ANNALS of Faculty Engineering Hunedoara
– International Journal of Engineering
Tome XIV [2016] – Fascicule 3 [August]
ISSN: 1584-2665 [print; online]
ISSN: 1584-2673 [CD-Rom; online]
a free-accessmultidisciplinarypublication
of the Faculty of Engineering Hunedoara

[1.]Tihomir LATINOVIC, [2.]Savo KALABIC,
[3.]Cristian BARZ, [4.]Paul Petrica POP, [5.]Adina POP VADEAN

PREVENTIVE COLLISION NEURAL NETWORK SENSING SYSTEM WITH OPTIMIZATION OF PROCESSING RADAR SYSTEM FOR THE PROTECTION OF CAR CRASH

[1.] Faculty of Mechanical Engineering, University of Banja Luka, BOSNIA & HERZEGOVINA
[2.] High School Prometej, BOSNIA & HERZEGOVINA
[3-5.] Technical University of Cluj-Napoca, Center University of North from Baia-Mare, Department of Electrical Engineering Electronics and Computers, ROMANIA

ABSTRACT: This paper describes one of the solutions RF oscillator radar to protect the car from collisions, which belong to the class of car radars that are very precisely defined norms and standards of work. This decision is based on the voltage controlled oscillator, which provides RF signal EM frequencies of the permitted range (23.6-25.6 GHz) and strength in the ISM band to 20 dBm with allowed elevation angle required signal / noise ratio of the receiving signal and angular resolution. Solution oscillator where simulated on a PC. A relatively narrow beam of either RF or optical electromagnetic radiation is scanned over a relatively wide azimuthal range. The return signal is processed to detect the range and velocity of each point of reflection. The idea that a lower false alarm rate might be achieved by a better form of signal processing that had been used to detect imminent crashes in earlier studies. Since many different heuristic strategies had all been tried without success, a radically different approach was thought to be needed. Recently, neural networks have received much acclaim for their ability to learn functional relations between two sets based on a sample data set. Such a device seemed like a solution to lower the high false alarm rate and perceive complex relationships between sensor data and collision prediction.

Keywords: RF oscillator radar, alarm, sensor data, collision prediction

---

1. INTRODUCTION

Modern cars use different types of automotive radar for protecting cars, avoiding collisions of cars and avoiding certain obstacles on the road. The installation and use of automotive radar are precisely defined with international standards and norms [1], [2].

To avoid collisions in the column of vehicles on the basis of data obtained from radar sensors on 150 m range, system ACC (Active Cruise Control) [8] calculates the best distance from the vehicle in front, takes into account the direction of the line, the vehicle speed, the next activity of the driver and optimize these parameters. Thus, the ACC system controls engine torque and braking system of the engine. It controls the vehicle speed, acceleration, and deceleration of the vehicle, and monitors the speed of the vehicle ahead. ACC system included in the vehicle is operated by a switch Cruise Control, and using the accelerator pedal automatically turns off ACC when the driver decided.

By raising your legs with the accelerator pedal, the ACC system performance on automatically. The minimum possible distance between vehicles can be adjusted as desired to control panel ACC, which is defined in the standard [1] and [2] and is typically 50 m.

The radar sensors are used for monitoring the motorcyclists, cyclists and pedestrians as traffic participants behind and to the side of the vehicle, which distance is measured based on reflected signals weaker power and frequency of 24 GHz, which is processed in a central computer ACC system. Based on these reflected signals computer calculates the distance and relative speed of these participants. If, however, these objects are behind the vehicle to the sides, the information will be displayed as symbols in the outside mirrors. The system has a sound signal if the vehicle is due to turn closer to the said or similar group of road users. Therefore, this system has a numeric, image (light) and sound signal.

In order to avoid non-coverage of all parts on the vehicle, radar sensors are installed at the front and rear of the vehicle, as well as on its sides, which is why the price of sensors must be very low.

To all participants: the traffic was protected from excessive radiation radar, as well as EMW would not impede the work of other systems, which operate on the principle of propagation EMW,

The theme of this paper is optimization of radar sensors in terms of meeting the criteria set standards in terms of power, frequency, range and price. In principle radar sensor is based on the high-frequency oscillator, which must meet one of the fundamental constraints that give VF EM signal frequencies from the permitted range (23.6 GHz -25.6 GHz) and the effective radiated power radar (ERPR) in the ISM band to 20 dBm. Standards are limited and radiation pattern of the radar antenna in terms of the permitted angle of elevation required signal / noise ratio of the receiving signal and angular resolution.

Signal / Noise ratio received signal and the angular resolution of the radar significantly increase a magnification orientation of the antenna, which is limited by the standards ERPR limits permitted transmitting power EMW radar. These limits allow the implementation of low-power radar.

On the other hand, prices of automotive radar must be at the level of a few tens of euros. For the above reason, the components used must be of low cost and suitable for installation, for very expensive and quite large an exterior shape of high-frequency oscillators based on the magnetron, klystron, and TWT tubes, used in standard applications radars in radiolocation and radio navigation [10].

Another way is to use components that are already in mass production and whose price is very low. The paper presents one solution generator HF radar signal permissible power and frequency based on a simple voltage controlled oscillator (VCO), which can be realized based on FET transistors, which are used in satellite television and which can be found in the market at very low prices.

2. REALIZATION VOLTAGE CONTROLLED THE OSCILLATOR (VCO)

In some ELN systems, it is necessary that the oscillation frequency of the oscillator is changed in the certain range of frequencies around some resonant frequency to change the control voltage, which is usually slow changeable unidirectional voltage. Thus, the frequency of the voltage controlled oscillator, we controlled the change of action DC voltage to the corresponding element of the resonator. It has extensive application in phase loops. Changing the frequency of the oscillator can be achieved by using the varicap diode, which is used as an integral part of the resonator.

VCO with varicap typically used at frequencies of order 1GHz. At a higher microwave range used conceptually and structurally different voltage-controlled oscillators. For frequencies up to 50GHz using the YIG (Yttrium Iron Garnet) oscillators, and for frequency greater than 50GHz used oscillators based Ganove diodes. Today there are VCO in which the varicap implemented in the appropriate integrated circuit.

The most suitable for this application are oscillators in which the parameter changes in resonant oscillation round impair the necessary conditions for sustaining oscillations. Usually, the oscillation frequency is adjusted variable capacitance, which is most suitable for these purpose oscillators with choke output and input circuits.

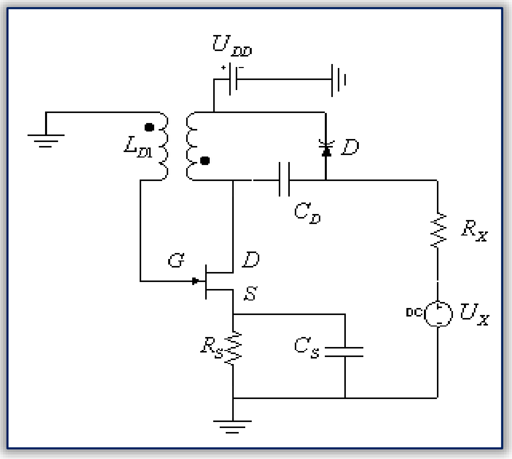

Figure 1. Scheme voltage controlled LC oscillator

Let as in Figure 1 at oscillator in which the capacitance of the resonant oscillation of the reverse-biased diode replaced D.

According to the scheme diode is reverse-biased voltage:

$$U_D = U_R = U_{DD} - U_x$$

U_x -Driver unidirectional voltage.

If it is $U_{izl} << U_{DD} - U_x$, then the capacitance of the inversely polarized diodes approximately constant for a given voltage inverse polarization. Bearing in mind that the PN junction capacitance depends on the voltage polarization to the change voltage polarization, the amount of which can be influenced by changing the DC voltage U_x as a control voltage, leading to changes in the oscillation frequency of the oscillator.

Diodes that are used in such oscillators must have high sensitivity capacitance with changing the voltage polarization, known as varicap Diode (variable capacitance), where the capacity is defined by the following general expression for the capacity of the PN-junction:

$$C_j = \left[\frac{\varepsilon q}{2} \cdot \frac{N_A N_D}{N_A + N_D}\right]^{1/2} S\left[U_K + U_R\right]^{-1/2} \tag{1}$$

To obtain undamped oscillations, it is necessary that the connection between LED and generator U_x effected by means of high resistance R_x. In the case of small amount of resistance, R_x May comes to a standstill and oscillation of the oscillator.

By using the Poisson equation in the transitional area of asymmetric PN junction ($N_D < N_A$ or $N_D > N_A$), where the width of the depleted areas of the P-count is greater than the N-side, we obtain an expression for the total width of the transition area in the thermodynamic equilibrium, by which we come to the expression for the capacity of depleted areas:

$$\frac{d^2\Phi}{dx^2} = -\frac{d\Phi}{dx} = -\frac{qN_D}{\varepsilon}, 0 \le x \le x_n \tag{2}$$

$$\frac{d^2\Phi}{dx^2} = -\frac{d\Phi}{dx} = -\frac{qN_A}{\varepsilon}, -x_p \le x \le 0 \tag{3}$$

$$C_j = \left[\frac{\varepsilon q}{2} \cdot \frac{N_A N_D}{N_A + N_D}\right]^{1/2} S\left[U_K + U_R\right]^{-1/2} \tag{4}$$

This equitation gives dependence capacity PN-junction of the concentration of impurities (donors N_D acceptor N_A) and inverse polarization voltage U_R PN-junction (diode). Capacity impoverished areas increase with increasing concentration of impurities on both sides of the PN-junction and to reduce the voltage of inverse polarization U_R, where there is a non-linear relationship between the voltage U_R and capacity C_j. The capacity of areas inverses polarized PN junction is very small amounts and ranges typically of the order pF or less.

Thus, the capacity of a PN junction, and thus the capacity capacitive diode decreases with increasing voltage reversal of polarization U_R because with the increase in that voltage comes to the spread of depleted areas, or to increase the distance between the PN junctions. This property of the PN - a compound used for the realization of the capacitive element or capacitance diode, which is used to create the HF oscillation depending on the change of polarization of inverse tension occurs. Normally, these diodes are performed as unbalanced PN-compounds, wherein the P-layer have a more conductive then N-layer ($N_D < N_A$) and the depleted area extends virtually to the N-side. Let the concentration of impurities in the n-layer, changing the distance x of PN-level according to law:

$$N_D(x) = B \cdot x^m \tag{5}$$

where are they B, m are constants.For $m = 0$ obtain a uniform distribution of the donor, and if the $m = 1$ a linear-donor gradual distribution of the N-side.

If it is $m < 0$, then $N_D(x)$ decreases with distance x and the so obtained. Hyper steep PN junction, by solving the Poisson equation for the distribution of donor according to (2.4), with inverse polarization voltage U_R, obtained capacity capacitance diode given by the following expression:

$$C_j = C_{j0}\left[1+\frac{U_R}{U_K}U_R\right]^{-S} \tag{6}$$

where is: U_K -contact potential, C_{j0} The capacity when $U_R = 0$

Exponent s is defined by: $s = \dfrac{1}{m+2}$

By selecting parameters s and m may provide the desired dependence of the capacitance of the voltage reversal U_R.

If capacitive diode applies instead of the capacitor capacitance as the oscillatory LC circuit, then the resonant frequency ω_r oscillatory circuit:

$$\omega_r = \frac{1}{\sqrt{LC_j}} = \omega_{r0}\left(1+\frac{U_R}{U_K}\right)^{\frac{s}{2}} \tag{7}$$

where is: U_K -contact voltage, ω_{r0} -resonant frequency oscillatory circuit in $U_R = 0$.

When is $s = 1$ or $m = -1{,}5$, it is a hipper steep PN junction, then the resonant frequency ω_r oscillatory circuit grows in the proportion to inverse voltage. These requirements provide a programmable phase epitaxy or ion implantation donors.

Technological process necessary to implement the capacitive diode with minimal serial resistance less conductive sides (N-hand), the leakage current through the PN junction and the surface of the silicon to the quality factor was the higher. For the practical application of capacitive diode, the ratio of the largest and smallest capacity should be as large as possible. In practice, usually achieved factor quality and about 20 range capacity of 6:1. Capacity range except factor m limited amount and breakdown voltage PN-junction.

Since the varicap relatively expensive to operate in the above-mentioned frequency range and since the oscillator should work in a narrow frequency range (23.6 GHz-25.6 GHz), the practice is perfect instead listed as a diode element with variable capacitance in microstrip technology used capacitance control electrode FET transistors, where the oscillator implemented in two Low-noise FET transistors.

3. ONE OF THE VCO REALIZATION THE MICROSTRIP TECHNOLOGY

The basic element that can be used for the realization of automotive radar sensor is a commercial low-noise transistor NE3210S01, which is used in the low-noise block in the receivers for reception of satellite television signals.[3] [4]

One of the realization of the VCO microstrip [5], is shown in Figure 2, which is arranged on the Teflon dielectric constant of 2.2 and a height of 0,254mm.

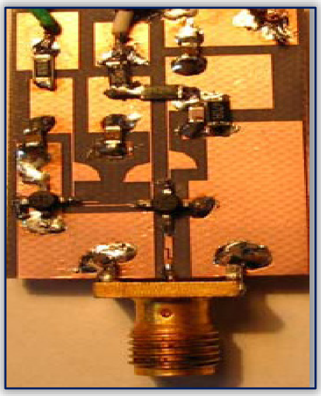

Figure 2. Only one of VCO implementation in microstrip

As capacitive elements in the microstrip used coupling between microstrip lines, which significantly reduces the price of this RF VCO oscillator, because the prices of the standard oscillator in the above-mentioned HF (23.6GHz-25.6 GHz) quite high, which would lead to price increases and the radar sensor as a whole. By changing the length microstrip lines can be set the scope of oscillation of the oscillator. With this approach, we can easily adjust the scope of operation of the oscillator.

As the element with variable capacitance, we are used capacitance control electrode of the second transistor to ground. Electrodes source and drain should be grounded. The dependence of the oscillation frequency voltage controlled oscillator based on the application of FET instead varicap with changing the voltage polarization of the gate in the range (0-1) [V], Shown in Figure 3.

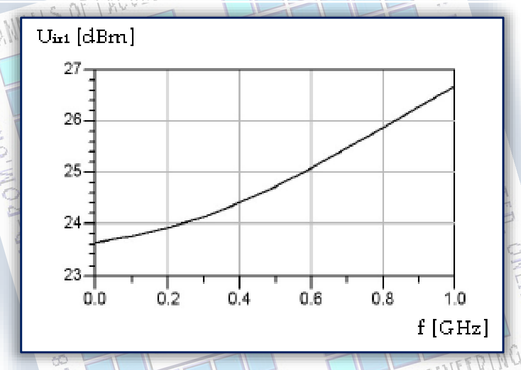

Figure 3. The range of the signal voltage controlled anoscillator for use in the frequency range (23.6 – 25.6 GHz)

4. NEURAL NETWORK-BASED SIGNAL PROCESSING [11]

Problems with the scanning radar approach lie in the necessity of the system to predict the traffic situation up to several seconds in advance. A large amount of lead-time is necessary for automatic braking or driver warning so that the car may adequately brake prior to the collision. To form this correlation between sensor data and collision outcome, a very large number of simulations of randomly selected traffic scenarios was run to form a database of sensor data sets and associated collision outcomes [9], sown on Figure 4.

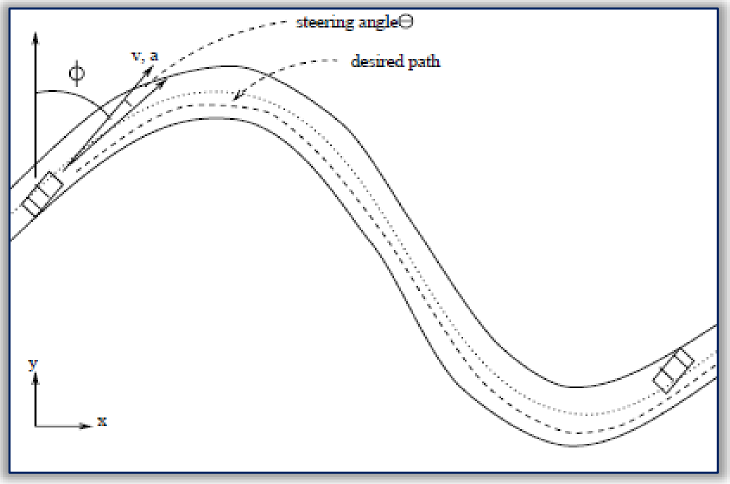

Figure 4. Traffic simulation scenario

On the Figure 4 we will see a traffic simulation scenario for this paper. One of the problem is how obtaining data with which to train the network. If we have a collision prediction problem, the physical process of data collection give us a large number of autos with a many sensor configuration.

This database was then used to train a feed-forward neural network using a backpropagation gradient descent algorithm [6] [7]. At the end of the network training, the correlation sought was contained in the gains and functions of the neural network, representing a functional relationship between the sensor outputs and the collision prediction. Evaluation of this correlation was accomplished by developing a second data base called an evaluation set by simulating a new set of randomly selected traffic scenarios and acquiring new sensor data set / collision outcome pairs. The already trained neural network was then tested against this data set to see how often it would correctly predict a collision, how often it would fail to predict a collision, and how often it would give a false alarm.

Collisions are detected in the same manner as sensor contacts. Four lines are drawn that define the edges of the test car Figure 5.

B.1. Case 1. Training condition: 1 obstacle vehicle and no roadside obstacles.
Vehicle speeds between 15 and 20 km/h
Evaluation conditions: 1 obstacle vehicle and no roadside obstacles. Vehicle speeds between 15 and 20 km/h range of roadside obstacles from roadside = 9-21 m.Sensors: 3 at -30°, 0°, and 30°, subtended angle = 4° for each and range = 9 – 21 m

Runs	Threshold	Collisions Occurred	Alarms Generated	Collisions Predicted	Warning interval
1000	0.60	71	24	17	0.132 sec
1000	0.40	68	27	22	0.168 sec
1000	0.20	62	19	15	0.153 sec
1000	0.00	52	42	29	0.190 sec
1000	-0.20	58	50	34	0.180 sec
1000	-0.40	87	92	53	0.259 sec
1000	-0.60	72	106	59	0.209 sec
1000	-0.80	53	175	46	0.377 sec

Figure 5. Training condition

5. CONCLUSION

The paper presents the analysis and optimization of parameters in accordance with the standards and regulations for automotive radar low power and one of the simple realization of the voltage controlled oscillator for power EM signal 20 dBm and a frequency of 24 GHz using commercial components satisfactorily low prices. Of course, that such a simple solution can only be used for radar sensors for smaller distances because of steep frequency characteristics that degrade phase noise.

The main accomplishment of this work was the development of a formal structure with which to study the concept of pre-collision sensing. Previous work was done without considering whether the assumptions made in modeling the system were valid. An examination of that work shows that the simplifications used were not necessarily true and led to poor performance.

A sensor configuration similar to that in existing literature was then considered. The major change from previous work was that the objective was changed from automatic braking to restraint optimization, and the collision warning law was to be determined empirically by neural network methods. An examination of this system pointed to the inherent uncertain nature of the system when the objective was to predict collisions at times around one second in advance.

References

[1.] S. Z. Sze, Physics and Technology of Semiconductor Devices, Yohn Wiley, New York, In 1985.

[2.] Ian Gresham, Alan Jenkins, Robert Egri, Channabasappa Eswarappa, Frank Kolak, Ratana Wohlert, Jacqueline Bennett, J-P Lanteri, “Ultra-Wide Band 24GHz Automotive Radar Front-End”, 2003 IEEE MTT-S Digest, pp 369-372

[3.] Ian Gresham. Alan Jenkins, Robert Egri, Channabasappa Eswarappa, Noyan Kinayaman, Nitin Jain, Richard Anderson, Ratana Wohlert, Frank Kolak, Shwan P Bawel, Jacqueline Bennett, J-P Lanteri, „Ultra Wide Band Radar Sensor for short Weather Vehicular Application “IEEE Transactions on MTT vol.52 No. 9. September 2004 pp 2105-2121.

[4.] In GUETTICHE, A Klaassen, M Claassen, “Monolithic 38GHz VCO with buffer MESFET amplifier for automotive collision avoidance “, European Microwave Conference, in 1995. pp. 290-293.

[5.] Z. Golubicic V.Smiljaković, “Microwave oscillator radar at 24GHz ISM band for protection of cars Collision”, ETRAN 2006

[6.] Peter Biljanovic, “Semiconductor electronic elements”, ETF Zagreb, 2001a.

[7.] Milos B. Živanov “Electronics - amplifying circuits“, Faculty of Engineering, New Sad, 2004th

[8.] M. Šunjeverić, “Fundamentals of radio communication with radio signal” Belgrade 2004th

[9.] D. E. Rumelhart and J. L. McClelland., “Parallel distributed processing: explorationsin the microstructure of cognition”. MIT Press, 1986.

[10.] P. D. Wasserman. “Neural computing: theory and practice”. Van Nostrand Reinhold, 1989.

[11.] Marsh, D. (2003). Radar reflects safer highways. EDN Europe, 2003(March), pp. 21-28

[12.] Tihomir Latinovic, Mihailo Lazarevic, Sorin Deaconu, Gabor Sziebig, Goran Milošević, ”Fuzzy logic combined with neural algorithm to control industrial robot”, DEMI 2013, str 1119-1024

ANNALS of Faculty Engineering Hunedoara
– International Journal of Engineering

FACULTY OF ENGINEERING HUNEDOARA,
5, REVOLUTIEI, 331128, HUNEDOARA, ROMANIA
http://annals.fih.upt.ro