

EMPLOYMENT OF THE AC DISTRIBUTION FACTOR FOR THE OPTIMAL PLACEMENT OF FACTS DEVICES

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ABSTRACT

This paper presents a method for determination of the optimal siting and sizing of the FACTS devices considering increase of bilateral transactions. The objective considered is to maximize the Available Transfer Capability (ATC) of a heavy transaction and minimize transaction losses. In this paper, the optimal FACTS problem is solved by using the Differential Evolution (DE) technique with the employment of the AC Distribution Factor (ACDF) for the ATC approximation. Performance of the method in terms of quality of the solutions considering objective value and the computational time is compared with that of the others such as the Genetic algorithm (GA) with the repeated power flow. It is found that, the method provides more computational efficient with a sufficient degree of solution accuracy.

KEY WORDS

AC distribution factor, Available transfer capability, Differential Evolution, Genetic Algorithm, Optimal FACTS placement,

1. Introduction

The electrical systems in the modern age are generally operates under deregulated environment of market. Moving away from monopoly, structures of the electricity markets may be different depending on conditions of countries [1]. The market mechanism of each structure can cause different power flow behaviour. Therefore, it is necessary to specify market structure when a typical problem is considered.

This paper considers the electric power system operated under the mixed power pool and bilateral transaction electricity market. The main trading of the market is made in the power pool where the supply-demand is matched with respect to the cheapest possible dispatch [2]. The direct trading, bilateral contract can be made between a generation company and a large customer. Bulk power transfer between zones can sometimes cause congestion problem and the market mechanism such as willingness-to-pay to avoid curtailment is applicable for solving problem [3]. However, in this paper the economic aspect

is not considered. Transmission upgrade is another option [4]. It can be done by building new transmission circuit or replacing old transmission lines by higher capacity one. In this paper, transmission upgrade using FACTS devices is considered for increasing bilateral transaction and the ATC is used to indicate the benefit of the devices. The calculations of the ATC are generally recursive. There are many ATC calculation methods such as the repeated power flow [5], the continuation power flow [6] and the linear approximation methods [7]. Utilization of each method depends on further implementation of the ATC value.

To obtain maximum benefit from the FACTS devices, their optimal installation problem is necessary solved. The technique for seeking solution is required for solving the optimal FACTS placement problem. It could be the application of the sensitivity index [8], conventional optimization [9] and heuristic optimization [10]. This paper utilizes two heuristic optimization techniques. The first technique is the Genetic Algorithm (GA). It is well-known and widely applied to the engineering problem. The second technique is the Differential Evolution (DE). It is increasing popularity due to its better performance in comparison to other evolutionary optimization. Both methods are easy for implementation and applicable for the real world problem [11, 12].

In this paper, the optimal placement of the FACTS device is determined to obtain the maximum ATC of considered transaction. The employment of the ACDF is presented for the objective evaluation. It is associated with the DE. Performance of the method is observed by comparison with the other methods involving different ATC calculations and the GA.

2. FACTS device modelling

In this section, very brief introduction to the most popular FACTS devices of series, shunt and combined types; named Thyristor Controlled Series Compensator (TCSC), Static Var Compensator (SVC) and Unified Power Flow Controller (UPFC) are provided. Their modeling and assumption generally used in the determination of the optimal FACTS allocation are also given and applied in the numerical study section in this paper.

2.1 Thyristor Controlled Series Compensator (TCSC)

The purpose of series capacitive compensation is to decrease the overall effective series transmission impedance between two buses as if the line was physically shortened when it is installed [13].

The TCSC consists of the series compensating capacitor shunted by thyristor-controlled reactor as shown in Figure 1. The capacitive impedance is fixed and the inductive impedance is variable.

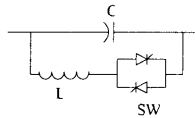


Fig. 1 Schematic of TCSC

TCSC is modelled by three ideal switches of capacitor, inductor and simple wire in parallel as shown in Figure 2 [10]. The simple wire represents zero compensation. The parameter of branch in which the device is located becomes a function of variable TCSC capacitance and inductance. To avoid overcompensation, the maximum capacitive compensation from the TCSC is 70 percent of line reactance and the maximum inductive compensation is 20 percent of line reactance.

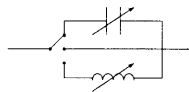


Fig 2 The TCSC parameter model

2.2 Static Var Compensator (SVC)

The variable impedance shunt compensators comprise the inductor and capacitor in parallel as shown in Figure 3. The purpose of shunt connected, fixed or mechanically switched inductor is to minimize the line over-voltage under light load conditions and that of shunt connected, fixed or mechanically switched capacitor is to maintain voltage levels under heavy load conditions. The overall purpose of applying reactive shunt compensators is to increase the transmittable power and voltage stability.

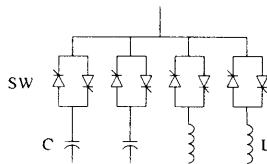


Fig 3 Schematic of SVC

The SVC is modelled with two ideal switches of capacitor, inductor and simple wire in parallel as shown in Figure 4 [10]. It may take the values characterised by the reactive power injection or absorption at 1 pu of voltage. Therefore, it is operated in the range of -100 MVar and 100 MVar.

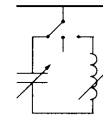


Fig 4 The SVC parameter model

2.3 Unified Power Flow Controller (UPFC)

UPFC is a combination of two voltage source converter based controllers. One is arranged in series and another is in shunt with the transmission line. It was proposed for the real-time control and dynamic compensation of AC transmission system. It provides multifunctional flexibility as it is able to control all the parameters affecting power flow in the transmission line. Simple model of the UPFC can be a combination of the TCSC and SVC models.

3. Available Transfer Capability (ATC) calculations

In this paper, the ATC is defined as the amount of power, incremental above normal base power transfers, that can be transferred over the transmission network without network violation. Three simple calculation methods of the ATC are selected and their calculation procedures are provided in this section. The methods are applied further in the numerical study in the later section.

3.1 Repeated Power Flow (RPF) method

For the ATC calculation using the RPF technique, both AC and DC power flow models can be employed. With the DC model, the computation is faster. However, voltage constraints are ignored and the result could have large amount of error. When the AC power flow model is utilized, the reactive power flow is taken into account. The computation takes longer time but it provides consideration in voltage constraints and more accurate solution.

The RPF method is proceeded by slightly increasing demand at the considered receiving bus/zone and increasing the generation output at the considered sending bus/zone to cover the increased demand and losses. The power flow is solved for every increasing step until any limitation is met. A typical step size for increasing load used in this paper is 1 MVA. Increased MW demand before the system limit is met is taken as the ATC value of the considered transaction.

3.2 Approximation method using DC power transfer distribution Factor (DC-PTDF)

The DC-PTDF represents a fraction of a considered transaction over a considered transmission line. In this paper, it is based on the approximation of the DC power flow model with consideration of the line resistance and losses as presented in [14].

By considering losses, the PTDF representing a fraction of a transaction from zone m to zone n that flows over a transmission line connecting bus i and bus j , ($PTDF_{ij,mn}$) [7] is calculated by

$$PTDF_{ij,mn} = \Omega_{ij} \cdot ((Z_{im} - Z_{jm}) - (Z_{in} - Z_{jn})) \quad (1)$$

$$\text{Where } \Omega_{ij} = \frac{x_{ij}}{r_{ij}^2 + x_{ij}^2} \quad (2)$$

r_{ij} is the resistance of the line connecting bus i to bus j

x_{ij} is the reactance of the line connecting bus i to bus j

Z_{im} is entry in the i^{th} row and the m^{th} column of the bus impedance matrix $[Z]$ which is the inversion of admittance matrix

The ATC is the minimum of the maximum allowable transaction over all lines.

$$ATC_{mn} = \min_{ij} P_{mn,ij}^{\text{Max}} = \min_{ij} \left(\frac{P_{ij}^{\text{Max}} - P_{ij}^0}{PTDF_{ij,mn}} \right) \quad (3)$$

Where P_{ij}^{Max} is the power flow limit of line connecting bus i and bus j and P_{ij}^0 is the base case power flow in line connecting bus i and bus j

3.3 Approximation method using AC distribution Factor (ACDF)

Without the contingency consideration in this paper, the factors comprise two sub-factors. They are AC Power Transfer Distribution Factor (AC-PTDF) and the Voltage Distribution Factor (VDF) [15].

Based on AC power flow model, the AC-PTDF of line connecting bus i and bus j due to transaction from bus/zone m to bus/zone n can be calculated using the following expression.

$$AC-PTDF_{ij,mn} = \frac{\Delta P_{ij}}{\Delta P_{mn}} \quad (4)$$

Where ΔP_{ij} is the change of real power flow in line ij due to the change of real power transfer between zones m and n by ΔP_{mn}

$$\Delta P_{ij} = P_{ij} - P_{ij}^0 \quad (5)$$

$$\Delta P_{mn} = P_{mn} - P_{mn}^0 \quad (6)$$

Where P_{mn} is the new transaction between zone m and zone n , P_{mn}^0 is the base case transaction between zone m and zone n and P_{ij} is the corresponding new power flow between bus i and bus j

The VDF of bus i due to transaction from bus/zone m to bus/zone n can be calculated using the following expression.

$$VDF_{i,mn} = \frac{\Delta V_i}{\Delta P_{mn}} \quad (7)$$

Where ΔV_i is the change of bus voltage magnitude at bus i due to the change of real power transfer between zones m and n by ΔP_{mn}

$$\Delta V_i = V_i - V_i^0 \quad (8)$$

Where V_i^0 is the voltage at bus i of the base case

V_i is the voltage at bus i under change of considered transaction

The ATC is the minimum of the maximum allowable transaction over all lines due to both power flow and voltage limits.

$$ATC_{mn} = \min_{ij} \left(\frac{P_{ij}^{\text{Max}} - P_{ij}^0}{PTDF_{ij,mn}}, \frac{V_i - V_i^{\text{min}}}{VDF_{i,mn}} \text{ or } \frac{V_i^{\text{max}} - V_i}{VDF_{i,mn}} \right) \quad (9)$$

Where V_i^{min} , V_i^{max} are the minimum and maximum voltage limits at bus i

In case the demand is inductive, the voltage to minimum limit is considered.

4. Heuristic optimizations

Two evolutionary optimization techniques are selected for implementation in this paper, although there are many algorithms developed based on the evolutionary concept. The well-known GA and the better performance DE are utilized. Their algorithms used in numerical study of this paper are provided in the following subsections.

4.1 Genetic Algorithm (GA)

GA is one of the most often chosen among the heuristic optimization techniques for real world applications. It has been widely applied to solve the FACTS allocation problem [10]. It consists of seven components which are chromosome representation, population, fitness evaluation, selection, mating/crossover, mutation and convergence. Feature and algorithm of the GA can be found in [11].

In this paper, the binary GA is applied with population of 40, roulette wheel selection, crossover of 0.5 and mutation of 0.01. The stopping condition for the GA searching process is met when the difference of the best solutions found in every 40 generations is not greater than 0.1 or when the iterations reach 200.

4.2 Differential Evolution (DE)

Differential Evolution (DE) is evolutionary strategy optimisation technique [12]. It was found to be the best genetic type of algorithm for solving the test function suite of the first international contest on evolutionary computation.

The searching process starts with random initialized population members. Two vectors are chosen randomly from the population. The first one is called 'base vector'. It is added with a 'weighted difference vector', which is computed from any two population members, to obtain 'mutant vector'. The second one is called 'target vector'. A crossover operation between the target and mutant vectors results in 'trial vector'. The fitness values of the target and trial vectors are compared. For a minimum

optimization, the vector with smaller fitness value is kept for a new population member.

In this paper, it is applied with the step size of 0.5 and crossover of 0.8. The population is 40. The stopping condition for the DE searching process is met when the difference of the best solutions found in every 40 generations is not greater than 0.1 or when the iterations reach 200.

5. The optimization problem formulation

The optimal allocation of the series compensator is determined to maximize the ATC of a considered transaction. The problem is now given as

$$\text{Max. } f = ATC - L_T \quad (10)$$

$$\text{St. } G_T = D_T + L_T \quad (11)$$

$$MVA_{ij} \leq MVA_{ij}^{\max} \quad (12)$$

$$G_i^{\min} \leq G_i \leq G_i^{\max} \quad (13)$$

$$V_i^{\min} \leq V_i \leq V_i^{\max} \quad (14)$$

Where ATC is the ATC value of considered transaction

G_T is the total system generation

D_T is the total system demand and compensators

L_T is the total system losses

MVA_{ij} is the line flow from bus i to bus j

MVA_{ij}^{\max} is the power flow limit of branch connecting

bus i to bus j

G_i is the real power output of generation i

G_i^{\min} , G_i^{\max} are the minimum and maximum real

power output of generation at bus i

The constraints are real and reactive power balance, power flow, voltage stability and generation limits. FACTS device limits are also required for taking into account as one of constraints.

For TCSC,

$$-0.2x_{ij} \leq x_{TCSC} \leq 0.7x_{ij} \quad (15)$$

Where x_{ij} is the reactance of transmission line connecting bus i and bus j

x_{TCSC} is the reactance of the TCSC

For SVC,

$$-100 \leq Q_{SVC} \leq 100 \quad (16)$$

Where Q_{SVC} is the reactive compensation from the SVC

Both equations (15) and (16) are taken as constraints for the UPFC.

6. Numerical study

In this section, the numerical study on AC distribution factor and its application on the ATC calculation and the optimal FACTS allocation for increasing ATC of the heavily loaded lines are provided. The number of the device is limited at one device per considered zone. The power flow is solved using the MATPOWER [16]. This study is given only for the TCSC but the technique can also be applied for the other types of the devices.

6.1 Case Network I

The modified Roy Billinton Test System (RBTS) is utilized. It is modified by adding generator at bus 4 and increasing loads to stress the system. All loads have 0.98 pf. Details of the modified network can be found in [7]. The network without FACTS device is used as a base case.

The DC and AC distribution factors of the transaction between bus 2 and bus 5 for the modified RBTS are shown in Table 1.

Table 1
The DC and AC distribution factors of the modified RBTS

Branch/Bus	DC-PTDF	AC-PTDF	VDF
1	-0.3579	-0.3620	0
2	0.3579	0.1856	0
3	0.3579	0.1856	-0.1128×10^{-3}
4	0.6421	0.3527	0
5	0.6421	0.3527	-0.3247×10^{-3}
6	-0.0947	-0.0903	-0.3322×10^{-3}
7	0.4526	0.4527	
8	0.5474	0.5527	
9	0.0000	0.0003	

From Table 1, the largest difference between the DC-PTDF and AC-PTDF values occurs for parallel branches 2 and 3. Percent discrepancy is 50 which is noticeably large and can cause large difference between the ATC values calculated from the DC- and AC-PTDF. However, the signs of the factors which indicate the effect of transaction on increase of branch flow from one end to another end are the same. It is noticed that the DC-PTDF for branch 9 is zero. It indicates that the considered transaction does not affect flow through this branch. Whilst the AC-PTDF is positive which indicates that the considered transaction results in increase of flow from bus 5 to bus 6 (branch 9). This is caused by the losses of the system considered in the AC power flow model. The VDF is negative as increase of inductive load causes increases of flows and decreases of voltage magnitudes.

By using equations (3) and (9), the ATC of transaction between bus 2 and bus 5 are 0.0857 and 0.0848 respectively. Calculated with the RPF methods, by using the DC power flow model, the ATC of this bilateral transaction is 1 and by using the AC power flow model, it is 1.96 with flow limit at branch 8 connecting bus 4 and bus 5. From the ATC values, although some of the PTDF values are much different, the ATC is not obviously affected.

The optimal location and rating of the TCSC on the modified RBTS determined using different combination of the ATC calculation for transaction 2 – 5 and optimization methods are shown in Table 2. The power flow model used in the RPF method is the AC and the low voltage limit is considered in the AC-DF method as demand at bus 5 is inductive. They are selected from the best of three runs for each method.

Table 2
The optimal placement and rating of TCSC on the modified RBTS

ATC calculation	Optimization technique	Optimal TCSC	Objective value	Computational time
RPF	DE	Branch 6, 69.5%	23.53	13.98
DC-PTDF	DE	Branch 7, 69.93%	26.65	6.84
AC-DF	DE	Branch 7, 67.6%	24.98	11.72
RPF	GA	Branch 7, 69.71%	26.47	247.30
DC-PTDF	GA	Branch 7, 69.8%	26.50	24.47
AC-DF	GA	Branch 7, 69.95%	26.44	58.47

From Table 2, branch 7 with 69.9% compensation is the most satisfactory solution as it provides the best value of the objective. The majority of solutions obtained from selected methods are branch 7. However, by using the RPF associated with the DE, branch 6 with 69.5% compensation is obtained. It seems that the GA gives better solution in terms of the objective value than the DE. However, it takes up to 20 times longer.

6.2 Case Network II

The IEEE-RTS is used to test the application of proposed method. The network consists of 24 buses and 38 branches. The total loads are 2850 MW, 580 MVar. At the base case without FACTS device installation, the generation dispatch can be found in [17].

The first considered transaction is the power delivery from bus 15 and bus 6. The ATC of the base case, calculated by using the RPF, DC-PTDF and AC-DF, are 134.19, 138.85 and 137.95 respectively. The maximum percent discrepancy of the three values is 3.4%. From the RPF method, the calculation terminated with limitation on branch connecting bus 10 and bus 6. To maximize the ATC of this transaction, the optimal location of TCSC is given in Table 3. Results shown in the Table are the best, taken from 3 runs of each method.

Table 3
The optimal placement and rating of TCSC on the IEEE-RTS considering transaction 15 – 6

ATC calculation	Optimization technique	Optimal TCSC	Objective value	Computational time
RPF	DE	Branch 5, 67.43%	200.79	897.4
DC-PTDF	DE	Branch 5, 62.38%	202.78	7.37
AC-DF	DE	Branch 5, 65.8%	208.00	16.56
RPF	GA	Branch 5, 64.30%	199.81	2260
DC-PTDF	GA	Branch 5, 69.89%	217.51	34.64
AC-DF	GA	Branch 5, 69.83%	216.19	85.26

From Table 3, all method can provide satisfactory solution on branch 5 of the system. Longer time is taken

when the RPF method is applied. The GA seems to give better solution in terms of the objective value for this case but takes longer computational time.

In this case, the accuracy of the ATC calculation method does not influence the optimal FACTS placement determination.

The second considered transaction is the transaction between bus 23 and bus 9. The base case ATC of this transaction calculated using the RPF, DC-PTDF and AC-DF are 336.94, 1038.5 and 428.89 respectively. The value obtained from using the DC-PTDF is more than 2 times higher than that obtained from the other methods. By using the RPF method, the calculation is terminated with low voltage limit at bus 9. Similarly, by using the AC-DF, the lowest ATC of the system is obtained from the VDF. The optimal allocation of the TCSC for the maximum transaction 23 – 9 of the IEEE-RTS is presented in Table 4.

Table 4
The optimal placement and rating of TCSC on the IEEE-RTS considering transaction 23 – 9

ATC calculation	Optimization technique	Optimal TCSC	Objective value	Computational time
RPF	DE	Branch 14, 41.7%	418.24	1440
DC-PTDF	DE	Branch 15, -19.3%	1062.80	7.68
AC-DF	DE	Branch 14, 66.76%	674.51	11.06
RPF	GA	Branch 14, 32.1%	393.75	1180
DC-PTDF	GA	Branch 35, 69.9%	1055.70	29.2
AC-DF	GA	Branch 14, 69.84%	696.94	82.41

From Table 4, the RPF and AC-DF methods associated with the DE and GA optimization give satisfactory solution for the optimal TCSC allocation on branch 14. In this case, using the RPF and GA tend to take longer computation. It is obvious that the DC-PTDF application provides different solution to the optimal TCSC problem. This solution is not reliable as the DC-PTDF cannot capture the voltage stability of the system. As seen from the ATC value calculated using this method is much higher than that calculated using the other methods, the DC-PTDF take only the branch flow limit into account. In the other words, the voltage limit is ignored.

7. Conclusion

This paper proposes the utilization of the AC-DF to determine the optimal location of FACTS device. The AC-DF is used to calculate the ATC value of a considered bilateral transaction which is further used as fitness of trial solution in the optimization procedure. The corresponding ATC values of the most accurate RPF and the AC-DF methods are compared. It is found that the discrepancy can be as large as 20% for a typical transaction of the 24-bus test network. However, its accuracy does not affect the quality of solution for the

optimal FACTS placement problem. Associated with a typical optimization technique, its calculation can be 100 times faster than the RPF method for selected transaction of 24-bus test network in this paper. The application of the DC-PTDF takes the shortest time but it cannot give the right answer in case voltage stability of the system is involved. In comparison between the GA and the DE utilised in this paper, the DE is generally faster. Therefore, the application of the AC-DF associated with a heuristic optimization technique can provide satisfactory solution to the optimal FACTS allocation problem in some degree of accuracy and better computational time in comparison to the application of recursive ATC calculation.

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บันทึกข้อความ

ส่วนราชการ หน่วยสนับสนุนการวิจัยและบริการ คณะวิศวกรรมศาสตร์ โทร.3319

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เรื่อง ขออนุมัติงบประมาณสนับสนุนการนำเสนอบทความวิชาการในการประชุมวิชาการระดับนานาชาติ

เรียน คณบดี

สืบเนื่อง จากการประชุมคณะกรรมการบริหารงานวิจัย (ERB) คณะวิศวกรรมศาสตร์ ครั้งที่ 7/2552 เมื่อวันที่ 11 กันยายน 2552 โดยได้พิจารณาการนำเสนอผลงานทางวิชาการระดับนานาชาติ ณ ประเทศจีน ของ ดร.บงกช สุขอนันต์ ตามความทราบแล้วนั้น

มติที่ประชุม ได้เห็นชอบในการสนับสนุนงบประมาณการนำเสนอผลงานทางวิชาการระดับนานาชาติ ณ ประเทศจีน ระหว่างวันที่ 12-14 ตุลาคม 2552 ของ ดร.บงกช สุขอนันต์ อาจารย์สังกัดภาควิชาวิศวกรรมไฟฟ้าและอิเล็กทรอนิกส์ โดยให้การสนับสนุนงบประมาณตามค่าจริงไม่เกิน 40,000 (สี่หมื่นบาทถ้วน) ทั้งนี้เป็นไปตามประกาศ คณะวิศวกรรมศาสตร์ ฉบับที่ 38/2549 เรื่อง หลักเกณฑ์การนำเสนอเผยแพร่ผลงานวิจัย/วิชาการ ระดับนานาชาติ (ฉบับที่ 2 พ.ศ. 2549) ลงวันที่ 31 กรกฎาคม 2551 โดยได้แนบเอกสารที่เกี่ยวข้องมาพร้อมนี้

จึงเรียนมาเพื่อโปรดพิจารณาอนุมัติ

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เรียน อ.สมเกียรติ

วันที่ 15/9/52

โปรดพิจารณาอนุมัติ

ในรายนามคณบดี

16 ก.ย. 2552

คณบดี

(รองศาสตราจารย์ ดร.สถาพร โภคา)

คณบดีคณะวิศวกรรมศาสตร์



บันทึกข้อความ

ส่วนราชการ ภาควิชาวิศวกรรมไฟฟ้าและอิเล็กทรอนิกส์ คณะวิศวกรรมศาสตร์

โทร 3329

ที่ ศธ 0529.8.6/ ๒๕1

วันที่

เรื่อง ขออนุมัติงบประมาณสนับสนุนเพื่อเสนอบทความทางวิชาการระดับนานาชาติ

เรียน รองคณบดีฝ่ายวิจัยและบริการวิชาการ

ด้วย ดร.บงกช สุขอนันต์ ตำแหน่ง อาจารย์ สังกัดภาควิชาวิศวกรรมไฟฟ้าและอิเล็กทรอนิกส์ มีความประสงค์จะเข้าร่วมการนำเสนอบทความทางวิชาการระดับนานาชาติ ในการประชุมวิชาการ International Association of Science and Technology for Development. ระหว่างวันที่ 12-14 ตุลาคม 2552 ณ ประเทศจีน บทความทางวิชาการที่นำเสนอเรื่อง “Employment of the AC Distribution Factor for the Optimal Placement of FACTS Devices” จึงถือเป็นโอกาสอันดีในการสร้างชื่อเสียงให้กับมหาวิทยาลัยอุบลราชธานี และประเทศไทยต่อไป

ดังนั้น ภาควิชาวิศวกรรมไฟฟ้าและอิเล็กทรอนิกส์ จึงใคร่ขออนุมัติงบประมาณสนับสนุนในการนำเสนอผลงาน รายละเอียดดังนี้

1. ค่าลงทะเบียน (US\$720)	จำนวน	25,200	บาท
2. ค่าเบี้ยเลี้ยงต่างประเทศ (3 วัน x 2,100 บาท)	จำนวน	6,300	บาท
3. ค่าเบี้ยเลี้ยงภายในประเทศ (2 วัน x 210 บาท)	จำนวน	420	บาท
4. ค่าพาหนะระหว่างประเทศ	จำนวน	22,000	บาท
5. ค่าพาหนะประจำทางและรถรับจ้างในต่างประเทศ	จำนวน	1,000	บาท
6. ค่าพาหนะภายในประเทศ	จำนวน	2,000	บาท
7. ค่าที่พัก (3 วัน x 3,000 บาท)	จำนวน	9,000	บาท
รวมทั้งสิ้น		65,920	บาท

(หกหมื่นห้าพันเก้าร้อยยี่สิบบาทถ้วน)

จึงเรียนมาเพื่อโปรดพิจารณา

เรียน รองคณบดีฝ่ายวิจัยและบริการวิชาการ

ได้ทราบแล้ว/ขอรับทราบ

ได้เสนอให้/ขอเสนอให้

ขอเสนอ/ขอเสนอให้

ขอเสนอ/ขอเสนอให้

ขอเสนอ/ขอเสนอให้

ขอเสนอ/ขอเสนอให้

ขอเสนอ/ขอเสนอให้

ขอเสนอ/ขอเสนอให้

(ดร.ประสิทธิ์ นกรราช)

หัวหน้าภาควิชาวิศวกรรมไฟฟ้าและอิเล็กทรอนิกส์

เสนอ ERB พิจารณา

18/08/52

**Canadian Secretariat
THE INTERNATIONAL ASSOCIATION OF SCIENCE
AND TECHNOLOGY FOR DEVELOPMENT**



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Ubonratchathani University
Electrical and electronics engineering
Faculty of engineering
Satholmark
Sriki, Warinchamrap Ubonratchathani
Thailand 34190

Dear Dr. Sookananta,

Re: 658-059 EMPLOYMENT OF THE AC DISTRIBUTION FACTOR FOR THE OPTIMAL PLACEMENT OF FACTS DEVICES.

Congratulations, your paper has been accepted for oral presentation and publication at the IASTED International Conference on Power and Energy Systems (AsiaPES 2009), to be held from October 12, 2009 to October 14, 2009, in Beijing, China. We cordially invite you to attend and present your paper at the conference. We also encourage you to register and book your flight as soon as possible, if you have not already done so.

Please complete the following by the registration deadline of August 28, 2009.

1. Registration Form and Payment (mandatory)
2. Author Information Form (mandatory)
3. Hotel Reservation Form (if you need assistance in reserving a hotel room)
4. Copyright Form (mandatory)

The above materials are available for viewing on our website at <http://www.iasted.org/conferences/home-658.html>. Please let me know if you have any questions regarding registration.

Once again, congratulations on your AsiaPES 2009 acceptance. We are very excited to be able to include your research and ideas in the conference, and we look forward to seeing you in Beijing, China.

Sincerely,

Jannell Lee
Conference Manager

Please note - For Visa Purposes:

The International Association of Science and Technology for Development (IASTED), is a non-profit organization founded in Zurich, Switzerland in 1977. The purpose of IASTED is to promote economic development through science and technology. After 30 years, IASTED continues to bring top scholars and members of industry together to develop and share new ideas, facilitate cultural exchange and encourage international unity