Agenda for
23rd Academic Council Meeting

BBSBEC Fatehgarh Sahib

Date 22-11-2005

PUNJAB TECHNICAL UNIVERSITY
JALANDHAR

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23.1 To confirm the minutes of the 22nd meeting of the academic council held at CT institute of Management& Technology, Jalandhar notified vide letter No. PTU/REG/5545 dated 13th Sept 2005.

23.2 Correction in the proceeding of 22nd meeting of Academic Council

Under ATR (22.2) the following corrections are applied

	Previous	Corrected
21.2 (b) & (c)	Dean academic informed the council that BOS for computer science and engineering, 17 and computer applications had a joint meeting, and have arrived following decision	Dean academic informed the council that BOS for computer science and engineering, Information Technology and computer applications had a joint meeting and have arrived at a decision appended at Appendix – A1 & A2
22.3.2 d(iv)	Week	Weak

23.4 Action taken report on the academic council meeting 20th to 22nd

23.5 This is being discussed as agenda 23.11

22.3 A letter PTU/REG/5395 dated 6th September 2005 has been issued asking for additional affidavit in case of student opting to change their option of the regulation

23.6 To approve the degrees to be conferred in the 4th convocation

The academic council may consider and approve the award of the degrees of students eligible in the session 2004-05

Ph.D.	03 (For recommendation to BOG)
M.Tech.	20
B.Tech	2885
B. Pharmacy	234
MBA	952
MCA	517
BBA	64
BCA	159

23.7 To consider the issue of Merit Certificate / Medals to the merit holders of the university.

The list of such students is placed at Appendix – B.

The same is presented before the academic Council for approval.

23.8 To report on admissions during session 2005 –06

This year PTU conducted Combined Entrance Test for admission to the following courses:

(i) B.Tech.
(ii) B. Pharmacy
(iii) B. Architecture

A total of 15908 applications were received and the examination was held on 3rd June 2005 in 54 Centres. 13400 candidates took the entrance test. The details of admission made during session 2005 –06 is as under:

Course	Through Counselling	Management Quota
B. Tech. 1st year	4273	4043
B. Tech 2nd year	753	959
B. Pharm 1st year	366	629
B. Pharm 2nd year	72	73
B.Arch.	24	116
BBA		715
BCA		1705
MBA	707	1215
MCA	199	529
HMCT		235
B.Sc. MLT		60
B.Sc. MLT (Lateral Entry)		51
B.Sc (IT)		66
B.Sc. (ATHM)		276
M.Sc (IT)		61
M.Sc. (ATHM)		282
M Sc.(SIM)		31
M.Tech in University Regional Centres	177	

23.7 To report on addition of new colleges during session 2005 - 06

The following new colleges have requested for affiliation to PTU from the session 2005 – 06:

Engineering Colleges

1. Rayat & Bahra College of Engineering & Biotechnology , Kharar
2. Baba Hira Singh Bhattal Engineering College, Lehragaga

Hotel Management Colleges

1. K.C. College of Hotel Mgt. & Carting Technology, Nawanshahr*
2. Chandigarh College of Hotel Mgt. & Carting Technology, Landran

Pharmacy Colleges

1. Chitkara College of Pharmacy, Rajpura
2. Chandigarh College of Pharmacy, Kharar
3. Swami Vivekanand College of Pharmacy, Ramnagar

Management Colleges

1. GNA Institute of Management & Technology, Mehtiana, Phagwara

*Certain observations raised by the regulatory committee of the University for affiliation have hence been reported to be fulfilled. Revisit of the PTU team is scheduled in the current week.

23.8 To report on regional centres of the university

The Punjab Technical University has established fourteen Regional Centers with the objective to promote research and provide opportunity for young faculty members to do their Post Graduation and peruse Ph.D. The state has not many institutions offering PG courses in Engineering and Technology. The establishment of these centers would fill a gap of requirement of qualified faulty in the engineering and technical colleges of the state.

PG courses in the Regional Centers are being organized keeping in view the high standard of Technical Education.

There exists a provision of organizing additional funds from various Govt/ private institutions like (DST, TIFAC, TDB, AICTE, DRDO, CSIR, etc.) by the regional centers.

M. Tech. & M. Pharm Courses run by the University at its Regional Centres

- Instrumentation & Control Engg.
- Mechanical Engg.
- Food Technology
- Mechanical (Production)
- Production Engg.
- Electronics & Comm. Engg.
- Electrical Engg.
- Power Engg.
- Industrial Engg.
- Civil (Structural)
- Civil (Soil & Foundation)
- Environment Sciences
- Information Technology
- M. Pharm (pharmacology)

The following two new regional centers of Punjab Technical University have been established in the current session.

1 Lovely Institute of Technology

2 Indo Soviet Friendship College of Pharmacy

The courses offered in these two are as under:

M.Tech (IT), Mechanical (Thermal Engg)

M.Pharm (Pharmacology)

23.9 To report on construction activities of the university

PTU has initiated the construction of its administrative complex in an area of about 75 acres. In phase I the university shall be constructing two administrative blocks. Front block comprising of G+3 floors shall house the senior management of PTU including the Vice Chancellor, Registrar, Deans, Seminar Halls, Reception and Student Facilitation Center and the rear block comprising of basement +G+7 floors will house the examination, Distance Education, Computer Center, Library, General Office, canteen stores etc. The two parts shall be constructed independently and simultaneously. The front part is likely to be completed within 11 months and whereas the 2nd part shall be completed in one and half years time. The approximate project cost of these two blocks has been worked out at Rs 40 crores. Services of Chief Engineer(construction) and others consultants for landscaping, fire fighting electrical, advisor for public health and HVAC have also been hired.

Tender document and bidding drawings have been prepared by the Architects and the university is in the process of finalizing the contractor. Work is likely to start on 1st January 2006.

23.10 To draw Academic Calendar for the year 2006 and for academic session 2006 –07

Proposed academic calendar for the even semester of 2005 –06 and odd semester of 2006 – 07 is placed at Appendix – C.

The Council may approve

23.11 To discuss the issue of six months practical training for B.Tech students of 2004 and onwards batches

The distribution of training load between even and odd semesters has already been approved by the previous Board and distributed to all the colleges. Accordingly the training is being conducted in 6th / 7th semester. This has been done keeping in view the slots available in the industries as well as the academic workload in the institutions.

In the academic regulations 2004 it was decided to discontinue 6 month industrial training. The university has received lot of requests from the colleges to continue the same.

The matter is placed before the academic council for consideration.

23.12 To approve composition of Boards of Studies

The term of previous boards of studies expired in June 2005. New Boards of have been constituted as per the recommendations made by Khandpur committee. Details of the regulations for constituting the boards are placed at Appendix – D. The newly constituted Board is placed at Appendix– D1 for approval of the Council.

23.13 To review Academic Regulations – 2004, in its applicability for attendance criteria.

The recommendations of the sub-committee constituted in the 19th Academic Council were sent to BOG for approval and the same has been approved with some modifications and is reproduced below:

As recommended by Academic Council	As approved by BOG
A student shall have to attend 75% of scheduled lecturers (theory & Practical independently) other wise he / she shall not be allowed to appear in that subject in the University Examinations. A student detailed in the course(s) would be allowed to appear in the subsequent University Examination only on having completed the attendance (when the course is offered as a Regular Course) in the said course (s) as per Rules. However, he / she will be allowed to appear in a maximum of 10 theory subjects in the University examination held at the end of the semester. Total number of years allowed to complete the programme shall be as per University Regulations. Subsequently, the Registrar may notify the decisions as approved by the BOG.	A student shall have to attend 75% of scheduled lecturers together with Theory & Practical, otherwise he / she shall not be allowed to appear in that subject in the University Examinations. A student detailed in the course(s) would be allowed to appear in the subsequent University Exam only on having completed the attendance in the subject, when the course is offered as regular course (s) as per rules."

The matter is placed before the Council for reconsideration

23.14 To brief on sports and culture activities of the university

- The report is placed at Appendix – E
- Sports calendar for even semester (session 2005-06) is to be finalized during sports council meeting being convened shortly. However, the following date venue of the Annual Athletic Meet is proposed
  Dates: 10-03-2006 to 12-03-2006
  Venue: BBSEBC Fatehgarh Sahib
- The university also intends to organize Virasat Mela from 04-03 2006 to 05-03-2006. The purpose is to provide the students a platform to exhibit the culture of Punjab to create awareness of VIRASAT amongst masses.

The matter is placed before the academic council for approval.

23.15 To consider the syllabus and eligibility criteria for M.Tech (IT) course.

Board of studies of CSE/IT met on 10th November, 2005 and decided that the eligibility criteria for admission in M.Tech. (IT) should be either B.Tech. (CSE) or B.Tech. (IT). Regarding syllabus of M.Tech. (IT) it was decided that first semester of M.Tech. (IT) will be similar to M.Tech. (CSE). The Council may approve

23.16 To consider the distribution of marks in B.Arch Programme

In the 18th meeting of BOG it was decided that each paper of B.Arch Programme shall be of 100 marks out of which the candidate shall be examined for 50 marks on the basis of external paper setting & evaluation and 50 marks in each paper shall be assigned to internal assessment.

Board of studies of B.Arch Programme met on 11th November 2005 and felt the equal weightage cannot be given to all subjects of B.Arch Programme.

The council may like to reconsider this matter in the light of observations of Board of Studies

23.17 To inform about the fee structure for Non-AICTE courses running in the regular colleges

On the recommendations of Kang's committee the fee structure for the various Non-AICTE courses has been prepared and is appended at **Appendix F to H** for the information of all the members of the Academic Council.

23.18 To consider payment to teachers for guiding seminars, projects and thesis

BCET, Gurdaspur has made a request to consider payment to teachers for guiding seminars and thesis of M.Tech students. as per the following rates:

Seminar	Rs 1500 per student
Project	Rs. 2500 per student
Thesis	Rs. 5000 per student

The item placed before the academic council for consideration

23.19 To consider transfer of students from regular mode to distance education mode

Doraha Institute of Management & Technology made a request to consider transfer of students from regular mode to Distance education mode within the university. The request is placed at Appendix J. The item placed before the academic council for consideration

Appendix - A(i)

PUNJAB TECHNICAL UNIVERSITY, JALANDHAR

Minutes of the meeting of the Board of Studies of Computer Applications held on September, 02, 2005 at 10:30 am

The meeting of Board of Studies of Computer Applications was held on 2nd September, 2005 at CT Institute of Management & IT, Jalandhar in which the following were present :

1. Dr. V.K. Arora, Dean (Academics), PTU
2. Prof. M.S. Seekree, Director, KIMT, Ludhiana
3. Dr. K.N.S. Kang, Director, PCTE, Baddowal
4. Dr. Manoj Sachan, Head, CSE, SLIET, Longowal
5. Dr. Ranjeev Kumar Chopra, AP, RIMT, Mandi Gobindgarh

The members of Board of Studies deliberated at length on various aspects of eligibility criteria for the admission to MCA course and decides as under :-

"All those candidates who have passed any recognized bachelor's degree of minimum three years duration with Mathematics / Statistics / Business Mathematics / Business Statistics / Quantitative Techniques as compulsory / optional / additional paper as one of the subjects either at 10+2 or at graduation level."

(Prof. M.S. Seekree) (Dr. K.N.S. Kang) (Dr. Manoj Sachan) (Dr. Ranjeev Kumar Chopra)

Dean (Academics)

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Appendix – AC(2)

PUNJAB TECHNICAL UNIVERSITY, JALANDHAR

Minutes of the meeting of the Board of Studies of IT held on September, 02, 2005 at 9:00 am.

The meeting of Board of Studies of Information Technology was held on 2nd September, 2005 at CT Institute of Management & IT, Jalandhar in which the following were present :

1. Dr. V.K. Arora, Dean (Academics), PTU
2. Prof. M.S. Seekree, Director, KIMT, Ludhiana
3. Prof. A.L. Sangal, Head, Computer Science & Engg. Deptt. NIT, Jalandhar
4. Ms. Manpreet Kaur, GNDEC, Ludhiana
5. Mr. Parminder Singh, GNDEC, Ludhiana

The members of Board of Studies deliberated at length on various aspects of eligibility criteria for the admission to M.Sc. (IT) and decides as under :

"All those candidates who have passed any recognized bachelor's degree of minimum three years duration with Mathematics / Statistics / Business Mathematics / Business Statistics / Quantitative Techniques as compulsory / optional / additional paper as one of the subjects either at 10+2 or at graduation level."

(Prof. M.S. Seekree), (Prof. A.L. Sangal) (Ms. Manpreet Kaur) (Mr. Parminder Singh)

Dean (Academics)

Ph.D

Sr	Regdno/ Rollno	Name	Fname	College/Institute	Specialization	Title of Thesis
1	07.03.03	SUSHMA GUPTA	K.L. BANSAL	SLIET, LONGOWAL	MATHEMATICS	CERTAIN DIFFERENTIAL SUBORDINATIONS AND THEI R APPLICATIONS TO UNIVALENT FUNCTIONS
2	04.05.02	ESAKKI MUTHU	SUBBAIAH PILLAI	SLIET, LONGOWAL	CHEMISTRY	STUDIES ON METAL COMPLEXES WITH SOME MULTI D ENTATE AND MACRO CYCLIC LIGANDS
3	02.04.03	HARISH KUMAR	KEWAL KRISHAN SINGLA	SLIET, LONGOWAL	ELECTRONICS & COMM. ENGG.	PERFORMANCE ANAYSIS OF BROADBAND OPTICAL COMMUNICATION SYSTEMS WITH FIBER IMPAIRMENTS

The Case at Sr. no 3 of Mr. Harish kumar has been recommended by the Academic Council in its 20th meeting under item 20.6

SUMMARY OF THE THESIS ENTITLED

CERTAIN DIFFERENTIAL SUBORDINATIONS AND THEIR APPLICATIONS TO UNIVALENT FUNCTIONS

SUBMITTED TO
PUNJAB TECHNICAL UNIVERSITY
JALANDHAR (PUNJAB), INDIA
FOR THE DEGREE OF
DOCTOR OF PHILOSOPHY
IN
MATHEMATICS

By
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2004.

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CERTAIN DIFFERENTIAL SUBORDINATIONS AND THEIR APPLICATIONS TO UNIVALENT FUNCTIONS

SUMMARY

The present thesis is divided into six chapters, the first one giving a brief introduction of certain subclasses of the univalent functions, various concepts used in the course of this study and a brief account of the work done.

We denote by $\mathcal{H}$, the class of functions analytic in the unit disc $E = \{z : |z| < 1\}$. Denote by $\mathcal{A}$ and $\mathcal{A}'$, the subclasses of $\mathcal{H}$ consisting of functions f which are normalized by the conditions $f(0) = f'(0) - 1 = 0$ and $f(0) = 1$, respectively. Also, let S denote the family of functions in $\mathcal{A}$ which are univalent in E.

A domain $D \subset \mathbf{C}$(the extended complex plane) is said to be starlike with respect to $z = 0$ if $0 \in D$ and the linear segment joining 0 to every other point $w \in D$ lies entirely in D, that is, $tw \in D$ whenever $w \in D$ and $0 \leq t \leq 1$. A function f in S is said to be starlike if, and only if, the domain $f(E)$ is starlike. The necessary and sufficient condition for a function $f \in \mathcal{A}$ to be starlike is

$$\mathrm{Re}\frac{zf'(z)}{f(z)} > 0, z \in E. \qquad (1)$$

We denote by St, the subclass of S consisting of starlike functions. For $0 \leq \alpha < 1$, let $St(\alpha)$ denote the subclass of $\mathcal{A}$ whose members f satisfy the condition

$$\mathrm{Re}\frac{zf'(z)}{f(z)} > \alpha, z \in E. \qquad (2)$$

Members of the class $St(\alpha)$ are called starlike functions of order α.

A function $f \in \mathcal{A}$ is said to be strongly starlike of order α, $0 < \alpha \leq 1$, if

$$\left|\arg \frac{zf'(z)}{f(z)}\right| < \frac{\alpha\pi}{2}, \ z \in E.$$

We denote the set of all such functions by $\tilde{S}(\alpha)$. Note that $\tilde{S}(1) \equiv St$.

A domain D in $\mathbf{C}$ is said to be convex if the line segment joining any two points of D lies entirely in D, that is, $\lambda w_1 + (1-\lambda)w_2 \in D$ whenever $w_1, w_2 \in D$ and $0 \leq \lambda \leq 1$. A function $f \in \mathcal{H}$ is said to be convex if it is univalent and $f(E)$ is a convex domain. It is well-known that the function f is convex if, and only if $f'(z) \neq 0$ and

$$\operatorname{Re}\left(1 + \frac{zf''(z)}{f'(z)}\right) > 0, \ z \in E. \tag{3}$$

The class of normalized convex functions, denoted by K, consists of all f in S for which $f(E)$ is convex. A special subclass of K is the class of convex functions of order β, $0 \leq \beta < 1$, and is defined as under:

$$K(\beta) = \left\{f \in \mathcal{A}: \operatorname{Re}\left(1 + \frac{zf''(z)}{f'(z)}\right) > \beta, \ z \in E\right\}.$$

A function $f \in \mathcal{A}$ is said to be close-to-convex in E if there exists a real number α, $-\pi/2 \leq \alpha < \pi/2$, and a convex function g (not necessarily normalized) such that

$$\operatorname{Re}\left(e^{i\alpha}\frac{f'(z)}{g'(z)}\right) > 0, \ z \in E.$$

In addition, if f is normalized by the conditions $f(0) = 0 = f'(0) - 1$, then the class of close-to-convex functions is denoted by C. It is well-known that

$K \subset St \subset C \subset S$. Let us define

$$R(\alpha) = \{f \in \mathcal{A} : \mathrm{Re} f'(z) > \alpha, 0 \leq \alpha < 1, z \in E\},$$

with $R(0) = R$. It is known that the functions in $R(\alpha)$ are close-to-convex for $0 \leq \alpha < 1$ and hence univalent in E.

Let the functions f and g be analytic in E. We say that $f \prec g$ in E (in symbols, $f(z) \prec g(z)$ in E) if g is univalent in E, $f(0) = g(0)$ and $f(E) \subset g(E)$.

Let $\Psi : \mathbf{C}^2 \to \mathbf{C}$ and let h be a univalent function in E. If p is analytic in E and satisfies the first order (in analogy with the order of differential equation) differential subordination

$$\Psi(p(z), zp'(z)) \prec h(z), h(0) = \psi(p(0), 0), z \in E, \tag{4}$$

then p is called a solution of the differential subordination (4). A univalent function q is called a dominant of the differential subordination (4) if $p \prec q$ for all p satisfying (4). The dominant $\tilde{q}$ that satisfies $\tilde{q} \prec q$ for all dominants q of (4) is said to be the best dominant of the differential subordination (4).

A detailed treatment of the theory of differential subordination is available in the book entitled "Differential Subordinations-Theory and Applications", authored by S. S. Miller and P. T. Mocanu [7]. We state below a celebrated and powerful result of Miller and Mocanu [4] which played a crucial role in the development of the theory of differential subordination.

Let F be analytic in E and let G be analytic and univalent in $\overline{E}$ except for points ζ such that $\lim_{z \to \zeta} G'(z) = \infty$, with $F(0) = G(0)$. If F is not

subordinate to G in E, then there exist points $z_0 \in E, \zeta_0 \in \partial E$ (boundary of E) and an $m \geq 1$ such that $F(|z| < |z_0|) \subset G(E)$, $F(z_0) = G(\zeta_0)$ and $z_0 F'(z_0) = m\zeta_0 G'(\zeta_0)$.

This beautiful result of Miller and Mocanu has played a pivotal role in our work also. Another concept, which has been extensively used in the present thesis is that of subordination chains [10,p.159]. We describe it below.

A function $L(z,t), z \in E$ and $t \geq 0$ is said to be a subordination chain (or Loewner chain) if $L(.,t)$ is analytic and univalent in E for all $t \geq 0$, $L(z,.)$ is continuously differentiable on $[0,\infty)$ for all $z \in E$ and $L(z,t_1) \prec L(z,t_2)$ for all $0 \leq t_1 \leq t_2$. Following characterization of subordination chain has been used in most of the present work.

The function $L(z,t) : E \times [0,\infty) \to \mathbf{C}$ of the form $L(z,t) = a_1(t)z + \ldots$ with $a_1(t) \neq 0$ for all $t \geq 0$, and $\lim_{t\to\infty} |a_1(t)| = \infty$, is a subordination chain if and only if $\mathrm{Re}\left[\frac{z\partial L/\partial z}{\partial L/\partial t}\right] > 0$ for all $z \in E$ and $t \geq 0$.

In the last two decades, a tremendous development has taken place in the field of differential subordination and its applications. A large number of articles (more than 300) have been written by various researchers working in this area. Even today it remains hot field of research and there remain many open problems. In the present work, we have made an attempt to explore the field of differential subordinations further and, as consequences, tried to unfold some hidden facts in univalent function theory. Using the sophisticated concept of subordination chains, we have been able to study certain differential subordinations, which when applied to univalent functions, yield some new sufficient conditions for univalence, close-to-convexity and star-

likeness. Moreover, certain known results pertaining to the classes St and C have been either strengthened or improved. A brief chapter-wise description of our work is given below.

Chapter 2. In the theory of univalent functions, several examples of non-autonomous differential subordination are available, e.g. Miller and Mocanu [5] proved that for a given function B, with $\mathrm{Re}\, B(z) \geq 0$ in E, if $p \in \mathcal{A}'$ satisfies the non-autonomous differential subordination

$$B(z)zp'(z) + p(z) \prec \frac{1+z}{1-z}, \; z \in E,$$

then, $\mathrm{Re}\; p(z) > 0$ in E. Recently, Ponnusamy [11] investigated a non-autonomous differential subordination of the type

$$p(z) + \lambda(z)zp'(z) \prec \left(\frac{1+z}{1-z}\right)^{\gamma}, \; z \in E,$$

where $p \in \mathcal{A}'$ and λ is a suitable complex function. The study of differential subordination related to a sector was initiated essentially by Miller and Mocanu [6], wherein they obtained conditions on α and β such that for $p \in \mathcal{A}'$,

$$p(z) + \lambda zp'(z) \prec \left(\frac{1+z}{1-z}\right)^{\alpha} \Rightarrow p(z) \prec \left(\frac{1+z}{1-z}\right)^{\beta},$$

in E, where $\lambda > 0$ is a real number.

In this chapter, we study the more general non-autonomous differential subordination of the type

$$(p(z))^{\theta}\left[1 + \lambda(z)\frac{zp'(z)}{p^k(z)}\right]^{\alpha} \prec \left(\frac{1+z}{1-z}\right)^{\gamma}, \; z \in E, \qquad (5)$$

and, for given α, β, δ and k, our aim is to find the largest number γ_k, $k = 1, 2, 3, \ldots$, and conditions on the function $\lambda : E \to \mathbf{C}$ such that (5) implies

$$p(z) \prec \left(\frac{1+z}{1-z}\right)^{\delta} \text{ in } E.$$

We observe that our results unify almost all the previously known results related to the study of differential subordination in a sector. As applications of this differential subordination to univalent functions, we derive some new and interesting conditions for strongly starlikeness and close-to-convexity. We mention below, two interesting results obtained in this chapter:

(i) For a given $\delta, 0 < \delta < 1$, and $\eta, \eta > 0$, suppose that $\lambda(z) : E \to \mathbf{C}$ is a function satisfying

$$\frac{\delta|\lambda(z)|\cos\psi}{x + \delta|\lambda(z)||\sin\psi|} \geq \eta, \ z \in E,$$

where $|\psi - Arg\lambda(z)| = \frac{\delta\pi}{2}$ and $x = (1+\delta)^{\frac{1+\delta}{2}}(1-\delta)^{\frac{1-\delta}{2}}$.

If $f \in \mathcal{A}$, $\frac{f(z)f'(z)}{z} \neq 0$ in E, satisfies the differential subordination

$$(1-\lambda(z))\frac{zf'(z)}{f(z)} + \lambda(z)\left(1 + \frac{zf''(z)}{f'(z)}\right) \prec \left(\frac{1+z}{1-z}\right)^{\gamma}, \ z \in E,$$

then,

$$\frac{zf'(z)}{f(z)} \prec \left(\frac{1+z}{1-z}\right)^{\delta}$$

in E i.e. $f \in \tilde{S}(\delta)$ in E, where $\gamma = \delta + \frac{2}{\pi}\arctan\eta$.

(ii) Let $\alpha \in [0, 1]$ be fixed and let $\delta \in (0, \delta_0]$, where δ_0 is the solution of the equation

$$\beta\delta\pi = 2\pi - \alpha\left(\frac{\pi}{2} + \arctan\eta\right)$$

for $\beta \geq 0$ and for a suitable fixed $\eta > 0$ such that $\lambda(z) : E \to \mathbf{C}$ satisfies

$$\frac{\delta \mathrm{Re}\lambda(z)}{1 + \delta|\mathrm{Im}\lambda(z)|} \geq \eta, \ z \in E.$$

If a function $f \in \mathcal{A}$, $f'(z) \neq 0$ in E, satisfies

$$(f'(z))^{\beta}\left[1+\lambda(z)\frac{zf''(z)}{f'(z)}\right]^{\alpha} \prec \left(\frac{1+z}{1-z}\right)^{\gamma}, \ z \in E,$$

then,

$$f'(z) \prec \left(\frac{1+z}{1-z}\right)^{\delta}, \ z \in E,$$

where,

$$\gamma = \beta\delta + \frac{2\alpha}{\pi}\arctan\eta, \ 0 < \delta \leq \delta_0.$$

Chapter 3. The work of this chapter is motivated by recent papers of Padmanabhan [9] and Li and Owa [3]. Padmanabhan, in the said paper, studied the differential subordination of the type

$$\frac{zf'(z)}{f(z)} + \alpha\frac{z^2f''(z)}{f(z)} \prec \frac{2\alpha(z^2+2z)+1-z^2}{(1-z)^2}$$

where $0 < \alpha \leq 1$ and $z \in E$ and proved that the functions f, $f \in \mathcal{A}$, satisfying above subordination are starlike in E. Li and Owa [3] proved that if $f \in \mathcal{A}$ satisfies the differential subordination

$$\frac{zf'(z)}{f(z)} + \alpha\frac{z^2f''(z)}{f(z)} \prec \frac{1-(1+\alpha)z}{1+z}, \ z \in E,$$

for some $\alpha \geq 0$, then $f \in St$.

In this chapter, we consider a general differential subordination of the form

$$\frac{zf'(z)}{f(z)} + \frac{\alpha z^2f''(z)}{f(z)} \prec \frac{zg'(z)}{g(z)} + \frac{\alpha z^2g''(z)}{g(z)}, \tag{6}$$

where α is a complex number with $\mathrm{Re}\ \alpha > 0$. We are interested in finding the conditions on the function g involved on the right hand side of (6) so that

it becomes the best dominant for the differential subordination (6). Choosing some distinguished functions as dominants, we obtain some interesting criteria for starlikeness. We note that most of the previous results in this direction are either improved or can be deduced as corollaries to our results. An interesting result obtained in this chapter is as under:

Let α, $\alpha > 0$, be a real number. Assume that β is a real number such that

(i) $0 \leq \beta < 1$ whenever $0 < \alpha \leq 1$; and

(ii) $\beta \geq \frac{1}{2} - \frac{1}{2\alpha}$ for $\alpha > 1$.

For all $z \in E$, let $f \in \mathcal{A}$, $\frac{f(z)}{z} \neq 0$ in E, satisfy the differential subordination

$$\frac{zf'(z)}{f(z)} + \alpha \frac{z^2 f''(z)}{f(z)} \prec h(z),$$

where

$$h(z) = (1-\alpha)\left(\frac{1+(1-2\beta)z}{1-z}\right) + \alpha\left(\frac{1+(1-2\beta)z}{1-z}\right)^2 + \alpha\left(\frac{2(1-\beta)z}{(1-z)^2}\right).$$

Then $f \in St(\beta)$.

If we write $h(z) = u + iv$, then $h(E)$ is the exterior of the parabola given by

$$v^2 = -\frac{(1-\alpha(1-2\beta))^2(2-2\beta)}{\alpha(3-2\beta)}\left[u - \left(\alpha\beta\left(\beta - \frac{1}{2}\right) + \beta - \frac{\alpha}{2}\right)\right]$$

with vertex at $\left(\alpha\beta\left(\beta - \frac{1}{2}\right) + \beta - \frac{\alpha}{2}, 0\right)$.

Another differential subordination which has been investigated, in this chapter, is of the type

$$\frac{zf'(z)}{f(z)}\left[1-\alpha+\alpha(1-\lambda)\frac{zf'(z)}{f(z)}+\alpha\lambda\left(1+\frac{zf''(z)}{f'(z)}\right)\right]\prec\frac{zg'(z)}{g(z)}\cdot$$

$$\cdot\left[1-\alpha+\alpha(1-\lambda)\frac{zg'(z)}{g(z)}+\alpha\lambda\left(1+\frac{zg''(z)}{g'(z)}\right)\right], \quad (7)$$

where f and g belong to $\mathcal{A}$ and α is a complex number with $\operatorname{Re}\alpha>0$ and λ, $\lambda>0$, is real. We obtain conditions which the function q must satisfy so that the differential subordination (7) implies $\frac{zf'(z)}{f(z)}\prec\frac{zg'(z)}{g(z)}$ in E. As a particular case, we obtain several criteria for starlikeness. As an example, we state below one such result:

For $\lambda>0$, if $f\in\mathcal{A}$ satisfies

$$\frac{zf'(z)}{f(z)}\left[(1-\lambda)\frac{zf'(z)}{f(z)}+\lambda\left(1+\frac{zf''(z)}{f'(z)}\right)\right]\prec\left(\frac{1+z}{1-z}\right)^2+\frac{2\lambda z}{(1-z)^2},\ z\in E,$$

then $f\in St$.

Chapter 4. In 1975, Hallenbeck and Ruscheweyh [2] proved that the best dominant for the differential subordination

$$p(z)+\frac{1}{\gamma}zp'(z)\prec h(z),\ z\in E, \quad (8)$$

is the solution of the differential equation

$$q(z)+\frac{1}{\gamma}zq'(z)=h(z)$$

where $\gamma\neq0$ is a complex number with $\operatorname{Re}\gamma\geq0$ and h is convex in E. Miller, Mocanu and Reade [8] established that instead of assuming h to be convex in E, the condition $\operatorname{Re}\left[1+\frac{zh''(z)}{h'(z)}\right]>-1/2$ in E, is sufficient to get the

same conclusion in above result. Here, in this chapter, using the technique of subordination chain, we show that above result holds even when, only q is taken to be convex in E. Note that in (8), convexity of q does not imply that h is convex (in fact, h is only close-to-convex) in E. In fact, we study a more general differential subordination

$$(p(z))^{\alpha}\left[1+\frac{\gamma z p'(z)}{p(z)}\right]^{\beta} \prec h(z),\ z\in E, \tag{9}$$

and prove the following result:

Let $\alpha > 0, \beta \in (0,1]$ be real numbers and let γ be a complex number with $\mathrm{Re}\,\gamma > 0$. Suppose that the differential equation

$$(q(z))^{\alpha}\left[1+\frac{\gamma z q'(z)}{q(z)}\right]^{\beta} = h(z),\ z\in E,$$

where $q(0) = h(0) = 1$, has an analytic and univalent solution q such that $(q(z))^{\alpha/\beta}$ is convex in E. If $p \in \mathcal{A}'_n$ satisfies the differential subordination (9) in E, then

$$p(z) \prec q(z)$$

in E. Moreover, q is the best dominant for the differential subordination (9). It is also shown that the best dominant of the differential subordination (9) exists in the form of an integral. Making suitable choices for the functions p and q, and parameters α, β and γ, several new conditions which imply univalence or starlikeness of an analytic function in the unit disc, have been obtained. Some already known sufficient conditions also follow as particular cases of our results. We give below two of the interesting results obtained in this chapter:

(i) For $f \in \mathcal{A}$, $f'(z) \neq 0$ in E,

$$1 + \frac{zf''(z)}{f'(z)} \prec 1 + \frac{2(1-\beta)z}{(1+(1-2\beta)z)(1-z)}, \ z \in E, \tag{10}$$

implies $f'(z) \prec \frac{1+(1-2\beta)z}{1-z}$ in E.

(ii) Let b be a complex number with $|b| \leq \beta/\alpha \leq 1$. If a function $f \in \mathcal{A}$, $\frac{f(z)f'(z)}{z} \neq 0$ in E, satisfies the differential subordination

$$\left(\frac{zf'(z)}{f(z)}\right)^{\alpha}\left[2 + \frac{zf''(z)}{f'(z)} - \frac{zf'(z)}{f(z)}\right]^{\beta} \prec \frac{1}{(1+bz)^{\alpha+\beta}}, \ z \in E,$$

then

$$\frac{zf'(z)}{f(z)} \prec \frac{1}{1+bz}$$

in E, i.e. $f \in St\left(\frac{1}{1+b}\right)$.

Chapter 5. In 1947, Robinson [12] proved that if $g(z) + zg'(z)$ is in S and

$$f(z) + zf'(z) \prec g(z) + zg'(z), \tag{11}$$

in $|z| < 1$, then $f(z) \prec g(z)$ at least in $|z| < r_0 = 1/5$. S. Singh and R. Singh [14], in 1981, worked on this problem of Robinson and proved that the constant r_0 can be increased to $2 - \sqrt{3} = 0.268\ldots$. Subsequently, in 1984, Miller, Mocanu and Reade [8] further increased this constant r_0 to $1 - \sqrt{1/3} = 0.3944\ldots$. Recently, Singh and Singh [13] pursued the problem initiated by Robinson in the case when $g \in K(\beta)$. In fact, they studied the cases when $g \in K$ and $g \in K(1/2)$ and found the largest discs for both the cases such that $f(z) \prec g(z)$ holds in these discs whenever (11) holds. In the

present chapter, we consider more general differential subordination of the type

$$f(z) + \beta(f(z))^2 + \alpha z f'(z) \prec g(z) + \beta(g(z))^2 + \alpha z g'(z),\ z \in E, \qquad (12)$$

where $f, g \in \mathcal{A}$ and α and β are suitably chosen real numbers. In particular, we show that the conclusion $f(z) \prec g(z)$ in the above-mentioned results of Singh and Singh [13] holds in the entire disc E and does not depend upon the order of convexity of the function g as claimed by them.

Chapter 6. For a fixed α and all $z \in E$, let $\mathcal{H}_\alpha(\beta)$ denote the family of functions in $\mathcal{H}$ which satisfy

$$\operatorname{Re}\left[(1-\alpha)f'(z) + \alpha\left(1 + \frac{zf''(z)}{f'(z)}\right)\right] > \beta,$$

where β, $0 \leq \beta < 1$ be a given real number. Al-Amiri and Reade [1], in 1975, showed that the function $f \in \mathcal{H}_\alpha(0)$, $\alpha \leq 0$, satisfies $\operatorname{Re} f'(z) > 0$ in E, and hence is univalent in E. They were unable to settle the question of univalence for $\alpha > 0$ except for the case $\alpha = 1$, when, obviously, f is convex in E.

In the present chapter, we have made an attempt to study the univalence of $f \in \mathcal{H}_\alpha(\beta)$ in the case when $\alpha > 0$. We have shown that for $0 < \alpha < 1$, $\mathcal{H}_\alpha(\alpha)$ consists of univalent functions and that the functions f in $\mathcal{H}_\alpha(1/2)$ satisfy $\operatorname{Re} f'(z) > 1/2$ for all z in E and for all $\alpha \geq 0$. Further, we have investigated the class $\mathcal{H}_{\alpha,h}$ defined as under:

$$\mathcal{H}_{\alpha,h} = \left\{f \in \mathcal{A} : (1-\alpha)f'(z) + \alpha\left(1 + \frac{zf''(z)}{f'(z)}\right) \prec h(z)\right\},$$

for some analytic and univalent function h in E and $0 < \alpha \leq 1$. Our purpose is to obtain the largest domain $h(E)$ such that the functions in the class $\mathcal{H}_{\alpha,h}$ are close-to-convex in E. Some of the interesting criteria obtained in this chapter are as follows:

(i) Let $a, 0 < a \leq 1$, be some real number. If $f \in \mathcal{A}$ satisfies the differential subordination

$$(1-\alpha)f'(z) + \alpha\left(1 + \frac{zf''(z)}{f'(z)}\right) \prec h(z), z \in E,$$

where

$$h(z) = 1 + (1-\alpha)az + \frac{\alpha az}{1+az}, 0 < a \leq 1,$$

then $|f'(z) - 1| < a$ in E.

(ii) For real numbers α and a, where $0 < \alpha \leq 1$ and $-1 < a \leq 1$, let $f \in \mathcal{A}$ satisfy the differential subordination

$$(1-\alpha)f'(z) + \alpha\left(1 + \frac{zf''(z)}{f'(z)}\right) \prec h(z), z \in E,$$

where

$$h(z) = \frac{1 + (1-\alpha)az}{1-z} + \frac{\alpha az}{1+az}.$$

Then $f'(z) \prec \frac{1+az}{1-z}$ in E.

(iii) Let $f \in \mathcal{A}$ be such that $f''(0) = 0$. If for a real number μ,

$$\left|\frac{1 + \frac{zf''(z)}{f'(z)}}{f'(z)} - 1\right| \leq \mu < 1 \qquad (13)$$

then

(i) f and $zf'(z)$ are univalent in E.

(ii) $f \in \mathcal{H}_\alpha(0)$, whenever $\mu \leq \frac{1}{\sqrt{1+\alpha^2}}$.

(iii) f is convex in E, whenever $\mu \leq \frac{1}{\sqrt{1+\alpha^2}}$ and $|\alpha| \geq 1$.

Above result (iii) provides a sufficient condition for a normalized analytic function f with $f''(0) = 0$ to be a member of the class $\mathcal{H}_\alpha(0)$. Some of the graphics presented in this chapter show the power of differential subordination technique over other methods.

Most of the work contained in the present thesis has either published or accepted for publication in various journals (see S. Singh and S. Gupta [15,16,17,18] and V. Singh, S. Singh and S. Gupta [19]).

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SUMMARY

OF THE THESIS

Studies on Metal Complexes of Some Multidentate and Macrocyclic Ligands

submitted to

Punjab Technical University
Jalandhar (Punjab), India

For The Degree of

Doctor of Philosophy

in

CHEMISTRY

By

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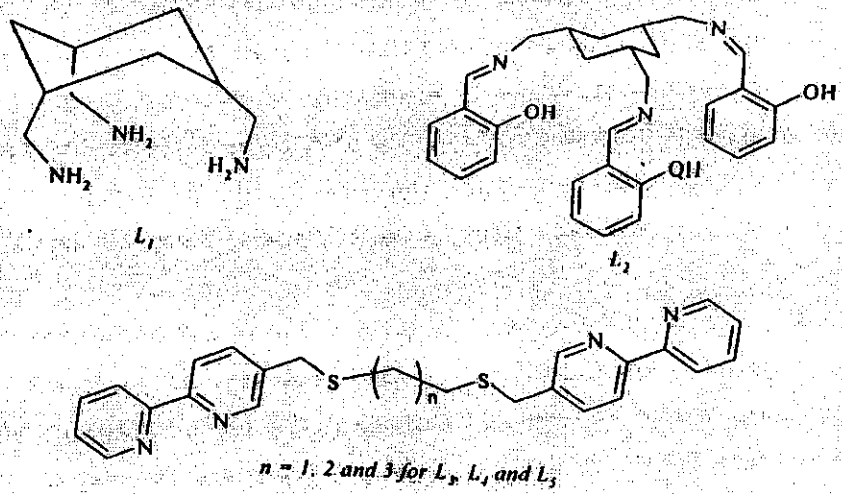
Summary

The coordination chemistry of polydentate and macrocyclic ligands has been the fascinating area of current interest to the inorganic chemists. These ligands form metal complexes with various metal ions, which are thermodynamically more stable than their open chain analogues. These complexes have potential applications in different fields like chemistry, biology, medicine and biotechnology etc.. Hence development of new macrocyclic ligands, their synthesis, structures and interaction with metals are of immense importance.

The present study deals with design and synthesis of a new tripodal face-capping amine ligand, its Schiff base derivative and some bridged 2,2'-bipyridyl ligands and study of their interaction with some transition metal and lanthanide ions in solution. Synthesis of two tripodal ligands having cyclohexane platform *viz.*, *cis,cis*–1,3,5-tris(methylamino)cyclohexane (*tmach*) (L_1), *cis,cis*-1,3,5-tris{(2-hydroxybenzilidene) aminomethyl}cyclohexane (*tmachsal*) (L_2) and three bipyridyl-bridged ligands, 1,2-bis(2,2':4',2"-bipyridyl-5-ylmethylsulfanyl)ethane ($C_2S_2bp_2$) (L_3), 1,3-bis(2,2':4',2"-bipyridyl-5-ylmethylsulfanyl)propane ($C_3S_2bp_2$) (L_4), 1,4-bis(2,2':4',2"-bipyridyl-5-ylmethylsulfanyl)butane ($C_4S_2bp_2$) (L_5) as shown in Figure 1 have been presented. Characterization of the ligands has been done through elemental analyses, UV-VIS, IR, ^{1}H NMR, ^{13}CNMR and Mass spectral data.



L_1 L_2

Figure 1 Ligands discussed in this thesis: L_1, L_2, L_3, L_4 and L_5.

The complexation behaviour of these ligands have been studied with some divalent transition metal ions *viz., Mn(II), Fe(II), Co(II), Ni(II), Cu(II), Zn(II)* and trivalent lanthanide ions *viz., Lu(III), Pr(III), Nd(III), Eu(III), Gd(III), Tb(III), Er(III), Yb(III)* and *Lu(III)* in solution by potentiometric and spectrophotometric methods (for L_2, L_3, L_4 and L_5 only). The protonation constants of the ligands and formation constants of their metal complexes have been calculated using computer programs Hyperquad-2000, pHAb and SPECFIT. The trend of stability has been explained with aid of available theories. The results have been compared with other similar ligands. Probable geometries of the ligands as well as their metal complexes have been proposed through molecular modeling calculations using molecular mechanics.

The entire thesis has been divided into five chapters and each chapter is self-contained.

Chapter 1 is an introductory chapter, which describes the development of supramolecular chemistry, fundamentals of complex formations, expressions for stability constants and the factors determining stability constants. The computational development and the use of molecular modeling calculations for structural elucidation of the complexes have also been discussed.

Chapter 2 describes the synthesis, characterization of the ligand *cis,cis*-1,3,5-tris(methylamino)cyclohexane (*tmach*) (L_1) and study of its metal complexes with some transition metal and lanthanide ions by potentiometric method in aqueous medium. The first part of the chapter begins with literature survey on tripodal ligands and their complexes, which is followed by the experimental details for determination of protonation constants of *tmach* and stability constants of its metal complexes. The next part describes the discussion and interpretation of the results obtained with similar tripodal ligands. Lastly, the probable structures of metal complexes have been proposed on the basis of molecular modeling calculations.

Chapter 3 describes the synthesis, characterization of a tripodal Schiff base ligand *cis,cis*-1,3,5-tris{(2-hydroxybenzilidene)aminomethyl}cyclohexane (*tmachsal*) (L_2), and its complexation with some transition metal and lanthanide ions by potentiometric and spectrophotometric methods in aqueous medium. The chapter begins with literature survey, which is followed by the experimental details for determination of protonation constants,

stability constants and then comparison of the results. Finally, the probable geometries of the metal complexes have been predicted through molecular modeling calculations.

Chapter 4 deals with the synthesis and study of three new bipyridyl bridged ligands *viz.*, L_3, L_4 and L_5. The chapter describes determination of protonation constants of the ligands and stability constants of their metal complexes with some transition metal and lanthanide ions by potentiometric and spectrophotometric methods. Comparison is made with other ligands and the results are interpreted as in previous chapters. Finally, the molecular modeling calculations have been done to propose the probable geometry of the metal complexes.

Chapter 5 describes the scope for future work.

PERFORMANCE ANALYSIS OF BROADBAND OPTICAL COMMUNICATION SYSTEMS WITH FIBER IMPAIRMENTS

(Ph. D. Thesis Abstract)

ABSTRACT

Optical communication is a relatively new and fast maturing field having terrific bandwidth and high quality of communication beyond comparison to any other available transmission medium. This technology has been growing at such a phenomenal pace that in a relatively short span of only a couple of decades, metamorphosed from a somewhat exotic research curiosity into a strong commercial reality it has accomplished the huge demand for bandwidth and longer transmission distance. Every day, there are new announcements of more and more fiber optic cable being deployed throughout the world and yet the cry for the greater capacity and faster access is growing louder. With all the improvement and advancement in the technology it is still a challenge to locally suppress the problem of impairments that limit the ability of the optical networks in realizing its vast technological potential. The photonic industry is thereby being driven to work upon the inherent impairments due to group velocity dispersion (GVD) and fiber nonlinearities degrading the system performance.

Plenty of work has been done in the past to compensate the dispersion effects limiting the bandwidth and transmission distance in optical communication systems. However, these investigations are being restricted to first-order dispersion effects only. Therefore, it is imperative to study the effect of second- and higher-order dispersion terms on the system performance. The impact of these terms should be analyzed and compensated to make paramount use of the bandwidth available with the optical communication systems. The shift from TDM (Time Division Multiplexing) to Wavelength Division Multiplexing (WDM) links and further to optical networks has only been feasible with the invention of

Erbium-Doped Fiber Amplifiers (EDFAs), which had removed the attenuation induced weakening of an optical signal as it travels down the optical fiber. With the use of EDFAs in WDM or Dense Wavelength Division Multiplexed (DWDM) systems and networks, the dispersion and fiber nonlinearities have become more decisive.

The research results presented here in through investigations are focused upon the effect of higher-order dispersion compensation in optical communication systems. The effect of higher-order dispersion compensation on, femto second Transform-Limited (TL) pulse generation by compensating linear chirp of Self Phase Modulation (SPM) spectra, intensity fluctuations due to Cross Phase Modulation (XPM) using Volterra Series method and Relative Intensity Noise (RIN) due to dispersive communication system are presented. It was felt that the study would be incomplete without the investigation of effects of higher-order dispersion compensation on the optical mm-wave Double Side Band (DSB) transmission systems, hence the same has also been presented in the last chapter.

In optical communication system the information carrier is a sequence of ultra short pulses, with a repetition rate of GHz generated by semiconductor laser diodes. In regard to the influence of higher-order effects of dispersion on the femto second TL- pulse by compensating linear chirp of SPM spectra in dispersion-shifted fibers the minimum propagation length and minimum pulse width and line width product has been investigated. It has been found that the minimum propagation length with first-order dispersion term is 23 m as reported earlier. It has been shown that if the higher-order dispersion effects are taken into consideration, this length reduces to 11.5 m. With the compensation of first-order dispersion term, this length can be enhanced to 6.8161×10^3 km. This length can be further improved to 6.0343×10^9 km by compensating first- and second-order dispersion terms together. The minimum pulse width and line width product

without dispersion, with dispersion including higher-order dispersion effects and with dispersion compensation have been found to be 0.44, 0.4418 and 0.4411 respectively.

The Fiber nonlinearities have not been fully analyzed and understood especially when other impairments like dispersion are also present. Their effects on the system performance can be analyzed by solving Non-Linear Schrodinger Wave Equation (NLSE). The intensity fluctuations due to XPM in the presence of higher-order dispersion effects using Volterra Series method have been investigated. The impacts of XPM on the Channel Spacing, Transmission Distance and Frequency have been studied in the presence of higher-order dispersion terms. It is found that at frequency 5 GHz, the intensity fluctuation reduces to –56 dB from –47 dB with first-order dispersion compensation and this can be further improved with first- and second-order dispersion compensation to –58 dB. It has been observed that for the same fiber length, the intensity distortions improve to –700 dB from –310 dB with first-order dispersion compensation and this can be further improved with first- and second-order dispersion compensation to –990 dB. The variance for the time-synchronized system in the presence of higher-order dispersion effects has also been presented.

The intensity noise resulting from the phase modulation to intensity modulation conversion of laser phase can be major impairments in direct detection systems. The amplitude fluctuation characterized by RIN is the most important factor to be analyzed and evaluated. The improved theoretical investigation into RIN including the impact of second-order dispersion term for dispersive optical communication systems has been presented. It has been shown that the second-order dispersion term has no impact on RIN even at high noise frequencies as reported in the existing literature but with first-order dispersion compensation, the RIN can be dramatically reduced thereby improving overall

system performance. Further, the impact of fiber length and laser linewidth has been investigated for RIN. It has been shown that as the fiber length increases, the value of RIN increases but the improvement over RIN with first-order dispersion compensation decreases. Also with decrease in the value of laser linewidth, the RIN can be reduced to great extent.

In the finishing stage of the research work, the all-optical millimeter wave DSB based system has been analyzed in the presence of higher-order dispersion effects using Fiber Bragg Grating (FBG) and Optical Phase Conjugation (OPC) dispersion compensation techniques. The impact of higher-order dispersion compensation on normalized signal power and transmission distance has been investigated in DSB transmission. It is conclusively proved that if there is dispersion compensation, the normalized power gets increased thereby optimizing the overall system performance. It has been empirically evaluated that the first-order dispersion compensation has the major impact on the system performance in comparison to the second-order dispersion compensation. It has been found that the transmission distance can be enhanced by 10^3 and 10^6 if dispersion compensation is performed using first-order and a combination of first- and second-order respectively.

Therefore, the present work establishes performance analysis of broadband optical communication systems with fiber impairments focusing on higher-order dispersion effects. The research work reported in chapters III, V and VI of this thesis have been published in various refereed International Journals as per the list at page (6) and the work reported in chapter IV has been submitted for publication.

PUBLICATIONS IN REFEREED JOURNALS

This thesis includes following papers in refereed Journals

1. Harish Kumar, R.S. Kaler, T.S. Kamal and Ajay Kumar Sharma, "Femto Second Transform Limited Pulse Generation with Higher Order dispersion effects for Dispersion Shifted Optical Communication System," Taylor and Francis, Fiber and Integrated Optics Incorporating International Journal on Optoelectronics, vol. 22, no. 6, pp. 405-413, Dec. 2003.

2. Harish Kumar, R.S. Kaler, T.S. Kamal and Ajay Kumar Sharma, "Effect of third order dispersion term on Relative Intensity Noise (RIN) for dispersive optical communication system," Taylor and Francis, Fiber and Integrated Optics Incorporating International Journal on Optoelectronics, vol. 22, no. 4, pp. 263-274, July 2003.

3. Harish Kumar, R.S. Kaler, T.S. Kamal and Ajay Kumar Sharma, "Performance of optical DSB Signal Based Millimeter Wave communication system with the Effect of Higher order dispersion," International Journal of Optics Communication, Elsevier Science, pp. 197-205, vol. 222, issue 1-6, July 2003.

4. Harish Kumar, R.S. Kaler and T.S. Kamal, "Variance for XPM Time-Synhronized System with Higher-Order Dispersion Effects Using Volterra Series Method," Journal of ET Institution of Engineers (India) (Submitted for Publication).

5. R.S. Kaler, Ajay K. Sharma, Harish Kumar and T.S. Kamal, "Validity of Third Order Dispersion Term for single mode fiber near zero dispersion wavelength," International Journal of Optics Communication, Elsevier Science, vol. 213, pp. 49-56, issue 1-3, Nov. 2002.

Sr	College	Position	Branch	Regdno/Roll no.	Name	Fname	Marks Obtained	Max Marks	%age
1	GZS, Bathinda	FIRST	Power Engineering	31605971	SANJU GARG	GOBIND RAM GARG	1553	2000	77.75
2	GNE, Ludhiana	SECOND	Power Engineering	31405964	CHARANPREET SINGH	KAJINDERJIT SINGH	1532	2000	76.6
3	GNE, Ludhiana	THIRD	Power Engineering	21405031	ARUN BALLA	SURINDER PAL	1269	1900	66.79
4	GNE, Ludhiana	FOURTH	Power Engineering	21405028	HARMEET SINGH	SURINDER SINGH	1255	1900	66.05
5	GNE, Ludhiana	FIFTH	Power Engineering	21405029	GURPREET SINGH	PARNAIL SINGH	1235	1900	65
6	GNE, Ludhiana	FIRST	Civil (Structural Engg.)	31401951	MANPREET KAGI	JASWINDER SINGH NAGI	1274	2000	63.7
7	GNE, Ludhiana	FIRST	Industrial Engg.	31407976	BALRAJ SINGH	MIRGND SINGH	1467	2000	73.35
8	GNE, Ludhiana	SECOND	Industrial Engg.	21407037	BALJIT SINGH	BIKKAR SINGH	1319	1900	69.42
9	GNE, Ludhiana	THIRD	Industrial Engg.	21407050	PALAM SINGH	JASWANT SINGH	1316	1900	69.26
10	GNE, Ludhiana	FIRST	Mech (Production) / Production Engg.	21411063	VARINDER KUMAR	PARKASH CHAND	1317	1900	69.32
11	GNE, Ludhiana	SECOND	Mech (Production) / Production Engg.	21411054	AMRINDER KAUR	SEETAL SINGH	1313	1900	69.11
12	GNE, Ludhiana	THIRD	Mech (Production) / Production Engg.	21411056	GAGANDEEP KAUSHAL	PAWAN KUMAR KAUSHAL	1185	1900	62.37
13	SLIET, Longowal	FIRST	Instrumentation Control Engg.	323038305	JASPAL SINGH AUJLA	SHAMSHER SINGH AUJLA	1295	1800	71.94
14	SLIET, Longowal	SECOND	Instrumentation Control Engg.	323038302	ASHU	N.K. KALIA	1267	1800	70.38
15	SLIET, Longowal	THIRD	Instrumentation Control Engg.	323038310	PARVINDER KAUR	SURINDER SINGH	1186	1800	65.88
16	SLIET, Longowal	FOURTH	Instrumentation Control Engg.	323038316	V.L. NARASIMHRAO	CHENNA KESHWARHA K	1165	1800	64.72
17	SLIET, Longowal	FIRST	Food Technology	323178334	GAURI ASIX	R.S. RANA	1355	1800	75.27
18	SLIET, Longowal	SECOND	Food Technology	323178340	RUBY GERSA	RAMDEV GUPTA	1323	1800	73.05
19	SLIET, Longowal	THIRD	Food Technology	323178337	NEELAM YADAV	R.N. YADAV	1288	1800	71.55
20	SLIET, Longowal	FOURTH	Food Technology	323178338	PARAMDEEP SINGH GHUMA N	JASPAL SINGH GHUMAN	1231	1800	68.38

Sr.	College	Position	Course	Regdno/Roll no	Name	Fname	Marks Obtained	Max. Marks	%age
1	PCTE, Baddowal	FIRST	M.B.A.	322543648	SHILPA SINGHANIA	RAVINDER KUMAR SINGHANIA	2853	3200	89.16
2	GGNIMT, Ludhiana	SECOND	M.B.A.	322483506	SUPRIYA JAIN	SATINDER JAIN	2826	3200	88.31
3	APJIMT, Jalandhar	THIRD	M.B.A.	322423164	DHRITICA NAYYAR	ARUN NAYYAR	2818	3200	88.06
4	PCTE, Baddowal	FOURTH	M.B.A.	322543630	PARDEEP JAIN	BRIJ LAL	2797	3200	87.41
5	PCTE, Baddowal	FIFTH	M.B.A.	322543587	G.AGANDEEP KAUR	BAHADER SINGH	2779	3200	86.84
6	PCTE, Baddowal	SIXTH	M.B.A.	327052	PARUL GOYAL	MOHINDER PAUL GOYAL	2767	3200	86.47
7	PCTE, Baddowal	SEVENTH	M.B.A.	322543618	MONIKA BANSAL	HARI CHAND BANSAL	2763	3200	86.34
8	LIM, Phagwara	EIGHTH	M.B.A.	32244336]	PARUN GUPTA	VINOD GUPTA	2745	3200	85.78
9	PCTE, Baddowal	NINETH	M.B.A.	322543575	AMAN SETHI	KEWAL KRISHAN SETHI	2736	3200	85.5
10	GNIMT, Ludhiana	TENTH	M.B.A.	322493565	SAVNEET KAUR	HARBANS SINGH	2732	3200	85.38
11	BGCET, SANGRUR	FIRST	M.C.A.	279210713	GURPREET KAUR	GURDARSHAN SINGH SOH	3454	3900	88.56
12	PCTE, BADDOWAL	SECOND	M.C.A.	254210310	DEEPAK KOCHAR	ASHOK KOCHAR	3443	3900	88.28
13	GNIM&T, LUDHIANA	THIRD	M.C.A.	249210271	MONIKA MATTA	ASHOK MATTA	3434	3900	88.05
14	PCTE, BADDOWAL	FOURTH	M.C.A.	254210314	GURPREET KAUR	CHARANJEET SINGH	3403	3900	87.26
15	APJIM, JALANDHAR	FIFTH	M.C.A.	242210087	RADHIKA CHOPRA	NARESH KUMAR CHOPRA	3393	3900	87
16	PCTE, BADDOWAL	SIXTH	M.C.A.	254210327	MANPREET KAUR MAKKAR	MR.GURJIT SINGH MAKKAR	3386	3900	86.82
17	LIM, PHAGWARA	SEVENTH	M.C.A.	244210171	DEEPIKA THAKUR	SATWANT SINGH	3372	3900	86.46
18	SLICS, BADHANI	EIGHTH	M.C.A.	273210638	GAURAV MAHAJAN	MUKESH MAHAJAN	3371	3900	86.44
19	APJIM, JALANDHAR	NINETH	M.C.A.	242210108	VANDITA SOOD	SUNDER SHAM SOOD	3368	3900	86.36
20	APJIM, JALANDHAR	TENTH	M.C.A.	242210072	KANIKA SOOD	RAM KRISHAN SOOD	3356	3900	86.05
21	PCTE, Baddowal	FIRST	B.C.A.	254230489	GURJOT KAUR	GURPAL SINGH	3825	4200	91.07
22	PCTE, Baddowal	SECOND	B.C.A.	254230468	ANUREET GILL	SIMER PAUL SINGH GILL	3695	4200	87.98
23	PCTE, Baddowal	THIRD	B.C.A.	254230451	AABHA ANEJA	NARINDER KUMAR ANEJA	3609	4200	85.93
24	GGNIMT, Ludhiana	FOURTH	B.C.A.	248230324	DEPINDER SINGH	BALBIR SINGH	3597	4200	85.64
25	GNIMT, Ludhiana	FIFTH	B.C.A.	249230363	CHARANPREET KAUR PANESAR	KAMALJIT SINGH	3593	4200	85.55