MANTECH Publications

Journal of Research in VLSI Design Tools and Technology
Volume 4 Issue 1, January-April 2019

Fast Assessment of Static Available Transfer Capability

K Uday Kumar Reddy[1], K Sainadh Singh[2], Dr. N Bhoopal[3]
Research Scholar[1], Assistant Professor[2], Professor & Head[3]
Department of E.E.E
University of Southern Queenland, Springfeild, Brisbane, Australia[1]
Padmasri Dr. B. V. Raju Institute of Technology, Hyderabad, India[2, 3]
Corresponding Authors' E-mail: *chandrababu.p@bvrit.ac.in, rapideet16@gmail.com*

Abstract

In recent years, the development in the deregulated electricity market structure increases the number of market participants thereby, makes the market more competitive. Therefore, it is important for the system operator to determine fast and accurate static available transfer capability (S-ATC) of the system to provide secure electricity power wheeling. This paper proposes the fast assessment of S-ATC in the deregulated environment by eliminating the Contingency pre-screening process. Application of Real coded genetic algorithm (RGA) is used as a tool in determining S-ATC without finding severe contingencies. The effectiveness of the proposed method of ATC assessment is analysed by carry out different bilateral/multilateral wheeling transactions on Sample six bus system and it is accuracy compared with the Conventional Repeated Power flow Method.

Keywords: *Component; Formatting; Style; Styling; Insert*

INTRODUCTION

The electrical utilities are getting restructured in several countries throughout the world, so as to introduce the competition at generation and distribution levels to reduce the cost of energy production and distribution, eliminate certain inefficiencies and increase the customer choice, while retaining the transmission network as natural monopoly for the techno-economic reasons. It is expected to overcome the inefficiencies prevalent in the monopoly franchise structure with assured revenue collection. Apart from the generating companies (Gencos).Transmission companies (Transco), Distribution companies (Discos) and customer, many other entities emerge in the electricity markets, such as Retail companies (Retailcos), System operator (SO), power traders, brokers, scheduling coordinators, etc.

The System operator (SO) is responsible to maintain system security and reliability of power system, apart from ensuring contractual power. It does no town any transmission, generation or distribution facility and has no financial interest in the market. The SO posts the information such as pricing, availability status, transmission constraints, load distribution and line losses and procures ancillary services, coordinate day-ahead scheduling and balancing/regulating services, frequency control ,reactive power/voltage control and reserve services.

Most of the emerging electricity markets have pool as well as bilateral/multilateral transactions. In the pool market model, the pool operator receives electricity transaction bids and offers from suppliers and customers in the power exchange. It settles hourly/half hourly bids. In a bilateral market model, sellers and buyers enter into transactions directly. The quantities traded and the trade prices are at the discretion of these parties and only the amount and points of transactions need to be informed to the System Operator (SO). A multilateral transaction is the generalization of bilateral transactions, where power brokers put together a group of energy producers and buyers to form a balanced transaction.

Methods for static ATC determination can be broadly categorized as Repeated Power Flow (RPF) methods, Continuation Power flow (CPF) methods, Sensitivity based methods (Power Transfer Distribution Factor method) and optimal power flow methods. Most researchers have proposed methods for determination of static ATC considering line flow limits and voltage Constraints.

The above Methods of determining static ATC involves two process. First process is to perform Contingency pre-screening to find out the severe contingencies. By means of contingency screening ATC assessment can be accelerated. Second process is to find out the minimized ATC from the base case condition and with the severe contingencies. Though the contingency pre-screening accelerated the ATC determination there may be a chance of getting minimized ATC with the contingency which is not considered as the severe contingencies. Hence it is necessary to consider all the line outage while determining the static ATC and also it is necessary to update the ATC very fast in the online website in order to proceed other transactions. The above issue is addressed by means of using the application of heuristic algorithm such as genetic algorithm

AVALABILITY TRANSFER CAPABILITY

A. Introduction

ATC evaluation is more important because it is the point at which power system reliability meets the electricity market efficiency. The ATC have a huge impact on market outcomes and system reliability, so that the results of the ATC are of great interest to all involved. NERC defines the available transfer capability (ATC). Mathematically ATC can be defined total transfer capability (TTC) less the transmission reliability margin (TRM), less the sum of the existing transmission commitment (ETC) and the capacity benefit margin (CBM).

$$ATC=TTC-ETC-CBM-TRM \qquad 1$$

$$ATC=TTC-ETC \qquad 2$$

Where, the TTC is defined as the amount of electric power that can be transferred over the interconnected transmission network or particular path or interface in a reliable manner while meeting all of a specific set of pre and post contingency conditions. Existing Transmission commitments(ETC) is the power flow over the transmission paths at the desired time at which ATC should be calculated.

This is already committed uses power on the transmission path. Utilities would have to adequately determine their ATCs to ensure that system reliability is maintained while serving wide range of transmission transactions. The ATC between and within their area of the interconnected power system, and the ATC for critical transmission paths between their areas would be continuously updated and changes posted in scheduled power transfer between their areas. The limits to be considered for the calculation of the transfer capability may be broadly classified as

1. Static Constraints
   - Line thermal limits
   - Bus Voltage (magnitude) Limits
   - Saddle Node Bifurcation (Steady state stability limit)

2. Dynamic Constraints
   - Small signal stability limit / Hopf-bifurcation limit

   - Large signal stability limit

The assessment of ATC with static limits is called as Static ATC and assessment of ATC with static limits as well as dynamic limits is called Dynamic ATC. In this article Static ATC is assessed. The Static ATC between the bus m and bus n using line flow limit and voltage criterion, is mathematically formulated as

ATC=min (ATC 0, mn, ATC ij,mn) ij € NL 3

A. *Methods of Static ATC Determination*

1. Methods based on linear sensitivity Factors

2. Methods based on Continuation Power flow method

3. Method based on optimization power flow.

STATIC ATC DETERMINATION

Static ATC with respect to a bilateral/multilateral contract can be calculated by increasing the generation at the seller bus/buses and simultaneously, the loads by the same amount at the buyer bus/buses until any of the system parameter such as such as magnitude and phase angle voltage of the each bus, real power line flow limit reaches the critical value. The new load and generation as follows.

$$P_{Di}^{new} = P_{Di}^{0}\left(1+\lambda * T_{SDi}\right) \qquad 4$$

$$P_{Gi}^{new} = \left[\sum_{i-1}^{NDT}\left(P_{Di}^{new} - P_{Di}^{0}\right)\right] * T_{SGi} + P_{Gi}^{0} \qquad 5$$

Where, are the base case load and generation at bus-i., are the transaction share ratio of load and generation at bus–i. NDT is the total number of load bus consider in the transaction tk. λ is the loading factor. Total transfer capability (TTC) and ATC in each contingency case are calculated as follows

$$TTC = \sum_{i=1}^{NDT} P_{Di}^{0}\left(1 + \lambda * T_{SDi}\right) \qquad 6$$

$$ATC = TTC - \sum_{i=1}^{NDT} P_{Di}^{0} \qquad 7$$

Contingency Screening Algorithm

In real time electricity market, fast assessment of ATC considering the effect of line contingencies is more important. The contingencies screening method provides the solution for the above issue by identifying severe line contingencies based on the Performance index value. This is explained through the following procedure.

Step1: Consider the wheeling transaction tk

Step 2: Additional amount of transaction say 5MW is considered for the wheeling transaction tk so that the minimum ATC will be greater than 5MW

Step3: Choose all the possible line contingencies.

Step4: Select a Line contingency

Step5: Compute the Performance Index PI L for each line using PILi = 〖Pl〗_i/ 〖〖Pl〗_i〗^max where Pli is the Real power flow in ith branch calculated by means of Newton's power flow

Step6: Check whether any PIL of the Line is greater than 1 and check whether any of the bus voltage violates the specified maximum and minimum limit due to the line outage. If yes the PI of the line outage=0 Otherwise the PI of the line outage=Max (PIL value of all the line outage)

Step7: Repeat Step 4-Step 6 until PI for all the possible line contingency is computed

Step8: Arrange the PI in descending order and select the top five contingenciesStep9: More the PI value indicates the severity of the Line outage.

B. Static ATC Determination Algorithm

Use either SI (MKS) or CGS as primary units. (SI units are encouraged.) English units may be used as secondary units (in parentheses). An exception would be the use of English units as identifiers in trade, such as "3.5-inch disk drive."

Step1. Read System input Data

Step2. Run the base case load flow in CEED with practical constraint Environment and determine the optimal generator settings

Step 3. Select the source bus/buses and sink bus/buses for the transaction tk.

Step 4. Initialize the loading factor $\lambda=0$ and incremental loading factor $\triangle\lambda=1$

Step 5. Increment the loading factor $\lambda = \lambda+\triangle\lambda$.

Step 6. Run the Newton's Power flow by changing the corresponding the load and generation bus value for the transaction tk is given as and 〖P^new〗_Gi=∑_(i=1)^NDT▒〖〖〖(P 〗_Di〗^new-〖P_Di〗^0)*T_SGi+〗〖P_Gi〗^0 to obtain the system parameters such as magnitude and phase angle voltage of the each bus, real power line flow limit

Step 7. Check whether all the obtained system parameters are within the limits, if yes goes to step 5 otherwise go to step 8.

Step8. Decrement the loading factor $\lambda = \lambda-\triangle\lambda$ and change the incremental load loading factor $\triangle\lambda=\triangle\lambda/10$.

Step 9. Check the $\triangle\lambda \leqslant 0.0001$, if yes goes to step 10 otherwise go to step 5.

Step 10. Calculation of TTC using λ as given in

Step 11. Calculation of ATC using

REAL CODED GENETIC ALGORITHM FOR DETERMINING FAST STATIC ATC

The Structure of Conventional ATC is shown in the Fig 5. From the fig: 1 it is inferred that in Conventional ATC Assessment, Contingency Pre-screening is first to determine the Severe Line contingencies and the ATC is determined for both base case and the top severe line contingencies.

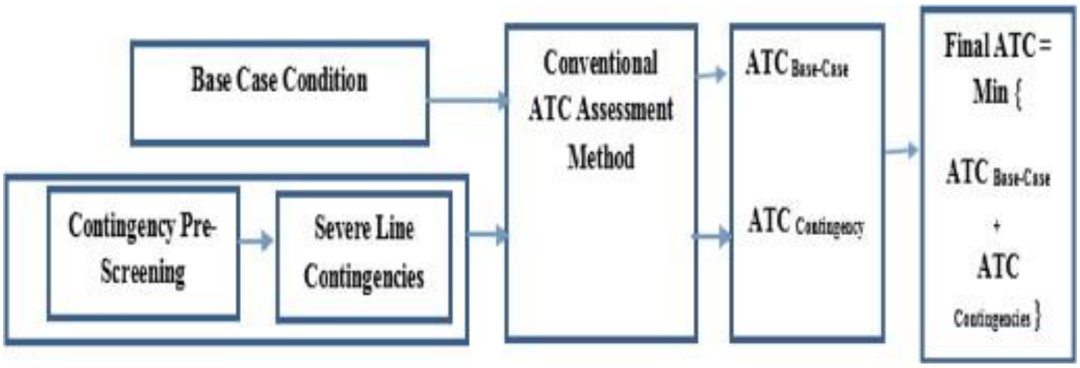


Fig: 1. Conventional ATC determination Structure

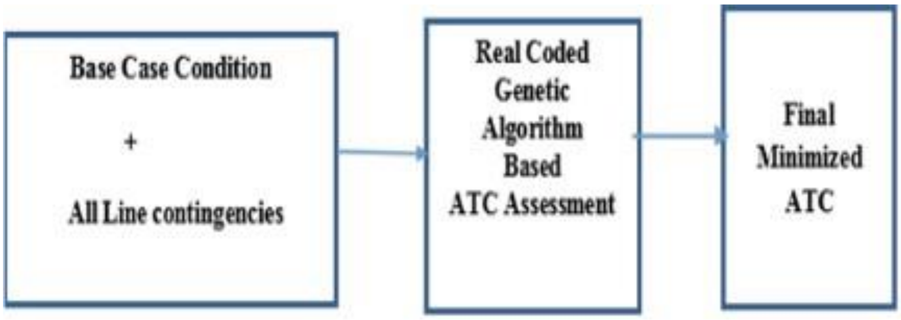


Fig 2. Structure of Genetic Algorithm based Static ATC determination

The time consumption for the pre-contingency line outage and the ATC determination for all severe line outage increases overall time computation for ATC determination and also there may be chance of getting minimized ATCresult in other contingencies which is not in the severe contingencies. Hence it is necessary to consider all the line outage while determining Static ATC and also it is necessary to update the ATC very fast in order to precede the other transactions To address the above issue application of Heuristics algorithm such as genetic algorithm must be used to provide fast and accurate ATC considering all the contingencies. The structure of Genetic Algorithm based ATC is shown in the Fig 2. From the figure it is inferred that the contingency Pre-screening process is not considered thereby reducing the overall computational time by avoiding separate ATC determination for base case and severe line outage.

A. Genetic Algorithm

A Genetic Algorithm (GA) is an iterative procedure which begins with a randomly generated set of solutions referred as initial population. For each solution in the set, objective function and fitness are calculated. On the basis of these fitness functions, pool of selected population is formed by selection operators; the solution in this pool has better average fitness then that of initial population.

The crossover and mutation operator are used to generate new solutions with the help of solution in the pool. The process is repeated iteratively while maintain fixed number of solutions in pool of selected population, as the iteration progress, the solution improves and optimal solution is obtained. During the selection process of the GA, good solutions are selected from the initial generated population for producing offspring. Good solutions are selected randomly from the initial generated population using a mechanism which favours the more fit individuals. Good individuals will probably be selected several times in a generation but poor solutions may not be selected at all.

The second GA operator is crossover. In the crossover two parents are selected randomly from the pool of selected/obtained population by the selection process. Crossover produces two offspring which has some basic properties of the parents. The mutation operator generates an offspring using a random solution from pool.

Each new solution is evaluated i.e. objective function and fitness values are calculated. These newly created off springs and the populations are combined. The combined population is put for selection by selection operator. With the above description, a simple Genetic Algorithm is given as follow

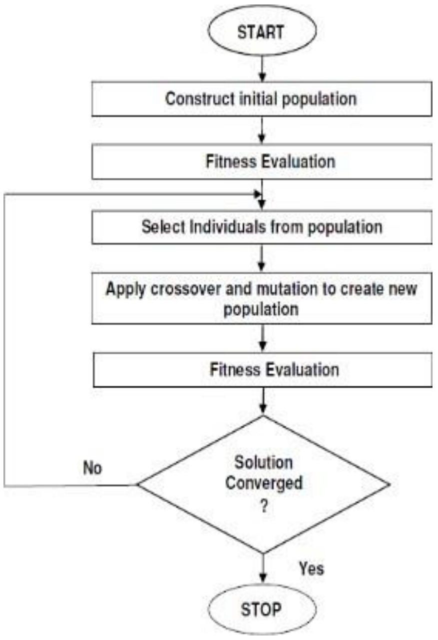


Fig 3 Genetic Algorithm flow chart

RESULTS AND DISCUSSION

A. Practical Constrained CEED problem for IEEE 30 Bus system

The IEEE 30 bus system consists of six-thermal units and 41 transmission Lines. The bus data and line data are given in Appendix A. The generator cost coefficients, emission coefficients with valve point data and generation limits with ramp rate, prohibited zone data and Effective upper and lower generation limits are given in Appendix B. In the base case, a single load level of 283.4 MW was assumed to the period of one hour for IEEE-30 bus test system.

To serve the load, all the available generators dispatch settings are optimized based on the minimization of fuel economy and emission output using the proposed RGA CEED algorithm for the test system and the results are given in table: 1. The cost and emission coefficients of IEEE-30 systems for the CEED problem are taken from Gnandass et.al.To validate the performance of RGA based CEED method, the results of CEED with line flow constraints (case A) are compared with the EP based Modified CEED proposed in Gnandass et.al. For the IEEE30 bus. From the Table.1 it is inferred that the RGACEED results considering case A constraints provide minimal and close solution in terms of total operating cost with the EPMCEED results for the both the test systems.

In practical cases, the online generators operating range are restricted by their ramp rate limit, prohibited zone and valve point loading due to physical operational limitation. Hence it is necessary to include these practical constraints along with line flow constraints (case B) while solving CEED problem. The RGA based CEED subject to practical constraints of case B is alsosimulated and the results are provided in table .I for the test systems. The practical constraints of case B for IEEE-30 for the CEED problem are given in Appendix B.The convergence Graph for case A and Case B using RGACEED method is given in Fig: 4. For the base case load, the best generation of IEEE-30 bus obtained from RGACEED algorithm with case A and case B is presented in the Fig 5 The case B optimal settings of generator is considered as the base case power flow for DATC assessment.

Table I. CEED Comparison with RGA and EP

Method	Case	Penalty factor $/lb	Fuel cost $/hr	Emission cost $/hr	Total cost $/hr	Total losses MW
EPM CEED [Gnanadas.et al]	A	3.7424	840.21	350.50	2151.27	6.063
RGA	A	3.7424	840.11	342.68	2122.59	6.245
CEED	B	3.7424	876.63	351.91	2211.13	7.067

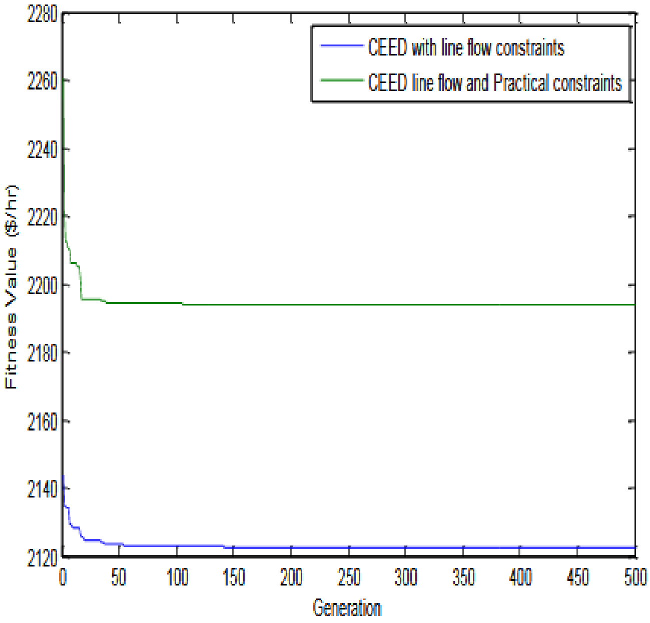


Fig: 4 RGACEED Converge Graph

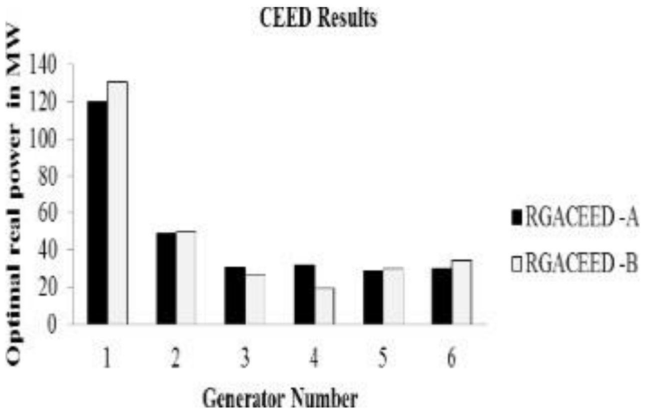
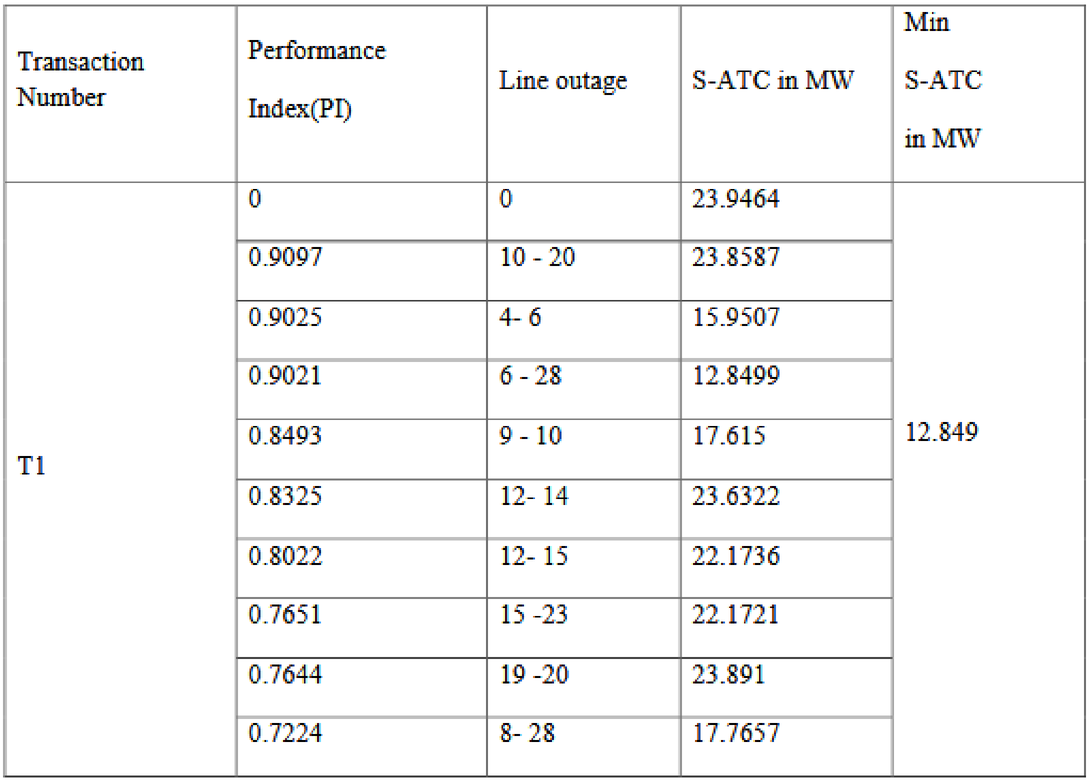


Fig: 5. Best generator settings of RGACEED with both cases—IEEE-30 bus system

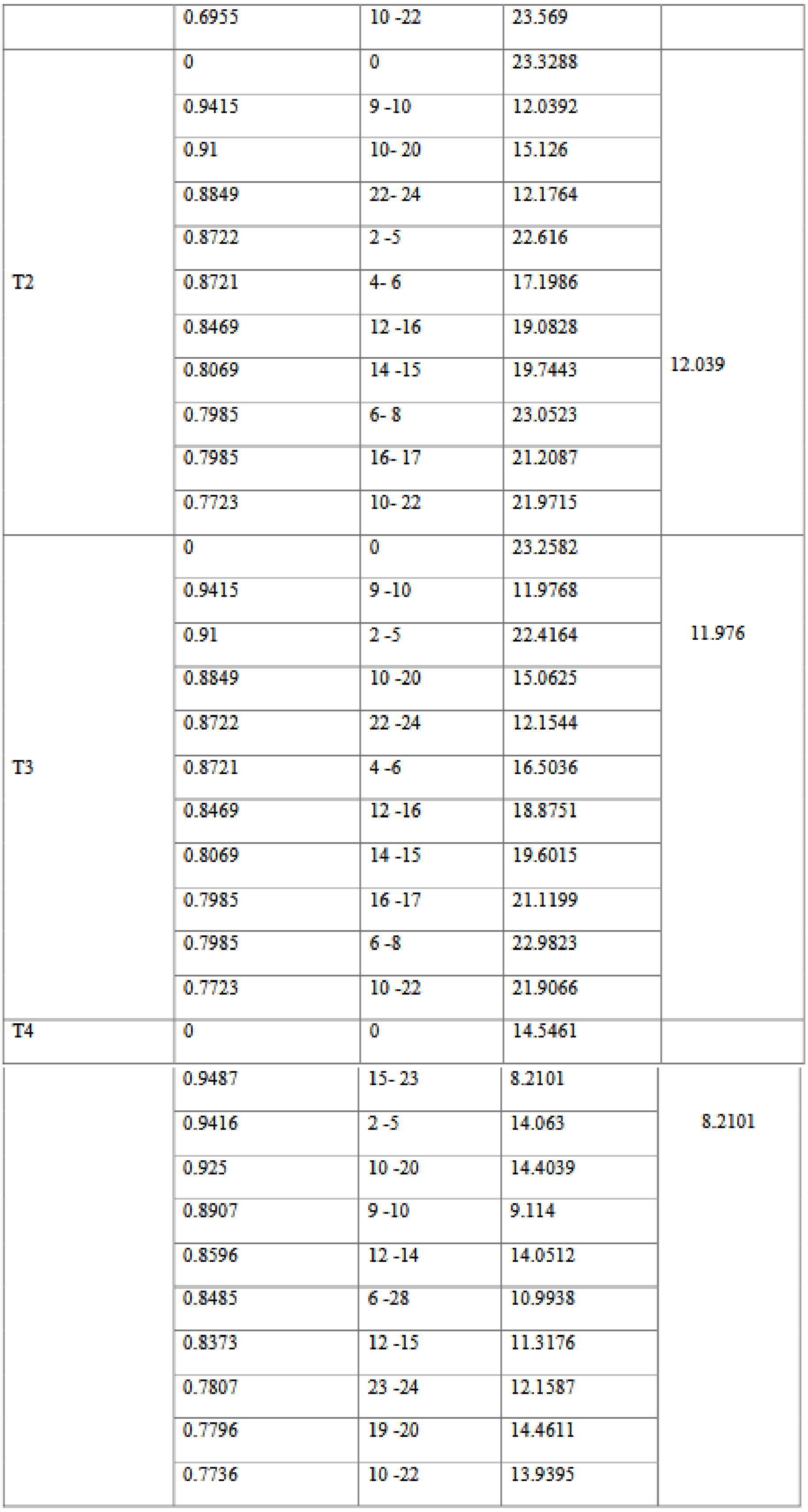
B. DATC Assessment in CEED environment for IEEE-30 bus system

The details of different power transactions carried out for the S-ATC assessment in CEED algorithm are as follows: Two bilateral transactions with transaction share ratio such as transaction T1 between the seller at bus 2 (1.0) and buyer at bus 28 (1.0) and transaction T2 between the seller at bus 5 (1.0) and buyer at bus 23 (1.0).Similarly, two multilateral transactions with transaction share ratio such as transaction T3 between the seller at buses 2(0.5), 5(0.5) and buyer at bus 23 (1.0) and transaction T4 between the seller at buses 2 (0.5) , 11(0.5) and buyer at buses 26 (0.5) , 28 (0.5). The S-ATC results assessed with the optimum generation setting obtained from RGACEED algorithm with line flow constraints and practical constraints of generator along with line flow constraints (Case B) as the base case power flow are given in table 2.

Table II. Static ATC in Ceed Environment for IEEE 30 Bus System



Transaction Number	Performance Index(PI)	Line outage	S-ATC in MW	Min S-ATC in MW
T1	0	0	23.9464	12.849
	0.9097	10 - 20	23.8587	
	0.9025	4- 6	15.9507	
	0.9021	6 - 28	12.8499	
	0.8493	9 - 10	17.615	
	0.8325	12- 14	23.6322	
	0.8022	12- 15	22.1736	
	0.7651	15 -23	22.1721	
	0.7644	19 -20	23.891	
	0.7224	8- 28	17.7657	



	0.6955	10 -22	23.569	
T2	0	0	23.3288	12.039
	0.9415	9 -10	12.0392	
	0.91	10- 20	15.126	
	0.8849	22- 24	12.1764	
	0.8722	2 -5	22.616	
	0.8721	4- 6	17.1986	
	0.8469	12 -16	19.0828	
	0.8069	14 -15	19.7443	
	0.7985	6- 8	23.0523	
	0.7985	16- 17	21.2087	
	0.7723	10- 22	21.9715	
T3	0	0	23.2582	11.976
	0.9415	9 -10	11.9768	
	0.91	2 -5	22.4164	
	0.8849	10 -20	15.0625	
	0.8722	22 -24	12.1544	
	0.8721	4 -6	16.5036	
	0.8469	12 -16	18.8751	
	0.8069	14 -15	19.6015	
	0.7985	16 -17	21.1199	
	0.7985	6 -8	22.9823	
	0.7723	10 -22	21.9066	
T4	0	0	14.5461	
	0.9487	15- 23	8.2101	8.2101
	0.9416	2 -5	14.063	
	0.925	10 -20	14.4039	
	0.8907	9 -10	9.114	
	0.8596	12 -14	14.0512	
	0.8485	6 -28	10.9938	
	0.8373	12 -15	11.3176	
	0.7807	23 -24	12.1587	
	0.7796	19 -20	14.4611	
	0.7736	10 -22	13.9395	

CONCLUSION

In this paper, the S-ATC assessment is carried out in real time limitation of CEED environment for the bilateral/multilateral transactions taken in the IEEE 30 bus system. The practical generators settings obtained from the CEED algorithm with line flow constraints and practical generation limitation constraints using real coded genetic algorithm values are used as the base case power flow for the S-ATC assessment. The proposed RPF based S-ATC assessment with real time constraints of CEED results as base case power flow measures more reliable online ATC for the real time market.

REFERENCES

I. North American Electric Reliability Council (NERC), "Available transfer capability definitions and determinations", June 1996.

II. Ejebe GC, Tong J, Waight JG, Frame JG, Wang X, Tinney WF, Available Transfer Capability Calculation, IEEE Transactions on Power System, Vol.13, No.4, pp 1521-7, Nov 1998.

III. M.H. Gravener, C.Nwankpa, T.S.Yeoh, ATC Computational Issues, Proceeding of 32nd Hawaii International Conference on system sciences, pp 1-6, Jan. 1999.

IV. D Hamoud G, Assessment of Available Transfer Capability of Transmission Systems, IEEE Transactions on Power System, Vol.15, No.1, Feb 2000, 15(1), pp 27-32, Feb 2000.

V. Ch.Sunil kumar, J.Amarnath, P.S. Subramanyam, Optimal power flow analysis and available transfer capability of deregulated power system, International Review of Electrical Engineering, Vol.4, No.3, pp 1279-89, June 2011 (Part B).

VI. A. Kumar, S.C. Srivastavam, S.N. Singh, Available Transfer Capability determination in a competitive market using AC distribution factors, Electric Power Components and Systems, Vol. 32, No.9, pp. 927-39, 2004.

VII. Nanda, J., Hari,L., and Kothari, M.L., "Economic emission load dispatch with line flow constraints using a classical technique, "IEE proc.Pt.C,Vol.141,No.1,pp.1-10,1994

VIII. Kulkarni, P.S., Kothari, A.G., and Kothari, D.P.,"Combined economic and emission dispatch using improved back propogation neural network," Elect. Mach. Power Syst., Vol.28,pp.31-44,2000

IX. Venkatesh, P., Gnanadass,R., Padhy,N.P., "Comparison and application of evolutionary programming techniques to combined economic emission dispatch with line flow constraints," IEEE Trans. Power Syst., Vol. 18, No. 2, pp. 688 –697, 2003

X. P H Chen and H C Cheng,'Large Scale Economic Dispatch by genetic Algorithm' IEEE Transactions as Power systems,Vol 10,no.4,1995,pp-1919-1926

XI. T.Jeyabharathi, G.Sadasivam and V.Ramachandran, "Evolutionary Programming Based Economic Dispatch of Generators with prohibited zones",Electric Power system Research, vol 52,1999,pp 261-256

XII. Gnandass, R.,Venkatesh, P., Palanivelu, T.G., Manivannan, K., "Evolutionary Programming Based Economic Dispatch of Generators with Multiple Fuel options, Ramp Rate Limits and prohibited operating Zones",JIE(India),Vol.86,Sep.2005 ,pp.123-12

XIII. Gnanadass, R., Narayana Prasad Padhy., and Manivannan, K., "Assessment of available transfer capability for practical power systems with combined economic emission dispatch," Elect. Power Syst. Res., Vol. 69, pp. 267–276, 2004.

XIV. Manikandan, B. V., Raja, S. C., Venkatesh, P., and Kannan, P. S., "Available transfer capability determination in the restructured electricity market," Elect. Power Compon. Syst., Vol. 36, No. 9, pp. 941 –959, 2008.