IJCSI International Journal of Computer Science Issues, Vol. 8, Issue 6, No 2, November 2011
ISSN (Online): 1694-0814
www.IJCSI.org

System Performance Ratings of High Speed Nano Devices Using Fuzzy Logic

Ak.Ashakumar Singh
Department of Computer Science

Thoubal College,Thoubal,
Manipur University,Manipur-795138, India.

Y.Surjit Singh
Dept. of Computer Science
CMJ University
Shillong, India

K.Surchandra Singh
Dept. of Computer Science
CMJ University
Shillong, India.

Abstract

A single dimension cannot quantify or properly express the performance of high speed Nano devices. It is very difficult to interpret high speed Nano devices parameters without knowing what application (users) are involved. The system performance parameters of (In, Ga)As are Ac mobility, Lattice Temperature, Electron Temperature, Carrier Concentration, and Channel Length. These system parameters need to be frequently updated based on feedbacks from implementation of previous parameters. These feedbacks are always stated in the form of ordinal ratings, e.g. “high speed”, “average performance”, “good condition”. The Different people can describe different values to these ordinal ratings without a clear-cut reason or scientific basis. There is need for a way or means to transform vague ordinal ratings to more appreciable and precise numerical estimates. The paper transforms the ordinal performance ratings of some system performance parameters to numerical ratings using Fuzzy Logic.

***Keywords*:** *Fuzzy Set Theory, System Performance, Performance Strategies, Transformation.*

1. Introduction

The performances of the high speed Nano devices are always measured in ordinal ratings such as, very good, average, poor, low or high. The creative challenges faced nowadays by circuit and system designers is to achieve three basic aspects i.e. speed, size and cost simultaneously in a single VLSI chip [1]. The matter of power dissipation was less visible in early VLSI design issues. But recently power dissipation has become the main design concern in several applications. However, power efficiently should not be achieved without compromising high performance, or minimum area, thereby creating a new design culture. Answering the needs of rapidly rising chip complexity has created significant challenges and aided the development of many areas, e.g. development of computer aided design tools, chip design, fabrication, packaging, testing and reliability qualification. The main objective, however, remains device miniaturization. Device miniaturization results in reduced unit costs per function and in improved performance. As a result, the cost per bit of memory chips has almost halved every two years for successive generations of random access memories. These all measurement parameters ratings are ordinal and are subject to ambiguity. This means that these ratings have some elements of uncertainty, ambiguity or fuzziness.

When humans are the basis for an analysis, there must be a way to assign some rational value to intuitive assessments of individual elements of a fuzzy set. There is need to translate from human fuzziness to numbers that can be used by a computer.

Lofti A Zadeh introduced Fuzzy Set Theory (FST) in the early 1960's as a means of modeling the uncertainty, vagueness, and imprecision of human natural language. It was built on the basis that as the complexity of a system increases, it becomes more difficult and eventually impossible to make a precise statement about its behavior, eventually arriving at a point of complexity where the fuzzy logic method born in humans is the only way to get at the problem.

[1] used genetic algorithm approach for optimized of highly efficient high speed nano devices. Fuzzy logic is used here for a square quantum well of $In_{0.53}Ga_{0.47}As$ having infinite barrier height to get the optimized system parameters viz. Channel width, Carrier concentration, Lattice temperature, electron temperature, and Ac mobility. The optimization of these system parameters of the two dimensional WQs is very essential for suitable applications in commercial markets.

[2] described *Fuzzy Set Theory (FT)* as the extension of classical set theory. The basic idea is that the membership of a value to a set cannot only assume the two values “yes” or “no”, but can be expressed by gradual membership function within a range from zero to normally “1” in case of full membership degree. Membership function can assume several forms, and in practice triangular or trapezium forms are often used (Figure 1).

2. Problem Defined

The system parameters of $In_{0.53}Ga_{0.47}As$ viz. Channel width, Carrier concentration, Lattice temperature, electron temperature and Ac mobilities are imprecise or fuzzy.

The ratings are in rough (imprecise, inexact or fuzzy) ranges, reflecting the variability in how each strategy could be implemented and the uncertainties involved in projecting the impacts of the strategies. For a meaningful numerical research, as stated in the introduction, these ordinal ratings need to be transformed to numerical ratings and this forms the thrust of the paper. That is, to transform opinion held by human beings, which would be "fuzzy" (e.g. low, mid-high performance) to being very precise (e.g. 15%, 80% performance), that is not "fuzzy" using fuzzy set theory [3], [4].

3. Theoretical Foundations

A fuzzy system is a system whose variable(s) range over states that are approximate. The fuzzy set is usually an interval of real number and the associated variables are linguistic variable such as “most likely”, “about”, etc. [4]. Appropriate quantization, whose coarseness reflects the limited measurement resolution, is inevitable whenever a variable represents a real-world attribute. Fuzzy logic consists of Fuzzy Operators such as “IF/THEN rules”, “AND, OR, and NOT” called the *Zadeh operators* [5].

The Membership Function is a graphical representation of the magnitude of participation of each input. It associates a weighting with each of the inputs that are processed, define functional overlap between inputs, and ultimately determines an output response. Once the functions are inferred, scaled, and combined, they are defuzzified into a crisp output which drives the system. There are different memberships functions associated with each input and output response. Some features of different membership functions are: SHAPE - triangular is common, but bell, trapezoidal, haversine and, exponential have been used also; HEIGHT or magnitude (usually normalized to 1); WIDTH (of the base of function); SHOULDERING; CENTER points (centre of the member and OVERLAP (Figure 1) [6].

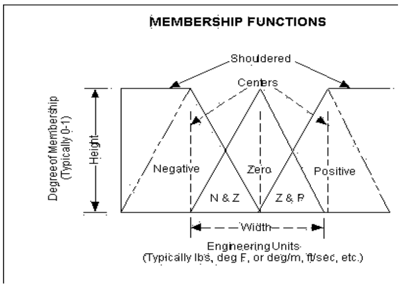


Fig. 1 Triangular membership function

The degree of fuzziness of a system analysis rule can vary between being very precise, that is not "fuzzy", to being based on an opinion held by a human, which would be "fuzzy." Being fuzzy or not fuzzy, therefore, has to do with the degree of precision of a system analysis rule.

The Degree of Membership (DOM) is the placement in the transition from 0 to 1 of conditions within a fuzzy set. The degree of membership is determined by plugging the selected input parameters into the horizontal axis and projecting vertically to the upper boundary of the Membership function(s) [7]. Fuzzy Variable includes words like red, blue, good and sweet are fuzzy and can have many shades and tints. A Fuzzy Algorithm is a procedure, usually a computer program, made up of statements relating linguistic variables. A Fuzzy Logic Control System- measures an input against a given situation and the system takes action automatically.

4. Methodology

The relative effectiveness of these system performance strategies is summarizes as shown in Table 1 in terms of four basic criteria: (1) Effectiveness, (2) Economic Efficiency, (3) Economic Equity and (4) Immediate Access flexibility. In the table, the system performs between ***medium to high*** on practical reduction effectiveness, ***high*** in terms of economic efficiency, ***medium to high*** on economic equity for the poor and ***medium to high*** on immediate access flexibility.

5. Notations

Effec.	Effectiveness
Eco.Eff.	Economic Efficiency
Eco Equity	Economic Equity
Imm.	Immediate
Flex.	Flexibility
m	medium
h	high
l	low
min	Minimun
Max	Maximum
Avg	Average

Perf	Performance
Temp	Temperature
Conc	Concentration

Table 1: System parameters ratings

Multi-objective Evaluation of the system				
	Ratings on Objectives (high = best)			
System parameters	Effec (P)	Eco. Eff. (N)	Eco. Equity (Q)	Imm. Acces s flex. (X)
AC mobility (a)	m-h	h	m-h	m-h
Lattice temp. (b)	m-h	m-h	m-h	m-h
Electron temp. (c)	l-m	l-m	m	h
Carrier conc.(d)	l-m	l	m	h
Channel length (e)	l-m	l	m	m

6. Fuzzy Variables

In the paper, the adjectives describing the fuzzy variables and the range of performance are shown in Table 2. The Range of Performance for the individual fuzzy variables is substituted in Table 1 to obtain Table 3.

Table 2: Fuzzy Variables and their ranges.

Fuzzy Variables	**Range of Performance %**
High (h)	75 – 100
Med-High (m-h)	55 - 80
Med (Medium)(m)	35 - 60
Low-Med (l-m)	15 - 40
Low (l)	0 - 20

Table 3**:** Fuzzy Range of Performance for the individual fuzzy variables.

Multi-objective Evaluation of the system				
	Ratings on Objectives (high = best)			
System parameters	**Effec. (P)**	**Eco.Eff. (N)**	**Eco.** Equity **(Q)**	**Imm. Acces s** Flex. **(X)**
AC mobility (a)	55 - 80	75 – 100	55 - 80	55 - 80
Lattice temp (b)	55 - 80	55 - 80	55 - 80	55 - 80
Electron temp (c)	15 - 40	15 - 40	35 - 60	75 – 100
Carrier Conc (d)	15 - 40	0 - 20	35 - 60	75 – 100
Channel length (e)	15 - 40	0 - 20	35 - 60	35 - 60

7. Fuzzy Mapping

The fuzzy variables in Table 1, were transformed to numerical ratings using *Fuzzy Set Theory* as shown in Figures 2–6.

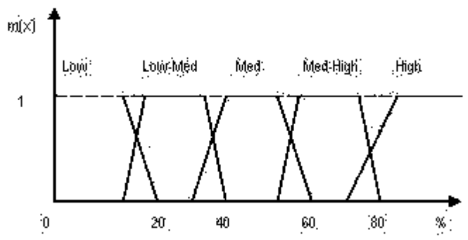


Fig. 2: Trapezoidal membership function

8. Aggregation of Fuzzy Scores

Using Figure 3, for each System parameters (SP) *i* and each criterion (CRIT) *j*,

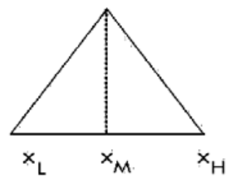


Fig. 3: Aggregation of Fuzzy Scores.

i = 1, 2, 3, ..., 7. and j = 1, 2, 3, 4.

For CRIT (j) when SP(i, j) = x_L THEN SPPER (i, j) = L

For CRIT (j) when SP(i, j) = x_M THEN SPPER (i, j) = M

For CRIT (j) when SP(i, j) = x_H THEN SPPER (i, j) = H

Where, CRIT (j) ≡ Criterion j (j = 1, 2, 3, 4)

SP (i, j) ≡ System parameters i under Criterion j

SPPER(*i*, *j*) ≡ System performance parameters *i* under Criterion *j* Performance:

$$SPSCORE(i) = \sum_j \frac{SP(i, j)}{4} \qquad (1)$$

9. Membership Functions of the Fuzzy Sets

Using Aggregation methods for the fuzzy sets to reduce it to a triangular shape for the membership function, overlapping adjacent fuzzy sets were considered with the membership values shown in Figure 4.

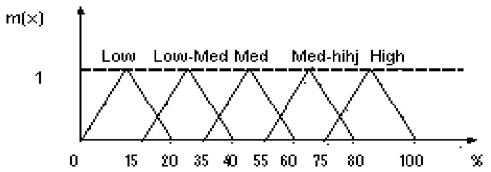
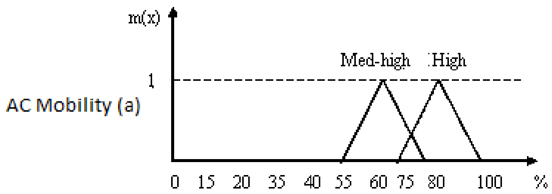
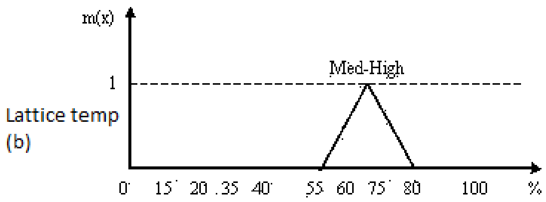


Fig. 4: Derived Triangular membership function

For the strategies and their performances, the membership functions shown in Figure 5 of the fuzzy sets were assigned.

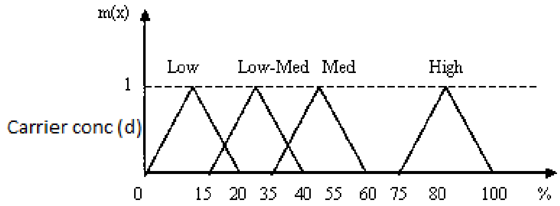


Criteria: (P, Q, X = med-high; N = high)

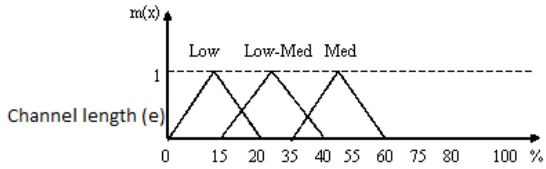


Criteria: (P, N, Q, X = med-high)

Criteria: (P, N = low-med; Q = med; X = high)



Criteria: (P = low-med; N = low; Q = med; X = high)



Criteria: (P = low-med; N = low; Q, X = med)

Fig. 5: Derived triangular membership functions for the System parameters.

The ranges in figure 4 and figure 5 were aggregated to singletons. For the average performance of all the strategies, we have the fuzzy scaled rating as shown in figure 6.

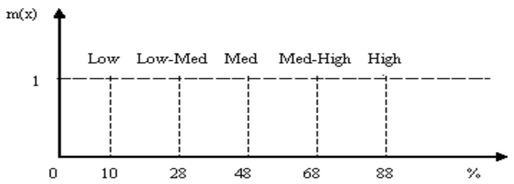


Fig. 6: Singleton aggregation of the ratings in table 1.

From Figs. 2–6, the Membership Values assigned to each set of Universe of Discourse can be tabulated as shown in Table 4.

Table 4: Fuzzy performance ratings of Membership Values assigned to each set of Universe of Discourse.

System Parameters	Criteria							
	Effectiveness (P)		Economic Efficiency (N)		Economic Equity (Q)		Immediate Access flexibility (X)	
AC mobility (a)	med-high		high		med-high		med-high	
	X	Y	X	Y	X	Y	X	Y
	55	0	75	0	55	0	55	0
	68	1	88	1	68	1	68	1
	80	0	100	0	80	0	80	0
Lattice temp (b)	med-high		med-high		med-high		Med-high	
	X	Y	X	Y	X	Y	X	Y
	55	0	55	0	55	0	55	0
	68	1	68	1	68	1	68	1
	80	0	80	0	80	0	80	0
Electron temp (c)	low-med		low-med		med		high	
	X	Y	X	Y	X	Y	X	Y
	15	0	15	0	35	0	75	0
	28	1	28	1	48	1	88	1
	40	0	40	0	60	0	100	0
Carrier conc (d)	low-med		low		med		High	
	X	Y	X	Y	X	Y	X	Y
	15	0	0	0	35	0	75	0
	28	1	10	1	48	1	88	1
	40	0	20	0	60	0	100	0
Channel length (e)	low-med		low		med		Med	
	X	Y	X	Y	X	Y	X	Y
	15	0	0	0	35	0	35	0
	28	1	10	1	48	1	48	1
	40	0	20	0	60	0	60	0
	X	Y	X	Y	X	Y	X	Y
	15	0	0	0	35	0	15	0
	28	1	10	1	48	1	28	1
	40	0	20	0	60	0	40	0

10.Results

From the above figure 3, it is shown that x_L, x_M and x_H are referred to as the Minimum performance, Average performance and Maximum Performance. Using equation (1), we can calculate the Average Scores of different LAN performance strategies for all the four criteria in respect of x_L referring to as the Minimum Performance (as shown in Table 5), in respect of x_M referring to as the Average Performance (as shown in Table 6), and in respect of x_H referring to as the Maximum performance (as shown in Table 7).

Table 5:Numerical transformation of LAN Strategies for Minimum Performance using fuzzy set theory.

Multi-objective Evaluation of the System					
	Ratings on Objectives (high = best)				
System parameters	Effec (P)	Eco Eff. (N)	Eco. Equity (Q)	Imm. Access Flex. (X)	Avg. Score
AC Mobility	55	75	55	55	60

(a)					
Lattice temp (b)	55	55	55	55	55
Electron temp (c)	15	15	35	75	35
Carrier conc (d)	15	0	35	75	31
Channel length (e)	15	0	35	35	21

Table 6: Numerical transformation of LAN Strategies for Medium Performance using fuzzy set theory.

Multi-objective Evaluation of The System					
	Ratings on Objectives (high = best)				
System parameters	Effec (P)	Eco Eff. (N)	Eco. Equity (Q)	Imm. Access Flex. (X)	Avg. Score
AC Mobility (a)	68	88	68	68	73
Lattice temp (b)	68	68	68	68	68
Electron temp(c)	28	28	48	88	48
Carrier conc(d)	28	10	48	88	44
Channel length (e)	28	10	48	48	34

Table 7: Numerical transformation of the system parameters for Maximum Performance using fuzzy set theory.

Multi-objective Evaluation of System					
	Ratings on Objectives (high = best)				
System parameters	Effec (P)	Eco Eff. (N)	Eco. Equity (Q)	Imm. Access Flex. (X)	Avg. Score
AC Mobility (a)	80	100	80	80	85
Lattice temp (b)	80	80	80	80	80
Electron temp (c)	40	40	60	100	60
Carrier conc (d)	40	20	60	100	55
Channel length (e)	40	20	60	60	45

Table 8: Comparison between the ordinal fuzzy ratings and the transformed ratings on various criteria of LAN performance.

Ordinal perf (Fuzzy Ratings)	System parameters	Min Perf	Avg Perf	Max Perf
m-h	AC Mobility	55	68	80
m-h	Lattice temp	55	68	80
m-h	Electron temp	15	28	40

Similarly, for other fuzzy ratings of different System criteria, their comparisons can be found out.

Hence, their performances ratings can be shown such as $x_L < x_M < x_H$.

11. Conclusion

Fuzzy logic was used to transform ordinal System parameters of high speed nano devices ratings that are imprecise and fuzzy in nature to precise and defuzzified numerical ratings used in the analysis of performance ratings of different optimized System performance parameters. The Technique used is the only way for solving any highly complex problem. The optimized system parameters will surely save the search time for technologies involved in the fabrication of high speed dimensional semiconductor.

Reference:

[1] Tirthanker Datta, optimized approach using genetic algorithm for highly efficient high speed nano devices, *IEMCON*, (2011)

[2] K.Heine, Potential application of fuzzy methods in geodetic fields. In *First International Symposium on Robust Statistics and Fuzzy Techniques in Geodesy and GIS*. Institute of Geodesy and Photogrammetry, Swiss Federal Institute of Technology, (Zurich: ETH Hoenggerberg. CH-8093, 2001

[3] L.A. Zadeh, Fuzzy sets, *Information and Control*, 1965, *8*, 338 – 353.

[4] L.A. Zadeh, Toward a theory of fuzzy information granulation and its Centrality in human reasoning and Fuzzy logic, *International Journal of Soft Computing and Intelligence*, *90*(2), 1997, 111 – 127.

[5] T.Sowell,*Fuzzy-Logic*,http://www.fuzzy logic.com/ ch3. Htm, (2005).

[6] S.D. Kaehler, *Fuzzy Logic*, http://www.seattlerobotics.org/encoder/mar98/fuz /flindex.html (1998)

[7] M.Kantrowitz,*Fuzzy-logic/part1*.[Online], 1997.

Biography:

Ak. Ashakumar Singh graduated in Mathematics from Manipur University, Imphal and passed MCA in the year 2000 from the same varsity. He was awarded Ph.D. in the area of Computer Science from the Dept. of Mathematics of the same varsity in the year 2008. Then produced eight M.Phil scholars in Computer Science and now supervising three scholars leading to Ph.D. in Computer Science. The area of research is on Soft computing and related applications of computer science.