Intelligent Automation And Soft Computing, 2019
Copyright © 2019, TSI® Press
Vol. 25, no. 3, 433–440
https://doi.org/10.31209/2018.100000015

Development of Available Transfer Capability Enhancement Using Intelligent Genetic Algorithm for IEEE Bus System

R. Rohini[1], Dasari Narasimha Rao[2], S. Ravi[3], V. Sampath Kumar[4]

[1]Vivekanandha College of Engineering for Women, India
[2]Defense University, Ethiopia
[3]Botswana International University of Science and Technology, Botswana
[4]Amity University, India.

ABSTRACT

Improving Available Transfer Capability is an important issue in the deregulated power systems. The Available Transfer Capability of a transmission network is the transfer capabilities of a transmission network for the transfer of power for further commercial activity, over and above already committed usage. It is a proven fact that Flexible Alternating Current Transmission System technology can control voltage magnitude, phase angle, and circuit reactance. Therefore, it is important to investigate the impact of Flexible Alternating Current Transmission System controllers on the available transfer capability. This paper is focuses on the evaluation impact of Thyristor controlled switched capacitors and static var compensators in the network. A real-coded genetic algorithm tested on IEEE 14 Bus System, and IEEE 24 bus system is used to analyze the transfer capability and enhancement in two modes, one with line outage and another without line outage on the flexible alternating current transmission network to obtain optimum results. In a competitive (deregulated) power market, the location of these devices and their control can significantly affect the operation of the system.

KEY WORDS: Available transfer capability, De regulated system, Genetic algorithm, Reliability, Transmission system.

1 INTRODUCTION

THE focus of restructuring electricity industry is to promote competition in power trading proposed by V.Ajarapu and C.Christie (1992) which results in consequence of the substantial increase in power transfers by Y.Dai, et.al. (1999). The available transmission capability is the unutilized capacity available for power transfer in a transmission network. This unutilized capability is used for the further commercial activity in the power transmission network proposed by G.C.Ejebe et.al. (1998), Y.S.Manjili et.al. (2013), M.Noroozian et.al. (1993), Peerapol Jirapong et.al. (2007). Adequate Available Transfer Capacity (AATC) is essential to ensure all economic transactions. While sufficient ATC is R.N.Ray et.al. (2008) required to aid electricity market liquidity, it is also obligatory to maintain economic and secure operation over a wide range of system operating conditions and constraints. However, due to constraints on the erection of new facilities influenced by various factors like economic restrictions, environmental, and social problems, it reduces the operational alternatives available leading to the intensive use of existing transmission facilities. On the other hand, it will benefit the power suppliers due to explorable market opportunities with reduced possibility of congestion incorporating power systems security enhancement by S.Ravi et.al.(2011). Adjusting generators' terminal voltage, Under Load Tap Changers (ULTCs) and rescheduling, generator outputs have resulted in boosting ATC considerably in various cases S.Ravi et.al. (2014), G.B.Wang et.al.(2001), Y.Xiao et.al. (2000).

It is promising to use circuit reactance, voltage magnitude, and phase angle as controls to redistribute line flow and regulate voltage profile applying FACTS concepts, and theoretically, it is a cost-effective alternative of ATC enhancement and will ensure new control facilities thereby ensuring steady state power flow control dynamically. Controlling power flow in

CONTACT R. Rohini ✉ rohinir84@gmail.com

electric power systems without generation rescheduling or topological changes can improve the network performance considerably.With suitable location, the effect of a TCSC and SVC on the ATC enhancement are studied and demonstrated through case studies.

The proposed system enhances the ATC from generating area to sink in a De-regualted situation. The system performance is analyzed at both normal and in contingency cases by placing FACTS compensation devices like TCSC and SVC for both IEEE 14 bus and IEEE 24 bus system. The intelligent Genetic algorithm used to find the control and location parameters of TCSC or SVC. The ATC is depend on system operation, and its limits, netwrok system other contingencies. The constraints in ATC is eliminated by the use of FACTS devices. Because of the implementation of FACTS devices the customers and Transmission System Operators (TSO) receive better services with reduced prices.

The first section of the paper introduces the system. The second one is with a description and highlighting the importance about ATC. The third section describes the modeling of TCSC and SVC with the help of a case study analysis for Newton Raphson power flow using TCSC and SVC, Control implementation for IEEE 24 bus system and Analysis of result, Conclusion.

2 AVAILABLE TRANSFER CAPABILITY

THE power producers and customers share a common transmission network in a deregulated power system structure. In this open environment, all producers may try to produce the energy from the cheaper source with a goal for higher profits, which may result in overloading and congestion of certain corridors of the transmission network. This may lead to disruption of line flow, voltage and stability limits and thereby undermine the system security. Utilities, therefore, need to determine their ATC adequately to ensure that system reliability is maintained while serving a wide range of bilateral and multilateral transactions.

Mathematically, ATC is termed as the Total Transfer Capability (TTC), less the Transmission Reliability Margin (TRM), less the sum of existing transmission commitments (which includes retail customer service) and the Capacity Benefit Margin (CBM), shown in Figure 1. The amount of electric power that is transmitted over the interconnected transmission network reliably while meeting all of the specific set of defined pre and post-contingency system conditions defines Total Transfer Capability (TTC).

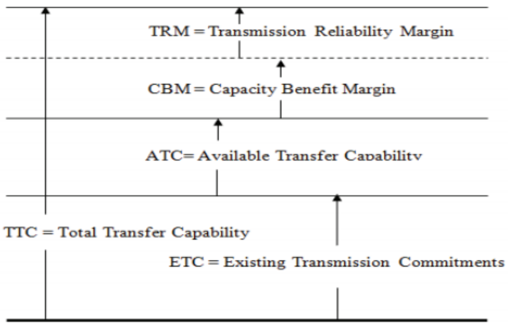

Figure 1. Basic definition of ATC.

3 MODELLING OF TCSC AND SVC

THE growing energy demand initiates the power system technologies to be continuously expanded and upgraded. The availability limited energy resources, time and capital required adds to speeding up the process. FACT are alternative transmission system devices that use electronic based static controllers for enhancing controllability and increase power transfer capability. FACTS controller technology enables the control of interrelated parameters that govern the operation of a transmission system having series, shunt impedance and admittance and other parameters. Enables the line to carry power equal to the thermal rating. The AC transmission system is working with the limits while maintaining the sufficient transient and steady state stability limit of system.

FACTS devices may be used to achieve several goals in power systems. In steady-state, for a meshed network, they permit transmission lines to be operated close to their thermal limits. In this respect, they can be used to supply or absorb the reactive power, to increase or decrease voltages and to control the series impedance or the phase-angle. Lumped π equivalent parameters represent transmission lines. The series compensator TCSC is simply a static capacitor/reactor with impedance jxc. Figure.2 shows an equivalent circuit of a line with TCSC.

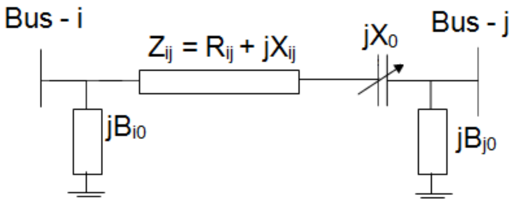

Figure 2. Equivalent circuit of a line with TCSC.

where X_{ij} is the reactance of the line, R_{ij} *is* the resistance of the line, B_{io} and B_{jo} are the half-lines charging susceptance of the line at bus-i and bus-j. The difference between the line susceptance before and after the addition of TCSC is expressed as:

$$\Delta y_{ij} = y'_{ij} - y_{ij} = (g'_{ij} + jb'_{ij}) - (g_{ij} + jb_{ij}) \qquad (1)$$

$$g_{ij} = \frac{r_{ij}}{\sqrt{r_{ij}^2 + x_{ij}^2}}, \quad b_{ij} = -\frac{x_{ij}}{\sqrt{r_{ij}^2 + x_{ij}^2}} \qquad (2)$$

$$g'_{ij} = \frac{r_{ij}}{\sqrt{r_{ij}^2 + (x_{ij} + x_c)^2}} \qquad (3)$$

$$b'_{ij} = -\frac{x_{ij} + x_c}{\sqrt{r_{ij}^2 + (x_{ij} + x_c)^2}} \qquad (4)$$

After adding TCSC on the line between bus I and bus j of a general power system, the new system admittance matrix Y_{bus} derived as.

$$Y'_{bus} = Y_{bus} + \begin{array}{c} \left[\begin{array}{ccccccc} 0 & 0 & 0 & \dots & 0 & 0 & 0 \\ 0 & \Delta y_{ij} & 0 & \dots & 0 & -\Delta y_{ij} & 0 \\ 0 & 0 & 0 & \dots & 0 & 0 & 0 \\ \dots & \dots & \dots & \dots & 0 & \dots & 0 \\ 0 & 0 & 0 & \dots & 0 & 0 & 0 \\ 0 & -\Delta y_{ij} & 0 & \dots & 0 & \Delta y_{ij} & 0 \\ 0 & 0 & 0 & \dots & 0 & 0 & 0 \end{array}\right] \begin{array}{l} \\ row-i \\ \\ \\ \\ row-j \\ \\ \end{array} \\ \begin{array}{ccccccc} & col-i & & & & col-j & \end{array} \end{array} \qquad (5)$$

4 TCSC AND SVC FACTS DEVICES IMPLEMENTATION FOR THE PROPOSED SYSTEM WITH GENETIC ALGORITHM

UNLIKE traditional methods that search from a single point, the genetic algorithm uses probabilistic selection rules and search parallelly from a population of points and can avoid getting trapped in an optimal local solution. The ATC is computed for a set of source/sink transfers on IEEE 14-bus system and IEEE 24 reliability test system. It is possible to increase the ATC margin further by proper location and control parameter of FACTs devices. TCSC and SVC are devices used as FACTs devices for this paper. Real-code Genetic Algorithm is used to find optimal location and control parameter of TCSC and SVC for maximizing of ATC. The study is split into two cases as ATC 1) with and 2) without line outage.

The ATC margin is limited by bus voltage magnitude and line flow rating. The voltage magnitude limits of all buses are set to V_{min}=0.95 (p.u) and V_{max}=1.15 (p.u). The line ratings of IEEE [7] 14-bus system and IEEE 24-bus system are given in appendix A and B respectively.

4.1 *Without line outage case*

The ATC is computed for a set of source/sink transfers using Continuous Power Flow (CPF). Table 1 shows the ATCs for IEEE 14-bus system without FACTs device.

Table 1. ATC without FACTS device

Source/Sink bus no.	ATC (M.W)	Violation Constraint (line flow/voltage)
1/9	53.0	Line-8 overflow
1/10	44.0	Line-8 overflow
1/12	30.0	Line-8 overflow
1/13	31.5	Line-8 overflow
1/14	42.0	Line-8 overflow
1/4	222.0	Line-1 overflow
1/3	157.5	Line-2 overflow

4.2 *Incorporation of TCSC*

TCSC incorporated in this system considers all lines, and there are 20 possible locations for the TCSC. The location code region is set as 20 integers numbering 1 to 20. The amount of compensation offered by TCSC is 0 to 40% (K_d). Applying, Real Genetic Algorithm, the results obtained are tabulated in Table 2. It indicates that with the flow control function TCSC increased the ATC significantly.

Table 2. ATC after incorporating TCSC

Source/ Sink bus no.	ATC without TCSC (M.W)	ATC with TCSC (M.W)	TCSC Location	Compensation (p.u)
1/9	53.0	68.5	Line-9	-0.088
1/10	44.0	62.0	Line-12	-0.075
1/12	30.0	47.0	Line -9	-0.130
1/13	31.5	48.5	Line -9	-0.128
1/14	42.0	57.0	Line -12	-0.110
1/4	222.0	250.0	Line -3	-0.070
1/3	157.5	210.5	Line -6	-0.081

Figure 3 shows the convergence characteristic of Real-code Genetic Algorithm, and it shows a graph of generation and fitness function, i.e., ATC (M.W) when source/sink transfer is between bus 1 and bus 9. After 89 generations, the optimal value of TCSC location and compensation value are found. It shows a real convergence of this algorithm.

The GA parameters selected were:

a) Population size = 40
b) Elitism probability = 0.15
c) Crossover probability = 0.60
d) Mutation probability = 0.01

Generations number = 100.

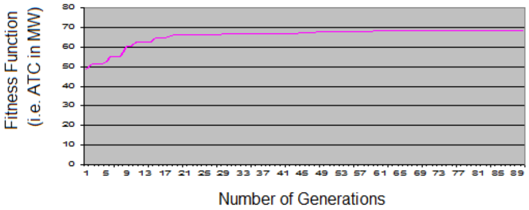

Figure 3. **Number of generations Vs fitness profile of ATC.**

4.3 *Incorporation of SVC*

SVC is incorporated in the system considers all buses of the system. There are 14 possible locations for the SVC under this scenario and the location code region is set as 14 integers numbering 1 to 14. The amount of compensation offered by SVC is 0 to 0.1 (p.u) i.e., B_{svc}. After using Real Genetic Algorithm, the results obtained are shown in Table 3. It shows that with the flow control function SVC increased the ATC significantly.

Table 3. **ATC after incorporating SVC**

Source/ Sink bus no.	ATC without SVC (M.W)	ATC with SVC (M.W)	SVC Location	Compensation (p.u)
1/9	53.0	61	Bus-10	0.081
1/10	44.0	49	Bus-10	0.081
1/12	30.0	40.5	Bus-12	0.097
1/13	31.5	42	Bus-12	0.091
1/14	42.0	57	Bus-12	0.097
1/4	222.0	228	Bus-9	0.091
1/3	157.5	160.5	Bus-13	0.075

4.4 *With line outage*

The Available Transfer Capability (ATC) is computed for a set of source/sink transfers using Continuous Power Flow (CPF) when line-16 is physically detached from the system that is connected between bus-13 and bus-14. Table 4 shows the ATCs for IEEE 14-bus system without FACTs device when line-16 is an outage. Figure 4 shows a graph voltage profile for the IEEE 14-bus system with and without outage cases.

Table 4. **ATC after incorporating SVC**

Source/Sink bus no.	ATC (M.W)	Violation Constraint (line flow/voltage)
1/9	45.0	Bus-14 voltage limit
1/10	44.0	Bus-10 voltage limit
1/12	34.5	Line-8 overflow
1/13	22.5	Bus-13 voltage limit
1/14	36.0	Bus-14 voltage limit
1/4	217.0	Line-7 overflow
1/3	157.5	Line-2 overflow

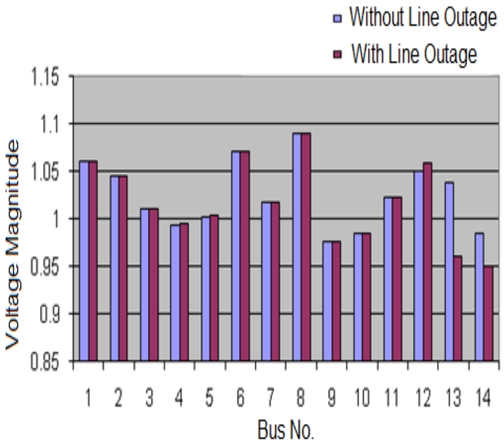

Figure 4. **Bus voltage profile for without and with line outage cases for IEEE-14 bus system.**

4.5 *Incorporation of TCSC*

Taking into account all lines in the system, when one TCSC is incorporated, there are 19 possible locations for the TCSC. The location code region is set as 20 integers numbering 1 to 20 except line 16. The amount of compensation offered by TCSC is 0 to 40% (K_d). After using real genetic algorithm, the results obtained are shown in Table 5. It indicates that with the flow control function TCSC increased the ATC significantly even under line outage.

Table 5. **ATCS after incorporating TCSC during line -16 outage**

Source/ Sink bus no.	ATC without TCSC (M.W)	ATC with TCSC (M.W)	TCSC Location	Compensation (p.u)
1/9	45.0	61.0	Line-6	-0.089
1/10	44.0	56.5	Line-6	-0.100
1/12	34.5	46.0	Line -12	-0.055
1/13	22.5	39.0	Line -9	-0.084
1/14	36.0	51.0	Line -12	-0.066
1/4	217.0	230.0	Line -8	-0.100
1/3	157.5	187.5	Line -6	-0.102

4.6 *Incorporation of SVC*

When one SVC is incorporated in the system, consider all buses of the system, there are 14 possible locations for the SVC. The location code region is set as 14 integers as 1 to 14. The amount of compensation offered by SVC is 0 to 0.1 (p.u) i.e., B_{svc}. After using a genetic algorithm, the results obtained are shown in Table 6. It indicates that with the voltage control function SVC increased the ATC significantly during the line-16 outage.

Table 6. **ATCS after incorporating SVC during line -16 outage**

Source /Sink bus no.	ATC without SVC (M.W)	ATC with SVC (M.W)	SVC Location	Compensation (p.u)
1/9	45.0	51.0	Bus-14	0.0984
1/10	44.0	46.0	Bus-10	0.0781
1/12	34.5	45.0	Bus-12	0.0940
1/13	22.5	31.5	Bus-13	0.0890
1/14	36.0	45.0	Bus-14	0.0970
1/4	217.0	226.5	Bus-9	0.0940
1/3	157.5	160.5	Bus-10	0.0960

5 IEEE 24 BUS RELIABILITY SYSTEM

5.1 *Without line outage case*

THE Available Transfer Capability (ATC) is computed for a set of source/sink transfers using Continuous Power Flow (CPF). Table 7 shows the ATCs for IEEE 24-bus system without FACTs device.

Table 7. **ATCS without FACTS device**

Source/Sink bus no.	ATC (M.W)	Violation Constraint (Line flow/Voltage)
23/15	770.0	Line-24 overflow
22/9	395.0	Line-38 overflow
22/5	260.0	Line-38 overflow
21/6	105.0	Line-10 overflow
18/5	260.0	Line-38 overflow

5.2 *Incorporation of TCSC*

When one TCSC is incorporated in the system, consider all lines of the system, there are 38 possible locations for the TCSC. The location code region is set as 38 integers as 1 to 38. The amount of compensation offered by TCSC is 0 to 40% (Kd). After using Real Genetic Algorithm proposed in this work, the results obtained are shown in Table 8. It shows that with the flow control function TCSC increased the ATC significantly.

Table 8. **ATCS without FACTS device**

Source/ Sink bus no.	ATC without TCSC (M.W)	ATC with TCSC (M.W)	TCSC Location	Compensation (p.u)
23/15	770.0	810.0	Line-28	-0.0103
22/9	395.0	420.0	Line-12	-0.0635
22/5	260.0	270.0	Line -15	-0.0239
21/6	105.0	120.0	Line -5	-0.0669
18/5	260.0	270.0	Line -15	-0.0283

5.3 *Incorporation of SVC*

When one SVC is incorporated in the system, if all buses of the system are considered then there are 24 possible locations for the SVC. The location code region is set as 24 integers as 1 to 24. The amount of compensation offered by SVC is 0 to 0.1 (p.u) i.e., B_{svc}. After using Real Genetic Algorithm, the results obtained are shown in Table 9. It shows that with the flow control function SVC increased the ATC significantly.

Table 9. **ATCS after incorporating SVC**

Source /Sink bus no.	ATC without SVC (M.W)	ATC with SVC (M.W)	SVC Location	Compensation (p.u)
23/15	770.0	790.0	Bus-20	0.099
22/9	395.0	405.0	Bus-5	0.086
22/5	260.0	265.0	Bus-11	0.081
21/6	105.0	110.0	Bus-11	0.082
18/5	260.0	262.0	Bus-5	0.091

5.4 *With line outage*

The Available Transfer Capability (ATC) are computed for a set of source/sink transfers using Continuous Power Flow (CPF), when line-8 is physically removed from the system that is connected between bus-4 and bus-9. The Figure 5 shows a graph voltage profile for the IEEE 24-bus system with and without outage cases. Table 10 shows the ATCs for IEEE 24-bus system without FACTs device, when line-8 is physically removed.

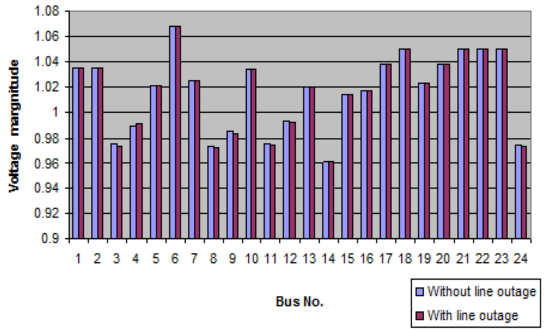

Figure 5. Bus voltage profile for without and with line outage cases for IEEE-24 bus system.

Table 10. ATCS without FACTS device during line-8 outage

Source/Sink bus no.	ATC (M.W)	Violation Constraint (Line flow/Voltage)
23/15	765.00	Line-24 overflow
22/9	385.00	Bus-9 voltage limit
22/5	214.20	Line-9 overflow
21/6	86.70	Line-10 overflow
18/5	214.20	Line-9 overflow

5.5 *Incorporation of SVC*

When one SVC is incorporated in the system, consider all buses of the system, there are 24 possible locations for the SVC. The location code region is set as 24 integers as 1 to 24. The amount of compensation offered by SVC is 0 to 0.1 (p.u), i.e., B_{svc}. After using Real Genetic Algorithm, the results obtained are shown in Table 11. It shows that with the flow control function SVC increased the ATC significantly during line-8 outage.

Table 11. ATCS after incorporating SVC during line-8 outage

Source/Sink bus no.	ATC without SVC (M.W)	ATC with SVC (M.W)	SVC Location	Compensation (p.u)
23/15	765.00	785.40	Bus-10	0.084
22/9	385.00	392.70	Bus-23	0.099
22/5	214.20	219.30	Bus-14	0.092
21/6	86.70	88.20	Bus-6	0.081
18/5	214.20	224.40	Bus-16	0.098

5.6 *Incorporation of TCSC*

When one TCSC is incorporated in the system, consider all lines of system, there are 19 possible locations for the TCSC. The location code region are set as 20 integers as 1 to 20 except line-8. The amount of compensation offered by TCSC is 0 to 40% (Kd). After using Real Genetic Algorithm proposed in this work, the results obtained are shown in Table 12. It shows that with the flow control function TCSC increased the ATC significantly even under line outage.

Table 12. ATCS after incorporating TCSC during line-8 outage

Source/Sink bus no.	ATC without TCSC (M.W)	ATC with TCSC (M.W)	TCSC Location	Compensation (p.u)
23/15	765.00	801.20	Line-25	-0.0101
22/9	385.00	413.10	Line-14	-0.0652
22/5	214.20	229.50	Line -2	-0.0304
21/6	86.70	91.80	Line -7	-0.0730
18/5	214.20	229.50	Line -2	-0.0328

The 14bus IEEE bus system validated against the PSS/E power flow using PSCAD and the results are given below in Table 13. The MATLAB Results are improving the results and power enhancement is also obtained.

Table 13. Source and line power comparison of IEEE 14-bus system

Bus	PSS/E		PSCAD	
	P [Pu]	Q[pu]	P[pu]	Q[pu]
1	2.323	-0.165	2.3230	-0.1548
2	0.400	0.436	0.3995	0.4493
3	0.000	0.251	0.0007	0.2613
6	0.000	0.127	0.0020	0.1498
8	0.000	0.176	-0.0011	0.1896
From Bus To Bus				
1 – 2	1.569	-0.204	1.5690	-0.2005
1- 5	0.755	0.039	0.7543	0.0450
2- 3	0.709	-0.016	0.7096	-0.0164
2-4	0.561	-0.030	0.5606	-0.0209
2-5	0.406	0.012	0.4043	0.0165
3-4	0.237	-0.048	0.2354	-0.0540
4-5	0.612	-0.158	0.6130	-0.1750
6-12	0.078	0.025	0.0781	0.0253
6-13	0.177	0.072	0.1782	0.0740.
7-8	0.000	0.176	0.0011	0.1844
7-9	0.281	0.050	0.2793	-0.0539
9-10	0.052	0.042	0.0511	0.0380
9-14	0.093	0.034	0.0878	0.0217
10-11	0.038	0.016	0.0390	0.0200
12-13	0.016	0.008	0.0166	0.0080
13-14	0.056	0.017	0.0568	0.0188

6 CONCLUSION

IN deregulated power systems, ATC analysis is presently a critical issue either in the operating or planning because of increased area interchanges among utilities. Sufficient ATC should be guaranteed to support free market trading and maintain an economical and secure operation over a wide range of system conditions. However, increasingly difficult economic issues, environmental regulations, and societal problems have encouraged the use of intensive sharing of existing transmission facilities by utilities and Independent Power Producers (IPPs). Due to FACTS operating limitations of the transmission system and control capabilities, technical feasibility of applying FACTS devices to boost ATCs are analyzed and identified.

The ATC is computed for various transactions using Continuous Power Flow method on IEEE 14-bus test system and IEEE 24-reliability test system during normal and contingency cases considering line thermal limit as well as bus voltage limit. The improvement of ATC using TCSC or SVC is studied and demonstrated with IEEE 14-bus test system and IEEE 24 reliability test system during normal as well as contingency cases. The location and control parameter of TCSC and SVC in the system also affects the enhancement of ATC. Implementation of the proposed Real code Genetic Algorithm has performed well when it is used to determine the location and compensation level of TCSC or SVC with the aim of maximizing the Available Transfer Capability. From the results, it is shown that installing SVC as a FACTS device will improve voltage profile as well as resulting ATC enhancement, whereas TCSC can improve ATC in both thermal dominant case and voltage dominant case. Finally, it is clearly known from the results that TCSC is more effective than SVC in improving ATC under both normal and contingency conditions. The output power is improved in the proposed system.

7 REFERENCES

V. Ajarapu and C. Christie, (1992). “The continuation power flow: a practical tool for tracing power system steady state stationary behavior due to the load and generation variations.” *IEEE Trans. Power Systems*, 7(1), 416-423.

Y. Dai, J.D. McCalley and V. Vittal, (1999). “Simplification, expansion and enhancement of direct interior point algorithm for power system maximum load ability,” *Proc. 21st Int. Conference Power Ind. Comput. Application.* 170-179.

G.C. Ejebe, J. Tong, J.G. Waight, J.G. Frame X. Wang and W.F. Tinney, (1998). “Available transfer capability calculations,” *IEEE Trans. Power Systems.* 13(4), 1521-1527.

Y.S. Manjili, R. Vega and M. Jamshidi, (2013). “Cost-Efficient Environmentally-Friendly Control of Micro-Grids Using Intelligent Decision-Making for Storage Energy Management,” *Intelligent automation and soft computing.* 19(4), 649-670.

M. Noroozian and G. Anderson, (1993) “Power Flow Control by Use of Controllable Series Components,” *IEEE Transactions on Power Delivery*. 8(3), 1420-1428.

Peerapol Jirapong and Weerakorn Ongsakul, (2007). “Optimal Placement of Multi-Type FACTS Devices for Total Transfer Capability Enhancement Using Hybrid Evolutionary Algorithm, *Electric Power Components and Systems.* 35(9), 981-1005.

R.N. Ray, Chatterjee and S.K. Goswami, (2008). “Reduction of voltage harmonic using optimization – based combined approach,” *IET Power Electronics.* 3(3), 334- 344.

S. Ravi and P.A. Balakrishnan, (2011) “Stable Self Tuning Genetic Fuzzy Temperature Controller for Plastic Extrusion System,” *International Journal of Reviews in Computing.* 5(4), 21-28.

S. Ravi and P.A. Balakrishnan, (2014) “Design of Synthetic Optimizing Neuro Fuzzy Temperature Controller for Twin Screw Profile Plastic Extruder Using LABview”, *Intelligent Automation and Soft Computing.* 20(1), 92-100.

G.B. Wang Feng and Shrestha, (2001). “Allocation of TCSC Devices to Optimize Total Transmission Capacity in a Competitive Power Market,” *Proceedings of Power Engineering Society Winter Meeting.* 3, 587-592.

Y. Xiao, Y.H. Song and Y.Z. Sun, (2000) “Available Transfer Capability Enhancement Using FACTS Devices,” *Proceedings of the 2000 IEEE/PWS Summer Meeting*, Seattle, 508-515.

8 DISCLOSURE STATEMENT

NO potential conflict of interest was reported by the authors.

9 NOTES ON CONTRIBUTORS

R.Rohini is presently Assistant Professor in the Department of Computer Science and Engineering, Vivekanandha College of Engineering for Women, Tamilnadu, India. She completed her Masters in Computer Science and Engineering degree in 2008. She Finished her Ph.D. in 2016 from Anna University. Her research area of Interests includes Wireless sensor networks, Image processing, embedded system. She has published 20 papers in both national and International conferences/journals.

Dasari Narasimha Rao is presently Assistant Professor in the Department of Electrical Power Engineering, College of Engineering and Technology, Defence University, Ethiopia He completed his Master in Power Electronics and Drives in the year 2012. His research area of Interests includes Power Electronics and Power System. He has published five papers in both national and International conferences/journals.

S.Ravi received his B.E degree in Electrical and Electronics Engineering from Periyar University, Salem, India in 2003. He received his M.E degree in Power Electronics and Drives from Anna University, Chennai, India in 2006. He received his Ph.D. degree in the area of Intelligent Control Systems from Anna University, Chennai, India in 2012. Presently he is working as a Associate Professor in the Department of Electrical, College of Engineering and Technology, Botswana International University of Science and Technology, Botswana. His research areas are intelligent control systems, Solar PV systems, Power Electronic Converters.

Sampath Kumar is a Research Scholar at Amity Business School, Amity University, Jaipur Rajasthan. He has received his Diploma in Electrical Engineering from Board of Technical Education, Karnataka, Bachelor’s degree in Information Technology from SHAITS and Master’s in Business Administration from Amity University Noida. He has over 25 years of experience in the field of engineering and technology. He is currently doing his research on Virtual Power Plant / Distributed Generation and is interested in AI, Cyber security impacts, cyber warfare, and cyber terrorism.