaussian monocycle pulse is $f_{c,monocycle} = \frac{1}{\pi\tau\sqrt{2}} = 4.421GHz$ [13].

- frequency study

The frequency study of the Gaussian monocycle pulse generator allows us to describe the characteristics of the pulses generated in terms of frequency band used and value of center frequency.

The Spectrum of a Gaussian monocycle pulse is shown in figure 12.

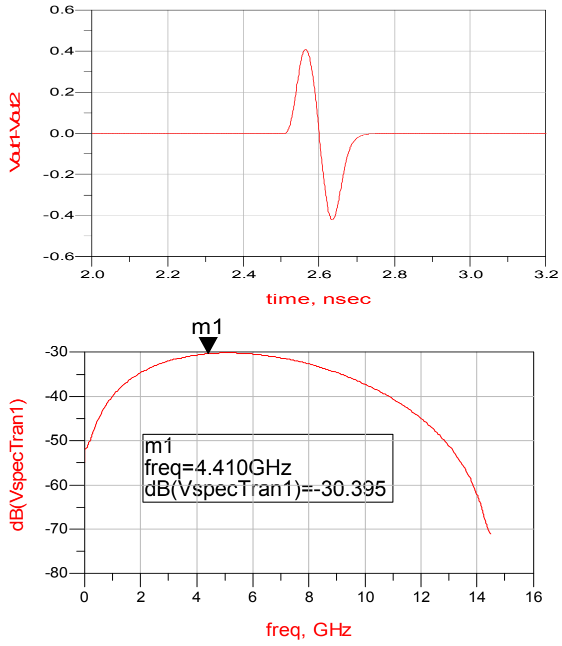


Fig.12 Spectrum of a Gaussian monocycle pulse

According to figure 12, the center frequency is $f_{c,monocycle} = 4.410GHz$ which corresponds to that obtained in the temporal study.

The Spectrum of a series of Gaussian monocycle pulses is shown in figure 13.

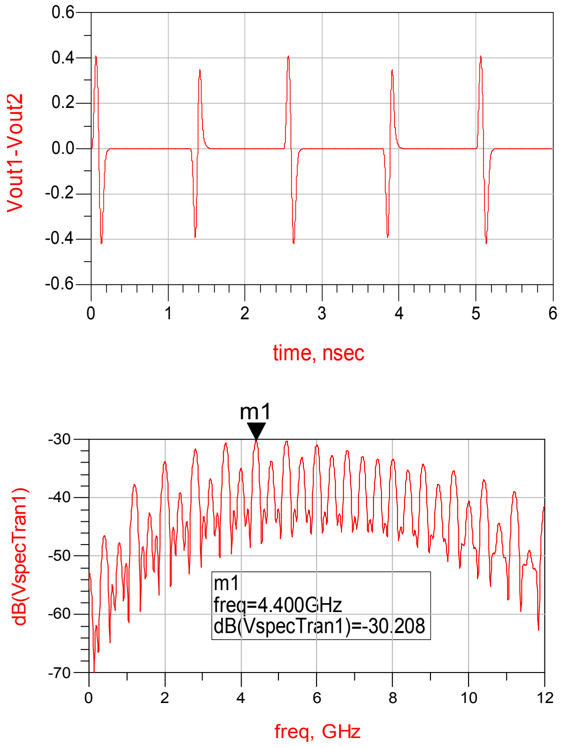


Fig.13 Spectrum of a series of Gaussian monocycle pulses

According to figure 13, the center frequency is $f_{c,monocycle} = 4.400GHz$ which corresponds to that obtained in the temporal study.

The frequency baseband of the Gaussian monocycle pulse must be selective to the band [3.1 - 5.1] GHz to respect the regulation constraints of the FCC.

## 4 Monocycle Pulse Generator Associated with a CMOS Ring Oscillator

The combination of a CMOS ring oscillator have the function of generation the rectangular signal, with a monocycle pulse generator represents the most important block of ultra wide band transceiver. This combination requires the addition of an adaptation circuit formed by a CMOS inverter represented in figure 14.

With $V_{2,1}$ = -0.292V, $V_{2,2}$ = 0.584V, $V_{2,3}$ = -1.46V, $V_{2,4}$ = -0.584V.

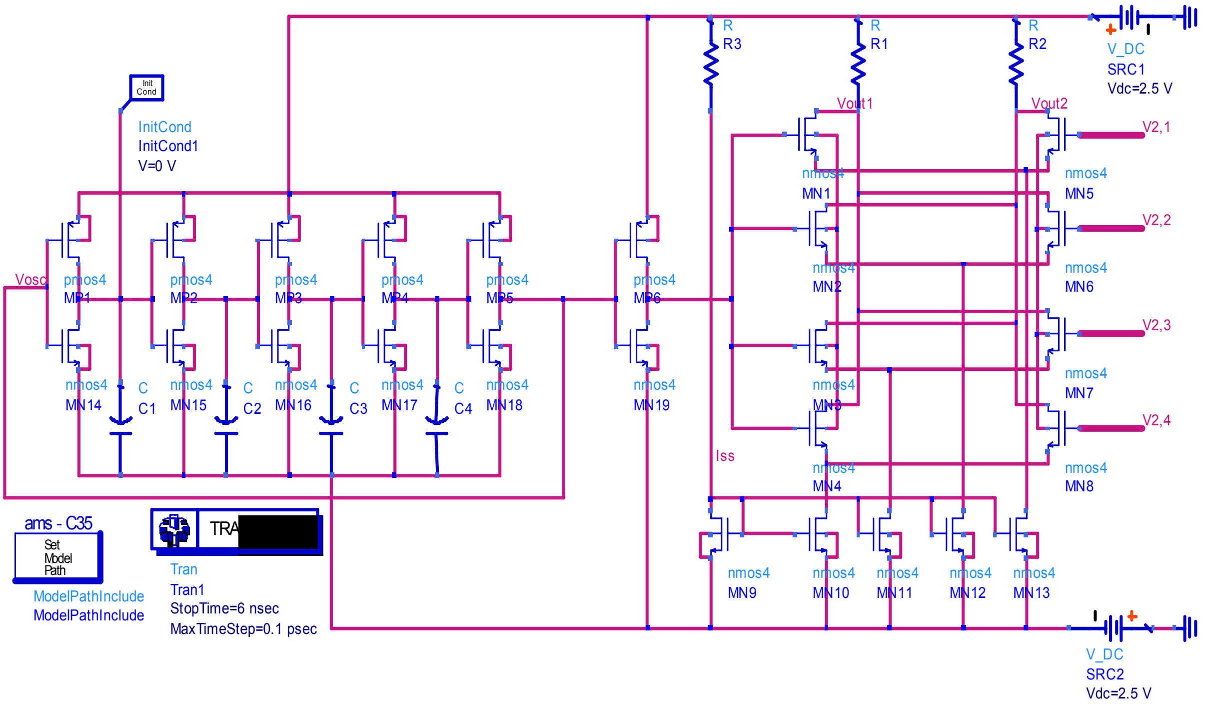


Fig.14 Monocycle pulse generator with a CMOS ring oscillator

The series of Gaussian monocycle pulses is shown in figure 15.

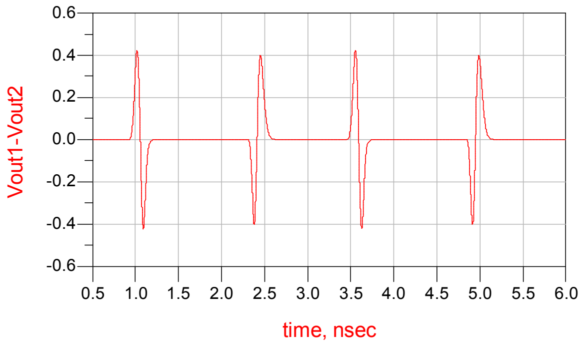


Fig.15 Series of Gaussian monocycle pulses

In figure 15 the generated Gaussian monocycle pulses are successively in phase and opposition of phase according to the transitions from the high and low levels of the rectangular signal and have amplitude of about 408 mV.

The comparison between theoretical and simulation results is given in Table 3.

Table 3: Comparison between theoretical and simulations performance characteristics of the monocycle pulse generator

| Voltage (V) / Hyperbolic tangent | $V_{e\ min}$ | $V_{e\ max}$ | $V_{o\ min}$ | $V_{o\ max}$ | $V_{Offset}$ | |
|---|---|---|---|---|---|---|
| -tanh($x$+1) | -1.332 | 0.748 | -0.480 | 0.480 | -0.292 | Theoretical results |
| +tanh($x$-2) | -0.456 | 1.624 | -0.480 | 0.480 | +0.584 | |
| +tanh($x$+5) | -2.5 | -0.420 | -0.480 | 0.480 | -1.46 | |
| -tanh($x$+2) | -1.624 | 0.456 | -0.480 | 0.480 | -0.584 | |
| -tanh($x$+1) | -1.332 | 0.763 | -0.480 | 0.480 | -0.292 | Simulation results |
| +tanh($x$-2) | -0.456 | 1.654 | -0.480 | 0.480 | +0.581 | |
| +tanh($x$+5) | -2.342 | -0.473 | -0.480 | 0.480 | -1.458 | |
| -tanh($x$+2) | -1.589 | 0.464 | -0.480 | 0.480 | -0.584 | |

# 5 Conclusion

So far we have studied the design of a new Gaussian monocycle pulse circuit, which presence is essential in a chain of communication ultra wide band. Equally, we have conducted a study of a CMOS ring oscillator whose role is to generate a rectangular signal characterized by its oscillation frequency and transition duration. Thus, we have studied and designed a monocycle pulses generator circuit in technology AMS 0.35µm. This circuit is based on exploitation of the transfer function of a MOS transistor differential pair, in total it contains four NMOS transistor differential pairs, and the important simulation results are presented. Finally, we have simulated the global architecture of monocycle pulse generator containing the designed generator circuit. The simulation results are satisfactory.

Future work: we will study and design a filter ultra wide band [3.1 - 5.1 GHz] whose role is to filter ultra short Gaussian monocycle pulses (244 ps) issued by the pulse generator circuit given in this article. It among a plan to join to the spectral mask defined by the American regulations.

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*Authors profile:*

**Mohamed Dhieb** was born in Sfax, Tunisia, on November 1978. He received the Electrical Engineering Degree from the National Engineering school of Sfax (ENIS)-Tunisia in 2004, the Electronic Master diploma from National Engineering school of Sfax (ENIS)-Tunisia, in 2005 and the Doctorate of Engineer in Electrical from National Engineering school of Sfax (ENIS)-Tunisia, in 2010.

Actually he is working toward the Ph.D. degree at Sfax University. In 2004, he joined the Team of Micro-Electronics and Medical Electronic, Laboratory of Electronics and Technology of Information (LETI), as a Research. His research interests are the techniques Radar for measurement without contact of the physiological parameters of the man.

**Mongi Lahiani** was born in Sfax, Tunisia, in 1957. He received the Electrical Engineering Degree from the University of Sciences and Techniques of Sfax-Tunisia in 1984 and the Doctorate of Engineer in Measurement and Instrumentation from University of Bordeaux1, France, in 1986.
Since 1988, he has been a Professor at Sfax University. He joined the Sfax National School of Engineering in 1990 and he is a Professor in the fields of analog electronics and microelectronics. His research interests are design of circuits in medical electronic and integration of microwave circuits of microstrips with screen-printed thick films technology.

**Hamadi Ghariani** was born in Sfax, Tunisia, on July 1956. He received the Electrical Engineering Degree from the "University of Sciences and Techniques of Sfax-Tunisia"in 1981, the "DEA" degree in 1981and his "Doctorate of engineer" in 1983 in "Measurement and Instrumentation" from the "University of Bordeaux France". He joined the National Engineering School of Sfax since 1984. Actually he is a Professor in the same School. His research activities have been devoted to several topics: Medical Electronic; Communication systems for Medical Telemetry, Measure and Instrumentation.