

# A Study on Job Satisfaction of Private Post Graduate College Teachers in Visakhapatnam City Using Henry Garrett Ranking Technique

<sup>1</sup>DR. CHAMOLI ANJANA, <sup>2</sup>DR. VINAY CHAITANYA GANTA

<sup>1</sup>HOD - Asst. Professor, <sup>2</sup>Assistant Professor, Department of Management Studies, Dr. Lankapalli Bullayya College, Visakhapatnam, Andhra Pradesh, India.

**ABSTRACT** - There may be various factors that can lead to a success of any educational institute but teachers are the eminent factor for the success of any institute. Teachers are the pillars of any society. They are the one who shape the future citizens of the society. Hence the job satisfaction of the teachers is an eminent and pivotal responsibility of any society. A satisfied teacher is happier and is more sincere towards his or her work and hence his/her performance. They perform well and are motivated to do best for the students and hence developing the society as a whole. This study is conducted to rank the various factors of job satisfaction of the teachers (like ability utilization, achievement, promotion, compensation, company policies. Co-workers, nature of work, supervision, working condition and social status. in private colleges of the Visakhapatnam by using Henry Garrett Ranking method. It is used to find out the most significant factor that influences job satisfaction.

**Keywords:** *Job Satisfaction, Happy, Teachers, Motivated, Performance.*

## I. INTRODUCTION

The growth and success of any institute/ college depends upon the efficiency and capability of their teachers. So the management needs to effectively utilize and tap the potentials of them. At the the same time the success also depends upon the sincerity and commitment of these teachers. All these becomes easy if the teachers have job satisfaction. Therefore, it is indisputable that the due consideration should be given to the factors influencing job satisfactions. Satisfactory performance can be expected from a teacher when he/ she is satisfied with the work. If there is job dissatisfaction, it results in low performance (Bretz & Thomas, 1992)<sup>1</sup>. The government is also consistently striving to improve the quality of the education especially of the higher education, but all the hard work would go into vain if the teachers are not satisfied. A satisfied teacher would perform better than a one who is not satisfied.

## II. REVIEW OF LITERATURE

Job satisfaction is a combination of emotions that employees possess towards role they are performing at the work place. Job Satisfaction is the essential component for employee motivation and encouragement towards better performance. According to Newstrom (2007)<sup>2</sup>, job satisfaction is a set of favourable or unfavourable feeling and emotions with which employee view their work and the supervisors need to be alert about employee job satisfaction level. Hoppok & Spielgler (1938)<sup>3</sup> defines job satisfaction as the integrated set

of psychological, physiological and environmental conditions that encourage employees to admit that they are satisfied or happy with their jobs.

The study of Bilal (2012)<sup>4</sup> has shown relationship between job satisfaction and compensation and working conditions. A teacher should be rewarded and recognized for her services otherwise his/ her satisfaction level might decrease which can have an impact on his/ her performance. Bavendam (2000)<sup>5</sup> opines that the job satisfaction of teachers is very important as otherwise their attitude will have an impact on the learning process of their students. A satisfied teacher performs well and have positive impact on performance and quality of teaching and retention rate is also higher for such teachers.

## III. OBJECTIVE OF THE STUDY

The main objective of the study is to rank the various factors affecting the job satisfaction of the private degree college teachers in the Visakhapatnam city and to find the most significant factor influencing the job satisfaction.

## IV. METHODOLOGY OF THE STUDY

Both the primary and the secondary data were collected for the study. The secondary data was collected from the websites and various journals and books. Primary data was collected by administering a questionnaire to rank the factors and also through interactions with the teachers directly.

The questionnaire was administered to 250 teachers of different private post graduate colleges in the

Visakhapatnam city who were selected through convenience sampling technique. Out of these respondents, 61 didn't respond or gave incomplete answers. Only 189 responses were complete and were considered for the study and analysis.

Henry Garret Ranking method was used as a statistical tool to rank the 10 factors (namely ability utilization, recognition & achievement, promotion, compensation, company policies. Co-workers, nature of work, supervision, working condition and social status) affecting job satisfaction of private post graduate college teachers of Visakhapatnam city.

Henry Garret techniques is used by the researchers in their study where there are many factors or determinants that need to be ranked to find out the most significance factor that influences the respondents. The merits given by the respondents are converted into ranks by using a formula. In this technique, respondents assign the rank for all factors and the outcomes of these ranks are converted into score value with the help of the following formula:

$$\text{Percent position} = 100 (R_{ij} - 0.5) / N_j$$

Where  $R_{ij}$  = Rank given for the  $i$ th variable by  $j$ th respondents

$N_j$  = Number of variables ranked by  $j$ th respondent

## V. ANALYSIS AND INTERPRETATION

### 1.1 Demographic profile of the respondents

Demographic variable	Respondents (In percentages)
<b>GENDER</b>	
Male	33.8
Female	66.2
<b>AGE(IN YEARS)</b>	
Less than 30	7

30-40	49.3
40-50	35.2
Above 50	8.5
<b>EDUCATIONAL QUALIFICATION</b>	
Degree	3.5
Masters/ Post Graduate	35.2
Doctorate	61.23
Post Doctorate Fellowship/ Others	0.07
<b>EXPERIENCE (IN YEARS)</b>	
Less than 5	10.6
5-10	35.2
10-15	28.2
15-20	10.6
20-25	9.9
More than 25	5.6
<b>MARITAL STATUS</b>	
Married	89.4
Unmarried	7.0
Single/ Divorced	3.5

Source: Primary data

Table 5.1 Demographic profile

Most of the respondents are females (66.2%) as we witness education sector being dominated by them in the Visakhapatnam city. The female teachers are able to balance work and life with the teaching job which usually have fixed hours of work. This is one of the reasons that married women choose this field as their career as evident with 89.4% of married respondents in my study. Most of the respondents belong to the age group of 30 to 40 years of age and with 61.23% of doctorates. The degree of doctorate is made mandatory for the teachers of the college and hence we find a good percentage of doctorates among the respondents.

5.2.1 Henry Garret Ranking method is used to assess which factors out of the 10 factors selected for the study are most impactful on job satisfaction of private post graduate college teachers in Visakhapatnam city. The factors were ranked as per the ranking method of Henry Garret.

### 5.2.2 Calculation of respondents Rank for 10 factors of job Satisfaction

Factors of Job Satisfaction	Rank									
	1	2	3	4	5	6	7	8	9	10
ability utilization	21	21	21	42	28	14	0	0	28	14
Achievement	42	42	49	21	7	7	0	14	7	0
Promotion	35	35	56	35	21	0	0	0	7	0
Compensation	63	21	21	28	7	21	7	0	7	14
company policies	0	14	7	7	35	7	21	14	35	49
Co-workers	0	7	7	21	35	42	14	28	14	21
nature of work	7	21	14	21	42	42	35	0	7	0
Supervision	0	7	0	0	0	7	70	49	28	28
working conditions	0	7	0	0	14	21	21	70	28	28
social status	21	21	7	14	0	28	21	14	21	42

Source: Primary data

Table 5.2: Respondents Ranking for Job Satisfaction factor

Table 5.2 displays the number of respondents giving the ranks for each factor of job satisfaction. 49 members have ranked the factor ‘company policy’ in the 10<sup>th</sup> position and no one has ranked this factor in the first position. 63 respondents have ranked ‘compensation’ in the first position, 42 respondents have ranked ‘achievement’ in the 1<sup>st</sup> position and 35 respondents ranked ‘promotion’ in the 1<sup>st</sup> position. These factors are valued important by the respondents towards job satisfaction when compared to other factors. None of the respondents have ranked ‘company policy’, ‘co-workers’, ‘supervision’ and ‘working condition’ in the 1<sup>st</sup> position. Instead, 70 respondents have ranked ‘working conditions’ in 8<sup>th</sup> position and ‘supervision’ in 7<sup>th</sup> position. These factors are not considered important by the respondents towards job satisfaction when compared to the other factors.

**5.3 Garret Value with percentage position value**

Factors of Job Satisfaction	percentage position value	Garret value
ability utilization	5	82
Recognition & appreciation	15	70
Promotion	25	63
Compensation	35	58
company policies	45	52
Co-workers	55	48
nature of work	65	42
Supervision	75	36
working conditions	85	29
social status	95	18

**Table 5.3: Garret value with percentage position value**

The percentage position values for each rank is found by using the formula as given below

**Percent position value = 100 (R – 0.5) / N**

Here, N=10 (as there are 10 job satisfaction factors)

Garret value for each rank is found from Henry Garret table for the respective percent position value.

**5.4 Henry Garret Rank for Job Satisfaction factors**

5.4.1 **Factor total:** The factor total is found for each of the 10 factors.

Factors of Job Satisfaction	1st*82	2nd*70	3rd*63	4th*58	5th*52	6th*48	7th*42	8th*36	9th*29	10th*18	total
ability utilization	1722	1470	1323	2436	1456	672	0	0	812	252	10143
Achievement	3444	2940	3087	1218	364	336	0	504	203	0	12096
Promotion	2870	2450	3528	2030	1092	0	0	0	203	0	12173
compensation	5166	1470	1323	1624	364	1008	294	0	203	252	11704
company policies	0	980	441	406	1820	336	882	504	1015	882	7266
Coworkers	0	490	441	1218	1820	2016	588	1008	406	378	8365
nature of work	574	1470	882	1218	2184	2016	1470	0	203	0	10017
Supervision	0	490	0	0	0	336	2940	1764	812	504	6846
working conditions	0	490	0	0	728	1008	882	2520	812	504	6944
social status	1722	1470	441	812	0	1344	882	504	609	756	8540

**Table 5.4.1: Factor total**

**5.4.2 Ranking of Job satisfaction factors**

Factors of Job Satisfaction	Total	Average score	RANK
ability utilization	10143	53.67	4
Achievement	12096	64.00	2
Promotion	12173	64.41	1
Compensation	11704	61.93	3
company policies	7266	38.44	8
Coworkers	8365	44.26	7
nature of work	10017	53.00	5
Supervision	6846	36.22	10
working conditions	6944	36.74	9
social status	8540	45.19	6

**Table 5.4.2: Ranking of Job satisfaction factors**

The Henry Garret rank is found by calculating average score for each factor.

**Average Score for each factor = Total response for each factor / Total number of respondents**

Here, total number of respondents are 189.

Average score for each factor is calculated using above formula. The factor with the highest average score is ranked first. The next highest average score is ranked second and so on.

## VI. DISCUSSION & CONCLUSION

Here, the factor promotion has the highest average score of 64.41 and hence is ranked first. Though the vertical levels of hierarchy are less in any educational institutions and hence the opportunities of promotion are less, the teachers expect promotion to senior positions. The factor promotion is the most significant factor in affecting the job satisfaction of private college teachers. This implies that those respondents getting promotion would be highly satisfied when compared to those not being promoted.

The second most influencing factor is Recognition & appreciation (average score of 64.00). The teachers are satisfied if their work and performances are recognised or appreciated. This motivates them to perform better. Compensation is ranked 3<sup>rd</sup> (average score of 61.93). A study by Pronay (2011)<sup>6</sup> and Ghafoor (2012)<sup>7</sup> revealed that the teachers receiving less salary /compensation were not satisfied. This shows how important the compensation factor is for the job satisfaction.

With an average score of 53.67, ability utilization is ranked 4<sup>th</sup> by the respondents, nature of work is ranked 5<sup>th</sup> (average

score of 53.00) and social status (average score of 45.19) is ranked 6<sup>th</sup> by the respondents.

The factors co-workers (average score of 44.26) and company policy (average score of 38.44) stands in 7<sup>th</sup> and 8<sup>th</sup> rank as per the respondents. The relationship with the co-workers and company policy of the college is not so important for these respondents of Visakhapatnam city. Working condition (average score of 36.74) is ranked 9<sup>th</sup> and supervision (average score of 35.15) is ranked 10<sup>th</sup>. All these factors are not so important for the employees.

As per the Herzberg's two factor theory, the factors namely co-workers, company policy, working conditions and supervision belong to the category of Hygiene factors whose absence will demotivate the employees but the presence do not motivate them. Hence these factors do not play a big role in influencing job satisfaction of employees. The factors namely promotion, Recognition and ability utilization belong to the category of motivators of Hygiene theory. The absence of these factors demotivates the employees and hence the role of these factors is worth enough to influence the job satisfaction of the employees (Herzberg, et.al, 1957)<sup>8</sup>. The factor namely compensation is valued by the respondents in affecting job satisfaction but this factor belongs to the Hygiene factor of Herzberg's theory which was contradicted by many researchers as compensation is one of the highly influencing factors of job satisfaction. In the study of Ghafoor (2012), it was found that the teachers with higher salary were more satisfied than with teachers of less salary.

## REFERENCES

- <sup>1</sup> Bretz, R. D., and Thomas, S. L. (1992), "Perceived Equity, Motivation, and final offer Arbitration in major league baseball", *Journal of Applied Psychology*, p. 280-287.
- <sup>2</sup> Newstrom, J. W. (2007), "Organizational Behavior", 12th edition Tata McGraw-Hill Publishing Company Limited New Delhi. p. 204-205
- <sup>3</sup> Hoppok, R., & Spielgler. (1938). "Job Satisfaction", *Occupations: The Vocational Guidance Journal*, 16(7), p. 636-643. Retrieved from <http://onlinelibrary.wiley.com/doi/10.1002/j.21645892.1938.tb00348.x/abstract>
- <sup>4</sup> Bilal, H. (2012), "Job Satisfaction of University Teachers: Impact of Working Conditions and Compensation", *Society of Interdisciplinary Business Research*, 1(1), p.101-113.
- <sup>5</sup> Bavendam, J. (2000), "Effective Management through Measurement", *Special Reports, Volume. (6). Managing Job Satisfaction*. Bevendam Research Inc.
- <sup>6</sup> Pronay, B. (2011), "Job Satisfaction of Non- Government College Teachers in Bangladesh", *Journal of Education and Practice*, 2(4), p.87-92.
- <sup>7</sup> Ghafoor, M. M. (2012), "Role of Demographic Characteristics on Job Satisfaction" *Far East Journal of Psychology and Business*, 6(1), p.30-45
- <sup>8</sup> Herzberg, F., Mausner, B., Peterson, R., & Capwell, D. (1957), "Job attitudes: Review of research and opinion", *Pittsburg: Psychological Service of Pittsburg*

# A Study on Job Satisfaction of Private Post Graduate College Teachers in Visakhapatnam City Using Henry Garrett Ranking Technique

<sup>1</sup>DR. CHAMOLI ANJANA, <sup>2</sup>DR. VINAY CHAITANYA GANTA

<sup>1</sup>HOD - Asst. Professor, <sup>2</sup>Assistant Professor, Department of Management Studies, Dr. Lankapalli Bullayya College, Visakhapatnam, Andhra Pradesh, India.

**ABSTRACT** - There may be various factors that can lead to a success of any educational institute but teachers are the eminent factor for the success of any institute. Teachers are the pillars of any society. They are the one who shape the future citizens of the society. Hence the job satisfaction of the teachers is an eminent and pivotal responsibility of any society. A satisfied teacher is happier and is more sincere towards his or her work and hence his/her performance. They perform well and are motivated to do best for the students and hence developing the society as a whole. This study is conducted to rank the various factors of job satisfaction of the teachers (like ability utilization, achievement, promotion, compensation, company policies. Co-workers, nature of work, supervision, working condition and social status. in private colleges of the Visakhapatnam by using Henry Garrett Ranking method. It is used to find out the most significant factor that influences job satisfaction.

**Keywords:** *Job Satisfaction, Happy, Teachers, Motivated, Performance.*

## I. INTRODUCTION

The growth and success of any institute/ college depends upon the efficiency and capability of their teachers. So the management needs to effectively utilize and tap the potentials of them. At the the same time the success also depends upon the sincerity and commitment of these teachers. All these becomes easy if the teachers have job satisfaction. Therefore, it is indisputable that the due consideration should be given to the factors influencing job satisfactions. Satisfactory performance can be expected from a teacher when he/ she is satisfied with the work. If there is job dissatisfaction, it results in low performance (Bretz & Thomas, 1992)<sup>1</sup>. The government is also consistently striving to improve the quality of the education especially of the higher education, but all the hard work would go into vain if the teachers are not satisfied. A satisfied teacher would perform better than a one who is not satisfied.

## II. REVIEW OF LITERATURE

Job satisfaction is a combination of emotions that employees possess towards role they are performing at the work place. Job Satisfaction is the essential component for employee motivation and encouragement towards better performance. According to Newstrom (2007)<sup>2</sup>, job satisfaction is a set of favourable or unfavourable feeling and emotions with which employee view their work and the supervisors need to be alert about employee job satisfaction level. Hoppok & Spielgler (1938)<sup>3</sup> defines job satisfaction as the integrated set

of psychological, physiological and environmental conditions that encourage employees to admit that they are satisfied or happy with their jobs.

The study of Bilal (2012)<sup>4</sup> has shown relationship between job satisfaction and compensation and working conditions. A teacher should be rewarded and recognized for her services otherwise his/ her satisfaction level might decrease which can have an impact on his/ her performance. Bavendam (2000)<sup>5</sup> opines that the job satisfaction of teachers is very important as otherwise their attitude will have an impact on the learning process of their students. A satisfied teacher performs well and have positive impact on performance and quality of teaching and retention rate is also higher for such teachers.

## III. OBJECTIVE OF THE STUDY

The main objective of the study is to rank the various factors affecting the job satisfaction of the private degree college teachers in the Visakhapatnam city and to find the most significant factor influencing the job satisfaction.

## IV. METHODOLOGY OF THE STUDY

Both the primary and the secondary data were collected for the study. The secondary data was collected from the websites and various journals and books. Primary data was collected by administering a questionnaire to rank the factors and also through interactions with the teachers directly.

The questionnaire was administered to 250 teachers of different private post graduate colleges in the

Visakhapatnam city who were selected through convenience sampling technique. Out of these respondents, 61 didn't respond or gave incomplete answers. Only 189 responses were complete and were considered for the study and analysis.

Henry Garret Ranking method was used as a statistical tool to rank the 10 factors (namely ability utilization, recognition & achievement, promotion, compensation, company policies. Co-workers, nature of work, supervision, working condition and social status) affecting job satisfaction of private post graduate college teachers of Visakhapatnam city.

Henry Garret techniques is used by the researchers in their study where there are many factors or determinants that need to be ranked to find out the most significance factor that influences the respondents. The merits given by the respondents are converted into ranks by using a formula. In this technique, respondents assign the rank for all factors and the outcomes of these ranks are converted into score value with the help of the following formula:

$$\text{Percent position} = 100 (R_{ij} - 0.5) / N_j$$

Where  $R_{ij}$  = Rank given for the  $i$ th variable by  $j$ th respondents

$N_j$  = Number of variables ranked by  $j$ th respondent

## V. ANALYSIS AND INTERPRETATION

### 1.1 Demographic profile of the respondents

Demographic variable	Respondents (In percentages)
<b>GENDER</b>	
Male	33.8
Female	66.2
<b>AGE(IN YEARS)</b>	
Less than 30	7

30-40	49.3
40-50	35.2
Above 50	8.5
<b>EDUCATIONAL QUALIFICATION</b>	
Degree	3.5
Masters/ Post Graduate	35.2
Doctorate	61.23
Post Doctorate Fellowship/ Others	0.07
<b>EXPERIENCE (IN YEARS)</b>	
Less than 5	10.6
5-10	35.2
10-15	28.2
15-20	10.6
20-25	9.9
More than 25	5.6
<b>MARITAL STATUS</b>	
Married	89.4
Unmarried	7.0
Single/ Divorced	3.5

Source: Primary data

Table 5.1 Demographic profile

Most of the respondents are females (66.2%) as we witness education sector being dominated by them in the Visakhapatnam city. The female teachers are able to balance work and life with the teaching job which usually have fixed hours of work. This is one of the reasons that married women choose this field as their career as evident with 89.4% of married respondents in my study. Most of the respondents belong to the age group of 30 to 40 years of age and with 61.23% of doctorates. The degree of doctorate is made mandatory for the teachers of the college and hence we find a good percentage of doctorates among the respondents.

5.2.1 Henry Garret Ranking method is used to assess which factors out of the 10 factors selected for the study are most impactful on job satisfaction of private post graduate college teachers in Visakhapatnam city. The factors were ranked as per the ranking method of Henry Garret.

### 5.2.2 Calculation of respondents Rank for 10 factors of job Satisfaction

Factors of Job Satisfaction	Rank									
	1	2	3	4	5	6	7	8	9	10
ability utilization	21	21	21	42	28	14	0	0	28	14
Achievement	42	42	49	21	7	7	0	14	7	0
Promotion	35	35	56	35	21	0	0	0	7	0
Compensation	63	21	21	28	7	21	7	0	7	14
company policies	0	14	7	7	35	7	21	14	35	49
Co-workers	0	7	7	21	35	42	14	28	14	21
nature of work	7	21	14	21	42	42	35	0	7	0
Supervision	0	7	0	0	0	7	70	49	28	28
working conditions	0	7	0	0	14	21	21	70	28	28
social status	21	21	7	14	0	28	21	14	21	42

Source: Primary data

Table 5.2: Respondents Ranking for Job Satisfaction factor

Table 5.2 displays the number of respondents giving the ranks for each factor of job satisfaction. 49 members have ranked the factor ‘company policy’ in the 10<sup>th</sup> position and no one has ranked this factor in the first position. 63 respondents have ranked ‘compensation’ in the first position, 42 respondents have ranked ‘achievement’ in the 1<sup>st</sup> position and 35 respondents ranked ‘promotion’ in the 1<sup>st</sup> position. These factors are valued important by the respondents towards job satisfaction when compared to other factors. None of the respondents have ranked ‘company policy’, ‘co-workers’, ‘supervision’ and ‘working condition’ in the 1<sup>st</sup> position. Instead, 70 respondents have ranked ‘working conditions’ in 8<sup>th</sup> position and ‘supervision’ in 7<sup>th</sup> position. These factors are not considered important by the respondents towards job satisfaction when compared to the other factors.

### 5.3 Garret Value with percentage position value

Factors of Job Satisfaction	percentage position value	Garret value
ability utilization	5	82
Recognition & appreciation	15	70
Promotion	25	63
Compensation	35	58
company policies	45	52
Co-workers	55	48
nature of work	65	42
Supervision	75	36
working conditions	85	29
social status	95	18

**Table 5.3: Garret value with percentage position value**

The percentage position values for each rank is found by using the formula as given below

$$\text{Percent position value} = 100 (R - 0.5) / N$$

Here, N=10 (as there are 10 job satisfaction factors)

Garret value for each rank is found from Henry Garret table for the respective percent position value.

### 5.4 Henry Garret Rank for Job Satisfaction factors

5.4.1 **Factor total:** The factor total is found for each of the 10 factors.

Factors of Job Satisfaction	1st*82	2nd*70	3rd*63	4th*58	5th*52	6th*48	7th*42	8th*36	9th*29	10th*18	total
ability utilization	1722	1470	1323	2436	1456	672	0	0	812	252	10143
Achievement	3444	2940	3087	1218	364	336	0	504	203	0	12096
Promotion	2870	2450	3528	2030	1092	0	0	0	203	0	12173
compensation	5166	1470	1323	1624	364	1008	294	0	203	252	11704
company policies	0	980	441	406	1820	336	882	504	1015	882	7266
Coworkers	0	490	441	1218	1820	2016	588	1008	406	378	8365
nature of work	574	1470	882	1218	2184	2016	1470	0	203	0	10017
Supervision	0	490	0	0	0	336	2940	1764	812	504	6846
working conditions	0	490	0	0	728	1008	882	2520	812	504	6944
social status	1722	1470	441	812	0	1344	882	504	609	756	8540

**Table 5.4.1: Factor total**

### 5.4.2 Ranking of Job satisfaction factors

Factors of Job Satisfaction	Total	Average score	RANK
ability utilization	10143	53.67	4
Achievement	12096	64.00	2
Promotion	12173	64.41	1
Compensation	11704	61.93	3
company policies	7266	38.44	8
Coworkers	8365	44.26	7
nature of work	10017	53.00	5
Supervision	6846	36.22	10
working conditions	6944	36.74	9
social status	8540	45.19	6

**Table 5.4.2: Ranking of Job satisfaction factors**

The Henry Garret rank is found by calculating average score for each factor.

**Average Score for each factor = Total response for each factor / Total number of respondents**

Here, total number of respondents are 189.

Average score for each factor is calculated using above formula. The factor with the highest average score is ranked first. The next highest average score is ranked second and so on.

## VI. DISCUSSION & CONCLUSION

Here, the factor promotion has the highest average score of 64.41 and hence is ranked first. Though the vertical levels of hierarchy are less in any educational institutions and hence the opportunities of promotion are less, the teachers expect promotion to senior positions. The factor promotion is the most significant factor in affecting the job satisfaction of private college teachers. This implies that those respondents getting promotion would be highly satisfied when compared to those not being promoted.

The second most influencing factor is Recognition & appreciation (average score of 64.00). The teachers are satisfied if their work and performances are recognised or appreciated. This motivates them to perform better. Compensation is ranked 3<sup>rd</sup> (average score of 61.93). A study by Pronay (2011)<sup>6</sup> and Ghafoor (2012)<sup>7</sup> revealed that the teachers receiving less salary /compensation were not satisfied. This shows how important the compensation factor is for the job satisfaction.

With an average score of 53.67, ability utilization is ranked 4<sup>th</sup> by the respondents, nature of work is ranked 5<sup>th</sup> (average

score of 53.00) and social status (average score of 45.19) is ranked 6<sup>th</sup> by the respondents.

The factors co-workers (average score of 44.26) and company policy (average score of 38.44) stands in 7<sup>th</sup> and 8<sup>th</sup> rank as per the respondents. The relationship with the co-workers and company policy of the college is not so important for these respondents of Visakhapatnam city. Working condition (average score of 36.74) is ranked 9<sup>th</sup> and supervision (average score of 35.15) is ranked 10<sup>th</sup>. All these factors are not so important for the employees.

As per the Herzberg's two factor theory, the factors namely co-workers, company policy, working conditions and supervision belong to the category of Hygiene factors whose absence will demotivate the employees but the presence do not motivate them. Hence these factors do not play a big role in influencing job satisfaction of employees. The factors namely promotion, Recognition and ability utilization belong to the category of motivators of Hygiene theory. The absence of these factors demotivates the employees and hence the role of these factors is worth enough to influence the job satisfaction of the employees (Herzberg, et.al, 1957)<sup>8</sup>. The factor namely compensation is valued by the respondents in affecting job satisfaction but this factor belongs to the Hygiene factor of Herzberg's theory which was contradicted by many researchers as compensation is one of the highly influencing factors of job satisfaction. In the study of Ghafoor (2012), it was found that the teachers with higher salary were more satisfied than with teachers of less salary.

## REFERENCES

- <sup>1</sup> Bretz, R. D., and Thomas, S. L. (1992), "Perceived Equity, Motivation, and final offer Arbitration in major league baseball", *Journal of Applied Psychology*, p. 280-287.
- <sup>2</sup> Newstrom, J. W. (2007), "Organizational Behavior", 12th edition Tata McGraw-Hill Publishing Company Limited New Delhi. p. 204-205
- <sup>3</sup> Hoppok, R., & Spielgler. (1938). "Job Satisfaction", *Occupations: The Vocational Guidance Journal*, 16(7), p. 636-643. Retrieved from <http://onlinelibrary.wiley.com/doi/10.1002/j.21645892.1938.tb00348.x/abstract>
- <sup>4</sup> Bilal, H. (2012), "Job Satisfaction of University Teachers: Impact of Working Conditions and Compensation", *Society of Interdisciplinary Business Research*, 1(1), p.101-113.
- <sup>5</sup> Bavendam, J. (2000), "Effective Management through Measurement", *Special Reports, Volume. (6). Managing Job Satisfaction*. Bevendam Research Inc.
- <sup>6</sup> Pronay, B. (2011), "Job Satisfaction of Non- Government College Teachers in Bangladesh", *Journal of Education and Practice*, 2(4), p.87-92.
- <sup>7</sup> Ghafoor, M. M. (2012), "Role of Demographic Characteristics on Job Satisfaction" *Far East Journal of Psychology and Business*, 6(1), p.30-45
- <sup>8</sup> Herzberg, F., Mausner, B., Peterson, R., & Capwell, D. (1957), "Job attitudes: Review of research and opinion", *Pittsburg: Psychological Service of Pittsburg*



# A COMPARATIVE STUDY OF RETAIL BANKING SERVICES OF SBI AND ICICI ON CUSTOMER PERCEPTION LEVELS LEADING TO CUSTOMER SATISFACTION WITH SPECIAL REFERENCE TO VIZAG. A.P

**Dr. KVB Ganesh<sup>1</sup>, Dr.G. Taviti Naidu<sup>2</sup>, Dr. T. Subba Rayudu<sup>3</sup>**

*<sup>1</sup>Assistant Professor, KLEF, Vijayawada*

*<sup>2</sup>Post-Doctoral Fellow, ICSSR, Andra University, Visakhapatnam*

*<sup>3</sup>Associate Professor, Andra Loyola Institute of Engg and Technology*

## ABSTRACT

Indian banking sector is under a competitive trench exclusively, both the private and public bank managements are at a appeal to provide healthier services to their customers in offering valid and efficient services. Customer satisfaction is most vital part of any organization to lead with profit maximization and its necessary to learn the key success factors impacting it and which leads to enhance real earning to the bank and in turn has proven crucial in order to increase customers in number. To develop and sustain business of a bank, they must ensure quality in customer service that can associate a cordial relationship with the customer. The present research article is an effort to measure satisfaction level of customers and identify the factors which promote the future growth of banking services of SBI and ICICI banks sited in Vizag. In banking sector, the whole range of activity and generation of income spins around the customer satisfaction, over the perception of bank serviceability.

**Key Words:** Retail Banking, Customer Satisfaction, Electronic fund transfer, documentation, Security levels, Serviceability.

## I. INTRODUCTION

Banking sector is a companion of government and status of financial development in the Indian economy. Government not only sets standards but protects and nourishes Indian banks from all types of competition, both from internal and external environment right from the establishment and nationalisation of banks. Through the reforms made from liberalisation, privatisation and globalisation the banks are merging with the standards and quality measures in the international accords. The concept of customer satisfaction was majorly limited to studies and recommendations from the various committees in early eighties. Since banking has undergone various reforms and drastic changes have taken place, facing intense competition in the market (Chandhari and Halbrook, 2002). With the emergence of new generation tech-savvy private banks and the expansion of operations of foreign banks, the banking sector has become too competitive to ignore “customer satisfaction”. Bedi (2010) mentioned that today's customer is not ready to settle anything less, than his or her expectations. Therefore, it is evident that banks must get aware of themselves about what customer need is and in fact provide it with a priority positioning in their policy planning.

In the span of mature and intense competitive pressure, it is imperative that banks have to maintain a robust and loyal customer base. The augmented internal and external competition in the area of banking has led to the profit compression compelling them to work proficiently with the available resources. The customer demand for comfort and security provided in lieu with cash transactions compared to digital services, making the bank operations more legible. There has been always positive relationship between the banks and their technologized services to capture market demographics and customers satisfactions with high orientation in service improvisation. The study of demographics reveals that the banks are facing problem in order to capture new customers from the market share where it is, costlier than the cost of retaining existing customer. Therefore, satisfied services of the accounties i.e., educated employees, businessman and youngsters who are a customised to technically equipped infrastructure and get updated with usage of services are assets for the banks who can make a positive promotion. Public sector banks are also making efforts to stay in the league of modern tech savvy

banks, for example online transactions, ATMs, host of products like special savings account and sweep-in-account, no frills account (merged with the basic savings bank deposits account in 2010 by RBI) and easy receive accounts, cash back offers in order to promote digitalisation of transactions etc, Private sector banks may have appeared to be winning the race, but public-sector banks, with their vast client base and unparalleled treasury of trust, are evolving their own brand of customer-friendliness. Public sector banks have also understood that in the era of competition, customer satisfaction is the key to success.

## II. LITERATURE:

The previous studies mainly reveal the diminishing trends of public sector banks and increasing eminence of new private sector banks and foreign banks. Sathye (2003) has analysed the productive proficiency of banks in India. All commercial banks in the market try to sell mere products (Cross-selling), adopt new self-motivated marketing strategies, to develop new innovative products and to place greater emphasis on both the existing and insubstantial aspects of their service (Petridon and Glaveli, 2003). As a result of this discriminating competition, bank service quality has become an increasingly important factor in determining market shares and profitability in the banking sector (Anderson et al., 1994; Spathis et al., 2002). Perceived service quality is a point of measurement from a comparison of consumer's expectation with their perceptions of the service delivered by the supplier (Kangis and Voukelatos, 1997). Gronross defined service quality as a mixture of three elements the quality of the consumption process itself is the quality of the outcomes of the process; and image of the provider of the service.

In order, to attain a goal of profit maximization, a company should have a high satisfaction rate from its clients. Though ultimate intention is to lead profit, substantially compelling the banking sector to pay much and more attention to satisfy customers (Management library, 2008). Researchers suggest that increased levels of customer satisfaction and loyalty are frequently attributed, linked to positive outcomes for a firm (Colgate, 1999). Measuring dimension of rate of customer satisfaction is also a measurement of how products and services supplied by an industry or bank, surpass customer expectation and it acts as a key performance indicator. This is due to the fact that one of the factors needed in order to attain high competency and also high competitiveness with a high market share through an increased, established and well sustained client population.

### Need for the study:

Though great study and literature has been constructed on banking and their developments to cope with upgraded infrastructure and customer service improvement still there is a great dearth which arrives with the customer perception, their expectations with service orientation, to improve customer loyalty. Both the public and private sector banks are competing in the market to improve the customer satisfaction to lead with customer loyalty. The present study is an approach made by the researcher to clear and attain a solution to problem lying between the customer expectations and provision of services in three different dimensions of the service transaction made by bankers with two most efficient and popular banks of Vizag city.

### Objectives:

- 1) To know the customer satisfaction level with regarding to fund transfer in SBI a public and ICICI a private sector bank.
- 2) To study satisfaction level of a customer in concern with the security levels of both the banks in Vizag.
- 3) To assess documentation process time and its satisfaction level of both banks in the customer point of view.

### Scope and limitations of the study:

The scope of the study is limited to the SBI and ICICI customer services data collected in the district of Vizag East, Telangana region. The study is pertaining to the period of data collection for six months from Oct 2016 to March 2017. And the study is limited to its certain locational branches and data collection limitations from the customer perception revelations.

## III. RESEARCH METHODOLOGY:

The research is purely based on the customer data collected through SBI a public sector and ICICI, a private sector bank. Customers' opinion was considered in Vizag city respondents to measure their satisfaction level with the help of a structured questionnaire for the collection of the primary data and the descriptive research has made

from the secondary data collection for the construction of an article from various sources such as the banks bulletins, various journals, thesis, and websites.

**Sample Size:**

Samples of 130 questionnaires were being distributed in the main areas of Maddilapalem, HB colony seetammadhara and MVP, areas of both ICICI and SBI. Where among those only 80 were returned from the customers of both banks and 30 of both the bank questionnaires were rejected due to the incomplete data found and only out of total collected 50 questionnaires were taken in to consideration for comparative study analysis of both banks in 3:2 ratio.

**Hypothesis:**

H01: There is no significant association between the type of bank and customer satisfaction levels towards electronic fund transfer.

H02: There is no significant association between type of bank and customer satisfaction levels towards bank security system.

H03: There is no significant association between type of bank and customer satisfactions towards documentation process.

Test of Reliability Table No: 1

Reliability Statistics		
Name of Bank	Cronbach's Alpha	No. of Items
SBI	.926	17
ICICI	.852	17

The test of reliability has been conducted in order to test the data standards and whether the data is suitable for further data analysis.

Table No:2

Scale Statistics				
Name of Bank	Mean	Variance	*Std. Deviation	No. of Items
SBI	65.25	119.454	10.929	17
ICICI	56.59	45.007	6.709	17

\*Std. Deviation- Standard Deviation

**Inference:** Cronbach’s alpha has been run for a check of their reliability. The above table displays some of the results obtained. The overall alpha for all items is 0.926 and 0.852 for two respective banks, which is high and indicates strong internal consistency among the given items.

**H<sub>01</sub>:** There is no significant association between type of bank and consumer satisfaction levels towards electronic fund transfer.

Table No: 3

Crosstab								
Particulars			E-fund transfer					Total
			Extremely satisfied	Satisfied	Somewhat satisfied	Dissatisfied	Extremely dissatisfied	
Name of the Bank	SBI	Count	1	2	4	15	8	30
		% within the type of Bank	3.3%	6.7%	13.3%	50.0%	26.7%	100.0%
	ICICI	Count	0	0	12	8	0	20
		% within the type of Bank	0.0%	0.0%	60.0%	40.0%	0.0%	100.0%

Total	Count	1	2	16	23	8	50
	% within the type of Bank	2.0%	4.0%	32.0%	46.0%	16.0%	100.0%

The above cross tab (table) indicates that, customers of both the banks are somewhat dissatisfied with e-fund transfer option but if we find out the satisfaction level of ICICI customers is better than SBI, in case of electronic fund transfer

Table No: 4

Chi-Square Tests			
Particulars	Value	Degrees of Freedom	Asymptotic Significance. (2-sided)
Pearson Chi-Square	15.761 <sup>a</sup>	4	.003
Likelihood Ratio	19.586	4	.001
Linear-by-Linear Association	4.027	1	.045
N of Valid Cases	50		

a. 6 cells (60.0%) have expected count less than 5. The minimum expected count is .40.

From the above table chi square is significant value is < 0.05, **reject null hypothesis**. The customer opinion regarding electronic fund transfer of both transfer is different i.e., the ICICI bank customers are to somewhat happy comparatively with SBI customers in above test.

H<sub>02</sub>: There is no relation between type of bank and consumer satisfaction levels towards bank security system

Table No: 5

Crosstab							
Particulars		17.6Security system inside the bank				Total	
		Extremely dissatisfied	Dissatisfied	Somewhat satisfied	Satisfied		
Name of Bank	SBI	Count	3	3	17	7	30
		% within the type of Bank	10.0%	10.0%	56.7%	23.3%	100.0%
	ICICI	Count	1	5	14	0	20
		% within the type of Bank	5.0%	25.0%	70.0%	0.0%	100.0%
Total		Count	4	8	31	7	50
		% within the type of Bank	8.0%	16.0%	62.0%	14.0%	100.0%

The above cross table value is also reflecting that, ICICI customers are little more satisfied than SBI customers with reference to bank security system though, both the banks are maintaining good standards in this regard.

Table No: 6

Chi-Square Tests			
Particulars	Value	Degrees of Freedom	Asymptotic Significance (2-sided)
Pearson Chi-Square	7.073 <sup>a</sup>	3	<b>.070</b>
Likelihood Ratio	9.533	3	.023
Linear-by-Linear Association	1.607	1	.205
N of Valid Cases	50		

a. 6 cells (75.0%) have expected count less than 5. The minimum expected count is 1.60.

From the above table chi square is not significant (sig. (significant) value is > 0.05), **no evidence to reject null hypothesis**. Almost both the banks in the Vizag East city are maintaining good security system for their premises to protect customer’s valuable money and jewellery, the same reflected in above study also.

H<sub>03</sub>: There is no significant association between type of bank and consumer satisfactions towards documentation process.

Table No: 7

Crosstab							
Particulars			Speed of Documentation				Total
			Extremely dissatisfied	Dissatisfied	Somewhat satisfied	Satisfied	
Name of Bank	SBI	Count	3	8	11	8	30
		% within the type of Bank	10.0%	26.7%	36.7%	26.7%	100.0%
	ICICI	Count	1	10	9	0	20
		% within the type of Bank	5.0%	50.0%	45.0%	0.0%	100.0%
Total		Count	4	18	20	8	50
		% within the type of Bank	8.0%	36.0%	40.0%	16.0%	100.0%

The above analysis table indicates that with respect to documentation process both the banks' customers are partially satisfied with the process and to some extent the dissatisfaction level is high with the ICICI the private sector bank compared to SBI a public-sector bank.

Table No: 8

Chi-Square Tests			
Particulars	Value	Degrees of Freedom	Asymptotic Significance (2-sided)
Pearson Chi-Square	7.731 <sup>a</sup>	3	.052
Likelihood Ratio	10.546	3	.014
Linear-by-Linear Association	2.649	1	.104
N of Valid Cases	50		
a. 4 cells (50.0%) have expected count less than 5. The minimum expected count is 1.60.			

From the above table chi square is significant (sig. (significant) value is  $\leq 0.05$ ), **reject null hypothesis**. Though SBI bank documentation process was little lengthy and tedious compare with ICICI bank documentation processing. The ICICI customers are feeling dissatisfaction with bank documentation time and process as a point of negligence towards the customers' requirements with speediness.

Table No: 9

Null Hypotheses	Significant Value	Result
H01: There is no significant association between type of bank and consumer satisfaction levels towards electronic fund transfer.	0.003	Rejected
H02: There is no significant association between type of bank and consumer satisfaction levels towards bank security system.	0.070	Accepted
H03: There is no significant association between type of bank and consumer satisfactions towards documentation process.	0.052	Rejected

**Regression (Overall Customer Satisfaction)**

Table No: 10

Model Summary
---------------

Name of Bank	Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
SBI	1	.814 <sup>a</sup>	.663	.593	.7921
ICICI	1	.952 <sup>b</sup>	.907	.873	.4799
1. Predictors: (Constant), 1.a. Communication with customers, 1.b. Maintenance of documents, 1.c. Security system inside the bank, 1.d. Speed of documentation, 1e. Locker facilities					
2. Predictors: (Constant), 2. a. Communication with customers, 2. b. Speed of documentation, 2. c. Maintenance of documents, 2. d. Locker facilities, 2.e. Security system inside the bank					

**Regression (Overall Customer Satisfaction)**

**R:** represents the multiple correlation coefficients with a range lies between 0 and +1. Since the R value of 0.757 it means dependent variable of overall bank customer satisfaction is positively correlated with independent variables. The variables are e-fund transfer, Bank Security system and complaint redressal time followed by documents maintenance.

**R square:** represents the coefficient of determination and ranges between 0 and 1. Since the R square value is 0.573, it means 57.3 % of the variation explained by dependent variable in terms of independent variables.

**Analysis through Anova**

Table No: 11

ANOVA <sup>a</sup>							
Name of Bank	Model	Sum of Squares	Degrees of freedom	Mean Square	F	Significance	
SBI	1	Regression	29.642	5	5.928	9.449	.000 <sup>b</sup>
		Residual	15.058	24	.627		
		Total	44.700	29			
ICICI	1	Regression	31.326	5	6.265	27.203	.000 <sup>c</sup>
		Residual	3.224	14	.230		
		Total	34.550	19			
1. Dependent Variable:1 OVERALL CUSTOMER SATISFACTION							
2. Predictors: (Constant), 2. a. Communication with customers, 2. b. Maintenance of documents, 2.c. Speed of documentation, 2.e. locker facilities, 2.f. Security system inside the bank.							
3. Predictors: (Constant), 3. a. Communication with customers, 3. b. Speed of documentation, 3.c. Maintenance of documents, 3.d. Locker facilities, 3.e. Security system inside the bank							

From the ANOVA table F, Where sig.(significant) Value is 0.000 < 0.05 it means that the dependent variable overall customer satisfaction is more efficient.

Table No: 12

Coefficients							
Type of Bank	Model	Unstandardized Coefficients		Standardized Coefficients	t (regression coefficient)	Significance	
		B (Slope Line)	Standard Error	Beta			
Public Sector SBI	1	(Constant)	-2.036	1.023		-1.990	.058
		1.a. Security system inside the bank	.059	.194	.041	.305	.763
		1.b. Maintenance of documents	.535	.300	.308	1.782	.087
		1.c. Speed of documentation	.133	.216	.103	.618	.542
		1.d. Locker facilities	.556	.246	.441	2.264	.033
		1.e. Communication with customers	.283	.241	.237	1.173	.252
Private Sector ICICI	1	(Constant)	-8.105	1.004		-8.072	.000
		2.a. Security system inside the bank	-.286	.298	-.125	-.961	.353

	2.b. Maintenance of documents	1.391	.305	.527	4.557	.000
	2.c. Speed of documentation	1.567	.304	.695	5.148	.000
	2.d. Locker facilities	.269	.135	.254	1.984	.067
	2.e. Communication with customers	.222	.140	.181	1.586	.135
a. Dependent Variable: OVERALL CUSTOMER SATISFACTION						

From the above table the required multiple regression line is

**Overall Customer Satisfaction (public sector banks) = -2.036 + 0.059 (Security system inside the bank) + 0.535 (maintenance of documents) + 0.133 (speed of documentation) + 0.556 (Locker facilities) + 0.283(Communication with customers)**

**Overall Customer Satisfaction (private sector banks) = -8.105 - 0.286 (Security system inside the bank) + 1.391 (maintenance of documents) + 1.567 (speed of documentation) + 0.269 (Locker facilities) + 0.222(Communication with customers)**

#### IV. DISCUSSION OF RESULTS:

Due to the wide variation of the responses and perceptions of both public and private bank customers, banks need to improve their weak areas of performance. This study derived on the basis from various data analysis made and also proved through the empirical findings with respect to customer satisfaction. To outline, the outcome of this research which led us to the following conclusion and guiding principle for implication in both public sector & private sector banks (specifically SBI and ICICI):

1. To be successful in banking sector, banks must provide service to their customer that at least meet or better if exceeds their expectations. And the present study will provide some sort of guidelines to the policy makers (managers) of banks to take appropriate decision to improve the quality of services in Indian banking according to the needs and requirements of their customers and better communication as a priority measure as to withhold the customer in long run.

2. The customer satisfaction in terms of quality-oriented service is a relational marketing paradigm. The relationships are mostly viewed from the perspective of the organization providing services. For a service firm, in our case the banks, to build up a strong relationship is an important factor, and it can be achieved by increased satisfaction in customer and make him or her delight with improved efficiency in service quality.

#### V. CONCLUSION:

The Indian banking sector has witnessed heightened competition with many banks coming up with all their potentialities and using their global strength to their advantage in order to establish themselves in the market. Private Banks seem to have satisfied customers with good services and they have been successful in retaining its customers by providing better facilities than Public sector Banks. But, still Private Banks need to go a long way to become customer's first preference. In an economy of innovative technologies and changing markets, each service quality variable has become important. New financial products and services innovative and which can fulfil the requirements and urgency needs of the clients must be introduced to stay competent in the market. Success mantra could be customer centric orientation, where the organization builds long term strategic relationships with its customers and private sector banks have been successful in achieving such relationship with customers however public-sector banks have to improve in this gap area. Private banks need to concentrate more on their credit facilities and insurance services since customers do not have a very good opinion about these facilities being offered by them. Public sector banks enjoy the trust of the customers, which they have been leveraging to stay in the race however they need to improve their service quality by improving their physical facility, infrastructure and most importantly giving proper soft skill trainings to their employees especially in public sector bank. The efforts must be made in the direction to enhance the retail banking experience.

#### REFERENCE

1. Anand, S., Customer Relationship Management in Indian Banks, Journal of Professional Banker, Dec. 2008, pp 66-70.
2. Anderson, E.W., Fornell, C and Sehman, D.R., "Customer Satisfaction, Market Share, and Profitability", Journal of Marketing, 1994, Vol. 58, July, pp. 53-66.

3. Bo Edvardson, "Service quality improvement". Managing Service Quality, The International Journal of Bank Marketing, 1998, Volume 8, pp: 142-149
4. Boyd, William, L., Leonard, Lyros and White, Charles., "Customer preferences for financial services', The International Journal of Bank Marketing, 1994, Vol.12:1, PP. 9-15
5. Bresinger, R.P and Lamtat, D.M "Can the SERVQUAL scale be Generalized to business-to-business service?", Knowledge Development in Marketing, AMA's Summer Educations Conference Proceedings, American Marketing Association, Chicago, IC, 1990, PP. 289
6. CMA Jayashree Ramanan, Dr. K. P. V. Ramana Kumar Chavan Jayshree, "Trends in Retail" International Journal of Business and Management Invention ISSN (Online): 2319 – 8028, ISSN (Print): 2319 – 801X, www.ijbmi.org, 2013, Volume 2 Issue 1 January, PP.55-62
7. Kajal Chaudhary and Monika Sharma, June "Performance of Indian Public-Sector Banks and Private Sector Banks: A Comparative Study", International Journal of Innovation, Management and Technolgy, June, 2011, Vol. 2 and PP. No. 3,
8. Thakur Satyendra, Singh A. P, "Impact of Service Quality on Customer Satisfaction and Loyalty. In the Context of Retail Outlets in DB City Shopping Mall Bhopal", International Journal of Management Research and Review,2011, Feb, Volume – 1, Issue- 1, Article No -3, Research Article.
9. VimiJham and Kaleem M Khan, "Customer Satisfaction with Usage of Banks Distribution Channels: An Empirical Investigation: International Journal of Financial Services Management, 2008, Vol. 3 and pp 283-284.
10. Keerthe P and Vijayalakshmi R. "A Comparative Study On The Perception Level Of The Service Offered By Banks", Indian Journal Of Marketing,2009, Vol.39, No.8, P.40-41

K. Vinaya Laxmi "A Comparative Study of Retail Banking Services of Sbi and Icici on Customer Perception Levels Leading To Customer Satisfaction with Special Reference to Vizag East District. "IOSR Journal of Business and Management (IOSR-JBM) 20.6 (2018): 58-64.



# DETERMINANTS OF DIVIDEND POLICIES FOR SELECT MANUFACTURING COMPANIES IN INDIA: AN EMPIRICAL ANALYSIS

Venkataramana arangi<sup>1</sup>, N. Kishore Babu<sup>2</sup>, Dr. G. Taviti Naidu<sup>3</sup>

<sup>1</sup>Junior Research Fellow, DCMS, Andhra University, Visakhapatnam,

E-mail: vivekarangi@gmail.com

<sup>2</sup>Professor, DCMS, Andhra University, Visakhapatnam,

E-mail: dr.n.kishorebabu@gmail.com

Post Doctoral Fellow, ICSSR, Andhra University, Visakhapatnam,

E-mail: dr.tavitinaidugongada@gmail.com

## ABSTRACT

The purpose of this paper is to make an analysis of the determinants of dividend policy for select manufacturing companies in India. This research topic is one of the advanced topics in corporate finance, and It has its worth doing research in the area of Dividend policy. In this research paper, a sample of four manufacturing companies listed at Bombay stock exchange has been selected using convenience sampling and were considered for analysis. This study re-examines the association between the various factors that have bearing on the dividend decision of the firm on the basis of annual reports of the companies listed in Bombay stock exchange for the period of 2015-2020 by using statistical methods. From the review of the literature, the researcher identified the factors like price earnings ratio, age of the firm, leverage ratio, return on equity, return on equity and earnings per share which affect the dividend pay-out ratio of the company. The empirical evidence from this study reveals that price earnings ratio, leverage ratio, earnings per share have significant impact on the equity dividend and also good predictors of equity dividend in the manufacturing sector.

**Key words:** dividend, manufacturing industry, dividend pay-out ratio, P/E ratio, leverage ratio, earnings per share

## I. INTRODUCTION

Dividend decision is considered as one of the three major decisions of financial management (financial, investing, dividend decision). The decision regarding dividend pay-out is a crucial decision as it determines the amount to be distributed among shareholders of the firm and the amount to be retained by the firm itself for reinvestment purpose. Here, the important internal source to the firm is retained earnings which plays a crucial role in the growth of the firm. The sharing of the available and accumulated profits among the existing shareholders is known as Dividend. The dividend decision will be greatly influenced by investment opportunities available to the firm and value of the firm. Every firm has its own dividend policy having a classification of the Dividend distribution and the retained earnings to ultimately having optimum mix of the both in achieving the maximisation of the wealth to the shareholders, which results finally in the form of high share price. Earnings are one of the most important factors that decide the quantum of dividend to be paid. In general, higher the earnings, will result in higher the level of the dividends. Dividend payment decisions are signals to the investor regarding what the incumbent management thinks about the future of the firm. The payment of a high dividend is considered a positive symptom and vice-versa, which may result in an up or down of the share price. There are so many determinants affect the dividend payment, and they communicate valuation of the firms. It is not challenging task to pick out the variables which impact the dividend payment decisions, however, but difficult to determine is how these factors interrelate among themselves. Since a large number of factors are influencing the level dividend of a company, in this study has researchers attempt to identify the factors that affect the dividend in select companies which belong to the manufacturing industry

The rest of the paper is organized as follows: section 2 presents a brief background of the manufacturing industry in India. Section 3 reviews of the existing literature. Section 4 presents need for the study. Section 5 objectives of the present study. Section 6 describes hypothesis of study. section 7 research methodology. Section 8 discussion. Finally, section 9 conclusion.

## II. BRIEF BACKGROUND OF INDIAN MANUFACTURING INDUSTRY

The manufacturing sector in India went through various phases of development which had a tremendous impact on the Indian economy. Since 1947, the manufacturing sector has gone through the following phases; they can be like from 1950 to 1956 , a basic industrial foundation, between the 1960 to 1980 government interference and the Government holding of the major strategic and the Non-strategic sectors in the manufacturing sector, from 1990s, the P.V.Narasimha Rao government had come up with LPG model to liberalise, Privatise, and globalise the Indian industrial sector, which can be known as turning point to the enhanced development of the Indian economy along with enhanced contribution from service sector to the GDP during the last two decades.(source).

Generally, Employment creation is an important integral part of the policy formations in a nation like India which may help in achieving Inclusive growth. Recently, the Prime Minister of India has come up with a new initiative to create purposeful employment opportunities as well as with an objective of achieving part of the contribution to be made by the industrial sector to GDP is 25% which was named as Make in India flagship scheme in the year 2014(source).

This initiative has created a new phase to several sectors, and also opportunities to Indian companies along with enhanced investments. Those can be categorised into various manufacturing, research and development, partnerships and collaborations or joint ventures, etc. Due to this scheme, both internationalisation and localisation were made possible by reaching the nook and corner of the country. The other factors that attracted the investors are, the huge Market base, Middle class growth phase, demographic dividend and the political stability that made India a trustworthy destination for investments. MII has made all the start-ups to come forward to encash their new ideas and to make India sustainable. The upcoming prospectus of the Indian manufacturing sector contribute majorly towards the GDP as a whole. The shift of the scenario of the world economy, and the international market is going to bring a profound impact on the Indian manufacturing sector in the short, medium, and long run.

## III. REVIEW OF LITERATURE:

Krishna(1963) said that a bird in the hand theory related to dividend distribution. Based on this theory investors are risk free in nature and their prefer dividend income rather than capital gain. The fundamental reason for equity market are uncertain and also information imbalance in the equity market system because investors are prefer dividend payment and not think about capital gains .

Husam et al(2007) scrutinize the determinants of corporate dividend policy in the context of Jordanian companies .this research attempt found that dividend payment decision are mainly dependent determinants on shareholders' interest and the government and further determinants are profitability of company, age of firm and size of firm

Bhattacharya(1979) did not accept the bird in hand theory because compared to dividend capital gains give more advantage to investors and also suggested that the level of dividend depends on the firm's accepted risk.

Mistry (2011) endeavoured to discover the influence of the factors affecting dividend decision of Indian cement industry a division of time from 2004-05 to 2008-09 based on secondary information of 28 out of 36 listed public firms listed NSE. This study shows that selected factors are significantly influence the dividend decision and also identify that confidently effect the chance in total assets and profitability of firm's and changes in the inventory turnover ratio and retained earnings of the company adversely affect dividend decision.

Rao and Sarma (1971) administered determinants of dividends of public and private limited enterprises -an empirical study. This study attempt revealed that the basic Lintner model was adequate to describe the dividend behaviour in the case of the majority of the industries such as coal mining, sugar, jute textiles, chemicals and cement industries.

## IV. NEED FOR THE STUDY

A number of studies talk about the determinants of corporate dividend policy. This study focuses on the various factors and the determinants of the dividend. There is a positive correlation between the profitability of

the company and the dividend paid by the company, that is the direct relationship. But here the profitability is being influenced by both the internal factors and the external factors relating to the company. These factors are useful and important for investors and managers. The awareness of adopting dividend policy is very important for investors and managers because the investors are interested in the information about dividend policies, managers will also tend to predict annual dividend and its distributable percentage so that they can forecast their cash budget and investment policies. This study may be useful to the investors for evaluating the efficiency of the companies for investment purposes, and also sensitize the shareholders about the company's stand regarding the profits. The results of the study help the top-level management to understand the o determinants of the dividend in a better manner, so the researcher has considered the topic as advancing in nature. This study tries to contribute to the existing literature through finding out the determinants of dividend policy in the manufacturing sector. The study also focuses on finding out the factors that might influence the determinants of dividend payment in select manufacturing companies.

## V. OBJECTIVES OF THE STUDY

The main objective of this study is to empirically analyse the determinants of dividend policy. The following are the specific objectives of the paper.

To analyse the dividend determinants of select companies in the Indian manufacturing sector.

To analyse the variation in the impact of dividend pay-out ratio due to price earnings ratio, age of the firm, leverage and profitability of select companies in manufacturing companies in India.

## VI. HYPOTHESES OF THE RESEARCH

H01: There is no significant impact of price earnings ratio on dividend policy.

H02: There is no significant impact of leverage ratio on dividend policy.

H03: There is no significant impact of Earnings per share on dividend policy.

## VII. RESERCH METHODOLOGY;

Variables used in this research dividend pay-out ratio of the firm is taken as the dependent variable, whereas age of the firm, price earnings ratio, leverage and profitability are taken as the independent variables.

$$\text{Dividend pay-out ratio} = \frac{\text{Cash Dividend}}{\text{Net Profit}} \times 100$$

The dividend pay-out ratio provides an idea of how well earnings support the dividend payment. Age of the firm is the number of the activity years of the company which is acquired through the difference between the current year of the establishing the company.

$$\text{Price earnings ratio} = \frac{\text{Market value per share}}{\text{Earnings per share}}$$

Higher price earnings ratio indicates that investors are anticipating higher growth in the future.

$$\text{Leverage} = \frac{\text{Total debt (short term and long term debts)}}{\text{Total share holder's fund}}$$

Profitability of the firm is measured by three parameters i.e., return on equity (ROE), Return on assets (ROA), Earnings per share (EPS).

$$\text{ROE} = \frac{\text{Net profit after preference dividend}}{\text{Book value of equity capital}}$$

$$\text{ROA} = \frac{\text{Net Profit}}{\text{Total asstes}}$$

$$\text{EPS} = \frac{\text{Net Profit}}{\text{Numbe r of Equity shares out standing}}$$

### VIII. DISCUSSION

For the present study a sample of four manufacturing companies listed at Bombay stock exchange (BSE) has been selected using convenience sampling for the period of five years i.e., 2015-16 to 2019-20. Every year is taken to mean an accounting year of the company consisting of twelve months. The companies considered for analysis in this study are Asian paints ltd, Ultra tech ltd, GHCL ltd, Titan ltd. The data have been collected from money control.com and companies' website.

#### Empirical Results:

Table-1: Model Summary:

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	F-Value	P-value
1	.991 <sup>a</sup>	.982	.930	1.10073	18.600	0.168 <sup>b</sup>
2	.946 <sup>a</sup>	.894	.577	2.69772	2.819	0.407 <sup>b</sup>
3	.996 <sup>a</sup>	.991	.965	6.87720	37.786	0.119 <sup>b</sup>
4	.725 <sup>a</sup>	.526	-.895	27.552319	3.721	0.024 <sup>b</sup>

1. Predictors: (Constant), Return on Assets, Leverage ratio, Earnings per share
2. Predictors: (Constant), Price earnings ratio, Earnings per share, Return on Assets
3. Predictors: (Constant), Return on Assets, Earnings per share, Leverage ratio
4. Predictors: (Constant), Return on Assets, Leverage ratio, Earnings per share

The models for dividend pay-out ratio based Return on Assets, Leverage ratio, Earnings per share, Price earnings ratio are formulated based primary data and shown in the above table. In the above table, the first model has shown for Asian paints. Here, the dependent variable is "dividend pay-out ratio" and independent variables are "Return on Assets, Leverage ratio, Earnings per share". It is observed from the above table that there is a positive correlation (0.991) dependent and independent variable. The R-square value (0.982) represents that the model can explain 98.2 percent of the data.

The second model has shown for GHCL. Here, the dependent variable is "dividend pay-out ratio" and independent variables are "Price earnings ratio, Earnings per share, Return on Assets". It is observed from the above table that there is a positive correlation (0.946) dependent and independent variable. The R-square value (0.94.6) represents that the model can explain 98.2 percent of the data.

The third model has shown for Ultratech. Here, the dependent variable is "dividend pay-out ratio" and independent variables are "Return on Assets, Earnings per share, Leverage ratio". It is observed from the above table that there is a positive correlation (0.996) dependent and independent variable. The R-square value (0.991) represents that the model can explain 99.1 percent of the data.

The fourth model has shown for Titan. Here, the dependent variable is "dividend pay-out ratio" and independent variables are "Return on Assets, Leverage ratio, Earnings per share". It is observed from the above table that there is a positive correlation (0.725) dependent and independent variable. The R-square value (0.526) represents that the model can explain 52.6 percent of the data.

#### Combined Regression of Return on assets:

In the table below, the regression model for "dividend pay-out ratio" based on "Return on assets, Price earnings ratio, Earnings per share, Leverage ratio, Age of the firm" by considering all the select companies together. It is observed that the correlation between dependent and variables is 0.755.

Table-2: Model summary of Return on assets

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	F-Value	P-value

1	.755 <sup>a</sup>	.571	.417	19.749237	3.721	.024 <sup>b</sup>
---	-------------------	------	------	-----------	-------	-------------------

a. Predictors: (Constant), Return on Assets, Price earnings ratio, Earnings per share, Leverage ratio, Age of the firm

The table shows a model description of regression analysis. The R-Square statistic is a widely used metric for assessing model fit. The R-square is equal to 1 minus the residual uncertainty ratio. The modified  $R^2$ , also known as the coefficient of multiple determinations, is the percentage of variation in the dependent variable explained by the independent variables independently or jointly. The ability to estimate Return on assets was discovered in the learning and growth section ( $R^2 = 57.1$ ). The  $R^2$  value in this model suggests that the Return on assets will explain 57.1 percent of the reported differences in return on assets. The remaining 42.9 percent is unaccounted for, suggesting that the remaining 42.9 percent of the return on assets is attributed to causes not found in the model. The F value ( $F=3.721$  and  $P 0.024$ ) indicates that this variation is extremely important. It gives the specifics of the model parameters (the beta values) as well as their importance. It indicates that  $\beta_0$  was the Y-intercept and that this is the constant's value  $\beta$ . So, according to the table,  $\beta_0$  is -96.86 which means that when no predictors exist (when  $X=0$ ), the model assumes that the  $\beta_0$  will be -96.86. Since  $\beta_1$ , an improvement in one unit of investment results in a 0.429 fold increase in total return. Other variables of  $\beta$  values are 0.414, 21.54 and so on.

Table-3: Un-standardized Coefficients

Model	Un-standardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
1 (Constant)	-96.865	61.977		-1.563	.140
Age of the firm	.429	.519	.305	.826	.422
Price earnings ratio	.414	.260	.386	1.592	.134
Leverage ratio	21.546	20.218	.320	1.066	.305
Earnings per share	.445	.154	.751	2.901	.012 *
Return on Assets	314.385	235.136	.586	1.337	.203

a. Dependent Variable: Dividend pay-out ratio

\* Significance at 0.05.

## IX. CONCLUSION:

This paper aims to understand the determinants of dividend policy of the manufacturing sector in India. The paper was based on a sample of four manufacturing companies; these are Asian paints ltd, Ultratech ltd, GHCL ltd and Titan ltd. The study uses combined evaluation for analysing the variables that have an impact on dividend pay-out ratio of the firm viz. price earnings ratio, leverage ratio, earnings per share. These factors were then subjected to multiple regression analysis with the dividend pay-out as the dependent variable and further it is observed that there is significant impact of divided pay-out is on Earnings per share. Thus, it is important to determine the deterministic element in dividend because it helps in deduction of investor risk in the expected receipt yield and on the other hand managers will adopt dividend policies with more awareness. Since the dividend policy affects many elements, these elements could be found in empirical research in the stock market on account of prevailing conditions on these stock markets.

## REFERENCES

1. Pandey, M. (2004), Financial Management. Vikas publishing house private limited. Navita Nathani and Ritugangil (2018), determinants of dividend policy in Indiancompanies: a panel data analysis.
2. Souvik Banerjee (2016), Determinants of dividend policy for selected information technology companies in India: An empirical analysis.Raj kumar and pawan kumar jha , determinants of corporate dividend policy in India- A study of listed IT companies at BSE. Jigar Omprakash Aggarwal(2020), the impact of factors affecting dividend decision byselected Indian firms.
3. Deep bisht and l.k.singh(2015) ,determinants of dividend policy: a study of Sensexincorporated companies.
4. Narinder pal singh and Aakarsh tandon(2019), the effect of dividend policy on stockprice: evidence from the Indian market.
5. R.Azhagaiah and Sandanam gejalakshmi(2014), determinants of dividend policy:Evidence from IT sector in India
6. R.Velmurugan(2015), Determinants of dividend in Indian fertilizer industry.
7. Anupam parua and Arindam gupta(2009). Dividend history and determinants in selected Indian companies: a study during 1993-94 to 2004-05.
- 9.

**ANNEXURES: DATA TAKEN FOR REGRESSION**

**1. Data for Asin Paints:**

Asian paints	Dividend pay-out ratio	Age of the firm	Price earnings ratio	Leverage ratio	Earnings per share	Return on Assets
2015 – 16	46.62	73	52.009	1.4723	16.92	0.184
2016 – 17	47.03	74	57.074	1.4694	18.80	0.190
2017 – 18	55.97	75	56.962	1.4859	19.75	0.182
2018 – 19	54.07	76	67.026	1.4798	22.26	0.143
2019 - 20	77.29	77	57.101	1.4373	27.67	0.199

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.991 <sup>a</sup>	.982	.930	1.10073

a. Predictors: (Constant), Return on Assets, Leverage ratio, Earnings per share

ANOVA <sup>a</sup>						
	Model	Sum of Squares	df	Mean Square	F	Sig.
1	Regression	67.607	3	22.536	18.600	.168 <sup>b</sup>
	Residual	1.212	1	1.212		
	Total	68.819	4			

a. Dependent Variable: Dividend pay-out ratio  
b. Predictors: (Constant), Return on Assets, Leverage ratio, Earnings per share

**2. Data for GHCL:**

Model Summary	GHCL	Dividend pay-out ratio	Age of the firm	Price earnings ratio	Leverage ratio	Earnings per share	Return on Assets
1	2015 – 16	8.60	32	4.653	2.814	25.57	0.087
	2016 – 17	12.88	33	6.826	2.566	38.82	0.111
	2017 – 18	9.29	34	7.00	2.234	37.32	0.101
	2018 – 19	13.44	35	6.670	2.051	36.88	0.090
	2019 - 20	19.01	36	1.999	1.922	41.51	0.095

a.  
Predictors:  
(Constant),  
Price  
earnings  
ratio,  
Earnings  
per  
share,  
Return  
on  
Assets

ANOVA <sup>a</sup>						
Model	Sum of Squares	df	Mean Square	F	Sig.	
1	Regression	61.541	3	20.514	2.819	.407 <sup>b</sup>
	Residual	7.278	1	7.278		
	Total	68.819	4			
a. Dependent Variable: Dividend pay-out ratio						
b. Predictors: (Constant), Price earnings ratio, Earnings per share, Return on Assets						

### 3. Data for Ultratech

Ultratech	Dividend pay-out ratio	Age of the firm	Price earnings ratio	Leverage ratio	Earnings per share	Return on Assets
2015 – 16	11.32	32	40.416	1.825	79.25	0.0574
2016 – 17	11.82	33	41.612	1.640	95.74	0.066
2017 – 18	14.62	34	50.695	2.097	81.27	0.0415
2018 – 19	73.67	35	47.551	2.482	84.33	0.0346
2019 - 20	84.91	36	16.907	1.875	189.15	0.0752

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.996 <sup>a</sup>	.991	.965	6.87720
a. Predictors: (Constant), Return on Assets, Earnings per share, Leverage ratio				

ANOVA <sup>a</sup>						
Model	Sum of Squares	df	Mean Square	F	Sig.	
1	Regression	5361.401	3	1787.134	37.786	.119 <sup>b</sup>
	Residual	47.296	1	47.296		
	Total	5408.697	4			
a. Dependent Variable: Dividend pay-out ratio						
b. Predictors: (Constant), Return on Assets, Earnings per share, Leverage ratio						

### 4. Data for Titan

Titan	Dividend pay-out ratio	Age of the firm	Price earnings ratio	Leverage ratio	Earnings per share	Return on Assets
2015 – 16	55.87	31	41.509	1.814	7.95	0.110
2016 – 17	0.465	32	54.195	1.928	8.58	0.091
2017 – 18	23.85	33	73.282	1.809	13.10	0.123
2018 – 19	28.91	34	74.289	1.855	15.48	0.119
2019 - 20	35.28	35	51.117	1.932	17.90	0.115

Model Summary				
---------------	--	--	--	--

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.725 <sup>a</sup>	.526	-.895	27.552319

a. Predictors: (Constant), Return on Assets, Leverage ratio, Earnings per share

ANOVA <sup>a</sup>						
	Model	Sum of Squares	df	Mean Square	F	Sig.
1	Regression	843.004	3	281.001	.370	.801 <sup>b</sup>
	Residual	759.130	1	759.130		
	Total	1602.134	4			

a. Dependent Variable: Dividend pay-out ratio

b. Predictors: (Constant), Return on Assets, Leverage ratio, Earnings per share

**Combined Regression:**

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.755 <sup>a</sup>	.571	.417	19.749237

a. Predictors: (Constant), Return on Assets, Price earnings ratio, Earnings per share, Leverage ratio, Age of the firm

ANOVA <sup>a</sup>						
	Model	Sum of Squares	df	Mean Square	F	Sig.
1	Regression	7257.025	5	1451.405	3.721	.024 <sup>b</sup>
	Residual	5460.453	14	390.032		
	Total	12717.478	19			

a. Dependent Variable: Dividend pay-out ratio

b. Predictors: (Constant), Return on Assets, Price earnings ratio, Earnings per share, Leverage ratio, Age of the firm



## The Development of a Low-cost General Purpose ATmega8535 Microcontroller Based Student Training Board

Sireesha Tankala<sup>\$</sup>, Prakash Malla<sup>\$</sup> and Kanaka Raju Pappala<sup>#\*</sup>

<sup>\$</sup> Research Scholar, Department of Physics and Electronics, Institute of Science, GITAM  
Electronics faculty at Dr.L.Bullayya College, Visakhapatnam, INDIA

<sup>#</sup> Department of Physics, GITAM Institute of Science, GITAM, Visakhapatnam, INDIA  
530045

\*Corresponding Author, e-mail id: kpappala@gitam.edu

**Abstract** - This paper reflects an exclusive low-cost general study purpose developing board for the family of AVR microcontrollers based multi component device for multiple purpose electronics learning; has been deployed. The intention behind this design is to endorse the graduates and scholars to exercise and at the same time to explore AVR microcontroller capability [1] with many of the communication protocols easy. It can be able to integrate on-board and off-board peripheral devices such as: various types of keypads, LED arrays USART devices, integrated ADCs and LCD display devices to design a unique and versatile test and study platform. The users group can simply be engaged in the development of this platform, and can use it as reference to application development. Significant effort was devoted to hardware development. The configuration of this device results in usage easiness, low cost and the provision of expanded flexibility in connecting the off- board peripherals to the microcontroller. This developed board is highly useful to those laboratories with limited funds [2], and as a microcontroller trainer board for teacher-learner community.

**Keywords:** Low-cost, ATmega8535 microcontroller, development board, learning with microcontrollers and versatile test and study platform.

### I. INTRODUCTION

Microcontrollers and Microprocessors are commonly useful for many industry applications: automobile industry, motor-control units, medical field, office machinery, remote controllers, electronic devices, robotics and other areas of industry. Due to these

reasons, it was an important applied course in the department of electrical/electronics and engineering in computer of all universities [3-5]. Thus, without limitations, it was necessary to know the vast fields of integrated circuit devices.

Many microprocessor/microcontroller based training boards are available in the microcontroller market by many individuals. However, the common problem among them is that, the connections between the microcontroller and peripheral devices get permanently fixed on the PCB. For an instance, the connections of a touch pad, an LCD, analog/digital data readers and the display unit are permanently soldered to specific microcontroller pins. During the process of writing a program, due to the permanent fixtures, flexibility in detachment may loss. Moreover, the change of connections of the peripheral devices to be applied to different pins of the microcontroller may not be possible. Another problem is that, the designed microcontroller training board lack of other peripheral devices to be used in the application [6].

By considering all those difficulties, hardware peripheral flexibility was provided to microcontroller development board which was developed and designed in this study. This board does not contains any onboard peripherals, but the flexibility is that, the user can connect a key pad / group of buttons, a group of LEDs, LCD screen, a 7-segments display, an analog input, an external EEPROM, step motor, buzzer, real-time clock, temperature sensor, universal serial bus (USB) and a serial communicating unit. In any of all these components, no connection can inhibits the programmer. All the industrial applications will be executed without any limitations of designing through using this training board [7].

Hence the motivation of this paper is that to design and develop a low-cost and basic general purpose (AVR) ATMEGA8535 microcontroller based student training board without fixed peripheral devices [9, 11].

## **II. ATmega8535 MICROCONTROLLER**

ATmega8535 is one of the most developed microcontrollers in the family of AVR enhanced RISC architecture. It was highly preferred for industrial, automobile and for medical applications and also for consumer electronics, since the architecture is more code efficient while achieving throughputs up to ten times faster than conventional CISC microcontrollers [9].

The ATmega8535 is a low-power CMOS 8-bit microcontroller based on the AVR enhanced RISC architecture. By executing instructions in a single clock cycle, the ATmega8535 achieves throughputs approaching 1 MIPS (Million Instructions Per Second) per MHz allowing the system designed to optimize power consumption versus processing speed. AVR core combines a rich instruction set with 32 general purpose working registers [13]. All 32 registers are directly connected to the Arithmetic Logic Unit (ALU), allowing two independent registers to be accessed in one single instruction executed in one clock cycle. Fig. 1 shows the pin diagram of ATmega8535 microcontroller [11].

ATmega8535 features:

- 8K bytes of In-System Programmable Flash with Read-While-Write capabilities
- 512 bytes EEPROM, 512 bytes SRAM
- 32 general purpose I/O lines and 32 general purpose working registers
- 3 -Timer/Counters with compare modes, internal and external interrupts
- a serial programmable USART and a byte oriented Two-wire Serial Interface
- an 8-channel, 10-bit ADC with optional differential input stage
- a programmable Watchdog Timer with Internal Oscillator
- An SPI serial port and six software selectable power saving modes.

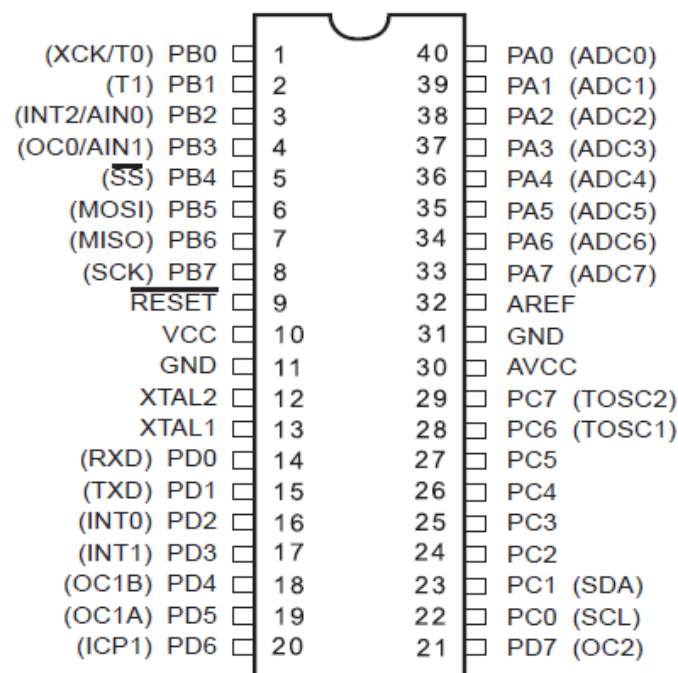


Fig. 1 Pinout diagram of ATmega8535

### III. DESIGN OF ATmega8535 TRAINING BOARD

While designing this microcontroller based development board, the circuit diagrams of all the sub-units were separately drawn and the hardware was tested in order to determine whether it works. The circuit diagram was drawn using ISIS (it is the software used to draw schematics and simulate the circuits in real time) component of PROTEUS program during the process of designing is seen in Fig. 2. Through the same, other units of the board were also designed; their circuit diagrams were as shown in Fig.3. After all the units of the training board were designed similarly, it was proceeded to draw the printed circuit [8].

The AVR general purpose development board is made from a single sided non-PTH (plated-through holes) Printed circuit board (PCB). This board can work on 7V to 15V AC or DC power supply. It has on-board built-in reverse polarity protection system. IC-7805 a voltage regulator has a heat sink for heat dissipation so that it can supply 1-ampere current continuously without getting over heated. It has reset power –on switches. All the ports of the microcontroller are connected to a standard 10 pin box header connectors. Open pads are provided for connecting the microcontroller's pins to for external peripheral devices. The flexibility of this board is that the user can add the required additional external components according to application [10, 12].

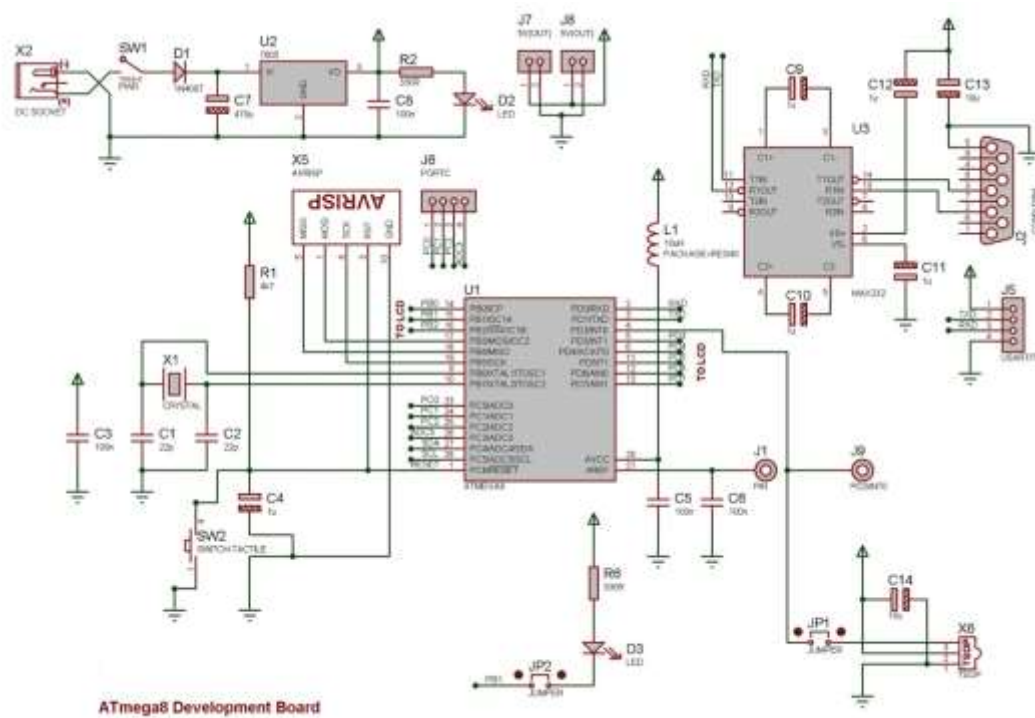


Fig. 2 Circuit diagram drawn during the process of designing ATmega8535 training board

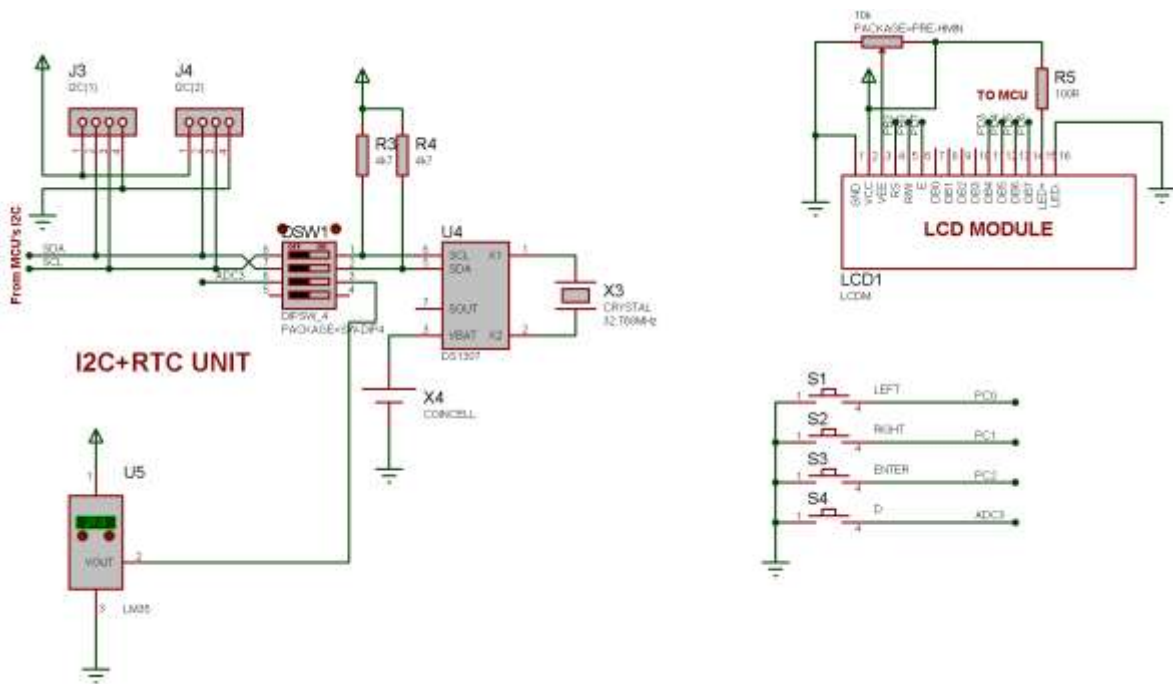


Fig. 3 Additional circuits for on-board and off-board connection with ATmega8535 training board

In order to avoid possible designing flaws while drawing the printed circuit, the 3D form of the board which is seen in Fig. 4 was examined with utmost care.

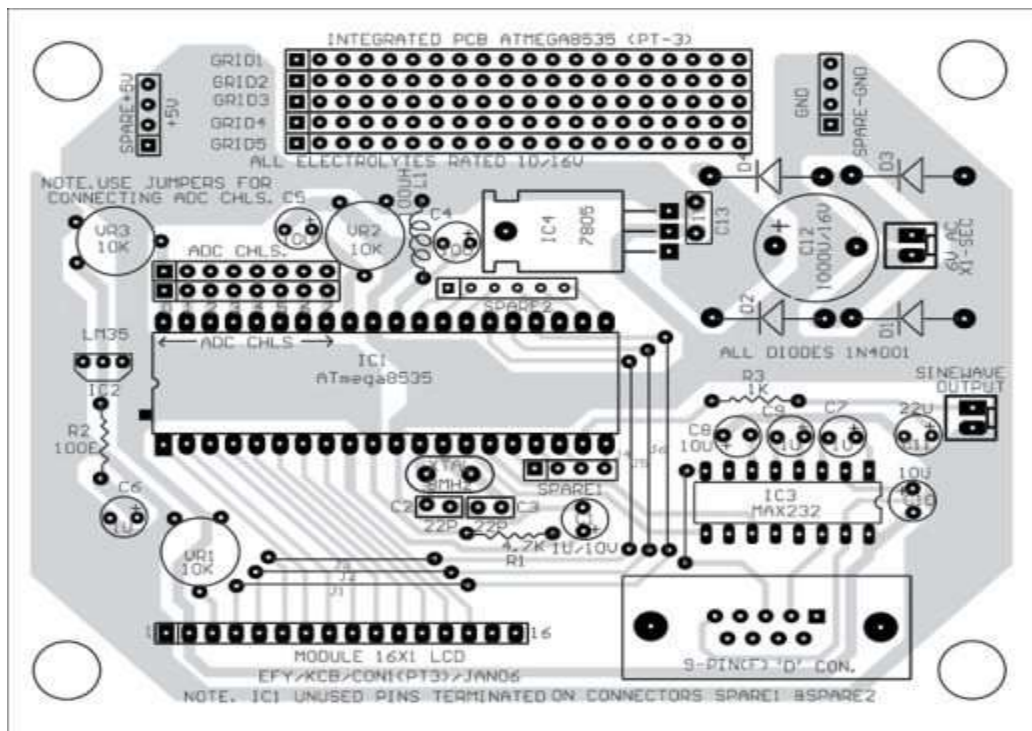


Fig. 4 3D form of the component layout of the PCB

Under proper executed controls, it was proceeded to print the printed circuit board, the final form is as seen in Fig. 5 was obtained. While developing this trainer board, the fixed connections were avoided in order to provide flexibility in the connections between the microcontroller and the peripherals [15].

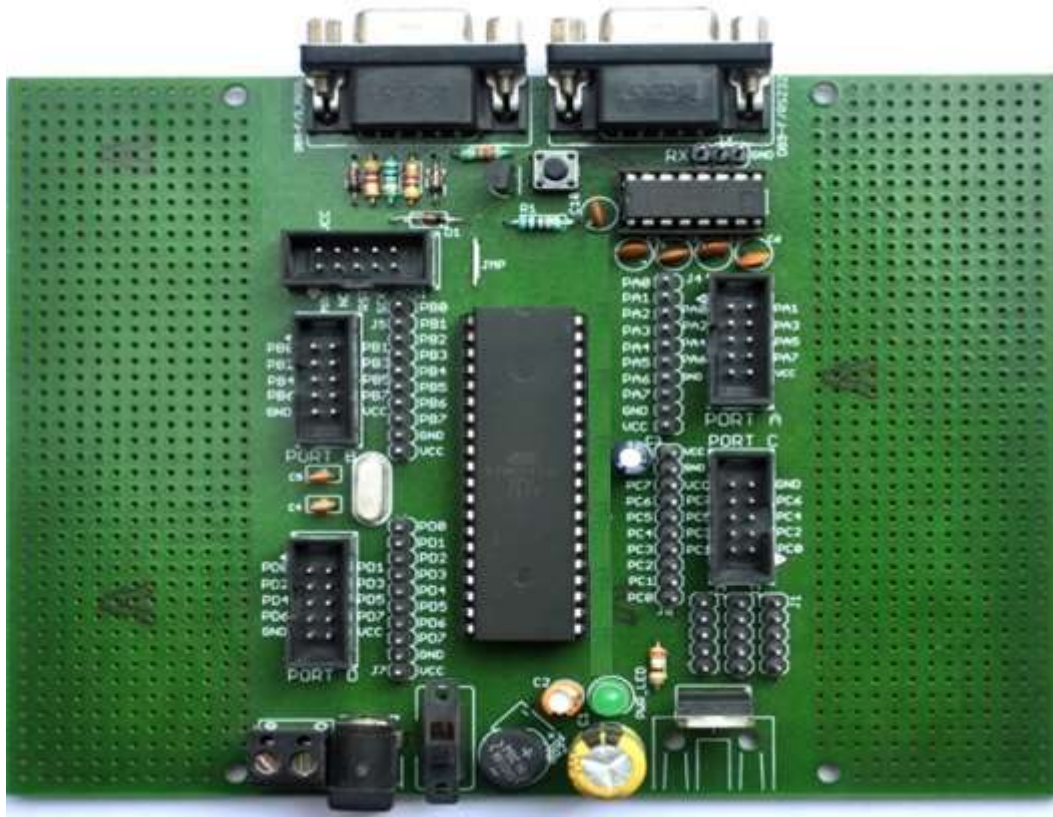


Fig. 5 Main board PCB layout with mounted components for ATmega8535/16/32

#### IV. SPECIFICATIONS AND FEATURES OF THE DESIGN

Features of the main board

- Pin compatible with 40 pin AVR and AT89S5x family of microcontrollers
- Single sided PCB, header for four I/O ports, ISP port and RS-232 port
- Built in +5V voltage regulator LM7805 with attached heat sink
- Built in +5V and +12V DC (depend on input voltage) with terminal screw connector for further expansion
- Onboard In System Programmer header
- Four 10 pin box connector for general purpose interfacing

Specifications for the connection of off-board (external) peripherals

- ATmega 16/32 Microcontroller
- LCD Display Interface
- Output LED's 8 in number
- Four data switches
- Stepper motor interface
- Provision for external power supply: 5V, 12V, -12V, GND.
- USB Interface using Rx/Tx of MCU for uploading/downloading
- Software supports up to Windows 7 and later

## V. OTHER COMPONENTS OF THE DESIGNED BOARD

MAX232 is an integrated circuit that converts signals from an RS-232 serial port to signals suitable for use in TTL compatible digital logic circuits. It is a dual driver/receiver and typically converts the Rx, Tx, CTS and RTS signals. The drivers provide RS-232 voltage level outputs (approximately  $\pm 7.5$  V) from a single + 5V supply via on-chip charge pumps and external capacitors. This makes it useful for implementing RS-232 in devices. The receivers reduce RS-232 inputs (which may be as high as  $\pm 25$ V) to standard 5V TTL levels. These receivers have a typical threshold of 1.3V and a typical hysteresis of 0.5 Voltage levels.

## VI. RESULTS AND DISCUSSION

This paper describes a simple interface for a multipurpose electronic microcontroller learning tool that can be used for various applications. It is a low-cost device since we have used limited number of electronic components such as ATmega8535 microcontroller and MAX232. The concept of using a generalized board for several applications can be extended for the development of any complicated system. This training board was exclusively designed for a specific task can be modified for any other similar task by simply changing the program using In-System Programming (ISP) [16].

The ATmega8535 training board was introduced to the students of undergraduates and graduates [14]. In this study, a development board was sheathed ATmega8535/16/32 could be programmed and various written programs could be tested without any limitations. The training boards designed up to now, the connection between the microcontroller and the

peripheral devices has been fixedly executed through a printed circuit board. For example, the LCD, graphic LCD, touch panel, analog data reading or display connections are fixedly connected to the definite pins of the microcontroller. Thus, the flexibility may be loss between those connections while the program is written due to those fixed connections [17]. But in this research work, all peripheral devices are designed separately on individual printed circuit boards, thus independently the user can connect any of the peripheral device to any one of the available port pins of the microcontroller. Moreover, the changes which should be executed in case the related peripheral units are required to be connected to different pins.

## REFERENCES

- [1]. Hammam A. Alshazly and M. Hassaballah, An Embedded System for a Bluetooth Controlled Mobile Robot Based on the ATmega8535 Microcontroller Egyptian Computer Science Journal (ISSN-1110-2586) Volume 40 – Issue1 January 2016
- [2]. G. C. Goodwin, A. M. Medioli, W. Sher, L. Vlacic and J. S. Welsh, "Emulation-based virtual laboratories: A low-cost alternative to physical experiments in control engineering education", *IEEE Trans. Educ.*, vol. 54, no. 1, pp. 48-55, Feb. 2011.
- [3]. A. Leva, "A hands-on experimental laboratory for undergraduate courses in automatic control", *IEEE Trans. Educ.*, vol. 46, no. 2, pp. 263-272, May 2003.
- [4]. S. Srivastava, V. Sukumar, and P. S. Bhasin, "A laboratory testbed for embedded fuzzy control", *IEEE Trans. Educ.*, vol. 54, no.1, pp. 14–23, Feb. 2011.
- [5]. Y. C. Chen and J. M. Naughton, "An undergraduate laboratory plat-form for control system design, simulation, and implementation", *IEEE Control Syst.*, vol. 20, no. 3, pp. 12–20, Jun. 2000.
- [6]. T. Umeno and Y. Hori, "Robust speed control of DC servomotors using modern two degrees-of freedom controller design," *IEEE Trans. Ind. Electron.*, vol. 38, no. 5, pp. 363–368, Oct. 1991
- [7]. P. Kanaka Raju et al, "Performance Evaluation of the Newly Developed Impedance Analyzer by Measuring and Comparing the Electrical and Thermal Properties of BaTiO<sub>3</sub> + Ni<sub>0.5</sub>Zn<sub>0.5</sub>Fe<sub>2</sub>O<sub>4</sub> Materials" *Materials Today Proceedings* 5 (2018) 25782-25788.
- [8]. Parai, M.K., Das, B. and Das, G, "An Overview of Microcontroller Unit: From Proper Selection to Specific Application", *International Journal of Soft Computing and Engineering (IJSCE)*, Vol. 2, No. 6, pp. 228-231, 2013.
- [9]. Widiana, T. and Harjoko, A, "Prototipe Meter Daya Digital Berbasis Mikrokontroler ATMEGA8535", *Indonesian Journal of Electronics and Instrumentations Systems (IJEIS)*, Vol.1, No.1, pp. 48-52, 2013.
- [10]. Loss, P.A.V., Lamego, M.M., Sousa, G.C.D. and Vieira, J.L.F, "A Single Phase Microcontroller Based Energy Meter", *Instrumentation and Measurement Technology Conference*, 18-21 May 1998, in *Conference Proceedings, IEEE*, Vol.2, 1998.
- [11]. Setiono, A, "Prototipe Aplikasi KWh Meter Digital Menggunakan Mikrokontroler ATMEGA8535 untuk Ruang Lingkup Kamar", *Jurnal Ilmu Pengetahuan dan Teknologi TELAAH*, Vol. 26, pp. 32-39, 2009.
- [12]. P. Kanaka Raju et al, "Examination of a Fabricated Impedance Meter by Analysing the Electrical Properties of Ni<sub>0.65</sub>Zn<sub>0.35</sub>Fe<sub>2</sub>O<sub>4</sub> (Ferro-Magnetic) Material" *International Journal of Innovative Technology and Exploring Engineering (IJITEE)* Volume-9 Issue-2S3, December 2019.
- [13]. Quazi, I., Gupta, S.K. and Rajendra Prasad, R, "Pre-paid Energy Meter Based on AVR Microcontroller", *International Journal of Engineering Research and Applications*, Vol. 1, No. 4, pp. 1879-1884, 2011.
- [14]. Reguera, "A low cost open source hardware in control education case study: Arduino feedback MS 150," *Jurnal: IFACPaper On Line* 48-29. Pp 117-122, 2015.
- [15]. P. KanakaRaju, M. PurnaChandra Rao "Design and Development of Portable Digital LCR Meter by Auto Balancing Bridge Method", *International Journal of Innovations in Engineering and Technology (IJJET)* Volume 7 Issue 3 October 2016.
- [16]. Rubio, "Using arduino to enhance computer programming course in science and engineering," *Spanyol.Proceeding of Edulearn 13 Conference*, ISBN. 978-84-616-3822-2, 2013.
- [17]. Liao, "Applying open source softwaresfritzing and arduino to course design of embedded systems," *Taiwan, International Journal of Automation and Control Engineering*, Vol. 4, No 1, April 2015.



## The Development of a Low-cost General Purpose ATmega8535 Microcontroller Based Student Training Board

Sireesha Tankala<sup>\$</sup>, Prakash Malla<sup>\$</sup> and Kanaka Raju Pappala<sup>#\*</sup>

<sup>\$</sup> Research Scholar, Department of Physics and Electronics, Institute of Science, GITAM  
Electronics faculty at Dr.L.Bullayya College, Visakhapatnam, INDIA

<sup>#</sup> Department of Physics, GITAM Institute of Science, GITAM, Visakhapatnam, INDIA  
530045

\*Corresponding Author, e-mail id: kpappala@gitam.edu

**Abstract** - This paper reflects an exclusive low-cost general study purpose developing board for the family of AVR microcontrollers based multi component device for multiple purpose electronics learning; has been deployed. The intention behind this design is to endorse the graduates and scholars to exercise and at the same time to explore AVR microcontroller capability [1] with many of the communication protocols easy. It can be able to integrate on-board and off-board peripheral devices such as: various types of keypads, LED arrays USART devices, integrated ADCs and LCD display devices to design a unique and versatile test and study platform. The users group can simply be engaged in the development of this platform, and can use it as reference to application development. Significant effort was devoted to hardware development. The configuration of this device results in usage easiness, low cost and the provision of expanded flexibility in connecting the off- board peripherals to the microcontroller. This developed board is highly useful to those laboratories with limited funds [2], and as a microcontroller trainer board for teacher-learner community.

**Keywords:** Low-cost, ATmega8535 microcontroller, development board, learning with microcontrollers and versatile test and study platform.

### I. INTRODUCTION

Microcontrollers and Microprocessors are commonly useful for many industry applications: automobile industry, motor-control units, medical field, office machinery, remote controllers, electronic devices, robotics and other areas of industry. Due to these

reasons, it was an important applied course in the department of electrical/electronics and engineering in computer of all universities [3-5]. Thus, without limitations, it was necessary to know the vast fields of integrated circuit devices.

Many microprocessor/microcontroller based training boards are available in the microcontroller market by many individuals. However, the common problem among them is that, the connections between the microcontroller and peripheral devices get permanently fixed on the PCB. For an instance, the connections of a touch pad, an LCD, analog/digital data readers and the display unit are permanently soldered to specific microcontroller pins. During the process of writing a program, due to the permanent fixtures, flexibility in detachment may loss. Moreover, the change of connections of the peripheral devices to be applied to different pins of the microcontroller may not be possible. Another problem is that, the designed microcontroller training board lack of other peripheral devices to be used in the application [6].

By considering all those difficulties, hardware peripheral flexibility was provided to microcontroller development board which was developed and designed in this study. This board does not contains any onboard peripherals, but the flexibility is that, the user can connect a key pad / group of buttons, a group of LEDs, LCD screen, a 7-segments display, an analog input, an external EEPROM, step motor, buzzer, real-time clock, temperature sensor, universal serial bus (USB) and a serial communicating unit. In any of all these components, no connection can inhibits the programmer. All the industrial applications will be executed without any limitations of designing through using this training board [7].

Hence the motivation of this paper is that to design and develop a low-cost and basic general purpose (AVR) ATMEGA8535 microcontroller based student training board without fixed peripheral devices [9, 11].

## **II. ATmega8535 MICROCONTROLLER**

ATmega8535 is one of the most developed microcontrollers in the family of AVR enhanced RISC architecture. It was highly preferred for industrial, automobile and for medical applications and also for consumer electronics, since the architecture is more code efficient while achieving throughputs up to ten times faster than conventional CISC microcontrollers [9].

The ATmega8535 is a low-power CMOS 8-bit microcontroller based on the AVR enhanced RISC architecture. By executing instructions in a single clock cycle, the ATmega8535 achieves throughputs approaching 1 MIPS (Million Instructions Per Second) per MHz allowing the system designed to optimize power consumption versus processing speed. AVR core combines a rich instruction set with 32 general purpose working registers [13]. All 32 registers are directly connected to the Arithmetic Logic Unit (ALU), allowing two independent registers to be accessed in one single instruction executed in one clock cycle. Fig. 1 shows the pin diagram of ATmega8535 microcontroller [11].

ATmega8535 features:

- 8K bytes of In-System Programmable Flash with Read-While-Write capabilities
- 512 bytes EEPROM, 512 bytes SRAM
- 32 general purpose I/O lines and 32 general purpose working registers
- 3 -Timer/Counters with compare modes, internal and external interrupts
- a serial programmable USART and a byte oriented Two-wire Serial Interface
- an 8-channel, 10-bit ADC with optional differential input stage
- a programmable Watchdog Timer with Internal Oscillator
- An SPI serial port and six software selectable power saving modes.

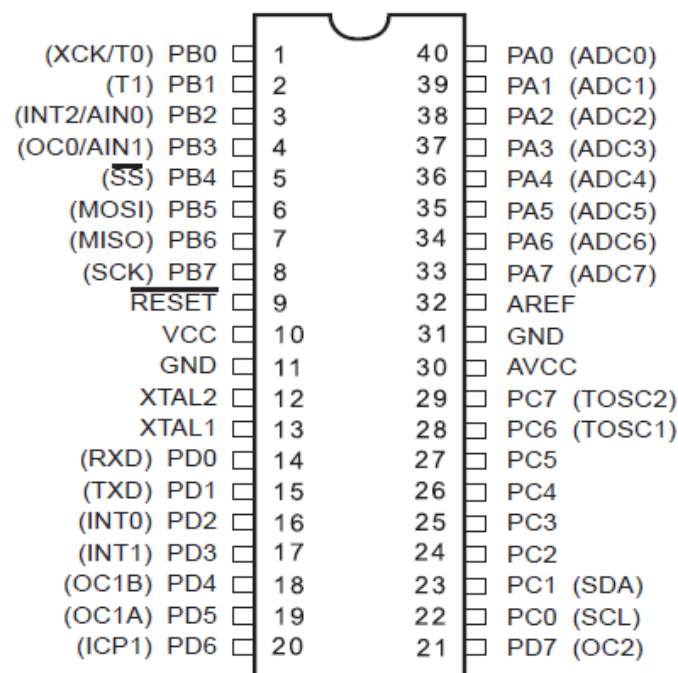


Fig. 1 Pinout diagram of ATmega8535

### III. DESIGN OF ATmega8535 TRAINING BOARD

While designing this microcontroller based development board, the circuit diagrams of all the sub-units were separately drawn and the hardware was tested in order to determine whether it works. The circuit diagram was drawn using ISIS (it is the software used to draw schematics and simulate the circuits in real time) component of PROTEUS program during the process of designing is seen in Fig. 2. Through the same, other units of the board were also designed; their circuit diagrams were as shown in Fig.3. After all the units of the training board were designed similarly, it was proceeded to draw the printed circuit [8].

The AVR general purpose development board is made from a single sided non-PTH (plated-through holes) Printed circuit board (PCB). This board can work on 7V to 15V AC or DC power supply. It has on-board built-in reverse polarity protection system. IC-7805 a voltage regulator has a heat sink for heat dissipation so that it can supply 1-ampere current continuously without getting over heated. It has reset power –on switches. All the ports of the microcontroller are connected to a standard 10 pin box header connectors. Open pads are provided for connecting the microcontroller's pins to for external peripheral devices. The flexibility of this board is that the user can add the required additional external components according to application [10, 12].

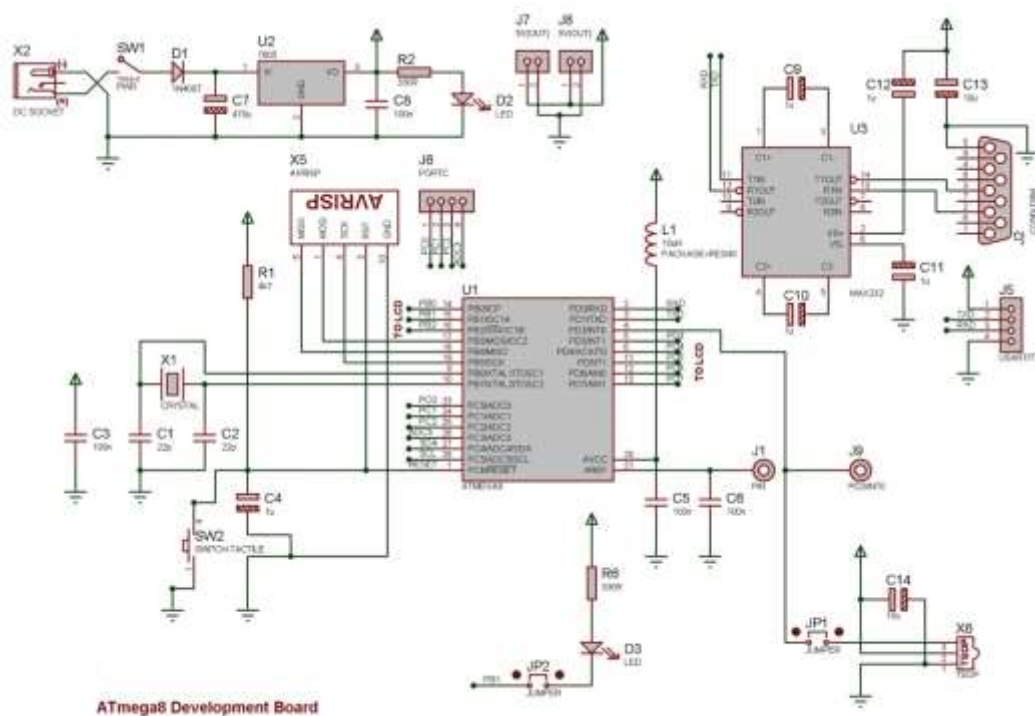


Fig. 2 Circuit diagram drawn during the process of designing ATmega8535 training board

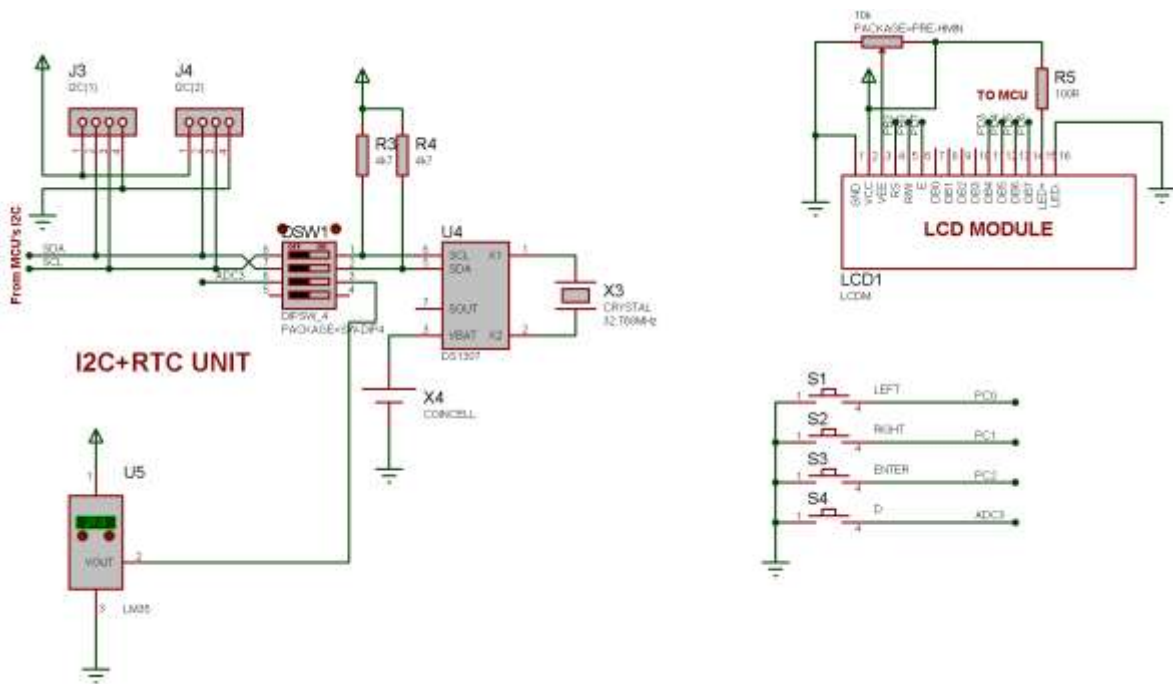


Fig. 3 Additional circuits for on-board and off-board connection with ATmega8535 training board

In order to avoid possible designing flaws while drawing the printed circuit, the 3D form of the board which is seen in Fig. 4 was examined with utmost care.

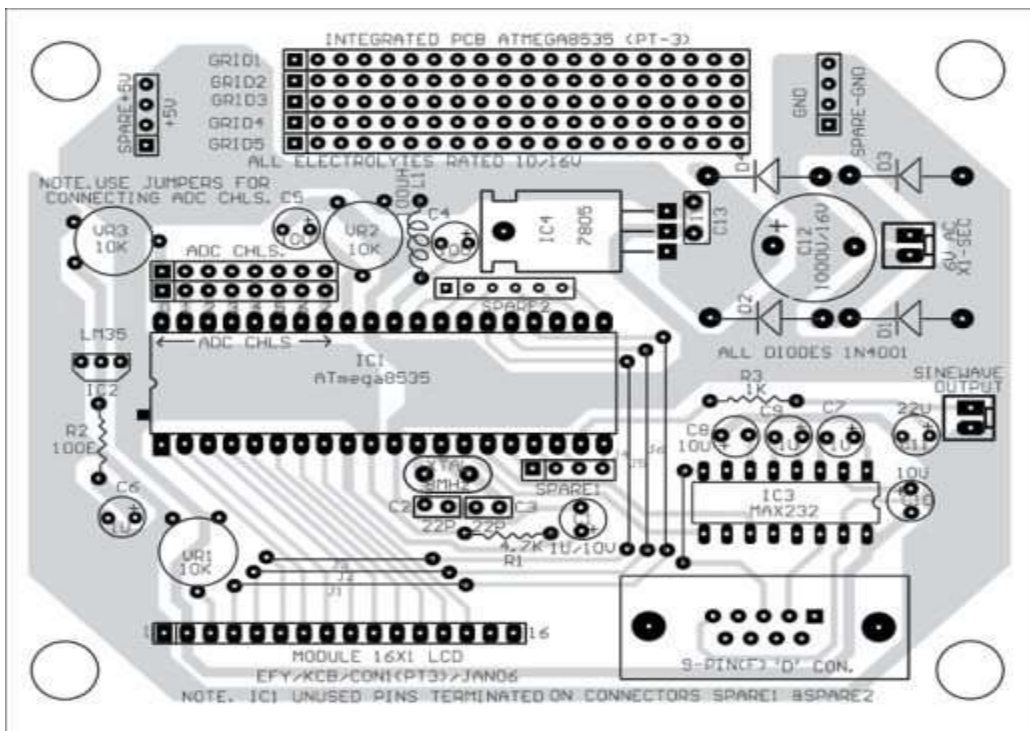


Fig. 4 3D form of the component layout of the PCB

Under proper executed controls, it was proceeded to print the printed circuit board, the final form is as seen in Fig. 5 was obtained. While developing this trainer board, the fixed connections were avoided in order to provide flexibility in the connections between the microcontroller and the peripherals [15].

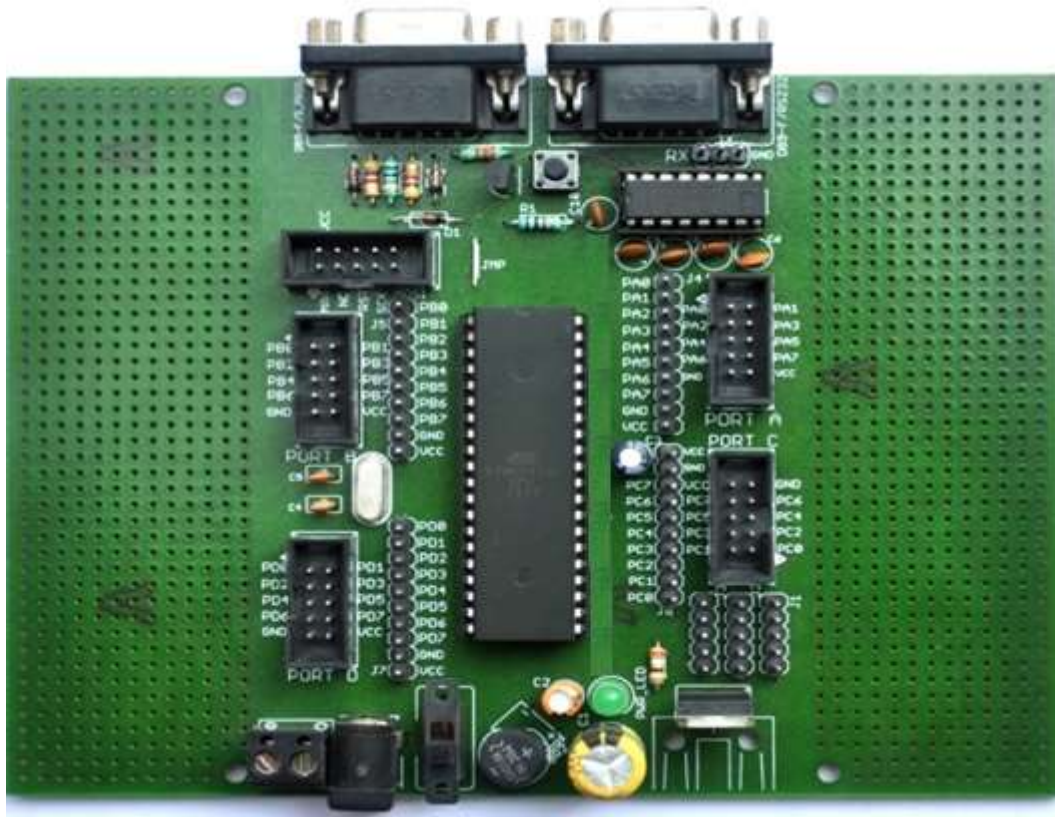


Fig. 5 Main board PCB layout with mounted components for ATmega8535/16/32

#### IV. SPECIFICATIONS AND FEATURES OF THE DESIGN

Features of the main board

- Pin compatible with 40 pin AVR and AT89S5x family of microcontrollers
- Single sided PCB, header for four I/O ports, ISP port and RS-232 port
- Built in +5V voltage regulator LM7805 with attached heat sink
- Built in +5V and +12V DC (depend on input voltage) with terminal screw connector for further expansion
- Onboard In System Programmer header
- Four 10 pin box connector for general purpose interfacing

Specifications for the connection of off-board (external) peripherals

- ATmega 16/32 Microcontroller
- LCD Display Interface
- Output LED's 8 in number
- Four data switches
- Stepper motor interface
- Provision for external power supply: 5V, 12V, -12V, GND.
- USB Interface using Rx/Tx of MCU for uploading/downloading
- Software supports up to Windows 7 and later

## V. OTHER COMPONENTS OF THE DESIGNED BOARD

MAX232 is an integrated circuit that converts signals from an RS-232 serial port to signals suitable for use in TTL compatible digital logic circuits. It is a dual driver/receiver and typically converts the Rx, Tx, CTS and RTS signals. The drivers provide RS-232 voltage level outputs (approximately  $\pm 7.5$  V) from a single + 5V supply via on-chip charge pumps and external capacitors. This makes it useful for implementing RS-232 in devices. The receivers reduce RS-232 inputs (which may be as high as  $\pm 25$ V) to standard 5V TTL levels. These receivers have a typical threshold of 1.3V and a typical hysteresis of 0.5 Voltage levels.

## VI. RESULTS AND DISCUSSION

This paper describes a simple interface for a multipurpose electronic microcontroller learning tool that can be used for various applications. It is a low-cost device since we have used limited number of electronic components such as ATmega8535 microcontroller and MAX232. The concept of using a generalized board for several applications can be extended for the development of any complicated system. This training board was exclusively designed for a specific task can be modified for any other similar task by simply changing the program using In-System Programming (ISP) [16].

The ATmega8535 training board was introduced to the students of undergraduates and graduates [14]. In this study, a development board was sheathed ATmega8535/16/32 could be programmed and various written programs could be tested without any limitations. The training boards designed up to now, the connection between the microcontroller and the

peripheral devices has been fixedly executed through a printed circuit board. For example, the LCD, graphic LCD, touch panel, analog data reading or display connections are fixedly connected to the definite pins of the microcontroller. Thus, the flexibility may be loss between those connections while the program is written due to those fixed connections [17]. But in this research work, all peripheral devices are designed separately on individual printed circuit boards, thus independently the user can connect any of the peripheral device to any one of the available port pins of the microcontroller. Moreover, the changes which should be executed in case the related peripheral units are required to be connected to different pins.

## REFERENCES

- [1]. Hammam A. Alshazly and M. Hassaballah, An Embedded System for a Bluetooth Controlled Mobile Robot Based on the ATmega8535 Microcontroller Egyptian Computer Science Journal (ISSN-1110-2586) Volume 40 – Issue1 January 2016
- [2]. G. C. Goodwin, A. M. Mediolio, W. Sher, L. Vlacic and J. S. Welsh, "Emulation-based virtual laboratories: A low-cost alternative to physical experiments in control engineering education", *IEEE Trans. Educ.*, vol. 54, no. 1, pp. 48-55, Feb. 2011.
- [3]. A. Leva, "A hands-on experimental laboratory for undergraduate courses in automatic control", *IEEE Trans. Educ.*, vol. 46, no. 2, pp. 263-272, May 2003.
- [4]. S. Srivastava, V. Sukumar, and P. S. Bhasin, "A laboratory testbed for embedded fuzzy control", *IEEE Trans. Educ.*, vol. 54, no.1, pp. 14–23, Feb. 2011.
- [5]. Y. C. Chen and J. M. Naughton, "An undergraduate laboratory plat-form for control system design, simulation, and implementation", *IEEE Control Syst.*, vol. 20, no. 3, pp. 12–20, Jun. 2000.
- [6]. T. Umeno and Y. Hori, "Robust speed control of DC servomotors using modern two degrees-of freedom controller design," *IEEE Trans. Ind. Electron.*, vol. 38, no. 5, pp. 363–368, Oct. 1991
- [7]. P. Kanaka Raju et al, "Performance Evaluation of the Newly Developed Impedance Analyzer by Measuring and Comparing the Electrical and Thermal Properties of BaTiO<sub>3</sub> + Ni<sub>0.5</sub>Zn<sub>0.5</sub>Fe<sub>2</sub>O<sub>4</sub> Materials" *Materials Today Proceedings* 5 (2018) 25782-25788.
- [8]. Parai, M.K., Das, B. and Das, G, "An Overview of Microcontroller Unit: From Proper Selection to Specific Application", *International Journal of Soft Computing and Engineering (IJSCE)*, Vol. 2, No. 6, pp. 228-231, 2013.
- [9]. Widiana, T. and Harjoko, A, "Prototipe Meter Daya Digital Berbasis Mikrokontroler ATMEGA8535", *Indonesian Journal of Electronics and Instrumentations Systems (IJEIS)*, Vol.1, No.1, pp. 48-52, 2013.
- [10]. Loss, P.A.V., Lamago, M.M., Sousa, G.C.D. and Vieira, J.L.F, "A Single Phase Microcontroller Based Energy Meter", *Instrumentation and Measurement Technology Conference*, 18-21 May 1998, in *Conference Proceedings, IEEE*, Vol.2, 1998.
- [11]. Setiono, A, "Prototipe Aplikasi KWh Meter Digital Menggunakan Mikrokontroler ATMEGA8535 untuk Ruang Lingkup Kamar", *Jurnal Ilmu Pengetahuan dan Teknologi TELAAH*, Vol. 26, pp. 32-39, 2009.
- [12]. P. Kanaka Raju et al, "Examination of a Fabricated Impedance Meter by Analysing the Electrical Properties of Ni<sub>0.65</sub>Zn<sub>0.35</sub>Fe<sub>2</sub>O<sub>4</sub> (Ferro-Magnetic) Material" *International Journal of Innovative Technology and Exploring Engineering (IJITEE)* Volume-9 Issue-2S3, December 2019.
- [13]. Quazi, I., Gupta, S.K. and Rajendra Prasad, R, "Pre-paid Energy Meter Based on AVR Microcontroller", *International Journal of Engineering Research and Applications*, Vol. 1, No. 4, pp. 1879-1884, 2011.
- [14]. Reguera, "A low cost open source hardware in control education case study: Arduino feedback MS 150," *Jurnal: IFACPaper On Line* 48-29. Pp 117-122, 2015.
- [15]. P. KanakaRaju, M. PurnaChandra Rao "Design and Development of Portable Digital LCR Meter by Auto Balancing Bridge Method", *International Journal of Innovations in Engineering and Technology (IJJET)* Volume 7 Issue 3 October 2016.
- [16]. Rubio, "Using arduino to enhance computer programming course in science and engineering," *Spanyol.Proceeding of Edulearn 13 Conference*, ISBN. 978-84-616-3822-2, 2013.
- [17]. Liao, "Applying open source softwaresfritzing and arduino to course design of embedded systems," *Taiwan, International Journal of Automation and Control Engineering*, Vol. 4, No 1, April 2015.



## **An Efficient Tenth Order Iterative Method for Solving Non-linear Equations with Chemical Applications**

**Mani Sandeep Kumar Mylapalli\***

Department of Mathematics, GITAM (Deemed to be University), Visakhapatnam, India.  
E-mail: mmylapal@gitam.edu

**Rajesh Kumar Palli**

Research Scholar, Department of Mathematics, GITAM (Deemed to be University),  
Visakhapatnam, India. E-mail: rajeshkumar.viit@gmail.com

**Ramadevi Sri**

Department of Mathematics, Dr. L. Bullayya College Visakhapatnam, India.  
E-mail: ramadevisri9090@gmail.com

**Muralidhar Pamerla**

Department of Chemistry, GITAM (Deemed to be University), Visakhapatnam, India.  
E-mail: mpamerla@gitam.edu

*Received October 07, 2020; Accepted November 16, 2020*

*ISSN: 1735-188X*

*DOI: 10.14704/WEB/V18SI02/WEB18009*

---

### **Abstract**

The scope of this paper is to establish a new tenth order convergent method to find the root of non-linear equations. Here we presented a modification of Newton's method with higher-order convergence and the study of convergence concluded that the order of convergence is tenth. With some numerical examples, we concluded that this algorithm is better than classical Newton's method and other methods with tenth order.

### **Keywords**

Iterative Method, Non-linear Scalar Equation, Functional Evaluations, Convergence Analysis, Efficiency Index.

## Introduction

In science and engineering, a lot of development happened in solving a non-linear scalar equation. In this proposal of finding a zero of non-linear equations, Newton's method (NR) [1] is one of the optimal second-order methods to obtain the root of a non-linear scalar equation.

$$g(t) = 0 \quad (1.1)$$

and is given by,

$$t_{n+1} = t_n - \frac{g(t_n)}{g'(t_n)} \quad (1.2)$$

$$n = 0, 1, 2, \dots$$

and NR method converges quadratically and its efficiency index is  $\sqrt{2} = 1.414$ .

An efficient three-step tenth order method (MA) without second derivative proposed by Hafiz [4] is given by,

$$y_n = t_n - \frac{g(t_n)}{g'(t_n)}$$

$$z_n = y_n - \frac{2g(y_n)g'(y_n)}{2g'(z_n)^2 - g(y_n)\rho_g(t_n, y_n)}$$

where  $\rho_g(t_n, y_n) = \frac{2}{y_n - t_n} \left( 2g'(y_n) + g'(t_n) - 3 \frac{g(y_n) - g(t_n)}{y_n - t_n} \right)$  (1.3)

$$t_{n+1} = z_n - \frac{g(z_n)}{g[z_n, y_n] + (z_n - y_n)g[z_n, y_n, y_n]}$$

$$\text{Here } g[z_n, y_n, y_n] = \frac{g[z_n, y_n] - g'(y_n)}{z_n - y_n}$$

Solving non-linear equations using a new tenth order method (PCMH) free from second derivatives proposed by Hafiz, Salwa, Al-Goria [4] is given by

$$y_n = t_n - \frac{g(t_n)}{g'(t_n)}$$

$$z_n = y_n - \frac{g(y_n)}{g'(y_n)} - \frac{[g(y_n)]^2 \rho_1(y_n)}{2[g'(y_n)]^3} \quad (1.4)$$

$$\text{Where } \rho_1(y_n) = g''(y_n) = \frac{2}{t_n - y_n} \left[ 3 \frac{g(t_n) - g(y_n)}{t_n - y_n} - 2g'(y_n) - g'(t_n) \right]$$

$$t_{n+1} = z_n - \frac{g(z_n)}{g[z_n, y_n] + (z_n - y_n)g[z_n, y_n, y_n]}$$

A quadrature based three-step tenth order iterative method (SK) proposed by Khattri [7] is given by

$$\begin{aligned}
 y_n &= t_n - \frac{g(t_n)}{g'(t_n)} \\
 z_n &= y_n - \frac{(t_n - y_n)g(y_n)}{g(t_n) - 2g(y_n)} \\
 t_{n+1} &= z_n - \frac{g(z_n)g'(z_n)}{(g'(z_n))^2 - g(z_n) \left( \frac{g(y_n) - g(z_n) - g'(z_n)(y_n - z_n)}{(y_n - z_n)^2} \right)}
 \end{aligned} \tag{1.5}$$

Tenth order iterative method (KN) for roots of non-Linear equations proposed by Nouri, Ranijbar [2] is given by

$$\begin{aligned}
 v_n &= x_n - \frac{f(t_n)}{f'(t_n)} \\
 \eta_n &= v_n - \frac{f(v_n)}{f'(v_n)} \\
 \lambda_n &= v_n + \frac{f(v_n)}{f'(v_n)} \\
 t_{n+1} &= v_n - \frac{(v_n - \eta_n)(f^2(x_n))(f(\eta_n) + f(\lambda_n))}{f^2(v_n)(f(\lambda_n) - f(\eta_n)) - 4f(v_n)f^2(\eta_n) - 6f^3(\eta_n)}
 \end{aligned} \tag{1.6}$$

In section II, we illustrated the new three-step iterative method, and section III, we proved this method is with tenth order convergence. At last in section IV, we compared our new method with other schemes with the same order of convergence using some defined examples.

### **Tenth Order Convergent (SKM) Method**

Consider  $t^*$  is an exact root of “(1.1)” where  $g(t)$  is continuous and has well defined first derivatives. Let  $t_n$  be the root of  $n^{\text{th}}$  approximation of “(1.1)” and is

$$t^* = t_n + \varepsilon_n \tag{2.1}$$

Where  $\varepsilon_n$  is the error.

Thus, we get

$$g(t^*) = 0 \quad (2.2)$$

Expanding  $g(t^*)$  by Taylor's series about  $t_n$ , we have,

$$g(t^*) = g(t_n) + (t^* - t_n)g'(t_n) + \frac{(t^* - t_n)^2}{2!}g''(t_n) + \dots$$

$$g(t^*) = g(t_n) + \varepsilon_n g'(t_n) + \frac{\varepsilon_n^2}{2!}g''(t_n) + \dots \quad (2.3)$$

By neglecting higher power  $\varepsilon_n$ , i.e. neglect terms from  $\varepsilon_n^3$  onwards. Using “(2.2)” and “(2.3)”, we have

$$\varepsilon_n^2 g''(t_n) + 2\varepsilon_n g'(t_n) + 2g(t_n) = 0$$

$$\varepsilon_n = \left[ -2g'(t_n) \pm \sqrt{4g'(t_n)^2 - 8g(t_n)g''(t_n)} \right] \div 2g''(t_n) \quad (2.4)$$

On Substituting  $t^*$  by  $t_{n+1}$  in “(2.1)” and from “(2.4)”,

We get

$$t_{n+1} = t_n - \frac{2g(t_n)}{g'(t_n)} \left( \frac{1}{1 + \sqrt{1 - 2\mu_n}} \right)$$

$$\text{Where, } \mu_n = \frac{g(t_n)g''(t_n)}{[g'(t_n)]^2}$$

and here

$$g''(t_n) = \frac{2}{t_{n-1} - t_n} \left[ 3 \frac{g(t_{n-1}) - g(t_n)}{t_{n-1} - t_n} - 2g'(t_n) - g'(t_{n-1}) \right] \quad (2.5)$$

Using divide difference formula, Newton's method “(1.2)”, can be written as

$$t_{n+1} = t_n - \frac{g(t_n)}{\left( \frac{g(t_n) - g(t_{n-1})}{t_n - t_{n-1}} \right)} \quad (2.6)$$

Here we developed a new algorithm by taking “(1.2)” as the first step and “(2.5)” as second step and “(2.6)” as third step.

### Algorithm

The iterative scheme is computed by  $x_{n+1}$  as,

$$\begin{aligned} z_n &= t_n - \frac{g(t_n)}{g'(t_n)} \\ y_n &= z_n - \frac{2g(z_n)}{g'(z_n)} \left( \frac{1}{1 + \sqrt{1 - 2\mu_n}} \right) \\ \text{where } \mu_n &= \frac{g(z_n)g''(z_n)}{[g'(z_n)]^2} \\ \text{and } g''(z_n) &= \frac{2}{t_n - z_n} \left[ 3 \frac{g(t_n) - g(z_n)}{t_n - z_n} - 2g'(z_n) - g'(t_n) \right] \\ t_{n+1} &= y_n - \frac{g(y_n)(y_n - z_n)}{g(y_n) - g(z_n)} \end{aligned} \quad (2.7)$$

The method “(2.7)” is known as tenth order convergent method (SKM), it requires three functional evaluations and two of its first derivatives.

### Convergence Criteria

*Theorem:* Let  $t_0 \in I$  be a single zero of a sufficiently differentiable function  $g$  for an open interval  $I$ . If  $t_0$  is in the neighborhood of  $t^*$ . Then the algorithm “(2.7)” has tenth order convergence.

### Proof

Let the single zero of “(1.1)” be  $t^*$  and  $t^* = t_n + \varepsilon_n$

Thus,  $g(t^*) = 0$

By Taylor’s series, writing  $g(t^*)$  about  $t_n$ , we obtain

$$g(t_n) = g'(t^*) (\varepsilon_n + c_2 \varepsilon_n^2 + c_3 \varepsilon_n^3 + c_4 \varepsilon_n^4 + \dots) \quad (3.1)$$

$$g'(t_n) = g'(t^*) (1 + 2c_2 \varepsilon_n + c_3 \varepsilon_n^2 + 4c_4 \varepsilon_n^3 + \dots) \quad (3.2)$$

Dividing “(3.1)” by “(3.2)”, we get

$$\frac{g(t_n)}{g'(t_n)} = \left( \varepsilon_n - c_2 \varepsilon_n^2 - (2c_3 - 2c_2^2) \varepsilon_n^3 - (3c_4 - 7c_2 c_3 + 4c_2^3) \varepsilon_n^4 + \dots \right) \quad (3.3)$$

From

$$z_n = t_n - \frac{g(t_n)}{g'(t_n)},$$

we get

$$z_n = t^* + \omega_n$$

Where

$$\omega_n = c_2 \varepsilon_n^2 + (2c_3 - 2c_2^2) \varepsilon_n^3 + (3c_4 - 7c_2 c_3 + 4c_2^3) \varepsilon_n^4 + \dots$$

Now

$$g(z_n) = g'(t^*) \left( c_2 \varepsilon_n^2 + (2c_3 - 2c_2^2) \varepsilon_n^3 + (3c_4 - 7c_2 c_3 + 5c_2^3) \varepsilon_n^4 + \dots \right) \quad (3.4)$$

Using the definition of second derivative in the scheme,

On simplification

$$g''(z_n) = g'(t^*) \left( \begin{array}{l} 2c_2 + 2(3c_2 c_3 - c_4) \varepsilon_n^2 \\ -4(3c_2^2 c_3 - 3c_2^2 - c_2 c_4 + c_5) \varepsilon_n^3 + \dots \end{array} \right) \quad (3.5)$$

$$\text{And } \frac{g(z_n)}{g'(z_n)} = L_1 \varepsilon_n^2 + L_2 \varepsilon_n^3 + L_3 \varepsilon_n^4 + \dots \quad (3.6)$$

$$\text{where } L_1 = c_2, L_2 = (2c_3 - 2c_2^2), L_3 = (3c_2^3 - 7c_2 c_3 + 3c_4)$$

From

$$\mu_n = \frac{g(z_n) g''(z_n)}{[g'(z_n)]^2} \text{ as defined in the scheme, we get}$$

$$2\mu_n = P_1 \varepsilon_n^2 + P_2 \varepsilon_n^3 + P_3 \varepsilon_n^4 + \dots \quad (3.7)$$

$$\text{where, } P_1=4c_2^2, P_2=4(6c_2c_3^2-2c_3c_4-6c_2^3c_3+2c_2^2c_4),$$

$$P_3=2(-8c_2^2c_3+4c_2c_4+2c_2^4)$$

From “(3.7)”, we get

$$\left(1+\sqrt{1-2\mu_n}\right)^{-1} = 2\left(1+M_1\varepsilon_n^2+M_2\varepsilon_n^3+M_3\varepsilon_n^4+\dots\right) \quad (3.8)$$

$$\text{where } M_1 = c_2^2, M_2 = 6c_2c_3^2 - 2c_3c_4 - 6c_2^3c_3 + 2c_2^2c_4,$$

$$M_3 = -4c_2^2c_3 + 2c_2c_4 + 6c_2^4$$

From “(3.5)” and “(3.8)”, we get

$$\frac{2g(z_n)}{g'(z_n)} \left( \frac{1}{1+\sqrt{1-2\mu_n}} \right) = \left( \begin{array}{l} L_1\varepsilon_n^2+L_2\varepsilon_n^3+L_3\varepsilon_n^4+L_4\varepsilon_n^5 \\ + (L_1M_3+L_3M_1+L_2M_2)\varepsilon_n^6+o(\varepsilon_n^7) \end{array} \right)$$

$$y_n = t^* + \left( L_1M_3+L_3M_1+L_2M_2 \right) \varepsilon_n^6 + o(\varepsilon_n^7) \quad (3.9)$$

$$y_n = t^* + Y$$

$$\text{Where } Y = \left( L_1M_3+L_3M_1+L_2M_2 \right) \varepsilon_n^6 + o(\varepsilon_n^7)$$

$$g(y_n) = g'(t^*) \left( y_n + c_2y_n^2 + c_3y_n^3 + c_4y_n^4 + \dots \right) \quad (3.10)$$

Using (3.10) and (3.4) in the third step of (2.7), i.e.

$$x_{n+1} = y_n - \frac{g(y_n)}{g(y_n) - g(z_n)} (y_n - z_n)$$

we get

$$\varepsilon_{n+1} = \left( \frac{1}{c_3^2} \left( 22c_2^3c_3 - 7c_2^2c_4 - 11c_2^5 - 4c_2c_3^2 \right) \right. \\ \left. \begin{array}{l} 36c_2^2c_4 - 84c_2c_3^3 + 60c_2^3c_3^2 + 24c_2^4c_3^2 \\ -14c_2^2c_3^3 + 48c_2^4 + 8c_2c_3^2c_4 - 32c_2^2c_3^5 \\ +36c_2^4c_4 - 84c_2^5c_3 + 60c_2^7 + 96c_2^8 \\ -182c_2^6c_3 + 80c_2^5c_4 - 32c_2^4c_5 - 192c_2^5c_3^2 \\ +384c_2^3c_3^3 - 96c_2c_3^4 - 160c_2^2c_3^2c_4 + 64c_2c_3^2c_5 \end{array} \right) \varepsilon^{10} + o(\varepsilon^{11})$$

Thus, it's proved that this new scheme is tenth order convergence and its efficiency index is  $\sqrt[5]{10} = 1.584$ .

### Numerical Examples

We consider the some examples considered by VBK Vatti, MMS [8], [5] and compared our method with NR, MA, PCMH, SK, KN methods. The computations are carried out by using mp math-PYTHON and the number of iterations for these methods are obtained for comparisons such that

$$|x_{n+1} - x_n| < 10^{-201} \text{ and } |g(x_{n+1})| < 10^{-201}.$$

The test functions and simple zeros are given below,

$$\begin{array}{ll} g_1(x) = (x+2)e^x - 1, & t^* = -0.442854010023885 \\ g_2(x) = x^2 + \sin\left(\frac{x}{5}\right) - \frac{1}{4}, & t^* = 0.4099920179891371 \\ g_3(x) = \cos x - x, & t^* = 0.7390851332151606 \\ g_4(x) = x^3 - 10, & t^* = 2.1544346900318837 \\ g_5(x) = e^{-x} + \cos x, & t^* = 1.7461395304080124 \\ g_6(x) = e^{\sin x} - x + 1, & t^* = 2.6306641479279036 \end{array}$$

A chemical equilibrium problem: Consider the equation from [6] describing the fraction of the nitrogen hydrogen feed that gets converted to ammonia (this fraction is called fractional conversion) in polynomial form as,

$$g_7(x) = x^4 - 7.79075x^3 + 2.511x - 1.674, \\ t^* = 0.2777595428417206$$



Volume from van der Waals equation: One has to find out the volume from Van der Waals' equation [6] in polynomial form as,

$$g_8(x) = 40x^3 - 95.26535116x^2 + 35.28x - 5.6998368, \quad t^* = -1.9707842194070294$$

**Table I (a): Analogy Of Efficiency**

Methods	P	N	EI
NR	2	2	1.414
MA	10	5	1.584
PCMH	10	5	1.584
SK	10	5	1.584
KN	10	5	1.584
SKM	10	5	1.584

Where P is the order of convergence, N is the number of functional values per iteration and EI is the Efficiency Index.

**Table I (b): Analogy of Different Methods**

<i>g</i>	Method	$x_0$	<i>n</i>	<i>er</i>	<i>fv</i>	$x_0$	<i>n</i>	<i>er</i>	<i>fv</i>
<i>g</i> <sub>1</sub>	NR	-0.7	10	6.9(201)	1.1(200)	0.2	10	2.4(201)	4.1(201)
	MA		4	2.8(201)	4.1(201)		4	2.0(201)	4.1(201)
	PCMH		4	7.3(201)	4.1(201)		4	4.8(201)	4.1(201)
	SK			DIVERGENT			6	4.4(201)	1.1(200)
	KN		4	2.4(201)	4.1(201)		4	1.6(201)	4.1(201)
	SKM		4	2.8(201)	4.1(201)		4	1.6(201)	4.1(201)
<i>g</i> <sub>2</sub>	NR	0.2	10	2.0(201)	2.2(201)	1.1	10	7.7(201)	7.7(201)
	MA		4	4.1(201)	2.2(201)		4	4.1(201)	2.2(201)
	PCMH		4	4.1(201)	2.2(201)		4	4.1(201)	2.2(201)
	SK		4	2.7(200)	2.2(201)		4	2.7(200)	2.2(201)
	KN		4	2.8(201)	2.2(201)		4	2.8(201)	2.2(201)
	SKM		4	2.0(201)	2.2(201)		4	1.2(201)	2.2(201)
<i>g</i> <sub>3</sub>	NR	0.1	10	1.6(201)	2.4(201)	1.2	9	1.6(201)	2.4(201)
	MA		4	8.1(201)	1.3(200)			DIVERGENT	
	PCMH		4	2.4(201)	2.4(201)		4	8.1(201)	1.3(200)
	SK		4	8.1(201)	2.4(201)		4	1.2(200)	2.4(200)
	KN		4	1.6(201)	2.4(201)		4	1.6(201)	2.4(201)
	SKM		4	8.1(201)	2.4(201)		4	1.6(201)	2.4(201)
<i>g</i> <sub>4</sub>	NR	1.5	10	1.6(200)	2.0(199)	3.2	10	1.6(200)	2.0(199)
	MA		4	3.2(201)	2.0(201)		4	3.2(201)	2.0(199)
	PCMH		4	2.6(200)	2.0(199)		4	2.6(200)	2.0(198)
	SK		8	3.2(201)	2.0(199)		8	3.2(201)	2.0(199)
	KN		4	8.8(200)	1.2(198)		4	1.3(200)	2.0(199)

	SKM	4	1.6(200)	2.0(199)	4	6.5(201)	2.0(199)		
g <sub>5</sub>	NR	1.5	9	4.8(201)	6.5(201)	-1.5	9	4.8(201)	6.5(201)
	MA	4	1.6(201)	6.5(201)	4	1.6(201)	6.5(201)		
	PCMH	4	1.3(200)	6.5(201)	4	1.3(200)	6.5(201)		
	SK	4	3.7(200)	6.5(201)	DIVERGENT				
	KN	4	3.2(201)	6.5(201)	5	3.2(201)	6.5(201)		
	SKM	4	4.8(201)	6.5(201)	4	4.8(201)	6.5(201)		
g <sub>6</sub>	NR	2.9	9	3.5(200)	8.8(200)	1.2	24	6.2(200)	1.4(199)
	MA	4	2.9(200)	8.8(200)	5	9.1(200)	8.8(200)		
	PCMH	4	7.5(201)	8.8(201)	18	7.5(200)	8.8(200)		
	SK	4	1.3(200)	8.8(200)	7	1.3(200)	8.8(200)		
	KN	4	6.8(200)	1.4(199)	15	1.9(200)	8.8(200)		
	SKM	4	2.6(200)	8.8(200)	5	4.2(201)	8.8(201)		
g <sub>7</sub>	NR	1.5	10	2.8(201)	3.4(200)	-0.3	10	2.8(201)	3.4(200)
	MA	4	9.3(201)	3.4(200)	4	9.3(201)	3.4(200)		
	PCMH	4	8.1(201)	3.4(200)	4	5.3(201)	3.4(200)		
	SK	5	4.1(201)	8.6(200)	4	6.9(200)	3.4(200)		
	KN	4	7.3(201)	8.6(200)	4	7.3(201)	8.6(200)		
	SKM	4	3.2(201)	3.4(200)	4	1.6(201)	3.4(200)		
g <sub>8</sub>	NR	1.8	25	1.6(200)	2.1(198)	3.0	27	1.6(201)	2.1(198)
	MA	9	4.8(201)	2.1(198)	10	4.8(201)	2.1(198)		
	PCMH	9	3.5(201)	2.1(201)	10	3.5(200)	2.1(198)		
	SK	11	6.5(200)	1.0(197)	10	6.5(200)	1.0(197)		
	KN	9	1.6(200)	2.1(198)	10	8.6(200)	1.0(197)		
	SKM	5	9.7(201)	2.1(198)	6	9.7(201)	2.1(198)		

Where  $x_0$  is the initial approximation,  $n$  is the number of iterations,  $er$  is the error and  $fv$  is the functional value.

## Conclusion

Here In this scheme, we introduced a new tenth order convergent iterative method with efficiency index 1.584. Table I (a) compares the efficiency of different methods and the computational results in table I (b) show that the method SKM competes with other efficient NR, MA, PCNH, SK, KN methods. Clearly, in some examples our method SKM is superior to the other methods in terms of iterations.

## References

- Traub, J.F. (1977). *Iterative Methods for the Solution of Equations*. Chelsea Publishing Company, New York.
- Nouri, K., Ranjbar, H., & Torkzadeh, L. (2019). Two High Order Iterative Methods for Roots of Nonlinear Equations. *Punjab University Journal of Mathematics*, 51, 47-59.
- Hafiz, M.A. (2014). An Efficient Three-Step Tenth-Order Method Without Second Order Derivative. *Palestine Journal of Mathematics*, 3(2), 198-203.

- Hafiz, M.A., & Al-Goria, S.M. (2013). Solving nonlinear equations using a new tenth-and seventh-order methods free from second derivative. *International Journal of Differential Equations and Applications*, 12(4), 169-183.
- Palli, R.K., Mylapalli, M.S.K., Chaganti, P., & Sri, R. (2020). An Optimal Three-Step Method for solving non-linear equations. *Journal of Critical Reviews*, 7(6), 100-103.
- Said Solaiman, O., & Hashim, I. (2019). Efficacy of optimal methods for nonlinear equations with chemical engineering applications. *Mathematical Problems in Engineering*, 2019.
- Khatti, S. (2013). Another note on some quadrature based three-step iterative methods for non-linear equations. *Numerical Algebra, Control & Optimization*, 3(3), 549-555.
- Vatti, V.K., Sri, R., & Mylapalli, M.K. (2017). Eighteenth order convergent method for solving non-linear equations. *Oriental Journal of Computer Science and Technology*, 10(1), 144-150.