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Optimal Strategy for ATC Enhancement and Assessment in presence of FACTS devices and Renewable Generation

Devesh Shukla
Dept. of Electrical Engineering
IIT(BHU) Varanasi, India
devesh.s.in@ieee.org

S. P. Singh
Dept. of Electrical Engineering
IIT(BHU) Varanasi, India
spsing.eee@itbhu.ac.in

S. R. Mohanty
Dept. of Electrical Engineering
IIT(BHU) Varanasi, India
soumya.eee@itbhu.ac.in

***Abstract*—Available Transfer Capability is determinental in facilitating operation of power system economically, reliably and securely. Advancements in the power generation techniques and shift in generation methodologies from centralized to dis-bursed/distributed generation with increased emphasis on renewable sources has complicated the assessment and enhancement of ATC. In this paper a multi-stage operational strategy for enhancement and assessment of ATC in the presence of renewable sources of generation and FACTS devices is presented. The developed method is implemented on Modified IEEE 24 bus test system.**

***Index Terms*—Available Transfer Capability (ATC), Static VAR Compensator (SVC), TCSC (Thyristor Controlled Series Capacitors), PV Array, Smart Inverter.**

I. INTRODUCTION

Available Transfer Capability (ATC) assessment and enhancement have been investigated by employing different tools and techniques. The issue of ATC assessment and enhancement is turning to be a field of interest to the research fraternity owing to the changes in the methods of Power Generation, Transmission and Distribution. Conventionally Power Generation, Transmission and Distribution were vertically integrated (prior to deregulation) but now they are horizontally integrated and provision of open access for generation transmission and distribution have been inducted into the grid. Open access implies that any valid costumer (producer,consumer/prosumer) can inject/withdraw power from the grid. These provisions though complicated the issue of ATC assessment and enhancement, the major challenges were yet to be encountered in terms of increase in renewable sources of generation both at transmission and distribution levels. Further, the challenges of electric vehicles as virtual power plants which may act both as sink and source depending upon the market and grid operating conditions would also impact the ATC.

Different techniques have been proposed in the literature for ATC assessment and enhancement [1–12]. Sensitivity factors such as AC PTDF and DC PTDF has been used for ATC evaluation [1], [2]. Continuation power flow (CPF) and Optimal Power Flow (OPF) have also been used for ATC evaluation [3] and [4]. In [5] the author investigates the efficacy of various FACTS devices for enhancing the ATC. OPF based solutions employing predictor-corrector primal-duel interior point linear programming (PCPDIP) for obtaining the ATC in presence of FACTS devices have been used. The ATC enhancement using FACTS devices and their optimal location have been done in [6] and [7]. Application of optimization techniques for ATC assessment have been proposed in [8] and [12]. In [12] a PS-NR based method been used.

In this paper a multi-stage approach has been proposed. The proposed method involves two stages, in $Stage1$ RTCA is performed for the input network information. The network information can be obtained from amulgum of information provided by the topology processor (TP) and SCADA measurements for the system. RTCA provides a set of credible contingencies which are used in the next stage for obtaining the ATC. In $Stage2$, ATC assessment and enhancement engine is proposed which utilizes pattern search optimization for obtaining the ATC. Further, the effects of FACTS (Flexible AC Transmission System) devices is employed for enhancing the ATC. The developed method is tested on modified IEEE24 bus test system whereby the effect of renewable generation (Solar PV) has been inculcated. Further, Real time monitoring equipments like Phasor Measurement Units (PMU) are exclusively being integrated into the power grid across the world and developing control and protection applications based on the information provided by them is an active area of research. In [13] and [14] Pseudo-PMU for emuluating the behaviour of PMU have been presented. Wide-range of feasible quasi-static scenarios can be generated and the method being proposed in this work be could employed for ATC assessment and enhancement.

The paper is primarily segregated into seven sections. Section I gives the introduction, section II discusses the multi-stage ATC assessment and Enhancement problem. FACTS and Renewable Source Modelling (PV System) along with the smart inverter has been delineated in III and IV. The solution methodology proposed is given in V, case study along with the results and discussion are given in VI while VII concludes the work.

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II. ATC DETERMINATION AND ENHANCEMENT:-PROBLEM FORMULATION

The amount of power which can be transmitted over and above the existing transmission commitments while providing for the Capacity Benefit Margin (CBM) and transient reliability margin (TRM) is defined as ATC [12].
ATC can be mathematically given as:-

$$ATC = TTC - (CBM + TRM) - ETC \tag{1}$$

In equation 1, TTC is the Total Transfer Capability, CBM is Capacity Benefit Margin, TRM is Transient Reliability Margin and ETC is the Existing Transmission Commitments. Contingencies plays a major role in determining the appropriate ATC value, the credible contingencies should be considered for assessing the ATC of the system. For real time ATC assessment real time contingency analysis has to be done. The ATC assessment problem requires the information pertaining to the credible and most severe contingency to which the system may be subjected. A method for real time contingency analysis for ATC has been formulated as $Stage1$ of ATC determination and enhancement.

A. Stage.1

Real Time Contingency Analysis (RTCA) is a vital function of modern energy management system. The RTCA is preformed to identify the critical contingencies that would adversely affect the performance and reliability of the power system [15]. As optimization is not required for performing RTCA, the computing process dose not enforces any constraints. In this work an algorithm for RTCA is developed using MATPOWER and equation 2 is applied for contingency ranking as used in [16].

$$PI_c = \Big[\sum_i \frac{d^u_{v,i}}{g^u_{v,i}}^{2n} + \sum_i \frac{d^l_{v,i}}{g^l_{v,i}}^{2n} + \sum_i \frac{d_{p,i}}{g_{p,i}}^{2n}\Big] \tag{2}$$

$$\begin{aligned} d^u_{v,i} &= \begin{cases} \frac{[V_i - F^u_i]}{V^d_i} & ;\text{if} \quad V_i > F^u_i \\ 0 & ;\text{if} \quad V_i \leq F^u_i \end{cases} \\ d^u_{v,i} &= \begin{cases} \frac{[F^l_i - V_i]}{V^d_i} & ;\text{if} \quad V_i > F^l_i \\ 0 & ;\text{if} \quad V_i \geq F^u_i \end{cases} \end{aligned} \tag{3}$$

$$\begin{aligned} g^u_{v,i} &= \frac{[V^u_i - F^u_i]}{V^d_i} \\ g^l_{v,i} &= \frac{F^l_i - V^l_i}{V^d_i} \end{aligned} \tag{4}$$

$$d^p_j = \begin{cases} \frac{[|P_j| - P^{F,j}]}{BaseMVA} & ;\text{if} \quad |P_j| > P_{F,j} \\ 0 & ;\text{if} \quad P_i \leq P_{F,j} \end{cases} \tag{5}$$

$$\tag{6}$$

$$g_{p,j} = \frac{[P_{P,j} - P_{F,j}]}{BaseMVA} \tag{7}$$

In the above equations PI_c is the contingency index, V^i is the voltage of i^{th} bus, V^d_i is the desired voltage at each node, $F^u_i, F^l_i, V^u_i, V^l_i$ are the alarm limits and the security limits with $d^u_{v,i}, d^l_{v,i}, g^u_{v,i}, g^l_{v,i}$ are their normalized upper and lower limit violation. Similarly, for line flows the normalized power flow limit violations are $d_{p,j}$ and $g_{p,j}$ is the normalization factor. The n is exponent used in hyper ellipse equation [16] and is taken as 2. The composite security index 2 is used for obtaining the contingency ranking. The contingency with highest index is most severe and with least value of index is least severe.

B. StageII: ATC Assessment and Enhancement Problem Formulation

The ATC as given in eq.1 can be formulated as an optimization problem [12] and is given as $Max \quad \sum_{i=1}^{N}(Pd_i - Pd0_i)$. The maximization is achieved while maintaining the power system operational constraints within limits. The ATC in system is effected by the presence of FACTS devices in the system. The ATC assessment formulation considering the impact of FACTS devices and considering the set of credible contingencies id given in eq.8.

$$MinMax \;\; f(Pd, c, B_{svc}, X_{tcsc}) \tag{8}$$

$$f(Pd, c) = c_k \sum_{i=1}^{N}(Pd_i - Pd0_i) \tag{9}$$

for k=1 to n_c (number of credible contingencies considered from RTCA output) The optimization is achieved while maintaining the equality and inequality constraints given in equation 10 to 15.

$$\sum_{i=1}^{M} P_{gi} - \sum_{i=1}^{N} P_{di} - \sum_{i=1}^{N}\sum_{j=1}^{N} V_i V_j Y_{ij} cos(\theta_{i,j} - \delta_i + \delta_j) = 0 \tag{10}$$

$$i, j \in 1, 2.......N$$

$$\sum_{i=1}^{M} Q_{gi} - \sum_{i=1}^{N} Q_{di} - \sum_{i=1}^{N}\sum_{j=1}^{N} V_i V_j Y_{i,j} sin(\theta_{i,j} - \delta_i + \delta_j) = 0 \tag{11}$$

$$i, j \in 1, 2.......N$$

$$P^{min}_{gi} <= P_{gi} <= P^{max}_{gi}; \quad i \in 1, 2.......M \tag{12}$$

$$Q^{min}_{gi} <= Q_{gi} <= Q^{max}_{gi}; \quad i \in 1, 2.......M \tag{13}$$

$$V^{min}_i <= V_i <= V^{max}_i; \quad i \in 1, 2.......N \tag{14}$$

$$P^{min}_{ij} <= P_{ij} <= Q^{max}_{ij} \quad i \in 1, 2.......N \tag{15}$$

$$c_k \subseteq C; \;\; C \textit{ is set of credible contingencies} \tag{16}$$

$$B^l_{svc} \leq B_{svc} \leq B^u_{svc}; \quad B^l_{svc} \textit{ and } B^u_{svc} \textit{ are limiting values of SVC} \tag{17}$$

$$X^l_{tcsc} \leq X_{tcsc} \leq X^u_{tcsc}; \quad X^l_{tcsc} \textit{ and } X^u_{tcsc} \textit{ are limiting values of SVC} \tag{18}$$

M and N in equations 10-18 are the number of generators and number of buses in the system. P_{gi},Q_{gi} are the active and reactive power of i^{ith} generator and P_{di},,Q_{di} represents the active and reactive power demanded at i^{ith} bus. The $MinMax$ optimization given in eq.8 strives to maximize the ATC corresponding to each credible contingency available in the set of credible contingencies, provided by the RTCA and at the same time yields the minimum value of ATC. This is done because the ATC corresponding to the contingency which would yield the minimum value of ATC would be considered as final value. If the system is scheduled considering minimum ATC, and any other credible contingency happens then the system would be able to operate reliably and securely. Contrarily, if higher value of ATC is scheduled and the contingency corresponding to minimum value of ATC happens than the system wont be able to satisfy its operational commitments.

III. FACTS MODELLING

FACTS devices namely SVC and TCSC has been considered in this work. The modelling of these devices have been given in the following sections.

A. TCSC Modelling

TCSC can be represented as shown in Fig. 1 Equivalent reactance of TCSC can be represented as a function of its capacitive, inductive recactances and the firing angle.

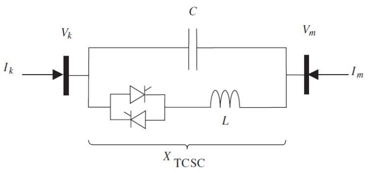

Fig. 1: Schematic representation of TCSC modelling.

$$X_{TCSC} = -X_C + C_1\{2(\pi-\alpha) + sin(2(\pi-\alpha))\} + C_2cos^2(\pi-\alpha)\{\omega tan[\omega(\pi-\alpha)] - tan(\pi-\alpha)\} \tag{19}$$

where,

$$X_{LC} = \frac{X_C X_L}{X_C - X_L} \tag{20}$$

$$C_1 = \frac{X_C + X_{LC}}{\pi} \tag{21}$$

$$C_2 = \frac{4X_{LC}^2}{X_L\pi} \tag{22}$$

The TCSC transfer admittance matrix between the nodes k and m is obtained as

$$\begin{bmatrix} I_k \\ I_m \end{bmatrix} = \begin{bmatrix} jB_{kk} & jB_{km} \\ jB_{mk} & jb_{mm} \end{bmatrix} \begin{bmatrix} V_k \\ V_m \end{bmatrix} \tag{23}$$

Modified active and reactive power injections at bus k on account of TCSC are

$$P_k = V_k V_m sin(\theta_k - \theta_m) \tag{24}$$

$$Q_k = -V_k^2 B_{kk} - V_k V_m B_{km} cos(\theta_k - \theta_m) \tag{25}$$

The linearised power flow equations considering the TCSC model considered is obtained as

$$\begin{bmatrix} \Delta P_k \\ \Delta P_m \\ \Delta Q_k \\ \Delta Q_m \\ \Delta P_{km}^{X_{TCSC}} \end{bmatrix} = \begin{bmatrix} \frac{\partial P_k}{\partial \theta_k} & \frac{\partial P_k}{\partial \theta_m} & \frac{\partial P_k}{\partial V_k}V_k & \frac{\partial P_k}{\partial V_m}V_m & \frac{\partial P_k}{\partial X_{TCSC}}X_{TCSC} \\ \frac{\partial P_m}{\partial \theta_k} & \frac{\partial P_m}{\partial \theta_m} & \frac{\partial P_m}{\partial V_k}V_k & \frac{\partial P_m}{\partial V_m}V_m & \frac{\partial P_m}{\partial X_{TCSC}}X_{TCSC} \\ \frac{\partial Q_k}{\partial \theta_k} & \frac{\partial Q_k}{\partial \theta_m} & \frac{\partial Q_k}{\partial V_k}V_k & \frac{\partial Q_k}{\partial V_m}V_m & \frac{\partial Q_k}{\partial X_{TCSC}}X_{TCSC} \\ \frac{\partial Q_m}{\partial \theta_k} & \frac{\partial Q_m}{\partial \theta_m} & \frac{\partial Q_m}{\partial V_k}V_k & \frac{\partial Q_m}{\partial V_m}V_m & \frac{\partial Q_m}{\partial X_{TCSC}}X_{TCSC} \\ \frac{\partial P_k^{X_{TCSC}}m}{\partial \theta_k} & \frac{\partial P_k^{X_{TCSC}}m}{\partial \theta_m} & \frac{\partial P_k^{X_{TCSC}}m}{\partial V_k}V_k & \frac{\partial P_k^{X_{TCSC}}m}{\partial V_m}V_m & \frac{\partial P_k^{X_{TCSC}}m}{\partial X_{TCSC}}X_{TCSC} \end{bmatrix} \tag{26}$$

here, $\Delta P_{km}^{X_{TCSC}} = P_{km}^{reg} - P_{km}^{X_{TCSC},cal}$ is the active power mismatch.

B. SVC Modelling

The SVC has been modelled as an adjustable reactance and the equivalent circuit diagram is shown in Fig.2 I_{SCV} which is the current drawn drawn by equivalent SVC model $I_{SVC} = jB_{SVC}V_k$ while the reactive power injected by the equivalent model is $Q_{SVC} = Q_k = -V_k^2 B_{SVC}$. Considering the B_{SVC} equivalent as state variable, the linearised equation is obtained as:-

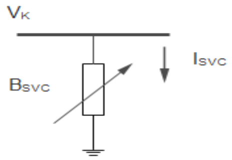

Fig. 2: Schematic representation of SVC modelling.

$$\begin{bmatrix} \Delta P_k \\ \Delta Q_k \end{bmatrix} = \begin{bmatrix} 0 & 0 \\ 0 & Q_k \end{bmatrix} \begin{bmatrix} \Delta\theta_k \\ \frac{\Delta B_{SVC}}{B_{SVC}} \end{bmatrix} \tag{27}$$

IV. RENEWABLE SOURCE MODELLING:-MODELLING OF SOLAR PV

The Solar PV has been modelled as an PQ load where P will be negative for generation (i.e. injection to grid) and Q would be positive or negative depending upon the operating conditions of SMART inverter through which the the PV is connected. The output power P at any operating instant for the PV module is the product of model output voltage and output current which are determined by the following equations eq.28 and eq.29 as in [17] :-

$$I(V) = I_{sc}\{1 - C_1\left[exp(\frac{V+\Delta V}{C_2 V_{oc}})\right]\} + \Delta I \tag{28}$$

where,

$$\begin{aligned} C_2 &= \frac{V_{mp}/V_{oc} - 1}{ln(1 - I_{mp}/I_{sc})} \\ C_1 &= (1 - I_{mp}/I_{sc}).exp[-V_{mp}/C_2.V_{oc}] \\ \Delta I &= \alpha(S/S_{ref})\Delta T + (S/S_{ref} - 1).I_{sc} \\ \Delta V &= -\beta.\Delta T - R_s \Delta I \\ \Delta T &= T - T_{ref} \\ T &= T_A + 0.02S \end{aligned} \tag{29}$$

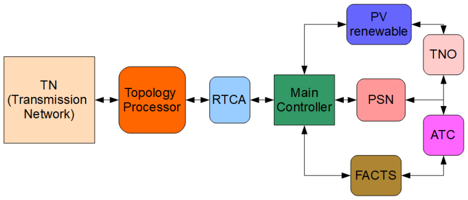

Fig. 3: Schematic representation of proposed method for ATC assessment and enhancement.

In the above equations α is current change temperature coefficient at reference insolation (Amps/°C); β is voltage change temperature coefficient at reference insolation (Volts/°C); I, I_mp and I_sc are Module Current, Maximum Power Current and Short Circuit Current (Amps); S and S_{ref} are total insolation and reference insolation.R_s is module series resistance. T, T_A, and T_{ref} are cell, ambient and refernece temperatures(°C) while ΔT is change in cell temperature; V, V_{mp} and V_{oc} are module voltage, maximum power voltage and open circuit voltage (Volts). The beta distribution have been taken to realize the probability density function of solar irradiance of each hour have been obtained using the beta distribution of that hour. The active and reactive power support available from the SMART inverter [18] including inverter is determined by the following equations:-

$$P^{inv} = P - P^{inv}_{losses} \tag{30}$$

$$Q^{inv} \simeq Q \tag{31}$$

$$P^{inv}_{losses} = (1 - \eta_{inv}).\sqrt{P^2 + Q^2} \tag{32}$$

The maximum value of Q^{inv}_{max} is a function of real power generation and is determined by eq.33

$$|Q^{inv}_{max}| = \sqrt{S^2_{max} - P^2} \tag{33}$$

V. Solution Methodology

The schematic of solution for problem of ATC assessment and enhancement is illustrated in Fig.3 and the overall process has been given as flowchart in Fig.4. The function of the different blocks is explained as under:

1) TN (Transmission Network): The test system under study is designated as the TN (Transmission Network) and fed as input to the topology processor. TN contains the information regarding the transmission lines, transformers,FACTS devices, generators,loads and areas in the considered system.

2) Topology Processor: The topology processor process the TN data to obtain the information like number of areas in the system, identifying tie lines between them, total load in each area, total generation in each area, available generation capacity (AGC) in each area. It forms the admittance matrix depending upon the status of the transmission lines and transformers in the system.

3) RTCA: RTCA developed in II-A has been used to determine the set of credible contingencies (CC). It employs the PSN solver (PSN) block for obtaining the PI_c. The set CC contains the contingency in the decreasing order of their severity. Therefore, the first item is the sever most contingency as far as the static security is concerned [16].

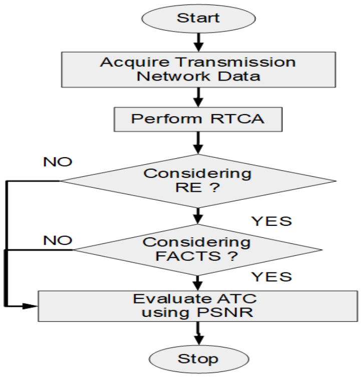

Fig. 4: Flowchart showing the various steps of the solution process.

4) Main Controller: Main Controller interacts with the different components for channelizing the process of ATC assessment and enhancement. Main Controller contains the subroutine which enables it to communicate the information $to and from$ the components such as PV element, FACTS devices, PSN, TNO, and ATC.

5) PV Renewable and FACTS: This block contains the PV and Smart inverter module and communicates with the main controller to know its status, location and mode of operation. The PV when connected to grid through smart inverters can provide reactive power depending upon their rating. FACTS block contains the models of the TCSC and the SVC, and they communicate with the main controller to know about the number of devices, their location in the system and their ratings.

6) PSN, TNO and ATC engine: PSN block contains different network solver subroutines such as Newton Raphson, Fast Decopled Load Flow, DC power flow, Optimal Power Flow and Continuation Power Flow. It communicates with the main controller block, TNO (Transmission Network Optimizer) blok and obtains the solution of the network using the solver asked by the master (communicating block). Transmission Network Optimizer communicates with the main controller, FACTS block to achieve optimal settings of control variables of FACTS devices. TNO also communicates with the ATC engine which contains subroutines of optimization technique which is used for solving the problem formulated in eq8. The ATC engine uses Pattern Search Optimization (PSO) proposed in [12] for ATC assessment and enhancement. PSO is a direct search optimization where the information regarding the gradient of the objective function is not required. Direct search algorithm searches a set of points around the current point, looking for the optimum point of the problem.

VI. Case Study

The developed method operational strategy is tested on modified IEEE 24 bus RTS test system . The data for the

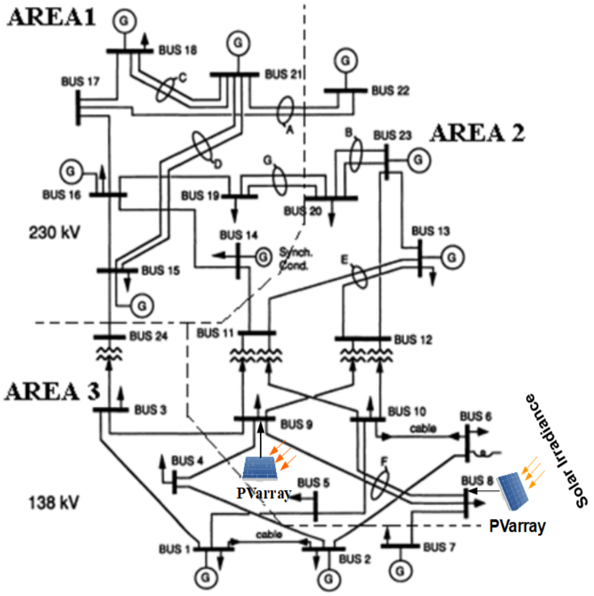

Fig. 5: Modified IEEE 24 BUS RTS test system.

system has been taken from [12]. The decription of the test system is given as under.

A. Description of the test System

The considered IEEE 24 bus test system is divided into three areas $AREA1(A1)$, $AREA2(A2)$ and $AREA3(A3)$ as shown in Fig5. The information of different areas is given in Table.I, tie lines in Table.II and modifications in generation capacity (Conventional generation) in Table.III. In addition to the above modifications a SVC is placed at bus 24. and TCSC is placed in $L19$ which is a line connecting the $Bus11$ and $Bus14$. The SVC is capable of providing -40/60 MVar compensation and TCSC is can provide 30% compensation to the line to which it is connected.

PV system of 10 MW is connected at $Bus9$ in area 2. The PV system comprises of 275 modules of PV arrays (each module consisting 52 PV panels) 5 connected in series and 55 in parallel. The parameters of the PV panel used in this work are given in Table.IV. The $I-V$ characteristic of the solar panel for different combination of S and T_A is given in Fig.6.

B. Results and Discussion

The method proposed in this paper is used to assess and enhance the ATC of the test system described above. RTCA is employed to obtain the set of credible contingencies for the system and the CC along with their PI_c are given in TableV. The ATC for transaction from area 1 (A1) to area 2 (A2) is evaluated. PSO discussed in section V-6 is used whereby loads in the sink area (A2) are increased and equivalent increment of generation is done in source area 1 (A1) so that the GLBM (Generation Load Balance Matching) is attained.

TABLE I: AREAS IN IEEE 24 BUS SYSTEM

Area	Bus	Gen Cap MW	Load MW	Margin	AGC
1	14,15,16,17,18,19,21	1170	1125	45	865
2	5,6,8,9,10,11,12,13,20,22,23	1551	1141	410	211.7
3	1,2,3,4,7,24	684	584	100	200

TABLE II: TIE LINES

Area	Tie Line
1 to 2	21-22,17-22,19-20(2),14-11
1 to 3	15-24
2 to 3	3-9,4-9,1-5,2-6,7-8

TABLE III: ADDITIONAL GENERATOR ADDED INTO THE SYSTEM

Area	Bus	No of Generator	Gen. Cap (MW) of single unit
1	18	1	400
1	16	2	155
1	15	1	155
2	13	1	197
3	7	1	100

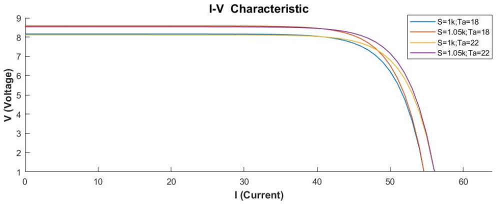

Fig. 6: I-V characteristic of considered solar pannels for different S and T_A.

TABLE IV: PV pannel parameters

α	0.12	V_{oc}	64.6
β	7.35	T_A	25
I_{mp}	7.84	I_l	7.8099
S_{ref}	1000	I_0	2.96E-010
R_s	0.39383	R_{sh}	313.3992
V_{mp}	54.7		

TABLE V: SET of Credible Contingencies

Se. No.	Line No	From Bus	To Bus	PI
1	7	3	24	0.6403627401
2	29	16	19	0.0526128873
3	22	13	23	0.0506682293
4	28	16	17	0.0246528461

TABLE VI: ATC for Transaction from A1 to A2

S.No	SVC	TCSC	PV	RTCA	TTC	CBM	ATC
1	0	0	0	0	352.9041	57.05	295.8541
2	1	0	0	0	354.8196	57.05	297.7695
3	0	1	0	0	424.7703	57.05	367.7203
4	1	1	0	0	424.7703	57.05	367.7203
5	0	0	1	0	354.0408	56.5908	297.4500
6	1	0	1	0	352.1204	56.5908	295.5295
7	0	1	1	0	426.3808	56.5908	369.7900
8	1	1	1	0	426.3808	56.5908	369.7900
9	0	0	0	1	245.1143	57.05	188.064322
10	1	0	0	1	252.4284	57.05	195.37844
11	0	1	0	1	244.6473	57.05	198.59738
12	1	1	0	1	244.5875	57.05	198.53750
13	0	0	1	1	247.0888	56.5908	190.4979
14	1	0	1	1	254.3822	56.5908	197.7914
15	0	1	1	1	272.5732	56.5908	215.9824
16	1	1	1	1	272.5732	56.5908	215.9823

The results of ATC enhancement while considering the various combinations of operation has been tabulated in Table.VI. The table shows device/RTCA status as 0 or 1 in the first four columns. The status 0 indicates that the device/RTCA have not been considered in evaluating the ATC whereas status 1 it is considered. For example, the ATC corresponding to row $R1$ is evaluated without considering any of the components while in row 16 all the components are considered. It can be seen from the Table that the ATC in $R1 < R2 < R3$ this implies that the ATC without considering any FACTS device is lesser than that obtained while considering the FACTS device. Further, the impact of TCSC in enhancing the ATC is much greater than that of SVC as $R2 < R3$, $R10 < R11$ and $R14 < R15$.The presence of PV (the solar insulation is considered as 1.2 pu day time) also effects the ATC value. The ATC increases due to consideration of PV system as can be seen from $R5 > R1$, $R13 > R9$. It can also be inferred from the results that if both the TCSC and ATC are present in the system than the final value of ATC controlled by the TCSC $R3 = R4$, $R11 = R12$ and $R15 = R16$,

VII. CONCLUSION

The paper presented an Optimal strategy for ATC assessment and enhancement. It proposes consideration of set of credible contingencies obtained from RTCA and using ATC optimization engine. The developed ATC optimization engine uses pattern search optimization for obtaining the solution of ATC. Impacts of TCSC and SVC on the ATC enhancement has been observed both in the presence and absence of renewable generation source (PV). It has been observed that the presence of PV system could significantly effect the ATC value. Future work would employ the impact assessment of load profile management using PV active and reactive power injections to the grid.

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