THE DESIGN OF SIMULATOR FOR NONLINEAR JUNCTION DETECTOR

Vo Duy Phuc, Ph.D
Faculty of Electronics and Telecommunication Engineering
University of Science and Technology - The University of Danang, Vietnam

According to technology development of super minimal electronic device industry, semiconductor have been developed and minimized. Sometimes, these devices are illegally used as hidden device with the industrial information included top secret. The illegal hiding method is also being skillful and ingenious. To prevent secret leakage, hidden devices should be detected. In order to detect the hidden device easily, the development os nonlinear junction detector (NLJD) with high performance has been studied [1]. Objects, which are detected by using nonlinear junction detector, are composed of radio elements with nonlinear characteristics (micro scheme, transistors, diode...). The working principle of NLJD is based on analysing the spectral component of the response signal (RS) – multiple harmonics of the probing signal.

In the field of searching hidden device could turn on structure of corrosion origin type ‘metal – oxide – metal’ (MOM - structure). The caught in probing MOM-structure radiate nonlinear product in spectrum of RS, which creates some difficulties in processes identification and detection hidden devices (HD). In the case of hidden devices, the levels of the second harmonics exceed to the level of third harmonics in 20 – 40 dB. In the case of MOM-structure, there is an inverse of the ratio. The CVC of semiconductor element in the part of HD is asymmetrical CVC and in the scattered MOM-structure is symmetric [2]. To improve the efficiency of detection by using NLJD, this paper presents the design of simulator, which is used to evaluate the maximum range, from the NLJD to object and successfully detected HD. To determine the maximum range of NLJD it is expedient to use the simulator based on two-wire planar spiral antenna (PSA) (Fig. 1a). The choice of such antenna system is based on the wide frequency band and elliptical polarization. Spiral antennas with overlap ratio in frequency from 1.5

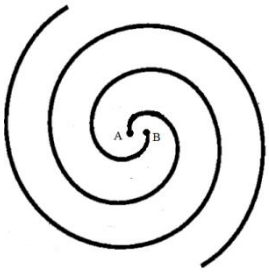

Fig.1a. Two-wire PCA

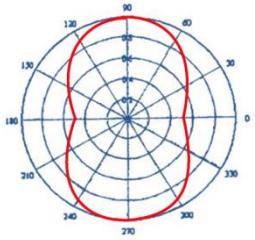

Fig. 1b. Diagram pattern of antennas for frequency f=1GHz

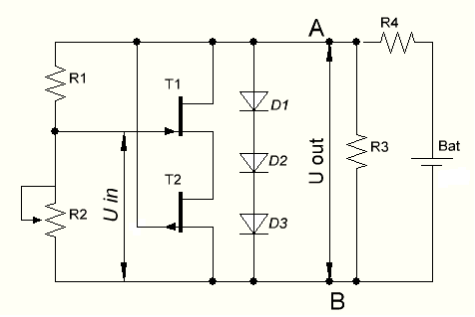

Fig. 2. The schematic of the load simulator

to 10 allow forming the unidirectional width from 90° to 180° DP with the directional coefficient (DC) from 2 to 8 (Fig. 1b). The two-wire PSA simulator is designed in the frequency band from 0.8 to 3 GHz.

In Fig. 2, the gate of transistor T2 connected to the drain of transistor T1, and the gate of transistor T1 connected to the drain of transistor T2. When the voltage U_{out} is applied between the point A and B (Fig. 2), in the transistor T1 and T2 proceeds total current, the voltage U_{out} is distributed among them, moreover the drain – source voltage of one of these transistors is the gate – source voltage of the last transistor. For increasing the voltage U_{out}, in each transistors improves as the source – drain voltage, increase the current of transistor, and the gate – source voltage, decrease this current. The first mechanism predominates at the low voltages on element; the second mechanism predominates at increasing voltages. So the result is the bell-like CVC. So the result is the bell-like CVC. By applying a positive input voltage, the CVC of element moves along the axes of voltage U_{out} and at the same time the current increases. By using diodes D1-D3 in the circuit, shown in Fig. 2, the CVC of nonlinear loading for PSA will receive N-like form, shown in Fig. 3. From the result in Fig. 3, by using the approximation method, the following function is received:

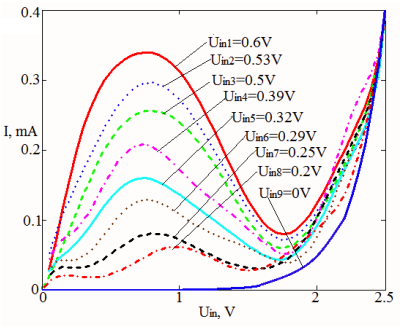

Fig. 3. The family curves of N-like CVC

$$F_1(\gamma_{st}, U_N) = \left(e^{8 \cdot U_N^2} - 1\right) \cdot 3{,}2 \cdot 10^{-4} + 3{,}45 \cdot \gamma_{st} \cdot U_N \cdot e^{\left(-5{,}4 \cdot U_N{}^2 + \gamma_{st}^3 \cdot U_N\right)}$$

where γ_{st} - deformation parameter of the concave area, which meets the input voltage varies in the interval from 0 to 1.

U_N – normalized voltage, ranges from 0 to 1.

Research the efficiency of the detection and identification of HD relates to the threshold correlation L of the levels of the second and third harmonics of RS. The ratio (%) of the total square of the area, in which satisfy the condition $I_{2N}/I_{3N} > L$ and all square of the test field (γ_{st}, U_{mN}) determines the probability of the correct identification of the simulator of RED by using the threshold L for fixing bias voltage U_{0N} (shown in Fig. 4).

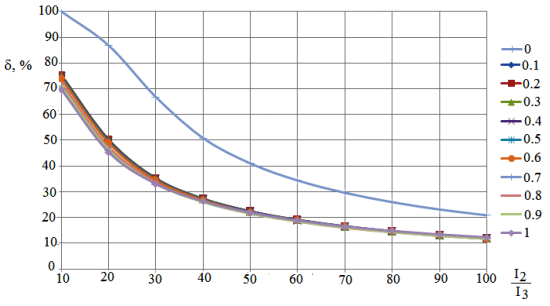

Fig. 4. The reliability of detection HD by using the threshold L at $U_{0N} = 0.78$

In experiment, finding the maximum distance between NLJD and simulator for the initial threshold L=40 at $\gamma_{st} = 0$ and $U_{0N} = 0{,}2$, after that when $U_{0N} = 0.2$ and $\gamma_{st} \neq 0$, for which at the distance $l_{\max}$ fixed the value of I_2/I_3.

When $I_2/I_3 > L$, increasing the threshold L. When $I_2/I_3 < L$, decreasing the threshold L.When $I_2/I_3 \approx L$, fixing the current threshold $L = L_T$ and the maximum distance $l_{\max} = l_{\max T}$. So, we can evaluate the maximum range of each NLJD. Besides that, this simulator could be used in the certification of NLJD.

Thus, the certification of NLJD can be done by using the simulator on the basis of a PSA with the package of active semiconductor in the load. The proposed simulator can change their scattering properties, to determine the maximum range of the reliable detection simulator.

Conclusions

NLJD is widely used in the technical protection information, for searching HD. The use of NLJD based on the property of the radio electronics device (spectral analyse of the response signal). For the reliable detection HD we use the method of identification the nonlinear objects by the ratio of the levels of harmonics.

By using the NLJD meet the high requirements of reliability of the detection HD. Certification NLJD involves the use of simulator with broadband, circular or elliptical polarization and directional transmission power. In the capacity of the certification of the simulator is proposed to use the scatter on the basis of two-wire flat spiral antenna with the "controlled" of non-linear load. The loads of simulator are semiconductor elements with N-like current-voltage characteristics (CVC). The certification of NLJD involves experimental determination of the maximum range of reliable detection simulator in different modes of the scatter of the signal response.

References

1. Audiotel International Limited, “Non-linear junction detector,” U.S. 01360667, 11.12, 2003

2. T. Jones. Overview of nonlinear location technology Special equipment. 1998, № 5.

3. Зінченко М.В., Во Зуй Фук, Зіньковський Ю.Ф.. Дослідження спектральних характеристик розсіюючих МОМ-структур в нелінійній локації// Вісник НТУУ «КПІ». Серія Радіотехніка. Радіоапаратобудування. - 2017. - № 70. - с.11-16.

Аннотація

Запропонована конструкція симулятора, направлена на підвищення надійності виявлення прихованих пристроїв для розрахунку використання нелінійних переходів детектора. Слідом за вчинення особливостей змін параметрів вхідних параметрів з метою підвищення ефективності нелінійного радіолокатора.

Ключові слова: Нелінійний радіолокатор МОМ - структура, приховане пристрій.

Abstract

The proposed design of simulator aims to improve the reliability of the detection hidden devices by using Nonlinear Junction Detector. The features of changes of the parameters of the input parameters should be considered in order to improve the efficiency of NLJD.

Keywords: NLJD, MOM – structure, hidden device.