LIST OF FIGURES

Figure 1.1:	Peak brightness of free-electron lasers in the VUV and X-ray regime compared to 3rd generation light sources.	**7**
Figure 1.2:	Free Electron Lasers (FELs) (a) Typical layout (b) Geometrical configuration (c) Schematics sketch.	**9**
Figure 1.3:	Free electron laser amplifiers configuration.	**15**
Figure 1.4:	Free electron laser oscillators configuration.	**16**
Figure 1.5:	Self-amplified spontaneous emission (SASE) FELs.	**16**
Figure 2.1:	Wiggler magnets arrangement.	**31**
Figure 2.2:	(a) The dispersion relation for the infinite length of interaction and (b) The dispersion relation for the finite length of interaction.	**33**
Figure 2.3:	Operating point of FELs.	**35**
Figure 2.4:	Frequency ranges from millimeter to sub millimeter wavelengths (between electronics and photonics regime).	**36**
Figure 2.5:	Schematic of physical mechanism interaction between electron beams and planner wiggler.	**37**
Figure 2.6:	Accelerating zones and retarding zone by Ponderomotive force with A_p .	**44**
Figure 2.7:	Phase (P,ψ) space trajectories of separatrix of the trapped-untrapped electrons.	**49**
Figure 2.8:	Spectral function for the spontaneous emission of a cold beam helical wiggler.	**60**
Figure 2.9:	Gain function for the spontaneous emission of a cold beam helical wiggler.	**62**
Figure 2.10:	Phase (P,ψ) space trajectories of the trapped electrons.	**71**
Figure 2.11:	Gain as a function of initial electron energy.	**73**
Figure 3.1:	Beat-wave excitation as FEL amplifiers (FELA).	**79**
Figure 3.2:	Dispersion Relation Curve to the Beam Modesand Radiation Modes. Curve I (Solid Line) and II (Dotted Line Validation)	**90**

	Represent the Beam Modes and Curve III Represent the Radiation Modes for the given parameters as Table 3.1.	
Figure 3.3:	Radiation Frequency (ω_1) versus Beam Voltage (V_b) for the given parameters as Table 3.1.	**91**
Figure 3.4:	Growth Rate (Γ) versus Beam Voltage (V_b) for the given Parameters as Table 3.2.	**93**
Figure 3.5:	Growth Rate (Γ) versus Normalized Lengths (z/L) for the given Parameters as Table 3.2.	**93**
Figure 3.6:	Normalized momentum versus normalized phase of beam electrons.	**99**
Figure 3.7:	Gain function (G) Versus Momentum (P_{in}) of trapped electrons.	**101**
Figure 3.8:	Efficiency (η) versus normalized distance (ξ).	**102**
Figure 4.1:	Typical layout (a) and 3-D schematic diagram for simulation of the FEL amplifiers (b & c).	**108**
Figure 4.2:	Flow chart of design procedure of the FEL amplifiers.	**119**
Figure 4.3:	Fields pattern of the FEL amplifiers for the desired TM_{01} mode (i) Electric field patterns at the input port (a) contour plot (b) vector plot (c) Magnetic field patterns at the input port , contour plot, and (ii) Magnetic field patterns at the output port (d) contour plot and (e) vector plot.	**126**
Figure 4.4:	FEL amplifiers simulated and desired observation for (a) S-parameters (b) Impedance in Ohm (c) Power accepted.	**128**
Figure 4.5:	FEL amplifiers output power vs radiated frequencies.	**129**
Figure 4.6:	Cross sectional view of the helical wiggler.	**132**
Figure 4.7:	Simulation results for the case of **Iron helix** with rectangular cross section as (a) The helix geometry without drift tube (b) Transverse Magnetic Field Amplitude B_x (T) & B⊥(T) without drift tube (c) The helix geometry with drift tube (d) Transverse Magnetic Field Amplitude B_x (T) & B⊥(T) with drift tube.	**134**
Figure 4.8:	Simulation results for the case of **steel helix** with round cross section as (a) The helix geometry without drift tube (b) Transverse Magnetic Field Amplitude B_x (T) & B⊥(T) without drift tube (c) The helix geometry with drift tube (d) Transverse Magnetic Field Amplitude B_x (T) & B⊥(T) with drift tube (e)	**137**

Transverse Magnetic Field Amplitude B_x(T) with drift tube (f) Transverse Magnetic Field Amplitude $B_\perp$(T) with helix wire diameter and The predictions of formula (4.15) is also validated for square cross section as shown in (f).

Figure 4.9: Simulation results for the case of **Iron helix** with round cross section as (a) The helix geometry without drift tube (b) Transverse Magnetic Field Amplitude B_x (T) & $B_\perp$(T) without drift tube (c) The helix geometry with drift tube (d) Transverse Magnetic Field Amplitude B_x (T) & $B_\perp$(T) with drift tube. **139**

Figure 4.10: Simulation results for the case of **Iron helix** with round cross section as (a) The helix geometry with copper drift tube (d) Transverse Magnetic Field Amplitude B_x (T) & $B_\perp$(T) with copper drift tube. **140**

Figure 4.11: Simulation results for the case of Iron helix with round cross section as (a) The helix geometry with copper drift tube (d) Transverse Magnetic Field Amplitude Bx (T) & $B_\perp$(T) with copper drift tube. **141**

Figure 4.12: CST design model of FEL amplifiers (a & b) Lay out (c) diagram for simulation of the FEL amplifiers. **144**

Figure 4.13: Wiggling view of the electron beams during PIC Simulations (a), & (b). **145**

Figure 4.14: Power evolution of the electron bunches transfer to the RF wave. **146**

Figure 4.15: Frequency spectrum of the TM_{11} mode. **146**

Figure 4.16: Temporal amplitude curve of the TM_{11} mode. **148**

Figure 4.17: Temporal power plot of the TM_{11} mode. **148**