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Power Quality Improvement Using Hybrid FACTS Devices in Multi Machine Systems

Authors: Vishal Singh[1], Imran Khan[2]
1.M.Tech Student, AZAD IET, Lucknow, vishalsingh.m4@gmail.com
2.Prof., EE DepttAZAD IET, Lucknow, pe.imran@gmail.com

Abstract

The reason for misfortune portion with regards to pool dispatch is to allocate to every individual age and burden the duty of paying for part of the framework transmission misfortunes. This progression is essential at whatever point, for reasons of computational effortlessness, the age dispatch and its clearing cost are determined through a legitimacy request approach that at first dismisses transmission misfortunes [1], [2]. Nonetheless, as force networks are definitely misfortune, units providing the necessary framework misfortune should be made up for this assistance, commonly at the framework minor cost. The misfortune assignment measure then, at that point decides how this extra cost ought to be disseminated among all generators and burdens in a fair way. The foremost trouble in assigning misfortunes to burdens, generators or to respective agreements is that, paying little mind to the methodology, the last distribution consistently contains a level of intervention. This is because of the way that the framework transmission misfortunes are a non distinguishable, nonlinear capacity of the transport influence infusions which makes it difficult to partition the framework misfortunes into the amount of terms, every one extraordinarily inferable from an age or burden. Subsequently, the issue of reasonableness will most likely never be completely settled by any misfortune designation technique. All things considered, it is feasible to recognize various qualities in a misfortune designation conspire that are, apparently, sensible and fundamental for the plan to be evenhanded or, at any rate, recognized as impartial. These qualities are additionally valuable in the examination of the different methodologies proposed in the writing. As a rule, the misfortune segments distributed among the transport ages and loads ought

1.1 INTRODUCTION

The requirement for more proficient power frameworks the board has led to imaginative innovations in power age and transmission. The consolidated cycle power station is a genuine illustration of another advancementin power age and adaptable AC transmission frameworks, FACTS as they are by and large known, are new gadgets that improve transmission frameworks. Overall transmission frameworks are going through consistent changes and rebuilding. They are getting all the more intensely stacked and are being worked in manners not initially imagined. Transmission frameworks should be adaptable to respond to more different age and burden designs. Likewise, the practical usage of transmission framework resources is of imperative significance to empower utilities in industrialized nations to stay cutthroat and to get by In agricultural nations, the advanced utilization of transmission frameworks ventures is additionally critical to help industry, make business and use productively scant monetary assets. Adaptable AC Transmission Systems (FACTS) is an innovation that reacts to these necessities. It essentially changes the manner in which transmission frameworks are created and controlled along with enhancements in resource usage, framework adaptability and framework execution.

1.2. MODELS AND ALGORITHMS

A. Power System Model

The standard power system model is basically a set of nonlinear differential algebraic equations, as follows:

$$x = f(x, yp)$$

$$0 = g(x, y, p) \qquad (1)$$

(1) where x arethestatevariables $x \in R^n$; Y arethealgebraicvariables $y \in R^m$; P aretheindependentvariables $p \in R^l$; $f$are the differential$f: R^n \times R^m \times R^l \to R^n$;and g are the algebraic equations$g: R^m \times R^m \times R^l \to R^m$. Power system tools uses in all algorithms, namely power flow, CPF, OPF, smaill-signal stability analysis, and time-domain simulation. Algebraic equations are obtained as the sum of all active and reactive power injections at buses:

$$g(x,y,p) = \begin{bmatrix} gp \\ gp \end{bmatrix} = \begin{bmatrix} gpm \\ gqm \end{bmatrix} - \sum_{C\in Cm} \begin{bmatrix} gpc \\ gpc \end{bmatrix} \qquad \forall m \in M \qquad (2)$$

In equation(2) where gpm and gqm are the power flows in transmission lines as commonly defined in the literature[15], is the set of net work buse sm and $[g_{pc}^T, g_{qc}^T]$ are the set and the power injections of components connected at bus, respectively$m$.PSAT is component-oriented, i.e., any component is defined independently of the rest of the program as a set of non linear differential-algebraic equations, as follows;

$$x_c = f_c(x_c, y_c, p_c)$$
$$P_c = g_{pc}(x_c, y_c, p_c)$$
$$Q_c = g_{qc}(x_c, y_c, p_c) \qquad (3)$$

In equation (3) where x_c are the component state variables, y_c the algebraic variables. (i.e.vandθt the buses to which the component is connected) and p_c are independent variables. Then differential equations fin(1) are built concatenating f_c of all components. Equations(3) alongwith Jacobians matrices are defined in a function which is used for both static and dynamic analyzes. In addition to this function, a component is defined by means of a structure, which contains data, parameters and the interconnection to the grid. For the sake of clarity, let us consider the following example, Namely the exponential recovery load (ERL)[14]. These to f differential-algebraic equations are follows: (4)

1.3 Methodology

Burden stream is a significant device utilized by power engineers for arranging, to decide the best activity for a force framework and trade of force between service organizations. To have an effective working force framework, it is important to figure out which strategy is reasonable and proficient for the framework's heap stream investigation. A force stream investigation technique may consume most of the day and in this way forestall accomplishing a precise outcome to a force stream arrangement as a result of ceaseless changes in power interest and ages. This paper presents examination of the heap stream issue in power framework arranging contemplates. The mathematical strategies: Gauss-Seidel, Newton-Raphson and Fast Decoupled techniques were thought about for a force stream examination arrangement. Recreation is completed utilizing Mat lab for experiments of IEEE 9-Bus, IEEE 30-Bus and IEEE 57-Bus framework. The reproduction results were thought about for number of emphasis, computational time, resilience worth and combination. The looked at results show that Newton Raphson is the most dependable technique since it has the most un-number of emphasis and meets quicker.

1.4 Results and discussion

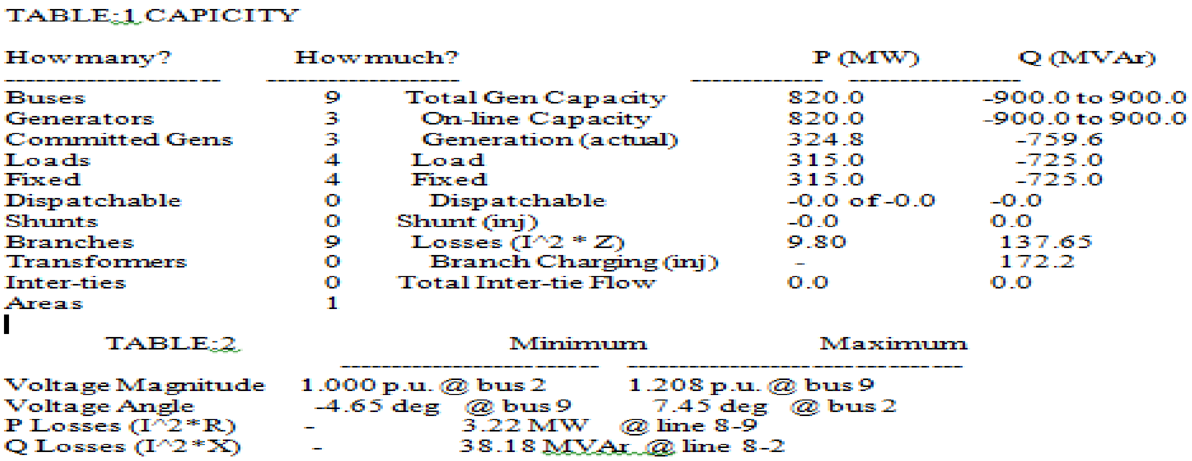

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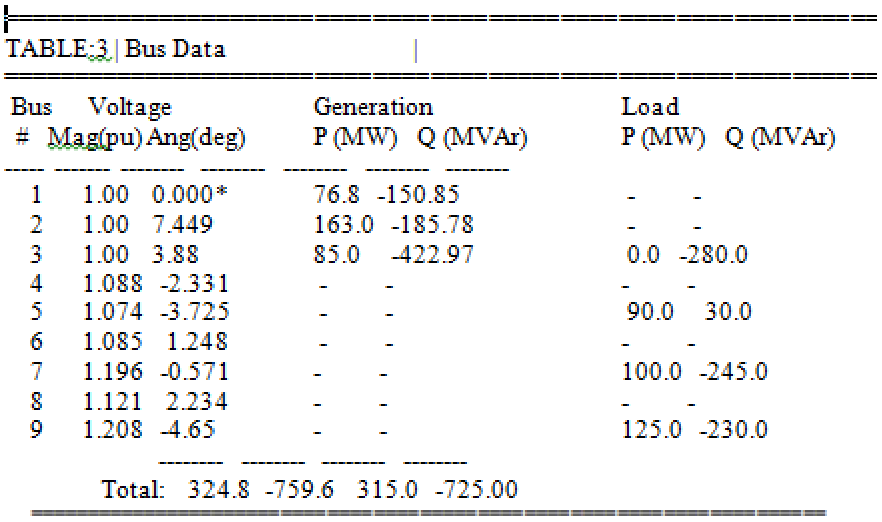
TABLE:1 CAPICITY

How many?              How much?                                P (MW)           Q (MVAr)
---------------------  ---------------------          -------------  -----------------
Buses                   9    Total Gen Capacity          820.0            -900.0 to 900.0
Generators              3      On-line Capacity          820.0            -900.0 to 900.0
Committed Gens          3      Generation (actual)       324.8               -759.6
Loads                   4     Load                       315.0               -725.0
Fixed                   4     Fixed                      315.0               -725.0
Dispatchable            0       Dispatchable             -0.0 of -0.0     -0.0
Shunts                  0    Shunt (inj)                 -0.0             0.0
Branches                9     Losses (I^2 * Z)           9.80              137.65
Transformers            0       Branch Charging (inj)     -                172.2
Inter-ties              0    Total Inter-tie Flow        0.0              0.0
Areas                   1

          TABLE:2                      Minimum                   Maximum
                          -------------------------  ------------------------------
Voltage Magnitude   1.000 p.u. @ bus 2       1.208 p.u. @ bus 9
Voltage Angle        -4.65 deg   @ bus 9       7.45 deg   @ bus 2
P Losses (I^2*R)    -                3.22 MW    @ line 8-9
Q Losses (I^2*X)     -               38.18 MVAr  @ line 8-2
```



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================================================================
TABLE:3 | Bus Data                  |
================================================================
 Bus      Voltage              Generation              Load
  #   Mag(pu) Ang(deg)      P (MW)   Q (MVAr)       P (MW)   Q (MVAr)
----- ------- --------  --------  --------  --------  --------
   1     1.00   0.000*      76.8  -150.85           -        -
   2     1.00   7.449       163.0  -185.78          -        -
   3     1.00   3.88        85.0    -422.97         0.0   -280.0
   4     1.088  -2.331      -        -              -        -
   5     1.074  -3.725      -        -              90.0    30.0
   6     1.085   1.248      -        -              -        -
   7     1.196  -0.571      -        -              100.0  -245.0
   8     1.121   2.234      -        -              -        -
   9     1.208  -4.65       -        -              125.0  -230.0
                 --------  --------  --------  --------
          Total:   324.8  -759.6   315.0  -725.00
================================================================
```

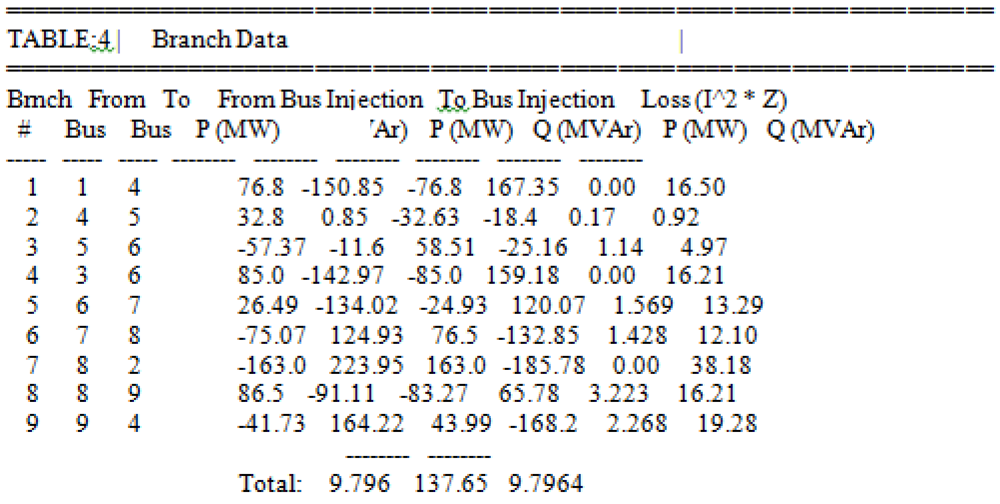

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TABLE:4 |     Branch Data                                   |
======================================================================
Brnch  From   To    From Bus Injection  To Bus Injection    Loss (I^2 * Z)
  #    Bus    Bus   P (MW)           'Ar)  P (MW)   Q (MVAr)  P (MW)   Q (MVAr)
-----  -----  -----  --------  --------  --------  --------  --------  --------
  1     1     4          76.8  -150.85   -76.8   167.35    0.00    16.50
  2     4     5          32.8     0.85   -32.63   -18.4    0.17     0.92
  3     5     6          -57.37   -11.6    58.51   -25.16    1.14     4.97
  4     3     6          85.0  -142.97   -85.0   159.18    0.00    16.21
  5     6     7          26.49  -134.02   -24.93   120.07    1.569    13.29
  6     7     8          -75.07   124.93    76.5  -132.85    1.428    12.10
  7     8     2          -163.0   223.95   163.0  -185.78    0.00    38.18
  8     8     9          86.5   -91.11   -83.27    65.78    3.223   16.21
  9     9     4          -41.73   164.22    43.99  -168.2    2.268    19.28
                                  --------  --------
                         Total:   9.796   137.65   9.7964
```

TABLE:5

Rect. pwr Ratings of SVC's	**Power loss with 3SVC**	**Power loss with 2SVC+1UPFC**
5	4.8299	4.8299
30	4.5791	4.5352
55	4.4749	4.3871
80	4.4517	4.32
105	4.3263	4.1507
130	4.2043	3.9848
155	4.0906	3.8271
180	3.9841	3.6768
205	3.8843	3.533
230	3.7905	3.3953
255	3.7021	3.263
280	3.6186	3.1356

IEEE 14 bus system results:

MATPOWER Version 5.1, 21-Mar-2115 -- AC Power Flow (Newton)

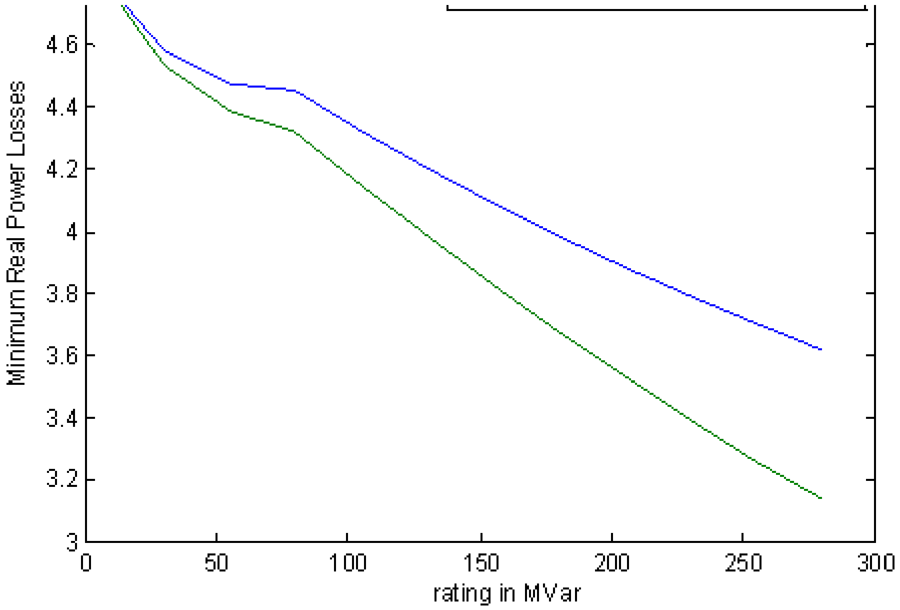

Figure 1: Comparative plot for Power loss for 9 bus system triple SVC (blue) two SVC &one UPFC(red).

```
Newton's method power flow converged in 6 iterations.
Converged in 1.12 seconds
================================================================
TABLE:6|     System Summary                                  |
=================================================================
How many?              How much?           P (MW)          Q (MVAr)
---------------------    -------------------  -------------  -----------------
Buses           14    Total Gen Capacity     772.4          -52.to 148.1
Generators        5    On-line Capacity      772.4          -52.to 148.1
Committed Gens     5    Generation (actual)    484.4          -233.8
Loads           11    Load                 259.          -811.5
Fixed           11      Fixed               259.          -811.5
DispatchableDispatchable          -1.of -1.      -1.1
Shunts          1    Shunt (inj)           -1.          33.6
Branches         2    Losses (I^2 * Z)       225.36          635.64
Transformers       3    Branch Charging (inj)    -              24.4
Inter-ties           Total Inter-tie Flow     1.            1.1
Areas           1
                  Minimum                    Maximum
           -------------------------  --------------------------------
Voltage Magnitude   1.11 p.u. @ bus 3         1.929 p.u. @ bus 14
Voltage Angle     -52.27 deg   @ bus 14        1.1 deg   @ bus 1
P Losses (I^2*R)           -              82.54 MW     @ line 9-14
Q Losses (I^2*X)           -              175.56 MVAr  @ line 9-14



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```
TABLE:7|    Bus Data                                          |
=====================================================================
 Bus      Voltage         Generation            Load
  #   Mag(pu) Ang(deg)  P (MW)   Q (MVAr)   P (MW)   Q (MVAr)
----- ------- --------  --------  --------  --------  --------
   1       1.16    1.111*   444.36    -39.79       -         -
   2       1.145   -9.55     41.1      85.11      21.7      12.7
   3       1.11   -21.278     1.1      22.1       94.2      19.1
   4       1.123  -21.742      -         -        47.8      -3.9
   5       1.111  -17.665      -         -         7.6       1.6
   6       1.17   -31.194     1.1    -242.55      11.2       7.5
   7       1.185  -31.124      -         -          -         -
   8       1.19   -31.124     1.1     -58.6         -         -
   9       1.33   -35.411      -         -        29.5      16.6
  1        1.277  -34.947      -         -         9.1       5.8
  11       1.171  -33.114      -         -         3.5       1.8
  12       1.156  -33.997      -         -         6.1       1.6
  13       1.232  -38.582      -         -        13.5       5.8
  14       1.929  -52.272      -         -        14.9    -881.1
                          --------  --------  --------  --------
             Total:     484.36   -233.82    259.1    -811.51
=====================================================================
```

```
TABLE:8|    Branch Data                                          |
=================================================================
Brnch   From   To   From Bus Injection   To Bus Injection     Loss (I^2 * Z)
  #     Bus    Bus   P (MW)   Q (MVAr)   P (MW)   Q (MVAr)   P (MW)   Q (MVAr)
-----  -----  -----  --------  --------  --------  --------  --------  --------
  1      1      2      296.13    -47.14   -281.67    88.5    15.462    47.21
  2      1      5      148.23      7.35   -137.61    31.19   11.615    43.82
  3      2      3      111.19      1.62    -95.87    11.98    4.326     18.23
  4      2      4      113.46    -14.6    -116.52    32.11    6.937    21.15
  5      2      5       85.32     -3.21    -81.52    11.15    3.797    11.59
  6      3      4        1.67     -8.88     -1.62     7.67    1.146     1.12
  7      4      5                -111.3     67.74   112.44   -61.1     2.138     6.74
  8      4      7      116.78    -59.73   -116.78    88.35    1.11     28.62
  9      4      9       63.86    -43.79    -63.86    73.72    1.11     29.93
 1       5      6       99.1      17.16    -99.1      4.6     1.11     21.67
 11      6     11        5.26    -56.2      -2.62    61.74    2.643     5.54
 12      6     12       13.11    -41.24    -11.1     45.42    2.11      4.18
 13      6     13       69.53   -157.21    -52.46   191.84   17.174    33.62
 14      7      8       -1.1      63.69      1.1    -58.6     1.11      5.19
 15      7      9      116.78   -152.14   -116.78   179.1     1.11     27.16
 16      9      1       13.42     77.98    -12.29   -74.99    1.127     2.99
 17      9     14      127.72   -313.81    -45.18   489.37   82.536   175.56
 18      1     11        3.29     69.19     -1.88   -63.54    2.415     5.65
 19     12     13        5.1     -47.12     -1.3     51.37    3.695     3.34
 2      13     14       41.26   -247.1      31.28   391.63   71.542   143.63
                                                  --------  --------
                 Total:   225.363   635.64
  225.3634
```

The Best Location for SVC in the system at Bus Number 13 and 5 and UPFC at 5 in ieee 14 BUS system

TABLE:9The value of SVC in MVarcrossponding to optimum position of SVC is 15 MVar.

Rect. pwr Ratings of SVC's	**Power loss with 3SVC**	**Power loss with 2SVC+1UPFC**
5	13.2998	13.2998
15	13.2896	13.2434
25	13.3141	13.2217
35	13.3178	13.1792
45	13.3409	13.1562
55	13.3831	13.1522
65	13.3933	13.1162
75	13.3933	13.07
85	13.3933	13.0238
95	13.3933	12.9776
105	13.3933	12.9314
115	13.3933	12.8853
125	13.3933	12.8391
135	13.3933	12.7929
145	13.3933	12.7467
155	13.3933	12.7005
165	13.3933	12.6543
175	13.3933	12.6081
185	13.3933	12.562
195	13.3933	12.5158
205	13.3933	12.4696
215	13.3933	12.4234
225	13.3933	12.3772
235	13.3933	12.331
245	13.3933	12.2849
255	13.3933	12.2387
265	13.3933	12.1925
275	13.3933	12.1463
285	13.3933	12.1001
295	13.3933	12.0539

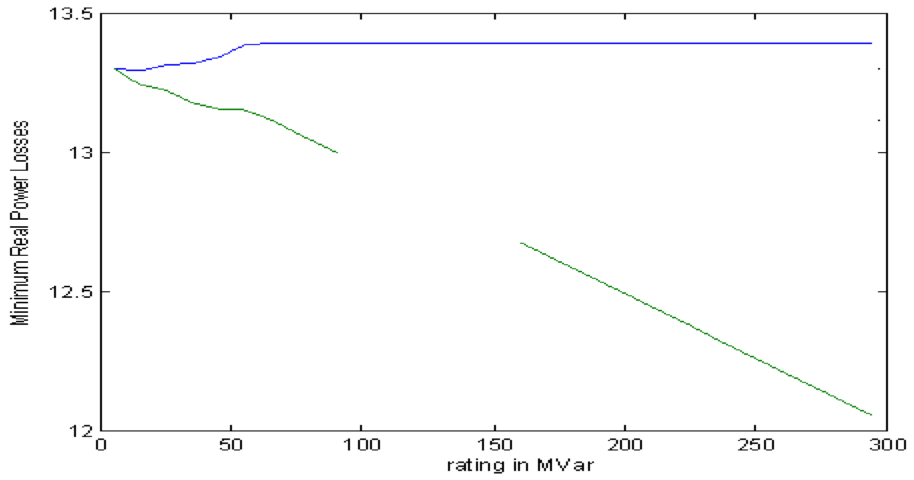

Figure 2: Comparative plot for Power loss for 14 bus system triple SVC (blue) two SVC &one UPFC(red).

1.5 Conclusion

Power loss minimization is acted in this work by the administration of responsive influence of and area of FACTS gadgets to improve the exhibition of ac influence frameworks. The idea of force misfortune pay accepts a wide and assorted field of both framework and client issues, particularly related with influence quality issues, since most influence quality issues can be weakened or tackled with a satisfactory control of influence misfortunes. As a rule, this work centers the issue of genuine force misfortune pay from two perspectives: load pay and voltage support. In load pay the goals are to build the worth of the framework power factor, to adjust the genuine force drawn from the air conditioner supply, to repay voltage guideline, and to dispose of current consonant parts delivered by huge and fluctuating nonlinear modern burdens. Voltage support is for the most part needed to lessen voltage change at a given terminal of a transmission line. Genuine force misfortune minimization utilizing SVC and UPFC remuneration in transmission frameworks additionally improves the steadiness of the air conditioner framework by expanding the most extreme dynamic influence that can be communicated.

This work explores the use of an UPFC and SVC to assist with the continuous activity of an IEEE 9 transport and 14 transport frameworks furnished with an UPFC and 2 SVC's during power stream tasks. These SVC gadgets are associated at the diverse transport areas where the breeze UPFC is associated with the force network at fixed situation to give consistent state power misfortune guideline and improve the momentary transient solidness. The SVC and UPFC power rating control plans are appropriately apply and coordinated.In future we can apply PSO or Genetic calculation for looking through the best force rating and transport area to upgrade the scanning speed for other enormous IEEE transport frameworks.

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