Chapter 6

Conclusion
The aim of this work has been the theoretical investigation of real solar cells and extract its various parameters. Extraction of parameters of any device is important in terms of describing its behaviour. The transcendental nature of current-voltage relation of solar cell have attracted interests of various researchers over last five to six decades for determining its exact analytical solution, but they were able to provide only numerical solutions. It was only in last decade that an exact analytical solution where current and voltage can be separated was provided using Lambert W-function. But due to the limitation of the method that it can be applied to equations that can be written in a particular form, focus has been diverted to a recently developed special trans function theory (STFT), which is also the heart of this work. Besides its ability to provide explicit solutions, differentiable property of STFT, makes it a powerful tool and efficient futuristic approach to study real solar cells. STFT has the advantage of applicability for arbitrary non-linear forms, superior accuracy and computational efficiency over the well-established Lambert W-function method.

The first objective achieved in this work was the exact analytical solution of the transcendental $i-V$ relation using STFT. Solar cell parameters are then extracted using both theoretical and graphical approaches and are compared with experimental results. They are found to be well in accordance with experimental results and with those evaluated using other established reported methods. Parameters extracted in this work includes short circuit current ($I_{sc}$), open circuit voltage ($V_{oc}$), dynamic series and shunt resistance ($R_{s0}$ and $R_{sh0}$) etc. A new method to determine ideality factor ($n$) and optimum load was also presented in this work.

The STFT method has been extended from inorganic solar cell to organic solar cells. The method became significant in solving the $i-V$ relations of organic based solar cells and hence estimating their parameters. More precisely, the method was applied to organic, plastic and dye sensitized solar cells. Accurate results were obtained when this method was applied to multi-exponential model (in this case double-diode model) of a real solar cell. A new analytical solution for $J-V$ characteristics of organic solar cells showing a kink near the open-
circuit point (S-shape) is presented using STFT. The simulations using STFT solution is in agreement with the experimental results. This exact analytical expression is presented for the first time corresponding to the proposed model available in literature. STFT method was also used to study the appearance of kink (S-shaped behaviour) in the $J-V$ characteristics of heterojunction solar cells near $V_{oc}$. Various curves were plotted to validate the method. The only limitation of the STFT method is its inability to find an explicit expression for fill factor ($FF$).

With the rapid advancement in the field of renewables, PVs too have taken a newer dimension in the last few years. There is a paradigm shift in PV technology moving from a very traditional $p-n$ junction to the advanced technologies like quantum dots, quantum ropes, polymer solar cells, nanocrystal solar cells, DSSCs, etc. Of late, the emphasis is laid on composite PV technology (hybrid technology) which is still in the nascent stage. This multi-prong research is targeted to develop the technology in a cost-effective manner which would go a long way towards making solar power a more practical alternative energy source.

In future, the STFT method could be exploited in the investigation of such hybrid solar cells which may provide a significant contribution towards the development of solar cell technology.