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COMPUTER CONTROL IN POWER SYSTEMS

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التحكم في نظم القوى الكهربيه
بالحاسب الآلي

هذا البحث يتعلق باستخدام الحواسب الآليه في التحكم في أنظمه القوي الكهربيه سواء المستخدم منها علي الخط (on - line) او من خارج الخط (off- line) وذلك في جميع أجزاء الشبكه. وقد تم استحداث طريقه تعتمد علي الوصف الطبولوجي للشبكه والتي من طريقها يتم وصف الشبكه وتوصيلاتها وحالتها وأوضاع تشغيلها. وقد تم تصميم برنامج يغذي به الحاسب الآلي ويبني بهذا الغرض . وتلذنا الطريقه والبرنامج للتحقق في حالة شبكه ج.م.ع وخصوصا محطه القاهره ٥٠٠ . وقد وضح ان طريقه الاستكمال عن طريق الخط اسرع كثيرا من تلك المستخدمه من خارج الخط. وقد تم ايضا استخدام الحاسب من خارج الخط لحساب حالة الشبكات الاستقراريه وذلك في شبكه ج.م.ع ذات الجهد الفائق (٥٠٠ ك.ف) ،تم الحصول علي تمثيل لحالات الشبكه الاستقراريه تحت ظروف تشغيل مختلفه والتي عن طريق معرفتها يمكن اتخاذ القرار المناسب لضمان الاتزان.

ABSTRACT :

This paper is concerned with the new applications of on line / off line computers in modern power systems.

In This paper, computer control from the power stations to the substation and transmission is extended. A new technique using a new topology description is developed. This technique has the facilities of describing topology connections , states, proparties as well as the optimal process of power stations . A program is constructed and used for performing the system interlocking.

The Egyptian 500 kV substation is checked by the proposed technique and its prespective program. The on-line intrlocking is found to have less computation time than the off- line interlocking . The off- line computer is applied for determining the stability of the 500 kV portion of Egyptian grid.

1-INTRODUCTION :

Implementation of computers in power systems has greatly increased in recent years . This is, beccause its low cost , fast flexibility ,and fast responses.

The application of small computers are either for on line or off line computation . The off line computers are used for analysis and in design while the on line computers have been used in some applications such as,controllers and some structures [1].

Therfore ,its usefull to distinguish the above two applications of digital computers in power system (off-line and on-line) applications.The former embraces the use of the large general purpose digital computers as a fast flexible computing device for the numerical solution of complex engineering problems. This was the earlist field of power system applications of computers and is a well developed with active research work being made in many directions . The on line application, envisages the use of the smaller "control computer" as a part of the system which controls the operation of various portions of the modern power system. It is , therefore implied that the speed of computation is at least comparable with the line scale of the operation being controled [2]

Two further areas of on line computer applications are introduced. These two areas which are of current interest are , the role of operator and the assessment of system security and system interlocking .

In this paper, technique , based on the system topology structure, is proposed and applied to A.R.E 500 kV CAIRO Power Station (CPS) for system interlocking .

2- ON - LINE COMPUTERS IN POWER SYSTEMS

At the present time it seems that the ultimate pattern of overall computer control in power system will be a hierarchical one.This is because each computer communnicating with others at the same level and at different levels of the hierarchy. Fig.1 is a schematic representation of ultimate organization .

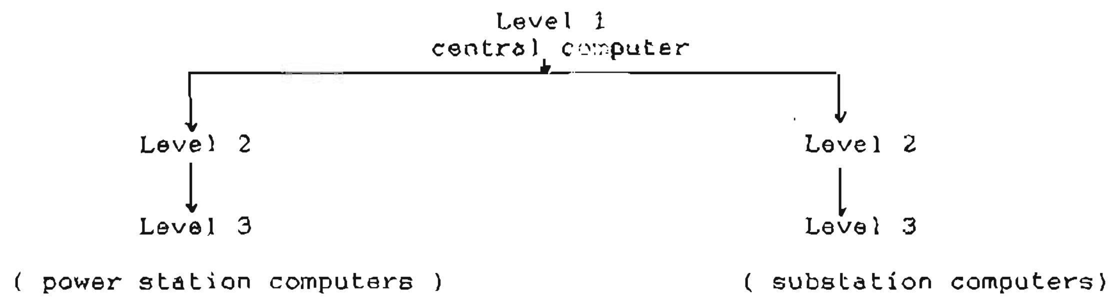

Fig.1 Schematic representation of ultimate orginization type

The centeral computer (level 1) will exercise a supervisory control over the various areas and provides amean of centralised command over the operations of the entire power system.

The area computers (Level 2) will contain the operation (steady state and emergency) of identifiable sub-region of the system. Each area computer will communicate with other area computers with regard to the achievement of desired interchange of energy between areas. For example., these computers will embody a number of the on line control features at present available as well as others added as the result of development.
The lowest level (level 3) will be the small "control computer" installed in individual power stations and substations.

The field of computer control in power system has developed in response to the need for more exact and complex automatic control as well as the availability of fast , compact and reliable small computers and peripheral equipment.

2.1 Area Computer:

The particular division of functions between area copmuters and station computers (power station and substitution) will depend upon system operating conditions and other factors. Several of functions discussed , subsequently , could clearly be allocated to either of these levels.

A substantial amount reasearch has already been done in the on - line application of computers for system control and operation at the area level [2,4] .In particular , the problem of economic dispatch of generating plants within the system, unit commitment ,maintenance, scheduling ,load frequency control. spinning reserve, have all been incorporated in various recent installations. Stagg et.al [5] describe a typical recent application in some details.

Two further areas of on line computer applications are introduced These two areas which are of current interest are , the role of the operator and the assessment of system security and system interlocking. The term " system security and system interlocking " are used to cover a new field of on -line computer application [6,7] in which the computer assesses the margin between the system condition and its capability,and initiates appropriate actions if the capability limits are reached .

In the A.R.E it is contemplated that security assessments will encompass not only the approaches to thermal limits but also dynamic instabilities due to the occurrence of certain contingencies such as the loss of the largest unit or major feeder.

The computer compares exiting operating levels with forcast levels and checkes if any of the known limits are to be exceeded and possibly takes action to avoide such occurrences. It well also contain a list of contingencies and evaluate the concequences of these actions .It may also takes appropriate action or instruct the operator to do so .

The problems in this field are formatable at present. These are due to that the computer will be required to perform on-line load flow ,and stability calculations. Further, the amount of information required to make these calculations and rate at which this must be acquired places a constrain on contemprorary communication systems.

2.2 Computers in Power Stations and Substations: .

In recent years, there have been a growing use of digital computers in power stations. The earlier installations were used mainly for momitoring important variables such as temperatures and pressures in boiler- turbine system . These were soon extended to include alarm analysis, efficiency calculations , and the supply of information to gide the operator in plant operation.

More recently a number of boiler start-up and shut- down procedures have been devised and practical schemes susccessfuly demonstrated . It also appears that these sequencing schemes will be used to an increasing extent in the future .

The predominant mode of computer control of boiler-turbine plant has been a mixture of analogue and digital devices . Recently, direct digital control of boiler and turbine functions has been successfully implemented in a number of installations , but a considerable amount of development remains to be done .

The substation computers are well developed and these are the most speculative areas of investigation . At the lowest level of the hierarchy of Fig.1, we propose the on - line computer control of various functions of a modern ,and large substations .

Conventional methods of detection and isolation of faults conccentrate on the various units in the system rather than on the coordnated control of substantial area.

Increasing complexity of major installations leads to a prolifeation of protective equipment withen the attendant difficulties of trend towards larger individual units, transformers and transmission of these units under fault conditions to the implications of each outage for the overall performance of the system attached to the particular substations as well as the area in which the substation is located [8] .

Most of the roles of the substations such the switching and protection of the modern system involves , fundamentally , rapid logical decision among a number of alternatives - an operation for which the digital computer is idealy suited. For this reason as well as those mentioned above ,it seems appropriate to consider more closely the possibility of computer control into the substation.

It is envisaged that , ultimately ,each substation of sufficient size would have its own small computer embodying the following functions (in increasing order of its operating time)

1-Protection , Detection and Isolation of Faults ;

- (i) Automatic reclosing and resynchronizing
  - a- Out -of-step relaying
- (ii) Circuit breaker operation for re-arrangement of circuits

2-Steady -State Control ;

- (i) Switching operations, dispatched form area control center;.
- (ii) Voltage control ,tap changing and
- (iii) Safety interlocks.

3-Data Processing ;

- (i) Data logging
  - (a)-Maximum demand and total demand
  - (b)-Sequence of events recording
  - (c)-Alarm annunciation and recoding

It can be reasonably anticipated that a computer will be able to provide greater flexibility ,ease of updating and compactness than present methods specially as the complexity of the system increases.

3- APPLICATION EXAMPLES :

a) On- Line Control Application :

An on - line technique for CAIRO - 500 substation interlocking are presented [7]. This technique uses a new topology description [4]. This description has the facilities of describing their topological connections,their states ,properties as well as the operational processes.

The On -Line computer is applied to Cairo - 500 substation for which the single line diagram is shown in Fig.2 . The topological description of Cairo - 500 substation is given in Fig.3 . A on-line program has been written to perform both the field -Interlocking(CW1 = CAIRO-WEST) .and the substation -Interlocking(CAIRO-500) .

The running time of the program is found to be 0.16 second for on -line field interlocking (CW1) ,while .for on -line substation interlocking its found to be .95 second.

b) Off-Line Computer Applications

An off- line program is constructed and stored in a PC copmuter . The program determines the stability conditions , specailly that concerned with unconventional frequencies.

The single line diagram of Fig.4 represents the 500 kV portion of the Egyptian electric utility which is used for the off line study

The data of the system are stored in an off-line memory while flowchart of Fig 5 illustrate the main computation steps.

The output of the off-line computer is shown by Figures 6 and 7.Fig.6 shows the output for the system when it is loaded and without load which indicates that the system is stable at 50 Hz and the unstable frequency is raised from 17.61 Hz to 24.6 Hz when the system load is raised from neglegable lpad to full load . these is however with the system is compensated to .8 pu compensation.

Fig 7 gives the same result but at another value of compensation level (1 pu.) which the cretical frequency drops to 11 Hz which increases to 22.85 HZ

4-CONCLUSIONS

1- Two applications of computer in power system are proposed and applied

2- A new technique for system interlocking using on line computer is and field interlocking .

4- The proposed technique of interlock is used for protection . detection ,and isolation of faults.

5- The running time of the program is found to be 0.16 second for on -line Field Interlocking(CW1) while for the on -Line substation interlocking (C- 500) it is found to be 0.95 second .

6- An off-Line computer is used to determines stability conditions related to unconventional frequencies of 500 kV portion of Egyptian utility.

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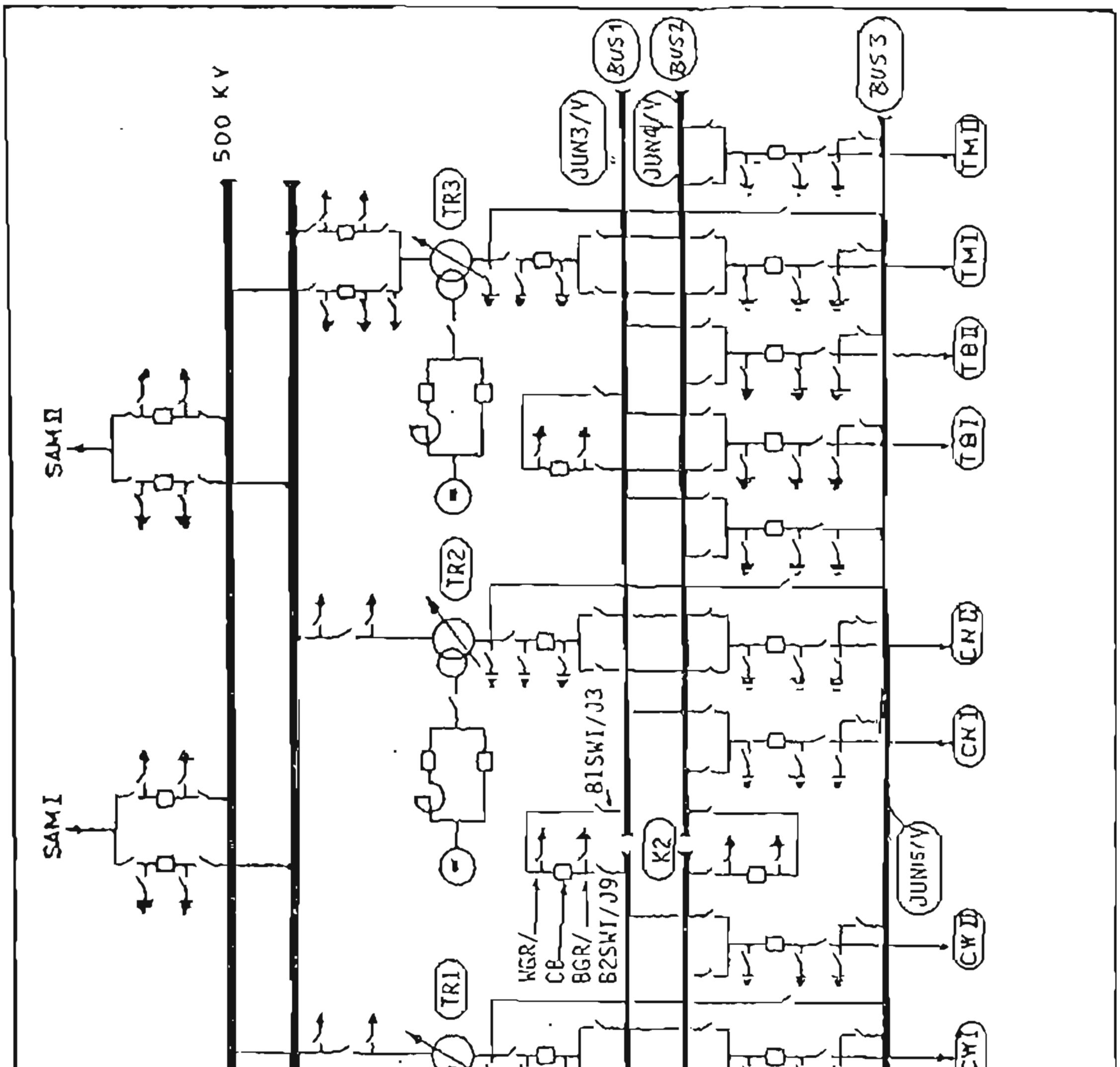

Fig.2 Single line Diagram of CAIRO 500 CPS

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'''C500
 ''220
  'BUS1[JUN9/V('CS1[B2SWI/J9]'CS2[B2SWI/J9]'CW1[B2SWI/J9]
              'CW2[B2SWI/J9]'TR1[B2SWI/J9]'K1[B2SWI/J9]
              'K2[B2SWI/J9]),SEPAR,
        JUN3/V('CN1[B2SWI/J3]'CN2[B2SWI/J3]'TB1[B2SWI/J3]
              'TB2[B2SWI/J3]'TM1[B2SWI/J3]'TM2[B2SWI/J3]
              'K3[B2SWI/J3]'K4[B2SWI/J3]'TR2[B2SWI/J3]
              'TR3[B2SWI/J3]))]
  'BUS2[JUN10/V('CS1[B1SWI/J10]'CS2[B1SWI/J10]'CW1[B1SWI/J10]
              'CW2[B1SWI/J10]'TR1[B1SWI/J10]'K1[B1SWI/J10]
              'K2[B1SWI/J10]),SEPAR,
        JUN4/V('CN1[B1SWI/J4]'CN2[B1SWI/J4]'TB1[B1SWI/J4]
              'TB2[B1SWI/J4]'TM1[B1SWI/J4]'TM2[B1SWI/J4]
              'K3[B1SWI/J4]'K4[B2SWI/J4]'TR2[B1SWI/J4]
              'TR3[B1SWI/J4]))]
  'BUS3[JUN15/V('CS1[ASWI/J15]'CS2[ASWI/J15]'CW1[ASWI/J15]
              'CW2[ASWI/J15]'CN1[ASWI/J15]'CN2[ASWI/J15]
              'TB1[ASWI/J15]'TB2[ASWI/J15]'TM1[ASWI/J15]
              'TR1[ASWI/J15]'TR2[ASWI/J15]'TR3[ASWI/J15]
              'K4[CON/J15]))]
  'CS1[X220A/Q('''CSOUT''220'C500[PEC/Q])]
  'CS2[X220A/Q('''CSOUT''220'C500<--?-->)]
  'CW1[X220A/Q('''CWEST''220'C5001[PEC/Q])]
  'CW2[X220A/Q('''CWEST''220'C5002[PEC/Q])]
  'CN1[X220B/Q('''CNORT''220'C5001[PEC/Q])]
  'CN2[X220B/Q('''CNORT''220'C5002[PEC/Q])]
  'TB1[X220B/Q('''TB''220'C5001[PEC/Q])]
  'TB2[X220B/Q('''TB''220'C5002[PEC/Q])]
  'TM1[X220B/Q('''TMATA''220'C5001[PEC/Q])]
  'TM2[X220B/Q('''TMATA''220'C5002[PEC/Q])]
  'TR1[X220A/Q('''C500''1'TR1[PEC2/Q])]
  'TR2[X220B/Q('''C500''1'TR2[PEC2/Q])]
  'TR3[X220B/Q('''C500''1'TR3[PEC2/Q])]
  'K1[B1SWI/J10,BGR/,CB*R,WGR/,B2SWI/J9]
  'K2[B2SWI/J9,BGR/,CB1*R,WGR/,B1SWI/J3,
     SEPAR,B2SWI/10,WGR1B/,CB2*R,WGR2B/,B3SWI/J4]
  'K3[B1SWI/J4,BGR/,CB*R,WGR/,B2SWI/J3]
  'K4[B1SWI/J4,WGR1B/,CB*R,WGR2B/,LSWI,
     FGR,B2SWI/J3,ASWI/J15]
 ''1
  'TR1[PEC1/Q(<-----500KV----->),TR3DAT,
      PEC2/Q('''C500''220'TR1[PEC/Q]),
      PEC3/Q(<-----KOHP----->)]
  'TR2[PEC1/Q(<-----500KV----->),TR3DAT,
      PEC2/Q('''C500''220'TR2[PEC/Q]),
      PEC3/Q(<-----KOHP----->)]
  'TR3[PEC1/Q(<-----500KV----->),TR3DAT,
      PEC2/Q('''C500''220'TR3[PEC/Q]),
      PEC3/Q(<-----KOHP----->)]
```

Fig. 3 Topology Discrption of CARO 500 CPS

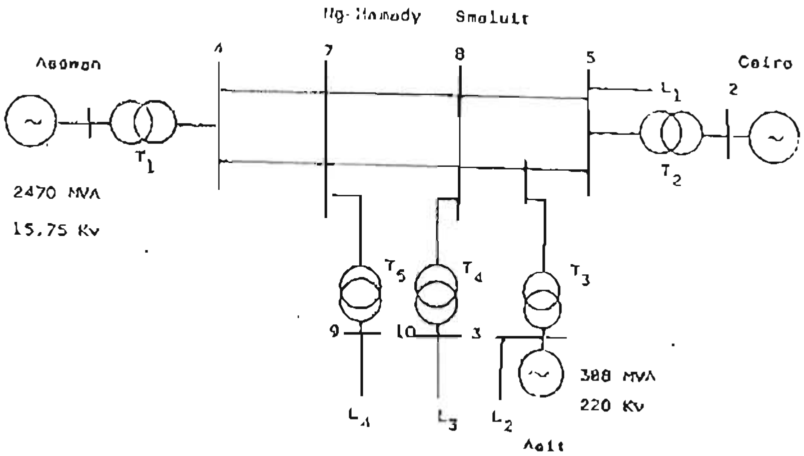

Fig. 4 Single line diagram of the 500 Kv study portion of the Egyptian electric network.

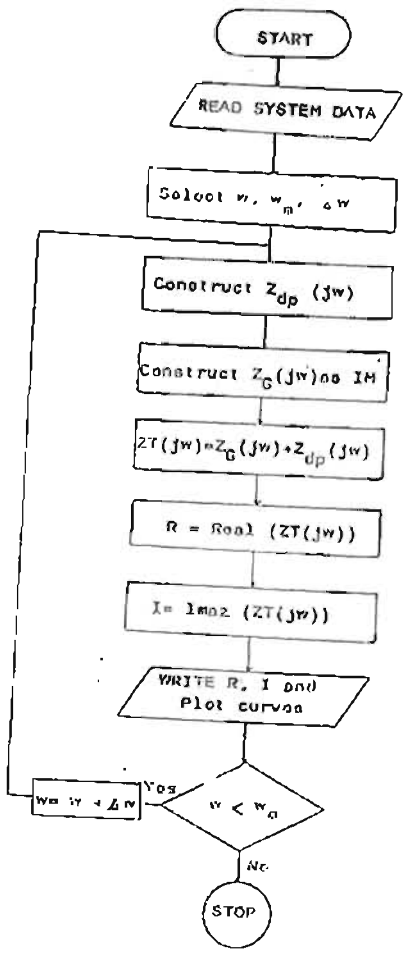

Fig 5 flowshart of the frequency scan program

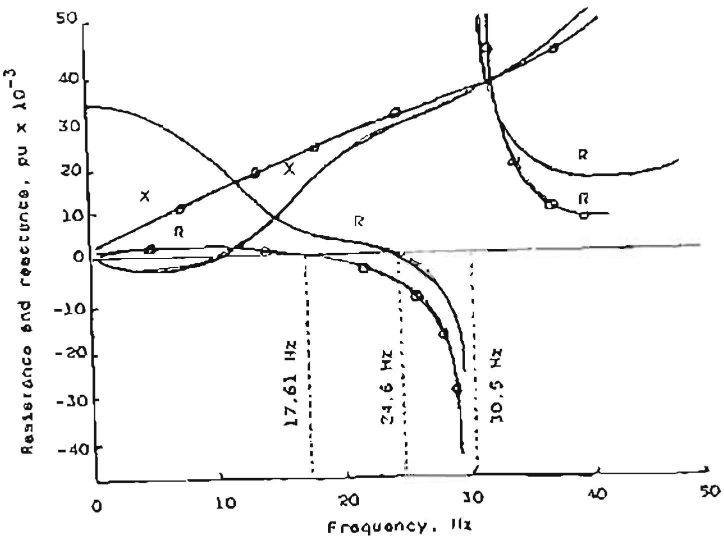

Fig. 6. : Frequency-scanning of the study portion of the Egyptian electric network for 0.8 pu series capacitor reactance, effect of system load.

—— Load

-●- no load

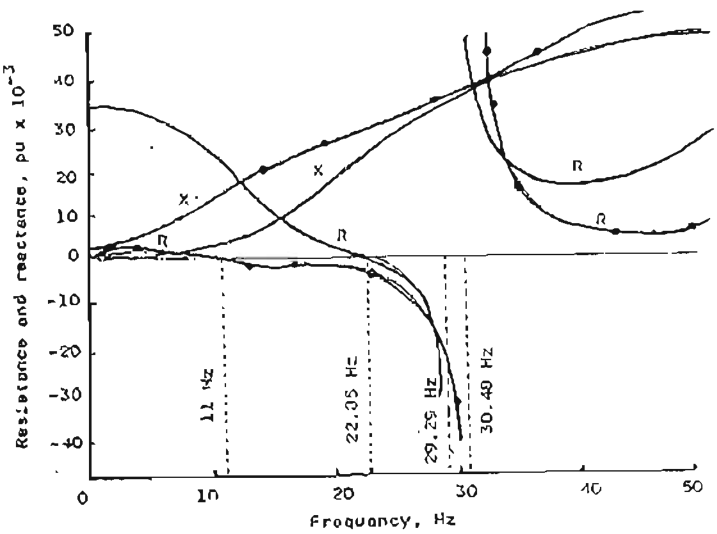

Fig. 7. : Frequency-scanning of the study portion of the Egyptian electric network for 1.0 pu series capacitor reactance, effect of system Load.

—— Load

-●- no Load.