A Review - Analysis of Power System Network like Real and Reactive Power Flows

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Abstract— AC power sources are essential pieces of equipment for providing flexible and reliable power generation. The concepts of power generation and power loss can be dangerous for end users. This is especially true when it comes to talking about the different types of power quantities. This study presents a comparative study for four evolutionary computation methods to the optimal active–reactive power dispatch problem. Theoretically, there is a coupling relation between active–reactive power dispatches. However, because of high X/R ratio existing in the transmission line, the problem of active–reactive power dispatch can be decomposed into two individual sub-problems by the decoupling concept, that is, active–reactive power dispatch problems. On-line power system analysis enables to make power mode-related decision based on information available at real time. The quality of the studies and efficiency of power system operation are closely associated with the accuracy of the power system models. Accurate and quick decision based on analysis on real time data has been necessary for making operational plan under the deregulation of power system worldwide.

Key words: Power system, analysis, active power, reactive power

I. INTRODUCTION

Information techniques are promoting the electric power system to go into the digital electric power stage, the dispatching commands' transmission; common management and official business in the electric power system depend on various network information systems more and more. The electric power system's monitoring and control network in the earlier period is a local area network which do not connect outside. This paper analyzes the characteristics of the electric power information network system, proposes the information network structure, and designs the security architecture of the electric power information network system.[6]

A. Complex Power (S):

The vector sum of the true and reactive power measured in volt amps (VA).

B. Apparent Power (|S|):

The magnitude of the complex power measured in volt amps (VA).Θ = phase angle. This is the angle used to describe the phase shift between the voltage and current. The larger the phase angle, the greater the reactive power generated by the system.

C. Active Power:

Alternative words used for Real Power (Actual Power, True Power, Watt full Power, Useful Power, Real Power, and Active Power) In a DC Circuit, power supply to the DC load is simply the product of Voltage across the load and Current flowing through it i.e., P = V I. because in DC Circuits, there is no concept of phase angle between current and voltage. In other words, there is no Power factor in DC Circuits. But the situation is Sinusoidal or AC Circuits is more complex because of phase difference between Current and Voltage. Therefore average value of power (Real Power) is P = VI Cosθ is in fact supplied to the load. In AC circuits, When circuit is pure resistive, then the same formula used for power as used in DC as P = V I.

D. Reactive Power :

Also known as (Use-less Power, Watt less Power) Power merely absorbed and returned in load due to its reactive properties is referred to as reactive power The unit of Real power is Watt where 1W = 1V x 1 A. Reactive power represent that the energy is first stored and then released in the form of magnetic field or electrostatic field in case of inductor and capacitor respectively. Reactive power is given by Q = V I Sinθ which can be positive (+ve) for inductive, negative (-Ve) for capacitive load.Unit of reactive power is VAR.

II. PROBLEM FORMULATION [2]

Active–reactive power dispatch (ARPD) is typically a multi-objective optimisation problem. The objectives and constraints of the ARPD solved in this paper are summarised below.

A. Reactive Power Dispatch:

Reactive power dispatch is a sub-problem of the OPF calculation. Typically, it minimises the active power transmission loss subject to a number of constraints. In this paper, the voltage magnitude deviation at each load bus is also considered an objective function.

B. Active Power Transmission Loss:

The objective of active power transmission loss can be expressed as follows

$$f_Q = \sum_{k\in(i,j)} P_{1,k} = \sum_{i,j=1}^{L}[g_{ij}(|V_I^2| + |V_J^2| - 2|V_I||V_J|\cos(\delta_I - \delta_J))] \quad (1)$$

Where fQ is the active power transmission loss,k is the active power transmission loss of branch k; L is the number of transmission lines; |Vi| is the voltage magnitude at bus I; gij is the conductance between bus i and j; and di is the voltage phase angle of bus i.

C. Voltage Magnitude Deviation:

The bus voltage magnitude is one of the important indices in security operation. The objective of voltage magnitude deviation is given as follows

$$V_{dev} = \sum_{i=1}^{Npq}\left(V_I - V_I^{ref}\right)^2 \quad (2)$$

Where Vref i is the ith specified reference value of the voltage magnitude for load buses, which is generally set at 1.0 pu and NPQ is the number of load buses. The reactive power dispatch of models (1) and (2) must satisfy the following constraints

Power balance constraint

$$P_{Bi} - P_{Di} - P_{Ii} = 0 \quad (3)$$

$$Q_{Bi} - Q_{Di} - Q_{Ii} = 0 \quad (4)$$

$$P_{Ii} = \sum_{J=1}^{L} |Y_{IJ}| \times |V_I| \times |V_J| \times \cos(\emptyset_{IJ} + \delta_I - \delta_J) \quad (5)$$

$$Q_{Ii} = \sum_{J=1}^{L} |Y_{IJ}| \times |V_I| \times |V_J| \times \cos(\emptyset_{IJ} + \delta_I - \delta_J) \quad (6)$$

Where PBi is the injected active power at bus I; PDi is the power demand at bus I; Pli is the active transmission loss at bus I; QBi is the injected reactive power at bus I; QDi is the reactive power demand at bus I; Qli is the reactive transmission loss at bus I; |Yij| is the admittance between buses i and j; and dij is the admittance phase angle between buses i and j.

D. *Reactive generation constraint:*

The reactive generation constraint is usually used on the generation bus (PV bus) as follows

$$Q_{BI,min} \le Q_{BI} \le Q_{BI,max} \quad (7)$$

Where QBi,min and QBi,max are the lower and upper limits of the injected reactive power at bus i.

E. *Bus Voltage Constraint:*

To preserve the stable operation of the power system, each bus voltage is controlled within the constraints. The bus voltage constraint is generally utilised on the load bus (PQ bus) as follows

$$V_{BI,min} \le V_{BI} \le V_{BI,max} \quad (8)$$

Where Vi,min and Vi,max are the lower and upper limits of the bus voltage at bus i.

Capacitor and transformer tap setting constraints: The constraints of the capacitor and transformer tap setting are defined as follows

$$Q_{C,min} \le Q_C \le Q_{C,max} \quad (9)$$

$$T_{K,min} \le T_K \le T_{K,max} \quad (10)$$

Where QC is the reactive power installed by capacitor, QC,min and QC,max are the lower and upper limits of the capacitor, Tk is the position of transformer k and Tk,min and Tk,max are the lower and upper positions of transformer k. In this paper, the capacitor and transformer tap settings are regarded as continuously adjustable variables.

F. *Active Power Dispatch:*

Traditionally, the active power dispatch minimises fuel cost subject to some constraints. However, with the increasing concern for environment protection, a revised active power dispatch accounting for emission functions is required. In this paper, three objectives including fuel cost, power wheeling cost and pollutant emission are considered.

1) *Fuel Cost:*

The fuel cost function of the system can be expressed as the quadratic function of the generators active power output as follows

$$F(P_G) = \sum_{I=1}^{N} a_i + b_i P_{Gi} + c_i P_{Gi}^2 \left(\frac{\$}{h}\right) \quad (11)$$

Where F(PG) is the total fuel cost of the system; PGi is the power output of the ith unit; N indicates the number of generators; ai, bi and ci are the cost coefficients that are generally obtained by the curve-fitting technique.

2) *Power Wheeling Cost:*

The evaluation of power wheeling cost can roughly be divided into four methods: the postage stamp method, contract path method, megawatt mile method and marginal cost method . In this paper, the megawatt mile method is adopted and can be expressed as follows

$$C_h(P_G) = \sum_{all\ k} \varphi_k \times |P_k(h)| \times L_k \quad (12)$$

Where Ch(PG) is the power wheeling cost of the hth exchange; 4k is the weighting value of the kth transmission line; | Pk(h)| is the absolute value of the active power flow for the kth transmission line on the hth exchange; and Lk is the length of the kth transmission line.

The active power flow Pk(h) in (12) can be calculated using the DC power flow method as follows

$$P_k(h) = \frac{1}{x_k}[\Delta\theta_k(h)] \quad (13)$$

Where xk is the reactance of the kth transmission line, Duk(h) denotes the variation in voltage phase angle for the kth transmission line on the hth exchange.

3) *Pollutant Emission:*

The emission function of the system can be expressed as the polynomial function of the generator active power output as follows

$$(P_G) = \sum_{i=1}^{n} \alpha_i + \beta_i P_{Gi} + \gamma_i P_{Gi}^2 + \cdots + \varphi_i P_{Gi}^{nk} \quad \left(\frac{\text{ton}}{\text{h}}\right) \quad (14)$$

Where a, b, g and w are emission coefficients and nk represents the order of emission function. The emission function of (14) may be one of all types of pollutants, such as NOx, CO2, SO2 , particulates, or thermal pollutants. The emissions of NOx and CO2 are separately considered as two different case studies in this paper.

The optimisation of the active power dispatch must be subjected to power balance constraints, generation capacity constraints and line overload prevention constraints, as defined in (3), (15) and (16), respectively.

$$P_{Gi,min} \le P_{Gi} \le P_{Gi,max} \quad (15)$$

$$\sum_{i=1}^{L} P_i^C - P_i \ge 0 \quad (16)$$

Where PGi,min and PGi,max are the lower and upper bounds of the ith power generation, Pi is the active power flow of the ith line and PC i is the maximal power flow capacity of the ith line.[2]

III. THE POWER SYSTEM EVENTS

Discrete events often occur when power system is under normal operation, and even more frequently when the operating condition is abnormal, especially under large disturbance. Power system's dynamics are a very complex procedure consisting of the interactions between the discrete control actions and continuous dynamics of physical equipments. These events can be briefly classified as follows.

A. *Automatic Control Events:*

Those events can be divided into three categories by their occurred frequency. Fist, frequent automatic control actions such as resetting of governor and exciter set points, the former for frequency control, the latter for voltage control. Second, less frequent automatic control actions include tap changing of OLTC and shunt capacitor banks switching for controlling local voltages. Third, infrequent but rapid automatic control actions include operation of a wide variety of protection relays to disconnect from the fault equipments, or under-frequency relays operating for protection load.

B. Manual Control Events:

Those events include connection or disconnection of major equipments, such as generator, transmission line, shunt capacitor and FACTs, and remote controls etc.

C. Autonomous Disturbance Events:

Those events can be divided into two categories by action frequency. First, frequent autonomous disturbances include load changes and arc furnace loads etc. Second, infrequent autonomous disturbances include unexpected sudden losses from service of major equipments, e.g., tripping of generator and transmission lines because of fault, and internal fault and external disturbance, such as lightning strikes. A distinct feature of these events is that at the instant that the event is occurring, there is an abrupt change and discontinuity on physical states, or during a very short period when the event is occurring, physical state is oscillating sharply.

Another type of dynamic is often analyzed in power system operation, which can also be defined as events. For instance, power system transient instability, voltage instability and system frequency instability. This type of dynamic is called abstract event in this paper. Before and after the abstract event there always exists a sequence of typical discrete events happening as in each power system blackouts [5]

IV. CONCLUSION

The events in power systems are a very important dynamic behavior, and there is all the time no good approaches of modeling and analysis due to its complexity. In this paper, a mathematic definition of the event is given after analyzing various power system events, and also gives a model framework of power system event, which is based on formal language theory. The hybrid dynamic behavior between power system discrete control actions and physical system is analyzed by using this framework, and a cascading event sequence occurred in the 8.14 blackout is used as an example to discuss the controllable of events. Then, the synthesis of supervisor of power system discrete events is also discussed. And we can also study about the differences between active power and reactive power in the power system.

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