List of Figures

		Page No.
1.1	Major long-term medical complications in diabetic subjects	**2**
1.2	The number of research articles on glucose monitoring throughout the stated period	**3**
2.1	Diabetes Mellitus classification	**12**
2.2	Invasive blood glucometers of (a) Roche Diagnostics (b) LifeScan (c) Abbott (d) Bayer HealthCare	**14**
2.3	Major compositions of the human blood	**43**
2.4	The D-Glucose transformation phenomenon	**44**
2.5	Structural morphology of the human skin	**45**
3.1	Absorption spectra of major intracellular absorbers	**57**
3.2	Absorption cross-section of oxyhemoglobin and reduced hemoglobin at Red-NIR region	**58**
3.3	Absorption spectrum of glucose dissolved in water within the spectral range extending from 900 nm to 2400 nm	**58**
3.4	Absorption spectrum of water and glucose in water from 800 nm to 1400 nm	**58**
3.5	Mini-spectrometer of Avantes Inc.,USA	**59**
3.6	Absorption profile of 10% Dextrose (glucose)-distill water within 300 nm to 1050 nm	**60**
3.7	(a) Digital spectrophotometer of M.S Electronics Pvt. Ltd. (India) and (b) Absorption spectra of glucose in distill water between 900 nm to 980 nm	**62**
3.8	The sine wave modulating signal	**64**
3.9	The modulated carrier wave signal	**64**
3.10	Simple depiction of Amplitude Modulated sine wave	**65**
3.11	Amplitude Modulator with input and output signals	**66**
3.12	Block diagram of noninvasive technique based prototype (MUS-IR) unit.	**67**
3.13	Modulating sine wave signal	**69**
3.14	Carrier sine wave signal	**71**
3.15	Functional block diagram of AD633	**73**
3.16	Amplitude Modulation circuit for providing modulation input to the Ultrasound Transmitter unit.	**73**
3.17	Amplitude Modulated signal waveform	**74**
3.18	Amplitude Modulated waveform pattern as provided to the finger holder.	**76**
3.19	The output waveform pattern from the USR unit as recorded by DSO	**76**

3.20	Finger holder probe of our noninvasive technique based prototype unit.	**77**
3.21	Square wave signal	**78**
3.22	Typical spectral intensity distribution of the IR LED used in our prototype	**79**
3.23	Infrared photodiode circuit diagram	**80**
3.24	Peak-to-peak amplitude spectrum (in FFT domain) measured at 940 nm from solutions with changing glucose concentration.	**82**
3.25	The peak-to-peak amplitude in FFT domain relationship with varying glucose concentration in fasting and 2 hour postprandial in-vitro samples	**83**
3.26	The typical output signal acquired from the fingertip of the study subject	**85**
3.27	The peak amplitude (mV) spectrum in the FFT domain	**86**
3.28	The observed signal of the study subject in absence of amplitude-modulated ultrasound in our noninvasive technique based prototype during before meal intake session	**87**
3.29	The observed peak amplitude spectrum from the study subject in absence of amplitude-modulated ultrasound in our noninvasive technique based prototype during before meal intake session	**88**
3.30	The observed signal from the study subject in presence of amplitude-modulated ultrasound in our prototype during before meal intake session	**88**
3.31	The observed peak amplitude spectrum from the study subject in presence of amplitude-modulated ultrasound in our noninvasive technique based prototype during before meal intake session	**89**
3.32	The observed peak amplitude spectrum from the study subject in presence of amplitude-modulated ultrasound in our noninvasive technique based prototype during one hour after meal intake session.	**89**
3.33	The observed peak amplitude spectrum from the study subject in presence of amplitude-modulated ultrasound in our noninvasive technique based prototype during one hour after meal intake session	**90**
3.34	The in-vivo signals based peak amplitude spectral variations in the FFT domain with respect to change in the blood glucose levels during fasting and 2-hour postprandial stages.	**90**
3.35	Accu-Chek Active of Roche Diagnostics GmbH, Mannheim, Germany (Invasive Glucometer) for Reference Blood Glucose Level measurement in human subjects	**93**
3.36	Our Noninvasive technique based prototype (MUS-IR) unit	**94**
3.37	Our noninvasive technique based prototype unit for Predicted (Noninvasive) Blood Glucose Level measurement in human subjects	**95**

3.38	Clarke Error Grid plot	**96**
4.1	Diagrammatic representation of the effect of glucose concentration on light transmission phenomenon	**100**
4.2	Flowchart for quantification of glucose level induced light transmission	**102**
4.3	Absolute value calculation from the signal waveform as acquired from the healthy subject	**104**
4.4	Absolute value calculation from the signal waveform as acquired from the diabetic subject	**104**
4.5	Square value calculation from the signal waveform as acquired from the healthy subject.	**105**
4.6	Square value calculation from the signal waveform as acquired from the diabetic subject	**106**
4.7	Absolute value peak to peak as obtained from Healthy and Diabetic Subjects	**107**
4.8	Square values peak to peak as obtained from the Healthy and Diabetic Subjects	**108**
4.9	Invasive Random Blood Glucose Levels as obtained from Healthy and Diabetic Subjects	**108**
5.1	**(a)** The observed signal as acquired from the subject 1 at 0 min and **(b)** its corresponding peak amplitude spectrum in the FFT domain	**113**
5.2	**(a)** The observed signal as acquired from the subject 1 at 60 min and **(b)** its corresponding peak amplitude spectrum in the FFT domain	**114**
5.3	**(a)** The observed signal as acquired from the subject 1 at 120 min and **(b)** its corresponding peak amplitude spectrum in the FFT domain	**114-115**
5.4	OGTT based time dependent sequential variations in the blood glucose levels; error bars indicate ±5 percentage error.	**115**
5.5	Clarke Error Grid Analysis plot as obtained from the OGTT investigation.	**116**
5.6	The effect of 25 gm/100 ml glucose solution (w/v) on the fasting BGL; error bars indicate ±5 percentage error.	**120**
5.7	The effect of 50 gm/100 ml glucose solution (w/v) on the fasting BGL; error bars indicate ±5 percentage error.	**120**
5.8	The effect of 75 gm/100 ml glucose solution (w/v) on the fasting BGL; error bars indicate ±5 percentage error	**121**
5.9	Clarke Error Grid Analysis	**122**
5.10	BGL after meal intake in healthy and pre-diabetic subjects; error bars indicate ±5 percentage error.	**126**
5.11	BGL after 75 gm/100 ml glucose intake in healthy and pre-diabetic subjects; error bars indicate ±5 percentage error.	**127**
5.12	Clarke Error Grid Analysis	**128**

5.13	R-BGL (Invasive) and P-BGL (Noninvasive) blood glucose levels of the healthy subjects during Fasting, Postprandial, and Random stage; error bars indicate ±5 percentage error.	**132**
5.14	R-BGL (Invasive) and P-BGL (Noninvasive) blood glucose levels of the Type I Diabetic subjects during Fasting, Postprandial, and Random stage; error bars indicate ±5 percentage error.	**133**
5.15	R-BGL (Invasive) and P-BGL (Noninvasive) blood glucose levels of the Type II Diabetic subjects during Fasting, Postprandial, and Random stages; error bars indicate ±5 percentage error.	**134**
5.16	Clarke Error Grid Analysis	**135**
5.17	The Blood Glucose Level values as obtained by the Predicted (noninvasive) and Reference (invasive) methods from the normal subject during 5 daily sessions of fasting, postprandial and random stages; error bars indicate ±5 percentage error.	**139**
5.18	The Blood Glucose Level values as obtained by the Predicted (noninvasive) and Reference (invasive) methods from the Type II Diabetic subject during five daily sessions of fasting, postprandial, and random stages; error bars indicate ±5 percentage error.	**139**
5.19	Depicts the Clarke Error Grid-based Analysis of the Blood Glucose Level values as obtained from both the Subjects (Normal and Type II Diabetic) during 5 daily sessions of Fasting, Postprandial and Random stages	**140**
5.20	Reference (invasive), predicted (noninvasive) fasting blood glucose values as obtained from the healthy subjects; error bars indicate ±5 percentage error.	**146**
5.21	Reference (invasive), predicted (noninvasive) fasting blood glucose values as obtained from the diabetic subjects; error bars indicate ±5 percentage error.	**147**
5.22	HbA1c values of the Healthy (1-10) and Diabetic (11-20) Subjects; error bars indicate ±5 percentage error.	**147**
5.23	Clarke Error Grid Analysis of reference (invasive) and predicted (noninvasive) blood glucose measurements as obtained from the normal healthy subjects (1-10) and diabetic subjects (11-20) altogether respectively; error bars indicate ±5 percentage error.	**148**
5.24	The relationship between blood glucose and blood pressure values of healthy normal subject II as observed during Day 1 of the clinical study; error bars indicate ±5 percentage error.	**160**
5.25	The relationship between Blood Glucose Levels and Blood Pressure values of Diabetic Subject IX respectively; error bars indicate ±5 percentage error.	**161**

5.26	The Clarke Error Grid Analysis of the blood glucose levels as obtained from Healthy Normal (I to V) and Diabetic (VI to X) Subjects respectively.	**162**
5.27	OGTT response curve of the study subjects (1 to 5) on 1st day; error bars indicate ±5 percentage error.	**166**
5.28	OGTT response curve of the study subjects (6 to 10) on 2nd day; error bars indicate ±5 percentage error.	**166**
5.29	OGTT response curve of the study subjects (11 to 15) on 3rd day; error bars indicate ±5 percentage error.	**167**
5.30	OGTT response curve of the study subjects (16 to 20) on 4th day; error bars indicate ±5 percentage error.	**167**
5.31	OGTT response curve of the study subjects (21 to 25) on 5th day; error bars indicate ±5 percentage error.	**168**
5.32	OGTT response curve of the study subjects (26 to 30) on 6th day; error bars indicate ±5 percentage error.	**168**
5.33	Clarke Error Grid analysis based plot for reference (invasive) and predicted (noninvasive) blood glucose measurement as obtained from 30 human subjects during OGTT analysis.	**169**
5.34	Random Blood Glucose tests of the Subjects (1-10); error bars indicate ±5 percentage error.	**171**
5.35	Random Blood Glucose tests of the Subjects (11-20); error bars indicate ±5 percentage error.	**172**
5.36	Random Blood Glucose tests of the Subjects (21-30); error bars indicate ±5 percentage error.	**172**
5.37	Clarke Error Grid analysis based plot for reference (invasive) and predicted (noninvasive) blood glucose measurement as obtained from 30 human subjects during Random blood glucose tests.	**173**
6.1	Clarke Error Grid Analysis of overall Reference (Invasive) and Predicted (Noninvasive) blood glucose measurement	**179**
6.2	Parkes Error Grid Analysis of overall Reference (Invasive) and Predicted (Noninvasive) blood glucose measurement	**182**
6.3	The scatter diagram of Reference and Predicted Blood Glucose Levels	**191**
6.4	The scatter diagram of Reference and Predicted Blood Glucose Levels	**193**
6.5	Bland-Altman Plot based analysis	**195**
6.6	Mountain Plot based analysis	**197**
6.7	Deming Regression based analysis	**202**