"HENRI COANDA"
AIR FORCE ACADEMY
ROMANIA

GERMANY

"GENERAL M.R. STEFANIK"
ARMED FORCES ACADEMY
SLOVAK REPUBLIC

INTERNATIONAL CONFERENCE of SCIENTIFIC PAPER
AFASES 2011
Brasov, 26-28 May 2011

# DETECTION OF ERRONEOUS OPERATION IN TTL INTEGRATED CIRCUITS USING MODULUS FUNCTIONS OF NOISE MARGINS

**Mircea Iulian PORTEANU**

Department of Power Engineering, University of Oradea, Oradea, Romania
Department of Electronic and Power Engineering, Institute of Metalurgy, Bucharest, Romania
P.O. Box 15-370, 053120, Bucharest, Romania
Phone / Fax : 00-40 -21-3109322

***Abstract:*** *This paper presents a procedure for detection of erroneous operation in present–day TTL integrated circuits, that is based on using of the modulus functions of noise margins. There are illustrated the values of the modulus functions of noise margins that allow to detect the erroneous operation in TTL integrated circuits.*

***Keywords:*** *logic integrated circuit, TTL, logic level, noise voltage, noise margin, modulus function, erroneous operation detection*

## 1. Introduction

The TTL integrated circuits have evolved rapidly towards high performances and increased complexity, becoming the logic integrated circuits with the largest utilization [1] – [4].

There is a diversity of functional parameters which must be considered for their using in apparatus and equipment destined to various applications. The noise margins have a distinct importance for the appreciation of functioning in the presence of electromagnetic disturbances [5] - [37].

The paper is organized as follows. The theoretic considerations regarding the definition of noise margins are presented in Section 2. The noise margins functions are developed in Section 3. Finally, conclusions are provided in Section 4.

## 2. Definition of noise margins

Considering the NAND Gates connected as shown in Fig. 1, the input voltage $V_I$ of the NAND Gate Load is equal with the output voltage $V_0$ from the NAND Gate Driver, so that

$$V_I = V_0 \tag{1}$$

If an unwanted voltage called as "noise voltage $V_N$" is induced into conductors between the NAND Gate Driver and the NAND Gate Load, from adjacent current-carrying conductors, as seen in Fig. 2, the input voltage $V_I$ becomes

$$V_I = V_0 \pm V_N \,. \tag{2}$$

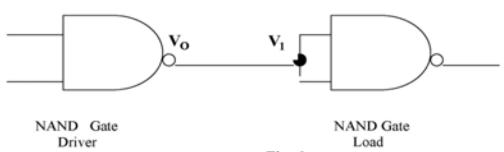

Fig. 1

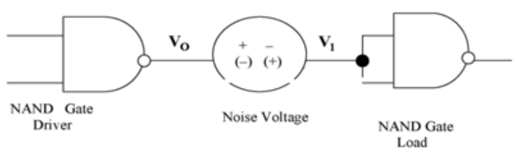

Fig.2

Corresponding to the logic levels low (L) and high (H), we have the input voltages :

$$V_{IL} = V_{OL} \pm V_{NL} \qquad (3)$$

and

$$V_{IH} = V_{OH} \pm V_{NH} \qquad (4)$$

respectively.

The worst case values are:

$$V_{IL}=V_{OL}+V_{NL} \qquad (5)$$

and

$$V_{IH}=V_{OH}-V_{NH} \qquad (6)$$

From (5) and (6), we obtain:

$$V_{NL} = V_{IL}-V_{OL} \qquad (7)$$

and

$$V_{NH} = V_{OH} - V_{IH} \qquad (8)$$

respectively.

The noise voltages $V_{NL}$ and $V_{NH}$ are known as ”direct current noise margins”, they represent the low and high noise margins, being denoted by $NM_L$ and $NM_H$, respectively.

With (7) and (8), the noise margins $NM_L$ and $NM_H$ can be expressed as

$$NM_{\boldsymbol{L}} = V_{IL}-V_{OL} \qquad (9)$$

and

$$NM_{\boldsymbol{H}} = V_{OH} - V_{IH} \qquad (10)$$

respectively.

When

$$NM_{\boldsymbol{L}} = NM_{\boldsymbol{H}} \qquad (11)$$

the noise margins are symmetric.

If

$$NM_{\boldsymbol{L}} \neq NM_{\boldsymbol{H}} \qquad (12)$$

the noise margins are asymmetric.

Depending on the values of input and output voltages for TTL NAND 7400/5400 series shown in Table 1, we obtain the values of noise margins illustrated in Table 2.

The voltages $V_{IL\ max}$ *and* $V_{IH\ min}$ represent the maximum input voltage recognized by a NAND Gate Load as a logic “0” and the minimum input voltage for a logic “1” , respectively. As regards the voltage $V_{OL\ max}$ *and* $V_{OH\ min}$ , they represent the maximum output voltage of a NAND Gate Driver for a logic “0” and the minimum output voltage for a logic “1”, respectively.

The noise margins $NM_L$ and $NM_H$ represent the maximum values of the noise voltages that assure the functioning of the TTL integrated circuits without destroying them and without degradation of L and H voltage levels.

The maximum noise margins are limited by the device characteristics and / or by considerations of symmetry between the low and high noise margins.

## 3. Detection of erroneous operations using modulus functions of noise margins

In a previous paper [37] we have defined the modulus functions of the noise margins $NM_L$ and $NM_H$ in the forms

$$f(V_{IL}, V_{OL}) = |V_{IL}-V_{OL}| = \begin{cases} V_{IL} - V_{OL} & \text{if } V_{IL} > V_{OL} \geq 0 \\ 0 & V_{IL} = V_{OL} \\ V_{IH} - V_{OH} & \text{if } V_{IH} > V_{OH} \geq 0 \end{cases} \qquad (13)$$

and

$$f(V_{OH}, V_{IH}) = |V_{OH}-V_{IH}| = \begin{cases} V_{OH} - V_{IH} & \text{if } V_{OH} > V_{IH} \geq 0 \\ 0 & V_{IL} = V_{OL} \\ V_{OL} - V_{IL} & \text{if } V_{OL} > V_{IL} \geq 0 \end{cases} \qquad (14)$$

respectively.

TABLE 1 VALUES OF INPUT AND OUTPUT VOLTAGES FOR TTL NAND 7400/5400

| Voltage | Measure | Family /Year of appearance | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | (TTL) | L | H | S | LS | F | ALS | AS |
| | | 1964 | 1967 | 1967 | 1969 | 1971 | 1979 | 1980 | 1982 |
| VIL max | V | 0.8 | 0.7 | 0.8 | 0.8 | 0.7 | 0.8 | 0.8 | 0.8 |
| VIH min | V | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| VOL max | V | 0.4 | 0.3 | 0.4 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 |
| VOH min | V | 2.4 | 2.4 | 2.4 | 2.7 | 2.7 | 2.7 | 2.7 | 2.7 |

TABLE 2 VALUES OF NOISE MARGINS

| Noise margins | | Measure | Family /Year of appearance | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | (TTL) | L | H | S | LS | F | ALS | AS |
| | | | 1964 | 1967 | 1967 | 1969 | 1971 | 1979 | 1980 | 1982 |
| NM | NML | V | 0.4 | 0.4 | 0.4 | 0.3 | 0.2 | 0.3 | 0.3 | 0.3 |
| | NMH | V | 0.4 | 0.4 | 0.4 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 |

The cases in which the modulus function are

$$f(V_{IL}, V_{OL}) = |V_{IL} - V_{OL}| = 0 \quad \text{if} \quad V_{IL} = V_{OL} \tag{15}$$

$$f(V_{IL}, V_{OL}) = |V_{IL} - V_{OL}| = V_{OL} - V_{IL} \quad \text{if} \quad V_{OL} > V_{IL} \geq 0 \tag{16}$$

$$f(V_{OH}, V_{IH}) = |V_{OH} - V_{IH}| = 0 \quad \text{if} \quad V_{OH} = V_{IH} \tag{17}$$

and

$$f(V_{OH}, V_{IH}) = |V_{OH} - V_{IH}| = V_{IH} - V_{OH} \quad \text{if} \quad V_{OL} > V_{IL} \geq 0 \tag{18}$$

correspond to a malfunction of the drive and / or load NAND Gate shown in fig. 1 We can detect thus the erroneous operation in TTL integrated circuits, using the modulus function of noise margins.

## 4. CONCLUSIONS

The noise margins have a distinct importance for logic integrated circuits with the propose of appreciation the functioning in the presence of electromagnetic disturbances. Their values must be considered both in the choosing as in the using of TTL integrated circuits in apparatus and equipment destined for various applications.

The paper has presented the procedure of detection of erroneous operation in TTL integrated circuit by using the modulus functions of noise margins.

## References

[1] Morris, R. L., Miller I.R., *Proiectarea cu circuite integrate TTL. (Design with TTL Integrated Circuits),* Editura Tehnica, Bucuresti, 1974

[2] Texas Instruments, *Design Consideration for Logic Products,* 1997

[3] Porteanu M., *Manual de circuite integrate TTL, (Handbook of TTL Integrated Circuits),* Centrul de Perfectionare a personalului din Industria Metalurgica CPMIM, Bucuresti, 1984.

[4] Porteanu M., *Ghid pentru utilizarea circuitelor integrate TTL., (Guide forUsing TTL Integrated Circuits),* Centrul de Perfectionare a personalului din Industria Metalurgica CPMIM, Bucuresti, 1986.

[5] Porteanu M., Slavov E., *Echipament cu circuite integrate TTL pentru statiile cu racord adanc de la Combinatul Siderurgic Galati, (Equipment with TTL Integrated Circuits for Substations Feeding Iron and Steel Plants of Galati),* Contract nr. 2229/1973, Institutul de Cercetari si Proiectari pentru Echipamente Termoenergetice, ICPET, Bucuresti, 1973

[6] Porteanu M., Slavov E., *Module cu circuite integrate pentru compartimentul masini al navelor, (Modules with TTL Integrated Circuits for Naval Engines Compartment),* Contract Nr.2235/1976, Institutul de Cercetari si Proiectari pentru Echipamente Termoenergetice, ICPET, Bucuresti, 1976.

[7] Porteanu M., *Increase of Noise Imunity in Relay Control Systems by Using On – Off Elements with Generalized Characteristic*, Proceedings of the International Symposium on Electromagnetic Compatibility, EMC, pp. 182–189, Wroclaw,1980.

[8] Porteanu M., *A Method to Increase the Noise Immunity in Digital Systems,* Proceedings of the International Conference on Digital Signal Processing, Florence, pp. 275, Italy, 1981.

[9] Porteanu M., *Structura logica cu imunitate ridicata la zgomot (A Logical Structure with Increased Noise Immunity)*, Lucrările Simpozionului Național de Teoria Sistemelor ), Vol. II, pp. 165 -169, Craiova, 1982.

[10] Porteanu M., *A Logical Structure with High Noise Immunity,* Proceedings of the International Conference on Electromagnetic Compatibility EMC, pp.199 - 202, Zurich, 1983.

[11] Porteanu M., *Increase of Noise Immunity in Electrical Drive Control Circuits,* Proceedings of the 4th National Conference on Electrical Drives, pp C. 168 – C. 175, Craiova, 1984.

[12] Porteanu M., *Noise Hazard in Switching Circuits and its Reduction,* Proceedings of the International Symposium on Electromagnetic Compatibility EMC, pp. 461- 463, Tokyo, 1985.

[13] Porteanu M., *Noise Effect on the Reliability of Electronic Circuits and Equipment,* Proceedings of the 6-th Symposium on Reliability in Electronics, pp. 776, Budapest, 1985.

[14] Porteanu M., *An Input Interface with High Noise Immunity,* Proceedings of the International Conference on Electrical Machines and Drive Systems INCEMADS, pp. C.13 61 - 66, Eforie Nord, 1986.

[15] Porteanu M., *ReliabilityAnalysis of Electronic Equipment in Power Systems Using Poisson Distribution, ,* American Power Conference, Chicago, Il., 1994.

[16] Porteanu M., *Reliability Evaluation of Electronic Equipment in Power Systems,* American Power Conference, Chicago, Il., 1996.

[17] Porteanu M., *Evaluation of Noise Effect on the Reliability of Electronic Components and Equipment*, Proceedings of the International Symposium on Signals, Circuits and Systems SCS '97, pp. 577- 580, Iasi, 1997.

[18] Porteanu M., *Noise Influence on Reliability of Electric Equipment in Power Stations,* American Power Conference, Chicago, Il., 1997.

[19] Porteanu M., *Reliability of Electronic Equipment Operating in Electric Noise Environment,* American Power Conference, Chicago, II, 1998.

[20] Porteanu M., *Aspects of Migration from Laboratory System to Industrial Systems,* International Conference on Accelerator and Large Experimental Physics Control Systems, Trieste, Italia, 1999.

[21] Porteanu M., *Reliability of Electric Equipment Operating in Variable Electric Noise Environment*, American Power Conference, Chicago, Il., 1999.

[22] Porteanu M., *Imunitatea la zgomot a circuitelor integrate TTL in conditii normale si speciale de functionare ( Noise Immunity of TTL Integrated Circuits Operating in Normal and Special Environment),* Buletinul Stiintific al Academiei Fortelor Aeriene "Henri Coanda" Brasov, Seria Electronica Si Electrotehnica, Vol. III, Nr. 2 (14) Noiembrie, pp. 125 – 140, 2002.

[23] Porteanu M., *Compatibilitatea statica de conectare a circuitelor integrate TTL in conditii de functionare normala si speciala , (Static Connecting Compatibility of TTL Integrated Circuits Operating in Normal and Special Environment ),* Buletinul Stiintific al Academiei Fortelor Aeriene "Henri Coanda" Brasov, Seria Electronica si Electrotehnica, Vol. III, Nr. 2 (14) Noiembrie, pp. 141 – 156, 2002.

[24] Porteanu M., *Increase of Noise Immunity in TTL Logic Circuits Used for Equipment of Power Stations and Substations,* Scientific Bulletin of The Polytechnica University of Timisoara - Transactions on Power Engineering, Vol. 48 (62), Nr. 1 - 2, pp. 413-415, 2003.

[25] Porteanu M., *Aspecte privind marginea de zgomot si rezerva de margine de zgomot la circuitele integrate TTL, (On the Noise Margin and Noise Margine Reserve of TTL Integrated Circuits),* Buletinul Stiintific al Academiei Fortelor Aeriene "Henri Coanda" Brasov, Seria Electronica si Electrotehnica, Vol. V, Nr. 1(15) Noiembrie, pp. 155-164, 2004.

[26] Porteanu M., *Determinarea parametrilor marginii de zgomot la circuitele integrate TTL, (Determination of Noise Margin Parameters of TTL Integrated Circuits),* Buletinul Stiintific al Academiei Fortelor Aeriene "Henri Coanda" Brasov, Seria Electronica si Electrotehnica, *(*Vol. V, Nr. 1(15) Noiembrie, pp. 165 – 170, 2004.

[27] Porteanu M., *Parametrii de zgomot ai circuitelor integrate TTL (Noise Parameters of TTL Integrated Circuits),* Proceedings of the 10th International Conference on Man in the Knowledge Based Organization Vol. XII, Electrotehnica, Electronica, Comunicatii, pp. 21- 28, Land Forces Academy Publishing House, Sibiu, 2005.

[28] Porteanu M., *Determinarea analitica a parametrilor de zgomot la circuitele integrate TTL (Analytical Computing of Noise Parameters for TTL Integrated Circuits),* Buletinul Stiintific al Academiei Fortelor Aeriene "Henri Coanda" Brasov, Seria Electronica si Electrotehnica, Vol. VI, Nr. 1(16), Mai, pp. 121- 124, 2006.

[29] Porteanu M., *Voltage Parameters of TTL Integrated Circuits,* Proceedings of the 11th International Conference on Man in the Knowledge Based Organization Vol. VIII, pp.33-41, Land Forces Academy Publishing House, Sibiu, 2006.

[30] Porteanu M., *Reprezentarea Grafică a Marginilor de Zgomot la Circuitele Integrate TTL Conectate din aceiaşi familie ( Graphic Representation of Noise Margins for TTL Integrated Circuits Connected from the Same Family)*, Proceedings of the International Conference on Education and Scientific Research at European Standards , vol.1 , Technical and Engineering Sciences, pp. 532-538, ,,Henri Coandă Air Force Academy Publishing House, Braşov, 2007.

[31] Porteanu M., *Reprezentarea Tabelară a Stărilor, Nivelelor Logice şi Tensiunilor la Circuitele Integrate TTL( Tabular Representation of Logic States, Logic Levels and Voltages for TTL Integrated Circuits)*, Proceedings of the International Conference on Education and Scientific Research at European Standards , vol.1 , Technical and Engineering Sciences, pp. 539-548, ,,Henri Coandă" Air Force Academy Publishing House, Braşov, 2007.

[32] Porteanu M., *Graphic Representation of Noise Margins for TTL Integrated Circuits Connected from Various Families*, Proceedings of the 13th International Conference on Man in the Knowledge Based Organization Vol. 10, Electronics, Electrotechnics, Communications, pp.68-75, Land Forces Academy Publishing House, Sibiu, 2007.

[33] Porteanu M., *Reduced Low Power Consumption by Using Low Voltage Integrated Circuits*, Proceedings of the International Conference on Education and Academic Research Structures of the Knowledge-Based Society, Vol.1, Economy and Engineering, pp. 248-252, Alma Mater Publishing House, Sibiu, 2008.

[34] Porteanu M., Torcica V.; *General Graphic Representation of Noise Margins for TTL Integrated Circuits*, Proceedings of the 14-th International Conference on Knowledge – Based Organization KBO 2008, Vol. 7, Comunications, Electronics and Electrotechnics, pp. 287 – 294 Nicolae Balcescu Land Forces Academy Publishing House, Sibiu, 2008.

[35] Porteanu M *Generalized Graphic Representation of Noise Margins for TTL Integrated Circuits,* Proceedings of the International Conference on Scientific Research and Education in The Air Force. Henry Coanda Air Force Academy Publishing House, Brasov, 2009.

[36] Porteanu M *Three – Dimensional Representation of Noise Margins for TTL Integrated Circuits,* Proceedings of the 33-rd Annual American Romanian Academy of Arts and Sciences Conference, Vol. II, pp. 135-138, Polytechnic International Press, Montreal, Quebec, Canada, 2009.

[37] Porteanu M *Modulus Functions of Noise Margins for TTL integrated Circuits,* Proceedings of the International Conference on Scientific Research and Education, Henri Coanda Air Force Academy Publishing House, Brasov, 2010.